2.4 Reconnaissance Survey of Six (6) Routes

2.4.1 Item of Study

Field reconnaissance of six Federal Roads was carried out for about 2 weeks. The results of the field reconnaissance are shown on the Schematic Geological Profiles in Appendix 2.4.and the example of Site Reconnaissance Sheet is shown in Figure 2.4.12.

The Schematic Geological Profile are sections along the roads and contain the information on ground elevation, geographical feature, vegetation, geology, weathering grade and trace of slope disasters.

(1) Ground Elevation

Ground elevations are collected from the topographic map of 1:50,000 scale issued by the Department of Survey and Mapping Malaysia (JUPEM).

(2) Geographical Feature

Geographical feature shows the topographical condition along the roads. Aerophotos are used for studying the roads. Satellite photos, SPOT4 (3.2.1Bands, 1:100,000 scale), are also used for study of the roads, especially to find lineaments which are defined as straight or gently curved, lengthy features of the earth's surface, some which may reflect structural features such as faults, zones of intense jointing.

(3) Vegetation

Vegetation data along the roads are collected by site survey and from the topographic map of 1:50,000 scale. Along the six federal roads, vegetation is classified into three vegetation classes and five cultivation classes as shown below.

Vegetation
- *Primary Forest*
- *Secondary Jungle*
- *Grass*

Cultivation
- *Rubber*
- *Oil Palm*
- *Coconut*
- *Sundry Tree Cultivation (STC)*
- *Sundry Non-tree Cultivation (SNTC)*
- *Wet Paddy*

Figure 2.4.1 Primary Forest along E-W Highway

(4) Geological Information

Geological information contains three items which are Formation, Rock Type and Structure. Formation is geological formation which is mostly the name of geological name such as Silurian, Ordovician. The formation is based on the geological map which is issued by the Geological Survey Department.

