CHAPTER 4

CHAPTER 4:
EXISTING ENVIRONMENT

This chapter presents the baseline data and information with respect to the existing environmental settings of the Project site.

4.1 CLIMATE AND METEOROLOGY

4.1.1 INTRODUCTION

The Project site is located in the central part of Peninsular Malaysia. The area experiences an equatorial type of climate characterised by warm and humid weather all year round. It is under the influence of the Asian Monsoon system. There are two distinct monsoon seasons, the Northeast Monsoon (from November to March) and the Southwest Monsoon (from May to September). The period between the monsoons, the months of April and October is commonly referred to as the inter-monsoon or transition period.

4.1.2 SOURCE OF DATA

No long term meteorological observations are available in Sungai Lembing and Jerantut. However, the Malaysian Meteorological Department (MMD) maintains a principal meteorological station, i.e. the Kuantan Airport Meteorological Station in Kuantan; which is close to Sungai Lembing and being inland, shares the same meteorological characteristics. Since the Kuantan Meteorological Station is the nearest meteorological station to the Project site, meteorological observation data from this station was used to describe the climate and meteorological conditions of the Project site.

It is noted that the common meteorological observations taken at a principal MMD meteorological station includes surface (10 m in height) wind, temperature, rainfall and relative humidity. These are the parameters used to describe the climate and meteorology at the Project site.

4.1.3 SURFACE WIND

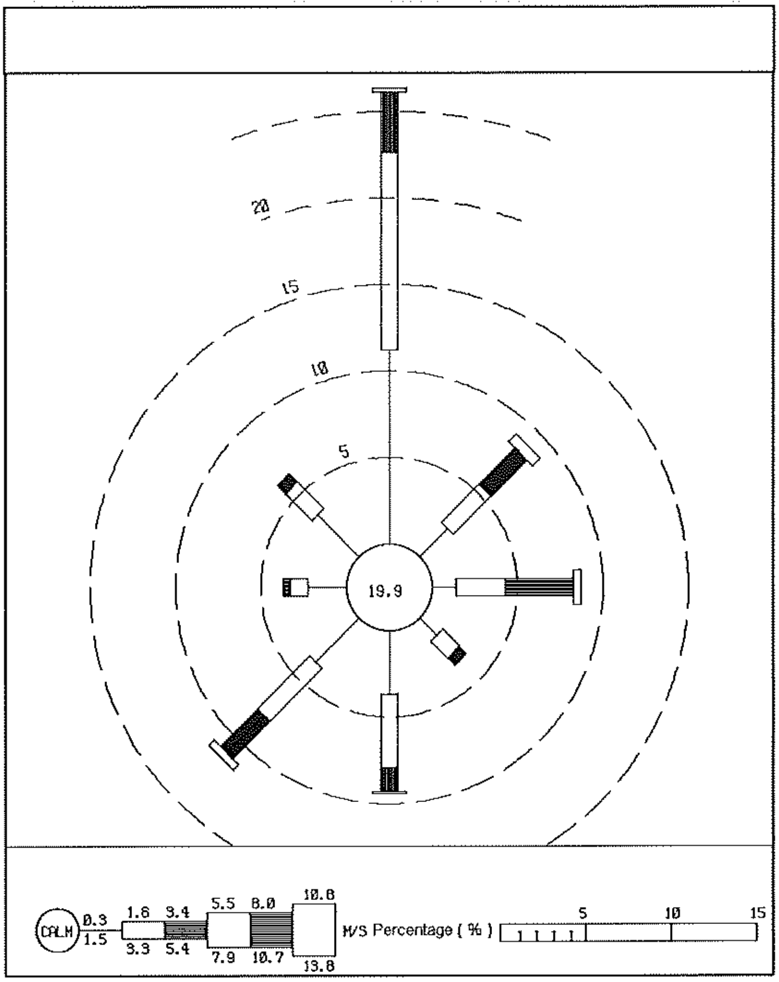
In air quality assessments, wind plays an important role in the transport and dispersal of pollutants. Thus, it is important to consider the general wind flow pattern at the Project site in this assessment. The annual wind rose and those for different monsoon periods for the Project site are given in **Figures 4.1.1** and **4.1.2**.

As the Project site is inland, land and sea breezes do not influence the behaviour of the diurnal surface wind. The annual and seasonal wind roses do not show sea and land breeze prominent features of the general wind pattern.

During the Northeast Monsoon season from November to March, the prevailing wind direction is from the north with moderate winds from the northeast and east. During the

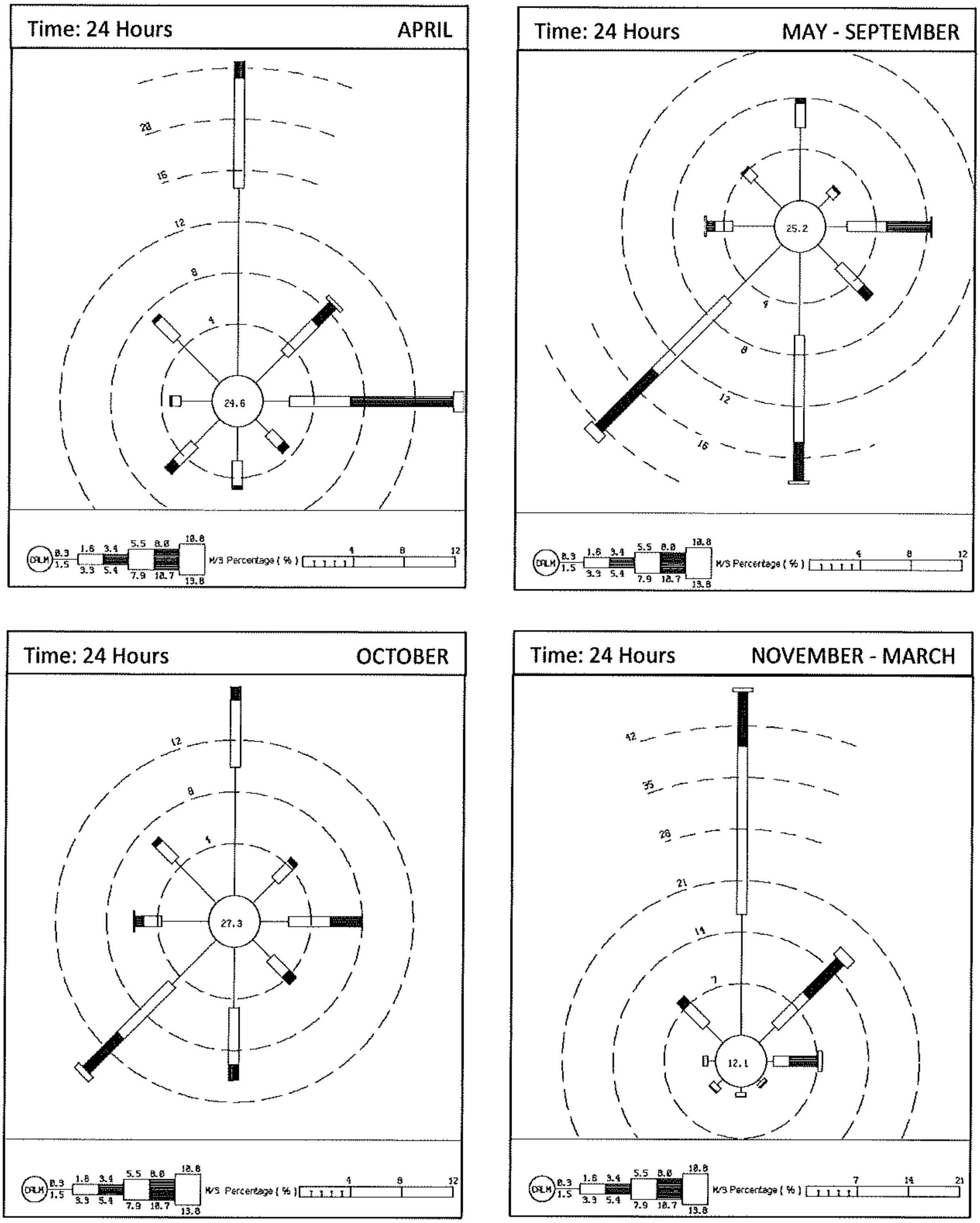
Southwest Monsoon season from May to September, the wind is generally the reverse to that of the Northeast Monsoon. The most common wind direction is from the southwest and south. In the absence of strong prevailing winds as well as the absence of sea and land breezes, the wind at the site is generally calm which is quite common and occurring up to 19.9% of the time.

Figure 4.1.1: Annual wind rose (1968 – 2012)



Source: MMD (2013)

Figure 4.1.2: Seasonal wind rose (1968 – 2012)



Source: MMD (2013)

4.1.4 RAINFALL

The mean monthly rainfall for the period of 1951 to 2012 (62 years) is given in **Table 4.1.1**. Although the monthly rainfall shows variations from year to year, generally, based on the mean monthly rainfall, this area experiences a typical monsoon type rainfall pattern. There is a low rainfall period and a wet season in the Project site. The dry period occurs from the month of February until September while the wet season starts from October and ends in January.

With an annual mean rainfall of approximately 2,983 mm, the Project site is considered to be located in a relatively wet area. The total rainfall amount has never been below 1,859 mm a year during the 62-year period between 1951 and 2012 and has never exceeded 4,268 mm.

On some occasions during the northeast monsoon season, heavy rainfall lasting several days with strong thunderstorm activity can occur in the Project site in the presence of a severe tropical storm in the South China Sea. The number of raindays in the Project site follows the amount of rainfall closely. Higher number of raindays occurs from October to January while February to September has lower raindays.

Table 4.1.1 and **Table 4.1.2** summarise the records of the mean, highest and lowest monthly and annual rainfall amounts and raindays, respectively.

4.1.5 TEMPERATURE AND RELATIVE HUMIDITY

As the Project site is inland, in addition to being in the equatorial region, there is no moderating effect of the sea on the temperature and humidity as well as extreme temperature and relative humidity changes. **Table 4.1.3** shows the 24-hour mean temperature, mean daily maximum and minimum temperature for each month of the year averaged over the period from 1968 to 2012. The table shows that the 24-hour mean temperature varies between a small range of between 25.0°C and 27.4°C. Relatively lower temperatures are experienced during the wetter months at the end and beginning of the year while the highest temperatures normally occur during the months of April, May and June.

Daily mean maximum temperatures of between 29.2°C and 33.2°C can be expected at the Project site while the daily mean minimum temperature is between 22.1°C and 23.7°C.

Table 4.1.4 shows the 24-hour mean monthly relative humidity averaged over the years 1968-2012. Throughout the year, the 24-hour mean monthly relative humidity remains high at above 83 percent with some variation between the dry and wet months. Generally it can be noted that, corresponding with the rainfall pattern, relative humidity is slightly higher during the end and beginning of the year.

Table 4.1.1: Records of Mean, Highest and Lowest of Monthly and Annual Rainfall (1968 – 2012)

Rainfall (mm)	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean	314.4	147.9	182.1	162.8	191.9	160.7	155.0	188.5	215.5	273.8	358.6	632.3	2983.8
Highest	934.7	475.5	657.1	362.2	389.6	380.4	403.6	367.0	387.6	591.2	1223.7	1471.1	4268.5
Year of Highest	1971	1967	1967	2012	1965	1978	1971	1968	1965	2004	1994	2001	1967
Lowest	9.2	1.2	4.1	2.1	28.3	50.3	12.9	59.0	13.1	71.4	140.9	114.8	1859.2
Year of Lowest	1976	1998	1972	1983	1997	1996	1958	1986	1997	1972	1997	1958	1977

Source: MMD (2013)

Table 4.1.2: Records of Mean, Highest and Lowest of Monthly and Annual Raindays (1968 – 2012)

Number of Raindays	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean	17	11	12	13	15	13	13	15	16	20	22	22	189
Highest	28	27	27	22	22	20	20	23	24	27	29	29	228
Year of Highest	1955	1964	1994	1982	1968	1994	2003	1999	1985	1964	1994	1957	1964
Lowest	3	1	2	1	9	6	4	7	6	12	15	13	140
Year of Lowest	1997	Sev.	1983	1983	1993 & 1997	1981 & 1985	1958	1990	1997	1961 & 1994	1968 & 1990	1979	1997

Note: Sev. - Several occasions.
Source: MMD (2013)

Table 4.1.3: Records of Temperature (1968 – 2012)

Temperature (°C)	January	February	March	April	May	June	July	August	September	October	November	December	Annual
24 Hr. Mean	25.0	25.7	26.4	27.1	27.4	27.2	26.8	26.8	26.6	26.4	25.7	25.1	26.4
Mean Daily Max.	29.5	30.9	31.7	32.8	33.2	32.9	32.5	32.6	32.4	32.0	30.6	29.2	31.7
Mean Daily Min.	22.1	22.2	22.9	23.5	23.7	23.5	23.2	23.2	23.1	23.1	23.0	22.6	23.0
Highest Max.	34.2	35.0	36.3	36.9	37.8	36.4	35.6	35.8	35.5	35.7	34.9	33.8	37.8
Year of Highest Max.	1998	1998	1983	1983	1998	1998	1996	1990	1977	1997	2003	2000	1998
Lowest Min.	16.8	17.4	17.3	18.8	21.1	20.0	19.9	20.3	20.2	20.1	20.2	19.4	16.8
Year of Lowest Min.	1972	1976	1974	1977	Sev.	1985	1985	1970	1974	1969	1968	1979	1972

Note: Sev. - Several occasions.
Source: MMD (2013)

Table 4.1.4: Records of Relative Humidity (1968 – 2012)

Relative Humidity (%)	January	February	March	April	May	June	July	August	September	October	November	December	Annual
24 Hr. Mean	86.2	83.8	84.2	84.0	84.5	84.0	83.8	83.7	84.3	86.2	89.0	89.1	85.2

Source: MMD (2013)

4.2 AMBIENT AIR QUALITY

4.2.1 BASELINE AMBIENT AIR QUALITY MONITORING

Baseline ambient air quality monitoring was conducted from 26 to 28 March 2013 to establish the baseline ambient air quality of the surrounding areas of the Project site. The monitoring was conducted at two locations, namely A1 and A2 as described in **Table 4.2.1** and shown in **Figure 4.2.1**. TSP and PM_{10} were collected by using a High Volume Sampler (Model Graseby GL2000H) while toxic gases were collected by using a portable air sampling pump.

Table 4.2.1: Location of baseline ambient air quality monitoring stations

Station	Location	GPS Coordinates	
		Latitude	Longitude
A1	Felda Lepar Utara 4	N 03° 54' 04.7"	E 102° 48' 39.2"
A2	Kuala Kenau, Sungai Lembing	N 03° 55' 55.9"	E 103° 02' 58.8"

4.2.2 BASELINE AIR QUALITY

As the Project site is located in a remote and slightly elevated area, air quality is expected to be good. This is supported by the results of total suspended particulate (TSP) and gaseous measurements made at the sites (**Table 4.2.2**). Certificate of Analysis (COA) on detailed baseline ambient air quality results are provided in **Appendix 4-1**.

All the air quality parameters monitored are below the limits prescribed in the *Malaysian Ambient Air Quality Guidelines (MAAQG).* TSP and PM_{10} levels were below the MAAQG limits of 260 μg/m^3 and 150 μg/m^3 respectively, while SO_2, NO_2 and CO levels were not detected throughout the monitoring.

Table 4.2.2: Results of baseline air quality monitoring

Test Parameter	Sampling Date & Time	Station		MAAQG Limits*
		A1	A2	
Total Suspended Particulate (TSP)	26 – 27/03/13 7.00 a.m – 7.00 a.m	73 μg/m^3	68 μg/m^3	260 μg/m^3
Particulate Matter (PM_{10})	26 – 27/03/13 7.15 a.m – 7.15 a.m	39 μg/m^3	35 μg/m^3	150 μg/m^3
Nitrogen dioxide (NO_2)	26 – 27/03/13 8.00 a.m – 8.00 a.m	ND (<0.005 ppm)	ND (<0.005 ppm)	0.04 ppm
Sulphur dioxide (SO_2)	26 – 27/03/13 7.30 a.m – 7.30 a.m	ND (<0.005 ppm)	ND (<0.005 ppm)	0.04 ppm
Carbon monoxide (CO)	26/03/13 8.00 a.m – 4.00 p.m	ND (<2 ppm)	ND(<2 ppm)	9 ppm

*Note: * MAAQG = Malaysian Ambient Air Quality Guidelines; < = less than; ND = Not Detected.*

4.3 NOISE LEVEL

4.3.1 BASELINE NOISE LEVEL MONITORING

Environmental noise level monitoring was conducted at two locations, namely N1 and N2 as described in **Table 4.3.1** and shown in **Figure 4.2.1**; to establish the baseline noise characteristic of the surrounding areas of the Project site. The monitoring exercise was conducted from 26 to 27 March 2013 for station N1 and from 22 to 23 May 2013 for station N2.

Table 4.3.1: Location of baseline noise monitoring stations

Station	Location	GPS Coordinates	
		Latitude	Longitude
N1	Felda Lepar Utara 4	N 03° 54' 04.7"	E 102° 48' 39.2"
N2	Kuala Kenau, Sungai Lembing	N 03° 55' 55.9"	E 103° 02' 58.8"

Noise level monitoring was conducted by using a data-logging sound level meter for 24 hours. Parameters measured during the monitoring are L_{eq}, L_{max}, L_{min}, L_{10} and L_{90} which were measured continuously throughout the day time and night-time for a duration of 15 hours and nine hours respectively. **Plates 4.3.1** and **4.3.2** below show the noise level monitoring exercise at stations N1 and N2, respectively.

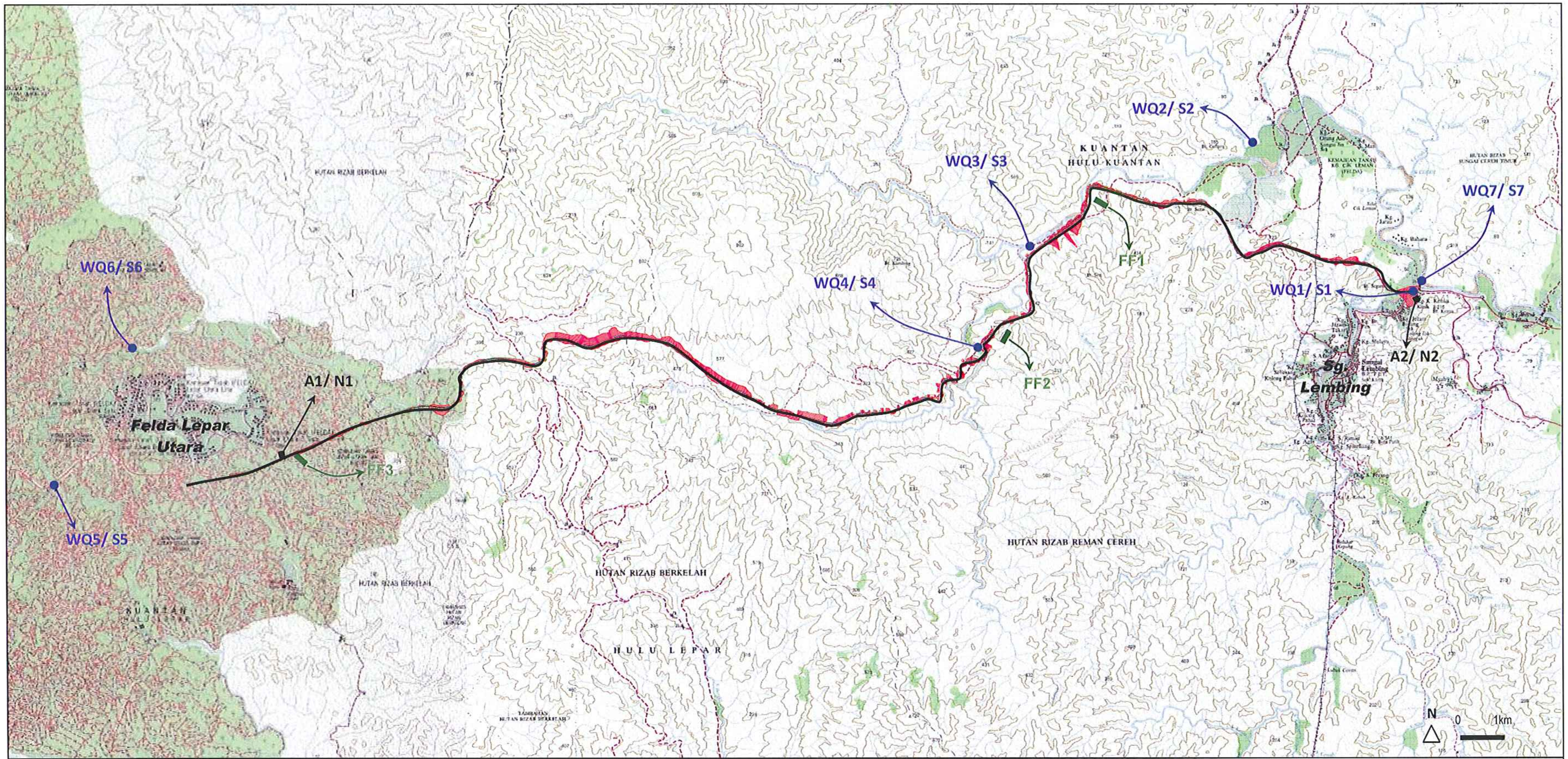
Plate 4.3.1: Noise level monitoring at station N1, Felda Lepar Utara 4.

Plate 4.3.2: Noise level monitoring at station N2, Kuala Kenau, Sungai Lembing.

4.3.2 BASELINE NOISE LEVEL

Results of the noise level monitoring are shown in **Table 4.3.2** below and the COA is attached in **Appendix 4-2**. It is evaluated against "Schedule 1 (Maximum Permissible Sound Level (L_{Aeq}) by Receiving Land Use for Planning and New Development)" of the DOE's *The Planning Guidelines for Environmental Noise Limits and Control, 2007.*

Figure 4.2.1: Locations of environmental baseline sampling stations



LEGEND:

- WQ#/ S# = Water Quality/ Aquatic Resources Sampling Points
- A#/ N# = Air & Noise Sampling Points
- FF# = Flora & Forest Survey Sites
- Proposed alignment of Sg. Lembing–Felda Lepar Utara Road
- Estimated extend of earthworks

Table 4.3.2: Results of baseline noise level monitoring

Station	Sampling Date & Time	DOE Limits	Baseline Noise level, dB(A)				
			L_{Aeq}	L_{max}	L_{min}	L_{10}	L_{90}
Day time Monitoring							
N1	26/03/13 7.00 a.m. to 10.00 p.m.	60 dB(A)	**64.7**	96.3	39.3	69.3	40.0
N2	22/05/13 7.00 a.m. to 10.00 p.m.		**68.7**	105.2	43.2	73.6	55.3
Night-time Monitoring							
N1	26 to 27/03/13 7.00 a.m. to 7.00 a.m.	50 dB(A)	45.0	88.3	39.0	47.1	40.9
N2	22 to 23/05/13 7.00 a.m. to 7.00 a.m.		**56.4**	89.1	35.6	58.9	52.6

Note: 1. Bold indicates readings that exceeded the stipulated limits.
2. DOE limits = Schedule 1 of The Planning Guidelines for Environmental Noise Limits and Control, 2007.

Daytime monitoring results showed that the noise levels throughout the monitoring period exceeded the limit of 60 dB(A) at stations N1 and N2. Daytime noise monitoring levels were recorded in the range of 64.7 dB(A) to 68.7 dB(A). Probable sources of noise were generally from vehicle movements, especially heavy vehicles such as lorries, trailers, etc. as well as the chirping sound of bird at the surrounding areas.

Night-time monitoring result for N1 was below the night-time limit of 50 dB(A). The noise level at station N2 exceeded the stipulated limit. Similarly, the high noise level was due to the movement of vehicles.

4.4 WATER QUALITY

4.4.1 BASELINE WATER QUALITY SAMPLING

River water samples were collected from seven sampling stations from 26 to 28 March 2013. Descriptions of the sampling stations are tabulated in **Table 4.4.1** and depicted in **Figure 4.2.1**.

Table 4.4.1: Location of river water quality sampling stations

Station	Location	GPS Coordinates	
		Latitude	Longitude
WQ1	Sg. Kenau before confluence with Sg. Kuantan	N 03° 55' 59.4"	E 103° 02' 57.5"
WQ2	Sg. Kuantan upstream of Sg. Jin *Orang Asli* settlement	N 03° 58' 01.6"	E 103° 01' 15.3"
WQ3	Sg. Kuantan after confluence with Sg. Keliu	N 03° 56' 31.4"	E 102° 58' 14.4"
WQ4	Sg. Kuantan downstream to its confluence with Sg. Berapit	N 03° 55' 17.6"	E 102° 57' 29.9"
WQ5	Sg. Lepar downstream to the Project activity and Felda Lepar Utara settlements	N 03° 53' 30.3"	E 102° 46' 09.4"
WQ6	Sg. Lepar downstream to the Project activity and upstream to Felda Lepar Utara settlements	N 03° 55' 20.9"	E 102° 48' 58.8"
WQ7	Sg. Kuantan downstream to the Project activity and before confluence with Sg. Kenau	N 03° 56' 01.8"	E 103° 02' 59.8"

In-situ measurements were taken for temperature, pH and dissolved oxygen (DO), whereas grab samples were collected for laboratory analysis of conductivity, salinity, *Escherichia coli* (*E. Coli*), oil and grease, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), ammoniacal-nitrogen and total suspended solids (TSS).

The methodologies of water quality sampling, preservation and handling were conducted in accordance to the *Standard Methods for Examination of Water and Wastewater APHA, AWWA, WPCF (2005) 21st Edition. In-situ* measurements were conducted on site by using the equipment as shown in **Table 4.4.2**. Grab samples were collected where possible in mid-stream approximately 30 cm below the water surface. The river water quality sampling activities are as depicted in **Plate 4.4.1** below. All the collected samples were kept in a cool box filled with ice cubes and ice packs prior to delivery to an accredited laboratory for analysis.

The COA on water quality monitoring is attached in **Appendix 4-3**. The water quality results are compared against the National Water Quality Standards (NWQS) Class IIA limits issued by the Department of Environment (DOE), Malaysia.

Table 4.4.2: *In-situ* Measurement Equipment

Equipment	Brand/ Model	Range	Accuracy
pH/ Temperature meter	HANNA/ HI 8424N	Temperature: -20.0 to 120.0 °C	±0.1 °C
		pH: - 2.00 to 16.00	±0.01 pH
Dissolved Oxygen meter	HANNA/ HI 9146-04	0 to 45.00 mg/l	±1.5% of full scale (mg/l)


Station WQ1


Station WQ2


Station WQ3


Station WQ4


Station WQ5

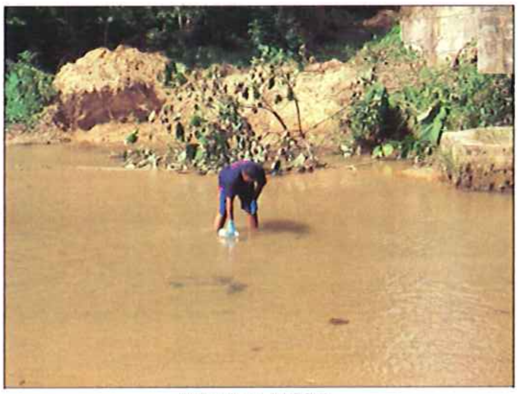

Station WQ6

Plate 4.4.1: Water quality sampling activities in the rivers.

4.4.2 BASELINE WATER QUALITY

Water quality sampling results are shown in **Table 4.4.3**.

Table 4.4.3: Baseline Water Quality Sampling Results

Parameter	Stations								
	Unit	Class IIA	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7
Sampling Date	dd/mm/yy	-	26/03/13	26/03/13	26/03/13	26/03/13	27/03/13	27/03/13	28/03/13
Time	hrs	-	1442	1551	1015	1223	1214	1427	1015
pH	-	6 – 9	6.66	6.40	6.22	6.05	6.01	6.08	**5.93**
Temperature	°C	Normal +2°C	31.4	31.3	31.4	30.0	30.9	31.4	31.4
Dissolved Oxygen	mg/l	5 – 7	6.28	6.25	6.18	5.99	5.98	5.94	5.82
Conductivity	µS/cm	1000	7.21	6.83	6.21	7.42	8.21	7.67	9.20
Salinity	ppm	1000	9	8	7	10	11	10	12
Biochemical Oxygen Demand	mg/l	3	3	**4**	2	**8**	**4**	**5**	**4**
Chemical Oxygen Demand	mg/l	25	12	16	8	**32**	16	20	16
Total Suspended Solids	mg/l	50	6	7	7	7	17	9	6
Oil & Grease	mg/l	0.04; N	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
Ammoniacal Nitrogen	mg/l	0.3	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)
Escherichia coli	CFU/100ml	-	15	18	10	14	20	22	12
DO Sub-index	-	-	93.71	92.57	92.24	88.69	89.39	89.80	87.27
BOD_5 Sub-index	-	-	87.71	83.48	91.94	68.76	83.48	79.25	83.48
COD Sub-index	-	-	83.14	77.82	88.46	61.04	77.82	72.50	77.82
NH_3-N Sub-index	-	-	100.50	100.50	100.50	100.50	100.50	100.50	100.50
TSS SI	-	-	93.92	93.34	93.34	93.34	87.77	92.17	93.92
pH SI	-	-	98.18	96.00	93.96	91.64	91.03	92.07	89.77
WQI Score	-	-	92.47	90.21	93.20	83.35	88.02	87.29	88.39
WQI Class	-	-	I	II	I	II	II	II	II
WQI Status	-	-	Clean	Clean	Clean	Clean	Clean	Clean	Clean

Note: 1. N= free from visible film sheen, discolouration and deposits; ND= Not Detected.
2. Bold indicates readings below or exceeding the National Water Quality Standards Class IIA limits.

The water quality results for all parameters were within the NWQS Class IIA limits except for a few parameters as follows:

i. BOD_5 at stations WQ2, WQ4, WQ5, WQ6 and WQ7;
ii. COD at station WQ4;
iii. Lower pH at station WQ7;

The river water of Sg. Kenau and Sg. Kuantan is clear, whereas Sg. Lepar is slightly turbid. River water temperatures at all the stations ranged from 30.0°C to 31.4°C during the water quality sampling and measurement period. Conductivity and salinity ranged from 6.21 µS/cm to 9.20 µS/cm and 7 ppm to 12 ppm respectively, below the stipulated limits. Total suspended solids level was low and below the stipulated limit of 50 mg/l. *Escherichia coli* (*E. coli*) count at all stations ranged from 10 CFU/100ml to 22 CFU/100ml while ammonical nitrogen as well as oil and grease were not detected.

Water Quality Index (WQI) was calculated for all stations, which ranged from 83.35 to 93.20. These values are equivalent to Class I and Class II within the clean category of the DOE Water Quality Index Classification (WQIC). Stations WQ1 and WQ3 were classified as Class I whereas stations WQ2, WQ4, WQ5, WQ6 and WQ7 were classified as Class II.

4.5 TOPOGRAPHY AND HYDROLOGY

4.5.1 TOPOGRAPHY

The topography of the proposed road alignment varies from flat (<3% slope) that makes up 65% of the area; 30% of rolling (3 - 25% slope) and 5% of steep slope (>25% slope) (**Figure 4.5.1**). Most of the hilly areas are scattered except for the mountain ranges located in the eastern part of Sg. Lepar and at Bukit Kambing on the western section of the Sg. Kuantan river basin that runs in the north-south direction. The flat to rolling areas are mostly found along the river valley of Sg. Kuantan at Kg. Kuala Kenau and its tributaries in the lower part of the Sg. Kuantan river basin. The elevation of areas surrounding the Project site rises from 20 m to 980 m above MSL within the lower portion of the Sg. Kuantan basin.

4.5.2 HYDROLOGY

The new road alignment is located within two major catchments, Jerantut and Kuantan (**Table 4.5.1**).

Table 4.5.1: Major Catchments Surroundings the Project site

No.	Catchment	Area (ha)
1.	Jerantut	736,346
2.	Kuantan	191,666

The Project area can be delineated into three independent main catchments – Sg. Tekam catchment (approx. 740 km²) and Sg Lepar catchment (approx. 132 km²) for the existing Felda Lepar - Jerantut road; and Sg. Kuantan catchment (approx, 585 km²) for the new proposed road. There are two major river basins within the Project site – Sg. Kuantan River Basin and Sg. Pahang River Basin. Most of the proposed new road is within the Sg. Kuantan River Basin. There are five main rivers namely Sg. Berapit, Sg. Jin, Sg. Kenau, Sg. Lepar and Sg. Kuantan within the Project site that act as the existing drainage system (**Figure 4.5.2**). Sg. Kenau, Sg. Berapit and Sg. Jin are the tributaries of Sg. Kuantan in the Sg. Kuantan River Basin while Sg. Lepar is tributary of Sg. Pahang that is considered affected by the proposed new road (**Figure 4.5.3**).

