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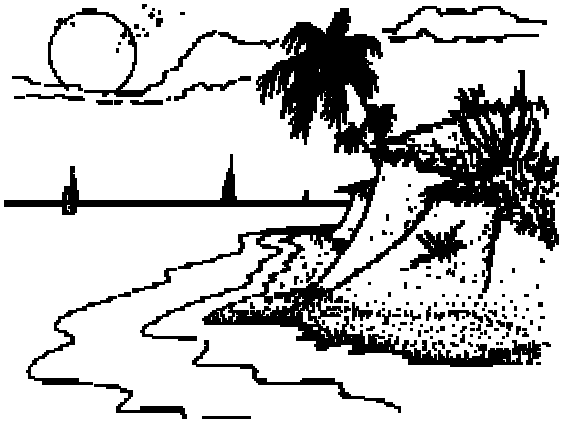
COAST AND BEACH STABILITY IN THE CARIBBEAN ISLANDS

PLANNING FOR COASTLINE CHANGE

1
COASTAL DEVELOPMENT SETBACK GUIDELINES IN ANTIGUA AND BARBUDA



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

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Crabhill Bay, Antigua, September, 1991. Buildings constructed on the beach are extremely vulnerable to storm and hurricane damage and their positioning so close to the water may lead to the ultimate loss of the beach.

1. EXECUTIVE SUMMARY

Coastlines, and beaches in particular, are dynamic fast-changing systems which are vitally important to the tourism-oriented economy of Antigua and Barbuda, 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 Antigua and Barbuda. These setbacks apply to all development: houses, hotels, villas, commercial buildings, whether made of wood or cement, airports, roads and 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 based on historical changes over the last thirty years, measured changes over the past six 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 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 100 feet (30 m) landward of the line of permanent vegetation;*
Category 3	*setback is 130 feet (40 m) landward of the line of permanent vegetation;*
Category 4	*setback is 300 feet (91 m) landward of the line of permanent vegetation.*

One exception has been made for beach bars/restaurants, (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) landward of the vegetation line.

Most of the beaches in Antigua fall into Categories 1 and 2, while three beaches fall into Category 3. The beaches along the south and west coast of Barbuda fall into Categories 3 and 4, with the exception of the sand bar from Low Bay to the southern end of Codrington Lagoon, where no development should take place. Beaches along the east coast of Barbuda are in Category 2.

On coasts fringed by mangroves and wetlands, specific setback determination must await completion of an ongoing mangrove inventory and prioritization project. In the meantime it is recommended that development in such areas should carefully follow the guidelines in the Development Control Authority Regulations (1996, No. 20). If development is permitted on small sandy cays, it is recommended that it be restricted to wooden piled structures. This is because of the vulnerability of these sandy cays to tropical storms and hurricanes.

Implementation of these setback guidelines will provide the planning authorities in Antigua and Barbuda 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 Antigua and Barbuda where the tourism industry is the mainstay of the economy and is still very much beach orientated. The up-market focus of the tourism industry makes it particularly sensitive to the quality of these resources.

Yet in Antigua and Barbuda, as has been seen in other Caribbean islands, the growth of the tourism 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 tourism 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 Antigua and Barbuda. 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 Antigua and Barbuda. This report is primarily addressed to planners and coastal manager. The project 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, 1996a). Within the project “Planning for Coastline Change” this same methodology is being adapted to Antigua and Barbuda, Nevis and St. Lucia. Antigua and Barbuda is the subject of this present report.

3. BACKGROUND

3.1 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 (10 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.

3.2 Existing Coastal Development Setbacks in Antigua and Barbuda

In Antigua and Barbuda, the coastal setback distance used to be 50 feet (15 m) from the high water mark. However, the Land Development and Control Regulations (1996, No. 20) made by the Minister under section 23 of the Land Development and Control Act Cap. 235 prescribe new conditions for development close to the shoreline, see Table 1. Part A of the Third Schedule of these regulations describes conditions for the development of the shoreline and submerged lands, and Part B deals with for reclaimed land. Part D prescribes new setback distances, specifically no building shall be closer than 100 feet (30 m) to the high water mark.

However, these Regulations have only recently been enacted in Antigua and Barbuda and are therefore in the preliminary stages of implementation by the Development Control Authority. Furthermore, they appear to be arbitrarily determined and therefore difficult to justify and explain to developers.

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. For instance in Nevis, very generous setbacks (300 feet / 90 m from the high water mark) have not been fully implemented mainly because people consider them unrealistic (Robinson, 1997).

Hurricane Luis, a Category 4 hurricane, which passed over Antigua and Barbuda in September, 1995, helped to change some of that thinking. There was dramatic shoreline erosion (Black *et al.*, 1996, Cambers, 1996b). However, public memory of such events is often very short.

Some countries 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 partially dependent on the tourism 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 tourism 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 Antigua and Barbuda 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.

Table 1. Conditions for the Development of Land Adjacent to the Shore and on Submerged and Reclaimed Lands. (Antigua and Barbuda Land Development and Control Regulations 1996, No. 20).

Part A Shoreline and Submerged Lands

1. Any application for development adjacent to the shoreline or on land which is wholly or partially submerged at some or all times will require the following additional data and be subject to the following conditions:

    (i) A written report by a competent professional describing the prevailing environmental conditions including the ecology, hydrogeology, and water movements in relation to the land and adjacent properties.

    (ii) A report containing the exact description of the land to which the application refers including maps, photographs, topographic contours and sub-surface profiles in such detail as is appropriate to the scope and complexity of the land and the proposed development.

    (iii) A report containing a complete description of the proposed development defining precisely the modifications, alterations and construction methods, with details of the procedures proposed for supervision and control of the proposed development.

2. No sand shall be removed from any land wholly or partially submerged, or being near to any beach without specific prior written approval of the Authority.

3. The applicant shall within six months of completion of the development to which this part applies submit to the Authority a report which will describe in detail the actual work carried out on the land, the movement of earth and the environmental conditions of the land including the properties adjacent to the land.

4. The provisions of Part D in this Schedule (which relates to set-backs) are also applicable to land to which this part of this Schedule applies.

Part B Reclaimed Land

1. A permit for the development of any reclaimed land shall include a condition that after completion of the development, the land shall have a minimum elevation of five feet above the high water mark

Part D Setbacks from Boundaries

5. With respect to land between a shoreline and a road:

    (i) No building shall be permitted unless the lot on which it is intended to stand is at least 150 feet in distance from the road to the mean shoreline measured from the high water mark at right angles to the nearest edge of the road right-of-way.

    (ii) No building shall be closer than 100 feet (30 m) to the high water mark.

    (iii) Setbacks at cliffs shall be at the discretion of the Authority.

4. METHODOLOGY

Based on the coastal form of the small Caribbean islands, five major coastal types can be identified in Antigua and Barbuda:

1. cliffs;
2. low rocky shores;
3. small sandy offshore cays;
4. mangrove coastlines;
5. 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.

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/metres 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 Antigua may be divided into three sections (Multer *et al* 1986):

- the Southwestern Volcanic Group where the Basal Volcanic Suite exists (this covers the coastline from Ballast Bay to Mamora Bay);
- the Central Plain Group which consists of sedimentary rocks and some volcanics (this covers the northwest coastline from St. John's to Wetherills Point and the southeast coastline in the Willoughby Bay area);
- the Northeastern Uplands which are made up of the Antigua Formation, a group of limestone rocks (this covers the coastline from Wetherills Point to Lynch Point in Willoughby Bay).

