38 ACTIONS TO CONTROL EROSION AND SEDIMENT

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38.1 BACKGROUND

A range of activities on construction sites has the potential to pollute stormwater. These include earthworks that result in erosion and sedimentation as well as contractor activities such as construction practices and materials, waste, vehicles, and equipment management, which can cause off-site contamination.

The primary objectives of stormwater quality control for construction activities are to:

- minimise erosion and sedimentation
- reduce impacts from other chemical constituents associated with materials usage/contractor activities within a construction site
- install appropriate measures to reduce impacts on downstream waterways from the finished project and provide a commitment that these measures will be maintained

This chapter provides guidance for planning, designing, and implementing appropriate control practices for construction activities. Owners of construction sites will be required to prepare and implement an Erosion and Sediment Control Plan (ESCP) before construction begins.

Sediment, which results from the excessive erosion of disturbed soils, is the primary pollutant of concern. However, other pollutants such as metals, nutrients, soil additives, pesticides, construction chemicals, and miscellaneous wastes are also of concern at construction sites.

38.1.1 Local Experience with Construction Sites

Bare eroding slopes and drains choked with sediment can often be observed at construction sites in developing areas throughout Malaysia. A number of measurements made indicate that massive amounts are transported from development sites. Sediment chokes urban waterways exacerbating flooding and often necessitating expensive river desilting and training works (DOE, 1996).

Urban development was particularly rapid in Kuala Lumpur and in the neighbouring urban centres of the Klang Valley in the late 1970s and 1980s. An untoward environmental effect of urban growth in the Kuala Lumpur area has been the frequent occurrence of excessive soil losses from construction sites and from sites cleared of vegetation but awaiting development. There has also been a deterioration in a number of watercourses due to severe siltation. Detailed investigations of sediment yields have been carried out in Kuala Lumpur and Penang (Douglas, 1978; Mykura, 1989; Balamurugan, 1991). Areas undergoing construction usually experience sediment yields 2 to 3 orders of magnitude greater than those under natural land cover conditions. In such catchments, the importance of extreme events is significant that between 35 and 80% of the annual load occurred in a single month at the Penang stations. Small bare areas/construction sites such as on deeply weathered rock, particularly granites, can yield huge quantities of sediment in short periods of time (Mykura, 1989).

Gullies are the major sediment source on exposed construction sites. Gullies increase in size more rapidly on fill materials than on cut slopes. Downcutting is the dominant gully enlargement process in cut material, while sidewall retreat dominates on fill.

38.1.2 Previous Guidelines

In an attempt to control the problem of soil erosion, the Federal Government introduced legislation enabling local authorities to exert greater control over the layout and management of construction sites. The DID published a guideline entitled "Urban Drainage Design Standards and Procedures for Peninsular Malaysia" in 1975 which included a section on sediment pond design.

The first formal document to assist planners, practitioners, and developers to control erosion was prepared by the DOE in 1978. Entitled "Guidelines for Prevention and Control of Erosion and Siltation" (referred to as ANNEX I), the publication was released four years after the enactment of the Environmental Quality Act, 1974. The Guidelines were prepared to address widespread soil erosion problems arising from housing and infrastructural development activities. The 1978 Guidelines refer to various preventive measures, such as sediment traps and ponds, which could be applied to many types of activities. The Guidelines were widely used after 1st April 1988 which made environmental impact assessment mandatory for 19 prescribed activities under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987.

The fact that soil erosion and sedimentation continue to be an environmental problem of significant proportions in the country suggests that additional and more definitive guidelines may be necessary and that more stringent monitoring and enforcement are required.

In 1992, twenty-six Government Departments, agencies, and academic institutions were called upon to identify activities that could cause substantial erosion and sedimentation and to recommend measures to check the resulting problems. The DOE Guidelines (1978) were reviewed and a new document entitled "Guidelines for the Prevention and Control of Soil Erosion and Siltation" (known as ANNEX III) was produced. It contained most of the 1978 guidelines together with additional new methodologies for the prevention of erosion.

Between 1994 and early 1996, the DOE produced guidelines relating to the preparation of environmental

impact assessments (EIA) for each of the 19 prescribed activities listed in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 1987. Each of these documents contains general guidelines pertaining to the control of erosion and sedimentation.

In addition to the above, many Government Departments and Agencies also have prepared guidelines and regulations to control erosion and sedimentation. Among these are the Department of Irrigation and Drainage (DID), Public Works Department (JKR), Mines Department, Geological Survey Department, Town and Country Planning Department, Soil Section of the Department of Agriculture and Institut Kerja Raya Malaysia (IKRAM).

