Ministry of Natural Resources and Environment
Malaysia



GUIDELINE FOR EROSION AND SEDIMENT CONTROL IN MALAYSIA

Department of Irrigation and Drainage
Malaysia

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http://www.water.gov.my

ISBN 978-983-41867-4-6

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT
DEPARTMENT OF IRRIGATION AND DRAINAGE
MALAYSIA

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October 2010

Published by
Department of Irrigation and Drainage (DID)
Jalan Sultan Salahuddin
50626 Kuala Lumpur, MALAYSIA

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Perpustakaan Negara Malaysia Cataloguing-in-Publication Data
A catalogue record of this book is available from the Perpustakaan Negara Malaysia

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ISBN 978-983-41867-2-2

GUIDELINES FOR EROSION AND SEDIMENT CONTROL IN MALAYSIA

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FOREWORD

Rapid economic growth in Malaysia has prompted big scale physical development throughout the country to house new urban, industrial and agricultural developments. Land opening activities expose soil to erosive agents such as water and wind. Uncontrolled land opening activities caused excessive erosion and sedimentation due to extended exposure of bare soil surface in many construction and land clearing sites. The effect of this excessive erosion and sedimentation has caused mudflow in urban areas and watercourses i.e. severe siltation. The situation also worsens flash flood condition in many major cities due to decreased waterway capacity. Water quality in natural water bodies were also compromised by excessive suspended solids in water, causing ecological disturbance to wildlife.

The Urban Stormwater Management Manual for Malaysia (MSMA) published by the Department of Irrigation and Drainage Malaysia (DID), 2000 has provided detailed erosion and sediment control guideline to manage erosion and sedimentation on-site to prevent further damage to the nation's water bodies. The objective of this new guideline is to provide a minimize standard procedure as a platform for comprehensive Erosion and Sediment Control Plan (ESCP) to manage and control erosion and sediment processes in construction and development sites. This new guideline was built upon the ESCP chapters in MSMA, and enhanced it with more accurate soil loss estimation calculation ESC facilities designs as well as its operation and maintenance during construction period.

This guideline consists of five chapters that includes introduction, rules and regulations, erosion and sedimentation processes, ESCP and ESC facilities. The all new annual soil loss and sediment yield calculations using local data were emphasized in the third chapter of this guideline, providing practical estimations to assist planning and designing of ESCP. The ESCP and ESC facilities chapters were enhanced to include more specific and stringent requirements and design criteria. The current guideline also provides a linkage between theory and practice by providing calculation and design examples based on actual development.

I wish to record my appreciation to all parties who involved in preparing this guideline and I am confident that their contributions in producing scientific and systematic approaches to effectively manage and control erosion and sediment processes will be appreciated by the users for many years to come.

Dato' Ir. Hj. Ahmad Husaini bin Sulaiman,
Director General,
Department of Irrigation and Drainage Malaysia

ACKNOWLEDGEMENT

The Consultant would like to express the utmost gratitude and appreciation to the Technical Committee which includes,

Kementerian Sumber Asli dan Alam Sekitar Malaysia

Jabatan Pengairan dan Saliran Malaysia

Jabatan Alam Sekitar Malaysia

Jabatan Mineral dan Geosains Malaysia

Institut Penyelidikan Hidraulik Kebangsaan Malaysia (NAHRIM)

Jabatan Pertanian Malaysia

Jabatan Kerja Raya Malaysia

Jabatan Perancang Bandar dan Desa Semenanjung Malaysia

Lembaga Lebuhraya Malaysia

for their cooperation and contribution throughout the study.

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CHAPTER 1
INTRODUCTION

1.0 BACKGROUND

Erosion is the detachment of a portion of the soil profile or soil surface. This can occur by either the impact of raindrops, or by the shear forces of water flowing across the soil surface. Soil particles can be transported over a short distance (such as the splash from a raindrop impact), or a longer distance (to the bottom of the slope, or into a water conveyance) before being deposited. The transportation and deposition process is called sedimentation.

Erosion and sedimentation are natural processes. These processes occur daily, on all land, as the result of wind, and water. However, the effect of natural erosion is usually only noticeable on a geologic time scale. Disturbance of the soil surface, including activities like construction, farming, or logging, greatly increases the amount of sediment loss from the site due to erosion (Price and Karesh, 2000).

Sediments that escape the site may eventually enter a stream or wetland, and changes the characteristics of a water body. These changes may result in physical hindrances to navigation or increased flood risks. Sedimentation in wetlands can alter the hydrology or destroy hydric vegetation. Sedimentation that occurs in streams can cover up habitat that certain integral parts of the food web rely on. Sediment may also smother nesting sites for fish or amphibians, or cover mussel beds that filter significant quantities of pollutants from water that ultimately becomes our drinking water (Price and Karesh, 2000).

The average erosion from a designated area over a designated time may be computed by using the Revised Universal Soil Loss Equation (RUSLE). RUSLE is an erosion model developed by the U. S. Department of Agriculture to provide decision support in soil conservation planning. It is a set of mathematical equations used to determine what conservation practices might be applied to a landscape to reduce or limit the amount of erosion and sediment loss. The original application for RUSLE was agriculture, primarily cropland production. Subsequent revisions have widened the program’s applicability to be useful to other land-disturbing activities like mining, forest management, and construction sites.

The four major factors that RUSLE uses to compute the amount of soil loss from a site are: climate, soil erodibility, topography, and land use. The important climatic variables are the amount of rainfall and the intensity of the rainfall. Soils differ in their inherent erodibility, which is based on their properties such as texture, structure, porosity, and chemistry. Climatic and soil variables are independent of the activities we undertake at a worksite, however, the length of time that a bare area is exposed to precipitation is considered within the climate factor of RUSLE and may considerably affect the soil loss from the worksite. In this way, phasing and sequencing the surface disturbing activities at a worksite reduces the total erosion and reduces the amount of sediment that must be controlled by other means (Price and Karesh, 2000).

Site topography, ground cover, and best management practices (BMPs) implementation are the most variable factors in determining erosion. These three factors are also what we have control over. Slope length, slope steepness, and slope shape are the important components of topography. Much of the work done at construction sites is to change the slope length, steepness, or shape to make the property better suited for development. Obviously, the original vegetation must be disturbed to accomplish physical development works. However, ground cover is the single most influential variable in determining soil loss. The soil loss from a site that has been graded bare and has no BMPs in use may be 100 times the soil loss from the same site with an average stand of grass present. BMPs can reduce the amount of sediment leaving the site, but no single practice is 100% effective (Price and Karesh, 2000).

There are three types of BMPs in erosion and sediment control. The first control is the erosion prevention practices. This type of BMPs emphasize on ground covers that prevent any of the types of erosion from occurring. Ground covers include vegetation, riprap, mulch, and blankets that absorb the energy of a raindrop's impact and reduce the amount of sheet erosion. The second type is known as runoff management control, which the purpose is to prevent further erosion in flowing water. Diversions, check dams, slope drains, and storm drain protection, while they may also trap sediment, are primarily used to prevent rill and gully erosion from starting. Rill and gully erosion are more difficult and expensive to repair, and will result in greater volumes of sediment to be dealt with.

The final type of BMPs, i.e. sediment control practices attempt to prevent soil particles that are already being carried in storm waters from leaving the site and entering streams or rivers. Silt fence, sediment traps, sediment basins, check dams, and even vegetative cover are sediment control practices. Of course, all BMPs must be chosen carefully, located and installed correctly, and maintained well to be effective at keeping sediment on a site.

It is important to note that a particular BMP may be an erosion prevention practice, or a sediment control practice, or it may serve both purposes at the same time.

By using RUSLE, it can be seen that a combination of erosion prevention, consisting of leaving original vegetation whenever possible and reestablishing vegetative cover as quickly as conditions allow, as well as sediment controls, like clean water diversions, silt fences, and sediment basins can prevent sediment loss from a construction site (or any other site) during most storm events (Price and Karesh, 2000).

1.1 LOCAL EXPERIENCE WITH CONSTRUCTION SITES

Bare eroding slopes (Figure 1.1) and drains choked with sediment (Figure 1.2) 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 in Malaysia was particularly rapid in Kuala Lumpur and their neighbouring urban centres in the past few decades. 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 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). 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. Small bare areas/construction sites such as on deeply weathered rock, particularly granites, can yield huge quantities of sediment in short periods of time.

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 (DOE, 1996).

Figure 1.1: Large-scale earth works without erosion control BMPs

Figure 1.2: Consequent severe sedimentation of drains and culverts downstream

1.2 NECESSITY OF THE GUIDELINE

Construction activities near streams, rivers and lakes have the potential to cause water pollution and stream degradation if erosion and sediment controls are not properly installed and maintained. In order to effectively reduce erosion and sedimentation impacts, Best Management Practices (BMPs) must be designed, installed, and maintained on construction sites, as have been described in the Urban Stormwater Management Manual for Malaysia (MSMA) (DID, 2000). The information in this guideline further enhances those found in the said manual.

As construction and development activities continue throughout Malaysia, large quantities of sediment will continue to be transferred to water bodies during precipitation events (Figure 1.3), if BMPs are not used. Pollution due to sedimentation can have physical, chemical, biological, and economic impacts to waters. Siltation causes changes in flow patterns, increased water treatment costs, hindrances to navigation, and the increased possibility of flooding. Sediment can also restrict light penetration, transport other pollutants into the water body, smother eggs and nests of fish, and cover stream substrates that provide habitat for fish and aquatic life.

The proper implementation of BMPs can be effective in preventing erosion and controlling sediment on construction sites. This Erosion and Sediment Control Guideline is designed to provide information to planners, developers, engineers, and contractors on the proper selection, installation, and maintenance of BMPs. It is intended for use during the design and construction of projects that require erosion and sediment controls to protect waters of the country. It also aids in the preparation of Erosion and Sediment Control Plans (ESCP) and other related reports, plans, or specifications required for any new development/construction sites in the country.

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

Figure 1.3: Sedimentation of waterways and coastal areas

1.3 OBJECTIVES OF THE GUIDELINE

The main purpose of this Guideline is to provide data to enable acceptable calculations for erosion and sedimentation in any new area of Peninsular Malaysia. To this end, erosivity values (R) and erodibility values (K) (as in the USLE equation) will have to be systematically derived and mapped out for the whole Peninsular. Without these 2 critical data, BMPs cannot be scientifically designed for, as required in an engineering project. At the same time, this Guideline will complement the existing DOE Guidelines (1996) 'Guidelines for Prevention and Control of Erosion and Siltation in Malaysia' in listing out BMPs and showing the appropriate use of them in controlling erosion and sedimentation in construction sites.

1.4 USAGE OF THE GUIDELINE

This guideline, in whole or in part, is generic and can be applied to most types of development activities. This guideline is to be used in conjunction with the latest edition of MSMA (DID, 2010).

- It has been prepared for a wide audience. They are intended for Federal and State Government Departmental and Agency staffs, who are engaged in land development planning, implementation and assessment; for private sector planners; for developers and for contractors and sub-contractors.
- By using the guideline, it is hoped that planners and project proponents will be able to identify potential erosion risk areas in their project sites, based on an understanding of the processes which underline the causes and effects of erosion and will then be able to plan and develop the site by avoiding such critical areas.
- The Chapters are arranged in a logical sequence to explain the successive steps necessary to manage erosion and sedimentation problems. Chapter 2 provides information on existing rules and regulations pertaining to erosion and sediment control, while Chapter 3 provides information on Erosion and sedimentation processes, relevant information required for the estimation of soil loss and sediment yield are provided and arranged in the forms of tables, charts, etc. Chapter 4 provides information on the preparation of an ESCP and the procedural stages involve in implementing an ESCP. Chapter 5 provides information and standard design for common BMPs in construction site for erosion and sediment control.
- Supplementary information is presented in the Appendices, which include the standard drawing of various Erosion and Sediment Control BMPs, a Checklist for ESCP Submission, and an example of an ESCP.
- It is stressed that the guidelines are not meant to replace the existing departmental and agency guidelines, but to complement them. Where such guidelines are still relevant, they should be consulted.

CHAPTER 2
RULES AND REGULATIONS

2.1 INTRODUCTION

At present government agencies in Malaysia such as Department of Irrigation and Drainage (DID), Department of Environment (DOE), Public Works Departments (JKR), Minerals and Geo-science Department (JMG), Department of Town and Country Planning (JPBD), Department of Agriculture (DOA) and Public Works Institute of Malaysia (IKRAM) have published numerous manuals and guidelines pertaining to erosion and sediment control (DID, 2000; Md. Noh, 2006). All these publications are meant to suit and serve clients comprising of land developers and farmers as well as for the references of government agencies. Nevertheless sediment loading from land development remains one of the worst ecological impacts of development, not because these techniques do not work, but more due to the lack of application on the ground. Therefore, the most effective control measure that Malaysia can bring to bear on this problem is to strictly enforce the requirement of an ESCP for any development/construction project in Malaysia. The ESCP must comply, wherever possible with all requirements in the submission checklists (Appendix A), and existing rules/regulations (Appendix B). Developers/ contractors should be required to obtain approval for the ESCP from the relevant authority before construction begins.

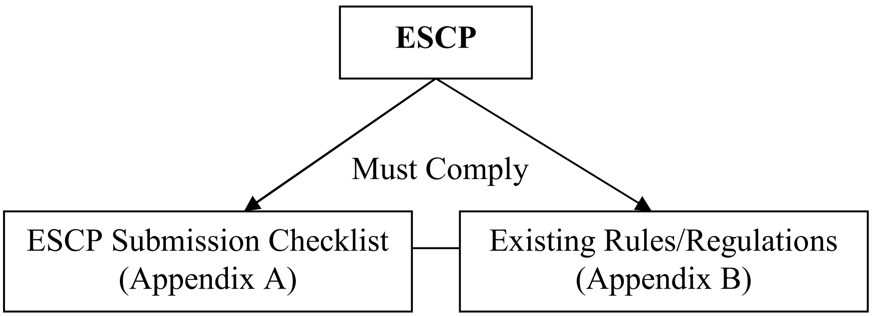

Figure 2.1: Compliance requirement for ESCP in Malaysia

2.2 FEDERAL AND STATE REGULATIONS

Current control measures fall into three categories: (1) statutory control and requirements contained in various acts, regulations and by-laws; (2) agency and other guidelines; and (3) operating practices. This section provides a brief description on statutory controls that relate both directly and indirectly to soil erosion and sedimentation control (DOE, 1996), which covers the following aspect:

(a) The Federal Constitution of Malaysian
(b) Government Policies
(c) Environment Quality and Control
(d) Land
(e) Forestry
(f) Mining
(g Quarries
(h) Rivers and Streams
(i) Town Planning
(j) Fisheries

For further information, please refer to the respective agencies or relevant publication with full documentation of the rules and regulations.

(a) The Federal Constitution of Malaysian

The distribution of legislative powers between the Federation and the States is for the most part contained in Articles 73-79, 95B-95E and the Ninth Schedule of the Malaysian Constitution (Government of Malaysia, 2006a).

The Ninth Schedule contains three 'Lists': a Federal List, a State List, and a Concurrent List. The Federal Government may make laws with respect to matters enumerated on the State and Concurrent lists.

The Federal Parliament may, in addition, make laws for specific purposes as detailed in Article 76 of the Constitution with respect to matters on the State List. It may make laws 'for the purpose of promoting uniformity of the laws of two or more States'. Such legislation does not, however, become effective in the States until it is adopted by the State Legislatures and gazetted.

Article 95D stipulates that the above provision does not extend to Sabah and Sarawak.

Matters on the lists relating directly or indirectly to soil erosion, sedimentation and water quality are shown in Table 2.1.

Table 2.1 Legislative powers related to soil erosion, sedimentation and water quality for federal and state governments in Malaysia (Adapted from Government of Malaysia, 2006a)

Federal List	• Ports and harbours; foreshores • Federal works and power, including:- - public works for federal purposes - water supplies, rivers and canals, except those wholly within one State or regulated by an agreement between the State concerned.
State List	• Except with respect to the Federal Territories of Kuala Lumpur and Labuan; land including land tenure; colonization, land improvement and soil conservation and mining leases; • Except with respect to the Federal Territories of Kuala Lumpur and Labuan, agriculture and forestry; • Local government outside the Federal Territories of Kuala Lumpur and Labuan; • State works and water: - Public works for State purposes; - Roads, bridges and ferries other than those in the Federal List, - Subject to the Federal List, water (including rivers and canals but excluding water supplies and services); control of silt; riparian rights.
Concurrent List	• Town and country planning, except in the Federal Capital; • Drainage and irrigation; • Rehabilitation of mining land and land which has suffered soil erosion

(b) Government Policies

Two key Federal Government policy documents, which are supported by all of the States, are the 'Second Outline Perspective Plan 1991-2000', and the 'Seventh Malaysia Plan 1996-2000'. These documents confirm the Federal Government's commitment to sound environmental management.

The 'Second Outline Perspective' (Government of Malaysia, 1991b) presents a 'New Development Policy' for the 1990s. One of the key components of the policy is:

- *'ensuring that in the pursuit of economic development, adequate attention will be given to the protection of the environment and ecology so as to maintain the long-term sustainability of the country's development.'*

In order to achieve this goal, it is stated that:

- *'Strategies for environmental protection will be incorporated into all development plans and programmes.*

- *The implementation of such strategies will give priority to adopting environmentally sound practices.*
- *Efforts will be taken to ensure effective and well-coordinated enforcement of such strategies and programmes by further upgrading the regulatory machinery at the State and Local Government levels.*
- *The promotion of greater awareness, responsibility and participation of the public and private sectors as well as society in general in achieving a clean and healthy environment will be further intensified through mass media, education and training,'*

In the 'Seventh Malaysia Plan' (Government of Malaysia, 1996), a whole chapter (Chapter 19) is devoted to environmental protection and management. It is stated in the Plan that '*Malaysia will continue to take appropriate action to ensure that development is sustainable and balanced.*' and to achieve this '*environmental and conservation considerations*' will increasingly be integrated with development planning.

It is acknowledged in the Plan that indiscriminate clearing for development projects, unsound practices in a range of activities, inadequate legislation and lack of enforcement of legislation has resulted in soil erosion and water quality problems. During the Plan period the Government will:

- integrate soil conversion planning with physical development
- review current legislation and guidelines, and
- consider the need for a Soil Conversion and Sediment Control Act

(c) Environmental Quality and Control

The most significant piece of legislation in Malaysia relating to environmental quality and control is the Federal Environmental Quality Act 1974 (Government of Malaysia, 2001). The Act applies to the Federal Territory and to all States except Sarawak.

The Environmental Quality Act 1974, which is described as '*An Act relating to the prevention, abatement, control of pollution and enhancement of the environment, and for purposes connected therewith*' provides for:

- The appointment of a Director-General of Environment and the establishment of Department of the Environment (Section 3);
- The establishment of an Environmental Quality Council (Section 4);
- The issuing of licenses for the emission or discharge of wastes (Part III);
- The licensing of prescribed premises (Part IV, Sections 18-20);
- The gazettement of '*any activity which may have significant environmental impact as a prescribed activity*' (Section 34A); and,
- The preparation of a report prior to the carrying out of any prescribed activity which contains '*an assessment of the impact such activity will have or is likely to have on the environment and the proposed measures that shall be undertaken to prevent, reduce or control the adverse impact on the environment*'. Such reports are known as 'Environmental Impact Assessments' (EIA's) (Section 34A).

The most significant provisions of the Act with respect to erosion and sediment control are those relating to prescribed activities and the preparation of Environmental Impact Assessments. The prescribed activities are specified in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987. In total some 19 activities are prescribed. For most of the prescribed activities, the Department of Environment has prepared 'Environmental Impact Assessment Guidelines', which contain some general recommendations relating to soil erosion and sediment control (Government of Malaysia, 2000).

The list of prescribed activities is comprehensive and can be added as and when circumstances warrant. One criticism could be that for some activities, the minimum areas specified are too large. For example, land conversion from forest to agricultural production involving 500 ha or less and development of housing estates involving less than 50 ha do not require an EIA. In many instances, relatively small areas could be environmentally sensitive and can contribute large amounts of sediment to the river systems.

It is mentioned in the *Environmental Quality Act* 1974 (Part IV) that:

- Section 25
  no person shall, unless licensed, emit, discharge or deposit any environmentally hazardous substances, pollutants or wastes into any inland waters in contravention of the acceptable conditions. Any person who contravenes the rule shall be guilty of an offence and shall be liable to a fine not exceeding one hundred thousand ringgit or to imprisonment for a period not exceeding five years or to both and to a further fine not exceeding one thousand ringgit a day for every day that the offence is continued after a notice by the Director General requiring him to cease the act specified therein has been served upon him.
- Section 29
  no person shall, unless licensed, discharge environmentally hazardous substances, pollutants or wastes into the Malaysian waters in contravention of the acceptable conditions. Any person who contravenes the rule shall be guilty of an offence and shall be liable to a fine not exceeding five hundred thousand ringgit or to imprisonment for not exceeding five years or to both.
- Section 46
  Notwithstanding any written law to the contrary, a Sessions Court in West Malaysia or a Court of a Magistrate of the First Class in East Malaysia shall have jurisdiction to try any offence under this Act and to award the full punishment for any such offence.

In addition to the Environmental Quality Act 1974, various policies and enactments in state level are also available for Environmental Quality and Control:

a) Sarawak Natural Resources and Environment (Amendment) Ordinance, 1993
b) Sarawak Natural Resources and Environment (Prescribed Activities) Order, 1994.
c) Sabah Conservation of the Environment Enactment
d) Sabah Water resources Enactment, 1998
e) Selangor Waters Management Authority Enactment (1999)
f) Kedah Water Resources Enactment (2007)

(d) Control of Erosion on Hill Land

Legislation to control soil erosion, particularly from hill lands, has a long history in Malaysia dating back to the Silt Control Enactment of the Federated Malay States, the Hill Lands Ordinance, 1937 of the Straits Settlements, and similar enactments introduced in Kedah in 1940, and Kelantan and Pahang in 1951. The various pieces of legislation were amalgamated to form the Federal Land Conservation Act 1960 (Forestry Department Malaysia, 1988; Government of Malaysia, 2006b), which is described as '*An Act relating to the conservation of hill land and the protection of soil from erosion and the inroad of silt*'.

This Act is only applicable in the States of Malaya and the Federal Territory of Kuala Lumpur. By virtue of Article 95a of the Federal Constitution, the Act is not applicable in the states of Sabah and Sarawak.

Since the Act deals with the matter falling within the sphere of State Legislatures, in accordance with Article 76(3) of the Federal Constitution, It can only become effective in any State if adopted by a State Law.

Therefore the Act was adopted by the following States:-

- a) Johore Vide Enactment No. 15 of 1960;
- b) Kedah Vide Enactment No. 13 of 1960;
- c) Kelantan Vide Enactment No. 6 of 1960;
- d) Malacca Vide Enacatment No. 7 of 1960;
- e) Enakmen Penempatan Terengganu, 1356;
- f) Negeri Sembilan Vide Enactment No. 21 of 1960;
- g) Pahang Vide Enactment No. 13 of 1960;
- h) Penang Vide Enactment No. 4 of 1960;
- i) Perak Vide Enactment No. 6 of 1960;
- j) Perlis Vide Enactment No. 12 of 1960;
- k) Selangor Vide Enactment No. 7 of 1960; and
- l) Terengganu Vide Enactment No. 9 of 1960.

The Main Provisions are contained in Part II and Part III of the Act which include the following:

- The provision relating to the declaration of areas as hill land by the state authority and the provision prohibiting the use of hill land for any purpose other than for limited agricultural purpose and for mining;
- No person is permitted to cultivate gazetted hill land or to clear or weed such land without a permit.
- The provision enabling the land administrator to take action against any landowner whose land has caused or is likely to cause damage to other land, water course or has interfered or is likely to interfere with the due cultivation of other land by earth, mud, silt, gravel or stone from his land;
- The provisions enabling the land administrator to take action against any landowner whose land has been damaged or is likely to be damaged as a result of erosion or displacement of earth, mud, silt, gravel or stone upon or from such land.

Any person who without reasonable excuse fails to comply with any order made under, or any provision of this Act, requiring him to do or prohibiting him from doing any act or thing shall be liable to a fine of not exceeding five thousand ringgit and in default of payment thereof to imprisonment for a term which may, subject to Section 283 of the Criminal Procedure Code, as the circumstances may require, extend to six months.

This Act however, cannot be enforced without the gazettement of ‘hill land’. At present only Penang and Pahang has done so.

(e) Forestry

Forests are a State matter but as noted, the Federal Government may introduce legislation for the purpose of achieving uniformity. Such legislation, however, has no legal standing in the States unless adopted by the State Legislatures and gazetted.

A National Forest Policy for Peninsular Malaysia was introduced in 1978 and was embodied in the National Forestry Act 1984 (Government of Malaysia, 1984). Some provisions in the Act were amended under the National Forestry (Amendment) Act 1993 (Act A864).

The Act provides for classification of permanently reserved forests into 11 categories of which only one category is intended for production forest where logging for timber under sustained yield will be allowed. The other 10 categories are essentially for protection forests, which means that there should be no logging and soil disturbance will be minimal. These 10 categories include, ‘soil protection forest’, ‘soil reclamation forest’ and ‘water catchment forest’.

There is no specific reference in the Act for the prevention of soil erosion but specific guidelines can be incorporated into the license requirements, Section 20(b) of the Act requires license applicants to prepare a forest management or harvesting plan and a reforestation plan in the manner specified by the Director. Requirements for the soil prevention and control measures would normally be included.

In addition to the above, the Forestry Rules 1986, if followed, should ensure that provisions relating to soil protection will be carried out. The Rules require all logging plans, management plans and rehabilitation plans to be certified prior to the start of logging which should ensure that erosion and sedimentation issues are addressed.

In 1993, the National Forestry Act (Government of Malaysia, 2006c) was amended to provide for stiffer penalties for illegal logging and enlisting the Police and Armed Forces to assist the Forestry Departments in carrying out enforcement to curb illegal logging, timber theft and encroachments.

The amendments introduced a mandatory one-year jail term, with a maximum of 20 years upon conviction (from a previous maximum of 3 years). The quantum of fines was also increased 50-fold, from a ceiling of RM10,000 to RM500,000. The amended Act also allowed the offer of rewards to informers, if the information led to seizures of stolen logs. These amendments enable the people to participate in being the "ears and eyes" of the government to help check illegal logging.

(f) Mining

In Malaysia, Mining is a matter on the State List. Activities relating to "mineral" and "rock material" are governed by separate laws. The two main legal instruments that govern activities relating to "mineral" are the Mineral Development Act, 1994 and the State Mineral Enactment. The Mineral Development Act came into force in August 1998, while the State Mineral Enactment (Cap 147) is currently at various stages of being adopted by the respective State Governments.

The Mineral Development Act 525 of 1994 defines the powers of the Federal Government for inspection and regulation of mineral exploration and mining and other related issues. The State Mineral Enactment provides the States with the powers and rights to issue mineral prospecting and exploration licenses and mining leases and other related matters. As at end of 2008, ten states have adopted the State Mineral Enactment (Adapted from Department of Minerals and Geoscience Malaysia):-

a) Kelantan, Mineral Enacment 2001;
b) Terengganu, Mineral Enacment (Terengganu) 2002;
c) Pahang, Mineral Enacment 2001;
d) Selangor, Mineral Enacment (Selangor) 2000;
e) N. Sembilan Mineral Enacment Negeri 2002;
f) Melaka, Mineral Enacment (Melaka) 2002;
g) Perak, Mineral Enacment (Perak) 2003;
h) Johor, Mineral Enacment (Negeri Johor) 2003;
i) Pulau Pinang, Mineral Enacment (Pulau Pinang) 2001;
j) Kedah, Mineral Enacment (Kedah) 2004;
k) Perlis, Mineral Enacment 2002;
l) Sarawak, Mineral Ordinance, 2004, Chapter 56.

The following section provides a description on the Mineral Development Act 1994 (Government of Malaysia, 2006d). Further information on the State Mineral Enactments can be referred to related agency in state government.

In Part Part III (Regulation of Exploration and Mining) of the Mineral Development Act, it is mentioned that:

- Good and safe practices and environmental standards
  Fossicking, panning, exploration, mining and mineral processing shall be carried out in accordance with good and safe practices and such environmental standards as may be prescribed under this Act and any written law relating to environment.

- Effluent Water
  - *Any holder of a proprietary mining license or mining lease or manager who uses water in connection with mining shall take such measures as to ensure that the water so used shall, before it leaves the mine or waste retention area in which it has been used, comply with such water quality standards as may be prescribed and where such standards have not been prescribed such water shall be reasonably free of solid matter and from chemicals and other substances deleterious to human, animal or vegetable life.*

- *The Assistant Director shall, on receipt of a complaint made in writing describing the failure on the part of any person to comply with the provisions of subsection (1), inquire into the matter of such complaint, and may at any time order such person complained of to:*
    - *undertake the necessary measures to ensure that water quality standards are complied with; or*
    - *suspend mining until such measures are taken to comply with water quality standards.*
- *Any measures taken to comply with an order issued under subsection (2) shall not operate to relieve any person from any liability arising under subsection (1).*

- Erosion.
    - *Every person who undertakes fossicking, panning, exploration or mining shall take such measures as are reasonable to prevent or minimise the erosion of the land which is the subject of the mineral tenement and the effects thereof.*
    - *Whenever directed by the Assistant Director, every holder of a mineral tenement and his manager shall provide and maintain such retention works or other place as are necessary and adequate to prevent the products of erosion from being discharged into any river or drainage system.*

In Parts V and VII of the Mineral Development Act, it is mentioned that:

- *A mines officer may for the purpose of enforcing this Act-*
    - *investigate in respect of any fossicking, panning, exploration or storage facility area or mine or mineral processing plant concerning the effect of any operation or practice upon the amenity of any area or place; or*
- *A mines officer may without warrant-*
    - *arrest any person found committing or attempting to commit or abetting the commission of an offence under this Act; and*
    - *the person arrested as aforesaid shall be dealt with as provided by the law relating to criminal procedure for the time being in force as if he had been arrested by a police officer.*
- *Any person who fails to comply with any written order issued by a mines officer shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding forty thousand ringgit or to imprisonment for a term not exceeding two years or to both.*
- *Any person who commits an offence under this Act shall, in the case of a continuing offence, be liable, in addition to any fine provided under this Act, to a further fine of two hundred ringgit for every day or part of a day during which the offence continues after conviction.*
- *The Minister may make regulations in respect of any matter which may be prescribed under this Act to prescribe environmental protection measures, effluent standards, noise standards, vibration standards and other standards and means to protect the environment. Provided that such prescribed measures, standards or means shall not conflict with any provision of the Environmental Quality Act 1974;*

(g) Quarries

In Peninsular Malaysia, activities relating to "rock material" are governed under the National Land Code 1965 (Government of Malaysia, 1991a). Of relevance are the Quarry Rules which have been made under Section 14 of the National Land Code. As at end of 2008 the states of Perak, Kelantan, Sabah, Selangor, Pahang and Terengganu have adopted and implemented the Quarry Rules to regulate quarrying activities (source: Ministry of Natural Resources and Environment). Further information on the State Quarry Rules such Perak Quarry Rules 1992, Selangor Quarry Rules 2003, etc. can be referred to related agency in state government.

(h) Rivers and Streams

Rivers and streams if located within a single state are State matters, but as noted in Section C (Environment Quality Control) above, a number of Federal Environmental Quality Regulations relate to water pollution.

Waters Act 1920 (Revised 1989), Act 418 stated that (Government of Malaysia, 1989):

- *Any person who shall in any State interfere with the bank of any river may by order of the State Authority be required to restore the same to the condition in which it was immediately prior to such interference or to remake the same in such manner as may be specified in such order.*
- *No person shall, except under and in all accordance with the terms of a licence under this Act, in any manner obstruct or interfere with any river.*
- *No person shall in any State after the commencement of this Act erect or build any wall or construct any revetment along the bank or any river or erect any building or structure within fifty feet of any such bank, or within any flood channel declared under this section, except under and in accordance with the terms of a written permission in that behalf from the State Authority.*
    - *Any person who contravenes this section shall be liable to a fine of two thousand ringgit; and any building or construction built or erected in contravention of this section may be removed by order of the State Authority and the cost of such removal shall be recoverable from such person by the State Authority,*

At State level, the various State Water Enactments were primarily introduced to control waters for irrigation and for floodplain management purposes. The enactments make no reference to soil erosion or sedimentation but do contain a provision enabling the control of discharges to waterways that might be deleterious to public health and safety or to any beneficial uses (DOE, 1996). Among the State Water Enactments are:

a) River Rights Enactment of Perak;
b) Kelantan River Traffic Enactment, 1955;
c) Pahang River Launches Enactment 6/49;
d) Sarawak Water Ordinance;
e) Sarawak Riverine Transport Bill (1993).

(i) Town Planning

In 1974 and 1976, the Federal Government consolidated legislation relating to local government and town and country planning into three Acts:

- The Local Government Act 1976 (Laws of Malaysia Act 171)
- The Town and Country Planning Act 1976 (Laws of Malaysia Act 172)
- The Street, Drainage and Building Act 1974 (Laws of Malaysia Act 133)

In 1984, Uniform Building By-Laws were introduced as provided for in the Street, Drainage and Building Act 1974.

These pieces of legislation, which were widely adopted by the States and local authorities, contain provisions relating to water quality and provisions enabling environmental matters, such as soil erosion and sedimentation, to be taken into account.

Local Government Act

Sections 69-71 of the Local Government Act 1976 (Government of Malaysia, 2006e) prohibit the deposition of trade wastes and refuse, solid or liquid sewage in or on the banks of any streams, drains or watercourses within a local authority area and empower local authorities to recover costs of any works that they undertake to rehabilitate watercourses.

Town and Country Planning Act

Part II of the Town and Country Act 1976 (Government of Malaysia, 2006f) requires the setting up of a State Planning Committee to oversee the general policy with respect to planning of all lands within every local authority in the State. Section 4 states the functions of the Committee as follows:

- to promote in the State, within the framework of the national policy, the conservation, use and development of all lands in the State;
- to advise the State Government, either on its own initiative or in response to a request by the State Government, on matters relating to the conservation, use and development of land in the State;
- to undertake, assist in, and encourage the collection, maintenance, and publication of statistics, bulletins, and monographs, and other publications relating to town and country planning and its methodology.

According, Section 5(1) states that every local authority shall be the local planning authority for the area. Two very important functions of the local authority are found in Section 6(1) as follows:

- to regulate, control, and plan the development and use of all lands and buildings within its area;
- to undertake, assist in, and encourage the collection, maintenance, and publication of statistics, bulletins and monographs and other publications relating to town and country planning and its methodology;

Part III of the Act requires the local authorities to prepare 'development' and 'structure' plans for their areas and 'local' plans for specified areas. Environmental consideration can be addressed in the plans. Environment matters must be examined during the preparation of development plans and structure plans and local plans must contain a statement relating to 'measures for the physical improvement of the environmental'.

Part IV of the Act stipulates that no development can commence or be carried out without planning permission. In 1995, the Act was amended to include provisions relating to environmental protection (*Town and Country Planning (Amendment)* Act 1995 – Act A933).

The new section 21A91) requires a proponent seeking planning approval to submit a development proposal containing:

- the development concept and justification;
- a location map and a site plan;
- particulars of land ownership and restriction, if any;
  - a description of the land including its physical environment, topography, landscape, geology, contours, drainage, water bodies and catchments and natural features thereon;
  - a survey of the trees and all forms of vegetation; and
  - particulars of a building, which may be affected by a development;
- a land use analysis and its effect on the adjoining land;
- layout plans, the details of which are specified in section 21B; and
- such other matters as may be prescribed by the local planning authority.

The amendment requires layout plans to provided showing the proposed development and in particular:

- measures for the protection and improvement of its physical environment;
- measures for the preservation of its natural topography;
- measures for the improvement of its landscape;
- measures for the preservation and planting of trees thereon;
- the location and species of trees with a girth exceeding 0.8 metre and other vegetation thereon;
- the making up of open spaces;
- the proposed earthworks, if any;
- a description of the works to be carried out

The local authority may impose conditions on the applicant with respect to any of the above, thus potentially giving local authorities a vital role in preventing and controlling erosion on development sites throughout the country. In addition, section 35A of the Act enables a local authority to issue tree preservation orders for amenity protection. In certain locations the preservation of trees could help control erosion.

Street, Drainage and Building Act

Section 70A of the Act (Government of Malaysia, 1988) stipulates that earthworks cannot be implemented without a permit from the local authority and allows a local authority to 'impose such conditions as it deems fit'. The term 'Earthworks' is defined as '*any act of excavation, levelling, filling with any material, piling, the construction of foundations, or felling of trees, on any land, or any other act of dealing with or disturbing any land*'. In addition, a local authority is empowered to make by-laws relating to earthworks. These provisions give local authority the ability:

- to require developers to undertake measures, and the ability to issue tree preservation orders for amenity protection.

- to require developers to have control measures to prevent and control soil erosion from development sites. The provisions do not apply to the Federal Governments, which would seem to be a weakness.

Section 70B empowers local authorities to carry out inspection and upon suspicion of defect in works, could request for a safety & stability review on the building, foundation or surroundings to be carried out by a qualified independent checker. If the construction activity is found unfit, the local authority could issue cessation of work order upon the construction activity, if no objection from related party is received within 14 days. The local authority can then required the developer to submit a fresh or amended plan to rectify the situation, which may include but not limited to slope stability, drainage facilities, retaining structures, or any supportive features or matter deemed necessary by the local authority.

Those defying or trying to obstruct the local authorities in execution of its power under this section is liable, upon conviction, a fine not exceeding one hundred thousand ringgit (RM100,000.00) or a term not exceeding five (5) years, or both. The local authority under section 70C, is enabled to revoke all approved construction plans and the convicted parties shall cease all work at site with immediate effect.

Section 71 clearly states the penalty for building, part of buildings, earthwork or part of earthwork failures, during or after a construction due to misconstruction/ lack of site supervision, misdesign or miscalculation, or misuse. Upon conviction, the person/party shall be subjected to a fine not exceeding five hundred thousand ringgit (RM 500,000.00) or a term not exceeding 10 years or both.

Uniform Building By-Laws
As the name implies, these by-laws relate mainly to building standards and specifications. The only Section directly relating to soil erosion is Section 83 which stipulates that *'All air-wells and open spaces in and around buildings shall be suitably protected against soil erosion'* (Government of Malaysia, 2006g).

(j) Fisheries

Section 38 of the *Fisheries Act* 1985 (Laws of Malaysia Act 317) provides for State authorities and the Federal Minister to make rules on specified matters for the 'proper conservation, development, management and regulation of turtles and inland fisheries'. Rules can be made (Section 38 (1)(k)) *'for the purpose of the conservation of fish in riverine water, to regulate and control the construction of any slides, dams or other obstruction, or the removal of sand or gravel or other alteration to the natural environment or habitat of fish'* (Government of Malaysia, 1985; Government of Malaysia, 1993)

This provision could conceivably be used to control development activities that directly or indirectly adversely impact on watercourses.

(k) Geological Hazards

The Geological Survey Department of Malaysia operates under the *Geological Survey Act* 1974 (*Laws of Malaysia Act 129*). The Act mainly relates to the structure of the organization, power and duties of officers, authority of Geological Survey and general obligations relating to Geological Survey. There are no clauses relating to geological hazards. Currently, the Department has only an advisory role in this area, and then only if requested. The Department's role is to identify the geological hazards and carry out hazard assessment which include among other location, area, intensity and magnitude of the hazards (Government of Malaysia, 2006h).

2.3 ENFORCEMENT AND PENALTIES

There is a considerable body of legislation in Malaysia that can be used to help minimize and control soil erosion and sedimentation. Clauses relating directly or indirectly to soil erosion, sedimentation and river water quality appear in a number of acts, by-laws and regulations.

The requirement to have the ESCP for all earthworks of developments has recently been amended into the Streets Drainage and Building Act (SDBA). Under this Act, local authorities have Bylaws (the Uniform Building Bylaws) which has a section on 'Earthworks'.

CHAPTER 3
SOIL EROSION AND SEDIMENTATION

3.1 SOIL EROSION AND SEDIMENTATION PROCESSES

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 is a result from human activities that expose 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 (aggradations) 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; DID, 2000), five of which are shown in Figure 3.1.

(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.

(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.

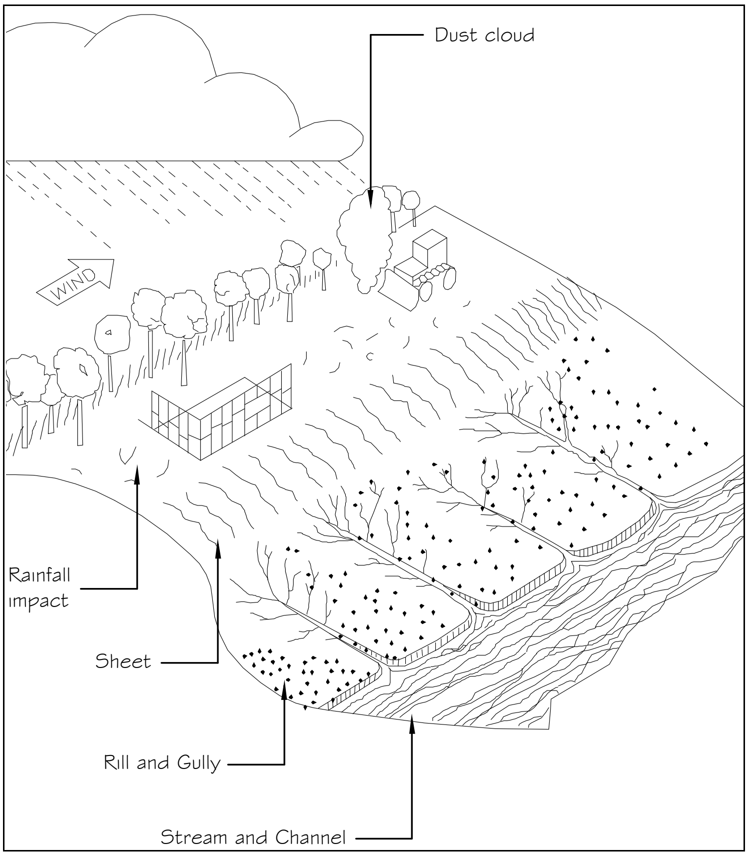

Figure 3.1: Types of Erosion Occurring at a Construction Site (DID, 2000)

(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 (DID, 2000).

3.2 SOIL LOSS AND SEDIMENT YIELD ESTIMATION

The development of erosion-prediction technology began in the USA with analyses such as those by Cook (1936) to identify the major variables that affect soil erosion by water such as susceptibility of soil to erosion, potential erosivity of rainfall and runoff, and soil protection afforded by plant cover. Zingg (1940) published the first equation for calculating field soil loss which described the effects of slope steepness and slope length on erosion. Smith (1941) added factors for a cropping system and support practices to the equation.

The effort was continued by Browning at al. (1947) that added soil erodibility and management factors to the Smith (1941) equation and prepared more extensive tables of relative factor values for different soils, crop rotations, and slope lengths. This approach emphasized the evaluation of slope-length limits for different cropping systems on specific soils and slope steepness with and without contouring terracing, or strip cropping. Smith and Whitt (1947) presented a method for estimating soil losses from fields of claypan soils. Soil-loss ratios at different slopes were given for contour farming, strip cropping, and terracing. Recommended limits for slope length were presented for contour farming. Relative erosion rates for a wide range of crop rotations were also given. Then Smith and Whitt (1948) presented a 'rational' erosion-estimating equation,

$$A = C.\ S.\ L.\ K.\ P \tag{3.1}$$

Where A - Annual soil loss, in tonnes ha $^{-1}$ year $^{-1}$.
C - average annual soil loss from claypan soils for a specific rotation, slope length, slope steepness, and row direction,
S - slope steepness,

L - slope length,
K - soil erodibility,
P - support practice

Musgrave (1947) added a rainfall factor, and the resulting Musgrave equation included factors for rainfall, flow characteristics of surface runoff as affected by slope steepness and slope length and vegetal cover effects. Further study carried out by Lloyd and Eley (1952) contributed to the development of graphs and tabulated values to solve the Musgrave equation.

To hasten the development of a national equation, joint conferences of key researchers and users were held at Purdue University in February and July of 1956. The participants concentrated their efforts on reconciling the differences among existing soil-loss equations and on extending the technology to regions where no measurements of erosion by rainstorms had been made. The equation that resulted had seven factors; they were for crop rotation, management, slope steepness, slope length, conservation practice, soil erodibility, and previous erosion. The group established the maximum permissible loss for any soil as 5 tons per acre per year, but set lower limits for many soils. Subsequent study also showed that the equation's crop rotation and management factors could be combined into one factor (Wischmeier et al. 1958).

On the basis of considerable experience with more than 10,000 plots in 20 years, Wischmeier, Smith, and others developed the Universal Soil Loss Equation, USLE (Wischmeier and Smith 1965, 1978). The USLE quantifies soil erosion as the product of six factors representing rainfall and runoff erosiveness, soil erodibility, slope length, slope steepness, cover-management practices, and support conservation practices.

The USLE overcame many of the deficiencies of its predecessors. The form of the USLE is similar to that of previous equations, but the concepts, relationships, and procedures underlying the definitions and evaluations of the erosion factors are distinctly different. Major changes include (1) more complete separation of factor effects so that results of a change in the level of one or several factors can be more accurately predicted; (2) an erosion index that provides a more accurate, localized estimate of the erosive potential of rainfall and associated runoff; (3) a quantitative soil-erodibility factor that is evaluated directly from research data without reference to any common benchmark, (4) an equation and nomograph that are capable of computing the erodibility factor for various soils from soil survey data; (5) a method of including the effects of interactions between cropping and management parameters; and (6) a method of incorporating the effects of local rainfall patterns throughout the year and specific cropping conditions in the cover and management factor (Wischmeier 1972).

3.2.1 Universal Soil Loss Equation (USLE)

This semi-empirical equation is developed (Musgrave, 1947; Wischmeier and Smith, 1978) for long-term assessments of soil losses (sheet and rill erosion rates) under different cropping systems and land management practices.

$$A = R \cdot K \cdot LS \cdot C \cdot P \qquad (3.2)$$

Where *A* - Annual soil loss, in tonnes ha^{-1} $year^{-1}$.

R - Rainfall erosivity factor, An erosion index for the given storm period in $MJmmha^{-1}h^{-1}$.

K - Soil erodibility factor, the erosion rate for a specific soil in continuous fallow condition on a 9% slope having a length of 22.1 m in tonnes/ ha/ ($MJmmha^{-1}$ h^{-1}).

LS - Topographic factor which represent the slope length and slope steepness. It is the ratio of soil loss from a specific site to that from a unit site having the same soil and slope but with a length of 22.1m.

C - Cover factor, which represents the protective coverage of canopy and organic material in direct contact with the ground. It is measured as the ratio of soil loss from land cropped under specific conditions to the corresponding loss from tilled land under clean-tilled continuous fallow (bare soil) conditions.

P - Management practice factor which represents the soil conservation operations or other measures that control the erosion, such as contour farming, terraces, and strip cropping. It is expressed as the ratio of soil loss with a specific support practice to the corresponding loss with up and-down slope culture.

The simple structure of the USLE formula (Equation 3.2) makes it easy to formulate transparent policy scenarios by changing the land use types (C and P factors) under given ecological conditions (R, K, L, and S factors). This, together with the low data requirements compared with physical-based models, such as WEPP and EUROSEM, explains the popularity of the USLE in small-scale water erosion studies at a continental (Van der Knijff et al., 2000), nationwide (Van der Knijff et al., 1999; Schaub and Prasuhn, 1998; UNEP/RIVM/ISRIC, 1996; Bissonnais et al., 1999), state-wide (Hamlett et al., 1992), regional (Folley, 1998), and catchment level (Mellerowicz et al., 1994; Merzouk and Dhman, 1998; Dostal and Vrana, 1998). The USLE is also popular in (nationwide) land evaluation studies where it is linked with rule based procedures to determine the decrease in productivity (Kassam et al., 1991; Struif-Bontkes, 2001) or to estimate changes in nutrient balances (Smaling, 1993).

However, the USLE has some intrinsic limitations which require attention. A nonparametric analysis of the original USLE data set (Keyzer and Sonneveld, 1998) reveals that data on higher soil losses is scarce and large errors can be expected for high rainfall data in combination with steep slopes and the lower and higher K values. This analysis also showed that observations are largely concentrated around the lower soil losses, where the model should give more reliable estimates. In a similar study, Nearing (1998) showed that small soil losses were consistently overestimated while the higher ones were underestimated. These results confirm earlier findings where the USLE model shows a rather poor statistical fit when used to explain annual soil losses (R^2 = 0.57) of the same data that was used for its calibration. Furthermore, the mathematical form of the USLE, the multiplication of six factors, leads to large errors whenever one of the factors is miss-specified (Wischmeier, 1976). This raises questions about the model specification of the USLE and robustness of the implicit parameter assignments, and therefore, this equation should be used with extra caution and with proper selection of the values for each parameter.

Due to the limitations and problems described above, additional research and experience have resulted in improvements in the USLE. These include new and (in some instances) revised rainfall erosivity maps; a time-varying approach to reflect freeze-thaw conditions and consolidation caused by extraction of moisture by a growing crop for the soil erodibility factor (K); a sub-factor approach for evaluating the cover-management factor (C) for cropland, rangeland, and disturbed areas; a new equation to reflect slope length and steepness (LS) (the new terms also reflect the ratio of rill to inter-rill erosion); and new conservation-practice values (P) for both cropland and rangeland practices.

Various attempts to improve the predictive capability of the USLE technology have been made in recent years, both along traditional and nontraditional avenues of inquiry. Along the traditional route, whereby we seek to improve the prediction capabilities of the model by focusing on better parameter estimations, the most extensive work is undoubtedly the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997). The changes from the USLE to the RUSLE generally fit into two categories: (a) incorporation of new or better data and (b) consideration of selected erosion processes. Recent data from the western United States was used to develop a new map for the rainfall erosivity factor, R. Obviously, this improvement and other similar improvements in the RUSLE that are based on new or better data will have impact only for regional or other applications for which the new data is relevant.

3.2.2 Modified Universal Soil Loss Equation (MUSLE)

The Modified Universal Soil Loss Equation (MUSLE) is perhaps the most frequently used equation for sediment yield estimation. It is developed by Williams (1975) to calculate sediment yields of a catchment as a result of a specific storm event. This empirical relationship is expressed by the following equation for individual storm events:

$$Y = 89.6\left(VQ_p\right)^{0.56}\left(K.LS.C.P\right) \tag{3.3}$$

Where Y - Sediment yield per storm event (tonnes)
V - Runoff volume in cubic meter
Q_p - peak discharge in m^3/s

The approach has seen widespread application, but should be used with caution as it was developed empirically based on limited data for Texas and the southwestern United States. The procedure should only be used on small catchments, and considerable judgment is required in selecting an appropriate slope length when determining the LS topographic factor.

3.3 SOIL LOSS AND SEDIMENT YIELD PARAMETERS

This section provides a description for each of the parameter required for the estimation of soil loss and sediment yield using USLE (Eq. 3.2) and MUSLE (Eq. 3.3). Also provided are the recommended methodology for the calculation of each parameter, and recommended values for each of the parameter in the forms of tables, charts, and nomographs. It should be noted that all the calculations and values recommended in this guideline are to be in standard S.I. unit.

3.3.1 Rainfall Erosivity Factor (R)

Soil erosion is a mechanical process of eroding away soil particles from the earth surface by the eroding agent. The paramount agent of erosion is rainfall. During rainfall, the impact of striking force subjected on the surface of the soil result in splash-out of soil particles. While striking and splashing the soil particles, some portion of rainfall will infiltrate and percolate until it reaches the saturation level after which the process ceases. The remainder of the rainfall goes to surface runoff. As the process goes on, the soil surface becomes weak and the particles loosen up. The surface runoff washes the soil particles down the slope until there is insufficient water to transport the soil particles further. This process will end up with deposition. These series of processes are well illustrated in Figure 3.2. The extent to which a region is affected by soil erosion varies greatly depending on the frequency and intensity of the rainfall as well as the sustainability of the soil strata.

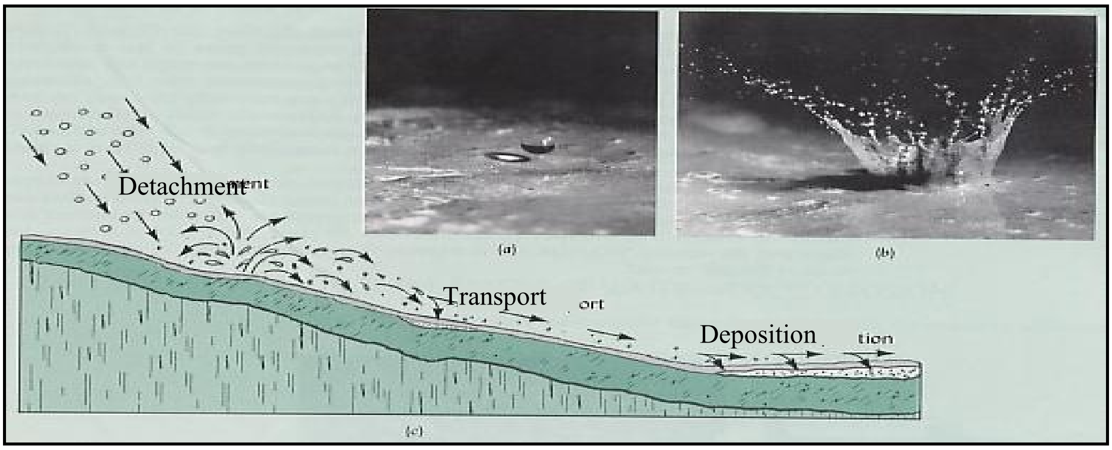

Figure 3.2: Mechanics of soil erosion (Brady & Weil, 1999)

The numerical value used for R in the USLE and RUSLE equations must quantify the effect of raindrop impact and must also reflect the amount and rate of runoff likely to be associated with the rain.

Therefore, A universally used equation (Equation 3.4) is recommended in this guideline:

$$R = \frac{1}{n}\sum_{j=1}^{n}\left[\sum_{k=1}^{m}(E)(I_{30})_k\right] \tag{3.4}$$

Where, E - total storm kinetic energy (MJ/ha)
I_{30} - maximum 30 minutes rainfall intensity
j - index for the number of years used to compute the average
k - index of the number of storms in each year
n - number of years to obtain average R
m - number of storms in each year.

The total storm kinetic energy for each storm, E is obtained by summation of the product of unit kinetic energy and the respective rainfall volume of all the increments in a rainfall event, as given below:

$$E = \sum_{r=1}^{k} e_r V_r \tag{3.5}$$

Where, E - total storm kinetic energy
K - number of storm intervals
R - index number of storm intervals
e_r - unit kinetic energy for the r^{th} interval
V_r - total rainfall depth for r^{th} interval

The energy of a rainfall event is a function of the amount of rain and of all the storm's component intensities. The median raindrop size generally increases with greater rain intensity (Wischmeier and Smith, 1978) and the terminal velocities of free-falling water drops increase with larger drop size. Since the energy of a given mass in motion is proportional to velocity squared, rainfall energy is directly related to rain intensity. Zainal (1992) presented the equations that describe the relationship as below:

$$e_r = 210 + 89\log_{10}(i_r) \qquad i_m \le 7.6 \ \text{cm/hr} \tag{3.6}$$

$$e_r = 288.4 \qquad i_m > 7.6 \ \text{cm/hr} \tag{3.7}$$

The unit for unit energy given by Equation 3.6 and 3.7 are tonne-metre per hectare per centimetre of rainfall (ton.m/ha.cm). The rainfall erosivity maps (R factor) for Peninsular Malaysia and each state, including W.P. Kuala Lumpur are shown in Figures 3.3 to 3.11.

The Universal Soil Loss Equation predicts the annual soil loss rate in an area, often expressed in tonnes/ha/year. However, it is also important to establish method for practitioners to estimate soil loss in a certain period within a year. This is because certain land disturbance activities will not require a year for completion. Hence prediction of soil loss within fraction of a year will provide more practicality for application, i.e. design of erosion and sediment control facilities. For example, an engineer might want to examine what is the quantity of expected soil loss for a half-year road construction project in order to size an adequate sediment basin.

