

KEMENTERIAN PERTANIAN MALAYSIA

**UPGRADING OF IRRIGATION & DRAINAGE SCHEMES
IN**

**BALIK PULAU AND SEBERANG PERAI
PULAU PINANG**

**INTERIM REPORT FOR
SEBERANG PERAI
AUGUST 1981**

BINNIE DAN RAKAN (M)
KUALA LUMPUR

in association with

HUNTING TECHNICAL SERVICES LTD.
UNITED KINGDOM

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HUNTING TECHNICAL SERVICES LTD.

UNITED KINGDOM

BIL. TUAN:

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303

The Secretary General,
Ministry of Agriculture,
Jalan Swettenham,
Kuala Lumpur.

10th August, 1981

Tuan,

Upgrading of Irrigation and Drainage Schemes
in Seberang Perai and Balik Pulau - Pulau Pinang

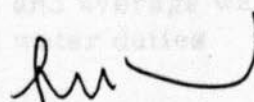
We have pleasure in submitting the Interim Report for Seberang Perai, as part of the above study. A separate interim report covering Balik Pulau will follow shortly.

The present report does not cover socio-economic aspects, since the arrangements to proceed with a socio-economic survey were only finalised recently; this subject will be treated in the draft final report.

This report also does not give recommendations in respect of the tree crop areas, since our priority for the work to date has been the padi irrigation schemes, especially the Kulim scheme. Analysis of the economics of drainage improvements in the tree crop areas depends on our receiving details of the existing agriculture, which are being collected by a Department of Agriculture team. It has become necessary to carry out topographic survey in the tree crop areas, for which we wish to make use of the provisional Survey Technician time in our Contract Agreement. With your approval of this, and with timely receipt of the data on existing agriculture, we shall make a full report on the tree crop areas as part of the draft final report.

Yang benar,
BINNIE DAN RAKAN (MALAYSIA)

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Abbreviations used in this report

CHO	Constant head orifice
CSDS	Coconut Smallholders Development Scheme
DOA	Department of Agriculture (Jabatan Pertanian)
DID	Drainage & Irrigation Department (see JPT)
FAMA	Federal Agricultural Marketing Authority
FMP	Fourth Malaysia Plan
FSL	Full Supply Level
IADP	Integrated Agricultural Development Project
JKR	Jabatan Kerja Raya (Public Works Department)
JPT	Jabatan Parit dan Taliair (Drainage & Irrigation Dept.)
J.Pert.	Jabatan Pertanian (Department of Agriculture)
LPN	Lembaga Padi Negara (National Padi Board)
LPP	Lembaga Pertubuhan Peladang (Farmers' Organisation Authority)
MADA	Muda Agricultural Development Authority (Kedah & Perlis)
MARDI	Malaysian Agricultural Research and Development Institute
MMS	Malaysian Meteorological Service
MOA	Ministry of Agriculture
NEP	New Economic Policy
PBA	Pihak Berkuasa Air (Penang Water Authority)
RISDA	Rubber Industry Smallholders Development Authority
SEPU	State Economic Planning Unit
SERU	Socio-economic Research Unit
TMP	Third Malaysia Plan
TOR	Terms of Reference
Sg.	Sungai
Kg.	Kampung
ac	acres
ch	chains
ft	feet
gt	gantangs (1gt = 5.6 lb of rice)
ha	hectares
in	inches
km	kilometres

kg	kilograms
L	Litres
lb	pounds
m	metres
mi	miles
m-m	man-month
s, sec	seconds
T	metric tonnes

EXECUTIVE SUMMARY AND RECOMMENDATIONS

(the recommendations are listed at the end of this section)

S.1 This report gives the results of studies to the end of July 1981 and includes provisional recommendations in matters of engineering design, agricultural improvements and development programme.

S.2 Socio-economic studies were commissioned in May 1981 as an addition to the Terms of Reference. The form of questionnaire for a survey has been approved and field work in obtaining replies has started. There is nothing further to report yet. The Juru scheme (244 ha) in Seberang Perai Tengah has not been treated in this report for two related reasons; its water supplies, already inadequate, have been rendered even more questionable by the proposed enlargement of the Butterworth/Bukit Mertajam Metropolitan Area, and as a result of this and other difficulties a socio-economic survey of the Juru scheme farmers is about to be conducted. It is therefore considered premature to put forward proposals.

S.3 The scope of our studies in the tree crop areas required clarification, which was obtained at a meeting held early in July 1981. A field survey to update the existing cropping patterns and areas, a necessary preliminary to the economic evaluation, is currently being undertaken by the Department of Agriculture. The engineering situation within the principal drainage (tree crop) areas is described, and outline design criteria are given.

S.4 The principal contents of this report are summarised below, using the same order as that of the main sections: (references to sub-sections of the main report are given in brackets).

Water resources (2.2) and requirements (5.1)

S.5 There is adequate surface water for double cropping of padi in all areas (except Juru, Alma and some other very small schemes) subject to the following points:

- for the dry year with 20% probability ("1-in-5 dry year") it may be necessary to delay planting in the off season in parts of the area, with a consequent risk of loss of a part of the crop if late August rains should be severe;
- for the dry year of 10% probability ("1-in-10 dry year") there could be a very serious shortage unless users of Sungai Muda and Sungai Kulim water in Kedah were subjected to a careful control of their abstractions;
- in the longer term there is need for agreement with Kedah State authorities on the apportioning of Sg. Muda and Sg. Kulim water in times of drought. This is the more necessary in view of plans to create off-channel storage in Kedah for Sg. Muda water, to be used for new irrigation schemes in that State (5.1.3). This probably would require the formation of an interstate river basin authority or else a flexible control system to safeguard the rights of Penang State users in respect of Kedah abstractions and releases from storage (5.5.3).

Groundwater (2.3)

S.6 There are significant resources in shallow sand aquifers which are already used on a very small scale by non-irrigation users. Sub-surface exploration and test pumping would be needed to give a quantitative assessment, though it is not expected that this resource could irrigate large areas.

Soils (2.4)

S.7 All soils in the project area are eminently suitable for rice cultivation, although certain coastal areas of Sungai Muda scheme are spongy in texture and badly require improved drainage. Acid sulphate conditions are only found at Juru. (the area surveyed to date does not include the tree crop areas)

Land values and development (2.5)

S.8 Land acquisition prices for the Sungai Kulim scheme have been estimated by the Federal Valuation office. Similar estimates for the other scheme areas will be obtained in the final report stage. Sungai Kulim scheme values range from \$13,000 to \$30,000 per acre, excluding road frontage land which may be as high as \$130,000 per acre.

Infrastructure improvements in areas whose land values are well in excess of the agricultural worth are not recommended.

Existing agriculture (chapter 3)

S.9 The project area inherits a total of about 14,200 ha (35,000 ac) of land divided into padi farms of around 0.8 hectare each in average area. Out of approximately 18,000 nominal farm households 50% rent their land, 45% are sole owners and the balance have other rights (ref. 10).^{*} The small farm sizes and inadequacy of land drainage have been the principal causes leading to very low returns to the farmers. When the demands of the factories showed alternative employment to be available land began to be abandoned. This process escalated with abandoned land harbouring pests which further reduced yields, so that by the 1980-81 main padi season 4,800 ha (34%) of the total area was left uncultivated.

S.10 If the abandonment of land had not occurred then the whole area already has the ability to grow two crops of rice a year. Average yields in Seberang Perai Utara are around 2,900 kg/ha (460 gt/ac) and in Seberang Perai Tengah they are around 2,250 kg/ha (360 gt/ac). These

* References are given at page 195

figures conceal wide variations between schemes; as a broad generalisation yields in the large scheme areas nearest to Sungai Muda are highest, and they are lowest in the smallest schemes in all districts, ranging from 3,750 kg/ha (600 gt/ac) at Pinang Tunggal to 1,460 kg/ha (230 gt/ac) at Tasek Gelugor and Machang Bubok.

S.11 Many varieties of padi are grown, and quite often seeds are mixed. The varying padi maturity periods which result, in fields in close proximity, reduce the ability of farmers jointly to plan their irrigation and field drying out operations. Rice is grown in nurseries and transplanted throughout the area, although experiments with direct sowing have been made. Land preparation is by tractors or power tillers in nearly all cases. Harvesting is done by hand in most areas although combine harvesters from Kedah have started work in some areas in recent seasons.

S.12 Possibly the most serious shortcoming in the system is the almost complete absence of any uniform cropping timetable in most areas. Padi can be seen at all stages of cultivation at any time. This detracts from yields for a number of reasons and provides a perennial source of food for rats.

Agricultural support services (chapter 4)

S.13 The State DOA (Jabatan Pertanian) has an extension service to padi farmers. The number of Agricultural Technicians is well below that needed to provide one extension worker for 600 farm families; to meet this criterion staffing would have to be increased from by nearly 100%.

S.14 The Lembaga Pertubuhan Peladang (LPP) has seven co-operatives in Seberang Prai with a membership now estimated at 37% of all farm families. The LPP is engaged in several schemes to reclaim abandoned padi areas. It is too early to say whether they will be successful in their objectives.

Cropping pattern (5.2)

S.15 Double cropping of padi should be synchronised to make best use of the weather patterns and water available, to permit proper water control in the fields and efficient prediction of demand, as well as for many independent reasons, such as removal of permanent food supplies to pests, and ability to shut down irrigation systems for maintenance. The dry season land preparation should start in early March with harvest in July and August. The main season land preparation should start in August with harvest in December to February (Fig. 5.1).

S.16 We recommend that larger schemes are cultivated in three operating blocks, with a two-week delay separating the start of each operation in each block. Land preparation in any one block would be spread over 6 weeks.

S.17 Peak water requirements at the intakes are estimated at 1.9 L/s/ha for large 3-block schemes, and for small schemes without staggered timing between blocks the peak requirement can reach 2.45 L/s/ha.

Irrigation schemes (chapters 6 and 8)

S.18 The irrigation schemes generally have adequate intake facilities and reasonable primary and secondary distribution systems. Only relatively minor improvements are proposed to these existing works, generally entailing raising canal banks and providing access roads along the canals. In the Sungai Muda scheme major changes to the alignments of two secondary canals are recommended.

S.19 The existing infrastructure at kampong and field level is generally inadequate, particularly if mechanisation is to be utilised to a greater degree and direct sowing of rice introduced. The criteria for improvements to the infrastructure are made specifically to meet the requirements for the water control necessary for these practices.

S.20 The irrigated areas should be divided into smaller tertiary units for improved management and water control, and measurement devices provided at every offtake. Within each tertiary unit, lined tertiary canals and unlined quaternary canals should be provided to give a direct supply to as many farms as possible.

S.21 The drainage system should parallel the canal network with quaternary (or 'field') drains serving the individual farms. Tertiary drains are required between each tertiary unit and improvements in some areas are necessary to the secondary drains. The use of controlled drainage for irrigation purposes should be discouraged except for short periods during presaturation of the fields.

S.22 Primary access to most of the schemes is good but better access into the irrigation areas is required for farm machinery, and for the transport of fertilizers and grain. The preliminary proposals are for access adequate for large combine harvesters to be provided into every tertiary unit along the tertiary canal. The capital costs of providing this level of access however are high, and the proposed level of access facilities may have to be downgraded.

S.23 Preliminary costs are given for implementation of the above improvements based on study of three sample areas. Excluding land acquisition the tertiary development work would cost from \$5,500 to \$7,600 per hectare (8.8.2). These figures, scaled up for the whole of the major schemes and with allowance for other work necessary, amount to the following totals, including engineering charges but excluding land acquisition:

Sg. Muda scheme : \$84 million

Sg. Kulim scheme : \$29 million

Drainage areas (chapter 7)

S.24 Engineering studies of the drainage areas started later than those in the padi irrigation areas, and no recommendations are made in this report. Many problems in the field have been identified and the existing situation is described (7.2 - 7.4).

S.25 Engineering criteria for drainage improvement design are given (7.5). They are based on the assumptions made for tree crops such as cocoa and coffee in the standard JPT procedures. The engineering design checks will require topographic survey work additional to that envisaged at the start of these studies. (7.7).

S.26 Agricultural and economics assessment will start after a survey of existing land use is completed by Jabatan Pertanian.

Agricultural improvements (chapters 9 and 10)

S.27 The most pressing need is to establish an effective new form of farming organisation to operate padi cultivation in rehabilitated, usually now abandoned, areas. We propose a system of farming in units of 50 to 100 hectares (250 - 500 acres) which, for identification purposes, are termed "group farms". Grouping farming is envisaged as covering the whole of the currently abandoned or uncultivated areas, while on the other hand the existing smallholders are expected to remain farming as at present in the areas where agriculture remains reasonably productive. (9.1 and 10.3.8, 10.3.9).

S.28 Improved agronomic practices are described (9.2) and means of direct sowing of padi are discussed (9.3). Direct sowing is expected to expand rapidly from its present experimental stage in the State. Labour requirements and costs are based on the assumptions of transplanting by hand in smallholder areas and direct sowing in group farm areas. Land preparation will be fully mechanised in both cases.

S.29 Machinery service centres are recommended as essential for the group farm requirements, with some spare capacity available for smallholders. Four centres are considered necessary to provide ready access to the major areas; they would operate a total of 90 tractors, 32 combine harvesters and smaller units (10.6).

S.30 Farming enterprises analysed are:

double rice	-	smallholders
double rice	-	group farms (mechanised)
rice-mixed vegetables	-	smallholders

It is assumed that padi yields for smallholders with the project will rise over three years from 3.35 T/ha average per crop to 4.3 T/ha average (530 gt/ac to 680 gt/ac). For group farms a four year growth to 4.0 T/ha average (640 gt/ac) is assumed.

S.31 Our farm budgets are analysed for smallholdings of 0.9, 0.8 and 0.67 ha. The incomes for tenant farmers would range from \$3,419 to \$2,545 per annum depending on farm size, while for owner-operators the corresponding figures are \$3,997 to \$2,975.

Development plan (chapter 11)

S.32 A preliminary development plan for infrastructure improvement is presented; this will be expanded in the final report. The plan requires early establishment of agricultural pilot areas to pioneer the group farming concept in padi areas currently abandoned. It is shown that construction of irrigation, drainage and access improvements could be phased over 5 years starting in January 1982 and ending in December 1986. This time-table requires that the necessary survey and design work should start not later than December 1981 and February 1982 respectively.

Recommendations

Section

- R.1 Joint operating authority with Kedah State to regulate use of waters of Sg. Muda, Sg. Kulim and minor sources. 5.1 & 5.5
- R.2 Double cropping of padi throughout Project area should be to a uniform timetable, controlled and synchronised by the operating authority. 5.1
- R.3 Large schemes to be cultivated in three operating blocks, with 2-week delay between starting dates for each. 5.2
- R.4 Minor changes only are needed to primary and secondary irrigation systems, although improvement of access roads beside canals involves significant cost. 6.2 & 6.4
- R.5 Irrigated areas to be divided into tertiary units, with flow measurement devices at each canal offtake. 8.3
- R.6 New tertiary canals are required; they should be concrete lined, and preferably have a canal-side road able to carry combine harvesters. 8.4
- R.7 Unlined quaternary canals should be provided to give irrigation supply directly to as many farms as possible. 8.4
- R.8 New tertiary and quaternary drains are required. 8.5

Recommendations (continued)

Section

- R.9 Farms in areas now uncultivated should be organised on a group basis, each group occupying a tertiary unit of 50 ha to 100 ha. 9.1 & 10.3
- R.10 Group farms would be fully mechanised and should practice direct sowing of padi seed as soon as possible. 10.3
- R.11 Four new machinery service centres should be set up to service the group farms. 10.6
- R.12 For early implementation of a development plan, the necessary survey and design work should start shortly. 11.2

1. INTRODUCTION

1.1 Objectives

1.1.1 The terms of reference (TOR) state that the principal objective of the study is "to formulate and implement proposals for the upgrading of irrigation, drainage and access facilities for each of the irrigation schemes in the project area, with the aim of raising efficiency, improving farm and water management and providing the necessary pre-conditions for increased productivity and farm incomes". In addition the addendum to the TOR requires the Consultants to study improvements necessary to raise the productivity of the JPT drainage areas, most of which are in Seberang Perai Selatan.

1.1.2 The most effective and probably the only way to raise farm incomes for all padi farmers and retain them on the land is to educate them in making the best use of the facilities and inputs becoming available so as to increase their rice production with the lowest practicable input of labour, and especially with the least possible amount of hard manual work in the fields. To this end the report lays strong emphasis on mechanisation and, for areas already abandoned, on new forms of working groups of farmers.

1.1.3 The supplementary activities which have been mentioned from time to time - aquaculture, poultry and livestock, or horticulture - will remain available to certain farmers depending on their location, aptitude and inclination as possible sources of additional income. However it appears unlikely that these activities will ever become adopted by more than a minority of farmers for purposes of augmenting family income, although possession of poultry and fruit trees at their houses is obviously beneficial. In our final report we shall show that poultry is not a profitable new enterprise.

1.2 Progress and Logistics

1.2.1 Since submission of the Inception Report in March 1981 work on the study of Seberang Perai areas has proceeded in parallel with work on Balik Pulau agricultural upgrading. At a Steering Committee meeting in

1.2.1 April 1981 and at another Committee in May the Consultants were asked to include socio-economic work in the studies, which had not been allowed for in the original programme. As a result, and for other reasons which have been explained to Ministry of Agriculture officials, this report has been delayed beyond the date of 30th June 1981 which was intended in the original Agreement. The socio-economic survey (1.3) has not yet been carried out in Seberang Perai and it will be reported on later.

1.2.2 Apart from some problems with office accommodation and equipment the study has proceeded smoothly. Very good co-operation has been received from State officials of all agencies concerned with the study, and from Federal Officers in Kuala Lumpur. The only field where provision of data is incomplete, and which could cause difficulties or delays, is that of maps and aerial photographs for the southern half of the area.

1.2.3 A complete set of 1:25,000 scale topographic maps was requested at the start of the job. Although a number of sheets were supplied, there were and still remain gaps in the set. This is particularly critical for the drainage areas since the detail on maps at this scale is not available from other sources. Although we have been told some sheets are not in print they have never been itemised as such in writing. We submit that it is in the Government's interest that we have and use the best available mapping for the project areas, and by "available" we include sheets which may be lying unused in the offices or archives of departments concerned with the project. In view of the need to take maps into the field the provision of a second copy for reference would add to office efficiency. (see 1.2.5)

1.2.4 Aerial photo-mosaics (one copy only) were provided at the start of the job covering the northern half of the project area. These mosaics have been most useful, but they only extend southward to Bukit Mertajam, and areas to the south are not shown. These mosaics are at a scale of 1:6,336, photographed in 1977. In May 1981 we requested copies of a different aerial photography series - 1:25,000 scale dated 1974 - to cover the remaining areas, but to date none have been received. There is therefore no coverage for our use of most of the drainage areas, or of Balik Pulau, by aerial photographs of any sort, and this is likely to handicap the future studies unless remedied quickly.

1.2.5 As a general comment we would now recommend that at least two copies of maps and aerial photographs are needed for efficient field and office work. If there is only one copy it is too valuable and too easily damaged for field use. As a true example of this fact we never released the photo-mosaics described in 1.2.4 for field use. They would be a most valuable and time saving aid to the field surveyors, but they would first have each to be cut into 9 or 12 pieces for convenient handling. Obviously this cannot be done when the only mozaic is also needed for drawing reproduction in the office. Photo-copying was tried but was unsuccessful.

1.2.6 The only other data needed is that which is being obtained for us by the Department of Agriculture regarding the present state of tree crop cultivation (7.6.1). This is not overdue, but will be needed in the next few weeks. We shall hope to receive at the same time a map of future land use proposals at the same scale (1:25,000) as the current cultivation survey.

1.3 Socio-economic surveys

1.3.1 At the Steering Committee meeting on 16th April 1981 we were requested to carry out a full socio-economic survey of Balik Pulau. At the Technical Committee held on 25th May our proposals for that survey were approved and we were requested also to carry out a similar survey of problem areas in Seberang Perai. "Problem areas" in this context means those subject to the more extreme pressures on land and labour resources from urban development and industrial employment within the Butterworth-Perai-Bukit Mertajam Metropolitan Area. The padi schemes covered by this definition are Kulim, Juru and Cherok Tok Kun, with a nominal total area of 4,000 ha (9,900 ac).

1.3.2 The necessary questionnaire forms were prepared, and reproduced after approval by the Government. Enumerators have been appointed, and their briefing is taking place at the time of writing. The work has unfortunately been delayed as a result of severe illness of our Rural Sociologist, Prof. Mohd Taib Osman, and it is expected that the

computer-processed results of the survey will become available in late September. There is nothing in the remainder of this report about sociological matters since the survey is in this early stage and our Sociologist has been unwell. However the information given in our memorandum dated 7th July is added here for reference.

Purpose

1.3.3 To conduct a socio-economic survey in the critical padi scheme areas of Seberang Perai, in order to ascertain, besides the basic socio-economic facts of the population, the following:-

- (i) family structure: domicile and dispersal;
- (ii) patterns of economic pursuits in the family.
- (iii) economic and educational status of members of the family;
- (iv) land ownership, tenancy, etc.;
- (v) the immediate problems, especially with regard to abandoned padi fields.

While the survey will definitely come up with a picture involving the immediate problems, especially those concerning the present abandonment of some rice fields, a greater importance will be given to the projection as to whether or not the agricultural population will be able to sustain its position against the encroachment and expansion of urban and industrial activities. In-depth information on the family structure is therefore needed, besides other socio-economic factors such as land ownership, tenancy and economic occupation of the target population. Apart from the direct responses of the farmers themselves with regard to their perception of the future of agriculture, particularly rice, in the area, it is imperative that independent conclusions be drawn from the data collected such as the tenacity of an agricultural family in the face of changing situations or the patterns ownership and tenancy of the padi lands.

Scope

1.3.4 The survey is divided into two areas: (All are within Seberang Perai Tengah) Mukims 21, 2, 3, 4 and 5 will constitute one area while Mukims 6, 7 and 8, together with Juru scheme (Mukim 12) will make up

the other. The former will centre on Lembaga Persatuan Peladang at Kampong Pelet, while the latter on LPP at Cherok Tok Kun. Altogether, about 200 households/families will form the sample for the former area, while about 300 for the latter. The sample size is around 20% of the total number of households/families in the two areas.

Though not a dry area, however, there is a significant dry period during the first half of the year from December to early March. In some years, water stress is experienced by some crops, especially those that are sensitive to dry weather during this dry period. With supplementary irrigation water, some fruit crops of vegetables and other crops are grown.

During the dry period, this dry period is followed by a short rainy season commencing from the middle of April and extending down to mid-June. Heavy rainfall is then, only the beginning. The long wet season commencing in September is the wet season. In October and about mid-November is followed by the dry season again from December to early March. A summary of the rainfall data for Banting from 1950 to 1959 is given below.

No.	Station name	Mean annual rainfall (mm)
1	Kuala Lumpur	2180
2	Kuala Lumpur	2180
3	Kuala Lumpur	2180
4	Kuala Lumpur	2180
5	Kuala Lumpur	2180
6	Kuala Lumpur	2180
7	Kuala Lumpur	2180
8	Kuala Lumpur	2180
9	Kuala Lumpur	2180
10	Kuala Lumpur	2180
11	Kuala Lumpur	2180
12	Kuala Lumpur	2180
13	Kuala Lumpur	2180

2. STUDY OF RESOURCES

2.1 Climate

2.1.1 Rainfall: The annual rainfall shows only slight variation between districts in Seberang Perai. Of the 13 stations given below, those with the highest and lowest values are both in Seberang Perai Tengah and only a few miles apart. However, there is a distinct dry period throughout the State from December to early March. In some years, water stress in agriculture constitutes the main limitation to crop production during this dry period. With supplementary irrigation water, excellent crops of vegetables and other annuals can be grown.

Under normal circumstances, this dry period is followed by a short rainy period commencing from the month of April and extending into May with lesser rainfall in June, July and August. The long wet season commences in September with peak rainfall in October and lesser rainfall in November followed by the dry season again from December to early March. A summary of the rainfall data for Bumbong Lima is shown in Table 2.1a.

No.	Station name	Mean annual rainfall (mm)
1	Permatang Bendahari	2360
2	Permatang Binjai	2234
3	Butterworth Met. Station	2234
4	Pinang Tunggal	2131
5	Malakoff Estate	2052
6	Sg. Kulim Headworks	2424
7	Bukit Merah	1999
8	Permatang Rawa	2319
9	Bukit Berapit Reservoir	2155
10	Cherok To'kun	2539
11	Batu Kawan Estate	2052
12	Sg. Acheh Area	2051
13	Simpang Ampat	2324

- 2.1.2 Additionally, an important feature of the rainfall pattern is its variability from month to month and year to year. Furthermore, the rains can be very localised and short outbursts of intense storms are common.
- 2.1.3 Temperature: The mean monthly temperature along coastal areas show little variation, ranging from 27°C in March and April to almost 26°C in October and December from records of Bayan Lepas. The diurnal range averages not more than 10°C as recorded in Bumbong Lima (Tables 2.1b and 2.1c).
- 2.1.4 Humidity: Relative humidity is high throughout the State. Seasonal variation occur with the lowest relative humidity of 76% in February and gradually increasing to 85% in May. Between June and September, the relative humidity level remains somewhat constant at 86% rising to a peak of 88% in the month of October. With the onset of the dry period from December, relative humidity drops to its lowest level of 76% again in February. Tables 2.1d and 2.1c provides a summary of relative humidity characteristics for Bumbong Lima station.
- 2.1.5 Wind systems: During May, the south-westerly winds prevail and remain dominant until the end of August. Wind direction changes to north-easterly towards the end of the year when the weather is influenced by the northeast monsoon which starts in September and ends in December. Table 2.1f gives a summary of the mean monthly wind run.
- 2.1.6 Evapotranspiration: The forest evaporation map published by the JPT shows that evapotranspiration over the study area approximates 1600 mm annually. Evaporation seems fairly constant as records from the Bumbong Lima stations shows (Table 2.1g).
- 2.1.7 Duration of daylight (including twilight): The State of Penang lies approximately between latitude 5° 5' N and 5° 35' N. The duration of daylight is shortest in December and January (12 hours 36 minutes) and longest in June (13 hours 11 minutes). The growth duration of a rice variety is strongly influenced by the length of the day during the season in which it is grown. Hence, the maturation period of a padi variety differs when grown in the main season vis-a-vis in the off-season, the difference may vary from a few days in a low

photosensitive variety to several months in a high photosensitive variety. The former is referred to as a period-fixed variety while the latter is referred to as a season-fixed variety.

2.2 Surface water

Data collection

2.2.1 From a hydrological view point, a good network of hydro-metric station is important. In this respect, the distribution of such stations in Seberang Perai can be said to be relatively satisfactory. Because of the need to monitor historic events, rainfall in particular, the JPT has been the major source for data collection. A list of the available stations is shown in the table below. The locations of the 13 rainfall stations are shown in Figure 2.1.

No.	Station name	Station No.	Grid reference	Period of record
1	Permatang Bendahari	5503031	QS 655178	1949-1977
2	Permatang Binjai	5503034	QS 674093	1955-1977
3	Butterworth Met.Station	5403042	QS 669048	1956-1977
4	Pinang Tunggal	5505033	QS 801151	1949-1980
5	Malakoff Estate	5404041	QS 754076	1933-1980
6	Sg. Kulim Headworks	5404043	QS 770015	1946-1980
7	Bukit Merah	5404044	QS 715993	1946-1980
8	Permatang Rawa	5304046	QX 748935	1953-1980
9	Bukit Berapit Reservoir	5304045	QX 788952	1935-1980
10	Cherok To'Kun	5304047	QX 785932	1935-1980
11	Batu Kawan Estate	5204049	QX 716819	1947-1980
12	Sg. Acheh Area	5104052	QX 722698	1947-1977
13	Simpang Ampat	5204048	QX 768852	1951-1980

2.2.2 The number of streamflow stations in Seberang Perai is relatively small. The only catchment areas being gauged are Sg. Muda at Batu Pekaka and Sg. Kulim at Ara Kuda. Therefore transposition of data becomes necessary for run-of-river yield calculations for ungauged catchments. Because most of the study area is divided into catchment areas (where padi schemes are found) which are in close proximity to

Sg. Kulim catchment, the latter is more appropriate for transposition of river flows. The procedure is explained later in the section.

2.2.3 Additionally, where point rainfall and evapotranspiration data are lacking, regional hydrological data are derived from isohyets, isopleths and evaporation isolines published by JPT in the form of Hydrological Procedures and Water Resources Publications. The publications that have been referred to are:

- (1) Hydrological Procedure No. 1
- (2) Hydrological Procedure No. 12
- (3) Water Resources Publication No.2.

Data analysis

2.2.4 From the thirteen rainfall stations listed, there remains the choice of representative rainfall stations for the study area. However, the main criteria for selection is their location in major padi schemes. As such, three representative stations have been chosen; Permatang Binjai (2), Permatang Rawa (8) and Batu Kawan Estate (11). Broadly, these stations represent the northern, central and southern portions of the study area. Two additional stations were selected to supplement the results. These are Pinang Tunggal (4) and Sg. Kulim Headworks (6). However, since the water requirements are more crucial, only the critical months of February, March, April and May have been analysed for these stations.

2.2.5 Rainfall analysis included the determination of mean values, 1 in 5 year values, and 10-day rainfall characteristics. A 10-day rainfall analysis is adopted because of the needs of irrigation scheduling. The method involves the division of a calendar into three 10-day periods, the third of these being 8, 10 or 11 days depending on the calendar month. Probability analysis was used to obtain the 80% exceedence or 1 in 5 year low rainfall values. This criterion in data analysis is in accordance to JPT's irrigation requirements.

2.2.6 Results for the mean monthly and 1 in 5 year rainfall values of the representative stations of Permatang Binjai, Permatang Rawa and Batu Kawan Estate are shown in Tables 2.2 and 2.3. It is clear that the mean values show double maxima in the annual rainfall pattern (months of

April and October). This is more clearly seen diagrammatically (Figures 2.2, 2.3 and 2.4). The 1 in 5 year monthly values are also shown in the figures. They show a somewhat similar pattern to the mean.

2.2.7 In view of the importance of the rice crops, supplementary rainfall data for the critical dry months were analysed for Pinang Tunggal and Sg. Kulim Headworks. The results are shown in Table 2.4. Figures 2.5 and 2.6 show the results diagrammatically.

Rainfall Station	Data description	Month			
		February	March	April	May
Pinang Tunggal	Mean monthly	76	113	161	193
	1 in 5 yr monthly	25	69	107	114
	1st 10-day	0	10.2	20.3	31.8
	2nd 10-day	5.1	5.1	16.5	25.4
	3rd 10-day	1.3	16.5	17.8	7.6
Sg.Kulim Headworks	Mean monthly	78	153	208	204
	1 in 5 yr monthly	41	104	150	155
	1st 10-day	0	11.4	33.0	24.1
	2nd 10-day	12.7	0	43.2	33.6
	3rd 10-day	0	33.0	20.3	5.1

Table 2.4 Rainfall data of additional stations (mm).

2.2.8 It has been observed that zero rainfall does occur on a 10-day division during analysis. This is especially true for the months of January, February and March. As such, it is not surprising that zero rainfall is obtained when 1 in 5 year 10-day analysis were done (Tables 2.3 and 2.4).

Run-off

- 2.2.9 For run-off analysis, it is always important that actual records for catchments be collated. This is because a general pattern of flow can be meaningfully depicted by analysing a history of records. In the study area, the number of streamflow stations having a lengthy period of record is very limited. The only rivers that have long records are the Sg. Muda and Sg. Kulim.
- 2.2.10 Sg. Muda: The Sg. Muda catchment at Batu Pekaka has a area of 3341 sq. km which is about 80% of the total catchment. The catchment is partly bounded in the south and east by the Sg. Perak basin and the north and west by the Sg. Kedah basin.
- 2.2.11 The average annual rainfall over the catchment is approximately 95 ins and ranges from 80 ins in the north east to about 120 ins in the headwaters of Sg. Sedim and Sg. Karangan. The rainfall pattern is relatively similar to the study area mostly because of its close proximity.
- 2.2.12 River flow data for Sg. Muda at Batu Pekaka are available from 1947 to 1977. However, records from 1947 to 1968 were analysed because of the construction of the Muda Dam the following year. In order to obtain a true natural flow pattern for Sg. Muda, it was therefore deemed appropriate to analysed the river flow data before 1969.
- 2.2.13 The river flow distribution of Sg. Muda at Batu Pekaka is summarised in Table 2.5. It is clear that the flow is seasonal, being highest during four months of the year, i.e. from September to December. On the average, flows tend to be lowest during the months of February and March. Flows during these two months represent only about 7% of the average annual flow. From Table 2.5 again, it can be seen that the 1 in 5 year flow values are very much lower than the mean monthly values. For the months of January, February and March, the difference in volume is almost half.

- 2.2.14 Because river flows downstream are essential for water requirement calculations, mean monthly and 1 in 5 year flow values have been calculated for Pinang Tunggal since this major irrigation intake is an important source for the distribution of irrigated water. The river flow distribution for Sg. Muda at Pinang Tunggal is determined by area proportion computation from values measured at Batu Pekaka. The obtained values are summarised in Table 2.5.
- 2.2.15 Sg. Kulim: Sg. Kulim is a tributary of Sg. Prai. The catchment area at the Ara Kuda gauging station measures about 130 sq. km. The catchment is bounded by the Sg. Jarak catchment in the north and the Sg. Juru basin in the south.
- 2.2.16 The average annual rainfall over the Sg. Kulim catchment is approximately 115 in and ranges from about 100 in in the north to over 120 in in the headwaters. Broadly, the rainfall pattern is relatively similar to that of the study area because of its close proximity. (Note: about 75 per cent of the catchment lies outside the state.)
- 2.2.17 River flow data for Sg. Kulim at Ara Kuda are available from 1957-1977. Mean monthly and 1 in 5 year monthly values were analysed. The results are listed in Table 2.5. There is a distinct seasonal pattern of flow with the highest flows occurring from September to December. Low flow values are experienced in February and March. Flows during these two months represent about 9% of the average annual flow. From Table 2.8 again, the 1 in 5 year flow values are very much lower than the mean monthly values, and the difference may range from 21 to 69 per cent.
- 2.2.18 Because river flows downstream are essential for water requirement calculations, mean monthly and 1 in 5 year flow values have been calculated for Sg. Kulim headworks. This headwork is an important source for irrigated water for the Sg. Kulim scheme. This river flow distribution for Sg. Kulim Headworks is determined by area proportion computation from values measured at Ara Kuda. The obtained values are summarised in Table 2.5.

- 2.2.19 Smaller rivers: Seberang Perai is broadly divided into three divisions, namely, Seberang Perai Utara, Seberang Perai Tengah and Seberang Perai Selatan. There are approximately fifteen irrigation schemes in the study area and are located in all three divisions. Figure 2.7 shows their respective locations. (Note: Cherok To'Kun, Mengkuang Mak Sulong and Sg. Duri not shown).
- 2.2.20 As stated earlier, only Sg. Muda and Sg. Kulim have a long series of flow records. In addition, because most of the padi schemes are located in catchments without any history of flow records or existing monitoring device, transposition of data becomes necessary to arrive at river flow values for the respective catchments.
- 2.2.21 The catchment areas are delineated from topographic maps. Because the nature of the problem requires the computation of water availability for the affected padi schemes, the drainage divides have been drawn up to the major headworks or intakes.
- 2.2.22 Transposition of data: Data transposed to ungauged catchments requires the determination of run-off for the respective basins. This can be estimated using a simple water balance equation:
- $$R = P - E$$
- Where,
- $$R = \text{Run-off}$$
- $$P = \text{Precipitation/rainfall}$$
- $$E = \text{Evapotranspiration}$$
- This equation assumes no change in storage, above or below ground. The results obtained for the delineated catchments are summarised in Table 2.6.
- 2.2.23 From this, the average annual flow (AAF) can be calculated:
- $$\frac{\text{Depth} \times \text{catchment area}}{3600 \times 12 \times 24} = \text{AAF}$$
- The monthly river flow distribution pattern for an ungauged basin can then be derived by using the monthly distribution pattern of Sg. Kulim made dimensionless by expressing the monthly values as a percentage of the AAF. The results are shown in Table 2.7. The

procedure for deriving the 1 in 5 year monthly flow is similar (Table 2.8). Table 2.9 shows the 1 in 5 year average daily flow distribution. It may be important to note that Sg. Kulim has been chosen for transposition of data because of its nearness to the ungauged catchments to ensure reasonable similarity in their climatological characteristics.

2.2.24 Spot discharge measurements were made during the dry weather flows for most of the ungauged catchment areas. These measurements were made on 2 occasions, i.e. in March and April. The results are summarised in Table 2.10 along with the 1 in 5 year daily flow estimate.

2.2.25 10-day river flows: As stated earlier, the river flows are important to determine the crop water requirements for the affected schemes. As such, a more detailed analysis, using a three 10-day divisions for a calendar month was undertaken. Following this, the water availability and requirements may be calculated, and this is dealt with in Section 5.

2.2.26 Very similar to the 10-day rainfall analysis, three 10-day periods were derived equally for each month with the exception of the third 10-day; the third 10-day may be 8, 10 or 11 depending on the calendar month. Specifically, the 1 in 5 year criterion has been employed. Calculations were done primarily for the critical months of February, March, April and May (Table 2.11).

Water quality

2.2.27 Water quality samples have been taken on 2 occasions; March and April 1981. The analyses were done by the Chemistry Department, Penang. The results are listed in Tables 2.12 and 2.13.

Salinity traverse

2.2.28 Fieldwork was carried out in June 1981 to obtain an indication of saline intrusion along the main rivers where padi schemes are located. The main river considered is Sg. Juru. A traverse was made up to 4 miles from the estuary. From the chemical analysis, the chloride contents detected ranges from 12000 ppm at the the fourth mile and 34000 ppm at the estuary. The results are also shown graphically in Figure 2.8.

Table 2.1a Bumbong Lima Station: Total monthly rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	17.4	171.2	67.8	188.2	182.8	72.0	114.1	143.8	294.4	270.5	200.7	1.8
1975	161.7	173.3	58.1	151.6	165.9	76.1	341.3	140.3	218.7	340.1	252.2	348.3
1976	0.0	37.6	60.4	312.9	388.1	139.3	94.6	180.9	330.5	307.3	266.5	136.1
1977	49.5	117.1	0.0	223.6	574.9	190.8	22.3	323.2	328.0	492.7	253.6	59.6
1978	60.7	39.9	73.5	148.9	403.4	396.2	130.2	257.5	239.2	392.5	294.2	17.8
1979	52.3	35.4	14.3	342.3	206.2	222.4	329.0	126.8	215.2	145.3	370.2	57.7
1980	1.7	70.4	62.3	192.5	229.7	107.8	206.1	319.4	654.6	411.9	298.9	143.6

Table 2.1b Bumbong Lima Station: Mean monthly maximum temperature (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	31.7	32.4	32.6	33.0	31.7	31.3	31.8	32.0	30.5	30.6	30.2	31.3
1975	31.7	31.7	32.0	32.3	31.2	31.1	30.9	32.2	30.3	30.5	30.3	29.8
1976	31.6	32.3	32.3	31.9	31.1	30.9	31.2	31.2	30.4	30.7	30.4	31.3
1977	32.1	32.5	33.4	32.8	N.A.	31.5	31.9	31.4	30.7	31.3	31.4	31.6
1978	31.9	33.1	32.9	32.3	32.1	30.9	30.6	31.0	30.0	30.2	30.9	31.5
1979	32.4	32.8	33.5	31.9	32.0	31.4	30.6	31.6	31.5	31.5	31.3	31.8
1980	32.2	33.2	32.7	32.6	32.4	31.6	31.9	30.7	30.8	30.5	31.2	30.7

Table 2.1c Bumbong Lima Station: Mean monthly minimum temperature (°C)

1974	19.6	20.9	21.7	22.8	22.7	22.8	22.2	22.7	22.7	22.9	22.8	21.9
1975	21.5	21.5	22.5	23.6	23.5	23.2	22.3	22.9	22.8	22.8	22.7	21.9
1976	19.5	20.9	22.8	23.2	23.3	22.8	22.5	22.4	22.4	22.8	22.5	22.3
1977	21.0	21.5	22.7	N.A.	N.A.	23.3	23.2	22.6	23.1	23.2	22.9	22.3
1978	21.7	21.9	23.3	23.5	24.4	23.4	22.8	23.0	22.8	23.0	22.8	21.9
1979	21.1	22.1	22.6	23.6	23.9	23.8	23.0	23.0	23.1	23.2	23.2	21.5
1980	21.4	21.4	22.7	23.7	24.3	23.9	23.5	22.3	23.1	23.5	23.4	22.7

N.A. = Not available

Table 2.1d Bumbong Lima Station: Mean monthly relative humidity at 1.30 p.m.(%)

1974	65	72	65	68	70	70	66	64	70	71	72	62
1975	67	67	66	66	74	72	70	67	73	74	72	74
1976	59	69	75	73	73	71	71	69	73	70	76	69
1977	66	64	N.A.	61	N.A.	69	68	68	72	69	67	64
1978	64	58	60	66	72	75	72	72	73	73	68	62
1979	54	57	57	68	71	70	72	70	69	65	67	59
1980	57	53	60	65	67	71	69	71	73	71	71	67

Table 2.1e Bumbong Lima Station: Mean monthly relative humidity at 7.30 a.m.(%)

1974	95	95	94	97	97	97	96	95	96	96	96	95
1975	95	93	95	97	97	97	97	97	95	95	95	95
1976	89	95	97	97	95	95	95	95	95	94	94	95
1977	95	95	89	92	94	95	96	95	96	95	93	90
1978	94	93	94	94	95	96	97	97	97	96	94	89
1979	89	94	94	96	95	96	97	97	97	93	94	86
1980	88	89	96	96	95	97	97	96	97	97	95	93

Table 2.1f Bumbong Lima Station: Mean monthly wind run (km)

1978	N.A.	N.A.	N.A.	N.A.	N.A.	50.49	45.67	56.84	67.49	79.20	78.04	93.43
1979	70.79	68.65	85.86	91.26	74.36	59.11	49.40	46.04	54.17	68.31	82.18	94.17
1980	73.64	60.82	71.38	77.19	70.20	51.89	45.22	47.08	60.16	63.73	66.77	71.65

Table 2.1g Bumbong Lima Station: Mean monthly evaporation rate (mm/day)

1978	-	-	-	5.8	5.5	3.5	3.3	3.9	3.5	4.4	4.5	4.5
1979	5.1	4.9	6.1	5.5	4.8	4.1	3.9	4.0	4.5	4.5	4.1	5.5
1980	5.1	5.1	4.9	5.1	5.1	3.8	4.6	3.6	4.9	3.9	4.2	3.7

N.A. = Not available

Table 2.2 Rainfall data of selected representative stations (mm).

Rainfall Station	Period of Record	Data Description	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2. Permatang Binjai	1959-1975	Mean 1 in 5 yr min. max.	55.4	70.1	97.5	163.8	191.0	215.9	185.7	224.0	325.4	369.3	245.9	140.0
			12.7	20.3	58.4	86.4	121.9	152.4	83.8	149.9	200.7	259.1	175.3	91.4
			1.3	0.0	18.8	0.8	36.3	53.1	66.8	79.5	109.5	165.1	59.7	15.2
			199.4	195.6	342.1	291.3	350.5	351.3	424.9	419.1	636.3	625.3	392.4	273.6
8. Permatang Rawa	1959-1975	Mean 1 in 5 yr min. max.	97.8	76.5	152.7	186.2	175.8	145.5	172.0	170.4	276.9	402.6	271.8	190.5
			35.6	36.8	83.8	116.8	94.0	99.1	91.4	101.6	149.9	266.7	172.7	139.7
			2.3	11.9	51.6	43.7	9.5	42.9	37.8	49.0	126.5	202.9	102.6	61.2
			308.6	216.2	338.6	343.2	386.8	231.4	355.3	280.4	571.0	773.9	460.5	373.9
11. Batu Kawan Estate	1959-1975	Mean 1 in 5 yr min. max.	86.6	65.0	140.0	192.8	162.3	139.0	159.0	160.5	234.4	313.4	230.1	163.3
			19.1	37.3	101.6	114.3	99.1	101.6	94.0	99.1	132.1	218.4	146.1	99.1
			4.3	11.9	47.5	76.7	49.5	68.6	48.0	80.0	104.4	138.7	45.2	37.1
			251.2	132.8	210.8	359.9	327.9	224.0	298.5	336.0	371.3	674.4	517.7	315.5

Table 2.3 1 in 5 yr 10-day rainfall values (mm) of selected representative stations.

Station	Data Description	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2. Permatang Binjal	1st 10-day	6.3	0	2.5	17.8	30.5	14.0	7.6	16.5	63.5	40.6	50.8	21.6
	2nd 10-day	5.1	5.1	4.6	12.7	43.2	39.6	7.6	20.3	43.2	81.3	40.6	12.7
	3rd 10-day	3.6	1.3	20.3	15.2	12.7	36.8	22.9	43.2	33.0	83.8	26.7	10.2
8. Permatang Rawa	1st 10-day	5.1	0	8.9	17.8	17.8	12.7	15.2	25.4	38.1	33.0	61.0	44.5
	2nd 10-day	0	1.3	5.8	27.9	35.6	15.2	20.3	25.9	35.6	78.7	52.1	31.0
	3rd 10-day	0	2.5	34.3	22.9	10.2	14.0	24.9	27.9	20.3	96.5	35.6	11.2
11. Batu Kawan Estate	1st 10-day	8.6	0	7.6	33.0	17.8	6.3	8.9	15.2	36.3	25.4	33.0	18.0
	2nd 10-day	0	3.0	2.5	29.2	30.5	26.4	13.5	17.8	25.4	39.4	30.5	6.8
	3rd 10-day	3.0	0	22.9	22.9	7.6	25.7	12.2	25.4	26.7	69.9	21.6	16.5

Table 2.5 Mean monthly and 1 in 5 yr flows by area proportion for abstraction points of Sg. Muda and Sg. Kulim in m³/sec x days

River Name	Data Description	Period Analysis	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sg. Muda		1947-1968												
	i) at Batu Pekaka	Mean monthly 1 in 5 yr.	2355 1133	1228 637	1361 685	1992 1147	3138 2214	2516 1387	2645 1557	2727 1699	3755 2011	6676 4786	6963 5097	4257 2549
	ii) at Pinang Tunggal	*Mean monthly 1 in 5 yr.	2920 1405	1523 790	1688 849	2470 1422	3891 2745	3120 1720	3280 1931	3381 2107	4656 2494	8278 5935	8634 6320	5279 3161
Sg. Kulim		1957-1977												
	i) at Ara Kuda	Mean monthly 1 in 5 yr.	165 104	112 76	131 77	177 99	181 125	148 83	141 83	126 83	194 118	605 188	345 229	269 179
	ii) at Headworks	*Mean monthly 1 in 5 yr.	195 123	132 89	155 91	209 117	214 148	175 98	166 98	149 98	229 139	714 222	407 270	317 210

* Transposed values derived from area proportion method

Table 2.6 Natural catchment runoff

Catchment	Catchment Area (km ²)	Rainfall (mm)	Forest Evapo- transpiration (mm)	Runoff (mm)	AAF (cume) days	Unit Area runoff (cume/km ²)
Sg. Machang Bubok	19.4	2,743	1,600	1,143	257	13
Sg. Tasek Junjong	13.2	2,743	1,600	1,143	175	13
Sg. Junjong @ K. Tasik	77.4	2,743	1,600	1,143	1,024	13
Sg. Junjong @ S. Ampat	79.7	2,743	1,575	1,168	1,079	14
Sg. Junjong Mati	24.6	2,260	1,575	660	188	8
Sg. Duri	4.9	2,489	1,600	889	51	10
Sg. Chempedak	18.0	2,743	1,600	1,143	236	13
Sg. Perangin	7.5	2,743	1,600	1,143	99	13
Sg. Kelang Ubi	10.4	2,489	1,600	35	107	10
Sg. Kreh	39.9	2,413	1,397	1,016	469	12
Sg. Jarak	116.5	2,718	1,448	1,270	1,713	15
Sg. Jawi	48.4	2,489	1,600	889	498	10

Table 2.7 Transposed mean monthly flow for Seberang Perai catchments

Seberang Perai Catchment	mean monthly flow in m ³ /sec x days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sg. Machang Bubok	18.4	12.5	14.4	19.8	22.9	16.4	15.7	13.9	21.5	33.6	38.3	29.8
Sg. Tasik Junjong	12.4	8.5	9.8	13.4	15.6	11.1	10.6	9.5	14.6	22.6	6.0	20.3
Sg. Junjong @ Kg. Tasik	72.9	49.7	57.5	78.8	91.3	65.3	62.4	55.5	85.9	133.8	152.5	118.9
Sg. Junjong @ S. Ampat	76.8	52.3	60.5	82.9	96.1	68.7	65.7	58.5	90.4	140.9	160.6	125.2
Sg. Junjong Mati	13.4	9.1	10.6	14.5	16.7	12.0	11.5	10.2	15.8	24.6	28.0	21.8
Sg. Duri	3.6	2.5	2.8	3.9	4.5	3.2	3.1	2.7	4.2	6.6	7.5	5.9
Sg. Chempedak	16.8	11.6	13.2	18.2	21.0	15.1	14.4	12.7	19.8	30.9	35.2	27.4
Sg. Perangin	7.1	4.8	5.6	7.6	8.8	6.3	6.0	5.4	8.3	8.3	14.8	11.5
Sg. Kelang Ubi	7.6	6.1	6.0	8.2	9.5	6.8	6.5	5.8	9.0	14.0	18.7	12.4
Sg. Kreh	33.3	23.0	26.3	36.1	41.7	30.0	28.6	25.3	39.4	61.4	69.9	54.4
Sg. Jarak	122.0	83.1	96.1	131.7	152.7	109.1	104.3	92.9	143.6	223.7	255.1	198.9
Sg. Jawi	35.5	24.2	27.9	38.3	44.4	31.7	30.3	27.0	41.8	65.1	74.2	57.9

Table 2.8 Transposed 1-in-5-year mean monthly flow for Seberang Perai catchments

Seberang Perai Catchment	1-in-5-years mean monthly flows in m ³ /sec x days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sg. Machang Bubok	11.6	8.5	8.5	11.3	13.9	9.3	9.3	9.3	13.1	20.8	25.4	19.3
Sg. Tasik Junjong	7.9	5.8	5.8	7.7	9.5	6.3	6.3	6.3	8.9	14.2	17.3	13.5
Sg. Junjong @ K. Tasik	46.1	33.8	33.8	45.1	55.3	36.9	36.9	36.9	52.2	83.0	101.4	78.9
Sg. Junjong @ S. Ampat	48.5	35.6	35.6	47.5	58.3	38.8	38.8	38.8	55.0	87.4	106.8	83.1
Sg. Junjong Mati	8.5	6.2	6.2	8.3	10.2	6.8	6.8	6.8	9.6	15.2	18.6	14.5
Sg. Duri	2.3	1.7	1.7	2.2	2.8	1.8	1.8	1.8	2.6	4.1	5.0	3.9
Sg. Chempedak	10.6	7.8	7.8	10.4	12.7	8.5	8.5	8.5	12.0	19.1	23.4	18.2
Sg. Perangin	4.5	3.3	3.3	4.4	5.3	3.6	3.6	3.6	5.0	8.0	9.8	7.6
Sg. Kelang Ubi	4.8	3.5	3.5	4.7	5.8	3.9	3.9	3.9	5.5	8.7	10.6	8.2
Sg. Kreh	21.1	15.5	15.5	20.6	25.3	16.9	16.9	16.9	23.9	40.0	46.4	36.1
Sg. Jarak	77.1	56.5	56.5	73.4	22.5	61.7	61.7	61.7	87.4	138.8	170.0	131.9
Sg. Jawi	22.4	16.4	16.4	21.9	26.9	18.0	18.0	18.0	25.4	40.4	49.3	38.4

Table 2.9 Transposed 1-in-5-years average daily flow for Seberang Perai catchments

Seberang Perai Catchment	1-in-5-years average daily flow in m ³ /sec											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sg. Machang Bubok	.37	.30	.27	.38	.45	.31	.30	.30	.44	.67	.85	.62
Sg. Tasik Junjong	.25	.20	.19	.26	.31	.21	.20	.20	.30	.46	.58	.43
Sg. Junjong @ Kg. Tasik	1.49	1.20	1.09	1.50	1.78	1.23	1.19	1.19	1.74	2.68	3.38	2.54
Sg. Junjong @ S. Ampat	1.56	1.27	1.15	1.58	1.88	1.29	1.25	1.25	1.83	2.82	3.56	2.68
Sg. Junjong Mati	.27	.22	.20	.28	.33	.23	.22	.22	.32	.49	.62	.47
Sg. Duri	.07	.06	.05	.07	.09	.06	.06	.06	.09	.13	.17	.13
Sg. Chempedak	.34	.28	.25	.35	.44	.28	.27	.27	.40	.62	.78	.59
Sg. Perangin	.15	.12	.11	.15	.17	.12	.12	.12	.17	.26	.33	.25
Sg. Kelang Ubi	.15	.13	.11	.16	.19	.13	.13	.13	.18	.28	.35	.26
Sg. Kreh	.68	.55	.50	.69	.82	.56	.55	.55	.79	1.29	1.55	1.16
Sg. Jarak	2.49	2.02	1.82	2.45	3.00	2.06	1.99	1.99	2.91	4.48	5.67	4.25
Sg. Jawi	.72	.59	.53	.73	.87	.60	.58	.58	.58	1.30	1.64	1.24

Table 2.10 Comparison of spot discharge measurement
with 1 in 5 yr daily flow estimate

River	* Date	Discharge (m ³ /sec)	1 in 5 yr av. daily flow estimate (m ³ /sec)
Sg. Kilang Kain	7.3.81	0.03	-
Sg. Kelang Ubi	18.4.81	0.17	0.16
Sg. Perangin d/s of Rd. bridge	7.3.81	0.27	0.15
Sg. Kulim at Lunas	8.3.81	4.84	-
Sg. Jarak d/s of Rd. bridge	8.3.81	7.29	2.45
Sg. Mengkuang	26.4.81	0.16	0.38
Sg. Machang Bubok	18.4.81	0.16	0.38
Sg. Chempedak	18.4.81	0.30	0.35
Sg. Duri	19.4.81	0.20	0.07
Sg. Jawi	19.4.81	1.41	0.73

* Discharge measurements taken during dry weather flow

Table 2.11 1 in 5 yr 10-day river flows by area proportion for abstraction points of Sg. Muda and Sg. Kulim in $m^2/sec \times days$

River Name	Feb			Mar			Apr			May			Period of Record
	1st 10	2nd 10	3rd 10	1st 10	2nd 10	3rd 10	1st 10	2nd 10	3rd 10	1st 10	2nd 10	3rd 10	
Sg. Muda													*1947-1968
i) at Batu Pekaka	238	212	156	195	173	255	260	368	425	456	713	620	
ii) at P. Tunggai	295	263	193	242	215	316	322	456	527	565	884	769	
Sg. Kulim													1957-1977
i) at Ara Kuda	28	27	21	23	21	26	29	29	35	39	41	36	
ii) at headworks	33	32	24	27	25	31	34	35	41	45	48	42	

* Records analysed prior to the construction of Muda Dam to determine natural flow patterns.

