THE BAHAMAS NATIONAL REPORT
INTEGRATING MANAGEMENT OF WATERSHEDS AND COASTAL AREAS IN SMALL ISLAND DEVELOPING STATES (SIDS) OF THE CARIBBEAN

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ACKNOWLEDGEMENTS

A Caribbean Environmental Health Institute and United Nations Environmental Programme Caribbean Regional Coordinating Unit - funded, *Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean* – Integrated Watershed and Coastal Management planning team comprising the Bahamas Environmental, Science, and Technology (BEST) Commission and the consulting firm ICF Consulting undertook the preparation of this National Report. The purpose of the project was to initiate the development of a Bahamas National Report to be used in part, for the preparation of a Regional Synthesis document, which will inform the development of a GEF Project Brief. The project was undertaken through the The BEST Commission, in the Office of the Prime Minister, under the direction of The Bahamas Ambassador for the Environment, The Honorable Earl Deveaux, and BEST Undersecretary and Project Coordinator, Dr. Donald Cooper.

The overall objective of this project is to integrate fresh water resources and coastal water management through multi-sectoral planning and management of island ecosystems. Specifically, the project will assist participating countries in improving watershed and coastal zone management practices in support of sustainable development.

The Bahamas Watershed and Coastal Areas planning team is composed of Dr. Donald Cooper (BEST – Undersecretary), Ms. Nakira Gaskin (BEST – Supervisor of Computer Operations), Mr. Philip Weech – (The Water and Sewerage Corporation – Hydrology Specialist), Brendan Sweeney (ICF Consulting - Environmental Management Specialist).

EXECUTIVE SUMMARY

In The Bahamas, the current national policies, regulatory responses, and enforcement of activities in the coastal areas do not adequately protect the environmental, social, and economic significance of coastal resources to the society. Relevant legislation is lacking or problematic, compared to the nature and significance of the environmental, social, and economic problems in the coastal zone. Because the coastal resources are critical and central to The Bahamas, the current legislative, regulatory, and institutional arrangements require review and improvements.

The fresh water resources of The Bahamas are both finite and vulnerable. The current estimate of available water per head of population will decrease with time as the increased demands from industry, agriculture, and population growth continues. The uncontrolled development of land is resulting in land use that will limit the abstraction of water from beneath sites of development due to incompatible land use. The lack of regulation and enforcement of existing regulations on land use, agriculture, pesticides, domestic sewage, landfill sites, solid waste disposal, and the abstraction of water has resulted in the degradation of the resource. To date, the pollution and degradation by natural as well as anthropogenic sources and causes is yet limited to specific sites, and limited in magnitude.

The conservation and responsible use of fresh water resources are an urgent need in some island communities in the country. A daily availability of less than one half of a cubic meter per head as in New Providence is a critical shortage. The result is increased cost for supplies that are dependent on high-energy input in the form of ocean transport or desalination. This state of scarcity and increased cost is likely to become country wide with few exceptions. The conservation of and responsible use of the resource at the national level, expected to delay the crisis state for many communities, will be offset if there is no drastic change in population growth, or control on the siting of population centers, and the shortage or alternately, incrementally higher cost for water is certain.

The Government of The Bahamas, and specifically, the Water and Sewage Corporation recognize the shortfall of existing regulations. The development of a comprehensive and cross-sectoral land use policy is the most effective way to control development and indirectly control activities that affect the coastal resources of The Bahamas.

Integrated Coastal Management (ICM) planning can afford the Government of The Bahamas (GoB) appropriate planning, management, and investment interventions designed for implementation at the national, island (cay), and local levels. Experiences in coastal zone management throughout the world suggest the need for an integrated, multi- and inter-disciplinary and multi-sectoral approach in planning actions to alleviate and preempt coastal problems and issues. This paper presents the current state of affairs in The Bahamas regarding the condition of coastal areas and management of coastal assets. Also, described in Sections Four and Five, are emerging integrated coastal planning interventions and techniques designed to afford the Government of The Bahamas the institutional capacity to manage their coastal zone in an integrated manner. What is needed is a pilot study and demonstration project to apply the methodologies and techniques to real Bahamian situations.

1.0 COUNTRY ORIENTATION

The Bahamas with a total surface area of 13,880 square kilometers, comprise thirteen major islands and seven hundred smaller islands and cays. The islands are aligned in a northwestern to southeastern direction for more than 1,400 km from the East Coast of Florida to the southeastern coast of Cuba.

1.1 Landscape

Topographically, the islands are typically flat with elevations of less than ten meters. A higher coastal ridge may occur, usually located along the exposed side of most islands. Islands of the southeast and central Bahamas are generally of higher elevation than the northern Bahamas. The highest point in the country is 206 feet at Mt. Alvernia in Cat Island. The terrestrial vegetation may be classified into three types in three zones from north to south. The islands of the north are covered by forests of Pinus caribea var. bahamanensis in the interior of the islands, with a coastal strip of broad-leaf coppice of hardwood species on the windward side of the island. The protected side of these islands is typically covered by mangrove in tidal flats with Rhizophus manzle as the dominant species. The islands of the Central Bahamas are covered by broad-leaved vegetation similar to that of the exposed coastal strip of the Northern Bahamas. This vegetation type is dominant on all islands in the central zone. Protected, leeward, coastal flats of the Central Bahamas are similarly covered by mangrove. A mixture of broadleaf coppice with an increasing amount drought resistant species progressively further southeastward covers the islands of the drier southeast. Vegetation of this zone is scrub-like and as with the previous two zones, mangroves are present on protected coastal flats.

1.2 Demographics

The population at the last census (2000) was 304,913 with most residents concentrated into two population centers in Nassau, the capital city, on the Island of New Providence, with 70%, and Freeport, located on the Island of Grand Bahama, with 15%. Thirteen major islands are populated to some degree. Utilities and essential services including roads, ports, airports, mail, telephone, electricity, secondary education, police presence, and limited medical care are extended to most communities. All communities of the north and central islands have access to managed water distribution schemes. Many communities of the southeast do not have access to managed distribution systems, either because adequate ground water is not available, or the number of residents and dispersed nature of settlement makes such a system prohibitively expensive. The islands of the drier southeast and central Bahamas are experiencing loss of population to the urban centers of Freeport and Nassau as residents seek improved opportunities for employment, education, and health care.

1.3 Economy

The economy is based principally on tourism, with lesser contributions from banking, fishing, and agriculture. The islands are singularly lacking in mineral resources, with aragonite mining from the sea-bed, and salt extraction by solar evaporation in the dry southeast are the only minerals exploited commercially.

Tourism **–** Tourism became a major industry for The Bahamas following the Second World War. The number of yearly visitors has risen from 45,000 in 1950 to about 4 million in 2000, producing one of the most remarkable and resilient economies of any small state in the word – one that has provided sustained growth over many decades. About 60 percent of visitors arrive by sea and the rest by air, contributing a total of $1.5 billion to the Bahamian economy, and supporting more than half of the workforce in the country. In addition to an equable climate and a friendly culture, tourists are attracted to The Bahamas by a clean, healthy, and beautiful environment. Marine biodiversity, in particular, has been an important lure for high-spending visitors seeking recreational fishing, scuba diving, other water sports, and fresh seafood.

Financial Services **–** Banking and financial services account for roughly 15% of the Gross Domestic Product (GDP) of The Bahamas and directly contribute over $300 million a year to the economy in salaries, fees, and other local overheads. More than 4,000 people are employed in the financial sector. In addition to a well-developed commercial banking network dominated by Canadian institutions, there is a large international offshore sector that provides asset management services.

Agriculture **–** The value of agriculture production is currently $50 million per year supported by approximately 8,000 hectares of land in production concentrated on Abaco, Andros, Grand Bahama, and Eleuthera. Domestic crops include citrus, bell peppers, tomatoes, potatoes, onions, avocadoes, pumpkins, corn, pigeon peas, cassava, cabbages, and tropical fruits. Six poultry farms are located in New Providence producing 16 million broilers and 4 million eggs annually for local markets. Livestock includes pork and mutton and total red and white meat production in 1999 was about $1.2 million.

Fisheries **–** The Bahamas supports the largest area of productive shallow water in the western Atlantic and its Economic Exclusion Zone incorporates habitats ranging from sea grass beds and coral reefs to deep oceanic waters. The Bahamas supports one of the world's major Spiny lobster fisheries as well as the most important fisheries for conch and Nassau grouper in the western Atlantic and Caribbean. Commercial fisheries generate $70 million a year, in exports, accounting for approximately 2.25 % of the GDP.

1.4 Climate

The Bahamas may be classified as a marine tropical climate dominated by Atlantic Southeast trade winds in the summer and coot dry North American high-pressure systems in winter. Approximately two-thirds of the country is north of the Tropic of Cancer. Average rainfall totals range from 600 mm in the dry southeastern islands to more than 1600 mm the northwestern part of the archipelago. Most rainfall occurs during the warm summer months from May to October. Limited rainfall is contributed in the cooler months from November to April, due to the passage of North American winter frontal systems. Annual rainfall totals vary significantly from the average due to the influence of tropical storms and hurricanes, both of which exert a great deal of influence on precipitation even when their tracts of passage is several hundred kilometers away from The Bahamas. Maximum temperatures range from 25 to 3 degrees Celsius and a range in minimum temperatures of 17 to 24 degrees Celsius from north to south. The Southeast Trade Winds dominate the weather for much of the year providing a cooling effect.

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2.0 CURRENT WATERSHED/WATER RESOURCES MANAGEMENT ISSUES

2.1 Summary of Observations

The fresh water resources of The Bahamas are both finite and vulnerable to degradation from both natural and anthropogenic sources of pollution. The resource occurs in limestone aquifers as unconfined lens shaped fresh water bodies at the center of islands. Thirteen islands contribute to a total reserve of 7. 7 x 10^9 M^3 of water that is scattered throughout the country in localized lenses of various sizes and quality. The geology, climate, and nature of the reserve have created a fragile resource that is highly susceptible to damage due to excessive abstraction rates, as well as pollutants.

The major sources of pollutants are inundation by sea water due to hurricanes and other severe weather phenomena, intrusion of sea water due to excessive abstraction, and anthropogenic sources such as domestic sewage, landfill leachates from solid waste, tourism, agriculture, residential, and light industries. Pollutants impacting the lens include sea water, sewage, solid waste effluents, pesticides, fertilizers, fuels and oils, and heavy metals.

The absence of adequate regulation of water abstraction schemes, sewage disposal systems, solid waste handling, landfill sites, waste handling from automobile service and repairs, fuel storage and dispensing, pesticides and their use, are continuing to degrade the fresh water resource at an increasing rate. The scattered nature of the resource provides some protection by limiting the effects of pollution to localized lenses. Current estimates of daily available water per head of population ranges from less than one half to more than 107 M^3 at different locations, the national average of 7.4 M^3 will decrease with increasing demand from population increase and increasing degradation.

The conservation of fresh water resources will come as a result of increased regulation of waste from industry, agriculture, domestic sewage; increased regulation of land use for fuel storage and dispensing, solid waste, agriculture, tourism, residential, and recreation sites; and finally the regulation of water abstraction methods, sites of abstraction, and rates of abstraction. Existing legislation must be strengthened and new legislation particularly with respect to national land use planning must be enacted. Even with conservation measures, the shortage of water and increasing prices of water now experienced by some island communities will become more commonplace.

2.2 Fresh Water Resources of The Bahamas

The groundwater resources of the Commonwealth comprise the fresh, brackish, saline, and hypersaline waters found in the near and deep subsurface and in lakes and ponds that intercept the surface. The fresh water resources occur as concave lens-shaped bodies that overlie brackish or saline waters at depths. In excess of 90 percent of the fresh water lenses are within five feet of the surface. All fresh water in The Bahamas comes from rainfall that is in a dynamic transit back to the ocean from which it came. It has been estimated that fresh water underlies only five percent of the total landmass of The Bahamas and some one- percent of the total archipelagic extent of the Commonwealth.

The physical geology and hydrology of The Bahamas and water resources are directly linked, as there are no true rivers in The Bahamas.

The known fresh water resources of The Bahamas are estimated at 7.7 x 10^9 M^3, stored in the islands, all in the form of ground water within limestone aquifers (Cant et al, 1986). Due to narrow profiles and the irregularity of breadth, many islands have several localized reserves that are distinct from adjacent fresh water bodies within the same island. Exploitable or available water is a mere fraction of the total reserves as the bulk of the reserve functions as the 'container' and is essential to maintain the geometry of the structure of the fresh water body, over exploitation will result in long term change in the shape and dimensions of the storage structure.

The actual volume of potable water available is assumed to be less, as the total volume is calculated for all water bearing land including residential and other sites not acceptable for abstraction of potable water. It is worthy of further note that the total volume is a cumulative total of many lenses on thirteen separate islands throughout The Bahamas. Available water per head of population is not the amount available to Bahamian residents for potable supplies as the characterization implies, other demands on available water includes tourism, industry, and agriculture.

The fresh water resources of The Bahamas occur in unconfined lens shaped structures described as Ghyben-Hertzberg lenses. The lens shaped reserves of fresh water are found in the limestone matrix at the center of islands. Typically, the lenses taper towards the edges of the islands. The existence of the fresh water bodies is described as dependent upon the differences in density between sea water and meteoric water, and the nature and the permeability of the confining strata. The recharge source is meteoric water directly to the containment area, unlike other types of aquifers that are partially or entirely fed by ground water flow, or surface flow from other catchment sites. Due to the very high natural porosity of the limestone rock and relatively flat terrain, there are no rivers or other forms of surface flow, except where human activity has resulted in surface sealing due to concrete and asphalt. Therefore, the extent of the water bodies is a function of the precipitation of the site less evapotranspirational losses and losses due to surface flow to the ocean. The nature of the confining strata, the permeability due, to intergranular and interfissure spaces, as well as the size and number of submerged karst structures determines the rate of outflow, if they are present.

2.3 Natural Influences on Fresh water Supply: Residence Time and Internal Flow

The residence times of water in these structures are dependent upon the nature of the confining strata, the breath of the strata, amount of rainfall, and the hydraulic conductivity. Bulk residence times have been calculated by McClain (1990) to be a function of the total volume of the lens and the volume of the recharge. A bulk residence time of 18 years was calculated for a lens of 20 meters maximum depth beneath a surface area of 1.2 kilometers square, in a Holocene deposit. The length of residence time is considered significant to the fate and persistence of certainly pollutants within the structure. The residence time of each water body is expected to be specific for the prevailing determinants of size of the body, conductivity of the confining strata, location of the body, and the climatological effects of recharge and evapotranspiration on the preceding determinants.

The direction and flow rate within the lens as described by Mclain (1990) is a function of both vertical and horizontal velocities from the point or line of greatest hydraulic head at the center of the water body. In real terms the flow is largely horizontal, as the vertical velocity is much smaller than the horizontal. The actual flow will be influenced by the many localized differences in density and permeability within the limestone and the degree of folding, amount of fractures, and the degree of karst development present.

