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Sabah, Malaysia

Environmental Impact Assessment (EIA) Guidelines for logging and forest clearance activities

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Appreciation

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Preface

Under the *Conservation of Environment Enactment 1996,* development activities related to land development and the utilisation of natural resources that are causing or might cause environmental degradation, are subject to an Environmental Impact Assessment (EIA).

According to *the Conservation of Environment* (*Prescribed Activities) Order 1999*, EIA is a mandatory requirement for logging operations involving forest areas in excess of 500 hectares in size. Prior to the actual felling of trees, logging proponents or initiators are required to submit an EIA report to the Director of the Environmental Conservation Department and sign an Agreement of Environmental Conditions.

These guidelines are intended for use by project proponents, environmental consultants and approving authorities involved in initiating, assessing and approving EIAs. Through use of these guidelines, it is intended that the key environmental considerations will be identified in the planning stages of logging and forest clearing activities. Early identification of the potential environmental considerations will ensure that subsequent activities will be carried out with minimal adverse environmental impacts.

EIA is an assessment and mitigation tool. Identification of the key impacts, proposing appropriate mitigation measures and means of implementation are therefore the core of these guidelines. Compliance monitoring, supported by an Agreement of Environmental Conditions will ensure that the stipulated environmental mitigation measures are correctly and appropriately implemented.

Adherence to the requirements set out in the present guidelines is an important step towards accomplishing the Department's objective of safeguarding the environment of the State and maintaining it as a desirable and habitable place to live. Stakeholder cooperation and support is therefore essential in making EIA work favourably for the interest of people in Sabah.

The ECD would like to express their appreciation to the Danish Cooperation for Environment and Development (DANCED) for assistance in the preparation of these guidelines through the ECD's Capacity Building Project. Appreciation is also extended to all government agencies, organisations and individuals that contributed towards the formulation of these guidelines.

Eric Juin

Director
Environmental Conservation Department

1 Introduction

The EIA procedures presented in these guidelines are for use in logging and forest clearance operations and should serve as an operating manual for EIA consultants and project proponents. The guidelines should help ensure that the EIA is conducted in a timely and responsible manner that will help avoid delays caused by inadequate or excessive assessment and reporting.

The guidelines should ensure that key environmental impacts are foreseen and appropriately assessed at an early stage in project planning. Once the key impacts are identified, the focus should switch to developing appropriate mitigation measure and subsequent monitoring programmes.

It should be noted that the guidelines described in this report are neither definitive nor comprehensive but rather should be seen as the framework for an assessment investigation. As such, consultants implementing the assessment are responsible for developing the assessment to an appropriate level that will assess and mitigate the key impacts by the best means possible.

It is intended that the guidelines provide a practical means of assessing environmental impacts, recommending mitigation measures and proposing monitoring programmes for the following activities:

- Selective logging operations and related activities
- Logging operations and logging-related activities carried out prior to the conversion of forest to a different land use.

If it is planned to convert an area to an alternative land-use, for example industrial tree or oil palm plantation, conversion activities, which can be better mitigated by inclusion *at this* stage of planning, should also be included in the EIA. Possible environmental impacts, mitigation measures and monitoring programmes for the end land-use may be covered in other guidelines, and as such should be consulted in conjunction with the present guidelines.

The guidelines are developed for use as a supplement to the Handbook for Environmental Impact Assessment (EIA) in Sabah (2001), issued by the Environmental Conservation Department, Sabah. The essential steps and procedures for conducting an EIA are presented in the Handbook and should be consulted prior to the usage of this guideline.

EIA and forest planning

Forest planning generally occurs at three levels, namely (i) National or State management plans, for example, Forest Management Unit planning in Sabah, (ii) the strategic planning level and (iii) the tactical planning level, for example, Reduced Impact Logging (RIL) planning or Comprehensive Harvesting Planning in Sabah.

At the *strategic planning level* the following issues are normally dealt with:

- Topography
- Zoning, including areas allowed for logging and areas excluded based on slope, river reserve, water catchment, conservation areas and others
- Vegetation types
- Main road structure
- Approximate boundary and size of coupe
- Estimated standing/log volume
- Extraction techniques
- Special conservation issues.

Strategic planning would normally take place at a scale of 1:25.000 – 1:50.000.

At the *tactical planning level* the following issues are normally dealt with:

- Inventory
- Secondary roads, skid trails and landings
- Stock survey, marking
- Detailed topography assessment
- Re- or additional zoning of slope, river, conservation areas
- Primary and secondary roads (plan, width, cut/fill, stream crossing, water diversion, grade, access, timing)
- Directional felling.

Tactical planning would normally take place at a scale of 1:2.000.

One of the main aims of applying EIA on forestry projects is to *strengthen the strategic forest planning level* by assessing adverse environmental impacts (especially soil erosion and impacts on human settlements) and thereafter proposing and applying appropriate mitigation and monitoring measures.

Assessments and proposed mitigation and monitoring measures will primarily be oriented towards traditional strategic forest planning issues as listed above with the addition of issues relating to human settlements.

Specific issues from *the tactical forest planning level* can be included in the EIA as proposed sound logging practices for subsequent inclusion in the Agreement of Environmental Conditions. This could, for example, include specific requirements for (i) secondary roads and skid trails (width, stream crossings, grade), (ii) landings and (iii) base camps.

However, it is important to stress that *forest issues at the tactical level* remain the responsibility and within the jurisdiction of the Forest Department.

EIA policy for forest logging and clearance activities

By applying EIA to logging and forest clearance activities it is intended to achieve the following:

A. Strengthen forest planning at the strategic level. All forest activities undertaking an EIA are required to assess and plan the potential impact on the environment. This assessment will require planning such as zoning, thereby contributing towards improved planning efforts undertaken at the strategic forest planning level.

B. Solving specific site-related issues. One of the core features of an EIA is the assessment and proposed mitigation measures based on *specific site issues or site characteristics.* For example, zoning based on soil erosion risk or by securing the drinking water supply to specific affected settlements.

C. To better protect the overall physical environment in Sabah. This will mainly be achieved by preventing soil erosion at critical phases of land development, by, for example:

- Mapping and monitoring of river reserves (20 meters for rivers more than 3 meters wide)
- Mapping, zoning and monitoring high risk soil erosion areas (based on an assessment of erosion risk).

The positive impact on the quality of the environment in Sabah will largely be achieved through the *cumulative* effect of imposing and monitoring compliance of conditions and mitigation measures as stipulated in the Agreement of Environmental Conditions.

D. To reduce downstream human settlement problems associated with logging activities in Sabah. Forest activities might influence local social issues adversely. If for example water supply is assessed as a concern, the EIA can secure a continued acceptable drinking water supply to adversely affected communities by, for example, implementing the appropriate mitigation measures, such as the exclusion of specific water catchment areas, or by the implementation of secondary rehabilitation measures such as securing water supply from elsewhere.

E. Contributing towards the protection of biodiversity in Sabah. The EIA can contribute to the better protection of ecology and biodiversity through, for example, protection of river reserves and steep hill slopes and restricting logging in or nearby ecologically sensitive areas.

F. As logging and forest clearance activities in Sabah are **increasingly taking place in remote and often very steep areas,** environmental concerns increase correspondingly. There is therefore an urgent professional need to help guide relevant assessments and the implement appropriate mitigation measures.

EIA procedures – a quick reference

The seven steps	Summary of main required activities
Step 1: Project screening	Project proponent: • Check Annex 1 to see if the project is required to undertake an EIA • Consult the ECD as to whether the project should undertake an EIA
Step 2: Selection of consultants	Project proponent: • Select consultants to undertake preparation of TOR and the EIA
Step 3: Preparation of TOR	EIA consultant: • Undertake scoping activities and present the results to ECD • Prepare a draft TOR • Undertake the public hearing activities required for Special-EIA • Finalise the TOR and obtain final approval from ECD
Step 4: Undertaking the EIA study	EIA consultant: • Assess environmental impacts • Assess mitigation measures • Assess monitoring programmes
Step 5: Preparation of the EIA report	EIA consultant: • Adhere to the ECD requirements and 'standard table of content' in the preparation of the EIA report • Prepare the EIA report in line with the ECD chapter-by-chapter recommendations
Step 6: Review of the EIA report	EIA consultant: • Submit the EIA report to ECD • Undertake the public hearing activities required for Special-EIA • Participate in review meetings • Submit additional information if required and finalise the EIA report
Step 7: Agreement of Environmental Conditions	Project proponent: • Review the draft Agreement of Environmental Conditions prepared by ECD • Co-sign the Agreement of Environmental Conditions • Implement mitigation measures and monitoring programmes.

2 Sabah context

2.1 Forest cover in Sabah

Sabah has a total land-mass of 7.37 million hectares of which about 60 per cent remains under some form of forest cover. The areas designated for *logging* consist mainly of the Commercial Forest Reserve which are managed for sustainable wood production, and State-land forests, most of which will eventually be used for permanent agriculture.

Table 2.1 Distribution of forest lands in Sabah in 1997

Land Status	**Area (million ha)**
Permanent Forest Estate (Commercial Forest Reserve)	3.594 (2.744)
State Land	0.496
Alienated Land	1.888

Of the 3.6 million hectares of *Permanent Forest Estate*, 2.7 million hectares are classified as Commercial Forest Reserve and are divided into 27 Forest Management Units and are required to operate under the principle of Sustainable Forest Management. To help achieve this objective, the State Government have allocated Forest Management Units to the private sector through long term Sustainable Forest Management License Agreements. These agreements give a license holder the right to manage a Unit for a period of 100-years according to a management plan, which is approved by Forestry Department.

Most of the remaining Permanent Forest Estate is situated on moderate to steep hills in the hinterland.

Table 2.2 Distribution of forest classes within Permanent Forest Estate (1997)

Class	**Land Status**	**Area (ha)**
I	Protection	342,216
II	Commercial	2,743,959
III	Domestic	7,355
IV	Amenity	20,767
V	Mangrove	316,024
VI	Virgin Jungle	90,382
VII	Wildlife	132,653
Total		3,653,356

Forests outside the Permanent Forest Estate on *State land* (0.496 million hectares) and *alienated lands* (1.888 million hectares) may be harvested under a valid timber-cutting license. Clearing forests on these lands, without utilising the timber does not require a timber-cutting permit. State and alienated lands are more usually situated in coastal areas and along major rivers and therefore occupy comparatively flat, lower elevation land.

2.2 Logging activities

Two main classifications can be made in relation to forestry impact assessments: *Selective logging,* i.e. forestry activities intended to remain commercially productive and *forest clearance,* i.e. forestry activities and otherwise that require the clearance of the original forest cover (e.g. land intended for alienation).

Selective logging is often the first in a series of stages that ultimately leads to forest clearance and conversion. The partial clearance of forest therefore often precedes total clearance before the land is eventually converted to a different land use. The general sequence of events is that forest will be logged, re-logged, clear-felled, and finally cleared of all remaining trees, stumps, shrubs and ground cover with the debris usually being stacked in rows before the establishment of a new land use. However, this sequence of events may extend over many years.

Selective logging

Permanent Forest Estate may be defined as land permanently reserved by Government for commercial and non-commercial forest services for the continued and overall benefit of the State. If not otherwise decided, it is the intention that such forests *remain* under forest cover. The Sustainable Forest Management License Agreements of 1997 signed between the State Government and the respective Forest Management Unit holders govern the commercial forests within the estate, to be managed according to the principles of sustainable forest management.

Logging operations, unless well managed, have a major environmental impact, which in turn affects the long-term sustainability of the operation. Factors impacting the environment e.g. soil erosion, therefore impact the regenerative capacity of the forest stand e.g. loss of productive forest area, providing an intimate link between good forest management and good environmental management. If the State is to maintain the capacity to generate revenue from commercial timber operations and maintain environmental quality in Sabah, practical and wise environmental management procedures must be implemented.

In general, the key environmental issues are well known, as are the mitigating methods. Research in Sabah has shown that Reduced Impact Logging techniques (RIL) mitigate most of the environmental impacts as well as minimizing damage to the residual forest stand.

The key factors controlling better environmental management of State forests, and indeed their future, lie at a policy level and relate to the intended long-term future of these forests. If it is intended for any of the State forests to remain in production or to provide other forest amenity functions, they should be subject to the same environmental guidelines as forests within Forest Management Units and the Permanent Forest Estate. Alternatively it would make sense to incorporate such forests into the Permanent Forest Estate. If there is no intention to retain the forest status or if the forests are degraded to such an extent that further useful production is unlikely, then such forests should be clearly assigned for conversion. Thereafter, alienation and conversion activities will be subject to the EIA controls for forest conversion and/or the subsequent development activity.

Forest clearance

As part of the land alienation process, land is converted from a primary or remnant natural forest cover to an alternative land-use. To a large extent, the intended land-use determines the severity of the environmental impact. Typically, secondary forest is cleared and the land prepared for either small or large-scale agriculture or tree plantations. Sustainable forest management recognises that industrial wood demand cannot be met by timber production from the natural forest alone. The establishment of forest plantations in commercial forest reserves to supplement the wood deficit is therefore an established and accepted forestry practice. As the global demand for paper continues to rise, the establishment of plantations to feed pulp mills is likely to play an increasingly important role in the future. Nevertheless, the establishment of such forest plantations has to be synchronized, within practical means, with the requirements of sustainable environmental management.

Within Forest Management Units, forests may be zoned in accordance to needs and suitability, and areas of degraded timber stand may be excised and allocated for conversion to plantation forest. Within Forest Management Units, plantation forests are referred to as Industrial Tree Plantations.

Plantations may also be established on lands other than Forest Management Units and therefore environmental zoning may only take place during the EIA procedure, requiring particular attention.

The additional activities involved in forest clearance compared to selective logging include clearance and removal of the remaining vegetative cover. Although illegal, the final stage of vegetation removal frequently involves burning. Again depending upon the intended use, the soil is often further prepared by scraping and terracing. It is during this process, that serious and often irreversible impacts to the environment occur, many of which may persist for years. Better environmental management and planning during the conversion process can significantly mitigate some of the adverse environmental impacts.

The environmental impacts associated with the majority of commercial forestry operations in Sabah may be generally grouped depending upon forest classification and type of alteration (Table 2.3).

Table 2.3 General forest classification and associated environmental impact of forest altering activities in Sabah

Type of Forest Alteration	Land Classification	Overall Environmental Impact
Selective logging	Permanent forest estate and Forest Management Unit	Low to moderate
Selective logging	State and alienated land	Moderate to severe
Forest conversion	Sate and alienated land	Very severe

2.4 Typical activities and methods

The series of activities typically associated with logging and forest clearance activities is presented in Table 2.4.

Table 2.4. Typical activities associated with logging and forest clearance

PHASE	ACTIVITIES
Selective logging	
1. Pre-harvest	
1.1. Boundary demarcation	Cutting 2-meter wide rentices
1.2. Stand inventory	Timber cruising
1.3. Harvest planning	Road and skid trail alignment, etc.
2. Harvest	
2.1. Road construction	Road construction/repairs of bridge/culverts
2.2. Base camp establishment	Clearing and construction of camp
2.3. Felling	Felling of timber
2.4. Landing construction	Clearing and construction
2.5. Skidding	Trail clearing and log skidding
2.6. Bucking / debarking	Cutting to lengths
2.7. Log loading & trucking	Log transportation to dumping
3. Post-harvest	
3.1. Camp demolition	Abandonment of camp
Forest clearance	
4. Clearance (e.g. plantation)	
4.1. Road & plantation track	Road/bridge/culvert construction and repairs
4.2. Nursery establishment	Preparation/clearing of nursery sites & buildings
4.3. Base camp establishment	Construction of buildings in base camps
4.4. Under brushing	Clearing & cutting of all under-brush
4.5. Clear felling	Clearing and cutting of all residual trees
4.6. Cross-cutting (lopping)	Chopping trees to pieces
4.7. Stacking	Stacking of woods/slashes in rows

Current logging methods in Sabah mainly employ a ground-based tractor system. Although skyline systems, - a combination of long-distance cable and crane – and Reduced Impact Logging techniques result in less physical damage to the environment, the high cost of operation has limited their widespread adoption and use. Tracked-skidder systems are therefore favoured as they are easier to use.

The level of environmental damage of the three logging methods currently employed in Sabah is shown below:

Logging method	Damage level (soil & vegetation)	Damage density (%) over net logged area
Skyline	Low	< 21 %
Reduced Impact Logging	Low - medium	30 – 40 %
Conventional	Severe	60 – 80 %

2.3 Approving authorities & present administration

Environmental Impact Assessment. Selective logging and forest clearance activities may be subject to an EIA under the Conservation of Environment (Prescribed Activities) Order 1999. The activities listed under the First Schedule are:

1. Agricultural development

(i) Development of agricultural estates or plantations covering an area of 500 hectares or more- (a) from land under secondary or primary forests.

2. Forestry

(i) Extraction or felling of timber covering an area of 500 hectares or more-
(ii) Extraction or felling of timber within or adjacent to any water catchment area whether it has or has not been declared under any written law; or
(iii) Development of forest plantation having an area of 500 hectares or more.

Failure to observe this directive, the authority, body or person in default shall be guilty of an offence and shall, on conviction, be liable to a term of imprisonment for 5 (years) and a fine of RM50,000.00 (Malaysian Ringgit fifty thousand only).

Approval of the EIA report to be obtained from:

The Director
Environmental Conservation Department
Tingkat 2 & 3, Wisma Budaya
88999 Kota Kinabalu. Sabah
Attention: Development Section
Tel: 088-251290/1
Fax: 088-238120
e-mail: jkas@sabah.gov.my
Homepage: *www.sabah.gov.my/jkas*

As part of the EIA procedure, technical comments will be sought from the relevant Departments, for example:

Department	Impact and mitigation issues to be commented upon
Land and Survey	Land title issues
District office	Local settlement issues, water use, complaints
Forestry	Issues in relation to the logging licence, proposed riparian reserves and steep land reserves
Wildlife	Wildlife issues
Drainage and Irrigation	Water supply issues and proposed riparian reserves

The ECD is charged with overseeing the EIA procedure in relation to the relevant prescribed activities and as such is interested in specific environmental management issues. The technical and silvicultural aspects of forestry including logging specifications and other forestry related regulations are covered by regulations and guidelines provided by the Forest Department.

Other approvals required to commence logging activities include for example:

- Notice of 30 days to be given to the Wildlife Department prior to commencement of any logging or land clearance activities in natural forest according to the Wildlife Conservation Enactment (1997)
- Approval for timber areas and issuance of timber licenses, fall under the authority of the State Forestry Department under the Natural Resources Office
- Approval of the development of oil palm plantations fall under the Department of Agriculture
- State land utilised for temporary resource extraction purposes requires a Temporary Occupation Lease in the form of Schedule IV, Section 18 of the Land Ordinance 1930 (Cap. 68), from the Lands and Survey Department
- The State Forest Enactment 1968 as amended, in particular Section 28a (1992) requiring the applications of Management Plans
- For the protection of watercourses approval is required from the Department of Irrigation and Drainage, under the Water Resources Enactment 1998
- Environmental Quality Act 1974 as amended, in particular Section 34 a (1985)

Application procedures. Upon obtaining the Land Title or Temporary Occupation Licence from the Land and Surveys Department, the project proponent must obtain the relevant permits to log the forest.

