HILLSIDE DEVELOPMENT MANUAL FOR JAMAICA

Prepared by
Mines and Geology Division
Ministry of Science, Technology, Energy and Mining

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Hillside Development Manual for Jamaica

A guideline document that outlines recommended hillside development practice to reduce the incidence of geologic hazards such as slope failures and erosion.

Prepared by

The Mines and Geology Division (MGD)

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In association with the Research and Mapping Unit

Aided by the comments and contributions of the following organizations:

NEPA, JIE, JIA, LSA, NWA, WRA, JET, UWI and the various Local Planning Authorities.

Notice to Reader

The following document forms part of the necessary addenda to the Development Approvals Process in Jamaica. Contribution to the manual came from four consultation workshops, technical review of hillside development documents in various countries as well as technical reviews by local external organizations. The manual is the first step to becoming a policy document to guide the development of hillsides in Jamaica. The manual will be reviewed after two years from date of publication to accentuate completeness in the approach to hillside development.

Keywords

Hillside Development Manual, hillside, erosion, slope failure, slope steepness, sediment control, residential densities, karst terrain, colluvium, planning, environment, visual impact, mining, geology, site grading, hydrology, surface drainage, Mines and Geology Division

PREFACE

The Hillside Development Manual for Jamaica began its journey in November 2008, when it became apparent that a hillside policy was needed for Jacks Hill, St. Andrew to guide development in that area. The demand for residential space and the problems of geological instability associated in Jacks Hill led to a number of discussions and meetings between the MGD and NEPA to address this issue. This resulted in the development of a draft policy for the Jacks Hill area. The volume of material reviewed to prepare the draft policy and the strong interest by stakeholders to have it extended to other selected areas convinced NEPA and the MGD that a set of hillside development guidelines/policy for Jamaica should be prepared in order to encourage good hillside development practices. Additionally, it was realized that Parish Development Orders and the Investment and Development Manual for Jamaica (2007) did not adequately address hillside development. It meant that developers and their professionals exploited the gaps that existed in the Development Approval Process.

Over 70 percent of Jamaica's landscape consists of hilly terrain. It is therefore inevitable that hillsides will be exploited to achieve national growth and development, especially infrastructure works and housing construction. The rapid expansion of urbanized areas has contributed significantly to an increase in hillside residential development on the fringe of urban centres, as homeowners view hillsides as a preferred choice to get away from the busy urbanized areas. However, this increase in residential expansion on steep hillsides has unfortunately increased the incidence of slope instability and erosion, environmental degradation and destruction of the aesthetic quality of hillsides. To address these issues, it was necessary to develop a comprehensive set of guidelines that would assist developers, planners, engineers, environmental professionals, Local Authorities, land surveyors, home owners and other relevant stakeholders in gaining further insights into best practices for safe hillside development.

The Hillside Development Manual for Jamaica is not intended to be an engineering document, but seeks to engender a holistic approach to hillside development. In taking this approach, the input of planners, geologists, geo-hazard specialists, engineers, environmental scientists, land surveyors, architects have been sought to prepare this manual. Chapters 1-2 describe the current status of hillside development practices in Jamaica and the rationale for a hillside development manual. Chapters 3 -9 deal primarily with the factors affecting hillside development and seek to explain in simple terms how these contributory factors impact hillside areas. The recommended guidelines are then presented as measures for improving hillside development.

It is evident that the Hillside Development Manual for Jamaica, when adopted will change the paradigm of current hillside development practices. This is important as the culture of developing hillsides has been based primarily on the same principle of development on flat lands.

The Hillside Development Manual for Jamaica sets specific guidelines for hillside development; however, there are some features of the manual that will have a greater positive impact on current hillside development practices. Some examples include: limiting development on slopes greater than 30 degrees (58%) gradient, beyond which no development is encouraged except under special circumstances; redefining residential zoning densities on hillsides; defining areas of developable and undevelopable land; grading plans as a requirement for building applications for hillsides including multi-family development.

The next phase of the journey is to develop hillside development regulations and standards as well as a grading code for hillsides. This will require more rigorous analysis than is presented in this manual, which is a first step in achieving this objective. The journey continues……..

ACKNOWLEDGEMENTS

The Mines and Geology Division (MGD) wishes to thank the National Environment and Planning Agency (NEPA) for having faith in the organization to develop the Hillside Development Manual for Jamaica. The collaboration between NEPA and MGD was cordial throughout the process and there was consistent dialogue which enabled obstacles to be removed during completion of the project. Thanks to Messrs. Alan Hamilton, Leonard Francis, Ainsley Henry, Marc Rammelaere (former NEPA staff) and Mesdames Ruth-Ann Sherrard and Aisha Bedasse. The MGD wishes to also recognize the financial and material support of NEPA and the Office of Disaster Preparedness (ODPEM) in the execution of the island wide Hillside Development Workshops. The Hillside Development Manual would not have been possible without their involvement and support.

Special thanks to the Commissioner of the MGD, Mr. Clinton Thompson for giving strong support to the project and consistently insisting on the timely completion of the Manual. To the MGD staff, thanks to Ms. Erica Dawkins and Mrs. Stacy Plummer who worked tirelessly and assisted in organizing the Hillside Development Regional Workshops. Mr. Suresh Bhalai, who contributed to the workshop activities and reviewed the Manual, which helped tremendously in the completion of the final draft. The expert contribution of Mrs. Taniquea Callam in organizing the workshops and ensuring that all public relations and communication tasks were of a high standard is greatly appreciated. To the Research and Mapping Unit of the MGD, we extend special thanks to Mrs. Marsha Downswell who contributed to the review of the Hillside Development Manual, worked tirelessly in organizing the workshops and was an inspiration to all during the planning process. The contribution of Ms. Zeaundra Gayle and Mr. Anthony Jones for preparing the illustrations in the manual is also recognized.

Many thanks to the ODPEM, the St Mary, Manchester and St. James Parish Councils for hosting the regional workshops; without your support, the workshops would not achieve the overwhelming success that it did.

To all the stakeholders who provided useful comments both verbally and in writing, we thank you for taking the time to give encouragement and positive feedback on the Hillside Development Manual. Without your support, the journey would have been very difficult. The stakeholders include: The Jamaica Institution of Engineers, The Jamaica Institute of Architects, The Land Surveyors Association of Jamaica, The Jamaica Environmental Trust, The Water Resources Authority, Ministry of Local Government, National Works Agency, Office of Disaster Preparedness and Emergency Management, the Technical Review Committee of the National Environment and Planning Agency, the Disaster Risk Reduction Centre of the University of the West Indies, Superintendents and the Directors of Planning at the various Parish Councils.

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ACRONYMS

DRC	Disaster Risk Reduction Centre
EFJ	Environmental Foundation of Jamaica
JIA	Jamaica Institute of Architects
JIE	Jamaica Institute of Engineers
KSAC	Kingston and St. Andrew Corporation
LPA	Local Planning Authorities
LSAJ	Land Surveyors Association of Jamaica
MGD	Mines and Geology Division
MLG	Ministry of Local Government
NEPA	National Environment and Planning Agency
NWA	National Works Agency
ODPEM	Office of Disaster Preparedness and Emergency Management
UWI	University of the West Indies
WRA	Water Resources Authority

1. INTRODUCTION

1.1. Historical Context

Jamaica's urban population has been increasing rapidly over the past 30-40 years. This rapid growth has led to demand for housing outside the fringes of the urban zone because of dense urbanization and the attractiveness of hillside areas. The demand for housing, particularly in the middle to upper income range, has seen a movement towards the hillsides which surrounds many of the major towns and cities in Jamaica. There is also a noticeable increase in hillside development in rural areas surrounding small urban townships that have developed as tourist centres.

Hillsides have increasingly become a preferred choice for developers and homeowners because of their scenic beauty, being an attractive place to live and also a get-away from the busy urban centres. However, hillsides pose unique challenges for the construction and maintenance of human settlements as they are prone to geological hazards and create topographic constraints in the design of the development. Increases in the demand for hillside real estate are commensurate with an increase in the occurrence of these geological hazards, following the passage of tropical storms and hurricanes. As a small island state, hillsides constitute about 70%-80% of the island's topography. The choice for suitable sites to accommodate urban population growth and expansion is limited because of the high proportion of the island's landmass comprising hillside areas.

Jamaica's population is estimated to be 2.68 million at the end of 2007 with a population growth rate of 0.5% over the past 4 years (Planning Institute of Jamaica). The main urban centre of Kingston and St. Andrew contains 28% of the population and the highest population density. The increase in urban growth and population towards the urban fringe is a trend that is not unique

to Jamaica, but is typical of other regions of the world where large urban centres or cities are flanked by hillsides and mountain slopes.

1.2. Rationale for Hillside Development Guidelines

Many of the larger urban centres in Jamaica, notably Kingston and St. Andrew, Montego Bay, Ocho Rios and Port Antonio, are flanked by hillside slopes that rise steeply from the alluvial plains of these urbanized areas. With the rapid expansion of residential houses on the urban fringe, hillside areas have increasingly become populated and this has brought about a number of challenges that were sometimes not anticipated in the initial planning and development of these areas.

The geology and geomorphology of the hills and mountain slopes are often characterized by steep slopes, weak, weathered and fractured rocks and geological faults. In addition, dense drainage systems emanating from the steep hillsides flow rapidly towards dense urbanized zones. Residential developments on these potentially unstable slopes give rise to geological hazards such as landslides, debris flows and flooding as well as severe erosion of hillsides resulting in high sediment load in rivers and gullies draining the hillside. Heavy rains following Hurricanes Ivan and Dean in 2004 and 2007 respectively and Tropical Storm Gustav in 2008, has left severe damage to houses and physical infrastructure in hillside areas as a result of landslides, debris flows and undercutting of gully banks. The susceptibility of hillside areas to natural hazards is unquestionable, therefore it is absolutely important that development must be done with due consideration to safety and environmental impacts of hillsides.

In following global trends and attitude with respect to environmental consciousness and awareness, hillsides and mountain slopes are considered a natural resource which must be protected and handled with great care to limit environmental damage. This often includes greenbelt preserves which are areas set aside to preserve the natural beauty and scenic quality of an area such as hillsides, as well as areas of natural attraction. The effect of urbanization and

hillside development on Jamaica's natural resources in areas of Kingston and St. Andrew was noted to be significant and that developers seem to be outbidding environmentalists for the use of areas identified for preservation (Simms 2008).

Existing Town and Country Planning Regulations, Development Orders and guidelines, are geared towards the different types of land-use and their planning and zoning requirements. These however do not deal in detail with hillside developments as a special area for consideration. Major gaps are therefore left for interpretation with respect to the development of hillside areas where the practice appears to be no different from development on flat land or gentle slopes.

1.3. Limitations of Existing Regulations

Planning and regulatory issues surrounding hillside development have led to different approaches by the Local Authority, advising agencies and professionals to the way in which development on hillsides should proceed. This leads to uncertainty in the development approval process, increases the time for processing applications and in some instances, accounts for poor decisions to the detriment of the homeowner and the environment at large. If left unregulated, hillside development can change the aesthetic value and scenic beauty of the community, increase the risk of geologic hazard and environmental damage and lead to loss of life and property.

Some of the limiting regulatory factors are as follows:

a) Current Planning and Zoning Regulations have limited information that deals with hillside development. The Development and Investment Manual (2007) however, addresses some of the issues relating to the protection of environmentally sensitive hillside areas from erosion, slope failures and the destruction of the flora. It also gives a list of items that should be submitted to process the application. Unfortunately this information is used

occasionally by developers when submitting their development applications, as the culture of existing development practices has been maintained and which continues to dominate the development process.

b) Existing regulations do not address slope steepness unless it is affected by significant slope stability problems. Any slope can be considered for development provided that there are no known or existing slope stability issues and the consulting engineer gives its seal of approval.

c) There are no regulations or guidelines covering site grading (cut and fill) and this has led to poor and unsafe hillside development practices, placing existing and adjacent developments in danger. A review of hillside development ordinances and regulations in many jurisdictions shows there are mandatory grading codes/standards for hillside areas and this becomes a major component of hillside regulation.

d) Natural features and topography of hillside land is not seen as a natural resource unless it is a heritage site or it may be preserved because of its biodiversity. Hillsides are often levelled and depressions filled to accommodate development.

e) Zoning regulations prescribed are usually based on proximity to urban centres and availability of amenities. Topography of the land is also included, but is often generalized. A zoning area with gentle sloping topography may fall in the same zoning area consisting of steep and vulnerable slopes because of proximity to main urban centres even though development for these steep and vulnerable slopes becomes extremely challenging.

f) Hydraulic structures are normally designed for pure water floods. As hillside development increases, de-vegetation of slopes and erosion also increases, especially in geologically sensitive areas. This has led to rapid increase in sediment load resulting in blockage of drainage structures to cause flooding. Erosion and sediment control

regulations/guidelines are not included in planning regulations or engineering codes, but such activities are carried out based on the engineer's competence and experience in this particular area.

g) One of the requirements that is sometimes requested for large developments is a soil investigation report and this is a requirement set out in the Manual for Development for Jamaica. However, this requirement is also seen as a panacea for approving hillside development, which unfortunately leads to erroneous conclusions in some instances with respect to geo-hazard and geotechnical factors. Site investigations for development on flat land and on hillside terrrain sometimes require different types of knowledge skills which may complement each other. An understanding of geological and engineering processes as well as geo-hazard and geotechnical knowledge skills and expertise are necessary requirements. It will therefore require the input of an engineering geologist, geo-hazard specialist or geotechnical engineer to assist in the process of site investigation and assessment for hillside areas.

1.4. Purpose and Intent

The provision set out in this document is intended to minimize the disturbance of natural slopes in a manner that will:

- Protect the natural and topographic character of the land
- Reduce the incidence of geological hazards (landslides, debris flows, flooding and, erosion) from hillsides caused by improper development
- Prevent inappropriate development on hillsides, especially in hazard prone areas
- Promote public health and safety through creative planning and design
- Protect fragile hillslopes and other environmental resources
- Preserve the scenic beauty and aesthetic quality of hillsides

The main purpose of the provision is to minimize the impact of development on hillsides that will increase the risk of landslides, debris floods and erosion and destroy the natural and aesthetic quality of the hillside. It is also intended to prevent/minimize scarring of the land by removal of trees and reduce erosion/sedimentation of the land. The guidelines are also intended to encourage the application of principles and good practice of civil/geotechnical engineering, physical planning and architectural designs to protect the resources of hillside areas and to preserve the aesthetic appearance of the hillsides.

1.5. Areas Designated As Hillsides

The guidelines contained in this document are applicable to development on lands situated on hillsides with slopes of 10 degrees (17 percent) or greater. In determining whether the guidelines apply, the natural slope of a given property shall be calculated perpendicular to topographic contours from property line to property line, prior to grading, using reputable topographic maps of the subject area or recent topographic survey of the subject area.