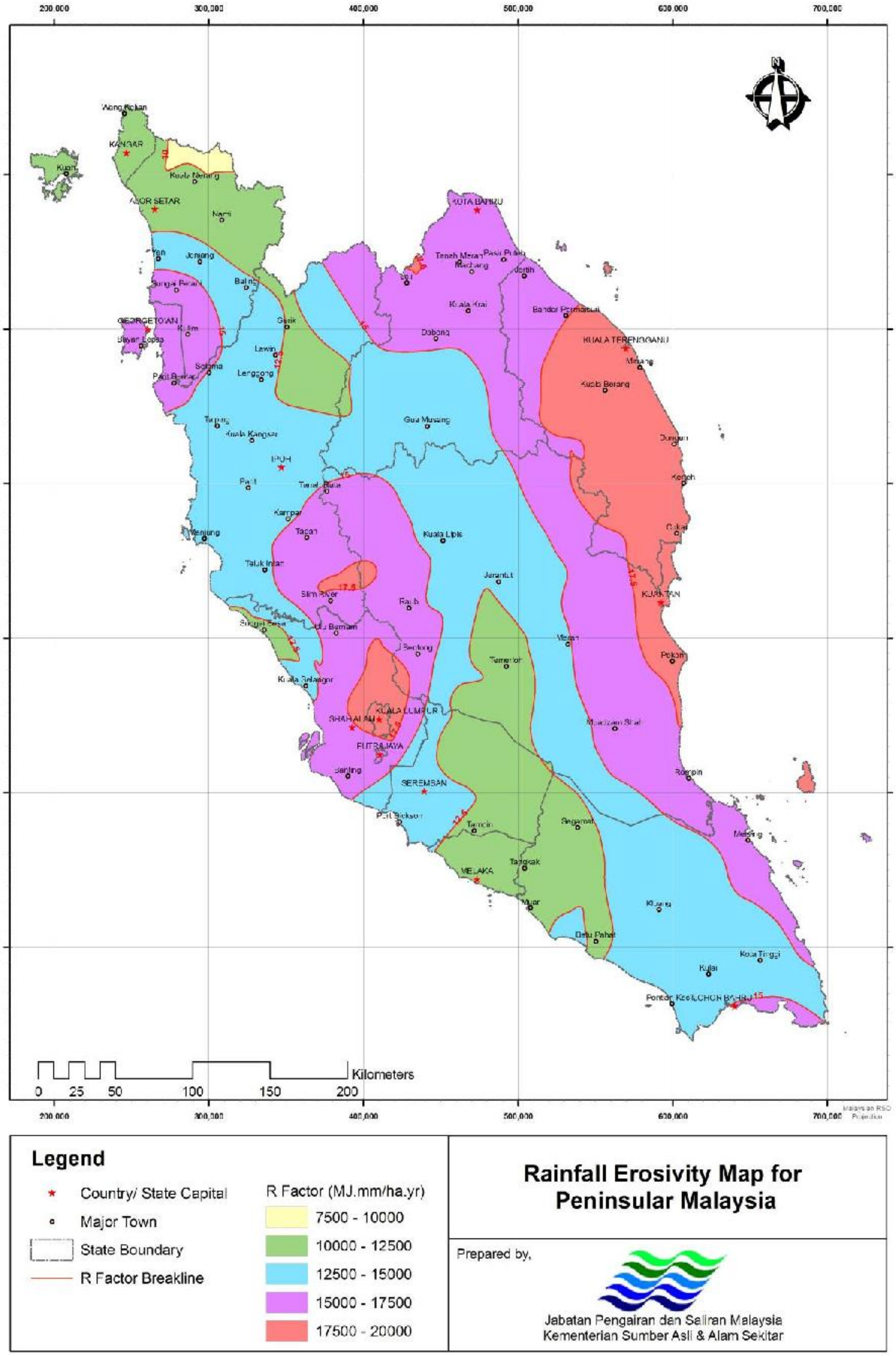

Figure 3.3: Rainfall Erosivity Map for Peninsular

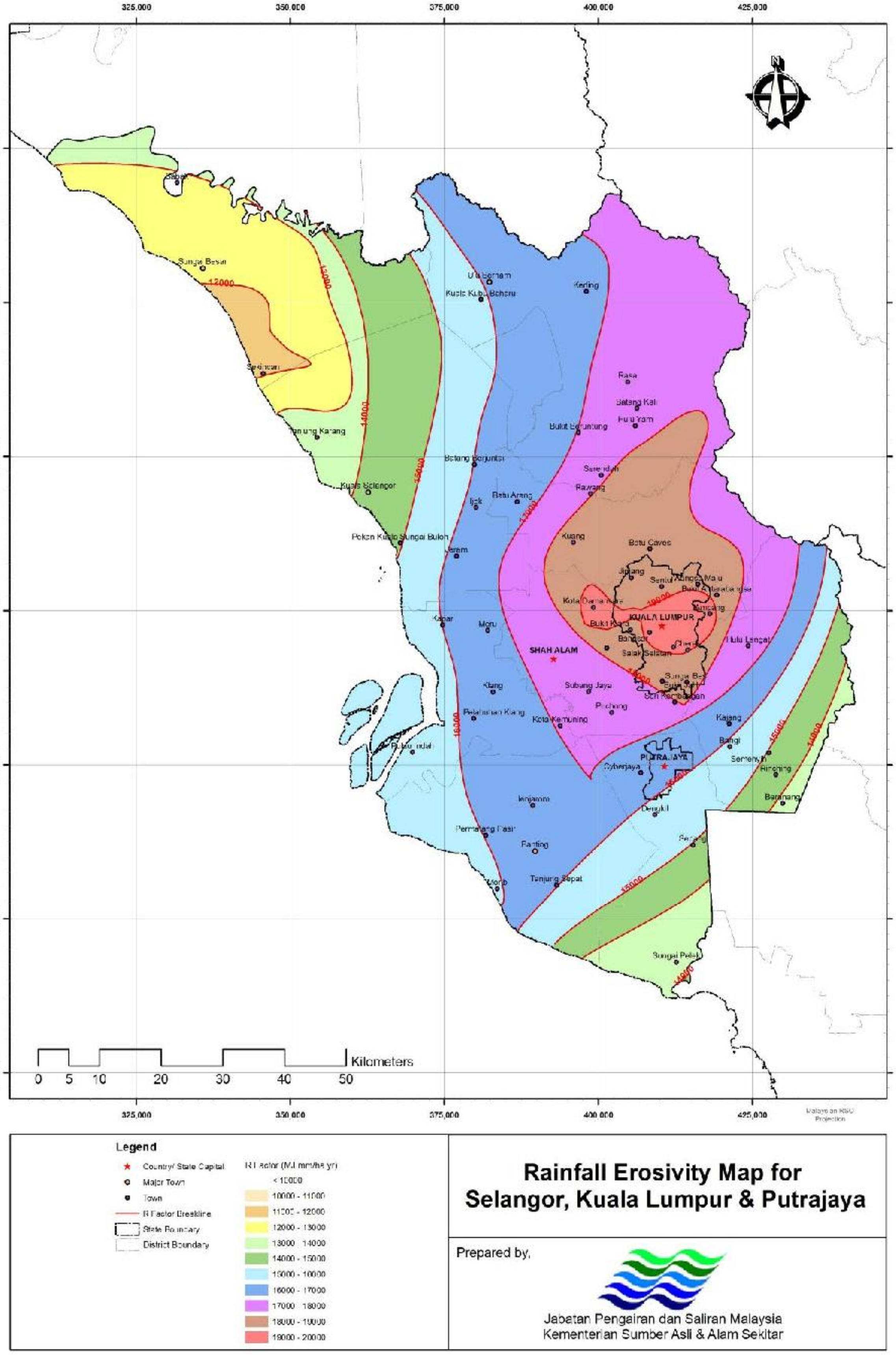

Figure 3.4: Rainfall Erosivity Map for Selangor State, Kuala Lumpur F.T., & Putrajaya

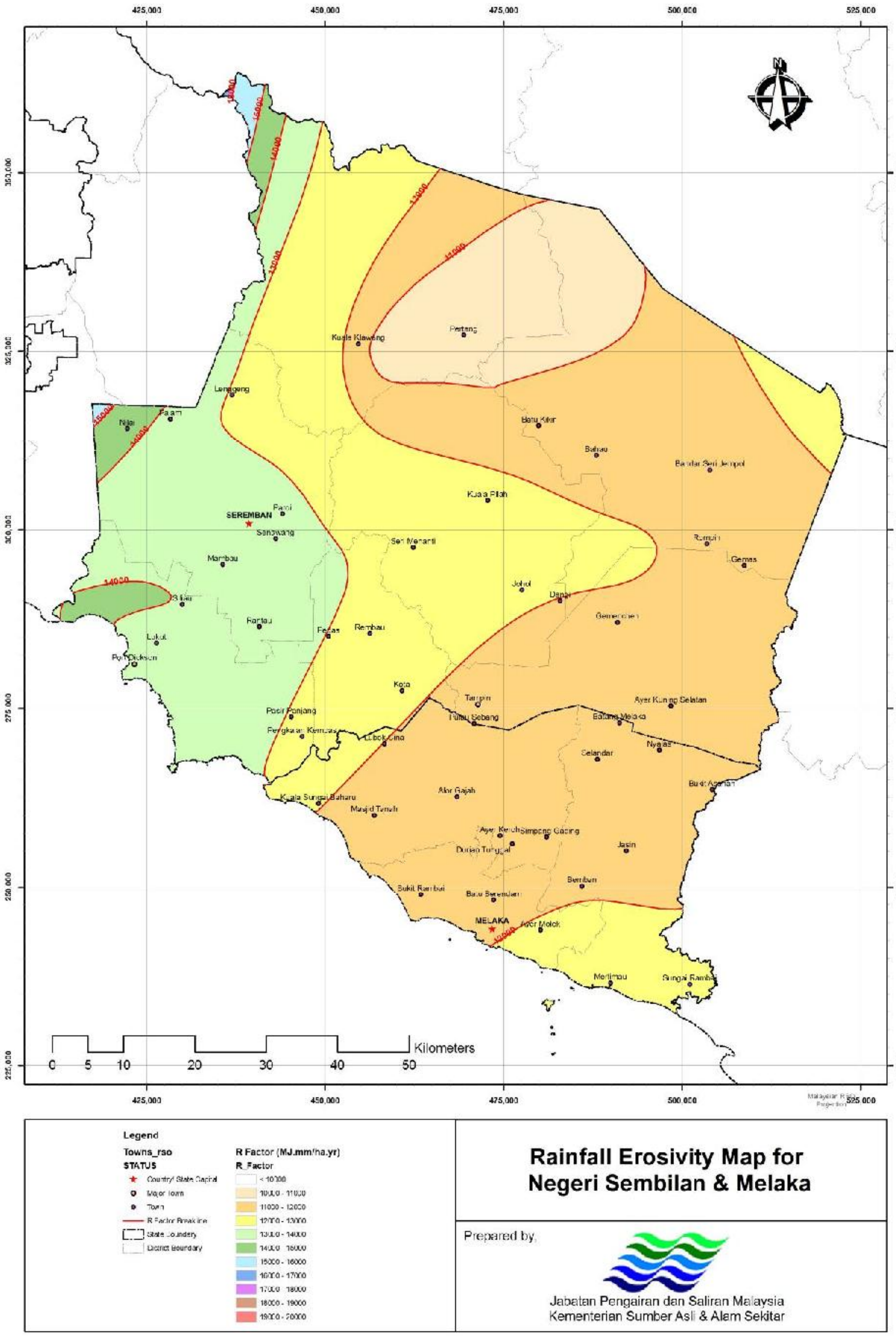

Figure 3.5 Rainfall Erosivity Map for Negeri Sembilan & Melaka States

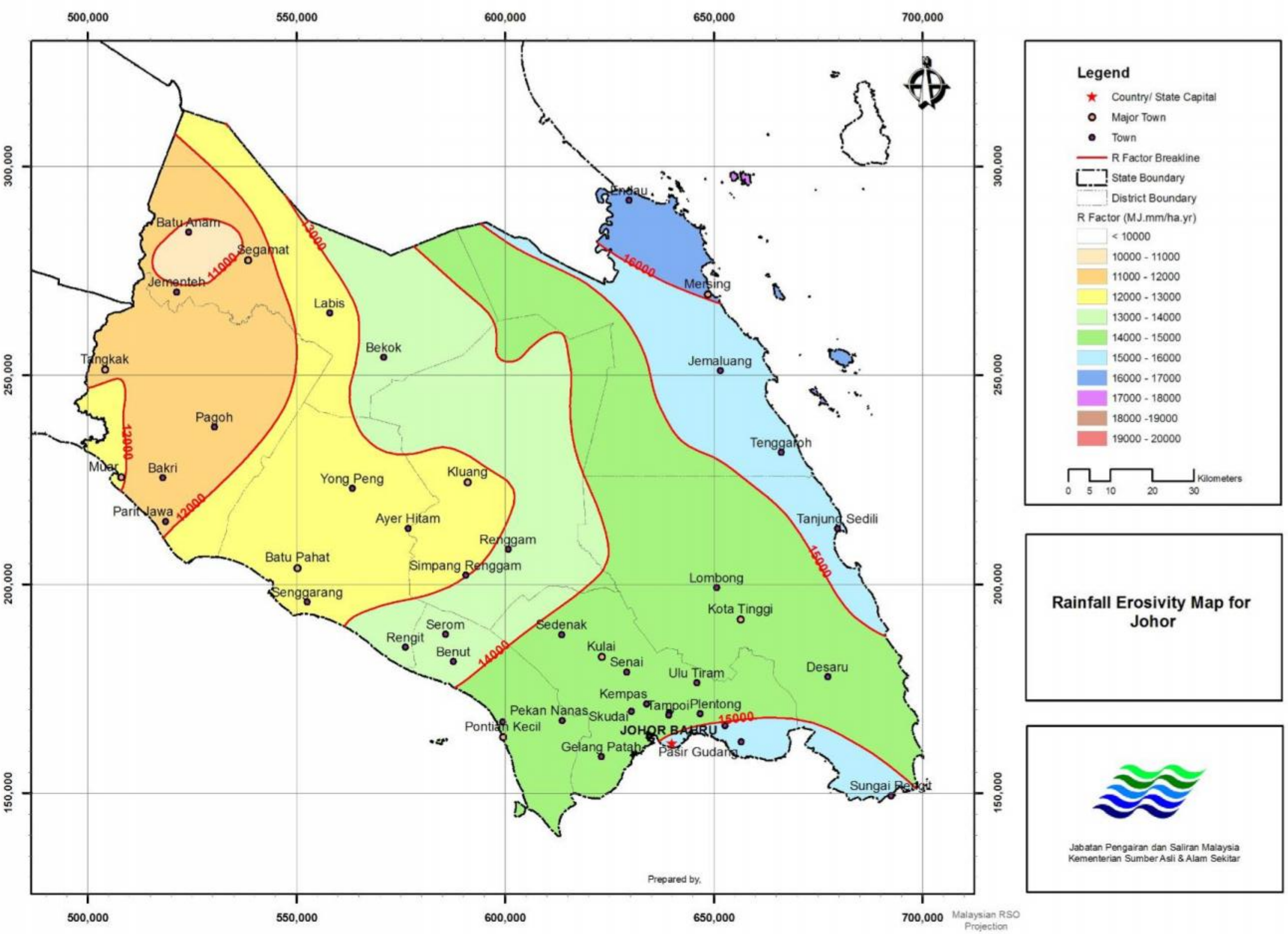

Figure 3.6: Rainfall Erosivity Map for Johor State

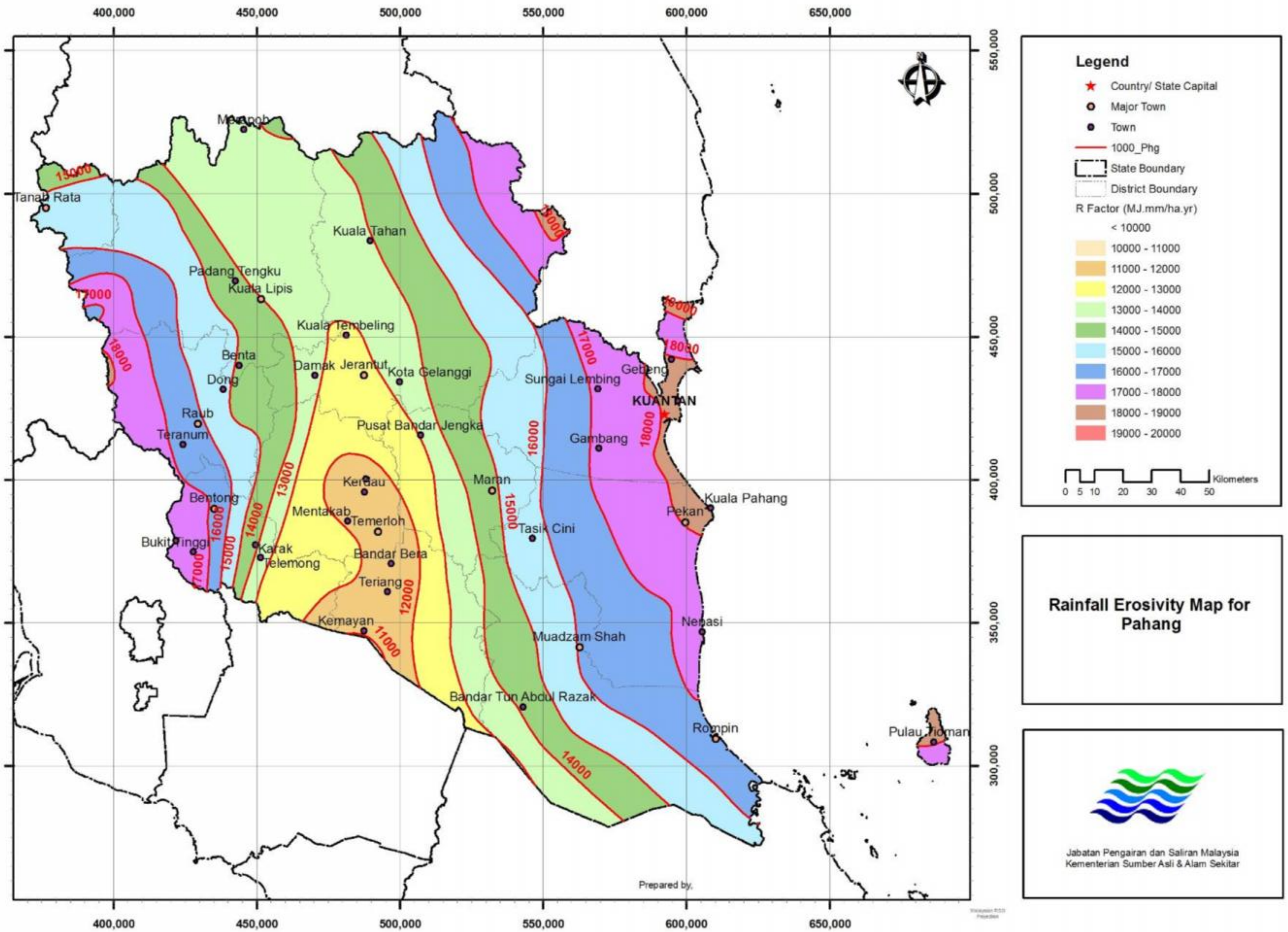

Figure 3.7: Rainfall Erosivity Map for Pahang State

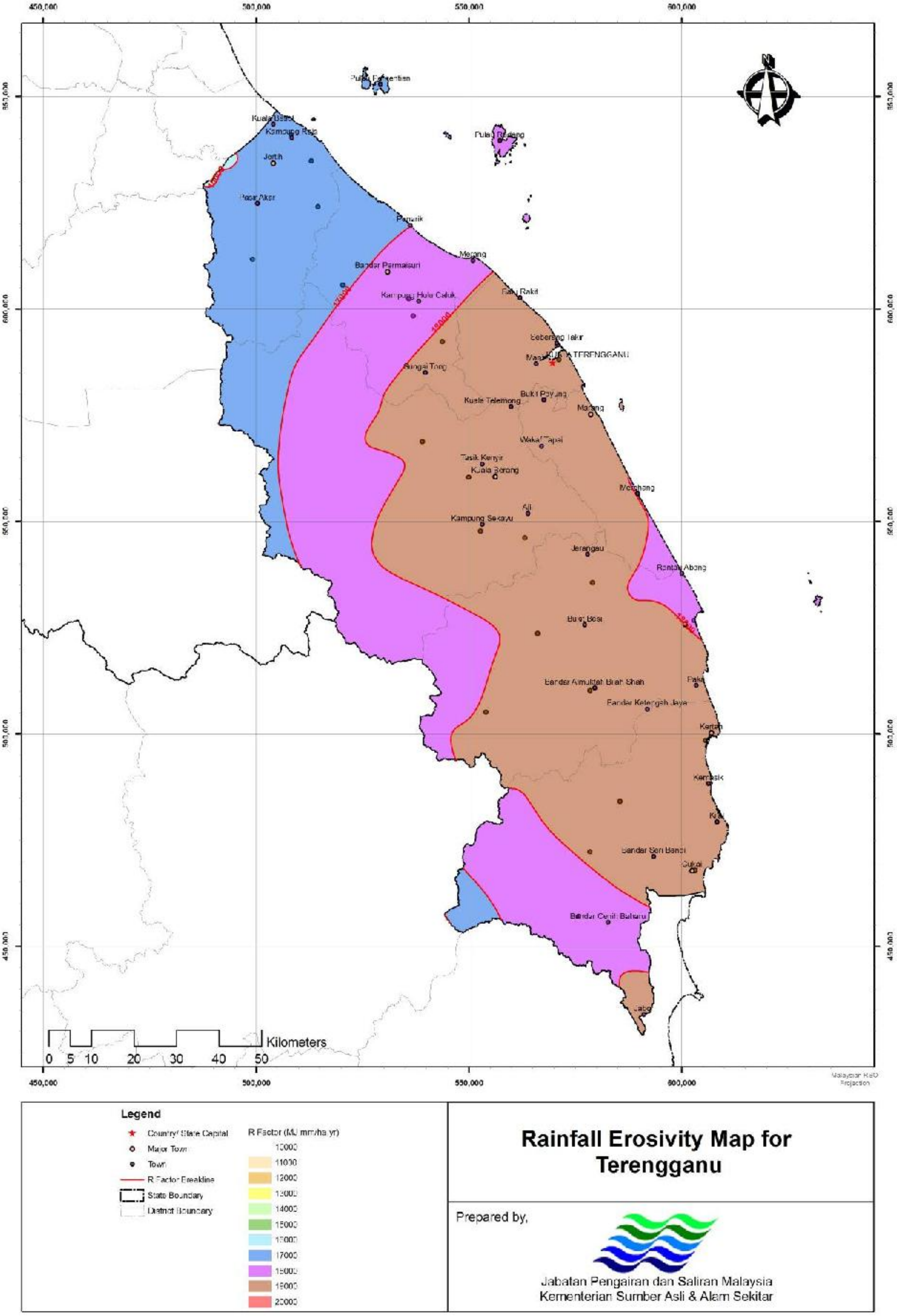

Figure 3.8: Rainfall Erosivity Map for Terengganu State

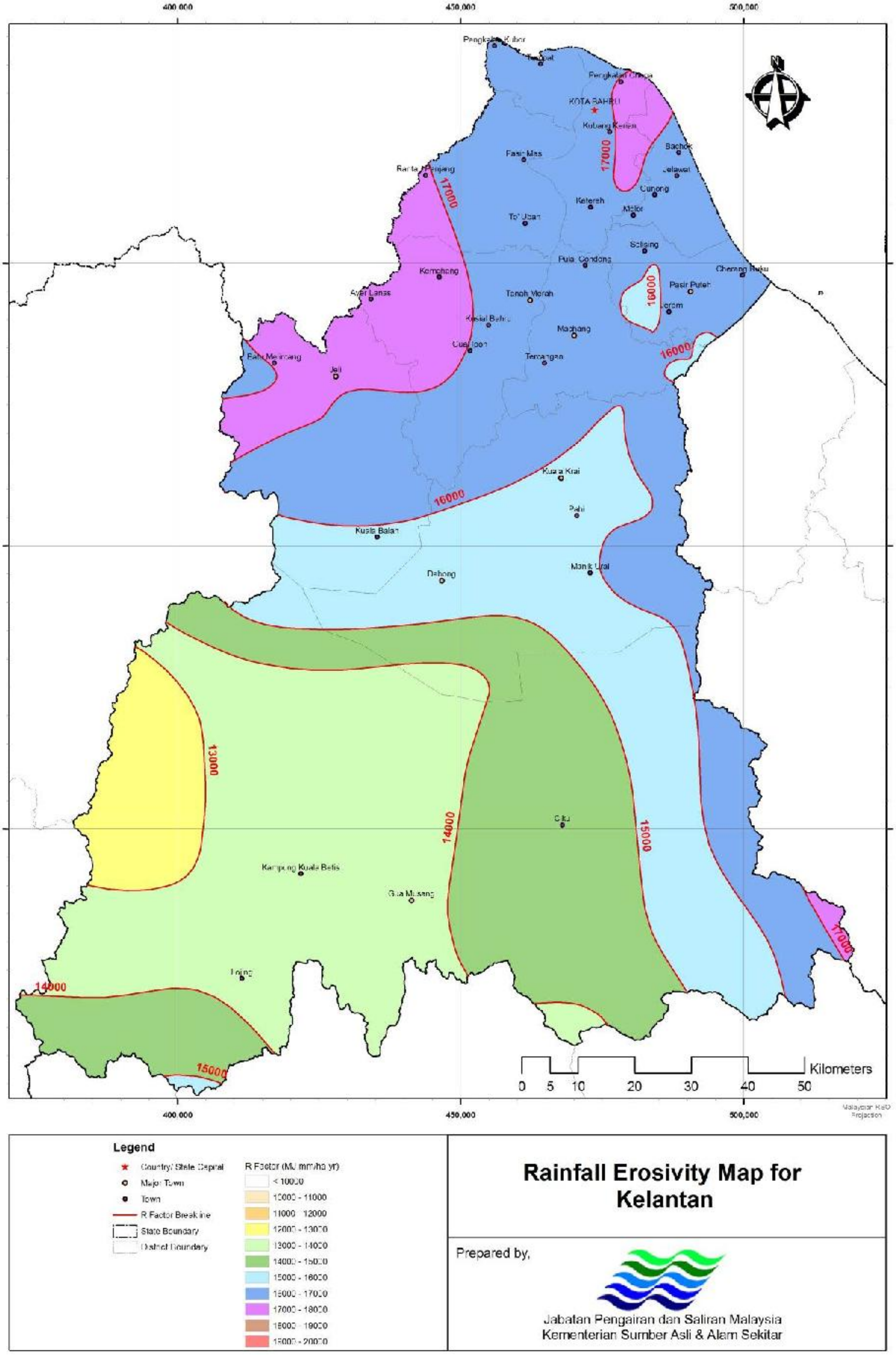

Figure 3.9: Rainfall Erosivity Map for Kelantan State

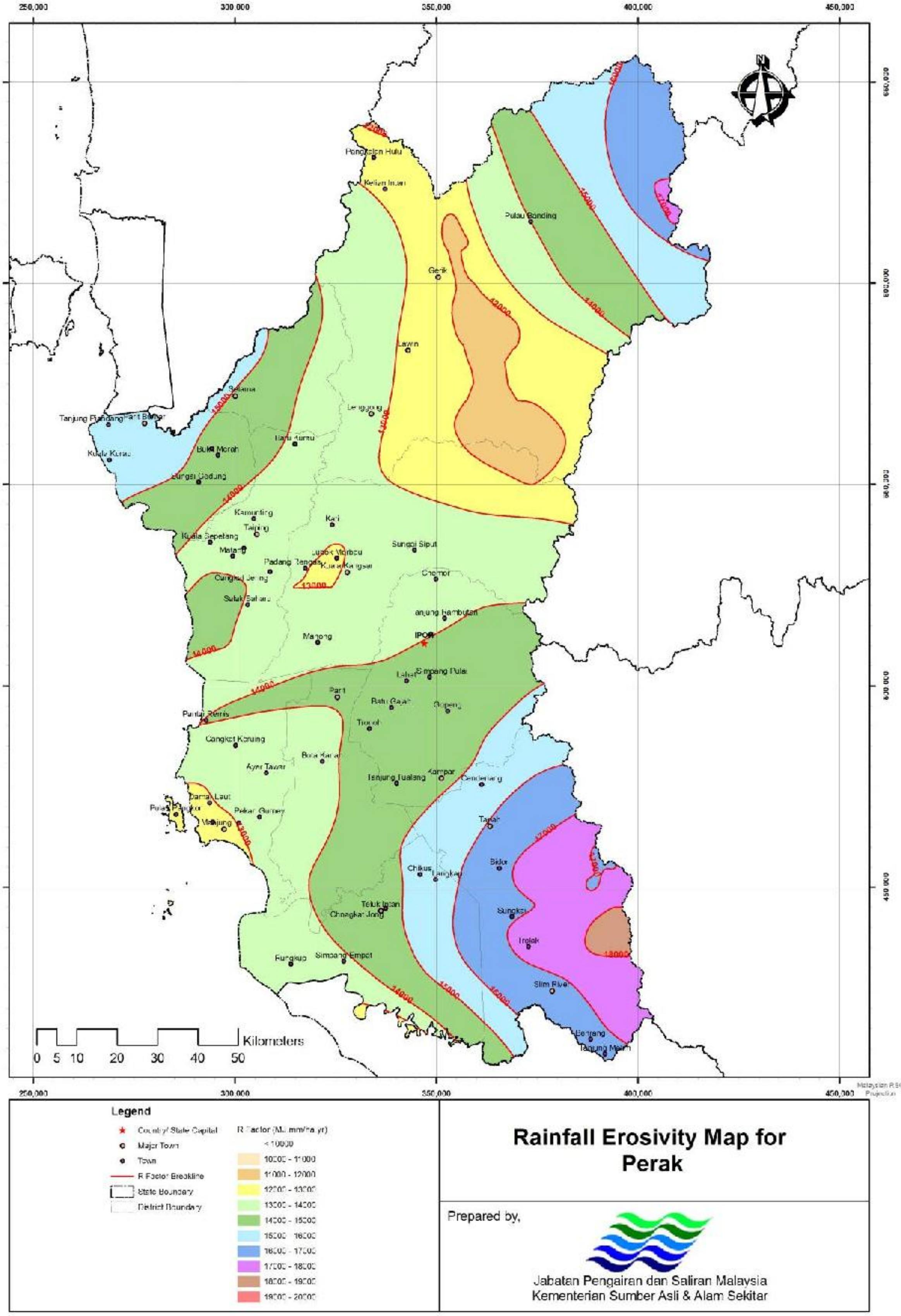

Figure 3.10: Rainfall Erosivity Map for Perak State

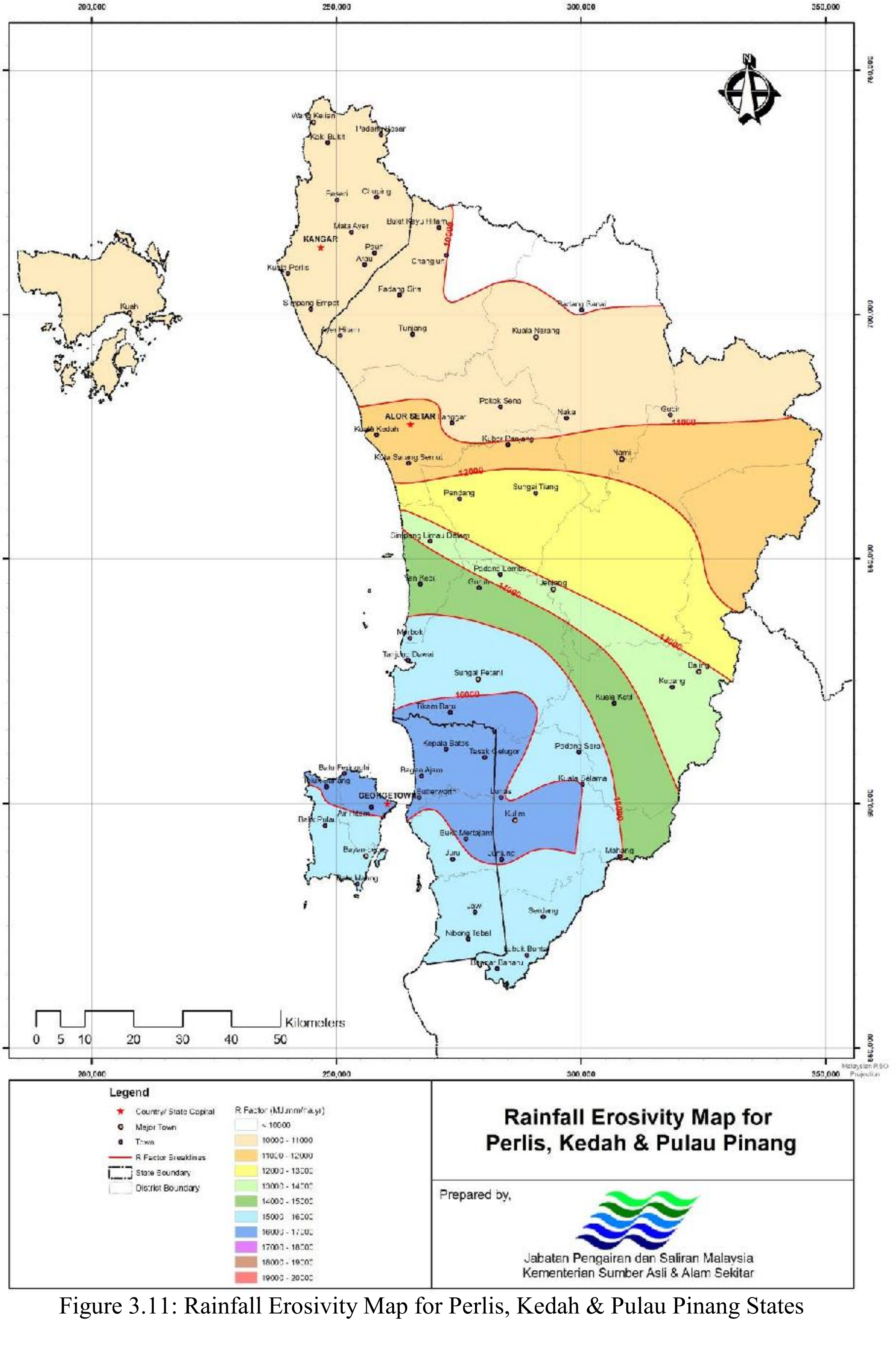

Figure 3.11: Rainfall Erosivity Map for Perlis, Kedah & Pulau Pinang States

The monthly adjustment factor, *M*, serves this purpose by allowing user to 'downscale' soil loss estimation using USLE to a certain fraction within a year. This can be done simply by relating the R factor to annual rainfall distribution of the area. By assuming direct proportion relationship between *R* and the amount of rainfall, the regional adjustment factor in Peninsular Malaysia is given in Table 3.1. The division of region can be found in Figure 3.12.

Table 3.1: Regional monthly adjustment factor for Peninsular Malaysia

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Northern	0.030	0.033	0.073	0.100	0.070	0.077	0.083	0.087	0.123	0.163	0.097	0.063	1.000
Central	0.064	0.054	0.088	0.102	0.070	0.066	0.074	0.064	0.084	0.114	0.130	0.090	1.000
Eastern	0.085	0.045	0.055	0.050	0.070	0.055	0.055	0.070	0.085	0.100	0.140	0.190	1.000
Southern	0.120	0.045	0.090	0.075	0.065	0.060	0.060	0.060	0.075	0.095	0.110	0.145	1.000

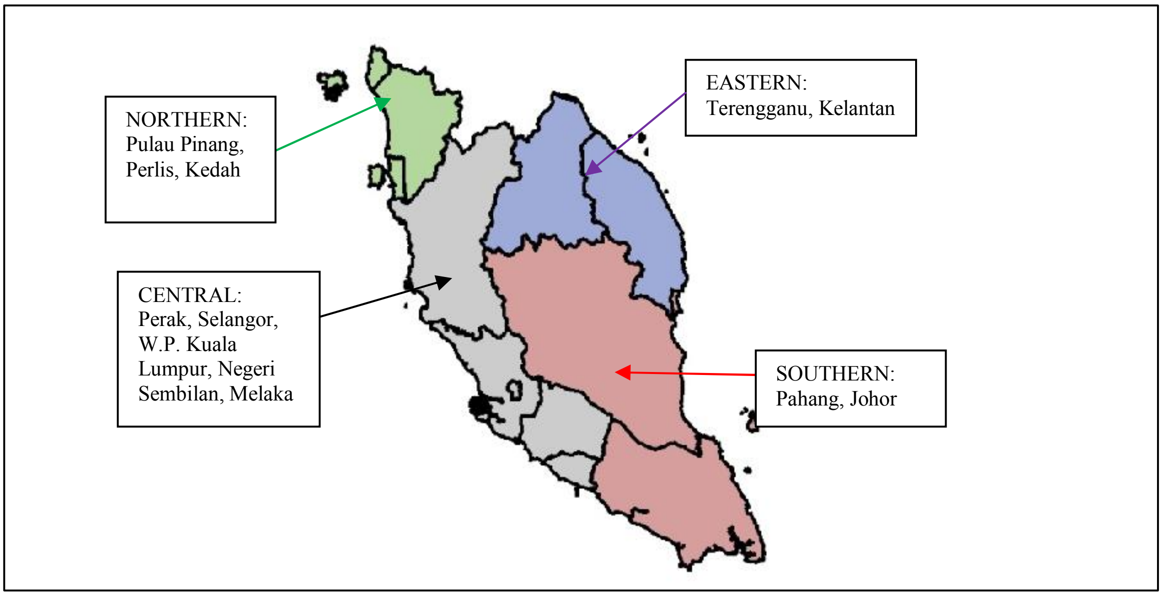

Figure 3.12: Monthly Modification Factor Regional Division for Peninsular Malaysia

3.3.2 Soil Erodibility Factor (K)

Soil erodibility defines the resistance of the soil to both detachment and transport. It is an important index to measure soil susceptibility to water erosion, and an essential parameter needed for soil erosion prediction. The soil-erodibility factor (K) represents the effect of soil properties and soil profile characteristics such as soil texture, aggregate stability, shear strength, infiltration capacity, organic and chemical content on soil loss.

Many attempts have been made to devise a simple index of erodibility based either on the properties of the soil as determined in the laboratory or the field, or on the response of the soil to rainfall (Weischmeier et al. 1971; Weischmeier and Smith, 1978; Tew, 1999; Williams et al., 1984; Shirazi and Boersma, 1984; Singh and Phadke, 2006; Helden, 1987). Of these studies, Tew Equation and Nomograph in Figure 3.13 (Tew, 1999) have been found to give the most satisfactorily estimation of K factor for Malaysia soil series, and are therefore recommended for the calculation of K factor in this guideline.

$$K = \left[1.0x10^{-4}(12 - OM)M^{1.14} + 4.5(s-3) + 8.0(p-2)\right]/100 \qquad (3.8)$$

Where,

K – Soil Erodability Factor, (ton/ac.)*(100ft.ton.in/ac.hr)
For SI unit (ton/ha)(ha.hr/MJ.mm), the conversion factor is 1/7.59.

M - (% silt + % very fine sand) x (100 - % clay)

OM - % of organic matter

S - soil structure code

P - permeability class

This equation comprises of 5 soil and soil-profile parameters: percent of modified silt (0.002-0.1 mm), percent of modified sand (0.1-2 mm), percent of organic matter (OM), class for soil structure (s) and soil permeability (p). The M value, which represents for silt, very fine sand and clay contents, can be obtained from particle size distribution of the soil by wet or dry sieving analysis in according to BS 1377: Part 2 (1990). The percentage of organic content in the soil can be determined by pre-treatment with hydrogen peroxide by taking the different of weight before and after the pre-treatment. In determination of the soil structure code*s*, the textural triangle as shown in Figure 3.14 which is identical to the Soil Textural Pyramid produces by USGS can be used by drawing horizontal and vertical lines corresponding to the percentage of clay and sand fraction. The value of soil structure code, can be determined from the intersection point of both lines; whereas the permeability code of a soil is a measure of the property which relates to fluid flow through its voids. It can be correlated with grain size distribution or texture of the soil as shown in Table 3.2.

Table 3.3 gives the information on different soil layers to be considered in determination of K factor for a particular site. Generally, the values of K for layer *a* is used when the soil is in natural state and not being disturbed, whereas, the respective values for *b* and *c* soil layers are used in determining soil loss at construction sites because these layers are normally left exposed after mechanical action.

A schematic diagram showing the overall procedure to determine the value of K factor is given in Figure 3.15. The values of K factor that has been determined for 74 soil series in Malaysia together with Soil Texture and Hydrological Soil Group are as given in Table 3.4.

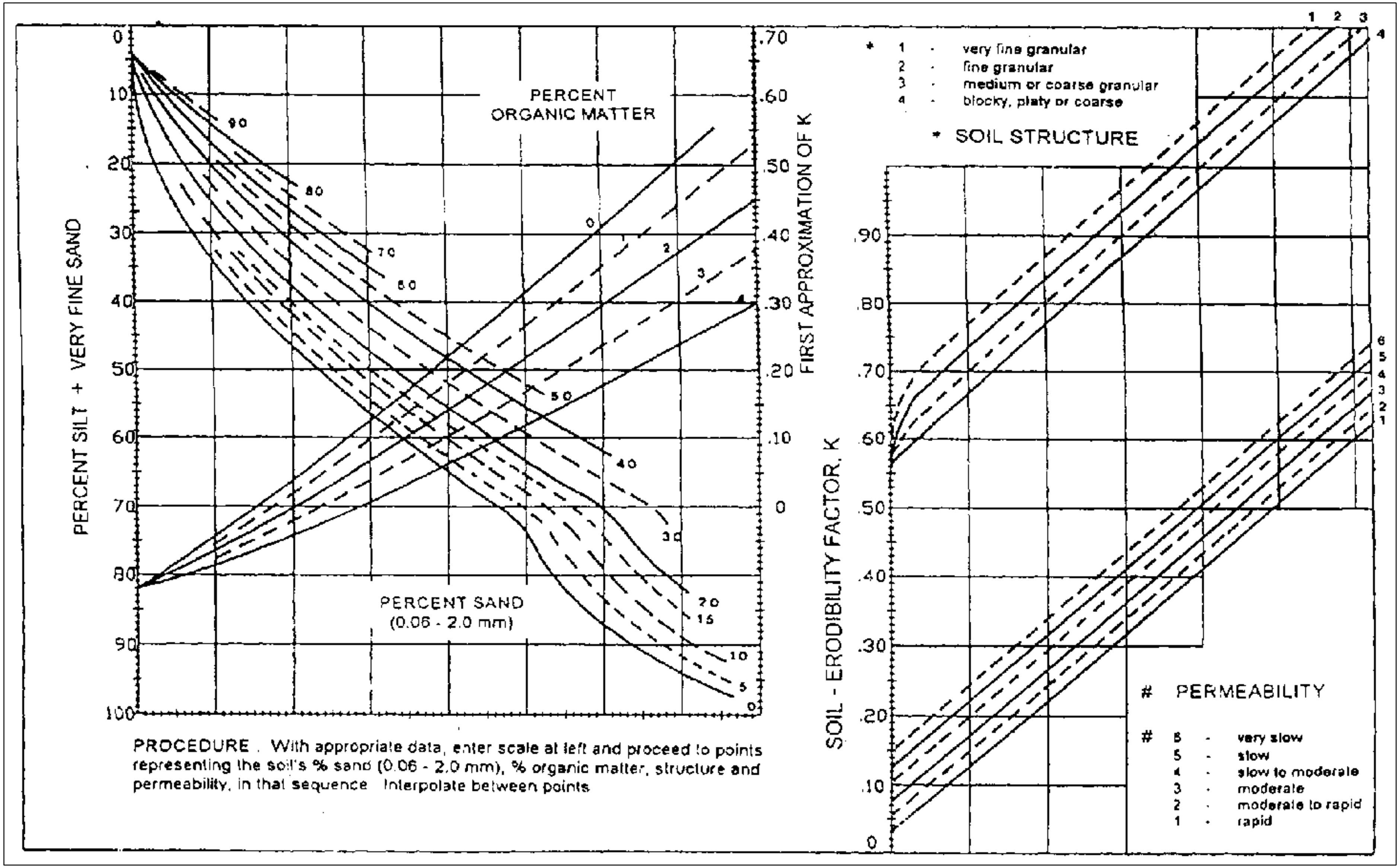

Figure 3.13: Soil erodibility factor, K , (ton/ac.)*(100ft.ton.in/ac.hr) (Tew, 1999) for Malaysia

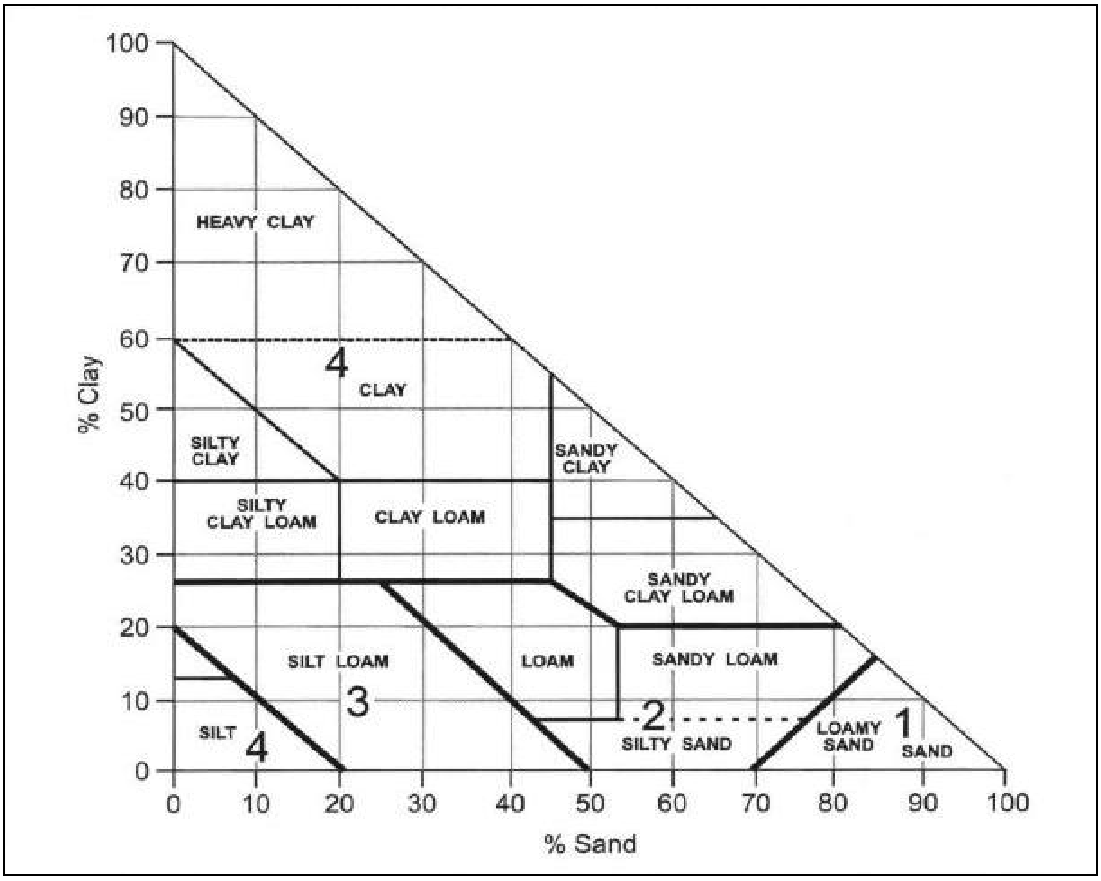

Figure 3.14: Soil Structure Code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

Table 3.2: Soil permeability code based on soil texture class

Soil Texture	**Permeability Code[1]**	**Hydrologic Soil Group[2]**
Heavy clay, Clay	6	D
Silty clay loam, Sandy clay	5	C-D
Sandy clay loam, Clay loam	4	C
Loam, Silt loam	3	B
Loamy sand, Sandy loam	2	A
Sand	1	A+

Note: 1 – National Soil Handbook (SCS, 1983)
2 – National Engineering Handbook (SCS, 1972)

Table 3.3: Soil Layer for Soil Series in Malaysia

Texture Layer	**Soil Layer Depth (m)**
A (Surface soil)	0.00 – 0.50
B (Subsoil)	0.51 – 1.00
C (Substratum)	1.01 – 1.50

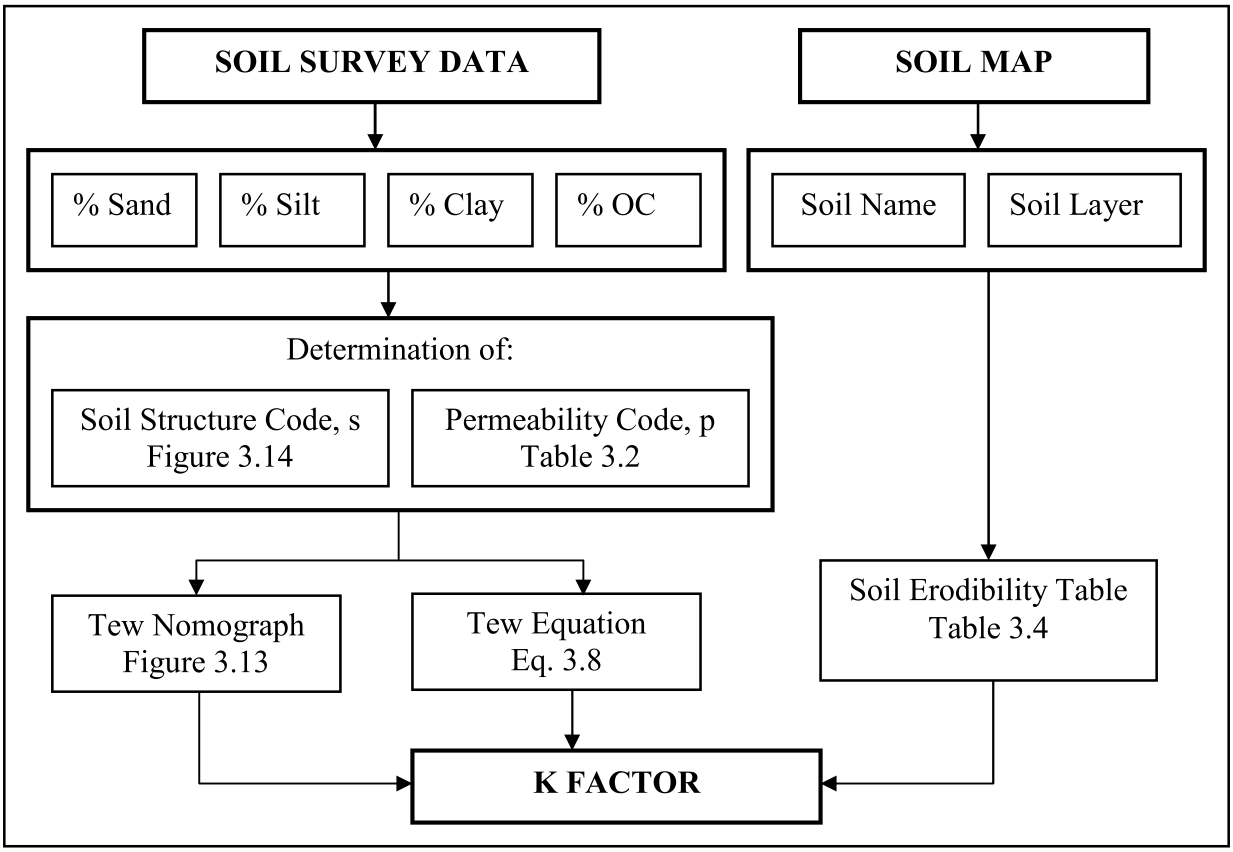

Figure 3.15: Schematic diagrams for determination of K factor

Table 3.4: Soil erodibility factors (K) for Malaysian soil series

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
1	Akob	A	0.053	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
2	Apek	A	0.045	clay loam	C
		B	0.055	clay loam	C
		C	0.062	clay	D
3	Batu Anam	A	0.056	clay	D
		B	0.057	clay	D
		C	0.051	clay	D
4	Batu Hitam	A	0.060	clay	D
		B	0.063	clay	D
		C	0.063	clay	D
5	Batu lapan	A	0.045	clay loam	C
		B	0.049	clay laom	C
		C	0.060	clay	D
6	Bukit Temiang	A	0.029	sandy clay loam	C
		B	0.038	sandy clay	C-D
		C	0.035	sandy clay loam	C
7	Beriah	A	0.053	clay	D
		B	0.057	clay	D
		C	0.057	clay	D
8	Bungor	A	0.036	sandy clay loam	C
		B	0.053	clay	D
		C	0.054	clay	D

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
9	Clay Over Organic	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
10	Chat	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
11	Chempaka	A	0.049	clay loam	C
		B	0.049	clay loam	C
		C	0.045	clay loam	C
12	Chengai	A	0.049	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
13	Chenian	A	0.056	clay	D
		B	0.058	clay	D
		C	0.060	clay	D
14	Durian	A	0.053	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
15	Guar	A	0.052	clay	D
		B	0.052	clay	D
		C	0.053	clay	D
16	Halu	A	0.051	sandy clay loam	C
		B	0.058	sandy clay loam	C
		C	0.051	sandy clay loam	C

Table 3.4: Soil erodibility factors (K) for Malaysian soil series (continued)

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
17	Harimau	A	0.056	sandy clay loam	C
		B	0.055	sandy clay loam	C
		C	0.057	sandy clay loam	C
18	Holyrood	A	0.035	sandy clay loam	C
		B	0.034	sandy clay loam	C
		C	0.033	sandy clay loam	C
19	Holyrood 1	A	0.004	sandy loam	A
		B	0.004	sandy loam	A
		C	0.004	sandy loam	A
20	Holyrood 2	A	0.05	clay	D
		B	0.053	clay	D
		C	0.053	clay	D
21	Hutan	A	0.054	clay	D
		B	0.058	clay	D
		C	0.058	clay	D
22	Idris	A	0.053	clay	D
		B	0.053	clay	D
		C	0.053	clay	D
23	Jerangau1	A	0.047	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
24	Jempol	A	0.046	clay	D
		B	0.048	clay	D
		C	0.052	clay	D

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
25	Kala 1	A	0.034	sandy clay loam	C
		B	0.045	clay	D
		C	0.046	clay	D
26	Kampung Tepus	A	0.049	clay	D
		B	0.049	clay	D
		C	0.049	clay	D
27	Kangkong1	A	0.05	clay	D
		B	0.05	clay	D
		C	0.05	clay	D
28	Kangkong2	A	0.052	clay	D
		B	0.051	clay	D
		C	0.052	clay	D
29	Kg. Bukit Pugor	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
30	Kangar	A	0.047	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
31	Katong	A	0.042	clay	D
		B	0.045	clay	D
		C	0.045	clay	D
32	Kelau	A	0.043	sandy clay	C-D
		B	0.041	sandy clay	C-D
		C	0.042	sandy clay	C-D

Table 3.4: Soil erodibility factors (K) for Malaysian soil series (continued)

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
33	Klau	A	0.041	sandy clay	C-D
		B	0.048	clay	D
		C	0.052	clay	D
34	Kranji	A	0.051	clay	D
		B	0.050	clay	D
		C	0.048	clay	D
35	Kundor	A	0.053	clay	D
		B	0.053	clay	D
		C	0.055	clay	D
36	Kuala Perlis	A	0.047	clay	D
		B	0.046	clay	D
		C	0.046	clay	D
37	Kuala Brang	A	0.035	sandy clay loam	C-D
		B	0.034	sandy clay loam	C-D
		C	0.029	sandy clay loam	C-D
38	Linau	A	0.029	sandy clay loam	C-D
		B	0.044	clay	D
		C	0.032	silt loam	B
39	Linau 1	A	0.030	sandy clay loam	C
		B	0.042	clay	D
		C	0.045	clay	D
40	Lubok Itek	A	0.045	clay	D
		B	0.030	clay loam	C
		C	0.028	sandy clay loam	C

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
41	Lubok Kiat	A	0.060	clay	D
		B	0.063	clay	D
		C	0.063	clay	D
42	Lunas1	A	0.028	sandy loam	A
		B	0.036	sandy clay loam	C
		C	0.039	sandy clay	C-D
43	Lundang1	A	0.046	clay loam	C
		B	0.045	clay loam	C
		C	0.045	clay loam	C
44	Manik	A	0.035	sandy clay loam	C
		B	0.042	clay	D
		C	0.042	clay	D
45	Malacca	A	0.049	clay	D
		B	0.052	clay	D
		C	0.052	clay	D
46	Marang	A	0.046	clay loam	C
		B	0.044	clay loam	C
		C	0.044	clay loam	C
47	Marang1	A	0.036	sandy loam	A
		B	0.040	sandy clay loam	C
		C	0.051	clay	D
48	Munchong	A	0.039	sandy clay	C-D
		B	0.039	sandy clay	C-D
		C	0.039	sandy clay	C-D

Table 3.4: Soil erodibility factors (K) for Malaysian soil series (continued)

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
49	Munchong1	A	0.054	clay	D
		B	0.052	clay	D
		C	0.052	clay	D
50	Munchong2	A	0.038	sandy clay	C-D
		B	0.052	clay	D
		C	0.052	clay	D
51	Organic Clay	A	0.050	clay	D
		B	0.035	clay	D
		C	0.032	silty clay loam	C-D
52	Organic Clay1	A	0.045	clay	D
		B	0.049	clay	D
		C	0.050	clay	D
53	Rengam	A	0.038	clay	D
		B	0.046	clay	D
		C	0.053	clay	D
54	Rengam1	A	0.028	sandy clay loam	C
		B	0.032	sandy clay	C-D
		C	0.032	sandy clay	C-D
55	Rengam2	A	0.023	sandy clay loam	C
		B	0.031	sandy clay	C-D
		C	0.032	sandy clay	C-D
56	Rengam3	A	0.042	clay	D
		B	0.050	clay	D
		C	0.050	clay	D

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
57	Rudua	A	0.027	silt loam	B
		B	0.017	silt loam	B
		C	0.017	silt loam	B
58	Rusila	A	0.013	silt loam	B
		B	0.015	silt loam	B
		C	0.014	silt loam	B
59	Rotan	A	0.052	clay	D
		B	0.050	clay	D
		C	0.052	clay	D
60	Sedu	A	0.040	clay loam	C
		B	0.046	clay	D
		C	0.046	clay	D
61	Selangor	A	0.055	clay	D
		B	0.060	clay	D
		C	0.043	sandy clay	C-D
62	Selangor1	A	0.051	clay	D
		B	0.053	clay	D
		C	0.053	clay	D
63	Sedaka	A	0.050	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
64	Sembrin	A	0.047	clay loam	C
		B	0.054	clay	D
		C	0.054	clay	D

Table 3.4: Soil erodibility factors (K) for Malaysian soil series (continued)

Bi	Series	Layer	K Facto (ton/ha)*(hr/MJ.mr	Texture	HSG
65	Serdang	A	0.036	sandy clay loam	C
		B	0.039	sandy clay loam	C
		C	0.042	sandy clay	C
66	Segamat	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
67	Sitiawan	A	0.051	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
68	Sogomana	A	0.050	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
69	Tavy	A	0.050	clay	D
		B	0.051	clay	D
		C	0.050	clay	D
70	Telemong	A	0.049	clay	D
		B	0.050	clay	D
		C	0.045	clay	D
71	Telok	A	0.051	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
72	Telok1	A	0.045	clay	D
		B	0.049	clay	D
		C	0.054	clay	D
73	Tok Yong	A	0.051	clay	D
		B	0.051	clay	D
		C	0.055	clay	D
74	Tualang1	A	0.052	clay	D
		B	0.054	clay	D
		C	0.055	clay	D

3.3.3 Slope Length and Steepness Factor (LS)

The rate of soil erosion by water is very much affected by both slope length (L) and slope steepness (S) in terms of gradient/ percent slope. Wischmeier and Smith (1978) defined slope length (L) as the horizontal distance (Figure 3.16) from the point of origin of overland flow to either of the following, whichever is limiting for the major part of the area under consideration:

- The point where the slope decreases enough that deposition begins, or
- The point where runoff becomes concentrated in a defined channel

By definition, the factor L is a ratio of field soil loss to that from a 72.6-foot slope, the value of L may be expressed as $(\lambda/\psi)^m$, where λ is the field slope length in feet (or m), Ψ is 72.6-foot (or 22.13 m) and the exponent m in this expression is not the same for all location. The slope-steepness factor (S) reflects the influence of slope gradient on erosion. It is the ratio of soil loss from the field slope gradient to that from a 9-percent slope under otherwise identical conditions.

