GUIDELINES FOR LOW-IMPACT TOURISM

ALONG THE COAST OF QUINTANA ROO, MÉXICO

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PREFACE

Several initiatives have emerged in recent years that reaffirm the importance of conservation of our coastal zone. Mexico's National Policy and Strategy for Sustainable Tourism sets out the overall framework for applying a number of environmental policy instruments to this goal, for example the *Environmental Strategy for Integrated Management of Mexico's Coastal Zone*.

Yet even with these important conservation efforts aimed at halting and mitigating environmental deterioration in the coastal zones of our country, we still face important challenges ahead. Current trends are leading towards increased levels of irreversible impact to these fragile ecological systems. Our environmental policy must be capable of achieving the national policy objective of growth with quality.

Quintana Roo is perhaps one of the states that best exemplifies this situation. Practically all of the coastal zone has ecological zoning ordinances at different stages of preparation. In some of the regions, such as the Cancun-Tulum coastal corridor, the plan is being updated. In others, plans have just recently been approved, such as Costa Maya and the mainland portion of Isla Mujeres. Quintana Roo also created Mexico's first biosphere reserve for the Sian Ka'an ecosystem.

In sum, we have made important advances in our knowledge of coastal ecosystems and expanded our ability to identify acceptable limits on changes in natural processes through planning and regulatory tools. However, these measures are proving difficult to implement in practice.

The complexity and magnitude of degradation of coastal ecosystems has made it clear that awareness of the problem of implementation be more widely appreciated. This will help in the search for leverage points and processes that will lead to sustainability, and help us foresee the indirect and long-term impacts of development.

The possibility of incorporating tourism activity as a strategic component of economic development, depends on our capacity to correctly identify environmental requirements and conditions for its success. This insight requires taking an integrated focus that is sensitive to local situations and priorities, sufficiently flexible and receptive to the continuous changes that occur in the coastal systems, and that is reinforced with other outreach tools and environmental regulations.

Mexico's legal framework for addressing tourism is contained in its general approach for regulating the direct impacts of any form of development in order to insure conservation of biodiversity and the protection of its habitat. Specific regulations address the control of the water and air pollution and the generation of solid waste and noise. These policies and regulations cover a variety of tourist-generated impacts, including the development of tourism infrastructure projects, and the implementation of tourism activities and services. Official Mexican guidelines are now being prepared for the design, construction, and operation of marinas and golf courses.

Other areas where progress is being made include the revision of the regulations governing the operation of municipal solid waste facilities and wastewater treatment plants in order to encourage the use of treated sludge as compost to improve soils or restore landscapes. Mexico is also working towards elimination of materials causing damage to the ozone layer; development of teams to fight forest fires; and preparing regulations for activities associated with wildlife as a tourism attraction such as hunting and bird watching.

The certification of tourist installations in terms of the use of good practices that reduce environmental impact provides an opportunity to address the challenge of implementing environmental improvement programs. Through a strong promotion effort, it will be possible to build awareness of the high long-term costs of inadequate infrastructure planning and support for mitigation measures now.

This book, *Guidelines for Low-Impact Tourism Along the Coast of Quintana Roo,* provides us with a practical tool that complements the other efforts being carried out by the private sector and government to reduce the pressures on coastal ecosystems, lower the costs of treating pollution, and open up new opportunities to address the energy crisis and attain a more efficient use of resources.

Lic. Victor Lichtinger Waisman
Secretary of Environment and Natural Resources, Mexico
June 2001

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PROLOGUE

This manual has been translated from the 1998 version of the *Normas Prácticas para el Desarrollo Turístico de la Zona Costera de Quintana Roo, México* as a reference for English-speaking stakeholders in Mexico and other regions of the world. The creation and promotion of the manual for tourism development in Mexico's Caribbean coast has provided an invaluable tool that could be beneficial for other coastal managers experiencing similar challenges. Tools such as this manual contribute not only technical knowledge for sustainable coastal development—they are critical to the process of building and maintaining a constituency to develop strategies that will be effectively implemented in the future.

As demonstrated over the past 25 years, tourism continues to be a flourishing economic development opportunity in Quintana Roo. While many economic benefits have been realized from Cancun, Playa del Carmen and other developments, there are lessons learned regarding planning, environmental protection and social impacts that can be drawn upon as new tourism destinations are developed in the southern part of the state.

In Quintana Roo, tourism has been identified as the key force of change, driving the need to develop strategies that integrate economic development opportunities with conservation strategies. Planning documents and legal instruments established by the government provide a framework for resource management and development. In this sense, Quintana Roo has put itself in the vanguard of environmentally-friendly tourism, with its system of natural protected areas and the first ecological land zoning plans in Mexico. The challenge thus lies in developing effective governance mechanisms and implementation strategies which truly integrate tourism and conservation.

This manual was initially conceived as a complementary, voluntary tool for promoting low-impact practices for new tourism infrastructure development. While developers often view regulations as disincentives for development, the *Guidelines for Low-Impact Tourism Along the Coast of Quintana Roo, Mexico* takes a positive approach. It outlines design and construction methods that result in the long-term reduction of costs to the environment and to maintaining tourism investments. Written with direct reference to the coastal resources found in the state of Quintana Roo, the manual provides practical guidance for creating new infrastructure in specific coastal areas. It includes measures for siting structures on beaches, maintaining natural vegetation cover and minimizing pollution to coastal waters. While many technical manuals have been written on these subjects, this manual differs in several ways.

First, the original Spanish-language manual provides information that is otherwise not readily available in Mexico written in the native language. Second, the manual describes the local characteristics of the coastal ecosystems, which provides a context for applying the guidelines. Finally, the manual was developed by the people of the place; this promotes ownership of the techniques and support for their implementation, a key ingredient for long-term success.

Within the bigger picture of promoting integrated coastal management, the guidelines have been an effective vehicle for engaging stakeholders and discussing critical coastal management issues with practitioners (such as engineers, architects, environmental consultants) and coastal managers (government and non-government sectors). Through training, field demonstrations and advisory opinions on environmental assessments, the team has promoted the voluntary use of these practices in a manner that complements existing regulatory processes. *The Conservation of Critical Ecosystems in Mexico Project* continues to actively work with both the private and public sectors to identify economic and policy incentives to employ low-impact practices in new development along the Quintana Roo shoreline. While not initially targeted as a primary audience, government officials have adopted this manual as a valuable resource for evaluating environmental impact assessments and establishing coastal policy for the region's coastal zone. The manual has been a key tool for initiating new partnerships that otherwise would not be feasible.

We hope that as developers, property owners, coastal management practitioners and decisionmakers you find this manual useful for making better decisions—choices that can contribute to both the conservation and use of coastal resources in a manner that promotes sustainable development and use of our shorelines.

INTRODUCTION

Tourism destinations along Mexico's Caribbean shore support 37 percent of the country's gross national product.

Tourism represents one of the most important sources of revenue for Mexico. It is particularly important in the Mexican Caribbean, where the primary attraction is the area's diverse ecosystems including coral reefs, sandy beaches and coastal lagoons. This region marks the entrance of the "Mundo Maya", the Mayan World—an area rich in Mayan archeological and cultural sites. Together, these attractions make the coastal shores of Quintana Roo one of Mexico's finest tourist destinations, drawing an increasing number of visitors and a constant flow of new investment projects to the region.

Along the coast of Quintana Roo, tourism has developed on different scales. To the north, the Cancun-Tulum corridor—with its extensive infrastructure—receives over two million visitors a year. To the south, in the Costa Maya corridor, current tourism activity is minimal but future tourism development potential is great.

The state government of Quintana Roo has articulated a distinct vision for new tourism development along the southern coast of the Costa Maya. This vision shows tourism complementing the region's plan for economic development by expanding and improving the existing infrastructure. Environmental considerations are woven throughout the plan, helping to ensure that development is "intelligent" about the use and conservation of natural resources. Such a development strategy complements the federal government's *Environmental Program 1995-2000*, which seeks to minimize environmentally destructive practices and initiate a process of ecological restoration.

For tourism development to be economically, socially and ecologically sustainable, it is essential to first understand the natural environment of the areas to be developed. Tourism development located in the coastal zone—at the union of terrestrial and marine ecosystems—is vulnerable to the powerful force of natural processes (including hurricanes, storms and erosion). Understanding the strong interrelationship between ecosystems in any coastal tourism development strategy is critical. Coastal development that does not take these natural forces into consideration may suffer expensive consequences. For example, in Cancun and Playacar, there has been great investments of time and money to restore beaches prematurely eroded due to "protective" coastal structures (such as seawalls and groins)—structures that in fact disrupt the natural process and thus prevent the beach from restoring itself.

The *Guidelines for Low-Impact Tourism Along the Coast of Quintana Roo* can serve as a guide to coastal stakeholders during the process of planning new developments in the coastal zone. It presents practical guidance on the design and location of coastal infrastructure. Its recommendations consider the dynamics of coastal ecosystems and recognize the value of and need for traditional uses of the shore. The goal of the *Guidelines* is to help protect tourism investment and at the same time preserve the coastal environment.

The *Guidelines* is divided into three parts. The first part (Introduction, Sections 100 and 200) establishes a foundation for understanding the characteristics and importance of coastal ecosystems. The second part (Sections 300, 400, 500, 600, 700 and 800) is divided into thematic areas of development concern. Each section gives a brief background on an important element of coastal development and proposes mitigating measures for low-impact design and placement of coastal structures. The final section (900) is an example of applying the practices recommended in the *Guidelines* within a real project in Southern Quintana Roo.

Examples from the state of Quintana Roo are used to illustrate many of the coastal management concepts and issues and how to apply low-impact practices within the setting of the specific ecosystems. These same practices, however, can sometimes be applied in other coastal regions that have similar conditions—whether that is in other coastal regions within Mexico or elsewhere around the world.

ESTABLISHING A VISION FOR FUTURE DEVELOPMENT

In the past few decades, the state of Quintana Roo has made significant advances in the protection of its natural resources and the improvement of coastal management through the designation of marine protected areas and the development of ecological land zoning plans. Protected areas such as the Sian Ka'an Biosphere Reserve and the National Marine Parks of Isla Mujeres, Punta Cancun, Punta Nizu, Cozumel, The Hague Declaration on Tourism identifies the essential relationship of the environment and tourism

An unspoiled natural, cultural and human environment is a fundamental condition for the development of tourism. Moreover, rational management of tourism may contribute significantly to the protection and development of the physical environment and the cultural heritage, as well as to improving the quality of life.

Infrastructure design should focus on integrating environmental protection with tourism opportunities.

Banco Chinchorro and Xcalak span a large portion of the coast. On the land side, the state has established a zoning plan for the Cancun-Tulum corridor and for the Costa Maya region in the south. Additionally, more detailed plans for developing high-density urban centers in the state are underway.

Together, these efforts support a vision that combines the economic success of tourism with the health of natural and cultural resources of Quintana Roo's coastal zone. Through these measures the government aims to promote a new model of sustainable development for Mexico, and to realize its vision for making Costa Maya a successful, low-impact tourism development/ destination.

The principles of sustainable development explicitly recognize the strong interdependence between the environment and economy. It is essential that Quintana Roo embrace a comprehensive planning and implementation mechanism that recognizes this, and that it develop a strategy that integrates development, tourism and the environment. Doing so may be a key to a successful and sustainable future of tourism in the region.

INTEGRATING THESE GUIDELINES INTO THE PLANNING PROCESS

There are various stages in the tourism development planning process where the public sector, investors and local communities need to recognize the condition and vulnerability of the natural resources in question. By considering the physical characteristics of a proposed development site, it is possible to identify practical alternatives for siting and design. Knowing what the alternatives are and the trade-offs of each alternative is critical to making sound economic and environmental decisions.

These *Guidelines* can play an important role in this planning process. Following the recommendations outlined in the *Guidelines* can help to:

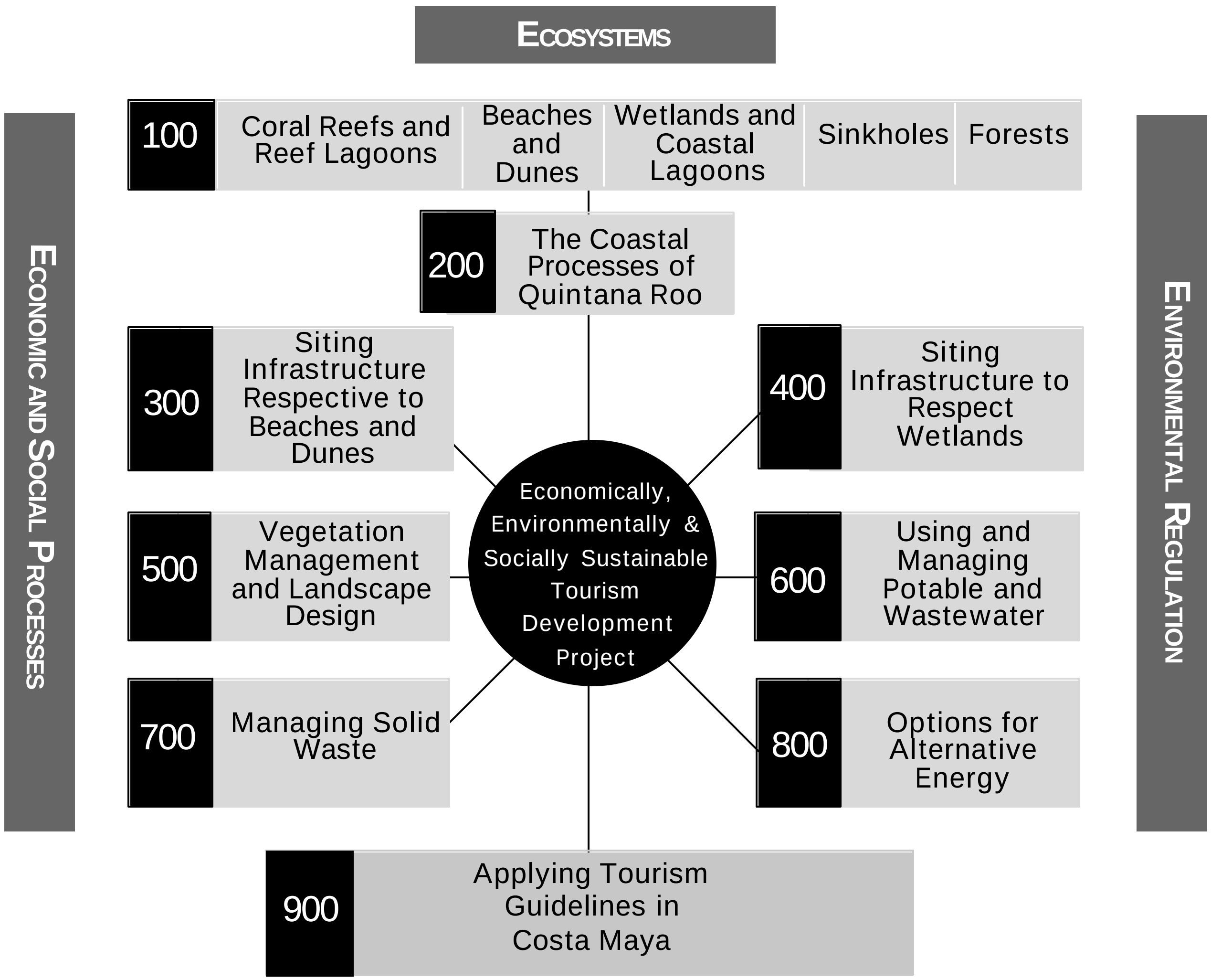
- Protect investments by reducing possible economic and environmental costs related to natural processes and coastal hazards impacts
- Maintain healthy ecosystems that will attract tourists and provide long-term economic benefits
- Complement existing or proposed environmental regulation, by incorporating best management practices into Environmental Impact Assessments or zoning decisions that aim to reduce or mitigate environmental impacts

Incorporating knowledge of coastal processes and applying best management practices for beaches, lagoons, vegetation, energy, solid waste, and wastewater to planning and infrastructure projects will contribute to local and regional sustainable development. The *Guidelines* can help an investor or architect to select construction techniques that mitigate the potential risk of negative impacts to the areas surrounding the development. Choosing these alternatives means long-term infrastructure costs can be reduced substantially. For example, locating a hotel building a sufficient distance from the shore may reap both economic and environmental advantages—it may save millions of dollars in the long term by avoiding storm and flood damage to the development, and it helps conserve the natural beaches and dunes as turtle and bird nesting sites.

Many hotels have already capitalized on the growing market for low-impact tourism alternatives by practicing effective environmental management. These businesses are benefiting from their ecological image. For example, hotels that participate in "Green Globe" and the "Environmentally Sensitive Hotel" certification programs, are able to promote themselves as environment-friendly businesses that use management techniques that conserve and protect the environment.

It is important to realize that although we believe applying the recommendations in the *Guidelines* is beneficial to the economy and environment alike, the actual application of the *Guidelines* is voluntary. Potential users are developers, property owners and the coastal communities in general who are constructing or have a stake in the construction of infrastructure in the coastal zone. The *Guidelines* and the existing national environmental regulations work together to encourage sound investment planning—planning that helps preserve the environment and promote long-term economic and environmental sustainability.

Key elements of planning and designing infrastructure projects are incorporated into the document, as noted by Sections 100 to 900 (at right).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The *Guidelines* also provide a resource for government decisionmakers to apply good practices to planning and permit decisions. Mexico's existing planning and regulatory process is designed to avoid damage to the environment caused by inadequate planning. The environmental zoning plan (*Ordenamiento Ecological Terretorial*) is a tool that evaluates, plans, and regulates land uses and activities within a geographic region according to natural, social and economic conditions of the region. The goal of these regional zoning plans is to establish criteria for new development that takes into consideration the need to protect the environment and maintain ecological equilibrium. In addition to these plans, there are environmental impact assessments, which analyze the potential environmental impacts of a proposed development and identify options, tools and techniques for reducing or avoiding negative environmental impacts.

During the project planning process, it is essential to examine the "big picture" context within which tourism development is taking place. This means considering both the positive and negative environmental, social and economic factors of the proposed development. Such examination helps define more clearly the short and long-term benefits and the potential for economic success of the tourist development and perhaps most importantly it can help ensure improvements to the quality of life of local communities and to the health of the natural resources. It is this last goal—ensuring the health of the natural resources—which is the key to attracting and maintaining a viable tourist-based economy. The *Guidelines* seek to help Quintana Roo and other coastal communities around the world realize both goals.

Shorefront development should consider long-term impacts from growth, including the social, economic and environmental.

For more information:

Guidance for best practices of tourism in the Wider Caribbean. Island Resources Foundation. 1996. *http://www.irf.org/ir_bmp.html*

The Best Practices for Human Settlements Database. UNCHS, Together Foundation. *http://www.bestpractices.org/*

Good Guidelines for Human Settlement Best Practices. *http://www.csc.noaa.gov/smartgrowth/text/guidelines.html*

World Tourism Organization. *http://www.world-tourism.org*

Codes of Ethics. Sustainable Tourism Research Interest Group. *http://www.yorku.ca/research/dkproj/string/rohr/*

Sustainable Building Sources. *http://www.greenbuilder.com/general/BuildingSources.html*

Ecotravel in Latin America. *http://www2.planeta.com/mader/*

The Ecotourism Society. *http://www.ecotourism.org/*

Legislation and Regulations. Mexico Secretariat for Environment and Natural Resources. *http://www.semarnat.gob.mx/legislacion_ambiental/index.shtml*

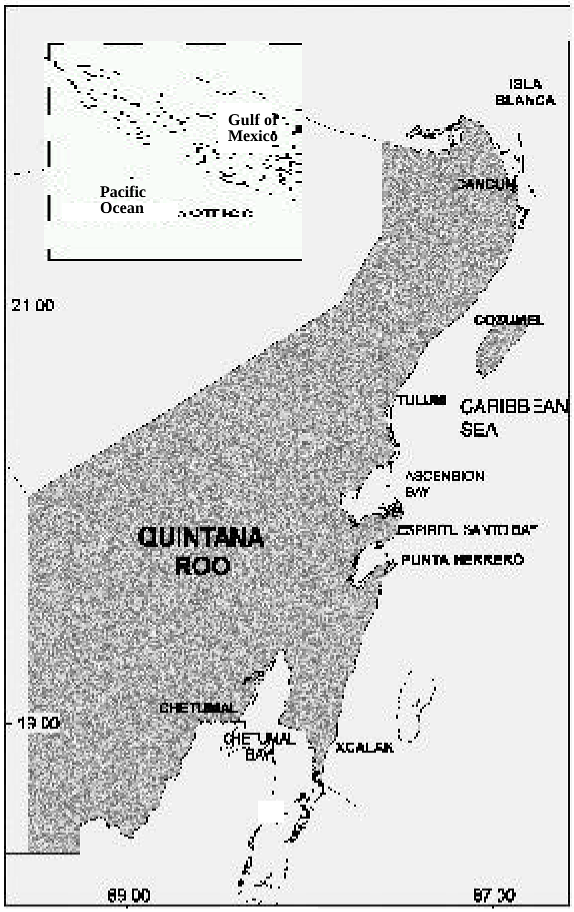
State of Quintana Roo Home Page. *http://www.quintanaroo.gob.mx/qroo2001/principal.htm*

Mexico Ministry of Tourism. *http://www.mexico-travel.com/mexico/owa/sectur.inicio*

Green Globe 21 Certification Program. *http://www.greenglobe.org/*

The newly created Xcalak Reefs National Park as seen from Xcalak's central beach area.

CHARACTERISTICS OF QUINTANA ROO'S COASTAL ZONE



Quintana Roo is located in the Yucatan Peninsula in southeastern Mexico. The peninsula is bordered by the Gulf of Mexico on the north and west, and by the Caribbean Sea on the east. It contains three states: Campeche, Yucatan and Quintana Roo.

The Caribbean coast of Quintana Roo is characterized by four ecosystem zones which parallel the shore—coral reefs and reef lagoons, beaches and dunes, wetlands and coastal lagoons, and forests. As seen in the map on the next page, these zones occur from east to west and are primarily governed by changes in elevation and topography. These ecosystems are discussed in more detail later in this chapter.

From north to south, the coast of Quintana Roo can also be divided into four regions, each with its own characteristic natural features:

1) The northern coast (Isla Blanca and Cancun) features barrier spits connected to the mainland by tombolos—sand bars or spits that connect or tie an island to the mainland. These barrier spits create saltwater lagoons on the inland side of the beaches, as exemplified by the Chacmochuc and Nichupte lagoons.

2) The coast from Cancun south to Tulum contains many small bays with sandy beaches and rocky headlands. In this region, an active groundwater aquifer dissolves surface limestone to form sinkholes, known locally as *cenotes*. Groundwater also dissolves the sedimentary rock as it flows towards the sea, forming underground caves. Often these caves collapse and form inlets (such as Xel-Ha inlet). These inlets exist throughout the region and contain a mixture of fresh and saltwater. As the inlets erode,

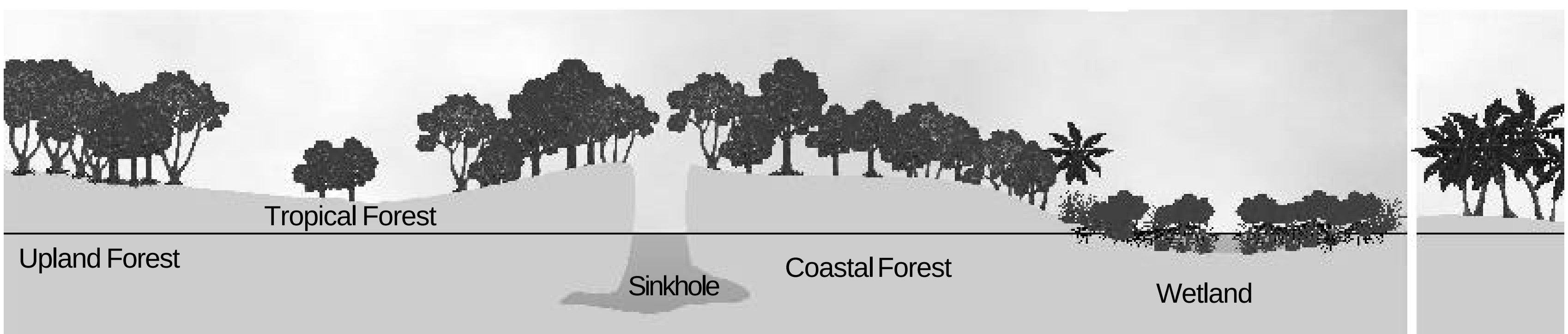
sand accumulates to form half-moon shaped sandy coves.

3) The central coast in the region of the Sian Ka'an Biosphere Reserve has great expanses of wetlands that rely on freshwater input from the surface and on shallow groundwater sources. Ascension and Espiritu Santo Bays are unique examples of bays bordered by barrier beaches forming small estuarine systems behind them.

