Guidelines for Minimising Impacts of Oil Palm Plantations and Palm Oil Mills on Quality of Rivers in Sabah

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GUIDELINES FOR MINIMISING IMPACTS OF OIL PALM PLANTATIONS AND PALM OIL MILLS ON QUALITY OF RIVERS IN SABAH

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FOREWORD

The 'Guidelines for Minimizing Impacts of Oil Palm Plantations and Palm Oil Mills on Quality of Rivers in Sabah' has been produced by the Environment Protection Department, Ministry of Tourism, Culture and Environment, Sabah, as part of the project on 'Impact Study of Palm Oil Mills, Oil Palm Plantations and Other Pollutants on the Quality of Selected Rivers in Sabah', which focused on five rivers in Eastern Sabah.

These guidelines aim to provide guidance to government agencies, the oil palm industry and relevant stakeholders on how to minimize impacts on rivers by the Oil Palm Sector and subsequently enhance the water quality of rivers in Sabah. These guidelines take a multi-pronged approach and tackle issues on regulatory/institutional requirements, development planning/site selection, Best Management Practices (BMPs) for both oil palm plantations and palm oil mills as well as monitoring and stakeholder relations. The best management practices promoted are based on industry experience throughout Malaysia and elsewhere over the past 30 years. We believe that the implementation of best management practices will not only minimise pollution but will also enhance performance and productivity of the plantations resulting in a win-win situation.

I would like to record my gratitude and appreciation to all agencies and individuals for their invaluable contribution and continued support.

Yabi Yangkat
Director of Environment Protection Department, Sabah
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<tr>
<td>ACLR</td>
<td>Assistant Collector of Land Revenue</td>
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<td>ADP</td>
<td>Agricultural Development Plan</td>
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<td>AEC</td>
<td>Agreement of Environmental Conditions</td>
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<td>Al</td>
<td>Aluminium</td>
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<td>AN</td>
<td>Ammoniacal Nitrogen</td>
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<td>ASMC</td>
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<td>CDM</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
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<td>COD</td>
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<td>Continuous Stirred Tank Reactor</td>
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<tr>
<td>Cu</td>
<td>Copper</td>
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<tr>
<td>DID</td>
<td>Department of Irrigation and Drainage</td>
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<tr>
<td>DO</td>
<td>Dissolved Oxygen</td>
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<td>DOA</td>
<td>Department of Agriculture</td>
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<td>Department of Environment</td>
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<td>Environment Conservation Department</td>
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<td>EFB</td>
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<td>Ethylene Propylene Diene Monomer</td>
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<td>EQA</td>
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<td>ESA</td>
<td>Environmental Sensitive Area</td>
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<td>ESS</td>
<td>Effluent Suspended Solids</td>
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<td>PPB</td>
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<td>Power Take-Off</td>
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<td>R &amp; D</td>
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<td>RAS</td>
<td>Return Activated Sludge</td>
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<td>Roughing Filter Solid Contract</td>
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<td>Use and Standard of Exposure of Chemical Hazardous</td>
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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter provides background information on the oil palm industry (plantations and mills) and its impacts on river water quality. It discusses key findings from the “Impact study of Palm Oil Mills, Oil Palm Plantation and other Pollutants on the Quality of Selected Rivers in Sabah” which focused on 5 rivers in Eastern Sabah (Muanad, Segaliud, Kalumpang, Pang Burong and Segama). These guidelines were produced as a standalone document, which is one of the deliverables of the overall project mentioned above. These guidelines aim to provide guidance to government agencies, the oil palm industry and relevant stakeholders on how to minimize these impacts and subsequently enhance the water quality of rivers in Sabah.

The objectives of these guidelines are as follows:

- To guide government agencies in monitoring and minimizing the impacts of the oil palm industry on river water quality;

- To guide the oil palm industry in sustainably managing plantations and mills to minimize pollution in rivers, as well as promoting self-regulation; and

- To guide and inform stakeholders on existing policy, guidelines, regulations and BMPs to minimize pollution from the oil palm industry on water quality of rivers. It must be emphasized compliance with these guidelines does not itself confer any immunity from legal obligations.

The following chapters provide some guidance on how to minimize impacts of the oil palm industry on river water quality. These guidelines take a multi-pronged
approach that tackles issues like regulatory/institutional requirements, development planning/site selection, Best Management Practices (BMPs) for both Oil Palm Plantations and Palm Oil Mills as well as monitoring and stakeholder relations. Brief descriptions of the following chapters are provided below:

- **Chapter 2 (Regulatory/Institutional Requirements)**
  This chapter elaborates on prevailing laws, regulations and guidelines, institutional frameworks and prevailing penalties if the laws are not complied with. It includes a summary of requirements related to:
  - The Sabah Land Ordinance 68;
  - Environmental Impact Assessments (EIAs);
  - Agricultural Development Plan (ADP) submissions;
  - Other laws, regulations and guidelines; and
  - It also highlights the role of different government agencies and other stakeholders related to the development and implementation of oil palm plantations and palm oil mills.

- **Chapter 3 (Development Planning and Site Selection)**
  From a sustainable development point of view, the process for land use planning and development needs enhancement at the State Government level, as well as by individual plantation companies. Although the Government has a vision for the conservation of the nation’s forest resources, the actual process for alienation of land for development, particularly for logging and plantation agriculture does not appear to be sufficiently effective. Besides economic considerations, typical assessments of land for oil palm cultivation have been based mainly on suitability of soil, terrain and climate. Development planning should be more holistic and take into consideration physical, environmental, social and financial factors; the interrelationship between these factors and selected evaluation criteria.

- **Chapter 4 (Best Management Practices for Sustainable Plantation Management)**
Being a well-established industry, the oil palm industry has a wide variety of established Best Management Practices (BMPs) focused on methods or techniques found to be the most effective and practical means in achieving successful plantations while making the optimum use of resources. Traditionally these BMPs focused on achieving good management and agronomic practices that contribute to high yields from estates but in recent years, BMPs have been developed to minimize environmental and social impacts of oil palm development.

- **Chapter 5 (Best Management Practices for Palm Oil Mill Operations)**
  Similar to Chapter 4 above, this chapter identifies and elaborates on a selection of BMPs targeting palm oil mill operations with the objective of reducing river pollution. The following BMPs take a 3-prong approach aimed at minimizing the impacts: 1) reducing POME, 2) improving POME treatment systems, and 3) improving pollution control of milling process.

- **Chapter 6 (Monitoring and Stakeholder Relations)**
  This chapter provides guidance on monitoring, use of appropriate technology and maintaining good stakeholder relations. Issues described include:

  - Public participation in monitoring (of the requirements to meet regulations and methodologies);
  - Monitoring of pollution parameters of POME treatment systems;
  - Monitoring work using appropriate technology (real time telemetry);
  - Self-regulation by plantations and mills; and
  - Good stakeholder relations.
1.2 BACKGROUND ON PALM OIL INDUSTRY

Malaysia’s palm oil industry is the fourth largest contributor to the national economy and currently contributed about 8 percent (RM1.889 billion) of the national GNI per capita. The industry spans the entire value chain from plantations (upstream) to downstream activities. As of 2009, Malaysia has a total of 4.70 million hectares of oil palm plantations and 416 palm oil mills (122 mills are located in Sabah). The industry is dominated by large plantation companies (private and government-linked) which hold 60 percent of total plantation land. Under the land ownership, the organized and independent smallholders account for 28 and 12 percent of the total area, respectively. Due to unavailability of suitable agricultural land, the potential expansion of oil palm in the future is quite limited. The expansion potential is estimated at a maximum of 1.3 million additional hectares of which 75 percent or 1 million hectares is located in Sarawak, while in Peninsular and Sabah, the planted area has only recorded marginal increases in recent years. The planted area with oil palm in Sabah in 2008 was at 1.33 million hectares, registering increases of 4.3%. Peninsular Malaysia accounted for 54% of the total planted area in the country with Sabah and Sarawak contributing the balance of 30% and 16% respectively (See Table 1.1 below).

Table 1.1: Malaysia Oil Palm Planted Area (ha)

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peninsular</td>
<td>2,362,057</td>
<td>2,410,019</td>
<td>2.03</td>
</tr>
<tr>
<td>Sabah</td>
<td>1,278,244</td>
<td>1,333,566</td>
<td>4.33</td>
</tr>
<tr>
<td>Sarawak</td>
<td>664,612</td>
<td>744,371</td>
<td>12.00</td>
</tr>
<tr>
<td>Total</td>
<td>4,304,913</td>
<td>4,487,956</td>
<td>4.25</td>
</tr>
</tbody>
</table>

(Source: Malaysian Palm Oil Association: Annual Report 2008)
The oil palm sector is a very important sector to Sabah’s economy. In terms of export earnings, this sector contributes more than 30 per cent of the total income from exports. In 1998, exports of palm oil reached a record of RM5 billion. Sabah is the largest producer of crude palm oil in the whole of Malaysia contributing about 25 per cent of the total production of crude palm oil in the country (Source: Sabah Institute Development of Studies (IDS), May 1999).

1.3 IMPACTS OF THE PALM OIL INDUSTRY ON RIVER WATER QUALITY

1.3.1 General Impacts: Oil Palm Plantations

Based on study findings (see following section on key findings), the palm oil industry has been identified as a contributor to river pollution. To better understand the impacts of the industry, the following are typical activities associated with oil palm plantation development (divided into six main stages) namely:

**Pre-development:** This stage involves feasibility studies, application/acquisition of land, preparation of EIA, and survey of boundary and plantation blocks.

**Nursery establishment:** Normally one ha of main nursery will cater for 10,000 seedlings and after culling (20%) and provisions for field supplying (5%), 7,500 will be available for field planting. At 136 palms/hectare, this will cater for a planting area of 55 ha. This stage will prepare high quality seedlings for field planting when the plantation proper site has been developed.

**Site preparation:** Existing vegetation is cleared and removed to enable land preparation (particularly terracing and drainage). Cover crops will be planted and maintained.

**Field establishment:** Field lining and holing will be carried out. Suitable seedlings from the nursery will be planted out in the field.

**Field upkeep, maintenance and harvesting:** Planted palm trees are maintained by regular manuring, weed management as well as the control of pests and diseases. Regular rounds of ablation and sanitation is carried out to remove inflorescences/young developing bunches during the immature phase up till 24 months from planting. Harvesting will normally commence between 26-30 months after field planting, depending on the growth and vigour of the palms.
**Re-planting/conversion:** After completion of the productive life span (25 to 30 years), decision will be made on either to replant or convert the land to other uses.

**Figure 1.1** further illustrates typical activities associated with oil palm plantation development. It is worthwhile to note that ‘Abandonment’ mentioned in the figure may not be a typical activity in recent times as most land planted with oil palm are usually replanted with oil palm or converted to other uses like other agricultural products or industrial/residential development.
Figure 1.1: Flow Diagram of Oil Palm Plantation Development Activities
Pollution sources from oil palm plantations can be divided into various phases such as during establishment of plantation, field maintenance, replanting and improper practices. Several factors that could result in environmental impacts are tabulated in Table 1.2 below:

**Table 1.2: Phases and Potential Environmental Impacts Related to Oil Palm Plantations**

<table>
<thead>
<tr>
<th>Phases/Stages</th>
<th>Potential impact(s)</th>
</tr>
</thead>
</table>
| 1. Establishment of plantation | i. Soil erosion  
ii. Surface run-off  
iii. Soil degradation  
iv. Nutrient run-off  
v. Leaching  
vi. Eutrophication  
vii. Increase level of Total Suspended Solid (TSS) and turbidity of river water  
viii. High sediment concentration  
ix. Silting of the river resulting in reducing its normal carrying capacity during rainy season – flooding  
x. Damage to river reserves leading to increased erosion, loss of biodiversity and impacts on water quality for surrounding communities |
| i. Clearing of land  
ii. Construction of road and drainage system  
iii. Felling  
iv. Stacking  
v. Terracing  
vi. Nursery establishment  
vii. Establishment of leguminous cover crops |
| 2. Field Maintenance |  
i. Fertilizer applications  
ii. Weeding  
iii. Soil and water conservation  
iv. Pruning  
v. Pests and disease control |
| 3. Replanting |  
| 4. Improper Plantation practices by the workers |
1.3.2 General Impacts: Palm Oil Mills

The progress of the milling and processing sectors has also been in tandem with the development of oil palm planting. The number of palm oil mills in Malaysia has increased tremendously, i.e. from about 10 mills in 1960 (Ma et al., 1993) to 416 palm oil mills in 2009 and about 122 mills are located in Sabah, (Dompok, 2011). However, the production of such large amounts of crude palm oil results in even larger amounts of palm oil mill effluent (POME) in which case in the year 2008 alone, at least 44 million tonnes of POME was generated in Malaysia and the figures are expected to rise every year. With this alarming figure, the palm oil mill industry in Malaysia is identified as a potential major contributor to the pollution load in rivers throughout the country. These potential impacts arise from improper management, insufficient mitigation measures and enforcement, accidental leakage/release of raw POME into the waterways. Many independent millers also not have plantations thus unable to apply treated effluent on land. Sufficient ponding capacity is also an issue for mills that have increased their capacities over the years while still maintaining the same amount of land area for effluent treatment ponds. For more details on impacts of palm oil mills on river quality, see following section on key findings.

1.4 KEY FINDINGS FROM IMPACT STUDY OF PALM OIL MILLS, OIL PALM PLANTATION AND OTHER POLLUTANTS ON THE QUALITY OF SELECTED RIVERS IN SABAH

While the following key findings result from a study on only 5 rivers in Eastern Sabah (Muanad, Segaliud, Kalumpang, Pang Burong and Segama), suggestions on minimizing impacts of the oil palm industry contained in the following sections of these guidelines are designed to be applicable to the whole of Sabah. Other similar studies (for example the DOE-commissioned study on Kinabatangan River) have shown that the oil palm industry impacts Sabah’s rivers in similar ways and common ground can be found in terms of solutions to these problems. In addition, the Technical Committee overseeing this project has also unanimously agreed that for practicality and effectiveness, these guidelines should applicable to all of Sabah.
1.4.1 Oil Palm Plantations

a) River reserves encroached

Satellite image analysis and field observations showed that planting of oil palms within river reserves by most oil palm plantations in the studied river basins was common. This was one of the significant contributing factors affecting river water quality.

b) Small tributaries neglected

In addition, it was observed that simply maintaining river reserves on main/major rivers may not be sufficient to prevent further silting of water courses. Silt can still wash into the main river via the smaller tributaries than feed the main river. It was also observed that virtually none of the oil palm plantations visited maintained any form of riverine buffer along the smaller tributaries that run across their estates.

c) High Total Suspended Solids (TSS) in rivers due to insufficient erosion control practices

The study also shows that high levels of Total Suspended Solids (TSS), most likely from soil erosion and siltation, was one of the major problems faced in the study area. Provision of main drains in poorly drained sites prior to felling and clearing is also rarely carried out in Sabah. During field visits, it was observed that the use of heavy machinery for land clearing during heavy rainfall season has detrimental effects to soil leading to increased erosion and compaction.

d) High organic matter in rivers due to excessive fertilizer run-off

Excessive algal blooms were recorded in almost all studied rivers. The most likely source of this problem is the over-application of fertilizer by oil palm plantations as well as POME discharge from the mills.

e) Implementation of Best Management Practices (BMPs) by oil palm sector not consistent

It was also found that the implementation of Best Management Practices (BMPs) was not widespread in the study area, especially for smallholders and medium-sized independent growers. Inadequate practices in terms of solid waste
management, erosion control and fertilizer/pesticide application resulted in the deterioration of river water quality.

1.4.2 Palm Oil Mills

a) Palm oil mills fail to comply with effluent discharge requirements, partly due to inadequate maintenance of treatment systems

The study found that only 5 out of 12 palm oil mills in the study area were successful in reducing their POME BOD levels to less than 100 ppm during low flow season and only 1 mill was close to complying with the requirement for new mills i.e. BOD less than 20 ppm. If treated POME with high BOD levels are not disposed properly, this can result in contamination of rivers. The study also found that the efficiency of POME treatment systems dropped tremendously in the long run and one of the contributing factors identified was inadequate maintenance of facilities and equipment by owners. From field visits/interviews, it was learned that most mills have not carried out desludging of their effluent treatment ponds in more than 5 years. Inadequately maintained treatment ponds are also subject to frequent overflows and leaching.

b) Erratic implementation of land irrigation requirements

Currently in Sabah, Land irrigation is regulated by law but guidelines on its implementation are not provided. From field visits, it was observed that most land irrigation schemes by oil palm plantations were implemented inconsistently. There was no consistency in methodology used and leaching to surrounding areas was common even without the occurrence of heavy rainfall. There were even instances where there was large-scale direct discharge of POME into waterways despite existing requirements.

If unmonitored, pollution from palm oil mills can have major impacts on river quality thus negatively affecting water supply, fisheries, livelihood, health and potential ecotourism in each river basin.
CHAPTER 2

REGULATORY AND INSTITUTIONAL REQUIREMENTS

2.1 INTRODUCTION

This chapter elaborates on prevailing laws, regulations and guidelines, institutional frameworks and prevailing penalties if the laws are not complied with. It includes a summary of requirements related to:

- The Sabah Land Ordinance 68;
- Environmental Impact Assessments (EIAs);
- Agricultural Development Plan (ADP) submissions;
- Other laws, regulations and guidelines; and
- It also highlights the role of different government agencies and other stakeholders related to the development and implementation of oil palm plantations and palm oil mills.

Although the conversion of land for agricultural activities is a necessary component of socio-economic development, if it is not done in a responsible manner, the impacts associated with the conversion can be severe and irreversible. Therefore careful and holistic planning is required.
2.2 LEGAL REQUIREMENTS: OIL PALM PLANTATIONS

The following is a summary of key laws and regulations applicable to the development and operation of oil palm plantations. Further elaboration on these laws is provided in Annex 1.

2.2.1 Environmental Impact Assessment (EIA)

Current legislation with regards to the conservation and protection of the State’s natural resources as well as the environment is governed by the Environment Protection Enactment 2002, which includes a requirement to submit an Environmental Impact Assessment (EIA) report or Proposal for Mitigation Measures (PMM) as stated under Part III, Sec. 12 (3) of the enactment, “No person shall carry out any development activity which is categorized under subsection (2) unless such person has submitted an environmental impact assessment report or proposal for mitigation measures as the case may require and such report or proposal has been approved by the director”.

Under the enactment, Environment Protection (Prescribed Activities) (Environmental Impact Assessment) Order 2005 outlines compulsory requirements of OPP developments under both of its First and Second Schedule to carry out PMM and EIA studies, respectively as follows:

`FIRST SCHEDULE: List of Prescribed Activities Requiring Proposal for Mitigation Measures Report`

1. AGRICULTURE

   i. Development of agricultural estates or plantations covering an area of 100 hectares or more but less than 500 hectares;

   ii. Development of agricultural estates or plantations involving change in type of crops covering an area of 100 hectares or more but less than 500 hectares; or

   iii. Conversion of wetland forests into agricultural estates or plantations covering an area of 20 hectares or more but less than 50 hectares.
SECOND SCHEDULE: List of Prescribed Activities Requiring Environmental Impact Assessment Report

1. AGRICULTURE

i. Development of agricultural estates or plantations covering an area of 500 hectares or more;

ii. Development of agricultural estates or plantations involving change in type of crops covering an area of 500 hectares or more; or

iii. Conversion of wetland forests into agricultural estates or plantations covering an area of 50 hectares or more.

The EIA Guidelines for Oil Palm Plantation Development (2002) by EPD outline the assessment of impacts against the size of the development and how it affects any identified sensitive areas.

2.2.2 The Sabah Agricultural Policy (1992–2010)

The Sabah Agricultural Policy (1992-2010) states that:

‘Section 10. Commodity Policy. Item 10.1.1 Oil Palm – To maximize returns from palm oil, production will be increased through expansion, productivity improvement, and upgraded efficiency particularly in the smallholder sub-sector. The adoption of automation and intensified mechanization will be encouraged to increase productivity and efficiency and as a long-term solution to the problem of labour shortage. Milling, bulking installation and refining facilities will be upgraded, expanded and increased to cater for increased production’.

‘Downstream processing to produce locally manufactured value-added palm oil products, such as oleo chemicals, will be encouraged to ensure a balanced and sustained growth of the industry. Environmentally friendly methods of oil palm cultivation, production and processing will be promoted’.

Responsible development of oil palm cultivation should not only meet the needs of investors and developers but also compliment in a broader sense the State’s socio-economic interests. Environmentally friendly methods of oil palm cultivation are clearly emphasized in the current Sabah Agricultural Policy.
2.2.3 The Sabah Land Ordinance 68

The requirement of river reserves is stipulated under the Land Ordinance Sabah Cap, Section 26 which states that:

- “Unless otherwise expressly provided in any title the entire property in and control of the water of all rivers, creeks, streams and watercourse, and of the seashore below high water mark is and be vested solely in the Government”; and

- “The Government also has power to reserve such portion of land as may be deemed advisable along the banks of rivers, streams or creeks, or along the seashore above high water mark, or along the ridges of hills. Such reservation shall be shown on all document of title”.

2.2.4 Agriculture Development Plan (ADP)

The existing policies, Section 36 under the Second Sabah Agriculture Policy (1999 – 2010), highlighted that “Environmentally-friendly methods of cultivation, production and processing will be promoted to minimize the negative impact of these activities on the environment. Recognizing the importance of soil as a resource vital for agriculture, efforts will also be undertaken to maintain the soil eco-system of the state to ensure its proper utilization and conservation. As such, steep terrain of between 20 and 25 degrees slope as defined in the "Soils of Sabah (1975) Study" will only be allowed for development under environmentally-friendly methods of cultivation which include proper soil and slope management measures in particular through the use of the sloping agriculture land use technology”.

Currently, the DOA is applying recommendations in Panduan Pembangunan Pertanian bagi Tanah Bercerun (2000) as the main guide in review and processing of the approval of ADP. In the ADP, DOA has divided the preparation into two (2) categories i.e. a non-comprehensive development plan for proposed development with area of 50 – 500 acres and a comprehensive development plan for area of more than 500 acres.

Approval is given if the ADP meets the requirements of the DOA, and the approved development plan will be distributed to the Director of Agriculture, Director of Land and Survey, Permanent Secretary of the Ministry of Agriculture.
and Food Industry, District Agriculture Officer as well as the owner for retention and monitoring. DOA will report to the LSD or DID the outcome of their ground investigation especially where the proposed development resulted in disturbance to river reserve and steep area.

2.2.5 Occupational Safety and Health Act (Act 514)

The Occupation Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 under its Occupational Safety and Health Act (ACT 514) is currently being enforced by the Department of Occupation Safety and Health (DOSH). According to the Department, this regulation applies to all places of work which are within the jurisdiction of the Act where chemicals hazardous to health are used. The act is applicable to oil palm plantations and mills.

2.2.6 Pesticides Act (1974)

The Pesticides Act 1974 gives the guiding principle for the registration, production, management and application of pesticides in Malaysia. The Pesticides Board of Malaysia, which is the pesticide-regulating authority, is under the purview of federal DOA. The Board has banned a number of pesticides gradually during the last two decades and Table A2 in Annex 1 shows the pesticides which have been voluntarily withdrawn by the parent company or partially/totally banned by the Pesticides Board over past twenty years.

2.2.7 Water Resources Enactment (1998)

Rivers are protected by Department of Irrigation and Drainage (DID) under the Sabah Water Resources Enactment (WRE), 1998. Section 40 of the enactment stipulates the establishment of river reserves.

However, stricter requirements during the planting stage of the development are given by the EPD at 20 m for river width of more than 3 m, 5 m for river width of less than 3 m. The department also takes into consideration EIA findings of proposed area whereby environmentally sensitive, wildlife, steep areas are required for provision of 50 – 100 m of river reserves.
2.3 LEGAL REQUIREMENTS: PALM OIL MILLS

2.3.1 Licensed Control as Prescribed Premises under Section 18

In recognizing that individual palm oil mills have an extremely high potential to pollute waterways, the “prescribed premises” approach of Section 18 of the EQA, which provides for licensed environmental control of individual factories, was deemed appropriate and chosen for exercising such control of the crude palm oil industry.

The Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order 1977, prescribed factories that process oil palm fruit or oil palm fresh fruit bunches into crude palm oil, whether as an intermediate or final product, as “prescribed premises”, which shall require a license under Section 18 of the EQA for the occupation or use of their respective premises.

Environmental control of crude palm oil mills is exercised through the imposition of appropriate conditions of license which may pertain, not only to acceptable conditions of effluent discharge, but also to other types of waste disposal including air emissions and disposal of scheduled waste.

New palm oil mills that are to be constructed must first obtain the prior written permission of the Director General of Environment under Section 19 of the EQA before commencement of site-preparation or any other construction work.

As a matter of procedure, the project proponent is also required to obtain environmental clearance for the proposed site of a new factory at the earliest planning stage to ensure its suitability and minimal environmental control impact.

2.3.2 Regulatory Control of Effluent Discharge

The following regulations have been promulgated under the Environmental Quality Act 1974 for environmental control of palm oil mills:

The Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977, promulgated under the enabling powers of Section 51 of the EQA, which are the governing regulations and contain the effluent discharge standards and other regulatory requirements to be imposed on individual palm oil mills through conditions of license.
The principal regulatory requirements and elements of regulatory control are:

- Application for an annual license using Form 1, and according to procedures in the Environmental Quality (Licensing) Regulations 1977;

- License fees charges consisting of processing fee of RM 100.00 plus an effluent–related amount computed according to the rates and procedures in the Third Schedule of the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977;

- Compliance with the applicable effluent standards (Second Schedule of the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977) and other acceptable conditions of effluent discharge imposed as conditions of the License (Form 2 of the Licensing regulations);

- The current effluent discharge standards ordinarily applicable to crude palm oil mills; Current pollution control practices, including commonly applied effluent treatment technologies, and available cleaner production measures that enable compliance with the effluent discharge standards; and

- Reporting of effluent discharge information to the DOE on a quarterly basis in the format of the Quarterly Return Form in the First Schedule of the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977.

2.4 NATIONAL POLICIES

Aside from the abovementioned legal requirements, development of the oil palm industry should also be in line with the following national policies and plans:

a) Vision 2020

Vision 2020 which aims for Malaysia to be a developed country by the year 2020 is the ultimate goal for all Malaysians. "Developed" in this context is not limited to an economic sense, but also in terms of national unity and social cohesion, social justice, political stability, system of government, quality of life, as well as social and spiritual values.
b) National Vision Policy (2001-2010)

The National Vision Policy aims to establish a united, progressive and prosperous Bangsa Malaysia. It endeavours to build a resilient and competitive nation and equitable society with the overriding objective of National Unity. It has seven thrusts, which include pursuing environmentally sustainable development.

### 2.5 RELEVANT GUIDELINES

In addition to the above laws and regulations, the following are the relevant guidelines pertaining to the oil palm industry in Sabah.

**Table 2.1: Guidelines Pertaining to Oil Palm Sector**

<table>
<thead>
<tr>
<th>Guidelines/BMP</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Palm Oil: Good Agriculture Practice Guidelines (Unilever)</td>
<td>Maintain riparian reserves along watercourses populated by native species. Plant native trees where they are absent. The size (width) of the reserve should at least equal the width of the watercourse if no national or regional requirements are in place.</td>
</tr>
<tr>
<td><em>Garispanduan Pembangunan Melibatkan Sungai dan Rizab Sungai</em> (Guideline for Development Involving Rivers and River Reserves) Drainage and Irrigation Department</td>
<td></td>
</tr>
<tr>
<td>Kelebaran Laluan air antara tebing (Width of water channel between banks)</td>
<td>Keperluan kelebaran rizab dari kedua belah tebing (River Reserve width requirements between both banks)</td>
</tr>
<tr>
<td>&gt; 40m</td>
<td>50m</td>
</tr>
<tr>
<td>20m - 40m</td>
<td>40m</td>
</tr>
<tr>
<td>10m - 20m</td>
<td>20m</td>
</tr>
<tr>
<td>5m – 10m</td>
<td>10m</td>
</tr>
<tr>
<td>&lt; 5m</td>
<td>5m</td>
</tr>
<tr>
<td>Roundtable on Sustainable Palm Oil (RSPO) Principles and Criteria for Sustainable Palm Oil</td>
<td>Proper practices for sustainable management of oil palm plantations and mills (see extracts in Annex 6)</td>
</tr>
<tr>
<td>Malaysian Palm Oil Board (MPOB) Codes of Practices</td>
<td>See boxed extracts in BMP sections</td>
</tr>
</tbody>
</table>
2.6 ROLE OF DIFFERENT GOVERNMENT AGENCIES

The role of different government agencies relevant to oil palm plantations and palm oil mills as well as the legislations under which they operate are listed below:

**Table 2.2: Role of Different Government Agencies In Regulating Oil Palm Industry**

<table>
<thead>
<tr>
<th>Department</th>
<th>Ordinance/Enactment/ Policy/Order/Guideline</th>
<th>Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSD</td>
<td>Land Ordinance (Sabah Cap.68) Sec 26</td>
<td>To issue Land Titles to develop oil palm plantation within the State as well as designation, gazettement of river reserves</td>
</tr>
<tr>
<td>DID</td>
<td>Water Resources Enactment (1998) Section 40</td>
<td>To comment on potential concern over hydrology and drainage issues in relation to the oil palm plantation development as well as provide guidance on river reserves</td>
</tr>
<tr>
<td>DOA</td>
<td>Second Sabah Agriculture Policy (1999-2010)</td>
<td>To review and comment on the plantation development plan and land/soil suitability for oil palm cultivation</td>
</tr>
<tr>
<td>DOE</td>
<td>Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987</td>
<td>To approve licenses for new palm oil mills and regulate effluent discharge from mills</td>
</tr>
<tr>
<td>EPD</td>
<td>Environment Protection Enactment 2002; EIA Guidelines Oil Palm Plantation (Aug 2002); and Handbook on Environmental Impact Assessment in Sabah (Nov 2005)</td>
<td>To approve EIA to commence activities for oil palm plantation development within the State and to monitor implementation</td>
</tr>
</tbody>
</table>
Table 2.2: Role of Different Government Agencies In Regulating Oil Palm Industry (ctnd)

<table>
<thead>
<tr>
<th>Department</th>
<th>Ordinance/Enactment/Policy/Order/Guideline</th>
<th>Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPOB</td>
<td>Malaysian Palm Oil Board Act 1998 (Act 582)</td>
<td>Promote and develop the oil palm industry in Malaysia as well as developing national objectives, policies and priorities for the orderly development of the industry</td>
</tr>
<tr>
<td></td>
<td>(a statutory body established in May 2000 incorporating the Palm Oil Registration and Licensing Authority and Palm Oil Research Institute of Malaysia)</td>
<td></td>
</tr>
</tbody>
</table>

2.7 OTHER KEY STAKEHOLDERS

Other key stakeholders involved in the development of oil palm in Sabah or who should be consulted over the development include:

- Oil palm plantation developers - carries out oil palm planting and to supply FFB (fresh fruit bunches) to palm oil mills, either as a company or private individual/smallholders;

- Palm oil mill operators - obtain fresh fruit bunches from oil palm planters to produce palm oil;

- Oil palm planters association - groups of oil palm cultivating companies and organizations for Malaysia (MPOA, EMPA, etc.);

- NGOs and Civil society organizations;

- Local Communities; and

- Local government
CHAPTER 3

DEVELOPMENT PLANNING AND SITE SELECTION

3.1 INTRODUCTION

From a sustainable development point of view, the process for land use planning and development can be improved at the State Government level, as well as by individual plantation companies. Although the Government has a vision for the conservation of the nation’s forest resources, the actual process for alienation of land for development, particularly for logging and plantation agriculture may not be sufficiently effective. Besides economic considerations, typical assessments of land for oil palm cultivation have been based mainly on suitability of soil, terrain and climate. Development planning should be more holistic and take into consideration physical, environmental, social and financial factors; the interrelationship between these factors and selected evaluation criteria.

