4.2 Population/Communities

4.2.1 Population Distribution

Table 4-1 shows the preliminary figures gathered by the Population Census conducted in 1980. According to this table, the total residential population of the Study Area was 79,203 persons, which clearly indicates a high density for the coastal and flat areas and a low density for the interior mountainous area. However, the population density is extremely low in comparison with the average of Sarawak (10.4 ps./km^2).

Table 4-1 POPULATION DISTRIBUTION

Adm. District	Sub-District	Area (sq.km)	Population (1980)		Density (Ps./sq.km)
Bintulu	Bintulu Tatau	11,844	26,791 14,067	(33.8) (17.8)	4.92
Kapit	Kapit	15,597	38,345	(48.4)	2.45
Sub-Total		27,441	79,203	(100.0)	3.52 1/
Bintulu	Sebauh	-	17,438		
Song	Song	3,934	16,887		4.29
Belaga	Belaga	19,404	12,229		0.63

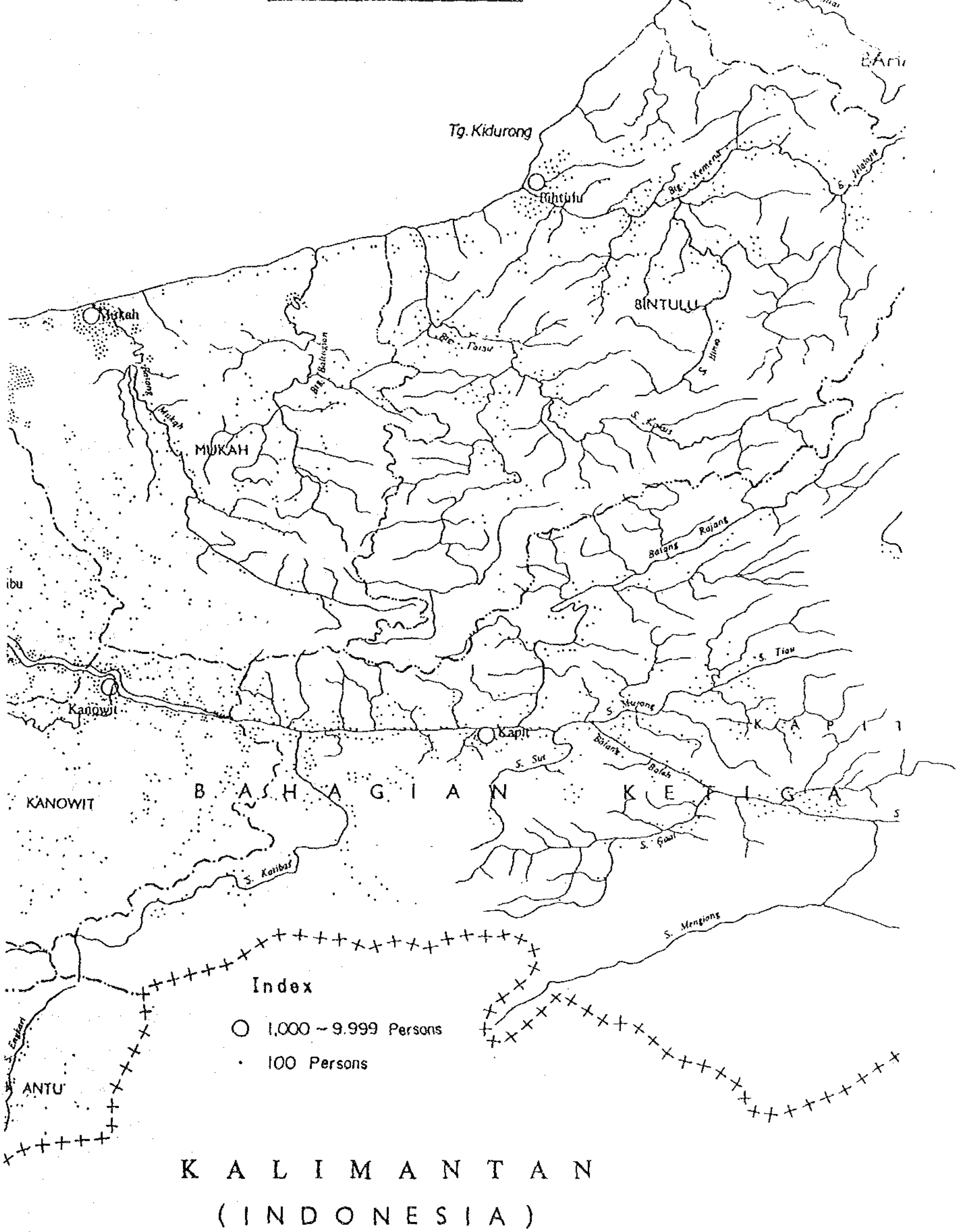
Note: 1/ Density is calculated based on data including the Sebauh Sub-district.

Source: Population & Housing Census 1980, State of Sarawak

4.2.2 Communities

Most of the communities in the Study Area are composed of Kampongs or Long Houses which mainly function as a base for farming and habitation. Fig. 4-1 shows the number of towns/Kampongs by population size in the Study Area scattered along rivers or roads. Each of the smallest dots on the figure represents 100 persons. It is thus reasonable to judge that most of the communities accounting for 45 to 50% of the total number of Kampongs, are populated by less than 100 inhabitants.

Fig. 4-1 POPULATION DISTRIBUTION



Bintulu is a growing industrial town in Sarawak. It will be many years to come before the status of city could be accorded to Bintulu. Also, Kapit, Belaga and Tatau have a small town area.

4.2.3 Estimation of Future Population

This section deals with population forecasted on the basis of the 1980 census data. The basic concepts and assumptions are as follows:

(1) The Kapit District and the two subdistricts, Bintulu and Tatau, were further divided into half, thereby creating six blocks and the population of these blocks was estimated (Fig. 4-2).

The breakdown is given below:

1) The Bintulu Subdistrict was divided into the Greater Bintulu area (Bintulu-A) and the residual area (Bintulu-B);

2) The Tatau Subdistrict is the area along the Ulu Batang Mukah-Bintulu road including Tatau (Tatau-A) and the residual area including Sangan (Tatau-B); and

3) The Kapit District is the area including the town area of Kapit and residential area, which spreads along the Rajang River (Kapit-A), and the residual area (Kapit-B).

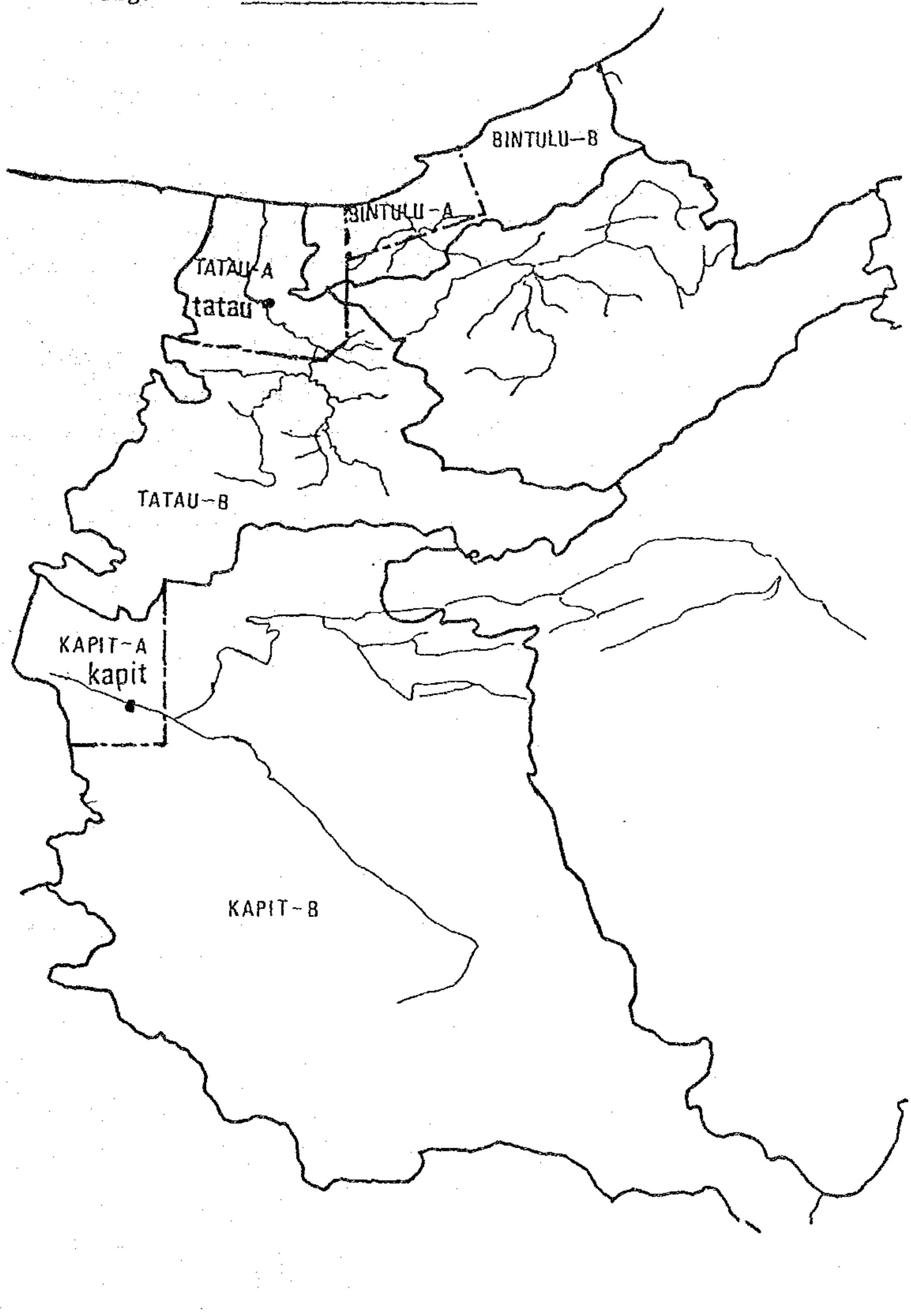
(2) The total population in Sarawak increased 2.4% annually from 1970-80. This total growth rate may be divided into two different growth rates: 3.9% annually in urban areas and 2.0% in rural areas.

In this project, it was assumed that Sarawak as a whole would have the same growth rate in the future: 2.4% annually for 1980-2005, with a growth rate of 3.9% in urban areas and 2.0% in rural areas, respectively.

(3) The population of each block was calculated assuming the following:

(a) the population in the Bintulu-A area will increase in accordance with the population forecasted in the Bintulu Regional Study from 1980-1990 and with 4.3% annual growth rate after 1990;

Fig. 4-2 DEMOGRAPHIC MODELS



(b) the population in the Kapit-A area will grow at a 3.0% annual rate from 1980-2005 due to the higher growth rate in the Kapit town area; and

(c) the population in the other blocks will grow in parallel with Sarawak's rural population growth rate.

(4) The development of Bintulu will accelerate the population concentration in the Bintulu-A block and cause a higher growth rate compared to any other area in the Study Area. Population expansion in this area is, however, expected to slow down after 1990 due to an ordinary growth rate in urban areas.

(5) The Kapit and Tatau town areas are assumed to have a higher population growth rate compared with rural areas. However, in the case of the Tatau town area, the population growth rate will diminish to the same level as rural areas as population concentrates in the Bintulu-A block.

The population in the Study Area is estimated at 121,600 in the year 1990, 141,300 in 1995 and 191,600 in 2005, as shown in Table 4-2.

Table 4-2 FORECAST POPULATION IN THE STUDY AREA

Unit: '000 population (%)

District/ Subdistrict	Block	Year					
		1980 (Base year)	1985	1990	1995	2000	2005
Bintulu	Bintulu-A	17.0	27.8(10.3)	44.2(9.7)	54.8(4.3)	67.6(4.3)	83.5(4.3)
	Bintulu-B	9.8	10.8(2.0)	11.9(2.0)	13.1(2.0)	14.6(2.0)	16.1(2.0)
	Total	26.8	38.6(7.6)	56.1(7.8)	67.9(3.9)	82.2(3.9)	99.6(3.9)
Tatau	Tatau-A	7.5	8.3(2.0)	9.1(2.0)	10.1(2.0)	11.1(2.0)	12.3(2.0)
	Tatau-B	6.6	7.3(2.0)	8.0(2.0)	8.9(2.0)	9.8(2.0)	10.8(2.0)
	Total	14.1	15.6(2.0)	17.1(2.0)	19.0(2.0)	21.0(2.0)	23.1(2.0)
Kapit	Kapit-A	13.0	15.1(3.0)	17.5(3.0)	20.3(3.0)	23.5(3.0)	27.3(3.0)
	Kapit-B	25.4	27.9(2.0)	30.9(2.0)	34.1(2.0)	37.7(2.0)	41.6(2.0)
	Total	38.4	43.0(2.4)	48.4(2.4)	54.4(2.4)	61.2(2.4)	68.9(2.4)
Study Area Total		79.3	97.2(4.2)	121.6(4.6)	141.3(3.1)	164.4(3.1)	191.6(3.1)
Sarawak		1,308.0	1,472.7(2.4)	1,658.1(2.4)	1,866.8(2.4)	2,101.9(2.4)	2,366.5(2.4)

Note: ( ) indicates the annual growth rate during the individual 5-year period

4.3 Agriculture

4.3.1 Agricultural Products

The purpose of this section is to outline the current state of agricultural production in the Study Area. A discussion on the feasibility for future development is summarized in the last part of this section.

The main crops found in the Study Area are rubber, paddy, pepper, cocoa and other minor crops which include fruit trees, coffee, bananas, pineapples maize and vegetables.

(1) Rubber

Rubber production in Sarawak has been decreasing due to the low international market price. In the Study Area, rubber planting was on the decline except that under the Rubber Planting Scheme. However, rubber is still one of the most important cash crops in the Study Area, especially in Kapit.

Table 4-3 shows a summary of rubber statistics in the Study Area. The hectarage is about 2,500 ha in the Tatau area and 52,000 ha in the Kapit District, all in small holdings. About 60% of this was planted with high yield clones in the Tatau area, while only 7% in the Seventh Division used the special clones. The rest were ordinary rubber.

About 70-80% of the above hectarage was tapable mature rubber trees. However, during the year under review most of this rubber was seriously under-tapped. The tapping was a part-time activity in the Long House as many farmers were more attracted to profitable works in the timber camps.

Rubber was sold as unsmoked sheets, the quality of which was generally poor. Any further increase in rubber production would have to be dependent on the progress of the government Rubber Planting Scheme.

(2) Paddy

Paddy farming is the most important agricultural activity in the Study Area.

Table 4-4 is a summary of paddy statistics for 1979, 1980 and 1981 with respect to both wet and hill paddy.

In the Study Area, 93% of the paddy planting area was utilized for hill paddy planted under traditional shifting cultivation in 1981. Only 7% of this was under wet paddy; most of it was located in the coastal and flat areas of the Tatau Subdistrict.

Table 4-3 RUBBER PRODUCTION IN THE STUDY AREA

Item		Ordinary Rubber				High Yielding			
		Mature Trees (ha)	Immature Trees (ha)	Yield (kg/tree/yr)	Production (tons)	Mature Trees (ha)	Immature Trees (ha)	Yield (kg/tree/yr	Production (tons)
Fourth Division									
Tatau	1980	729	243	1/	-	1,377	140	2/	-
	1981	749	261	1/	55	1,377	162	2/	205
Seventh Division									
Kapit	1980	35,035	13,948	2.3	9,269	1,240	832	4.1	2,000
	1981	35,000	13,968	2.2	1,500	1,240	1,110	4.1	100
	1982	34,800	13,968	2.2	1,512	1,240	1,272	4.0	98
	1983	35,280	13,688	2.2	2,127	1,494	1,366	4.0	164
Song	1980	5,381	1,848	3.2	2,242	1,098	236	4.1	597
	1981	5,377	1,840	2.5	262	1,097	342	4.0	85
	1982	5,380	1,800	2.0	213	1,097	422	4.0	87
	1983	5,413	1,806	2.0	280	1,132	439	4.0	131
Belaga	1980	398	44	0.6	68	221	231	1.6	10
	1981	370	85	2.8	20	221	199	4.2	18
	1982	395	62	2.8	22	223	200	4.2	19
	1983	398	68	2.4	36	683	542	4.2	17
Total	1980:	40,814	15,834	2.0	11,579	2,559	1,299	3.3	2,566
	1981:	40,747	15,893	2.5	1,782	2,558	1,571	4.1	193
	1982:	40,575	15,830	2.3	1,746	2,560	1,894	4.1	203
	1983:	41,091	15,562	2.2	2,443	3,309	2,347	4.1	312

Source: Annual Report, Tatau Subdistrict and Seventh District Agriculture Department

Note: 1/ 1.8 ∿ 3.6 kg 2/ 6.8 ∿ 9.1 kg

Table 4-4 PADDY PRODUCTION IN THE STUDY AREA

		Tatau	Kapit	Song	Belaga	Total
Wet Paddy						
Area Planted (ha)	1979	770	532	81	39	1,422
	1980	871	505	61	10	1,447
	1981	1,053	427	32	25	1,537
Area Harvested (ha)	1979	689	527	79	39	1,334
	1980	689	483	61	10	1,243
	1981	535	400	30	25	990
Average Yield (Gantang/Yr)	1979	740	568	630	593	632.8
	1980	864	590	370	600	606
	1981	793	540	310	600	560.8
Production (tons)	1979	1,214	713	119	71	2,117
	1980	1,325	712	56	15	2,108
	1981	1,300	540	23	38	901
Hill Paddy						
Area Planted (ha)	1979	1,499	10,860	5,613	2,835	20,807
	1980	1,701	10,860	5,950	3,240	21,751
	1981	1,661	10,730	4,560	3,320	20,271
Area Harvested (ha)	1979	1,418	10,801	5,529	2,808	20,556
	1980	1,418	10,500	5,060	3,200	33,178
	1981	1,438	10,450	2,740	3,270	17,898
Average Yield (Gantang/Yr)	1979	346	284	314	296	310
	1980	358	300	200	300	289.5
	1981	346	300	210	300	289
Production (ton)	1979	1,167	7,302	4,128	2,912	15,509
	1980	1,360	7,880	2,530	2,400	14,170
	1981	860	7,840	1,440	2,450	12,590

Source: Annual Report, Department of Tatau Subdistrict and the 7th District

Paddy productivity in the Study Area is low. This is apparent in the Kapit District, which registered only about half of the average yield of Sarawak with respect to both wet and hill paddy. Hill paddy is characterized by lower productivity in comparison to wet paddy. Thus, the larger the share of the hill paddy planting area, the lower the average yield of the paddy per hectare. This explains the low productivity of the paddy in the Kapit District.

(3) Pepper

Pepper has been the second major agricultural revenue earner in the Study Area. However, interest in pepper planting has been declining since 1981. Many established plantations were left unattended. Among the major factors behind this situation was the unattractive price of pepper and the high cost of input, particularly fertilizers and agrichemicals. However, in the Belaga District pepper is still the main cash crop. (refer to Table 4-5)

(4) Cocoa

This crop is remarkably increasing in the Study Area, particularly in the Seventh Division. Farmers were given incentives to diversify their sources of income, particularly when pepper prices were hardly rewarding. The Cocoa Subsidy Scheme succeeded in accelerating the establishment of new gardens. (Refer to Table 4-6)

However, large scale planting was restricted by the unavailability of adequately large, suitable areas. Farms of a few acres were found scattered over the Study Area. As a result, no market incentives were available as shopkeepers were usually reluctant to buy the few kilograms of cocoa beans that farmers would sell. Therefore, Table 4-6 shows negligible production. If the farmers could succeed in collecting a few hundred kilograms, that could open up market possibilities for the product.

4.3.2 Potential Agricultural Land

Distribution of potential agricultural land in the Study Area, especially those areas along the Project Road, is currently under study by the State Department of Agriculture. Suitable land for agriculture is selected by the said research committee according to the criteria of steepness and soil quality (including fertility).

Fig. 4-3 shows the location of the potential agricultural lands along the Project Road. The three major sections of potential land are located in

Table 4-5 PEPPER PRODUCTION IN THE STUDY AREA

Item		Immature Vines (ha)	Mature Vines (ha)	Vines Destroyed (ha)	Yield kg of Green Berries per Mature Vine	Production (tons)	
						Black	White
Fourth Div.							
Tatau Sub-district	1980	40.5	75.7	2.8	6.4	-	-
	1981	45.0	80.2	3.2	6.2	180	73
Seventh Div.							
Kapit	1980	172.4	219.2	15.6	7.3	1,037	-
	1981	119.1	179.5	27.2	6.7	521	-
	1982	38.0	127.0	69.0	4.5	370	-
	1983	34.1	104.8	37.5	4.5	310	-
Song	1980	123.1	115.4	6.1	6.4	481	1.3
	1981	118.6	135.6	10.1	6.4	495	-
	1982	48.5	87.0	139.2	4.7	262	-
	1983	27.1	69.0	18.0	4.5	199	-
Belaga	1980	15.6	35.2	5.0	4.5	104	-
	1981	19.6	32.1	8.0	2.4	30	-
	1982	17.5	34.3	6.7	2.1	46	
	1983	21.6	34.9	3.4	2.1	47	-
Total	1980	311.1	369.9	26.6	6.1	1,621	1.3
	1981	257.3	347.2	45.3	5.2	1,046	-
	1982	104.0	248.3	214.9	3.9	679	-
	1983	82.7	208.7	58.9	3.7	556	-

Source: Annual Report, Department of Agriculture, Tatau Subdistrict and the 7th District

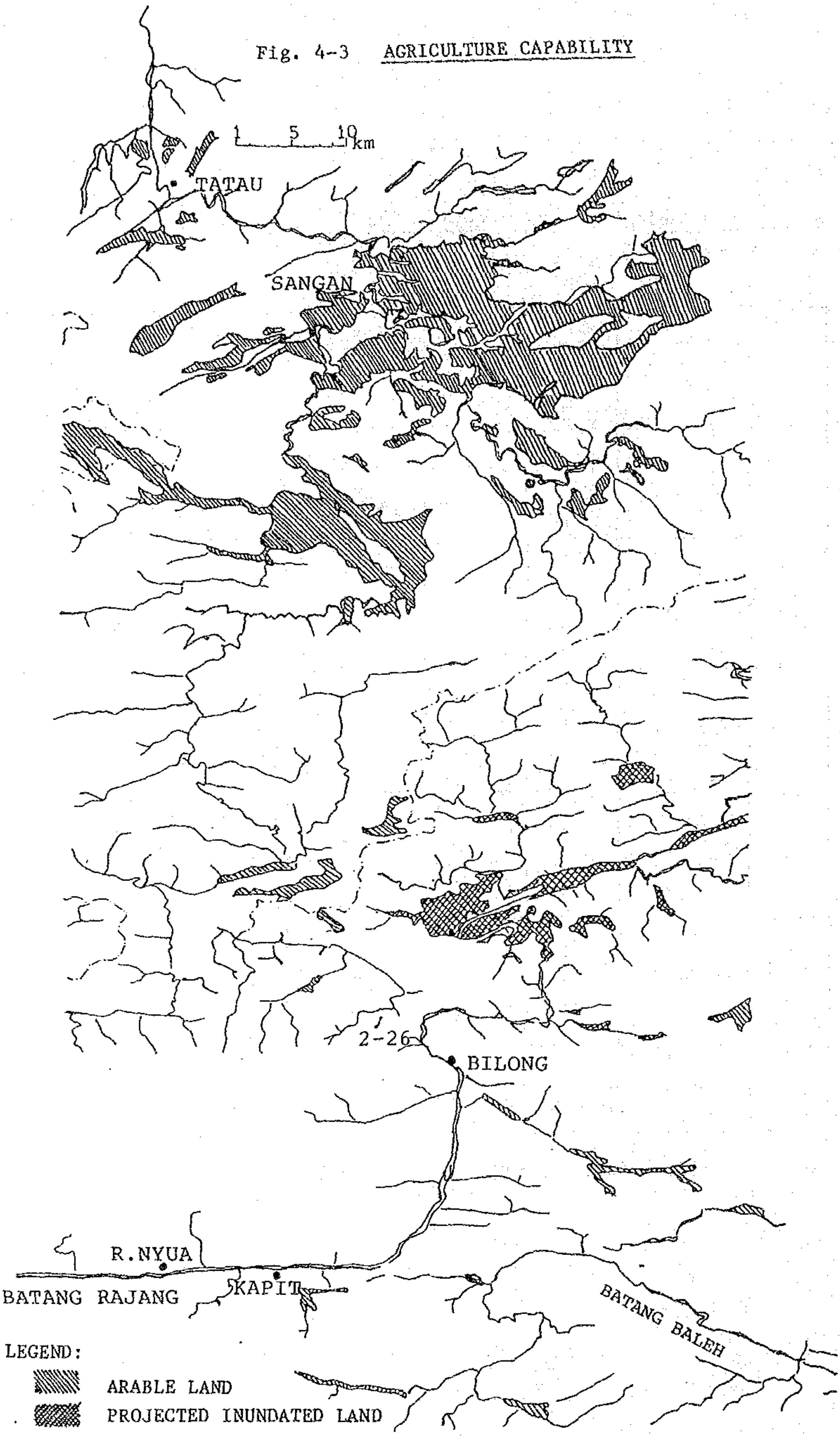
Table 4-6 COCOA CULTIVATION IN THE STUDY AREA

Item	Year	Hectare			
		Pure Stand		Intercrop	
		Mature	Immature	Mature	Immature
Tatau Sub-district	1980 1981	- -	- -	121 125	117 121
Kapit District	1980 1981 1982 1983	35 51 85 100	63 68 485 567	8 6 11 11	11 10 10 10
Song District	1980 1981 1982 1983	- N.A 3 24	36 80 119 98	12 12 20 26	20 20 25 20
Belaga District	1980 1981 1982 1983	3 43 290 350	3 76 80 121	- - - -	- - 8 -

Source: Annual Report, Department of Agriculture
Tatau Sub-district and the 7th Division

Note: N.A - Not available

Fig. 4-3 AGRICULTURE CAPABILITY



(i) the middle part of the Tatau Subdistrict around Sangan;

(ii) the southern part of the Tatau Subdistrict; and

(iii) the banks of Rajang River, upstream from the planned Pelagus Hydroelectric Power site.