Table: 2.12

Water quality samples taken in March 1981 for Seberang Perai

Chemical analysis (mg/litre)	Sg. Kilang Kain (Alma) upstream	Sg. Kelang Ubi (Alma) (upstream)	Sg. Perangin d/s of road bridge	Sg. Junjong u/s of road bridge	Sg. Kulim at Lunas u/s of wooden bridge	Sg. Jarak d/s of road bridge	Sg. Junjong Mati at Juru J.P.T. pumping station (intake)	Sg. Kelang Ubi Alma (downstream)
Time sample taken	11.30 am	12.50 pm	1.54 pm	2.20 pm	10.50 am	1.45 pm	5.20 pm	-
Date sample taken	7.3.81	7.3.81	7.3.81	7.3.81	8.3.81	8.3.81	8.3.81	16.3.81
pH at 26°C	6.4	5.6	5.9	5.8	6.1	5.8	3.5	6.5
Electrical conductivity (umhos/cm ³)	59	220	20	20	20	30	2300	350
Nitrate nitrogen	0.26	0.002	0.26	0.18	0.24	0.20	1.63	0.68
Chloride (as Cl ⁻)	5.0	2.0	2.0	2.0	3.0	4.0	550.6	5.0
Sulphate (as SO ₄ ⁻⁻⁻)	8.0	6.5	0.5	3.0	7.0	0.5	145.0	25.0
Total solids dried at 105°C	45	385	25	30	30	30	1475	400
Suspended solids dried at 105°C	25	120	10	20	20	20	10	35
Dissolved solids	20	265	15	10	10	10	1465	365
Iron (as Fe)	0.5	2.0	<0.10	0.2	0.2	0.3	1.0	0.1
Total Hardness as CaCO ₃	10	35	3	3	3	5	220	30
Manganese (as Mn)	0.1	Not detected	0.1	Not detected	Not detected	Not detected	Not detected	0.1
Sodium (as Na)	5.6	17.2	2.5	3.5	2.5	2.5	315	42.5
Calcium (as Ca)	3.2	12.8	0.8	0.8	0.8	1.6	20	8
Magnesium (as Mg)	0.49	0.73	0.24	0.24	0.24	0.24	41.3	2.43
Potassium as (k)	2.6	20	1.0	1.6	1.4	2.1	25	25
Boron (as B)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected

Table: 2.13

Water quality samples taken in April 1981 for Seberang Perai

Chemical analysis (mg/litre)	Sg. Kreh at Kg. Air Melintas Besar	Sg. Kreh at Kubang Menderong	Sg. Kreh d/s of pump house	Sg. Jarak pump house d/s Sg. Jarak	Sg. Kulim at Ara Kuda	Sg. Junjong bridge
Time sample taken	8.55 am	9.25 am	9.55 am	10.20 am	11.30 am	10.05 am
Date sample taken	23.4.81	23.4.81	23.4.81	23.4.81	23.4.81	26.4.81
pH at 26°C	6.6	6.6	6.6	6.1	6.4	6.6
Nitrate nitrogen	0.70	0.45	0.75	0.25	0.53	0.01
Chloride (as Cl ⁻)	3.0	4.0	3.0	5.0	3.0	5.0
Sulphate (SO ₄ ²⁻)	8.0	14.0	11.0	12.0	2.0	6.0
Boron (as B)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Total solids dried at 105°C	50	45	50	30	40	40
Suspended solids dried at 105°C	25	35	30	10	25	30
Dissolved solids	25	10	20	20	15	10
Conductivity (umhos/cm ³) at 27°C	40	40	40	40	30	45
Iron (as Fe)	1.0	0.6	0.4	0.4	0.4	0.6
Total Hardness (as CaCO ₃)	10.0	10.0	10.0	10.0	10.0	10.0
Alkalinity (as CaCO ₃)	15.0	15.0	15.0	10.0	15.0	20.0
Manganese (as Mn)	0.1	Not detected	Not detected	Not detected	Not detected	Not detected
Sodium (as Na)	1.68	1.88	1.76	1.60	2.0	3.76
Potassium (as K)	2.22	2.52	2.46	2.52	1.68	1.56
Calcium (as Ca)	3.2	2.8	2.4	2.0	1.6	2.4
Magnesium (as Mg)	0.49	0.73	0.97	1.22	0.24	0.97

Table 2.13 Cont'd

Water quality samples taken in April 1981 for Seberang Perai

Chemical analysis (mg/litre)	Sungai kelang Ubi downstream	Sungai Machang Bubok d/s of headworks	Sungai Chempedak at Rd Bridge	Sungai Duri downstream of Rd Bridge
Time sample taken	2.05 pm	3.35 pm	4.45 pm	2.20 pm
Date sample taken	18.4.81	18.4.81	18.4.81	19.4.81
pH at 26°C	6.6	6.8	6.4	6.8
Conductivity ($\mu\text{mhos}/\text{cm}^3$)	150	35	30	20
Nitrate nitrogen	2.43	0.35	0.08	0.07
Chloride (as Cl^-)	45	3.0	3.0	2.0
Sulphate (as SO_4^{--})	1.6	15	1.0	17
Total solids dried at 105°C	155	55	55	70
Suspended solids dried at 105°C	10	10	5	40
Dissolved solids	145	45	50	30
Iron (as Fe)	0.1	0.2	0.10	0.1
Boron (as B)	Not detected	Not detected	Not detected	Not detected
Manganese (as Mn)	0.01	Not detected	Not detected	0.01
Potassium (as K)	8.7	1.6	1.6	1.6
Sodium (as Na)	12	2.4	2.8	2.4
Calcium (as Ca)	9.0	6.0	2.0	2.0
Magnesium (as Mg)	1.1	0.4	0.3	0.1
Hardness (as CaCO_3)	20	10	5.0	3.0

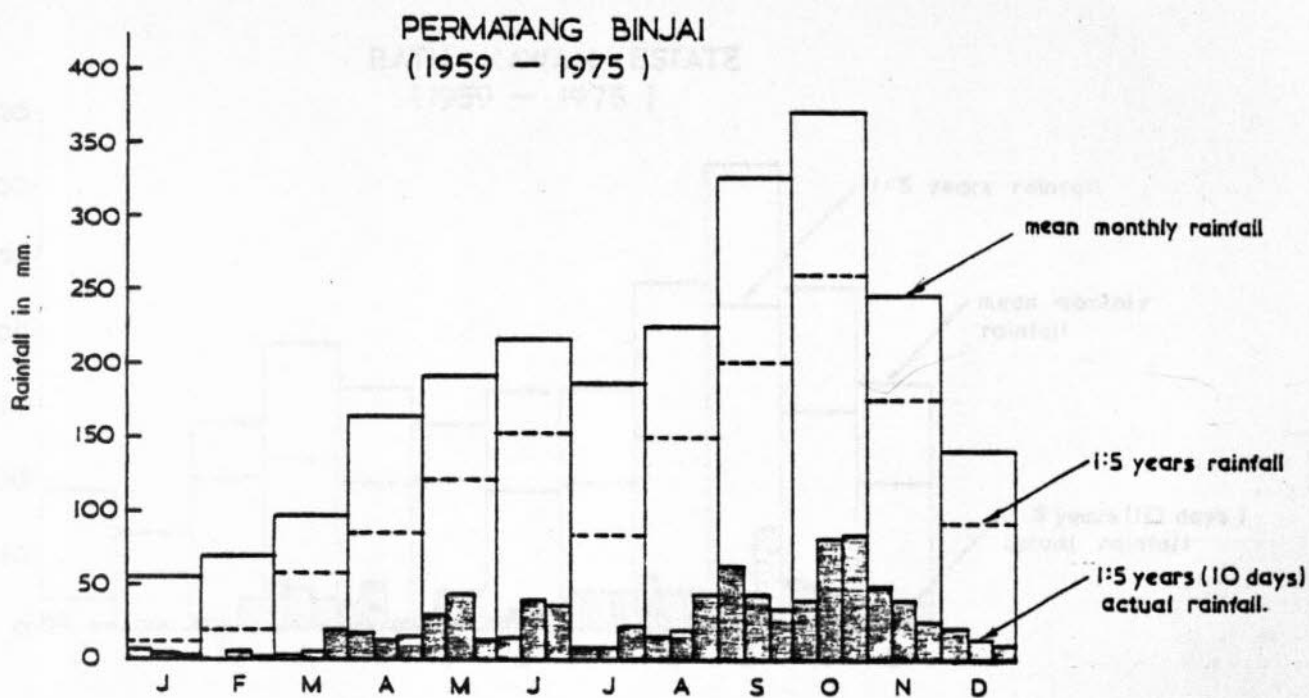


Fig. 2.2 Permatang Binjai : Rainfall characteristics

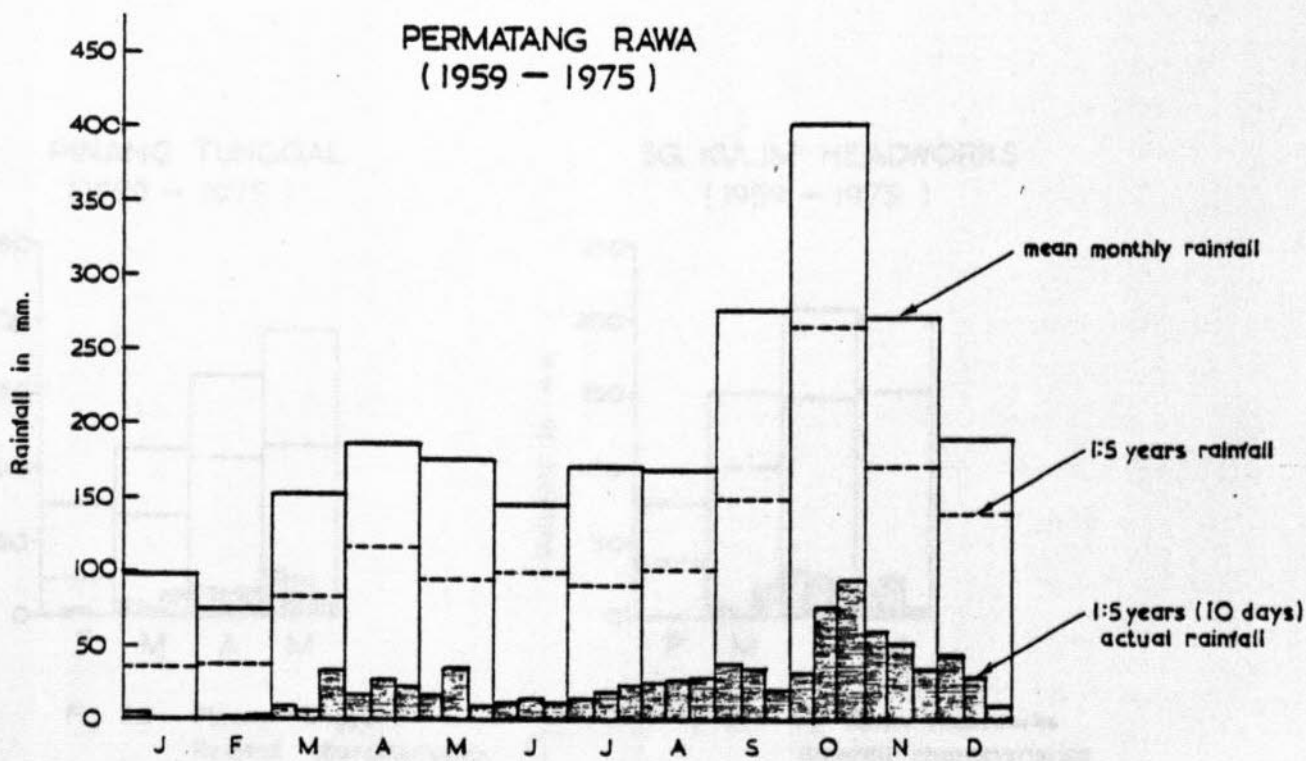


Fig. 2.3 Permatang Rawa : Rainfall characteristics

BATU KAWAN ESTATE (1959 - 1975)

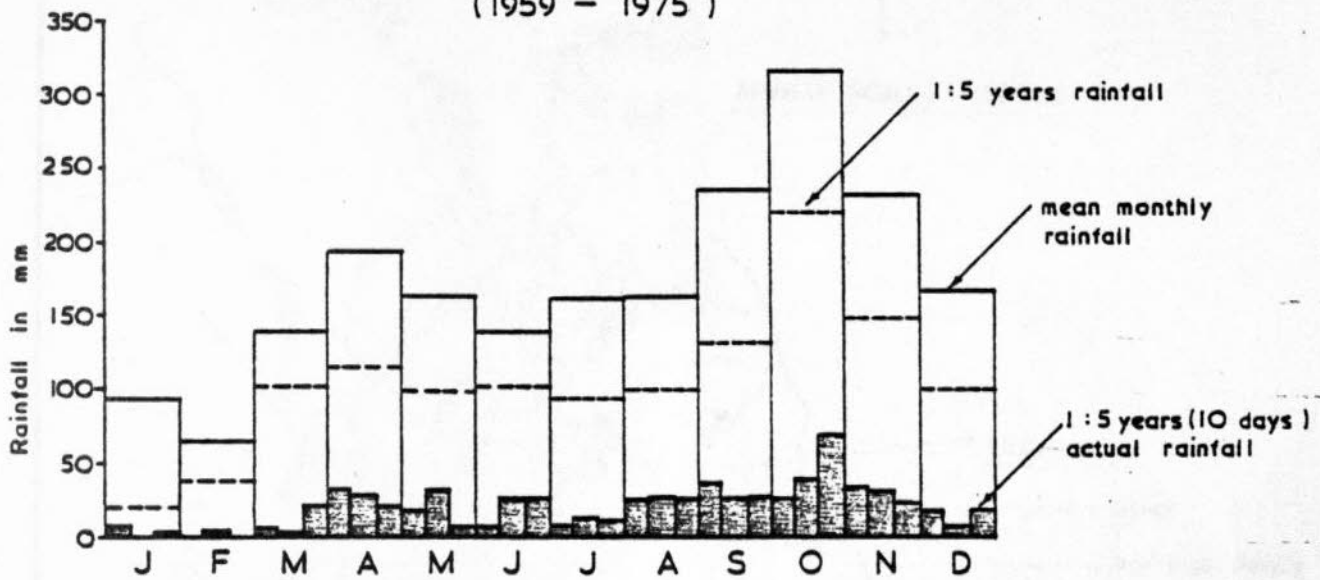


Fig. 2.4 Batu Kawan Estate : Rainfall characteristics

PINANG TUNGGAL (1959 - 1975)

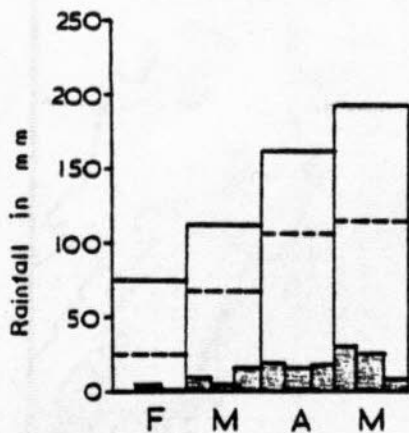


Fig. 2.5 Pinang Tunggai :
Rainfall characteristics

SG. KULIM HEADWORKS (1959 - 1975)

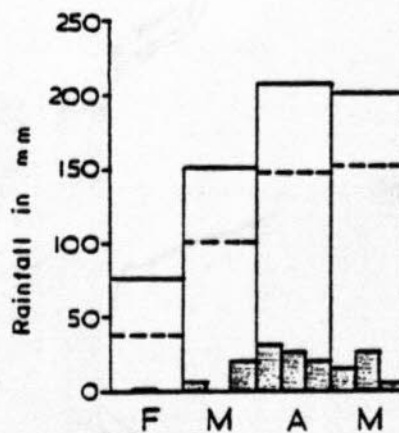


Fig. 2.6 Sg. Kulim Headworks
Rainfall characteristics

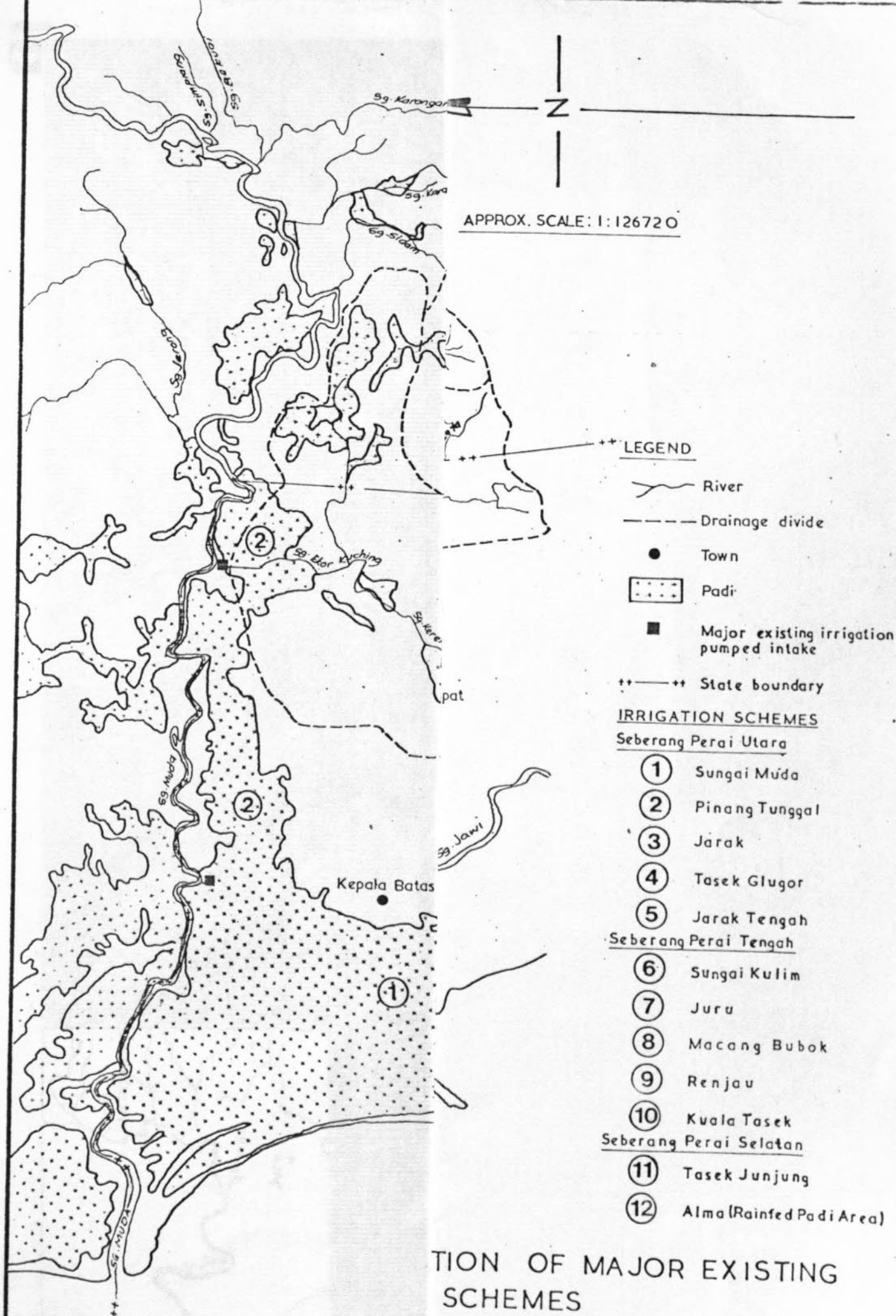
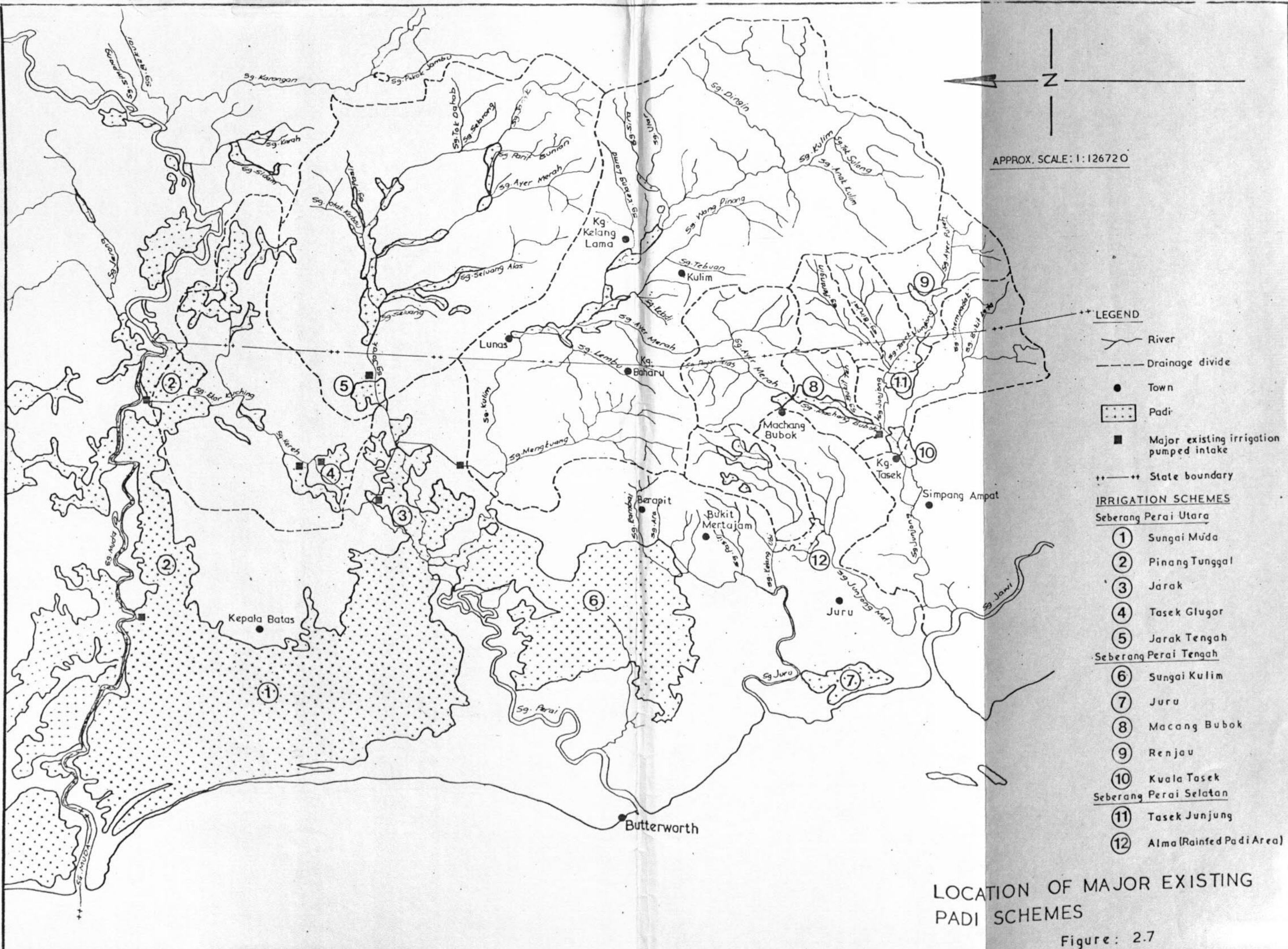
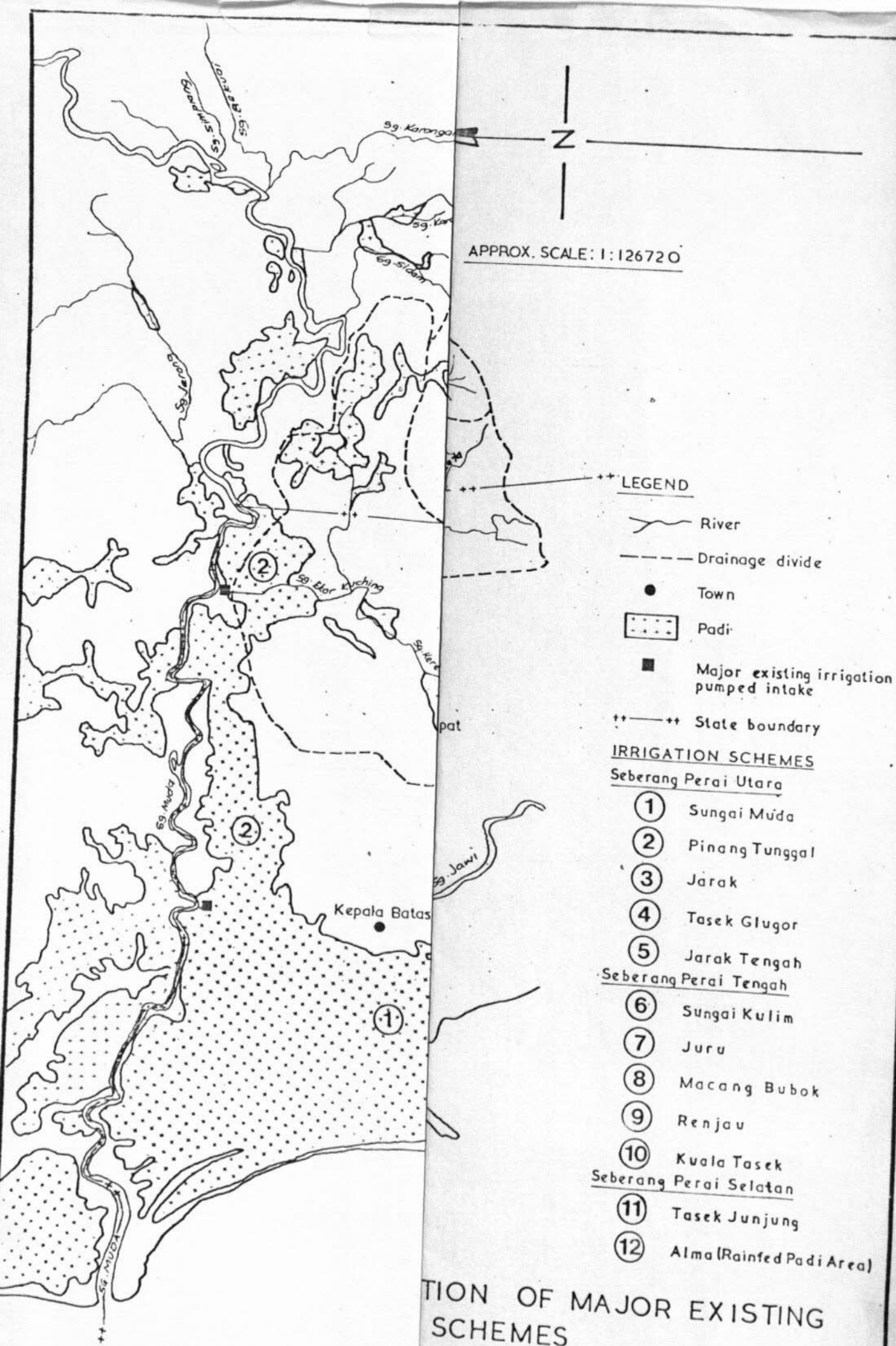


Figure: 2.7



LOCATION OF MAJOR EXISTING PADI SCHEMES

Figure: 2.7



LOCATION OF MAJOR EXISTING IRRIGATION SCHEMES

Figure: 2.7

2.3 Hydro-geology

Introduction

- 2.3.1 Field studies and desk assessments have been carried out to appraise the potential of developing ground water for agricultural use. The JPT have considered that it is necessary to assess this potential as ground water could provide valuable supplementary resources for rice irrigation. It is possible that large unit yields may not be available; in such a situation ground water could be used for other crops.

Review of existing data and reports

- 2.3.2 A review of existing data and reports reveals that there is very little or no information available on the ground water resources of Seberang Perai. Lenk Chevitch's report on the ground water potential of selected areas and general notes by the Geological Survey (GSM) appear to be the only systematic sources to date. (ref. 8)

- 2.3.3 The geology of the area has been mapped and the Geological Survey's 1 inch to 1 mile scale maps and associated memoirs contain much valuable information. The alluvial deposits have been investigated by the Minerals Investigation Drilling Unit (MIDU). Boreholes have been constructed by JKR for site investigation of the Pulau Pinang-Seberang Perai bridge. Data from a few drillers has also been obtained. (ref. 9)

- 2.3.4 A deep borehole, to 540 ft, was constructed for the Butterworth Power Station water supply. The log and construction details were obtained from the GSM.

Existing ground water use

- 2.3.5 Our field visits revealed that there are numerous operational tubewells in the area. Almost invariably they have been drilled by the simplest methods, usually consisting of a 3" tube, wash drilled into the aquifer to some suitable depth. The rising main is then connected to an end-suction pump, driven either by a diesel or electric engine. Users of this type of borehole are factories ranging from paper mills to tapioca processors and livestock rearers.

- 2.3.6 Domestic users usually install dug wells not more than 5 m deep, lined with concrete rings or brick and mortar. Abstraction is usually

by bucket and occasionally by centrifugal pumps. At the other end of the spectrum there are crude dug pits which supply shallow ground water or store rain water.

Potential aquifers

- 2.3.7 An appraisal of ground water potential based on the lithology of rock formations indicates that only the superficial alluvials are likely to yield reasonable quantities although boreholes drilled into the fracture zone of granites may also be sufficiently productive. The remaining formations are not likely to produce usable quantities of ground water.
- 2.3.8 The structure and geological evolution of the quarternary alluviums suggests that coarse sands are found near the granite massive and further away towards the coast these grade into finer sands which are invariably overlain by marine clays. Courtier's (1974) descriptions of the alluvial formations were based on results of drilling carried out by MIDU. These results have been confirmed subsequently by site investigation boreholes constructed by JKR and in other boreholes.
- 2.3.9 Lack of time precluded the performance of a proper pumping test although there are a number of suitable boreholes belonging to industrialists or estates which could be tested in the future. As a consequence the grain size distribution data was used to assess the likely ranges of aquifer parameters of the alluvial sands. These suggested that the transmissivity could range between $75 \text{ m}^2/\text{d}$ to $300 \text{ m}^2/\text{d}$. Estimates of thicknesses of aquifer sands suggest a range between 10 m and 30 m. By inserting these assumed values into the appropriate ground water flow equation, estimates of likely range of borehole yields vary between $900 \text{ m}^3/\text{d}$ to $5,200 \text{ m}^3/\text{d}$.
- 2.3.10 The appropriate siting of boreholes will be an important factor since there is a likelihood of saline aquifer close to the coastal area. Recent drilling in Banda Baharu area has indicated that below the saline zone, there is a further aquifer which contains relatively fresh water. It is not clear whether such conditions are found further northwards but some suggestion of such a situation being present was

deduced from the 540 ft deep borehole log at Butterworth. It indicated that at a depth of 180 ft, the water was "less brackish". Quantitative data on conductivity or chemical analysis was not obtained and so at present it is best to use this information with caution. Boreholes drilled in this area must be carefully logged and assessed before any final judgement can be given.

Estimate of resources available

2.3.11 Hydrological analyses suggest that the annual infiltration to aquifers may be 300 mm. Although this estimate will require refinement later, it is suggested that the figure is of the correct order of magnitude.

2.3.12 An estimate of resources can be made by assessing the outcrop area of the aquifer through which annual infiltration takes place and accounting for all other sources of water such as leakage through the overlying clays and silt. Using the above methodology the resources are assessed as follows:-

Area of outcrop of sands	102.6 km ²
Area of clays or silts contributing leakage to the sands	5.1 km ²

If it is assumed that the permeability comparison between the sands and the overlying clays results in 5% of potential recharge leaking through to the sand aquifer and a similar quantity from the granites, then the replenishable resources are assessed as $30 \times 10^6 \text{ m}^3$ (24,000 ac-ft), replenishable on an annual basis.

Further exploratory investigations

2.3.13 Exploratory work is required to locate the extent of the potential sand aquifer and also to test the quantity and quality of water that may be obtained from boreholes. In order to obtain the maximum amount of information boreholes should be drilled by reverse circulation rotary or percussion drilling methods. During construction water samples would have to be regularly tested together with bailer tests to assess the yield and quality. The final design of production boreholes should await the results of exploratory drilling.

- 2.3.14 Geophysical methods may be used in conjunction with boreholes in order to obtain additional data on areal extent of the sand. Geophysical methods in isolation from borehole drilling cannot yield quantitative information.

Conclusion and recommendations

- 2.3.15 Field surveys and investigations have revealed the presence of a shallow aquifer of low electrical conductivity and pH which is invariably used by the local population for their domestic needs. In addition there is a sand aquifer, dipping towards the coast and out-cropping at the foothills of the granite massive. It is overlain by marine clays which gradually increase in thickness closer to the sea coast.
- 2.3.16 An estimate of replenishable resources available suggests that $30 \times 10^6 \text{ m}^3/\text{annum}$ may be exploited from the aquifer. There is likely to be some additional water available in storage, however its exploitation may induce saline intrusion to occur over a period of time.
- 2.3.17 Ground water abstraction would have to take place from boreholes ranging in depths to at least 30 m. The holes will require screens and gravel packs and for low rates of abstraction i.e. less than 15 L/s centrifugal end-suction pumps may be adequate. For larger rates of abstraction submersible or line shaft pumps would be required. The water may have dissolved H_2S and some problems with iron deposition may be encountered, leading to possible clogging of well screens and pipes unless proper measures are taken to counteract them.

2.4 Soils

- 2.4.1 The term of reference require that all soils in the study area be checked with view to assessing the soil capability and the formulation of cropping systems appropriate to each kind of soil (soil type) within the study area and to highlight limitations, if any, by way of toxicities, inordinate soil water losses through percolation, chronic soil deficiencies and other soil properties that might affect the scope for agricultural development in the study area.

- 2.4.2 The main soil textural types present in all the schemes have been identified and described. This also applies to the major soil series present. The soil fertility status and details of fertiliser requirements for specific areas and for specific crops will be provided for in the Draft Final Report.
- 2.4.3 The highlight of the soils report is that the soils are eminently suited to padi and offer no restraints whatsoever, except in the Juru area of Seberang Perai, where acidity coupled with water shortage problems are limiting factors to improving padi yields.
- 2.4.4 In the small schemes, minor valleys of Cherok Tok Kun and Machang Bubok, "clay + $\frac{1}{2}$ silt" values are marginal to poor. Here alternative dryland crops to padi may be considered.
- 2.4.5 The main schemes under study for upgrading are the Sg. Muda, Pinang Tunggal and the Sg. Kulim making up an area in the region of 12,000 ha, about 85% of the total land area of all the schemes under study. The soils in all these schemes are clays, highly suited to padi, and presenting no limitations whatsoever to the double cropping of padi under under mechanisation. Drawing No. 1 shows the sample locations in the main schemes listed above as well as in the Jarak irrigation scheme and the smaller schemes, namely Tasek Gelugor, Jarak Tengah, Machang Bubok, Tasek Junjong, Alma, Cherok Tok Kun and Juru.

The Sg. Muda scheme

- 2.4.6 This is the largest single scheme. The soils of the scheme are all clays (see Table 2.14) and comprise the following soil series, the characteristics of which are given in Appendix A. Kuala Kedah, Sedaka, Rantau, Sintok, Jundor and Tualang. They are all extremely fertile soils and are ideally suited to padi. An area where soft spongy soils occur has been demarcated on Drawing No. 1. Improved drainage here of surface water is essential. Except for this area the soils can be regarded as dominated by class I padi soils. CEC's range from 17 - 32 meq/100 gm soil: average CEC is about 24.5 meq/100 gm.

The Pinang Tunggal scheme

- 2.4.7 Soil here are also clays (see Table 2.14) and comprise the following soil series: Kundor, Tualang and AKOB series. CEC's here are fairly consistent and the average value is about 17.5 meq/100 gm. The soils are highly suitable to padi and offer no limitations to padi culture.

Sg. Kulim scheme

- 2.4.8 Here the soils are clays and clay loams and the average CEC's are about 14 meq/100 gm of soil. The soils here comprise the following series: Bakau, Kundor and Tualang. The area is highly suitable for padi and presents no problems to mechanisation.

Table 2.14 Particle Size Fractionation of Typic Pedons (6" - 12" layer)

Scheme	Location*	Clay	Silt	Sand	Clay + $\frac{1}{2}$ Silt	Textural Type
S. Muda	(A)	64	31	5	79	Clay
S. Muda	(B)	51	40	9	71	Clay/silty clay
S. Muda	(C)	65	30	5	80	Clay
S. Muda	(D)	84	13	4	90	Clay
S. Muda	(E)	66	28	6	80	Clay
S. Muda (Penaga)	(F)	60	33	8	76	Clay
S. Muda	(G)	59	38	3	78	Clay
P. Tunggal	(1)	76	22	2	87	Clay
P. Tunggal	(2)	70	29	1	85	Clay
P. Tunggal	(3)	74	25	2	86	Clay
P. Tunggal	(4)	77	21	2	87	Clay
S. Kulim	(1)	64	29	5	78	Clay
S. Kulim	(2)	43	32	26	59	Clay loam
S. Kulim	(3)	41	30	28	56	Clay loam
S. Kulim	(4)	36	30	30	51	Clay loam
S. Kulim	(5)	59	37	1	77	Clay
Jarak	(1)	54	37	9	72	Clay loam
Jarak	(2)	52	20	27	62	Sandy clay
Jarak	(3)	55	22	14	66	Clay

* See Drawing No. 1 for location of sample sites.

Table 2.15 Particle Size Fractionation of Typic Pedons (6" - 12" layer)

Scheme	Clay	Silt	Sand	Clay + $\frac{1}{2}$ silt	Textural Type
Tasek Junjong (A)	50	16	34	58	Clay
Tasek Junjong (B)	36	16	48	44	Sandy clay loam
Jarak Tengah	42	15	43	50	Clay loam
Cherok Tok Kun	36	10	55	41	Sandy clay loam
Alma	39	10	52	44	Sandy clay
Tasek Gelugor	43	32	25	58	Clay
Machang Bubok*	16	8	77	20	Loamy sand

* See Drawing No. 1 for locations of samples.

All these soils are largely formed on colluvia/alluvia deposits, CEC values for Cherok Tok Kun, Machang Bubok, Tasek Junjong, Tasek Gelugor, Jarak Tengah are all about 10 meq/100 gm soil.

2.5 Land and urban development

Scope

2.5.1 The study covers all the land within Seberang Perai which is cultivated for rice or which remains available for such cultivation. It also covers certain defined JPT (agricultural) drainage areas and, in respect of flood protection or mitigation matters, it includes certain other areas of the State.

2.5.2 The issue which distinguishes this from most agricultural/irrigation studies is the degree of competition for use of the historic agricultural land from urban development of all sorts, whether factories, housing or their necessary infrastructure of roads and services. This competition has forced the prices of land higher and higher, such that in extreme cases it is impossible to show financial justification for irrigation or drainage improvements, because the land acquisition requirement for new canals, etc., through the area would involve prohibitive expense. Even in cases where agricultural improvement can be made without the land having to be acquired by the State, we doubt whether land which is, or certainly soon will be, valued at prices in excess of its agricultural worth should be the subject of any form of government agricultural investment. An exception to this statement could arise if and where it can be shown that the present value is based on a misconception of future development prospects.

Land prices

2.5.3 Detailed estimates of land prices are being prepared for use in this study by the Federal Valuation Office (Pejabat Penilaian dan Perkhidmatan Harta), but to-date only the area of the Sungai Kulim scheme has been covered in detail. The valuation is on the basis of market value ignoring betterment, and assumes the existence of Grade 1 titles. When these values vary widely, and exceed, as is the case, the agricultural floor price by factors of four or more we must assume that the market does not accept the permanence of current dividing lines between urban and agricultural use. Clearly the market may put a development value on land which takes little account of today's planning limits to metropolitan growth.

2.5.4

Table 2.16 gives a representative range of prices of the Kulim scheme land supplied by Federal Valuation Office.

Table 2.16 Kulim Scheme Land Valuation

Area	Nearest Road	Proximity to Road	Price (mean) \$ per acre
3	Jalan Permatang Pauh E side - Simpang Ampat	Frontage 3rd layer in from road ≥ 30 ch (600 m) from road ≥ 50 ch (1 km) from road	87,000 30,000 18,000 13,000
6/7	Permatang Pauh - Permatang Ara - Kubang Semang	Frontage 10 ch-20 ch (200-400 m) ≥ 30 ch (600 m) from road	17,000 15,000 12,000
4	Bund-way from Kampung Pertama to Kubang Semang	Frontage	16,000 -21,000
8	Tanah Liat - Kubang Semang	10 ch-20 ch (200-400 m) from road ≥ 20 ch (400 m) from road	15,000 -30,000 14,000
5	Bukit Mertajam new road Jalan Muthupalaniappa	2nd layer from road 3rd layer from road	130,000 44,000

Metropolitan area and growth centres

2.5.5

The Butterworth-Bukit Mertajam Metropolitan Area is the principal feature of any up-to-date map of Seberang Perai, and it nearly bisects the State from West to East. Drawing No. 1 at the back of this report shows the boundary of the Metropolitan Area as at April 1981. Within the last 2 months extensions southwards of the area have been made known, and it is believed to be only a matter of months before a major extension south to Sungai Jawi (Jejawi) is confirmed by the State Authorities. This extension, reaching to the villages of Kampung Permatang Tinggi and Simpang Ampat, would include virtually the whole

of the Bukit Minyak/Bukit Tengah Drainage Area, as well as the Alma irrigation scheme.

2.5.6

The existing (April 1981) Metropolitan Area already includes parts of Cherok Tok Kun irrigation scheme and the boundary touches the edge of the Alma scheme. The fact of being inside a Metropolitan Area does not rule out the continuation of agricultural use in the short term, and indeed the preservation of green open space would have positive amenity value to the town dwellers and workers. The notion of continued agricultural use within a scheduled future or actual urban area is considered acceptable by the Planning Officer of MPSP (Seberang Perai Municipal Council), but its preservation from competing labour opportunities and land shortages would not be easy. Development recommendations will depend upon land prices still to be obtained.

2.5.7

Much smaller urban growth centres are planned at Kepala Batas and Nibong Tebal/Sungai Bakap, in the extreme north and south of the province respectively. These will have only a marginal effect on our agricultural and engineering studies. In the case of Kepala Batas a small strip of gazetted padi land may come under development pressures, but the great majority of the new town area is east of the main north-south road and its southward extension to Kampong Pajak Song. This area is not part of any padi scheme, or of any drainage area under study by the present Consultants. The proposals in the Southern District are located within the Bukit Tambun and Nibong Tebal Drainage Areas, and urban development there could easily aggravate the problems of drainage in the agricultural areas downstream. General questions affecting successful drainage of mixed urban and agricultural areas are treated in Section 7.2.

3. EXISTING AGRICULTURE

3.1 Rice cultivation, general

3.1.1 Surveys undertaken in the study covering a total of 14,200 hectares (35,213 acres) give an estimated total of 17,800 farm households each cultivating an average of 0.8 hectare (2.0 acres) of padi land (ref. 10). Of the 17,800 farm households nearly 50% are tenant cultivators. For rice cultivation to be economical it has been stated that a holding of 5.9 acres, double-cropped, with an average yield of 1.25 tonnes (500 gantangs) per acre per crop is required (ref. 11). No scheme in the study area has average holdings near to this figure. Although yields of more than 500 gantangs per acre per crop are reported in the better irrigated schemes e.g. Sg. Muda and Pinang Tunggal, yields of less than 500 gantangs are obtained in the rest of the schemes, thus indicating that there is potential for increasing yields with the use of better seeds and agricultural practices, improvement of irrigation facilities and more intensified agricultural extension.

3.1.2 In view of small and uneconomical farm sizes, farmers cannot depend solely on incomes derived from their padi crops only and are thus compelled to seek off-farm jobs for their supplementary incomes. Rapid urban and industrial development have attracted young men and women to various industries and these have brought a serious shortage of farm hands in the agricultural sector. Labour for padi cultivation is drawn from amongst the older people and children who are left behind, so that mechanisation has become increasingly more important to overcome the labour shortage. Fortunately mechanisation in land preparation has been an established practice but labour for transplanting and harvesting are in short supply and cost has risen sharply. The use of combine harvesters has begun to make its appearance in Seberang Perai Utara in the 1980/81 main season and is likely to increase in the foreseeable future.

3.1.3 Several varieties of padi are grown but the more popular are listed in Table 3.1. These varieties have maturation periods from 120 - 155 days but in a double-cropping system for the project area,

varieties of 120 - 125 days are best for the off-season but for the main season, varieties of up to 135 - 140 days may be used.

Abandoned Padi Land

3.1.4 There has been a steady decline in areas under padi cultivation in the State. Starting with 300 acres uncultivated in 1974, the decline became quite alarming by 1978 when 2,580 acres were reported abandoned and by 1980, the figure increased to almost 9,000 acres, see Table 3.2. Some of the reasons given in interviews with farmers and officials are:

- (i) Shortage of labour brought about by industrialisation
- (ii) Staggered planting
- (iii) Deficiencies in irrigation infrastructures
- (iv) Absentee landlords
- (v) Land speculations
- (vi) Lack of enforcement of laws relating to padi cultivation

The definition of "Tanah Rang" or abandoned padi land so far as it applies to the State of Penang is "padi land which has not been cultivated for four consecutive seasons (double-cropping areas)". This definition has been accepted by the Jawatan Kuasa Penyelarasan Kementerian Pertanian Negeri Pulau Pinang on 7.3.79.

3.1.5 Labour shortage: In the last decade, there was rapid industrialisation in the State both on the island of Penang and on the mainland. A large number of young able-bodied people (men and women) were attracted to work in factories close to kampongs resulting in a big shortage of farm labour previously engaged in padi planting.

3.1.6 Staggered planting: Staggered planting first started when there occurred continuous outbreaks of pests and diseases for several consecutive seasons, rat damage being the most serious. This resulted in one farmer wanting to plant later than his neighbour to avoid attacks and planting at different time started. With such a practice there was a continuous supply of food for rats favouring rapid multiplication of the pest. As a result many farmers lost their entire crop or obtained unsatisfactorily low yields and suffered loss in income. Many gave up planting padi to look for off-farm jobs.

- 3.1.7 Deficiencies in irrigation infrastructures: Although Penang was the first State in Malaysia to practice double-cropping of padi, the irrigation system and infrastructures have become out-dated to cater for the demand as areas under double-cropping grew in size from its inception in the fifties when irrigation systems were designed to service a limited area only. As a result, there were problems on the part of DID to cope with water demand and these were further aggravated by demands for water for other uses.
- 3.1.8 Absentee landlord: The State of Penang has limited lands for development and because of pressure on the limited land resources prices have risen to almost unrealistic levels, so much so that cheaper padi lands and kampong lands are being sought after by purchasers for housing and small industries. Attracted by the high prices offered, many padi lands have changed hands and such lands have been left uncultivated thus contributing to the increase in size of "tanah rang".
- 3.1.9 Land speculation: Land speculation is another contributing cause to the increase in areas under "tanah rang". This is particularly true in the Central District, and the S.W. District in Penang Island. Such speculators have little interest in renting out the lands for padi cultivation and less so in cultivating the lands themselves. Their main aim is to wait for an opportune time to dispose of the lands for maximum profits.
- 3.1.10 Attempts have been made by DOA in 1975 and in 1979 to rehabilitate abandoned padi lands under a crash programme under which assistance to farmers was given in the form of land preparation. The programme met with only limited success as the farmers were reported to be rather indifferent to the programme. A similar programme in three parts of the Project Area is currently being organised by the LPP.
- 3.1.11 Lack of enforcement of laws relating to padi cultivation: Chapter 145, Ordinance No. 39 of 1934 cited as the Rice Cultivation Ordinance was promulgated "to control the time and method of the

preparation and cultivation of land for the growth of rice". Under the Ordinance, rules may be made and gazetted for compliance by padi planters failing which they can be brought before a Police Court and penalised. It is assumed that the Ordinance has not been enforced as the amount of penalty provided for non-compliance is too small to have any deterrent effect on the offenders. Laws relating to padi cultivation are out of date, requiring close studies and revision.

Areas Not Cultivated

- 3.1.12 The project area under study consists of 11 irrigation schemes in the Seberang Perai area covering a total acreage of 34,600 acres of padi, and 4 rainfed areas of Alma, Sg. Duri, Mengkuang Mak Sulong and Cherok Tok Kun totalling 613 acres. The schemes are listed in Table 5.5.
- 3.1.13 Of the 5 irrigation schemes in Seberang Perai Utara (SPU) totalling 24,034 acres, 2,000 acres or 8.3% have since been abandoned and designated as "tanah rang".
- 3.1.14 Of the 5 irrigation schemes in Seberang Perai Tengah (SPT) totalling 10,048 acres, 5,375 acres or 53.3% are designated as "tanah rang".
- 3.1.15 In Seberang Perai Selatan (SPS), the Tasek Junjong Irrigation Scheme and the rainfed area of Sg. Duri totalling 632 acres are cultivated both in the main and off-season.
- 3.1.16 The other rainfed areas of Alma and Mengkuang Mak Sulong totalling 563 acres are also double-cropped. Cherok Tok Kun is totally abandoned.
- 3.1.17 Of the total nominal area of 35,213 acres (14,250 ha), the total acreage already reported to be under "tanah rang" is 7,375 acres or 21%. However if recently uncultivated land (as from September 1980) is included this total rises to 34%.