3.2 HOLISTIC LAND USE PLANNING

Most environmental damage by the palm oil industry results from where plantations and mills are located. If expansion can be limited to appropriate sites, many of the problems common to the industry could be eliminated. Appropriate sites can be areas suitable and appropriately zoned for agriculture as well as situated away from conservation and environmentally sensitive areas. More effective zoning and land-use planning will be the cornerstone of successful strategies to reduce environmental damage from oil palm cultivation. Plans should include protecting areas that are important for the maintenance of ecosystem functions (particularly along rivers and on steep slopes) from conversion to oil palm plantations.
Proper zoning can be done at the larger landscape or ecosystem level. Estate owners or even associations of small holders can zone their own lands to reduce their impacts and improve their profitability. Oil palm producers are beginning to understand that fighting rivers and steep slopes actually lowers their overall production because they spend time and resources focusing on environmental problems like landslides and seasonal flooding. By leaving (or zoning) such areas (e.g. river reserve areas or steep slopes) for wildlife corridors and watershed and stream protection, producers actually increase their net profits because they focus their attention not on the problems but on raising the average production on most of their plantings.

Some of the key issues that relate to site selection for development of oil palm plantations include:

- **Selecting suitable soils**: The area of oil palm plantations on fragile and marginal soils should be minimized as far as possible. Oil palm should be planted on suitable soils and areas with appropriate agro-climatic conditions. New plantings or replanting should not be undertaken on land more than 300 m above sea level. Refer to Annex 1 Table A 1 for Agricultural Development Plan (ADP) requirements in terms of soil surveys.

- **Avoiding of steep slopes**: For Sabah, slopes 25 degrees and above are considered high risk erosion areas and cannot undergo planting or replanting unless specified in the EIA report [Environment Impact Assessment (Order 2005)] and approved by the Environment Protection Department (EPD).

- **Avoiding Environmentally-Sensitive Areas (ESAs)**: There should be no conversion of Environmentally-Sensitive Areas (ESAs) such as wildlife reserves, river reserves, wildlife corridors, permanent forest reserves etc. to oil palm plantations. It is useful to note that when land titles are issued, a developer is required to develop a minimum of 75% of the land area whereby up to 25% of the land may be left undeveloped and set aside as buffer zones for conservation and environmentally-sensitive areas (LSD, pers comm).

- **Avoiding plantings in floodplains or wetland areas**: Floodplains or wetlands such as peat swamp, freshwater swamp or mangrove forests
are all sensitive areas that play key roles in the management and protection of water resources. Development of these areas can affect river and groundwater levels and quality as well as increase vulnerability to coastal or riverine erosion and saline intrusion.

MPOB’s Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings provides some guidance on site planning and environmental issues in **Box 3.1** below:

**Box 3.1: Guidance on site planning and environmental issues from “MPOB Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings”**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4</td>
<td>Site history and site management</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Site history</td>
</tr>
<tr>
<td>4.4.1.1</td>
<td>An appropriate recording system should be established for the site history and layout of fields of their crop history</td>
</tr>
<tr>
<td>4.4.1.2</td>
<td>For all new oil palm plantings, a risk assessment should be carried out by a competent agriculturalist, taking the following into account: Prior use of the land; Potential impacts of the production on adjacent crops and areas; Potential impact of activities carried out on adjacent areas; and The information on the risk assessment should be recorded.</td>
</tr>
<tr>
<td>4.4.1.3</td>
<td>All new oil palm plantings shall not be cultivated on land of more than 300m above sea level</td>
</tr>
<tr>
<td>4.4.1.4</td>
<td>All new oil palm plantings should not be cultivated on land of more than 25 degree slope</td>
</tr>
<tr>
<td>4.4.1.5</td>
<td>Extensive planting on marginal, problematic and fragile soils is avoided</td>
</tr>
<tr>
<td>4.13</td>
<td>Environmental issues</td>
</tr>
</tbody>
</table>
4.13.1 Impact of farming on the environment – Crop producers should conform to the Environmental Quality Act 1974 (Act 127) and Regulations which covers the concerns of air, water, soil and other environmental issues such as the practice of zero burn replanting, protection of water courses through maintenance of riparian buffer zones and avoidance of adverse impacts on downstream users.

4.13.2 Wildlife and biodiversity conservation

4.13.2.2 Where Environmental Impact Assessment (EIA) is required, consideration for the conservation of biodiversity and wildlife shall include the following areas:

A baseline audit to understand existing animal and plant diversity on the plantation;

Action to avoid damage and deterioration of habitats on the plantation; and

An action plan to enhance habitats and increase biodiversity, in particular agricultural biodiversity on the plantation.

4.13.3 Unproductive sites – Crop producers are encouraged to convert unproductive sites (e.g. swamps, steep slopes, deep peat, etc.) into conservation areas for natural flora and fauna.
3.2.1 Project Site Assessment

Sabah’s EIA Guidelines on Oil Palm Plantation Development (2002) provides further guidance on how to assess land and describe future projects:

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

a) 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** shows an example of a site location map from an EIA report.
Figure 3.1: Example of Project Locality Map
b) Initial data II: Description of the project site, including maps

It is imperative that all maps include an indication of scale and a clearly marked coordinate system (e.g. 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 reports will be required and provision should be made so that all maps remain legible.

c) 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 3.2). This information should be taken as indicative and not absolute (Figure 3.3). All 4th 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 4th order rivers are at least this size.

**Explanatory note on classification of streams/rivers:** When using stream order to classify a stream/river, the sizes range from a first order stream all the way to the largest, a 12th order stream. A first order stream is the smallest of the world's streams and consists of small tributaries. These are the streams that flow into and "feed" larger streams but do not normally have any water flowing into them. In addition, first and second order streams generally form on steep slopes and flow quickly until they slow down and meet the next order waterway.

First through third order streams are also called headwater streams and constitute any waterways in the upper reaches of the watershed. It is estimated that over 80% of the world’s waterways are these first through third order, or headwater streams. Going up in size and strength, anything larger than third order (up to 12th order) is considered a river.
Figure 3.2: Assessment of Stream Order
Using the river drainage system data, the project area should then be classified into individual catchment areas (Figure 3.3). Photographic information can provide useful supplementary information.

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.
d) Initial data IV: Provide details on agreements governing the initiation of the project

This includes for example the project status in relation to approvals (received/applied) and other comments from official authorities.

e) Initial data V: Listing all main project activities

This includes the timing of the planned project activities, proposed clearance system and activities, road plan, machineries to be used, transportation routes, proposed layout plan, phase of development and schedule of activities under each phase.

3.2.2 HCV Assessments: A Land Use Planning Tool

The concept of High Conservation Value Forests (HCVFs) was developed to provide a framework for identifying forest areas with special attributes that make them particularly valuable for biodiversity and / or local people. The aim of applying this framework is to design and implement appropriate management options for these areas in order to preserve or enhance their key ecological and socio-economic values. The HCVF concept was first introduced by the Forest Stewardship Council (FSC) in 1999 when it included HCVFs in one of its requirements for timber companies seeking forest certification.

Over the past 10 years, this concept has been included in various sets of principles and criteria for natural resource management to specify where conversion of HCV areas is prohibited including for soy and palm oil. See Figure 3.4 for an illustration of potential applications of the HCV concept. International multi-stakeholder initiatives like the Roundtable on Sustainable Palm Oil (RSPO) have developed production standards for their crops that include the HCV concept. For example RSPO’s Principles and Criteria Criterion 7.3 specifically states that “New plantings since November 2005, have not replaced primary forest or any area required to maintain or enhance one or more High Conservation Values”.

3-10
Figure 3.4: Potential Applications of the HCV Concept

RSPO states that areas containing secondary and degraded forests and non-forest vegetation can be important for environmental conservation and community well-being and that these forests, as a matter of course, must be considered as part of any High Conservation Value assessment and in any subsequent certification process. The RSPO standards make no assumptions that only primary forests are important from a conservation perspective, much to the contrary, all types of forest and non-forest vegetation must be included in an HCV assessment.
The RSPO Principles and Criteria define High Conservation Values as:

### Table 3.1: Category of High Conservation Value Forests (HCVFs)

<table>
<thead>
<tr>
<th>HCV</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCV1</td>
<td>Areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species)</td>
</tr>
<tr>
<td>HCV2</td>
<td>Areas containing globally, regionally or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance</td>
</tr>
<tr>
<td>HCV3</td>
<td>Areas that are in or contain rare, threatened or endangered ecosystems</td>
</tr>
<tr>
<td>HCV4</td>
<td>Areas that provide basic services of nature in critical situations (e.g. watershed protection, erosion control)</td>
</tr>
<tr>
<td>HCV5</td>
<td>Areas fundamental to meeting basic needs of local communities (e.g. subsistence, health)</td>
</tr>
<tr>
<td>HCV6</td>
<td>Areas critical to local communities’ traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities)</td>
</tr>
</tbody>
</table>

There are three main steps in the HCV process, also applicable to the application in oil palm development, summarized as follows:

- Identification of HCVs present, leading to identification of HCV management areas and proposals of management prescription to maintain or enhance these areas.
- Development and implementation of HCV management plan.
- Implementation of a monitoring programme to assess effectiveness of the HCV management plan.
Practical efforts to implement HCV concepts in oil palm development planning should naturally start at the government level under relevant agriculture policies and land use planning exercises. Major oil palm plantation companies are also required to undertake HCV assessments to fulfil RSPO requirements.

In terms of minimizing impacts on river water quality, future oil palm developments should in particular identify, manage and enhance land areas containing HCV3, HCV4 and HCV5. This would help safeguard important fresh water-related resources like areas with peat and other fragile soils (HCV3), watershed areas and river reserves (HCV4 and 5).


3.3 SITING AND PLANNING FOR NEW PALM OIL MILLS

For palm oil mills, the DOE issued conditions approved by the State Cabinet of Sabah in 2006. The guidelines stipulated that new mills must be situated in the middle of estates with at least 500-meter radius of buffer zone. Proper planning for mill siting is essential to reduce impacts of future mill operations on river quality. It must be ensured that the mill capacity is adequate to meet peak harvesting periods for a designated hectare of oil palm plantation. If peak harvests increases later because of increased hectare, then it should be mandatory to expand mill capacity in order to prevent overloading of original facilities. It has been suggested that MPOB be involved/consulted during this process. MPOB’s Code of Good Milling Practice for Palm Oil Mills provides some further guidance on mill construction/design (Box 3.2).
Box 3.2: Guidance on mill construction/design and environmental issues from “MPOB Code of Good Milling Practice for Palm Oil Mills”

4.3 Mill construction and design

4.3.1 Building and structure

4.3.1.1 Proper facilities and equipment should be provided for processing FFB

4.3.1.2 Plants, buildings and structures should be properly designed and constructed to facilitate maintenance and to provide a conducive environment for the production of good quality and contaminant free oil palm products

4.27 Environment

4.27.1 All relevant environmental legislation/regulation should be complied with, such as Environmental Quality Act 1974 and Regulations

4.27.2 Policies and procedures for minimizing the production of waste and its impact on the environment should be developed, implemented and maintained

4.27.3 All waste products should be appropriately disposed of in accordance with existing legislation
CHAPTER 4

BEST MANAGEMENT PRACTICES FOR SUSTAINABLE PLANTATION MANAGEMENT AND MINIMISING RIVER POLLUTION

4.1 INTRODUCTION

Being a well-established industry, the oil palm industry has a wide variety of established Best Management Practices (BMPs) focused on methods or techniques found to be the most effective and practical means in achieving successful plantations while making the optimum use of resources. Traditionally these BMPs focused on achieving good management and agronomic practices that contribute to high yields from estates but in recent years, BMPs have been developed to minimize environmental and social impacts of oil palm development. The following are a selection of BMPs focused specifically on reducing the impacts of the oil palm industry on river water quality. Table 4.1 provides a summary and brief description of each BMP described in this document.
Table 4.1: Summary of BMPs for Minimizing Impacts of Oil Palm Plantations on River Water Quality

<table>
<thead>
<tr>
<th>BMP 1: Land clearing activities (new plantings and replanting)</th>
<th>Covers BMPs for land clearing activities during establishment of new plantations and replanting phases including issues like erosion control, zero burn techniques and road construction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP 2: Soil and moisture conservation practices</td>
<td>Describes the basics of tackling soil erosion and surface run-off problems by using cover crops and mulching (application of EFB).</td>
</tr>
<tr>
<td>BMP 3: Optimized fertilizer use and precision fertilizer management</td>
<td>Describes the 2-prong approach of optimizing fertilizer use and precision fertilizer management to minimize the impacts of fertilizer application on river quality.</td>
</tr>
<tr>
<td>BMP 4: Integrated Pest Management (IPM) principles</td>
<td>Provides basic information on IPM, an ecosystem-based strategy that focuses on long term management of pests through a combination of biological control, habitat manipulation, modification of cultural practices and use of resistant varieties.</td>
</tr>
<tr>
<td>BMP 5: Waste management</td>
<td>Describes the basics of identifying and managing waste and sources of pollution from plantation support resources like workers, fuel storage areas, etc.</td>
</tr>
<tr>
<td>BMP 6: Identifying, managing and enhancing river reserves</td>
<td>Explains the importance of river reserves for water quality improvement, flood mitigation and riverbank stabilization as well as methods to identify, manage and enhance river reserves.</td>
</tr>
</tbody>
</table>
4.2 BMP 1: LAND CLEARING ACTIVITIES (NEW PLANTINGS AND REPLANTING)

4.2.1 Land Clearing

When site clearing is carried out prior to oil palm planting, existing vegetation within the area would most likely be damaged. It is therefore essential to propose measures to preserve flora and fauna and to minimize the damages to the environment. That way, total clearing of the land is avoided and only areas that are to be planted are cleared leaving the natural vegetation in place; which means there is minimal disturbance to the vegetation in the location. This is also important to reduce mitigation costs in the long run for activities like rehabilitating cleared river reserves, etc.

Damage to both land and soil is inevitable during land clearing operations and realistic attempts must be made to minimize the damage by working when weather conditions permit and by restricting work when the ground is very wet, especially during the monsoon period, where soil erosion into the waterways and rivers can be significant. The greatest damage to soil will occur during wet conditions and movement of heavy machinery over wet soils will results in deep ruts which eventually become pools of stagnant water, particularly on poorly drained soils. The cutting of main drains in poorly drained sites prior to felling and clearing is rarely carried out in Sabah. To avoid widespread damage to soils in such areas during land clearing operation, main drains should be constructed before felling. Based on local conditions, soil and terrain, drain construction may be required to be carried out at least one year before felling. With proper planning, this will not impact the development while successfully reducing soil erosion from land clearing activities.

Soil compaction could results as a consequence of using heavy machinery on any land during land clearing operation. As a result of this, cover crops are difficult to establish. To overcome this problem, sub-soiling or other methods should be carried out at the first opportunity when the soil has dried out sufficiently to effectively break up the compacted soil layers. Where possible, ploughing and rotovation can also be carried out to overcome soil compaction. MPOB’s Code of Good Agricultural Practice provides some guidance on land clearing activities below (Box 4.1).
Box 4.1: MPOB’s Code of Good Agricultural Practice on land clearing activities

<table>
<thead>
<tr>
<th>4.5</th>
<th>Soil and substrate management</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5.1</td>
<td>Soil type mapping</td>
</tr>
<tr>
<td>4.5.1.1</td>
<td>An appropriate soil map should be prepared for the estates and smallholdings to facilitate infrastructure planning, land clearing, land preparation, inter-cropping, livestock integration and replanting programmes</td>
</tr>
<tr>
<td>4.5.1.2</td>
<td>Topography map should be used to assist land clearing, preparation and planting</td>
</tr>
</tbody>
</table>

4.2.2 Erosion Control

It is important to assess the extent of soil erosion due to land clearing and development. Factors that determine soil erosion include intensity and frequency of rainfall, disintegration of soil as some soils are easily loosened up during rain while others take a longer time, the slope of the land as generally soil erosion is extensive in slopes and terrain compared to undulating and flat land and finally the nature of the cover in the area. Increased rate of erosion occur when there is no or lack of adequate ground vegetation or cover on bare slopes. In the natural landscape (prior to land clearing) the tree canopies intercept the impact of rain before rain water falls to the ground thereby reducing erosion. Once the soil is exposed, erosion takes place through a sequence of actions where the detached soil particles are washed down forming sheet, rill and gully erosion. Gullies form when rills increase in depth. Intensive rilling and gullying indicate that large volume of soil has been eroded from the area. With proper planning and development of the area in stages (in smaller self-contained parcels) the impact of erosion can be reduced. Foothill drains, silt traps and terracing are useful measures that can be taken on slopes where this is a significant factor.

During the preliminary stages when the site is cleared and the roads are built, there is a possibility of damage to the soil particularly when total clearing is carried out. This normally happens when roads are constructed along slopes and ridges where there is total exposure to the surface of the soil. As there is no vegetation to protect the surfaces of these roads, extensive erosion could occur.
This could be prevented if road construction is carried out during dry weather so that by the time the rainy weather sets in, the top surface of the road is hardened causing less erosion. Many plantations are developed after timber logging concessions end. Here, quite often the existing network of ex-logging roads is maintained. These roads usually are not constructed following the contour of the land. This then becomes a major source of erosion. In the long run, it is better to revamp such roads since it will also be more costly to maintain them. Storm drains (water conservation drains) can be constructed at 50-100m intervals (depending on terrain) to divert rain water into the planted areas, which will reduce erosion of the roads along slopes and provide moisture to the palms.

Other mitigation measures that can be implemented include the establishment of leguminous cover crops (such as *Pueraria* species and Vetiver grass) and the conservation of natural vegetation to control erosion of the slopes. Vetiver grass or Guatemala grass, which establish very fast could be planted on the slopes prior to the rainy season so that by the time the rain sets in, the cover crops are well established to prevent soil erosion.

Plate 4.1: Cover crops or turf need to be established on the plantation to minimize erosion during planting/replanting.
During preparation of the site, one of the factors that need to be considered is the generation of large quantities of biomass. Land clearing with activities such as felling and under-brushing generate biomass that has to be removed. Apart from that, when terracing and planting rows are established, there is a need to clear the biomass in the area for easy access to the rows. While the traditional method of burning is not allowed due to air pollution and haze problems, various measures are suggested to overcome this problem. The first step would be to estimate the amount of biomass within the site area so that proper measures could be taken to remove them without further destruction to the soil. The next step would be to make provisions in the designing of terraces to have adequate space to stack the biomass along the contour (against the direction of the slope) to minimize erosion. It may also be useful to identify the reusable materials within the biomass and extract these (footbridge construction, etc.), which will help reduce the amount of biomass that needs to be handled. The remaining biomass can then be cleared using zero burning techniques. Zero burning enhances soil organic matter and helps to restore the fertility and richness of the soil. Implement various measures for the least damage to the soil and measures to preserve the existing vegetation.

4.2.3 Zero-Burn Techniques

The zero burning technique is a method of land clearing whereby the tree stand, either logged over secondary forests or an old area of plantation tree crops such as oil palm, are felled, shredded, stacked and left in-situ to decompose naturally.

For the past 20 years zero burning has been promoted and adopted by many companies. It has been found that eliminating burning is practical for replanting or new oil palm plantings. With this method, remaining ripe FFB is harvested and the palm biomass are left on the ground where they can be spread out to provide protective ground cover, or piled into rows to prevent run-off and erosion.
The main issue of concern with zero burning is that it might lead to the infestation of *rhinoceros beetle* pests and risk of *Ganoderma* stem rot disease. Ploughing or pulverizing debris followed by planting legumes helps accelerate the decomposition of the debris thereby minimizing these risks.

The main benefit derived from zero burning is the benefits from the recycling of organic matter and the slow release of nutrients during decomposition so that they can be utilized by the newly planted trees. This reduces per-hectare inorganic fertilizers needed at the time of planting (e.g., nitrogen by 738 kilograms, phosphorus by 205 kilograms, potassium by 848 kilograms, and magnesium by 487 kilograms) (Clay 2004).

The organic matter also improves the soil and when used properly, can help with the growth of palms on the terraces (where organic matter and nutrients are lower) and the reduction of erosion from run-off.

One study found that in 1993, the zero burning technique reduced costs for establishing plantations by RM1,070 to RM1,415 when compared with plantations where burning was used. This is primarily because zero burning reduces the fallow time needed and allows harvesting to commence earlier compared to the open burning technique when dry weather is needed for effective burning. This
method also exposes soil far less than other methods, and it lets replanting occur gradually throughout the year whenever there is sufficient rainfall for the seedlings.

Basic steps in Zero Burning techniques for replanting of oil palm to oil palm:

i. Planning for replanting
ii. Removal of *Ganoderma* diseased palms
iii. Pre-lining
iv. Construction of roads and drains
v. Felling and shredding/chipping
vi. Stacking/windrowing
vii. Ploughing and harrowing in coastal areas
viii. Construction of terraces in inland undulating to hilly areas
ix. Establishment of legume covers
x. Lining, holding and planting of oil palm seedlings
xi. Pulverization
xii. Post-planting management

Basic steps in Zero Burning techniques for development of new oil palm plantings:

i. Macro planning for development of new oil palm plantations
ii. Planning for new planting
iii. Under-brushing
iv. Lining and construction of roads and drains
v. Felling
vi. Stacking of residual wood biomass
vii. Legume cover crop establishment
viii. Planting of oil palm seedlings
a) Post-planting management

For further guidance on Zero Burning techniques replanting of plantation crops to oil palm, development of new oil palm plantings and alternative approaches, refer to Annex 3: Guidelines for the Implementation of the ASEAN Policy on Zero Burning.

4.2.4 Road Construction

Construction of a systematic network of roads is necessary to provide access for good plantation management and evacuation of harvested crops. But roads must be constructed in manner that will minimize the risk of soil erosion. General guidelines for road construction are as follows: Cambering and road side drainage is important to remove water from the road surface and drains must be provided to lead the water away. Silt-traps or diversion ditches should be constructed on the cut sections of main road to divert water from the above cut sections and to lead it to a roadside drainage system thus reducing soil erosion. Unchecked erosion of cut sections should not be allowed and attempts to control erosion by the construction of bamboo wattles should be made. Bamboo wattles are inexpensive and effective methods of checking erosion on cut sections.

Plate 4.3: Small silt pits (traps) on cut sections of main roads, reduce run-off and erosion and conserve moisture.
General guidelines for road construction are as follows:

**Planning for a road system:** Plans should show a proposed network of primary, secondary and tertiary roads.

**Grading and side drain construction:** Widen, scrape and grade to formation level, the full section of the proposed or existing agricultural roads between the side drains. Proper gutters, ditches and culverts reduce ponding and softening of the road sub-base. The grading and side drain construction is done at the same time. The ditches ('V' or rounded) must be deep, wide and sloped, enough to channel the surface water. At the same time, an extended slope, crown and camber are formed on the road surface.

Dimensions of roads would depend if it is a primary, secondary or tertiary road but in general, the width of the roads should be 4.85 m with a 30 cm side table on either side of the road. Where road construction is on hill slopes or in dry areas, side drains are to be constructed along the cut hill toe. The size of drain should be 30 cm wide and 15 cm deep. The camber of the road should be within the range 1:15 to 1:20 sloping towards the edge of the bank to allow for proper road surface drainage. Outlet drains should be constructed at every 20 to 30 m to reduce erosion.

- **Ripping the road surface:** The road is ripped or scarified to 20-25 cm depth of the full section of proposed road to loosen the top soil (surface) by using the ripper bars of a motor grader. Two passes are required. All oversized rocks or boulders, tree roots and buried logs that are found along the proposed road are removed.

- **Pulverizing:** When the soil becomes loose, a rotary hoe is used to pulverize the soil until friable material is achieved, up to a depth of 15 cm to 20 cm. Two rounds of rotovations are required. This phase is generally only required for roads that will be treated with chemical stabilizers.

- **Formulation spraying:** Consider the use of stabilizers like TerraZyme, a natural non-toxic biodegradable liquid that easily suspends in water. Stabilizers act to reduce the voids between soil particles and minimize absorbed water in the soil for maximum compaction. Spray the formulation on the pulverized soil. The sprayed soil is again pulverized to properly mix the formulation. The soil mixture is required to cure for 4 to
24 hours (depending on the weather) before compaction is allowed. During this time, the moisture of the soil mixture is checked to see whether it is ready for compaction.

- **Compaction:** Compaction and road shaping should be carried out in one operation after the required curing period. A vibrator roller is used for the first and second passes. Further compaction should be done without vibrator to avoid cracking. Sufficient compaction must be applied to obtain maximum density until a hard and dry surface is achieved. A total of six passes are required. After final compaction, the 15 cm later of loose soil is now compacted to 7-10 cm hard core. Normal traffic is only allowed after 72 hours of compaction.

### 4.3 BMP 2: SOIL AND MOISTURE CONSERVATION PRACTICES

Under high rainfall and temperature conditions in Sabah, soil erosion and surface run-off is a serious problem. Perhaps the most critical operation in the context of soil conservation is that the soil should not be left bare at all for any period of time after land clearing and should be planted immediately with leguminous cover crop. Soil erosion may be expected to be most severe at planting or replanting when the previous vegetation cover has been removed and not yet replaced resulting in bare soil exposed to the frequent and intense tropical rains.

For Sabah, slopes 25 degree and steeper are considered high risk erosion areas and cannot undergo replanting unless specified in the EIA report Environment Protection (Prescribed Activities) (Environment Impact Assessment) Order 2005 and approved by the Environment Protection Department (EPD). Slopes between 20-25 degrees have a significant erosion risk and should only be developed with appropriate mitigation measures.

MPOB’s Code of Good Agricultural Practice for oil palm estates and smallholdings provide some guidance on soil and moisture conservation (Box 4.2).
Box 4.2: Guidance on soil erosion and surface run-off from “MPOB Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings”

<table>
<thead>
<tr>
<th>4.5</th>
<th>Soil and substrate management</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5.3</td>
<td>Soil erosion and surface run-off – Field cultivation techniques that minimize soil erosion and surface run-off shall be adopted.</td>
</tr>
<tr>
<td>4.5.3.1</td>
<td>Mechanization – The types and sizes of machines to be used should be considered in relation to soil condition to minimize soil compaction and rutting.</td>
</tr>
<tr>
<td>4.5.3.2</td>
<td>Soil and moisture conservation – Cultivation techniques that minimize soil erosion surface run-off such as establishment of legume cover crops, conservation pits and application of empty fruit bunches (EFB) should be adopted.</td>
</tr>
</tbody>
</table>

The beneficial effects of cover crops are well documented and include the protection of soil from heavy rain and hot sun, reduction of erosion and surface run off and improve moisture retention. Establishment of ground covers in an oil palm plantation is important and beneficial in providing protection to the top-soil from soil erosion, surface run-offs and noxious weeds, reducing environmental pollution as well as improvement in soil fertility through enhanced organic matter and fixation of nitrogen. Ground covers are especially critical when the soil is bare after the land is cleared for planting particularly in high rainfall and hilly areas. Besides its benefits, ground cover management is mandatory RSPO (Roundtable to Sustainable Palm Oil) certification to prevent polluting and silting up the public waterways.
There are two distinct phases in the management of ground cover i.e. before and after the ground is shaded by palm canopy, corresponding to immaturity and maturity of palms:

- In the first phase, common leguminous cover crops (LCC) which are deep rooting and provide vigorous dense cover such as *Pueraria javanica, Calapogonium caeruleum* and *Mucuna bracteata*, the latter 2 species being shade tolerant, are planted to cover the exposed soil soon after land clearing. It provides protection to the soils during the first 3-5 years, during immaturity and early maturity and is efficient in immobilizing and recycling nutrients. The legume cover should not be sprayed out discriminately when preparing circles and paths for harvesting in the third year.

- In the second phase, when the palms are older (exceeds 5 years) and *Pueraria* LCC dies from shading, the soil should continue to be covered and protected from noxious weeds and bare ground with ferns, soft grasses, shade tolerant *Calapogonium caeruleum*, *Mucuna bracteata* or mulched with pruned fronds and empty fruit bunches. In mature fields, palm and palm circles should not be over-sprayed, making the ground bare. To avoid bare ground, circle/path spraying should be controlled. Natural covers such as soft grasses and *Nephrolepis* should be encouraged to succeed conventional LCC when they die off.

It is important to time seed sowing and planting with onset of wet season (for *M. bracteata*, plant 6-8 weeks old seedlings in polybags). Full coverage is usually achieved within 6 to 9 months, but it can be delayed if dry weather and long drought prevail after planting. The best way to maintain good ground cover under mature palms is to plant *M. bracteata* when the land is cleared because *M. bracteata* covers can persist under 9-10 years old palms.
Oil palm biomass such as empty fruit bunch (EFB) and pruned fronds are readily available in oil palm plantations. Mulching of oil palm biomass and placement of pruned fronds in the inter-rows and across terraces should be made a standard practice in oil palm plantations. The beneficial effects of EFB mulching and pruned fronds placement in soil conservation measures and as a source of organic fertilizers are well accepted. The palm trunks are removed at replanting, normally once in 25 years. Currently, most plantations practice the zero-burn technique where the trunks are chipped and shredded and with the fronds, left to rot in the fields. With time, substantial amount of nutrients will be released and organic matter will be added to the soil thus improving the soil fertility and sustainability of the plantations.

Plate 4.4: Leguminous cover crops reduce surface run-off and soil erosion as well as enhancing soil fertility.
Plate 4.5: Placement of Oil Palm fronds in the inter-rows reduce soil erosion and conserve moisture as well as contributing to soil organic content and nutrient status.

Plate 4.6: EFB as organic mulch release nutrients and improve soil fertility.
4.4 BMP 3: OPTIMIZED FERTILIZER USE AND PRECISION FERTILIZER MANAGEMENT

This BMP proposes a 2-prong approach to minimize the impacts of fertilizer application by oil palm plantations on river water quality. Firstly, the use of inorganic fertilizer should be reduced by utilizing alternatives like mulch, compost, mill waste, etc. Secondly, over application of inorganic fertilizer should be avoided by implementing precision fertilizer management principles.

MPOB’s Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings also provides some general guidance on fertilizer management (Box 4.3).

Box 4.3: Guidance on fertilizer management (organic and inorganic) from “MPOB Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings”

4.6 Fertilizer management (organic and inorganic)

4.6.1 Nutrient requirement

4.6.1.1 Management practices should take into consideration the site yield potential and productivity to ensure nutrient balance and minimize nutrient loss. Fertilizer rates should be based on crop requirement, soil and leaf nutrient levels.

4.6.2 Fertilizer utilization

4.6.2.1 Usage of fertilizers should be in accordance with science-based recommendations by competent agriculturist.

4.6.2.2 The type, quantity, method, placement, timing and frequency of fertilizer application should be carefully observed so as to maximize benefits and minimize losses.

4.6.3 Records of application – All applications of fertilizers should be recorded. Records should include location, date of application, type and quantity of fertilizer applied, the method of application and name of operator.
4.6.4 Application machinery – Fertilizer application machinery should be kept in good working condition and calibrated.

4.6.5 Fertilizer source and storage

4.6.5.1 Fertilizer stock records should be kept up-to-date and made available for inspection.

4.6.5.2 Fertilizers should not be stored in the same room with pesticides. If this is not possible, the fertilizers and the pesticides should be physically separated and labeled accordingly.

4.6.5.3 Fertilizers should be stored in a covered, clean, dry location where there is no risk of contamination of water sources.