4.5.3 HYDROLOGICAL STATION

The rainfall stations maintained by the Department of Irrigation and Drainage (DID) near the Project site in the Districts of Kuantan and Jerantut are listed in **Table 4.5.2**. The nearest rainfall station is at the Pahang Consolidated Company Limited (PCCL) mill, Sg. Lembing and the data was used for the hydrological modelling.

Figure 4.5.1: Topography of the Project Area

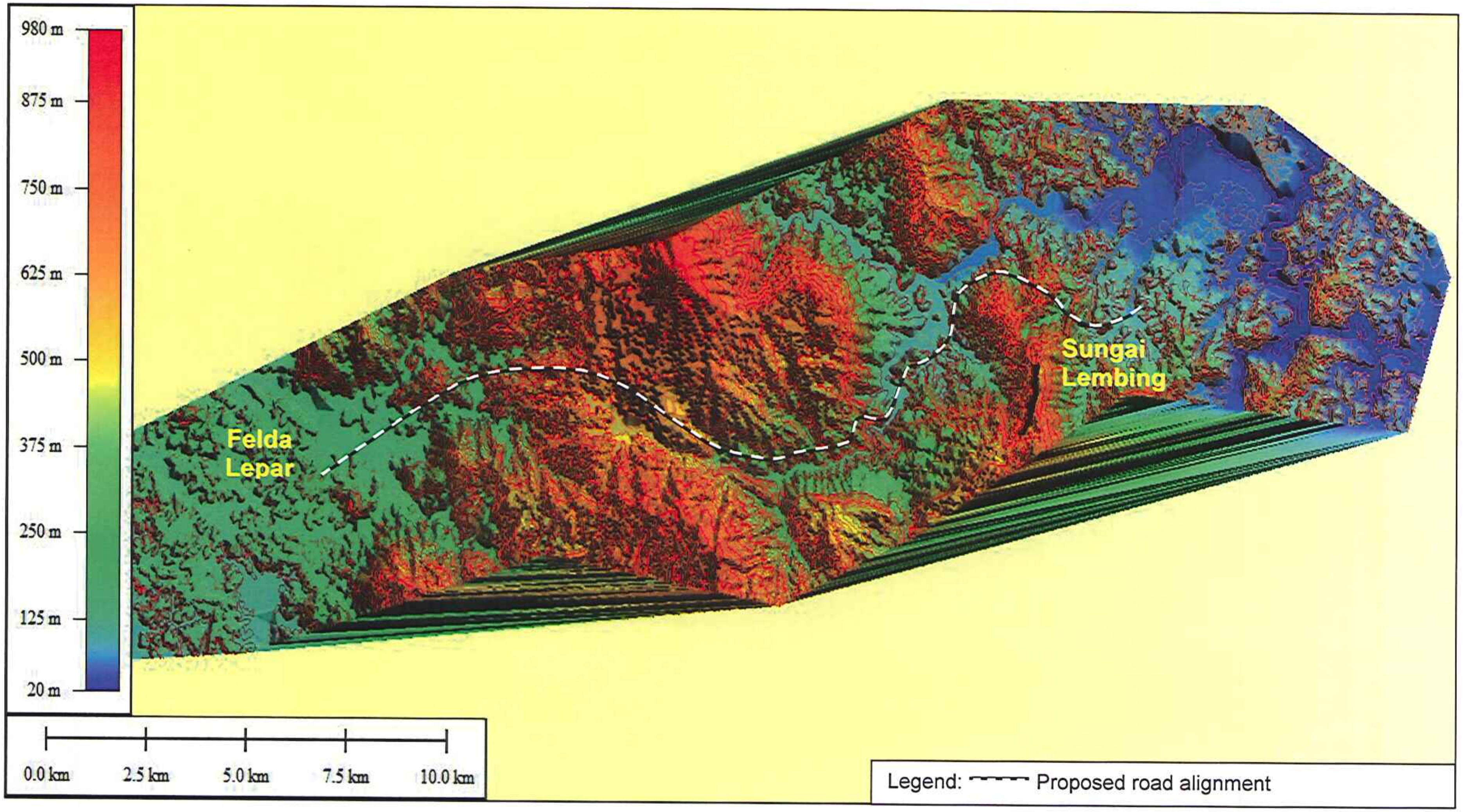


Figure 4.5.2: Existing Drainage Pattern by Digital Terrain Model (DTM) within the Project

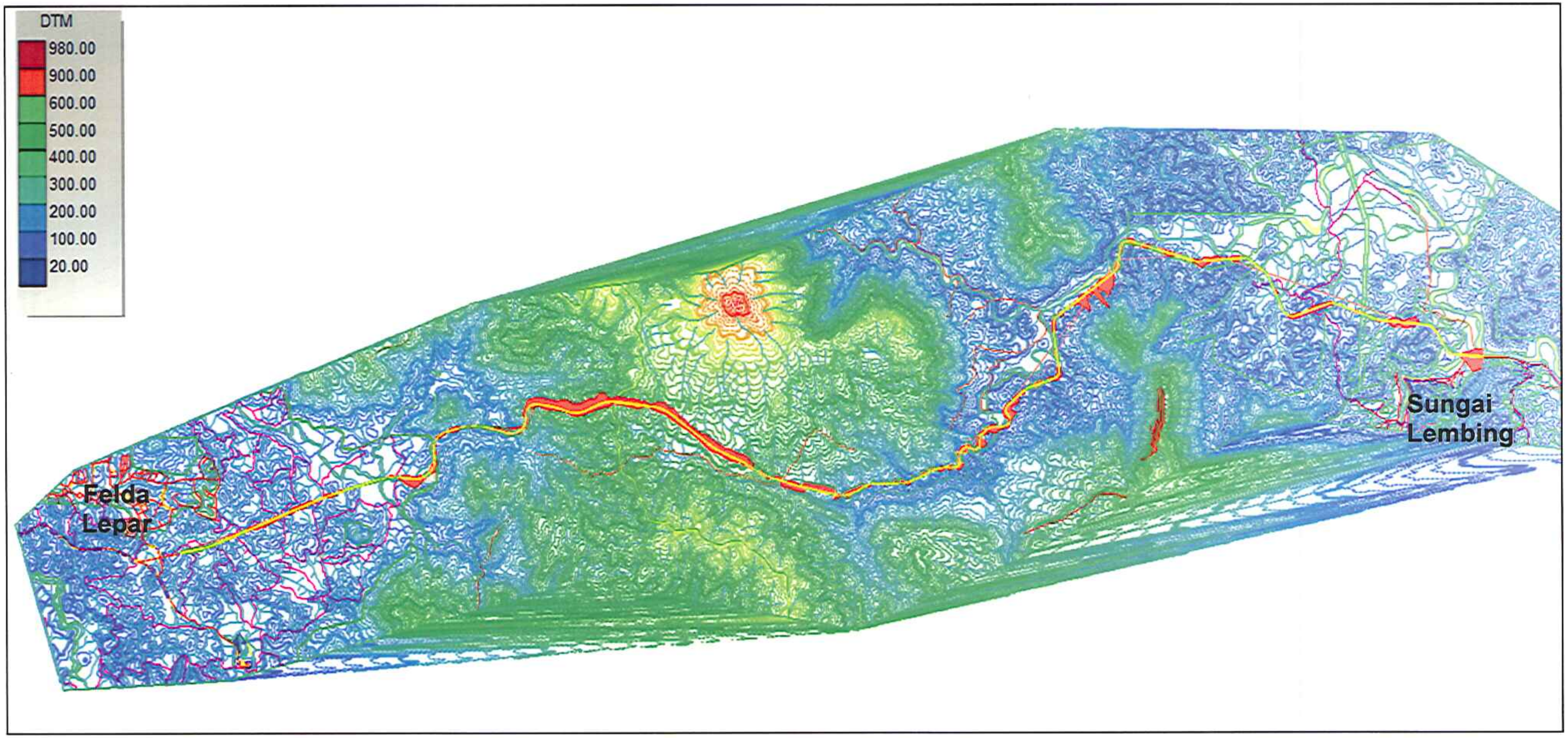
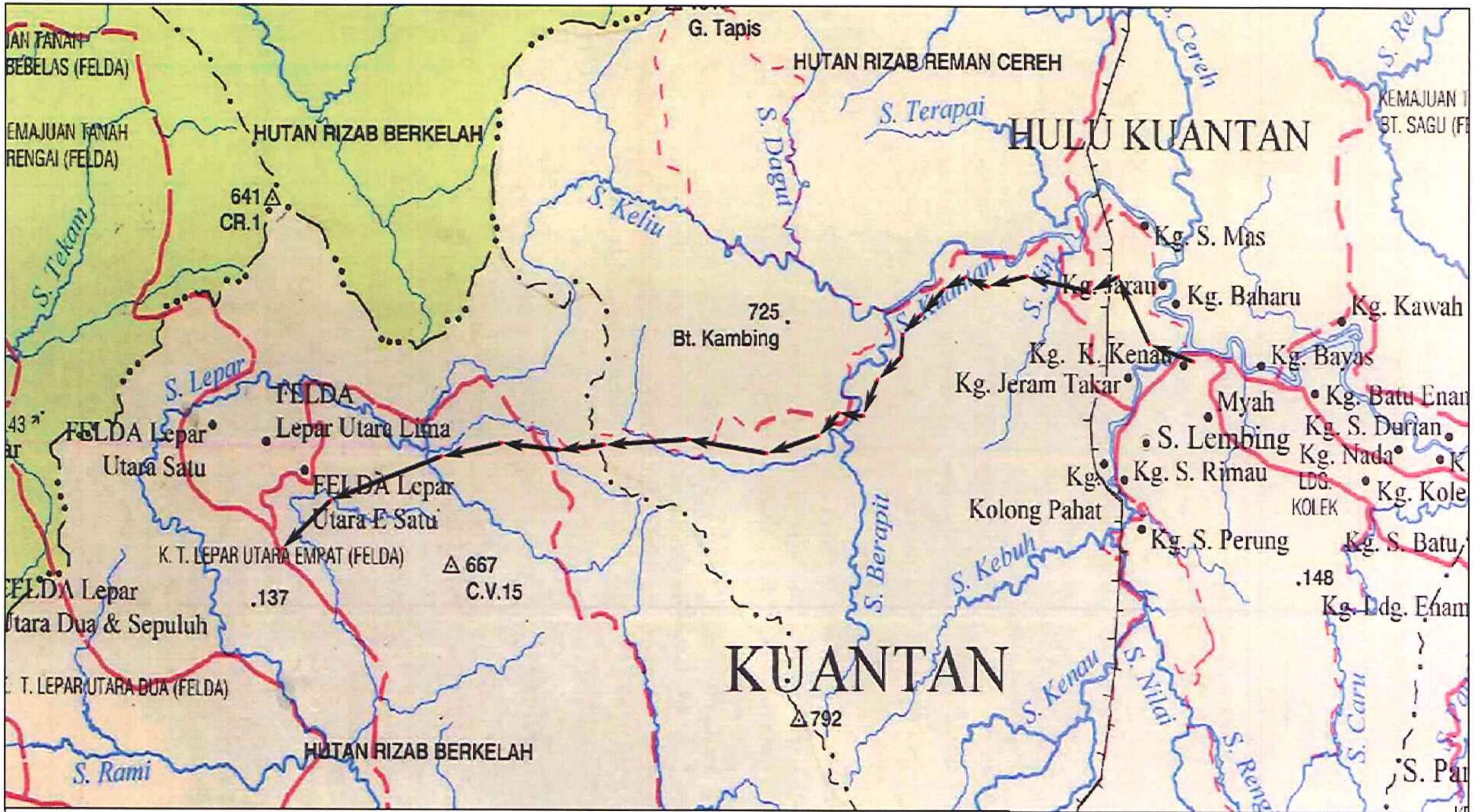


Figure 4.5.3: Proposed New Road Alignment and Major River Catchment within the Project



Legend: ◄◄ Proposed Sg. Lembing – Felda Lepar Utara Road; (red line) Existing Road

Table 4.5.2: List of Rainfall Station adjacent to the Project Site

Station ID	Station Name	District	River Basin
4227001	Ulu Tekai 1	Jerantut	Sg. Pahang
4324001	Kuala Tahan	Jerantut	Sg. Pahang
4023001	Sg. Yap	Jerantut	Sg. Pahang
3830001	Ladang Mentega	Kuantan	Sg. Kuantan
3929001	Sg. Lembing	Kuantan	Sg. Kuantan
3930012	*PCCL Sg. Lembing*	*Kuantan*	*Sg. Kuantan*
3930013	Bukit Kenau	Kuantan	Sg. Kuantan
4031001	Bukit Sagu	Kuantan	Sg. Kuantan
3831002	Felda Pancing	Kuantan	Sg. Kuantan
3831001	Pasir Kemudi	Kuantan	Sg. Kuantan
3832020	Kuantan By-pass	Kuantan	Sg. Kuantan
3833002	Kuantan By-pass	Kuantan	Sg. Kuantan
3432001	Sri Damai	Kuantan	Sg. Kuantan

Source: DID Pahang

Similarly, the water level station nearest to the Project site is important to determine the suitable road level to prevent the road from flooding during flood event. **Figure 4.5.4** shows the location of the rainfall and water level stations nearest to the Project site.

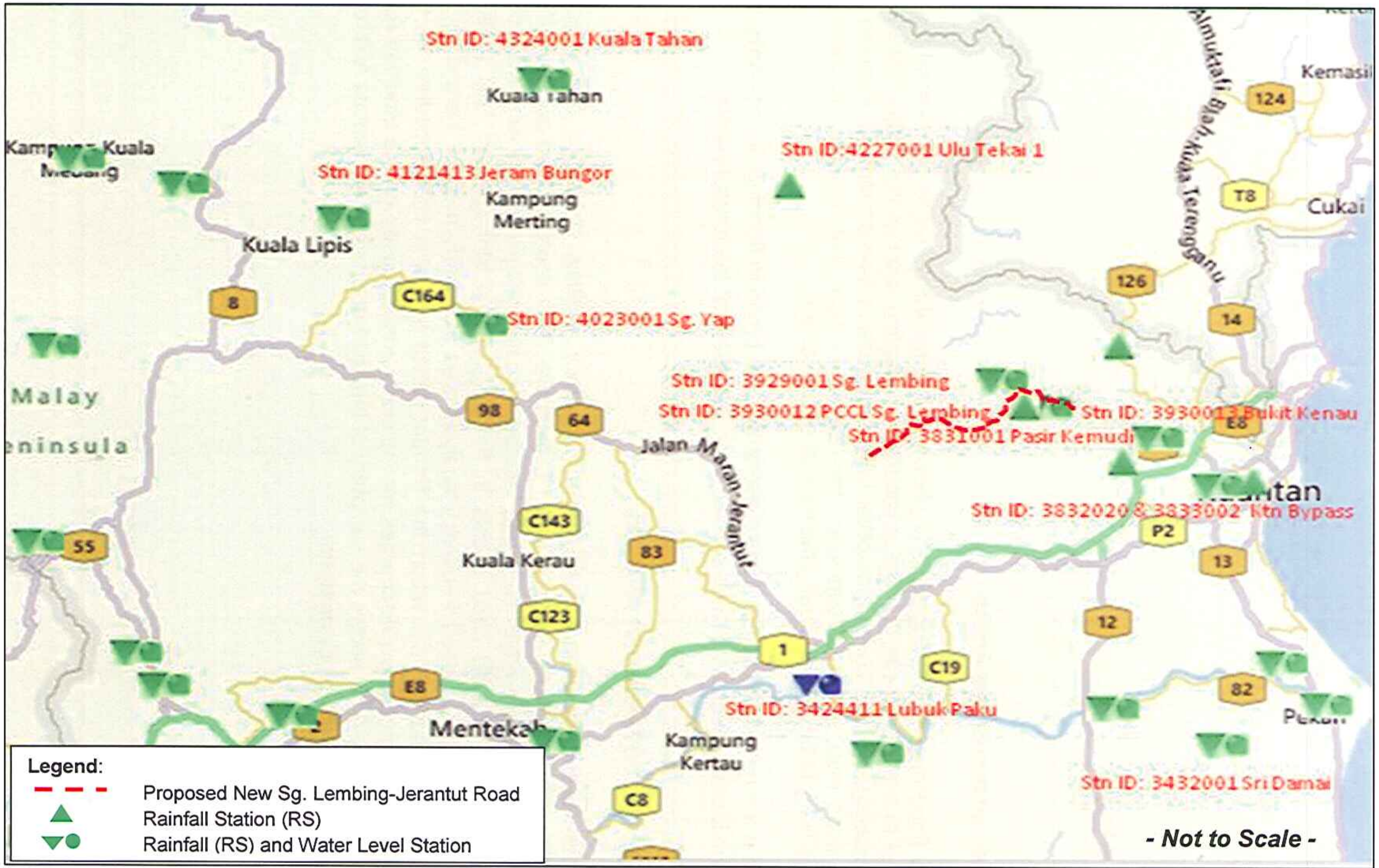
Table 4.5.3 shows the recorded river water levels at existing DID stations surrounding the Project site. The danger level is defined as the maximum water level when the river water starts to overspill at the river bank and should be used as a guide for the flood level. The proposed finished road level should be higher than the danger level to prevent flooding at the proposed road.

Table 4.5.3: Recorded Water Level at Rivers Affecting the Project site

Station ID	Station Name	District	River Basin	River Level (m)	Normal Level (m)	Alert Level (m)	Warning Level (m)	Danger Level (m)
4324454	Sg. Tembeling at Kuala Tahan	Jerantut	Sg. Pahang	59.66	60	64	66	68
4023412	Sg. Pahang at Sungai Yap	Jerantut	Sg. Pahang	43	44	48	50	52
3725401	Kg. Chenor, Sg. Pahang	Maran	Sg. Pahang	17.1	16.8	20.7	22.1	23.5
3527410	Sg. Pahang at Lubuk Pasu	Maran	Sg. Pahang	12.73	14	17	18	19
3929401	Sungai Lembing	Kuantan	Sg. Kuantan	31.76	32	34	35	36
3930401	Sg. Kuantan at Bukit Kenau	Kuantan	Sg. Kuantan	16.08	17	20	20.75	21.5
3831401	Sg. Kuantan at Pasir Kemudi	Kuantan	Sg. Kuantan	1.13	2	4.6	6.4	8.2
3432401	Sg. Belat di Sri Damai	Kuantan	Sg. Kuantan	1.87	1.5	3	4	5

Source: DID (2013)

Figure 4.5.4: Location of Rainfall and Water Level Stations Surrounding the Project Site in the Sg. Kuantan River Basin



Source: DID (2013)

4.5.4 DESIGN RAINFALL

The design rainfall was adopted from Manual Saliran Mesra Alam (MSMA) 2nd Edition produced by the DID with the latest Intensity Duration Frequency (IDF) curve for rainfall station at PCCL's mill (3930012). The 1-hour storm for various Annual Recurrence Interval (ARI) is shown in **Table 4.5.4**.

Table 4.5.4: 1-hour storm for various ARI

ARI	Intensity (mm/hr)
100	117
50	100
20	83
10	71.5
5	61
2	50

4.5.5 FLOOD PRONE AREAS

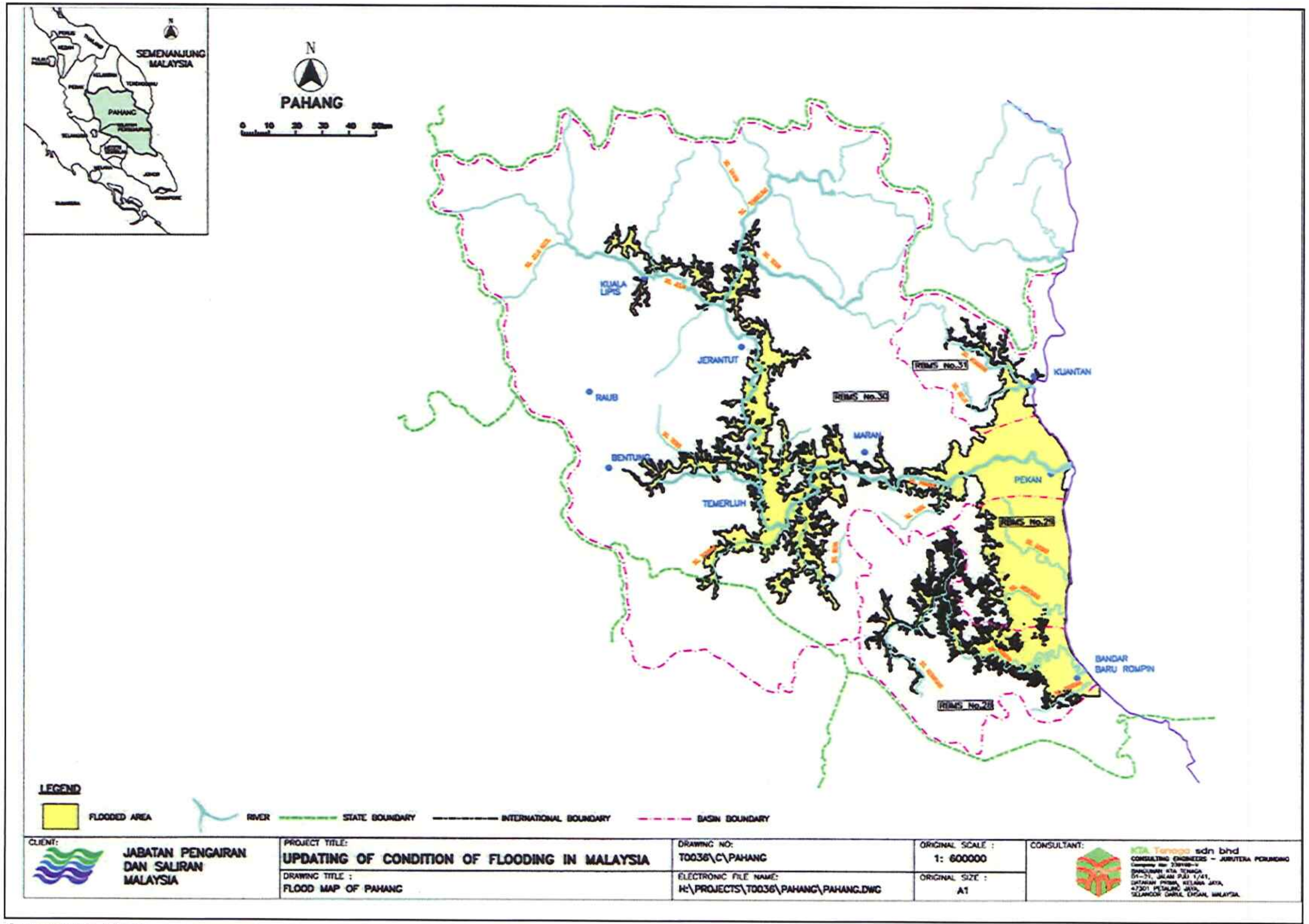
The flood map of Pahang state is shown in **Figure 4.5.5**. There are several locations close to the Project site that are susceptible to flooding such as Kg. Pulau Tawar, Kuala Tembeling, Kg. Sg. Tekam and other low lying areas at downstream Sg. Kuantan. From the flood map, it can be concluded that Pekan, Rompin and Kuantan are the districts most likely to be flooded during the tropical storm season.

There are no formal records of rural areas that are prone to flooding during heavy rainfall at the location nearest to the proposed road; especially at the forest reserve.

4.5.6 FLOOD FREQUENCY ANALYSIS

Table 4.5.5 shows the recorded flood frequency analysis of various JPS streamflow stations (m^3/s) at areas nearest to the Project site. The recorded flood events in Pahang are shown in **Table 4.5.6**. The flood frequency analyses were used to determine the ARI of the worst reported flood events in the River Basin Management Unit (RBMU) in Pahang State. The flood frequency analysis was also performed by Perunding Zaaba (2002) for various rivers within the Pahang State by using HP Procedure No.1. The calculation of peak flow discharges for the study area is based on the Modified Rational Method. **Table 4.5.7** shows the summary of the flood discharges for various ARI resulted from the flood frequency analysis.

Figure 4.5.5: Flood Map of Pahang



Source: DID (2003)

Table 4.5.5: Flood Frequency Analysis of various DID Streamflow Stations near to the Project site

No.	State	Catchment Area (km^2)	Station No.	River	Q_T (m^3/s) Return Period T (Years)						
					T=2	T=5	T=10	T=20	T=25	T=50	T=100
1	Pahang	25600	3527410	Sg. Pahang at Lubuk Paku	2668	4099	5114	6142	6480	7555	8680
2		560	3629403	Sg. Lepar at Jambatan Gelugor	260	374	446	512	533	594	652
3		582	3930401	Sg. Kuantan at Bukit Kenau	1409	2086	2490	2848	2955	3270	3560

Source: DID (2003)

Table 4.5.6: Number of Flood Events (1980 – 2001) by RBMU in Pahang

Year of Flood	RBMU		No. of Flood Events
	No.	Name	
1982	30	Pahang	1
	31	Kuantan	1
1983	30	Pahang	1
	31	Kuantan	1
1984	30	Pahang	3
	31	Kuantan	3
1986	30	Pahang	2
	31	Kuantan	2
1987	28	Rompin	1
	30	Pahang	1
	31	Kuantan	1
1988	28	Rompin	1
	30	Pahang	1
	31	Kuantan	1
1992	30	Pahang	1
1993	30	Pahang	1
	31	Kuantan	2
1994	30	Pahang	1
	31	Kuantan	1
1995	30	Pahang	2
	31	Kuantan	1
1996	30	Pahang	1
1998	30	Pahang	1
	31	Kuantan	2
1999	30	Pahang	5
2001	30	Pahang	1
	31	Kuantan	1
		Total	40

Source: DID (2003)

Table 4.5.7: Estimated Flood Discharges for Selected Catchment

Catchment	Flood Frequency (Cusec)			
	2 Year	5 Year	10 Year	100 Year
Sg. Tekam basin	27157.59	31601.55	36539.3	39995.72
Sg. Siam basin	7616.16	9731.76	11212.68	15232.32
Sg. Galong basin	10801.64	13232	15392.33	21063.19
Sg. Renyai basin	19679	23487.84	27296.68	34914.35
Sg. Kuantan at Bkt. Kenau	54723.02	64856.92	72964.03	93231.82
Sg. Lepar Ulu basin	11488.24	13326.36	14704.95	18381.18

Source: Perunding Zaaba (2002)

4.5.7 LOW FLOW ANALYSIS

DID's Hydrological Procedure (HP) No. 12 was used to estimate low flow at downstream of the Project site based on ungauged sites at ungauged stream method.

The critical low flow is determined from the review of existing hydrological conditions of the river basins and their sub-basins. In sub-basins where there are no stream flow records, the estimation is carried out following the procedure for the ungauged catchment as described in HP No. 12. Occasionally, streams are gauged at certain locations that are not necessarily near the point where minimum flow will be determined. Therefore, ungauged method was applied to determine low flow at a particular location even though there is a gauged station just upstream or downstream of that location.

The data from the Lubuk Pasu rainfall station located at Sg. Pahang for low flow is tabulated in **Table 4.5.8. Table 4.5.9** shows the result of estimated low flow, 7Q10 (annual minimum flow for seven consecutive days is equal on average to once in 10 years) based on HP No. 12 for ungauged site and ungauged stream for the Project.

Table 4.5.8: Estimated Low Flow for Sg. Pahang

Item	Description
Station ID	3424411
Station Name	Sg. Pahang at Temerloh (Lubuk Pasu)
District	Temerloh
River Basin	Sg. Pahang
Normal Water Level (m)	26
Average Water Level (m)	24.52
River Flow (m^3/s)	297.89
7Q10 (m^3/s)	90.75

Table 4.5.9: Estimated Low Flow for Project Based on HP No.12 (Regional)

Item	Description
Station ID	3424411
Station Name	Sg. Pahang at Temerloh (Lubuk Pasu)
District	Temerloh
River Basin	Sg. Pahang
Estimated Catchment Area (km^2)	19,000
Catchment Mean Annual Rainfall (mm)	2,250
Regional Mean Annual Minimum Flow (m^3/s)	133.534
7Q10 (m^3/s)	61.142

4.6 GEOLOGY AND SOIL

4.6.1 INTRODUCTION

For any road development project, knowledge of rock and soil types could assist early cost estimate. This is because earth cuts into hills and rock blasting along hilly stretches, and earth and soil excavation along alluvial and river flood plain stretches will involve major work and a lot of major cost. On the other hand, levelling and grading, aggregating and premixing, which are civil work, require less time and cost. Geological data on rock types and geological structures, namely bedding, folds and faults will be needed when designing hill cuts and slope designs.

In general, geology is essentially about rocks of the earth crust, their types, composition, physical and chemical properties, their mineral wealth, i.e. tin, copper, iron, gold, coal, oil and gas as well as industrial materials; their fossil contents, and the weathering products of the rocks in the form of soils as well as the combined products of physical and chemical weathering; what can grow or what can/ cannot be erected on, the forms of terrains, i.e. of mountains, hills, valleys, plains, swamps, beaches and seas, including the drainage systems formed through the weathering processes by heat (temperature), water (and snow), wind, etc.; and more importantly, especially for new road alignment across hilly terrains, it looks into rock structures, including bedding and folds, faults, joints, fractures, and lineaments, as well as geological processes – including rock - falls as well as rock and soil slumping and sliding, and geological/tectonic activities, including earthquakes and volcanism.

The purpose of this section is to - a) describe the geology along the alignment and the corridor areas of the Project; b) to provide information on rock types and soil, geological structures and other related information.

4.6.2 GEOLOGY

A. Regional Geological Setting

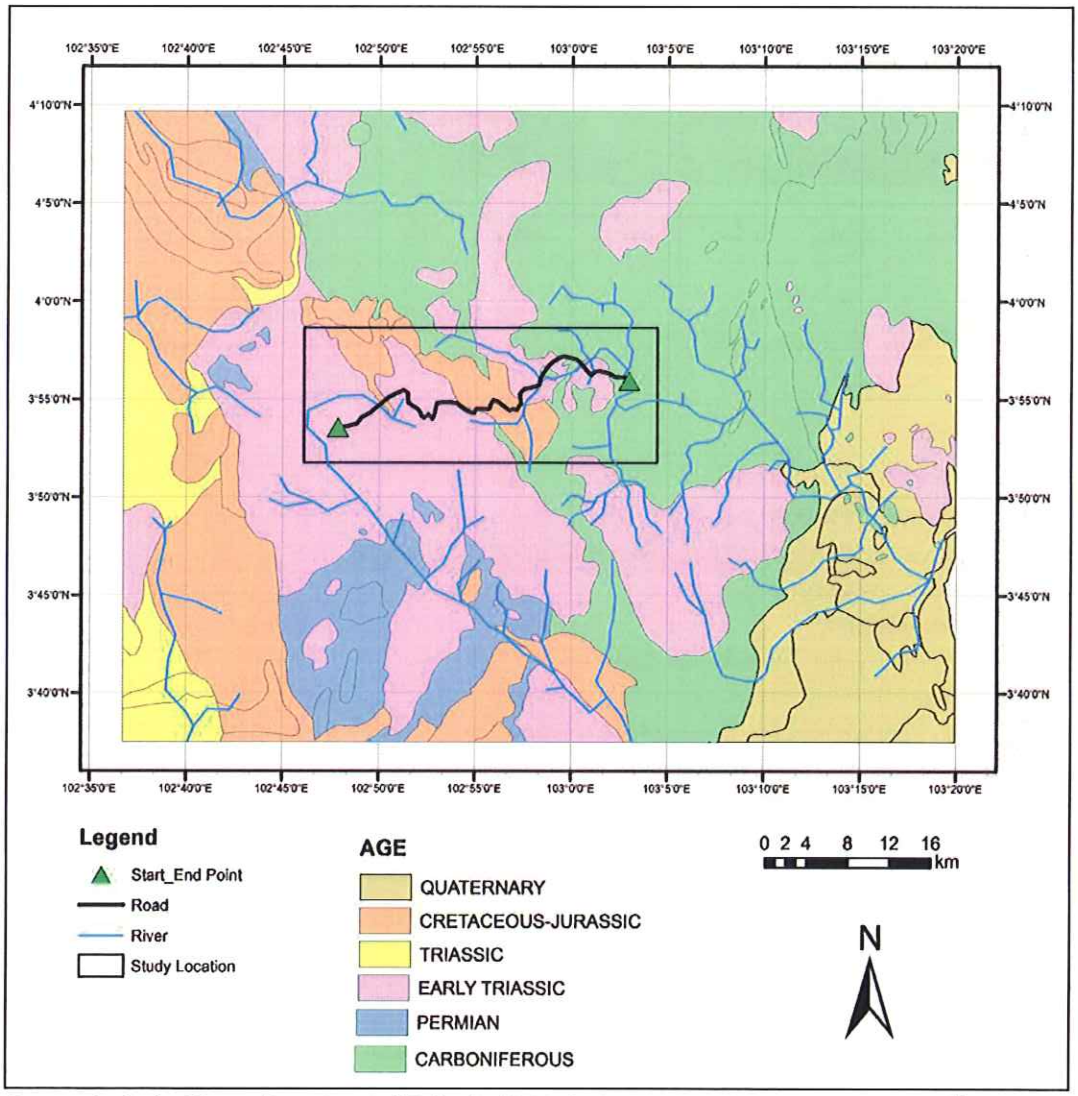
The regional geological setting is briefly introduced in order to set the geological framework of the area where the proposed new road will cut through. Hutchison (2007) divided the eastern part of the Malay Peninsula into three geological terrains, namely Terrain A, Terrain B and Terrain C. Terrain A starts from the north of Terengganu, including Redang Island, and extends to the south to Sungai Pahang. Terrain B starts from the south of Sg. Pahang and extends right down to Singapore and the offshore Indonesian Islands of Batam, Bintan and Lingga. Terrain C starts from North Kelantan, runs almost parallel to the western margin of Terrain A and southwards to link up with Terrain B. The proposed road alignment will be within Terrain A.