4) The southern coast (Punta Herrero to Xcalak) is lined by a thin strip of sandy barrier beaches with rock outcrops of ancient coral. In this region, coastline retreat is a result of continental submersion and/or sea-level rise. Adjacent to the beach on the landward side of the barriers are extensive wetland and lagoon systems.

Natural resources have played an important role in the economy and in the quality of life for the people of Quintana Roo for hundreds of years. From the mid-1600s to the early 1900s, inland communities harvested dyewood (palo de tinte) trees for color dyes. In the late 1800s, the primary harvest changed to zapote trees, which were used to extract chicle for chewing gum. While inland inhabitants exploited forest resources for chicle, coastal communities depended on copra (coconut meat) for their primary economic resource. This changed, however, as a result of Hurricane Janet in 1955. The hurricane caused extensive damage to coconut plantations, and the copra industry declined drastically. As a result, fisheries became the coast's primary economic interest. By the mid-1970s, fishing not only remained a key resource for local consumption, but started to become an important export industry. At the same time, the state began to promote its white sand beaches and, with the development of Cancun,

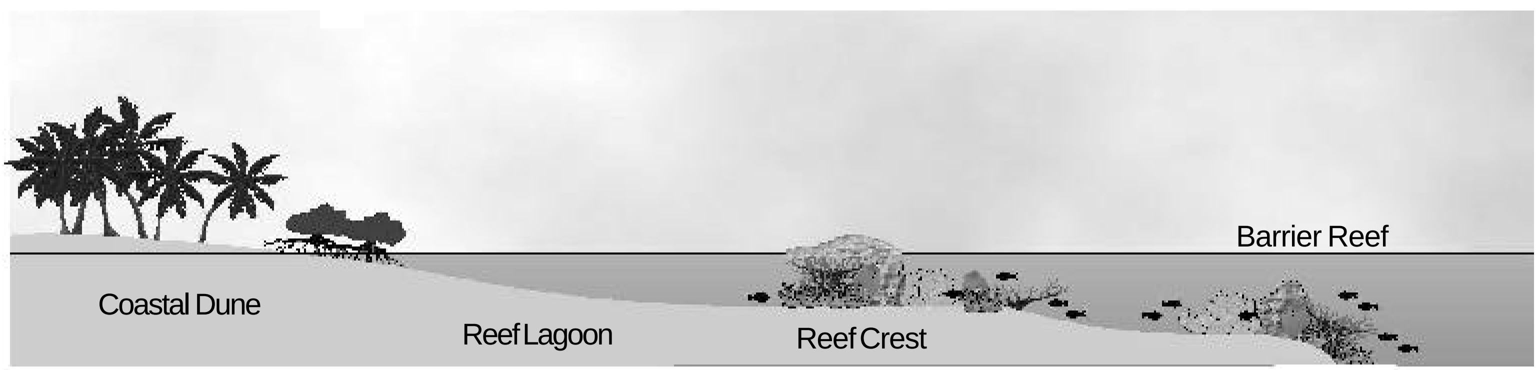
The distribution of ecosystems in the coastal zone of Quintana Roo.



began to develop a successful tourism industry. Today, tourism plays an increasingly important role in the economic development of Quintana Roo's coast where natural resources—beaches, coral reefs, fish and birds— provide the foundation for this emerging market.

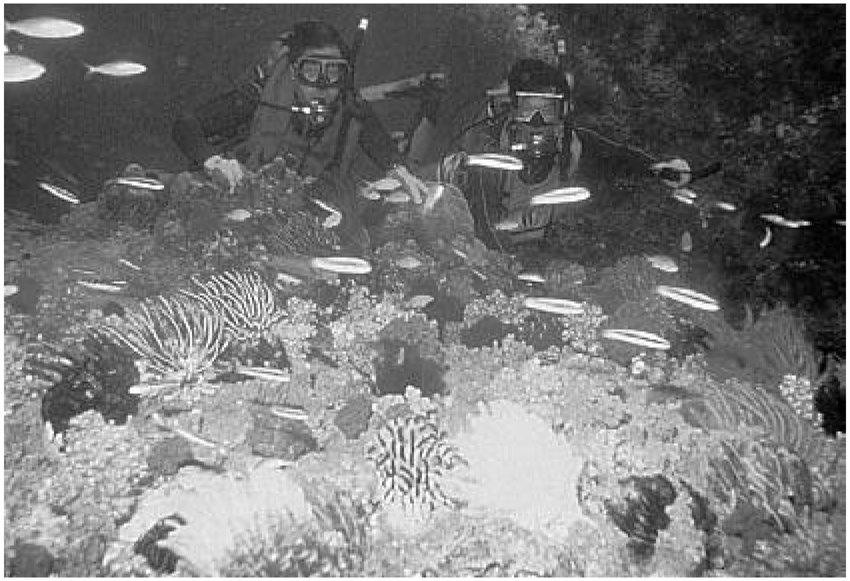
Today, the ecosystems of Quintana Roo are in delicate balance. While the tourism economy relies on the environment to attract and maintain its market, demands for new infrastructure place extreme pressures on these same natural resources. Uncontrolled development can severely impact and alter the ecosystem's natural functions, biodiversity, and traditional uses of its resources. For example, when lagoons and estuaries—important spawning and rearing areas for juvenile fish—are altered, coastal fisheries may be jeopardized. Other possible impacts of coastal development include: a) habitat loss from development of infrastructure such as piers, houses, hotels and agricultural farms; b) alteration of water flow; c) groundwater pollution; d) extraction of resources and raw materials such as fish and quarry products; e) erosion and sedimentation; f) decrease in biodiversity of land and water habitats; and g) loss of access for traditional and recreational uses by local communities.

Recognizing this precarious balance, planning for the sustainable development of Quintana Roo requires a regional vision—one that shows an understanding of both the physical characteristics and the uses of the natural resources, and one that values the economic and cultural roles of those resources. Only once the characteristics and interrelationships of Quintana Roo's coastal resources and ecosystems are understood, can informed decisions on new development be



made. The outcome of such a vision is that many potentially harmful effects of development can be avoided or mitigated. Beyond the vision, it is critical to develop and implement sensible guidelines and appropriate management practices. Following such guidelines and practices during the siting and design of new coastal structures can protect investments and benefit both the environment and tourism.

Following is a summary of the key features and characteristics of the coastal resources of Quintana Roo. Understanding such resources may aid developers in the planning and design of infrastructure.



Scuba diving is one of the principal tourism activities in Quintana Roo.

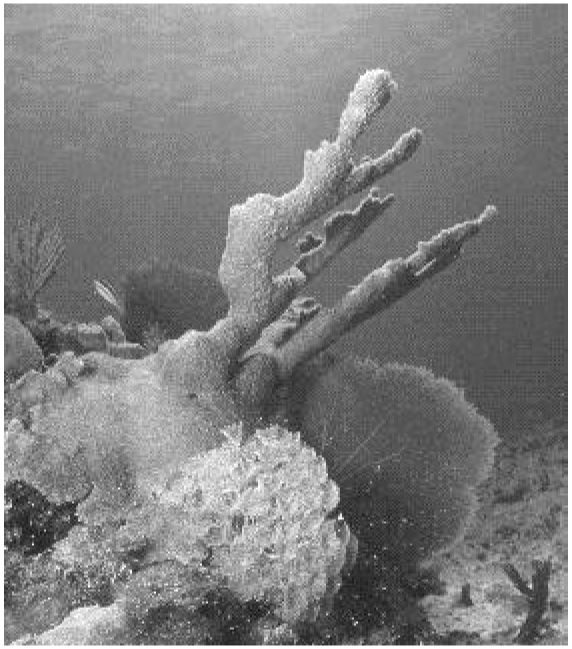
COASTAL ECOSYSTEMS

110. CORAL REEFS AND REEF LAGOONS

Coral reefs play a central role in the economic, social and cultural life of Quintana Roo, especially in coastal areas where the population depends on them for fishing and increasingly for tourism. The “Meso-American Reef”—an extensive reef system that parallels the shore from Cancun to the Bay Islands in Honduras—is one of the longest barrier reefs in the world, second only to the Great Barrier Reef in Australia.

With its close proximity to the coast (ranging from 500 to 1000 meters), the reef helps protect Mexico’s Caribbean shore from high waves during frequent storms and hurricanes. Even in calm weather, the reef plays an important role—serving as a breakwater that helps reduce wave action that erodes the shore. In other countries such as Sri Lanka and the Philippines, studies have shown that shoreline erosion has increased in areas where reefs were destroyed by dynamite fishing.

Reef lagoons are found on the landward side of reefs between the barrier reef and the shore. Sea grasses (*Thalassia sp.* and *Syringodium sp.*) grow in these lagoons, and are an important part of the reef ecosystem. By nourishing various species of marine turtles that nest on the beaches from May to October and by providing a nursery ground for invertebrate and fish larvae, the sea grasses contribute to the reef's high biodiversity. These grasses also trap sediment and stabilize the bottom, which in turn helps reduce coastal erosion. Unfortunately, sea grasses are commonly thought to be unimportant and are often removed to improve the appearance of the beach for swimming and recreation.



Coral reefs play an important role in protecting the shoreline from wave action and providing habitat for aquatic species.

Reef characteristics vary greatly along the coast of Quintana Roo. In the north, the continental shelf is very wide, with deeper areas of the reef primarily covered with algae and only sparsely populated with coral. The reef crest and the back reef are well developed with dense coral. Arrowsmith Bank, the only completely submerged bank in Quintana Roo, is located at the north end of the state. This bank has an abundant diversity and volume of fish that are commercially harvested by fishers from Cancun and Cozumel.

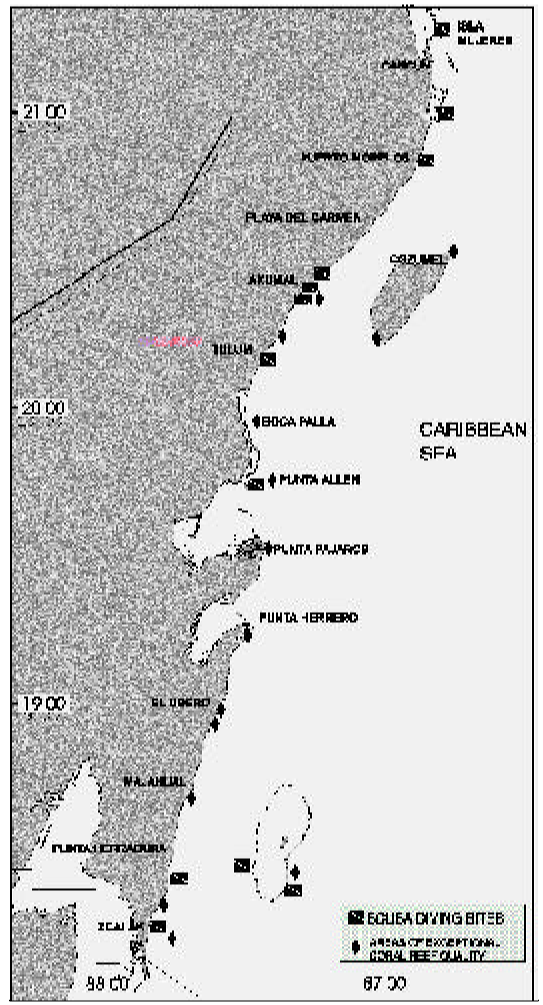
In Mujeres Bay (*Bahía de Mujeres*), located between Cancun and Isla Mujeres, dispersed reef patches are located primarily in areas that are less than 15 meters deep and have sea grasses and sandy bottoms. The island of Cozumel in northern Quintana Roo has fringing reefs that are known worldwide by recreational divers. On the southwest side of the island, an ancient reef is located at the edge of the continental shelf. Thousands of divers visit annually to view the spectacular formations on this vertical coral wall. On the west side of the island, the fringing reefs are also well developed, but are located only in deep water.

Off the mainland coast, from Punta Maroma to Puerto Adventuras, coral develops only in small isolated colonies on a sandy platform—the result of a strong current in the Cozumel Channel between the island and the mainland.

In the central and southern coasts of Quintana Roo, from Puerto Adventuras to the Belize border, the continental shelf narrows and has an extensive frontal reef with spur and groove structures of medium to high relief and high coral cover.

Chinchorro Bank, located 30 kilometers off the southern coast of Quintana Roo, is a “false” atoll—an oval-shaped barrier reef that surrounds four small islands and resembles the shape of an atoll. The area is characterized by abundant coral communities along its entire perimeter and high biodiversity in shallower areas. Its large populations of lobster, conch and other commercially important fish make it a principal fishing zone for small communities on the southern coast. The natural beauty of the Bank’s coral, its abundance of fish and its numerous shipwrecks also attract divers. All these characteristics contributed to designation as a Federal Biosphere Reserve in 1998.

Because it allows visitors to observe marine flora and fauna without traveling far from shore, the entire coral reef system along the coast of Quintana Roo has enormous tourism potential. Yet, too often the very infrastructure put in place to increase access to the reefs (such as marinas and hotels), combined with the sheer number of visitors to the reefs can have serious impacts—a potential decrease in the reef’s productivity, biodiversity and recreational value. Only when tourism infrastructure, land-based activities, and



Quintana Roo's barrier reef and coral communities are important environmental and economic resources.

Recreational uses of beaches and dunes will depend on the physical characteristics of the site and the need to conserve the natural processes.

marine tourism are well-planned and maintained are these negative impacts minimized or avoided. Only with the appropriate use and management of the reef and its surrounding ecosystem will long-term economic and biodiversity benefits associated with a healthy reef be guaranteed.

120. BEACHES AND DUNES

Beautiful sandy beaches make the shores of Quintana Roo—often referred to as the "Turquoise Coast" for its transparent sea and its signature turquoise color—some of the most attractive in Mexico. Besides being attractive to humans, the beaches are nesting, feeding and resting sites for a large diversity of birds, crustaceans and marine turtles. The beaches and dunes also play a critical role in protecting landward resources, including coastal development, against the direct impacts of waves and floods.

Quintana Roo's shoreline is defined by a complex of barrier spits (also referred to as barrier beaches) and sand plains. Barrier spits run parallel to the coast and are formed of sand and gravel beaches/dunes that accumulate from wind, wave and tidal action. The barrier spits are on the seaward side of lagoons or wetland systems. Typical examples of these formations are seen in the hotel zone of Cancun, the Punta Allen peninsula in the Sian Ka'an Biosphere Reserve, and the barriers that front the lagoons in the southern part of the state near the Belize border.

The same wave, current, tide and wind action that creates the barrier spits also brings constant change to the beaches and dunes of Quintana Roo. These beaches and dunes differ greatly from each other—shaped by the adjacent land and type of marine environment, and the presence or absence of a reef crest and reef lagoon. (See Section 200.) Yet, in spite of the constant change and the dynamic processes occurring in this

zone, beaches and dunes have adapted well.

In Placer and Xcalak in the southern part of the state, the wide sandy beaches have relatively flat slopes. Here the reef is located approximately 500 meters from shore and acts as a barrier for breaking waves, thereby reducing energy and sediment transport. In contrast, beaches near Cancun and in Mosquitero, near the Sian Ka'an Biosphere Reserve, have no reef crest in front of the beach and as a result have 20-meter high dunes formed from the high wave energy and nearshore sediments approaching the beach.

In the north, nearer to Cancun, the coast is typically erosional. After storms—when erosion is more severe—rock ledges are commonly exposed. To the south, where there is a series of sandy bays between rocky headlands, low beaches and tidal flats are accretional (accumulation of sand). These rock outcrops and headlands are actually exposed ancient coral reefs that date back 125,000 years and are the source material for adjacent cobble beaches.

A unique characteristic of many beaches in the state is their narrow width (40-400 m) bordered by the Caribbean to the east and wetlands to the west. This feature severely limits the land available for new development. This in turn challenges decisionmakers as they determine appropriate limits to growth in an effort to reduce alterations to the landscape and ecosystem. It also pressures developers to design, site and construct infrastructure that will attract tourists, while protecting both their investments and the natural resources.

Unfortunately, the beauty and the geological attributes of the Caribbean beaches that attract developers and tourists are frequently modified by inappropriate construction practices. This places beach areas at risk from storms, erosion and other natural phenomena. When dunes are leveled for construction, their ability to protect the backshore and its infrastructure is compromised. Often, this natural protective system of dunes is replaced with man-made

Quintana Roo's coastal zone is characterized by a diversity of ecosystems.

shore protection such as sea walls, structures that may not even withstand hurricane conditions. In Cancun and Playacar (45 km to the south), man-made structures have created a rigid coast, one that impedes the natural transport of sediments. This increases erosion and reduces the beach width that fronts the hard structures, creating a situation that threatens the very structures themselves.

FOR MORE INFORMATION SEE SECTION 200

Beaches support a variety of recreational activities.

130. WETLANDS AND COASTAL LAGOONS

Landward of Quintana Roo's thin, sandy, barrier beaches lies a wide strip of wetlands and coastal lagoons. Historically, wetlands were considered unusable, worthless land. As a result many were eliminated, filled, or drained by canals while others were converted into dumps for domestic and industrial waste. More recently, the perspective on wetlands and coastal lagoons has changed. They are now valued as a critical component of our global environment. On the seaward side of barrier beaches, in low energy zones behind the reef, fringing mangroves are common.

The low-lying coastal areas of Quintana Roo are especially susceptible to the effects of storms and hurricanes. Here, wetlands and lagoon systems provide an important buffer against high wave energy. Fringing mangroves along the coast also help stabilize the coastline amidst strong wave energy, ocean currents and other erosive forces.

There are two types of coastal lagoons, intermittent and permanent. Intermittent lagoons exist only during the rainy season; permanent lagoons, such as Rio Huache Lagoon close to the Belize border, have water year round. Each lagoon ecosystem supports different flora and fauna, as well as different recreational and commercial uses. Some lagoons in the northern part of the state attract tourists with kayaking, sailing, water skiing, and wind surfing. Cancun's Nichupte Lagoon and to some extent the Boca Paila Lagoon in the Sian Ka'an Biosphere Reserve are popular destinations for sport fishing and various ecotourism activities; and lagoons in the south are commercially valuable for local fishers.

Wetlands and lagoons have strong interrelationships with adjacent uplands, sea grasses and coral reefs. These systems depend on each other both physically and biologically. Wetlands and lagoon habitats provide important reproduction, nursery and feeding grounds, and support the migration of fish, crustaceans, birds and mammals at this dynamic interface. Wetlands and lagoons are also important for maintaining healthy sea grasses and coral reefs, as they act as filters and clean the water that enters the coastal waters by trapping sediments and carbon, and removing excessive nutrients that may cause eutrophication.

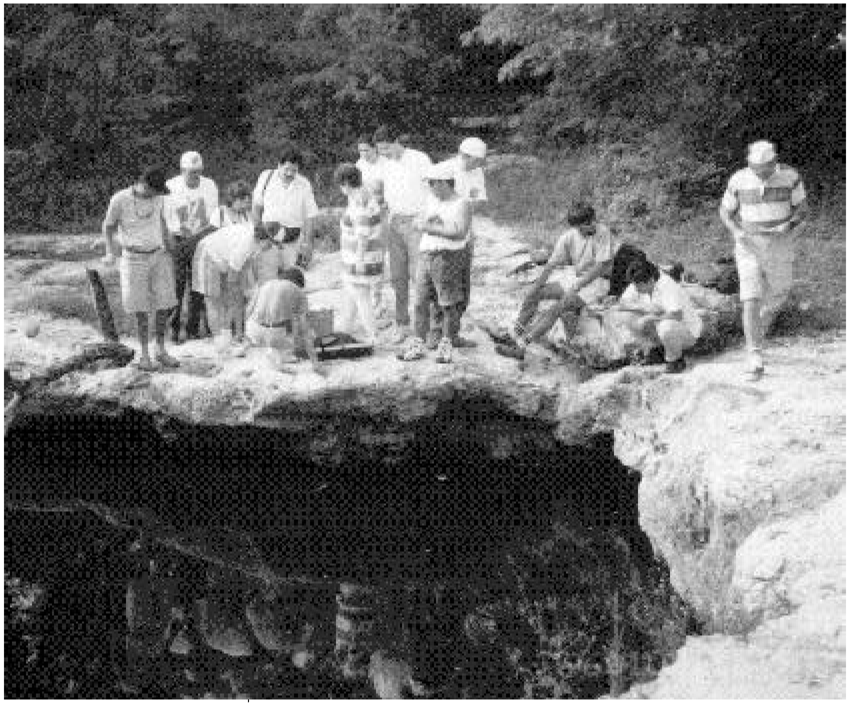
Eutrophication is a major form of pollution affecting lagoons and bays. Eutrophication is the excessive growth of algae (primary productivity) within a water body that leads to a decrease in oxygen in the water. When there are excessive nutrients in the water body (such as from inadequately treated wastewater discharge or changes in natural circulation), the biological and aesthetic value of the coastal waters is compromised and human health is often adversely affected. Dealing with these adverse effects usually requires costly clean-up and restoration activities, such as those currently

Coastal mangroves support a wide array of flora and fauna which can be conserved while providing valuable tourist attractions.

FOR MORE INFORMATION SEE SECTION 300

Sinkholes (*cenotes*) provide a "window" to the otherwise underground system of freshwater rivers, and have become popular for swimming and diving.

underway in Nichupte Lagoon in Cancun. Such problems can be avoided, however, when appropriate knowledge and planning are combined with use of appropriate technologies for wastewater treatment.



140. SINKHOLES

Another ecosystem typical to Quintana Roo is sinkhole formations known locally as *cenotes*. Characteristic of limestone topography and common in the Yucatan Peninsula, sinkholes are formed when limestone surface rock is dissolved by subsurface water flows and eventually collapses. Unlike inland sinkholes that can be quite deep, their coastal equivalents are shallow because the distance from the ground surface to the groundwater level is shallow.

As there are no rivers in Quintana Roo, sinkholes compose a large portion of the state's freshwater and many of them are primary sources of potable water. Sinkholes also provide refuge for a diverse range of flora, fauna, and aquatic communities of great interest to the scientific community, and some have archeological significance within the Mayan culture. Sinkholes also have potential for ecotourism development. For example, in the coastal sinkholes of Dos Ojos, Chan-Chik and Cristalino, activities such as swimming, cave diving, fishing and bird watching are increasingly popular.

Since sinkholes are part of a water system connected by an intricate network of groundwater channels, it is critical to carefully consider the type of activities that take place in and around the area. These areas need to be managed properly to ensure continued safety for human use and to preserve their high ecological value as a source of potable water. The quality of the water in a sinkhole can have a direct impact on the quality of the overall drinking water supply in an area. Sinkhole waters can mix with the groundwaters that flow to other regions and can create additional ecological impacts.

150. FORESTS

In Quintana Roo, forests are typically located at higher elevations and adjacent to the inland side of wetlands. Occasionally, however, forest vegetation is found close to the coast, interspersed with coconut palms and mangroves. Wherever it is found, the forest ecosystem has high biodiversity and plays an important role in the environment—affecting both the land and the air. For example, rich soil forms from the forest's organic material such as leaves and trees that fall to the ground degrade and decompose. This soil then supports the growth of vegetation which, in turn, helps regulate the local climate by naturally using up carbon dioxide and creating oxygen. In addition, the fruits, leaves, seeds, roots and bark of plants in the forest nourish many species of wildlife.

Since pre-Hispanic times, the forests of Quintana Roo have been used to harvest wood and fruit, as well as to extract chicle from zapote trees to make chewing gum. More recently, new management practices have been put in place to help reverse the rapid degradation of the forest ecosystem, caused by the expansion of agriculture and the harvest of forest resources.

Within forests, tourists can observe a variety of interesting flora and fauna.

Also, forests are now recognized for their ecotourism potential. Increasing numbers of flora and fauna tours have been designed, and walkways and boardwalks have been built to enhance the tour experience and reduce negative impacts on the forest. Tourists can also observe flora and fauna in the private botanical garden in Puerto Morelos and in the Ejido forest in Punta Laguna.

For more information:

Coastal Ecosystems. World Resources Institute. *http://www.wri.org/wr2000/coastlines.html*

Coastal Tropical Ecosystems, CARICOMP. *http://www.unesco.org/csi/pub/papers/kjerfve.htm#Environmental management*

Good Practices for the Protection and Management of Coral Reefs; International Coral Reef Initiative. *http://www.environnement.gouv.fr/icri/index.html*

Reef Check Foundation. *http://www.reefcheck.org*

Florida Keys National Marine Sanctuary. *http://www.fknms.nos.noaa.gov/sanctuary_resources/welcome.html*

Mangroves. University of Maryland. *http://cbl.umces.edu/~atlss/mngrv001.html*

US Geological Survey. *http://capp.water.usgs.gov/GIP/gw_gip/ Groundwater*

Quintana Roo's coast is a favorite nesting ground for sea turtles.