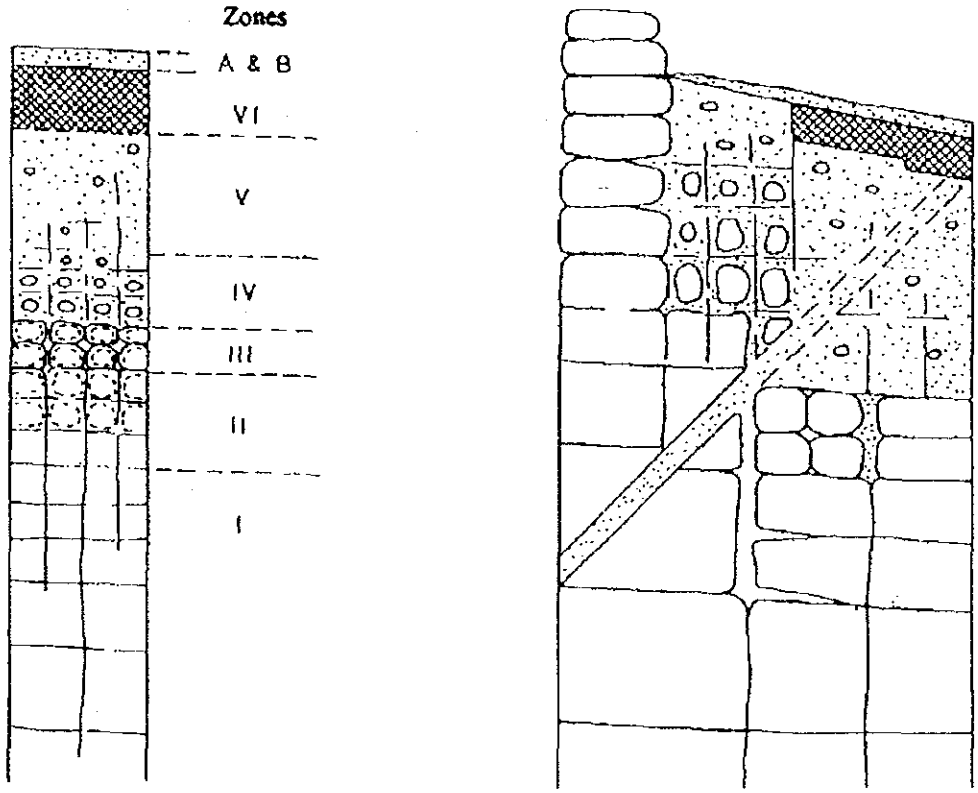
(5) Weathering Grade

Weathering Grade is shown as penetration depth of weathering based on the BS 5930 as shown on the following page. As weathering condition changes kaleidoscopically place to place, the Weathering Grade on the Schematic Geological Profile takes dominant weathering condition at the areas.

Table 2.4.1 Scale of Weathering of Rock Mass

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.	I
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering.	II
Moderately weathered	Less than half of the rock material is decomposed or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.	III
Highly weathered	More than half of the rock material is decomposed or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	IV
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Source: BS 5930 : 1981



Zone A and B are pedological zones
(a) Example of a Complex Profile (b) Idealized Weathering Profile

Figure 2.4.2 Diagrammatic Representation of a Simplified Weathered in Massive Rock

(6) Trace of Disasters

Nine types of slope disasters can be found on six (6) study roads. Trace of Disasters is shown as symbols as below.

(Refer to Appendix2.4.1 ~ 2.4.5 ; Nine types of slope disasters are tentative field classification. These failure types are classified into six groups in Chapter 3)

1. Surface Failure	▲
2. Surface Failure – below shoulder	△
3. Landslide	■
4. Embankment Failure	□
5. Wedge Slip	▼
6. Rock Fall	X
7. Debris Flow	↓
8. Settlement of Road	○
9. Gully	//

A typical figure of each failure is shown below.

Figure 2.4.3 Surface Failure (Cameron Rd. 30 km)

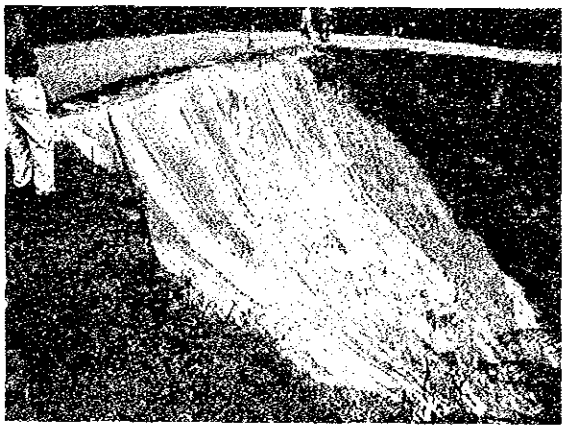


Figure 2.4.4 Surface Failure below Road Shoulder (Cameron Rd. 23.8 km)

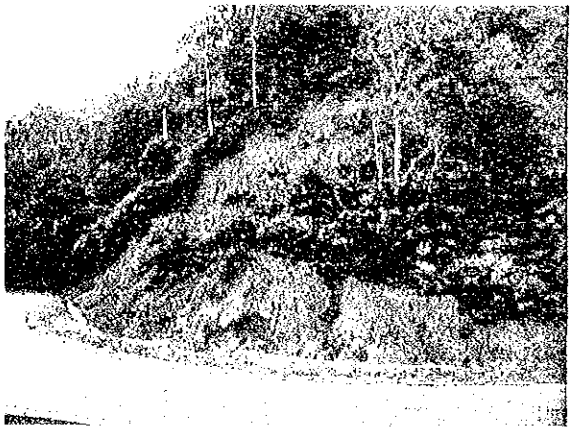


Figure 2.4.5 Landslide (Cameron Rd. 33 km)

Figure 2.4.6 Embankment Failure (Sabah Rd. 94.5 km)

Figure 2.4.7 Wedge Slip (E-W Highway, 15.1 km)