Figure 4.6.1 shows the distribution of rocks according to geological ages (stratigraphic), whereas **Figure 4.6.2** shows the distribution rocks according to rock types (lithologic) for Terrain A. The eastern part of the map area is underlain by Carboniferous rocks named as the Kuantan Group in the Kuantan area, mainly at Sungai Lembing (Alexander, 1959). The central part of the road alignment is underlain by Jurassic to Cretaceous rocks. The western part of the map area is underlain by Early Triassic igneous rocks. Permian to Cretaceous igneous rocks in this area ranges from gabbro to monzogranite and granite (Cobbing *et al.*, 1992). Quaternary deposits occurred at the southeast near to the river valley, especially at Kuantan town.

Terrain A is characterised by an enormous volume of granitoid plutons (accurately dated to be at 255 – 270 Ma by Rb-Sr isochrones and by U-Pb zircon radiometric dating: middle to late Permian). It has minor younger granitoid intrusion of 220 – 240 Ma (middle Triassic). The oldest granitoid confirmed in this terrain is Late Permian (Liew, 1983). They intruded through the predominantly Lower Carboniferous sedimentary rock.

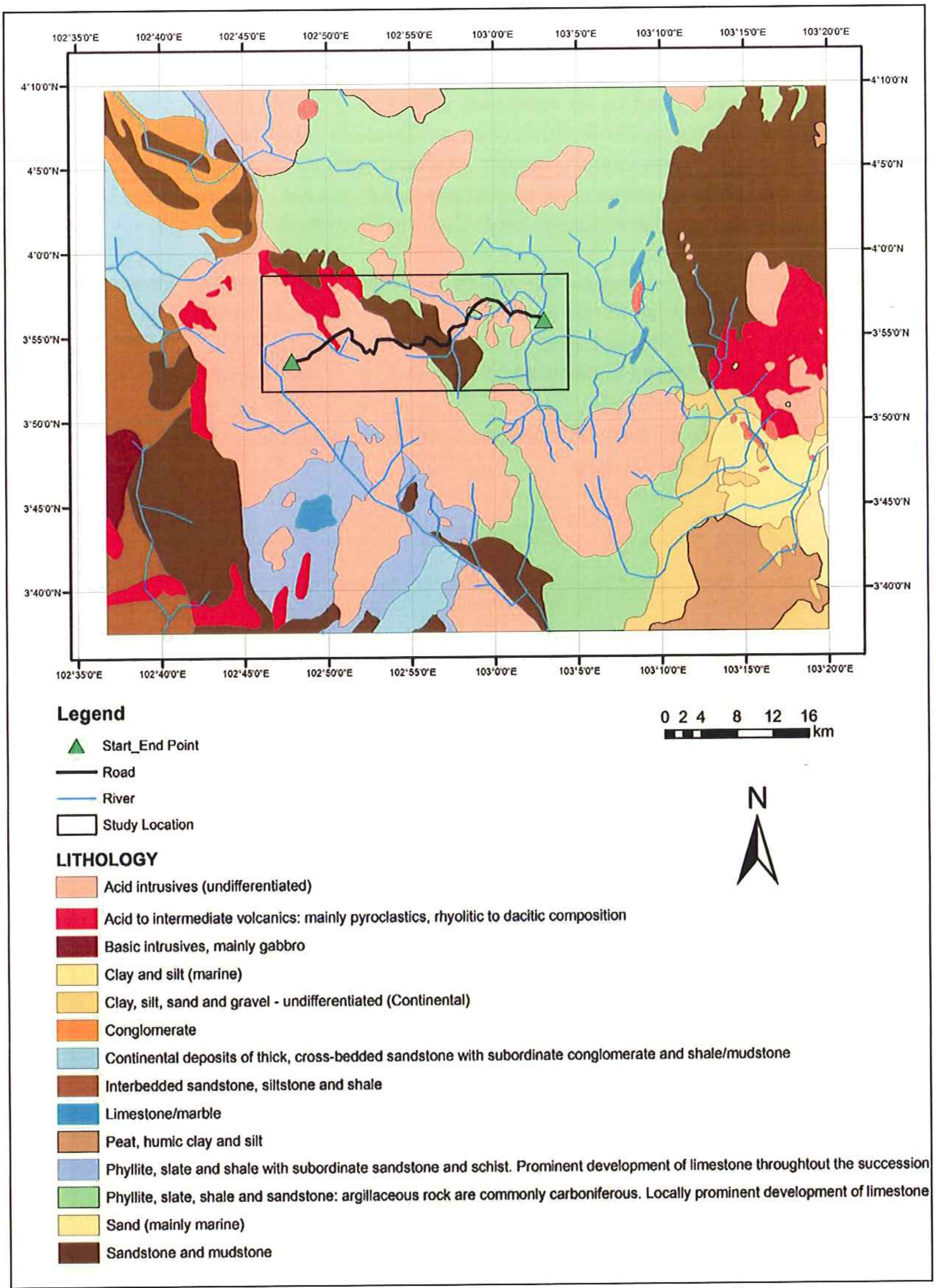
The Paleozoic rocks in Terrain A include the Pinang and Redang Beds offshore of Terengganu, the Sungai Perlis Beds on the east coast of Terengganu, the Kuantan Group rocks to the north and west of Kuantan, the Kambing Beds and Seri Jaya Beds found at the east of Maran in Central Pahang, and the Dohol Formation in east Johor.

Figure 4.6.1: Map of part of Terrain A showing rock distribution according to geological ages



Source: Geological Survey Department of Malaysia (1985) Geological Map of Peninsular Malaysia, 8th edition.

Figure 4.6.2: Map of part of Terrain A showing rock distribution according to lithology or rock types



Source: Geological Survey Department of Malaysia (1985) Geological Map of Peninsular Malaysia, 8th edition.

B. Rock Formations

a. Carboniferous Rocks

Carboniferous Kuantan Group rock is the main rock group/ formations in the area covered by the map for Terrain A (**Figure 4.6.1**). The rock group underlies the central area and extends from north to the south. It consists dominantly of argillaceous rock of well-bedded shale, mudstone and siltstone, some of which are metamorphosed to slate, phyllite, argillite and schist, and with subordinate limestone, sandstone and volcanic. Sandstone and mudstone are found at the north-eastern part. At the eastern part, sandstone and mudstone pass into interbedded sandstone, siltstone and shale. The limestone consists of massive crystalline limestone and forms prominent isolated hills, such as Bukit Panching, Bukit Sagu and Bukit Charas. The Kuantan Group is later subdivided into Charu Formation, Panching Limestone and Sagor Formation (Metcalfe *et al.*, 1980). Apart from normal sedimentary rocks, Kuantan Group has interbedded pyroclastic rhyodacite and andesites as well as minor flow.

The Charu Formation is predominantly of interbedded sequence of sandstone, siltstone and shale, with one limestone locality in the Sungai Lembing mine (Yeap 1966). It is Visean to Namurian (Lower Carboniferous) in age and is a steeply easterly dipping sequence about 1,600 m thick. The strata predominantly strike north, but swing easterly around early Triassic granite pluton at Sungai Lembing.

The Panching Limestone, named after Bukit Panching, conformably overlies the Charu Formation and is a steeply dipping lenticular reef which intermittently continues north along the strike to Bukit Sagu. It is about 600 m thick. The limestone consists of biomicrite, biosparite, biosparudite, oomicrite and recrystallised micrite that contain very rich macro and micro-fauna indicative of Namurian age.

The Sagor Formation consists of sequence of conglomerate, sandstone, shale, mudstone and radiolarian mudstone. It is at least 1,500 m thick.

b. Jurassic-Cretaceous Rocks

Jurassic-Cretaceous rocks are found in the western part of the map area. It was named as the Tembeling Formation (Koopmans, 1968) and consists of alternations of conglomerate, sandstone and mudstone deposited as continental deposits. The conglomerate and sandstone are fairly resistant to erosion and form prominent hill ridges.

This Jurassic-Cretaceous conglomerate and sandstone is likely to be a difficult terrain to cut through.

c. Igneous Rocks

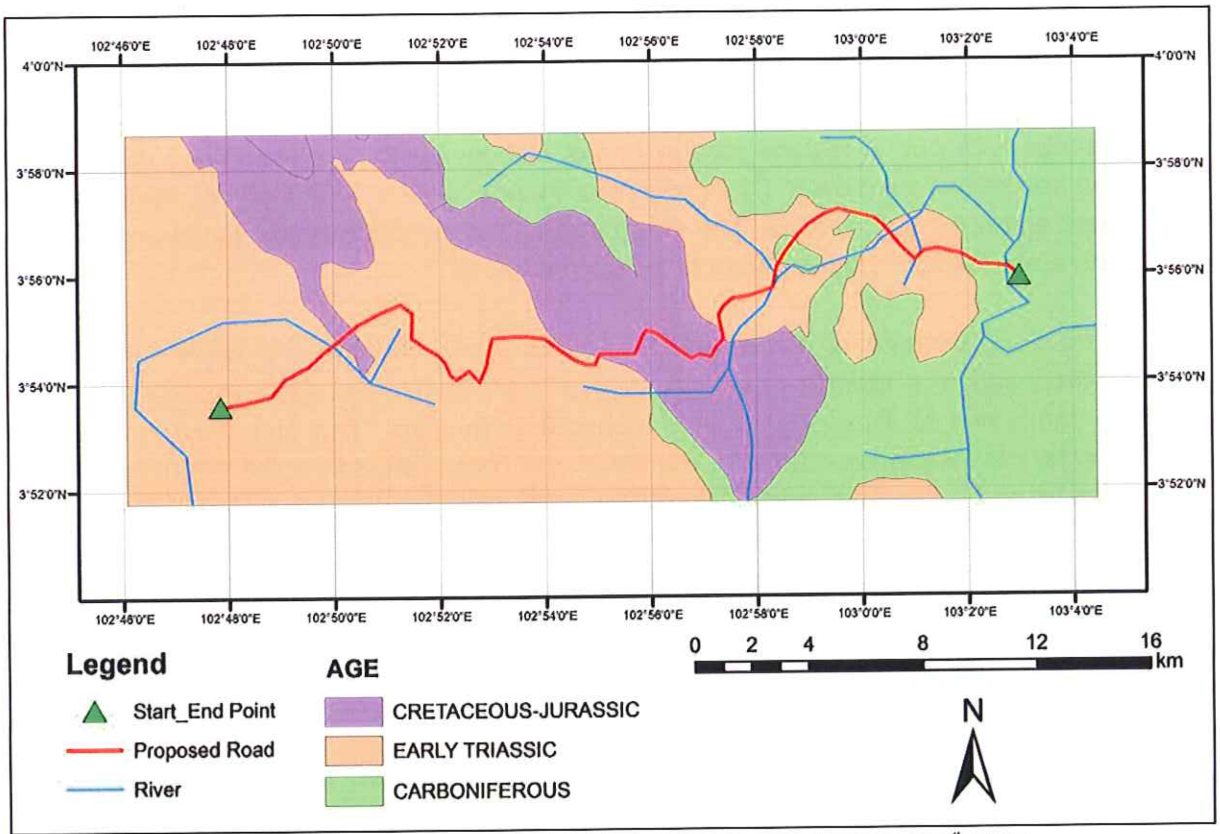
Igneous rocks are mainly intrusive types and are granitic. In **Figure 4.6.2**, it is found in the central and western parts of the map area. It forms prominent mountain ranges and is part of the Terengganu Highlands. This granitic rock is going to be a difficult terrain to cut through or even to go around.

C. Geology along the Corridor of the Proposed Road Alignment

Geology maps of the proposed road alignment showing rock distribution according to rock ages and rock types are depicted in **Figure 4.6.3** and **Figure 4.6.4**, respectively.

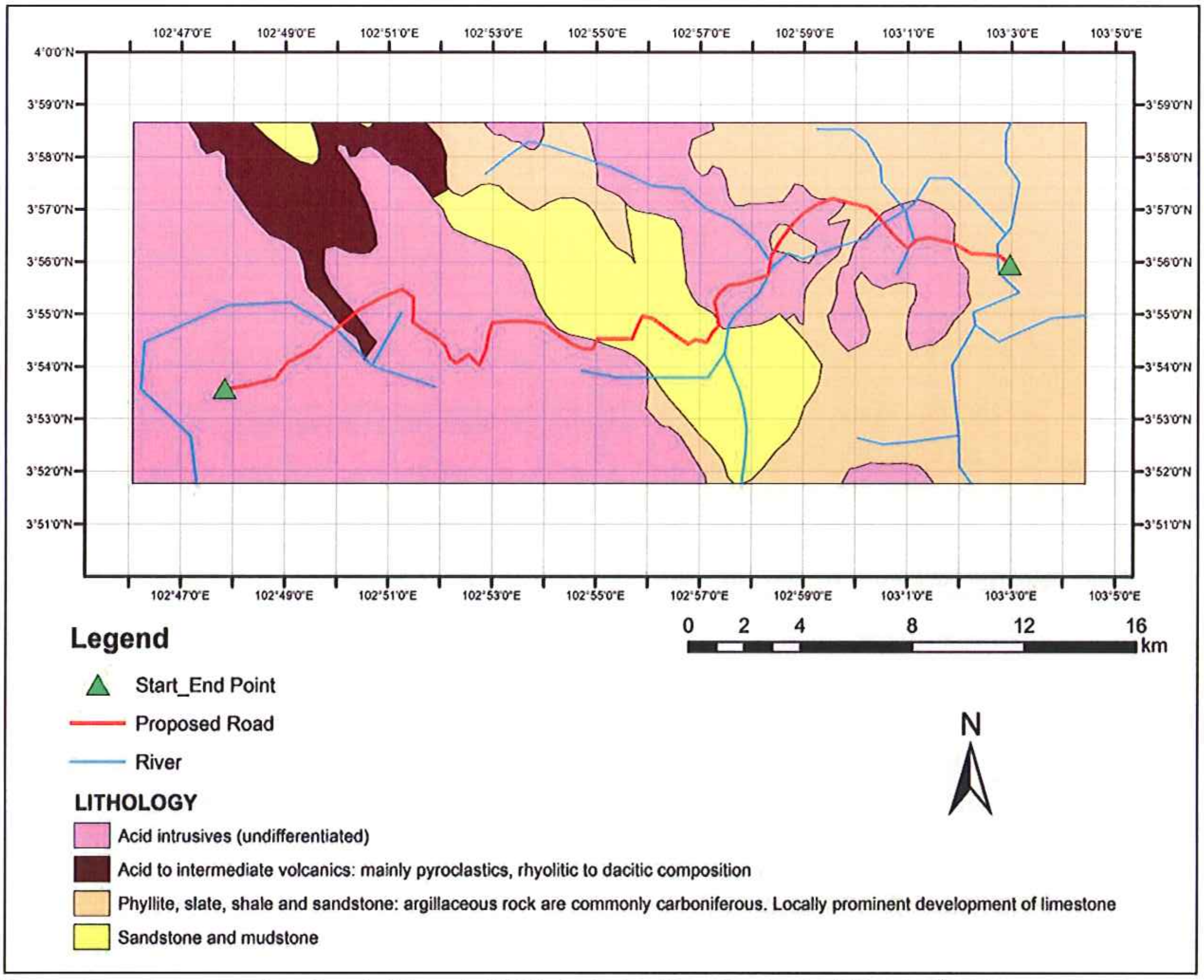
As evident from **Figure 4.6.3**, the eastern part of the proposed road alignment is in the Carboniferous Kuantan Group rocks consisting of phyllite, slate, shale and sandstone and in granites. The middle portion of the alignment is in Jurassic-Cretaceous rock of the Tembeling Formation consisting of conglomerate, sandstone and mudstone. The western part of the alignment is in acid to intermediate volcanic rock composed mainly of pyroclastic, rhyolitic to dacitic composition.

Figure 4.6.3: Geology map of the proposed road alignment showing rock distribution according to rock ages



Source: Geological Survey Department of Malaysia (1985) Geological Map of Peninsular Malaysia, 8th edition.

Figure 4.6.4: Geology map of the proposed road alignment showing rock distribution according to rock types



Source: Geological Survey Department of Malaysia (1985) Geological Map of Peninsular Malaysia, 8th edition.

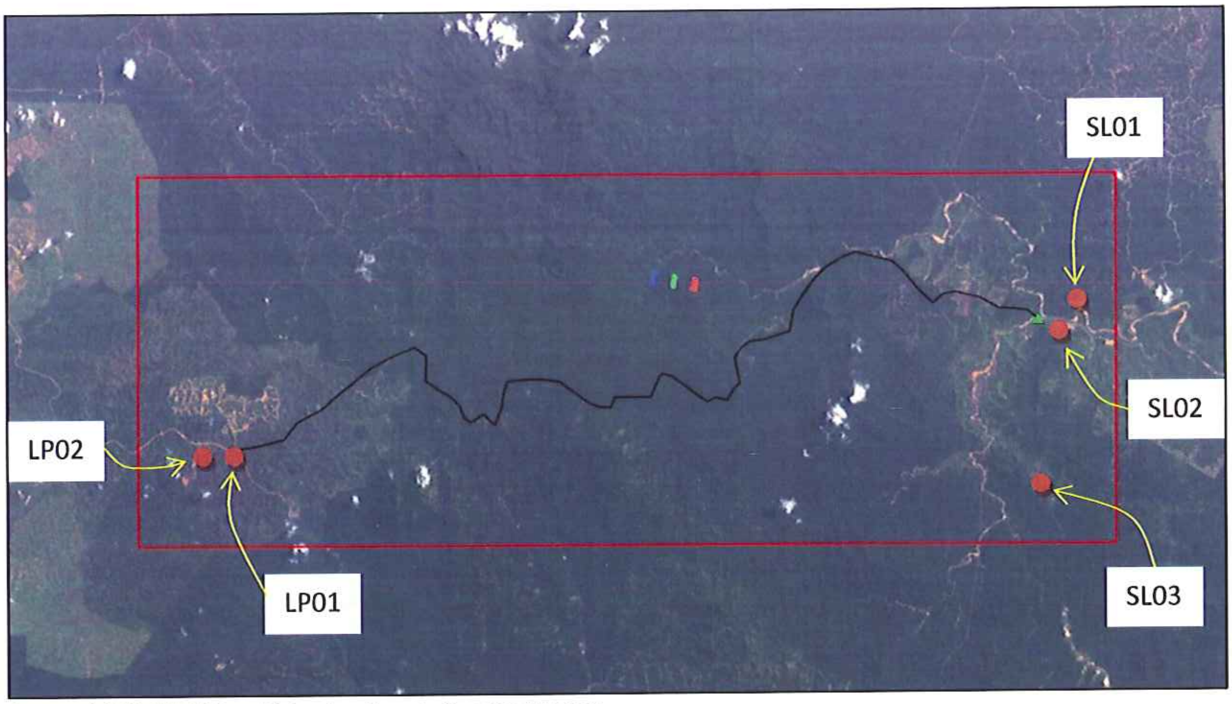
Brief field observations were made at three localities at Sungai Lembing and two localities at Felda Lepar Utara in the area concerned, and as shown in **Figure 4.6.5** where localities are marked as SL01, SL02, SL03, LP01 and LP02. About 12 km from Sungai Lembing the rock type that represents the Panching Limestone is located.

The first locality SL01 (**Plate 4.6.1**) is located about 50 m from Sg. Bayas on the right of the road cut to Sungai Lembing town. The rock consists of interbedded argillaceous rock of well-bedded shale, mudstone and siltstone, light grey to white in colour. The bedding direction and dipping is 310/60, which is almost north direction.

The second locality, SL02, consists of well-bedded shale, mudstone and siltstone weathered into red soil (**Plate 4.6.2**). Whilst at the Sungai Lembing Mine (Tei Pei Tong) the rock consists dominantly of shale (**Plate 4.6.3**).

At locality LP01 in Felda Lepar Utara 4 area, weathered granite soil is more than 50 m thick at the cut slopes (**Plate 4.6.4**). Granite boulders are still abundant.

Figure 4.6.5: Satellite imagery of the proposed road alignment showing observation localities



Source: LANSAT TM from Malaysian Remote Sensing Agency.

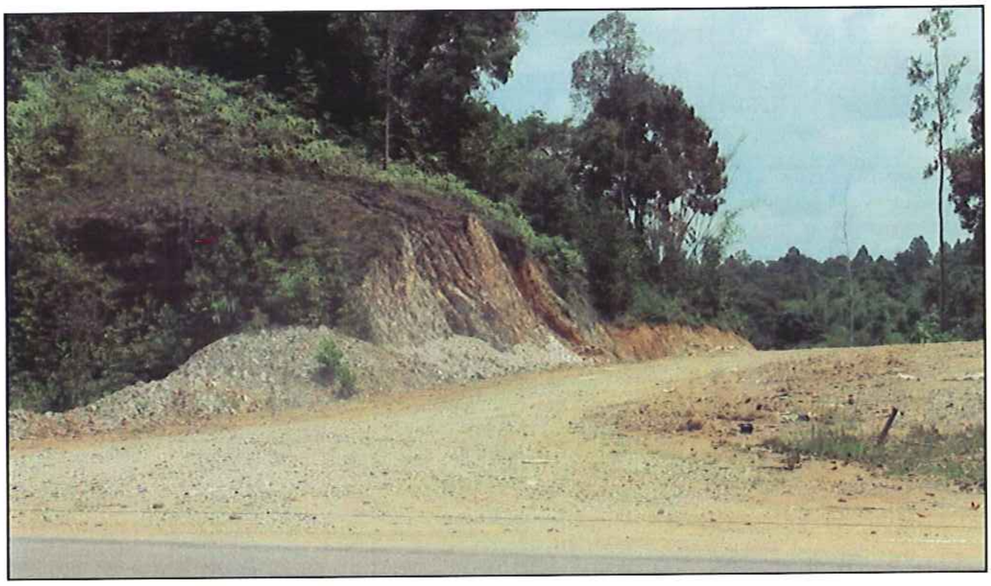


Plate 4.6.1: Exposed shale of the Kuantan Group observed at SL01.

Plate 4.6.2: Reddish soil weathered from mudstone observed at SL02.

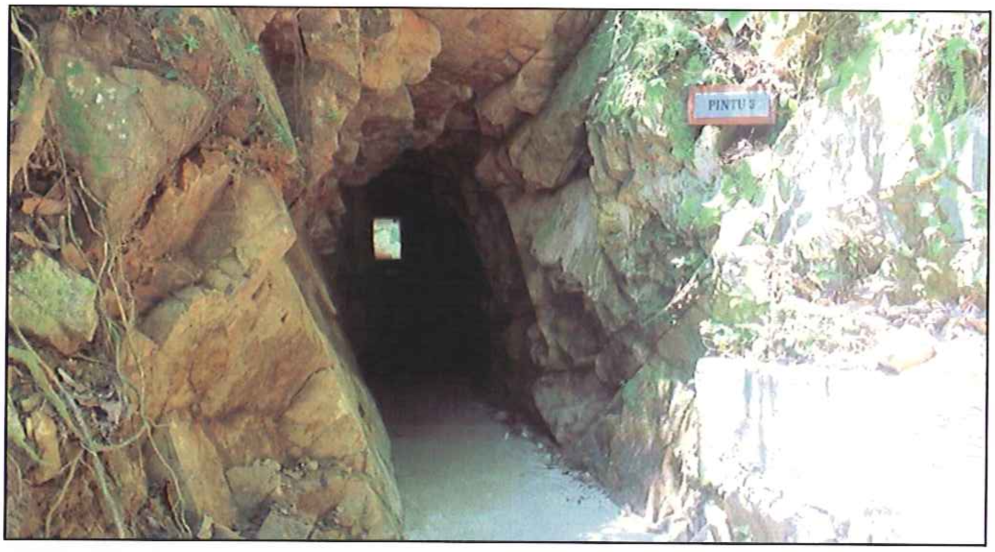


Plate 4.6.3: Weathered shale at the entrance of a tunnel at SL03.

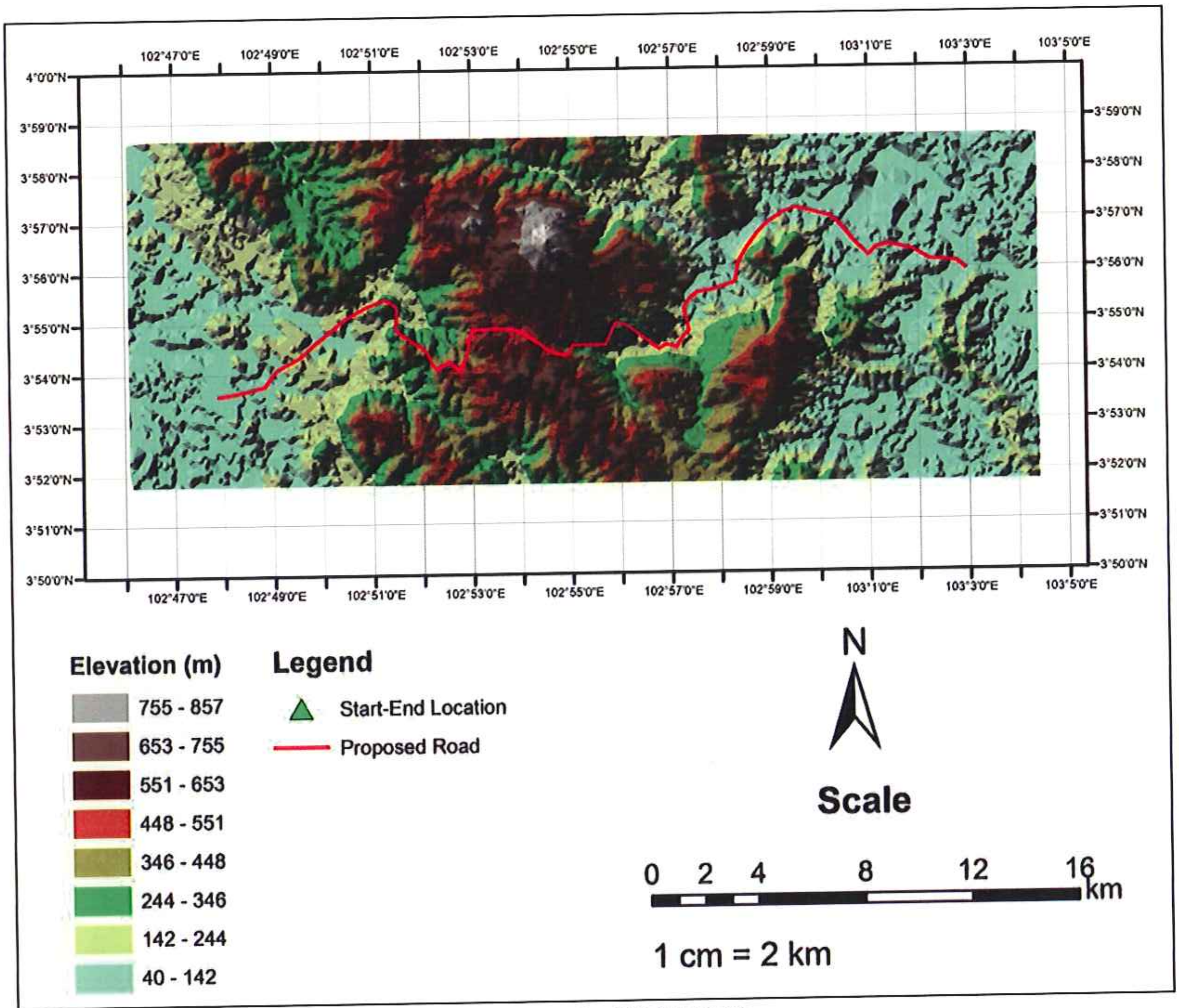
Plate 4.6.4: Cut hill slope exposing very thick weathered granite soil observed at LP01.

D. Geological Structure

The general structural trend for the area, as it is for much of Peninsular Malaysia, is NNW-SSE. This structural trend is often shown by terrain feature (**Figure 4.6.6**). Based on literature study, minor lineaments extension of Lebir Fault Zone is traceable down to this area. The Lebir Fault Zone trends curvilinear NNW-SSE along Sungai Lebir near Manek Urai, Kelantan. The lineaments can be continuously traced to the south, passing along the remarkably straight boundary of the granite batholiths east of Sungai Lebir, western margin of Gagau Formation and the eastern margin of the Koh Formation. It terminates at the intersection with the Lepar Fault Zone at the south of Kuantan (**Figure 4.6.7**).

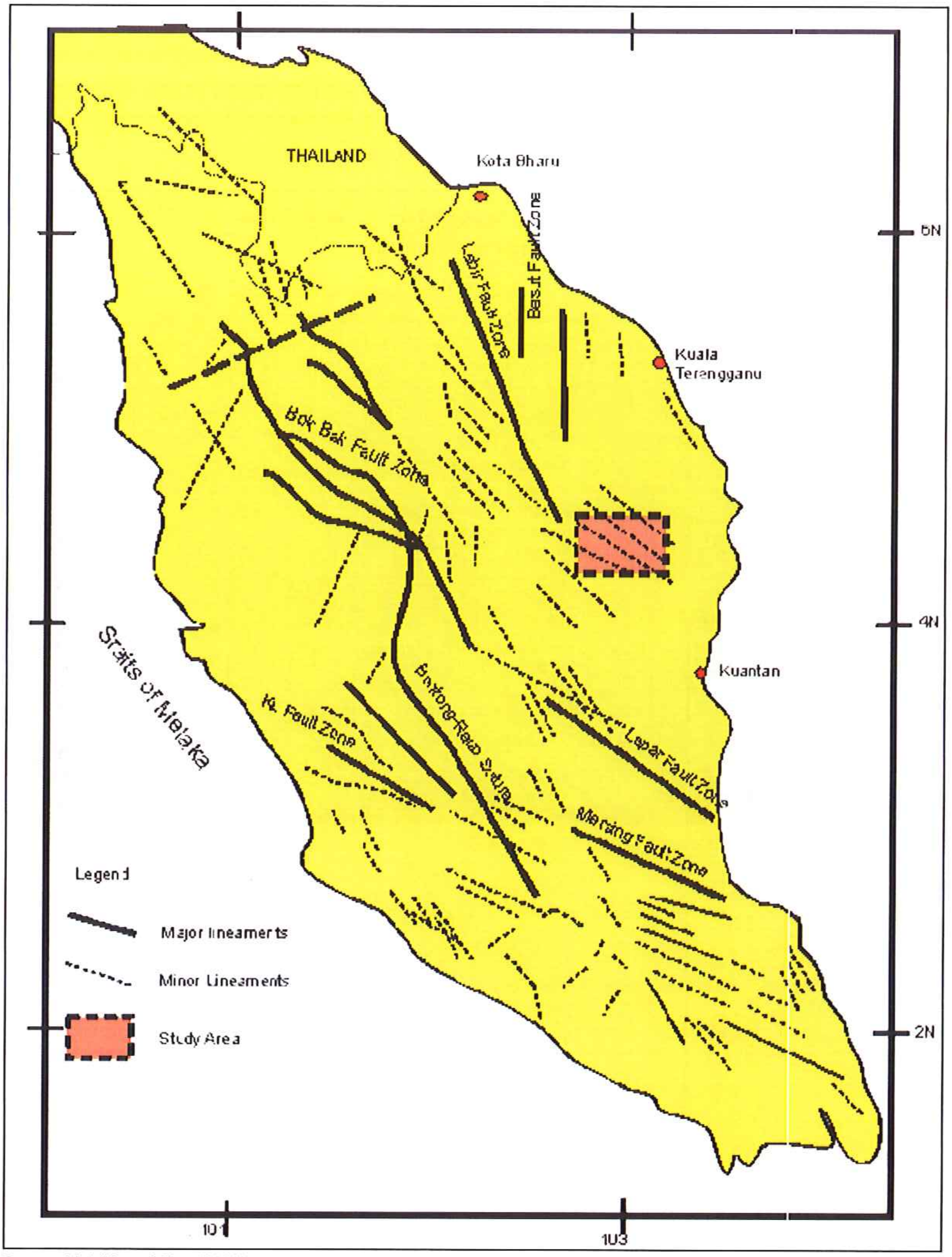
The fault zone is at least 10 km wide, spanning the gap between Sg. Lebir and the eastern margin of Taku Schist near Kuala Krai. Tracing to the south, this zone is displaced sinistrally at the boundary of Triassic rock and Jurassic to Cretaceous rock.