3.2 Padi cropping patterns

Double-cropping

3.2.1 Double-cropping of padi is practised in areas where there is an assured supply of irrigation water for the cultivation of two crops, the main and the off-season crop in a calendar year. In the main season which coincides with the high rainfall period, the problem of water shortage does not arise. In the off-season, however, water becomes the main constraint and where irrigation water is obtained by pumping or gravity intake from an adjacent river, off-season padi growing becomes uncertain and areas under cultivation each off-season are determined by the source of supply. In a dry year, water supply combined with the existing inadequate tertiary distribution systems may limit the extent of area to be cultivated. Insufficient supply during the critical stage of growth of the crop, may result in crop failure. In less severe cases, yields are often seriously affected.

3.2.2 In the State of Penang, the natural short wet season usually begins about mid-March when supply of irrigation water for field presaturation begins to allow for sowing of seeds to commence in early April and transplanting to complete before the end of April and harvesting to finish by mid-August. Late sowing beyond mid-April is highly undesirable as the crop may subsequently run into a wet harvest with serious consequences.

3.2.3 Padi varieties cultivated in the off-season are as a rule varieties with low photo period sensitivities (period fixed) and of short maturations varying between 120 - 135 days. Most of the popular varieties now grown in double-cropping areas belong to this group and these are also grown in single cropping areas.

Single cropping

3.2.4 Single cropping of padi is practised in rainfed areas which are mainly dependent on direct rainfall when there is a period of uninterrupted supply of water necessary for field preparation, sowing of seeds and growth of the crop from transplanting to flowering. In Penang, the period falls between September and November which is

followed by a gradual decline in rainfall with the onset of the dry season from December to February, traditionally the harvesting season of the main season crop.

3.2.5 In the years before the introduction of short maturation (period-fixed) varieties, only long maturation season-fixed varieties were used. Some of the varieties were Seraup 50, Siam 29, Serendah Kuning, Radin Ebos, Nachin, etc. These varieties have maturation periods of 5 - 6 months and are tall and highly prone to lodging with poor response to fertilisers.

3.2.6 These have now been replaced by varieties developed by the Department of Agriculture (DOA) and the Malaysian Agricultural Research and Development Institute (MARDI) which are of short maturation, short to medium in height, resistant to lodging and highly responsive to fertilisers and therefore have potentials for high yield. Some of the varieties are Mahsuri, Bahagia, Sri Malaysia, Jaya, Setanjung and Sekincang.

3.3 Agronomic practices

3.3.1 Nursery preparation: The wet nursery method is common throughout. Seeds are normally soaked in water for a day and are then removed and spread out and covered with a wet gunny sack for a further period of 48 hours to hasten germination before broadcasting onto a prepared nursery bed or onto a well puddled plot. Although the recommended sowing rate is one gantang of seed for every 500 sq. ft. of nursery, farmers generally sow at a higher seed rate of up to $1\frac{1}{2}$ - 2 gantangs seeds for the same areas using up to 8 gantangs of seeds for each acre of field padi. The seed bed is usually fertilised with subsidised fertiliser Ammophos 11:48 at the rate of 2.2 lb per 500 sq. ft. of nursery as recommended by the Department of Agriculture. After sowing of the pre-germinated seeds, the seed bed is covered with a layer of mulch or banana leaves for a period of 2 - 3 days as a precaution against birds. Water level is gradually increased as the seedlings grow in height.

3.3.2 Land preparation: Land preparation is commonly done by contractors using a four-wheeled tractor with a rotovator attachment or by a power tiller. The contract rate has risen to \$80 - \$100/ac for two rotovation rounds and payment is cash after work. For single rotovation, the rate is \$45 - \$55/ac. On exceptionally deep areas, land preparation is done manually at a cost of \$170/ac.

- In Seberang Perai Utara, it is estimated that 65% of the field preparation is done by four-wheeled tractors, 30% by power tillers and only 5% by hand.
- In Seberang Perai Tengah, the corresponding ratio is 40:40:20.
- In Seberang Perai Selatan and Balik Pulau, most of the work is done by hand because of the prevalence of deep land unsuitable for mechanised cultivation. Hand preparation consists of slashing, heaping and spreading of the partially decomposed weeds under flooded condition.

3.3.3 In recent years, farmers who rely on contractors to prepare their fields are experiencing difficulties in obtaining their services due to the fall in tractor population. Because of the increasing areas of abandoned padi land, contractors were said to have insufficient work and have moved out to other contract jobs in the urban and industrial sectors. Another contributing factor is said to be poor payment which has discouraged contractors to continue providing services to farmers.

3.3.4 Transplanting: Most rice in the project areas are transplanted either by contract or by mutual help (gotong-royong). Seedlings used vary from 25 - 40 days but 30 day old seedlings are commonly used. Spacing used is generally 30 cm x 30 cm (12" x 12") irrespective of varieties and because of the traditional use of the "kuku kambing", planting tends to be generally deeper than desirable. The number of seedlings per hill also tends to be higher than recommended. Whereas 3 - 4 seedlings per hill are adequate, twice the number are used, hence the high seed rate used by farmers in most cases.

Observations tend to suggest that although spacing of 30 cm x 30 cm (12" x 12") is intended, in actual practice the spacing always tends to be higher resulting in a planting density of only 9 to 10 hills per

square metre. Better yield can be obtained if a higher planting density is adopted - 16 hills/m².

3.3.5 Weed control: The traditional practice of weed control is hand weeding during the period 30 - 60 days after transplanting. The number of weeding rounds depends on the degree of weed infestation but one round is common and is done usually before topdressing of fertilisers. Because of high labour cost, two weeding rounds are rare. The use of herbicides for weed control is not yet widely practised. From reports gathered from Koperasi Peladang Managers, it would appear that farmers are beginning to switch over to the use of chemicals for the control of weeds. Rumputox (butylester of 2, 4-D) and Esteron 45P (butylester of 2, 4-D) are two popular brands of herbicides used. They are mixed together with fertilisers and applied about 14 days after transplanting.

3.3.6 Fertiliser applications: Fertilisers for padi planting are fully subsidised by Government under the Padi Fertilisers Subsidy Scheme launched in 1979. Every padi farmer under this Scheme is entitled to receive 1 x 4 kg bag of Ammophos 11:48 for the nursery, 2 x 20 kg of urea and 4 x 20 kg bags of NPK basal mixture 23:11:11 for every acre of padi to be planted up to a maximum of seven (7) acres per planter. LPP handles the distribution through its area Koperasi Peladang.

Official recommendations for fertiliser applications are as follows:-

Levels of Nutrient

	Total		
	N	P	K
	(lb/ac)		
Off-season/Main Season :	80	20	20
For padi Mahsuri 1/s and m/s :	60	20	20

Time of Application

<u>Application</u>	<u>Time</u>	<u>Rate</u>
First topdressing	14 days after transplanting	Half the nitrogen and all the phosphorous and potassium
Second topdressing	At panicle initiation stage	Balance half of the nitrogen

3.3.7

It is reasonable to assume that all subsidised fertilisers received are being used. Little is known if there are malpractices such as fertilisers being sold in exchange for cash. As regard time of application, farmers do not as a rule adhere strictly to the recommendations and maximum benefits of the Scheme are thus not obtained. Extension efforts of the Department of Agriculture under its 2L System should help to correct any shortcomings in proper technology of fertiliser use.

3.3.8

It is further observed that in the project areas, planting of rice is carried out at all times of the year. The full benefit and effects of the nutrients supplied in the fertilisers will not be realised in crops which do not receive sufficient sunshine during their reproductive phase of growth i.e. the last 45 - 50 days of the life of the plant. Hence it is important that the planting seasons be strictly regulated and all padi planting activities be re-scheduled i.e. late March/early April sowing for o/s padi and September sowing for m/s padi.

o/s m/s
off / main season

3.3.9

Padi varieties: No less than 10 different varieties of padi are grown in the various scheme areas (see Table 3.1). The most popular variety is Katek (syn. Seribu Gantang) which is a short-strawed, erect and high yielding variety with a maturation period of 135 - 138 days. It is not an officially released variety but nevertheless popular among farmers. Improved Mahsuri (syn. Anak Dara) is also another popular variety. It is short-strawed, erect and high yielding with a maturation period of 125 - 128 days. Other popular varieties are Mat Candu, Bahagia, Mahsuri. Two varieties released in 1979 viz. Setanjung and Sekencang and officially recommended for planting in the project areas of Seberang Perai are now being encouraged by the Department of Agriculture but their full endorsement by farmers have yet to be seen.

3.3.10

Field visits and observations have clearly shown that there is an urgent need for a full scale seed renewal exercise. A very high proportion of fields are carrying crops of mixed varieties thus necessitating more than one round of harvesting because of uneven ripeness which affect quality of padi for sale. The extension service of the Department of Agriculture can help to rectify this unhealthy situation.

TABLE 3.1

Varieties of Padi Cultivated in the Scheme Areas

Variety	Parentage	Maturation (days)		Height cm	Grain	Lodging resist- ance	Blast resist- ance	Threshing quality	Yield potential gantang/ acre
		Main season	Off season						
Setanjung (MR 1)	IR 22 x Pazudofusu	135	140	110-120	Long	High	Medium	Easy	1001
Sekencang (MR 7)	Jaya x Tadukan	120	125	97-120	Long	High	Medium	Easy	1166
Mahsuri	Mayang Ebos 80 x Taichu 65	134	138	110-115	Short	Medium	Low	Easy	760
Bahagia	Peta x Tangkai Rotan	137	145	100-115	Long	Medium	Medium	Easy	900
Improved Mahsuri (Anak Dara)	IR 8 x Mahsuri	125	128	85	Medium	High	Low	Easy	1000
Katek (farmer's Seribu Gantang selection)	(Engkatek x Sacupak) x IR 8 (?)	135	138	80	Medium	High	Medium	Easy	1000
Mat Candu (farmer's selection)	Peta x BPI 76 (?)	150	155	120	Long	Medium	Low	Easy	600

Source: Dept. of Agriculture, Pulau Pinang
MARDI, Bumbong Lima

TABLE 3.2

**Acreages of Padi Land under "TANAH RANG"
in various Districts, Pulau Pinang 1974/81**

District Year	Seb. Perai Utara		Seb. Perai Tengah		Seb. Perai Selatan	Total	
	ha	(acres)	ha	(acres)		ha	(acres)
1977	-	-	-	-	-	-	-
1978*	30	(80)	530	(1,300)	-	560	(1,380)
1979*	140	(350)	660	(1,630)	-	800	(1,980)
1980*	400	(1,000)	1,300	(3,200)	-	1,700	(4,200)
1981*	800	(2,000)	2,200	(5,375)	-	3,000	(7,375)

*Figures according to new definition of "tanah rang".
Whole area is in Sg. Muda scheme (SPU) and Sg. Kulim
scheme (SPT).

Source: Department of Agriculture, Pulau Pinang.

Recent estimates of land not cultivated in the main season
1980/81 give:

Seb. Perai Utara	:	2,000 ha (5,000 ac)
Seb. Perai Tengah	:	2,800 ha (6,900 ac)
Total		4,800 ha (11,900 ac)

4. AGRICULTURAL SUPPORT SERVICES

4.1 Department of Agriculture (DOA)

4.1.1 The State Department of Agriculture (DOA) provides a variety of supporting services which are mainly directed towards increasing output and production of essential food for the growing population as well as basic raw materials for agro-based industries and for export. It is primarily concerned with the extension of improved agricultural technologies to the farmers. With the launching of the National Extension Project in 1978, a Training and Visit System (syn. 2L System) was introduced in the State and under this System, farmers are organised into informal groups and regularly visited and trained by specially assigned extension workers (agricultural technicians) supported by Subject Matter Specialists (SMS) from the Federal Department of Agriculture. Supplementary training is also provided at regional centres in Relau and Cherok Tok Kun on specially selected subjects for farm youths and women.

4.1.2 Besides training, other support services provided include the production and distribution of high quality seeds and planting materials, demonstrations on new seeds, fertiliser use, pesticides etc., provision of agricultural inputs under the Agricultural Input Subsidy and Development Programme (AID) with a view to increase production and income of farmers and encouraging the cultivation of specified crops suitable to the State.

4.1.3 The total number of farming families in the State is estimated at 51,695 (Perangkaan Asas Pertanian Negeri Pulau Pinang). The number of agricultural extension workers (all levels) servicing farming families in the various districts are given as follows:-

<u>District</u>	<u>No. of Families</u>	<u>No. of Extension Workers</u>	<u>Ratio</u>
S. P. Utara	17,078	13	1:1,314
S. P. Tengah	10,569	10	1:1,055
S. P. Selatan	15,469	11	1:1,406
Barat Daya	6,560	7	1:937
Timor Laut	2,019	5	1:404
Training Centres	-	3	-
Supervisory Officers	-	7	-
Total	51,695	56	1:923

4.1.4

The ratio of extension workers to farming families as set out under the National Extension Project is 1:600. To achieve the target for more effective extension, the following additional staff are deemed necessary:-

District	Existing	Additional	Total to achieve ratio 1:600
S.P.U. (AT)	13	15	28
S.P.T. (AT)	10	8	18
S.P.S. (AT)	11	15	26
Barat Daya (AT)	7	4	11
Timor Laut (AT)	5	-	4
Training Centres (AT)	3	1	4
Supervisors (AA)	7	2	9
Total	56	45	101

AT = Agricultural Technician - Certificate Level

AA = Agricultural Assistant - Diploma Level

4.2

Farmers' Organisation Authority (LPP)

4.2.1

The Farmers' Organisation Authority (LPP) in its early years of establishment in 1973 was concerned with the re-organisation of kampong farmers' associations and agro-based co-operative societies into area farmers co-operatives (koperasi peladang kawasan). Resulting from the re-organisation exercise, there are now eight (8) koperasi peladang kawasan (KPK) in the State and these are given in Table 4.1 below:-

Table 4.1 Details of State Farmers' Organisations

Name of KPK	District	Mukim	No. of Farming Families	No. of Members	Percent Members
1. Kawasan 1, Penaga	SPU	1-5	3,045	1,742	57.2
2. Kawasan 2, Lahar Bubu	SPU	7-10	3,007	1,321	43.9
3. Kawasan 3, Pokok Sena	SPU	6,11-13,16	2,460	1,383	56.2
4. Kawasan Utara, Kg. Pelet	SPT	2,5,18-21	4,785	1,111	23.2
5. Kawasan Bukit Mertajam	SPT	1,6-17	4,365	1,045	23.9
6. Kawasan 1, Sg. Acheh	SPS	7-10	1,662	891	53.6
7. Kawasan 2, Tasek	SPS	1,6-15	1,900	263	13.8
8. Kawasan Sri Pulau	B. Daya	B. Daya	3,370	914	27.1
			24,594	8,670	37.3

4.2.2

It is suggested that a concerted effort be made to increase the membership to a target of at least 70% to make the KPK more effective in servicing the farmers within their organic areas of control. The supporting services provided by LPP through the KPK include the distribution of padi fertilisers under the Padi Fertilisers Subsidy Scheme, the provision of mechanisation services, the provision of transport services, the provision of seasonal and medium term loans, warehousing and marketing. KPK are also engaged in consumer trading and sale of various agricultural inputs on the use of which technical guidance is also provided. They also provide services to farmers in group farming projects which are generally encouraged. A revolving fund by LPP is provided to each KPK to facilitate farmers to obtain agricultural inputs at reduced cost and this is further supplemented by KPK's own fund.

4.2.3

In order to encourage mechanisation and tractor ownership, LPP also provide loans whereby farmers may obtain loans on a small down payment and the balance to be paid in six (6) instalments on a reduced interest rate of only 4% per annum. In 1979, 89 farmers were provided with loans under the scheme made up of 79 farmers in S P Utara and 10 farmers in S P Tengah. All tractors purchased were power tillers made up of 60 SUZUE, 16 KUBOTA, 5 YANMAR and 8 DAIDONG with an average cost of \$4,762 each. In addition to the loan scheme, LPP is presently in the course of establishing a centralised farm mechanisation centre at Pokok Sena, SPU. The centre will provide repair services to all KPK machines which are used on farmers' fields.

4.3 LPP "Tanah Rang" Schemes

4.3.1

Under the first phase of the rehabilitation of "tanah rang" (abandoned land) exercise, 6,475 acres have been targetted constituting 4,675 acres in Seberang Perai Tengah (SPT) and 1,800 acres in Seberang Perai Utara (SPU). Necessary funds have been allocated to LPP to carry out the exercise and are to cover the cost of spraying and land preparation up to the stage ready for transplanting. The cost of transplanting and subsequent operations is the responsibility of individual farmers. Fertilisers are free under the Padi Fertilisers Subsidy Scheme.

4.3.2 A modest start has been made commencing with the 1981 off-season crop covering 224 acres in Sama Gagak in Mukim 2, and 100 acres in Kampong Kota Ptg. Pasir in Mukim 3, Seberang Perai Tengah. In Seberang Perai Utara, the exercise covers approximately 600 acres in Mukim 8 and 300 acres in Pulau Mertajam Penaga in Mukim 1. In addition, 2 areas viz. 41 acres in Kuala Tasek and 38 acres in Machang Bubok have also been rehabilitated with LPP's assistance.

4.4 Co-operative ventures

4.4.1 A subsidiary company (Padi Integrated Sdn Bhd) of Koperasi Gabungan Negeri Pulau Pinang has been formed and registered in May 1981 with a view of venturing into co-operative farming on members' land which are hitherto under "tanah rang". The farm(s) will be commercially managed in sizeable blocks. Member-owners will receive agreed rents and may participate as paid workers. Such a venture is to be encouraged and is in consonance with the idea of co-operative land use enunciated by A H Ahmad Sarji (see p. 95 - 96 Farmers' Co-operatives - Institution for small Farmers in Malaysia (ref. 14)).

5. WATER REQUIREMENTS AND AVAILABILITY

5.1 General

All the schemes under study in Seberang Perai have run-of-the-river supplies with abstraction either by gravity or low-lift pumping. By far the major source is Sg. Muda for which supplies are abstracted for the Sg. Muda scheme (7,125 ha - existing gross area), Pinang Tunggal scheme (1,618 ha) and, by a transfer system of canals and rivers, Tasek Gelugor (250 ha), and a major part of the Jarak (790 ha) and Kulim (3,664 ha) schemes during periods of water shortage. The catchment of Sg. Muda is entirely within the State of Kedah as are much of the catchments of the other mainland river sources.

5.1.2 At present the only regulating control in any of these catchments is the Muda dam on the upper catchment of Sg. Muda. This reservoir effectively diverts all the useful runoff from about 25% of the total catchment - the only releases being excess flood flows. Thus the river flows can be considered presently as being the uncontrolled runoff from a reduced catchment.

5.1.3 To meet present water shortages particularly in the Muda Irrigation Scheme (Kedah) and projected increasing requirements for potable water, irrigation and industrial use, a number of storage and transfer schemes have been studied as part of the Kedah-Perlis Water Resources Management Study (ref. 15). A systematic development of the more favourable schemes are proposed in that report which takes into account the requirements of the State of Penang from Sg. Muda*. Over the next 20 years the flows in Sg. Muda would become increasingly controlled by the construction of regulating reservoirs if these proposals are implemented.

* Note that the assumptions in that report regarding the existing and future areas of padi in Penang State are incorrect. The existing area is approximately 13,820 ha with no projected increase whereas the figures quoted are a present area of 5,000 ha with a projected increase to 9,680 in year 2000.

5.1.4 None of these proposed schemes have yet reached the detailed design stage and no detailed operating guidelines or rules are available on the management of low flows in Sg. Muda. It is beyond the scope of this report to attempt to lay down such guidelines which can only be made in the context of the integrated management of water availability and use in the interconnected river and irrigation systems of Kedah, Perlis and Penang. Such a management would require the setting up of a single controlling authority probably with corresponding legislative changes to the constitutional powers each state has over its own water resources.

5.1.5 Notwithstanding the above, certain broad assumptions must be made regarding the availability of water in the Sg. Muda and the effect on agriculture in Seberang Perai. The programme of development recommended in ref. 15, involves the construction by 1985 of the Jeniang transfer which basically consists of the diversion to storage of flows of up to $40 \text{ m}^3/\text{s}$ (1,400 cusecs) from flows in Sg. Muda in excess of the requirements of downstream users. Associated with this, although possibly delayed until 1990, is the construction of the Reman reservoir which would be used for long term strategic storage and could be used to supplement low flows in Sg. Muda. However as this latter scheme may not come into service until 1990 it will be assumed that for at least 10 years there will be no significant regulation of low flows in the Muda. (Other schemes proposed in this period are unlikely to be of benefit in supplementing Muda low flows.) Allowance will be made for increasing abstractions but essentially, for this period, the irrigation schemes in Seberang Perai will remain run-of-the-river with peak abstraction rates and the patterns of demand and available water of paramount importance. As supply will not be from storage, total use is of less importance than peak rates, except in terms of pumping costs and the degree to which abstractions at Jeniang are limited.

5.1.6 Beyond 1990 the situation is more difficult to predict. Increasing abstractions by other users will reduce the available flow but on the other hand there will be an increasing capability to supplement low flows which in turn may allow changes in the cropping programme and reduce peak demands. In view of the uncertainties involved however we

5.1.2 have based cropping patterns and water requirement estimates on the existing run-of-the-river situation.

5.1.7 Rivers other than Sg. Muda are all unregulated and are likely to remain so in the foreseeable future. Abstractions are thus considered as run-of-the-river throughout.

5.2 Cropping patterns and average water requirements

5.2.1 Minimum river flows occur at the end of the dry season during late February and March. This is also the start of land preparation for the 'off-season' crop when irrigation requirements are highest. In view of the increasing strain on the water resources, particularly of Sg. Muda, precise scheduling and control of the cropping pattern is of paramount importance. For the double cropping of rice, assuming the continuation of the practice of transplanting, an optimum schedule for the climatological pattern in Penang is shown by II. Fig. 5.1. The 'main season' crop would be planted in the rainy season in September and harvested in the dry period in late January. The second or 'off-season' crop would be sown in late March at the beginning of the second rains and harvested in the dry spell at the beginning of August. The indicated programme however assumes each activity (transplanting, harvesting, etc.) is completed throughout the entire area within 2 weeks. In practice limitations on availability of labour, machinery and water require that the programme is spread over a longer period. To minimise these requirements a spread of activities over a total period of about 8 weeks is desirable; however social and agricultural requirements indicate a shorter period. In the Muda scheme in Kedah for example, a compromise of 6 weeks has been adopted between the planners' initial proposal of 8 weeks and the farmers' preference for 4. In this case the limitations on water availability during February and March at the start of the off-season crop, and the need to complete harvesting of this crop before the rainy season starts in late August, suggest that 6 weeks is about the longest period that can be accommodated with reasonable confidence. (For assessment of water requirements the period is taken as 1½ months.)

- 5.2.2 A suitable programme is indicated in Figure 5.1. Minimum river flows occur during March. With peak water requirements occurring during the presaturation period at the start of the season it is desirable to delay this peak for as long as possible. The start of field preparation is therefore shown at the beginning of March with the peak requirement being delayed until the first part of April. Any later start of irrigation requires harvesting of the last fields continuing into the rains of September even with the short maturation (125-day) rice varieties recommended for the off-season crop.
- 5.2.3 For the main season crop there are few restrictions on the programming or the rice varieties that can be grown. For estimating water requirements land preparation is assumed to start about 20 days after harvesting of the off-season crop and a variety with 140-day maturation is considered.
- 5.2.4 With this programme there is a period in excess of 4 weeks during the driest spell in February when no irrigation is required for any area, and canals can be emptied if required for maintenance.
- 5.2.5 Although activities over the whole of the larger schemes are spread over 6 weeks, for operation of the irrigation system we propose that the areas are divided into 3 'blocks', each following a separate programme. Commencement of supply to each block will be staggered by 2 weeks, and there will be a corresponding stagger of activities within each block so that each activity is uniformly spread over the full 14 days. (Note that for calculation of water requirements these periods have been approximated to $1\frac{1}{2}$ and $\frac{1}{2}$ month respectively.)
- 5.2.6 Water requirements have been assessed for 10-day periods. Because the schemes are run-of-the-river it is necessary to ensure the adequacy of available supplies during each period of consideration. For assessing the project feasibility and establishing design criteria this is carried out for the 1-in-5-year driest periods. Because of the relative constancy of evaporation values but the strong correlation between rainfall and river flows, this condition has been taken as the combination of average evapotranspiration together with the rainfall and river flows with an 80% probability of exceedance. In addition

consideration has been given to the average annual requirements in order to assess pumping costs.

A. Transplanted rice

5.2.7 Water requirements during the presaturation period have been calculated following the methods in DID Information Paper No. 2 (ref. 16). For each irrigation block the period of presaturation has been taken as 20 days and for the 1-in-5-year condition the presaturation requirement has been taken as 150 mm for the off-season crop, following the dry months, and 100 mm for the main season crop with a shorter break since cessation of irrigation and more rainfall in this intervening period. For the average year the presaturation requirement has been reduced by 50 mm.

5.2.8 The build up water layer to 100 mm has been assumed to occur during the presaturation period to facilitate ploughing in the heavy clays and to achieve the hydraulic gradients necessary for field-to-field flow. However as transplanting should be carried out in no more than 25 mm of water we have assumed the draining off of 75 mm and its re-application over the two 10-day periods following transplanting. No allowance has been made for draining fields for fertilizer application. Such practices though desirable would be dependant on the availability of water.

5.2.9 Open water-surface evaporation and grass evapotranspiration (ET_0) values have been taken from the published data for Bayan Lepas. In view of the small and gradual variation from month to month, 10-day values have been taken as one-third of the monthly ones.

5.2.10 During the growth period of the crop, the consumptive use (i.e. the crop evapotranspiration) is given by:

$$ET_{\text{crop}} = k_c ET_0$$

where k_c is the crop coefficient appropriate to the stage of growth. Table 5.1 indicates the crop factors used. Before transplanting there is open water in the fields corresponding to a coefficient of 1.25 and

it is assumed that the value remains at this after transplanting when the fields are still flooded and the foliage cover is small. The coefficient is taken as zero for the last two periods of ripening when irrigation supplies are discontinued. For calculation of average water requirements for each irrigation block (see Table 5.2) the coefficients have been weighted to take into account the 15-day variation of growth stage across the block and, as irrigation is discontinued, the corresponding reduction in irrigated area.

5.2.11 During presaturation it is assumed that drainage water levels would continue to be controlled as is presently practised and that percolation losses are negligible. Thereafter, in order that farmers can control water depths and drain as required, drainage levels should be lowered and an allowance for percolation losses of 2 mm/day has been assumed.

5.2.12 Table 5.2 summarises the water requirement calculation. Values are expressed in mm/day average over 10-day period. The peak average field water requirement of one irrigation block is 17.4 mm/day (presaturation requirement) which is equivalent to 2.0 L/s/ha. With the effect of staggering the irrigation blocks, the peak field water requirement averaged over a whole scheme reduces to about 14 mm/day.

5.2.13 A significant part of the total water requirement can be provided by direct rainfall on the fields. That proportion of the total rainfall which can be utilized to reduce the irrigation requirement is termed the effective rainfall. The percentage of total rainfall which is effective with flooded rice irrigation is a function of not only the rainfall characteristics but also of the irrigation and drainage systems, their method of operation and control and even the amount of effective rainfall allowed in the irrigation scheduling. The matter will be discussed in more detail in the Final Report but, in view of the complexity of the problem and the uncertainties involved, it is dubious whether an accurate assessment is possible. However in this case the rainfall with 80% probability of exceedance during the most critical period (March/April) is only about 20% of the total water requirement, thus inaccuracies in the estimation of the effective

rainfall will have only a small effect on irrigation requirements and will be insignificant in comparison with inaccuracies in the assessment of other parameters. We have adopted, therefore, the following criteria:-

- During presaturation, when many of the fields are empty or only partially full, the effective rainfall is taken as 75% of the 10-day period total of actual rainfall.
- During the remainder of field preparation and subsequently when the water layer is being built up and some storage is available in most fields: 60% of actual rainfall.
- For the remainder of the crop calendar when the water depth is limited - 50% of actual rainfall.

In addition, however, to take some account of the reduction of effectiveness of intense rainfall, a further criterion has been established based on the USDA method (ref. 17). From their data (relevant to dry, or 'upland', crops - not strictly applicable to flooded rice) a curve has been plotted relating efficiency percentage to total monthly rainfall for a crop of average monthly ET of about 150 mm. The actual effective rainfall has been taken as the lower of the two criteria applicable to the field condition. This is shown in Figure 5.2.

5.2.14 Because of the water stored in the standing layer in the fields a deficit of total supply in one 10-day period is not critical (a total absence of rainfall in one period during the critical months would represent an average reduction in the depth of the water layer of less than 2 cm.) We consider therefore that for the design 1-in-5-year case the total monthly rainfall values are applicable rather than the more severe combination of individual 10-day 1-in-5-year values. For the irrigation requirement calculation the monthly totals have been divided into 10-day values as described in Section 2.1.

5.2.15 Analysis of the rainfall patterns of the various mainland rainfall stations suggests that the station at Permatang Binjai, which is located centrally in the Sg. Muda scheme, has a reasonable design rainfall pattern. The annual total is close to the average of

all the stations considered, but during the critical period of March and April both the 1-in-5-year and the mean rainfalls are below average. For schemes other than Sg. Muda, therefore, some small reduction in the peak irrigation requirement might be expected.

5.2.16 Field irrigation requirements for the 1-in-5-year rainfall case (i.e. field water requirements less effective rainfall) are indicated in Table 5.2 for each of the irrigation schedules, together with the average field requirements over each scheme, assuming equal-sized irrigation blocks. Total intake requirements must take into account losses from the distribution systems and inefficiencies in the control and distribution of the flow. At times of water shortage with particular effort being made to minimise wastage, fairly high efficiencies should be achievable. For the 1-in-5-year design conditions, the following efficiencies have therefore been assumed:-

tertiary systems	- 80%
main and secondary distribution systems	- 85%

i.e. an overall efficiency of 68%.

Table 5.3 summarises the field and average intake requirements for the average year with mean monthly rainfalls. For this case it is likely water control will be less rigorous and we have therefore assumed an overall system efficiency of 60%. Total average intake requirements are estimated at $18,600 \text{ m}^3/\text{ha}/\text{yr}$ (1,860 mm/yr).

B. Direct seeded rice

5.2.17 As discussed elsewhere in this report the future cultivation of rice in Penang must involve a greater degree of mechanisation and less labour intensive methods. In particular the practice of direct seeding is likely to be more widely introduced. There are 2 basic methods that can be employed:

- (i) dilling of the seeds into a relatively dry seed bed with water applied gradually after seeding to saturate the soil and build up the water layer as the seedlings grow.

- (ii) broadcasting the seeds onto an already prepared and puddled surface, the fields having been presaturated, with again the water layer being built up with the plant growth.

5.2.18 The former method, although requiring particularly good control of water application during the soil saturation period after seeding, should not require any greater quantities, or higher rates of application of water, than estimated for transplanted rice. Moreover, because all irrigation requirements are applied after seeding during the growth of the plant, the timing of peak applications will be no earlier than assumed for transplanted rice and, if anything, they are likely to be delayed and spread over a longer period, thus reducing the peak requirement. It can be assumed therefore that direct drilling will neither increase peak requirements nor adversely affect the cropping calendar.

5.2.19 The second method however requires presaturation and field preparation before the seeds are planted. Thus if the harvesting period for the off-season crop is to be maintained as indicated in Figure 5.1 before the rains of September, the presaturation must commence earlier than for transplanted rice. Since the presaturation requirements are substantially the same in both cases, this would bring the peak requirement forward and increase the likelihood of water shortage. The alternative is to delay the planting dates and allow harvesting to extend into September, with consequent loss of yield and difficulties of combine harvester operation in wet conditions. The total extension of the crop season is however reduced to 7 days by the shorter growth period of non-transplanted rice, and the introduction of any new rice varieties with periods shorter than 125 days would eliminate most of the remaining extension. (We understand MARDI are investigating the possibilities of development of shorter term varieties.) In view of this and the fact that peak application rates are not increased over those of transplanted rice, we consider that this method of direct seeding will not significantly affect the amounts or pattern of total water requirements.

C. Crops other than rice

- 5.2.20 A number of other crops requiring irrigation - mainly vegetables - are presently grown in the project area in small quantities. Possible additions to these are discussed in Section 9. In certain areas - particularly the east side of the Pinang Tunggal scheme they constitute a significant total area. Generally a mix of vegetables is grown either instead of the off-season rice crop or throughout the year, with as many croppings as possible in the available time. With no fixed planting or harvesting dates and a variety of crops, only typical average values for the irrigation requirement can be assessed and a simplified approach has been adopted.
- 5.2.21 The total water requirement of a dry-land crop is taken as the consumptive use, percolation losses being included in non-effective rainfall and in field irrigation application efficiencies. As indicated for rice (5.2.10) the consumptive use (ET) is related to the reference evapotranspiration of short green grass by a crop factor k_c . Figures 5.3a and 5.3b show the variations of k_c for a typical selection of vegetables and other non-perennial crops; based on values given in reference 17. In both figures a single criterion has been chosen as representative of a typical crop, and in both cases the maximum values for these k_c factors are about 1.1. In the absence of scheduled crop seasons, for estimation of peak crop water requirements, this mid-season peak is assumed to occur at any time throughout the year.
- 5.2.22 Effective rainfall has been estimated using the method and data proposed by the USDA and summarised in reference 17. Values have been calculated for each 10-day period for the 1-in-5-year case (i.e. rainfall with 80% probability of exceedance) and for the mean rainfall using data from the station at Permatang Binjai. (n.b. The main area with non-rice crops is the east block of Pinang Tunggal. Rainfall data from Pinang Tunggal headworks station show slightly higher reliable rainfalls during the driest months but lower annual totals for both cases. It is considered therefore that Permatang Binjai is a reasonable representative station for this purpose.) The crop irrigation requirement is the total water requirement less the effective rainfall. The

peak 1-in-5-year value (field design water duty) is 4.85 mm/day occurring during the first period of March when the effective rainfall is zero. Figure 5.4 illustrates the pattern of peak crop-water and crop-irrigation requirements.

5.2.23 The total irrigation requirement for an area must take into account the field application efficiency, the distribution efficiency and the fact that the crops may be at differing growth stages with some fields in between crops and unplanted. The field application efficiency is taken as 60% for the dry-land crops, corresponding to a fairly low value for furrow irrigation (or sprinkler irrigation should it be introduced) in medium to heavy soils. Thus the maximum field irrigation requirement is 0.94 L/s/ha (8.1 mm/day). The distribution system will also be serving rice areas and the efficiencies are therefore taken as the same - i.e. 80% within the tertiary unit; 85% for the main system and an overall efficiency of 68%. To take into account the variation of plant growth over a large area, the total scheme irrigation requirements have been taken as 80% of the total calculated using the maximum field requirement. Thus the peak average intake requirement is taken as:

$$0.94 \div 0.68 \times 0.80 = 1.1 \text{ L/s/ha for the 1-in-5-year case} \\ \text{and } 0.82 \text{ L/s/ha for the average year.}$$

5.3 Scheme areas and water duties

Scheme Areas

5.3.1 The gross area of each scheme is defined for the purpose of this study as the gross area of irrigable land including canals, internal roads, drains, field bunds and paths, isolated buildings and minor patches of non-irrigated land (gardens, etc). It excludes areas of tree crops, kampongs, etc. which can be readily excluded from any measurement.

5.3.2 The present gross areas of each irrigation scheme have been measured from maps at scales of either 8 or 16 chains to 1 inch (1:6,336 or 1:12,672), and they are listed in Table 5.4. Some discrepancies exist between these values and those given by JPT (quoted in

the Terms of Reference), probably due to differences regarding inclusion of non-irrigated areas (canals, drains, flood bunds, etc). In addition in some areas there have probably been some minor changes of land use.

5.3.3 For two main reasons the future size of several of the projects may be reduced from that now existing:

- Two major road projects are presently being studied and designed - the North/South Expressway the East/West Highway - which will affect the Sungai Kulim, Sungai Muda and the Pinang Tunggal schemes. Land will be lost directly to the road reservations, including access roads and interchanges, and indirectly by the isolation of small pockets of land. (Studies are also being carried out on the road system around Butterworth and upgrading the existing Kulim/Butterworth road. In neither case are final proposals likely to effect significantly the irrigation schemes.)
- The approved extensions of the Metropolitan Area between Butterworth and Bukit Mertajam, which includes some land presently part of Sungai Kulim scheme, and of Kepala Batas, which will result in a small loss to the Sungai Muda Scheme.

Approximate irrigable areas lost by these projects have been assessed and indicated in Table 5.4. In addition it must be realistically expected that there will be minor encroachments for housing and industrial use along the southern edge of the Sungai Kulim scheme. Without defining where such developments might occur we have allowed for some loss of land in the scheme totals.

5.3.4 The net areas of each scheme that are actually cropped (i.e. excluding all infrastructure, housing and even field bunds) will be less than the gross area, the actual percentage varying from scheme to scheme. Based on a study of the sample areas we estimate the existing non-effective land use at about 5% - 6% for canals, drains, etc., including 2% for field bunds. The proposed improvements in infrastructure will increase this by between 4% and 6%. The net cropped area will therefore be assumed to be about 90% of the measured gross. These net scheme areas are shown in Table 5.4. For estimation

of the water requirements we have assumed a net area of 95% of the gross area (to include evaporation losses from the canals and field bunds.)

Water duties

5.3.5 Peak total intake water requirements for each scheme have been assessed on the basis of 200% rice cropping, except for Pinang Tunggal where there is a gross area of about 200 ha of vegetables and other crops. For the larger schemes - 200 ha and over - we have assumed the 3-schedule cropping pattern (5.2.5) with an overall efficiency of 68% (5.2.16) - i.e. peak average requirement of 1.89 L/s/ha (37 acres/cusec). For the smaller schemes consisting of only 2 or 3 tertiary units a 3-schedule pattern is unlikely to be operated, and the peak requirement is taken for a 2-schedule system. However the distribution systems for these small schemes are simpler and we have therefore assumed an overall efficiency of 75%. The peak average intake requirement for these schemes is then 2.00 L/s/ha. The four very small schemes, Renjau, Kuala Tasek, Sungai Dori and Kubang Menderong have been treated as tertiary units following a single schedule. The distribution efficiency is taken as 80% and the peak intake requirement is 2.46 L/s/ha. The figures for each scheme are summarised in Table 5.5.

5.4 Available flows

5.4.1 Natural river flows (i.e. assuming no upstream abstraction or diversion) are given in Table 2.5 for Sg. Kulim and Sg. Muda and in Table 2.7 for the remaining rivers. To assess the flows available for the irrigation schemes allowance must be made for other users:-

- abstractions for water supply,
- abstractions for irrigation,
- abstractions for industrial use,
- compensation flows, including allowance for downstream users.

5.4.2 The three largest river sources, Sg. Muda, Sg. Kulim and Sg. Jarak all have the major part of their catchments in Kedah and are used in that state for irrigation and potable water supply. Application has been made to JPT (Kedah) and JKR (Kedah) for details of existing and

proposed schemes. In addition, Penang Water Authority (PWA) abstract from Sg. Muda and Sg. Kulim. Details of all these abstractions are given in Tables 5.6 to 5.9 and are discussed in the following paragraphs. The smaller rivers, particularly those supplying the small schemes in Central and Southern Districts, have no other major users but a number of factories abstract on a regular or occasional basis. A survey of these factories was commenced but the results were so inconclusive that results are not presented. Few of the plants had abstraction permits and generally the facilities are used only when other sources - groundwater or piped supply - are inadequate. Thus accurate figures on frequency of use and rate of abstraction are not available. However much of any abstracted flow is returned and the consumptive use, compared to the irrigation requirements, is small. We have therefore simply allowed a percentage of the minimum river flows for downstream compensation and upstream industrial use. For Sg. Muda there is no downstream compensation requirement - the tidal barrage at Kg. Rantau being closed at times of low flow. An allowance of $0.5 \text{ m}^3/\text{s}$ has been made for upstream industrial use. For Sg. Kulim $0.3 \text{ m}^3/\text{s}$ and for Sg. Jarak $0.2 \text{ m}^3/\text{s}$ have been allowed. For the other rivers 20% of the 'natural' flow at the intake has been deducted for compensation and industrial use.

5.4.3 An outline of proposals for development of Sg. Muda is given in 5.1. The major existing abstraction is at the Muda dam which, except at high flows, effectively diverts the runoff from 23% of the catchment. The 'natural' low flows at Pinang Tunggal must therefore be reduced by this amount. The proposed diversion at Jeniang must be assumed not to affect low flows. As well as the PWA abstraction at Lahar Tiang, which has a priority requirement of $1.57 \text{ m}^3/\text{s}$ (30 m.g.d.) there are other present and planned water supply abstractions, detailed in Table 5.6 that by 1990 will total $2.54 \text{ m}^3/\text{s}$ (48.5 m.g.d.) including the PWA requirement.

5.4.4 As well as the diversions at the Muda dam for the Kedah Muda scheme, irrigation abstractions are made for 39 other irrigation schemes of various sizes, (Table 5.7) at present operated by or planned to be upgraded and taken over by JPT. In addition there are a large number of

rainfed schemes. Detailed information on these is not available however figures supplied by the Ministry of Agriculture for the total cultivated areas of rice in each district allow estimates of the areas within the Muda catchment to be made. In Kuala Muda and Kulim districts the areas of rainfed schemes in the Muda catchment are assumed to be the same percentages of the total as those for the JPT schemes. Most of the irrigation schemes are within the Sg. Muda catchment and will have drainage return flows to the river. However several of the larger schemes in Kuala Muda drain into the Merbok estuary and it is estimated that only 47% of the JPT schemes and 85% of the rainfed areas have return flows to Sg. Muda. Total areas of the JPT and rainfed schemes are given in Tables 5.8 and 5.9. To estimate the pattern of irrigation abstractions it has been assumed that the average intake requirement is the same as for Penang (Tables 5.2 and 5.3). This assumes the most unfavourable condition - i.e. the same cropping pattern - and a peak 1-in-5-years requirement slightly higher than estimated in reference 18. For simplicity the JPT schemes are assumed 100% double cropped and the rainfed schemes 100% single cropped, in the main season only. Neither assumption is likely to be strictly correct but the average condition is considered a reasonable approximation. Return flows are allowed at 30% of the abstractions.

5.4.5 Upstream irrigation abstractions in the Sg. Kulim and Sg. Jarak catchments have been assessed in the same way and the areas are given in Tables 5.8 and 5.9. The return flows are small and have been ignored. PBA have a present abstraction priority of $0.52 \text{ m}^3/\text{s}$ (10 m.g.d.) at Bukit Toh Alang from Sg. Kulim and JKR plan to abstract from the same river up to $0.39 \text{ m}^3/\text{s}$ (7.5 m.g.d.) by 1990 for water supply for Kulim Town and district. (This latter supply is anticipated to increase to 10 m.g.d. by 2000 for which a pumped storage reservoir may be necessary.)

5.4.6 A direct comparison between the maximum irrigation requirement of each scheme and the minimum available flow in the river directly supplying it would appear to indicate that in most cases there is inadequate water, at least 1 year in 5, to double crop the entire scheme. However the timings of the two events are not coincident -

minimum river flows generally occurring in mid-March while peak irrigation demands of the proposed cropping schedule occur in the first 10-day period of April. It is necessary therefore to consider in greater detail the patterns of available river flows and irrigation requirements during this critical period. The situation is further complicated by the transfer system of pumping stations and canals linking Sg. Muda with Sg. Kereh, Jarak and Kulim and necessitating that the overall balance of requirement and available supply for the schemes fed from these rivers is considered in conjunction.

5.4.7 Average 10-day river flows with an 80% probability of exceedance have been assessed for Sg. Muda and Sg. Kulim as discussed in Chapter 2 for each 10-day period from February to May. For the other rivers, without gauged records, flows have been assessed by transposition from Sg. Kulim, as for the monthly periods.

5.4.8 Figure 5.5 indicates the arrangement of the Sg. Muda to Sg. Kulim transfer system and the schemes in Seberang Perai which are supplied wholly or in part from Sg. Muda. These comprise about 94% of the total area. Table 5.10 gives details of the irrigation requirements, river flows and transfer requirements through the critical two-month period for the 1-in-5-year case. As can be seen the available flow in Sg. Kulim, when the water supply abstractions are fully taken up, will be adequate for only about 25% of the Sg. Kulim scheme to be double cropped thus the balance of the water must be transferred from Sg. Jarak. However Sg. Jarak has enough water only for the Jarak and Jarak Tengah schemes and this flow must therefore come from Sg. Muda via Sg. Kereh. The original design of the transfer system apparently allowed for a 25% loss of water down Sg. Kereh at times of peak discharge. In fact, however, Sg. Kereh has a sizeable catchment of its own at the headworks from where the flow is abstracted for transfer to Sg. Jarak and an estimated 1-in-5-year minimum monthly flow of $0.50 \text{ m}^3/\text{s}$. Unless there is considerable seepage loss into the underlying sandy aquifer, it appears more likely that there may be a net gain in flow. It is hoped that this can be checked during a forthcoming pumping test. However we have assumed, for estimation of the flows to be transferred from Sg. Muda, no gain or loss of flow down Sg. Kereh. (It should be noted

that the individual scheme water requirements in Table 5.10 assume that all the schemes are operated together as part of a 3-schedule system. The requirements shown have been calculated using the average requirements for a 3-schedule system - actual peak requirements for individual schemes are listed in Table 5.5).

5.4.9

The peak total requirement from Sg. Muda for all the Seberang Perai schemes is $20.2 \text{ m}^3/\text{s}$ and occurs during the first period of April when the available flow may be only $9.8 \text{ m}^3/\text{s}$ - i.e. a deficit of $10.4 \text{ m}^3/\text{s}$. However there are substantial deficits in the 1-in-5-year available flow for most of March and April, the peak deficit of $11.4 \text{ m}^3/\text{s}$ occurring in mid-March.

5.4.10

In an average year the transfer requirement is greatly reduced as irrigation requirements are less and available flows in each river greater. Only during the first period of April are flows in Sg. Kulim inadequate for Sg. Kulim scheme and flows need be pumped from Sg. Kereh to supply only the area of Jarak scheme between Sg. Kereh and Sg. Jarak. Moreover flows in Sg. Kereh itself are probably adequate for all the schemes abstracting from this river. Pinang Tunggal P.S is required therefore to pump only for direct supply to Pinang Tunggal scheme and to Pokok Jeneris which abstracts from Sg. Korok.

5.4.11

The water requirements for the Group D small schemes in the Central and Southern Districts are compared to the available flows in Table 5.11. With the exceptions of Alma and Sg. Duri the schemes are all on tributaries of Sg. Junjong and the available flow for Kampong Tasek must take into account the irrigation abstractions upstream. For the larger schemes requirements have been indicated for each of the two combinations of a 2-schedule system. Generally the earlier scheduling (Schedule I plus II) is the more critical case as peak irrigation demands coincide with minimum river flows in mid-March. For the small schemes with only one schedule again the earliest schedule (I) is the most critical. If adequate flow is available for the first schedule then there will be adequate for either of the other recommended ones.

5.4.12 Water requirements for the Juru scheme, assuming a 3-schedule operation, are compared in Table 5.12 with the available flows estimated in the present source of Sg. Junjong Mati. The catchment of this river/drain is part of the Bukit Tambun drainage area and because of the interconnecting system of drains it is difficult to be precise about the present catchment area. However even with new control structures to divert as much as possible of these drainage flows to the intake pumping station there would appear to be adequate water for only about 120 ha of double cropping out of a total of 244 ha.

5.5 Water shortages

Groups A, B and C schemes

5.5.1 Because their water requirements and resources are integrated by the transfer system, the schemes abstracting partly or wholly from Sg. Muda have been considered altogether with regard to the availability of water. In the average year there is adequate water in Sg. Kulim, Sg. Jarak and Sg. Kereh for there to be no need for water to be transferred from Sg. Muda for the schemes so connected, i.e. Sg. Kulim, Sg. Jarak, Jarak Tengah, Tasek Gelugor, Pokok Jeneris, Kubang Menderong and Kg. Tasek, and there is ample available flow in Sg. Muda for the two schemes abstracting directly - Sg. Muda and Pinang Tunggal. In the 1-in-5-year case there is adequate available total flow in the three rivers to meet total demands during the ten months from May to February although for part of this time water would need to be transferred from Sg. Muda. Thus there are no supply restrictions on the main crop on any of these schemes. However during March and April shortages will occur.

5.5.2 Because during these two months minimum river flows and peak water demands occur, the exact pattern of available flow and total water requirements are of crucial importance. Table 5.10 gives a detailed breakdown of the scheme requirements and available river flows for each 10-day period in a 1-in-5-year case, assuming that all other water users are abstracting their full requirements. For the proposed cropping programme there will be a period through most of March and the first part of April when there is a total deficit of

up to about $12 \text{ m}^3/\text{s}$. This represents over 60% of the corresponding total requirement of the schemes in Penang State. However in this case there are factors which suggest that the problem is not as serious as it appears.

5.5.3 The shortage occurs during the field pre-saturation period at the beginning of the crop season - not during the growing season when a shortage could lead to total crop failure. One simple solution is therefore to delay the cropping schedule. The consequence would be to delay the harvesting into the rainy season of September with a corresponding risk of reduction of yield and increased cost of harvesting and drying of grain. The delay in the off-season programme would have some effect on the following main season crop but there is considerable flexibility in the annual programme and a delay of say one month could be made up within the year. Obviously the introduction of shorter period rice varieties would further improve the situation. The important point with delaying the programme however is that, once an area is supplied with water and the nurseries have been planted, supply must be continued. It is necessary therefore river flows and catchment rainfall be closely monitored in order that decisions on starting irrigation to each area can be made with reasonable confidence. Since the catchments and, for Sg. Muda, the river gauging stations are all in Kedah, this could only be done effectively by an overall river basin authority, or other control system. At present during low flow periods distribution is largely a matter of upstream users having priority.

5.5.4 In view of this we do not consider that any of the schemes that make use of water from Sg. Muda need be restricted in terms of crop type or designed cropping area.

Group D schemes

5.5.5 These are the small schemes in the Central and Southern Districts and except for Kuala Tasek, which abstracts from Sg. Junjong downstream of Machang Bubok, Renjau and Tasek Junjong, they all have supplies independent of each other. In all cases there is adequate water for the main season crop, however in several cases the maximum requirement

exceeds the minimum available supply. We have therefore considered the patterns of demand and available flow for each scheme in detail for the critical months of March and April. These are given in Table 5.11.

5.5.6 Generally there appears to be adequate water to support double cropping on the 1-in-5-year criterion for most schemes and where there are occasional minor deficits these can be alleviated by delaying the crop schedule as discussed in Section 5.5.3. However in two cases serious shortages appear likely.

5.5.7 With the proposed cropping programme Tasek Junjong has enough water for only about 50% double cropping. At present however two crops are achieved through most of the area and no serious water shortages are reported. It appears likely therefore that the present cropping programme is either very delayed or spread over a much longer stagger, thus reducing peak demands. In view of this it may be unwise to try to impose a rigid adherence to the cropping programme proposed generally, as enforced delays are likely fairly regularly. In this case a delay to the programme until the beginning of April is probably necessary even though harvesting will extend into September. Alternatively a dry season crop such as maize could be grown.

5.5.8 According to the figures in Table 5.11, Alma is likely to suffer from some water shortages although not to the extent that a delay to the programme would not help. However the available flows are calculated on the premise that the catchment is unaffected by urban development, whereas the approved extension to Bukit Mertajam actually covers about 50% of the catchment. The effect of urbanisation on a catchment is difficult to assess accurately but will certainly increase peak runoff rates and greatly reduce dry weather low flows. In the extreme case the 1-in-5-year low flows during the dry season could be reduced to almost zero from an urbanised catchment. In this case the figures given in Table 5.11 would be reduced to about half. In addition runoff from several of the small tributary streams at the head of the catchment are diverted for water supply thus reducing the quoted values even more. Thus the Alma scheme is likely to face increasing and very severe water

shortages to an extent at which double cropping would not be possible unless alternative sources can be found. Here also a dry season crop of maize may be practicable. The only other alternative appears to be ground water.