The Central Plain Group of sedimentary rocks are softer and more vulnerable to erosion. However, there are very few coastal cliffs in this geological formation, only at Corbison Point and Wetherills Point on the northwest coast and around Willoughby Bay in the southeast. The limestone cliffs in the northeast and volcanic cliffs in the southwest may be considered "hard" rock cliffs and have not been differentiated for the purposes of setbacks. So therefore a blanket guideline of 50 feet (15 m) from the cliff edge is recommended for development close to coastal cliffs.

Barbuda consists of low Pleistocene limestones overlapped by modern reef and sand deposits. Most of the land surface is less than 25 feet (8 m) high. The Highlands near the east coast are the only area of significant height reaching more than 100 feet (30 m). Since these are composed of limestone, the same guideline of 50 feet (15 m) from the cliff edge is recommended for development here.

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 Antigua and Barbuda, 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 Antigua, these shores are usually composed of limestone or sometimes volcanic rock, while in Barbuda they are made of limestone. 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 windward coasts, there may be no tree of 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 Small Offshore Cays

There are several small offshore cays in the North Sound area off the northeastern coast of Antigua and in the northern section of Barbuda. Most of the cays in the North Sound area are rocky or at least have a rock base. One exception is Maiden Island in North Sound which was formed wirh material dredged from the Airport project. Sandy cays in particular, are very vulnerable formations, they may temporarily or permanently disappear during a major hurricane. Furthermore, they may reform after the hurricane in a different location. For these reasons it is recommended that if development is permitted on these sandy cays, then it should consist of small individual buildings made of wood and with no concrete foundations. Actual setback distances should be determined using setback values for nearby beaches on the mainland. On rocky cays, the same setbacks as described for low rocky shores on the mainland of Antigua and Barbuda should be applied, see Section 4.2.

On small sandy offshore cays, if new development is permitted, it should consist of small individual buildings made of wood and with no concrete foundations.

4.4 Setback Guidelines for Mangrove Coastlines

Much of the eastern coast of Antigua, extending from Barnacle Point near the airport to Nonsuch Bay consists of a mangrove coastline. It has been estimated that more than 11% of Antigua's coastline consists of mangroves/wetlands (Cambers, 1991). These wetland systems may consist of narrow bands of fringing mangroves or extensive mangrove forests extending several hundred yards inland as at Fitches Creek or to the east of Parham. Similarly in Barbuda there are extensive wetland systems on the northern part of Goat Island and at the northern end of Codrington Lagoon.

Development in wetland areas requires special consideration. Wetlands, besides being immensely important ecologically and economically from a fisheries perspective, also play an important role in pollution reduction, formation of new land and the protection coastal areas during storms and hurricanes. As with beaches, it is impossible to provide just one blanket setback distance for all mangrove areas. Each wetland area is different - physically, ecologically and economically.

Furthermore, the concept of the permanent tree line as the baseline for measurement may have to be reconsidered in these coastal forests.

A wetland inventory is being prepared by the Environmental Awareness Group in Antigua and Barbuda under the GEF Small Grants Program entitled "Information Gathering for Wetlands Conservation." This inventory will list and assess all the wetland areas and will also prioritize the wetlands in terms of physical, ecological and socio-economic characteristics. This inventory is scheduled for completion by the end of 1998. Once complete, the government of Antigua and Barbuda will be in a position to determine which wetland areas should or should not be developed, and if development is to be permitted, the width and the nature of appropriate buffer zones and setbacks.

Furthermore, the Fisheries Division are reviewing a list of proposed marine reserves, these include the following:

Hanson Bay and the Flashes,
Pinching Bay,
Yorks Salt Pond,
Johnson's Point to Old Road Bluff,
Willoughby Bay/Christian Cove,
Area between Green Island and Indian Town Point,
Boon Point to Indian Town
Barbuda Lagoon including the Bird Sanctuary.

If and when these reserves are designated, then special conditions relating to development in these areas will prevail.

Since these two projects, the wetlands inventory and the marine reserve designation, are in progress, further detailed recommendations regarding coastal development in wetland areas must await the completion of these projects. However, in the meantime it is recommended that any persons wishing to develop land in wetland areas should be advised to carefully follow the guidelines laid out in Part A of the Third Schedule of the Regulations for the Land Development Control Act, see Table 1. Furthermore, it is recommended that the Fisheries Division and the Environment Unit should be fully involved in the review of such applications.

4.5 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 Antigua and Barbuda. This allows for greater setbacks on eroding beaches 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. Furthermore, 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 landward of the primary dune, see Figure 1. Sometimes there is no "tree line" in sand dune areas, instead the dunes are covered with grass and vines. In such cases the baseline for measurement will be the crest (top) of the primary (most seaward) dune. It is essential to maintain the primary dune intact and free of development.

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

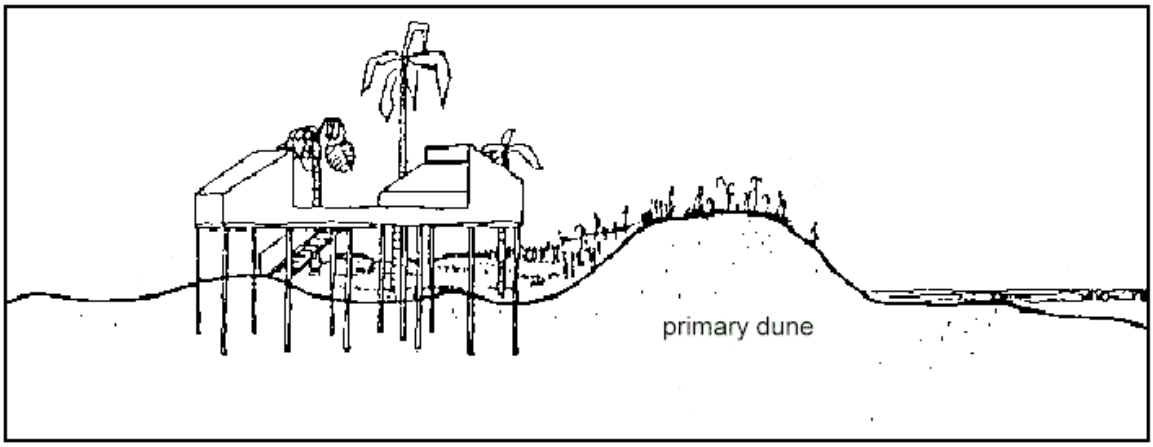


Figure 1. Recommended Construction on a Dune.

The primary dune has been left intact. The building has been built on piles so as to allow 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).

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 Antigua one setback value was calculated for each beach. However, in Barbuda the coastline is not divided by rock headlands into separate beaches. So in Barbuda the coastline was divided into sections.

Setbacks have been developed for individual beaches 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 1968 and 1997 in Antigua and 1958 and 1997 in Barbuda;

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.

In Antigua, aerial photographs from 1968 and 1991 were compared to determine historical coastline changes. In Barbuda the photographs from 1958 and 1991 were compared. Beach monitoring has been ongoing in Antigua since 1991 and in Barbuda since 1995 and is conducted by the Fisheries Division within the regional Coast and Beach Stability in the Caribbean Islands (COSALC) project. Trends from these two data sets were used to project coastline changes over the next 30 years ("**a**" in the above formula). In most, but not all, cases the historical data from the aerial photographs was used to determine **"a**" mainly because of the longer time period. However, there were some exceptions, see Appendix I and the specific data for each beach in Appendix II.

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 Antigua and Barbuda 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 in Antigua and Barbuda. 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 the sea level will rise in Antigua and Barbuda by 1 feet (0.3 m) over the next 100 years. 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.

5. COASTAL DEVELOPMENT SETBACKS IN ANTIGUA AND BARBUDA

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

- on 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.

