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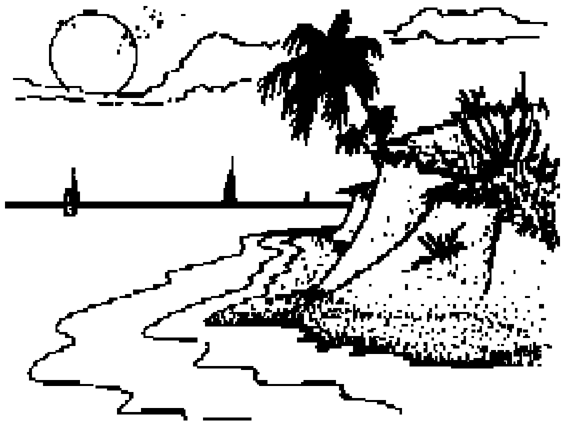
COAST AND BEACH STABILITY IN THE CARIBBEAN ISLANDS

PLANNING FOR COASTLINE CHANGE

2a
COASTAL DEVELOPMENT SETBACK GUIDELINES IN NEVIS



by
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Environment and Development in Coastal Regions and Small islands

University of Puerto Rico Sea Grant College Program

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Acknowledgments

I would like to thank the staff of the Physical Planning Unit and the Fisheries Division of the Nevis Island Administration, together with the Nevis Historical and Conservation Society, for their assistance with the preparation and review of this report. I would also like to thank Dr. A. Suzyumov of UNESCO's Coasts and Small Islands Unit for reviewing the report.

Pinney's Beach, August 1995.
The restaurant and swimming pool are located just behind the tree line.

Pinney's Beach, October, 1995.
Hurricane Luis eroded the beach and the land behind the beach undermining the foundations of the restaurant and the swimming pool. The implementation of adequate setback provisions would have prevented much of this damage.

1. EXECUTIVE SUMMARY

Coastlines, and beaches in particular, are dynamic fast-changing systems which are vitally important to the tourism-oriented economy of Nevis, as well as to other small Caribbean islands. The prudent use of coastal development setbacks, which establish a safe distance between the upper limit of wave action and new development, provides for beach preservation, reduction of erosion, as well as improved access, vistas and privacy for beach users and property owners.

This report develops coastal setback guidelines for Nevis. These setbacks apply to all development: houses, hotels, commercial buildings, airports, roads, swimming pools. For cliffed coasts, the setback is 50 feet (15 m) from the cliff edge. On low rocky shores, the setback is 100 feet (30 m) from the natural vegetation line. Setbacks for beaches have been determined for individual beaches/beach sections based on historical changes over the last forty-five years,predicted impacts of a major hurricane (based on the measured impact of Hurricane Luis in 1995), predicted change due to sea level rise, and other factors including coastal form, man's activities and planning considerations. Setbacks for beaches are measured from the line of permanent vegetation, (the tree line or scrub line).

Based on these setbacks, beaches have been grouped into four categories for ease of implementation:

Category 1	*setback is 60 feet (18 m) landward of the line of permanent vegetation;*
Category 2	*setback is 80 feet (24 m) landward of the line of permanent vegetation;*
Category 3	*setback is 120 feet (37 m) landward of the line of permanent vegetation;*
Category 4	*setback is 500 feet (152 m) landward of the line of permanent vegetation.*

One exception has been made for beach bars (defined as small individual buildings made of wood and with no concrete foundations, to be used exclusively as restaurants and/or bars) on the grounds that their economic viability depends on their proximity to the beach. The setback for these structures is 25 feet (8 m) landwards of the vegetation line.

Most of the beaches in Nevis fall into Categories 2 and 3. The northwest coast beaches from Cades Bay to Mosquito Bay as well as most of the north coast beaches (with the exception of the Nisbett to Camps section) are in Category 2. While Gallows Bay, the entire length of Pinney's Beach, the Nisbett to Camps section, as well as White Bay and Indian Castle on the southeast coast fall in Category 3. Longhaul Bay, a very sheltered site on the northeast coast, is the only beach in Category 1. Category 4 was created specifically for the short stretch of mangrove coastline from the mouth of the Camp River to Nisbett, where it is recommended that special measures should be put in place to conserve this coastal mangrove wetland.

Implementation of these setback guidelines will provide the Planning Authorities in Nevis with a framework which will facilitate coastal development and reduce beach erosion. Awareness and education of the public and special interest groups is a vital component of the successful implementation of these setbacks.

2. INTRODUCTION

Beaches are among the most dynamic systems in nature, they show visible changes over hours, days, months and years. They also represent one of the most important natural and economic resources of small island states such as St. Kitts and Nevis where the tourist industry, the mainstay of the economy, is still very much beach orientated. The up-market focus of the tourist industry makes it particularly sensitive to the quality of these resources.

Yet in St. Kitts and Nevis, as has been seen in other Caribbean islands, the growth of the tourist industry, which depends largely on the beaches, often creates problems for those same beaches. All too often, developers wish to position their properties as close as possible to the water, having little regard for seasonal beach changes or the infrequent, yet catastrophic hurricanes. It is not only tourist properties which are positioned adjacent to the beach or coastline, but other infrastructure as well, such as houses, roads, airports and commercial properties.

The vista of long white sand beaches, sand dunes, palm trees and clear blue waters is essential for the tourism industry and is a part of the natural heritage of the people of St. Kitts and Nevis. Forward planning through the use of coastal development setbacks can assist in ensuring that such vistas are not replaced by ugly rock revetments, groynes and narrow beach strips.

One of the dominant characteristics of beaches is their constant changes in form, shape and sometimes the very material of which they are composed. The best way to conserve beaches is to allow them the space to move - in a seaward direction when sand is building up (accretion) and in a landward direction during erosion phases. The prudent use of coastal development setbacks or establishing a safe distance between buildings and the active beach zone can ensure that space is provided for a beach to move naturally, both during normal events and infrequent hurricanes, thereby ensuring the beach is conserved for all to enjoy and that coastal infrastructure remains intact.

The purpose of this report is to prepare a set of guidelines for coastal development setbacks in Nevis. (Nevis is a part of the twin island state of St. Kitts and Nevis). This activity is part of a regional project "Planning for Coastline Change" and is funded by UNESCO through their Environment and Development in Coastal Regions and Small Islands endeavour and by the University of Puerto Rico Sea Grant College Program through their Multi-Program and Regional Development facility. A generic methodology has been developed for coastal setback determination (Cambers, 1997) and has already been applied in one Caribbean territory, Anguilla (Cambers, 1996). Within the project “Planning for Coastline Change” this same methodology is being adapted to Antigua and Barbuda, Nevis and St. Lucia. Nevis is the subject of this present report.

3. BACKGROUND

3.1 Natural Resources Legislation in Nevis

The National Conservation and Environment Protection Act, 1987 - 5, provides for the management and development of the natural and historic resources of St. Kitts and Nevis. This Act declares that all rights in and over the beach are vested in the Crown and that the public have the right of access and the right to use or enjoy the beach for recreational activities and purposes. The Act also regulates the controlled removal of sand, stone and vegetation from the beach. The term "beach" is defined as follows:

> *"Beach" means the sloping area of unconsolidated material typically sand, that extends landward from the mean high water mark to the area where there is a marked change in material or natural physiographic form or when there is no such marked change in the material or natural physiographic form, the beach shall be deemed to extend to a distance of twenty metres landward from the mean high water mark or such lesser area as may be determined by the Minister in consultation with the Conservation Commission and in all cases shall include the primary sand dune.*

This definition is slightly different to that which pertains in many Caribbean islands in that it defines a specific distance for the landward limit of the beach when there is no physiographic change in form or material and it specifies that the primary dune is part of the beach.