The combined effect of residence time and flow characteristics inside the lens will have a significant impact on the fate of introduced substances particularly as the chemistry of the aquifer changes from the vadose zone, to the zone of partial saturation, to the upper, saturation, aquifer by internal flow characteristics and residence time. Pollutants of to deeper zones within the aquifer. Pollutants of high solubility are predicted 'to be affected most immiscible characteristics are likely to be least affected by internal flow.

2.4 Impacts to Fresh water Resources

Nine major factors are identified as sources of impact on the ground water resources of The Bahamas. Severe weather, a non-anthropogenic impact source is a very significant agent of pollution. Severe weather in combination with anthropogenic sources such as solid waste, sewerage, agriculture, coastal construction, tourism, residential, and the service and distribution industries can magnify the effects and extent of pollution from these sources. Abstraction of water for distribution may become a significant impact source on the resource, particularly with respect to the methods and rates of abstraction. Brief discussions of the major factors influencing groundwater in The Bahamas are described below.

2.4.1 Role of Hurricanes and Tropical Storms in Releasing and Dispersing Pollutants in Coastal Areas

The significance of the predicted surges and their possible magnification is realized when it is noted that most human activity including coastal development, agriculture, industry, and residential sites are at elevations of one to four meters above sea level, with the greatest concentration between one and, three meters above sea level. A direct hit of a category five hurricane will result in significant property damage, possible loss of life, and possible long-term damage to the aquifer. As previously stated, more than 90% of all fresh water resources are to be found within 1.5 meters of the surface.

An event that results in significant ponding of sea water behind a coastal ridge and above a significant aquifer will result in increased persistent salinity until dilution is achieved by further meteoric recharge. The rate of dilution is expected to depend upon the size of the aquifer and the amount of sea water ponded in the event. Similar behavior is expected in the event of contamination by sewerage and highly soluble chemicals. In addition to dilution, some degree of biodegradation is expected in the event of sewerage or chemical contamination, the rate is expected to be controlled by hydro chemistry and the nature of the contaminant. Pollutants of low solubility in water such as petroleum products are not expected to be widely dispersed but to persist for very long periods within the aquifer. Cant reports one such fuel spill on the island of New Providence that remains a source of pollution after 12 years of efforts to clean it up (Cant, 1984).

Past events of landfall by hurricanes have shown significant effects due to coastal inundation by sea water in the form of storm surges, localized flooding due to heavy precipitation, and the possibility for contamination of soil and ground water due to sea water, sewerage, petroleum products, pesticides, and any other objectionable substances that are not adequately secured or stored. The force of hurricane winds and wind driven surges are capable of demolishing storage facilities. The movement of localized flood waters and storm surge waters are capable of releasing and spreading pollutants widely over soil and into the aquifer. Contamination of the aquifer by sewerage during a flooding event is routinely assumed to be the case until testing determines otherwise.

Seasonal coastal inundation by weather phenomenon other than hurricanes is fairly common events to certain low lying coastal areas. These events are caused by a combination of high winds, ocean Spring Tides of the astronomical tidal cycle, and specific coastal formations, all occurring at the same time. Susceptible coastlines are typically around tidal creeks and sounds that permit wave piling due to high winds, along with the prerequisite of Spring Tides that are higher than normal tides. Spring Tides occur when the alignment of the moon, earth, and sun are in a straight line thereby magnifying normal tidal fluctuations by the combined effect of lunar and solar gravitational fields on the oceans.

The effect of seasonal coastal inundation that is not related to hurricanes or tropical storms is less dramatic and less widespread than that due to hurricane events, but these events are more frequent and in a local setting have the same potential for both soil and ground water contamination by salt and other pollutants.

2.4.2 Impacts from Sea Water Intrusion on Fresh water Resources

Sea water introduced into the lens by inundation is expected to persist until eventual dilution by meteoric recharge. Events such as hurricanes and tropical storms are normally accompanied by heavy precipitation; hence dilution begins during and immediately after these events. The rate of dilution and time to return to former salinity levels are dependent upon the amount of sea water introduced and subsequent rainfall. Compromised lenses in the drier islands of the southeast Bahamas are expected to maintain higher levels of residual salinity for longer periods than lenses of islands in the northern Bahamas.

The intrusion of sea water into the aquifer due to excessive abstraction is different as the amount of fresh water in the lens is reduced and replaced by sea water, loss of fresh water is accompanied by reduction and deformity of the lens structure. Recovery of former stored quantity and lens structure is dependent upon the accumulation of meteoric recharge. The rate of accumulation is a function the annual rainfall less the losses due to Evapotranspiration, outflow to the ocean, and continued abstraction, if abstraction is continuing. The time required is expected to be largely dependent upon degree of damage and the recharge rate. The estimation of bulk residence time is not likely to be a realistic indicator, as it does not account for changes in lens dynamics as the size of lenses change.

2.4.3 Impacts from Waste Generation

In The Bahamas, waste generation and disposal of wastes as sources of pollution are proving to be difficult and expensive to manage. Waste disposal options are often limited to confined areas with limited water resources. The problem of waste disposal and environmental pollution becomes critical to the maintenance of the fresh water resource. For island states such as The Bahamas that are solely dependent upon ground water, which is directly beneath the surface on which human habitation, recreation, industry, and agriculture are taking place, the survival of the population, is dependent upon the maintenance of that resource. All land-based activities of construction, industry, agriculture, and domestic activities related to occupation and residence, are certain to have an impact on the soil and ground water quality. In The Bahamas more than 90% of the total fresh water resources are reported to occur within one and one-half meters of the surface (Water and Sewerage, 1994). Thin soils of coarse texture and low sorption capacity offer little protection to the water resource.

Severe weather has the potential to exacerbate pollution of the fresh water resource on a massive scale in a single event. Inundation of the areas containing fresh water resources by sea water, due to severe weather may be considered as pollution from a natural source. Such events are certain to have occurred in the past, recovery is also certain, but the time to recovery is the unknown. With the continued expansion of populations and the demands on the resource, the impact of such an event will increase with development. The certainty of extreme weather phenomena all but guarantees a major pollution event by sea water at some time in the near future. In the meantime, domestic waste, landfill leachates, petroleum products, detergents, industrial wastes, pesticides, and fertilizers are all certain to enter the fresh water body at specific source points as with industry and agriculture and a more dispersed source as with human habitation. The nature of the fresh water resource, the soil, the climate, and geology of The Bahamas collectively have created unique circumstances that are relevant to the consideration of waste disposal and pollution.

To appreciate the vulnerability of The Bahamas fresh water resource and the implications of the contamination of the resource, the nature of the confining strata, the climate, geology, and nature of the fresh water resource must be understood.

2.4.4 Impacts from Sewage

The method of individual sewage containment systems in common use has resulted in wide spread contamination of ground water by sewage in residential areas of the capital (Water and Sewage, 1994), the magnitude is expected to be less in other communities but ground water contamination is certain at these locations also ground water pollution studies by the Water and Sewage Corporation through the period 1991 to 1994 at various locations in New Providence, confirmed elevated levels of nitrates, phosphates, fecal coliforms, and streptocci bacteria.

The physical characteristics of high porosity, karst conduits, and caverns in the Bahamian aquifer can permit the movement of ground water and accompanying sewage to locations removed from the point of input without the benefit of filtration. Sewage released in to aquifer will undergo biodegradation in a largely anaerobic environment as any oxygen present in the vadose zone or upper lens will be rapidly consumed in the initial degradation. There is no available information on the survival of pathogenic microbes and the rate of decomposition under local conditions in the aquifer.

2.4.5 Methods of Sewage Collection and Disposal

Sewage collection and handling in The Bahamas is a mixture of systems from a centralized sewer in parts of the capital to on-site treatment plants for large resorts, and individual septic tanks for most households. Only twenty percent of residences in the capital city are connected to the central sewer system, apart from resorts. The remaining residences collect sewerage in individual septic units. Septic tanks or cesspits are most commonly used, but do not always conform to the Building Code and, therefore, do not function properly. Typically, these systems consist of an open pit in the ground where contaminants are prone to infiltrate the groundwater. Disposal of the effluent from the central unit is by deep well injection following primary and secondary treatment. Injection wells are cased to depths of 200 meters; below this depth the effluent is forced into the cavernous limestone. Large volumes of effluent are disposed of in this system, including effluent from household septic units. Independent private contractors collect effluent from residential tanks and deliver to the central processing facility (Report, Groundwater Pollution, 1994).

Individual household units are usually a tank with a drainage field attached, most are assumed to be operating below building code specifications due to faulty construction or poor maintenance. These units long suspected of causing wide spread pollution of ground water, were confirmed to be responsible, particularly in areas of high population densities on the Island of New Providence (Weech 1993).

Relatively small treatment plants employed by the larger tourist resorts are limited to treatment of in-house sewerage, the final effluent is usually disposed of on green areas and golf courses on premises.

2.5 Demands on Fresh Water Resources: Abstraction Systems

Cant (undated) reports multiple abstraction schemes are used in The Bahamas for the abstraction of ground water. The shallow depth of 1.5 meters, and often less, to the water table allows easy access to ground water. Abstraction methods include hand-dug wells, bore hole wells, trenches, pits, and direct use or water from fresh water marshes. Power sources for abstraction include wind, diesel power, and electrically powered units.

The Water and Sewerage Corporation of The Bahamas, a government owned corporation formed in 1976, claims 60 abstraction and distribution systems on 26 separate islands. Daily delivery by the corporation exceeds 45,424 M^3, however this represents only a part of the consumption, as there are thousands of private abstraction schemes by individuals and other mass distribution schemes. The Grand Bahama Utility Company, a private company, supplies the second most populous town of Freeport. Piped water was available to residents in the capital since 1920. Today, an estimated 88 percent of the population has access to piped water supplies. On the island of New Providence, the Water and Sewerage Corporation supplies only 50 percent of the water consumed by the 213,000 residents and the booming tourism industry. Additional 12,000 private abstraction schemes are known to supply the remaining water. Of the water supplied by the Corporation, 50 percent is barged from the neighboring island of Andros.

Cost of Water Supp1ies by Source

Source of Water	Cost Estimate Low $ per M^3	Cost Estimate High $ per M^3
Groundwater	$0.50	$1.00
Groundwater Blended with Barged Water	$2.40	$4.28
Reverse Osmosis from Brackish Water	$2.40	$4.28
Reverse Osmosis from Sea Water	$4.40	$6.60

Source: Cant, (Undated). Water Supply and Sewerage in a Small Island Environment: The Bahamian Experience.

Barged volumes of water are recorded at 22,700 M^3 per day in 1980, 29,000 M^3 per day in 1986, and 31,700 M^3 per day at present. Water destined for New Providence is pumped into temporary storage in North Andros before barging- to New Providence where it is chlorinated and fed into the distribution system.

The cost of blended water is reported to be equal to water produced from reverse osmosis using brackish water as a raw water source. The dispersed nature of the supplies countrywide in relation to the population centers will probably dictate a continued rise in water rates as population expansion continues. Some locations are already in difficulty with respect to available supplies and amount available per head of population. The total availability per head of population on a country wide scale is not generous, it would appear that supplementation of ground water with water from other sources is a certainty, particularly in view of the high usage normally attributed to tourism.

2.6 Tourism Sector Demands on Water Consumption and Waste Disposal

Total visitor arrivals to The Bahamas have exceeded three million persons annually for a number of years. Tourism as the major industry for the country has grave implications for the fresh water resources. Average daily consumption of water by tourists is estimated at 400 to 1,000 liters per head per day, this is in contrast to residential consumption of 150 to 200 liters per head. Expansion of tourism in future will demand increasing amounts of potable water from a limited source of exploitable water.

Marine based tourism in the Bahamian context may be defined as tourist arriving by sea and usually residing at sea either in small sailing and power boats or in large cruise ships. Large cruise ships typically carry very large numbers of persons for relatively short periods, usually days. The volume of solid waste and sewage generated by a cruise ship is equal to that of a small town. The intermittent nature of the load complicates the management of this waste. Until very recently both sewage and solid waste were dumped at sea, international agreements have since reduced this practice, the onus is now on the receiving port of call to provide facilities to adequately transport, treat, and dispose of this waste. The success of this policy will result in a further increase in the waste load on cruise ship destinations.

Small pleasure craft and sailboats though smaller in size are great in number, and the length of stay is longer, from weeks to months usually in several locations. The operators of these crafts have generally proven to be responsible in handling solid waste but the concentration of untreated sewage at some popular mooring sites have resulted in localized pollution of the environment.

2.7 Service Industries Demands on Water Consumption and Waste Disposal

Service and light industries account for a significant contribution of toxic and persistent inputs into the aquifer. These industries account for a large portion of the non-aqueous-phase liquids, heavy metals, and other water soluble pollutants into the water table. Fuel bulk storage, and dispensing sites are major sources of many non-aqueous-phase liquids (NAPL) in the form of fuels, lubricants, hydraulic fluids, and cleaning, solvents. These sites are also sources of heavy metal contamination, including copper and lead compounds. Other products contributed at these points include detergents and anti-freeze liquids.

2.8 Water and Sewerage Regulatory Authority: The Water and Sewerage Corporation

The Water and Sewerage Corporation is the only water resources authority, and regulating agency for water and sewer in The Bahamas. The functions of the Water and Sewerage Corporation include the following:

1. To control and ensure the optimum development and use of the water resources of the Commonwealth of The Bahamas;
2. To ensure the co-ordination of all activities which may influence the quality, quantity, distribution, or use of water;
3. To ensure the appropriate application of standards and techniques for the investigation, use, control, protection, management, and administration of water;
4. To provide adequate supplies of suitable water for domestic use, for livestock, for irrigation, and agricultural purposes, for urban and industrial use; and
5. To provide adequate facilities for drainage and safe disposal of sewerage and industrial effluents.

2.9 Conclusions

The ground water resources of The Bahamas are both finite and the vulnerable. The current estimate of available water per head of population will decrease with time as the increased demands from industry, agriculture, and population growth continues. The uncontrolled development of land is resulting in land use that will limit the abstraction of water from beneath sites of development due to incompatible land use. The lack of regulation and enforcement of existing regulations on land use, agriculture, pesticides, domestic sewage, landfill sites, solid waste disposal, and the abstraction of water has resulted in the degradation of the resource. To date the pollution and degradation by natural as well as anthropogenic sources and causes is yet limited to specific sites, and limited in magnitude.

The conservation and responsible use of the resource is an urgent need in some island communities in the country. A daily availability of less than one half of a cubic meter per head as in New Providence is a critical shortage. The result is increased cost for supplies that are dependent on high-energy input in the form of ocean transport or desalination. This state of scarcity and increased cost is likely to become country wide with few exceptions. The conservation of and responsible use of the resource at the national level is expected to delay the crisis state for many communities, if there is no drastic change in population growth, or control on the siting of population centers, the shortage or alternately, incrementally higher cost for water supplies is certain.

