MALAYSIA

FEASIBILITY STUDY ON THE TATAU-KAPIT TRUNK ROAD PROJECT IN SARAWAK

FINAL REPORT SUMMARY

AUGUST 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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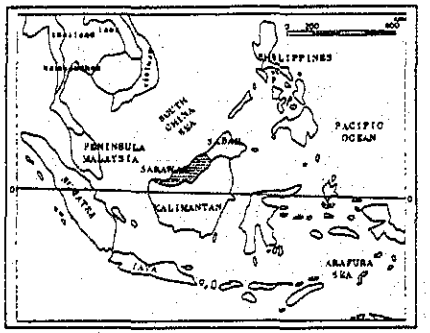
LOCATION MAP



LEGEND

DIVISIONAL BOUNDRY

ROAD

DIVISIONAL HQ.

AIRPORT, AIRFIELD

PORT

STUDY AREA

PROJECT ROAD

BRUNEI

LIMBANG

LAWAS

MIRI

MARUDI

FIFTH DIVISION

BATANG BARAM

FOURTH DIVISION

BINTULU

TATAU

BELAGA

SOUTH CHINA SEA

MUKAH

THIRD DIVISION

SIBU

SARIKEI

KANOWIT

SEVENTH DIVISION

BATANG RAJANG

KAPIT

SIXTH DIVISION

KUCHING

FIRST DIVISION

SECOND DIVISION

SRI AMAN

INDONESIA

KALIMANTAN

SUMMARY

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Summary

1. Objectives of the Study

The state of Sarawak is the largest among 13 states in Malaysia with a territory of about 120,000 km^2 located in the northern part of Borneo Island.

For its vast area, Sarawak has an extremely undeveloped road network, with only the First Trunk Road connecting the major towns along the coast. The First Trunk Road was completed with a gravel surface in September 1982, and Sarawak seems to require the construction of the Second Trunk Road connecting the coast with the inland areas as the next step.

The subject of the Study is the Tatau-Kapit Trunk Road connecting the Tatau-Bintulu area in the Fourth Division with the Kapit area in the Seventh Division by the Second Trunk Road.

Located along the coast, the Tatau-Bintulu area is already connected with major towns in Sarawak by the First Trunk Road.

Along with the development of LNG resources on the coast, Bintulu has rapidly proceeded with port development and industrial development on the basis of the Bintulu Development Project. This area has a future role as the industrial center of Sarawak.

Located in the inland upstream area of Batang Rajang Basin, the Seventh Division has a population of about 38,000 but remains less developed. The administrative and commercial center of the Seventh Division is Kapit town, with a population of about 3,000 facing the Batang Rajang. No roads connect Kapit with other Divisions.

Given these circumstances, the Sarawak State Government attaches importance to the construction of the Tatau-Kapit Trunk Road connecting the Fourth Division with the Seventh Division by the shortest possible route, expecting development benefits from the Project Road construction, namely the development of inland agriculture and forestry, etc. In addition, the Project Road passes by both the Hydroelectric Dam Project site at Pelagus and the coal deposits area, with good potential to contribute to these projects.

The objectives of the Study is to complete an economic and technical feasibility study on the construction of a part of the Second Trunk Road. This report consists of three volumes as follows:

1. Main Text
2. Summary
3. Drawings

2. Methodology of the Study

2.1 Progress of Study

This study was executed separately for Phase I and Phase II, in accordance with the "Scope of Works" which was set up in February, 1982 by the joint work of the JICA Preliminary Survey Mission and the Malaysian Government as follows:

(1) Phase I Study (from July, 1982 to December, 1982).
Several alternative routes are studied according to the topographical map at a scale of 1:50,000 owned by the Government of Sarawak State. The actual situation regarding the topography, the traffic and the socio-economy was investigated. Using the results of the situation survey, the best route was selected, and the drawing extension of the topographical map with a scale of 1:10,000 was determined. The details of the Phase I Study are stipulated in the Interim Report submitted to the Government of Malaysia in December, 1982.

(2) Phase II Study (from May, 1984 to August, 1985).
The refined best route was selected by using a new map of the 1 km wide area along the best route. The map was of a scale of 1/10,000 and based on aerial photographs. Supplemental traffic and socio-economic studies etc. were conducted. Finally, a comprehensive evaluation, including an economic evaluation, was carried out for the project and the Draft Final Report was submitted to the Malaysian Government in February, 1985. The Final Report is to be submitted in August, 1985, incorporating revisions based on the comments and the observations of the Malaysian Government given in May 1985.

2.2 Methodology

The work carried out by the Study Team may be divided into the following:

2.2.1 Phase I Study

(1) Traffic studies including an actual traffic situation survey at Tatau and Kapit, etc.
(2) Socio-economic studies
(3) Alternative route studies by using a map with a scale of 1:50,000
(4) Engineering studies on road construction
(5) Best route selection and determination of the drawing extension of the topographical map with a scale of 1:10,000 used in the Phase II Study.

2.2.2 Phase II Study

(1) Supplemental socio-economic study, including a supplemental traffic survey at Tatau and Kapit, etc.*
(2) Engineering studies including soil and geology
(3) Refinement of the best route using a map with a scale of 1:10,000
(4) Transport cost and construction cost studies
(5) Economic evaluation and comprehensive evaluation

* The traffic survey conducted in the Phase II Study is a supplementary survey to account for the following situation change in the Study Area during the interruption of the study .

1. In Tatau, a new generation of car traffic has evolved, with subsequent traffic pattern changes.
2. In Kapit, traffic pattern changes are due to the approximately 50 percent increase in express launch services.

Table 1 shows the conducted Traffic Surveys in the Phase I and Phase II.

Table-1 Conducted Traffic Surveys

		River Traffic Survey		Road Traffic Survey
Survey Place	Phase	Vessel Traffic	Express Launch Passenger Traffic	Car Traffic
Tatau	I	Conducted	Conducted	-
	II	Conducted	Conducted	Conducted
Kapit	I	Conducted	Conducted	-
	II	-	Conducted	-
Survey Method		Interview Survey of Vessel Operators	Interview Survey of Express Launch Passengers	Road-Side Interview Survey of Drivers

Note:

(1) Phase I survey conducted in 1982
(2) Phase II survey conducted in 1984
(3) Vessel denotes speed boat, long boat and cargo ship

3. Study Area

(1) Geography outline of the Study Area

The Study Area has an area of approximately 27,000 km^2 in the central part of the State of Sarawak, and encompasses a part of the Tatau District of the Fourth Division and the Kapit District of the Seventh Division.

The Tatau District, the starting point of the Project Road, is located in the coastal area along the South China Sea. The First Trunk Road was opened in September, 1982.

The major town in this district is Tatau. Urban development in Tatau started with the opening of the First Trunk Road.

In the Kapit district, the terminal point of the Project Road is located in the less developed area upstream of the Batang Rajang. The major town, Kapit, has a completed urban development to some extent as the administrative center of the Seventh Division.

The Project Area is divided into two parts, northern and southern, by the watershed dividing the Batang Tatau Basin and Batang Rajang Basin in the area between Tatau and Kapit.

Topographically, however, the two parts are characterized by similar undulated jungle traversed by many tributaries of the two rivers. The population density is rather low in this area, and transport relies only upon the river waterways.