For coastlines fringed by mangroves and wetlands, setbacks will be determined for individual systems based on the ongoing mangrove inventory and the relative importance of particular mangrove systems. As with beaches, there will be different setbacks for individual mangrove systems. Until the mangrove inventory is complete (end of 1998/beginning of 1999), it is recommended that the Land

Development Control Authority Regulations (1996, No. 20) should be applied to all applications dealing with development in wetlands, especially Parts A and B of the Third Schedule, see also Table 1. It is further recommended that during the review process, applications for development in wetlands should be referred to the Fisheries Division and the Environment Unit.

Specific setbacks have been determined for individual beaches in Antigua and Barbuda. In all cases these are measured landwards of the line of permanent vegetation (tree line/scrub line). These setbacks apply to all types of development - houses, hotels, villas, commercial buildings, whether wood or concrete, roads and 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 beach restaurants and/or bars, on the grounds that their economic viability depends on their proximity to the beach. In the past they have sometimes been permitted on the beach itself, however, these structures should be set back at least 25 feet (8 m) landwards of the vegetation line.

Table 2 shows the setbacks for specific beaches in Antigua and Barbuda. Setbacks have been calculated for all the major beaches in Antigua. However, there are some smaller beaches where no specific setback has been determined. For these beaches, setbacks should be determined on the basis of the value for the nearest adjacent beach provided they have similar characteristics. Appendix II details how the setback was calculated for each beach.

While Table 2 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 100 feet (30 m) landward of the line of permanent vegetation;
Category 3	Setback 130 feet (40 m) landward of the line of permanent vegetation;
Category 4	Setback 300 feet (91 m) landward of the line of permanent vegetation.

Table 2. Setback Distances for Beaches in Antigua and Barbuda

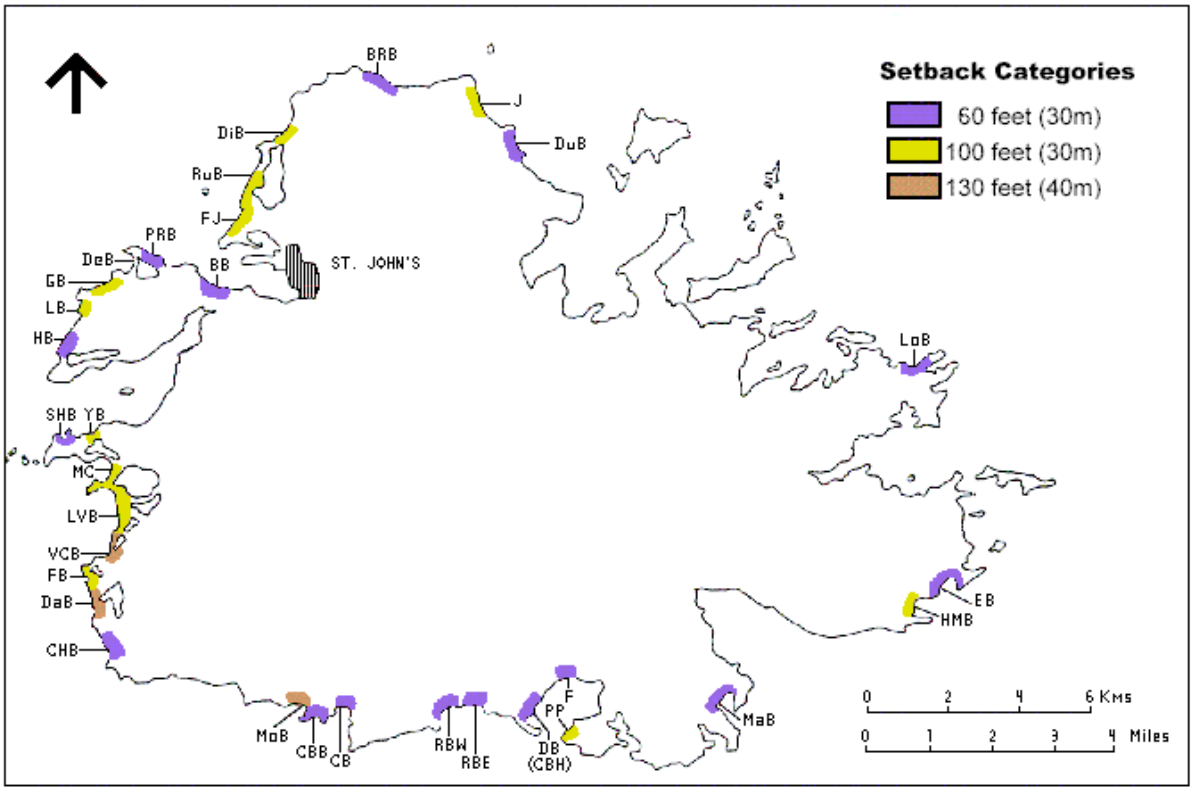
Beach/Coastal Section	Setback distance in feet	Setback distance in metres	Beach/Coastal Section	Setback distance in feet	Setback distance in metres
ANTIGUA			Carlisle Bay	79	24
Dickenson Bay	102	31	Rendezvous Bay West	46	14
Runaway Bay	105	32	Rendezvous Bay East	75	23
Fort James	98	30	Deep Bay (Colony Hotel)	39	12
Ballast Bay	56	17	Falmouth	36	11
Pillar Rock Bay	49	15	Pigeon Point	98	30
Deep Bay	79	24	Mamora Bay	49	15
Galley Bay	82	25	Halfmoon Bay	82	25
Landing Bay	102	31	Exchange Bay	56	17
Hawksbill Bay	62	19	Long Bay	52	16
Yorks Bay	102	31	Dutchman Bay	43	13
Stony Horn Bay	49	15	Jabberwock	98	30
Mosquito Cove	92	28	Blackrock Bay	56	17
Lignumvitae Bay	98	30	**BARBUDA**		
Valley Church Bay	121	37	Low Bay	276	84
Ffryes Bay	102	31	Palmetto Point	374	114
Darkwood Beach	135	41	Dulcina Hotel - Jetty	212	37
Crab Hill Bay	75	23	Cocoa Point	315	96
Morris Bay	118	36	Governor Bay	115	35
Curtain Bluff	79	24			

In each category the setback is the minimum acceptable, greater setbacks should always be encouraged. Table 3 lists the beaches under the various categories and Figures 2 and 3 show maps with the setback categories in Antigua and Barbuda.

Table 3. Setback Categories for Beaches in Antigua and Barbuda

Category 1 Setback = 60 feet (18 m)	**Category 2 Setback = 100 feet (30 m)**	**Category 3 Setback = 130 feet (40 m)**	**Category 4 Setback = 300 feet (91 m)**	**No Development Category**
ANTIGUA Ballast Bay, Pillar Rock Bay, Deep Bay, Hawksbill Bay, Stony Horn Bay, Crab Hill Bay, Curtain Bluff Bay, Carlisle Bay, Rendezvous Bay West, Rendezvous Bay East, Deep Bay (Colony Hotel), Falmouth, Mamora Bay, Exchange Bay, Long Bay, Dutchman Bay, Blackrock Bay.	**ANTIGUA** Dickenson Bay, Runaway Bay, Fort James, Galley Bay, Landing Bay, Yorks Bay, Mosquito Cove, Lignumvitae Bay, Ffryes Bay, Pigeon Point, Halfmoon Bay, Jabberwock. **BARBUDA** East coast beaches from Spanish Point to Hog Point.	**ANTIGUA** Valley Church Bay, Darkwood Beach, Morris Bay. **BARBUDA** Dulcina Hotel to Airstrip near Cocoa Point, Governor Bay.	**BARBUDA** Cocoa Point spit, Palmetto Point spit (promontory), sand bar west of Codrington Lagoon and north of Low Bay.	**BARBUDA** Sand bar west of the Codrington Lagoon between Low Bay and the southern end of the lagoon.