THE COASTAL PROCESSES OF QUINTANA ROO

Seeking water views and beach access, people often build in inappropriate locations on the beach—disregarding the fact that beaches continually change and adjust from seasonal wind and wave conditions. Sand that is present at one time of year can be removed by storms or even normal wave conditions at other times of year. Yet, when the dynamics of the coastal zone are understood and taken into consideration, it is possible to appropriately site and design new buildings and infrastructure. Certain construction techniques may also be used that help guarantee the long-term viability of these infrastructures, while minimizing impacts on adjacent ecosystems.

The sea and its energy strongly affect the coast of Quintana Roo. Where land and sea meet, waves, currents, tides and wind constantly change the shoreline. The combined effects of these forces are complex and difficult to predict, and are further complicated by man-made and natural hazards. Some of the most frequent coastal problems are associated with erosion and accretion—natural processes that can change the shoreline drastically, threaten poorly sited structures and cause serious financial loss to coastal property owners. Many coastal developers spend large sums of money—not always successfully—in attempts to slow nature's powerful forces and protect their structures from erosion.

In addition to natural coastal processes, soil conditions, the movement of groundwater, and other local topographic and geological features influence the Yucatan Peninsula shoreline. Due to its limestone formation, there are no rivers that flow in this region; however, groundwater flows favor the creation of expansive wetland environments behind barrier beaches and in the coastal fringe. And in several locations, as groundwater flows toward the sea, it dissolves sedimentary rock to form coastal inlets rich in habitat and marine life.

Coastal infrastructure is frequently impacted by natural processes if not properly sited.

FOR MORE INFORMATION SEE SECTION 100

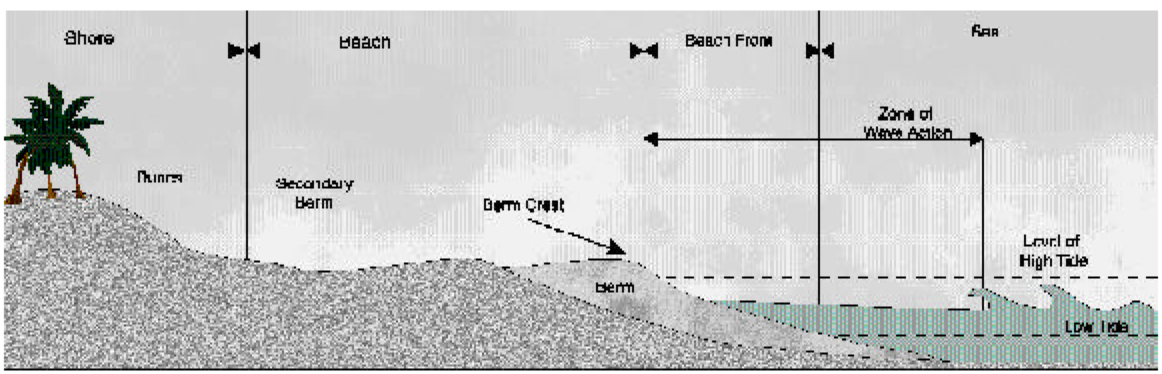
210. SEDIMENT TRANSPORT

Directly affected by ocean forces, beaches are one of the most dynamic areas within the coastal zone. Extending from the inter-tidal zone landward of where waves break, beaches are formed where sand and rocks are deposited. In Quintana Roo, this beach sand is composed of particles of crushed coral and shells, which are continually transported by wind, waves and currents.

Sediment transport depends largely on the slope of the beach face, the characteristics of currents and breaking waves, and the sediment composition. Transport is both perpendicular to the coastline (onshore/offshore movement) and parallel to the coastline (longshore transport), resulting in changes to the beach height, width and shape.

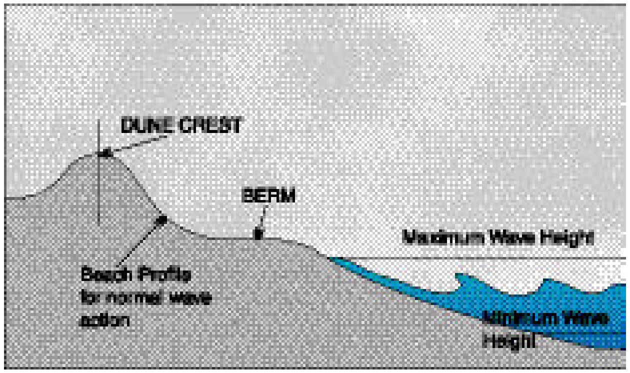
Beach characteristics change with each season. During the fall-winter storm season, large, high-energy waves build a steep, sloped beach. In the summer or pre-storm season, small, low-energy waves create a smooth, wide beach. In the Caribbean, summer winds are predominantly southeast while winter winds are northerly. A typical summer beach profile has relatively high dunes. In the winter, however, storm waves buffer the beach, the dunes erode and sand is temporarily deposited offshore. These same offshore sand deposits then replenish the beach after the next storm season passes.

Wave characteristics include the angle of approach, the time between two consecutive waves, and the wave height. These characteristics are directly influenced by the predominant winds—southeast wind in summer and northerly winds in

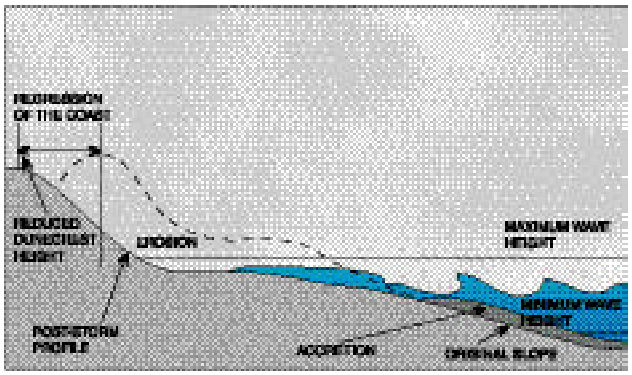


The zones of the beach. Mexico's "Federal Zone" extends 20 meters above high tide.

Profile A



Profile B

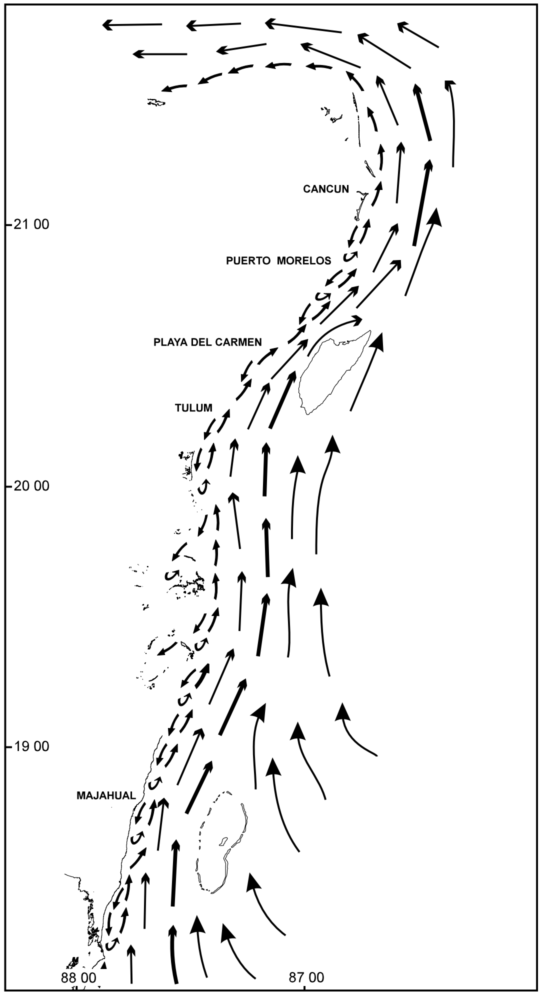


Seasonal changes in beach width. Profile A shows a summer/pre-storm beach. Profile B shows a winter/post-storm beach. The beach has eroded from higher waves that occur in the winter or during storms.

winter. The presence or absence of a reef crest that can act as a breakwater determines wave energy along Quintana Roo's shoreline. Nevertheless as waves move toward the coast, they break and dissipate energy. The resulting current that parallels the shore is the driving force behind longshore sediment transport, called the littoral current.

In 1983, Merino described overall surface currents in the Mexican Caribbean as south to north, with a reverse southerly current occurring in the nearshore reef lagoon between prominent rock headlands. This reverse in direction causes surface currents to collide and form small circulation cells. (See map.) The intensity and size of these cells vary, depending on wind and tides, and distance between headlands. Merino's circulation model was corroborated with a geologic characterization of the Costa Maya developed by Shaw and Boothroyd in 1995. Their research on the beach orientation and the shape of bays and rock headlands, concluded that the net transport of sediment was also south to north.

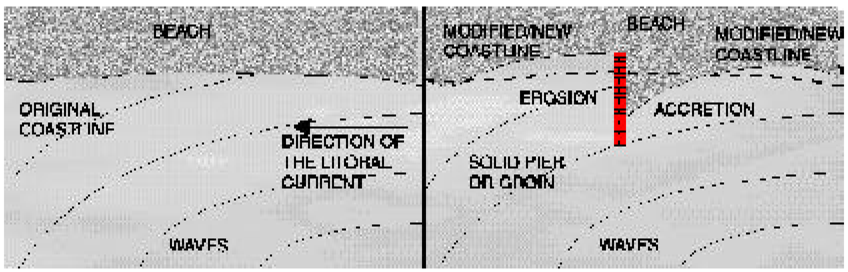
When man-made structures such as groins, jetties, or solid piers are constructed along the shoreline, the natural longshore transport of sediments can be interrupted. This often results in increased erosion in certain areas and accretion (increased sedimentation) in others. For example, in Playa del Carmen, south of Cancun, nearshore currents run from north to south. When a ferry



The general pattern of surface water currents along the coast of Quintana Roo. While net flow is from south to north, there are typically counter-currents from north to south directly along the shoreline (Merino 1983).

pier was constructed at Playa del Carmen, the natural longshore transport pattern was interrupted causing significant sediment deposit to the north of the pier and severe erosion to the south.

The pier in Playa del Carmen creates a barrier that impedes the natural longshore transport of sand, as seen in the section to the right.



220. NATURAL HAZARDS

In the Yucatan Peninsula, Quintana Roo is the state most exposed to meteorological phenomena including tropical storms, hurricanes and strong winter storms called "northers." Quintana Roo is particularly vulnerable along the northern coast where storms hit highly populated areas between Cabo Catoche, Cancun and Carrillo Puerto.

In 1988, Hurricane Gilbert, one of the more severe storms in the recent past, substantially damaged the northern coast of Quintana Roo. The storm, with tidal surges reaching 30 to 40 meters, diminished the width of Cancun's beaches, breached barrier beaches along the coast, modified the bottom contour (bathymetry) of the sandy ocean floor, formed several new canals within the wetlands, and stranded shrimp boats in Puerto Juarez. The National Tourism Development Fund Agency reports the hurricane also damaged approximately 4,000 hotel rooms in Cancun and 1,350 rooms on Cozumel. Thankfully, Quintana Roo is not hit annually by hurricanes the magnitude of Gilbert. It is, however, routinely threatened by tropical storms and hurricanes from July to October, when storm waves, tides, and winds cause flooding and other damage. Storm tides can produce waves 10 meters or higher. These waves can demolish coastal infrastructure, radically alter the configuration of the beach, and strand large vessels on shore. Beaches erode during storms, making them narrower and forming sandbars directly offshore. While many of these effects are temporary, occasionally intense storms change the configuration of a barrier spit by opening or closing tidal inlets, thereby altering water flow between the coastal lagoons, wetlands and the sea. Heavy rain and tidal surges can flood upland areas near the sea by preventing interior waters in lagoons and wetlands from draining. The hard, clay-filled, impermeable soil of Quintana Roo often takes several days to absorb rainwater thereby increasing the risk of flooding. Hurricane force winds are capable of knocking down trees, electric and telephone lines and antennas; damaging buildings, agricultural lands and forests; and causing objects to fly inland.

The northers (storms caused by northerly winds from October through January) have different origins than hurricanes. Yet, their affects on land and sea are similar. While hurricanes originate with tropical, summer winds over the ocean, northers originate as subtropical winds and winter storms over the continent. Because hurricanes occur in summer and northers occur in winter, the natural beach process that restores equilibrium after a storm is sometimes prevented. When both meteorological phenomena occur consecutively, the natural deposition of sand in winter is counteracted by the effects of northers that begin shortly after hurricane season, resulting in a temporary shoreline retreat.

Considering the growing importance of tourism, these natural phenomena can have a significant impact on the state's economy. Although natural hazards cannot be avoided, proactive planning and informed decisionmaking for the siting and design of new development projects can help mitigate extreme damages.

Despite the potential for disaster, these natural storm phenomena are not entirely destructive. Many regions in Mexico, especially the Yucatan Peninsula, lack rivers and thus depend on annual storms to replenish much-needed freshwater supplies.

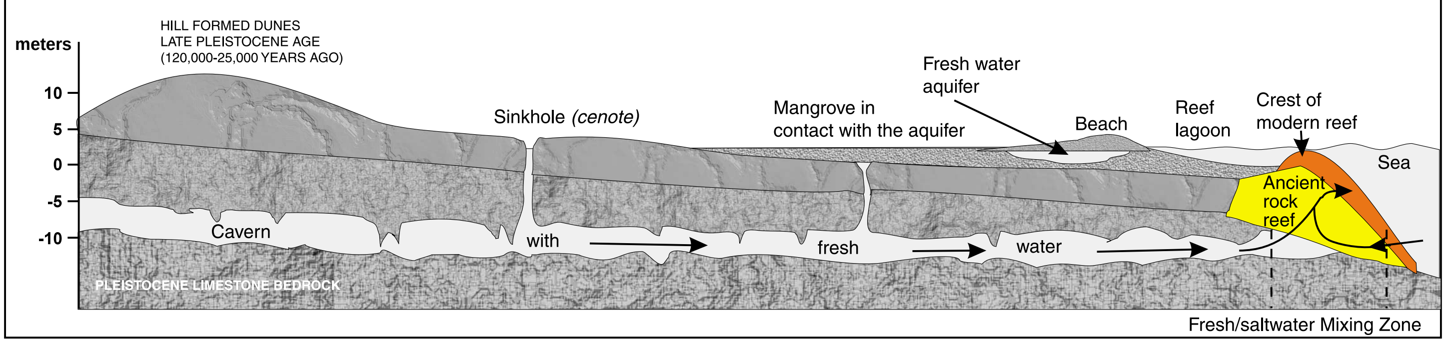
Coastal infrastucture is vulnerable to damage from natural hazards such as hurricanes and tropical storms.

230. Groundwater

The Yucatan Peninsula is a vast limestone plain running on a slight decline from its center towards the coast. The peninsula's relatively flat topography does not allow rainwater to form rivers on the land's surface. Instead, it passes through the surface layers of limestone to form an underground flow of water, called groundwater. The water accumulates in rock cavities and creates an underground lens or aquifer—the source of potable water. This freshwater flows seaward in the groundwater aquifer (see figure below). Along its path to the sea, the freshwater infiltrates porous underground limestone and flows through interconnected channels at various depths. In some places, the groundwater slowly dissolves calcium rocks to form caverns and caves which eventually collapse to form sinkholes, or *cenotes*, which are visible from the surface.

Due to the coastward decline in topography, the water table gets closer to the surface as it approaches the coast. When the water table meets surface waters at or above sea level, it contributes to vast expanses of fringing wetlands, which make up hundreds of kilometers of the Yucatan Peninsula's shoreline. In some places, the boundaries between land and sea are almost indistinguishable, resulting in a transition zone where land gradually turns into water over a great extent of silty intertidal zone with varying salinities. This type of terrain borders Ascension and Espiritu Santo bays along the central coast of Quintana Roo.

Dynamics of groundwater in the coastal zone.



Barrier beaches that protect the numerous wetlands and lagoons that lie between the barrier beaches and the mainland line much of the rest of Quintana Roo's coast. A secondary aquifer, used by residents for household wells, lies beneath the barrier beaches, the porous sand of which permits the recharge of this aquifer during the rainy season. Differences in water densities cause fresh rainwater layers to lie above the saltwater layers in this aquifer. While these barrier beaches are often a "boundary" between the freshwater wetland system and the saltwater ocean system, in some cases there is actually a direct exchange of water within the groundwater aquifer causing some bays and coastal lagoons to contain a brackish mix of salt and freshwater. In other cases, springs of freshwater appear in the reef lagoon. Both conditions illustrate the varied dynamics of the freshwater/saltwater interface.

Because groundwater is essential to a variety of ecosystems and human settlements in Quintana Roo, any contamination from land-based activities can have far-reaching consequences. Groundwater is the sole drinking water supply for local communities, and as such groundwater is extremely important to human health. Groundwater also supplies coastal ecosystems such as wetlands, coastal lagoons and coral reefs with freshwater. If the groundwater becomes polluted these ecosystem resources are endangered.

To avert the potential impacts of land-based development, it is fundamental to understand the region's geologic and hydrologic characteristics and to consider its natural coastal processes. The interactions of land and water, man and environment, and onshore and offshore dynamics are complex and the implications of ignoring them are enormous. Understanding the fundamentals of natural hazards, sediment transport and groundwater dynamics is key to ensuring long-term sustainability of coastal development. These forces must be extensively evaluated during the planning and design phases of new development.

In some locations it is difficult to determine the limits of the upland and the sea.

For more information:

Merino, I.M 1983. *Aspectos de la circulación costera superficial del Caribe Mexicano con base en observaciones utilizando tarjetas de deriva.* An.Ins.Cienc. del Mar y Limnol. Univ. Nal. Autón. México, 13 (2): 31-46.

Shaw C., Boothroyd J., Klinger J., Rubinoff P. 1997. *Coastal geology and the water resources of the Xcalak region*.

Amigos de Sian Ka'an, Bulletin 17. *http://crc.uri.edu/comm/lac_pubs.html*

Kelly, Joseph T., Kelly A., Pilkey O.H. Sr. *Living with the Coast of Maine*. 1989. *http://www.eos.duke.edu/Research/psds/psds.htm*

Federal Emergency Management Agency. *How to Mitigate. http://www.fema.gov/MIT/how2.htm*

Caribbean Disaster Mitigation Project. *http://www.oas.org/en/cdmp/publist.htm*

Hurricane Proceedures Manual; Caribbean Hotel Asso. & Caribbean Tourism Organization. *http://www.oas.org/en/cdmp/document/chaman/chaman.html*

Respecting the natural dynamics of beaches and dunes is critical to sustainable infrastructure development.

SITING INFRASTRUCTURE RESPECTIVE TO BEACHES AND DUNES

Designing development to maintain the dynamics of beach and dune processes will support sustainable tourism development.

Guidelines for Building on Beaches and Dunes

Minimize risks from erosion and wave action

310. Establish construction setbacks or restriction zones for new construction
320. Design and construct development to complement natural conditions

Minimize damage from storms and floods

330. Elevate structures in flood-prone areas
340. Design infrastructure to withstand the effects of wind and waves

Conserve natural environments

350. Reduce the impacts to nesting marine turtles

Introduction

Beaches and dunes are valuable resources, from both an ecological and economic standpoint. They are the prime resource for tourism, provide habitat for many species, and provide necessary access for artisanal fisheries common in Quintana Roo. Throughout the local coast, the beaches differ in width, slope, sediment composition and dune height. Many are barrier beaches forming a thin strip of land (40-400 meters) between the wetlands and lagoon systems, and the Caribbean Sea. These beaches are particularly vulnerable to erosion and storms. Daily they are altered by changing tides; seasonally by storms, hurricanes and northers; and over long time periods by human modifications, global changes and sea level rise. The natural processes support the beach's function as a barrier to the backshore lagoon and wetlands, a sediment source for vegetation, and a habitat for flora and fauna (e.g. nesting turtles or birds).

Given these characteristics, the area available for new construction is marginal. The challenge thus becomes one of how to design, site and construct development that is attractive for tourism, yet protects developers' investments. At the same time, it must consider the physical constraints and the dynamic natural processes of the area. This last point is key to ensuring long-term sustainability of new development and infrastructure—project design must respect that the coastline is a dynamic system vulnerable to continual change.

MINIMIZE RISKS FROM EROSION AND WAVE ACTION

Erosion and accretion are natural processes necessary for the long-term stability of the shore. In the absence of humans, natural erosion typically is not a problem since the system will return to its equilibrium with time. However, when people build structures in dynamic coastal areas, erosion can threaten human safety, infrastructure and economic stability.

Principles for planning and designing projects along the beach

- *Plan and design to minimize risks from storms, hurricanes and erosion—this will reduce repair costs and environmental loss*
- *In evaluating alternative designs for beachfront construction, long-term impacts and associated costs (economic and ecological) for constructing shoreline protection structures must be considered prior to construction, along with the potential need for ecosystem restoration.*

FOR MORE INFORMATION ON BEACH CHARACTERISTICS AND DYNAMICS SEE SECTIONS 100 AND 200

When designing and building new structures, it is critical to ensure that erosion is not increased as a result of that new development, and that coastal processes remain as natural as possible. Following the guidelines in this manual will help to minimize the impacts of coastal construction, including erosion.

Inappropriately located buildings often

Applying design guidelines that consider beach characteristics can help reduce long-term impacts to both the beach and structures.

Construction setbacks or restricted zones would help mitigate wave impacts to shorefront properties, such as below.

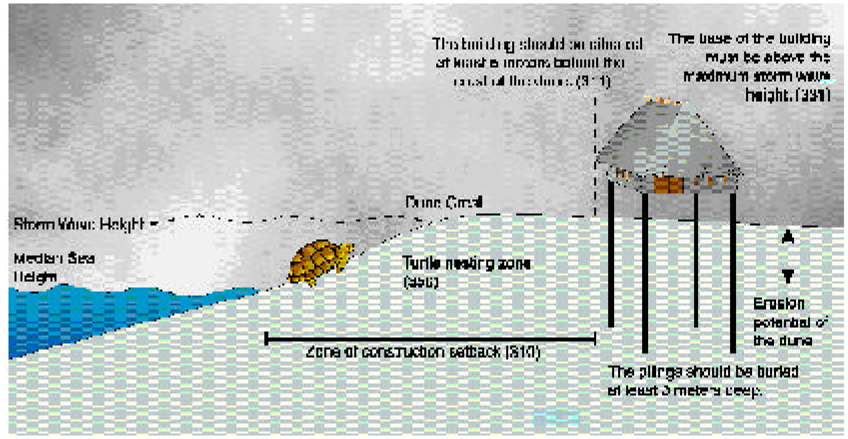
experience erosion, in which case the first reaction of a shorefront landowner is to put a wall around their property and "harden" the shoreline to prevent further damage. This hard-structure solution, however, may in fact increase beach erosion—particularly in front of and adjacent to the wall—and may decrease the recreational and economic value of the beachfront property. This is the case in many areas of Cancun and Playacar.

Maintaining a natural buffer (often called a setback or restricted zone) between the sea and the new development is one of the most appropriate, proactive methods to reduce damage from erosion and floods. If risks of damage increase, it is recommended that "non-structural" alternatives (often called "soft solutions") be evaluated first—before walls and barriers are built. Examples of non-structural methods for coastal protection include moving buildings landward, elevating buildings, and increasing the size of the beach or dune through beach nourishment. It is important to note, however, that the success of non-structural measures depends greatly on the specific conditions of the site and the potential natural hazard risks.

SEE SECTION 9OO FOR AN EXPLANATION OF HOW THESE GUIDELINES ARE APPLIED IN A DEMONSTRATION SITE

310. ESTABLISH CONSTRUCTION SETBACKS OR RESTRICTED ZONES

Construction setbacks (or restricted zones) allow beaches and dunes to maintain their natural functions while buffering infrastructure from storm conditions. The recommended width of construction setbacks varies according to beach type and profile, and the location of the primary dune. In Mexico, the Federal Marine Zone (*Zona Federal Marítimo Terrestre*, or ZFMT) is 20 meters from the high tide line. Activities in this zone fall under federal jurisdiction and must be authorized by the Office of the Marine Zone Program in the National Environmental Agency (*Secretaría de Medio Ambiente Recursos Naturales*, or SEMARNAT). At many Quintana Roo beaches, current setback zones are not sufficient to protect structures and as a result erosion has occurred. Since there is no long-term shoreline change data available, setbacks should be established on a site-by-site basis, depending on the specific characteristics (i.e., wind, wave, beach profile, and erosion history) with the minimum being the 20-meter Federal Zone.