Both the length and steepness of the land slope substantially affect the rate of soil erosion by water. The two effects have been evaluated separately in research and are represented in the soil loss equation by L and S, respectively. In field application, however, considering the two as a single topographic factor, LS, is more convenient.

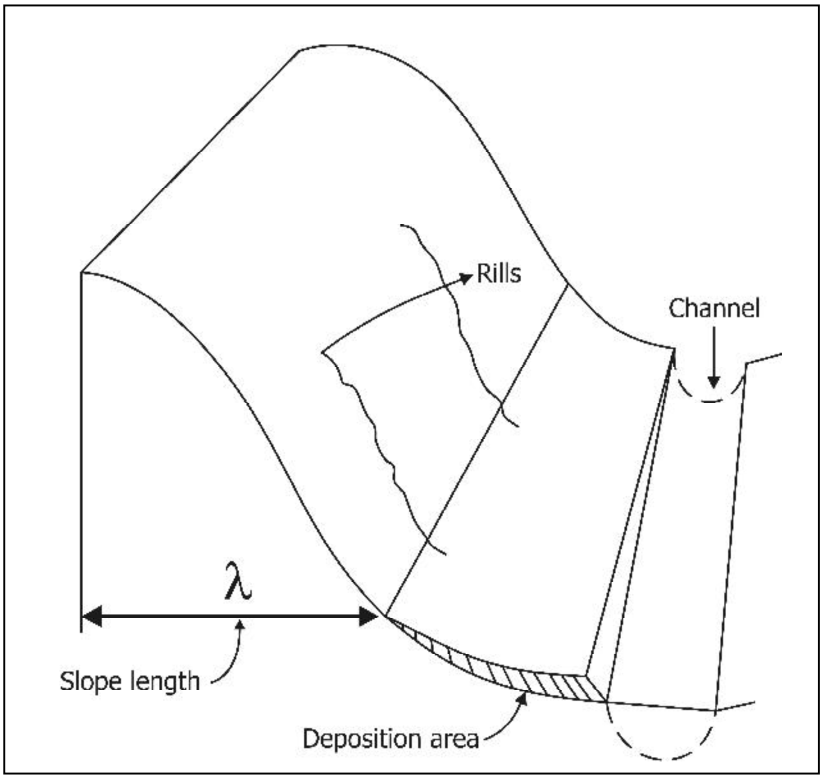

Figure 3.16: RUSLE Schematic slope profile

The LS factor can be calculated using methodology suggested in Chapter 15, MSMA (DID, 2000), which applied the equation defined by Wischmeier (1975);

$$LS = (\lambda / \Psi)^{m} \text{ x } (0.065 + 0.046s + 0.0065s^{2}) \quad (3.9)$$

Where, λ = sheet flow path length (m or feet)
Ψ = 22.13 for SI Units and 72.6 for English Units (BU)
s = average slope gradient (%)
m = 0.2 for $s < 1$,
= 0.3 for $1 \leq s < 3$,
= 0.4 for $3 \leq s < 5$,
= 0.5 for $5 \leq s < 12$ and
= 0.6 for $s \geq 12\%$

The values obtained using different slope length and slope steepness is tabulated in Table 3.5 for practical application.

3.3.4 Cover Management and Erosion Control Practice Factors (C and P)

Crop Management, C factor and Erosion control Practice, P factor are two management factors that can be used to control soil loss at a specific site. The C factors which include such techniques as ground cover, vegetation, and pavements is important to reduce soil erosion at a construction site or disturbed land. If erosion is already taking place then the P factor is needed to stop the silt and sediment in flowing water from running off the site. Combining both the techniques for C and P factors, it is possible to minimize erosion at a construction site and reduce sediment loading to downstream receiving water bodies.

Values of commonly found C related to Malaysian conditions are provided in Tables 3.6 to 3.8. P values for common support practices found in Malaysia in given in Table 3.9. It should be noted that the C and P factors being suggested are of typical values under average runoff condition, and therefore, it should be used with extra caution for other surface and runoff conditions.

Table 3.5: Slope Length and Steepness Factor (LS)

Slope Steepness, s (%)	Slope Length, λ (m)											
	2	5	10	15	25	50	75	100	150	200	250	300
0.1	0.043	0.052	0.059	0.064	0.071	0.082	0.089	0.094	0.102	0.108	0.113	0.117
0.5	0.055	0.067	0.076	0.083	0.092	0.106	0.114	0.121	0.131	0.139	0.146	0.151
1	0.057	0.075	0.093	0.405	0.122	0.150	0.170	0.185	0.209	0.228	0.243	0.257
2	0.089	0.117	0.144	0.163	0.190	0.234	0.264	0.288	0.325	0.354	0.379	0.400
3	0.100	0.144	0.190	0.224	0.275	0.362	0.426	0.478	0.563	0.631	0.690	0.742
4	0.135	0.195	0.257	0.302	0.371	0.489	0.575	0.646	0.759	0.852	0.932	1.002
5	0.138	0.218	0.308	0.377	0.487	0.688	0.843	0.973	1.192	1.376	1.539	1.686
6	0.173	0.273	0.387	0.474	0.612	0.865	1.059	1.223	1.498	1.730	1.934	2.119
8	0.255	0.404	0.571	0.699	0.903	1.277	1.564	1.806	2.212	2.554	2.855	3.128
10	0.353	0.559	0.790	0.968	1.250	1.767	2.165	2.499	3.061	3.535	3.952	4.329
15	0.525	0.909	1.378	1.757	2.388	3.619	4.616	5.486	6.997	8.315	9.506	10.605
20	0.848	1.470	2.228	2.841	3.860	5.851	7.463	8.869	11.311	13.442	15.368	17.145
25	1.249	2.164	3.279	4.183	5.683	8.613	10.986	13.055	16.651	19.788	22.623	25.239
30	1.726	2.991	4.533	5.782	7.855	11.906	15.185	18.046	23.017	27.353	31.272	34.887
40	2.911	5.045	7.646	9.752	13.250	20.083	25.614	30.440	38.824	46.139	52.749	58.846
50	4.404	7.631	11.567	14.753	20.044	30.382	38.749	46.050	58.733	69.798	79.798	89.023
60	6.204	10.751	16.296	20.784	28.239	42.802	54.590	64.875	82.744	98.333	112.420	125.416
70	8.312	14.404	21.833	27.846	37.833	57.344	73.138	86.917	110.856	131.741	150.615	168.026
80	10.728	18.590	28.177	35.938	48.827	74.008	94.391	112.174	143.070	170.025	194.383	216.854
90	13.451	23.309	35.329	45.060	61.221	92.793	118.350	140.648	179.386	213.182	243.723	271.898
100	16.482	28.560	43.289	55.212	75.014	113.700	146.016	172.337	219.803	261.214	298.637	333.159

Table 3.6: Cover Management, C factor for forested and undisturbed lands[1] (modified from: Layfield, 2009; Troeh et al., 1999; Mitchell and Bubenzer, 1980; ECTC, 2003; Ayad, 2003)

Erosion control treatment	**C Factor**
Rangeland	0.23
Forest/Tree	
25% cover	0.42
50% cover	0.39
75% cover	0.36
100% cover	0.03
Bushes/ Scrub	
25% cover	0.40
50% cover	0.35
75% cover	0.30
100% cover	0.03
Grassland (100% coverage)	0.03
Swamps/ mangrove	0.01
Water body	0.01

Note: 1 - average runoff condition

Table 3.7: Cover Management, C factor for agricultural and urbanized areas[1] (modified from: Layfield, 2009; Troeh et al., 1999)

Erosion control treatment	**C Factor**
Mining areas	1.00
Agriculturel areas	
Agricultural crop	0.38
Horticulture	0.25
Cocoa	0.20
Coconut	0.20
Oil palm	0.20
Rubber	0.20
Paddy (with water)	0.01
Urbanized areas	
Residential	
Low density (50% green area)	0.25
Medium density (25% green area)	0.15
High density (5% green area)	0.05
Commercial, Educational and Industrial	
Low density (50% green area)	0.25
Medium density (25% green area)	0.15
High density (5 green area)	0.05
Impervious (Parking lot, road, etc.)	0.01

Note: 1 - average runoff condition

Table 3.8: Cover Management, C factor for BMPs at construction sites[1] (modified from: Layfield, 2009; Troeh et al., 1999; Mitchell and Bubenzer, 1980; ECTC, 2003; Israelsen et al. 1980; HDI, 1987; SCS, 1986; Weischmeier and Smith, 1978; Kuenstler, 2009;)

Erosion control treatment	**C Factor**
Bare soil / Newly cleared land	1.00
Cut and fill at construction site	
Fill Packed, smooth	1.00
Freshly disked	0.95
Rough (offset disk)	0.85
Cut Below root zone	0.80
Mulch	
plant fibers, stockpiled native materials/chipped	
50% cover	0.25
75% cover	0.13
100% cover	0.02
Grass-seeding and sod	
40% cover	0.10
60% cover	0.05
≥90% cover	0.02
Turfing	
40% cover	0.10
60% cover	0.05
≥90% cover	0.02
Compacted gravel layer	0.05
Geo-cell	0.05
Rolled Erosion Control Product:	
Erosion control blankets / Turf reinforcement mats	0.02
Plastic sheeting	0.02
Turf reinforcement mats	0.02

Note: 1 - average runoff condition

Table 3.9: Support Practice, P factor for BMPs at construction/ developing sites[1] (modified from: Layfield, 2009; Troeh et al., 1998; Mitchell and Bubenzer, 1980; ECTC, 2003; Israelsen et al. 1980; HDI, 1987; SCS, 1986; Weischmeier and Smith, 1978; Kuenstler, 2009)

Support/ Sediment Control Practice		**P Factor**
Bare soil		1.00
Disked bare soil (rough or irregular surface)		0.90
Wired log / Sand bag barriers		0.85
Check Dam		0.80
Grass buffer strips (to filter sediment laden sheet flow)		
Basin slope (%)		
0 to 10		0.60
11 to 24		0.80
Contour furrowed surface (maximum length refers to downslope length)		
Slope (%)	Max. length	
1 to 2	120	0.60
3 to 5	90	0.50
6 to 8	60	0.50
9 to 12	40	0.60
13 to 16	25	0.70
17 to 20	20	0.80
> 20	15	0.80
Silt fence		0.55
Sediment containment systems (Sediment basin/Trap)		0.50
Berm drain and Cascade		0.50
Terracing		
Slope (%)		
1 to 2		0.12
3 to 8		0.10
9 to 12		0.12
13 to 16		0.14
17 to 20		0.16
> 20		0.18

Note: 1 - average runoff condition

3.3.5 Curve Number (CN) and Surface Runoff (V)

For runoff estimation, the Curve Number method developed by US National Resources Conservation Services (NRCS) or previously known as US Soil Conservation Service is widely used. It is perhaps the most widely used method by hydrologists to compute runoff from rainfall (Hawkins, 1993; Ponce and Hawkins, 1996). The method's popularity is based partly on the fact that it is relatively easy to use and provides consistent results. This method was developed primarily for agricultural land use, although it has been extended to other land-use types. Perhaps the only method currently available that considers the effects of soil type, land use/treatment, surface condition, and antecedent condition (Ponce and Hawkins 1996) in predicting the runoff volume generated from a storm event.

Tables 3.10 and 3.11 provide runoff curve numbers for various cover types on different hydrologic soil groups in Malaysia. For example Forest in good condition on an HSG "C" soil has a runoff curve number of 70. Figure 3.17 provides a method of determining runoff from rainfall on catchments for specific curve numbers. In the example above, if rainfall is 150 mm in a catchment whose curve number is 70, the runoff will be approximately 70 mm. The volume, V as required in Equation 3.3 can then be calculated by multiplying the runoff depth with the area involved.

For a catchment with sub-areas of different soil types and land cover, a composite runoff curve number can be computed by weighting the CN's for the different subareas in proportion to the land area associated with each CN value (Gumbo et al 2002 and Wong et al 2001) using the following equation, or by using the runoff worksheet provided in Figure 3.18.

$$CN_c = CN_1(A_1/A_{total}) + CN_2(A_2/A_{total}) + \ldots\ldots CN_n(A_n/A_{total}) \qquad (3.10)$$

Table 3.10: CN values factor for forested and undisturb lands[1] (modified from: Shamshad et al., 2008; SCS, 1986; Leow et al, 2009; Seeni Mohd & Mohd Adli, 2000)

Ground Conditions	**CN value**			
	A	**B**	**C**	**D**
Rangeland	59	74	82	86
Forest[2]				
Poor	45	66	77	83
Fair	36	60	73	79
Good	30	55	70	77
Bushes				
<50% cover	54	72	81	86
50 to 75% cover	63	77	85	88
>75% cover	55	66	80	87
Grassland				
< 50% cover	68	79	86	89
50 to 75 % cover	49	69	79	84
>75% cover	39	61	74	80
Swamps/ mangrove	77	80	83	86
Water body	100	100	100	100

Note: 1- Average runoff condition
2 - Poor - small trees, brush are destroyed by having grazing or regular burning.
Fair - woods are grazed but not burn, some forest litter cover the soil.
Good- woods are protected from grazing, litter and brush adequately cover the soil.

Table 3.11: CN factor for agricultural and urbanized areas[1] (modified from: Shamshad et al., 2008; Leow et al., 2009; Fifield, 2004)

Ground Conditions	**CN values**			
	A	**B**	**C**	**D**
Rubber	64	74	81	85
Oil palm	50	66	80	87
Cocoa	64	74	81	85
Coconut	71	80	87	90
Horticulture	62	70	78	81
Paddy	64	75	83	86
Mining areas	68	79	86	89
Bare land/ Newly Graded land	71	86	91	94
Impervious (Pavement, Roof etc)	98	98	98	98
Established Urban Areas: (including Residential, Commercial, Educational and Industrial)				
Low density (50% green area)	57	72	81	86
Medium density (25% green area)	77	85	90	92
High density (5% green area)	89	92	94	95

Note: 1- Average runoff condition

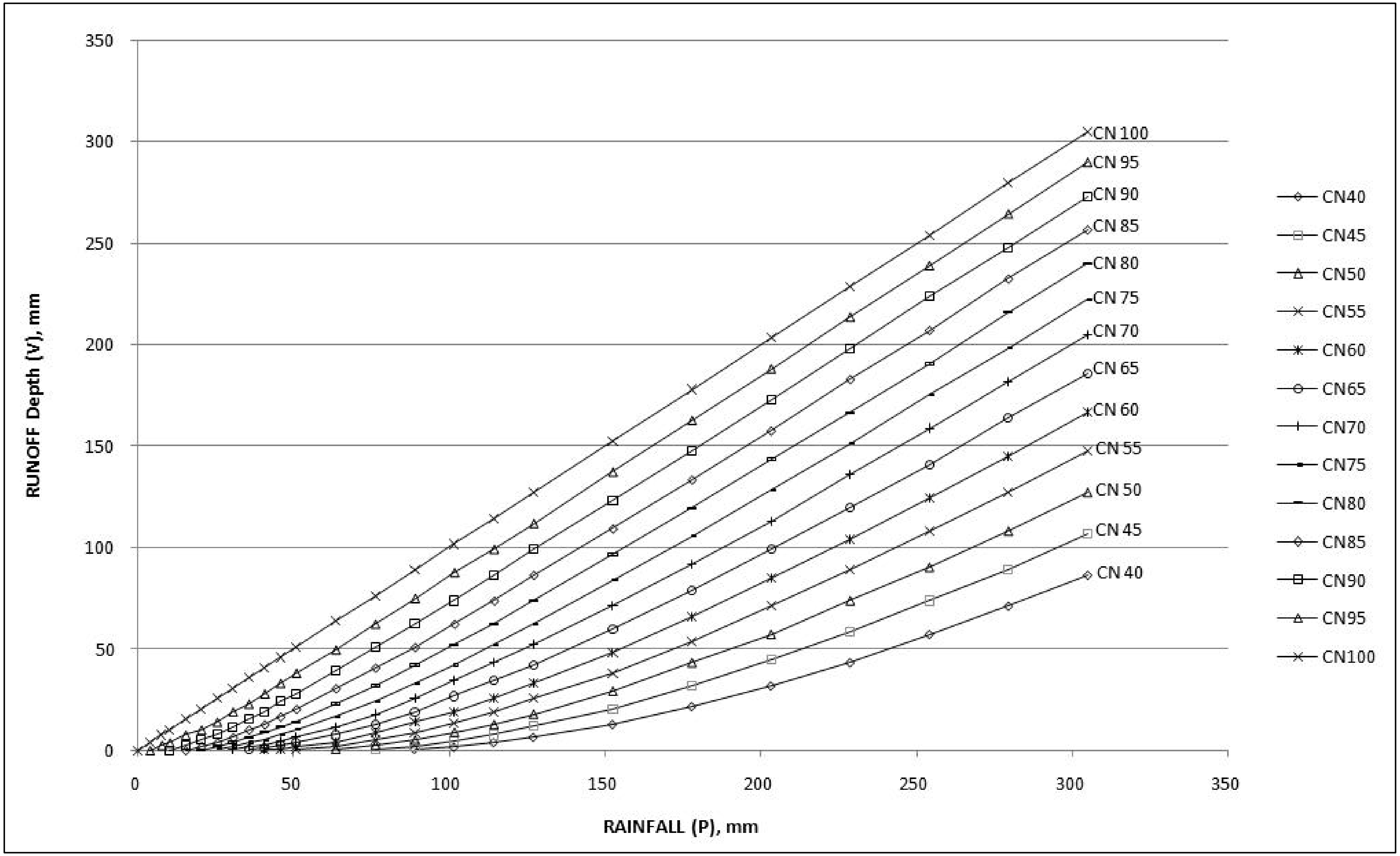

Figure 3.17: SCS Rainfall - Runoff Chart

A schematic diagram showing the overall procedure to determine the value of runoff volume, V is given in Figure 3.18.

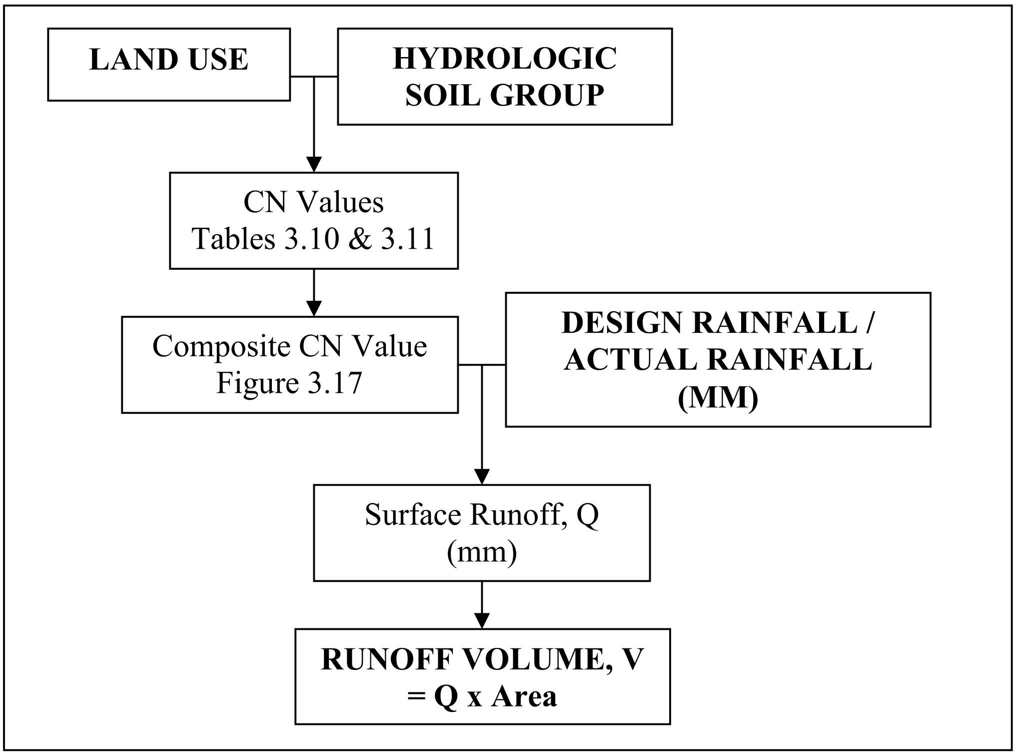

Figure 3.18: Schematic Diagram for determination of runoff volume

3.3.6 Peak Discharge (Q_p)

For the determination of peak discharge, Q_p, A number of methods are available such the Rational Method (DID, 2000), Time Area Method (DID, 2000), TR-55 Graphical Method (SCS, 1986), SCS Triangular Unit Hydrograph (SCS, 1972), etc. However based on the recommendation in MSMA (DID, 2000), the Rational Method (for small catchment only), and Time Area Method are recommended for peak discharge estimation in Malaysia.

3.4 SUMMARY

Estimation of soil loss and sediment yield is important for the soil conservation. They are necessary for the design of BMPs at construction site to reduce the amount of soil loss and sediment that can deteriorate the surrounding environment, in particular water resources. The overall procedure involved for the calculation of soil loss and sediment is summarized in Figure 3.19.

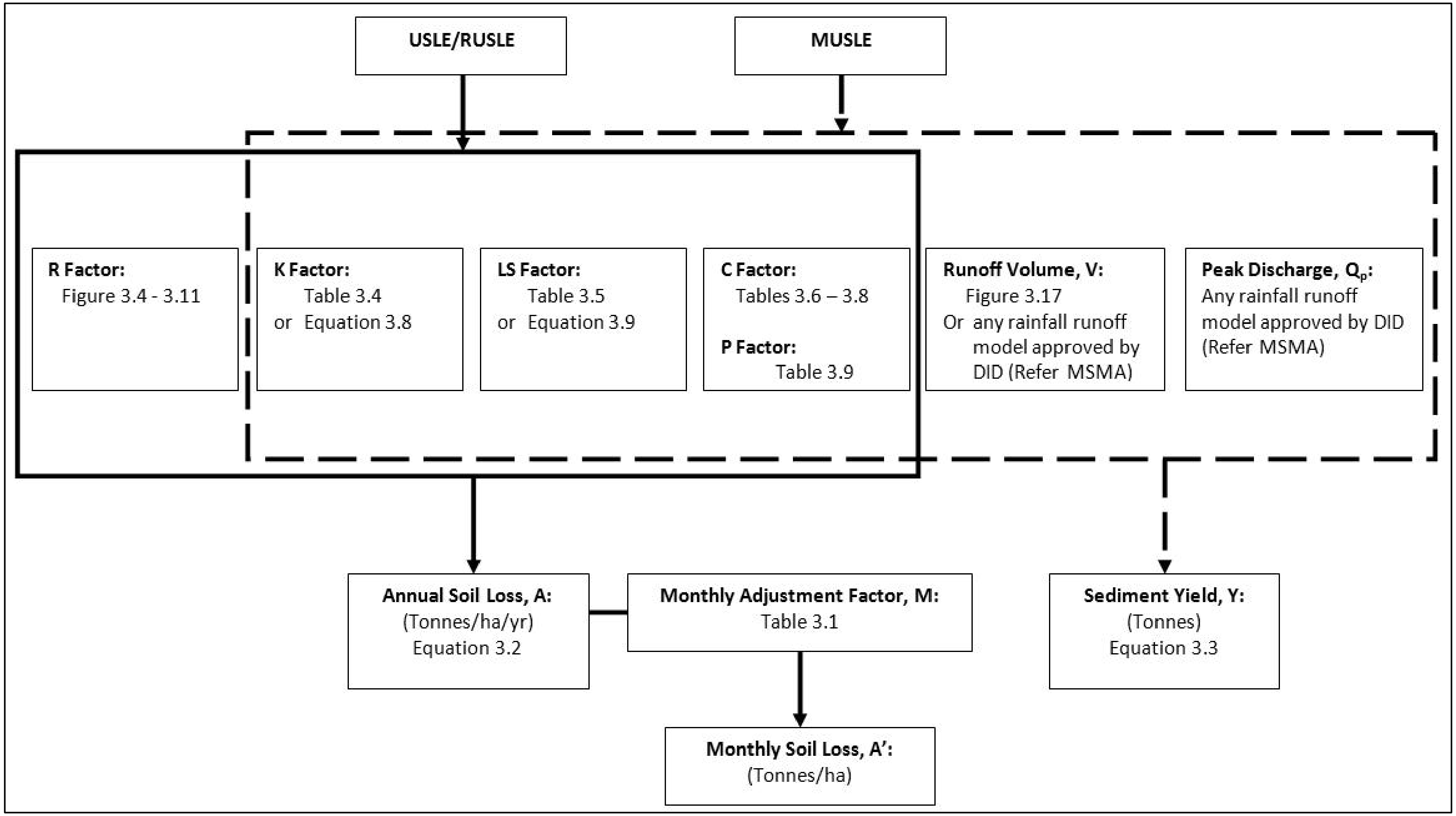

Figure 3.19: Schematic Diagram for determination of Soil loss and sediment yield

CHAPTER 4
EROSION AND SEDIMENT CONTROL PLAN

4.1 INTRODUCTION

Preparing and implementing an ESCP need not be time-consuming and can best be accomplished using and/or slightly revising current planning, design, and construction activities employed by most projects. The best ESCPs are those that are prepared as an integral part of these typical project activities. This is because much of the information required for an ESCP is already part of the project design documentation and because the design may need to be modified to incorporate controls during construction and post-construction activities.

4.2 SUBMISSION REQUIREMENTS FOR CONSTRUCTION ACTIVITY

ESCP must be submitted to Local Authority for development which involves an area of **more than 1 ha** (DID, 2010). However, ESCP can be requested by local authority for any development sites (including those less than 1ha) as a supporting plan, as empowered by the Street, Drainage, and Building Act (1974). ESCP must conformed to the requirements and design criteria laid out in this guideline.

4.2.1 Who Should Obtain Approval?

The ESCP for construction activity should be submitted by the general contractor in charge of day-to-day supervision of site operations, specifically those that include ground-disturbing activity. The reason for this advice was that the applicant should be the individual exercising direct control over operations. However, because site planning lead times tend to be long, and time between award of construction contracts and undertaking of ground disturbing activities are often short, typically developers or their architect-engineers are better situated than general contractors to meet the application deadlines. The guidance of local authorities in the matter is more of a preference than a strict requirement, and may not be consistent with advice given in state program offices.

4.2.2 Deadlines

In order to obtain the permit so that scheduled work can be started on time, it is suggested that the ESCP should be submitted to related local authority ***at least two (2) months*** in advance or longer period according to the requirement of local authority. Approval for ESCP must be obtained from related local authority ***at least fourteen (14) calendar days*** before the beginning of construction activity.

4.2.3 Compliance with Other Plans

The plan must also comply with all requirements in existing rules/regulations listed in Appendix B.

4.2.4 Minimum Requirements of ESCP

A submission checklist (Appendix A) contains all the submission requirements for ESCP is given in the latest edition of MSMA (DID, 2010). Full content required for ESCP is explained in detail in Section 4.6 of this guideline. Among the information provided are:

- General
  - To provide information regarding the name of proposed project, name of developer, engineering firm of individual who prepared the plans, professional engineer etc.
- Site Plans
  - To provide location plan with appropriate scale showing the location and project boundary, general vicinity of the project within 10 km radius, existing development if any in the surrounding area, proposed layout plan showing the proposed main drain reserves, existing outlet drain/river reserve, etc.
- Erosion and Sediment Control Plan
  - To provide a loose leaf binder containing the erosion and sediment control report. The report shall include the minimum coverage of the following information:
    - narrative and mapping on project location and site description
    - narrative and mapping on proposed project development
    - narrative and mapping on erosion and sediment control including the calculation of soil loss, sediment yield and BMPs design.
    - narrative on inspection and maintenance
- Information on final erosion and sediment control plans and detailing.

4.3 GENERIC GUIDELINES FOR ESCP

In order to prepare a comprehensive ESCP, planner is required to provide details that have 8 components as given in Figure 4.1 (DID, 2000).

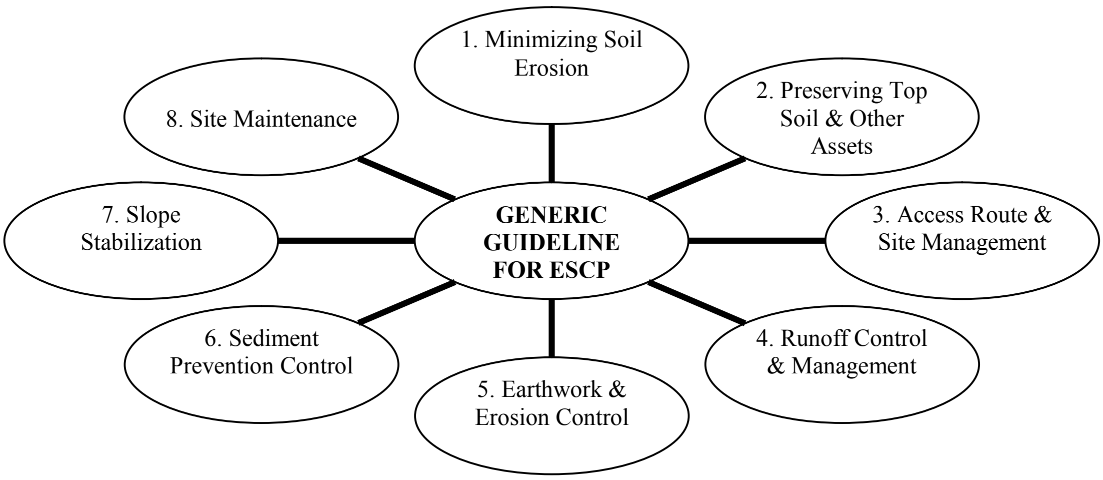

Figure 4.1: Components of generic guidelines for ESCP (DID, 2000)

4.3.1 Minimizing Soil Erosion

- Before development begins, preventative measures shall be put in place to minimise erosion through the preparation of:
  - a preliminary Site Evaluation (PSE)
  - an Erosion and Sediment Control Plan (ESCP)
- 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.
- 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.
- Timing of the development activities shall, wherever possible, spreads evenly over the development time-scale to ensure that the deleterious effects arising from development activities are minimised.
- Development activities shall take into consideration the hydrological and climatic conditions experienced in the area, in particular, the rainfall and runoff patterns.
- 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.
- Stream buffers shall be retained. For rivers, the width of the buffers shall follow DID regulations on river reserves. For small streams/ waterways, the designated reserves width must be clearly stated in ESCP for approval of DID.

4.3.2 Preserving Top Soil and Other Assets

- Sensitive ecological areas within a development site such as salt licks, natural springs, unusual rock outcrops, etc. shall be demarcated and preserved.
- All known archaeological sites within the development site shall be demarcated and preserved. Advice from the Curator of Museum should be sought.
- All known rare and endemic flora and fauna areas or niches within the development site shall be demarcated and preserved.
- 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.
- 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 (DID, 2000).

4.3.3 Access Routes and Site Management

- 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.
- Access roads should be kept to a minimum with other areas off-limits to traffic.
- 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.
- Road shoulders should be protected mechanically or vegetatively against erosion.
- 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.
- 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.
- 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.

4.3.4 Drainage Control/ Runoff Management

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. Further details on BMP measures for Drainage Control/ Runoff Management are provided in Chapter 5.

- 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.
- 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
- Construct drainage routes and channels in such a way that the beds do not degrade and contribute to the sedimentation problems.
- Remove the sediment load accumulated in channels during the dry season to avoid downstream sedimentation.
- 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.

- 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.
- 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.
- Temporary interceptor ditches and berms with filters at inlets should be constructed to direct runoff from the development area into any sediment basin.
- The drainage and deviation of natural watercourses, including provisions of bunds and culvert shall be carried out wherever appropriate.
- 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 is provided with the drainage works.
- 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.
- Drains that are not mechanically stabilised shall be grassed and maintained.
- Ineffective drainage should be noted (especially during wet weather) and promptly corrected (DID, 2000).

4.3.5 Earthwork and Erosion Control

In general, earthworks should be stabilized as early as possible to minimize the rates of soil erosion. Further details on BMP measures for Earthwork and Erosion Control are provided in Chapter 5.

The following activities 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 (DID, 2000).

- 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.
- 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.

- Notwithstanding 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.
- Extraneous runoff shall be directed away from exposed soils by drains.
- Contour plough or deep-rip so as to leave a rough surface to increase infiltration.
- Provide protection covers such as vegetation and plastic sheets on exposed areas.
- Earthworks should be confined to periods of low expected precipitation.
- 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 stabilising the area after grading is completed.
- All earthworks exceeding 1.5 m in height or depth shall not be cut or cleared until the site is ready to be worked.
- Clearing and grading should be done with care to protect and maintain previously installed temporary control measures.
- 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.
- 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.
- 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.
- Maximum gradient of cuts shall vary with soil texture. However, measures taken should ensure that slumping will not occur.
- Land clearing and soil cultivation shall only take place in dry season. Immediately after clearing, conservation measures shall be installed. This shall include silt traps and the maintenance and/ or establishment of a vegetative belt of at least 2 chains away from the edge of permanently flowing waterway. There shall be no obstruction whatsoever to flow by fallen timber or other debris.
- 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.
- On no account should cleared vegetation and debris be deposited or pushed into watercourses, streams, or rivers.
- Holes and cavities resulting from clearing, grubbing, destumping, and derooting shall be backfilled with acceptable materials and compacted to approximate densities of adjacent areas.
- 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).

4.3.6 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 5.

- Wherever feasible, sediment taps and basins shall be installed. They should be adequately sized and constructed prior to the start of earthworks.
- Small temporary sediment traps operates 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.
- 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.
- Sediment traps and other temporary control measures should only be removed and dismantled when the permanent vegetative cover and control measures are satisfactorily established.
- When necessary, erosion and sediment control measures shall be constructed on hauling roads in order to reduce siltation into natural waterways.

4.3.7 Slope Stabilization

- All critical areas along streams must be marked on the ESCP and the recommended methods of stabilisation indicated.
- Stream stabilisation shall be scheduled during periods of dry weather flow whenever possible.
- 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.
- 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.
- All slopes shall be protected against erosion.
- 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.
- 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.
- 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.

- For hilly land (12° and greater) terracing shall be done and maintained. Cover plants shall be established on the slopes of the platforms and walls of the terrace immediately after commencement of earthworks.
- Slope steeper than 35° shall not be worked and should instead be identified, stabilized and maintained.
- No person shall employ any means of temporarily raising the top of any spillways without sanction of the authority concerned

4.3.8 Site Maintenance

- 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.
- All erosion and sediment control measures shall be constructed and maintained by the Contractor.
- Any water discharged from sediment traps and/or sediment basins shall comply with ambient standards for TSS (150 mg/l and below (DOE, 1996)) 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 National Water Quality Standard for Malaysia is as follows:

Table 4.2: Standards for TSS and turbidity in National Water Quality Standard (NWQS) for Malaysia

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.

- The Contractor shall provide all necessary temporary drainage for keeping the site and other areas free of standing water.
- Mitigating measures must be put in place before site clearing and earthworks are carried out.
- 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.

4.4 PLAN PREPARATION STAGES

The ESCP must be prepared before construction begins, ideally during the project planning and design phases. It may be completed at the end of the design phase or early in the construction phase, as shown in Figure 4.2. Implementation of the ESCP begins when construction begins, typically before the initial clearing, grubbing, and grading operations since these activities usually increase erosion potential on the site. During construction, the ESCP should be referred to frequently and refined by the owner and contractors as changes occur in construction operations, which have significant effects on the potential for discharge of pollutants.

The ESCP may be very dynamic for large, complicated projects constructed in multiple stages over a long period of time. Planning, design, and construction of these projects may be occurring simultaneously. In such cases, it may be useful to prepare the ESCP in sections, with each section covering a stage or portion of the project and an overview section generally discussing the entire project.

The following sections give guidance on how to incorporate ESCP preparation into the planning, design, and construction phases of a project.

4.4.1 Planning Phase

The planning phase is the source of much of the information needed for the ESCP. The basis for erosion and sediment control decisions is also made at this phase via the normal review process with the Local Authority. Four activities, which occur during planning that are important to the preparation of an ESCP as shown in Figure 4.3.

(a) Assess Site Conditions / Erosion Risk Assessment

The planning phase of any construction project defines the characteristics of the site and how these characteristics will impact the project. Information on what will be built, how it will be constructed, drainage patterns, soils, topography, rainfall, and special site conditions (e.g. existing vegetation, unique cultural or environmental features) is usually obtained and used for initial planning of public works or land development projects. This information will be used in selecting control measures for the project and typically should be included in or referenced by the ESCP (DID, 2000).

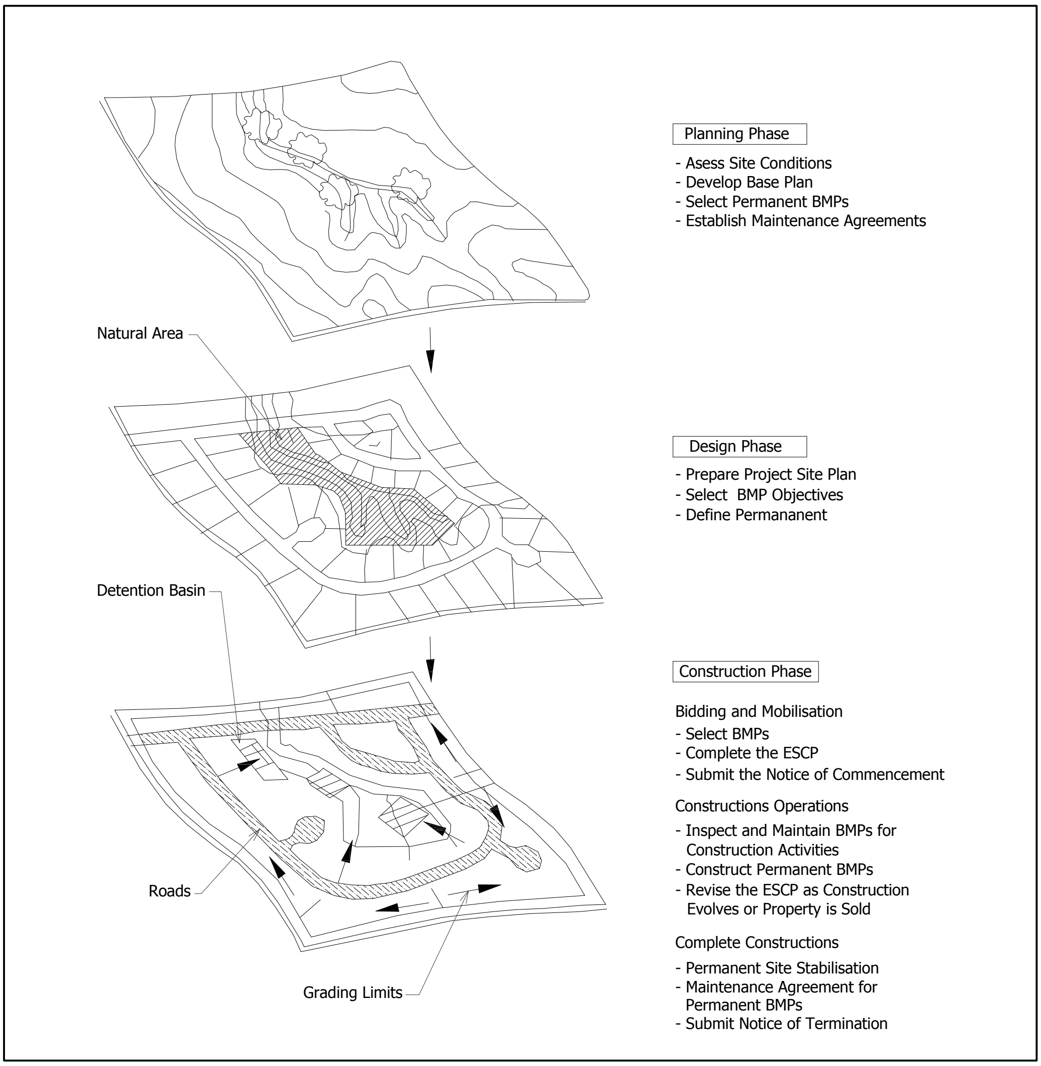

Figure 4.2: Integrating the Preparation of an ESCP into the Normal Site Development Process

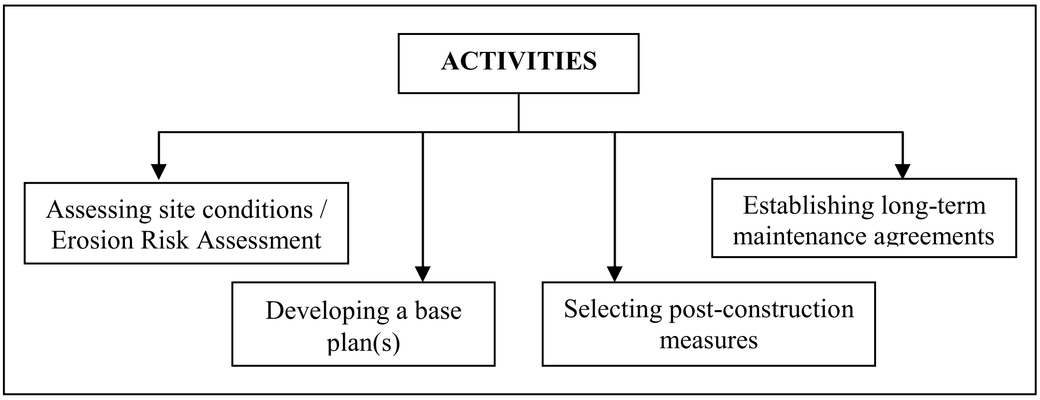

Figure 4.3 Preparation of ESCP: principal activities during planning phase

(b) Develop a Base Plan(s)

The designer will generally prepare a site analysis as either a formal document or as an information plan. The site analysis should review the physical conditions of the site and adjacent areas, the site constraints, and applicable zoning and development requirements. To avoid duplication of effort and reduce costs, the owner and the designer should prepare a site base plan to be shared by the ESCP and other site analyses (Table 4.4).

Table 4.4: Requirement of base plan(s) for construction site

Base Plan(s) of Site for ESCP and Other Site Planning • use a scale large enough to distinguish existing and proposed features of the site • location plan should extend 500 m beyond the property boundary • site plan(s) should show: – topography – limits of construction – conceptual project layout – surface water bodies, watercourses, known wetlands, springs, and wells – locations where drainage leaves or will leave the property – existing land use – existing vegetation – steep or unstable slopes – areas used to store soils and wastes – areas of cut and fill – existing and planned paved areas and buildings

(c) Select Post-Construction Control Measures

Permanent control measures are the final improvements to the configuration of a project which are designed to control long-term stormwater pollution. Permanent measures are normally *selected* in the planning phase in conjunction with the approval of the project master plan, *designed* during the project design phase and *completed* to the satisfaction of the Local Authority and/or the ultimate owner. Occasionally, unforeseen natural or man-made factors may require revisions to or additions of permanent controls during the construction phase. Permanent controls are typically integrated with the normal project features (Table 4.5). In the planning phase (master plan), it is important to indicate the maintenance responsibility for the permanent controls.

During construction, the contractor must ensure that the permanent BMPs are installed properly and that any maintenance that may be necessary during construction is performed. After the project is complete, it will be the responsibility of the owner, private or public, to provide for long-term operation and maintenance.

Table 4.5: Typical functions of post-construction BMPs

Typical Post-Construction BMPs • Stabilise the site by establishing final land grades, contours, and drainage patterns. • Control of the volume, flow, and/or velocity of stormwater runoff by such means as detention and/or retention basins, porous pavements, dry wells, etc. • Channel stabilisation, energy dissipaters, or other drainage structures. • Permanent landscaping, rock riprap, vegetation, or other permanent ground cover designed to stabilise the soil or slopes.

(d) Establish Maintenance Agreements

The Local Authority may have an established policy defining maintenance responsibilities for community infrastructure and may require a maintenance agreement as a condition of approval of a master plan. Two fundamental choices exist for post-construction operation and maintenance of stormwater infrastructure:

Private maintenance: After construction is complete, the property owners retain responsibility for maintenance. The responsible party may be the owner or an association of property owners and/or homeowners. It is advisable that a formal agreement (such as a deed restriction recorded on the property) be drawn up between the Local Authority and the party responsible for maintenance.

Public Maintenance: The Local Authority agrees to assumes responsibility for maintenance for some or all of the infrastructure. Such maintenance may be incorporated into a municipality-wide program, funded from the municipality's general fund or user fee structure. Alternatively, an agency or special district may be established, to assess property owners within the district. Common examples of special funding methods would include community service areas, area drainage plans, and benefit assessment areas.

4.4.2 Design Phase

There are three principal activities that are typically incorporated into the ESCP during the design phase as shown in Figure 4.4. Design considerations for permanent structural water quality control measures are provided in Part G of MSMA (DID, 2000). This section discusses how to incorporate the other two activities with little additional effort beyond normal project design activities.

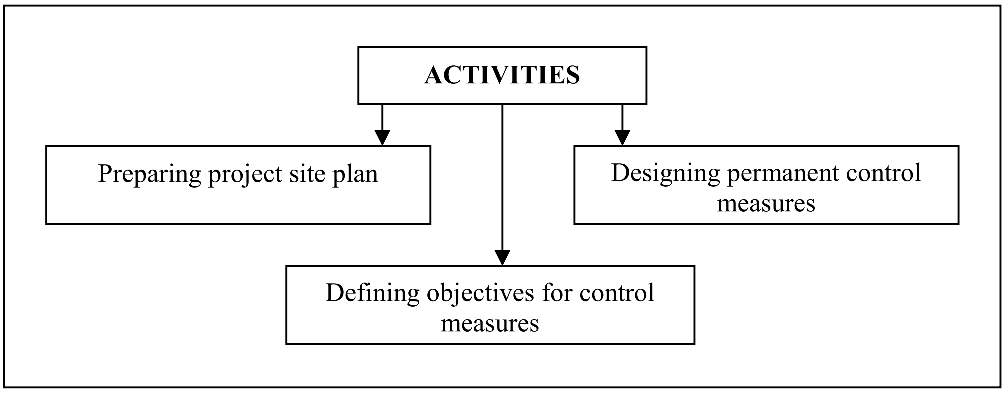

Figure 4.4: Preparation of ESCP: principal activities during design phase

(a) Prepare Project Site Plan

Numerous studies, reports, and documents are typically prepared during preliminary and final design as the basis for many decisions about the project (Table 4.6).

A Hydrology Report, Drainage Study, or similar document is typically required as part of project infrastructure design. Such a study may be required by the Local Authority as a condition of approval of a project master plan for land development, or as part of improvement plans or concept plans for public projects. The Hydrology Report should address the design storm, which will be used for erosion and sediment control.

A Soils Report based upon site soil sampling is normally prepared to identify soil constraints, design criteria, slope stability, etc. Both of these reports should be used by the engineer to prepare the preliminary grading and drainage plan. They also form the technical basis for selection of erosion and sedimentation control and permanent measures. Figure 4.5 shows a typical preliminary site layout based on information, which is usually readily available during the preliminary design phase of a building project. This preliminary site plan includes several items, which are required for the ESCP:

- locations of buildings and paved areas
- proposed flow paths:
  - on-site flow paths where erosion during construction may occur and erosion and sediment control BMPs should be applied
  - locations where runoff will leave the site
  - diversion of or conveyance for upstream runoff
- locations of flood control facilities and permanent structural BMPs
- approximate locations where cut and fill will occur
- access points for construction traffic
- areas where existing vegetation may be preserved
- areas to be paved
- areas most suitable for the contractor's yard, material storage area, and vehicle maintenance area (consider locating in areas to be paved)

Table 4.6: Required studies and reports during project design

Type of Report	Information Available for an ESCP
1. Preliminary Design	
• Soils Report	• areas of highly erodible soils
• EIR/EA	• previous and proposed uses of toxic materials on the site
• Preliminary Site Layout	• locations of buildings and paved surfaces and/or lot layouts
2. Final Design	
• Drainage or Hydrology Report	• drainage patterns and catchment boundaries • stormwater conveyance structures • detention/retention facilities
• Grading/Drainage Plan	• areas of cut and fill • slopes during and after construction • protection of existing vegetation • areas of soil disturbance
• Landscape Plan	• buffer areas and set backs • permanent site stabilisation • multi-purpose uses of open space

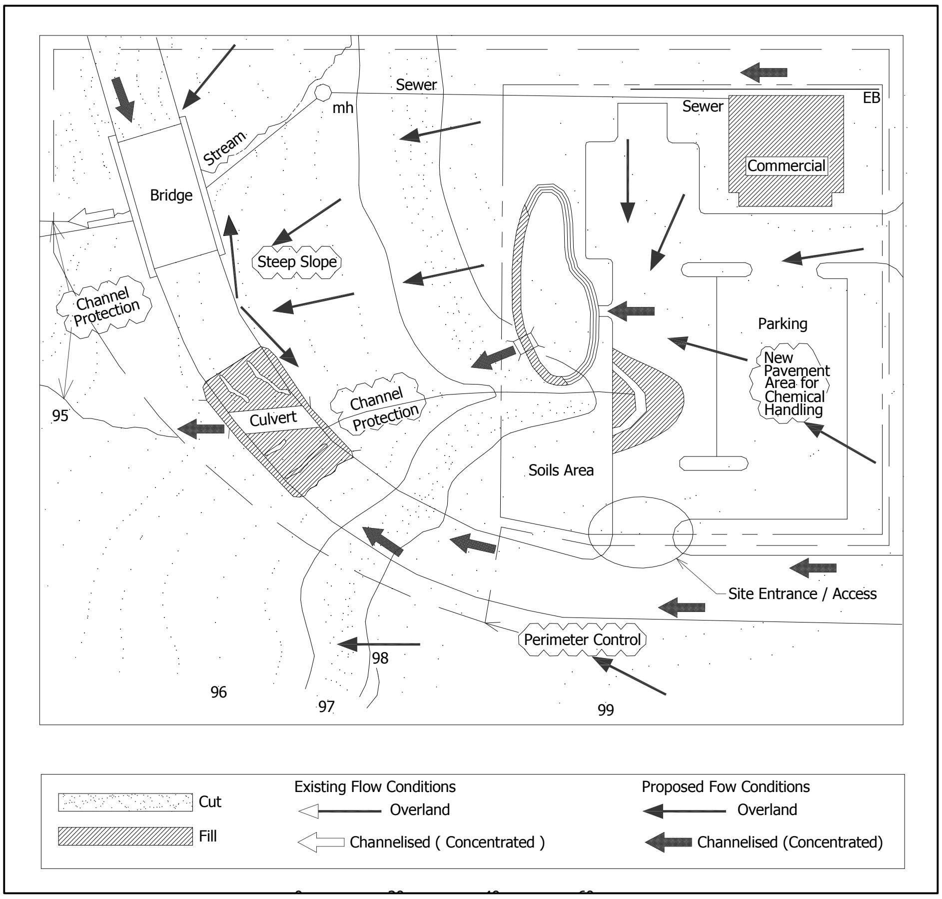

Figure 4.5: Identification of BMPs objectives on preliminary base plan (City of Austin, 1989)

(b) Define Objectives for Control Measures

During the final project design process, the engineer, architect, or landscape architect will prepare detailed grading plans, paving and drainage plans, landscape plans, and other plans as necessary for the successful construction of the project. These plans provide the construction design requirements, specifications, and other construction documents necessary for the construction bidding, permitting, and inspection. For the ESCP to be compatible with the other engineering plans, the most practical process may be for the engineer or architect to develop BMP objectives for the construction period based on contractor activities and the grading and drainage plan for the site.

A narrative discussion of these objectives should be prepared for inclusion in the ESCP, as well as to guide the BMP selection process. The locations of various objectives can be shown on a site plan (Figure 4.6). Determining objectives facilitates the selection of BMPs.

This step can occur as part of the preparation of the grading and drainage plan and be included in the bid package and/or construction documents for consideration by the contractor. This allows the owner to explicitly address unique site conditions, which may impact on stormwater pollution control during construction. Alternatively, the owner could require the contractor to prepare such a plan to justify the selection of BMPs.

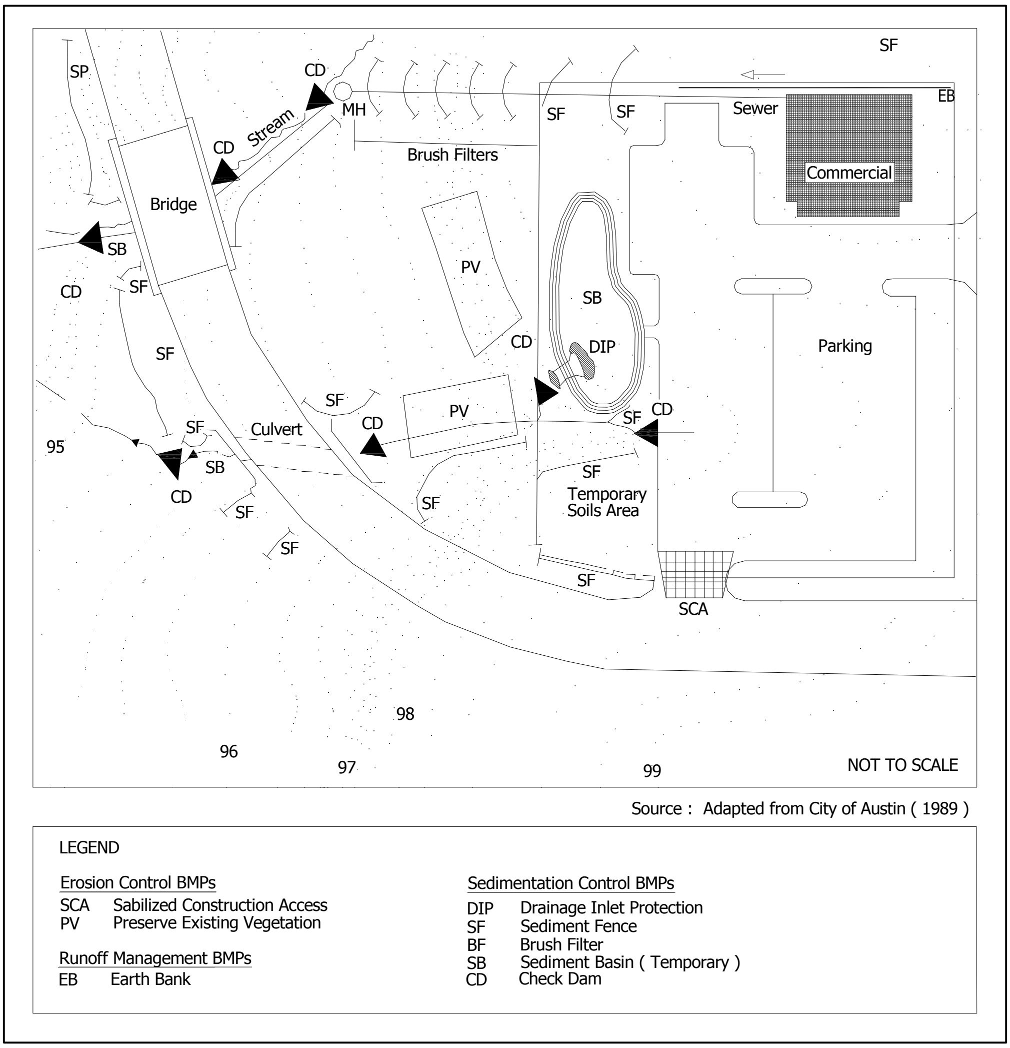

Figure 4.6: Site Plan Showing Locations of BMPs for Erosion and Sedimentation Control (City of Austin, 1989)

4.4.3 Construction Phase

There are three aspects to be considered in preparing an ESCP during the construction phase as shown in Figure 4.7.

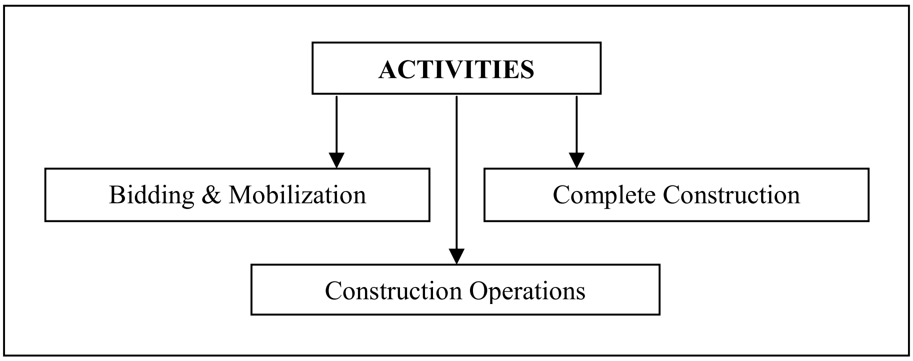

Figure 4.7: Preparation of ESCP: principal activities during construction phase

(a) Bidding and Mobilization

During bidding and mobilisation, the owner selects a contractor(s), who in turn plans and prepares to construct the project according to the construction plans and specifications. Three activities, which should be addressed during this phase, include:

(i) Select BMPs

The owner, the owner's design consultant, or the contractor may perform these activities at the discretion of the owner and the Local Authority. The construction documentation should specify what the responsibilities of the owner and the contractor are with regard to water quality control before, during, and after construction.

(ii) Complete the ESCP

All of the necessary planning work has been done during the site planning and design process. The final step consists of consolidating the pertinent information and developing it into a specific ESCP for the project.

Figure 4.6 is a typical site plan showing locations of erosion and sediment control BMPs based on the BMP objectives indicated in Figure 4.5.

The ESCP should be directed to personnel involved in the construction project (e.g. supervisors, foremen, and inspectors). The ESCP should provide specific guidance on actions to be taken by these personnel, and should be presented in a format which accommodates day-to-day use (e.g. loose leaf, pullout sections, check lists, etc.).

(iii) Train Personnel

Training of construction personnel is imperative to the success of the BMPs plans. Adequate training is required for BMPs to be properly installed and maintained to perform their intended function.

Thus, only trained personnel should be assigned these responsibilities. An effective training program is based on four objectives:

- how to identify a stormwater pollution problem
- how to define solutions (i.e. select BMPs)
- making every employee responsible for preventing stormwater pollution and finding solutions to problems
- soliciting feedback to improve installed BMPs

(b) Construction Operations

During construction, the owner/contractor is responsible for implementing the BMPs according to the ESCP. Because site conditions will inevitably vary during construction, the ESCP should be revised as necessary, with any changes highlighted on the copy maintained at the construction site. There is no formal revision process; upon inspection, the ESCP must reflect the existing status and condition of the site.