4.6.5.4 Fertilizers should not be stored with nursery stock.

4.6.5.5 Fertilizers should not be stored with fresh produce.

4.6.5.6 All hazard and risk areas to humans should be clearly indicated.

4.6.5.7 Records of source and chemical content of fertilizers used should be made available.

4.6.6 Organic fertilizer

4.6.6.1 Organic fertilizer should be stored and handled in an appropriate manner to reduce the risk of contamination of the environment.

4.6.6.2 The use of untreated and treated human sewage and pig waste are prohibited.

4.6.6.3 To avoid pollution by heavy metals of by nitrate leaching, nutrient content, heavy metals and other potential pollutants in organic fertilizers should be analyzed before application. The nutrient contribution of all organic fertilizers should be taken into consideration.

4.6.6.4 Use of organic fertilizer should be integrated with the inorganic fertilizer programme.
4.6.6.5 Source of organic fertilizer used shall be recorded. These includes oil palm biomass such as palm oil mill effluent (POME), EFB, shell and fibre, pruned fronds, palm trunks, etc.

4.4.1 Optimized Fertilizer Use

Oil palm trees require some form of fertilization to produce yields that are viable economically. A number of options are available, however, to reduce the amount of inorganic fertilizer applied.

**Well-rounded assessment before use:** Palm oil producers should be encouraged to evaluate the types of fertilizers used in order to assess ways to increase the efficiency and reduce the environmental impacts of their use. This would allow for the identification of specific application practices or the timing of applications that should be encouraged, as well as those that should be discouraged or even banned. For example, any techniques that reduce surface run-off will reduce leaching of nutrients, which in turn minimizes contamination of surface and groundwater with nitrogen and phosphorus. To complement this, nitrogen-fixing legumes should be included in cover crops to reduce the need for purchased nitrogen fertilizers. Ideally to maintain a balance, added fertilizers should never exceed the amounts of nutrients exported in the harvested product plus what erodes, leaches, or volatilizes annually or when replanted.

**Nutrient recycling:** Another way to greatly reduce the use of nutrient inputs from inorganic fertilizers is through nutrient recycling, particularly from palm oil wastes and/or by-products. One of the main categories of waste on oil palm plantations is the empty fruit bunches remaining after processing. Every 23 metric tonnes of full fruit bunches yield 16 metric tonnes of empty fruit bunches. This can be returned to the fields. If applied at a range of 30-40 metric tonnes per hectare per year, given average yields, eventually it can return half of the nutrients originally harvested in the bunches once it decomposes. It is noted that it may not be practical to distribute EFB to every field on the estate due to costs associated with logistics and handling. Usually, priority is given to areas closest to the mill and in areas where maximum benefit can be obtained. This will include areas with sandy soils, areas replanted with young palms and on hilly areas where soil moisture is low. Application rates also vary, based on palm age and soil type. Young areas are usually applied at 25-35 tons/ha/yr and in mature older areas,
usually about 50 tons/ha/yr. This can generally replace most inorganic fertilizers but sometimes, some supplementary doses are needed based on yield and nutrient levels as well as soil type.

To the extent that it is feasible financially, this waste should be spread around young palms throughout the plantation. In mature palms, it is either applied between palms along the row (where pruned fronds are stacked in alternating non-harvesting avenues) or in the non-harvesting avenue where pruned fronds are stacked between palms. A problem with recycling this material is that many of the mills return it to their own land rather than to the lands of those who sell FFB to them.

**Recycling palm oil effluent:** The other main waste product that should be recycled is the palm oil effluent. This is one of the most difficult wastes to handle as it is in liquid form. It should be applied back to the fields, as it makes an excellent soil additive. Land application of POME (at less than 10 cm REY/Ha) can largely replace inorganic fertilizers and has been shown to give better yield response over conventional inorganic fertilizers. This is in part due to the irrigation effect, which reduces soil moisture stress. However, it is important to note that land application practice in Sabah currently requires approval from DOE.

**Using mature tree trunks:** Trunks of mature trees that have been cut to allow replanting should be recycled more effectively. They contain up to 1,000 kilograms per hectare of potassium. Windrowing the trunks gives a slow breakdown of the material. This is the best way to release the nutrients.

Chipping or shredding releases all the nutrients within 2-3 years, and unless the chips are spread over a much larger area than the replanted area, the nutrients released would exceed the uptake capacity of the new trees. One other important factor that has to be considered is whether the existing palm stand is infected with *Ganoderma* disease and/or if the disease has been known to be endemic in the area. If *Oryctes beetle* pest or *Ganoderma* disease are a problem in the area, then it may be best to chip, pulverize or grind the trunks to reduce the time over which the biomass is available for beetle breeding and to destroy the disease inoculums tissue.

**Fruit bunches and trunks: good source of mulch:** Empty fruit bunches and trunks can be chipped and used as mulch if they are free of diseases.
used in circles around mature trees, the mulch can reduce herbicide requirements, but it may be a less efficient way to recycle nutrients than when spread over a larger area. For young trees, biodegradable mulch sheets can also reduce herbicide use.

There are 3 areas where improvements could reduce fertilizer use. First, avoid over-application of potassium and application of palm oil mill effluent and EFB in the same areas as well as the application of fertilizers during the rainy season. Secondly sludge from POM effluent ponds can be applied to fields that are low in organic matter. And third, increased monitoring is needed to understand better nutrient use, storage, and loss.

**Numerous options at hand:** Composting residues from oil mills and using them as mulch are seen as effective ways to maintain or build soil nutrients.

Oil palm trees are regularly pruned throughout the year during harvesting and sanitation rounds to remove senescent and moribund fronds. As palms grow, they produce new fronds, i.e. 24 fronds/palm/year at full maturity. This provides a regular and sustainable source of organic mulch which is recycled in the field. In addition, empty fruit bunches from oil palm mills must be disposed of; they are largely applied back on land and to a lesser extent burnt for the production of bunch ash, which is a valuable source of Potash fertilizer.

All in all, the weight and volume of waste far exceeds the commercially viable products produced from oil palm seeds. In addition, overly mature trees (25 years or older) are felled and either left lying on the ground or gathered and chipped.

Many plantation owners now put most of the mill by-products back to land as mulch. However, the level of utilization of these by-products can still be increased in the plantation industry. There is still considerable potential for preparations of other by-products such as fertilizers.

**Tables 4.2 and 4.3** below show a 2001 estimate by United Plantations Berhad of the level of utilization and fertilizer value of oil palm biomass residues when successfully recycled on land.
Table 4.2: Level of utilization of oil palm biomass residues and waste in United Plantations Berhad in Year 2001 (dry matter basis)

<table>
<thead>
<tr>
<th>Biomass</th>
<th>Quantity Produced</th>
<th>Quantity Utilised</th>
<th>% Utilisation</th>
<th>Method of Utilisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pruned fronds</td>
<td>202,800</td>
<td>202,800</td>
<td>100</td>
<td>Mulch</td>
</tr>
<tr>
<td>Trunks and fronds at replanting</td>
<td>130,55</td>
<td>104,400</td>
<td>80</td>
<td>Mulch</td>
</tr>
<tr>
<td>Spent male flowers</td>
<td>23,400</td>
<td>23,400</td>
<td>100</td>
<td>Organic matter</td>
</tr>
<tr>
<td>Fibre</td>
<td>38,410</td>
<td>36,490</td>
<td>95</td>
<td>Fuel</td>
</tr>
<tr>
<td>Shell</td>
<td>26,081</td>
<td>24,777</td>
<td>95</td>
<td>Fuel</td>
</tr>
<tr>
<td>POME</td>
<td>15,885</td>
<td>14,297</td>
<td>90</td>
<td>Nutrient source and organic fertilizer</td>
</tr>
<tr>
<td>EFB</td>
<td>38,173</td>
<td>34,356</td>
<td>90</td>
<td>Mulch and bunch ash</td>
</tr>
<tr>
<td>TOTAL</td>
<td>475,249</td>
<td>440,520</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Level of utilization = 93%

Table 4.3: Estimate fertilizer value of oil palm biomass residues recycled on land in United Plantations Berhad in 2001

<table>
<thead>
<tr>
<th>Biomass Residues</th>
<th>Method of Utilisation</th>
<th>Quantity Utilised on Dry Basis (tonnes)</th>
<th>Fertiliser Equivalent (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Urea</td>
<td>Rock Phosphate</td>
</tr>
<tr>
<td>Trunk &amp; fronds at replanting</td>
<td>Mulch</td>
<td>104,400</td>
<td>1,307</td>
</tr>
<tr>
<td>Pruned fronds</td>
<td>Mulch</td>
<td>202,800</td>
<td>4,583.0</td>
</tr>
<tr>
<td>Spent male flowers</td>
<td>Organic matter</td>
<td>23,400</td>
<td>770</td>
</tr>
<tr>
<td>EFB</td>
<td>Mulch</td>
<td>25,050</td>
<td>435.9</td>
</tr>
<tr>
<td>Digested POME</td>
<td>Irrigation</td>
<td>4,600</td>
<td>64.4</td>
</tr>
<tr>
<td>Total (tonnes)</td>
<td></td>
<td>360,250</td>
<td>7,160.3</td>
</tr>
<tr>
<td>Monetary value (US$ in millions)</td>
<td></td>
<td>1.065</td>
<td>0.160</td>
</tr>
<tr>
<td>Total monetary value US$</td>
<td></td>
<td>3.139 million</td>
<td></td>
</tr>
</tbody>
</table>

4-21
4.4.2 Precision Fertilizer Management

Currently, the fertilizer management and practices adopted by most oil palm plantation is quite general in approach and often resulted in serious losses of plant nutrients through leaching and surface run-offs (particularly in hilly and sandy soil areas). There are two aspects to precision fertilizer management. First, is the assessment of specific nutrient requirements. The overarching principle is total nutrient inputs should match the total nutrient exported through crops and biomass. If inputs exceed exports, then there is a case of excessive use, resulting in economic wastage and higher risk for pollution of river water. The second aspect is on efficient use or application of fertilizer that had been precisely determined earlier. Using available and affordable modern technologies such as global positioning system (GPS), geographic information system (GIS), and remote sensing (RS), planters can now gather precise data on production variables in an oil palm plantation. This information can be used by planters to manage their fertilizer program efficiently according to the soil types and palm resources (available in the plantation) and precisely to fit the variable conditions in each specific area of the plantations. Using this site-specific approach (also known as precision agriculture method) in managing fertilizer program and practices in oil palm plantations could help in reducing pollution from fertilizers and chemicals usage.

Applying the above technology, an agronomist can make precise fertilizer recommendations (as related to the suitable types and rates of fertilizer to be applied) based on the chemical and physical characteristics of the soils and palm requirements. As the approach involves implementation of the best management practices and techniques available for the specific soils and palms on-site, the site-specific approach is the ‘model’ for the way forward in maximizing productivity and efficiency while conserving soil fertility and river water quality.

Presently, fertilizers alone constitute more than 35 percent of the total production cost of oil palm in Malaysia. The present escalating fertilizer prices for ammonium chloride and muriate of potash (the major components required by the oil palm) would increase the cost further and put more pressure on the plantations to economize. Thus, the practice of applying higher fertilizer rate to ensure nutrient efficiency and act as a safety net may not be tenable now despite the current high palm oil prices.
One of the best options to reduce production cost is to sustain maximum yield at any one site. Greater care in developing and recommending a fertilizer program and monitoring palm health and soil fertility status are required in good fertilizer management. The fertilizer recommendation system for oil palm should encompass the computation of optimum fertilizer rates and other components which include correct timing, placement and methods of fertilizer application and right source of fertilizer which must be correctly implemented. In addition, it is recommended that fertilizer program should integrate the use of mineral fertilizers with plant biomass available in oil palm plantations and residues from the mills. Weather trends should also be taken into consideration for any fertilizer management plan.

Plate 4.7: Mechanized fertilizer application.

4.5 BMP 4: INTEGRATED PEST MANAGEMENT (IPM), PESTICIDE STORAGE AND DISPOSAL

4.5.1 Integrated Pest Management (IPM)

Monocultures such as oil palm planting encourage pests by providing massive abundance of food and favourable growing conditions for pests adapted to feed on the crop and/or that thrive under the same cultural conditions that favour the crop. When pesticides became available, they were used to favour crops with less attention on possible collateral effects. The surge of resistance from
massive and intense use of pesticides shifted the evolution towards those that were more tolerant. The destruction of natural enemies of pests by pesticides often resulted in pest resurgence where infestations became even higher than before the pesticide was applied. Soon the massive use of pesticides prompted health, environmental and economic concerns, that questioned the sustainability of highly pesticide-dependent agriculture.

Pest management chemicals often consist of noxious or toxic compounds that are hazardous to humans and lethal to soil and water ecosystems. Run-off, spillage or poor management practices jeopardize human health and ecosystems.

Integrated pest management (IPM) is an essential component of a sustainable oil palm plantation that allows rationalizing and reducing pesticides use. IPM is an ecosystem-based strategy that focuses on keeping pest populations below economic threshold level through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control tools are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

**Total pesticide toxicity allowance:** In some instances, pesticides will be necessary to insure profitable yields. Palm oil producers should be encouraged to evaluate the types of pesticides they use in order to increase the efficiency and reduce the environmental impacts of use. This would allow for the identification of specific chemicals and application practices that should be discouraged or even banned.

Only pesticides that are approved in the country of production and the country of consumption should be used. In general, the least toxic and least persistent pesticide should be used to address each problem. In general, chemicals should be used only as the last resort.

The equipment for applying these chemicals should ensure that the required quantity of pesticide is applied effectively with minimal impact on people or the environment.
**Understanding pest dynamics:** One of the best ways to develop an appropriate IPM system is to undertake regular census of the main pests. This should include an understanding of the pest's life cycle and its natural enemies.

The next issue is to understand what levels of infestation cause economic losses. These would be the action thresholds, and no pest control would be required until infestations reach these action thresholds.

Barn owls are effective predators of rats, the main mammal pest in oil palm plantations. Owl boxes can be established and monitored for occupancy. If poisons are used, it is important to choose warfarin baits that are not toxic to predators that may inadvertently consume poisoned rats i.e. to reduce secondary poisoning to non-target animals. Maintaining adequate populations of predators will reduce the need for poisons.

**Effective IPM measures:** Integrated pest management is already being used by some palm oil producers to reduce the use of pesticides. General IPM measures that reduce pests significantly are as follows:

- Close monitoring of disease and pest infestations allows them to be more easily controlled with or without chemical inputs;
- Planting species that support or attract natural enemies of oil palm pests helps minimize pest problems;
- Proper shredding and rapid decomposition of old trunks suppress the pest *Oryctes rhinoceros* (Rhinoceros beetle) from breeding;
- Use of a biological agent, a native baculovirus, to attack *Oryctes rhinoceros* has been proven 80-95% effective;
- Growing thick legume cover crops helps suppress *Oryctes* from breeding in the debris; and
- Encouraging barn owls and black-shouldered kites help to reduce rat populations.
- It is clear that some of the IPM practices have to be adjusted as other management practices shift. For example with zero-burning policies, additional control measures are needed to keep pests such as beetles...
and rodents in check. These and other IPM efforts should be further documented and as appropriate shared with other producers and government officials.

Specific guidance on the application of beneficial plants to control biological pests is shown in **Table 4.4** below:

**Table 4.4: Guidance on the Application of Beneficial Plants to Control Biological Pests**

<table>
<thead>
<tr>
<th>Cassiaco banensis (60%)</th>
<th>Antigonon leptopus (20%)</th>
<th>Turnera subulata (20%)</th>
<th>a) Euphorbia heterophylla</th>
<th>Entomopathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum = 10m strip/ha</td>
<td>Minimum = 10m strip/ha</td>
<td></td>
<td>Cordyceps pruinosa</td>
<td>- for the control of Setoranitens</td>
</tr>
<tr>
<td>Ideal = 40m strip/ha</td>
<td>Ideal = 30m strip/ha</td>
<td></td>
<td>Cordyceps militaris</td>
<td>– for the control of Setothosea asigna</td>
</tr>
<tr>
<td>Area of protection from leaf pest attack = 120m radius</td>
<td>Area of protection from leaf pest attack = 450m radius</td>
<td>Granulosis virus</td>
<td>– for control of Bagworms</td>
<td></td>
</tr>
<tr>
<td>Plants are perennial</td>
<td>Phased planting recommended due to short-lived nature of plant</td>
<td>Nuclear polyhedrosis virus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.4: Guidance on the Application of Beneficial Plants to Control Biological Pests

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<td></td>
<td></td>
</tr>
</tbody>
</table>
Plate 4.8: Beneficial plants for control of biological pests (Clockwise from top left): *Cassia cobanensis*, *Antigonon leptopus* and *Turnera subulata*.

4.5.2 Pesticide Storage

Proper storage of pesticides in oil palm plantations can effectively reduce the occurrence of accidental spills and leakages thus reducing the risks of river contamination. SIRIM (Malaysian Standards) Code of Practice for the Packaging and Storage of Pesticides provides some general guidance on pesticide storage:
a) General

- Pesticides shall at all times be stored in the originally labelled container, with the label plainly visible.

- Storage areas for pesticides shall be clearly defined, and exclusively set aside.

- Pesticides shall not be stored near food, feed or other items which can become contaminated by spillage, breakage of pesticide containers, volatilization of pesticides, odours, etc. Where pesticides are stored for display for sale separate enclosures should separate the products from other products displayed.

- Volatile pesticides shall not be stored for display in restricted atmosphere such as in air-conditioned rooms. Volatile pesticides shall be stored separately from other pesticides in order to prevent cross contamination.

- The pesticide shall be stored in such a manner that its shelf life is not adversely affected.

- The method of storage shall be such that damage is prevented.

b) The storage area

- Large quantities of pesticides shall at all times be stored in ware houses or warehouse-areas specifically designed for this purpose.

- Pesticide storage areas should have impervious floors (such as concrete floors) with drainage to a sump or other holding-area where contaminated water can be decontaminated before release. Earthen or wooden floors are not suitable.

- The storage area should be dry and well-ventilated.

- Storage warehouses shall be positioned away from dwellings and factories.

- Where dusts and other volatile pesticides are stored, the storage area shall have assisted ventilation (with exhaust/ventilating fans) facilities which can be operated from both inside and outside the warehouse.
a) **Security and hazard precautions**

- Pesticide storage areas should be locked. Suitable steps should be taken to prevent theft and unauthorized access. Such areas should also be identified by permanent signs at their entrances. The signs should also have appropriate warning or cautionary statements or symbols.

- All pesticide stocks in the storage area should be examined periodically for leaks, spills or any signs of deterioration. Any spillage material, damaged containers, etc., should be completely removed, and the area decontaminated and cleaned properly.

- Steps should be taken to make certain that run-off water from cleaning activities would not contaminate residential areas, livestock, feeding areas or water catchment areas. Pesticide storage areas should be diked or otherwise arranged in such a manner that all run-off water can be trapped in a suitable pool or sump for proper decontamination and disposal.

- Since pesticide fires present grave dangers, adequate fire prevention and precaution installations in storage and warehousing areas shall be set up. These may include installation of effective fire detection and warning systems, adequate spark-proof electrical wiring and equipment, and properly earthed electrical equipment. Appropriate fire fighting and safety equipment e.g. built-in sprinklers, etc. of adequate capacity and in adequate numbers shall be available throughout the pesticide storage area. All operating personnel should be thoroughly familiarized with its use.

- Pesticide storage areas shall be away from steam lines, heating lines and other heat sources.

- Protective and safety equipment such as fire blankets, complete protective clothing such as hats, boots, caps, gas masks, respirators, face shields, etc. shall be readily accessible, regularly checked and maintained in workable condition. All workers and supervisory personnel involved in the handling, transportation and storage of pesticides shall have ready access to qualified medical aid, and information on the stored chemical, including detailed information on how to deal with spills.
b) **Duration of storage**

- Acquisition of pesticides shall be scheduled and implemented so as to minimize storage time.

- Where pesticides have to be stored from one season to the next, such storage shall be held to a minimum and under no circumstances should time lapse between manufacture and use be allowed to exceed the shelf life of the product.

**4.5.3 Recycling of Pesticide Containers and Disposal of Rinsate**

The Department of Agriculture (DOA) provides guidance and promotes proper disposal and recycling of used pesticide containers. The objectives of recycling used pesticide containers are as follows:

- To protect the environment
- To abide by good agricultural practices
- To avoid the misuse of pesticide containers

Why the need to rinse used pesticide containers at least 3 times?

- To reduce health risks from remnant pesticides
- To reduce risk of environmental pollution so that containers can be accepted by recycling centres

Step-by-step instructions to rinse used pesticide containers 3 times:

- Pour remnant pesticide into spraying tank. Let pesticide drip and wait 30 seconds.

- Fill a quarter of the empty used pesticide container with clean water. Close the container with the cover.

- Face the container opening to the left and shake the container to the left and right continuously for 30 seconds.

- Pour rinsate into spraying can.
• Fill a quarter of the empty used pesticide container with clean water. Close the container with the cover. Face the container opening to the bottom and shake the container to the left and right continuously for 30 seconds. Pour rinsate into spraying can.

• Fill a quarter of the empty used pesticide container with clean water. Close the container with the cover. Face the container opening to the top and shake the container to the left and right continuously for 30 seconds. Pour rinsate into spraying can.

• Wash the outside of the container and punch a hole at the bottom of the container.

• Place the container appropriately and let dry before sending to the collection centre.

For illustrations, see Annex 8 for Department of Agriculture’s brochure on recycling used pesticide containers.

Proper disposal of rinsate (if not sprayed in the field):

• Treat rinsate with hydrated lime at a rate of 10kg/1000 litres of rinsate.

• Dispose of treated rinsate in a special rinsate disposal pit with the following criteria:
  ▪ Situated in a specialized location where groundwater is low (away from surface) and at least 50m from the nearest natural water source/well/residential area.

  ▪ Depth of pit should be 0.5-1 m.

  ▪ Pit should be treated with hydrated lime.

  ▪ Area should be fenced and marked with warning signs.

  ▪ Pit should be covered with organic matter and earth when not in use anymore.

MPOB’s Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings provides general guidance on crop protection and pesticide handling (Box 4.4).
Box 4.4: Guidance on crop protection and pesticide handling from “MPOB Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings”

4.8 Crop protection

4.8.1 Basic elements of crop protection

4.8.1.1 The use of pesticides to protect the crop should be minimized.

4.8.1.2 Wherever possible, crop producers should apply recognized Integrated Pest Management (IPM) techniques. Non-chemical control measures are preferred over chemical treatments.

4.8.1.3 Crop producers are encouraged to seek advice on IPM from competent agriculturalists.

4.8.2 Choice of agrochemicals

4.8.2.1 Appropriate agrochemicals should be utilized for crop protection purpose.

4.8.2.2 Crop producers should only use chemicals that are officially registered under the Pesticide Act 1974 (Act 149) and Regulations and Food Act 1983 (Act 281) and Regulations for use on the crop that is to be protected.

4.8.2.3 Selective products specific to the target pest which have minimal effect on populations of beneficial organisms, aquatic life, cattle, workers and consumers and are not detrimental to the ozone layer should be used.

4.8.2.4 Instructions on the label shall be followed to ensure effective application and to avoid risks to operators, consumers and the environment.

4.8.2.5 An anti-resistance strategy (e.g. use of correct dosage and alternative chemicals) should be adopted to avoid reliance on any one chemical.

4.8.2.6 Crop producers shall not use chemicals that are banned or disallowed
in importing countries.

4.8.2.7 Crop producers should consult their customers to determine if any additional commercial restrictions exist wherever necessary.

4.8.3 Advice on pesticide usage – Crop producers are encouraged to seek advice on pesticide usage from competent agriculturists.

4.8.4 Records of application – All records of pesticide applications should include crop name, any intercrop and animal integration location, date and reason for application, trade name of pesticide used, dosage, method of application and name of operator

4.8.10 Pesticide storage

4.8.10.1 Pesticides shall be stored in accordance with local regulations.

4.8.10.2 Pesticides shall be stored in a secured, water resistant, well ventilated and well-lit location away from other materials.

4.8.10.3 All shelves should be of non-absorbent material.

4.8.10.4 The pesticide store should be able to retain spillage (e.g. to prevent contamination of water courses).

4.8.10.5 There should be adequate facilities for measuring and mixing pesticides.

4.8.10.6 There should be emergency facilities (e.g. plenty of clean water, sand, sawdust) to deal with contamination and accidental spillage.

4.8.10.7 Keys and access to the store should be limited to personnel with adequate training in the handling of pesticides.

4.8.10.8 A procedure to handle accidents, a list of contact telephone numbers and the location of the nearest telephone should be available within the immediate vicinity of the store. Similar information should also be available next to the designated telephone.

4.8.10.9 An inventory of the pesticide store should be kept and be readily available for inspection.
4.8.10.10 All pesticides should be stored in their original packaging.

4.8.10.11 Only pesticides registered for use on oil palm or other crops on the farm should be stored.

4.8.10.12 Powders should be stored on shelves above liquids or separately.

4.8.10.13 Warning signage of potential dangers should be places on access doors.

### 4.6 BMP 5: SOLID WASTE MANAGEMENT

The “Solid Waste Management Master Plan Study in Sabah” estimates that one palm oil mill produces 90,000 tonnes of solid waste per annum. This solid waste mainly consists of empty fruit bunches (EFB), fruit fibres, shells and unprocessed/unwanted fresh fruit bunches (FFB). The following sections of this guideline elaborates on zero waste concepts and the need to minimize waste but for oil palm plantations, uncontrolled waste from the estate’s support resources like workers, fuel storage areas, etc. can also find its way to nearby rivers. It is recommended that all waste products and sources of pollution are identified. Once identified, an operational plan should be developed and implemented to avoid or reduce pollution.

Scheduled waste is to be disposed as per EQA 1974 (Scheduled Wastes) Regulations, 2005. This should include recycling of used HDPE pesticide containers. Municipal waste disposal as per local authority or district council is in accordance to the Ministry of Health guidelines (i.e. specifications on landfills, licensed contractors, etc) or Workers’ Minimum Standards of Housing and Amenities Act 1990 (Act 446).

If landfills are the preferred method of solid waste disposal due to logistical considerations, do note that designing a landfill is a complex activity. Reference can be made to the “Technical Guideline on Sanitary Landfill, Design and Operation” by JICA (2004). Landfill regulations are also increasingly stringent and landfill costs are increasing. Key issue is to choose a site location that result in the most environmentally cost-effective landfill. Issues regarding policies and regulations include the identification of wastes by type for disposal, provision of the appropriate classification of landfill, control of waste movement to the landfills,
rejection of illegal wastes from the site, and establishment of a means of financing the closure and post closure maintenance of the site.

MPOB’s Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings also provides some guidance on waste management and disposal issues (Box 4.5).

**Box 4.5:** Guidance on by-products, waste and pollution management from “MPOB Code of Good Agricultural Practice for Oil Palm Estates and Smallholdings”

<table>
<thead>
<tr>
<th>4.8.11</th>
<th>Empty pesticide containers</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.8.11.1</td>
<td>Empty pesticide containers should not be reused and their disposal shall be in a manner that avoids exposure to humans and contamination of the environment.</td>
</tr>
<tr>
<td>4.8.11.2</td>
<td>Official collection and disposal systems should be used if available</td>
</tr>
<tr>
<td>4.8.11.3</td>
<td>Empty containers should be rinsed at least 3 times with water and the washings returned to the spray tank.</td>
</tr>
<tr>
<td>4.8.11.4</td>
<td>Unless participating in established recycling programmes or with expressed permission from the authorities, rinsed containers shall be pierced to prevent reuse.</td>
</tr>
<tr>
<td>4.8.11.5</td>
<td>Empty containers should be secured until disposal.</td>
</tr>
<tr>
<td>4.8.11.6</td>
<td>Disposal or destruction of containers should be in accordance with the Pesticides Act 1974 (Act 149) and/or any other relevant local regulations.</td>
</tr>
<tr>
<td>4.8.12</td>
<td>Obsolete pesticides – Obsolete pesticides should only be disposed through an approved chemical waste contractor.</td>
</tr>
</tbody>
</table>

4.11 By-products, waste and pollution management

4.11.1 All possible by-products, waste and sources of pollution should be identified in all areas of oil palm production.

4.11.2 Having identified wastes and pollutants, an operational plan should be
developed and implemented to avoid and reduce wastage and pollution. Pruned fronds, biomass at felling, EFB and POME should be mulched in the field.

4.11.3 Estate and smallholding shall not allow dumping of external waste in their property

4.7 BMP 6: IDENTIFYING, MANAGING AND ENHANCING RIVER RESERVES

4.7.1 Importance of Maintaining River Reserves

River reserves are essentially the land adjacent to streams and rivers; a unique transitional area between aquatic and terrestrial habitats. Although constituting only a small part of the landscape, river reserves that are intact and functional are important habitats for biodiversity and provide ecosystem services, which are essential to the well-being of human populations. The main functions of river reserves are:

**Water quality improvement**: on-point sources of pollution, including run-off from agricultural lands and plantations introduce a variety of pollutants into the river system. These pollutants, which include sediments, nutrients, organic wastes, chemicals and metals, are difficult to control, measure and monitor.

River reserves serve as buffers, which intercept non-point sources of pollution. In particular, riparian vegetation absorb the heavy metals and nutrients, trap sediments suspended in surface run-off and provide a habitat for microorganisms that help break down the pollutants. In plantations where fertilizer, pesticides and herbicides are used, the maintenance of a vegetated river reserve of sufficient width is therefore extremely important to minimize the amount of these pollutants that enter the rivers.

**Flood mitigation**: Riparian vegetation increases surface and channel roughness, which serves to slow down surface water that enters the river and reduce flow rates within the river. This helps to slightly alleviate the magnitude and intensity of flooding downstream.

**Riverbank stabilization**: Riparian vegetation protects riverbanks from erosion or scouring caused by rain, water flow, etc. Erosion caused by removal of riparian vegetation results in sedimentation of the river which increases flood levels, as
well as bank failure, which may bring about the need for expensive remediation measures such as dikes, levees and flood walls.

**Figure 4.1** below provides a visual illustration of the ecological and biological function of river reserves.

![Illustration Describing the Function of River Reserves](source)

(Source: Ministry of Natural Resources and Environment, 2009)

**Figure 4.1: Illustration Describing the Function of River Reserves**

Many river reserves in Sabah have been altered in the course of resource use or development. In plantations, crops have been planted right up to the river margins. This has led to altered riparian ecosystems that are no longer able to perform their beneficial functions, and have very low biodiversity value.
Plate 4.9: Lack of river reserve (foreground) and river reserve maintained by oil palm plantation (background).

Plate 4.10: Oil palms planted right up to the riverbank.

Oil palm plantations have a role to play in identifying, managing and enhancing river reserves that are on their land. River reserves should be identified during initial stages of plantation development. These areas need to be conserved/managed and where necessary, restored/rehabilitated. This activity during the
initial stages is crucial to avoid extensive costs to restore and rehabilitate cleared or planted (oil palm) river reserves in the long run.

In terms of legislation, the establishment of river reserves in Sabah is provided for under Section 40 of the Sabah Water Resources Enactment 1998, which states that River Reserves “are to be established on land which is within 20 metres of the top of the bank of every river, including its estuary, where the channel is not less than three metres in width”. River Reserves may also be established along channels less than three metres wide, upon the recommendation of the Sabah Water Resources Council. The purpose of the establishment of River Reserves under Section 40 is for “protecting the volume or flow of water in water bodies and preventing the degradation of the quality of water resources and damage to the aquatic environment in water bodies”.

From a legal and/or management perspective, the width of river reserve may be either fixed or variable. Fixed-width zones are easier to gazette, enforce and administer, but fails to provide for many ecological functions. Variable-width zones can be designed to carry out specific functions at various sections, taking into account the site-specific conditions and requirements along the length of the river reserve. Protection needs should include surface erosion of stream side slopes, fluvial erosion of the stream/river channel, soil productivity, habitat for riparian dependant species and pollution control.