Groundwater

5.5.9 Some groundwater potential is considered to exist in Seberang Perai, with possible total aquifer yields of about $30 \times 10^6 \text{ m}^3$ per year (Section 2.3.12). This is of the order of the total 1-in-5-year deficit of all irrigation supplies, but the latter occurs over a period of only about one month. In view of our comments on the extent of and timing of water shortages in the principal scheme groups (5.5.1 and 5.5.4) we do not consider that ground water need be investigated as a possible alternative supplementary source for these large areas (13,000 ha approx.) In the case of Group D schemes (less than 600 ha total) such as Alma the difficulties caused by industrial pollution of sources, increase in urbanised proportion of the catchment area and other factors may well justify consideration of supplementary ground water supply. The issue to be decided is whether such relatively expensive investment is justified for small irrigation areas whose land is sought after for urban use.

Juru scheme

5.5.10 Discussion of alternative cropping patterns and water sources for Juru will be left until after the results of the socio-economic survey presently being carried out in the area.

Table 5.1 Rice: Crop Factors

'125-day' varieties			'140-day' varieties		
10-day period after transplanting		k_c	10-day period after transplanting		k_c
1	Transplanting	1.25	1	Transplanting	1.25
2	Vegetative growth	1.25	2	Vegetative growth	1.25
3		1.29	3		1.28
4		1.36	4		1.32
5	Reproduction	1.40	5	Reproduction	1.38
6		1.35	6		1.39
7	Heading	1.27	7	Reproduction	1.33
8		1.19	8		1.26
9	Ripening	0	9	Heading	1.18
10	Irrig. discontinued Harvesting	0	10	Irrig. discontinued	1.1/0
			11	Ripening	0
			12	Harvesting	0

DOUBLE CROPPING OF RICE
1-IN-5 YEAR WATER REQUIREMENTS
TABLE 5.2

MONTH		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NOTES
10-DAY PERIOD		1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36	
1	Open-water evaporation (E_o) mm/d	51	55	57	56	49	49	47	47	47	45	45	44	(5.214)
2	Gross evapotranspiration (ET_o) mm/d	41	43	45	44	39	39	38	38	38	36	36	35	
3	Rainfall (adjusted 10-day) mm/d		152 032	051 102 432	330 229 305	432 607 178	203 650 610	178 178 508	305 363 813	914 610 483	508 1016 1064	762 610 406	457 254 203	
IRRIGATION BLOCK I														Weighted coeffs. (5.210)
4	Crop-coefficients (k_c) mm/d				125	125 125 127	131 136 137			125	125 125 127	136 131 124	108 077	
5	Presaturation requirement mm/d			174 174					140 140					
6	Water layer mm/d				136 34 25	06				13 34 25	06			From Figure 5.2
7	Percolation loss mm/d				20 20 20 20	20 20 20	20 20 13	03		20 20 20	20 20 20	20 20 20	19 07	
8	Consumptive use ($k_c ET_o$) mm/d				57 56 56 56	51 53 53	51 49 32	07		47 47 47 48	46 48 49	49 47 45	38 27	
9	TOTAL FIELD WATER REQ. mm/d			174 174 77	89 110 101	77 73 73	71 69 45	10	140 140 67	80 101 93	69 68 69	69 67 65	57 34	Detailed analyses not shown
10	Effective rainfall mm/d			04 076 28	19 14 18	26 30 09	10 33 30	09	23 27 49	55 37 29	27 51 53	38 30 20	21 05	
11	NET FIELD IRRIGATION REQ. mm/d			170 166 49	70 96 83	51 43 64	61 36 15	01	117 113 18	25 64 64	42 17 16	31 37 45	36 29	
12	BLOCK II: NET FIELD IRRIGATION REQ. mm/d	06												Assuming equal size irrigation blocks
13	BLOCK III: NET FIELD IRRIGATION REQ. mm/d	55 3.6		166 142	104 65 83	78 47 63	63 40 39	52 13	56 79	42 36 63	69 18 07	28 36 48	42 49 34	
14	AVERAGE FIELD IRRIG REQ. mm/d	19 1.2			153 160 58	56 67 86	64 40 42	61 59 19	-04	72 94 38	48 38 27	27 38 49	45 53 53	
15	INTAKE REQUIREMENT mm/d	28 1.8		57 83 64	109 107 75	62 52 71	63 39 32	38 24 06	38 56 32	46 65 55	53 24 17	29 37 47	41 44 29	68% Distribution efficiency
				85 123 96	163 160 112	93 78 106	94 58 48	57 36 09	57 84 48	69 97 82	79 36 25	43 55 70	61 66 43	
		0.32 0.21		0.98 142 11	189 185 130	11 090 12	11 067 055	066 042 010	066 037 055	080 11 095	091 042 029	050 063 081	071 076 050	

Table 5.3 Average Rice Irrigation Requirements

Month	Average monthly requirements			Total monthly requirement (m ³ /ha)
	Field (mm/d)	Intake (mm/d)	(L/s/ha)	
January	1.00	1.67	0.19	509
February	-	-	-	-
March	5.20	8.67	1.00	2,678
April	7.43	12.38	1.43	3,707
May	4.30	7.17	0.83	2,223
June	3.56	5.93	0.69	1,788
July	1.57	2.62	0.30	804
August	3.00	5.00	0.58	1,553
September	3.06	5.11	0.59	1,529
October	1.40	2.33	0.27	723
November	2.87	4.78	0.55	1,425
December	3.23	5.39	0.62	1,660
Total				18,599 m ³ /ha

Table 5.4 : Scheme Areas

1. Sg. Muda

Existing gross area:-	7,125 ha	
(incl. 75 ha outside main flood bund)		
Area estimated lost to N/S expressway:	75 ha	
Area estimated lost to urban development:	<u>100 ha</u>	
Gross area assumed for project	<u>6,950 ha</u>	(17,165 ac)

2. Pinang Tunggal

Existing gross irrigated area under JPT control (incl. 160 ha outside main bund)	1,366 ha	
Area estimated lost to N/S expressway	<u>16 ha</u>	
	1,350 ha	
(includes approx. 135 ha presently planted with vegetables)		
Kg. Tasek gross area	106 ha	
(includes approx. 65 ha presently planted with vegetables)		
Pokok Jeneris gross area	90 ha	
Kubang Menderong	<u>39 ha</u>	
Gross area assumed for project (incl approx. 200 ha presently planted with vegetables)	<u>1,585 ha</u>	(3,915 ac)
In addition water required for MAARDI research station & Min of Agriculture station:	<u>118 ha</u>	

3. Jarak

Existing gross area, approx.	790 ha	
(This includes part of area north of main canal and south of Tasek Gelugor town. This will be fed entirely from Ayer Melintas P.S in Tasek Gelugor scheme.)		
Gross area assumed for project	<u>778 ha</u>	(1,900 ac)

4. Tasek Gelugor

Existing gross area approx.	250 ha	
(See note for Jarak scheme)		
Gross area assumed for project	<u>262 ha</u>	(647 ac)
n.b. Area supplied from Tok Bedu P.S: 70 ha		
Area supplied from Ayer Melintas P.S: 192 ha		

5. Sg. Kulim

Existing gross area	3,664 ha	
Areas estimated lost to expansion of Perai/ Bukit Mertajam urban area	175 ha	
Area lost to N/S expressway:	25 ha	
Area lost to E/W highway:	35 ha	
Areas lost to other minor urban encroachments:	<u>60 ha</u>	
Gross area assumed for project	<u>3,369 ha</u>	(8,320 ac)

6. Alma

Existing gross area	99 ha	
Area estimated lost to expansion of Bukit Mertajam urban area	<u>17 ha</u>	
Gross area assumed for project	<u>82 ha</u>	(203 ac)

There are no clear indications that there be changes to the areas of the remaining small schemes. Although minor changes to land use may occur, for this project the areas are assumed as presently measured:-

7. <u>Jarak Tengah</u>	98 ha	(242 ac)
8. <u>Juru</u>	244 ha	(603 ac)
9. <u>Machang Bubok</u>	136 ha	(336 ac)
10. <u>Renjau</u>	20 ha	(50 ac)
11. <u>Kuala Tasek</u>	24 ha	(59 ac)
12. <u>Tasek Junjong</u>	167 ha	(412 ac)
13. <u>Kg. Kepala Gajah</u>	66 ha	(163 ac)
14. <u>Sg. Duri</u>	20 ha	(50 ac)

Table 5.5 Scheme Intake Requirements

Scheme	Gross Area (ha)	Assumed distribution efficiency (%)	Assumed irrigation schedules	Peak intake ⁽¹⁾ requirement (L/s/ha) (m ³ /s)	
Sg. Muda	6,950	68	3	1.89	12.4
Pinang Tunggal					
rice:	1,333 ⁽²⁾	68	3	1.89	
veg.:	135	68	-	1.11	2.54
Kg. Tasek	106 ⁽³⁾	75	2	2.00	0.20
Pokok Jeneris	90	75	2	2.00	0.17
Kubang Menderong	39	80	1	2.46	0.09
Jarak	769	68	3	1.89	1.38
Tasek Gelugor					
Ayer Melintas:	192	75	2	2.00	0.36
Tok Bedu :	70	75	2	2.00	0.13
Jarak Tengah	98	75	2	2.00	0.19
Sg. Kulim	3,369	68	3	1.89	6.05
Juru	244	68	3	1.89	0.44
Macang Bubok	136	75	2	2.00	0.26
Renjau	20	80	1	2.46	0.05
Kuala Tasek	24	80	1	2.46	0.06
Tasek Junjong	167	75	2	2.00	0.32
Kepala Gajah	66	75	2	2.00	0.13
Alma	82	75	2	2.00	0.16
Sg. Duri	20	80	1	2.46	0.05

- Notes: (1) Peak intake requirements assume equal sized irrigation blocks. Detailed operational considerations may indicate the need for unequal sized blocks in which case the peak intake requirements will be slightly altered from those given.
- (2) Includes area of MARDI and Ministry of Agriculture stations.
- (3) Scheme should be designed for 200% rice cultivation.

Table 5.6 Development of Surface Sources for Potable Water Supply

Catchment	1980		1990		2000	
	(m.g.d.)	(m ³ /s)	(m.g.d.)	(m ³ /s)	(m.g.d.)	(m ³ /s)
Sungai Muda						
Naok Treatment Plant ⁽²⁾	-	-	(6)	(0.31)	(6)	(0.31)
Pendang T.P. ⁽²⁾	-	-	(6)	(0.31)	(12)	(0.61)
Teloi Kanan T.P.	1.5	0.08	1.5	0.08	3	0.16
Pinang Tunggal T.P.	4.5	0.24	15	0.79	20	1.05
Baling T.P.	0.3	0.02	2.0 ⁽³⁾	0.10	2	0.12
Lahar Tiang Intake (PBA)	30 ⁽⁴⁾	1.57	30 ⁽⁴⁾	1.57	30 ⁽⁴⁾	1.57
Totals	36.3	1.91	48.5	2.54	55	2.90
Sungai Kulim						
Kulim T.P.	-	-	7.5	0.39	10	0.52
Bukit Toh Allang T.P (PBA)	10	0.52	10 ⁽⁵⁾	0.52	10 ⁽⁵⁾	0.52
Totals	10	0.52	17.5	0.91	20	1.04

- Notes:
- (1) Information from ref. 15 and JKR (Kedah) for abstractions within Kedah State. Information from PBA for abstractions within Penang State.
 - (2) Naok and Pendang treatment plants will abstract from Naok and Reman reservoirs respectively. These abstractions do not therefore affect low river flows and are not included in the totals.
 - (3) Value increased from 1.3 m.g.d. in ref. 15 after discussion with JKR (Kedah).
 - (4) 30 m.g.d. represents priority abstraction. Actual abstractions may increase to 60 m.g.d. in 1980 and 109 m.g.d. in 1990 if flows available.
 - (5) 10 m.g.d. represents priority abstraction. Actual abstractions may increase to 70 m.g.d. if flow available when the storage reservoir at Mengkuang is fully developed.

Table 5.7 JPT Operated Irrigation Schemes in Kedah, Within Catchment of Sg. Muda

Scheme	Area (ha)	Daerah	Return flows to Sg. Muda (ha)
Pinang Tunggal	280	Kuala Muda	
Sidam Kiri	264 (219)	"	
Pekula	1,825 (1,781)	"	-
Kota II (Bukit Meriam)	1,460	"	-
Pantai Perai	260	"	260
Bukit Kecil/Telok Wang	405	"	-
Kg. Lubok Kiab	53	"	53
Kg. Kemumbong	69	"	69
	4,616		382
Terat Batu	28 (26)	Kulim	28
Sidam Kanan	469 (453)	"	469
Merbau Pulas	95	"	95
Selarong Panjang	40	"	40
Titi Karangan	290	"	290
Kg. Padang Meha/Pagar Museh	150	"	150
Kg. Lobak	28	"	28
Kg. Matang Durian	80	"	80
	1,180		1,180
Pulai	207 (240)	Baling	207
Kg. Iboi	155 (186)	"	155
Kg. Tawar	38 (40)	"	38
Simpang Empat	28 (28)	"	28
Ulu Bakai	70 (75)	"	70
Kg. Luar	182 (97)	"	182
Ulu Sidim (Siputeh)	114 (80)	"	114
Kg. Badang	71 (75)	"	71
Kg. Landok	40	"	40
Kg. Mempelam	70	"	70
Tanjung Pari	100	"	100
Sg. Tiak	110	"	110
Kg. Banggol Berengam	80	"	80
Kg. Tembak	120	"	120
Sg. Limau/Carok Bemban	77	"	77
Kg. Selarong	95	"	95
Kg. Guar Cempedak/Badak	135	"	135
Pantai Cicak	36	"	36
	1,728		1,728
Tanjung Sik	88 (91)	Sik	88
Kg. Parit	114 (192)	"	114
Tanjung Besar	175	"	175
Sg. Teloi	60	"	60
Padang Cicak	70	"	70
	507		507
Totals	8,031 ha		3,797 ha

Notes:

- (1) Areas according to JPT (Kedah) except where two values are given. For those schemes there are inconsistencies between the areas quoted by JPT (in brackets) and the areas given in the Draft Final Report of the "Study on the Intensification of Irrigated Agriculture in Kedah and Perlis" (reference 18). As these latter are presumed to have been checked as part of that study they are adopted.
- (2) Schemes are all existing schemes but may be presently under JPT operation or in process of being improved and taken over or planned to be so.

Table 5.8 Summary of JPT Operated Irrigation Schemes in Kedah State

Catchment	Area (ha)	Percentage of area providing return flows to Sungai Muda
<u>Sungai Muda</u> ⁽¹⁾		
Kuala Muda District	4,616	8.2 %
Sik District	507	100 %
Baling District	1,728	100 %
Kulim District	1,180	100 %
Totals	8,031	47 %
<u>Sungai Jarak</u>	120 ⁽²⁾	- ⁽³⁾
<u>Sungai Kulim</u>	280	- ⁽³⁾

- Notes:
- (1) Abstractions for Muda scheme from Muda dam are assessed separately by a reduction in the effective catchment, see Section 5.3.8.
 - (2) Gross area of JPT scheme - Otak Kerbau - is about 180 ha. Ref. 18 considers adequate water for 67% of area only proposes change of crop to suit.
 - (3) Return flows discounted - see Section 5.4.5.
 - (4) Information from JPT (Kedah) and from ref. 18. Where slight discrepancies exist in the areas quoted by the two sources, the latter have been accepted as more recently checked.
 - (5) Schemes included are those presently operated or being uprated by JPT and those planned for uprating in the future.

Table 5.9 'Rainfed' Irrigation Schemes in Kedah State

Catchment	Area (ha)	Percentage of area providing return flows to Sungai Muda (1)
<u>Sungai Muda</u>		
Kuala Muda District	1,552	8.2 %
Sik District	2,173	100 %
Baling District	5,622	100 %
Kulim District	433	100 %
Totals	9,780	85 %
<u>Sungai Jarak</u>	64	-
<u>Sungai Kulim</u>	102	-

Notes: (1) Percentages assumed same as for JPT schemes.

(2) Information from JPT (Kedah). Areas in Kuala Muda and Kulim District (including the Sungai Jarak and Sungai Kulim) are taken as proportional to the JPT operated areas.

Table 5.10 Transfer Scheme: Peak 1-in-5-Year Flows

10-day period	March			April		
	1	2	3	1	2	3
	(m ³ /s)			(m ³ /s)		
1. Sg. Kulim scheme requirement	2.9	4.4	4.1	6.0	5.6	4.2
2. Available flow in Sg. Kulim	1.2	0.8	1.4	1.6	1.7	2.4
3. Flow to be transferred from Sg. Jarak	1.7	3.6	2.7	4.4	3.9	1.8
4. Jarak schemes(s) requirement	0.3	0.5	0.4	0.6	0.6	0.4
5. Available flow in Sg. Jarak (allowing for Jarak Tengah scheme)	1.3	1.1	1.3	1.5	1.6	2.1
6. Flow to be transferred from Sg. Kereh	0.7	3.0	1.8	3.5	2.9	0.3
7. Jarak scheme (N) requirement	0.4	0.6	0.5	0.8	0.7	0.5
8. Total requirement from Sg. Kereh (via Kereh P.S)	1.1	3.6	2.3	4.3	3.6	0.8
9. Tasek Gelugor scheme requirement	0.2	0.4	0.3	0.5	0.5	0.3
10. Pokok Jeneris etc. requirements	0.2	0.3	0.3	0.4	0.4	0.3
11. Pinang Tunggal scheme requirement	1.4	2.1	1.9	2.6	2.5	1.8
12. Total intake requirement (1) (Pinang Tunggal P.S)	2.9	6.4	4.8	7.8	7.0	3.2
13. Sg. Muda scheme requirement (Bumbong Lima P.S)	6.3	9.5	8.9	12.4	12.2	9.0
14. Available flows in Sg. Muda	9.5	4.5	12.2	9.8	20.5	29.7
15. Surplus/Deficit in Sg. Muda	+0.3	-11.4	-1.5	-10.4	+1.3	+17.5

Note: (1) Available natural flow from Sg. Kereh assumed zero.

(2) Scheme crop scheduling and requirements assumed to be arranged such that there are 3 equal sized irrigation blocks for combined total of schemes.

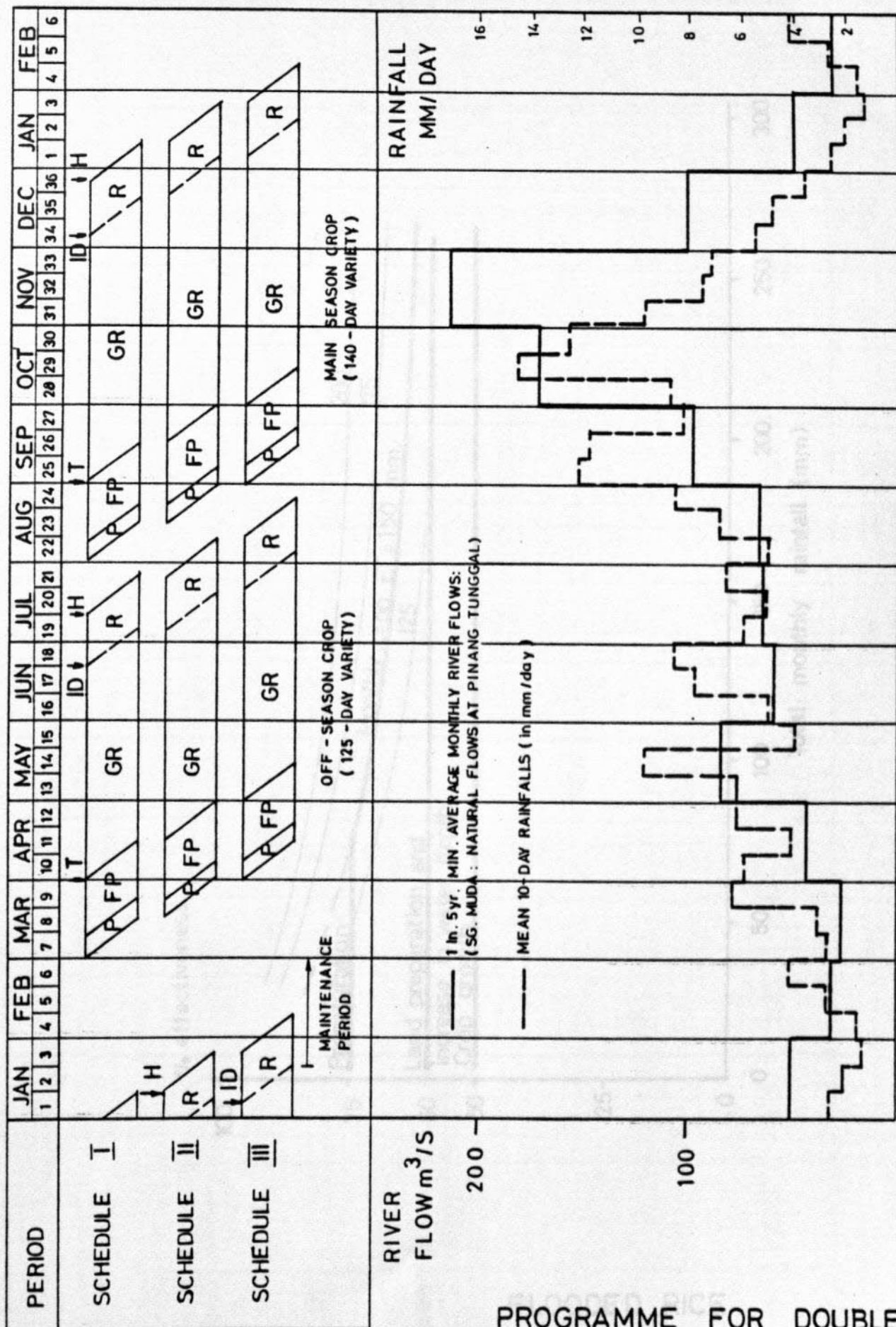
Table 5.11 Water Requirements and Availability for Group D Schemes

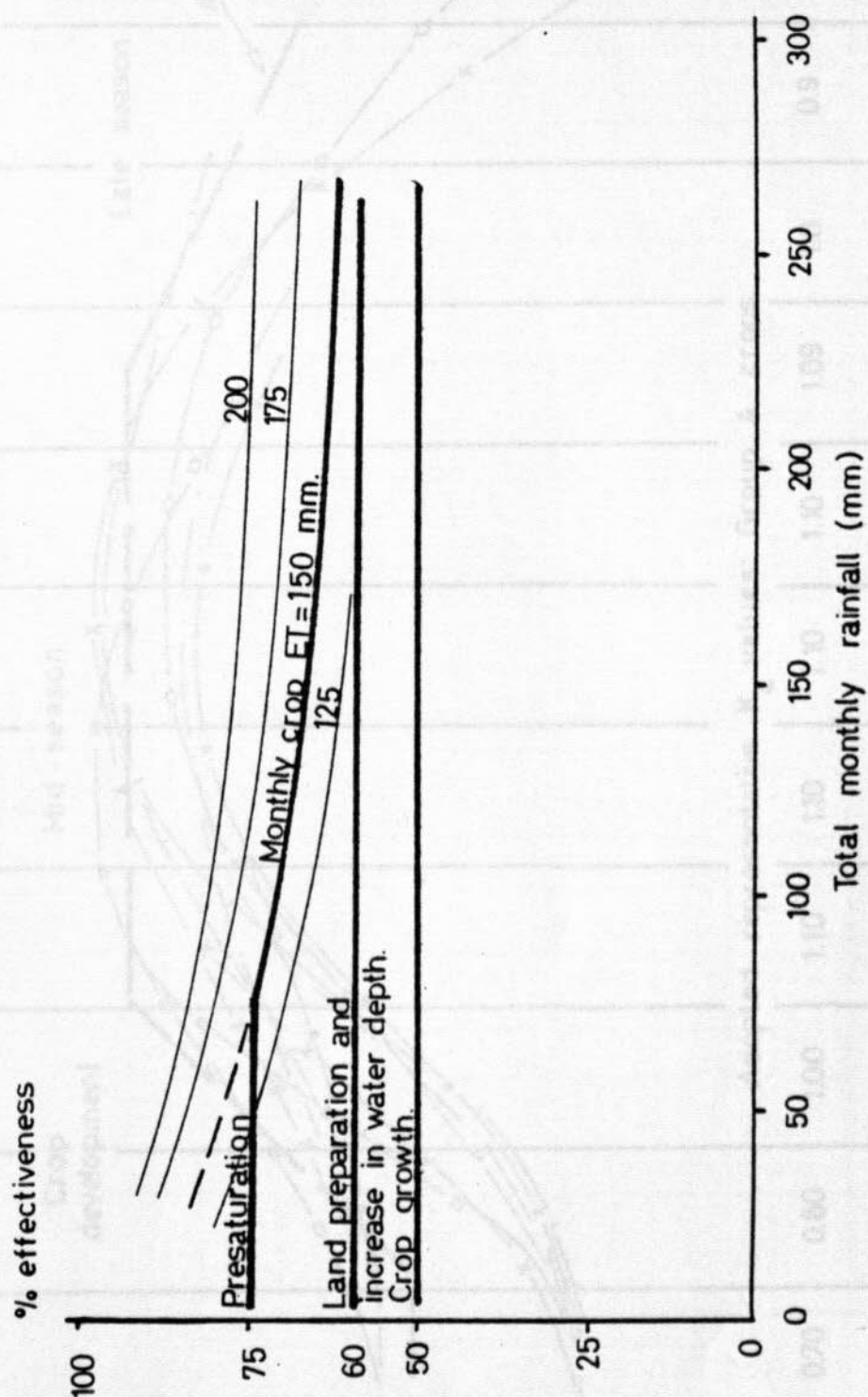
	March			April			May		
	1	2	3	1	2	3	1	2	3
Alma (82 ha gross)									
Available flow in Kelang Ubi (1)									
Total requirement : I + II	0.09	0.08	0.09	0.11	0.11	0.13	0.14	0.15	0.12
" : II + III	0.10	0.15	0.12	0.10	0.10	0.10	0.08	0.05	0.08
" : II + III	-	0.05	0.09	0.16	0.14	0.09	0.09	0.07	0.09
Machang Bubok (136 ha)									
Available flow in Sg. M. Bubok	0.21	0.18	0.22	0.26	0.26	0.31	0.34	0.37	0.30
Total requirement : I + II	0.17	0.25	0.19	0.17	0.16	0.17	0.13	0.09	0.13
" : II + III	-	0.08	0.14	0.26	0.22	0.14	0.14	0.11	0.15
Tasek Junjong (167 ha)									
Available flow in Sg. T. Tanjong	0.14	0.13	0.14	0.18	0.18	0.21	0.23	0.25	0.20
Total requirement : I + II	0.21	0.31	0.23	0.21	0.20	0.20	0.16	0.11	0.16
" : II + III	-	0.10	0.17	0.32	0.28	0.17	0.18	0.14	0.18
Kg. Kepala Gajah (66 ha)									
Available flow in Sg. Chempedak	0.18	0.17	0.19	0.24	0.24	0.29	0.32	0.34	0.27
Total requirement : I + II	0.08	0.12	0.09	0.08	0.08	0.08	0.06	0.04	0.06
" : II + III	-	0.04	0.07	0.13	0.11	0.07	0.07	0.06	0.07
Renjau (20 ha)									
Available flow in Sg. Perangin	0.08	0.07	0.08	0.10	0.10	0.12	0.14	0.14	0.11
Total requirement : I	0.05	0.05	0.01	0.02	0.03	0.02	0.01	0.01	0.02
Kg. Tasek (24 ha)									
Nat. river flow in Sg. Junjong	1.02	0.93	1.06	1.28	1.28	1.55	1.72	1.81	1.46
u/s irrig. abstraction (2)	0.39	0.44	0.41	0.52	0.48	0.39	0.34	0.27	0.35
Available flow (3)	0.50	0.39	0.52	0.61	0.64	0.93	1.10	1.23	0.89
Total requirement : I	0.06	0.05	0.02	0.02	0.03	0.03	0.02	0.01	0.02
Sg. Duri (20 ha)									
Available flow in Sg. Duri	0.04	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.06
Total requirement : I	0.05	0.05	0.01	0.02	0.03	0.02	0.01	0.01	0.02
" : II	-	0.02	0.04	0.03	0.02	0.02	0.02	0.01	0.02

- Notes: (a) I, II and III refer to irrigation schedules starting at the beginning of March, middle of March and beginning of April respectively - see Figure 5.1 and Table 5.2.
- (b) Available flows taken as 80% of river flows, to allow for minor u/s abstractions and d/s compensation requirements.
- (c) Underlined figures indicate requirement exceeds available supply.
- (1) Assumes no urban development in catchment.
- (2) Upstream abstractions for Machang Bubok, Tasek Junjong and Renjau taken as maximum calculated requirement or total flow from source river whichever is less.
- (3) See note (b).

Table 5.12Juru Scheme: 1-in-5-year Irrigation Requirements
and available flows

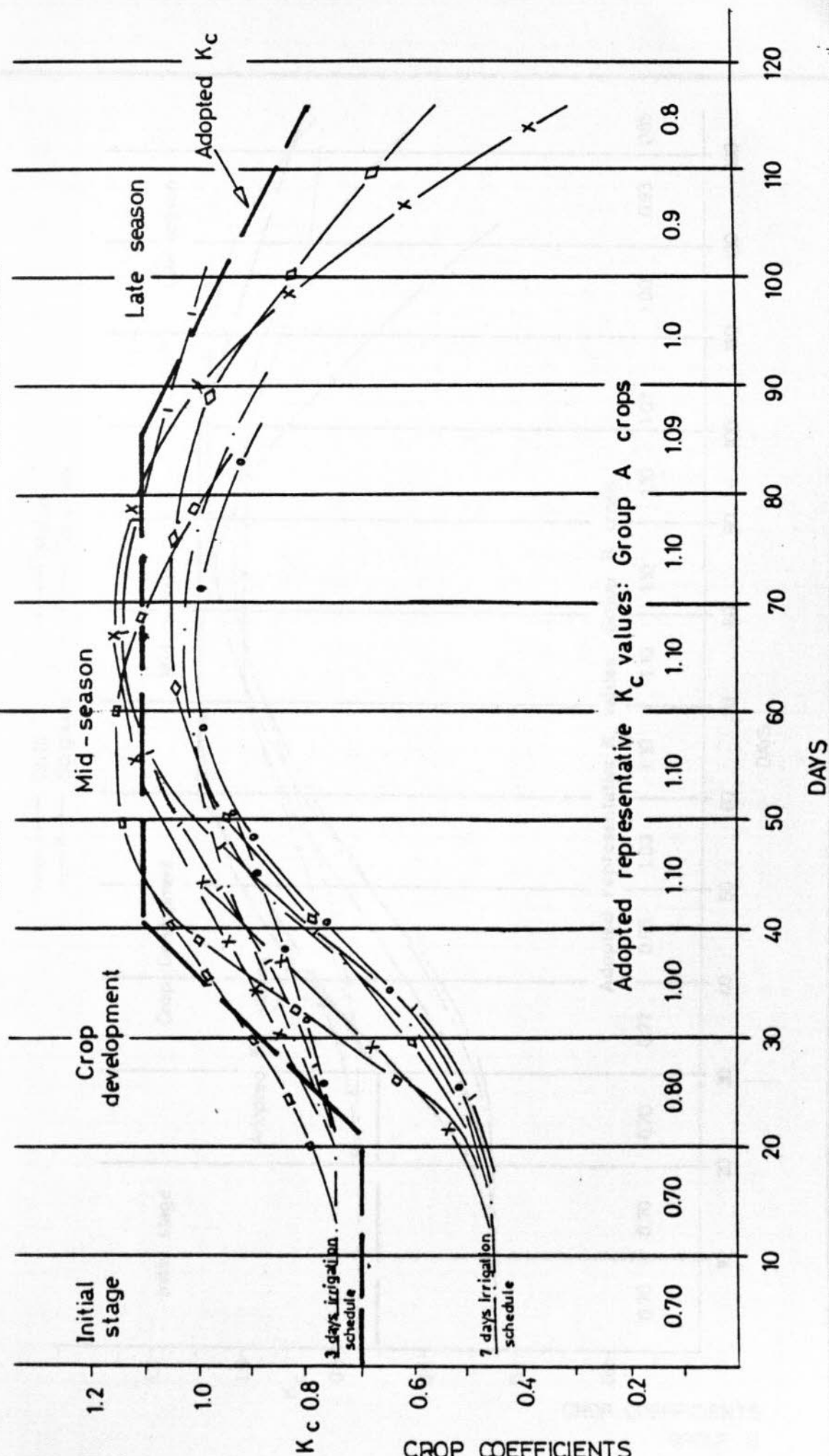
Period	Av. Irrig. Req. for whole scheme (3 schedules) (m ³ /s)	Available flow (m ³ /s)	Possible area of rice (% of total scheme area)
January	0.04	0.27	100
February	-	0.22	100
March	1 0.24 2 0.35 3 0.27	0.19 0.17 0.19	79 49 (120 ha) 70
April	1 0.46 2 0.45 3 0.32	0.24 0.24 0.28	52 53 88
May	1 0.27 2 0.22 3 0.29	0.32 0.33 0.27	100 100 93
June	0.19	0.23	100
July	0.09	0.22	100
August	0.18	0.22	100
September	0.23	0.32	100
October	0.13	0.49	100
November	0.16	0.62	100
December	0.16	0.47	100



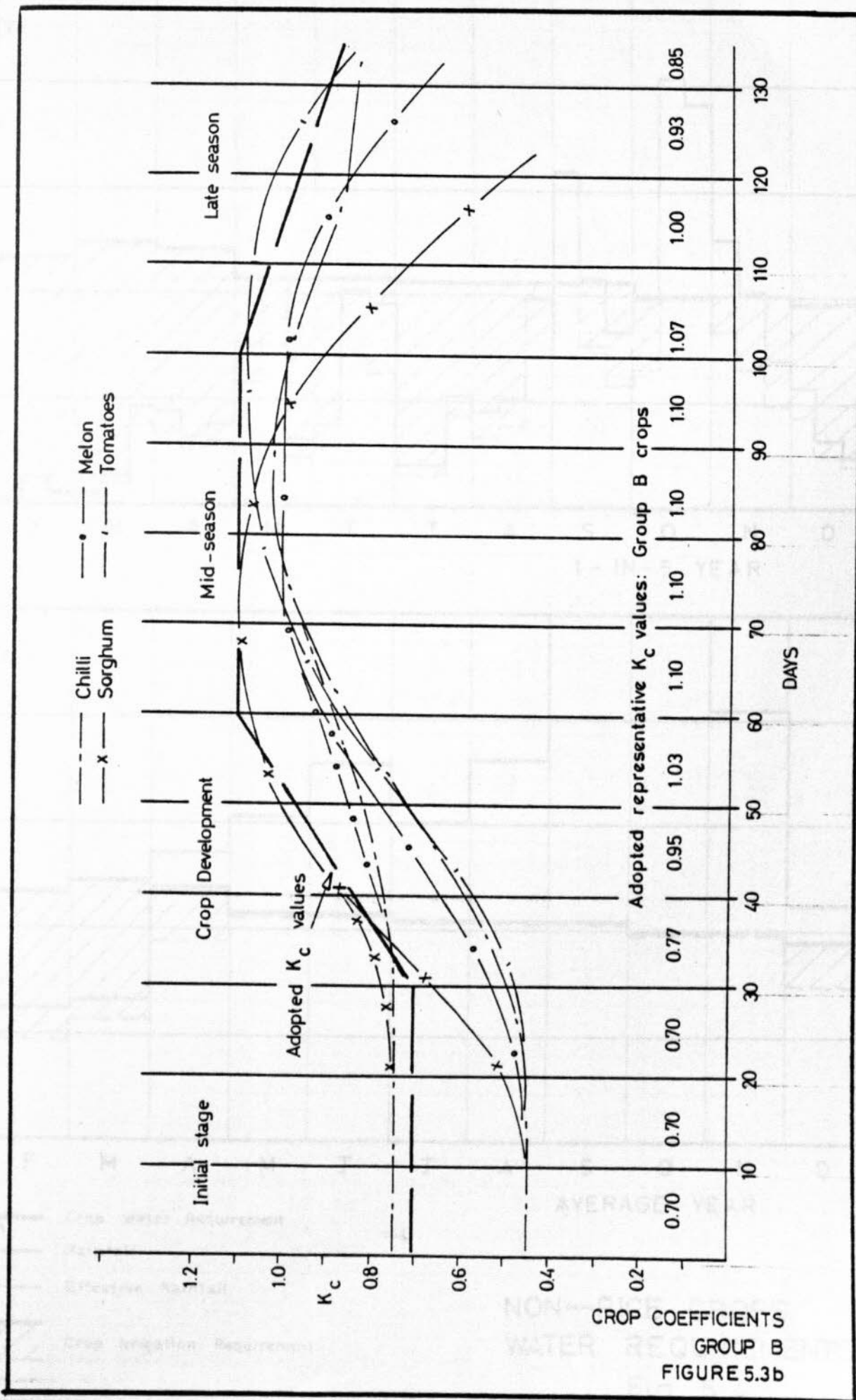


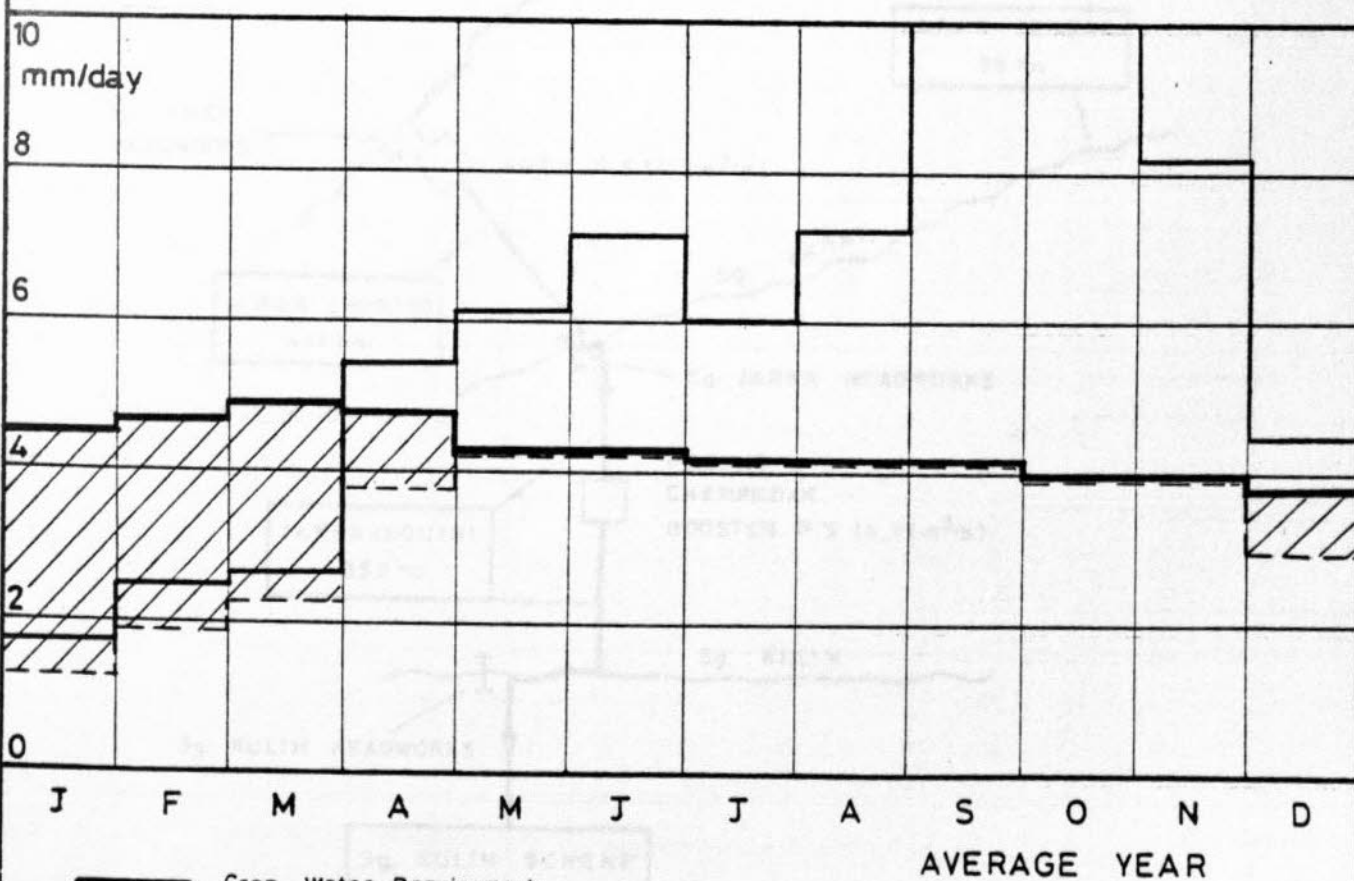
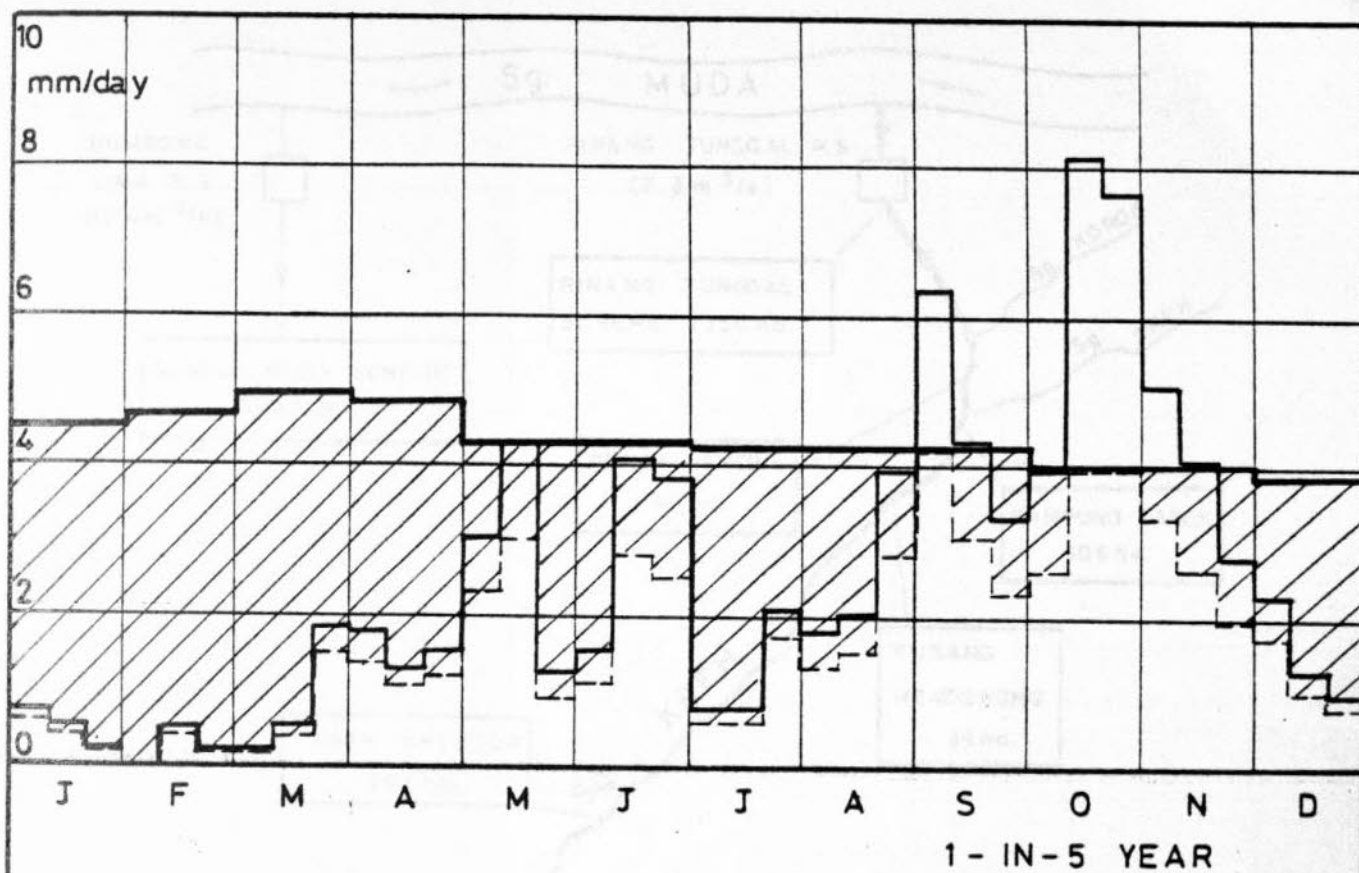
FLOODED RICE
CRITERIA FOR EFFECTIVE RAINFALL
FIGURE 5.2

- | | | | |
|-------|------------------|-------|----------------------|
| — | Beans / Cabbages | — | Peas |
| — x — | Lentils | — o — | Groundnuts |
| — • — | Lettuce | — p — | Maize (sweet - corn) |



CROP COEFFICIENTS
GROUP A
FIGURE 5.3a

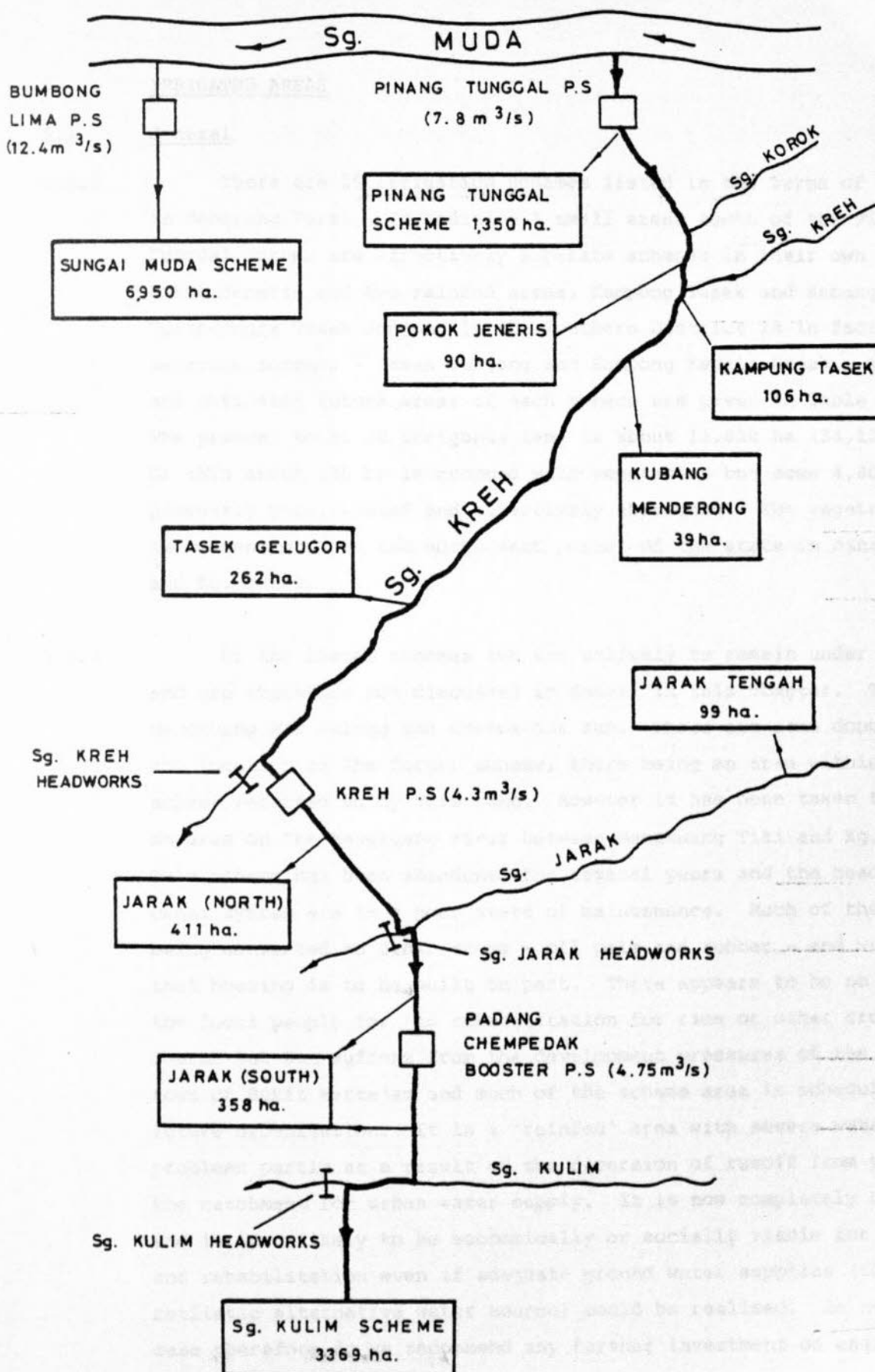




- Crop Water Requirement
- Rainfall
- - - Effective Rainfall
- /// Crop Irrigation Requirement

NON-RICE CROPS WATER REQUIREMENTS

Fig. 5.4



TRANSFER SYSTEM
AND SCHEMES ABSTRACTING FROM SUNGAI MUDA
FIGURE 5.5

6. IRRIGATED AREAS

6.1 General

6.1.1 There are 15 irrigation schemes listed in the Terms of Reference in Seberang Perai. In addition 3 small areas south of the Pinang Tunggal scheme are effectively separate schemes in their own right - Pokok Jeneris and two rainfed areas, Kampong Tasek and Kubang Menderong. Furthermore Tasek Junjong in the Southern District is in fact two separate schemes - Tasek Junjong and Kampong Kepala Gajah. The present and estimated future areas of each scheme are given in Table 5.4. The present total of irrigable land is about 13,820 ha (34,135 acres). Of this about 200 ha is cropped with vegetables but some 4,800 ha is presently uncultivated and effectively abandoned. The vegetable area is concentrated in the north east corner of the state in Pinang Tunggal and Kg. Tasek.

6.1.2 Of the listed schemes two are unlikely to remain under irrigation and are therefore not discussed in detail in this chapter. These are Mengkuang Mak Sulong and Cherok Tok Kun. There are some doubts as to the location of the former scheme, there being an area within the Kulim scheme referred to by this name. However it has been taken to refer to an area on the Mengkuang river between Mengkuang Titi and Kg. Mengkuang. This scheme has been abandoned for several years and the headworks and canal system are in a poor state of maintenance. Much of the area is being converted to other crops - oil palm and rubber - and we understand that housing is to be built on part. There appears to be no desire by the local people for its rehabilitation for rice or other crops. Cherok Tok Kun suffers from the development pressures of the expanding town of Bukit Mertajam and much of the scheme area is scheduled for future urbanisation. It is a 'rainfed' area with severe water shortage problems partly as a result of the diversion of runoff from part of the catchment for urban water supply. It is now completely uncultivated, and it is unlikely to be economically or socially viable for upgrading and rehabilitation even if adequate ground water supplies (the only realistic alternative water source) could be realised. In neither case therefore do we recommend any further investment on engineering infrastructure.

6.1.3 The remaining schemes have been separated into five groupings for study. These groupings have been chosen both for the geographical location and interrelation between the schemes, particularly with water control and management, and because of general similarities in the types of schemes and their problems. The groupings are:-

- A - Sg. Muda scheme.
- B - The schemes in the north east of the state - Pinang Tunggal, including Pokok Jeneris, Kampong Tasek and Kubang Menderong, Kuala Tasek, Jarak and Jarak Tengah.
- C - Sg. Kulim scheme.
- D - The small schemes in the Central and Southern Districts - Alma, Machang Bubok, Renjau, Tasek Junjong, Kg. Kepala Gajah, Kuala Tasek and Sg. Duri.
- E - Juru scheme.

Juru scheme will not be treated in the present report since the area has unusual difficulties and is the subject of a special socio-economic survey. This will be reported on later.