(c) Complete Construction

Permanent water quality control BMPs (if any) should be properly installed according to the construction plans and specifications, with responsible parties designated for operation and maintenance and funds committed to long-term maintenance needs. The Local Authority may have a policy concerning the installation and maintenance of permanent BMPs and should therefore be consulted.

Among the post construction obligations to be delivered by contractors include:

- Remove all treatment techniques or structures that are no longer required using method approved by authorities;
- Ensure that sediment and other unwanted materials are disposed in an approved manner;
- Ensure slope/embankment, vegetation and planting areas have been properly established, including area occupied by all temporary erosion and sediment control structures;
- Ensure site access is returned to its original condition or approved final layout depending on site-specific circumstances
- All permanent structures constructed to serve as part of ESCP should be returned to its designed condition, i.e. this might include the removal of sediment from a sediment basin that is to be transferred to the relevant party(s).
- Ensure all safety standards are conformed and that facilities (buildings and infrastructures) are safe to be occupied or used.
- Ensure that all drainage way, pond area, stormwater/ river reserves are properly gazetted in the final site plan after completion
- Produce Standard Operation Procedure (SOP) or Maintenance Plan for stormwater structures whenever deemed necessary by authorities.

4.5 INSPECTION AND MAINTENANCE

The final step in the preparation of an ESCP is to develop a program to monitor how well the BMPs work and to evaluate whether additional BMPs are required. Inspection and Maintenance Plan/Program should be presented as an element of all ESCPs. They are documents that detail the inspection, testing and acceptance requirements for specific activities such as those associated with land development. A Submission Checklist for Inspection and Maintenance (Appendix A) which contains all the submission requirements, and an Erosion and Sediment Inspection Log (Appendix C) are provided in this guideline. Site management should keep a complete set of the Self-audit Check Sheets on site and make them available to any officer of local authority or other authorized person on request. The following sections provide a general description on main tasks/activities to be considered in preparing a monitoring program.

An inspection and maintenance plan should be prepared with the following objectives:

- to inspect BMPs regularly, as well as prior to and after a storm event
- to aid in implementation of the ESCP
- to measure the effectiveness of the BMPs

To meet these objectives, the monitoring effort requires the following elements:

- site inspection
- BMP monitoring
- record keeping
- ESCP review and modification (DID, 2000)

4.5.1 Site Inspection

At a minimum, inspections shall be conducted at the site prior to commencement of land clearing activities, At the start of a construction project (e.g. clearing, grubbing, earth movement), after every storm event during construction, periodically during construction, at the completion of construction activities and removal of any temporary BMPs, and as specified thereafter in an agreed-upon inspection schedule proposed by the developer in consultation with either the contractor who will build the project or a consulting contractor and approved by the planning board and the planning board's consulting engineer, to insure that stormwater management structures or techniques are performing effectively (NHDES, 2008).

The results of the inspection and assessment must be recorded in writing. Inspection records must be retained for three years. A sample inspection form is provided in Appendix D. The written report must contain the following information (DID, 2000; NHDES, 2008):

- the date of the inspection,
- the location of the inspection,
- the person(s) who performed the inspection,
- the observation, e.g. whether construction is in compliance with the approved stormwater management plan, Variations from approved construction specifications.
- Photographic documentation of each erosion and sediment control BMP and any other site level techniques employed pursuant to this regulation, such as but not limited to seeding of fill piles, marking of root zone areas of trees, disposal of construction debris, and implementation of any state or federal level record-keeping or reporting procedures related to erosion and sediment control.
- Recommended actions for replacement, repair, or substitution of BMPs, that are not functioning properly.

It is possible that activities may have changed by type or location since the last inspection. These should be noted. New BMPs and adjustments to the ESCP may be necessary to accommodate such changes.

4.5.2 Monitoring

The type of BMP monitoring depends on the type of BMPs used. For contractor activity BMPs, the monitoring consists of visual inspection to ensure that the BMP has been implemented and maintained according to the ESCP. Such inspection would include:

- looking for evidence of spills and resulting clean-up procedures (e.g. supplies of spill cleanup material)
- examining the integrity of containment structures

- verifying the use of employee education programmes for the various activities
- noting the location of activity (e.g. outdoor vs. indoor, concrete vs. grass)
- verifying adequacy of trash receptacles
- verifying waste disposal practices (e.g. recycle vs. hazardous waste bins)

For sediment and erosion control BMPs, the monitoring program should consist of regular inspection to determine the following (DID, 2000):

(a) Are the installed BMPs effective?
The effectiveness of the BMP would be based on the presence of silt behind or within control devices, the presence of silt downstream of the site, and sign of erosion in stabilised areas after a storm event. The system may be deemed ineffective if:

- silt is present outside of the control area
- structural controls are breached or fail under storm events of minor intensity (e.g. less than 2 year ARI)
- rills and gullies are present in stabilised slopes
- evidence of silt build up in downstream stormwater drains and waterways is apparent
- controls are not maintained in accordance with design guidelines

(b) Have drainage patterns changed?
If the site has undergone significant grading operations, which change the drainage patterns, adjustments to the BMP controls will likely be required to address this change. The inspector shall determine the extent of the drainage pattern changes, if the changes are addressed in the ESCP, and if modifications to the erosion and sediment control BMPs are required to address this change.

(c) Are sediment and erosion control BMPs installed properly?
The ESCP BMPs should include details or references to allow for the proper construction of structural or vegetative erosion and sediment control devices. The inspector should ensure that these systems are installed according to the ESCP in the proper locations.

(d) Are areas stabilised as quickly as possible after completion of construction activities in an area?
Active construction areas (inactive construction areas may be defined as areas in which no construction activity will occur for a period of 30 days or longer) which have been disturbed should be stabilised through the use of vegetation, mulch, erosion control matting or structural methods within 7 calendar days from the last construction activity in the area. If construction, climatological, or other site conditions do not allow stabilisation within 7 days, the ESCP should define alternative approaches (e.g. watering or chemicals for dust control).

(e) Are the BMPs properly maintained?
Maintenance of the erosion and sediment control devices is the most critical as well as potentially the most expensive item in the ESCP. The inspector should inspect the site on a regular basis and after any rainfall of 15 mm or greater to determine maintenance requirements and the general condition of the installed system. The Local Authority may also inspect the site on a typical bi-weekly basis to assess the maintenance performed on the systems. The following maintenance tasks should be performed on a regular basis and all maintenance related to a storm event should be completed within 48 hours of the storm event.

i. Removal of silt from barriers and sediment traps and basins.
ii. Replacement or repair of worn or damaged geotextile fabric.
iii. Repair or replacement or damaged structural controls.
iv. Seeding or mulching of damaged stabilised areas.
v. BMPs for any chemicals or fuels not addressed in the ESCP must be developed.
vi. Any other control maintenance that is specified in the approved ESCP.

Monitoring should also be carried out wherever possible beyond the project boundaries to include the types of landuse or development located upstream or downstream of the project site (DOE, 1996).

4.5.3 Record Keeping

Records of all inspections, compliance certifications, and non-compliance reporting are to be retained for at least 3 years by the owner/developer.

It is suggested that records of incidents such as spills or other episodic releases be kept. Analysing a history of this information can provide insight into modifying the BMPs. The history may suggest a predominance of spills in particular locations, from particular activities, and/or of particular materials. Efforts can be focused accordingly. Photographs may be useful. A record should be kept of maintenance activities or any other BMPs that are of an "action" nature. It is easy to demonstrate that a BMP involving a physical change, such as berming or covering, has been accomplished, but actions that relate to good housekeeping can only be demonstrated by record keeping. Keeping a record of sediment trap cleaning, for example, also provides insight into how soon it takes for the trap to refill (DID, 2000).

4.5.4 Plan Review and Modification

During the course of construction, unanticipated changes may occur which affect the ESCP, such as schedule changes, phasing changes, staging area modifications, off-site drainage impacts, and repeated failures of designed controls. These changes must be made known and the ESCP revised accordingly. During the preparation and review of the modified ESCP, construction may continue with temporary modifications to the erosion and sediment control BMPs.

Revisions to the ESCP are also required when the properly installed systems are ineffective in preventing silt transport off the site. This may be due to unforeseen site conditions or construction techniques, which adversely affect the system as designed. Revisions to the ESCP are also required if there is a new, deleted, or moved activity that could result in the discharge of significant amounts of pollutants (DID, 2000).

4.5.5 Specific Activities

The key to controlling erosion and sediment is the implementation and maintenance of ESCPs. This is best achieved by undertaking a regular site inspection program to ensure that the ESCP is always operating in accordance with its design intent. It requires records to be kept of rainfall, maintenance works, and other matters that contribute to the standard of performance of site work practices. These records might be required for review by DOE or Local Authority Officers, especially if any damage or pollution of the environment occurs during construction. It is recommended that the following activities be undertaken (after NSW EPA, 1996):

(a) When and What to Inspect

Inspections should be undertaken:

- during any storm event that threatens to exceed the available capacity in sediment basins and permanent water quality control structures
- after any storm that has caused runoff
- daily, during hot or dry weather when grass cover is less than 100% on vegetated areas
- weekly (on Mondays) as a matter of site routine for all site work practices
- before site closure or any other time when it might be otherwise unattended for more than twelve hours
- from the site access in a clockwise direction around the site, which will allow others (replacement worker, DOE or consent authority officers) to follow the recorded inspection route

(b) Installation

A logbook should always be kept on site for inspection by DOE or Local Authority Officers with entries made at least weekly on:

- dates of installation and removal of site work practices
- repair of any damage to site work practices
- rainfall depths, durations, and times
- storage capacity available in pollution control structures
- condition of site work practice structures and stabilised surfaces
- time, date, volume, and type of any additions of flocculants
- estimates of water volumes discharged
- estimate of pollutant volumes removed

(c) Typical Program

Begin the following program each Monday or as otherwise required.

- Inspect catch drains, earth banks, table drains, and slope drains and clean as required.
- Remove any stockpiled material or sediment that has encroached within 2 m of surface drain.
- Restore any low spots in earth banks and diversion drains to their original height and compact.
- Where necessary, construct extra earth drains and/or diversion drains that help separate on-site dirty waters from other waters.
- Install any new erosion and sediment control measures that have become necessary since previous inspections because of severe storms or progress in the site's development.
- Check to ensure that all earth banks, diversion drains, and waterways are operating within the safe limits for their surface conditions by noting any evidence of scour.

- Ensure that any construction work at the site since the previous inspection has not diverted sediment and water away from any site work practice.

(d) Removing Sediment and Other Pollutants from Structures

Regularly inspect pollution control site work practices, especially after each runoff event and arrange to remove pollutants as necessary. This might include:

- monitoring dust daily or any time when vehicle movements increase and apply water, soil binder, or a permanent surface sealing agent as necessary
- removal of sediment from sediment basins and traps and disposal in compliance with local regulations
- clearing trash racks of all bulky and floatable material after each heavy storm or as otherwise required to avert flooding of their surroundings

(e) Maintenance of Vegetated Surfaces

Observe revegetated surfaces and ascertain if they are progressing as planned. Where they are not:

- seek professional agricultural advise as appropriate
- consider the following:
  - additional irrigation (watering)
  - application of fertilisers
  - reseeding
  - mulching
  - weed control
  - other forms of maintenance

(f) Repairing Damaged and Breached Structures

Make inspections of all structures for damage, especially after any significant rainfall, and:

- repair, re-pin, or replace torn, detached, or otherwise damaged liners, biodegradable blankets, geofabric, etc
- fill and compact any low spots and breaches in earth banks and diversion drains where vehicles or other factors have reduced the design height or stability
- repair any breached sediment traps or basins, with the benefit of appropriately qualified advice and soil data
- repair (restabilise) any areas of soil erosion to reduce further erosion

(g) Recording, Measuring, Observing, and Sampling Site Work Practice Performances

The Supervising Engineer should:

- Collect any samples of sediment, water, chemical additive, or other pollutants required by the DOE or Local Authority.
- Keep accurate records with respect to the time, place, and nature of the sample.
- Make any necessary declarations with respect to the samples.

4.6 CONTENT OF ESCP

A complete ESCP consist of 3 major components, i.e., report, site plans and engineering drawings, as well as inspection and maintenance plan, shall be submitted as one document for evaluation of relevant authorities for approval.

4.6.1 Report

The ESC Report is a written document, which explains the erosion, sediment, and other pollutant control decisions made for a particular project and the justification for those decisions. The report should contain concise information concerning existing site conditions, construction schedules, and other pertinent items, which are not contained in a typical site plan. The report shall include, but not limited the following subcomponents.

(a) Site Plans

A written text shall be prepared to narrate the site, especially in describing the location, climate, topology and current land use. Information gathered through site investigation, local authorities or any reliable sources shall be furnished in this text. The text shall provide a clear picture of the existing site condition. The proposed development shall also be narrated herein. Details on size of development, the purpose and proposed layout shall be included (DID, 2000).

After existing condition and final objective (development) is described, the planner shall illustrate how ESCP is planned to materialize the development from existing site condition. Items below provide some important points that shall be included. Local authorities may request for other information to facilitate in evaluation process. If more than one phase of activity is planned, description of the following items much be provided for each phase of major earthwork (bulk grading).

- Earthwork Phases
- Securing of site perimeter
- Access points & traffic control
- Management of stockpile
- Slope stabilization
- Erosion control measures
- Runoff management on site
- Sediment control measures
- General inspection & maintenance planning

(b) Site Assessments

The ESCP planner shall carry out assessment to evaluate the site while planning the ESCP. The assessment shall be presented as part of the submission. The methodology used and results of assessment shall be presented to facilitate evaluation of the ESCP. Two assessments are required, i.e. hydrological & hydraulic assessment, and soil loss assessment (DID, 2010).

- Hydrological & Hydraulic Assessment
  - Perform hydrological & hydraulic assessment for pre-, during, and post-construction condition at site.
  - If earthwork is planned in phases, during construction condition shall include individual assessment of site condition for each phase of earthwork.
  - The assessment shall be performed to examine the prefixed design stormed criteria mentioned below, or as instructed by plan evaluator.

- Soil Loss Assessment
  - Perform soil loss assessment using USLE model (or any approved method agreed by evaluator) to assess the soil loss conditions for the site. Site condition to be considered are:
    a) Existing condition
    b) During construction (without ESCP)
    c) During construction (with ESCP)
    d) Post construction (after site is stabilized and ESC removed)
  - For condition b) and c), each phase of earthwork shall be considered separately.
  - Assessment shall be provided for each design points, as determined by the site condition.

(c) Engineering Design & Calculation

The ESC facilities shall be designed in accordance to the assessment result, to ensure than the proposed ESCP is able to minimize soil loss or sediment yield at site during construction. Generally, all ESC temporary facilities shall be designed in accordance to designed criteria proposed in Table 4.7. However, DID reserves the right to increase the protection level should the site condition/location is deemed critical/ sensitive environmentally (DID, 2010).

Table 4.7 Proposed Temporary ESC Facilities Design Criteria

Construction Period	Water Quality Criteria	Water Quantity Criteria
< 2 years	first 40mm of rainfall	up to 2 years ARI
2 years and above	first 50mm of rainfall	up to 10 years ARI

While most erosion control measures can be applied without design, other ESC components must be provided with design calculation to justify its application. These components include:

- Runoff management system such as, diversion channels, waterway crossing, natural stream protection (temporary or permanent) for the site.
- Sediment control facilities for the site to counter identified erosion on site, including check dams, sediment basin & silt fence.
- Slope stabilizing structures (if any) such as retaining wall and terracing.

The design must state clearly the dimension and location of the facilities. Calculation must prove that the proposed facilities will be able to serve the site in accordance to standard design procedures.

(d) Other Supporting Documents

The ESCP Report shall be furnished with the following documents to facilitate plan evaluation by the relevant authorities.

- Bill of Quantities (BQ)
- Specification/ Installation Instruction of materials/ commercial product proposed.

The BQ should be prepared such that each individual ESC facility is billed independently. This is to ensure all proposed facilities are included in budget and that contractors shall have no construction/ maintenance/ financial constrain in carrying out the ESCP.

4.6.2 Site Plans & Engineering Drawings

Site Plans are simple illustrations of the project site, showing key physical ESC-related features including levels, slopes, ESC facilities, site management (access roads) etc. Site plans shall provide a clear impression and interpretation of all ESC controls designed for the site. Essentially, site plans shall be provided for 2 stages, i.e. pre-bulk grading and post bulk grading. Engineering drawings shall be prepared for all ESC facilities proposed.

(a) Pre-bulk Grading Site Plan

The pre-bulk grading site plan shall clearly portray the existing land condition and the planned grading activity to transform the terrain into the final development levels. This shall include the following information,

- Pre development topology – drainage pattern, contour, and catchment delineation
- Areas (with quantity) in which grading (cut & fill) will be performed
- Specify grading phasing.
- Specify stockpile management (location, protection etc)
- Perimeter controls including buffer, hoarding and site perimeter drains.
- Delineate new catchment area based on graded topology (to be used for ESC facilities design)
- Identify and delineate waterway buffers
- Specify ESC facilities (size, location etc) to be implemented at this stage

(b) Post-bulk Grading Site Plan

The pre-bulk grading site plan shall clearly portray actual construction site condition after the major earth work or grading is completed. The plan shall essentially show the ESC practices to be implemented, which includes,

- The graded contour (topology after major earthworks)
- Project development phasing

- Proposed drainage patters and catchment delineation
- Specify ESC facilities (size, location etc) to be implemented at this stage

(c) Engineering Drawings

Engineering drawing shall be prepared for all ESC facilities selected for the site. This shall consists but not limited to,

- Typical engineering drawings for erosion control facilities such as erosion blanket.
- Detailed engineering drawings for temporary and permanent (if the permanent components are used as ESC facilities) runoff management facilities such as diversion drain and swales.
- Detailed engineering drawings for sediment control facilities such as check dams and sediment basin
- Detailed engineering drawings for slope stabilization such as terracing and retaining wall.

4.6.3 Inspection & Maintenance Plan

Every BMP installed on a construction site must be checked periodically and maintained sufficiently to ensure proper performance. An Inspection and Maintenance Plan should be prepared and implemented. The purpose of the plan is to:

- Clearly specify personnel assigned/responsible for BMP inspection and maintenance.
- Determine maintenance requirements of any BMP and subsequently present regular maintenance schedule.
- Determine and present methods/ procedures/ checklist/ record logs to be used for in-house BMPs inspections.

The plan shall provide the following details in regards of Inspection & Maintenance Plan (Appendix C).

- *Schedule for Inspection & Maintenance* – a Gantt Chart indicating the scheduled date for regular inspection and expected facilities maintenance. Major maintenance such as servicing of sediment basin, must be included.
- *State responsibility of stakeholders* – a list of contacts to summarise person (or party) in charge of all ESCP aspects (from design, construction, maintenance, inspection, and operation).
- *Record Keeping* – The database used in record keeping shall be specified. Methods used to store engineering drawings, ESCP plans, inspection results & maintenance log etc, shall be clearly stated. If applicable, example of templates can be provided.

CHAPTER 5
EROSION AND SEDIMENT CONTROL FACILITIES

5.1 INTRODUCTION

In order to control sediment yield from construction sites, ESCP are to be site tailored to provide holistic plan for management and control of erosion and sediment processes on site. To achieve this objective on implementation level, many erosion and sediment control facilities are designed and developed throughout the years to meet the stringent environmental requirements of construction sites. While some Best Management Practices in ESCP are non-structural practices, physical/ structural facilities can go the distance in contributing to soil erosion and sediment control at site. Generally, soil erosion are divided into 3 main groups, targeting 3 major contributor of sediment yield from construction site, that is, erosion control, runoff management and finally, sediment control.

This chapter gives detail review of the most commonly used/applied ESC facilities in the country. Typical engineering drawings of the facilities are given in Appendix D, while design examples of some facilities are made available in Appendix E for reference.

5.2 EROSION CONTROL FACILITIES

Erosion control BMPs protect the soil surface and prevent soil particles from being detached by rain and wind. These tend to be the least expensive and most effective BMPs. Erosion control treats soil as a resource with value and works to keep it in place. Erosion control BMPs are the first line of defence against erosion and sedimentation.

The following information is provided on each BMP:

- a description of the BMP
- suitable applications
- design/ application criteria
- maintenance requirements (where applicable)
- relative cost (where applicable)
- limitations

5.1.1 Seeding & Planting

a) Description

Seeding of grasses and planting of trees, shrubs, and ground covers provides long-term stabilisation of soil (Figure 5.1). For example, vegetation may be established along landscaped corridors and buffer zones where they may act as filter strips. Additionally, vegetated swales, steep or rocky slopes and stream banks can also serve as appropriate areas for seeding and plantings.

Figure 5.1: Examples of seeding and turfing

b) *Planning Consideration*

- Appropriate for site stabilisation both during and after construction.
- Any graded/cleared areas where construction activities have ceased.
- Open space cut and fill areas.
- Steep slopes.
- Spoil stockpiles.
- Vegetated swales.
- Landscaped corridors.
- Stream banks.
- When stripping a site, topsoil should be stockpiled for later use.
- Where a suitable planting medium is not present, topsoil shall be imported and incorporated into the site.
- Irrigation should be supplied until seeds and plants are stabilized.
- Low maintenance plants, as well as native species, should be used to ensure long-lasting erosion control.

c) *Design / Application Criteria*

- Manufacturer/supplier must be consulted to confirm appropriate method of seeding and seed species to ensure successful germination and provide an effective measure.
- Effective on shallow slopes typically 2H: 1V or flatter.
- For interim erosion control measures, the proponent must ensure no sediment is entrained off the area and must provide at minimum temporary seeding of native or non-invasive species.
- Caution should be used when seeding during drought/ dry conditions. Subsequent applications of mechanical seeding may be required for successful vegetation establishment and soil stabilization.
- A minimum 150 mm of top soil should be applied to all areas subject to permanent landscaping.
- All seeded areas should be mulched, and the mulch should be adequately secured.
- If hydro-seeding is conducted, mulching should be conducted as a separate, second operation.

- All containerized nursery stock should be kept in a live and healthy condition prior to installation.
- Seedbed surface should be rough, firm but not too loose or too compacted.

Type of vegetation, site, and seedbed preparation, planting time, fertiliser, and water requirements should be considered for each application. Table 5.1 lists the recommended vegetation for slope or erosion protection.

(i) Grasses/ Ground Cover
- Select grasses that are tolerant of short-term temperature extremes and waterlogged soil conditions.
- Soil must be fertilised and mechanically stabilised.
- Use in shallow-based soils with good drainage and ground slope of 2(H):1(V) or flatter.
- Grasses develop well and quickly from seeds.
- Mowing, irrigating, and fertilising are vital for promoting vigorous grass growth.

(ii) Trees and Shrubs
- Select trees and shrubs on the basis of vigor, species, size, shape, and wildlife food source.
- Select species appropriate for soil, drainage, and acidity.
- Other factors that should be considered are wind exposure, temperature extremes, and irrigation needs.

d) Maintenance Requirements

The following maintenance are recommended for seeding and planting:
- Shrubs and trees must be adequately watered, fertilised, and pruned if needed.
- Grasses may need to be watered and mowed.
- Access to and grazing on recently revegetated areas should be limited with temporary fencing and signage while plants are becoming established (normally the first year).
- Weed infestations should be managed using appropriate physical, chemical, or biological methods as soon as possible.
- Stakes and guy wires for trees should be maintained and dead or damaged growth should be pruned.
- Mulch should be maintained by adding additional mulch and redistributing mulch, as necessary.
- Areas of excessive erosion should be repaired and stabilized.
- Some sites, particularly large ones, may have to be cleared and seeded several times during the project construction period.

Table 5.1: List of trees, shrubs and ground cover suitable for erosion control

Scientific Name	Local Name
Trees	
Andira surinamensi	Kedondong Hutan
Cassia surattensis	Yellow Cassia
Cassia Fistula	Rajah Kayu
Cassia spectabilis	Cassia
Fagraea fragrans	Tembusu
Khaya senegaliensis	Khaya
Mellettia atropurpurea	Tulang daing
Pheltophorum pterocarpum	Batai Laut
Shrubs	
Cassia biflora	Bushy Cassia
Caesalphina pulcherrima	Jambul
Dillenia suffruticosa	Simpoh Air
Dillenia indica	Simpoh India
Hymenocallis littoralis	Spider lily
Heliconia spp	Siantan
Mussaenda eryhrophylla 'Dona luz'	Janda Kaya
Melastoma malabathricum	Senduduk
Ground Cover	
Arachis pintoi	Arachis
Wedelia trilobata	Wedelia
Pandanus pygmaeus	Pandanus

(Source: NLDM, 2008)

e) Limitations

- Irrigation is sometimes required, especially during dry period. Irrigation source and supply may be limiting.
- Fertiliser requirements may have the potential to create stormwater pollution if improperly applied.
- Seeding & planting on steep and long slope is not encouraged as it provides minimal protection and stabilization effect. Furthermore, seeding in steep slope is difficult to maintain and growth rate is slow. Designers should consider geotextile blanket for additional erosion protection.
- Construction activities are likely to injure or kill trees unless adequate protective measures are taken. Direct contact by equipment is the most obvious problem, but damage is also caused by root stress from filling, excavation, or compacting too close to trees.
- Temporary seeding can only be viable when adequate time is available for plants to grow and establish.

5.1.2 Mulching

a) Description

Mulching is a temporary ground covering that protects the soil from rainfall impacts, increases infiltration, conserves moisture around trees, shrubs, and seedings, prevents compaction and cracking of soil, and aids the growth of seedings and plantings by holding the seeds, fertilisers, and topsoil in place until growth occurs. Figure 5.2 shows the example of mulching works.

Mulching can be used either to temporarily or permanently stabilise cleared or freshly seeded areas. Types of mulches include organic materials, straw, wood chips, bark or other wood fibres, decomposed granite, and gravel. A variety of mats of organic or inorganic materials and chemical stabilisation may be used with mulches.

Primary functions of mulching include:

- To reduce runoff and erosion
- To conserve moisture
- To promote germination of seed
- To prevent surface compaction or crusting
- To protect seed from birds
- To modify soil temperature
- To increase biological activity in the soil

Figure 5.2: Examples of mulch application

b) Planning Consideration

- Temporary stabilisation of freshly seeded and planted areas.
- Temporary stabilisation during periods unsuitable for growing vegetation.
- Temporary stabilisation of areas that cannot be seeded or planted (e.g. steep slopes).
- Mulches such as gravel and decomposed soils may be used as permanent BMPs.

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. Surface mulch is one of the most effective means of controlling runoff on disturbed land.

There are several forms and methods of mulching. The choice of materials for mulching will be based on the type of soil to be protected, site conditions, landscape requirements, and economics. Additionally, consider that:

- Organic mulch materials, such as straw, wood chips, bark, and wood fibre, have been found to be the most effective where re-vegetation will be provided by reseeding.
- Chemical soil stabilizers can enhance the mulching effectiveness by binding organic mulches together or to stabilize flat areas such as roadways.
- A variety of nets and mats developed for erosion control may also be used as mulches, particularly in critical areas such as waterways. They may be used to hold other mulches to the soil surface.
- Seeding or other re-vegetation methods should be used in conjunction with mulching. Decomposed granite, gravels and bark are also effective as ground cover in landscaped areas.

c) Design Criteria

Mulching consists of furnishing all materials, preparing the soil surface, and applying the mulch to all soil surface areas designated on the project plans or established by the Engineer.

d) Installation/Application Criteria

The choice of mulch should be based on the size of the area, site slopes, surface conditions (such as hardness and moisture), weed growth, and availability of mulch materials.

- May be used with netting to supplement soil stabilisation.
- Apply to planting areas where slopes are 2(H):1(V) or greater.
- Binders may be required for steep areas, or if wind and runoff is a problem.
- Type of mulch, binders, and application rates should be recommended by manufacturer/contractor.

e) Maintenance Requirements

Maintenance requirements vary greatly based on the type of mulch used and the type of vegetation to be established. Inspection of the application should be performed along with other regularly scheduled erosion and sediment control inspections. Any areas that have washed out due to high storm water flows should be reconsidered for different BMP use, or at least retreated. Areas that have been disturbed by blowing wind should be retreated. Maintenance needs identified in inspections or by other means shall be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

f) *Limitations*

- Organic mulches are not permanent erosion control measures.
- Mulches tend to lower the soil surface temperature, and may delay germination of some seeds.
- Mulches are susceptible to erosion and may be washed away in large storm events.
- Maintenance is necessary to ensure that mulches provide effective erosion control.
- Chemical soil stabilizers are less effective than mulches when used alone.

5.1.3 Geotextile & Mats

a) *Description*

Mattings made of natural or synthetic material, which are used to temporarily or permanently stabilise soil (Figure 5.3). Mattings reduce erosion from rainfall impact, hold soil in place, and absorb and hold moisture near the soil surface. Additionally, mattings may be used alone or with mulch during the establishment of protective cover on critical slopes.

The primary functions of geotextile include:

- To prevent erosion of the soil surface
- To promote seed germination
- To protect young vegetation
- To prevent erosion of seed
- To prevent wind dispersal of seed or mulch
- To allow for easy installation of seed and/or mulch

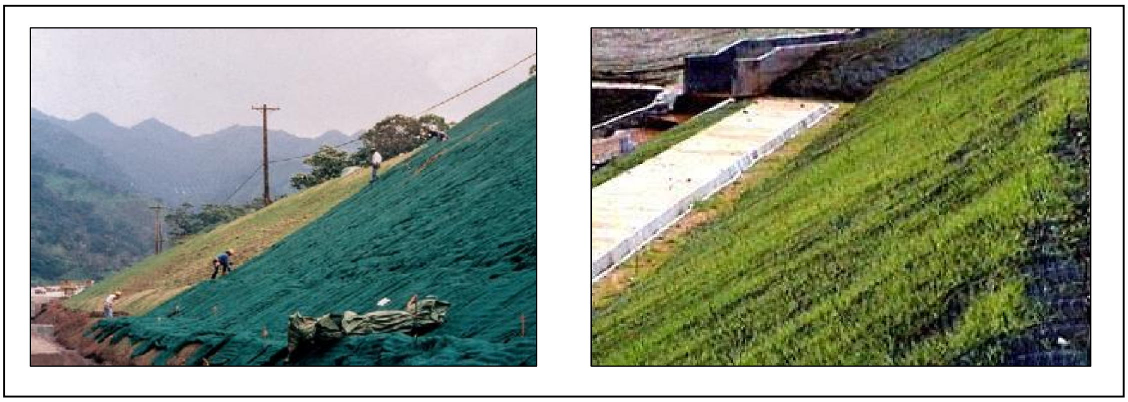

Figure 5.3: Example of mattings using Geotextile

b) *Planning Consideration*

Some general considerations for geotextile and mats applications are:

- Can be used to protect steep slope (steeper than 2:1) by providing medium for plant growth and retain eroded soil.

- Can be used in unlined channel (swale, diversion drain, earth banks) to protect channel bank/ embankment subjected to shear force induced by flowing water.

Care must be taken to choose the type of blanket or matting which is most appropriate for the specific needs of a project. Manufacturer's recommendations should be followed when choosing products.

c) Design Criteria

The application of geotextile does not require professional design for most uses. If hydrostatic pressure is a concern for stability of a retaining wall, consult a professional experienced in the selection of geotextile fabric.

Matting for conveyance system such as swale or channel bank shall fulfil hydraulic requirements of the conveyance (Refer swale and waterways design in MSMA) for maximum flow velocity, shear force, and toe scouring.

d) Installation/Application Criteria

Geotextiles should be installed according to manufacturer's specifications. The installation site should be prepared without voids, and without rocks, clods, or debris greater than 25mm in size. The geotextile should be placed loosely, with no wrinkles or folds, in direct contact with the soil surface.

Overlap of successive sheets should place the upstream or upslope sheet on top of the downslope sheet. Field joining of sheets should be accomplished by sewing or thermal welding for critical applications such as stream diversions or steep slopes. Field joining for regular applications may also be accomplished by overlapping and then using stakes or staples in the overlapped portion. The amount of overlap depends on the size and positioning of the stakes or staples.

Aggregate should be placed carefully onto geotextile to prevent damage. It should never be dumped from a height greater than 1.5m. Damaged portions may be patched with fabric overlapping on all sides a minimum of one foot, or the specified seam overlap, whichever is greater. Construction vehicles should not be driven directly onto the geotextile.

Planners are encouraged to refer to manufacturers for installation method and requirements when choosing a geotextile or mat. Due to difference in manufacturing materials, techniques, and product properties, method of installation may vary significantly.

e) Maintenance Requirements

- Inspect monthly and after significant rainfall.
- Re-anchor loosened matting and replace missing matting and staples as required.
- Reapply or replace temporary soil stabilization when protected area becomes exposed or exhibits visible erosion.

f) Relative Cost

Relatively high compared to other BMPs.

g) Limitations

- Mattings are more costly than other BMP practices, limiting their use to areas where other BMPs are ineffective (e.g. channels, steep slopes).
- Installation requires an experienced contractor to ensure soil stabilisation and erosion protection.
- Generally not suitable for excessively rocky sites, or areas where the final vegetation will be mowed (since staples and netting can catch in mowers).
- Mats of plastic sheets are easily vandalized, easily torn, photodegradable, and must be disposed of at a landfill.
- Plastic sheets results in 100% runoff, which may cause serious erosion problems in the areas receiving the increased flow.

5.2 RUNOFF MANAGEMENT FACILITIES

Runoff management is a process to control the direction, volume and velocity of the transport medium and safely convey stormwater so that its potential for erosion is reduced. They help to direct stormwater away from exposed soils. Transport control should direct the flow to areas where the sediment can be trapped and removed.

The four D's of Transport Control are:

- Decrease the amount of runoff
- Detain runoff to reduce its velocity
- Divert runoff from erodible areas
- Dissipate the flow of runoff

The following information is provided on each BMP:

- a description of the BMP
- suitable applications
- design/ application criteria
- maintenance requirements (where applicable)
- relative cost (where applicable)
- limitations

5.2.1 Earth Bank

a) Description

A temporary earth bank is a temporary berm or ridge of compacted soil used to divert runoff or channel water to a desired location, thereby reducing the potential for erosion and off-site sedimentation. Earth banks may also be used to divert runoff from off-site and from undisturbed areas away from disturbed areas, and to divert sheet flows away from unprotected slopes.

An earth bank does not in itself control erosion or remove sediment from runoff, it prevents erosion by directing runoff to an erosion control device such as a sediment trap or basin or directing runoff away from and erodible area. Temporary earth banks should not adversely impact adjacent properties and must conform to any local floodplain management regulations. They should not be used in areas with slopes greater than 10%.

b) Planning Consideration

Earth banks are typically used to divert concentrated runoff through disturbed areas into another BMP (e.g. a sediment trap or basin), to divert runoff away from disturbed or unstable slopes, to divert runoff from off-site and undisturbed areas around disturbed areas, and as a containment for construction materials and wastes. The banks should remain in place until the disturbed areas are permanently stabilised. The banks must be on-site and must safely convey anticipated flood flows.

c) Design Criteria

Table 5.2: Design criteria for temporary earth bank (DID, 2000)

Parameter	**Requirement**
Design Storm	2-year ARI
Contributing catchment area	Not more than 4 hectares
Dimension	Side Slope: 2:1 or flatter Height: Minimum of 450mm Top Width: Minimum of 600mm
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated.
Scour Protection	• Inlet & outlet protection shall be provided. • Channel bed and banks can be stabilised using various erosion control method such as turf, riprap or geomats.
Embankment Material	95% compaction by earth moving machine

d) Installation/ Application Criteria

- All banks should be compacted by earth-moving equipment.
- All banks should have positive drainage to a stabilised outlet.
- Top width may be wider and side slopes may be flatter at crossings for construction traffic.

- Banks should direct sediment-laden runoff into a sediment trapping device.
- Banks should be stabilised with vegetation, chemicals, or physical devices.

e) Maintenance Requirements

- Inspect periodically and after every significant rainfall.
- Repair as necessary

f) Relative Cost

Relatively cheap, as most material, labour and machinery can be found at site.

g) Limitation

- Earth banks may create more disturbed areas on site and become barriers to construction equipment.
- Earth banks must be stabilised immediately, which adds cost and maintenance concerns.
- Diverted stormwater may cause downstream flood damage.
- Re-grading the site to remove the bank may add additional cost.

5.2.2 Diversion Channel

a) Description

Temporary diversion channels (Figure 5.4) may be used to divert off-site runoff around the construction site, divert runoff from stabilised areas around disturbed areas, and direct runoff into sediment traps or basins. Diversion channels should be installed when the site is initially graded and remain in place until permanent BMPs are installed and/or slopes are stabilised. A temporary channel constructed to convey stream flow around in-stream construction.

Figure 5.4: Example of diversion channels.

b) Planning Consideration

A temporary diversion channel should be provided at the top of a cut or fill slope to safely divert runoff to a location where it can be safely brought to the bottom of the slope. Temporary diversion channels are appropriate for diverting any upslope runoff around unstabilised or disturbed areas of the construction site in order to:

- Prevent slope failures.
- Prevent damage to adjacent property.

Prevent erosion and transport of sediments into waterways.

- Increase the potential for infiltration.
- Divert sediment-laden runoff into trapping devices.

Several key considerations for considering diversion channel are as below:

- All temporary swales should have uninterrupted grade to an outlet.
- Diverted runoff from a disturbed area shall be conveyed to a sediment trapping device.
- Diverted runoff from an undisturbed area shall discharge directly into an undisturbed stabilized area at non-erosive velocity.

c) Design Criteria

Table 5.3: Design criteria for temporary diversion channel

Parameter	**Requirement**
Design Storm	2-year ARI
Dimension	Side Slope (if applicable): 2:1 or flatter
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated.
Scour Protection	• Inlet & outlet protection shall be provided. • Channel bed and banks can be stabilised using various erosion control method such as turf, riprap or geomats. • Perform checking of maximum shear & velocity • Must conform to channel/ drainage design criteria given in MSMA.
Embankment Material	95% compaction by earth moving machine

d) Installation/Application Criteria

Diversion channels are only effective is they are properly installed. They are more effective than earth banks because they tend to be more stable. Temporary diversion channels will effectively convey runoff and avoid erosion if built properly. Several important considerations for installation include:

- All trees, brush, stumps, and obstructions, may need to be removed and disposed of so as not to interfere with the proper functioning of the swale, but can remain for sediment filtration.
- Fills should be compacted by earth moving equipment.
- All earth removed and not needed on construction should be placed so that it will not interfere with the functioning of the swale

e) Maintenance Requirements

- Inspect weekly and after each rainfall.
- Repair any erosion immediately, which commonly includes:
  - ditches and berms for washouts
  - lost riprap
  - damaged linings or soil stabilizers
- Remove sediment, which builds up in the channel and restricts its flow capacity.
- Temporary conveyances should be completely removed as soon as the surrounding drainage area has been stabilized, or at the completion of construction.
- For diverted natural waterways, diversion channel should be inspected at the end of each day to make sure that the stream flow control measures and construction materials are positioned securely.

f) Relative Cost

The cost of a diversion channel increases with drainage area and slope. Typically, channels for controlling internal erosion are inexpensive.

g) Limitation

- Temporary diversion channels or any other diversion of runoff should not adversely impact upstream or downstream properties.
- Temporary diversion channels must conform to local floodplain management requirements.
- Swales can be expensive to construct if a liner is required.
- Interceptor swales must be stabilized quickly upon excavation in order not to contribute further to the sediment loading.

5.2.3 Drainage Outlet Protection

a) Description

Drainage outlet protection (Figure 5.5) is a physical device composed of rock, grouted riprap, or concrete rubble which is placed at the outlet of a culvert, conduit, or channel to prevent scour of the soil caused by high flow velocities, and to absorb flow energy to produce non-erosive velocities. Various products can also be installed for velocity reduction including hydrobrakes, vortex valves, and drop shafts. Alternatively, designer can opt for energy dissipaters such as ripraps, gabions, plunge pools or energy dissipating basins. Outlet protection and velocity dissipation reduces the velocity and energy of the runoff water, thereby preventing the flow from eroding the receiving downstream reach.

Figure 5.5: Examples of drainage outlet protection.

b) Planning Consideration

Several planning considerations for drainage outlet protection include:

- Outlet protection should be provided wherever discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach.
- Rock outlet protection is best suited for temporary use during construction because it is usually less expensive and easier to install than concrete aprons or energy dissipaters.

- A sediment trap below the drainage outlet is recommended if runoff is sediment-laden.
- Permanent rock riprap protection should be designed and sized by an engineer as part of the culvert, conduit, or channel design.
- The selection of rock/rip rap size is crucial in determining the stability of structure. Outlet with high discharge will required more rigid structures such as gabions, or even concrete structures.

c) Design Criteria

The hydraulic design of drainage outlet protection shall comply with erosion and scour protection recommended in MSMA (DID, 2000). The designed structure shall also be checked for seepage and structural stability.

d) Installation/Application Criteria

Rock outlet protection is effective when the rock is sized and placed properly. When this is accomplished, rock outlets do much to limit erosion at pipe outlets. Rock size should be increased for high velocity flows. The best results are obtained when sound, durable, angular rock is used.

e) Maintenance Requirements

- Inspect after each significant rainfall for erosion and/or disruption of the rock, and repair immediately.
- Grouted or wire-tied rock riprap can minimise maintenance requirements.
- Inspect apron for displacement of the riprap and/or damage to the underlying fabric. Repair fabric and replace riprap that has washed away.
- Inspect for scour beneath the riprap and around the outlet. Repair damage to slopes or underlying filter fabric immediately.
- Temporary devices should be completely removed as soon as the surrounding drainage area has been stabilized, or at the completion of construction.

f) Relative Cost

The cost is very much dependant on the type of protection/ design requirements. Riprap basin/ apron is relatively cheaper than most rigid structure such as a concrete stilling basin.

g) Limitation

- Large storms often wash away rock outlet protection and leave the area susceptible to erosion.
- Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.

5.2.4 Temporary Waterway Crossing

a) Description

A temporary access waterway crossing is a temporary culvert, ford, or bridge placed across a waterway to provide access for construction purposes for a period of less than one year. The purpose of a temporary crossing is to provide a safe, erosion-free access point across a waterway for construction equipment. An engineer should establish minimum standards and specifications for the design, construction, maintenance, and removal of the structure. Crossings may be necessary to prevent construction equipment from causing erosion of the waterway and tracking of pollutants into the waterway.

There are two main temporary access waterway crossings that are generally constructed:

- Temporary Bridge Crossing: A temporary access bridge causes the least erosion of the stream channel crossing when the bridge is installed and removed. It also provides the least obstruction to flow and fish migration. Provided that the bridge is properly designed and appropriate materials are used, a temporary access bridge typically is long lasting and requires little maintenance. It may also be salvaged at project's end and used again in the future. However, a temporary bridge crossing is generally the most expensive crossing to design and construct. It also creates the greatest safety hazard if not adequately designed, installed, and maintained.

- Temporary Culvert Crossing: A temporary access culvert is the most common stream crossing. It can control erosion effectively, but can cause erosion when it is installed and removed. A temporary culvert can be easily constructed and enables heavy equipment loads to be used. However, culverts create the greatest obstruction to flood flows and are subject to blockage and washout.

b) Planning Consideration

Temporary waterway crossings should be installed at all designated crossings of perennial and intermittent waterways on the construction site, as well as for dry channels which may be significantly eroded by construction traffic.

A crossing may be required:

- Where construction equipment or vehicles need to frequently cross a waterway.
- When alternate access routes that do not cross streams impose significant constraints to the project
- Construction activities will not last longer than one year.

For temporary crossings of streams with large catchments, the crossing may also be designed based on the low-flow channel conditions as a low water crossing. The culvert size would be adequate to convey base flows, but high water events would overtop the structure and make the crossing temporarily unusable.

c) Design Criteria

The design of temporary crossing should generally comply with specifications outlined by culverts design in this manual and further incorporate criteria as below:

Table 5.4: Design Criteria for Temporary Crossing

Parameter	Requirement
Design Storm	2-year ARI
Dry Weather Flow	To be prepared to allow existing natural flow regime
Overspill	All flow greater than 2 year ARI shall safely bypass the crossing
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated.
Hydraulic	Refer Culvert Design of MSMA.
Scour Protection	Inlet & outlet protection shall be provided.

d) Installation/Application Criteria

- Traffic shall be prohibited until the access way (temporary crossing) is constructed and surrounding area stabilized.
- The bed of crossing shall be laid with a minimum depth of 200 millimetres of gravel/ riprap to prevent scouring and erosion.

e) Maintenance Requirements

- Inspect weekly and after each significant rainfall, including assessment of foundations.
- Periodically remove silt, debris, from crossings and surroundings.
- Replace lost aggregate from inlets and outlets of culverts.
- Remove the crossing when it is no longer required.
- Rehabilitate the area following the vegetation management plan or other site rehabilitation plan.

f) Relative Cost

The cost can be high if bridge crossing is required considering the foundation of the structure. Normal culvert crossing however are relatively much cheaper and flexible to be moved.

g) Limitations

- May be an expensive measure for a temporary improvement.
- Requires other BMPs to minimise soil disturbance during installation and removal.
- Upstream & downstream flooding problems need to be assessed.

5.3 SEDIMENT CONTROL FACILITIES

Sedimentation control BMPs collect sediment on the site in selected locations and minimize the sediment transfer off the site. Sedimentation controls are generally passive systems that rely on filtering or settling of soil particles out of the water or air. Sedimentation control treats soil as a waste product and works to remove it from the transport system. Sedimentation control BMPs are the last line of defence against erosion and sedimentation.

The following information is provided on each BMP:

- a description of the BMP
- suitable applications
- design/ application criteria
- maintenance requirements
- relative cost
- limitations

5.3.1 Check Dams

a) Description

A check dam (Figure 5.6) is a small temporary dam constructed across a diversion channel or swale. Check dams reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the diversion channel or swale and promoting sedimentation behind the dam. Small barriers consisting of rock, sand bag, or earth berms are suitable material for check dams.

Figure 5.6: Examples of check dam.

b) Planning Consideration

- Primarily used in small channels in steep terrain where velocities exceed 0.6 m/s.
- Used to prevent erosion by reducing the velocity of channel flow in small intermittent channels and temporary swales.
- May also promote sedimentation behind the dam, but should not be considered to be a primary sediment trapping device because subsequent storms will scour and resuspend much of the trapped sediment.

- Many commercial products such as gabions and sand bags can be used effectively as check dams.
- A deep sump may be provided immediately upstream of the check dam to capture excessive sediment.

c) Design Criteria

Table 5.5: Design criteria of check dam for sediment control

Parameter	Requirement
Design Storm	2-year ARI, unless specified otherwise by Authorities
Overspill	All flow greater than 2 year ARI shall safely bypass the crossing.
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated.
Dimension	• Height (centre) of dam shall not exceed 1m • For rock check dam: ▪ Upstream slope: 2:1 or flatter ▪ Downstream slope: 4:1 or flatter • Centres of the dam shall be notched to centre to promote concentrated flow (approx. 0.15m) • Outer sides of dam shall be at least 0.5m higher than centre to avoid undermining. • Spill crest shall be of at least 100mm in width parallel to flow
Intervals	Series of check dam can be placed such that the height of subsequent check dam must be equal or lower than the base of the check dam before it.
Geotextile	Check dam with height more than 450mm shall be laid with geotextile to avoid seepage & structural failure.
Scour Protection	• Structure shall withstand sheer force induced by a 2 year ARI flow. Materials (rocks, earth, gabion) must be selected to meet this requirement. • Additional scour protection downstream of check dam shall be provided if deemed necessary.

d) Maintenance Requirements

- Inspect for sediment build-up and signs of erosion around the check dam after each rainfall.
- Remove accumulated sediment/debris whenever it reaches one-third of the height of the dam, or one-half of the sump depth if a sump is provided.

- Removal of a check dam should be completed only after the contributing drainage area has been completely stabilized. Permanent vegetation and mulching should replace areas from where the check dam has been removed.
- Replace stone and repair dams as necessary to maintain the correct height and configuration.

e) Relative Cost

Relatively inexpensive. Construction will only require minimal labour and easily available materials.

f) Limitation

- Use only in small open channels.
- Not to be used in streams, or in lined or vegetated channels.
- Check dams are not to be used as a stand-alone substitute for other sediment trapping devices.

5.3.2 Silt fence

a) Description

A sediment fence (Figure 5.7) is a temporary sediment barrier consisting of filter fabric stretched across and attached to supporting posts, entrenched, and, depending upon the strength of the fabric used, backed by a wire fence for support. This measure does NOT filter runoff, but acts as a linear barrier creating upstream ponding which allows soil particles to settle out thereby reducing the amount of soil leaving a disturbed area. The sediment control fence also decreases the velocity of sheet flow and low to moderate level concentrated flows.

They are relatively effective at retaining suspended solids coarser than 0.02 millimetres. They are simple to construct, relatively inexpensive and easily moved as development progresses. Sediment fences are generally ineffective in locations where the flow is concentrated and are only applicable for sheet or overland flows.

Figure 5.7 Examples of silt fence.

b) Planning Consideration

- Along the perimeter of the site.
- Below the toe of a cleared slope.
- Along streams and channels.
- Around temporary stockpiles.
- Below other small cleared areas.

c) Design Criteria

Table 5.6: Design criteria of silt fence for sediment control

Design Parameter	Requirement
Design Storm (Both Quantity & Quality)	• First 40mm rainfall for site < 2 year construction period • First 50mm rainfall for site ≥ 2 year construction period
Maximum Contributing Area	0.4 hectares
Hydraulic	For any point along the fence, • Concentrated flow shall not exceed 50l/s • Maximum water depth shall not exceed 600mm
Sitting of facility	• SHALL NOT be installed in areas receiving concentrated flow, i.e. stream or ditches. • Maximum length of each fence segment shall not exceed 30m • The at least 1m from ends of each segment shall be turned uphill to prevent runoff flowing around the fence
Slope	• Slope draining to fence shall be 1:1 or flatter • Length of draining to fence shall not exceed 60m
Storage Area	Storage area to be provided behind fence. Approximately 280m^2 per ha of contributing area is required.

d) Installation / Application Criteria

- Leave an undisturbed or stabilised area immediately downslope of the fence.
- Select filter fabric which retains 85% of the soil, by weight, based on sieve analysis, but is not finer than an equivalent opening size of 70.
- Sediment fences should remain in place until the disturbed area is permanently stabilised.
- Posts should be spaced a *maximum* of 1.5m apart and driven securely into the ground a *minimum* of 900mm.

- A trench should be excavated approximately 200mm wide and 300mm deep along the line of posts and upslope from the barrier.
- The use of joints should be avoided. When joints are necessary, filter cloth should be spliced together only at a support post, with a minimum 150mm overlap and both ends securely fastened to the post.
- The trench should be backfilled with 20mm minimum diameter washed gravel or compacted native material.
- The ends of the filter fence should be turned uphill to prevent stormwater from flowing around the fence.
- Provide an undisturbed or stabilized outlet suitable for sheet flow.

e) Maintenance Requirement

- Inspect weekly and after each rainfall.
- Repair wherever fence is damaged.
- Remove sediment when it reaches one-third of the height of the fence.
- A supply of sediment control fence should be kept on site to provide for quick repairs or the installation of an additional fence as required.
- If any section of silt fence is knocked down frequently (because it was installed in an area of concentrated flow) then other measures such as a sediment trap and diversion or super silt fence must be given consideration and installed as replacement.

f) Limitations

- Do not place the fence on a slope, or across any contour line.
- Do not use in streams, channels, or anywhere the flow is concentrated.
- Do not use in locations where ponded water may cause flooding.
- Silt fences are less effective in areas with predominately clay soil types.
- Silt fences will create a temporary sedimentation pond on the upstream side of the fence, which may cause temporary flooding.
- Silt fences are not practical for large/ concentrated flows.
- Silt fences may not filter runoff effectively if the pore size of the fabric is incorrectly selected.

5.3.3 Sediment Traps

a) Description

A sediment trap is a small temporary ponding area, usually with a gravel outlet, formed by excavation and/or construction of an earthen embankment (Figure 5.8). The purpose of the trap is to detain runoff from disturbed areas for a long enough period of time to allow for a majority of the coarser suspended soil particles in the runoff to settle out. It is intended for use on small catchment areas with no complex drainage features, where construction will be completed in a reasonably short period of time.

The trap is a temporary measure with a design life of approximately six months, and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures. This practice is one of the most efficient and cost effective methods of sediment control. When possible, sediment traps should be constructed as a first step in any land-disturbing activity.

Figure 5.8: Example of Sediment Trap.

b) Planning Consideration

- Any disturbed area less than 2 hectares.
- Around and/or upstream of drainage inlet protection measures.
- At any point within the site where sediment-laden runoff can enter stabilised or natural areas or waterways.
- Sediment trap must be placed where it poses least threat to safety hazard (especially for children) and shall be properly secured with fencing.

c) Design Criteria

Table 5.7: Design criteria of sediment trap for sediment control

Design Parameter	Requirement
Runoff Quantity Design	Up to 10 years ARI
Runoff Quality Design	Water Quality Design Storm for ESCP • First 40mm rainfall for site $<$ 2 year construction period • First 50mm rainfall for site $\geq$ 2 year construction period
Overspill	All flow up to 10 year ARI shall safely bypass the trap.

Table 5.7: Design criteria of sediment trap for sediment control (continued)

Design Parameter	Requirement
Runoff Retention	All flow up to runoff quality design flow shall be retained within basin. Extended drawdown can be permitted by authority when deem necessary.
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated.
Maximum Contributing Area	2 hectares
Storage Volume	• Total Storage: 125 m^3/ ha of contributing area • Permanent Pool: half of total storage
Basin Dimension	• Minimum length to width ratio: 2:1 • Minimum depth of 1m • Depths exceeding 2m are not recommended. In unavoidable circumstances, provide perimeter fencing for safety.
Embankment	• Inside embankment: 2:1 or flatter • Outside embankment 3:1 or flatter • Max embankment height should not exceed 1.5m
Lining Materials	• Suitable size rocks/ rip raps.
Erosion Protection	Outlet protection shall be provided for the emergency spillway.

d) Installation/Application Criteria

- Construct the trap outside the area to be graded before clearing, grubbing, and grading begin.
- Locate where sediment can be easily removed.
- The outlet of the trap must be stabilised with rock, vegetation, or another suitable material.
- The fill material for the embankment must be free of roots and other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable matter. The embankment may be compacted by traversing with equipment during construction.
- Proper compaction control must be used when constructing the embankment to ensure its stability;
- The spillway installation is critical to prevent failure of the structure during high flows and all specifications provided by the designer must be implemented;

e) Maintenance Requirements

- Inspect weekly and after each rainfall.
- Remove sediment when the sediment storage zone is no more than 300 mm from being full.
- If captured runoff has not completely drained within 36 hours. Then the sediment trap must be dewatered.
- Inspect trap banks for embankment seepage and structural soundness.
- Inspect outlet structure and rock spillway for any damage or obstructions. Repair damage and remove obstructions as needed. Inspect outlet area for erosion and stabilize if required.
- Inspect fencing for damage and repair as needed.

f) Limitations

- Only used for drainage areas up to 2 hectares
- Only removes coarse sediment (medium silt size and larger).
- Requires large surface areas to permit infiltration and settling of sediment.
- Requires protective fencing and can pose safety hazard for children.
- Not to be located in live streams.

5.3.4 Sediment Basin

a) Description

A sediment basin (Figure 5.9) typically consists of an impoundment, a dam, a riser pipe outlet, and an emergency spillway. The size of the structure will depend upon the location, size of the drainage area, soil type, land cover/use, rainfall amount, and any unique site conditions favourable to producing high runoff volume, velocity, or sediment. The basin is a temporary measure (with a design life of 12 to 18 months) and is to be maintained until the site area is permanently protected against erosion or a permanent detention basin or water quality control structure is constructed.

Sediment basins are suitable for nearly all types of construction projects. Wherever possible, sediment basins should be constructed before clearing and grading work begins.

Figure 5.9: Example of sediment basin

b) Planning Consideration

- At the outlet of all disturbed catchment areas greater than 2 hectares.
- At the outlet of smaller disturbed catchment areas, as necessary.
- The basin MUST not be located in a stream/ natural waterway but should be located to trap sediment-laden runoff before it enters the stream
- Preferably, where permanent detention basins or water quality control structures will be located.
- Should be used in association with earth banks, diversion channels pipes, and other measures used to divert disturbed areas into the basin and divert undisturbed areas around the basin.
- Type of sediment basin shall be determined by site soil properties (Table 5.8).

Table 5.8 Sediment Basin Types and Design Considerations (DID, 2000)

Category	**Soil Description**	**Hydrological Soil Group**	**Basin Type**	**Design Considerations**
I	Coarse-grained sand, sandy loam: less than 33% <0.02mm	A	Dry	Settling velocity, sediment storage
II	Fine-grained loam, clay: more than 33% < 0.02mm	B	Wet	Storm impoundment, sediment storage
III	Dispersible fine-grained clays as per type F, more than 10% of dispersible material	C, D	Wet	Storm impoundment, sediment storage, assisted flocculation

c) Design Criteria

Table 5.9: Design criteria of sediment basin for sediment control

Design Parameter	**Requirement**
Basin Type	Refer Table 5.8
Runoff Quantity Design	Up to 10-years ARI
Runoff Quality Design	Water Quality Design Storm for ESCP • First 40mm rainfall for site < 2 year construction period • First 50mm rainfall for site ≥ 2 year construction period
Runoff Control	• All flow up to runoff quality design shall be retained within trap • Basin should drain in 24 hrs (dry)/ 36 hrs (wet) after water quality design storm. • Primary outlet/riser should be used to control stormwater runoff. • Emergency spillway for conveying flow up to 10 years ARI
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated
Minimum Contributing Area	2 hectares
Storage Volume	Total Storage: Refer Table 5.10 (Dry) or Table 5.11 (Wet) Settling zone volume: half of total storage Sediment zone volume: half of total storage
Basin Dimension	• Minimum length to width ratio: 2:1 • Maximum length to settling depth ratio: 200:1 • Minimum settling zone depth: 0.6m • Minimum sediment storage zone depth: 0.3m
Embankment	• Side slope: 2:1 or flatter
Erosion Protection	Outlet protection shall be provided for the emergency spillway.
Sediment Trapping	At least 70% of coarse sediment greater or equal to 0.02mm particle size for the water quality design storm.
Maintenance Frequency	Determined by dividing sediment storage capacity to the amount of sediment collected in a water quality design storm.