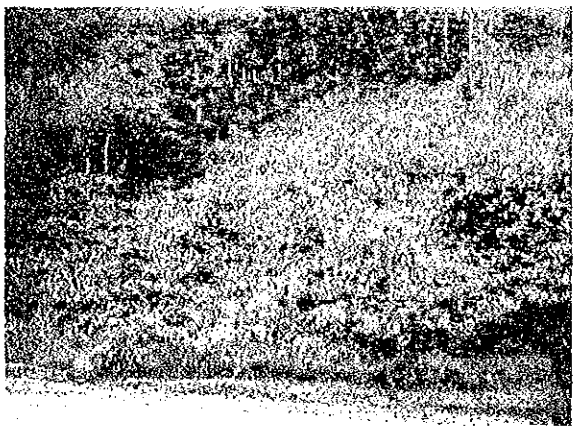


Figure 2.4.8 Rock Fall (Sabah Rd. 78.6 km)

Figure 2.4.9 Debris Flow (Sabah Rd. 99.5 km)

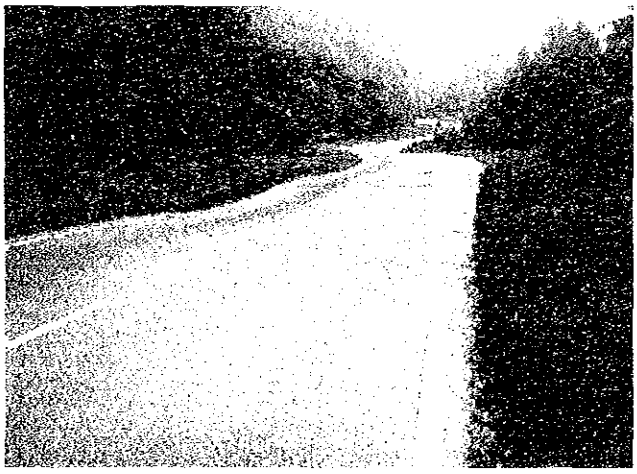


Figure 2.4.10 Settlement of Road (Sabah Rd. 74.5 km)

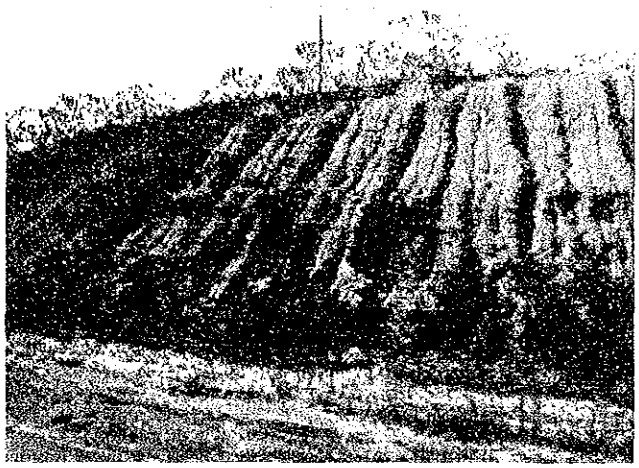


Figure 2.4.11 Gully (Sabah Rd. out of project area)