(2) Population Distribution

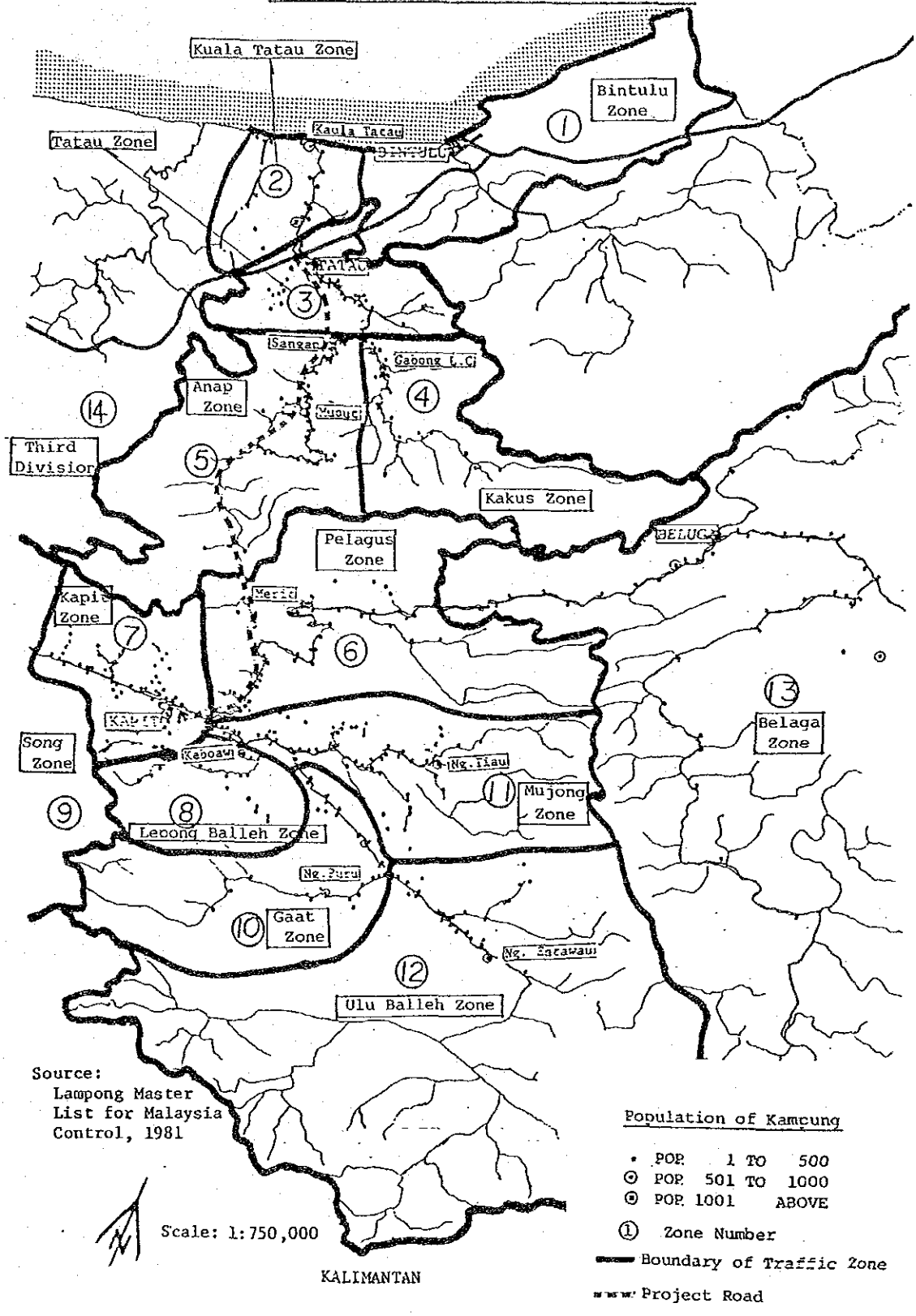
The Study Area represents 21 percent of the land area of the State, and its population of 79,000 represented 6 percent of the State population in 1980.

The population density is 3.5 persons/km^2, which is extremely low in comparison with Sarawak's average of 10.4 persons/km^2.

(3) Communities

Most of the communities in the Study Area are composed of towns and Kampongs or Long Houses. Fig.1 shows the distribution of Kampongs and Long Houses by 1-500, 501-1,000, and more than 1,000 population-size in the Study Area. Most of the communities are scattered along the rivers in the Study Area.

Fig. 1 POPULATION DISTRIBUTION AND ZONING MAP FOR TRAFFIC ANALYSIS



(4) Industries

Forestry and agriculture are the major industries in the Study Area, although manufacturing is developed in Bintulu. Agricultural activities largely depend on shifting cultivation. Major agricultural products are paddy, rubber and pepper with low activity.

The forestry industry has been very active in the upstream areas of the Sungai Anap, a tributary of the Batang Tatau, and upstream of the Batang Rajang and the Batang Balleh. Forestry production was 2,300,000 tons in 1981 in the Study Area, and is an important export item, not only for the Study Area but also for the State of Sarawak. Forestry production provides inland people with one of their major sources of income.

4. Development Potential in the Study Area

(1) 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 for energy consumption not only 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 2. All the proposed dam construction sites are located in remote and sparsely populated areas, creating many problems for construction materials transportation. The Project Road will contribute to the construction of the hydroelectric dam at Pelagus, which is to be completed in 2005.

Table 2 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

Note: Location of Pelagus dam is shown in Fig. 2.

(2) Mining Resource Development

At present, there are no mining activities in the Study Area. However, coal deposits are spread upstream of the Sungai Pelagus and upstream of the confluence with the Sungai Pelagus of the Batang Rajang as shown in Fig. 2.

The estimated amount of coal deposits in this area amounts to 200 million tons. The coal is lignite with comparative good quality.

A feasibility study of the development of these coal deposits is being carried out at present. Regarding coal transportation, large ships cannot navigate upstream of the Batang Rajang and the Sungai Pelagus

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.

(3) Potential Agricultural Land

The potentiality of agricultural land in the Study Area, especially the land along the Project Road, is currently under study by the Department of Agriculture of the Sarawak State Government. The following three suitable land areas for agriculture are selected based on the criteria of steepness and soil quality (including fertility) as shown in Fig-2.

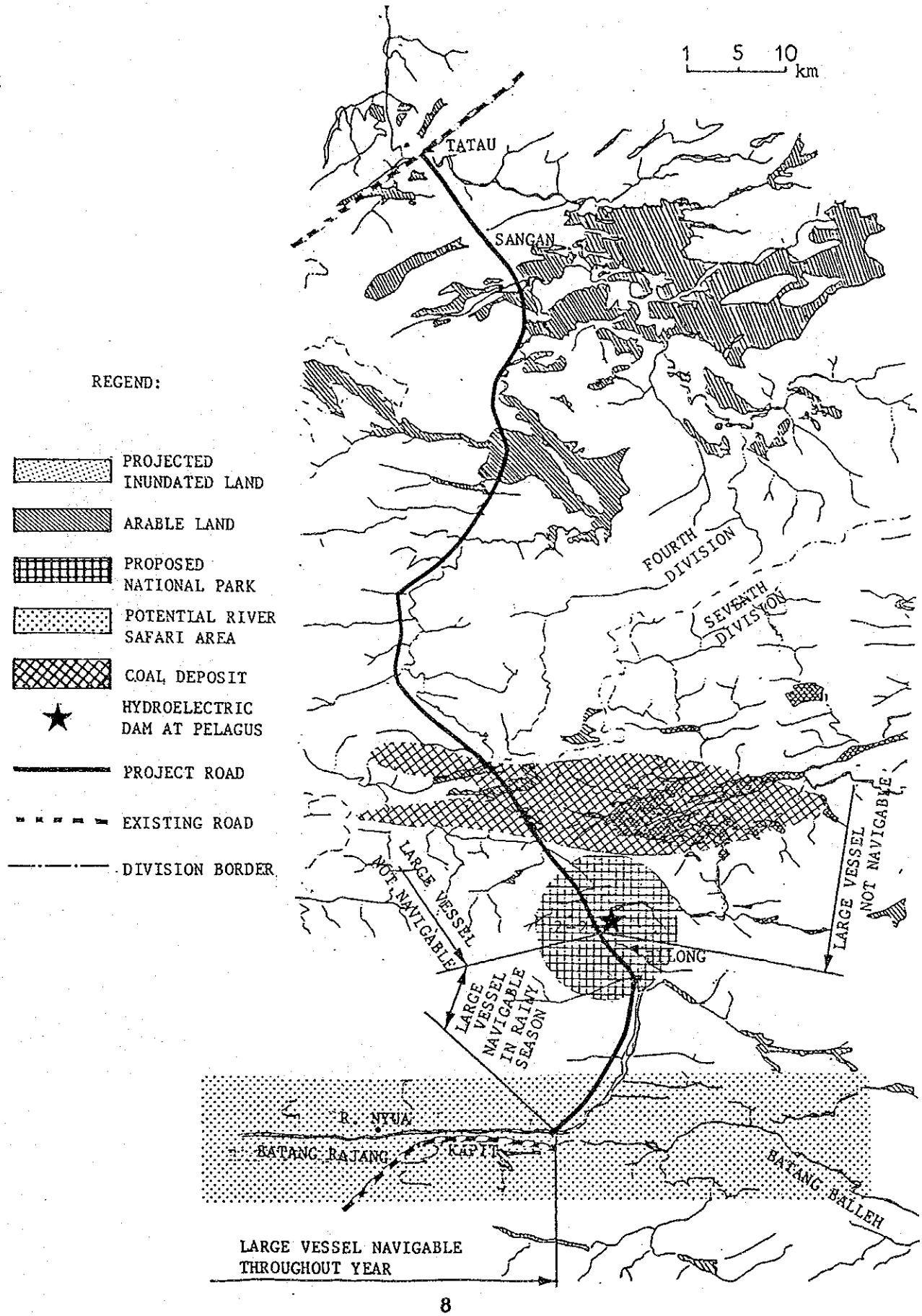
1) the middle part of the Tatau Subdistrict around Sangan;

2) the southern part of the Tatau Subdistrict; and

3) the banks of the Batang Rajang, upstream beyond the planned Pelagus Hydro-electric Power site.
However, it is believed that the third choice above totalling 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.

The completion of the Project Road will allow access to approximately 60,000 hectares of potentially arable land.

Fig. 2 DEVELOPMENT POTENTIAL AREAS



(4) 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 expand further during 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, about 40,000 persons were living 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.

