tapping in the tributaries at the existing intake points by the PWD is assumed to be consented by SCC, both now and in the future.

It is assumed that the first dam constructed will be operational by 1992.

5.2 Water Resources Development Plan

The overwhelming water demand in towns in the central area such as Johor Bahru, Senai, Kurai, Tebrau and Masai incur the largest water deficit in the Johor river together with the demand of PUB. The estimated total water deficit is 5 x 10^6 m^3/y in 1985 assuming that the hydrological conditions experienced in 1971 would recur. In year 1995, the deficit will increase to 28 x 10^6 m^3/y and it will increase further to 69 x 10^6 m^3/y in 2005 as summarized in Table 15.

To meet these deficits, the provision of dams and reservoirs as well as coastal barrages was studied to impound excess water in the rainy season and to release water to augment the flow in the dry season. The dams studied were Sayong dam, Linggiu dam, Pengli dam and Telor dam. The coastal barrages studied were Layang Ic, and estuary barrages on the Johor and Pendas rivers.

As stated above, it was assumed that the first dam would come into operation in 1992. The first dam was also planned to have sufficient capacity to meet the water deficit up to year 1997 or so.

The water demand and supply balance was studied for several differently assumed effective storages or supply capacities through simulation. If an assumed storage could not meet the water demand up to 2005, a second storage, and further a third storage if necessary, was provided with an assumed supply capacity. The economic construction cost for each storage considered was estimated for each assumed storage volume. The costs required for the second and third storages were discounted by applying a discount rate of 10%. Thus the present value in 1986 of the total cost for storage to meet water demand up to 2005 was estimated for each alternative combination of storages.

The economic costs of the dams were estimated on the basis of the financial cost of dams as discussed in Chapter 4. Economic costs were estimated for each scale of dam in terms of high water levels. In this economic cost estimation, transfer payments such as land compensation, taxes and local contractor's profits were substracted from the financial costs. Production foregone was applied in assessing land costs of rubber plantations, oil palm plantations and forest within the proposed reservoir area rather than land compensation costs on the basis of present productivity. The estimated production foregone was M$12,300/ha for rubber plantation, M$13,000/ha for oil palm plantation and M$2,000/ha for forest land.

In this comparative study, costs for treatment plant, pumping facilities and pipeline are not included since these costs will be determined by the magnitude of demand but not by the scale of storage. The results of the study indicated that following plans are conceivable from the economic point of view:

(1) Sayong dam with a high water level of EL. 17.0 and an effective storage of 98 x 10^6 m^3: this capacity would reduce the deficit by an estimated 79 x 10^6 m3 and would meet demand upto 2005 by itself. The present worth of economic cost was estimated to be M$75.6 x 10^6.

(2) Linggiu dam with a high water level of EL. 34.0 and an effective storage of 107 x 10^6 m^3: this capacity would reduce the deficit by an estimated 82 x 10^6 m^3 and would meet demand upto 2005 by itself. The present worth of economic cost was estimated to be M$85.0 x 10^6.

(3) Sayong dam with a high water level of EL. 16.0 and an effective storage of 73 x 10^6 m^3: this capacity would reduce the deficit by an estimated 55 x 10^6 m^3 and would meet demand upto 2001. The present worth of economic cost was estimated to be M$69.3 x 10^6. Telor dam with a high

water level of EL. 24.0 would be constructed by 2001 as the second dam and would come into operation in 2001. The dam would have an effective storage of 18 x 10^6 m^3 and in combination with Sayong reservoir mentioned above would be capable of supplying the deficit of 69 x 10^6 m^3/y. This combination could meet the demand upto 2005. The present worth of economic cost was estimated at M$15.9 x 10^6. As a consequence the total economic cost of this plan was estimated to be M$85.2 x 10^6.

(4) Linggiu dam with a high water level of EL. 33.0 and an effective storage of 89 x 10^6 m^3: this capacity would reduce the deficit by an estimated 60 x 10^6 m^3/y and would be able to meet demand upto 2002. The present worth of economic cost was estimated at M$83.5 x 10^6. Telor dam with a high water level of EL. 24.0 would be constructed by 2002 as the second dam and would come into operation in 2003. The dam would have an effective storage of 18 x 10^6 m^3 and in combination with Linggiu reservoir mentioned above would provide sufficient capacity to meet the deficit of 69 x 10^6 m^3/y. This combination could meet the demand upto 2005. The present worth of economic cost was estimated at M$13.1 x 10^6. As a consequence the total economic cost is estimated to be M$96.6 x 10^6.

(5) Sayong dam with a high water level of EL. 16.0 would be able to meet demand upto 2001 as mentioned in (3). The estuary barrage would be provided in 2001 and would come into operation in 2002 at Seng Heng to meet further demand. The barrage would provide adequate sufficient supply capacity up to 2005. The present worth of economic cost for the construction of barrage was estimated at M$16.4 x 10^6. As a consequence the total cost of this plan was estimated at M$85.7 x 10^6.

On the basis of the least costly alternative criteria, Sayong dam with a high water level of EL. 17.0 was selected as the optimum water resources development scheme for the regional water demand and supply balance under the water demand projected up to 2005. While, Linggiu dam with a high water level of EL. 34.0 m was identified as the second priority scheme (See Table 25).

With regard to this selection of schemes, it should be noted that candidate schemes for the first water resources development facilities should have a supply capacity of over 28 x 10^6 m^3/y because the deficit in 1995 is projected at 27.9 x 10^6 m^3/y. Consequently Telor dam and Seng Heng barrage must be excluded regardless of their economic viabilities. And only Sayong and Linggiu dams were selected as the candidates.

Suitable dam sites are limited yet water demand will continue to grow even after 2005. The water resources development plan should therefore allow for the maximum conceivable development, or at least, it should preserve the possibility of developing the site at the maximum scale in the future. The optimum scales of development were therefore examined for Sayong and Linggiu dam sites.

In this optimization, following benefits and costs were taken into account.

The economic benefit of water supply was estimated assuming a unit value of water to be M¢19.0 on the basis of the alternative unit cost of water derived from Layan Ic project. The growth of water demand during the period from 2005 to 2010 was assumed to be similar to that in the period from 2000 to 2005.

The benefit accruing from water supply has two aspects. One is the benefit derived from eliminating the deficit in the existing intake capacity of 728 Mld or 160 Mgd. This benefit can be evaluated as the product of the projected water deficit and the assumed water value. The other benefit is the capacity to supply additional water over the existing intake capacity of 728 Mld or 160 Mgd with a certain dependability. This benefit can be evaluated as the product of the projected additional volume of water supply and the assumed water value.

Flood attenuation incidental to a proposed reservoir is another benefit. Regulated flood discharges were routed to Kota Tinggi and flood damage reductions in and around Kota Tinggi town were estimated against the corresponding flood attenuation. A benefit of M$3.7 x 10^6 would be estimated for the Sayong dam of a high water level of EL. 17.0 assuming an evaluation period of 50 years and with a discount rate of 10% at 1985 constant price. This benefit will increase to M$4.1 x 10^6 if the high water level is set at EL. 18.0.

The annual economic benefit was obtained from the total of the benefits due to water supply and flood attenuation. The present value of the benefit was estimated by summation of the annual economic benefits for an evaluation period of 50 years from 1986 applying a discount rate of 10%. The water supply benefit obtained after 2005 was assumed to increase year by year in accordance with the increase in demand upto the given supply capacities.

The economic benefits and costs are summarized in Table 26 for Sayong and Linggiu dams for each scale of development. The relationship between the benefits and costs are illustrated in Fig. 10. These data show that the maximum benefit minus cost of Sayong dam will be derived by constructing the dam with a high water level of EL. 18.0 and Linggiu dam, with a high water level of EL. 36.0. It is concluded that Sayong dam with a high water level of EL. 18.0 is the optimum development and Linggiu dam with the high water level of EL. 36.0 is the second best alternative development.

In view of the above, two alternative schedules were compared regarding the development of Sayong dam. One would be to develop the dam with a high water level of EL. 17.0 allowing for heightening by 1 m when the increased demand requires (two stage development). The other schedule would be to develop the dam with a high water level of EL. 18.0 in 1991 (single stage development).

In order to develop Sayong dam, some preparations would be necessary for the second stage works in the former case. One of the major preparations would be land acquisition for the reservoir area. It is very hard to enlarge a reservoir area after it is once delineated. Accordingly it is necessary to purchase the reservoir area corresponding to the high water level of EL. 18.0. The estimated financial cost would be M$107.0 x 10^6 and the economic cost M$82.2 x 10^6. The cost to be incurred by the heightening, presumably in 2006, was estimated at M$0.1 x 10^6 on the time basis of 1986.

The present worth of economic benefits, costs and benefit minus cost was compared for the two cases. In this comparison the water supply benefits were assumed to be derived from water supply to the demand which was assumed not to increase after 2005. The heightening work is assumed to be completed in 2006, but the benefits cannot be assessed at this stage.

The results obtained may be summarized as follows;

Two-stage development:
The water supply benefit of M$126.0 x 10^6 and flood attenuation benefit of M$3.9 x 10^6 makes the total benefit of M$129.9 x 10^6. The initial cost of M$82.2 x 10^6 and the heightening cost of M$0.1 x 10^6 makes the total cost of M$82.3 x 10^6. The consequent benefit minus cost is M$47.6 x 10^6.

Single-stage development:
The water supply benefit of M$126.0 x 10^6 and flood control benefit of M$4.1 x 10^6 makes the total benefit of M$130.1 x 10^6. The cost is estimated at M$82.3 x 10^6. The consequent benefit minus cost is M$47.8 x 10^6. Up to 2005 the projected deficit would be met by storage with a high water level of EL. 17.0. Accordingly, in the case of single stage development, the capacity between EL. 17.0 and EL. 18.0 could be utilized for other purposes. The present worth of incremental economic benefit was estimated to be M$1.9 x 10^6 if the space is utilized for the flood control. However this space could only be utilized for the limited period from 1992 to 2005 and the benefit obtained therefrom was not counted for the study.

The single stage development would provide a larger benefit minus cost than double stage development. Accordingly it was judged that to construct Sayong dam with a high water level of EL. 18.0 in a single stage would be more advantageous than to develop the dam in two stages. It was concluded that Sayong dam should be constructed with a spillway crest elevation of EL. 18.0 and be operated at a high water level of EL. 17.0 up to year 2005. The high water level would be raised to EL. 18.0 after 2005 when a deficit may be expected at a high water level of EL. 17.0.

The main design parameters of the recommended optimum development scheme are preliminarily designated as follows:

Location of dam:	Kg. Sayong Pinang
Height of dam and crest EL.:	31 m and EL. 25.5
Crest length of dam:	1,140 m
Flood water level:	EL. 20.1
High water level (HWL):	EL. 18.0
Low water level (LWL):	EL. 12.0
Effective storage volume:	128×10^6 m^3
Reservoir surface area HWL:	34 km^2
Dam type:	Homogeneous earthfill
Embankment volume:	808,00 m^3
Crest elevation of spillway:	EL. 18.0
Crest length of spillway:	50 m
Discharge capacity of spillway (Normal F.W.L.):	300 m^3/s
River outlet:	2 sets of steel pipe diameter 2.2 m

The cash flow of the recommended optimum scheme is presented in Table 27. In this calculation the obtainable benefit corresponding to the water supply was assumed to be the same as that in 2005 thereafter regardless of the supply capacity and the foreseeable increase in demand. As shown in the Table, the economic benefit minus cost of M$47.8 $\times 10^6$ was derived for an assumed evaluation period of 50 years with the time base of 1986 and a discount rate of 10%. The economic internal rate of return (EIRR) would be 13.1%.

If stagnation in the economy depresses the GDP growth rate, socio-economic figures may be depressed accordingly. If a GDP growth rate of 5% is assumed for the period from 1985 to 2005, the per capita GRP in the State of Johor becomes M$2,840 in 1995 and M$3,820 in 2005. These figures are 83 and 74% of the original figures projected in this study. The water demand at R41 and R42 is estimated at 728 Mld in 1990, 790 Mld in 1995, 856 Mld in 2000 and 1,003 Mld in 2005. The present worth of the economic benefit is estimated at M$90.1 x 10^6 which is 69.3% of the original case, assuming a unit value of water at M¢19.0/m^3 and a discount rate of 10%. Even in this case an economic internal rate of return (EIRR) of 10.6% would be secured. Accordingly the recommended plan to construct Sayong dam with a high water level of EL. 18.0 is judged to be economically stable and desirable.

5.3 Water Supply Works

To meet increasing water demand in the Johor Bahru area, construction of new water supply works will be required by 1991 as well as construction of a dam in the Johor river basin.

In the study, water released from the dam is assumed to be extracted at the proposed intake at the Kg. Tai Hong site, 2 km upstream of Kota Tinggi and the existing intake R41. The proposed intake site was selected through a reconnaissance survey along the Johor river. The proposed intake site was selected so as to ensure that the ports would be submerged to a sufficient depth at all stages of the river. Site comparisons were also made from several other technical viewpoints. A downstream intake site has an advantage over an intake upstream in abstracting available discharge from a larger basin. While an intake downstream would suffer saline intrusion problem in the dry season or at high tide periods more frequently than that further upstream.

Through the intake site selection, which is a kind of trade-off decision on advantage between upstream and downstream, finally Kg. Tai Hong is recommended as the construction site for water supply works.

As mentioned earlier, the water demand to the proposed intake is estimated to be 488.5 Mld (107 Mgd) by 2005. A new treatment plant to treat this amount of water will have to be constructed at Kg. Tai Hong. The type of treatment plant would be a type of rapid-filtration plant of which the essential features would be chemical coagulation accomplished in flocculation basins, clarification accomplished in settling basins, and filtration. A plan of the treatment plan is shown in Plate 25.

The required area for the plant with the capacity of 107 Mgd is estimated at 50 ha. The construction cost for the water supply works including two sets of intakes, a treatment plant and a pumping station is estimated at M$113 x 10^6 at 1985 constant price.

To convey treated water from the treatment plant to the demand area, a new pipeline (transmission main) will be required. At this master planning stage it is proposed that the new pipeline route should be laid parallel to the existing PUB pipelines. The pipeline route was selected from a map study at a scale of 1:25,000 with due consideration to topography, accessability from existing roads and minimizing the total length. The route will have to be studied by detailed survey at a future stage. The proposed pipeline route is shown in Fig. 11.

The required new pipeline would be of steel pipe in double-lane with a diameter of 1.6 m. The land space required for a new pipeline would be approximately 20 m in width. The financial construction cost is estimated to be M$ 46 x 10^6 at 1985 constant price.

The construction of a new distribution system will be required with the growth of the water demand in the areas served such as Johor Bahru, Skudai and Kulai areas. This distribution system would consist of pipes, valves, hydrants and appurtenances and may include extensions to and reinforcing mains for existing systems. The financial cost for the distribution system to have the required 2005 supply capacity is estimated to be M$ 278 x 10^6 at 1986 present value.

The total financial cost for whole water source and supply facilities is estimated to be M$ 538 x 10^6 at 1985 constant price, while the total water supplied by these facilities will be 638 x 10^6 m^3 during the evaluation period of 50 years. Thus the unit water cost at the consumers' end is estimated to be M¢84/m^3.

The construction time schedule for the Sayong dam and related water supply works is shown in Fig. 12.

5.4 Environmental Assessment

The proposed Sayong dam may be a barrier to migratory fish such as Hampala and Macrobrachium rosenberri. These migrant species will decrease and stagnant water species such as Monopterus albus and Kryptopterus will increase in their populations in the proposed reservoir area. The reservoir will become a good fishing ground for local people.

In the downstream reach of the Johor river Macrobrachium rosenbergi (freshwater prawn) will decrease due to water abstraction at the proposed intake site. The prawn spawns in the brakish water zone which contains 10 to 40% of seawater throughout the year. Their spawning ground will be reduced in area and duration by water abstraction in the downstream reach from Kota Tinggi.

Other impacts to fish fauna are considered to be insignificant according to experience in existing reservoirs such as Machap, Layang and Semberong. The same impact is foreseeable in construction of Linggiu dam.

Since the proposed Linggiu reservoir will submerge part of the Endau-Kota Tinggi wildlife reserve, the reservoir may be a kind of barrier to the movement of the protected wildlife. The effects of this need to be studied more in detail. The submerged area of the proposed reservoir is presently a habitat for small animals. The proposed Sayong reservoir however will have no such impacts on wildlife.

Historical graveyards in Sayong Pinang such as Makam Tujuh and Makam Dua are located at about 4 km upstream from the proposed damsite. Their located elevations are estimated to be EL. 13.6 m for Makam Tujuh and EL. 12.6 m for Makam Dua and will be submerged by Sayong reservoir. These assets should be relocated in accordance with the official procedures. In Linggiu reservoir area, it is believed that a historical asset called "Black Fort" is situated. Since the location and value of this are not known, details should be obtained and assessed out prior to implementation of the dam.

The catchment area of the proposed Sayong dam has been well developed for agricultural lands such as rubber and oil palm plantations. According to "LONG-TERM EFFECTS OF LOGGING IN PENINSULAR MALAYSIA" prepared by LEONG HING NIM, the annual soil loss ratio from catchments are estimated at 31 $m^3/km^2/y$ from undisturbed jungle and 46-87 $m^3/km^2/y$ from mature rubber and oil palm. These figures are consistent with general knowledge that the erosion from a forest without grasses is double that of a thick forest. The yield of eroded material is much higher when the oil palm is replanted. A considerable part of the eroded material will be come into and remain as sediment in the reservoir. However the water quality downstream reach is not expected to improve substantially because even now a substantial part of the sediment is being deposited in the swampy flood prone areas which are located in the proposed reservoir area.

The agricultural chemicals used on the oil palm and rubber plantations are not considered likely to cause any serious problems in water use, according to experience with the existing reservoir. Sixty (60) percent of the catchment area of Layang dam is covered by rubber and forty (40) percent by oil palm, and yet the water has remained within acceptable limits.

Notwithstanding the expectations mentioned above, development in the catchment area should be carefully controlled. In this way erosion in the catchment area will be minimised, the life of reservoir will be extended and the water quality may be improved. Thick forest will decrease flood peak discharges and increase low flow discharges from the catchment area thereby enabling the reservoir to function more effectively.

6. FLOOD MITIGATION PLAN

6.1 River Conditions and Flood Problems

Most rivers in the Region rise in low hills and have easy gradients. The channel slopes of the Pontian Kechil river and the Pulai river are less than 1/3,000 even in their upper reaches. The channel slopes of the Pontian Besar, Sedili Besar and Sedili Kechil rivers are as small as 1/10,000 to 1/20,000 in their middle and lower reaches. The Johor river and the Benut river have slopes of 1/1,000 at their upper reaches. However channel slopes decrease to 1/5,000 in their middle reaches. All the rivers described above have marshes in their middle or lower reaches. The flat channel slopes limit flow capacity which is liable to bring about frequent inundation.

The Tebrau and the Skudai rivers have no distinctive marsh areas. The channel slopes are 1/1,000 in their upper reaches and 1/1,500 in their lower reaches.

Except for some river stretches which have been improved by DID, flow capacities of rivers in the Region are estimated at around 0.1 to 0.3 $m^3/s/km^2$ of catchment area, which can hardly discharge a flood occurring every year. Floods of the Benut, Pontian Besar, Pontian Kechil, Skudai, Tebrau and Johor rivers have caused considerable flood damage to towns and agricultural land located along these rivers. Floods of the Pulai, Sedili Kechil and Sedili Besar rivers have caused less serious devastation because land uses along these rivers are not as yet so intensive.

Flood damage in December 1969 was extraordinarily serious and extensive. The floods were the largest in the major rivers in the past 20 years. On that occasion, rainfall of 250 to 300 mm was recorded over 4 to 7 days. Rivers in the Region inundated as shown in Fig. 13. The total flooded area was about 570 km^2. The duration of flooding was 5 to 7 days and depth was 1 to 2 m.

Recent major floods have been those which occurred in December 1978, November 1979 and December 1981. The flood in December 1978 hit mainly the southwestern part of the Region covering the Skudai, Tebrau, Pontian Besar, Pontian Kechil and Pulai river basins. On the other hand, the November 1979 flood caused inundation in the Johor River Basin located in the northern part of the Region. As for the flood in December 1981, the flooded area was concentrated on the eastern part of the Region covering the Sedili Besar and Sedili Kechil rivers.