6.1.4 Common to virtually all the schemes is the lack of adequate tertiary and farm level facilities - supply canals, drains and access roads. A general discussion of these problems and proposals and criteria for improvement of the infrastructure is given in Chapter 8. Because of the universal nature of these needs they are not discussed in the following sections except to highlight particular problems. The recommendations of this chapter are thus primarily concerned with the headworks, the main and secondary distribution and drainage systems and access along these routes. The excellent state-wide road system provides, or will provide under approved JKR plans for the rural road programme, good primary access into all schemes. The lack of access is within the irrigation areas and this is discussed in Chapter 8.

6.1.5 Another aspect common to all schemes is the lack of quantitative flow-control devices - i.e. measurement control allowing flows to be set to a predetermined value. The need for good control of water is

stressed throughout this report particularly in view of the likelihood of water shortages one year in five. At such times the accurate, equitable and efficient distribution of water is vital. We propose therefore that a simple measurement facility is provided at every canal division - secondary offtakes, tertiary offtakes and tertiary division boxes for the quaternary offtake. The latter two are discussed in Chapter 8. At secondary and branch canal offtakes we propose constant head orifice (CHO) structures where new structures must be constructed. Where the existing simple gated offtakes are adequate a measurement weir or flume should be provided in the canal downstream.

6.2 Sg. Muda scheme (Group A)

6.2.1 The Sg. Muda scheme lies in the north west quadrant of Seberang Perai. The present irrigable area is about 7,125 ha of which about 1,500 ha are abandoned (tanah rang with two years of non-cultivation) or have been left uncultivated long enough to require rehabilitation. Taking into account the future construction of the North/South Expressway through part of the scheme and minor encroachments of urbanisation, we estimate the gross area of the scheme will be reduced to about 6,950 ha (Table 5.4).

6.2.2 Supply is entirely from the Sg. Muda via a single pumped intake at Bumbong Lima. River levels are controlled by tidal barrage downstream near Kg. Rantau Panjang and two pumping stations with combined capacity of $14 \text{ m}^3/\text{s}$ (500 cusecs - three No. 100 cusec and one No. 200 cusec electric pumps) raise the flow through a maximum total lift of 4.0 m into the main canal. The peak intake requirement for the scheme is estimated at $12.4 \text{ m}^3/\text{s}$ so the existing pumping capacity is adequate. No major problems of siltation of either the inlet channel nor the canal systems are reported.

6.2.3 Drawing No. 3 indicates the existing canal and drain layout and the major structures. The main canal runs due south for a distance of 12.3 km with secondary or branch canals A, B, C, D, E and F feeding areas to the west. At the southern end of the main canal further secondaries/branch canals supply the southern area. The canal passes under the three major drainage channels from the Pinang Tunggal scheme

and Bertam and Malakoff estates - Sg. Tembus, Sg. Lahar Endin and Pt. Loga - which bear west or south-westwards, by inverted syphon structures. Many areas are reported to have command difficulties (Drawing No. 2) and study of the available, fairly coarse-grid survey of the irrigation area suggests that the design FSLs of the main canal should be at least 0.25 m higher over most of the canal to enable adequate command of all areas. (The canal has probably been operated with higher water levels in the past by encroachment on the freeboard.) This will need to be checked when the detailed survey of all areas is available during the design stage but, since such a survey is likely to indicate isolated spots higher than picked up by the existing survey, we have allowed for a raising of water level and canal banks of 0.5 m. In any case we propose an access road along the entire length of the canal, which would itself necessitate a topping up of the bund.

6.2.4 There are no escape weirs on the main canal (or elsewhere in this system). It is usually advisable to provide such safety features in each gated reach of a canal, however in view of the good operational record they would not appear necessary. However we would recommend a control structure at the end of the main canal with an escape weir for control of canal water levels and a turnout gate for emergency or maintenance use.

6.2.5 The problems of command may require raising of water levels in several of the secondary or branch canals. Except in the sample area where the detailed survey will shortly be available, final decisions must await the detailed surveys. However an allowance for possible earthworks associated with this will be provided in the estimate of scheme costs. A minor re-routing of part of secondary canal B, in the sample area and an increase in its capacity to supply the whole compartment, is proposed and this is shown on Drawing No. 3. The one major improvement proposed for the system is the re-routing of the secondary canal C. The present alignment is through a low-lying area creating considerable difficulties with command of the areas either side. We propose the conversion of this canal to a drain and the construction of two new secondary canals paralld to but north and south of the present alignment. These are shown on Drawing No. 3.

6.2.6 The other recurrent problem throughout the scheme is poor drainage. Drawing No. 2 indicates the areas with inadequate facilities. Paradoxically in some areas there are both command and drainage problems due to distance from supply points and drains and the flat gradients or slight undulations of the topography. Adding to the problem is the necessity in many areas for the use of 'controlled-drainage' irrigation because of the distance and difficulties of supply. As discussed in 5.2 we do not generally recommend the continuation of such practices except during land preparation, and with the improved distribution systems it should not be necessary. (There are however a few areas, north of Penaga, where rice is being grown on particularly sandy soils and the control of drainage levels is necessary to sustain a water layer in the fields. Control should however be carried out at the tertiary level, not in the main drainage channels.)

6.2.7 The provision of tertiary and quaternary drains as discussed in Chapter 8 should eliminate many of the drainage difficulties. At the present time however most of the secondary canals also serve as drains in their lower reaches when drainage of excess water rather than irrigation is required. This does not allow the degree of control of water levels on-farm necessary for the increased mechanisation requirements and the irrigation supply and drainage system must be separated. Proposals for new secondary drains are indicated on Drawing No. 3.

6.2.8 Maintenance of the drainage system is a major task with weed growth occurring rapidly in the flat gradient, slow-moving flow. It is difficult to see how an increase in the costs of such maintenance can be avoided as it will be vital that the drains are kept clear. The difficulties are high-lighted by the secondary drains either side of the road between Kepala Batas and Kampong Bahru. These also act as the main drains for Kepala Batas and take the road runoff. As a result they are heavily silted and choked up with weeds, leaving the fields undrained and causing flooding when it rains. Between them they drain an area of about 1,200 ha. Both these channels need major improvement.

6.2.9

The three main east/west drainage channels exit through tidal gates at the coast. These appear adequately sized however the outlet channel on the Sg. Tembus is being blocked by a sand bar forming across the mouth. This appears to be a local problem of beach movement under wave action which has occurred during the first season since the new tidal gate and straightened channel of Sg. Tembus were constructed. The situation is not improved by the need to keep the tidal gate closed to back up water for the pumped supply to the small isolated area of Guar Tuan Syed. Backing up the flow in Sg. Tembus also has adverse repercussions on the drainage of Bertam estate and a study is being carried out to see if the area of Guar Tuan Syed can be economically supplied by gravity from the secondary canal B.

6.2.10

The southern part of the scheme drains southwards into St. Perai. This was a tidal estuary but the main barrage has recently been completed and the river in this reach is now no longer subject to tidal fluctuations. This will improve the drainage of the Sg. Muda scheme and the swamps along the river, some of which could be converted to rice production. However the large block east of Butterworth is planned for urban development and it is likely that similar pressures for urbanisation will exist around Sg. Dua. In view of the more important need to upgrade the existing padi areas and to get abandoned land back into production we do not consider it presently worthwhile to try and expand the scheme into new areas, and we have not included any proposals for upgrading the present system for possible future extension. Should the proposals of this study be successfully implemented in the present schemes then the position might be reviewed. The State JPT have prepared outline plans for a number of small pumping schemes for reclaimed areas along Sg. Perai using water from this river. Should it eventually be considered worthwhile to develop these areas for rice then we would recommend that such systems be introduced, rather than extension of the existing schemes which are already short of water.

6.3 The North-eastern schemes (Group B)

6.3.1 As well as from their geographical location these schemes have been grouped mainly because their supply systems are interconnected as part of the Sg. Muda to Sg. Kulim transfer scheme. Figure 5.5 shows the principle features of this transfer system which allows flows to be drawn from Sg. Muda to supplement those in Sg. Jarak and Sg. Kulim. The main intake for this transfer system is at Pinang Tunggal on Sg. Muda, where the flow is pumped into a canal leading to Sg. Korok. This in turn leads into Sg. Kereh. The flow is abstracted from this river about 10 km downstream with a pumped intake at the Sg. Kereh headworks. A canal transfers the flow to Sg. Jarak, immediately upstream of the Jarak headworks, from where a second canal offtakes on the southern side of this river. This canal connects with Sg. Kulim via the Chempedak booster pumping station in Kampong Jarak Atas. The flow is finally released into Sg. Kulim about 0.5 km upstream of the Kulim headworks enabling it to be abstracted for use in the Kulim scheme.

6.3.2 With the exception of Jarak Tengah, for which abstraction is made from Sg. Jarak about 2 km upstream of the headworks, all the remaining group B schemes are supplied from this transfer system - Pinang Tunggal from immediately downstream of the intake pumping station and from the first canal, Pokok Jeneris, Kampong Tasek, Kubang Menderong and Tasek Gelugor from the Korok/Kereh river system and Jarak from both of the two transfer canals between Sg. Kereh and Sg. Kulim. The operation of these schemes, particularly with regard to water use and scheduling must therefore be integrated, together with that of Sg. Kulim scheme.

6.3.3 Because of the integrated use of water from four sources, Sg. Muda, Sg. Kereh, Sg. Jarak and Sg. Kulim, the scheduling of water to minimise pumping is fairly complicated. However, except for the southern part of the Jarak scheme which can be fed from Sg. Kulim, the system works such that water is transferred north to south as required. As discussed in Chapter 5 in an average year the resources of Sg. Kulim, Jarak and Kereh are probably adequate for all the schemes except for Pinang Tunggal and Pokok Jeneris which are supplied directly from

Sg. Muda. In the dry years however there is a considerably shortage and the system is called into operation. The normal pumping requirements are thus low but the peak duties occurring for short periods once in five years are high. The system has recently been uprated with additional pumping capacity installed at the three pumping stations. The estimated duties and the installed capacities of these stations are:-

	<u>Estimated Duty</u> (m ³ /s)	<u>Total Installed Capacity</u> (m ³ /s)
Pinang Tunggal P.S	7.8	11.47 (405 cusecs)
Kereh P.S	4.3	5.95 (210 cusecs)
Pdg. Chempedak P.S	4.75	4.25 (150 cusecs)

From these figures it would appear the Pdg. Chempedak station is somewhat undersized, however the capacity is adequate for all but one 10-day period in five years and the consequence of this undersizing would be only that a small part of the Kulim scheme would, in the dry year, have a delay in receiving water for presaturation. This we consider acceptable. Moreover as discussed in Chapter 5 it appears likely that in any case there would be inadequate water in Sg. Muda to meet this peak requirement. We do not therefore propose any increase in the pumping capacity at this station.

6.3.4

Checks on the capacities of the various canals in the system are not yet completed but it appears that generally they are adequately sized. It is reported however that the gated control structure at the head of the canal downstream of Pinang Tunggal P.S is too constricted and may need to be enlarged. This will be checked. A new control structure is proposed at the end of this canal where it discharges into Sg. Korok to enable the FSL to be maintained at low discharges for supply to the Pinang Tunggal scheme without affecting the drainage into the Korok.

6.3.5

The Korok/Kereh river system is required to transfer up to about $5.2 \text{ m}^3/\text{s}$ (184 cusecs). At present the river is narrow, winding and overgrown. Flow measurements taken on 13th May, 1981, with one pump operating at Pinang Tunggal but following heavy rain, indicated a bankful discharge (with a risk of flooding) in the vicinity of Ayer Melintas pumping station (Tasek Gelugor) of only about $4.5 \text{ m}^3/\text{s}$. However JPT are about to start construction of major improvements to the Sg. Kereh primarily to relieve flooding. These works will consist of enlarging and straightening the river source and construction of retired flood bunds. The scheme is designed for a maximum flood of about $45 \text{ m}^3/\text{s}$ and the improved channel will be ample for the irrigation transfer flows.

6.3.6

In the past Korok and Kereh rivers have acted as flood overflow channels for Sg. Muda. This function has been largely superseded by the construction of flood bunds along the southern bank of the Muda, however some flooding is still reported as occurring by over-topping of the bund in Kedah and also from back flow via a flood relief culvert through the bund. In both cases it is advisable to prevent such flows if practicable. However any such works must be considered in the context of the whole river regime.

Pinang Tunggal Scheme

6.3.7

The Pinang Tunggal scheme lies in the north east corner of the state along the southern bank of Sg. Muda. The total irrigated area is about 1,366 ha at present of which about 200 ha is cropped with vegetables - the actual area of vegetables varying from season to season. A small reduction to about 1,350 ha will be caused by the construction of the N/S expressway along the western edge of the scheme. These areas do not include Pokok Jeneris, Kampong Tasek or Kubang Menderong. In addition provision must be made for the system to supply an area of 85 ha currently being developed by MARDI at Bertam as a research station and an area of 33 ha presently used by MARDI at Bumbong Lima which we understand will revert to the Ministry of Agriculture as a rice multiplication station.

6.3.8 The scheme is presently the most successful area farmed in Seberang Perai, with close to 100% double cropping on the rice areas and with the farmers following fairly closely the optimum cropping schedules. This might suggest that the need for improvements in the infrastructure is less than elsewhere. However far from being better than in other scheme the supply system at the tertiary level is possibly inferior and although there is a good main drain, Sg. Tembus, there are virtually no tertiary level drains. The success of the farming is thus largely due to the farmers themselves who in many cases have provided their own pumps to abstract from the canal system and even to pump from field to field to obtain command of higher areas, or to drain low-lying pockets without a gravity outlet. It is estimated that there are about 40 small pumps being privately operated within the scheme and improvements in the tertiary infrastructure would aim to remove the need for these.

6.3.9 Included in the total are three areas, together about 160 ha, which lie between the main Sg. Muda flood bund and an older outer bund no longer maintained. These three pockets are well farmed but are subject to periodic flooding, reported as occurring annually. Since this outer bund already restricts the flood channel of the Sg. Muda until it is overtopped, a repairing and possible heightening should be carried out to reduce the incidence of flooding of the enclosed padi areas. Provided any such heightening does not raise the crest of the outer bund to the level of the main bund, floods of a level likely to endanger the latter will still overtop the outer bund and will not be restricted or raised any more than with the present situation. As noted in 6.3.4 however the effect on flood levels in Sg. Muda will need to be studied in more detail before implementation - in particular any adverse effects on the flood protection works downstream and in Kedah. For costing however a bund level 0.6 m below the main bund crest is assumed.

6.3.10 The scheme is divided into two parts by the north/south line of the railway. The intake is at Pinang Tunggal immediately east of the railway where a pumping station provides water both for this scheme and to the transfer system (6.3.1). The uprated station has three

electrically powered pumps each with rated capacities of $3.8 \text{ m}^3/\text{s}$ (135 cusecs) two with a total lift of 4.6 m (15' - 0") and the recently installed pump with a total lift of 4.9 m. The total capacity of the station is thus $11.4 \text{ m}^3/\text{s}$. The forebay of the station, between the river and the pump intakes, reportedly is subject to sand deposition and material is also drawn through the pumps and deposited in the outlet bay. It appears that under normal operation the flow velocity in the downstream canals is too low to carry the material further and no serious problem of canal siltation has been reported. Consideration is being given to possible silt exclusion works at the inlet to the forebay. However any such works requiring construction in or adjacent to the river are likely to prove expensive especially with the need to allow abstraction at very low river levels. It may prove more realistic to continue mechanical clearing of the material, though possibly on a regular basis, with drag line or suction dredger.

6.3.11 The main distribution system divides immediately downstream of the pumping station, the area to west of the railway being supplied by gravity, the eastern area being presently supplied by a small booster pumping station. The distribution system in the large western block appears to work reasonably well and no major alterations are proposed. However in many places the banks of the main and secondary canals are too low to accommodate the full supply levels and, particularly in view of the command problems to many small areas around the edge of the irrigated area, a programme of raising the bunds should be carried out. As elsewhere this work would be combined with the provision of the recommended access along main and secondary canals.

6.3.12 The eastern block contains virtually all the vegetable crops. The precise areas vary from season to season depending on the availability of water and the farmers' inclinations. Several farmers have indicated that they would prefer to grow more rice in the area but that command difficulties make it uneconomic. For supply to the vegetables they are providing their own pumps and about 30 permanent or semi-permanent installations abstract from the canal system or from Sg. Korok. This area is being studied in more detail as one of the sample areas and we propose to design the system on the basis that any field could be planted with rice.

6.3.13 At present the main supply to the area is pumped from the transfer canal linking with Sg. Korok, (Tali Air Selatan). The station has two $0.27 \text{ m}^3/\text{s}$ (10 cusec) diesel pumps with a lift of 3 m. Part of the pumped flow is syphoned back under the canal to the block of land between this canal and the railway. Studies are not complete yet but it appears that this area could be supplied by gravity if the canal levels can be controlled at the design FSL. We are proposing a control structure at the end of the transfer canal at the confluence with Sg. Korok so that the design FSL can be maintained without affecting the drainage into Sg. Korok.

Pokok Jeneris

6.3.14 This is a small JPT maintained scheme of about 90 ha (220 acres) on the right bank of Sg. Kereh south of Pinang Tunggal. Supply is by gravity from the Sg. Korok via a pair of intake gates (0.45 m and 0.6 m dia.), upstream of the gated control structure across the river at Kg. Tasek. A small canal "Parit Siam" leads to the irrigation area on the western side of the railway.

6.3.15 At present only about 35 ha on the left bank of Parit Siam and a few isolated areas are being cultivated. Most of the area on the right bank is low and drainage is difficult. The existing drain for this area is situated along the fringe of the padi area bordering Bertam Estate, and discharges into the estate outlet drain. This drain discharges into Sg. Kereh via a flap gate and the river level is reported frequently to be too high for the drains to discharge effectively. The proposed JPT canalisation works should lower the normal water levels in the river, however the invert of the drain outlet structure appears to be too high and this structure should be replaced.

6.3.16 The padi area at the downstream end of the canal is higher, and command is difficult. This is aggravated by low bunds along the canal and the size of the canal which is too small. Localised land levelling may be more economic than raising the canal levels along the entire length. Moreover raising the supply level to gain command of these furthest areas would increase the drainage problems in the eastern part of Pinang Tunggal and Kg. Tasek draining into Sg. Korok. In any

case access at present is poor and a farm road should be provided along the entire length of the canal from Sg. Korok.

Kampong Tasek

- 6.3.17 This is an area of about 106 ha on the left bank of Sg. Korok mainly between Sg. Korok and Sg. Kereh. Although traditionally padi land, there are no JPT irrigation and drainage facilities and supply is by private pumps drawing from Sg. Korok. In the area about 65 ha are presently cropped with vegetables. We would recommend that supply and drainage facilities under JPT control are provided, designed, as the eastern block of Pinang Tunggal, with the capacity for 100% rice irrigation to give the flexibility of crop choice. Supply would need to be pumped from Sg. Korok; a gravity supply would require backing up Sg. Korok to a level which would cause drainage problems upstream.

Kubang Menderong

- 6.3.18 This is another small area, 39 ha, on the left bank of Sg. Kereh opposite Pokok Jeneris. Like K3. Tasek it is a traditional rice growing area but is supplied by private pump. Again we recommend this is taken over by JPT and provided with a central pumped supply from the river.

Tasek Gelugor

- 6.3.19 Tasek Gelugor scheme consists of two separate areas independently supplied by pump from Sg. Kereh. On the right bank of the river is the Tok Bedu scheme, 70 ha, and on the left bank the Ayer Melintas scheme, 192 ha. There is no control of the river levels in this reach and, when the canalisation works are carried out on the river, there could be problems with pumped abstraction at low river stages. This is being considered further. It may be necessary for a control structure to be built across the river at the Ayer Melintas intake, although adequate depth may be maintained by control at the Kereh headworks about 4 km downstream. The matter is complicated by the discharge into Sg. Kereh immediately upstream of Ayer Melintas P.S of the main drain from Ladang Choong Lye Hock (Tasek Gelugor Drainage area, 7.4.8 - 7.4.10). Control of the river levels downstream of this discharge point may adversely affect the drainage of these areas. One possibility being

considered is a low fixed crest weir upstream of the drain with supply to the pumping station forebay being syphoned under the drain. The weir would need to be low enough to be drowned out during floods without affecting the upstream stage but high enough to provide a depth control for the abstraction at Kubang Menderong upstream.

6.3.20 The Ayer Melintas pumping station has 2 No. diesel pumps each of $0.42 \text{ m}^3/\text{s}$ (15 cusec) with a total lift of 3.0 m. The required capacity is $0.36 \text{ m}^3/\text{s}$ so the existing installation is adequate. Part of the area supplied from this pumping station is south of Tasek Gelugor town and we propose that all the area between the town and the Jarak main canal be included in the Tasek Gelugor scheme - at present part of this area is supplied by direct offtake from the Jarak canal.

6.3.21 The main problems in the Ayer Melintas area are command of a number of high areas and flooding from Sg. Kereh. The latter problem should be alleviated by the proposed improvements to the river. Most of the command difficulties will be reduced by improvements to the canal system as discussed in Chapter 8, but isolated areas may require levelling. In addition there are inadequate drainage facilities in the Kg. Peng Batu area south of Tasek Gelugor town and a new secondary drain running southwards into Sg. Jarak is required.

6.3.22 The Tok Bedu pumping station has 2 No. $0.14 \text{ m}^3/\text{s}$ diesel pumps with a lift 3.4 m (5 cusecs at 11 ft); the required capacity is $0.13 \text{ m}^3/\text{s}$. The main problem in the area is flooding from Ladang Malakoff on the north and west sides. At present the only outlet for flooding outside the bund at Kg. Tok Bedor is via the main canal and frequently the main canal bund is breached by the local people to facilitate this. We propose a new drain through the irrigation area to discharge these flood waters and to serve the scheme.

Jarak Tengah

6.3.23 Jarak Tengah is a scheme of about 100 ha on the right bank of Sg. Jarak about 20 km upstream of the main Jarak scheme headworks. A small pumping station with 1 No. $0.14 \text{ m}^3/\text{s}$ (5 cusec) diesel pump with a total lift of 1.8 m abstracts from Sg. Jarak. It had been

intended to install a second pumping station at the other, east end of the scheme with similar capacity but this was never completed. The maximum calculated requirement for the whole scheme is $0.19 \text{ m}^3/\text{s}$ so that if the entire area is to be irrigated then either the second station must be completed or the existing station uprated with provision of a second pump.

6.3.24 The main problem is one of flooding and this has been one of the major causes of abandonment of fields so that less than 50% of the area is presently cropped in the higher fields near Kg. Besar. There are two reasons for the flooding. Firstly the flood bund along the river is apparently too low and is reportedly overtopped during high floods. (It is also reported by JPT, Kedah, that flooding occurs in the Otak Kerbau scheme in Kedah upstream of Jarak Tengah.) The second cause of flooding is that part of the drainage from the Mayfield estate to the north flows through the irrigation area and with the high river levels it cannot be discharged. A perimeter drain, possibly with associated flood bund, needs to be constructed on the north eastern side of the scheme to divert this flow to the main drain through the scheme. Even with these works however drainage problems are likely to remain because of the high river levels preventing discharge of excess water from the padi area. It may therefore be necessary to consider supplementary pumping of drainage flows from the Jarak Tengah area.

6.3.25 In view of the drainage problems within the existing scheme we cannot recommend the extension of the irrigation facilities into the low-lying areas along the river outside the flood bund and downstream between the Tasek Gelugor/Ara Kuda road and the railway line. These areas are unalienated State land but have in the past been farmed on a 'rainfed' basis.

Sg. Jarak

6.3.26 The Sg. Jarak scheme lies in two main blocks either side of Sg. Jarak. The area on the right bank (411 ha) is fed from Sg. Kereh via the main transfer system canal. The left bank area (358 ha) is fed from Sg. Jarak via the Jarak/Kulim transfer canal; approximately

half the area being supplied by gravity from the canal upstream of Padang Chempedak Booster P.S, and the other half from downstream of this pumping station. The latter can also be supplied, when adequate flow is available, from Sg. Kulim by reversing the flow in the last reach of the transfer canal, thus reducing the operation of the pumping station.

6.3.27 Presently most of the scheme, probably in excess of 80%, is uncultivated and effectively abandoned. Although the primary reasons for the abandonment are probably socio-economic they are accentuated in this scheme particularly by command difficulties and poor drainage. Most of the areas have a fairly high density of canals but lack of proper maintenance, in turn due partly to lack of vehicle access along the main and secondary canals, has led to settlement and deterioration of bunds so that operation at the design full supply water levels is frequently impossible. This is particularly bad along the left bank transfer canal, upstream of the Pdg. Chempedak P.S, and with the secondary canals in the Lubok-Meriam and Pdg. Songson areas on the right bank. An extensive programme of improvement is needed although this will be associated with the provision of access as discussed in Chapter 8.

6.3.28 The drainage problems should be improved now that the Perai Barrage is operational and the Jarak, Kereh and Kulim rivers are no longer tidal downstream of their respective headworks. However a number of areas lack access to drains and a secondary drain to Sg. Jarak is required from the Pdg. Manora area.

6.4 Sg. Kulim scheme (Group C)

6.4.1 This is the second largest scheme in Penang State comprising an existing irrigable area of 3,664 ha (9,050 acres). This scheme is located in the Central District being bounded by Sg. Perai in the north, the Bukit Mertajam to Pdg. Manora road in the east, the main Butterworth to Bukit Mertajam road in the south and the industrial areas of Perai to the west. As discussed in Section 5.3 it is likely that there will be a significant reduction in the irrigable area in the future due to the expansion of the metropolitan area of Perai/Bukit

Mertajam, the construction of the North South Expressway along the western edge of the scheme and the likely routing of the East West Highway through the centre of the scheme. As a result of these encroachments we estimate the future area of the scheme to reduce to about 3,370 ha (8,320 acres). Figure 6.1 shows the existing works.

6.4.2 The scheme actually comprises two old schemes - the original Sg. Kulim scheme, supplied from the present headworks on Sg. Kulim, and the smaller Kubang Semang scheme. This latter area, about 380 ha, was supplied from Sg. Kubang Semang by gravity but due to insufficient flows during the off-season and pollution of the supply by upstream factories this source was abandoned and the two schemes amalgamated with the Kubang Semang area being supplied by a booster pumping station (2 No. $0.35 \text{ m}^3/\text{s}$ electric pumps with lift of 1.2 m). A second booster pumping station (capacity $0.42 \text{ m}^3/\text{s}$ - 2 No. $0.21 \text{ m}^3/\text{s}$ electric pumps with lift of 1.5 m) was later constructed at Permatang Rawa to extend irrigation to about 120 ha of high land in the south eastern corner of the scheme adjacent to Bukit Mertajam. A small area in the north at Permatang Pasir is also supplied from a booster pumping station.

6.4.3 The main source of irrigation supply is Sg. Kulim with a gravity intake at a gated headworks across the river at Kg. Mengkuang Mak Sulong. As discussed in Chapter 5, Sg. Kulim has not adequate resources for supply to the whole scheme in a dry year. In the past, double cropping of most of the area has been possible by the use of controlled drainage and the maximum use of rainfall - this was the first scheme in the country to practice double cropping. However increasing water supply abstractions and a number of very dry years in the last decade indicated the need for the transfer system (discussed in 6.3) to supplement the flows in Sg. Kulim from Sg. Muda. However, our studies suggest that significant use of this transfer system should only be required in years drier than average.

6.4.4 The outstanding problem affecting this scheme is the vast abandonment of the padi fields, the extent of which has now reached about 90% of the total scheme area. The proximity of the scheme to the urban areas of Butterworth, Perai and Bukit Mertajam make it particularly

susceptible to the pressures on labour and land. Although there are areas subject to problems of supply and drainage and flooding, in themselves they are not sufficient reason for this major decrease in farming activity. However as discussed in Chapter 8 if the scheme is to be re-established the tertiary level infrastructure must be improved as at present the density of canals and drains is very low.

6.4.5 The main distribution system is fairly good and though there are a number of minor improvements that should be made we are proposing no major changes to the system.

6.4.6 The drainage system however has more problems and various improvements are necessary. In general there is a lack of drains, particularly at the tertiary level, and controlled drainage has been effected by control on secondary and primary drains. As discussed in Chapter 8 if the requisite control of water is to be achieved there must be free draining facilities and control of drain levels, if practised at all, should be only during presaturation and at the tertiary level. Many of the primary and secondary drainage control structures should therefore not be used and preferably removed.

6.4.7 The northern part of the scheme drains northwards into Sg. Perai and with the commissioning of the barrage and the provision of adequate tertiary drainage most of the drainage problems should be resolved. The central area of the scheme in Mukims 4 and 5 drains into Sg. Derhaka which in turn drains westward into Sg. Perai, downstream of the barrage, via a tidal control gate. Secondary drains are required in the areas both north and south of Sg. Derhaka. These would discharge into this main drain, running between the existing tertiary/branch canals. The southern area is drained by a number of channels which run southwards into Sg. Juru, upstream of the Juru 'dam' in the Bukit Minyak/Bukit Tengah drainage area. Operation of the outfall there is reported to be inadequate at times to discharge excess water satisfactorily. The problem is complicated by the proposed inclusion of much of this drainage area in the metropolitan expansion of Bukit Mertajam and Perai. The south-western corner of the scheme should drain out to Sg. Ganti and thence to the sea. However the outlet control to Sg. Ganti is kept

closed apparently to relieve downstream flooding. The matter is being considered further, and a new outlet for drainage of this area may be required. Proposals for improvements to the drains are shown in Fig. 6.2.

6.4.8 The area between the northern edge of the scheme and Sg. Perai is presently swamp. With the completion of the barrage and the resulting improvements to the drainage it would be possible to convert this area into padi. However as discussed for Sg. Muda scheme (6.2.10) the immediate objective of this project is to bring the main scheme back into full production and to ensure the future continuation. We do not therefore recommend at this stage any investment in extending the area of the scheme. Should the project be successful then this should be reviewed. The State JPT have prepared provisional plans for development of this area with a number of small schemes separately pumping from Sg. Perai, as for the area on the north bank of the river. If the area is developed then we would recommend such systems and we do not propose upgrading the distribution system of Sg. Kulim to cater for a possible future expansion.

6.5 Central and southern district schemes (Group D)

Machang Bubok

6.5.1 This scheme is located south of Kg. Machang Bubok and consists of an area of 136 ha (335 acres) in a long narrow strip between Sg. Machang Bubok on the west and Sg. Bukit Teh on the south-east. The main supply is from Sg. Ayer Merah via a gravity intake at the gated headworks but subsidiary supplies for two small areas are taken from Sg. Machang Bubok in the north near the kampong and from Parit Balik Bukit which feeds a small area east of the Machang Bubok-Kampong Tasek road.

6.5.2 The scheme suffers from water shortage as a result of which some areas have delays in their water scheduling at the start of the dry season. This is borne out by the water balance analysis in Table 5.11 which indicates that with careful control of the scheduling and efficient use and distribution there would be only just enough water. However as discussed in Chapter 5 the problem can be minimised by delaying the cropping schedule if inadequate water is available and we do not consider the limitations on water need restrict the area of double cropping of

rice. There is however some diversification of cropping with a small area of vegetables being grown (partly under sprinkler irrigation) in the area beside Parit Balik Bukit.

6.5.3 Because of the layout of the scheme, with the main canal along the eastern side and the parallel drain of Sg. Machang Bubok on the west, and the regular arrangement of fairly large holdings, the densities of canals and drains, and the number of holdings with direct access to supply and drainage are high. Little in the way of tertiary improvements are needed therefore, and we propose no significant changes to the main systems.

6.5.4 The only works that do need to be carried out are river training works along Parit Balek Bukit. The stream is steep and deeply incised and bank erosion, endangering some of the adjacent padi fields, is occurring. Bank stabilisation works are required or possibly drop structures on the drain though this would be expensive. Further consideration is being given to this.

Sg. Renjau

6.5.5 The scheme is a small area of only about 20 ha (50 acres) fed by gravity from an intake with gated control structure across the Sg. Renjau. The scheme is divided, the area west of the road having no irrigation facilities and controlled drainage being practised. It is proposed to extend the existing canal system into this area. Drainage is good with Sg. Renjau in the south and Sg. Perangin along the northern side of the scheme. No additional facilities are required.

Tasek Junjong

6.5.6 The Tasek Junjong scheme is actually the eastern block of the two areas indicated as making up the scheme - the other being Kg. Kepala Gajah. The scheme (167 ha - 412 acres) is fed by gravity from a head-works on Sg. Tasek Junjong. No serious water shortages are reported although the hydrological studies would suggest that in dry years significant shortages might be expected (Table 5.11). However the problem does not appear to be as severe as indicated by the figures and any shortages that do occur appear to be minimised by delaying the cropping programme in the areas affected.

- 6.5.7 The distribution system has a fairly high density of canals and the shape and size of the holdings enables a high percentage to have direct access to a canal. Minor improvements to the irrigation facilities should be made by extending canals to provide more direct supply to some of the fringe areas. The area is served by a reasonably efficient drainage system having direct access to Sg. Junjong and Sg. Tasek Junjong. No major improvements are required.

Kg. Kepala Gajah

- 6.5.8 The area, 66 ha (163 acres), lies to the south of Sg. Junjong, either side of Sg. Chempedak from which it is supplied by gravity from a gated headworks. Both the canal and the drainage systems are good and there are no obvious needs for improvements. Canal densities are high and there are no reports of water shortages. There is no vehicle access into the area however and this should be provided along the canals as discussed in Chapter 8.

Kuala Tasek

- 6.5.9 This scheme is located on the north bank of Sg. Junjong opposite Kepala Gajah. Supply is taken from the river by a small pumping station with a capacity of $0.085 \text{ m}^3/\text{s}$ (3 cusecs). This compares with the calculated peak requirement of $0.06 \text{ m}^3/\text{s}$. A low concrete weir downstream of the intake controls river water levels. Only minor extensions of the canal system are required and drainage is good with the river fairly deeply incised. Vehicle access is poor however. The most suitable route for a road would be along the river bank however this may necessitate extensive river training works to stabilize the bank which is being eroded.

Sg. Duri

- 6.5.10 Sg. Duri is a small isolated scheme of about 20 ha in the Southern District. It consists of two separate areas supplied from separate headworks on Sg. Duri. However the lower area has apparently been abandoned for some years. The upper scheme is still being cultivated but probably only on a part time basis by families primarily involved in the surrounding rubber estates. The scheme is classed as

rainfed and there are no reports of water shortages or requests to JPT for improvements. There appears little demand for it to be taken over by JPT, and in view of this and the management and operational difficulties posed by its isolation from the other schemes, we do not consider that any significant capital investment can be warranted. However further consideration is being given to the possibilities of minor improvements.

Alma

6.5.11 Alma is a small non-gazetted area of about 100 ha, 3 to 4 km south of Bukit Mertajam. About 17 ha will be lost under the approved urban extensions of the Metropolitan Area and is likely to be almost surrounded by urban development if proposals for further extensions of the Metropolitan Area are implemented. The scheme presently suffers from water shortages and serious pollution of the river sources, Sg. Kelang Ubi and Sg. Kelang Lain, by upstream factories. As discussed in Section 5.5 the water shortage is likely to increase as the urban development extends into the catchment (approximately 50% of the catchment is scheduled for development).

6.5.12 In view of these pressures on land and water there must be serious doubts as whether the scheme will survive and in particular whether the area should be adopted by JPT and upgraded. The matter is still being considered and recommendations will be made in the final report. Early on in this project, before the full implications of the urban development extensions were known, Alma was chosen as one of the Sample Areas for detailed study, in order that topographic survey could proceed. Therefore, notwithstanding the uncertainties about the future of the scheme, a detailed engineering study is being carried out to obtain typical detailed costs of a small rainfed scheme.

6.5.13 Figure 8.6 shows the existing and proposed works. At present water is abstracted from both rivers, with three intakes on Kelang Ubi, A, B and C, and an additional brushwood dam on the Kelang Lain tributary diverting water to part of the right bank area. This last intake will not be required but the other three intakes would be retained. Intake A serves the area east of the railway, Intake B would be the main intake serving the central and southern area and C would supply the north western corner, picking up any additional flow from the Kelang Lain.

6.5.14 The northern and eastern areas have a simple system of canals but the same is not so in the southern area and we propose extending the system into this area. Drainage at present is at the fringe of the scheme only and tertiary drains are required extending into the scheme.

6.6 Sample Areas

6.6.1 In order to assess the requirements and arrive at accurate costs for the upgrading of the tertiary level infrastructure, a number of areas have been chosen for detailed study. The areas were picked as being reasonably representative of the overall schemes, not necessarily areas of particular difficulty but ones which would illustrate the general level of infrastructure required and from which costs could be extrapolated to cover total schemes with reasonable confidence.

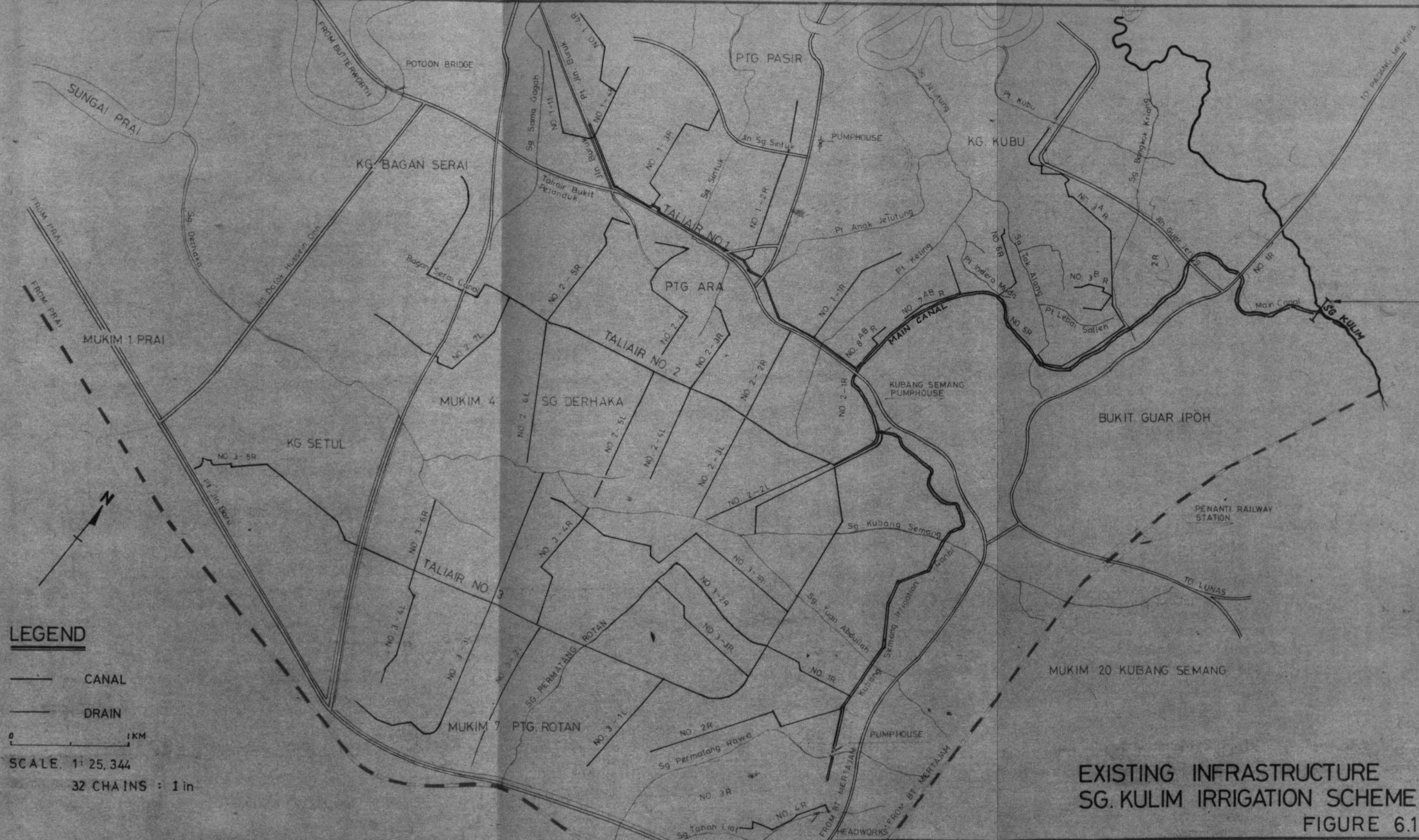
6.6.2 Four areas have been chosen totalling approximately 1,730 ha gross, i.e. about 13% of the total area:-

- (i) a block of about 810 ha gross in the north of the Sg. Muda scheme, bounded by two major drainage channels - Sg. Tembus to the north and Sg. Lahar Endin in the south - and extending from the main canal in the east to the coast in the west.
- (ii) a block of 580 ha in the Kulim scheme, north of the Permatang Pauh to Kubang Semang road.
- (iii) the whole of the Alma scheme - 82 ha.
- (iv) about 260 ha of the eastern block of Pinang Tunggal.

6.6.3 A more detailed description of the areas and the preliminary proposals for the upgrading works is given in Section 8.8. Each area however is, as far as possible, a self-contained unit fed by a single canal or source. Each sample area can thus be designed in some detail without the need for survey of outside areas.

6.6.4

Although the surveys for Alma, Sg. Muda and most of the Kulim sample areas have been completed they had not yet been plotted. The layouts must therefore be treated as preliminary only and may need changes before the Final Report is presented.



LEGEND

- CANAL
- DRAIN

0 1 KM

SCALE. 1: 25,344
32 CHAINS : 1 in

EXISTING INFRASTRUCTURE
SG. KULIM IRRIGATION SCHEME
FIGURE 6.1

7. DRAINAGE AREAS

7.1 General

7.1.1 Study of the problems and needs of the DID rated drainage areas has not formed a major part of our work up to the present, since guidance received from our Technical Committee has emphasized that priority must be given to the irrigated rice areas. This section is therefore limited to a description of the areas and their problems, and a statement of the design criteria it is proposed to use.

7.1.2 The areas to be studied are listed in the Addendum to the Terms of Reference. They include all the rated drainage areas in the State except the one at Bertam. The total acreage is recorded as 15,817 ha (39,068 ac), made up as follows:-

	<u>ha</u>	<u>(ac)</u>
1. Bukit Minyak/Bukit Tengah	3,493	(8,629)
2. Bukit Tambun	4,277	(10,563)
3. Nibong Tebal	5,485	(13,547)
4. Tasek Gelugor	982	(2,426)
5. Sg. Udang/Tanjung Berembang	1,293*	(3,194)
6. Sg. Chenaham/Sg. Udang Kechil	117	(290)
7. Benteng Kg. Melayu (Balik Pulau)	170	(420)
	<u>15,817</u>	<u>(39,068)</u>

7.1.3 In addition we are required to study possible drainage improvements to a stated 13,300 ha (32,800 ac). The details of these areas are only beginning to be clarified and they are not therefore discussed further in this report.

7.1.4 It is considered probable that the Bt. Minyak/Bt. Tengah area will be removed from the Terms of Reference since it lies wholly within the proposed extension of the Bt. Mertajam Metropolitan Area.

* Area taken from State DID returns. The TOR give an area of 1,030 acres which appears to be in error.

- 7.1.5 The drainage areas are composed mainly of smallholdings which were formed as a result of fragmentation of large estates. Their size range from 1 to 40 ha (3 to 100 ac), although smallholdings larger than 4 hectares are uncommon and the average size is about 2 ha. The proportion of area occupied by estates larger than 40 ha is not yet known, but the information is expected shortly.
- 7.2 Present situation
- 7.2.1 The JPT at present maintain the secondary and main drainage. As far as the smallholdings are concerned there are practically no functional internal drains. Existing large estates like Byram and Simpang Ampat have their own internal drains. Watertable control structures are absent and the smallholders often request the DID to use the tidal gates to perform this function. This is not their correct function and drainage control structures for maintaining water levels in the field drains may be needed at entry to the secondary or main drains.
- 7.2.2 Existing main and secondary drains are often old river courses that meander around the area. These drains should be realigned and straightened to provide better drainage by reducing hydraulic head losses and simplify maintenance.
- 7.2.3 Some of the outlets of existing gates are silted up quite regularly. This is particularly true in automatic flap gate structures. Open-flume structures are less susceptible to blockage of the outlet due to their high flushing capacities.
- 7.2.4 Road and rail culverts appear to be often a cause of local flooding and they may need to be enlarged. As they form a main transportation link the design discharge criteria should be more stringent since even a few hours of flood would cause numerous problems. Therefore the design flood discharge must be passed without ponding.
- 7.2.5 A more difficult problem to handle administratively is when new urban development induces worse flooding in downstream agricultural areas than occurred before. This arises from three main causes:

- reduction of flood plain storage,
- greatly increased runoff coming from areas no longer covered with vegetation,
- silt from new earthworks washing into drains and reducing their capacity.

7.2.6 At present we understand there is no machinery whereby the JPT can recover costs from municipal authorities in respect of the damage done to the drainage system from the above causes. Any arrangement to assess the contribution due to Drainage Area funds from municipal developers would be difficult to administer so long as the two sides remained mutually independent.

7.2.7 It is suggested that either a joint urban/agricultural drainage board will be necessary or else that drainage from municipal areas is conveyed to the nearest tidal outlet by a separate system to be entirely the responsibility of the urban authority. The second alternative could be more costly in terms of capital expense but it would make a simple and equitable division of costs. Furthermore if pumping should be necessary it would only have to be done for the quantity involved in protecting the more valuable urban areas. In the actual circumstances in Seberang Perai Selatan the future urban areas could probably discharge their runoff direct to the rivers Krian, Jawi and Junjong by relatively short canals terminating respectively at Nibong Tebal, Jawi and Simpang Ampat.

7.2.8 The existing access into the drainage areas is 'deplorable' as described by the JPT officials. As a result programmes to desilt, de-weed and maintain drains are very often hindered, and there is no proper access to transport material for bund repairs. Most of the coastal and river bunds are made up of material dug up from borrow pits. These materials are soft and degenerate due to erosion. Large stretches of bunds are not accessible even by motorcycle after heavy rain. Access on the side of existing drains is equally bad. At some places due to the absence of reserves along the drain, access roads could not be constructed and maintenance is often carried out by manual labour which is inefficient. It is proposed that additional land be acquired to enable provision of a 4 metre wide access along the main drains.

7.3 Field drainage

7.3.1 The JPT inform us that there is a need for new field drainage systems in almost all of the smallholdings. The smallholders do not have the management and organisation capabilities of the large estates from which they were fragmented. As a result the internal drain systems of the original estates were not taken care of and were left to degenerate. There is an absence of organised and collective labour to clear and maintain the smallholdings and their internal drains. Co-operation between neighbouring smallholders is often poor. Enterprising smallholders may construct their own drainage facilities but as they are not co-ordinated, often they do more harm than good by transferring some of the flooding problems downstream. Often smallholders introduce new higher value cash crops or even poultry or hogs which demand higher drainage requirements which are not often met. Crops or livestock are lost as a result.

7.3.2 Drainage problems are very often not highlighted as the smallholders are not very vocal in their complaints and very often a crop is already lost by the time the smallholder approaches the JPT for assistance. There are some areas which are inundated for periods up to three weeks e.g. at the Simpang Estate of the Bt. Tambun area north-east of the railway.

7.4 Description of areas

7.4.1 Seven separate drainage areas are listed in Section 7.1. Brief notes follow on the principal schemes (five in number) which are in Seberang Perai.

Bukit Tambun drainage area - 4,277 ha (10,564 ac)

7.4.2 This area is located in the Southern District of Seberang Perai north of the Nibong Tebal Drainage Area. Almost all of the plantations belong to smallholders. It is within the area described by the Sg. Jawi (or Sg. Jejawi) in the west, Sg. Bakap in the south, Sg. Junjong and the Simpang Ampat-Tasek road in the north and the Tasek-Sg. Bakap town road in the east. It is bisected by the main north-south railway line.

7.4.3 There is a total of 12.3 km (7.6 miles) of riverside bunds to protect the low-lying and flat area west of the railway. There are a total of 9 tidal gates along this bund. Access roads within the drainage area are scarce and insufficient for proper maintenance; some small-holders find it difficult to transport their harvested products out for marketing. There is a total of about 35 km (21.5 miles) of main and secondary drains maintained by the JPT which gives a drain density of 8.2 m/ha.

7.4.4 Flooding up to periods of more than 10 days is very often experienced. Flooding occurs in areas at the Sg. Bingai (or Drain C) upstream of the tidal gate C, at two railway bridges along Drain F1, and at four road crossings. Flooding is very often due to undersized road and railway culverts, so it may be necessary to remove these culverts and substitute them with larger ones. There are some existing old gates across the drains which are not being used, which cause constriction to the flow and should be removed. Flooding may also be caused by overloading of a tidal gate. As the tidal gates are all connected by a borrow pit, this borrow pit often transfers water from a gate upstream (due to it being at a high elevation) to a downstream gate. The result is the upstream gate being under-utilised while the downstream gate is overtaxed.

Nibong Tebal drainage area - 5,485 ha (13,547 ac)

7.4.5 This scheme is located at the southern portion of Seberang Perai Selatan and is bounded by the Sg. Krian in the south, the sea in the west, Sg. Tengah in the north-west, and Sg. Bakap - Sg. Jawi in the north while the eastern boundary is not clearly defined. The area west of the railway is low-lying and flat with an average ground level of about +1.00 near to the sea. At the rivers and the sea-shore a tidal bund was constructed. There is another bund on the eastern side of the railway which protects the area north of the Sg. Krian. The total length of these tidal protection bunds is 26.2 km (16.2 miles). These bunds were constructed to allow for vehicular access for inspection, maintenance and tidal gate operation. The bund building material was obtained from local marine swamp soil which is easily eroded, rendering the bund surface too soft for vehicular access during rainy seasons.

Certain stretches of the bund have deteriorated and render access impossible except for short stretches. Access into the smallholdings and plantations is reasonably good. There is a reasonable concentration of both metalled and all-weather laterite roads within the drainage area.

7.4.6 Most of the 11 tidal gates are of the box culvert type which is operated automatically. Only one gate is the open-flume type. Most of the tidal gates are located in remote areas and access is poor, especially so for tidal gate D.

7.4.7 This area is served by a network of drains running up to a total of 73 km. The drains are maintained three times a year according to the schedule observed by the JPT. There is some flooding up to periods of one week at Sg. Tiram at the south-west corner of the scheme. The area flooded includes reclaimed land planted with pineapple while waiting for the reclaimed soil to leach, a process that may take 1 - 2 years. Another area which is flooded is the area around the drain B2. There is a new housing development scheme along this drain and apparently siltation takes place as a result of upstream erosion. Road culverts serving this drain are observed to be undersized and overgrown with weeds. There is localised flooding in other places.

Tasek Gelugor drainage area - 982 ha (2,426 ac)

7.4.8 This drainage area is located at the north-eastern corner of Seberang Perai just south of the Pinang Tunggal Irrigation area. More than half of the area, 587 ha (1,450 ac), belongs to smallholders of Kampong Selamat, while the remainder belongs to the Choong Lye Hock Estate, a privately owned rubber estate. The JPT at present maintain about 30 km of main and secondary drains. Drainage problems here are mainly confined to the Choong Lye Hock Estate, through which passes the Parit Besar which collects all the excess water from the drains in Kampong Selamat. The drainage problem there is apparently due to the high stage of the Sg. Kreh to which the Parit Besar and the Parit Air Melintas discharge their excess water. The Sg. Kreh at present is in a very poor state of maintenance, and a scheme prepared by State JPT for its improvement as a flood channel is about to be constructed, using Fourth Malaysia Plan funds.

7.4.9

The Kampong Selamat area does not suffer any substantial flooding. This village forms a resettlement scheme and all the lots of about 0.8 ha (2 acres) each are uniformly shaped and well arranged. The village enjoys a good and well-planned drainage and access facilities. The access roads are all metalled surfaced with spacings of about 400 m apart. There are a total of about 23,500 m of secondary drains running alongside roads, with a density of about 40 m/ha. Flooding is practically absent due to this intense drainage system. The smallholders have constructed ditches which are linked to the secondary in their plantations to more effectively drain the area of any excess water. The Kampong Selamat area is an example of a drainage area where drainage and access facilities are good and we are considering whether to use it as a model for other drainage areas in the south where the existing drainage is bad. However Kampong Selamat enjoys land with sufficient slope to render drainage works relatively easy, which is not the case in the southern areas.