Beach management in Nevis falls under the umbrella of several government agencies including those with responsibility for planning, fisheries, public works and tourism. However, it is the Planning Unit which has in recent years played a lead role in coordinating beach management, e.g. in the preparation of a beach management policy in 1996.

3.2 General Concepts Governing Coastal Development Setbacks

Coastal setback provisions ensure that development is prohibited in a protected zone adjacent to the water's edge.

A coastal development setback may be defined as a prescribed distance to a coastal feature, such as the line of permanent vegetation, within which all or certain types of development are prohibited.

Coastal development setbacks have several functions :

- They **provide buffer zones** between the ocean and coastal infrastructure, within which the beach zone may expand or contract naturally, without the need for seawalls and other structures, which may imperil an entire beach system. Thus in this sense they may actually reduce beach erosion.

- They **reduce damage** to beachfront property during high wave events, e.g. hurricanes.

- They **provide improved vistas and access** along the beach.

- They **provide privacy** for the occupiers of coastal property and also for persons enjoying the beach as a recreational resource.

Most Caribbean islands use high water mark as the baseline for measurement. The planning standards developed for the countries belonging to the Organization of Eastern Caribbean States (OECS) (Wason & Nurse, 1994) use the high water mark as the baseline for measurement. However, there are several problems with the use of this criterion. For instance the position of the high water mark varies from day to day, sometimes its position can change by more than 30 feet (9 m) from one day to the next, particularly if there is a winter swell event. It is also somewhat subjective unless defined by an accurate vertical height, which is not the case in the Caribbean islands. Thus developers and planners may differ in the interpretation of high water mark as a baseline.

3.3 Existing Coastal Development Setbacks in Nevis

Prior to the 1980s there was no specific coastal development setback policy in Nevis. The "Inns of Nevis" provided most of the tourist accommodation and these for the most part were not located on the coast. However, starting in the mid 1980s the focus turned more towards the coast. In 1987-1988, a zoning map and report was prepared which provided a basis for physical planning in Nevis, (Corker, 1988). The island was zoned into areas suitable for urban development, tourism, agriculture and national parks. By this time the serious nature of coastal erosion in Nevis, particularly at Pinney's Beach had been identified and was a cause for concern. The zoning plan developed guidelines for development on the beaches with tourist potential, specifically Pinney's Beach and Nisbett (Newcastle to Burnaby). These guidelines were adopted by the Town and Country Planning Board in 1987 specifically for Pinney's Beach, see Table 1.

Table 1. Guidelines for Development on the Beaches with Tourist Potential on Nevis.

Objective

The Town and Country Planning Board wish to encourage development of tourism, but wish Pinney's Beach to retain the appearance of an unspoilt coconut plantation in perpetuity.

1. No building within 120 ft (37 m) of high water mark.

2. Where the 10 ft (3 m) contour is more than 300 ft (91 m) from high water mark, development should be limited to small individual buildings without foundations, such as a wooden beach bar, or recreational facilities other than buildings that will not be damaged by storm seas, such as tennis courts or gardens.

3. More than 300 ft (91 m) from the high water mark, development will be permitted, subject to the following conditions:

    (a) maximum building height of 30 ft (9 m) from the lowest point that the building meets the ground;

    (b) architecture to reflect traditional Nevis design, and to be in keeping with the natural surroundings;

    (c) only hotel development should be encouraged along the beach area;

    (d) minimum setback of 50 ft (15 m) from property boundary to any building;

    (e) all sites to be landscaped to retain the natural beauty of Pinney's Beach as a coconut plantation;

    (f) any natural ponds or water courses should be left undisturbed.

4. Where the 10 ft (3 m) contour is closer to high water mark than 300 ft (91 m), development should be allowed above the 10 ft (3 m) contour, subject to an absolute minimum of 120 ft (37 m) from high water mark.

5. No structure, floating or non-floating, shall be fixed or moored off the sea bed along Pinney's Beach.

Hon. U. Swanston.
Chairman, Town and Country Planning Board
16th October, 1987.

Based on these guidelines, three zones were identified for Pinney’s Beach:

- High water mark to 120 ft (37 m) inland: no development;
- Between 120 and 300 ft (37-91 m) from the high water mark: small buildings without foundations, gardens, tennis courts;
- More than 300 ft (91 m) from the high water mark: development with certain conditions attached, see Table 1.

Figure 1 shows these zones.

When the land behind the beach is less than 10 ft (3m) high.

When the land behind the beach is more than 10 ft (3m0 high

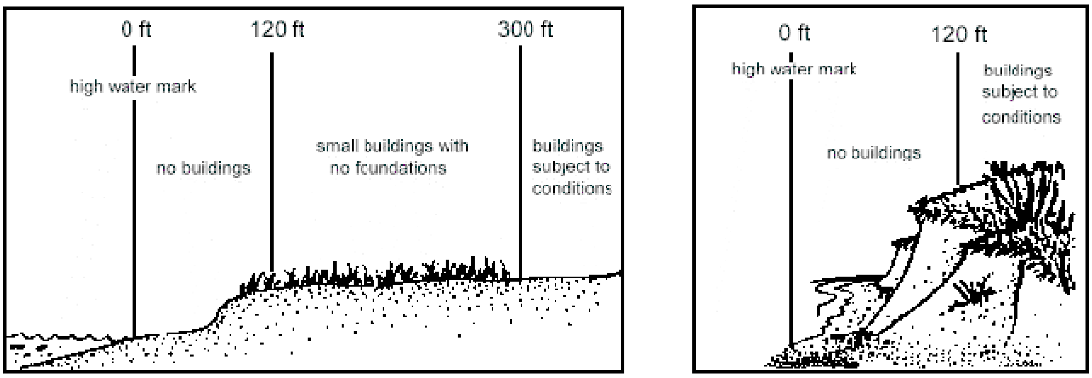


Figure 1. Diagram Showing Existing Setbacks in Nevis.

In 1991 the Nevis Zoning Ordinance was adopted. This applied the 1987 guidelines for Pinney’s Beach to all beach areas designated for hotels and tourism, see Table 2.

However, problems with the implementation of these guidelines were already apparent at the beginning of the 1990s. The Four Seasons Resort, which was built at Clark’s Estate, Pinney’s Beach, between 1989 and 1991, had several buildings within the high water mark to 300 ft (91 m) zone, including a restaurant with solid foundations, swimming pool and some hotel buildings. Other buildings have also been permitted within the “no building” zone at Pinney’s Beach and at other beaches.

Table 2. Land Use for Hotels and Tourist Areas (Nevis Zoning Plan Ordinance, 1991-1)	
Hotels and Tourism Area	Primary Use The number and design of buildings and their uses will be strictly regulated to maintain so far as possible the unspoilt appearance of the areas. The following additional considerations will be taken into account in considering any planning applications: (1) No development shall be nearer than 120 feet (37m) from high water mark. (2) No building shall be nearer than 300 feet (91m) from high water mark.

Coastal development setbacks have to be carefully designed. From a beach dynamics perspective, large setbacks are beneficial, however, from a developer's viewpoint, these setbacks leave a lot of valuable land tied up and unavailable for development, and they may meet with considerable resistance. This is the most likely reason why the setbacks laid out in the 1991 Zoning Ordinance have not been fully implemented - people felt that they were unrealistic (Robinson, 1997).