During the preparation of the most recent DOE document entitled "Guidelines for Prevention and Control of Soil Erosion and Siltation in Malaysia", the 1978 and 1992 DOE Guidelines and guidelines from other Departments and Agencies in Malaysia and overseas were reviewed. Relevant materials from all these guidelines were incorporated in this 1996 document to provide a range of information and methods for the assessment and control of soil erosion in Malaysia.

The DOE also stressed that its 1996 Guidelines are not meant to replace existing departmental and agency guidelines, but to complement them. The DOE Guidelines do not contain technical geo-engineering, hydrological, or hydraulic information per se.

38.1.3 Soil Erosion and Sedimentation Process

Soil erosion is the detachment, entrainment, and transport of soil particles from their place of origin by the agents of erosion, such as water, wind, and gravity. It is a form of land degradation and can be categorised as either geological or accelerated surface soil erosion. The latter results from human activities exposing the soil surface and thus enabling erosive agents such as rain to wash away topsoil. Dislodged soil particles are often stored within depressions in the land but may be dislodged during storm events. The amount of silt or sediment delivered into water systems through the processes of entrainment, transportation, and deposition is a function of changes in surface drainage patterns, terrain roughness, vegetation, and climatic conditions.

Water is the most significant agent of soil erosion. The removal of vegetative cover and the breakdown of soil structure through compaction and loss of organic matter often reduce infiltration and accelerate runoff and the entrainment of soil particles. The amount and sizes of soil particles transported as sediment increase as the volume and velocity of runoff increase. Hence, on project sites under development, drainage control is pre-requisite to erosion control.

Sedimentation is the build-up (aggradation) of sediment on the land surface or the bed of a watercourse. Sedimentation in drainage systems and in rivers leads to the raising of bed levels resulting in flash floods during heavy rainstorms. It is a dynamic process and is dependent upon the geomorphic and hydraulic characteristics of the drainage system. The deposited sediment tends to remain in place for short periods of time, the next rain flushing the sediment downstream. Thus, sediment tends to be transported in pulses depending on the flow characteristics of the drainage systems.

Suspended sediment is empirically one of the best indicators of sediment delivery into the drainage system or watercourse from the land during land clearance and earthwork activities. It can be used to indicate the relative magnitude of soil loss from a project site.

The following sections outline various types of erosion processes (DOE, 1996), five of which are shown in Figure 38.1.

(a) Rainsplash Erosion

The force of falling raindrops can dislodge soil particles, which are then available for entrainment by slope runoff. Bare soil surfaces in Malaysia are extremely susceptible to rainsplash erosion during high intensity rainstorms.

(b) Sheet Erosion

Sheet erosion occurs when loose or detached soil is transported downhill in a uniform layer, with no discernible concentrated flow. The shallow layer of flowing water rolls many particles downslope, but fine particles may be carried in suspension. Sheet erosion occurs rapidly during heavy rain but is readily interrupted by vegetation. Where surface irregularities break the laminar sheet wash, turbulence may cause incision and the initiation of rill formation. The amount of soil loss depends on the depth and velocity of flow, soil structure, and terrain. A serious consequence of sheet erosion is the very noticeable subsoil layer that is exposed at the surface after the topsoil is removed. Vegetation is particularly hard to re-establish in such layers.

(c) Rill Erosion

Entrainment of soil particles over an exposed terrain causes rill formations. Rills are shallow channels usually no more than 30 cm deep but can be metres long. They may be widespread on compacted, exposed surfaces, which are devoid of vegetation. Water flows more quickly in a rill because it is concentrated and this increases the detachment and transportation of soil particles. Vegetation plays an important role in dissipating runoff velocity and encourages deposition on-site.