According to the records of the Department of Welfare, hundreds of people fled to evacuation centers due to the recent major floods discussed above. Furthermore, floods often cut the highways linking Johor Bahru to Mersing and to Ayer Hitam. The railroad going to Kuala Lumpur from Singapore was inundated by the flood of December 1969.

Problems of sediment, erosion and meandering are not serious in the Region. Only land reclamation for housing development along Skudai river is producing distinctive sediment, causing the aggradation of the riverbed.

The major river structures in the Region are two intake weirs with pump stations owned by PUB located in the lower reaches of Skudai and Tebrau rivers. Each weir is provided with 3 spillway gates. The gates are 6.5 feet in height and 20 feet in width at Skudai weir, and 7 feet in height and 20 feet in width at Tebrau weir.

6.2 Existing and On-Going Flood Mitigation Facilities

DID has completed flood mitigation works for strategic reaches of the Skudai, Tebrau, Benut, Pontian Besar and Pontian Kechil rivers. These works comprised the enlargement of low flow channels by dredging and provision of dikes.

Skudai and Tebrau river

The river channel improvement works on the Skudai and Tebrau rivers were completed in 1974 for reaches downstream from PUB's intake weirs. By these works, flow capacities equivalent to the discharge of a 20-year flood are provided in the improved channel of 6 km in the downstream reach of the Skudai river, and that equivalent to the discharge of a 10-year flood to 5 km in the downstream reach of the Tebrau river. Existing flood mitigation works are shown in Fig. 14.

Benut river

Tidal dikes are provided on both banks of the Benut river in the downstream reach for 11 km from the estuary. Dikes are also provided to the Pingam river, a tributary of the Benut river joining at Benut. Dredging work was carried out for 18 km from the end point of the tidal bank mentioned above to Simpang Renggam. These river improvement works were planned with for a design discharge of 160 m^3/s, which is equivalent to a flood discharge of 5 years in recurrence interval.

For the Macap river, a tributary of the Benut river, having a catchment area of 78 km^2 the Macap dam was constructed in its upper reaches. The primary purpose of this dam is flood control against a design inflow equivalent to a 25-year flood to protect the lower basin including Simpang Renggam town and its environments. It has a gross storage capacity of 30.6×10^6 m^3, out of which 10.4×10^6 m^3 is used for the flood control, another 10.4×10^6 m^3 is for the water supply of about 10 Mgd and the remaining 9.8×10^6 m^3 is dead storage.

Furthermore, the Ulu Benut Catch Drain and Benut High Level Drain are provided on the right bank in the middle reach of the Benut river to drain lowlying lands.

Pontian Besar River

Tidal dikes are provided on both banks of the downstream reach of the Pontian Besar river from the estuary to the confluence of the Pontian Besar river and the Ayer Hitam river, a principal tributary. Dredging was carried out for the channels of the Pontian Besar river from the confluence to near Sedenak Estate for 14 km. Dredging was also conducted on the Ayer Hitam river from the confluence to Alor Bukit for 7 km. The flood mitigation works provided are illustrated in Fig. 14.

Pontian Kechil River

The river channel was dredged to increase its flow capacity from Kampong Duku, located about 3 km upstream of its estuary for 11 km to Pengkalan Raja. The river channel dredged is shown on Fig. 14.

Pulai, Johor, Sedili Besar and Sedili Kechil rivers

No flood mitigation measures have yet been provided on the Pulai, Johor, Sedili Besar and Sedili Kechil rivers.

On-Going Flood Mitigation Schemes

DID plans to extend existing flood mitigation works. The plan envisions river channel improvement works on the Skudai river from the PUB's intake to Kulai with an improvement length of about 15 km as shown in Fig. 14. The channel flow capacity will be increased from the existing 45 m^3/s to 310 m^3/s, which is equivalent to the 10-year flood. The channel improvement will reduce present high flood damage in Senai and Kulai, of which the population is growing rapidly.

Channel improvement works downstream from the Macap dam are almost completed as shown in Fig. 14. This channel improvement together with flood control by the Macap dam will act to mitigate a 25-year flood.

6.3 Flood Damage

The average number of persons per household within the flood vulnerable area was assessed from the 1980 Population and Housing Census.

The present unit value of asset was estimated as shown in Tables 28, 29 and 30, referring to the Property Market Report, 1983 prepared by the Valuation Department. The figures adopted in NWRS and the study for Western Johor Agricultural Development Project were also referred to in the estimation.

Flood damageable ratios were estimated for tree crops, horticulture, paddy and houses and infrastructure by depth and duration of flooding as shown in Tables 28, 29 and 31 on the basis of the ratio adopted by NWRS and the study for Western Johor Agricultural Development Project.

Economic losses due to suspension of production, trade, transportation and communications, called the indirect damage, are assumed to be 30% of the total value of the direct flood damage.

The estimated damageable values in 1985 and damageable ratio produced the possible damages to be incurred by the floods assuming that the magnitudes thereof are same as the floods that have occurred in the past. The flood of 1978 in the Skudai river, had it occurred in 1985 and without the present river improvement works would have caused an estimated M$7.8 x 10^6 of damage. This would have been the largest damage in the Region since 1974. Next to this was the flood of the Johor river which occurred in 1969, which caused an estimated M$5.8 x 10^6 of damage. The estimated possible damages are shown in Table 32.

The damageable quantities and values for each asset were estimated for the year of 2005. In this case, it was assumed that the damageable quantities of houses and properties will increase in proportion to the population growth, and the values of house and properties will increase in proportion to per capita GRP. The possible damages were estimated to increase to M$34.1 x 10^6 for the 1978 flood in Skudai river basin and M$19.6 x 10^6 for the 1969 flood in Johor river basin. The estimated possible damages are shown in Table 33.

The probabilities of occurrence of floods in the Region were estimated through a frequency analysis of storm rainfall and corresponding flood discharge. The floods experienced and the estimated probabilities of recurrence are shown in Table 34. The return period of the flood which occurred in the Skudai river in 1978 is estimated at about 33 years, while that of the flood in the Johor river in 1969 is about 24 years. The obtained occurrence probabilities were applied to the corresponding flood damages. Thus probable flood damages were assumed for 1985 and 2005 for each river by each stretch as presented in Tables 35 and 36.

The average annual possible damage of M$1.9 x 10^6 was estimated for the Skudai river in 1985 and M$5.8 x 10^6 in year 2005. Almost 90% of the probable damage would be concentrated in the middle reach of the river. The damage in Senai and Kulai towns contributed much to this concentration.

The average annual possible damage of M$1.7 x 10^6 was estimated for the Johor river in 1985. More than half the amount estimated is attributable to damage in and around Kota Tinggi town. The damage is projected to increase to M$3.9 x 10^6 in 2005. The share of the damage in Kota Tinggi area is estimated to increase to more than 60% in this year.

The estimated flood damage in the Tebrau river is next to the damages of the Skudai and Johor rivers. The estimated average annual damage is M$0.7 x 10^6 in 2005. The estimated damages for other rivers are as small as less than M$0.5 x 10^6 even in 2005.

6.4 Flood Mitigation Plan

Several measures were contemplated to provide flood mitigation for each stretch of each river. River improvement was mainly adopted as the flood mitigation measure for all rivers. The retarding of peak flood discharge in an existing marshy area as located along most rivers was also accepted as an effective flood mitigation measure. The allocation of flood control capacity in the Sayong dam and the Linggiu dam was considered as a candidate flood control measure for the Johor river. In the downstream reach of the Johor river, stretch No. 1 (See Fig. 14), a cut-off channel was proposed to divert flood flow to detour the densely populated part of Kota Tinggi town as an alternative measure.

The reduction of flood damage secured by flood mitigation works was examined for each stretch of the Johor river. The corresponding construction costs were also estimated in the premises of the design flood discharge listed in Table 37. Thus net benefits of flood mitigation works were obtained for each level of flood mitigation. The net benefits obtained showed that only the flood mitigation works for some stretches of the Skudai and the Johor rivers would be beneficial from the economic point of view. Consequently the flood mitigation by means of river channel improvement has only been recommended for the Skudai and Johor rivers as follows:

Skudai River

The recommended scheme is an improvement of the river channel from the PUB intake site to the Kulai town area with a design flood of 20 years in return period. The channel length to be improved is 15 km. About 8 km of river channel was improved in 1974 for the stretch downstream from the PUB intake point and with a design flood of 20 years in return period. The principal features of recommended flood mitigation scheme are summarized in Table 38.

The total financial cost is estimated to be M$13.6 x 10^6 at 1985 price levels for the proposed river channel improvement, including a construction cost of M$9.5 x 10^6.

The annual average flood damage of M$2,664 x 10^3 will be reduced by M$2,158 x 10^3 or 81% along stretches No.2 and No. 3 by the proposed river channel improvement. The value of EIRR is estimated to be 11.0%.

As for the population affected by floods, 12,000 people will be affected by flood on an annual average in 2005 along river stretches No. 2 and No. 3, assuming no further flood mitigation works. However, if the proposed river channel improvement is completed, about 10,200 people or 86% of the above affected people will be relieved from the risks of flood.

This flood mitigation plan is envisioned in the DID's flood mitigation plan.

Johor River

River channel improvement of 6.7 km in length is recommended and with a design flood level of 30-year return period. Channel improvement would start about 3.5 km downstream from Kota Tinggi bridge and continue to the PUB intake point.

A flood control dam is not proposed as the flood mitigation measure due to economic considerations. The principal features of the recommended flood mitigation scheme are presented in Table 38.

The total financial cost for the river channel improvement is estimated at M$7.7 x 10^6 at 1985 price levels, including the construction cost of M$5.2 x 10^6.

It is expected that the annual average flood damage of M$1,363 x 10^3 along the river stretch No. 1 will be reduced by M$1,181 x 10^3 or 87% in 2005 by the proposed river channel improvement. The value of EIRR is estimated to be 10.7%.

It is also estimated that an average of about 4,600 people a year will be affected by flood in the riverine area along stretch No. 1 by 2005, if no flood mitigation work is provided. Among the aforesaid population affected by flood, about 4,100 people or 90% will be relieved by the proposed river channel improvement.

Tebrau, Benut, Pontian Besar and Pontian Kechil rivers

Since the basins are already protected by river channel improvements with design flood levels of 5 to 10 years in return period, tidal dikes and the Macap dam, no further flood mitigation measures are judged to be economically feasible.

Pulai, Sedili Besar and Sedili Kechil rivers

Although no flood mitigation measures have been provided, the damage potential is extremely small and no flood mitigation measures are recommended for the period to 2005.

As a whole, the flood mitigation master plan will reduce the regional flood damage by M$ 3,339 x 10^3 out of M$ 6,202 x 10^3. The population to be relieved is estimated at 14,300. This is around 60% of total 2005 vulnerable population of 24,100 in the Region.

6.5 Preliminary Design of Flood Mitigation Works for the Johor River

6.5.1 Flood hydrology

The objective river stretch of this preliminary design is shown on Fig. 14.

Hourly flood discharge and rainfall data were collected for the 1978 flood recorded at Jam Johor Tenggarah and Sek Men Bekit Besar. These two gauging stations are located near the proposed Sayong dam site. One-day rainfall data are also available for the last 20 years at 8 gauging stations located in and around the catchment area of the proposed Sayong dam site. A simulation study on the flood discharge at the proposed Sayong dam site was carried out and a simulation model was established by use of Storage Function Method. In this study river channel storage and discharge rating curves were examined on the basis of the topographic maps and the measured river cross section. The established simulation model and storage function showed a good fit with recorded flood discharge and hourly rainfall.

Hourly distribution of daily rainfall was also studied for various storm rainfalls. Thus the hourly distribution pattern of a storm rainfall was estimated. The established pattern was applied to the estimated probable daily basin rainfall. Then probable flood runoff was estimated by applying the probable rainfall to the simulation model.

The same was carried out for river stretch No. 1 of the Johor river. In this way the probable flood hydrograph was established as shown in Fig. 15.

Data on tidal stage are available for the gauging station of Sembawang Shipyard which is located at the mouth of the Johor River, $1^{o}28'$N and $103^{o}50'$E. The mean high water spring tide (MHWS) is observed to be 1.37 m above the mean sea level (MSL) at the gauging station, while the riverbed elevation ranges from -5.0 to -3.0 m above MSL at the objective river stretch. Accordingly, the water stage is affected by the tidal level up to 15 km upstream from Kota Tinggi including the objective streach of the proposed improvement.

The water surface profile of the river stretch was calculated, for various river discharges under the condition of MHWS by means of non-uniform flow calculation method. The estimated water surface profile is shown in Fig. 16.

On the basis of the results of the non-uniform flow calculation present channel flow capacity was estimated as shown in Fig. 17.

The present channel flow capacity is between 450 m^3/s and 500 m^3/s in the stretch above Kota Tinggi bridge, that riverine area is developed as the populated town center. However, the flow capacity decreases to less than 200 m^3/s about 4 km upstream from Kota Tinggi bridge, where only the agricultural and swamp areas are observed.

Thus, present channel flow capacities are divided roughly into two groups; one with 450 m^3/s to 500 m^3/s along the populated town center, and the other with 200 m^3/s along agricultural and swamp areas. As compared with the probable flood discharges the channel with capacity of 450 m^3/s to 500 m^3/s will discharge a 5-year return period flood harmlessly, while the flow capacity of 200 m^3/s is not sufficient to discharge even a 2-year return period flood.

The channel flow capacities were also estimated for the larger tributaries. The existing bank elevation of Permandi river is less than 2.0 m above MSL even 1.0 km upstream from the confluence of the Permandi river and the Johor river, as shown in Fig. 18. This bank elevation is generally lower than the water stage of the Johor river in case of MHWS. Accordingly, the channel flow capacity of the Permandi river is estimated to be almost nil during a high spring tide. In an extraordinary high tide or King Tide water runs back up the Permandi river channel and overflows from both banks. By contrast the banks of the Tembeyoh river have relatively high elevations of 2.5 m to 3.3 m above MSL, and the flow capacity of the Tembeyoh river is estimated to be 10 m^3/s to 50 m^3/s even at the time of a high spring tide.

6.5.2 Alternative studies

Alternative measures to mitigate the flooding in the objective river stretch were studied as follows:

(1) River channel improvement

A comparative study was made of the following alternatives for river channel improvement.

- Alternative A: Construct levees only without dredging the existing river channel.

- Alternative B: Construct levees and dredge the existing river channel to a profile set at the existing riverbed level.

- Alternative C: Construct levees and dredge the existing river channel to a profile set at 1.0 m below the existing riverbed level.

- Alternative D: Construct levees and dredge the existing river channel to a profile set at 2.0 m below the existing riverbed level.

The preliminary design for the above alternatives would be defined by the following parameters:

- The river channel slope would be determined to preserve the existing slope of 1:4,000, since neither serious erosion nor sedimentation is observed in the objective river stretch and the existing riverbed slope is judged to be stable.

- The existing river channel crosses the most urbanized part of Kota Tinggi town. Accordingly land acquisition for the right-of-way should be minimized. Consequently the existing river channel should be utilized as much as possible and the maximum width for the improvement work space is assumed to be 120 m in view of the present channel width.

- Design criteria as follows:

  The allowable maximum flow velocity would be 2 m/sec if earth embankment/confining levees are provided. The crown width of a levee would be 3 m for the main channel and tributaries. Channel side slopes would be 1:2.0. However revetment works would be provided if necessary. A freeboard of 1.0 m would be provided for the main river and 0.5 m for tributary.

Based on the above premises, the cost of each alternative was estimated for each design discharge, as shown in Table 33. The least costly measure for river channel improvement is Alternative A for a design discharge of 300 m^3/s. However the cost of Alternative B becomes the least if the design discharges is increased to more than 500 m^3/s. Thus, it was concluded that river channel improvement by deepening the riverbed in the manner of Alternatives C and D would not be as effective.

(2) Flood diversion channel

The effectiveness of a flood diversion channel was examined as an alternative means of reducing the design discharge of the main channel by diverting a part of the flood runoff. The flood diversion channel would short cut the objective river stretch connecting a point 1.5 km upstream from the bridge to a point 2.5 km downstream from the highway bridge, as illustrated in Fig. 19. The diversion channel would have a total length of 2,600 m and a channel slope of 1:2,600. The diversion channel would cut across an area which is to be developed as a residential area and half of which has a ground elevation of more than 15 m.

Possible diversion discharges were estimated by a non-uniform flow calculation method for each design discharge and various depths and widths of diversion channel. This estimation was done on the assumption of the main channel being improved by means of Alternative B and the tide level being the mean high water spring.

The work volume and costs required for the diversion channel were also estimated for various depths and widths of the diversion channel.

The most economical size of diversion channel was thus fixed for each design discharge, and the total necessary cost was estimated for the most economical combination of river channel improvement of main channel and construction of diversion channel, as shown in Table 40.

(3) Optimum flood mitigation measure

The relationship between design discharge and most economical construction cost is shown in Fig. 20 for river channel improvement with and without a flood diversion channel. River channel improvement without a diversion channel may be seen to be recommendable for a design discharge of less than 850 m^3/s, while it is better to provide a diversion channel for a design discharges greater than 850 m^3/s. A design discharge of 850 m^3/s corresponds approximately to a 50-year return period flood.

The construction cost for the above recommendable measures were further converted to the average annual cost, and compared with the annual average of damage reduction, as shown in Table 41.

It is concluded that the greatest net economic benefit is brought about by river channel improvement by means of Alternative B with a design flood discharge of a 30-year return period or 770 m^3/s.

The lower reaches of Johor River are presently observed to have saline water intrusion. The river channel improvement recommended here would not increase saline water intrusion, since it would maintain the riverbed level almost exactly at present as shown in Fig. 21.

From the above considerations it is concluded that the optimum flood mitigation measure would be river channel improvement by means of Alternative B with design flood discharge of a 30-year return period. The diversion channel was thus evaluated as of lower priority.

6.5.3 Design

(1) Design premises

Preliminary design was done on the basis of the following premises:

(a) In accordance with the optimum measure selected in the previous section, river channel improvement by means of Alternative B without a diversion channel for a 30-year return period design flood discharge, namely 770 m^3/s, was adopted as the objective of the preliminary design.

(b) The design was based on the results of longitudinal and cross sectional surveys. Among the cross sectional survey points, cross sections No. 1 and No. 2 have a present flow capacity of over 770 m^3/s. Accordingly, river channel improvement is assumed to start from cross section No. 3.

(2) Preliminary design for the main channel

The riverbed profile would be the same as the existing average riverbed with an average channel slope of 1:4,000. The cross section and its high water levels would be as found by the non-uniform flow calculation method assuming the proposed riverbed profile and MHWS.

The proposed alignment and the typical cross section would therefore be as shown in Plate 26, and the longitudinal profile as in Plate 27. Typical cross sections are shown in Fig. 21.

(3) Preliminary design for the tributaries

The existing bank elevation is 2.5 m of the Permandi is lower than the proposed dike elevation of the main channel. The design would therefore be arranged as follows:

- A weir would be provided at the confluence of the main channel to prevent backwater flow from the main channel to upstream of Permandi.

- The height of the dike would be almost the same as the height of the adjacent ground level to avoid interruption of inland drainage.

For Tembeyoh, since both the adjacent ground level and the existing bank levee are relatively high, the levees would be constructed on the existing bank with heights the same as those proposed for the main channel.

6.5.4 Preliminary construction plan

The construction of the project is scheduled for 5 years, including 1 year for preparation and detailed engineering.

River improvement work would consist of excavation, embankment, construction, and remodelling of Kota Tinggi bridge, etc. It is assumed that these works would be executed from downstream towards upstream and from the main channel up the tributaries.

Of the above-mentioned works, the earthworks comprising excavation and embankment construction would have critical work volume, i.e. the critical path of the schedule would be determined by the progress of earthwork. The construction schedule was prepared, therefore, as shown in Fig. 22 with the average annual work period restricted to 8 months from April to November to exclude the rainy season.

The maximum annual volumes of earthwork would be 67,000 m^3 of excavation and 40,000 m^3 of embankment. The required heavy equipment was estimated as listed in Table 42.

6.5.5 Preliminary cost estimation

Costs were estimated from the preliminary design described above. The work items, work volumes and costs for the river channel improvement are listed in Table 43. The estimated costs represent the financial cost at 1986 price levels for both construction and compensation costs.