However, it is believed that in the third major section approximately 7,200 hectares would be inundated as a result of the rise in the water level caused by the construction of the planned Pelagus Dam. Aside from the three major potential sections mentioned above, very little arable land is available in the Kapit District.

Completion of the Project Road will allow access to approximately 60,000 hectares of the potential land.

4.3.3 Forecast of Agricultural Production

For the purpose of forecasting the production of four major crops, the following assumptions were made:

(i) The construction of the Project Road will commence in 1987 and is expected to be completed in 1995-99.

(ii) By the year 2005 about 50% of all the agricultural area along the Project Road will have been developed and used for cultivation.

(iii) In the new cultivated area, hill paddy and cocoa are projected to be planted. Hill paddy will be produced to cope with the demand required by a large population in Bintulu. Cocoa is a strategic crop for increasing income since it has high "value-added" characteristics.

(iv) The completion of the Project Road will expand the area under cultivation and improve the yield per hectare. The existing cultivated land will be expected to gradually grow by expanding to the neighbouring land. Improvement of yield per hectare will be realized with the help of various fertilizer schemes, the modernization of planting methods, etc.

To project the impact of the Project Road construction on agricultural production, two forecasts are adopted: "Without" the Project Road and "With" the Project Road.

In the case of "Without", the future production is estimated on the assumptions that

(i) the estimated value for future production is dominated by past trends and is under the influence of limiting factors peculiar to the Study Area;

(ii) yield per unit of acreage remains constant or shows a slight increase due to the introduction of various subsidy schemes and technical training; and

(iii) area planted is slightly expanded.

In the case of "With", the following assumptions are adopted:

(i) the completion of the Project Road will give farmers the motivation to improve the yield per unit of acreage and expand the area under cultivation due to the possible and favourable money earning opportunities; and

(ii) the potential lands will be opened for cultivation in addition to the production in the case of "Without".

A comparison of the two cases is summarized in Table 4-7. Judging from this table, the estimated production after the completion of the Project Road doubles and in some cases, even triples. A more detailed explanation of the two projected cases is described in Appendix 2-1. (refer to Appendices 2-1-1, 2-1-2, 2-1-3, 2-1-4, 2-1-5, 2-1-6, 2-1-7, 2-1-8, 2-1-9 and 2-1-10)

Table 4-7 PRODUCTION FORECAST (SUMMARY TABLE)

Unit: Ton

Crop	Area	Case	Base year 1981	1985	1990	1995	2000	2005
Rubber	Tatau	without	1,296	1,362	1,432	1,505	1,581	1,662
		with	1,296	1,362	1,432	3,037	3,192	3,354
	Kapit	without	19,440	19,440	19,440	19,440	19,440	19,440
		with	19,440	19,440	19,440	39,240	39,240	39,240
Wet Paddy	Tatau	without	1,242	1,370	1,509	1,666	1,836	2,027
		with	1,242	1,450	1,676	2,003	2,103	2,213
	Kapit	without	560	588	616	648	680	716
		with	560	600	640	720	800	800
Hill Paddy	Tatau	without	1,065	1,065	1,065	1,065	1,065	1,065
		with	1,065	1,065	12,369	14,538	17,045	20,024
	Kapit	without	7,668	7,668	7,292	6,865	6,463	6,023
		with	7,668	7,884	8,305	8,741	8,962	9,188
Pepper	Tatau	without	344	378	414	451	632	887
		with	344	378	414	451	495	551
	Kapit	without	860	900	940	980	1,020	1,080
		with	860	900	940	1,029	1,137	1,254
Cocoa	Tatau	without			-	-	-	-
		with			175	223	285	364

4.4 Forestry

4.4.1 Current Status of Forestry Production

(1) Bintulu Section

Total timber production from both hill and swamp forestries in the Bintulu Section is shown in Table 4-8. For example, in 1980, the forestry industry in Bintulu marked a 23% increase in production due to good export prices for round logs and an increase in logging activities. In the following year, expansion slowed due to the poor market for logs in the second half of the year. Production, however, reached a total of 1,742,445 metric tons in 1983. The Bintulu Section has 24 sawmills.

(2) Kapit Subsection

Forestry activities, namely logging and sawmilling, were among the most significant economic activities of the Seventh Division and the leading sectors generating employment opportunities for the local population.

Forestry production in the Kapit Subsection is shown in Table 4-9. Total log production in 1983 was 947,751 metric tons, a decrease of 11,160 metric tons as compared to the 1982 figures. In 1981 forest harvesting accelerated tremendously, showing an increase of 99% in production (668,836 metric tons). The continuous and intensified development of logging has been attributable to (i) the establishment of new logging camps and (ii) the deployment of more and heavier categories of logging machinery. The number of operational logging camps increased from 10 in 1979 to 15 in 1980.

Log processing was insignificant and no development was observed.

4.4.2 Forecast of Forestry Production

To forecast forestry production, the Study Area as well as the adjacent Belaga Subdistrict were stipulated to be the area greatly affected by the construction of the Project Road.

Kapit, which comprises the bulk of the Seventh District's forests, is presumed to have the largest total forest area with the most development potential. This assumption was supported by FAO. The total forest area is estimated to reach approximately 3,500,000 hectares in the Seventh Division. In the Bintulu Section, total land under forestry is estimated to be 1,200,000 hectares. Timber and forest produce will most likely

Table 4-8 FORESTRY PRODUCTION IN THE BINTULU SECTION

Year	Metric Tons		(cu.meter)	
	Hill	Swamp	Total	Export
1979	N.A.	N.A.	1,336,404	1,603,814
1980	1,322,739	320,827	1,643,567	1,935,053
1981	1,446,288	228,825	1,675,113	N.A.
1983	1,528,248	214,197	1,742,445	–

Source: Annual Report, Forestry Department, Bintulu Section
Districts of External Trade, Sarawak 1980

Table 4-9 FORESTRY PRODUCTION IN THE KAPIT SECTION

(In cu.meter)

Year	Export	Milling	Grand Total		
			Logs (Number)	Volume	Volume in metric tons
1979					
1980	451,721	25,196	158,828	476,916	336,836
1981	925,099	8,350	264,451	946,870	668,755
1982	1,712,682	18,204	415,350	1,730,836	958,911
1983	1,696,632	14,118	410,538	1,710,750	947,751

Source: Annual Report, Forestry Department, Kapit Subsection be brought to Kapit by way of upstream of the Rajang River and the Balleh River which runs across the Belaga District.

The State Government's policy is to gradually diminish the production of logs in proportion to the production of sawn timber, plywood, etc. as Sarawak's export. The objective is to increase the value added within the state thereby uplifting the income level and accelerating the development process of the interior region.

The Study Team therefore projected constant timber production in the Seventh District and a bolstering of the plywood manufacturing sector in Kapit, eventually generating employment opportunities for 740 persons.

Table 4-10 shows the projected annual production of logs, sawn timber and plywood from the benchmark year up to 2005.

Table 4-10 <u>FORECASTED TIMBER PRODUCTION</u>

(True tons, x 1,000)

Item		Base Year 1981	1985	1990	1995	2000	2005
Tatau Sub-district	Total Production	1,675	1,660	1,414	1,068	1,032	787
	Log Volume	1,515	1,394	1,167	833	750	609
	Sawn Timber Volume	109	175	155	144	134	103
	Plywood	51	91	92	91	148	75
Kapit District	Total Production	669	1,000	1,000	1,000	1,000	1,000
	Log Volume	669	1,000	1,000	832	786	766
	Sawn Timber Volume	-	-	-	127	140	147
	Plywood	-	-	-	41	74	87

4.5 Tourism

4.5.1 Outline of the Current Situation

Tourism as an industry does not play an important role in the economy of Sarawak. In 1980, the economic activities of restaurants and hotels represented only a negligible share, less than 1%, of Sarawak's domestic product.

If developed, however, tourism could emerge as an important economic sector in terms of creating opportunities for business expansion and employment, and generating higher personal income. Further, tourism could assist in minimizing the current reliance on forestry and agricultural production.

In 1980, approximately 148,000 tourists came to Sarawak. Out of this total, about 68% were tourists on vacation.

Tourists from Brunei accounted for the largest share (31.0%) of visitors coming for leisure purposes, followed by Peninsula Malaysia (28.0%) and Singapore (8.8%). These neighbouring countries together account for 68% of the total. Other countries include the United Kingdom (5.6%), United States (2.9%), Netherlands (2.2%) and Australia (1.8%). Fig. 4-4 shows the major tourism resources in Sarawak.

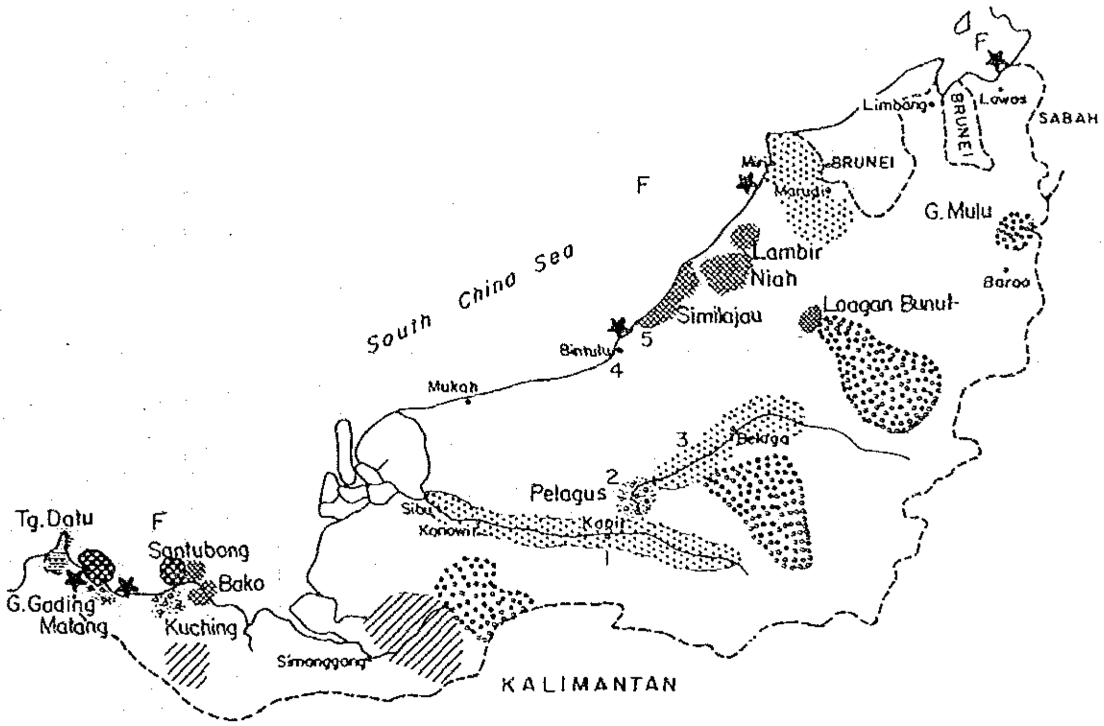
4.5.2 Estimation of Visitors into Kapit

With the figures cited in the Sarawak Tourism Master Plan, the inflow of visitors into the Kapit area via Bintulu and Sibu are tabulated in Tables 4-11 and 4-12. According to the Master Plan, tourism is expected to grow at 10.3% from 1980 - 1985, 8.5% from 1986 - 1990 and 6.6% from 1991 - 1995. After this tourism boom, the growth rate is expected to continue at a moderate pace of 5% per annum.

In the case of visitors coming from Sibu, the share of sightseeing and holiday visitors is assumed to be 60%.

With the completion of the Second Trunk Road from Tatau to Kapit, visitors to Kapit are expected to flow in through this new road. In the case of visitors coming from Bintulu, growth rates quoted from the Tourism Master Plan were applied. Then it was assumed that 50%, 33% and 25% of Bintulu's visitors will travel down to Kapit. Among these projections, the case of "25%" is most likely.

Fig. 4-4 MAJOR TOURISM RESOURCES



LEGEND:

- Coral Reef
- Existing National Park
- Proposed National Park
- Potential National Park
- Existing Wildlife Sanctuary
- Proposed Wildlife Sanctuary
- Longhouse Tour Areas
- Potential River Safari Areas
- F Fishing
- ✱ Major Beach Sites

Table 4-11 PASSENGER MOVEMENT FROM SIBU TO KAPIT

Unit: Person/year

Item / Year	Total No. of Passengers — Sibu-Kapit	Share of Tourists (60%)	Growth Rate	Expected No. of Visitors To Jamboru Site (Pelagus)
1981	4,867	2,920	-	*50% from Tatan 50% from Sibu
1985	7,204	4,322	10.3%	
1990	10,832	6,499	8.5%	
1993	13,121	7,873	6.6%	
1995	14,910	8,946	6.6%	27,375
2000	19,029	11,417	5%	27,375
2005	24,286	14,574	5%	27,375

Note: 60% expected to continue travel to Tatan
40% expected to return through the same route.

Table 4-12 PASSENGER MOVEMENT FROM BINTULU TO KAPIT

Unit: Person/year

Item / Year	No. of Visitors to Bintulu	Growth Rate	Estimated No. of Visitors Travelling to Kapit		
			1/2 of Bintulu's Visitors	1/3 of Bintulu's Visitors	1/4 of Bintulu's Visitors
1980	10,808	-	-	-	-
1985	17,645	10.3%	-	-	-
1990	26,532	8.5%	-	-	-
1993	32,140	6.6%	16,070	10,713	8,035
1995	-	6.6%	18,261	12,174	9,131
2000	-	5%	23,306	15,537	11,654
2005	-	5%	29,745	19,830	14,874

Note: 60% expected to continue travel to Sibu

40% expected to return through the same route

Case of "1/4 of Bintulu's Visitors" is most likely to occur.

4.6 Associated Development Project

4.6.1 Bintulu Regional Development Plan

To promote further industrialization in Sarawak, a Bintulu Development Master Plan was set up and construction is progressing in the areas concerned. According to the Bintulu Development Authority (BDA) plan, the project area covers 4,352 km^2 and will extend over a period of the Fourth Malaysian Plan 1981 - 1985. BDA estimates the plan will generate new employment opportunities for 18,000 workers up to the year 1995. In 1980, roughly 40,000 people lived in the Bintulu area, including suburban residents; the population of the area will thus expand 1.45 times by 1995 as a result of the plan. Fig. 4-5 indicates the allocation of various project sites.

There are additional projects to construct a regional hospital, an agricultural college and thousands of houses. An international airport has been proposed.

4.6.2 Hydroelectric Project

Since Sarawak has abundant water resources, hydroelectrical power development is expected to be the energy supply source for economic development.

In the Batang Rajang Basin, the largest river in Sarawak where the Study Area is located, large scale hydroelectrical power projects have been proposed to supply electricity not only for consumption within Sarawak, but also for consumption in Sabah and Peninsula Malaysia, etc.

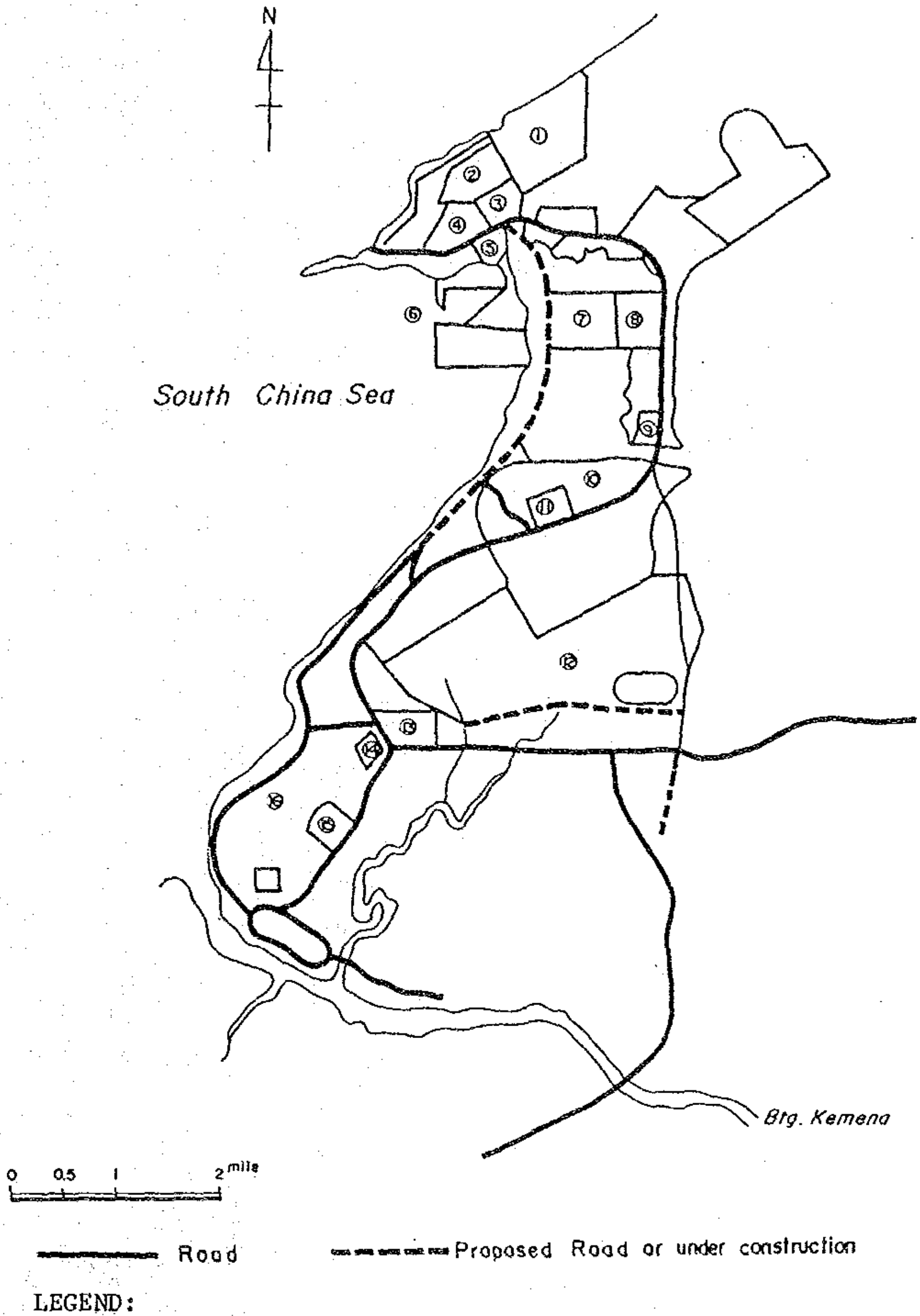
According to the Sarawak Electric Supply Corporation (SESCO), the hydroelectric development program in the Study Area will proceed as outlined in Table 4-13.

Table 4-13 Hydroelectric development program in the Study Area

Name of Project	Generating Power	Year of Completion
Bakun	2,400 MW	1995
Murum	1,000 MW	2000
Pelagus	770 MW	2005
Balleh	1,000 MW	2010

The proposed route of the transmission system is shown in Fig. 4-6.

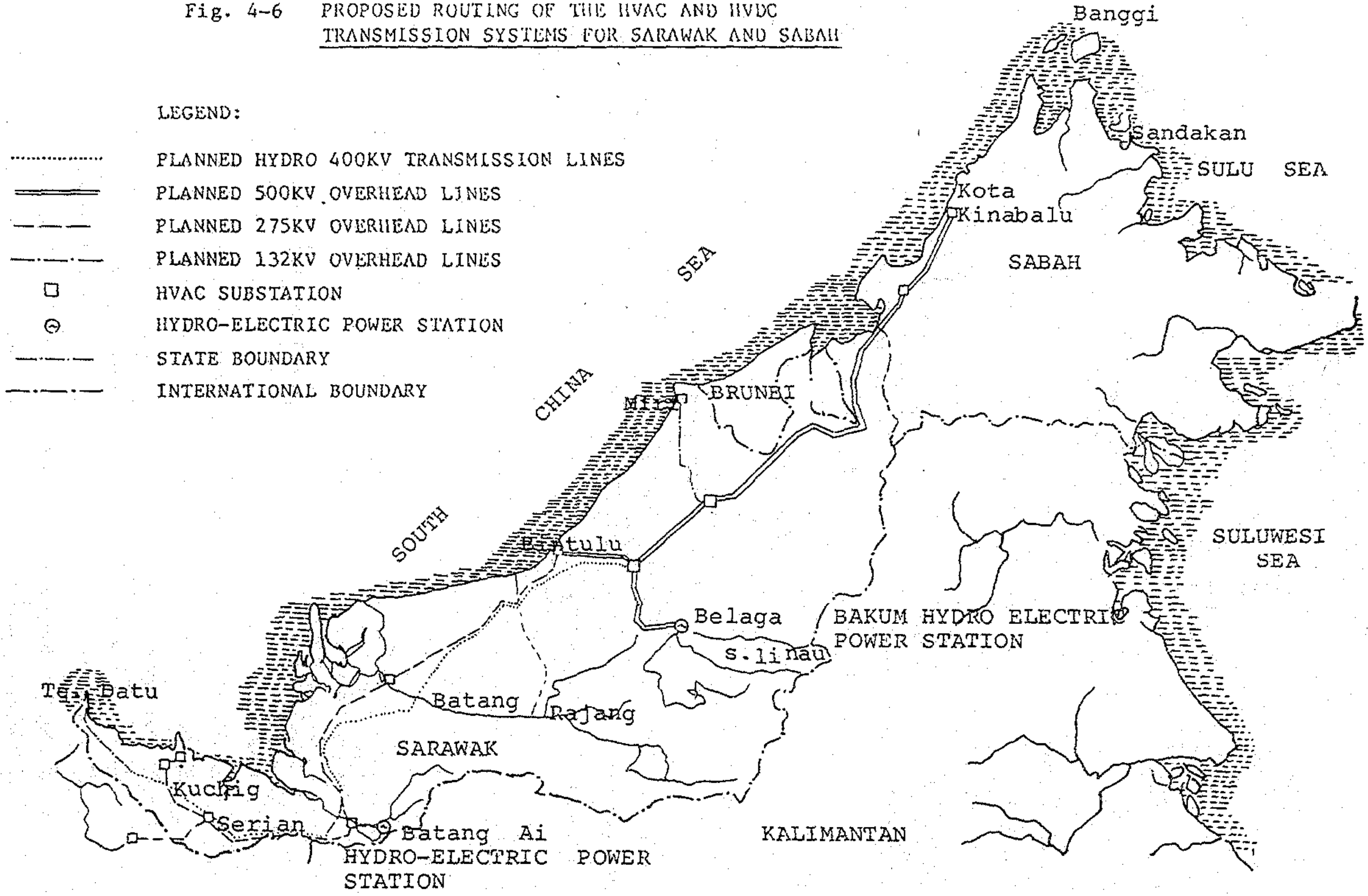
Fig. 4-5 FUNCTIONAL BOUNDARY OF BINTULU REGIONAL DEVELOPMENT PLAN



LEGEND:

① LNG Plant	⑧ ⑯ Light Industry Estate
② Crude Oil Terminal	⑨ Vocational School
③ Urea / Ammonia Plant	⑩ Residence Zone
④ Iron Ore Plant	⑪ ⑮ Regional Center
⑤ Palm Oil Plant	⑫ University Agriculture Branch Campas
⑥ Deep Sea Port	⑬ Bintulu Development Authori Office
⑦ Aluminium Smeltor Plant	⑭ Sarawak Radio Broadcasting Relay Station

Fig. 4-6 PROPOSED ROUTING OF THE HVAC AND HVDC TRANSMISSION SYSTEMS FOR SARAWAK AND SABAH



4.6.3 Mining Resource Development

At present, there are no mining activities in the Study Area. However, big coal deposits can reportedly be found along the Project Road as shown in Fig. 4-7.