7.4.10

The area covered by the Choong Lye Hock Estate (formerly Air Melintas Estate) has unusual drainage problems. Flooding is experienced more as a result of back-water from Sg. Kreh than from runoff within the catchment. Furthermore there is a JPT main drain, Parit Air Melintas, wholly within the estate land. Parit Besar which drains Kampong Selamat appears to have a much greater slope than Pt. Air Melintas and does not overtop so readily. The correct division of responsibility between the JPT and the estate for its drainage problems is not easy to assess, but in our opinion the JPT should assume responsibility for the cost of any works needed to prevent flooding due to backing-up of water in the Sg. Kreh. The impact of the Kreh/Kroh improvement works mentioned above upon this flooding problem has yet to be studied.

Sungai Udang/Tanjong Berembang drainage area

7.4.11

This scheme is located in the southern portion of Seberang Perai just north of the Krian Irrigation Scheme. This scheme was originally designed to protect from tidal inundation the existing and potential agricultural land on the left bank of the Sg. Krian stretching from the Sg. Udang Village to Tanjong Berembang. The breakdown of the agricultural and potential agricultural lands is shown overleaf:

<u>Land</u>	<u>Area (ha)</u>
Padi	225
Coconut	756
Reclaimed swampland	312
Total	<u>1,293</u>

There are a total of 12.3 km of riverside and coastal bunds; two drainage controls; four tidal gates; and a total of 2.6 km of drains. There are no appreciable problems in this area except for the area served by the Drain No. 2. The Drain No. 2 acts as a major drainage outlet for the padi fields as well as for an oil palm estate.

Sungai Chenaham/Sungai Udang Kechil drainage area - 117 ha

7.4.12

This scheme is located south of the Sg. Udang/Tanjong Berembang Scheme and east of the Krian Irrigation Scheme. The scheme was planned to reclaim 117 ha of swampland and to improve the drainage facilities of about 324 ha of existing padi area in the Sg. Acheh area. The scheme comprises a total of 4 km of coastal bunds; two tidal gates; and two drainage control gates at the irrigation areas. Reclamation works are still in progress at the time of study. Urban, as well as agricultural development, is planned.

7.5

Design criteria for drainage areas

7.5.1

The drainage areas consist principally of coconut, rubber and oil palm plantations, but with a future emphasis on phasing out of rubber and replanting coconut with high yield varieties interplanted with coffee or cocoa. Pineapples are also grown extensively on newly cleared land. The need for interplanting to increase smallholders' revenue in the early years is an essential part of the current policy for replanting subsidies. It is therefore taken to be necessary to adopt the design flood intensity appropriate to cocoa and coffee trees given in HP No. 18 (ref. 19). Table 1 of this reference gives rain storm durations for flood design purposes for various crops. The shorter the duration the greater the rainfall intensity, therefore the longer durations imply a less severe design requirement. Since a rectangular hydrograph is used HP No. 18 assumes the duration of overland

7.5.1 flooding may be equated to the rain-storm durations. This assumption is probably optimistic, but it is part of the simplified hydrological method which has apparently been found to work empirically.

7.5.2 The relationship between crop, design duration and uniform runoff intensity for the key crops is given in Table 7.1.

Table 7.1 Crop - storm duration - runoff relationship

Relevant Crop	Design Duration	Runoff Intensity	
	(hours)	(in/hr)	(mm/hr)
Coconut, rubber, oil palm	72	0.09	2.2
Cocoa, coffee	48	0.12	3.0
Pineapple	24	0.21	5.3

Given the assumptions of constant rates of rainfall and runoff the design discharge is directly proportional to the rainfall (runoff) intensity. It can be seen that the increase in capacity implied by changing duration from 72 hours to 48 hours is only 36%, whereas it would be 240% if a change were made from 72 hours to 24 hours. For this reason and because pineapples only or a temporary crop while tree crop plantations are maturing, we do not propose to use the 24 hours criterion. All areas however will be assessed for the 48 hour criterion since it is impracticable to separate on a sub-catchment basis the oil palm areas from the cocoa/coffee interplanted areas.

7.5.3 Discharge through tidal gates will be assessed on the basis of an equal quantity discharged in each of the four tidal cycles of a 48 hour period; water level within the compartment will be assumed to revert to the bank-full stage (no flooding) at the end of each "gate open" cycle. This work and that indicated in 7.5.4 and 7.5.5 will require additional topographic survey (see 7.7).

7.5.4 The principal factors requiring a more subjective assessment for hydraulic calculation purposes are the type of tide taken to coincide with the design storm, and the flood stage taken to occur simultaneously in rivers receiving discharge through tidal gates. During flood such a gate may not in fact experience tidal fluctuations downstream sufficient for any useful discharge from the drainage compartment. It has been brought to our notice that some existing schemes suffer from this difficulty. The Bukit Tambun scheme contains two gates discharging into Sungai Junjong up to 4 km upstream of the outfall into "Kuala Jawi" and the Sungai Jawi also receives flow from several tidal gates near Jawi village; all of these may be affected by the foregoing comments, although the reported areas subject to flooding are not obviously related to these tidal gates remote from the sea.

7.5.5 With regard to tides we propose using the commonest "average" tide experienced, as taken from the 1980 Tide Tables. That is we shall not select Spring or Neap tides because to do so would introduce a compounding element in the 1-in-5-year probability of rainstorm occurrence which ought not to be interfered with. Occurrence of direct storm runoff in the receiving rivers, Junjong and Jawi in the case of Bukit Tambun, is not an independent event so far as probability is concerned, and it seems that their average annual peak flood would be appropriate to combine with the 5-year flood inside the drainage area. The best available local information will be used to estimate these flood levels. However it is unlikely that records will cover the mangrove estuarial areas such as Sungai Tengah/Sungai Jawi which have no road approaches or inhabited localities.

7.6 Agriculture in the drainage areas

Assessment of present and future cropping

7.6.1 The most recent details available of the agriculture within the JPT drainage areas are based on aerial photography taken in 1974. A land use survey was carried out by the MOA from these photographs (at 1:25,000 scale) and this has been published (ref. 20). The published tables give breakdown of land use by Mukim for the whole State. An interpolation of these tables to give areas by drainage scheme would

be possible for the larger schemes, though with uncertain accuracy, but the results would still be seven years out of date. None of the Government agencies involved - JPT, Jabatan Pertanian, RISDA, CSDS or District Offices - maintain statistical records of recent agricultural changes except on a District area basis in some cases. It was therefore agreed at a meeting at MOA early in July 1981 that the Jabatan Pertanian would carry out a field survey to update the 1974 data using their own staff.

7.6.2

With regard to future crops in the drainage areas it was decided, at the meeting just referred to, that the proposed land use recommended by the working group of the IADP on Land Use Planning should be adopted by the Consultants in their studies. An advance copy of this working group report was made available to us at the end of June 1981. The relevant proposals are summarised as:

- | | | | |
|-------------------------|---|------|--|
| "Rubber | - | | all rubber now grown on marine clay soils will be converted to a non-rubber crop depending on the soil suitability rating for the crop(s), as these soils are least suitable for rubber. |
| "Oil Palm | - | | all oil palm now grown on soils suitable to marginal for oil palm will remain in oil palm. |
| "Coconut | - | (i) | all coconut grown on marine clay soils which do not contain acid sulphate conditions will remain in coconut to be intercropped with cocoa or other suitable crop(s). |
| | | (ii) | coconut grown on acid sulphate soils which cannot be intercropped with cocoa or other crop(s) may be converted to oil palm. |
| "Dusun
(fruit trees) | - | | all dusun now grown on soils suitable to marginal for dusun will remain in dusun; these areas cover most of the present areas identified as mixed horticulture (2H) in the present land use map (1974)." |

The working group report is accompanied by a coloured map at scale 1 in. to 1 mile (1:63,360) which depicts the 1974 land use modified by the above criteria. It is uncertain how quickly the main changes would be implemented, that is:

- a) replacement by oil palm of rubber now grown on acid sulphate marine soils.
- b) replacement by coconut intercropped with cocoa (coffee) of rubber now grown on non-acid sulphate marine soils.
- c) replacement by oil palm of coconut now grown on acid sulphate marine soils.
- d) replacement by high yield coconut intercropped with cocoa (coffee) of old coconut areas not currently intercropped.

7.6.3

Other crop area data given in the working group report includes that in the following table:

Crop	Total Acreage (ha)	Date of Information	District
Cocoa	800	end 1979	Seberang Perai (SP) (all districts)
Coconut	7,760	1974	SP ("most on marine clays")
Oil Palm	3,600	?	SP (all districts)
Oil Palm	3,300	?	SP Selatan, marine clays

7.6.4

The current distribution of tree crop types in the principal drainage areas should become known by the time this report is issued, to a sufficient degree of accuracy, as a result of the field survey by Jabatan Pertanian. However we are informed that the persons doing this survey cannot be expected to distinguish between smallholdings and estates. It will therefore be necessary for the Consultants to make a broad assessment of the split between the two categories since both yields and infrastructure costs will differ between them.

Cost/benefit analysis

7.6.5

The cost of engineering works proposed for improving the standard of drainage must be compared with the expected resultant agricultural benefit. This will require assessment of existing and future with and without-project yields, making due allowance for the present areas liable to flooding or subject to excessively high water tables. The former areas can be identified from records maintained by the JPT, and the high water table areas will be extrapolated from them using existing topographic surveys. With improved drainage resulting from application of the criteria in 7.5 it is hoped to show that the water table in nearly all parts of the drainage area will fall to a satisfactory level. Yields in both the existing and future conditions will be based on experience of the individual major crops in similar areas, making due allowance for the different results obtained by estates and smallholders. Government officials have stated that they can supply adequate yield information from other project reports in Malaysia.

7.7

Topographic survey

7.7.1

We had assumed up to June 1981 that it would not be necessary to undertake field survey work in the drainage areas. However as our studies developed it has become clear that survey checks will be required for the matters mentioned below. Topographic survey of the agricultural areas (in excess of 9,000 ha) is not proposed since this represents an unacceptably large commitment. The study must therefore depend on the original JPT surveys which usually consisted of lines of levels taken at half mile intervals.

7.7.2

The State JPT does not possess record drawings to show the cross-sectional size of main drains, either as built or as existing after routine maintenance. The JPT does possess record of gates, their size and invert levels, but does not record tide levels at any of the gate sites. We therefore propose to carry out limited check surveys on the following features:-

- tidal cycle water levels at three or four typical gates on each scheme.
- main drain cross-sections for 1 or 2 km from tidal gate.
- perimeter drain ("borrow pit") cross-sections.

Cross-sections will only be taken at wide spacing to derive representative data. Provisionally we only expect to do this work in the Nibong Tebal and Bukit Tambun areas, but field work will also be undertaken at Tasek Gelugor to cover its particular problems.

8. CRITERIA FOR IMPROVED ENGINEERING INFRASTRUCTURE

8.1 Existing situation

8.1.1 The various irrigation schemes in the project area were originally planned and constructed with a reasonably comprehensive layout of the main and secondary canal systems but with few tertiary or field canals. Thus supply to an area was generally via a gated offtake on a secondary canal with farm-to-farm flow over areas of several hundred hectares and distances in excess of 1 km. Main and secondary drainage courses were generally existing rivers and streams and these were improved but virtually no smaller drains were provided.

8.1.2 Since the original construction the State JPT has improved the situation with the construction of additional tertiary canals and drains, providing booster pumping stations to provide supply to areas out of command, improving drainage facilities, particularly in the low-lying coastal areas, and various other works. However these improvements have, of necessity, been directed to solving particular, severe problems and with limited funds, and many areas still experience difficulties with supply, either due to distance from the supply point or to lack of command, drainage and access. Table 8.1 lists the present densities of canals, drains and farm roads in each project. Although such figures can be misleading, the optimum densities depending so much on the particular location, layout and topography of a project, generally the present values are well below those considered desirable.

8.1.3 The present situation with long distances of farm-to-farm supply and drainage leads to a number of adverse consequences that could be alleviated by improvements to the canal and drain infrastructure. Some of the more noticeable shortcomings are:-

- Farmers furthest from a supply point have little security of supply, being dependent on their upslope neighbours for water. During presaturation it may take several weeks for water to reach the furthest fields (if at all) and there is considerable unevenness in the efficiency of distribution and, equally important, reliability of supply.

- Because of the topography in most areas - very flat or slightly undulating ground - command of fields distant from a supply point may require an unacceptable depth of water in intervening fields.
- Because of the difficulty of supply many of the lower areas most distant from the main canals have been operated as 'controlled drainage' systems. In such systems control of water depths in individual fields is virtually impossible. Moreover excess water cannot be easily discharged and the lower farms are frequently subject to flooding problems.
- Even in irrigated areas drainage is frequently a problem with the field-to-field flow preventing rapid discharge of excess rainfall. Although short period flooding is tolerable the topography is such that many areas have limited or no access to drains.

8.1.4

In view of these problems farmers have little opportunity for improving their agricultural practices. They are reliant on upstream farmers for their water and must not interrupt the supply through their farms because of the needs of the downstream farmer. It is not feasible to control water depths to suit the stage of plant growth or for application of fertilisers. Frequently it is not possible to drain their fields prior to harvesting because other lower farmers may still require water or higher farmers be draining off. Moreover because of the delays in receiving water and the unreliability of supply, it is difficult for farmers to keep to the optimum cropping schedules and the situation has now been reached in some areas where farmers are at all stages of the crop season thus creating further difficulties of control of supply and drainage. It is noticeable that in the areas at present most successfully farmed - i.e. the northern part of Sg. Muda scheme and Pinang Tunggal scheme - there is frequent use by the farmers of their own pumps, both for supply from a canal or drain, and for field-to-field supply in areas with command problems.

8.2 The need for improved infrastructure

8.2.1

Though the existing canal and drainage systems do have some deficiencies, mainly in the lack of tertiary and quarternary canals

and drains, these are not the main cause of the abandonment of rice growing in the project schemes, although they may be a secondary contributing factor. This problem is discussed elsewhere in this report and appears to be primarily a social and economic matter associated with the small average holding size and the opportunities for labour in the industrial sector. Thus improvements to the infrastructure are not in themselves likely to reverse the present trend of abandonment. The only significant benefits to be gained would be in an increase in yields due to better control and use of water in those areas likely to remain rice-producing, and possibly a slowing down or even a halt in the rate of abandonment.

8.2.2

If there is to be a major future for rice production in the State of Penang then one of the necessary changes must be a reduction in the labour requirements from the traditional methods of cultivation. There are two main aspects to this. The first is the greater use of machinery for field preparation and harvesting and the second is the elimination of the labour intensive practice of transplanting, probably by one or more of the various methods of direct seeding. Both these practices require a greatly increased control of water use, particularly in the latter which needs accurate control of water levels in the fields. To achieve such control a considerable increase in density of canals and drains is required, ideally providing supply and drainage to each individual field. Additionally improvements are necessary for vehicle access, particularly for the agricultural machinery, ideally to enable each farm to be reached without necessitating passage over adjacent farms. Thus the proposed improvements and additions to the infrastructure must be considered as a necessary part of the overall project implementation.

8.2.3

The criteria laid out in the following sections, particularly those relating to size and layout of units must be considered as guidelines only. There are considerable difficulties in standardizing criteria for the development of infrastructure on an existing pattern of farm holdings such as exists in Penang. Some exceptions to these criteria must therefore be expected where their rigid application would result in an unreasonable solution. In addition, many of the criteria are based on the premise that a strict control of water and

scheduling of farming activities can be eventually imposed. While the importance of this cannot be too highly stressed, particularly as occasional water shortages are likely, it is appreciated that there are considerable practical difficulties in achieving this. However none of the proposed improvements place restrictions on the continuation of present practices during the period of implementation or during the gradual ensuing co-ordination of farming activities.

8.3 General criteria

8.3.1 The existing layouts of farm holdings within each scheme are generally very irregular with average farm sizes of less than 1 ha and a range of sizes from less than 0.2 ha to greater than 10 ha. As pointed out in 8.2.2, ideally not only every farm but every field should have access to a canal and drain if the desirable degree of water control is to be achieved. However with such an irregular pattern of small farms and even smaller fields it is clearly impracticable to achieve this with the main distribution and drainage systems. Considerable simplifications could be made to the system layouts if consolidation and redistribution of farm holdings were possible. (Figure 8.1 illustrates as an example the possibilities of such a re-arrangement for part of the sample area in the Sg. Muda scheme). The social and legal complications of such a procedure would be formidable however, and it has therefore been assumed that generally no re-arrangement of farm boundaries is feasible.

8.3.2 The possibilities of organising groups to farm discrete blocks of land are discussed in Chapter 10. Even within such a block it is unlikely that redistribution of land holdings would be feasible but some economies in construction and improvements in water distribution efficiency might be achievable with fields re-defined in a regular pattern on a larger scale without regard to farm boundaries. However the use of larger fields would involve considerable expense in land levelling if the degree of water level control required for direct seeding is to be achieved. In this respect the existing smaller fields have an advantage in that the tolerances on level are more easily achieved. The other advantage of larger fields is an increase in the

efficiency of machinery use, particularly with the combine harvesters. However compared to the use of the combines in the existing small fields this increase in efficiency is not likely to have a significant effect on the farm or project economies. Moreover if a block of farmers are operating a group system with inputs and profits shared according to area of farm holding, there is no reason why the operation of combines need be restricted by field bunds. Rarely is there a significant difference in level between adjacent fields and the damage to field bunds could be easily repaired. We consider therefore that generally there is little advantage in increasing field sizes, and the infrastructure improvements are proposed assuming no major changes to either farm or field boundaries. As far as is reasonable the distribution, drainage and access systems will follow farm boundaries, and will make use of existing facilities where these exist.

8.3.3

Because of the small size and haphazard arrangement of farms we have introduced, for the purposes of design and management, the concept of the 'quarternary unit' as the smallest discrete unit of the system. This is an area of generally between 5 and 10 ha, within which the farmers should work closely as a group whether as part of a larger group farm or as individual farmers. Within the quarternary unit supply and drainage may need to be from farm to farm and road access, if provided within the tertiary unit at all, would be to the edge of the unit only. Because it is not feasible to provide vehicle access to every farm, machinery used for ploughing or harvesting must work from farm to farm as it would not be possible for a tractor or combine harvester to reach a distant isolated field across the intervening cultivation. With the larger combines presently being introduced into some areas, a quarternary unit could be harvested within 1 or 2 days. Thus it is desirable, if the combines are to be used efficiently, that cropping activities are closely co-ordinated throughout the unit - i.e. within 3 to 4 days, the time during which the crop is ready for harvest. Since on average only about 10 farmers are involved in a quarternary unit such co-ordination should be feasible, even where group farms are not established.

8.3.4 Tertiary units - i.e. the area controlled by a single irrigation outlet from a secondary or branch canal - will be made up of a number of quarternary units. For good management and efficient water use it is desirable that there is a degree of co-ordination between these quarternary units and that the whole tertiary unit follows the same general cropping schedule. It is our experience elsewhere that units of about 50 ha are of the optimum size for water management and we have therefore planned tertiary units to be between about 40 and 100 ha with a preferred size of about 50 ha. Although on other schemes in Malaysia larger units are usual, the small average size of farms on this project (less than 1 ha) suggests that the social/management problems of larger units might be considerable.

8.3.5 Boundaries of tertiary units will generally be chosen for topographical reasons and will generally coincide with physical features - i.e. secondary canals, tertiary and secondary drains. Ideally they would also coincide with social boundaries such as kampong holdings, however it would be almost impossible to reconcile the two criteria and moreover the fragmented nature of the farms and complications of absentee landlords make such an aim unrealistic.

8.3.6 Operation of the larger schemes is recommended to be with 3 cropping schedules, each staggered by 2 weeks (Chapter 5). The smaller schemes may have only 2 schedules and those less than 200 ha are likely to have a single schedule. Each schedule is applied to an 'irrigation block' which consists of about one-third of the total of the tertiary units. There are some advantages - minimisation of canal sizes and the movement of labour - in having the tertiary units of each block distributed throughout each scheme. However existing practices both in Penang State and elsewhere in Malaysia are for contiguous blocks, and, with the increasing use of machinery and the possible introduction of direct seeding techniques, labour movement is of less importance. Irrigation blocks therefore will be defined as discrete units, as far as possible coinciding with physical boundaries, such as areas supplied by secondary canals.

- 8.3.7 Some improvements in matching irrigation requirements to supply may be possible with unequal sized irrigation blocks. However such improvements are relatively limited and moreover, with equal staggers between schedules, imply a non-uniform spread of farming activities. For both labour and machinery requirements this is undesirable and therefore irrigation blocks should be chosen to be as nearly equal in area as possible subject to suitable physical boundaries. Equal blocks have the advantage that the schedules can be rotated year by year so that all farmers are equally treated over a period of years with regard to optimum climatic conditions and possible water shortages. The complications in management of varying the size of irrigation blocks for each crop are not recommended.
- 8.3.8 Better control of farming activities, particularly in spreading activities uniformly throughout a scheme, can be achieved by splitting each schedule into two - i.e. 6 schedules with 1 week stagger between each and a 1 week spread of activities in each block. This requires an increase in water management and increases the social/management problems of getting the farmers to follow a particular schedule. Initially therefore a 3 block schedule is recommended but the system will be designed so that a 6-schedule operation could be introduced. Rather than splitting each of the 3 main irrigation blocks into 2 large 'sub-blocks', such a system could be introduced at the tertiary level with, for example, alternate tertiary units within an irrigation block staggered by 1 week.
- 8.3.9 It is worth noting that with a 6-schedule system the activities within each tertiary unit should be spread over 1 week. The average size of the tertiary units is such that a combine harvester should complete a unit in this time. Thus if a strict scheduling of the cropping could be universally introduced, the movements of a single combine would be minimised, with 2 tertiary units of 1 block completed in the 2 weeks before moving to the next irrigation block.
- 8.3.10 Rotation of supply is not recommended, at either the tertiary level or within the tertiary units, for immediate introduction except possibly on a limited experimental basis. It is not employed to any significant extent elsewhere in Malaysia. Moreover there are considerable

8.4.3 rable difficulties in designing a sensible system suitable for rotational operation on top of an existing complicated farm layout. The systems will however be designed as far as possible for eventual conversion to a rotational system with the minimum disruption, should its introduction be considered at a later date.

8.3.11 JPT will control distribution by means of gated control/measurement structures at each secondary and tertiary offtake. Quantitative control of flows is important not only at times of water shortage when equality of distribution is vital, but at all times in order to maintain high efficiency and reduce pumping costs. Normal operation, once all farmers are following the appropriate schedules, would require gates to be adjusted, on a regular, probably weekly, basis to flows corresponding to the calculated values for the average year. The gate operators/irrigation inspectors would make further adjustments to increase or decrease the supply as necessary in response to rainfall and the excess flows passing to the drains.

8.4 Irrigation distribution systems

8.4.1 As discussed in Chapter 6 the existing main distribution systems (i.e. main, branch and secondary canals) are extensive and we propose no major alterations to the systems. (The only changes proposed are the rerouting of one or two secondary canals for reasons of command.) However we recommend that all secondary and branch canal offtakes should have flow and measurement control. Rather than demolishing existing offtakes and rebuilding as CHO structures we propose introducing low-afflux Crump measurement weirs in the canals downstream.

8.4.2 Supply to a tertiary unit will be from a secondary or branch canal via a flow-control offtake structure. Generally we recommend the use of CHO offtakes but in some locations where head is very limited it may be necessary to use an offtake with lower head loss such as a simple control gate with downstream flow measurement by Crump weir, as for secondary offtakes.

8.4.3 Even if a rotational system of irrigation is eventually introduced for normal operation this would be within the tertiary unit and supply to the unit would be continuous. Design water duty is for presaturation of the whole unit within 14 days - i.e. an irrigation duty of 3.0 L/s/ha, allowing for the 80% tertiary system efficiency. The tertiary offtake should be designed for a maximum capacity 10% in excess of this.

8.4.4 Many of the schemes in Malaysia, designed or upgraded in recent years, have a simple tertiary system with direct farm offtakes from the single canal. The disadvantage of such a system is that either JPT must control each offtake or there may be a low distribution efficiency with farmers near the top of the canal having unlimited access to the water, while the lower farmers are reliant on the upper farmers not to abstract excess quantities. To work well such a system requires the co-operation of all the farmers within the tertiary unit. We prefer a different system in which each of the quarternary units is supplied by a 'quarternary' or 'field' canal. Farm offtakes are from the quarternary only with no direct off-taking from the tertiary canal. JPT would control the division boxes on the tertiary canal but would not control offtakes from the quarternary. Equality of distribution would depend on the co-operation of the farmers within each quarternary unit only.

8.4.5 Despite the proposal for supply from quarternary to farm only, the existing layout of farm holdings makes the rigid application of such a system difficult and results in frequent cases of two or three canals side by side. Although such systems are not uncommon elsewhere the relatively high costs of land acquisition here and the structures necessary for mechanised plant access make it difficult to justify only incremental improvements in water management and control. We propose therefore to adopt a compromise system in which supply will be from quarternary canals where reasonable, but farms abutting tertiary canals may be supplied directly from the tertiary. (Less than one-third of the farms are supplied direct.)

8.4.6 Ideally every farm should have direct access to a supply canal, particularly if the water control necessary for direct seeding is to be achieved. However the small average size of holdings makes such an aim impracticable. We have therefore adopted the following objectives:-

- Direct supply should be to as many farms as possible.
- Where this is not practicable, farm-to-farm supply should be over distances not exceeding 300 m, and preferably through no more than 3 farms.

8.4.7 In line with practice in Malaysia we propose that all tertiary canals are concrete-lined. Although the capital cost of construction is greater there are some savings in land acquisition costs compared to unlined canals, and significant savings in maintenance costs. This is becoming increasingly important with the rise in demand for labour throughout the State. Moreover the reduced friction losses of concrete lining will allow flatter gradients and improved command of many areas presently experiencing supply problems. Some savings in canal water losses will also be achieved.

8.4.8 Tertiary canals will be designed for a flow of 3.0 L/s/ha, as discussed in 8.4.3, except that where the canal serves two quarternary units or an equivalent area - say, less than 15 ha - the size should be increased to enable the design flow to be provided to both quarternary units. Quarternary canals are sized for a presaturation period of the quarternary block of 7 days in an average year. This requires a design capacity of 4 L/s/ha. The peak 1-in-5-year requirement, equivalent to about 5 L/s/ha, can be provided either by encroachment on the canal freeboard or by extending the presaturation period of the quarternary units in those occasional years.

8.4.9 For tertiary canals of capacity less than 70 L/s (2.5 cusecs) standard precast concrete 'block' section channels will be used. For larger canals the lining will consist of precast slab sections, as indicated in Figure 8.2, with side slopes 1:1 unless local soil conditions dictate otherwise. Bund widths will be a minimum 0.5 m although generally access requirements will dictate a wider bund (Section 8.6.3). The length of tertiary canals should be limited to about 1.5 km.

8.4.10

Quarternary canals are unlined and generally are found to be of minimum size as indicated in Figure 8.2. Only for large quarternary units in flat areas may it be necessary to provide canals of greater size. Maximum length should be kept to about 500 m. Usually such canals are left to the farmers to construct and maintain however this rarely proves fully satisfactory, and we recommend that the land is acquired and the canals constructed as part of the project costs. Maintenance however is assumed to be carried out by the farmers benefitting from the canals.

8.4.11

'Turnout boxes' will be provided at each quarternary canal offtake (Figure 8.3). These will incorporate a gated offtake to the quarternary and a gated control on the tertiary canal. Because measurement is desirable, either to set flows proportional to area during normal continuous operation or to adjust flows to areas of differing crops, we recommend the use of a measurement device - such as a Cipolletti weir - integral with the gates. Additional gated controls will be introduced as necessary on tertiary canals to control water and provide adequate head for direct farm offtakes at times of low flows.

8.4.12

Farm offtakes from tertiary canals will be piped through the bund and must have a control gate or valve to allow the offtake to be closed as required. We understand that development work is proceeding at present on farm offtake design by MADA scheme in Kedah and the details of the standard offtake should be decided only in the light of their recommendations. Offtakes from quarternary canals will be simple pipes through the batas, without control gates.

8.5

Drainage systems

8.5.1

The drainage system serves two functions. Firstly it enables removal of excess rainfall from the fields and secondly it enables farmers to drain their fields when required, for instance for application of fertilisers or prior to harvesting. The first function determines the size of drains but the second function, particularly in a situation of increasing mechanisation and the possible introduction of direct seeding requiring accurate control of water levels, determines the density and layout of the channels.

- 8.5.2 The need for individual control of water indicates that the drainage system should parallel the canal system with ideally, every farm having access to a drain. However with the existing farm layouts this is impracticable and therefore similar criteria as for the layout of canal systems are adopted. As with canals we would prefer farm discharge into a quarternary or field ditch but in many cases it is impracticable to provide quarternary drains and therefore direct discharge to tertiary drains is accepted.
- 8.5.3 The design capacity of drains is based on the recommendations of JPT Procedure No. 18 (ref. 19). Flooding is permitted up to a depth of 0.3 m (12") for a period not exceeding 3 days. The 1-in-5-year design 72 hour rainfall varies in Seberang Perai between about 180 mm and 235 mm. For the drainage design a value of 220 mm has been adopted representing an average design discharge of 8.5 L/s/ha (0.12 cusecs/acre).
- 8.5.4 The water level at the design drain discharge is taken as existing ground level (i.e. field level). Typical sections are indicated in Figure 8.2. Side slopes are taken as 1:1 in smaller channels and 1:1.5 in the larger tertiary drains. Gradients are generally flat and there is little possibility of velocities approaching permissible limits for the soils. The size of both quarternary and tertiary drains is dictated by the volume of excavated material required to form bunds either side and is costed on this basis. If, however, as is usual, the quarternary drain is constructed alongside an existing field bund then the section may be reduced to the required hydraulic size.
- 8.5.5 Control of drainage water levels during presaturation will be effected with a gated control structure at the outlet of each tertiary drain. These have been costed as standard JPT structures.
- 8.6 Access
- 8.6.1 Vehicle and plant access requirements into the irrigation areas can be classed under two main categories:-

- for agricultural machinery and for transport of fertilisers and produce.
- for maintenance and operation of the irrigation and drainage systems.

The farmer requires an access road of reasonable standard suitable for regular use, designed for the largest equipment and loads likely. The O & M requirement is for lower standard track adequate for light vehicles and the occasional access of maintenance plant.

8.6.2

As with the canal and drainage systems, ideally an access road should be provided to each farm; however with the existing farm layout this would not only be impracticable but also extremely expensive in capital cost and in loss of productive land. We therefore considered initially, giving the best access reasonably possible i.e. provision of roads to each quarternary unit or equivalent area (5 - 10 ha). Within each such area it must be assumed the farmers will be working to the same cropping schedule, and it would be possible for tractors or harvesters to work through the unit from farm to farm from the point of entry. Access for such machinery to isolated farms out of step with the schedule of the majority of farms would be difficult. However, as such roads and the capital costs involved are considerable, and we are reconsidering the economic justification for roads within the tertiary unit. One of the main requirements for such access roads is the need for movement of combine harvesters between quarternary units. However if good synchronisation of cropping can be achieved then the systematic working of a combine through a tertiary unit, without the need for access to individual quarternary units, is possible, and much of the requirement for access roads is removed. The introduction of group farms would increase the probability of a well co-ordinated planting and cropping schedule.

8.6.3

The criteria and arguments in the following paragraphs are directed at the possible provision of full access roads and maintenance of tracks within the tertiary unit, and preliminary costs have been estimated on that basis. Our final recommendation however may be for a lower standard of access - either for limited (small) vehicle access

along tertiary canals only or for no vehicle access within tertiary units at all. In the latter case the assumptions would be that operation and inspection were to be carried out by motor cycle, fertilisers and grain would be carried in and out of the unit by cycle or by tractor/trailer, that combines would work from field to field crossing over quarternary canals and drains, and maintenance vehicles would gain access only between cropping seasons when the fields are fallow. In view of the uncertainties involved in the agricultural and economic success of the project the minimisation of capital expenditure is desirable and it is likely our recommendation will be for a low standard of tertiary access.

8.6.4 If full access is provided it should be designed for the large combine harvesters presently being introduced into the State. Although these machines are possibly larger than desirable it is unrealistic to assume that they can be prevented from being employed in view of the numbers presently operating in Kedah. The largest of these have track widths in excess of 3 m (10' - 0") and table widths of about 4.5 m (14' - 6"). Access roads would therefore be on bunds at least 5.5 m wide. Maintenance tracks would have an overall width of 2.5 m and bicycle paths, if possible, to every farm, 1 m.

8.6.5 Access roads should be provided along every main and secondary canal and along the major drainage courses. In many cases there are existing roads; some will need improving and upgrading; a few have been adopted by JKR and are being uprated as part of the on-going rural roads development programme.

8.6.6 If provided within the tertiary units the roads may be along either the tertiary canals or the complementary tertiary drains. If alongside the canals, then they should be at the level of the canal bank as indicated in Figure 8.2 to avoid damage to a smaller raised canal bund by the combines. If along the drain then they can be at a lower level but should still be a minimum 0.6 m above the field level to remain clear of the design flood. On the other hand a maintenance track could be at a lower level than the canal bund if alongside the tertiary canal and on earthwork quantities alone the cheaper solution

appears to be for the access roads to be alongside the drains with maintenance tracks beside the canals. However there are factors which offset this conclusion:

- local experience indicates that in many areas excavated material is generally unsuitable for fill particularly for a bund subjected to heavy road loadings. Thus the fill material for a road bund must be imported, whereas the material under the maintenance track may be excavated soil particularly if this can be placed and allowed to drain and consolidate for a period of a year or so.
- culvert access is required, at intervals of about 300 m an average to quarternary blocks on the far bank. The size of culverts across the drains are about four times larger on average than those across the canals. Moreover the canal culvert replaces that length of concrete lining and the drain culvert does not.

Thus overall there is a small cost advantage to having the access road beside the canal and we would recommend this solution generally in view of the greater importance of good access along the canal for operation and maintenance if indeed, access is provided. However in some individual cases it may be more suitable to provide such access along the drain.

8.7 Summary of main recommendations

- 8.7.1 The schemes should be operated on a 3-schedule system with a total stagger of 1½ months: 2 weeks between each schedule.
- 8.7.2 Each scheme should be divided into approximately equal blocks, each block to follow one of the schedules.
- 8.7.3 Tertiary units should be between 40 ha and 100 ha with an optimum size of about 50 ha. Flow control with measurement should be provided at the tertiary offtake.

- 8.7.4 Layouts of tertiary distribution and drainage systems are based on the existing layout of farms. To provide the best control of water for the likely increased degree of mechanisation each farm should have direct access to a supply canal and to a drain; however with the existing farm layouts this is not practicable in all cases.
- 8.7.5 Irrigation supply and drainage points should be provided to each 'quaternary' unit - an area of between 5 and 10 ha within which farmers must co-operate and closely follow the same cropping schedule.
- 8.7.6 Where reasonable, supply and drainage should be from and to quaternary/field canals and drains. Farm-to-farm flow should generally be limited to three farms or 300 m. Farms adjacent to tertiary canals and drains may in some cases have direct access to the tertiary channels.
- 8.7.7 Tertiary canals should have concrete lining. Quaternary canals would be unlined. Quaternary offtakes should have gated control with a flow measurement device.
- 8.7.8 Road access suitable for combine harvesters should be provided along main and secondary canals and the major drainage channels. Road access along tertiary canals and maintenance tracks along tertiary drains are desirable but may not be economically justifiable.
- 8.8 Sample areas: Preliminary designs and costs
- 8.8.1 Figures 8.4, 8.5 and 8.6 show preliminary layouts for part of Sg. Muda sample area, part of Sg. Kulim sample area and the whole of the Alma scheme. These illustrate the application of the criteria discussed in the previous sections. Changes may be made to these layouts when the surveys are fully plotted, and additionally one or two aspects are still under consideration. For instance the need for quaternary canals in the illustrated part of the Kulim sample area (Figure 8.5) is arguable - it would be possible to supply direct from the tertiary although this would require field to field flow over a distance of about 300 m - the maximum suggested as a criterion.

8.8.2 Preliminary costs for these three sample areas are detailed in Appendix B. The unit area costs of the tertiary development alone excluding land acquisition are calculated as:-

Sg. Muda sample area : \$7,600/ha

Sg. Kulim sample area: \$5,500/ha

Alma scheme : \$7,000/ha

The difference in unit cost between the areas reflects the more regular pattern of farm holdings in the Kulim scheme which enables shorter, more direct tertiary canals and drains and the existing layout of canals which favours tertiary units, on average, larger than that proposed as a criterion and found suitable in the Sg. Muda area. (The proposed densities of tertiary canals in the three areas are 25 m/ha, 15 m/ha and 21 m/ha respectively.)

8.8.3 These costs are fairly high for development of this type but must be considered as a preliminary estimate of the upper limit of costs. A number of the items included must be reconsidered in the light of these costs - the main one being the standard of access, as discussed in 8.6.2. The tertiary canals and associated access roads - designed for combine harvesters - represent between about 50% and 75% of these costs. As can be seen from Table B.2 the tertiary access road represents at least 30% of the total canal costs i.e. of the order of \$1,500/ha.

8.8.4 In addition other concepts must be given further consideration for example the provision of maintenance access beside tertiary drains, and the extension of tertiary canals through to end-control structures adjacent to drains - frequently this last reach of canal could be an unlined quaternary, without access alongside.

8.8.5 It is likely therefore that the costs of the final recommendations will be lower than those quoted here.

Scheme costs

8.8.6 As a preliminary estimate of total scheme costs Tables B.7 and B.8 present a total cost of constructing all the works in the Sg. Muda and Sg. Kulim schemes. These costs must be treated as provisional only.

They have been estimated assuming a uniform tertiary development cost through the whole of each scheme based on the value for the sample area. Main and secondary canal and drain costs have been estimated only approximately - detailed analyses of the individual proposals have not been completed.

8.8.7 The total costs for each scheme, including engineering design and supervision but not including land acquisition are calculated as:-

Sg. Muda scheme : $\$85.4 \times 10^6$

Sg. Kulim scheme: $\$29.1 \times 10^6$

8.8.8 The land acquisition costs vary considerably through the province and within each scheme. Preliminary estimates of the areas required and the average cost, based on information from the Federal Valuation Office (Section 2.5) are:-

Sg. Muda scheme 460 ha at $\$20,000/\text{ha} = \9.2×10^6

Sg. Kulim scheme 210 ha at $\$40,000/\text{ha} = \8.4×10^6

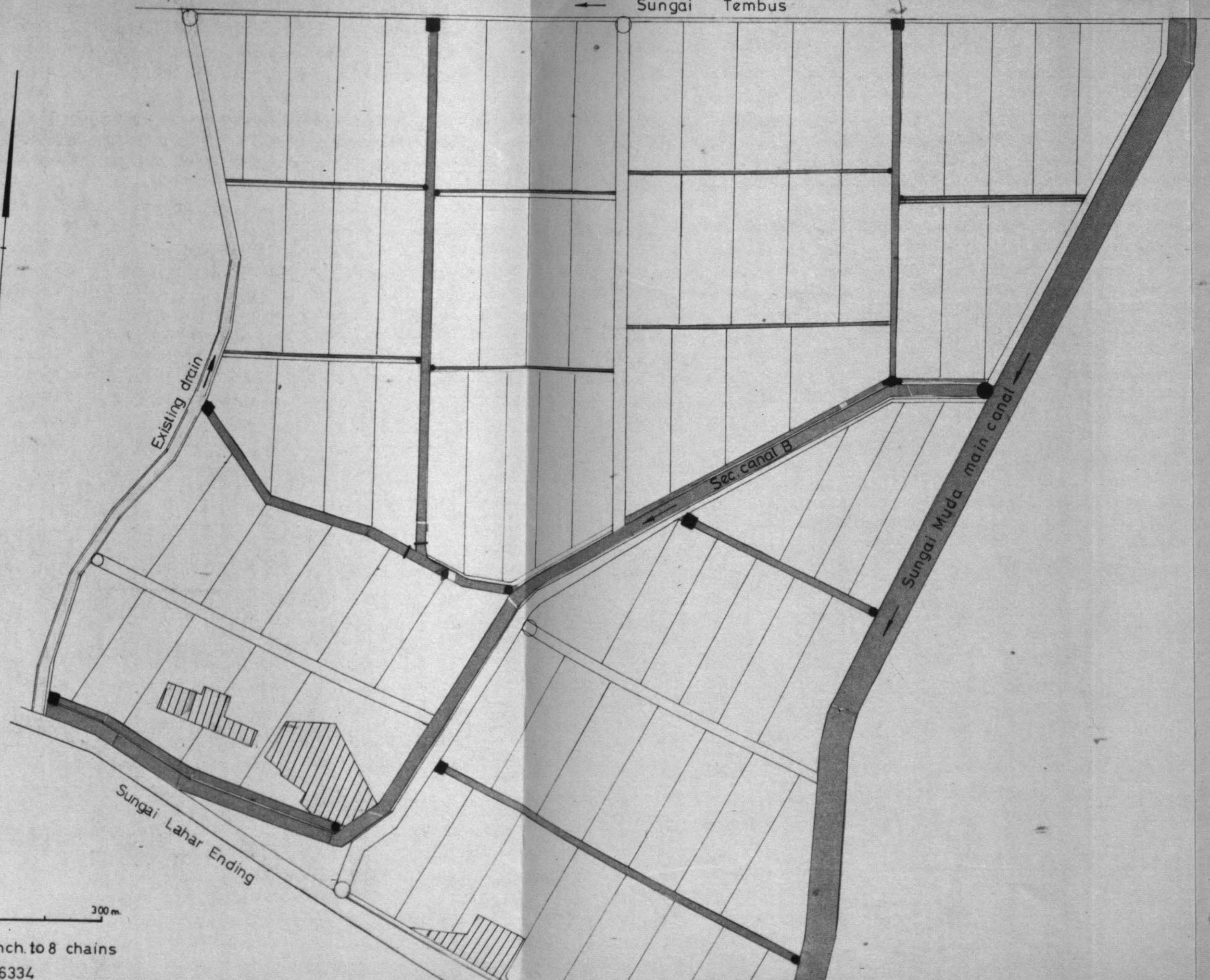
Table 8.1 Summary of Existing Canal and Drain Densities

Scheme	Present Gross area (ha)	Canals		Tertiary		Drains	
		Main (m/ha)	Sec. (m/ha)	(m/ha)		Main (m/ha)	Sec. & Tert. (m/ha)
Sg. Muda	7,125	1.7	10	14		9	5
Pinang Tunggal (incl. Pokok Jeneris)	1,366	8	8	12		8	5
Tasek Gelugor	250	← 37 →		9		16	
Sg. Jarak	781	13	23	7		8	8
Jarak Tengah	98	← 25 →		14		18	
Sg. Kulim	3,369	2	5	16		13	
Machang Bubok	136	22	← 40 →			26	27
Renjau	20	← 41 →				100	
Kuala Tasek	24	← 41 →				35	13
Tasek Junjong	167	← 36 →				20	27
Kg. Kepala Gajah	66	← 55 →				20	37
Alma	99	← 22 →				6.5	4

SUNGAI TEMBUS
Sungai Tembus

LEGEND

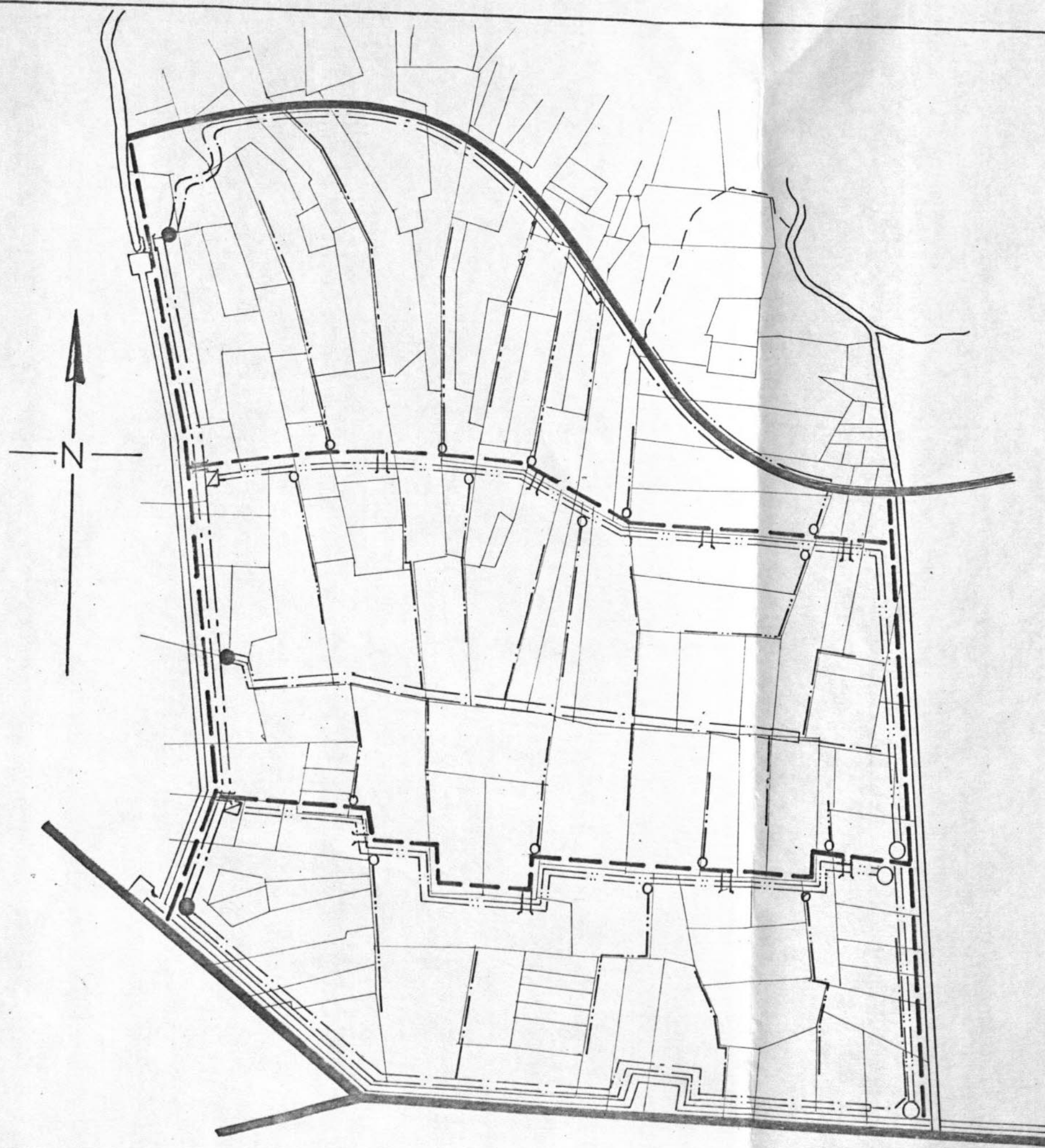
- CONSTANT HEAD ORIFICE OFFTAKE
- IRRIGATION CONTROL
- DRAINAGE CONTROL
- MAIN CANAL
- SECONDARY CANAL
- TERTIARY CANAL
- QUATERNARY CANAL
- MAIN DRAIN
- SECONDARY/TERTIARY DRAIN
- FIELD DRAIN
- KAMPUNG LAND



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SUNGAI MUDA SCHEME
PART SAMPLE AREA
LAYOUT WITH LAND CONSOLIDATION

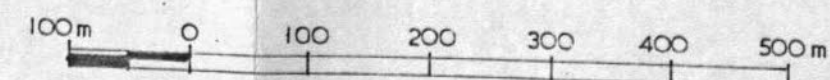
FIGURE 8.1



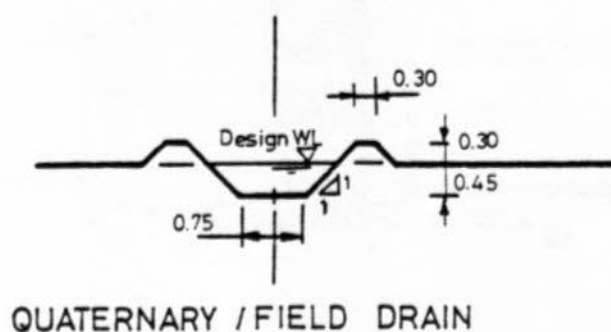
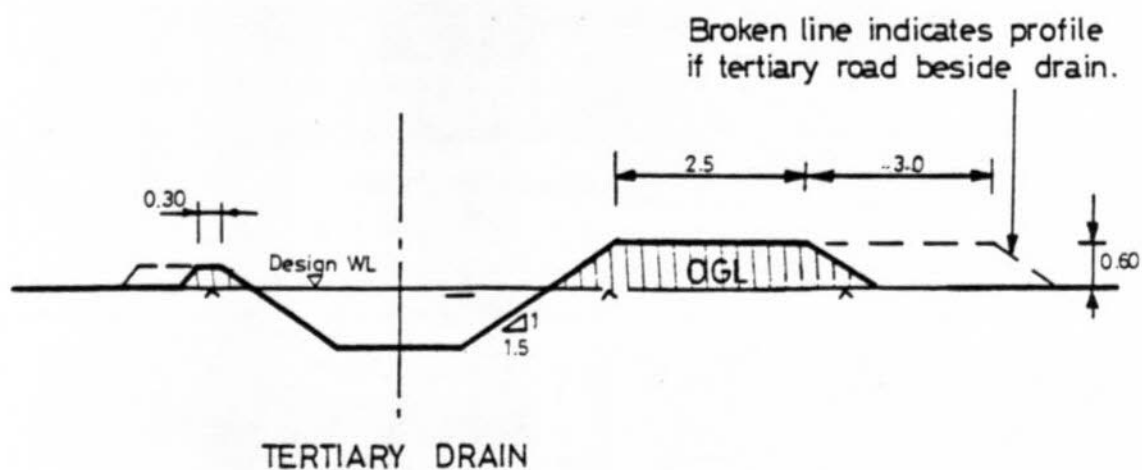
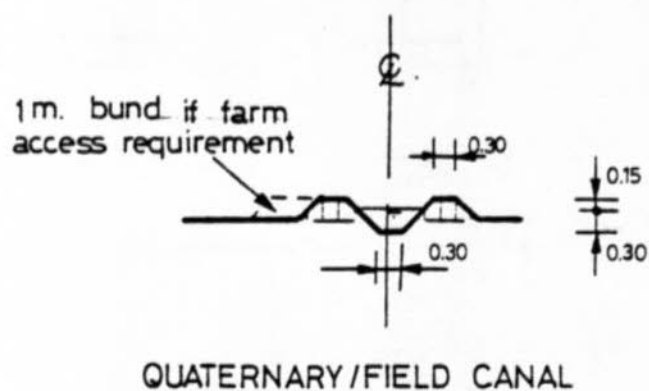
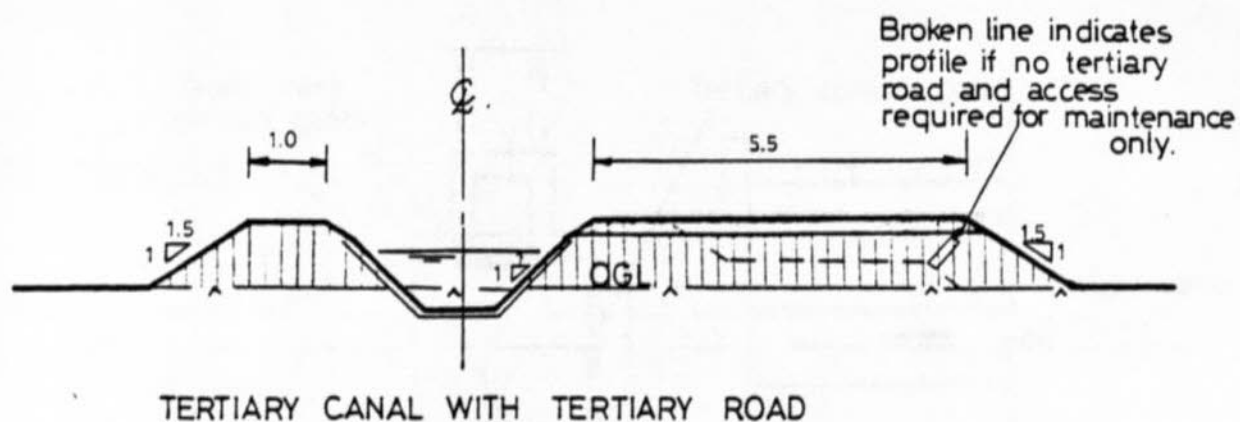
LEGEND

- Existing rivers and drains
- Proposed tertiary drains
- Proposed field drains
- Existing sec./tert. canals
- Proposed tertiary canals
- Proposed quat. canals
- Existing roads
- Proposed farm roads
- Proposed CHO turnout
- Proposed quat. turnout box
- Proposed drain control
- Existing irrigation end control
- Proposed irrigation end control
- Proposed access culverts

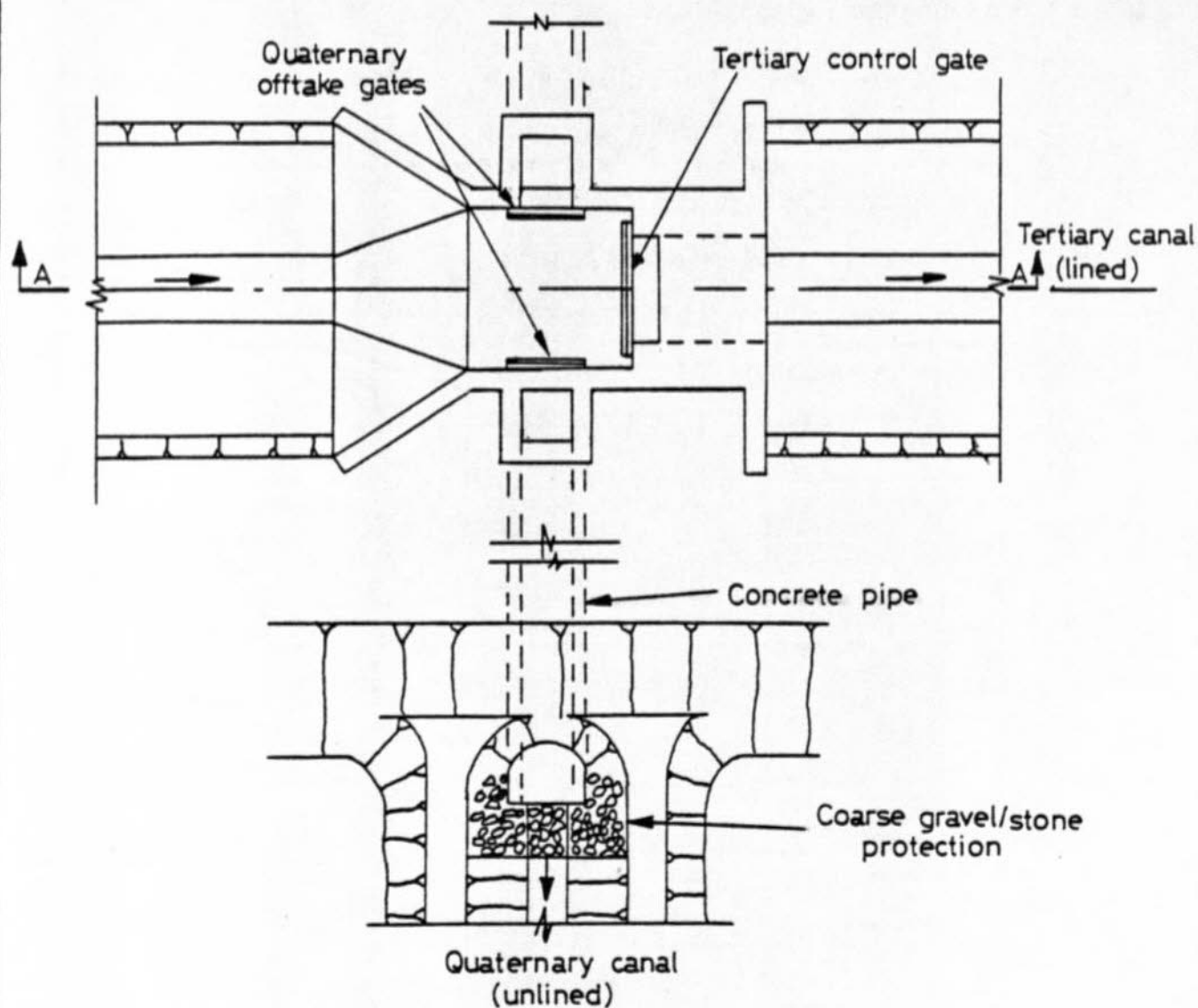
SCALE:- 1 : 6,336



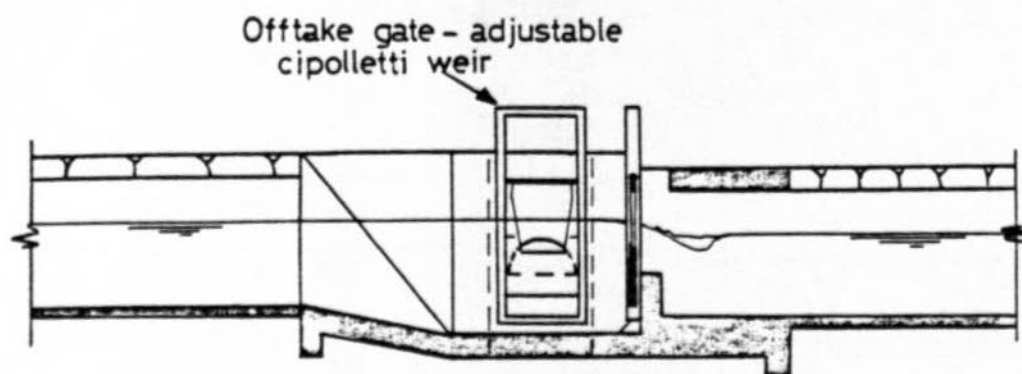
SG. KULIM SCHEME
PART SAMPLE AREA LAYOUT
PRELIMINARY
FIGURE 8.5



CANAL AND DRAIN DETAILS
FIGURE 8.2



PLAN



SECTION A - A

QUATERNARY TURNOUT BOX
FIGURE 8.3



LEGEND

- EXISTING MAIN AND SECONDARY DRAIN
- PROPOSED TERTIARY DRAIN
- PROPOSED FIELD DRAIN
- PROPOSED SECONDARY DRAIN
- EXISTING MAIN AND SECONDARY CANAL
- PROPOSED TERTIARY CANAL
- EXISTING TERTIARY CANAL
- PROPOSED QUATERNARY CANAL
- EXISTING QUATERNARY CANAL
- PROPOSED FARM ROAD
- EXISTING MAIN EXCESS
- PROPOSED DRAINAGE CONTROL
- PROPOSED IRRIGATION END CONTROL
- PROPOSED QUATERNARY BOX
- PROPOSED CHO
- EXISTING UNDER DRAINAGE CULVERT
- PROPOSED IRRIGATION SIPHON
- PROPOSED ACCESS CULVERT
- PROPOSED IRRIGATION CONTROL
- EXISTING BRIDGE CROSSING
- PROPOSED BRIDGE CROSSING

0 500 m.