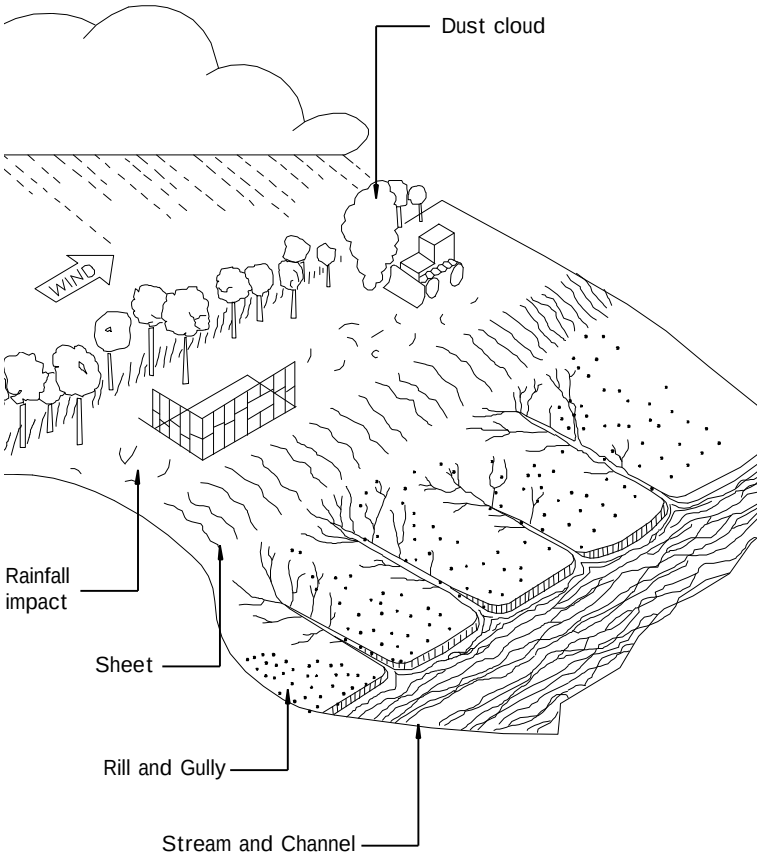

Figure 38.1 Types of Erosion Occurring at a Construction Site (CDM, 1993)

(d) Gully Erosion

Gullies are incised channels, which often began as rills. The headwall of a gully tends to cut back upslope and the sidewalls retreat through slumping associated with subsurface water altering the stability of the gully sides, or undercutting by surface water flowing over the head or sides of the gully. Gullies are highly effective conveyors of sediment to rivers and their density and depth are indicators of the severity of erosion.

(e) Riverbank Erosion

Rivers constantly adjust the shape of their channels and erode their banks under natural conditions. Much of the sediment carried by rivers in a natural rainforest state is derived from bank erosion. However, changes in runoff and sediment loads alter the stability of river channels and rapid bank erosion may occur as a consequence.

(f) Tunnel Erosion

Tunnel erosion frequently occurs in areas where the texture of the overburden or weathered rock and soil changes. Water moving readily through coarser materials may not be able to infiltrate into an underlying finer layer and thus moves downslope. Such water tends to converge and develop a subsurface natural pipe, which can enlarge as fine particles are carried away. Eventually the pipe may enlarge into a tunnel whose roof may collapse leaving a hole, which develops into a surface gully. Increased infiltration accelerates tunnel erosion and gully development by tunnel collapse.

(g) Wind Erosion

Wind erosion occurs on dry surfaces, particularly where loose fine material is abundant. Although not usually a problem in Malaysia, it may be a nuisance where bare ground on construction sites dries out yielding dust, which is blown onto neighbouring premises. The majority of dust generated and emitted is related to earth moving demolition, construction traffic on unpaved surfaces, and wind over disturbed uncompacted soil.

38.1.4 Impacts of Erosion and Sedimentation

The serious consequences of soil erosion and sedimentation are well known. Currently, the efficiency of mitigation measures in reducing the impact of soil erosion

and sedimentation on the environment and receiving waters is little known. On-site and off-site effects of soil erosion, sediment transport, siltation, and deposition are illustrated as follows (DOE, 1996):

(a) On-site

- loss of topsoil and resulting costs to communities
- undermining of roads and utilities
- sediment and mud on roads with associated traffic problems and road safety issues
- clogged drains and increased nuisance flooding
- sedimentation and bank damage on construction sites
- increased down-time on construction and building sites after storm events
- unsightly appearance of construction works
- sedimentation and accelerated loss of capacity in sediment basins
- high cost for reconstruction and maintenance

(b) Off-site

- sedimentation in reservoirs and other storage structures, with resulting loss of water storage capacity
- instability of stream channels caused by increased runoff and sediment loads: channel change and bank erosion may affect adjacent buildings and other infrastructure
- siltation and sedimentation of rivers will cause a reduction in channel capacity leading to greater frequency of floods
- proliferation of exotic weeds within watercourses due to the high nutrient content of silt and sediments
- smothering of aquatic and marine flora and fauna: high turbidity in rivers excluding light penetration affecting fish life
- land degradation caused by gully erosion and sediment deposition
- increased pollution of rivers and streams
- loss of navigable reaches of a river or watercourse
- adverse ecological effects of high sediment loads, deposition, and dredging and de-silting of waterways
- decline or total loss of recreational and commercial fishing, particularly as a result of increased turbidity
- reduced recreational and aesthetic value of riverbanks and waterways

38.1.5 Factors Influencing Erosion

There are primarily four factors that influence erosion:

- soil characteristics
- vegetative cover
- topography
- climate

Soil characteristics : The characteristics, which determine the erodibility of the soil, are particle size and gradation, organic content, soil structure, and soil permeability. Soils with a high proportion of silt and very fine clays are generally the most erodible. Organic matter creates a favourable soil structure, improving its stability and permeability. This increases infiltration capacity, delays the start of erosion, and reduces the amount of runoff. Soil characteristics affect soil stability, permeability, and infiltration capacity. The less permeable the soil, the higher the likelihood for erosion.