2. THE HILLSIDE DEVELOPMENT GUIDELINE PROCESS

2.1. Review of Ordinances and Hillside Development Practices in other Countries

Development ordinances, codes and guidelines were reviewed mainly from the United States of America. The availability of documented hillside ordinances and guidelines from developing countries, were relatively small and as such the review of these are less. In addition, articles on hillside development practices in various countries were reviewed with emphasis on the United States, Hong Kong and Malaysia.

The main aim is to review best practices for residential development in hillside communities and to assess those guidelines that would be most favorable for Jamaica's situation as it relates to geological, topographical and environmental factors. In addition, the existing practice and state of physical/urban planning and economic development of the island is also considered in the review.

According to Olshanky (1998), the variety of purposes cited for hillside ordinances and regulations in the United States are mainly based on protecting scenic quality, preserving the natural physical environment and protection from natural/geological hazards. In developing countries however, the purpose for hillside regulations reviewed was mainly as a response to natural/geological hazards, particularly slope failures and erosion problems. These developing states have been impacted severely from deaths and destructions caused by hillside failures in the past.

2.2. Existing Planning Regulation in Jamaica

2.2.1. The Town and Country Planning Act

The Town and Country Planning Act (1957) provides the statutory requirement to control and guide development in Jamaica. The Act also includes provision for the preparation, confirmation and modification of Development Orders. Development Orders are the principal instrument for guiding and regulating the use of land and ensuring that the Government Policies under the Act are followed. This Act is currently administered by the National Environment and Planning Agency (NEPA).

2.2.2. The Local Improvements Act

The Local Improvements Act (1914) regulates the subdivision of land. All planning and environmental legislations are used to assist with the subdivision of land in Jamaica. However, this and other acts are limited in the provision of regulations and guidelines for hillside development.

2.2.3. The Parish Council Building Act (1908)

The Parish Council Building Act is mainly concerned with the structural integrity of buildings for construction purposes. This has been the main focus, irrespective of the type of terrain and its vulnerability to natural and geological hazards. However, following Hurricane Ivan (2004) which caused severe damage to real estate property, there has been a shift towards reviewing applications where the level of vulnerability of the site is taken into consideration with respect to natural and geological hazards.

2.3. Hillside Development as a Multi-Dimensional Endeavour

According to Olshansky (1998), there are different opinions among professionals who advise Government on how to approach hillside development. This, he contends, is based on conflicting world views due to their differing design disciplines. For example, some professionals see development of hillsides as a public safety problem; others see it as an aesthetic opportunity for development, while other professionals view such development as environmentally unsound and aesthetically undesirable. As such, it is therefore difficult for all professionals (architects, planners, engineers, geologists among others) to agree on all the issues, but a consensus must be arrived at to ensure the sustainability of the environment.

Olshansky further commented that hillside planning and development should be part of a comprehensive land-use planning process and that it is absolutely necessary to explicitly address the underlying rationale for such regulation. This, invariably would assist in arriving at a consensus among the professionals on how to proceed with, and approach hillsides for development purposes.

2.4. Current Practices for Regulating Hillside Development in Jamaica

In Jamaica, a Development Order has provisions for regulating the use of land for the different types of land-use class (residential, commercial, industrial and so on) and offers guidelines for private and public use for example, parks, open space and public roads. It is the main instrument that regulates planning in Jamaica. Unfortunately many of the Development Orders are outdated and therefore not in sync with the dynamic changes with respect to urban expansion and development planning. The recently updated Development Orders recognize conservation areas as a natural resource, which must be protected. These conservation areas are normally selected as sites having natural attractions, high levels of biodiversity as well as heritage sites and parks.

Currently, the main land-use activity on Jamaican hillsides other than agriculture/subsistence farming is residential and resort development, normally around the margins of urban towns and cities. Resort development in the form of tourist villas has become increasingly popular around the tourist centres, particularly on the northern coastal areas of the island.

The Planning and Development Manual (2007) provides the only document that addresses issues relating to hillside development. Chapter 7 of the Development Manual is devoted to Rural and Hillside Development and provides information and basic requirements for addressing hillside development. Densities and lot sizes are the criteria used to control development on hillsides; however these are usually very generalized as they tend to be the same for all hillside classes. For example, the Development Manual provides guideline for minimum lot size in rural areas of approximately 1,000 m^2. This will include hillsides having a minimum slope gradient of 10 degrees (17 %) to very steep slopes of 45 degrees (100%). Developers, in maximizing on their development tend to use the minimum lot size requirement, irrespective of the slope or type of terrain of the land.

In the determination of residential densities for hillside areas, the densities are calculated based on the total land area, even though in some cases large sections of the land are not developable because that section of the property is located in a deep gully or ravine.

Based on a review of the Local planning guidelines/regulations and the absence of detailed guidelines for hillside developments, it is therefore essential that a hillside development manual be developed. This will address all hillside development issues to complement existing planning and development regulations.

2.5. Project Team/Working Group

The initial arrangement was to form a project team to include professionals from different background: architects, engineers, geologists, planners, environmentalists/environmental scientists and developers. Unfortunately, this arrangement did not materialize, as it was recognized early, that having a group together for long periods on a voluntary basis would be challenging. In discussion with NEPA it was agreed that the Mines and Geology Division (MGD) should develop the Manual with input from stakeholders and professionals during the process.

The process for the final draft of the Hillside Development:

Figure 2.1: Process flow for preparation of final draft of the Hillside Development Manual

3. SLOPE STEEPNESS

3.1. Background

A review of hillside ordinances in the United States and East Asian countries shows that many hillside communities use slope steepness to define where developments should be prohibited. The rationale for this is that, as slopes become steeper, grading and infrastructure works become more challenging and costly and the risk of slope instability increases. In addition, the amount of hillside modification, loss of aesthetic attractiveness and environmental degradation become greater.

For most ordinances and hillside regulations in the United States, a greater percentage of communities that use slope steepness as a method of control uses 18 degrees (35 % or 1:3 slope) as the maximum slope steepness. A smaller percentage of hillside regulations allow for maximum of 26 degrees (50% or 1:2 slope) as the limit. Beyond this, development is prohibited. In the far eastern territories (Malaysia, Singapore and Hong Kong) where landslides, slope stability and land degradation are the major issues, slopes exceeding 35 degrees (71 % or 1:1.4 slope) are prohibited from development. However slope classes of 25-35 degrees, although permitted for development have onerous conditions applied that inhibit most types of development.

With respect to the Jamaican situation, the factors used to define slope gradient categories and define the limit for the maximum allowable slope gradient are:

- Geological factors that promote slope failures, erosion and high sediment load

- Major challenges for construction activity and risks associated with construction on steep hillside areas (Plate 3.1)

- Lessons learnt and experience gained from the impact of planned and unplanned hillside development on the physical environment

- Relationship between the incidence of landslides and slope gradient obtained from the Mines and Geology Division's database

Plate 3.1: Example of poor hillside construction practice

3.2. Guidelines

(i) Hillside development shall be permitted on slopes up to 30 degrees (58 % slope). Developments may however be allowed in areas in excess of 30 degrees under extraordinary circumstances subject to special conditions. These conditions will include, but not limited to the following:

Non-residential type development such as electrical towers/power transmission lines; zip liners, conveyor belts, cellular towers, trails (bike and walking), environmental parks, public roads, water-mains, mining activity among others.

(ii) Development on hillside within all slope classes will only be permitted where the slope is stable. Existing landslide susceptibility/hazard maps should be used where available to assist in this process.

(iii) Hillsides with the potential for landslides, erosion and debris floods shall have limiting conditions applied for permission to be granted. In such cases, slope gradients, particularly those in excess of 26 degrees (50% or 1:2 slope) shall have extraordinary provisions that would allow developments to proceed with minimal disturbance. Engineering geology/geotechnical study shall be a pre-requisite for these developments.

(iv) Where vehicular access to a hillside property becomes problematic due to steep slopes or deep, vertical cuts (>5m) from main access road, developments may not be permitted if access cannot be provided or clearly demonstrated that this can occur without great difficulty.

(v) Guidelines for development in this manual are classed into slope categories for hillside development. These are shown in Table 3.1.

Table 3.1: Slope Gradient Categories and Development Issues

CLASS	SLOPE CATEGORY	SLOPE GRADIENT		*ISSUES TO BE CONSIDERED FOR HILLSIDE DEVELOPMENT*
		Degree	%	
Not Hillside Area	Gently Sloping	0 - 9	1-16	***These are slopes that are not considered as hillside slopes as they do not normally have the problems typical of hillside areas. Developments should proceed as guided by existing regulations.***
1	Moderately Sloping	10 - 17	17- 31	***Slopes begin to create challenges for development. Grading begins to become difficult as roads and building site will require cut and fill. Roads will be designed along contours or diagonally across slopes. The risk of slope failures and excessive erosion and debris flood intensifies at this gradient. Development is permitted, however some study may be required where problematic rocks/soils dominate the slope. Erosion and slope protection measures are considerations particular at the upper end of this slope category.***
2	Steeply Sloping	18 - 25	32-48	***Steepness of cut and fill slopes tend to exceed natural slopes. Slope steepness is critical in this slope range. Grading will result in large cuts and deep fill, requiring the use of earth retaining structure to prevent slope failures and erosion problems. Rock falls near to fault scarps on hillsides begin to be a cause for concern. Development is permitted for all hillside areas except on active or reactivated hillside slopes (slopes that show signs of continuous movement or where movement occurs during rainy seasons) or colluvial soil which have demonstrated to be poor geological material for engineering purposes. Special attention to hillsides which may have average slopes within this category, but have sudden or sharp topographic changes. Geological/geohazard studies recommended for large developments (>60 lots). Impact of geological fault as well as access (ingress/egress) to lots will also be important considerations. Drainage designs on rock slopes consisting of loose and erodible material will be***

				vigorously reviewed due to potential problems of erosion and flooding. Slope stability problems increases in this slope range.
3	Steep – very steeply sloping	26 - 30	49-58	***Within this slope range, grading and construction problems become extremely difficult. Slope instability becomes critical and fault scarps become more dominant on geological fault slopes. While development is permissible, it is highly restricted in this slope range. Developments will be limited to very low densities, minimal grading, and very stable rock slopes. Hillsides consisting of geological formations with history of slope instability will be prohibited. Only limited grading will be allowed in this zone. A detailed engineering geology/geotechnical report must accompany such developments for consideration. Most hillside regulations do not permit developments in this zone.***
4	***Very steep-near vertical slopes***	*>30*	*>58*	***Permission will not be granted for developments on hillsides exceeding 30^0 (58) slopes, except under extraordinary circumstances. Costs become prohibitive, grading destructive to natural slopes and exceeding the limit of grading requirements. These are normally areas that dominate upper watersheds and hillside gullies and fault scarps.***

A schematic representation of slope categories used in this manual is shown in Figure 3.1. A graphical representation of the different levels of slope steepness based on slope gradients in percentages and degrees is given in Figure 3.2.

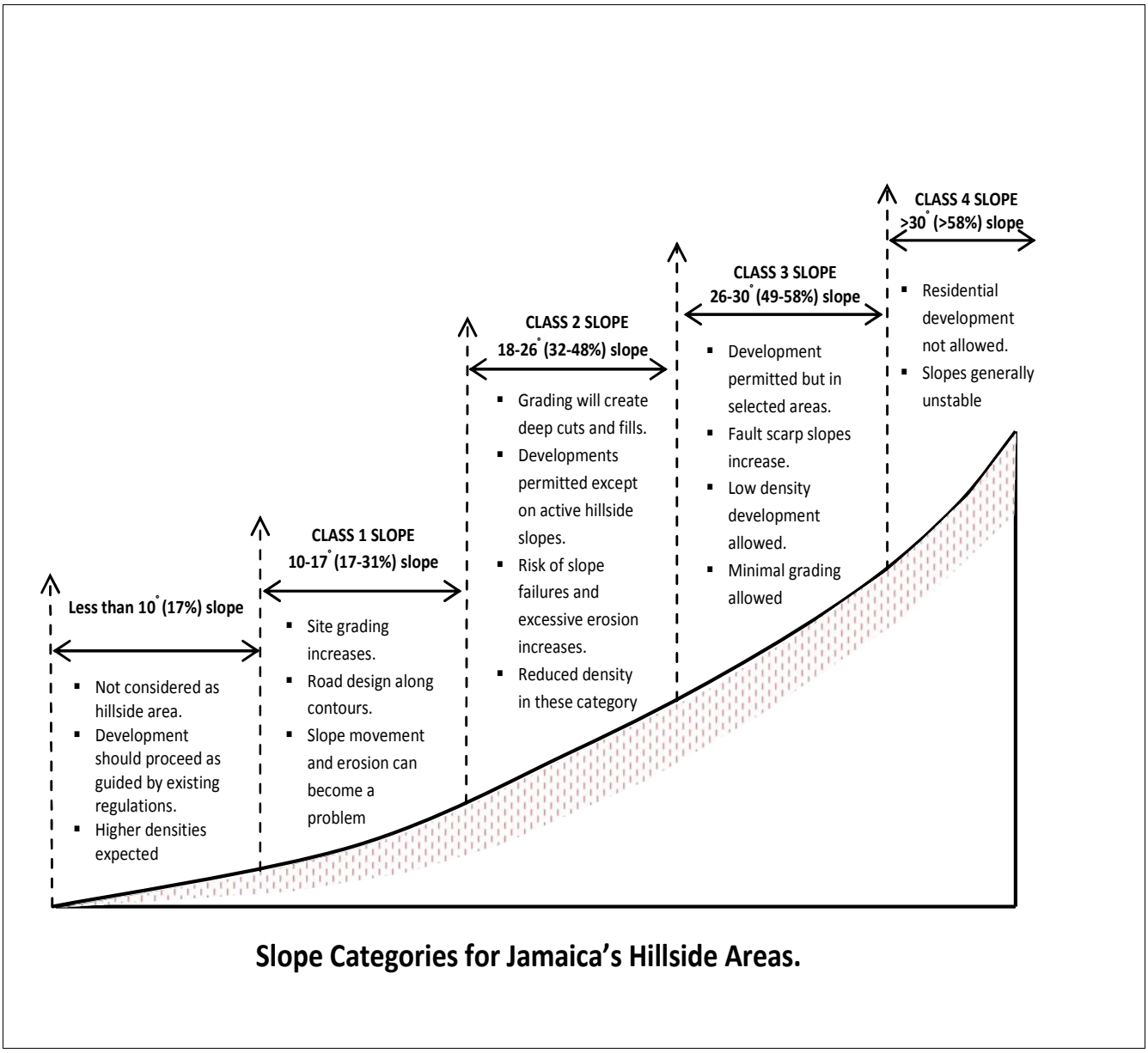


Figure 3.1: Schematic Representation of Slope Categories Source: Adapted for Hillside (Source: Adapted from Hillside Ordinances and Regulations for Brekenridge, Carlsbad, California)