Figure 4.6.6: Satellite imagery of the road alignment area showing terrain relief which is an expression of the NNW-SSE trend of structure



Source: DEM generated from Shutter Radar Topography Mission (SRTM) (2000).

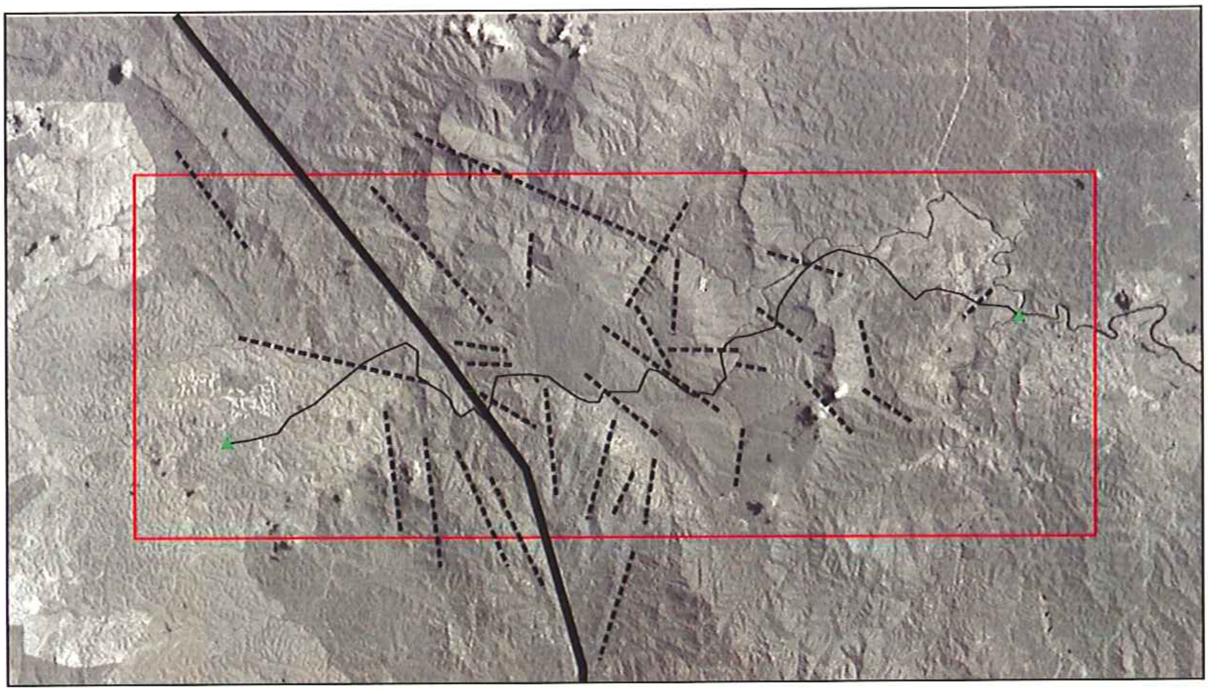
Figure 4.6.7: Lineaments map showing the Lebir and Lepar Faults



Source: Hutchison & Tan (2009).

Along the Project corridor, the extension of the Lebir Fault Zone can be traced at the boundary of Early Triassic granite and Jurassic to Cretaceous acid volcanic, and sandstone and mudstone of Charu Formation. The minor lineament here is shown in **Figure 4.6.8**. The general trend of strike, measured during site investigation, is to the north with dipping around 50 to 60 degree. The small fold was found in the outcrop with axes 310E to 160E. In order to get the stable slope in the road cut, the direction of the road should be almost perpendicular with the direction of bedding strike.

Figure 4.6.8: Structural map of the proposed road alignment showing the Lepar Fault and other faults and lineaments



Source: LANSAT TM from Malaysian Remote Sensing Agency.

4.6.3 SOILS

A. Soil composition and texture as related to parent materials and climate

Soils are the weathering products of parent rocks/ materials. Different soil types (composition and texture) may result from different rock types and different climatic zones. For example, very little soil material is produced under hot and dry desert climate like Sahara and cold and dry Tundra like Greenland. However, under hot and wet equatorial climate throughout the year, most minerals weather into clays except for the very resistant quartz, weathering is deep and soils produced are thick. It is relevant to understand this relationship.

Parent rocks along the alignment and corridor areas of the Project are well-bedded shale, mudstone and siltstone, some of which are metamorphosed to slate, phyllite, argillite and schist, and with subordinate limestone, sandstone and volcanic on the eastern side and mainly granite with some acid to intermediate volcanic on the western side of the alignment.

a. Soils from Sandstone, Shale, Mudstone and Phyllite of Kuantan Group

Sandstone will produce fine to medium sand with some clays while shale and mudstone will produce clays. Texturally, the soil is dominantly clays and fine sands as shown in **Plates 4.6.2** and **4.6.3** above.

Sedimentary rock soil is relatively thick, up to 20 m and non-homogenous since the parent rocks themselves are bedded.

b. Soils from Granites and Volcanic rocks

Granite is composed of quartz and feldspars (plagioclase, microcline and orthoclase porphyry) and accessory minerals (biotite and muscovite). Under hot and wet equatorial climate, quartz remains while most other minerals are weathered to clay minerals. Soil product is sand and clay (sandy clay) in texture and is composed of quartz, and clay minerals (illite, montmorillonite, chlorite and kaolinite).

Granite soils are usually very thick and homogenous (see **Plate 4.6.4**).

4.7 LAND USES

4.7.1 BACKGROUND

The proposed road alignment covers mainly forest reserve and agriculture land. The estimated length of the road is 35 km which will also involve the building of bridges crossing Sg. Lepar, Sg. Kuantan and Sg. Kenau as well as viaducts.

4.7.2 LAND USE ALONG ROAD ALIGNMENT

The proposed road alignment will pass through Hutan Simpan Reman Cereh and Hutan Simpan Berkelah from Sungai Lembing towards the Felda agricultural scheme Lot PT 201 and end at the south of Felda Lepar Utara at the intersection of the main road to the settlement.

The schemes and breakdown of areas under the oil palm plantations at Felda Lepar Utara are as shown in **Table 4.7.1** below.

Table 4.7.1: Planted areas in Felda at Lepar Utara

Name of Plantations	Planted area (ha)
Felda Lepar Utara 1	1,467.19
Felda Lepar Utara 2	2,693.96
Felda Lepar Utara 4	4,689.80
Felda Lepar Utara 5	3,224.28
Felda Lepar Utara 10	10,103.97
Felda Lepar Utara 14	3,006.92

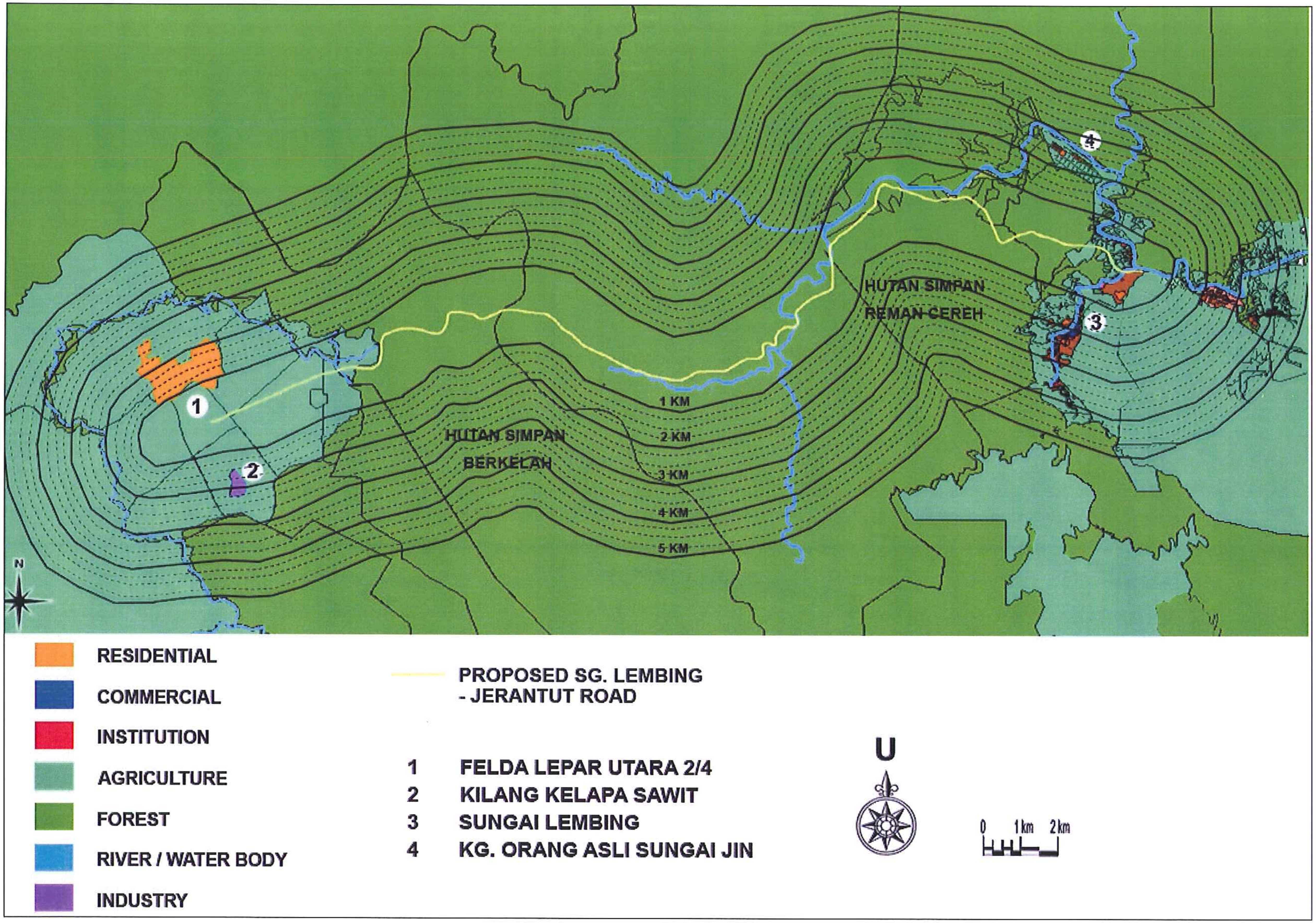
Source: AgroVet GmBH (2011).

At the eastern side at Sungai Lembing, the alignment cuts through mostly agricultural areas at Lot PT 418 and PT 101, consisting mostly of orchards and also part of the Reman Cereh Forest Reserve (Tambahan) (**Figures 4.7.1** and **4.7.2**).

The existing land use and physical condition can be described as hilly and with forest cover namely the Reman Cereh and Berkelah Forest Reserves (**Figure 4.7.3**).

Although there will be non-human impact at the forest areas, flora and fauna will be affected due to the cutting of trees for road and bridge constructions. Potential new land that will be opened for development in future will contribute towards more economic activities within this new corridor.

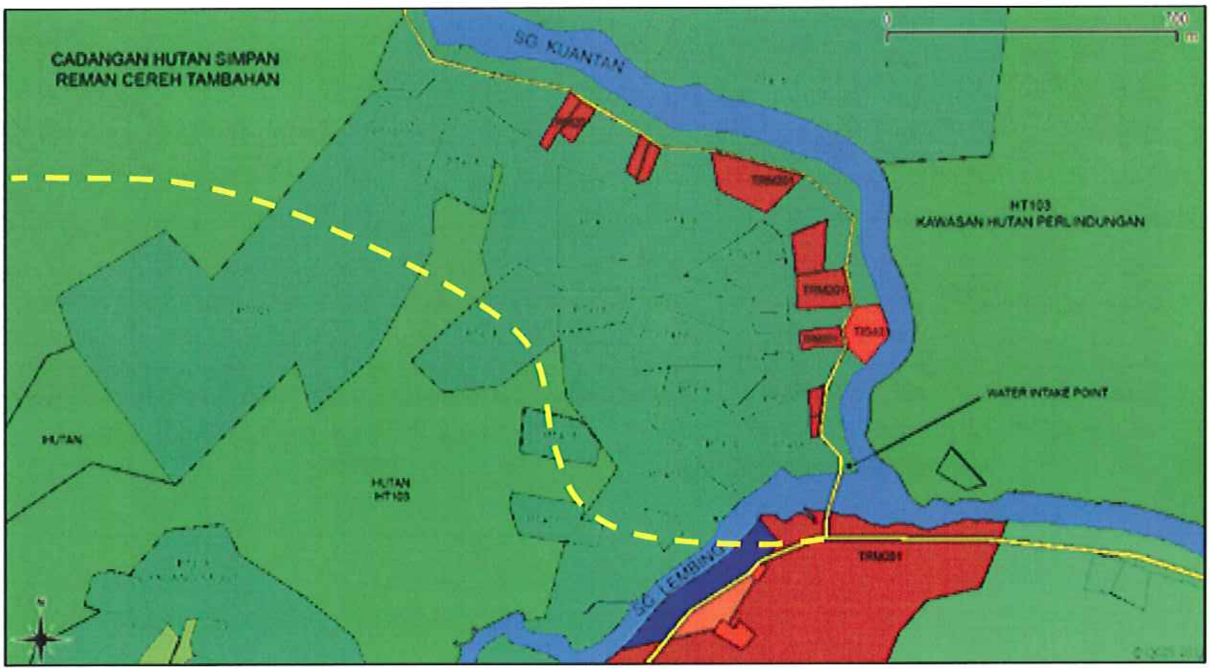
Figure 4.7.3: Land uses and 5 km zone of impact along proposed road alignment



Source: Jabatan Perancangan Bandar dan Desa, Pahang (February, 2013).

Figure 4.7.1: Aerial view showing road at the eastern side at Sungai Lembing where the proposed road starts

Figure 4.7.2: Alignment of the proposed road cutting through several land lots at Sungai Lembing



Source: JPBD Pahang (2013)

4.8 TRAFFIC CONDITION

The proposed new road will be connecting Sungai Lembing from the existing Sungai Lembing – Kuantan State Road C4 to the Felda Hulu Lepar local road. State Road C4 (**Plate 4.8.1**) provides connection between Kuantan town with areas at the northwest of Kuala Kuantan and Hulu Kuantan districts. It serves as a distributor road for local traffic movements between Kuantan, Sungai Lembing and various settlements located along the lower Sg. Kuantan Valley. With the construction and completion of the proposed Sungai Lembing – Felda Lepar Utara road, the hierarchy of state road C4 will change from a local road to a primary road as it will be connecting the regional centres of Cameron Highland, Kuala Lipis and Jerantut to the State's commercial and administrative centre at Kuantan.

As reported in the *Feasibility Study for the Proposed Jerantut – Sungai Lembing Road, Final Report* (Perunding Zaaba, 2002), a survey had been conducted to determine the traffic conditions at the existing Sungai Lembing – Kuantan road. The survey was conducted for morning peak (0700-0800 hours), noon peak (1200-1300 hrs) and evening peak (1700-1800 hours). It has been determined that, the Sungai Lembing – Kuantan (C4) road is a 2-lane single carriageway with light traffic of average 147 vehicles per hour. The morning peak recorded an average of 251 vehicles per hour while the noon peak and evening peak recorded 188 and 167 vehicles per hour, respectively.

The existing road at Felda Lepar Utara where the proposed new road will end is a rural road that provides access between the various settlements in the scheme. It is a 2-lane single carriageway with very light traffic (**Plate 4.8.2**).

Plate 4.8.1: State road C4 near Kuala Kenau, Sungai Lembing.

Plate 4.8.2: Rural road in Felda Lepar Utara.

4.9 TERRESTRIAL FLORA

4.9.1 FORESTRY

A. Overview

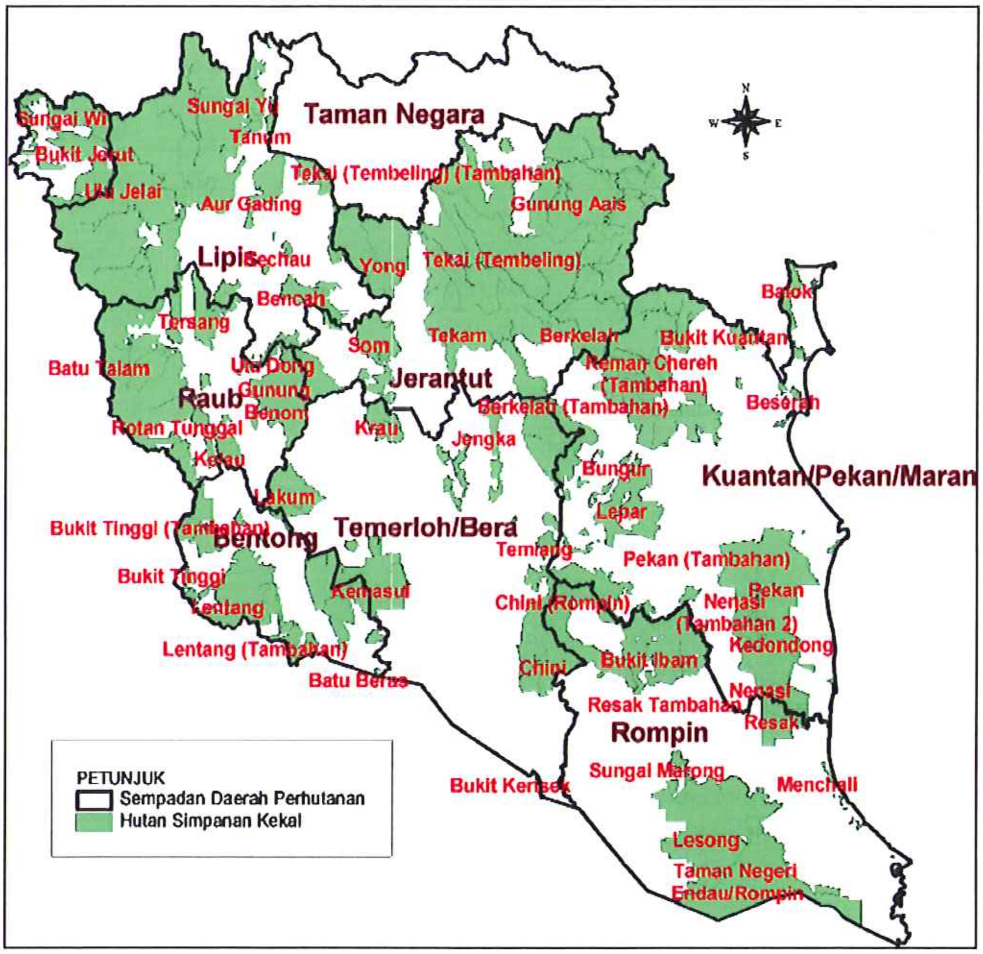
As of December 2010, The State of Pahang has a total forested area of over 2.068 million ha. Out of these, a total of 1.562 million ha are gazetted under the Permanent Forest Reserve (PFR) classification (**Table 4.9.1**). **Figure 4.9.1** below shows the distribution of these PFR. These PFRs are further categorised into Protection Forest, Production Forest, Amenity Forest as well as Research and Education Forest.

Table 4.9.1: Forest Lands in the State of Pahang

No.	Description	Area (ha)
1.	Pahang State total land area	3,596,585.00
2.	Permanent Reserve Forests	1,562,902.00
3.	Wildlife Reserves	399,740.00
4.	State Land Forests	105,962.98

Source: http://forestry.pahang.gov.my/index.php/status-sumber-hutan.html.(accessed on 30 April 2013).

Figure 4.9.1: Permanent Forest Reserves in Pahang



Source: http://forestry.pahang.gov.my/download/Peta-HSK.jpg. (accessed on 30 April 2013).

The forests are managed under the principles of Sustainable Forest Management (SFM) i.e. to sustain the provision of products, goods and services; economic viability, social acceptability and the minimisation of environmental/ ecological impacts. As such, the goals of SFM in Pahang generally emphasises the roles in regulating timber supply, maintaining environmental goods and services as well as the provision of amenity and forest-related support for the social needs of the public[1].

Management of the forests in the State is vested under the Pahang State Forestry Department, and administered on ground by the seven Forest District Offices i.e. Kuantan/ Pekan/ Maran, Rompin, Temerloh/ Bera, Jerantut, Lipis, Bentong and Raub/ Cameron Highlands.

B. Forests Reserve Affected by the Project

The proposed Sungai Lembing – Felda Lepar Utara Road will traverse through two PRFs i.e. Reman Cereh Forest Reserve and Berkelah Forest Reserve (**Figure 4.9.2**). Forests within the proposed 60 m wide road alignment will be affected. Brief information regarding these two Forest Reserves is shown in **Table 4.9.2** below.

Table 4.9.2: Forest Reserves Affected by the Project

No.	Forest Reserves	Forest District	Area (ha)
1.	**Reman Cereh Forest Reserve**		
a.	*Hutan Simpan Reman Cereh*	Kuantan/ Pekan/ Maran	44,986.80
b.	*Hutan Simpan Reman Cereh (Tambahan)*	Kuantan/ Pekan/ Maran	8,485.80
	Sub-total		**53,472.60**
2.	**Berkelah Forest Reserve**		
a.	*Hutan Simpan Berkelah*	Kuantan/ Pekan/ Maran	35,522.96
b.	*Hutan Simpan Berkelah (Tambahan)*	Kuantan/ Pekan/ Maran	3,247.00
c.	*Hutan Simpan Berkelah (Tambahan)*	Kuantan/ Pekan/ Maran	34.39
d.	*Hutan Simpan Berkelah (Jerantut)*	Jerantut	45,890.00
e.	*Hutan Simpan Berkelah (Temerloh)*	Temerloh	18,374.00
	Sub-total		**103,068.35**

Source: Laporan Tahunan 2010, Jabatan Perhutanan Negeri Pahang.

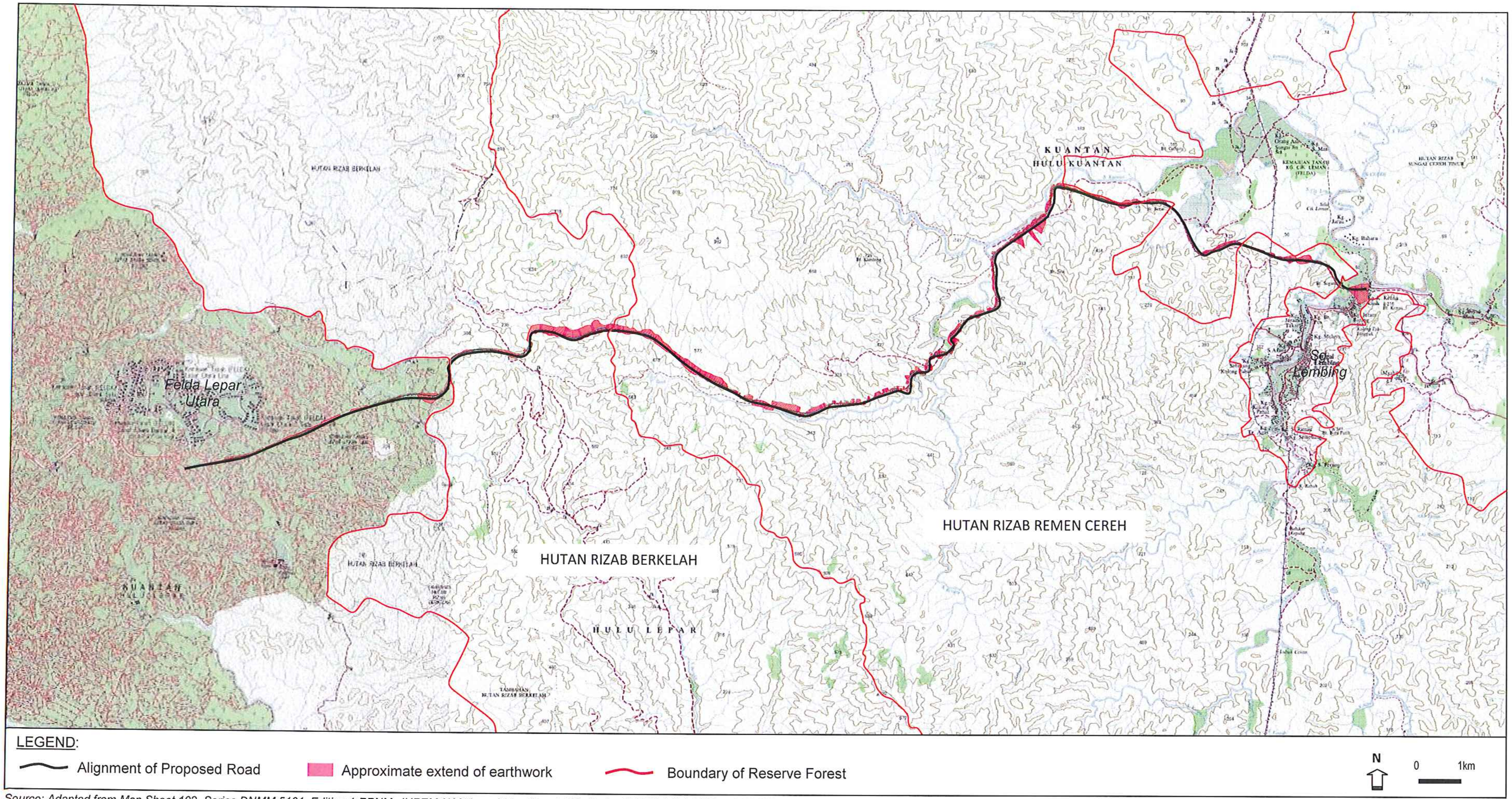
4.9.2 Flora Diversity

A. Overview

Rapid ecological assessment of the forest areas indicated that there are several vegetation types along the corridor of the proposed road alignment. The first two to three kilometre of the road from Sungai Lembing passes through fruit orchards and secondary forest (*belukar*). The road then traverses through the Reman Cereh Forest Reserve and Berkelah Forest Reserve which are largely logged over regenerating lowland Dipterocarp

[1] Executive Summary of Pahang State Forest Management Plan. http://forestry.pahang.gov.my/index.php /executive-summary.html

Figure 4.9.2: Forest Reserves affected by the Project



Source: Adapted from Map Sheet 102, Series DNMM 5101, Edition 1-PPNM, JUPEM (1997); and Map Sheet 103, Series DNMM 5101, Edition 1-PPNM, JUPEM (1994).

forest with riparian forest along the river networks. The last seven kilometres of the alignment is located within an oil palm estate which was recently replanted.

B. Lowland Dipterocarp Forest

i. Study Area

Floristic sampling was conducted within the lowland dipterocarp forest within the Forest Reserves. During the floristic surveys several random paths or tracks were followed on foot and also tracks perpendicular to the road to cover most of the Project site. Some representative or problematic samples or materials were collected and brought back to the herbarium at Universiti Kebangsaan Malaysia for identification, however most of the samples were identified *in-situ*. For tall trees where the canopies were unreachable, fallen leaf samples were sampled and morphology of the tree bark were used for identification. **Table 4.9.3** shows the plots, locations and altitudes of the study sites at Reman Cereh Forest Reserve, Sungai Lembing, Pahang.

Table 4.9.3: Location of Flora Survey

Plot No.	Locations/ GPS Coordinates		Altitude (m)
	Latitude	Longitude	
C	N 03° 55' 45.0"	E 102° 58' 05.9"	91
D	N 03° 56' 03.2"	E 102° 58' 19.3'	111

ii. Objectives

The surveys were undertaken to:

i. Determine the plant species present in the Project site;
ii. Determine the frequency and habit of the plant species; and
iii. Ascertain their scientific and conservation status.

iii. Methodology

Plots establishment

In this study, two plots with measurement of 50 m x 20 m each were established randomly in the study area. The total area of the study plots was 0.2 ha. Both study plots were set up by using compass, measurement tape and wood stakes, with a view to establish plots that are as accurate as possible (**Plate 4.9.1**). For sapling study, two small quadrats (5 m x 5 m) were established inside the 50 m x 20 m plot.

Plate 4.9.1: Establishment of plots.

Sampling

- ***Tree census***

All trees with diameter at breast height (DBH) of 5 cm and above which occur in both plots were enumerated by using a diameter tape (**Plate 4.9.2**). The standard measurement technique for tree DBH measurement is 1.3 meters from the ground. However, in several cases (e.g. high buttress, leaning tree, multiple stems), different technique were applied following methods proposed by LaFrankie (2005), Husch et al. (2003) and Manokaran et al. (1990). All measured trees were tagged to avoid repetition of sampling. The tag consists of the plot code and the tree number (**Plate 4.9.3**). All the specimens of the measured tree were collected for the preparation of voucher specimens and species identification.

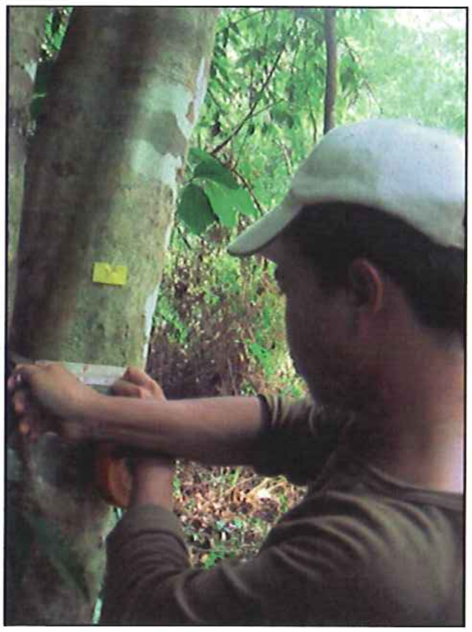


Plate 4.9.2: Measurement of tree.

Plate 4.9.3: Tree's tag.

- ***Sapling and seedling census***

As for 5 m x 5 m quadrats, all saplings and seedlings with diameter ranges of 1.0 - 4.9 cm DBH were recorded. The measurement of diameter at breast height was measured by using diameter tape. Woody climbers and creepers were excluded in the census. All specimens were labelled by using card board tags and all information of sapling census was recorded. Specimens were also collected for identification purposes.

iv. Random Survey

A random survey through observation of vegetation and flora was conducted along the gravel road during this study as shown in **Plate 4.9.4**. Specimens were collected and deposited in the herbaria at Universiti Kebangsaan Malaysia (UKM).

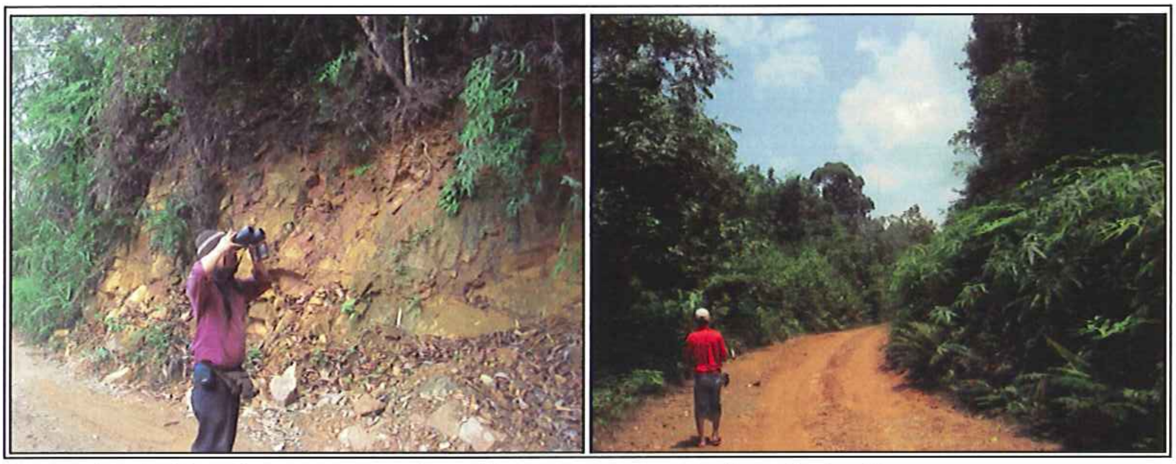


Plate 4.9.4: Random surveys along the access road in the study site.

v. Biomass

Estimation of the total biomass is calculated by combining the Above Ground Biomass (AGB) and Below Ground Biomass (BGB). The AGB and BGB values were determined by using an equation as provided by Kato *et al.* (1978) and Niiyama *et al.* (2010), respectively. The total estimated tree biomass in the study plots at the Project site is 567.03 t/ha which was represented by 490.56 t/ha of AGB and 76.47 t/ha of BGB.