The shortfall of existing regulations is recognized by the Water and Sewage Corporation, there is a pending draft legislation intended to cover most areas of concern by amending existing legislation. Conservation of the resource should come from enforcement of existing legislation and the passage of legislation on pesticide use (also pending), and land use. The Development of a comprehensive land use policy is the most effective way to control development in a finite indirectly control activities that affect the resource. Legislation in one sector will not way and address the problems of all sectors, a land use policy that is complimentary to legislation of specific sectors will cover all areas.

3.0 CURRENT COASTAL ZONE MANAGEMENT ISSUES

3.1 Summary of Observations

In The Bahamas, the current national policies, regulatory responses, and enforcement of activities in the coastal areas do not adequately protect the environmental, social, and economic significance of coastal resources to the society. Relevant legislation is lacking or problematic compared to the nature and significance of the environmental, social, and economic problems in the coastal zone. Because the coastal resources are critical and central to The Bahamas, the current legislative, regulatory, and institutional arrangements are undergoing review and improvements.

Integrated Coastal Management (ICM) planning can afford the Government of The Bahamas (GoB) appropriate planning, management, and investment interventions designed for implementation at the national, island (cay), and local levels. Experiences in coastal zone management throughout the world suggest the need for an integrated, multi- and inter-disciplinary and multi-sectoral approach in planning actions to alleviate and preempt coastal problems and issues.

In The Bahamas, development and implementation of coastal policies and regulation have been ad hoc and sectoral in nature. Specifically, no consolidated and substantive regulation or comprehensive institutional capacity exists for planning, managing, and enforcing coastal policies. Institutional capacities for the requisite monitoring and enforcement practices have been inadequate. Additionally, legal difficulties arise when public access to beaches, government control of wetlands, and other coastal assets reside in private ownership. The resulting environmental problems and related juridical deficiencies are significant and deep-rooted. A significant obstacle to Government management of coastal resources concerns the pattern of land ownership. Coastal land under ownership and control of the GoB is managed reasonably well but real challenges are posed by land in private ownership or control.

Several plausible explanations exist for the lack of dedicated ICM regimes. The Bahamas geography, consisting of 700-plus islands, thousands of miles of coastline, and economic development concentrated on a few of the comparatively smaller islands (e.g., New Providence, Grand Bahama), means that no real distinction is possible between land use planning problems and ICM applications that include both land and marine environments and issues. To illustrate this point, the entire country is and should be considered a coastal zone. The expense and difficulty of communications between the central government and the local governments from the more geographically distinct Family Islands, further exacerbate the ineffectual centralized regulatory control of the coastal zone. Furthermore, the *Local Government Act, 1996* appears to make provision for local government predicated largely upon the concept of island governance. The Act transfers some responsibility to local government agencies to make decisions regarding upkeep and maintenance of coastal assets. The institutional capacity to efficiently facilitate and maintain coordination between central government and local government regarding planning and management of coastal areas does not exist with in the GoB.

Currently, the GoB mandate for ICM planning is executed through the Ministry of Works and Transportation (MoWT) that, historically, has considered Integrated Coastal Zone Management (ICZM) as the rebuilding of coastal infrastructure and sea defenses and not integrated, cross-sectoral planning aimed at avoiding coastal hazard zones.

3.2 Applicable Regulations

The Bahamas does not possess policies or legislation to adequately regulate problems or conflicting uses in the coastal zone on a comprehensive basis. Currently, relevant regulation is found in diverse sectoral and ad hoc legislation. In some instances, the legislation is outdated and requires review and careful consideration to ensure conformity with constitutional protection of private property rights.

The two local government entities with regulatory functions in relation to the coastal zone are the district councils and town councils, both erected by the *Local Government Act, 1996*. The Act appears to make provision for local government predicated largely upon the concept of island governance. The Act also transfers some responsibility to local government agencies to make decisions regarding upkeep and maintenance of coastal assets. The *Town Planning Act, 1961* is relevant in that it empowers the Department of Physical Planning to prescribe areas approving, restricting or forbidding building. The legislative refusal to discriminate between coastal and terrestrial management has recently been given virtual codification with the advent of local government. Local governments may also join in making provisions in respect to the upkeep and maintenance of local ports, docks, harbors, wharves, and jetties. Provision for the protection of the coast against erosion and encroachment by the sea is made by *the Coast Protection Act, 1968*. The Act enables the Minister responsible for Ports and Harbors to carry out necessary coast protection works (including maintenance or repair). The cost of the work may be apportioned among landowners that benefit from the protection works and requires ministerial consent.

Additional applicable regulations mention throughout the report *include Conservation and Protection of the Physical Landscape of the Bahamas Act*, *Local Government Act*, RAMSAR Convention, Biodiversity Convention, *Ports and Harbors Act*, and *Fisheries Resources Act*.

The GoB's, *Enabling Expanded Private Investment Component II: Strengthening of Environmental Management*, an IDB-funded project, is intended to support the development of the country's environmental laws and regulations and the establishment of a national ministry for the environment to implement and enforce the regulations. The immediate challenge will be to harmonize and integrate the existing regulations and the associated institutional and legal issues and/or create a new coastal zone management act.

3.2 Marine Parks of The Bahamas

The Bahamas National Trust (BNT) is a unique organization that grew out of efforts to rescue the West Indian Flamingo from extinction and create the world's first land and sea park. The Trust was established by Act of Parliament in 1959. It is a unique collaboration of governmental, private sector, and scientific interests dedicated to the conservation of the natural and historic resources of the Bahamas for the enjoyment and benefit of the Bahamian people.

3.2.1 The Bahamas National Trust Act By-Laws 1987

By-laws passed in 1986 govern all Land and Sea Parks and Reserves, and include the following stipulations:

1. Land and Sea Parks have been designated marine replenishment areas for The Bahamas. Hunting, trapping, netting, captures or removal of a fish, turtle, crawfish, conch or whelk is prohibited.
2. Destruction, injury or removal of any living or dead plant life, beach sand, corals, sea fans or gorgonians is prohibited.
3. Molestation, injury or destruction of any land animal or bird life or the eggs of any animal or bird is prohibited. Use of nets or snares is prohibited.
4. Permission may be granted for capture or removal of a designated number of land or sea animals or plants required for valid scientific research.
5. Dumping of any wastes, oil or rubbish on land or sea is prohibited.
6. No person shall injure, deface or remove any building, structure, sign, ruins or other artifacts.
7. Posting of any sign, placard, advertisement or notice is prohibited.
8. No person shall display or use fire, or discharge any explosive, firearm or harpoon gun within the parks.
9. With reference to privately owned property, these bye-laws do not affect the existing rights of any person acting legally by virtue of any estate right or interest in, over or affecting lands of the Parks.
10. Willful obstruction, disturbance or annoyance of anyone in the proper use of the lands and submarine areas or any officer of The Bahamas National Trust in the exercise of his or her duties is prohibited.
11. Any person charged with an offence against any of these by-laws shall be liable on summary conviction to a penalty up to $500. Any boat, vessel or aircraft and all equipment, stores, provisions or other effects used for committing an offence may be confiscated.

One of the primary functions of The BNT is to build and manage the National Park/Protected Area System of The Bahamas. This responsibility, mandated by act of parliament, makes The National Trust unique for, as far as we know, no other non-governmental organization in the world manages a country's entire national park/protected area system.

As mandated by Government, BNT has built and manages the National Park System. BNT has a good record of maintaining the existing National Parks and has made proposals to Government for additional park and protected areas. Efforts to obtain government approval for these areas must be sustained. BNT will continue efforts to establish an integrated system of national parks that will include the most significant natural and historic resources of The Bahamas.

Outside the National Parks the need for preservation of wildlife and marine resources is ever more pressing in view of the expansion of population and related development in the country. The Bahamas National Trust will work toward establishing species/habitat priorities and work actively towards their protection. Within its scope of work, the BNT aims to hold "in trust" the heritage of the islands of The Bahamas by managing the National Parks, historic preservation, conservation education, policy planning, research, protecting the indigenous species of The Bahamas, i.e. the white crowned pigeon, flamingo, hutia and Bahama parrot.

The most celebrated BNT success story is that of the legendary Inagua National Park. There, on 287 square miles, lives the world's largest colony of West Indian Flamingos. Driven almost to the point of extinction, our flamingo "fine feathered friends" now number in the thousands, more than 60,000 in fact.

3.2.2 Bahamas National Parks

The National Parks of The Bahamas are neither government funded or owned and are run on a not-for-profit basis. However government policy and structure support them. Here is a list of current Bahamian national parks and protected areas:

Abaco National Park - Established on May 9, 1994, this beauty comprises 20,500 acres of Southern Abaco. It is the major habitat for the Abaco population of the Bahama parrot.

Inagua National Park - This Park on Great Inagua Island is internationally famous as the site of the world's largest colony of wild West Indian flamingos. In Bahamian dialect these birds are called "fillymingos" and/or "flamingas".

Union Creek Reserve - This enclosed tidal creek of seven square miles on Great Inagua serves as a captive breeding research site for giant sea turtles, with special emphasis on the Green Turtle. Green Turtle Cay was famous for having sea waters chockablock with magnificent Green Turtles.

Exuma Cays Land And Sea Park - This park, inaugurated in 1958, is the first of its kind anywhere on the planet. It comprises 176 square miles of outstanding anchorages and a stunning marine environment. It was the Caribbean's first marine fishery reserve. Many a worldly yachtsperson will tell you that the Exumas are the world's most picturesque yachting grounds.

Pelican Cay National Park - For sensational undersea caves, seemingly endless coral reefs and abundant plant and marine life - sail away to this sister of the Exuma Cays Land and Sea Park. It is located eight miles north Cherokee Sound, Great Abaco Island.

Conception Island National Park - This is another Bahama park that is "for the birds", so to speak. Conception is one of three Bahama islands believed to have been visited by Columbus. The island is a major sanctuary for migratory birds, and a rookery for a variety of sea birds as well as a known egg-laying venue for the Green Turtle.

The Retreat - Aforementioned headquarters of the BNT, The Retreat was once a private home and is located on Village Road in residential Nassau.

Lucayan National Park - Named for the aborigines who lived here long before the arrival of Columbus, this 40-acre park is east of the Bahamian "Second City", Freeport/Lucaya, Grand Bahama Island. It boasts one of the longest charted underwater cave systems in the world. More than six miles of caves and tunnels have been charted. Some of the caves have yielded important archaeological finds relating to habitation centuries ago by the Lucayan-Taino-Arawaks of pre-Columbian times.

Black Sound Cay - This miniature park just off Green Turtle Cay comprises a thick stand of tropical mangrove that provides an important habitat for waterfowl and avifauna which winter in the region.

Tilloo Cay National Protected Area - This cay, between Marsh Harbour and the Pelican Cays Land and Sea Park, provides BNT protection for endangered species such as the Tropic bird.

The Rand Nature Center - This center comprises 100 acres of stunning natural beauty just two miles from downtown Freeport. There is a 2,000-ft. nature trail through native coppice and pine barrens. The center has a library as well as a resident flock of West Indian flamingos. Administrative offices of the BNT in Grand Bahama are located in the center. Bird-watching and other eco-related activities are important new features of the Rand Nature Center. (242) 352-5438.

Peterson Cay National Park - A one and a half-acre geological wonder this is the only cay off Grand Bahama's leeward shore.

3.3 Coastal Habitats and Ecosystems Management Issues

In The Bahamas, coastal resources such as healthy coral reefs, mangroves and wetlands, sand beach and dune systems, and seagrass beds provide the “first line of defense” protecting coastal infrastructure, facilities, and coastal land uses. For these reasons, coastal resources must be considered valuable, natural, and economic assets and need to be carefully managed and protected to ensure their health and continued ability to provide these essential and critical services for The Bahamas. The following summarizes the issues related to these valuable natural assets that need to be addressed in a national coastal zone management program.

3.3.1 Coral Reef Management Issues

Coral reefs receive varied levels of protection under the *Fisheries Resources Act, 1977* and protected areas may also be declared under protection “for the purposes of this Act.” The Act can also be interpreted to include protection of corals and grants permission for their exploitation only for scientific purposes.

Fisheries are conserved and protected under the *Fisheries Resources Act, 1977*. The interviewees suggested that resources within the primary fishery zones are currently being harvested within their carrying capacity, although no scientific data supports this claim. Fishing issues include the following:

- Using bleach to catch fish may have the side effect of killing corals.
- Substantial anchor damage can be realized in popular cruising anchorages.
- Recreational and commercial fisheries impact coral reefs if undertaken improperly.
- Snorkeling and diving activities can have serious impacts on corals.
- Land-based and marine-based sources of pollution (e.g., cruising yachts, cruise ships, and other ocean-going ships) can have serious impacts on corals.
- Coastal construction that results in sedimentation of the coastal waters can damage coral reef ecosystems.
- Climate change is increasingly impacting the health of coral reefs.

3.3.2 Mangrove and Wetland Management Issues

No dedicated legislation exists for the protection of mangroves or wetlands in The Bahamas. Provisions found in the statutes under which these assets are regulated are widely considered to be inadequate. Protection for mangroves and wetlands is imposed through the GoB membership to the international *Ramsar Convention* for the protection of wetlands.

- Dredging for marinas, boat channels, and other coastal developments cause irreparable damage to mangrove and wetland systems.
- Improper construction of roads that do not respect the natural water flows causes mangroves to suffer from changing drainage conditions.
- Mangroves and wetlands suffer damage from changes in water salinity.

Figure 1: Mangroves provide hurricane protection, reduce coastal erosion, and habitat.

Figure 2: Pristine mangroves support habitat and nursery grounds for fish and shellfish.

Figure 3: Proposed marina and inland channeling will destroy these vital mangroves.

3.3.3 Sand Beach and Dune Systems Issues

- Channeling through sand beaches and dune systems to create an entrance to a marina destabilizes the sand beach and dune coastal system and creates a serious maintenance problem, which increases the costs to keep the channel open.
- Improper construction in sand dunes causes dune erosion and instability to coastline.
- Ad hoc private home owners construction of groynes causes erosion downshore and forces neighboring land owners to spend money developing their own groynes until the entire beach system is a groyne field and the property furthest downshore is devoid of sand, e.g., Treasure Cay.
- Sand beaches and dune systems suffer from pressures of sand mining or dredging that destabilizes the dunes.

Figure 4: Poor resort planning calls for dredging this pristine beach to create a harbor.

3.3.4 Iron (Rocky) Coastline Management Issues

- Private property owners may clear cut the vegetation above iron coasts to the embankment edge causing soil erosion, sedimentation, and impacts on near shore habitats such as seagrass beds and coral reef systems, e.g., Harbor Island.

3.3.5 Seagrass Beds Management Issues

- Dredging in the vicinity of seagrass beds causes physical damage and loss of seagrasses and habitat.
- Improper fishing practices (dragging nets) damage seagrass beds.