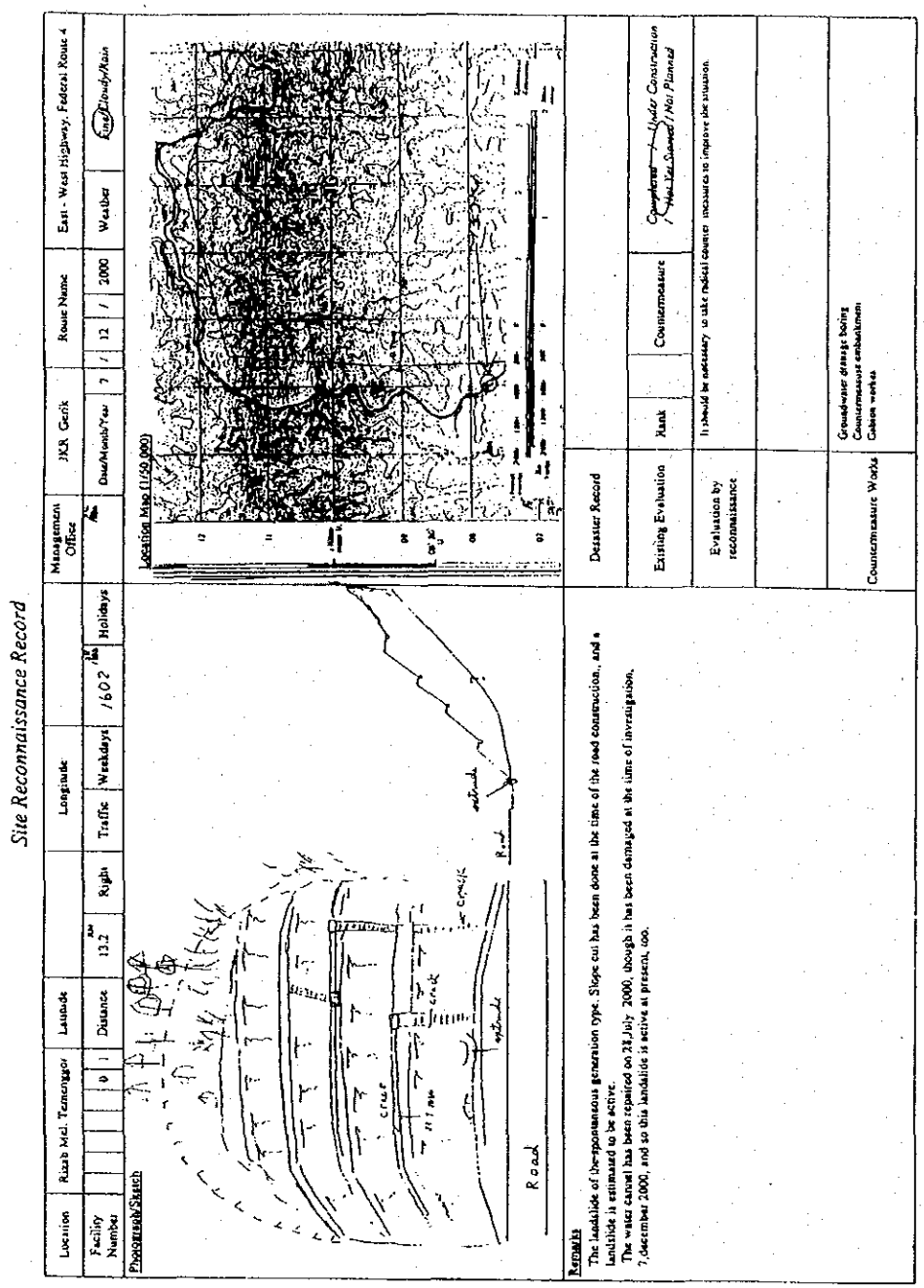


Figure 2.4.12 Example of Site Reconnaissance Record

2.4.2 East-West Highway <Route 4>

The road is 124 km in length from Gerik to Jeli. There is no major town along the road.

(1) Geographical Feature

The highest point of the road with an altitude of 1,050 m is at 65 km from Gerik. The road is mostly on a mountainside except near Gerik, - hill area, and Jeli, - valley area. The road runs along a mountain ridge from 65 km to 80 km and crosses Temengor Lake at around 35 km.

Lineaments running northwest and southeast are distinguished on satellite photos. These lineaments could reflect the geological major structures such as formations and fault zones.

(2) Vegetation

About 80% of the whole length of the road runs through Primary Forest. Near Gerik and Jeli, it is in Rubber Farm or Secondary Jungle.

(3) Geological Information

The geology along the road consists of two major types of rocks which are granite and metamorphic rocks. Granite is found at 2 places from 50 km to 65 km and from 83 km to 98 km. The valley near Jeli granite may be covered by quaternary deposit.