At the Reman Cereh Forest Reserve, Dipterocarpaceae contributed the highest biomass value of 114.18 t/ha (20.14%) of the total biomass estimated, which included the AGB of 99.08 t/ha and BGB of 15.11 t/ha as shown in **Table 4.9.4**. This was followed by Euphorbiaceae with an estimated biomass of 103.93 t/ha (18.33%) and Olacaceae of 46.81 t/ha (8.26%). Genus-wise **(Table 4.9.5)** *Shorea* (Dipterocarpaceae) had the highest total biomass estimated at 94.29 t/ha (16.63%). It was followed by *Sapium* (Euphorbiaceae) and *Scorodocarpus* (Olacaceae) with total biomass estimated at 50.31 t/ha (8.87%) and 44.54 t/ha (7.85%), respectively. At species level, *Sapium baccatum* (Euphorbiaceae) indicated the highest estimated biomass with 50.31 t/ha (8.87%). It was followed by *Scorodocarpus borneensis* (Olacaceae) and *Pentaspadon motleyi* (Anacardiaceae) with estimated biomass of 44.54 t/ha (7.85%) and 42.43 t/ha (7.48%) respectively as shown in **Table 4.9.6**.

Table 4.9.4: Total biomass of ten leading families in study plots at the Reman Cereh Forest Reserve, Sungai Lembing, Pahang

Family	AGB (t/ha)	BGB (t/ha)	Total biomass (t/ha)	Percentage (%)
Dipterocarpaceae	99.08	15.11	114.18	20.14
Euphorbiaceae	90.21	13.71	103.93	18.33
Olacaceae	39.96	6.85	46.81	8.26
Anacardiaceae	36.51	6.03	42.54	7.50
Myrtaceae	32.62	5.30	37.92	6.69
Fagaceae	30.39	4.60	34.99	6.17
Tiliaceae	27.69	4.35	32.05	5.65
Leguminosae	22.65	3.41	26.05	4.59
Myristicaceae	15.04	2.34	17.37	3.06
Sapotaceae	13.00	2.00	15.01	2.65

Table 4.9.5: Total biomass of ten leading genera in study plots at the Reman Cereh Forest Reserve, Sungai Lembing, Pahang

Genus	AGB (t/ha)	BGB (t/ha)	Total biomass (t/ha)	%
Shorea	81.85	12.43	94.29	16.63
Sapium	43.65	6.66	50.31	8.87
Scorodocarpus	37.99	6.55	44.54	7.85
Pentaspadon	36.42	6.01	42.43	7.48
Syzygium	32.62	5.30	37.92	6.69
Lithocarpus	30.39	4.60	34.99	6.17
Pentace	27.54	4.33	31.87	5.62
Macaranga	25.96	3.90	29.86	5.27
Myristica	12.36	1.93	14.29	2.52
Pouteria	11.06	1.70	12.76	2.25

Table 4.9.6: Total biomass of ten leading species in the study plots at Reman Cereh Forest Reserve, Sungai Lembing, Pahang

Species	AGB (t/ha)	BGB (t/ha)	Total biomass (t/ha)	%
Sapium baccatum	43.65	6.66	50.31	8.87
Scorodocarpus borneensis	37.99	6.55	44.54	7.85
Pentaspadon motleyi	36.42	6.01	42.43	7.48
Shorea leprosula	28.83	4.40	33.23	5.86
Syzygium glaucum	25.88	4.29	30.17	5.32
Macaranga gigantea	22.62	3.40	26.03	4.59
Pentace triptera	18.08	2.90	20.99	3.70
Shorea bracteolata	16.96	2.60	19.56	3.45
Shorea lepidota	13.49	2.04	15.52	2.74
Shorea parvifolia ssp. *parvifolia*	12.42	1.87	14.29	2.52

vi. Taxonomic Composition of Saplings and Seedlings

Enumeration of saplings and seedlings with DBH ranges of 1.0 - 4.9 cm in the study plots at the Reman Cereh Forest Reserve, Sungai Lembing recorded a total of 34 individuals in 0.005 ha plot. They were represented by 18 species, 18 genera and 12 families. The number of genera, species and tree individuals represented by each family in all plots are shown in **Tables 4.9.7** while identification of genus is as shown in **Table 4.9.8**. Based on the number of species, the most species were from Rubiaceae family with 4 species followed by Annonaceae, Dipterocarpaceae and Moraceae with 2 species, respectively.

Table 4.9.7: Total number of genera, species and individual of 12 families of saplings and seedlings in the study plots

Family	No. of genus	No. of species	No. of individual
Annonaceae	2	2	2
Dipterocarpaceae	2	2	12
Ebenaceae	1	1	1
Euphorbiaceae	1	1	1
Flacourtiaceae	1	1	5
Leguminosae	1	1	2
Moraceae	2	2	3
Myrsinaceae	1	1	1
Polygalaceae	1	1	1
Rubiaceae	4	4	4
Sterculiaceae	1	1	1
Tiliaceae	1	1	1
Total	**18**	**18**	**34**

Table 4.9.8: List of 18 genera of saplings and seedlings in the study plots

No.	Genus
1.	*Archidendron*
2.	*Ardisia*
3.	*Croton*
4.	*Diospyros*
5.	*Dipterocarpus*
6.	*Ficus*
7.	*Goniothalamus*
8.	*Hopea*
9.	*Hydnocarpus*
10.	*Ixora*
11.	*Leptonychia*
12.	*Nauclea*
13.	*Polyalthia*
14.	*Porterandia*
15.	*Schoutenia*
16.	*Streblus*
17.	*Tarenna*
18.	*Xanthophyllum*
Total	**18**

vii. Flora along the Road Corridor and Surrounding Areas

The list of plant species recorded is attached in **Appendix 4-4**. The flora diversity is quite indicative of the lowland dipterocarp forest either in Pahang or Peninsular Malaysia. Species total does not represent an accurate picture of the floral diversity, richness and significance as surveys were only conducted during the period of three days along the logging road and covering less than 10% of the Project site. This is acceptable as the Project site consists of only two vegetation types and is quite homogenous in their flora. The number of species may be increased if the survey period was longer and more areas were covered.

The predominant lowland dipterocarp forest covers all the area within the Reman Cereh and Berkelah Forest Reserves, except those along the rivers and streams. According to the Pahang Forestry Department, the forest area has been logged once in the last 20 years and tree regeneration has been good. As the ground flora is quite sparse, it is believed that the forests have not been disturbed since the logging exercise some 20 years ago.

The lowland dipterocarp forest is dominated by species of the Dipterocarpaceae family, namely *Dipterocarpus kunstleri, D. lowii, D. grandiflorus, D. rigidus, D. costatus, Hopea pubescens, H. nervosa, Shorea parvifolia, S. singkawang, S. ovalis, S. pauciflora, S. resinosa, S. multiflora, Vatica umbonata and Neobalanocarpus heimii.* Even though the forest area had been logged some 20 years ago, the presence of second rotation crops are eminent. In particular, important timber stands such as of *D. rigidus, D. costatus, Hopea pubescens, H. nervosa, Shorea parvifolia, S. singkawang* and *S. Ovalis* were present. These trees are the backbone of the timber industry in Peninsular Malaysia.

Among the non-dipterocarp timber species observed are *Alstonia angustifolia, Canarium caudatum, Dacryodes costata, Diospyros sumatrana, Actinodaphne sesquipedalis, Litsea grandis, Intsia palembanica, Koompassia excelsa, Knema oblongifolia, Horsfieldia sucosa, Pellacalyx axilliaris, Madhuca malaccensis, M. curtisii, Palaquium rostratum, P. gutta* and many others. The non-timber species include *Mangifera grifithii, M. caesia, Swintonia floribunda, Alphonsea elliptica, Goniothalamus scortenchinii, G. lanceolatus, G. macrophyllus, Aralidium pinnatifidum, Durio griffithii, Parinari rigida, Dillenia grandifolia, D. reticulate, Elaeocarpus nitidus, Antidesma pendulum, Baccaurea parvifolia, B. racemosa, Macaranga gigantean, M. hypoleica, Garcinia nigrolineata, G. nervosa, G. bancana, Stemonurus umbellarus, Barrintonia scortechinii, Leea indica, Aglaia malaccensis, Artocarpus elasticus, A. scortechinii, Streblus elongatus, Ardisia Montana, A. colorata, A. crassa, Ochanostachys amentacea, Galearia fulva* and *Flacourtia rukam.*

The shrubs are represented by *Mussaenda glabra, Lasiathus filiformis, L. oblongus, Hedyotis philippinensis, Ficus fistula, Ixora javanica, Pavetta Montana, Urophyllum macrophyllum, U. hirsutum, Tarenna mollis, Saprosma pubescens* and many others. Notable palms include *Arenga pinnata, Iguanura wallichiana, Licuala* sp., *Pinanga malayana* and a few species of *Calamus.* The herbaceous flora consists of *Tacca integrifolia, Zingiber spectabile, Globba pendula, Etlingera triogalis, E. maingayi, Amischotolype gracilis, Aglaonema nitidum,* and numerous species of grasses.

The forest that fringes the banks of Sg. Kuantan and Sg. Lepar and their tributaries is best described as riparian vegetation and this forest is prone to flooding. The plant species observed include *Dipterocarpus oblongifolius, Saraca cauliflora, Donax grandis, Poikilospermum suaveolens, Buchannania sessifolia, Sauraia roxburgii, Didissandra wrayi, Leea indica, Pentaphragma ellipticum, Neolamarckia cadamba, Nauclea subdita, N. officinalis, Rinorea anguifera, Amorphophallus elatus, Scindapsus perakensis, Pothos peninsularis, Zingiber spectabile, Rhynchospora corymbosa, Hanguana malayana* and several others. Ferns and fern-allies observed include *Nephrolepis biserrata, Asplenium nidus, Davallia denticulata, Vittaria ensiformis, Stenochlaena palustris, Selaginella willdenowii* and *Nephrolepis biserrata.*

C. Orchards and *Belukar*

Within the orchards and *belukar*, the dominant plant species include *Aglaia domestica*, *Artocarpus integer*, *A. hereophylla*, *Campnosperma* spp., *Dellinia suffruticosa*, *Durio zibethinus*, *Mallotus spp.*, *Garcinia* spp., *Mangifera odorata*, *Macaranga* spp., *Melastoma malabathricum*, *Neolamarckia cadamba*, *Nephelium lappaceum* and *Pometia pinnata.* Other edible flora species including *Musa* spp., *Bambusa* spp., *Manihot* spp. and *Areca* sp. were also observed.

D. Oil Palm Estate

Within the oil palm estates, apart from the replanted oil plams, the area is dominated by weed species. Dominant among them are *Asystasia gangentica*, *Chromolaena odorata, Mikania micrantha, Ageratum conyzoides, Mimosa pudica* and *Sida rhombifolia.* These are weed species which spread quite easily via wind from one habitat to another. They are very adaptable to colonise new niches.

4.10 WILDLIFE

4.10.1 OBJECTIVES

The objectives of this wildlife study are:

i. To identify and document areas with High Conservation Value (HCV) for terrestrial habitats within and/ or adjacent to the Project site so as to enable appropriate mitigation measures to be formulated.
ii. To conduct a wildlife reconnaissance survey and rapid assessment to identify threatened species (classified as Critically Endangered, Endangered or Vulnerable in the IUCN Red list), Totally Protected and/ or Protected species within and/or adjacent to the Project corridor.
iii. To confirm the presence and/ or absence of large mammals including Elephant, Rhinoceros, Seladang, Tapir, Sambar Deer and Tiger within the Project site and the surrounding areas; and to determine their movements and/ or migration patterns (if any) which are relevant in the context of the proposed Project.
iv. To formulate and recommend pragmatic mitigation and management measures that can be incorporated into the Project design stage and implemented during the construction and operation phases in an environmentally sound and socially acceptable manner with regard to wildlife management.
v. To ensure compliance to applicable legal requirements related to wildlife management and JKR's policies.

4.10.2 METHODOLOGY

The methodology for carrying out the wildlife survey and impact assessment included a combination of conducting literature reviews, consultation with selected stakeholders and conducting field reconnaissance survey. Due to the nature of the Project and the practical constraints of conducting the field survey, amphibians, bats and insects were excluded from the study. The detailed methodology is as follows:

A. Literature Review

Existing literature and data on wildlife reported to occur in the vicinity of the Project site was reviewed and a species list compiled. This specifically covered the Reman Cereh Forest Reserve and the Berkelah Forest Reserve that will be traversed by the proposed road alignment as well as Taman Negara which is located approximately 70 km to the north with contiguous forest cover as a supplementary reference.

The international conservation status of species was determined based on the IUCN Red list (www.iucnredlist.org.) and the legal protection status was determined based on the *Wildlife Conservation Act 2010*. Sources of information include:

- Department of Wildlife and National Parks (PERHILITAN);
- Department of Town and Country Planning (JPBD);

- Malaysian Nature Society (MNS);
- Publications, journals, survey reports, acts, other documents and the internet; and
- Species specific management strategies and plans for: Elephant, Tiger, Tapir, etc.

B. Stakeholder Consultation

Stakeholder consultations were carried out through interviews, telephone conversations and/or correspondence with key personnel from the following parties:

- The PERHILITAN Headquarters and Pahang state office;
- The local Semoq Beri *Orang Asli* village at Kg. Sungai Jin near Sungai Lembing;
- Felda Lepar Utara (FLU) Oil Palm Plantation settlers; and
- A logging company truck driver currently working at the logging camp at Berkelah Forest Reserve adjacent to Felda Lepar Utara 4 (FLU4).

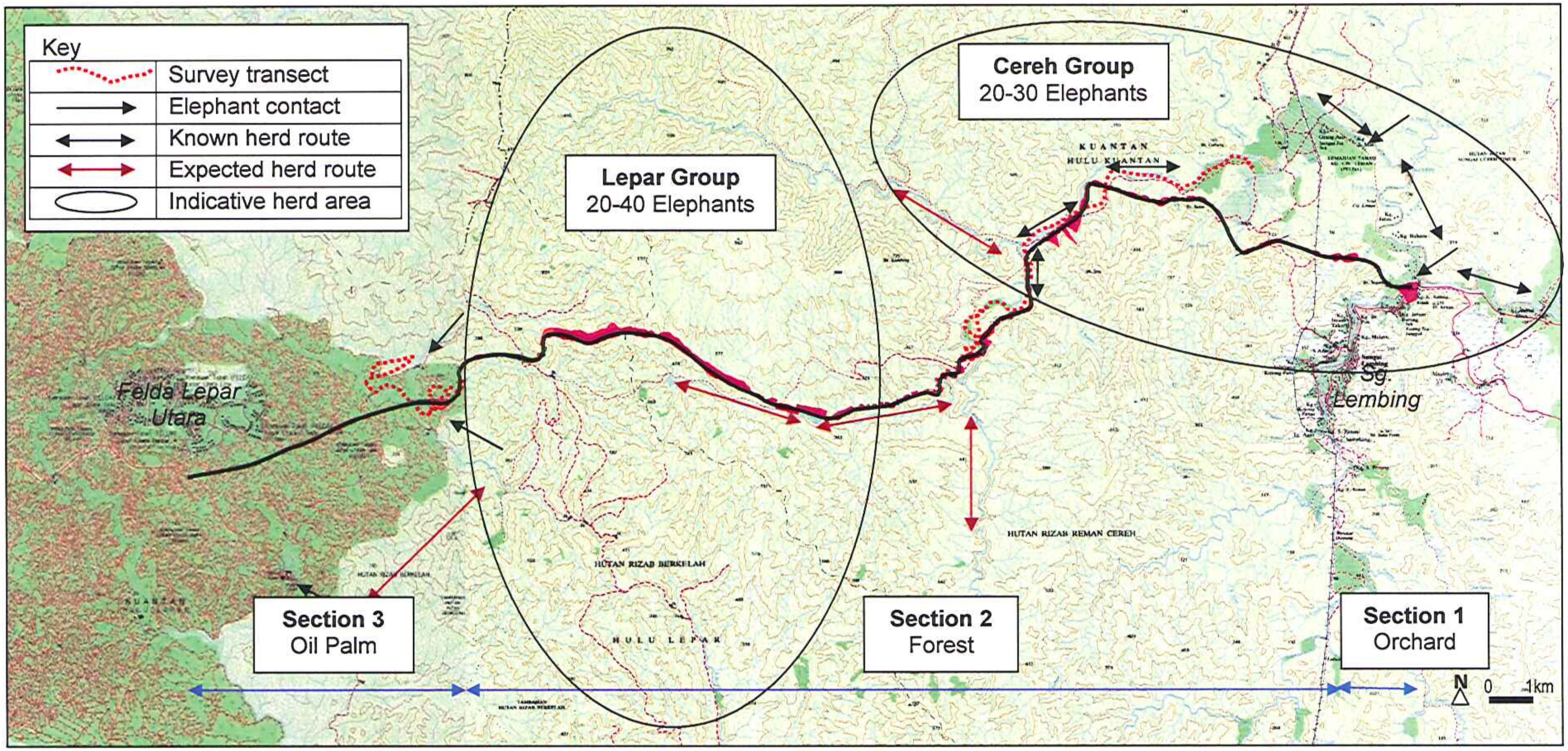
C. Field Wildlife Survey

The field reconnaissance survey was carried out on 1-2 May 2013 at selected accessible sampling points along the proposed road alignment and adjacent habitats. The survey transects are shown in **Figure 4.10.1**. PERHILITAN provided wildlife inventory data compiled from surveys carried out in the Reman Cereh Reserve Forest from 2008 - 2009.

The survey methodology employed included:

- Walking transects along the selected stretches of the proposed road alignment and branching off into the forest particularly along rivers and streams, ponds/ lakes and isolated forest areas. Wildlife present was detected by sightings, calls, tracks, droppings, markings and/ or any other signs that can confirm the presence of a particular species on site. The focus of the survey was to identify:
  - Critically endangered, endangered and/ or threatened species in the area;
  - Confirm the presence of large mammals particularly Elephant, Seladang, Tapir, etc. and their movement patterns that will be of prime concern with regards to the Project.
- Recording wildlife road kills in the vicinity of the Project site to gain appreciation of the existing situation on the ground.
- Field equipment used included: Leica 8x40 Binoculars, Cannon EOS 40D with 250 mm Zoom Lens, Cannon Digital Ixus 6.0 and Garmin 76 GPS.

Figure 4.10.1: Wildlife survey transects



Note: 1. The area shown for the Lepar and Cereh herds are only indicative and not definitive territorial range boundaries.
2. Elephant contact areas were reported by PERHILITAN, Orang Asli and FLU4 settlers.

4.10.3 WILDLIFE HABITATS ALONG SECTIONS OF THE ROAD ALIGNMENT

The proposed road alignment traverses a range of habitats which vary from being very rich and diverse in wildlife to monoculture plantations that only support a very low diversity of common wildlife species. The proposed alignment does not pass through any National Park, State Park, Wildlife Reserve or Wildlife Sanctuary. The alignment passes through the Reman Cereh and the Berkelah Forest Reserves (RCBFR) and is approximately 70 km to the south of Taman Negara National Park. The habitats traversed, together with the movements of Elephant herds in the area, are shown in **Figure 4.10.1**.

The road alignment has been divided into three sections to facilitate the assessment of impacts on wildlife as follows:

- **Section 1 - Orchard**: Consist of smallholder orchards and villages from Kg. Kuala Kenau along Sungai Lembing road to the forest edge. This stretch is about 2 km.
- **Section 2 - Forest**: Logged over lowland dipterocarp forest in the lowland and gradually grading to sub-montane forest on the higher hill slopes. This stretch runs through the Reman Cereh and the Berkelah Forest Reserves (RCBFR) for approximately 26 km.
- **Section 3 - Oil Palm Plantation**: This section is approximately 7 km, located at Felda Lepar Utara 4 (FLU4).

A. SECTION 1: ORCHARD

This section consists of a mosaic of smallholder plots of rubber and mixed fruit/ vegetable orchards typical of most Malaysian rural villages. This section traverses Kg. Kuala Kenau and the Kg. Sungai Jin *Orang Asli* village area.

The fruit trees and *belukar* typically support common species of birds, squirrels and lizards. Species recorded include Wild Boar, Long-tailed Macaque, Jungle Fowl (in the oil palm estates) and common birds like bulbuls, sunbirds and flowerpeckers. A herd of elephants periodically move along Sg. Kuantan and decimate orchards along the river. It should be noted that the wildlife in this area is severely depleted due to subsistence hunting by the *Orang Asli*.

B. SECTION 2: FOREST

The road alignment traverses the RCBFR which consist of logged over lowland dipterocarp forest at the lowlands and sub-montane forest on the higher hill slopes. It also includes riparian forests along rivers and streams as well as steep forested hill crests. Large mammal species are not restricted between these forest types and the animals move freely and unrestricted throughout the forest. This is clearly the section of the road where potential impacts on wildlife is the most prominent.

Various compartments of the forest have been logged at varying periods in the past and some active logging activities are still on-going within the Berkelah Forest Reserve, but outside the Project site. The active logging activities have temporarily driven large mammals away from the Berkelah Forest Reserve area fringing FLU4.

The forest section is characterised by the following features:

- There was an extensive network of logging tracks found throughout the Forest Reserves within and adjacent to the road alignment. Sections of the proposed road follow old logging road alignments.
- Pioneer species like *Macaranga* spp. and dense undergrowth are recolonising gaps created by logging roads. This provides rich browsing habitat for ungulates.
- Large trees of commercial value are absent and the canopy is fragmented except on pockets of steep ridge which would support Gibbons and possibly Serow.
- Old logging bridges were dismantled but 4x4 vehicles could still cross rivers at shallow sandy or pebbled stretches in the dry season.

The RCBFR were adjacent to and contiguous with the greater Taman Negara forest complex (Taman Negara is located approximately 70 km to the north) and were found to support abundant wildlife. It is worthy to note that the road alignment cuts through a relatively remote and relatively isolated forest that lies within the core area of the Central Forest Spine (JPBD, 2010a). This stretch is of utmost importance for wildlife.

Riparian forest found along the banks of rivers and streams consist of a mosaic of regenerating tall forest stands, grassland on sandy banks and small ponds and marshes that provides ideal habitat for large mammals to graze, browse and wallow. On steeper slopes, the riparian forest form tall stands that allow free movement of arboreal species. This habitat is the most important for wildlife as they form natural conduits that are commonly used by large mammals when in search for fresh feeding grounds within their home range.

The original riparian forest stand has been retained along Sg. Lepar and its tributaries within the FLU4 estate. Arboreal species like monkeys and squirrels were observed in the riparian area which has fruiting fig trees. The tall stand of trees also provides perching spots for raptors like the Crested Serpent Eagle while the vegetation facilitated movement of reptiles and amphibians.

Based on the review of the topography maps and literature, discussion with PERHILITAN and the *Orang Asli* in the area, there were no known salt licks along the proposed alignment or the immediate vicinity. However, the possibility of the existence of undocumented salt licks within the road corridor or in the areas immediately to the north and south of the alignment cannot be ruled out (A salt lick is a mineral spring or ground containing or bearing salt or any other minerals that is frequented by elephants, ungulates and other animals that require the salts to maintain their healthy dietary requirement). Due to this, salt licks become natural focal points in the forest where large mammals frequent. As a result, there is usually 'heavy movement' of wildlife in the vicinity of salt licks as animals periodically move to and from the salt licks.

C. SECTION 3: OIL PALM PLANTATION

Oil palm plantations are a markedly different habitat comprising of a monoculture stand of oil palm trees that is relatively a poor species habitat for wildlife. In addition, the FLU4 estate was recently clear-felled and replanted (first replanting cycle) and hence is devoid of a canopy. The FLU plantations have adopted the Roundtable on Sustainable Palm Oil (RSPO) principles and have retained river reserves with the original vegetation remaining intact along the rivers. This was observed along Sg. Lepar where the riparian area supported monkeys (Long-tailed Macaque), Plantian Squirrel, Crested Serpent Eagle, Water Monitor, Wild Boar and birds like Blue Breasted Quai, Spotted Dove, Yellow Bellied Prinia and Barn Owl.

There are electrified fencing and trenches constructed all along the plantation boundary with the Berkelah Forest Reserve to deter elephants from entering the plantation. This has proven to be effective in FLU4 but intrusions were still reported to occur at FLU5 and at the palm oil mill to the south.

Barn Owls are being used as part of the integrated pest management programme for biological control of rats. Nest boxes were placed throughout the estate and Barn Owls are observed at dusk.

The forest fringe is an area where intrusions by wildlife are common and this was true for the FLU oil palm plantations. Intrusions recently reported by settlers include:

- A Sun Bear entered the FLU4 nursery but did not do any damage.
- A Tapir entered the plantation and wandered up to the settlement area before returning to the forest.
- A calf was taken by a Tiger recently in the adjacent FLU estate located to the north of the road alignment. There were herds of goats roaming within FLU4 but there were no cases of livestock being taken by the Tiger at FLU4.
- There were intrusions by Elephants in the past but this has ceased after the electric fencing was installed. Intrusions still occur at FLU5, FLU10 and the palm oil mill located to the south.
- Troops of Pig-tailed Macaque frequently enter the estates and are a pest to the replanted crops as they destroy young oil palm shoots. Long-tailed Macaques also enter the estates but do not damage the crop.
- Wild boar is very common throughout the FLU estates as the local settlers are predominantly Malay and do not hunt the species. Some crop damage occurred due to their diggings at the base of young palms.

It is important to note that many of the wildlife species that intrude into the estate from the adjacent forest do not reside within the plantation area. Most of the large mammals enter the plantation from the adjacent forest and return to the forest. Even species that are restricted to forest may be sighted along the forest fringe and some may occasionally stray into the estate. It was not surprising that the forest fringe along the oil palm plantation boundary was the area where most human–wildlife contact was reported.

4.10.4 WILDLIFE ALONG THE ROAD CORRIDOR AND SURROUNDING AREAS

The lists of wildlife species for mammals, reptiles and birds are given in **Appendix 4-5**. Selected species and/ or groups of species that are relevant to the proposed road are discussed in the ensuring sections.

A. MAMMALS

A total of 68 species of mammals were recorded, reported or expected to occur within the Reman Cereh and Berkelah Forest Reserves (RCBFR). Large mammals are clearly the main concern of the Project as it is a new road that cuts through the RCBFR. The mammals recorded and/ or reported to occur in the vicinity of the road alignment area include: Elephant, *Seladang*, Tapir, Tiger, Leopard, Sun Bear, Wild Pig, Sambar Deer, Barking Deer, *Kijang*, *Pelanduk*, Long-tailed Macaque, Pig-tailed Macaque, White Handed Gibbon, *Siamang*, *Binturong*, Civets, Otter and Leopard Cat.

Threatened species of importance for conservation that were classified as Critically Endangered, Endangered or Vulnerable on the current International Union for the Conservation of Nature and Natural Resources (IUCN) Red List include:

- Critically Endangered = Nil: Sumatran Rhinoceros (*Dicerorhinus sumatrensis*) has not been recorded in the RCBFR in recent surveys undertaken by PERHILITAN (Magintan, 2013).
- Endangered = 9 species: Asian Elephant (*Elephas maximus*), Tapir (*Tapirus indicus*), Tiger (*Panthera tigris corbetii*), Red Dog (*Cuon alpinus*), Pangolin (*Manis javanica*), Flat Headed Cat (*Felis planiceps*), Siamang (*Symphalangus syndactylus*), White Handed Gibbon (*Hylobates lar*) and Smoky Flying Squirrel (*Pteromyscus pulverulentus*).
- Vulnerable = 11 species: Bearded Pig (*Sus barbatus*), Sambar Deer (*Cervus unicolor*), Malayan Gaur (*Bos femoralis*), Serow (*Capricornis sumatraensis*), Slow Loris (*Nycticebus caucang*), Clouded Leopard (*Neofelis nebulosa*), Binturong (*Arctictis binturong*), Small-clawed Otter (*Aonyx cinerea*), Marbled Cat (Felis marmarata), Sun Bear (*Helarctos malayanus*) and Pig-tailed Macaque (*Macaca nemestrina*).

A total of 34 species were under "Totally Protected" status and 13 species were "Protected" under the Wildlife Conservation Act 2010 as listed below:

- Totally Protected Species = 34 species: Asian Elephant, Tapir, Bearded Pig, Seladang, Serow, Slow Loris, Malayan Pangolin, Spotted Leopard, Clouded Leopard, Tiger, Red Dog, Masked Palm Civet, Malay Civet, Linsang, Small-toothed Palm Civet, Binturong, Short-tailed Mongoose, Small-clawed Otter, Marbled Cat, Flat-headed Cat, Leopard Cat, Yellow-throated Marten, Malay Weasel, Sun Bear, Siamang, White-handed Gibbon, Agile Gibbon, Cream-coloured Giant Squirrel, Black Giant Squirrel, Large Black Giant Flying Squirrel, Red Giant Flying Squirrel, Horsfield's Flying Squirrel, Smoky Flying Squirrel and Grey-cheeked Flying Squirrel.

- Protected Species = 13 species: Wild Pig, Sambar Deer, Barking Deer, Lesser Mousedeer, Large Mousedeer, Brush-tailed Porcupine, Malaysian Porcupine, Common Palm Civet, Dusky Leaf Monkey, Banded Leaf Monkey, Silvered Leaf Monkey, Pig-tailed Macaque, Long-tailed Macaque.

a. Elephant (*Elephas maximus*)

Elephant is a key species which is of critical importance for the Project. Two herds of elephant with a total estimate of 40 - 70 elephants are believed to be found roaming along the proposed alignment in RCBFR. Information on the two herds is summarised in **Table 4.10.1** below.

Table 4.10.1: Elephants Along the Proposed Road Alignment

No.	Elephant Herd	Estimated No. of Animals	Remarks
1	Cereh Group	20-30	• Home range includes the Reman Cereh Forest Reserve. • Cause human – elephant conflict at Felda Bukit estates around Sagu, Sg Lembing and the border area with Terengganu. • This herd is known to move along Sg. Kuantan and raids orchards at Kg. Sungai Jin, Kg. Kuala Kenau, Kg. Batu Enam and nearby oil palm plantations. • There were intrusions reported every year but with no specific schedule or season. • Elephant dung was found along abandoned logging trails (**Plate 4.10.1**). • The abandoned chalets along Sg. Kuantan had *cili padi* planted around the chalets to deter elephants. • Clear elephant trails were found criss-crossing the riparian area of Sg. Kuantan and its tributaries. • The proposed road will certainly cut through the elephants' home range and frequently used movement conduits of this herd.
2	Lepar Group	20-40	• Home range includes the Berkelah Forest Reserve. • Cause human – elephant conflict at Kg, Paya Bungur, Paya Rambutan, Gelugor, estates around Sri Jaya and Lepar Utara • This herd had caused conflicts with the FLU oil palm estates and has destroyed newly planted palms at the plantations. • The entire eastern boundary of FLU4 has been fenced with electric fencing and trench to halt intrusions. • Recent intrusions reported by the settlers were at FLU5, FLU10 and the Felda Lepar Utara palm oil mill. • The herd is likely to move along Sg. Lepar and the fringe skirting the FLU boundary with the forest. • The road alignment will certainly cut through the elephants' home range of this herd and its frequently used movement conduits along Sg Lepar and its tributaries.

Note: *1. The number of animals are as estimated by PERHILITAN Pahang.*
*2. The known and expected herd movements are shown in **Figure 4.10.1**.*

The Cereh herd has caused human – elephant conflict in Felda Bukit Sagu, Sg. Lembing Estate and the area bordering Terengganu (PERHILITAN, 2013). The field survey confirmed that the Cereh herd that comprises of approximately 20-30 elephants commonly move along Sg. Kuantan and raid crops at Kg. Sungai Jin, Kg. Kuala Kenau, Kg. Batu 6 and even into the oil palm smallholder plots along Jalan Sungai Lembing. Within the RCBFR, the movement pattern is expected to follow rivers, particularly along stretches where the river flows through steep terrain. The small ponds and marshes along the banks of the rivers are also frequented and there were clear elephant trails from Sg. Kuantan to these areas along the foothills.

The Lepar herd roams the area surrounding the FLU estates. The proposed road will also pass through the home range of this herd that comprises of an estimated 20-40 elephants.

It is also likely that there will be lone bull elephants that roam widely in the RCBFR and visit different herds. The movements of these bulls are difficult to predict and may vary widely.

It is clearly evident that the proposed road alignment will pass through prime elephant habitat that is known to support at least two herds with an estimate total of 40-70 animals. Elephant herds have a large home range and herds are known to continue crossing roads that traverse their home range to continue moving along their traditional routes within their range.

The presence of the elephant herds is very significant and cannot be ignored. It is very difficult, if not impossible, to accurately predict the actual routes that the elephants will take to cross a new road with the altered topography. Elephants are intelligent animals and will carefully survey barriers or obstacles along their routes and select the safest and easiest option for crossing. This has been reported for elephants entering oil palm estates even after electrified fencing and trenches are constructed to prevent entry (Khan, 1991).

b. Seladang (*Bos gaurus*) and Other Ungulates

Seladang was confirmed present in the RCBFR by PERHILITAN but there were no estimates of the number of herds or total numbers. PERHILITAN has confirmed that the Berkelah Forest Reserve was an area where studies on Seladang had been carried out and has been declared as area where hunting is prohibited (*Perintah Pemuliharaan Hidupan Liar (Tempat Mana-Mana Hidupan Liar Boleh Diburu) 2013* [NRE 44/1/4/08]; [PN(PU^2)113/VI]). Seladang move in herds and often browse along grass and shrubs along major rivers and clearings in the forest. Herds are known to move along rivers but are not restricted to this habitat and can readily scaling up very steep terrain.