3.3.6 Dunes and Other Natural Shorelines

The threat of significant and increasing beach erosion exacerbated by commercial sand mining (particularly for export) played a major role in the GoB changing policies regarding the harvesting of sand from beaches. The *Conservation & Protection of the Physical Landscape of The Bahamas Act, 1997* prohibits all significant excavation, landfill, operation, quarrying, or mining of physical natural resources (including sand) on the coastline. The Act applies to beaches, sand dunes, and the seashore and applies to the Crown Lands. But its applicability to mining activity on private land remains unclear and probably subject to challenges.

3.3.7 Public Access to Coastal Areas

All Bahamians have the common law right to use the foreshore and beach for swimming, fishing, and navigation. However, there is no legislation guaranteeing the right to access the foreshore.

3.3.8 Inland Lakes

Most of the Bahamian lakes are linear or crescentic in shape, and this is easily identifies their origin in depressions between ridges. Inland lakes are shallow, usually only a few feet deep, and rarely more than three to four meters deep. They typically have swampy islands of mangroves within them and along the perimeters. Gradually, the swamps expand and as a result the lakes decrease in size, so that all the lakes eventually mature into swamps. All the major Bahamian islands have such marshy areas that were once lakes and which usually flood when the water table rises in the rainy season. Inland lakes are not sources of potable water in The Bahamas.

Geologically two types of lakes predominate throughout The Bahamas, ridgeland and rockland lakes. Ridgeland lakes will form whenever the land between two ridges falls below the level of the water table. Lakes in The Bahamas are usually small in size. A second type of lake is a shallow, saucer-like depression in the rockland. Presumably rockland lakes were formed while the rockland was still below sea-level, and in some cases tidal currents may have been responsible. In general, rockland lakes are less common throughout The Bahamas than ridgeland lakes.

3.4 Coastal Infrastructure and Management Issues

3.4.1 Infrastructure and Utilities Management Issues

The Bahamas' roads in the path of Hurricane Floyd suffered various degrees of "wash out" damage at almost all locations where the roads were adjacent to the shoreline. The degree of damage was, in part, dependent on the protection, or lack of protection, provided by the associated sea defenses. In almost all cases where the sea defenses failed, either because of sea surge or wave action, the adjacent road and/or shoulder suffered damage. The main variables relating to the amount of damage was the elevation Above Sea Level (ASL), distance of the road from the high water level, and, to a lesser degree, the presence or absence of vegetation between the road and the sea.

In some cases, waves overtopping the sea defenses caused shoulder and road washouts on the landside of the seawall. The conditions were worsened as the seawalls acted as a barrier to the wave surges returning to the ocean. Waves and surges also caused erosion and destruction of the natural vegetation cover. Erosion damage to roads was limited to those near the sea defenses because no heavy rains were associated with the hurricane.

3.4.2 Marinas and Mooring Areas

Provision for the protection of the coast against erosion and encroachment by the sea is made by the *Coast Protection Act, 1968*. The Act enables the Minister responsible for Ports and Harbors to carry out necessary coast protection works (including maintenance or repair). The cost of the work may be apportioned among landowners that benefit from the protection works. Private coast protection work requires Ministerial consent. Local Governments may also join in making provisions in respect to the upkeep and maintenance of local ports, docks, harbors, wharves and jetties.

- New construction of commercial marinas (> 12 slips) and reconstruction of damaged marinas should incorporate sewage pump out facilities and spill prevention plans.

- The design of new marinas and reconstruction of damaged marinas should incorporate best management practices in the development of new bulkheads, e.g., preference to rock mounds construction and aquatic vegetation rather than walls.

- Marinas should incorporate the use of wetlands and mangroves to buffer wave action.

- Regulations and guidelines should be developed for the establishment of mooring buoys for permanent anchoring areas near or around coral reefs and seagrass beds.

Figure 5: Remnants of small boat harbor destroyed during Hurricane Floyd because the marina wall completely failed.

3.4.3 Dredging

Dredging for marinas and canals is a significant problem compounded by the fact that construction work generally occurs on privately owned land. Presently, no adequate regulation of dredging exists.

Dredging regulation is generally enforced through the *Town Planning Act, 1961* since permission for the development of land is required. Dredging harbors and ports require permits from the Ministry of Transport.

Figure 6: Large dredging operation impacts mangroves and alters fresh water habitats.

3.4.4 Electrical Utilities and Solid Waste Facilities

- New utility construction or reconstruction of damaged infrastructure should design the placement of the infrastructure on the landward side of the roadways to provide additional protection.

- The placement of electrical transfer stations should be on the landward side of the roadway.

- Solid waste facilities are being designed and constructed to minimize land-based sources of solid waste pollution. Solid waste facilities should be located in contained areas away from open water.

Figure 7: Poor administration turns solid waste transfer facility into permanent dump.

Figure 8: Poor planning places new construction on top of dune and subject to washout.

3.4.5 Coastal Land Use Planning Issues

The main coastal land use planning, permitting, and approval issues identified during the field visit include the following.

- No coordination between central government and local town councils regarding land planning and construction project approvals.
- No coastal plans – mostly ad hoc development.
- No “Best Practices” to minimize impacts resulting from construction are in place.
- Criteria for Government approval of projects in the region are somewhat ambiguous, e.g., different standards exist for international versus national investor and for the relative size of the development.
- Coastal land use planning is reactive versus proactive, i.e., reacting to major development proposals without some overall guidance for developers and Government managers.
- Often people at the local level who are approving coastal land use projects are the same ones who are building the projects or otherwise indirectly vested in the success of the project.
- Coastal land ownership is sometimes a question. Clear definition of property lines and land ownership needs to be addressed including definition of crown land, common land, generation land, and private land.
- Social Impact Assessment (SIA), Environmental Impact Statement (EIS), and Environmental Impact Assessment (EIA) processes are not well understood or developed and have not been applied consistently throughout The Bahamas.
- No building codes for construction in sensitive areas, i.e., sand dunes or flood areas.
- New beachfront construction should require building setbacks from the landward base of the dune.

3.5 Climate Change and Natural Disasters

The Bahamas, as many other low-lying island states are especially vulnerable to climate change and associated sea-level rise because much of its land area rarely exceeds three to four meters above the present mean sea level. Coastal areas with slightly higher elevations are also susceptible to climate change effects, where the main settlements and vital economic infrastructure invariably concentrated. The coastal region of The Bahamas, compared to other parts of the country, is the most important and economically most valuable both from development and environmental points of view.

Certain species of corals that inhabit The Bahamas are very sensitive to sea water temperature changes. Elevated sea water temperatures (above seasonal maxima) can seriously damage coral ecosystems by bleaching and also impair reproductive functions, and lead to increased mortality. It is expected that mangroves will be more adaptive to climate change by species, as well as local salinity regime and biological interactions. Coastal land loss and the presence of infrastructure in coastal areas will also reduce the natural capacity of mangroves to adapt and migrate landward.

Fresh water lens storage and capacity is a serious problem in The Bahamas because of the dependence on rainwater replenishment. Changes in the patterns of rainfall may cause serious problems to the islands of The Bahamas.

Higher rates of erosion and coastal land loss, and increased sea flooding, inundation and salinization (of soils and fresh water lenses) are expected as a direct consequence of the projected rise in sea level.

Throughout The Bahamas, tourism resorts, coastal towns and infrastructure will be at risk, given their location at or near present sea level and their proximity to the coast. Relocation or fortifying coastal infrastructure for coastal protection will become financially burdensome for The GoB, particularly in the Family Islands. As discussed later in this report, integrated coastal planning will afford the GoB the tools to help minimize hazards of flooding and erosion and investments in coastal structures and optimize performance.

Tourism is increasingly recognized as an important source of foreign exchange for The Bahamas. Climate change and sea level rise will affect tourism directly and indirectly due to: loss of beaches to erosion and inundation, salinization of fresh water aquifers, increasing stress on coastal ecosystems, damage to coastal infrastructure from storm events, and the overall loss of amenities would jeopardize the viability and threaten the long-term sustainability of the tourism industry in The Bahamas.

Uncertainties in climate change projections may discourage planning and adaptation, especially because of the lack of information and options will be costly or require changes in societal norms and behaviors. The GoB should develop the national policies and land use regulations aimed at minimizing the potential affects of climate change and sea level rise.

This report recommends new standards and procedures for construction and development in the coastal areas of The Bahamas. The GoB would benefit greatly from the practical application of these new coastal planning and engineering principles through undertaking an integrated coastal planning pilot project for a selected island in the Family Islands. A pilot project would afford the GoB opportunities to develop policies, standard construction procedures, and implement proven measures with respect to disaster preparedness and climate change.

3.6 Transboundry Threats

Due to its isolation as an island, The Bahamas does not have any land-based transboundry threats. Water-borne transboundry threats include impacts resulting from migration of toxic substances (oil spill) or diseases on oceanic currents. Shipping commerce can also act as a vector in transmitting disease or non-native species to The Bahamas.

3.7 Information Management Issues

Below are the main information and information management issues identified during the field visit.

- Central authorities do not have ready guidelines to provide local decision-makers regarding sustainable coastal development.
- No clear definition of "no build zones" such as flood prone areas and Environmentally Sensitive Areas (ESAs), e.g., sand dunes and mangroves.
- Lack of ready availability of national information contained in the various Ministries that could be of immediate value for coastal zone planning and local decision-making, e.g., flood prone areas.
- Relevant tools for coastal zone planning are not readily available or applied to coastal zone management, e.g., Geographic Information Systems (GIS), remote sensing imagery, and Digital Elevation Models (DEMs).

3.8 Social and Cultural Issues Relating to Implementing Coastal Management

Below are the typical social and cultural issues identified during the field visit.

- Representatives from the Local Town Councils often presented a cavalier mentality towards development in the Family Islands.
- Independent spirit of people in the Family Islands makes it difficult to set and implement standards and guidelines.

3.9 Governmental and Non-Governmental Eco-Conscious Organizations in The Bahamas

The Adventure Learning Center

A non-profit, charitable organization aimed at nature-centered education for all children, pre-school to grade 6. The center is based in over 100 acres of wetlands; home to nature trails and haven to 150 species of indigenous animals. Soon to be opening to tourists interested in the ecology of The Bahamas. Tel: (242) 324-3166

ARK
"Animals Require Kindness". A society actively is preventing the cruelty of animals. Tel: (242) 394-3757

Bahamas Environment Science & Technology (Best) Commission
Bahamas Environmental Science and Technology Commission having an effect upon legislation in all matters concerning the environment. BEST also ensures that The Bahamas complies with international regulations on environmental protection. Tel: (242) 327-4691/3, e-mail: bestnbs@batelnet.bs.

Bahamas Reef Environmental Educational Foundation (Breef)
Is dedicated to encouraging Bahamian children to become well-informed and active stewards of our environment. Sponsors of teacher training in The Bahamas and in the USA. Holding workshops on the role of reefs in these islands' systems at the Bahamas Field Station. Tel: (242) 326-7938, e-mail: breef@bahamas.net.bs.

Bahamas National Trust
First established in 1959, it is a collaboration of governmental, private sector, and scientific interests dedicated to the conservation of the natural and historic resources of The Bahamas. Holding in "trust" the heritage of the beauty of the Bahamas. Managing the national parks, policy planning, conservation education and research. Tel: (242) 393-1317, e-mail: bnt@bahamas.net.bs.

The Bahamas Marine Mammal Survey
A long-term research program affiliated to Earthwatch concerned with documenting the occurrence, seasonality and abundance of dolphins and whale species in Bahamian waters. The overall, long-term research goal is to characterize the marine mammal fauna of The Bahama Islands for scientific understanding and conservation purposes. Since the survey began in 1991, there have been over 200 encounters with fourteen species of dolphins and whales and over 700 sighting reports from other boaters. To date, 17 different species of dolphins and whales have been documented and seen in Bahamian waters, as well as the West Indian manatee. This research has been instrumental in increasing public knowledge and affecting local management policy for the capture of wild dolphins within The Bahamas. Tel/Fax: (242) 367-4505
"BNE Tours" on VHF Ch. 65A.

The Bimini Biological Field Station
A worldwide shark research center devoted to the conservation of shark species in the wild. The Center, since 1990, works under a research permit from TheGoB, which includes an annual scholarship to a Bahamian student. The Center is associated with the University of Miami's Rosentiel School of Marine and Atmospheric Science. Tel: (305) 274-0628 or (305) 361-4146.

Cape Eleuthera Marine Conservation Project
The Cape Eleuthera Island School is a unique campus and research center serving the needs of students, teachers, scientists, and the local community. It boasts access to one of the most biologically diverse and pristine marine environments in the world. The mission of The Island School is to understand and preserve the ocean through education. The program is sponsored by The Lawrenceville School and funded by private foundations. Tel: (609) 620-6700 or Eleuthera: (242) 334-8300, e-mail: ischool@batelnet.bs

Caribbean Marine Research Center
Founded in 1984 by the Perry Foundation and lying 110 miles southeast of Nassau on Lee Stocking Island is the Caribbean Marine Research Center. The center is internationally recognized for focusing on research in ecology, nature resource management, coral reef habitats, climatic change and marine geological change processes. Of particular concern are the over-fishing and reproductive habits of queen conch, spiny lobster and the Nassau Grouper. The center is utilized by scientists and students from all over the world because of its diversity in geographical environments and variation in biological habitats. The pristine waters of Exuma make it particularly suitable for baseline data in scientific research. Tel: (242) 345-6039, (561) 741-0192. Internet: http://www.cmrc.org.

Ecotourism Association Of Grand Bahama
Formed to educate and promote natural, cultural and historical features of Grand Bahama Island to visitors and residents whilst also addressing issues of protection in the use of our natural environment. The association has a criterion for involvement including - use of natural and cultural features of the environment; education and interpretation; ecological and cultural sustainability; benefits to the local community. Tel: (242) 352-5438

The Garden Clubs of Nassau
Gardening clubs aimed at beautifying the Islands of The Bahamas. They also support gardening projects on the island, hold shows and competitions and give awards annually. Tel: (242) 324-2211. **International Garden Club** Tel: (242) 324-6994

Marine Group
The marine group organizes itself to promote research and conservation of The Bahamian marine environment. They are currently working on collating research bibliographies and mapping the Andros reef system. Tel: (242) 393-1317.

National Pride Association
An organization concerned with the beautification of the islands of The Bahamas. Tel: (242) 326-3330.

Oceanwatch
Oceanwatch Bahamas Ltd. is a volunteer non-profit company established for the purpose of reef and ocean conservation in and around The Bahamas. Projects so far have included: the installation of 40 mooring buoys around New Providence, relocating a

sand-dredging project away from famous diving sites, stopping longline fishing and an annual Reef Sweep/clean-up. At present, Oceanwatch is aiming to establish marine preserve at the western end of New Providence. Tel: (242) 327-8554, e-mail: oceanwatch@batelnet.bs.

The Ornithology Group
Associated with the Society of Caribbean Ornithology and concerned with the preservation of Bahamian birds. Tel: (242) 393-1317.

Re-Earth
To educate consumers on the selection of eco-conscious products. Action group for environmental issues within The Bahamas. Working in schools and in the community. Tel: (242) 322-3128/393-7604.