The metamorphic rock consists of schist, phyllite and other metaclastics. According to GSM2000 (Geological Society of Malaysia, Annual Geological Conference 2000), there are four major structural lines closing the road, such as Sinstral Fault Zone at 10 km, Sheared Olistostrome at 25 km, Rock Fault Zone at 45 – 50 km and Benton Suture at 65 – 81 km. Proof of their existence could not be found, but near the zones except Benton Suture, highly weathered rocks were seen.

(4) Weathering Grade

Outlook of the weathering grade along this road is low weathering grade after 65 km and high weathering grade before 65 km because of the structural lines.

(5) Trace of Disasters

Various types of slope disasters can be seen on many big cut slopes along this road. However many of them have enough spaces between the road and few slopes could have an influence on the road.

2.4.3 Cameron Highlands Road <Route 59>

The road is 65 km in length from Tapah to Berincang. There are few Kanpong along the road.

(1) Geographical Feature

The road climbs to Cameron Highlands on Banjaran Titiwangsa and goes uphill from start to end all the way. The highest point of the road with an altitude of 1,467 m is at the end, 65 km from Tapah. Mostly the road is on a mountainside. The road runs lakeside at around 50 km from Tapah. . The end of the road is Tana Rata and Berincang where geographical features are gentle.

(2) Vegetation

About 50% of whole road runs through Primary Forest. The remains are in Rubber plantation or Sundry Tree Cultivation such as tea plantation.

(3) Geological Information

Around Cameron Highlands, Banjaran Titiwangsa Mountains consists of mainly granite. The road runs on granite area. Phyllite can be seen from 40 km to 52 km. From 52 km to 56 km, phyllite alternates with granite.

Non-cemented gravel, sand and silt are found at 64 km in Berincang. We think that these gravel, sand and silt are sedimentary layers deposited in an old lake at Cameron Highlands.

Figure 2.4.13 Gravel Layer at Berincang

(4) Weathering Grade

Basically, fresh to moderately weathered rocks crop out at the stream crossing the road and highly weathered rocks are exposed at other places. However low weathering grade dominates at 35 km to 50 km.

(5) Trace of Disasters

Almost all slope disasters found along this road are only surface failures. The slope disasters concentrate from 34 km to 45 km.

2.4.4 Gap – Fraser's Hill Road <Route 56>

The road is 6 km in length from the junction with Route 55 at Gap to Fraser's Hill. Kubu Baharu to Teranum. There is no residential house along the road except at Bukit Fraser, the end of the road.

(1) Geographical Feature

The road goes uphill from start to end all the way. The highest point of the road with an altitude of 1,200 m is at the end, 6 km from Gap Junction. The road is on a mountainside for the first 4 km and on a mountain ridge for the last 1km.

(2) Vegetation

Almost the whole road runs through Primary Forest.

(3) Geological Information

It is granite area along the road.

(4) Weathering Grade

Basically, fresh to moderately weathered rocks crop out at the stream crossing the road and highly weathered rocks crop out at other places.

(5) Trace of Disasters

Almost all slope disasters found along this road are only surface failures.

2.4.5 Kuala Kubu Baharu – Gap – Teranum <Route 55>

The road is 54 km in length from Kubu Baharu to Teranum.

(1) Geographical Feature

The road climbs to Gap Junction on the ridge of Banjaran Titiwangsa Mountains and goes downhill from Gap to the end, Teranum. The highest point of the road with an altitude of 852 m is at 32 km, Gap Junction. Mostly the road is on a mountainside. For the first 17 km, the road goes at the bottom of the gouge which is along Sungai Kelempongand (Kelempong River) Sungai Selangor (Selangor River). For the last 2 km, the road runs along Sungai Teranung (Teranung River).

Two clear lineaments on the satellite photo running north-west and south-east cross the road at around Km22.5 and Km35.0. They may reflect the geological structures such as fault zones.

(2) Vegetation

About 70% of the whole road runs through Primary Forest. The remains are in Secondary Jungle or Rubber plantation.

(3) Geological Information

Around Fraser's Hill, Banjaran Titiwangsa Mountains consists mainly of granite. The road runs through a granite area except after 47 km. Phyllite can be seen from 47 km to the end, 54 km. There are some debris deposits overlying Granite.