Additional future projects are the construction of a regional hospital, an agricultural college and thousands of houses. An international airport has also been proposed.

The completion of the Project Road will facilitate access to and from the Seventh Division.

(5) Tourism

Tourism as an industry does not play an important role in the economy of Sarawak. For example 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 by creating opportunities for business expansion and employment, and by generating higher personal income. Further, tourism could assist in minimizing the current reliance on forestry and agricultural production.

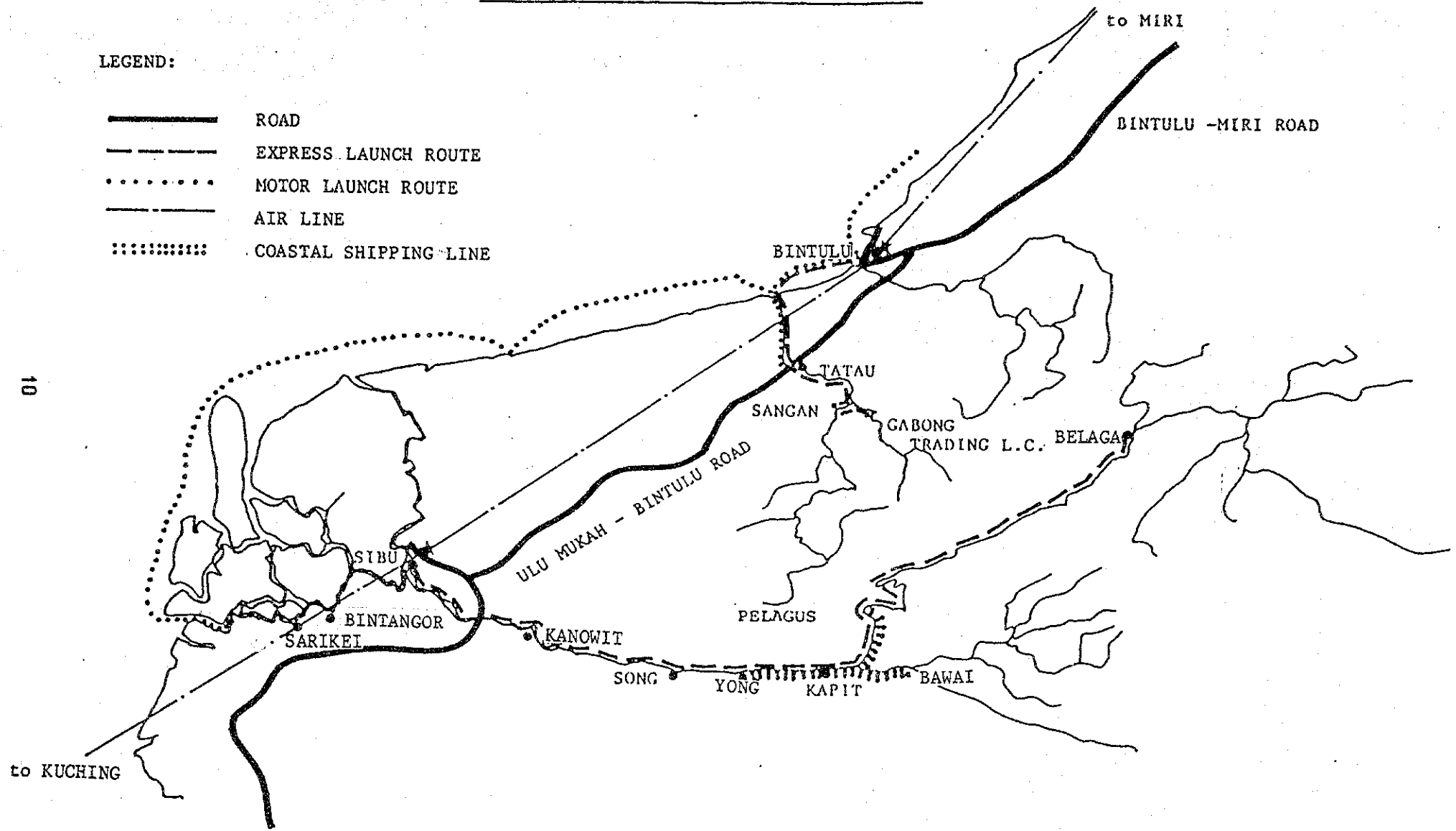
Potential tourist sites are shown in Fig. 2. The Project Road will contribute to tourism development in the Study Area.

5. Transport Network and the Project Road

(1) An Outline of Transport in the Study Area

The transport network in the Study Area consists of roads, rivers, and air and coastal shipping, as shown in Fig. 3. 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. Kapit, Tatau and Bintulu towns are the major transport terminals or transfer points in these river basins.

Fig. 3 TRANSPORTATION SYSTEM IN THE STUDY AREA



There are two airports in the Study Area, in Bintulu and in Kapit. Bintulu airport caters to regular air service by Malaysian Airline Systems (MAS) from major towns in Sarawak. There are no regular flights at Kapit airport.

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

1) 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.

Fig-4 shows the Trunk Road System in Sarawak. Sarawak State Government completed construction of The First Trunk Road with gravel surface. Therefore, Construction of the Second Trunk Road system has been planned.

2) Rivers

'a) The Batang Tatau and its tributaries

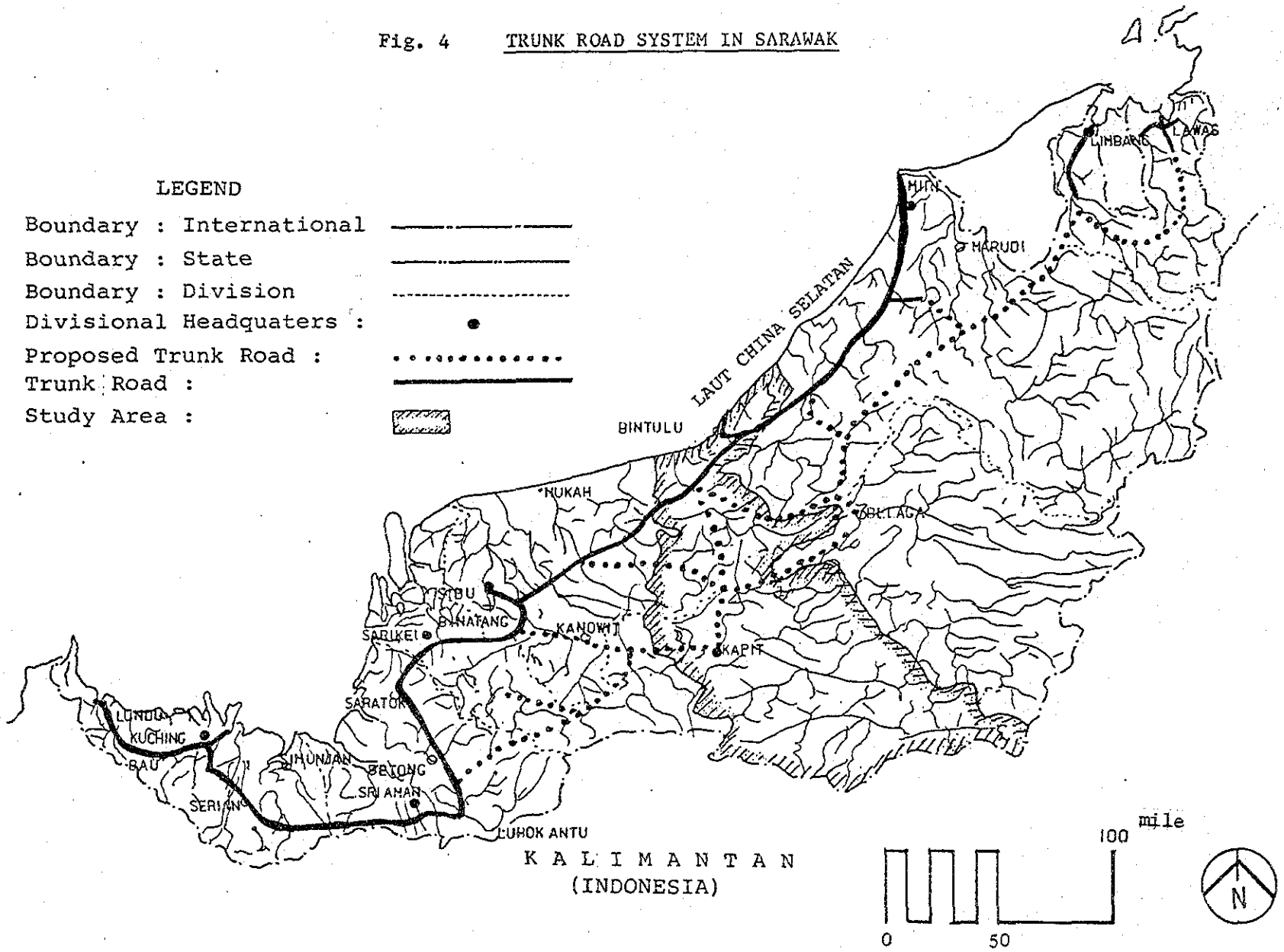
The Batang Tatau is relatively wide and deep between Kuala Tatau (the mouth of the river) and Tatau, and provides a reliable water transport channel for small coastal ships and barges. Above Tatau, although the river becomes narrower and heavily meandering, motor launches and barges can come up the river as far as Sangan, 48 km upstream on the Sungai Anap from Tatau or 50 km on the Sungai Kakus. Above Sangan only small vessels such as long boats and speed boats can navigate.