Sambar Deer was confirmed present but is not common whereas Kijang and Pelanduk were widespread. These species have been subjected to hunting pressure particularly close to Sungai Lembing. The PERHILITAN Pahang has suspended issuing hunting licenses for Sambar Deer and Kijang due to the depletion of local populations.

These deer species are also prey for Tigers and Leopards. They are also wary and shy in behaviour. They are cautious nocturnal animals and are sensitive to the presence of man. Their shy behaviour and ability to move fast makes them less likely to be hit by vehicles along the road. That being said, the potential for road kills if these animals cross at grade still exist.

Serow are generally rare and usually inhabit limestone outcrops. It is possible that this species inhabit the steepest ridge tops along the alignment.

Sambar Deer, Kijang and Mousedeer are likely to be more common along the rivers.

c. Sumatran Rhino (*Dicerorhinus sumatrensis*)

Sumatran Rhino was reported in the Project's Feasibility Study Report (Perunding Zaaba, 2002) where a total of five animals were known to inhabit the RCBFR in the past. However, this species has not been recorded by PERHILITAN in recent years and has never been seen by the *Orang Asli* of Kg. Sungai Jin. The IUCN distribution map restricts its southern distribution to the Taman Negara area. However, there is a possibility that this species may be present in the new road alignment area where individuals from Taman Negara may venture southwards.

d. Large Predators (Tiger, Leopard and Clouded Leopard)

The proposed road alignment passes prime tiger habitat that occupied by wild boar which is its favourite prey. Tiger was confirmed present in the area and a tiger was reported taking a calf in FLU but no cases occurred at FLU4 where goats and cattle roam freely. Past estimates reported ten tigers present in the Berkelah Forest Reserve (Perunding Zaaba, 2002). Noting that the tigers are solitary and territorial with territories in a good habitat covering an area of 10 km^2, it can be estimated that the proposed road alignment will conservatively traverse through three to five tiger territories with resident animals. Leopard was confirmed to be present and Clouded Leopard is highly likely to be present in RCBFR.

For large predators, tiger is taken as the key species for which mitigation measures prescribed will also be suitable for the Leopard and Clouded Leopard. For territorial predator species, provision of safe crossing all along the entire stretch of road is necessary as individuals in habitats that saddle or fringe the road are only likely to cross the road section within their respective territorial boundaries.

Tigers and Leopards are very intelligent, wary and agile. These species are expected to utilise the safest routes when crossing roads and only cross during the night time which reduce the risk of collisions with vehicles. Clouded Leopard is the most arboreal in its habits and would utilise overpasses.

e. Tapir (*Tapirus indicus*)

Tapir was present in RCBFR and was recorded along Sg. Kuantan (**Plate 4.10.2**). There are also reports of Tapir entering FLU4. The species is apparently common in the area and browse on shoots along the river edge and along logging roads. There were two recent cases of road kills reported along the East Coast Expressway (Zaide, 2013).

f. Sun Bear (*Helarctos malayanus*)

Sun Bear was confirmed present in the RCBFR. One animal reportedly entered into the FLU4 nursery recently. Sun Bear will be at an increased risk to road kills and poaching.

g. Wild Pig (*Sus scrofa*) and Bearded Pig (*Sus barbatus*)

Wild pigs are very abundant in the new road corridor and tracks were recorded throughout the survey transects as well as all sections of the proposed alignment. Wild pigs typically move in groups where the slowest animals may not be fast enough to avoid collision with oncoming vehicles. Road kills were already occurring as recorded during the site survey. Wild pig was also very common throughout the FLU estates.

h. Gibbons

White-handed Gibbon, Agile Gibbon and Siamang occur in the area and inhabit the forest canopy. Gibbons are dependent on tall forest and cannot survive in oil palm plantations and thus are not found within the FLU estates. Gibbons were also not present in the vicinity of the *Orang Asli* village.

Gibbons are diurnal, arboreal and territorial animals and mated pairs will remain within and will protect their territories (Territories are spaces out in the forest, each with a resident mated pair). Gibbons do not usually descend to the ground and the cleared road corridor will be a barrier to the free movement of gibbons. This impact will be experienced by animals whose territories have been divided by the road alignment. When young animals reach adulthood, they will be driven off from the territory of the adults and may cross the new road and move to other areas. These gibbons will be at a risk of getting hit by passing vehicles if they cross the road at grade. However, it is likely to be a one-time event for young animals.

i. Monkeys (Macaques and Leaf Monkeys)

Monkey troops were present within the RCBFR as well as the FLU4 oil palm plantation. Monkey troops are territorial and will most likely cross the new road alignment and continue to move within their home range foraging for food. Intrusions into FLU4 are common incidents where Pig-tailed Macaques have become a pest. Occasional road kills are also common in the area. But primates have the ability to learn about the dangers of passing vehicles and avoid them and cross roads safely.

j. Small Mammals

A wide range of small mammals were recorded, reported and expected to occur within the RCBFR. These include Civets, Sunda Pangolin, Malayan Porcupine, Slow Loris, Squirrels, Rats, Otter and Leopard Cat.

Road kills were already occurring along the roads in the area (**Plate 4.10.3**) and the occasional road kills are expected to continue. It is worthy to note that whilst individual animals may be killed on roads and it is sad to witness, the populations of these species in the surrounding areas of contiguous forest will survive and repopulate the niches left vacant in the habitats fringing the road. This dynamic process has already been occurring in the adjacent areas.

B. BIRDS

The RFBFR is contiguous with Taman Negara that supports a very high diversity of avifauna. A total of 225 species of lowland species have been recorded at Taman Negara (**Appendix 4-5**) which may also be present within the new road alignment area. A total of 207 species were totally protected and 10 species were protected under the Wildlife Conservation Act 2010. The Malayan Peacock Pheasant was the only species endemic to Peninsular Malaysia.

Threatened species of importance for conservation that were listed in IUCN Red List were:

- Critically Endangered = Nil.
- Endangered = 1 species: Masked Finfoot (*Heliopais personata*).
- Vulnerable = 5 species: Crestless Fireback Pheasant (*Lophura erythrophthalma),* Malaysian Peacock Pheasant (*Polyplectron malacense),* Large Green Pigeon (*Treron capellei),* Great Salty Woodpecker (*Mulleripicus pulverulentus)* and Straw-headed Bulbul (*Pycnonotus zeylanicus).*

Of all the wildlife that is present along the proposed road alignment, the least impacted are birds as most can readily fly across the road. Some species recorded during the survey were well adapted to survive along the forest edge, in disturbed forests and in oil palm plantations. With regard to avifauna, relevant issues are:

- The Masked Finfoot prefers wetlands and is likely to forage along rivers. It is not expected to be adversely impacted by the new road.
- The risk of road kills is only realistic to be considered for ground birds like the Crestless Fireback Pheasant and the Malaysian Peacock Pheasant. Crossings provided for other species should serve these species and no specific mitigation measures are warranted for birds.
- Forest songbird species like the White Rumped Shama and Straw Headed Bulbul would be more exposed to poaching due to the improved accessibility (**Plate 4.10.4**).
- Similar to other species, birds will be more at risk to subsistence hunting by the *Orang Asli.*

C. REPTILES

Similar to birds, as the RCBFR is contiguous with Taman Negara, it is expected to be rich in reptile diversity. A total of 125 reptiles are listed in the reptile species list as shown in **Appendix 4-5**. Two species were totally protected and 67 species were protected under the Wildlife Conservation Act 2010.

Threatened species of importance for conservation that were listed in IUCN Red List were:

- Critically Endangered = Nil.
- Endangered = Four species: Spiny Turtle (*Heosemys spinosa),* Malayan Giant Terrapin (*Orlitia borneensis),* Elongated/ Yellow Tortoise (*Indotestudo elongate)* and Brown Asian Giant Tortoise (*Manouria emys*).
- Vulnerable = Six species: Asiatic Soft-shelled Turtle (*Amyda cartilaginea),* Malayan Box Turtle (*Cuora amboinensis),* Asian Giant Terrapin (*Heosemys grandis),* Broad-backed Terrapin/ Malayan Flat Shelled Turtle *(Notochelys platynota),* Black Marsh Turtle/ Smiling Terrapin *(Siebenrockiella crassicollis)* and King Cobra (*Ophiophagus hannah*).

Snakes and lizards that either slither or crawl across roads are at risk of being rolled over by passing traffic. Road kills were common along the existing roads even before this Project. A Water Monitor Lizard was recorded as a fresh road kill during the survey along Jalan Sungai Lembing in the vicinity of the Project site. These road kills of lizards and snakes are often erroneously perceived as "acceptable collateral damage" by road users. Monitor lizards were very common in the FLU estates but were notably absent in the vicinity of Kg. Sungai Jin.

Plate 4.10.1: Elephant (*Elephas maximus*) dropping along the logging on the banks of Sg. Kuantan.

Plate 4.10.2: Fresh tracks of a young Tapir (*Tapirus indicus*) recorded within the alignment. Note: The highlighter is 12.6 cm, in length.

Plate 4.10.3: A fresh road kill of a Leopard Cat (*Prionailurus bengalensis*) along Jalan Jerantut (P98) (2/5/13).

Plate 4.10.4: A White Rumped Shama (*Copsychus malabaricus*) trapped by a poacher in Reman Cereh Forest Reserve (1/5/13).

4.11 AQUATIC FLORA AND FAUNA

4.11.1 WATER QUALITY IN RELATION TO AQUATIC BIOLOGICAL RESOURCES

While the assessment of the water quality is discussed more fully in the earlier section, the results of the analyses are also discussed herein as they relate to aquatic biological resources. The seven water quality sampling points (WQ1 - WQ7) are positioned as such to give a representative picture of the water quality prior to the implementation of the Project. The data was compared with the *National Water Quality Standards* (**Appendix 4-6**) as well as various published water quality standards for aquatic organisms (**Table 4.11.1**). The description of each sampling point is shown in **Table 4.11.2** and the locations of the sampling points are indicated in **Figure 4.2.1**.

Table 4.11.1: Water Quality Limits for Aquatic Organisms

Parameter	Limit	Reference
pH	6.5 - 9.0	Zweig *et al.*, 1999
Temperature	25 - 30°C	Zweig *et al.*, 1999
Dissolved Oxygen, DO	>5 mg/l	Zweig *et al.*, 1999
Biological Oxygen Demand, BOD_5	<3 mg/l	Liong, 1984
Total Suspended Solids, TSS	<80 mg/l	Liong, 1984
Ammoniacal Nitrogen, NH_3-N	0.05 mg/l	Boyd, 1998

The river water quality monitoring results indicated that the water quality in the study area were well within the recommended limits for aquatic biological resources, except for biological oxygen demand (BOD_5) and *E. coli,* which were recorded as high at certain stations. The detailed discussions on each parameter are as follows:

A. pH

pH can be defined as the concentration of hydrogen ions in the water column (Sawyer *et al.*, 1994). Normally, the acidity and alkalinity of river water is influenced by the presence of mineral salts such as chloride, sulfate, nitrate and phosphate (Train, 1979; Kemmer, 1987).

The current pH levels (5.93 - 6.66) indicate that the water was slightly acidic and within the Class III limit (5 - 9) of the National Water Quality Standards for Malaysia (NWQS). Most of the levels recorded exceeded the standard limit of pH for freshwater organisms i.e. 6.5 - 9.0 (Zweig *et al.*, 1999), except WQ1 (6.66). Lloyd (1992) has reported that below pH 6.5, some species of fish may experience slow growth.

In comparison, the pH level for the current study was lower when compared with several other river studies such as in Ulu Jelai, Cameron Highlands, Sg. Kuantan and Sg. Terengganu which recorded a range from 6.9 – 8.9 (AECOM, 2011), 6.19 – 7.17 (MERC, 2010a) and 6.25 – 6.76 (MERC, 2010b), respectively.

B. TEMPERATURE

Water temperatures can have an effect on physiological processes in fish and crustacean such as respiration rates, feeding, growth and behaviour. High levels of temperature can affect physiological functions of planktonic community (phytoplankton, zooplankton) and benthic population by creating stress and thereby affecting the population density (Kinne, 1963; Markowski, 1960). Zweig *et al.* (1999) indicated that high temperature levels can affect behaviour, feeding, metabolism and growth rates of fishes and as well as their immunity to disease.

Temperature levels recorded at the study site (30.0 - 31.4°C) were recorded slightly higher than the recommended limit of 25 – 30°C for aquatic organisms (Zweig *et al.*, 1999). In addition, the current levels were also found to be higher than 20.5 – 24.0°C recorded in Ulu Jelai, Cameron Highlands, 25.5 – 30.7°C in Sg. Kuantan and 25.7 – 30.0°C in Sg. Terengganu (AECOM, 2011; MERC, 2010a; MERC, 2010b).

C. DISSOLVED OXYGEN (DO)

DO concentration is a good indicator of aquatic ecosystem health since oxygen is essential for the respiration of aquatic organisms (Jack *et al.*, 2009; Chui and Choon, 2008). The amount of oxygen available in the water column depended on several factors that affect the oxygen solubility, including water temperature, water depths, primary productivity and organic loading (Ainon *et al.*, 2011; Jack *et al.*, 2009; Chua *et al.*, 1998). Low DO condition affect metabolic and behavioural processes in aquatic organisms such as restricted feeding, swimming and migration activities of fish (Chui and Choon, 2008; Karna, 2003). As a result, fish growth was reduced and their distribution was affected, which subsequently makes the fish more susceptible to disease and predation (Davis, 1975).

DO levels at the study area ranged from 5.82 - 6.28 mg/l, which all falls under Class II (5 – 7 mg/l) of the NWQS. The levels were well within the recommended safe level of >5 mg/l for aquatic organisms (Zweig *et al.*, 1999). The DO levels were within the range recorded at Sg. Kuantan (2.19 – 8.32 mg/l) (MERC, 2010a) and Sg. Terengganu (3.56 – 7.92 mg/l) (MERC, 2010b) but slightly lower than the levels recorded in Ulu Jelai, Cameron Highlands (6.36 – 7.50 mg/l) (AECOM, 2011).

D. BIOLOGICAL OXYGEN DEMAND (BOD_5)

BOD_5 could be defined as a chemical procedure for determining the rate of uptake of dissolved oxygen by biological organisms in a body of water (Train, 1979). BOD_5 levels obtained during the study ranged from 2 – 8 mg/l. Most of the levels fall within the Class III limit (6 mg/l) of the NWQS, except WQ1 and WQ3 which are under the Class II limit (3 mg/l), and WQ4 under Class IV limit (12 mg/l).

Most BOD_5 levels recorded were beyond the recommended safe limit (<3 mg/l) for aquatic organisms as reported by Liong (1984). High BOD_5 level suggests high organic matter in the water column, since degradation of organic matter by microorganisms consume large amount of oxygen, thus, resulting in the depletion of dissolved oxygen (Zweig *et al.*, 1999).

Low dissolved oxygen may affect fish feed consumption, metabolic rate and energy expenditure (Yovita, 2007; Elliott, 1982).

In comparison, the current BOD_5 levels recorded were higher than the BOD_5 levels at Sg. Terengganu (2 – 3 mg/l; MERC, 2010b) and comparable to Ulu Jelai, Cameron Highlands (1 – 8 mg/l; AECOM, 2011).

E. CHEMICAL OXYGEN DEMAND (COD)

The COD level in the water represents the amount of oxygen required to convert all oxidisable matter to carbon dioxide and water (Metcalf and Eddy, 2003). COD levels recorded during the study ranged from 8 – 32 mg/l, which mostly fall within Class II (25 mg/l) of the NWQS. In comparison, the current COD levels recorded were higher than the levels at Sg. Terengganu (5 – 16 mg/l; MERC, 2010b), but lower than in Ulu Jelai, Cameron Highlands (6 – 40 mg/l; AECOM, 2011).

F. TOTAL SUSPENDED SOLIDS (TSS)

TSS represents the actual measure of mineral and organic particles suspended in the water column (Bash *et al.*, 2001). TSS levels recorded were low, ranging from 6 – 17 mg/l and were well within Class I (25 mg/l) of the NWQS. In addition, the levels were also found to be well within the safe limits of <80 mg/l for aquatic organisms (Liong, 1984). In comparison, the levels were lower when compared with the study in Ulu Jelai, Cameron Highlands (18 – 338 mg/l; AECOM, 2011) and Sg. Terengganu (1 – 70 mg/l; MERC, 2010b).

G. OIL AND GREASE (O&G)

Oil and grease was not detected (below the detection limit of 1 mg/l) at all sampling stations.

H. AMMONIACAL NITROGEN (NH_3N)

Ammoniacal nitrogen consists of organic nitrogen, nitrogen gas, ammonia, nitrite and nitrate. High NH_3N can cause direct poisoning to the fish and other aquatic organisms. Excessive levels of ammoniacal nitrogen can affect the fish in terms of growth rate, hatching and changes in tissues of gills, liver and kidneys (Eddy, 2005).

The NH_3N levels were below the detection limit of 0.01 mg/l at all sampling stations. The levels were well within Class I (0.1 mg/l) of the NWQS as well as the recommended safe level (0.50 mg/l) for aquatic organisms (Boyd, 1998). The levels were also lower than the studies undertaken in Ulu Jelai, Cameron Highlands and Sg. Terengganu, which recorded <0.01 – 0.06 mg/l and 0.01 – 0.64 mg/l, respectively (AECOM, 2011; MERC, 2010b).

I. *ESCHERICHIA COLI* (*E. coli*)

The source of *E. coli* in water is from animal and human excretion. The presence of *E. coli* in the water body is an indication of water pollution by sewage, domestic wastewater, urban and land runoffs. At the study area, the *E. coli* counts ranged from 10 – 22 CFU/100ml. *E. coli* is not pathogenic to fish, and there is no information in the scientific literature that show *E. coli* and faecal coliform affects the growth, reproduction, health or survival of the fish (DWAF, 1996). There are no guidelines for bacteria in aquatic ecosystems. However, *E. coli* has been found in the intestinal tract of fish (Ampofo and Clerk, 2010; Newman *et al.*, 1972), gills, muscles and skin (Ogbondeminu, 1993). According to Salle (1964), the most heavily contaminated parts are the intestines and the skin. Their presence in fish intended for human consumption could constitute a potential danger not only in causing disease, but, also possible transfer of antibiotic resistance from aquatic bacteria to human infecting bacteria from nonaquatic sources (Ampofo and Clerk, 2010; Fapohunda *et al.*, 1994; Olayemi *et al.*, 1991).

4.11.2 PHYTOPLANKTON

Phytoplankton assessment involved the collection of both primary (sampling) and secondary data [literature review of all existing data, reports (published and unpublished), records and other secondary sources with respect to the study area]. Sampling was carried out at a total of seven sampling stations which coincided with the water quality sampling stations. The sampling stations area almost similar to the water quality sampling stations. Details of the aquatic flora and fauna sampling stations are tabulated in **Table 4.11.2**. Details of the sampling and analytical regimes are provided below.

At each sampling station, the following standard procedures were applied:

- Water samples were collected into 1.5 litre labelled polyethylene terephthalate bottles.
- 15 ml of Lugol's iodine solution was added as preservative (**Plate 4.11.1**).

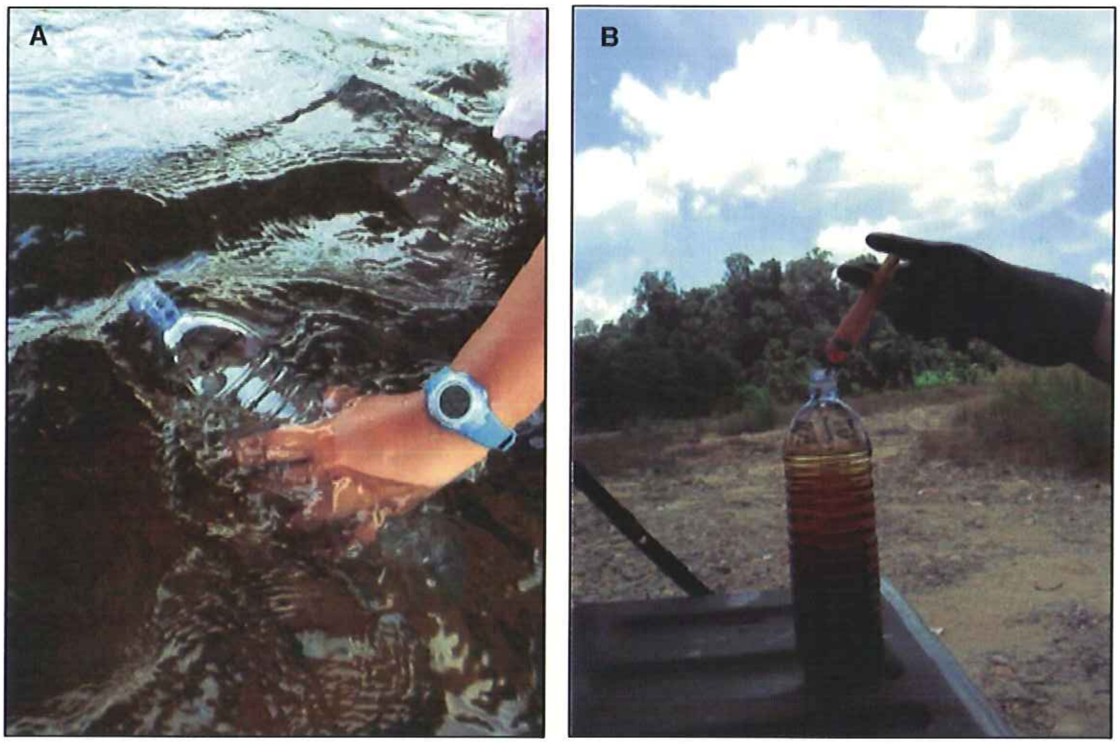


Plate 4.11.1: Phytoplankton samples collected into PET plastic bottle (A); and preserved with 15 ml Lugol's iodine solution (B).

Table 4.11.2: Description of Aquatic Flora and Fauna Sampling Stations

Description	Station						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Coordinates	N 03° 56.007' E 103° 02.959'	N 03° 58.021' E 103° 01.263'	N 03° 56.531' E 102° 58.229'	N 03° 55.289' E 102° 57.503'	N 03° 53.505' E 102° 46.157'	N 03° 55.353' E 102° 48.962'	N 03° 56.030' E 103° 02.996'
Location	Sg. Kenau	Sg. Kuantan	Sg. Kuantan	Sg. Kuantan	Sg. Lepar	Sg. Lepar	Sg. Kuantan
Date	25/3/2013	25/3/2013	26/3/2013	26/3/2013	27/3/2013	27/3/2013	28/3/2013
Time	1444	1210	1006	1230	1400	1555	1040
Weather	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Depth	0.3 m	0.8 m	0.3 m	0.5 m	0.2 m	0.3 m	2.0 m
Water Clarity	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Sediment type	Coarse Sand	Coarse Sand	Coarse Sand	Coarse Sand	Coarse Sand	Coarse Sand	Coarse Sand

At the laboratory:

- Phytoplankton composition and diversity were determined by first concentrating, then sub-sampling and counting using an inverted microscope. Plankton samples were identified at family and genus/species levels using a high magnification compound microscope.
- Phytoplankton was enumerated in terms of number of cells per millilitre (cells/ml).
- Species diversity was also assessed based on the Shannon-Weiner Diversity Index (H'), which provides important information about rarity and commonness of the species in a community. A high H' value indicates that the community has a high level of species diversity or that many equally abundant species are present. The index was calculated based on the following formula:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

where,

H' = index of species diversity
s = number of species
p_i = proportion of the i^{th} species in the total sample of S species.

Phytoplankton are the main primary producers in the majority of aquatic ecosystems, thus constituting the base of the food chain for zooplankton as well as other linked communities, such as benthos and nekton (Conde *et al.*, 2007; Townsend *et al.*, 2000; Wetzel, 1983). In addition, the productivity of any water body is determined by the amount of phytoplankton it contains as they are major primary producers (Davies *et al.*, 2009). In view of this relationship, primary productivity also closely correlates with fish yields (Sreenivasan, 1968; Sreenivasan, 1964).

Phytoplankton also play an important role in the biomonitoring of water pollution (Wetzel, 1983). Their distribution, abundance, species diversity and species compositions are used to assess the biological integrity of the water body (Townsend *et al.*, 2000). Barnes (1980), reports that pollution affects plankton distribution. Specific environmental factors, such as pH, light, temperature, salinity, alkalinity, dissolved oxygen and nutrient levels are known to affect their composition, distribution and abundance (Parsons *et al.*, 1977).

The results from this study recorded five phyla namely, Chlorophyta, Bacillariophyta, Euglenophyta, Dinoflagellata and Cyanophyta (**Table 4.11.3**). Among the phyla listed, Chlorophyta was found to be the most abundant phylum, since it covered 75.1% of the total phytoplankton density, followed by Bacillariophyta (16.0%), Dinoflagellata (4.5%), Euglenophyta (3.1%) and lastly by Cyanophyta (1.2%) (**Figure 4.11.1**). The density of phytoplankton ranged from 9.68 – 619.60 cells/ml or averaged at 105.39 mg/l. The highest density was recorded at S7, while the lowest was at S1 (**Figure 4.11.2**).

Chorophyta was the most dominant phylum and recorded density ranging from 1.21 – 537.83 cells/ml or averaged at 79.17 cells/ml. The highest density was recorded at S7, which was mostly contributed by *Ankistrodesmus* (352.50 cells/ml) and *Staurastrum* (107.20 cells/ml). Other genera i.e. *Chodatella, Cosmarium* and *Scenedesmus* were only recorded at 52.69 cells/ml, 19.99 cells/ml and 5.45 cells/ml respectively. As for the other stations (S1 –

S6), the density was low ranging from 0.61 – 6.05 cells/ml. According to Huynh and Serediak (2006), the presence of *Ankistrodesmus* is a good indicator of clean water, since they tend to disappear from the algal community in very polluted systems. In addition, *Staurastrum* also commonly grows in area that is free from pollution.

The second most dominant phylum was Bacillariophtya with a density that ranged from 1.21 to 43.03 cells/ml or averaged at 16.87 cells/ml. The highest density was recorded at S4, while the lowest was at S1. The averaged density of unidentified diatom (11.86 cells/ml) and *Navicula* (3.89 cells/ml) was found to be higher as compared to *Cymbella* (0.95 cells/ml) and *Pinnularia* (0.17 cells/ml). *Navicula* has been known for high tolerance to poor water condition due to high content of organic matter (Khare and Saxena, 2013; Khare, 2006; Khare, 1999).

Phylum Dinoflagellata was the third most dominant phylum, represented by *Peridinium*. However, it was only found at S3 (0.61 cells/ml) and S7 (32.71 cells/ml). As for Euglenophyta, it was represented by *Euglena* that was only found at S2 and S3 with 0.61 cells/ml each and *Trachelomonas* that was found at S1 (2.42 cells/ml), S2 (0.61 cells/ml), S3 (0.61 cells/ml) and S7 (18.17 cells/ml). The least dominant phylum was Cyanophyta. It was only represented by *Oscillatoria* at one station i.e. S7 (9.09 cells/ml).

Overall, phytoplankton densities at the study area ranged from 9.68 - 619.60 cells/ml and had an average density of 105.39 cells/ml. This average density was higher as compared to other riverine studies undertaken in Ulu Jelai, Cameron Highlands, Sg. Kuantan and Sg. Terengganu, where the average densities recorded were 4.06 cells/ml, 7.58 cells/ml and 14.03 cells/ml respectively (AECOM, 2011; MERC, 2010a; MERC, 2010b). In addition, most of the species found during the current study such as *Ankistrodesmus, Closterium, Cosmarium, Scenedesmus, Staurastrum, Navicula, Pinnularia, Euglena, Trachelomonas* and *Oscillatoria* were also recorded at Sg. Kuantan and Sg. Terengganu (MERC, 2010a; MERC, 2010b) and thus not endemic to the rivers sampled in this study.

Species diversity was important for biological monitoring in determining the health of the environment (Ogbeibu and Edutie, 2002). In this study, the diversity index ranged from 0.79 – 1.91 (**Figure 4.11.3**). Most of the stations had moderate diversity pattern (1.0 – 1.91), except S1 (0.90) and S5 (0.79) which showed low diversity. Compared with the previous studies, the diversity indices were higher than Ulu Jelai, Cameron Highlands (0.00 – 1.39), Sg. Kuantan (0.00 – 1.30) and Sg. Terengganu (0.00 – 1.89) (AECOM, 2011; MERC, 2010a; MERC, 2010b).