Construction costs cover direct costs, engineering costs (10% of direct cost), and physical contingencies (30% of the former two). Compensation costs cover both those for resettlement of houses and for procurement of agricultural land. Objects for compensation were identified from data such as the land use map prepared by DOA in 1984 and the map of the Urbanizing Structural Plan for Kota Tinggi prepared by the State Government.

The total cost amounts to M$7.7 x 10^6 out of which M$5.2 x 10^6 would be attributable to construction cost.

7. WATER POLLUTION ABATEMENT PLAN

7.1 Water Pollution Projection

There are 8 towns, 30 palm oil mills, 20 rubber factories, 7 pineapple factories, and 49 animal husbandry units in the Region which have been identified as sources of pollution. The locations of these sources of pollution are shown in Fig. 5.

The concentration of BOD in river water is taken up as a representing parameter of man-made pollution. The BOD load of each source of pollution and existing purification methods are as follows;

<u>Sewerage System</u>

Almost 50% of the total population use a pour-flush type toilet. In this system the liquid component percolates into ground and sullage is discharged to drains. The purification efficiency is very small.

About 30% of the total population use the septic tank system. The system is assumed to have purification efficiency of 45 to 85% removal.

<u>Rubber Processing Factories</u>

The anaerobic pond with facultative pond system is generally used by rubber processing factories. This purification system is expected to decrease the pollution load of effluent from 2,320 mg/l to the DOE's target of 50 mg/l in terms of BOD.

<u>Palm Oil Mills</u>

The anaerobic pond with facultative pond system is generally used by palm oil mills. This purification system is expected to decrease the pollution load of effluent from 22,000 mg/l to the DOE's target of 50 mg/l in terms of BOD.

Pineapple Processing Factories

Land disposal or anaerobic pond with facultative pond systems are used. These purification systems are expected to decrease the pollutant load of effluent from 1,120 mg/l to the DOE's target of 50 mg/l in terms of BOD.

Animal Husbandry

The most common purification systems used are anaerobic ponds, aerobic ponds, oxidation ditches, barrier ditches and biological filtration.

Inventories of purification systems for industrial effluent were prepared for each river and for each industry on the basis of data furnished by DOE. The present capacities of the sewerage and purification systems for domestic sewage were also estimated from the statistics of DOE.

The ratio of effluent volume to customer's water demand (the discharge ratio) was estimated for each type of pollution source. The ratio of load reduction during the course of conveyance from the outlet of the pollution source to the river (the runoff ratio) was also for each type of pollution source. The ratio of sewage infiltration from urban sewerage had to be also assumed. The other ratio estimated was the ratio of pollutant load reduction within the river channel (residual purification ratio).

The DOE has tried hard to achieve the target of keeping the BOD concentration of effluent discharged from a factory below 50 ppm by introducing effective effluent purification systems.

The BOD concentration of each river was estimated for 1995 and 2005 by applying all the ratios mentioned above to the projected domestic and industrial water demand and the projected farm animal populations, and assuming that the DOE target is achieved by 2005. In this estimation, the estimated runoff from 1963 to 1984 was used for river flow.

The BOD concentration in part of the Skudai river will reach 43 ppm in 1995 and 68 ppm in 2005 if present purification capacities remain as they are. That in the Johor river will rise from 13 ppm in 1995 to 33 ppm in 2005, even though runoff in the river is by far the largest in the Region. Other high BOD concentrations are 13 ppm for the Pontian Besar river in 1995 and 17 ppm in 2005, and 19 ppm for the Pontian Kechil river in 1995 and 26 ppm in 2005. A summary of projected BOD load and BOD concentrations is given in Table 44.

7.2 Recommended Water Pollution Abatement Plan

7.2.1 Target of water quality for planning

For maintenance of water quality, a target with two criteria for water pollution abatement is recommended from the environmental point of view. 1) to maintain BOD concentration in a river at less than 5 mg/l where an intake for domestic and industrial water supply is located, and 2) to maintain BOD concentration in a river at less than 10 mg/l for conservation of the river environment.

7.2.2 Sewerage development plan

Sewerage development plans for some towns in the Region are included in 4MP. The outlines of these plans are as follows:

<u>Johor Bahru Town</u>

The plan for Johor Bahru includes two treatment sites. One is to the west of the Sungai Skudai estuary (West Site) and the other is to the east of the Sungai Tebrau estuary (East Site). Although ultimately treatment by the aerated ponds system is planned for flows at the West Site, the facultative maturation pond system is initially recommended in the plan.

Skudai Valley

Local treatment sites are proposed in the urban areas of Kulai, Senai and Skudai.

Treatment by facultative aerated and maturation systems has been proposed for Kulai and Senai. For Skudai site, the facultative aerated system has been proposed.

Pasir Gudang Corridor

The construction of treatment facilities is proposed at Masai site. Treatment by the facultative maturation system is proposed in this plan.

All of these plans have been taken into account in the recommended pollution abatement plan of this Study.

7.2.3 The recommended plan

In the plan formulation, it was assumed that purification systems would be installed for oil palm, rubber and pineapple factories to reduce the BOD concentration in effluent discharged from these factories to less than 50 ppm.

For purification of effluent from palm oil mills and pineapple factories, it was assumed that anaerobic digestion with extended aeration or land disposal would be provided at each factory by private enterprise to achieve the target of DOE. For treatment of effluent from rubber factories, it was assumed that the aerobic and facultative pond method would be provided for SMR and the oxidation ditch method for Latex Concentrate.

For the public sewerage system, the aerated lagoon process is proposed in this Study. This process was developed from the stabilization pond. A floating aerator is commonly used for surface aeration to supply the necessary oxygen and accelerate reduction of the load. A maturation pond is necessary to reduce the coliform concentration after treatment in the aerated lagoon. The BOD concentration in the effluent from a sewerage system is estimated to be 20 mg/l.

River water qualities were simulated and projected by rivers as mentioned above in Section 7.1 assuming that DOE's target for BOD concentrations in factory effluent is achieved. The BOD concentration of river water however does not meet the criteria mentioned in Section 7.2.1.

It was assumed that public sewerage systems would be provided in the urban areas by 1995 and 2005 in accordance with the plans envisioned in 4MP. And in this connection it is noted that the domestic effluent from Pontian Kechil is projected to be significant after 1995 and that this will pollute the Pontian Kechil river. Accordingly a public sewerage system is recommended for Pontian Kechil.

Kota Tinggi and Bandar Tenggara are developing rapidly and their domestic effluent has become one of the main sources of pollution in the upper and middle reaches of the Johor river. Public sewerage systems are therefore proposed. The additional public sewerage systems recommended to 4MP may be summarized as follows:

Basin Name	Town
Pontina Kechil	Pontian Kechil
Johor	Kota Tinggi and Bandar Tenggara

Rengqam and Layang-Layang are located in the upper reaches of the Johor river. The pollution load from these towns will be carried to the proposed Sayong reservoir. In order to treat sewage in these small towns, it is recommended that the underground trench combined with septic tank system be employed, since the simulation model showed that this would result in a significant reduction in pollution of the Johor river. An outline of the proposed public sewerage system is given in Table 45.

The effects of the pollution abatement plan were assessed by river water quality simulation. By 1995 and 2005, BOD concentrations in river water will be reduced from the projected concentrations. This assumes that improvements will have been carried out to the purification systems in rubber factories, palm oil mills, pineapple factories, and in the construction of public sewerage systems in urban areas. However, at some intake points for D&I water supply in the upstream of the Johor river and the Skudai river, there will still remain BOD concentration exceeding 5 mg/l in 2005. Furthermore at the river mouth in the Pontian Besar river basin and Pontian Kechil river basin, the BOD concentration will be over 10 mg/l in 2005. As these will only occur on a few days in a 20 year period it should be possible to reduce the discharge of effluent on those days. BOD load and maximum BOD concentration in 1995 and 2005 by basin with and without project are shown in Table 46. High BOD concentrations mentioned above apply to values in a limited stretch of river. The average BOD concentrations in each kilometer stretch were estimated to be less than 10 ppm for all the rivers as shown in Table 47.

7.3 Cost Estimate

7.3.1 Construction cost

Construction costs of purification facilities for palm oil mills, rubber factories, pineapple factories and sewerage facilities for urban areas including ditches, pumping stations and treatment facilities were estimated on the basis of data provided by DOE and previous studies available, e.g., the Butterworth project, Feasibility Study for Sewerage and Drainage Project, Feb. 1979, JICA. The construction cost of pretreatment facilities for domestic and industrial water supply was estimated from the data of the previous studies available.

The construction cost was estimated in four categories, i.e. (1) direct construction costs, (2) engineering service & administration, (3) land acquisition, and (4) physical contingency. Engineering services and administration costs were assumed to be 10% of the direct costs. Physical contingencies were assumed to be 30% of the total of the above (1) to (3).

If river water has a BOD concentration of more than 2 ppm, it should be purified for D & I water use before being sent to a main treatment plant. For pretreatment of such water, two treatment methods are proposed. If BOD concentration in raw water is between 2 mg/l and 20 mg/l, pretreatment can be carried out by rapid sand-filters and activated carbon absorption (Secondary treatment). For a BOD concentration of between 20 mg/l and 200 mg/l, an aerated lagoon or maturation pond (Primary treatment) is required in addition.

The total cost of the public sewerage system is presented in Table 48 and the total cost for purification systems of factory effluents are summarized in Table 49.

8. LEGAL AND INSTITUTIONAL ARRANGEMENTS

8.1 Legal and Institutional Arrangements in the Light of the Stipulation of DEED (Agreement with Singapore)

The Government (the State of Johor) has an agreement (Deed) with Singapore City Council regarding water abstraction from the Johor river as stated earlier. PUB of Singapore developed solely the intake R41 and the related water supply facilities at Kota Tinggi in accordance with the stipulation of the agreement. However the water resources development proposed herein aims mainly the benefit of Malaysia. Accordingly the development should be carried out solely by the Government of Malaysia or jointly by the Government of Malaysia and Singapore. And the solo development by Singapore is not conceivable. In view of this, certain legal and institutional arrangements are necessary and the Agreement should be supplemented in relation to the water resources development of the Johor river covering the matters as described below:

(1) Development of a dam in the Johor river basin

The Deed includes schedules for alienation of land to SCC for construction of treatment plantyards and the right-of-way of pipe lines, but it does not provide for dam and reservoir construction, unlike the Indenture.

Accordingly it is considered that while the Deed does not grant Singapore any right to construct a dam in the Johor river basin, it does not forbid construction of a dam by Singapore in the Johor river basin. Accordingly it is considered that both parties may construct a dam without special revision of the Deed. An agreement should stipulate, however, the development of a dam jointly with regard to conditions of joint development.

(2) Water measurement and the method of flow estimation

The construction of a dam would entail a considerable change in flow conditions of the Johor river especially in the downstream reaches. Since the Deed granted Singapore full and exclusive rights to use of Johor river water at a maximum rate of 1,137 Mld or 250 Mgd, the water resources development scheme should be planned as not to jeopardize the right. In other words, the water resources development scheme for the benefit of the State of Johor should handle water in excess of that required by and granted to Singapore. In order to ensure that the operation of a dam does not infringe the rights of Singapore river runoff should be continuously recorded and the runoff under without scheme condition should be estimated. The methods for recording and estimation should be agreed between the parties.

(3) Water tapping by the State of Johor

In formulating the water resources development plan account was taken of the water tapping of 109.6 Mld by the State of Johor from the PUB's water main as decided by the Government of Malaysia. However, the existing Agreement stipulates a right to tapping of not more than 2% of the water conveyed to Singapore through the causeway which would be 14.5 Mld assuming that the water conveyed is 728 Mld or 160 Mgd. The present level of tapping has been reached with the goodwill of both parties. However it is advisable that such tapping should be covered by an agreement.

(4) Water abstraction by the State of Johor in the upstream reach

In the Indenture it is stipulated that the State of Johor may abstract water from the Skudai and Tebrau rivers provided that the State has the prior consent of Singapore. This provision is absent from the Deed which granted Singapore the full and exclusive right to abstract water upto 250 Mgd from the Johor river provided that Singapore does not cause any problem due to shortage of the river maintenance flow. In spite of this the State of Johor has constructed 6 intakes, R25, R26, R34, R35, R39 and R40 upstream of the PUB intake site R41. The total abstraction from these 6 intakes was estimated to be 6.0 Mld in 1983. The demand on these intakes is projected to increase to 54.8 Mld by 2005.

The state PWD has a plan to divert 7.4 Mld into the upstream basin, to Sayong, Renggam and Layang Layang. The return flow from this water is expected to be around 40% leaving a net consumption of river flow in the upstream reach of around 27.4 Mld by 2005. This consumption will be relatively insignificant compared with the total demand at R41 and R42 of 1,216.4 Mld in 2005 but it may not be economical to transfer a water of 27.4 Mld from anywhere outside of the Region. Although it seems likely that Singapore would consent to the abstraction by the state PWD at the 6 intakes mentioned above because the whole present situation appears to be based on the mutual goodwill, it is desirable that the agreement confirms the Singapore's consent.

8.2 Required Agreement with Singapore

In addition to the legal and institutional arrangement in relation to the existing Agreement mentioned in the previous section, further agreement is necessary as follows;

If the water resources of the Johor river are to be developed jointly by the State of Johor and Singapore the following matters should be discussed with Singapore to reach prior agreement.

(1) Scale of development

Cooperation is required between Singapore and the State of Johor in developing the water resources facilities to eliminate the water deficits of both the State and Singapore. The proposed facilities should eliminate the annual water deficit of 69×10^6 m^3 in 2005 although only 20×10^6 m^3 would be attributable to the demand of Singapore.

(2) Executive authority

If the State forms the executive body for the implementation and operation of the project, the system for monitoring and inspection by Singapore should be established in the form of an official agreement similar to the existing Agreement or Deed.

If an executive body is formed jointly by the State and SCC, legal arrangements may be necessary in the form of an international treaty in addition to the agreement with Singapore on the operation. This would necessarily involve the Federal Government according to the Constitution.

(3) Land acquisition

According to the National Land Code, all the lands belong to the State and the State are entitled to use the land for the public works. The State may acquisit the land already leased or alienated in the light of Land Acquisition Act. Further, it is common that the State lease or alienate a part of lands which have been once acquired by the Satate to the third parties. Thus land acquisiiton and use thereof are legally possible. However the agreement should stipulate rights to use of land by Singapore in the State of Johor.

(4) Allotment of costs

The agreement should cover sharing of costs between the State and Singapore. The agreement should also stipulate the ownership on the structures corresponding to the investment undertook. Land cost should be also shared by Singapore. With this regard, it should be noted that the state land, use thereof by the State is free, should also be charged on Singapore.

(5) Reservoir operation against flood

The provision of a dam must not cause any deterioration in hydrologic conditions of either up- or downstream especially for floods. The reservoir operation rule against flood should therefore be established with due regard to this. The established executive authority would administrate on this matter.

(6) Water shortage

Should the plan fail to eliminate the water deficit the parties should reduce their abstractions in an agreed manner. The agreement should cover the manner of such reductions.

If the Government of Malaysia would undertake the water resources development of the Johor river solely and sell water to Singapore, legal and institutional arrangement required is rather simple provided the rights granted to Singapore be not jeopardized. The main issue to be agreed by both parties is the water tariff to be charged on the water abstraction by Singapore. The tariff should be determined reflecting the cost of land including the state land. The cost of land is to be evaluated by Land and Mines Department of the State Government. Singapore would pay water charge to the Government of Malaysia according to the tariff and the water abstracted by herself. The rate stipulated in the existing agreement (Deed) might be applied to the water which could have been abstracted by Singapore without the water resources development up to 1,137 Mld or 250 Mgd.

8.3 Necessary Institutional Procedures

In order to implement the water resources development project, following institutional arrangements are required according to the regulations and common procedures of the Government of Malaysia.;

(1) Project Initiation

The implementing agency should notify its intention to implement the Project to other agencies, especially to EPU or State EPU.

(2) Feasibility Study

The feasibility of the proposed project should be examined from the technical, economic, social and environmental points of view.

(3) Interdepartmental adjustment

With regard to water use, land use and environmental impact, some adjustments between the agencies concerned may have to be carried out. For this purpose, a committees are usually established and managed by EPU.

(4) Budgetary and financial preparation

In view of the considerable cost estimated for the project implementation, the budget of Federal Government will have to be applied through the Development Fund Act. If a corporation is established to implement the project, the budget of the Federal Government may be applied through the State Government.

(5) Approval

All the public works must be approved. Approval of the project will be attained by introduction of the project into the Malaysia Five Years Development Plan.

(6) Land acquisition

The State should acquire all land necessary and should alienate the land to the implementation agency. As for land acquisition, compulsory acquisition is the normal practice based on the Land Acquisition Act.

TABLES

Table 1 LIST OF DIRECT PARTICIPANTS IN THE STUDY

Colombo Plan Expert	Study Team		Counterpart Officer	
E. Sazawa (MOC)	Team Leader		Chief Counterpart	
	I. Kuno	(NK)	Sieh Kok Chi	(DID)
	Deputy Team Leader		Chief Counterpart (State)	
	N. Takayanagi	(NK)	Abdul Latiff Bin Yusof	(SEPU)
	Member			
	Y. Motoki	(NK)	**Contacting Officer**	
	T. Suzumura	(NK)		
	K. Mikami	(NK)	Federal	
	R. Naito	(NK)	Low Chee Par	(PWD)
	M. Akagawa	(NK)		
	M. Kimura	(NK)	State	
	H. Sasaki	(NK)	Ng. Soo Har	(DID)
	T. Hiruta	(NK)	Ho Pak Cherun	(SEDC)
	T. Kimishima	(NK)	How Pow Whee	(PWD)
	S. Sato	(NK)	Azman Bin MD Said	(KEJORA)
	M. Otogawa	(CTI)	Mohd. Ishak Bin Thani	(DOE)
	H. Saito	(CTI)		
	M. Suzuki	(NK)		
	S. Heishi	(CTI)		
	M. Doi	(SSC)		
	A. Takato	(NK)		
	S. Isoda	(NK)		
	M. Fujinami	(NK)		

Special Abbreviations

SEPU : State Economy Planning Unit
DID : Drainage and Irrigation Department
PWD : Public Works Department
DOE : Department of Environment
KEJORA : Lembaga Kemajuan Johor Tenggara
MOC : Ministry of Construction
NK : Nippon Koei Co., Ltd.
CTI : CTI Engineering Co., Ltd.
SSC : System Science Consultants Co., Ltd.

Table 2 LIST OF MEMBERS OF COMMITTEES ESTABLISHED TO SUPPORT THE STUDY

Advisory Committee

Chairman:

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Dato' Leong Hing Nim	(DOF)
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Mohd. Zabran Ismail	(SEDC)
Azman Bin MD Said	(KEJORA)
Sharon Bin Mohd.Lani	(KEJORA)
Ishak Bin Amin	(Land & Mine Dept.)
Mohd. Fauzi Bin Zain	(TNC Planning)
Anaspekri Bin Hj. Mahido	(TNC Planning)

Secretary:

Abdul Latiff Bin Yusof	(SEPU)

Japanese agencies concerned: Embassy of Japan in Kuala Lumpur
JICA (Tokyo)

JICA (Kuala Lumpur)

Special abbreviations:

MOFA : Ministry of Foreign Affairs
MOC : Ministry of Construction
WRDPC : Water Resources Development Public Corporation

Table 3 MONTHLY RUNOFF AT RANTAU PANJANG

River: Johor

Catchment area: 1,130 km2 Unit: 10^6 M^3

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1963	N.R	N.R	N.R	N.R	N.R	N.R	N.R	N.R	57	82	117	131	-
1964	88	85	284	129	150	32	91	33	71	56	24	170	101
1965	136	37	20	63	113	39	29	60	37	115	172	165	82
1966	116	45	53	84	63	65	92	109	72	107	155	150	92
1967	235	269	143	123	181	70	51	31	60	65	N.R	N.R	-
1968	N.R	N.R	N.R	(98)	102	66	N.R	N.R	N.R	(91)	137	103	-
1969	81	26	20	N.R	(99)	115	84	116	88	135	82	376	111
1970	81	49	39	139	147	68	(111)	(70)	49	50	122	130	88
1971	265	28	N.R	N.R	(15)	24	25	60	59	(37)	N.R	(174)	-
1972	43	30	16	84	95	62	20	29	67	46	122	117	61
1973	115	84	59	124	125	93	72	(72)	72	91	103	74	90
1974	22	49	39	53	64	58	66	33	98	64	43	51	53
1975	34	23	91	142	134	98	78	(59)	65	(42)	103	85	80
1976	23	10	N.R	N.R	(57)	32	39	33	29	105	73	163	-
1977	165	72	35	18	47	55	36	56	62	152	141	(79)	76
1978	162	40	64	82	123	43	86	38	39	(50)	122	(198)	87
1979	121	(45)	75	141	55	58	57	49	85	(59)	(324)	126	99
1980	98	46	51	87	91	83	62	128	(100)	(135)	162	178	102
1981	(49)	17	(26)	115	144	52	40	28	47	75	86	214	74
1982	101	37	71	161	150	119	76	80	57	58	140	(240)	107
1983	165	44	41	26	80	48	55	105	142	76	141	370	108
1984	244	452	188	111	163	110	114	76	50	83	113	219	160
MEAN	117	74	73	99	105	66	64	63	67	81	124	167	93

Remarks: Figures between parenthesis include simulated daily runoff.