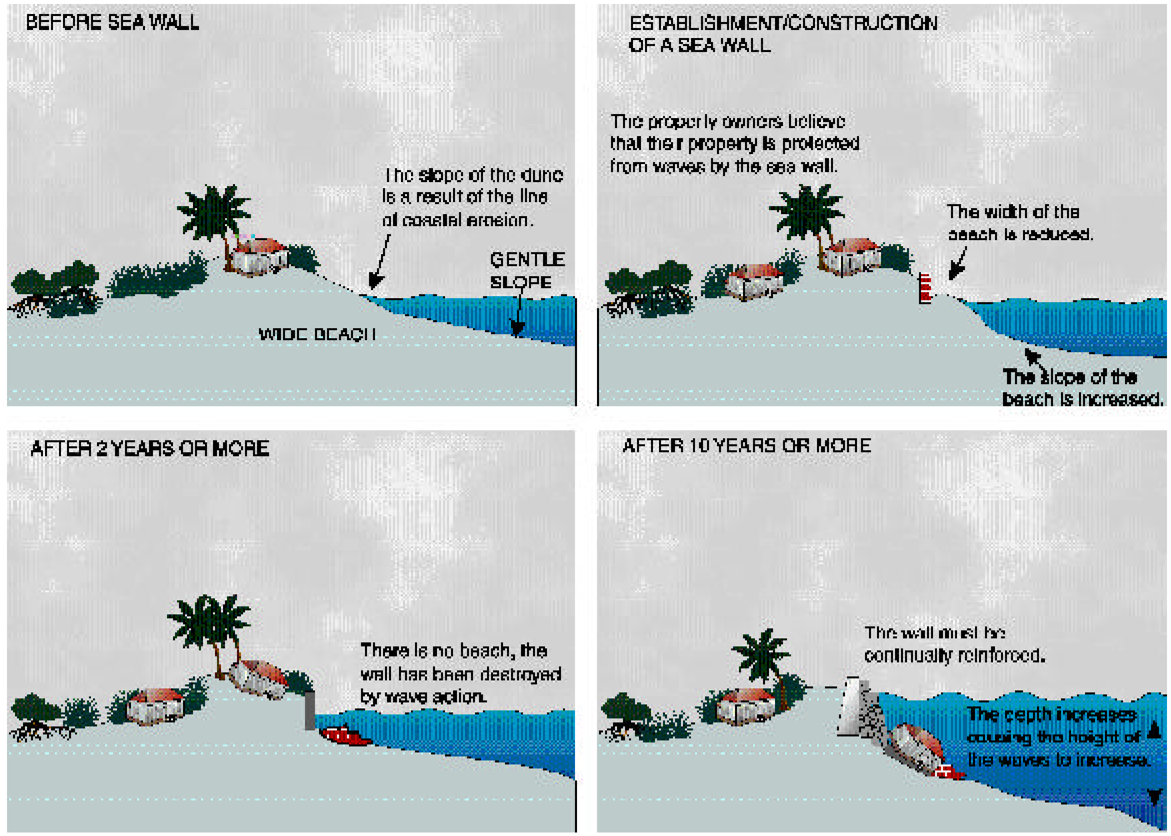


Several design elements can be employed to minimize impacts to infrastructure and natural resources. (Numbers refer to the guidelines presented in this section.)

311. ***Construction should be located landward of dunes.*** **I**t is recommended that all permanent structures be built at least five meters landward of the dune crest (highest point on the dune) to allow normal seasonal erosion and deposition cycles to continue, without damage to infrastructure. The design of all structures should minimize disruption to the dune's profile, and reduce alterations which could cause the dune to breach from approaching waves. Although structures constructed behind dunes have greater protection than those constructed on top or in front, the dune should not be considered indestructible as it is subject to erosion and washing over during storm events. A beach transect can easily identify the dune crest.

312. ***Place only modest or temporary structures in the buffer zone***. Non-permanent structures such as wooden *palapas* (thatched roof huts) or sunbathing umbrellas are more appropriate in the buffer zone than are enclosed, permanent structures. Non-permanent structure can be easily removed before storms, or if damaged, will not result in significant economic loss or alteration of the landscape.

313. ***Avoid constructing rigid structures on the beach and frontal dune***. While often used to protect buildings and development, seawalls or solid foundations often increase damage to both infrastructure and the beach. As seen in the sketch on the next page, solid vertical walls cause



(Adapted by Kelley, 1989)

The consequences of building a wall parallel to the beach over a long period of time.

increased erosion at the base of the structure during storms. This is because the solid barrier prevents wave energy from dissipating (reducing) thereby concentrating its erosive forces at the base of the wall.

320. DESIGN DEVELOPMENT TO COMPLEMENT NATURAL CONDITIONS

In some places along the coast of Quintana Roo, dunes are very high and easily identifiable, while in other places the dune is not as prominent, since the natural form of the dune is flatter or has been altered by past development (such as coconut plantations or hotels). Coastal dunes are formed when sand or gravel accumulates on the beach from wind and waves. These dunes are commonly covered with vegetation; they provide habitat for birds and animals, and also provide a natural barrier to the backshore. Dunes constantly change shape from wind and waves and are naturally renourished with sediment from nearby beaches. Project design and construction techniques should specifically avoid damage to dunes, ensuring they can continue to perform their natural functions including serving as a natural protection against storm damage. When planning new development, consider the following recommendations.

321. ***Maintain stable, well-vegetated dunes.*** Conserving natural vegetation on dunes helps trap sand which in turn helps stabilize the dunes and the surrounding area. Section 500 details native species and other vegetation suitable for dunes and outlines ways to maintain habitat for flora and fauna while designing a landscape that is aesthetically pleasing.

322. ***Design access ways to minimize impacts***. Walkways should be narrow and parallel the dunes, or should zigzag and wind through the dunes, since perpendicular paths tend to create

Preserving a stable, well-vegetated dune helps mitigate damages from erosion during the storm season.

Wooden fences act as sand traps for wind-blown sand which helps to maintain dunes.

channels for water flow during high tides or storms. When access over the top of a tall dune is required, one option is to construct an elevated wooden walkway. This allows dune sands to move freely beneath the structure, with minimum disturbance to the dune. Locate roads and parking lots away from dune areas to reduce the need for continuous maintenance from erosion and windblown sand.

323. ***Place wooden fences along the beach berm or in front of primary dunes to trap sand.*** Wooden fences placed at an angle to the wind can help trap sand that is transported by the wind. Increasing the height of the dune in this way also decreases the potential for backshore storm damage. The rate of sand accumulation varies depending on the location of the fence, angle of the wind and seasonal conditions.

324. ***Identify inland sources of sand for construction material***. Removing or mining sand from beaches and dunes for construction material significantly increases beach erosion. In Quintana Roo, sandy soils that are located in inland-forested areas should be used as an alternative material.

MINIMIZE DAMAGE FROM STORMS AND FLOODS

The vulnerability of coastal development to flooding and storm damage depends in part on its location with respect to the direction of wind and waves, beach height and width, and dune profile. Additionally, the presence of an exposed offshore reef crest can reduce wave energy by acting as a breakwater. Well-designed structures that consider the effects of winds, waves, and the physical characteristics of the beach and nearshore environment, can significantly reduce economic loss and increase the safety of inhabitants during storms.

330. ELEVATE STRUCTURES IN FLOOD-PRONE AREAS

In communities such as Xcalak or San Pedro (Belize), many older houses are constructed on pilings, a technique historically used to minimize damages from flooding. Floodwaters then can pass below the living space and reduce impacts to the structure and its contents. This technique has been used in the United States as a building code regulation for constructing in floodplains.

331. ***Design structures so that the living space is above the maximum height of storm waves***. The first floor of the structure should be elevated to a height of the expected storm surge during a hurricane or winter norther. This flood elevation depends on the dynamics of individual beaches, the presence or absence of any barrier reefs and reef crests, and many other factors, including wind and wave conditions. Unfortunately, official historical records or scientific data are often not available. For Quintana Roo however, field observation, interviews with community elders and old photographs provide invaluable information on storm surge elevations.

332. ***Use pilings as foundations in flood-prone areas.*** Pilings should be driven deep enough to withstand hurricane force winds and wave forces. In the absence of detailed engineering studies, the U.S. Federal Emergency Management Agency recommends that pilings in beach areas subject to erosion be embedded to a depth of three meters below mean sea level. Ensuring that the depth is relative to mean sea level and not the beach's existing grade is a critical point, as beaches or dunes can erode during a storm and render the pilings unstable. If the use of pilings is not feasible, and solid foundations are necessary, cement foundations should be constructed with walls perpendicular (not parallel) to the coastline. This allows water to be channeled under living spaces to the backshore as opposed to creating a solid seawall parallel to the coast, which may enhance erosion of the beach, as well as destabilizing the structure.

In communities like Xcalak, local architecture has adapted to environmental conditions, where downtown streets can be inundated by storms.

340. DESIGN INFRASTRUCTURE TO WITHSTAND THE EFFECTS OF WIND AND WAVES

Storms and hurricanes bring intense winds and waves that may overturn structures or tear them off their foundations. Roofs may collapse or be lifted off, and glass windows smash from impacts of these strong forces of nature.

341. ***Incorporate venting in roofs to release excess pressure***. During storms, the barometric pressure decreases, thereby creating differential pressure between the inside and outside of a building. This increases the risk of structural damage to foundations and walls. This risk can be reduced, however, by installing vents to release pressure. Many of the typical thatched, palapa roofs in Quintana Roo have been designed and constructed through the centuries to avoid such problems and have often withstood these intense hurricane force winds.

342. ***Design boat piers to withstand waves, or undermining from erosion or floodwaters***. Pier decking should be anchored to pilings and horizontal beams to avoid having them float off their foundations when flood-waters rise. Vertical pilings and cross-bracing should be designed to withstand the force of larger waves and hydrostatic pressures from higher tides that occur during storms and hurricanes.

Vertical seawalls parallel to the shore increase wave energy, often resulting in increased beach erosion.

CONSERVE NATURAL ENVIRONMENTS

Intertidal areas, dunes and beaches are important habitats for invertebrates, birds, turtles, and small mammals. The vegetation in these areas is a source of food and provides camouflage from predators. Beaches provide nesting areas for turtles, many of which are endangered to the point of near extinction. Intertidal areas are rich in small invertebrates—a primary food source for migratory birds. Development should be designed in a way that avoids destruction of intertidal areas, dunes and beaches, and promotes their continued existence as natural habitats.

350. REDUCE THE IMPACTS TO NESTING MARINE TURTLES

Each year between May and October, various species of marine turtles (loggerhead, green, hawksbill and leatherback) return to their birthplaces to nest, laying their eggs on beaches and dunes above the 20-meter federal public access zone. Nesting turtles will frequently choose vegetated areas or dunes, as these areas are safer from waves.

351. ***Limit exterior lighting in beach areas to minimize disturbances to turtles***. Turtles are photosensitive. White lights are a particular concern for nesting turtles because while mothers are merely bothered by the lights, babies are attracted to them. The hatchlings are disoriented by the lights and move towards them as opposed to towards the water—where their chances for survival are much improved. When designing coastal development with outdoor lighting, consider the following guidelines:

- Use red or yellow bulbs and low-profile, low-intensity lighting on walkways adjacent to the beach
- Direct terrace lighting away from the beach
- Install polarized glass in buildings directly adjacent to the beach so guests can view turtles without disturbing them.

352. ***Implement setback regulations and avoid building hard structures***. Avoid constructing hard structures such as seawalls that create obstacles for nesting turtles. Establish construction setbacks and build behind the primary dune in turtle nesting areas. This will both protect the turtle nesting habitat and also provide additional storm protection to structures.

353. ***Restrict use of vehicles on beaches***. During sea turtle nesting seasons, avoid mechanical beach cleaning with tractors. Use hand tools such as rakes which penetrate less than two inches into the sand. Prohibit the use of motorized patrol vehicles or recreational vehicles on the beach.

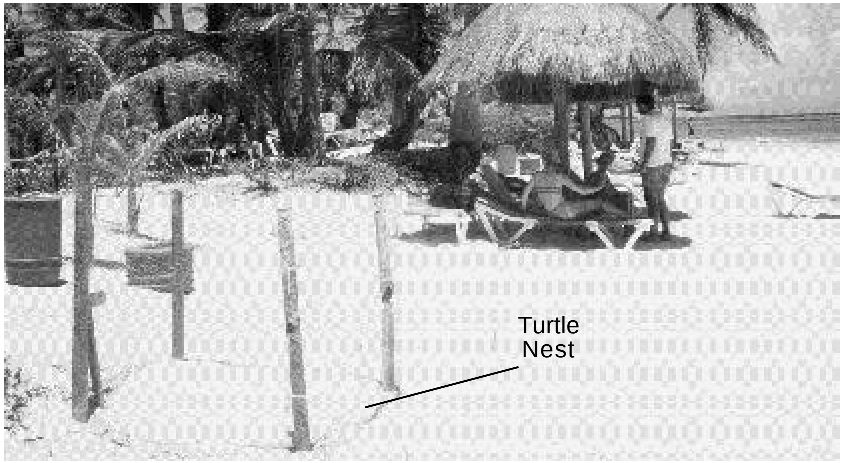
354. ***Collaborate with groups that protect or relocate turtle nests***. Many local nongovernmental organizations have community-based programs to protect turtle eggs by fencing off the nests or relocating the eggs. Contact these groups or the National Environmental Agency (*Secretaría de Medio Ambiente Recursos Naturales*, or SEMARNAT) for information on nesting locations, development guidelines and turtle protection programs.

For more information:

Building Performance from Hurricane Fran, North Carolina FEMA-290 Item 9-1078. *http://www.fema.gov/MIT/bpat/bpat008.htm*

Coastal Construction Manual. Federal Emergency Management Agency. *http://www.fema.gov/MIT/bpat/bpn0600e.htm*

Coping with Beach Erosion. UNESCO and Puerto Rico Sea Grant Program. *http://www.unesco.org/csi/pub/source/ero1.htm*



The beaches of Quintana Roo are important for nesting turtles. Several local groups have established programs for protecting nests and eggs.

Coastal Guide on Dune Management. *http://www.coastalguide.org/dune/index.html*

Beach Nourishment and Protection. 1995. National Academy of Sciences. *http://books.nap.edu/books/0309052904/html/1.html*

Guidelines for Construction Setbacks. UNESCO. *http://www.unesco.org/csi/pub/info/info4.htm*

Blue Flag Beach Certification. *http://www.blueflag.org/frameset/criteria.htm*

Sport-fishing has become a major tourist attraction in Quintana Roo.

Siting Infrastructure to Respect Wetlands

To contribute to sustainable tourism development, use practices that prevent water pollution, conserve critical coastal habitats and maintain public access to water bodies.

Guidelines to consider when designing developments near lagoons, wetlands and other water bodies

Maintain the hydrological function of wetlands

410. Design development to maintain the coastal wetlands as a functioning habitat
420. Avoid alterations that reduce quality of wetlands and mangroves

Reduce impacts and contamination to water bodies

430. Reduce impacts from land-based runoff
440. Reduce discharge of contaminants to wetlands

Utilize low-impact methods of enhancing public access to water bodies

450. Evaluate the siting and design of docks and piers
460. Use integrated methods to develop marinas

Introduction

The coast of Quintana Roo is known worldwide for its clear blue waters, its extensive coral reefs and the degree of conservation of its natural resources. These waters—both coastal and inland—and their adjacent lands are essential components of valuable ecosystems that provide habitat for fisheries, plants and animals; serve as a natural flood protection system; and provide extensive opportunities for low-impact recreation. Today, as tourism development expands around the lagoons and wetlands of Quintana Roo, the coast becomes increasingly vulnerable—directly impacted, for example, by the cutting or filling of mangroves and indirectly impacted by such things as changes in drainage patterns. Risks to the coast are high simply due to the very geomorphology—revealing how the landscape functions within a geological and hydrological context—of the Yucatan Peninsula.

Looking at Quintana Roo in a regional context, its flat limestone bedrock topography results in the connection of various ecosystems (including wetlands, lagoons and coral reefs) through groundwater. While this subsurface water movement contributes to the extensive number of habitats that exist within the lagoons and wetlands, it also increases the potential for ecological damage from land-based contamination to be distributed through groundwater. Additionally, the narrow barrier beaches lining the coast of Quintana Roo limit the land available for development. When development does happen, the pressure on adjacent wetlands and lagoons is further increased.

With new developments constantly emerging along Quintana Roo's coast, there are many opportunities to plan and design new developments that avoid and reduce negative impacts of pollution and habitat destruction, while at the same time

Principles for planning and designing projects in and adjacent to lagoons, wetlands and other waterbodies:

- *Reduce costs of future project maintenance or ecological restoration by maintaining natural hydrological processes and ecological characteristics necessary for healthy ecosystems*
- *Maintain high water quality and avoid the input of contaminants to ensure enhanced fisheries and recreational opportunities*
- *Promote economic opportunities appropriate for the natural environment*
- *Provide opportunities for low-impact recreation for visitors and communities*

maintaining adequate public access to the water resources for visitors and communities. Fortunately, existing regulations require the evaluation of all new hotels and community infrastructures to ensure that alterations to the natural ecosystem are minimized or that negative, long-term environmental impacts are mitigated.

Instead of subjecting fragile lands to development, these lands can be set aside for conservation purposes. This creates opportunities

Restoration costs are often higher than incorporating mitigation measures into the original design. In Cancun, current efforts are being implemented to mitigate water pollution impacts.

Elevating structures minimizes impacts to habitats while reducing potential flood damage.

for ecotourism at the same time that it supports the region's environmental sustainability goals. Such foresight is critical when developing a region's long-term economic plan—which must show not only projected ecotourism dollars flowing into the system but also projected dollar savings that would result if habitats and water quality are responsibly managed and future restoration costs are avoided. For example, Cancun's Nichupté Lagoon suffers from eutrophication (deterioration of water quality from increased organic decomposition) caused by nutrient loading— a result of reduced water circulation and insufficiently treated sewage from tourism development. At a cost of almost $2 million U.S., the restoration program has provided an aeration system to improve the water quality and reestablish the lagoons natural conditions.

In coastal areas where extensive lagoon and wetland systems thrive, planning and policy choices need careful evaluation including an assessment of both the long-term costs and benefits of development. Development along ecosystem borders can have potential long-term, negative consequences including loss of habitat functions and natural resource values. Contaminated lagoons reduce opportunities for safe recreation (e.g. swimming); reduce mangroves and fisheries nursery habitats; and reduce future fisheries catch. Also, filled-in wetlands tend to increase the flooding potential of adjacent development. Again, carefully made development decisions can help keep the environment healthy—a prerequisite for long-term, sustainable tourism development.

MAINTAIN THE HYDROLOGIC FUNCTION OF WETLANDS

Along the coast of Quintana Roo, the barrier beaches are very narrow (40-400 meters in width) and are bordered on the landward side by lagoons and wetlands. The hydrologic functions of these wetlands and lagoons are determined by the geologic formations of the barrier beaches, and the flow of groundwater to and from the sea. When new development is designed and constructed, it should allow these natural water flows and coastal processes to continue uninterrupted to help maintain this dynamic system.

Narrow areas of shoreline that are backed by a lagoon-wetland system are usually not appropriate for development. A key reason is that typically these areas are more vulnerable to storm damage and washing over by high waves. Additionally, in highly productive, fragile areas, these areas should ideally be maintained as natural beaches—i.e. without infrastructure. In certain cases it may be appropriate to consider constructing modest elevated *palapa* structures within the backshore wetlands zone—and even then, only when designed appropriately so as to maintain natural wetland functions and avoid impacts to vegetation and water quality. Again these are decisions that should be made with full consideration of appropriate planning and regulatory regimes that view the public benefits and costs of such development within an ecosystem providing values and benefits of a different source and magnitude.

410. DESIGN DEVELOPMENT TO MAINTAIN THE FUNCTION OF WETLANDS

Maintaining the ecological balance between water flow, vegetation and animal habitat is critical to the wetlands function within an ecosystem. Cutting off water circulation, or filling a wetland without mitigation can impact drainage to adjacent property and vegetation, cause increased flooding, and destroy the entire habitat through subsequent changes in soil composition and vegetation. Altered wetlands change the system's ability to be a "sponge" for floodwaters, or a filter for pollutants.

This conduit in a road bed allows water to circulate between the wetlands on both sides of the road.

411. ***Avoid wetlands filling***. Construct buildings and facilities away from wetlands, and design them in a way that complements existing wetland landscapes. Wetlands should not be considered wastelands that can be filled to produce hard substrate for development. However, considering the situation along Quintana Roo's coasts—extensive wetlands along with the promotion of tourism development—limited amounts of wetland filling in certain areas may be authorized. In such cases, it is essential to remember, however, that impacts can be greatly reduced by using appropriate planning and mitigation measures. (See Section 420.)

412. ***Avoid wetlands deforestation.*** Avoid cutting or deforesting wetlands, which can cause fragmentation or loss of complete habitats, which in turn may cause the extinction of local plant and animal species (many of which are endemic to Mexico). When vegetation is cut or altered, changes occur in the hydrology or water flow regime resulting in increased potential for flooding.

413. ***Construct roads in areas of higher elevation.*** Identify areas of higher elevation for road placement. This will not only avoid unnecessary wetlands alteration, it will greatly reduce chances of road flooding. If there are no routing alternatives and portions of road construction must pass through the wetland, design the project to incorporate bridges or below-grade culverts. Consider the water elevations that occur during high tide and storm events, and ensure that water can adequately flow—even during these times—to help maintain a well-functioning wetland and to reduce maintenance requirements for the road.

420. AVOID ALTERATIONS THAT REDUCE THE QUALITY OF WETLANDS AND MANGROVES

Project alternatives and mitigation methods are often evaluated as part of an environmental impact assessment process overseen by the government. Priority should be given to project design alternatives that avoid the alteration of any wetland and that preserve outright the healthiest wetlands. If this is not entirely feasible, establish techniques that mitigate the damage to ecosystems during the planning phase of a project. This will help reduce future impacts and restoration costs. In cases where impacts are unavoidable, actions can be identified to compensate for the loss of habitat or wetland functions. For example, restoring a degraded habitat within the same development site, or contributing to a wildlife conservation program in the region may be considered appropriate compensation for habitat loss. Solutions vary from site to site, depending on the type and value of the wetland habitat and the opportunities available for compensation.

421. ***Balance the use of mangrove, beach and dune areas for new development.*** To avoid excessive environmental damage and ensure sustainable and marketable development for the long term, a balance should be established between protecting a sensitive area and developing that area. Where the barrier beach is narrow, the land can not accommodate intensive, high impact use without harming the adjacent wetlands or shorefront beach processes. As such, development in such areas should be small in scale. For example, to avoid extensive alteration of the beach/wetland, it may be more appropriate to construct one small, two-story building, instead of two single-story cabanas to avoid extensive alteration of the beach/wetland. As mentioned in Sections 100 and 200, when the beach is very narrow, the design may incorporate small, elevated structures and low-impact use of the wetlands to ensure that water flow is maintained within the wetland system.

422. ***Use pile foundations instead of filling land to construct a stable building***. In instances where it is necessary to construct buildings, boardwalks or piers within wetlands, use wooden piles to raise the structure above the wetland. This is essential for adequate water flow during the rainy season, when ground-water is at its highest.

The limited space on the narrow barrier beach has forced the development of infrastructure within adjacent wetlands.

423. ***Use permeable materials for fill.*** If an approved road passes through a wetland, it is advisable to use permeable materials such as rocks, gravel or sand. Permeable fill allows water to flow throughout and thus helps maintain the water circulation necessary for proper wetland functioning. Clay is an example of a non-permeable fill. Instead, it restricts water flow and causes unnecessary alterations to wetlands. Culverts should be installed to promote adequate flow within the wetland as stated in Section 413.

424. ***Identify on-site methods to compensate for wetland losses.*** Developers should seek opportunities to compensate for wetlands loss, through enhancement of another on-site habitat or habitats in adjacent areas. When alterations are authorized by the National Environment Agency (SEMARNAT), they may require the creation and planting of new wetlands to help compensate for those lost by the project. A recent permit in Cancun to build an amusement park allowed limited alterations to mangroves with the condition that the owners plant a new community of mangroves in adjacent waters. Wetlands creation and restoration projects should be designed appropriately to help ensure successful habitat functioning.

> ***Note***: The legal requirements for implementing mitigation and compensation are defined by SEMARNAT and are outlined in the agency's Environmental Impact Assessment guidelines.

REDUCING IMPACTS AND CONTAMINATION TO WATER BODIES

Tourism development and recreational activities depend upon excellent water quality in lagoons, along the bathing beaches and within snorkeling/diving areas. With a direct hydrological relationship between groundwater, coastal lagoons and coral reefs, it is important to carefully consider the potential for pollution and its impacts on water quality and habitat health within these associated environments.