Vegetative cover : This plays an extremely important role in controlling erosion by shielding the soil surface from the impacts of falling rain, slowing the velocity of runoff (thereby permitting greater infiltration), maintaining the capacity of the soil to absorb water, and holding soil particles in place.

Topography : Slope length and steepness are key elements in determining the volume and velocity of runoff. As slope length and/or steepness increase, the rate of runoff increases and the potential for erosion is magnified.

Rainfall : The frequency, intensity, and duration of rainfall are fundamental factors in determining the amount of erosion produced. When storms are frequent, intense, or of long duration, erosion risks are high. In Malaysia, the erosion risk period is typically highest in the monsoon season (November through January) where thunderstorms may occur. On the other hand, erosion from wind and vehicle traffic can occur all year round.

38.1.6 Other Construction Impacts

Sediment from erosion is the pollutant most frequently associated with construction activities. However, other pollutants of concern include nutrients, trace metals, other toxic chemicals, and miscellaneous wastes. These pollutants originate from a variety of construction activities.

(a) Nutrients

Nitrogen, phosphorous, and potassium are the major plant nutrients used for fertilising new landscape at construction sites. Heavy use of commercial fertilisers can result in discharge of nutrients to water bodies where they may cause excessive growth of algae. Phosphorous and nitrogen from fertilisers, pesticides, petroleum products, construction chemicals, and solid waste are often generated by construction site activity (Berman et al., 1991).

(b) Trace Metals

Many of the artificial surfaces of the urban environment (e.g. galvanised metal, paint, or preserved wood (Berman et al., 1991)) contain metals which enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. Over half the trace metal load carried in stormwater is associated with sediments (Schueler, 1987).

(c) Pesticides

The three most commonly used forms of pesticides at construction sites are herbicides, insecticides, and rodenticides (USEPA, 1976). Unnecessary or improper application of these pesticides may result in direct water contamination, indirect pollution by drift, or transport off soil surfaces into water (Washington DOE, 1991).

(d) Other Toxic Chemicals

Often synthetic organic compounds (adhesives, cleaners, sealants, solvents, etc.) are widely applied and may be improperly stored and disposed. Deliberate dumping of these chemicals into stormwater drains and inlets (especially used crankcase oils) causes environmental harm to waterways.

(e) Miscellaneous Wastes

Miscellaneous wastes include wash water from concrete mixers, paints and painting equipment cleaning activities, solid wastes resulting from trees and shrubs removed during land clearing, wood and paper materials derived from packaging of building products, sanitary wastes, and food containers such as paper, aluminium, and metal cans. The discharge of these wastes can lead to unsightly and polluted waterways.

38.2 CONSTRUCTION ACTIVITIES

The DOE, 1996 provided generic and specific guidelines for twenty six (26) activities of which nineteen (19) are prescribed activities listed under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987. Of the 26 activities listed, the following are considered to be relevant to this manual:

Activity 7	Housing (Prescribed)
Activity 8	Industry (Prescribed)
Activity 9	Infrastructure (Prescribed)
Activity 16	Transportation (Prescribed)
Activity 17	Resort and Recreational Development (Prescribed)
Activity 20	Land Conversion for Golf Course
Activity 21	Hill Slope Development
Activity 22	Development of Ecologically Sensitive Areas

38.3 PLANNING GUIDELINES AND LAND CLEARING MEASURES

Specific planning guidelines and land clearing measures for each activity that may occur within urban or urbanising areas are reproduced from DOE, 1996 as follows. Generic guidelines that apply equally to all activities are presented in Section 38.4. These generic guidelines are also drawn from DOE, 1996.

38.3.1 Housing

(a) Planning Guidelines

1. Guidelines with respect to erosion control in housing development areas are often associated with plans to beautify the area (refer Akta Perancangan Bandar dan Desa (Pindaan, 1995)). The layout plans generally have information relating to:
   (i) measures for the protection and improvement of the physical environment
   (ii) measures for the preservation of natural topography
   (iii) landscape improvement measures
   (iv) the preservation and planting of trees
   (v) the location and species of trees (with a girth exceeding 0.8 m) and other vegetation
   (vi) provision of open space
   (vii) proposed earthworks, if any
   (viii) a description of works to be carried out
2. Developers are prohibited from:
   (i) damaging the land, its physical environment, natural topography, and landscape
   (ii) removing or altering of the natural features of the land
   (iii) felling of trees of a certain size, age, type, or species at any particular location unless it is to comply with any written instruction from the relevant authorities

(b) Land Clearing Measures

1. Great care should be taken to ensure that slopes potentially prone to landslide are not developed unless appropriate precautionary measures are undertaken (refer also to the Standard Specification for Road Works (JKR, 1988)).
2. All cut and fill slopes and benches should be stabilised as rapidly as possible and suitable drainage installed.
3. Vegetation buffers should be maintained along watercourses for erosion control, recreational and aesthetic purposes.