(4) Weathering Grade

Basically, fresh to moderately weathered rocks outcrop at the stream crossing the road and highly weathered rocks outcrop at other places. From 10 km to 22 km, weathering grade of Granite changes from complete weathering to moderate weathering alternately. On the other places, completely weathered rock is on the top surface 5 – 10 m. Below the completely weathered rock, moderately weathered rock is found.

In Phyllite area, completely weathered rock becomes deeper and highly weathered rock is found below completely weathered rock.

(5) Trace of Disasters

Almost all slope disasters found along this road are only surface failures. The slope disasters concentrate in phylite area, 47 km to 54 km.

2.4.6 Penang Road <Route 6>

The road which is a circumferential road around Penang Island runs 56 km from Kg. Masjid (Tanjung Tokong) at the north-west end of George Town to Gelugur at the south end of George Town.

In Penang Island, two directions of lineaments running north and south, northeast and southwest are distinguished on satellite photos. These lineaments could reflect the geological major structures such as fault zones. Faults on the geological map, Pulau Pinang 1:63,360-scale issued by Geological Survey Malaysia in 1994 consist with the lineaments on satellite photos. One lineament runs along the road from Km19 to Km27.

(1) Geographical Feature

The road runs along a coastal area from the start, 0 km to 14 km. The road runs in mountain areas from 17 km to 23 km and from 34 km to 43 km. From 23 km to 34 km and after 43 km to end, the road is in flat areas. The maximum height of the road is 187.5 m altitude at 22 km.

(2) Vegetation

Rubber and Sundry Tree Cultivation such as durian trees are found in the mountain area. Other areas contain sundry tree cultivation, coconut trees or rubber trees. There is no primary forest along the road.

(3) Geological Information

Penang Island consists of Granite and some covered material such as quaternary sediments or debris. According to the geological map issued by Malaysian Geological Survey, the granite is sorted into two groups by the geological age, Palaeozoic and Mesozoic. Mesozoic granite is distributed in the northern part of the island; and Palaeozoic granite is in southern part of the island.

A fault on the geological map runs along the road from Km19 to Km27.

(4) Weathering Grade

In the coastal area, moderately weathered granite outcrops. In the mountain area, weathering penetrates into the rock deeply at some places, especially Km16 to Km26.

(5) Trace of Disasters

Almost only surface failure can be seen along the road.

2.4.7 Penampang – Tambunan – Keningau Road <Route 500>

The road is 120 km in length from Keningau to Penenpang near Kota Kinabaru through Tambunan.

(1) Geographical Feature

Around Keningau and Tambunan, it is the flat area which was formed by old Sugai Pegalan (Pegalan River) as terrace. The road crosses over a hill area between Keningau plane and Tanbunan Plane. The hill area is in the foothill of the mountains which lie along west coast of Sabah.

From Tambunan to Penanpang the road is in a mountain area. The highest point of the road with an altitude of 1,753 m is at 80 km from Keningau. The road is on a mountain ridge from 75 km to 96 km.

(2) Vegetation

Wet Padis and grass spread over the terrace plane around Keningau and Tambunan. Almost the whole area of mountain is covered with primary forest along the road. After 99 km, rubber becomes rich.

(3) Geological Information

The geology along the road consists of only one type of base rock which is tertiary sedimentary rocks. The layers of sedimentary rocks are mostly an alternation of shale and sandstone layers.

Gravel layers cover the terrace plane around Keningau and Tambunan.

(4) Weathering Grade

Weathering penetrates deeply in the hill area from 25 km to 42 km. moderately weathered rock can be seen at the top of mountain at 80 km and around 97 km.

(5) Trace of Disasters

Various types of slope disasters can be seen along this road. The remarkable point of this road is that there are many road settlements and traces of debris flow. The road settlement concentrate from 68 km to 75 km.