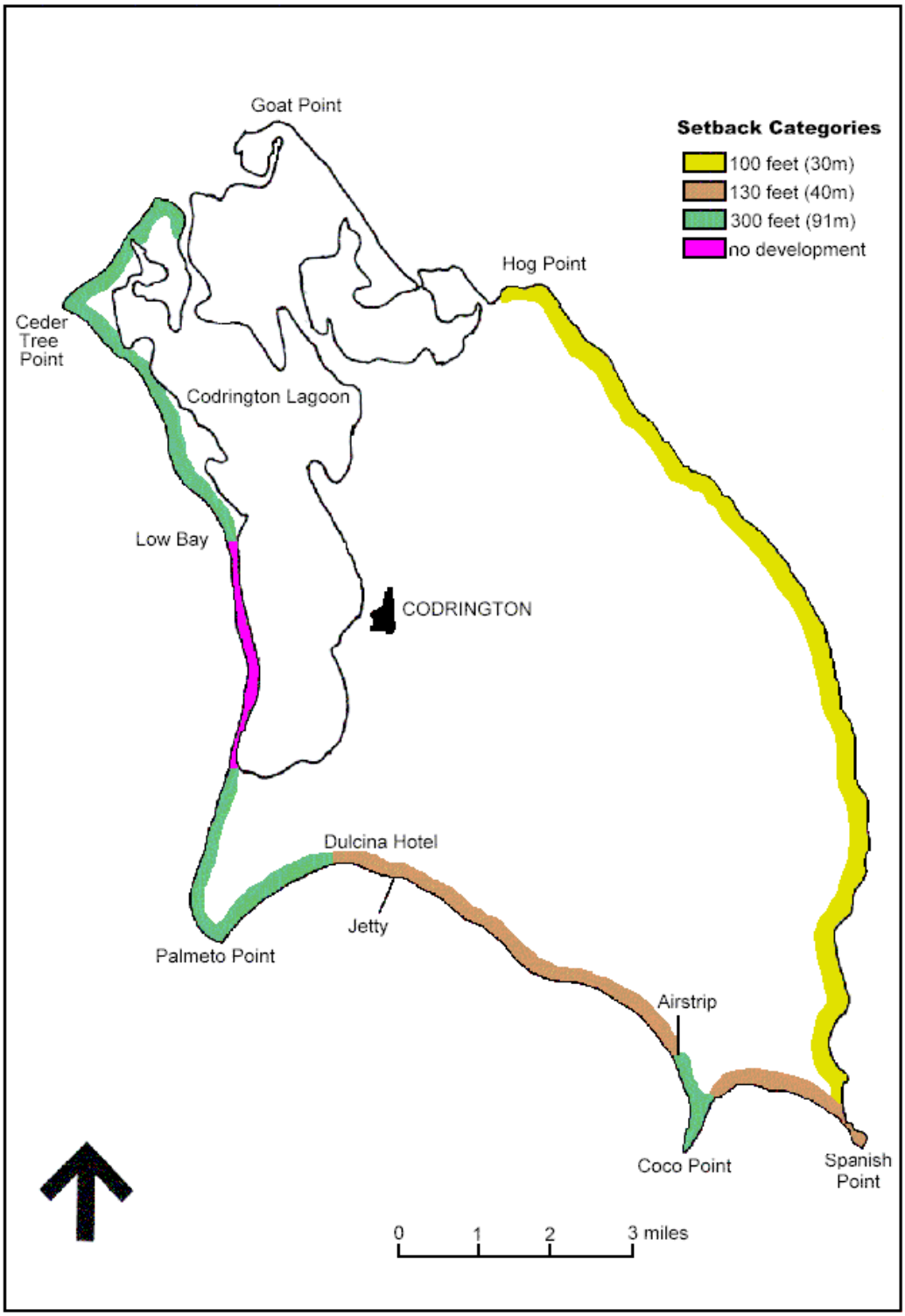
Figure 2. Beach Setback Categories in Antigua.



Key

BB	Ballast Bay	EB	Exchange Bay	MaB	Mamora Bay
BRB	Black Rock Bay	F	Falmouth	MC	Mosquito Cove
CB	Carlisle Bay	FB	Ffryes Bay	MoB	Morris Bay
CBB	Curtain Bluff Bay	FJ	Fort James	PP	Pigeon Point
CHB	Crab Hill Bay	GB	Galley Bay	PRB	Piller Rock Bay
DaB	Darkwood Bay	HB	Hawksbill Bay	RBE	Rendezvous Bay East
DB/	Deep Bay/	HMB	Halfmoon Bay	RuB	Runaway Bay
CBH	Colony Beach Hotel	J	Jabberwock	RBW	Rendezvous Bay West
DeB	Deep Bay	LB	Landing Bay	SHB	Stony Horn Bay
DiB	Dickenson Bay	LoB	Long Bay	VCB	Valley Church Bay
DuB	Dutchman Bay	LVB	Lignumvitae Bay	YB	Yorks Beach

Figure 3. Beach Setback Categories in Barbuda.



In Antigua most of the beaches fall into the two lower setback categories: 60 feet (18 m) and 100 feet (30 m). Three beaches: Valley Church Bay, Darkwood Beach and Morris Bay fall into Category 3, 130 feet (40 m). In all cases the setback distance is to be measured from the line of permanent vegetation.

In Barbuda the setback distances are higher. This is mainly a function of the low lying, exposed nature of Barbuda's coastline. (In Antigua, the coastline is very indented and many of the beaches lie at the head of sheltered bays). Furthermore, along the west coast of Barbuda and at places on the south coast, the coastline is made up of sand bars and sand spits. These features are very vulnerable to changes during tropical storms and hurricanes. Thus in Barbuda, the south coast, with the exception of Cocoa Point and Palmetto Point (see Figure 3) falls into the Category 3 setback group, 130 feet (40 m). Cocoa Point and Palmetto Point fall into Category 4, 300 feet (91 m). Again setback distances are measured from the line of permanent vegetation.

The sand bar separating the Codrington Lagoon from the sea is very narrow in places (less than 50 m) and tropical storms and hurricanes result in channels being cut through this narrow bar to the lagoon. While the channels usually become filled with sand and disappear in the months after the storm event, the bar must nevertheless be regarded as a temporary formation and is not suitable for permanent development. In particular no development should be permitted between Low Bay and the southern end of Codrington Lagoon, see Figure 3. The section of the bar north of Low Bay is wider (maximum 2 000 feet, 600 m) and here the recommended minimum setback is 300 feet (91 m) from the line of permanent vegetation and any development should be restricted to wooden piled structures with no concrete foundations.

Setback distances have been estimated only for the low lying parts of the east and north coast of Barbuda. Along parts of the east coast there is a sand terrace, 200 - 300 feet (60 – 90 m)wide, below a limestone cliff. Many of the beaches here are protected with coral reefs. It is recommended that development here be located a minimum of 100 feet (30 m) from the line of permanent vegetation (Category 2).

These setback categories will allow for ease of implementation by the Development Control Authority in Antigua and Barbuda. For specific applications, planners can refer to Table 1 to obtain the specific setback value for a beach, and to Appendix II for details on the way in which the setback was calculated as well as specific data on recent hurricane damage and beach changes during the past six years.