4. Every attempt should be made to minimise runoff to avoid flash flooding and reduce sedimentation of downstream watercourses.

38.3.2 Industry

(a) Planning Guidelines

1. Industrial projects will require lands to be cleared and therefore fall under erosion guidelines similar to those for land clearance.
2. In addition to the above, some specific guidelines are:
   (i) Environmental Impact Assessment Guidelines for Industrial Estates (DOE, 1994)
   (ii) Environmental Impact Assessment Guidelines for Industrial Projects (DOE, 1995)
   (iii) Town and Country Planning Act (Amended) 1995
   (iv) Guidelines for the Siting and Zoning of Industries (DOE, 1996)

The first two, (i) and (ii), have guidelines for the control of erosion through installation of sediment traps and basins during the construction stage while (iii) has specific guidelines for environmental control and enhancement.

38.3.3 Infrastructure

(a) Land Clearing Measures

Land clearing measures for any infrastructural projects are quite generic in nature. In particular:

1. Clearing should be restricted to those areas only where earthwork is required to be executed.
2. Long exposure of bare surfaces lead to unnecessary erosion and should be avoided.
3. The areas to be cleared should be set out on the ground by the Contractor and clearing commences only after the Site Officer is satisfied that the areas delineated are the areas where clearing is necessary.
4. All spoil materials removed by clearing should be disposed of properly, either within the property or in designated areas for such purposes. The Contractor shall be responsible for compliance with all laws and regulations relating to disposal.
5. Any existing buildings, structures, and superficial obstructions, which are located in the way of or otherwise affected by the construction work should be removed and disposed of as directed.
6. Existing turf which is required to be removed from the construction area should be cut into convenient sizes and transported to an area as directed, stacked, and kept well watered until required for re-laying.
7. Turf over areas, which do not require regrading is to be preserved to the maximum extent and any damage is to be remedied immediately.

38.3.4 Transportation

(a) Planning Guidelines

1. It is important that thorough soil and geological surveys are undertaken prior to roads being designed.
2. It is recommended that the JKR's '*Standard Specification for Road Works Chapter 2'* be used as a planning guide, especially for the design and maintenance of cut and fill slopes and drainage works.
3. Drainage and slope stabilisation systems should be specifically designed to take into account the geology, soils, and terrain of the affected areas.
4. Required standards of compaction and vegetative protection must be adhered to.

(b) Land Clearing Measures

1. Drainage and maintenance of unsealed, laterite, and gravel roads during clearing must be given high priority as an erosion control measure
2. Clearing for highway and road construction should be done in manageable phases, clearing as little as practically possible at any one time
3. Tree planting should be undertaken as an important erosion control measure

38.3.5 Resort and Recreational Development

(a) Planning Guidelines

1. Development of resort and hotel facilities involves site clearing and earthworks, construction of buildings and facilities, utilities, roads, and drainage works which result in soil erosion and sedimentation. The planning guidelines are the same as given in Section 38.4.

(b) Land Clearing Measures

The construction stage of a resort development will have adverse impacts, particularly in terms of terrain and landform disturbance. Erosion, runoff, and sedimentation are the major problems during this stage. Appropriate drainage, erosion, and sedimentation control measures must be adopted to control sedimentation generation, ecological damage, and water pollution. Relevant measures include:

1. Careful planning of cut-and-fill slopes in hilly terrain to minimise erosion, including revegetation of exposed areas. Avoid site clearing during rainy monsoon periods.

2. Careful design and construction of drainage diversion channels and sediment traps or sedimentation basins to reduce sediments.
3. Buffer zones are recommended, especially if the site is located in sensitive environments such as along the coast or hilly areas.
4. Provision of adequate sediment traps to hold runoff as the resulting erosion can be very damaging to sensitive marine ecological habitats and beach and recreational areas.

38.3.6 Land Conversion for Golf Course

(a) Planning Guidelines

1. Golf course design should take advantage of the natural topography thus minimising the need for earthworks and cut and fill slopes (refer EIA Guidelines for Golf course Development (DOE, 1994)).

(b) Land Clearing Measures

1. Land should be cleared and developed in progressive stages.
2. Vegetation buffer strips should be retained along watercourses for erosion control, water quality improvement, wildlife corridors and sanctuaries, and for aesthetic reasons.
3. During the land clearance of vegetation and shaping of the golf course, silt and sediment are moved around causing very high sediment yields in the river system. It is recommended that a good system of temporary drainage be laid during these stages to channel runoff laden with sediments to sediment traps and basins.
4. Precautions should be taken to minimise the quantities of fertilisers entering drainage systems.