Table 2.4.2 Slope Disasters along Six Route

Disaster Type & Symbol			R4		R59		R56		R55		R6		R500	
			no	%	no.	%	no	%	no.	%	no	%	no	%
Collapse	**Total**		**23**	**44**	**128**	**93**	**12**	**86**	**92**	**80**	**23**	**67**	**32**	**35**
	Surface Failure	▲	17	32	128	93	12	86	92	80	23	67	27	30
	Gully	∫∫	6	12	0	0	0	0	0	0	0	0	5	5
Rock Rall	Rock Fall	X	**6**	**12**	**0**	**0**	**2**	**14**	**7**	**6**	**6**	**18**	**1**	**1**
Rock Mass Failure	Wedge Slip	▼	**6**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Landslide	**Total**		**11**	**20**	**2**	**1**	**0**	**0**	**10**	**8**	**1**	**3**	**37**	**41**
	Landslide	■	11	20	2	1	0	0	10	8	1	3	17	19
	Settlement of Road	○	0	0	0	0	0	0	0	0	0	0	20	22
Debris Flow	Debris Flow	↓	**2**	**4**	**1**	**1**	**0**	**0**	**3**	**3**	**2**	**6**	**13**	**14**
Embankment Failure	**Total**		**4**	**8**	**7**	**5**	**0**	**0**	**3**	**3**	**2**	**6**	**2**	**9**
	Embankment Failure	□	2	4	0	0	0	0	0	0	0	0	1	1
	Surface Failure – bellow shoulder	Δ	2	4	7	5	0	0	3	3	2	6	7	8
	Total		**52**	**100**	**138**	**100**	**14**	**100**	**115**	**100**	**34**	**100**	**91**	**100**

R4 : East-West Highway
R59 : Cameron Highlands Road
R56 : Gap-Fraser's Hill Road
R55 : Kuala Kubu B.-Gap- Teranum Road
R6: Peneng Road
R500: Penampang-Tambnan- Keningau Road (Sabah)

2.5 Selection of Case Study Route

2.5.1 Six (6) Alternative Routes

As was shown in the Chapter 1, six roads were nominated as the alternative of the case study route and offered to the comparison of the conditions from various aspects. The alternative routes are listed in Table 2.5.1.

Table 2.5.1 List of Six Alternative Routes for the Case Study

Alternative No.	Name of Road	Route No.	Extension (m)
1	East-West Highway	Fed. Road 4	124 km
2	Cameron Highlands Road	Fed. Road 59	65 km
3	Gap-Fraser's Hill Road	Fed. Road 56	6 km
4	Kuala Kubu Baharu-Gap- Teranum Road	Fed. Road 55	54 km
5	Penang Road	Fed. Road 6	56 km
6	Penampang-Tambunan-Keningau Road	Fed. Road 500 (since Jan 2001)	120 km
Total			425 km

To select the case study route out the above six, several factors were compared and studied. Those factors are listed as follows:

1) Natural conditions: Geology, Topography and others.
2) Slope conditions: Slope failure types anticipated.
3) Road design conditions: Construction age, Geometric design standard, Slope height, and others.
4) Management operation: Number and level of staff, Budget for slope related work, Maintenance performance, and others.
5) Availability of Data: Record on disaster, Countermeasure implementation, and others.
6) Socio-economic Conditions: Traffic volume, Agriculture and Industrial activity, and Population growth.

Each item of the conditions of six alternative roads is compared and shown in Table 2.5.3. The supporting material of more details is attached in Appendix 2.5 (A.Table 2.5.1- - 2.5.4).

2.5.2 Procedures of Case Study Route Selection

(1) Objective of Case Study

The purpose of the case study is to build up a model system of road slope disaster management including slope database and information system. The selection of the case study route should be carefully made so that the model system could be most effectively applied to all the federal roads nationwide.

Please refer to Figure 1.1.1, which summarizes the flow of this study and contents of the work in each stage. Based on the findings and result of analysis in Phase I study, in the case study, development of slope information system (SIMS) and planning of slope maintenance and disaster management shall be studied taking the selected Case Study Route as model case.