Forestry is a State matter regulated by the Forest Enactment 1968 and administered by the State Forest Department under the Natural Resources Office. The cutting of timber is permitted through the issuance of a cutting permit.

Applications for Land Title / TOL / Forest Management Unit License

↓

Applications for Logging / Timber Cutting Permit

↓

Preparation and submission of Logging / Plantation Development Plan & **EIA**

↓

Commencement of Operations

Box 2.1: Application procedure for forest clearance and logging activities in Sabah

3 Environmental impacts

What are the main environmental impacts?

Steps	***Activities***	***Issues***
Step 1	Assessment of impacts	Key environmental impacts include: • River pollution due to increased soil erosion • Adverse impacts on human settlements • Impact on flora and fauna.
Step 2	Mitigation measures	
Step 3	Monitoring	

This chapter is designed to assist in the identification and prioritisation of impacts that need to be assessed. The chapter :

- Outlines and describes the known key environmental impacts associated with selective logging and forest clearance
- Suggests assessment methodologies that can be used to evaluate the scale and extent of the impacts.

3.1 Key environmental impacts

The key environmental impacts associated with selective logging and forest clearance activities are:

- River pollution due to increased soil erosion
- Adverse impacts on human settlements
- Impact on flora and fauna.

Other environmental impacts include (i) increased fire hazard, and (ii) waste and biomass handling.

Initial project description and assessment

In order to later propose realistic mitigation measures, the following *initial* information should be obtained prior to embarking on any field surveys or assessment. This information has to be included in the scoping note and the draft *Terms of Reference* submitted to the ECD and will provide the basic framework for the assessments made in the EIA report.

- ***Initial data I: Clearly identify the geographical location and area of the project.*** Depending on the size of the project area, the EIA study may extend well beyond the project boundary and should include an assessment of downstream, adjacent and coastal impacts (Figure 3.1 - also refer to ECD EIA Handbook).

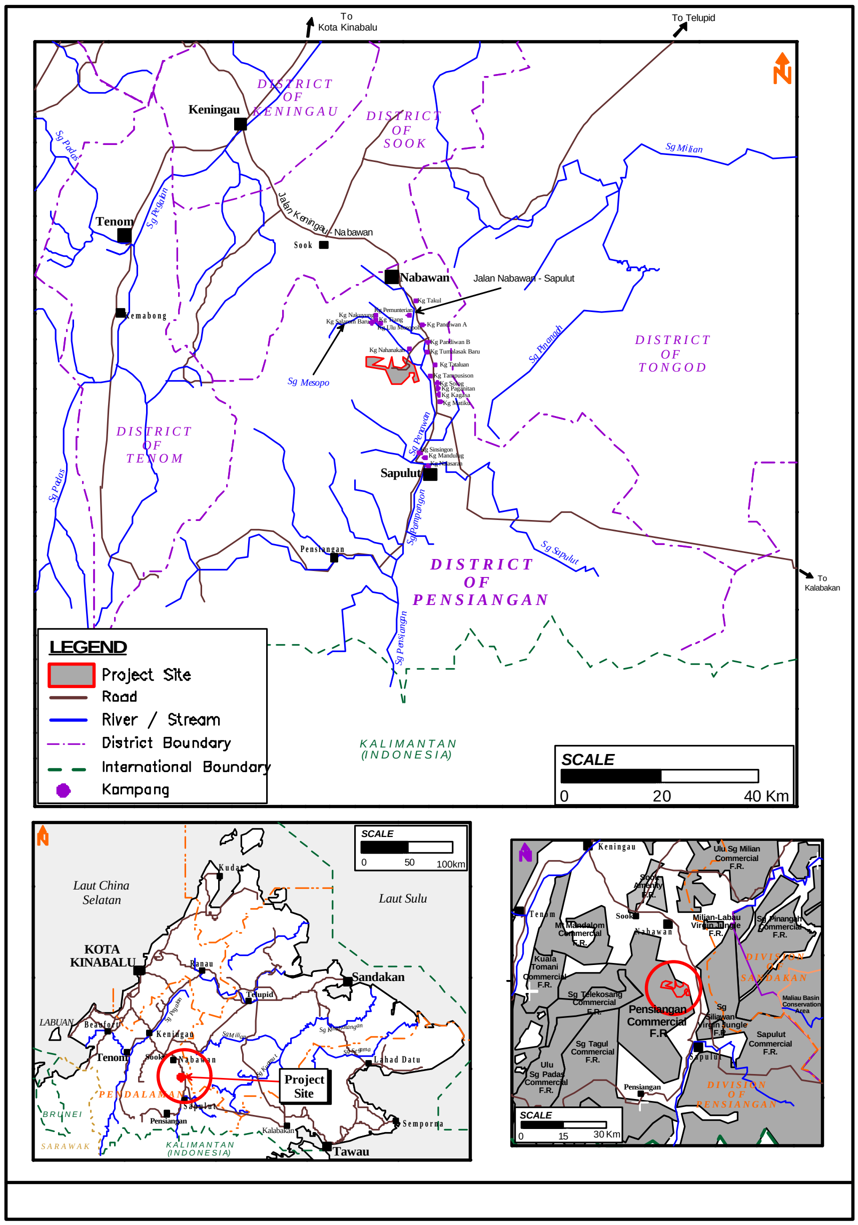


Figure 3.1 Project locality map

- ***Initial data II: Description of the project site, including maps.*** It is imperative that the all maps include an indication of scale and a clearly marked coordinate system (longitude and latitude). One of the location maps should also clearly identify and describe neighbouring land-use which should include the nearest protected area, other sensitive habitats including position in relation to river system. All text presented on the map should be readable. It should be borne in mind that duplicate copies of the reports will be required and provision should be made so that all maps remain legible (Figures 3.2 and 3.3)

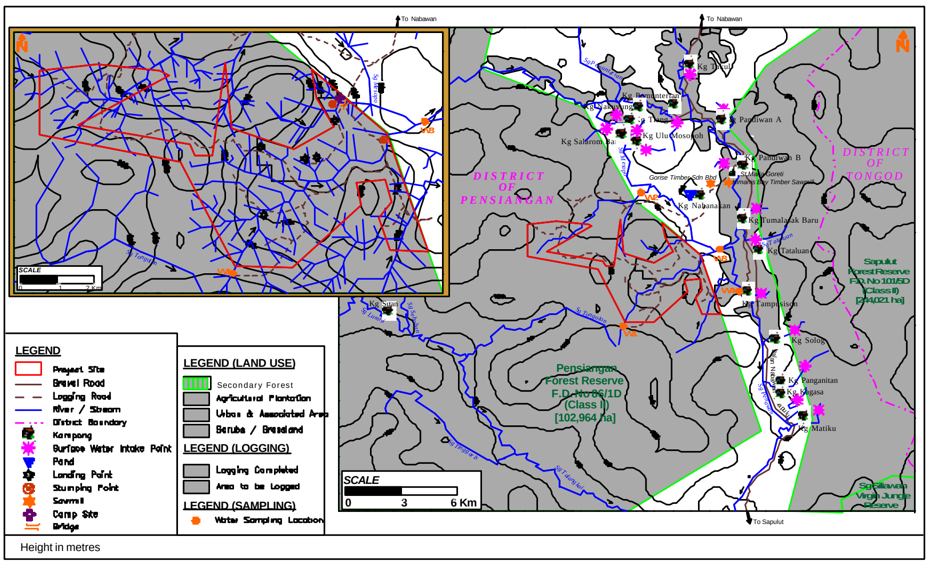


Figure 3.2 Example of existing land use map

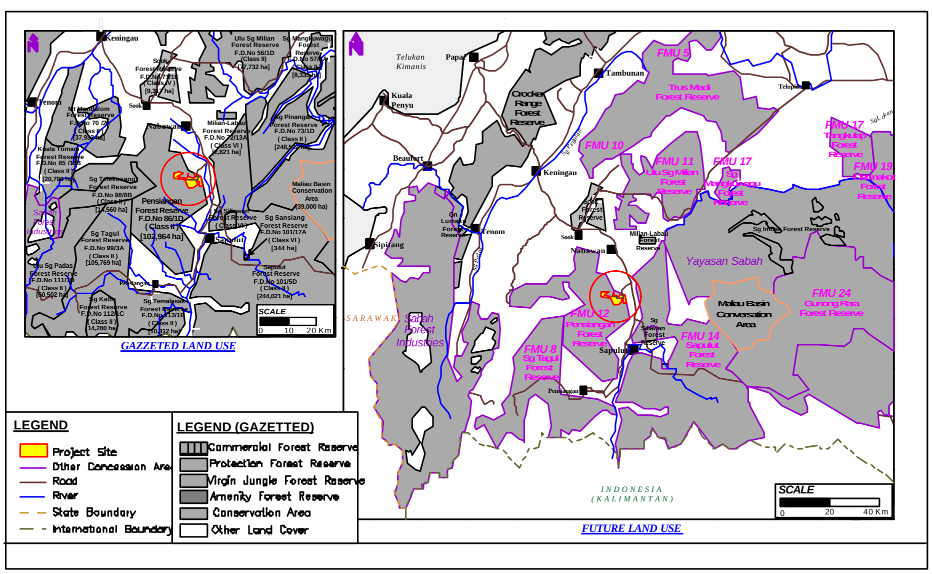


Figure 3.3 Example of future land use map

- ***Initial data III: Description of river systems***. River systems and catchment areas as represented on the National 1:50,000 maps should be digitally presented (Figures 3.4 & 3.5). However, during interpretation it should be borne in mind that the representation of streams on maps is notoriously subjective and is dependent upon a range of factors including the technique used to abstract and transfer data from the original air photographs. In the absence of ground truthing it is difficult to gauge how representative the stream networks are. This is particularly so for forested catchments where drainage is often inferred from topographic relief as determined from the vegetation canopy. Again map scale is important. Small streams represented on large-scale maps will not necessarily be represented on smaller scale maps. A first order stream sustains perennial flow under normal climatic conditions. Zero order streams contain intermittent storm based ephemeral flow. At the 1:50,000 scale it is probable that most drainage lines recorded as 1^{st} order are in fact 2^{nd} or in some cases even 3^{rd}. In addition, some of the larger rivers may have switched or altered course considerably. Therefore this information should be taken as indicative and not absolute (Figure 3.5 & 3.6). All 4^{th} order rivers and higher must be clearly identified and marked. In part this matches the requirements of the Water Resource Enactment (1998), i.e. to provide a 20 m river reserve for rivers wider than 3 metres, as most 4^{th} order rivers are at least this size

  Using the river drainage system data, the project area should then be classified into individual catchment areas (Figure 3.6). Photographic information can provide useful supplementary information (Plate 3.1)

  Water quality samples/measurement can be taken in order to indicate the general condition of rivers in the project area. Total suspended solids would normally be the parameter of interest, however, the number of parameters may vary depending upon site-specific requirements. An interpretation of the data needs to be clearly presented

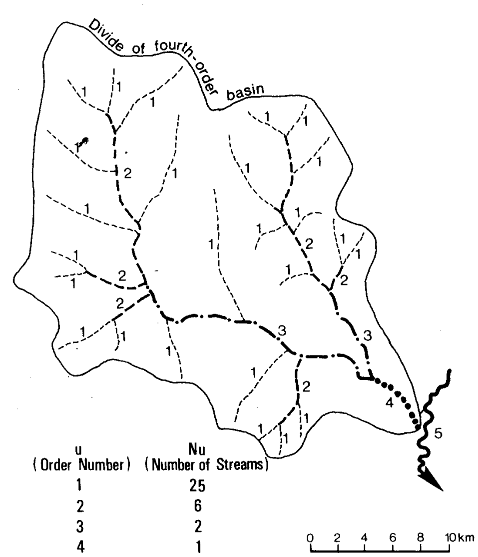


Figure 3.4 Assessment of stream order (after Strahler, 1964). When two first order streams meet, the river becomes 2^{nd} order and when two 2^{nd} order streams join the river is then classified as 3^{rd} order.

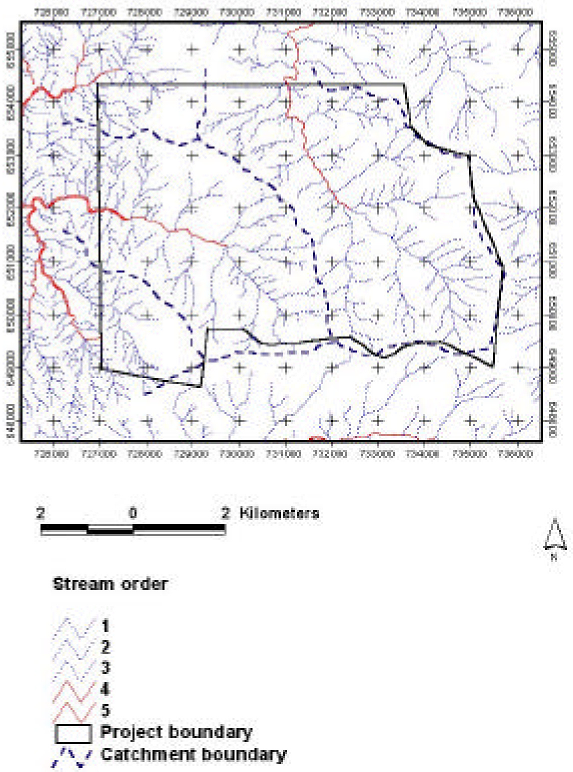


Figure 3.5 Assessment of river size based on stream order

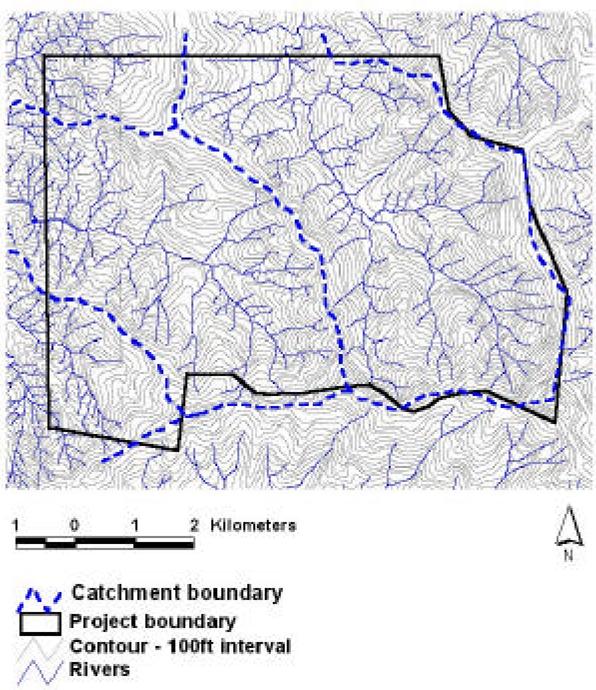
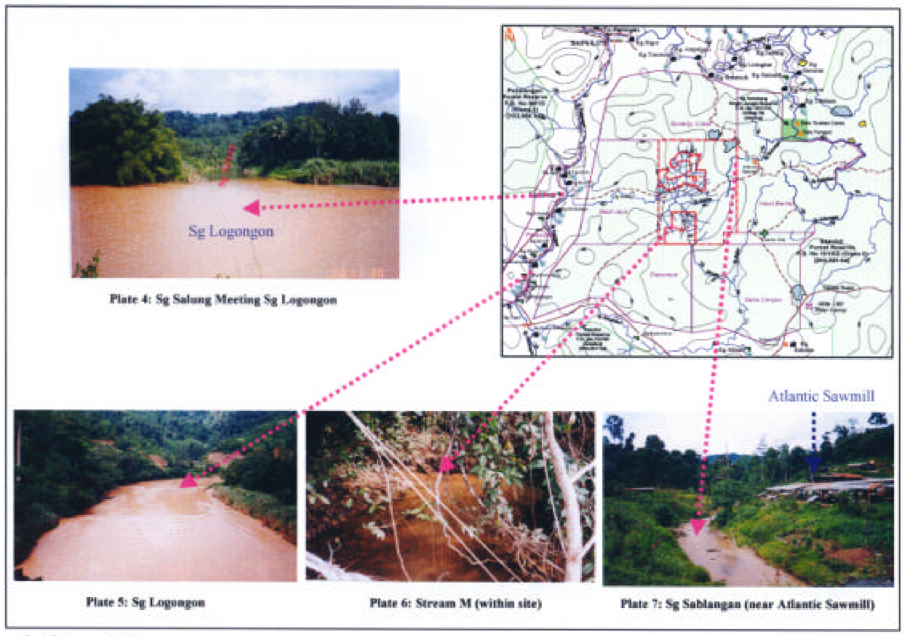


Figure 3.5 Catchment boundaries for the project area as abstracted from a 1:50,000 map

Plate 3.1 Example of photographic data used to supplement the assessment



- ***Initial data IV: Provide details on the land status and development trends in the area and State.*** For the project site, affirm the land classification and the intended use of the land. For example, state whether the logging operation is: (i) selective logging on State-land, (ii) selective logging of Permanent Forest Estate, (iii) forest conversion on State Land, (iv) forest conversion within Permanent Forest Estate

- ***Initial data V: Provide details on agreements governing the initiation of the project.*** This includes for example the project status in relation to approvals (received/applied), permit number or license, permitted logging period i.e. start and end date, and other comments from official authorities

- ***Initial data VI: Listing all main project activities.*** This includes the timing of the planned project activities, proposed logging system and activities, forest road plan, machineries to be used, log transportation routes, proposed layout plan, phase of development and schedule of activities under each phase.

GIS and computer models. The representation of spatial data by means of a Geographical Information System (GIS) provides an appropriate tool for representing and analysing spatial data sets, particularly for larger, more complex and sensitive projects. Geographical Information Systems therefore offer good opportunities to examine the environmental impact of forest logging and conversion activities.

Results obtained from computer models need to be verified against field data. It should be recognised that for the results to be representative, the data requirements are high and limited by the quality of the input data. To enable verification by ECD actual procedures must be made available. Before using computer models, prior consultation and approval with ECD is advisable.

On assessment techniques and methodology

Literature on the impacts of logging and forest conversion activities already exists and in the first instance this should be consulted. A review of known impacts documented for similar environments is likely to provide a good foundation for the basis of the impact assessment.

It should be noted that many of the impacts associated with forest removal have only been quantified following prolonged and detailed research programmes. Such investigations require careful planning and execution and are demanding on financial, technical and manpower resources - and even then the conclusions and interpretations that can be drawn from the results often remain open to interpretation. The limited time and resources that can be allocated to an EIA study must therefore take this into consideration and the available resources should be prioritised.

Assessment studies must also be planed with due consideration given to the available mitigation measures that are likely to be implemented. Prolonged data collection that does not lead to, or support the effective implementation of mitigation measures may be counterproductive. Time spent on baseline data collection must be justified in terms of the potential validity and usefulness of the results. A snapshot picture of the environment provided by a limited data collection programme may provide spurious information and further mislead decision makers. It is therefore strongly recommended that already known and documented impacts are recognised and thereafter the study should focus on appropriate assessment and mitigation measures.

When deciding upon methodologies for assessing the key environmental impacts it is recommended that each assessment should include:

- A review of known and expected environmental impacts. These results should then be discussed in relation to the project being assessed
- A clear description of impact assessment methodology to include data collection methods, rationale and analytical procedures
- Description and assessment of impacts.

The assessment methodologies and data required will depend on various factors such as project size, land status, intended land-use if conversion is required and schedule and order of operations. The impacts to be monitored, data to be collected and possible methodologies to evaluate the impact will be discussed and defined during the preparation of the Terms of Reference for the EIA study.