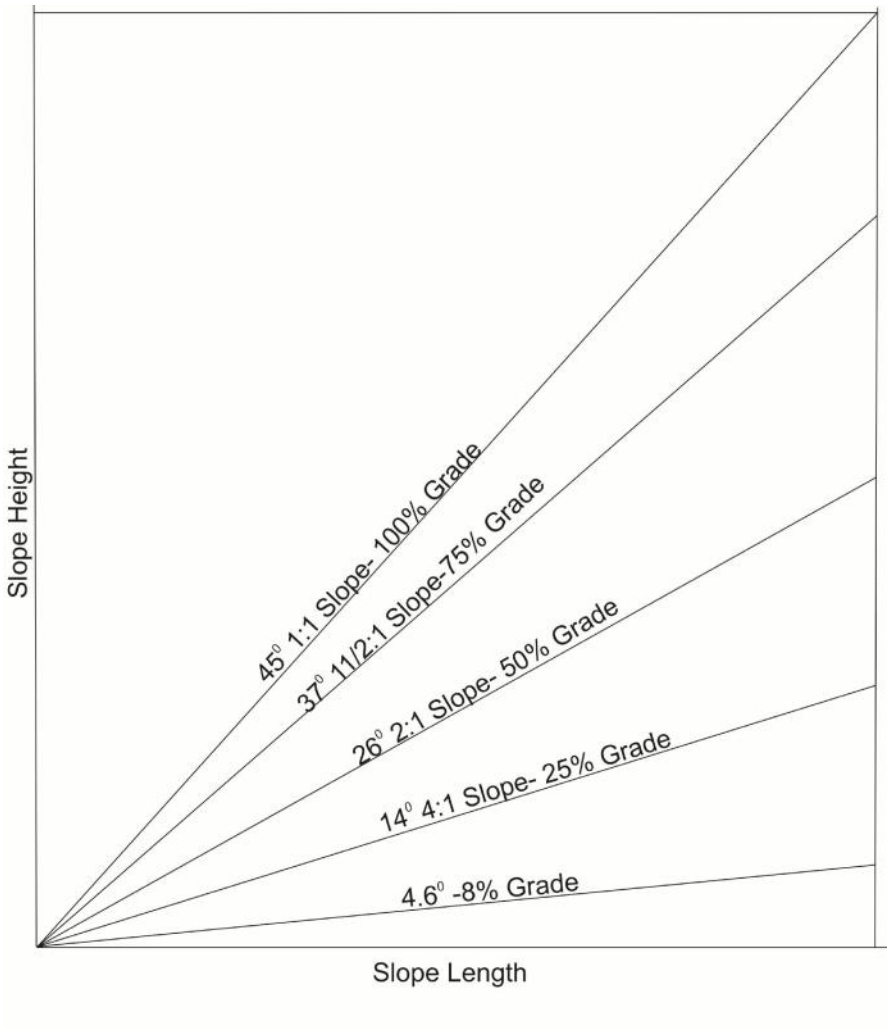


Figure 3.2: Graphical representation of slope gradients in percentage and degrees

4. SLOPE STABILITY

4.1. Background

Safety is one of the critical issues that must be taken into account for developments on hillsides. Slope failures tend to occur on moderate to steep slopes and are to some extent dependent on geological factors that are impacting the slopes. The incidence of landslides, accelerated erosion and downstream flooding increases with steeper slopes. Steep slopes are usually in a state of equilibrium and disturbance of the hillsides for development often creates instability leading to slope movement (Figure 4.1 and Figure 4.2).

Rock falls in areas that are affected by geological faults have increasingly become a problem (Figure 4.3). These can be destructive and result in serious injury or loss of property. Some types of hillside areas, because of their geological and drainage characteristics, following intense rainfall have a greater incidence of debris flows down existing channels resulting in damage to properties at the foot of the slope (Figure. 4.4).

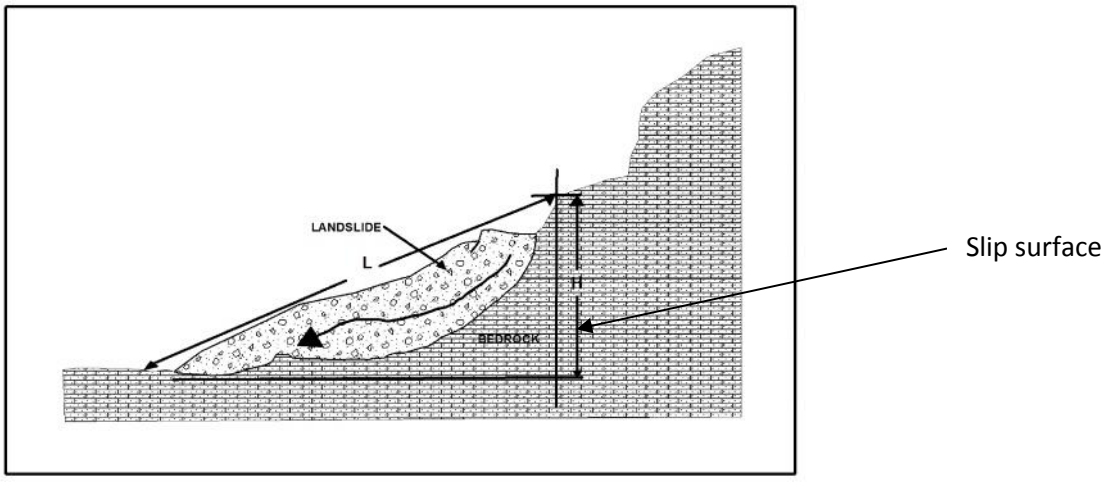


Figure 4.1: An example of rotational slope failure that occurs on Jamaica's unstable hillsides. (Source: Landslides; Investigation and Mitigation, Special Report 247)

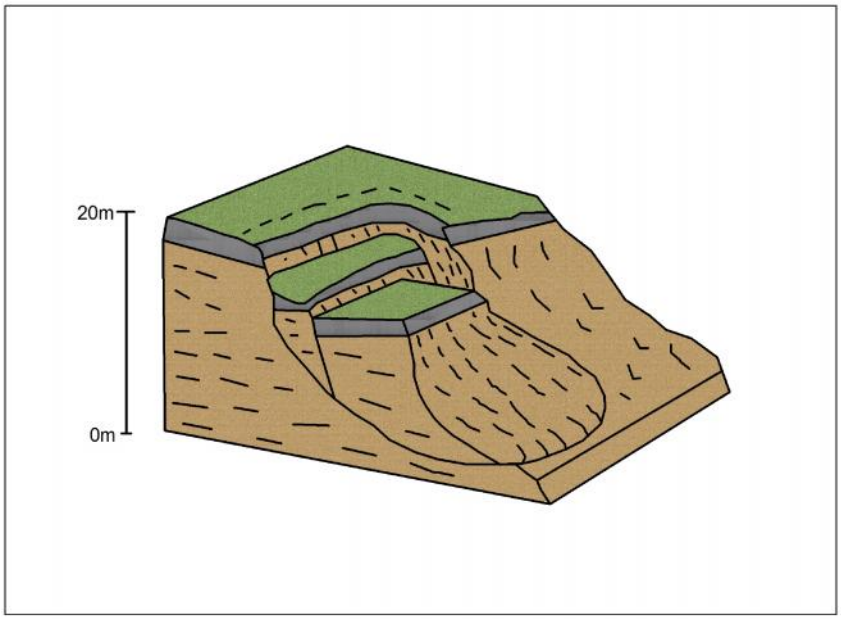


Figure 4.2: Second example of a rotational failure.

(Source: Landslides; Investigation and Mitigation, Special Report 247)

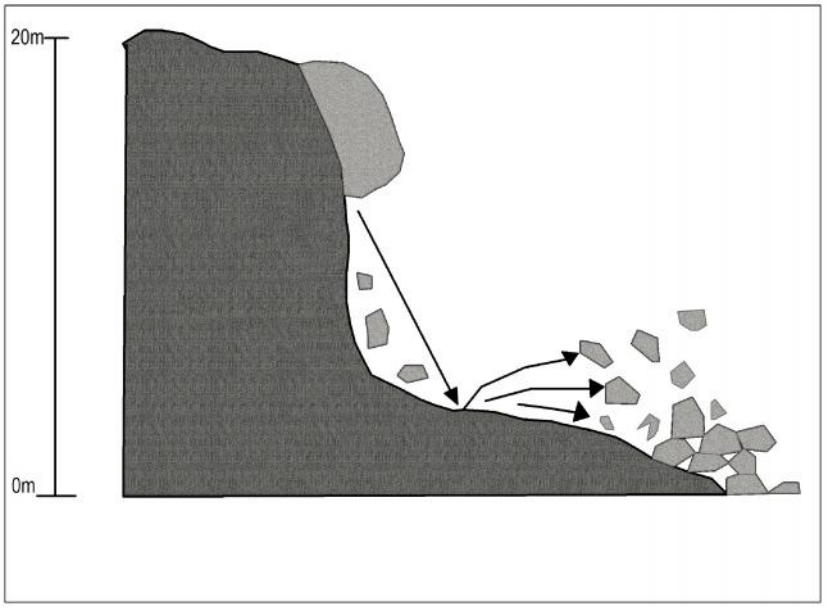


Figure 4.3: Example of rock falls, a common feature on scarp slopes.

(Source: Landslides; Investigation and Mitigation, Special Report 247)

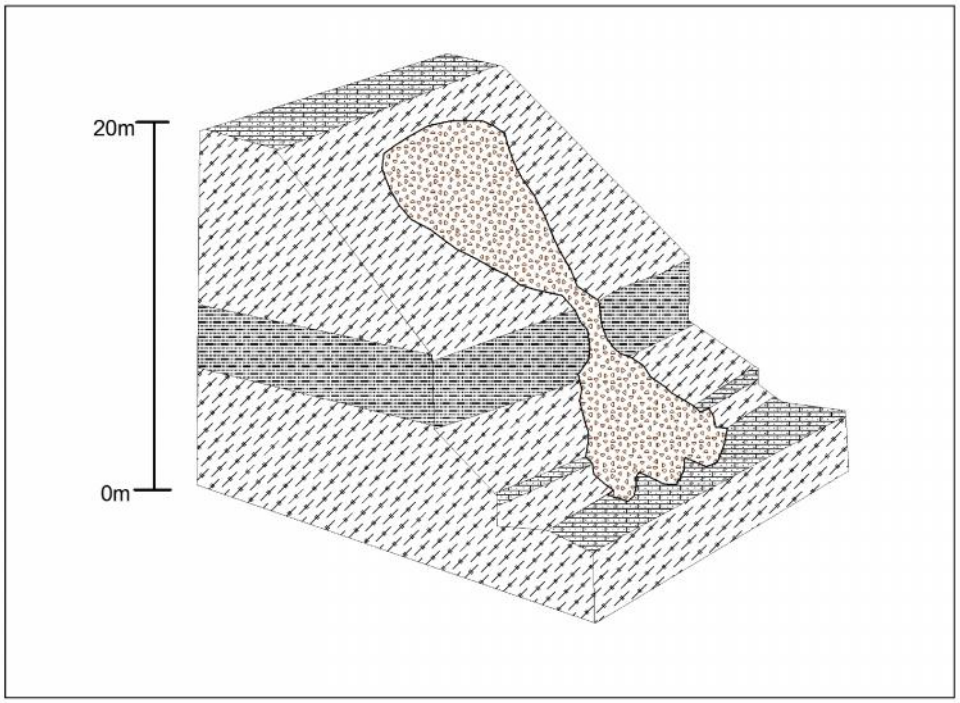


Figure 4.4: Example of debris flow that occurs in river/gully channels in steep hillside areas. (Source: Landslides; Investigation and Mitigation: Special Report 247)

4.2. Landslide Susceptibility (Hazard) Maps

Landslide hazard maps at a scale of 1:50,000 are now available for a number of parishes in Jamaica. These maps are useful tools that can assist developers, engineers and other professionals in determining the level of landslide hazards for a particular area of interest. This aids in the planning and design of their development. These maps, where they are available, are recommended to be used in conjunction with hillside regulations (Appendix 1).

4.3. Guidelines

i. No development shall be permitted on slopes that are in an active state (persistent or continuous slope movement) or has a known history of landslides and slope failures.

ii. Developments in high landslide prone areas should be avoided

iii. Developments may be permitted on Colluvium (old landslide deposits) only under special circumstances:
    a. On slopes not exceeding 18 degrees (34% or 1:3 slope)
    b. Detailed geotechnical investigation is conducted on the site
    c. Special engineering features are designed for structural safety, which must be approved by the relevant Authority

iv. Hillside construction (including roads) above existing developments on slopes containing loose rocks (boulders, cobblestones and so on.) which may become mobilized shall be removed or, have earth retaining structures, berms or other suitable barriers erected before construction work commences. This is to ensure that material is kept within the boundary of the site and to improve public safety (Plate 4.1).

v. Where engineering considerations become prohibitive for the control of rock falls on unstable slopes and is a direct threat to public safety, permission shall not be granted for these developments.

vi. Hillsides, which are to be excavated as part of the development exercise, shall have slope stabilization measures employed where the hillsides are potentially unstable. This is required in order to improve stability of the area.

vii. Height of retaining walls/structures taken from ground level or the base of the cut should not exceed 4 metres unless otherwise approved by the Authority (Plate 4.2). Where this height is exceeded, the following conditions should apply for approval to be considered:

a. The earth retaining structure protects the excavated cut for the main roadway

b. It supports the excavated cut and/or fill on the down slope end of the property and is not visible from the main road or arterial road

c. Demonstrates aesthetic designs that will allow for 'greening' of the earth retaining structure to minimize visual intrusion

d. Earth retaining structure exceeding 2.5 metres in height should be designed by a qualified engineer and in accordance with the revised version of the International Building Code (IBC) for Jamaica

viii. Landslide hazard (susceptibility) maps shall be used where available to assist with the planning and design of hillside developments

ix. A geo-hazard or geotechnical analysis, while not mandatory, may be required as part of the condition of approval where there is the risk of slope movement.

Plate 4.1: Loose boulders located on slopes are susceptible to rock falls from severe rainfall or earthquake events. These must be removed during site preparation.

Plate 4.2: Height of this retaining wall is approximately 12m (39.4ft) and is used to support deep fill. This is not recommended. Stepped retaining wall is normally the preferred option.

5. SITE GRADING (CUT AND FILL)

5.1. Background

Developments on hillside slopes will involve excavation cuts and fills to prepare the site for building construction (Figure 5.1). The steeper the hillside, the more extensive will be the cut and fill operation. Many hillsides are at, or near equilibrium and if disturbed by cutting into slopes will result in slope failures, erosion problems and other unstable conditions. Where a hillside is extensively graded for development purposes during the two rainy seasons (May-June and October - November), it contributes significantly to high sediment load into gullies and other off-site areas resulting in blockage of drains and eventually leading to flooding.

There are a number of jurisdictions which uses site grading regulations and codes as the main tool for controlling hillsides without considering the use of slope gradient as a limiting factor. Where this is practiced, a system of mandatory grading permits, inspection and certification is required before approval can be granted. These regulations and codes also form part of the building code for the area.