38.3.7 Hillslope Development

(a) Planning Guidelines

1. For extensive developments, soil and geological surveys should be undertaken.
2. The development of slopes with high potential for landslides should be avoided.
3. All cut and fill slopes should be stabilised immediately after construction by means of appropriate drainage and vegetative cover.
4. Road construction should be kept to a minimum.

(b) Land Clearing Measures

1. Logs should be removed in such a manner as to reduce erosion.
2. Only relatively small areas should be cleared at any one time.
3. Clearing should be scheduled to avoid likely periods of heavy rainfall.
4. Buffer strips should be left along all waterways.
5. All stream crossings should be protected.
6. Steep slopes should be monitored regularly for any sign of erosion or mass movement and remedial measures implemented immediately if required.

38.3.8 Development of Ecologically Sensitive Areas

(a) Planning Guidelines

1. It is essential that detailed flora, fauna, and habitat surveys be undertaken at the outset to identify ecologically sensitive areas and to identify any rare, vulnerable, endangered, and protected plant and animal species.
2. Development plans must be designed to protect significant sites and species.

(b) Land Clearing Measures

1. Vegetated buffer strips should be left along all watercourses and islands of vegetation should be left to provide wildlife sanctuaries (refer Section 43.2.4).
2. Care should be taken to protect significant trees and other vegetation during the construction phase.

38.4 GENERIC GUIDELINES

38.4.1 Minimising Soil Erosion

1. Before development begins, preventative measures shall be put in place to minimise erosion through the preparation of:
   (i) a preliminary Site Evaluation (PSE)
   (ii) an Erosion and Sediment Control Plan (ESCP)
   Erosion and Sediment Control Plans are discussed in detail in Chapter 41.
2. Reducing the working area:
   The working area for various facilities within a development site should be kept to less than twice the plan area of the building.
3. Regulate phases of development:
   The development schedule must be clearly defined. The completion date for each phase of development shall be indicated and all clearing, grading, and stabilisation operations shall be completed before moving onto the next phase.
4. Timing of the development activities shall, wherever possible, be spread evenly over the development time-

scale to ensure that the deleterious effects arising from development activities are minimised.

5. Development activities shall take into consideration the hydrological and climatic conditions experienced in the area, in particular, the rainfall and runoff patterns.

6. Existing vegetation shall be maintained as filters along contours to reduce velocity and improve water quality. When retained in development sites, they break up the length of long slopes and act as buffers to minimise erosion.

7. Stream buffers shall be retained. For rivers, the width of the buffers shall follow DID regulations. For small streams within a development site, the following could be used as a guide:

Watercourse Type	Average Grade	
	(<15^o)	(>15^o)
Intermittent	10 m	20 m
Permanent	20 m	30 m

Source: SCA of Victoria, 1979, Guidelines for Minimising Soil Erosion from Development Sites in Victoria.

38.4.2 Preserving Topsoil and Other Assets

1. Sensitive ecological areas within a development site such as salt licks, natural springs, unusual rock outcrops, etc. shall be demarcated and preserved.

2. All known archaeological sites within the development site shall be demarcated and preserved. Advice from the Curator of Museum should be sought.

3. All known rare and endemic flora and fauna areas or niches within the development site shall be demarcated and preserved.

4. All excavated topsoil shall be stockpiled and later used for revegetation. Topsoil should be stockpiled in areas where it will not contribute to erosion and sedimentation. Temporary stabilisation is necessary for exposed stockpiles.

5. All trees that are rare shall be fenced and preserved or carefully removed and transferred to a nursery or another site for replanting. Expert advice should be sought from the Department of Forestry or Forest Research Institute of Malaysia on the amount of soil that needs to be retained to protect roots during relocation of trees.

38.4.3 Access Routes

1. All right-of-ways or access routes shall be shown on the ESCP and it shall be the responsibility of the Project Proponent to ensure that all vehicular traffic stays within the designated right-of-ways.

2. Access roads should be kept to a minimum with other areas off-limits to traffic.

3. Roads and permanent stormwater drains should be installed as early as possible so that they can control runoff during development. However, they should be temporarily connected to sediment basins until stabilisation of graded areas is achieved.

4. Road shoulders should be protected mechanically or vegetatively against erosion.

5. All movement of development vehicles over unpaved roads and areas should be kept to a minimum. Haul roads should be sprayed with water to reduce dust pollution during dry periods.

6. All access roads to the site shall be paved for a distance of at least 10 m from where these access roads join the existing paved roads.

7. All vehicles should enter and leave the development site at a limited number of points. The exit points should provide for the washing of vehicles as they leave. The washing bay should be the full width of the exit.

38.4.4 Drainage Control at Development Sites

Rates of soil erosion are often greatest where runoff water becomes concentrated along drainage lines and stream. Erosion control measures in these locations can have a major effect in reducing the risk of downstream sedimentation. Commonly used measures for drainage control are presented in Chapter 39.