Water circulation within coastal lagoons and reef lagoons is typically poor due to shallow depths and a lack of water movement between the sea and the lagoons. These conditions make lagoons particularly vulnerable to contamination from land-based activities. Nutrients from fertilizers and sewage treatment plants, sediments from construction, and petroleum products from road runoff all have the potential to enter the lagoons through rain runoff and enter the groundwater by filtration. This can, in turn, cause drastic results in terms of levels of pollution, subsequent impacts to a tourist-based economy, and to public health.

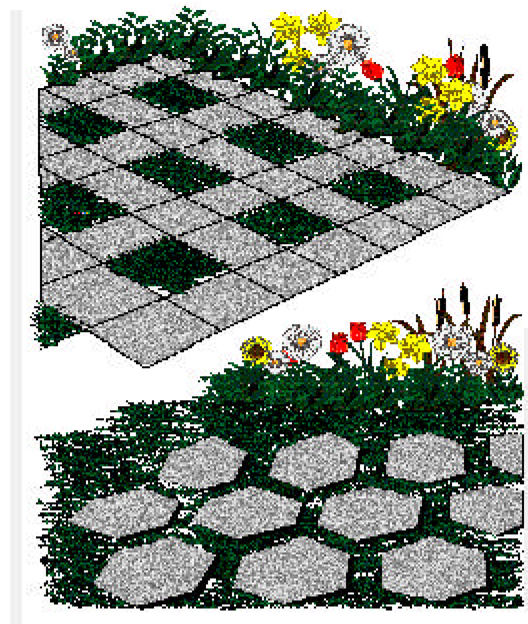
430. REDUCE IMPACTS FROM LAND-BASED RUNOFFS

During the rainy season, land-based runoff carries sediments and contaminates to waters and wetlands. Because buildings and paved roads increase the volume of runoff, it is recommended that all new development designs incorporate the use of vegetation and permeable materials. Use of these materials promotes natural filtration, and reduces the volume of drainage and contamination, while increasing the aesthetics of the new development.

431. ***Cluster new development and maintain green space.*** Grouping buildings onsite maximizes the open space available for vegetation and landscaping, which promotes natural filtration and drainage while reducing runoff to lagoons and coastal waters.

432. ***Reduce impacts of sedimentation during construction by installing temporary barriers.*** Placing palm leaves, straw, or plastic fencing along the banks of the shore (lagoon or sea) will help minimize erosion of construction areas and reduce sedimentation in adjacent waters during construction.

433. ***Incorporate a 10-meter vegetation strip along the shoreline.*** Designing a buffer zone of natural vegetation adjacent to lagoons and wetlands is a low-cost, natural method for leaching out pollutants from upland activities, reducing runoff velocity, and filtering out sediments. Additionally, an undisturbed vegetated buffer provides an essential habitat for wildlife and erosion protection. This vegetation strip corresponds to the 10-meter zone under jurisdiction of the Federal Maritime Zone.



When designing pavement surfaces, incorporate permeable materials to help filter runoff contaminants to waterbodies. (Dark boxes indicate grasses or vegetation; light boxes are concrete or brick pavement.)

434. *Maintain a vegetation strip adjacent to roads and parking areas.* In addition to enhancing natural drainage and minimizing the accumulation of water on roads and parking areas, vegetation within or adjacent to roads and parking areas will help to filter contaminants (such as petroleum from cars). When designing these areas, keep in mind that these vegetated areas will require maintenance to ensure that they continue to function as filters. In some cases, vegetated buffer strips may not be practical and a gravel filter may be a more appropriate alternative next to roadways.

FOR MORE INFORMATION ON VEGETATION SEE SECTION 500

435. *Construct walkways, roads, and parking areas with pervious materials.* Designs that incorporate shell, gravel or open paving blocks with vegetation will minimize runoff to nearby coastal waters. These techniques will promote absorption and filtration to the ground—a resulting benefit is increased safety due to improved drainage of the site. Designs should ensure that subgrade materials are also porous. This will further encourage the percolation of water. In areas with high auto traffic, leave greater spaces between interlocking pavement blocks to allow grass to grow in the openings. This creates two benefits—it provides good load-bearing capacity and it provides pervious openings that encourage good drainage.

436. ***Adequately channel rainwater runoff.*** Minimize the flow of untreated water to wetlands and waterbodies. Runoff should be filtered before entering wetlands, lagoons and embayments. This can be accomplished with the aid of vegetation, gravel or appropriate municipal drainage systems.

440. REDUCE DISCHARGE OF CONTAMINANTS TO WETLANDS

Due to slow water circulation and the delicate balance that exists in lagoons and wetlands, excess nutrients (nitrogen and phosphorus) and other chemicals can easily pollute these areas. Coastal waters, bays and lagoons eventually feel the cumulative detrimental effects of chemicals, nutrients and debris and soon water quality, vegetation, wildlife, and ultimately humans suffer. Specifically, pollution brings unfavorable changes to flora and fauna; creates serious problems for drinking, swimming and fishing; and causes aesthetics problems as well—for example, increased algae or fish kills.

Chapter 3 of Mexico's Federal Ecological Regulations incorporates criteria for wastewater treatment in tourist zones. Article 21 stipulates that reuse of treated water for irrigation of lawns and landscape is a requirement for obtaining approval of environmental impact assessments.

441. ***Do not directly discharge untreated wastewater to lagoons, wetlands, or coastal waters.*** Wastewater should be treated to ensure that both coliform and nutrients are removed before the effluent enters lagoons or coastal waters.

FOR MORE INFORMATION ON WASTEWATER MANAGEMENT SEE SECTION 600

442. ***Minimize the use of fertilizers for landscaping.*** Using native plants for landscaping significantly reduces the need for fertilizers or pesticides. Native plants are also very attractive. (See Section 500.) In cases where fertilizers are needed, it is important to limit their use before an expected heavy rain. Runoff of excess nutrients can cause eutrophication with increased algae growth in wetlands and lagoons.

443. ***Implement a garden debris program***. Discarding landscaping waste or rubbish by dumping it into canals or waterways can cause problems with drainage and lead to flooding during the rainy season. Additionally, the added organic matter to wetlands or waterways may cause additional problems. Identify alternative methods of disposal, such as composting. (See Section 700.)

444. ***Identify appropriate methods for disposing cleaners, motor oil, paint or other household chemicals***. Inappropriate disposal of such hazardous materials can severely degrade ground and surface water quality, with long-term results that are costly to mitigate.

445. ***Use cleaning products that do not contain harmful chemicals***. Cleaning chemicals, even small quantities, contribute to the contamination of ground water or coastal waters. It is important to identify alternatives and minimize the use of phosphate detergents, which cause pollution and excess algae growth within certain fresh water environments.

UTILIZE LOW-IMPACT METHODS OF ENHANCING PUBLIC ACCESS TO WATER BODIES

Boating is an important element of tourism and commercial enterprises all along Quintana Roo's shoreline. When planned properly, marinas and boating can provide an excellent alternative to land development, or complement land-based activities. One important consideration, however, is the scale of the development considered. Although impacts from one pier may be minimal, the cumulative impacts from many piers and boats can be substantial and should be considered when planning developments and community waterfronts. Poor design and location of piers can impact boat navigation, deter access along the shore, or interrupt coastal processes (e.g. sediment transport and current flow). Increased boating activity (recreational or commercial) should consider operations issues such as disposal of solid waste and wastewater, maintenance of vessels, and oil spill contingency plans, as well as potential impacts to coastal habitats within the shallow coastal waters. Additionally, new facilities should avoid displacement of traditional uses of the shore such as access for fisherman and community beach activities, and where appropriate, incorporate such amenities to support the local community.

450. EVALUATE THE SITING AND DESIGN OF PIERS

Boats commonly use individual piers or municipal piers to access the open water. In many communities, boats are stored on the beach as an easy access for fisherman and boat owners. While piers provide necessary and convenient access for boats, poor design can cause irreversible impacts to submerged grasses, increase sedimentation and erosion, or promote unsafe navigation within the bay. Siting the structure near a natural break in the reef provides access to a natural navigation channel, without need for dredging a new entrance channel. In

Traditionally, small-scale piers are constructed with wood on pilings.

terms of personal safety and health, areas designated for piers and boating should be set away from swimming beaches. Depending upon the site and the use, it should be determined if a community pier that accommodates several boats and businesses is more economical and ecologically appropriate than many individual piers. This can be a cost savings for construction and maintenance, as well as a solution to the cumulative impacts of many piers.

451. ***Piers should be constructed in areas with sufficient water depth***. Boats need a particular water depth to function properly without harming engines, boat hulls or the subsurface vegetation within the area. Preliminary siting design should consider the boats' draught, and the available depths of water within the site. Where water is very shallow, longer piers may be constructed to reach the required depth, as long as navigation will not be impacted. Proper siting will minimize dredging requirements (both initial and for maintenance) which will benefit fisheries, shellfish habitat, and submerged and emergent vegetation. Although a longer pier may initially cost more to construct than a short pier, the long-term costs of maintenance dredging will likely reduce the overall project cost.

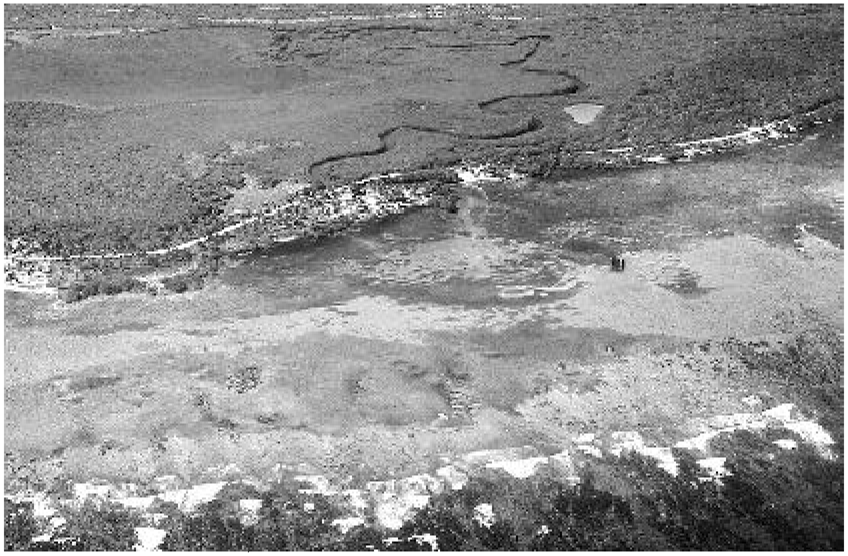
452. ***Utilize techniques to reduce impacts during construction***. Mechanisms such as floating silt fences should be temporarily employed around the construction site to reduce sediment and contaminant impacts to reefs and wetland habitats when driving piles or dredging.

The construction of multiple piers in one small area increases the potential for cumulative impacts to navigation and beach access.

In this fragile wetland lagoon system, boating access and infrastructure should be limited to avoid impacts to fisheries and wetland habitats.

453. ***Select boating activities that meet the physical constraints and the ecological opportunities of the area***. In shallow waters, it is more appropriate to use smaller boats that do not require deep water. In lagoons where many mangroves surround the edges and the bottom provides a fisheries habitat, the use of canoes, kayaks or small launches may be more appropriate than large motorized tour boats.

454. ***Use materials that enhance natural aesthetics***. Modest wooden piers are traditional to the coast of Quintana Roo. Identify woods that are naturally resistant to degradation. If chemically treated wood is to be used, make sure it was treated with non-leaching materials. This will help avoid introducing chemicals into the environment. For example, creosote-treated wood is strongly discouraged as creosote is toxic to both humans and fish.



455. ***Pile structures are recommended for pier construction***. Use pile structures to reduce the probability that water circulation will be impeded. When solid-fill structures are built, water circulation is curtailed and shoreline erosion increases. See Section 210 for more details on shoreline processes.

456. ***Design and siting of a pier should carefully consider the impacts of hurricanes, waves and wind forces***. Similar to buildings on land, piers and associated facilities must be adequately designed for hurricanes and storms. Ideally, these facilities should be located behind the coral reef crest or in a cove that receives natural protection from larger waves. However, even locating facilities properly does not ensure they are hurricane-proof. In any case, the developer must balance storm-proof construction costs (i.e. higher decking elevation or deeper pilings to accommodate storm tides and waves) with the potential cost of repairs to damage that might occur to normal construction. Building structures that can withstand hurricane forces are more expensive in the short term, but may actually be less expensive over the long term. Careful consideration and critical evaluation should be given before constructing breakwaters and wave protection walls—structures that are not only expensive to construct and maintain, but that often increase chances for sedimentation and wave impacts to adjacent properties and navigation channels.

457. ***Consider constructing a larger, community pier.*** In places where many small piers are planned for a local area, instead consider building a community pier—one owned and operated by several individuals. It could be less expensive. Having one community pier also reduces the cumulative impacts (impediments to navigation and public access, and damage to turtle grass habitat) that typically result from clusters of small piers. Additionally, the design of small piers makes them less resistant to hurricane damage than larger piers. For individual owners, the cost to fully replace or make major storm damage repairs to their piers may create an unnecessary economic hardship.

460. USE INTEGRATED METHODS TO DEVELOP MARINAS

As both small craft boating and larger cruise ships gain popularity in Quintana Roo, it is important to find a balance—how to support the economic growth opportunities these activities present while meeting the demands of recreational and commercial industries. With proper planning and sensible design and siting, marinas can provide valuable services and be economically profitable, while minimizing adverse environmental impacts and maintaining good environmental quality. Poor siting decisions, bad construction practices and inappropriate marina operation can, however, result in water contamination and irreversible physical alterations to the watershed.

Clean water is the key to a prosperous boating community and the economic livelihood of

Costs and benefits should be evaluated when planning infrastructure for marinas to determine the most appropriate design with the least environmental impacts.

marinas. It is cheaper to implement reasonable environmental safeguards at the start of a project than to clean up the water in the future. When faced with continual maintenance of facilities and adjacent channels and shorelines, it becomes important to identify locations and designs for marina infrastructure that will be most economical in the long term. When planning a marina, the investor should evaluate economic, physical, environmental and social elements to ensure financial success. Each marina should be designed on a case-by-case basis for its market, use, environment, and site constraints and opportunities.

461. ***Evaluate the market for the marina***. Examine the existing market (0-5 years), the potential market (5-15 years) and the projected long-term market (15-30 years) to help determine the number of boat slips, the size of the slips, and the types of facilities (i.e., fuel, boat sales, parking) necessary for the marina. Not all marinas need to provide the same facilities and services to be competitive and successful. It may be preferable to plan within a larger network of marinas to have different amenities to meet the needs of various boating clients.

462. ***Evaluate environmental constraints and opportunities***. Coastal construction inevitably changes the existing environment. Its impacts can be both positive and negative. Environmental regulations outline both broad goals and specific regulations that help define the physical boundaries of a project and the elements needing an environmental assessment. Such assessments will help identify how to protect fisheries, wetlands and clean water, while minimizing potential negative impacts from dredging or oil contamination of coastal waters. Where negative impacts are unavoidable, use proactive mitigation techniques to minimize their effects as much as possible before the damage is irreversible.

463. ***Identify the most economically and environmentally appropriate site for the marina.*** When determining the economic viability of a project, it is critical to consider the marina's location—can it provide safe navigation, shelter from wind and waves during storms, convenient land and water access, and an environment which the boating public will continue to demand? Clearly, such an economic viability assessment must take into account both first-time costs and long-term maintenance costs of infrastructure and navigation channels—critical input for deciding the most feasible site(s) for the marina.

In Quintana Roo, both the coastal sites and lagoon marinas that have been developed, carried with them associated benefits and costs. For example, constructing jetties to stabilize navigation channels at the entrance to the lagoons aids navigation. On the other hand, jetties have created costly long-term maintenance problems worldwide. In those regions where barrier reefs provide wave protection and access is available through natural breaks in the reef, it is critical to consider how vulnerable the reef is to potential contamination and habitat impacts from marina activities. There are also potential safety issues to consider—for example, the ability to safely navigate through the reef. In contrast, when building marinas along coasts where there is no barrier reef, the developer must consider the potential costs and benefits of building a breakwater. On the benefits side, the breakwater may provide wave protection. On the costs side, it bears construction costs, may increase erosion to adjacent beaches, and raise the cost of maintaining the infrastructure. In the case of semi-enclosed lagoons, limited depth and fragile ecosystems have opened an opportunity for low-impact recreational boating. However, this activity also increases the vulnerability of these waters to water quality contamination. Fortunately, shallow water depths should keep the growth in the number of marinas at a sustainable level.

Siting decisions for marinas are not easy. One must consider factors such as long-term income generation, benefits to the community and the economy of the region, in addition to costs that include infrastructure, maintenance and environmental impact mitigation. The Environmental Impact Assessment is an important tool to identify the options and alternatives important to this decision process.

464. ***Evaluate marina use***. Many of the communities in Quintana Roo currently use the shore for small-scale commercial fishing, tour and ferry boating, as well as for their resorts and recreational beaches. When proposing a new marina development, it is important to consider existing uses in the area and accommodate these needs into new designs. It is critical to evaluate the zoning plans and development initiatives in operation by the local, state and federal governments, and identify ways where the marina can be consistent with these plans and complement the ongoing initiatives.

For more information:

Wise Use of Wetlands. RAMSAR. *http://www.ramsar.org/wurc_index.htm*

Sea Grant Coastal Recreation & Tourism. *http://seagrant.orst.edu/crt/index.html*

Environmental Guide for Marinas. Rhode Island Sea Grant. *http://seagrant.gso.uri.edu/riseagrant/BMP/BMP.html*

Seagrasses. University of Hawaii. *http://www.botany.hawaii.edu/seagrass/*

Water Conservation. Environmental Protection Agency. *http://www.epa.gov/ow/you/intro.html*

Clean Coastal Waters. National Research Council. *http://www.nap.edu/catalog/9812.html*

VEGETATION MANAGEMENT AND LANDSCAPE DESIGN

Conserving the natural landscape and enhancing the scenic beauty of tourism development contributes to the high quality of coastal habitat, one of the area's principal attractions.

Guidelines for Managing Vegetation and Associated Landscapes

Preserve coastal habitats

510. Evaluate existing physical characteristics
520. Utilize native vegetation in landscape designs
530. Eliminate the use of exotic species

Mitigate potential site erosion

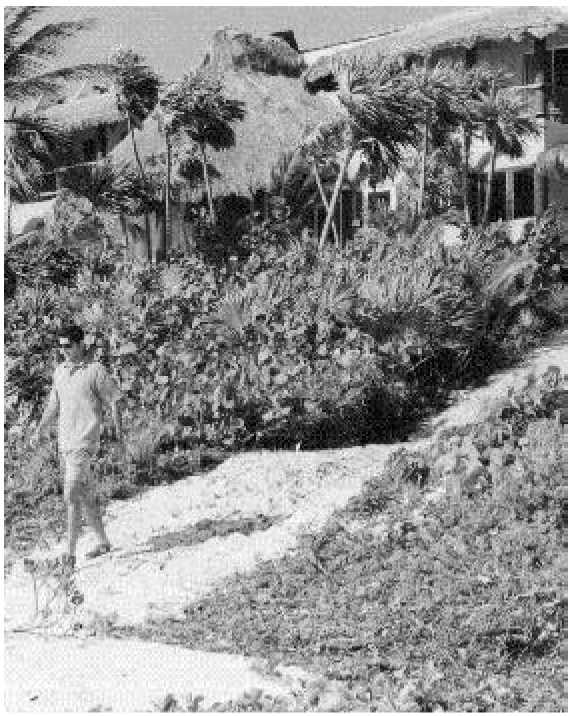
540. Replant areas that have been devegetated
550. Maintain buffer zones from water

Introduction

The coastal zone is a dynamic area, where the processes of sedimentation and erosion continually shape its landscape. Although coastal winds, sea spray and periodic storms often render this zone an unstable environment, many types of natural vegetation have adapted to these conditions and contribute to a healthy and biologically diverse coastal habitat. Vegetation has many important functions in the coastal zone:

- Dune vegetation acts as a sand trap, contributing to dune stabilization and reduced erosion
- Submerged vegetation in the reef lagoon provides habitat for fish and shellfish, in addition to trapping sand and reducing the impacts of sedimentation on near-shore reefs
- Fringing mangroves function as a wave barrier, buffering the direct impacts of wave action on landward beaches
- Landside vegetation bordering lagoons and water bodies acts to filter upland runoff which may contain sediments or land-based pollutants
- Terrestrial and submerged vegetation provides an excellent habitat for many species where both native and migrant animal and bird species rely on these areas for nesting and feeding grounds

In Quintana Roo's coastal zone, vegetative habitats are formed by communities of plants and trees distributed in bands of varying width that run from north to south, corresponding to both land elevation and soil substrate. Soil salinity and moisture content also determine plant distributions, and influence a plant's ability to adapt to special environmental conditions. Dune vegetation is generally found along the shoreline



Principles for planning and designing landscape-sensitive projects

- *Maintain vegetation in order to mitigate erosion caused by wind and water*
- *Preserve and restore areas of vegetation critical for feeding, reproduction and refuge of flora and fauna to maintain biodiversity and aesthetic qualities*
- *Maintain a vegetated buffer around lagoons, sinkholes (*cenotes*) and wetlands to filter contaminants and maintain high water quality*

in sandy sediments, while backshore and inland, either mangroves or coastal jungle vegetation predominate depending on soil substrates and water conditions. Mangrove vegetation is found in lagoon and wetland areas where the substrate has a high organic content and is inundated with fresh or brackish water.

Development poses a severe change to vegetation habitats. Landowners commonly "clear cut" (remove all existing vegetation) construction sites, build new developments and then replant a landscape of new urbanized species of vegetation. This is often done without recognizing that

Aesthetics and landscape design are key elements for tourism development and natural resource management.

Integrating vegetation and landscape design into resort construction helps mitigate erosion from wind and rain, while maintaining viable habitat for flora and fauna.

denuding a landscape leads to severe soil or sand erosion from strong winds and rain; destroys valuable plant and animal habitat, and often introduces non-native species ill-suited to the local environment.

Similarly, the water quality of lagoons and sinkholes (*cenotes*) can be adversely affected by removing adjacent vegetation. This vegetation helps to filter pollutants and is called a "vegetated buffer." For example, plant roots absorb nutrients contained in fertilizers. The plant then uses these nutrients as food while at the same time cleaning the runoff that is entering the lagoon, sinkhole or sea. By preserving the vegetated buffer, the threat of pollution from upland runoff can be reduced, thereby protecting habitats and recreation opportunities.

When there is an understanding of the characteristics and functions of native vegetation, it is easier to utilize it as a natural landscape in a way that helps protect the existing habitat. In addition, integrating native vegetation into tourist and residential developments can yield exceptional benefits, by creating habitats for birds, creating shade screen, and perhaps even producing an edible harvest from native fruit trees.

PRESERVE COASTAL HABITATS

Landscape design and vegetation management can increase the scenic beauty of new resorts and community developments while preserving existing natural habitats—the physical and biological foundation that defines how flora and fauna function within an ecological community. Evaluating conditions, habitats and species on both the development site and on adjacent properties prior to construction provides a strong design foundation in which native flora and fauna can successfully complement the new landscape.

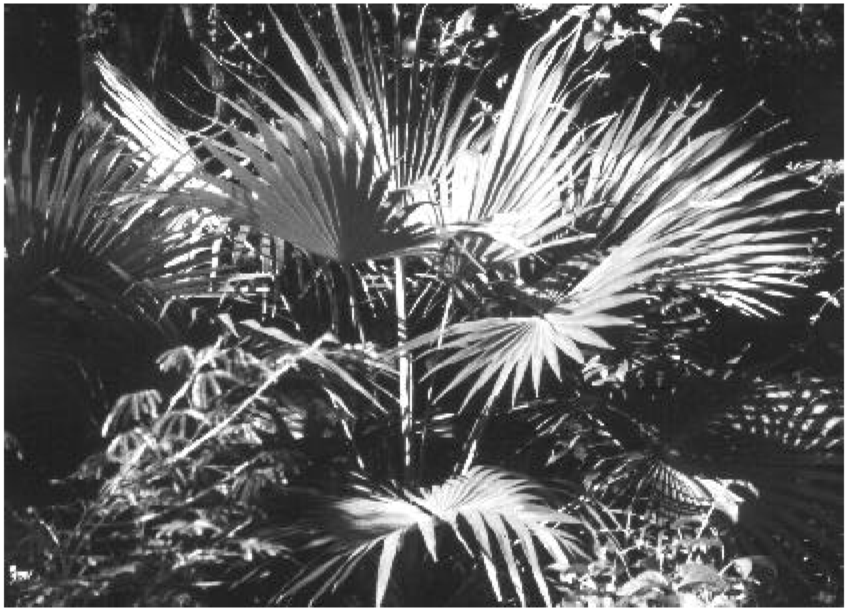
The following guidelines are designed to maximize the use of landscape design and vegetation management to preserve the natural landscape.