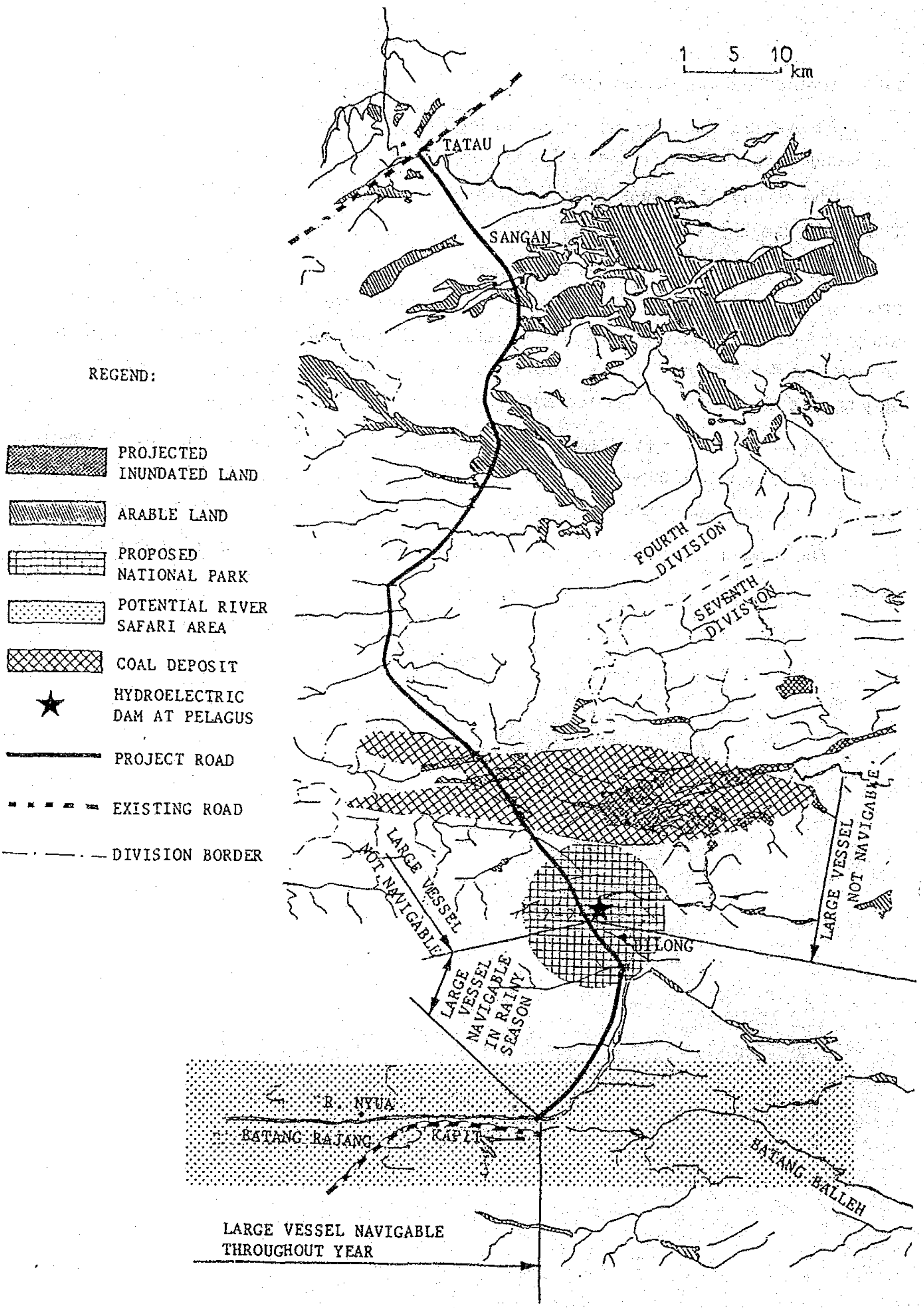
The estimated amount of coal deposits in this area amounts to 200 million tons. The quality is a high-grade lignite.

A feasibility study of the development of these coal deposits is being carried out at present. The Project Road will be used for coal tranport since large ships cannot navigate along the Batang Rajang beyond the confluence with the Sungai Pelagus because of the famous rapids upstream of the confluence with the Sungai Pelagus along the Batang Rajang, and also because of the remarkable seasonal water level variation.

Therefore, coal must be transported from the coal deposit area to the loading spot by land if it is to be shipped to Sibu. Since the project road passes through the coal deposit area, the route could be utilized as a part of the land transport route.

The Project Road will help save construction costs for a part of the coal transport road.

Fig. 4-7 DEVELOPMENT POTENTIAL AREAS



CHAPTER 5

CONTENTS

CHAPTER 5 TRAFFIC STUDIES IN THE PROJECT AREA

5.1 Transport Network

5.1.1 General

The transport network in the Study Area consists of roads, rivers, air and coastal shipping. As shown in Fig. 5-1, road services are very much limited in the Study Area and certain parts of the area are entirely dependent on water transport. The major rivers in the area are the Batang Rajang, the Batang Tatau and the Batang Kemena and their tributaries. These rivers form the major transport network system. Kapit, Tatau and Bintulu towns are the major transport terminals or transfer points in these river basins.

There are two airports in the Study Area: in Bintulu and in Kapit. The Bintulu Airport caters to regular air services by MAS from major towns in Sarawak.

Coastal shipping is an important transport means for carrying cargo between the Study Area and other parts of Malaysia and foreign countires. The two existing ports for coastal shipping are at Bintulu and Tatau.

5.1.2 Roads

The road network in the Study Area is quite limited. The principal road in the area is the First Trunk Road, which connects with Sibu, Bintulu and Miri and forms a part of the trans-Sarawak Trunk Road. There are also a few road networks only in the Bintulu and Kapit town areas. The outline of the existing roads and road construction projects in the Study Area is shown in Table 5-1.

5.1.3 Rivers

There are three river basins in the Study Area: the Batang Tatau, the Batang Rajang and the Batang Kemena. However, the greater part of the Batang Kemena basin is outside of the Study Area. A description of water transport on the former two rivers is offered below.

(1) The Batang Tatau and its tributaries

The Batang Tatau flows out of the mountains dividing the Fourth from the Seventh Division and empties into the South China Sea. Batang Tatau and its major tributaries of Sungai Anap and Sungai Kakus provide transportation for the whole

Fig. 5-1 TRANSPORTATION SYSTEM IN THE STUDY AREA

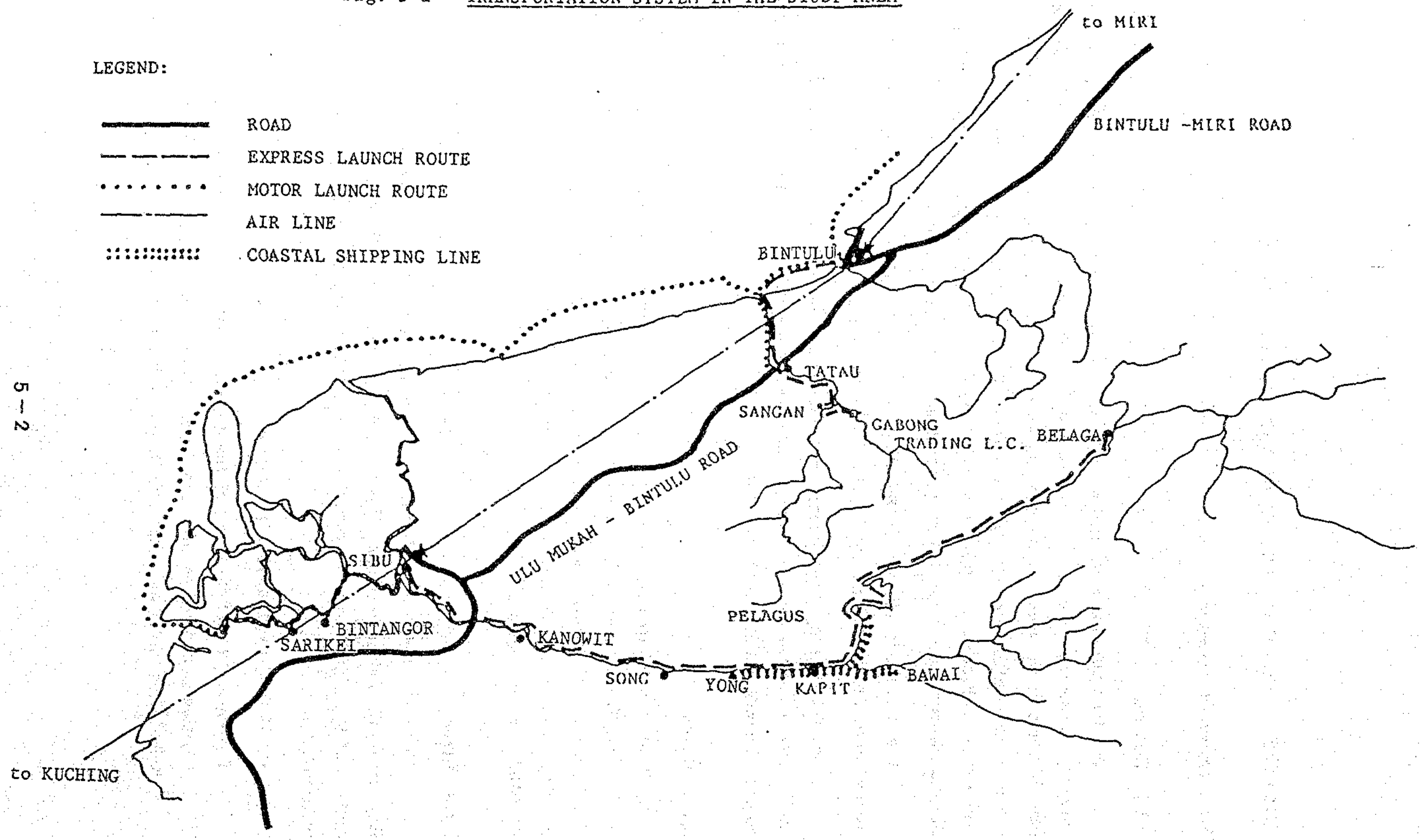


Table 5-1 EXISTING ROAD AND ROAD CONSTRUCTION PROJECTS IN THE STUDY AREA

Name of Road	Classification	Road Length (km)	Surface	Completed in 31/12/77 (km)	Remarks
(A) Road Approved 1st Malaysia Plan					
Miri/Bintulu	T	230.1	G.B	230.1	Completed in 1972
(B) Road Approved 2nd Malaysia Plan					
Ulu Btg. Mukah/ Bintulu Rd.	T	133.6	G	41.0	Under construction
Selirik Rd. Kapit	D	5.7	G.B	5.7	Completed in 1977
Tanjung Kidurong	T	16.1	G.B	15.4	Completed in 1976
Sibiew Rd. Bintulu	D	7.2		4.9	Under construction
(C) Road Approved 3rd Malaysia Plan					
Kampong Rd. Bintulu	D	3.2		-	
Miri/Bintulu/Labang/ Tubau/Belaga Rd.	T	128.7		-	
Kapit/Bkt. Goram Rd.	D	17.7		-	
Song/Ng. Sipan Rd.	D	4.8		-	

Note T: Trunk Road D: Development Road
G: Gravel B: Bitumen

of the Tatau Subdistrict as well as the communities that have developed along these waterways.

Batang Tatau is relatively wide and deep between Kuala Tatau (the mouth of the river) and Tatau, and provides a reliable water transport channel for small coastal ships and barges. Above Tatau, although the river becomes narrower and meandering, motor launches and barges can come up the river as far as Sangan, 78 km (48 miles) upriver on Sungai Anap or Gabong Trading Logging Company (Gabong L.C.) 80 km (49 miles) on Sungai Kakus. Above Sangan or Gabong L.C. only small vessels such as long-boats and speed boats can navigate.

Although the area along the river is heavily forested, there is some cultivatable land and Long Houses are found along both sides of the river. Tatau town at 30 km (19 miles) from the river mouth is the major commercial centre of the river basin, with a small bazaar and some government offices. Above Tatau, Sangan is a secondary centre which also has government branch offices. Below Tatau, Kuala Tatau has a small bazaar and is a collecting point for logs and timbers.

Table 5-2 shows the distance between major points along Batang Tatau and its tributaries.

(2) The Batang Rajang and its tributaries

The Batang Rajang is the longest river in Sarawak. Its main stream has a length of about 450 km from its mouth to Belaga and has a basin of over 50,000 square kilometers that is about 40% of the land area of Sarawak.

The Batang Rajang has abundant water and a stable water level throughout the year, forming a reliable water transport channel between its mouth and the confluence between the Batang Rajang and the Batang Balleh which is 291 km (157 miles) upriver. However, above there the water level is not stable. Particularly well-known is Pelagus Rapids, above the point where the Batang Balleh meets the Batang Rajang, which has been the major obstacle to river navigation. In addition, the water level may vary greatly in a few days, depending upon rainfall in the mountain area. Only recently has it been possible to provide regular transport service to the people living above the rapids by Express

Table 5-2 DISTANCE BETWEEN MAJOR POINTS ALONG THE BATANG TATAU AND ITS TRIBUTARIES

From	To	Distance	
		Kilometers	Miles
Bintulu	Kuala Tatau	30	19
	Tatau	60	37
Kuala Tatau	Tatau	30	19
	Sangan	78	48
	Gabong L.C.	80	50
Tatau	Confluence of Sungi Anap and Sungai Kakus	38	24
	Sangan	48	30
	Gabong L.C.	50	31
	Muput	64	40
	Takan	135	84

Launch with steel hull and twin powerful engines. However, express services are often interrupted by low water levels in the dry season.

Below Kapit, the river flows more slowly, widening and deepening with the flows of numerous tributaties. Particularly below Kanowit, 182 km from the mouth, the river becomes much wider and forms the Rajang Delta at Sibu which is located 130 km (81 miles) from the river mouth. Between Kuala Rajang (the river mouth) and Sibu are Tanjung Mani anchorage and three major ports at Sarikei, Bintangor and Sibu.

Tanjung Mani is known as a good sheltered anchorage for oceangoing ships loading export logs and timbers. Sarikei and Bintangor are the collecting and distributing points of goods and agricultural products, and there is regular express ship service between Sarikei and Kuching. Sibu is the second largest town in Sarawak. It is the main commercial centre of the Third, Sixth and Seventh Divisions and is also important as a port and trading centre for the Batang Rajang river basin.

Above Sibu Kanowit, Song, Kapit and Belaga are the district centres. Kapit is the largest town in the Seventh Division and is the administrative headquarters of the Division. It is also a main commercial centre and transport terminal in the upper Rajang area.

Table 5-3 shows the distance between major points along Batang Rajang and its tributaries.

5.1.4 Coastal Shipping

There is very little information on the operation of coastal ships, although they play an important role in cargo transport between the Study Area and outside. Since most ship operators are relatively free from Government regulation, it is difficult to establish a comprehensive figure for these services.

The ports located in Bintulu and Tatau are the bases of coastal shipping in the Study Area. The Bintulu port is situated on the north bank of the Batang Kemena, about 2 km from the mouth. Its main customs wharf has a length of 50 m and a draft alongside of at least 0.6 m, 2.4 m at high tide. In addition, there is an open anchorage outside the river for exporting logs and timber. The port is linked with Kuching, Sibu, Sri Aman, Miri, Niah and Tatau by coastal vessels of sizes ranging from 20 to 800 tons, but vessels of 50 to 200 tons are the most common.

The Tatau port has a length of 24 m with a belian wharf having a draft alongside of at least 4 m. The Tatau area receives all its supplies at present from Kuching, Sibu and Bintulu by small coastal vessels of 10 to 150 tons. There are scheduled coastal shipping services from Sibu and Kuching at least once a week. The major cargo carried by coastal vessels in this area is rice, foods, fuel and other incoming consumer goods, and agricultural and forestry products produced from the area.

Logs are carried by barges or rafts with tug boats to the river mouth and loaded onto oceangoing vessels outside the river.

The Bintulu Deepwaer Port situated at Tanjung Kidurong has been open since the end of 1982. It is used mainly for oceangoing vessels.

5.1.5 Air

There is an Airport at Bintulu and an airfield at Kapit in the Study Area. The Bintulu Airport is situated in the central part of Bintulu town. It was built during World

Table 5-3 DISTANCE BETWEEN MAJOR POINTS ALONG THE BATANG RAJANG AND ITS BRANCHES

From	To	Distance m	Distance k.m
1. Distance - Batang Rajang			
Entrance Kuala Rajana	Tanjung Mani	16	30
	Sarikei	30	56
	Binatang	40	74
	Sibu	70	130
Entrance Kuala Paloh	Sibu	51	94
Sibu	Entrance Kut Canal	42	78
Kg.Kut (Kut Canal Length)	Kampung Kakan	5.5	10
Sibu	Kanowit	28	52
	Song	53	98
	Kapit	82	152
Kapit	Pelagus Rapids	18	33
	Kokok Rapids	69	128
	Bungan Rapids	78	144
	Belaga	92	170
2. Distance - Batang Balui			
Belaga	Bakum Rapids	18	33
	Entrance Sungai Linau	25	46
	Long Juman	49	91
	Kesumo Rapids	55	102
	Perong Rapids	59	109
	Long Bulan	93	173
	Long Jawi	106	196
	Batu Nga'at Rapids	110	204
3. Distance - Batang Baleh			
Kapit	Bifuroation Batang Rajang/Bt. Baleh	5	9
Bifurcation	Sungai Mujong	11	20
	Sungai Gaat	33	61
	Sungai Merirai	42	78
	Entawau	49	91
Entawau	Wong Putai Rapids	6	11
	Batu Babi Rapids	15	28
	Batu Rumah Rapids	16	30
	Batu Abau	19	35
	Sungai Mengiong	21	39
	Resthouse Serani	51	94
Resthouse Serani	Long Singut	18	33

War II and has been improved and expanded. It has a runway of 1,372 m x 18 m (1,500 yards x 20 yards) with a bitumen surface and night landing facilities. The airport can only accommodate small aircraft up to the Fokker Friendship F 27.

The Bintulu Airport caters to regular flight services by Malaysia Airline System (MAS) from Kuching, Sibu Miri, Kota Kinabalu and Mukah. Air transport was virtually the only form of passenger transport from Bintulu to Kuching and Sibu, before the Trunk Road system was completed.

In view of the limited possibilities of extending the Bintulu Airport to meet the growing demand, a new international airport with a runway of 4,000 m is proposed in the south of Bintulu town, about 34 km from the town centre.

The Kapit Airfield has a runway of 427 m x 18 m (1,400 ft. x 60 ft.) with a crush stone surface. It allows only small aircraft up to BN 2 with capacities for eight passengers. The airfield had scheduled air services by MAS until 1981; but regular air services are interrupted at present due to decreasing demand and a shortage of aircraft.

5.2 Road Traffic

5.2.1 Road Traffic Survey

The only major road in the Study Area is only the Ulu Batang Mukah-Bintulu First Trunk Road, which was opened to traffic in 1983. The Project Road is proposed to connect with this Trunk Road near the Tatau town. Therefore, to determine the characteristics of road traffic, road traffic surveys were carried out on the Trunk Road by the Study Team in 1984.

The survey outline is shown in Table 5-4. Some results of the survey follow:

Table 5-4 ROAD TRAFFIC SURVEY

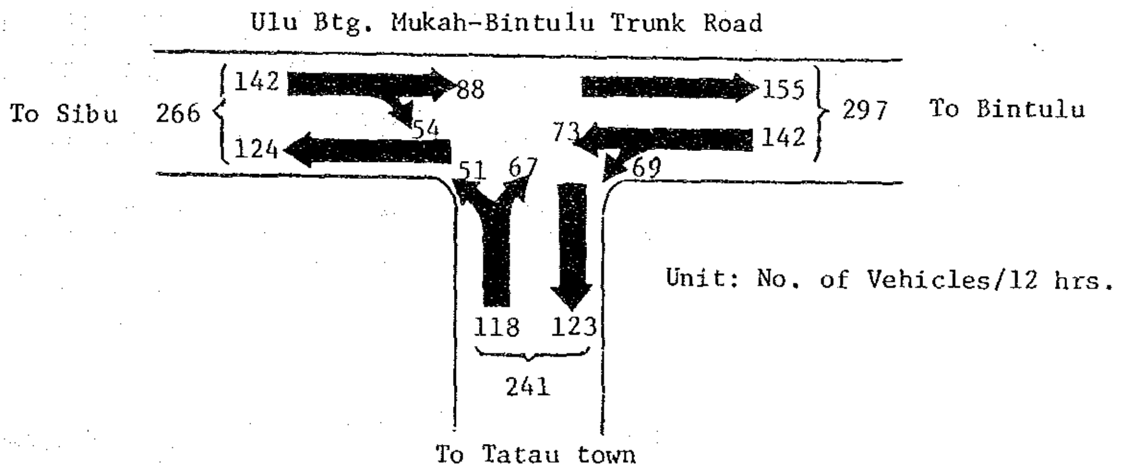
Type of Survey	Survey Station	Survey Period	Major Survey Item
1. Road Traffic Count Survey	Ulu Btg. Mukah-Bintulu Road At Tatu Junction	30th Oct. (Tue.) 31st Oct. (Wed.)	• Number of Vehicles by Type •Origin and Destination
2. Roadside Interview Survey	" At Tatau Junction and Ferry Boat Jetty	6:00 AM ~ 6:00 PM	• Trip Purpose • No. of Passengers

(1) Average Daily Traffic (ADT)

ADT came to 279 vehicles on the Ulu Batang Mukah-Bintulu Trunk Road and 241 vehicles on the access road to Tatau town in both directions.

The results of the Traffic Count Survey are shown in Fig. 5-2.

Fig. 5-2 ADT BY DIRECTION AT TATAU JUNCTION



For reference, the ADT on the other sections of the First Trunk Road are shown in Appendix 3-1 with the location map of the survey station. (refer to Appendix 3-1-1, 3-1-2, 3-1-3)

The ADT on the Ulu Batang Mukah-Bintulu Road is still very small compared with other sections of the Trunk Road.

(2) Trip Distribution by Direction

The origin and destination of vehicle trips are shown in Table 5-5. Out of total vehicle trips, 37% are between Tatau and Bintulu, while 10% are between Tatau and Sibu. Long distance trips passing through Tatau town are about 35%.

Table 5-5 ORIGIN AND DESTINATION OF VEHICLE TRIPS

Unit: Vehicles/day (%)

	Tatau		Bintulu		Other Places		Total	
Tatau	56	(13.9)	148	(36.7)	6	(1.7)	210	(52.3)
Sibu	39	(9.7)	76	(19.0)	21	(5.1)	136	(33.8)
Other Places	14	(3.4)	15	(3.8)	27	(6.8)	56	(13.9)
Total	109	(27.0)	239	(59.5)	54	(13.5)	402	(100%)

Source: Roadside Interview Survey

(3) Traffic Composition

Traffic composition by vehicle type is summarized in Table 5-6, which indicates that passenger cars (cars and taxis) constitute 29% and freightcars constitute 57% of traffic. For reference, the traffic compositions on the Miri-Bintulu Road and in Tatau are shown in Appendix 3-2 and 3-3. The low percentage of passenger cars is characteristic of traffic in rural areas.