Hurricane Luis, a category 4 hurricane, which passed close to Nevis in September, 1995 helped to change some of that thinking. There was dramatic shoreline erosion at most west coast beaches and also extensive damage to coastal infrastructure (Barrett and Huggins, 1997). One beachfront restaurant built on Pinney's Beach just prior to the hurricane, and positioned 120 ft (37 m) from the high water mark, was completely destroyed. However, public memory of such events is often very short.

Partly as a result of Hurricane Luis, the Government of Nevis recognized the need to design new setbacks specific to each beach which would maximize the use of beachfront land, and at the same time provide for the protection of buildings from wave attack. A request for assistance was made in 1996.

Some countries already utilize variable setbacks which make allowances for natural variations in shoreline trends from one beach to another. So on beaches that are eroding the coastal development setback will be greater than on stable beaches or on those beaches that are building-up (accreting). For example, in South Carolina in the U.S.A., the width of the setback is prescribed as a distance 40 times the annual erosion rate measured from the most seaward dune (National Research Council, 1990).

Since there is a need for further development in the coastal zone in the interests of the country's economic well-being which is at least partly dependent on the tourist industry, setback policies must be designed to ensure that new development is sustainable. Thus new development should not threaten the integrity of the coastal - marine environment which is the foundation of the tourist industry. The concept of variable setbacks, which make allowances for differences in the behaviour, characteristics, erosional history and use of beaches, can best fulfill this function in Nevis as well as in other Caribbean islands.

However, it must be recognized that it is one matter for planners to prescribe setbacks, but in order for them to be successful, groups such as architects, draftsmen, developers and the general public, must be shown the rationale and the need for such planning tools. As with other facets of coastal area management, the need for education, participation and communication is of paramount importance.

4. METHODOLOGY

Based on the coastal form of small Caribbean islands, four major coastal types can be identified in Nevis:

1. cliffs;
2. low rocky shores;
3. mangrove coastlines;
4. sand or stone beaches.

Setback guidelines are developed for each coastline type. The methodology utilizes geomorphological, geological, oceanographic and ecological characteristics as well as observed rates of change and socio-economic factors. (In some other Caribbean islands there is a fifth category: small sandy offshore cays, however, these do not exist in Nevis).

4.1 Setback Guidelines for Cliffed Coasts

Geological composition and wave processes are major factors determining cliff retreat. "Hard" rock cliffs composed of volcanic and limestone rocks will generally erode much more slowly than cliffs composed of "soft" rocks such as clays and sandstones, where erosion rates may be as high as several yards a year. Cliff retreat rates are generally higher on windward coasts where wind and wave action is more intense. Cliff erosion is usually not a gradual process, but a sudden one as large blocks collapse especially in fractured rocks such as limestone.

Geologically Nevis is a volcanic island dominated by the central Nevis Peak, however, several other volcanic centres exist (Island Resources Foundation, 1991). Most of the east coast south of Potworks Estate and extending along the south coast to Fort Charles consists of an upland coast. In places this consists of volcanic cliffs, up to 30 m (100 ft) high, e.g. at Saddle Hill on the south coast. Along other stretches, there is a steep vegetated slope rising from a rocky shore or sometimes a wave cut platform. The rocks are of volcanic origin consisting of andesites and dacites.

Along the west coast, north of Fort Charles, and on the north coast, the coastal area is low lying and consists of alluvium and raised beach deposits. However, volcanic cliffs outcrop in the region of Cades Point and Hurricane Hill.

The volcanic cliffs in Nevis may be considered “hard” rock cliffs and have not been differentiated for the purposes of setbacks. So therefore a blanket guideline of a minimum of 50 feet (15 m) from the cliff edge is recommended for development close to coastal cliffs.

However, it must be remembered that cliff collapse is a sudden process with large sections of cliff falling at one time. So the above recommendation should be regarded as a minimum.

On cliffs in Nevis, all new developments should be set back a minimum of 50 feet (15 m) from the cliff edge.

4.2 Setback Guidelines for Low Rocky Shores

In Nevis, these shores are usually composed of volcanic rock. Generally they show low levels of retreat, however, development in these areas is vulnerable to seawater inundation during tropical storms and hurricanes, thus a setback of 100 feet (30 m) from the vegetation line is recommended. On some sections of the windward coast there may be no tree or scrub line, in such cases the shrub/grass edge is the starting point for measurement of the setback distance.

On low rocky shores, all new development should be set back a minimum of 100 feet (30 m) from the natural vegetation line.

4.3 Setback Guidelines for Mangrove Coastlines

Along the leeward coast of Nevis there is a system of freshwater lagoons. These are the result of underground springs and mountain runoff. Some of these lagoons drain to the ocean regularly, others only during very heavy rainfalls. These lagoons exist behind Gallows Bay and Pinney's Beach on the west coast and behind Hurricane Hill/Seahaven Estate and Newcastle/Nisbett on the north coast. Mangroves are associated with many of the lagoons. Except for intermittent channels the lagoons are separated from the sea by extensive sand beaches and sometimes palm plantations. As a result, the actual length of mangrove shoreline in Nevis is very small. The only significant length of coastline where mangroves front the ocean is near the Camp River mouth, to the west of Nisbett Plantation, where there is a 656 feet (200 m) length of coastline fringed by mangroves (Cambers, 1989).

Since this short length of mangrove coastline is unique in Nevis, it is recommended that this wetland/coastal mangrove area be conserved and any development in this area be located landward of the wetland and designed so as to maintain the integrity of the mangrove system. Already the mangroves fronting the shoreline are dying as a result of recent hurricanes and erosion which is caused by several groynes located [illegible]ift (east) which are reducing the sand supply to the area.

4.4 Setback Guidelines for Sand and Stone Beaches

Due to the complexity of beaches and their changes, as well as their importance for tourism, recreation and development, setbacks have been determined individually on a beach by beach basis in Nevis. Furthermore, very long beaches such as Pinney's Beach, have been divided into several sections for the purpose of setback determination. This allows for greater setbacks on eroding beaches/beach sections, which will in turn provide for the preservation of beaches, protection of beachfront property and the reduction of erosion caused by certain beach protection structures. Moreover such setbacks will reduce the need for beach protection measures.

The line of "permanent" vegetation has been used as the baseline for measurement. This is the tree line or scrub line and can be easily defined and agreed by different observers. Also it shows only slight change apart from the relatively rare tropical storms and hurricanes. Features such as high water mark vary according to the tidal cycle and are very subjective especially when used by untrained observers.

The line of permanent vegetation is used as the baseline for setback determination for beaches.

Some beaches are backed by sand dunes. Sand dunes are reservoirs of sand which supply the beach with sand during tropical storms and hurricanes, thus they are temporary features. New development should always be placed behind (landward of) the primary dune, see Figure 2. In Nevis there are only two beaches backed by sand dunes: White Bay and Indian Castle, setbacks at these beaches have been designed to preserve the primary dune. (Although at Indian Castle, past dune mining has virtually destroyed an extensive system of dunes).