510. Evaluating Existing Physical Characteristics

Evaluating the physical characteristics of a development site and incorporating them into the landscape design is essential. This contributes to a more suitably developed environment that reduces maintenance costs, heightens the attractiveness of the development, and enhances the area as a habitat for flora and fauna.

511. *Evaluate soil types and site conditions.* Important factors to consider are the site's exposure to natural elements such as wind, rain and sea spray; the influence of salt water and flooding during storms and hurricanes; the erosion potential of the land; the effects of changing levels of groundwater; and property contour and elevation.

A. ENDEMIC SPECIES	COMMON NAME
Echites umbellata	-
Echites yucatanensis	-
Guapira linearibrateata	Tatzi palm
Coccothrinax readii	Nakax palm
Thrinax radiata	Chit palm
Passiflora yucatanensis	-
Asemnanthe pubescens	-
Serjania yucatanensis	-
B. ENDANGERED SPECIES	
Beaucarnea ameliae	Despeinada palm
Coccothrinax readii	Nakax palm
Pseudophoenix sargentii	Kuka palm
Thrinax radiata	Chit palm
C. SPECIAL PROTECTION SPECIES	
Conocarpuserectus	Botoncillo mangrove
Laguncularia racemosa	White mangrove
Rhizophora mangle	Red mangrove
Avicennia germinans	Black mangrove



***Trinax radiata*, or Chit, is a coastal plant native to Mexico and should be used in landscaping rather than exotic species.**

512. *Identify characteristics of existing vegetation and habitats.* Trees, bushes, grasses and the soil in which they live all contribute to a habitat for flora and fauna within dunes, wetlands and forests. It is important to identify the specific plants, their location within the site (i.e. near the beach or on the wetland's edge), and the way they are grouped to understand how they function as a habitat. Once understood, this habitat can be maintained and/or replicated in a new landscape.

List of Native Vegetation

SPECIES	SPANISH NAME	ENGLISH NAME
Beaucarnea ameliae	despeinada	palm
Pseuphoenix sargentii	kuka	palm
Thrinax radiata	chit	palm
Coccothrinax readii	nakax	palm
Opsiandra maya palma	cimarrona	palm
Ceiba pentandra	yaaxché	Silk Cotton tree
Clusia salvinii	chunup	Pitch Apple
Coccoloba uvifera	uva de mar	Sea Grape tree
Cordia sebestena	siricote	Geiger tree
Ficus sp.	sak away	Fig tree
Gliricidia sepium	sakyab	Mother of Cocoa
Plumeria obtusa	sak nikté (flor de mayo)	Frangipani tree
Pseudobombax ellipticum	amapola	tree
Senna racemosa	x'kanhabin	tree
Bursera simaruba	chaká, (palo mulato)	Gumbo-limbo tree
Tecoma stans	tronadora	Yellow Elder
Malvaviscus arboreus	tulipan de monte	Wax/Turk cap mallow
Chamaedorea seifrizii	xiat	Endemic bush
Chysobalanus icaco	icaco	Coco-plum
Tournefolia gnaphalodes	sikimay	Sea Lavender
Ageratum littorale	hawayche	Endemic plant
Ambrosia hispida	margarita de mar	Coastal Ragweed
Ipomea pes-caprae	riñonina	Railroad Vine
Hymenochallys littorali	lirio araña	Spider Iris
Salicornia bigelovi	salicornia	Annual Glasswort
Portulaca pilosa	portulaca	Pink Purslane
Sesuvium portulacastrum	verdolaga de playa	Sea Purslane
Rhoeo discolor	chaktsam	Oyster Plant
Hymenocalyx littoralis	lirio de mar	Sea Iris

520. Utilize Native Vegetation in Landscape Designs

Utilizing native vegetation within a new development reduces the costs of landscape maintenance since native species are better adapted to the soil and environmental conditions and are more resistant to natural disease.

521. ***Conserve existing native plants on the site and avoid "clear cutting."*** Maximize the use of existing plants as part of a natural landscape within the new development. If necessary, plants can be temporarily removed or transplanted during construction and then replanted at the completion of the project. Guidelines for the use and distribution of endangered species and species under special protection are found in the Official Mexican Regulations, NOM-059-ECOL-1994, published in the federal register on May 16, 1994. Listed in the table on page 64 are some species present in Quintana Roo that are recognized as endemic, endangered, or under special protection.

522. ***Design the landscape with native species.*** Landscaping with native species can produce an aesthetically pleasing environment and a new habitat for flora and fauna. These areas can also serve as a botanical garden in which species can be identified for educational purposes for tourists and the community-at-large. In

Quintana Roo's coastal zone, there are numerous endemic (local to the region) species that are endangered and under special protection. When present at a development site, these species can be used for landscaping. This helps preserve the species while at the same time presents an attractive view for tourists.

Over 200 species of native plants have been identified for use in ornamental landscaping. Native plants known for their beauty and adaptability to the coastal environment, and recommended for use in landscaping new development are listed on the previous page.

523. ***Use walkways and observation areas within vegetated areas.*** Incorporate walkways and observation areas into landscape design to minimize impacts on vegetation. Walkways and observation areas encourage ecotourism activities such as bird watching and tree identification that helps people learn about and appreciate the region's natural resources.

530. ELIMINATE THE USE OF EXOTIC SPECIES

Plants play an important role in both the pristine and the developed landscape. Unfortunately, a great majority of the species used to landscape new development in Quintana Roo are not native to the coastal region and introducing non-native (exotic) species often harms native species and alters the ecosystem.

One example is the Australian Pine or Sea Pine (*Casuarina spp*). Its rapid propagation and resistance to disease has made it a popular shade tree. Unfortunately, the fast-growing roots of these trees tend to kill much of the surrounding vegetation. In addition, their shallow roots are not well suited for coastal conditions. These trees often fall during high winds causing damage to buildings, and their spreading roots crack building foundations. In 1995, Hurricane Roxanne downed many Australian Pines in the Sian Ka'an Biosphere Reserve. Many boats stored on the beaches were damaged and clean-up costs increased significantly.

These non-native Australian Pines can often present problems to coastal infrastructure during high winds, due to their shallow roots.

531. ***Remove and avoid the propagation of exotic species***. Today, a program is in place to eradicate the Australian Pines and replace them with native plants that provide shade. The development guidance in the 1994 Ecological Land Ordinance for the Cancun-Tulum corridor, restricts the following exotic species from being planted: Casuarina (*Casuarina equisetifolia*), Piru (*Schinus terebinthifolius*), *Melaleuca quinquenervia, Colubirna asiatica,* eucalyptus (*Eucalyptus sp.*), melina (*Gmelina sp.*), and ficus (*Ficus sp.*). Similarly, the other ecological land ordinances in development for Costa Maya and Sian Ka'an Biosphere Reserve specify exotic species restrictions.

MITIGATE POTENTIAL SITE EROSION

Along the coast of Quintana Roo, it is common to observe expansive areas of beach devoid of native dune vegetation. In many instances, this is the result of former coconut plantations and the industry of extracting coconut milk (copra). Unfortunately, the coconut groves were decimated by a lethal yellowing plague, leaving the beaches and dunes bare and prone to wind erosion. Similarly, erosion is enhanced when new development causes excessive clearing of vegetation along the shoreline beaches and dunes. The following guidelines help in mitigating erosion problems with the use of vegetation along the coast of Quintana Roo.

Following a storm, this road is covered with windblown sand from the dune at left, a result of the devegetation of the adjacent beach and dune for house construction.

540. Replant Areas that are Devegetated

Establish and maintain new plant communities in the coastal zone to promote soil stability and help to mitigate erosion. Vegetated areas also help capture rainwater and minimize runoff, thereby promoting groundwater recharge and filtration.

541. ***Examine adjacent areas to identify elements of the natural environment.*** Examine the plant communities in an adjacent, undisturbed environment. This provides a list of species and distribution of vegetation and other landscape elements that once existed and are suitable to the site. These same species and elements can be incorporated into the landscape of the new development as a method of re-creating the natural habitat.

542. ***Choose deforested areas for construction sites.*** Preserve critical habitats and existing green space to maintain undisturbed areas for native species. Prioritize devegetated areas as construction zones, thereby reducing impacts to well-vegetated habitats and natural landscapes. Supplement existing native plants with new plantings to inhibit erosion.

543. ***Analyze annual climate cycles and determine the appropriate season for planting.*** In Quintana Roo the best months for planting new landscapes are November to January. These are relatively cool months with frequent rains—conditions that promote the successful growth of the new vegetation.

544. ***Establish plant communities that form a dense ground cover.*** Dense ground covers and vegetation with extensive root networks provide protection against wind and water erosion.

Vegetation provides a natural filter for upland contaminants, reducing the pollution of water bodies.

545. ***Place protective structures or barriers around new plant communities.*** Use support structures (stakes or guy wires) to protect trees from wind until they grow more extensive root structures. For other vegetation, install small protective fencing to help minimize wind damage until roots are well established. Ideally, planting should occur after the storm season to help allow root growth before the next storm season.

546. ***Use a sufficient number and variety of plants to firmly establish the plant community.*** In creating new landscapes, it is important to plant a sufficient number of species that can evolve into a functional habitat. Additionally, it is necessary to plant species at different stages of growth to ensure that some of each type will survive harsh climatic conditions.

550. MAINTAIN BUFFER ZONES

Vegetated buffer zones—a strip of vegetation adjacent to lagoons, ponds and rivers—provide long-term benefits to minimize erosion, increase filtration of contaminants and enhance the zone as a habitat for flora and fauna. Buffers can be established on dunes, coastlines, and lagoon/river shores.

Coastal dune vegetation helps buffer the erosive forces of wind and rain by trapping sand and building dunes. Fringing mangroves function as a windbreak and sediment trap, reducing the potential for land erosion. In places where rainwater runoff channels to the sea—eroding dunes, river banks or coastal banks in its path—vegetation can help slow the water flow and prevent sediments from washing away. Vegetation adjacent to rivers and lagoons also reduces the impacts of wave action through its root network. Finally, vegetation filters land-based contaminants, reducing the input of nitrogen and pesticides into lagoons, rivers and other water bodies.

551. ***Conserve native vegetation on dunes to minimize wind erosion and help stabilize dunes.*** Utilize design techniques that incorporate the use of vegetation and other non-structural methods for erosion control. (See Section 320.)

552. ***Maintain a buffer strip of vegetation along the shores of water bodies.*** Construction around lagoons and river banks should include buffer strips to help protect man-made structures from damaging forces of water and wind, and help minimize damage from flooding. Additionally, the vegetated buffers enhance filtration of upland contaminants and trapping of sediments.

FOR MORE INFORMATION ON LAGOONS AND WETLANDS, SEE SECTION 400

For more infomation:

Cabrera E., 1996. *Plantas ornamentales de los hoteles Royal Mayan, Royal Caribbean y Royal Islander de la Ciudad de Cancún, Quintana Roo.* Informe Técnico. Amigos de Sian Ka'an A.C.

Castillo J.R. 1992 Aprovechamiento de plantas silvestres con fines ornamentales. *Boletín 11*. Amigos de Sian Ka'an, A.C.

A Guide to Environmentally Friendly Landscaping; University of Florida. *http://hort.ufl.edu/hand.htm*

Non-Point Source Pollution Control; Environmental Protection Agency. *http://www.epa.gov/owow/nps/MMGI/Chapter7/ch7-2c.html*

Guide to Pest Control. EPA. *http://www.epa.gov/OPPTpubs/Cit_Guide/citguide.pdf*

Low Impact Design Strategies. Non-Point Source Pollution. Prince Georges County, Maryland. *http://www.epa.gov/owow/nps/lidnatl.pdf*

USE AND MANAGEMENT OF POTABLE WATER AND WASTEWATER

To guarantee a long-term supply of healthy drinking water and productive coastal ecosystems, developments should be designed to optimize the consumption of potable water and the treatment of wastewater.

Guidelines for Water Resource Management

Maximize availability and quality of drinking water

610. Optimize design and siting of wells
620. Reduce water use

Manage wastewater appropriately

630. Reduce contaminant discharge to water bodies
640. Site septic systems in appropriate locations
650. Utilize alternative septic systems to enhance treatment

Introduction

The principal source of drinking water in the Yucatan Peninsula is groundwater. This is due in part to the area's unique geologic characteristics. The peninsula sits on a porous limestone plain that does not permit the flow of surface water or rivers. Instead, an underground aquifer, or reservoir, is recharged by rainwater that filters through the limestone. On its path towards the groundwater aquifer, the rainwater often dissolves the limestone to form caverns and caves that store this valuable freshwater resource.

In the coastal zone there is an equilibrium between continental water (including groundwater) and seawater levels. Overexploitation of the aquifer (when the volume of extraction exceeds the capacity of the aquifer to be recharged by rainwater) causes an imbalance of this equilibrium that often results in the intrusion of saltwater into the well. This in turn degrades the quality of the potable water available to communities and developments. Additionally, the biological and chemical characteristics of Quintana Roo's coastal ecosystems strongly depend on the dynamics of the groundwater system—lagoons, mangroves, wetlands and coral reefs are all interconnected by groundwater flow and can be significantly altered if the water flow is contaminated from inadequately treated wastewater or saltwater intrusion. The result is diminished water quality for human consumption, fishing and recreational activities.

Groundwater contamination is not easily seen and pollutant sources are not easily located. As a result, it is difficult to remediate or treat groundwater contamination. In fact, contamination may advance undetected to the point where the potable water supply has to be temporarily or permanently abandoned. Unfortunately, identifying contamination sources and determining appropriate water quality restoration and purification techniques is not only difficult, but is time-consuming and expensive.

Because the coastal zone's hydrologic characteristics are interconnected and because the groundwater aquifer is the primary source of drinking water, these resources must be used and managed wisely. Water resource management techniques must ensure long-term, contamination-free supplies of potable water. Since an aquifer is a reservoir of underground water, good management practice requires that the land area above and adjacent to the aquifer—land known as the "recharge area"—be protected. When developing land (including constructing buildings, roads and parking lots) within a recharge area employ low-density, low-impact techniques; ensure that land use will not contribute contaminants; make sure to include an adequate filtration system; and retain non-disturbed vegetative areas.

For instance, water-saving measures can reduce the volume of groundwater that must be extracted from wells or surface reservoirs in order to meet municipal or industrial demands. Optimizing water consumption and minimizing wastewater helps preserve the natural equilibrium of water habitats, conserve healthy ecosystems,

Principles for water use and wastewater management

- *Maintain good water quality for consumption, recreational activities and ecosystem habitats by constructing development that reduces impacts to groundwater and adjacent water bodies*
- *Ensure long-term supplies of potable water by evaluating the hydrological characteristics during development design and by managing its use consistent with the natural constraints of the water supply and adjacent natural resources*
- *Reduce costs of obtaining and treating water by optimizing water use*

and enhance tourism and recreational activities. One innovative approach is to establish a "closed-cycle" system in which water initially used for human consumption is recycled for use in landscaping. Such wastewater management methods reduce the energy required to treat the water and minimize its potential to contaminate the aquifer, rivers, lakes or ocean.

DETERMINE DRINKING WATER AVAILABILITY

One of the critical factors limiting growth and development in Quintana Roo is the lack of sufficient drinking water. When planning coastal development, it is extremely important to maintain and protect high quality water resources. The density of the development should be determined after studies are undertaken to assess the quantity and quality of water sources. Another consideration is the well depth, which will vary depending on the quantity of freshwater needed and on salinity present; since groundwater is often brackish, it may require desalinization before it is ready for potable use.

Potable water is a critical element in site development.

In Quintana Roo, there are specific zones within the municipalities of Othon P. Blanco, Solidaridad, Benito Juárez and Cozumel where water extraction is restricted. The volume of water that can be removed from groundwater wells is determined by The National Water Commission (*Comisión Nacional de Agua*). The commission should be consulted at early phases of development planning.

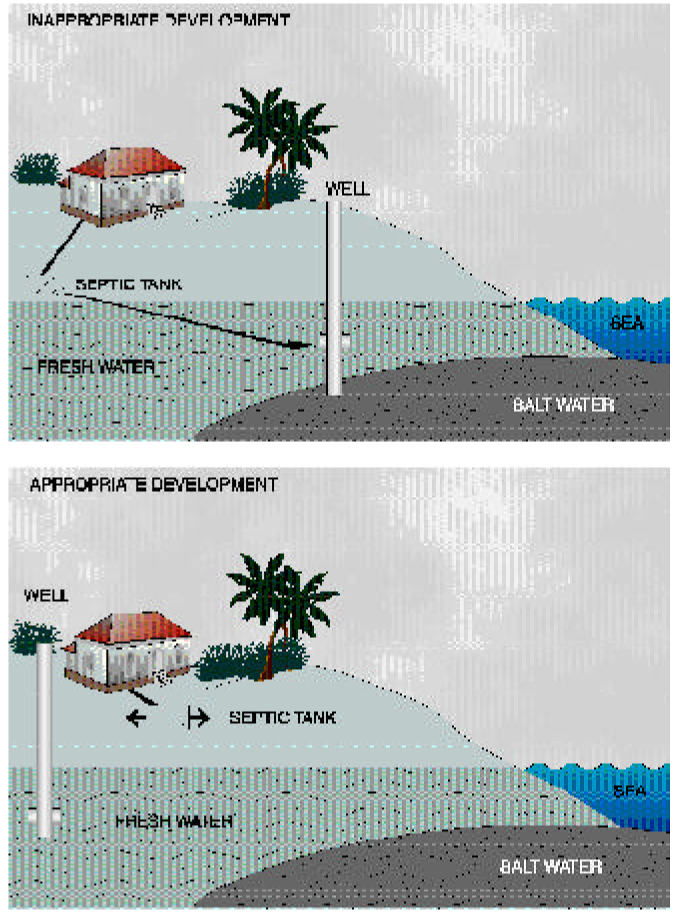
610. OPTIMIZE DESIGN AND SITING OF WELLS

Proper siting of wells is critical to maintaining high quality drinking water, protecting wells from contamination, and ensuring an adequate supply of water for developing tourism and municipal infrastructure. Sources of well contamination include wastewater disposal facilities; fertilizers from agriculture, lawns or golf courses; and saltwater intrusion.

611. ***Determine water sources, available volume, and potential water demand during the planning phases of development.*** The size and scope of new development should consider the availability of groundwater—to ensure there is an adequate supply and that natural sources are not adversely impacted by contaminants. The National Water Commission's state office has information about water sources and the volumes of groundwater aquifers. Within the Costa Maya tourism corridor, the State Tourism Development Fund (FIDECARIBE) also has this information.

612. ***Perform a hydrologic study before drilling a well.*** Drill a test well and perform a pump test to determine the quantity and quality of water at different groundwater elevations and to determine its fluctuations over time. At a minimum, this should be done during the dry season to determine the lower limits of groundwater availability and preferably it should be done at different times of the year to evaluate seasonal fluctuations.

613. ***Design wells to minimize over-exploitation of the aquifer and reduce the potential for saltwater intrusion.*** Install a "window" or horizontal tube at the bottom of the well's vertical pipe to ensure that freshwater flows horizontally into the well head. This helps to reduce the potential for saltwater intrusion into the well from over-pumping. Upon request, the National Water Commission provides technical assistance in designing such systems in



(Adapted by Sullivan, 1995)

Proper location of wells can optimize accessibility to fresh water, and minimize the risk of contamination from salt water intrusion and septic systems.

accordance with site-specific properties, such as soil permeability, hydraulic conditions and water availability.

614. ***Identify probable contamination sources to reduce potential impacts to the new well.*** According to guidelines in the Mexican regulations, NOM-003-CAN-1996, a recharge area of at least 30 meters in radius from the well should be free of contamination sources. This helps to ensure that point sources of contamination (such as discharge from a wastewater treatment facility) or non-point sources of contamination (such as runoff of fertilizers) do not impact water quality.

620. OPTIMIZE WATER USE

Two of the best methods for optimizing water availability are to diminish consumption and to develop reuse practices. In residential developments, it is estimated that 60 percent of total water demand is within the house. Of that 60 percent, 40 percent is used for sanitary purposes. Creative design and management can substantially reduce costs and increase efficiency of water use within large tourist resorts. For example, "low-flow" devices that supplement water distribution systems are used in both tourist and residential construction projects throughout the world. Recycling water to gardens, for instance, will aid in optimizing the use of this valuable resource. Once in place, a well and distribution system should be monitored to assure that a development has a continuous supply of clean potable water for consumption and use.

621. ***Select low-flow toilets, or modify toilets to use less than eight liters of water.*** Low-flow toilets can substantially reduce water demand as well as the volume of wastewater produced. In new construction, install low-flow toilets. In existing buildings, replace high volume toilets or install an object in the toilet's water tank (i.e. a brick) which reduces the volume of water necessary to refill the tank upon flushing.

622. ***Use composting toilets as an alternative wastewater treatment system.*** Composting toilets do not require water. Instead they use biologic decomposition (a natural process) that decomposes the volume of organic solids by 90 percent, converting wastes into small quantities of organic matter that can be used as a natural fertilizer.

623. ***Incorporate rain collection systems in development design.*** Along the southern coast of Quintana Roo and Belize, annual precipitation averages 1,200 to 1,500 millimeters.

Techniques That Optimize Water

• Recycle water. Both homes and hotels can recycle "gray" water—discharge from showers or sinks—for other uses such as watering lawns and plants. In the home, water can also often be reused for cleaning activities.

• Test water supply systems for leaks. Monitor the water meter during a time of no use. After two hours, recheck the meter to determine if there is a change—a change would indicate a leak in the system that should be located.

• Repair leaky hoses. A leaking hose can represent a water loss of 2,700 gallons per year, which in turn can significantly increase water costs to the user.

• Install low-flow regulators (plumbing fixtures and faucets) that are well-designed and quality constructed. Bathroom showers use 20 percent of the total water within the home. Installing regulators that reduce flow from 20 liters per minute to 11 liters per minute will result in savings of approximately 90,000 liters of water per year.

• Install pressure-reducing valves on faucets to further reduce the quantity of water used.

• Use laundry or dishwashing machines at full capacity or adjust the water level appropriately when partially full.

• Promote simple actions to save water in hotels. For example, give guests the option to have or not have towels and sheets washed daily.

• Design garden and landscapes to minimize water needs. One method to reduce water use is to group plants with similar water needs. Additionally, native plants tend to require less water than introduced species.

During the rainy season from May to December, cisterns are used to collect substantial amounts of water that run off the roofs of buildings.

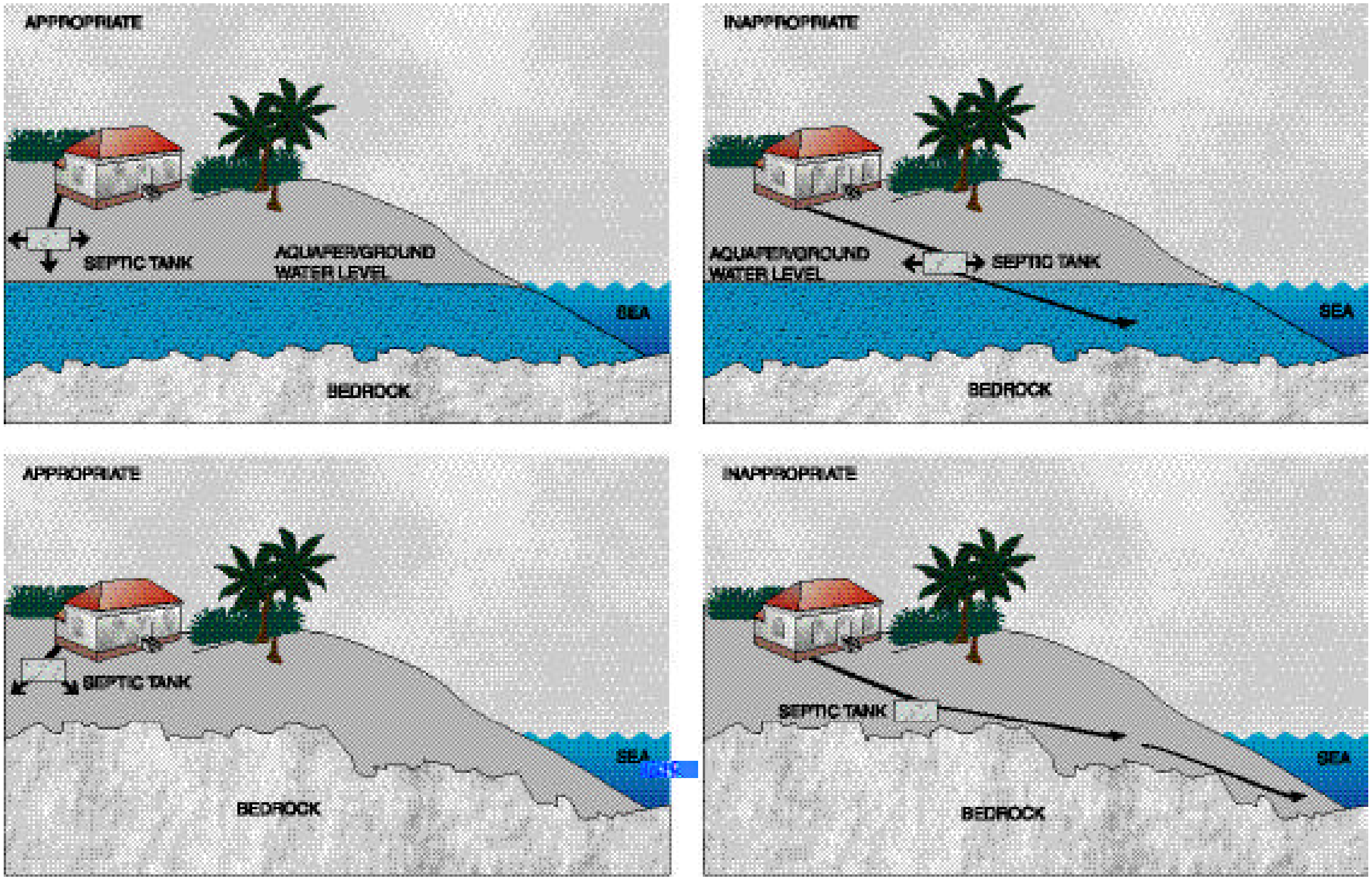
624. ***Use desalinization techniques to support water needs and enhance water quality.*** In a region of limited fresh water, alternatives such as desalinization are an expensive, yet appropriate technology when managed properly. Desalinization processes treat brackish groundwater and extract salt from seawater. When designing desalination plants, ensure that the concentrated salt extracts produced during the desalinization process are not discharged directly into the sea or mangroves as they can severely impact adjacent areas of coral and fish. At this time, no municipal or commercial disposal operations for salt exist in Quintana Roo; therefore, on-site solutions will need to be sought.