Table 5.10: Dry Sediment Basin Sizing Guidelines (DID, 2000)

Parameter	Design Storm	Time of Concentration of Basin Catchment (minutes)				
		10	20	30	45	60
Surface Area (m^2/ha)	3-month ARI	333	250	200	158	121
	6-month ARI	n/a	500	400	300	250
Total Volume (m^3/ha)	3-month ARI	400	300	240	190	145
	6-month ARI	n/a	600	480	360	300

Notes:
1. Interpolate intermediate values.
2. Design storm event is either the 3 month ARI or 6 month ARI as discussed above.
3. Settling zone depth = 0.6 m.
4. Total volume = half as sediment storage volume and half as settling zone volume. In highly erodible soils, adjust sediment storage volume to equal the 2-month soil loss from the catchment (use MUSLE).
5. n/a indicates that the removal target of 85% cannot be achieved with a reasonable basin size for these conditions.

Table 5.11: Wet Sediment Basin Sizing Guidelines (DID, 2000)

Parameter	Site Runoff Potential	Volume (m^3/ha of Catchment) Magnitude of Design Storm Event in mm				
		20	30	40	50	60
Settling Zone Volume	Moderate to high runoff	70	127	200	290	380
	Very high runoff	100	167	260	340	440
Total Volume	Moderate to high runoff	105	190	300	435	570
	Very high runoff	150	250	390	510	660

Notes:
1. Interpolate intermediate values
2. Design storm event is either the 5-day 75th percentile or 5-day 80th percentile as discussed below.
3. Total volume = half as sediment storage volume and half as settling zone volume. In highly erodible soils, adjust sediment storage volume to equal the 2-month soil loss from the catchment (use MUSLE).

Volume recommendations for wet sediment basins are based on the observation that traditional approaches to settling fine sediments, particularly dispersible clays, have been ineffective. The approach adopted is therefore one of storm containment, fully impounding runoff from a nominated design event.

The design event is selected using a risk-based approach. The rainfall and predicted runoff from that design event is then used to size the 'settling' zone of the basin.

- The duration of the design event should be 5 days. This is a reasonable estimate of the time necessary to achieve effective flocculation, settling, and pump out of the stormwater; allowing for weekends and other days when the site may not be attended.

- For most construction situations, the 75th percentile 5-day rainfall event should be used as the design event. This is the rainfall that is not exceeded in 75% of rainfall events. The figure can be derived by analysis of daily rainfalls.
- Where the construction site is upstream of an environmentally sensitive area, or construction is expected to take longer than 2 years, the 80th percentile 5-day event should be used.
- The Volumetric Rational Method is used to estimate the runoff volume. The appropriate volumetric runoff coefficient is to be selected to suit the soil runoff potential.

d) Installation/Application Criteria

- Sediment basins must be installed entirely within the limits of the site.
- Construct before clearing and grading work begins.
- Basins must not be located in a stream.
- All basins should be located where failure of the embankment would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities.
- Local ordinances regarding health and safety must be adhered to.
- Large basins may be subject to State and/or Federal dam safety requirements.

- Sediment traps are attractive to children and can be very dangerous. Adequate safety precautions must be provided by restricting access to the site or access to the basin with suitable fencing.
- For dry basins, securely anchor and install an anti-seep collar on the outlet pipe/riser.
- Sediment basins may be capable of trapping smaller sediment particles if sufficient detention time is provided. However, they are most effective when used in conjunction with other BMPs to minimise the amount of sediment mobilised and carried to the basin.

e) Maintenance Requirements

The management and operation of sediment basins also depends primarily on the nature of the soil materials likely to be eroded and washed into the basin.

(i) General

- Inspect weekly and after each rainfall.
- Inspect sediment basins before and after rainfall events or exceptionally large storms.
- Examine basin banks for seepage and structural soundness.
- Check inlet and outlet structures and spillway for any damage, obstructions, or erosion.
- Sediment basins should be drained within 36 hours after a rain event.
- Remove accumulated sediment when its volume reaches one-third the volume of the sediment storage. Properly dispose of sediment and debris removed from the basin, within the construction site.
- Check fencing for damage and repair.

(ii) Dry Sediment Basins
A properly designed and maintained dry sediment basin should drain naturally after heavy rain, through the embankment or outlet riser.

(iii) Wet Sediment Basins
In the case of wet sediment basins, the captured stormwater in the settling zone should be drained or pumped out within the five day period following rainfall, provided that an acceptable water quality has been achieved.

The target water quality should be specified by the Local Authority in terms of the National Water Quality Standards for Malaysia (NWQS). Typically, Class II standards will be required (e.g. TSS < 50 mg/L). If this quality is not achieved by settling, a flocculating agent (e.g. gypsum, enzymes) should be added to the stored water.

A peg or other mark should be placed in the basin to indicate the top of the sediment storage zone. A floating inlet should be used on the pump to ensure that settled sediment is not picked up during the dewatering process.

Because Type D soils contain a significant level of dispersible materials, sediment basins for these soils must be dosed with a flocculating agent. Supplies of flocculant shall be kept on or near the site for this purpose. Such dosing should occur within 24 hours of a rainfall event.

f) Relative Cost

Cost shall cover the initial construction and subsequent maintenance requirements. It is relatively expensive compared to the other sediment control facilities.

g) Limitations

- The basin should have shallow side slopes (maximum 4(H):1(V)) or be fenced to prevent drowning.
- Sites with very fine sediment (fine silt and clay) may require longer detention times for effective sediment removal.
- Basins in excess of certain depth and storage volume criteria must meet State and/or Federal dam safety criteria.
- Standing water may cause mosquitoes or other pests to breed.

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APPENDIX A:
SUBMISSION OF PLANS FOR EROSION AND SEDIMENT CONTROL – CHECKLIST

EROSION AND SEDIMENT CONTROL PLANS SUBMISSION REVIEW CHECKLIST

Project Title: ______________________________ Engineering Firm: ____________________

Property Address: ___________________________ Address: ___________________________

____ ___________________________________

Land Title No.: _____________________________ Phone No.: _________________________

____ Contact Person: ____________________

DID USE ONLY

Submittal Date: ____________________________ Review Date & Initials: ____________

Submission Acceptable/Approval/Rejected Date: ______ Approved/Rejected by: ____________

Legend:

{ **/** } Complete
{ **x** } Incomplete/Incorrect
{ **na** } Not Applicable

This checklist has been developed to provide specific instructions to engineers. The purpose of this checklist is to expedite and facilitate the review process. This checklist gives the minimum requirements needed for review. All items are expected to be addressed in the first submittal, unless indicated otherwise. All items shall be checked as included or marked NA. Failure to do so will result in rejection of the submittal without review. Consultant shall review the entire check list, prior to first submittal, and check the box in the left-hand column ("Consultant's Initial Submission") to indicate compliance. Consultant must sign the first page.

TO THE CONSULTANT

Your submission for Landuse Coversion and/or Land Subdivision approval has been reviewed. The review was made per the following checklist. Please return the checklist and plans comment sheets with your resubmittal. If you do not address a checklist item, including comments on the plan sheets, explain your reasoning.

I, the undersigned, acknowledge by signature that these documents meet or exceed the design standards of the Department of Irrigation and Drainage Malaysia and that they were prepared under my supervision. I, the undersigned, further acknowledge that to the best of my knowledge and belief, the products resulting from these documents will function as intended.

______________________ ______________________ __________

Consultant's Signature Professional Seal Date

______________________ ______________________

Title Company Name

Consultant's Initial Submission	Items	SUBMISSION REQUIREMENTS	DID Remarks
	1	**GENERAL**	
{ }	1.1	Name of proposed project development and address.	
{ }	1.2	Name of developer with address, and telephone number on first sheet.	
{ }	1.3	Name, address and telephone number of engineering firm or individual who prepared the plans.	
{ }	1.4	Seal, signature and license number of a Malaysian Professional Engineer on all sheets.	
{ }	1.5	Name and signature of License Surveyor on plans prepared by the surveyor.	
	2	**SITE PLANS MINIMUM REQUIREMENTS**	
{ }	2.1	Location plan with appropriate scale. A map showing the general location of the project and the state boundary where the project is located.	
{ }	2.2	Key plan with 1:50,000 scale showing the general vicinity of the project within 10 km radius and the river/main drain catchment.	
{ }	2.3	Site plan with 1:3,000 or 1:6,000 scale showing the lot to be developed and the surrounding lots showing existing developments if any, standard sheet no, name of Mukim, district, rivers and streams, roads and infrastructure for rivers and drains.	
{ }	2.4	Topography Survey plan 1:500 or 1:1000 scale. The survey should be based on Ordinance Survey Datum and the datum (Bench Mark or Temporary Bench Mark) must be clearly shown. The contour line shall be at 0.5 m interval and site spot levels not more than 10 m distance. (with extensions into adjoining properties to cover additional distance of 30 m for development < 10 hectares; 50 m for development 10 - 50 hectares; 100 m for development > 50 hectares).	
{ }	2.5	Proposed layout plan 1:500 or 1:1000 scale showing the proposed main drain reserves, existing outlet drain/river reserve (if applicable).	
{ }	2.6	A similar plan as per item 2.5 but superimposed with existing topography survey.	
{ }	2.7	Plans of the river/main drains if the land is crossed by the river/main drain. The plan comprises Cross-section Survey at every 20m intervals (at scale of 1:100 vertical, 1:100 horizontal) and Longitudinal Survey (at scale of 1:100 vertical, 1:1,000 horizontal) The survey should extend up to at least 150m at upstream and downstream of the lot boundary.	
{ }	2.8	Hydrographic survey of existing pond/lakes/sea if applicable (1:500 or 1:1000 scale) with spots level at 10m interval.	
{ }	2.9	All plans submission shall be in hardcopy and digital format in RSO or CASSINI coordinate.	

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Consultant's Initial Submission	Items	**SUBMISSION REQUIREMENTS**	DID Remarks
{ }	3.1.10	Describe the areas that have the potential to present erosion or water quality problems due to the land disturbance from the proposed site. Show critical areas within or near the development such as:	
{ }		- Public Water Supply / Raw Water Intake	
{ }		- Reservoir	
{ }		- Swimming Beach	
{ }		- Recreational/Tourism area	
{ }		- Flood prone area	
{ }		- Fishing area/aquaculture	
{ }		- Mangrove Land Forest	
	3.2	**Proposed Project Development**	
	A	***Report Requirements;***	
{ }	3.2.1	The total project area that will be developed in Ha.	
{ }	3.2.2	Provide a general description of the proposed development, which should include the breakdown details of project components, the development area in Ha of each component and percentage to total development area.	
{ }	3.2.3	The proposed project implementation periods and stages/ phases of project development with timing and duration.	
{ }	3.2.4	Indicate the area and amount of grading volume that were proposed for each stage/phase.	
{ }	3.2.5	Describe the permanent stormwater management system and the use of these facilities for sediment control during the construction period.	
	B	***Mapping Requirements***	
{ }	3.2.6	Show the boundary of each project component, the area in Ha and their project development stages/phases.	
{ }	3.2.7	Show the limits of clearing and grading for each phase of the development. Each boundary line should be identified as to the timing and duration of disturbances.	
{ }	3.2.8	Proposed layout plan with 1:500 or 1:1000 scale which clearly shows the proposed main drain reserve, outlet drain reserve and river reserve (if applicable).	
{ }	3.2.9	Proposed layout plan of 1:500 or 1:1000 scale superimposed with topography survey details.	
{ }	3.2.10	Show the drainage divides and flow directions for each drainage area after the development and show the changes resulting from grading. Include a contour plan of the finished grades using an appropriate scale (1:2000).	
{ }	3.2.11	Indicate the location and sizes of permanent storm drain inlets, pipes, outlets and other permanent drainage facilities such as swales, waterways, detention ponds, etc.	

Consultant's Initial Submission	Items	**SUBMISSION REQUIREMENTS**	DID Remarks
	3.3	**Erosion and Sediment Controls**	
	A	***Report Requirements;***	
{ }	3.3.1	Determine runoff quantities for pre-development and during construction stage for 3 and 6 months ARI (ie 40 mm and 50 mm rainfall depth for water quality control facilities) and 1, 2 and 10 year ARI (for water quantity control structure and erosion/scour protection).	
{ }	3.3.2	The design flows for the water quality facilities within the construction site shall be based on the following criteria;	
{ }		– 3 month ARI (ie 40 mm rainfall depth to capture and detain at least 90% of 24 hours storm events runoff volume) for construction projects that will take 2 years or less to complete	
{ }		– 6 month ARI (ie 50 mm rainfall depth to capture and detain at least 95% of 24 hours storm events runoff volume) for construction projects that will take longer than 2 years to complete.	
{ }	3.3.3	Each drainage area before and after development must be shown together with the respective dividing lines, sizes in ha, and the direction of flow.	
{ }	3.3.4	The development schedule must be clearly defined, the completion date for each phase of development shall be indicated and a detailed sequence of construction must be documented.	
{ }	3.3.5	Identification of critical areas; areas which have the potential to present serious erosion and sedimentation within the site, during pre-bulk grading stage and post-bulk grading stage.	
{ }	3.3.6	Erosion and Sediment Control Plans (ESCP) shall be developed for pre-bulk grading stage and post-bulk grading stage.	
{ }	3.3.7	Pre-Bulk Grading Plan shall include;	
{ }		– Grading phasing.	
{ }		– Quantity cuts and fills.	
{ }		– Specify where excess cut is to be stockpiled and where additional fill is to be obtained.	
{ }		– Plan shall be based on existing topography (based on appropriate datum) and shall not show the proposed development.	
{ }		– Perimeter controls based on existing drainage pattern of the site.	
{ }		– Delineation of drainage areas for controls.	
{ }		– Identify areas for soil stockpiles. Locate stockpiles on areas with little or no slope. Stockpiles must be surrounded by silt fence or other suitable sediment control practice.	
{ }		– Identify areas from where material required to construct perimeter controls will be obtained (include sediment controls for these areas as necessary).	
{ }		– Delineate areas intended for infiltration to ensure that such areas are not compacted during construction.	
{ }	3.3.8	Post-Bulk Grading Plan shall include;	
{ }		– Proposed contours (based on appropriate datum) and proposed project development.	
{ }		– Project development phasing.	
{ }		– Modified and/or new sediment controls based on proposed drainage patterns.	

Consultant's Initial Submission	Items	**SUBMISSION REQUIREMENTS**	DID Remarks
{ }	3.3.9	Transition from pre-bulk grading controls to post-bulk grading controls shall be consistent with the specified phasing of the project and reflected in the construction sequence.	
{ }	3.3.10	Existing vegetation shall be maintained as filters along contours to reduce velocity and improve water quality and act as buffers to minimise erosion.	
{ }	3.3.11	Stream buffers shall be retained. For small streams within a development site, the following could be used as a guide:	
{ }		– Intermittent watercourse (slope<15°; 10m and slope>15°; 20m)	
{ }			
{ }	3.3.12	– Permanent watercourse (slope<15°; 20m and slope>30°; 30m)	
{ }	3.3.13	All excavated topsoil shall be stockpiled and later used for re-vegetation. Describe how such stockpile will be protected during construction and the intentions for final stabilization of such areas. All access roads to the site shall be stabilised and paved for a distance of at least 10 m from where these access roads join the existing paved roads. 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.	
{ }	3.3.14	Determine a drainage system (diversion channel) so that it does not flow across disturbed and unstable areas.	
{ }	3.3.15	Sediment controls (such as sediment pond or sediment trap) shall be proposed to intercept sediment from disturbed areas prior to release of the flow from the site.	
{ }	3.3.16	For hillside areas, slope drains must be constructed, such drains include berm drains, cascading drains, and sumps at the toes of the cascading drains to reduce the velocity of flow.	
{ }	3.3.17	Adequate velocity reduction control measures (e.g. check dam) are to be provided to reduce the flow velocity to less than 0.6 m/s.	
{ }	3.3.18	Soil stabilization should be the first line of defense and shall be completed within 2 weeks time. Describe how each portion of the site will be stabilized after construction is completed and during construction by using either permanent or temporary soil stabilization (vegetative and non-vegetative measures).	
{ }	3.3.19	Identify temporary and permanent control methods.	
{ }	3.3.20	List down good housekeeping practices.	
{ }	3.3.21	List down the types and scheduling of individual erosion control measures, including interim or short-term measures (less than 45 days duration).	
{ }	3.3.22	The locations of the erosion and sediment control and stormwater management practices to be used on the site must be shown clearly in drawing.	
{ }	3.3.23	Erosion and sediment control practices must be shown using appropriate symbols as illustrated in MSMA.	
{ }	3.3.24	CALCULATIONS used in designing all structural practices must be included.	
{ }	3.3.25	Any structural practices used must be illustrated with detailed drawings and specifications.	

Consultant's Initial Submission	Items	**SUBMISSION REQUIREMENTS**	DID Remarks
{ }	3.3.26	Sediment retention facilities shall be installed prior to the grading or disturbance of any contributing area. Allowance must be made for sediment removal.	
{ }	3.3.27	Permanent water quality control measures such as ponds can be temporarily used as sediment basins during construction.	
{ }	3.3.28	Sediment basins shall be sized in accordance with MSMA to retain a minimum of 70% of coarse sediments greater than or equal to 0.02 mm for all storms of 3 month ARI and 6 month ARI	
{ }	3.3.29	Adequate detention storage shall be provided to store the design runoff (3 month ARI and 6 month ARI) from the catchment. No overflow is allowed through the sediment basin for flows less than the design flow.	
{ }	3.3.30	The design of sediment trap shall at least comply with the following criteria: – It is intended for use on small catchment areas which disturbed area less than 2 ha. – The trap is a temporary measure with a design life of approximately 6 months. – The length to width ratio should be greater than 2:1. – The outlet of the trap must be stabilised with rock, vegetation, or another suitable material. – The fill material for the embankment must be suitable material and shall be compacted during construction. – A stable emergency spillway must be installed to safely convey flows up to and including 10 year ARI. – Remove sediment when the sediment storage zone is no more than 300 mm from being full.	
{ }	3.3.31	For areas greater than 2 ha, provide sediment basin at every outlet complying with the following criteria;	
{ }		– An overall particle removal target of 85% has been adopted.	
{ }		– Construct before clearing and grading work begins.	
{ }		– A stable emergency spillway must be installed to safely convey flows up to and including 10 year ARI.	
{ }		– The basin length to settling depth ratio should not be less than 200:1.	
{ }		– The basin length to width ratio should be greater than 2:1.	
{ }		– Side slopes should not be steeper than 2(H):1(V).	
{ }		– Sediment basin shall be capable of trapping smaller sediment particles with sufficient detention time more than 24 hours.	
{ }		– The settling zone shall be at least 0.6 m deep to contain runoff and allow suspended sediment to settle.	
{ }		– The sediment storage zone shall be at least 0.3 m deep to store settled sediment until the basin is cleaned out. In some cases, basins may be sized to trap sediment for the life of the construction activity.	
{ }		– Temporary sediment basins should be kept in service until the works for which they were designed are completed and the contributing catchment has been stabilised.	
{ }		– In highly erodible soils, adjust sediment storage volume to equal the 2-month soil loss from the catchment.	

Consultant's Initial Submission	Items	SUBMISSION REQUIREMENTS	DID Remarks
{ }	3.3.32	Types of Erosion and Sediment Control Measures proposed shall be shown including;	
{ }		– Scheduling	
{ }		– Preservation of Existing Vegetation	
{ }		– Seeding & Planting	
{ }		– Mulching	
{ }		– Geotextiles and Mats	
{ }		– Dust Control	
{ }		– Temporary Waterway Crossing	
{ }		– Construction Road Stabilisation	
{ }		– Construction Access Stabilisation	
{ }		– Diversion of runoff using earth bank	
{ }		– Diversion of runoff using diversion channel	
{ }		– Diversion of runoff using slope drain	
{ }		– Drainage outlet protection	
{ }		– Check Dam	
{ }		– Sediment Fence	
{ }		– Sand Bag Barrier	
{ }		– Rock Filter	
{ }		– Drainage Inlet Protection	
{ }		– Sediment Traps	
{ }		– Sediment Basins	
		Mapping Requirements	
{ }	3.3.33	Indicate the locations, types and sizes/dimensions of the proposed temporary and permanent erosion and sediment control measures including ponds/sedimentation basins and inlet protection.	
{ }	3.3.34	Show types, locations and dimensions of erosion and sediment control measures on a plan, for each phase of construction. Provide details of ESC measures as required.	
{ }	3.3.35	The location and size of each stockpile should be indicated and annotated with the volume and height.	
{ }	3.3.36	Show the locations and dimensions of silt fences, sedimentation traps/ponds, berms, etc.	
{ }	3.3.37	Clearly indicate the measures to be maintained during the construction period.	
		Inspection and Maintenance	
		Report Requirements;	
{ }	3.3.38	Provide a schedule of regular inspections and expected repairs of erosion and sediment control devices.	
{ }	3.3.39	Record changes made to ESC Plan due to changing conditions.	
{ }	3.3.40	Specify whose responsibility it will be to inspect and perform maintenance, to repair and stabilize erosion and sediment controls practices during construction.	
{ }	3.3.41	Include the site inspection checklist and inspection log book.	
{ }	3.3.42	A copy of the maintenance agreement for all erosion and sediment practices must be provided with the plan.	

Consultant's Initial Submission	Items	SUBMISSION REQUIREMENTS	DID Remarks
	4	**FINAL EROSION AND SEDIMENT CONTROL PLANS AND DETAILING MINIMUM REQUIREMENTS**	
		General	
{ }	4.1	Plan view of the entire site at a reasonable scale (entire site appears on one sheet) showing limits of disturbance, wetlands, floodplains, steep slopes, other environmentally sensitive areas, project phasing, sediment controls by symbols, lot numbers, street addresses, a north arrow and names of adjacent property owners.	
{ }	4.2	Location plan shall include a North Point indicator and the names of a minimum of two roads leading to the site.	
{ }	4.3	A copy of the approved layout plan together with copy of the planning permission shall be submitted.	
{ }	4.4	Proposed finished site levels on topographic plan with contours at intervals of 2 meters for gradients greater than 1:2 and there under, at intervals of 3 meters.	
{ }	4.5	A key plan showing the contour together with proposed layout and existing natural watercourse and proposed main drains shall be submitted.	
{ }	4.6	The topographic plan should show existing drainage patterns and flow paths (together with flow direction) throughout the site with their catchment boundary and catchment area in Ha.	
{ }	4.7	Drawings of proposal including location and layout plan, relevant longitudinal and cross-section and details.	
{ }	4.8	A suitable index or key plan showing the reference sheet no for each portion of the development area shall be provided if the various portions of layout are shown on separate drawings.	
{ }	4.9	Structural details, if any, shall be indicated on separate drawings as these are submitted for record purposes only.	
{ }	4.10	Drawings shall not be bound together. All drawings submitted shall be neatly folded to A4 size, the title block on the front face and in a manner where the drawings can be opened from left to right.	
{ }	4.11	Title block shall be provided at the bottom right hand comer of all drawings and properly completed. Title of drawings must indicate the exact nature of works for which approval is sought. There should be a margin of at least 50mm all round the drawing.	
{ }	4.12	All drawings submitted must bear the signature of the submitting Engineer/Architect/Surveyor with his full name, address and relevant professional qualifications.	
{ }	4.13	All documents submitted for approval shall be certified by the submitting Engineer as following; "I hereby certify that these works have been designed by me in accordance with sound engineering practice and that I take full responsibility for the design and proper performance of the same."	
{ }	4.14	All drawings must be countersigned by the owner. The full name and address of the owner must be indicated.	
{ }	4.15	Adequate empty space shall be allowed on all drawings for the Approval stamp.	
{ }	4.16	Specify whose responsibility it will be to repair and stabilize erosion and sediment controls practices during construction, including areas disturbed.	

Consultant's Initial Submission	Items	**SUBMISSION REQUIREMENTS**	DID Remarks
{ }	4.17	Specify whose responsibility it will be to inspect and perform maintenance and/or repairs of the erosion and sediment control practices.	
{ }	4.18	Specify inspection schedule and procedure for inspection and maintenance of erosion and sediment controls practices.	
{ }	4.19	Legend for all symbols of sediment control devices shall be chosen as recommended in MSMA.	
{ }	4.20	Provide the detail layout of erosion and sediment control plan which clearly shows the location and sizes of proposed diversion drains and their outlets and erosion and sediment control facilities such as waterways, check dam, sediment trap, sediment basin, temporary crossing culvert, etc.	
{ }	4.21	Plan shall be prepared using appropriate scales as shown below;	
{ }		– Location plan (1:1000)	
{ }		– Site and layout plan (1:1000)	
{ }		– Longitudinal section; Horizontal (1:1000), Vertical (1:100)	
{ }	4.22	– Cross-section and other details (1:100).	
		All sheets of final Sediment Control package shall be numbered consecutively.	
{ }	4.23	Match lines corresponding sheet to sheet shall be shown.	
		Plans	
{ }	4.24	Show property lines, owners/legal description, and site owner name for adjacent properties.	
{ }	4.25	Show and label existing and proposed improvements (utilities, streets, buildings, etc.).	
{ }	4.26	Show existing and proposed topography (0.5m contour intervals maximum).	
{ }	4.27	Pre- and post-development drainage areas - Dividing lines, number of Hectare, and the direction of flow for each drainage area before and after development must be shown. Use separate plan sheets for clarity.	
{ }	4.28	Existing features to be lighter or screened from proposed improvements in CAD submission.	
{ }	4.29	Limits of disturbance shall be outlined and labeled.	
{ }	4.30	The boundaries of different soil types must be delineated.	
{ }	4.31	Critical areas - Areas which have the potential to present serious	
{ }	4.32	Erosion or water quality problems must be delineated.	
{ }	4.33	Any designated wetlands (including 10m buffer) shall be delineated and labeled.	
{ }	4.34	Proposed slopes shall not exceed 2:1; (3:1 on lawn maintenance areas)	
{ }	4.35	No sediment control devices are to be located within 10m of building foundations.	
{ }	4.36	Protection of existing interior trees that to be save and undisturbed areas as the buffer as shown on plans.	
{ }	4.37	Protection of property adjacent to excavations shall be shown on plans.	
{ }	4.38	The locations of the *erosion and sediment control practices and proposed sediment control devices* to be used on the site must be shown.	

Consultant's Initial Submission	Items	**SUBMISSION REQUIREMENTS**	DID Remarks
{ }	4.40	Sediment trap(s): Provide safety fences; inflow point protection; proper outlet location (maximizing flow length from inflow points); dewatering as necessary (include dewatering device detail); Provide trap data information on the sediment control plan as follows: trap type; existing drainage area; developed drainage area; storage required; storage provided; weir crest elevation; weir crest detailing; storage depth; top storage dimensions; bottom dimensions; cleanout elevation (1/2 design depth); channel depth of flow; maximum side slopes (specify cut and/or fill); bottom elevation; embankment elevation; riser dimensions; barrel dimensions.	
{ }	4.41	Sediment basin(s): Include sediment basin design and construction information as required by MSMA, Low Hazard Class assured; barrel outfall cross-section; dewatering device detail; inflow point protection; safety fence; and baffles as necessary. Show and address construction access and stockpiling on sediment control plan and address sediment control during basin installation. Limit initial disturbance to installation of principle spillway. If there is a base flow, provide a clean water diversion; if there is no base flow, provide diversion dikes above disturbed area.	
{ }	4.42	Earth dikes for off-site diversion of runoff must have channel treatment at a minimum.	
{ }	4.43	Temporary storm drain diversion: Include in sequence of construction, show profile, give invert elevations of temporary pipe into trap on plan view, profile, and details, and show the diversion on the storm drain plan.	
{ }	4.44	Sequence of construction. (Include pre-construction meeting and consider all stages of site conditions with regard to sediment control).	
{ }	4.45	Off-site grading requires documentation of permission from owner (letter of permission on plan or grading easement document submitted).	
{ }	4.46	Plan of storm drain system with topography for each outfall.	
{ }	4.47	All outfalls must release runoff to an existing system, adequate receiving channel, or grounds having slope less than or equal to 2%.	
{ }	4.48	Provide outfall cross-section detail(s) with the following information specific to each outfall: outfall dimensions, rip-rap or gabion slope, length, size and class; and filter cloth underneath.	
{ }	4.49	Standard detail for sediment control devices shall be shown.	
{ }	4.50	Detail drawings and specifications for structural practices - Any structural practices used must be illustrated with DETAILED DRAWINGS CONTAINING ALL DIMENSIONS AND SPECIFICATIONS.	
{ }	4.51	Practices must conform to the specifications indicated in MASMA. Soil stockpiles and borrow areas - The locations of stockpiles and borrow areas must be shown with adequate protection measures included. If these locations are off-site, an addendum to the plan must be submitted to show the areas.	

ADDITIONAL REQUIREMENTS

COMMENTS

APPENDIX B:
LIST OF LEGISLATION, RULES AND GUIDELINES

Legislation

1. Waters Act, 1920
2. Geological Survey Act, 1974
3. Irrigation Areas Act, 1953
4. Street, Drainage and Building Act, 1974
5. The Forest Act, 1984
6. The National Land Code, 1965
7. The Drainage Works Act, 1954
8. The Fisheries Act, 1985
9. Environmental Quality Act, 1974
10. Land Conservation Act, 1960
11. Town and Country Planning Act, 1976
12. Local Government Act, 1976
13. Selangor Waters Management Authority Enactment, 1999
14. Mining Enactment, 1929
15. Sewerage Services Act, 1993
16. Sarawak Given Ordinance, 1993
17. Sabah Water Resources Enactment, 1998
18. Sabah Conservation of the Environment Enactment
19. Sabah Land Ordinance, 1930
20. Sabah Forest Enactment, 1965
21. Sarawak Water Ordinance, 1994
22. Sarawak Land Code, 1958
23. National Resources and Environment Ordinance, 1958, Sarawak
24. Local Authority Ordinance, Sarawak, Cap. 117
25. Local Government Enactment, Sabah Ordinance 11/1961
26. Town & Country Planning Enactment, Sabah, Cap. 141
27. Town & Country Planning Ordinance, Sarawak, Cap. 87
28. Forest Ordinance, Sarawak, Cap. 126
29. Drainage & Irrigation, Sabah Ordinance 15/1956
30. Drainage Works Ordinance, 1966, Sarawak
31. Mining Enactment, 1960, Sabah
32. Mining Ordinance, 1949, Sarawak

Municipal Rules

33. Uniform Building By-laws
34. Earthworks By-Laws
35. Stray Animal By-laws
36. Licensing of Trades, Businesses and Industries By-laws
37. Refuse Collection, Removal and Disposal By-Laws
38. The Public Cleansing By-Laws
39. Anti-Litter By-laws
40. Parks By-laws

Guidelines

41. Urban Drainage Design Standards and Procedures in Malaysia, 1975, Federal DID.
42. Guidelines on River Front Development, Federal DID
43. Guidelines on the Prevention and Control of Soil Erosion and Siltation in Malaysia, 1996, DOE
44. Use of Flood Detention Ponds as Part of Open Space, JPBD 1997.
45. Urban Stormwater Management Manual for Malaysia, 2000, DID Malaysia.
46. Urban Stormwater Management Manual for Malaysia, Second Edition, 2010, DID Malaysia.

APPENDIX C: ESCP INSPECTION AND MAINTENANCE CHECKLIST

INSPECTION CHECK SHEET

Sheet ___of ___

GENERAL INFORMATIONS

Project Name: ____ File No.__________

Developer Name: __________________________ Contractor Onsite:____________________

Inspection Date: __________ Time:_______ Weather:_________ mm of Rain Last Week:_______
Inspection Type: { } Routine Weekly { } Pre-Rain { } During Rain { } Post Rain

STAGE OF CONSTRUCTION

{ } Pre-Construction Conference; { } Clearing and Grubbing; { } Rough Grading;
{ } Finish Grading; { } Building Construction; { } Final Stabilization;

INSPECTION CHECKLIST

Yes No NA (Not Applicable)

Part 1: Inspection on Erosion Controls Measures

{ } { } { } Is the clearing of the construction area carried out in phases?

{ } { } { } Are the areas which designated to be preserve of the existing vegetation intact is not disturbed?

{ } { } { } Are all erosion control devices in-place and functioning in accordance with the erosion control plan?

{ } { } { } Are all temporary stockpiles or construction material located in approved areas and protected from erosion?

{ } { } { } Are soil stockpiles adequately stabilized with seeding and/or sediment trapping measures?

{ } { } { } Have all denuded areas requiring temporary or permanent stabilization been stabilized?
Seeded? yes/no Mulched? yes/no Gravelled? yes/no

{ } { } { } Does permanent vegetation provide adequate stabilization?

{ } { } { } Are all exposed slopes protected from erosion through the implementation of acceptable soil stabilization practices?

{ } { } { } Are finished cut and fill slopes adequately stabilized?

{ } { } { } Is there any evidence of erosion of cut or fill slope?

Part 2: Inspection on Sediment Controls Measures

{ } { } { } Have sediment-trapping facilities been constructed as a first step in stripping and grading?

{ } { } { } For perimeter sediment trapping measures, are earthen structures stabilized?

{ } { } { } Are sediment basins, sediment traps, sediment fence/barriers and check dam/rock weir installed where needed as per ESC Plan?

{ } { } { } Are sediment basins, sediment traps, sediment fence/barriers and check dam/rock weir properly maintained, repairs and sediment was regularly removed and clean as per ESC Plan maintenance schedule?

{ } { } { } Are sediment controls in place at site perimeter and storm drains inlets?

{ } { } { } Is the water from the construction site adequately prevented from directly entering the permanent drainage system unless it is relatively sediment free (i.e. the catchment area has been permanently landscaped and/or any likely sediment has been treated)?

{ } { } { } Are the sediment controls measure onsite adequately installed and the sediment are effectively treated from the stormwater runoff from the construction site?

{ } { } { } Is there any evidence that the sediment is leaving the construction site without adequately treated?

Part 3: Inspection on Conveyances and Flows Controls Measures

{ } { } { } Are on-site channels, inlet and outlet are adequately stabilized and protected?

{ } { } { } Do all operational storm drainage inlets have adequate inlet protection?

{ } { } { } Are stormwater conveyance channels adequately stabilized, protected and lined with suitable material at badly eroded stretches?

{ } { } { } Are stormwater conveyance channels, culvert, conduit, roadside ditches, toe of slopes etc. adequately stabilized and with proper inlet/outlet protection and energy dissipater?

{ } { } { } Are the outlet of sediment basins and sediment traps are adequately stabilized with proper outlet protection and energy dissipater?

{ } { } { } Are adequate check dam/rock weir or any others energy dissipater method which are used to reduce the erosive effects of flows velocity in the stormwater conveyance channels

{ } { } { } Are temporary stream crossings of non-erodible material installed where applicable?

{ } { } { } Are the stormwater conyevance channels, the riprap, check dam, rock weir, stream crossing, etc. properly maintained, repairs and deposited sediment was regularly removed and clean as per ESC Plan maintenance schedule?

Part 4: Others

{ } { } { } Are properties and waterways downstream from development adequately protected from erosion and sediment deposition due to increases in peak stormwater runoff?

{ } { } { } Are soil and mud kept off public roadways at intersections with site access roads?

{ } { } { } Are utility trenches stabilized properly?

{ } { } { } Is there any self-auditing of ESCP was carried out onsite (based on onsite records of inspection check sheets and inspection log book)

{ } { } { } Have all temporary control structures that are no longer needed been removed?

{ } { } { } Do any structural BMPs practices require repair or clean-out to maintain adequate function? If yes, indicate in details.

{ } { } { } Does the ESCP require revisions? If yes, explain:

Comments:

Inspected by: ______________________ Developer's Representative: ________________

Position: __________________________ Position: ______________________________

Signature: _______________ Signature: _________________

EROSION AND SEDIMENT INSPECTION LOG

Site: ______________________ **Contractors on Site:** ______________________

Heavy Equipment on Site: ______________________ **Activities on Site:**

Date: ______________ **Weather:** ______________________ **mm of rain in last week:** ______________

Note condition of the following measures and sediment levels where applicable:

MEASURE	CONDITION/LOCATION	SEDIMENT LEVEL	ACTION REQUIRED YES/NO	TYPE OF ACTION	ACTION COMPLETED (DATE)	INITIALS
Silt fences						
Temporary Storage Facilities						
Outlet of Temporary Storage Facilities						
Interceptor Swales						
Steeper Slopes						
Cover of Rough Grades						
Catchbasins Filtering Controls						
Dust Control						
Mud Tracking						
Debris Control						

Other Comments (Summarize):

____

____

____

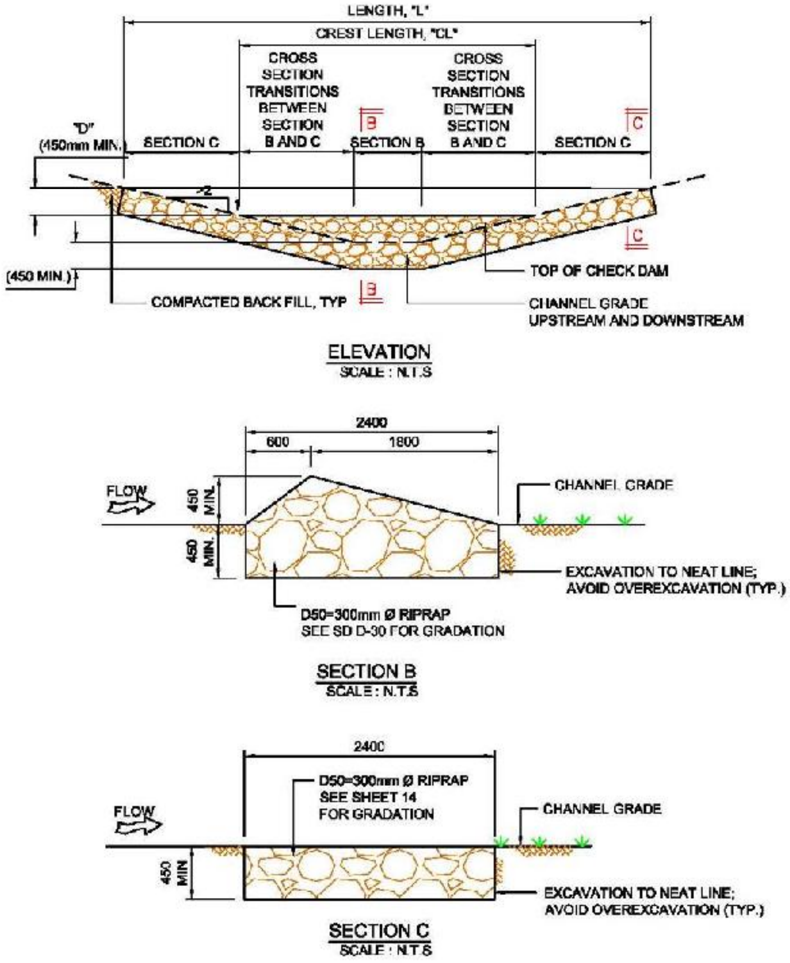
Inspectors Signature: ______________________ **Inspectors Name** ______________________

APPENDIX D:
TYPICAL DRAWINGS FOR EROSION & SEDIMENT CONTROL FACILITIES

EROSION AND SEDIMENT CONTROL PLAN (ESCP)
STANDARD DRAWING GENERAL NOTES

1. THE ADEQUACY OF THIS ESC PLAN LIES WITH THE ORIGINAL DESIGN ENGINEER.
2. THE ESC PLAN SHALL BE CONSIDERED VALID FOR TWO (2) YEARS FROM THE DATE OF ACCEPTANCE BY THE AUTHORITIES, AFTER WHICH TIME THE PLAN SHALL BE VOID AND WILL BE SUBJECT TO RE-VIEW AND RE-ACCEPETANCE BY THE AUTORITIES.
3. ALL MATERIALS AND WORKMANSHIP SHALL BE SUBJECT TO INSPECTION BY THE AUTHORITIES. THE AUTHORITIES RESERVES THE RIGHT TO ACCEPT OR REJECT ANY SUCH MATERIALS AND WORKMANSHIP THAT DOES NOT CONFORM TO THE ESC PLAN AND PERMISION.
4. THE PLACEMENT OF THE EROSION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICE (BMPs) SHALL BE ACCORDANCE WITH THE APPROVAL OF THE ESC PLAN BY THE AUTHORITIES.
5. ANY VARATION IN MATERIAL, TYPE OR LOCATION OF THE EROSION AND SEDIMENT CONTROL BMPs FROM THE AUTHORITIES – ACCEPTED ESC PLAN WILL REQUIRE APPROVAL FROM AN COUNTABLE REPRESENTATIVE OF THE AUTHORITIES.
6. THE FIRST BMP TO BE INSTALLED ON SITE SHALL BE CONSTRUCTION FENCE OR OTHER APPROVED MEANS OF DEFINING THE LIMITS OF CONSTRUCTION, INCLUDING CONSTRUCTION LIMITS ADJACENT TO STREAM CORIDORS AND OTHER AREA TO BE PRESERVED.
7. CONSTRUCTION SHALL NOT BEGIN UNTIL THE AUTHORITIES APPROVED THE ESC PLAN SUBMISSION BY THE DEVELOPER.
8. NATURAL VEGETATION SHALL BE RETAINED AND PROTECTED WHENEVER POSSIBLE. EXPOSURE OF SOIL TO EROSION BY REMOVAL OR DISTURBANCE OF VEGETATION SHALL BE LIMITED TO THE AREA REQUIRED FOR IMMEDIATE CONSTRUCTION OPERATIONS.
9. A COPY OF APPROVED ESC PLAN AND ESC FIELD INSPECTION FORM SHALL BE ON SITE ALL THE TIMES.
10. ALL CONSTRCUTION TRAFFIC MUST ENTER/EXIT THE SITE THROUGH THE APPROVED ACCESS POINT BY THE AUTHORITIES. A VEHICLE TRACKING CONTROL PAD IS REQUIRED AT ALL ACCESS POINT OF THE SITE. ADDITIONAL STABALIZED CONSTRUCTION ENTERANCES MAY BE ADDED WITH THE PERMISSION OF THE AUTHORITIES.
11. APPROVED EROSION AND SEDIMENT CONTROL BMPs SHALL BE MAINTAINED AND KEEP IN GOOD REPAIR FOR THE DURATION OF THE PROJECT. THE ESC ENGINEER SHALL INSPEC ALL BMPs IN ACCORDANCE WITH THE APPROVED ESC PLAN. ACCUMULATED SEDIMENT AND CONSTRUCTION DEBRIS SHALL BE REMOVED AND PROPERLY DISPOSED.
12. TOPSOIL SHALL BE STRIPPED AND STOCKPILED IN THE LOCATION SHOWN IN THE ESC PLAN.
13. SOILS THAT WILL BE STOCKPILED FOR MORE THAN THIRTY (30) DAYS SHALL BE SEEDED AND MULCHED WITHIN FOURTHEEN (14) DAYS OF STOCKPILE CONSTRUCTION. NO STOCKPILES SHALL BE PLACED WITHIN THIRTY (30) METER OF THE DRAINAGE WAY.
14. ALL WORK ON SITE SHALL STAY A MINIMUM OF FIFTY (50) METER AWAY FROM THE DRAINAGE WAY OR EXISTING WATER BODY.
15. ALL DEWATERING ON SITE SHALL BE FREE OF SEDIMENT.

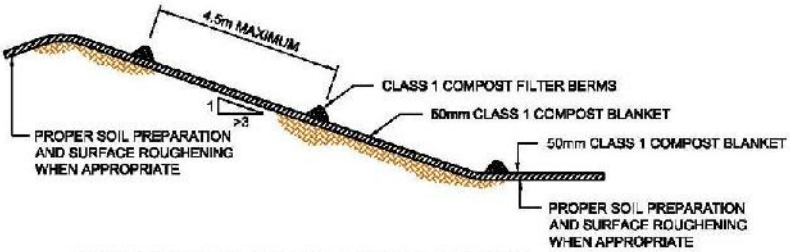
BMPs LEGEND AND PLAN SYMBOL			
ITEM	DRAWING NO	BMPs LEGEND	BMPs PLAN SYMBOL
1	SD D-1	CD CHECK DAM	
2	SD D-2	CB COMPOST BLANKET	
3	SD D-3	CFB COMPOST FILTER BERM	
4	SD-D4	CWA CONCRETE WASHOUT AREA	
5	SD D-5	CF CONSTRUCTION FENCE	
6	SD D-6	DW DEWATERING	
7	SD D-7	DD DIVERSION DITCH	
8	SD D-8	OP DRAINAGE OUTLET PROTECTION	
9	SD D-9	EB EARTH BANK	
10	SD D-10(a) - D-10(b)	ECB EROSION CONTROL BLANKET	
11	SD D-11(a) - D-11(c)	IP INLET PROTECTION	
12	SD D-12	RCD REINFORCED CHECK DAM	
13	SD D-13	RRB REINFORCED ROCK BERM	
14	SD D-14	RRC RRB FOR CULVERT PROTECTION	
15	SD D-15	SBB SAND BAG BARRIER	
16	SD D-16	SCL SEDIMENT CONTROL LOG	
17	SD D-17(a) - D-17(f)	SB SEDIMENT BASIN	
18	SD D-18(a) - D-18(c)	ST SEDIMENT TRAP	
19	SD D-19	ST SEDIMENT TRAP	
20	SD D-20	SM SEEDING AND MULCHING	
21	SD D-21	SF SILT FENCE	
22	SD D-22	SSA STABILIZED STAGING AREA	
23	SD D-23	SPA STOCKPILE AREA	
24	SD D-24	SR SURFACE ROUGHENING	
25	SD D-25	TSD TEMPORARY SLOPE DRAIN	
26	SD D-26	TSC TEMPORARY STREAM CROSSING	
27	SD D-27	TER TERRACING	
28	SD D-28	VTC VEHICLE TRACKING CONTROL	
29	SD D-29	WW VTC WITH WHEEL WASH	
30	SD D-30	ROCK AND RIPRAP GRADIATIONS	
31	SD D-31	LOC LIMITS OF CONSTRUCTION	
32	SD D-32	MSA MATERIALS STORAGE AREA	



NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

CHECK DAM	SD D-1



COMPOST BLANKET AND COMPOST FILTER BERM
SCALE : N.T.S

COMPOST BLANKET NOTES:
1. SEE PLAN VIEW FOR AREA OF COMPOST BLANKET.

2. MAY BE USED IN PLACED OF STRAW MULCH OR EROSION CONTROL BLANKET IN AREAS WHERE ACCESS IS DIFFICULT DUE TO LANDSCAPING OR OTHER OBJECTS OR IN AREAS WHERE A SMOOTH TURF GRASS FINISH IS DESIRED.

3. SHALL ONLY BE UTILIZED IN AREAS WHERE SHEET FLOW CONDITIONS PREVAIL; SHALL BE PROHIBITED IN AREAS OF POSSIBLE CONCENTRATED FLOW.

4. SOIL PREPARATION SHALL BE COMPLETE PER THE SPECIFICATIONS OUTLINED IN THESE CRITERIA PRIOR TO APPLICATION.

5. WHEN TURF GRASS FINISH IS NOT DESIRED, SURFACE ROUGHENING ON SLOPES SHALL TAKE PLACE PRIOR TO APPLICATION.

6. SHALL BE EVENLY APPLIED AT A DEPTH OF 50mm.

7. MAYBE APPLIED UTILIZING PNEUMATIC BLOWER, OR BY HAND.

8. SEEDING SHALL BE DRILLED PRIOR TO THE APPLICATION OF COMPOST OR SEED MAY BE COMBINED AND BLOWN WITH THE PNEUMATIC BLOWER.

9. COMPOST FILTER BERM SHALL BE UTILIZED ON SLOPES WITH A MAXIMUM SPACING OF 45mm PER THE REQUIREMENTS FOUND IN THE COMPOST FILTER BERM SECTION.

10. THE ESCP MANAGER SHALL INSPECT WEEKLY, DURING AND AFTER ANY STORM EVENT.

11. COMPOST USED IN THE APPLICATION OF THE COMPOST BLANKET SHALL BE A CLASS 1 COMPOST AS DEFINED BY THE FOLLOWING PHYSICAL, CHEMICAL, AND BIOLOGICAL PARAMETERS:

PARAMETERS	CLASS 1 COMPOST FOR COMPOST BLANKET
MINIMUM STABILITY INDICATOR	STABLE TO VERY STABLE
SOLUBLE SALTS	MAXIMUM 5mmhos/cm
PH	6.0 - 8.0
AG INDEX	> 10
MATURITY INDICATOR EXPRESS AS PERCENTAGE OF GERMINATION / VIGOR	80+ / 80+
MATURITY INDICATOR EXPRESSED AS AMMONIA N/ NITRATE N RATIO	< 4
MATURITY INDICATOR EXPRESSED AS CARBON TO NITROGEN RATIO	20 : 1
TESTED FOR CLOPYRALID	YES / NEGATIVE RESULT
MOISTURE CONTENT	30-60 %
ORGANIC MATTER CONTENT PARTICLE SIZE DISTRIBUTION	25-45 % OF DRY WEIGHT 3" (75mm) 100% PASSING 1" (25mm) 95% TO 100% PASSING 3/4" (19mm) 85% TO 90% PASSING 3/8" (9.5mm) 50 % TO 60% PASSING #4 20 TO 35% PASSING

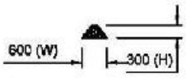
NOTE: CLOPYRALID IS THE COMMON NAME OF A HERBICIDE THAT KILLS BROAD-LEAVED WEEDS SUCH AS DANDELIONS, CLOVER AND THISTLE.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

COMPOST BLANKET

SD D-2



COMPOST FILTER BERM DETAIL

COMPOST FILTER BERM NOTES:

1. SEE PLAN VIEW FOR AREA OF COMPOST FILTER BERM.
2. SHALL BE APPLIED TO ALL SLOPES RECEIVING A COMPOST BLANKET AT 4.5m INCREMENTS.
3. FILTER BERMS SHALL RUN PARALLEL TO THE CONTOUR.
4. FILTER BERMS SHALL BE A MINIMUM OF 300mm H x 600mm w.
5. FILTER BERMS SHALL BE APPLIED UTILIZING PNEUMATIC BLOWER, OR BY HAND.
6. SHALL ONLY BE UTILIZED IN AREAS WHERE SHEET FLOW CONDITIONS PREVAIL; SHALL BE PROHIBITED IN AREAS OF POSSIBLE CONCENTRATED FLOW.
7. SOIL PREPARATION SHALL BE COMPLETE PER THE SPECIFICATIONS OUTLINED IN THESE CRITERIA PRIOR TO APPLICATION.
8. WHEN TURF GRASS FINISH IS NOT DESIRED, SURFACE ROUGHENING ON SLOPES SHALL TAKE PLACE PRIOR TO APPLICATION.
9. SEEDING SHALL BE DRILLED PRIOR TO THE APPLICATION OF COMPOST OR SEED MAY BE COMBINED AND BLOWN WITH THE PNEUMATIC BLOWER.
10. THE ESCP MANAGER SHALL INSPECT WEEKLY, DURING AND AFTER ANY STORM EVENT.
11. COMPOST USED IN THE APPLICATION OF THE COMPOST BLANKET SHALL BE A CLASS 1 COMPOST AS DEFINED BY THE FOLLOWING PHYSICAL, CHEMICAL, AND BIOLOGICAL PARAMETERS:

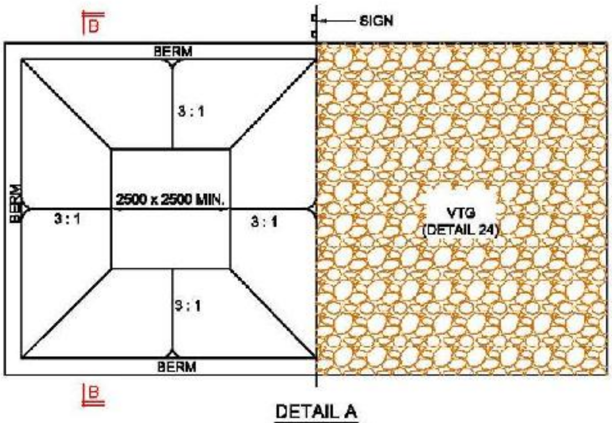
PARAMETERS	CLASS 1 COMPOST FOR COMPOST BLANKET
MINIMUM STABILITY INDICATOR	STABLE TO VERY STABLE
SOLUBLE SALTS	MAXIMUM 5mmhos/cm
PH	6.0 - 8.0
AG INDEX	> 10
MATURITY INDICATOR EXPRESS AS PERCENTAGE OF GERMINATION / VIGOR	80+ / 80+
MATURITY INDICATOR EXPRESSED AS AMMONIA N/ NITRATE N RATIO	< 4
MATURITY INDICATOR EXPRESSED AS CARBON TO NITROGEN RATIO	20 : 1
TESTED FOR CLOPYRALID	YES / NEGATIVE RESULT
MOISTURE CONTENT	30-60 %
ORGANIC MATTER CONTENT	25-45 % OF DRY WEIGHT
PARTICLE SIZE DISTRIBUTION	3" (75mm) 100% PASSING 1" (25mm) 95% TO 100% PASSING 3/4" (19mm) 85% TO 90% PASSING 3/8" (9.5mm) 50 % TO 60% PASSING #4 20 TO 35% PASSING

NOTE: ALL UNITS IN MILIMETERS (mm)

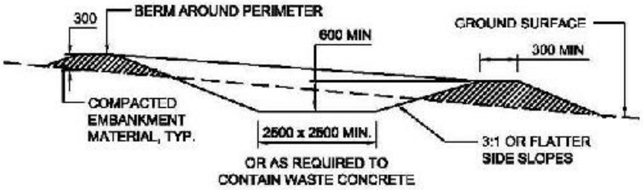
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

COMPOST BERM

SD D-3



DETAIL A
SCALE : N.T.S



SECTION B
SCALE : N.T.S

CONCRETE WASHOUT AREA INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATIONS OF CONCRETE WASHOUT AREA.
2. THE CONCRETE WASHOUT AREA SHALL BE INSTALLED PRIOR TO ANY CONCRETE PLACEMENT ON SITE.
3. VEHICLE TRACKING CONTROL IS REQUIRED AT THE ACCESS POINT.
4. SIGNS SHALL BE PLACED AT THE CONSTRUCTION ENTRANCE, AT THE WASHOUT AREA, AND ELSE WHERE AS NECESSARY TO CLEARLY
5. EXCAVATED MATERIAL SHALL BE UTILIZED IN PERIMETER BERM CONSTRUCTION.

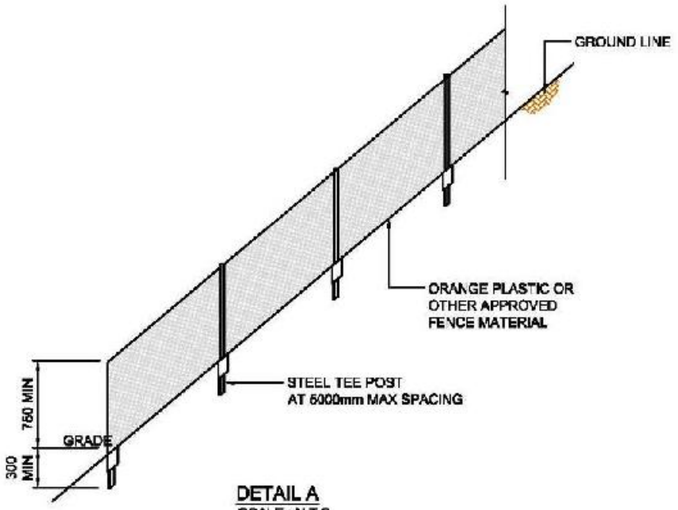
CONCRETE WASHOUT AREA MAINTENANCE NOTES

1. THE CONCRETE WASHOUT AREA SHALL BE REPAIRED AND ENLARGED OR CLEANED OUT AS NECESSARY TO MAINTAIN CAPACITY FOR WASTED CONCRETE.
2. AT THE END OF CONSTRUCTION, ALL CONCRETE SHALL BE REMOVED FROM THE SITE AND DISPOSED OF AT AN APPROVED WASTE SITE.
3. WHEN THE CONCRETE WASHOUT AREA IS REMOVED, THE DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED IN MANNER APPROVED BY THE COUNTY.
4. INSPECT WEEKLY, DURING AND AFTER ANY STORM EVENT.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

CONCRETE WASHOUT AREA	SD D-4



DETAIL A
SCALE : N.T.S

CONSTRUCTION FENCE INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - TYPE OF CONSTRUCTION LIMIT INDICATOR.
   - LOCATIONS OF CONCRETE WASHOUT AREA.
2. CONSTRUCTION FENCE INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO OTHER BMPs AND ANY LAND-DISTURBING ACTIVITIES.
3. STEEL TEE POSTS SHALL BE UTILIZED FOR SUPPORT OF CONSTRUCTION FENCE. MAXIMUM SPACING FOR TEE POSTS SHALL BE 4.5m.

CONSTRUCTION FENCE MAINTENANCE NOTES

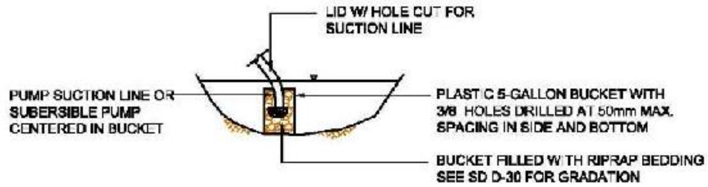
1. ANY DAMAGED FENCE OR MARKERS SHALL BE REPAIRED ON A DAILY BASIS.
2. FENCE SHALL BE REMOVED AT THE END OF CONSTRUCTION. IF ANY DISTURBED AREA EXISTS AFTER FENCE REMOVAL, IT SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERMWISE STABILIZED IN A MANNER APPROVED BY THE COUNTY.