Tatau town at 30 km 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 the secondary centre which also has government branch offices. Below Tatau, Kuala Tatau also has a small bazaar and is a collecting point for logs and timber.

(b) 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 km^2 that is about 40% of the land area of Sarawak.

Fig. 4 TRUNK ROAD SYSTEM IN SARAWAK



The Batang Rajang has abundant water and a stable water level throughout the year and forms a reliable water transport channel between its mouth and 291 km upstream, where the Batang Balleh meets. Above there, a stable water level is not available for navigation. Particularly well-known is Pelagus Rapids which has been the major obstacle to river navigation.

Only recently has it been possible to provide regular transport service to the people living above the rapids by express launch. But express services are often interrupted because of low water levels in the dry season.

Three major ports are in the lower part of Batang Rajang: Sarikei, Bintangor and Sibu.

(2) Roles of the Project Road

The Project Road will play the following roles in traffic, socio-economics etc. in the Study Area:

(i) The Project Road is a part of The Second Trunk Road System, which directly connects Tatau along the coast with inland Kapit.
The Project Road will connect Kapit with the major cities in Sarawak through the First Trunk Road.

(ii) The transport network has not been well developed in Sarawak, and economic influence areas are centered in the river basins.

Economic relations between Bintulu located in the Batang Kemena Basin and Kapit located in the Batang Rajang basin are rather weak.

When the Project Road combining Bintulu and Kapit is completed, economic exchanges between the two towns will increase.

(iii) The Project Road will contribute to the development of hydroelectricity, agriculture, mining and tourism in the Study Area, bringing economic benefits and increased social welfare to the inhabitants.

(iv) Finally, with the Project Road, the efficient regional administration of the Sarawak State Government will be able to penetrate deeply into the isolated interior areas in Sarawak.

6. Engineering Study

6.1 Engineering Survey

The following engineering surveys have been carried out:

(1) Soil Survey

Various laboratory tests of soil samples along the route have found the soil is good for the subgrade of the road.

(2) Drilling Test

Drilling tests at the Batang Rajang bridge construction sites have found that a bearing layer is 2 - 3 meters on the left side and 10 meters on the right side of the river. The pile foundation is judged appropriate to deal with these soil conditions.

(3) Mackintosh Probe Test

Mackintosh probe tests at 20 points at 10 bridge sites indicate that a bearing layer is 6 meters deep on average. The pile foundation is judged reasonable to deal with this soil condition.

(4) Aggregate Investigation

Sufficient aggregate can be obtained locally to construct the Project Road from the Batang Rajang, Pelagus Rapids, the Sungai Pelagus, Bukit Kana and Bukit Arib.

(5) Cost Studies

To estimate cost, labour, materials, equipment, and construction costs inclusive of taxes and duties were surveyed.

(6) Geometric Design Criteria

The Sarawak State Government has adopted the geometric design criteria normally used in Peninsula Malaysia as shown in Fig. 5 and Table 3.

(7) Pavement Design Standard

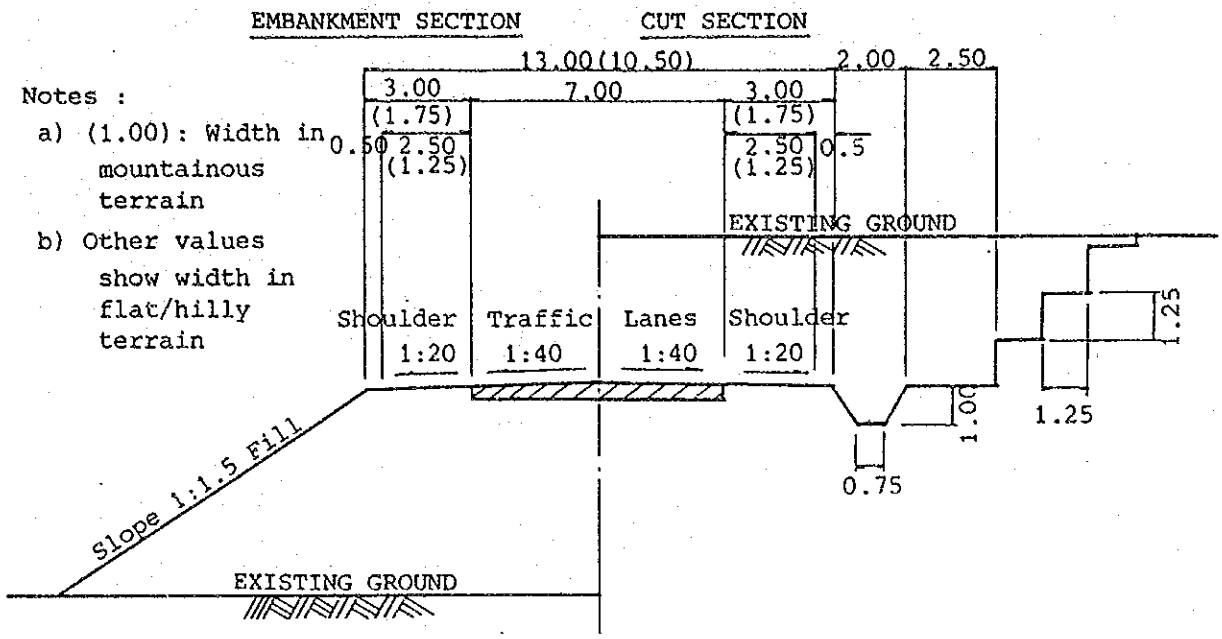
Road Note 31 is adopted.

(8) Bridge Design Standard

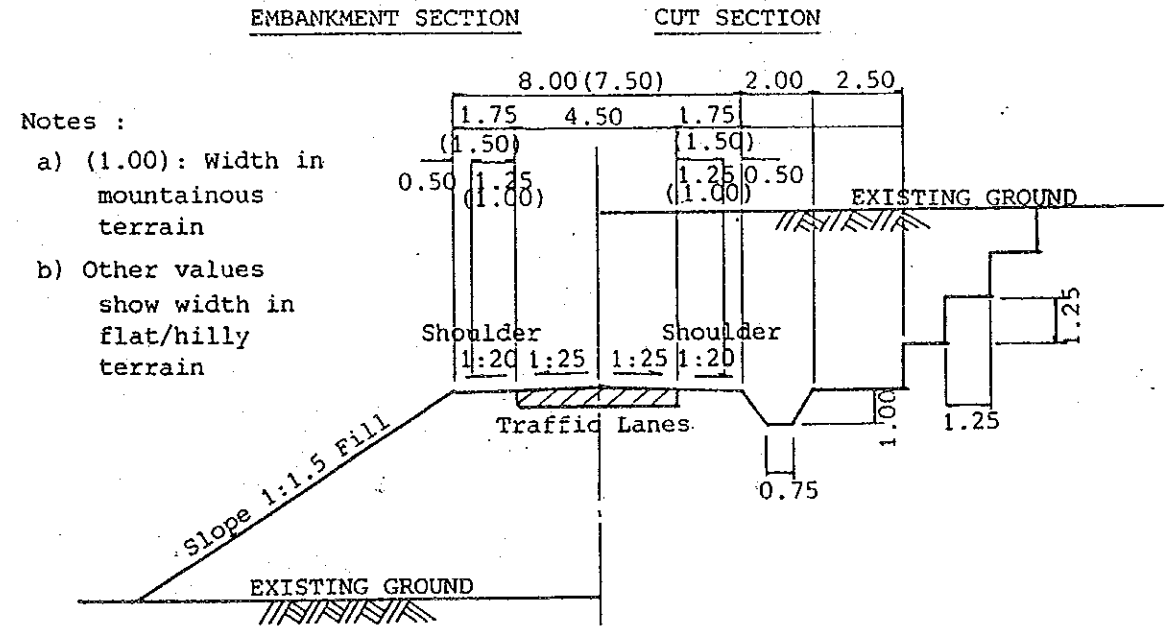
The British Standard (BS) is used.