The overall purpose of the assessment is to provide an answer to the following question:

- What areas should be identified as sensitive - prohibiting clearance or only allowing operations to proceed with extreme caution because of physical, ecological or social constraints

It is important to stress that that focus of the assessments should be on the key environmental impacts that can be mitigated. When solutions and mitigation measures to abate the key impacts are put in place, many of the minor impacts often will also be mitigated.

3.2 Key impact I: River pollution due to soil erosion

The early stages of logging operations require the penetration of roads into previously undisturbed forest. Heavy logging equipment is used to cut, bulldoze and push earth during the initial and subsequent extraction phases of logging activity. Exposure and compaction of soil leads to hydrological change, increased erosion rates and water quality problems. During the course of the log extraction process there may be multiple passes of heavy machines on skid trails, coupled with the movement of tractors, loaders and trucks on roads and landings during log production - all of which contribute towards the exposure and compaction of soil (Plate 3.2).

The network of roads, skid trails and landings directly alters the catchment drainage pattern and subsequently impacts water yield, water quality and river channel morphology. This in turn may affect dry and wet season flow, storm flow volume or peak discharge, with consequences and impacts for aquatic ecosystems. Hydrological changes will subsequently impact the soil resource, causing increased erosion rates and associated sedimentation problems.

The disturbance activity and the subsequent impacts are a series of closely linked events that need to be addressed as a continuum. Recognising and mitigating problems at source and implementing preventative mitigation measures is imperative. For example, once the main factors contributing to the soil erosion hazard have been established, there is little point monitoring water quality for suspended sediment when it is mitigation at source that will reduce the impact.

Plate 3.2 Soil erosion due to road construction activity

Factors influencing soil erosion. Under undisturbed conditions the dominant factor controlling soil erosion are the erosivity of the eroding agent, which in the case of Sabah, will principally refer to *rain*, which in turn is controlled by:

- The erodibility of the soil
- The slope of the land
- The nature of the vegetation cover
- The location of project activities
- The area of land exposed to erosion
- The period of exposure.

Hydrological changes. Logging operations of any type inevitably disturb the soil surface and the remaining vegetative cover. This has implications for site hydrology, which in turn need to be appreciated to understand other associated impacts (Plate 3.3).

Plate 3.3 A logging trail that crosses a stream severely impacts the physical environment.

When vegetation is removed the hydrological cycle is altered as water that would normally have been returned to the atmosphere by means of plant transpiration processes under undisturbed circumstances, now remains within the soil layer. The impact or additional volume of water retained increases approximately in proportion to the amount of vegetation removed, therefore the greater the amount of vegetation removed, the greater the hydrological impact. Absence of vegetation also allows a greater proportion of direct rainfall to reach the forest floor. The additional rainfall and reduced rates of evapotranspiration translate into increased volumes of water leaving the catchment.

When the amount of disturbed and compacted surfaces are high there will be an accompanying increase in the fast routing of surface runoff or the stormflow component of streamflow. However, most of the additional water drains more gradually through the soil, contributing to the slower baseflow component of hydrological routing. Ninety per cent of erosion in managed tropical forests originates from the construction of roads and skid trails (Hodgson, 1986), and under normal operating conditions up to 50 per cent of the land area may be disturbed/exposed during selective logging operations.

Although it is popularly reported that deforestation results in an increased incidence of flood, it must also be borne in mind that floods are a natural hazard, particularly in areas that receive heavy rainfall. The speed at which water runs off into a river system determines the height and duration of a flood. Again the changes in volume and timing of storm runoff will be approximately proportional to the extent and amount of reduction in vegetation cover.

Water catchment studies at the Bukit Berembun experimental site, Peninsular Malaysia, confirmed that water yield increased after logging, with increased baseflow accounting for most of the increase. This was found to be true for both supervised and unsupervised logging practices. For the supervised treatment, using environmentally friendly guidelines, requiring closely specified prescriptions for layout, gradients and drainage of tractor tracks, the overall water yield was increased by 40 per cent compared with pre-logging conditions. Total water yield was increased by about 70 per cent by logging using generally practised methods in the adjacent catchments.

Monitoring for any form of hydrological impact requires long term instrumentation of catchments as the natural flow conditions need to be established and documented before any changes can be attributed to changes in the treatment i.e. logging. Within the framework of an EIA study, such experiments are not normally feasible, nor indeed necessary. Although care must be taken when extrapolating results from one catchment to another, it will be necessary to draw upon experiences and results from relevant examples. Acknowledging that removing vegetation does alter streamflow volumes and timing should form the core of the impact statement and mitigation measures should be planned accordingly.

Soil erosion under selective logging. Increased rates of erosion occur when there is disturbance of the tree canopy and litter layer, resulting in increased exposure of the soil surface. Once exposed, erosion of the soil surface takes place through a sequence of processes starting with the detachment of soil particles by rainfall splash, progressing to sheet, rill and gully erosion. Sheet erosion takes place when water flows over the surface of compacted ground. Topographic irregularities often lead to the concentration of surface water flow into micro-channels called rills. Gullies form when rills increase in depth. In undisturbed forests, both splash and sheet erosion produce low volumes of sediment but will produce substantial amounts of sediment after the soil is bared (Figure 3.7).

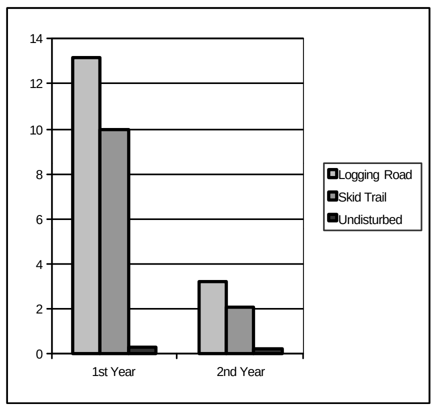


Figure 3.7 Annual soil losses from the Jengka experimental basin in Tekam Forest Reserve, Pahang, Malaysia. (Source: Kasran, 1995)

After disturbance, both rill and gullies frequently occur on poorly located skid and tractor tracts and along badly drained feeder roads. Intensive rilling and gullying is a sign that large volumes of soil material have been eroded from the site. Mass wasting or landslides often associated with poorly constructed and maintained roads may also supply significant volumes of sediment and remain potentially active well after the initial disturbance. Often there is a progression from one form of erosion to another, the significance being that sheet erosion is easier to mitigate than rill, and rill easier to mitigate than gully.

Eroded soil once mobilised, becomes available for transport through the drainage system.

The effect of land conversion on soil erosion is not always apparent in measurements of catchment sediment yield i.e. the amount of sediment leaving the catchment via the drainage system. This is because not all eroded material enters the system immediately but may remain in temporary storage in dips and hollows on the ground surface, or trapped by vegetation and leaf litter. Sediment may also be temporarily stored within the river channel itself. Therefore the downstream effects may take many years to become apparent. This time lag increases with catchment size and the sediment delivery, although low compared to amounts actually eroded, will persist for many years. The significance of these processes needs to be acknowledged as even if all man induced erosion in catchments could be eliminated at once, many years may be required before the amounts of sediment carried by major rivers to their lower reaches began to subside. The reason for this lies in the fact that there is so much sediment stored in the system, both from previous man-caused and natural erosion, forming a long-term supply. Upland reforestation to mitigate erosion therefore requires some specification of both the spatial and time scales involved.

In addition, attributing changes in sediment yield solely to deforestation is problematic as short-term monitoring programmes often fail to register the significance of extreme rainfall events and long-term trends related to climatic variability.

Despite the difficulties and limitations associated with measuring erosion and suspended sediment, in Sabah, there is a clear link between logging activity and increases in sediment yield. Under natural forest conditions in Malaysia, rates of erosion have been reported as been very low (Table 3.1). Studies in the Ulu Segama region, Sabah, have found that sediment yields from logged catchments far exceeded those of nearby undisturbed catchments. Increases in sediment yield correlated with three sequential periods of logging activity, namely:

- Road construction
- Logging adjacent to the road
- Log extraction.

The main post logging sediment sources were gullies, which formed on skid trails along which logs had been extracted by dragging behind a bulldozer. Immediately after logging, large amounts of sediment continued to enter the stream system, however, as vegetation recovered and some degree of ground protection was provided, rates of erosion began to subside. Several years after the logging much higher magnitude discharges were needed to move the remaining sediment that had been trapped in the system, and slumping of roads continue to provide sporadic but significant supplies of sediment.

Table 3.1 Sediment yield from small forested and disturbed catchments, Ulu Segama, Sabah, Malaysia (Source: Douglas et al., 1992)

catchment name	treatment	catchment area km^2	sediment yield $t\ km^{-2}\ y^{-1}$
W8S5	undisturbed	1.1	312
Baru	selective logging	0.56	1600

Soil erosion under clear-cutting. Clear-cutting operations compound the known impacts associated with selective logging. The conversion requires the complete removal of all remaining tree cover, possibly some time after commercial logging has taken place. This is then followed by under-brushing, pruning; stacking, stump removal, mechanical cultivation, sowing of cover crops and finally planting of the tree crop. For several tree crops a complete clearance, burning, stumping and cultivation sequence is carried out every few decades to establish the next crop.

The major soil erosion events and loss of topsoil happens during the conversion phase. Indeed, conversions of forest to other land use types in the tropics often does not seem to be sustainable without large inputs of fertilisers[1].

Assessment methods for soil erosion risk

An overview of the proposed overall method for assessing soil erosion impacts is outlined below:

Impacts	Suggested method of assessment
Soil erosion	• *Erosion hazard assessment* incorporating biophysical data i.e. slope, stream drainage network – and when requested vegetation cover, rainfall distribution and/or intensity and soil classification. • *Assessment of intended management procedures* i.e. area to be exposed, length of time exposed and schedule of logging in relation to forest clearance (if forest is to be cleared).

The impact analysis should focus on identifying potential areas of erosion hazard. A theoretical approach would be to analyse thematic data layers based on the factors that control erosion, i.e. slope, rainfall, vegetation cover and intended sites and schedules of disturbance i.e. location of roads and other clearings. Additional layers should include all permanent streams and catchment boundaries. Subsequent overlay analysis of these factors will help identify site suitability at a reconnaissance scale of mapping, based on erosion hazard.

However, given the poor resolution of available rainfall intensity and soil data in Sabah, suitable data is seldom available and will not normally be required given the associated difficulties of making good decisions based on such data. However, for specific projects it may be required that such data is produced when it is thought that such an assessment can better assist decision-making.

Sites identified as high-risk sites may require additional attention and investigation. If a soil map is not available and an assessment is based on slope and rainfall alone, but a high risk is indicated, this could merit the initiation of a soil survey to further assess the risk.

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[1] The halting or reduction of soil erosion has been stated as being one of the benefits of the widespread planting of plantations in the tropics. Tree cover does reduce soil loss, however, the soil losses that occur beneath plantations are generally much greater than beneath natural forest. Soil loss can be especially pronounced in the early stages of plantation establishment before the canopy has had time to close. It has also been recorded that when litter was removed by burning, soil erosion increased by between 10 and 90 fold, depending on rainfall intensity. However, replacing forest with tree crops is usually less damaging to the long-term hydrological and erosional behaviour of watersheds than many other changes in land use. Long-term hydrological changes after the conversion phase are most probably limited to minor increases in water yield and subtle changes in flood peak timing

Although GIS is well suited for overlay analysis, manual methods may also be employed. Careful consideration should be given to the type of data to be included as it mustcontribute towards the hazard assessment.

Data requirements. The assessment of erosion hazard is a specialised form of land resource evaluation, the objective of which is to identify areas of land that will be threatened by or are prone to excessive soil loss. The assessment aims at dividing a land area into regions of similar erosion hazard as a basis for planning project activities and soil conservation work (Morgan, 1995).

Although the rate and amount of soil erosion under undisturbed conditions is controlled by a number of known factors, the impact of the disturbance often overrides these. This therefore requires the identification of the existing or planned disturbance i.e. road network.

As a minimum requirement an assessment should include the flowing steps and data layers:

Step 1: Elevation and slope

- Topographical data should be abstracted from the available 1:50,000 national map sheets. If larger scale 1:25,000 data are available, this may be used or at least reported that it is available. Elevation data is required to derive slope (Figure 3.8 & 3.9). A minimum data requirement is that slope is captured from topographic data from the 1:50,000 scale maps using the minimum contour interval spacing available, which on most map sheets is 100 feet. Once data on elevation has been captured it is usually easier to utilise computerised methods to determine slope and several commercial software packages are available to do this. Details of the software and the basic principles of the derivation should be presented with the slope map. Digitally derived slope maps captured from 1:50,000 topographic maps provide a general assessment of the distribution of steep land, however, it should be recognised that important local topographic variation may be missed, why the local erosion risk may be underestimated

- Slopes of 25 degrees and above to be clearly marked on a map. As described above, factors other than slope do affect rates of erosion, however, such a map will provide important indicative information as to high risk areas. It is also recognised that in some cases when other data is not available, then slope may be the only indicator of erosion hazard available

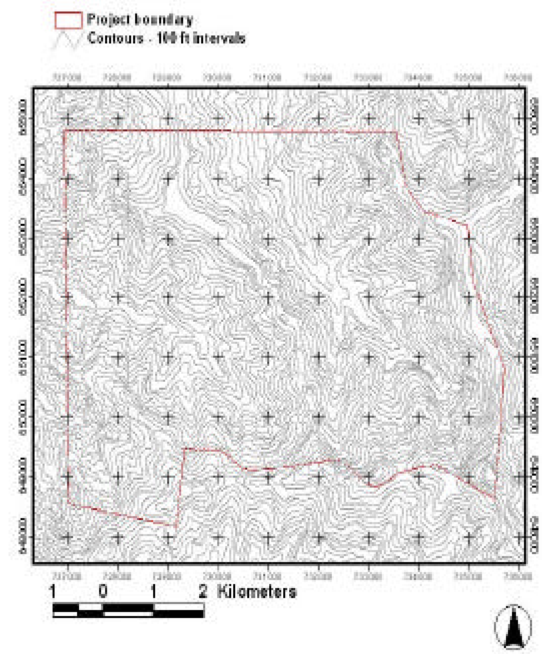


Figure 3.8 Elevation and geographical location of project abstracted from 1:50,000 map sheet (Required to derive slope – RSO projection).

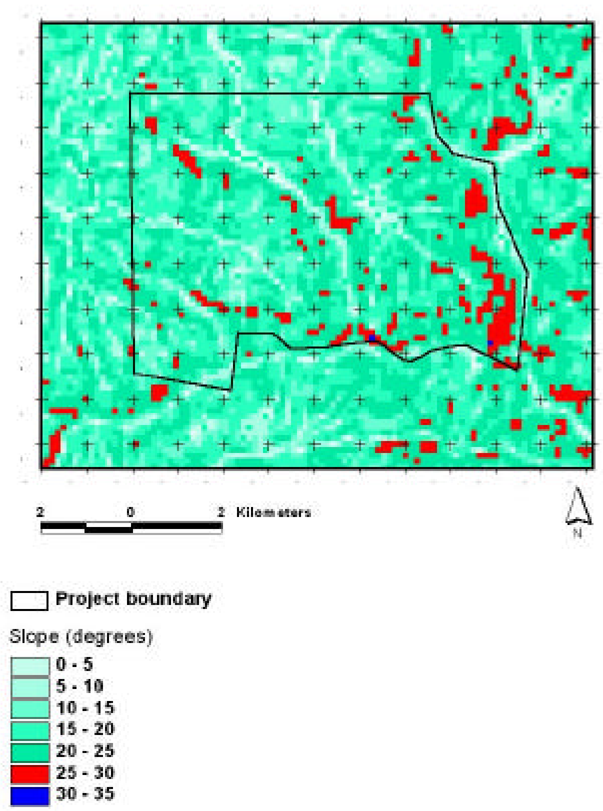


Figure 3.9 Slope as derived from elevation (Figure 3.8).

Step 2: Additional information. Additional information and data layers that may be used of specifically requested include:

- *Vegetation*: Available data on vegetation cover, habitat and/or current land-use should be presented at the same 1:50,000 scale. If current information is not available this data may be mapped for larger Forest Management Units, by for example satellite imagery or air photographs, or by site visits for smaller projects. In the context of soil erosion, vegetation acts as a protective layer or buffer between the atmosphere and the soil, absorbing some of the energy of falling raindrops, running water and wind. The below ground root system also contributes to the mechanical strength of the soil. Therefore plant cover can play an important role in reducing erosion provided that the cover extends over a sufficient proportion of the soil surface. Forests provide the most effective cover but a dense cover of grass or other herbaceous growth may be almost as efficient and quicker to establish. For adequate protection at least 70 per cent of the ground surface must be covered but experimental results have shown that a reasonable protection can be achieved with 40 per cent cover. However, it should be recognised that it is the removal of vegetation that increases the hazard, therefore the intended or existing road network may also provide important information

- *Rainfall:* Data on average annual rainfall over the project location, presented at the same 1:50,000 scale, may in some instances provide information for planning and assessment. If more appropriate rain data is available i.e. data available from agricultural stations, research stations, DID etc., this data should also be incorporated. Soil loss is closely related to rainfall volumes and intensity, partly by means of the detaching power of raindrops striking the soil surface and partly through the contribution of rain to runoff. This applies particularly to erosion by overland flow and rills for which intensity is generally considered to be the most important rainfall characteristic. Although antecedent conditions may have some influence on rates of erosion, in general rates will increase with increased rainfall intensities. The most suitable expression of the erosivity of rainfall is an index based on the kinetic energy of the rain. Thus the erosivity of a rainstorm is a function of its intensity and duration. A spatial map of an erosivity index derived from rainfall intensity measurements extrapolated over the project site could provide important additional information, however, it is recognised that the distribution of recording gauges maybe limited. In general, high intensity rainfalls occur frequently throughout Sabah and are capable of producing powerful erosive events. Higher annual rainfall totals would normally indicate a greater chance that such events will occur. The eastern seaboard of Sabah is drier than the rest of the State

- *Soil:* Erodibility defines the resistance of soil to both detachment and transport. Although a soil's resistance to erosion depends in part on topographic position, slope steepness and the amount of disturbance, erodibility varies with soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical content. Given the inherent difficulties associated with determining any one of these factors - a thematic layer might be constructed using available soils data, also preferably at a scale of 1:50,000 or the largest scale available (see for example 'The Soils and Crop Suitability Report of the Sungai Bole Area, Lahad Datu - map scale 1:25,000). It may be that if a site is identified as potentially having a high erosion hazard, more data or an additional survey will be requested. If additional information is requested, the survey adopted should be an internationally accepted procedure e.g. Food and Agriculture Organisation of the United Nations guidelines for soil description (FAO, 1970) or should follow the recommendations of the Department of Agriculture, Sabah. This procedure should also refer to existing topography, geology, soils and relevant work in the area, which in turn assists in deciding the level of groundwork and coverage required. Observable properties such as soil depth, particle size distribution, texture, structure and stoniness should be recorded using the FAO guideline for soil description. The soils of Sabah have been described down to the Family (1975). A soil family is a unit of classification defined specifically by the type of parent material, which in Sabah has been quite broadly classified. The soil parent material would for example be described as sedimentary, intrusive igneous or crystalline basement rock. For the existing soils map of Sabah, soil associations have been mapped at a scale of 1:250,000. A soil association is not a classification unit but has been adapted to enable mapping based on landform classes, dominant soil units and characteristic vegetation, this mapping level is broad and may be used for the initial assessment. In general large particles are more resistant to transport because of the greater force required to entrain them. Fine particles are also resistant to detachment because of their cohesiveness. The least resistant particles are silts and fine sands. When necessary a geologic data layer should be provided. It should be borne in mind that following disturbance the physical properties of most soils are changed so dramatically that often there is little relationship to the original data and survey results. If soil data is used for erosion risk modelling or is presented as part of the assessment, the significance of the data must be stated. For example, one soil type may be more erodible because it has a higher percentage of sands and silts. The presentation of soil data without accompanying explanatory information is not acceptable.