Looking beyond legislative requirements for recommended river reserve widths, stream size and stream order can also influence the size of the buffer needed. Headwater streams, for example, may not require the same degree of buffering as larger streams to provide the same benefit (Palone and Todd, 1997). Buffer widths should also account for the goals of the landowner and the desired functions. Designing riparian forest buffers to improve water quality is complicated by the need to control three different types of pollutants at the same time: sediment adsorbed pollutants in surface run-off, dissolved pollutants in surface run-off, and dissolved pollutants in groundwater (Palone and Todd, 1997). The design must also take into account the area's hydrology, soils, and pollutant loads.

Buffers of 15 to 30 metres are generally recommended to trap sediment, although wider buffers are required where there are high sediment loads or steep slopes (as a rule of thumb, the buffer should expand about 1.5 metres for every 1% increase in slope) (Palone and Todd, 1997). On flat sandy soils where
sediment loads are low, narrower buffers may be as effective (Magette and others, 1989). However, only very wide buffers will be effective in trapping small clay particles. For example, researchers in Arizona found that grass buffers trap most sand from shallow surface run-off within about 3 metres and trap most silt within 15 metres, but found that 90 to 120 metres of buffer was required to trap small clay particles (Wilson, 1967).

Riparian habitats are unique ecosystems where terrestrial and aquatic plant communities meet. The unique micro-climate and proximity to water make river reserves excellent habitats for many species of animals, especially birds and amphibians. In addition, salt licks, which are important source of nutrients for ungulates are usually found in the vicinity of rivers and streams. This makes the river reserves a critical component in the landscape ecology as they serve as conduits for wildlife and consequently allow for the movement of genetic material, nutrient and energy across the landscape.

They are in essence natural corridors which link landscapes across regions, from uplands headwaters to the floodplains in the lowland - corridors that have critical ecological functions and considered as having High Conservation Value (or HCV). The Kinabatangan – Corridor of Life (KCoL) Project can be a good local example in this to showcase how to create a balance between the growing demands of private land development (mainly of oil palm plantations), the local community and the need to protect the unique wildlife, whilst maintaining a functional and viable river reserve at the landscape level.

Some oil palm plantations, mainly large companies that are members of RSPO, have undertaken efforts to restore river reserves on their property (Plate 4.11) It is noted that further guidance as well as technical resources and incentive mechanisms are needed to ensure smallholder growers are able to be involved in any concerted effort to rehabilitate river reserves.
Plate 4.11: River reserve rehabilitation area in an oil palm plantation along the Segama River showing a signboard and abandoned oil palms interspersed with planted native tree species.

Plate 4.12 shows that despite the increase in efforts by major plantations to conserve and restore river reserves along large rivers, the smaller tributaries running through their plantations are commonly ignored and usually planted with oil palms right up to the banks. It is important to note that smaller tributaries transport large amounts of sediments, suspended solids and agrochemicals to main rivers. In some instances river reserves along the small streams are more important than river reserves along the main rivers as due to the drainage patterns in many estates the plantations drain into the small streams rather than directly into the main rivers. To completely tackle the problem of river pollution, river reserves along these smaller tributaries need to be managed as well. Under the current DID guidelines – river of less than 3 metres wide still need a River Reserve of 5 metres.
Plate 4.12: No river reserve along smaller tributaries in oil palm plantations.

Once river reserves are identified and demarcated, these areas need to be secured to prevent encroachment. Human activities like spraying of agro-chemicals, hunting, fishing, waste dumping, burning, etc. should be prohibited.

4.7.2 Restoring River Reserves

The following outlines key considerations for the restoration of river reserves as habitats and/or corridors for biodiversity, buffers to protect river water quality and considerations for tree planting and maintenance. It is important to have a good understanding of the existing and historical physical and biological conditions of the site, so that rehabilitation methods employed are appropriate to meet the objectives. As such it should be noted that a number of different site assessments may be required in order to address each key consideration below:

Key considerations for biodiversity:

- Plant a variety of suitable species
- Ensure suitable vertical stratification
- Ensure continuity of canopy cover
- Ensure availability of nesting material
- Retain dead branches, logs and leaf litter
- Ensure sufficient width
- Keep landscape connectivity in mind

Key considerations for water quality improvement:
- Plant appropriate vegetation types
- Ensure sufficient width

Species selection and layout

There are two modes of habitat establishment:

- **Natural regeneration** – allowing nature to take its course with minimal intervention. This method is suitable for areas where the riparian vegetation is recovering naturally through secondary growth. Such areas may have secondary tree species that provide ready cover, habitat and food source. Enrichment planting and silviculture may be required in these areas.

- **Replanting** – the establishment of a new plant assemblage. This is required in areas that have little or no vegetation. Although more labour intensive and expensive than natural regeneration, it allows for greater control of the plant species composition.

Normally, the choice of plant species to be planted or conserved includes endemic species, species that will help prevent riverbank erosion (Vetiver grass for short term, bamboo sp for long term measures) and species that can increase the population carrying capacity of the area and increase biodiversity by providing food sources for birds, small mammals and aquatic creatures. Further guidance on suitable native plants for rehabilitating river reserves are provided in **Annex 7**. For smaller tributaries, it may be more appropriate to plant smaller shrubs and ferns.

**Planting and maintenance**: A tree that is properly planted will require less maintenance and have a higher chance of survival. Thus the following are important considerations:
Seedlings and saplings: Seedlings and saplings may be obtained from nurseries specializing in forest species. Alternatively, seeds, seedlings and saplings may be obtained from adjacent riparian areas. Many large oil palm plantations that have undertaken river reserve restoration projects establish and maintain their own native tree nurseries as shown below (Plate 4.13).

Plate 4.13: Native tree nursery within an oil palm plantation to supply seedlings for a river reserve rehabilitation project.

Site preparation: Some limited land preparation may be required to increase bank or slope stability around the planting site. It is important to minimize any disturbance of the soil along the riverbanks. It helps to stop all chemical weeding well ahead of a planned river reserve restoration project and if the tree species chosen requires some shade in the early establishment phase, then appropriate fast growing tree species can be established ahead of the actual tree species, which is intended for long term purposes. This increases the likelihood of survival, especially for many tropical forest plants.

Planting: Saplings should be of appropriate size/age and should be hardened for at least 2 weeks prior to planting in order to acclimatize them to stressful conditions such as minimal watering and increased exposure to sunlight. The diameter of the planting hole should be 3 times the diameter of the polybag and the height equal to the height of the polybag. Branches and leaves should be pruned and kept to a minimal (25% of actual leaf or branching contents) just
before planting to reduce transpiration. It is often necessary to protect saplings from animals.

**Maintenance:** Intensive maintenance, including watering, should be carried out within the first 3 months after planting, or at least until the saplings start to grow new leaves. This is also the time when fertilizers need to be applied. It is preferred that organic fertilizers and EFB be used in these areas rather than inorganic fertilizers for minimizing impacts to the waterways. No chemical weeding should be carried out; instead regular rounds of manual weeding can be carried out around the planted saplings. Periodical inspection for insect pests should then be carried out and it is preferred that biological insecticides such as *B. Thuringiensis*-based products are used instead of chemical based insecticides where possible. Initially, monthly rounds of maintenance is required but over time (as the trees get established), this can be reduced to once every six months.

**Riparian Restoration and Management Programme:** It is recommended that plantations that do not have the expertise to carry out restoration work on their own, seek advice or services from qualified consultants, university academics or and/or collaborate with NGOs like WWF and HUTAN in drawing up their restoration programs. This will ensure the success of the project.
The following Best Management Practices take a 3-prong approach aimed at minimizing the impacts of palm oil mill operations on river water quality:

a) Reducing POME
   - BMP 1: Conversion of mill waste into value-added products
   - BMP 2: Reduction of POME generation with Decanter Dryer System
   - BMP 3: Reducing and recycling water used for palm oil mills

b) Improving POME treatment systems
   - BMP 4: Operation and improvement in POME treatment processes and routine maintenance of systems

c) Improving pollution control of milling process
   - BMP 5: Control of Oil Spillages and Leaks
   - BMP 6: Separation of Effluent and Storm-water Drainage Systems
   - BMP 7: Proper Interim Storage of Solid Waste Materials
   - BMP 8: Enhancing Land Irrigation Systems for Treated POME
### Table 5.1: Summary of BMPs for minimizing impacts of Palm Oil Mills on river water quality

<table>
<thead>
<tr>
<th>BMP</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP 1: Conversion of mill waste into value-added products</td>
<td>Describes basic “zero-discharge” concepts, benefits of converting mill waste to value-added products like compost and various related technologies.</td>
</tr>
<tr>
<td>BMP 2: Reduction of POME generation with Decanter Dryer System</td>
<td>Provides information about reducing POME generation by modifying the standard oil clarification process using the Decanter Dryer System.</td>
</tr>
<tr>
<td>BMP 3: Reducing and recycling water used for palm oil mills</td>
<td>Describes the role of water reduction in minimizing POME production and methods using evaporation technology.</td>
</tr>
<tr>
<td>BMP 4: Enhanced operation and improvement in POME treatment processes and routine maintenance of systems</td>
<td>Describes the biological treatment of POME based on anaerobic, aerobic and facultative processes as well as related technology.</td>
</tr>
<tr>
<td>BMP 5: Control of oil spillages and leaks</td>
<td>Provides basic information on the control of oil spillages and leaks as well as oil trap maintenance and operation.</td>
</tr>
<tr>
<td>BMP 6: Separation of effluent and stormwater drainage systems</td>
<td>Describes the importance of maintaining separate system of drains for stormwater and effluent.</td>
</tr>
<tr>
<td>BMP 7: Proper interim storage of solid waste materials</td>
<td>Describes proper interim storage of solid waste materials from palm oil mills.</td>
</tr>
<tr>
<td>BMP 8: Enhancing land irrigation systems for treated POME</td>
<td>Describes various land irrigation systems as well as the process for land application of POME.</td>
</tr>
</tbody>
</table>
MPOB’s Code of Good Milling Practice for Palm Oil Mills provides guidance on pollution and environmental issues related to mill operations (Box 5.1).

**Box 5.1: Guidance on pollution and environmental issues from “MPOB Code of Good Milling Practice for Palm Oil Mills”**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.27</td>
<td>Environment</td>
</tr>
<tr>
<td>4.27.1</td>
<td>All relevant environmental legislation/regulation should be complied with, such as Environmental Quality Act 1974 and Regulations.</td>
</tr>
<tr>
<td>4.27.2</td>
<td>Policies and procedures for minimizing the production of waste and its impact on the environment should be developed, implemented and maintained.</td>
</tr>
<tr>
<td>4.27.3</td>
<td>All waste products should be appropriately disposed of in accordance with existing legislation.</td>
</tr>
<tr>
<td>4.27.4</td>
<td>Palm oil mill effluent (POME) – The treatment system adopted must be continuously and regularly maintained to meet the requirements of the Malaysian environmental authorities.</td>
</tr>
<tr>
<td>4.27.5</td>
<td>Fibre and shell – Any excess fibre and shell should be stored and dealt with according to established procedures.</td>
</tr>
<tr>
<td>4.27.6</td>
<td>Empty fruit bunches (EFB) – EFB should be properly managed in compliance with environmental legislation.</td>
</tr>
</tbody>
</table>
5.1 BMP 1: CONVERSION OF MILL WASTE INTO VALUE-ADDED PRODUCTS

Large quantities of water are required in the palm oil milling process. It is estimated that 5-7 tonnes of water is required to produce one tonne of palm oil. About half of the water used ends up as palm oil mill effluent (POME). POME is a mixture of sterilizer condensate, separator sludge, and hydro-cyclone wastewater. POME is highly organic in nature and is highly polluting due to its high BOD concentration.

Concerted research and development efforts have been conducted to develop an effective POME treatment system and disposal technologies for palm oil mills. However, to-date most of these technologies are not able to comply with the stringent environmental control regulations. The palm oil industry is compelled to look seriously into “zero-waste” or “zero-discharge” concept to help solve the environmental problem.

Converting all types of wastes generated at the mill into value-added products is straightforward and economically viable. Extensive R & D have been conducted to show that with proper handling and management, the wastes or biomass generated by the palm oil mill can be utilized and converted into valuable resources. The practice of recycling crop residues such as EFB and POME as a source of plant nutrients and organic matter needs to be fully exploited. Alternatively, using current technology these wastes could also be converted into compost or organic fertilizers.

A sampler of currently available composting methods/technology includes:

**Vermicomposting**: Vermicomposting is described as composting or natural conversion of biodegradable waste into high quality fertilizer with the help of earthworms. Vermicomposting is the process in which earthworms are used to convert organic materials into humus-like material known as vermicompost or earthworm compost. Through vermicomposting process physical, chemical and biological reactions take place, resulting changes in the organic matter. The resultant product (vermicast) is much more fragmented, porous and microbially active. In contrast to traditional microbial waste treatment, vermicomposting process results in bioconversion of the organic wastes into two useful products: the earthworm biomass and the vermicompost. Earthworm biomass can further be processed into proteins as a source of animal feeds. The latter product (vermicompost/casting) is considered as homogenous, has reduced levels of...
contaminants and tends to hold more nutrients. During the vermicomposting process, important plant nutrients such as nitrogen, phosphorus, potassium, etc. present in the waste are converted into much soluble and available to plants. It has been reported that the nutrient composition of vermicompost may increase the plant nutrients as compared to simple composting.

**Controlled Environment Chamber (CEC):** The use of CEC technology to produce compost is already happening in several pilot sites in Sabah. CEC basically provides a controlled environment for producing compost. EFB from palm oil mills is first shredded and then deposited into various chambers each day. The temperature in each chamber is maintained between 55 to 65 degrees Celsius via the spraying of POME with added microbes (to aid decomposition). Fans in each chamber maintain moisture levels at an optimum level of around 50%. Leachate from the chambers is collected and returned to POME ponds. Studies show that there is a 50% reduction in BOD and COD levels in POME. The resulting compost is reapplied to the estate or sold to outside sources. Studies show that when this compost is returned to the fields, there is an overall 15-20% reduction in total inorganic fertilizer use. The following photos depict the main components of a CEC operation.
Plate 5.1: Production of compost using Controlled Environment Chamber (CEC) technology: row of chambers.

Plate 5.2: Production of compost using Controlled Environment Chamber (CEC) technology: Individual chamber.
Plate 5.3: Production of compost using Controlled Environment Chamber (CEC) technology: microbe storage area.

Plate 5.4: Production of compost using Controlled Environment Chamber (CEC) technology: EFB shredder
CEC technology is one of many available and proven technologies for producing compost from mill and plantation waste. Several companies are already operating composting facilities or have pilot projects in Sabah.

Another similar example to the CEC technology described above is Asia green’s Integrated Natural Fertilizer (INF) plant, which is a covered composting technology designed to integrate with the palm oil mill to off-take waste streams generated by the mill and process them into a nutrient rich organic fertilizer compound called NF (Natural Fertilizer). The NF is intended to be applied back into the surrounding oil palm estates with multiple benefits of reducing chemical fertilizer usage, improving FFB yield and allowing the client to produce CPO via an eco-friendly, sustainable, and cost-effective system of recycling mill waste stream into valuable nutrient-rich organic fertilizer compound.

Further benefits of NF over chemical fertilizer usage are provided by Asia green and depicted in Table 5.2:

<table>
<thead>
<tr>
<th>NF from Integrated Natural Fertiliser (INF) Plant</th>
<th>Chemical Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains Nitrogen, Phosphorus, Potassium, Magnesium, Calcium, Organic Matter, Humic Acid, and trace elements such as Sulphur, Copper, Boron, Manganese, Zinc, Iron and Molybdenum</td>
<td>Straight fertilizer contains 1 type of nutrient only while compound fertilizer contains up to 5 types of nutrients (no presence of organic matter, humic acid or trace elements)</td>
</tr>
<tr>
<td>Contains microorganisms to assist in decomposition and nutrient production</td>
<td>No presence of microorganisms</td>
</tr>
<tr>
<td>Uses harmless organic raw materials such as palm oil mill waste</td>
<td>Uses chemical substances that cause the soil to harden and deplete oxygen captured in the soil after long and repeated applications</td>
</tr>
<tr>
<td>Slow release, fast-acting, additional organic matter, humic acid and trace elements, and minimum nutrient loss from leaching even during rainy and monsoon seasons</td>
<td>High nutrient losses from leaching during rainy and monsoon seasons typical of the tropical climate for oil palm cultivation</td>
</tr>
<tr>
<td>Has pH of 7 – 9.5, which reduces soil acidity, enhances fertility and nutrient absorption by the oil palm</td>
<td>Depending on the type of fertilizer soil becomes acidic after long and repeated applications, which reduces soil fertility and nutrient absorption capability of the oil palm</td>
</tr>
</tbody>
</table>
Table 5.2: Comparison of NF and chemical fertilizer applications (*cntd*)

<table>
<thead>
<tr>
<th>NF from Integrated Natural Fertiliser (INF) Plant</th>
<th>Chemical Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to slow release of nutrients, the effectiveness of the NF lasts longer and due to its lumpy, fibrous form, the NF is not easily washed away during the rainy and monsoon seasons (only 1 round of application is required per year)</td>
<td>In their liquid, lightweight form, chemical fertilizers are easily washed away (high nutrient losses) during the rainy and monsoon seasons (require 6 rounds of application for single nutrient, straight fertilizers and 3 rounds of application for compound fertilizers)</td>
</tr>
<tr>
<td>Usage of NF in the fields doubles the oil palm’s fertilizer-use efficiency and helps to prevent or reduce soil erosion. Proven sustainability of or increase in oil palm fresh fruit bunch (FFB) yield with combined application of NF and chemical fertilizer supplements.</td>
<td>Field application of nitrogen-based chemical fertilizer results in nitrous oxide emissions (with global warming potential of 300 times that of carbon dioxide). Increases nitrate and nitrite deposits in the oil palm after prolonged usage, reduces quality of FFB yield.</td>
</tr>
<tr>
<td>Replenishes organic matter and revitalizes the soil in mature and old oil palm estates</td>
<td>Increases chemical contamination in soil from prolonged usage of chemical fertilizers, which causes soil toxicity and water pollution (when chemicals in fertilizer are washed into rivers or water courses during rainy and monsoon seasons).</td>
</tr>
<tr>
<td>No pest or fungi problem with the slow nutrient-release NF</td>
<td>The rapid, lush growth caused by chemical fertilizers attracts pests and fungi to the oil palms</td>
</tr>
<tr>
<td>Reliable and consistent supply of NF at allow, predetermined price with pre-agreed inflation rate (usually 3.5% per annum) over a long term of 20 years</td>
<td>Unreliable supply at overall escalating prices due to high demand, unexpected output decrease, rise in petroleum prices, increase in transportation costs, etc.</td>
</tr>
</tbody>
</table>
The key elements of Asiagreen INF Plant comprises of:

- **EFB Shredding Station**

  The EFB Shredding station is designed and equipped in terms of capacity, sizing and EFB storage area to cope with the respective mill’s daily output of EFB and running hours. EFB exiting the mill is linked by scapper conveyors or transported by tipper lorries to convey the EFB to the Shredding Station where high speed shredding machines are used to shred the EFB into Fibre. The EFB Fibre is then transferred by a conveyor system / dump trucks to the NF Processing Silo of the INF plant. Any excess EFB Fibre yet to be processed in the NF Processing Silo is kept at the EFB Fibre storage bay built as an integral part of the EFB Shredding Station.

- **POME Pumping Stations**

  Two POME Pumping Stations are constructed, 1 Pumping Station located beside the Sludge Pit of the palm oil mill to pump the daily requirement of POME to the Cooling/Holding Ponds next to the NF Processing Silo, and the other Pumping Station located beside the NF Processing Silo to pump POME from the Cooling/Holding Ponds into the NF Processing Silo for application onto the EFB Fibres (and any other mill waste streams) during the composting process. Self priming centrifugal pumps and HDPE piping are selected for low-maintenance and trouble-free operation. All the pumps, motors and electrical switchboard are housed within the POME Pumping Stations.

- **NF Processing Silo**

  The building structure is designed for prolonged life span using concrete floor slab, concrete/brick walls, steel portal frames and metal sheet roofing. The NF Processing Silo is lighted up using high-bay metal halide lighting. A gantry-type NF Turner is deployed within the NF Processing Silo to create maximum aeration during the composting process which guarantees that the oxygen content at all times is above 10% (main CDM criteria in the audit of Certified Emission Reductions (CERs) generated from composting plant projects) and to ensure thorough mixing of different mill waste streams delivered to the NF Processing Silo. The NF Turner (KOMPMAX Turner) is designed, engineered and fabricated in-house by
Asiagreen at its Balakong machine fabrication plant, and is available with diesel-engine or electric-motor operation options.

The POME application system is based on Asiagreen’s in-house design which is integrated with the NF Turner to ensure even distribution of POME, consistent nutrient content in NF produced, and prevent any over-application and leaching of excess POME from the NF Processing Silo (integrated application system enables simultaneous turning of mill waste heap and spraying of POME over the mill waste heap).

The fresh EFB Fiber and other mill waste streams are loaded at one end of the NF Processing Silo whilst the finished product i.e. NF will be harvested at the other end of the NF Processing Silo. The NF Processing Silo has a maintenance bay for the servicing of the NF Turner, and is constructed with perimeter roads, drainage system and fencing with a gate (for security).

**NF Store**

An NF Store is constructed and maintained by the Mill Owner as part of the overall LINF plant. The store is designed to keep up to 7 days production of NF and ideally located next to the NF Processing Silo. The NF Store is designed with simple concrete floor slab, 6 meter in height with steel structure frame and metal roofing.
Figure 5.1: Process Flow for INF Plant

(Source: Asia Green)
Biomass wastes from palm oil mills can also be a source of energy. The following are two examples:

- **Biomass power plant**: Dewatered EFB from palm oil mills is combusted in a biomass boiler to provide steam for generating electricity. Recent developments in pre-processing EFB to eliminate clinker formation have greatly enhanced the operational efficiencies of this technology. It is now feasible for biomass power plants to convert large amounts of palm oil mill biomass into useful energy and also resolve the solid waste disposal difficulties and associated air emissions.

- **Biodiesel plant**: The remnant oil recovered from dewatering of EFB from palm oil mills could be used as feedstock for the preparation of biodiesel in a biodiesel plant. There are several stages requires in biodiesel production, namely raw material preparation, catalyst preparation, transesterification reaction, washing and purification. A typical plant can be designed for producing 8 tons/day of biodiesel from sludge oil with methanol in the presence of a base and acid catalysts. The main product from the trans-esterification process is biodiesel (methyl esters) 97% and 3% glycerol as a side product.

**Financing through the Clean Development Mechanism (CDM)?**

The Clean Development Mechanism (CDM) allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol.

The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction limitation targets.

There are at least 28 projects involving the Malaysian palm oil industry currently registered under the UNFCCC’s CDM initiative. These projects all involve composting of mill waste and methane capture. The state government and oil palm sector companies should explore opportunities for funding future composting or biomass utilisation activities through the CDM. More information: [http://cdm.unfccc.int/](http://cdm.unfccc.int/)
5.2 BMP 2: REDUCTION OF POME GENERATION WITH DECANTER SYSTEM

POME generation can be reduced by modifying the standard oil clarification process and prevent effluent from being produced in this station. Generally crude oil extracted direct from the press requires heavy dilution with hot water before efficient separation of impurities can take place. In the decanter system, the introduction of the decanter facilitates separation without water addition. This system could reduce the volume of effluent produced in the clarification station which accounts for approximately 75 percent of the total BOD load discharged from a mill. The remaining 25 percent of the effluent is generated by the sterilizer condensate and hydro-cyclone wash water which can be treated in anaerobic ponds (Whiting 1979). Although the decanter system has been through many modifications over the years (like the Eco-D system), this section describes the United Plantations (UP) Decanter Drier System, one of the earlier and basic established systems.

Installing the Decanter Drier System can modify the standard oil clarification process and prevents effluent from being produced in this station, and in exchange a valuable by-product is produced (Jorgensen and Gurmit 1984). The greatly reduced water content is of fundamental importance to the system because it is now possible to dry the moisture by evaporation process, and at the same time produce a dry sludge cake referred as palm oil meal. The palm oil meal obtained could be used as a source of organic fertilizer or animal feed.

5.3 BMP 3: REDUCING AND RECYCLING WATER USED FOR PALM OIL MILLS

Reducing and recycling of water in the palm oil mill is a key strategy both to enhance productivity/as well as minimize waste production. The more the use of water is reduced – the less POME that will be produced.

Palm oil mills that practice good water usage require less than 1.5 cubic metres of clean water per tonne of FFB processed. Field observations indicate that excessive water usage is attributed to the factors as presented in Table 5.3
Table 5.3: Cleaner Production Measures for the Control of Water Usage

<table>
<thead>
<tr>
<th>Causes of excessive water usage</th>
<th>Cleaner production measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to shut off valves, water taps and water hoses immediately</td>
<td>Proper staff supervision is needed</td>
</tr>
<tr>
<td>Tank overflows, especially in the press room and clarification station, due to lack of overflow control</td>
<td>Level or float controllers need to be installed in all water and oil storage tanks</td>
</tr>
<tr>
<td>Poor equipment maintenance and significant oil leaks leading to excessive washdown</td>
<td>Need for improved preventative maintenance</td>
</tr>
<tr>
<td>Improper operation of the hydrocyclones resulting in excessive water usage</td>
<td>Operators need to be better trained to ensure awareness and skilled operation</td>
</tr>
<tr>
<td>Use of water to flush out spillages of oil and solid waste materials into drains</td>
<td>Spilled oil should first be recovered and dry removal/cleaning of remnants practised</td>
</tr>
<tr>
<td>Leaks in water pipelines and valves</td>
<td>Regular maintenance is needed</td>
</tr>
</tbody>
</table>

One of the best options to recover the water for reuse and add value to the solid concentrate obtained from palm oil mill is through evaporation technology. Evaporation technology has been commercially applied to produce natural rubber serum concentrate from wastewater generated by latex factories. Similar technology has been successfully evaluated to process POME (Ma et al., 1994).

About 85% of the water in the POME can be recovered as distillate. The quality of the distillate has been found to be good and can be reused as boiler feed water or process water with minimal chemical treatment. It is estimated that the quantity recovered is sufficient to meet the boiler feed water requirement. This would offset the water intake from the river or water reservoirs. Cost for water treatment could be reduced and more importantly, there is no liquid discharge from the mill. Energy requirement is the major consideration in the evaporation process. The heat (from steam) and electrical energy required can be provided by the palm oil mill’s energy production system.
The basis for and the results of work on water use reduction through evaporation are:

- POME contains about 96% water and 4% total solids. About 2%-3% is suspended solids comprising mainly of remnants of the mesocarp of oil palm fruits, and 0.7% is residual oil. By evaporation of POME the water can be recovered and the residual solid concentrate utilized;

- Vacuum evaporation technology was initially evaluated in the laboratory using a rotor evaporator. Efficient evaporation of the water is achieved by taking advantage of the available heat in fresh POME at its average temperature of 80°C and applying a vacuum of 600 mg Hg to lower its boiling point to about 60°C; a clear distillate is obtained;

- The laboratory rotor-evaporator demonstrated that POME can be evaporated to a very dry solid. The laboratory results were confirmed in a pilot plant using a single-effect (flash) evaporator of 200-liter capacity. A schematic flow diagram of the pilot plant is presented in Figure 5.2;

- The maximum solids concentration achieved in the concentrated liquor was about 30%, after which it became too viscous and could no longer be pumped;

- POME used for the pilot trial contained about 3.3% total solids and the solid concentrate produced contained about 20% - 30% solids. Thus, about 85% of the water was evaporated and recovered;

- The quality of the distillate is considered generally good in terms of the total solids content of less than 150 mg/l. The distillate which is slightly acidic due to the presence of carryover free fatty acids, which during distillation can be re-used as process water or boiler feed water with minimal additional treatment;

- Based on an 85% water recovery rate, a 30-tonne FFB per hour mill which generates about 19.5 tonnes of POME will result in 16 tonnes of water being recovered for recycling. This is sufficient to supply all the boiler feed-water required for the mill operation. If the need arises, the distillate can be mixed with raw water and treated before reuse;
For the 30-tonne FFB per hour mill, the rate of generation of the effluent concentrate with a solids content of 20% will be about 3.2 tonnes per hour; i.e., a substantial reduction of about 84% from 19.5 tonnes of POME per hour which will result in easier material handling reduction; and

The energy requirement is the major consideration in evaporation. However, the heat required is largely inherent in the fresh POME that is discharged at a temperature of 80°C to 90°C. The additional evaporation energy can be economically derived from the surplus electricity usually generated by palm oil mills, or alternatively from the combustion of empty fruit bunches (EFBs). For mills having excess boiler and electricity-generating capacities the additional investment is minimal.

Commercial-scale evaporation plants have now been constructed and use multi-stage evaporation systems. These plants achieve a higher solids concentration in the effluent concentrate due to introduction of a forced-circulation system to pump the concentrated liquid.

Figure 5.2: Evaporation Process for Palm Oil Mill Effluent
5.4 BMP 4: ENHANCED OPERATION AND IMPROVEMENT IN POME TREATMENT PROCESSES AND ROUTINE MAINTENANCE OF SYSTEMS

5.4.1 Biological Treatment of POME

The organic content of POME is generally biodegradable and treatment is based on anaerobic, aerobic and facultative processes. The processes are essentially biochemical and rely on the enhanced growth and metabolic activities of suitable microorganisms to breakdown the organic matter into simple end-products gases such as methane, carbon dioxide and hydrogen sulphide, and water.

The microorganisms involved are primarily bacteria and algae which result in the production of excess biomass (microbial cells) that needs to be disposed-off in the form of sludge. This sludge can be appropriately land-applied in the oil palm plantation as soil conditioner. A large number of biological treatment processes have been researched specifically for palm oil mill effluent in attempts to arrive at the most cost-effective treatment systems. These include:

- Anaerobic processes such as the anaerobic pond, conventional anaerobic digester, anaerobic contact process, and up-flow anaerobic sludge blanket (UASB) reactor; and

- Aerobic (and facultative) processes such as the extended aeration system, aerated pond and aerobic stabilization ponds.