Once the setback standards are incorporated into Antigua and Barbuda's 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 Halfmoon Bay falls into Category 2, so the setback here should be 100 feet (30 m). However, reference to Table 3 and Appendix II shows that the specific setback calculation for Halfmoon Bay is 82 feet (25 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 82 feet (25 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 Development Control Authority can work to ensure that coastal development in Antigua and Barbuda is sustainable and that beach erosion is reduced. It is recommended that the government of Antigua and Barbuda incorporate these setback guidelines into their planning regulations as soon as the Physical Development Bill, at present under consideration, is passed into law. It is envisaged that the setbacks can be revised as the beach monitoring programme conducted by the Fisheries Division continues and as other information becomes available. As Antigua and Barbuda move towards developing an integrated coastal area management approach, the implementation and further revision of these setback guidelines will provide an important tool.

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APPENDIX I

DETAILED METHODOLOGY FOR THE CALCULATION OF SETBACKS AT BEACHES

a) Projected change based on historical measurements ("a")

Several sets of aerial photographs exist for Antigua and Barbuda dating back to the 1940s. These have been listed by Williams, 1990. However, very few sets of photographs covering the entire island are stored at the Surveys Division in Antigua and some of these were damaged during Hurricane Luis. Based on the available sets of photographs at the Surveys Division, historical changes in coastline position were determined for the major beaches in Antigua using the following aerial photographs:

1968 black and white aerial photographs flown by Fairey Survey, U.K., at a scale of 1:20,000 for the entire island and at a scale of 1: 12,500 for the area north of Freemans Village.

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

For changes in Barbuda the following sets of photographs were used:

1958 black and white aerial photographs flown by the USAF at a scale of 1:24,000 covering the entire island.

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

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 downwards 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 two 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. Two sets of photographs were used, these represent just two time series: March, 1968 and February, 1991 for Antigua and January, 1958 and February/March, 1991 for Barbuda. 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 week to the next especially if a major winter swell or "groundsea" event occurs. Furthermore some of the photographs were taken during winter swell conditions. For instance both the 1968 and 1991 photographs of the west coast of Antigua were taken during winter swell conditions which sometimes made it difficult to determine position of the

the position of the offshore step. Tidal variations also exist, although tidal range in Antigua and Barbuda 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 nineteen beaches around Antigua and along the west, south and east coasts of Barbuda. These data are detailed and far more accurate than the historical changes determined from the aerial photographs. However, they only cover a short time period, 1991-1997 for Antigua and 1995-1997 for Barbuda, and do not cover all the beaches.

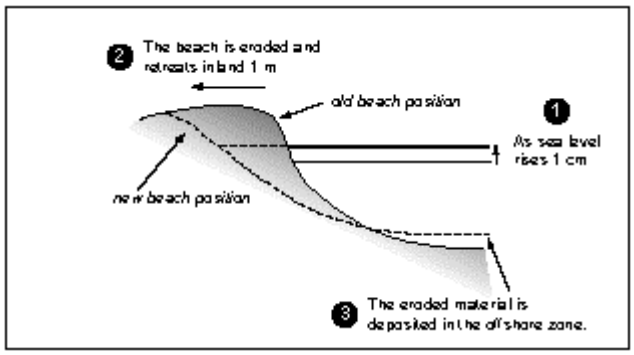
For each beach a coastline change per year figure was calculated. Two data sources were used: the aerial photographs and the beach monitoring data. In most cases the beach monitoring data showed higher rates of change, this is thought to be due to the shorter time period. So the figure obtained from the aerial photographs was used in most cases to determine "**a**.". However, a few cases arose in which the two measurements conflicted e.g. historically a site showed erosion but within recent years, the beach monitoring data showed accretion. In such cases local information was used to determine which time frame should take precedence. Usually the historical data took precedence because it covered a much longer time period. However, in cases where a recent sea defence structure such as a groyne or breakwater had been constructed, the more recent trend might take precedence. Alternatively at a few beaches where trends were in the opposite direction, the average of the two trends was used. The data for each beach, see Appendix II, shows in detail how the projected change based on historical measurements ("**a**") was determined.

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 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. At non-monitored beaches, visual observations were combined with measurements from the adjacent monitored beaches. These data were used to estimate the likely change from a future major hurricane at each beach in Antigua and Barbuda.

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. Bays protected by nearshore reefs usually experienced less erosion during the 1995 hurricanes than those which were more exposed. Coastline shape was another factor, e.g. in Antigua, which has a very indented coastline where there are small bays within larger bays, the more sheltered bays suffered less damage during Hurricane Luis (Black *et al.*, 1996).
- **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 Antigua & Barbuda. Most of the observations relating to offshore systems was derived from Weiss and Multer, 1988. This map was produced before Hurricane Hugo in 1989 and Hurricane Luis in 1995, both of which probably caused extensive changes to the offshore ecosystems.

- **Coastal features and formations**: Features such as exposed beachrock provide indicators of long term erosion. Similarly 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 and dunes remove protective barriers which can damage the 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 feet (30 m) 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 countries such as Antigua and Barbuda. 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. A value of 1 means that none of the factors are especially significant, while a value of 2 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;
1.2-1.3	one or more factors result in moderate vulnerability to coastline change;
2	one or more factors result in high vulnerability to coastline change.

APPENDIX II

SETBACK CALCULATIONS FOR INDIVIDUAL BEACHES IN ANTIGUA AND BARBUDA

(Note that in the calculation of **"a**" Projected change in coastline position based on recorded changes 1968-1997, the value has been based in most cases on the aerial photograph comparison only. In cases where other data have been used, such as the recent beach changes 1991-1997, this is explained in the text of the table dealing with each beach).

ANTIGUA

Dickenson Bay
Runaway Bay
Fort James
Ballast Bay
Pillar Rock Bay
Deep Bay
Galley Bay
Landing Bay
Hawksbill Bay
Yorks Bay
Stony Horn Beach
Mosquito Cove
Lignumvitae Bay (Jolly Beach)
Valley Church Bay
Ffryes Bay
Darkwood Beach
Crab Hill Bay
Morris Bay
Curtain Bluff
Carlisle Bay
Rendezvous Bay West
Rendezvous Bay East
Deep Bay (Colony Beach Hotel)
Falmouth
Pigeon Point
Mamora Bay
Halfmoon Bay
Exchange Bay
Long Bay
Dutchman Bay
Jabberwock
Blackrock Bay (Boons Bay)

BARBUDA

Low Bay
Palmetto Point
Dulcina Hotel (abandoned) to the Jetty
Cocoa Point
Governor Bay

Dickenson Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 102 feet (31 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(15 + 6 +10)1	=	31 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.50 m
Recent changes 1991-1997 (without the effects of Hurricane Luis 1995)	=	-1.08 m
Projected retreat over the next 30 years	=	0.5 x 30
	=	15 m

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

Land/dune retreat resulting from H. Luis in 1995	=	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, the bottom consists of seagrass beds and some scattered patch reefs. The aerial photographs for 1968 show a channel connecting Mc Kinnons Pond to the sea at the southern end of Dickenson Bay. By 1991, the pond had no seaward exit due to road construction. Many of the buildings on this beach are protected with walls and rock revetments. There is a boulder groyne near the centre of the bay in front of Antigua Village Hotel. The bay is exposed to wave action and winter swells. Most of the beach frontage is already developed. The factor ‘d’ remains 1.0.

Runaway Bay, Antigua

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
(7 + 10 +10)1.2	=	32 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.22 m
Recent changes 1991-1997 (without the effects of Hurricane Luis 1995)	=	-0.58 m
Projected retreat over the next 30 years	=	0.22 x 30
	=	7 m

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

Land/dune retreat resulting from H. Luis in 1995	=	10 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 bare sand and further out there is seagrass. Parallel to the southern part of the bay there are some small patches and banks of corals. At Corbison Point and south of Sunset Cove Hotel there are some rock outcrops offshore. There are several hotels on this beach although the development is not as dense as Dickenson Bay. The bay is exposed to wave action and winter swells. Since 1996 the northern section of the bay has experienced severe erosion and several property walls have collapsed and been replaced with sheet piling and rock revetments. In view of the severe recent erosion the factor 'd' is 1.2.