Table 4 REVENUE AND EXPENDITURES OF WATER SUPPLY IN THE STATE OF JOHOR IN 1982

Unit: M$ 10^3

District	Revenues	Recurrent Expenditures/1
1. Johor Bahru	13,077 (0.30)/2	7,999 (0.18)/2
2. Muar	2,082 (0.13)	4,465 (0.27)
3. Batu Pahat	2,067 (0.13)	4,557 (0.29)
4. Kluang	3,301 (0.28)	2,624 (0.22)
5. Segamat	1,348 (0.20)	2,358 (0.35)
6. Pontian	939 (0.20)	1,518 (0.33)
7. Kota Tinggi	970 (0.14)	4,290 (0.62)
8. Mersing	454 (0.06)	914 (0.12)
Total	24,238	29,719

Remark; /1: Consists of maintenance of water supplies, other maintenance expenditures, administration and collection cost and capital charges

/2: Figures in parenthesis are unit revenues or expenditures (M$/$m^3$)

Table 5 ABSTRACTION RECORD OF RAW WATER FROM THE STATE OF JOHOR BY SINGAPORE

Unit: Mld

	Source				
Year	Pulai River	Skudai River	Tebrau River	Johor River	Total
1980	71	153	203	219	646
1981	66	140	159	249	614
1982	66	137	200	274	677
1983	60	145	192	271	668

Source: State PWD (Unpublished)

Table 6 DETAILS OF EXISTING WATERWORKS (1/2)

Intake Number	R30	R31(PUB)	R32(PUB)	R33
District	Johor Bahru	Johor Bahru	Johor Bahru	Johor Bahru
Name of Treatment Plant	Bkt. Batu	Skudai	Tebrau	Kong Kong
Water Source	Ulu Pontian-Kechil R.	Skudai R.	Tebrau R.	Serai R.
Design Capacity (Mgd)	0.61	35.00	30.00	0.19
Demand Center	Bukit Baru Sedenak Kelapa Sawit	Johor Bahru Singapore	Singapore	FELDA Kong Kong

Intake Number	R34	R35	R36	R37
District	Kota tinggi	Kota Tinggi	Kota Tinggi	Kota Tinggi
Name of Treatment Plant	Kota Tinggi	Kulai Kompleks	Telok Mahkota	Air Tawar
Water Source	Pelepha-Kenan R.	Semangar R.	Gembut R.	Seluyut R.
Design Capacity (Mgd)	1.00	0.50	0.40	0.55
Demand Center	Kota Tinggi-Town	Kulai Complex-FELDA	Tenjong Lembu Telok Mahkota FELDA Bukit-Aping	Air Tawar FELDA Complex Johor Lama Telok Sengat

Intake Number	R38	R39	R40	R41(PUB)
District	Kota Tinggi	Kota Tinggi	Kota Tinggi	Kota Tinggi
Name of Treatment Plant	Pengerang	Bandar Tenggara	Sungai Linggiu	Kota Tinggi
Water Source	Rengit R.	Pengli R.	Linggiu R.	Johor R.
Water Capacity (Mgd)	0.10	0.50	0.25	60.00
Demand Center	Sungai Rengit Pengerang Buklt Ramunia	Bandar Tenggara Sungai Sebol		Ulu Tebrau Ulu Tiram Pulada Pacir Gudang Johor Bahru Kota Tinggi Singapore

Table 7 DETAILS OF EXISTING WATERWORKS (2/2)

Intake Number	Res 9	Res 10	R24	R25
District	Kota Tinggi	Kota Tinggi	Kluang	Kluang
Name of Treatment Plant	J. Bahru	Sungai Lebam	Simpang Renggam	Renggam
Water Source	Layang R.	Lebam R.	Ulu Benut R.	Sayong R.
Desing Capacity (Mgd)	23.00	1.60	0.55	0.18
Demand Center	Johor Bahru Pasir Gudang FELDA-Kong Kong Masai Plentong		Simpang Renggam Macap	Remggam

Intake Number	R26	R29	Res 8 (PUB)	
District	Kluang	Pontian	Pontian	
Name of Treatment Plant	Layang Layang	Kayu Ara Pasong	G. Pulai	
Water Source	Sayong R.	Pontian Besar R.	Pontian Kechil R.	
Design Capacity (Mgd)	0.42	0.16	15.00	Total 165.01 MGD ($751x10^3$ m^3/d)
Demand Center	Layang Layang FELDA Bkt. Permai	Pontian Besar	Pontian Town and Rural Areas: Skudai-Senai-Kulai: Ulu Choh-Gelang Patah -Tanjong Kupang: Tampoi: Johor Bahru Singapore	

Table 8 PROJECTED POPULATION IN THE REGION BY TOWN AND DISTRICT RURAL (1/2)

Unit: 10^3

District	Town/Rural	Historical			Projected				
		1970	1980	1983	1985	1990	1995	2000	2005
1. Johor Bahru	Johor Bahru	142	256	300	335	432	540	663	797
	Kulai	12	25	31	35	51	70	96	123
	Ulu Tiram	4	7	8	9	13	17	23	30
	Senai	5	7	8	8	11	14	17	20
	Kelapa Sawit	5	6	7	7	8	12	14	15
	Masai & Pasir Gudang	5	14	17	19	23	30	37	45
	urban total	154	295	348	389	530	683	850	1,030
	district rural	129	132	135	136	113	92	75	57
	Total	283	427	483	525	643	775	925	1,087
2. Kota Tinggi	Kota Tinggi	9	14	16	18	24	31	41	49
	Bandar Penawan	-	-	-	1	2	4	6	13
	P2	-	-	-	7	8	9	12	14
	P4	-	-	-	8	8	9	12	14
	P7	-	-	-	8	9	12	14	15
	Bandar Tenggara	-	-	-	10	12	18	25	31
	urban total	0	14	16	28	36	61	104	136
	district rural	64	99	109	112	133	134	123	117
	Total	64	113	125	140	169	195	227	253

Table 9 PROJECTED POPULATION IN THE REGION BY TOWN AND DISTRICT RURAL (2/2)

Unit: 10^3

District	Town/Rural	Historical 1970	1980	1983	1985	Projected 1990	1995	2000	2005
3. Pontian	Pontian Kechil	9	22	28	32	44	59	76	97
	Pontian Nanas	9	10	10	10	11	12	12	13
	urban total	0	32	38	42	55	71	88	110
	district rural	123	92	90	87	80	72	64	54
	Total	123	124	128	129	135	143	152	164
4. Kluang	Simpang Renggam	4	5	6	6	7	8	9	13
	Layang-Layang	3	4	5	5	6	7	9	13
	Renggam	3	4	5	5	6	7	8	13
	urban total	0	0	0	0	0	0	0	39
	district rural (a part within the Region)	43	52	59	63	71	79	85	56
	Total (a part within the Region)	43	52	59	63	71	79	85	95
5. Mersing	district rural (a part within the Region)	7	3	3	3	3	3	2	1
Region Total	Urban	154	341	402	459	621	815	1,042	1,315
	Rural	366	378	396	401	400	380	349	285
	Total	520	719	798	860	1,021	1,195	1,391	1,600

Table 10 ASSUMED ECONOMIC DATA FOR JOHOR AND GDP MALAYSIA

	1983	1985	1990	1995	2000	2005
GRP Johor (M$$10^6$)	3,520	3,980	5,500	7,740	10,580	14,170
- do - per capita (M$)	2,010	2,170	2,690	3,430	4,250	5,190
Value added of manufacturing sector (M$$10^6$)	780	910	1,390	2,240	3,660	5,420
- do - shearing GRP (%)	22.1	22.3	25.2	29.0	34.6	38.3
Gross value of manufacturing output (M$$10^6$)	2,710	3,170	4,350	7,830	12,670	18,590
GDP Malaysia (M$$10^6$)	30,810	35,250	49,450	69,360	95,020	127,160

Table 11 PROJECTED D&I WATER DEMAND IN THE REGION BY DISTRICT OF SUPPLY FOR 1983 - 2005 (1/2)

Unit : Mld

DISTRICT NAME	MUKIM NAME	TOWN/RURAL NAME	INTAKE POINT	1983	1985	1990	1995	2000	2005
1.Johor Bahru	Johor Bahru, Pelentong, Tebrau	Johor Bahru	R41/R42	132.0	96.7	84.5	191.0	287.3	472.9
			Res9		61.6	139.7	124.6	108.2	90.0
		Masai & Pasir Gudang	R33 (1983)	29.3					
			Res9(1985-)		32.2	40.7	52.8	64.4	74.3
		TOWN TOTAL		161.3	190.5	264.9	368.4	459.9	637.2
		Rural	R33(1983)	4.7					
			Res9(1985-)		5.5	6.0	6.4	6.6	6.6
	MUKIMS TOTAL			166.0	196.0	270.9	374.8	466.5	643.8
	Pulai, Tg.Kupang	Rural	R42/Res8	2.5	3.3	4.1	4.7	4.9	5.2
	MUKIMS TOTAL			2.5	3.3	4.1	4.7	4.9	5.2
	Senai Kulai, Sedenak	Kulai	R41/R42/Res9	12.9	15.7	25.5	37.5	48.8	82.9
		Senai	R41/R42/Res9			4.7	6.8	8.9	13.1
		Kelapa Sawit	R30				5.8	7.3	10.6
		TOWN TOTAL		12.9	15.7	30.2	50.1	65.0	106.6
		Rural	R30/R41/R42/RES9	12.4	11.9	11.2	9.7	10.3	10.0
	MUKIMS TOTAL			25.3	27.6	41.4	59.8	75.3	116.6
	Sg.Tiram	Ulu Tiram	R33(1983) Res9(1985-)			5.6	8.2	12.5	20.0
		Rural	R33(1983)	3.3					
			Res9(1985-)		4.1	1.8	2.1	2.1	2.1
	MUKIM TOTAL			3.3	4.1	7.4	10.3	14.6	22.1
DISTRICT URBAN				174.2	206.2	300.7	426.7	537.4	763.8
RURAL				22.9	24.8	23.1	22.9	23.9	23.9
DISTRICT TOTAL				197.1	231.0	323.8	449.6	561.3	787.7
2.Kota Tinggi	Johor Lama, Pa.Timur, Pengerang, Tg.Surat	Ba.Penawan	Res10						8.9
		P4	Res10					6.7	9.5
		P7	Res10				5.8	7.6	10.4
		TOWN TOTAL					5.8	14.3	28.8
		Rural	R37/R38/Res10	7.7	11.7	16.1	16.5	16.5	15.5
	MUKIMS TOTAL			7.7	11.7	16.1	22.3	30.8	44.3
	Kota Tinggi	Kota Tinggi	R34/R41/R42	7.4	9.4	13.2	18.3	24.6	34.9
		Rural	R34/R41/R42	2.0	2.2	3.6	4.7	6.1	6.9
	MUKIM TOTAL			9.4	11.6	16.8	23.0	30.7	41.8
	Sedili Kechil, Sedili Besar	P2	R36					6.7	9.5
		Rural	R36	0.8	3.1	3.5	5.6	1.9	1.9
	MUKIMS TOTAL			0.8	3.1	3.5	5.6	8.6	11.4
	Ulu Sg.Sedili Besar, Sedili Kambau	Rural	R36	1.1	1.4	2.2	2.7	4.1	5.0
	MUKIMS TOTAL			1.1	1.4	2.2	2.7	4.1	5.0
	Ulu Sg.Johor	Ba.Tenggara	R39		3.6	6.0	9.0	14.2	21.2
		Rural	R35/R39/R40	4.6	4.1	5.0	6.6	7.7	8.5
	MUKIM TOTAL			4.6	7.7	11.0	15.6	21.9	29.7
DISTRICT URBAN				7.4	13.0	19.2	33.1	59.8	94.4
RURAL				16.2	22.5	30.4	36.1	36.3	37.8
DISTRICT TOTAL				23.6	35.5	49.6	69.2	96.1	132.2

Remarks : R42,Hypothetical intake to be provided at Kg. Tai Hong by PWD.

Table 12 PROJECTED D&I WATER DEMAND IN THE REGION BY DISTRICT OF SUPPLY FOR 1983 - 2005 (2/2)

Table 12 PROJECTED D&I WATER DEMAND IN THE REGION BY DISTRICT OF SUPPLY FOR 1983 - 2005 (2/2)

Unit : Mld

DISTRICT NAME	MUKIM NAME	TOWN/RURAL NAME	INTAKE POINT	1983	1985	1990	1995	2000	2005
3.Pontian	Api-Api, Ayer Baloi,Benut, Sg.Pinggan	Rural	R24/Res8	4.6	5.1	6.0	7.2	8.0	7.9
	MUKIMS TOTAL			4.6	5.1	6.0	7.2	8.0	7.9
	Pontian,	Pontian Kechil	R24/Res8	12.8	15.7	19.9	34.4	45.1	68.4
	Rimba Terjum	Rural	R29/Res8	2.7	2.7	3.1	3.8	4.1	4.4
	MUKIMS TOTAL			15.5	18.4	23.0	38.2	49.2	72.8
	Jeram Batu	Pekan Nanas	R24/Res8	4.6	4.9	5.3	7.3	7.9	9.5
	Pengkalan-Raja	Rural	R24/Res8	0.8	0.8	0.8	1.3	1.9	1.9
	MUKIMS TOTAL			5.4	5.7	6.1	8.6	9.8	11.4
	Ayer Masin,Serkat, Sg.Karang	Rural	R24/Res8	1.4	1.9	2.2	2.4	2.2	2.7
	MUKIMS TOTAL			1.4	1.9	2.2	2.4	2.2	2.7
DISTRICT URBAN				17.4	20.6	25.2	41.7	53.0	77.9
RURAL				9.5	10.5	12.1	14.7	16.2	16.9
DISTRICT TOTAL				26.9	31.1	37.3	56.4	69.2	94.8
4.Kluang & Mersing	Ulu Benut,Macap	Rural	R24	1.0	1.4	2.2	3.3	4.4	6.3
	MUKIMS TOTAL			1.0	1.4	2.2	3.3	4.4	6.3
	Layang-Layang	Layang-Layang	R26						8.9
		Rural	R26	2.7	3.5	4.6	5.8	7.5	3.3
	MUKIM TOTAL			2.7	3.5	4.6	5.8	7.5	12.2
	Renggam	Renggam	R25						8.9
		Simpang-Renggam	R24						8.9
		TOWN TOTAL							17.8
		Rural	R24/R25	5.7	6.9	8.5	11.8	14.2	7.4
	MUKIM TOTAL			5.7	6.9	8.5	11.8	14.2	25.2
	Mersing	Rural	R36	1.5	1.9	1.9	2.7	2.5	2.5
	MUKIM TOTAL			1.5	1.9	1.9	2.7	2.5	2.5
DISTRICT URBAN									26.7
RURAL				10.9	13.7	17.2	23.6	28.6	19.5
DISTRICT TOTAL				10.9	13.7	17.2	23.6	28.6	46.2
THE REGION	URBAN TOTAL			199.0	239.8	345.1	501.5	650.2	962.8
	RURAL TOTAL			59.5	71.5	82.8	97.3	105.0	98.1
THE REGION TOTAL				258.5	311.3	427.9	598.8	755.2	1,060.9

Table 13 CATCHMENT AREA, ANNUAL RAINFALL, ANNUAL RUNOFF AND KEY STATIONS FOR STRATEGIC POINTS

Name of Key Station, Dam and Intake	River Basin	Catch-ment Area (km^2)	Annual Rainfall (mm)	Annual Runoff ($10^6 m^3/y$)	Key Station
Hydrological Stations					
Kg. Rantau Panjang	Johor	1,130	2,299	1,092	-
Jam. Johor Tenggara	Sayong	624	2,246	576	-
Ran. Tanah Jengeli	Linggiu	209	2,418	216	-
Saleng	Skudai	91	2,354	93	-
Proposed Damsites					
Benut	Benut	37	2,193	33	Kg. Rantau Panjang
Pontian Besar	Pontain Besar	40	2,350	41	"
Sayong	Sayong	662	2,312	655	Jam. Johor Tenggara
Upper Pengli	Pengli	127	2,312	126	"
Linggiu	Linggiu	206	2,435	216	Ran Tanah Jengeli
Telor	Telor	38	2,294	37	Kg. Rantau Panjang
Layau Kiri	Lebam	31	2,546	38	"
Sedili	Sedili Besar	224	2,613	290	"
Existing Dam					
Macap	Benut	78	2,193	70	Kg. Rantau Panjang
Headworks					
Res 8 (G.Pulai,PUB)	Pontian Besar	12	2,490	14	"
Res 9 (Layang)	Layang	31	2,321	31	"
Res 10 (Lebam)	Lebam	18	2,546	22	"
R24	Benut	170	2,193	152	Kg. Rantau Panjang
R25	Sayong	8	2,312	8	Jam. Johor Tenggara
R26	Sayong	98	2,312	97	"
R29	Pontian Besar	160	2,350	163	Kg. Rantau Panjang
R30	Pontian Besar	53	2,350	54	"
R31 (PUB)	Skudai	187	2,379	196	Saleng
R32 (PUB)	Tebrau	118	2,383	124	"
R33	Serai	12	2,321	12	Kg. Rantau Panjang
R34	Panti	8	2,496	9	"
R35	Semangar	46	2,294	45	"
R36	Sedili Besar	78	2,721	109	"
R37	Seluyut	7	2,496	8	"
R38	Rengit	4	2,546	5	"
R39	Pengli	55	2,312	54	Jam. Johor Tenggara
R40	Linggiu	387	2,435	406	Ran. Tanah Jengeli
R41 (PUB)	Johor	1,550	2,496	1,826	Kg. Rantau Panjang

Table 14 WATER DEMAND AT INTAKE POINT

Unit : Mld

INTAKE No.	RIVER NAME	1983	1985	1990	1995	2000	2005	REMARKS
R24	Benut	16.6	21.0	32.0	48.3	62.9	97.4	
R25	Sayong	1.8	2.3	3.7	5.8	7.9	12.1	
R26	Sayong	1.0	1.6	2.9	4.0	6.1	10.9	
R29	Pontian Besar	1.9	1.9	2.5	3.0	3.3	3.3	
R30	Pontian Besar	2.5	2.3	2.8	7.3	9.3	12.6	
R31*	Skudai	145.2	145.2	145.2	145.2	145.2	145.2	PUB intake
R32*	Tebrau	191.8	191.8	191.8	191.8	191.8	191.8	PUB intake
R33	Serai	25.3	--	--	--	--	--	
R34	Panti	1.3	1.9	2.9	3.6	4.1	4.4	
R35	Semangar	0.8	0.7	1.1	1.7	2.1	2.6	
R36	Sedili Besar	1.1	3.4	4.9	7.3	11.0	14.7	
R37	Seluyut	1.0	2.1	3.3	3.7	3.6	3.4	
R38	Rengit	1.4	1.6	1.9	2.2	2.5	2.7	
R39	Pengli	0.5	3.8	6.2	10.0	15.2	22.9	
R40	Linggiu	0.6	0.5	0.7	1.1	1.4	1.8	
R41*	Johor	180.4	315.0	624.0	624.0	624.0	624.0	PUB intake
R41**	Johor	114.8	103.8	103.8	103.8	103.8	103.8	PUB intake
R42	Johor	--	--	9.0	135.3	253.1	488.5	Kg.Tai Hong
Res 8*	G.Pulai	54.5	54.5	54.5	54.5	54.5	54.5	PUB intake
Res 8**	G.Pulai	5.8	5.8	5.8	5.8	5.8	5.8	PUB intake
Res 9	Layang	--	93.7	182.0	182.0	182.0	182.0	40MGD supply
Res 10	Lebam	0.9	3.2	6.0	12.2	20.3	34.1	
Private intakes***		57.8	60.0	56.9	58.7	57.3	55.6	
Total		806.8	1,016.2	1,443.9	1,611.3	1,767.2	2,074.2	