Table 5-6 TRAFFIC COMPOSITION AT TATAU JUNCTION

	Cars	Taxis	Vans, Pickup	Lorries (Trucks)	Buses	Motor Cycles	Others	Total
No. of Vehicles	64	70	128	133	16	41	4	456
Percentage	14.0	15.4	28.1	29.2	3.5	9.0	0.9	100.0%

Note: Traffic is in all directions

Source: Traffic count survey

(4) Number of Passengers

The average number of passenger in the vehicles estimated from the samples by vehicle type is shown in Table 5-7. Passenger cars usually carried more than 3 passengers, including drivers. Vans, pickups and trucks are sometimes used for carrying passengers.

Table 5-7 AVERAGE PASSENGERS IN VEHICLES

	Car	Taxi	Van, Pickup	Medium Truck	Heavy Truck	Truck Trailer	Bus
No. of Samples	103	91	133	55	54	2	32
No. of Passengers	325	392	445	147	204	4	864
No. of Pass. on Board	3.2	4.3	3.3	2.7	3.8	2.0	27.0

Passengers include driver

Source: Roadside Interview Survey

5.2.2 Road Transport

(1) Buses

Express buses are operated on the Trunk Road twice a day in each direction between Sibu and Bintulu for 4 hours. The fare is M$ 18.00 one way. Bus services are provided 3 times a day between Tatau and Bintulu. The fare is M$6.00. The average daily number of passengers on board is about 90.

(2) Taxis

In 1983, 77 taxicabs were registered in the Study Area, of which 73 were in Bintulu and 4 were in Kapit. (Refer to Table 5-8) In the Study Area, taxis play an important role in towns and also between towns due to the low frequency of bus service. In addition, private taxis operate on the Tatau-Bintulu Road section. At least 6 to 7 private taxis are observed in Tatau town. The fare between Tatau and Bintulu is M$15.00 per a passenger and taxis usually carry 4 passengers.

Authorized taxi fares are proportional to the distance: M$0.40 for evey 800 m with a basic minimum fare of M$1.20 for the first 1.5 km.Air-conditioned taxi fare is a little higher. Taxis are not equipped with a meter counter in Sarawak.

Table 5-8 NO. OF TAXICABS IN THE STUDY AREA (1983)

Town	Total	Native	Non-native	Joint venture
Bintulu	73	19	31	23
Kapit	4	2	1	1
Total	77	21	32	24

Source: Land Transport Department

(3) Trucks

Trucks used in the Study Area have a loading capacity of only 5 to 6 tons, although some construction and oil companies have a few trucks with a higher loading capacity. Some timber companies have truck-trailers with 20-ton loading capacities mainly driven on their own logging roads.

There are public carriers in Bintulu, Sibu and Kapit towns. Of these, 72% (329) are concentrated in Bintulu due to the high cargo demand related to development projects in Bintulu. The number of public carriers in each district is shown in Table 5-9.

Table 5-9 NUMBER OF PUBLIC CARRIERS (1983)

District	Total	Native	Non-native	Joint venture
Bintulu	329	69	56	204
Sibu	124	12	87	25
Kapit	1	-	-	-
Total	454	81	144	229

Source: Land Transport Department

5.2.3 Vehicle Ownership

Statistics on vehicle registration are available only by Division. Table 5-10 shows the growth of the number of motor vehicles in the Fourth and Seventh Division. The number of vehicles excluding motorcycle registrations in the Fourth Division grew at a high annual average rate of 17.7% between 1973 and 1983. The number of cars and motorcycles in the Seventh Division has remarkably increased, although there is no road network connected with other parts of Sarawak.

Table 5-10 NUMBER OF MOTOR VEHICLES REGISTERED IN THE 4TH AND 7TH DIVISIONS

Year	4th Division						7th Division					
	Cars	Trucks	Buses	Sub-Total	Motor Cycles	Total	Cars	Trucks	Buses	Sub-Total	Motor Cycles	Total
1973	3,700	719	33	4,452	3,439	7,891	10	4	-	14	21	35
1974	4,340	865	36	5,241 (17.7)	3,739	8,980 (13.8)	21	5	-	21 (85.7)	49	75 (114.3)
1975	4,861	981	45	5,887 (12.3)	4,324	10,211 (13.7)	32	3	-	35 (34.6)	76	111 (48.0)
1976	6,526	1,110	50	7,686 (30.6)	3,072	10,758 (5.4)	39	4	-	43 (22.9)	93	136 (22.5)
1977	7,319	1,479	57	8,855 (15.2)	3,424	12,279 (14.1)	46	5	-	51 (18.6)	150	201 (14.1)
1980	12,158	2,484	56	14,698 (18.4)	5,578	20,276 (18.2)	74	12	-	86 (19.0)	335	421 (27.9)
1981	12,597	2,083	95	14,775 (0.5)	5,699	20,474 (1.0)	82	20	-	102 (18.6)	390	492 (16.9)
1982	16,243	2,607	78	18,928 (28.1)	7,828	26,756 (30.7)	104	26	-	130 (27.5)	434	564 (14.6)
1983	20,014	2,689	90	22,793 (20.4)	9,812	32,605 (21.9)	110	27	1	138 (6.2)	507	645 (14.4)

( ) Annual growth rate: %

Source: Land Transport Department

5.3 River Traffic

5.3.1 River Traffic Survery

Although river transport plays an important role not only for cargo but also for passengers, comprehensive studies on river traffic in the Study Area have not been conducted. Because information on river traffic is very scarce, the following surveys on river traffic were carried out by the Study Team at Tatau and Kapit which were the transport terminals in the Study Area in 1982 and 1984.

(1) Vessels traffic count survey

This survey collected data on the total volume of river traffic by type of vessel at two points; upstream and downstream of the bazaar in Tatau and Kapit, for 12 hours per day for 5 days in 1982, and 2 days in 1984.

(2) Interview survey with vessel operator

This survey collected information on the origin, destination, purpose of trip and number of passengers from a sample of 300 vessels in Tatau in 1984 and 600 in Kapit in 1982.

(3) Interview survey for express launch passengers

This survey collected information from a sample of express launches in Tatau and Kapit, covering the origin, destination, trip purpose and passenger characteristics. The outline of these surveys is shown in Table 5-11.

5.3.2 River Traffic in Tatau Area

(1) Type and Traffic Level of Vessels

Transport in upper Tatau is completely dependant on the river transport system. River transport consists of express Launches, motor launches, motorized long boats and speed boats. express launches provide mass transit for passengers. Regular services to destinations between Tatau and Lana via Sangan use two vessels seating 64 persons and travelling at an average speed of 35 km per hour.

Motor launches which are relatively slower than express launches are used mainly for cargo transport and frequently used as mobile shops for the Long Houses in the area.

Long boats owned by traders, shop owners or groups of Long House residents are mainly used for daily short distance trips to the market and some of them provide

Table 5-11 CONDUCTED RIVER TRAFFIC SURVEY

Type of Survey	Survey Station	Survey Period	Major Survey Items
Vessel Traffic Count	1. Tatau P.W.D. Jetty	21 July - 26 July (1982) 7:00 AM - 7:00 PM 2 Nov. - 3 Nov. (1984) 6:00 AM - 6:00 PM	- Number of Vessels by Type, by Hour
	2. Tatau Wharf	- do -	- Number of Passengers of Long/Speed Boat
	3. Kapit P.W.D. Jetty	4 Aug. - 7 Aug. (1982) 22 Oct. - 23 Oct. (1984) 6:00 AM - 6:00 PM	
	4. Kapit New Bazar Wharf	- do -	
Interview Survey with Vessel Operator	5. Tatau Wharf	21 July - 22 July (1982) 2 Nov. - 3 Nov. (1984)	- Origin and Destination - Trip Purpose - Number of Passengers - Tonnage and Type of Cargo
	6. Kapit Wharf	5 Aug. - 7 Aug. (1982)	
Interview Survey for Express Launch Passengers	7. On the Launches Tatau-Sangan	28 July (1982) 2 Nov. - 3 Nov. (1984)	- Origin and Destination - Trip Purpose - Characteristics of Passengers
	8. Kapit Wharf	8 Aug. - 10 Aug. (1982) 22 Oct. - 23 Oct. (1984)	

taxi services to and from the major market center. Speed boats are generally used by timber companies as well as by river taxi services. A certain volume of cargo is individually carried by long boat and speed boat as well as by express launch with passengers.

The following data has been collected as shown in the results of the river traffic survey in Tatau.

1) Average Daily Traffic Volume by Vessel Type

In the ADT, 350 vessels in terms of mixed traffic were observed upstream of Tatau bazaar and 300 were observed downstream in 1982 in both directions. In 1984, 220 vessels upstream and 160 downstream were observed. The figure for 1982 is bigger than that for 1984 because the survey was conducted during the Hari Raya holidays. Half the total volume consists of long boats, most of which make short distance trips. Table 5-12 shows the average daily traffic volume on the Batang Tatau by vessel type.

Table 5-12 AVERAGE DAILY RIVER TRAFFIC IN BTG. TATAU (VESSELS)

Unit: No. of Vessels

Survey Station	Year	Long Boat	Speed Boat	Express Launch	Motor Launch	Tug/ Barge	Others	Total
Upstream Tatau Bazaar	1982	174 (49.3)	139 (39.4)	2 (0.6)	22 (6.2)	15 (4.2)	1 (0.3)	353 (100%)
	1984	120 (54.1)	78 (35.1)	4 (1.8)	8 (3.6)	12 (5.4)	1 (0.5)	222 (100%)
Downstream Tatau Bazaar	1982	146 (47.7)	118 (38.6)	8 (2.6)	7 (2.3)	27 (8.8)	- (-)	306 (100%)
	1984	71 (44.1)	70 (43.5)	- (-)	2 (1.2)	18 (11.2)	2 (1.2)	161 (100%)

Source: River Traffic Count Survey

2) Trip Distribution by Direction

The origin and destination of vessels interviewed are shown in Table 5-13. Of these vessels, those which travel within Tatau account for more than 40% of the total.

Table 5-13 ORIGIN AND DESTINATION OF VESSEL TRIP (TATAU)

Unit: No. of Vessels/day

	Tatau		Sungai Kakus		Sungai Anap		Total	
Tatau	157	(42.6)	44	(11.9)	79	(21.3)	280	(75.8%)
Kuala Tatau	76	(20.6)	-	(-)	2	(0.6)	78	(21.3%)
Bintulu	6	(1.6)	2	(0.6)	2	(0.6)	10	(2.9%)
Total	239	(64.8)	46	(12.6)	83	(22.6)	368	(100%)

Note: In both directions
Source: Interview survey for vessels in 1984

C) Number of Passengers on Board

The average number of passengers on board estimated from the samples by vessel type is shown in Table 5-14. The long boats and speed boats which amount to about 90% of total traffic volume carry 4 to 5 persons per boat.

Table 5-14 NUMBER OF PASSENGERS ON BOARD

	Long Boat	Speed Boat	Motor Launch	Tug/ Barge	Cargo Ship	Others
No. of Vessels	56	42	6	1	1	2
No. of Passengers	253	171	17	3	7	3
No. of Passengers/ on Board	4.5	4.1	2.8	3.0	7.0	1.5

Source: Interview Survey for Vessels in 1982

(2) River Passenger Traffic by Express Launch

Express launches are operated twice daily in each direction between Tatau and Lana via Sangan. Two launches owned by one company are in service for the Tatau - Sangan - Lana section, seating 64 persons.

The outline of the express launch operations is shown in Table 5-15.

The fare system of express launch services is approximately proportional to the distance travelled. Launches stop wherever passengers want to embark or disembark.

Table 5-15 EXPRESS LAUNCH OPERATION IN TATAU AREA

	Tatau - Sangan (Lana)
Distance	48 km
Average Travel Time	1.4 hours
Average Speed	35 km/hr
Fare (1984)	M$6.00
Capacity	64 seats x 2
Average No. of Passengers/Year	
- 1982	36,000
- 1984	72,000

Source: Interview with shipping company

Table 5-16 shows the monthly total number of express launch passengers carried on the Tatau - Sangan - Lana section for the last five years, based on data from a shipping company in Bintulu. This indicates a high growth rate compared to the population growth rate in the Study Area. Due to the increase in demand, the express launch service increased to twice daily from August, 1982.

Table 5-16 NUMBER OF PASSENGERS MOVING BY EXPRESS LAUNCH BETWEEN TATAU AND GABONG TRADING L.C.

Year	No. of Passengers/Month	Annual Growth
1980	1,500	- (%)
1981	2,000	133
1982	3,000	150
1984	6,000	150

Source: Interview with shipping company

The distribution of passenger traffic by express launch operation between Tatau Sungai Anap (Sangan) and Sungai Kakus (Lana) is summarized in Table 5-17.

Table 5-17 ORIGIN AND DESTINATION OF EXPRESS LAUNCH PASSENGERS (1984)

Unit : Person (%)

	Tatau		Sungai Kakus		Sungai Anap		Other Places	Total	
Tatau	46	(21.8)	60	(28.2)	45	(20.8)	-	151	(70.7%)
Bintulu	16	(7.4)	12	(5.6)	23	(10.6)	-	51	(23.6%)
Other Places	-	(-)	5	(2.3)	7	(3.2)	-	12	(5.6%)
Total	62	(29.2)	77	(36.1)	75	(34.7)		214	(100%)

Source: Interview survey for express launch passengers

5.3.3 River Traffic in Kapit Area

(1) Characteristics of Type and Traffic level of Vessels

The only form of transport in the Batang Rajang basin is River Transport, although some vehicle transport takes place within towns.

As far as river transport in the Kapit area is concerned, express launches, motor launches, long boats, and speed boats, cater to passengers, and motor vessels and tug boats with barges and rafts cater to cargoes.

The express launch operates 9 times daily in the section between Kapit and Sibu and twice daily for the section between Kapit and Belaga. In addition, there are six regular Motor Launch service sections from Kapit to Pelagus, Bawai, Balleh, Mujong, Gaat and Yong, each once or twice daily. These regular express launch and motor launch services are not only for passengers but also for goods. Light goods and perishables such as fish and deer meat are frequently carried by express launch. However, the major form of goods transport downriver of Kapit is motor cargo vessels which have capacities of up to 50 tons. They ususally operate between Kapit and Sibu, carrying general goods from Sibu and agricultural products from upriver of Batang Rajang. Upriver of Kapit, the motorized long boat is the major source of goods transport from Long Houses to the market.

For heavy goods and logs, tug boats with barges or rafts operated by shipping and timber companies travel up to downstream of the rapids on Batang Rajang and some distance on Batang Balleh. The following data, dealing with river traffic volume and characteristics in the Kapit area, was obtained from the river traffic survey conducted by the Study Team.

1) Average Daily Traffic by Vessel Type

Table 5-18 shows the average daily river traffic volume by vessel type on Batang Rajang in Kapit town. Upstream of Kapit, the daily traffic volume of all types of vessels amounted to 430 vessels, compared to only 295 vessels downstream in 1984, as Kapit is the principal transport point and secondary distribution point for the upper Rajang area. Long boats account for about 70% of the river traffic.

Table 5-18 AVERAGE DAILY RIVER TRAFFIC IN BATANG RAJANG (VESSEL)

Survey Station	Year	Long Boat	Speed Boat	Express launch	Motor Launch	Tug/ Barge	Others	Total
Upstream of Kapit Bazaar	1982	328 (78.1)	69 (16.4)	2 (0.5)	7 (1.7)	12 (2.9)	2 (0.5)	420 (100%)
	1984	323 (75.3)	50 (11.7)	19 (4.4)	14 (3.3)	22 (5.1)	3 (0.7)	429 (100%)
Down-stream of Kapit Bazaar	1982	178 (80.2)	14 (6.3)	12 (5.4)	8 (3.6)	6 (2.7)	4 (1.8)	222 (100%)
	1984	192 (65.1)	43 (14.6)	30 (10.2)	9 (3.1)	17 (5.8)	6 (2.0)	295 (100%)

Source: River Traffic Count Survey

2) Trip Distribution by Direction

The origin and destination of vessels interviewed and summarized in traffic zones are shown in Table 5-19. Vessels travelling only within the Kapit town are about 35% of the total, and almost 100% of the vessels are either arriving or leaving Kapit town. The largest flows are observed between Kapit and Batang Balleh basin, including Lepong Balleh, Gaat, Mujong and Ulu Balleh. The Traffic volume between Kapit and the upper Rajang area including the Belaga district, is supposed to be smaller because of the low water level of Batang Rajang above Kapit.

Table 5-19 ORIGIN AND DESTINATION OF VESSEL TRIP (KAPIT)

Unit: Vessel/day

	Kapit	Pelagus	Belaga	Lepong Balleh	Gaat	Mujong	Ulu Balleh	Total
Kapit	240(35.0)	82(12.0)	4(0.6)	142(20.6)	47(6.8)	87(12.6)	43(6.2)	645(93.8%)
Song	12 (1.8)	-	-	-	-	2 (0.3)	-	14 (2.1%)
3rd Div.	28 (4.1)	-	-	-	-	-	-	28 (4.1%)
Total	280(40.8)	82(12.0)	4(0.6)	142(20.6)	47(6.8)	89(13.0)	43(6.2)	687(100%)

3) Number of Passengers on Board

Table 5-20 shows the average number of passengers on board by vessel type. The long boats carried about 4 to 5 passengers in the Kapit area as well as in the Tatau area.

Table 5-20 NUMBER OF PASSENGERS ON BOARD

	Long Boat	Speed Boat	Motor Launch	Tug/ Barge	Cargo Ship	Others
No. of Vessels	505	71	7	9	7	5
No. of Passengers	2,382	265	153	24	43	43
Passengers/Vessels	4.7	3.7	21.8	2.7	6.1	8.6

Source: Interview survey for vessels in 1982

(2) River Passenger Traffic by Express and Motor Launch

The express launch operation between Kapit and Sibu has been in regular service since 1968. Express launches with capacities for 60 passengers with 300-500 horse power engines operate 9 departures daily from Kapit to Sibu. They travel at a high speed of 35 - 40 km per hour and make a 4-hour trip between Kapit and Sibu. Although a timetable exists, delays of half an hour to one hour frequently occur because of irregular stops for embarking and disembarking passengers.

The express launch service with a 6-hour trip between Kapit and Belaga is operated by 4 express launches twice daily in each direction. An outline of these express launches is summarized in Table 5-21.

Table 5-21 EXPRESS/MOTOR LAUNCH OPERATION IN KAPIT

Route	Frequency of Service (Daily both directions)	Passenger Capacity (Seats)	Average Travel Time (Hours)	Fare (M$)
Kapit Sibu	18	60	3.5 ~ 4.0	12 (with Air-conditioning)
Kapit — Belaga	4	60	5.5 ~ 6.0	18
Kapit — Pelagus	4	60	2.0 ~ 2.5	4
Kapit — Balleh	2	60	6.0 ~ 7.0	10
Kapit — Mujong	2	60	1.5 ~ 2.0	3
Kapit — Bawai	2	60	1.5	2.5
Kapit — Ng. Gaat	2	60	2.5	6
Kapit — Ng. Yong	2	60	1.3	5

Source: Interview with express launch drivers

Besides the express launch, there are 6 regular motor launch services from Kapit to Pelagus and Yong on Batang Rajang and Bawai, Balleh, Mujong, Gaat on the Batang Balleh. The fare for a trip by express launch from Kapit to Sibu is M$12.00, and the fare from Kapit to Belaga is M$18.00.

The number of passengers moving by express launch from Kapit was surveyed, adding up to 995 passengers as shown in Table 5-22. The distribution of this passenger traffic is summarized in Table 5-23. The largest volume was observed between Kapit and Sibu.

Table 5-22 NUMBER OF EXPRESS/MOTOR LAUNCH PASSENGERS BY ROUTE

	Route	No. of Services	Average Daily Passengers in both directions
Express Launch	Kapit - Sibu	18	400
	Kapit - Belaga	4	130
Motor Launch	Kapit - Pelagus	4	100
	Kapit - Balleh	2	100
	Kapit - Mujong	2	30
	Kapit - Bawai	2	70
	Kapit - Ng. Gaat	2	120
	Kapit - Ng. Yong	2	40
Total		36	990

Table 5-23 ORIGIN AND DESTINATION OF EXPRESS LAUNCH PASSENGERS (KAPIT)

	Kapit	Pelagus	Belaga	Lepong Balleh	Mujong	Gaat	Ulu Balleh	Others	Total
Kapit	105	180	35	89	11	9	1	-	430
Song	92	4	-	1	2	2	2	-	103
3rd Div.	341	11	10	16	2	2	1	1	384
6th Div.	17	-	-	-	2	1	-	-	20
2nd Div.	3	-	-	-	-	-	2	1	6
1st Div.	22	1	2	1	2	1	1	-	30
Others	12	-	1	5	2	1	1	-	22
Total	592	196	48	112	21	16	8	2	995

5.3.4 Pasenger Movement in the Study Area

The interzonal road passenger traffic flows arriving and leaving Tatau are shown in Table 5-24. The traffic compositions used for estimation are in Appendix 3-3. The average number of passengers are calculated from the figures in Table 5-7.

The interzonal river passenger traffic flows arriving and leaving Tatau , including express launch traffic, are summarized in Tables 5-25. The total passenger flow in the Tatau Area is summarized in Table 5-26. Table 5-27 shows the passenger traffic flows in the Kapit Area.

Fig. 5-3 shows the passenger traffic flows in the Study Area.