Step 3: Schedule and phasing of operations. The schedule and phasing of operations should be clearly stated and when possible represented in a spatial format. If the project will eventually result in forest clearance, information on the time lag between logging, clearance and conversion to the alternative land-use is required. The conversion to another land use, for example oil palm plantation or industrial tree plantation, should preferably take place in phase or immediately after the forest clearance and clear-cutting operations. If replanting is delayed, the adverse physical environmental impacts will increase, resulting in long term consequences, particularly in relation to soil erosion and water pollution.

Step 4. Hazard assessment map. The overall assessment of erosion hazard could either be based on slope alone or incorporate the above data layers. The resulting hazard map should identify regions that are at risk should they be disturbed, i.e. a range or collection of steep regions with high erosion hazard or isolated areas of high erosion hazard i.e. single hill slopes (Figures 3.10). Each locality should be given an identification number or code for reference. Due to the difficulties associated with locating and identifying specific steep areas in the field, the data will later require the integration of other data e.g. human impacts, to focus the assessment on specific high-risk areas.

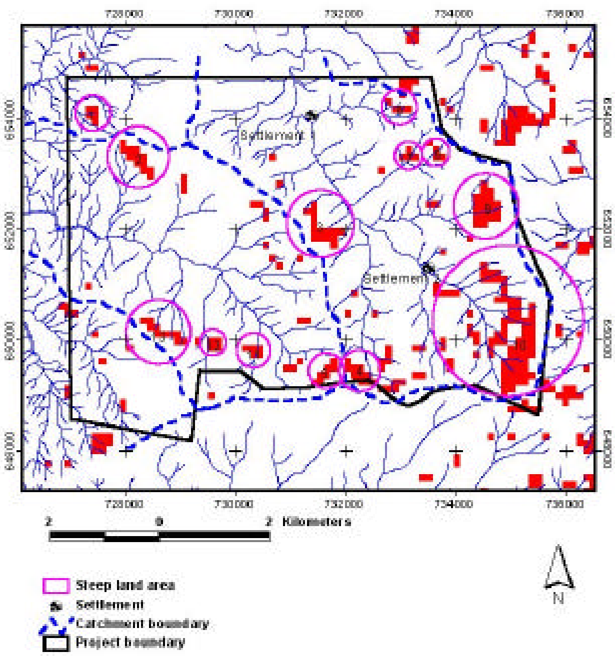


Figure 3.10 Erosion risk as derived from data on slope, vegetation and rainfall.

3.3 Key impact II: Impact on human settlements

Logging and forest clearance activities can result in a number of interrelated adverse impacts on human settlements, with the greatest impact being felt by nearby residents. The potential impacts that require investigation include:

- **Deterioration of drinking water quality**. Increased sediment loads and improper waste handling may degrade the quality of drinking water obtained from Gravity Feed Systems or water intake points, and thereby increase health hazard issues

- **Landscape degradation and loss of existing and potential eco-tourism opportunities.** Excessive damage to the natural vegetation cover may degrade the landscape and impact aesthetic values. Logging debris and sediment polluted rivers may lead to the degradation or loss of water recreation sites

- **Landownership issues,** for example land ownership conflicts and disagreements, increased landlessness, loss or degradation of sacred areas i.e. areas that have cultural or religious value for the local residents

- **Dust and noise problems** related to road construction, operation and timber haulage

- **Biomass disposal.** Improper biomass disposal into streams and rivers may clock or pollute rivers, and may create dangers to downstream settlements

- **Disruption of traditional income generating practices**, for example loss of land for shifting cultivation, reduction in available forest produce in the form of fruits, wildlife, rattans and other non-wood forest produce due to forest disturbance during the logging process or increased competition from external sources

- **Flood hazard**. Increased water yield during storm flows may cause flooding which is detrimental to not only agricultural crops but may also endangering lives and lead to the need for resettlement.

If the EIA study reveals other adverse impacts on local settlements, these must also be documented, studied and assessed in the EIA study.

Assessment method for impacts on human settlements

The objective of the assessment is to identify areas that may need special attention, and appropriate assessment methodologies need to be identified depending upon the scale and significance of the project. The following steps are suggested:

Step 1. Initial assessment of potential adverse impacts. An initial assessment based on available data, information, interviews and maps should be undertaken.

Step 2. Survey of potential affected settlements. Based on the initial assessment, a semi-structured questionnaire should be developed. The questionnaire should include; (i) a number of close-ended questions, for example; 'Where do your house get water from?' 'Do you use the forest for income-generation purposes?' and, (ii) a number of open-ended questions, including for example; 'What do you think are the main problems associated with the project?' and, 'What are the important mitigation measures that you would like to have imposed'. An example questionnaire is shown (Table 3.3).

Project Title:
Household no./address:
Name:
Open questions (to be qualitative reported and analysed), for example:

Main problems associated with the project

____
____

Ideas for improvements of project implementation

____
____

Closed questions (to be quantitatively reported and analysed), for example:

	4	3	2	1
I support the implementation of the project				
Xxx				
Xxx				

Box 3.1 Sample semi-structured questionnaire form

The results of the questions have to be quantified and/or documented. Two maps of the settlements/houses shall be provided. The first map should be at the same 1:50,000 base scale as the other data layers and the second shall be at a larger scale and include the name and/house location of the respondents. If logistically feasible, all directly impacted settlements should be included in the survey (Figure 3.11). Photographs may also be used to supplement survey data (Plates 3.4 and 3.5).

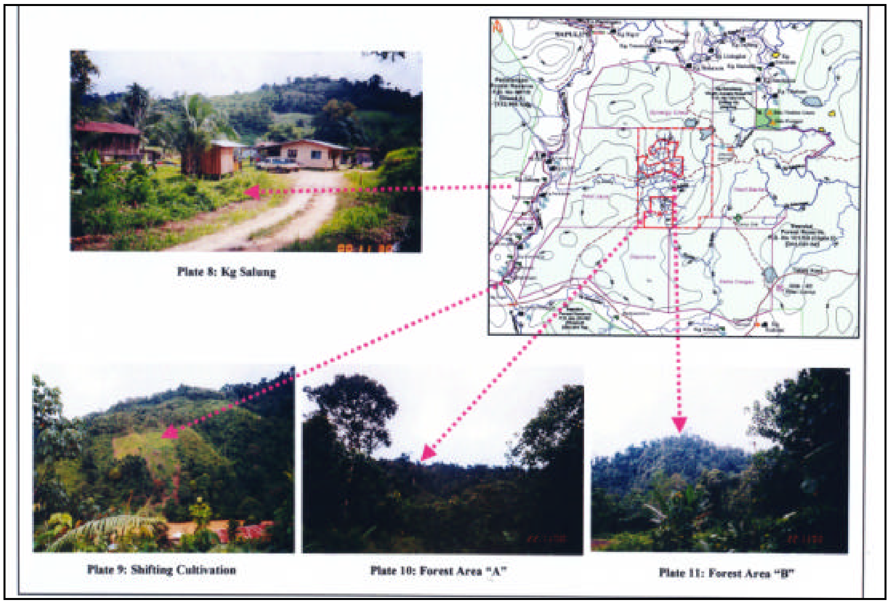


Plate 3.4 Photographs used to supplement social survey

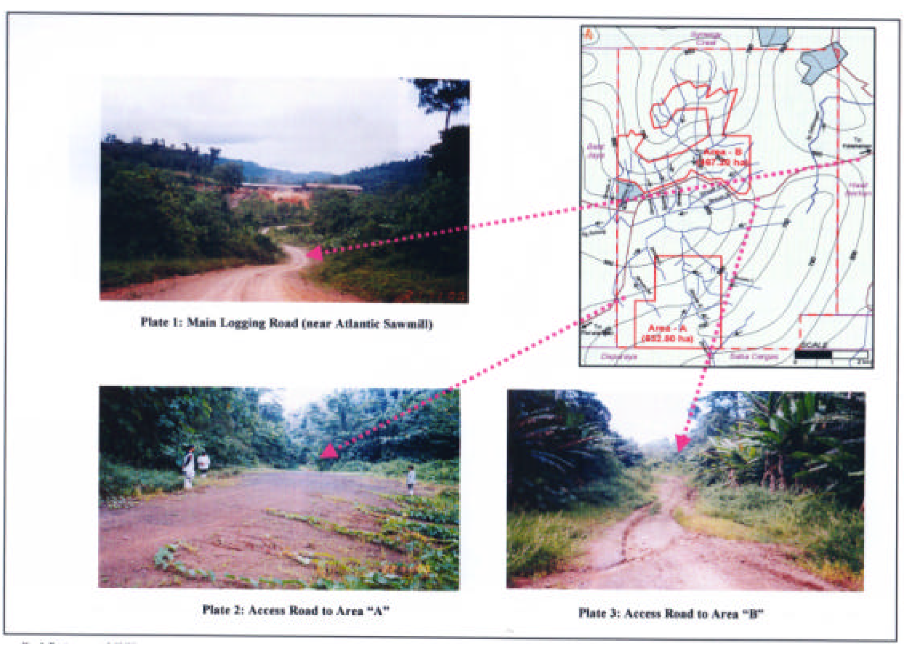


Plate 3.5 Photographs used to supplement social survey

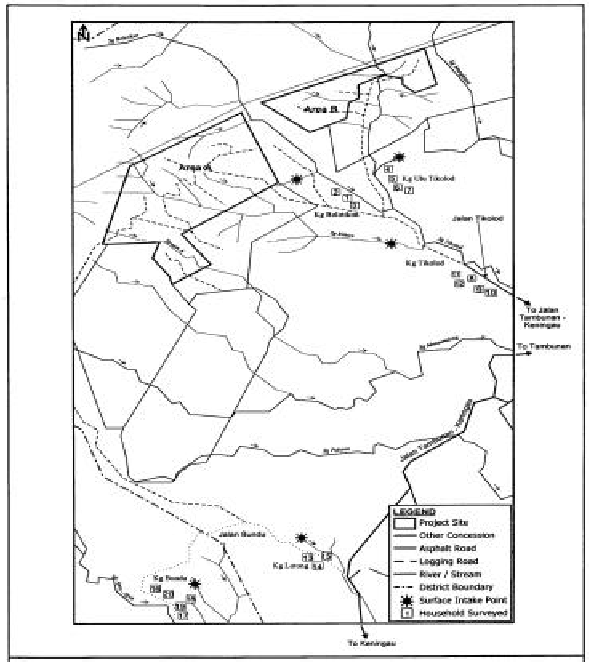


Figure 3.11 Example of location map to supplement survey data at a project site

- **Step 3. Detailed study and assessment of the key adverse impacts.** Based on the results of step 1 and 2, a detailed study and assessment of specific impacts should be undertaken. For example:

- *Landownership issues,* for example the reason and seriousness of the land ownership conflicts, or the number of settlers to be relocated

- *Disruption of traditional income generating practices,* for example assessment of the area of shifting cultivation, fishing, forest produce, number of users, approximate income generated, short or long term impact of the logging or forest clearance process

- *Landscape degradation and loss of existing and potential eco-tourism opportunities,* for example the severity and extent of landscape degradation (e.g. compared to other similarly logged sites, the extent of damage to water ways, mapping and photographing existing valuable landscapes as for example waterfalls, rocky streams, flat riverbanks for picnics, hills with views, plateaus with hills, scenic lookouts, wildlife, rare plants, scenic forest stands, geological formations, archaeological sites, culture heritage sites

- *Deterioration of potable water supply,* for example mapping existing catchments used for potable water, documenting number of on-site and downstream users, investments costs to install alternative water supply, with reference to the physical impacts state the probable length of time the impact will last e.g. during the period of active logging only, short term or permanent (Figure 3.12)

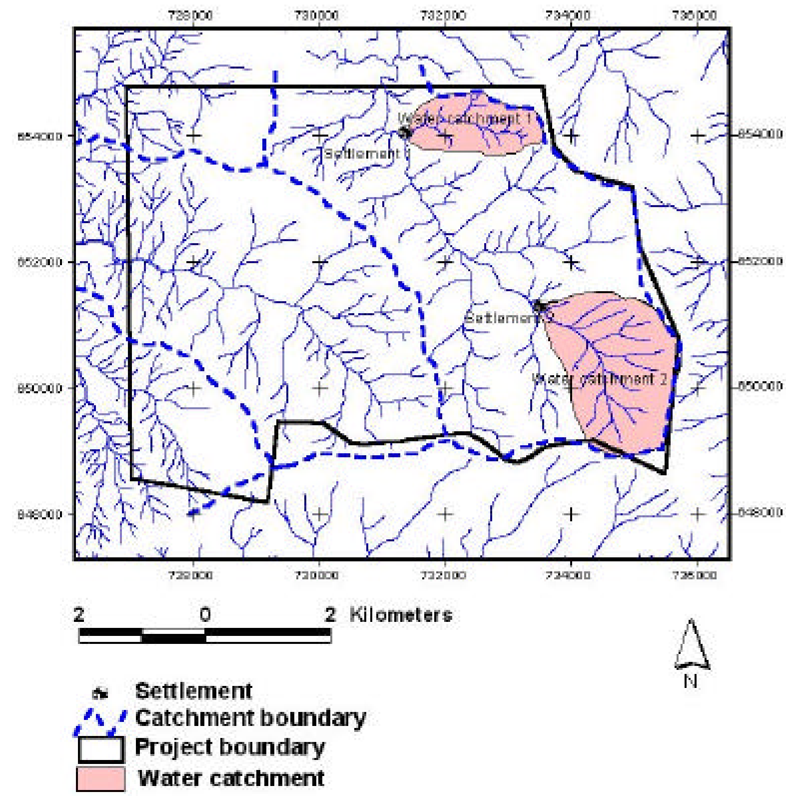


Figure 3.12 Social assessment highlighting gravity feed water supply catchments.

- *Dust and noise problems* related to road construction, worker transportation and log haulage to be assessed by predicting the increase in traffic, the timing and scheduling of the transport activities, comparisons with transport activities in similar areas in Sabah, the number and location of settlements affected. The existing or intended log haulage route should be clearly marked alongside settlements that potentially may be impacted (Figure 3.13).

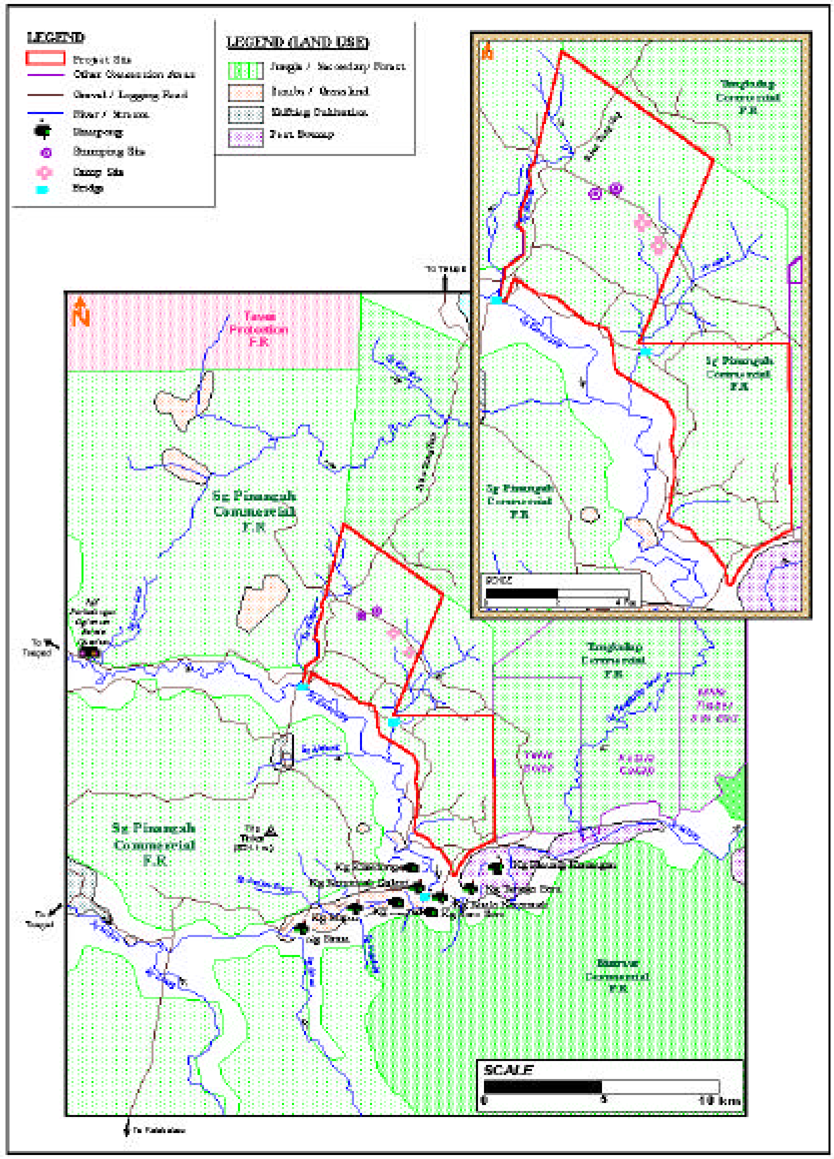


Figure 3.13 Map of log haulage route and settlements.

3.4 Key impact III: Impact on flora and fauna

The cumulative loss of habitat at a local level has resulted in biodiversity issues fast becoming a global concern. Biodiversity is first lost at the local level and this perspective needs to be considered alongside national and international biodiversity issues. To what extend impacts should or can be mitigated will in part depend upon the proximity and location of protected areas and the level of protection already afforded to the species/community/habitat.

The management of natural tropical forests for timber production is a difficult procedure. For rain forest management units to be viable they necessarily need to be large. The number of individual species persisting during and after the logging portions of the forest will depend upon how closely the forest management procedures mimic natural regeneration processes, which necessarily includes a consideration of the total areas left in a largely undisturbed state. Following disturbance it is clear that there is some dependence by some species on nearby un-logged forest blocks or undisturbed patches within the logged forest mosaic. The patch size and dispersion opportunities necessary to support viable populations of most species are, however, at present unknown.

In common with impacts on the physical environment, the level of damage is dependent upon the volume of timber taken and intensity of the extraction activities. The most common impacts relate to the physical loss and damage of the forest stand, creation of canopy gaps and vegetation composition change.

Flora. Selective logging systems have been seen as an ideal solution to the long-term management of forests in the region. In this system regeneration is derived from mixed size seedlings below exploitable size. However, there is one provision; that the forest retains an adequate stock of trees that will survive the logging undamaged and develop enough growth before the next felling. At higher levels of timber extraction and associated damage, the loss of a few trees due to poor felling or management practices causes disproportionately more losses than would be the case under low logging levels. Following this argument, it may also be predicted that repeated logging before full regeneration has taken place is likely to cause permanent reductions in plant diversity. The high initial losses of natural vegetation diversity are unlikely ever to be regained.