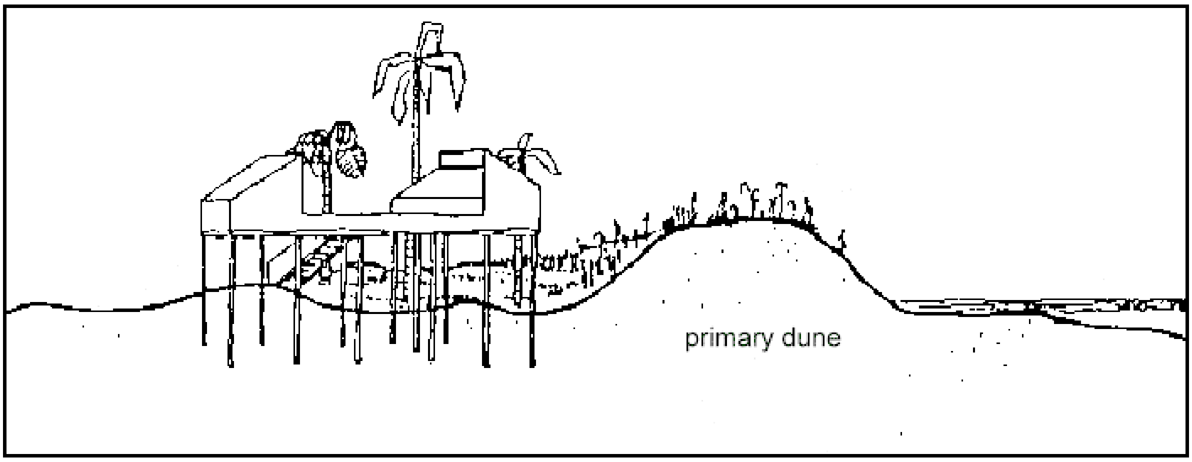


Figure 2. Recommended Construction on a Dune.

The primary dune has been left intact. The building has been built on piles so as to allow for the uninterrupted flow of floodwater and has been positioned behind the primary dune. (Figure adapted from the U.S. Department of Housing and Urban Development, 1981).

The setback applies to all permanent development e.g. residences, hotels, villas or commercial buildings, whether wood or cement, swimming pools and roads.

No development should be permitted seaward of the baseline, that is the "permanent" vegetation line, with the obvious exceptions of jetties and docking facilities.

In Nevis one setback value was calculated for each beach/beach section. Setbacks were calculated based on the following formula:

$$(a + b + c)d = \text{setback}$$

a is the projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1991 in Nevis;

b is the projected change in coastline position likely to result from a major hurricane;

c is the predicted coastline retreat by 2030 resulting from sea level rise;

d represents other factors including ecological, planning and social considerations.

(The factor "**d**" was not specifically mentioned in the generic methodology (Cambers, 1997), however, the ecological, planning and social considerations were incorporated into the setback calculation).

In Nevis, aerial photographs from 1946, 1982 and 1991 were compared to determine historical coastline changes. Recent changes were determined from the beach monitoring database. Beach monitoring has been ongoing in Nevis since 1988 within the regional Coast and Beach Stability in the Caribbean Islands (COSALC) project. The monitoring is coordinated by the Nevis Historical and Conservation Society with the assistance of the Physical Planning Unit and the Fisheries Division. Historical coastline changes alone were used to project coastline changes over the next 30 years ("**a**" in the above formula). While the beach monitoring data are undoubtably more accurate than the aerial photograph data, they only cover a short time period, ten years. They have been tabulated for each beach/beach section in Appendix II, where they will provide planners with high quality information on recent changes at each beach.

Data from the beach monitoring programme were used to determine the changes in the land edge or dune edge that occurred as a result of Hurricane Luis in 1995. This provided the basis for the projected change from a major hurricane, "**b**" in the above formula. It is anticipated that Nevis will be impacted by at least one major hurricane in the next 30 years. (This does not mean that the hurricane centre has to pass directly over the country but rather that it will pass close enough to cause severe damage).

As sea level rises, low sandy shorelines retreat inland. The Bruun Rule (1962) was used to compute this change, "**c**" in the above equation. This factor is somewhat speculative since there is no long term tide gauge data for Nevis. However, for the purposes of this report and on the basis of historical tide gauge data for other parts of the Caribbean, it has been assumed that sea level will rise in Nevis over the next 100 years by 1 ft (0.3 m), see also Appendix I.

The factor "**d**" in the above equation represents a combination of the following:

- coastline shape and how sheltered a beach is from incoming waves;
- coastal features such as sand spits and bars;
- offshore features such as coral reefs;
- man's activities such as sand mining, offshore dredging;
- planning considerations such as lot size, national park designations.

While the incorporation of these factors involves qualitative decisions, they are nevertheless too important to be omitted.

Appendix I contains a more detailed discussion of these parameters and the methodology utilized.

5. COASTAL DEVELOPMENT SETBACKS FOR NEVIS

Blanket setbacks have been determined for cliffed coasts and low rocky shores, these are:

- on cliffed coasts, the setback is a minimum of 50 feet (15 m) from the cliff edge;
- on low rocky shores, the setback is a minimum of 100 feet (30 m) from the natural vegetation line.

On the coastal stretch fringed by mangroves, by the Camp River mouth, west of Nisbett, a minimum setback of at least 500 ft (152 m) from the seaward edge of the mangrove is recommended. Furthermore an environmental impact assessment should be conducted for any proposed development here so as to ensure the integrity of this coastal wetland is maintained.

Specific setbacks have been determined for individual beaches in Nevis. In all cases these are measured landwards from the line of permanent vegetation (tree line/scrub line). These setbacks apply to all types of development - houses, residences, hotels, commercial buildings, roads, swimming pools.

However, a special provision has been made for small individual buildings, made of wood and with no concrete foundations, to be used exclusively for the purpose of restaurants or bars, on the grounds that their economic viability depends on their proximity to the beach. It is recommended that they be placed 25 ft (8 m) landwards of the permanent vegetation line. In the past they have sometimes been permitted on the beach itself, and a recent survey of four beach bars located along Pinney's Beach showed that these four structures were located at the line of permanent vegetation (pers. com. Ms. S. McGibbon). During Hurricane Luis in 1995, almost every structure within 100 ft (30 m) of the normal high water mark was damaged or destroyed (Barrett and Huggins, 1996). Using Pinney's Beach as an example, the maximum distance from the high water mark to the vegetation line in 82 ft (25 m), based on the beach monitoring data. (Obviously this value varies seasonally). By placing these beach bar structures 25 ft (8 m) landwards of the vegetation line, they are beyond the zone of maximum damage likely to be sustained during a major hurricane.

Table 3 shows the setbacks for specific beaches in Nevis. Setbacks have been calculated for each beach/beach section. Appendix II details how the setback was calculated for each beach.

Table 3 Setback Distances for Beaches in Nevis

Beach/Beach Section	Setback distance in feet	Setback distance in metres
Gallows Bay	125	38
Pinney's Beach 1 (Pinney's Beach Hotel to Golden Rock)	125	38
Pinney's Beach 2 (Clark's Estate, Golden Rock to Jessup)	105	32
Pinney's Beach 3 (Jessup to Cotton Ground)	128	39
Pinney's Beach 4 (Cotton Ground to Lawrence Estate)	108	33
Cades Bay	85	26
Jones Bay	79	24
Mosquito Bay	98	30
Hurricane Hill to Seahaven Estate	79	24
Seahaven Estate to Newcastle Bay	85	26
Camp River Mouth (Mangrove Shoreline)	500	152
Nisbett to Camps	135	41
Camps to Burnaby	89	27
Longhaul Bay	59	18
White Bay	131	40
Indian Castle	125	38

While Table 3 gives a specific setback value for each beach, this may provide too much detail and prove difficult to implement from a planning perspective. The data have therefore been grouped into four different categories as follows:

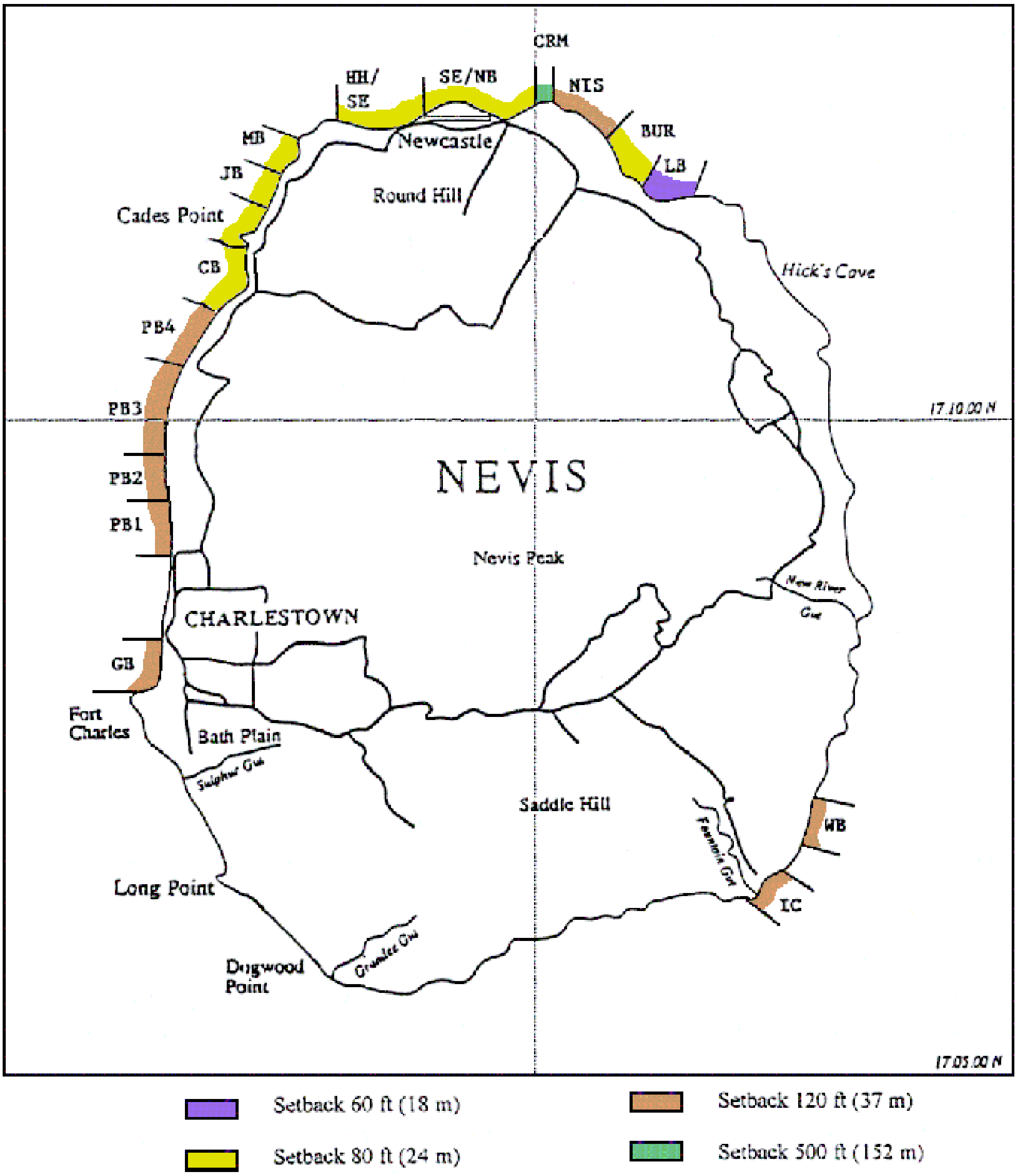
Category 1 Setback 60 feet (18 m) landward of the line of permanent vegetation;
Category 2 Setback 80 feet (25 m) landward of the line of permanent vegetation;
Category 3 Setback 120 feet (37 m) landward of the line of permanent vegetation;
Category 4 Setback 500 feet (152 m) landward of the line of permanent vegetation.

In each category the setback is the minimum acceptable, greater setbacks should always be encouraged. Table 4 lists the beaches under the various categories and Figure 3 shows a map with the setback categories.

Table 4 Setback Categories for Beaches in Nevis.

Category 1 **Setback = 60 feet** **(18 m)**	**Category 2** **Setback = 80 feet** **(24 m)**	**Category 3** **Setback = 120 feet** **(37 m)**	**Category 4** **Setback = 500 feet** **(152 m)**
Longhaul Bay.	Cades Bay, Jones Bay, Mosquito Bay, Hurricane Hill to Seahaven Estate, Seahaven Estate to Newcastle Bay, Camps to Burnaby.	Gallows Bay, Pinney’s Beach 1 (Pinney’s Beach Hotel to Golden Rock), Pinney’s Beach 2 (Clark’s Estate, Golden Rock to Jessup), Pinney’s Beach 3 (Jessup to Cotton Ground), Pinney’s Beach 4 (Cotton Ground to Lawrence Estate), Nisbett to Camps, White Bay, Indian Castle.	Camp River Mouth (Mangrove Shoreline).

Figure 3. Beach Setback Categories in Nevis



Key			
BUR	Camps to Burnaby	MB	Mosquito Bay
CB	Cades Bay	NIS	Nisbett to Camps
CRM	Camp River Mouth (mangrove shoreline)	PB1	Pinney's Beach (Hotel to Golden Rock)
GB	Gallows Bay	PB2	Pinney's Beach (Clark's Estate)
HH/SE	Hurricane Hill to Seahaven Estate	PB3	Pinney's Beach (Jessup to Cotton Ground)
IC	Indian Castle	PB4	Pinney's Beach (Cotton Ground to Lawrence Estate)
JB	Jones Bay	SE/NB	Seahaven Estate to Newcastle Bay
LB	Longhaul Bay	WB	White Bay

Most of the beaches/beach sections in Nevis fall in two groups. The three beaches on the northwest coast: Cades, Jones and Mosquito Bays, as well as the north coast beaches from Hurricane Hill to Burnaby (with the exception of the stretch from the Camp River mouth to Nisbett and Camps) are in Category 2 with a setback of 80 feet (24 m from the vegetation line). Gallows Bay and Pinney's Beach (along its entire length) fall into Category 3 with a setback of 120 feet (37 m) from the vegetation line. The north coast beach section from Nisbett to Camps, as well as the two beaches on the southeast coast: White Bay and Indian Castle, also fall into Category 3.

Longhaul Bay on the northeast coast is the only beach in Category 1, with a setback of 60 feet (18 m) from the vegetation line. The short section of mangrove coastline around the Camp River mouth is the only section that falls in Category 4, with a setback of 500 feet (152 m) from the vegetation line.

It is useful to compare the recommended setbacks with the existing setbacks. For instance along Pinney's Beach the recommended setback from the vegetation line is 120 feet (37 m). The distance from the vegetation line to the high water mark varies from 0 - 82 feet (0-25 m) depending on the site and the time of year. Taking the maximum value, the recommended setback translates to 202 feet (61 m) from the high water mark.

Existing setback	= 300 feet from the high water mark
Recommended setback	= 120 feet from the vegetation line + 82 feet (maximum distance vegetation line to high water mark)
	= 202 feet from the high water mark.

Thus although the recommended setback is not as generous as the existing one, it is perhaps more realistic and represents a compromise that the planner, beach conservationist and developer can accept.

These setback categories will allow for ease of implementation by the Physical Planning Unit in Nevis. For specific applications, planners can refer to Table 3 to obtain the specific setback value for a beach and to Appendix II to see the way in which the setback was calculated and specific data such as recent hurricane damage and beach changes during the past ten years.