Table 5-24 PASSENGER FLOW OF VEHICLE TRIPS (TATAU)

Unit: person/day

	Tatau	Bintulu	Other Places	Total
Tatau	181	656 (162)	20	857 (162)
Sibu	195 (71)	397 (145)	69	661 (216)
Other Places	45	50	89	184
Total	421 (71)	1,103 (307)	178	1,702 (378)

( ) Bus passengers

Table 5-25 PASSENGER FLOW OF VESSEL TRIPS (TATAU)

Unit: person/day

	Tatau	Sg. Kakus	Sg. Anap	Total
Tatau	724 (46)	251 (60)	388 (45)	1,363 (151)
Kuala Tatau	343 (16)	12 (12)	32 (23)	387 (51)
Bintulu	26	14 (5)	16 (7)	56 (12)
Total	1,093 (62)	277 (77)	436 (75)	1,806 (214)

( ) Bus passengers

Table 5-26 TOTAL PASSENGER FLOW IN TATAU AREA

Unit: person/day

	Tatau	Sg. Kakus	Sq. Anap	Total
Tatau	905	251	388	1,544
Kuala Tatau	343	12	32	387
Bintulu	702	14	16	732
Sibu	240	-	-	240
Total	2,190	277	436	2,903

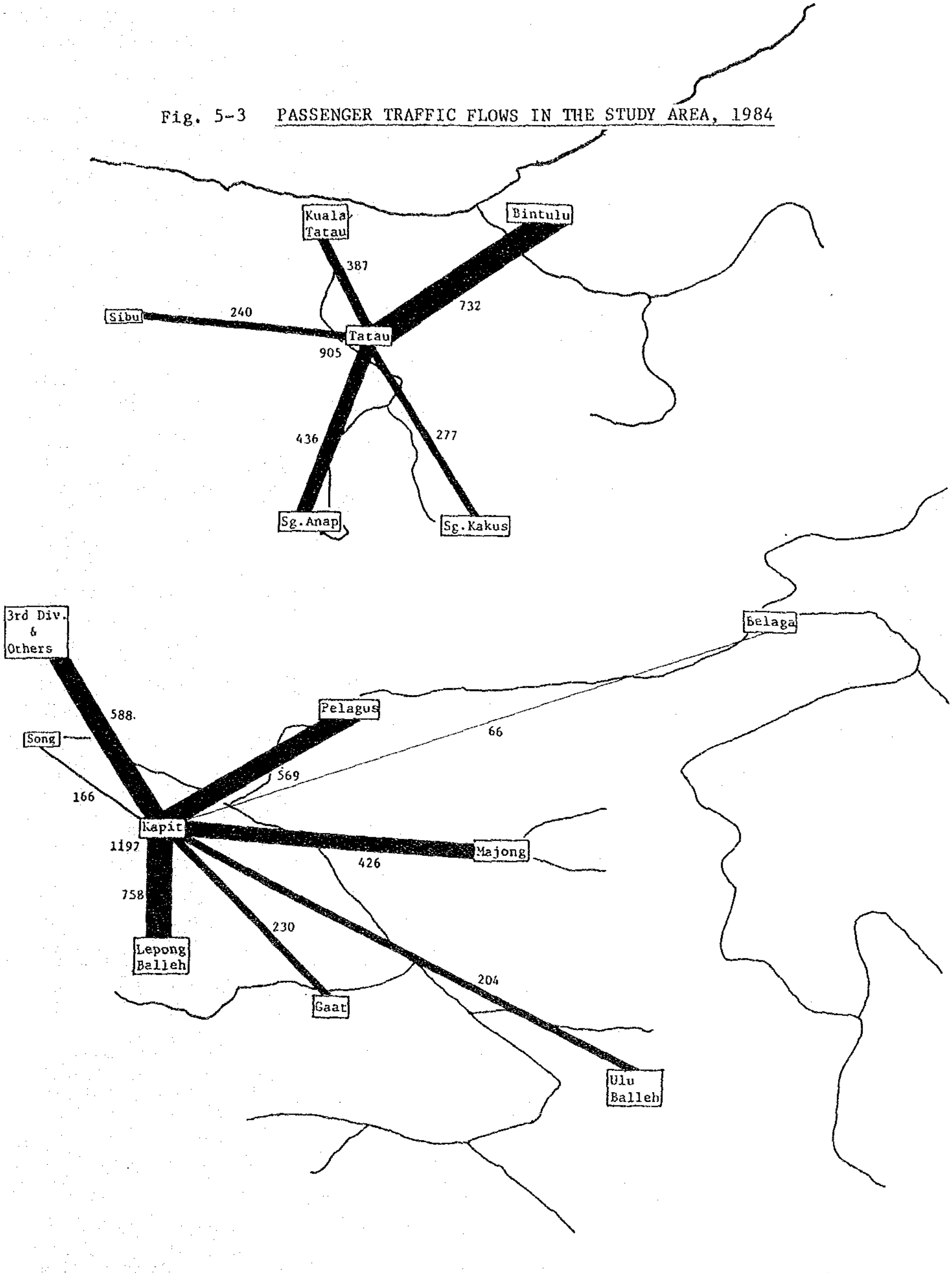
Table 5-27 PASSENGER TRAFFIC FLOW IN KAPIT AREA

Unit: person/day

	Kapit	Pelagus	Belaga	Lepong Balleh	Mujong	Gaat	Ulu Balleh	Others	Total
Kapit	1,197(105)	553(180)	53(35)	735(89)	407(11)	223(9)	197(1)	-	3,365(430)
Song	146 (92)	4 (4)	-	1 (1)	11 (2)	2(2)	2(2)	-	166(103)
3rd Div.	467(341)	11 (11)	10(10)	16(16)	2 (2)	2(2)	1(1)	1(1)	510(384)
6th Div.	17 (17)	-	-	-	2 (2)	1(1)	-	-	20 (20)
2nd Div.	3 (3)	-	-	-	-	-	2(2)	1(1)	6 (6)
1st Div.	22 (22)	1 (1)	2 (2)	1 (1)	2 (2)	1(1)	1(1)	-	30 (30)
Others	12 (12)	-	1 (1)	5 (5)	2 (2)	1(1)	1(1)	-	22 (22)
Total	1,864(592)	569(196)	66(48)	758(112)	426(21)	230(16)	204(8)	2(2)	4,119(995)

( ) Express Launch

Fig. 5-3 PASSENGER TRAFFIC FLOWS IN THE STUDY AREA, 1984



CHAPTER 6

CONTENTS

CHAPTER 6 ENGINEERING STUDY

6.1 Existing Roads

As is shown in Fig. 6-1, there are no public roads excepting the First Trunk Road and Lepong Balleh Road. There are, however, private logging roads developed by logging companies for temporary use under the license issued by the Forest Department of the State of Sarawak. For reference, the conditions of the existing roads are summarized in Table 6-1.

6.1.1 First Trunk Road

The First Trunk Road was constructed mostly along the coast of the South China Sea with two traffic lanes mainly gravel-surfaced. The road has had a completed gravel surface since September 1982.

The First Trunk Road extends approximately 1,090 km with three ferry sites, namely at Lundu to cross Batang Lundu in the First Division, at Kanowit to cross Batang Rajang in the Third Division and at Kuala Baram to cross the Batang Baram in the Fourth Division.

The First Trunk Road rural area is bumpy due to 4,000 - 6,000 mm of rainfall each year. Therefore, passengers are obliged to bear uncomfortable driving. The Government of Malaysia has a policy to pave the whole section of the First Trunk Road, by 1990.

6.1.2 Lepong Balleh Road

Lepong Balleh Road was constructed along the left bank of the Batang Rajang in 1984 as a "Rural Road" about 9 km long from Kapit to the East. Although it was originally planned as a standard one traffic lane road, it is now gravel-surfaced with two traffic lanes in most parts.

6.1.3 Logging Roads

As stated in Item 6.1, the logging roads are planned and constructed by the licensee and classified into three categories as follows:-

(a) The main logging roads are those which traverse almost the whole extent of the licensed area. They are constructed so that logs can be carried from the logging site to the public roads or waterways. Therefore, they should be good

Fig. 6-1 EXISTING ROAD NETWORKS IN THE PROJECT AREA

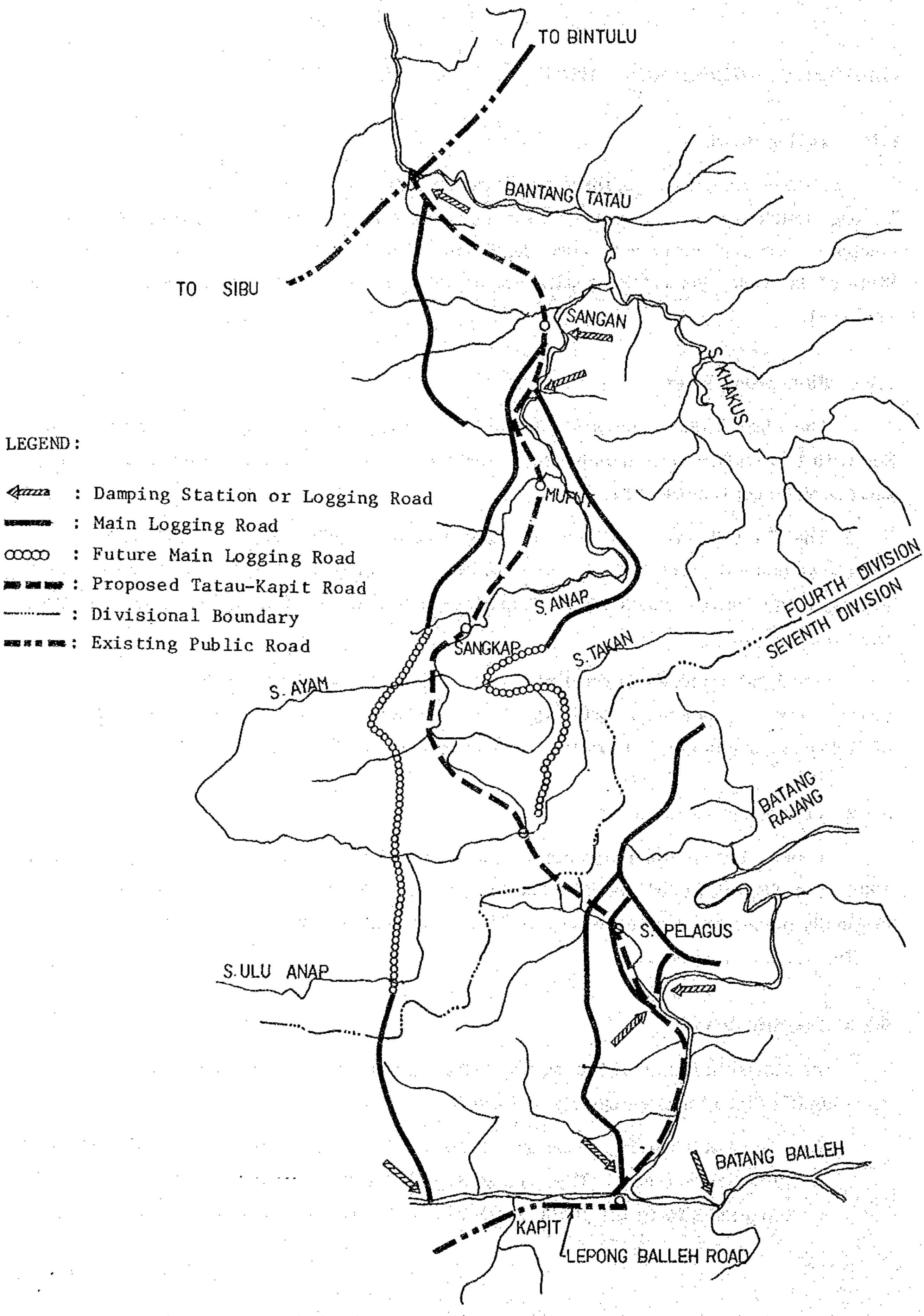
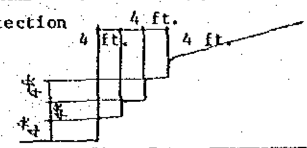
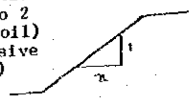
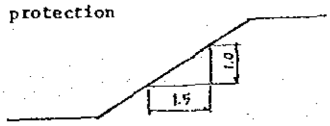


Table 6-1 EXISTING ROADS IN THE PROJECT AREA

			First Trunk Road (Sibu-Bintulu Road)	Rural Road (Lepong Balleh Road)			Logging Roads		
							Main	Secondary	Feeder
Design standard	Geometric design criteria		Sarawak JKR Standard				Sarawak Forest Department Standard		
			Any terrain	Flat	Hilly	Mountainous			
	Design speed (km/h)		80	50	50	30	50	30	15
	Shoulder width (m)		3.05 X 2	1.75 X 2					
	Traffic lane width (m)		7.30	4.50					
	Total width (m)		13.40	8.00			10/8	8/6	6/4.5
	R. O. W.		150 ft. - 200 ft.	99 ft.			60m	50m	40m
	Steepest vertical gradient (%)	Preferable	5	7			8/10 a)	10/14 a)	12/17 a)
		Absolute	8	10			6/8 a)	8/12 a)	10/14 a)
	Sharpest horizontal curve (m)	Preferable	1000 ft.	500 ft.			100	75	40
		Absolute	750 ft.	300 ft.					
	Slope protection	Cut slope	No protection  4 ft. 4 ft. 4 ft.				No protection n=1-1/2 to 2 (Sandy soil) n=1 (Cohesive soil) n=1/8-1/4 (Rock)  1 n		
		Embankment slope	No protection  1.0 1.5				No protection  1 n; n = 2 or more (Loose sand) n=1-1/2 (Clay) n=1-1/4 (Rock)		
Existing situation	Structures	Bridge	Temporary traffic one lane bridge (Wooden or Bailey bridge)	- ditto - (Wooden bridge)			4 meters wide log bridge with earth surface		
		Culvert	Corrugated pipe	Corrugated pipe			Logs		
	Alignment	Horizontal	Mainly straight line with partial large horizontal curve	Comparatively small curves to pass steep topography			Small curve than design criteria		
		Vertical	Flat with some exceptions	Many steep sections			Steeper due to passing mountainous terrain		
		Cross section	1.5 ∿ 2.0 m wider than criteria						
	Pavement		Gravel				Earth		
	Slope protection		Occurrence of falls due to ooze out of ground water from slope, and due to weathering.				Road construction by cut completely/good maintenance against falls		
	Drainage		Side ditch at roadsides is filled up due to falls in a short period. Occurrence of falls at high embankment slope utilized for final outlet of road surface drainage.				V type side ditch is maintained well by motor-graders		

Notes
1. R.O.W. ...... Right of Way
2. a) 8/10 8: Gradient of uphill towards forests
10: Gradient of uphill towards mill or dumping station

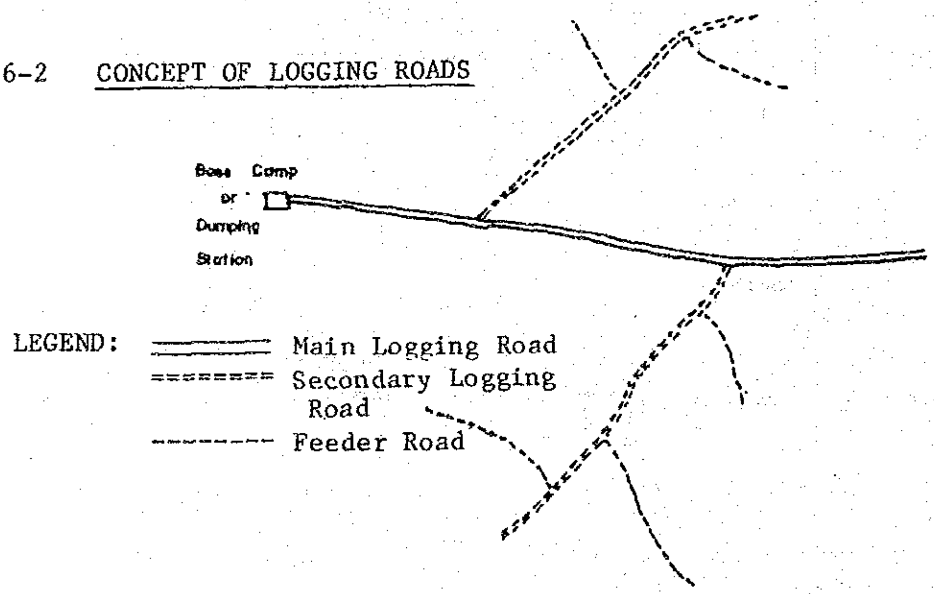
all-weather (gravelled) roads designed for traffic of heavy logging trucks at a normal speed during the entire period of the license.

(b) The secondary logging roads are branches of the main logging roads enabling access to the logging blocks to be harvested. They should preferably be all-weather roads designed for traffic of heavy logging trucks at a moderate speed.

(c) The feeder roads are short roads constructed throughout the logging blocks connecting to the secondary logging Road. they are not all-weather roads and will usually be used for very short periods of about two months. They should be designed for the same type of trucks used for the secondary and main logging roads.

This concept is shown in Fig. 6-2, a typical logging road network. The logging license of each block in the project area is given one by one, effective one year or up to a maximum of 25 years. The harvest is carried out for 150 -200 days a year.

Fig. 6-2 <u>CONCEPT OF LOGGING ROADS</u>



6.2 Geology and Soil

6.2.1 Geological Outline

The geological strata of Sarawak, which is located in the Northwest area of Borneo Island, consists chiefly of sedimentary rocks accumulated on the geosyncline called the Northwest Borneo Geosyncline. The geosyncline, located on the North side of the continental core extending into Kalimantan, the southern part of Borneo called "the Sunda Shield", is believed to be a development arising from the sunda orogenic movements in the Neogene. In addition to the above, in Sarawak State there are volcanic rocks, e.g., andesite, rhyolite, basalt, etc. and plutonic rocks, e.g., granite and gabbro, which are comparatively narrowly distributed as shown in Fig. 6-3.

6.2.2 Geology in the Study Area

Fig. 6-4 is the geological map of the Study Area showing the distribution of the four formations, i.e. Belaga, Tatau, Buan and Nyalau.

(1) Belaga Formation

Approximately half the Project Road will run over the Belaga Formation of predominantly dark shale which has been transformed into argillite, slate and phyllite as a result of dynamic metamorphism. Some rigid massive sandstone, as well as alternations of slate and sandstone, are also encountered in some places such as the outskirts of Pelagus Rapids.

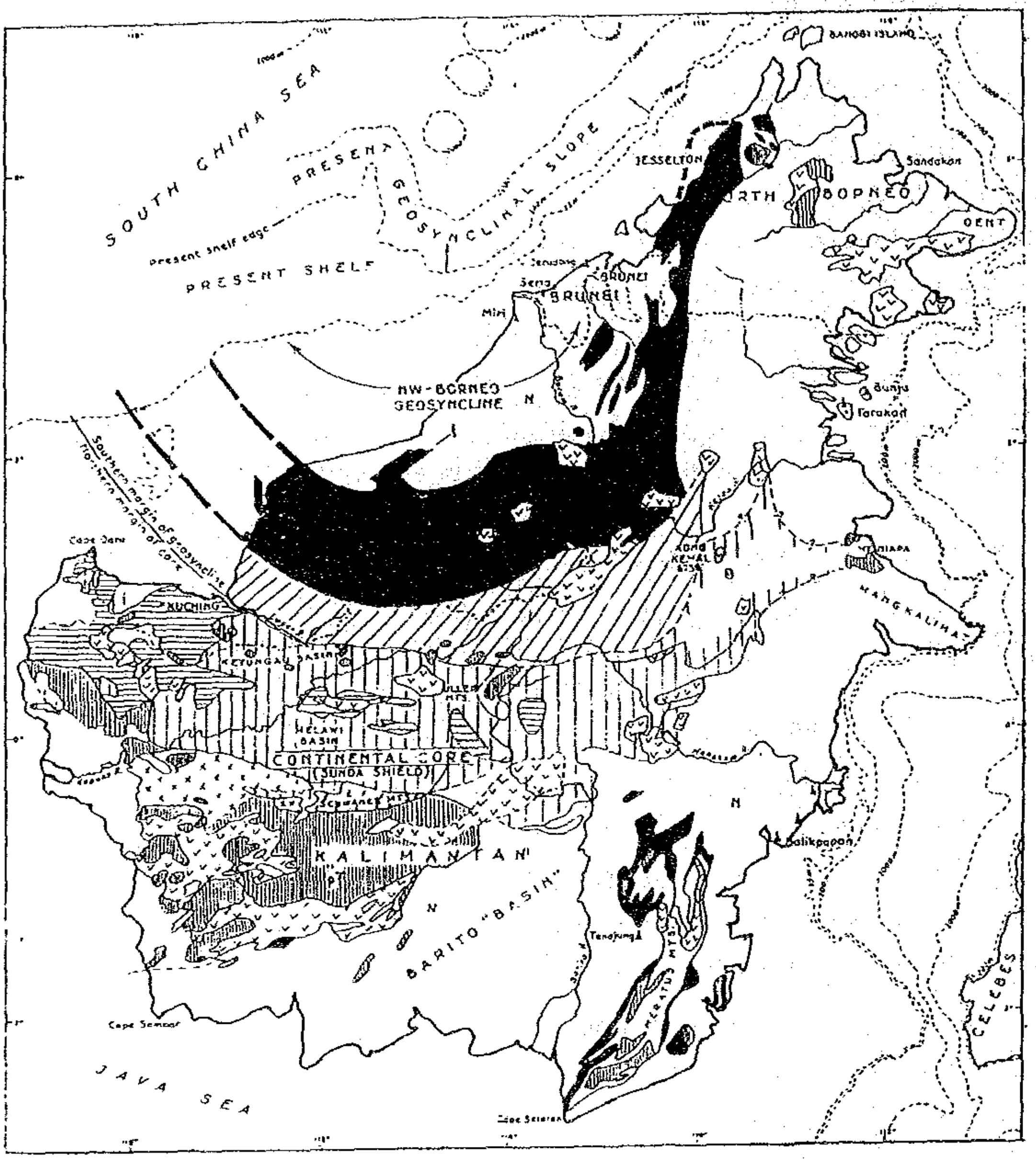
The Belaga Formation can be classified into four stages on the basis of paleontological evidence which can be identified by slightly different rock formations facing each other.

The Belaga Formation has been intensely folded, but details of the geological structures are still vague. As for the geological profile, Stage I on the bottom belongs to the late Cretaceous of Mesozoic and others belong to Pliocene and Miocene of Cenozoic. Basalt lava is distributed through the Fourth Stage in the area of the River Anap and Pelawan Valley.

(2) Tatau Formation

The Tatau Formation rests unconformably on the Belaga Formation. The Tatau Formation consists chiefly of sandstone and Shale and subsequently of marl and lenses of grey massive limestone. Thus the upper part of the Tatau Formation features the calcareous stones.

Fig. 6-3 SKETCH MAP SHOWING THE REGIONAL SETTING OF THE CONTINENTAL CORE AND NW-BORNED GEOSYNCLINE



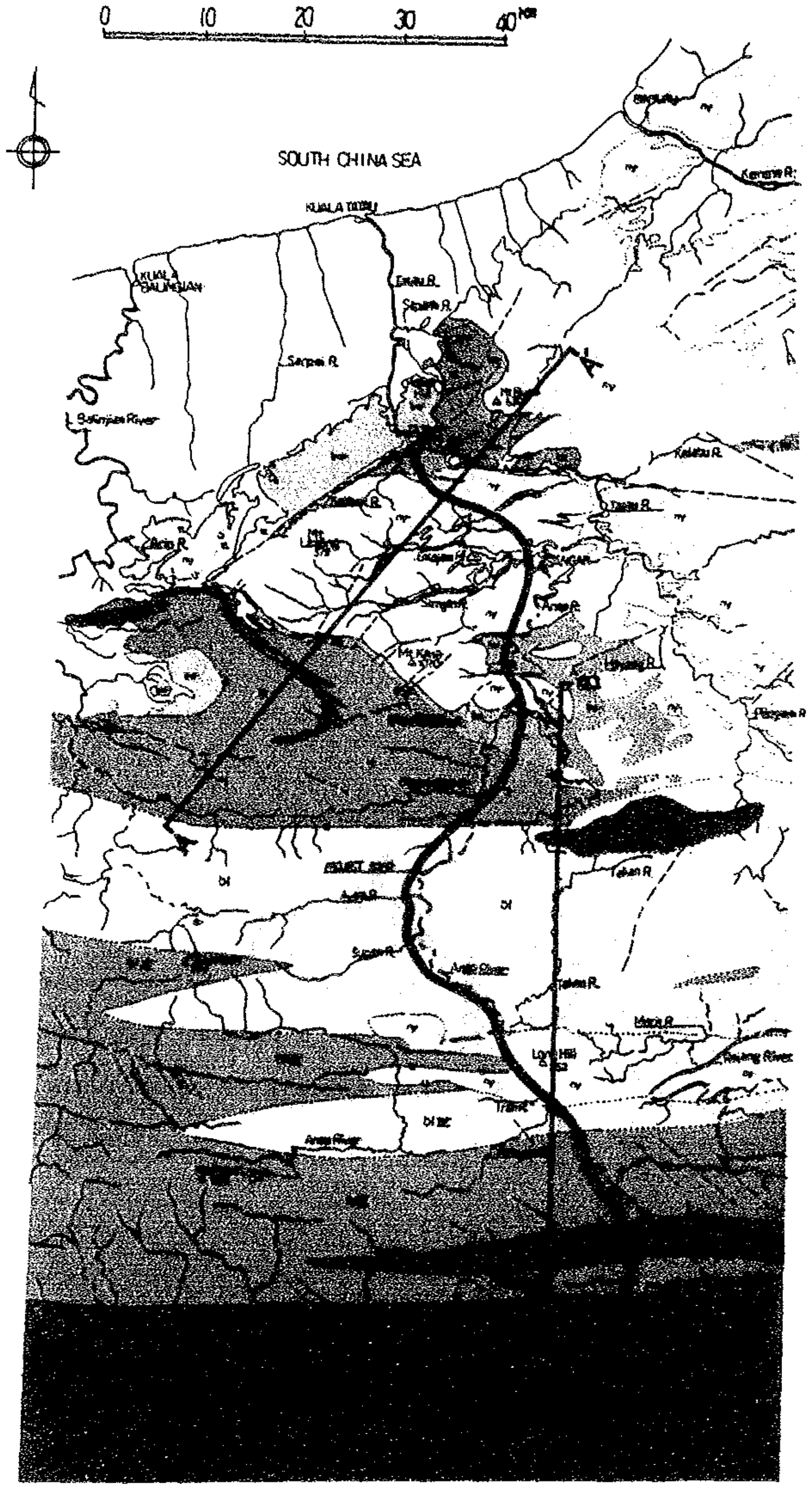
LEGEND:

(blank)	Alluvium or unknown area
N	Neogene, including some To and Tcd in NW-Borneo
(solid black)	Palaeogene, mainly Palaeocene-Eocene
(diagonal hatching)	Cretaceous, including Chert-Soilite developments (Danau Formation, Lupar Formation & Merarus mountains)

CONTINENTAL CORE & ADJOINING SHELF AREA

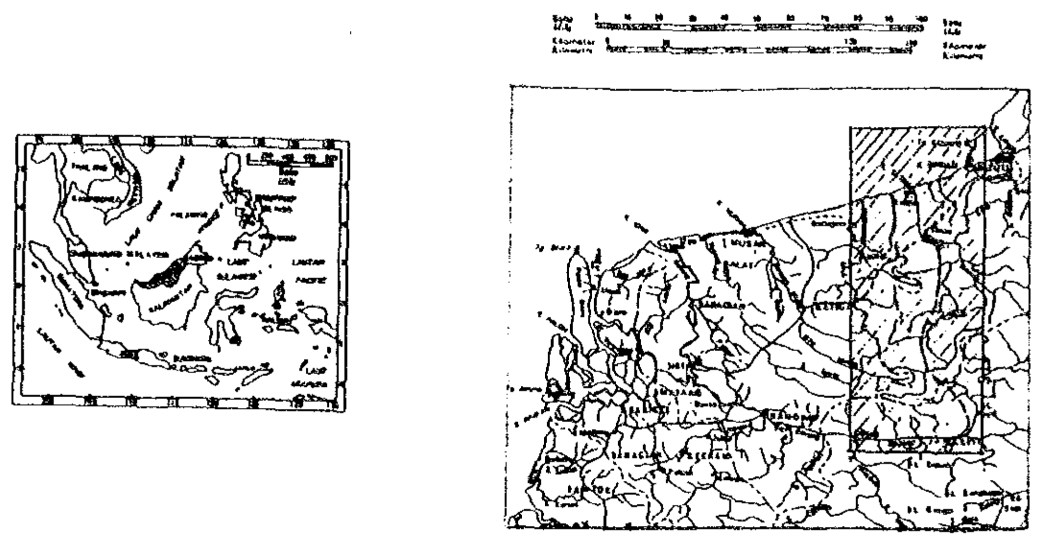
(vertical lines)	Undifferentiated Tertiary cover
(horizontal lines)	Palaeozoic & Mesozoic (major occurrences only of Carbo-Permian, Triassic, Jurassic & Cretaceous)
V V V	Acid, intermediate & basic extrusive rocks
(dense vertical lines)	Granite, granodiorite & quartz porphyry
x x x	Diorite & syenite, mostly pre-Tertiary & basic intrusives (Gabbro, Peridatite etc.)