NOTE: ALL UNITS IN MILIMETERS (mm)

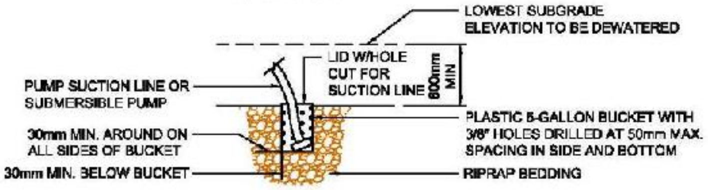
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

CONSTRUCTION FENCE

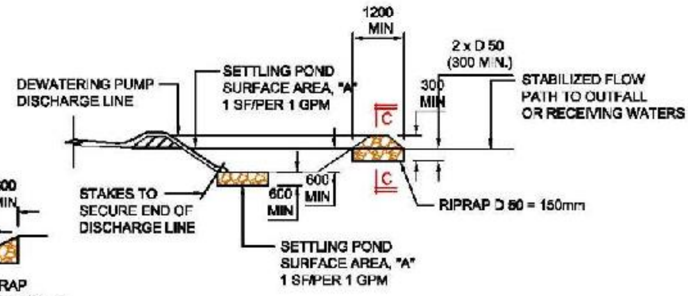
SD D-5

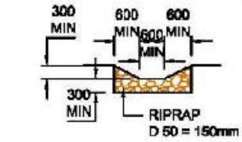


ALTERNATIVE FOR DRAINING POND
ALREADY FILLED WITH WATER
SCALE : N.T.S



DEWATERING SUMP FOR SUBMERSIBLE PUMP - DETAIL A
SCALE : N.T.S





BASIN OULET - SECTION C
SCALE : N.T.S

SUMP DISCHARGE
SETTLING BASIN - DETAIL B
SCALE : N.T.S

DEWATERING INSTALLATION NOTES

1. THE ESCP MANAGER SHALL OBTAIN A CONSTRUCTION DISCHARGE (DEWATERING) PERMISION FROM THE AUTHORITIES . ALL DEWATERING SHALL BE IN ACCORDANCE WITH THE REQUIREMENT OF THE DISCHARGE PERMISION AND SHALL BE COORDINATED WITH THE AUTHORITIES OFFICER.

2. THE ESCP MANAGER SHALL PROVIDE, OPERATE, AND MAINTAIN DEWATERING SYSTEMS OF SUFFICIENT SIZE AND CAPACITY TO PERMIT EXCAVATION AND SUBSEQUENT CONSTRUCTION IN DRY CONDITIONS AND TO LOWER AND MAINTAIN THE GROUNDWATER LEVEL A MINIMUM OF 600mm BELOW THE LOWEST POINT OF EXCAVATION AND CONTINUOUSLY MAINTAIN EXCAVATIONS FREE OF WATER UNTIL BACKFILLED TO FINAL GRADE.

3. DEWATERING OPERATIONS SHALL USE ONE OR MORE OF THE DEWATERING SUMPS SHOWN ABOVE OR OTHER MEANS APPROVED BY THE COUNTY TO REDUCE THE PUMPING OF SEDIMENT, AND SHALL PROVIDE A TEMPORARY BASIN FOR SETTLING PUMPED DISCHARGES PRIOR TO RELEASE OFF SITE OR DISCHARGE SETTLING BASIN SHOWN ABOVE.

4. A 1.2m SQUARE RIPRAP PAD SHALL BE PLACED AT DISCHARGE POINT.

5. THE DISCHARGE END OF THE LINE SHALL BE STAKED IN PLACES TO PREVENT MOVEMENT OF RIPRAP PAD

DEWATERING MAINTENANCE NOTES

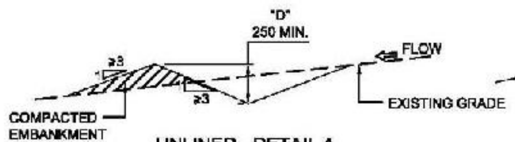
1. THE ESCP MANAGER SHALL INSPECT DEWATERING SYSTEMS AND PERFORM ANY NECESSARY REPAIRS OR MAINTENANCE ON A HOURLY BASIS.

2. TEMPORARY SETTLING BASINS SHALL BE REMOVED WHEN NO LONGER NEEDED FOR DEWATERING OPERATIONS. ANY DISTURBED SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED.

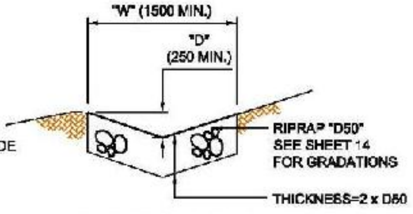
NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

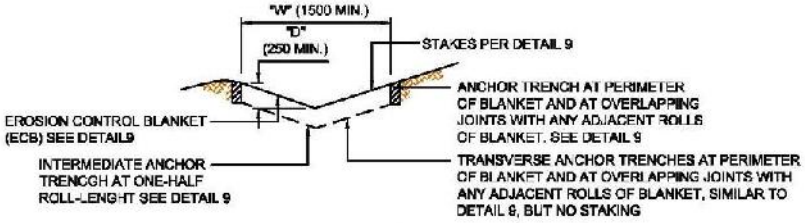
DEWATERING	SD D-6



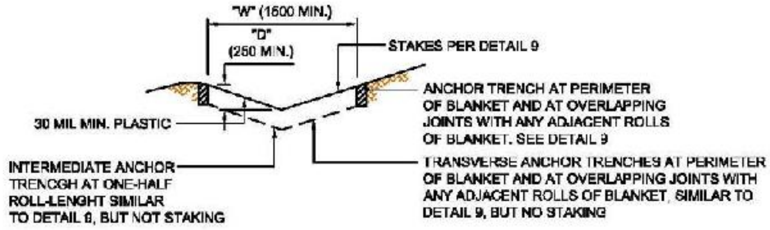
UNLINED - DETAIL A
SCALE : N.T.S



RIPRAPLINED - DETAIL D
SCALE : N.T.S



EROSION CONTROL BLANKET (ECB) LINED - DETAIL B
SCALE : N.T.S



PLASTIC LINED - DETAIL C
SCALE : N.T.S

DIVERSION DICTH INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF DIVERSION DITCH.
   - TYPE OF DITCH (UNLINED, ECB LINED, PLASTIC LINED OR RIPRAP LINED).
   - LENGTH OF EACH TYPE OF DITCH.
   - DEPTH, "D", AND WIDTH, "W" DIMENSIONS.
   - FOR ECB LINED DITCH, EROSION CONTROL BLANKET TYPE (SEE DETAIL 9).
   - FOR RIPRAP LINED DITCH, SIZE OF RIPRAP, "D50".
2. SEE DRAINAGE PLANS FOR DETAILS OF ANY PERMANENT CONVEYANCE FACILITIES OR DIVERSION DITCHES EXCEEDING A 2-YEAR FLOW RATE
3. DIVERSION DITCHES INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO ANY LAND-DISTURBING ACTIVITIES.
4. FOR ECB LINED DITCHES, INSTALLATION OF EROSION CONTROL BLANKET SHALL CONFORM TO THE REQUIREMENTS.
5. IN LOCATIONS WHERE CONSTRUCTION TRAFFIC MUST CROSS A DIVERSION DITCH, THE DEVELOPERS SHALL INSTALL A TEMPORARY CULVERT WITH A MINIMUM DIAMETER OF 300mm.

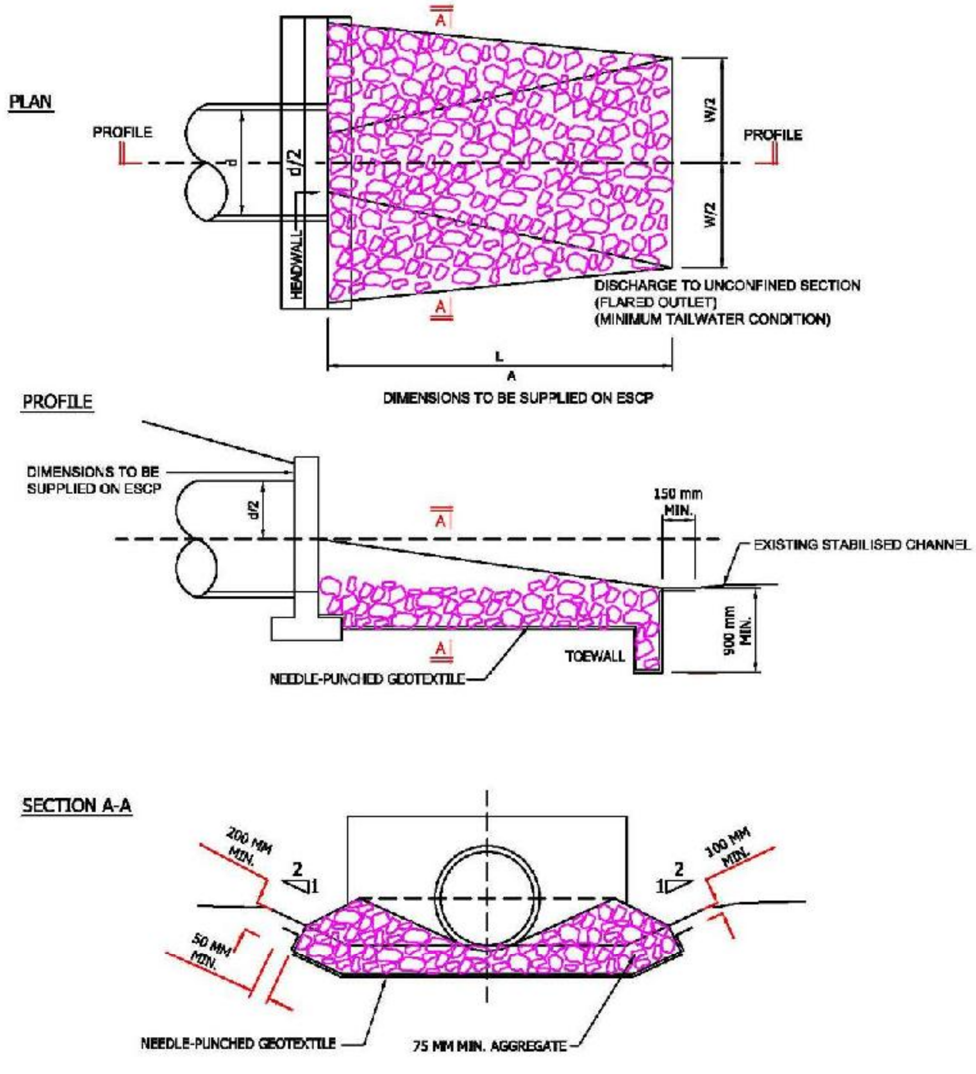
DIVERSION DICTH MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT DIVERSION DITCHES WEEKLY, DURING AND AFTER ANY STORM AVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.
2. DIVERSION DITCHES ARE TO REMAIN IN PLACE UNTIL THE END OF CONSTRUCTION.
3. IF DIVERSION DITCHES ARE REMOVED, THE DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE AUTHORITY.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

DIVERSION DICTH	SD D-7

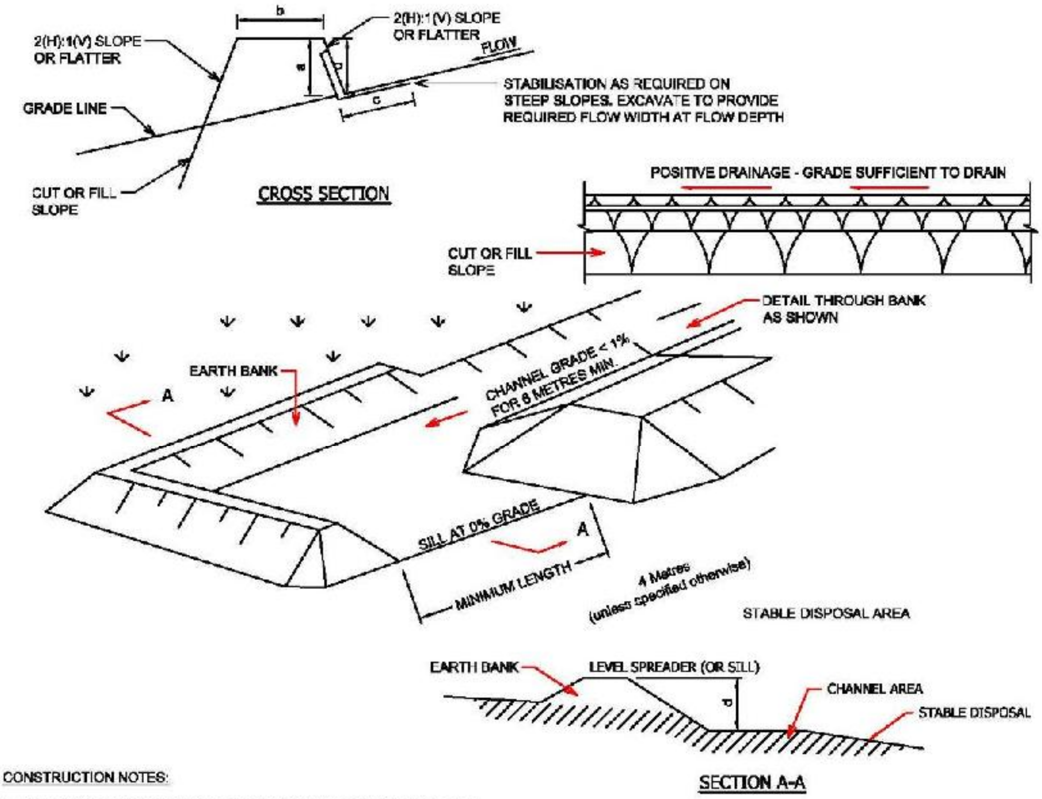


CONSTRUCTION NOTES:

1. SUBGRADE FILL TO BE COMPACTED TO THE DENSITY OF THE SURROUNDING UNDISTURBED MATERIAL.NTY
2. ENSURE THAT CONCRETE OR RIPRAP USED FOR ENERGY DISSIPATOR OR OUTLET PROTECTION CONFORMS TO.
3. ENSURE THAT THE GEOTEXTILE DOES NOT SUSTAIN SERIOUS DAMAGE BY PREPARING A SMOOTH, EVEN FOUNDATION.
4. REPAIR MINOR DAMAGE TO THE GEOTEXTILE BEFORE SPREADING ANY AGGREGATE. FOR REPAIRS, PATCH ONE PIECE OF FABRIC OVER THE DAMAGE, MAKING SURE THAT ALL JOINTS AND PATCHES OVERLAP MORE THAN 300 MM.

SOURCE : NSW DEPT OF HOUSING, 1998

DRAINAGE OUTLET PROTECTION | SD D-8



CONSTRUCTION NOTES:

1. ALL BANKS SHALL BE COMPACTED BY EARTH MOVING EQUIPMENT.
2. ALL BANKS SHALL HAVE POSITIVE DRAINAGE TO AN OUTLET.
3. TOP WIDTH MAY BE WIDER AND SIDE SLOPES MAY BE FLATTER IF DESIRED TO FACILITATE CROSSING BY CONSTRUCTION TRAFFIC.
4. FIELD LOCATION SHOULD BE ADJUSTED AS NEEDED TO UTILISE A STABILISED SAFE OUTLET.
5. OUTLETS SHALL FUNCTION WITH A MINIMUM OF EROSION. RUNOFF SHALL BE CONVEYED TO A SEDIMENT TRAP OR BASIN WHERE EITHER THE BANK CHANNEL OR THE DRAINAGE AREA ABOVE THE BANK ARE NOT ADEQUATELY STABILISED.
6. STABILISATION SHALL BE AS FOLLOWS:-

FLOW CHANNEL STABILISATION

TYPE OF TREATMENT	CHANNEL GRADE	EARTHBANK A	EARTHBANK B
1	0.5-3.0%	SEED AND STRAW MULCH	SEED AND STRAW MULCH
2	3.1-5.0%	SEED AND STRAW MULCH	SEED USING JUTE OR EQUIVALENT: BITUMEN, SOD OR 50 MM AGGREGATE
3	5.1-8.0%	SEED WITH JUTE OR 50 MM AGGREGATE	LINED RIP RAP 100-200 MM
4	8.1-15.0%	Lined Rip Rap 100-200 mm	ENGINEERING DESIGN

A. STONE TO BE 50 MM AGGREGATE ORRRECYCLED CONCRETE EQUIVALENT, IN A LAYER AT LEAST 100 MM THICK AND BE PRESSED INTO THE SOIL WITH CONSTRUCTION EQUIPMENT.

B. RIP RAP TO BE 100-200 MM IN A LAYER AT LEAST 250 MM THICK AND PRESSED INTO THE SOIL.

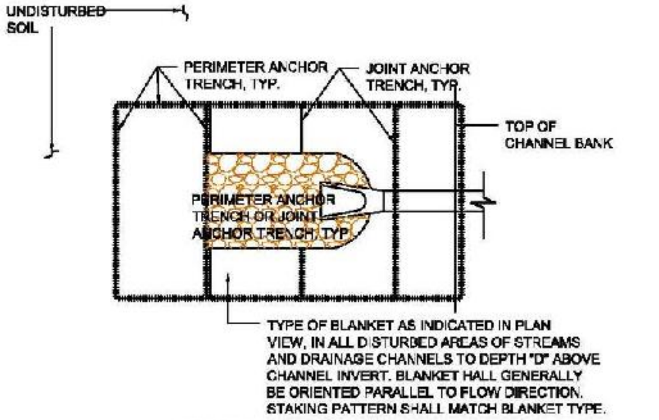
C. APPROVED EQUIVALENTS CAN BE SUBSTITUTED FOR ANY OF THE ABOVE MATERIALS.

7. PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

SOURCE : NSW DEPT OF HOUSING, 1998

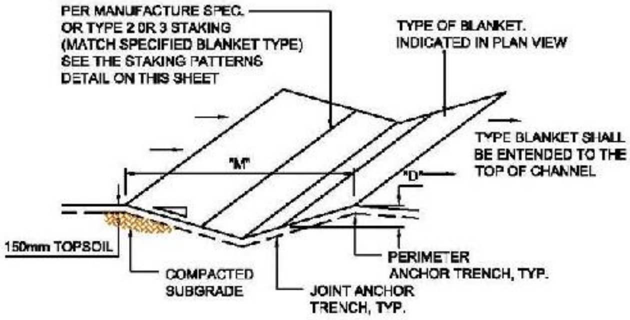
EARTH BANK

SD D-9



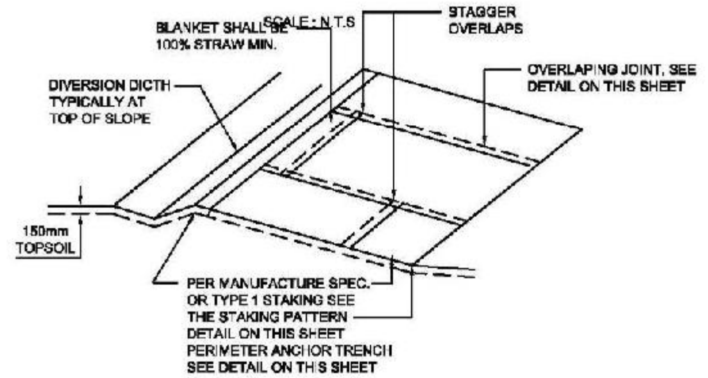
IN DISTURBED AREAS OF
STREAMS AND DRAINAGE CHANNELS - DETAIL A

SCALE : N.T.S



IN DIVERSION DICTH OF
SMALL DICTH DRAINAGEWAY- DETAIL B

SCALE : N.T.S



NOTE: ALL UNITS IN MILIMETERS (mm)

OUTSIDE OF STREAMS
AND DRAINAGE CHANNELS - DETAIL C

SCALE : N.T.S

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

EROSION CONTROL BLANKET	SD D-10

EROSION CONTROL BLANKET INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF PERIMETER OF EROSION CONTROL BLANKET.
   - TYPE OF BLANKET (STRAW, STRAW-COCONUT, COCONUT OR EXCELSIOR).
   - AREA "A" IN SQUARE METER OF EACH TYPE OF BLANKET.

2. ALL EROSION CONTROL BLANKETS AND NETTING SHALL BE MADE OF 100% NATURAL AND BIODEGRADABLE MATERIAL: NO PLASTIC OR OTHER SYNTHETIC MATERIAL, EVEN IF PHOTO DEGRADABLE, SHALL BE ALLOWED.

3. IN AREAS WHERE EROSION CONTROL BLANKET IS SHOWN ON THE PLANS, THE DEVELOPER SHALL PLACE TOPSOIL AND PERFORM FINAL GRADING, SURFACE PREPARATION, AND SEEDING BELOW THE BLANKET IN ACCORDANCE WITH THE REQUIREMENT OF SEEDING AND MULCHING. SUB GRADE SHALL BE SMOOTH AND MOIST PRIOR TO BLANKET INSTALLATION AND THE BLANKET SHALL BE IN FULL CONTACT WITH SUB GRADED NO GAPS OR VOIDS SHALL EXIST UNDER THE BLANKET.

4. PERIMETER ANCHOR TRENCH SHALL BE USED AT OUTSIDE PERIMETER OF ALL BLANKET AREAS.

5. THE OVERLAPPING JOINT DETAIL SHALL BE USED TO JOINT ROLLS OF BLANKETS TOGETHER FOR BLANKET ON SLOPES.

NOTE: ALL UNITS IN MILIMETERS (mm)

EROSION CONTROL BLANKET INSTALLATION NOTES - CONTINUED

6. SEE DRAINAGE DESIGN PLANS FOR MAJOR DRAINAGEWAY STABILIZATION MEASURES THAT MAY EXCEED THE DESIGN CONDITIONS ASSOCIATED WITH THE DETAILS ABOVE.

EROSION CONTROL BLANKET MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT EROSION CONTROL BLANKETS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS AS NECESSARY.

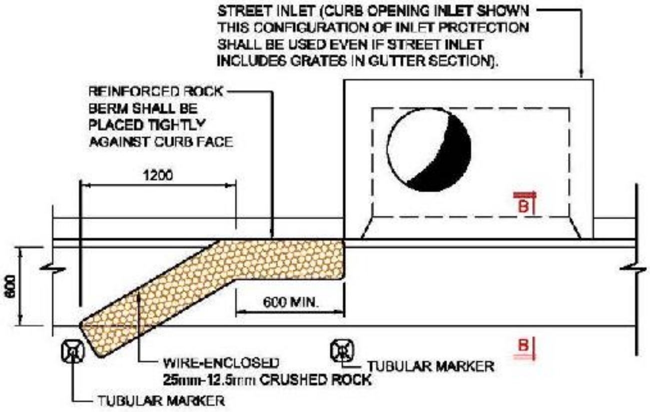
2. EROSION CONTROL BLAKET IS TO BE LEFT IN PLACE UNLESS REQUESTED TO BE REMOVED

3. ANY EROSION CONTROL BLANKET PULLED OUT, TORN OR OTHERWISE DAMAGED SHALL BE RE-INSTALLED ANY SUBGRADE AREAS BELOW THE BLANKET THAT HAVE ERODED TO CREATE A VOID UNDER THE BLANKET, OR THAT REMAIN DEVOID OF GRASS SHALL BE REPAIRED, RESEEDED AND MULCHED AND THE EROSION CONTROL BLANKET REINSTALLED.

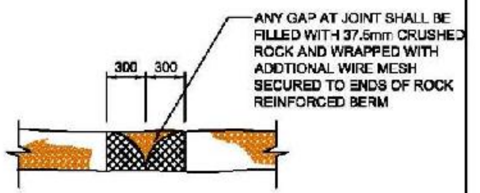
   NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

EROSION CONTROL BLANKET	SD D-10 (a)



STREET INLET ON CONTINUOUS GRADE
(AFTER PAVING) - PLAN
SCALE : N.T.S



JOINT DETAIL
SCALE : N.T.S

INLET PROTECTION INSTALLATION NOTES:

1. INTERIM CONFIGURATION OF INLET PROTECTION IN STREETS SHALL BE INSTALLED WITHIN 48 -HOURS OF POURING INLET. INLET PROTECTION (AFTER PAVEMENT) SHALL BE INSTALLED WITHIN 48 HOURS AFTER PAVING IS PLACED.
2. INLET PROTECTION AT AREA INLETS SHALL BE INSTALLED WITHIN 48-HOURS OF POURING INLET.
3. CRUSHED ROCK SHALL BE FRACTURED FACE (ALL SIDES) AND SHALL COMPLY WITH GRADATION SHOWN ON SHEET 14 (1-1/2" MINUS). RECYCLED CONCRETE MEETING THIS GRADATION MAY BE USED.
4. WIRE MESH SHALL BE FABRICATED OF 10 GAUGE WIRE TWISTED IN TO A MESH WITH A MAXIMUM OPENING OF 1.0INCH (COMMONLY TERMED "CHICKEN WIRE"). ROLL WIDTH SHALL BE 48 - INCHES.
5. WIRE MESH SHALL BE SECURED USING " HOG RINGS" OR WIRE TIES AT 6 INCH CENTERS ALONG ALL JOINTS AND AT 2-INCH CENTERS ON ENDS OF BERM.
6. REINFORCED ROCK BERM SHALL BE CONSTRUCTED IN ONE PIECE OR SHALL BE CONSTRUCTED USING JOINT DETAIL
7. TUBULAR MARKERS SHALL MEET REQUIREMENTS OF MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD), AS AMENDED.
8. THE TOP OF REINFORCED ROCK BERM SHALL BE 1/2"-1" BELOW TOP OF CURB

INLET PROTECTION MAINTENANCE NOTES:

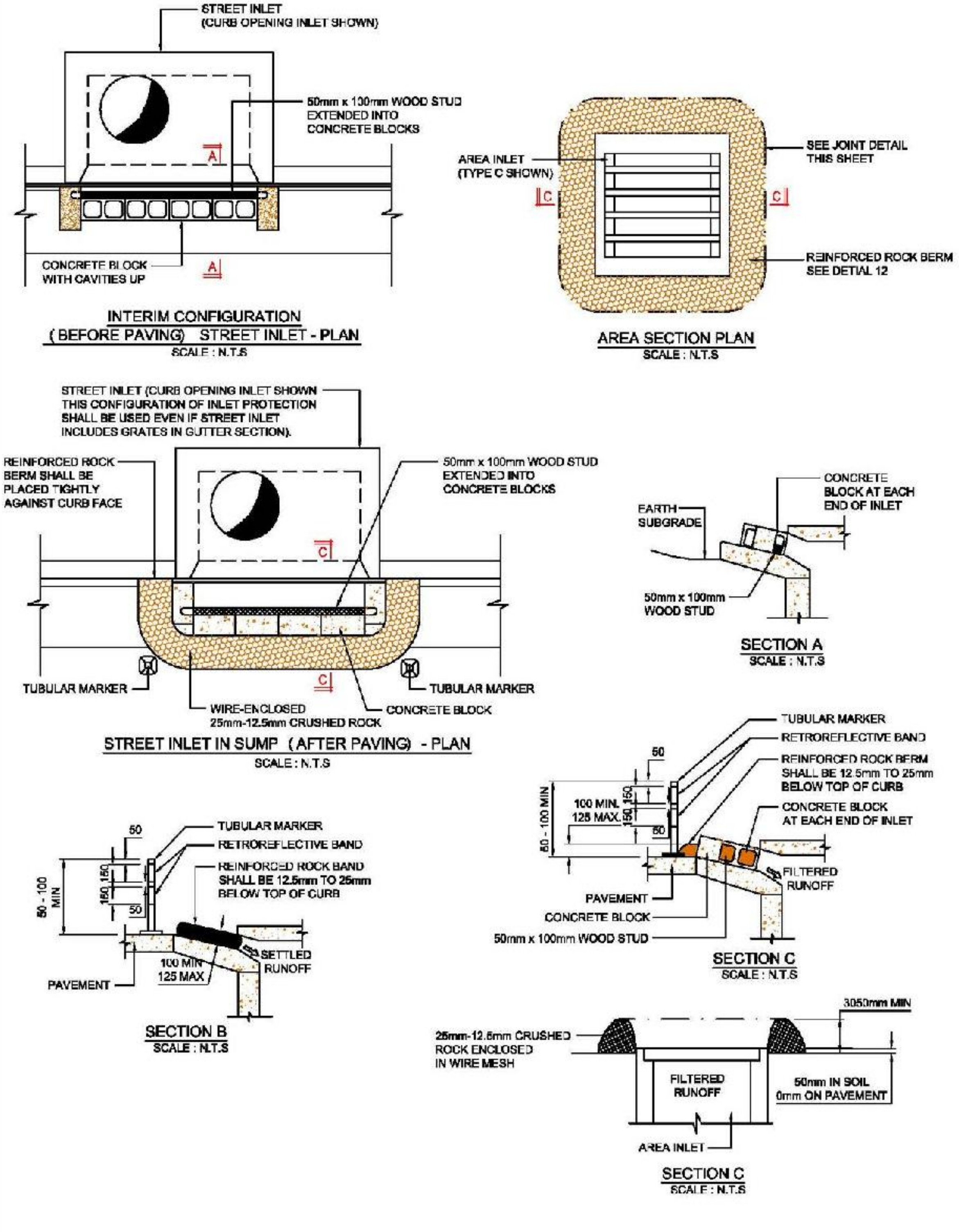
1. THE ESCP MANAGER SHALL INSPECT INLET PROTECTION WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY. MORE FREQUENT INSPECTIONS AND REPAIRS SHALL BE REQUIRED DURING WINTER CONDITIONS TO FREEZE/THAW PROBLEMS.
2. SEDIMENT ACCUMULATED UPSTREAM OF INLET PROTECTION SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF ROCK BERM IS WITHIN 2-1/2 INCHES OF THE CREST.
3. INLET PROTECTION IS TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED, UNLESS THE COUNTY APPROVES EARLIER REMOVAL OF INLET PROTECTION IN STREETS.
4. WHEN INLET PROTECTION AT AREA INLETS ARE REMOVED, THE DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE COUNTY.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

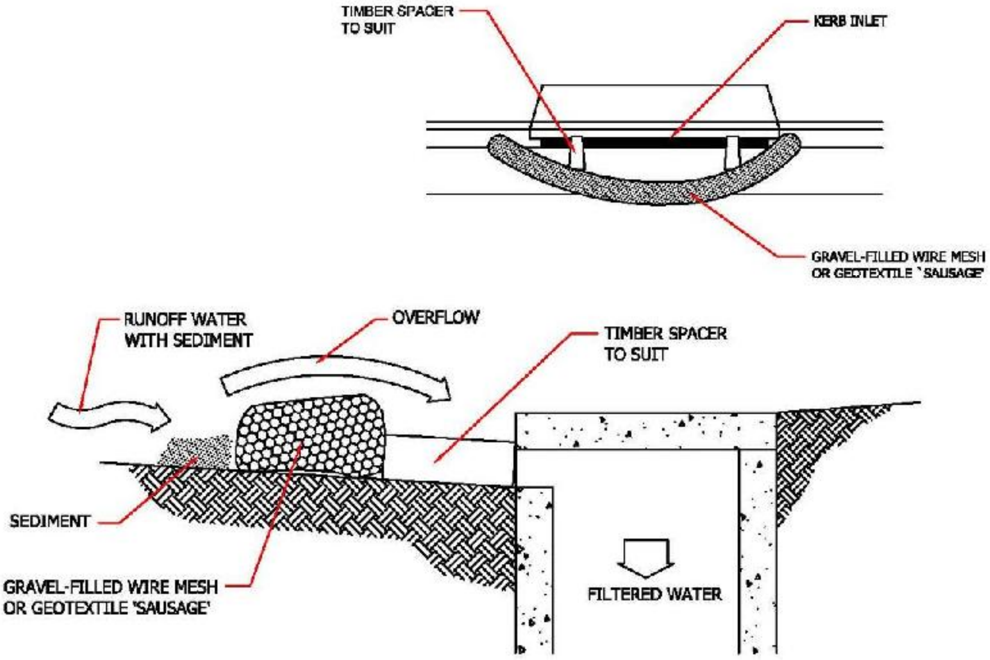
INLET PROTECTION

SD D-11(a)



SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

INLET PROTECTION	**SD D-11(a)**



NOTE:

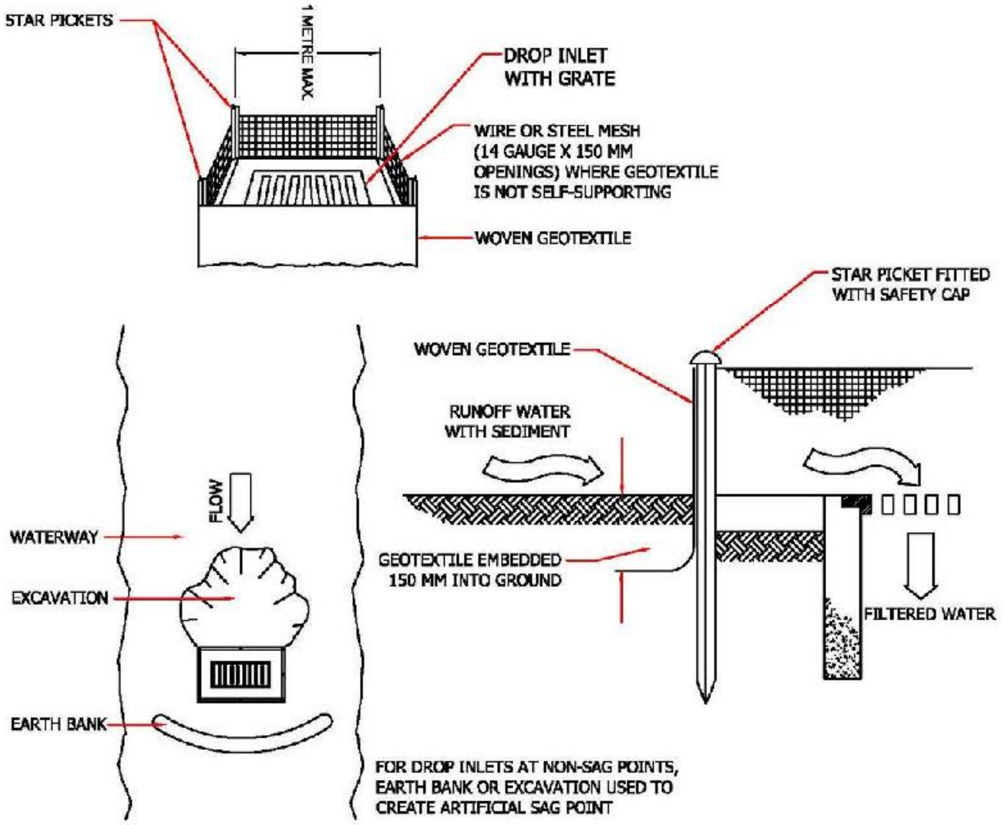
THIS PRACTICE ONLY TO BE USED WHERE SPECIFIED IN AN APPROVED ESCP

CONSTRUCTION NOTES:

1. FABRICATE A SLEEVE MADE FROM GEOTEXTILE OR WIRE MESH LONGER THAN THE LENGTH OF THE INLET PIT.
2. FILL THE SLEEVE WITH 25 MM TO 50 MM GRAVEL.
3. FORM AN ELLIPTICAL CROSS SECTION ABOUT 150 MM HIGH X 400 MM WIDE.
4. PLACE THE FILTER AT THE OPENING OF THE KERB INLET LEAVING A 100 MM GAP AT THE TOP TO ACT AS AN EMERGENCY SPILLWAY.
5. MAINTAIN THE OPENING WITH SPACER BLOCKS.
6. FORM A SEAL WITH THE KERBING AND PREVENT SEDIMENT BYPASSING THE FILTER.
7. FIT TO ALL KERB INLETS AT SAG POINTS.

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

INLET PROTECTION	SD D-11(b)



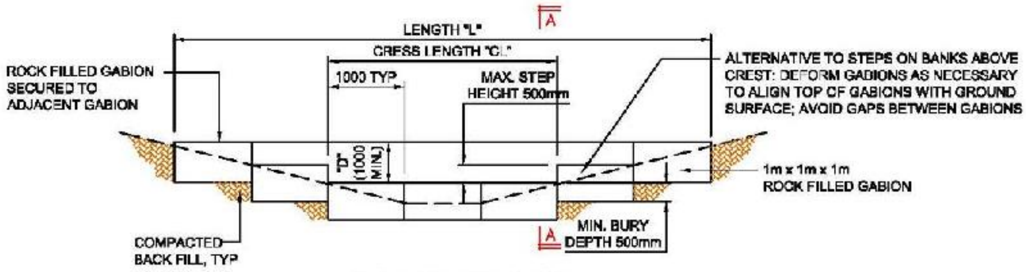
CONSTRUCTION NOTES:

1. FABRICATE A SEDIMENT BARRIER MADE FROM GEOTEXTILE.
2. SUPPORT GEOTEXTILE WITH MESH TIED TO POSTS AT 1 METRE CENTRES.
3. DO NOT COVER INLET WITH GEOTEXTILE.
4. CONSTRUCTION DETAILS ARE SIMILAR TO STANDARD DRAWING SDI-11

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

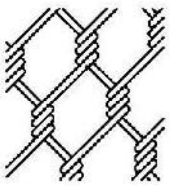
INLET PROTECTION

SD D-11(c)



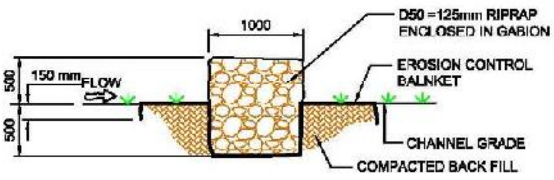
REINFORCED - ELEVATION

SCALE : N.T.S



BLOW UP OF TWISTED WIRE GABION

SCALE : N.T.S



REINFORCED - SECTION A

SCALE : N.T.S

REINFORCED CHECK DAM INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF CHECK DAMS.
   - CHECK DAM TYPE (CHECK DAM OR REINFORCED CHECK DAM).
   - LENGTH, "L" CREST LENGTH, "CL", AND DEPTH, "D".

2. CHECK DAMS INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED AFTER CONSTRUCTION FENCE, BUT PRIOR TO ANY UPSTREAM LAND-DISTURBING ACTIVITIES.

3. RIPRAP UTILIZED FOR CHECK DAMS SHALL HAVE A D 50 MEDIAN STONE SIZE OF 150mm.

4. THE CHECK DAM SHALL BE TRENCHED INTO THE GROUND A MINIMUM OF 500mm.

5. EROSION BLANKET SHALL BE PLACED IN THE REINFORCED CHECK DAM TRENCH EXTENDING A MINIMUM OF 500mm ON BOTH THE UPSTREAM AND DOWNSTREAM SIDES OF THE REINFORCED CHECK DAM.

REINFORCED CHECK DAM MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT CHECK DAMS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.

2. SEDIMENT ACCUMULATED UPSTREAM OF CHECK DAMS SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF FILTER IS WITHIN ½ OF THE HEIGHT OF THE CREST.

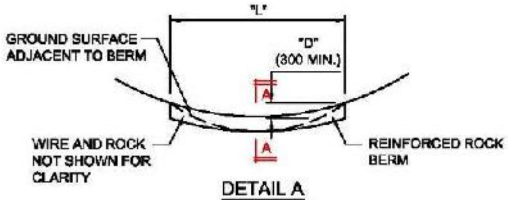
3. CHECK DAMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED.

4. WHEN CHECK DAMS ARE REMOVED, EXCAVATIONS SHALL BE FILLED WITH SUITABLE COMPACTED BACK FILL. ANY DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED AND COVERED WITH EROSION CONTROL BLANKET OR OTHERWISE STABILIZED.

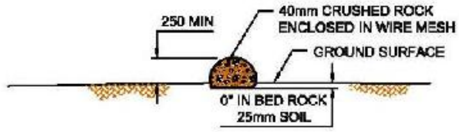
NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

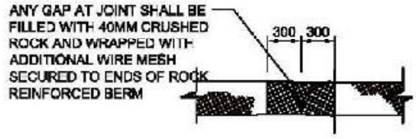
REINFORFED CHECK DAM	SD D-12



DETAIL A
SCALE : N.T.S



SECTION D
SCALE : N.T.S



JOINT DETAIL
SCALE : N.T.S

REINFORCED CHECK DAM INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF REINFORCED ROCK BERM.
   - LENGTH, "L" AND DEPTH, "D". DIMENSIONS

2. REINFORCED ROCK BERM SECTION APPLIES TO CULVERT INLET FILTER AND INLET PROTECTION.

3. CRUSHED ROCK SHALL BE FRACTURED FACE (ALL SIDES) AND SHALL COMPLY WITH GRADATION (1-1/2" MINUS). RECYCLED CONCRETE MEETING THIS GRADATION MAY BE USED.

4. FOR CONCENTRATED FLOW AREAS THE ENDS OF THE REINFORCED ROCK BERM SHALL BE 300mm HIGHER THAN CENTER OF THE BERM.

REINFORCED CHECK DAM MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT REINFORCED ROCK BERM WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.

2. SEDIMENT ACCUMULATED UPSTREAM OF REINFORCED ROCK BERM SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF FILTER IS WITHIN 150mm OF THE CREST.

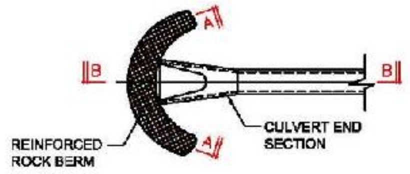
3. REINFORCED ROCK BERMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED.

4. WHEN REINFORCED ROCK BERM ARE REMOVED, ANY DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE COUNTY.

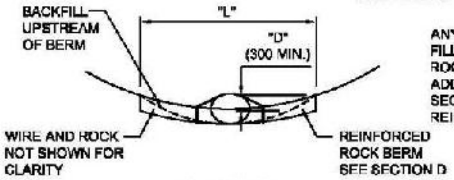
NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

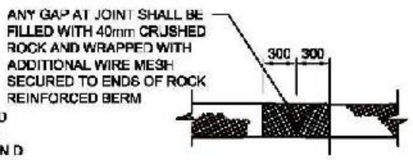
REINFORCED ROCK BERM	SD D-13



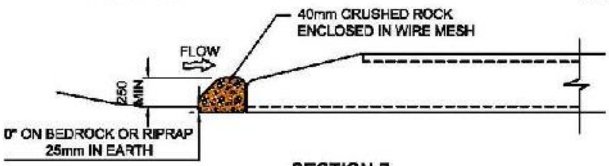
PLAN
SCALE : N.T.S



SECTION A
SCALE : N.T.S



JOINT DETAIL
SCALE : N.T.S



SECTION B
SCALE : N.T.S

INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF CULVERT INLET FILTERS.
   - LENGTH, "L" AND DEPTH, "D"

2. CRUSHED ROCK SHALL BE FRACTURED FACE (ALL SIDES) AND SHALL COMPLY WITH GRADATION SHOWN ON SD D-30 (25-12.5 MINUS). RECYCLED CONCRETE MEETING THIS GRADATION MAY BE USED.

3. WIRE MESH SHALL BE FABRICATED OF 10 GAUGE WIRE TWISTED INTO A MESH WITH A MAXIMUM OPENING OF 25mm (COMMONLY TERMED "CHICKEN WIRE").

4. WIRE MESH SHALL BE SECURED USING "HOG RINGS" OR WIRE TIES AT 150mm CENTERS ALONG ALL JOINTS AND AT 50mm CENTERS ON ENDS OF BERM.

5. THE ENDS OF THE REINFORCED ROCK BERM SHALL BE 300mmHIGHER THAN CENTER OF THE BERM.

MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT REINFORCED ROCK BERM WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.

2. SEDIMENT ACCUMULATED UPSTREAM OF REINFORCED ROCK BERM SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF FILTER IS WITHIN 150mm OF THE CREST.

3. REINFORCED ROCK BERMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED.

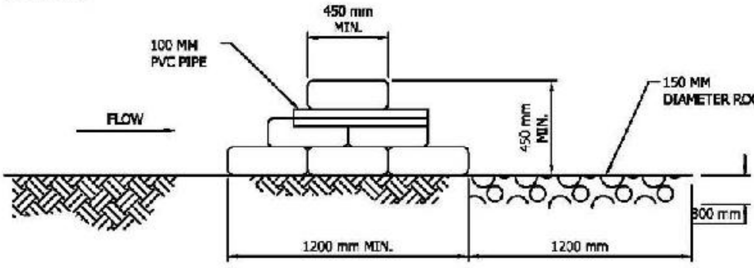
4. WHEN REINFORCED ROCK BERM ARE REMOVED, ANY DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

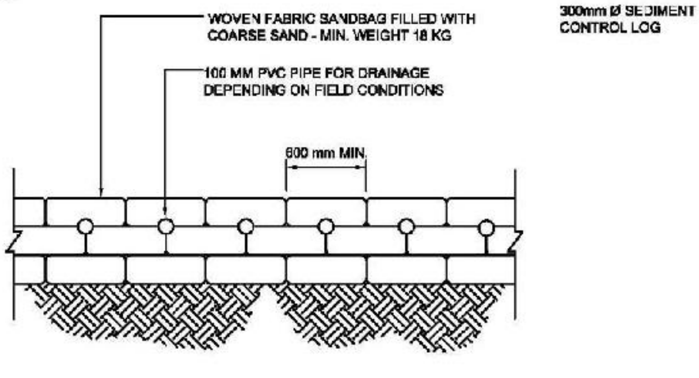
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

RRB FOR CULVERT PROTECTION	SD D-14

SECTION

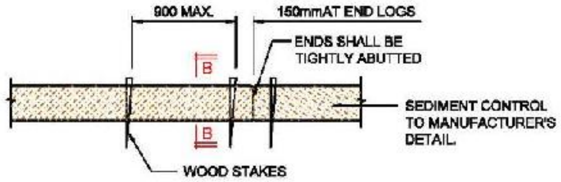


FRONT VIEW

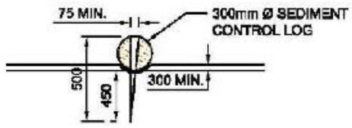


SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SAND BAG BARRIER	SD D-15



DETAIL A
SCALE : N.T.S



SECTION B
SCALE : N.T.S

SEDIMENT CONTROL LOG INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION AND LENGTH OF SEDIMENT CONTROL LOG.
2. SEDIMENT CONTROL LOG INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO ANY LAND-DISTRURBING ACTIVITIES.
3. SEDIMENT CONTROL LOGS SHALL CONSIST OF STRAW, COMPOST, EXCELSIOR OR COCONUT FIBER.
4. NOT FOR USE IN CONCENTRATED FLOW AREAS.
5. THE SEDIMENT CONTROL LOG SHALL BE TRENCHED INTO THE GROUND A MINIMUM OF 50mm.

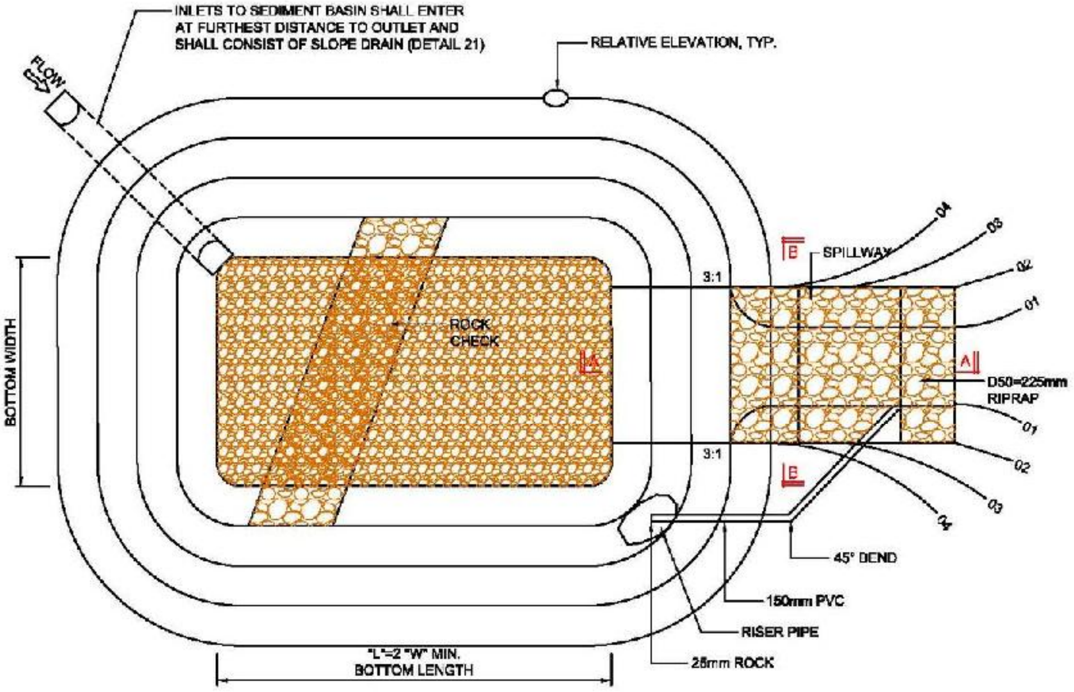
SEDIMENT CONTROL LOG MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT SEDIMENT CONTROL LOGS DAILY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT UPSTREAM SEDIMENT AS NECESSARY.
2. SEDIMENT ACCUMULATED UPSTREAM OF SEDIMENT CONTROL LOGS SHALL BE REMOVED WHEN THE UPSTREAM SEDIMENT DEPTH IS WITHIN 1/2 THE HEIGHT OF THE CREST OF LOG.
3. SEDIMENT CONTROL LOG SHALL BE REMOVED AT THE END OF CONSTRUCTION. IF ANY DISTURBED AREA EXISTS AFTER REMOVAL, IT SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SEDIMENT CONTROL LOG	SD D-16



STANDARD BASIN - PLAN

SCALE : N.T.S

REINFORCED CHECK DAM INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF SEDIMENT BASIN.
   - TYPE OF BASIN (STANDARD BASIN OR NON-STANDARD BASIN)
   - FOR STANDARD BASIN, CREST LENGTH, "CL", BOTTOM WIDTH, "W", AND HOLE DIAMETER. "HD"
   - FOR NON-STANDARD BASIN, SEE CONSTRUCTION DRAWINGS FOR DESIGN OF BASIN INCLUDING RISER HEIGHT, "H", NUMBER OF COLUMNS, "N", HOLE DIAMETER, "HD", AND PIPE DIAMETER "D".
2. FOR STANDARD BASIN, BOTTOM DIMENSION MAY BE MODIFIED AS LONG AS BOTTOM AREA IS NOT REDUCED.
3. SEDIMENT BASINS INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO ANY OTHER LAND-DISTURBING ACTIVITY.
4. EMBANKMENT MATERIAL SHALL CONSIST OF SOIL FREE OF DEBRIS, ORGANIC MATERIAL, AND ROCKS OR CONCRETE GREATER THAN 75mm AND SHALL HAVE A MINIMUM OF 15 PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE.
5. EMBANKMENT MATERIAL SHALL BE COMPACTED TO AT LEAST 95 PERCENT OF MAXIMUM DENSITY WITHIN 2 PERCENTAGE POINT OF OPTIMUM DENSITY IN ACCORDANCE WITH ASTM D698.
6. PIPE SCH 40 OR GREATER SHALL BE USED.

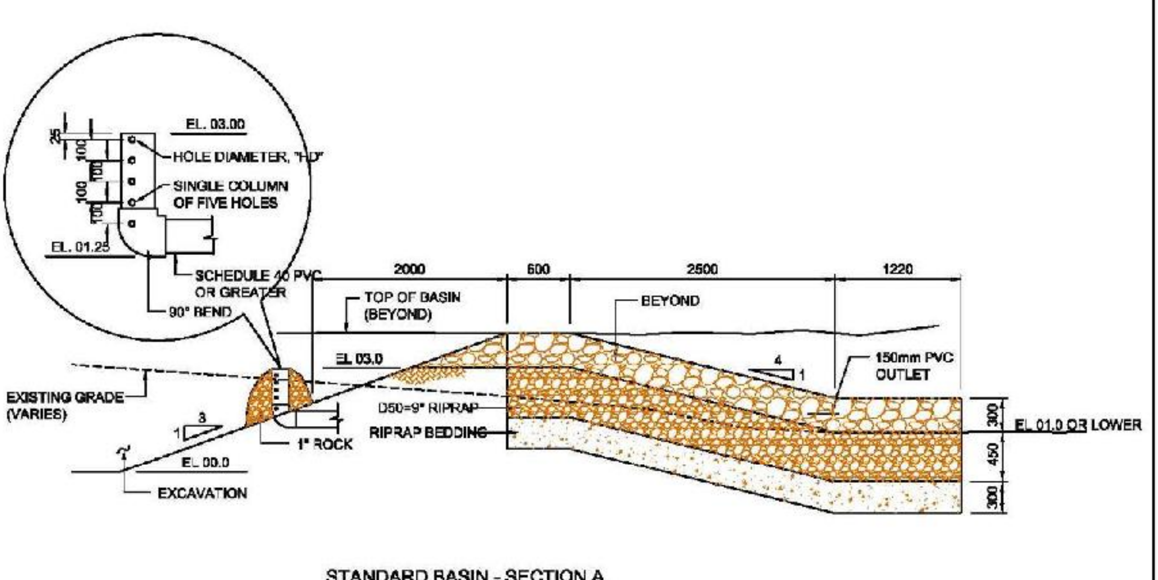
NOTE: ALL UNITS IN MILIMETERS (mm)

TT

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

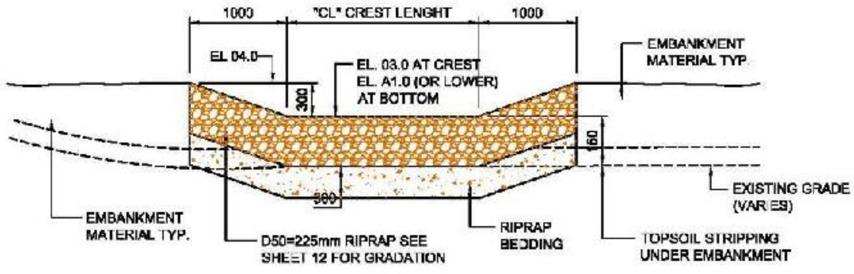
SEDIMENT BASIN

SD D-17(a)



STANDARD BASIN - SECTION A

SCALE : N.T.S



STANDARD BASIN - SECTION B

SCALE : N.T.S

SEDIMENT BASIN MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT SEDIMENT BASIN WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.

2. SEDIMENT ACCUMULATED IN SEDIMENT BASIN SHALL BE REMOVED WHEN THE SEDIMENT DEPTH IS WITHIN 600mm OF THE CREST OF THE SPILLWAY.

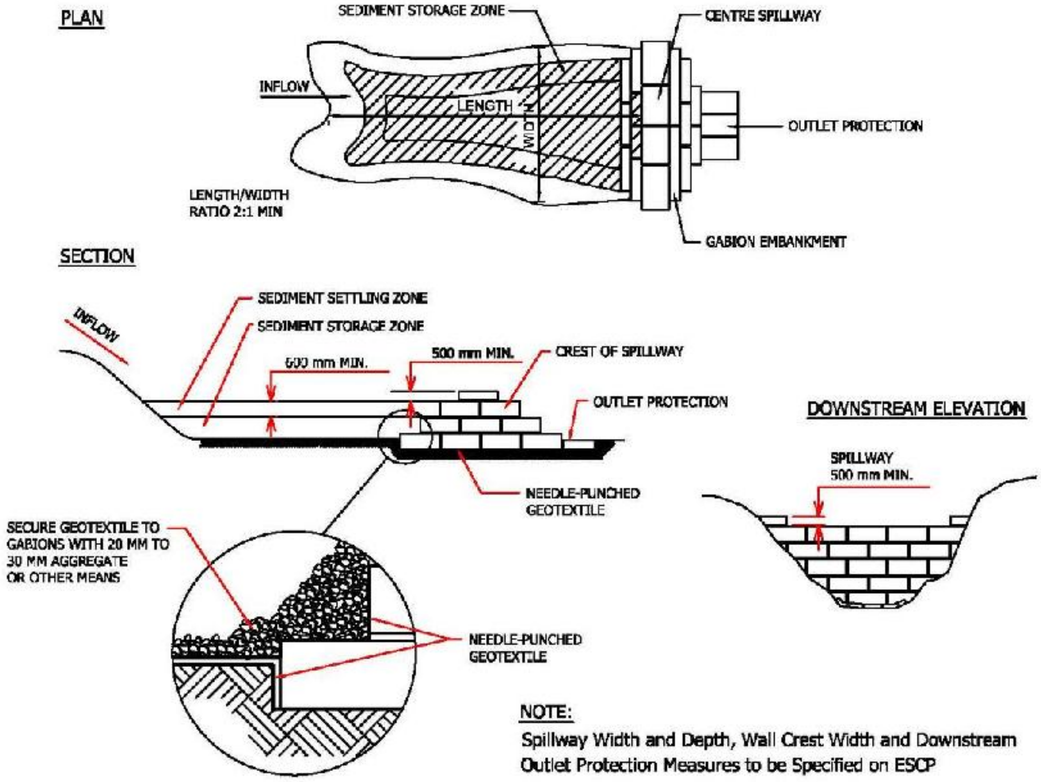
3. SEDIMENT BASINS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED.