The Rob Palmer Blue Holes Foundation
The Blue Holes Foundation is a not-for-profit organization dedicated to the scientific and physical exploration of Blue Holes within The Bahamas, and related Cave environments. Blue Holes are one of the world's last unexplored frontiers, a unique environment with a unique ecosystem that may have remained little changed for over 150,000,000 years. The goals of the foundation are: to explore and survey speleological resources in The Bahamas; to encourage education in and conservation of Bahamian caves, and Blue Holes and their associated terrestrial and marine habitats; to promote the concept of integrated ecosystems within the Bahamian environment; the development of safe and appropriate techniques for the exploration of Bahamian caves and Blue Holes; the documentation and publication of exploration and research in Bahamian caves, and the creation of a database on Bahamian Caves. Tel/Fax: (242) 373-4483.

3.10 Institutional Issues

Institutional management of coastal assets is fragmentary and dispersed over a variety of legislation. The absence of dedicated institutional management is compounded by an inadequate or non-existence legislative basis for some of the most important management agencies including the BEST Commission. Most critically, the administrative provisions for consultation and coordination are weak and often by-passed in practice.

Coastal and terrestrial management in the Family Islands has recently been given recognition with the approval of local government. The *Local Government Act, 1996* appears to make provisions for local government, based largely upon the concept of island governance.

- Limited collaboration and coordination between central authorities and local town councils.

Figure 9: The Ambassador for the Environment meets with local citizens in Family Islands to discuss current issues.

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4.0 PRELIMINARY RECOMMENDATIONS FOR DEVELOPMENT IN THE COASTAL ZONE OF THE BAHAMAS

4.1 Introduction

During the development of any coastal project in The Bahamas, it is extremely important to have a clear understanding of the overall objectives for protecting human life and enhancing natural coastal assets, including the following.

- Preserve and restore beaches
- Minimize hazards of flooding and erosion
- Minimize investment in coastal structures
- Maximize performance of coastal structures
- Maintain water quality standards to preserve reefs and recreational beaches
- Maintain existing coastal resources in general

In order to accomplish these objectives and to manage for development in the coastal zone, it is necessary to have a detailed understanding of several coastal parameters. The information noted below is required to maintain existing coastal resources as well as for the development or maintenance of coastal facilities including restoration of beaches, recreational beaches, resort developments, infrastructure (e.g., coastal roadways and piers), and other related coastal structures.

In order for these facilities to be designed and constructed properly, it is essential that the designers, planners, and government agencies reviewing the applications understand the following issues.

- The water levels and wave heights to which the facilities will be exposed.
- The nearshore area (reef topography/health), beach/dune (topography, grain size), and other shoreline characteristics, including the presence or absence of coastal protection.
- How frequently structures or beaches will be exposed to extreme conditions.
- How the beach/coastal facilities react to these conditions.

With this knowledge base, it is possible to avoid failures, minimize impacts to the natural environment, and minimize costs related to both the initial capital cost and future maintenance expenditures. It is also possible to preserve and even restore beaches.

This Chapter provides an overview of the processes required to establish setback or build/no build zones, develop cost effective, quality infrastructure design, and develop guidelines to ensure that this process is clear, focused, and results in significant benefit to the people and GoB. This Chapter also provides a series of recommendations to assist in achieving the stated objectives and an introduction to construction related issues in the coastal zone.

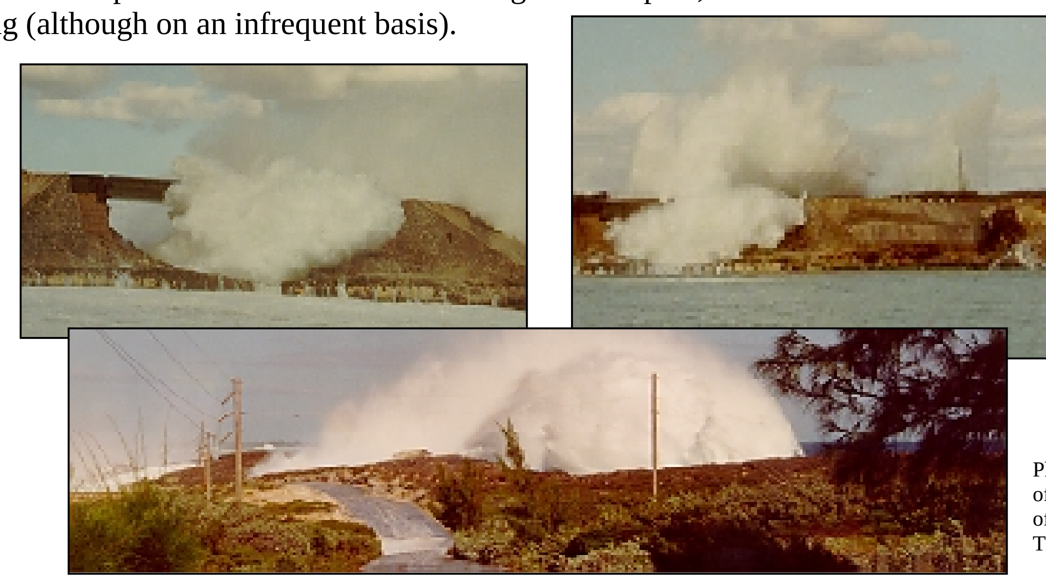
4.2 Process to Determine Build and No Build Zones Based on Flood Hazard and Erosion Analysis in The Bahamas

In The Bahamas, flooding and erosion generally occurs during severe wave attack at elevated sea levels (high tide combined with surge). Under these conditions, waves erode protective beaches and dunes and cause wave and flooding damage to the adjacent lands, buildings, and infrastructure. These hazards may be defined through the following steps:

- Evaluating the possible extreme wave and water level conditions
- Determining the local nearshore, beach, and dune characteristics
- Classifying the shore into like reaches; determining the flood and erosion response for these reaches based on tested numerical models; and presenting this information on maps and air/satellite photos
- Present findings in a GIS database

The challenge in determining the design values for waves and water levels relates to the fact that The Bahamas, which consists of over 700 islands, has an extremely diverse range in exposures to both water level variation and wave heights. These include exposure to "normal" conditions (water level changes related to varying tidal conditions and trade wind generated waves) and exposure to "extreme" wave and water level conditions.

Extreme wave conditions in The Bahamas may be generated by both hurricanes and waves generated in the Atlantic Ocean. Exposure also varies depending on the specific features and location on the particular island under consideration. For example, some sites (such as Glass Window, Eleuthera) are exposed to extreme wave conditions from both hurricanes and the Atlantic. Other sites (such as Rock Sound, Eleuthera) are relatively protected from waves, but are exposed to very large storm surges or increases in water levels during hurricane events. This large increase in water level occurs as a result of the shape of the island and surrounding water depths, and results in serious flooding (although on an infrequent basis).



Photos courtesy of the Ministry of Works and Transportation

Figure 11: Extreme Atlantic wave conditions at Glass Window, Eleuthera

Wind is the primary driving force behind both the water level variation and wave heights. The effect of the wind varies dramatically depending on numerous factors (i.e., shape of island, water depths around site, wind direction, wind speed), which in turn are affected by whether they are driven by normal trade winds, storm conditions, or a hurricane. Nearshore currents are also a consideration at many locations, either wind or tidal driven. Finally, atmospheric pressure also affects water levels and must be a consideration.

The following schematic defines the required steps in the proposed design process for all coastal structures. Additional detail relating to this process is provided in Section 3.

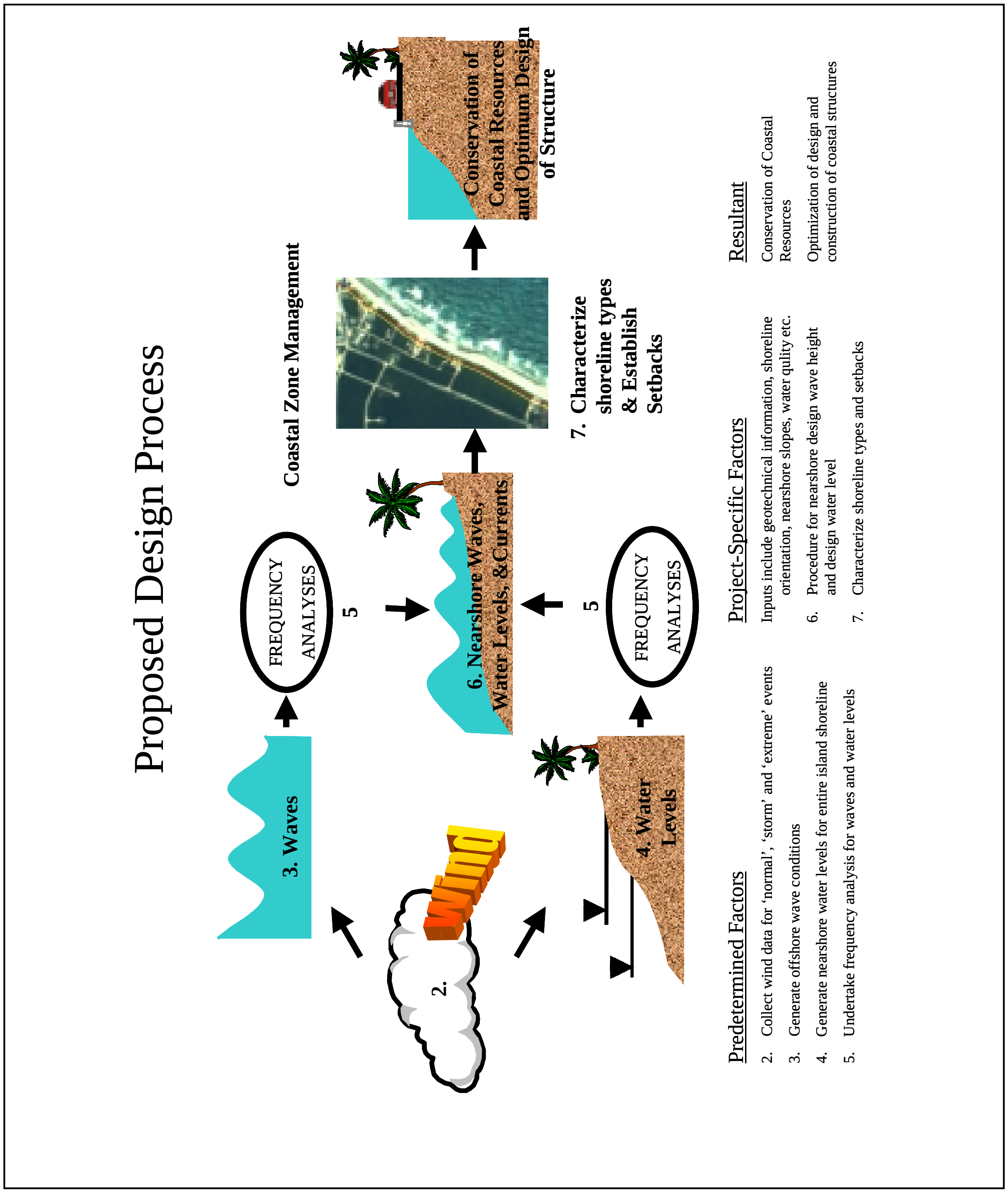


Figure 12: Proposed design process for Integrated Coastal Management Planning.

The government can also minimize impacts on coastal resources (e.g., coral, mangroves, and beaches) and optimize coastal infrastructure investment by considering all of the applicable factors. The various factors that must be considered are summarized in Figure 13 and listed below.

- Assessing and selecting appropriate values for the coastal environmental conditions (i.e., wind, waves, water levels, and currents) Presiding fiscal conditions (i.e., necessity of project and availability of funds)
- Cost benefit analyses (performance versus cost of range of solutions)
- Construction issues such as availability of equipment and site access
- Conservation of natural marine resources which in many cases provide a critical portion of the protection for coastal sites
- Compare design to overall Integrated Coastal Management Plan.

All of this information can be stored in a GIS database and reviewed on a project specific basis as each project is considered.

Proposed Design Process

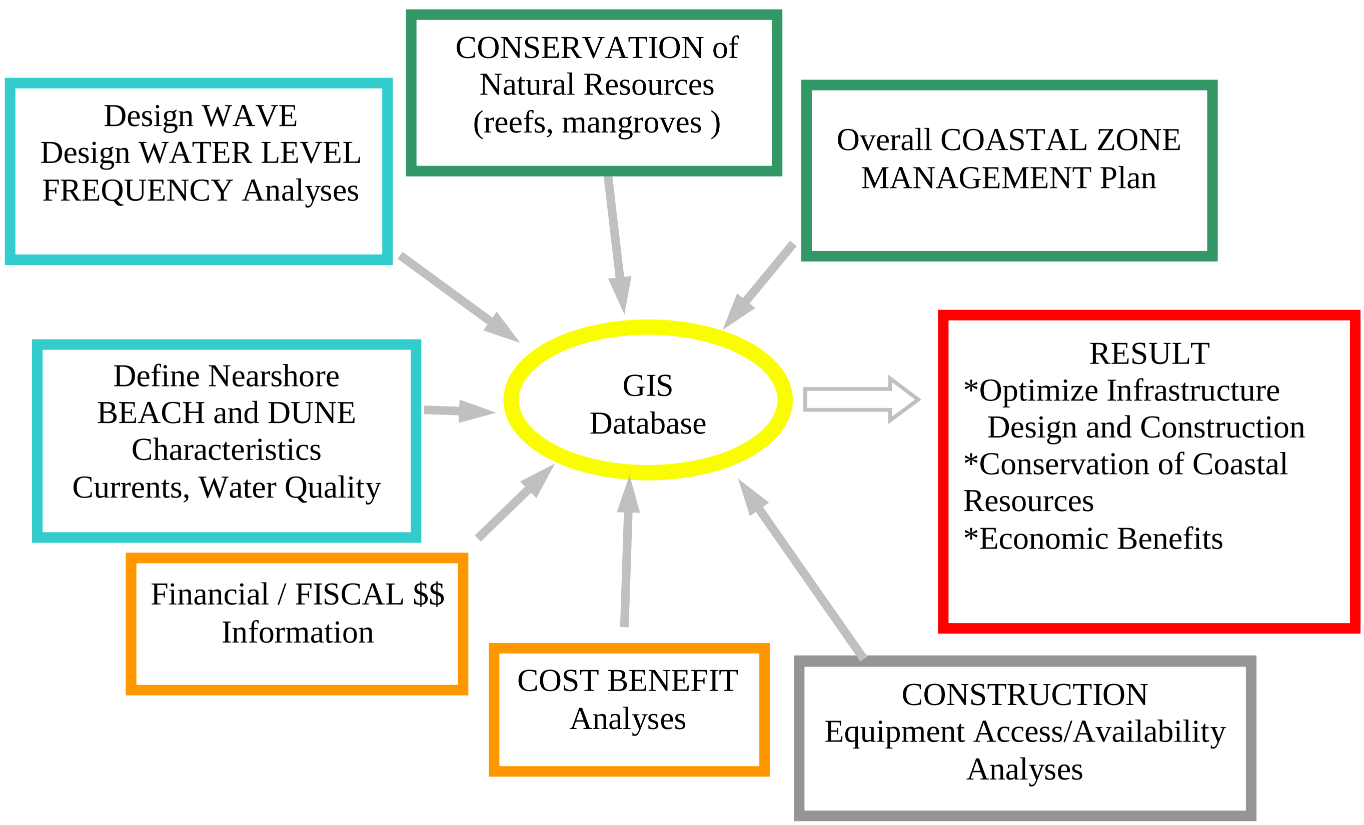


Figure 13: Schematic Diagram of Data Required to Properly Assess Individual Coastal Sites, Optimize Infrastructure Design and Construction,

The following sections outline the tasks required to define the wave and water level environment for the populated areas of The Bahamas to suggest setback distances and build/no build zones. To support the setback determinations, a discussion of how to use this information in the future to design and construct structures which are sturdy yet reflect the environment (waves and water levels) to which they are exposed are described. This process will result in less environmental impact and better coastal infrastructure benefiting all Bahamians.