FIG. 6-4 GEOLOGICAL MAP OF THE STUDY AREA



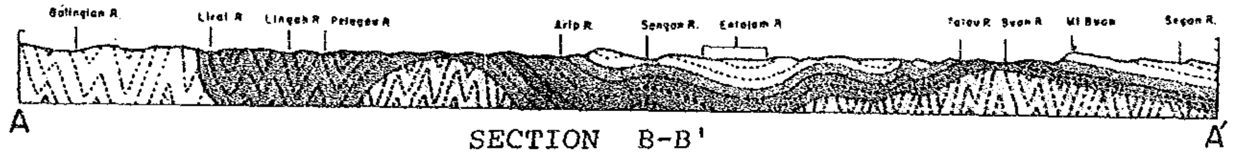
SOURCE : E.W.WOLFENDEN (1960) & H.J.C.KIRK (1957)
THE GEOLOGY AND MINERAL RESOURCES OF THE UPPER RAJANG AND ADJACENT AREAS, SARAWAK.

MALAYSIA (SARAWAK)

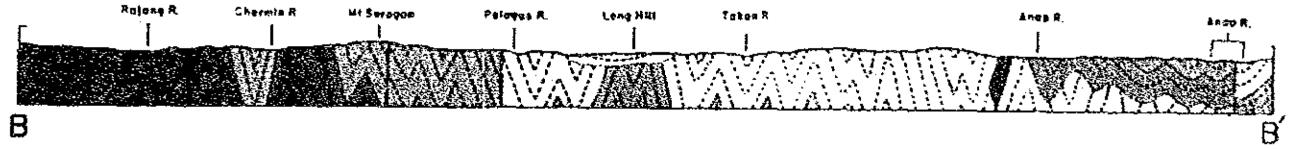


GEOLOGIC PROFILES

SECTION A-A'



SECTION B-B'



SEDIMENTARY AND VOLCANIC ROCKS

AGE	LITTER CLASSIFICATION		FORMATION NAME AND LITHOLOGY
QUATERNARY			Alluvial sand, silt, clay, and peat Some high-level alluvium, mainly gravel and sand
		Unconformity	
PLIOCENE	Tgh	la	*LIANG FORMATION* · Sand, clay, and lignite, with local basal conglomerate
		Unconformity	
		bh	*BEGRIH FORMATION* : Sand and clay, with basal conglomerate
		Unconformity	
MIOCENE (Including Aquitanian)	Tf	bw	*BALINGIAN FORMATION* : Sandstone, shale, and lignite
	Te_5		Strata of Te_5 age have not been proved
	Te_{1-4}	ny	*NYALAU FORMATION* : Hard sandstone and shale passing upwards into friable sandstone and clay. Massive sandstone occurs in the Kalibas Valley, and gravel, sandstone, clay, and lignite in the Pelagus Valley
OLIGOCENE	Tcd		*BUAN FORMATION* : Sandy shale with thin beds of siltstone and fine-grained sandstone
		a)	*TATAU FORMATION* : Sandstone, siltstone, shale, argillite, slate, marl, and some limestone lenses, with (a) rhyolite lava and welded tuff, and locally andesite lava
		Unconformity	
UPPER EOCENE	Tb	b) a)	*STAGE IV* · Shale, mudstone, argillite, slate, conglomerate, and sandstone, includes (a) basalt lava, tuff, and agglomerate, and (b) *BAWANG MEMBER* consisting of argillite, slate, phyllite, and sandstone
MIDDLE EOCENE			*BELAGA FORMATION OF RAJANG GROUP* — *STAGE III* : Argillite, slate, rare phyllite, graywacke, and graywacke conglomerate, with some tectonic breccias
LOWER EOCENE / PALEOCENE	Te		*STAGE II* · Argillite, slate, rare phyllite, graywacke, and graywacke conglomerate. Tectonic breccias are common in some parts
UPPER CRETACEOUS			*STAGE I* Argillite, slate, some phyllite, and graywacke

INTRUSIVE IGNEOUS ROCKS

AGE		FORMATION NAME AND LITHOLOGY
UPPER EOCENE OR YOUNGER		Granophyre, granite, and granodiorite

Meanwhile rhyolite and andesite are distributed in the Anap and Muput Valley, and Granite instrusive rocks in Piling Hill. The prevolcanic part of the Tatau Formation consists chiefly of carbonaceous shale and siltstone, normally including a sandstone stratum with a thickness of about 15 m. It is impossible to distinguish the shale in the Tatau Formation from that in the Belaga Formation. The fold in the Tatau Formation is not as complicated as that in the Beleaga Formation.

As for the geological age, this formation belongs to the upper eocene oligocene.

(3) Buan Formation

The Buan Formation demonstrates a belt-like distribution between the Tatau Formation and the Nyalau Formation and consists of siltstone and shale with a thin stratum of sandstone. This Formation belongs to the oligocene.

(4) Nyalau Formation

Arenaceous rocks are predominant in the Nyalau Formation which consists of alternations of sandstone and shale. The shale proportion increases towards the top. The Nyalau Formation is found broadly distributed through the area of Tatau - Anap - Arip, where the hard sandstone forms a steep hill slope, the bottom of it like Mt. Kana. At the top of this Formation is a strata with comparatively poor resistivity, forming a moderate configuration. The Nyalau Formation consists of rocks of oligocene - early miocene.

6.2.3 Soil Survey

(1) Mackintosh Probe Test

The Mackintosh Probe Test was conducted at 20 points of about 10 m off the water level on both sides of 10 rivers, where bridge construction is proposed, as in Fig. 6-5. The Probe Test was to discover the Bearing Stratum for the bridge foundation.

The strata in the test points is believed to consist of (1) fluvitile deposit, (2) the weathering part of the basement and (3) basement rock judging from the view of the ground surface.

As shown in Appendix 4-1, the test results suggest that, with some irregularities in the formation of the geological profile in the test points, the formation thickness averages about 4 m in the soft fluvitile deposit and about 2 m in the weathering part of basement rock. The bearing stratum is provided at a depth of about 6 m.

(2) Soil Test Results

Table 6-2 shows both the results of the soil test conducted for Phase I in 1982, and the data obtained in Phase II. Fig. 6-6 indicates the soil sampling points. Judging from the table, the design CBR of the subgrade for the pavement structure could be estimated at a minimum of 7%.

6.2.4 Bridge Foundation Ground

(1) Short Span Bridges

As mentioned in (1) of section 6.2.3, the bearing stratum for the bridge foundation is available at 6 m depth on the average. At this bearing stratum depth, a spread foundation type cannot be built and it is not economical to construct a larger type of foundation e.g. caisson etc. Therefore, a pile foundation is adopted as it is the most popular type used for this bearing stratum depth.

(2) The Batang Rajang Bridge

The Bearing Stratum was identified based upon the results of the boring tests conducted in Phase I. The pile foundation type is adopted for the same reasons as above.

6.2.5 Aggregate Survey

The potential quarry sites were surveyed to secure the aggregate used for the project road construction. Rock tests were carried out with respect to the rocks sampled from several potential quarry sites.

Fig. 6-6 shows the locations of potential quarry sites in the Project Area.

(1) Potential Quarry Site

(a) Sedimentary Rock

Since the geological strata in this area abound in argillaceous rock, it is difficult to expect a supply of aggregate with favorable quality from the sedimentary rock. Nonetheless, Pelagus Rapids (Point B) and the Nyalau Formation in Bukit Kana and Naong (Point E) are promising for the supply of massive and hard sandstone. A small-scale limestone deposit (Point F) is found in the North-eastern area from Tatau Town.

Fig. 6-5 MODEL PROFILE OF RIVER AND SHOWING MACKINTOSH PROBE TEST POINTS

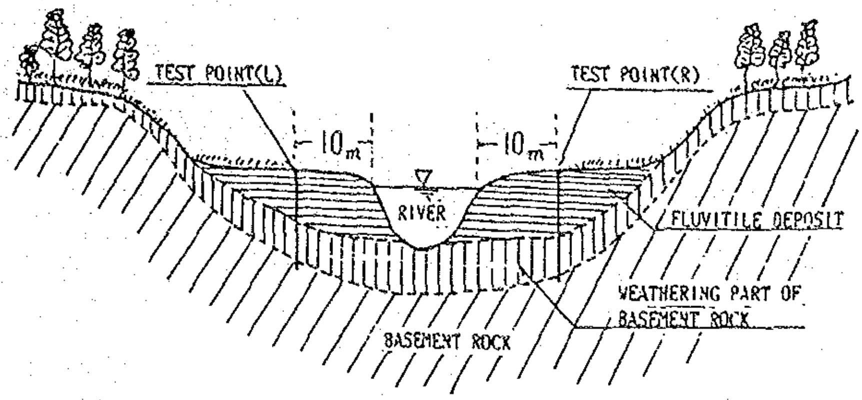


Fig. 6-6 MAP SHOWING LOCATIONS OF POTENTIAL QUARRY SITES, MACKINTOSH PROBE TESTS AND SOIL SAMPLING POINTS

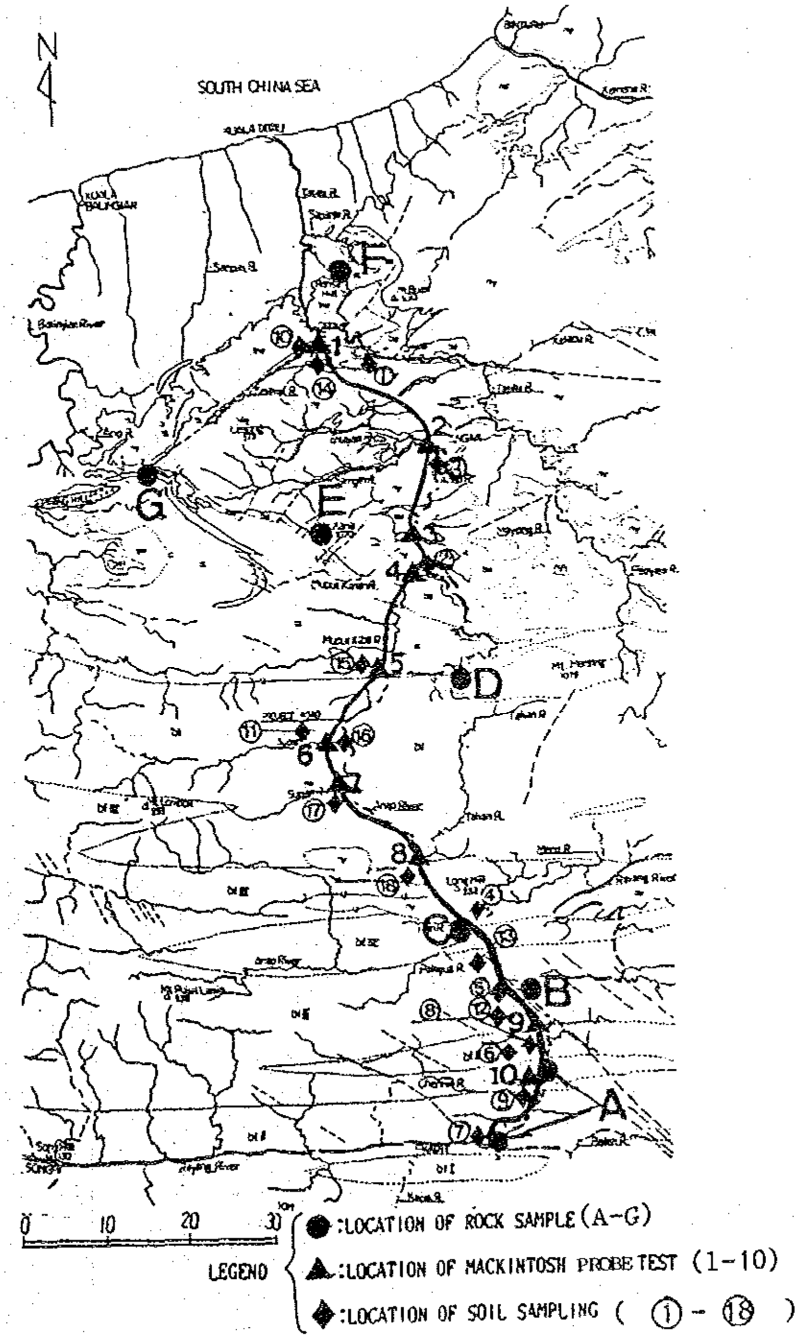


Table 6-2 SOIL TEST RESULTS

Phase	Sample	Natural Moisture Content Ratio (%)	Compaction Test: Optimum Moisture Content (%)	Compaction Test: Max Dry Density (g/cm^3)	Compaction Test: Modified C.B.R.	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Soil Gravity	Visual Classification
PHASE I	No. 1	11.7	10.5	2.01	70		N.P.		2.62	Dull yellow silty fine and moderately cemented with clay binder, forming lumps of weak silt stone/sand stone, with some rootlets. The sample is weathered, moist, loose with low-medium dry strength and has low plasticity and cohesion.
	No. 2	10.6	12.0	1.91	68		N.P.		2.65	Reddish yellow silty sand, mostly fine grained, moderately cemented with clay binder, forming lumps of weak silt stone/sand stone, with some rootlets. The sample is more sandy than the other two.
	No. 3	12.4	12.0	1.93	72	32	17	15	2.64	Yellow silty fine sand, with some clay binder, moist, soft, lumpy, with low plasticity and cohesion.
	No. 4	12.3	11.7	1.95	81	35	19	16	2.65	Yellow cohesive silty clay, laminated, weathered, with some white quartz gravel and fine sand moderately cemented, forming lumps of weak siltstone.
	No. 5	13.6	11.7	1.94	74	33	19	14	2.63	Dull yellow silty clay, with low plasticity, mixed with fine sand and gravel, forming weak siltstone, lumpy, weathered, moist.
	No. 6	11.6	11.5	1.91	72	27	23	4	2.64	Reddish yellow weathered fine sandy silt cemented with clay binder, low plasticity and cohesion, mixed with gravel, forming lumps of weak siltstone.
	No. 7	15.5	13.0	1.87	74	40	23	17	2.66	Light brownish yellow silty clay, low to medium plasticity with some fine sand and little gravel weathered, with lumps of weak siltstone.
	No. 8	19.7	13.0	1.90	70	28	21	7	2.65	Light yellow silty sand, coarse to fine grained, with gravel, moderately cemented with clay binder, having low cohesion, moist, forming lumps of fine sandstone.
	No. 9	18.2	14.0	1.83	66	38	28	10	2.59	Brownish yellow clayey silt with some fine sand, crumbly, weathered, low plasticity, with organic matter.
PHASE II	No.10	24.4	-	-	6	34	26	8	2.57	Reddish brown clayey silt with much fine sand, wet.
	No.11	22.1	-	-	15	28	18	10	2.60	Reddish clayey silt with some fine sand and fibrous roots, soft, moist.
	No.12	19.1	-	-	-	38	29	9	2.60	Reddish clayey silt with some fine sand and plant roots, soft, moist.
	No.13	26.3	-	-	-	31	24	7	2.58	Greyish brown clayey silt, mixed with much sand and stones, some decayed plant remains, loose, soft, wet.
	No.14	30.9	15.0	1.18	-	47	28	19	2.69	Reddish yellow silty clay mixed with fine sand, weathered, medium to high plasticity, wet, lumpy.
	No.15	43.7	20.0	1.62	7	51	29	22	2.66	- ditto - more clayey than above
	No.16	33.5	13.0	1.87	10	44	32	12	2.64	Dark brown silty clay with some fine sand and much decayed plant roots, soft, wet.
	No.17	43.6	17.5	1.74	9	49	34	15	2.66	- ditto -with some plant roots and fine gravels.
	No.18	32.9	14.0	1.85	-	48	34	14	2.60	Brownish silty clay with some fine sand, weathered, with rootlets, soft, wet.

Note: Tested by the Central Materials Laboratory of the Public Works Department, Sarawak

(b) Volcanic Rock

Basalt in the Belaga Formation (point D) and volcanic rock in the Tatau Formation (Point G) can be expected as satisfactory sources of aggregate. Basalt from the Belaga Formation is a tight, darkgrey microcrystalline rock and estimated to form a stratum about 1,200 m thick. Volcanic rock from the Tatau Formation forms a stratum about 450 m thick at the most.

The base of the volcanic succession consists chiefly of rhyolite Lava and partly of Andesite Lava.

(c) River Gravel

A few river gravel deposits are available in the Batang Rajang (Point A) on the side of Tatau and the Sungai Pelagus (Point C) on the side of Kapit. They are chiefly sandstone deposits. Gravel sorting is possbile since the gravel is almost round in shape with a diameter ranging from 10 cm to 15 cm.

(2) Rock Test Results

Table 6-3 shows results of the tests conducted on rocks sampled from 5 potential quarry sites (A, B, D, E, F), suggesting that there are no problems in any of the stones used as aggregate for the Project Road construction.

Although the Los Angeles Abrasion Value (L.A.A.V.) was not conducted for sites A, B, C and E, the L.A.A.V. on eight similar sandstone samples of cretaceous -tertiary by Dennis N.K. (1982) showed results ranging from 19 - 37% with an average of 26%, sufficiently satisfying the requirement for the P.W.D. standard value shown in Appendix 4-2. As for the volcanic rocks from points D and G, visual and rock-hammer tests have revealed ample applicability in aggregate.

(3) Comparison between Potential quarry sites

An evaluation was carried out to select suitable quarry sites for the Project Road constuction in terms of subjects listed in Table 6-4. Appendix 4-3 includes a "General Description of Potential Quarry Sites". Sites C, E and G were judged good; sites A and B fair; and sites D and F were judged poor.

Table 6-3 SUMMARY OF ROCK TEST RESULTS

Item	A	B	C	D	E	F	G
	Batang Rajang River Gravel	Belaga Formation	Sungai Pelagus River Gravel	Bukit Mersing	Nyalau Formation Bukit Naong	Sungai Separai	Bukit Arib
Sampling Point Items	River Gravel	Sandstone	Sandstone	Basalt	Sandstone	Limestone	Andesit
Aggregate Crushing Value (%)	20	11	not necessary	10	16		not necessary
Aggregate Impact Value (%)	20	11	to test	10	19		to test
Modified Aggregate Impact Value (%)	29	23	(strong enough)	10	25	19	(strong enough)
Water Absorption (%)	2.3	1.8		0.6	1.4	0.4	
Applicability for the Project	good	good	good	good	good	good	good

Note: Tested by Central Materials Laboratory of Public Works Deparment, Sarawak

Table 6-4 COMPARISON OF THE POTENTIAL QUARRY SITES

Items / Quarry Site Points	Location	Rock Type	Quantity (m^3)	Direct distance from Project Road (km)	Means of Transpor-tation	1) Evaluation
A	Batang Rajang	River Gravel Sandstone	2) 350,000	1.0	Waterway	fair
B	Pelagus Rapids	Belaga Formation Sandstone	Sufficient	1.5	Access Road to the site	fair
C	Sungai Pelagus	River Gravel Sandstone	500,000	0.5	Access Road to the site	good
D	Bukit Mersing	Basalt	Sufficient	10	Waterway	no good
E	Bukit Kana	Nyalau Formation Sandstone	Sufficient	13	Road	good
F	Sungai Separai	Limestone	3) 30,000	7	Sibu-Bintulu Road	no good
G	Bukit Arib	Rhyalite or Andesit Lana	Sufficient	25	Sibu-Bintulu Road about 1 hour by trunk	good

Note 1) : Evaluation by the Study Team

2) : Source: SESCO (1982) Pelagus hydro-electric project
DENNIS N.K. (1982) feasibility report

6.3 Hydrological Conditions

6.3.1 Climate

The State of Sarawak generally features high temperatures and high humidity with annual rainfall of 4,000 - 6,000 mm. The temperatures range from 20°C to 32°C and are mostly constant throughout the year. Precipitation is particularly heavy from November to January, while comparatively frequent even in the dry season.

6.3.2 River Water Level

Along the Batang Rajang on the side of Kapit, however, the catchment area extends widely with remarkable, quick changes in the water level. The water level changes often as much as 15 m in two or three days.

Appendix 4-4 shows records of the water level in the Batang Rajang at Kapit. Appendix 4-5 shows water level (H) - river current velocity (V) curve at Kapit of the Batang Rajang. If the water level is 7.9 m, the current river velocity is 8 sea-knots, which is the maximum cruising speed of the ferry boats normally used in Sarawak.

There are on average about 140 days each year in which the current river velocity exceeds 8 sea-knots.

6.3.3 Estimation of Rainfall Discharge

The rainfall discharge is estimated by the following method for deciding the bridge length and culvert dimensions:

(1) Rainfall Intensity

The following intensity of rainfall has been adopted on the basis of a 50-year probability by reference to the Hydrological Year Book 1977 and 1980 prepared by the Drainage and Irrigation Department of Sarawak:

R24 = 230 mm/day On the Tatau side

R24 = 175 mm/day On the Kapit side

(Note: The border between the Tatau side and the Kapit side is the middle point of both sides.)

(2) Runoff Coefficient

The runoff Coefficient has been decided as C = 0.5 on the mountainous terrain, and C = 0.4 in the flat hilly area.

(3) Estimated Rainfall Discharge

The estimated rainfall discharge has been obtained from the Rational Formula, as follows:

$$Q = \frac{1}{3.6} \cdot C \cdot R \cdot A \ (m^3/sec)$$

$$R = \frac{R24}{24} \left(\frac{24}{T}\right)^{2/3}, \quad T = T_1 + T_2$$

where,
- Q : Estimated Rainfall Discharge (m^3/sec)
- C : Runoff Coefficient
- R_{24} : Rainfall (mm/day) at 50-year Probability
- A : Catchment Area (km^2)
- T : Time of Concentration (hr)
- R : Rainfall Intensity (mm/hr)
- T_1 : In-flow Time (hr) (T_1 = 0.5 hr)
- T_2 : Concentration Time along the River (hr)

The Catchment Area for the determination of the dimension of road structures is obtained from a topographical map with a scale of 1:50,000 for the Alternative Routes study as well as of 1:50,000 and 1:10,000 for the Best Route study.