Remarks ; R42 : Hypothetical intake to be provided at Kg. Tai Hong by PWD
* : Water supply from PUB's intake to Singapore
** : Water supply from PUB's intake to Johor
*** : Excluding RESP water demand

Table 15 WATER DEFICIT AT INTAKE POINT

Intake No.	River	1983 MEAN ($10^6 m^3$)	1983 MAX ($10^6 m^3$)	1983 No. of Deficit Year	1985 MEAN ($10^6 m^3$)	1985 MAX ($10^6 m^3$)	1985 No. of Deficit Year	1990 MEAN ($10^6 m^3$)	1990 MAX ($10^6 m^3$)	1990 No. of Deficit Year
R24	BENUT *	0.4	1.1	15	0.5	1.4	17	0.0	0.0	0
R25	SAYONG **	0.0	0.1	6	0.0	0.1	7	0.0	0.2	12
R26	SAYONG **	0.0	0.0	2	0.0	0.0	2	0.0	0.1	2
R29	PONTIAN B.	0.1	0.5	6	0.1	0.5	6	0.1	0.6	7
R30	PONTIAN B.	0.0	0.3	10	0.0	0.2	9	0.0	0.3	10
R31	SKUDAI	5.6	16.1	21	5.6	16.1	21	5.6	16.1	21
R32	TEBRAU	16.4	33.0	22	16.4	33.0	22	16.3	32.9	22
R33	SERAI	2.3	4.3	20						
R34	PANTI	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2
R35	SEMANGAR	0.0	0.0	2	0.0	0.0	2	0.0	0.0	2
R36	SEDILI	0.0	0.3	4	0.0	0.4	7	0.0	0.5	8
R37	SELUYUT	0.0	0.0	2	0.0	0.0	3	0.0	0.1	11
R38	RENGIT	0.0	0.0	6	0.0	0.0	9	0.0	0.0	11
R39	PENGLI	0.0	0.0	2	0.0	0.1	2	0.0	0.1	3
R40	LINGGIU	0.0	0.2	1	0.0	0.2	1	0.0	0.2	1
R41&R42	JOHOR	0.1	1.6	3	0.4	4.8	6	4.0	20.1	14
RES 8	G.PULAI	-	-	-	-	-	-	-	-	-
RES 9	LAYANG	-	-	-	-	-	-	-	-	-
RES 10	LEBAM	-	-	-	-	-	-	-	-	-
IRRIGATION SCHEME										
LUKUT		0.2	0.5	20	0.2	0.5	20	0.5	0.8	20
ULU BENUT		0.3	1.0	15	0.3	1.0	15	0.4	1.4	19
TOTAL		26.0	59.0		24.1	58.3		28.9	75.9	

Intake No.	River	1995 MEAN ($10^6 m^3$)	1995 MAX ($10^6 m^3$)	1995 No. of Deficit Year	2000 MEAN ($10^6 m^3$)	2000 MAX ($10^6 m^3$)	2000 No. of Deficit Year	2005 MEAN ($10^6 m^3$)	2005 MAX ($10^6 m^3$)	2005 No. of Deficit Year
R24	BENUT*	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
R25	SAYONG**	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
R26	SAYONG**	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
R29	PONTIAN B.	0.1	0.6	8	0.1	0.6	8	0.1	0.6	8
R30	PONTIAN B.	0.1	0.5	12	0.1	0.6	12	0.2	0.7	14
R31	SKUDAI	5.7	16.2	21	5.7	16.2	21	5.7	16.2	21
R32	TEBRAU	16.4	33.1	22	16.4	33.1	22	16.4	33.1	22
R33	SERAI									
R34	PANTI	0.0	0.0	2	0.0	0.0	2	0.0	0.0	2
R35	SEMANGAR	0.0	0.0	2	0.0	0.0	2	0.0	0.0	2
R36	SEDILI	0.1	0.6	9	0.1	0.7	9	0.1	0.9	11
R37	SELUYUT	0.0	0.1	11	0.0	0.1	11	0.0	0.1	11
R38	RENGIT	0.0	0.1	13	0.0	0.1	14	0.0	0.1	15
R39	PENGLI	0.0	0.3	4	0.1	0.6	7	0.2	1.8	12
R40	LINGGIU	0.0	0.2	1	0.0	0.2	1	0.0	0.2	1
R41&R42	JOHOR	7.3	27.9	15	11.2	37.7	15	22.7	68.9	21
RES 8	G.PULAI	-	-		-	-		-	-	
RES 9	LAYANG	-	-		-	-		-	-	
RES 10	LEBAM	-	-		-	-		-	-	
IRRIGATION SCHEME										
LUKUT		0.5	0.8	20	0.5	0.8	20	0.5	0.8	20
ULU BENUT		0.4	1.4	19	0.4	1.4	19	0.4	1.4	19
TOTAL		33.9	87.4		39.6	100.2		57.2	142.4	

Remarks: * : Water deficit at R24 after 1990 will be supplemented by Siompang Renggam Scheme Stage I.
** : Water deficit at R25 and R26 after 1995 will be supplemented by Kluang Scheme Stage I.

Table 16 CONDITION OF ALTERNATIVE DAMSITES

SITE CONDITIONS	BENUT	PONTIAL BESAR	LINGGIU	UPPER PENGLI	SAYONG	TELOR	SEDILI	LAYAU KIRI Main	LAYAU KIRI Sub
River System	Benut River	Pontian Besar River	Johor river	Johor River	Johor River	Johor River	Sedili Besar River	Johor River	Johor River
Location of Damsite	1°52'53"N 103°19'44"E	1°44'28"N 103°25'49"E	1°54'27"N 103°41'38"E	1°51'31"N 103°35'34"E	1°48'59"N 103°41'24"E	1°43'00"N 103°47'08"E	2°02'21"N 103°50'42"E	1°35'54"N 104°04'24"E	1°35'30"N 104°06'12"E
Catchment Area	37 Km^2	40 Km^2	206 Km^2	127 Km^2	662 Km^2	38 Km^2	224 Km^2	31 Km^2	
Damsite Topography	Flat and wide valley	Flat and wide valley	Steep left abutment	Flat and wide valley	Gentle slope valley	Gentle slope valley	Rather steep slope on both abutment	Flat and wide valley	
Valley Bottom Width	1.1 Km	1.7 Km	0.4 Km	1.3 Km	0.4 Km	0.6 Km	0.4 Km	1.0 Km	
Geology & Construction Materials 1) Geology	Shale and sandstone of Mesozoic	Shale and sandstone of Mesozoic	Mainly sandstone of Paleozoic, fractured by fault, highly permeable	Semi-consolidated clayey silt of Pleistocene to Pliocene	Fresh tight granite partly weathered	Weathered granite	Phyllite of Paleozoic, moderarely weathered	Weathered granite	
2) Soils	Mostly sandy silt	Silty sand	Clayey to sandy silt	Silty sand	Mainly sandy silt	Sandy silt to silty sand	Sandy silt	Sandy silt to clay	
Scale of Dam and Reservoir									
1) Gross Storage at H.W.L. (m^3)	20×10^6	51×10^6	123×10^6	130×10^6	179×10^6	49×10^6	85×10^6	41×10^6	
2) Effective Storage at H.W.L. (m^3)	18×10^6	48×10^6	107×10^6	120×10^6	128×10^6	46×10^6	61×10^6	38×10^6	
3) High water Level (m)	29.0	25.5	34.0	41.0	18.0	28.0	20.0	22.0	
4) Flood Water Level (m)	31.1	27.3	35.2	43.1	20.1	29.6	21.1	23.8	
5) Dam Height (m)	30	29	32	33	31	29	32	29	27
6) Crest Length (m)	2,000	2,400	560	2,200	1,140	2,200	490	1,600	1,100
7) Dam Volume (m^3)	1.9×10^6	3.1×10^6	0.9×10^6	2.8×10^6	0.8×10^6	0.9×10^6	0.7×10^6	1.3×10^6	0.6×10^6
Land Use in Reservoir Area EL. (m)	31.1	27.3	35.2	43.1	20.1	29.6	21.1	23.8	
1. Rubber (ha)	322	675	-	-	203	-	-	-	
2. Oil Palm (ha)	379	316	-	1,060	1,853	53	-	658	
3. Other Agricultural Land (ha)	-	38	-	-	502	-	-	-	
4. Residential Land (ha)	-	-	-	-	-	-	-	48	
5. Factory Area (ha)	-	64	-	-	-		-	-	
6. Forest (ha)	-	254	2,027	1,850	1,747	1,087	2,140	4	
7. Mine (ha)	-	-	73	-	-	-	-	-	
Total Area (ha)	701	1,347	2,100	2,910	4,305	1,140	2,140	710	
8. Houses (nos)	-	89	-	13	33	-	-	66	
9. Road (main) (km)	-	8.2	-	3.6	5.0	-	-	7.6	
10. Transmission Line (km)	-	-	-	-	2.7	-	-	-	
11. Pumping Station (nos)	-	-	-	1	-	-	-	-	
Investment Cost of Dam (M$ 10^6)									
Total Cost	99	163	132	181	132	65	61	117	
(Compensation)	(13)	(35)	(-)	(35)	(55)	(7)	(-)	(19)	
Special Problems		Submerge highway	Permeable foundation		Land acquistion			Lebam dam is enough	

Table 17 PRESENT LAND USE IN BENUT RESERVOIR AREA

Land Use		Unit	Reservoir Water Level (EL. m)		
			15.2	22.9	30.5
1.	Rubber				
	1.1 FELDA	ha	-	-	-
	1.2 Others	ha	43	151	310
	Sub-total	ha	43	151	310
2.	Oil Palm				
	2.1 FELDA	ha	-	-	-
	2.2 Others	ha	-	11	352
	Sub-total	ha	-	11	352
3.	Cocoa	ha	-	-	-
4.	Sugarcane	ha	-	-	-
5.	Pepper	ha	-	-	-
6.	Crops and Vegetables	ha	-	-	-
7.	Grassland	ha	-	-	-
8.	Residential Land	ha	-	-	-
9.	Forest Land				
	9.1 Unalienated	ha	-	-	-
	9.2 Alienated	ha	-	-	-
	Sub-total	ha	-	-	-
10.	Mine	ha	-	-	-
	Total Land Area	ha	43	162	662
11.	Houses/Buildings	nos	-	-	-
12.	Road	km	-	-	-
13.	Transmission Line	km	-	-	-
14.	Railway	km	-	-	-
15.	Gas Pipe Line	km	-	-	-
16.	Pumping Station	nos	-	-	-

Table 18 PRESENT LAND USE IN PONTIAN BESAR RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m) 15.2	22.9	30.5
1. Rubber				
1.1 FELDA	ha	-	-	-
1.2 Others	ha	20	337	925
Sub-total	ha	20	337	925
2. Oil Palm				
2.1 FELDA	ha	-	-	114
2.2 Others	ha	62	179	302
Sub-total	ha	62	179	416
3. Cocoa	ha	-	-	-
4. Sugarcane	ha	-	-	-
5. Pepper	ha	24	31	69
6. Crops and Vegetables	ha	24	32	70
7. Grassland	ha	-	-	-
8. Residential Land				
8.1 Kawasan Jalan Johor	ha	-	-	***
8.2 Ldg. Kulai Besar Bkg. Utara	ha	-	6	6
8.3 Kg. Pisang	ha	-	1	1
8.4 Kg. Melayu Bukit Batu	ha	-	2	2
Sub-total	ha	-	9	9
8. Factory Area	ha	-	43	80
9. Forest				
9.1 Unalienated	ha	-	-	-
9.2 Alienated	ha	79	87	375
Sub-total	ha	79	87	375
(Forest Reserve)	(ha)	(-)	(-)	(375)
10. Mine	-	-	-	-
Total Land Area ha	ha	209	718	1,944
11. Houses/Buildings				
11.1 Kawasan Jalan Johor	nos	-	-	***
11.2 Ldg. Kulai Besar Bkg. Utara	nos	-	60	60
11.3 Kg. Pisang	nos	3	5	8
11.4 Kg. Melayu Bukit Batu	nos	1	22	22
Sub-total	nos	4	87	90
12. Road	km	7.0	7.3	8.9
13. Transmission Line	km	-	-	-
14. Railway	km	-	-	-
15. Gas Pipe Line	km	-	-	-
16. Pumping Station	nos	-	-	-

Remarks: *** : Numbers are not available.
Number of houses/buildings to be removed was estimated on the maps prepared by the Malaria Department.

Table 19 PRESENT LAND USE IN LINGGIU RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m)		
		30.5	38.1	45.7
1. Rubber				
1.1 FELDA	ha	-	-	-
1.2 Others	ha	-	-	-
Sub-total	ha	-	-	-
2. Oil Plm				
2.1 FELDA	ha	-	-	-
2.2 Others	ha	-	-	-
3. Cocoa	ha	-	-	-
4. Sugarcane	ha	-	-	-
5. Pepper	ha	-	-	-
6. Crops and Vegetables	ha	-	-	-
7. Grassland	ha	-	-	-
8. Residential Land	ha	-	-	-
9. Forest Land				
9.1 Unalienated	ha	1,238	2,193	4,859
9.2 Alienated	ha	-	-	-
Sub-total	ha	1,238	2,193	4,859
(Forest Reserve)	(ha)	(126)	(329)	(2,149)
10. Mine	ha	39	88	112
Total Land Area	ha	1,277	2,281	4,971
11. Houses/Buildings	nos	-	-	-
12. Road	km	-	-	-
13. Transmission Line	km	-	-	-
14. Railway	km	-	-	-
15. Gas Pipe Line	km	-	-	-
16. Pumping Station	nos	-	-	-

Table 20 PRESENT LAND USE IN UPPER PENGLI RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m) 30.5	38.1	45.7
1. Rubber				
1.1 FELDA	ha	-	-	-
1.2 KEJORA	ha	-	-	-
1.3 Others	ha	-	-	-
Sub-total	ha	-	-	-
2. Oil Palm				
2.1 FELDA	ha	-	24	754
2.2 KEJORA	ha	-	-	352
2.3 Others	ha	122	279	344
Sub-total	ha	122	303	1,450
3. Cocoa	ha	-	-	-
4. Sugarcane	ha	-	-	-
5. Pepper	ha	-	-	-
6. Crops and Vegetables	ha	-	-	-
7. Grassland	ha	-	-	-
8. Residential Land				
8.1 Ulu Pengli (FELDA)	ha	-	-	20
Sub-Total	ha	-	-	20
9. Forest Land				
9.1 Unalienated	ha	59	207	344
9.2 Alienated	ha	96	1,152	1,757
Sub-total	ha	155	1,359	2,101
10. Mine	ha	-	-	-
Total Land Area	ha	277	1,662	3,571
11. Houses/Buildings				
11.1 Ulu Pengli	nos	-	-	155
Sub-total	nos	-	-	155
12. Road	km	-	-	5.4
13. Transmission Line	km	-	-	-
14. Railway	km	-	-	-
15. Gas Pipe Line	km	-	-	-
16. Pumping Station	nos	1	1	1

Table 21 PRESENT LAND USE IN SAYONG RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m) 15	17.5	20	22.9	30.5
1. Rubber						
1.1 FELDA	ha	-	-		-	617
1.3 Others	ha	5	77	195	537	3,400
Sub-total	ha	5	77	195	537	4,0177
2. Oil Palm						
2.1 FELDA	ha	850	1,078	1,177	1,658	3,632
2.2 KEJORA	ha	-	-	-	-	156
2.3 Others	ha	308	506	605	706	3,845
Sub-total	ha	1,158	1,584	1,782	2,364	7,633
3. Cocoa						
3.1 FELDA	ha	104	154	217	316	345
Sub-total	ha	104	154	217	316	345
4. Crops and Vegetables	ha	14	18	81	139	201
5. Grassland	ha	89	113	185	252	165
6. *Residential Land*						
8.1 Kg. Tengah	ha	-	-	-	-	*2
8.2 Kg. Bahru	ha	-	-	-	-	*2
8.3 Twitchin Estate	ha	-	-	-	-	18
8.4 Kg. Melayu	ha	-	-	-	-	6
8.5 Layang Layang	ha	-	-	-	6	85
8.6 Kg. Paya	ha	-	-	-	1	4
8.7 *Kg. Jaya Sepapakat*	ha	-	-	-	2	4
8.8 Kg. Siam	ha	-	-	-	4	5
8.9 Kg. Murni Jaya	ha	-	-	-	2	18
8.10 Permai FELDA	ha	-	-	-	-	48
8.11 Kg. Bahru MCA	ha	-	-	-	-	20
8.12 Inas FELDA	ha	-	-	-	-	34
8.13 Sg. Sayong FELDA	ha	-	-	-		18
8.14 *Bandar Tenggara*	ha	-	-	-	-	72
8.15 Pengli Timor FELDA	ha	-	-	-	-	58
8.16 Muda Jaya	ha	-	-	-	-	-
8.17 Kg. Sayong Pinang (State land)	ha	-	-	-	-	-
Sub-total	ha	-	-	-	15	394
9. *Forest*						
9.1 Unalienated	ha	355	380	790	903	1,070
9.2 Alienated	ha	435	587	890	1,233	5,120
Sub-total	ha	790	967	1,680	2,136	6,190
10. Mine	ha	-	-	-	-	-
Total *Land Use*	ha	2,160	2,913	4,140	5,759	18,945
11. Houses/Buildings						
11.1 Kg. Tengan	nos	-	-	-	-	*10
11.2 Kg. Bahru	nos	-	-	-	-	*10
11.3 Twitchin Estate /1	nos	-	-	-	-	194
11.4 Kg. Malayu /1	nos	-	-	-	-	59
11.5 Layang Layang /2	nos	-	-	-	276	1,427
11.6 Kg. Paya /1	nos	-	-	-	13	44
11.7 Jaya Sepapakat /1	nos	-	-	-	21	38
11.8 Kg. Siam /1	nos	-	-	11	39	46
11.9 Kg. Murni Jaya /1	nos	-	-	-	10	176
11.10 Permai FELDA /3	nos	-	-	-	-	103
11.11 Kg. Bahru MCA /3	nos	-	-	-	-	24
11.12 Inas FELDA /2	nos	-	-	-	-	18
11.13 Sg. Sayong FELDA /2	nos	-	-	-	-	19
11.14 Bandar Tenggara /4	nos	-	-	-	-	-
11.15 Pengli Timor/ *Sg. Selol FELDA* /4	nos	-	-	-	-	141
11.16 Muda Jaya /1	nos	-	1	1	1	1
11.17 Kg. Sayong Pinang /5	nos	-	21	21	21	21
Sub-total	nos	-	22	33	399	2,321
12. Road	km	4.5	4.7	4.9	5.0	19.7
13. Transmission Line	km	2.0	2.3	2.7	3.0	9
14. Railway	km	-	-	-	-	*1
15. Gas Pipe Line	km	-	-	-	-	-
16. Pumping Station	nos	-	-	-	-	1
17. Palm Oil Mill	nos	-	-	1	2	2

Remarks:
- * : Numbers are assumed.
- /1 : Estimated by the maps prepared by Malaria Department.
- /2 : Estimated by the maps prepared by Town and Country Planning Department.
- /3 : Estimated by the ratio of the area to be submarged to the total area.
- /4 : Estimated by the maps preapred by KEJORA.
- /5 : Estimated by the maps prepared by aborigines Department.