The available effluent treatment technologies for POMEs are based on a combination of the biological treatment processes and treatment units listed above. The current POME treatment methods are summarized in Table 5.4.
Table 5.4: Summary of Various Current POME Treatment Methods

<table>
<thead>
<tr>
<th>System</th>
<th>Brief description</th>
</tr>
</thead>
</table>
| Ponding System (Chin and Wong, 1982; Chan and Chooi, 1982; Chin et al., 1996) | - Combination of anaerobic, aerobic and facultative ponds or ponds.  
- About 85% of Malaysia’s palm oil mills applying this system to treat POME.  
- Main components of the system include de-oiling tank, acidification ponds, methanogenic ponds, facultative ponds and sand beds.  
- Long treatment period of 45 to 60 days.  
- High maintenance required due to huge treatment area. |
| Aerated Ponding System (Thani et al., 1999) | - Similar to the ponding system except the facultative ponds are replaced with mechanically-aerated ponds.  
- Treatment period is usually between 15 to 20 days. |
| Conventional Anaerobic Digester (Lim et al., 1983) | - Combines the anaerobic process in a digester tank with the aerated ponds.  
- The digester tank is a continuous stirred tank reactor (CSTR) with no solid recycle.  
- Requires a longer treatment period (20 days) to prevent washout of microorganisms and to achieve desired treatment efficiency.  
- High treatment cost. |
| Anaerobic Contact Process (Ibrahim et al., 1984) | - Similar to the Conventional Anaerobic Digester except the raw wastewaters are mixed with recycled sludge solids and then digested in a continuously stirred digester tank (CSTR).  
- Gas formation in the settling tank inhibits effective settling of the sludge and enhanced buoyancy of the suspended solids. |
| Up-flow Anaerobic Sludge Blanket (UASB) Reactor (Thani et al., 1999, Najafpour et al., 2006) | - Combines the anaerobic process in a digester tank with the aerated ponds.  
- The digester tank is a UASB Reactor based on upward flow of wastewater through a suspended layer or sludge blanket of active biomass.  
- Biochemical activity converts organic matter to methane and carbon dioxide gas. |
Table 5.4: Summary of Various Current POME Treatment Methods (*cntd*)

<table>
<thead>
<tr>
<th>System</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close Tank Digester (Mahabot and Harun, 1986)</td>
<td>• The biogas is collected and treated wastewater is discharge via an overflow weir</td>
</tr>
</tbody>
</table>
|                                                  | • The digesters are operated as a conventional high-rate system.  
• The treatment period is about 10 days.  
• Biogas generated from the digester is compressed and discharged into the emitter utilized for heat and electricity generation and excess biogas is flared off. |
| Trickling Filter (Norulaini *et al.*, 2001)       | • 50% of COD was achieved for the influent COD of 26,000mg/L.                                                                                                                                                      |
| Aerobic Ponding System (Oswalet *et al.*, 2002)   | • Similar to aerated pond system except special species of microorganism is used.  
• A tropical marine yeast (*Yarrowia* *polytica*) is used for the degradation of POME in a pond.  
• 95% COD removal was achieved at the retention time of 2 days. |
| Aerobic Rotating Biological Contactor (Najafpour *et al.*, 2005) | • 88% COD removal for the retention time of 55 hours with the influent COD of 16,000mg/L.                                                                                                                           |
| Land Application System (Wood *et al.*, 1979; Eapen, 1977) | • Anaerobic digested POME is utilized as a source of organic fertilizer.  
• The POME is pumped to distribution tanks and then applied directly as fertilizer onto the cropland by gravity flow or by pumping onto a system of inter-row flatbeds, long-beds or furrow. |
Table 5.4: Summary of Various Current POME Treatment Methods (cntd)

<table>
<thead>
<tr>
<th>System</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporation Process (Ma, 1999)</td>
<td>• Evaporation to remove solids content of POME.</td>
</tr>
<tr>
<td></td>
<td>• Energy obtained from burning unwanted fiber and shell.</td>
</tr>
<tr>
<td></td>
<td>• Generate large amount of air pollutants; creating another environmental problem.</td>
</tr>
</tbody>
</table>

The biological treatment systems commonly employed are described in more details as follows:

- Anaerobic-cum-Facultative Ponding System;
- Anaerobic-cum-Aerated Ponding System;
- Anaerobic Reactor-cum-Aerated Ponding System;
- Anaerobic Pond-cum-Land Application System; and
- Anaerobic Reactor-cum-Land Application System.
Plate 5.5: A typical aeration pond.

Plate 5.6: A typical Ponding system.

a) Anaerobic-cum-Facultative Ponding System

The “ponding” system, which essentially consists of a combination of anaerobic, aerobic and/or facultative ponds or lagoons, is the most commonly used by Malaysian palm oil mills, about 85%. In this system, the anaerobic treatment process takes place in anaerobic ponds or lagoons. A schematic representation
and the principal design features of a typical anaerobic-cum-facultative ponding system, based the original design by one of the major plantation groups, is presented in Figure 5.3.

The essential components of the system are:

i. De-oiling Tank;
ii. Acidification ponds;
iii. Methanogenic ponds;
iv. Facultative ponds; and
v. Sand beds.

The essential process components and basic design features of the anaerobic-cum-facultative ponding system (based on original ponding system configuration of the Boustead Plantation Group) are:

i. De-oiling tank of concrete construction and hydraulic retention time (HRT) of 1.5 days for oil recovery, equalization and cooling of the effluent; and
ii. Two-phase anaerobic treatment in ponds - an Acidification Phase and a Methanogenic Phase;

- The Acidification Phase of the anaerobic process takes place in two (2) ponds in series, each with a hydraulic retention time of 2 days. Acid-forming anaerobic bacteria or acidogens convert the hydrolysed complex organics into free fatty acids;
- The Methanogenic Phase of the anaerobic process takes place in two ponds in series – a primary anaerobic pond of 30-day HRT and an anaerobic maturation pond of 15-day HRT in which methane-forming bacteria or methanogens convert the free fatty acids into methane, carbon dioxide and other minor gases, and water;
- The anaerobic ponds are typically 5 to 7 metres deep to prevent or minimize introduction of oxygen through photosynthetic activity and/or atmospheric penetration; and
- The anaerobically-treated effluent is then treated aerobically in a parallel-series system of four (4) facultative ponds having a combined HRT of 8 days.
Figure 5.3: Anaerobic-cum-facultative Ponding System (Bi-phasic)
The facultative ponds are relatively shallow with depths of between 1 and 1.5 metres to enable sunlight penetration and algal photosynthesis which is the source of the oxygen needed by the aerobic microorganisms;

Sludge accumulated at the bottom of the ponds is periodically pumped using submersible slurry pumps onto the sand-drying beds or other sludge drying options such as Geo-bags; the dewatered sludge is applied on the oil palm plantation as soil conditioner.

The overall treatment efficiency of this type of treatment system is about 99.5%, but extensive land areas are required.

The effluent from the anaerobic pond(s) is stabilized in the facultative pond(s) by biochemical oxidation of organic matter using air from natural atmospheric aeration as well as oxygen from algal photosynthesis. In the facultative pond, the bacteria and algae co-exist symbiotically.

The bacteria decompose organic matter utilizing oxygen in the process and generating carbon dioxide. During photosynthesis, the algae utilize the carbon dioxide and produce oxygen. The dominant group of algae is the chlorella group.

A well-designed and operated anaerobic-cum facultative ponding system is able to treat POME to meet the prevailing DOE effluent standards for crude palm oil mills.

The energy requirement of the anaerobic-facultative ponding system is minimal if gravity flow is exploited throughout. Limited pumping is needed mainly for the periodic transfer of sludge from the ponds to the sludge beds and the energy requirement may be as low as 20 kW. A part-time attendant is sufficient to maintain the treatment system.

b) Anaerobic-cum-Aerated Ponding System

This treatment system is similar to the Anaerobic-cum-Facultative Ponding System, except that the facultative ponds are replaced with mechanically-aerated ponds in which the oxygen for the aerobic biological processes is mechanically supplied. However, the first-stage treatment also uses the anaerobic ponding process, but the number of ponds and the basic design configurations may differ.

Facultative ponds are designed to be shallow for sunlight penetration and natural oxygen-supply through algal photosynthesis, and therefore occupy extensive land
area. The use of mechanical surface aerators or diffused air aeration systems to supply oxygen in the case of aerated ponds, enables the use of deeper ponds which occupy much less land space. This type of treatment system also produces a more consistent treated effluent quality.

c) Anaerobic Reactor-cum-Aerated Ponding System

This system combines the anaerobic process with the aerated pond. However, the anaerobic process takes place in a tank digester instead of anaerobic ponds. The anaerobic reactor processes have in the past found limited application in the palm oil industry due to the high material and construction costs, whereas available cheap plantation land and lower construction costs greatly favour the land-intensive anaerobic ponding systems. However financial incentives through the Clean Development Mechanism (CDM) of the UN Framework Convention on Climate Change (UNFCCC) have supported the application of this technology in a number of existing and new mills.

Plate 5.7: Photo of tank digesters and biogas recovery system.

Tank digesters may have an open top or closed top for the purpose of increased treatment efficiency as well as to enable biogas recovery. In the closed-type, the biogas generated can be utilised as a source of energy. Plate 5.7 illustrates the tank digester and biogas recovery systems.
The principal types of anaerobic reactor processes are briefly described below.

d) **Conventional Anaerobic Digester**

The conventional anaerobic digester is essentially a Continuous Stirred-Tank Reactor (CSTR) with no solids recycle, i.e. the Mean Cell Residence Time (MCRT) of the system equals the Hydraulic Retention Time (HRT). This type of anaerobic reactor requires a longer HRT to prevent washout of microorganisms and to achieve desired treatment efficiency. Mixing of the digester contents is performed using mechanical stirrers, or alternatively by gas recirculation mixing in which the biogas is recycled through an emitter and draught tube (refer **Figure 5.4**). The longer HRTs of up to 20 days required for this type of anaerobic digestion process for POME significantly increase the cost of the system.

**Figure 5.4: Anaerobic digester with gas recirculation mixing**

**Anaerobic Contact Process**

The anaerobic contact process is the anaerobic equivalent of the activated sludge process. In the anaerobic contact process, the raw wastewaters are mixed with recycled sludge solids and then digested in a Continuously-Stirred Digester Tank (CSTR). The anaerobic contact reactor includes a settling tank for biological solids separation and recycles. Pond depths of up to 5 metres can be applied, while the hydraulic retention time is usually between 15 and 20 days; i.e. extended aeration.
The treatment efficiency of mechanically-aerated ponds is also generally higher; the overall treatment efficiency of the anaerobic-cum-aerated ponding system can exceed 99.8%; final BOD$_3$ concentrations of less than 100 mg/L are consistently achievable. The operating costs are high due to the energy consumption of the mechanical aeration equipment and added maintenance requirements as formation in the CSTR normally continues to occur in the settling tank, and this tends to inhibit effective settling of the biomass to enhanced buoyancy of the suspended solids. This can be a major limitation of the process. Design modifications are needed to overcome the problem such as degasification and flocculated settling. This process has been used successfully for the stabilization of high-strength soluble wastes.

**Up-flow Anaerobic Sludge Blanket (UASB) Reactor**

The UASB reactor system is based on upward flow of wastewater through a suspended layer or sludge blanket of active biomass. The wastewater, which enters at the bottom of the reactor, flows upward through the sludge blanket and during contact with the biomass biochemical conversion of the organic matter to methane and carbon dioxide gas occurs.

After passing through the sludge blanket, the supernatant liquor and biogas enter a three phase gas-solid-liquid separator. The biogas is separated in an inverted cone, while the liquor solids are allowed to settle in the settling zone. The treated wastewater is discharged via an overflow weir. Reported data indicate very favourable performance of UASB reactors. Design loading rates range between 8 and 17 kg COD/m$^3$/day with COD removal efficiency of up to about 90%.

A typical Anaerobic Reactor-cum-Aerated Ponding System, which uses the open-top and completely-mixed anaerobic tank digester, is shown schematically in **Figure 5.5**. Anaerobic tank digesters are much more capital intensive than anaerobic ponds, but have the following advantages:

- Extremely compact and occupy a fraction of the space required by anaerobic ponds;
- Higher organic loading rates and therefore much shorter hydraulic retention times;
- HRTs are about 10 to 20 days for closed tank digesters compared to about 45 to 80 days for anaerobic ponds;
- Closed tank digesters with complete internal mixing and operating at the high thermophilic temperature range of between 42 degree C and 55 degree C require an HRT of about 10 days or less;

- The organic loading rate for closed-tank anaerobic digesters is typically about 3.0 to 5.0 kg BOD₃/m³/day;

- Open tank digesters without internal mixing and operating at the normal mesophilic temperature range of about 30 degree C to 35 degree C require an HRT of about 20 days;

- The organic loading rate for open tank anaerobic digesters is typically about 0.8 to 1.0 kg BOD₃/m³/day;

- Higher treatment efficiency of between 60% and 90% BOD removal; and

- Biogas generated can be recovered and utilised as energy source.
Figure 5.5: Typical Anaerobic Reactor-cum-Aerated Ponding System

Results of pilot studies on the treatment performance of a Thermophilic Anaerobic Contact Process are presented in Table 5.5. The overall treatment efficiency of the Anaerobic Reactor-cum-Aerated Ponding System exceeds 99.8% and can produce a treated effluent that consistently meets the DOE prevailing BOD₃ standard of 100 mg/l.
Table 5.5: Performance of Thermophilic Anaerobic Contact Process

<table>
<thead>
<tr>
<th>Parameter/Temperature</th>
<th>45°C</th>
<th>50°C</th>
<th>55°C</th>
<th>60°C+</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD Loading, kg/m³/day</td>
<td>3.1*</td>
<td>3.4*</td>
<td>3.3</td>
<td>3.0</td>
</tr>
<tr>
<td>BOD Removal, kg/m³/day</td>
<td>2.9</td>
<td>3.2</td>
<td>2.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Gas Production, m³/day</td>
<td>28.8</td>
<td>36.0</td>
<td>47.0</td>
<td>42.5</td>
</tr>
<tr>
<td>Gas Yield, m³/kg BOD added</td>
<td>0.9</td>
<td>1.1</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Methane, %</td>
<td>60</td>
<td>65</td>
<td>64</td>
<td>69</td>
</tr>
<tr>
<td>Hydraulic Retention Time, Days</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>BOD Removal Efficiency, %</td>
<td>92.6</td>
<td>93.3</td>
<td>89.9</td>
<td>96.0</td>
</tr>
</tbody>
</table>

5.4.2 Desludging/dewatering technology

Effluent can be pumped directly from the pond or if a clarifier/thickener is used, effluent from the underflow can be diverted through a geo-textile container or bag, eliminating the requirement for an expensive mechanical dewatering device. Geo-textile units can be used to capture fines, silts, and total solid from the effluent prior to discharge into the ponds.

Geo-textile bags or sacks will help separate and dewater the fines and allow disposal without expensive dredging and transporting operations. Chemical conditioners or polymers may be used to promote flocculation to improve solids retention and filtrate quality.
Plate 5.8: Geo-textile dewatering containers.

Geo-textile containers (Plate 5.8) can also be used to utilize the fines to build dikes and containment berm. The permeate will be either returned back into pond or channelled out to downstream for further polishing for final compliance.

Simple installation: Because geo-textile containers can be custom-sized to the application, they can be placed in available space between other structures, and removed once dewatering is complete. Geo-textile technology is used for large and small projects due to simplicity and low costs.

Geo-textile dewatering technology has been used in water and wastewater treatment applications, including pond, tank and digester cleanouts. It can provide dewatering and containment in one operation, with 60% to 70% reduction of BOD in the effluent.

Basic guidelines for desludging (DOE)

The following is a checklist used by DOE for desludging applications:

i. Distance of discharge area from water supply and information on nearest river (the suggested distance of the holding pond from waterways must not be less than 500 m)

ii. Desludging schedule

iii. Method to be used
iv. Engineering plans for the overall effluent treatment system that clearly shows pond(s) to be desludged and holding ponds

v. Engineering plans for the holding pond that is to be constructed

vi. Basis for design calculations including quantity of effluent that can be contained in the abovementioned pond

vii. Soil type where the abovementioned pond is to be constructed (if the holding pond is to be constructed on peat or sandy soils, a non-permeable layer to avoid penetration needs to be prepared)

viii. Precautionary measures for desludging effects and steps to control it

Applications for desludging must provide the following information:

i. Time
   - Work can only be carried out during dry season
   - Work can only be carried out during ‘low crop’ season and not during ‘peak crop’ season

ii. Method used
   - Pump is used to transfer effluent
   - Effluent from the pond to be desludged needs to be separated by pumping the effluent to a temporary holding pond
   - After desludging, effluent from the temporary holding pond needs to be pumped back

iii. Area (plan/drawings)
   - Related effluent treatment ponds
   - Temporary holding ponds
   - Land irrigation area in plantations
   - Nearest waterway or river (not less than 500 m)
   - All locations must be shown in the drawings
iv. Precautionary and control measures

- Includes precautionary measures for potential problems during desludging works
- Actions that need to be taken if problems arise
- Examples of problems: breached barriers, weather, and accidental effluent leakages during transfer process, etc.

v. Pond volume calculations

- Total volume of pond to be desludged
- Total volume of temporary holding pond
- Total volume of holding pond needs to be 10% less than the pond to be desludged
- Volume = P \times L \times D where P is length, L is width and D is depth

vi. Retention time

- Important for determining the number of days allowed for desludging a pond
- Retention time = Pond volume / effluent flow rate where effluent flow rate is the total effluent produced in a single day during the milling process

Some additional tips on effluent pond design:

- Input and throughput of the mill should be carefully calculated to ensure the design of corresponding retention ponds are sufficient to handle effluent produced.
- It is advisable to deliberately ‘over-design’ capacity and retention ponds to accommodate peak FFB harvest seasons. Calculations for this should also take into consideration the fact that most oil palm mills tend to buy FFB from smallholder producers in addition to FFB from their own estates.
5.4.3 Tertiary Treatment

DOE encourages all palm oil mills to invest in Tertiary Treatment to enable the POME treatment to meet the target of BOD 20mg/l. A range of technologies to enhance POME treatment are available (see Table 5.6 below for summary):

Table 5.6: Brief Description of Technologies for Tertiary Treatment of POME

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Aerators</td>
<td>Floating Surface Aerator</td>
</tr>
<tr>
<td></td>
<td>Floating Jet Aerator</td>
</tr>
</tbody>
</table>
Table 5.6: Brief Description of Technologies for Tertiary Treatment of POME (cntd)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddlewheel Aerator</td>
<td>Paddlewheel aerators also utilize air-to-water contact to transfer oxygen from the air in the atmosphere to the pond. They are most often used in the aquaculture (rearing aquatic animals or cultivating aquatic plants for food) field. Constructed of a hub with attached paddles, these aerators are usually powered by a tractor power take-off (PTO), a gas engine, or an electric motor. They tend to be mounted on floats. Electricity forces the paddles to turn, churning the water and allowing oxygen transfer through air-water contact. As each new section of water is churned, it absorbs oxygen from the air and then upon its return to the water, restores it to the pond. In this regard paddlewheel aeration works very similarly to floating surface aerators.</td>
</tr>
<tr>
<td>Submerged Membrane Diffuser Aerator</td>
<td>Fine bubble aeration is widely accepted as the most efficient way to transfer oxygen to a pond. A blower on shore pumps air through a hose, which is connected to an underwater aeration unit. Attached to the unit are a number of diffusers. These diffusers come in the shape of discs, plates, tubes or hoses that are constructed from glass-bonded silica, porous ceramic plastic, or perforated membranes made from EPDM (ethylene propylene diene Monomer) rubber. With EPDM rubber units, there are approximately eight thousand holes per disk through which air is diffused. When the air is pumped through the hose it reaches the diffuser membranes and is then released into the water at a rate of roughly 30-50 thousand bubbles per second.</td>
</tr>
<tr>
<td>Roughing Filter</td>
<td>Roughing Filter Solid Contact (RFSC) - RFSC utilizes special biofilters that are used</td>
</tr>
</tbody>
</table>
### Table 5.6: Brief Description of Technologies for Tertiary Treatment of POME (cntd)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aeration System</strong></td>
<td>to reduce heavy organic loadings to activated sludge units, or other similar secondary treatment process unit. Most new roughing filter installations are now utilizing a plastic type media on which to grow their zoogleal film. These units are installed to substantially reduce the organic loading to a downstream secondary process.</td>
</tr>
<tr>
<td><strong>Ultra Filtration System</strong></td>
<td>Ultra filtration is a separation process using membranes with pore sizes in the range of 0.1 to 0.001 micron. Typically, ultra filtration will remove high molecular-weight substances, colloidal materials, and organic and inorganic polymeric molecules. Low molecular-weight organics and ions such as sodium, calcium, magnesium chloride, and sulphate are not removed. Because only high-molecular weight species are removed, the osmotic pressure differential across the membrane surface is negligible. Low applied pressures are therefore sufficient to achieve high flux rates from an ultra filtration membrane.</td>
</tr>
<tr>
<td><strong>Membrane Bio-Reactor</strong></td>
<td>Membrane Bioreactors combine conventional biological treatment processes with membrane filtration to provide an advanced level of organic and suspended solids removal. When designed accordingly, these systems can also provide an advanced level of nutrient removal. In an MBR system, the membranes are submerged in an aerated biological reactor. The membranes have porosities ranging from 0.035 microns to 0.4 microns (depending on the manufacturer), which is considered between micro and ultra filtration. This level of filtration allows high quality effluent to be drawn through the membranes and eliminates the sedimentation and filtration processes.</td>
</tr>
</tbody>
</table>
Table 5.6: Brief Description of Technologies for Tertiary Treatment of POME (*cntd*)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multimedia Filter</td>
<td>The process of filtration involves the flow of water through a granular bed, of sand or another suitable media, at a low speed. The media retains most solid matter while permitting the water to pass. The process of filtration is usually repeated to ensure adequate removal of unwanted particles in the water. This type of slow filtration over a granular bed. It is the oldest method of filtration but still widely used in municipal water treatment plants today.</td>
</tr>
<tr>
<td>Clarifier System</td>
<td>Clarification is the separation of solids from the liquid stream to produce a clarified effluent with low effluent suspended solids (ESS) levels. Thickening is the conveyance of sludge particles to the bottom of the tank, resulting in a slightly concentrated underflow, or return activated sludge (RAS). The clarifier most important function is to clarify and only permit supernatant with minimum solid to overflow into the final discharge.</td>
</tr>
</tbody>
</table>

Typically used for wastewater treatment. Because the need for sedimentation is eliminated, the biological process can operate at a much higher mixed liquor concentration. This dramatically reduces the process tankage required and allows many existing plants to be upgraded without adding new tanks. To provide optimal aeration and scour around the membranes, the mixed liquor is typically kept in the 1.0-1.2% solids range, which is 4 times that of a conventional plant.
This study concludes that the polishing plant technologies available in the market are still in the learning curve to consistently treat the POME to comply with the \( \text{BOD}_3 < 20 \text{ mg/l} \). Based on information gathered, the design of the polishing plant is on the right track of moving toward achieving final discharges of \(< 20 \text{ mg/l} \). It has been suggested that MPOB and DOE should take the lead continuously to source and evaluate the technology from time to time for the purpose of improving the system to comply with the \( \text{BOD}_3 < 20 \text{ mg/l} \).

Currently, all polishing systems are focusing on the aspects below as further improvements of the BOD issue:

- Improving the anaerobic digestion process.
- Improving the aerobic digestion process.
- Filtration of the suspend solids as a final polishing state.

However, results gathered indicate that none of the tertiary plants are consistently producing final discharge samples with \( \text{BOD}_3 < 20 \text{ mg/l} \) but the inconsistency of the results may not due solely due to system performance. As shown in this study, human operations and maintenance schedules need to be taken into serious consideration.

In order to ensure polishing plants are performing efficiently, implementation of the ‘operate and manage’ concept by system providers are strongly recommended. This way, system providers are required to guarantee the polishing plants’ performance allowing mill owners to focus on their core business without doubting the performance of treatment systems installed.

In this scenario, implementation of all best practices on operations and maintenance by the system provider can be enforced effectively and they can continuously improve the polishing system to strive toward achieving final discharge compliance on \( \text{BOD}_3 < 20 \text{ mg/l} \).

In addition, it has also been suggested that technology providers of tertiary polishing plants/other technologies at acceptable cost should:(a) voluntarily register themselves with MPOB, as agreed in the DOE-MPOB-MPOA Working Committee on tertiary treatment technologies, (b) provide suitable training for an adequate period for operators, (c) be associated with the clients for at least 3
years instead of a turnkey basis, (d) provide detailed Standard Operating Procedures, and (e) supply quality parts and components from reliable sources.

Findings from MPOB’s Seminar and Workshop on Palm Oil Mill Effluent Tertiary Treatment Technologies (POMET3) in July 2010 also echo the study findings above: despite the importance of POME tertiary treatment systems, further research is needed to ensure that the treatment systems consistently meet present effluent discharge requirements. The following is a summary of POMET3:

Four main issues were discussed:

- Industry’s experience with tertiary treatment plants

  Many mills were unable to consistently meet the 20mg/l requirement with their existing plants.

- Current technologies on tertiary/polishing plants

  Most technology providers agreed that their technology is not able to achieve BOD$_3$ 20 mg/l using biological processes alone and will only meet the requirement if it is coupled with chemical treatments followed by proper operation and maintenance.

- New technologies on tertiary and polishing plants

  The latest technology available for POME tertiary treatment includes membrane, chemical and physical polishing, microfiltration and ozonation technology. These technologies are widely used for other wastewater treatment but are yet to be fully tested for POME.

- It is worth noting that a joint project by DOE and MPOB to assess BOD$_3$ < 20 mg/l compliance in Peninsular Malaysia, Sabah and Sarawak is ongoing and it is hoped that further guidance will be provided by MPOB and DOE on this matter in the near future.
5.5 BMP 5: CONTROL OF OIL SPILLAGES AND LEAKS

Oil spillages and leaks can be quite significant, especially, in the press station and the oil clarification station due to poor equipment maintenance and improper operation. These conditions not only lead to excessive oil losses but also contribute to extremely high waste treatment loads and treatment costs. Regular preventative maintenance and strict operator supervision are needed to minimize such occurrences.

Good design and the proper operation of oil traps are important as in-plant measures to enable oil recovery and minimize oil losses before the waste load reaches the wastewater treatment plant. Oil traps may be located in individual stations such as the press room and clarification station. However, a single well-designed oil trap may also be used to remove residual oil from the combined sterilizer condensate and clarification station wastewaters. The oil trap should be designed for a hydraulic retention time of at least one (1) day and provided with an adequate number of baffled compartments to enhance turbulent mixing and release of oil to the wastewater surface for removal.

The temperature of the combined sterilizer condensate and clarification station wastewaters is usually about 80 to 90°C, and at this temperature the oil is able to separate out from the wastewater quite easily. Some mill operators also use steam or a hot water jet to further aid oil separation and removal of the floating oil layer.

5.6 BMP 6: SEPARATION OF EFFLUENT AND STORMWATER DRAINAGE SYSTEMS

Palm oil mills should have separate sets of drains for stormwater and effluent. If using a combined system, this can pose a difficult problem in relation to effluent treatment, particularly in tropical climates where intensive rainfall often results in a surge of stormwater entering the effluent drains and the treatment system. The sudden surge of stormwater, especially during initial rainfall, will cause excessive dilution of the effluent as well as washout of the essential active biomass from the treatment system. The net result is a recurrent drop in treatment efficiency following periods of intense rainfall.

In order to avoid this problem, it is crucial that a separate system of drains be provided for collecting and transporting the effluent from the milling operations to the treatment system. It is also important to ensure the following:
Roofs of factory buildings are properly equipped with perimeter rainfall gutters and drain pipes to channel the rainfall to the stormwater drainage system; and

Stormwater from the factory yard, paved areas and plantation land is prevented from entering the effluent drainage system, especially in the case of open effluent drains.

### 5.7 BMP 7: PROPER INTERIM STORAGE OF SOLID WASTE MATERIALS

The following solid waste materials are generated and sometimes stored temporarily at interim sites in the factory before being moved to long-term storage facilities for use or ultimate disposal:

- Empty fruit bunches (EFB);
- Mesocarp fibre and shell;
- Decanter and sludge centrifuge solids and residues; and
- Boiler and incinerator ash.

It is important to ensure that during interim storage of these materials they do not gain access into effluent or stormwater drainage systems. The areas in which these materials are temporarily stored should be away from drains, and it is preferred that these areas are provided with containment measures and sheltered from rainfall. The objective is to prevent these materials from finding access into effluent or stormwater drains and contributing to the pollution load entering the wastewater treatment systems or public watercourses.

### 5.8 BMP 8: ENHANCING LAND IRRIGATION SYSTEMS FOR TREATED POME

The palm oil industry generates a large quantity of effluent, usually about 0.5 to 1.0 cubic meter per tonne FFB processed. The application of the treated effluent to appropriate cropland, not only provides water to the vegetation, but is also a means of ultimate disposal of the effluent. As the effluent percolates through the soil the organic matter is reduced substantially by filtration, adsorption and biological degradation.
Treated effluent is applied to cropland at rates corresponding to the moisture requirement of the particular crop as well as soil type (different adsorption levels). The effluent is pumped to distribution tanks and then applied directly onto the cropland by gravity flow or by pumping onto a system of inter-row flatbeds, long-beds or furrows. The available methods of land-irrigation of effluent are briefly described in the following sections. The choice of the method of application for any plantation depends on several factors, such as soil-type, climatic conditions and the terrain of the area. The following are some basic guidelines on enhancing land irrigation systems for treated POME based on ground observations from field visits to land irrigation sites as part of the overall study. The main consequence of not properly implementing land irrigation systems is the risk of overflows and leakages into natural watercourses, which is highly undesirable.

5.8.1 Planning land irrigation systems

In designing and planning for land irrigation systems, it is important to incorporate findings from research/studies on the area allocated for land irrigation, land topography as well as soil type and permeability. Proposed land irrigation sites should not be located near natural watercourses and important human health facilities like water treatment plants. This is to reduce health risks in the event of accidental overflows or leaks. Palm oil mills have to allocate sufficient area/land for irrigating treated POME. This calculation should be based on the production capacity of the mill and type of effluent treatment system employed to ultimately determine the daily amount and rate of POME produced. This information combined with results of soil permeability studies and land surveys should be sufficient to estimate the amount of area required for land irrigation. As with designing effluent treatment ponds, it is advisable to over-design the land irrigation system as contingency to allow for any unforeseen increases in POME production in the near future. Areas rich in clay or other impermeable soils as well as areas with naturally high water tables should be avoided. Low lying areas that are constantly flooded should also be avoided.

5.8.2 Implementing land irrigation systems

Proper implementation of the abovementioned land irrigation plans is crucial. Knowledgeable staff should oversee the construction of the system to ensure design criteria are met. It is advisable to implement a maintenance schedule action plan to ensure land irrigation systems are not silted-up or clogged and are
structurally sound to avoid overflows and leakages. Pipes used to transport treated effluent should also be checked regularly to ensure there is no leakage. The entire land irrigation system should be a closed system with minimal or zero surface flow to the environment.

Day to day operations of the land irrigation system should be managed by knowledgeable staff to ensure there are no accidental overflows. This is especially crucial for manual systems where filling up of trenches with treated effluent or operation of sprinklers rely on the discretion of the operator. It is important to consider weather conditions/trends when applying POME to land irrigation systems. Application during periods of heavy rainfall should be avoided as there will be a high risk of overflows occurring. Continuous monitoring of land irrigation systems is another important component to detect any potential problems at an early stage.

The available methods of land irrigation of effluent are briefly described below:

a) Flatbed and Long-Bed Systems

The flatbed system consists of a series of shallow bunded-beds of about 15 centimetre depth. Flatbeds system is suitable for digested effluent and is usually applied on undulating and hilly areas. The system would ensure uniform distribution of treated POME to the palms.

They are constructed along alternate inter-rows and usually occupy about one third of the inter-row space between oil palm trees. These flatbeds are interconnected by channels. The treated POME is allowed to flow by gravity, or otherwise pumped to the topmost bed and then flows by gravity from bed-to-bed. When the lowest bed is filled up, the channel is closed and the effluent is directed to the next row of beds. This is continued until all the beds are filled. In flat terrain, the long-bed system is adopted in which the construction is similar to the flatbed, except that each bed may be as much as 70 metres in length.
Plate 5.9: Long bed systems for land irrigation.

b) **Spray-Line-Sprinkler Irrigation System**

Generally the sprinkler system is well adapted to flat and gently undulating, with good infiltration type of soils. The system is more suitable for mature palms. The treated POME is applied by means of a fixed or movable spray-line sprinkler system. This system consists of a network of pipes with attached sprinkler heads spaced at regular intervals within the cropland. The fixed network system covers the entire cropland with a system of manually operated valves that are used to distribute the effluent to selected segments of the cropland on a rotation basis. The movable spray-line is more economical as it need not cover the entire cropland, and consists of a detachable network of pipes and valves and a set of detachable sprinkler heads that can be moved, installed and used segment by segment of the cropland. Some of the problems associated with this system include blockages of pipes and clogging of sprinklers, and occasional pipe burst, if the system is not maintained and operated properly.

c) **Tractor-Tanker Spraying System**

The equipment required for this system is a tractor-tanker and centrifugal pump. Treated POME is transported to the field in a tractor-drawn tanker. The effluent is applied onto the cropland by spray-pumping with the assistance of a centrifugal
pump mounted on the tanker. This system is also suitable for commercial application in oil palm area with a flat to gently undulating terrain.