Once natural forest is cleared and converted to a different land use, the technical constraints of, for example, plantation forestry, generally lead to the use of non-native species with fast growth rates. Plantations of such species support a lower diversity than natural forests and reduce the original habitat and range of local fauna and flora.

Table 3.2 Examples of the impact of forest conversion activities on flora

Activity	Impact: Extent of canopy opening	Typical effects
Reduced impact logging	Low	• Some invasion of secondary forest species • Some drying out of forest floor leaf litter • Some increase in fire risk • Increased accessibility by poachers
Conventional logging	Moderate to high	• Severe timber stand damage and forest clearing • Irreversible loss of habitat • High fire risk

		• Volume of commercial growing stock reduced, high competition with pioneer species, high rehabilitation cost • Difficult to rehabilitate with indigenous timber species • Loss of shade-tolerant plant species • Invasion of secondary forest species • Loss of rare species • Mortality of herbaceous succulents that need high humidity and shade for survival
Forest clearance	Complete removal	• Local loss of all species • Increased fire risk

Fauna. The response of vertebrates to disturbance is dynamic. The extent of faunal dietary specialisation may be important in that animals specialised to exploit food sources that are less common following disturbance should logically also become less common. On the other hand, complex food chains should show considerable resistance to environmental fluctuations. However, considerable methodological difficulties have limited the collection of good data and thus the actual processes that impact biodiversity loss remain poorly understood and many assumptions are made. Most impact studies have been comparative in nature where a disturbed site and a nearby-undisturbed site are compared, however, this does not explain variation that may be present due to local spatial variation in topography that may be quite marked and significant.

Logging changes the structure of the vertical vegetation profile and creates shifts in foraging height. This causes complications for survey techniques pre and post logging. However, despite these limitations some interesting observations have been recorded for Malaysia (Johns, 1992). Analysis of ecosystem response to logging disturbance suggests that the loss of about 50 per cent of trees during felling may not cause permanent damage to overall biodiversity at the site. Although there is a considerable initial impact in terms of reduction of numbers of some species of plants and animals, the level of resilience shown by the affected communities is remarkably high. A study in Peninsular Malaysia recorded that almost all vertebrate species present in unlogged forest either persisted or had recolonised the site by 12 years after the logging event – although the relative abundance of animal species was different (Johns, 1992). Primates and frugiverous birds such as hornbills retained their numbers even when it was recorded that 73 per cent of the trees were lost. However, primates ceased to breed during the logging period. Smaller less mobile species, on the other hand, do show reductions in population numbers. It should be noted that in many dipterocarp forests, logging levels have already resulted in the loss on site of 50 per cent of trees. Studies in the Ulu Segama region, Sabah, showed that certain bird species may be prone to local extinction following logging, in particular species of under-storey flycatchers, woodpeckers, trogons and extreme specialists such as the Malaysian honeyguide (Lambert, 1992). Other results from the same area have shown that animals found after logging are not immigrants from elsewhere but are indeed the original population. This suggests that during logging, animals retreat to pockets that remain untouched, or less disturbed.

It has been observed that some terrestrial browsing species such as deer prefer to feed in logged forest because of the greater abundance of browse near the ground. Most plants protect themselves from herbivores with poisonous chemicals and indigestible compounds. Such compounds may poison the animal that eats them or interfere with digestive processes. Elephants have a digestive system that makes them particularly susceptible to toxins and tannins. They must search for plants that contain only small amounts of such chemicals or for those not protected at all - such as the fast growing herbaceous species that colonise disturbed forest sites. Therefore elephants prefer to feed in secondary forest. This situation will increasingly result in conflict between human land-use and the elephant population.

These above results would suggest that large areas of selectively logged forest are of importance to wildlife conservation. But in general terms the patchy distribution of food resources in logged forest may affect ranging patterns, breeding success and even gene flow unless species are able to re-occupy the regenerating forest. Unfortunately logged forest is particularly susceptible to serious forest fires. Hence, although most species can survive the effects of selective logging, these areas should not be considered as alternatives to the protected area network but rather and in important supplement.

Clear cutting and forest conversion that results in the permanent loss of forest will result in the local extinction of nearly all species. If nearby undisturbed forest exists and it is assumed that it is in ecological equilibrium, opportunities for the absorption of displaced neighbouring populations will be extremely limited, if they exist at all. It can only be further assumed that displaced individuals die or out-compete the resident individuals, resulting in their displacement or eventual death.

Elephants in Sabah. Elephants provide an interesting case study for the increasing conflict between land-use issues in Sabah. Sabah shares with Indonesian Kalimantan the only elephant population in Borneo. Viable elephant populations must have certain minimum areas of habitat for their long-term survival. Killing of elephants, usually as a result of conflict with agriculture, continues both legally by wildlife staff and illegally by others but on a small scale. Loss of habitat poses a much greater threat to the species than direct killing. The range of elephants in Borneo has expanded only slightly during the past 100 years, despite free access to apparently suitable habitat elsewhere (Figure 3.14). Soils in Borneo tend to be young, leached and infertile and it has been speculated that elephant distribution in Sabah may be limited by the distribution of natural mineral resources (Davies and Payne, 1982). There are two major elephant conservation problems in Sabah, first saving those elephants displaced by habitat loss; and second, ensuring that the most important conservation areas and a contiguous chains of forest reserves continue to enjoy adequate protection.

Figure 3.14 Elephant distribution in Sabah and Kalimantan (Source: Andau & Payne, 1990)

Assessment methods for impacts on flora and fauna

The assessment might be undertaken in a basic or detailed form.

Basic flora and fauna impact assessment

If the scoping activities determine that there is little need for studying flora and fauna, the TOR will request that only a basic study shall be undertaken. Such a study would include for example:

- Assessment of the geographical location and the size of the project area
- Assessment of the land status and land development trends in the area and within the State
- Proximity to other protected areas
- Relate to existing flora and fauna data, for example existing distribution maps
- Possibilities of the area containing endangered species.

For a small to medium scale logging or forest clearance project on State land, there would generally be little purpose to study the flora and fauna impacts as the land has already been designated for alienation. As such there are no mitigation measures available unless there is a mechanism and willingness to change the land status. Similarly concessions within Commercial Forest Reserves cannot be effectively assessed on a project-to-project basis, as the same constraints will limit the implementation of mitigation measures. Flora and fauna assessments of forestry operations within Forest Management Units should consider the whole unit rather than at the individual concession level.

Detailed assessment of impacts on flora and fauna

If the scoping activities determine a need for studying flora and fauna in detail the TOR will request that a more detailed study of the impact on flora and fauna assessment shall be undertaken. This will be the case when, for example, the proposed project covers large forested areas or is situated adjacent to existing protected areas.

The overall objective of a flora and fauna assessment would be to identify areas that may need special attention and treatment or protection because of an identified significance. Appropriate assessment methodologies need to be identified depending upon the scale and significance of the project. The following assessment method might be applied:

- **Step 1. Habitat classification and mapping of the project site and surrounding areas**. A useful inventory for management purposes is a habitat map based on aerial photography or satellite imagery with ground checks augmented by information on the distribution of important species. Habitat mapping based on altitude, precipitation and evapotranspiration are other possible ways of further subdividing the landscape (Figure 3.15). The habitat scale of analysis may provide opportunities for estimating the given range of a species. For example, it may be known that a particular species occur from sea level to nearly 1,000 meters in elevation, as long as there is adequate forest cover. Existing data and maps of habitat and species distribution should be consulted to prepare the habitat maps. Range data are often more readily available for mammals such as primates or popular bird species. Reptiles, fish, insects and plant range data are generally not as well documented. A faunal survey of Sabah was compiled in 1982 (Davies & Payne, 1982).

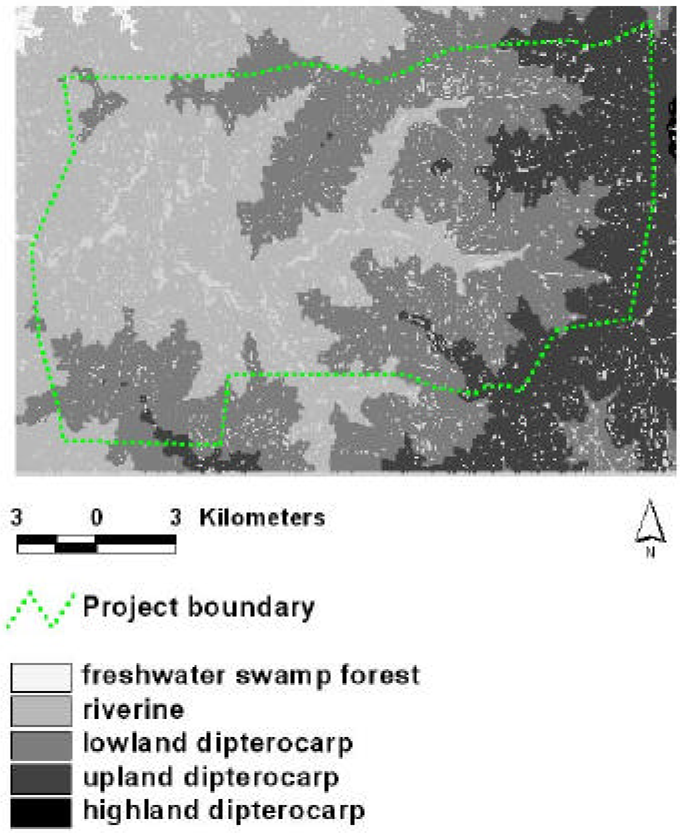


Figure 3.15 Zoning of a project area by vegetation type

- **Step 2. Initial flora and fauna inventory survey.** An initial flora and fauna inventory survey should be undertaken. The survey should include collection of the following data: (i) data from Wildlife Department and other relevant governmental and non-governmental organisations, (ii) data from the local villagers. List of consulted persons shall be included in the EIA report.

An assessment, based on step 1 and 2, should identify sensitive habitats/species by determining the conservation status of the habitat/species within the project area and the surrounding areas. For example, if forest conversion is likely to result in the extinction or endangerment of a species at an international level, there would be strong grounds for conducting a more detailed survey with the ultimate aim of protecting the habitat to ensure the survival of the species. However, if for example the species is found elsewhere or is sufficiently protected in other conservation areas - then the assessment would have to acknowledge that locally the loss of that species might not be significant. Legally protected are listed by the State *Wildlife Conservation Enactment (1997).*

- **Step 3. Design the field survey**. If it is specified in the TOR that a detailed flora and fauna assessment must be conducted, a team of relevant specialist shall be commissioned. Detailed flora and fauna surveys are time consuming and are typically associated with actual field observations. It is strongly advised that the Wildlife Department are consulted in planning the survey and that the overall approach is approved by the ECD prior to embarking on any fieldwork.

  The job of *monitoring* fully large areas of forest including hundreds or thousands of species is impossible. One of the problems faced in tropical countries is the high level of diversity with many species remaining poorly studied. Even in intensely studied areas, data is hard to come by. However, a rapid flora and faunal survey as described below should provide some indication of species present and their distribution.

  The simple listing of species observed at a single locality provides limited information because of the difficulties associated with the sighting of some species, the unknown range of the species compared to the point of observation and temporal variation in species behaviour, which may sometimes be seasonally dynamic. Some species are difficult to observe visually, therefore it is often necessary to rely upon indirect evidence of their presence such as tracks, waste or remains.

  The survey should answer the question: What species communities occur within the project site, where and approximate numbers. Data should be collected on those species which are ecologically dominant forms, endangered species or species whose numbers reflect important ecological processes. Even crude indications of *the numbers* of these species will add to the value of the inventory. Generally an assessment can be completed during a single visit and its accuracy will increase as more new areas are sampled rather than by re-sampling the same area. Highly precise numbers are seldom important except where populations are to be managed intensively, as for example, when managing elephant populations.

- **Step 4. Indicator species survey.** Given the limited time and resources available for assessments, it is recommended that the survey be selective and should restrict observations to a few *indicator species* or key phenomena that reflect broader trends, and to other measurements that give an indication of the general biological condition of the environment. Plant species, vertebrates and butterfly distributions are commonly utilised as indicator species in the overall assessment of biodiversity. Although plant species do not pose the data collection problems exhibited by the mobility of vertebrates, plant species distributions are often unmapped. Further, vegetation communities are typically defined by the dominant species - which tend to be generalist species. Indicator species must be common enough to be readily mapped but not so common as to occupy the entire landscape, as do generalist species. Threatened and endangered species, although they may be considered in the final conservation recommendations, are not always useful as indicator species, especially when they are exceptionally rare. Likewise, riparian species or other species associated with narrow habitat ranges may not be effective indicator species. If an indicator species is used for surveys, consideration will have to be given to habitat requirements. The species selected should be easily identified in the field by non-specialists or unambiguously recognised during interviews with the general public and government officials. Both techniques are useful in extending the survey coverage (Savitsky *et al*., 1998)

From the above steps a map identifying sites of possible ecological significance should be produced. Data represented spatially on maps are easier to evaluate than a database format only (Figure 3.16).

For the largest most important sites, habitat maps should ideally, consist a polygon-structured base map to which point structured wildlife data are related. The polygons need to contain data that are specific enough to be meaningful in diagnosing spatial trends in the wildlife data but general enough to be achievable and manageable. Converting the wildlife data points into a meaningful measure of presence within a given habitat has been described in Scott *et. Al.,* (1993). A point-in polygon procedure was utilised to convert the wildlife sightings data to polygons more closely corresponding to the wildlife range. First, the wildlife data were overlaid on the habitat map. Then every resultant habitat polygon that contained a point of a certain species was tagged as having that species present. It is necessary to refine this system by limiting the size of the polygons in the habitat map before overlaying it with the wildlife data points. Without a spatially imposed limitation, a point representing a wildlife sighting in a clearing on the edge of a forest would be characterised as having as range as expansive as all of the connected forest clearings on the edge of forested land. Likewise, a bird species sighted flying over a plantation could result in marking an entire agricultural zone of the country as the habitat for the species. Although limiting the size of the habitat polygons does not eliminate the problem, the process reduced the extent of it.

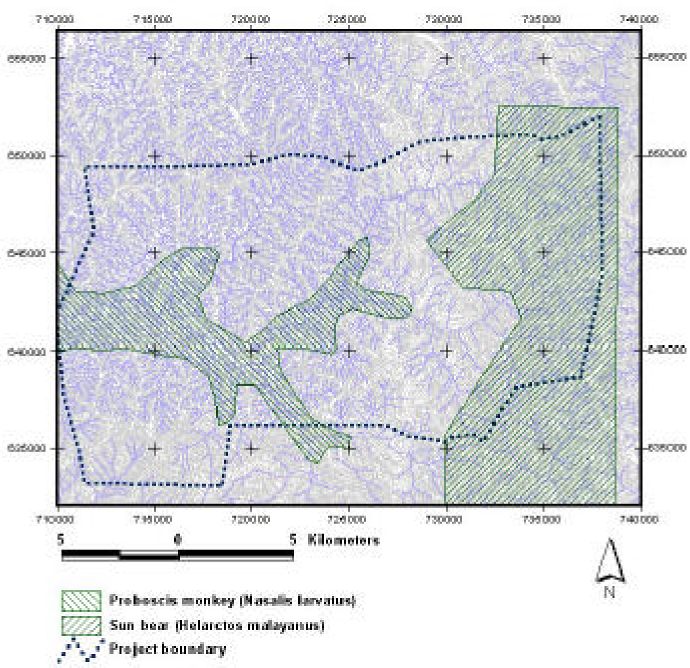


Figure 3.16 Approximate range of two indicator selected species for the project area

- **Step 5. Assessment of procedures to provide protection.** If the steps above have shown the presence of important species the study should proceed with an assessment of alternatives for providing protection. The assessment as to whether or not some form of protected status should be given to an area is a difficult and complicated process and is largely dependent upon an assessment of the protected area needs of the State alongside the conservation requirements of a given habitat/species. Opportunities for protection are also largely governed by the current land status and intended land use for the site. Ideally, in the first instance, this should be determined at a national/State level using some form of spatial analysis (GIS) of existing protected areas, habitat and species distribution. Conservation gaps – gap analysis – highlight the difference between 'what needs to be protected' and 'what is actually being protected'. The protection of an individual site would generally not be sufficient to protect general levels of biodiversity, instead an appropriate and well-planned network of protected areas is needed. Protected area ‘gaps’ then need to be assessed alongside mechanisms for providing protection, i.e. what are the options for gazetting an area and affording it realistic long-term protection. Whereas some opportunities may exist to incorporate parts of the Permanent Forest Estate into existing protected areas, or if the area is of sufficient importance it could be gazetted as a protected area on its own right, it must be recognised that as part of the overall economic development process, large areas of State land will continue to be alienated. As such, opportunities for conservation will often be related to the size and location of the project.

Buffer zones, forest fragmentation and wildlife corridors. As a general principle, intensive agriculture, of any form including plantations, /and protected areas do not make good neighbours and the development of buffer zones or some areas of intermediate land use is often desirable between the two. Sometimes it may be sufficient to utilise an adequate natural barrier such as a river, estuary, ridge crest or swamp that forms a deterrent to exotic species and human incursion.

- **Buffer Zones.** Protected area buffer zones can be defined as areas adjacent to protected areas, on which land use is partially restricted to give an added layer of protection to the protected area itself while providing valued benefits to the neighbouring land-user. Extension buffering extends the areas of those habitats contained within the protected area into the buffer zone, thus allowing larger total breeding populations of plant and animals than could survive within the reserve alone. An example of such buffering can include selectively logged production forests.

  In determining the type and extent of buffer zones needed, the following factors should be considered: (i) needs of threatened wildlife species for use of additional habitat outside the reserve boundaries. Knowledge of the habits and range of the species will give some indication of the extent of the buffer zone, (ii) The need of the buffer zone to serve other protective functions, such as soil and water conservation or fire break protection, (iii) The need to contain wildlife species likely to move out of the reserve, (iv) The amount of land available for buffer use, whether it is currently under natural or other vegetation and whether it is vacant or being used, and (v) Forest buffers outside protected area boundaries include logged forest, enriched secondary or even plantations where the emphasis is on maximising sustained yield of timber for various uses while maintaining good soil and water protection.

- **Forest Fragmentation.** As land and vegetation is converted, forests become fragmented until the remaining undisturbed habitats are isolated as patches. In tropical forests the isolation process may take many years, undergoing several stages of development, particularly if the forest is part of a rotational production stand. Rates of species survival will depend upon the remaining habitat and the proximity to other undisturbed areas. The fate of the remaining habitat islands and the changes that result from the isolation has drawn much research. The impacts are complicated by a number of variables and no one example is representative of all, however, it is generally acknowledged that larger reserves minimise edge effects and are better able to accommodate wide ranging species. However, it is also acknowledged that small well-placed reserves play an important role as a number of small reserves may be better able to conserve a greater variety of habitat types and more populations of rare species than a large block of the same area.

As a fragmented area diminishes in size it will eventually reach a stage when it is no longer able to support the critical minimum population size for more and more species. A species in a patch may become locally extinct, only to recolonise later. This will depend on the species and the proximity of the next fragment containing the species.