Table 22 PRESENT LAND USE IN TELOR RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m) 15.2	22.9	30.5
1. Rubber				
1.1 FELDA	ha	-	-	-
1.2 Others	ha	-	-	-
Sub-total	ha	-	-	-
2. Oil Palm				
2.1 FELDA	ha	-	-	60
2.2 Others	ha	-	-	-
Sub-total	ha	-	-	60
3. Cocoa	ha	-	-	-
4. Sugarcane	ha	-	-	-
5. Pepper	ha	-	-	-
6. Crops and Vegetables	ha	-	-	-
7. Grassland	ha	-	-	-
8. Residential Land	ha	-	-	-
9. Forest Land				
9.1 Unalienated	ha	112	392	1,182
9.2 Alienated	ha	-	-	-
Sub-total	ha	112	392	1,182
10. Mine	ha	-	-	-
Total Land Area	ha	112	392	1,242
11. Houses/Buildings	nos	-	-	-
12. Road	km	-	-	-
13. Transmission Line	km	-	-	-
14. Railway	km	-	-	-
15. Gas Pipe Line	km	-	-	-
16. Pumping Station	nos	-	-	-

Table 23 PRESENT LAND USE IN SEDILI RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m)		
		15.2	30.5	45.7
1. Rubber				
1.1 FELDA	ha	-	-	-
1.2 KEJORA	ha	-	-	-
1.3 Others	ha	-	-	-
Sub-total	ha	-	-	-
2. Oil Palm				
2.1 FELDA	ha	-	-	-
2.2 KEJORA	ha	-	-	-
2.3 Others	ha	-	-	-
Sub-total	ha	-	-	-
3. Cocoa	ha	-	-	-
4. Sugarcane	ha	-	-	-
5. Crops and Vegetables	ha	-	-	-
7. Grassland	ha	-	-	-
8. Residential Land	ha	-	-	-
9. Forest Land				
9.1 Unalienated	ha	773	6,224	11,090
(Forest Plantation)	(ha)	(88)	(248)	(440)
9.2 Alienated	ha	-	-	-
Sub-total	ha	773	6,224	11,090
(Forest Reserve)	(ha)	(773)	(6,224)	(11,078)
10. Mine	ha	-	32	96
Total Land Area	ha	757	6,256	11,186
11. Houses/Buildings	nos	-	-	-
12. Road	km	-	-	-
13. Transmission Line	km	-	-	-
14. Railway	km	-	-	-
15. Gas Pipe Line	km	-	-	-
16. Pumping Station	nos	-	-	-

Table 24 PRESENT LAND USE IN LAYAU KIRI RESERVOIR AREA

Land Use	Unit	Reservoir Water Level (EL. m) 15.2	22.9	30.5
1. Rubber				
1.1 FELDA	ha	-	-	-
1.2 KEJORA	ha	-	-	56
Sub-total	ha	-	-	56
2. Oil Palm				
2.1 FELDA	ha	381	647	1,195
2.2 Others	ha	-	-	-
Sub-total	ha	381	647	1,195
3. Cocoa	ha	-	-	-
4. Sugarcane	ha	-	-	-
5. Pepper	ha	-	-	-
6. Crops and Vegetables	ha	-	-	-
7. Grassland	ha	-	-	-
8. Residential Land	ha	-	-	-
8.1 Air Tawar IV FELDA	ha	-	-	48
8.2 Air Tawar V FELDA	ha	20	44	80
Sub-total	ha	20	44	128
9. Forest Land				
9.1 Unalienated	ha	-	-	-
9.2 Alienated	ha	-	-	32
Sub-total	ha	-	-	32
10. Mine	ha	-	-	-
Total Land Area	ha	401	691	1,411
11. Houses/Building				
11.1 Air Tawar IV FELDA	nos	-	-	63
11.2 Air Tawar V FELDA	nos	-	23	320
Sub-total	nos	-	23	383
12. Road	km	7.3	7.6	8.0
13. Transmission Line	km	-	-	-
14. Railway	km	-	-	-
15. Gas Pipe Line	km	-	-	-
16. Pumping Station	nos	-	-	-

Remarks: Number of houses/buildings to be removed was estimated by the maps prepared by the Town and Country Planning Department.

Table 25 LIST OF ALTERNATIVE DEVELOPMENT PLANS

Present Value/1 of Dam Cost in 1986 (M$10⁶)	First Dam				Second Dam				
	Dam	/2 HWL	/3 S	/4 Year	Dam	HWL	/3 S	/4 Year	Ranking
75.6	Sayong	17	98	1991	-		-	-	1
85.0	Linggiu	34	107	"	-		-	-	2
85.2	Sayong	16	73	"	Telor	24	18	2000	3
85.7	Sayong	16	73	"	Sen Heng Barrage		-	2000	4
96.6	Linggiu	33	89	"	Telor	24	18	2002	5

Note: /1: Time basis; 1986, the commencement of service; 1992 and discount rate; 10%

/2: High water level; EL. m

/3: Active storage in 10^6 m^3

/4: Completion of dam construction

Table 26 ASSUMED ECONOMIC BENEFIT AND COST BY DAM SCALE

H.W.L. (m)	Economic Construciton Cost (M$10^6)	Benefit: Unit Price M¢19 (M$10^6)	Benefit: Unit Price M¢15 (M$10^6)
Sayong Dam			
16.0	69.3	108.2	86.1
17.0	75.6	129.9	103.3
18.0	82.3	148.6	118.1
19.0	92.6	155.6	123.8
20.0	105.9	161.0	128.2
21.0	122.7	165.4	131.8
22.0	131.1	168.1	134.0
Linggiu Dam			
31.0	81.0	87.9	69.6
32.0	82.3	104.4	82.6
33.0	83.5	113.9	90.1
34.0	85.0	127.3	100.8
35.0	86.3	136.5	108.0
36.0	87.6	142.3	112.6
37.0	100.2	147.6	116.8
38.0	113.3	152.5	120.7
39.0	118.0	156.1	123.5
40.0	122.6	159.3	126.1

Table 27 ECONOMIC CASH FLOW AND EIRR SAYONG DAM PROJECT

Unit: M$$10^6$

Year	Financial Cost			Economic Cost			Economic Benefit		
	Construction Cost	OMR	Total	Construction Cost	OMR	Total	Water Supply	Flood Attenuation	Total
1986	0	-	0	0	-	0	-	-	-
1987	33.06	-	33.06	25.46	-	25.46	-	-	-
1988	36.86	-	36.86	28.38	-	28.38	-	-	-
1989	34.81	-	34.81	26.80	-	26.80	-	-	-
1990	17.19	-	17.19	13.24	-	13.24	-	-	-
1991	10.11	-	10.11	7.78	-	7.78	-	-	-
1992	-	0.35	0.35	-	0.27	0.27	5.22	0.46	5.68
1993	-	0.35	0.35	-	0.27	0.27	6.97	0.46	7.43
1994	-	0.35	0.35	-	0.27	0.27	8.72	0.46	9.18
1995	-	0.35	0.35	-	0.27	0.27	10.47	0.72	11.19
1996	-	0.35	0.35	-	0.27	0.27	12.11	0.72	12.83
1997	-	0.35	0.35	-	0.27	0.27	13.74	0.72	14.46
1998	-	0.35	0.35	-	0.27	0.27	15.37	0.72	16.09
1999	-	0.35	0.35	-	0.27	0.27	17.01	0.72	17.73
2000	-	0.35	0.35	-	0.27	0.27	18.64	0.72	19.36
2001	-	0.35	0.35	-	0.27	0.27	21.91	0.72	22.63
2002	-	0.35	0.35	-	0.27	0.27	25.17	0.72	25.89
2003	-	0.35	0.35	-	0.27	0.27	28.44	0.72	29.16
2004	-	0.35	0.35	-	0.27	0.27	31.70	0.72	32.42
2005	-	0.35	0.35	-	0.27	0.27	34.96	0.72	35.68
2006-2035	-	0.35	0.35	-	0.27	0.27	34.96	0.82	36.43
Total	132.03	15.40	147.43	101.66	11.88	113.54	1,220.63	33.90	1,254.53

Economic Benefit: 130.1 (Discounted by 10%)

Economic Cost : 82.3 (Discounted by 10%)

Economic B-C : 47.8 (Discounted by 10%)

Economic Internal Rate of Return (EIRR): 13.1%

Table 28 UNIT VALUE AND FLOOD DAMAGE FACTOR OF AGRICULTURAL CROPS (1/2)

Crop Item	Age of Crop (Year)	(1) Value If Killed (M$/ha)	Flood Duration <14 Days (2) Kill Factor	(3) Loss From Death [(1)x(2)] (M$/ha)	Flood Duration >14 Days (4) Kill Factor	(5) Loss From Death [(1)x(4)] (M$/ha)
Rubber	1	2,371	0.95	2,252	1.00	2,371
	2	3,435	0.85	2,920	0.95	3,263
	3	4,711	0.40	1,884	0.60	2,827
	4	6,235	0.30	1,871	0.50	3,118
	5	7,767	0.20	1,553	0.20	1,553
	6	10,055	0.10	1,006	0.20	2,011
	7	10,825	0.10	1,082	0.20	2,165
	8	11,204	0.05	560	0.10	1,120
	9	11,484	0.05	574	0.10	1,148
	10	11,488	0.05	574	0.10	1,149
	11	11,492	0	0	0.05	575
	12-25	-	0	0	0	0
				Average* = 571		Average* = 852
Oil Palm	1	3,514	0.95	3,338	1.00	3,514
	2	5,706	0.65	3,710	0.85	4,850
	3	9,220	0.30	2,766	0.60	5,532
	4	12,075	0.20	2,415	0.30	3,623
	5	14,241	0.20	2,848	0.30	4,272
	6	15,226	0.10	1,523	0.20	3,045
	7	16,510	0.05	826	0.20	3,302
	8	16,958	0.05	848	0.20	3,392
	9	17,543	0.05	877	0.10	1,754
	10	17,351	0	0	0.10	1,735
	11	17,100	0	0	0.05	855
	12-25	-	0	0	0	0
				Average* = 766		Average* = 1,435
Mixed Horticulture	1	2,300	1.00	2,300	1.00	2,300
	2	4,222	0.95	4,011	1.00	4,222
	3	6,703	0.60	4,022	0.90	6,033
	4	9,635	0.50	4,818	0.80	7,708
	5	12,666	0.30	3,800	0.50	6,333
	6	15,897	0.20	3,179	0.40	6,359
	7	18,697	0.20	3,739	0.30	5,609
	8	19,464	0.10	1,946	0.20	3,893
	9	20,598	0.05	1,030	0.10	2,060
	10	22,184	0.05	1,109	0.10	2,218
	11-20	-	0	0	0	0
				Average* = 1,498		Average* = 2,337
Other Crops (Represented by Coconut Palm)	1	2,457	1.00	2,457	1.00	2,457
	2	3,062	0.75	2,297	0.95	2,909
	3	4,014	0.40	1,606	0.60	2,408
	4	4,431	0.20	886	0.40	1,772
	5	4,835	0.05	242	0.20	967
	6	5,012	0	0	0.10	501
	7	5,183	0	0	0.05	259
	8	5,128	0	0	0.05	256
	9	5,075	0	0	0.05	254
	10	4,780	0	0	0.05	239
	11-25	-	0	0	0	0
				Average* = 300		Average* = 481

Note; *: The average value of flood damage is the sum of the total loss per hectare at each year of age divided by the total number of years considered. It assumes an even distribution of crops of all ages in the flood area.

Source : Western Johor Integrated Agricultural Development Project, Phase II.

Table 29 UNIT VALUE AND FLOOD DAMAGE FACTOR OF AGRICULTURAL CROPS (2/2)

Crop Item	Age of Crop (Year)	(1) Unit Value (M$/ha)	Flood Duration <14 Days (2) Flood Damage Factor	(3) Loss of Production Value [(1)x(2)] (M$/ha)	Flood Duration >14 Days (4) Flood Damage Factor	(5) Loss of Production Value [(1)x(4)] (M$/ha)
Rubber	1-6	0	-	0	-	0
	7	1,952	0.045	88	0.08	156
	8	2,370	0.0475	113	0.09	213
	9	2,509	0.0475	119	0.09	226
	10	2,788	0.0475	132	0.09	251
	11	2,788	0.05	139	0.095	265
	12-14	2,788	0.05	139	0.10	279
	15-19	3,067	0.05	153	0.10	307
	20-25	3,346	0.05	168	0.10	335
			Average* =	111	Average* =	220
Oil Palm	1-3	0	-	0	-	0
	4	1,035	0.08	83	0.21	217
	5	2,295	0.04	92	0.14	321
	6	3,860	0.045	174	0.08	309
	7	3,860	0.0475	183	0.08	309
	8	4,896	0.0475	233	0.08	392
	9	4,896	0.0475	233	0.09	441
	10	5,590	0.05	280	0.09	503
	11	5,590	0.05	280	0.095	531
	12-14	5,590	0.05	280	0.1	559
	15-19	5,160	0.05	258	0.1	516
	20-25	4,730	0.05	237	0.1	473
			Average* =	203	Average* =	405
Mixed Horticulture	1-2	0	-	0	-	0
	3	488	0.16	78	0.09	44
	4	943	0.15	142	0.16	151
	5	1,945	0.14	272	0.25	487
	6	2,698	0.08	215	0.24	647
	7	4,063	0.04	162	0.21	853
	8	6,357	0	0	0.16	1,017
	9	6,357	0	0	0.09	572
	10	6,443	0	0	0.045	290
	11-20	8,020-8,397	0	0	0	0
			Average* =	43	Average* =	203
Other Crops (Represented by Coconut Palm)	1-5	0	-	0	-	0
	6	346	0.05	17	0.18	62
	7	346	0.05	17	0.095	33
	8	691	0.05	35	0.095	66
	9	691	0.05	35	0.095	66
	10	1,100	0.05	55	0.10	110
	11-25	1,100	0.05	55	0.10	110
			Average* =	39	Average* =	79

Note; *: The average value of flood damage is the sum of the total loss per hectare at each year of age divided by the total number of years considered. It assumes an even distribution of crops of all ages in the flood area.

Source : Western Integrated Agricultural Development Project, Phase II.

Table 30 UNIT VALUE OF NON-AGRICULTURAL ASSETS

Item of Asset	Unit Value
1. Private House in Urban Area	M$9,500/house
2. Private House in Rural Area	M$3,700/house
3. Public House/Building	M$200/person

Source: Property Market Report, 1983, and National Water Resources Study, Malaysia, Sectoral Report Vol. 5.

Table 31 FLOOD DAMAGE FACTORS OF NON-AGRICULTURAL ASSETS

Flood Depth (m)	<0.25	0.25-0.50	0.50-1.00	1.00-2.00	2.00-3.00	>3.00
Damage Factor (%)	3	5	7	11	15	22

Source: National Water Resources Study, Malaysia, Sectoral Report Vol. 5.

Table 32 ESTIMATED POSSIBLE FLOOD DAMAGE IN 1985

Unit: M$$10^3$

River	Year of Flood Event	House and Infra-structure	Agri-culture	Indirect Damage	Total Damage
Johor	1969	4,724	1,310	1,810	7,844
Johor	1979	3,104	1,137	1,272	5,513
Johor	1983	1,676	776	736	3,188
Johor	1982	571	349	276	1,196
Johor	1981	507	268	233	1,008
Johor	1978	372	364	170	736
Skudai	1978	6,777	1,222	2,400	10,399
Skudai	1981	2,088	469	767	3,324
Skudai	1979	1,102	233	400	1,735
Tebrau	1978	2,163	787	885	3,835
Tebrau	1982	21	187	63	271
Benut	1969	1,034	3,691	1,417	6,142
Benut	1981	264	180	133	577
Pontian Besar	1969	785	3,022	1,142	4,949
Pontian Besar	1978	364	542	272	1,178
Pontian Kechil	1969	115	2,432	764	3,311
Pulai	1969	18	315	100	433
Pulai	1978	10	205	65	280
Sedili Besar	1981	79	71	45	195
Sedili Kechil	1981	0	0	0	0
Grand Total					56,114

Table 33 FUTURE FLOOD DAMAGE VALUE IN 2005

Unit: M$$10^3$

River	Year of Flood Event	House and Infra-structure	Agri-culture	Indirect Damage	Total Damage
Johor	1969	13,861	1,211	4,522	19,594
Johor	1979	8,799	1,073	2,961	12,833
Johor	1983	3,597	792	1,317	5,706
Johor	1982	903	361	379	1,643
Johor	1981	803	278	325	1,406
Johor	1978	589	202	237	1,028
Skudai	1978	25,779	463	7,873	34,115
Skudai	1981	6,478	163	1,992	8,633
Skudai	1979	3,731	78	1,143	4,952
Tebrau	1978	7,229	596	2,348	10,173
Tebrau	1982	13	185	59	257
Benut	1969	3,162	3,552	2,014	8,728
Benut	1981	248	116	109	473
Pontian Besar	1969	738	2,804	1,063	4,605
Pontian Besar	1978	342	459	241	1,042
Pontian Kechil	1969	108	2,403	753	3,264
Pulai	1969	17	310	98	425
Pulai	1978	10	202	63	275
Sedili Besar	1981	125	73	59	257
Sedili Kechil	1981	0	0	0	0
Grand Total					119,409

Table 34 OCCURRENCE PROBABILITY OF PAST MAJOR FLOODS

River Basin	Flood Event	Return Period of Net Precipitation		Return Period of Max. Flood Discharge		Adopted Return Period (yr.)
		Precipitation (mm)	Return Period (yr.)	Discharge (m^3/s)	Return Period (yr.)	
Johor	Dec. '69	377	25.6	437	23.8	23.8
	Nov. '79	264	6.3	337	6.7	6.7
	Dec. '83	N.R.	-	312	4.6	4.6
	Dec. '82	243	4.3	296	4.2	4.2
	Dec. '81	228	3.6	279	3.6	3.6
	Dec. '78	202	2.6	244	2.6	2.6
Skudai	Dec. '78	349	33.3	N.R.	-	33.5
	Dec. '81	203	2.5	N.R.	-	2.5
	Nov. '79	177	2.0	N.R.	-	2.0
Tebrau	Dec. '78	349	33.3	N.R.	-	33.5
	Dec. '82	210	3.5	N.R.	-	3.5
Benut	Dec. '69	318	52.6	N.R.	-	52.6
	Dec. '81	212	5.9	N.R.	-	5.9
	Nov. '79	187	3.1	N.R.	-	3.1
Pontian Besar and Kechil	Dec. '69	436	50.0	N.R.	-	50.0
	Dec. '78	349	33.3	N.R.	-	33.3
	Dec. '82	210	3.5	N.R.	-	3.5
Pulai	Dec. '78	349	33.3	N.R.	-	33.5
	Dec. '82	212	3.5	N.R.	-	3.5
Sedili Besar and Kechil	Dec. '81	618	14.3	N.R.	-	14.3
	Dec. '78	470	6.7	N.R.	-	6.7
	Dec. '82	247	2.0	N.R.	-	2.0

NOTE: Flood discharges of the Johor River were observed at Rantan Panjang (catchment area: 1,130 km^2).