4. IF SEDIMENT BASINS ARE REMOVED, THE DISTURBED AREA SHALL BE SEEDED AND MULCHED OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SEDIMENT BASIN	SD D-17(b)



NOTE:

Spillway Width and Depth, Wall Crest Width and Downstream Outlet Protection Measures to be Specified on ESCP

CONSTRUCTION NOTES:

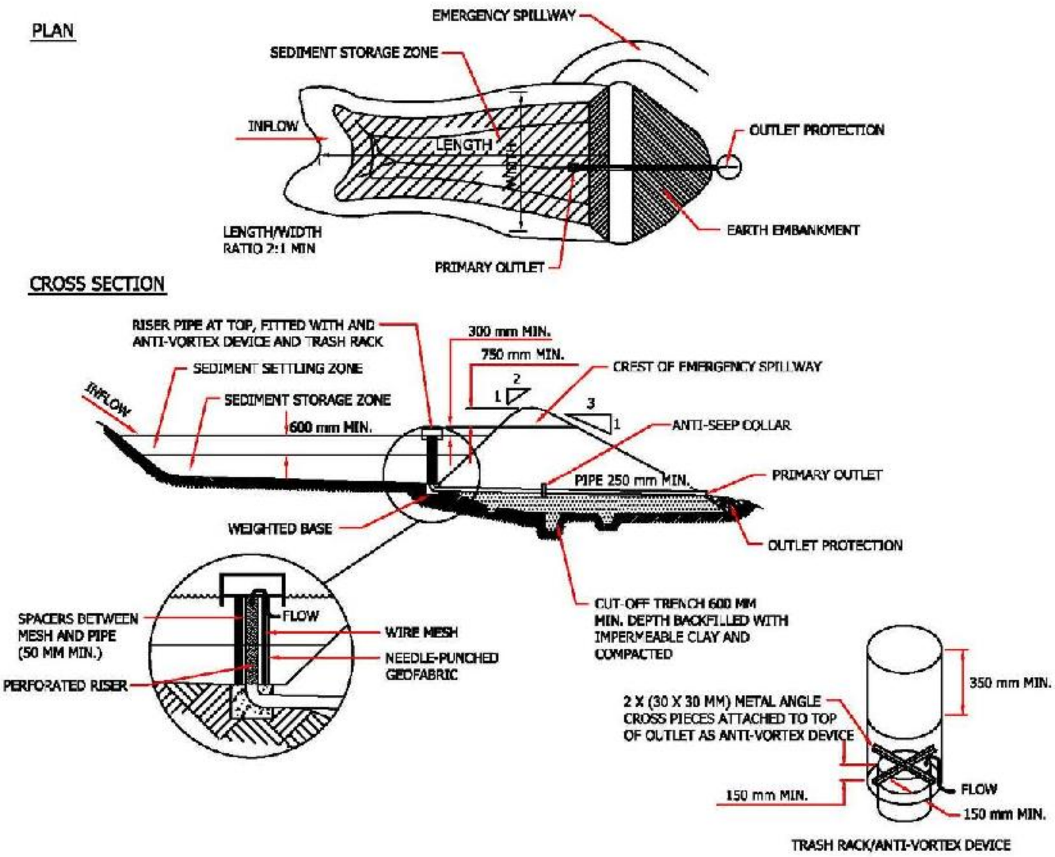
1. REMOVE ALL VEGETATION AND TOPSOIL FROM UNDER THE DAM WALL AND FROM WITHIN THE STORAGE AREA.
2. EXCAVATE TO 300 MM DEPTH FOR DAM BASE AND OR A LEVEL BASE FOR THE GABIONS
3. LINE THE EXCAVATION WITH A NEEDLE-PUNCHED GEOTEXTILE ALLOWING SUFFICIENT GEOTEXTILE TO LINE FROM THE TOE OF THE DAM, UNDER THE WALL, OVER THE UPSTREAM GABIONS AND SPILLWAY TO 500 MM BELOW THE SPILLWAY EXIT ON THE DOWNSTREAM FACE.
4. WALL PROFILE AND OUTLET PROTECTION SHALL BE MADE UP OF GABION UNITS FILLED WITH GRADED ROCK AS SPECIFIED ON ESCP.
5. CONSTRUCT A SPILLWAY 500 MM BELOW THE CREST OF THE DAM AND FOR WIDTH SPECIFIED ON THE ESCP.
6. LAP THE GEOTEXTILE OVER THE UPSTREAM FACE AND THROUGH THE SPILLWAY AND FIX IN PLACE WITH THE TOP ROW OF GABIONS.
7. COVER THE UPSTREAM FACE AND GEOTEXTILE WITH 20 MM TO 30 MM GRAVEL.
8. PLACE A "FULL OF SEDIMENT" MARKER TO SHOW WHEN LESS THAN DESIGN CAPACITY OCCURS AND SEDIMENT REMOVAL IS REQUIRED.
9. REPLACE UPSTREAM GEOTEXTILE LAYER IF DAMAGED OR PUNCTURED WHEN SEDIMENT IS REMOVED.

SOURCE : NSW DEPT OF HOUSING, 1998

SEDIMENT BASIN - GABION

(APPLIES TO TYPE C SOILS ONLY)

SD D-17(c)



CONSTRUCTION NOTES:

1. REMOVE ALL VEGETATION AND TOPSOIL FROM UNDER THE DAM WALL AND FROM WITHIN THE STORAGE AREA.
2. FORM A CUT-OFF TRENCH UNDER THE CENTRELINE OF THE EMBANKMENT 600 MM DEEP AND 1200 MM WIDE EXTENDING TO A POINT ON THE GULLY WALL ABOVE THE RISER SILL LEVEL.
3. MAINTAIN THE TRENCH FREE OF WATER AND RECOMPACT THE MATERIALS TO 95% STANDARD PROCTOR DENSITY.
4. SELECT FILL ACCORDING TO THE DIRECTIONS OF THE ESCP THAT IS FREE FROM ROOTS, WOOD, ROCK, LARGE STONE OR FOREIGN MATERIAL.
5. PREPARE THE SITE UNDER THE EMBANKMENT BY RIPPING AT LEAST 100 MM DEEP TO HELP BOND COMPACTED FILL TO EXISTING SUBSTRATE.
6. SPREAD FILL IN 100 MM TO 150 MM LAYERS AND COMPACT AT OPTIMUM MOISTURE CONTENT IN ACCORDANCE WITH THE ESCP.
7. INSTALL PIPE OUTLET WITH SEEPAGE COLLARS AS SPECIFIED IN ESCP.
8. FORM BATTER GRADES AT 2(H):1(V) UPSTREAM AND 3(H):1(V) DOWNSTREAM OR AS SPECIFIED IN ESCP.
9. INSTALL PIPE RISER AS SPECIFIED IN ESCP.
10. CONSTRUCT EMERGENCY SPILLWAY 300 MM ABOVE SILL HEIGHT OF RISER PIPE.
11. REHABILITATE STRUCTURE IN ACCORDANCE WITH THE ESCP.
12. GEOTEXTILE TO BE REPLACED WITH THE SPECIFIED MATERIAL IF BASIN DOES NOT FREELY DRAIN WITHIN 24 HOURS.
13. PLACE A "FULL OF SEDIMENT" MARKER TO SHOW WHEN LESS THAN DESIGN CAPACITY OCCURS AND SEDIMENT REMOVAL IS REQUIRED.

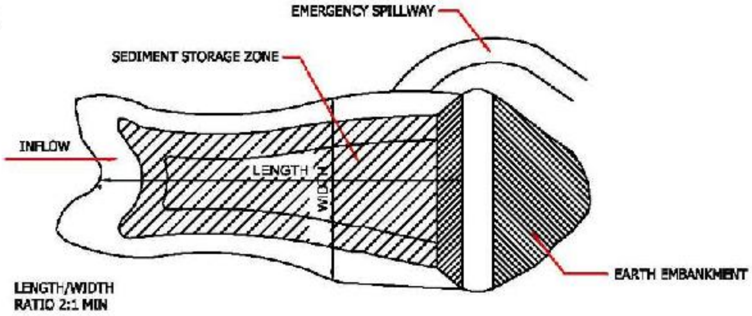
SOURCE : NSW DEPT OF HOUSING, 1998

SEDIMENT BASIN - EARTH

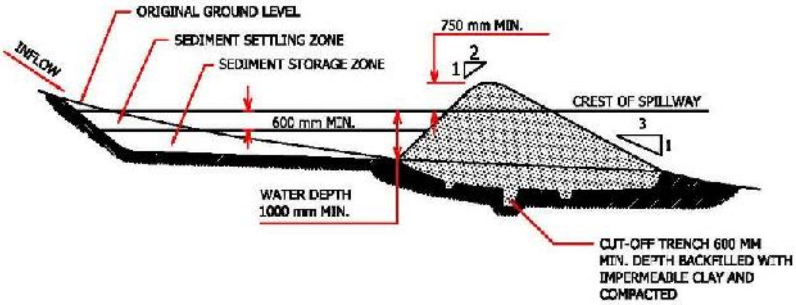
(APPLIES TO TYPE C SOILS ONLY)

SD D-17(d)

PLAN



SECTION

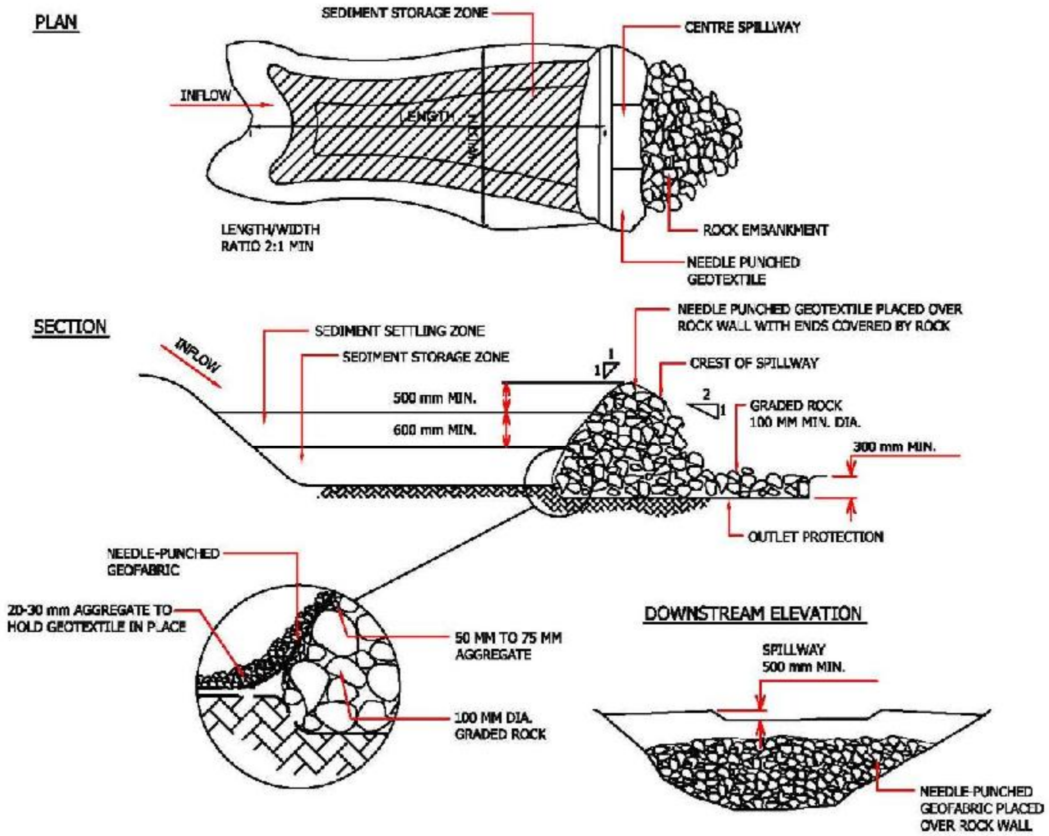


CONSTRUCTION NOTES:

1. REMOVE ALL VEGETATION AND TOPSOIL FROM UNDER THE DAM WALL AND FROM THE STORAGE AREA.
2. CONSTRUCT A CUT-OFF TRENCH 600 MM DEEP AND 1200 MM WIDE ALONG THE CENTRELINE OF THE EMBANKMENT EXTENDING TO A POINT ON THE GULLY WALL LEVEL WITH THE RISER CREST.
3. MAINTAIN THE TRENCH FREE OF WATER AND RECOMPACT THE MATERIALS TO 95% STANDARD PROCTOR DENSITY.
4. SELECT FILL ACCORDING TO THE DIRECTIONS OF THE ESCP THAT IS FREE OF ROOTS, WOOD, ROCK, LARGE STONE OR FOREIGN MATERIAL.
5. PREPARE THE SITE UNDER THE EMBANKMENT BY RIPPING AT LEAST 100 MM DEEP TO HELP BOND COMPACTED FILL TO EXISTING SUBSTRATE.
6. SPREAD FILL IN 100 MM TO 150 MM LAYERS AND COMPACT AT OPTIMUM MOISTURE CONTENT ± 2 %
7. CONSTRUCT EMERGENCY SPILLWAY.
8. REHABILITATE STRUCTURE IN ACCORDANCE WITH THE ESCP.
9. PLACE A "FULL OF SEDIMENT" MARKER TO SHOW WHEN LESS THAT DESIGN CAPACITY OCCURS AND SEDIMENT REMOVAL IS REQUIRED.

SOURCE : NSW DEPT OF HOUSING, 1998

SEDIMENT BASIN - EARTH (APPLIES TO TYPE F AND TYPE D SOILS ONLY)	**SD D-17(e)**



NOTE:

SPILLWAY WIDTH AND DEPTH, WALL CREST WIDTH AND DOWNSTREAM OUTLET PROTECTION MEASURES TO BE SPECIFIED ON ESCP

CONSTRUCTION NOTES:

1. REMOVE ALL VEGETATION AND TOPSOIL FROM UNDER THE DAM WALL AND FROM WITHIN THE STORAGE AREA.
2. EXCAVATE TO 600 MM DEPTH FOR DAM BASE AND LINE WITH NEEDLE-PUNCHED GEOTEXTILE. ALLOW ENOUGH TO LINE FROM THE TOE OF THE DAM, UNDER THE DAM, OVER THE UPSTREAM BATTER AND SPILLWAY TO 500 MM BELOW THE SPILLWAY EXIT ON THE DOWNSTREAM FACE.
3. WALL PROFILE AND OUTLET PROTECTION SHALL BE MADE UP OF 100 MM MIN. DIAMETER GRADED ROCK. A LAYER OF 50 MM TO 75 MM DIAMETER AGGREGATE SHALL BE SPREAD OVER UPSTREAM BATTER FOR A MORE EVEN SURFACE, AND 100 MM TO 150 MM OF 20 MM TO 30 MM GRAVEL SHALL BE ADDED OVER THE 50 MM TO 75 MM DIAMETER AGGREGATE.
4. LAY GEOTEXTILE OVER THE UPSTREAM BATTER AND THROUGH SPILLWAY, FIXING WITH 100 MM ROCK. REMOVAL IS REQUIRED.
5. PLACE A "FULL OF SEDIMENT" MARKER TO SHOW WHEN LESS THAN DESIGN CAPACITY OCCURS AND SEDIMENT REMOVAL IS REQUIRED.
6. REPLACE UPSTREAM GEOTEXTILE LAYER IF DAMAGED OR PUNCTURED WHEN SEDIMENT IS REMOVED.

SOURCE : NSW DEPT OF HOUSING, 1998

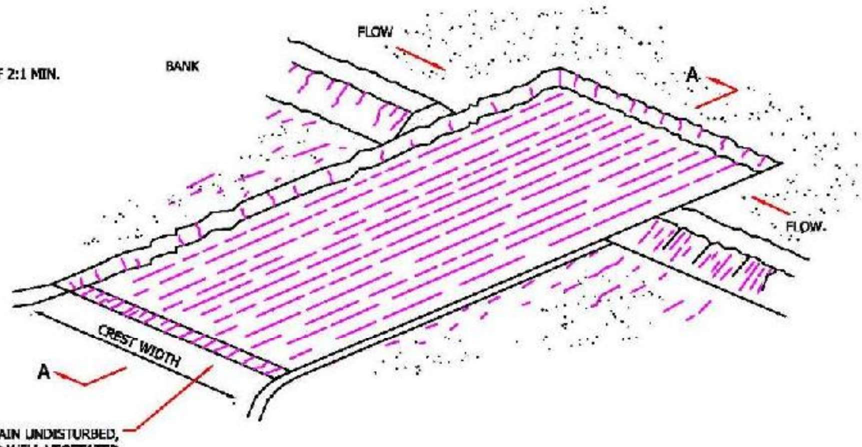
SEDIMENT BASIN - ROCK

(APPLIES TO TYPE C SOILS ONLY)

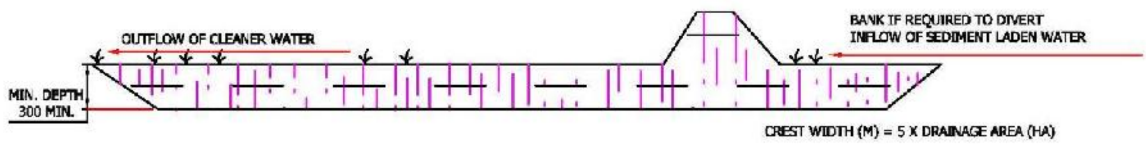
SD D-17(f)

PLAN

LENGTH WIDTH RATIO OF 2:1 MIN.



SECTION A-A



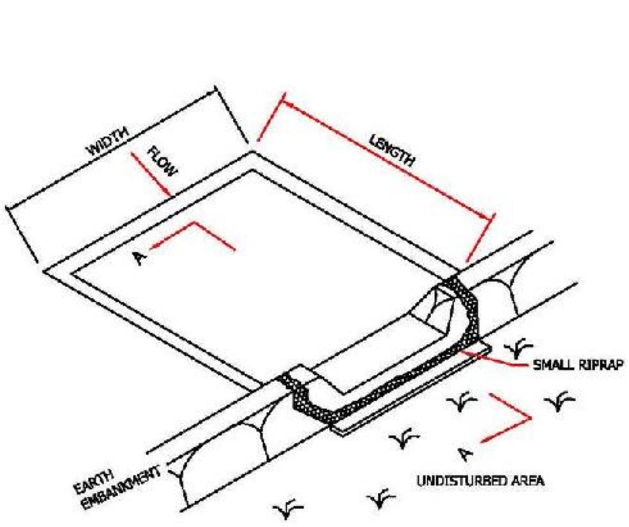
CONSTRUCTION NOTES:

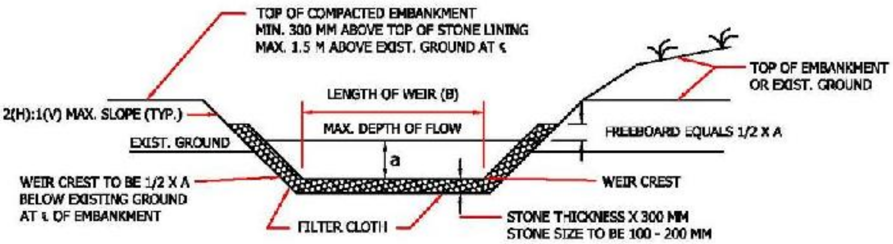
1. MINIMUM CREST WIDTH (M) SHALL BE 5 X DRAINAGE AREA (HA), BUT ALSO CONFORM TO LEVEL SPREADER CRITERIA.
2. SEDIMENT SHALL BE REMOVED AND THE TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND IN SUCH A MANNER THAT WILL NOT ERODE.
3. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN EVENT AND REPAIRS MADE AS NEEDED.
4. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION SHALL BE MINIMIZED.
5. THE SEDIMENT TRAP SHALL BE REMOVED AND AREA STABILIZED WHEN THE REMAINING DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.
6. ALL CUT SLOPES SHALL BE 1(H):1(V) OR FLATTER.

MAXIMUM DRAINAGE AREA : 2 HA

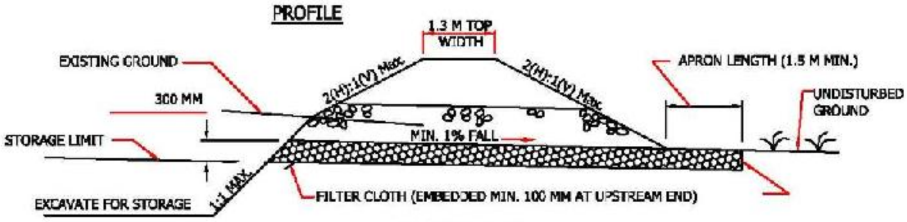
SOURCE : NSW DEPT OF HOUSING, 1998

SEDIMENT TRAP - GRASSED OULET	SD D-18(a)





PROFILE



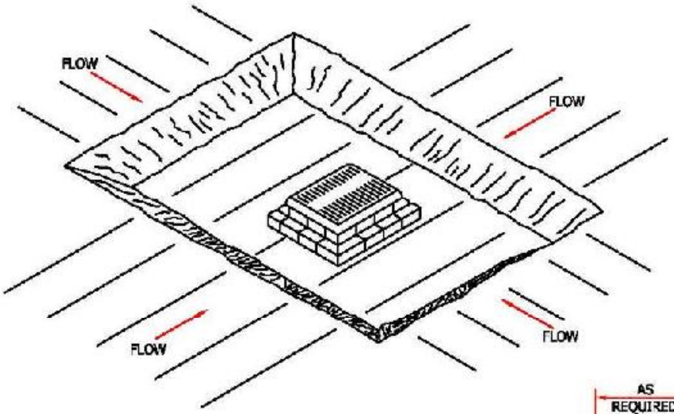
CROSS SECTION

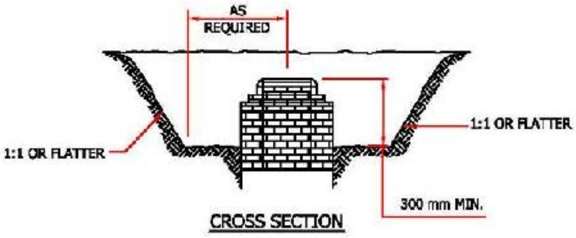
CONSTRUCTION NOTES:

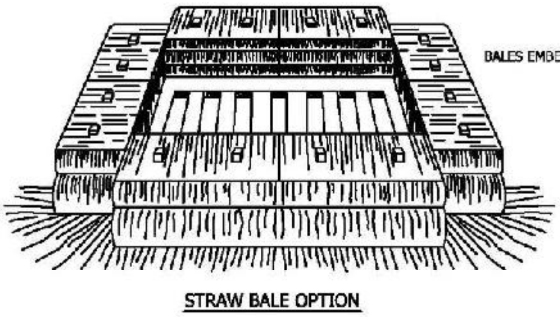
1. AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.
2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS AND OTHER WOODY VEGETATION AND OVERSIZED STONES, ROCK, ORGANIC MATERIAL OR OTHER OBJECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED.
3. ALL CUT AND FILL SLOPES SHALL BE 2(H):1(V) OR FLATTER.
4. SEDIMENT SHALL BE REMOVED AND THE TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND IN SUCH A MANNER THAT WILL NOT ERODE.
5. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN EVENT AND REPAIRS MADE AS NEEDED.
6. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION IS MINIMIZED.
7. THE STRUCTURE SHALL BE REMOVED AND THE AREA STABILIZED WHEN THE DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.

SOURCE : NSW DEPT OF HOUSING, 1998

SEDIMENT TRAP - ROCK OUTLET	**SD D-18(b)**





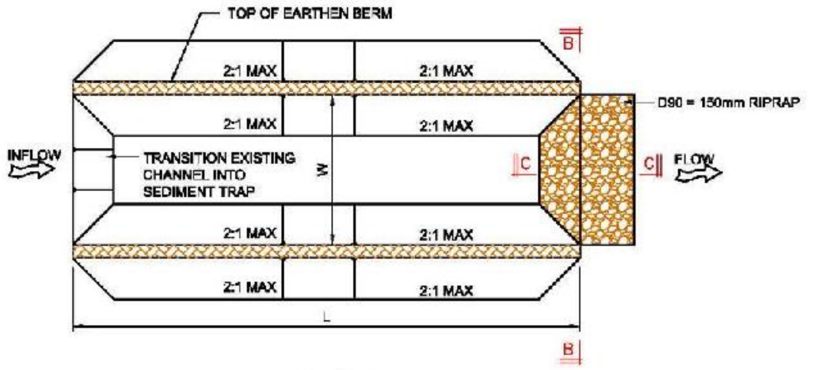


CONSTRUCTION NOTES:

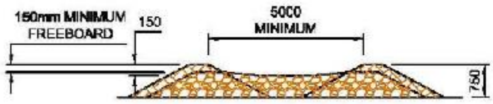
1. SEDIMENT SHALL BE REMOVED AND THE TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND IN SUCH A MANNER THAT IT WILL NOT ERODE.
2. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN EVENT AND REPAIRS MADE AS NEEDED.
3. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION SHALL BE MINIMIZED.
4. THE SEDIMENT TRAP SHALL BE REMOVED AND THE AREA STABILIZED WHEN THE CONSTRUCTED DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.
5. ALL CUT SLOPES SHALL BE 1:1 OR FLATTER.

SOURCE : NSW DEPT OF HOUSING, 1998

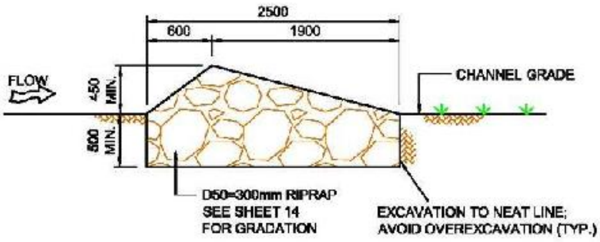
SEDIMENT TRAP - DROP INLET	SD D-18(c)



DETAIL A
SCALE : N.T.S



SECTION B
SCALE : N.T.S



SECTION C
SCALE : N.T.S

SEDIMENT TRAP INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION, LENGTH AND WIDTH SEDIMENT TRAP.
2. SEDIMENT TRAP INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO ANY LAND-DISTRURBING ACTIVITIES.
3. SEDIMENT TRAP BERM SHALL BE CONSTRUCTED FROM MATERIAL FROM EXCAVATION. THE BERM SHALL BE COMPACTED TO 95% OF THE MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698.
4. RIPRAP OUTLET SHALL BE CONSTRUCTED WITH D50=300mm RIPRAP WITH A MINIMUM OVERFLOW OF 150mm
5. THE TOP OF THE EARTHEN BERM SHALL BE A MINIMUM OF 150mm HIGHER THAN THE TOP OF THE RIPRAP OUTLET STRUCTURE.
6. THE ENDS OF THE RIPRAP OUTLET STRUCTURE SHALL BE MINIMUM OF 150mm HIGHER THAN THE CENTER OF THE OUTLET STRUCTURE.

SEDIMENT TRAP MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT SEDIMENT CONTROL LOGS DAILY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT UPSTREAM SEDIMENT AS NECESSARY.
2. SEDIMENT ACCUMULATED UPSTREAM OF SEDIMENT CONTROL LOGS SHALL BE REMOVED WHEN THE UPSTREAM SEDIMENT DEPTH IS WITHIN 1/2 THE HEIGHT OF RIPRAP OUTLET STRUCTURE.
3. SEDIMENT TRAPS SHALL BE REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVERAGE IS APPROVED.
4. WHEN SEDIMENT TRAPS ARE REMOVED THE DISTURBED AREA SHALL BE DRILLED SEEDED AND CRIMP MULCHED OR STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SEDIMENT TRAP	SD D-19

SEEDING AND MULCHING INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - AREA OF SEEDING AND MULCHING.
   - TYPE OF SEED MIX (PERMANENT, TEMPORARY, OR LOW-GROWTH).

2. ALL BRANDS FURNISHED SHALL BE FREE FROM SUCH NOXIOUS SEED AS RUSSIAN OR CANADIAN THISTLE, COARSE FESCUE, EUROPEAN BINDWEED, JOHNSON GRAS, KNAP WEED AND LEAFY SPURGE.

3. THE SEEDER SHALL FURNISH TO THE CONTRACTOR A SIGNED STATEMENT CERTIFYING THAT THE SEED FURNISHED IS FROM A LOT THAT HAS BEEN TESTED BY A RECOGNIZED LABARATORY. SEED WHICH HAS BECOME WET, MOLDY, OR OTHERWISE DAMAGED IN TRANSIT OR IN STORAGE WILL NOT BE ACCEPTABLE. SEED TICKETS SHALL BE PROVIDED TO DOUGLAS COUNTY UPON REQUEST.

4. DRILL SEEDING MIX SHALL CONFORM TO THE TABLE ON THE RIGHT:

5. IF THE SEDD AVAILABLE ON THE MARKET DOES NOT MEET THE MINIMUM PURITY AND GERMINATION PERCENTAGES OF PURITY OR GERMINATION BY FURNISHING SUFFICIENT ADDITIONAL LESSER PERCENTAGE OF PURITY OR GERMINATION BY FURNISHING SUFFICIENT ADDITIONAL SEED TO EQUAL THE SPECIFIED PRODUCT. THE TAGS FROM THE SEED MIXED MUST BE SUPPLIED TO CONTRACTOR AND FORWARDED TO THE DOUGLAS COUNTY ESCP INSPECTOR.

6. THE FORMULA USED FOR DETERMINING THE QUANTITY OF PURE LIVE SEED (PLS) SHALL BE (POUNDS OF SEED) X (PURITY) X (GERMANATION) = POUNDS OF PURE LIVE SEED (PLS).

7. PERMANENT SEED MIX SHALL BE USED UNLESS OTHERWISE APPROVED BY THE COUNTY.

8. ALL AREAS TO BE SEEDED AND MULCHED SHALL HAVE NATIVE TOPSOIL OR APPROVED SOIL AMENDMENTS SPREAD TO A DEPTH OF AT LEAST 6 INCHES (LOOSE DEPTH). HAUL ROADS AND OTHER COMPACTED AREAS SHALL BE LOOSENED TO A DEPTH OF 6 INCHES PRIOR TO SPREADING TOPSOIL.

9. SOIL IS TO BE THOROUGHLY LOOSENED (TILLED) TO A DEPTH OF AT LEAST 6 INCHES PRIOR TO SEEDING. THE TOP 6 INCHES OF THE SEED BED SHALL BE FREE OF ROCKS GREATER THAN 4 INCHES AND SOIL CLODS GREATER THAN 2 INCHES. SEEDING OVER ANY COMPACTED AREAS THAT HAVENT'T BEEN THOROUGHLY LOOSENED SHALL BE REJECTED.

10. SEED IS TO BE APPLIED USING A MECHANICAL DRILL TO A DEPTH OF 1/4 INCH. ROW SPACING SHALL BE NO MORE THAN 6 INCHES. MATERIAL USED FOR MUCH SHALL CONSIST OF LONG-STEMMED STRAW. AT LEAST 50 PERCENT OF THE MULCH, BY WEIGHT, SHALL BE 10 INCHES OR MORE IN LENGTH. MULCH SHALL BE APPLIED AND MECHANICALLY ANCHORED TO A DEPTH OF AT LEAST 2 INCHES. MULCH SHALL BE APPLIED AT A RATE OF 4000 LB. OF STRAW PER ACRE.

11. IF THE PERMITTEE DEMONSTRATES TO THE COUNTY THAT IT IS NOT POSSIBLE TO DRILL SEED, SEED IS TO BE UNIFORMLY BROADCAST AT TWO TIMES THE DRILLED RATE, THEN LIGHTLY HARROWED TO PROVIDE A SEED DEPTH OF APPROXIMATELY 1/4 INCH, THEN ROLLED TO COMPACT, THEN MULCHED AS SPECIFIED ABOVE.

12. SEEDING AND MULCHING SHALL BE COMPLETE WITHIN 30 DAYS OF INITIAL EXPOSURE OR 7 DAYS AFTER GRADING IS SUBSTANTIALLY COMPLETE IN A GIVEN AREA (AS DEFINED BY THE COUNTY). THIS MAY REQUIRE MULTIPLE MOBILIZATIONS FOR SEEDING AND MULCHING.

13. MULCH SHALL BE APPLIED WITHIN 24-HOURS OF SEEDING.

14. TACKIFIER SHOULD BE UTILIZED TO HELP WITH STRAW DISPLACEMENT.

NOTE: ALL UNITS IN MILIMETERS (mm)

SEEDING AND MULCHING INSTALLATION NOTES

1. SEEDED AND MULCHED AREAS SHALL BE INSPECTED FOR REQUIRED COVERAGE MONTHLY FOR A PERIOD OF TWO YEARS FOLLOWING INITIAL SEEDING. REPAIRS AND RE-SEEDING AND MULCHING SHALL BR UNDERTAKEN AFTER THE FIRST GROWING SEASON FOR ANY AREAS FAILING TO MEET THE REQUIRED COVERAGE.

2. REQUIRED COVERAGE FOR STANDARD, OPEN SPACE AND LOW GROWTH SEED MIXED SHALL BE DEFINED AS FOLLOWS:

   1. THREE (3) PLANTS PER SQUARE FOOT WITH A MINIMUM HEIGHT OF 3 INCHES. THE 3 PLANTS PER SQUARE FOOT SHALL BE OF THE VARIETY AND SPECIES FOUND IN THE DOUGLAS COUNTY-APPROVED MIX.

   2. NO BARE AREAS LARGER THAN 4 SQUARE FEET (TWO-FEET BY TWO-FEET OR EQUIVALENT).

   3. FREE OF ERODED AREAS.

   4. FREE FROM INFESTATION OF NOXIOUS WEEDS IN ACCORDANCE WITH SECTION 6.4 OF THE GESC CRITERIA MANUAL.

3. REQUIRED COVERAGE FOR TURF GRASS AREAS SHALL BE DEFINED AS FOLLOWS:

   1. AT LEAST 80 % VEGETATIVE COVER OF GRASS SPECIES PLANTED.

   2. NO BARE AREAS LARGER THAN 4 SQUARE FEET (TWO-FEET BY TWO-FEET OR EQUIVALAENT).

   3. FREE OF ERODED AREAS.

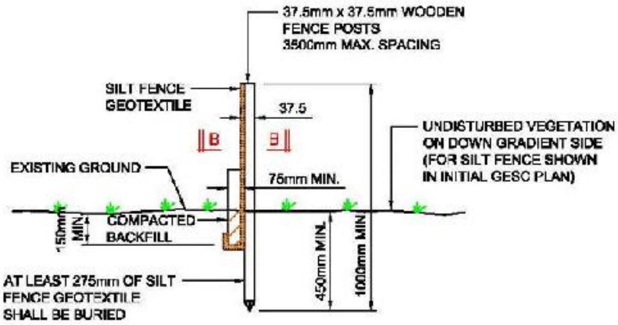
   4. FREE FROM INFESTATION OF NOXIOUS WEEDS IN ACCORDANCE WITH SECTION 6.4 OF THE GESC CRITERIA MANUAL.

4. RILL AND GULLY EROSION SHALL BE FILLED WITH TOPSOIL PRIOR TO RESSEDING. THE RESEEDING METHOD SHALL BE APPROVED BY THE COUNTY.

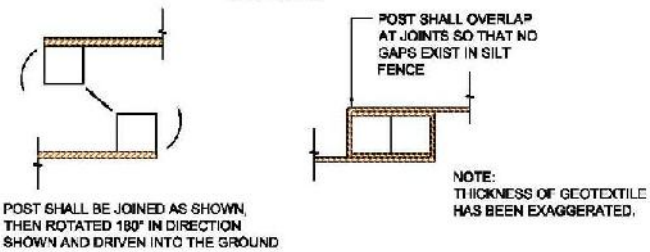
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SEEDING AND MULCHING

SD D-20



DETAIL A
SCALE : N.T.S



JOINTS - SECTION B
SCALE : N.T.S

SILT FENCE INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION AND LENGTH OF FENCE.

2. ANCHOR TRENCH SHALL BE EXCAVATED WITH TRENCHER, OR WITH SILT FENCE INSTALLATION MACHINE; NO ROAD GRADERS, BACKHOES, ETC. SHALL BE USED. TRENCH SHALL BE COMPACTED BY HAND, WITH "JUMPING JACK", OR BY THE WHEEL ROLLING, COMPACTION SHALL BE SUCH THAT SILT FENCE RESISTS BEING PULLED OUT OF ANCHOR TRENCH BY HAND.

3. SILT FENCE INDICATED IN INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO ANY LAND-DISTURBING ACTIVITIES.

SILT FENCE MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT SILT FENCE DAILY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT UPSTREAM SEDIMENT AS NECESSARY.

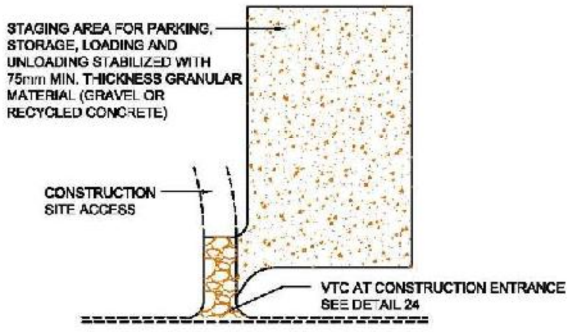
2. SEDIMENT ACCUMULATED UPSTREAM OF SILT FENCE SHALL BE REMOVED WHEN THE UPSTREAM SEDIMENT REACHES A DEPTH OF 150mm.

3. SILT FENCE SHALL BE REMOVED AT THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED BY THE COUNTY. IF ANY DISTURBED AREA EXISTS AFTER REMOVAL, IT SHALL BE SEEDED AND MULCHED OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SILT FENCE	SD D-21



PLAN
SCALE : N.T.S

STABILIZED STAGING AREA INSTALLATION NOTES

1. SEE PLAN VIEW FOR GENERAL LOCATION OF STAGING AREA, CONTRACTOR MAY MODIFY LOCATION AND SIZE OF STABILIZED STAGING AREA WITH COUNTY APPROVAL.

2. STABILIZED STAGING AREA SHALL BE LARGE ENOUGH TO FULLY CONTAIN PARKING, STORAGE, AND UNLOADING AND LOADING OPERATIONS.

3. STAGING AREA SHALL BE STABILIZED PRIOR TO ANY OTHER OPERATIONS ON THE SITE.

4. THE STABILIZED STAGING AREA SHALL CONSIST OF A MINIMUM OF 75mm" OF GRANULAR MATERIAL (GRAVEL OR RECYCLED CONCRETE).

STABILIZED STAGING AREA MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT THE STABILIZED STAGING AREA WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT UPSTREAM SEDIMENT AS NECESSARY.

2. ESCP MANAGER SHALL PROVIDE ADDITIONAL THICKNESS OF GRANULAR MATERIAL IF ANY RUTTING OCCURS OR UNDERLYING SUB GRADE BECOMES EXPOSED.

3. STABILIZED STAGING AREA SHALL BE ENLARGED IF NECESSARY TO CONTAIN PARKING, STORAGE, AND UNLOADING AND LOADING OPERATIONS.

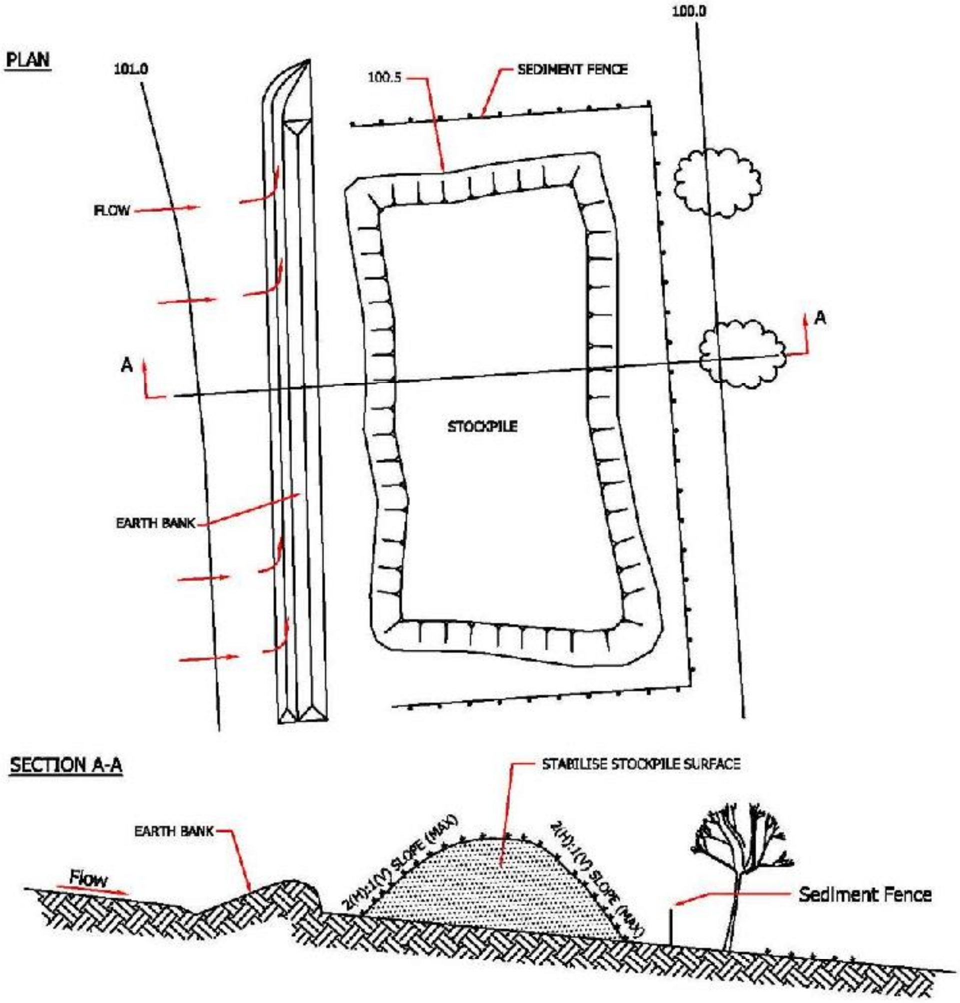
4. ANY ACCUMULATED DIRT OR MUD SHALL BE REMOVED FROM THE SURFACE OF THE STABILIZED STAGING AREA.

5. THE STABILIZED STAGING AREA SHALL BE REMOVED AT THE END OF CONSTRUCTION. THE GRANULAR MATERIAL SHALL BE REMOVED OR, IF APPROVED BY THE COUNTY, USED ON SITE, AND THE AREA TOP SOILED, DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

STABILIZED STAGING AREA	SD D-22

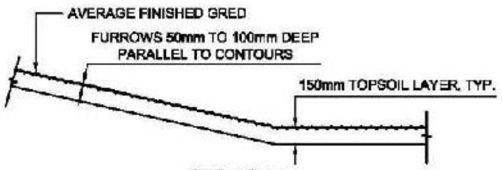


CONSTRUCTION NOTES:

1. LOCATE STOCKPILE AT LEAST 5 METRES FROM EXISTING VEGETATION, CONCENTRATED WATER FLOWS, ROADS AND HAZARD AREAS.
2. CONSTRUCT ON THE CONTOUR AS A LOW, FLAT, ELONGATED MOUND.
3. WHERE THERE IS SUFFICIENT AREA, TOPSOIL STOCKPILES SHALL BE LESS THAN 2 METRES IN HEIGHT.
4. REHABILITATE IN ACCORDANCE WITH THE ESCP.
5. CONSTRUCT EARTH BANK (STANDARD DRAWING SDI-5) ON THE UP SLOPE SIDE TO DIVERT RUNOFF AROUND THE STOCKPILE AND A SEDIMENT FENCE (STANDARD DRAWING SDI-11) 1 TO 2 METRES DOWN SLOPE OF STOCKPILE.

Source : NSW Dept of Housing, 1998

STOCKPILE AREA	SD D-23



SECTION A
SCALE : N.T.S

SURFACE ROUGHENING INSTALLATION NOTES

1. SURFACE ROUGHENING SHALL BE PROVIDED ON ALL FINISHED GRADES (SLOPES AND "FLAT" AREAS) WITHIN 2 DAYS OF COMPLETION OF FINISHED GRADE (FOR AREAS NOT RECEIVING TOPSOIL) OR WITHIN 2 DAYS OF TOPSOIL PLACEMENT.

2. AREAS WHERE BUILDING FOUNDATIONS, PAVEMENT, OR SOD IS TO BE PLACED WITHIN 7-DAYS OF FINISHED GRADING DOT NOT NEED TO BE SURFACE ROUGHENED.

3. DISTURBED SURFACES SHALL BE ROUGHENED USING RIPPING OR TILING EQUIPMENT ON THE CONTOUR OR TRACKING UP AND DOWN A SLOPE USING EQUIPMENT TREADS.

SURFACE ROUGHENING MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT THE SURFACE ROUGHENING WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT UPSTREAM SEDIMENT AS NECESSARY.

2. VEHICLES AND EQUIPMENT SHALL GENERALLY BE CONFINED TO ACCESS DRIVES AND SHALL NOT BE DRIVEN OVER AREAS THAT HAVE BEEN SURFACE ROUGHENED.

3. IN NON-TURF GRASS FINISHED AREAS, SEEDING AND MULCHING SHALL TAKE PLACE DIRECTLY OVER SURFACE ROUGHENED AREAS WITHOUT FIRST SMOOTHING OUT THE SURFACE.

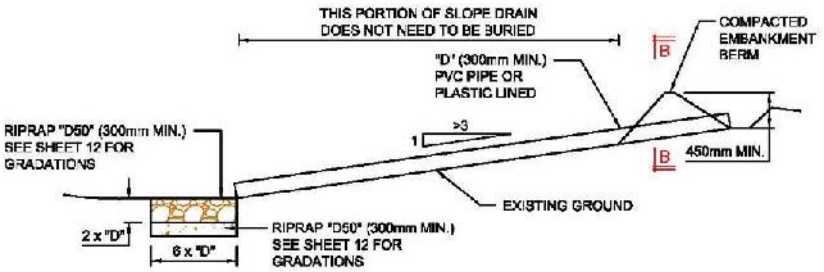
4. IN AREAS NOT SEEDED AND MULCHED AFTER SURFACE ROUGHENING, SURFACES SHALL BE RE-ROUGHENED AS NECESSARY TO MAINTAIN GROOVE DEPTH AND SMOOTH OVER ANY RILL EROSION.

NOTE: ALL UNITS IN MILIMETERS (mm)

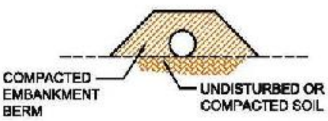
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

SURFACE ROUGHENING

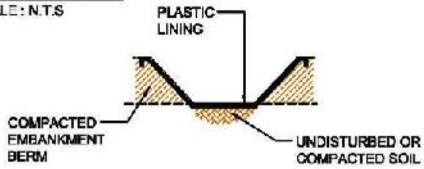
SD D-24



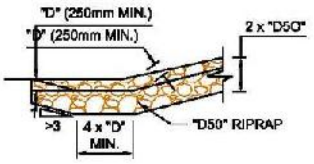
SLOPE DRAIN - DETAIL A
SCALE : N.T.S



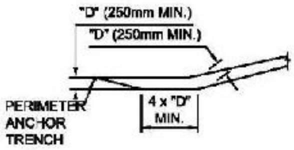
SLOPE DRAIN - SECTION B
SCALE : N.T.S



PLASTIC LINE DRAIN - SECTION E
SCALE : N.T.S



TERMINATION OF RIPRAP LINED
SLOPE DRAIN -DETAIL D
SCALE : N.T.S



TERMINATION OF RIPRAP LINED
SLOPE DRAIN -DETAIL C
SCALE : N.T.S

SLOPE DRAIN INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION AND LENGTH OF SLOPE DRAIN.
   - PIPE DIAMETER, "D" AND RIPRAP SIZE, "D50".
2. SLOPE DRAIN DIMENSIONS SHALL BE CONSIDERED MINIMUM DIMENSIONS; CONTRACTOR MAY ELECT TO INSTALL LARGER FACILITIES. ANY DAMAGE TO SLOPE OR SLOPE DRAIN DURING RUNOFF EVENTS SHALL BE THE CONTRACTOR'S RESPONSIBILITY.
3. SLOPE DRAINS INDICATED ON INITIAL ESCP PLAN SHALL BE INSTALLED PRIOR TO ANY UPSTREAM LAND-DISTURBING ACTIVITIES.
4. FOR TEMPORARY SLOPE DRAINS, PIPE MAY BE INSTALLED ON TOP OF SLOPE; HOWEVER, 300mm MIN. COVER AT TOP O SLOPE SHALL BE PROVIDED.
5. A RIPRAP PAD SHALL BE PLACED AT THE OUTFALL OF THE SLOPE DRAIN.

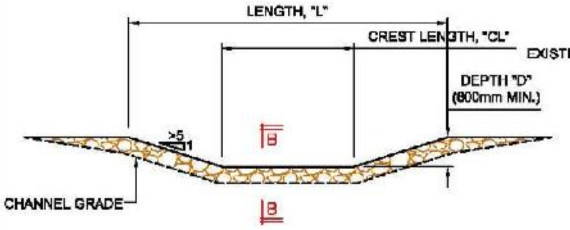
SLOPE DRAIN MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT CHECK DAMS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.
2. TEMPORARY SLOPE DRAINS ARE TO REMAIN IN PLACE UNTIL NO LONGER NEEDED, BUT SHALL BE REMOVED PRIOR TO THE END OF CONSTRUCTION. WHEN SLOPE DRAINS ARE REMOVED, THE DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE COUNTY.

NOTE: ALL UNITS IN MILIMETERS (mm)

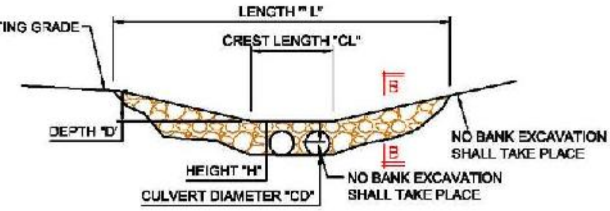
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

TEMPORARY SLOPE DRAIN	SD D-25



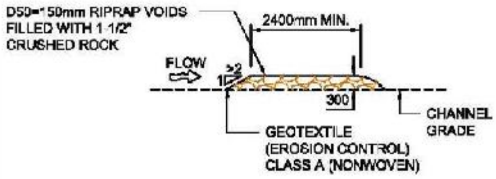
FORD CROSSING - DETAIL A

SCALE : N.T.S



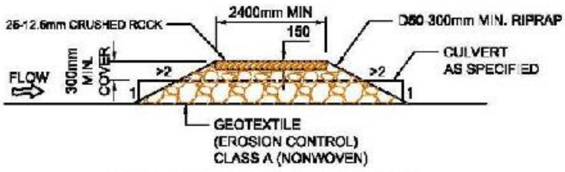
CULVERT CROSSING - DETAIL A

SCALE : N.T.S



FORD CROSSING - DETAIL B

SCALE : N.T.S



CULVERT CROSSING - SECTION B

SCALE : N.T.S

TEMPORARY STREAM CROSSING INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF TEMPORARY STREAM CROSSING.
   - STREAM CROSSING TYPE (FORD OR CULVERT).
   - FOR FORD CROSSING: LENGTH, "L", CREST LENGTH, "CL", AND DEPTH. "D"
   - FOR CULVERT CROSSING : LENGTH, "L", CREST LENGTH, "CL", CROSSING HEIGHT, "H", DEPTH, "D", CULVERT DIAMETER, "CD". AND NUMBER, TYPE AND CLASS OR GAUGE OF CULVERTS.

2. TEMPORARY STREAM CROSSING DIMENSIONS, D50, AND NUMBER OF CULVERTS INDICATED (FOR CULVERT CROSSING) SHALL BE CONSIDERED MINIMUM DIMENSIONS; ENGINEER MAY ELECT TO INSTALL LARGER FACILITIES. ANY DAMAGE TO STREAM CROSSING OR EXISTING STREAM CHANNEL DURING BASEFLOW OR FLOOD EVENTS SHALL BE THE CONTRACTOR'S RESPONSIBILITY.

3. FOR A TEMPORARY STREAM CROSSING THAT WILL CARRY LOADS, THE TEMPORARY STREAM CROSSING MUST BE DESIGNED BY THE DESIGN ENGINEER.

TEMPORARY STREAM CROSSING MAINTENANCE NOTES

1. THE ESCP MANAGER SHALL INSPECT CHECK DAMS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.

2. SEDIMENT ACCUMULATED UPSTREAM OF STREAM CROSSING SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF CROSSING IS WITHIN 150mm OF THE CREST 9FORD CROSSING) OR GREATER THAN AN AVERAGE DEPTH OF 300mm (CULVERT CROSSING).

3. STREAM CROSSING ARE TO REMAIN IN PLACE UNTIL NO LONGER NEEDED, BUT SHALL BE REMOVED PRIOR TO THE END OF CONSTRUCTION.

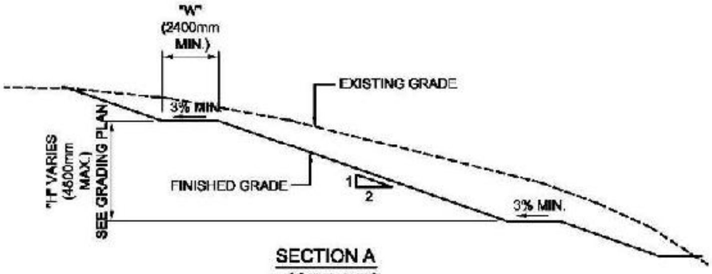
4. WHEN STREAM CROSSINGS ARE REMOVED, THE DISTURBED AREA SHALL BE DRILL SEEDED AND CRIMP MULCHED AND COVERED WITH EROSION CONTROL BLANKET OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

TEMPORARY STREAM CROSSING

SD D-26



SECTION A

SCALE : N.T.S

TERRACING INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - WIDTH, "W", AND SLOPE, "Z"

2. TERRACING IS NOT REQUIRED FOR SLOPES OF 4 TO 1 OR FLATTER.

3. EARTH (VEGETATED) SLOPES STEEPER THAN 3 TO 1 ARE NOT ALLOWED ON THE SITE.

TERRACING INSTALLATION NOTES

1. THE GESC MANAGER SHALL INSPECT THE SURFACE ROUGHENING WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT UPSTREAM SEDIMENT AS NECESSARY.

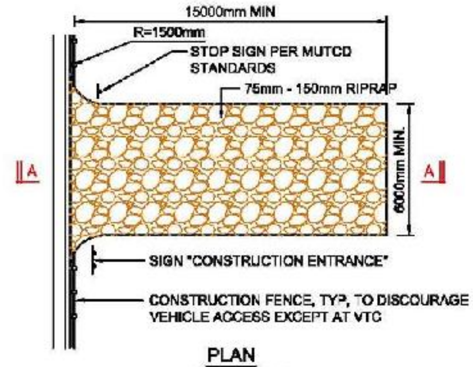
2. ANY RILL EROSION OCCURING ON SLOPES SHALL BE REPAIRED AND RESEEDED AND MULCHED IN ACCORDANCE WITH DETAIL 17.

NOTE: ALL UNITS IN MILIMETERS (mm)

TER TERRACING 27

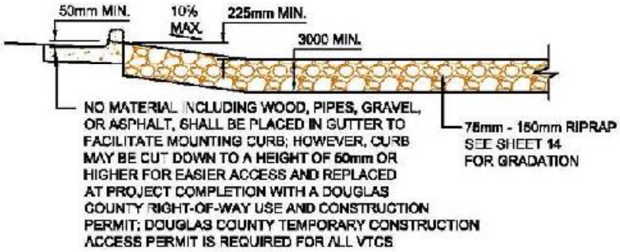
SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

TERRACING	SD D-27



PLAN

SCALE : N.T.S



SECTION A

SCALE : N.T.S

VEHICLE TRACKING CONTROL INSTALLATION NOTES

1. VEHICLE TRACKING CONTROL PADS SHALL BE INSTALLED AT EVERY ACCESS POINT TO SITE.

2. VEHICLE TRACKING CONTROL PADS SHALL CONSIST OF HARD, DENSE, DURABLE STONE, ANGULAR IN SHAPE AND RESISTANT TO WEATHERING, ROUNDED STONE OR BOULDERS WILL NOT BE ACCEPTABLE. THE STONES SHALL BE 3" WITH A MAXIMUM SIZE OF 6" THE STONE SHALL HAVE A SPECIFIC GRAVITY OF AT LEAST 2.6 CONTROL OF GRADATION WILL BE BY VISUAL INSPECTIONS.

3. ANY CRACKED OR DAMAGED CURB AND GUTTER AND SIDEWALK SHALL BE REPLACED BY PERMITEE.

5. A STOP SIGN SHALL BE INSTALLED THE VTC.

VEHICLE TRACKING CONTROL MAINTENANCE NOTES

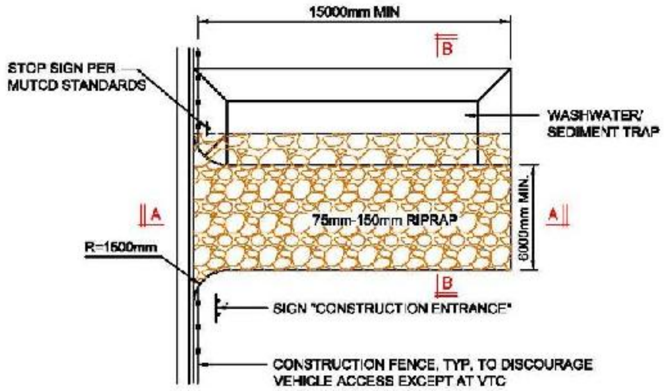
1.ESCP MANGER SHALL INSPECT VEHICLE TRACKING CONTROL DAILY. GRAVEL SURFACE SHALL BE CLEAN AND LOOSE ENOUGH TO RUT SLIGHTLY UNDER WHEEL LOADS AND CAUSE LOOSE GRAVEL TO DISLODGE MUD FROM TIRES. WHEN GRAVEL BECOMES COMPACTED OR FILLED WITH SEDIMENT SO THAT THE EFFECTIVENESS OF THE PAD IS DIMINISHED, CONSTRACTOR SHALL RIP, TURN OVER, OR OTHERWISE LOOSEN GRAVEL, PLACE ADDITIONAL NEW GRAVEL, OR REPLACE WITH NEW GRAVEL AS NECESSARY TO RESTORE EFFECTIVENESS.

2. VEHICLE TRACKING CONTROL SHALL BE REMOVED AT THE END OF CONSTRUCTION, THE GARVEL MATERIAL REMOVED OR, IF APPROVED BY THE COUNTY, USED ON SITE, AND THE AREA TOPSOILED, DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED.

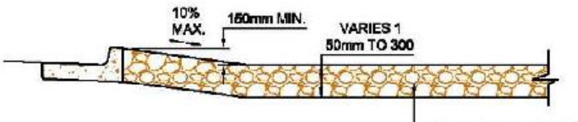
NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

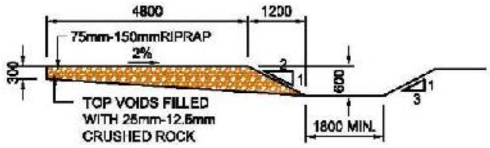
VEHICLE TRACKING CONTROL	SD D-28



PLAN
SCALE : N.T.S



SECTION A
SCALE : N.T.S



SECTION B
SCALE : N.T.S

VEHICLE TRACKING CONTROL INSTALLATION NOTES

1. ALTHOUGH NOT NORMALLY USED, THE COUNTY RESERVES THE RIGHT TO REQUIRE VEHICLE TRACKING CONTROL WITH WHEEL WASH FACILITIES AT SITES WHRE TRACKING ONTO PAVED AREAS BECOMES A SIGNIFICANT PROBLEM.

2. IF VEHICLE TRACKING CONTROL WITH WHEEL WASH FACILITIES ARE REQUIRED, ALL WHEELS ON EVERY VEHICLE LEAVING THE SITE SHALL BE CLEANED OF MUD USING A PRESSURE-WASHER, THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING A WATER SOURCE.

3. VEHICLE TRACKING CONTROL PADS SHALL CONSIST OF HARD, DENSE, DURABLE STONE, ANGULAR IN SHAPE AND RESISTANT TO WEATHERING. ROUNDED STONE OR BOULDERS WILL NOT BE ACCEPTABLE, THE STONES SHALL BE 3" WITH A MAXIMUM SIZE OF 6", THE STONE SHALL HAVE A SPECIFIC GRAVITY OF AT LEAST 2.6. CONTROL OF GRADATION WILL BE BY VISUAL INSPECTIONS.