Once the setback standards are incorporated into Nevis' planning legislation and the development plan, it is recommended that they be applied on a fixed basis with deviations being allowed only in very exceptional circumstances. Planners may exercise some flexibility in cases where the calculated setback for a particular beach/beach section is **less** than the category value. For instance Pinney's Beach 4 (Cotton Ground to Lawrence Estate) falls into Category 3, so the setback here should be 120 ft (37 m). However, reference to Table 3 and Appendix II shows that the specific setback calculation for Pinney's Beach 4 is 108 ft (33 m). Thus a planner reviewing an application for this beach may decide to accommodate a developer's wish to build closer to the beach by relaxing the setback to the 108 ft (33 m) value. Such accommodation should only be permitted where the calculated setback for a particular beach is **less** than the category value assigned to that beach. These setbacks, which can be fully justified and explained to developers, should facilitate future coastal development.

However, it must be emphasized that any setback policy must be combined with an education and awareness campaign so that members of the public as well as special interest groups such as architects, contractors and politicians, fully understand the need for such setbacks.

6. CONCLUDING REMARKS

The proposed setbacks for coastal development provide a framework in which the Physical Planning Unit can work to ensure that coastal development in Nevis is sustainable and that beach erosion is reduced. It is recommended that the Nevis Island Administration incorporate the new setbacks into planning legislation and the development plan. It is envisaged that the setbacks can be revised as the beach monitoring programme continues and as other information becomes available. The implementation of the setbacks will also play an important role in the conservation of Nevis' beaches and in the development of a shoreline management policy in Nevis. A framework for such a shoreline management policy has been developed in Volume 2b of this series (Cambers, 1998). As Nevis moves towards integrated coastal area management, the implementation and further revision of these setback guidelines will provide an important tool.

References

Barrett, A., Cambers, G., Leandro, C. 1994. Analysis of Beach Changes in Nevis between 1988 and 1993. COSALC report. 52 pages.

Barrett, A., Huggins, L. 1997. Hurricane Impacts in Nevis. In Cambers, G. (Ed.) 1997. Managing Beach Resources in the Smaller Caribbean Islands. Papers presented at a UNESCO - University of Puerto Rico Workshop, 21-25 October, 1996, Mayaguez, Puerto Rico. Coastal region and small island papers, No. 1, UPR/SGCP-UNESCO, Mayaguez, pp 42-54.

Bruun, P. 1962. Sea Level Rise as a Cause of Shore Erosion. Journal of Waterways and Harbours Division, ASCE 88, pp 117-130.

Cambers, G. 1989. Report on Sea Defences at Nisbett Plantation Inn, Nevis. Report prepared for Windward Properties Ltd. 22 pages.

Cambers, G. 1996. The Impact of Hurricane Luis on the Coastal and Marine Resources of Anguilla: Coastal Development Setback Guidelines. British Development Division in the Caribbean. 39 pages.

Cambers, G. 1997. Planning for Coastline Change. Guidelines for Construction Setbacks in the Eastern Caribbean Islands. CSI info 4, UNESCO, Paris, viii + 14 pages.

Cambers, G. 1998.Planning for Coastline Change. 2b Shoreline Management in Nevis: A Position Paper. COSALC report. 38 pages.

Corker, I.R. 1988. Nevis: Resource Assessment and Zoning Plan. Overseas Development Natural Resources Institute, Bulletin No. 6.

Island Resources Foundation. 1991. St. Kitts and Nevis Country Environmental Profile. Published by Caribbean Conservation Association. 277 pages.

National Research Council. 1990. Managing Coastal Erosion. National Academy Press. 182 pages.

National Research Council. 1991. Responding to Changes in Sea Level: Engineering Implications. National Academy Press. 148 pages.

Robinson, D. 1997. Baseline Data Spells Relief. In Cambers, G. (Ed.) 1997. Managing Beach Resources in the Smaller Caribbean Islands. Papers presented at a UNESCO - University of Puerto Rico Workshop, 21-25 October, 1996, Mayaguez, Puerto Rico. Coastal region and small island papers, No. 1, UPR/SGCP-UNESCO, Mayaguez, pp 13-17.

Scott Wilson Kirkpatrick. 1993. Report on Sand Resources Study. The Government of St. Kitts Nevis. Report prepared under assignment from the Overseas Development Administration.

U.S. Department of Housing and Urban Development and Federal Emergency Management Agency. 1981. Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas. FIA-7. 189 pages.

Wason, A., Nurse, L. 1994. Planning and Infrastructure Standards. UNCHS and UNDP, 173 pages.

APPENDIX I

DETAILED METHODOLOGY FOR THE CALCULATION OF SETBACKS AT BEACHES

a) Projected change based on historical measurements (“a”)

The aerial photographs used to determine historical change were:

1946 black and white aerial photographs flown by the USAAF at a scale of 1:17,500. These covered the entire island.

1982 black and white aerial photographs flown by J.A. Storey and Partners, U.K., at a scale of 1:17,500. These covered the entire island.

1991 colour aerial photographs flown for CIDA at a scale of 1:10,000 covering the entire island.

The 1946 photographs are stored at the Horatio Nelson Museum and the 1991 photographs at the Physical Planning Unit. The 1982 photographs are stored at the Lands, Housing and Development Department.

Stereoscopic pairs of the photographs were studied and general changes regarding each beach were recorded. Then reference points close to the beach such as buildings and road intersections were selected, these reference points had to be visible on each set of photographs. Measurements were made from these reference points to the offshore step, this is the seaward toe of the beach. It is marked by a vertical downward step near the wave breakpoint and is a distinctive feature on some beaches and can also be distinguished on the photographs usually as a colour change or shade change. The number of points per beach depended on the number of reference points that could be identified on the sets of photographs, in some of the less developed areas there were only one or two measurements per beach. These measurements were then compared and changes in the position of the offshore step were determined and calculated as a distance per year figure (metres/year).

There are many errors involved in this technique e.g. distortion towards the edge of the photographs, difficulty in identifying fixed locations (reference points), and difficulty in identifying the offshore step.

Besides possible errors in the measurements, there are other factors which must be considered when using aerial photographs for assessing coastal change. Three sets of photographs were used, these represent just three time series: January, 1946, January-March, 1982, and January-March, 1991. Beaches change dramatically from week to week and also seasonally. All the photographs were taken during the winter months which to some extent reduces the variation resulting from seasonal changes. However, beach profile measurements show that during the winter, measurements may vary dramatically from one day to the next especially if a major winter swell event occurs. Tidal variations also exist, although tidal range in Nevis is very low, and in these measurements the offshore step was used rather than a particular water line.

Based on the foregoing, the assessment of shoreline change using aerial photograph measurements provides only an estimation of the actual change. However, in this study, historical shoreline change represents only one of several factors included in the setback calculation.

Beach profiles are surveyed on a regular basis every three months at eighteen sites around Nevis. These data are detailed and far more accurate than the historical changes determined from the aerial photographs. However, they only cover a relatively short time period, 1988-1997. The beach monitoring data was used to calculate shoreline change by comparing the average value for the baseline year of 1988 with the average value of all the following years (1989-1997). So all the variations between 1988 and 1997 were included.

For each beach/beach section an historical change value was calculated in metres per year using the 1946, 1982 and 1991 photographs, and a recent change was calculated using the beach monitoring database.