Table 35 PROBABLE FLOOD DAMAGE (1985)

River Basin	Stretch No.	Flood Damage (M$10³/y) 5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average	People To Be Affected (person/y) 5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average
Johor	1	1,785	3,410	4,162	4,477	4,754	898	5,946	9,045	9,379	9,519	9,642	2,484
	2	371	514	617	660	698	155	1,279	1,656	1,806	1,868	1,924	500
	3	927	1,044	1,197	1,261	1,318	345	3,515	3,667	3,762	3,802	3,837	1,224
	4	496	628	741	788	830	197	1,879	1,965	2,047	2,081	2,111	658
	5	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0
	7	125	653	806	870	927	130	363	1,715	1,853	1,910	1,961	324
	Total	3,704	6,250	7,524	8,057	8,527	1,724	12,981	18,048	18,847	19,181	19,476	5,191
Skudai	1	0	0	0	1,795	2,041	67	0	0	0	5,068	5,761	189
	2	1,263	1,733	2,204	2,479	2,690	538	4,930	5,547	6,165	6,526	6,802	1,819
	3	2,803	3,707	4,610	5,139	5,544	1,162	11,028	12,788	14,548	15,578	16,366	4,156
	4	301	439	577	658	720	134	701	959	1,217	1,368	1,484	298
	Total	4,367	5,879	7,391	10,071	10,994	1,902	16,659	19,294	21,930	28,539	30,413	6,463
Tebrau	1	0	0	2,207	2,720	3,114	178	0	0	8,441	10,405	11,909	679
	2	265	447	629	736	818	132	438	814	1,189	1,409	1,577	236
	3	118	151	185	204	219	48	0	0	0	0	0	0
	Total	382	598	3,021	3,661	4,151	357	438	814	9,631	11,814	13,487	915
Benut	1	0	0	2,011	2,679	3,520	173	0	0	470	626	823	40
	2	0	238	314	359	415	41	0	753	893	975	1,078	119
	3	0	0	0	1,774	2,207	56	0	0	0	5,532	6,789	172
	Total	0	238	2,325	4,812	6,142	269	0	753	1,363	7,133	8,690	332
Pontian Besar	1	0	0	0	0	1,800	36	0	0	0	0	4,684	93
	2	0	0	0	0	2,057	41	0	0	0	0	2,136	42
	3	0	123	176	207	215	22	0	0	0	0	0	0
	4	0	551	788	927	877	95	0	1,716	2,455	2,888	3,352	309
	Total	0	674	964	1,134	4,949	193	0	1,716	2,455	2,888	10,172	444
Pontian Kechil	1	0	0	2,368	2,785	3,311	190	0	0	1,066	1,253	1,490	85
Pulai	1	4	7	10	11	54	3	19	34	48	57	98	11
	2	87	153	219	258	379	47	26	45	64	75	137	14
	Total	91	160	229	269	433	49	45	79	112	132	235	25
Sedili Besar	1	19	33	44	48	53	9	0	0	0	0	0	0
	2	51	90	119	130	145	25	209	367	487	533	591	104
	3	21	37	49	54	60	11	81	143	189	207	230	40
	4	0	0	0	0	0	0	0	0	0	0	0	0
	Total	91	160	212	232	257	45	290	510	676	740	821	144
Sedili Kechil	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total		8,635	13,959	24,036	31,022	38,765	4,730	30,413	41,214	56,080	71,680	84,784	13,599

Table 36 PROBABLE FLOOD DAMAGE (2005)

River Basin	Stretch No.	Flood Damage ($M\$10^3/y$)						People To Be Affected (person/y)					
		5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average	5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average
Johor	1	4,482	10,149	12,858	13,990	14,988	2,548	9,765	18,048	19,370	19,922	20,409	4,592
	2	498	699	852	916	972	210	1,336	1,730	1,886	1,952	2,009	523
	3	1,276	1,450	1,685	1,783	1,869	478	3,672	3,831	3,930	3,972	4,009	1,279
	4	683	846	1,006	1,074	1,133	269	1,963	2,053	2,138	2,174	2,206	687
	5	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0
	7	349	1,826	2,265	2,449	2,611	363	674	3,169	3,391	3,483	3,565	597
	Total	7,287	14,969	18,666	20,212	21,574	3,867	17,410	28,830	30,716	31,503	32,198	7,678
Skudai	1	0	0	0	5,854	6,655	219	0	0	0	12,057	13,707	451
	2	3,012	4,212	5,412	6,114	6,652	1,302	7,815	8,635	9,455	9,934	10,302	2,847
	3	8,498	12,382	16,267	18,539	20,279	3,788	23,547	29,769	35,992	39,632	42,420	9,445
	4	1,008	1,557	2,106	2,427	2,673	470	2,464	3,371	4,277	4,808	5,214	1,048
	Total	12,518	18,151	23,785	32,934	36,259	5,778	33,826	41,775	49,724	66,431	71,642	13,790
Tebrau	1	0	0	7,193	8,866	10,148	579	0	0	20,083	24,755	28,333	1,616
	2	233	382	531	618	685	114	184	341	498	591	661	99
	3	118	151	185	204	219	48	0	0	0	0	0	0
	Total	351	533	7,909	9,689	11,052	740	184	341	20,581	25,345	28,994	1,715
Benut	1	0	0	1,995	2,658	3,493	172	0	0	292	389	511	25
	2	0	203	274	316	368	35	0	468	554	605	669	74
	3	0	0	0	3,781	4,867	122	0	0	0	10,589	13,617	342
	Total	0	203	2,269	6,755	8,728	329	0	468	846	11,583	14,797	441
Pontian Besar	1	0	0	0	0	1,662	33	0	0	0	0	2,908	57
	2	0	0	0	0	1,990	39	0	0	0	0	1,326	26
	3	0	123	176	207	215	22	0	0	0	0	0	0
	4	0	473	677	796	738	82	0	1,065	1,524	1,792	2,080	192
	Total	0	597	853	1,004	4,605	176	0	1,065	1,524	1,792	6,314	276
Pontian Kechil	1	0	0	2,335	2,746	3,264	187	0	0	661	778	925	53
Pulai	1	3	5	8	9	50	2	12	21	30	35	61	7
	2	86	152	217	255	375	46	16	28	40	47	85	9
	Total	89	157	225	264	425	49	28	49	70	82	146	15
Sedili Besar	1	19	33	44	48	53	9	0	0	0	0	0	0
	2	72	126	168	183	204	36	218	383	508	557	617	109
	3	29	51	68	75	83	15	85	149	198	216	240	42
	4	0	0	0	0	0	0	0	0	0	0	0	0
	Total	120	210	279	306	339	60	303	532	706	773	858	151
Sedili Kechil	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total		20,365	34,821	56,322	73,909	86,247	11,185	51,751	73,060	104,828	138,287	155,873	24,119

Table 37 MINIMUM CONSTRUCTION COST REQUIRED FOR EACH DESIGN FLOOD LEVEL

Design Level (R.P. year)	Design Discharge (m^3/s)	Flood Mitigation Measure*	Minimum Construction Cost (M$$10^6$)
5	460	I	5.3
10	530	I	6.1
20	660	I	6.8
30	770	I	7.7
40	820	I	8.7
50	870	II	9.5
100	1080	II	11.0

Note; *: I = River channel improvement only
II = River channel improvement and flood diversion channel

Table 38 PRINCIPAL FEATURES OF RECOMMENDED FLOOD MITIGATION SCHEME

Description	Johor River Basin	Skudai River Basin	Total
1. Project Component			
1.1 Major Target Area	Kota Tinggi	Senai and Kulai	
1.2 Design Flood Level	30-Year Return Period	20-Year Return Period	
1.3 Flood Mitigation Measure	Channel Improvement (Length: 6.7 km)	Channel Improvement (Length: 15.0 km)	
1.4 Project Cost (M$$10^6$)	7.7	13.6	21.3
2. Economic Effect			
2.1 Flood Damage Without Scheme (M$$10^6$/y)	1.36	2.66	4.03
2.2 Flood Damage Reduction With Scheme (M$$10^6$/y)	1.18	2.16	3.34
2.3 Net Economic Benefit (M$$10^6$/y)	0.57	1.16	1.73
2.4 EIRR (%)	10.7	11.0	10.9
2.5 Ratio Between 2.1 and Total Damage in the Region* (%)	22.4	43.0	64.9
2.6 Ratio Between 2.2 and Total Damage in the Region* (%)	19.0	34.8	53.8
3. Social Effect (As of 2005)			
3.1 Population Damage Without Scheme (person/y)	4,952	12,292	17,244
3.2 Population Damage Reduction With Scheme (person/y)	4,116	10,275	14,391
3.3 Ratio Between 3.1 and Total Damage in the Region** (%)	20.5	51.0	71.5
3.4 Ratio Between 3.2 and Total Damage in the Region** (%)	17.1	42.6	60.0

NOTE; *: Total damage in the Region amounts to M$6,202, considering that there is no future flood mitigation work.

**: A total of 24,119 people in the Region will be affected by a flood in the year 2005, considering that there is no flood mitigation work.

Table 39 CONSTRUCTION COSTS OF ALTERNATIVE RIVER CHANNEL IMPROVEMENT PLANS

Design Discharge (m^3/s)	Cost for Alternative A ($M\$10^6$)	Cost for Alternative B ($M\$10^6$)	Cost for Alternative C ($M\$10^6$)	Cost for Alternative D ($M\$10^6$)
300	4.58	5.32	7.07	9.16
500	5.84	5.81	7.44	9.45
700	8.56	6.98	8.47	10.35
900	10.71	10.11	11.20	12.90
1000	12.38	12.09	13.09	14.70

Table 40 TOTAL COST FOR COMBINATION OF RIVER CHANNEL IMPROVEMENT AND DIVERSION CHANNEL

	Size of Diversion Channel		Possible Diverting Discharge		Cost		
Design Discharge (m^3/s)	Bed Width (m)	Channel Depth (m)	Johor River (m^3/s)	Diversion Channel (m^3/s)	River Improvement ($M\$10^6$)	Diversion Channel ($M\$10^6$)	Total ($M\$10^6$)
600	10	3	536	64	5.98	2.15	8.13
700	10	4	587	113	6.27	2.33	8.60
800	10	5	613	187	6.45	2.68	9.13
900	10	5	702	198	6.99	2.68	9.67
1000	20	5	703	297	7.00	3.39	10.39

Note: River improvement for the main channel is assumed to be done by the manner of Alternative B.

Table 41 COMPARISON OF ANNUAL AVERAGE OF CONSTRUCTION COST AND FLOOD DAMAGE REDUCTION

Design Level (R.P. year)	Annual Average Construction Cost (M$106/y)	Annual Average Damage Reduction (M$106/y)	Net Economic Benefit (M$106/y)
5	0.42	0.37	-0.05
10	0.48	0.77	0.29
20	0.54	1.06	0.52
30	0.61	1.18	0.57
50	0.75	1.28	0.53

Table 42 REQUIRED NUMBER OF MAJOR CONSTRUCTION EQUIPMENT FOR RIVER CHANNEL IMPROVEMENT OF MODEL RIVER STRETCH

Equipment Item	Work for Excavation	Work for Embankment	Total
Dredger	1	-	1
Anchor Barge	1	-	1
Backhoe	2	-	2
Wheel Loader	2	1	3
Dump Truck	10	6	16
Bulldozer	2	1	3
Asphalt Engine Sprayer	-	1	1
Asphalt Finisher	-	1	1
Road Roller	-	1	1
Tired Roller	-	1	1
Soil Compactor	-	5	5

Table 43 COST OF RIVER CHANNEL IMPROVEMENT FOR MODEL RIVER STRETCH

Work Item	Unit Rate	Volume	Amount
I. Construction			
(1) Site Clearance	M$6,000/ha	1.9 ha	M$ 11,400
(2) Excavation	M$4.4/$m^3$	257,000 m^3	1,130,800
(3) Embankment	M$8.8/$m^3$	138,000 m^3	1,214,400
(4) Sod Facing	M$3.7/$m^2$	104,000 m^2	384,800
(5) Levee Pavement	M$11.8/$m^2$	40,000 m^2	472,000
(6) Reconstruction of Bridge	M$10,000/m	120 m	1,200,000
(7) Weir	M$25,000/$m^2$	30 m^2	750,000
Total			M$5,163,400
II. Compensation			
(1) Resettlement of House	M$44,000/house	4 houses	M$ 176,000
(2) Procurement of Agricultural Land	M$35,000/ha	1.5 ha	52,500
Total			M$ 228,500
III. Engineering Services (10% of I)			M$ 516,300
IV. Physical Contingencies (30% of I, II & III)			M$1,772,500
Grand Total			M$7,680,700

Table 44 SUMMARY OF PROJECTED BOD LOAD AND BOD CONCENTRATION

Basin Name	1995 BOD LOAD From Source (ton/d)	1995 BOD LOAD Into River (ton/d)	1995 BOD Concentration in River (mg/l)	2005 BOD LOAD From Source (ton/d)	2005 BOD LOAD Into River (ton/d)	2005 BOD Concentration in River (mg/l)
Benut	1.7	0.3	0- 2	2.9	1.0	0- 8
P. Besar	2.5	1.2	0-13	3.4	1.6	0-17
P. Kechil	6.6(4.9)	0.5	0-19	12.9(9.8)	0.7	0-26
Pulai	2.3	0.8	0- 4	2.8	1.0	0- 6
Skudai	9.0	5.0	0-43	16.7	9.6	0-68
Tebrau	0.4	0.1	0- 1	0.5	0.1	0- 1
Johor	10.9	4.6	0-13	20.4	10.2	0-33
S. Besar	1.7	0.5	0- 1	2.8	1.1	0- 2
S. Kechil	0.3	-	-	0.4	-	-
Total	35.4(4.9)	13.0		61.9(9.8)	25.3	

Remarks: ( ) : BOD load discharged to the sea directly

Table 45 OUTLINE OF PROPOSED PUBLIC SEWERAGE SYSTEM

City/Town	Basin	1995 Treatment Capacity (10^3 m^3/d)	1995 Service Factor (%)	1995 Served Population (10^3)	2005 Treatment Capacity (10^3 m^3/d)	2005 Service Factor (%)	2005 Served Population (10^3)
Johor Bahru	-	108	40	216	345	70	558
Masai & P.G.	-	41	85	26	65	95	43
Kulai	Skudai	27	85	60	73	100	123
Senai	Skudai	5	85	12	12	100	20
Kota Tinggi	Johor	0	0	0	14	50	25
B.Tenggara	Johor	6	85	15	17	100	31
P.Kechil	P.Kechil	23	85	50	56	100	97
Total		210	-	379	582	-	897

Remarks: The public sewerages system in Johor Bahru, Masai & P.G. and P. Kechil do not affect river water quality.

Table 46 POLLUTANT LOAD BY BASIN WITH AND WITHOUT PROJECT

1995

Basin Name	Without Project: BOD Load into River (ton/d) PRP	UI	RA	Total	Max.BOD in River (mg/l)	With Project: BOD Load into River (ton/d) PRP	UI	RA	Total	Max.BOD in River (mg/l)
Benut	0.1	0.1	0.1	0.3	2	0.1	0.1	0.1	0.3	2
P. Besar	0.5	0.6	0.1	1.2	13	0.1	0.6	0.1	0.8	8
P. Kechil	0.4	0	0.1	0.5	19	0	0	0.1	0.1	5
Pulai	0	0.7	0.1	0.8	3	0	0.7	0.1	0.8	4
Skudai	0.7	4.2	0.1	5.0	43	0.1	1.3	0.1	1.5	11
Tebrau	0.1	0	0	0.1	1	0	0	0	0	0
Johor	0.6	3.7	0.3	4.6	13	0.3	3.0	0.3	3.6	7
S. Besar	0.2	0.2	0.1	0.5	1	0.1	0.2	0.1	0.4	1
S. Kechil	0	0	0	0	0	0	0	0	0	0
Total	2.6	9.5	0.9	13.0		0.7	5.9	0.9	7.5	

2005

Basin Name	Without Project: BOD Load into River (ton/d) PRP	UI	RA	Total	Max.BOD in River (mg/l)	With Project: BOD Load into River (ton/d) PRP	UI	RA	Total	Max.BOD in River (mg/l)
Benut	0.1	0.8	0.1	1.0	8	0.1	0.8	0.1	1.0	8
P. Besar	0.5	1.0	0.1	1.6	17	0.1	0.8	0.1	1.0	10
P. Kechil	0.6	0	0.1	0.7	120	0.1	0	0.1	0.2	16
Pulai	0	0.9	0.1	1.0	6	0	0.9	0.1	1.0	6
Skudai	0.7	8.8	0.1	9.6	68	0.1	1.8	0.1	2.0	11
Tebrau	0.1	0	0	0.1	1	0	0	0	0	0
Johor	0.6	9.2	0.4	10.2	33	0.3	5.6	0.4	6.3	9
S. Besar	0.2	0.8	0.1	1.1	2	0.1	0.8	0.1	1.0	2
S. Kechil	0	0	0	0	0	0	0	0	0	0
Total	2.8	21.5	1.0	25.3		0.8	10.9	1.0	12.7	

Remarks: PRP: Palm oil mill, rubber factory and pineapple factory effluent
UI: Urban domestic and urban industry effluent
RA: Rural and animal husbandry

Table 47 RIVER STRETCH WITH BOD CONCENTRATION

Unit: km

Basin Name	Studied Length	Length of Stretch with high BOD Concentration over 10 mg/l			
		1995		2005	
		Without	With	Without	With
Benut	41	0	0	0	0
P. Besar	33	8	0	8	0
P. Kechil	18	18	0	18	0
Pulai	28	0	0	0	0
Skudai	37	37	0	37	0
Tebrau	30	0	0	0	0
Johor	85	42	0	56	0
S. Besar	67	0	0	0	0
S. Kechil	35	0	0	0	0
Total	374	105	0	119	0

Table 48 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM

Unit: M$ 10^6

City/Town	5MP	6MP	7MP	8MP	Total
Johor Bahru	61	118	134	100	413
Masai & P.G.	25	31	22	18	96
Kulai	16	26	26	20	88
Senai	5	3	7	5	25
Kota Tinggi	3	8	10	8	29
B. Tenggara	6	9	9	7	31
P. Kechil	14	22	21	16	73
Total	130	222	229	174	755

Table 49 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR PURIFICATION SYSTEM IN RUBBER FACTORIES, PALM OIL MILLS AND PINEAPPLE FACTORIES

Unit: M$ 10^6

Basin Name	5MP	6MP	7MP	8MP	Total
Benut	1.5	1.5	0.6	0.6	4.2
P. Besar	2.4	2.6	1.2	1.2	7.4
P. Kechil	1.8	2.2	1.6	1.3	6.9
Pulai	0	0	0	0	0
Skudai	5.3	5.4	2.2	2.2	15.1
Tebrau	2.7	2.7	1.1	1.1	7.6
Johor	16.2	16.8	7.5	7.3	47.8
S. Besar	2.7	3.0	1.5	1.4	8.6
S. Kechil	0	0	0	0	0
Total	32.6	34.2	15.7	15.1	97.6