4.3 Determine Appropriate Infrastructure Design Process for the Coastal Zones of The Bahamas

As described in the previous section, the design of a coastal structure requires a clear understanding of, and accurate values for, the design wave height, design water level, and frequency of occurrence of these events. In addition, it is important to have an understanding or description of the nearshore beach (cross section, sand grain size), dune dimensions, and related adjacent shoreline (rock outcrops, wetland etc.). All of this information affects the resulting design of coastal structures and the related capital and maintenance costs.

Using wave height and related wave energy, it is possible to demonstrate why it is critical to have accurate design values and information in order to design coastal structures. As shown in the chart below, wave energy varies as a function of wave height squared. To illustrate the concept, a three-foot wave height has nine times the energy of a one-foot wave. Wave energy generates the damage and erosion that occurs during storm events. It is, therefore, extremely important to develop accurate values for wave height and the related wave energy to be used in the design of coastal infrastructure, as even small differences will have a significant impact on the final design.

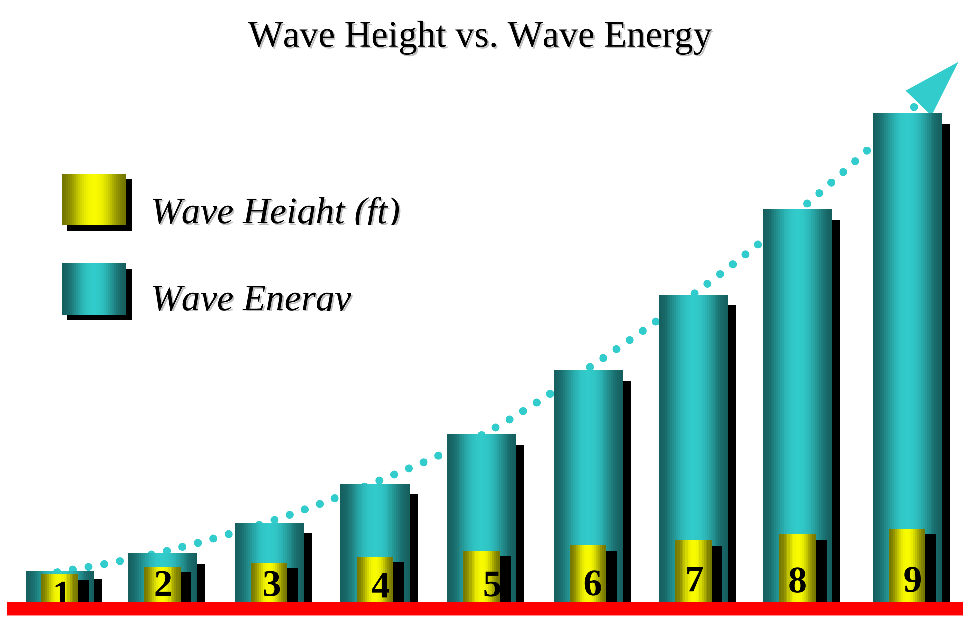


Figure 14: An increase in wave height results in an exponential increase in wave energy and the related potential for damage to coastal structures.

Similar issues exist in regard to an accurate estimate of the nearshore water level. Throughout The Bahamas, the nearshore water level typically defines the wave height that reaches the shoreline. The schematic below indicates the effect of correctly establishing the design water level. A low water level results in a much lower wave height at the shoreline. If the engineer does not take into account the water level increases which occur near the shoreline during storm conditions, they will underestimate the design wave height and subsequently the required size and strength of the coastal structure or the erosion potential for a particular beach. Alternatively, overestimating the water level will result in the construction of excessively large and costly structures whose performance is often inferior. In addition, the aesthetic and ecological impacts are generally much greater for larger, oversized structures than for those properly designed using accurate design wave and water level values.

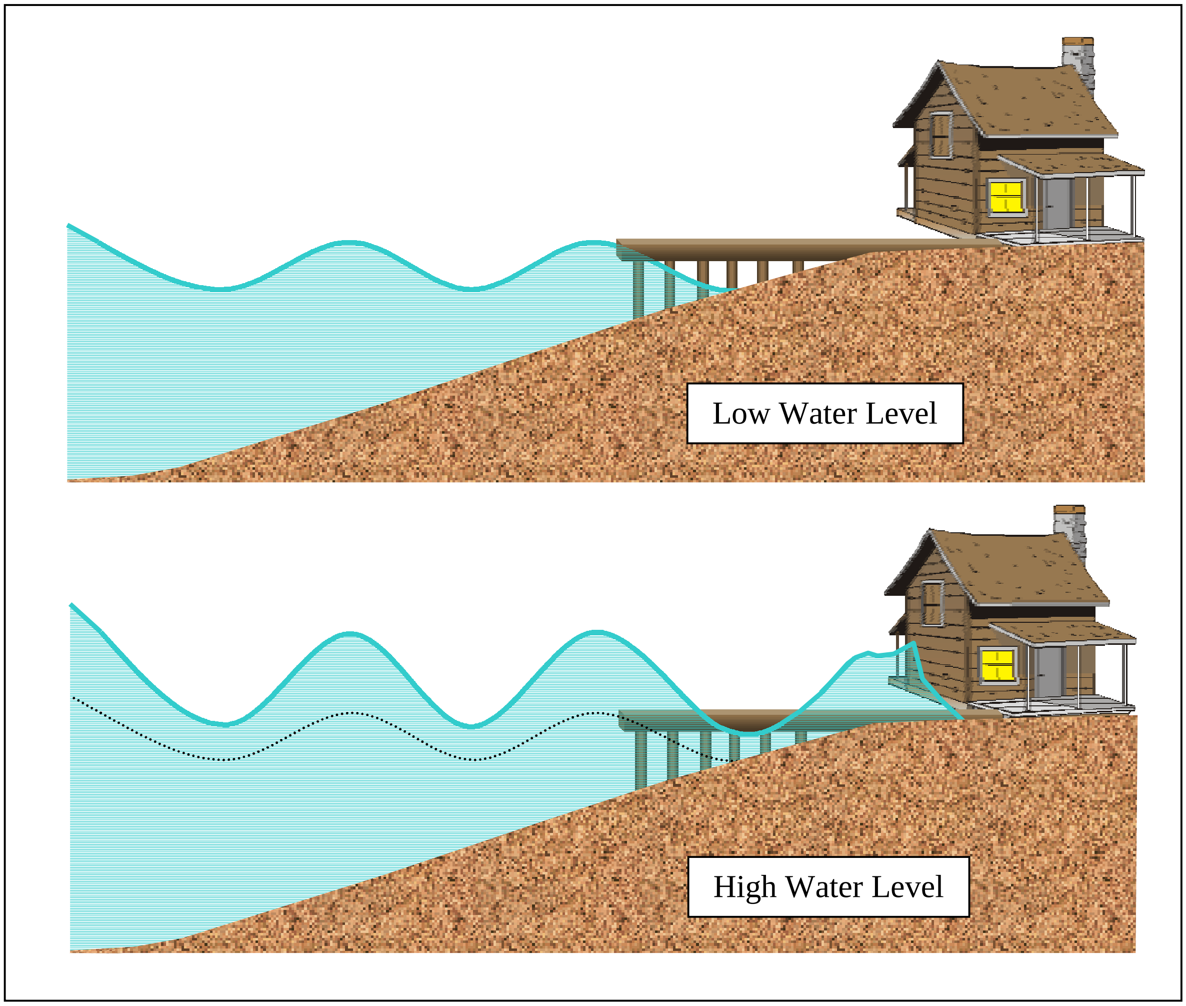


Figure 15: Accurate water level information is essential, as the water level defines the wave height and subsequently the wave energy that reaches the shoreline as well as the related potential for damage.

Hurricane Floyd caused extensive damage throughout The Bahamas on a variety of coastal structures including piers, seawalls, and roadways, in addition to beach and dune erosion and damage to shoreline vegetation.   Using seawalls as an example, it is possible to highlight some of the design flaws of existing structures and emphasize the requirement for new planning procedures and related final construction designs.

There are many reasons for seawall failure including toe erosion, structural failure of small sections of the wall itself, and collapse of sections of seawall toward the sea. In many locations it has been suggested that the reconstruction of seawalls should include increasing the height of the seawall. However, the failure of many seawalls occurred as a result of the existing seawall being too high and unable to support the load of water trapped on the land side of the wall during the hurricane event, thus causing the wall to topple toward the sea. The higher seawalls also increase the amount of trapped water and related flooding, as well as increase the duration of flooding.

Figure 16: Failure and Repair of a Seawall

New Providence Low Crested Sea Wall and Adjacent Beach   New Providence Failed Sea Wall

The objectives of sea wall construction are to balance the design to accomplish the following:

- Natural beach is maintained or enhanced in front of the seawall
- Hazards of flooding and erosion are minimized
- Flooding occurs for the minimum amount of time during infrequent hurricane events
- Hurricanes do not destroy the infrastructure
- Minimize investment in coastal structures and maximize performance

The schematic provided below summarizes a few of the issues related to flooding and damage during hurricane events on improperly designed seawall structures.

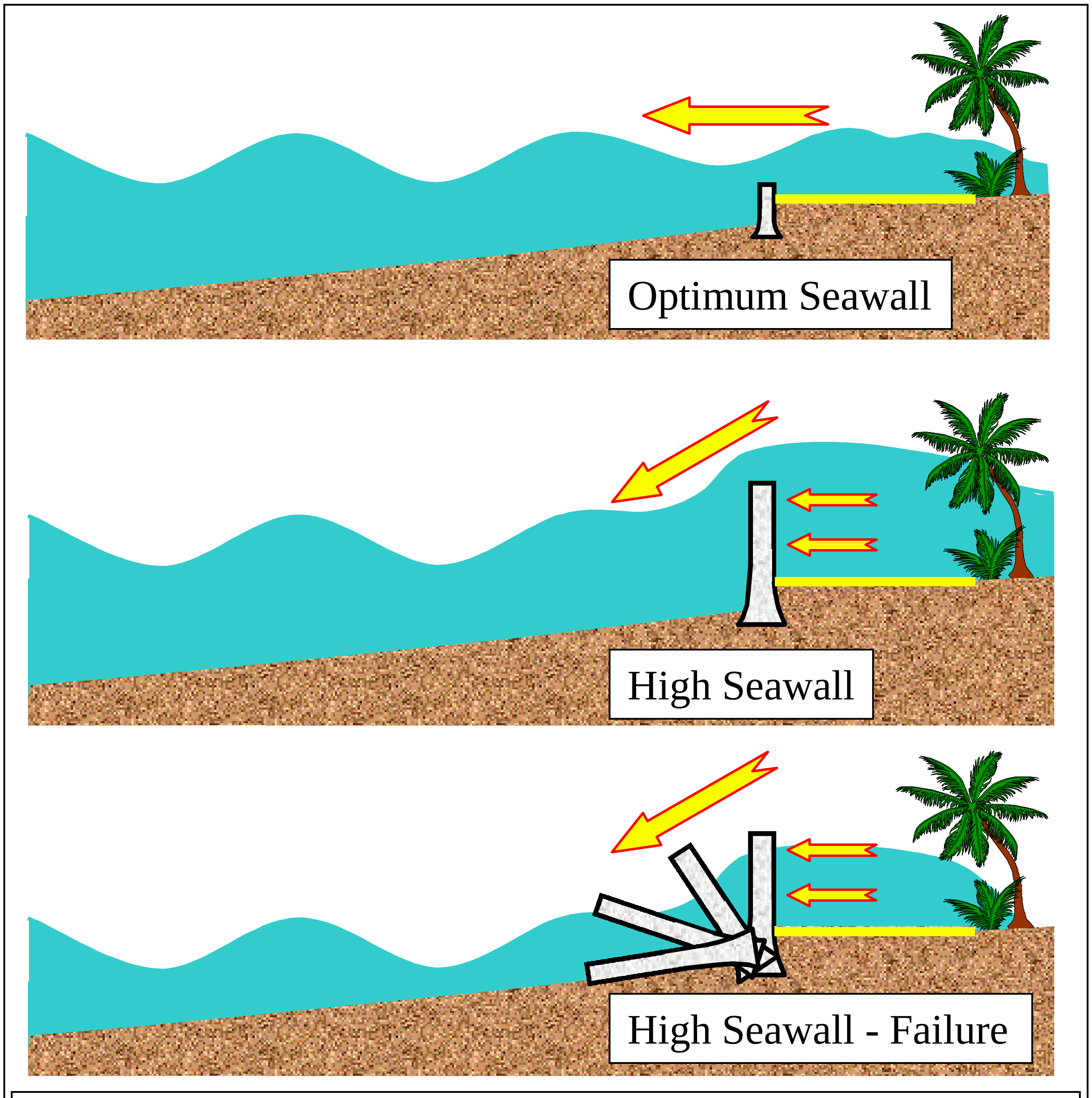


Figure 17: High Seawalls often trap receding floodwaters prolonging the flooding condition and resulting in failure of the seawall in some cases, as indicated above.

It is important to note that the capital cost of infrastructure is often less when the designer has an accurate estimate of the design water levels and wave heights, as well as an understanding of the frequency with which they occur. As shown during actual conditions and damage generated by Hurricane Floyd, lower, less expensive seawalls were often adequate and provided better overall performance than high seawalls. Although the lower seawalls would tend to overtop earlier in the hurricane (probably a few hours or less), the flooding water is able to return to the sea quicker and the potential for significant structural damage is generally less.

It is also important to note that failure due to the load generated by trapped water is not the only mode of failure for coastal structures. The structures are often undermined by an eroding shoreline and damaged by wave impacts or other coastal phenomena. All of these possibilities must be taken into consideration during the design process.

4.4 Requirements for Guidelines for Development at Each Coastal Zone

By determining and documenting the wind, water level, and wave parameters in advance, as well as the frequency of each event, the GoB could develop a thorough understanding of the coastal environment. This information, in addition to the nearshore characteristics of the shoreline, could be stored in a GIS database. This would allow the government to accurately review submissions for new coastal projects as well as provide guidance for the improvement or reconstruction of existing coastal infrastructure. The ultimate benefit would be the preservation or even enhancement of existing beaches and other coastal resources that are so important to The Bahamas.