4. ANY CRACKED OR DAMAGED CURB AND GUTTER AND SIDEWALK SHALL BE REPLACED BY CONTRACTOR.

5. A STOP SIGN INSTALLED IN ACCORDANCE WITH THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD). AS AMENDED, SHALL BE INSTALLED FOR EXISTING TRAFFIC AT THE VTC.

VEHICLE TRACKING CONTROL WITH WHEEL WASH MAINTENANCE NOTES

1. GESC MANAGER SHALL INSPECT VEHICLE TRACKING CONTROL WITH WHEEL WASH FACILITIES DAILY, ACCUMULATED SEDIMENTS SHALL BE REMOVED FROM PAD SURFACE.

2. ACCUMULATED SEDIMENT IN THE WASHWATER/SEDIMENT TRAP SHALL BE REMOVED WHEN THE SEDIMENT DEPTH REACHES AN AVERAGE OF 12-INCHES.

3. VEHICLE TRACKING CONTROL WITH WHEEL WASH FACILITY SHALL BE REMOVED AT THE END OF CONSTRUCTION, THE RIPRAP MATERIAL REMOVED OR, IF APPROVED BY THE COUNTY, USED ON SITE, AND THE AREA TOPSOILED, DRILL SEEDED AND CRIMP MULCHED OR OTHERWISE STABILIZED.

NOTE: ALL UNITS IN MILIMETERS (mm)

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

VTC WITH WHEEL WASH	SD D-29

TABLE 1. RIPRAP GRADATIONS

D50 MEDIAN STONE SIZE (mm)	% OF MATERIAL SMALLER THAN TYPICAL STONE	TYPICAL STONE EQUIVALENT DIAMETER (mm)	TYPICAL STONE WEIGHT (POUNDS)
150	70 - 100 50 - 70 35 - 50 2 - 10	300 225 150 50	85 35 10 0.4
225	70 - 100 50 - 70 35 - 50 2 - 10	375 300 225 75	160 85 35 1.3
300	70 - 100 50 - 70 35 - 50 2 - 10	525 450 300 100	440 275 85 3
450	100 50 - 70 35 - 50 2 - 10	750 600 450 150	1280 650 275 10
600	100 50 - 70 35 - 50 2 - 10	1050 825 600 225	3500 1700 650 35

TABLE 2. RIPRAP BEDDING

SIEVE SIZE	MASS PERCENT PASSING SQUARE MESH SIEVES
	CLASS A
3"	100
1 1/2"	20 - 90
NO. 4	0 - 20
NO. 200	0 - 3

MATCHES SPECIFICATIONS FOR CDOT CLASS A FILTER MATERIAL AND UDFCD TYPE 1 BEDDING. ALL ROCK SHALL BE FRACTURED FACE, ALL SIDES.

TABLE 3. 37.5mm CRUSHED ROCK

SIEVE SIZE (mm)	MASS PERCENT PASSING SQUARE MESH SIEVES
	CLASS A
50	100
37.5	90 - 100
25	20 - 55
18.75	0 - 15
9.4	0 - 5

MATCHES SPECIFICATIONS FOR NO. 4 COARSE AGGREGATE FOR CONCRETE PER AASHTO M43. ALL ROCK SHALL FRACTURED FACE, ALL SIDES.

ROCK AND RIPRAP GRADATIONS

SOURCE : DOUGLAS COUNTRY, COLORADO (2005)

ROCK AND RIPRAP GRADATIONS

SD D-30

APPENDIX E:
EXAMPLE OF ESC PLANS & BMPs DESIGNS

Proposed ESCP for Lot 1587, Blue Valley, Cameron Highland

The ESCP must be prepared before construction begins, ideally during the project planning and design phase. It has to be completed at the end of the design phase or early in the construction phase.

The planning phase is the source of much of the information needed for the ESCP. The basis for erosion and sediment control decisions is also made at this phase via the normal review process with the Local Authority. Four activities, which occur during planning that are important to the preparation of an ESCP are:

- Assessing site conditions;
- Developing a base plans;
- Selecting post-construction measures
- Establishing long-term maintenance agreements.

Implementation of the ESCP begins when construction commences, normally before the initial clearing, grubbing, and grading operations, as these activities usually increase erosion potential on site. During construction, the ESCP should be referred to frequently and refined by the owner and contractors as changes may occur in construction operations, which have significant effects on the potential for discharge pollutant.

The overall ESCP for the construction site is given in Figure E1, when the bulk grading (earthworks) is completed. The details of the selected ESC facilities can be found in Figure E2, which concentrate on Plot 1 & Plot 6 used in following examples of calculation.

The earthwork of this development is designed in four stages as shown in Figure E3, Figure E4, Figure E5, and Figure E6. The ESCP develop at this moment would only cater for Lot 1587. The proposed future development on Lot 1592 will be carried out at later stage of time in order to create a better hydroponic farming's platform level for the respective owners.

The four-stage construction ESCP for the develop area would include the following:

- construction of four numbers of temporary silt-traps, which to be back filled at various stages of construction as the earthworks progresses;
- temporary earth drains and six numbers of temporary silt-basins/wet-sediment-basins/on-site-detentions for Plots 1-6 are to be constructed at various stages of earthworks;
- temporary earth drains are to be constructed along the access road and later to be converted to permanent cascade drain upon completion of the earthworks;
- hydro seeding of slope surfaces as the slope construction progresses;
- cut and fill of earth for the completed four-stage construction is to be balanced; and
- all temporary earth drains and silt-basins/wet-sediment-basins/on-site-detentions would need to be in place (except for access road) until the Greenhouse Shade Structure is completely constructed, and eventually are to be replaced with a permanent drainage system via rain gutter along the roof and pipes to be channeled to underground on-site detentions (OSD) tanks.

From the above ESCP mentioned, it can be seen that the erosion and sediment control measures were implement concurrently at the area so that the surface water quality during the construction stage will not affecting the downstream or existing stream of development area. The proposed BMPs in the study area are detailed as follow. Detailing & location of the proposed BMPs can be found in Figure E2.

(1) Dry/Wet Sediment-basins

The function of sediment control system is to create conditions for sedimentation where the sediment or soil particle in suspension is allowed to settle. Silt-basin/wet-sediment-basins are hydraulic controls that functions by modifying runoff hydrograph and slowing down water velocities and this allows for the deposition of suspended particles by gravity. This pond system should provide sufficient volume for capturing suspended particles and able to drain the water continuously. Example of dry basin can be found in Plot 1 (Figure E2) and wet basin can be found in Plot 6 of the same figure.

(2) Hydro seeding/turfing

Turfing or hydro seeding is one of the economical methods in stabilizing and protecting soil surface from rainfall and runoff of the disturbed area. The implementation of this measure must be as soon as possible during the earthwork or construction activities. The selections of hydro seeding or turfing works are depending on the availability of the material and also surface application area in the construction site. In this study area, the hydro seeding method was use for the slope surface during the slope constructions. Both cut and fill slope surface are to be stabilised with hydroseeding.

(3) Temporary Earth Drain

Temporary diversion channels may be used to divert off-site runoff around the construction site, divert runoff from stabilized areas around disturbed areas, and direct runoff into sediments trap or basins. Diversion channels should be installed when the site is initially graded and remain in place until permanent BMPs or drainage-system is installed and/or slopes are stabilized. Temporary diversion channel should be sized using Manning's formula and local drainage design criteria.

(4) Silt Fences

Silt fences are very useful for retaining sediment from small bare areas or sites with low slope angles. They are not generally designed for concentrated runoff flows and are therefore usually unsuitable for large catchments, ditches etc. Fences usually fail through undercutting or by being outflanking and required constant maintenance. If not sited correctly, they also fail through being flattened or overtopped. In this ESCP, silt fence are applied to the toe of the cut slope. The silt fence is placed at a 2m offset from the toe of slope to allow space for water impoundment and sediment settlement behind the fence which originates from the cut slope.

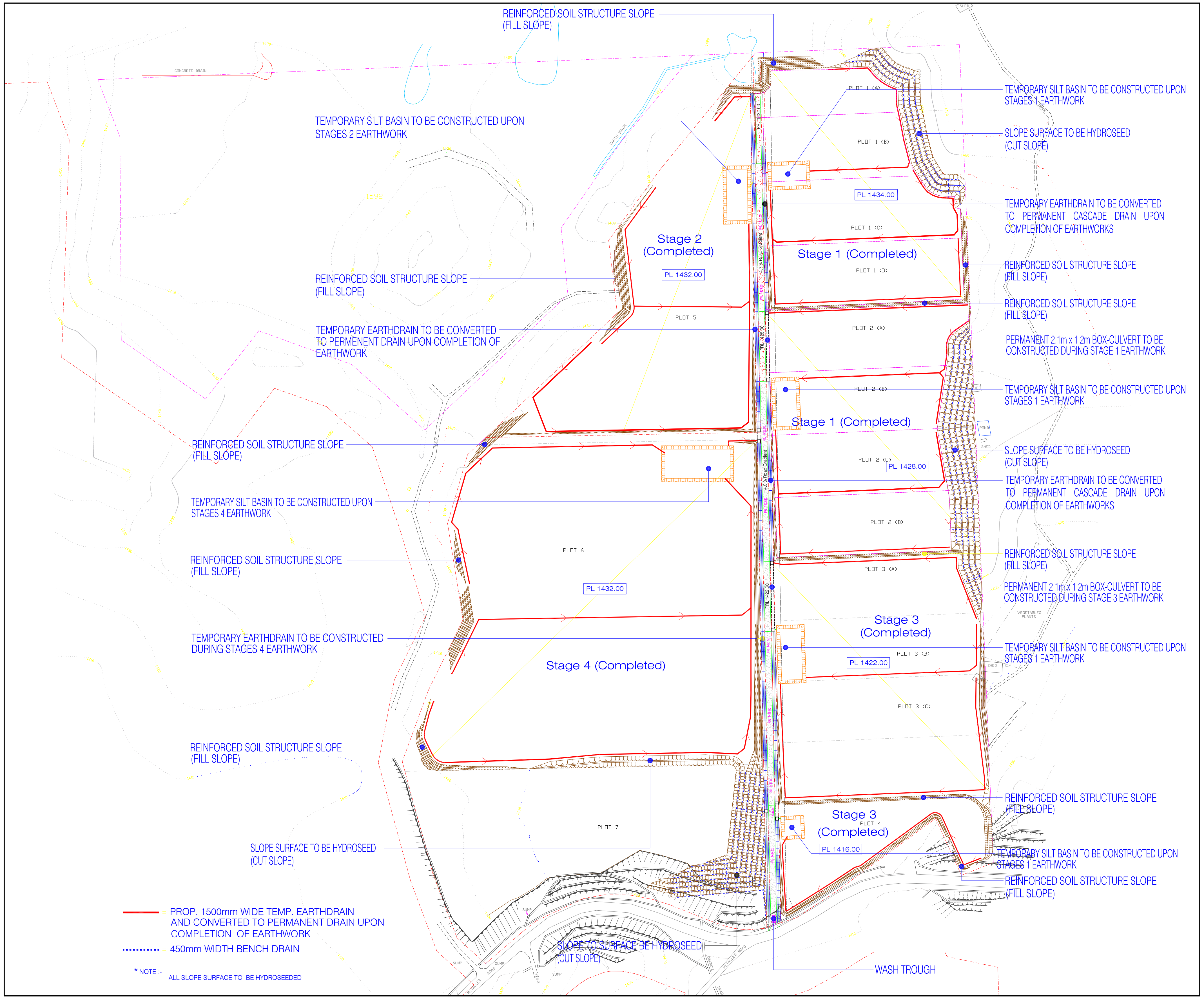


Figure E1: Overall Stage of ESC Plan for Proposed Development Area (Deng Seng, 2004).

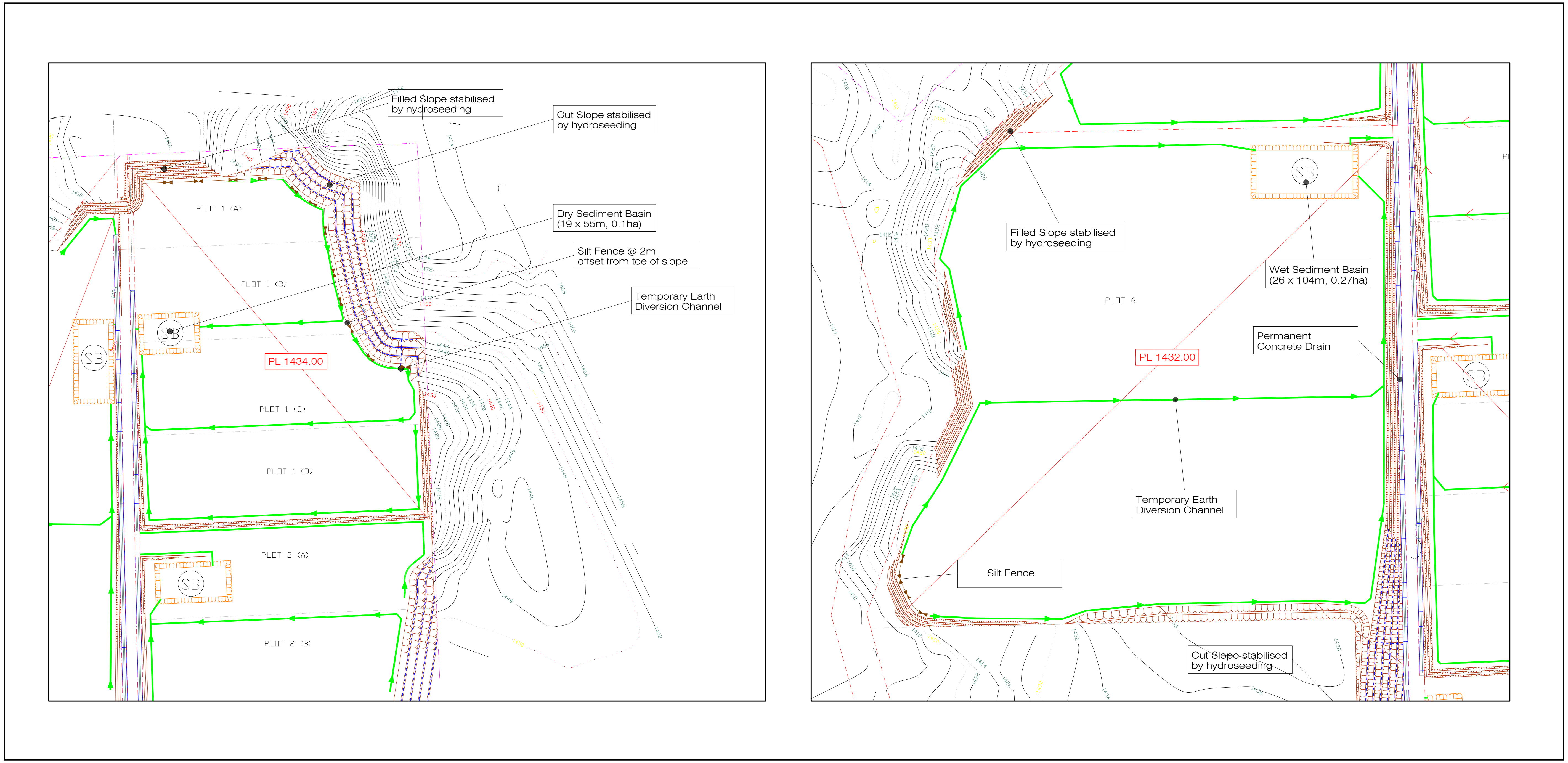


Figure E2: ESCP for Plot 1 and Plot 6 at post-bulk grading stage

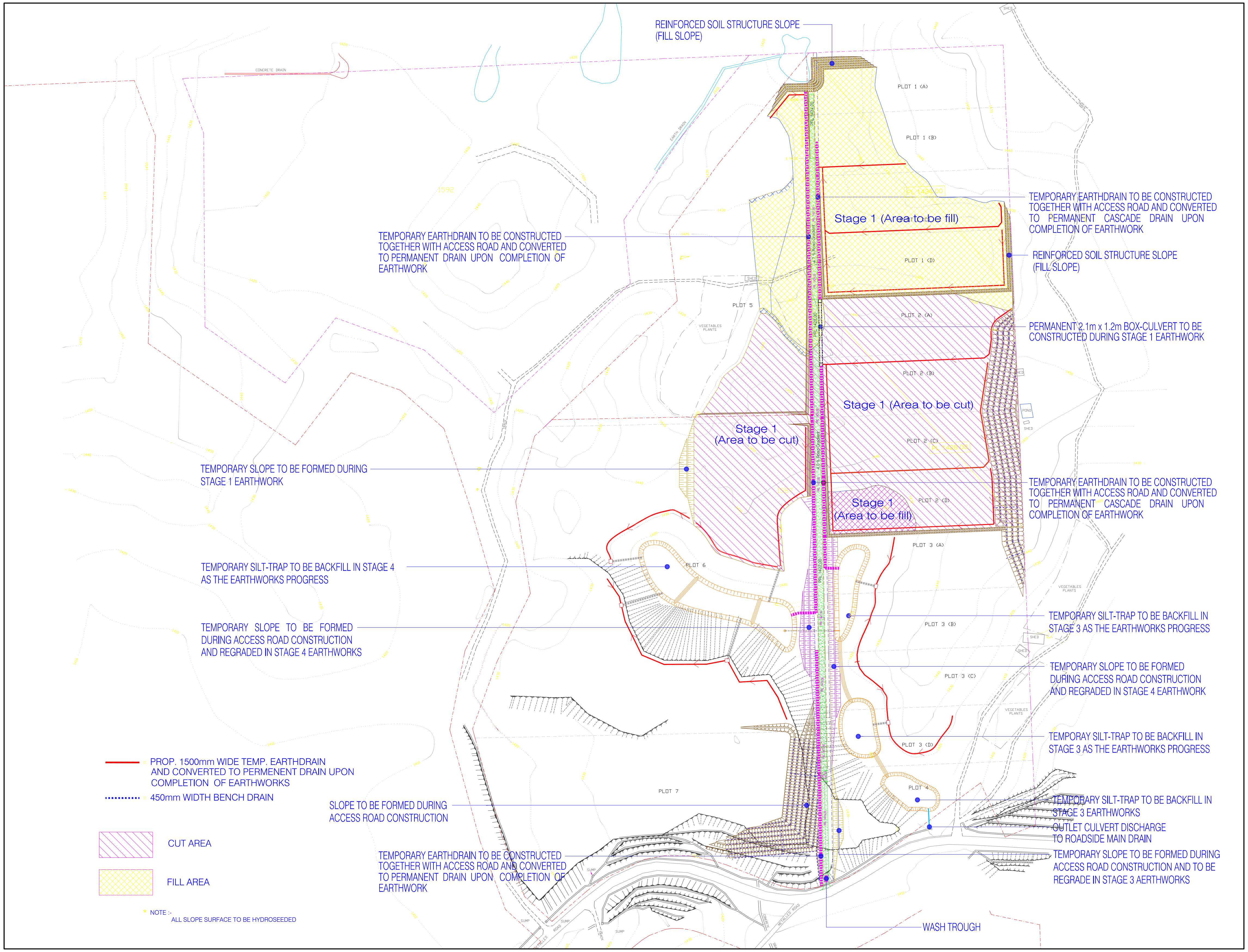


Figure E3: Stage 1 ESC Plan for Proposed Development Area (Deng Seng, 2004).

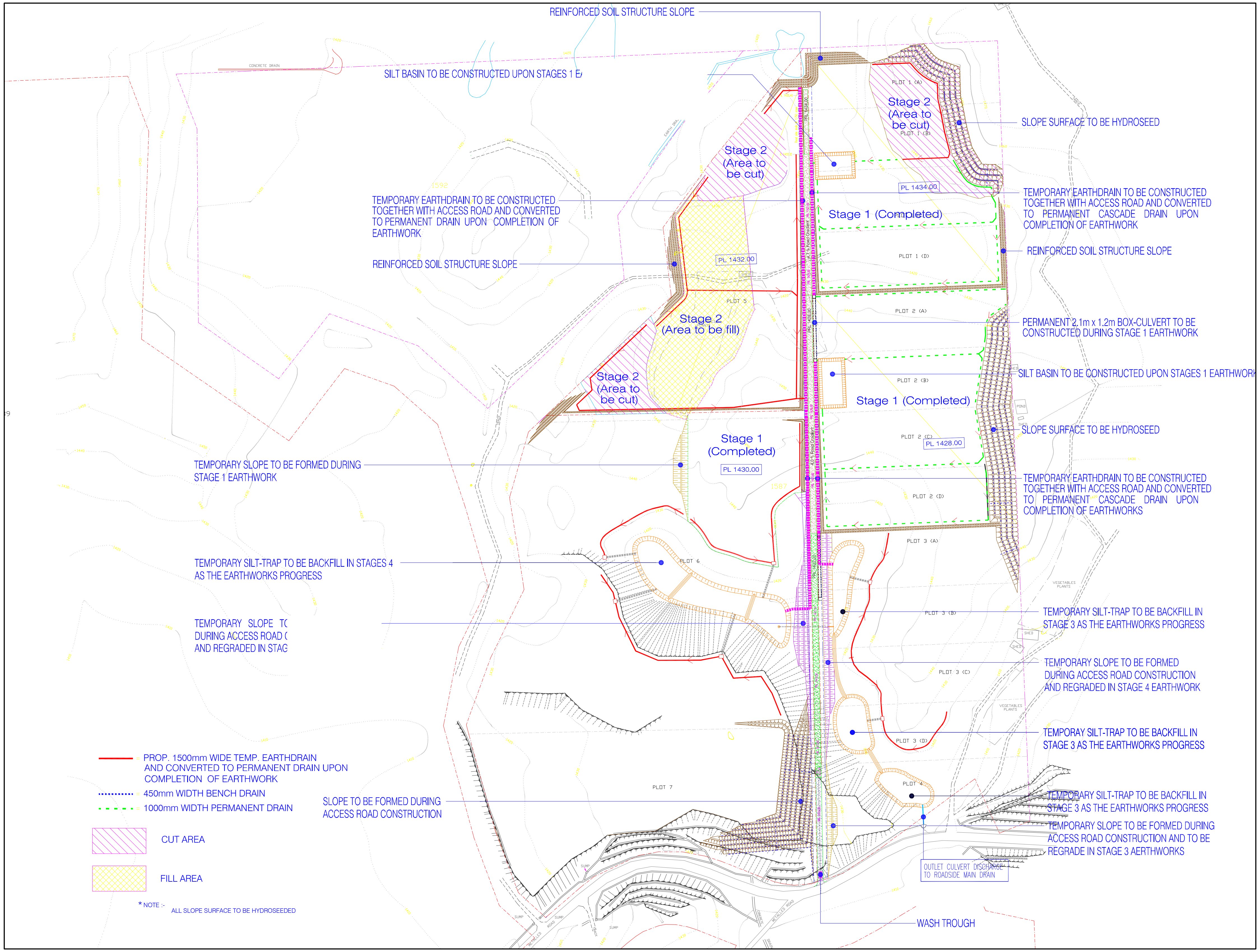


Figure E4: Stage 2 ESC Plan for Proposed Development Area (Deng Seng, 2004).

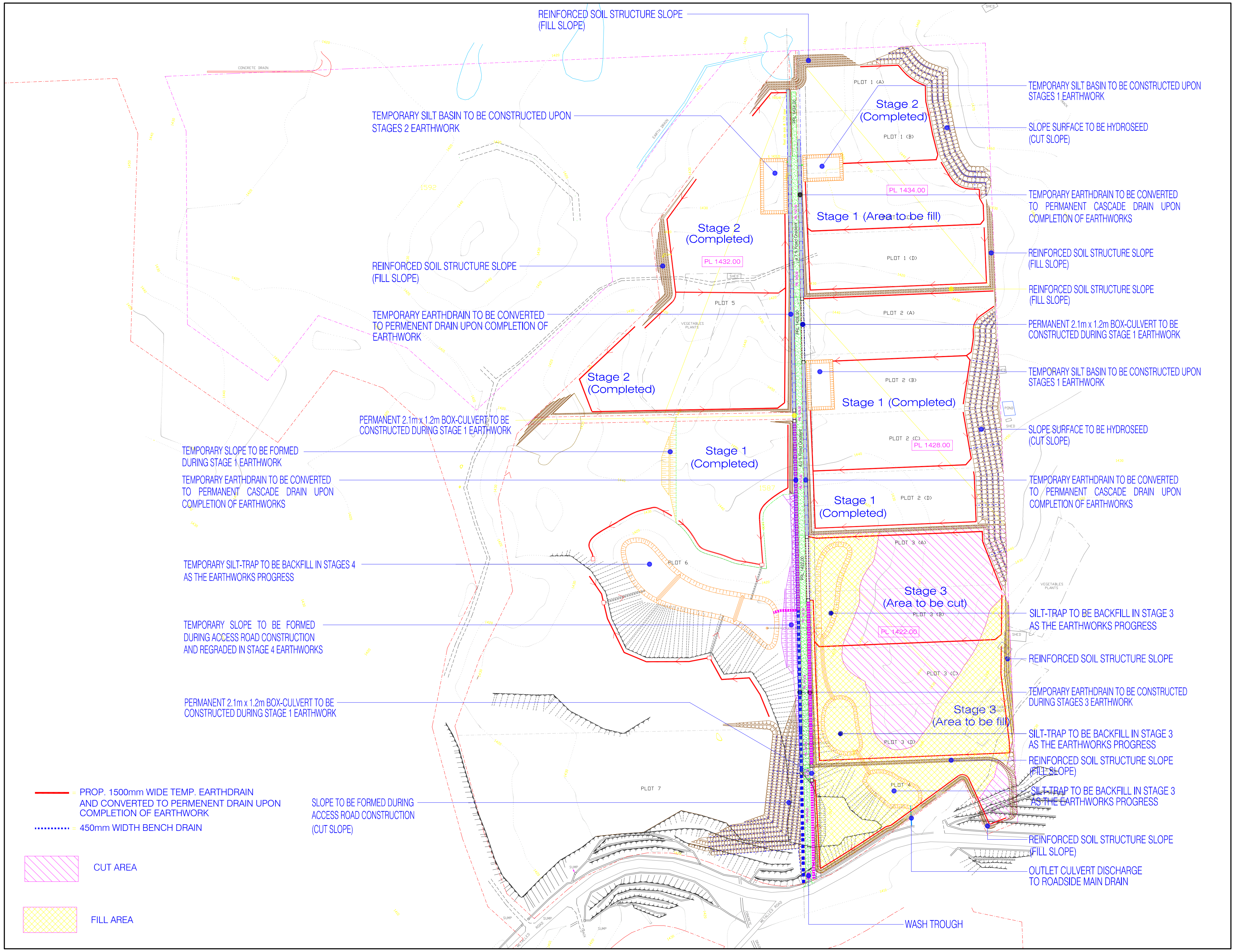


Figure E5: Stage 3 ESC Plan for Proposed Development Area (Deng Seng, 2004).

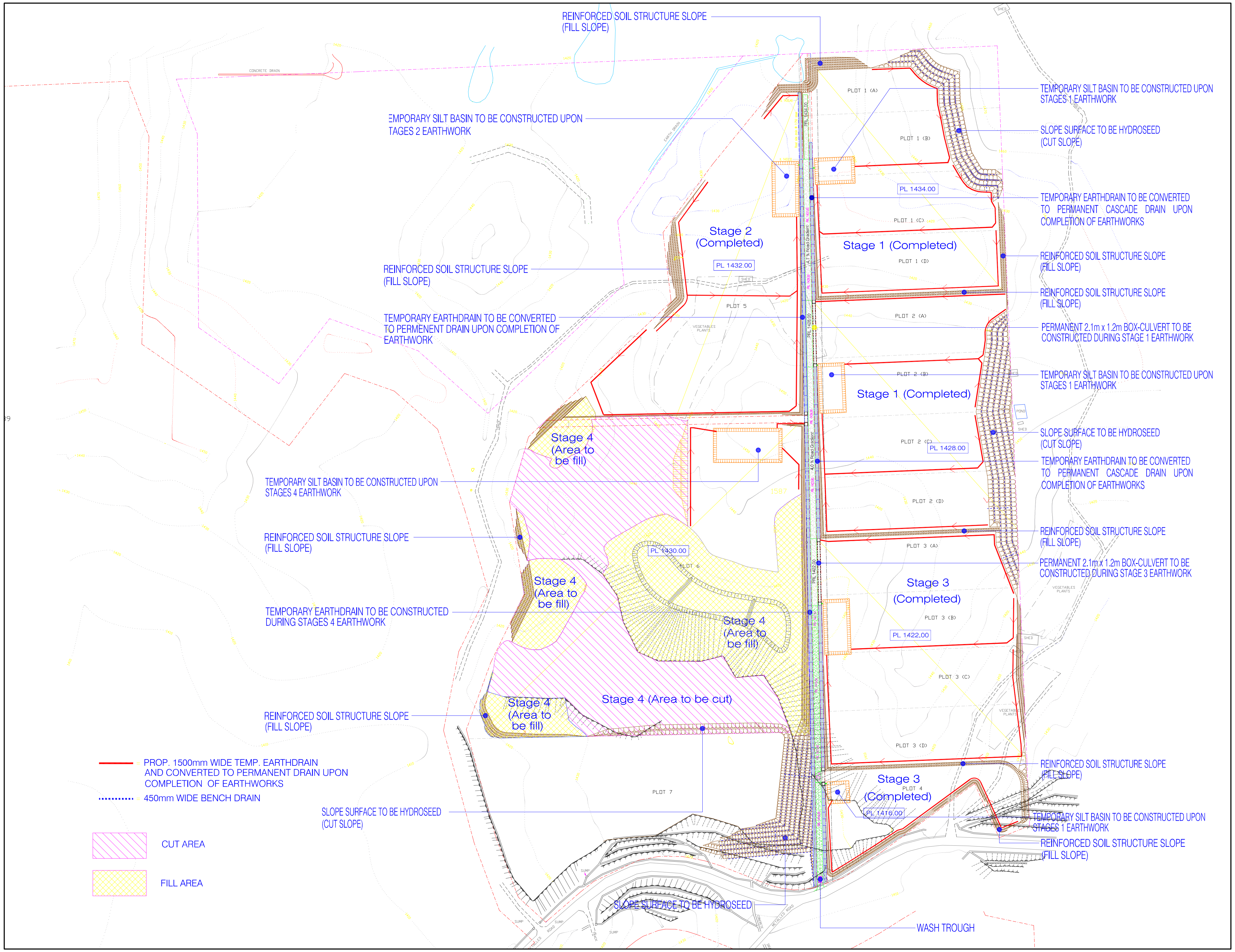


Figure E6: Stage 4 ESC Plan for Proposed Development Area (Deng Seng, 2004).

Soil Loss Estimation For Project Site

The soil loss from Plot 1 of this case study area is estimated using Universal Soil Loss Equation, USLE (Wischmeier and Smith, 1978).

A = RKLSCP

Where, A = Average annual Soil Erosion Loss (t/ha/yr)
R = Rainfall Erosivity Factor (MJ.mm/(ha.hr.yr))
K = Soil Erodibility Factor (t.ha.hr/(ha.MJ.mm))
L = Slope Length Factor
S = Slope Steepness Factor
C = Cover and Management Factor
P = Conservation Practice Factor

All values of parameters in this equation will be obtained using data that been obtained for Malaysia condition as presented in Chapters 3 of this guideline. It is important that by using all the data provided and obtained in this report will give a better understanding to all engineers or designers in estimating soil loss for a proposed construction site in the erosion and sediment control plan (ESCP). The step by step calculations of soil loss for Plot 1 in the study area are as follows.

(1) Catchment Area

Total Catchment Area for Plot 1 = 38,500 m^2
= 3.85 ha

(2) Determination of Rainfall Erosivity, R Factor (See Section 3.3.1):

From Figure 3.7 for Pahang, consider the area of Tanah Rata, and by interpolation, the R factor for the study area is ≈16,000 MJ.mm/ha.hr.yr

(3) Determination of Soil Erodibility, K Factor (See Section 3.3.2):

In determining the K factor of the develop area, soil data obtained from hand auger method for all plots is used. The soil samples are tested and the results are shown in Table E1.

Table E1: Summary of Laboratory Test Result of Soil Data (Deng Seng, 2004)

Hand Auger No.	Sample Number	Depth (m)	Particle Size Distribution (%)				Organic Matter (%)
			Clay	Silt	Sand	Gravel	
HA 1	A	0.5	10.8	30.3	43.1	15.9	0.1
	B	1.0	10.3	27.2	27.1	35.4	0.1
HA2	A	0.5	4.8	29.7	53.1	12.3	0.1
	B	1.0	1.7	21.7	56.0	20.6	0.1
HA3	A	0.5	6.4	30.3	54.3	8.9	0.1
	B	1.0	13.2	36.9	38.8	11.1	0.1
HA4	A	0.5	7.4	27.7	50.8	14.1	0.1
	B	1.0	4.2	32.2	52.9	10.6	0.1
HA5	A	0.5	11.5	26.2	49.1	13.2	0.1
	B	1.0	19.6	22.8	38.5	19.1	0.1
HA6	A	0.5	18.0	65.8	16.0	0.2	0.1
	B	1.0	20.4	65.6	13.9	0.1	0.1

The soil erodibility analysis is then carried out for all data above using Tew Equations (Eq. 4.2), through a simple Excel Worksheet. The result is shown in Table E2. Based on Tew Equation, only particle with size ≤ 2.00 mm are considered in the calculation of K factor, the fraction of Gravel in Table 8.2 has to be eliminated and the percentages of Clay, Silt and Sand in the soil sample are recalculated base on their weight as shown in Table E2

Table E2: Result Summary of Soil Erodibility Analysis

Hand Auger No.	Sample Number	Depth (m)	Particle Size Distribution (%)			Organic Matter (%)	Structure Code (S)	Permeability Code (P)	K Factor
			Clay	Silt	Sand				
HA 1	A	0.5	12.83	35.99	51.19	0.1	2	3	0.0244
	B	1.0	15.94	42.11	41.95	0.1	2	3	0.0266
HA2	A	0.5	5.48	33.90	60.62	0.1	2	2	0.0142
	B	1.0	2.14	27.33	70.53	0.1	2	2	0.0113
HA3	A	0.5	7.03	33.30	59.67	0.1	2	2	0.0136
	B	1.0	14.85	41.51	43.64	0.1	2	3	0.0266
HA4	A	0.5	8.61	32.25	59.14	0.1	2	2	0.0128
	B	1.0	4.70	36.06	59.24	0.1	2	2	0.0155
HA5	A	0.5	13.25	30.18	56.57	0.1	2	2	0.0110
	B	1.0	24.23	28.18	47.59	0.1	2	3	0.0190
HA6	A	0.5	18.04	65.93	16.03	0.1	3	3	0.0387
	B	1.0	20.42	65.67	13.91	0.1	3	3	0.0377

$$K = \left[1.0x10^{-4}(12 - OM)M^{1.14} + 4.5(s-3) + 8.0(p-2)\right] / 100 \qquad (4.2)$$

Where M - (% silt + % very fine sand) x (100 - % clay)
OM - % of organic matter
S - soil structure code
P - permeability class

In using the values of K factor above, selected layer of soil will be used in calculating the soil loss. This can be done through the depth of cut and fill process during the design or planning stages. In this case, the layer B of **HA1 (K=0.0266**) will be use in calculating the soil loss for the plots.

(4) Determination of LS Factor (See Section 3.3.3)

The averaged slope steepness in the study area, s = 10.0%, and slope length, λ = 60.0 m. Hence, From Table 3.5:

LS = 1.935

(5) Determination of CP Factor (See Section 3.3.4)

Assuming the condition at site is bare land without erosion and sediment control measures (newly cleared area):

CP Factor = 1.00

(6) Determination of Soil Loss

The estimation of soil loss for each plot in the study area using USLE equation for Malaysia condition is as follow:

A = R.K.LS.CP

For Plot 1 : A = R x K x LS x CP
= 16,000 x 0.0266 x 1.935 x 1.00
= **823.54 tonne/ha/yr**

Sediment Yield Estimation

The sediment yield from Plot 1 of the study area can be estimated using MUSLE equation:

$$Y = 89.6(VQ_p)^{0.56}(K.LS.C.P) \qquad (2.3)$$

Where Y - Sediment yield per storm event (tones)
V - Runoff volume in cubic meter
Q_p - peak discharge in m^3/s

In estimating the sediment yield for the study area, the peak discharge, Q_p, was determined based on Rational Method (DID, 2000), as recommended in the Urban Stormwater Management Manual, MSMA (DID, 2000).

(1) (a) Design storm event for Plot 1

Design Storm	=	3 month ARI
Catchment area	=	38,500 m2
Overland flow length	=	500 m
Duration of storm	=	16.2 min
Intensity of design storm, I	=	104.8 mm/hr
Runoff Coefficient, C	=	0.74

(b) Design storm event for Plot 6

Design Storm	=	3 month ARI
Catchment area	=	77,000 m2
Overland flow length	=	550 m
Duration of storm	=	20.1 min
Intensity of design storm, I	=	104.8 mm/hr
Runoff Coefficient, C	=	0.85

(2) Calculation of Sediment Yield using MUSLE

In this case, the value of K, LS and CP factors are assumed the same as for soil loss estimation above.

Sub Catchment area, ***A*** (m^2)	Runoff Volume, ***V*** (m^3)	Peak flow Discharge [***Qp = C.I.A***] (m^3/s)	K Factor	LS Factor	CP Factor	Sediment Yeild, Y (tone)
38,500	806.15	0.829	0.0266	1.935	1.00	176.14
77,000	1143.00	1.905	0.0377	1.935	1.00	483.70

Thus, the Total Sediment Yield for Plot 1: **Y = 176.14 tonnes per storm event**
And Total Sediment Yield for Plot 6: **Y = 483.70 tonnes per storm event**

Sizing of Dry Sediment Basin (Plot 1)

The sediment basin sizing is done according to the criteria set in Chapter 39, MSMA. The following steps are taken:

(1) Determination Type of soil

According to Table E2, the soil in the Plot 1 is sandy loam which is considered as Type C in Table 5.8. Hence, a dry sediment basin is chosen.

(2) Determination of Basin Dimension

From Table 5.10 for a 3 month ARI, the required surface area is 250 m^2/ha and the required total volume is 300 m^3/ha. Figure E7 illustrates the final dimensions of the sediment basin.

The surface area required for the site = 250 x 3.85 = 962.50 m^2
(Note: this is the average surface area for the settling zone volume, i.e. at mid-depth)

The total basin volume required for the site = 300 x 3.85 = 1155 m^3

(a) <u>Settling Zone:</u>

From Table 5.10, the required settling zone V_1 = 578 m^3 (half the total volume) and the settling zone depth y_1 = 0.6 m.

Try a settling zone average width W_1 = **18 m**

Required settling zone average length $L_1 = \frac{V_1}{W_1 \times y_1} = \frac{578}{18 \times 0.6} = 53.5$ m , say **54 m**

Average surface area = 54 x 18 = 972 m^2 > 962.5 m^2 ; OK

Check settling zone dimensions (see page 39-16):

$\frac{L_1}{y_1}$ ratio $= \frac{54}{0.60} = 90$ < 200; OK

$\frac{L_1}{W_1}$ ratio $= \frac{54}{18} = 3$ > 2; OK

(b) <u>Sediment Storage Zone:</u>

The required sediment storage zone volume is half the total volume, V_2 = 578 m^3

For a side slope Z = 2(H):1(V), the dimensions at the top of the sediment storage zone are,

$W_2 = W_1 - 2 \text{ x } \frac{d_1}{2} \text{ x } Z = 18 - 2 \text{ x } 0.3 \text{ x } 2 = 16.8 \text{ m}$

$L_2 = L_1 - 2 \text{ x } \frac{d_1}{2} \text{ x } Z = 54 - 2 \text{ x } 0.3 \text{ x } 2 = 52.8 \text{ m}$

The required depth for the sediment storage zone, which must be at least 0.3 m, can be calculated from the following relationship,

$V_2 = Z^2 y_2^3 - Z y_2^2 (W_2 + L_2) + y_2 (W_2 L_2)$

Which gives,

$$578 = 4 y_2^3 - 139.2 y_2^2 + 887 y_2$$

Use trial and error to find y_2 ,

For y_2 = 0.5 m,	V_2 = 409 m^3	
For y_2 = 0.7 m,	V_2 = 554 m^3	
For $\boldsymbol{y_2}$ **= 0.8 m,**	V_2 = 623 m^3	$y_2 >$ 0.3 m and $V_2 >$ 578 m^3 ; OK

(c) Overall Basin Dimensions:

At top water level:	$W_{TWL} = W_1 + 2 \text{ x } Z \text{ x } \frac{y_1}{2} = 19.2 \text{ m}$	say, 19 m
	$L_{TWL} = L_1 - 2 \text{ x } Z \text{ x } \frac{y_1}{2} = 55.2 \text{ m}$	say, 55 m
Base:	$W_B = W_1 - 2 \text{ x } Z \text{ x } \left(\frac{y_1}{2} + y_2\right) = 13.6 \text{ m}$	say, 15 m
	$L_B = L_1 - 2 \text{ x } Z \text{ x } \left(\frac{y_1}{2} + y_2\right) = 49.6 \text{ m}$	say, 50 m

Depth: Settling Zone, y_1 = 0.60 m
Sediment Storage Zone, y_2 = 0.80 m

Side Slope Z = 2(H):1(V)

(3) Sizing of Emergency Spillway

The spillway for this sediment basin must be design for 10-years ARI (see section 39.7.6, Chapter 39, MSMA). The determination of the spillway is base on Eq. 20.9 (Chapter 20,MSMA). The proposed spillway dimension is 1.5m wide x 0.3m high.

The sill level must be set a minimum 300 mm above the basin top water level. To simplify the calculations, the following assumptions are made:

- assume riser pipe flow is orifice flow through the top of the pipe only
- riser pipe head is 300 mm, i.e. the height between the top of the pipe and the spillway crest level

$$Q_{\text{spillway}} = Q_{10} - Q_{\text{riser}}$$

From Equation 14.7,

$$Q_{10} = \frac{C.{}^{10}I_{10}.A}{360}$$

The 10 year ARI rainfall intensity for Cameron Highland is derived from Equation 13.3 and Table 13.3, for a 20 minute duration. ${}^{10}I_{60}$ = 61.5 mm/h, ${}^{10}I_{30}$ = 96.1 mm/h, and F = 0.47. Therefore,

$${}^{10}I_{20} = 115.26 \text{ mm/hr}$$

From Equation 14.7, with C = 0.85 (Category (4) in Design Chart 14.3,Chapter 14 MSMA),

$$Q_{10} = \frac{C.{}^{10}I_{20}.A}{360} = \frac{0.85 x 115 x 3.85}{360} = 1.05 \text{ m}^3/\text{s}$$

From Equation 20.2 for orifice flow and assuming an orifice discharge coefficient of 0.60,

$$Q_{riser} = C_0 A_0 \sqrt{2gH_0} = 0.6 \text{ x } \frac{\pi(0.9)^2}{4} \text{ x } \sqrt{2 \text{ x } 9.81 \text{ x } 0.3} = 0.93 \text{ m}^3/\text{s}$$

Therefore, allowing for the riser pipe flow the required spillway capacity is:

$$Q_{\text{spillway}} = 1.05 - 0.93 = 0.12 \text{ m}^3/\text{s}$$

From Equation 20.9,

$$Q_{spillway} = C_{sp}\ B\ H_p^{1.5}.$$

Trial dimensions: B = 1.5 m , H_p = 0.3 m and C_{sp} = 1.65 from Design Chart 20.2,

$$Q_{\text{spillway}} = 1.65 \times 1.5 \times 0.3^{1.5} = 0.41 \text{ m}^3/\text{s} \;\; > 0.12 \text{ m}^3/\text{s}; \text{ OK}$$

Therefore, the total basin depth including the spillway is,

0.6 + 0.8 + 0.3 + 0.3 = **2.0 m**

(4) Trapping Efficiency

From previous calculation in Section 8.3.4, the soil loss is estimated at 271.39 tonnes for the design storm. With the design sediment trapping efficiency of 70% (Table 5.9), the total sediment trapped for the design event is 189.97 tonne or 118.7m^3 (converted from soil density). The total volume in the selected dry sediment basin is 1155m^3. Hence, the provided sediment basin can contain the settled sediment from Plot 1. The design storm is expected to only use about 10.3% of the sediment storage volume.

(5) Maintenance Frequency

Sediment trapped (as calculated above) from a design storm of 3 months ARI is 118.7m^3 and the volume available for sediment settlement is 1155m^3.

Therefore the number of storm event until sediment volume is entirely taken up is 1155/118.7 = 9.7 (assume 9 storm events).

Hence the basin shall be maintained every time after 9 moderate storm events. This estimated frequency of maintenance can then itemised in bill of quantities (BQ) for proper financial allocation, as well as planned in the inspection & maintenance plan. Both documents, together with the design calculation above shall be submitted as part of the ESCP for approval from local authority.

Sizing of Wet Sediment Basin (Plot 6)

The wet sediment basin sizing will be designed for Plot 6 (7.7ha) and design criteria will be according to Chapter 39,MSMA (DID, 2000). The following steps are taken:

(1) Determination Type of soil

According to Table E2, the soil in the Plot 6 is clay loam which is considered as Type F in Table 39.4 (Chapter 39, MSMA). Hence, a wet sediment basin is chosen.

(2) Determination of Basin Dimension

Selected rainfall depth for 3-month ARI is 40mm (DID, 2010) and the site runoff potential is moderate to high runoff.

From Table 5.11 (Chapter 5) the required surface area is 200 m^3/ha and the required total volume is 300 m^3/ha. Figure E8 illustrates the final dimensions of this wet sediment basin.

The settling zone volume required for the site = 200 x 7.70 = 1540 m^3

The total basin volume required for the site = 300 x 7.70 = 2310 m^3

(a) <u>Settling Zone</u>:

The minimum settling zone depth y_1 = **0.6 m.**

Try a settling zone average width W_1 = **25 m**

The settling zone average length $L_1 = \frac{V_1}{W_1 \times y_1} = \frac{1540}{25 \times 0.6} = 102.7$ m , say **103 m**

Check settling zone dimensions,

$$\frac{L_1}{y_1} \text{ ratio } = \frac{103}{0.6} = 170 \qquad < 200; \text{ OK}$$

$$\frac{L_1}{W_1} \text{ ratio } = \frac{103}{25} = 4.12 \qquad > 2; \text{ OK}$$

(b) <u>Sediment Storage Zone:</u>

The required sediment storage zone volume is one-third the total volume or the difference between the total volume and the settling zone volume, V_2 = 770 m^3

For a side slope Z = 2(H):1(V), the dimensions at the top of the sediment storage zone are,

$$W_2 = W_1 - 2 \text{ x } \frac{d_1}{2} \text{ x } Z = 25 - 2 \text{ x } 0.3 \text{ x } 2 = \mathbf{23.8 \text{ m}}$$

$$L_2 = L_1 - 2 \text{ x } \frac{d_1}{2} \text{ x } Z = 103 - 2 \text{ x } 0.3 \text{ x } 2 = \mathbf{101.8 \text{ m}}$$

The required depth for the sediment storage zone, which must be at least 0.3 m, can be calculated from the following relationship,

$$V_2 = Z^2 y_2^3 - Z y_2^2 (W_2 + L_2) + y_2 (W_2 L_2)$$

Which gives,

$$770 = 4 y_2^3 - 251.2 y_2^2 + 2423 y_2$$

Use trial and error to find y_2 ,

For y_2 = 0.3 m, V_2 = 704 m^2

For y_2 = 0.4 m, V_2 = 929 m^2 $y_2 >$ 0.3 m and $V_2 >$ 528 m^2; OK

(c) Overall Basin Dimensions:

At top water level: $W_{TWL} = W_1 + 2 \text{ x } Z \text{ x } \frac{y_1}{2}$ = 26.2 m say, **26 m**

$L_{TWL} = L_1 + 2 \text{ x } Z \text{ x } \frac{y_1}{2}$ = 104.2 m say, **104 m**

Base: $W_B = W_1 - 2 \text{ x } Z \text{ x } \left(\frac{y_1}{2} + y_2 \right)$ = 22.2 m say, **22 m**

$L_B = L_1 - 2 \text{ x } Z \text{ x } \left(\frac{y_1}{2} + y_2 \right)$ = 100.2 m say, **100 m**

Depth: **Settling Zone, y_1 = 0.60 m**
Sediment Storage Zone, y_2 = 0.4 m

Side Slope Z = 2(H):1(V)

(3) Determine overland flow time of concentration (minutes)

From Equation 14.1, $t_o = \frac{107\, n\, L^{0.333}}{S^{0.2}}$

For Plot 6; n = 0.02 (from Table 14.3 for bare clay)

$$t_o = \frac{107 \text{ x } 0.02 \text{ x } 550^{0.333}}{0.5^{0.2}} = 20.1 \text{ minutes}$$

Adopted time of concentration = 20 minutes

(4) <u>Sizing of emergency spillway</u>

The emergency spillway must be designed for a 10 year ARI flood when the basin is already full. The sill is set at the basin top water level.

$$Q_{\text{spillway}} = Q_{10}$$

From Equation 14.7,

$$Q_{10} = \frac{C.^{15}I_{10}.A}{360}$$

The 10 year ARI rainfall intensity for Cameron Highland is derived from Equation 13.3 and Table 13.3, for a 20 minute duration. ${}^{10}I_{60}$ = 61.5 mm/h, ${}^{10}I_{30}$ = 96.1 mm/h, and F = 0.47. Therefore,

$${}^{10}I_{20} = 115.26 \text{ mm/hr}$$

From Equation 14.7, with C = 0.85 (Category (4) in Design Chart 14.3,Chapter 14 MSMA),

$$Q_{10} = \frac{C.^{10}I_{20}.A}{360} = \frac{0.85x115x7.70}{360} = 2.10 \text{ m}^3/\text{s}$$

From Equation 20.9, $Q_{spillway} = C_{sp}\ B\ H_p^{\ 1.5}$.

Trial spillway dimensions:
$\boldsymbol{B}$ **= 5.0 m ,** $\boldsymbol{H_p}$ **= 0.45 m** and C_{sp} = 1.53 from Design Chart 20.2.

Therefore,

$$Q_{\text{spillway}} = 1.53 \text{ x } 5.0 \text{ x } 0.45^{1.5} = 2.31 \text{ m}^3/\text{s} \quad > 2.10 \text{ m}^3/\text{s}; \text{ OK}$$

Therefore, the total basin depth including the spillway is,
0.6 + 0.4 + 0.45 = **1.45 m**

Therefore this design is adopted.

(5) Trapping Efficiency

From previous calculation in Section 8.3.4, the soil loss is estimated at 483.70 tonnes for the design storm. With the design sediment trapping efficiency of 70%, the total sediment trapped for the design event is 338.59 tonne or 211.62m^3 (converted from soil density). The total volume in the selected wet sediment basin is 2310m^3. Hence, the provided sediment basin can contain the settled sediment from Plot 6.

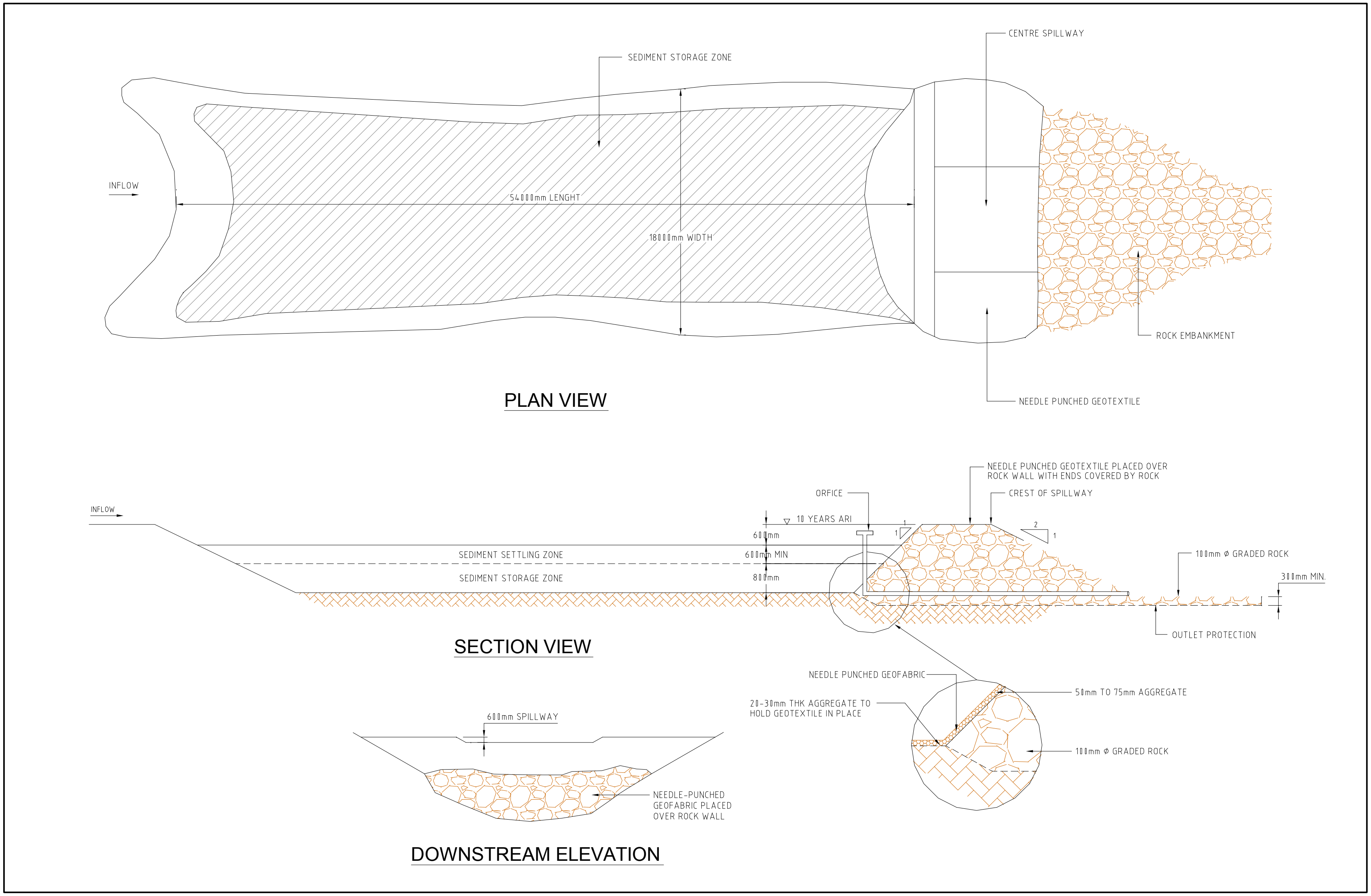


Figure E7: Details of Dry Sediment Basin for Plot 1

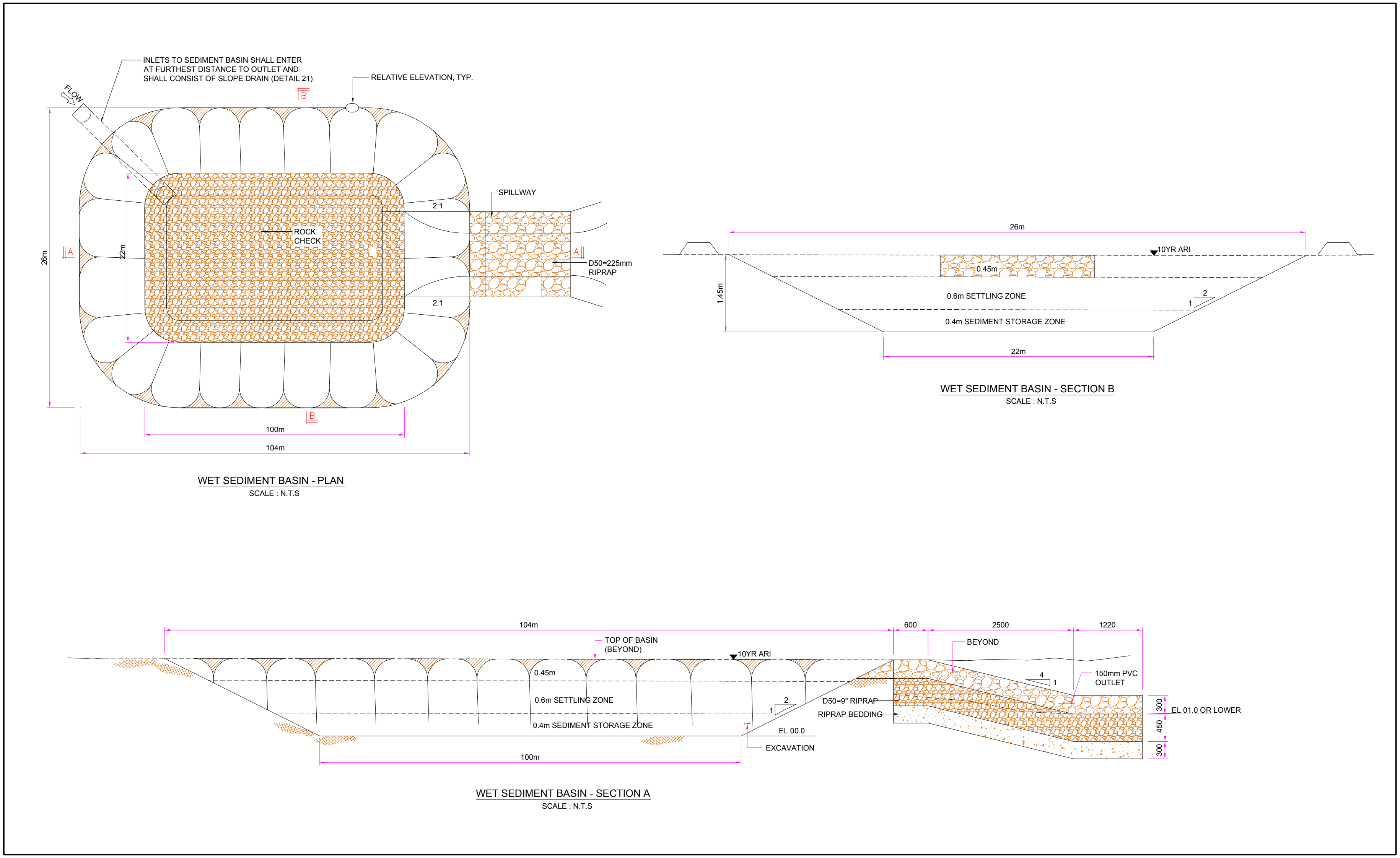


Figure E8: Details of Wet Sediment Basin for Plot 6