Fig. 5 TYPICAL CROSS SECTIONS

1. Trunk Road (Group 04 of the Criteria)



2. Rural Road (Group 01 of the Criteria)



3. Bridge of Trunk Road

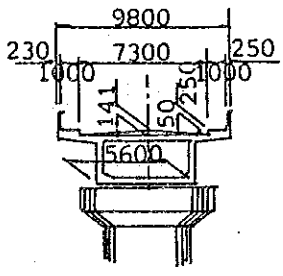


Table 3 MINIMUM GEOMETRIC DESIGN CRITERIA FOR NEW ROADS IN RURAL AREAS (METRIC)

			LIGHT								MEDIUM						HEAVY		
1. TRAFFIC																			
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 DISTANCE - MIN. 3		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
	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.		
	UNDER PASS WIDTHS BETWEEN ABUT. WALLS	M	7.0			7.0			8.5			11.0			16.5			SINGLE OPENING 2 @ 0.5 DBL.OP.		
	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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6.2 Best Route

(1) Alternative Route Studies

The proposed Tatau-Kapit Trunk Road is about 140 km (90 miles) long from its starting point on the First Trunk Road, close to Tatau. The terminal point of the road is located on the Lepong Balleh Road about 2 km to the East from Kapit, the administration centre of the Seventh Division.

Regarding alternative routes, 2 major alternatives at one particular point and also 10 minor alternatives at the other points are considered in the course of the Study using a topographical map with a scale of 1:50,000. The best alternative route was selected mainly from a technical point of view, as shown in Fig. 6, since the alternatives have similar socio-economic characteristics.

The topography along the proposed Tatau-Kapit Trunk Road route is chiefly characterized by long but narrow saw-toothed, hilly terrain, which restricts the number of alternative routes.

(2) Best Route Alignment

The best route was selected taking into account the reduction of earth work volume and good alignment using an approximately 1,000 meter wide topographical map with a scale of 1:10,000, as shown in the "Drawings."

(3) River Crossing Method for the Batang Rajang

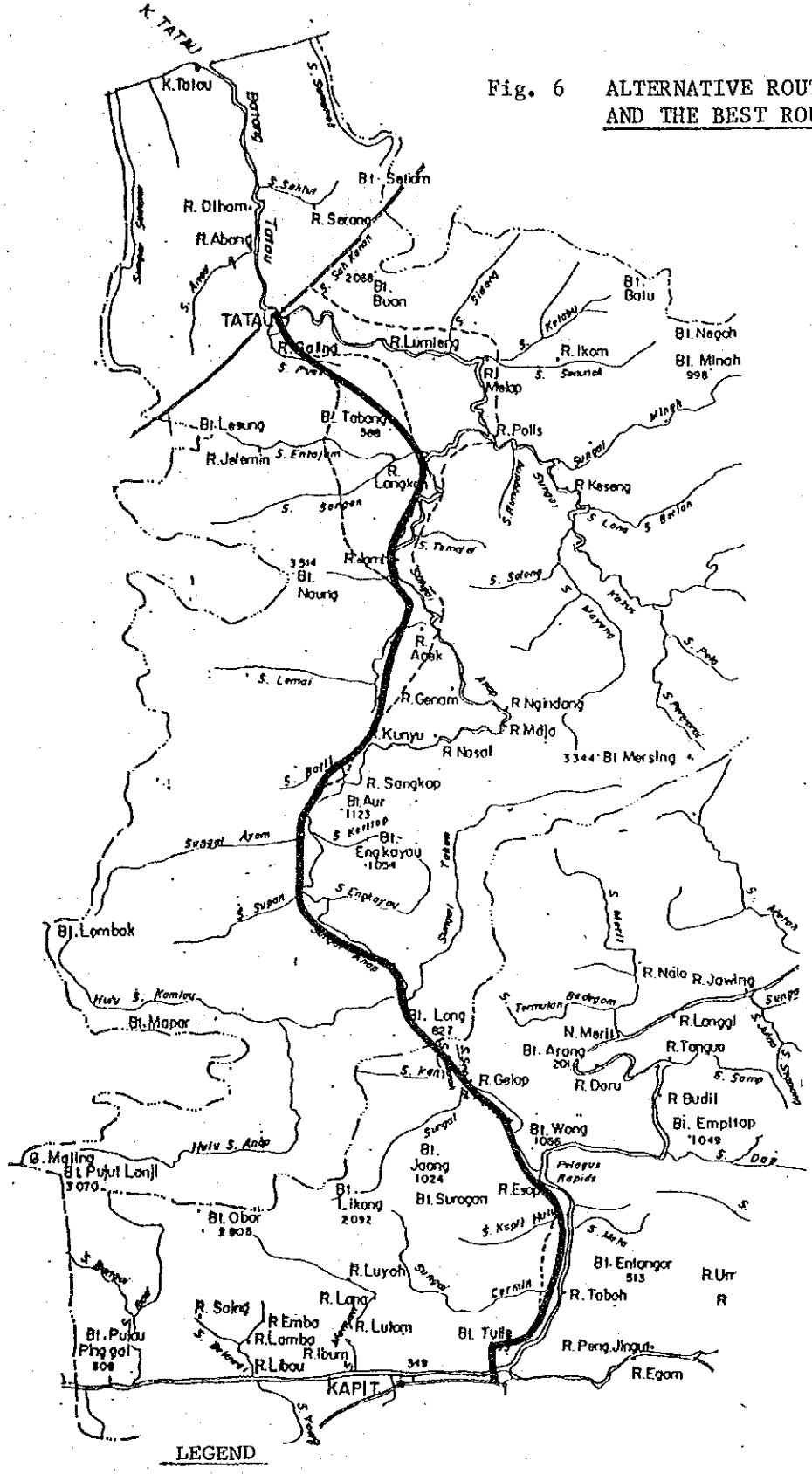
The P.C. Box Girder type bridge is selected as the best river crossing method through the following comparison study regarding (i) and (ii):

(i) As a result of an investigation taking into account local conditions (the steep mountainous terrain and the remarkable water level variation of the river around the crossing point), the Quay plan was selected as the best alternative for the ferry boat plan and the P.C. Box Girder type bridge was selected as the best alternative for the bridge plan.

(ii) According to a comparative study between the said two best alternatives, the bridge plan is judged superior to the ferry boat plan from the viewpoints of maintenance, operation cost and ferry boat service cancellation estimated at approximately one third (1/3) of each year.

Vertical clearance to the bridge of about twenty meters will allow large ships to navigate underneath the bridge with a six meter allowance at the high water level.

Fig. 6 ALTERNATIVE ROUTES AND THE BEST ROUTE



LEGEND

BEST ALTARNATIVE ROUTE

COMPARED ALTERNATIVE ROUTE

There are no obstacles to constructing a high level P.C. Box Girder type bridge due to a new construction method which has been developed recently (refer to Table 4).

Table 4 Cost Comparison of Two Alternatives for Crossing the Batang Rajang

Unit: M$

Alternative	Item	Cost		Twenty Years Total
		Construction	Maintenance	
1. Ferry	a. Quay construction cost at both sides	5,883,000	0	5,883,000
	b. Ferry boat construction cost	1,000,000	0	1,000,000
	c. Operation expense (incl. maintenance) M$500,000 x 20 yrs.	0	10,000,000	10,000,000
	d. Engine replacement (estimated) after 10 years usage	0	350,000	350,000
	Total	6,883,000	10,350,000	17,233,000
2. Bridge	P.C. Box Girder Bridge (430 meters length)	6,888,000	10,200	6,898,200
	Balance	-5,000	+10,339,800	+10,334,800

(4) Rural Roads

Two rural roads branched from the Trunk Road are planned as feeder roads as follows:

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

Sangan and Muput are secondary administrative and commercial centers in the Project Area.

7. Construction Schedule and Cost

7.1 Construction Schedule

The Project Road was divided into 8 construction sections as shown in Fig. 7. Five construction schedules are proposed as shown in Figs. 8 and 9.

The priority order by construction section for the stage construction plan was determined comprehensively based on future traffic volume and construction difficulties.

7.2 Construction Cost

The following assumptions were taken into account for the estimation of construction cost:

(1) Construction cost with profit and execution by general contractors

(2) Unit cost prevailing in October, 1984

Estimated construction cost by construction section is shown in Table 5, which indicates Road Section 3 (construction sections 3, 4 and 5) are by far the most expensive.

Construction cost by item is shown in Table 6, which indicates that earth work characteristically accounts for a quite large portion of construction costs.