Fort James, Antigua

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
(10 + 10 +10)1	=	30 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.33 m
Recent changes 1991-1997 (without the effects of Hurricane Luis 1995)	=	-0.62 m
Projected retreat over the next 30 years	=	0.33 x 30
	=	10 m

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

Land/dune retreat resulting from H. Luis in 1995	=	10 m*

* This figure is based on observations of the loss of the coastal road and the measured damage at an adjacent beach (Runaway Bay).

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

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

d) Other factors:

This beach formed the seaward face of a sandy spit. Offshore, there used to be a sandy bottom which gave way to a bank of coral. However, the area has been extensively dredged and altered. In addition is has experienced sand mining and vegetation removal. The beach is exposed to wave action and winter swells. There is some development behind the beach. The factor 'd' remains 1.0.

Ballast Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 56 feet (17 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(1 + 6 + 10)1	=	17 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.04 m
Recent changes 1991-1997 (without the effects of Hurricane Luis 1995)	=	No data
Projected retreat over the next 30 years	=	0.04 x 30
	=	1.2 m

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

Land/dune retreat resulting from H. Luis in 1995	=	6 m*

* This figure is based on measurements from nearby beaches, Runaway Bay and Deep Bay.

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. At the eastern end of the beach, undermined and fallen trees indicated erosion. There is very little development behind this beach. The beach has some degree of shelter but is still exposed to winter swells. The factor ‘d’ remains 1.0.

Pillar Rock Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 49 feet (15 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(+1 + -6 + -10)1	=	15 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	+0.04 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	No data
Projected change over the next 30 years	=	0.04 x 30
	=	+1.2 m

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

Land/dune retreat resulting from H. Luis in 1995	=	6 m*

* This figure is based on measurements from nearby beaches, Runaway Bay and Deep Bay.

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 fringing and bank reefs. There is some beachfront development at this bay. The bay is exposed to wave action but receives some protection from nearby reefs. The factor 'd' remains 1.0.

Deep Bay, Antigua

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
(12 + 2 + 10)1	=	24 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.39 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	-0.86 m
Projected retreat over the next 30 years	=	0.39 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	=	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:

This bay is very sheltered, protected by two prominent headlands. Offshore there are seagrass beds and scattered coral reefs at the two headlands. The beach encloses a saltpond. There is a major hotel development at this beach. The factor ‘d’ remains 1.0.

Galley Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 82 feet (25 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(5 + 10 + 10)1	=	25 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.17 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	0.17 x 30	
		=	5.0 m

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

Land/dune retreat resulting from H. Luis in 1995 = 10 m*

* This is based on reports of extensive damage to the beach and hotel by Hurricane Luis in 1995 and the measured change at a nearby beach with a similar aspect - Runaway Bay.

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 sand with scattered coral heads, which then gives way to seagrass beds. The bay is exposed to wave action. The beach encloses a saltpond. There is a major hotel development at this beach. The factor ‘d’ remains 1.0.

Landing Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 102 feet (31 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(15 + 6 + 10)1	=	31 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.50 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	0.50 x 30	
		=	15.0 m

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

Land/dune retreat resulting from H. Luis in 1995 = 6 m*

* This is based on measurements at Runaway Bay, a beach with a similar aspect, and a nearby beach, Deep Bay.

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 and reefs at the southern headland. The bay is exposed to wave action. There is a hotel development at the southern end of the beach. The factor ‘d’ remains 1.0.

Hawksbill Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 62 feet (19 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(3 + 6 + 10)1	=	19 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.11 m
Recent changes 1991-1997 (without the effects of Hurricane Luis 1995)	=	No data
Projected retreat over the next 30 years =	0.11 x 30	
	=	3.3 m

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

Land/dune retreat resulting from H. Luis in 1995	=	6 m*

* This is based on measurements at Runaway Bay, a beach with a similar aspect, and a nearby beach, Deep Bay.

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 scattered coral reefs which give way to seagrass beds. The bay is exposed to wave action. There is a hotel development along the length of the bay and a seawall at the southern section. The factor ‘d’ remains 1.0.

Yorks Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 102 feet (31 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(20 + 1 + 10)1	=	31 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.65 m
Recent changes 1996-1997		=	-0.29 m
Projected retreat over the next 30 years	=	0.65 x 30	
		=	20 m

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

Land/dune retreat resulting from H. Luis in 1995	=	1.3 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 sandy bottom with some coral species, beyond this there are seagrass beds. The bay, while exposed to wave action, receives some protection from the Five Islands Peninsula to the north. There is no development behind this beach. However, the beach has been extensively mined for sand in the past. The factor 'd' remains 1.0.

Stony Horn Beach, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 49 feet (15 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(5 + 0 + 10)1	=	15 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.17 m
Recent changes 1996-1997	=	+1.0 m
Projected retreat over the next 30 years	=	0.17 x 30
	=	5.1 m

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

Land/dune retreat resulting from H. Luis in 1995	=	0 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 sandy bottom which gives way to seagrass beds. The bay, while exposed to wave action, receives some protection from two prominent headlands and the Five Islands Peninsula to the north. There is no development behind this beach. However, the beach has been extensively mined for sand in the past. The factor ‘d’ remains 1.0.

Mosquito Cove, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 92 feet (28 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(18 + 0 + 10)1	=	28 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.61 m
Recent changes 1996-1997		=	+0.27 m
Projected retreat over the next 30 years	=	0.61 x 30	
		=	18.3 m

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

Land/dune retreat resulting from H. Luis in 1995	=	0 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 used to be extensive seagrass beds. However, after the dredging for the Jolly Harbour Marina, an entrance to the marina was created and sand was dumped offshore at Mosquito Bay. The bay, is exposed to wave action. There is no development behind this beac The factor ‘d’ remains 1.0.

Lignumvitae Bay (Jolly Beach), Antigua

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
(10 + 3 + 10)1.3	=	30 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	No data*
Recent changes 1993-1997		
(without the effects of Hurricane Luis 1995)	=	-0.32 m
Projected retreat over the next 30 years	=	0.32 x 30
	=	9.6 m

*It was impossible to determine historical changes at this beach due to extensive changes resulting from development and the dredging of the salt pond to create a marina. The recent changes are therefore used in the calculation, however again it must be noted that extensive sea defence works built in 1995/6 have influenced recent beach changes.

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

Land/dune retreat resulting from H. Luis in 1995	=	3 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:

This alteration of the coastal area through dredging and the construction of a series of sea defences (breakwaters and groynes) have significantly altered the beach dynamics in this bay. The bay is exposed to wave action and winter swells. There is a major hotel and marina development at this beach. In view of the changes to the coastal system, the factor 'd' is 1.3. The setback value for this beach should be reviewed in the short term (2-5 years) as information from the beach monitoring will show the effects of the sea defence works.

Valley Church Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 121 feet (37 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(13 + 14 + 10)1.0	=	37 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.43 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	No data
Projected retreat over the next 30 years =	0.43 x 30	
	=	12.9 m

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

Land/dune retreat resulting from H. Luis in 1995	=	14 m*

* This was based on measurements at an adjacent beach, Ffryes Bay.

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 and behind the beach there is a salt pond. There is no development behind this beach. The beach is exposed to wave action and winter swells. The factor ‘d’ remains 1.0.