- **Wildlife corridors.** It has been argued that, by conserving corridors of land between similar habitats, recolonisation may be aided and the overwhelming problem of habitat fragmentation may in part be addressed. However, some researchers and practitioners who argue that the negative aspects of corridors are detrimental to the larger conservation area dispute this. Corridors may provide a pathway for the spread of disease and fire. After the debate, however, often there is no other choice than to manage the remaining fragments as best possible (Figure 3.17).

  Corridors that facilitate the natural patterns of migration will probably be most successful at protecting species, however, the equatorial humid tropics with limited seasonality experiences little or no migrations of terrestrial land vertebrates although there may be irregular grouping and movements of some animals such as pigs and elephants. Corridors facilitating the movement of wildlife have to be well thought out with a priority of joining areas of **like** habitat. Often there are only very limited options for expanding the protected area network with corridors

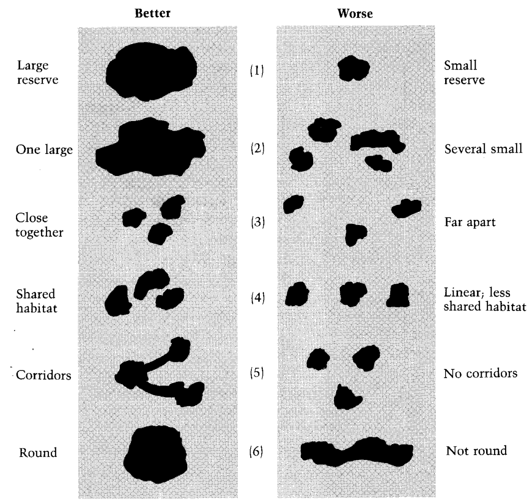


Figure 3.17 The basic theoretical principles for protected area design (Source: Primack, 1993)

3.5 Additional impacts

Other impacts that might be included in the EIA study are listed below. These additional impacts might be included in the EIA study depending on project size, location, initial scooping and screening assessments, and the TOR.

Additional I - waste and biomass handling

People at the project site will normally generate sewage during logging and conversion activities. Improper treatment of sewage will result in elevated COD, BOD and microbiological contents of the waterways. Use and storage of hazardous materials such as used lubricants may also bring about potential pollution to the environment, particularly surface water quality. Improper waste disposal from timber camps such as oil, grease and other refuse is a health hazard (Plate 3.6).

Plate 3.6 An example of a poorly located fuel tank – spilt fuel can flow directly into the river system

Improper biomass disposal into streams and rivers may block and pollute them, creating a hazard for downstream settlements.

Additional II - fire hazard

Increased fire hazard associated with logging is related to a number of factors including increases in the available fuel for burning in the form of logging debris. It has been shown that a selective logging operation that removes 4-8 trees per hectare may reduce the canopy cover by half. Such disturbance is enough to transform previously fire resistant forest into fire susceptible forest with post logging fuel loads being three times higher than before. In Sabah, large gaps in the forest canopy allow the groundcover and logging debris to reach a condition of being able to burn after 5-6 rainless days in the dry season.

In Sabah, following the El Nino/Southern Oscillation phenomena of 1982-83 during which rainfall was only 15 per cent of normal, over 1 million hectares of forest burned, of which 86 per cent was logged over forest.

Forest fires can also trigger complex-drainage basin responses such as changes in sediment source area. There is a mounting body of evidence from temperate regions supporting the view that fires facilitate the development of an impervious hydrophobic soil layer, diminishing the infiltration potential of soil and thus increasing overland flow. Water quality may also be affected in ways other than increased sediment with reports of increased acidity of rainfall as a result of the smoke pollution. After the Kalimantan fires of 1982-1983, the acidity of river waters increased which in turn apparently affected fish populations in the Mahakam River.

Loss of forest by burning equates to burning of wildlife habitat and although the impacts have yet to be studied systematically, it is know that many plants and animals were killed as a result of the fires and populations continue to be impacted as a result of habitat loss. Although the fires initially destroyed mostly scrub and degraded forest with relatively low wildlife value, increasingly primary forest and protected areas have been damaged. In Kalimantan, Indonesia as a direct result of the 1997-1998 forest fires, Orang utan (*Pongo pygmaus*) were driven from burning forests to land utilised by humans. Found only on the islands of Borneo and Sumatra, Orang utan are amongst the world's most endangered primates and the population has dropped by between 30-50 per cent in the last decade.

Fire hazard can be assessed through an investigation of the fire history of the area including frequency of droughts, local burning practices. Review of existing forest fire management plans for the project site can also be undertaken.

4 Mitigation measures

What are the main mitigation measures?

Steps	***Activities***	***Issues***
Step 1	Assessment of impacts	
Step 2	Mitigation measures	Key mitigation measures include: • Provision of hill/steep land reserves • Provision of river reserves • Reducing adverse impact on settlements
Step 3	Monitoring	

This chapter is designed to assist in determining possible preventative, remedial or compensatory measures for each of the adverse impacts evaluated as significant. Mitigation will consist of a number of related actions, many of which comprise of ensuring effective management and control of site or operational activities. Mitigation measure should be site specific and based on the results of the assessment (Figure 4.1). General proposals such as “all rivers to maintain a 20 m river reserve” are unacceptable. For example, If a reserve is proposed for a specific river, the location and length of the reserve should be clearly detailed.

4.1 Key mitigation measures

This section outlines possible key mitigation measures, however, whether a project will have to undertake them will depend upon the overall assessment and through consultation with ECD.

The key mitigation measures are:

- Provision of hill/steep land reserves
- Provision of river reserves
- Reducing adverse impacts on human settlements

These key mitigation measures will, if implemented, solve a broad range of potential impacts, for example river pollution, habitat protection and water supply for settlements.

Additional mitigation measures include:

- Protection of other rivers
- Provision of wildlife buffer zones or corridors
- Provision of buffer zones, corridors and protected area management
- Wildlife management
- Fire prevention and control
- Phased logging and clearance
- Reducing the land area disturbed
- Resolving landownership issues
- Responsible waste handling
- Provision of alternative income generating activities
- Preservation of landscape and ecotourism opportunities
- Staff training
- Abandonment.

4.2 Key mitigation measure I: Provision of steep land reserves

From the results of the soil erosion high-risk hazard assessment, the project site should be zoned accordingly. Areas comprising of significant regions of high risk will need to be either excised from the project plan or marked for development with particular care or with a specified treatment. If the steep areas are few and isolated, then a decision may be taken to progress with the development.

Intensive conversion should ideally be restricted to low risk more gentle terrain, generally in the lower parts of catchments.

No trees are to be felled within the hill reserves (Plate 4.1). Trees immediately outside the hill reserves must be felled in a direction away from the reserve. Machine access is prohibited in the hill reserve.

Plate 4.1 A steepland/hill reserve that was excised from a forest clearance project.

Risk areas as identified in the assessment, shall be clearly mapped, numbered and described in the EIA report. Global positioning system (GPS) or other waypoint data of all high-risk areas are required (Table 4.1). If it is already possible to access the site, the boundary of the high-risk area should be surveyed. If it is not possible to access the site, the coordinates of the boundary should be abstracted from the 1:50,000 base map (Figure 4.2). To facilitate the monitoring of compliance and to aide implementation, recommended mitigation measures should be described or mapped in such away i.e. information transferred back to the original 1:50,000 base map scale, so as to allow position location to be unmistakably determined in the field.

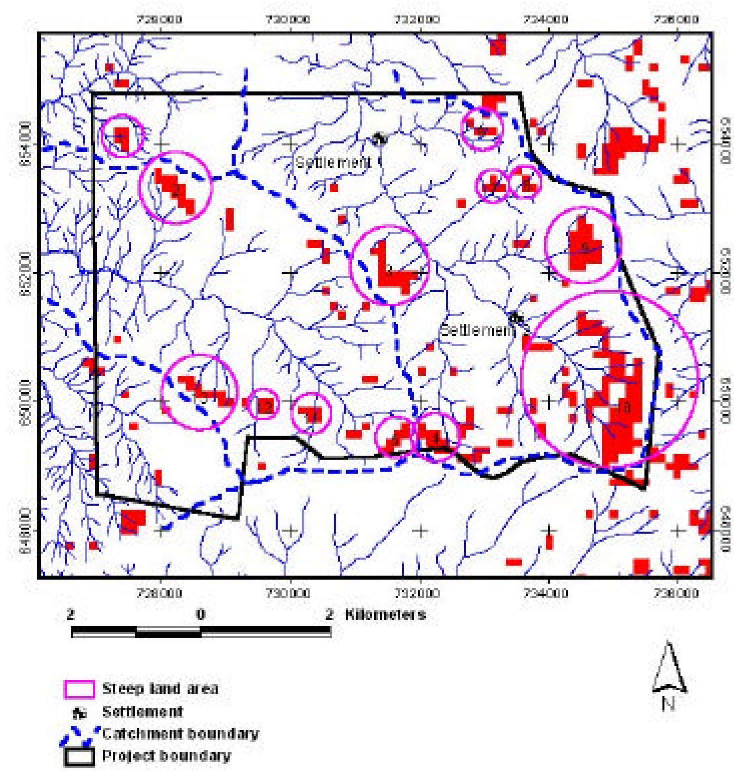


Figure 4.1 Identified high risk erosion / steep land areas

Exclusion of high-risk soil erosion areas

- The high-risk soil erosion area to be clearly mapped in the EIA report
- The identified high-risk soil erosion areas to be demarcated in the field (e.g. red or yellow paint) within two months of signing the Agreement of Environmental Conditions
- GPS waypoints for the demarcated area to be provided
- If it is proposed to excise an area then an *estimate of lost revenue* should be made.

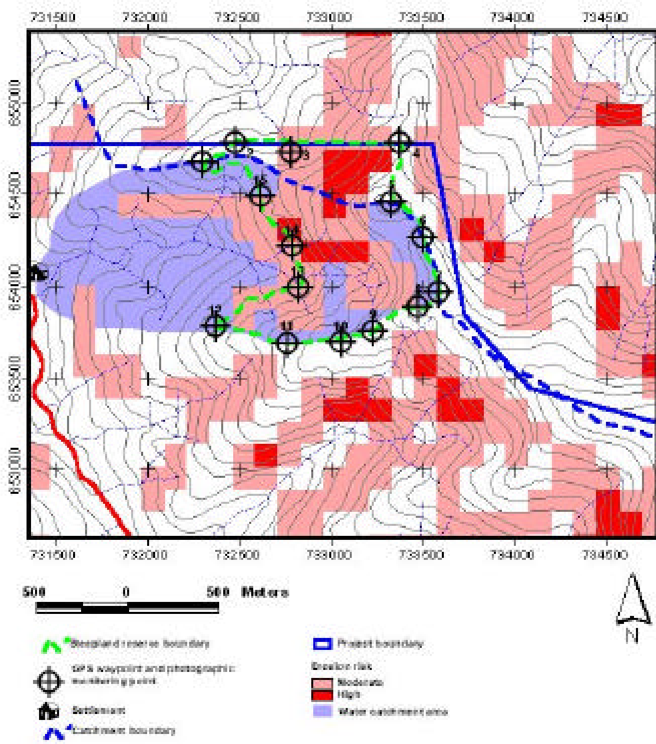


Figure 4.2 In this mitigation example it is proposed to exclude the upper part of a catchment, an area of high risk soil erosion coinciding with a catchment area, which is used to supply water by means of a gravity feed system. At intervals along the boundary, waypoint data is provided. The waypoint will later be used for photographic monitoring points.

Table 4.1 Example of GPS waypoint data for locating and demarcating steep land reserve

N4.76712	E116.92590	Point 1
N4.76900	E116.92423	Point 2
N4.76984	E116.92176	Point 3
N4.74087	E116.96955	P5A-NT
N4.74454	E116.96515	P5B
N4.74336	E116.97051	P5C
N4.74318	E116.88271	P6A
N4.73634	E116.88340	P6B
N4.73292	E116.88396	P6C
N4.74250	E116.91799	P7A
N4.75357	E116.91913	P7B
N4.76394	E116.92719	P7C
N4.76710	E116.92588	P 1-1

4.3 Key mitigation measure II: Provision of river reserves

In accordance with the Water Resources Enactment (1998), all permanent watercourses *more than 3 metres wide should maintain a river reserve of at least twenty metres from the top of each riverbank.* During logging operations or land clearance activities this should be adhered to at all times. However, river reserves that are identified as being of high importance must take this requirement one stage further by first clearly identifying the reserves on a map of proposed mitigation measures, and second, to translate this information to the field i.e. the reserves should be surveyed and clearly marked to assist and guide field operations. If it is unclear as to where the bank of the river is, river reserve measurements should be made from the point on the bank where permanent vegetation growth is present. Such areas shall be clearly mapped and described in the EIA report. Global positioning system (GPS) or other waypoint data of all proposed reserves are required. If it is not possible to access the site, coordinates defining the proposed boundary to be excised should at least be abstracted from the 1:50,000 base map (Figure 4.3).

Provision of river reserves

- The river reserves to be clearly mapped in the EIA report
- The identified river reserves to be demarcated in the field (e.g. red or yellow paint) within two months of signing the Agreement of Environmental Conditions
- GPS waypoints for the demarcated area to be provided

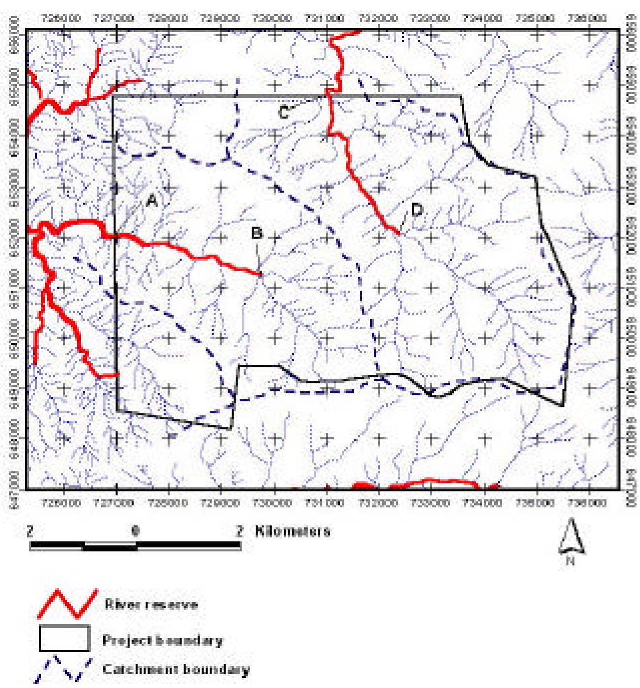


Figure 4.3 Rivers assessed as requiring a river reserve. In this example all fourth order rivers and above have been identified. Waypoint data for the start and finish of each riparian reserve section is required. For example:

River section A – B RSO coordinates = (727051, 652003) (729097, 651088)
River section C – D RSO coordinates = (731751, 654945) (732909, 652088)

The width of the river reserves proposed should be at least 20 m, but might be wider depending on elevation contours, landscape and the provision of protection for flora and fauna protection.

The purpose of maintaining river reserves along rivers is to minimize the amount of sediments entering the river system, to minimize erosion of riverbanks and to minimize destruction of riparian habitat. In addition the reserves maintain an aesthetic value and provide cover for some wildlife. The implementation of river reserves and protected steep areas will also help protect the hydrological environment.

No trees are to be felled within the river reserves. Trees immediately outside the river reserves must be felled in a direction away from the reserve. Machine access is prohibited in the river reserve, except for the specifically assigned road routes.

The same regulations apply during conversion activities as some of the physical impacts of clear-cutting can be minimised by the provision of buffer zones along riverbanks, streams, adjacent conservation areas and roads.

Zoning activities like hill and river reserves which may result in the loss or limitation of development opportunities will need to consider the economic implications of limiting the project i.e. volume of timber lost, productive land lost and may warrant an additional economic assessment (Table 4.2).

The overall availability of commercial forest is controlled by the status of the land while the specific location of projects is largely determined by forest availability and type. However, there does remain some flexibility as to the location and size of operations. This is particularly so within Forest Management Units that allow for the zoning of different forest activities within the unit. Zoning may be based on the integrated overlay assessment

Irregular terrain may complicate demarcation of the reserve strip in the field, particularly for smaller rivers in steeper terrain but any proposed reserve must be clearly identified and maintained. At no time must a vehicle or tractor enter a riparian reserve or cross a perennial stream unless provision to do so has been made i.e. culvert or bridge.

Table 4.2 An indicative estimate of land area excised for provision of river reserves in Sabah

Concession size	Length of rivers	Percentage land area excised
970 hectares	8 km	32 hectares

4.4 Key mitigation measure III: Reducing impacts on settlements

A number of adverse impacts on human settlements may result from logging and forest clearance activities. The most important and common issues that may require mitigation are:

Securing potable water supply

Water supply problems must be mitigated through, for example, conservation and exclusion of specific water catchment areas (Figure 4.4), strict adherence to specified reducing impact logging procedures in clearly demarcated water intake areas or by providing alternative sources of water supply e.g. rainwater storage tanks.

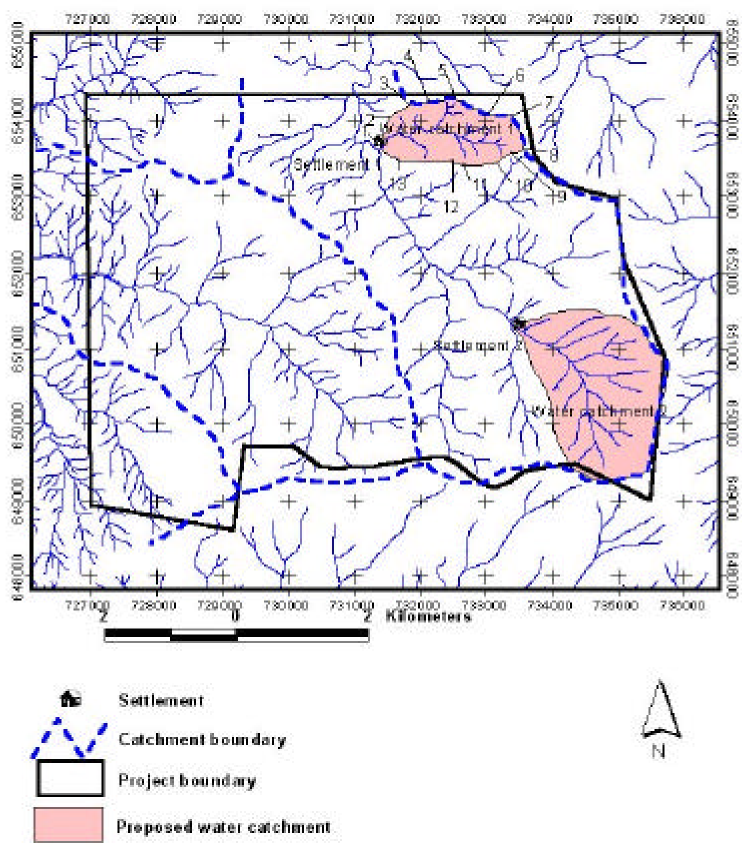


Figure 4.4 Identification of water supply catchments. For this example Waypoint/GPS locations have been identified for water catchment 1 (See also Figure 4.2)

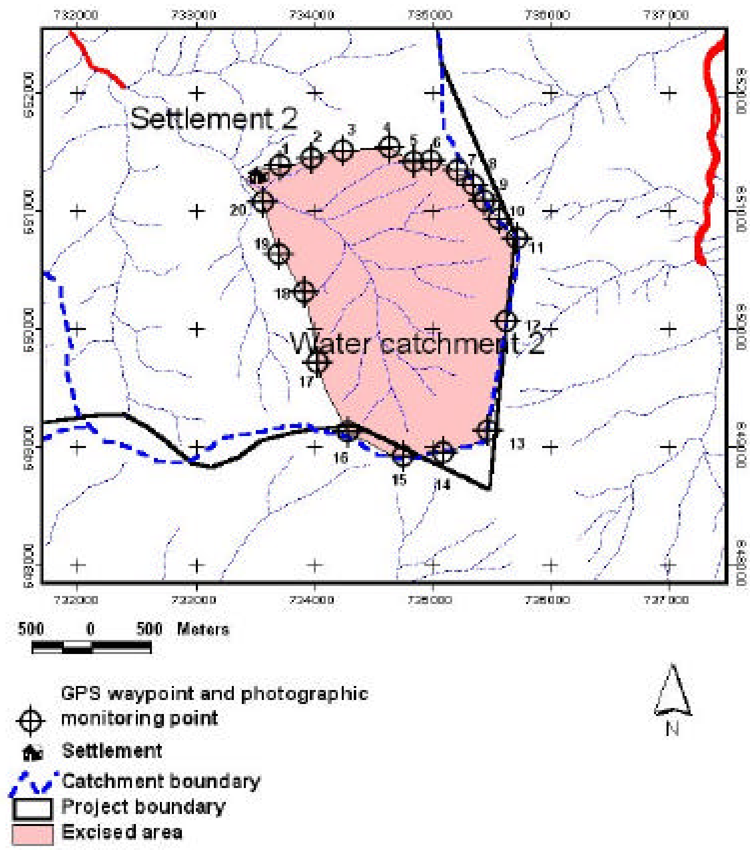


Figure 4.5 Waypoint/GPS locations for water catchment 2 (See Figure 4.4).