Fig. 7 CONSTRUCTION SECTIONS

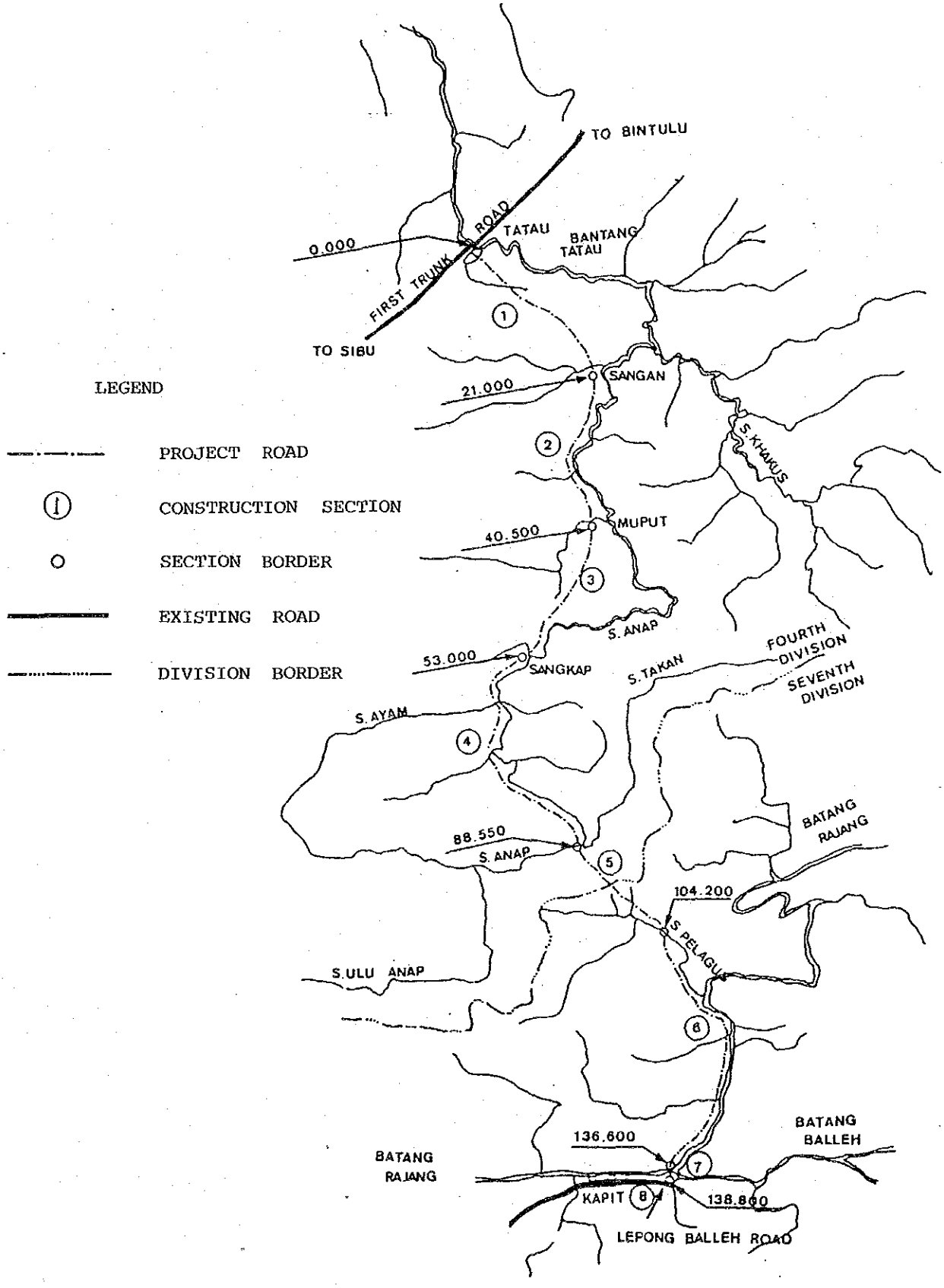
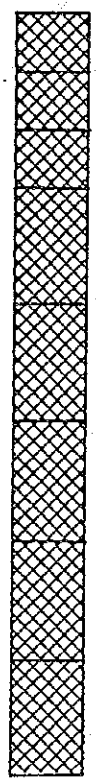
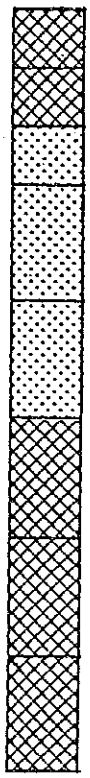


Fig. 8 CONSTRUCTION ORDER BY ALTERNATIVE

		One-Stage Construction		Two-Stage Construction	Three-Stage Construction	Distance
						km
1	Tatau					21.0
2	Sangan					19.5
3	Muput					12.5
4	Sangkap Sungai					35.55
5	Ulu Anap Pelagus					15.65
6	Right side of Batang Rajang					32.40
7	Lepong Balleh					2.2
8	Road Junction Kapit					5.0
						143.8
Pavement		Bitumen	Gravel	Bitumen	Bitumen	
Alternative type		A-1	A-2 A-3	B	C	

Note : First Stage, Second Stage, Third Stage

Fig. 9 CONSTRUCTION SCHEDULE

1. One stage construction plan with bituminous surface (A-1) with gravel surface (A-2)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Detailed Design & Prequalification																			
Earth Work																			
Pavement																			
Bridges																			
Drainage and Miscellaneous																			

2. One stage construction plan with gravel surface (A-3)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Detailed Design & Prequalification																			
Earth Work																			
Pavement																			
Bridges																			
Drainage and Miscellaneous																			

3. Two stage construction plan with bituminous surface (B)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Detailed Design & Prequalification																			
Earth Work																			
Pavement																			
Bridges																			
Drainage and Miscellaneous																			
Construction Section			1, 2, 6, 7, 8				3, 4, 5												

4. Three stage construction plan with bituminous surface (C)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Detailed Design & Prequalification																			
Earth Work																			
Pavement																			
Bridges																			
Drainage and Miscellaneous																			
Construction Section			1, 2				3, 6, 7 8				4, 5								

Table 5 CONSTRUCTION COST BY CONSTRUCTION SECTION

Section	Construction Section	Construction Cost (M$'000) [1]	Ratio (%)		Distance (Km)	Cost/Km (M$'000) [2]
1	1	36,185	11.4	11.4	21.00 Km	1,407
2	2	38,307	12.1	12.1	19.50	1,605
3	3	24,018	7.6	49.4	12.50	1,567
	4	104,647	32.9		35.55	2,404
	5	28,183	8.9		15.65	1,470
4	6	69,064	21.7	21.7	32.40	1,739
5	7	15,563	4.9	5.4	2.20	5,776 [4]
	8	1.630	0.5		5.00	-
Total		317,600	100.0		143.80	1,868 [3]

Notes: 1) Value included Supervision, Detailed Design, Contingency and Compensation
2) Value excluded Supervision, Detailed Design, Contingency and Compensation
3) Value excluded Construction Section 8
4) Value included Batang Rajang Construction Cost

Table 6 CONSTRUCTION COST BY ITEM

Unit: M$'000

Item	FC	LC	TAX	TOTAL	Ratio (%)	
(1) Tree Cut	1,189	1,878	24	3,091	1.5	1.0
(2) Clearing and Grubbing	4,941	3,587	61	8,589	4.1	2.7
(3) Earthwork	76,290	44,559	2,110	122,959	59.3	38.7
(4) Pavement	25,845	10,805	3,210	39,860	19.2	12.6
(5) Bridge	10,671	7,020	1,349	19,040	9.2	6.0
(6) Drainage	5,779	2,467	691	8,937	4.3	2.8
(7) Miscellaneous	2,569	2,393	0	4,962	2.4	1.5
(8) Sub-Total (Direct Cost)	127,284	72,709	7,445	207,438	100.0	65.3
(9) Construction Cost with and Profit (8)x1.25	159,105	90,886	9,306	259,297		81.6
(10) Supervision (9)x0.05	7,955	4,544	465	12,964		4.1
(11) Contingency [(9)+(10)]x0.10	16,706	9,543	977	27,226		8.6
(12) Total	183,766	104,973	10,748	299,487		94.3
(13) Detailed Engineering with Contingency (9)x0.066	10,501	5,998	614	17,113		5.4
(14) Compensation	0	1,000	0	1,000		0.3
Grand Total	194,267	111,971	11,362	317,600		100.0
Cost per Km: M$259,297/138.8 Km = 1,868						

8. Estimation of Future Traffic Demands

8.1 Method for traffic demand forecast

The future generated traffic volume in the urban transport study usually is estimated based on home base data such as occupation, income level, car ownership etc., which are obtained from the Home Interview Survey.

Future traffic volume in this study, however, is forecasted based upon river traffic survey data etc., instead of home base data for the following reasons:

(i) It is practically impossible to conduct home interview surveys because the population is broadly scattered in the interior region.

(ii) A household income survey has not been conducted with the inhabitants who live in the interior region. Even if the survey were conducted, it would not be easy to gather data on household income and expenditures.

(iii) Since there are no roads to connect with other regions in most of the Study Area, it is difficult to forecast the generated traffic volume after the completion of the Project Road based upon present home attributes.

8.2 Types of future traffic demand

Traffic demands have been forecasted into the following types:

(1) Diverted traffic

Diverted traffic is defined as the traffic which diverts from river to road due to transport cost reductions after the completion of the Project Road.

Diverted traffic will be generated at the traffic zones:

Tatau-Anap and Kapit-Pelagus

1) Passenger diverted transport

The unit cost of passenger transport indicates road transport is cheapter than river transport.