Environmental regulations for the palm oil industry have undergone vast changes over the past decade. The Department of Environment has imposed increasingly stringent standards for POME discharge into watercourses, especially for new palm oil mills. In some pollution-sensitive areas, palm oil mills are not allowed to discharge effluent with a BOD$_3$ exceeding 20 mg/l, while in certain strategic areas requiring stringent pollution prevention a zero-discharge requirement has been imposed.

Most POME treatment plants have been constructed to meet a BOD$_3$ concentration limit of 100 mg/l. This effluent BOD$_3$ limit is ordinarily achievable if the treatment systems are well-designed and operated. Nevertheless, it is observed that not all palm oil mills comply with the discharge standard consistently or at all the times. Therefore, there may be a need to review the waste management strategies for palm oil mills.

Present trends in industrial waste management are towards waste minimization at source and/or recycling of wastes. Over the last 10 years, the paradigm of management of palm oil mill wastes has shifted from “treatment and disposal” to “beneficial utilization of an asset”. POME contains substantial quantities of valuable plant nutrients and may be used as a fertilizer substitute. Land-application of POME has become a standard practice for those mills with oil palm plantations or other suitable cropland nearby. This has resulted in substantial savings in fertilizer costs and increased incomes from higher FFB or other crop yields. **Box 5.2** provides further information on the concept of land application of POME.
Box 5.2: Land Application of POME as practiced in Peninsular Malaysia

Land Application of POME

In terms of volume and polluting potentials, the palm oil mill effluent (POME) generated by the palm oil industry is tremendous and certainly needs proper management by both the industry and government authorities. Under the Environmental Quality Act (1974), palm oil mills are required to treat their effluent to a prescribed level before final discharge into the waterways. The practice of treating and discharging effluents into the waterways is not only costly and a waste of a valuable resource, but will also pollute the river and affect its water quality. This is because POME is essentially organic wastes but high in plant nutrient contents, and thus could be recycled as inorganic fertilizer replacements for many crops including oil palm.

The volume of POME production on the average palm oil mill is about 65 to 70 percent for every tonne of fresh fruit bunch (FFB) processed. Based on this rate, the annual production of raw POME from mills with processing capacity ranging from 30 to 80 tonnes per hour can be computed as shown in the following Table:

<table>
<thead>
<tr>
<th>Annual Rate of Production</th>
<th>Mill Processing Capacity (T FFB/Hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Total FFB processed</td>
<td></td>
</tr>
<tr>
<td>(capacity x 16hr x 300 days)</td>
<td>144,000</td>
</tr>
<tr>
<td>Effluent Production</td>
<td></td>
</tr>
<tr>
<td>(FFB x 0.67%)</td>
<td>96,480</td>
</tr>
</tbody>
</table>

Sources: Zin et al. (1990)

Palm oil mill effluent is essentially non-toxic and is highly polluting. The solid content of POME comprises of mainly fruit constituents and small amounts of material eroded or otherwise picked up from processing machinery, in a suspended or dissolved state. The suspended is predominantly colloidal, mainly carbohydrate in nature, plus oil and other organic and inorganic solids. POME in the fresh form has an extremely high concentration of biochemical and oxygen demands (BOD and COD) and also high in plant nutrient contents, especially for nitrogen and potassium. After treatment processes, various types of POME are
available and their chemical composition are shown in the Table below:

<table>
<thead>
<tr>
<th>Types of POME</th>
<th>Chemical Composition (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BOD</td>
</tr>
<tr>
<td>Raw</td>
<td>25,000</td>
</tr>
<tr>
<td>Digested (Anaerobic)</td>
<td></td>
</tr>
<tr>
<td>Stirred tank</td>
<td>1,300</td>
</tr>
<tr>
<td>Supernatant</td>
<td>450</td>
</tr>
<tr>
<td>Bottom slurry</td>
<td>1000-3000</td>
</tr>
<tr>
<td>Digested (Aerobic)</td>
<td></td>
</tr>
<tr>
<td>Supernatant</td>
<td>100</td>
</tr>
<tr>
<td>Bottom slurry</td>
<td>150-300</td>
</tr>
</tbody>
</table>

Sources: Zin et al. (1990)

Generally, anaerobic digestion of POME may drastically reduce the BOD concentrations but at the same time much of the nutrients, especially nitrogen and potassium may be lost through leaching and settling of sludge solids at the bottom fraction of the pond. In the tank digestion treatment system, the effluent liquor is kept agitated and stirred and the process does not greatly change the nutrient contents. The breaking down of organic solids into less complex molecules would make it more readily available for plant uptake. From nutritional point of view, the tank digested effluent would make a good source of plant nutrients especially for recycling in the field.

POME application on land

The principles underlying the concept of POME application on land is utilization, which is distinct from the terms discharge or disposal. In real terms, utilization is interpreted as making use of the effluent through returning or recycling the POME onto cropped land by means of controlled application techniques, with a view of deriving agronomic benefits from such practice and with minimal environmental impacts. This is in contrast with the terms discharge or disposal, which is defined as the act of uncontrolled release of the effluent (with or without pre-treatment) from the mill into watercourse or onto land. In 1990, the Malaysian Palm Oil Board (then known as PORIM) has set a guidelines on application of POME on land for the palm oil industry (Zin, et al., 1990).

The utilization concept seeks to make a practical use of POME as a valuable resource. This concept could be approached in several ways in which land
application is considered as one of the techniques. The rationale behind this concept is that whatever is removed from the soil-crop system is safe enough to be returned or recycled back to the cropped land by means of controlled application techniques. POME has been proven to be a good source of organic fertilizers and is currently available in large volume at little cost. Applied at rates corresponding to the nutrient requirement of crops, it will not have detrimental impact on the environment. Studies have shown that soil-plant system is an effective natural filter capable of screening undesirable contaminants in the effluent during the process of land application.

It is important to point out that excess rates of POME application could be detrimental to the performance of the crop and the environment. Excess application could results in crop yield to decline due to water logging and anaerobic condition which affect the growth of the palm. For mature palms, the maximum rate of POME application should be based on twice the rate of nitrogen requirement of the palm or a maximum equivalent of 650 kg N per hectare per year. In terms of frequency, application should be spread out at no less than three rounds a year and each application should not exceed 2.5cm rain equivalent.

When POME is applied onto soils, the organic and inorganic constituents it contains may be retained by the soil, taken up by the palm, leached through the soil or washed by surface run-offs. There is a need to monitor the subsurface water quality in land application of POME scheme. Groundwater quality should be monitored immediately below the water-table surface near the site of application. This is to ensure that any polluting materials entering the groundwater system which have a tendency to remain in the upper layer are detected.

Note that land application of POME as practiced in Peninsular Malaysia (primarily for fertilizer value) is different to land irrigation of fully treated effluent as practiced in Sabah (which is primarily for disposal of treated effluent – avoiding direct discharge to rivers).
CHAPTER 6

MONITORING AND
STAKEHOLDER RELATIONS

6.1 INTRODUCTION

This chapter provides guidance on monitoring, use of appropriate technology and maintaining good stakeholder relations. Issues described include:

- Public participation in monitoring (of the requirements to meet regulations and methodologies);
- Monitoring of pollution Parameters of POME treatment systems;
- Monitoring work using appropriate technology (real time telemetry);
- Self-regulation by plantations and mills; and
- Good stakeholder relations.

Within the State Structure Plan 2020, three recommendations were made specifically to strengthen current environmental protection and monitoring within the State, i.e.:

- Development and implementation of protection and monitoring tools, such as rules, regulations and standards.

This amongst others include calling for new environmental regulations such as for oil palm plantations, enabling the environmental audit of natural resources management and protection, and setting up of inter-
departmental Environmental Monitoring Committee to consider all aspects of monitoring with coordinating/monitoring agencies.

- Development of the application of the EIA tool

It is now considered that improvements in the environmental screening related to the land alienation and development plan procedures provides better opportunities for environmental planning. Although the exercise may reduce the number of EIAs required but it will improve the effectiveness of the tool.

- Development of specific policies and actions plans for environmental protection.

Development of policies and action plans for specific environmental areas of concern. This could include for example the protection of river reserves and river water quality, etc.

6.2 MONITORING OF POLLUTION CONTROL AND EFFLUENT TREATMENT FACILITIES

There is a need for more comprehensive monitoring of the pollution control systems of palm oil mills – especially for treatment of POME. At present the work undertaken by DOE primarily relates to collection and testing of water samples from the final discharge point of the POME treatment system. The current inspections generally do not determine the compliance with other approval requirements and do not look at the functioning of pollution control systems to determine the problems (if any) with their operation.

The Industrial Processes and the Environment, Handbook No.3, for Crude Palm Oil Industry (DOE, 1999) provides clear, detailed guidelines on the inspection of palm oil mills which include industrial processes and effluent treatment systems. Comprehensive inspections are an optimal tool to monitor, assess and identify where facilities are inadequate and improvements can be made.

It is proposed that in future, at least two inspections shall be made at each mill every year. The inspections shall include focus on (1) water consumption and pollution loading, (2) pond design and construction, and (3) pond maintenance (including mechanical equipment and desludging activities) (4) Land irrigation.
The inspections are expected to yield better records on the mills and provide enforcement officers with opportunity to directly engage mill managers on any issues or problems. Inspection procedures could be varied according to the performance of the mills – with mills with high performance ratings as well as those which are RSPO certified being inspected less often.

The reinforced monitoring and enforcement programme should include: Amendment of sampling frequency, visit objective and monitoring schedule. Evaluation of mill control parameter log sheet should be included on every visit. Evaluation checklist consisting important parameters should be included to ensure all the monitoring procedures are implemented effectively.

6.3 SELF-REGULATION BY PLANTATIONS AND MILLS

In order to encourage good practices and to make more efficient use of resources for monitoring and enforcement of regulations – self regulation and reporting by oil palm plantations and mills is encouraged. A suggested self-monitoring checklist for monitoring POME treatment systems is provided under Annex 5.

Several mechanisms to promote good practice and self-regulation have been established. These include: ISO 14000 standards, Roundtable on Sustainable Palm Oil (RSPO) Principles and Criteria and Certification Systems and the Malaysian Palm Oil Board (MPOB) Code of Practice.

6.3.1 RSPO

The Roundtable on Sustainable Palm Oil (RSPO) was established in 2004 with the principal objective of promoting the growth and use of sustainable palm oil through co-operation within the supply chain and open dialogue between its stakeholders. The RSPO’s Principles & Criteria (P&C) was finalised in 2007 and is the performance standard for certification of sustainable palm oil. It takes into account responsible social and environmental management issues as well as good agricultural and mill operation practices. The P&C consist of 8 principles, 39 criteria and 123 specific national indicators. The eight principles are described in Box 6.1 below and selected criteria are elaborated in Annex 6.
Box 6.1: The Eight Principles from RSPO’s Principles and Criteria

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle 1:</td>
<td>Commitment to transparency</td>
</tr>
<tr>
<td>Principle 2:</td>
<td>Compliance with applicable laws and regulations</td>
</tr>
<tr>
<td>Principle 3:</td>
<td>Commitment to long-term economic and financial viability</td>
</tr>
<tr>
<td>Principle 4:</td>
<td>Use of appropriate best practices by growers and millers</td>
</tr>
<tr>
<td>Principle 5:</td>
<td>Environmental responsibility and conservation of natural resources and biodiversity</td>
</tr>
<tr>
<td>Principle 6:</td>
<td>Responsible consideration of employees and individuals and communities by growers and millers</td>
</tr>
<tr>
<td>Principle 7:</td>
<td>Responsible development of new plantings</td>
</tr>
<tr>
<td>Principle 8:</td>
<td>Commitment to continuous improvement in key areas of activity</td>
</tr>
</tbody>
</table>

Principle 1 stresses the need for transparency – this includes making available information on practices and achievements to appropriate stakeholders. Principle 2 relates to compliance with laws and regulations including those relating to EIA and treatment of mill effluent. Principle 4 stresses the need to implement best management practices, which includes: (1) the minimization and control of erosion and degradation of soils, (2) the maintenance of surface and ground water quality and availability and (3) the implementation of integrated pest management strategies that minimize the use of agrochemicals.

As of March 2009, about 117,388.8 ha of oil palm estates and 17 mills have been certified by RSPO in Malaysia (Table 6.1). Over half of these areas are located in the east coast of Sabah.
### Table 6.1: RSPO Certified Palm Oil Estates and Mills in Malaysia

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>No. of Mills</th>
<th>Size of Estates (Ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOI Corporation</td>
<td>Sandakan, Sabah</td>
<td>1</td>
<td>13460.0</td>
</tr>
<tr>
<td>Kulim</td>
<td>Johor</td>
<td>3</td>
<td>22175.7</td>
</tr>
<tr>
<td>PPB Oils</td>
<td>Beluran, Sabah</td>
<td>3</td>
<td>19355.0</td>
</tr>
<tr>
<td>Sime Darby Plantations</td>
<td>Sandakan, Sabah</td>
<td>1</td>
<td>11966.0</td>
</tr>
<tr>
<td>Sime Darby Plantations</td>
<td>Kunak/Tawau, Sabah</td>
<td>3</td>
<td>14729.1</td>
</tr>
<tr>
<td>United Plantations</td>
<td>Perak/Selangor</td>
<td>6</td>
<td>35703.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>17</td>
<td>117388.8</td>
</tr>
</tbody>
</table>

Source: RSPO (2009)

Although not all companies operating in Sabah are RSPO members – some of the companies with large areas of plantations such as Sime Darby Berhad and PBB Oils are active members. The member organizations are in the process of certifying all their mills in Sabah together with the associated plantations according to a time-bound plan. Refer to [www.rspo.org](http://www.rspo.org) for updates on recently certified mills.

### 6.3.2 MPOA

The members of the Malaysian Palm Oil Association (MPOA), which groups many of the oil palm companies in Sabah, have also made a commitment in the form of the MPOA Environmental Charter (see Box 6.2)
**Box 6.2: MPOA’s Environmental Charter**

“We, the members of MPOA, hereby declare that we care for the well-being of our environment. We are committed to protect and conserve it for future generations. We shall strive to maintain good balance between environmental conservation and business objectives. We shall therefore aim to use natural resources in an ecologically sustainable manner.

We Shall:

Establish appropriate infrastructures and responsibility for environmental affairs within our organizations and carry out appropriate and routine assessment and reporting procedures on such matters;

Endeavour to preserve high conservation value tropical forest and natural areas of unique scientific, historical and cultural interest for posterity;

Undertake to carry out Environment Impact Assessment (EIA) studies on new land development in compliance with Department of Environment (DOE) requirements;

Adhere and conform to all relevant environmental legislation of the country;

Adopt and implement best management practice at all times currently established in the Industry;

Take judicious actions to minimize environmental pollution;

Operate with due regard for the welfare, health and safety of employees, the local community and the wider public;

Educate our employees and our business partners to accept, uphold and apply this Charter judiciously”.
6.4 PUBLIC PARTICIPATION IN MONITORING

Studies have shown that government agencies are currently facing shortages in manpower and resources to carry out efficient monitoring of river water quality and pollution issues. Increasing public participation in monitoring can help meet these deficiencies. Options for this can include:

- Conduct awareness-building sessions for the public and local communities to increase awareness of the importance of healthy rivers and empower them to play a watchdog role to help monitor cases of river pollution and non-compliance with approval conditions.

- Explore the potential deployment of voluntary, community or honorary wardens (similar to SWD's endorsement and utilization of Honorary Wildlife Wardens for enforcement) for each river to address manpower and resource problems faced by government agencies in terms of monitoring.

- Allocate Resources for 3rd party monitoring by NGOs or environmental audit professionals of oil palm plantation management and implementation of BMPs.

- Make available on the web all approval conditions, layout plans, designated river reserves, pollution control plans etc. to enable monitoring and verification by NGOs and community groups.

- Publish monthly POME treatment system effluent discharge results to DOE website as well as actions taken to manage and improve effluent treatment systems.

- Conduct awareness-building and training for oil palm plantations, palm oil mills and government agencies to increase awareness and technical know-how on self-monitoring and monitoring plans.

- Schedule periodic dialogue sessions with local stakeholders affected by mill operations to gather additional feedback and information.

- Develop and implement public feedback mechanism(s) to allow local communities to provide information to government agencies and/or Oil
Palm plantation managers/ Palm oil mill operators in terms of cases where pollution is occurring.

- The Sabah Wildlife Department has had good experience in the appointment of villagers and representatives of NGOs, plantation companies and others as honorary wardens. More than 200 Honorary Wildlife wardens have been appointed in Sabah. The appointment of honorary wildlife wardens is provided for under Section 7 of the Wildlife Conservation Enactment 1997. This is either to assist in carrying into effect the provisions of the Enactment. The appointment of an honorary wildlife warden shall, be made for a period of three years but may be renewable. Before any person is appointed an honorary wildlife warden, he or she will have to attend a two and a half day course. This is to familiarize the participant with the offences and penalties provided for in the Wildlife Conservation Enactment 1997; with the enforcement procedures in accordance to the requirements of the Wildlife Conservation Enactment 1997, Penal Code and Evidence Act; and understand the roles and responsibilities of honorary wildlife wardens.

- An honorary wildlife warden is empowered with the power of arrest and supplied with a warrant card and vest to be used in carrying out duties in their respective area. They are required to submit a report to the department on their activities and any recommendations once every three months.

- Villagers appointed as honorary wildlife wardens had also assisted the department staff in putting to an end illegal poaching activities in their respective area. Representatives of NGOs such as WWF appointed as wildlife wardens have played a very useful role in minimizing degradation or clearing of riverine corridors along the Kinabatangan River and similar approach could be applied to other rivers such as the Segama River.

- This same concept could be adapted further by the Environment Protection Department to develop a community river patrol group or river ranger group.
6.5 TECHNOLOGY FOR MONITORING

There are a range of options for the use of appropriate technology to support the monitoring of oil palm plantations and mills. One of the most useful technologies is remote sensing – in particular satellite monitoring.

Satellite imagery is very useful to monitor the protection of river reserves and high conservation value (HCV) areas and ensure that they are not converted to oil palm plantations. Satellite monitoring can also help with monitoring of development of steep slopes or other environmentally sensitive areas. They can also be used to confirm whether or not cover crops, silt traps and other measures to reduce erosion during initial planting or replanting activities. The layout of mill sites and treatment ponds can also be verified in relation to distance from rivers. They can also be used to detect new oil palm developments which may or may not have submitted EIAs.

In order to determine detailed issues such as river reserves or land clearing techniques – high resolution images – such as DigiGlobe or IKONOS images are required. Detection of new plantation development can utilize lower resolution images such as Landsat (currently available free), SPOT or Aster.

Examples on the use of satellite imagery are shown in Figures 6.1 to 6.8 in the proceeding pages.
Figure 6.1: Satellite Image of land clearing and terracing in Segama River Catchment October 2005
Figure 6.2: Satellite Image of Oil Palm Plantation Adjacent to HCVF area in Segama River Basin February 2005
Figure 6.3: Satellite Image of oil Palm Development Without Cover Crop
October 2005, Segama River Catchment
Figure 6.4 : Oil Palm development in Reclaimed Mangrove Forest Near to Tawau – Showing Large Areas with Water Logging and Poor Growth
Figure 6.5: Satellite Image to Show Variable Application of River Reserve on Either Side of the River
Figure 6.6: Satellite Image from February 2005 Showing Proximity of POM and POME Treatment Ponds to Segama River (100m – Yellow Line). Also note the High Growth of Vegetation on Inlet Pond Indicating Possible Seepage from Treatment Ponds
Figure 6.7: Satellite Image from February 25\textsuperscript{th} 2005 Showing Development of Oil Palm Plantation Along Small Tributary of Segama River With No River Reserve and Indications of Flooding (Brown Vegetation and Stunted/Absent Growth Of Oil Palm)
Figure 6.8: Composite of two satellite images of the Segama River from February 25\textsuperscript{th} 2005 (left portion of image and October 30\textsuperscript{th} 2005 (right portion) – note the difference in water colour silt load and also the planting of oil palm close to the banks. Yellow mark shows river is 60m wide and so should have a 50m River Reserve according to DID guidelines.

Air photographs

Air photographs can also be used for survey and monitoring purposes as per the examples (Figures 6.9 to 6.16).
Figure 6.9: Air Photo of one of the Palm Oil Mills in Sg. Muanad, January 2011

Figure 6.10: Muanad I Village, Sg. Muanad, January 2011
Figure 6.11: Adjacent to Sg. Muanad, January 2011. Note river buffer too narrow

Figure 6.12: Air photo of land clearing for replanting near Sg. Segaliud, January 2011
Figure 6.13: New Plantation at Sg. Muanad, January 2011

Figure 6.14: Air Photo of Mature Oil Palm Plantation Next To Segama River. Note No Riparian Area, January 2011
Figure 6.15: Degraded Virgin Jungle Reserve adjacent to plantation. Sg. Segaliud, January 2011

Figure 6.16: Air photo of Segama River January 2011. Note the flooding of low lying areas and oxbow lakes
Satellite fire detection

Other uses of satellite technology are for detection of fires for land clearing. NOAA satellites with a resolution of 1km are sufficient to detect land clearing fires. Daily satellite images from NOAA identifying fire hotspots are available free of charge through the web site of the ASEAN Specialised Meteorological Centre (ASMC) in Singapore. ASMC provides information daily to the Malaysian government on the location of hotspots – which can be used to identify sites using fire for land clearing. Areas cleared by fire will be more susceptible to erosion and hence will lead to more river pollution. Prompt detection can lead to control measures to be taken.

![Figure 6.17: Fires and smoke haze along the western coast of Sabah, in the northern part of Borneo (note red indicates intact vegetation and black burnt areas)](image)

**Notes:**


B: Image of the same area in February 1998, the town of Sipitang is located to the right of the image. Acquired 24 February 1998.
C: Image of the same area two weeks later. Acquired 8 March 1998.

D: Large burnt scars (blackish areas) are visible on the image. Acquired 4 April 1998.

Source: All images are acquired by the SPOT satellites. Copyright of images belongs to CNES (Centre National d'Etudes Spatiales). Images are acquired and processed by the Centre for Remote Imaging, Sensing and Processing, National University of Singapore.

![Figure 6.18: NOAA/AVHRR Satellite image of Borneo on March 5th 1999 Showing Extensive Fires (Red Dots) and Haze (Yellow)](image)

6.5.1 Water Quality Monitoring

Monitoring of water quality in the plantation and mill area and in receiving waterways is an important activity to assess the correct functioning of pollution control measures.

a) Water Quality Sampling Parameters

In-situ
Several water quality parameters should normally be sampled and recorded to monitor the changes in chemical composition of the river water. Generally, both in-situ and ex-situ sampling are conducted. Parameters that should be considered during in-situ sampling are pH, Dissolved Oxygen (DO), temperature and conductivity. Table 6.2 below tabulates the parameters and descriptions.

Table 6.2: In situ Parameters/Unit Importance

<table>
<thead>
<tr>
<th>Parameter/units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>pH is a measure of the concentration of hydrogen ions in the water. This measurement indicates the acidity or alkalinity of the water. A reading of 7 is considered to be &quot;neutral&quot;, readings below 7 indicate acidic conditions, while readings above 7 indicate the water is alkaline, or basic. The pH of the water is important because it affects the solubility and availability of nutrients, and how they can be utilized by aquatic organisms.</td>
</tr>
<tr>
<td>Dissolved Oxygen (DO), mg/l and %</td>
<td>Dissolved oxygen is the amount of oxygen dissolved in water, measured in milligrams per liter (mg/L). This component in water is critical to the survival of various aquatic life in streams, such as fish. The ability of water to hold oxygen in solution is inversely proportional to the temperature of the water. For example, the cooler the water temperature, the more dissolved oxygen it can hold.</td>
</tr>
</tbody>
</table>
Table 6.2: In situ Parameters/Unit Importance (cntd)

<table>
<thead>
<tr>
<th>Parameter/units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, °C</td>
<td>Temperature is a measure of how cool or how warm the water is, expressed in degrees Celsius (°C). Temperature is a critical water quality parameter, since it directly influences the amount of dissolved oxygen that is available to aquatic organisms.</td>
</tr>
<tr>
<td>Conductivity, µS/cm</td>
<td>Conductivity is the ability of the water to conduct an electrical current, and is an indirect measure of the ion concentration. The more ions present, the more electricity can be conducted by the water. This measurement is expressed in microsiemens per centimeter (µS/cm) at 25°Celsius.</td>
</tr>
</tbody>
</table>

The above parameters can be measured in situ with a Multi-parameter Sonde/probe.

Ex-situ

Several key parameters can only be measured in the laboratory following collection of samples. For cost-effective sampling, proper selection of ex-situ parameters is required. The main six (6) critical parameters (pH, BOD, COD, DO, SS and AN, are selected to determine the water quality status with reference to the Water Quality Index (WQI). Oil & grease and turbidity would further assist to validate physical observation by any assessor. Seven (7) additional parameters i.e. TDS, Chloride, Fluoride, Alkalinity, Hardness, Colour and Al should also be analyzed upstream of any water intake or water treatment plant. As for other parameters such as Cu, Fe, Mn and Zn, these parameters have been noted to influence the water quality of the studied rivers in eastern Sabah and have been shown to exceed the recommended standards.

The parameters that should be analysed during ex-situ sampling are tabulated in Table 6.3.
Table 6.3: Ex-situ Water Quality Parameters, Unit Method References

<table>
<thead>
<tr>
<th>Parameters, Unit</th>
<th>Method References</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>APHA 4500-H+ B</td>
</tr>
<tr>
<td>Biological Oxygen Demand at 5 Days (BOD5), mg/l</td>
<td>APHA 5210 B</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD), mg/l</td>
<td>APHA 5220 D</td>
</tr>
<tr>
<td>Suspended Solids (SS), mg/l</td>
<td>APHA 2540 D</td>
</tr>
<tr>
<td>Copper (Cu), mg/l</td>
<td>APHA 3120 B</td>
</tr>
<tr>
<td>Iron (Fe), mg/l</td>
<td>APHA 3120 B</td>
</tr>
<tr>
<td>Manganese (Mn), mg/l</td>
<td>APHA 3120 B</td>
</tr>
<tr>
<td>Zinc (Zn), mg/l</td>
<td>APHA 3120 B</td>
</tr>
<tr>
<td>Oil &amp; Grease, mg/l</td>
<td>APHA 5200 B</td>
</tr>
<tr>
<td>Turbidity, NTU</td>
<td>APHA 2130 B</td>
</tr>
<tr>
<td>Total Nitrogen (N), mg/l</td>
<td>APHA 4500 –NO3- H &amp; 4500 - NORGB</td>
</tr>
<tr>
<td>Ammoniacal Nitrogen (NH3-N), mg/l</td>
<td>APHA 4500 NH3 G</td>
</tr>
<tr>
<td>Nitrate (NO3-), mg/l</td>
<td>APHA 4500 –NO3- H</td>
</tr>
<tr>
<td>Nitrite (NO2-), mg/l</td>
<td>APHA 4500-NO2- B</td>
</tr>
<tr>
<td>Phosphorus (P), mg/l</td>
<td>APHA 4500-PF</td>
</tr>
<tr>
<td>Potassium (Ka), mg/l</td>
<td>APHA 3120 B</td>
</tr>
<tr>
<td>Sulphate (SO4-), mg/l</td>
<td>APHA 4110 B</td>
</tr>
<tr>
<td>Fecal Coliform, MPN/100ml</td>
<td>APHA 9221 B</td>
</tr>
<tr>
<td>Total Dissolved Solids (TDS)</td>
<td>APHA 2540 C</td>
</tr>
<tr>
<td>Chloride, mg/l</td>
<td>APHA 4500Cl B,E</td>
</tr>
<tr>
<td>Fluoride, mg/l</td>
<td>APHA 4500 C,D</td>
</tr>
<tr>
<td>Alkalinity, mg/l</td>
<td>APHA 2320 B</td>
</tr>
<tr>
<td>Hardness, mg/l</td>
<td>APHA 2340 B,C</td>
</tr>
<tr>
<td>Colour, mg/l</td>
<td>APHA 2120 B</td>
</tr>
<tr>
<td>Aluminum (Al), mg/l</td>
<td>APHA 3120 B</td>
</tr>
</tbody>
</table>

(Source: DOE Guidelines, 1991)

b) Preparation for Sampling

Proper planning should be done before conducting any water sampling activity such as arrangement of vehicles, budget, equipment and etc. as described below:

i. Prepare plan of sampling according to the schedule. It should include days of outstation, time, sampling team members, and availability of vehicles, equipment and weather. It is best to have a checklist for proper planning.
ii. Ensure that bottles are sufficient and clean for the sampling. Preservative for the samples should also be checked. This should be done at least 3 weeks before the sampling journey.

iii. Check whether the vehicle is in a good condition.

iv. Weather forecast should be checked so the sampling activity goes smoothly.

v. Preparation of equipment via checklist which comprise the following items:
   - Bottles
   - Ice
   - Preservatives
   - Cooler box (sufficient amount)
   - GPS
   - Distilled water
   - Calibration solution
   - Marker pen
   - Life jacket
   - Tool box and first aid kit
   - Sampling sheet
   - Rope
   - Camera
   - Van Dorn sampler with rope and messenger

c) **Sampling Procedure**

Water sample should be collected using standard procedure to avoid any contamination. Preservation must be ready to hold the water samples until the samples reached the laboratory. Generally, the staff of the contract laboratory will assist the sample collector in the handling of samples.

ASEAN Secretariat. 2003. Guidelines for the implementation of the ASEAN policy on zero burning.


Chan, K.S., & Chooi, C.F. 1982. Ponding system for palm oil mill effluent.*Palm oil research institute of malaysia (PORIM)* proc. of reg. worksp. on palm oil mill techy. and effl. treat (pp185).


Department of Environment (DOE) 1999. Industrial processes and the environment (handbook no 3) crude palm oil industry.


Ma, A. N., & Ong, A.S.H 1985. Pollution Control in Palm Oil Mills in Malaysia. JAOCs, 62, : 261 – 266.


RSPO Malaysia national interpretation 2008. Indicators and Guidance to Establish the RSPO Principles & Criteria.


WWF.Palm Oil: Better Management Practices:

http://wwf.panda.org/what_we_do/footprint/agriculture/palm_oil/solutions/roundtable_on_sustainable_palm_oil/better_management_practices/


LINKS

Malaysian Palm Oil Board (MPOB): www.mpob.gov.my

Roundtable on Sustainable Palm Oil (RSPO): www.rspo.org

High Conservation Value (HCV) Resource Network: www.hcvnetwork.org
Annex 1

Key Laws and Regulations Applicable to the Development and Operation of Oil Palm Plantations

Environmental Impact Assessment

Current enforcing legislations with regards to the conservation and protection of the State’s natural resources as well as the environment are governed by the Environment Protection Enactment 2002, whereby requirement to submit an Environmental Impact Assessment (EIA) report or Proposal for Mitigation Measures (PMM) are as stated under Part III, Sec. 12 (3) of the enactment, “No person shall carry out any development activity which is categorized under subsection (2) unless such person has submitted an environmental impact assessment report or proposal for mitigation measures as the case may require and such report or proposal has been approved by the director”.