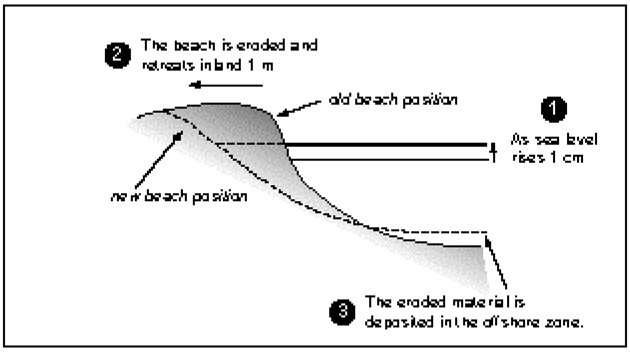
The beach monitoring data are undoubtably more accurate than the aerial photograph data. However, in all cases the aerial photograph data were used in the determination of predicted change, "**a,**" mainly because they cover a longer time period (1946-1991). Nevertheless the beach monitoring data have been tabulated in the detailed site data in Appendix II, since they will help planners by providing high quality information on recent changes. Appendix II, shows in detail how the projected change based on historical measurements was calculated for each beach/beach section.

b) Projected change in coastline position likely to result from a major hurricane ("b")

Beaches experience severe erosion during hurricanes, this was seen during Hurricane Luis in 1995. However, in most cases the beaches recovered in the following months either partially or totally. However, the major long term change resulting from Hurricane Luis was the retreat of the shoreline (coastal land edge or dune edge). This was viewed as a "permanent" change, since land and sand dunes take decades to form. At all of the monitored beaches, detailed measurements exist relating to the retreat of the land or dune edge during Hurricane Luis in 1995. However, at a few sites the beach profile reference point was lost during the hurricane, so then data from adjacent sites were used. These data were used to estimate the likely change from a future major hurricane at each beach/beach section in Nevis.

c) Predicted coastline retreat by 2030 resulting from sea level rise ("c")

The Bruun Rule shows that as sea level rises, material is eroded from the upper beach and deposited on the nearshore ocean bottom (Bruun, 1962). Consequently the ocean moves landwards, or in other words there is shoreline recession. The concept is based on an equilibrium beach profile which is a statistical average profile that maintains its form apart from small fluctuations including seasonal effects. The following figure illustrates the Bruun Rule.



Schematic Representation of the Bruun Rule

The shoreline recession resulting from predicted sea level rise over the next 30 years is factored into the setback calculation. This is calculated as follows: a rise of sea level of y metres causes a shoreline recession of y times 100 m. Based on a predicted sea level rise of 0.3 m by the year 2100 (this is one of the lower estimates), this represents 0.1 m by the year 2030, thus the shoreline recession is 0.1 x 100 = 10 m. (Most development has an economic life of 30 years, so this time period has been used for the calculation).

d) Other factors ("d")

Several other factors are also evaluated in the setback determination. These include:

- **Offshore characteristics**: Coral reefs and wide shallow offshore shelves often provide protection to particular beaches. Beaches on the north coast of Nevis, which are protected by a barrier reef, experienced less erosion during the 1995 hurricanes than the west coast beaches.

- **Changes in offshore ecosystems**: Coral reefs provide an important natural breakwater function. However, many of these reefs were reduced to rubble by Hurricane Luis, thus water depths may have increased providing the potential for higher wave action and beach erosion. However, little quantitative data was available about such changes in Nevis. Most of the observations relating to offshore systems was derived from Scott Wilson Kirkpatrick, 1993.

- **Coastal features and formations**: Features such as exposed beachrock provide indicators of long term erosion. Accretionary features such as sand spits and bars are very vulnerable to storm waves and may show dramatic and permanent changes during and after a major hurricane.

- **Man's activities**: Practices such as mining sand from the beach or dune remove protective barriers which can damage beach/dune systems. Dunes are natural sand reservoirs which supply beaches with sand during storms and hurricanes. Their removal for the construction industry interrupts this process and results in increased erosion.

- **Planning factors such as lot size, existence of marine parks and designations such as pristine coastal areas:** Some coastal lots may be very narrow, less than 100 ft in depth. Setbacks may cause some of these lots to become unsuitable for development. Government acquisition may be a solution in some of these cases, but for economic reasons, it is rarely a feasible option in small developing islands such as Nevis. Thus setback guidelines must take such limitations into account.

If any of these factors apply to a particular beach they are grouped and represented as a multiple with a value of 1 to 2.5. A value of 1 means that none of the factors are especially significant, while a value of 2.5 represents the maximum value. The assignment of the particular value for "**d**" is based on local knowledge. The following scale has been used:

1 no particular factors especially significant;
1.5 one or more factors result in moderate vulnerability to coastline change;
2 one or more factors result in high vulnerability to coastline change;
2.5 one or more factors result in very high vulnerability to coastline change.

APPENDIX II

SETBACK CALCULATIONS FOR INDIVIDUAL BEACHES IN NEVIS

(Note that in the calculation of **"a"** Projected change in coastline position based on recorded changes 1946-1991, the value has been based on the aerial photograph comparison only. The recent changes, between 1988 and 1997, are based on the beach monitoring data, and have been included for information. These recent changes are not used in the calculation of "**a**").

Gallows Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 125 feet (38 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(23 + 5 +10)1	=	38 m

a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
c predicted coastline retreat by 2030 resulting from sea level rise;
d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.78 m
Recent changes 1988-1997 (beach monitoring)	=	-1.35 m
Projected retreat over the next 30 years	=	0.78 x 30
	=	23.4 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	4.5 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, the bottom consists of seagrass beds and sand. Behind the beach there is a wetland system “The Bogs.” The land reclamation and a solid jetty at the port of Charlestown have acted as a groyne, particularly during southerly wave conditions, resulting in beach accretion at the northern end of the bay. The beach frontage is not developed. The factor ‘d’ remains 1.0.

Pinney’s Beach 1 (Pinney’s Beach Hotel to Golden Rock)

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 125 feet (38 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(23 + 5 +10)1	=	38 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991 (aerial photographs)	=	-0.75 m
Recent changes 1988-1997 (beach monitoring)	=	-0.61 m
Projected retreat over the next 30 years	=	0.75 x 30
	=	22.5 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	5.4 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, the bottom consists of seagrass beds and sand. Behind the beach there is a wetland system which drains to the sea near the southern end of the beach section adjacent to the hotel. Pinneys’s Beach Hotel is protected with a boulder revetment and forms a headland at the southern end of the beach. The beach frontage is not developed except for some beach bars near Golden Rock. Here the foundations of a former beach bar are now in the sea and causing some localized accretion. The factor ‘d’ remains 1.0.

Pinney's Beach 2 (Clark's Estate, Golden Rock to Jessup)

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 105 feet (32 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(17 + 5 +10)1	=	32 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991 (aerial photographs)	=	-0.57 m
Recent changes 1988-1997 (beach monitoring)	=	-0.57 m
Projected retreat over the next 30 years	=	0.57 x 30
	=	17.1 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	4.8 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, the bottom consists of seagrass beds and sand. Most of the beachfront land is occupied by the Four Seasons Resort. Some of the buildings, particularly north of the jetty are close to the beach. A beach nourishment project was undertaken along this beach stretch in 1995 following Hurricane Luis. The factor 'd' remains 1.0.

Pinney's Beach 3 (Jessup to Cotton Ground)

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 128 feet (39 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(11 + 18 +10)1	=	39 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.38 m
Recent changes 1988-1997 (beach monitoring)	=	-0.74 m
Projected retreat over the next 30 years	=	0.38 x 30
	=	11.4 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	17.8 m*

* The shoreline retreat at the site of the former Sandpipers restaurant (120 ft) has been included in the calculation along with that recorded at Jessup and Cotton Ground.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, the bottom consists of algae and rock. This coastal section, which forms a slight bulge projecting into the sea, experienced very serious erosion during Hurricane Luis. The beachfront lands have some development, mainly restaurants and private residences. The factor 'd' remains 1.0.