There are currently no guidelines/regulations that address site grading for hillside areas in Jamaica and the current practice is to provide grading profiles only for roads in some subdivision developments. Building applications on steep hillsides, for example have been devoid of proper grading plans and this makes the applications difficult or impossible to assess. With the rapid increase in hillside development, it becomes necessary to have grading plans for building applications as a specific requirement. In addition, subdivision applications that are planned as ‘design and build’ (town house developments or duplex and for subdivisions where the developer intends to build houses on all or some portion of the lots) shall have grading plans included as part of the development approval process. For the purpose of this manual, mandatory grading permits are not required at this time for hillside development.

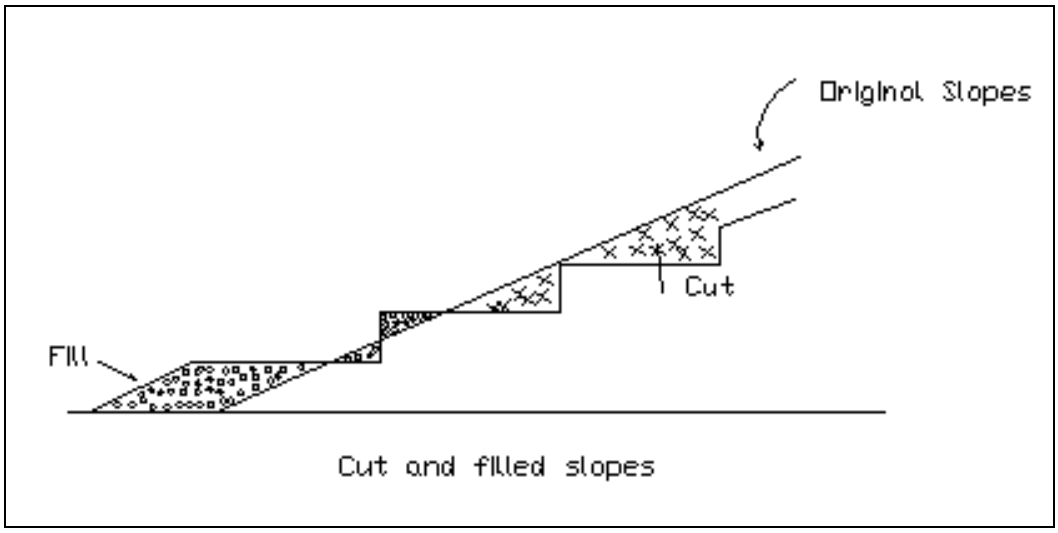


Figure 5.1: Example of cut and fill slopes for hillsides recommended as part of good hillside development practices.

5.2. Guidelines

i. Excavated cuts shall not be permitted on slopes steeper than 30 degrees (58% slope), except under special circumstances, as approved by the Authority. For any consideration under 'special circumstances', the applicant must demonstrate to the Authority that cuts into slopes exceeding the 30 degrees (58 % slope) limit will improve the stability of the slope and enhance the safety of the development. *This provision is limited to areas outside of the building floor space and on slopes not exceeding 35 degrees (70% slope)*

ii. Fills shall not be permitted on natural slopes in excess of 30 degrees (58% slope), except under special circumstances, as approved by the Authority. This however may be considered where there is the need for fill to be used for landscaping purposes. For any consideration under 'special circumstances', the applicant must demonstrate to the Authority that fills on slopes exceeding the 30 degrees (58 % slope) limit will improve the stability of the slope and enhance the safety of the development. *This provision is limited*

to areas outside of the building floor space and on slopes not exceeding 35 degrees (70% slope)

iii. For larger hillside developments {>60 lots or 1 hectares (2.5 acres) and for multi-family developments}, grading shall be phased so as to encourage rapid re-vegetation, or it may be necessary to conduct earthwork construction or other measures to minimize erosion and movement of sediments

iv. Hillside lands or subdivisions that are for 'design and build', the applicant shall submit to the Authority grading plans, which must include the requirements set out in Section 11.5 of this manual

v. In submitting a building application for hillside development, a grading plan shall be prepared to include the original and final grade of all natural features and man-made structures (See Section 11.5 and Appendix 2)

vi. Deep cuts (> 4metres) shall not be made below the main road or main thoroughfare to cause the road to become unstable. Deep cuts made below the main road and parallel to the roadway shall not be less than 10 metres from the nearest road boundary. As a rule, the setback from the main road boundary should be 2.5 times greater than the depth of cut

vii. Excavated cuts shall not compromise the stability of main roads or main access ways. Where deep cuts are unavoidable, particularly in geological material of poor quality, they should be braced or protected during construction in accordance with best practices and all storm water diverted away from the cut

viii. The natural topography/grade of the slope shall be maintained as best as possible by limiting cut and fill. Techniques such as split-level or stepped foundations or pole foundations may be used to achieve this

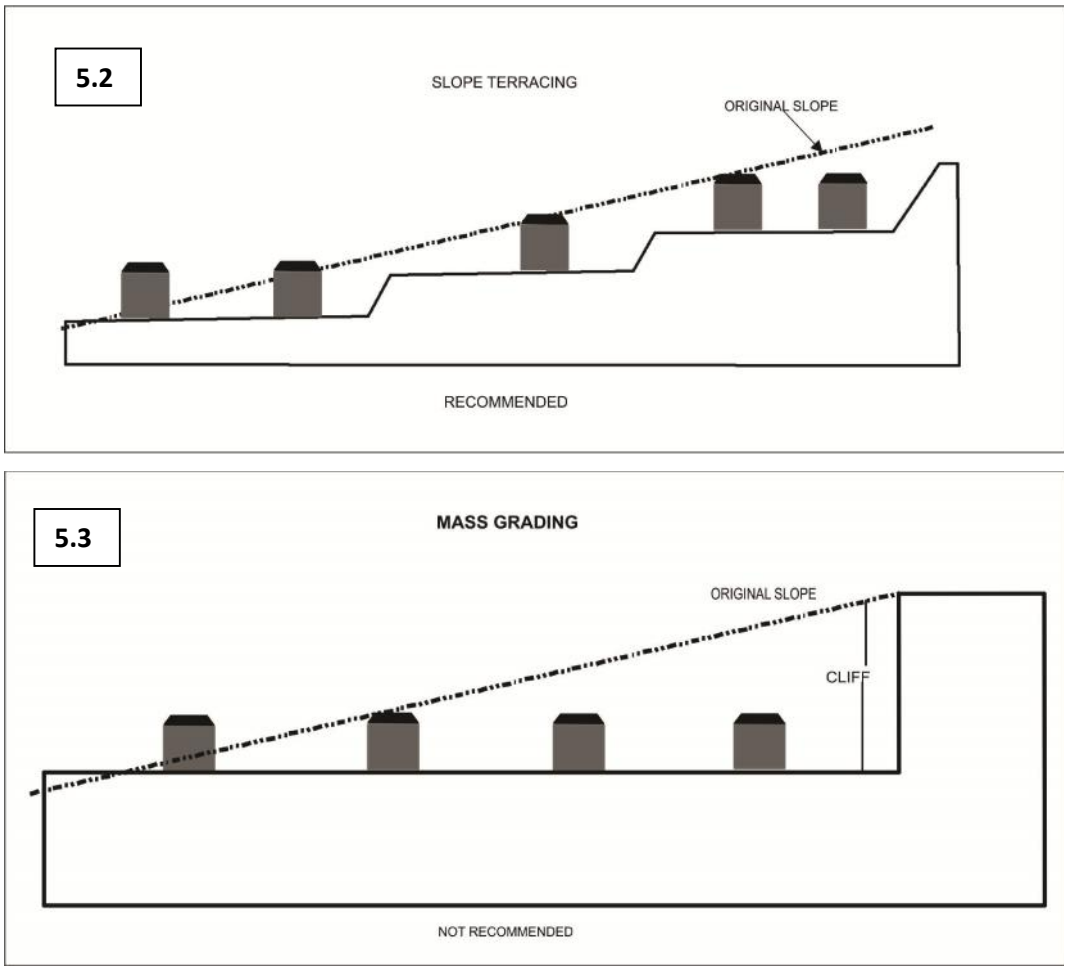
ix. 'Leveling' of land for development extended over the entire plot of land by grading shall be avoided (Figures 5.2 and 5.3)

x. Significant mass grading (extensive cut and fill) shall be avoided. As a guide, site grading as a percentage of developable land/lot is recommended under conditions set out in Table 5.1

xi. Where excavated materials are to be used for future on-site use, these should be properly stored, protected and stockpiled. Material from grading activities must be maintained within the boundary of the site

xii. Where excess material is generated and is to be removed for off-site purposes, a license to dispose of the material is required from the Mines and Geology Division

xiii. Grading, especially for large tracts of land for development shall be encouraged outside of the two rainy seasons that is May - June and October - November. Where this is unavoidable, additional measures for the control of erosion and movement of sediments will be required to prevent material from leaving the construction site and prevent flooding. Silt fences and sediment basins are examples of sediment control measures for such purposes.



Figures 5.2 and 5.3: 5.2 - recommended as the preferred option for site grading.
5.3 – example of mass grading which is not recommended.

Table 5.1: Proposed Percentage of Site Grading (Cut and Fill) Recommended on Individual Lot for Different Slope Categories

Slope Class	Slope Category	Slope Gradient		Maximum % Grading to Individual Lot or Land
		Degree	%	
1	Moderately sloping	10-17	17-31	40
2	Steeply sloping	18-25	32-48	30
3	Steep – very steeply sloping	26-30	49-58	20
4	Very steep – near vertical slopes	>30	>58	Development not permitted

6. HILLSIDE EROSION AND SEDIMENT CONTROL

6.1. Background

Erosion is a typical feature in hillside areas, particularly in upper watersheds. Erosion of land, if uncontrolled can result in debris flows and floods, landslides, scouring of hillside land and damage to road infrastructure. The velocity of storm water increases as slopes become steeper and is susceptible to erosion. Communities on the banks of rivers and streams are also vulnerable to property damage and in severe cases, loss of lives.

The physical properties of rocks and soils vary from location to location depending on factors prevailing on the hillsides. Hillsides will therefore display different levels of vulnerability to erosion based on:

- Geology (rock type, weathering characteristics and geological faults/fractures)
- Vegetation cover
- Land use
- Intensity and magnitude of rainfall
- Slope aspect and geometry

On some hillside areas, high surface runoff occurs where there is little infiltration of water. Where rocks are weak (highly weathered and fractured or weakly cemented), they are easily eroded, contributing to heavy sedimentation into stream flows. This sometimes results in the blockage of hydraulic structures and drainage ways, leading to flooding.

Maintaining vegetation cover on hillside, particularly during the construction process is an effective way of controlling erosion. Phasing of grading activities and minimizing the disturbance of land contributes to effective erosion control and management of sloping areas. In hillside

areas where erosion cannot be effectively controlled by vegetation of the slopes, structural erosion control measures will need to be employed to provide adequate protection. These may include but not be limited to: gabions, graded terraces, check dams, rip-rap among other methods.

Sediment control measures involve the trapping of detached soil particles and rock material that are transported and deposited on site or off site to prevent damage. This will include structures such as sediment control basins, check dams, sediment/silt traps and other similar devices, to arrest the movement of sediments.

The following are Non-Structural and Structural Guidelines for development of erosion and sediment control.

6.2. Guidelines for Erosion Control – Nonstructural

i. Removal of vegetation should only be done for areas on the hillside that are to be used for construction

ii. Natural vegetation must be preserved on steep slopes, near perennial or intermittent streams within a development site

iii. Where appropriate, streamline buffer strips (riparian buffer zones) should be created or maintained in order to filter sediments from surface runoff from entering stream flow and preventing erosion along banks of rivers, streams and gullies (Figure 6.1)

iv. Construction equipment and vehicles should be excluded from designated no disturbance areas to preserve natural vegetation

v. All graded or disturbed areas on hillsides shall be protected during clearing and construction until they are permanently stabilized

vi. Where appropriate, permanent vegetation cover should be established on graded slopes, unprotected fills and cleared areas in order to stabilize the soil. This must be done to prevent soil erosion and improve aesthetics on the site.

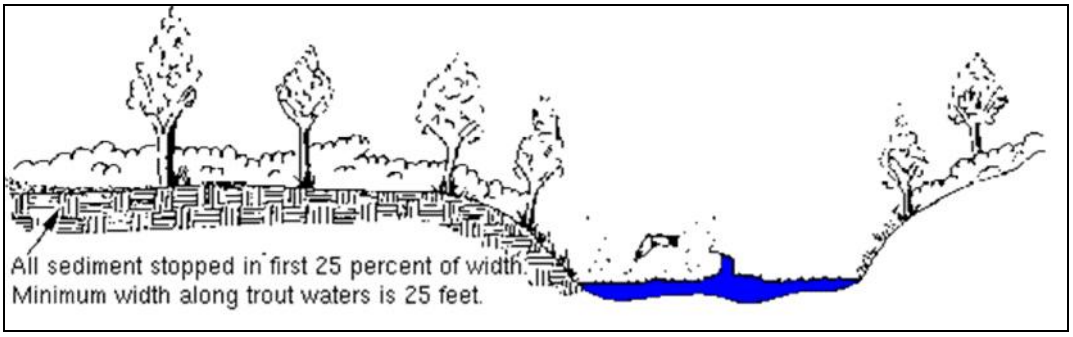


Figure 6.1: Streamline buffer zones to reduce erosion along gully/river banks

6.3. Guidelines for Erosion and Surface Protection – Structural

(i) Gabions, riprap, erosion control mats/blankets, reno mattresses, among others are to be used in areas for surface channel and river bank protection, which are subjected to very high erosive forces (Plates 6.1 and 6.2)

(ii) Gully/stream channel outlets shall have special protection from scouring where high velocity, high flow discharge exerts high erosive forces. These will require special protection devices such as riprap, gabions, erosion control mats or blankets, reno mattresses, among others

(iii) Where applicable, gradient terraces shall be constructed with suitable spaces to intercept and reduce rapid surface runoff and channeled to a stable outlet at low rates

of velocity. These however, should not be installed in deep stony or sandy soils, weak or highly erodible rock, or in uncompacted fill.

Plate 6.1: Gabion baskets as a method for slope and erosion protection for roadway in Buff Bay Valley, Portland

Plate 6.2: Example of erosion control mats to protect hillsides from erosion

6.4. Sediment Capture and Retention

i. During construction, all sediments shall be captured on site using sediment control structures such as berms, silt fences or other devices that will prevent sediments from entering off-site areas (Plates 6.3 and 6.4)

ii. Sediment capture and control shall be carried out in disturbed areas of steep slopes comprised of deep stony soils or weak and highly erodible rock. These may include but not limited to catch basins, siltation ponds/sediment control basins or other devices that provide effective methods for sediment capture and retention

iii. Waterways (gullies, streams) with high flow discharge rates, which drain steep hillsides and are bordered by, or drain within areas to be disturbed for construction purposes shall be provided with sediment control structures such as check dams, sediment/siltation basins, catch basins, reno mattresses or other devices for trapping and retaining sediments (Plate 6.5)

iv. As a temporary measure, a storm drain inlet protection or sediment barrier shall be constructed around a storm drainage system to prevent sediment laden runoff from entering the storm drain during construction activities

v. In the calculation of storm water flow discharge for the design of hydraulic structures for hillside development, the physical characteristics of the drainage system and estimation/calculation of sediment load shall be included in the analysis to aid in the design of sediment control and retention structures.