Under the enactment, Environment Protection (Prescribed Activities) (Environmental Impact Assessment) Order 2005 has outlined compulsory requirements of OPP developments under both of its First and Second Schedule to carry out PMM and EIA studies, respectively as follows:
FIRST SCHEDULE: List of Prescribed Activities Requiring Proposal for Mitigation Measures Report

1. AGRICULTURE -

- Development of agricultural estates or plantations covering an area of 100 hectares or more but less than 500 hectares;
- Development of agricultural estates or plantations involving change in type of crops covering an area of 100 hectares or more but less than 500 hectares; or
- Conversion of wetland forests into agricultural estates or plantations covering an area of 20 hectares or more but less than 50 hectares.

SECOND SCHEDULE List of Prescribed Activities Requiring Environmental Impact Assessment Report

1. AGRICULTURE -

- Development of agricultural estates or plantations covering an area of 500 hectares or more; or
- Development of agricultural estates or plantations involving change in type of crops covering an area of 500 hectares or more; or
- Conversion of wetland forests into agricultural estates or plantations covering an area of 50 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 2 years and a fine of Ringgit 50,000.00 (Malaysian Ringgit fifty thousand only).

Any person who intends to undertake oil palm plantation development activities in the State of Sabah shall submit to the Director of the Environmental Conservation Department (ECD) an EIA Report for approval.

The EIA Guidelines for Oil Palm Plantation Development (2002) by EPD outline the assessment of impacts against the size of the development and how it affects any identified sensitive areas.


Section 10. Commodity Policy. Item 10.1.1 Oil Palm – To maximize returns from palm oil, production will be increased through expansion, productivity improvement, and upgraded efficiency particularly in the smallholder sub-sector. The adoption of automation and intensified mechanization will be encouraged to increase productivity and efficiency and as a long-term solution to the problem of labour shortage. Milling, bulking installation and refining facilities will be upgraded, expanded and increased to cater for increased production.

Downstream processing to produce locally manufactured value-added palm oil products, such as oleochemicals, will be encouraged to ensure a balanced and sustained growth of the industry. Environmentally friendly methods of oil palm cultivation, production and processing will be promoted.

Responsible development of oil palm cultivation should not only meet the needs of investors and developers but also compliment in a broader sense the State’s socio-economic interests. Environmentally friendly methods of oil palm cultivation are clearly emphasized in the current Sabah Agricultural Policy.

The procedure for developing an oil palm plantation begins with the application for land (Figure A1). The procedure is summarized as follows:

- Application shall be made in writing to the Assistant Collector of Land Revenue (ACLR)
- The Assistant Collector of Land Revenue shall refer the application to the Land Utilization Committee (LUC) for technical comments. Permanent members of the Land Utilization Committee are the Director or Deputy Director of Lands and Survey Department (Chairperson), District Surveyor, Department of Agriculture, Forestry Department, Department of Irrigation and Drainage, Fishery Department and community leaders.

Community leaders and surveyors will ensure that the land is available and unencumbered.

The Department of Agriculture provide technical comments in terms of land suitability and will also consider the proposed Agriculture Development Plan and make recommendations to the Assistant Collector of Land Revenue. The recommendations do not bear any regulatory weight but if applied by the
Enforcement Section of the Lands and Survey Department under the regulations stipulated in the Land Code, the recommendations may be used to prosecute any breach of the requirements under the Code.

- The application is then forwarded to the Director of Lands and Survey Department who will then forward it to the Secretary of Natural Resources for approval by the YAB Chief Minister;
- An approved application is returned to the Director of Lands and Survey Department who will direct the Assistant Collector of Land Revenue to make an offer to the applicant and a Draft Land Title is subsequently issued;
- The applicant shall approach the District Surveyor to establish the Registered Survey Paper through the service of a Registered Surveyor who will then produce a Draft Survey Plan;
- The Draft Survey Plan will be reviewed and checked by the District Surveyor before the survey data are submitted to the Lands and Survey Department for official Registration;
- Upon completion of the tasks required by Lands and Survey Department, the Land Registrar will issue the lease to the applicant and the Final Title is produced; and
- Having obtained the Land Title, the applicant will then carry out an EIA (if it is a prescribed activity) for submission to the ECD. The EIA will assist in determining the final planted area of the plantation and the location of the boundary, which amongst other things will be included in the Agreement of Environmental Conditions (AEC) to be entered between the Project Proponent and the ECD.
Agriculture Development Plan (ADP)

The existing policies, Section 36 under the Second Sabah Agriculture Policy (1999 – 2010), highlighted that “Environmentally-friendly methods of cultivation, production and processing will be promoted to minimize the negative impact of these activities on the environment. Recognizing the importance of soil as a resource vital for agriculture, efforts will also be undertaken to maintain the soil eco-system of the state to ensure its proper utilization and conservation. As such, steep terrain of between 20 and 25 degrees slope as defined in the “Soils of Sabah (1975) Study” will only be allowed for development under environmentally-friendly methods of cultivation which include proper soil and slope management measures in particular through the use of the sloping agriculture land use technology”.

Figure A.1: Application Procedures for Oil Palm Plantation Development
Currently, the DOA is applying recommendations in *Panduan Pembangunan Pertanian bagi Tanah Bercerun (2000)* as the main guide in review and processing of the approval of ADP. In the ADP, DOA has divided the preparation into two (2) categories i.e. a non-comprehensive development plan for proposed development with area of 50 – 500 acres and a comprehensive development plan for area of more than 500 acres. See *Table A1*.

**Table A.1: Type of (ADP)**

<table>
<thead>
<tr>
<th>Categories</th>
<th>Proposed Area</th>
<th>Soil Information Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive Development Plan</td>
<td>&gt; 500 acres</td>
<td>Reproduction of existing available soil and topographic maps together with a write-up on the soil types, terrain and drainage based on existing reports and on extra data obtained during the field investigation. Field investigation includes verification of the soil mapping unit by making traverse that must cut all Soil Association in the map at least once and by undertaking auger description up to 90 cm depth at intervals of at least 100 metres. Soil Pits: Two (2) contrasting soil types per association with profile description and chemical analysis from every soil horizon (layer) are required. Soil Map: This should be large enough to cover at least one full-scale page with indication of scale.</td>
</tr>
<tr>
<td>Non-comprehensive Development Plan</td>
<td>50- 500 acres</td>
<td>Items (ii) and (iii) above are not required. However, one traverse cutting across the most representative soils and terrain of the area, plus the associated soil auger and terrain description</td>
</tr>
</tbody>
</table>

(Source: Department of Agriculture)

Approval is given if the ADP meets the requirements of the DOA, and the approved development plan will be distributed to the Director of Agriculture, Director of Land and Survey, Permanent Secretary of the Ministry of Agriculture and Food Industry, District Agriculture Officer as well as the owner for retention and monitoring. DOA will report to the LSD or DID the outcome of their ground investigation especially where the proposed development resulted in disturbance to river reserve and steep area.
Pesticides Act 1974

The Pesticides Act 1974 was the guiding principles for the registration, production, management and application of pesticides in Malaysia. The Pesticides Board of Malaysia, which is the pesticide-regulating authority, is under the purview of DOA. The Board banned a number of pesticides gradually during the last two decades and Table A2 shows the pesticides which have been voluntarily withdrawn by the parent company or partially/totally banned by the Pesticides Board over past twenty years.

BANNED PESTICIDES

Table A.2: Pesticides withdrawn or Partially/Totally banned by the Pesticides Board of Malaysia

<table>
<thead>
<tr>
<th>Active chemicals</th>
<th>Status</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4,5-T</td>
<td>Banned</td>
<td>1998</td>
</tr>
<tr>
<td>dinoseb</td>
<td>Banned</td>
<td>1993</td>
</tr>
<tr>
<td>Aldrin</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>Chlordane</td>
<td>Banned</td>
<td>1997</td>
</tr>
<tr>
<td>Chlordimeform</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>Chlorobenzilate</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>DDT</td>
<td>Banned</td>
<td>1999</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>DNOC</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>Banned</td>
<td>1996 (paddy only), 2005</td>
</tr>
<tr>
<td>Lindane</td>
<td>Banned</td>
<td>1999</td>
</tr>
<tr>
<td>methomyl</td>
<td>Banned</td>
<td>1974</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>Banned</td>
<td>1999</td>
</tr>
<tr>
<td>Parathion methyl</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Phosphamidon</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Mercury compounds</td>
<td>Banned</td>
<td>1994</td>
</tr>
</tbody>
</table>

(Source: Department of Agriculture)
RESTRICTED PESTICIDES

Table A.3: Pesticides withdrawn or Partially/Totally banned by the Pesticides Board of Malaysia

<table>
<thead>
<tr>
<th>Active chemicals</th>
<th>Restriction</th>
<th>Effective date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acephate</td>
<td>Requires permit – coconut and oil palm only</td>
<td>2004</td>
</tr>
<tr>
<td>Methamidophos</td>
<td>Requires permit – coconut and oil palm only</td>
<td>1997, 2004</td>
</tr>
<tr>
<td>Monocrotophos</td>
<td>Requires permit – coconut and oil palm only</td>
<td>1995</td>
</tr>
<tr>
<td>Profenofos</td>
<td>Prohibited for vegetables</td>
<td>2004</td>
</tr>
<tr>
<td>Prothiofos</td>
<td>Prohibited for vegetables</td>
<td>2004</td>
</tr>
<tr>
<td>Phenthoate</td>
<td>Prohibited for vegetables</td>
<td>2004</td>
</tr>
<tr>
<td>Quinalphos</td>
<td>Prohibited for vegetables</td>
<td>2004</td>
</tr>
<tr>
<td>Triazophos</td>
<td>Prohibited for vegetables</td>
<td>2004</td>
</tr>
</tbody>
</table>

(Source: Department of Agriculture)

FUNGICIDES

Table A.4: Pesticides withdrawn or Partially/Totally banned by the Pesticides Board of Malaysia

<table>
<thead>
<tr>
<th>Active chemicals</th>
<th>Status</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binapacryl</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Captathion</td>
<td>Banned</td>
<td>1997</td>
</tr>
<tr>
<td>Folpet</td>
<td>Banned</td>
<td>1998</td>
</tr>
<tr>
<td>Sodium PCP</td>
<td>Banned</td>
<td>2000</td>
</tr>
</tbody>
</table>

(Source: Department of Agriculture)

RODENTICIDES

Table A.5: Pesticides withdrawn or Partially/Totally banned by the Pesticides Board of Malaysia

<table>
<thead>
<tr>
<th>Active chemicals</th>
<th>Status</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoroacetamide</td>
<td>Never been registered</td>
<td></td>
</tr>
</tbody>
</table>

(Source: Department of Agriculture)
### Table A.6: Pesticides withdrawn or Partially/Totally banned by the Pesticides Board of Malaysia

<table>
<thead>
<tr>
<th>Active chemicals</th>
<th>Status</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4,5-T</td>
<td>Banned</td>
<td>1998</td>
</tr>
<tr>
<td>Dinoseb</td>
<td>Banned</td>
<td>1993</td>
</tr>
<tr>
<td>Aldrin</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>Chlordane</td>
<td>Banned</td>
<td>1997</td>
</tr>
<tr>
<td>Chlordimeform</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>Chlorobenzilate</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>DDT</td>
<td>Banned</td>
<td>1999</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>DNOC</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>Banned</td>
<td>1996 (paddy only),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Lindane</td>
<td>Banned</td>
<td>1999</td>
</tr>
<tr>
<td>Methomyl</td>
<td>Banned</td>
<td>1974</td>
</tr>
<tr>
<td>heptachlor</td>
<td>Banned</td>
<td>1994</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>Banned</td>
<td>1999</td>
</tr>
<tr>
<td>Parathion</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Parathion methyl</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>phosphamidon</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>Banned</td>
<td>Never been registered</td>
</tr>
<tr>
<td>Mercury compounds</td>
<td>Banned</td>
<td>1994</td>
</tr>
</tbody>
</table>

(Source: Department of Agriculture)
Annex 2


The contents of the report shall consist of the following:

- Chapter 1: Executive Summary
- Chapter 2: General Information
- Chapter 3: Project Description
- Chapter 4: Impact Prediction and Evaluation
- Chapter 5: Recommended Mitigation Measures
- Chapter 6: Recommended Monitoring Programme

Report Annexes

The report shall also include; (i) table of content, (ii) list of tables, (iii) list of figures, (iv) list of pictures, (v) list of maps and (vi) table of abbreviations. The latter should be kept to a minimum.

CHAPTER 1: EXECUTIVE SUMMARY

The executive summary shall be regarded as a non-technical résumé of the findings and recommendations of the study. The executive summary shall be in Bahasa Malaysia and English, and shall include the following two sections.

- **Project Description**
  A short description of the proposed development project.

- **Findings**
  Findings in relation to each of the environmental issues defined in the scoping note, TOR or identified during the study are summarized in relation to the assessed environmental impacts; recommended mitigation measures; and recommended monitoring programme. Environmental impacts that are irreversible or threaten fauna and flora, environmental quality and sustainable development should be highlighted.
CHAPTER 2: GENERAL INFORMATION

This chapter shall contain 3 sections outlining information related to the conduct of the study.

- **Project Title and Project Proponent**
  Name of firm; address, telephone and fax number; name and designation of contact person responsible for the project; and other projects subject to PMM and EIA reports which have been carried out, are being carried out, and/or will be carried out.

- **Environmental Consultants**
  Name of firm; address, telephone and fax number; list of team members involved in the preparation of the report and their field of expertise; list of PMM and EIA reports which have been carried out. Each team member is required to attach his/her signature in the report.

- **Public Hearing**
  For Special-EIAs, information concerning the public hearing (procedures, duration and availability of the report to the public) shall be included in the report.

CHAPTER 3: PROJECT DESCRIPTION

This chapter provides a description of the proposed project with a clear explanation for the need, content and scope of the project. The chapter is divided into 3 sections.

- **Statement of Need**
  Short argumentation for the need for the project, including identification of the aim and beneficiaries of the project.

- **Concept and Phases**
  This section introduces the project concept and the intentions of the project proponent. Each phase of project activity shall be described separately. Planned or possible future project expansions shall also be described.
• **Description of Location**

This section shall make it possible to assess the existing location and environment in and around the project area. The section shall consist mainly of location maps, photos and other visual information, but shall also include *a brief site description*, including the pertinent features in the project area, for example, rivers, mangroves, hill slopes, etc.

• **Maps, descriptions, etc.**

The site descriptions, geographical and visual information provided shall include:

a. Photographs of the existing environment in the project and surrounding area;

b. Location, including longitude/latitude or UTM co-ordinates and geographic boundaries of the project area and the assessment area;

c. Local plan development and requirements;

d. Location of nearby land owned or leased by the project proponent;

e. Land use and existing environment of project site and surrounding areas;

f. Ongoing developments within the project area or adjacent area;

g. Position and distance of nearest protected area, sensitive or undisturbed habitat;

h. Drainage/hydrology indicating watershed system surrounding the project area; and

i. Slope map derived from 1:10,000 topographic maps or larger.
The environmental consultant is also expected to provide additional information such as:

a. Cadastral plan;

b. Visualisations, for example before/after;

c. Three-dimensional slope aspect maps;

d. Other land titles in surrounding areas; and

e. Proposed/planned development activities in surrounding areas.

- **Project Status**

A description of the status of implementation of the project shall be provided under this section. Is the project on the planning stage? Has implementation begun and if so, which activities have been undertaken when and where?

The section shall also include a concise overview of the approval procedures for the project. What approvals are needed and when? What approvals have already been received, submitted and/or will be submitted, when submitted, and from which authority?

**CHAPTER 4: IMPACT PREDICTION AND EVALUATION**

This chapter describes the impact assessments of the environmental issues identified in the scoping note or TOR of the study. Additional environmental issues identified during the study shall also be included and assessed. This chapter shall contain 3 sections.

- **Significant Environmental Impacts**

This section describes in brief the environmental impacts that have been evaluated to be likely the most significant and thus become a prioritised issue.
The section describes the assessment matrix of the key environmental impacts in relation to the project cycle and provides an overview of all adverse environmental impacts evaluated in the study.

The matrix format divides the impacts into stages. As in the scoping exercise, the study shall be divided according to the project life cycle such as:

a. Exploration and construction/implementation stage;
b. Operational, production and maintenance stage; and
c. Abandonment stage.

<table>
<thead>
<tr>
<th>Environmental assessment/ Main adverse environmental impacts</th>
<th>Magnitude</th>
<th>Permanence</th>
<th>Reversibility</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration and construction/ implementation stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational, production and maintenance stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abandonment stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All environmental impacts identified in the study shall be assessed according to the criteria and scores as follows:

a. **Magnitude of change/effect. Score:** 1 - change/effect only within the project site, 2 - change/effect to local conditions and/or to areas immediately outside project site, 3 - change/effect at regional/ national/ international level

b. **Permanence of the impact. Score:** 1 - no change/not applicable, 2 - temporary; 3 - Permanent

c. **Reversibility of the condition. Score:** 1 - no change/not applicable, 2 - reversible, 3 – Irreversible

d. **Cumulative impact. Score:** 1 - no change/not applicable, 2 - non-cumulative/single, 3 - cumulative.
Impact assessment

In this section, each of the environmental impacts listed in the assessment matrix shall be assessed and prioritised. For each environmental impact, the specific methodology of review, data collection and analysis shall be described and the results of the analysis and conclusions of the assessment presented. The methodologies used for the review, data collection and analysis are to be clearly stated and documented.

The results of the analysis and conclusion of the assessments have to be presented in a clear and concise manner. The conclusion must clearly and specifically summarise the results of the analysis and must correspond to the scores given in the assessment matrix. It is important to refer to existing environmental guidelines, and published literature and case studies in the analysis and drawing up of conclusions.

It should be noted that under section 56 of the Environment Protection Enactment 2002, any person who willfully deceives the Director shall be guilty of an offence, and shall, on conviction, be liable to a fine not exceeding ten thousand ringgit or an imprisonment for a term not exceeding one year or both fine and imprisonment.

CHAPTER 5: RECOMMENDED MITIGATION MEASURES

This chapter describes the recommended and possible mitigation measures for the environmental impacts assessed in chapter 4 of the report. Adverse impacts that cannot be mitigated must be highlighted. The chapter shall contain 2 sections.

Recommendations

This section gives an account of the priority list of the most important mitigation measures that the project proponent shall adopt, as recommended by the environmental consultant.

Data collection and assessment of the recommended mitigation measures shall be properly documented.
It is important that the environmental consultant works closely with the project proponent in preparing the shortlist of recommended mitigation measures in order to ensure that the mitigation measures are practical, cost-effective and at the same time sufficient to abate the environmental impacts.

The recommended mitigation measures shall provide the basis for the preparation of the Agreement of Environmental Conditions to be agreed upon by the project proponent and the Department.

Each of the recommended mitigation measures shall be described in detail. This includes for example when and how the recommended mitigation measures should be incorporated into the detailed project design and in the construction contract documents. Wherever possible, the cost-estimations for all proposed mitigation measures should be provided.

- Additional Mitigation Measures

This section describes the additional mitigation measures which may include measures that:

Should be implemented, even though they are directed towards addressing adverse environmental impacts of minor significance;

Have been analysed and assessed, but for some reasons, (e.g. not cost-effective), were considered inappropriate to implement; or

Are indirectly linked to the development project, (e.g. rehabilitation efforts in adjacent areas).

The additional mitigation measures, after being reviewed by the department and Review Panel, may be included in the Agreement of Environmental Conditions.
CHAPTER 6: RECOMMENDED MONITORING PROGRAMME

This chapter describes the recommended monitoring programme for:

- Compliance of the recommended mitigation measures; and
- The residual impacts of the project on the environment.

Compliance of Mitigation Measures

This section clearly outlines methods to monitor the compliance of the recommended mitigation measures. The methods shall be designed in such a way that it will be possible for the project proponent to demonstrate that the mitigation measures are fully and effectively implemented. The methods shall specify details on how compliance of the recommended mitigation measures will be monitored and shall include description of the following:

- **Methodology** to check that actual implementation of recommended mitigation measures has taken place;
- **Location** of mitigation measures and monitoring sites on maps and photographs;
- **Time schedule** indicating frequency of site visits in relation to the project duration;
- Periodic reporting; and
- Methods and schedule of *audit/review* of results.

Residual Impacts

This section clearly describes the recommended monitoring programme that will measure key residual environmental impacts of the project. The programme shall be designed in such a manner that the project proponent can demonstrate that the impacts of the identified key environmental issues are acceptable within the standards or threshold set. The monitoring programme shall also specify details on how the key adverse environmental changes will be monitored and among others shall include the following:

- **Indicators** for key environmental issues.
Environmental standards and the application in relation to the project.

Methodology, location and schedule. The methodology for monitoring shall be clearly described. Maps, photographs and co-ordinates of proposed sampling points shall be presented. Regular monitoring in accordance with a recommended time schedule shall be provided.

Responsibilities of the project proponent. The project proponent shall provide adequate staffing and budget, and consultancy requirements to ensure the proper implementation of the monitoring programme. The estimated budget shall be provided. A description on how the monitoring programme will be incorporated into the detailed project design and contract documents shall also be provided.

Monitoring reporting including responsibility and schedule.

REPORT: ANNEXES

Annexes shall constitute all information not immediately relevant to the main text of the report and shall include the following:

Annex 1: Baseline Environmental Data and Information

This annex shall include additional relevant information, maps and photographs of the existing environment at the proposed development site not included in chapter 3 of the report. The annex shall primarily include description of immediate relevance to the impact assessment and the recommendations made in chapters 4-6 of the report.

Annex 2: Methodologies and Analysis of Data

This annex describes the methodologies applied in the assessment of environmental impacts, and mitigation measures with the appropriate references. All data collected, modeled and extrapolated during the study shall be provided. Environmental sampling reports, for example data on ambient air, noise levels, and water quality shall be presented in detail.
Annex 3: List of References

This annex provides a listing of references used for the preparation of the report.

Annex 4: Scoping Note or Terms of Reference of study including activities undertaken by the environmental consultant

This annex describes all other relevant information for the review of the report, for example:

a. Description of scoping note or TOR of the study;
b. List of consultations held; and
c. Details of involvement of key stakeholders (how, when, who).
The main steps in the zero burning replanting of oil palm planting with a new generation of palms are described below:

- **Planning for Replanting**

  In planning for zero replanting, a proper design of the estate is essential. Consideration would have to given to the scope of work, availability of appropriate machines and equipment, timing of operations and budget.

  If personnel from the plantation company and or their contractors do not have previous experience with zero burning technique, a training or practice session should be conducted. If possible, a study field trip to a plantation that has undertaken replanting by zero burning would be beneficial.

  Replanting provides the opportunity to rectify any physical problems or inadequacies that have been encountered in the previous crop for instances, the need for realignment of the road or drainage systems must be identified during the planning stage.

- **Prelining**

  Prelining of micro lining is done to identify the new planting rows, roads, harvesters, paths and drains as shown in Figure 2 for replanting on flat to undulating terrain. Prelining on hilly terrain would have to follow the land contours. This operation facilitates the placement of the shredded materials and other field operations.

  The tips of lining pegs should be painted with colors to identify various field operations.

  In order to minimize the risk of *Ganoderma* infection in coastal areas, new planting rows are placed in between the previous rows.

- **Construction of Roads and Drains**

  The construction of collection and field of subsidiary drains can be done before or immediately after felling of palms.

  In situation where the old field drains do not fall in place with the new field layout, they are filled up with soil and new drains that were prelined earlier are constructed. Where the existing drains can be retained, they are desilted and until they are of the same depth as the new drains.
In coastal areas, field drains are constructed every fourth or eight palm row while the collection drains are placed in the center of two field roads.

A double rotary ditcher can be used for the construction of new drains.

Bulldozers or excavators are suitable for construction of new roads, which should be chambered up to a height of about 30 cm in the center to ensure adequate drainage and all year road access to vehicular traffic.

- **Felling and Shredding/Chipping**

  The old palms are directionally felled using an excavator’s hydraulic boom that is fitted with a chipping bucket.

  For effective shredding, the chipping bucket’s cutting edge should be made of high tensile carbon steel.

  The palm trunk is cut at an angle of 45° - 60° into 5-10 cm thick slices of about 0.8 to 1.0 m in length. Thinner slices of trunk tissues would hasten the rate of disintegration and decomposition. The shredding or chipping operation normally commences from the basal end of the palm trunk. Bole tissues and the adjoining root mass should also be shredded.

  A 120 HP track-type excavator is capable of felling and shredding 50 to 80 palms, depending on the height of palms, ground conditions and ground conditions.

- **Stacking/Windrowing**

  In straight-lined plantings on flat to undulating terrain, the shredded materials are stacked as follows:

  In an area where the field drain intensity is 1 in every 4 palm rows, the shredded materials are stacked in the center avenue of 4 palm rows between the two field drains.

  In an area where the field drain intensity is 1 in every 8 palm rows, the shredded materials are stacked at alternate avenues except along the drain avenues.

  In hilly areas, the shredded materials are spread out evenly on the inter-terrace slopes.
• **Ploughing and Harrowing in Coastal Areas**

After completion of felling, shredding and stacking, ploughing and harrowing are done along the new planting strips to produce a friable and level planting surface.

• **Construction of Terraces in Inland Undulating to Hilly Areas**

On land with slopes exceeding 10°, planting terraces of about 4 m width should be constructed, except on shallow soils where narrower terraces are made to avoid cutting into parent materials/rocks. The terraces should follow contour lines.

In areas where the slope is between 5-10°, soil conservation terraces should be constructed, the distance between terraces is about 30 m.

If the area to be replanted has a history of severe infestation of *Ganodermaboninense*, which causes Basal Stem Rot, a higher initial planting density ought to be considered, particularly in coastal areas (both on clay soils and peat soils) and the requirement for oil palm materials from the nursery and the field layout would have to be raised accordingly.

• **Removal of *Ganoderma* Diseased Palms**

In areas with a high incidence of Basal Stem Rot, a detailed census of *Ganoderma* diseased palms should be undertaken. Vacant points should also be recorded as they are likely to be due to *Ganoderma*.

Diseased palms should be felled ahead of the replanting operations and the palm bole and the adjoining root mass should be removed by an excavator and placed in the interrow, away from any new planting points. The bole and root mass should also be shredded.

The palm trunks are left behind for shredding along with the rest of the old palm stand during the replanting operations.
# Annex 4


<table>
<thead>
<tr>
<th>No</th>
<th>Production Flow Sequence</th>
<th>Model Situation</th>
<th>Inspection Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw materials reception areas for fresh fruit bunch</td>
<td>Areas clean, tidy and free of accumulation of bruised fruits and rotten empty bunches</td>
<td>Look out for: Crushing of loose fruits Oil and dirt accumulation Cleaner Production Opportunities Cleaning of reception areas after unloading of FFB with pressure host Removal of dirt and other unwanted materials</td>
</tr>
<tr>
<td>2</td>
<td>Loading of FFB into cages</td>
<td>Clean and tidy area Provision for spillage containment Proper loading system based on first come first load principle</td>
<td>Look out for: Over-filling of cages Cleaner Production Opportunities Recover EFB and loose fruits on ground Remove all dirt and waste materials</td>
</tr>
<tr>
<td>3</td>
<td>Control of water usage</td>
<td>Less than 1.5m³/tonne FFB processed</td>
<td>Look out for: Water faucets and hoses kept open when not in use Leaking pipe joins, valves and faucets Cleaner Production Opportunities Flow meeting of water consumption and effluent discharge Installing float valves/cut off switch for water tanks Training of factory operators in</td>
</tr>
<tr>
<td>No</td>
<td>Production Flow Sequence</td>
<td>Model Situation</td>
<td>Inspection Focus</td>
</tr>
<tr>
<td>----</td>
<td>--------------------------</td>
<td>-----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>4</td>
<td>Control of oil clarification temperature</td>
<td>Not less than 90°C in batch or continuous settling tank</td>
<td>Look out for: Poor oil separation and excessive losses to clarification station waste water. Under – flow sludge from static settling tank should have less than 1% oil content. Cleaner Production Opportunities: Improved temperature control in crude oil settling tanks to minimize oil losses to clarification station wastewater.</td>
</tr>
<tr>
<td>5</td>
<td>Control of oil spillage and leaks</td>
<td>Proper preventative maintenance and speedy response in the event of oil spill occurrences</td>
<td>Look out for: Oil storage tank overflows and absence of level controllers. Leaking pipe and appurtenances. Cleaner Production Opportunities: Minimum oil losses to wastewaters and reduced organic loading of treatment facilities.</td>
</tr>
<tr>
<td>6</td>
<td>Proper design and operation of oil/fat traps</td>
<td>Good design of oil/fat traps with minimum HRT of about 1 day</td>
<td>Look out for: Basic design dimensions and features and determine the HRT. Poor oil separation and high oil content in effluent. Cleaner Production Opportunities: Minimum oil losses to wastewaters and reduced organic loading of treatment facilities.</td>
</tr>
<tr>
<td>7</td>
<td>Proper design of boiler and dust scrubbing system</td>
<td>Incorporated with dust scrubber, appropriate chimney height and stack gas sampling</td>
<td>Look out for: Sampling port, platform, ladder and chimney height. Smoke detector analysis and maintenance schedule.</td>
</tr>
<tr>
<td>No</td>
<td>Production Flow Sequence</td>
<td>Model Situation</td>
<td>Inspection Focus</td>
</tr>
<tr>
<td>----</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>access, boiler feeding system and smoke detector/recorder</td>
<td>Fuel feed system Scrubber maintenance record and efficiency test. KWh- readings (after turbine fluctuations)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Proper interim storage of solid by-product and waste materials</td>
<td>Storage areas should be away from drains and preferably sheltered from rainfall and provided with containment bunds</td>
<td>Look out for: Solid waste and by product materials and residues finding access into storm water or effluent drains Cleaner Production Opportunities Absence of solid waste materials in drainage systems reflects good housekeeping</td>
</tr>
</tbody>
</table>
### Annex 5

**Proposed POME Treatment Checklist for Self-Monitoring by Palm Oil Mills**

#### Daily Record of Anaerobic Pond

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow rate (m³/hr)</th>
<th>pH</th>
<th>Temp (°C)</th>
<th>SV₃₀ (mL)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

#### Daily Record of Aerobic Pond

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow rate (m³/hr)</th>
<th>pH</th>
<th>DO (mg/L)</th>
<th>SV₃₀ (mL)</th>
<th>DO Uptake Rate (mg/L.min)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

#### Weekly or Monthly Record of all Ponds

<table>
<thead>
<tr>
<th>Date</th>
<th>BOD₅ (mg/L)</th>
<th>MLSS (mg/L)</th>
<th>MLVSS (mg/L)</th>
<th>Nutrient (mg/L)</th>
<th>F/M Ratio</th>
<th>SVI</th>
<th>Microscopic Examination of Protozoa</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>In</td>
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<td>Out</td>
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</tbody>
</table>
Example: A POME Polishing Plant Functionality Check List

<table>
<thead>
<tr>
<th>Date</th>
<th>Equipment Running Hrs</th>
<th>Flow rate (m³/month)</th>
<th>Pump Functionality (✓ / ×)</th>
<th>Chemical Dosages (mg/L)</th>
<th>Remarks</th>
</tr>
</thead>
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### Annex 6

**Relevant RSPO Principles and Criteria based on Malaysian National Interpretation of Indicators and Guidance to Establish the RSPO Principles & Criteria**

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**Criterion 4.2: Practices maintain soil fertility at, or where possible improve soil fertility to, a level that ensures optimal and sustained yield.**

**4.2.1** Monitoring of fertilizer inputs through annual fertilizer recommendations.

Minor compliance

**4.2.2** Evidence of periodic tissue and soil sampling to monitor changes in nutrient status.

Minor compliance

**4.2.3** Monitor the area on which EFB, POME and zero-burn replanting is applied.

Minor compliance

**Guidance:**

Long-term fertility depends on maintaining the structure, organic matter content, nutrient status and microbiological health of the soil. Managers should ensure that best agricultural practice is followed. Nutrient efficiency must take account of the age of plantations and soil conditions.
Criterion 4.3: Practices minimize and control erosion and degradation of soils.