Pinney's Beach 4 (Cotton Ground to Lawrence Estate)

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 108 feet (33 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(12 + 11 +10)1	=	33 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.40 m
Recent changes 1988-1997 (beach monitoring)	=	-0.81 m
Projected retreat over the next 30 years	=	0.40 x 30
	=	12.0 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	11.1 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, the bottom consists of algae and rock. The beachfront lands have some development, mainly restaurants and private residences. The factor 'd' remains 1.0.

Cades Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 85 feet (26 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(8 + 8 +10)1	=	26 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.27 m
Recent changes 1988-1997 (beach monitoring)	=	-0.03 m
Projected retreat over the next 30 years	=	0.27 x 30
	=	8.1 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	8.0 m *

* There was no data for the shoreline retreat at this site because of the existence of a wall at the shoreline, so the mean value of the two adjacent sites was calculated and used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there are reefs and seagrass beds. The southern section of the bay consists of a low cliff so the setback guidelines for cliffed coasts applies here. There is some development (a restaurant) behind the beach here. The factor ‘d’ remains 1.0.

Jones Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 79 feet (24 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d = setback
(6 + 8 +10)1 = 24 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.20 m
Recent changes 1988-1997 (beach monitoring)	=	No data
Projected retreat over the next 30 years	=	0.2 x 30
	=	6 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995 = 8.0 m *

* There was no data for the shoreline retreat at this site, because this is not a beach monitoring site, so the mean value of the two adjacent sites was calculated and used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise = 10 m

d) Other factors:

Offshore, there are seagrass beds. There is some (mainly residential) development behind the beach here. The factor ‘d’ remains 1.0.

Mosquito Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 98 feet (30 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(15 + 5 +10)1	=	30 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.51 m
Recent changes 1988-1997 (beach monitoring)	=	+0.35 m
Projected retreat over the next 30 years	=	0.51* x 30
	=	15.3 m

* The historical trend shows erosion and the recent trend shows accretion. The historical trend is used here, because although the northern end of the beach has accreted over recent years, the southern end has eroded as evidenced by a recently constructed rock revetment.

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	4.8 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there are seagrass beds. There is residential and tourist development behind this beach. The factor ‘d’ remains 1.0.

Hurricane Hill to Seahaven Estate

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 79 feet (24 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(9 + 5 +10)1	=	24 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.31 m
Recent changes 1988-1997 (beach monitoring)	=	-0.63 m
Projected retreat over the next 30 years	=	0.31 x 30
	=	9.3 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	4.8 m*

* There was no data at this site because of a rock outcrop behind the beach, so the data for Mosquito Bay was used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there is a barrier reef and seagrass beds. There is some residential development at the eastern end of this beach. The factor ‘d’ remains 1.0.

Seahaven Estate to Newcastle Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 85 feet (26 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(10 + 6 +10)1	=	26 m

a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
c predicted coastline retreat by 2030 resulting from sea level rise;
d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991 (aerial photographs)	=	-0.32 m
Recent changes 1988-1997 (beach monitoring)	=	-0.20 m
Projected retreat over the next 30 years	=	0.32 x 30
	=	9.6 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	6.2 m*

* There was no data at this site because of the loss of a reference point, so the data for Nisbett was used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there is a barrier reef and seagrass beds. There is some residential development and the airport behind this beach. The factor ‘d’ remains 1.0.

Nisbett to Camps

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 135 feet (41 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(25 + 6 +10)1	=	41 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.83 m
Recent changes 1988-1997 (beach monitoring)	=	-0.48 m
Projected retreat over the next 30 years	=	0.83 x 30
	=	24.9 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	6.2 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there is a barrier reef and seagrass beds. There is some residential and hotel development behind this beach. The factor ‘d’ remains 1.0.

Camps to Burnaby

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 89 feet (27 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d = setback
(2 + 6 +10)1.5 = 27 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.05 m
Recent changes 1988-1997 (beach monitoring)	=	No data
Projected retreat over the next 30 years	=	0.05 x 30
	=	1.5 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995 = 6.2 m*

*No data, so the data for Nisbett was used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise = 10 m

d) Other factors:

Offshore, there is a barrier reef and seagrass beds. There is some residential development behind this beach. At Burnaby there is an accretionary feature projecting into the sea and protected by reefs. Based on experience in other islands, e.g. Dieppe Spit in St. Kitts, such features are vulnerable to very rapid change should there be any damage to the reefs as a result of a hurricane. The factor ‘d’ is therefore 1.5.

Longhaul Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 59 feet (18 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(+(4) + -6 + -10)1.5	=	18 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	+0.13 m
Recent changes 1988-1997 (beach monitoring)	=	+0.03 m
Projected change over the next 30 years	=	+0.13 x 30
	=	+3.9 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	6.2 m*

*No data, so the data for Nisbett was used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there are extensive seagrass beds and the bay is protected by coral reefs. There is some residential development behind this beach. There is an accretionary feature projecting into the sea at the southeastern end of the bay, this was not present in the 1946 photographs. Based on experience in other islands, e.g. Dieppe Spit in St. Kitts, such features are vulnerable to very rapid change should there be any damage to the reefs as a result of a hurricane. The factor ‘d’ is therefore 1.5.

White Bay

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 131 feet (40 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(4 + 2 + 10)2.5	=	40 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.05 m
Recent changes 1988-1997 (beach monitoring)	=	-0.83 m
Projected retreat in the next 30 years	=	-0.05 x 30
	=	-1.5 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	3.6 m*

*No data, so the data for Indian Castle was used.

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there are coral reefs. The land behind the beach is largely undeveloped. It is backed by extensive sand dunes. The primary sand dune must be viewed as a temporary feature since its function is to supply sand to the beach during storms and hurricanes. The primary dune should remain undeveloped, so new development should be positioned landward of the primary dune. The factor ‘d’ is therefore 2.5.

Indian Castle

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 125 feet (38 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(1 + 4 + 10)2.5	=	38 m

- a projected change in coastline position over the next 30 years based on recorded changes between 1946 and 1997;
- b projected changes in coastline position likely to result from a major hurricane (based on data from Hurricane Luis);
- c predicted coastline retreat by 2030 resulting from sea level rise;
- d other factors.

a) Projected change in coastline position based on recorded changes 1946-1991:

Historical change 1946-1991(aerial photographs)	=	-0.03 m
Recent changes 1988-1997 (beach monitoring)	=	-1.99 m
Projected retreat in the next 30 years	=	-0.03 x 30
	=	-0.9 m

b) Projected changes in coastline position resulting from a major hurricane:

Land/dune retreat resulting from H. Luis in 1995	=	3.6 m

c) Predicted coastline retreat resulting from likely sea level rise:

Coastline retreat by 2030 due to sea level rise	=	10 m

d) Other factors:

Offshore, there are coral reefs. The land behind the beach is largely undeveloped. It used to be backed by extensive sand dunes and a palm plantation. However, in the 1980s these dunes were extensively mined and after the mining stopped in the early 1990s some sand was pushed up into low mounds where the dunes had been. These partially restored sand dunes are temporary features since they will be eroded to supply sand to the beach during storms and hurricanes. These partially restored dunes should be left undeveloped, so new development should be positioned landward of the partially restored dune. The factor ‘d’ is therefore 2.5.

List of Reports in the Series "Planning for Coastline Change"

1. Coastal Development Setback Guidelines in Antigua and Barbuda.

2a. Coastal Development Setback Guidelines in Nevis.

2b. Shoreline Management in Nevis: A Position Paper.

3. Coastal Development Setback Guidelines in St. Lucia.

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