Plate 6.3: Silt Fence for sediment control

Plate 6.4: Example of silt fence to prevent sediments from leaving the site

Source: Harrison Packaging Ltd

Plate 6.5: Reno Mattresses and Gabions used for erosion and sediment control.

Source: IWT Carboguard

7. HYDROLOGY AND SURFACE DRAINAGE

7.1. Background

Surface drainage on hillsides is normally more sensitive to development practices than flat or gently sloping areas. Uncontrolled surface runoff on hillsides leads to increased erosion, blockage of hydraulic structures, and increased flooding in downstream areas. The geological material on the slope will determine the extent of runoff or surface drainage to be expected based on the level of rock/soil permeability. For example, areas in the White Limestone Group, which covers a large section of the island has high secondary permeability due mainly to faults, fractures, solution features, sinkholes and fissures, therefore surface drainage is mainly minimal to non-existent in these areas. In clay soils and clay-rich rocks (igneous and sedimentary rocks), permeability is low and runoff increases as a result of the very low capacity of the rock/soil to allow for infiltration.

An understanding of the discharge rate of runoff during pre and post development is necessary for the determination of storm water drainage control measures and the type of drainage/hydraulic designs to minimize erosion and flooding. It should be appreciated that developments on hillsides will create higher levels of storm discharge because of an increase in impermeable areas such as roadways, roofs of houses, driveways, sidewalks, among others, which will have higher velocity flows on hillside areas. In developing hillsides, the most appropriate methods should be used to minimize impermeable areas, maintain natural vegetation cover and provide measures to capture and control flows to reduce storm water velocity, erosion and flooding.

7.2. Guidelines

i. Natural areas and vegetation shall be conserved and protected. Native trees shall be protected and areas identified for replanting of drought resistant trees and shrubs where necessary

ii. Developments shall be sufficiently set back from natural and artificial waterways such as rivers and streams, gullies, earth drains and canals. This should be done in accordance with the setback requirements stipulated by the relevant Authority

iii. Walkways, trails, parking lots and low traffic areas shall be constructed with permeable surfaces (turf block, unit pavers or pervious concrete) to improve infiltration and reduce runoff

iv. Design of vegetated or green roofs shall be considered as a means of minimizing roof run-off. Added benefits include reduced heating (lower temperatures) and improved water and air quality

v. Where possible, runoff from roofs and impervious areas on site shall be captured and dispersed to adjacent designated areas (vegetation buffers, sinkholes, depressions, soak-away etc.) where it will not negatively affect other activities

vi. Detention areas such as catch basins, soak-away pits shall be constructed on hillside areas to reduce storm water run-off. Where possible, these can be conveyed to landscaped on-site or off-site areas

vii. Existing natural drains shall be maintained in its natural state as much as possible and be left unhindered – that is not altered or buried, but left open and free flowing

viii. Where required, interceptor drains shall be established above steep slopes in such a manner, so as not to saturate or erode soil. The intercepted water shall be conveyed in an approved manner to a storm drainage system or retention area

ix. Natural flow of surface water shall not be altered or obstructed by grade changes or other means that may adversely affect another property by either contributing to pooling of water or intensify surface runoff to negatively impact another property

x. Development sites containing drainage systems with the potential for flooding shall include in their design, drainage basins, soak-away or other flood control devices to reduce peak flow of the natural drainage

xi. Soak- away drainage on hillsides should not be located in close proximity to buildings or structures as it could change the behavior of the soil and negatively impact the structure. As a guide, the minimum distance of soak-away from a building or structure is presented in Table 7.1.

Table 7.1: Minimum recommended distance of soak away from buildings per slope class. (Source: Adopted from National Works Agency Requirement for Soak away Pits).

Slope Class	Slope Category	Slope Gradient		Min. Distance of Soak Away from Building (Metres)
		Degree	%	
1	Moderately sloping	10-17	17-31	5
2	Moderately steep slopes	18-25	32-48	8
3	Steep slopes	26-30	49-58	10
4	Very steep to near vertical slopes	>58	>30	Development not permitted

xii. Detention ponds as a drainage control device shall not be used for storm water capture on steep hillside areas (slopes exceeding 10 degrees or 17%).

xiii. Hillside sites with a history of flooding, or which carry high sediment load during intense rainfall with the potential to cause severe damage on site and/or offsite and which will create major challenges to mitigate using structural measures shall not be permitted for development.

xiv. In the design for storm water drainage for hillside areas, post-development peak flows should not exceed pre-development flows.

8. RESIDENTIAL DENSITIES AND LOT SIZES

8.1. Residential Densities

Density is a planning concept used to regulate the magnitude of development that is allowed within a particular area. Limiting densities on hillsides is normally desirable and reasonable because of the problems slopes create for development. Slope steepness, instability, erosion problems and visual intrusion/impact are some of the issues that affect hillsides. These must be included as essential factors to address density and its application to hillside areas.

In areas that are controlled by Development Orders, density standards are applied based on the availability of social amenities, infrastructure, special considerations and physical limitations of the site. There are currently no specific requirements for hillside densities in the Development Orders particularly with respect to slope categories. However, hillside densities tend to fall within medium to low density developments ranging from 125 habitable rooms per hectare (30 habitable rooms per acre) to about 20 single family houses per hectare (3-8 single family units per acre).

8.2. Developable and Undevelopable Hillsides

Higher densities on steep slopes generally pose a number of challenges. In some instances, large sections of the slope are stripped of vegetation and the site is mass graded. This is in mast instances done in order to fit the maximum density provided under the zoning regulation for that area. In the case of multi-family developments, blocks of townhouses and apartments will require amenities such as parking lots, sewage effluent disposal facility and open spaces in accordance with the number of habitable rooms per hectare as well as spaces for access. Erosion/sediment control and slope stabilization structures are often required to improve safety of the development which increases the amount of space to be utilized for the development of hillsides. The removal of large areas of vegetation cover, extensive site grading and the

attendant increase in erosion and slope stability problems are major concerns relating to intensive development on hillsides.

Another concern relates to the current calculation of residential densities which is based on the number of habitable rooms per hectare regardless of the physical constraints (steep- sided gully banks, cliff faces among others) These landform features limit the area of the site that can be developed. In instances where the existing residential density regulations have been exploited by developers, the common practice is to extend construction into undevelopable areas, increasing the risk of slope movement, erosion and damage from storm water drainage. It is also common practice to use the undevelopable land as recreational open space and construction of parking lots and sewage facility, when in reality it creates serious challenges for development including environmental and slope stability problems. Where large parcels of land in a subdivision cannot be developed due to their physical constraints and instability, the developable area is usually 'over-densified' in order to exploit maximum zoning density requirement for the area. *It is therefore recommended that any area of land within a subdivision that is deemed undevelopable should be excluded from density calculations.*

8.3. Guidelines

i. In the determination of residential densities, only areas that are developable shall be included (Figure 8.1).

ii. Hillside land for residential density consideration shall not include: steep sided gullies, scarp slopes, unstable hillsides, cliff faces, steep slopes exceeding 30 degrees (58%).

iii. For steep hillside land, residential zoning densities shall only be considered if the developable land has been determined based on Section 8.3 (ii). In order to determine hillside zoning density, the slope category within the developable portion of the land

shall be used as the guideline for residential densities. Table 8.2 provides recommended guidelines for hillside slopes and residential densities.

iv. Hillside land that falls totally within the developable area shall have residential densities determined using the recommended guidelines in Table 8.2.

v. In general, the developable area on a hillside site shall be contiguous (boundaries are in contact and not scattered throughout the site). If the site is to be used for multi-family purposes, the size of the lot shall be a minimum of 0.8 hectares (2 acres).

vi. Hillside areas that are within the developable zone, but falls outside of the contiguous developable area shall be included as part of the total developable area only if that portion of the site is accessible and of a minimum size of 0.2 hectares (0.5 acre) for single family development and 0.8 hectares (2 acres) for multi-family development.

vii. Where the hillside is to be used for development and straddles all slope gradient categories, the average slope shall be used to determine residential zoning density.

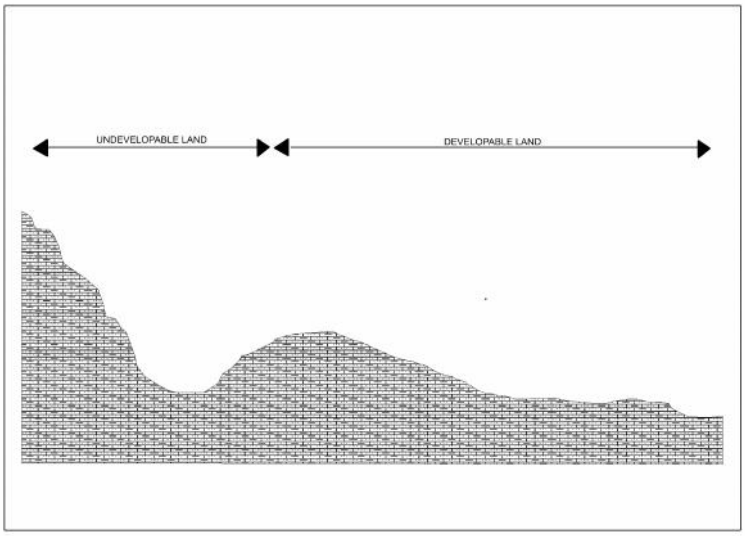


Figure 8.1: An illustration of developable and undevelopable land. Only the developable portion of the land should be used to determine residential density**.**

Table 8.1: Guidelines For Proposed Residential Densities Per Slope Gradient Category

Slope Class	Slope Category	Slope Gradient		Density	
		Degree	%	*HRPA	*HRPH
1	Moderately Sloping	10-17	17 – 31	30	70
2	Moderate – Steeply sloping	18 – 25	32 – 48	20	50
3	Steeply Sloping	26 – 30	49 – 58	Single Family Development	
4	Very Steeply Sloping	>30	>58	Development not Permitted	

***HRPA – Habitable Room per Acre**
***HRPH – Habitable Room per Hectare**

8.4. Minimum Lot Size (Single Family)

The minimum lot size requirements presented in the Planning and Development Guidelines (2007) prepared by NEPA, are classified according to residential types (apartments, townhouses, among others) and spatial setting (urban vs. rural). In the urbanized areas in Kingston & St. Andrew, residential developments of all classes can be seen not only on the flat or gentler slopes, but also in the steep hillsides in suburban areas surrounding the main urbanized areas. The character, layout and densities are somewhat controlled by subdivision regulations and building ordinances along with their zoning code. The zoning code used is normally generalized without due consideration to the varying complexities of hillside development in these areas. This observation and practice is not only for Kingston & St. Andrew, but for other urban centres in Jamaica surrounded by steep hillsides.

As a small island state, hillsides surrounding main urban centres in Jamaica do not always ascend gradually from the coastal alluvial plains but in many instances rise abruptly from the coastal alluvial areas. Many of these hillside slopes are not stable, often prone to landslides, erosion and

high velocity runoff, which contribute to flooding of urban centres. The zoning densities for these areas must be carefully applied to ensure that new developments are controlled in a manner that reduces the negative impact of natural/geological hazards, minimize environmental damage and preserves the visual character of the hillsides.

The use of minimum lot size for each slope category is viewed as an appropriate method for controlling residential densities of subdivision land based on the spatial setting (rural, suburban, urban) of the area. This ensures that the hillside area is not 'over-densified' and that construction challenges are minimized. Table 8.2 provides guidelines for minimum lot sizes and frontages for hillside subdivision development.

Table 8.2: General Guidelines for Minimum Lot Sizes, Lot Frontages and Slope Gradients for Single Family Subdivision Development

Slope Class	Slope Category	Slope Gradient		Lot Frontage (Metres)	Lot Sizes					
					Rural Towns		Sub-Urban		Rural Areas	
		Deg	%		Sq.m	Sq.ft	Sq.m	Sq.ft	Sq.m	Sq.ft
	Flat - Gently Sloping	0-9	10-16	12	550	5,914	750	8,064	1,100	11,828
1	Moderately Sloping	10- 17	17-31	17	850	9,140	1,000	10,752	1,300	13,978
2	Moderate – Steeply Sloping	18 - 25	32-48	22	1,250	13,440	1,300	13,978	1,500	16,130
3	Steeply Sloping	26 - 30	49-58	28	N/A	N/A	1,600	17,204	1,800	19,354
4	Very Steeply Sloping	>30	>58	*N/A	N/A	N/A	N/A	N/A	N/A	N/A

1 sq.ft = 0.093 sq.m.

Notes:

a. Slopes in excess of 30 degrees shall not be considered for residential development

b. Unstable or active slopes on which development is proposed shall not be used for residential purposes

c. Geological formations which are normally problematic for construction for example, shales, colluvial soils and some non- limestone rock slopes shall be excluded from Class 3 slope (steeply sloping). These may be viewed on a case by case basis.

d. Subdivision roads with circular/rectangular cul-de sacs shall have minimum lot frontages of 8 metres for class 1 slope, 10 metres for class 2 slope, and 14 metres for class 3 slope provided that the back boundary is at least 3.5 times the length of the frontage (Fig 8.2).

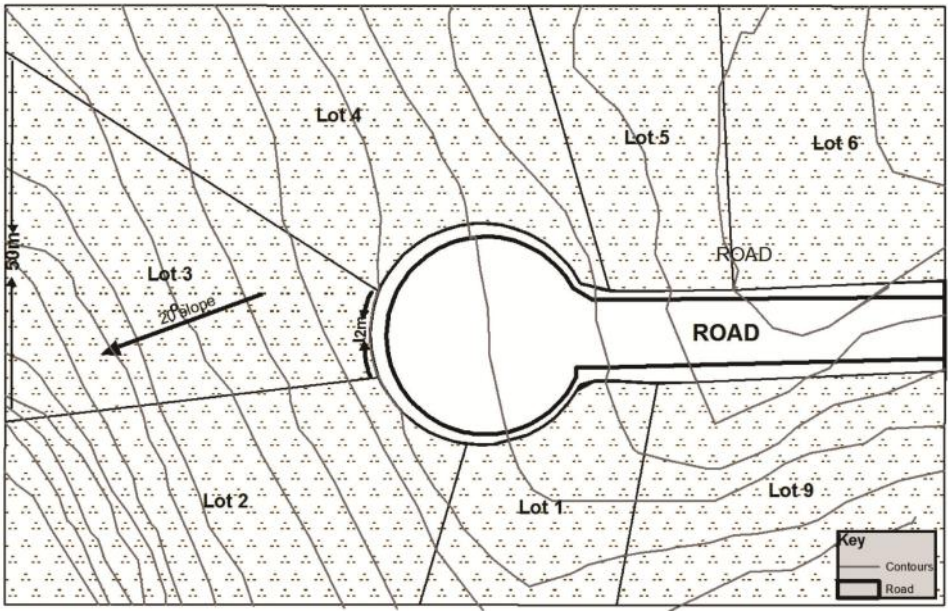


Fig 8.2: Lot frontages can be reduced at cul-de-sacs provided the back lot boundary conforms to suggested guidelines.