Indicators:

4.3.1 Documented evidence of practices minimizing soil erosion and degradation (including maps).

Minor compliance

Specific Guidance:

Replanting on sloping land must be in compliance with MSGAP Part 2: OP (4.4.2.2)

For Sarawak, steep slopes are considered high risk erosion areas and cannot undergo replanting unless specified in the EIA report and approved by the Natural Resources and Environment Board (NREB).

For Sabah, slopes 25 degree and steeper are considered high risk erosion areas and cannot undergo replanting unless specified in the EIA report [Environment Protection (Prescribed Activities)(Environment Impact Assessment) Order 2005] and approved by the Environment Protection Department (EPD).

Slope determination methodology (slope analysis) should be based on average slope using topographic maps or topographical surveys.

4.3.2 Avoid or minimize bare or exposed soil within estates.

Minor compliance

Specific Guidance:

Appropriate conservation practices should be adopted.

4.3.3 Presence of road maintenance programme.

Minor compliance
4.3.4 Subsidence of peat soils should be minimized through an effective and documented water management programme.

Minor compliance

Specific Guidance:

Maintaining water table at a mean of 60 cm (within a range of 50-75cm) below ground surface through a network of weirs, sandbags, etc. in fields and watergates at the discharge points of main drains.

4.3.5 Best management practices should be in place for other fragile and problem soils (e.g. sandy, low organic matter and acid sulphate soils).

Minor compliance

Guidance:

Techniques that minimize soil erosion are well-known and should be adopted, wherever appropriate. These may include practices such as:

Expediting establishment of ground cover upon completion of land preparation for new replant.

Maximizing palm biomass retention/ recycling.

Maintaining good non-competitive ground covers in mature areas.

Encouraging the establishment/regeneration of non-competitive vegetation to avoid bare ground.

Construction of conservation terraces for slopes >15 degrees

Advocating proper frond heap stacking such as contour/L-shaped stacking for straight line planting and stacking along the terrace edges for terrace planting.

Appropriate road design and regular maintenance.

Diversion of water run-off from the field roads into terraces or silt pits.

Construction of stop bunds to retain water within the terrace.
Maintaining and restoring riparian areas in order to minimize erosion of stream and river banks.

**Criterion 4.5: Pests, diseases, weeds and invasive introduced species are effectively managed using appropriate Integrated Pest Management (IPM) techniques.**

Indicators:

4.5.1 Documented IPM system.
   Minor compliance

4.5.2 Monitoring extent of IPM implementation for major pests.
   Minor compliance
   **Specific Guidance:**
   Major pests include leaf eating caterpillars, rhinoceros beetle and rats.

4.5.3 Recording areas where pesticides have been used.
   Minor compliance

4.5.4 Monitoring of pesticide usage units per hectare or per ton crop e.g. total quantity of active ingredient (a.i.) used/ tonne of oil.
   Minor compliance

**Guidance:**
Growers should apply recognised IPM techniques, incorporating cultural, biological, mechanical or physical methods to minimize use of chemicals. Native species should be used in biological control wherever possible.
Criterion 4.6: Agrochemicals are used in a way that does not endanger health or the environment. There is no prophylactic use of pesticides, except in specific situations identified in national Best Practice guidelines. Where agrochemicals are used that are categorized as World Health Organization Type 1A or 1B, or are listed by the Stockholm or Rotterdam Conventions, growers are actively seeking to identify alternatives, and this is documented.

Indicators:

4.6.1 Written justification in Standard Operating Procedures (SOP) of all agrochemicals use.

Major compliance

4.6.2 Pesticides selected for use are those officially registered under the Pesticides Act 1974 (Act 149) and the relevant provision (Section 53A); and in accordance with USECHH Regulations (2000).

Major compliance

Specific Guidance:

Reference shall also be made to CHRA (Chemical Health Risk Assessment)

4.6.3 Pesticides shall be stored in accordance to the Occupational Safety and Health Act 1994 (Act 514) and Regulations and Orders and Pesticides Act 1974 (Act 149) and Regulations.

Major compliance
Criterion 5.1: Aspects of plantation and mill management, including replanting, that have environmental impacts are identified, and plans to mitigate the negative impacts and promote the positive ones are made, implemented and monitored, to demonstrate continuous improvement.

Indicator:

5.1.1 Documented aspects and impacts risk assessment that is periodically reviewed and updated.

Major compliance

5.1.2 Environmental improvement plan to mitigate the negative impacts and promote the positive ones, is developed, implemented and monitored.

Minor compliance

Guidance:

Non-restrictive format e.g. ISO 14001 EMS and/or EIA report incorporating elements spelt out in this criterion and raised through stakeholder consultation.

Criterion 5.3: Waste is reduced, recycled, re-used and disposed off in an environmentally and socially responsible manner.

Indicators:

5.3.1 Documented identification of all waste products and sources of pollution.

Major compliance

5.3.2 Having identified wastes and pollutants, an operational plan should be developed and implemented, to avoid or reduce pollution.

Minor compliance

Specific Guidance:
Schedule waste to be disposed as per EQA 1974 (Scheduled Wastes) Regulations, 2005. Reference to be made to the national programme on recycling of used HDPE pesticide containers. Municipal waste disposal as per local authority or district council in accordance to the Ministry of Health guidelines (i.e. specifications on landfills, licensed contractors, etc) or Workers’ Minimum Standards of Housing and Amenities Act 1990 (Act 446).

5.3.3 Evidence that crop residues / biomass are recycled (Cross ref. C 4.2).

Minor compliance

Specific Guidance:

POME should be discharged in compliance with the Environmental Quality Act 1974 (Act 127) and Regulations.

For Sabah and Sarawak, POME should be discharged according to the respective state policies.

Criterion 5.4: Efficiency of energy use and use of renewable energy is maximized.

Indicators:

5.4.1 Monitoring of renewable energy use per tonne of CPO or palm product in the mill.

Minor compliance

5.4.2 Monitoring of direct fossil fuel use per tonne of CPO or kW per tonne palm product in the mill (or FFB where the grower has no mill).

Minor compliance

Guidance:

To establish baseline values and observe trends within appropriate time-frame.
Growers and millers should assess the energy use including fuel and electricity, and energy efficiency of their operations. The feasibility of collecting and using biogas, biodiesel and biofuels should be studied if possible.

**Criterion 5.5: Use of fire for waste disposal and for preparing land for replanting is avoided except in specific situations, as identified in the ASEAN Guidance or other regional best practice.**

Indicators:

5.5.1 No evidence of open burning. Where controlled burning occurs, it is as prescribed by the Environmental Quality (Declared Activities) (Open Burning) Order 2003.

   Major compliance

5.5.2 Previous crop should be felled/mowed down, chipped/shredded, windrowed or pulverized/ ploughed and mulched.

   Minor compliance

   Specific Guidance:

   A special dispensation from the relevant authorities should be sought in areas where the previous crop or stand is highly diseased and there is a significant risk of disease spread or continuation into the next crop.

5.5.3 No evidence of burning waste (including domestic waste).

   Minor compliance
Criterion 7.1: A comprehensive and participatory independent social and environmental impact assessment is undertaken prior to establishing new plantings or operations, or expanding existing ones, and the results incorporated into planning, management and operations.

Indicators:

7.1.1 An independent and participatory social and environmental impact assessment (SEIA) to be conducted and documented (Cross ref. to C 7.2, 7.3, 7.4, 7.5, 7.6).

Major compliance

Specific Guidance:

SEIAs to include previous land use / history and involve independent consultation as per national and state regulations, via participatory methodology which includes external stakeholders.

For Sabah, slopes 25 degrees and above are considered high risk erosion areas and cannot undergo replanting unless specified in the EIA report [Environment Impact Assessment (Order 2005)] and approved by the Environment Protection Department (EPD).

For Sarawak, steep slopes are considered high risk erosion areas and cannot undergo replanting unless specified in the EIA report [Natural Resources and Environment (Prescribed Activities) Order 1994] and approved by the Natural Resources and Environment Board (NREB).

7.1.2 The results of the SEIA to be incorporated into an appropriate management plan and operational procedures developed, implemented, monitored and reviewed.

Minor compliance

7.1.3 Where the development includes smallholder schemes of above 500ha in total, the impacts and implications of how it is managed should be documented and a plan to manage the impacts produced.
Minor compliance

Guidance:

The terms of reference should be defined and impact assessment should be carried out by accredited independent experts, in order to ensure an objective process. Both should not be done by the same body. See also C 5.1 and C 6.1. This indicator is not applicable to development of smallholder schemes below 500ha.

For Sabah, new planting or replanting of area 500ha or more requires EIA. For areas below 500ha but above 100ha, proposal for mitigation measures (PMM) is required.

For Sarawak, only new planting of area 500ha and above requires EIA. Onus is on the company to report back to the DOE on the mitigation efforts being put in place arising out of the EIA.

Assessment of above and below ground carbon storage is important but beyond the scope of an EIA.

Criterion 7.2: Soil surveys and topographic information are used for site planning in the establishment of new plantings, and the results are incorporated into plans and operations.

Indicators:

7.2.1 Soil suitability maps or soil surveys adequate to establish the long-term suitability of land for oil palm cultivation should be available.

Major compliance

7.2.2 Topographic information adequate to guide the planning of drainage and irrigation systems, roads and other infrastructure should be available.

Minor compliance
Guidance:

These activities may be linked to the SEIA (C7.1) but need not be done by independent experts.

Soil surveys should be adequate to establish the long-term suitability of land for oil palm cultivation. Soil suitability maps or soil surveys should be appropriate to the scale of operation and should include information on soil types, topography, soil depth, moisture availability, stoniness, fertility and long-term soil sustainability. Soils unsuitable for planting or those requiring special treatment should be identified.

This information should be used to plan planting programmes, etc. Measures should be planned to minimize erosion through appropriate use of heavy machinery, terracing on slopes, appropriate road construction, rapid establishment of cover, protection of riverbanks, etc.

**Criterion 7.3: New plantings since November 2005, have not replaced primary forest or any area required to maintain or enhance one or more High Conservation Values.**

Indicators:

7.2.1 Soil suitability maps or soil surveys adequate to establish the long-term suitability of land for oil palm cultivation should be available.

Major compliance

7.2.2 Topographic information adequate to guide the planning of drainage and irrigation systems, roads and other infrastructure should be available.

Minor compliance

Guidance:

These activities may be linked to the SEIA (C7.1) but need not be done by independent experts.
This criterion applies to forests and other vegetation types. This applies irrespective of any changes in land ownership or farm management that have taken place after this date. High Conservation Values (HCVs) may be identified in restricted areas of a landholding, and in such cases new plantings can be planned to allow the HCVs to be maintained or enhanced.

Specific Guidance to the above indicator is listed below:

New plantings within Nov 05 and Nov 07 must be in compliance with existing regulatory requirements that relate to social and environmental impacts assessment i.e. SEIA (ref.C7.1) and also comply with the legalized land spatial planning.

Where it can be proven that the land did not contain HCV after Nov 2005, the land can enter the RSPO certification programme.

Where the HCV status of the land is unknown and/or disputed, the land will be excluded from the RSPO certification programme, until an acceptable solution for HCV compensation has been developed.

Companies owning such land can enter other estates in the programme. This arrangement is valid only for land development between Nov 05 and Nov 07 which was the RSPO P&C initial pilot implementation period.

7.3.2 No conversion of Environmentally Sensitive Areas (ESAs) to oil palm as per Peninsular Malaysia’s National Physical Plan (NPP) and Sabah Forest Management Unit under the Sabah Forest Management License Agreement.

Major compliance

Specific Guidance:

ESA rankings and management criteria as per the NPP are listed in Appendix 3.

7.3.3 No new plantings on floodplains (reference to be made to State DID).

Major compliance
7.3.4 Dates of land preparation and commencement are recorded.

Minor compliance

**Criterion 7.4: Extensive planting (to be determined by SEIA) on steep terrain, and/or on marginal and fragile soils, is avoided.**

Indicators:

7.4.1 All new plantings should not be cultivated on land more than 300m above sea level and on land more than 25 degrees slope unless specified by local legislation (Ref: MSGAP Part 2: OP 4.4.1.3 & 4.4.1.4)

Major compliance

7.4.2 Where planting on fragile and marginal soils is proposed, plans shall be developed and implemented to protect them without incurring adverse impacts (e.g. hydrological) or significantly increased risks (e.g. fire risk) in areas outside the plantation.

Minor compliance

Guidance:

This activity should be subjected to a comprehensive EIA as required by C 7.1. Marginal and fragile soils, including excessive gradients and peat soils, should be identified prior to conversion to plantation.
Criterion 7.7: Use of fire in the preparation of new plantings is avoided other than in specific cases as identified in the ASEAN Guidance or other regional best practice.

Indicators:

7.7.1  No evidence of clearing by burning. This activity should be integrated with the SEIA required by C 7.1

Major compliance

7.7.2  Evidence of approval for controlled burning, as per Environmental Quality (Declared Activities) (Open Burning) Order 2003.

Major compliance
Annex 7

Checklist of native plants (Sabah) suitable for river reserve rehabilitation
(Source: Guideline for Managing Biodiversity in the Riparian Zone, Ministry of Natural Resources and Environment)

<table>
<thead>
<tr>
<th>SPECIES DATA</th>
<th>PLANTING DATA</th>
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<tbody>
<tr>
<td><strong>Species: (Family) : (Local name)</strong></td>
<td><strong>Habit</strong></td>
</tr>
<tr>
<td><em>Acer laurinum</em>; (Medang)</td>
<td>Tree to 30m tall</td>
</tr>
<tr>
<td><em>Alstonia augustifolia</em> (Pulai)</td>
<td>Small tree about 10m tall</td>
</tr>
<tr>
<td><em>Alstonia pneumatophara</em> (Pulai Basong)</td>
<td>Tree to 40m</td>
</tr>
<tr>
<td><em>Archidemdon kunstleri</em></td>
<td>Shrub or small tree to 1.5m tall</td>
</tr>
<tr>
<td><em>Avicennia alba</em>; (Api-api hitam)</td>
<td>Tree to 21m tall</td>
</tr>
<tr>
<td><em>Avicennia officinata</em>; (Api-api ladat)</td>
<td>Tree to 18m tall</td>
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<tr>
<td>SPECIES DATA</td>
<td>PLANTING DATA</td>
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<tr>
<td><strong>Species: (Family) : (Local name)</strong></td>
<td><strong>Habit</strong></td>
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<tr>
<td><strong>Barringtonia acutuangulara</strong> (L); (Putatnasi)</td>
<td>Shrub or small tree to 13m tall</td>
</tr>
<tr>
<td><strong>Blumeodendron nakbrut; (Calnam budak)</strong></td>
<td>Tree to 36m tall sometimes still rooted</td>
</tr>
<tr>
<td><strong>Brackenridgea palustris</strong>; (Ladah mura)</td>
<td>Tree to 9m tall</td>
</tr>
<tr>
<td><strong>Brownlowia argentata</strong>; (Dungun)</td>
<td>Shrub or small tree to 18m tall</td>
</tr>
<tr>
<td><strong>Brugniera parviflora</strong>; (Berus)</td>
<td>Tree to 24m tall</td>
</tr>
<tr>
<td><strong>Campnosperma auriculatum</strong>; (Terentang daun besar)</td>
<td>Big tree to 33m tall</td>
</tr>
<tr>
<td><strong>Campnosperma squamatum</strong>; (Terentang daun kecil)</td>
<td>Tree to 30m tall</td>
</tr>
<tr>
<td><strong>Cebera odollum</strong>; (Pong-pong)</td>
<td>Small tree</td>
</tr>
<tr>
<td><strong>Chionanthus ramiflorus</strong></td>
<td>Tree to 17m tall</td>
</tr>
<tr>
<td>SPECIES DATA</td>
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<tr>
<td><strong>Species: (Family) : (Local name)</strong></td>
<td><strong>Habit</strong></td>
</tr>
<tr>
<td><em>Cratoxylum arborescens</em> (Geronggang)</td>
<td>Large tree to 42m tall</td>
</tr>
<tr>
<td><em>Cynometra ramiflora</em> (Katong Laut)</td>
<td>Bushy crowned tree to 25m tall</td>
</tr>
<tr>
<td><em>Dacryodes incurvata</em>; (Kedondong)</td>
<td>Tree to 30m tall</td>
</tr>
<tr>
<td><em>Dialium indum</em>; (Keranji paya)</td>
<td>Tree to 35m tall</td>
</tr>
<tr>
<td><em>Diperocarpus oblongifolius</em>; (Keruing neram)</td>
<td>Large tree</td>
</tr>
<tr>
<td><em>Dolichandrone spathacea</em> (Tui)</td>
<td>Tree to 24m tall</td>
</tr>
<tr>
<td><em>Dyera costulata</em>; (Jelutong)</td>
<td>Huge lactiferous tree to more than 60m tall</td>
</tr>
<tr>
<td><em>Elaeocarpus griffithii</em>; (Medang kelawar)</td>
<td>Tree to 7m tall</td>
</tr>
<tr>
<td><em>Excoecaria agallocha</em>; (Buta-buta)</td>
<td>Small tree to 15m tall</td>
</tr>
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<td>PLANTING DATA</td>
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<tr>
<td><strong>Species: (Family) : (Local name)</strong></td>
<td><strong>Habit</strong></td>
</tr>
<tr>
<td><em>Ficus microcarpa</em>; (Jejawi)</td>
<td>Large tree with aerial roots</td>
</tr>
<tr>
<td><em>Gonystylus bancanus</em>; (Ramin melawis)</td>
<td>Tree to 27m tall</td>
</tr>
<tr>
<td><em>Gliria pleuropteris</em>; (Penyamok)</td>
<td>Tree to 10m tall</td>
</tr>
<tr>
<td><em>Gynotroches axillaris</em>; (Mata keli)</td>
<td>Tree to 36m tall</td>
</tr>
<tr>
<td><em>Helicia attenuata</em> ; (Golang paya)</td>
<td>Shrub or small tree to 20m tall</td>
</tr>
<tr>
<td><em>Helicia robusta</em>; (Medang keladi)</td>
<td>Small tree to 10m tall</td>
</tr>
<tr>
<td><em>Heritiera littoralis</em>; (Dungun)</td>
<td>Small bushy tree to 1.5m tall</td>
</tr>
<tr>
<td><em>Hibiscus tiliaceus</em>; (Baru-baru)</td>
<td>Tree to 12m tall</td>
</tr>
<tr>
<td><em>Intsia bijuga</em>; (Merbau ipil)</td>
<td>Tree to 25m tall</td>
</tr>
<tr>
<td><em>Jackiopsis ornata</em>; (Medang gambut)</td>
<td>Tree to 35m tall</td>
</tr>
<tr>
<td>Species: (Family) : (Local name)</td>
<td>Habit</td>
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<tr>
<td><em>Knema curtisii</em>; (Pendarahan)</td>
<td>Tree to 10m tall</td>
</tr>
<tr>
<td><em>Lagerstroemia speciosa</em>; (Bungor)</td>
<td>Tree to 15 m tall</td>
</tr>
<tr>
<td><em>Lophopetalum multinervium</em>; (Perupok)</td>
<td>Tree to 35 m tall often with short columnar pneumatophores</td>
</tr>
<tr>
<td><em>Macaranga motleyana</em> (Mahang bulan)</td>
<td>Small bushy tree</td>
</tr>
<tr>
<td><em>Madhuca motleyana</em> ; (Nyato ketiau)</td>
<td>Tree to 35m tall</td>
</tr>
<tr>
<td><em>Mallotus floribundics</em>; (Balik angina)</td>
<td>Small tree</td>
</tr>
<tr>
<td><em>Mussaendopsis beccariana</em>; (Merlimau penyabong)</td>
<td>Tree to 35m tall</td>
</tr>
<tr>
<td><em>Neesia malayana</em>; (Bengang)</td>
<td>Tree to 25m tall</td>
</tr>
<tr>
<td><em>Neoscorchlinia philippinensis</em>; (Beki)</td>
<td>Small tree</td>
</tr>
<tr>
<td><em>Nephelium lappaceum</em>; (Rambutan)</td>
<td>Tree to 25m tall</td>
</tr>
<tr>
<td>Species: (Family) : (Local name)</td>
<td>Habit</td>
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</tr>
<tr>
<td><strong>Nephelium ramboutan-ake;</strong> (Pulasan)</td>
<td>Tree to 35m tall</td>
</tr>
<tr>
<td><strong>Norrisia major;</strong> (Sarapak paya)</td>
<td>Tree to 24m tall</td>
</tr>
<tr>
<td><strong>Nypa fruticans</strong> (Nipah)</td>
<td>Palm to 6m tall</td>
</tr>
<tr>
<td><strong>Pimelodendron macrocarpum;</strong> (Perah ikan)</td>
<td>Tree to 18m tall</td>
</tr>
<tr>
<td><strong>Polyalthia glauca;</strong> (Mempisang)</td>
<td>Tree to 45m tall</td>
</tr>
<tr>
<td><strong>Polyathia hypoleuca;</strong> (Mempisang)</td>
<td>Tree to 30m tall</td>
</tr>
<tr>
<td><strong>Pometia pinnata;</strong> (Kasai daun besar)</td>
<td>Tree to 40m tall</td>
</tr>
<tr>
<td><strong>Pterocarpus indicus;</strong> (Angsana)</td>
<td>Tree to 30m tall</td>
</tr>
<tr>
<td><strong>Rhizophora apiculata;</strong> (Bakau minyak)</td>
<td>Stilts-rooted tree to 30m tall</td>
</tr>
<tr>
<td><strong>Rhizophora mucronata;</strong> (Bakau kurap)</td>
<td>Stilt-rooted tree to 30m tall</td>
</tr>
<tr>
<td><strong>Ryparosa hulletii</strong></td>
<td>Shrub or tree to</td>
</tr>
<tr>
<td>SPECIES DATA</td>
<td>PLANTING DATA</td>
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<tr>
<td><strong>Species: (Family) : (Local name)</strong></td>
<td>Habit</td>
</tr>
<tr>
<td>Saraca cauliflora; (Gapis)</td>
<td>Tree to 15m tall</td>
</tr>
<tr>
<td>Shorea palebanica; (Meranti tekawang ayer)</td>
<td>Tree of middle size</td>
</tr>
<tr>
<td>Stemonurus secundiflorus; (perapat bukit)</td>
<td>Tree to 12m tall</td>
</tr>
<tr>
<td>Tetramerista glabra; (Punah)</td>
<td>Tree to 35m tall</td>
</tr>
<tr>
<td>SPECIES DATA</td>
<td>PLANTING DATA</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td><strong>Species:</strong> (Family) : (Local name)</td>
<td>Habit</td>
</tr>
<tr>
<td><strong>Tristaniopsis whiteana;</strong> (Pelawan)</td>
<td>Tree to 24m tall</td>
</tr>
<tr>
<td><strong>Vatica venulosa;</strong> (Resak letop)</td>
<td>Small tree</td>
</tr>
<tr>
<td><strong>Xylocarpus granatum;</strong> (Nyireh bunga)</td>
<td>Tree to 15m tall</td>
</tr>
</tbody>
</table>
**Abbreviations:**

Distribution:

PM=Peninsular Malaysia, Ps=Perlis, Kd=Kedah, Pn=Pulau Pinang, Kl=Kelantan, Tg=Trengganu, Pk=Perak, Ph=Pahang, Sl=Selangor, NS=Negeri Sembilan, MI=Melaka, Jh=Johor, Sb=Sabah, Sw=Sarawak

Type of river habitats for planting:

MS=Montane stream, SS=Saraca stream, NS=Neram stream, RS=Rasaustream, FS=Freshwater stream, PS=Peatswamp, MF=Mangrove

Maximum height/forest cover:

CA=Canopy, MS=Middle storey, GR=Ground

Planting zones near river bank:

LB=Lower bank, UB=Upper bank, TF=Terrace face, UT=Upper terrace

Socio-economic/Ecological benefits:

BV=Beverages, DT=Dyes and tannins, EC=Ecology/reafforestation, EO=Essential oils, EX=Exudate/resins, FB=Fibre/thach, FF=Fruits, flowers and seeds (food for wildlife), FU=Fuel/charcoal, FV=Vegetables, MD=Medicinal plants, OR=Ornamental, PO=Poison, SF=Spices/flavours, TS=Timber/structure, VO=Vegetable oils, WQ=Water quality improvement
Sources used to compile species and planting data:


Annex 8: Department of Agriculture Brochure on Recycling Used Pesticide Containers

BAGAIMANA CARA BILAS 3 KALI

1. Tuangkan sisa racun perosak ke dalam tang percikan. Biarkan racun mentrans dan tinggalkan selama 30 saat lagi.

2. Letakkan bekas racun ke dalam tang bersih. Tutupkan bekas dengan tebal.

3. Tuangkan sisa racun ke dalam tang bersih. Tutupkan bekas dengan tebal.


5. Tuangkan sisa racun ke dalam tang bersih. Tutupkan bekas dengan tebal.


KITAR SEMULA BEKAS RACUN PEROSAK
SATU AMALAN PERTANIAN BAIK

Untuk mengelakkan sisa racun tak dihancurkan, pasukan pembalakan dilakukan selama dalam waktu 8 jam setiap hari. Bila tidak, sisa racun bakal digunakan.

Pola kerja pengelompokan untuk menunjang sisa racun adalah untuk kegunaan racun perosak jenis yang sama.
**KITAR SEMULA BEKAS RACUN PEROSAK**

**Objektif**
- Memelihara kesejahteraan alam sekitar
- Mematuhi kehendak Amalan Pertanian Baik
- Mengelak salah guna bekas racun perosak

**Kenapa Perlu Bilas 3 Kali**
- Sisabaki perawis aktif sangat minimum (Lihat jadual di bawah)
- Dapat mengurangkan pencemaran alam sekitar
- Boleh diterima untuk kitar semula

Amaun perawis aktif yang masih ada dalam bekas racun perosak muatan 20 liter

<table>
<thead>
<tr>
<th>Keadaan Bekas</th>
<th>Amaun Sisabaki Racun Perosak (g)</th>
<th>Peratusan Residu Racun Perosak (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selepas titisan terakhir disalirkan.</td>
<td>14.2</td>
<td>50.07</td>
</tr>
<tr>
<td>Selepas bilasan pertama</td>
<td>0.2</td>
<td>0.07</td>
</tr>
<tr>
<td>Selepas bilasan kedua</td>
<td>0.0003</td>
<td>0.001</td>
</tr>
<tr>
<td>Selepas bilas ketiga</td>
<td>0.00005</td>
<td>0.00017</td>
</tr>
</tbody>
</table>

Sumber: Pest Management Principles for the Wisconsin Farmer

**Di mana Pusat Pengumpulan**

Bekas-bekas yang telah dibilas 3 kali dan ditebuk boleh dihantar ke Pusat Pengumpulan berhampiran. Untuk maklumat lanjut hubungi:

31 Lorong Hilltop 2,
Casa Fabulosa,
88200 Kota Kinabalu, Sabah
Tel: 0168336533 (Mr. Chong)

P.O. Box No. 114,
91207 Kunak, Tawau
Tel: 088-444282
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Ara 7-17, Lot 4G2, Wisma Tani, Presint 4
Pusat Pentadbiran Kerajaan Persekutuan
62632 PUTRAJAYA
Tel: 03-8870 3000 Fax: 03-8870 3378
http://www.doa.gov.my

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## GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic condition</td>
<td>A condition in which “free” (atmospheric) or dissolved (molecular) oxygen is present in the aquatic environment.</td>
</tr>
<tr>
<td>Algae</td>
<td>Plants which contain chlorophyll and live floating or are suspended in water or attached to structures. Algae produce oxygen during sunlight hours and use oxygen during the night hours.</td>
</tr>
<tr>
<td>Anaerobic condition</td>
<td>A condition in which “free” (atmospheric) or molecular (dissolved) oxygen is not present in the aquatic environment.</td>
</tr>
<tr>
<td>Biodegradable</td>
<td>Organic matter that can be broken down by microorganisms e.g. bacteria to more stable forms which will not create a nuisance or give off foul odours.</td>
</tr>
<tr>
<td>Biodegradable Organics</td>
<td>Composed principally of proteins, carbohydrates, and fats.</td>
</tr>
<tr>
<td>Biomass</td>
<td>Material derived from plants</td>
</tr>
<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand. The rate at which organisms use the oxygen in water or wastewater while stabilizing decomposable organic matter under aerobic conditions.</td>
</tr>
<tr>
<td>Clarifier</td>
<td>Settling Tank, Sedimentation Basin. A tank or basin in which wastewater is held for a period of time during which the heavier solids settle to the bottom and the lighter materials float to the water surface.</td>
</tr>
<tr>
<td>Cleaner Production</td>
<td>An approach to production and manufacturing that focuses on source reduction, waste minimization, energy efficiency and low-waste and non-waste technology.</td>
</tr>
<tr>
<td>Coagulation</td>
<td>The clumping together of very fine particles into larger particles caused by the use of chemicals (coagulants). The chemicals neutralize the electrical charges of the fine particles and cause destabilization of the particles. This clumping together makes it easier to separate the solids from the liquids by settling, skimming, draining or filtering.</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand. The amount of oxygen that is consumed in chemical reactions (i.e. the oxidation of organic and inorganic matter), under test conditions. It is used to</td>
</tr>
</tbody>
</table>
measure the total amount of organic and inorganic pollution in wastewater.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter-current</td>
<td>Two different media moving in opposite directions of each other.</td>
</tr>
<tr>
<td>Crude Palm Oil</td>
<td>The primary liquid product from a palm oil mill.</td>
</tr>
<tr>
<td>Depericarper</td>
<td>Equipment to separate the fibres and nuts in the press cake.</td>
</tr>
<tr>
<td>Effluent</td>
<td>Wastewater or other liquid - raw (untreated), partially or completely treated - flowing from a reservoir, basin, treatment process, or treatment plant.</td>
</tr>
<tr>
<td>Empty Fruit Bunch</td>
<td>The fibrous core of the fruit bunch after stripping of the fruitlets during the milling process.</td>
</tr>
<tr>
<td>End-of-pipe</td>
<td>Waste management solutions that are applied to the waste at the point of emission or discharge.</td>
</tr>
<tr>
<td>Facultative bacteria</td>
<td>Facultative bacteria can use either molecular (dissolved) oxygen or oxygen obtained from food materials such as sulphate or nitrate ions. Facultative bacteria can live under aerobic or anaerobic conditions.</td>
</tr>
<tr>
<td>HRT</td>
<td>Hydraulic Retention Time. The time required to fill a tank at a given flow rate or the theoretical time required for a given flow of wastewater to pass through a tank.</td>
</tr>
<tr>
<td>Kernel</td>
<td>The endosperm or seed (excluding the shell) of the palm oil fruitlet.</td>
</tr>
<tr>
<td>Mesocarp</td>
<td>The fleshy fibrous layer of the palm oil fruit from which palm oil is extracted.</td>
</tr>
<tr>
<td>Mulching</td>
<td>The recycling of pruned fronds, shredded palm biomass at replanting as well as excess mesocarp fibre and empty fruit bunches back on land in the plantation.</td>
</tr>
<tr>
<td>Neutralization</td>
<td>Addition of an acid or alkali to a liquid to cause the pH of the liquid to move pH of 7.0.</td>
</tr>
<tr>
<td>Potash</td>
<td>Potassium compound obtained from fertilizer sources (e.g. Potassium Chloride, etc.) as well as from ashes from incineration of EFB (bunch ash or BA) in the mills.</td>
</tr>
</tbody>
</table>