Table 4.11.3: Phytoplankton Density (cells/ml) and Diversity (H') at the Study Area

Taxa	Station						
	S1	S2	S3	S4	S5	S6	S7
Phylum: Chlorophyta							
Ankistrodesmus	-	-	-	-	-	-	352.50
Chodatella	-	-	-	-	-	-	52.69
Spirogyra	-	-	-	-	1.21	-	-
Closterium	-	-	-	-	-	0.61	-
Cosmarium	6.05	1.21	1.21	1.21	-	-	19.99
Oedogonium	-	1.82	0.61	0.61	-	-	-
Pleurotaenium	-	0.61	-	0.61	-	0.61	-
Scenedesmus	-	-	-	-	-	-	5.45
Staurastrum	-	-	-	-	-	-	107.20
Subtotal (cells/ml)	**6.05**	**3.64**	**1.82**	**2.43**	**1.21**	**1.22**	**537.83**
Phylum: Bacillarophyta							
Cymbella	-	0.61	-	4.85	-	1.21	-
Navicula	1.21	2.42	1.82	7.88	6.05	2.42	5.45
Pinnularia	-	0.61	-	0.61	-	-	-
Other diatom	-	4.24	9.09	29.69	14.52	9.09	16.35
Subtotal (cells/ml)	**1.21**	**7.88**	**10.91**	**43.03**	**20.57**	**12.72**	**21.80**
Phylum: Euglenophyta							
Euglena	-	0.61	0.61	-	-	-	-
Trachelomonas	2.42	0.61	0.61	-	-	-	18.17
Subtotal (cells/ml)	**2.42**	**1.22**	**1.22**	**0.00**	**0.00**	**0.00**	**18.17**
Phylum: Dinoflagellata							
Peridinium	-	-	0.61	-	-	-	32.71
Subtotal (cells/ml)	**0.00**	**0.00**	**0.61**	**0.00**	**0.00**	**0.00**	**32.71**
Phylum: Cyanophyta							
Oscillatoria	-	-	-	-	-	-	9.09
Subtotal (cells/ml)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**9.09**
Density (cells/ml)	**9.68**	**12.74**	**14.56**	**45.46**	**21.78**	**13.94**	**619.60**
Diversity Index (H')	**0.90**	**1.91**	**1.29**	**1.09**	**0.79**	**1.07**	**1.45**

Figure 4.11.1: Phytoplankton Composition at the Study Area

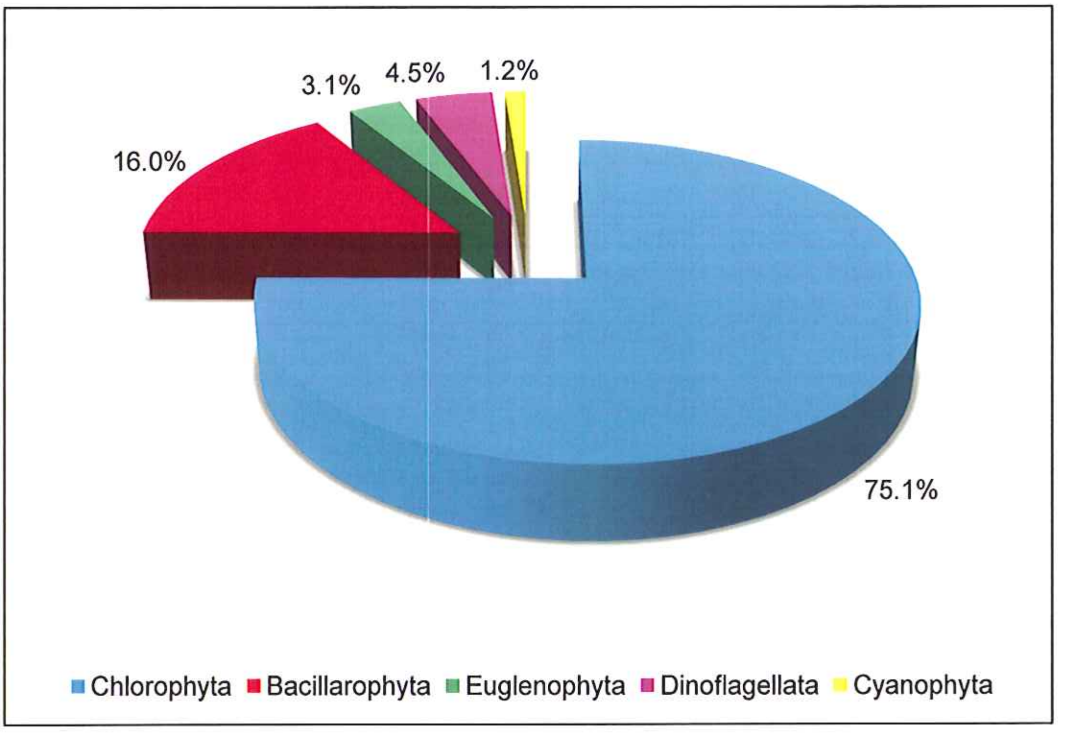


Figure 4.11.2: Phytoplankton Density (cells/ml) at the Study Area

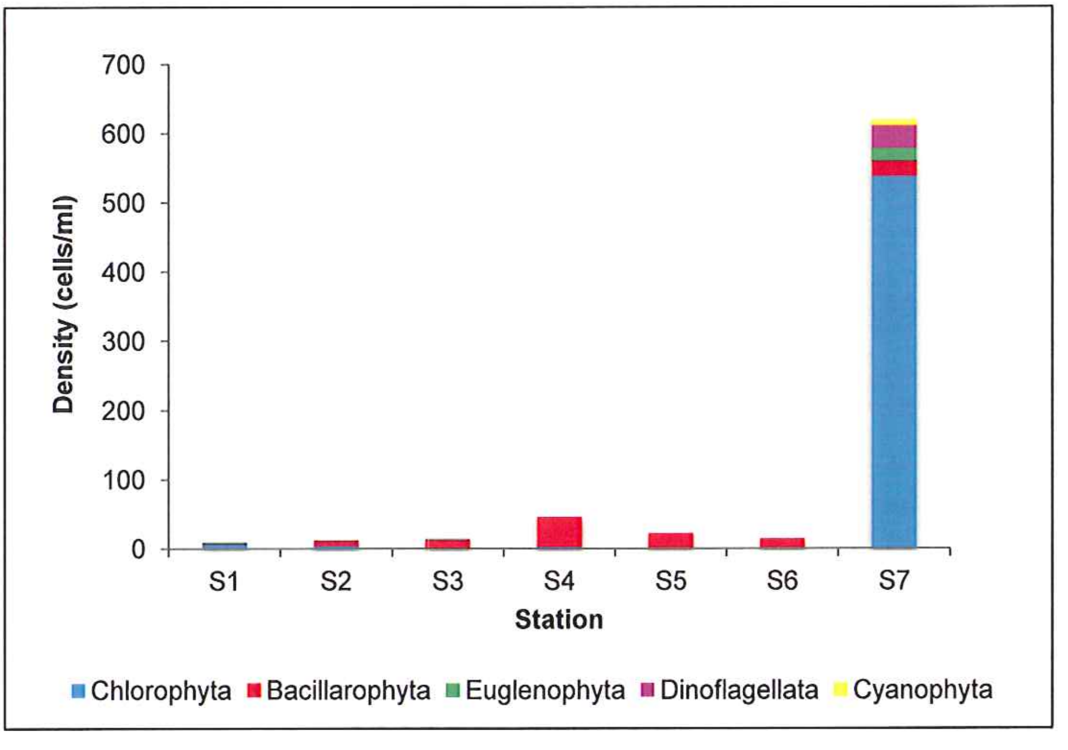
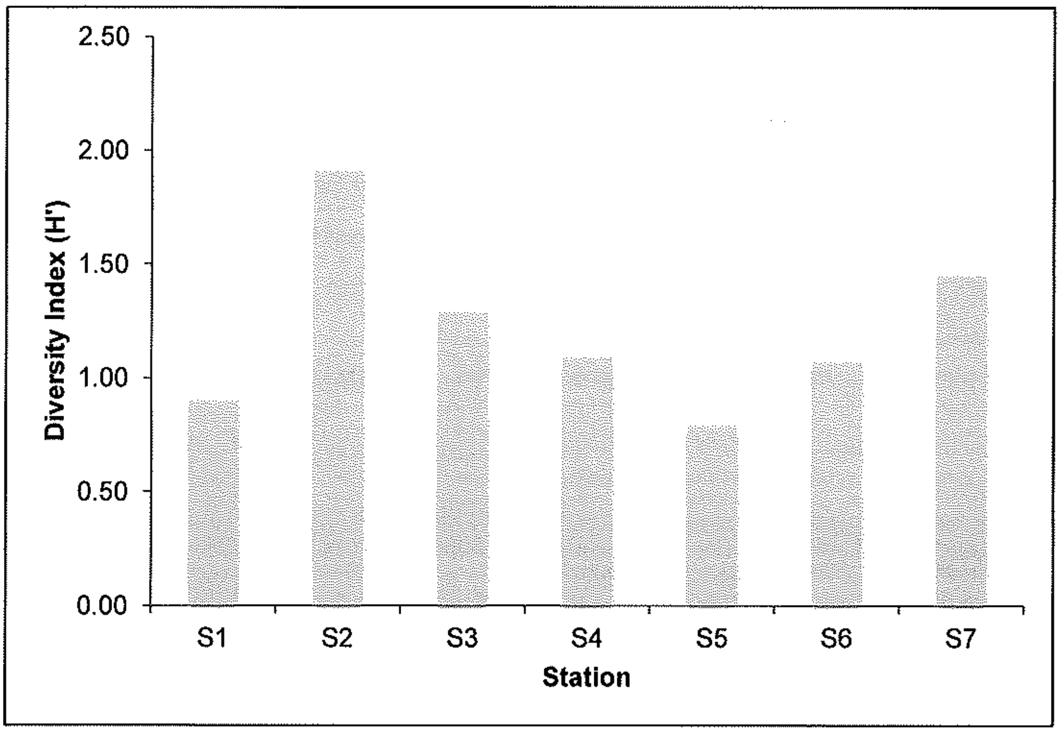


Figure 4.11.3: Diversity Index (H') of Phytoplankton at the Study Area



4.11.3 ZOOPLANKTON

Zooplankton assessment was also involved the collection of both primary (sampling) and secondary data [literature review of all existing data, reports (published and unpublished), records and other secondary sources with respect to the study area]. Sampling stations coincided with the phytoplankton sampling stations.

At each sampling station, the following standard procedures were applied:

- 20 litres of water samples were filtered through a140µm plankton net.
- Zooplankton samples retained on the plankton net were washed into a plastic bottle (**Plate 4.11.2**).
- 10% formaldehyde was added as preservative and labelled prior to laboratory analysis.

Plate 4.11.2: Collecting and preserving of zooplankton.

At the laboratory:

- Zooplankton composition and diversity were determined by first concentrating, then sub-sampling and counting using an inverted microscope. Samples were identified at the family and genus/species levels using a high power compound microscope.
- Zooplankton was enumerated in terms of individuals per litre (ind./l).
- Zooplankton diversity was assessed based on Shannon-Weiner Diversity Index (H').

Zooplankton assumes a great ecological significance in aquatic ecosystems as they play a vital role in the food web, nutrient recycling and in the transfer of organic matter from primary producers to consumers like fishes (Krishnamurthy *et al.*, 1979). According to Suontama (2004), zooplankton was a type of fish food that contains lower amounts of environmental toxins as compared to the organisms higher up the food chain since the toxins accumulate as they move up the food chain. Moreover, Annalakshmi and Amsath (2012) also reported that certain fishes would totally feed on zooplankton, thus, the zooplankton abundance could directly act as an indicator of fish populations.

In addition, zooplankton species were also used as indicators of water quality and pollution, since they respond quicker to environmental changes compared to fishes (Mola, 2011; El-Enany, 2009). Species composition and abundance of zooplankton communities can be influenced by a number of physical, chemical and biological factors. However, the factors recognised as the most important were temperature, quality and availability of food, competition and predation. In natural environments these factors act simultaneously and may also interact to different degrees, modifying the zooplankton composition in different ways (Anil *et al.* 2004; Rocha *et al.*, 1999).

The result from the sampling comprised three major phyla of zooplankton, i.e., Protozoa, Arthropoda (Crustacea) and Rotifera (**Table 4.11.4**). Protozoa was the most dominant phylum, consisting of 49.4% of the total zooplankton. As for Arthropoda (Crustacea) and Rotifera, they covered 25.8% and 24.7% respectively (**Figure 4.11.4**). In terms of sampling stations, the highest density found at S7 (2.90 ind./l), followed by S5 (0.80 ind./l) and S6 (0.55 ind./l). No zooplankton was found at S1 and S2 (**Figure 4.11.5**).

Protozoa was the most dominant phylum recorded with an average density of 0.31 ind./l. This phylum is represented by *Arcella* sp. and *Difflugia* sp.. Protozoa was among the major zooplankton group recorded in the freshwater environment that has limited locomotion (Sultana, 2011; Battish, 1992). Protozoa are also an important link in the food web since they consume large quantities of phytoplankton and bacteria (Porter *et al.*, 1979). In terms of sampling stations, the highest density of protozoans was found at S7 (0.95 ind./l), while the lowest density was found at S3 (0.05 ind./l).

Arthropoda (Crustacea) was represented by Copepoda (Naupli, Copepodids and *Mesocylops*) and Cladocera (*Alona*). They were all found in S7, ranging from 0.10 to 0.50 ind./l. Copepoda dominated at 91.3% of the Arthropod density.

Rotifera was represented by seven genera i.e *Brachionus, Dipleuchlanis, Euchlanis, Lecane, Monostyla, Platyas* and *Philodina.* Most of them were found at S7 (0.05 – 0.60 ind./l), except *Dipleuchlanis* and *Monostyla.* At S6, only *Dipleuchlanis* was found (0.05 ind./l), while at S5 *Brachionus* (0.10 ind./l), *Dipleuchlanis* (0.05 ind./l) and *Monostyla* (0.10 ind./l) were found.

Table 4.11.4: Zooplankton Density (ind./l) and Diversity (H') at the Study Area

Taxa	Station						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Phylum: Rotifera							
Brachionus	-	-	-	-	0.10	-	0.05
Dipleuchlanis	-	-	-	-	0.05	0.05	-
Euchlanis	-	-	-	-	-	-	0.05
Lecane	-	-	-	-	-	-	0.05
Monostyla	-	-	-	-	0.10	-	-
Platyas	-	-	-	-	-	-	0.05
Philodina	-	-	-	-	-	-	0.60
Subtotal (ind./l)	**0.00**	**0.00**	**0.00**	**0.00**	**0.25**	**0.05**	**0.80**
Phylum: Arthropoda (Crustacea)							
Copepoda							
Nauplii	-	-	-	-	-	-	0.20
Copepodids	-	-	-	-	-	-	0.35
Mesocylops	-	-	-	-	-	-	0.50
Cladocera							
Alona	-	-	-	-	-	-	0.1
Subtotal (ind./l)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.15**
Phylum: Protozoa							
Arcella	-	-	-	-	0.35	0.25	0.40
Difflugia	-	-	0.05	0.15	0.20	0.25	0.55
Subtotal (ind./l)	**0.00**	**0.00**	**0.05**	**0.15**	**0.55**	**0.50**	**0.95**
Density (ind./l)	**0.00**	**0.00**	**0.05**	**0.15**	**0.80**	**0.55**	**2.90**
Diversity Index (H')	**0.00**	**0.00**	**0.00**	**0.00**	**1.40**	**0.93**	**2.05**

Figure 4.11.4: Zooplankton Composition at the Study Area

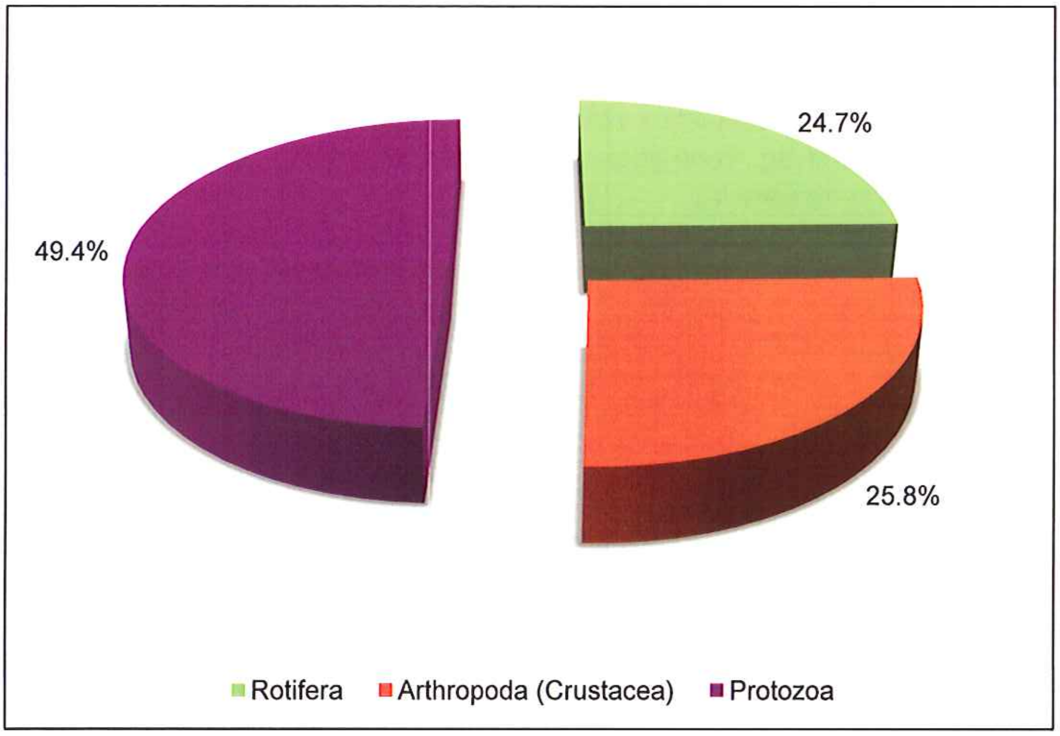
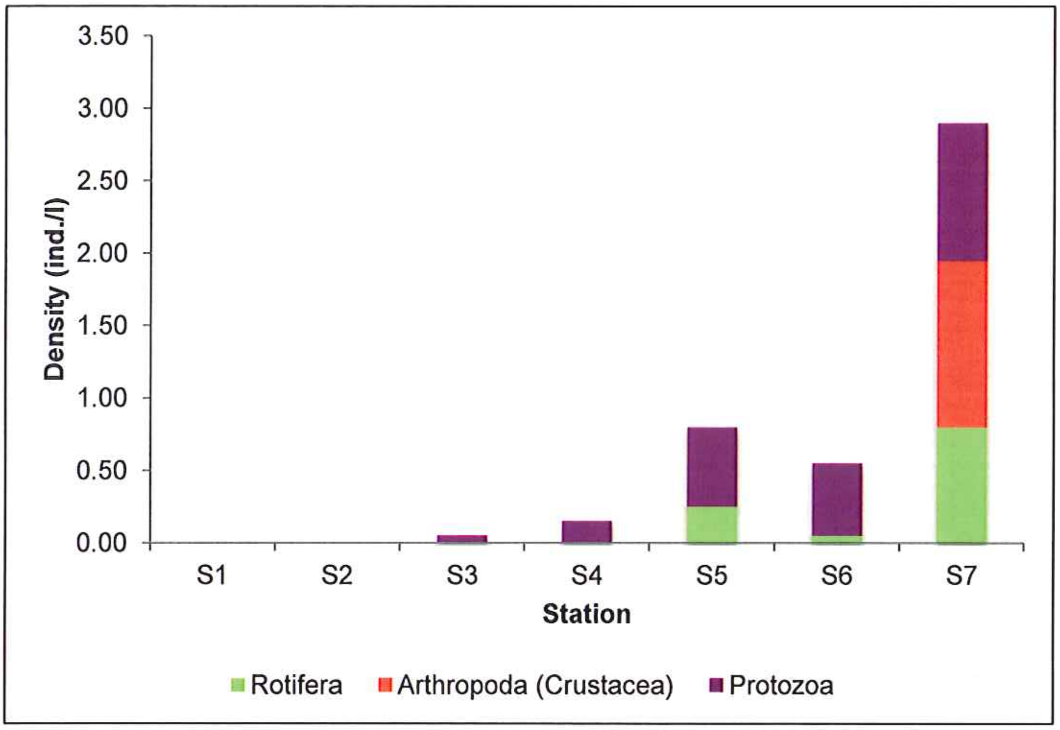


Figure 4.11.5: Zooplankton Density (ind./l) at the Study Area

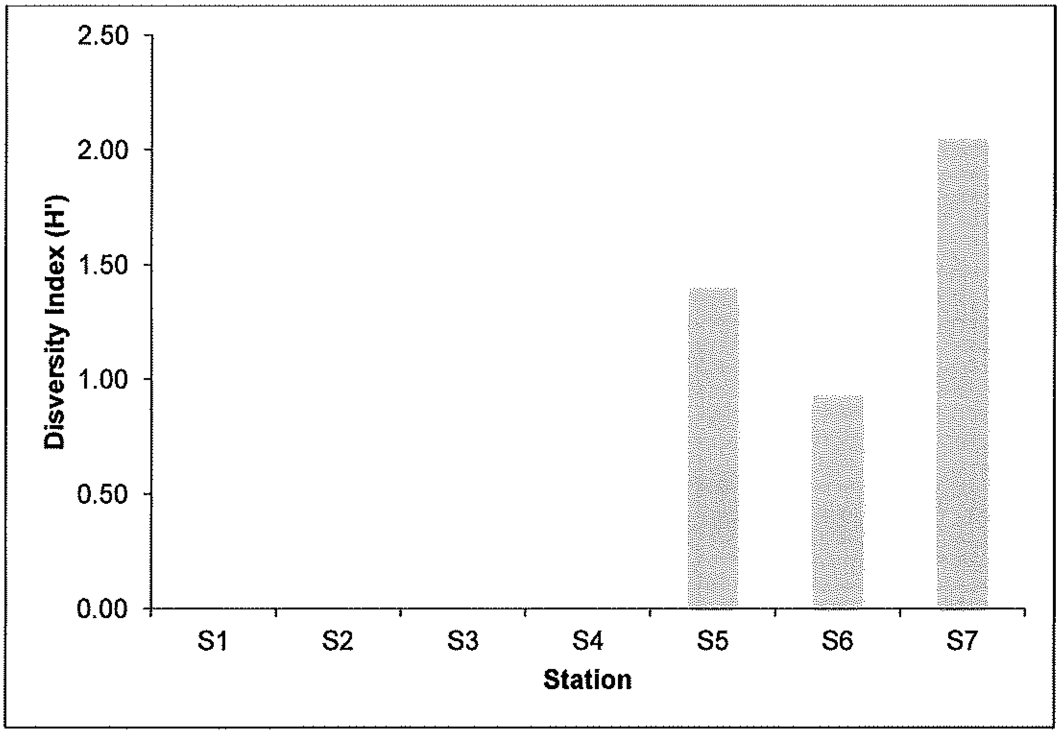


Overall, zooplankton densities at the study area ranged from 0.00 – 2.90 ind./l with an average density of 0.64 ind./l. The average density was lower as compared to other riverine studies such as 1.07 ind/l in Sg. Kuantan and 1.25 ind./l in Sg. Terengganu (MERC, 2010a; MERC, 2010b). However, most of the species found during the current study such as *Brachionus, Euchlanis, Lecane, Monostyla, Philodina, Mesocylops, Arcella and Difflugia* also recorded at Sg. Kuantan and Sg. Terengganu (MERC, 2010a; MERC, 2010b) and are not endemic to the river that were sampled.

As for species diversity, the Shannon wiener diversity index (H') ranged from 0.00 – 2.05, in which most of the stations having low diversity, except S7 (2.05; high diversity) and S5 (1.40; moderate diversity) (**Figure 4.11.6**). As compared to other riverine studies, the levels were found to be lower than 0.87 - 1.72 in Sg. Kuantan and 0.41 - 2.03 in Sg. Terengganu (MERC, 2010a; MERC, 2010b).

Low density and diversity of zooplankton in the study area possibly due to the fast water flow during the sampling period. The same situation also reported during the MERC (2010a; 2010b) studies in the upper stream of the Sg. Kuantan and Sg. Terengganu, where low zooplankton densities and diversities were recorded at most stations that have fast water flow. According to the Baranyi *et al.* (2002) the density of zooplankton, especially crustacean and rotifer is higher in rivers with slower flow compared to faster-flowing rivers since slower flows provides better conditions for most zooplankton species to reproduce.

Figure 4.11.6: Diversity Index (H') of Zooplankton at the Study Area



4.11.4 MACROBENTHOS

For the macrobenthos study, it also involved the collection of both primary (sampling) and secondary data [literature review of all existing data, reports (published and unpublished), records and other secondary sources with respect to the study area]. Sampling stations also coincided with the phytoplankton sampling stations.

At each sampling station, the following standard procedures were applied:

- Benthic organisms were sampled using a *Van Veen Grab*. Three replicates were taken at each sampling station.
- Samples were then washed and filtered through a 500 µm sieve (**Plate 4.11.3**).
- Specimens and coarse sediments that were retained in the sieve were collected in a plastic bag and preserved with 10% formalin (**Plate 4.11.4**).
- Samples were then labelled and transferred to the laboratory.

Plate 4.11.3: Sediment samples collected using a Van Veen Grab, washed and filtered through a 500µm sieve.

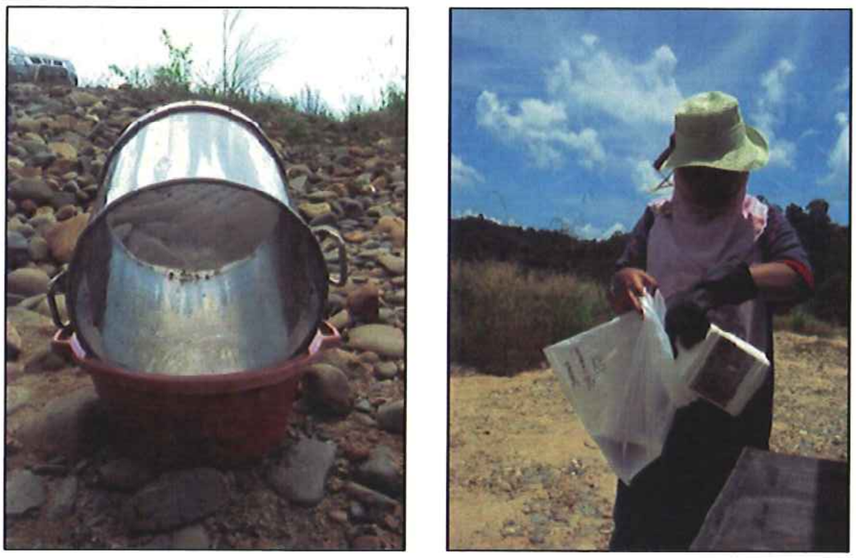


Plate 4.11.4: Macrobenthos samples transferred into a plastic bag and preserved in 10% formalin solution.

At the laboratory:

- The sieved specimens were sorted and identified at the family and genus/ species levels using a stereomicroscope and a high power compound microscope.
- Density was calculated in terms of number of individuals per square meter (ind./m^2).
- Macrobenthos diversity was assessed based on Shannon-Weiner Diversity Index (H').

Macrobenthic fauna are important components of the benthic community. These organisms play an important role in the food web and nutrient cycles of ecosystems. Most of them can move by crawling on the bottom substrate or boring into sediment, thus affecting the sediment structure. They usually form major food items for other aquatic creatures. As their movements are limited, they are useful indicators of pollution (Coull and Chandler, 1992; Kikuchi). In the freshwater environment, the distribution of macrobenthos is commonly influenced by the concentration of dissolved oxygen as well as particulate matter (Margalef, 1986).

The result from the study area (**Table 4.11.5**) identified two phyla namely Arthropoda and Annelida. The most dominant phylum was Arthropoda, which contributed 85.4% of the total macrobenthos density, followed by Annelida with 14.6% (**Figure 4.11.7**). Arthropoda and Annelida were the main phyla that contributed to the freshwater macro invertebrates' community (MERC, 2010a; AECOM, 2011). In terms of stations, the densities of the macrobenthic organisms ranged from 30 – 970 ind./m^2, with the highest and lowest density recorded at S4 and S2, respectively (**Figure 4.11.8**).

Arthropoda was the most dominant phylum recorded during the study and was represented by Class Insecta. Insecta consisted of five Orders i.e. Ephemeroptera, Diptera, Odonata, Coleoptera and Trichoptera. The most dominant Order was the Ephemeroptera (average density: 103 ind./m^2), followed by Diptera (average density: 93 ind./m^2) and Odonata (average density: 54 ind./m^2). Other orders such as Coleoptera and Trichoptera only recorded average densities of less than 10 ind./m^2. In terms of sampling stations, the highest density of Arthropods was recorded at S4 (890 ind./m^2) while the lowest was at S2 (20 ind./m^2).

As for Order Ephemeroptera, it was only recorded at S3 (40 ind./m^2), S4 (360 ind./m^2), S6 (240 ind./m^2) and S7 (80 ind./m^2). Ephemeropterans have been known as the common benthic insects in running waters (Brittain and Saltveit, 1989). They are prey for carnivorous aquatic insects such as stoneflies (Stewart and Stark, 1993). In addition, they are often found in waters that have a high concentration of dissolved oxygen and are unpolluted by organic waste (Kamsia *et al.*, 2008; Steinman *et al.*, 2003). This finding coincided with the recent water quality result, where high DO levels (5.82 – 6.18 mg/l) were recorded with no detection of ammoniacal nitrogen (<0.01 mg/l) at S3, S4, S6 and S7. As for S1, S2 and S5, Ephemeroptera was not found.

The phylum Annelida was represented by the Class Clitellata (subclass Oligochaeta) with three species i.e *Mesenchytraeus* sp. from Family Enchytraeidae; *Dero* sp. from Family Naididae and *Limnodrilus hoffmeisteri* from Family Limnodrillidae. The highest average density was recorded by *Mesenchytraeus* sp. with 21 ind./m^2, followed by *Dero* sp. and *Limnodrilus hoffmeisteri* with 11 ind./m^2 each. Past studies have reported that Oligochaete was the most common group found in freshwater environment (MERC, 2010a; MERC, 2011; AECOM, 2011). As for sampling stations, the highest and lowest densities were recorded were at S4 (80 ind./m^2) and S2 (10 ind./m^2) respectively.

Overall, the average density of the macrobenthos at the study area was 304 ind./m^2, which was higher than 93 ind./m^2, 81 ind./m^2 and 33 ind./m^2 recorded at Ulu Jelai, Sg. Kuantan and Sg. Terengganu, respectively (AECOM, 2011; MERC, 2010a; MERC, 2010b). In terms of species diversity, the Shannon Weiner Diversity Index (H') at the study area ranged from 0.64 – 1.81 (**Figure 4.11.9**), S3 to S7 had moderate diversity pattern, while S1 (0.68) and S2 (0.64) had low diversity. As a comparison, the levels were found to be lower than the studies undertaken in Ulu Jelai, Cameron Highlands (1.31 – 1.77), but higher than Sg. Kuantan (0.00 – 1.22) and Sg. Terengganu (0.00 – 1.01) (AECOM, 2011; MERC, 2010a; MERC, 2010b).

Table 4.11.5: Macrobenthos Density (ind./m^2) and Diversity (H') at the Study Area

Taxa	Station						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Phylum: Arthropoda							
Class: Insecta							
Order Ephemeroptera							
Family Ecdyonuridae	-	-	40	360	-	240	80
Order Diptera							
Family Chironomidae	30	20	50	290	50	60	40
Family Chaoboridae	-	-	-	20	20	40	10
Family Culicidae	-	-	-	10	-	10	-
Order Odonata	-	-	20	180	-	120	60
Order Coleoptera	-	-	-	30	-	-	10
Order Trichoptera							
Family Psychomyidae	-	-	10	-	-	20	-
Subtotal (ind./m^2)	**30**	**20**	**120**	**890**	**70**	**490**	**200**
Phylum: Annelida							
Class: Clitellata (Oligochaeta)							
Family Enchytraeidae							
Mesenchytraeus sp.	40	-	10	50	30	-	20
Family Naididae							
Dero sp.	-	10	-	-	20	20	30
Family Limnodrillidae							
Limnodrilus hoffmeisteri	-	-	20	30	20	-	10
Subtotal (ind./m^2)	**40**	**10**	**30**	**80**	**70**	**20**	**60**
Density (ind./m^2)	**70**	**30**	**150**	**970**	**140**	**510**	**260**
Diversity Index (H')	**0.68**	**0.64**	**1.62**	**1.54**	**1.53**	**1.48**	**1.81**

Figure 4.11.7: Macrobenthos Composition at the Study Area

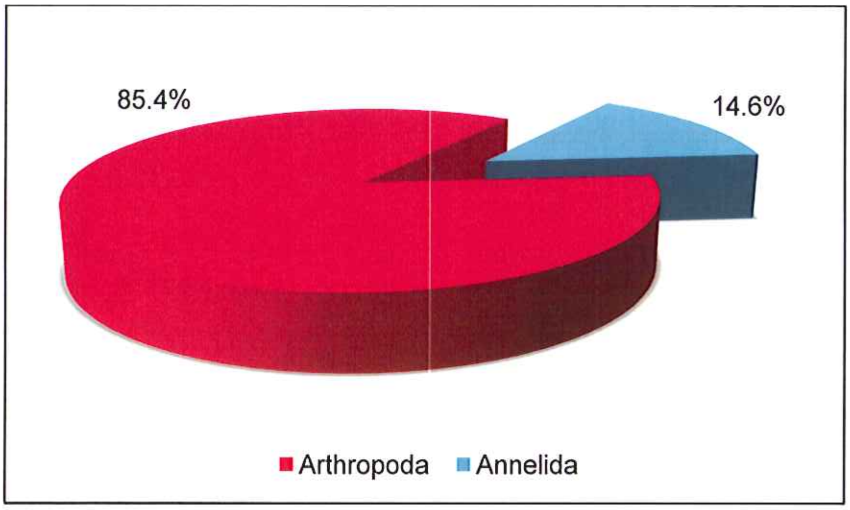


Figure 4.11.8: Macrobenthos Density (ind./m^2) at the Study Area

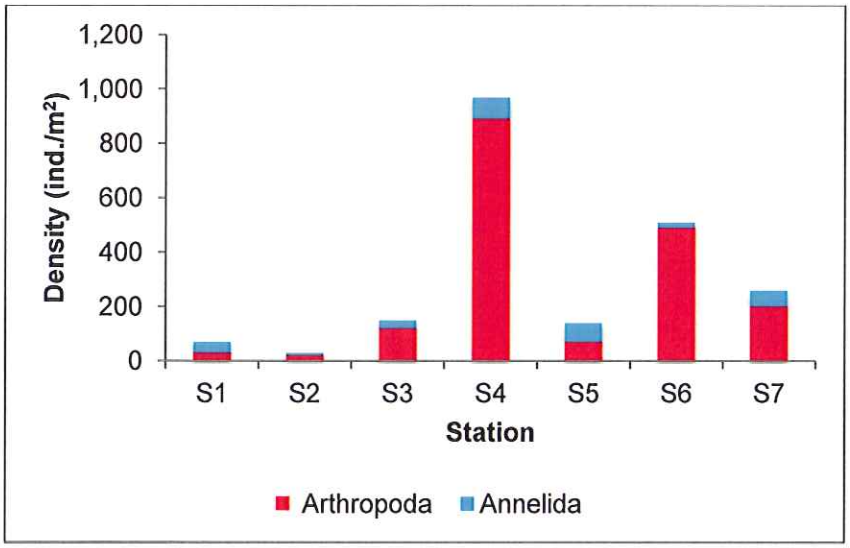
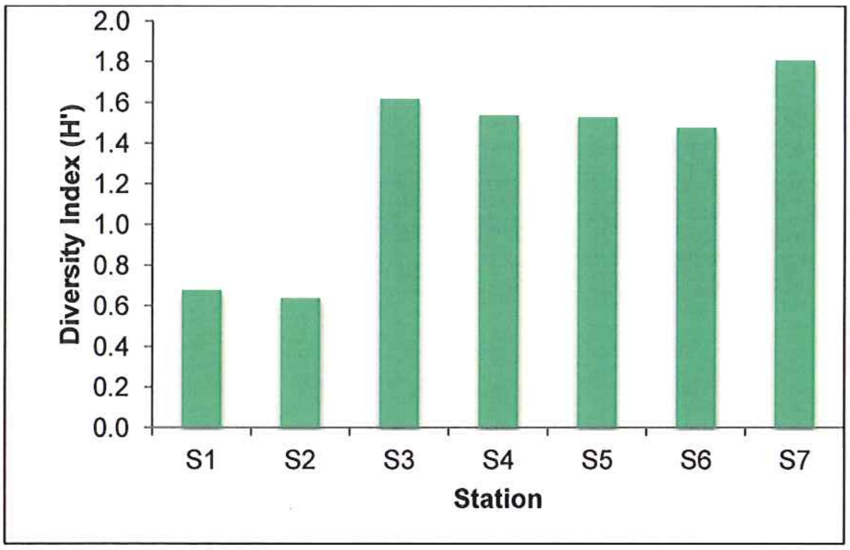


Figure 4.11.9: Diversity Index (H') of Macrobenthos at the Study Area



4.11.5 Fish Fauna

For the fish fauna assessment, it also involved the collection of both primary (sampling) and secondary data [literature review of all existing data, reports (published and unpublished), records and other secondary sources with respect to the study area). Sampling stations also coincided with the phytoplankton sampling stations. Field assessment of fish and fisheries in the river systems was undertaken using a cast net.