Scale: 8 chains to 1 in. — 1:6334

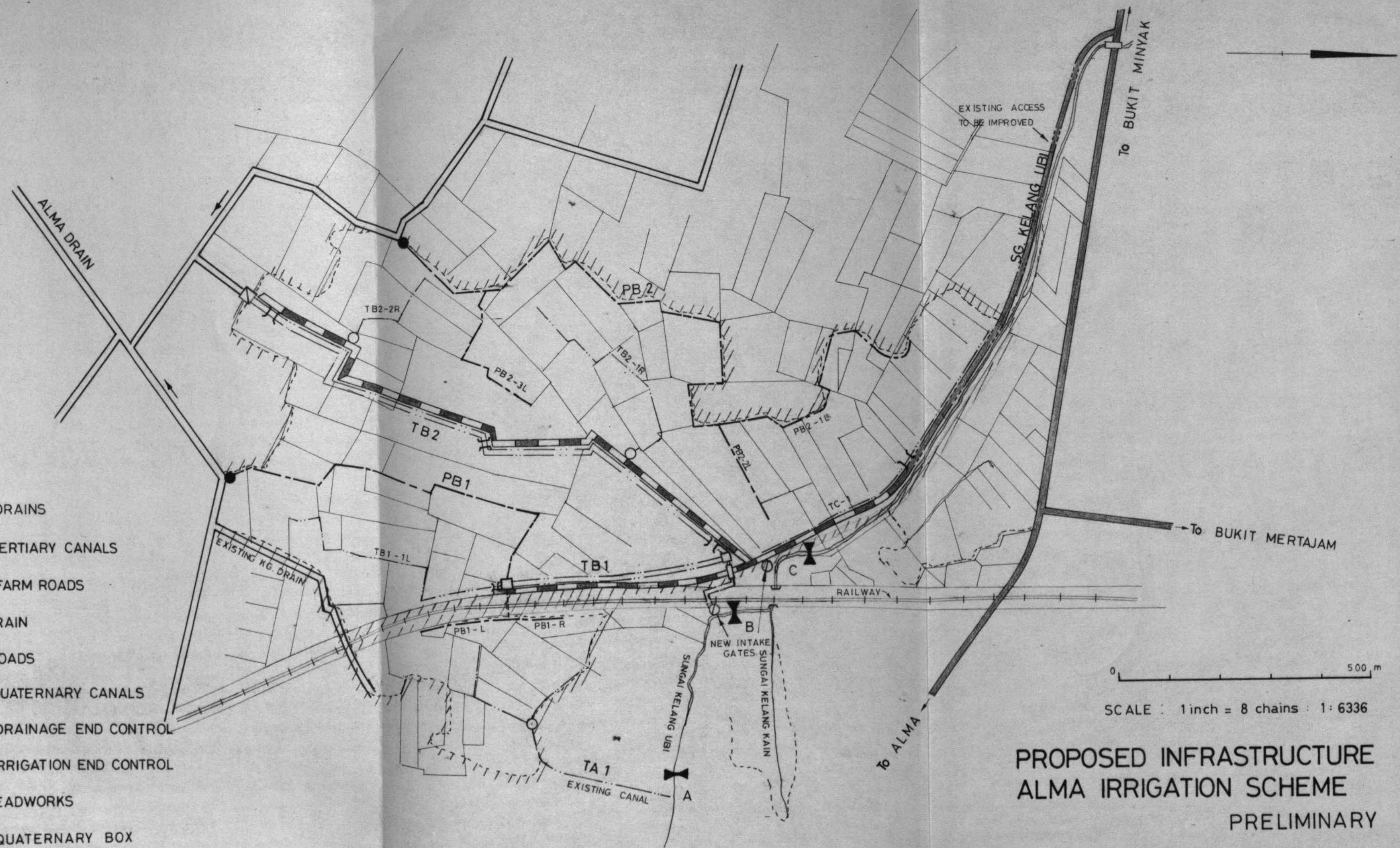
SG. MUDA SCHEME
PART SAMPLE AREA LAYOUT
PRELIMINARY
FIGURE 8.4

SCALE: 1 inch = 8 chains

LEGEND

- PROPOSED DRAINS
- === PROPOSED TERTIARY CANALS
- == PROPOSED FARM ROADS
- == EXISTING DRAIN
- == EXISTING ROADS
- PROPOSED QUATERNARY CANALS
- PROPOSED DRAINAGE END CONTROL
- ▣ PROPOSED IRRIGATION END CONTROL
- ⌵ EXISTING HEADWORKS
- PROPOSED QUATERNARY BOX
- PROPOSED DIVISION BOX

== PROPOSED ACCESS CULVERT



PROPOSED INFRASTRUCTURE
ALMA IRRIGATION SCHEME
PRELIMINARY
FIGURE 8.6

9. PROPOSALS FOR AGRICULTURAL IMPROVEMENTS

9.1 General

9.1.1 The most important requirement for successful future agriculture is to persuade the farming community that, with the various forms of assistance due to be provided, there is a future in agriculture in the State and that it can and will provide a proper standard of living. However the farmers will have to accept that in order to realise this aim their farming practices will have to change, and above all that farm working in large units must be adopted in all areas where the independent farm operator is failing to maintain either his agricultural output or his living standards. The expression "group farming" is used in this report to cover all of the possible methods available for enlarging the operating farm unit; a few of these, based on co-operative principles, are already in an experimental or prototype stage. (Section 4.3).

9.1.2 Agricultural improvement is often limited by a number of constraints namely physical, socio-economic and technical. The small size of holdings as is encountered in the project area makes them uneconomical to operate except for subsistence agriculture, but a change in the farming system from the existing to an intensive type of system or group farming can still make farming attractive despite the limitation of farm size. The constraint of water can often be overcome by engineering innovations and designs and the constraint of soils by suitable management and intelligent choice of crops and soil improvement practices. Socio-economic constraints such as farmers' attitudes, values, customs, taboos, etc. are more difficult to overcome but are not insurmountable through a sustained educational process and extension.

9.1.3 In the case of technical constraints, it can be said that the technology of high productivity is generally available, such as good seeds and planting materials, fertiliser practices, pests and diseases control etc., but the available technologies are too slow in becoming adopted by the farmers. The availability and access to production inputs are adequately covered by Government schemes through its various agencies and in the case of padi, through the Padi Fertilisers Subsidy Scheme serviced by the LPP. But yields of padi fall far short of

expected yield despite use of high yielding varieties and subsidised fertilisers. Investments in irrigation infrastructures are only justified if there is an added investment in increasing the number of grassroot extension workers (AT) and improving the qualities of these workers through a sustained programme of training. The present ratio of extension workers of 1:1,300 farming families is too wide a ratio for agricultural extension to be effective. It is highly desirable for the ratio to be narrowed down to 1:600 or 800 in the shortest possible time.

9.1.4 The basis used for projecting future farm incomes for both small-holders and members of group farms is given in Section 10.3.

9.2 Padi production and improvement

Introduction

9.2.1 Padi production in the project areas, both irrigated and rainfed, is low when compared with production in the Muda Irrigation Project in Kedah/Perlis. Yield trials carried out on farmers' fields by MARDI using high yielding varieties (HYV) Sri Malaysia 2 and Sekencang (MR7) have clearly demonstrated that yield of 6,496 kg/ha (1,030 gt/ac) for Sri Malaysia 2 and 6,000 kg/ha (950 gt/ac) for Sekencang (MR7) are possible. These yield figures are used as a basis for assessing production efficiency in the project areas. Compared with yields in the Muda Agricultural Development Authority (MADA), yields of padi in Seberang Perai Utara represent only 85% and 68% in terms of padi unit area production for the main and off-season respectively. Yields in Seberang Perai Tengah again when compared with those in MADA represent only 66% and 54% for the main and off-season respectively. For Seberang Perai Utara and Tengah, therefore, there appears to be immense scope for improvement of padi yields even to the level of production in MADA. Whereas the average production of MADA is 64% of the yield potential of Sekencang (MR7), that of Seberang Perai Utara is 48% and Seberang Perai Tengah is 37.6% of the yield potential of Sekencang (MR7). See Table 9.1.

9.2.2 Many environmental factors affect rice growth and yield and these may be divided into 2 broad groups, namely, the physical factors and the environmental factors introduced by man. The physical factors consist of elements of weather and soil whereas the environmental factors introduced by man include variety, fertilisation, weed control, pests and diseases control and water management. The highest yielding variety cannot be expected to express its full potential under unfavourable physical and introduced environment. Conversely, a low yielding variety, even if given the most favourable environment, will not yield well. Maximum yield, therefore, is only possible when different factors for growth are controlled and utilised efficiently.

Varieties

9.2.3

Not less than 10 different varieties of padi are grown in the various scheme areas. The most popular varieties are Katek, Improved Mahsuri (Anak Dara), Mat Candu and some earlier released varieties such as Bahagia and Mahsuri. These varieties have maturation periods between 120 - 150 days and are suitable for double cropping. Shorter maturation varieties of 120 - 125 days such as Sekencang (MR7) or Improved Mahsuri (also known as Anak Dara) takes priority over longer maturation varieties and from management point of view it allows greater latitude for delayed sowing in the event of delays in the supply of water. In any chosen variety, purity of seeds is equally important to ensure uniform ripening of grains thus reducing loss due to birds and other pests.

Missing the point have

Nursery management

9.2.4

The key to a good rice crop starts with the raising of healthy and robust seedlings. Healthy and robust seedlings withstand transplanting shock better and recover earlier to produce early valid tillers. It has been established that there is a direct correlation between seedling quality, seedling age and ultimate yield. To raise good, robust and healthy seedlings, the wet seed bed method is preferred. The nursery should be finely worked and seed beds of $1\frac{1}{2}$ m (5 ft) wide raised to a height of 5 - 6 cm (2 in) are constructed leaving a shallow drain of 25 - 30 cm (10 - 12 in) between the beds to facilitate walking and supervision. The beds are properly levelled and fertilised with mono-ammonium phosphate (Ammophos 11:48) at the rate of 1 kg (2.2 lb) for every 500 sq. ft. of nursery. Pre-germinated seeds are used and sowing rate is one gantang of seed per 500 sq. ft. nursery. Pre-germinated seeds are prepared by soaking the seeds for 24 hours and incubated for a further 48 hours. During the first few days of growth of the seedlings, water is admitted just enough to saturate the soil. After this period, water level is gradually increased as the seedlings grow in height. The water level is then maintained at a depth of 5 cm (2 in) with occasional draining to encourage vigorous seedlings with short roots. A supplementary topdressing with $\frac{1}{2}$ kg (1 lb) urea for every 500 sq. ft. of nursery seedlings at 15 days after sowing may be necessary.

The nursery seedlings are regularly inspected and necessary measures are taken to control pests and diseases. At the 6-leaf stage or 25 - 30 days after sowing, the seedlings are ready for transplanting as tillering begins about this time.

Transplanting

- 9.2.5 Seedlings are transplanted at about 5 - 6-leaf stage or between 20 - 30 days old. Healthy and robust seedlings may be transplanted at an early age to encourage early tillering of valid tillers and to obtain better yield. Spacing is in accordance with recommendation depending on variety and square planting in straight rows is preferred to facilitate better weed control by use of mechanical row weeder. A planting density of about 16 hills/m² (25 cm x 25 cm) is suggested. With present day varieties, there is generally a favourable response to higher plant density, more so in less fertile soils. On seedling number, 3 - 4 per hill appear to be quite adequate although for certain variety e.g. Setanjung (MR1), 8 seedlings per hill with a plant density of 25 hills/m² (20 cm x 20 cm) gave the highest yield (MARDI Information Paper No. 1). Planting depth varies between 5 cm to 15 cm (2 in to 6 in) depending on ages of seedlings and varieties. Older seedlings > 25 days appear to be least affected by deeper planting (15 cm) but younger seedlings appear to yield better at shallow planting depth (5 cm). However, too deep planting (> 15 cm or 6 in) is to be avoided as tiller number can be considerably reduced and maturation period extended.

Fertilisers

- 9.2.6 Fertilisers are absolutely necessary to achieve high yield and this is particularly relevant when using present day high yielding varieties (HYV) which have potential yields of 5,000 - 6,000 kg/ha (790 - 950 gt/ac). The level of nutrients depends on several factors such as fertility of soil, quality of irrigation water, variety and season grown. Fertilisers are either in the form of mixtures or compounds containing the 3 essential elements nitrogen (N), phosphorus (P) and potassium (K). For Seberang Perai Utara and Tengah, the recommended level of nutrients per acre is 80 lb N, 20 lb P and 20 lb K

for both the main and off-season (MARDI Information Paper No. 7, 1979) and it is also recommended that 40 lb N and all the P and K be applied 14 days after transplanting. The balance of the 40 lb N should be applied at about panicle initiation stage which is 6 - 7 weeks after transplanting or about 30 days before heading. For Mahsuri variety, the total N should be reduced to 60 lb/ac.

9.2.7 On the form of fertilisers for the various nutrients, it is suggested that N is to be applied as Urea which could be used in the basal mixture or topdressing application. The use of ammonium sulphate or ammonium chloride is not recommended owing to their acid-forming character. N in nitrate form is not recommended because of leaching and denitrification losses. Phosphorus is applied as Christmas Island Rock Phosphate (CIRP) and Potassium as Muriate of Potash (KCL). It is as yet too premature to recommend the application of K as a topdressing although recent studies by MARDI have shown that increase in grain yield has been obtained in Seberang Perai.

9.2.8 To enhance grain yield, the time of application of nitrogen is of considerable importance. On soils deficient in nitrogen, it is necessary to apply nitrogen at transplanting but on better soils, nitrogen may be applied after transplanting during the active valid tillering stage. At the panicle initiation stage, nitrogen application enhances spikelet number and hence the final yield of grain. When applying fertilisers, particularly urea, it is important to incorporate them into the reducing zone of the soil to obtain maximum effect.

Crop protection

9.2.9 Weeds are one of the major causes of low rice yields as they compete with the rice plants for nutrients, sunlight and space and they also serve as alternative host plants of various pests and diseases thus increasing their infestations. Control of weeds is generally done by hand and cost \$30 - \$40 per acre per round. Because of the high cost of manual weeding, it is suggested that more use of herbicides be made for weed control. In the project areas, broadleaved weeds are more prevalent than grass weeds. Grass weeds can be reasonably controlled by early inundation of the fields after transplanting. For the control

How applied?

probably too late for
the herbicide and
the pesticides may
not be necessary.

of broadleaved weeds, it is suggested that 2, 4-D butylester e.g. RUMPUTOX or ESTERON (Zeland D) be used and applied at the rate of 2 lb/ac at 3 weeks after transplanting. However, in order to save cost of applying fertilisers and the herbicides separately, both may be mixed and applied together in a single operation.

9.2.10 Of the insect pests, stemborers, planthoppers and padi bugs are the most important. Stemborers are controlled by the use of Endosulfan or Gamma BHC at the rate of 1.5 lb a.i per acre. Planthoppers are controlled by fogging with DDT or spraying with Carbaryl at 0.1% a.i. Padi bugs can be controlled by spraying with either Carbaryl, Gamma BHC or Endosulfan or Diazinon, all at 0.1% a.i. As many of the chemicals are very specific in their use and concentration for the control of various species of insect pests, the Department of Agriculture should always be consulted for advice.

9.2.11 Of the diseases, Seedling Blast, Neck Rot and Sheath Blight are common in the project areas. These are difficult to control once there is an outbreak although various fungicides are marketed. Many varieties of padi have been bred for their resistance to the diseases and should be used to replace susceptible varieties wherever possible.

9.2.12 Rat is by far the most serious in the study area. It attacks rice in all stages of growth. In the 1978/79 main season and the 1980 off-season, rat attack was reported over 1,093 ha (2,700 ac) and 654 ha (1,616 ac) respectively (refs. 21,22). Rat infestation persists because of large areas of abandoned fields and blukar lands which serve as harborage for rats and where they multiply unmolested. Secondly, there are abundant food sources in idle farm areas. Control requires community action and total involvement of the entire village or kampong. A smooth and functional organisation should be created and maintained.

Irrigation water management

9.2.13 There are two methods of irrigating lowland rice, namely, continuous submergence and intermittent irrigation and drainage. Results of experiments conducted in Taiwan and in the Philippines show no differences in yields between the two methods of irrigation. In either method, it

is important that water in the field should be drained 7 - 10 days before harvesting or when the grains are turning from green to yellowish, to hasten the maturity of late tillers and improve harvesting conditions. Too early draining, especially in lighter soil, soon after heading may give rise to poorly developed grains and ultimately lower yield. In the study area, there is a general tendency for farmers to commence draining early and such a practice is to be discouraged.

- 9.2.14 Depth of flooding is yet another point to be considered. Farmers in the study area have a tendency to transplant in deep water. Under this condition the tendency is towards the use of older and taller seedlings and deep planting to avoid seedlings to float out of the soft soils. Transplanting should ideally be done in a shallow sheet of water (2.5 cm) which lends itself to the use of younger seedlings and shallow planting for better yield. However the land in the project area is seldom level enough to permit this. Subsequent flooding should be limited to a depth of not more than 10 cm as there is no distinct advantage in flooding fields beyond this depth.

9.3 Direct sowing of padi

- 9.3.1 In view of the labour shortage, direct sowing of padi without the laborious task of transplanting has considerable attractions. We assume that direct sowing will be necessary for the group farms we are putting forward. Brief notes on the method as it affects agricultural inputs and engineering criteria follow.

Land preparation and irrigation control

- 9.3.2 Land must be as level as possible as not to allow any part of the field exposed when flooded. Weeds are normally found in areas not covered by water. Land can be prepared dry or wet but the dry method is preferred for large scale mechanisation to obtain a fine seed bed for drilling. Positive control of water is essential as it is desirable to be able to control irrigation, drainage and maintain water level as and when required for management of the rice plant in the early stages of growth and to effectively control the growth of weeds.

Rice variety

- 9.3.3 Not all varieties are suitable for direct sowing. Suitable varieties are those which are stiff-strawed and resistant to lodging. Varieties such as Setanjung (MR1), Sekencang (MR7) and Jaya are all suitable.

Rates of application

- 9.3.4 Sowing rate depends on the tillering rate of the variety used. Higher seed rate is used for low tillering variety and vice versa. Seeds of lower germination require a higher seed rate. It is however advisable to use seeds with a high germination percentage and as far as possible, use of seeds with germination of less than 80% should be avoided. Normal seed rate used in other countries is of the order of 80 - 100 kg/ha (70 - 90 lb/ac). However much lower rates are being tried in experiments under way in the State.

Method of direct sowing

- 9.3.5 There are several methods, namely:

- (a) Drilling in dry soil
- (b) Broadcast on mud
- (c) Broadcast in water
- (d) Drill on mud

- 9.3.6 Drilling in dry soil is the standard method used and is also the method now practised in Tanjung Karang where approximately 5,000 acres of padi are directly seeded. The seeds are drilled in 1 - 1.5 cm below the soil surface spaced at approximately 25 cm or 10 in. between rows and covered. After drilling, water is admitted just enough to wet the soil. As the seedlings grow, the depth of the water is gradually increased in the same way as seedlings in wet nurseries are managed. The other three methods (b) - (d) require the use of pre-germinated seeds.

- 9.3.7 Direct seeding has two advantages and these are:-

- (a) It cuts down labour cost by eliminating seed bed preparation, care of seedlings in the seed bed, pulling and transporting seedlings and transplanting.

- (b) Directly seeded rice matures 7 - 10 days earlier than transplanted rice.

As far as yield is concerned, there are no fundamental differences in yield between direct seeding and transplanted rice if good management is used with each method. Good yields are understood to be obtained in both the Tanjung Karang and MADA areas.

	Direct Seeding	Transplanting	Ratio
Yield (kg/ha)	2,445	2,542	1.039
Yield (kg/ha)	2,727	2,715	0.996
Yield (kg/ha)	25.3	24.7	0.976
Yield (kg/ha)	28.2	28.3	1.004
Yield (kg/ha)	23.4	22.2	0.949
Yield (kg/ha)	22.4	22.9	1.022
Yield (kg/ha)	21.2	20.2	0.953

AVERAGE CROP YIELDS AND PRODUCTION EFFICIENCY

Yield Potential a) Variety Sri Malaysia 2^a = 6,496 kg/ha
 b) Variety Sekencang (MR 7) = 6,000 kg/ha

Production/ areas Crops	Pen. Malaysia ^{b/}	MADA ^{b/}	SPU ^{c/}	SPT ^{c/}
Main season	2,492 kg/ha	3,418 kg/ha	2,905 kg/ha	2,245 kg/ha
Off-season	2,862 kg/ha	4,227 kg/ha	2,875 kg/ha	2,271 kg/ha
Production efficiency	%	%	%	%
Main season a)	38.3	52.6	44.7	34.6
b)	41.5	60.0	48.4	34.9
Off-season a)	44.1	65.1	44.3	37.4
b)	47.7	70.4	47.9	37.8
Average production efficiency (% of Sekencang)	45.0	64.0	48.0	37.6

a/ MARDI Report No. 54, 1977, ref. 23

b/ Padi Production Survey, DOA 1978, ref. 24

c/ JPT Pulau Pinang (unpublished data)

10. ENTERPRISE SELECTION AND FARM PLANNING

10.1 Introduction

10.1.1 Traditionally the irrigation schemes of Seberang Perai have been almost entirely devoted to rice monoculture with two crops per year being grown throughout the majority of the area. A small area of diversified cropping, about 200 hectares of rice and vegetables, is practised in part of the Pinang Tunggal scheme, where topography and land levels have precluded double rice cropping. Double rice cropping has come under increasing pressure in recent years and padi land has been abandoned at an alarming rate. The reasons for abandoning land are well known and are generally listed as poor drainage, staggered planting, difficulty in controlling rodent pests, the small size of holdings, and high proportion of tenant farmers. Together they have resulted in low levels of income which have not been competitive with incomes offered in other rapidly expanding sectors in the urban-industrial areas.

10.1.2 The existence of highly competitive alternative employment opportunities has therefore been an important factor influencing the agricultural proposals in this chapter. It has not so much influenced the choice of crop, since this will primarily be determined by soil and agronomic considerations, but the system under which the crop will be grown. There has been no deliberate attempt to create rural employment through the promotion of labour intensive production systems or techniques. Instead the primary aim has been to retain those areas presently being cultivated and to bring abandoned land back into cultivation. Thus, priority has been attached to identifying systems of cultivation which are practically feasible and which will provide those participating in them with incomes and working conditions that are competitive with those offered in other industries. This has meant that the introduction of more intensively mechanised operations has received considerable attention and that economic criteria such as returns to farmers' labour have assumed greater importance.

10.2 Crop selection

Land and water

10.2.1 The main factors influencing the choice of suitable crops and ultimately cropping patterns proposed, are the quality of the soils and availability of irrigation water. The majority of soils throughout the area are deep, moderately developed, heavy clays of marine origin. Whilst their fine texture and slow drainage characteristics make them well suited to rice cultivation, they restrict their suitability for the cultivation of other annual crops.

10.2.2 In terms of water usage rice has the highest requirement of the potential annual crops. The irrigation water supplies in the average year however, are adequate for rice cultivation in the main and off-seasons, throughout all of the Seberang Perai schemes apart from Juru. In one year in five water shortages may be experienced in the major schemes. These will occur at the beginning of the off-season and will be of about one-third of the crop. Potentially, one in ten year low flows could be much more serious, but existing plans for regulation of the major water sources in Kedah State should result in the impact of low flows in these years being negligible in the future. Overall the availability of water does not impose a serious constraint on the selection of crops.

Markets

10.2.3 The availability of markets for agricultural produce is not likely to restrict the type or quantities of crops grown. Pulau Pinang is a deficit rice producing area with the balance between production and consumption being made up by transfers from the neighbouring State of Kedah. Malaysia as a whole is a net importer of rice and the Government has a stated objective (Fourth Malaysia Plan: 1981 - 1985) of attaining self-sufficiency in rice production. In terms of Government policy, increasing rice production is clearly important. Of the other grains, maize is also important with almost 300,000 tonnes being imported in 1980. There should be little difficulty in marketing maize grain in Seberang Perai particularly as the area has a well developed feed milling industry located at Butterworth.

10.2.4 The market potential for fruit and vegetables is also good. The recently completed market studies for the Balik Pulau/Seberang Perai: Integrated Agricultural Development Project (MIDF Industrial Consultants Sdn Bhd: July 1980) indicated that to satisfy the market potential in 1985 the areas of vegetables and fruits could be increased by about 1,040 and 8,360 hectares respectively. The potential for bananas was particularly important (2,550 hectares).

Selected crops

10.2.5 Given the limitations on land capability and the Government's policy to encourage rice cultivation, it is essential that rice cultivation should feature to the maximum extent possible in the cropping proposals for the area. The farmers themselves prefer to cultivate rice and are familiar with its husbandry. Furthermore the Government's agricultural services provided through Jabatan Pertanian and LPP are particularly geared towards this crop. Given the present price structure, subsidies and potential yields, it is a crop giving relatively high returns to both land and labour. (Section 10.4 Table 10.1). There is no good reason therefore, to propose any major alternative to rice monoculture.

10.2.6 Although large scale expansion of vegetable growing cannot be recommended, vegetable production by the existing growers will be continued with the project. Interviews with farmers indicated that with an improved irrigation reticulation and better command of the current vegetable areas, the farmers would continue to grow vegetables in the off-season. They would prefer however, to have a mixed system with a rice crop in the main season.

10.2.7 The introduction of perennial fruit such as bananas as an alternative to double rice cropping is not recommended. The fine textured soils and poor drainage whilst well suited to rice cropping are not suitable for the cultivation of fruits. Given that double rice cropping is possible virtually throughout the Seberang Perai schemes, the additional costs of drainage and soil ameliorative measures which would be necessary for fruit cultivation could not be justified.

10.3 Crop production systems

10.3.1 The current system of rice production (and vegetables in Pinang Tunggal) is based on individually operated smallholdings ranging in size from less than 0.2 ha to over 2 ha with an average holding size of between 0.8 and 0.9 hectares. The production system is dependent upon a labour intensive technology with land preparation being the only operation completely mechanised. Mechanised harvesting employing contractors however, has recently been introduced on a minority of farms. This system has continued to operate successfully in the north-eastern part of the Sg. Muda scheme, Pinang Tunggal and some of the smaller schemes. In these areas a cropping intensity of 200% has largely been maintained. Being distant from the urban-industrial centres, they are less susceptible to the pressures created by alternative employment opportunities than areas to the south, and it is quite likely that a system of individual smallholder cultivation will persist.

10.3.2 In the southern part of the Sg. Muda scheme and Seberang Perai Tengah (mainly the Kulim scheme) smallholder cultivation has not survived, and since an alternative production system has not evolved, large areas of land (about 4,800 hectares) have been left uncultivated. If this process is to be halted and abandoned land returned to cultivation, an alternative system of production which is less dependent upon hand labour and employs higher levels of technology will have to be introduced. A number of labour saving innovations have already been adopted in other rice growing areas of Malaysia. For instance, the use of combine harvesters is now widespread throughout the MADA scheme in Kedah, and direct sowing is being carried on successfully in parts of MADA and at Tanjung Karang in Selangor.

10.3.3 Although these innovations are probably more easily introduced into larger scale units where irrigation can be more rigidly scheduled, they are clearly becoming important in smallholder rice production also. In view of this we do not believe that re-organisation of smallholders into larger units or groups is essential to the introduction and adoption of labour saving innovations, and therefore propose that smallholder production systems should continue in those areas where they are currently operating successfully and which are expected to

remain in production were the project not to be implemented. Should the farmers voluntarily form larger groups or producer associations with a view to introducing larger scale mechanised operations they should be given every encouragement.

10.3.4

As it is unlikely that smallholder cultivation can be easily reintroduced throughout those areas already abandoned, a larger scale mechanised system based on groups of farmers (owner-operators and tenants) is proposed. The experience in other schemes in Malaysia suggests that such a system would be technically possible and that it could lead to more rapid rehabilitation of abandoned land. The major problems with group farming however, are expected to be organisational and it is proposed that immediate priority should be given to establishing "pilot group farming areas" in order that suitable organisational farms can be tried and developed by the time engineering works are completed and full scale agricultural operations are about to commence (11.1.4). The two major farming systems proposed are described briefly in the following sections.

Smallholder farming systems

10.3.5

Smallholder farming can be expected to persist throughout a significant proportion of the area. It is unlikely however, that the system will remain completely unchanged and no doubt there will be a gradual uptake of innovations. This is already occurring with harvesting and could well spread to other operations. The present use of combine harvesters should not preclude the possibility of other intermediate harvesting innovations such as self-propelled binders (cutting and binding) and stationary threshers which might be more appropriate. Similarly, direct sowing techniques such as those employed at Tanjung Karang and practised to a limited extent on MADA could also be adopted by smallholders.

10.3.6

It is impossible to predict the rate at which technical innovations such as these will be taken up. Overall they are not expected to have any significant impact on crop yields but will have a more direct influence on the pattern of labour usage. Since the rate of

uptake of innovations is unpredictable and will in any case be unlikely to have a major impact on the economics of rice production, the following practices have been assumed in the preparation of crop budgets and farm models (Sections 10.4 and 10.5):

- (a) Land preparation will be completely mechanized with either power tiller or four-wheeled tractor powered tractor.
- (b) Rice will be hand transplanted.
- (c) Weed control will be mainly through use of herbicides supplemented by hand weeding.
- (d) The majority of the rice will be harvested by hand methods.

Yield improvements will be largely attributable to availability of recommended seeds, fertilisers, herbicides and pesticides, improved control and availability of water, more timely planting of the rice crop and an intensified extension effort.

10.3.7

Rice monocropping with two crops per year will predominate on smallholdings throughout Seberang Perai apart from 200 ha in Pinang Tunggal where a mixed system of main crop rice and off-season vegetables will be practised. All field operations for vegetables apart from land preparation will be by hand methods.

Group farming

10.3.8

Group farming is proposed for those areas that have already been abandoned and for those which are expected to be abandoned within the next four years, if the project were not to be implemented. The group farm will comprise all of the holdings within a tertiary irrigation unit and thus would vary in size, both in terms of members and overall areas, depending upon the size of the tertiary unit. Throughout Seberang Perai the group farms would range between 50 and 100 hectares comprising between 60 and 120 members. Members would include the landowners, owner-operators and tenant farmers who had most recently been farming the area. The group would elect its own committee (or board) who would be responsible for determining and

implementing policies. This committee would in turn be responsible for hiring or appointing from within the group members, a manager and two supervisors who would be responsible for organising and supervising field operations.

10.3.9 The farming system would be based on mechanised rice monocropping with two crops being grown each year. It would have the following features:-

- (a) Mechanised land preparation.
- (b) Direct sowing.
- (c) Use of herbicides supplemented by hand weeding for weed control.
- (d) Mechanised harvesting (combine harvester).

Two principal systems of direct sowing are possible; broadcasting of pre-germinated seeds into a wet seed bed, or drilling of dry seed into a dry seed bed using the technique and equipment developed at Tanjung Karang. It is likely that both would eventually be used with the choice between systems being determined mainly by weather and soil conditions from season to season. For budgeting purposes however, broadcasting of pre-germinated seed has been assumed. It is proposed that the mechanised operations, land preparation and harvesting should be carried out by plant supplied by machinery service centres located throughout the project area (Section 10.6). This proposal is consistent with current proposals to increase the capability of the LPP to provide this service. The possibility of some farms having their own tractor and cultivating equipment should not be ruled out and this decision would be dependent upon the willingness and financial resources of the group members. We have opted however, for establishing machinery centres to service the majority of farms on the grounds that the farm group members may not have the financial resources, and that maintenance, repairs and effective operation of machinery might be more easily arranged at service centres. Similarly whilst one farm could not justify owning a combine harvester for its own crop, it could operate as a contractor to surrounding farms. Whilst it is recognised that this should be encouraged, it is unlikely that many farms would have the financial resources, and the majority of farms would be dependent on service centres for harvesting their crop.

10.4 Crop budgets

10.4.1 Budgets have been prepared for the proposed cropping systems:-

- smallholder rice
- smallholder vegetables
- mechanised rice production (group farms)

The detailed cost of mechanisation, material and labour inputs are given in Appendix D. The crop budgets (at project maturity) showing returns to land and labour at market prices are summarised in Table 10.1. Mixed vegetables (based on 65% okra, 10% long beans, 10% cucumbers, 10% brinjals and 5% chilli) is the most attractive enterprise in terms of returns to land and also has a high return to labour. It is a technically demanding enterprise and has a high requirement for hand labour which will limit the overall extent to which it is grown.

10.4.2 Mechanised padi production on group farms has the highest return to labour while its return to land is of a similar order to that for smallholder padi. Provided that the anticipated levels of yields are attained, the potential returns to labour from all of the enterprises should provide sufficient incentive for farmers to participate effectively in an irrigation and drainage rehabilitation programme.

10.5 Farm models

Smallholder farms

10.5.1 Farm models indicating the expected levels of farm incomes from the two systems, double rice cropping and rice and mixed vegetables, are summarised in Tables 10.2 and 10.3 respectively.

(a) Double rice cropping:

10.5.2 The farm sizes assumed, 0.9 ha, 0.8 ha and 0.67 ha, are based on average farm sizes estimated for the larger schemes, Sg. Muda, Kulim and Pinang Tunggal respectively. They are based on an analysis of farm sizes in areas of 750 ha (about 900 farms) in Sg. Muda, 350 ha in Kulim (about 500 farms) and 320 ha (about 600 farms) in Pinang Tunggal. These areas are largely consistent with average farm sizes quoted by LPP officials. They do not however, reflect the distribution of farm

sizes and for all schemes the average size is generally higher than the most frequently occurring size (group 6-6 ~ 6.8 ha).

10.5.3

Yields are expected to build up over a three year period from 6.7 tonnes per ha per year (two crops) to 8.6 t/ha per year. The first year's yield has allowed for a limited amount of disruption due to engineering works continuing. The construction activities should not disrupt agriculture to the extent that a seasons cropping is lost over any part of the area.

10.5.4

For owner-operators net farm incomes (return to farmers labour and investment) would range between M\$2,975 and M\$3,997 per annum depending upon farm size. Assuming a rental of M\$321 per hectare per crop, tenant farmers' incomes would range between M\$2,545 and M\$3,419. Direct subsidies on price and fertilisers would make up about 43% and 50% of owner-operator and tenant incomes respectively.

(b) Rice and mixed vegetables

10.5.5

These farms are generally smaller than the all rice farms and the model has therefore been based on a holding size of 0.5 ha. The yields are again expected to be built up over a three year period and allowance has been made for possible disruption to agricultural activities due to construction works in the first year. In this model incomes of owner-operators range between M\$4,600 and M\$4,214 depending upon the extent to which hired labour is used to replace family labour. Assuming rents of M\$321 per ha per crop, tenant farmers' incomes range between M\$3,893 and M\$4,279 per annum. Direct subsidies would amount to around 10% of the total net revenue.

Group farms

10.5.6

The expected level of net income from the Group Farms is indicated in Table 10.4. Farm sizes will depend upon the size of the tertiary irrigation unit and will vary between 50 and 100 hectares. The size chosen for the model is 60 ha with a group membership of 75 farm families. Since a relatively new technology (direct sowing) is to be introduced, a four year period for yields to build up to a maximum of

8 t/ha from two crops a year is assumed. After payment of rents to external and group member land owners, and salaries of supervisory and book-keeping staff, the margin for distribution amongst group members is expected to build up from M\$62,780 to M\$136,220 in the fourth year, giving an average income per member of M\$1,816. In addition there would be an opportunity to share in the M\$45,360 required annually for farm labourers' wages. Although the overall labour requirement would amount to about 86 man-days per participating family, in practice it is more likely that a permanent labour force of about 15 members would be recruited from the participating families and the balance of the labour requirement (about 2,250 man-days) would be hired as casual labour when required. The system would leave a major part of the family labour supply free to find permanent employment off the farm if desired. Those opting to form part of the permanent labour force could expect to earn M\$1,974 per annum which together with their share of net revenues would provide an annual income of M\$3,790 per annum. Table 10.5 shows the potential incomes for various levels of participation in the group.

Table 10.5 Group Farms: Potential Incomes from Various Levels of Participation

Level of Participation	Annual Farm Income (M\$)
Landlord ⁽¹⁾ and permanent worker	4,304
Tenant and permanent worker	3,790
Participant non-worker	1,186
Non-participant landlord ⁽¹⁾	514

Note: (1) Assumes 0.8 ha holding.

10.6 Machinery service centres

10.6.1 Four machinery service centres would be required to provide the machinery necessary for land preparation and mechanised harvesting on the group farms. Although their primary function would be to service the group farms, they would have additional capacity to service a limited area of smallholdings. Two centres are already planned under the Integrated Agricultural Development Project (ref. The proposals however, are limited and are not adequate to support the scale of operations envisaged in the proposed upgrading of Irrigation and Drainage programme. It is recommended therefore that the facilities at the two centres be reviewed and subsequently upgraded to provide the facilities indicated in Table 10.6 when implementation of the rehabilitation programme commences. Table 10.6 shows the four centres and the machinery complements required.

Table 10.6 Machinery Service Centres: Location and Machinery Complements

Centre	Tractors (No)	Combine Harves- ters (No)	Rota- vators (No)	Disc Harrows (No)	Trailers (No)
A. Sg. Muda North	25	10	20	5	5
B. Sg. Muda E. Central	25	10	20	5	5
C. Sg. Kulim North	20	6	16	4	4
D. Sg. Kulim South	20	6	16	4	4

10.6.2 Locations of the centres should be based on nearness to the padi schemes served. Where convenient the existing Farmers' Organisation premises could be enlarged and combined with the machinery service centre. This method appears possible for all the centres except D, Kulim South. The LPP centre at Cherok Tok Kun is separated from the southern Kulim padi areas by at least 6 km of urban roads including Bukit Mertajam town centre, and it would therefore be unsuitable. We therefore suggest the following locations:-

Machinery Centre

LFP Centre

- A. Sg. Mada North
- B. Sg. Mada E Central
- C. Sg. Kulim North
- D. Sg. Kulim South

Pongpa
Pokok Sena
Kg. Sg. Sena
(New site near Simpang
Ampek)

10.6.3

Each centre would comprise a small office, a store for oil, grease, tools and spare parts, a fuel tank, covered service area, hard standing for tractors and machinery. Service facilities would include a compressor, welding equipment, and range of basic tools for general maintenance and minor repairs. One centre would comprise an area of approximately 5,000 sq. metres enclosed by a wire mesh fence.

10.6.4

Each would be staffed by a Manager, Field Supervisor, Wages and Fuel Clerk, a Mechanic, Assistant Mechanic, and tractor and combine harvester drivers and assistants. Each centre would be provided with a pick-up truck and motor cycle to facilitate transport of spares and supervision in the field.

Table 10.1 Crop Budgets: Returns to Land and Labour at Market Prices

Crop	Yield (1) (tonnes/ha)	Market Price (2) (M\$/tonne)	Direct (3)		Labour (mandays) (\$/ha)	Returns to land (\$/ha) (5)	Returns (6) to labour (\$/manday)
			Gross Revenue (\$/ha)	Production Costs (M\$/ha)			
Padi: Smallholders	4.3	612	2,632	411	115	1,416	19.3
Vegetables: Smallholders ⁽⁷⁾	17.7	496	8,779	1,800	220	1,540	31.7
Padi: Mechanised	4.0	612	2,448	635	54	1,435	33.6

Source: Consultants estimates; detailed in Appendices

- Notes: (1) Yield at project maturity achieved after 3 years for smallholder rice and vegetables and after 4 years for group farms.
 (2) 1980 prices.
 (3) Excluding labour.
 (4) Gross Revenue - direct costs excluding labour.
 (5) Net Revenue - labour costs.
 (6) Net Revenue - number of mandays.
 (7) Based on a mixture of 65% okra, 10% long bean, 10% cucumber, 10% brinjal and 5% chilli.

Table 10.2 Farm Model: Smallholder Double Rice Cropping

Revenues & Gross Margins (per ha)	Year		
	1	2	3
Yield per year (tonnes) (1)	6.7	8.0	8.6
Farm gate price (M\$/tonne) (2)	612	612	612
Gross revenue (M\$)	4,100	4,896	5,263
Production Costs (excluding labour + fertilizer) (3)	822	822	822
Gross Margin per ha	3,278	4,074	4,441
Labour Requirement (mandays)	230	230	230
Gross Margin per manday	14.3	17.7	19.3
Direct Subsidies per ha (4)			
Price subsidy	1,108	1,323	1,422
Fertilizer subsidy	470	470	470
	1,578	1,793	1,892
Farm Incomes (M\$/annum) (5)			
Owner Operator			
0.9 ha farm			
0.8 ha farm	2,950	3,667	3,997
0.67 ha farm	2,662	3,259	3,552
Tenant Farmer (6)	2,196	2,730	2,975
0.9 ha farm			
0.8 ha farm	2,372	3,089	3,419
0.67 ha farm	2,148	2,746	3,039
Direct Subsidy per farm	1,766	2,299	2,545
0.9 ha farm			
0.8 ha farm	1,420	1,614	1,702
0.67 ha farm	1,262	1,434	1,514
	1,057	1,201	1,268

- Notes:
- (1) Two crops.
 - (2) Includes subsidy of \$10 per picul.
 - (3) Family labour. Fertilizers are subsidised by the government
 - (4) Price subsidy \$165.4 per tonne (\$10 per picul). Fertilizer \$235 per crop/ha.
 - (5) Farm sizes are based on mean farm sizes for Sg. Muda, Kulim and Pinang Tunggal schemes which represent the main areas of smallholder double rice cropping.
 - (6) Rent is at a level of M\$321 per ha for crop.

Table 10.3 Farm Model: Smallholder Rice & Mixed Vegetables (Pinang Tunggal)

<u>Revenues & Gross Margins (per ha)</u>	Year		
	1	2	3
<u>Rice: Main Season Crop</u>			
Yield per season (tonnes)	3.35	4.0	4.3
Farm gate price (M\$/tonne)	612	612	612
Gross Revenue per hectare	2,050	2,448	2,632
Production Costs (excl labour & fertilizer)	411	411	411
Gross Margin per ha (M\$)	1,639	2,037	2,221
Labour Requirement (mandays) → <i>presumably per ha</i>	115	115	115
Direct subsidies per ha	789	896	946
<u>Mixed Vegetables: Off-season Crop</u>			
Yield (tonnes/ha)	15	16.5	17.7
Average price per tonne of mixed vegetables	496	496	496
Gross Revenues	7,440	8,184	8,780
Direct Production Costs all family labour (1)	1,800	1,800	1,800
Direct Production Costs 50% family labour (2)	2,573	2,573	2,573
Gross Margin all family labour	5,640	6,384	6,980
50% family labour	4,867	5,611	6,207
<u>Farm Income 0.5 ha Farm (M\$)</u>			
1. Owner Operator <i>14\$ per man day</i>			
all family labour for vegetables	63.3	73.2	80.0
50% hired labour for vegetables	3,639	4,210	4,600
	3,252	3,824	4,214
2. Tenant Farmer			
all family labour for vegetables	3,318	3,889	4,279
50% family labour for vegetables	2,931	3,503	3,893
Subsidies per farm (M\$)	394	448	473

Notes: (1) No hired labour
(2) 50% of labour requirement hired

10.4 GROUP FARMING - DOUBLE RICE CROPPING

Revenues & Gross Margins (per ha)	Year			
	1	2	3	4
Yield per year (tonnes) ⁽¹⁾	6.0	6.8	7.5	8.0
Farm gate price (M\$/tonne) ⁽²⁾	612	612	612	612
Gross Revenue (M\$)	3,672	4,126	4,590	4,896
Production Costs ⁽³⁾ (excl fertilizers)	2,027	2,027	2,027	2,027
Gross Margin (excl fertilizers)	1,645	2,135	2,563	2,869
Subsidies per ha				
Fertilizers	450	450	450	450
Price subsidy ⁽⁴⁾	992	1,125	1,240	1,323
	1,442	1,575	1,690	1,773

Farm Incomes - 60 ha farm (75 members) = 0.8 ha per member (family?)

Farm gross margin (M\$)	98,700	128,100	153,780	172,140
Rents payable to landowners (M\$)	27,720	27,720	27,720	27,720
Field Supervisor & Book-keepers' salaries	7,200	7,200	7,200	7,200
Incidental expenses	1,000	1,000	1,000	1,000

Margin available for distribution amongst group members	62,780	92,180	117,860	136,220
Annual farm income for group members	837	1,229	1,571	1,816
Wage income available per farm	45,360	45,360	45,360	45,360
Potential wage income per family	605	605	605	605
Labour supply required per family (mandays)	86	86	86	86

M\$ per man day

16.8 21.3 25.3 28.15

The annual income per family

1442 1834 2176 2421

- Notes:
- (1) Two crops.
 - (2) Includes subsidy M\$10 per picul.
 - (3) Fertilizers are subsidized. It is assumed that farmers will be paid wages for their labour inputs. ∴ labour costs are included.
 - (4) \$165.4 per tonne (\$10 per picul).

11. PRELIMINARY DEVELOPMENT PLAN

11.1 General

11.1.1 Our proposals for implementation of the project have not been worked out in detail at this stage but outline proposals for discussion are given in this section; they form the basis for our economic and financial analysis.