Ffryes Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 102 feet (31 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(7 + 14 + 10)1.0	=	31 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.22 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	-0.39 m
Projected retreat over the next 30 years =	0.22 x 30	
	=	6.6 m

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

Land/dune retreat resulting from H. Luis in 1995	=	14 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 sand bottom which then gives way to seagrass beds. The beach is exposed to wave action and winter swells. There is no development behind this beach. The factor 'd' remains 1.0.

Darkwood Beach, Antigua

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
(9 + 15 + 10)1.2	=	41 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.29 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	+1.06 m
Projected retreat over the next 30 years =	0.29 x 30*	
	=	8.7 m

*Despite recent accretion, the historical trend is used in the calculation, mainly because of the history and vulnerability of this beach, see d) below.

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

Land/dune retreat resulting from H. Luis in 1995	=	15 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 sand bottom which then gives way to seagrass beds. The pond behind the beach has been extensively mined for sand and the beach has also been mined at times. The coastal highway runs parallel to the sea and is located on a sand bar between the sea and the pond. Beachrock ledges are exposed along this beach. There are some beach bars at the southern end of the beach. The beach is exposed to wave action and winter swells. The factor ‘d’ is 1.2 because of the vulnerability and past history of mining at this beach.

Crab Hill Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 75 feet (23 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(7 + 6 + 10)1.0	=	23 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.22 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	+1.34 m
Projected retreat over the next 30 years	=	0.22 x 30*	
		=	6.6 m

*Despite recent accretion, the historical trend is used in the calculation.

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

Land/dune retreat resulting from H. Luis in 1995		=	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 is a fringing reef system extending south to Johnsons Point. The beach is exposed to wave action and winter swells. There is some residential and hotel development behind this beach. The factor ‘d’ remains 1.0.

Morris Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 118 feet (36 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(17 + 9 + 10)1.0	=	36 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.57 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	-0.12 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	=	9 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:

This beach is located on the south coast. Offshore there are seagrass beds and reefs at the two headlands. There is a major reef system, Cades Reef off this coast. There is some development near this beach. There are extensive beachrock ledges on this beach, some of which were only exposed after Hurricane Luis. The beach is exposed to wave action and winter swells. The factor 'd' remains 1.0.

Curtain Bluff, Antigua

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
(5 + 9 + 10)1.0	=	24 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.17 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	0.17 x 30	
		=	5.1 m

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

Land/dune retreat resulting from H. Luis in 1995 = 9 m*

*This was based on measurements at an adjacent bay, Morris Bay.

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

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

d) Other factors:

This beach is located on the south coast. Offshore there is sand and seagrass beds and reefs at the two headlands. There is a major reef system, Cades Reef off this coast. There is some hotel development near this beach. The beach is exposed to wave action and winter swells. The factor 'd' remains 1.0.

Carlisle Bay, Antigua

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)1.0	=	24 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.30 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	0.30 x 30	
		=	9.0 m

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

Land/dune retreat resulting from H. Luis in 1995 = 5 m*

*This was based on measurements at an adjacent bay, Falmouth, which has a similar degree of exposure to Carlisle Bay.

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

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

d) Other factors:

This beach is located on the south coast. Offshore there are seagrass beds and scattered corals at the two headlands. There is some hotel development near this beach. The beach is very sheltered. The factor ‘d’ remains 1.0.

Rendezvous Bay West, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 46 feet (14 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(+7 + -9 + -10)1.2	=	14 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	+0.24 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	No data
Projected change over the next 30 years	=	+0.24 x 30
	=	+7.2 m

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

Land/dune retreat resulting from H. Luis in 1995	=	9 m*

*This was based on measurements at an adjacent bay, Morris Bay.

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

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

d) Other factors:

This beach is located on the south coast. Offshore there is a sandy bottom with some patch reefs. While the bay is somewhat sheltered by the headland at Tucks Point, there is deep water close inshore. There is no development at this beach. The beach is exposed to wave action and winter swells. The factor 'd' is 1.2 mainly because of the deep water close inshore and therefore the bay's exposure during high wave events.

Rendezvous Bay East, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 75 feet (23 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(0 + 9 + 10)1.2	=	23 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	0 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	0 x 30	
		=	0 m

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

Land/dune retreat resulting from H. Luis in 1995 = 9 m*

*This was based on measurements at an adjacent bay, Morris Bay.

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

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

d) Other factors:

This beach is located on the south coast. Offshore there is a sandy bottom with some patch reefs. While the bay is somewhat sheltered by the headland at Tucks Point, there is deep water close inshore. There is no development at this beach. The beach is exposed to wave action and winter swells. The factor 'd' is 1.2 mainly because of the deep water close inshore and therefore the bay's exposure during high wave events.

Deep Bay (Colony Beach Hotel), Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 39 feet (12 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(0 + 2 + 10)1.0	=	12 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	0 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	0 x 30	
		=	0 m

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

Land/dune retreat resulting from H. Luis in 1995 = 2 m*

*This was based on measurements at a nearby beach in Falmouth Harbour, Pigeon Point.

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

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

d) Other factors:

This beach is located on the south coast in a fairly sheltered bay, Falmouth Harbour. Offshore there are seagrass beds and coral reefs around the southern headland at Proctors Point. There is an abandoned hotel behind this beach. The factor ‘d’ remains 1.0.

Falmouth, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 36 feet (11 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(+4 + -5 + -10)1.0	=	11 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	+0.14 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	+1.95
Projected change over the next 30 years	=	0.14 x 30
	=	+4.2 m

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

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

This beach is located on the south coast at the head of a sheltered bay, Falmouth Harbour. Offshore there are seagrass beds and scattered patch reefs. There is some residential development behind this beach. The factor ‘d’ remains 1.0.

Pigeon Point, Antigua

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
(18 + 2 + 10)1.0	=	30 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.61 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	+0.44 m
Projected retreat over the next 30 years =	0.61 x 30	
	=	18.3 m

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

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

This beach is located on the south coast in a fairly sheltered bay, Falmouth Harbour. Offshore there are seagrass beds and a large reef system off the southern headland. There is some residential development behind this beach. The factor ‘d’ remains 1.0.

Mamora Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 49 feet (15 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(5 + 0 + 10)1.0	=	15 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	+0.48 m
Recent changes 1993-1997			
(without the effects of Hurricane Luis 1995)		=	-0.83 m
Projected retreat over the next 30 years	=	-0.18* x 30	
		=	5.4 m

* The historical change data reflects the effects of sea defence structures and the adding of sand to the beach. So the mean of the historical and the recent changes has been used to determine the projected change over the next 30 years.

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

Land/dune retreat resulting from H. Luis in 1995	=	0 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:

This beach lies at the head of a very sheltered bay. Offshore there are seagrass beds and a large reef system, the Mamora Reef, at the mouth of the bay. There is a large hotel at the eastern end of the bay, in front of which there are several sea defence structures - groynes and breakwaters. The factor ‘d’ remains 1.0.

Halfmoon Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 82 feet (25 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(11 + 0 + 10)1.2	=	25 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.38 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	-1.01 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	=	0 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:

This beach lies on the east coast of Antigua and is exposed to high wave energy. Offshore there are seagrass beds at the southern part of the bay. There is a large reef system extending from the southern headland, Soldier Point, northwards to York Island. There is a hotel at the southern end of the bay. The factor 'd' is 1.2 mainly because of the wave exposure.

Exchange Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 56 feet (17 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(4 + 0 + 10)1.2	=	17 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.15 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	-0.15 x 30	
		=	4.2 m

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

Land/dune retreat resulting from H. Luis in 1995	=	0 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:

This beach lies on the east coast of Antigua and is exposed to high wave energy. Offshore there is sand and beyond this a large reef system which extends from Half Moon Bay to the south, to York Island in the north. There is a hotel at the southern end of the bay. The factor 'd' is 1.2 mainly because of the wave exposure.