1. The principles to be followed in establishing a drainage system in development sites are to direct runoff water so that it does not run across disturbed and unstable areas.

2. Locate and study the hydraulic characteristics of the drainage system which include:

   - overall drainage pattern
   - dimensions and flow of any rivers and streams
   - springs and wells including flow and well logs
   - subsurface conditions including aquifer type and capacity, depth to water table, and location of perched water table
   - natural drainage depressions, basins, and sinks
   - floodplains, both on-site and downstream, that will undergo change due to grading and development

3. Construct drainage routes and channels in such a way that the beds do not degrade and contribute to the sedimentation problems.

4. Remove the sediment load accumulated in channels during the dry season to avoid downstream sedimentation.

5. For hillside areas, slope drains must be constructed or extended as work progresses. Such drains include berm drains, cascading drains, and sumps at the toes of the cascading drains to reduce the velocity. Diversion banks may be necessary to intercept runoff from higher areas and to divert it away from exposed areas. The longitudinal slope of the bank must not be excessive or the bank itself will erode.
6. In granular soil areas, a diversion drain may serve the same purpose as a diversion bank, but is more effective if it is lined with a geofabric material to resist erosion of the drain.
7. For unsealed roads, culverts and cross drains must be constructed where the road intercepts a stream depression or natural drainage channels. The practice has been to direct the runoff from the table drains into the upstream end of the culverts. To reduce erosion, it is better to locate table drain culverts 20 – 30 m from the watercourse so that it provides a natural filter for the runoff before it enters the stream.
8. Temporary interceptor ditches and berms with filters at inlets should be constructed to direct runoff from the development area into any sediment basin.
9. The drainage and deviation of natural watercourses, including provisions of bunds and culvert shall be carried out wherever appropriate.
10. No watercourse or the reserve along the watercourse shall be disturbed until full plan details of the proposed works have been submitted to and approved by the DID. A system shall be maintained such that existing downstream water quality with respect to total sediment load is maintained, or improved if so directed by the authorities concerned. The authorities concerned shall approve any sediment traps that are provided with the drainage works.
11. The authorities concerned may require permanent drains to have sediment traps of adequate capacity and other conservation measures. The sediment traps shall have the capacity to hold no less than 10 cm of silt and sediment at any time. Material removed from the traps shall not be placed in such a way that it becomes a source of sedimentation of stormwater drains downstream.
12. Drains that are not mechanically stabilised shall be grassed and maintained.
13. Ineffective drainage should be noted (especially during wet weather) and promptly corrected.

38.4.5 Earthworks and Erosion Control

In general, earthworks should be stabilised as early as possible to minimise the rates of soil erosion. Commonly used measures for earthworks and erosion control are presented in Chapter 39.

The following should be carried out where sediment traps and basins are not used and the soil is to remain exposed for more than a few months, or where vegetation is difficult to establish.

1. The development specifications shall clearly define the maximum length of time that a graded area will be left exposed and shall state what short-term stabilisation practices will be performed in the event of a lengthy delay.
2. Earthworks to be carried out shall be phased in the proposed order for such work as outlined in the development schedule approved by the authorities concerned. Earthworks shall not commence or continue to the next phase unless the engineer submitting the plans certifies in writing that the earthworks are not likely to cause nuisance or damage to surrounding properties.
3. Not withstanding the above, the authorities concerned may require the following conservation measure at any time before the earthworks continue to the next phase. The standards and specifications of such conservation measures shall be in accordance with the specifications of the DID.
4. Extraneous runoff shall be directed away from exposed soils by drains.
5. Contour plough or deep-rip so as to leave a rough surface to increase infiltration.
6. Provide protection covers such as vegetation and plastic sheets on exposed areas.
7. Earthworks should be confined to periods of low expected precipitation.
8. As small an areas as practical should be exposed and graded at a time. The size of the area will depend on the potential erodibility of the soil and the time required to stabilise the area after grading is completed.
9. All earthworks exceeding 1.5 m in height or depth shall not be cut or cleared until the site is ready to be worked.
10. Clearing and grading should be done with care to protect and maintain previously installed temporary control measures.
11. Fills should be placed in horizontal layers and the faces of the fill slopes should be maintained as filling progresses. The materials to be used and the degree of compaction shall be clearly specified.
12. Where it is intended that cleared ground is to be planted, the area should be landscaped and the planting carried out as soon as possible, even prior to the completion of the whole work.
13. Trees and other vegetation should not be cut or cleared until the earthwork site is ready to be worked.

The cleared ground shall be revegetated (turfed) within three months after commencement of earthworks during the dry season and within one month after commencement of earthworks during the wet season.

14. Maximum gradient of cuts shall vary with soil texture. However, measures taken should ensure that slumping will not occur.