4.4.1 Process to Develop Database of Coastal Information

This process is outlined below and described in greater detail in Sections 4.4.1.1 through 4.4.1.7.

1. Select specific islands for analyses (e.g., Grand Bahama, New Providence, Abaco, Andros, Exuma, Eleuthera, Cat Island)
2. Collect wind data for ‘normal,’ ‘storm,’ and ‘extreme’ events
3. Generate offshore wave conditions
4. Generate nearshore water levels for the entire island shoreline
5. Undertake frequency analyses for waves and water levels
6. Calculate nearshore wave conditions and related exposure zones
7. Characterize shoreline types and develop setback recommendations by shoreline reach, consistent with the overall ICM Plan
8. Repeat the process for each island to be considered

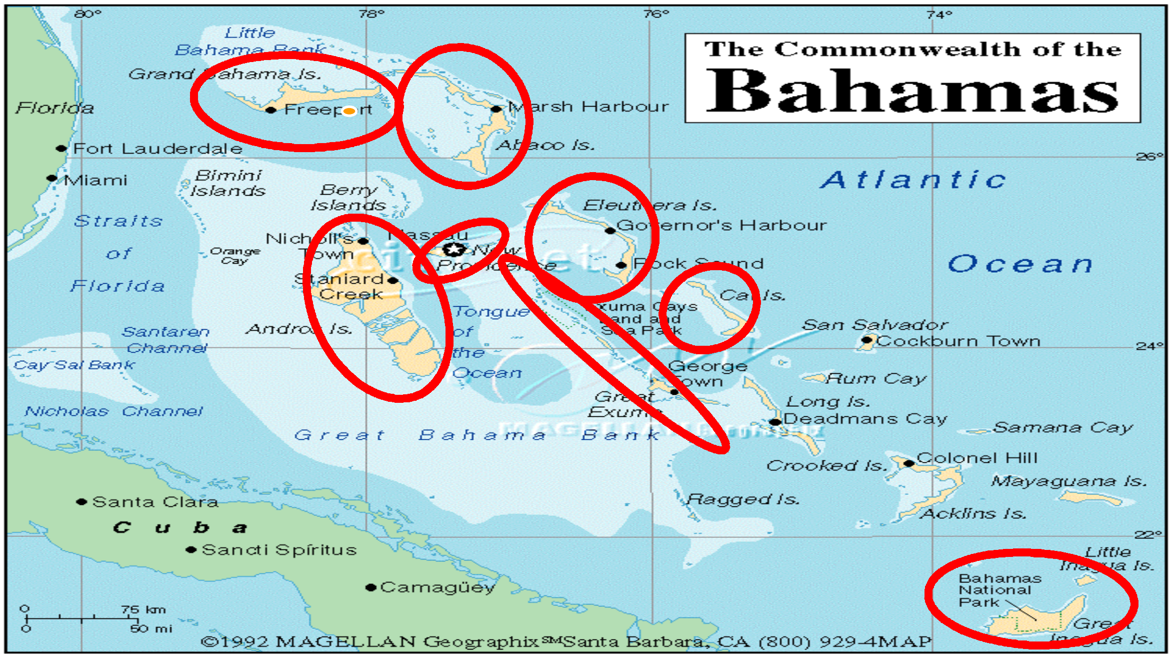


Figure 18: Recommended areas for detailed coastal studies and development of database.

4.4.1.1 Select Specific Islands for Detailed Wind, Wave, and Water Level Analyses (e.g., Grand Bahama, New Providence, Eleuthera, Cat Island)

Specific islands would be selected for the development of a coastal database, as prioritized by the GoB, based on existing stress on coastal resources, requirement for replacement of existing infrastructure or the construction of new infrastructure, population, and other factors.

4.4.1.2 Collect WIND Data for 'Normal,' 'Storm,' and 'Extreme' Events

Wind data for "normal," "storm," and extreme events (hurricanes and tropical depressions) will be collected and analyzed to develop a long-term (fifty plus years) wind database.

4.4.1.3 Generate Offshore Wave Conditions

Using the long-term wind statistics developed in Section 4.3 above, the offshore wave conditions will be developed for each island selected for detailed design. This will include hourly values of offshore wave height and hurricanes/storm waves covering a period adequate to develop long term wave statistics.

4.4.1.4 Generate Nearshore Water Levels for Entire Island Shoreline

Using the long-term wind statistics developed in Section 4.3 above, the nearshore water levels will be developed for each island selected for detailed design. This will include hourly values covering a period adequate to develop long-term water level statistics.

4.4.1.5 Undertake Frequency Analyses for Waves and Water Levels

The statistical assessment and related selection of a design level is particularly important. The level of protection needed for a coastal region is normally based on an assessment of the frequency of occurrence of both wave conditions and storm surge. As such, it is important to define the magnitude of the maximum wave heights and surge levels for each location as a function of return period. Selecting a design level (i.e., 1 in 20 years versus 1 in 50 years) has a significant influence on the capital cost of construction as well as potentially on repair and maintenance costs. For example, the selection of a higher return period will result in a more robust structure, but also the potential for significantly higher capital cost.

It is important to consider the likelihood of occurrence of these events. For example, a 1 in 20-year event has a 5% chance of occurring in any one year. Further, a 1 in 20-year event has a 65% probability of occurring in the next 20 years (star on Figure 19), whereas a 50-year event has a 34% probability of occurring in the next 20 years. The net outcome of the statistical analysis procedure is the definition of the magnitude of wave height and water level at the site of interest, as a function of return period.

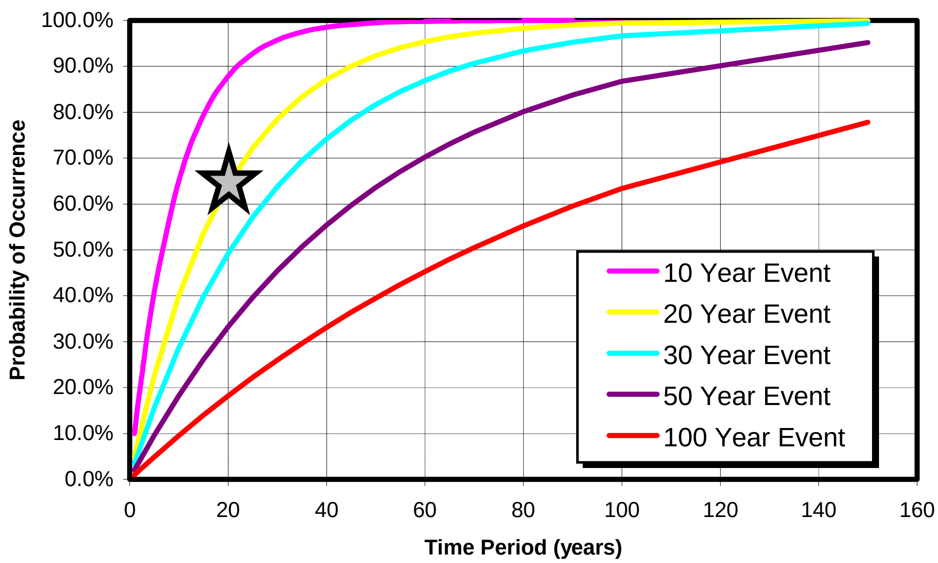


Figure 19: Frequency Analysis Example: Note that there is a **65%** chance that the 1 in 20-year storm will occur within 20 years

4.4.1.6 Calculate Nearshore Wave Conditions and Related Exposure Zones

A procedure is also required for developing a nearshore design wave height based on a variety of parameters. In some cases, the procedure will be very simple and not require any professional review. In other more exposed locations, the determination of the nearshore design wave height and procedure required to develop the value will require professional review. This whole process should be carefully established in advance in the design. Calculated wave height ultimately defines the cost and longevity of the structure in many coastal locations. The definition of the type of review required based on exposure is summarized in the graphic below.

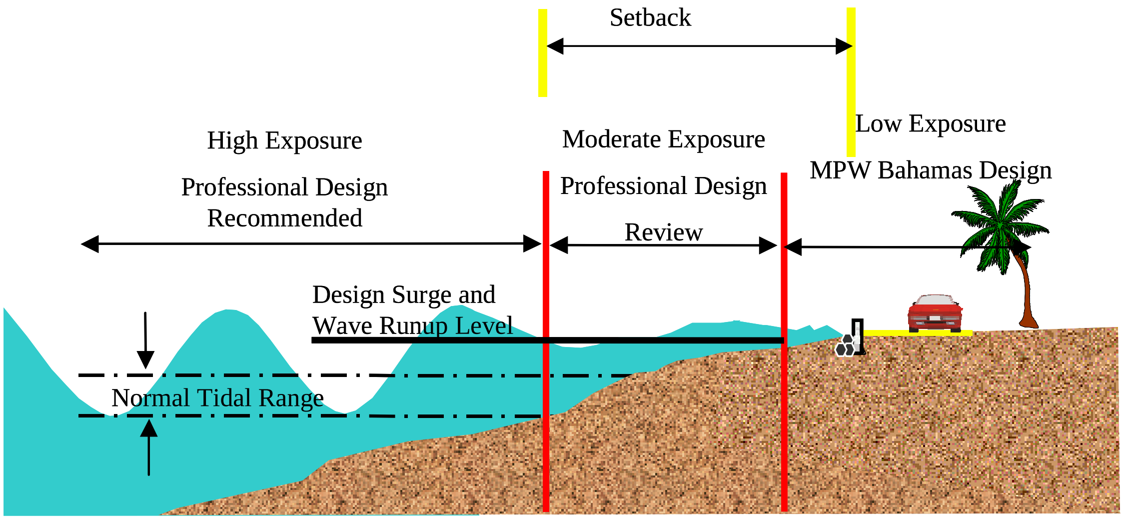


Figure 20: Determination of the nearshore design wave height and procedure required to develop the value requiring professional review.

A key step in the development of conceptual designs for any coastal structure is the definition of representative "exposure zones," considering factors such as design waves and water levels (considering shoreline orientation relative to typical storm tracks, sheltering effects, etc.), nearshore profile (water depth at structure and nearshore slope), erosion potential of nearshore profile, and subsurface conditions. Assuming that the design water level and offshore design wave heights are available, it is possible to determine the structural design wave height through the application of standard coastal engineering principles.

4.4.1.7 Characterize Shoreline Types and Develop Related Setback Recommendations By Shoreline Reach

A variety of shoreline types exist throughout The Bahamas including fine silt/sand materials, sandy beaches, and rocky shorelines. After you characterize the shoreline type and exposure to waves and water levels it is possible to establish setback recommendations based on quantifying and minimizing the risk of damage. The setback allowance will also vary depending on the type and value of the proposed development and acceptable level of risk.

Figure 21: Risk based shoreline setback lines

The proposed steps to develop appropriate setback recommendations are below.

1. Estimate flood and erosion hazard setback recommendations for reaches of shoreline with common characteristics related to wave and water level exposure and shoreline conditions.
2. Address protection of existing structures/buildings that fall within the setback recommendation requiring protection for these structures (i.e., piled foundation).
3. Incorporate setbacks in zoning policy and legislation.
4. Develop educational material describing why setbacks and building specifications are required.
5. Promote the setback concept with local insurance and real estate agents.

The final data set (design waves and water levels, setback line locations, etc.) could be stored in a GIS database. An example of setback lines taken from Elbow Cay and stored in a GIS database is shown in Figure 21.

4.4.2 Summary

The proposed approach to future development along the coastlines of The Bahamas outlined in this document will do the following:

- Assist in the preservation, enhancement, and restoration of beaches
- Minimize hazards of flooding and erosion
- Result in a coastal design information database, accessible to the public
- Minimize investment in coastal structures and optimize performance
- Allow the unique characteristics of each site to be taken into account
- Simplify the design process and allow the use of standard pre-approved MoWT designs in many cases
- Make the permitting and review process consistent between projects

In order to achieve these objectives the following recommendations are suggested.

1. Develop deepwater and nearshore information on DESIGN WAVES AND WATER LEVELS for key islands.
2. Define NEARSHORE CHARACTERISTICS including profile, beach, and dune characteristics. Site-specific characteristics may need to be incorporated in many cases depending on the shoreline exposure, type, sensitivity, and other factors. This would be the project proponent's responsibility.
3. Develop a MONITORING program consisting of satellite or aerial images. nearshore beach profiles, wave and water level gages (a portion of this exists).
4. Develop a WATER QUALITY standards and monitoring program (essential to the long-term health of the offshore reefs).
5. Establish SETBACK recommendations and requirements including the related legislation, policy, and educational materials.
6. Develop a comprehensive COASTAL DATA BASE for the selected islands accessible to the public.

This entire process will result in a comprehensive GIS-based coastal database for The Bahamas, including all of the key islands and many surrounding islands. The design wave, design water level, frequency of each event, shoreline types, related setback recommendations, and coastal resources would be input into a GIS database so that it could be readily accessed. As each project is submitted for review, the GoB could either sell this design data or simply use it to review the values used in each submission. The information would also be extremely valuable for the design or reconstruction of public coastal infrastructure.

4.5 Introduction to Design and Approach to Construction in the Coastal Zone of The Bahamas

The design and construction of coastal structures in The Bahamas requires consideration of many factors. Some of these are standard coastal design and construction issues and others relate specifically to The Bahamas. It is important to take all into account including the variation that occurs throughout The Bahamas. For example, the availability and cost of materials and construction equipment varies widely throughout the islands. The exposure and type of shorelines covers an incredibly wide range of situations. The scale of the project (size of pier, draft of access channel, etc.) varies widely from one situation to another. All of these factors and many more must be taken into account when selecting a design for a specific coastal structure.

As mentioned previously, consideration of the design wave height, design water level, and frequency of events are critical inputs to the design selection. In many cases, it is simply unreasonable to design facilities such that they do not flood during hurricane events. In order to avoid flooding entirely, the capital cost of the structure would be excessive and rarely utilized. By determining the design water level and design wave height in advance, it is possible to select a roadway elevation and slope protection that will survive exposure to a hurricane and flood for a brief period, yet cost a fraction of the no-flood alternative. Using a coastal roadway as an example, the challenge is to design the roadway to be stable under all conditions (average storms and hurricanes), yet only flood briefly during hurricane events. This approach results in a lower structure, requiring less slope protection and a much lower overall cost. Relative performance is almost identical, as the structures in most cases will only be exposed to hurricane wave and flooding conditions for a matter of hours once every few years or less. Designing to these standards can only be accomplished with an advanced detailed knowledge of the design wave, water levels and their frequency of occurrence.

Similar approaches also apply to piers and other coastal structures. For example, it is often more cost-effective to design piers to “tear away” during a hurricane event. In this case the decking is designed to withstand "regular" high tides and storm conditions, but it is also designed with decking sections that will separate from the main supporting infrastructure (piles and pile caps) during a hurricane event. This typically represents the most cost-effective approach by reducing the initial capital investment and minimizing the cost of repairs following a hurricane.