Long Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 52 feet (16 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(3 + 3 + 10)1.0	=	16 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.09 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	-0.32 m
Projected retreat over the next 30 years	=	-0.09 x 30	
		=	2.7 m

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

Land/dune retreat resulting from H. Luis in 1995	=	3 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:

This beach lies on the north coast of The Willikies Peninsula. Offshore there are seagrass beds and beyond that a large reef system which extends westward to Pelican Island. There is a hotel at the western end of the bay. The reefs provide considerable protection to this beach and wave energy is usually low. The factor ‘d’ remains 1.0.

Dutchman Bay, Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 43 feet (13 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(+7 + -10 + -10)1.0	=	13 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.52 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	+1.0 m
Projected change over the next 30 years	=	+0.24* x 30
	=	+7.2 m

* An offshore breakwater at the southern part of this beach has provided protection and reversed the erosion trend. Since the breakwater only protects the southern part of the beach the mean of the historical and recent changes has been used to project the retreat over the next 30 years.

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

Land/dune retreat resulting from H. Luis in 1995	=	10 m*

* This was based on measurements at the southern end of the bay and estimations at the northern end of the bay.

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

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

d) Other factors:

This beach lies on the northeast coast and is exposed to high wave energy although Long Island provides some protection. Offshore there is a sandy bottom which then gives way to seagrass beds. There is a reef at the northern headland. The factor ‘d’ remains 1.0, the wave exposure is offset by the protection afforded by the breakwater.

Jabberwock, Antigua

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
(7 + 13 + 10)1.0	=	30 m

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991	=	-0.24 m
Recent changes 1991-1997		
(without the effects of Hurricane Luis 1995)	=	+0.18 m
Projected retreat over the next 30 years =		-0.24 x 30
	=	7.2 m

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

Land/dune retreat resulting from H. Luis in 1995	=	13 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:

This beach lies on the northeast coast and is exposed to high wave energy although Long Island and the reefs of North Sound provide some protection. Offshore there are seagrass beds which then give way to a sandy bottom. There is a reef at the northern headland and some patch reefs off the southern part of the bay. Coral reef debris forms a natural breakwater protecting the southern part of the bay where beach accretion is taking place. The factor 'd' remains 1.0.

Blackrock Bay (Boons Bay), Antigua

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 56 feet (17 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d		=	setback
(1 + 6 + 10)1.0	=	17 m	

a projected change in coastline position over the next 30 years based on recorded changes between 1968 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 1968-1997:

Historical change 1968-1991		=	-0.04 m
Recent changes 1991-1997			
(without the effects of Hurricane Luis 1995)		=	No data
Projected retreat over the next 30 years	=	-0.04 x 30	
		=	1.2 m

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

Land/dune retreat resulting from H. Luis in 1995 = 6 m*

* This was based on measured changes at Dickenson Bay and reports of severe damage during Hurricane Luis at nearby Blue Waters Bay.

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

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

d) Other factors:

This beach lies on the north coast and has a fairly sheltered wave environment. The north coast of Antigua from Boon Point to Beggars Point is protected with a fringing reef. There are several groynes on this north coast and sand has accreted on the updrift (east) side. The beach is widest at the western end of the bay in front of the Sandpiper Hotel. The factor 'd' remains 1.0.

Low Bay, Barbuda

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 276 feet (84 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(17 + 15 + 10)2.0	=	84 m

a projected change in coastline position over the next 30 years based on recorded changes between 1958 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 1968-1997:

Historical change 1958-1991	=	-0.55 m
Recent changes 1996-1997	=	-1.07
Projected retreat over the next 30 years	=	0.55 x 30
	=	16.5 m

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

Land/dune retreat resulting from H. Luis in 1995	=	15 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:

This beach lies on the west coast of Barbuda. It is located on a narrow sand bar which separates Codrington Lagoon from the sea. During tropical storms and hurricanes, waves often breach the bar and cut channels through to the lagoon. Offshore there are fringing reefs parallel to the northern section of the bar. Wave exposure is moderate. The factor 'd' is 2.0 mainly because of the vulnerability of the sand bar.

Palmetto Point, Barbuda

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 374 feet (114 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(30 + 17 + 10)2.0	=	114 m

a projected change in coastline position over the next 30 years based on recorded changes between 1958 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 1968-1997:

Historical change 1958-1991	=	-9.45* m
Recent changes 1996-1997	=	No data
Projected retreat over the next 30 years	=	1.0* x 30
	=	30 m

* This figure was based on the loss of sand at the end of the spit, a recurved promontory 300 m in length disappeared between 1958 and 1991. A more realistic projected change for the entire Palmetto Point promontory (spit) is -1 m per year, although near the point itself more dramatic changes are likely.

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

Land/dune retreat resulting from H. Luis in 1995	=	17* m

* This was based on changes at Low Bay and Dulcina Hotel.

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

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

d) Other factors:

This sand spit lies on the southwest coast of Barbuda. Wave exposure is moderate and the wave pattern is complex. The factor ‘d’ is 2.0 mainly because of the vulnerability of such sand spits.

Dulcina Hotel (abandoned) to the Jetty, Barbuda

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 121 feet (37 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(9 + 18 + 10)1.0	=	37 m

a projected change in coastline position over the next 30 years based on recorded changes between 1958 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 1968-1997:

Historical change 1958-1991	=	-0.30 m
Recent changes 1996-1997	=	-0.47 m
Projected retreat over the next 30 years	=	0.3 x 30
	=	9 m

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

Land/dune retreat resulting from H. Luis in 1995	=	18 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:

This beach lies on the south coast of Barbuda. Wave exposure is moderate. There are several fringing reefs along the south coast of Barbuda. The factor ‘d’ remains 1.0.

Cocoa Point, Barbuda

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 315 feet (96 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(18 + 20 + 10)2.0	=	96 m

a projected change in coastline position over the next 30 years based on recorded changes between 1958 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 1968-1997:

Historical change 1958-1991	=	-0.61 m
Recent changes 1996-1997	=	+1.33 m
Projected retreat over the next 30 years =	0.61 x 30	
	=	18.3 m*

* The historical change is used in this calculation, the recent accretion in 1996-1997 is most likely a recovery phase following Hurricane Luis.

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

Land/dune retreat resulting from H. Luis in 1995	=	20 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:

This sand spit lies on the south coast of Barbuda and is anchored by coral reefs. Wave exposure is moderate and is complex near the spit. Such accretionary features as sand spits are intensely vulnerable to change. The factor ‘d’ is therefore 2.0.

Governor Bay, Barbuda

THE RECOMMENDED SETBACK FOR NEW BUILDINGS AT THIS BEACH IS 115 feet (35 m) LANDWARD OF THE PERMANENT VEGETATION LINE.

Setback calculation:

(a + b + c)d	=	setback
(5 + 20 + 10)1.0	=	35 m

a projected change in coastline position over the next 30 years based on recorded changes between 1958 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 1968-1997:

Historical change 1958-1991	=	-0.15 m
Recent changes 1996-1997	=	+2.36 m
Projected retreat over the next 30 years	=	0.15 x 30
	=	4.5 m*

* The historical change is used in this calculation, the recent accretion in 1996-1997 is most likely a recovery phase following Hurricane Luis.

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

Land/dune retreat resulting from H. Luis in 1995	=	20 m*

* This is based on measured changes at Cocoa Point.

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

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

d) Other factors:

This bay lies between Cocoa Point and Spanish Point on the south coast of Barbuda. There are extensive coral reefs offshore. Wave exposure is moderate. The factor ‘d’ remains 1.0.

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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