15. Unsuitable materials and surplus earth shall be disposed off in designated spoil tips. If additional disposal areas (spoil tips) are required, the contractor shall be responsible for identifying these disposal areas to be approved by the Site Officer.

16. On no account should cleared vegetation and debris be deposited or pushed into watercourses, streams, or rivers.

17. Holes and cavities resulting from clearing, grubbing, destumping, and derooting shall be backfilled with acceptable materials and compacted to approximate densities of adjacent areas.

18 The surface of batters or terraces exposed after earthworks represent a special and severe case. While the surface may be protected by a number of measures, the resistance of the batter to erosion will be determined primarily by the engineering design. Batters must be designed to satisfy stability criteria. For stable soils, batter slopes should not be steeper than 2(H):1(V).

38.4.6 Sediment Prevention and Control

Check dams, sediment traps, and sediment basins are effective for trapping sediment and reduce flow velocities.

Commonly used measures to control sediment are presented in Chapter 39.

1. Wherever feasible, sediment taps and basins shall be installed. They should be adequately sized and constructed prior to the start of earthworks.

2. Small temporary sediment traps operate by slowing or stopping runoff at some point on its route, so causing it to deposit its sediment loads. Allowance must be made for sediment removal and the sediment must be deposited in a suitable area in such a manner that it will not slide back into any traps.

3. Permanent water quality control measures such as ponds and gross pollutant traps can be constructed and temporarily used as sediment basins, provided they are satisfactorily maintained and cleaned out after development to ensure efficient operation as designed.

4. Sediment traps and other temporary control measures should only be removed and dismantled when the permanent vegetative cover and control measures are satisfactorily established.

5. When necessary, erosion and sediment control measures shall be constructed on hauling roads in order to reduce siltation into natural waterways.

38.4.7 Slope Stabilisation

1. All critical areas along streams must be marked on the ESCP and the recommended methods of stabilisation indicated.

2. Stream stabilisation shall be scheduled during periods of dry weather flow whenever possible.

3. All temporary and permanent practices for stabilising waterways shall be defined, stating where and when sodding, temporary seeding, and permanent seeding are to be used. The specifications shall include ground preparation, sod quality, seed type and quality, and fertilisation and mulching.

4. In cases where permanent retaining structures or slope stabilisation are exempted by the authorities concerned, details must be provided on proposed temporary retaining structures or stabilisation of slopes during continuance of such earthwork.

5. All slopes shall be protected against erosion.

6. Cut and fill slopes should be fertilised (if appropriate) and regularly irrigated to encourage faster growth. Development should proceed with minimum disturbance of any planted areas and temporary control measures.

7. Walls of cuts shall be protected with vegetation and/or chemical stabilisers and/or approved retention structures. Non-permanent retention structures need to be maintained in order to ensure that they continue to be effective. Vegetation, if used, shall provide a complete cover.

8. There shall be no obstruction or interference with the natural waterways. Where a road is to be cut across a river or stream, bridges and culverts as prescribed by the enforcement authority shall be constructed and maintained according to specifications.

38.4.8 Maintenance

1. A maintenance programme for the control facilities shall be prepared that includes plans for the removal and disposal of materials from the control facilities in the project area.

2. All erosion and sediment control measures shall be constructed and maintained by the Contractor.

3. Any water discharged from sediment traps and/or sediment basins shall comply with ambient standards for TSS and turbidity for the designated beneficial use

of the receiving water into which water from traps or basins is discharged.

The receiving water could be a drain, stream, river, pond, lake, or estuary. The standard for five classes of beneficial water use identified in the Proposed Interim National Water Quality Standard (INWQS) for Malaysia (DOE, 1985) is as follows:

Class	TSS (mg/l)	Turbidity (NTU)
I	25	5
II A	50	50
II B	50	50
III	150	-
IV	300	-
V	300	-

Water quality monitoring must be carried out on a regular basis with all results submitted to the state offices of the DOE.

4. The Contractor shall provide all necessary temporary drainage for keeping the site and other areas free of standing water.
5. Mitigating measures must be put in place before site clearing and earthworks are carried out.
6. Cleared vegetation and debris should be disposed off in designated spoil tips, which must be approved by the Site Officer. The Contractor shall be responsible for identifying these disposal areas. The disposal areas are to be finalised before any earthworks are allowed to be carried out on site.

38.5 ENFORCEMENT

Erosion and sediment control guidance has been around a long time and still sediment loading from land development is one of the worst ecological impacts of development. It is not because these techniques do not work, it is because contractors do not use them. Therefore, one of the most effective control measures that Malaysia can bring to bear on this problem is to require contractors to submit an Erosion and Sediment Control Plan (ESCP) before construction begins. That plan should be posted at the construction site, and relevant Authority should periodically visit the site to inspect the control measures and enforce the plan if necessary.