Unit costs for bus services are less than express launch unit costs and likewise, travel by passenger car is cheapter than by long boat. After completion of the road, total transport costs suggest road transport will be more advantageous than river transport, because road transport distance is substantially shorter than river transport distance.

Therefore, almost all river passenger traffic will divert to road traffic in the area along the Project Road.

However, a 70% diversion rate from river to road is assumed in the zones Kakus, Pelagus and Leppong Balleh which will be less affected by the Project Road.

2) Goods diverted transport

The unit cost of goods transport indicates that river transport is cheaper than road transport. However, the total cost on the competitive transport routes shows road transport to be more profitable than river transport in the case of carrying general cargo, because road transport routes are much shorter than river transport routes. Therefore, most river goods transport will also be divered to road transport.

In the case of log transport, the total river transport costs will be still cheapter than road transport costs. The diversion to road transport will not occur for log transport.

(2) Development traffic

Passenger and goods traffic will be generated by the implementation of various development projects which will become possible upon the completion of the Project Road. Development traffic was projected based on the passenger and goods volume generated from agriculture and tourism development projects.

The traffic generated from Pelagus Hydroelectric Project has not been counted as development traffic because such traffic will only be generated in the short term.

(3) Induced traffic

Induced traffic is defined as the traffic which is newly generated due to the reduction in transport cost resulting from the completion of the Project Road.

In this project, induced traffic will occur in almost all traffic zones with substantial cost reductions.

However, it is difficult to estimate induced traffic apart from the other types of traffic. In this study induced traffic is estimated from the balance between overall traffic demand and other types of forecast traffic.

Overall passenger traffic demand is estimated based on the relations between traffic volume and transport cost including the future growth factor.*

Overall goods traffic is calculated based upon the present traffic composition by vehicle type on the Trunk Road after the conversion from passenger base to vehicle base.

8.3 Forecasted traffic volume

(1) Forecasted Traffic Volume

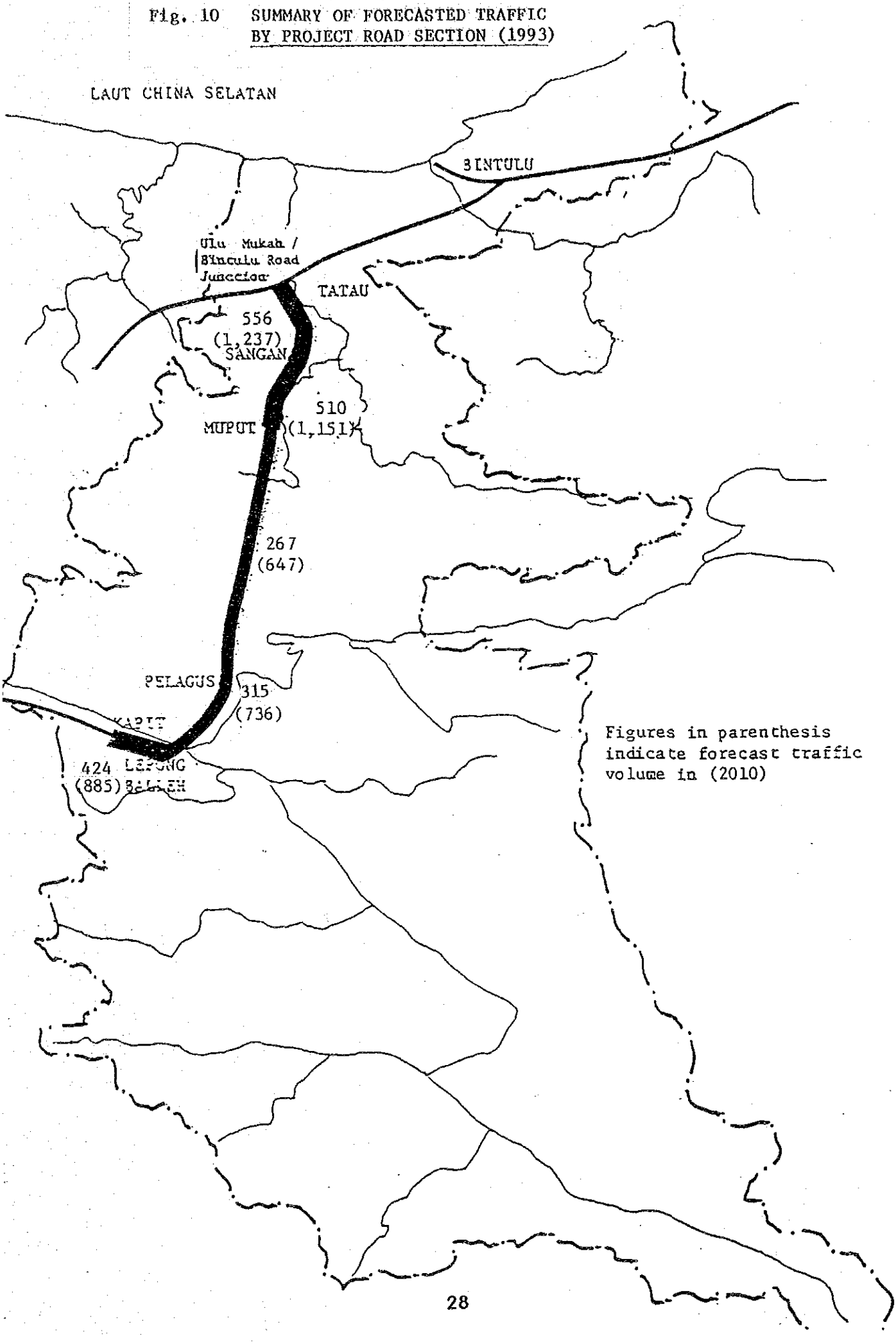
A summary of forecasted traffic volume on the Project Road is shown in Table 7 and Fig. 10. The average annual growth rates of the forecasted traffic will amount to about 6 - 7% in the years 1995 - 2000 and 3 - 5% in the years 2000 - 2010.

Table 7 SUMMARY OF FORECAST TRAFFIC VOLUME ON THE PROJECT ROAD SECTION (AVERAGE DAILY TRAFFIC)

Road Section	1993	1995	2000	2005	2010	Average Annual Growth Rate (%)		
						1995-2000	2000-2005	2005-2010
Ulu Mukah/ Bintulu Rd. - Sangan	556	628	840	1,014	1,237	6.0	3.8	4.1
Sangan - Muput	510	575	770	983	1,151	6.1	4.7	3.4
Muput - Pelagus	267	302	409	518	647	6.3	4.8	4.5
Pelagus - Lepong Balleh	315	361	513	610	736	7.3	3.5	3.8
Lepong Balleh - Kapit	424	479	663	756	885	6.7	2.7	3.2

*) The method used is an application of simple price theory. In traffic engineering, Mr. Gerald Kraft used this method to forecast inter-city traffic volume in his "Demand for Intercity Passenger Travel in the Washington-Boston Corridor (1963)". His methodology is usually referred to as the Kraft Model.
The Kraft Model is considered suitable for forecasting traffic patterns in this project, accounting for many more traffic purposes other than commuting traffic.

Fig. 10 SUMMARY OF FORECASTED TRAFFIC BY PROJECT ROAD SECTION (1993)



(2) Relationship between traffic forecast and car ownership

Future traffic volume is not forecasted based upon car ownership as stated in 8.1. For the sake of caution, approximate unit passenger car ownership is estimated based upon the traffic forecast in 1993 in Table 8.

Table 8. PASSENGER CAR OWNERSHIP

	Area	Population	Passenger Cars	Population/ Passenger Car
Present	First Division	453,000 (1980)	44,054 (1983)	10
	Fourth Division	199,000 (1980)	20,014 (1983)	10
	Seventh Division	63,000 (1980)	110 (1983)	573
	Study Area	52,500 (1980)	** 200 1983)	263
Future	Study Area	65,500 (1990)	*1,400 (1993)	47

Note: * 35 percent of person trips use passenger cars (three passengers)
** Based upon an estimate by the Study Team.

9. Economic Evaluation

9.1 Elements of benefit

The benefits of this road construction project may be distinguished as the following:

(1) Quantified Benefits

1) Benefits to existing traffic

a) Benefits to normal traffic

The benefits to normal traffic arise from the difference between vehicle operating costs on the existing road and costs on the road after improvement. For the Project Road, normal traffic has not been projected, because there are no existing public roads, except the section between Kapit and Lepong Balleh which has just recently been completed.

b) Benefits to diverted traffic

After the completion of the Project Road, benefits to diverted traffic will arise from the savings between vessel operating costs on the river and vehicle operating costs on the road. Therefore, the savings in transport operating costs are obtained by multiplying diverted traffic by the cost difference between river transport and road transport.

2) Benefits to generated traffic

a) Benefits to development traffic

Some traffic, aside from diverted traffic, is expected to be generated due to agricultural and tourism developments in the Project Area. The benefit to this type of traffic has been estimated as benefit to development traffic, at one-half of the benefit to diverted traffic.

b) Benefit to induced traffic

The benefit to induced traffic is calculated at one-fourth rather than one-half of the benefit to diverted traffic, the latter being the most widely accepted measure.