FIGURES

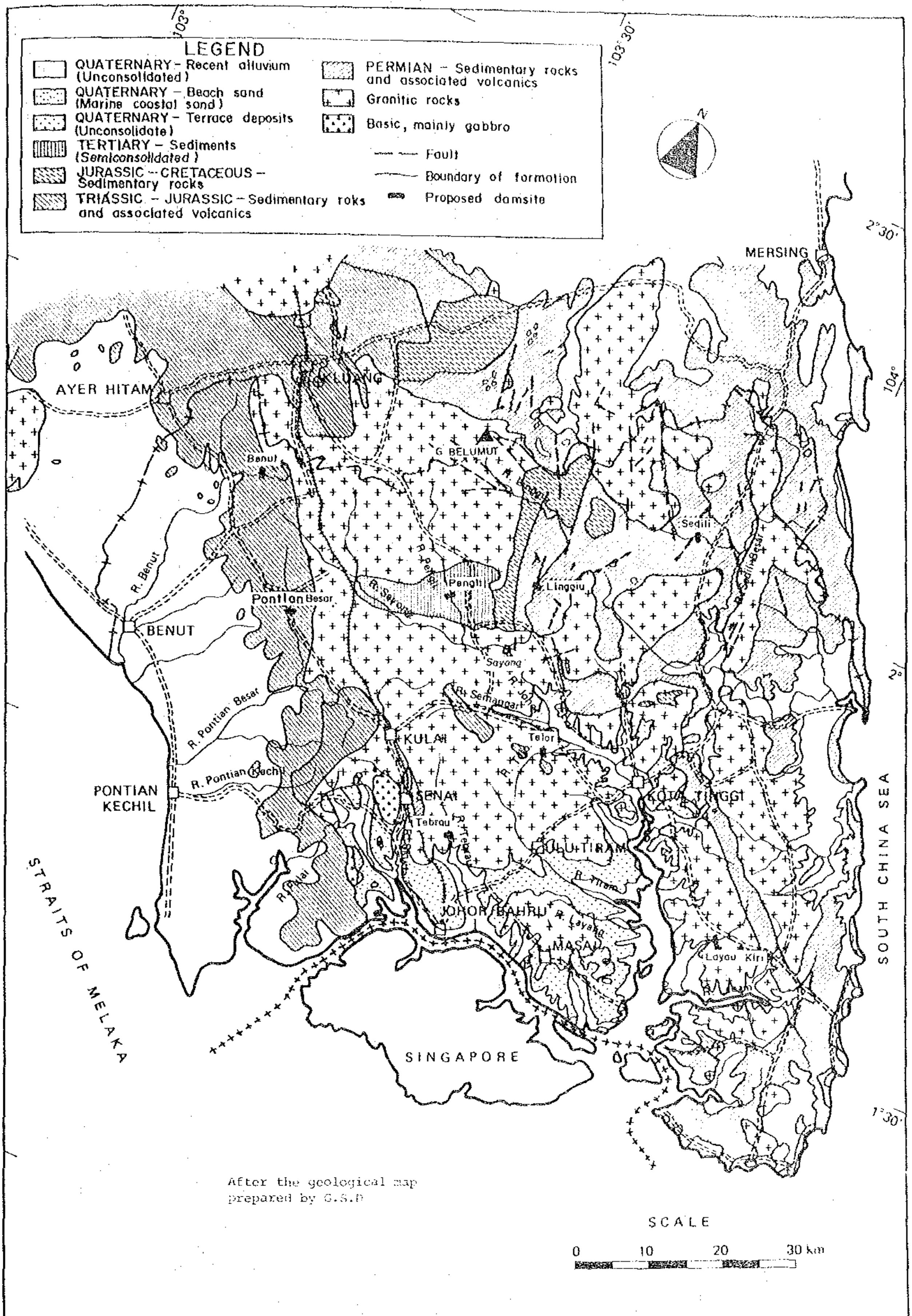

Fig. 1 Geological Map of the Region

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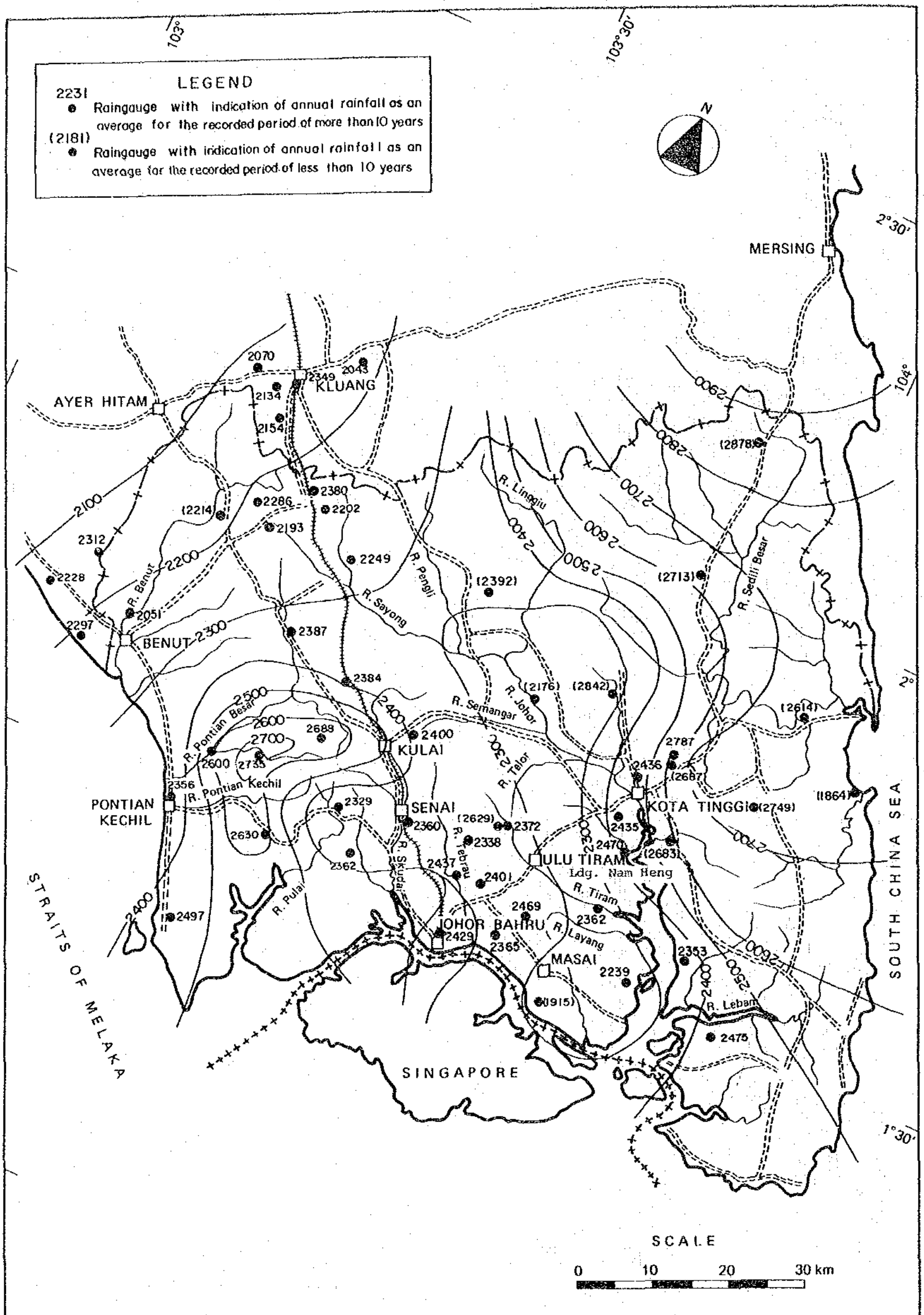

Fig. 2 Isohyetal Map of Annual Rainfall

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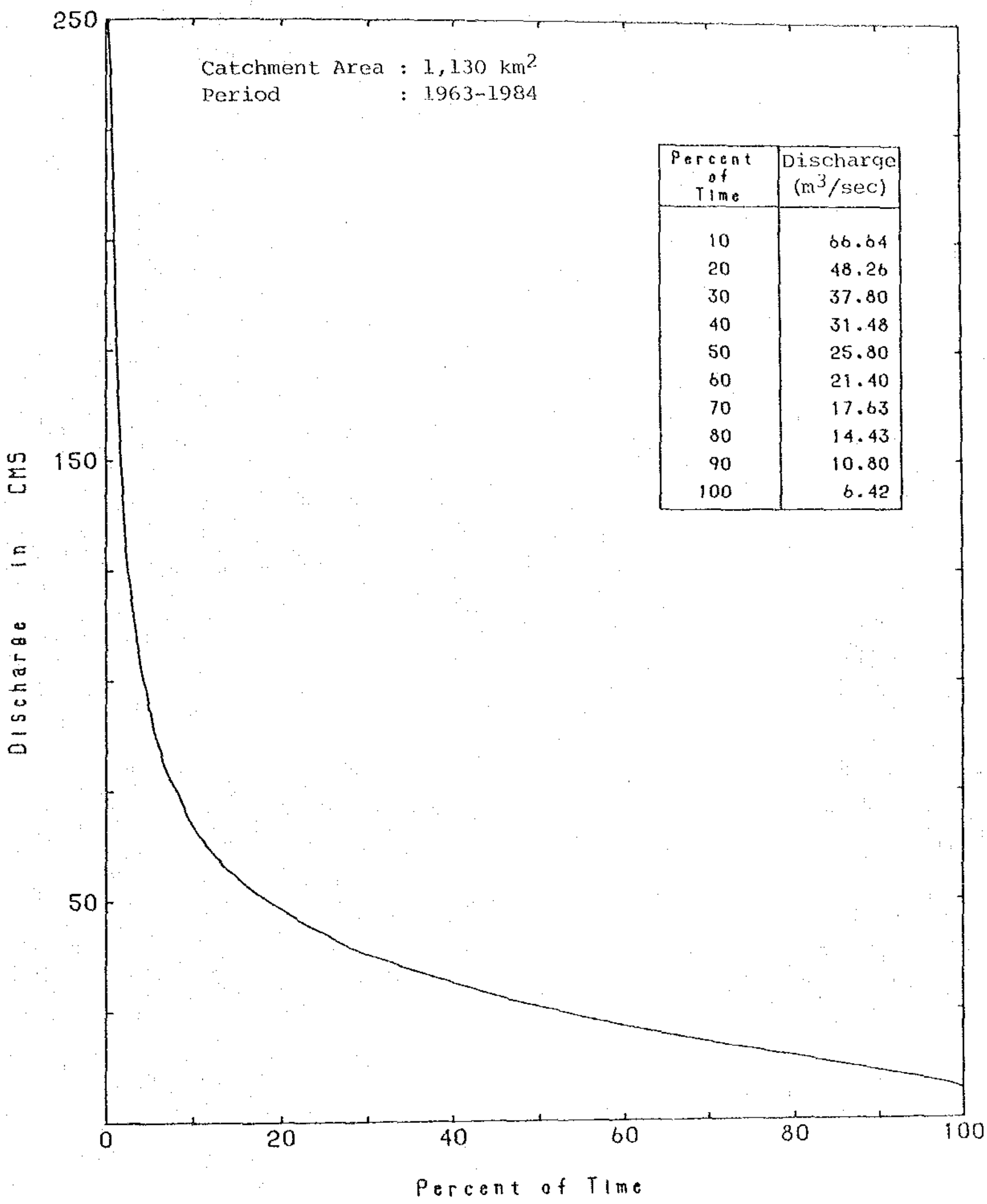

Percent of Time	Discharge (m^3/sec)
10	66.64
20	48.26
30	37.80
40	31.48
50	25.80
60	21.40
70	17.63
80	14.43
90	10.80
100	6.42

Fig. 3 Flow Duration Curve at Rantau Panjang

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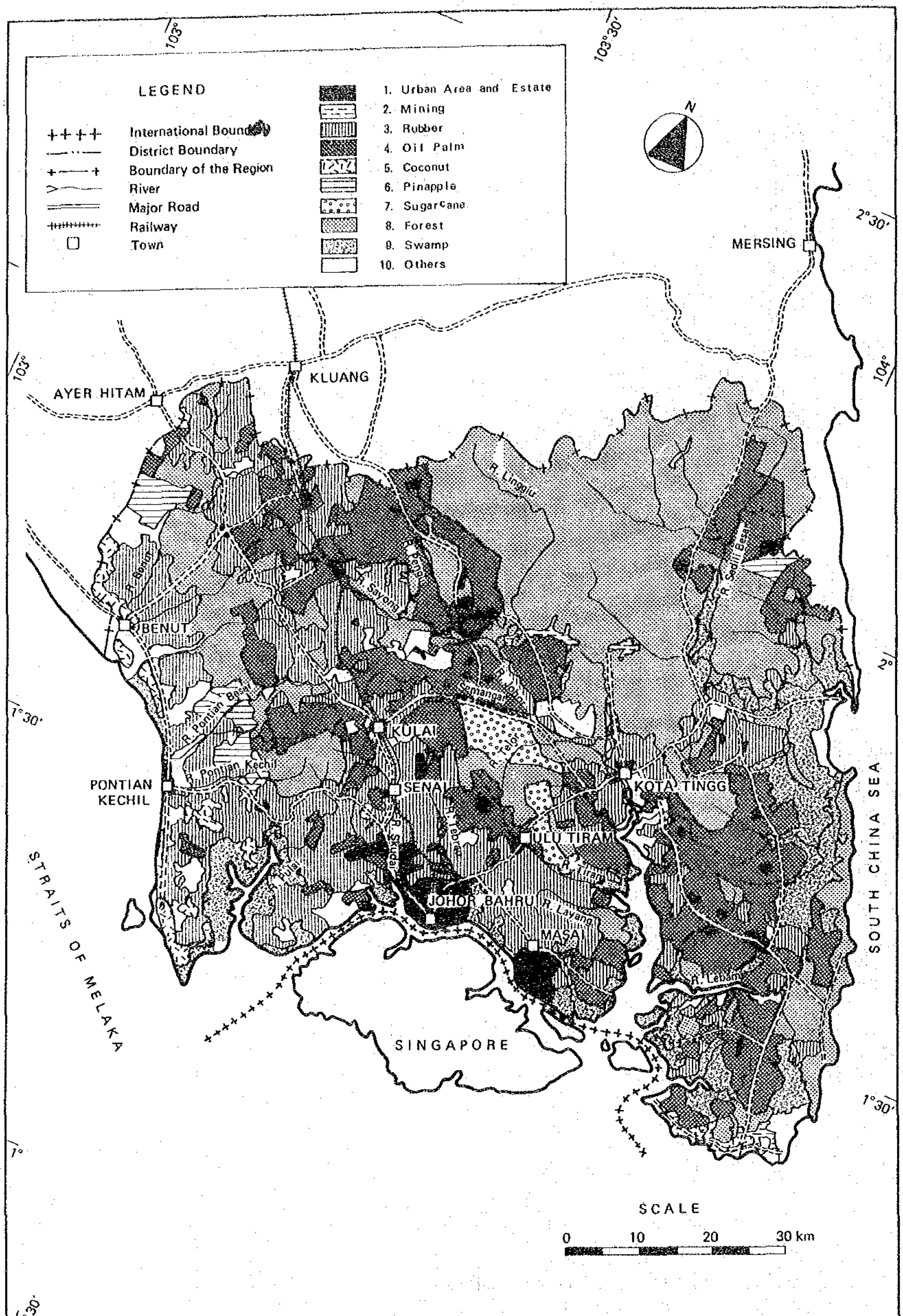

Fig. 4 Present Land Use in the Region

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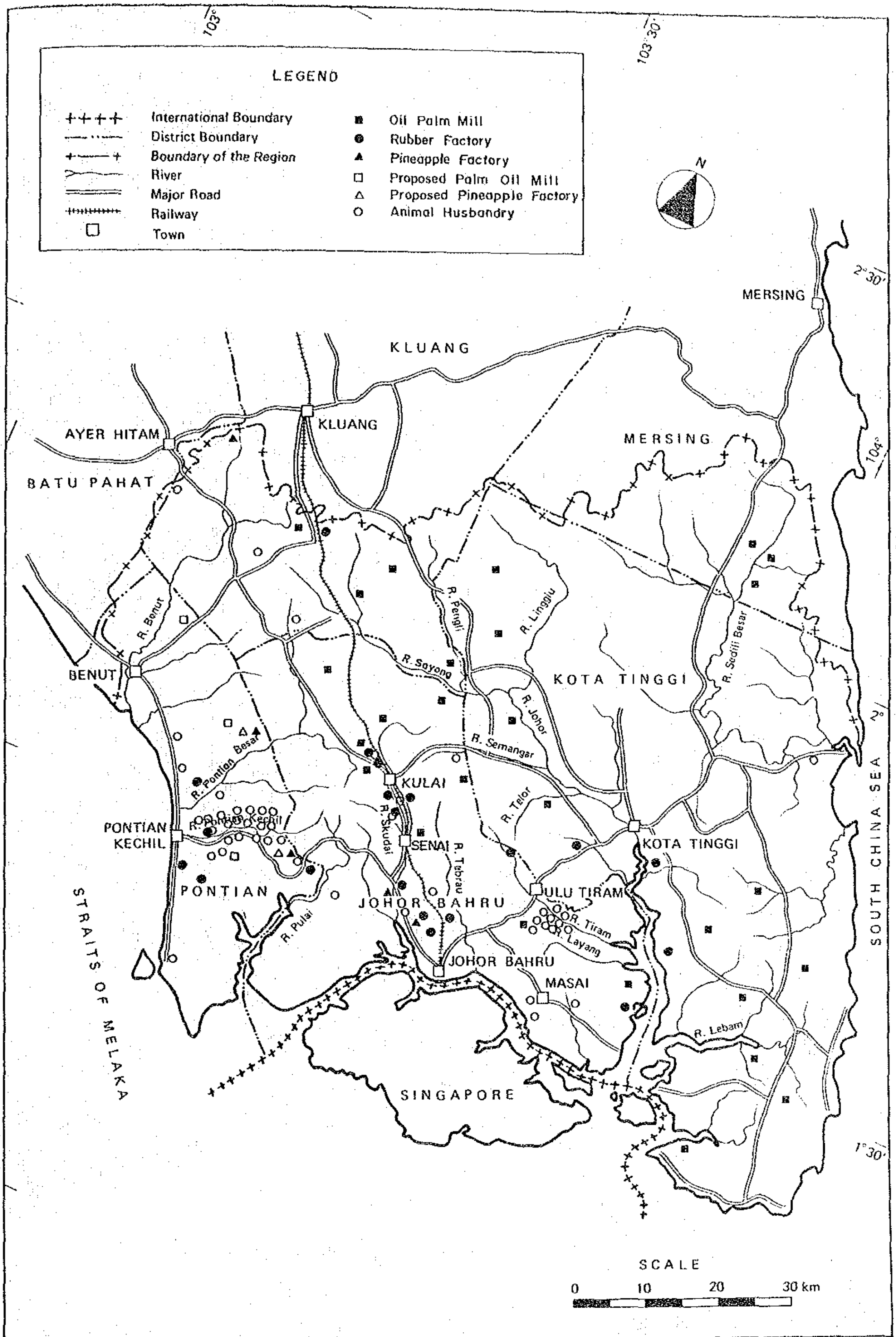

Fig. 5 Location of Pollutant Sources

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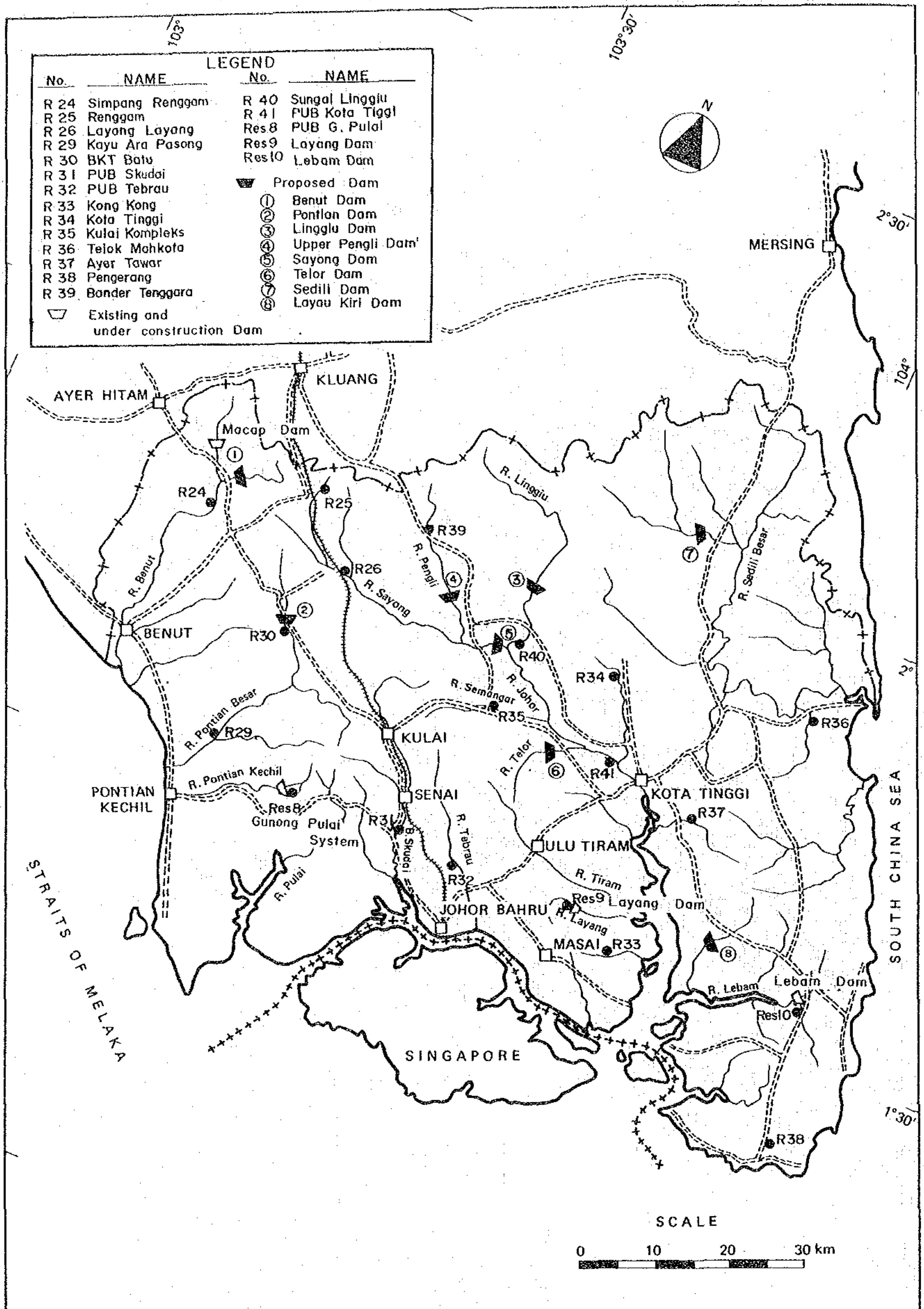

Fig. 6 Location Map of Existing Water-Works and Proposed Damsites

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