(4) Vertical Clearance to Bridge Over the Design High Water Level

In general the vertical clearance from the bottom of short span bridges to the design high water level should be +1.00 m (3.3 feet) or more, following the Sarawak Government Standard. The HWL is to be prescribed at the water level which has not been exceeded for 10 continuous days in previous records. However, in the Batang Rajang, the vertical clearance should be 15 m or more since cargo boats and timber shippping boats transport upstream from the bridge point.

6.4 Construction Method

6.4.1 Local Contractors

Contractors are classified as follows:

Head I. Engineering Contractors
II. Building Contractors
III. Road, Quarry and Earth Work Contractors

The scale of the contractors are classified into eight separate classes by contract price as shown in Table 6-5.

There are 13 Class 'A' registered local contractors in Sarawak at present. All road construction works are carried out by registered local contractors under the supervision of P.W.D., except for small bridges and long span bridges which are constructed by foreign contractors.

6.4.2 Project Implementation Method

In this Project, since a huge volume (14 million m^3) of earth work should be executed by heavy equipment, the contractor should possess sufficient equipment and technical capability for the execution. From this point of view, the selection of the contractor for this project should be decided based on the following alternatives:

Alternative 1: Direct management by P.W.D.
Alternative 2: Contract with foreign contractors by international tender
Alternative 3: Contract with joint ventures of foreign and local contractors

Considering that the construction equipment owned by the State Government is so limited in its capacity and number and also that most of it is fully in use, it is not likely that P.W.D. could execute such a large scale construction project like this unless they are provided with large scale reinforcement of heavy equipment and capable personnel.

For this reason, Alternative 1 is not recommendable. Alternative 2 is also not recommendable as it will not bring any merit to the local construction industry in spite of the big investment.

Alternative 3 has many merits. For example, it will provide technology transfer to local contractors through construction by joint venture with the technically advanced foreign contractors and also it will contribute many economic benefits to the local society. From the above points of view, it is recommended that this project be implemented by Alternative 3.

Table 6-5 NUMBER OF REGISTERED LOCAL CONTRACTORS CLASS 'A' TO 'BX' BY CLASSIFICATION

Classes	Contract Price	Number of Contractors for Head III
Class 'A' for contracts: for works or supplies estimated to cost	$100,001 and above	13
Class 'B' for contracts: for works or supplies estimated to cost	$100,001 and $2 million	6
Class 'BX' for contracts for works or supplies estimated to cost between	$100,001 and $1 million	4
Class 'C' for contracts for works or supplies estimated to cost between	$75,001 and $500,000	-
Class 'D' for contracts for works or supplies estimated to cost	$50,001 and $250,000	-
Class 'F' for contracts for works or supplies estimated to cost	$35,001 and $150,000	-
Class 'EX' for contracts for works or supplies estimated to cost	$15,001 and $75,000	-
Class 'F' for contracts for works or supplies estimated to cost up to	$35,000	-

Source: Public Works Department List of Registered Constructions in Kuching

CHAPTER 7

CONTENTS

CHAPTER 7 ALTERNATIVE ROUTE

7.1 Design

7.1.1 Design Standard

(1) Geometric Design Criteria

From January 1st, 1983, the Sarawak State Government adopted the metric system normally used in Peninsula Malaysia instead of the yard-pound system. Consequently, the Sarawak State Government uses the same geometric design criteria as that of Peninsula Malaysia shown in Fig. 7-1 and Table 7-1.

Therefore, this study follows Group-04 for the Trunk Road and Group-01 for Rural Road of the criteria of Peninsula Malaysia, with reference to the forecasted traffic volume in Chapter 9.

(2) Structure Design Criteria

1) Bridges

(a) Specifications

As regards bridges, the specifications should follow the current one published by the Sarawak Government. The dead load should accord with BS 648 and BS 5400, Part 5, and the live load (including the impact load and the wind load) should accord with BS 153, Part 3A.

(b) Loadings

According to the B.S., loadings are shown below:

i) Super-structure
- dead load
- live load

ii) Sub-structure
- dead load
- live load
- earth pressure
- running water pressure
- impact load by drift wood
- buoyancy

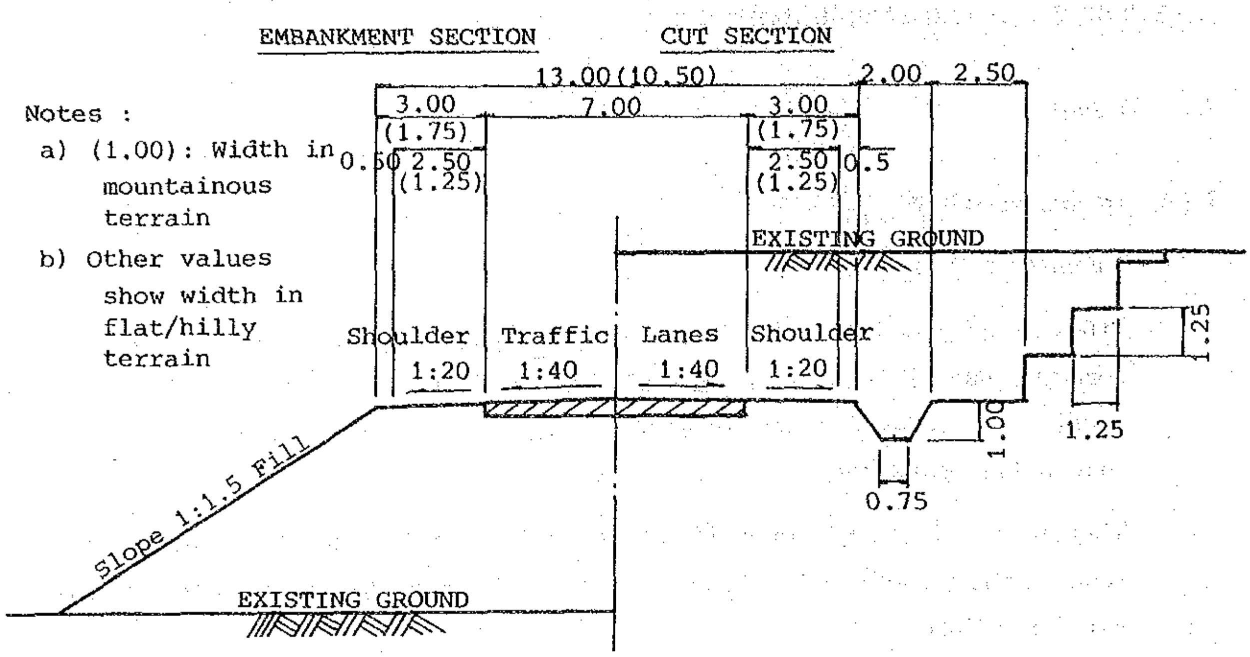
Fig. 7-1 TYPICAL CROSS SECTIONS

1. Trunk Road (Group 04 of the Criteria)

Notes :

a) (1.00): Width in mountainous terrain

b) Other values show width in flat/hilly terrain

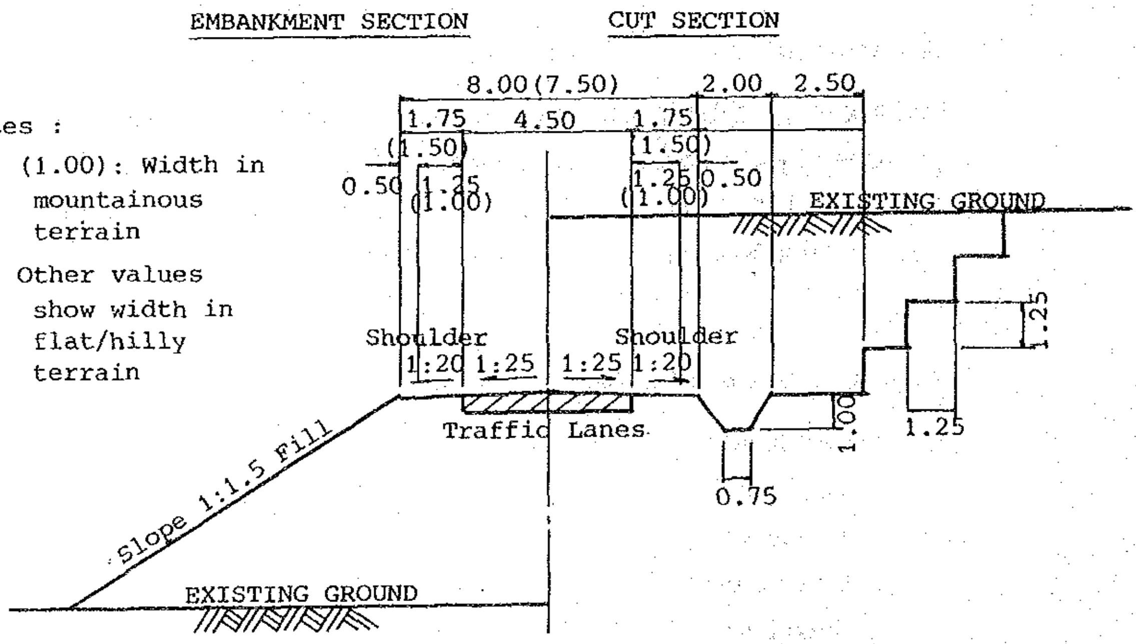


2. Rural Road (Group 01 of the Criteria)

Notes :

a) (1.00): Width in mountainous terrain

b) Other values show width in flat/hilly terrain



3. Bridge of Trunk Road

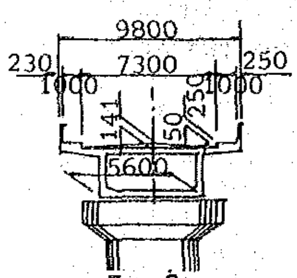


Table 7-1 MINIMUM GEOMETRIC DESIGN CRITERIA FOR NEW ROADS IN RURAL AREAS (METRIC)

1. TRAFFIC		LIGHT			MEDIUM		HEAVY
2. GROUP		01	02	03	04	05	06
3. ADT TWO WAYS	VEH/DAY	<100	100 - 250	250 - 400	400 - 750	-	-
4. DHV TWO WAYS	VEH/HR	-	-	-	100 - 200	200 - 800	>800 8
5. TERRAIN	-	F R M	F R M	F R M	F R M	F R M	F R M
6. DESIGN SPEED	KM/HR	50 50 30	60 50 40	80 60 50	80 60 50	100 80 60	120 100 80
7. PAVEMENT TYPE	-		TO BE DETERMINED				
8. SURFACE WIDTH	M	4.5	5.0	5.0	7.0	7.5	3.5 EACH LANE 3.75 DESIRABLE
9. USABLE SHOULDER WIDTH - MIN.	M	1.25 1.25 1.00	1.25 1.25 1.00	2.00 2.00 1.00	2.50 2.50 1.25	3.00 3.00 1.25	3.00 3.00 1.50
10. FORMATION WIDTH 1	M	8.0 8.0 7.5	8.5 8.5 8.0	11.0 11.0 9.0	13.0 13.0 10.5	14.5 14.5 11.0	24 24 21
11. CENTRAL RESERVATION	M	-	-	-	-	-	VAR 3.00 MIN.
12. RESERVE WIDTH - MIN.	M	20	20 - 30	30	40 DESIRABLE 30 MINIMUM	40	40
13. MAX. GRADIENT	%	7 9 10	5 8 10	4 6 9	4 6 9	3 5 8	3 4 7
14. CRITICAL GRADE LENGTH 2	M	NOT APPLICABLE	USE LAY BYES	350 180 120	350 180 120	500 250 150	500 350 150
15. STOPPING SIGHT 3 DISTANCE - MIN.	M	60 60 60	80 60 60	110 80 60	110 80 60	160 110 80	210 160 110
16. PASSING SIGHT DISTANCE - MIN.	M	USE LAY BYES	430 350 350	560 430 350	560 430 350	700 560 430	- - -
17. MIN. RADIUS	M	80 80 30	120 80 50	210 120 80	210 120 80	350 210 120	530 350 210
18. TRANSITION CURVE 4 MIN. LENGTH	M	NOT APPLICABLE	70 60 60	80 70 60	80 70 60	90 80 70	100 90 80
19. WIDENING	M	0.75 1.00 1.50	0.75 1.00 1.50	- 1.00 1.25	- 1.00 1.25	- - 0.75	- - -
20. SUPERELEVATION	RATIO	1:10	1:10	1:10	1:10	1:10	1:10
21. CAMBER / CROSS FALL	RATIO	1:25	1:30	1:30	1:40	1:40	1:50
22. VERTICAL CURVE 3 — CREST - MIN. K	M/%	10 10 10	15 10 10	30 15 10	30 15 10	60 30 15	105 60 30
22. VERTICAL CURVE 3 — SAG - MIN. K	M/%	12 12 8	16 12 10	24 16 12	24 16 12	38 24 16	52 36 24
23. ACCESS CONTROL	M	NONE REQUIRED	NONE REQUIRED	NONE REQUIRED	NONE REQUIRED PARTIAL DESIRABLE	PARTIAL 7	LIMITED 6
BRIDGE — OVER PASS WIDTHS BETWEEN PARAPETS	M	7.0	7.5	8.0	9.0	9.0	18 SINGLE OPENING 2 @ 9 DBL. OP.
BRIDGE — UNDER PASS WIDTHS BETWEEN ABUT. WALLS	M	7.0	7.0	8.5	11.0	16.5	SINGLE OPENING 2 @ 0.5 DBL.OP.
BRIDGE — VERTICAL CLEARANCE OVER ROADWAYS	M	4.50	4.50	4.50	4.50	4.75	4.75

REMARKS

1. FORMATION WIDTH INCLUDES 0.5M EACH SIDE FOR ROUNDING
2. USE TRUCK CLIMBING LANES IF CRITICAL GRADE LENGTH IS EXCEEDED
3. STOPPING SIGHT DIST. TO BE INCREASED ON DOWN GRADE
4. VALUES GIVEN ARE FOR MIN. LENGTH REQUIRED FOR 10% SUPERELEVATION RUN-OFF. SPIRAL SHOULD NOT BE LESS THAN RUN-OFF LENGTH. SEE A.A.S.H.O. FOR MIN. RUN-OFF LENGTH OF OTHER RADII & SUPERELEVATION RATES
5. MINIMUM LENGTH OF VERTICAL CURVE 'L'=KA

   L CURVE LENGTH IN METERS

   A ALGEBRAIC DIFFERENCE OF GRADE IN PERCENT
6. ALLOWING GRADE CROSSINGS WITH OTHER ROADS & RAIL ROAD BUT NO PRIVATE ACCESS
7. ACCESS BY PRIVATE PROPERTY OWNERS AT INTERVALS NOT LESS THAN 400 M
8. CONSIDERATION SHOULD BE GIVEN TO DEFERRED CONST. OF ADDITIONAL LANES WHERE D.H.V. <1000 IN ONE DIRECTION.

ABBREVIATIONS

M = METER
F = FLAT
R = ROLLING
M = MOUNTAINOUS
D.H.V. = DESIGN HOURLY VOL.
DBL = DOUBLE
VEH. = VEHICLE
VAR = VARIABLE
DES = DESIRABLE

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(c) Influence of earthquakes

It is unecessary to worry about the influence of earthquakes since no earthquake damage has been experienced in Sarawak.

(d) Influence of temperature changes

Temperature is usually stable throughout the year, varying within only 15 degrees centigrade which is considered too small to affect the design structure.

(e) Bridge width

Bridge width is indicated in Fig. 7-1.

(3) Pavement Design Standard

Road note 31 is used.

7.1.2 Road/Structure Design

(1) Road Alignment

The alternative route alignment plan is carried out using a topographcial map with 100 feet contour line intervals at a scale of 1:50,000 obtained from the Sarawak Land and Survey Department through the Sarawak Public Works Department. According to the map and field survey, the topography along the Tatau-Kapit corridor is characteristically undulated like a so-called long, saw-toothed, hilly terrain mostly covered with tropical jungle. This limits the number of alternative routes as well as the extent of possible route locations.

As shown in the location map, the road alignment for the first 90 km follows the valley of Batang Tatau and Sungai Anap. For the remaining 50 km, the proposed alignment crosses the watershed between the Fourth Division and the Seventh Division and passes the proposed hydroelectric dam site at Pelagus Rapids, continuing to run along the right bank of the Batang Rajang to a point downstream of the confluence with the Batang Balleh. The Project Road crosses the Batang Rajang by bridge or by ferry boat to the Lepong Balleh Road.

Regarding alignment design, the following considerations are taken into account:

i) Steepest gradient 8%

ii) Aiming at balance of cut and fill volume in earth work.

(2) Structural Design

The structures along the alternative routes consist of bridges and road crossing drainage structures. For bridges, a concrete bridge type is adopted unconditionally because the Public Works Department of the Sarawak State Government has decided to adopt concrete bridges rather than steel bridges from a maintenance point of view. The Study Team has followed this concept.

Table 7-2 is prepared to determine the structural dimensions.

1) Bridges

If bridges are constructed in the river channel, the minimum span should be as in Table 7-2 according to the river water discharge. In the case of a single span bridge without a pier, a pre-tensioning concrete beam produced in Sarawak is used. The beam should be L=9.1 m (30 feet) at a minimum.

2) Road Crossing Structure for Drainage

A box culvert or a pipe culvert is adopted for small rivers with water discharge of 50 m^3/sec. or less.

7.2 Alternative Route Location of the Project Road

7.2.1 Topographical Map

In the Phase I Study, based on the map with a scale of 1:50,000, the best route is selected through comparison of several alternative routes for the Tatau-Kapit Trunk Road. The topographical map with a scale of 1:50,000 used in this Study is the same one which the Land and Survey Department of the Sarawak State Government possesses. To select a more detailed Best Route alignment, a newly developed map with a scale of 1:10,000 was used. However, since aerial photographs could not be taken in time owing to unfavourable weather conditions, the Phase II Study was postponed about two years until after the mapping of the aerial photographs.

7.2.2 Conditions for Alternative Route Selection

The following conditions were considered for the selection of alternative route alignments:

Table 7-2 RELATIONSHIP BETWEEN RAINFALL DISCHARGE AND DIMENSION OF ROAD STRUCTURES

Rainfall Discharge (m^3/sec)	Dimension	Structures	Remarks
	Diameter		
- 2.7	ϕ 1,066 mm	Corrugated Pipe	
2.8- 5.7	ϕ 1,524 mm	Corrugated Pipe	
	Culvert Box		
5.7- 6.3	1.50m x1.50m	Precast P.C. Culvert Box	
6.4-11.2	2.00x2.00	Precast P.C. Culvert Box	
11.3-17.5	2.50x2.50	Precast P.C. Culvert Box	
17.6-21.0	3.00x2.50	Precast P.C. Culvert Box	
21.1-25.2	3.00x3.00	Precast P.C. Culvert Box	
25.3-35.0	2-2.50x2.50	Precast P.C. Culvert Box	
35.1-42.0	2-3.00x2.50	Precast P.C. Culvert Box	
42.1-50.0	2-3.00x3.00	Precast P.C. Culvert Box	
	Span Length		
50.1- 100	9.1m	Single Span 1 x 30 feet Beam	Precast Concrete Bridge
101 - 160	16.4	" 1 x 54 feet Beam	
161 - 300	24.4	" 1 x 80 feet Beam	
301 - 400	27.4	" 1 x 90 feet Beam	
401 - 500	30.4	" 1 x 100 feet Beam	
501 - 1,000	30.5 + 0.0022 Q*	Double Span 2 x 80 feet Beam	
		2 x 90 feet Beam	
		2 x 100 feet Beam	
		Triple Span 3 x 100 feet Beam	
More than 1,000	53 m	Batang Rajang	

Note Q*: Rainfall Discharge (m^3/sec).

Design capacity is 80% of theoretical capacity

(1) Topography

From a topographical point of view, the alternative routes are selected out of routes which link Tatau to Kapit along the Batang Tatau, the Sungai Anap in the Fourth Division and the Sungai Pelagus, the Batang Rajang in the Seventh Division towards Kapit.

(2) Government Offices and Large Communities

Between Tatau, the starting point of the proposed road, and Kapit, the terminal point, the Government branch offices - the Agricultural Department and the Police Station - are solely located in Sangan. A large community is located at Mutput. Therefore, the Project Road should pass as closely as possible to Sangan and Mutput.

(3) Long Houses

The local population is small and scattered along the rivers. Long Houses are mostly located downstream of Rumah Gerina (Sangkap) along the Sungai Anap in the Fourth Division. There are only four Long Houses beyond Sangkap along the Sungai Anap. One Long House with nine doors was built in 1983 and three Long Houses are at the confluence of Sungai Anap and Sungai Takan. For the selection of alternative routes, attention was paid not to intrude into the boundaries of the Long Houses.

(4) Hydroelectric Dam Construction Project at Pelagus

There is a proposed hydroelectric dam construction project at Pelagus Rapids along the Batang Rajang. This project figures prominently in the Malaysian Energy Policy.

The proposed road should be located as close as possible to the dam site so that it can be used as an access road.

(5) Soil Condition

No large swamp areas are located along the proposed road, which traverses alluvium stretching along the Sungai Sangan, Sungai Sabuloh and Sungai Muput in the Fourth Division. Soil conditions seem to pose no obstacles to any of the potential areas figuring in the selection of alternative routes.

(6) Agricultural Development Potential Areas

Although as of yet no agricultural development project exists in the area mainly due to rugged topography, an alluvium plain along the Sungai Sangan, and the

Sungai Muput in the Fourth Division means some agricultural development potential exists, as stated in 4.3.2.

Easy access to the above areas was taken into consideration in the selection of alternative routes.

(7) Forestry and Logging Roads

Logging, which has contributed to export trade, is brisk in the Project Area. The shipment of logs is carried out at dumping stations around stable water levels available along the rivers.

a) Logging in the Fourth Division

At Sangan, the water level of the Sungai Anap is stable and navigation of express launches, barges for log shipments and speed boats is available throughout the year. But upstream of the Sungai Anap beyond Sangan the water level is too low during the dry season. Therefore, the farthest point for log shipment is around Sangan and the Project Road should accordingly pass as closely as possible to Sangan.

Although logging roads have been well developed between Tatau and Sangkap, virgin jungle is distributed between Sangkap and the watershed dividing the Fourth Division and the Seventh Division. Subsequent future logging is expected in the area

For this purpose, the main logging road will reach from Sangan up to a place about 9 km downstream from Kapit along the Batang Rajang by 1995 - 2005.

b) Logging in the Seventh Division

Around the confluence of the Batang Rajang and the Batang Balleh, the water level is stable and express launches, barges for log shipments and speed boat navigation are available throughout the year. Log shipment is conducted at dumping stations between the confluence and Pelagus Rapids. But this is only possible for half the year, for the water level is not stable during the dry season.

Therefore, logging roads are well developed in the area extending from the points around the confluence of the Batang Rajang and the Batang Balleh up to Pelagus Rapids.

Accordingly, the Project should pass as closely as possible to those dumping stations. The geometrics of existing logging roads are much inferior to that of the Trunk Road Standard, which indicates a new road with high standards should be constructed for the Project Road.

7.3 Major Alternative Routes

7.3.1 Outline of Major Alternative Routes

The major alternative route means an alternative route extending a long distance. In this Project, the Project Road is obliged to pass through either the left side or the right side of the rivers due to topographical restrictions. It is worthwhile to study the major alternative routes only in the Tatau-Sangkap section along the Batang Tatau and Sungai Anap. The remaining sections have no alternative routes, as the route is determined automatically due to topographical conditions.

(1) Major Alternative Section

1) Tatau-Sangkap Section

There are two major alternative routes in this section as shown in Fig. 7-2.

(a) Major Alternative Route - 1

This route goes along the left side of the Batang Tatau and the Sungai Anap in the undulated area. The starting point is located at a point along the Ulu Batang Mukah-Bintulu Road about 0.8 km away from Tatau bridge across the Batang Tatau. For this route the volume of earth work is much greater, but bridge construction costs are less than for the other route.