11.1.2 Development of the improved irrigation, drainage and farm roads system is the core of the work and it forms the project principal capital cost. However, equally important is the development of new farming units - group farms - which can make the most of the scarce labour available through the best possible use of mechanisation, and thereby yield a reasonable income and standard of living to those working on them. Since we consider it essential to have feed-back into the designs and organisational matters from the farmers' practical experience, we are proposing two types of working prototype to be implemented before the work on the bulk of the irrigation areas is far advanced.

11.1.3 Sample areas for infrastructure improvement were selected early in the Study so as to follow up immediately with detailed topographic survey. There are four areas, one in each of the principal scheme groups, with a total area of 1,700 ha. These areas were selected to be representative of the different agricultural and engineering situations now found in the project area. They were not selected primarily as being "problem areas", but rather as being representative of the different agricultural and irrigation systems existing.

11.1.4 On the other hand the measures to be considered in rehabilitating abandoned land, which we believe require the adoption of group farming methods, need to be tried out in areas where there are good chances of success, in order to act as an example. Since it is also necessary to implement the changes as soon as possible, the trial areas should preferably not have too many engineering problems. The criteria are therefore to select land:-

- (a) which is at present abandoned
- (b) where a sufficient number of farm workers can be attracted back into their traditional work quickly
- (c) where the owners and tenants are agreeable to a group farming pilot scheme
- (d) where the engineering infrastructure is serviceable, or can be made so with a minimum of construction work.

It will be evident that the requirements for engineering sample areas and agricultural pilot areas are too diverse to coincide. In fact none of the sample areas include any significant abandoned land.

11.1.5 We propose for the first pilot area that part of Sg. Muda scheme in Mukim 8 which is currently one of the areas operated by the LPP for rehabilitation of tanah rang. It consists of 175 ha south-west of Kepala Batas in a very accessible block. There should also be a pilot area within the Sg. Kulim scheme, preferably of 3 or 4 adjacent tertiary units (180 - 240 ha approx.). We have not selected any area yet, and will discuss the alternatives with the Jabatan Pertanian and LPP.

11.1.6 Our development programme therefore is based on the earliest possible implementation of agricultural pilot areas of about 400 ha, followed by the improved infrastructure in engineering sample areas of 1,700 ha. Thereafter the whole project area should receive upgrading in all senses, agricultural, management and engineering, as soon as practicable. The whole programme must be based on a sound appreciation of the people's needs and objectives and it must carry full support from the farmers and their representatives, without which the whole scheme of construction and agronomic improvements would be wasted.

11.2 Programme detailing

11.2.1 The project area for irrigated land is 13,800 hectares approximately, of which 1,700 ha are taken up by the sample areas described above. We propose dividing the remaining 12,100 ha into five construction contracts to permit phasing the engineering works by area and in time (detail below). Due to irregular sizes of the areas in each scheme group (6.1.3) this requires the rehabilitation contracts to vary in size from 670 to 3,100 ha. If necessary the largest can be sub-divided.

11.2.2 Survey of agricultural pilot areas should start as soon as possible, preferably running on from the current Phase 1 survey without a break. Completion of detailed topographic survey for the whole 12,100 ha is a critical activity which we assume will last until October 1983. Detailed engineering design and contract preparation should commence in January 1982 and would continue until June 1984.

11.2.3 We have allowed in all cases one year for completion of land acquisition; this period would start four months after the start of detailed design. Assuming construction contracts can be executed in from 18 to 24 months, depending on size, this results in the works for the engineering sample areas (1,700 ha) being completed by October 1984, and the final contracts completed by December 1986. The timing is shown in tabular form in Table 11.1. We must emphasize that this programme is preliminary, and is largely based on the experience reported by MADA.

Table 11.1 Implementation Programme

Contract No.	Scheme Group	Scheme/Areas	Area served (ha)	Survey start	Design start	Land Acquisition start	Land Acquisition finish	Construction finish
1	-	Agricultural pilot areas	400	Sept '81	Jan '82	None possible	Feb '83 ⁽¹⁾	
2	-	Engineering sample areas	1,700	complete	Jan '82	Mar '82	Feb '83	Oct '84
3	A	Sg. Muda North	2,900	Nov '81	July '82	Nov '82	Oct '83	Sept '85
4	B	North-eastern schemes	2,500	June '82	Nov '82	Mar '83	Feb '84	Dec '85
5	D, E	Southern schemes	700	June '82	Sept '82	Jan '83	Dec '83	June '85
6	C	Sg. Kulim	2,800	Nov '82	Oct '83	Feb '84	Jan '85	Dec '86
7	A	Sg. Muda South	3,200	Oct '82	Aug '83	Dec '83	Nov '84	Oct '86

Notes: (1) Contract 1 is for minimum works to implement group farming. Full rehabilitation included in later contracts.
(2) Completion of design and tendering/contract award stages are included within land acquisition period.

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APPENDICES

SOIL SERIES DESCRIPTIONS

Soil Series	- Akob Series
Location	- Kampung Lahar Tiang, Seberang Perai
Map & Grid Reference	- Sheet 2I/6 - 160885
Landform	- River terrace
Vegetation	- Paddy
Parent Material	- Riverine alluvium
Drainage	- Moderately well drained

Profile DescriptionAhp 0 - 15 cm

Greyish brown (2.5Y 5/2) silty clay; firm; weakly to moderately well developed medium subangular blocky structure; abundant pores; few fine faint yellowish brown (10YR 5/8) mottles; many roots; boundary distinct.

Ahps 0 - 15 cm

Grey (10YR 5/1) silty clay; firm; massive structure; few pores; many fine distinct strong brown (7.5YR 5/6) mottles; few roots; boundary indistinct.

AB 15 - 36 cm

Light brownish grey (2.5Y 6/2) clay; firm to friable; moderately well developed to strongly developed medium angular blocky structure; almost continuous clay-skins; few pores; abundant medium distinct strong brown (7.5YR 5/6) mottles; few roots; boundary indistinct.

B_g 36 - 71 cm

Light grey (2.5Y 7/1) clay; friable; strongly developed coarse angular blocky structure; discontinuous clayskins; abundant medium distinct brownish yellow (10YR 6/8) and many medium distinct red (2.5YR 5/8) mottles; boundary diffuse.

BC_g 71 + cm

Light grey (2.5Y 7/1) clay; friable; moderately well developed coarse angular blocky structure; discontinuous clayskins; few coarse distinct red (2.5YR 4/8) mottles.

Soil Series	- Bakau Series
Location	- Sungai Bakau, Seberang Perai
Map & Grid Reference	- 2I/14 - 066364
Landform	- Coastal Plain
Vegetation	- Paddy
Parent Material	- Marine alluvium
Drainage	- Poorly drained

Profile Description

Ah 0 - 3 cm

Dark grey (10YR 4/1) clay; friable; weakly developed medium crumb structure; many pores; many fine distinct strong brown (7.5YR 5/6) mottles along former root channels; many fine roots; boundary sharp.

B_g 3 - 13 cm

Greenish grey (5GY 6/1) clay; slightly sticky; moderately well developed coarse to very coarse blocky structure; patchy clayskins; many pores; many medium to coarse, distinct to prominent reddish brown (5YR 4/4 to 5/4) mottles along former root channels; few roots and many channels; boundary indistinct.

B_{gcn}(mn) 13 - 51 cm

Greenish grey (5GY 5/1) clay; sticky; weakly developed coarse to very coarse blocky structure; patchy clayskins and few pores; many medium distinct olive brown (2.5Y 4/4) mottles on structure faces; many dark brown small manganese concretions; boundary diffuse.

Cr 51 - 102 cm

Greenish grey (5BG 5/1) clay; sticky; massive structure.

Soil Series	- Kuala Kedah
Location	- -
Map & Grid Reference	- -
Landform	- Flat depression
Vegetation	- Paddy
Parent Material	- Marine alluvium
Drainage	- Very poorly drained

Profile Description

Apl 0 - 17 cm

Dark grey (10YR 4/1) clay, dark grey (10YR 3/1) when moist; abundant coarse prominent red (2.5YR 4/6) iron deposits on pad faces and root channels; massive; very hard (dry); some fine sand; many fine roots and root mat; clear and wavy boundary to.

C1G 17 - 40 cm

Greenish grey (5G 5/1) wet clay; many fine distinct strong brown (7.5YR 5/6) iron deposits on former root channels in upper part of horizon; massive; sticky and slightly plastic (wet); very few fine roots; clear boundary to.

C2G 40 - 74 cm

Greenish grey (5G 6/1) wet clay; many medium distinct olive (5Y 5/4) deposits; weakly developed coarse prismatic and angular blocky; sticky and slightly plastic (wet) diffuse boundary to.

C3G 74 - 96 cm

Greenish grey (5G 6/1) wet clay; many medium distinct olive (5Y 5/4) deposits along former root traces; massive; very sticky and plastic (wet) diffuse boundary to.

C4G 96 cm +

Greenish grey (5G 5/1) wet clay; many gritty greyish green (5G 5/2) deposits; massive; very sticky and plastic (wet).

The soil cracks only in the Ap in extremely dry periods, 2 cm wide.

Soil Series	- Kundor Series
Location	- Butterworth - Bukit Merah Road, Seberang Perai
Map & Grid Reference	- Sheet 28 - 105710
Landform	- Marine Terrace
Vegetation	- Paddy
Parent Material	- Marine alluvium
Drainage	- Imperfectly drained

Profile Description

Ahp 0 - 13 cm

Dark grey (10YR 4/1) silty clay; friable; moderately well developed fine to medium subangular blocky structure; abundant pores; many fine distinct dark brown (7.5YR 4/4) mottles along former root channels; some mica flakes; many roots and channels; boundary distinct.

Ahps 13 - 20 cm

Dark grey (10YR 4/1) silty clay; sticky; massive structure; few pores; few medium distinct strong brown (7.5YR 5/6) mottles along former root channels; many roots and few channels; boundary distinct.

Bgj 20 - 33 cm

Grey (5Y 5/1) clay; friable; moderately well developed coarse angular blocky structure and weakly developed medium prismatic structures; patchy clay-skins and few pores; many coarse distinct yellowish red (5YR 4/8) mottles along former root channels; few roots; boundary diffuse.

Bg 33 - 71 cm

Grey (10YR 5/1) clay; friable; weakly to moderately well developed medium prismatic and moderately well developed medium to coarse angular blocky structures; almost continuous clayskins; many pores; abundant coarse distinct yellowish red (5YR 4/8) mottles along former root channels and structure faces; many channels.

Soil Series	- Rantau Series
Location	- Between 46 and 45 $\frac{1}{2}$ milestone Tikam Batu, Kota Kuala Muda Road, South Kedah
Map & Grid Reference	- Sheet 16 - 692174
Landform	- Terrace
Vegetation	- Paddy
Parent Material	- Mixed riverine and marine alluvium
Drainage	- Imperfectly drained

Profile Description

Ahp 0 - 10 cm

Grey (10YR 5/1) clay; firm; massive structure; many pores; many medium distinct dark brown (10YR 4/3) and few medium distinct red (2.5YR 5/8) mottles; many fine roots and channels; boundary distinct.

Ahps 10 - 23 cm

Dark grey (10YR 4/1) clay; very firm; massive structure; few pores; abundant fine faint to distinct reddish yellow (7.5YR 7/8) and many fine distinct strong brown (7.5YR 5/6) mottles; few fine roots; micaceous; boundary distinct.

Bg 23 - 58 cm

Light grey (5Y 7/1) clay; friable to slightly sticky; moderately well developed medium columnar structure, breaking into moderately well developed medium angular blocky; discontinuous clayskins and many pores; many medium distinct red (10R 5/8) and yellow (10YR 7/8) mottles; many fine distinct reddish yellow (7.5YR 6/8) mottles along former root channels; few fine roots and channels; micaceous; boundary indistinct.

Bcg 58 - 91 cm

Light grey (5Y 7/1) clay; slightly sticky; weakly developed medium angular blocky structure; discontinuous clayskins and few pores; pockets of fine sand; many medium distinct light olive brown (2.5Y 5/6) and yellowish brown (10YR 5/6) mottles.

Soil Series	- Sedaka Series
Location	-
Map & Grid Reference	-
Landform	- Almost flat coastal plain
Vegetation	- Paddy
Parent Material	- Marine alluvium
Drainage	- Poorly drained

Profile Description

Ap 0 - 27 cm

Very dark grey (10YR 3/1) moist to dark grey (10YR 4/1) dry silty clay many fine distinct brownish yellow (10YR 6/8) dry mottles on root traces; massive; dry, extremely hard; many fine roots; abrupt smooth boundary.

B2g 27 - 68 cm

Light olive grey (5Y 6/2) moist clay; many medium distinct yellow (10YR 7/8) mottles on ped faces; strongly developed coarse angular blocky; firm (moist); slightly sticky and slightly plastic (wet); many slickensides; diffuse wavy boundary.

B3G 68 - 100 cm

Greenish grey (5G 6/1) wet clay; many medium distinct olive (5Y 5/4) mottles, weakly developed very coarse angular blocky; slightly sticky and slightly plastic; occasional slickensides; diffuse wavy boundary.

CG 100 - 150 cm

Greenish grey (5BG 5/1) wet clay; many medium distinct pale green (5G 6/2) mottles; many fine distinct reddish brown (5YR 5/4) iron deposits along root traces; massive; sticky and plastic.

Soil Series	- Sintok Series
Location	- Kampung Permatang Kuang, Seberang Perai
Map & Grid Reference	- 2I/6 - 065843
Landform	- Marine terrace
Vegetation	- Paddy
Parent Material	- Mixed riverine and marine alluvium
Drainage	- Poorly drained

Profile Description

Ahp 0 - 18 cm

Dark grey (10YR 4/1) clay; friable; moderately well developed medium subangular blocky structure; abundant pores; few medium distinct olive brown (2.5Y 4/4) mottles; many roots and many channels; boundary distinct.

Ahps 18 - 25 cm

Grey (5Y 5/1) clay; firm; massive structure; few pores; few fine faint dark grey (2.5Y 4/1) mottles; few roots; boundary distinct.

Bg 25 - 48 cm

Light greenish grey (5BG 7/1) sandy clay; slightly sticky; weakly developed coarse angular blocky structure; almost continuous clayskins and many pores; many coarse distinct strong brown (7.5YR 5/6) mottles along former root channels; few roots; boundary indistinct.

BCg 48 - 69 cm

Light bluish grey (5B 7/1) sandy clay loam; slightly sticky; weakly developed coarse angular blocky structure; many pores; many fine distinct strong brown (7.5YR 5/8) mottles.

Soil Series	- Tebengau
Location	- -
Map & Grid Reference	- -
Landform	- Flat Coastal plain
Vegetation	- Paddy
Parent Material	- Marine alluvium
Drainage	- Poorly drained

Profile Description

Ap1 0 - 10 cm

Dark grey (10YR 4/1) clay, dark grey (10YR 3/1) when moist; many fine distinct reddish yellow (7.5YR 6/8) iron deposits on root traces and crack faces; massive; very hard (dry); few pores; many fine roots; gradual boundary to.

Ap2 10 - 23 cm

Black (10YR 2/1) clay, black (10YR 2/0) when moist; few fine distinct reddish yellow (7.5YR 6/8) iron deposits on root channels and crack faces; massive; extremely hard (dry); few fine roots; abrupt boundary to.

C1G 23 - 50 cm

Greenish grey (5GY 6/1) wet clay; many medium to coarse distinct strong brown (7.5YR 5/8) mottles; massive; slightly sticky and slightly plastic (wet); diffuse boundary to.

C2G 50 - 97 cm

Grey to light grey (5Y 6/1) wet clay; few medium faint pale olive (5Y 6/4) mottles; massive; sticky and slightly plastic (wet); many soft, very dark grey (5YR 3/1) manganese concretions; few old root traces; clear boundary to.

C3G 97 cm +

Greenish grey (5BG 5/1) wet clay; many gritty greyish green (5G 5/2) deposits; massive; sticky and plastic (wet).

The soil cracks in the Ap1 and Ap2 in dry periods (1-2cm wide).

Soil Series - Tualang
 Location - -
 Map & Grid Reference - -
 Landform - Flat coastal plain
 Vegetation - -
 Parent Material - Riverine alluvium overlying marine alluvium
 Drainage - Poorly to imperfectly drained

Profile Description

Apl 0 - 7 cm

Light brownish grey (10YR 6/2) clay loam, light brownish grey (10YR 5/2) when moist; few fine distinct brownish yellow (10YR 6/8) iron deposits on root channels; massive; soft to slightly hard (dry); many fine roots; diffuse boundary to.

Ap2 7 - 18 cm

Grey (10YR 5/1) clay, grey (10YR 4/1) when moist; many medium distinct brownish yellow (10YR 6/8) mottles on pad faces; massive; very hard (dry) abrupt boundary to.

B1 18 - 38 cm

Grey (10YR 5/1) moist clay; abundant medium distinct brownish yellow (10YR 6/8) and few medium distinct red (10YR 4/8) mottles on pad faces; strongly developed coarse angular blocky breaking into fine and medium subangular blocky; firm (moist); diffuse boundary to.

(B)2g 38 - 84 cm

Grey to light grey (10YR 6/1) moist clay; many to abundant coarse distinct brownish yellow (10YR 6/8) and few medium distinct red (10YR 5/8) mottles on pad faces, the latter tending to form soft concretions; weakly developed coarse angular blocky breaking into medium and fine angular blocky; friable (moist) diffuse boundary to.

83g 84 - 130 cm

Grey (10YR 5/1) moist clay; many medium distinct yellow (10YR 7/8) mottles on pad faces; weakly developed coarse angular blocky breaking into medium angular blocky; slightly friable (moist); occasional organic stains on old root traces.

Cracks (less than 1 cm side) occur only in the Apl and Ap2.

APPENDIX B

PRELIMINARY ENGINEERING COSTS

B.1 Unit Rates

- B.1.1 Unit rates, to be used in the costing of the proposed works, are listed in Table B.1 for the major items of construction. These rates have been assessed as representative of rates for similar types of work in north-west Malaysia as of mid-1981. They have been arrived at after discussions with JPT, both locally and centrally, and after comparison with rates in other reports, in recent contracts and those suggested in discussions with local contractors. In addition they have been checked against rates built up from basic costs - i.e. materials, transport, labour and plant with allowances included for the contractors' overheads and profit.
- B.1.2 In arriving at these unit rates it has been assumed that all the works proposed would be carried out under fairly large contracts by national or international contractors - not on a piecemeal basis by small local firms.
- B.1.3 It is possible that some variation to the rates should be allowed from scheme to scheme, particularly with regard to imported fill with haulage being a major component of the cost. However it is not possible to identify with certainty the source of material a particular contractor might choose to use on a particular contract and moreover it is not necessarily the case that haulage distance would be directly reflected in a tendered rate. We have therefore adopted an average set of rates which will be applied to the costing of all schemes. (For the imported fill item we have assumed an average haul distance of 10 km at a cost of \$0.4 per tonne per km of haulage.)
- B.1.4 Where considered applicable allowance has been made for difficult site access and increased transport costs for imported fill - for example in construction of quaternary canals where access would have to be through the fields and possibly limited to periods between crops. Similarly allowance is made in such cases for manual excavation and construction of bunds.

B.2 Canal and Drain Unit Costs

B.2.1 Generally works proposed on main and secondary canals are improvement works - widening where necessary, heightening of bunds, provision of access roads, etc. The extent and cost of such work depend on the size and present condition of the canal and they will be assessed individually for each scheme.

B.2.2 Tertiary canals will be concrete-lined. There will be 4 standard sections. For flows below 70 L/s (2.5 cusecs) one of 3 U-shaped precast concrete block sections will be used. For greater flows a trapezoidal canal section lined with precast concrete slabs 65 mm (2½") thick is proposed. (Figure 8.2). Unit costs for these canals, including construction of access roads of various widths are given in Table B.2. For preliminary assessment of costs an average rate per metre of tertiary canal has been calculated for a typical canal serving a tertiary block of about 65 ha. For the design capacities as laid down in Section 8.4.8 it is found that the two smaller sections are not a large proportion of the total length of the canal and the average cost is estimated to be about \$180/m, assuming a 5.5 m road bund width.

B.2.3 Quaternary canals are unlined and as noted in Section 8.4.10 for costing purposes, a standard size is assumed throughout. (Figure 8.2). The cost is estimated at \$6.5/m.

B.2.4 Tertiary drains, if constructed to the optimum hydraulic section, will vary in size depending on the accumulated area they serve. A breakdown in cost for three typical sections is given in Table B.3. For preliminary costing we have assumed the provision of a maintenance track beside the drain as discussed in Section B.6, although our final recommendation may be to dispense with this. The quantities assume a 25% shrinkage of the excavated material and imported fill as necessary to top up the bund. Because the quantity of imported fill needed decreases as the size of the drain increases a minimum price of about \$16/m is found with the largest size likely to be required and therefore this section and price have been used throughout for preliminary costing.

B.2.5 Quaternary drains, like quaternary canals, have been taken as a single size for costing. The excavated volume is assumed to balance the fill requirements. The unit cost is estimated at \$4.0/m.

B.3 Structure Unit Costs

B.3.1 As with the main and secondary canals, costs of structures particular to a location or scheme will be assessed individually however 4 types of structure are required for the infrastructure development in all areas, namely:-

- Offtakes (generally constant-head orifice)
- Quaternary offtake boxes (Figure 8.3)
- Canal access culverts
- Tertiary drain end-control structures

B.3.2 For preliminary costing an average cost for each of these types of structure has been assessed as follows:-

CHO offtakes	\$ 8,250
Quaternary offtake boxes	\$ 3,800
Canal access culverts	\$ 3,200
Tertiary drain end-control structures	\$10,500

B.4 Total Costs

B.4.1 To the costs as estimated from the measured items are added the following percentages:-

- (i) Contractor's mobilisation preliminary and general items - 10%.
- (ii) Physical contingencies - 15% of the total including (i).
- (iii) Engineering design and supervision of construction - 8% of the accumulated total.

B.4.2 Land acquisition costs are treated separately. They are not included in the economic analysis but are required for the financial arrangement, thus the totals calculated as indicated above do not include these costs. Moreover the percentage additions in B.4.1 are not applied to the land acquisition costs.

B.5 Tertiary Development Costs

B.5.1 Using the unit costs for canals, drains and structures, detailed total costs have been estimated for the tertiary development in three of the sample areas (see Section 6.6). These are given in Tables B.4, B.5 and B.6 and include for mobilisation and general items, contingencies and engineering.

B.5.2 The areas of land to be acquired in each of the sample areas for the construction of the works are given in those Tables. They have been calculated from a detailed estimate for each canal and drain including the access roads. As a percentage of the total gross area of each sample area they represent the following:-

Sg. Muda sample area :	5.8%
Sg. Kulim sample area:	5.2%
Alma scheme	: 7.3%

B.5.3 Land acquisition costs have also been indicated in these areas. These are estimates based on the information from the Federal Valuation Office (Section 2.5) and are approximate only. For the Final Report it is hoped a more detailed analysis can be made. The value shown for Alma has been taken as the same as that for Sg. Kulim sample area, in the absence of specific values for that area. In actual fact it may well be higher than this with the pressures of urbanisation from the Metropolitan Area of Bukit Mertajam being considerable.

B.6 Scheme Costs

B.6.1 As a preliminary estimate of total scheme costs, total values have been calculated for the Sg. Muda scheme and Sg. Kulim scheme. Tertiary development has been assumed to be at a constant cost throughout the total scheme areas. Preliminary estimates have been made of the improvement works to main and secondary canals and drains in the remaining areas. These total scheme costs are shown in Tables B.7 and B.8.

Table B.1 Unit Rates

Item	Unit	Rate
Cement (on site)	tonne	250
Fine aggregate/sand (on site)	m ³	33
Coarse aggregate (on site)	m ³	45
Canal/drain bulk excavation (machine)	m ³	2.5
Canal/drain excavation (manual)	m ³	6.5
Trimming excavation	m ²	1.0
Excavation for structures (including trimming and backfill)	m ³	25
Imported fill	m ³	17
Addition cost on imported fill for poor access	m ³	1.5
Laterite surface for access roads	m ³	19
Mass concrete (including shuttering)	m ³	190
Structural concrete	m ³	160
Structural concrete (including shuttering)	m ³	370
Structural concrete (including shuttering and reinforcement)	m ³	485
Concrete for canal linings (including shuttering)	m ³	280
M.S. reinforcement	kg	1.75
Bakau piles	No.	90

Table B.2 Unit Costs of Tertiary Canals

Canal Section	Road Bund Width		
	1.0 m	2.5 m	5.5 m
	(\$/m)		
"15 inch" block section	75	100	135
"18 inch" block section	90	115	150
"24 inch" block section	105	130	170
Trapezoidal section	140	165	205

Table B.3 Tertiary Drain Unit Costs

Item	Unit	Rate (\$)	D=0.7m		D=0.8m		D=0.9m		B=2.0m	
			Qty (m ³)	Cost/m (\$)	Qty (m ³)	Cost/m (\$)	Qty (m ³)	Cost/m (\$)	Qty (m ³)	Cost/m (\$)
Excavation	m ³	2.5	1.44	3.6	2.16	5.4	3.02	7.55		
Imported fill	m ³	17	0.75	12.75	0.21	3.75	-	-		
Laterite road surface	m ³	19	0.41	7.79	0.41	7.79	0.41	7.79		
Totals				24.15		16.76				15.34

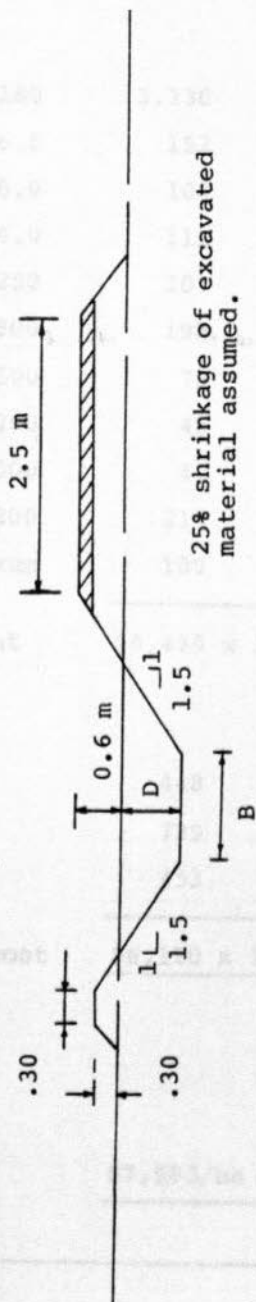


Table B.4 Sq. Muda Sample Area: Tertiary Development Costs

Item	Unit	Quantity	Rate (\$)	Cost (\$ x 1,000)
Tertiary canals	m	18,500	180	3,330
Quaternary canals	m	23,400	6.5	152
Tertiary drains	m	6,250	16.0	100
Field (quaternary) drains	m	28,000	4.0	112
Tertiary offtakes (CHO)	No.	13	8,250	107
Quaternary turnout box	No.	52	3,800	198
Tertiary /field offtakes	No.	150	500	75
Access culverts	No.	14	3,200	45
Quaternary drain culverts	No.	47	1,000	47
Drainage control structures	No.	21	10,200	214
Miscellaneous other items			Lump sum	100
Total cost of tertiary development (measured items)				<u>\$4,480 x 10³</u>
Contractors preliminary and general items				448
Physical contingencies				739
Engineering				453
Total cost				<u>\$6,120 x 10³</u>
Gross area = 806 ha				
Total cost per unit area gross (excluding land acquisition)				<u>\$7,593/ha</u>
Land acquisition 47 ha at \$20,000/ha				<u>\$904 x 10³</u>
Cost per unit area of land acquisition				<u>\$1,166/ha</u>

Table B.5 Sg. Kulim Sample Area: Tertiary Development Costs

Item	Unit	Quantity	Rate (\$)	Cost (\$ x 1,000)
Tertiary canals	m	8,580	180	1,544
Quaternary canals	m	21,750	6.5	141
Tertiary drains	m	9,500	16.0	152
Field (quaternary) drains	m	18,000	4.0	72
Tertiary offtakes (CHO)	No.	7	8,250	58
Quaternary turnout box	No.	28	3,800	107
Access culverts	No.	30	3,200	96
Drainage control structures	No.	10	10,200	102
Miscellaneous other items			Lump sum	60
Total cost of tertiary development (measured items)				<u>\$2,332 x 10³</u>
Contractors preliminary and general items				233
Physical contingencies				385
Engineering				236
Total cost				<u>\$3,186 x 10³</u>
Gross area = 580 ha				
Total cost per unit area gross (excluding land acquisition)				<u>\$5,493/ha</u>
Land acquisition 30 ha at \$40,000/ha				<u>\$1,200 x 10³</u>
Cost per unit area of land acquisition				<u>\$2,070/ha</u>

Table B.6 Alma Scheme Costs

Table B.7 Group A: St. John Scheme Costs

Item	Unit	Quantity	Rate (\$)	Cost (\$ x 10 ³)
Tertiary canals	m	1,725	135	233
Quaternary canals	m	2,100	6.5	14
Tertiary drains	m	2,100	16.0	34
Quaternary drains	m	1,440	4.0	6
Offtake structures (CHO)	No.	3	8,250	25
Quaternary turnout box	No.	2	3,800	8
Tertiary/field offtakes	No.	19	500	10
Access culverts	No.	9	3,200	29
Drainage control structures	No.	2	10,200	20
Access road improvements			Lump sum	15
Miscellaneous other items			Lump sum	25
Total cost of measured items				<u>\$419 x 10³</u>
Contractors preliminary and general items				42
Physical contingencies				69
Engineering				43
Total cost				<u>\$573 x 10³</u>
Gross area = 82 ha				
Total cost per unit area (excluding land acquisition)				<u>\$7,000/ha</u>
Land acquisition 6 ha at \$40,000/ha				
				<u>\$240 x 10³</u>
Cost per unit area of land acquisition				<u>\$2,930/ha</u>

Table B.8 Group C: Sg. Kulim Scheme Costs

(\$ x 10⁶)

Tertiary infrastructure : 3,369 ha at \$4,020/ha :		13.5
Main canal improvements		1.5
Secondary canal and drainage works		6.3
Total measured items		\$21.3 x 10 ⁶
Contractors preliminaries and general items		2.1
Physical contingencies		3.5
Engineering		2.2
Total (excluding land acquisition)		\$29.1 x 10 ⁶

Estimated land acquisition:-

For tertiary development : 170 ha

For main and secondary, canal
and drain improvements : 40 ha

210 ha @ \$40,000/ha: 8.4 x 10⁶

Table B.6 Alma Scheme Costs

Item	Unit	Quantity	Rate (\$)	Cost (\$ x 10 ³)
Tertiary canals	m	1,725	135	233
Quaternary canals	m	2,100	6.5	14
Tertiary drains	m	2,100	16.0	34
Quaternary drains	m	1,440	4.0	6
Offtake structures (CHO)	No.	3	8,250	25
Quaternary turnout box	No.	2	3,800	8
Tertiary/field offtakes	No.	19	500	10
Access culverts	No.	9	3,200	29
Drainage control structures	No.	2	10,200	20
Access road improvements			Lump sum	15
Miscellaneous other items			Lump sum	25
Total cost of measured items				<u>\$419 x 10³</u>
Contractors preliminary and general items				42
Physical contingencies				69
Engineering				43
Total cost				<u>\$573 x 10³</u>
Gross area = 82 ha				
Total cost per unit area (excluding land acquisition)				<u>\$7,000/ha</u>
Land acquisition 6 ha at \$40,000/ha				
				<u>\$240 x 10³</u>
Cost per unit area of land acquisition				<u>\$2,930/ha</u>

Table B.7 Group A: Sg. Muda Scheme Costs

		(\$ x 10 ⁶)
Tertiary infrastructure :	6,950 ha	
	at \$5,560/ha :	38.6
Main canal improvements		3.5
Secondary canal and drain improvements:		
Compartment	A	\$2.6 x 10 ⁶
	B	2.6
	C	9.4
	D	0.3
	E	0.4
	F	2.7
	G	0.7
	H	0.3
	J	1.0
	Pokok Sena	0.4
		<u>20.4</u>
Total measured items		\$62.5 x 10 ⁶
Contractors preliminaries and general items		6.3
Physical contingencies		10.3
Engineering		<u>6.3</u>
Total (excluding land acquisition)		<u>\$85.4 x 10⁶</u>

Estimated land acquisition:-

For tertiary development : 400 ha

For secondary canal and drain
improvement : 60 ha

460 ha @ \$20,000/ha: 9.2 x 10⁶

Table B.8 Group C: Sg. Kulim Scheme Costs

	(\$ x 10 ⁶)
Tertiary infrastructure : 3,369 ha at \$4,020/ha :	13.5
Main canal improvements	1.5
Secondary canal and drainage works	6.3
Total measured items	\$21.3 x 10 ⁶
Contractors preliminaries and general items	2.1
Physical contingencies	3.5
Engineering	2.2
Total (excluding land acquisition)	\$29.1 x 10 ⁶

Estimated land acquisition:-

For tertiary development : 170 ha

For main and secondary, canal
and drain improvements : 40 ha210 ha @ \$40,000/ha: 8.4 x 10⁶

APPENDIX C

I. MACHINERY & MECHANIZATION COSTS

1. LAND PREPARATION

1.1 Power Tiller

(a) Base Data

Capital cost M\$5,800

Life 5 years or 3,000 working hours (600 hours/year)

Interest charges 10%

(b) Hourly Operating Costs:

- hourly capital charge (depreciation + interest)

- fuel 3 l.

- repairs and maintenance

- insurance

Sub-total (rounded) \$6.00 per hour

(c) Cost of Cultivation per hectare

- 1st cultivation 14 hours per ha

- 2nd cultivation 11 hours per ha

Cost per hectare (rounded)

(d) Current Contract Rates for two cultivations (per ha)

(e) Margin for labour and contractors' profit (per ha)

1.2 Four Wheeled Tractor (60-70 HP) & Rotavator

(a) Base Data: Tractor

Capital cost M\$48,420

Life 6 years or 6,000 hours (1,000 hours/year)

Interest charges 10%

(b) Hourly Operating Costs:

- hourly capital charge (depreciation + interest)

- fuel 10 l. at M\$0.45 per l.

- repairs and maintenance

- insurance

- driver's wages per hour

(c) Base Data: Rotavator

Capital cost M\$9,360

Life 6 years or 4,800 hours (800 hours/year)

Interest charges 10%

Operating costs per hour

- hourly capital charge (interest + depreciation)

- repairs and maintenance

Hourly operating cost

(d) Hourly Cost of Rotavating (b) + (c)

(e) Cost of Rotavation per hectare		
- 1st cultivation 5 hours per ha		
- 2nd cultivation 2 hours per ha		
	7 hours @ \$30.10	M\$ 210.70
	Rounded cost per hectare	210.00
(f) Contract price M\$250.00 per hectare		
1.3 <u>Four Wheeled Tractor: Disc Harrowing followed by Rotavating</u>		
(a) Tractor hourly operating cost		25.60
(b) Rotavator hourly operating cost		4.50
(c) Disc harrow operating costs		
- capital cost M\$8,280		
- life 8 years @ 800 hours/year		
- hourly capital charge M\$1.90		
- repairs and maintenance M\$1.60		
	Hourly operating cost	3.50
(d) Land Preparation Cost per hectare		
Disc harrowing 4 hours @ \$29.1		116.40
Rotavating 2 hours @ \$30.1		60.20
	Cost per hectare	176.60
	Rounded cost per hectare	177.00
(e) Contractors margin \$6.00 per tractor hour		
2. RICE HARVESTING: COMBINE HARVESTER		
(a) Basic Assumptions		
Capital cost M\$185,000 (inclusive of extras + trailer		
	for table)	
Life 8 years or 6,000 hours (750 hours/year)		
Interest charges 10%		
(b) Hourly Operating Costs		
- hourly capital charge (depreciation + interest)		46.20
- 15 l. @ \$0.45		6.80
- repairs and maintenance		37.00
- insurance + registration		13.30
- operator + attendants M\$12 per hour		12.00
	Hourly costs	115.30
(c) Cost per hectare		
- average rate of work (allowing for transporting, etc)		
0.6 ha per combine hour		
- Cost per hectare		192.00
(d) Contractors' rate		250.00

II. WITH PROJECT: CROP BUDGETS AT MARKET PRICES

1. SMALLHOLDER: RICE PRODUCTION

1.1 Direct Production Costs per hectare

(a) Materials		M\$
Seeds 25 kgs per ha transplanted		15.00
Plastic sheeting for nursery		2.50
Wooden posts for fencing nursery		14.00
Fertilizers 10 kgs Ammophos for nursery		10.20
100 kgs Urea		75.00
200 kgs of NPK compound		150.00
Pesticides 23 kgs Gamma BHC		32.50
2,5 l. dieldrex		16.80
Herbicides 4.5 kgs Rumpotox		38.00
Miscellaneous		25.00
Sub-total		379.00
(b) Machinery Contractors ⁽¹⁾		224.00
(c) Depreciation on tools and equipment		15.00
(d) Labour inputs per hectare		
	<u>Mandays</u>	
Land preparation nursery	5	35.00
Bund maintenance and irrigation	20	140.00
Transplanting and carrying	30	210.00
Fertilizing	6	42.00
Application of herbicides	6	42.00
Application of pesticides	6	42.00
Weeding	2	14.00
Harvesting, threshing & cleaning	40	280.00
	<u>115</u>	<u>805.00</u>
(e) Quit Rent and Irrigation		28.1
Summary:		
Total direct costs		1,451.00
Direct costs excluding fertilizers		1,261.00
Direct costs excluding fertilizers and labour		411.00

Notes:

- (1) Assumes 50% by two wheeled power tiller and 50% by four wheeled tractor.

2. GROUP FARMING: MECHANISED RICE PRODUCTION

2.1 Direct Production Costs

(a) Materials		M\$
Seeds 100 kgs of seed per hectare		60.00
Fertilizers 100 kgs urea		75.00
200 kgs NPK		150.00
Pesticides 23 kgs Gamma BHC		32.50
2.5 l. Dioldrex		16.80
Herbicides 6.5 kgs Rumpotox		55.90
Other inputs (sacking incidentals)		25.00
		415.20
(b) Mechanisation		
Land preparation (1)		210.00
Harvesting		192.00
Depreciation on hand tools and sprayers		15.00
(c) Labour inputs per hectare		
	Mandays	
Bund maintenance	5	35.00
Preparation of pre-germinated seed	1	7.00
Broadcasting seed	3	21.00
Fertilizer application	6	42.00
Irrigation	15	105.00
Application of herbicides	9	63.00
Application of pesticides	6	42.00
Spot weeding	5	35.00
Bagging and handling grain	4	28.00
	54	378.00
(d) Quit Rent and Irrigation Charges		28.1

Summary:

Total direct costs	1,238.30
Direct costs excluding fertilizers	1,013.30
Direct costs excluding fertilizers and labour	635.30

Notes:

- (1) Carried out by Group Farm equipment or Machinery service centre:
Contractors rates of \$250.00 per hectare for land preparation and harvesting are used in farm budgets.

3. SMALLHOLDER: MIXED VEGETABLES

(65% okra; 10% long beans; 10% cucumbers; 5% chilli; 10% brinjal)

3.1 Okra

(a) Materials		M\$
Seeds 12 kgs per hectare		60.00
Fertilizers NPK compound 500 kgs/ha		398.00
Urea 200 kgs		150.00
Pesticides Thiodan 110 litres		173.00
Dieldrex 5.5 litres		37.00
Azodrin 1.2 litres		43.00
Thiram 1 kg		10.00
Benlate 0.6 kg		37.00
Miscellaneous		150.00
		1,058.00
(b) Land Preparation (Contractor for 3 Cultivations)		336.00
(c) Labour		
	<u>Mandays</u>	
	210	1,470.00
Total costs per ha		2,864.00
Costs excluding labour (i.e. all family labour)		1,394.00
Costs assuming 50% family labour		2,129.00

Yield 20 tonnes: main crop 10 tonnes; 1st ratoon 6 tonnes; 2nd ratoon 4 tonnes.

3.2 Long Bean

(a) Materials		
Seeds 10 kgs @ M\$8.50		85.00
Fertilizers NPK 500 kgs		398.00
CCM 500 kgs		270.00
Pesticides		130.00
Herbicides		40.00
Staking materials		690.00
Miscellaneous		150.00
		1,763.00
(b) Land Preparation (3 Cultivations)		336.00
(c) Labour		
	<u>Mandays</u>	
	190	1,330.00
(d) Total costs per ha		3,429.00
Costs excluding labour		2,099.00
Costs including 50% labour		2,764.00
(e) Yield 12 tonnes per ha		

3.3 Cucumbers

(a) Materials		M\$
Seeds 1.5 kgs		30.00
Fertilizers Urea 125 kgs		94.00
NPK compound 600 kgs		475.00
Pesticides		180.00
Staking materials		690.00
Other miscellaneous inputs		150.00
		1,622.00
(b) Land Preparation (3 Cultivations)		336.00
(c) Labour		
	<u>Mandays</u>	
	185	1,295.00
(d) Total costs per ha		3,253.00
Costs excluding labour		1,958.00
Costs including 50% labour		2,605.00
(e) Yield 20 tonnes per ha		

3.4 Chilli

(a) Materials		
Seeds 3 kgs		21.00
Fertilizers - poultry dung		450.00
- NPK compound 1,800 kgs		1,433.00
Pesticides		880.00
Miscellaneous inputs		300.00
		3,084.00
(b) Land Preparation (3 Cultivations)		336.00
(c) Labour		
	<u>Mandays</u>	
	360	2,520.00
(d) Cost Summary		
Total costs		5,940.00
Costs excluding labour		3,420.00
Costs including 50% labour		4,680.00
(e) Yield 13 tonnes per ha		

3.5 Brinjals

(a) Materials	M\$	
Seeds 3 kgs		40.00
Fertilizers - poultry dung		700.00
- NPK compound 620 kgs		494.00
Pesticides - Malathion 80% 25 l.		295.00
- Benylate 16 kgs		1,056.00
Other miscellaneous inputs		250.00
		2,835.00
(b) Land Preparation (3 Cultivations)		336.00
(c) Labour	<u>Mandays</u>	
	290	2,030.00
(d) Cost Summary		
Total costs		5,201.00
Costs excluding labour		3,171.00
Costs including 50% labour		4,186.00
(e) Yield 24 tonnes per ha		

Direct Production Costs per Hectare of Mixed Vegetables (M\$/hectare)

Crop	Costs		Proportion of crop mixture %	Contribution to Weighted Costs	
	50% family labour	all family labour (1)		50% family labour	all family labour
Okra	2,129	1,394	65	1,384	906
Long bean	2,764	2,099	10	276	210
Cucumber	2,605	1,958	10	260	196
Brinjal	4,186	3,171	10	419	317
Chilli	4,680	3,420	5	234	171
Weighted costs per ha of vegetable mixture				2,573	1,800

Note:

(1) Labour excluded from costs

Revenues and Gross Margins from Mixed Vegetables (M\$/hectare)

Crop	Yield (1) (tonnes)	Price (2) (M\$/tonne)	Revenue per ha (M\$)	Direct Costs		Proportion of crop mixture (%)	Contribution to Weighted		Labour Requirement (mandays)
				50% labour	excluding labour		Gross Margin 50% labour	Gross Margin excluding labour	
Okra	18	500	9,000	2,129	1,394	65	7,606	4,466	68
Long bean	12	490	5,880	2,764	2,099	10	3,781	312	10
Cucumber	20	350	7,000	2,605	1,958	10	5,042	440	9
Brinjal	22	470	10,340	4,186	3,171	10	7,169	615	15
Chilli	13	930	12,090	4,860	3,420	5	8,670	361	9
Weighted Gross Margin per hectare of mixed vegetables							6,194	6,976	110

- Return to family labour assuming no hired labour, M\$32 per manday
- Return to family labour assuming 50% of labour is hired, M\$56 per manday
- Average market price per tonne of mixed vegetables M\$496

Notes: (1) Consultants Estimate assuming improved drainage and water control
(2) Based on farmer interviews, FAMA data and wholesale market surveys

DRAWINGS

1924

DRAWINGS

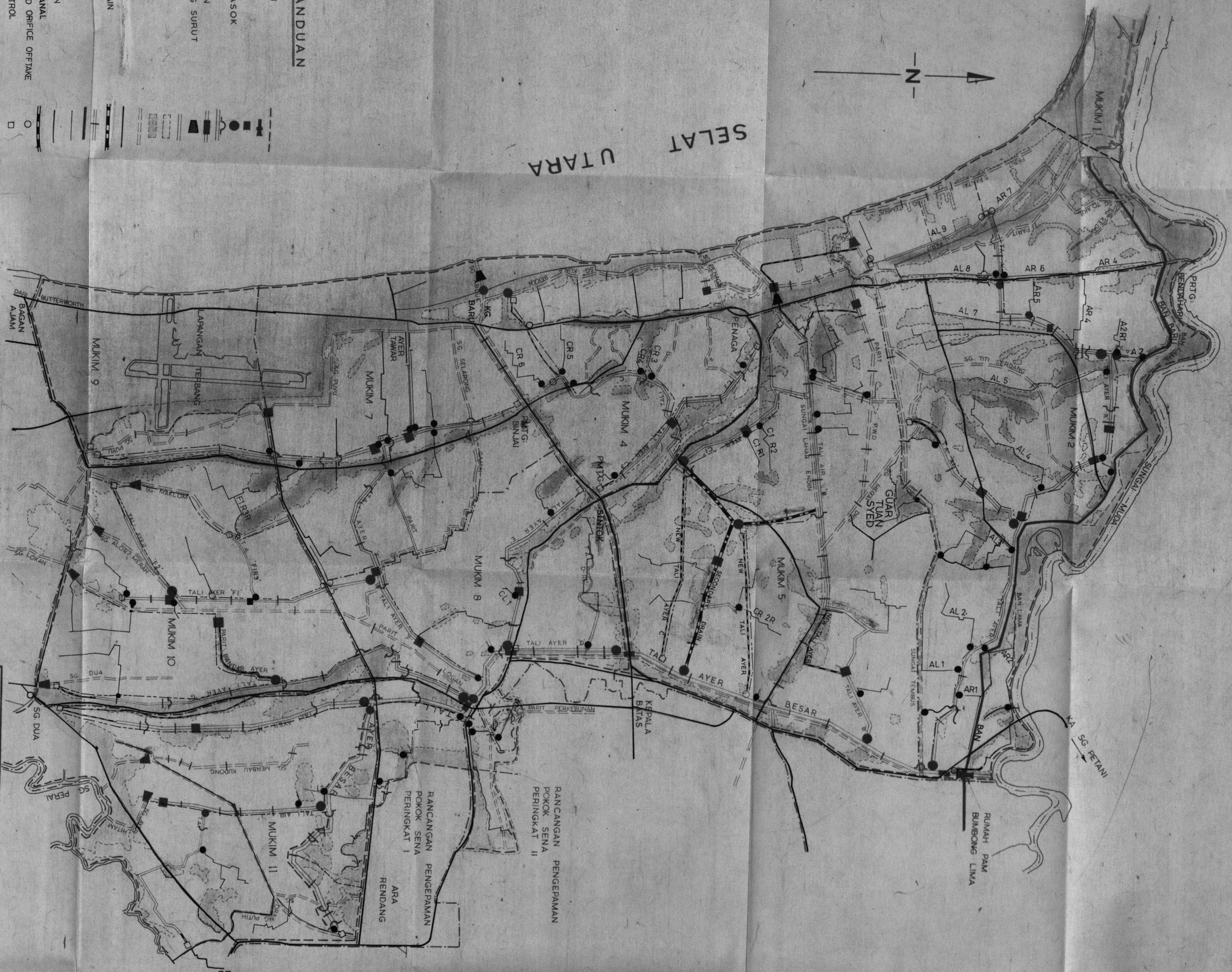
1924

DRAWINGS

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Library copy

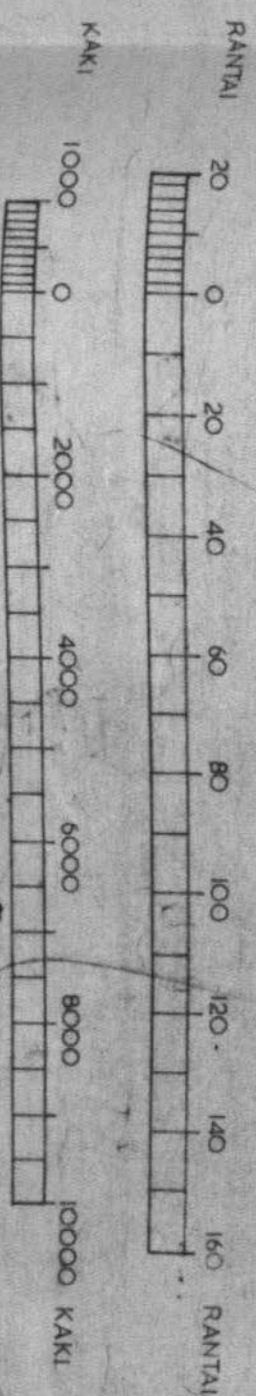
KEDAH



PANDUAN

KAWASAN PENGALIRAN
RUMAH PAM
EMPANG TERJUN
KAWALAN SALOR MASOK
SAIAN
PEMBENTONG JALAN
PINTU KAWAL PASANG SURUT
TALL AIR CABANG
BENDANG
KAMPONG
PARIT DAN SUNGAI
JALAN JHR
PROPOSED SECONDARY DRAIN
TITIAN
DRAIN
PARIT GILA
EXISTING COLLECTOR DRAIN
PROPOSED SECONDARY CANAL
PROPOSED CONSTANT HEAD ORIFICE OFFTAK
PROPOSED IRRIGATION CONTROL
EXISTING MAIN FARM ACCESS ROAD
PROPOSED MAIN FARM ACCESS ROAD
PROPOSED MAIN TERTIARY CANAL

SEKIL: 1 INCHI = 32 RANTAL



KEMENTERIAN PERTANIAN MALAYSIA

PULAU PINANG

BALIK PULAU AND SEBERANG PRAI

56. MUDA IRRIGATION SCHEME

BINNIE DAN RAKAN (MALAYSIA)

Jurutera Perunding

Bangunan Bank Hongkong. Kuala Lumpur

DATE _____

November 1980

DRG. NO.: 3

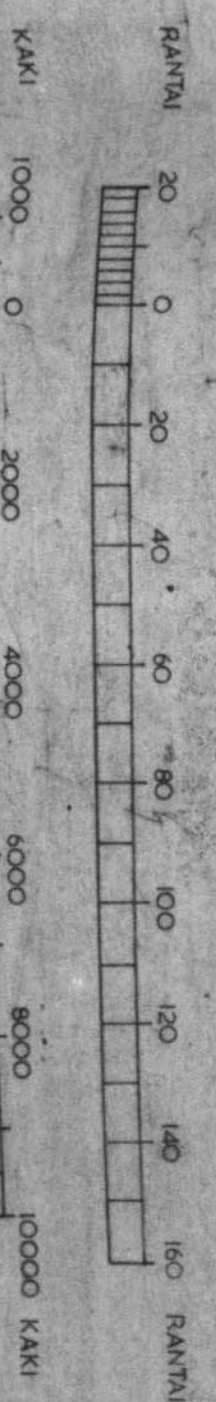
KEDAH



PANDUAN

KAWASAN PENGIRAAN
RUMAH PAM
EMPANG TERJUN
KAWALAN SALOR MASOK
SAIAN.
PEMBENTONG JALAN
PINTU KAWAL PASANG SURUT
TALI AYER
BENDANG
KAMPONG
PARIT DAN SUNGAI
JALAN JKR
TALAN PERKEBUNYAN
TITIAN
BAN
COMMAND PROBLEM AREAS
DRAINAGE PROBLEMS AREAS

SEKIL: 1 INCHI = 32 RANTAI



KEMENTERIAN PERTANIAN MALAYSIA

PULAU PINANG

INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT
UPGRADING OF IRRIGATION AND DRAINAGE SCHEMES
BALK PULAU AND SEBERANG PRAI

SG. MUDDA IRRIGATION SCHEME

EXISTING SITUATION

BINNIE DAN RAKAN (MALAYSIA)

Jurutera Perunding

Bangunan Bank Hongkong. Kuala Lumpur

DATE:

November 1980

DRG. NO.: 2