Many hotels implement programs to optimize water use.

625. ***Monitor the quality of well water.*** Monitoring provides information necessary to establish appropriate pumping limits to avoid over-exploitation. Periodic measurements of conductivity (ability of water to transmit energy) can identify increases in water salinity, which indicate that saltwater intrusion has occurred from over-pumping. The National Water Commission has laboratories that can analyze water samples and evaluate water quality. Monitoring helps identify the presence of elements such as nitrogen, phosphorus and fecal coliform—indicators of well contamination from nearby sources of pollution such as septic system discharge.

MANAGE WASTEWATER APPROPRIATELY

Due to the physical characteristics of the coastal zone and the fact that groundwater is the primary source of potable water on the coast, it is important to adequately manage wastewater to eliminate contamination of valuable water resources. The following recommendations detail ways to design and manage effective treatment systems.



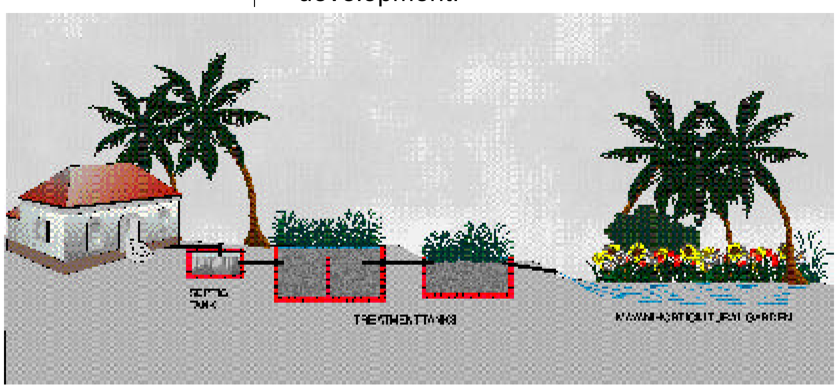
(Adapted by Sullivan, 1995)

Consider the characteristics of subsoils prior to siting septic tanks.

630. Reduce Contaminant Discharge to Water Bodies

Discharging untreated or insufficiently treated wastewater directly into lagoons, nearshore waters, reef lagoons or wetlands often contaminates these water bodies. The resulting increase in nitrogen, bacteria and phosphorous levels leads to an overpopulation of algae, which in turn contributes to the decline of the ecosystem (eutrophication and nitrification), often making it unusable for human activities. Additionally, allowing untreated or insufficiently treated water to be discharged into the groundwater may have tremendous impacts on groundwater as a potable water source and on associated ecosystems. Various technologies, treatment levels and discharge options must be carefully evaluated to determine the most appropriate system for each development.

Artificial wetlands can be constructed adjacent to septic systems to filter wastewater and reduce nutrients in the effluent.



Mexico's Federal Law on wastewater treatment (February 25, 1997) identifies guidelines for the design and operation of facilities. The enforcement code (December 13, 1996) specifies that any person responsible for the "discharge, deposit or infiltration of wastewater, chemicals or biochemicals, wastes or contaminants into the soils, marine waters, rivers, watersheds, pipelines or other federal waters that result in impacts to public health, natural resources, flora and fauna, water quality of the watersheds or ecosystems" will be penalized.

631. ***Design for secondary or tertiary treatment levels.*** The most common approach to wastewater disposal for large developments is to discharge treated water into a deep well (deep well injection). In order to avoid groundwater contamination, however, wastewater should at a minimum be treated to secondary or preferably tertiary levels—a level at which discharge of total dissolved solids is equal to or greater than 19,000 parts per million (PPM). Tertiary treatment will reduce nutrients, thereby reducing the potential to contaminate the water supply or otherwise impact ecosystems that are nutrient sensitive. A monitoring program should be established to ensure that these discharge limits are maintained and there are no negative impacts on groundwater quality, potable water supply, lagoons or nearshore coastal waters.

640. SITE SEPTIC SYSTEMS AT APPROPRIATE LOCATIONS

A septic system consists of a septic tank and a leach field, which filters contaminants from the wastewater. Inappropriately constructed or sited septic systems, however, can contaminate surface water bodies and groundwater resources. To avoid this, consider the following guidelines when siting new systems.

641. ***Consider the location of existing wells when installing a septic system.*** Mexican standards require wells and septic systems to be located at least 30 meters apart. A greater distance is recommended for tourist developments where water demands and wastewater quantities are typically greater and the risks for contamination are increased. (See Section 610 for siting guidelines.)

642. ***Situate septic systems so that leachate liquids flow away from the well.*** The walls and floors of septic tanks should be impermeable to prevent leakage of untreated, high-nutrient waters to surrounding groundwater, before entering the leach field. The drainage (leach) field should be designed to adequately filter wastewater before entering the soil and groundwater.

The National Water Commission provides technical assistance for water management. A "Request for Hydraulic Services" must be submitted for:

- New water concessions or assignments of water rights
- Regulation of concession or assignment of water rights
- Permit for discharge of residual waters
- Modification of discharge permits for residual waters
- New concession or assignment for occupation of Federal Zone and regulations
- Modification of the occupation of the Federal Zone
- Certification of effluent water quality
- Non-compliance with discharge of residual waters

643. ***Evaluate the depth of groundwater after the rainy season to eliminate contamination of potable water.*** Septic systems and drainage fields should be designed for a one-meter vertical separation above the water level of the aquifer and no less than 10 meters horizontal distance from lakes, rivers or other water bodies.

645. ***Locate septic systems in appropriate soil types.*** In areas where an underground rock ledge is close to the tank, it is possible that leachate will flow above the rock ledge and into the groundwater without appropriate treatment. To ensure this does not happen, the leachate discharge should be situated a minimum of one meter from the rock ledge.

650. UTILIZE ALTERNATIVE SEPTIC SYSTEMS TO ENHANCE TREATMENT

To reduce contamination of water resources, utilize technologies that incorporate constructed wetlands, recirculating sand filters, and other filtration systems that complement traditional septic system designs. These systems—appropriate for single-family homes or groupings of houses/hotel rooms—are designed to reduce nitrogen and coliform, thereby providing a higher level of treatment than traditional septic systems. Studies in Akumal, a community in the Cancun-Tulum corridor, show that wastewater contamination has seriously degraded the surrounding Bay, habitat and reef resources. In response to this situation, the community has constructed several wetlands systems to help reduce the amount of wastewater nutrients seeping into the groundwater.

651. ***Constructed wetlands systems.*** South of Cancun, in Akumal, wetlands have been constructed to aid in the treatment of nutrients being discharged from a septic system. The Planetary Coral Reef Foundation and the Akumal Ecological Center have implemented a program that uses these constructed wetlands— also known as Hydro-Botanic Treatment or a Biological-Macrophitic Filtration System. Wastewater flows laterally through tanks of wetland plants, in which the plants' roots absorb waste products and utilize the nutrients in the wastewater. The resulting effluent of treated water is used to water their Mayan plant garden.

The constructed wetlands system consists of three components:

- An impermeable underground septic tank that filters the solid wastes and initiates the process of biological decomposition (aerobic and anaerobic).
- A sealed tank with two cells or treatment compartments. Constructed of concrete and containing gravel, this tank contains wetland plants on the surface. The plants are a diverse collection of local species including palms, bushes and regional grasses that thrive in wet soils.
- A Mayan horticultural garden planted around the system utilizes the remaining nutrients in the effluent.

The system does not require chemicals, pumps or mechanical maintenance for proper operation. Occasionally it is necessary to cut some of the plants in the two tanks to stimulate their growth. The vegetation can be harvested for animal feed or for artisanal uses, such as crafts or weavings. It is not recommended for eating by humans.

The design of each treatment plant is unique, taking into consideration the needed capacity or volume of wastewater, the system's surrounding ecology, and the geologic features of the area. Regardless of the type of treatment used, the post-treatment effluent should comply with the maximum permissible standards for contaminants reaching federal waters as established in Official Mexican Regulations, NOM-001-ECOL-1996.

In Akumal, over 50 of these "constructed" wetlands have been employed as tertiary treatment, to reduce nitrogen input to groundwater and reduce impacts to coastal lagoons and coral reefs.

For more information:

Sullivan K., De Silva L., White A., Wijeratne M. 1995. *Environmental Guidelines for Coastal Tourism Development in Sri Lanka*. The University of Rhode Island and The Coast Conservation Department, Sri Lanka. 74 pp.

National Small Flows Clearinghouse. *Techniques for decentralized wastewater treatment*. *http://www.nesc.wvu.edu/nsfc/NSFC_ETI.html*

Wastewater Gardens, Planetary Coral Reef Foundation. *http://pcrf.org/field.html*

Waterwiser: The Energy Efficiency Clearinghouse. *http://www.waterwiser.org/frameset.cfm?b=2*

The Water Quality Association. *http://www.wqa.org/*

Composting toilets. The Resource Institute. *http://www.riles.org/projects.htm*

MANAGEMENT OF SOLID WASTE

Implementing sound solid waste management practices can help reduce threats to human health and promote environmental conditions that contribute to sustainable tourism development goals.

Guidelines for Solid Waste Management

Reduce the amount of trash destined for landfills

710. Reduce, Reuse, Recycle

720. Collaborate with businesses involved in managing recycled materials

Design sanitary landfills appropriately

730. Identify appropriate locations for a landfill

Introduction

An increased number of residents and visitors to Quintana Roo's shoreline generate millions of tons of trash each year. As a result, appropriate solid waste disposal is an increasingly difficult and costly issue. Nevertheless, proper handling and disposal of solid waste is essential for maintaining human and environmental health and is a key factor for continued success of tourism development.

Solid waste concerns are not limited to the large cities and municipalities of Quintana Roo. This problem is also an issue in low-density and uninhabited areas of the state where large quantities of trash litter the shoreline and wetland areas. While some of the trash is generated locally, commonly this shoreline debris originates in places as far away as South America, and is carried by ocean currents to the beaches of Quintana Roo. Beach trash destroys the aesthetic beauty of the area's prime tourist attraction, and often limits local recreation opportunities for community members. Debris may also alter wildlife habitat and disrupt nesting activities of both marine turtles and birds. Because of the lack of adequate waste management throughout the region, it is local communities and landowners that continually bear the burden of maintenance and cleanup costs.

Landfills are currently used in many communities of the region to dispose of solid waste. Yet as development increases and land becomes scarcer, communities will need to locate and manage additional sites for waste disposal. New landfills will tend to be larger and further from community centers, thereby increasing disposal costs. As the volume of solid waste increases, landfills will face even greater challenges as they try to avoid contamination of natural resources, such as groundwater. The growth of cruise ship tourism promotes additional challenges for solid waste management, where large volumes are disposed of weekly. While this can provide an opportunity for municipal revenue, the risks of pollution are increased with such great volumes of waste to be managed.

Adopting new solid waste management methods for tourism destinations can produce both economic and natural resources savings. The strategy of "reduce, reuse and recycle" minimizes the quantity and/or volume of materials destined for landfills, increases the long-term utility of landfills, and reduces long-term costs of solid waste management. For this strategy to be effective, industry, tourists and local communities alike must commit to adapting their routine activities and changing today's patterns of waste generation and disposal.

Businesses in the region have begun to adapt their activities to include recycling solid waste and composting organics. In Cancun, the *100% Natural* restaurant chain composts 500-900 kilograms of organics daily. The commercial hotel zone also implemented a trash-separating program for recycling as have the communities of Akumal and Chemuyil. As demand for these programs increases in Quintana Roo, the associated industry for recycling and distributing recycled materials will become more common along the coast. Developers can also help promote recycling by undertaking appropriate solid waste management initiatives as they progress through the planning, construction and operation phases of their work.

Principles for managing solid waste

- *Identify alternative solutions to managing waste and implement actions that prevent pollution, minimize risks to public health and the environment, and enhance the aesthetics of the coast.*

- *Reduce long-term economic costs and impacts to natural resources by endorsing a strategy to reduce, reuse and recycle man-made and organic materials, thereby reducing the demand and volume requirements for landfills.*

REDUCE THE AMOUNT OF TRASH DESTINED FOR LANDFILLS

710. REDUCE, REUSE, RECYCLE

Solid waste separation programs help reduce the volume of waste destined for landfills.

Two of the most effective means to reduce potential problems caused by waste are to: 1) limit the volume of solid waste to be discarded; and, 2) avoid using materials which are difficult to dispose of. These methods can easily be practiced by hotels that want to reduce the volume of their solid waste. For example, they can minimize the number and/or volume of plastic containers that are disposed by purchasing different types or sizes of product (bulk) or purchasing containers that are recyclable.

711. ***Identify methods for reducing volumes of waste during construction.*** Careful design, selection, and purchase of materials can substantially decrease the quantity of waste and debris generated during construction. For example, choosing standard dimensions for building components that correspond to lengths of commercially cut wood will reduce the amounts of wasted wood. Wood forms used during construction can be incorporated into landscape designs.

712. ***Purchase products in bulk or with reduced packaging.*** Use bulk products (e.g. liter bottles vs. small cans) to eliminate the amount of packaging material that ends up in landfills. This can apply to both food and beverage products or to maintenance products items such as detergent and cleaners.

713. ***Use products made from recycled materials.*** Use products made from recycled paper, plastic, metal and glass. This reduces the need for raw materials in the manufacture of the products. It also creates a market for goods made from recycled materials thereby increasing the need for and benefit of recycling.

714. ***Implement a trash separation and recycling program.*** Trash separation programs should be designed according to the composition of waste, with properly labeled public receptacles established for depositing recycled trash. This increases awareness of what types of trash are generated. Increased awareness helps promote better trash management programs and policies (by industry and government alike). Individual tourists, as well as whole communities, can easily participate in recycling programs. In the Cancun-Tulum corridor, several communities have sponsored a waste separation programs and in Chemuyil, the community has sponsored both a waste separation and a composting program.

715. ***Involve resort guests in recycling programs.*** Today, waste reduction and recycling programs are found throughout the world. This makes it easier for hotel/resort visitors to understand and participate in such programs. It is a good way to involve clients in helping achieve the goals of a waste reduction program to reduce pollution, promote efficient resource use, and reduce costs of disposal. Clients/hotel guests can help by separating trash into waste receptacles, choosing optional newspaper delivery, or using refillable mugs/cups to reduce paper and plastic cups.

716. ***Identify alternative markets for recycled materials.*** Waste disposed by one person is a valuable resource for another. Materials can be sold to benefit the business or community, reduce landfill costs and generate additional income. As an example, the blue glass that is commonly recycled in Mexico is sold around the world and has become a great export market product for the country. Also, plastics can be recycled into furniture and other items while metals can be melted and reused.

7l7. ***Develop a composting plan.*** Approximately 40-50 percent of trash is comprised of organic wastes, which can be easily composted and decomposed. Reusing organic waste generated in hotels or in communities for compost can be an economic and effective tool in reducing the amount of material transported to landfills. Composting is a relatively simple process. It can be set aside in a designated area and needs minimal management. Larger composting operations, however, should be monitored during the rainy season to prevent runoff. Composted solids from septic systems and composting toilets can be combined with other organic waste and used as a fertilizer for the hotels and gardens.

Beaches can be impacted by inadequate waste disposal from both land-based and water-based activities.

720. DESIGN SANITARY LANDFILLS APPROPRIATELY

Poorly designed landfills have contaminated groundwater and caused public health problems for nearby communities. Prior to designing a landfill, evaluate the characteristics of the proposed site and determine the volume of waste that will be generated. The site's soil composition should be evaluated in the design of an impermeable base that will prevent leaching of contaminants to groundwater. Where soil conditions are unfavorable, liners should be installed.

730. IDENTIFY APPROPRIATE LOCATIONS FOR LANDFILLS

Mexican Federal Law NOM-083-ECOL-1994 establishes provisions for designing sanitary landfills. According to the regulations, landfills should be located:

- At least 10 meters above the groundwater table
- At least one kilometer from lands that provide recharge for the aquifer, or provide a potable water supply
- At least one kilometer from flood-prone areas, standing bodies of water and/or rivers

- At least 500 meters from urban areas; 70 meters from roads and highways; three kilometers from natural protected areas and airports; 20 meters to either side of electric power lines, pipelines and gasoline lines; and 150 meters from gasoline storage areas

For more information:

The Center for Renewable Energy and Sustainable Technology. *http://www.solstice.crest.org/environment/grotwh/general/solid/html/reduce.html*

Reduce, Reuse, and Recycle. Environmental Protection Agency. *http://www.epa.gov/epaoswer/osw/rrr.htm*

Composting. Cornell University. *http:/www.cfe.cornell.edu/compost Composting_homepage.html*

International Coastal Cleanup. Center for Marine Conservation. *http://www.cmc-ocean.org/cleanupbro/index.php3*

OPTIONS FOR ALTERNATIVE ENERGY

Wind and solar energy, supplemented with conventional sources of energy, provide appropriate alternatives to meet the demands for tourism development while reducing the demand for fossil fuels.

Introduction

In the Yucatan Peninsula, most energy generating facilities—from municipally operated plants to household generators—use fossil fuels to produce electricity. The perceived greatest advantage to conventional oil, gas or coal-fired generators is their low initial investment, yet long-term production costs can actually be up to four times greater than that of renewable resources. Fossil fuel systems have high maintenance and operation costs and produce many negative environmental impacts that may be able to be avoided.

However, for small and medium-scale operations there are numerous renewable energy systems—systems where energy is derived from sources that can be replenished—that reduce fossil fuel use, cost less to operate and maintain, increase operation safety, and cause less pollution to air and water. Solar energy, for example, is an energy source (the sun) that can not be depleted. Other such sources include wind, water, and oceanic and tidal energy.

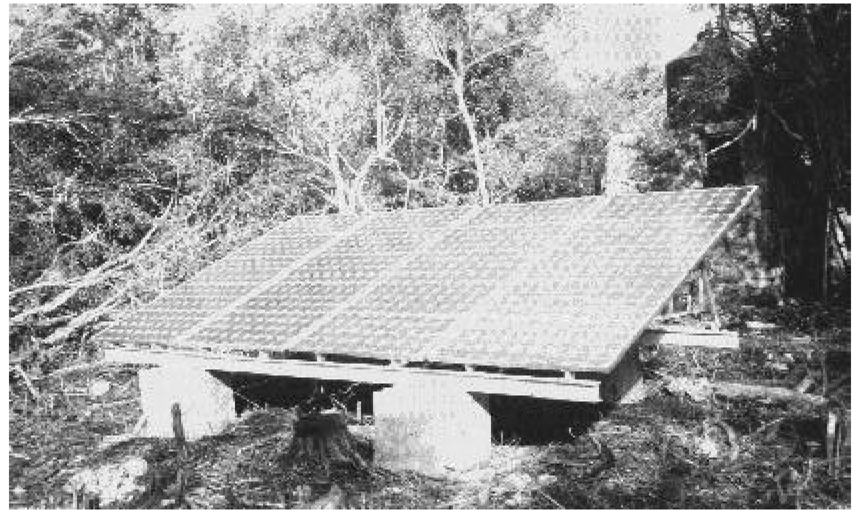
To support sustainable development, planners, developers, managers and their clients must promote the use of renewable energy sources and reduce conventional energy consumption. In the process of doing this, it is essential that a balance be established between supply and demand—satisfying the needs of the community and tourists without sacrificing the quality of service delivered to them. Toward this end, developers can install lighting, ventilation, refrigeration and water pumping equipment that uses less energy and is powered from renewable sources. Many hotels today are identifying methods where all electric appliances (e.g. air conditioners) and light fixtures are operable only when guests are in the room. Others hotels are opting to include fans instead of air conditioning in guest rooms. Developers should also consider energy-conscious design for the facility. For example, vegetation can be used to support microclimates, buildings can be oriented to enhance ventilation, and structures can be insulated to prevent energy loss.

Finally, there are market incentives to support the use of energy-efficient methods. Many ecotourism destinations worldwide use renewable energy sources to promote resource conservation while enhancing their reputations as ecotourism establishments. These resorts employ techniques to reduce energy consumption and demand during their design, planning, construction and operation phases. In addition, organizations such as the World Tourism and Travel Council identify and promote the benefits of energy efficient practices with their Green Globe certification program for environmentally sensitive hotels, which provides a marketing niche for participant hoteliers.

OPTIONS AND APPLICATIONS FOR RENEWABLE ENERGY

The coast of Quintana Roo has sufficient solar resources and often enough wind to generate renewable energy for tourism development. This includes thermal energy for heating water, photovoltaic cells powered by the sun for generating electricity and wind energy for producing electricity. Additionally, biomass production (use of decaying organic matter) can produce energy in the form of gas. These renewable energy sources provide an excellent opportunity to produce power in areas where municipal electric networks do not exist, are too expensive to extend to rural areas, or where construction of these systems is prohibited, such as in the Sian Ka'an Biosphere Reserve.

In Quintana Roo's remote coastal locations of Xcalak and Punta Allen, renewable energy is currently used. Xcalak employs a system of 234 solar panels in combination with a wind-powered photovoltaic cell—one of the 10 largest systems in the world of its kind. While this system was well-designed, its optimum output has never been realized due to operation and maintenance problems, as well as community administration problems. Lessons learned in this case reveal that implementation of these programs must include operator training and community education, mechanisms for sustainable financing and program



Using solar power for energy is becoming more common in Quintana Roo.

maintenance. Additionally, "appropriate technology" may not be appropriate at all if new parts can not be obtained or if local mechanics can not repair them.

Nevertheless, along Quintana Roo's coast today, there are over a dozen private enterprises that produce energy using renewable resources such as wind generators, solar collectors and photovoltaic cells. Similar technologies have been used for radio communication, water pumping, and interior and exterior lighting in facilities at the Sian Ka'an Reserve.

Some tourist developments use renewable energy as a cost effective alternative source for electricity.

810. Options and Applications for Renewable Energy

As development increases in areas where conventional electrical networks are absent, an opportunity exists to initiate renewable energy programs for both small and large-scale projects. This reduces the demand for fossil fuels and their negative environmental impacts. In addition, it supports low-impact tourism goals that are promoted by the government and tourism industry.

It is important to remember that even when development is located on an existing electric network, there are many techniques that can be used to support energy conservation, mitigate impacts of energy production and reduce energy costs.

811. ***Advantages of renewable energy***. Compared to conventional energy systems, renewable energy technology has many advantages. Renewable energy systems:

- Are installed on the site where energy is required, reducing the need for extensive roadside reconstruction of lengthy electrical networks
- Are designed to meet energy needs—as demands increase, modules can be added to meet this demand
- Have their energy provided by sun, wind or water—three resources that are free, do not produce secondary by-products or waste, and do

not degrade with usage. Systems are relatively easy to install and very reliable. A typical system for an ecotourism resort may take 2-10 days for installation. When appropriately maintained, these systems can be effective for up to 30 years following these guidelines:

- Require minimum knowledge for installation
- Have low maintenance requirements and are less expensive than other types of energy production; the local population can be trained in system maintenance
- Are well-designed systems that guarantee high performance at reasonable costs and are totally automated. Additionally, they can use a combination of technologies to meet energy demands
- Can be easily relocated. Some are portable (such as windmills) for removal in the case of severe storms
- Can become a part of a tourist development's fixed assets and contribute to a high resale value

APPROPRIATE TECHNOLOGIES

820. SOLAR POWER

In Quintana Roo, there are various methods of generating energy (photovoltaic cells) and heating water (thermal cells) using the area's unlimited

solar resources. Photovoltaic and thermal cells are known as passive solar technologies, as they do not require moving parts.