(2) Requirements for Case Study Route

Among many items representing the present conditions of each road, following six items were carefully selected as the required items that the case study route should keep to meet the objective of case study.

(a) All of Typical Slope Failure Types:

Case study route should include most types of slope failure typically found in the country, as the developed system in case study is required to apply to nationwide federal roads.

(b) Existence of Landslide:

Case study route should include landslide; as it is important part in road slope disaster management planning.

(c) Existence of High Cut Slope:

Case study route should include high slope over 20m of cut and embankment, as it may require various new technique other than conventional simple ones.

(d) High standard of geometric design:

Case study route shall be the road that was designed in accordance with higher standard (R4, R5 or R6) in geometric design. The road of high geometric standard is designed and constructed with smaller radius of curvature, then generally create high slope of cut and embankment, those require special slope engineering.

(e) Good slope management operation:

Case study route should keep suitable organization, staff and operation for road slope management, and budget allocation of high level.

(f) Data Availability:

Case study route should keep good documentation in relation to slope design, construction and maintenance, including record of the past disaster and repair work. Those data are needed for the study of management system.

(g) Socio-economic Conditions:

Although data collection and review was carried out for this subject, (including traffic volume, agriculture and industrial activity, and population growth), those were not be judged as basic requirement for case study route selection.

2.5.3 Selection of Case Study Route

After careful study of selection of case study route, JICA study team reported a recommendation to the steering committee held on 8th January 2001, as below:

1) The East–West Highway (Federal Route 04) is recommended as the most suitable route for the case study.
2) Other 5 routes are not assessed as suitable for model study, due to lack of most requirements mentioned above.
3) However, if any other road is requested to select for trial testing of the new slope management system, Penampang-Tambunang-Keningau Road (Sabah) is recommended, because this route has many of high slopes including landslide to be managed urgently.

Table 2.5.2 Summary of Case Study Route Selection
<Evaluation as Case Study Route>

	1	2	3	4	5	6
Road Conditions	E-W Highway	Cameron Highland	Fraser's Hill Road	Kuala KB --Trenum	Penang Road	(*)Sabah Road
Geology Types	+	-	-	-	-	+
Variety in Slope Failure Types	+	-	-	-	-	+
Road Design; High slopes	+	-	-	-	-	+
Management Operation	+	-	-	-	+	+
Availability of Slope Data	+	-	-	-	-	-
Evaluation as Route for Case Study and for Trial Test	**Recommended for Case Study**	**not suitable**	**not suitable**	**not suitable**	**not suitable**	**Recommended for Trial Test**

(+) Assessed as good level (-) Assessed as not enough level

(*) Sabah Road: Penampang- Tambunan-Kuningaun Road

Here is brief explanation of the basis of study team's recommendation.

(a) Geology types and Landslide

East-West Highway is geologically unique route among six alternative routes, along which both types rock of massive rock (granite etc) and layer-structure rock (schist etc) widely occur. It was found that no other routes meet this condition among the six alternatives..

(b) Variety in Slope Failure Types

Almost all types of slope failure, which are typical in Malaysia, can be observed along East-West Highway. In particular landslide and rock mass failure are found in East-West Highway, and in Sabah road; those types of failure generally requires careful engineering study and implementation of higher cost countermeasure work.

(c) Higher Geometric Road Design; Existence of Many of High Slopes

East-West Highway was designed in accordance higher standard (R5) of geometric design. As a result, it includes many high slope of cut and embankment. On the other hand, other alternative routes except Sabah road do not keep high cut slope (h>20 m) due to the construction in older age and not following high grade design standard .

(d) Better Slope Management Practice

In respect with slope management operation, including organization, staff, and budget allocation, East-West Highway is superior to any of other alternative routes.

(e) Availability of Data for Slope Disaster Management

For the availability of data on slope including record of past disaster and repair work, East-West Highway is also superior to any of other alternative routes.

The result of study taking the foresaid requirements into consideration is summarized in Table 2.5.2. (More detail are attached as A.Table 2.5.1- - 2.5.4 in Appendix 2.5.)