At each sampling station, the following standard procedures were applied:

- The cast net was shot ten times at each sampling point (**Plate 4.11.5**).
- Fish caught were collected, separated and identified up to genus or species level. Identification was based on keys in Azmi *et al.* (2010), Inger and Chin (2002) and Mohsin and Ambak (1983).
- Samples were identified and measured for length (cm) and weight (g). The total length (TL) of the fish was measured from the snout until the outer tip of the tail. A portable weighing scale and measuring tape were used for weight (g) and length measurements (cm) (**Plate 4.11.6**).
- Photographs of the representative fish specimens were taken at each sampling station.
- Representative fish specimens were also preserved in formalin solution for further documentation and identification purposes.

Plate 4.11.5: Cast net shot at the sampling station.

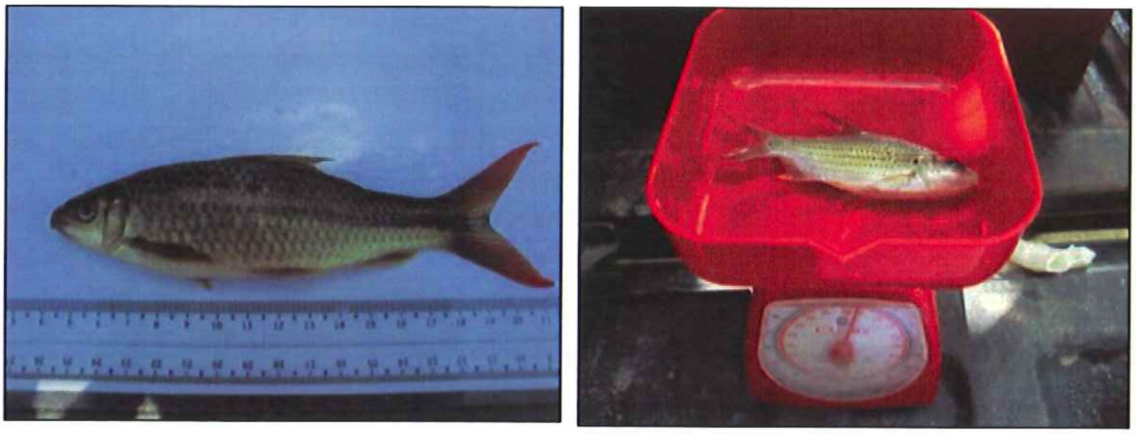


Plate 4.11.6: Fish caught were measured and weighed.

Malaysia is rich in diverse species of freshwater fish, thus, implying an importance of freshwater fish as a protein source for the country (Rahman and Hamidah, 2012). In 1996, Zakaria-Ismail (1996) reported that there were more than 300 species of freshwater fish in Peninsular Malaysia, while Lim and Tan (2002) cited 278 native species and 24 introduced species in Peninsular Malaysia. Recently, Zulkafli *et al.* (2010) reported approximately 616 species of freshwater fish in Malaysia. However, the actual number of freshwater fish in Peninsular Malaysia was undetermined since the studies of whole river systems and specific stretches of river are still lacking (Amir Shah Ruddin *et al.*, 2009; Salam and Gopinath, 2006).

In the present study, a total of 35 fish were caught. It was represented by 13 species belonging to three families, i.e Cyprinidae, Nandidae and Belonidae. Cyprinidae recorded the highest number of species, comprising of 11 species, while Nandidae and Belonidae were only represented by one species each (**Table 4.11.6** and **Plate 4.11.7**).

Cyprinidae was found to be the most abundant group during the recent study since they recorded the highest number of species i.e. 11 species and a total of 33 individuals. The cyprinid species caught are also common in the Malaysian freshwater environment (Lee, 2003; Zakaria *et al.*, 1999; Ng *et al.*, 1992; Mohsin and Ambak, 1983). Cyprinids have been known to form the major group of freshwater fish within Asian and Southeast Asian regions (Rainboth, 1996; Lowe-McConnell, 1987; Lowe-McConnell, 1975). In Malaysia, Salam and Gopinath (2006) stated that around 30% of freshwater fish were Cyprinids. This largest family of fish has highly adapted body forms and mouth structures, enabling them to occupy diverse habitats (Beamish *et al.*, 2006; Ward-Campbell *et al.*, 2005). Cyprinids also could be classified according to their diet such as herbivores, algivores, detritivores, terrestrial insectivores and benthic insectivores (Beamish *et al.*, 2006; Steffens and Wirth, 1997).

As far as the Project site is concerned, cyprinids were caught at all sampling stations, with the highest number of species caught at S3 (four species), followed by S2 (three species), while other stations were only represented by one to two species. The difference in the number of fish species commonly attributed by several factors such as water depth, water velocity, temperature and dissolved oxygen. However, with respect to the study area, the intensity and extent of these factors on fish community was unclear since these factors could fluctuate due to rainfall events. Moreover, fish distribution and composition also might be influenced by food availability and breeding sites (Samat *et al.*, 2005; Beamish *et al.*, 2003; Ali *et al.*, 1988).

The most abundant cyprinid caught was *Ikan Sia* (*Mystacoleucus marginatus*). It was caught at most of the sampling stations (16 individuals), except S2 and S4. Most of the fish caught were juveniles with a total length that ranged from 4.5 – 8.6 cm and weight that ranged from 5 – 10 g. However, there were also four individuals that were adults, with a total length of 10.1 – 13.2 cm and weights that ranged from 10 - 50 g. According to Rainboth (1996), adult *Mystacoleucus marginatus* were commonly more than 10 cm in length. Several studies reported that this species were occasionally found in well-oxygenated running water with substrates of sand or gravel and often present in rock and boulder-filled headwater streams (Kottelat and Widjanarti, 2005; Kottelat, 1998; Rainboth, 1996). All this characteristics are found at the study area which has good oxygen levels (5.82 – 6.28 mg/l) with substrates of sand and gravel. The main diet include insects, crustaceans, worms, algae and aquatic plants (Rainboth, 1996).

As for the other species, there were there individuals of *Seluang* (*Rasbora myersi;* S7), two individuals each of *Bagoh* (*Puntius lateristriga;* S2), *Seluang* (*Rasbora sumatrana;* S2), *Lampam* (*Puntius* sp.; S3), *Sikang* (*Raiamas guttatus;* S6) and *Susur Batang* (*Osteochilus waandersii;* S2 and S4) and one individual each of *Chemperas* (*Cyclocheilichthys apogon;* S3), Kawan (*Labiobarbus sumatranus;* S3, *Labiobarbus* sp.: S5) and *Sebarau* (*Hampala macrolepidota;* S5) caught at the study area. All species caught were juveniles.

As for Family Nandidae, it was represented by Ikan Patong (*Pristolepis fasciatus*). This species commonly inhibits slow or standing waters, among bushes of shore vegetation (Taki, 1978). The main diets include filamentous algae, submerged land plants, fruits and seeds, aquatic insects and crustaceans (Rainboth, 1996). Only one individual of juvenile *Pristolepis fasciatus* was caught at S3, with had a total length and weight of 6.1 cm and 25 g respectively. The adult size is approximately >15 cm (Menon, 1999).

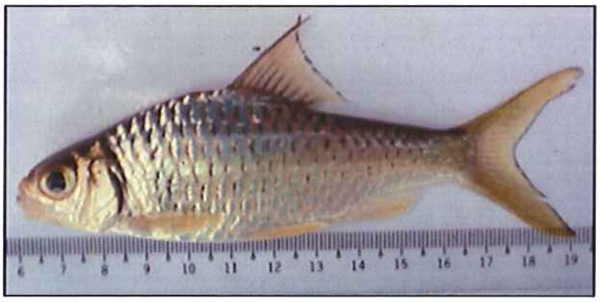
As for Family Belonidae, it was represented by *Ikan Julong* (*Xenontodon cancila*), which was caught at S7. This type of fish often found in clear slow-flowing pools in rivers with a rock or sand substrate (Dey, 2010; Pethiyagoda, 1991). They mainly feed on crustaceans (Pethiyagoda, 1991), other fishes and insects (Rainboth, 1996). The species caught at S7 was a juvenile with a total length of 18.1 cm and weight of 10 g.

In comparison, the number of species caught during the study was lower than the studies conducted in Sg. Kuantan and Sg. Terengganu; 22 and 18 fish individuals respectively (MERC 2010a; MERC, 2010b). Both studies also reported the domination of family Cyprinidae.

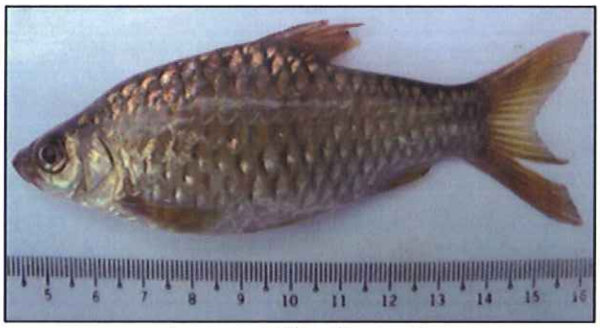
Most fish are known to be threatened by man-made stress which consequently degrade their habitat and affect natural diversity (Wright and Flecker, 2004; Smith, 1999; Froese and Torres, 1999; Zakaria-Ismail, 1994). Several studies have found that overfishing and human development such as construction of hydropower plants, housing development, mining and agriculture activities deteriorate water quality at the adjacent area, leading to depletion of the number of fish species (Zakaria *et al.*, 1999; Reddy, 1999; Hussain and Mazid 1997).

Table 4.11.6: Fish Species Caught at the Study Area

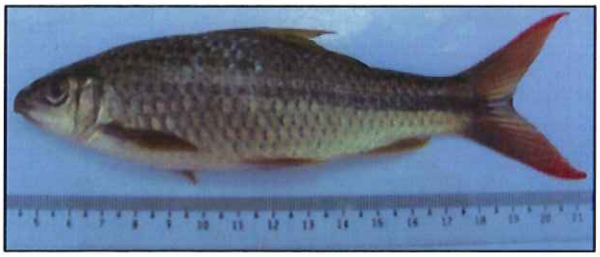
Station	Family	Scientific Name	No.	Total Length (cm)	Weight (g)
S1	Cyprinidae	*Mystacoleucus marginatus*	4	6.8	10
				7.6	10
				11.7	40
				13.2	50
S2	Cyprinidae	*Puntius lateristriga*	2	4.5	5
				4.6	5
		Rasbora sumatrana	2	5.3	3
				5.5	3
		Osteochilus waandersii	1	17.7	50
S3	Cyprinidae	*Mystacoleucus marginatus*	5	8.3	10
				8.3	10
				8.5	10
				8.5	10
				8.7	10
		Puntius sp.	2	12.1	50
				13.8	50
		Cyclocheilichthys apogon	1	10.9	40
		Labiobarbus sumatranus	1	14.2	50
	Nandidae	*Pristolepis fasciatus*	1	6.1	25
S4	Cyprinidae	*Osteochilus waandersii*	1	19.3	70
		Hampala macrolepidota	1	7.5	10
S5	Cyprinidae	*Mystacoleucus marginatus*	2	4.5	5
				4.6	5
		Labiobarbus sp.	1	13.7	25
S6	Cyprinidae	*Mystacoleucus marginatus*	3	6.8	5
				9.0	5
				10.4	15
		Raiamas guttatus	2	7.1	5
				18.1	40
S7	Cyprinidae	*Rasbora myersi*	3	7.6	5
				8.6	5
				9.5	7
		Mystacoleucus marginatus	2	8.6	7
				10.1	10
	Belonidae	*Xenontodon cancila*	1	18.1	10
		Total	**35**	**-**	**670**



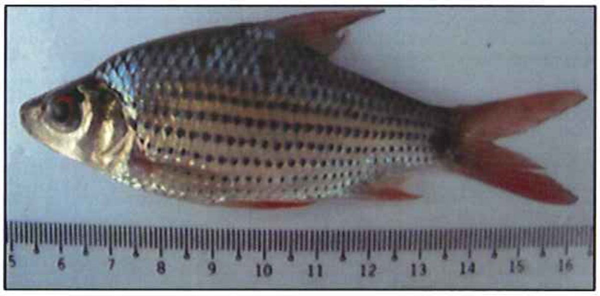
Sia (*Mystacoleucus marginatus*)



Lampam (*Puntius* sp.)



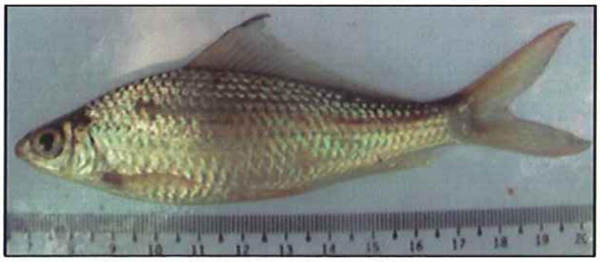
Susur Batang (*Osteochilus waandersii*)



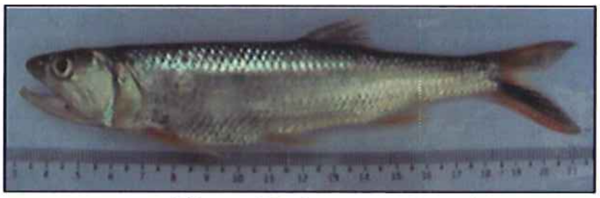
Chemperas (*Cyclocheilichthys apogon*)

Kawan (*Labiobarbus sumatranus*)

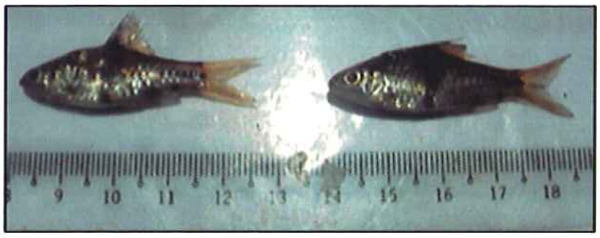
Sebarau (*Hampala macrolepidota*)



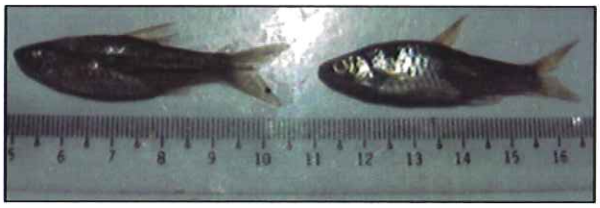
Kawan (*Labiobarbus* sp.)



Sikang (*Raiamas guttatus*)

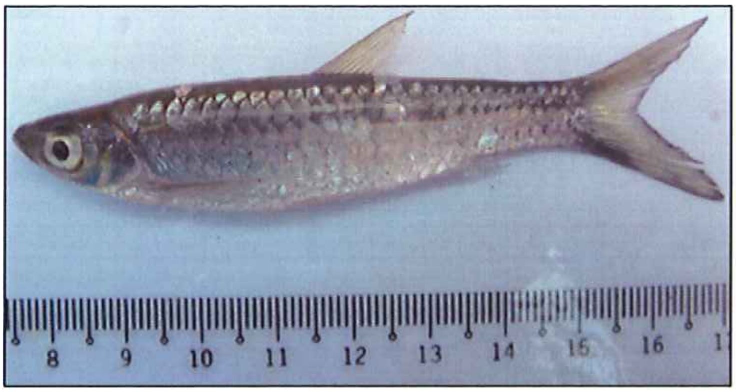


Bagoh (*Puntius lateristriga*)



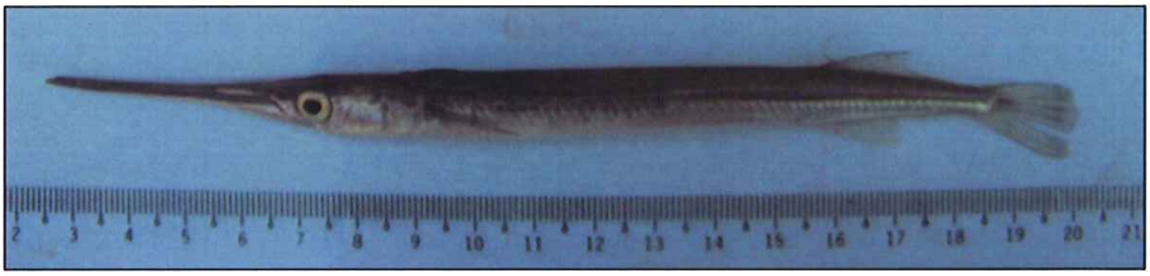
Seluang (*Rasbora sumatrana*)

Plate 4.11.7: Fish Species Caught at the Study Area.



Seluang (*Rasbora myersi*)

Patong (*Pristolepis fasciatus*)



Julong (*Xenentodon cancila*)

Plate 4.11.7: Fish Species Caught at the Study Area (Cont.)

4.11.6 RECREATIONAL FISHERIES

Recreational fishing, also known as angling is often called sport fishing to distinguish it from commercial fishing. This type of fishing usually requires the use of rod, line and hook. There is little data on angling activities in Malaysia. However, anecdotal information coupled with case studies indicate that this activity is widespread. One assessment indicated that there might be as many as 2 million active anglers in the country. However, this may be an underestimate. Estimates by the Malaysian Angling Association (*Persatuan Memancing Malaysia* or PeMM) in 1998 indicated that there were at least one million active anglers in the Klang Valley alone. This amounts to 25% of the region's population.

Malaysia has had a long-standing tradition of fishing, either commercially or for recreation. In the past, fishing as a hobby was undertaken at nearby ponds, rivers, disused mining pools, swamps and rice fields in inland areas or from tidal lagoons or estuaries along the shoreline. Thus, angling has strong traditional linkages and is part of the cultural landscape of most Malaysians. The rapid urbanisation and development of the country meant that more people now live in built-up areas with little time or access to nature-based recreational facilities on a day-to-day basis. This has created a demand for outdoor-leisure-based activities, of which angling is among the most popular.

Another major factor that supports the continual growth of the angling competitions and the recreational fisheries industry is its egalitarian appeal and easy entry requirements. Entry is generally open-ended and the activity can be undertaken in any water body that lends itself to the purpose. The equipment requirements are also flexible; ranging from a basic rod and line with minimal cost very little to sophisticated deep sea trolling ensembles that can cost RM20, 000 or more.

During the study, recreational fishing activities were observed at the study area, particularly at S1 (Sg. Kenau) and slightly further up of S7 (Sg. Kuantan – Kg. Sg. Mas). Interviews were carried out in the span of two days - 25 and 26 March 2013). Data were collected through assessments as well as interviews with the anglers. The assessment in this document was based on the following assumptions:

- The anglers fish during night-time as well as during the day. Their numbers increase during weekends as well as public and school holidays. For the purpose of this assessment, neither school nor public holidays are taken into account.
- The fishing effort is based on a person - day; with each person controlling one to two rods.
- A person - day is 8 person - hours.
- There are 106 weekend days and 260 weekdays.
- Fishing time is broken up into time segments as follows:
  - 2.00 pm - 7.00 pm (weekends; 5 hours)
  - 4.00 pm - 7.00 pm (weekdays; 3 hours)
  - 7.00 pm to 1.00 am (weekends and weekdays; 6 hours)

A. S1 - Sg. Kenau

During the study, at least 5 - 10 anglers were recorded fishing starting from afternoon to late evening, particularly at the bridge area that crossed the river from Jalan Sultan Abu Bakar to Kg. Sg. Mas (**Plate 4.11.7**). Over the weekends, 15 - 25 anglers fish day and night at that jetty area. They each spent between 3-5 hours, fishing. The rod-and-line is the preferred gear. *Polychaetes* worm (*Pumpum*), live prawn, small fish, oil palm seeds, crickets and bread were used as bait. The main catch at this area are the Kelah (*Tor* spp.), Sebarau (*Hampala macrolepidota*), Lampam Sungai (Puntius *schwanenfeldii*) as well as various species of Lampam (*Puntius* spp.). From the investigation, the total recreational fishing effort at S1 is 5,109 person days a year (**Table 4.11.7**).

B. S7 - Sg. Kuantan

Recreational fishery was also observed further up from S7- particularly at the picnic area (*Perkelahan Pasir Kubur*). It is estimated that 2 - 3 anglers spend 3 - 5 hours of fishing every day. Small live fish or prawn, oil palm seeds, crickets and earthworm were used as bait. The species generally caught are Kelah (*Tor* spp.) and Sebarau (*Hampala macrolepidota*). Other common species caught include Lampam Sungai (*Puntius schwanenfeldii*) and various species of Lampam (*Puntius* spp.). From the investigation, the total recreational fishing effort is 1,096 person days a year (**Table 4.11.7**).

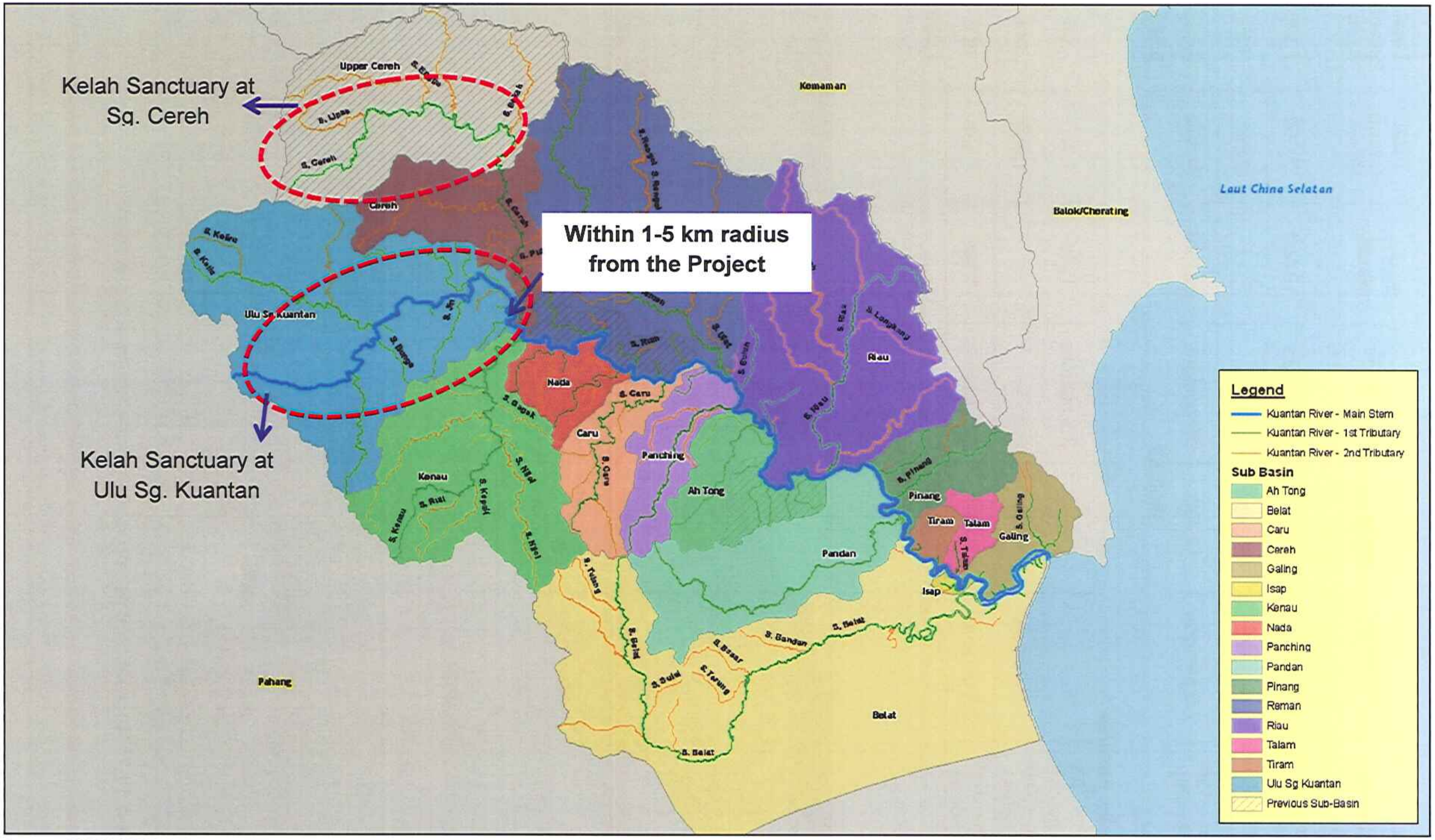
Overall, Sg. Kenau has continuously supported recreational fishing activity, where the total recreational fishing effort has increased by 183 person days a year (3.7%) from 4,923 in 2009 (MERC, 2010a) to 5,106 during the current study. As for S7, there is no previously recorded recreational fishing data in which comparisons can be made. In addition, it is important to note that, MERC (2010a) had proposed Ulu Sg. Kuantan and Sg. Cereh to be gazetted as Kelah Sanctuaries (**Figure 4.11.10**). The sanctuary at Ulu Sg. Kuantan is located within 1 – 5 km radius from the proposed Project site at Sg. Lembing area, while the sanctuary at Sg. Cereh is located more than 20 km from the Project site.

Table 4.11.7: Angling Effort at S1 (Sg. Kenau) and S7 (Sg. Kuantan)

Time Segment	Weekdays	Person hours/yr	Weekends	Person hours/yr	Total Person Hours	Total Person days
S1 - Sg. Kenau						
2pm – 7pm (5 hours)	-	-	20 persons	10,600	10,600	1,325
4pm – 7pm (3 hours)	7.5 persons	5,850	-	-	5,850	731
7pm – 1am (6 hours)	7.5 persons	11,700	20 persons	12,720	24,420	3,053
Subtotal						**5,109**
S7 - Sg. Kuantan						
2pm – 7pm (5 hours)	-	-	2.5 persons	13.25	1,325	166
4pm – 7pm (3 hours)	2.5 persons	1,950	-	-	1,950	244
7pm – 1am (6 hours)	2.5 persons	3,900	2.5 persons	1,590	5,490	686
Subtotal						**1,096**
Total						

Plate 4.11.7: Recreational fishing activity undertaken at Sg. Kenau.

Figure 4.11.10: Location of Proposed Kelah Conservation Area at Sg. Cereh and Ulu Sg. Kuantan



Source: MERC (2010a)

4.12 SOCIO-ECONOMY

4.12.1 INTRODUCTION

Socio-economic impact assessment is a process of analysing, predicting and evaluating the future social and economic effects of the Project and actions on the well-being of people, and their businesses, institutions and communities. It aims is to protect and enhance the quality of life by ensuring that potential socio-economic impacts are minimised.

The purpose of the study is to identify the socio-economic system within the Project location as well as surrounding areas; and determine and analyse the impact of the Project on the socio-economic environment. The objectives of study are:

i. To identify and analyse the socio-economic parameters of the Project site;
ii. To identify and analyse the main economic activities within the Project site;
iii. To determine the positive and negative impact of the Project on the socio-economic environment of the study area; and
iv. Identify ways of avoiding, mitigating, enhancing or managing those changes to caution the negative impact of the Project on the socio-economic environment, if any.

4.12.2 SOCIO-ECONOMIC ENVIRONMENT

A. AREA OF COVERAGE

The area of coverage includes the impacted settlements of Felda Lepar Utara 2 and 4, as well as the villages within Sungai Lembing. Both are located within the district of Kuantan although Felda Lepar is reachable via Jerantut District. Felda Lepar is located in Mukim Hulu Lepar while Sungai Lembing in Mukim Ulu Kuantan. A blank questionnaire as used in the socio-economic survey is attached in **Appendix 4-7**.

B. POPULATION

a. Kuantan District and Mukims Ulu Kuantan and Hulu Lepar

The following **Table 4.12.1** shows the district's and respective mukims' population for 2000 and 2010. While the district shows population increase by 2.5%, both Mukim Ulu Kuantan and Hulu Lepar experienced a decline in population by 1.7% and 0.1% respectively.

Table 4.12.1: Population in Kuantan District and Mukims

District\ Mukim	2000	2010	Percentage of Change (%)
Kuantan District	344,319	443,796	2.5
Mukim Uu Kuantan	8,434	7,102	-1.7
Mukim Hulu Lepar	17,028	16,897	-0.1

Negative growth for both mukims is the result of stagnate economic activity in the area. Mukim Ulu Kuantan is mainly a traditional agriculture area. Previously, economic activities took place in Sungai Lembing, once an important mining area. Since 2000, the mukim's young working population moved out to seek employment elsewhere; within the district or other districts or states. In Felda Lepar, the scenario is similar. Employment opportunity is limited. The key employment is agriculture and the works offered by relevant agencies around it – Felda settlers and the oil palm mill. More often than not, the new working population entering the employment market has left to work elsewhere since the palm oil mill and the plantations have a limited number of opening. The palm oil mill does engage some locals to work in the mill but most are not local. Similarly, most of the agencies import work forces from other areas.

b. Felda Lepar Utara

Table 4.12.1 shows the total population of Mukim Hulu Lepar in 2010 is 16,897. This mukim comprises of two key settlements i.e. FLU2 and FLU4 as one settlement and FLU1 and FLU3 as another. These settlements are located about 4 km apart. FLU2 and FLU4 are nearer to the proposed road, about 2 km away. Thus this study focuses on this settlement.

Felda Lepar Utara 2 and 4 house a total of 360 settlers with a total population of 1,620. Besides the settlers, the population of this settlement also include employees of the palm oil mill and staff of the respective government agencies within the settlements, including Felda, clinics, school and police. This accounts for another 1,400. Thus, the total population within this settlement is estimated at 3,020. This settlement is basically a Malay area.

c. Sungai Lembing

Sungai Lembing was a mining town some 42 km northwest of Kuantan. Until the 1970s, Sungai Lembing was a major producer of underground tin. Once the richest town in Pahang, the town of Sungai Lembing today is in decline. Sungai Lembing basically makes up the population of Ulu Kuantan. There are several Malay villages, an *Orang Asli* settlement and a Chinese new village. The heart of Sungai Lembing is the town which is located about 3 km from the starting point of the new road.

Base on the information from the *Penghulu*, the total population in 2012 is estimated at less than 7,000. Compared to the 2010 population data, it indicates further population decline. This mukim has about 60.5% Malays. Chinese accounts for 17.7% and Indians only 2.2%. The *Orang Asli* settlements population is larger than Indian with 6.3%. This mukim also has a high percentage of foreign workers but is located quite a distance from the proposed road; mainly working for the oil palm plantation nearby.

C. HOUSEHOLD INCOME

a. Felda Lepar Utara

The estimate on household income is based on the socio-economic survey conducted in April 2013. For Felda Lepar, the average household income is less than RM 2,000. Since the palm oil trees are still young (after replanting), the settlers take home RM 1,300 a month as living allowance. Some of the settlers do other works to supplement their income including working at the palm oil mill and as general labourers. Similarly, the workers/ labourers working at the palm oil mill earn less than RM 2,000 a month. Most of the households have only one income earner. Only 18.3% households earn more than RM 3,000 and 3% earn more than RM 3,000[2].

b. Sungai Lembing

The estimated average household income of Sungai Lembing is also less than RM 2,000. The finding indicates that more than 51% earn less than RM 1,000 per month. This estimate is not conclusive since our field visits do not indicate such a scenario. Even the *Penghulu* estimates the average household income as between RM 1,500 to RM 2,200.

D. KEY ECONOMIC ACTIVITIES

a. Felda Lepar Utara

The main economic activity is agriculture. The key crop is oil palm. The other activity is manufacturing; i.e. palm oil mill. Small scale sundry businesses only cater for local needs.

b. Sungai Lembing

Agriculture and small scale businesses are the two main economic activities. Others include fisheries, small scale manufacturing and tourism (**Plate 4.12.1**).

Plate 4.12.1: Hotel in Sungai Lembing.

[2] The findings of the survey indicate some 15% earning less than RM 1,000. Our check with Felda office indicates that all settlers get RM 1,300 per month as living allowance since their palms are replanted and have not generate income to the settlers. Those with household income of less than RM 1,000 are among the other agencies workers and palm oil mill labourers.

E. EMPLOYMENT STRUCTURES

a. Felda Lepar Utara

Agriculture and manufacturing are the key employment sectors[3]. The settlers which comprise 50% of the work force are in agriculture. Another 42% are in manufacturing (palm oil mill), mainly as labourers. Various government agencies (including Felda officers, teachers, police personnel, clinic and trainers [Giat MARA]) accounts for 7% employment.

b. Sungai Lembing

The employment structure for the Kuantan district is fairly diversified. Most (i.e. 70%) are engaged in the services sector (trade, commercial, business services and tourism). Employment within the agriculture sector (refers mainly to agriculture services and fishing) is also significant, accounting for 22% of the working population.

[3] Of the population, 360 are settlers (agriculture) and 260 (palm oil mill). There are another 10 in businesses and 40 from various Government agencies.