Photovoltaic systems generate electricity ranging from several watts to megawatts. Large pilot programs in Spain and the United States have shown this technology capable of supporting high-energy demands. Solar panel collectors for heating water are also used successfully around the world. Presently it is estimated that Mexico has more than 60,000 photovoltaic cell systems, and close to 220,000 square meters of solar collectors, of which 70 percent are used for heating swimming pools in tourist resorts. While initial investment costs are relatively high when compared to other

Renewable energy programs are often successful in rural communities.

Uses for wind energy include lighting, pumping water, desalinizing water and filling dive tanks.

technologies such as gas heaters, lower operation and maintenance costs make the net cost over time of this energy highly competitive with traditional energy sources for tourism facilities, both in urban areas and in rural areas. Each year, solar technology improves and costs decrease. Increased use of solar technology by government programs further reduces the cost.

830. WIND-GENERATED ENERGY

The potential for producing wind-generated energy in Quintana Roo is very high. Energy from wind can pump water using wind turbines, or generate power for a variety of uses including lighting, cooling, desalinization and water distribution. In general, wind systems are often combined with other techniques such as solar-powered photovoltaic cells and have back-up systems powered by diesel fuel to supply energy during low wind seasons.

Mexico's National Meteorology Service and local airports currently provide adequate information on different sites within the region where wind energy is a feasible alternative. In addition, a map showing where wind energy is feasible in Quintana Roo will soon be produced. With this basic information available, specialists can make site-specific evaluations to ensure that wind-energy systems are correctly designed, located and operated.

IMPLEMENTING A RENEWABLE ENERGY SYSTEM

840. COST COMPARISONS

When choosing between a conventional electrical network and renewable energy alternatives, a case by case evaluation should be completed. This is best done with the assistance of a trained professional. In the short term, conventional energy is less expensive than renewable energy. Over the long term, however, renewable energy proves more cost effective because the energy source is free and maintenance costs are low. The cost of renewable energy systems varies depending on the type of technology used, the project's architecture and type of operation. In the following table, costs of design, materials and installation are combined to illustrate the relative costs of the energy ($US/watt). Keep in mind that operating costs are virtually free when using solar or wind power, and maintenance costs per watt decrease with increased capacity. For photovoltaic systems, the maintenance cost per kilowatt hour ($US/kwh) is less than $.01/kwh. For wind systems, maintenance is more frequent and more costly ($.02 - .04/kwh). Nevertheless, both alternatives are more economical than a diesel generator (more than $.45/kwh).

Capacity (watts)	Cost ($US/watt)
Wind systems	
Greater than 3,000	$ 9-$12
Greater than 10,000	$ 7-$10
Greater than 100,000	$ 5-$8
Photovoltaic Solar Systems	
Greater than 500	$14-$18
Greater than 1,500	$13-$16
Greater than 5,000	$10-$12
Greater than 20,000	$ 8-$10

This hotel in Tulum uses both solar panels and wind power to meet its energy needs.

Successful installation of a renewable energy system requires sufficient knowledge of energy demands and availability of an energy source. At a minimum, the system must generate sufficient energy to meet current needs. Preferably, it should be capable of generating sufficient energy to exceed required capacity. To calculate demand, consider all of the activities and appliances that need electricity, and the amount and time of day of their use. This will help in identifying the maximum daily load and the time(s) of day when peak use occurs. This information will in turn help in designing an optimum system. The developer can estimate these demands during the initial design phase. An energy specialist can follow up with a more detailed evaluation.

In areas where meteorological conditions do not permit year-round renewable resource use, mixed systems of renewable and traditional energy should be installed.

850. IMPLEMENTING RENEWABLE ENERGY SYSTEMS WITHOUT ENVIRONMENTAL IMPACT

Unfortunately, some aspects of using renewable resources may directly or indirectly impact the environment. In order to avoid these problems, the following recommendations should be considered during planning, construction and maintenance of a renewable energy system.

- Batteries used to store energy, if disposed of improperly, can cause environmental damage. A recycling location/program should be identified. Often the manufacturer will have a program to collect used batteries to reduce the local impact of disposal
- Windmills often disrupt flyways for birds. If this occurs, windmills can be painted certain colors to reduce accidents
- Windmill systems used for pumping groundwater from a well should be optimized with respect to the capacity of the aquifer and the need for groundwater recharge. The groundwater supply,

if over-exploited, can adversely affect the aquifer and the resources it feeds.

To help meet sustainable development goals and reduce reliance on fossil fuels, it is important to employ a combination of renewable energy alternatives. These alternatives complement more traditional energy options, and can help optimize the use of energy on a daily basis. Renewable energy systems are an excellent option for tourism developments and associated community infrastructure. They are inexpensive to operate and cause negligible impacts to the environment. Investments in renewable energy systems should be assessed by an energy specialist in order to maximize both short- and long-term benefits.

For more information:

Mexico Renewable Energy Program. *http://solar.nmsu.edu/mexico/*

Renewable Energy Policy Project and the Center for Renewable Energy and Sustainable Technology (REPP-CREST). *http://solstice.crest.org/docndata.shtml*

Bioenergy Technologies. US Department of Energy. *http://www.eren.doe.gov/RE/bioenergy.html*

Sustainable Building Technical Manual. US Department of Energy. *http://www.sustainable.doe.gov/articles/ptipub.shtml*

Applying Tourism Guidelines in Costa Maya

Introduction

Applying *Guidelines For Low-Impact Tourism* during the planning stage of a project can help avoid a variety of environmental impacts often caused by new construction, and help ensure the long-term viability of a project—both environmental and economic. With this in mind, the Amigos de Sian Ka'an (ASK) and the University of Rhode Island's Coastal Resources Center (CRC) collaborated with the developers of a new Costa Maya resort, Carecores, and applied these guidelines to their development. The technical assistance provided by the ASK/CRC team included on-site visits, characterization of ecological resources, and an evaluation of the preliminary project design. The site evaluation and recommended design modifications are summarized below.

Proposed Development (Carecores Project)

The property chosen for the Carecores resort is located in southern Quintana Roo on the Costa Maya, approximately 300 kilometers south of Cancun, at kilometer marker 35 along the Majahual-Punta Herrero Highway. The proposed project is situated on one hectare of land (Lot 19 of La Casona district) and includes 18 single cabanas, eight double cabanas, a clubhouse, a service area and a small pier. The property has 110 meters of waterfront.

Site Characteristics

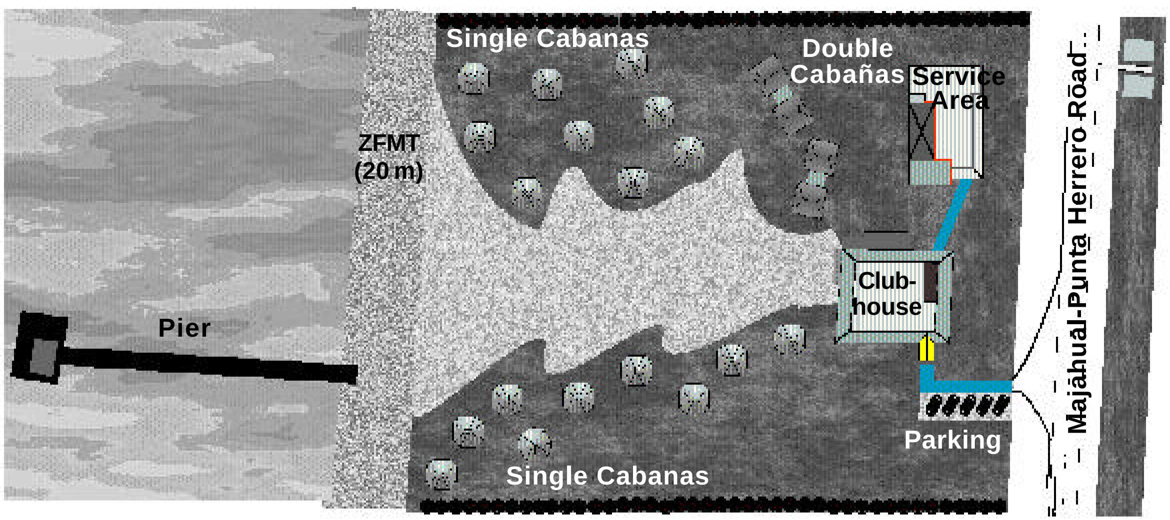
The barrier beach has an average width of 160 meters and is bordered on the east by the Caribbean Sea and on the west by expansive wetlands. This large wetland and lagoon system extends approximately 2,750 meters inland to low forest. The lagoons nearest to the property are Punta Gruesa to the north and Puerto Chico to the south.

Mangroves on the western edge of the property are found in areas of silty soil, which are often muddy from retaining rainwater due to the high groundwater table and poor drainage. The water here is brackish (a mixture of salt and freshwater), due to the influence of tidal action on groundwater.

The beach of the Carecores site consists of an intertidal area, a berm and a primary dune, and is considered a barrier beach. The beach berm is relatively wide and extends 40 meters inland to where the dune forms and then rises with a five percent slope (approximately two meters over the 40-meter width). Coastal dune vegetation covers much of the site, with different plant communities extending inland from 50 to 250 meters of the water line. Observations indicate that plant species are distributed naturally throughout the area in a manner that conforms to environmental conditions. Factors that determine which types of vegetation are present in specific areas are the degree of protection against wind, the soil conditions and the depth of the subsurface soils.

Two types of vegetation dominate the Carecores property—primary dune vegetation and coastal scrub. Primary dune vegetation is natural to the site and undisturbed by previous human landscape alterations. This vegetation grows in fine, well-drained soils and is found in the sandy beach and dune areas adjacent to the intertidal zone, at elevations up to one meter above sea level. This vegetation contributes to the stability of the area's dunes, and is well adapted to the changing conditions near the sea, where tides and waves strongly influence the shape of the beach and impact groundwater levels within the deep layers of sandy soils on site.

Coastal scrub is the other vegetation common to this area, appearing in clusters at elevations of three to five meters above mean sea level. Coastal



Note: ZFMT = Federal Maríne Zone

The initial plan for Carecores

scrub favors areas where soil is less sandy and the back dune area is relatively flat.

Although there is no historical information on wave height, longshore transport, or hurricanes for this location, site characteristics provide important information that can be interpreted to understand the coastal processes affecting this site. A coral reef (characterized as a barrier reef) with an exposed reef crest is observed approximately 850 meters offshore of the Carecores site. A shallow reef lagoon filled with sea grasses extends from the reef to the shoreline beach. Additionally, the beach's slope is relatively low. Together, these characteristics indicate a relatively low-energy beach, with some protection against high storm waves from the exposed barrier reef.

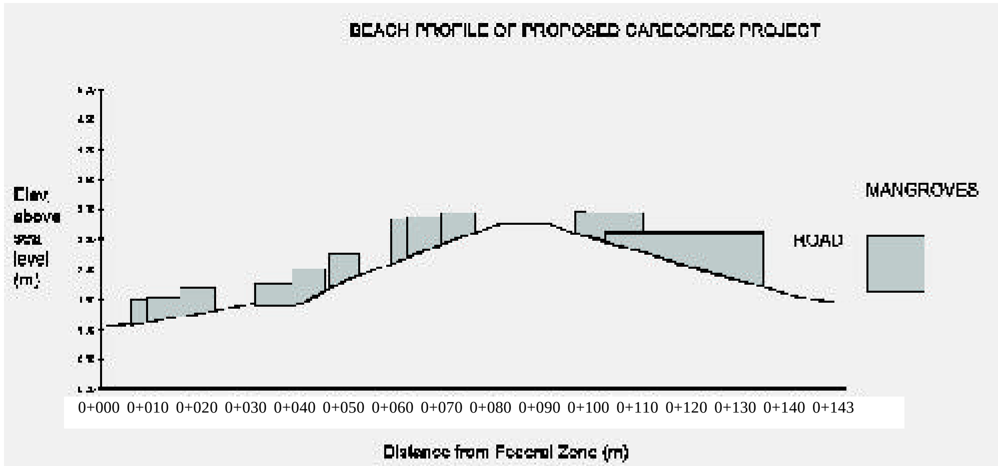
When considering the resort's location it is important to remember that Quintana Roo's coast is the most vulnerable region in the Yucatan Peninsula to natural disasters such as tropical storms, hurricanes and "northers." Hence, a concern for human safety and the high risk of extreme damage to coastal development must be considered when designing coastal resorts. While natural disasters can not be prevented, the loss they cause to human life and property can be minimized or eliminated by incorporating proactive mitigation techniques, implementing safety precautions and conserving natural processes. Such actions can also contribute to effective decisionmaking on siting and constructing new development, where one aims for a balance of economic, environmental and social considerations.

Analysis for Siting of Infrastructure in Relation to Beaches and Dunes *(Refer to Section 300 for general guidelines)*

Considering La Casona's physical characteristics and surrounding environment, recommendations were made to modify the resort's design to correspond to the site's natural conditions. As discussed in Sections 200 and 300, coastal development is susceptible to dynamic processes such as high winds from hurricanes and storms that may result in erosion and flooding. Vulnerability to damage, however, depends on the siting of the structure and the characteristics of the area (i.e. beach elevation, dune width, the presence of a barrier reef, and/or the predominant strength and direction of wind and waves). Recommendations included:

Minimize Erosion by Wave Action

The shape or profile of the beach changes naturally throughout the year, with winds and waves changing seasonally, and hurricanes and tropical storms occurring seasonally. (See Section 200.) In order to reduce risks to infrastructure, a buffer zone or restricted construction zone should be



The topographic profile for La Casona shows buildings relative to the dune's elevation.

incorporated into all designs. This area should remain free of permanent infrastructure to allow natural processes to continue. (See Section 310 for detailed recommendations.)

Given the topography and characteristics of the La Casona property, it was recommended that the Carecores resort be built with a setback of 50 meters from high tide—30 meters landward of the Federal Zone—because the shallower buffer zone would be subject to direct wave action during the storm season. To create this buffer zone, it has been recommended that the six cabanas closest to the sea be relocated as shown in the initial design. This will reduce direct wave and wind impacts to buildings during storms and hurricanes and reduce the potential for erosion around these structures.

Ideally, the topography of the site would indicate that the resort's buildings be located behind the dune crest to take advantage of the dune's natural protection. Evaluation of the profile above shows that the dune crest is approximately 100 meters landward of the high water line (80 meters landward of the Federal Zone) or adjacent to the third row of proposed cabanas. However, due to the limited width of the barrier, and the desire to construct more rooms, a setback of 50 meters is suggested as discussed above.

Minimize Storm Damage

Because the property is situated on the narrow barrier beach between the sea and the mangroves, it is difficult to locate all of the proposed buildings behind the dune. Elevating cabanas on pilings should be considered to reduce interference with dune processes, reduce potential for erosion, and minimize flood potential during storms. (See Section 340 for detailed recommendations.)

- Buildings should be designed with the first floor above the maximum storm flood level. Since no historic information is readily available, the designer should interview local community members to assess the past effects of storms, such as Hurricane Gilbert in 1988 or Hurricane Janet in 1955. This information can then be incorporated into the design.
- Pilings are recommended to elevate buildings. However the resort's architect indicated that this is inconsistent with Carecores' architectural design. As a result, the foundation walls should be aligned perpendicular to the shoreline. With this configuration, flood waters can be channeled through the walls, under the cabanas. This will also help reduce erosion that would typically result from high waves breaking on vertical walls that parallel the shore.

Analysis for Developing Near Wetlands, Lagoons and Water Bodies

(Refer to Section 400 for general guidelines)

Mitigate Alterations to Wetlands

The initial design located a service area within the mangroves on the western edge of the property. This report recommends relocating the service area away from the mangroves to be consistent with federal regulations and to maintain the area's excellent habitat and water quality conditions. (See Section 410 for discussion on mangroves and management guidelines.)

While it is recommended that the resort's service area be relocated to the beach side of the existing road, if permission is granted by federal authorities to build within the mangrove zone, it is recommended that structures be elevated on piles to avoid alternation of the hydraulic circulation of the wetlands. Where fill is required, the use of permeable material will aid in maintaining the water flow between the wetland and coast.

Evaluate the Location and Design of Piers

The Carecores resort is considering a pier for small diving and fishing boats. Design details are still in primary stages. (See Section 450 for detailed recommendations.)

- With a shallow reef lagoon, the pier's design and its long-term operation should be consistent with the area's physical constraints, so that dredging is unnecessary and impacts to adjacent reef and submerged vegetation are minimized. Therefore, shallow draught boats should be encouraged, in addition to kayaks and skiffs.
- Using piles for pier construction (as opposed to solid fill) is recommended to allow nearshore circulation and longshore sand

movement to continue. Traditionally in Quintana Roo, piers are constructed with native wood which is naturally resistant to degradation and thus helps guarantee long-term durability. (See Section 450.)

Analysis for Vegetation Management and Landscape Design

(Refer to Section 500 for general guidelines)

Vegetation plays an important role in the landscape of a resort and in maintaining the natural biodiversity. The La Casona site, with its heavily vegetated dunes, provides a natural environment that can enhance the aesthetics of the resort. With the mangroves on the backside of the barrier beach, design and use of this property should be carefully considered to ensure that the mangrove habitat is not degraded.

Preserving the Coastal Habitat

An initial analysis identified the site's types of vegetation and the distinct habitats of its dune. (See Sections 510, 520 and 550 for specific recommendations for vegetation management and landscaping.)

- One non-structural method of mitigating the effects of erosion is to incorporate natural vegetation into the design of the new development. While often it may be easier to clear the land than retain the natural vegetation, there are economic, ecological and aesthetic benefits that often justify taking the latter approach. Incorporating existing vegetation into the landscape design can create an aesthetically pleasing environment while maintaining the natural function of beaches and dunes and a habitat for wildlife.
- The architect agreed that by selectively clearing vegetation in the construction site, the remaining native plants could be utilized and incorporated into a botanical garden within the landscape design. Additional native plants would be planted as ground cover for the dunes.
- The chart on page 104 shows the extended use of walkways throughout the resort to maintain natural vegetation and provide privacy for guests.

Analysis for Managing Potable Water and Wastewater

(Refer to Section 600 for general guidelines)

Within the Quintana Roo region, there is no municipal water supply or sewage system. The most viable source for potable water is the groundwater aquifer. For the size of the Carecores development, a modified septic system is recommended to reduce contamination to the groundwater. Appropriate water management techniques should be employed to ensure a long-term water supply that remains contamination-free and is cost effective for a small development.

Potable Water
(Refer to Sections 610, 620 and 630)

- A water system designed to recycle/reuse water lowers the volume of water needed, reduces the necessity for extensive and costly water supplies, and minimizes the required capacity of the wastewater treatment plant. A "closed system," in which high quality water is available first for human consumption and then reused for inferior use (e.g. watering landscapes), can effectively optimize water use.
- Since the resort's potable water will be extracted from a deep well, the design of the well should incorporate a "window" in the pipe to help prevent salt water intrusion.
- A rainwater collection system should be designed to provide a complementary source for potable water. Such a system would be worthwhile because although the average rainfall is 743 mm from June to October, during the dry season the average falls to only 200 mm.
- Since a large volume of water is typically needed for sanitary purposes, the use of composting toilets would substantially reduce water demand.
- The resort's well should be placed far away from possible pollution sources to protect the well's recharge area from contamination. As specified in NOM-003-CNA-1996, the well should be a minimum of 30 meters away from any wastewater discharges or other sources of contamination.

Wastewater
(Refer to Sections 640, 650 and 660)

On-site treatment for wastewater disposal is recommended for the Carecores resort. With limited potable water in the region, it is advisable to design a system that can reuse all or part of the treated wastewater for other purposes. Initial plans for Carecores wastewater included the use of closed septage tanks that require regular pumping, transportation and disposal. Because there are no facilities within a 100-kilometer radius that will accept such waste, and because there are few commercial pumping enterprises servicing the area, this closed-tank option has extremely high costs. It also increases the potential for mishandling of wastewater which—if disposed of improperly—could result in environmental damage to wetlands and water bodies.

- Artificial wetlands are one of the systems that have been used successfully to help treat wastewater in many parts of the world, including Akumal and other locations in Quintana Roo. A modified septic system, designed by the Planetary Coral Reef Foundation in Akumal, separates solids naturally in the first phase. Wastewater then flows through shallow tanks filled with vegetation, and is purified by a biological process whereby plants use the wastewater's nutrients for growth. This effluent can then be reused for landscape maintenance. This system is also known as biological-macrophitic filtration, a hydro-botanic system, or the "root zone method."

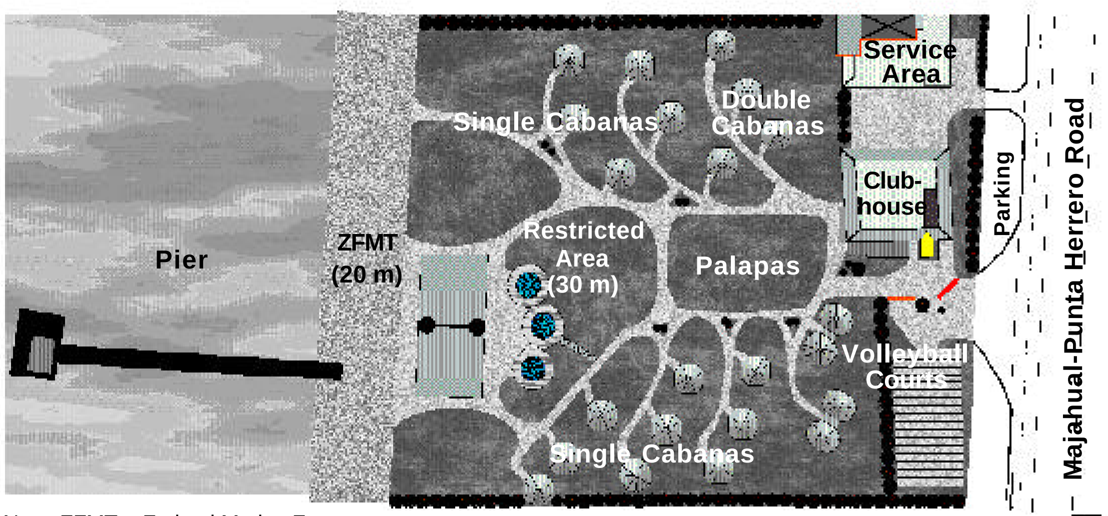
- Design of the wastewater facility should comply with applicable federal regulations. For instance, the water quality of the effluent that is to be discharged or reused must comply with the permissible maximum limits of polluting agents established by the Federal Ecological Regulations. Additionally, reuse of treated water for irrigation of lawns and landscape is a requirement for obtaining approval of environmental impact assessments.

Implementation of the Guidelines by the Developer

Given the analysis and recommendations identified above, the architect and developers of the property chose to adopt the following modifications for Carecores, as depicted below.

A. Vegetation

- Selectively clear vegetation in construction sites and utilize remaining native plants



Note: ZFMT = Federal Marine Zone

This plan for Carecores includes all the modifications recommended in this manual.

- Incorporate a botanical garden within the landscape design
- Clearly mark walking paths to minimize disturbance to dune

B. Siting of Infrastructure

- Establish a 30-meter restriction zone to respect coastal dynamics and minimize flooding
- Designate the exclusive use of a setback zone to a volleyball area and sunbathing beach

C. Wastewater Treatment

- Redesign the treatment system from a closed tank system to a septic system with biological filtration treatment through vegetation, disinfection, and aeration
- Reuse treated effluent for on-site irrigation

D. Potable Water

- Pump potable water for general use from a deep well with devices to minimize salt water intrusion
- Supplement well service with cistern rainwater collection system from cabanas and the clubhouse

The practices adopted here illustrate the voluntary use of *Guidelines for Low-Impact Tourism*. Application of the guidelines in this manual should be made on a site-specific basis with knowledge of the natural processes and the physical characteristics of the area of concern. Implementing a suite of low-impact practices helps to maximize economic benefits of new tourism infrastructure, while mitigating potential environmental impacts.

Conservation of Critical Coastal Ecosystems in Mexico is part of the Coastal Resources Management Project II, a partnership between the United States Agency for International Development and the Coastal Resources Center at the University of Rhode Island.

This five-year project aims to conserve critical coastal resources in Mexico by building capacity of NGOs, universities, communities and other key public and private stakeholders to promote an integrated approach to participatory coastal management and enhanced decisionmaking.