(b) Major Alternative Route -2

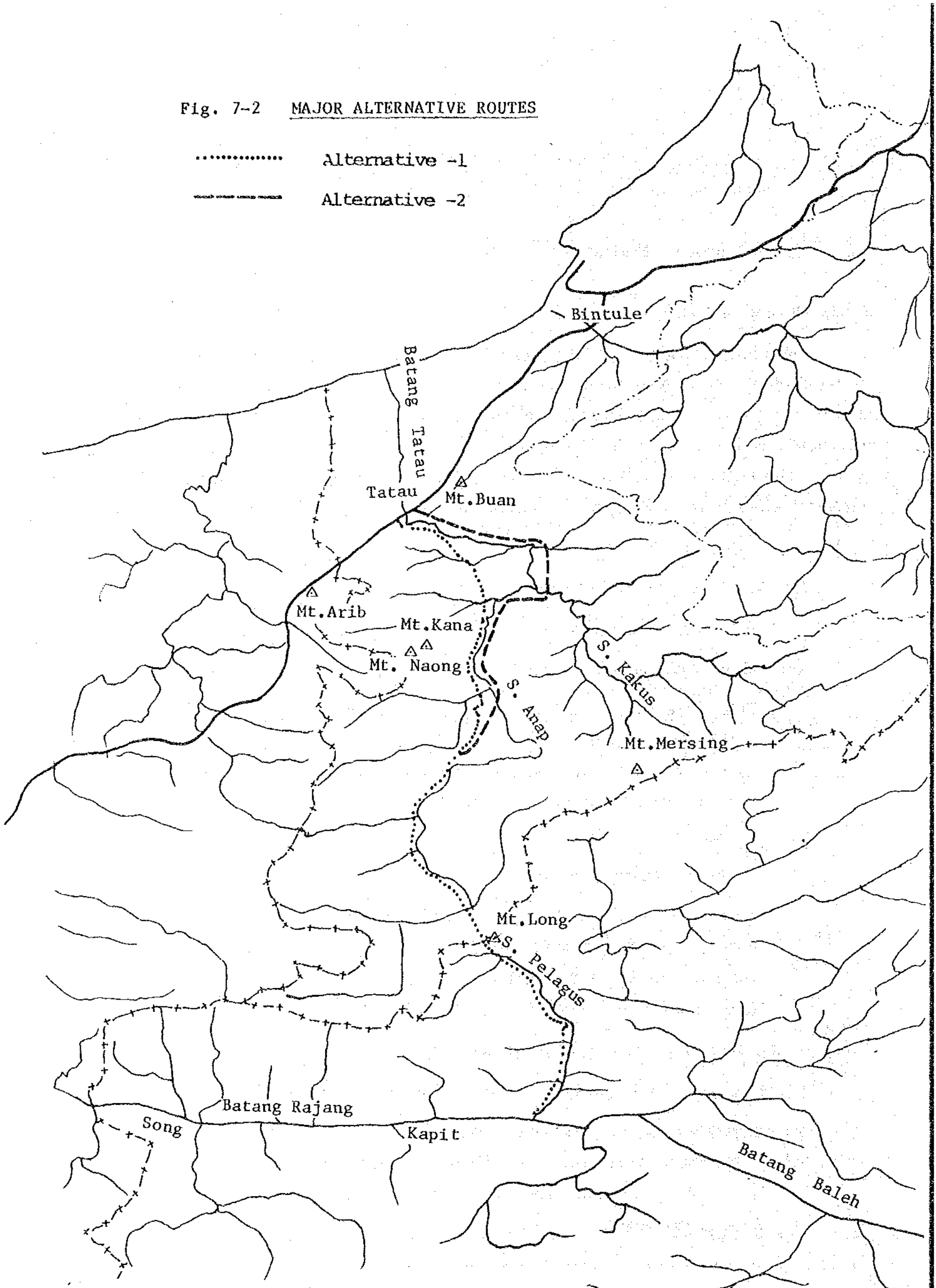
This line goes along the right side of the Batang Tatau and the Sungai Anap, mostly in moderate land. As both rivers meander down in a more indirect fashion, this route is longer than Route - 1 by 12 km, and this route needs 2 long span bridges to cross the Sungai Khakus and the Sungai Anap.

(2) Topographically Determined Alignment Section

1) Sangkap - Confluence of the Sungai Anap and the Sungai Takan

Any side route is acceptable because similar topography lies along both sides of the river in this section. Since Sangkap is located on the left side of the Sungai Anap, a route should be selected along the Sungai Anap to save construction costs.

Fig. 7-2 MAJOR ALTERNATIVE ROUTES



2) Confluence of the Sungai Anap and the Sungai Takan - Pelagus Rapids Section

As similar topography lies along both sides of the Sungai Pelagus, any side route is acceptable in terms of alignment and construction costs.

A route along the right side of the Sungai Pelagus, however, is selected because the route runs along the right side of the Batang Rajang up to somewhere close to Pelagus Rapids.

3) Section from around the confluence of the Batang Rajang and the Batang Balleh to Pelagus Rapids

The route crosses the Batang Rajang somewhere downstream of the confluence of the Batang Rajang and the Batang Balleh to save construction costs, and passes along the right side of the Batang Rajang and reaches close to Pelagus Rapids.

7.3.2 Selection of the Best Major Alternative Route

(1) Evaluation Method

As the socio-economic conditions are almost the same in the areas along the major alternative routes, it is obvious that the best major alternative route is the one with the lowest construction costs.

(2) Selection of the Best Major Alternative Route

The best major alternative is route-1, since construction costs are lower than for Route-2, as shown in Table 7-3.

Table 7-3 COMPARISON OF CONSTRUCTION COST OF MAJOR ALTERNATIVES

Major Alternative Route		Direct Construction Cost (M$'000)
1	52.4 km	55,849
2	64.2 km	62,214

Note: 1. A comparison of major alternative routes on vertical alignment and structure is shown in Appendix 5-1.

2. A breakdown of construction costs is shown in Appendix 5-2.

7.4 Minor Alternative Route

The minor alternative routes are considered in the 5 sections along the best major alternative route as shown in Fig. 7-3. Each segment has two alternative routes.

7.4.1 Alternatives of the Tatau-Sangkap Section

(1) Segment 1

(a) Line A

The route passes through Sangan, where government branch offices are located. The line is 2.2 km longer than Line B.

(b) Line B

The route passes far from Sangan, requiring an access road 7 km long to Sangan.

(2) Segment 2

(a) Line A

The route goes southward in the western saddle part of Bukit Bigiou.

The route is 2.5 km shorter than Line B.

(b) Line B

The line goes southward in the east of Bukit Bigiou along the Batang Tatau.

(3) Segment 3

(a) Line A

The route is closer to the mountainous area around Rumah Jamba compared with Line B.

The route is 0.45 km shorter than Line B.

(b) Line B

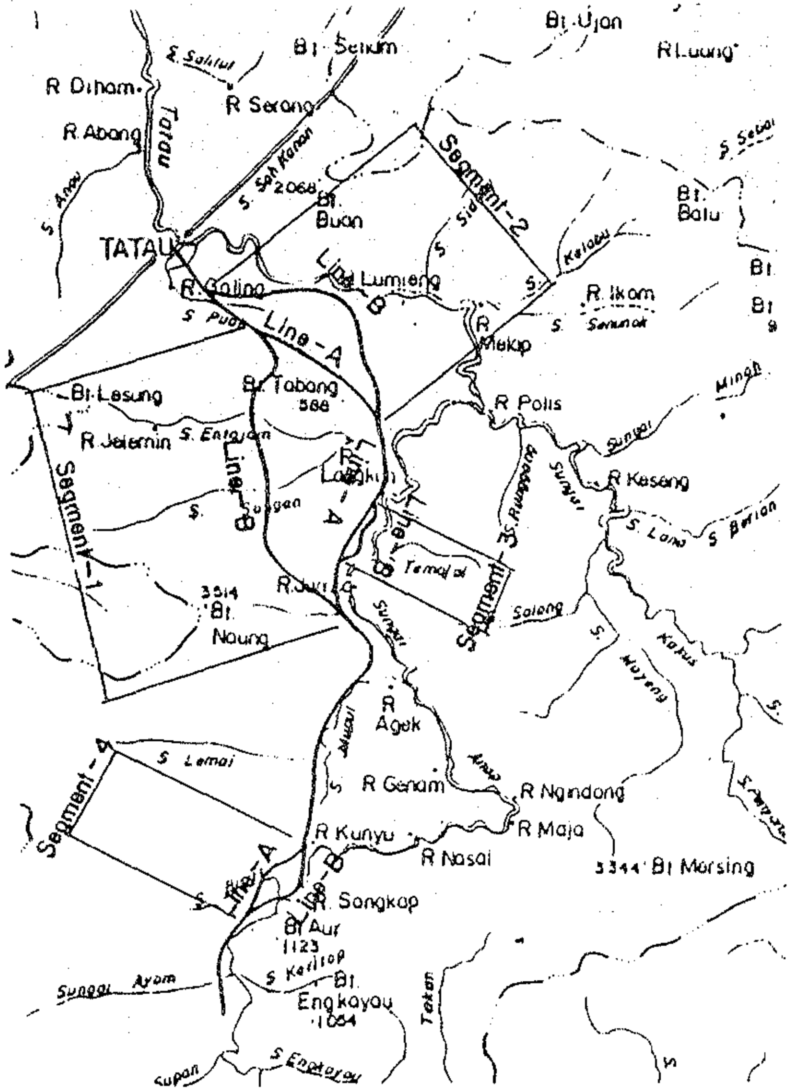
The route goes along the east of the Sungai Anap around Rumah Jamba.

(4) Segment 4

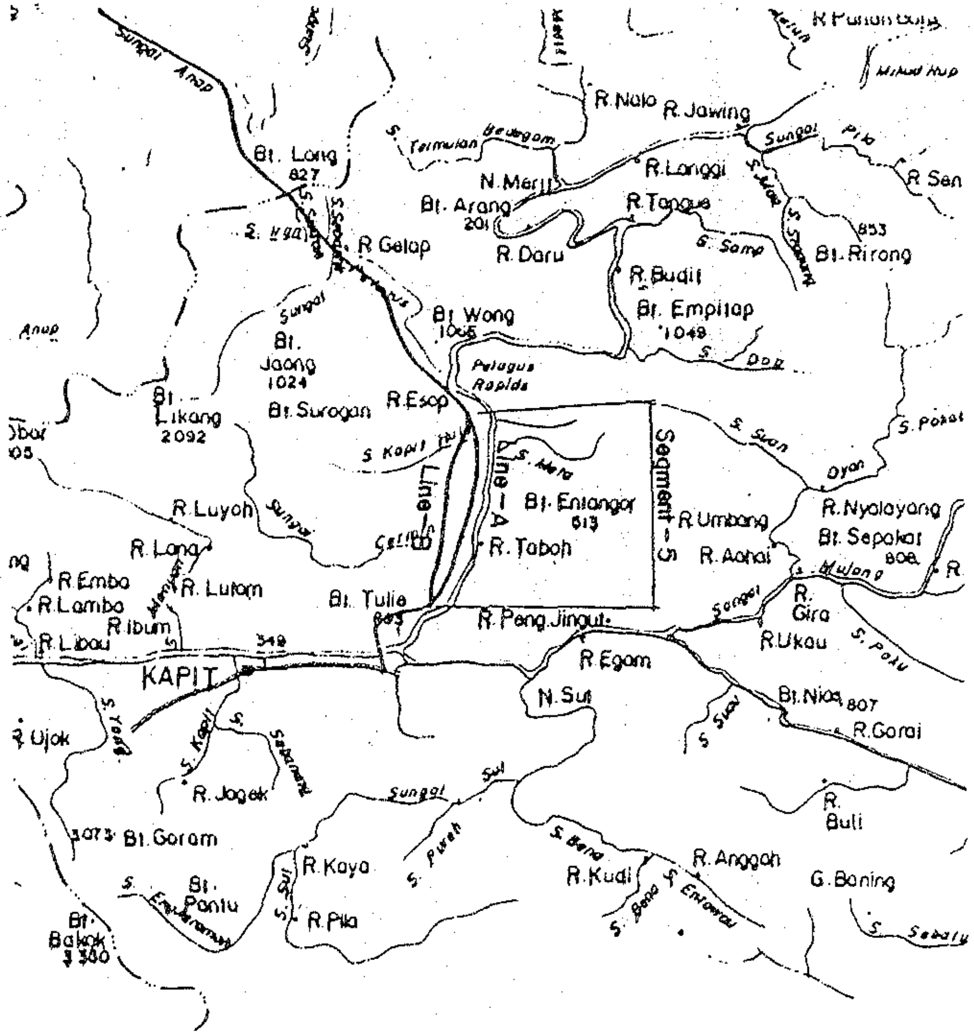
(a) Line A

The route goes closer to the mountainous area around Rumah Sangkap compared with Line B.

Fig. 7-3 MINOR ALTERNATIVE ROUTES



Segment 1 ~ 4



Segment 5

The route is 0.65 km shorter than Line B.

(b) Line B

The route goes along the east of the Sungai Anap around Rumah Sangkap.

7.4.2 Alternatives of the Pelagus Rapids - Kapit Section

(1) Segment 5

(a) Line A

The route goes along the east of the Batang Rajang.

The route is shorter than Line B.

(b) Line B

The route goes along the east of the Batang Rajang closer to mountainous areas than Line A.

7.4.3 Selection of Best Minor Alternative Routes

Since the topography is characterized by tropical jungle along all the minor alternative routes, the impact on the regional economy is almost the same, regardless of the alternative route selected.

As shown in Table 7-4, a comparison of construction costs of the minor alternative routes, Line A is naturally selected as the best minor alternative route in all cases because of lower construction costs.

Table 7-4 COMPARISON OF THE DIRECT CONSTRUCTION COST OF MINOR ALTERNATIVE ROUTES

(Unit: M$'000)

Item	Line A	Line B
Segment 1	31,847	34,859
Segment 2	20,505	23,905
Segment 3	11,368	12,041
Segment 4	12,613	13,757
Segment 5	20,193	20,995

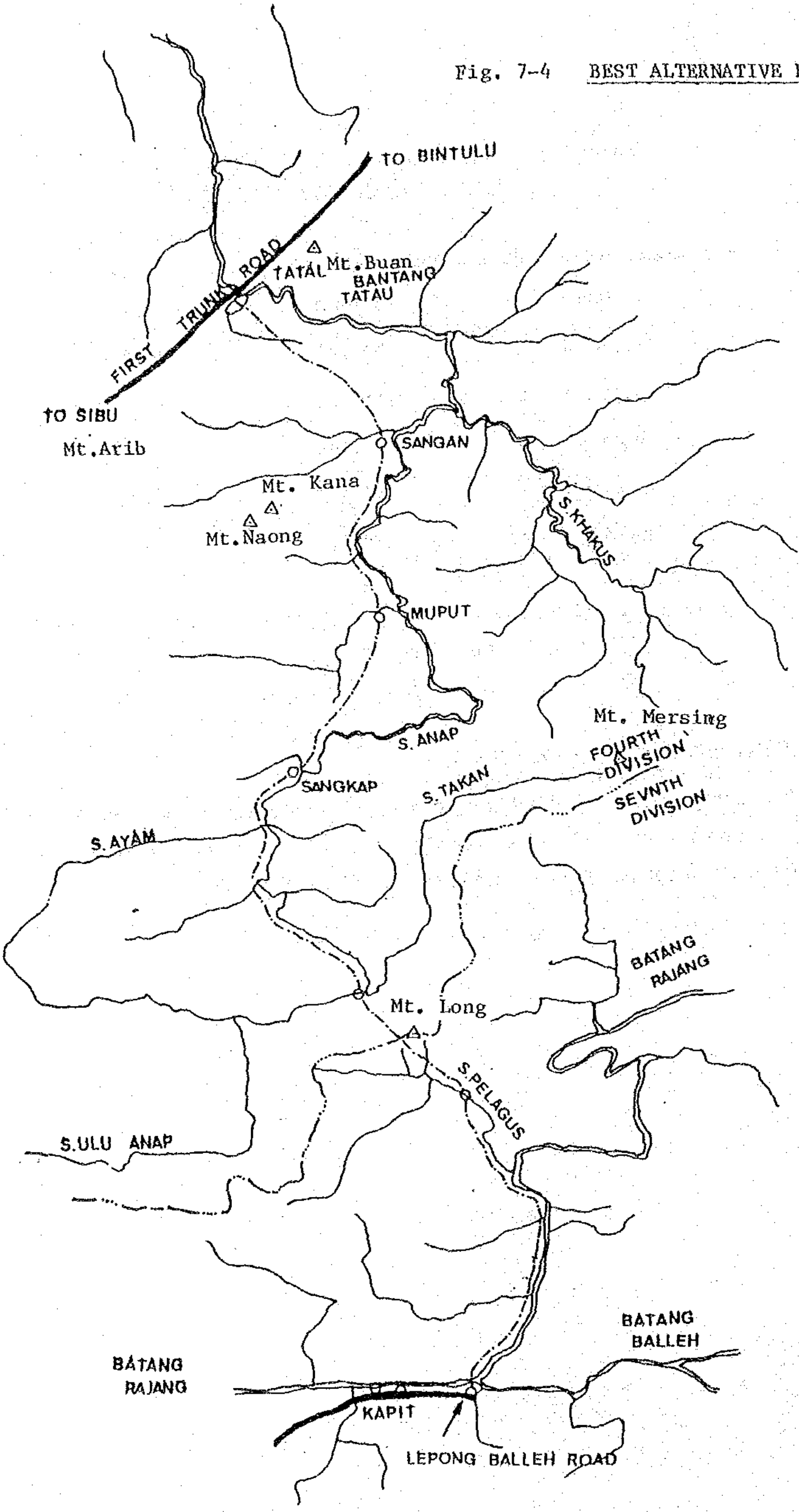
Notes: 1. A comparison of minor alternative routes on vertical alignment is shown in Appendix 5-3

2. A breakdown of construction costs is shown in Appendix 5-4.

7.5 Determination of the Best Route

The best route was determined through a comparison of major and minor alternative routes as shown in Fig. 7-4. Then, aerial photographs were taken along the best route, and the extent of mapping was determined for the Phase II Study.

Fig. 7-4 BEST ALTERNATIVE ROUTE



CHAPTER 8

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CHAPTER 8 BEST ROUTE

8.1 Engineering Study of the Best Route

8.1.1 Refinement of the Best Route Alignment

(1) Topographical Map at a Scale of 1:10,000

The best route, selected through the Phase I Study using a topographical map at a scale of 1:50,000, was refined further using a topographical map at a scale of 1:10,000 in extension of a 1 km width, prepared by the Mapping Team with the help of the Sarawak Land and Survey Department. For the contour line, a 100 feet (30 m) interval was used in 1:50,000 map, while 2 m in moderate terrain and 10 m in steep terrain were used for the 1:10,000 map.

(2) Refinement of the Best Route Alignment

As the topographical map of 1:50,000 in Phase I could not present the subtle change of topography due to the undulation of the Project Area, a discrepancy of about 10 km occurred between both alignments of the best route in Phase I and Phase II.

The following were considered to refine the best route alignment:

(a) The steepest gradient is 8 percent.

(b) The sharpest horizontal curve radius is 150 m.

(c) Attention is paid to balancing the volume of cut with the fill as much as possible.

Results of the refinement of the best route is shown in the "Drawings".

8.1.2 Road/Structure Design

(1) Trunk Road Design

The route is divided into 7 construction sections and 1 upgrading section of the Lepong Balleh Road. The outline of each section is as follows:

(a) Construction Section 1 (Tatau Junction - Sangan 21 km long)

The route goes almost straight south to connect Tatau and Sangan, branching off at a point about 0.8 km from Tatau Bridge across the Batang Tatau along the Ulu Mukah - Bintulu Road, a portion of the First Trunk Road. The route crosses the Sungai Kelawit and the Sungai Sangan with comparatively less earth work volume, excepting an approximately 35 m deep cut for passing the watershed with 150 m altitude located at about 14 km from the starting point of the route. The construction cost per kilometer is similar to that of Construction Section 5 (Sungai Ulu Anap - Pelagus), which is the smallest among the 7 sections.

(b) Construction Section 2 (Sangan - Muput 19.5 km long)

Since the strike ridges are closely located along the right side of the Sungai Anap, the route is obliged to pass the mountainside of the masses at a comparatively high altitude. After passing the saddle part at an altitude of about 130 m, about 29.5 km from the starting point by an approximately 40 m very deep cut, the route passes through flat alluvial terrain and crosses the Sungai Muput.

(c) Construction Section 3 (Muput - Sangkap 12.5 km long)

Although the route passes through terrain with a great number of undulations, the further the route goes, the steeper the topography becomes.

The route crosses the Sungai Melat, a tributary of the Sungai Anap, where the route passes by the left side of the Sungai Anap very close to the river channel. The construction cost per kilometer is medium scale among the 7 sections.

(d) Construction Section 4 (Sangkap - Sungai Ulu Anap 35.55 km long)

As the Sungai Anap runs north, eroding geological weak-points of the strike ridges lie in an east-west direction, and steep strike ridges lie very close to both sides of the Sungai Anap. The route is set along the mountainside and the foot of the mountains, bypassing the mountain masses. The route is characterized by very rugged terrain with much cut volume making it very difficult to balance the cut and embankment volume. This section is the most expensive to construct among the 7 construction sections.

The construction cost per kilometer is 170 percent more than that of Section 1, the cheapest section.

(e) Construction Section 5 (Sungai Ulu Anap - Pelagus 15.65 km long)

The route passes by the low watershed at about 100 m altitude near the border of the Fourth Division and the Seventh Division, which decreases earth work volume. Passing by the watershed, the route runs along the left side of the Sungai Pelagus. There is a deep cut portion around a sharp corner of the Sungai Pelagus, and the route terminates just after crossing the Sungai Pelagus. The construction cost per kilometer is very low, similar to that of Section 1.

(f) Construction Section 6 (Pelagus - Right side of the Batang Rajang 32.4 km long)

The route passes by the hillside on the right side of the Sungai Pelagus to reach close by to the Pelagus hydroelectric dam site, and then runs along steep mountainside on the right side of the Batang Rajang. Although the route passes mostly along the river channel of the Batang Rajang, the route runs through two saddle parts at 140 m altitude by deep cut, instead of running through steep mountainside located along the right side of the river. The right side of the Batang Rajang Bridge is then reached.

The earth work volume is remarkably large due to the steep topography. The construction cost per kilometer is ranked second to that of Section 4, and is 124 percent of that of Section 1.

(g) Construction Section 7 (Right side of the Batang Rajang - Lepong Balleh Road 2.2 km long)

Crossing the Batang Rajang by about a 400 m long bridge, the route bends sharply to the east to the mass of mountains located close to the end of the bridge, reaching the Lepong Balleh Road. A lot of earth work volume is required for road construction since the route passes through steep mountainside paying attention not to pass the boundary of Long Houses.

(h) Construction Section 8 (Lepong Balleh Road 5 km long)

Aside from the above construction sections 1 to 7, the Lepong Balleh Road will be upgraded to meet the conditions of other sections. The content of the construction work is as follows:

- improvement of vertical alignment exceeding 9 percent
- improvement of pavement

Replacement of the existing wooden bridge across the Sungai Keropak with a permanent bridge.

The vertical gradient distribution by section is shown in Table 8-1.

Table 8-1 VERTICAL GRADIENT DISTRIBUTION BY SECTIONS

Section	Vertical Gradient (%)				Total (Km)
	0 - 2	2 - 4	4 - 6	6 - 8	
1	8.80	5.10	4.85	2.25	21.00
2	8.35	5.50	2.25	3.40	19.50
3	4.00	2.15	6.35	0	12.50
4	6.75	7.25	15.75	5.80	35.55
5	10.15	2.10	2.85	0.55	15.65
6	18.55	8.55	4.25	1.05	32.40
7	0,50	0.80	0.90	0	2.20
Total	57.10	31.45	37.20	13.05	138.80

(2) Rural Roads

Rural roads branched off from the Trunk Road are planned to contribute to the development of isolated communities as follows:

a) about 1 km long to Sangan
b) about 1 km long to Muput

Since the Trunk Road passes close to the dam site at Pelagus, no rural road to the site is considered.

(3) Structure Designs

Structural dimensions are decided based upon Table 7-2. The number of proposed bridge construction sites is almost the same as in Phase I, but the number of proposed box culvert and pipe culvert construction sites is increased remarkably due to the discrepancy between the respective topographical maps used for Phase I and Phase II. Appendix 6-1 shows bridge inventory, Appendix 6-2 shows box culvert inventory and Appendix 6-3 indicates pipe culvert inventory along the best route.