Estimated costs for securing potable water supply to affected settlements should be stated. If tanks are proposed, the number of tanks and intended recipients should also be detailed

Reducing dust and noise problems

Dust and noise problems related to road construction, operation and traffic should be mitigated by limiting or rerouting traffic movements. If this is proposed as a mitigation measure then detail on how this is to done and who will be responsible is required. If installation of speed bumps is proposed the specific location should be given alongside estimated costs. If it is proposed to spray water on roads to reduce dust, a schedule and conditions for implementation e.g. spraying to start after 3 days of no rain as recorded at xxxxxxx, should be proposed, alongside detail as to how the operation will be implemented e.g. where will the water be taken from.

4.5 Integrated analysis and assessment

An assessment could be made and sensitive sites prioritised by considering multiple impacts and by integrating concerns, i.e. a combination of physical, ecological and social factors. Disturbance of a site that will result in multiple impacts would necessarily receive more attention than a single impact alone. If an extensive area of steep land coincides with other environmentally sensitive sites, i.e. as identified in the overall integrated assessment e.g. water catchment areas, rivers that require the establishment of reserves or ecologically important areas, then this could be highlighted (Figure 4.6). In such instances, it is better to demarcate an area on the basis of water catchments units or sub-units. In the field it is often easier to identify and demarcate a catchment boundary compared to identifying specific steep areas or river reserves.

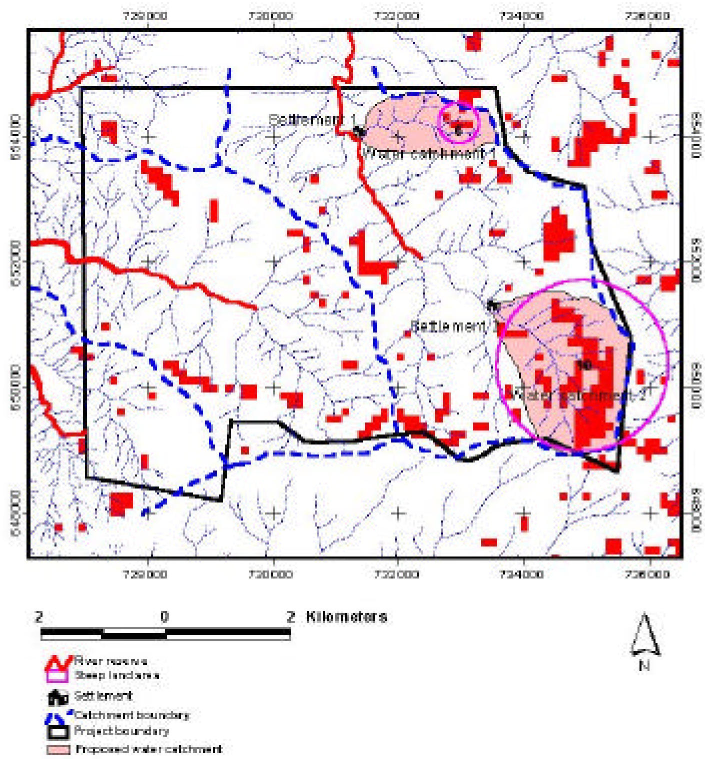


Figure 4.6 An integrated assessment to further refine the identification of key steep land areas (circled above).

4.6 Additional mitigation measures

In addition to the above listed key mitigation measures that should be assessed and described in detail, proposals in relation to the following mitigation measures might be included in the EIA study depending on the initial site specific assessments done during the scoping phase and the subsequent Terms of Reference.

Additional I - protection of rivers not having river reserves

Buffer zones of 20 or more meters for rivers not having river reserves (as described above) should be provided. Specific restriction for logging activities in the buffer zones should be given. This could for example include that :

- Tress shall be felled in a direction away from the river
- Machine access shall cross by the shortest possible distance
- River crossing bridges/culvert structures shall be constructed to minimise impacts on the river and surrounding vegetation
- All debris shall be removed if a tree has been inadvertently felled into a watercourse without disturbance to the river banks
- Skidding along rivers shall not be allowed.

Additional II - phased logging and forest clearance

In order to reduce the magnitude of soil erosion at any one time and to provide some form of protection for wildlife, phased logging and scheduled siting of annual clear-cut sites should be exercised for large scale projects.

The *conversion to other land use*, for example oil palm plantations or industrial tree plantations, normally takes place immediately after the forest clearance and clear-cutting operations. However, if there is a prolonged period from the time of forest clearance to the time of establishment of the new land use, then the adverse environmental impact of the forest clearance activities will increase and often cause long-term environmental problems in relation to, for example, soil erosion and water pollution.

The forest conversion schedule should minimise the time between logging, conversion and planting, thus minimising the period of exposure and increased erosion risk. Large exposed areas should be re-vegetated with fast growing species. The use of ground cover plants to reduce soil erosion has long been a practice in commercial plantations. Ground cover not only protects against soil erosion but if leguminous plants are used they may also enrich the soil through their nitrogen fixing abilities.

A phased forest clearance and replanting plan, where specific sections are clear-cut and replanted before new areas are clear-cut and replanted will reduce soil erosion and water pollution problems.

Phased logging could for example be done through carrying out logging in blocks progressively on one side of the river before proceeding to the next.

Phased logging and clearance can also *support wildlife protection* through scheduling in a manner that supports the requirement that as new areas is harvested, wildlife is given adequate opportunity to escape and seek refuge in a nearby-uncut area. The schedule and siting should provide adequate escape routes (see for example Figure 4.7).

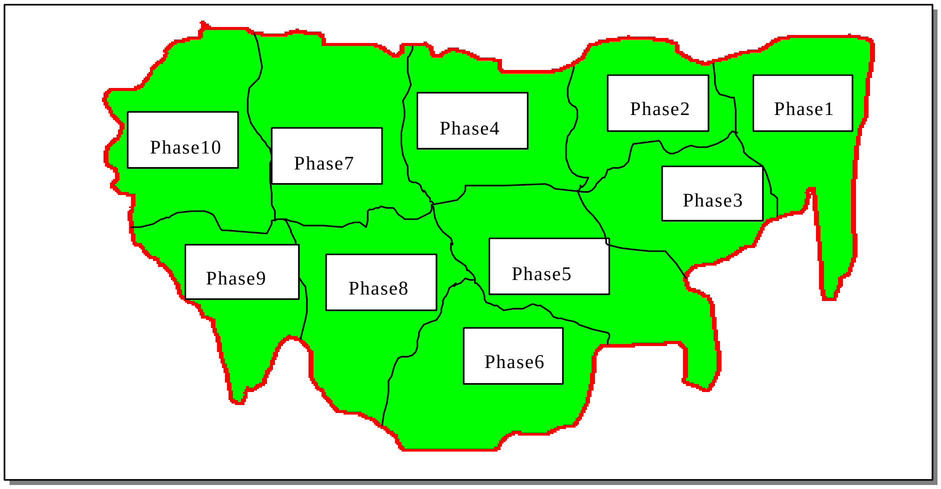


Figure 4.7 Example of scheduling and siting of logging activities

Additional III - reducing the land area disturbed

They key mitigation measure of reducing the area of disturbed land may be achieved by planning and limiting the density of roads, skid trails and landings. The total area occupied by roads, skidding trails and landings should *not exceed 12 per cent of the unit area being worked or annual allowed cut.*

Main roads, secondary roads and skid trails. The existing or planned road structure should be assessed in relation to environmental impacts, and a proposed main road structure should be given. Requirements for secondary roads and skid trails could be given. The proposed road structure and requirements could for example include:

- The use of existing main roads, secondary roads and skid trails, thereby reducing the creation of new exposed areas
- If old roads are upgraded or new roads constructed, no pushing of soil towards river banks
- Main and secondary roads not having a width of more than 6 m
- Cutting and filling shall be kept to a minimum to reduce the exposure of bare soil and its potential to erode
- Provision of proper maintenance of main and secondary roads in relation to road surface, roadside ditches, cross drains and road river crossings. Continuous application of aggregate cover in order to minimise soil erosion and allow traffic during bad weather
- Skid trail width not exceeding 4 m.

Landings and campsites. The existing or planned landing and campsite structure should be assessed in relation to environmental impacts, and a proposed landing and campsite structure should be given. The proposed structure and requirements could for example include:

- Reuse of old landings and campsites
- Location of new landings and campsites in low erosion risk areas
- Size of landings to be kept at maximum 0.2 ha (30 x 60 m), and campsites not exceeding for example 0.4 ha (60 x 120 m) in size

- Location of landings and campsites at least 20 m from rivers
- Diversion of runoff from landings and campsites to vegetated areas and not directly to rivers.

Table 4.4 Indicative rates of machine hire in relation to improved RIL working practices

Machines/operator/control measures	Unit	Rates (RM)
Bulldozers / tractors	hr	175 to 250
Excavator	hr	90 to 150
Sawyer & chainsaw	day	50 to 80
Cross-drains	piece	30 to 50
Landing re-shaping / ripping	hr	130 to 175
Reduced Impact Logging costs (planning + supervision)	ha	130 to 160

Additional IV - provision of buffer zones, corridors and protected area management

If a detailed ecological survey was undertaken as part of the EIA study and the area was assessed as being ecologically significant, then based on the results, decisions should be made as to whether an area should be excised for protection or zoned for limited activities (See for example Figure 4.8).

When this is considered necessary, activities should be closely coordinated with the Wildlife Department and other relevant authorities.

If the assessment concludes that additional protection should be given to the area or that the area is proposed for protected area status then the mitigation proposal should state:

- Reasons for protecting the area (species/habitat present and status)
- Management options for the protected area
- Who will manage the protected area (i.e. does the licensee have to safeguard the protection of these areas, especially from fire, illegal encroachment, illegal hunting etc.)
- Proposed legal status of the protected area.

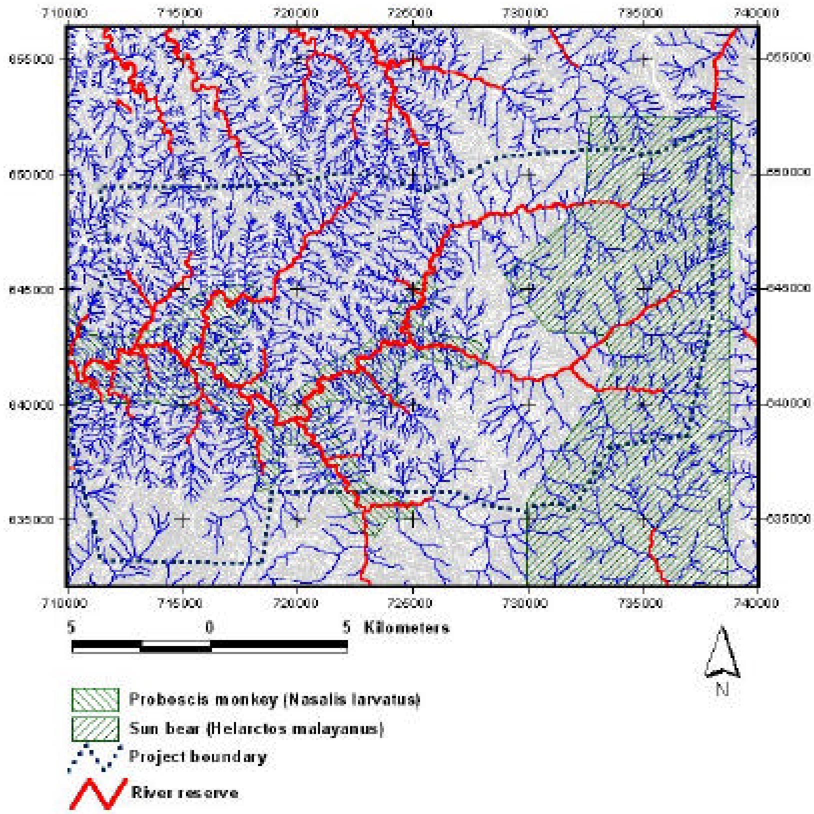


Figure 4.8 In this example the habitat of the Proboscis monkey (Nasalis larvatus) coincides with the river reserve. The ensure the conservation of Nasalis larvatus it could be further proposed, for example, that the river reserve be extended to 500m on either side of the river.

If an area is afforded some form of protected area status, to remain v iable it must fall under a management authority and some form of jurisdiction. Continued and successful protection of the area will then ensure the benefits of protecting the area in the first place.

Additional V - wildlife management

If deemed necessary from the assessment, the provision of escape routes and corridors to adjacent habitat systems must be enforced. Conservation of adequate, contiguous and suitable habitat may provide a sanctuary to support animals that are forced to temporarily leave the operations site.

Other wildlife management mitigation measures that may need to be considered include:

- Access restrictions, for example road blocks
- Camp management, including the use of the Wildlife Departments warden system
- Relocation of endangered wildlife species needs to be exercised
- Prevent wildlife poaching by providing awareness campaigns
- Providing long-term employment of affected villagers.

There are some indications that either electrified fencing or the construction of trenches or ditches, are able to prevent elephants from entering plantations, however, to remain effective they both require continuous maintenance (Plate 4.2).

Plate 4.2 A two-meter deep ditch separating recently planted oil palm plantation (left) from secondary forest.

It should be noted that protected areas and patches of forest often perform other useful services, for example, protecting neighbouring agricultural areas by reducing the flood hazard. Moreover, many wild species resident in the protected areas are important to the well being of the surrounding agricultural lands. Birds may help control levels of insects and rodent pests. Various species of vertebrates and insects perform vital fertilisation functions and bats control insects and pollinate many tropical fruits. However, some species may be less beneficial as they move out of reserves, often under increased and considerable pressure due to shrinking habitats, into agricultural lands where they may become a serious nuisance. Some measure of control is often needed and it is important that the protected area management authority is involved. Inappropriate control measures can pose a serious threat to protected wild populations. In particular, any use of poisons must be carefully monitored to prevent their spread through the waterways and food chains

The spread of fire into protected areas from deliberately burned fields and the invasion of protected areas by exotic species, domestic animals and by man himself are threats to reserves. These further underline the need for the protected areas management authority to develop close links with neighbouring land users to avoid negative interactions and to settle any problems that may arise.

Additional VI - fire prevention

Formulation and implementation of a fire management plan to prevent fire hazard based on detection and suppression.

Undertake prescribed burning in areas where no other option is available and solely for the purpose of forest debris that may pose as fire hazard during dry season.

Additional VII - resolving landownership issues

Landownership problems might be resolved through, for example, mitigation measures that will lead to a reduction in the cause and magnitude of land ownership conflicts and disagreements or to resettlement of people that have become landless as a result of the logging or conversion activities

Additional VIII - proper waste handling

Provision of proper sewage facilities for staff and implementation of effective storage and disposal of hazardous materials such as used lubricants from the workshop.

Additional IX - provision of alternative income generating activities

Problems related to the disruption of traditional income generating activities might be mitigated through for example employment of people that has or will experience a reduction in income.

Additional X - preservation of landscape and ecotourism opportunities

Landscape problems might be mitigated through, for example, conservation of specific scenic or valuable landscapes e.g. waterfalls, rocky streams, flat riverbanks for picnics, hills with views, plateaus with hills, scenic lookouts, wildlife, rare plants, scenic forest stands, geological formations, archaeological sites, culture heritage sites.

Additional XI - staff training

Adverse environmental impacts can only be minimised through the adoption of appropriate work procedures. Therefore most of the above measures required to mitigate physical impacts require improved planning and implementation. For this to happen, decisions have to be effectively conveyed to the field crews. It may therefore be necessary to designate and train specific members of the field crew to participate in pre-logging planning and general co-ordination of field activities.

It is important to stress that project proponents will be held responsible for the implementation of recommended mitigation measures, also in cases where contractors are used for the actual logging and forest conversion activities.

Additional XII - abandonment

Orderly removal, rehabilitation and stabilisation of all structures put up by the Project Proponent should be carried out, and proposals for this should be given in the EIA report.

4.7 Secondary rehabilitation activities

In circumstances where it is not possible to mitigate or fully mitigate an impact, mitigation measures can be employed off site to reduce the severity of the impact. The following additional complementary mitigation measures could be considered:

Improvement of aesthetic values

Aesthetic degradation occurs when large areas of forest are logged and cleared. In this respect, additional mitigation measures may be required in scenic areas or sites nearby tourism destinations. The leaving of appropriate buffer zones may be necessary.

Local road improvement scheme or impact of road

Transportation activities between the project site and processing site may utilise local or village roads and the impact of high frequency use of heavy vehicles must be monitored and an appropriate inspection and maintenance schedule implemented by the project proponent.

Table 4.5 Indicative rates for selected civil works in Sabah

Control Measures	Unit	Rates (RM)
Crushed aggregate road base	m^3	50 to 100
Supply, lay and compact double bituminous surface dressing on the prepared road base	m^3	15 to 30
Walling of 100 m diameter *bakau* piles 6 m long	m/run	350 to 400

5 Monitoring

What type of environmental monitoring is required?

Steps	***Activities***	***Issues***
Step 1	Assessment of impacts	
Step 2	Mitigation measures	
Step 3	Monitoring	Environmental monitoring includes: • Compliance monitoring • Impact monitoring.

This chapter includes the following:

- Recommending key monitoring requirements to ensure compliance of the recommended mitigation measures
- Recommending key residual environmental impacts to be monitored, including identifying baseline data required for effective evaluation of the project's impacts.