8.5. Minimum Lot Size (Duplexes)

Recommended guidelines for minimum lot sizes for duplexes are shown in Table 8.3

Table 8.3: Recommended Minimum Lot Size for Duplexes Per Slope Category

Slope Class	***Slope Category***	***Slope Gradient***		***Duplex (Semi-detached) sq.m.***
		Degree	%	
	Flat – Gently sloping	0-9	1-16	280
1	Moderately sloping	10-17	17-33	400
2	Moderately-Steeply sloping	18-26	34-50	650
3	Steeply Sloping	26-30	50-58	Not Recommended
4	Very Steeply Sloping	>30	>58	N/A

8.6. Residential Cluster Development

A cluster subdivision generally sites houses on smaller parcels of land so that the additional land can be used by the developer to preserve ecological and geological sensitive areas, historical sites and other unique characteristics of the subdivision. The conventional subdivision regulations for a particular zoning area would need to be redefined for this to be done. Although smaller lots are allowed, the zoning density for the particular site remains the same, except that larger open spaces are created.

Residential clustering is a planning concept, which is increasingly being used by developers, especially in developed countries to undertake development because of reduced infrastructure and site development costs, increased open space for community residents and for preserving natural features and aesthetic value.

In consultation with developers and their representatives, it is observed that there is a noticeable increase in the request to cluster development for hillside land without a clear understanding of the concept of residential clusters. The rationale for clustering by local developers often relates to existing hillside subdivisions where a parcel of land (lot) is being developed, but only a small fraction of the land is developable. In order to maximize on the zoning requirement, the small parcel of land is 'overdensified' and in many instances encroaches on undevelopable land to make the development viable. The conventional subdivision or building regulatory rules are normally applied, often leading to poor and unsafe hillside development. In cases like this, clustering within a subdivision development is not considered in the preliminary stages of planning, but after the land has been subdivided.

Residential subdivision cluster is a planning concept that will be supported by the Hillside Development Manual, but this should be done in accordance with best practices worldwide. It therefore implies that a new set of regulatory standards and guidelines should be developed by

the Authority to achieve this. This provides an alternative to conventional subdivision development as a means of encouraging good hillside development practices.

9. SPECIAL AREAS FOR HILLSIDE DEVELOPMENT

9.1. Development in Limestone Karst Terrain

9.1.1. Background

An estimated 60% to 65% of Jamaica is made up of geological formations of the White Limestone Group. This is comprised mainly of karst landforms consisting of conical hills, sinkholes, depressions, interior valleys and isolated residual hills. The limestone karst is formed from the dissolution of limestone along lines of weaknesses such as faults and fractures. Some physiographic features of limestone karst include the absence of surface drainage, due to high secondary permeability, the presence of surficial and subterranean features such as fissures, cavities, caves, caverns and other underground features.

Steep conical hills, sharp ridges and deep elongated valleys are also characteristic features of karst regions. Slopes are often steep and scarp slopes (steep vertical slopes) are common features which may become unstable and susceptible to rock falls, especially if associated with geological faults. Additionally, sharp sudden changes in elevation are not uncommon in karst areas, and this sometimes pose challenges when undertaking development. Limestone depressions also present varied geomorphic features which could pose different challenges for development. Some depressions in hillside areas are steep sided and deep, while others are gentle sloping and shallow. Some depressions may have direct opening into the underground and function primarily as recharge for aquifers, while others may be covered at the bottom with soil from natural processes.

9.1.2 Challenges in Karst Development

There is a general perception that developments in limestone areas are safer than other hillside sites because of greater slope stability due to the mechanical strength of the rock. While this is so in general terms, the areas of greatest concern relate to:

- Flooding of depressions and sinkholes,
- Collapse features or ground subsidence caused by underground cavities
- Problem of rock falls/slides near fault scarps

Developments are increasingly sited in limestone depressions and the final outfall for storm water drainage is sometimes led into sinkholes as part of the subdivision development, often resulting in blockage and eventual flooding.

In some cases, limestone cavities and depressions are buried or covered during site preparation for housing development to provide additional land for development. This invariably creates foundation problems for buildings in the medium term due to collapse of the soil (fill) above the cavities or it may cause excessive settlement in the fill if not adequately compacted (Figure 9.1 and Figure 9.2).

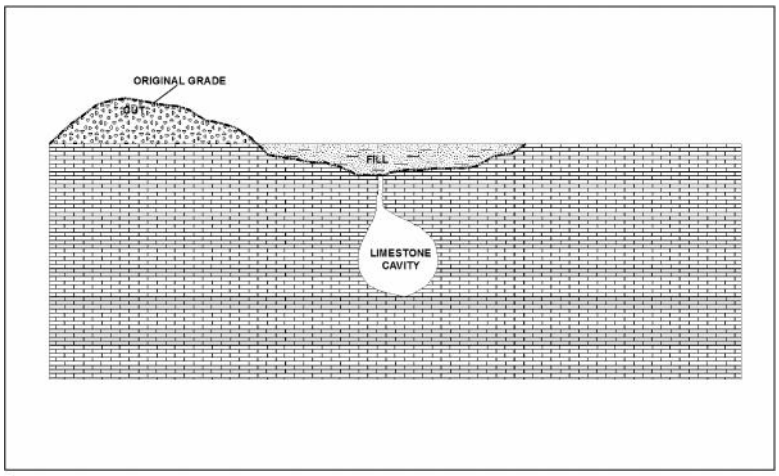


Figure 9.1: Illustration of modification in limestone karst. Fill placed in depression above limestone cavity.

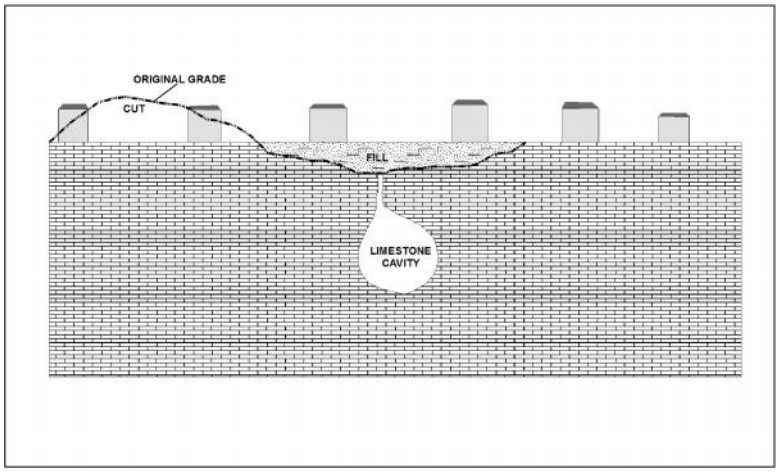


Figure 9.2: Illustration of houses constructed on cut and fill. The potential for collapse of fill into underground cavity is high.

9.1.3 Guidelines in Limestone Karst:

i. Development on karst slopes shall be subjected to the guidelines in Sections 3.2.(i); 3.2.(ii); and 3.2.(iii)

ii. Sinkholes and depressions shall be recommended to be used as final storm water outfall within a subdivision where there is more than one sinkhole on the site. The rate of

discharge and the capacity of the sinkholes must be determined to accommodate calculated runoff rates after development

iii. Depressions and sinkholes with a history of flooding or ponding shall not be used for residential purposes

iv. Any development that is partially or totally dependent on storm water discharge into depressions or sinkholes on site shall have hydrological/hydro-geological studies conducted to determine the level of flooding. The hydrological study to determine flood risk should be based on a 100-year return period for a 24-hour rainfall. The methodology for calculation must be appropriate for karst areas

v. Where appropriate, sinkholes which are to be used for storm water discharge shall be prevented from blockage using trash rack or other devices and the water treated to tertiary level before final discharge

vi. During site preparation for development, sinkholes, depressions or cavities shall not be covered or buried, but be left open. A qualified professional, for example a geologist or a geotechnical engineer should be notified to further assess the limestone cavities

vii. Vegetation around sinkholes and depressions shall be kept in its natural state

viii. All sinkholes within a subdivision shall be fenced and be protected to improve safety and security

ix. Underground features or cavities are difficult to determine from visual inspection since they are below the ground surface, unless there is a clear entrance leading to it, such as a cave or cavern

x. No development shall take place above, or in close proximity to caves or caverns unless these have been adequately explored or investigated to ensure safety of the development

xi. No development shall be permitted above caves that are national attractions and have revenue potential for the country. These areas shall be reserved for future development

xii. Development sites that are susceptible to major rock falls and slides shall not be permitted for development.

9.2. Hillside Developments on Mined-out Bauxite Lands

9.2.1. Background

The major bauxite bearing areas are in the central region of the island and are located on rocks of the White Limestone Group. After extracting the bauxite, the land must be rehabilitated in accordance with regulations covered under the Mining Act. This process is monitored by the MGD.

Subdivision applications in hillside bauxite lands are characterized by limestone hills and valleys and bauxitic soils located in depressions. The bauxite is first mined from the depressions and the pits eventually restored close to its original state. Once restored, the land is commonly used for farming and for relocation of displaced residents from bauxite operations. The restoration process requires the placement of fill in the mined-out pits using limestone aggregate and topsoil without any need for compaction (Plate 9.1). This restored land is sometimes used for the relocation of residents and is normally done under the Local Improvements Act. If used for residential purposes, subsidence or excessive settlement of buildings will be considerable if the fill is not adequately compacted leading to damage to structures.

Plate 9.1: Mined-out bauxite land being restored for development

9.2.2. Guidelines

In the development of hillside areas on reclaimed mined-out bauxite land for subdivision residential purposes, the following should be adhered to:

i. A grading plan for the site shall be submitted to the Authority, which should identify those areas on the land that have been modified by cut and fill.

ii. Construction of houses for residential and other load bearing purposes shall not be permitted on land that is not compacted, or is poorly compacted.

iii. Sinkholes which receive storm water discharge shall not be filled, but left open to facilitate storm water runoff from the site.

9.3. Restoration of Limestone Quarry for Residential Purposes

9.3.1. Background

Operation of limestone quarries in Jamaica commonly takes place on hillside slopes. Under the Quarries Control Act (1983), the land can be converted to other types of land use activity following closure of the quarry. In some instances, the limestone quarry is converted into a residential subdivision as a long term commercial activity. Unfortunately some quarries which operate in Jamaica do not follow good quarry practices, leaving behind very high quarry faces, large depressions in the quarry floor, extensively scarified faces, unstable slopes as well as changes in surface drainage patterns. To rehabilitate the quarry for a residential subdivision can sometimes be problematic for the Authorities because the restoration is not always properly, as slope faces are unstable and pits are often filled but left uncompacted.

9.3.2 Guidelines:

i. Limestone quarries to be rehabilitated for residential subdivision shall operate using best practices in accordance with the MGD's recommendations.

ii. There shall be a setback of the housing lots from quarry slope face. Setback distances will be variable depending on stability of cut slope face, height of slope face and the mechanism of slope movement on the cut face of the quarry. A rule of thumb is that setback from the quarry face should be equal to or exceed the height of the quarry face.

iii. Quarry pits shall be restored by the placement of approved fill, and compacted in accordance with the current ASTM standard.

iv. Restoration of the quarry for residential purposes shall be approved by the MGD prior to an application for residential purposes being submitted through the development approval process.

9.4. Development on Colluvium Slopes

9.4.1. Background

Colluvium is the name given to deposits of poorly sorted and unconsolidated rock and soil derived from old landslides and debris flows. They are normally brought down to its location by the action of gravity and are commonly seen on the foothill of mountain slopes and hillsides. The island, with its rugged mountain slopes, weak rocks, high magnitude and intense rainfall and earthquake hazards is predisposed to large historical landslides and slope failures. Some hillside areas in Jamaica including the eastern parishes and Kingston and St. Andrew contain large deposits of colluvium at the base of hill slopes and alluvial valleys (Plate 9.2)

Colluvial soils have unpredictable engineering behaviour due to their variable engineering properties and are difficult to work with for construction purposes. This is because colluvial deposits are prone to slope failure and erosion, with a history of slope stability and foundation problems on building structures in the suburban areas around Kingston and St. Andrew. Colluvial deposits should be avoided as much as possible. Where they are identified on hillsides within a subdivision, these sites will be limited to very low intensity development and special foundation designs in order to minimize problems of geological hazards. It is important that colluvial slopes be identified during site investigation in order that these areas are either avoided, or that under special circumstances, the most appropriate engineering solutions are used to mitigate against slope failure. The geologist/engineering geologist/geotechnical engineer should work closely with the civil/construction engineer, in developments on colluvial slopes.

Plate 9.2: Excavation in colluvial soil slope, St Andrew

9.4.2 Guidelines:

i. Colluvial slopes shall be avoided for large-scale development as these are highly unstable and prone to landslide and erosion.

ii. Developments on colluvium shall only be approved by the Authority where there is extensive geotechnical information to satisfy and convince the Authority that the development can proceed without having any negative impacts.

iii. Deep foundation shall be used for building structures on colluvial soils, unless it can otherwise be demonstrated that an alternative suitable foundation design is acceptable to the Authority.

iv. Excavated soils on colluvial slopes shall not be permitted to be used as fill for load bearing purposes. Colluvial soils shall only be used for landscaping or other non-load bearing purposes.

v. Developments that are proposed on colluvial slopes shall be supported by an engineering geology/geotechnical report, irrespective of the size of the development.

10. VISUAL IMPACT AND CHARACTER OF HILLSIDES

10.1. Background

There is now a general acceptance globally that a hillside is seen as a natural feature or resource of the environment and must be preserved. In most suburban hillsides in the United States, visual impact/character and their scenic quality are seen as a major reason for regulating hillside areas. Overdevelopment of hillsides, environmental degradation, deforestation and slope instability are all factors contributing to poor scenic quality and visual character caused by poor and unregulated hillside development practices. The visual effects of development and the importance of hills as landform that defines the landscape are now concepts that have become increasingly important in addressing issues relating to hillside development.

In addressing visual character and preferences for hillside areas, a number of factors are considered. These are:

1) *Preferred types of buildings*:
    a) High rise or vertical; low rise or horizontal; large mass or single mass structures
2) *Areas on the hillside where buildings should be located*
    a) Hilltop zones, mid slope, foothills among other locations
3) *Distribution of buildings on the hillside*
    a) Isolated single structures; clustered buildings; structures distributed evenly throughout the hillside
4) *Density of Development*
    a) High, medium, low density (Plate 1)
5) *Orientation of Buildings*

a) Buildings sited along contours (parallel to slope), buildings sited up or down the slope (perpendicular to contours) {Figs 10.1 and 10.2}.