Induced traffic benefit is normally one-half of the benefit to diverted traffic, and this has been adopted in the case of development projects using the same transport means that existed beforehand. But this measure is not necessarily appropriate for the evaluation of road projects, such as the

Trunk Road Project, which divert transport means through an area with no roads. Since diverted traffic benefit, defined as operating cost savings caused by the diversion of transport means, will be great because of the remarkable difference in distance between river and road transport, it is feared that induced traffic benefits will be evaluated excessively if the value of one-half is used. Therefore, to evaluate benefits conservatively, induced traffic benefits are adopted at one-fourth of operating cost savings resulting from the diversion of transport means.

(2) Benefit not involved in the economic evaluation

1) Benefits to traffic

a) Time saving benefits

Time saving benefits are important for the transport project. The evaluation of time savings is extremely difficult between the different modes of transport such as river transport and road transport. In addition to this, it is difficult to evaluate the time savings value in terms of money in the Project Area. Therefore, time saving benefits have not been considered to avoid the uncertainty of estimating the benefits.

b) Benefits from accident savings

Some river transport routes have danagerous rapids. Therefore, the Project Road construction is expected to reduce accidents. However, no data for accident savings were available.

2) Benefits brought about by development projects

a) Benefit to Pelagus Hydroelectrical Dam construction project

The Pelagus Hydroelectric project is the largest associated with the Project Road.

Benefits brought about by the Hydroelectrical Dam project are excluded because reduction of electric charge costs etc. should be included in the Hydroelectrical Dam project itself.

The study team assumed the following two benefits:

i) Benefit to cost savings of building a road exclusively for use for the Hydroelectric project

ii) Benefit as a transport road for construction materials.

The benefit to cost savings of building a road exclusively for use for the Hydroelectrical Dam construction project are excluded because the Hydroelectrical Dam construction project involves large indefinite factors (delay of construction schedule etc.).

The benefits as a transport road for construction materials for the Hydroelectrical Dam project are excluded because construction materials will be transported only for a limited short period.

b) Benefits to coal mining resources development

A part of the Project Road will certainly be utilized for coal mining development, when it is realized.
However, these benefits are excluded because the feasibility of coal mining development, considering the demand in the coal market, is not yet certain.

3) Other intangible benefits

As for the other following miscellaneous benefits resulting from the project implementation, no means are available to compute the amount of benefit in terms of money. However, these benefits are considered in the comprehensive evaluation of the Project Road.

- o Increased accessibility to hospitals and schools
- o Increased opportunities for agricultural and industrial development
- o Improvement of administrative efficiency, etc.

9.2 Economic Evaluation

The economic evaluation has been carried out in terms of the Benefit/Cost Ratio (B/C), the Net Present Value (NPV) and the Internal Rate of Return (IRR) on the alternative construction plans shown in Table 9.

The results of the economic evaluation are shown in Table 10. Using a discount rate of 10%, all alternative plans are not feasible from an economic standpoint.

Table 9 ALTERNATIVE CONSTRUCTION PLANS FOR PROJECT ROAD

Construction Stage		Initial Type of Road Surface	Case
One Stage	Whole section will be open for traffic in 1993	Asphalt Paved	A-1
		Gravel	A-2
	Whole section will be open in 1992	Gravel	A-3
Two Stage	1st Stage (1993) Ulu. Mukah/Bintulu Road to Sg. Muput Kapit to Pelagus 2nd Stage (1997) Sg. Muput to Pelagus	Asphalt Paved	B
Three Stage	1st Stage (1993) Ulu. Mukah/Bintulu Road to Sg. Muput 2nd Stage (1997) Kapit to Pelgus Sg. Muput to R. Sangkap 3rd Stage (2001) R. Sangkap to Pelagus	Asphalt Paved	C

Table IO PRESENT VALUE OF COST/BENEFIT FOR ALTERNATIVE PLANS (DISCOUNT RATE OF 10%)

(M$ 000)

Alternative Case	Benefit				Cost	B/C Ratio	NPV (B-C)	IRR (%)
	Diverted	Develop-ment	Induced	Total				
A-1	94,659	2,717	21,701	119,076	226,880	0.53	-107,803	4.20
A-2	86,994	2,377	21,701	111,023	223,331	0.50	-112,308	3.90
A-3	92,748	2,377	22,240	117,365	223,331	0.53	-105,996	4.15
B	94,659	2,419	16,772	113,921	188,082	0.61	-74,161	4.95
C	86,419	2,119	11,993	100,530	144,693	0.70	-44,163	5.89

Note : B/C - Benefit Cost Ratio
NPV- Net Present Value

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Comprehensive Evaluation

The following shows the results of an economic evaluation, taking into account the benefis with high reliability.

- Internal Rate of Return (IRR): 5.89
- Benefit/Cost Ratio (B/C Discount Rate at 10%) : 0.70
- Net Present Value (NPV) : -44.163 million M$

Purely from an economical viewpoint, the above values are too low to justify the feasibility of the Tatau-Kapit Trunk Road. However, the economic feasibility of the Trunk Road Project improves by taking the following benefits into consideration, aside from the benefits involved in the economic evaluation.

a) Contribution to Pelagus Hydro-electric Dam Construction Project

If the Project Road is not realized, SESCO will build a transportation road for construction materials at its own expense for the dam, which is scheduled to be completed in 2005.

Therefore, the Project Road will save construction costs of the transport road and will also help to transport construction materials. Since these benefits involve large indefinite factors (delay of contstruction schedule, etc.), they have been excluded in the economic evaluation. If they are considered, the IRR value will be 7.92, and the B/C will be 0.85 in Case C. However, value of benefit is still lower than that of cost.

b) Contribution to Coal Mining Development

Coal deposits spread along the project road near the border of the Fourth Division and the Seventh Division, on which the feasibility study has been carried out. The Project Road will be used as a part of the coal transportation road.

The benefits are excluded in the economic evaluation as the development program is not formulated yet.

c) Tourism Promotion

Minimum tourism development is involved in the economic evaluation. The Project Road will provide ready access to the Seventh Division and thereby contribute to the development of tourism along the Project Road much more than expected.

d) Contribution to the Development of the Lumber Industry

The lumber indstry has been developed actively in the Project Area, particularly upstream from Sangkap along the Sungai Anap. However, lumbering will be restricted to preserve forest resources in abouf ten years. Nevertheless, logging will continue at a constant volume. Sapling plantation, etc. using appropriate means will be devised for preservation of the harvested forest. Traffic will use the Project Road, and therefore, the Project Road will benefit the lumber industry.

e) Promotion of Employment Opportunities

The construction of the Project Road will promote agricultural development, coal mine development, etc., leading to the promotion of new employment opportunities.

f) Contribution to the Sarawak State Government for the Efficient Regional Administration of Isolated Areas

It is very difficult for the Sarawak Government, under the current conditions of a river-dependent economy, to promote any efficient regional administration development.

For example, no traffic routes connect Kapit, which is the administration center of the Seventh Division, with other Divisions, except for the water way through the Batang Rajang.

In addition, during high water levels, it often becomes difficult to maintain river traffic. Under the circumstances, the construction of the Second Trunk Road connecting to the First Trunk Road will assume a good degree of importance as the most reliable traffic route.

g) Other Benefits

Other benefits include increased accessibility to the hospital, and the schools, and industial development opportunities.

10.2 Conclusion and Recommendations

(1) Conclusion

a) The Project Road seems to offer little in the way of economic feasibility. However, taking into consideration a number of benefits disregarded in

the economic evaluation, namely, the contribution to the hydroelectric dam at Pelagus, coal mining, and forestry development, regional administration development, etc., it may be said that the earliest possible construction of the Project Road is preferable.

(2) Recommendations

1) The Sarawak State Government should make efforts to improve road benefits by promoting the agricultural development projects and tourism development projects along the Project Road.

2) Project Road should be constructed on the basis of a three-stage construction plan, viz.:

1st Stage: Tatau/Mutput Area in the Fourth Division where traffic volume is large
2nd Stage: Kapit Pelagus area in the Seventh Division
3rd Stage: Remaining sections

3) The Project Road should preferably be fully paved by the time it is open to public traffic.

4) It took four years to complete the feasibility study of the Project Road because of the two-years required for aerial photography. During the period, project circumstances have changed slightly. The Study Team was informed of the new hydroelectric dam construction project close to Sangkap along the Sungai Anap in Februay 1985.

It is, however, very difficult to involve, in the Final Report, the results of the alternative alignment study, caused by the new dam project, taking into account the study flow and little information on the dam project. Therefore, aside from the Formal Final Report, a Study Report is to be submitted regarding the preliminary alternative alignment resulting from the new dam construction project.

It is strongly recommended that the alternative alignment caused by the new dam project be studied when the Project Road is realized.

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