5.1 Compliance monitoring

The ECD requires that compliance monitoring is afforded high priority, and as such, the suggested mitigation measures should be practical to implement and easy to monitor.

The overall objective of compliance monitoring is to employ relatively easy and economically viable methods to check the compliance of mitigation measures. Therefore, the EIA report must design in detail a compliance-monitoring programme for all key proposed mitigation measures. The EIA report should include the first data set for monitoring compliance e.g. photographs of existing river reserves, GPS reading and location map indicating where photographs were taken.

The following are examples of monitoring requirements that could be considered in relation to the key mitigation measures.

A. Exclusion of high-risk soil erosion areas

- The high-risk soil erosion areas identified in the assessment, with proposed mitigation measures, to be clearly mapped in the EIA report
- GPS waypoint data used for demarcation as proposed under mitigation measures to be provided (Figure 5.1)
- Self-monitoring to include submission to the ECD of, for example (i), a description of works undertaken in relation to protection and demarcation of the high risk soil erosion area, (ii) a map at the largest available scale showing the actual demarcated area, and (iii) pictures of the demarcation as per map in the EIA report, from at least five different locations (locations to be indicated on map)
- Schedule to follow up site visits to provide updated information on the above. This should include at least a midterm and end of project compliance report.

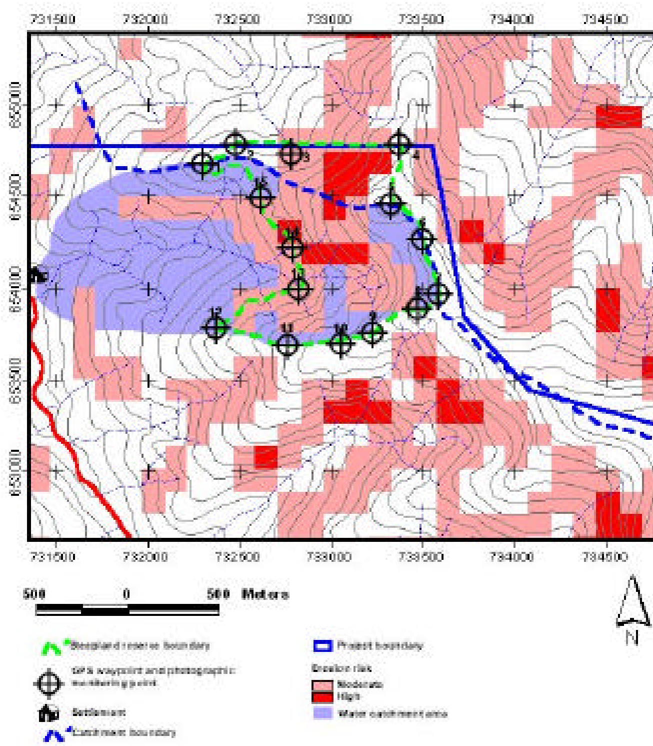
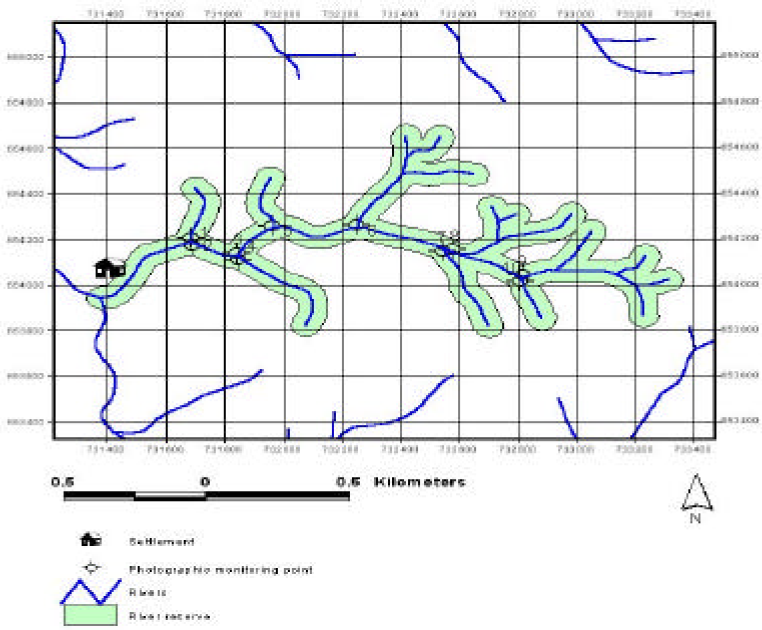


Figure 5.1 Compliance monitoring locations for the proposed mitigation measures (refer also to Figure 4.2)

B. Provision of river reserves

- The river reserves to be clearly mapped in the EIA report
- GPS waypoints for the demarcated area to be provided
- Self-monitoring to include submission to the ECD of, for example (i), a description of works undertaken in relation to protection and demarcation of the river reserves, (ii) a map at the largest available scale showing the actual demarcated area, and (iii) pictures of the demarcation as per map in the EIA report, from at least five different locations (locations to be indicated on map – Figure 5.2)
- Schedule two follow up site visits to provide updated information on the above. This should include at least a midterm and end of project compliance report.



Photographic monitoring	X coordinate (RSO)	Y coordinate (RSO)
1	731682.04	654223.74
2	731692.33	654172.31
3	731846.63	654141.45
4	731849.20	654108.02
5	731967.5	654262.32
6	732255.53	654264.89
7	732548.76	654151.74
8	732579.56	654159.49
9	732818.72	654048.87
10	732813.58	654015.44

Figure 5.2 Example of map used to plan river reserve compliance monitoring activities.

Irregular terrain may complicate demarcation of the reserve strip in the field, particularly for smaller rivers in steeper terrain but any proposed reserve must be clearly identified and maintained. At no time must a vehicle or tractor enter a riparian reserve or cross a perennial stream unless provision to do so has been made i.e. culvert or bridge.

C. Adverse impacts on human settlements, e.g. water supply

- Self-monitoring to include submission to the ECD of, for example, a description and map of mitigation measures implemented to secure continued supply of drinking water
- Schedule two follow up site visits to provide updated information on the above. This should at least include a midterm and end of project compliance report.

D. Examples of monitoring of other areas

Campsites and oil storage locations in the first instance should be self-monitored, which would require submission to ECD of maps and pictures of the actual and/or planned campsites and oil storage locations. The maps and pictures should indicate (i) whether the sites are new or old (reused), (ii) the size of the areas used and (iii) the distances to the nearest rivers. Two follow up site visits should be scheduled to provide updated information on the above. This should at least include a midterm and end of project compliance report.

Monitoring techniques. Compliance monitoring will be undertaken primarily by means of the techniques listed below:

Photographs. Photographs to provide evidence of the implementation of the recommended mitigation measures. Photographs could, for example, be used to verify compliance with

- Provision of hill/steep land reserves
- Provision of river reserves
- Reducing the land area disturbed
- Reducing the time of soil exposure after disturbance
- Landscape and eco tourism preservation
- Flood hazard mitigation
- Reducing dust and noise problems.
- Provision of buffer zones, corridors and protected area management
- Wildlife management, for example elephant ditches
- Fire prevention
- Proper waste handling
- Phased clearance and replanting.

When photographs are submitted for compliance monitoring, the exact location should be clearly marked on a map together with a GPS reading and a direction bearing. The date and time shall be noted.

Field checks. Periodic field checks at appropriate stages of the operation should be undertaken in order to ensure compliance of e.g.

- Provision of hill/steep land reserves
- Provision of river reserves

- Reducing the land area disturbed. For example, may a condition like "*allowable exposed area is 12 per cent of the net logged area*" be measured in the field by means of a GPS (or by abstracting measurements from a r emotely sensed image, see above)
- Reducing the time of soil exposure after disturbance
- Improved working practices/management procedures
- Resolving landownership issues
- Provision of alternative income generating activities
- Landscape and eco tourism preservation
- Maintaining potable water supply
- Flood hazard mitigation
- Reducing dust and noise problems
- Provision of buffer zones, corridors and protected area management
- Wildlife management
- Proper waste handling
- Phased clearance and replanting.

Impact statements concerning affected settlements. Periodic statements, in written or oral form, from affected settlements can be used to check compliance of for example

- Provision of hill/steep land reserves
- Provision of river reserves
- Resolving landownership issues
- Provision of alternative income generating activities
- Maintaining potable water supply
- Reducing dust and noise problems.

Satellite images. Larger projects or projects nearby sensitive sites, might be required to utilise satellite imagery taken at various stages during the life cycle of the project to monitor compliance i.e. implementation of mitigation measures such as

- River reserves
- Hill/steep land reserves
- Other designated protected zones.
- Percentage area of exposed soil and vegetated zones.
- Provision of buffer zones, corridors and protected area management
- Phased clearance and replanting.

All requirement laid down in the Agreement of Environmental Conditions, which is possible to check through the use of satellite images, as for example the above, will be overlain on the image to check for compliance.

If satellite imagery is used, a compromise has to be made between cost and spatial resolution. An appropriate imagery would be SPOT as it has a resolution of 20 metres for multispectral images and 10 metres for panchromatic. The land area covered by a full SPOT image is 60km x 60km

Normally two satellite images will be required: One before initiation of the project and one (or two or more for large scale projects) at the near end of the project activities (Plate 5.1).

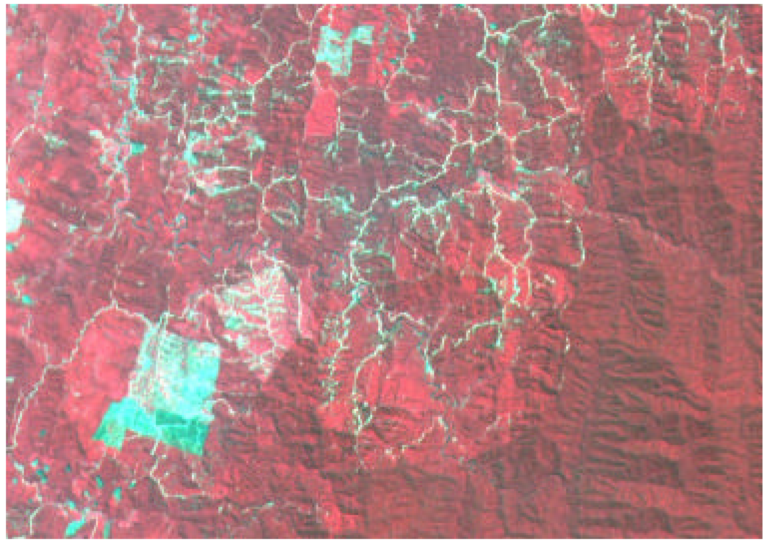


Plate 5.1 This SPOT image shows undisturbed forest (far right) and logging roads and skid trails (centre and above). The bright area left of centre represents an area that has been clear felled.

Table 5.1 Approximate costs as of September 2000. If the image is purchased overseas, costs will also vary with exchange rates

Description	Unit Price (RM)
SPOT Scene in level 1B Multi-spectral (XS) Full scene / Quarter scene 60km x 60km or 30km x 30 km	8,580
SPOT Scene in level 1B Panchromatic (P) or Multi-spectral (XI i.e. SPOT 4) Full scene / Quarter scene 60km x 60km or 30km x 30 km	11,440

Scheduling and responsibilities. As the EIA covers the entire project period as opposed to annual logging or clear cutting activities, the need for images and other monitoring requirements should be planned accordingly. The monitoring programme should be formulated in advance, by the EIA consultant in collaboration with the ground operator in accordance with the schedule of operations, and be approved by ECD through the Agreement of Environmental Conditions.

The EIA should clearly state the responsibilities and actions to be taken in relation to compliance monitoring:

- Allocate institutional/administrative responsibilities for planning, management implementation and monitoring of the environmental requirements
- Allocate responsibilities to execute mitigation measures, including the detailed design of the mitigation measures.

Non-compliance will normally be followed by the issuance of an Order to comply and a simultaneously and immediate compounding of the non-compliance offence according to the Compounding of Environmental Offences Rules, 1999, ECD.

Penalties for not complying with the mitigation measures should be spelt out.

5.2 Impact monitoring

Water quality sampling and monitoring – Logging and forest clearance activities

Due to the complexities associated with sampling for suspended sediment in water and the accompanying difficulties of interpreting the data, alongside the lack of suitable mechanisms to effectively mitigate for sediment pollution in streams once sediment has been mobilized from the erosion source, unless specifically requested, an EIA for logging and forest clearance activities does not require water quality monitoring.

In line with other baseline monitoring requirements, the rationale for monitoring needs to be clearly identified. If mitigation measures cannot be linked to the impact, then there is little point in monitoring the impact. In forestry projects mitigation for soil erosion after the physical impact is not possible. It is therefore imperative that the focus remains on ensuring that appropriate soil erosion mitigation measures are effectively implemented and to monitor for compliance of such measures.

The key water quality parameter of concern associated with logging and forest clearance projects is the increased supply of total suspended solids – largely in the form of suspended sediment. Other water quality parameters are not significantly affected by logging or forest clearance activities and therefore do not require monitoring.

The concentration of suspended sediment in rivers is largely controlled by:

(i*) Hydraulic factors* - the faster the river flow the greater the amount of sediment that can be transported as the water has more energy to carry more and larger particles, therefore during floods, large volumes of sediment can be mobilised. Very little sediment is transported under non-flood conditions. For example, a flood event on a single day, 19 January 1996 on the Sg. Segama (721 km^2) removed more sediment than the combined annual totals of the 3 previous years (Douglas *et al*., 1999). These results are in accordance with other studies around the world which indicate that most of the total sediment load is transported during only 5 per cent of the time.

(ii*) Supply factors* - within an undisturbed forest site the supply of available sediment may be quickly exhausted. If there has been a period of little or no rain, available sediment may accumulate and the first flush may produce high volumes of sediment. However, a subsequent rain event of similar or greater magnitude may result in much reduced sediment concentrations as the sediment supply may have been exhausted. Following disturbance by logging, the number and range of potential erosion sites is greatly increased. Consequently the variability associated with suspended sediment concentration in water increases accordingly (Figure 5.1). Considerable lags between sediment arriving into the river system and erosion from the original site often occurs, which in turn causes additional variability (refer also to section 3.2).

Therefore*, in order to characterize the water quality of a river, many samples have to be taken over a wide range of flow and hydrometeorological conditions. A few random samples provide little useful information*. Even when water samples are taken at similar water levels, values may vary greatly due to differences in rainfall intensity, the number of days since the last flood event, the magnitude of the last flood event and the spatial distribution of rainfall within a catchment. A representative sampling programme therefore requires the dedication of resources and time that are out of proportion to the resources and time available for most EIA studies.

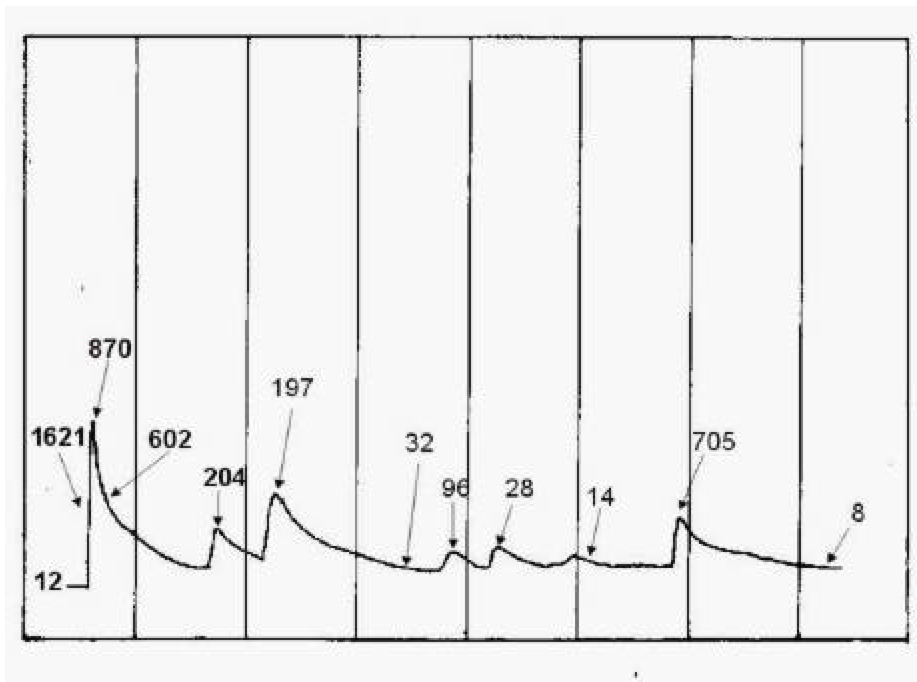


Figure 5.1 *A weekly water level chart for Sg Steyshen Baru, Ulu Segama (0.5 km^2), with each vertical line marking a 24 hour division). The numbers values of suspended sediment concentration in mg/L and the arrows point to the time and water level at which point the sample was taken. The horizontal trace represents recorded water level with the vertical axis representing water level height. The water level trace starts at 10.00am on a Monday and the measured suspended sediment concentration is 12 mg/L. At about 2.00 pm, in response to a heavy rain event, the water level rises sharply before gradually falling over the next 24 hours. At one point on the rising stage of the flood, suspended sediment levels reached 1621 mg/L. At the flood peak, concentrations have already declined to 870 mg/L suggesting that the supply of sediment was limited. At exactly the same water level on the falling stage, 602 mg/L was recorded. The following day, a small flood event peak recorded suspended sediment levels of 204 mg/L. However, the day after, during a higher flood peak, only 197 mg/L was recorded, again suggesting that the sediment supply was exhausted. This example illustrates that even within a small-forested catchment, variation in water quality in the form of suspended sediment is considerable and difficult to characterize. In larger catchments with more complex sediment supply issues as a result of different land uses upstream, the situation becomes even more complex.*

Summary - water quality impact monitoring. When conclusions are drawn from a few unrepresentative samples it is difficult to establish cause-effect relationships, which makes decision-making difficult and compromises the professional capacity of the d ecision makers i.e. poor data leads to poor decisions.

If sediment data or other water quality data is required i.e. for reasons outside the requirements for the EIA, then the parameters to be sampled for require careful consideration and for financial reasons need be fully justified. All monitoring programmes require careful planning and design and must be carried out in accordance to professional procedures e.g. Institute of Hydrology, UK (Bolton, 1983 and Herschy, 1985). Since suspended sediment and most other parameters vary with water discharge, samples must be taken with reference to a river height datum (stage) or discharge measurement. To facilitate this a permanent monitoring station should be established with a stage fixed in a permanent position. Alternatively, sampling should take place at an already established gauging station e.g. Department of Irrigation and Drainage. Even then the limitations of the data should be acknowledged as sediment concentrations will also vary depending on whether or not the sample was taken on the rising or falling flood stage of flood height.

As the overall concentration of sediment varies through the water column i.e. higher concentrations are found nearer the river bed, sample collection needs to sample equally all parts of the water column, requiring the use of some form of integrated depth sampler e.g. U.S.D.H 48 integrated depth sampler. Similarly, the cross section of the river needs to be sampled representatively.

Flora and Fauna

It may be necessary for wildlife management reasons to monitor species or community trends, particularly for projects impacting species that many come into conflict with neighbouring land-users e.g. elephants.

Monitoring frequencies

Frequencies of monitoring depend upon the timing and schedule of project activities.

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