Plate 10.1: Visual impact of natural hillside reduced due to dense hillside development

These are all considerations which help to define the visual character of a hillside along with its zoning regulations. In the Jamaican scenario, the type and configuration of the hillside largely determines how the site will be developed without giving due consideration to visual effects or scenic beauty. The Authority should now begin to consider hillside areas or regions that have unique visual charm and to have these areas identified in order to preserve their visual character.

In some jurisdictions, “Environmental Quality Districts” are created provided they are defined by special characteristics and are designated as special hillside districts as part of their city ordinances. Hillside protection and green belt reserves are also some of the provisions used within zoning requirements to preserve the natural attractiveness of hillside areas.

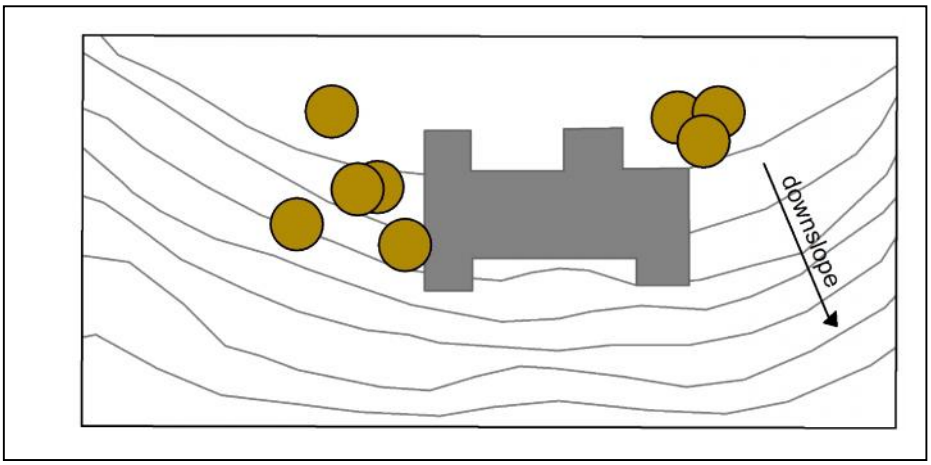


Figure 10.1 Building structure aligned parallel to contour: Recommended

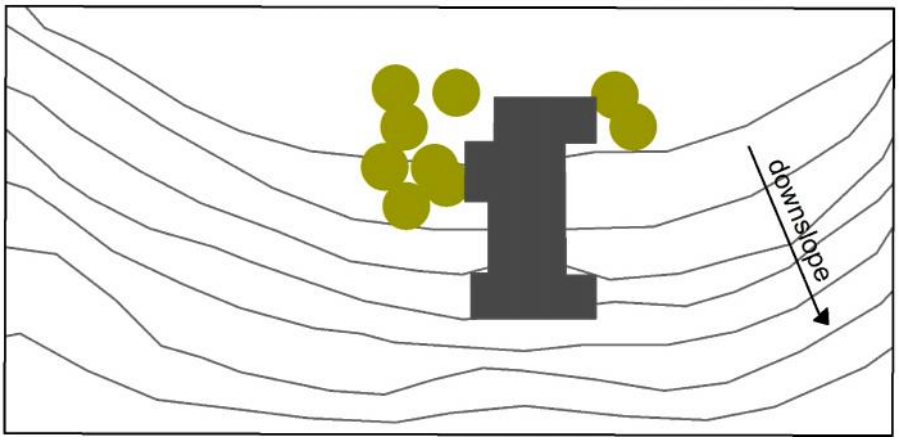


Figure 10.2: Building structure aligned perpendicular to contour: Not recommended

10.2 Guidelines

i. Developments shall be designed to blend with the natural features of the hillside and to avoid site constraints.

ii. Development projects shall attempt to maintain the natural, open space character of the hillsides.

iii. Developments shall not be designed to dominate the hillside, but rather to achieve harmony between natural and built environment

iv. Buildings shall be sited to allow for the planting of trees or for screening to minimize 'intrusiveness' of the development.

v. Natural features of the hillside should be conserved, including topography, vegetation, wildlife habitat, natural drainage, geological landmarks among other features.

vi. Buildings shall be designed to conform to the natural topography and character of the site in order to reduce bulk and mass.

vii. Architectural styles that are viewed as massive and bulky shall be avoided.

viii. Stepping of building foundations and roofs with the natural slope shall be encouraged.

ix. To protect the aesthetic quality and character of hillsides, it is recommended that qualified/professional architects are engaged for hillside development and construction projects.

11. DOCUMENTATION AND REQUIREMENTS FOR HILLSIDE DEVELOPMENTS

1) **Pre-consultation**

A pre-consultation with the Mines and Geology Division or the Development Assistance Centre (DAC) is recommended prior to formally submitting an application for development. In the absence of pre-consultation, an outline application is recommended. This is necessary to discuss with the applicant any concerns relating to the proposed development prior to submission. Additionally this will minimize costs which may have otherwise been incurred by the developer during the planning and design stage.

2) **Site Location Map**

A site location map is required as part of the submission of a development plan at a scale of 1:10,000 or 1:12,500. Remote sensing images such as Google Earth and I-map can be used to support the site location maps.

3) **Detailed Contour Plan**

A detailed contour plan shall be submitted for the site to be developed at a scale not exceeding 1:1,000 with contour intervals of 0.5 metre to 2 metres (Appendix 3). Contour intervals of 3 metres will be accepted for very large developments (>400 lots). Spot heights may be provided where deemed necessary.

4) **Slope Analysis**

A slope analysis shall be submitted for hillside sites exceeding 1 hectare (2.5acres) to be used for multi-family development. Slope analysis may be considered for smaller lots for multi- family development on a case by case basis. An example of slope analysis map is shown in Appendix 4.

5) **Grading Plan**

Grading plans shall be drawn to a scale that provides sufficient details that will indicate the nature and extent of the work proposed for the site. The grading plans shall indicate the following information:

a) *Existing elevations and finished (final) elevations to be achieved by site grading*
b) *Cross-sectional location and elevation (including dimensions) of any proposed cuts and fills*
c) *Location and details of all structures (buildings, retaining walls, erosion/sediment control structures) and any other protective works for the site. Natural features (rivers, gullies, pond etc) which may be affected or altered by grading*
d) *Contour interval should be a maximum of 1metre for building plans and 2 metres for 'design and build' subdivision developments*
e) *Setback distance of slopes and/or cuts and fills from lot boundaries*
f) *Detailed sections of stabilization measures of cut and fill slopes such as benching, terracing, earth retaining structure as well as requirements for compaction and/or treatment of fill slopes*
g) *Location of areas for slope re-vegetation*

6) **Road Gradient Profile**

Profiles and cross-section of proposed and natural grade at the centre line of the road and the proposed building setback lines shall be required.

7) **Material Disposal**:

A description shall be included of methods to be employed in disposing of soil and other material removed, including location of disposal site.

8) **Geotechnical/Engineering Geology Report**:

A detailed geotechnical report shall be prepared by a qualified geotechnical engineer or engineering geologist for large developments and sensitive sites (colluvial slopes, landslide and erosion prone areas, fault scarps and difficult terrain). The report shall include, but not be limited to:

a) A geological description of rock and soil

b) An assessment of geological hazards which may be present

c) Identification and nature of geological faults

d) Subsurface description (profile) of rock and soil on site

e) Presence of ground/perched water table

f) Slope stability analysis

g) Atterberg limit test

h) Grain Size Distribution Analysis

i) Bearing Capacity Analysis

j) Design parameters for earth retaining structure

k) Recommendation for building foundation designs

9) **Geology/Engineering Geology Statement/Report**:

A geology or engineering geology statement or report may be required for small developments (<10 lots) that are sited on hillsides vulnerable to geo-hazards. This geology/engineering geology statement or report will describe:

a) Surface geology

b) Faults

c) An assessment of slope stability

d) Erosion and sediment control assessment/analysis

e) Effect of geological conditions on the proposed development

f) Recommendations for safe development: This recommendation will determine whether further analysis (for example: geotechnical analysis) will be required.

12. GLOSSARY OF TERMS

ASTM: American Standard for Testing and Materials

Active Landslide: Landslide that is in a continuous state of motion over a long period of time.

Authority: In this Manual refers to the Town and Country Planning Authority (Town and Country Planning Act, 1957) and the Local Planning Authority (for Kingston and St Andrew - Council of the Kingston and St Andrew Corporation; for other Parishes - Parish Council of such parish). The National Environment and Planning Agency (NEPA) now provides technical and administrative support to the Town and Country Planning Authority under the Town and Country Planning Act.

Bedrock: Rock in its natural state that has been unaltered.

Berm: Low earthen barrier or wall commonly used to control erosion as well as prevent or control sediments, storm water and waste water from entering an area**.**

Boulders: Large rocks or stones normally detached from the parent rock.

Cavities: General term used to describe small or large surface/underground openings/fissures that are common in soluble rocks such as limestone or gypsum that are formed from dissolution by rainwater.

Cliff: A high wall of rock commonly formed by natural or geological processes such as geological faulting (uplift) or wave action from the sea. It can also be formed from human activity such as site grading or quarry/mining activity.

Colluvium: Deposits of poorly sorted, chaotic mass of rock, soil and debris derived from past landslides normally located at the foot of steep hillsides. Colluvial deposits are usually considered as problematic soils for engineering purposes.

Cobblestones: Technically these are small stones ranging in diameter from 73mm (3 inches) to 125mm (5 inches).

Competent Rock: Hard, compact rock not affected by major joints or fractures and not influenced by geological faults.

Cut: A portion of land surface or areas, from which the earth material has been removed or will be removed by excavation; the depth below the original ground surface or excavated surface.

Debris Flood: A very rapid surging flow of water heavily charged with debris in a steep channel.

Debris Flow: A rapid to very rapid non-plastic or viscous flow of saturated debris in a steep channel.

Deep Cut: The removal of a minimum of 4 metres depth of earth or land surface by excavation below the original ground surface or excavated surface.

Depression: An area of land that is completely surrounded by higher ground. Depressions are commonly associated with limestone areas in Jamaica.

Development: As defined in the Town and Country Planning Act is "the carrying out of building, engineering, mining or other operations in, over, or under land, or the making of any material change in use in buildings or other land."

Developable Area: Developable area in this manual refers to land that is devoid of high cliffs, unstable slopes, steep sided gullies, deep depressions and land consisting of slope gradients up to 30 degrees (58% slope).

Development Orders: The principal instrument for guiding and regulating the use of land and ensuring adherence to Government Policy**.** The Development Order allocates land for various uses such as residential, commercial, recreational, open space and other public uses as well as existing uses which it proposes to retain.

Earth Retaining Structures: Structures designed and constructed to resist the movement of soil. It is especially designed to protect unstable soil slopes, excavated cuts and earth fill.

Engineering Geology Report: Provides qualitative (detailed description of rocks and soils for engineering purposes) and quantitative description (recorded measurements of the engineering properties of rocks and soils). It also interprets and predicts the behavior of the geological environment for civil engineering applications. The report also provides assessments and analysis on geo-hazards (slope movement, debris flows, land subsidence, earthquakes etc) and its impact on civil engineering works, physical planning and disaster risk mitigation.

Environmental Degradation: The deterioration of the quality of the environment as a result of the depletion of air, water and land resources. Included in this also are the damage/ destruction to ecosystems by natural activities and climate change (flood, drought, erosion) or human activities such as construction, removal of vegetation, population growth, mining and quarrying among others.

Erosion: The general process whereby soils are detached and moved by the flow of surface water, wind, and gravity.

Erosion Control Mats: Also referred to as blankets are normally used to stabilize slopes that are being eroded by water. They are usually woven devices made from chosen material {straw, coconut fibre, polypropylene (plastics), jute} used to reduce the flow of water across a surface. It is designed with ridges and obstruction to retard the speed of water.

Excavation: Removal of soil or other materials by any means whatsoever from water or land on or beneath the surface, whether exposed or submerged.

Fill: Deposits of soil, rock or other materials by other than natural means.

Finish Grade: The final grade or elevation of the ground surface after grading is completed.

Gabions: Are structures made of large rocks or concrete encased in wire baskets normally designed and constructed in layers for use in civil engineering for river and gully bank protection, shoreline erosion protection, and road construction.

Geotechnical Report: Provides quantitative information on the engineering (mechanical) behavior of rocks and soils for engineering purposes and how an understanding of their behavior will predict the response to civil engineering and construction works and to find appropriate solutions for such works. It is the document that assists the engineer to design and implement civil engineering and construction activities.

Geological Fault: A fracture in the rock or earth's crust that shows some form of vertical or horizontal displacement.

Geo-Hazard Report: A geo-hazard report provides information on geological and natural processes that has the potential to cause damage or has caused damage to property and impact human lives in the past. Natural and geological processes include, earthquakes, landslides, debris flows, volcanic activity, land subsidence, flooding, among others.

Grade: The degree of rise or descent of a sloping surface.

Grading: Any excavating, cutting or filling, stockpiling of land or earth or combination thereof, including the conditions resulting from any of the above.

Habitable Room: Any room or space intended primarily for human occupancy other than kitchen and bathrooms, or a storeroom not exceeding 6.5 square metres in area. In hotels, it includes hotel bedrooms for guests and staff.

Hillside Area: Includes land in all zoning districts in the Municipality with an average percent slope of 10 degrees (17%) or greater.

Karst Topography: Formed from the dissolution of soluble rocks such as limestone, dolomite and gypsum. It is characterized by underground drainage systems, with sinkholes, caves and caverns. In Jamaica limestone karst is dominant in the central and north western sections of the country.

Landslide: The movement of rock, soil and debris downslope along a failure surface.

Land Restoration: In this manual it relates specifically to mined-out bauxite and quarry sites where material has been extracted, but is restored for agriculture, residential or other development purposes.

Limestone: Sedimentary rock consisting of greater than 50 percent calcium carbonate, usually white to buff colour, but can occur as pink, dusty grey or yellow in colour.

Load Bearing Soil/Ground: Any soil (natural or artificial/man-made ground) that has structural or building loads imposed on it.

Natural Ground Surface: The ground surface in its original state before any grading, excavation or filling.

Permeability: A measure of the ability of the soil or rock or any porous material to allow water/fluid to pass through it.

Re-Activated Landslide: A landslide that has failed in the past and is activated periodically, especially during the wet season.

Residential Density: The number of habitable rooms per hectare/acre and is calculated by adding all habitable rooms in a selected area and dividing by the acreage.

Residential Cluster Development: A residential cluster development is a grouping of residential properties on a development site in order to use the extra land as open space for recreation, agriculture, among others.

Reno Mattresses: Gabion-type structures with a more planar area and are small in thickness. They are filled with rocks encased in mesh and are divided into compartments. Reno mattresses are commonly used for river bank and scour protection, channel linings and for erosion control and embankment stability.

Rip-Rap: Rock or other material used to armour shorelines, stream beds, gully bank slopes, bridge abutments etc. against scour or erosion by water.

Rock Fall: The process by which rock is detached from a rock slope and falls at the bottom of the slope.

Run-Off: The part of precipitation and/or surface drainage which flows over land without filtering into the soil.

Scarp Slope: A very steep and high slope (near-vertical slope) that is normally associated with geological faults. Rock falls are the common geological hazards that occur on these slopes.

Secondary Permeability: A measure of the ability of a rock mass to allow water/ fluids to pass through openings in the rock instead of internal pore spaces (primary permeability) in the bedrock. In limestone rock for example, secondary permeability is high because of the presence of cavities, fissures, solution features and faults that provide openings on the bedrock surface that are formed from the dissolution of limestone.

Sediment Control Basins: A temporary pond built on a construction site to capture eroded or disturbed soil that is removed or eroded during heavy rainfall. It is also used to protect water quality of a nearby stream, river or lake. A sediment basin is normally used on large construction sites of 5 acres or more.

Shale: A thinly, often inter-bedded detrital sedimentary rock consisting of mudstone and siltstone. Its common characteristic is that it is fissile (splits easily along partings in the rock) and is a weak rock for civil engineering purposes. As such, engineers tend to use the term 'shale' in a generic way to describe any rock that is weak and problematic for civil engineering works.

Silt Fence: A temporary sediment control device designed and constructed to prevent sediment from entering a neighboring property and to protect water quality of nearby streams, rivers and lakes.

Sinkhole: A sinkhole is usually associated with karst limestone topography. It is a depression (area of land surrounded by higher ground), but is directly connected to the subsurface or underground by conduits or openings.

Soak-Away Pit: An underground feature or well designed and constructed to collect storm water/waste water and to allow for infiltration into the surrounding soil or ground.

Slope Stabilization: Any structural or non-structural methods for improving the stability of slopes or protecting the hillsides from slope failures.

Subdivision: Improved or unimproved land or lands divided or proposed to be divided into two or more lots, parcels, sites or other divisions of land for the purpose, whether immediate or future, of sale, lease rental, transfer of title to or interest in any or all of such parcels and shall include re-subdivision and when appropriate to the context, shall relate to the process of subdividing of the land or territory subdivided.

Weathered Rock: Rock that has gone through varying stages of physical and, or chemical decomposition.

Vegetation Buffer Zone: Referred to as riparian zone is an undeveloped area directly adjacent to a water body. Vegetation buffers are comprised of existing plants on the site or it may consist of new plantings. Its purpose is to prevent sediments from entering water bodies and to reduce erosion of stream banks and shorelines.

Zoning Regulations: Land-use planning term normally used by Local Government that seeks to direct where specific developments may take place. It is the practice of designating permitted uses of land based on mapped zones to separate one set of land-use from another.

13. BIIBLOGRAPHY

Campbell, B. (2000). *The Politics of Landslides and Building on Landslides in Colorado Springs.* Colorado Springs Independent. Retrieved from http://www.csindy.com/coloradosprings/risky-business/Content?oid=1109329

Chargin Falls Ohio. (n.d.). *Hillside Protection Regulations.* Retrieved from Chargin Falls Ohio website: http://www.balancedgrowth.ohio.gov/Portals/0/BLLUP/Toolkit/slopes1.pdf

City of Calimesa. (2014). *Chapter 18.55 HILLSIDE DEVELOPMENT REGULATIONS*. Retrieved from Codepublishing Inc. website: http://codepublishing.com/CA/Calimesa/html/calimesa18/Calimesa1855.html#18.55

City of Carlsbad. (1998). *Hillside Development and Design Guidlines.* Retrieved from http://web.carlsbadca.gov/services/departments/planning/Documents/HillsideGuidelines.pdf

City of Elko Nevada. (n.d.). *HILLSIDE DEVELOPMENT REGULATIONS AND GUIDELINES*. Retrieved from Sterling Codifiers Inc website: http://www.sterlingcodifiers.com/codebook/index.php?book_id=316

City of Folsom. (2014). *Chapter 14.33 HILLSIDE DEVELOPMENT STANDARDS*. Retrieved from Codepublishing Inc. website: http://www.codepublishing.com/CA/Folsom/html/Folsom14/Folsom1433.html

City of Kelowna. (1998). *Best Management Practices for Erosion and Sediment Control - Upland Works.* Retrieved from http://www.kelowna.ca/CityPage/Docs/PDFs/%5CEnvironment%20Division%5C5CWatershed%20Health/Erosion%20%26%20Sediment%20Control--Upland%20Works.pdf

City of Petaluma . (n.d.). *Chapter 16 Hillside Protection.* Retrieved from City of Petaluma website: http://cityofpetaluma.net/cdd/pdf/izo/chapter16-hillside-protection.pdf

Coch, N. K. (1995). *Geohazards: Natural and human*. Englewood Cliffs, N.J: Prentice Hall.

Coquitlam (2005). *Guide to Best Site Development Practices*, (Formerly Hillside Development Standards & Guidelines)

County of San Diego. (n.d.). *Policy I-73 Hillside Development Policy.* Retrieved from County of San Diego website: http://www.sdcounty.ca.gov/cob/docs/policy/I-73.pdf

Elmore County. (2009). *Elmore County Amended Zoning and Development Ordinance.* Retrieved from Elmorecounty.org: http://www.elmorecounty.org/Land%20Use/PDFs/Z&D%20Ordinance%202012-09-19/Chapter%2014%20Areas%20of%20Critical%20Concern%20and%20Hillside%20Development.pdf

Erosion and Sediment Control Best Management Practices
http://www.dep.wv.gov/WWE/Programs/stormwater/csw/Pages/ESC_BMP.aspx

Georgia Department of Community Affairs. (n.d.). *HILLSIDE AND RIDGELINE PROTECTION* . Retrieved from Georgia Department of Community Affairs website: http://www.dca.state.ga.us/development/planningqualitygrowth/programs/documents/Part3c3-4HillsideandRidgelineProtection.pdf

Geotechnical Technical Division, The Institution of Engineers, Malaysia. (2009). *Report on 'Safe Hill-site Development' Seminar Study: Details of Procedures and Findings. pp. 95-115.*

Hamilton County Soil and Water Conservation District, The Metropolitan Sewer Distric of Greater Cincinnati. (2007). *Erosion Prevention and Sediment Feild Handbook.* Retrieved from http://www.msdgc.org/downloads/customer_care/permits_and_records/hcsw_tappers_handbook.pdf

Hillside Trust (Cincinnati, Ohio). (1991). *A Hillside Protection Strategy for Greater Cincinnati.* Cincinnati: The Trust.

IOWA Department of Natural Resources. (n.d.). *NPDES/Storm Water.* Retrieved 2014, from IOWA Department of Natural Resources website: http://www.iowadnr.gov/InsideDNR/RegulatoryWater/NPDESStormWater/GuidanceApplicationForms.aspx

Maccaferri-USA. (2014). *Documents*. Retrieved from http://www.maccaferri-usa.com/documents/15606-1.html

Miller, L. A. (1992). Preliminary assessment of the economic cost of land degradation: the Hermitage catchment, Jamaica. *Caribbean Geography*, Vol. 3, no. 4.

Mines & Geology Division. (n.d.). *The Quarries Control Act 1983.* Retrieved 2014, from Mines & Geology Division website: http://moj.gov.jm/sites/default/files/laws/Quarries%20Control%20Act_0.pdf

National Environment & Planning Agency. (2007). , Vol.1 Sec.1, Manual for Development. Retrieved from www.nepa.gov.jm

Ohio State University. (n.d.). *Community Development Fact Sheet Index*. Retrieved from Ohio State University website: http://ohioline.osu.edu/cd-fact/

Olshansky, R. B. (1998). Regulation of hillside development in the United States. *Environmental Management*, *22*(3), 383-392.

Planning, Development & Finance Department, Development Services Zoning Administration. (1996). *Hillside Development Guidelines Manual.* Retrieved from Colorado Springs website: https://www.springsgov.com/Files/Hillside.pdf

REHDA Bulletin (2009). *Towards Sustainable Development*; Industry Submits Views on Proposed Hillside development Guideline

Residential Cluster Development. (2014.). In *Wikipedia*. Retrieved from http://en.wikipedia.org/wiki/Residential_cluster_development

RV. (2009, Februay 12). *Building on Landslides in Asheville: Lessons to be Learned from Colorado Springs' Hazardous Land Development*. Retrieved 2014, from WNCSOS: http://wncsos.blogspot.com/2009/02/building-on-landslides-in-asheville.html

San Bernardino County. (2006). *DEVELOPMENT CODE.* Retrieved from http://www.sbcounty.gov/uploads/lus/DevelopmentCode/DCANotice20140619.pdf.

Scullin, C. M. (1983). *Excavation and Grading Code Administration, Inspection, and Enforcement*

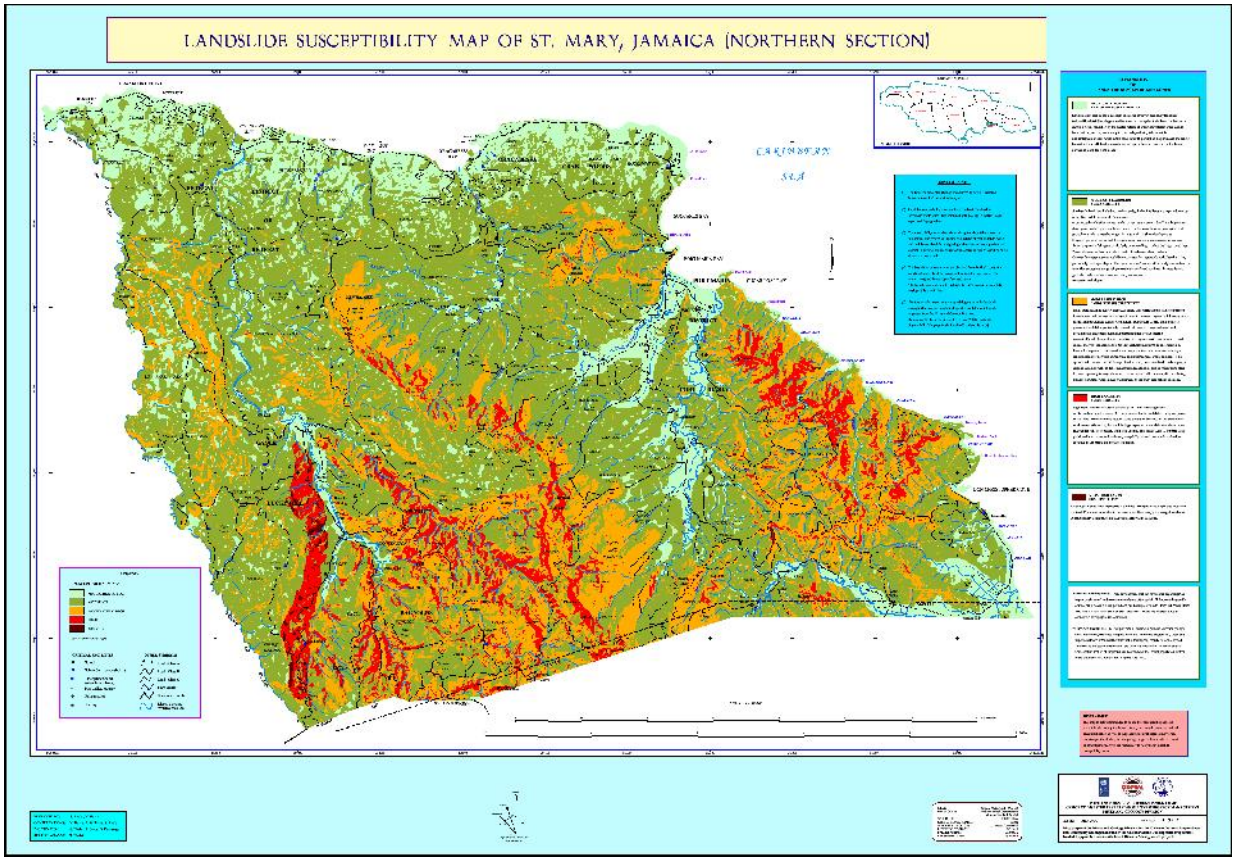
Simms, D. (2008). *The Effects of Urbanization on Natural Resources in Jamaica.* 44th ISOCARP Congress.

Too, E. G., Adnan, N., & Trigunarsyah, B. (2011). *Project governance in Malaysia hillside developments. In Proceedings of the Sixth International Conference on Construction in the 21st Century: Construction Challenges in the New Decade*. Kuala Lumpar, Malaysia.

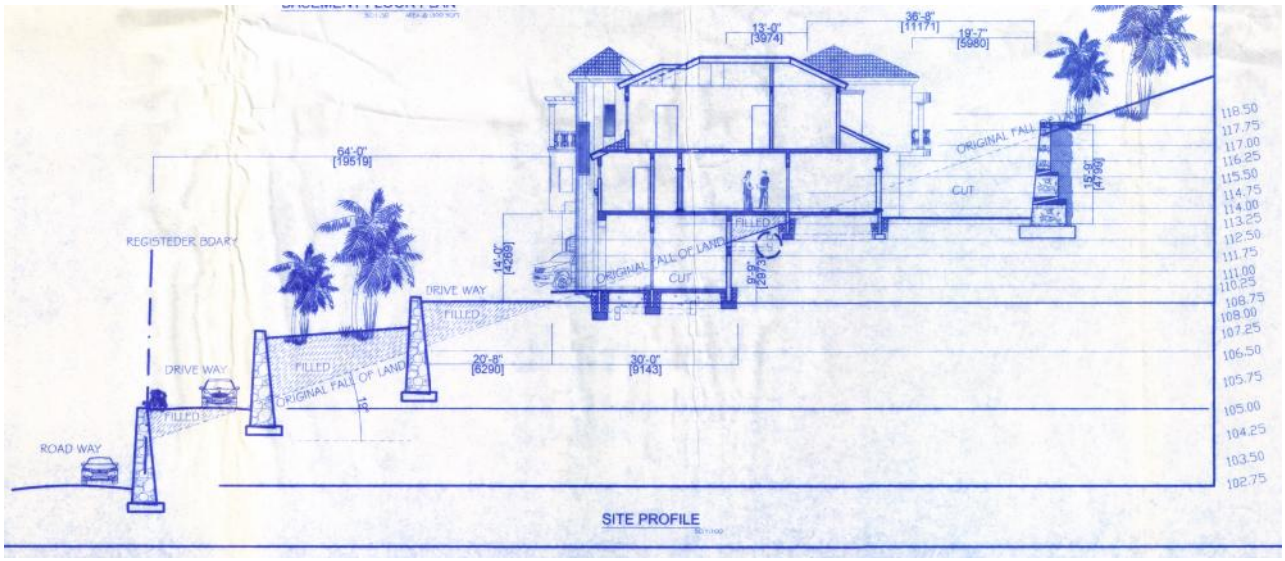
Turner, A. K., & Schuster, R. L. (1996). *Landslides: Investigation and mitigation*. Washington, D.C: National Academy Press.

14. Appendix

14.1. Example of Landslide Hazard Map



14.2. Example of Grading Plan



14.3. Example of Slope Map