It is also very important to have an appreciation of The Bahamian-specific issues relating to each project. This may include the availability of construction equipment, access for construction equipment (what size/type can access the site), land versus marine-based construction and so on. The availability of materials for shore protection and construction is also an important consideration that frequently impacts the selection of a final design.

In summary, it is important to have an appreciation of coastal specific construction issues (i.e., the likelihood of exposure to storms during construction, construction access--marine or land based), as well as Bahamian-specific issues such as available equipment, import duties, available materials, and so on.

5.0 STRATEGY FOR THE BAHAMAS NATIONAL COASTAL ZONE MANAGEMENT PROGRAM

The Bahamas geography, with over 700 islands and thousands of miles of shoreline, suggests the need for comprehensive coastal zone management structures. The Bahamas occupies an area approximating the distance between Puerto Rico and Trinidad and Tobago and provides an excellent illustration of the requirement for environmental control that distinguishes between marine, coastal, and terrestrial management. The Bahamas possesses the longest coastline of all Commonwealth Caribbean states. It also boasts of at least one individual island (Andros) that is larger than some Commonwealth Caribbean island States (e.g., Barbados, St. Kitts, and Nevis).

5.1 A Vision for ICM in The Bahamas

The Bahamas would benefit from a national program and plan that provides a “blueprint” toward achieving national objectives for long-term sustainability of the coastal environment. ICM planning can serve as the springboard from which appropriate planning, management, and investment interventions could be implemented at the national, island (cay), and local levels. Nowhere is this more warranted than in The Bahamas coastal zone, which essentially encompasses the entire country of 5,000 square miles of land, spread across 700 islands.

The concept of sustainable development (embraced by The Bahamas) implies environmentally sound and economically productive planning for the long-term to ensure benefits to future generations. Three basic principles uphold an approach to sustainable coastal development:

1. The people whose lives are affected by development programs must be involved in the design and implementation of coastal resource management interventions.
2. Management of the coastal zone will involve many government ministries and agencies, requiring teamwork, consultation, cooperation, and coordination between and among them.
3. Sustainable use of coastal resources requires combining traditional systems, institutions, and approaches with new technologies for planning and management.

One important linking element for all activities, assessments, and products of ICM studies is information management and communication. The use of Geographic Information Systems (GIS), Global Positioning systems (GPS), and remote sensing, along with the practical application of these tools and environmental and economic analyses are key aspects of ICM planning.

Experiences in coastal zone management throughout the world suggest the need for an integrated, multi- and inter-disciplinary and multi-sectoral approach in planning actions to alleviate and preempt coastal problems and issues. This Inter-American Development Bank (IDB)-funded environmental management activity is expected to contribute to this end significantly.

5.2 Definition of Coastal Zone

In The Bahamas, no codified regulations or definition of the coastal zone exists. Application of coastal zone-related legislation relies upon common law understandings. Terms such as "beaches," "coastline," "sand dunes," and "seashore" are commonplace in Bahamian legislation. However, there has been no attempt at comprehensive definition of the concepts of "coastal zone," "coastal areas," or "coastal resources."

Figure 22: Typical and diverse coastal areas throughout The Bahamas

5.3 Components of a National Integrated Coastal Management Program

The following description of the components of a national ICM program is based on the varied experiences of the Team members over the last thirty years in coastal zone management and environmental management projects. While each project is unique, the basic principles remain the same.

The following list describes the essential components of a national ICM program. These components also apply whether dealing with a small coastal region within a country or planning and managing the entire coastal zone of a country. If any of these components is missing or incomplete, the overall ICM program or plan may suffer.

A national ICM program includes the following components, which are described in Sections 5.3.1 through 5.3.8.

- Policies and Goals
- Institutional Arrangements
- Legislation and Regulations
- ICM Plan Formulation
- ICM Plan Implementation
- Professional Staff Training
- Public Education
- Monitoring and Enforcement

5.3.1 Policies and Goals

This group of activities may include the following items.

(1) ICM Plans and Guidelines
This includes the development of a national policies and guidelines for land use planning in the coastal zone to include satellite imagery and GIS map based inventory.

(2) Permit Review/Approval Process
This provides for national and local coordination and assessment of all major developments in the coastal zone and assures that the permits issued are consistent with established ICM plans and guidelines.

(3) Code of Construction in the Coastal Zone
This includes preparation of a Code of Practice for construction in the coastal zone with respect to coastal setbacks, construction techniques, and construction in flood prone areas.

(4) Preparation of Development Guidelines and Agreements
This includes the preparation of general policies geared towards the conservation and management of coastal and marine resources. In addition, guidelines regarding coastal setback limits, coastal erosion prevention, building heights, site coverage, architectural restoration, rehabilitation and new construction, and site plan control. Agreements will ensure that the guidelines are formally included in all development agreements with the private sector to be executed in the country.

(5) User Charges
This activity would allow for tourist hotels to pay local institutions responsible for environmental protection to ensure that development is sustainable and biodiversity assets of the coastal region are protected.

5.3.2 Legislation and Regulations

This component includes the creation/completion of national laws and/or specific ICM regulations in The Bahamas, plus specific coastal development regulations in the coastal communities. The IDB funded project will begin to address many of the legislative and regulatory issues through the development of the country's environmental laws and regulations, many specifically pertaining the coastal areas, and the establishment of a national ministry for the environment.

5.3.3 Institutional Arrangements

This group of activities could include any of the following items.

(1) Establish/Enhance the Coastal Zone Management Authority
The authority will be responsible for planning and management in the coastal zone of each island or by each town council. It will manage and guide the preparation of plans and channel the available resources for biodiversity conservation, sustainable coastal development, and institutional strengthening.

(2) ICM Coordination
This provides for the national and local multi-sectoral and inter-sectoral coordination, planning (steering committee, working groups, coordination meetings, scoping meetings, public hearings, coordination among national and local councils), and inputs into the review and approvals process.

(3) Management Studies
These include a series of ICM management studies to support institutional decision-making, such as sustainable coastal tourism marketing strategy and marketing plan, "user-pay" system for infrastructure related to new tourist facilities, "user-rights" for fisheries, and economic incentives to phase out negative activities. Preparations of specific Environmental Management Plans (EMPs) are examples of these types of studies.

(4) Local Group Organization
This activity supports the local NGOs, interest groups, small-scale resource users, and others to participate actively in the ICM planning and management process.

NGOs play an important role in regulation and management of coastal assets but (with exception to The Bahamas National Trust) no general legislation exists to facilitate their emergence, operation, and participation in The Bahamas.

The BNT was given statutory recognition by the *Bahamas National Trust Act*, *1959* and functions to promote permanent preservation of lands and marine areas of beauty and national historical interest. The Trust is obligated to preserve the natural aspects, features, and animal, plant, and marine life found in these areas.

5.3.4 ICM Plan Formulation

(1) Finalize ICM Plan
Work should be undertaken on the preparation of a series of plans both at the national level and at the island level, based on the framework jointly developed by the national team and the local communities. The plan may include the following components: flood prone zone mapping, coastal protected areas management plans, biodiversity management plans, sustainable tourism development plans, emergency preparedness, sea level rise, and response plans for hurricanes, oil spills, etc.
.

(2) Establish Coastal Development Guidelines
A set of national guidelines for coastal development or a "Code of Practice" for construction in the coastal zone should be prepared. This common Code for coastal development will be important for all to understand. Of course, there may be variations based on the specific needs of each island.

(3) Maintain Information Management and GIS System
Information collection, storage, and manipulation are fundamental elements in a successful ICM program.

5.3.5 ICM Plan Implementation

Capital investments for implementing ICM plans may include facilities that will protect and enhance biodiversity protection and achieve sustainable tourism development, fisheries management, etc. These investments are usually prepared as part of a comprehensive ICM planning process.

5.3.6 Professional Staff Training

This component might involve any of the following items:

(1) Profession ICM Planning Training
This will incorporate training of national and local experts in Environmental Planning, Environmental Impact Assessment (EIA) techniques, application of GIS technology, remote sensing analysis, site planning and design, implementation of ICM plans and projects, reviewing development proposals, participating in the review and approvals process, and participation in the inspection, monitoring, and evaluation process.

(2) Sustainable Tourism and Protected Areas Training
General training in reviewing and evaluating tourism development proposals, as well as more specific training for management of coastal and marine protected areas and training in understanding coastal geomorphological process and how the coastal zone responds to major storm events. This could include participation in international workshops, training sessions, in situ, and international study tours.

(3) Water Quality Monitoring Training
Training of management and technical staff in sampling techniques for water quality monitoring. This could include training in Quality Control/Quality Assurance (QA/QC) methodology. Training should be offered to all agencies conducting water quality monitoring. Standardization of monitoring techniques and QA/QC practices will allow for the exchange of water quality data among agencies and jurisdictions.

5.3.7 Public Education

This component involves local implementation of a national program for public awareness and education regarding sustainable use and management of coastal and marine resources. Participation in environmental awareness programs will enable coastal communities' full participation in the national program. This may include all kinds public outreach programs such as training of NGOs, local communities, and school programs carrying out demonstration projects in coastal areas.

5.3.8 Monitoring and Enforcement

This activity could include the following items:

(1) Enforcement and Monitoring
This activity covers municipal and tourist facility waste discharge; port, marina, and anchorage discharges; and industrial discharges. This will require the necessary equipment such as vehicles, boats, computer equipment (hardware and software), and sampling and analysis equipment.

(2) Information Management
This includes establishment of an environmental information system for ICM planning and other information requirements (information dissemination, reporting).

(3) Environmental Audits
Where there was some concern about data gaps or the availability of information in areas critical to investment decisions, audits may be recommended.

5.4 Bahamas Integrated Coastal Planning Strategy

Introduction

The Bahamas is now experiencing significant private investment and has been experiencing substantial growth led by private investment in sectors such as tourism, construction, and banking. Dramatic improvement in public investment efficiency and regional integration among all sectors is critical for an efficient and a coherent development strategy, led by the private sector in The Bahamas and approved by the public sector and the stakeholders (the public). It is difficult for local people, the GoB, and other stakeholders to make decisions on the "best use" of their islands without the benefit of a comprehensive, long-term, strategic plan for the management of their islands that considers all the options in a cross-sectoral and integrated manner.

In The Bahamas, regional planning and public investment programming are currently carried out in an ad hoc manner. An Integrated Coastal Management plan, as described in Section 5.3, would enable the GoB and donors (Inter-American Development Bank, Caribbean Development Bank, Overseas Development Agency) opportunities to finance Public Investment Projects, with the ICM plan supporting and enhancing the proposed private sector investments such as the tourism resorts.

One of the main tactical objectives of the ICM planning is to strengthen The Bahamas public sector's ability to deliver quality products and services and create a business environment that enables the private sector to thrive. This ICM project will begin to contribute towards the achievement of this objective by identifying the appropriate ways and means to account for the views of key regional and local stakeholders. In particular, those in the private/non-governmental sectors must be involved in the decision-making process for establishing regional and local development policies and investment priorities.

5.4.1 National and Regional Economic Development Strategies

The concept underpinning ICM planning is that regional and local economic growth and development led by the private sector investment is critical to long-term growth and development in The Bahamas. In order for planned economic growth to materialize, a coherent decision-making process for near-term public investment (energy, water supply and treatment, sewage and solid waste, roads, bridges, airports, communications, schools, and hospitals) must be established. The process should be based on a strategic, cross-sectoral plan that supports and guides the future private sector efforts. Building public-private partnerships in support of regional and local priorities derived from the ICM planning will be instrumental in promoting more sustainable development of the country as a whole.

In regional ICM plans with multiple stakeholders, the financing plan for core economic infrastructure and community facilities--roads, water and sewer systems, parks, schools, and fire stations--provides the regional economic framework that is needed to determine a financially feasible scale and mix of core and support industries, level of community amenities, and timing of improvements.

This ICM planning implementation process evaluates regional economic assets, and performs a quantitative industrial cluster analysis, and evaluates market trends as a basis for comprehensive planning and facility (infrastructure and utilities) programming efforts. ICM planning integrates an understanding of infrastructure and market forces on regional, national, and local levels to assure that outcomes have broad, long-term relevance.

Creating a more conducive business environment in The Bahamas requires better quality and more productive public investment, in particular, better public investment coordination, better spatial planning, enhanced synergy with private sector investment, and a decentralized and cross-sectoral decision-making process for preparing the public investment projects within the islands.

5.4.2 The Role of Integrated Coastal Management Planning

Privatization strategies for public sector infrastructure and utilities and other innovative means of facilitating public-private partnerships can only be achieved through a dramatic change in The Bahamas' regional planning and local investment programming process, which ICM planning is designed to initiate. To facilitate this evolution, it is key to integrate information management tools--remote sensing technologies and geographic information systems (GIS)--in to the strategic regional planning processes for the islands or "economic region." The ability of such tools is expected to enhance the key regional stakeholders' knowledge and understanding of major regional issues, thus leading to sound regional planning and investment programming and reducing the risk for private investment projects.

This ICM process will assist private investors in promoting their projects within the regional environmental and economic frameworks and obtaining agreement prior to large investments by assuring the project is consistent with the overall ICM strategic plan for The Bahamas and accepted by the public sector and stakeholders.

Traditionally, the coastal resources of The Bahamas, as in most places, have been developed in a sectoral manner with little regard to the inherently integrated nature of coastal and marine ecosystems. Coastal zones have usually only been managed around political/administrative/family boundaries rather than environmental units, which often results in overlapping jurisdictions and responsibilities. Finally, sectoral approaches often focus on short-term rewards without taking in to account the long-term costs of resource depletion. If The Bahamas maintains a status quo of ad hoc and sectoral environmental management and investment strategies, the result will be further decline in environmental quality and functioning, an increase in conflicts among the users of the coastal zone, and diminishing resources available to those users.

5.4.3 An Integrated Coastal Management Strategy for The Bahamas

While there are numerous reasons why The Bahamas needs an ICM strategy, the two most important reasons are the following. The coastal region of The Bahamas, compared to the other parts of the country, is the most important and economically most valuable from both development and environmental points of view. The initiation of an ICM plan represents powerful tools for securing the rational use of the natural resources, protection of biodiversity, and the creation of the institutional foundation for the formulation and implementation of an appropriate development strategy based on the concept of sustainable development.

Basic ICM principles will facilitate the integration of sectoral interests, productive coordination of responsible GoB institutions, resource use compatibility, and equity of values among different users. Given the important role of The Bahamas' coastal and marine habitats, biodiversity and environmental considerations should be considered first and from there determine what level of development an area can sustain. It is essential that downstream or indirect impacts, as well as the impacts of adjacent activities, be accounted for. Criteria for the establishment of "environmentally sensitive areas" should be conducted first and from this allocation of different ranges of protected areas.

As mentioned above, tourism is increasingly recognized as an important source of foreign exchange for The Bahamas. Given the relatively good health of The Bahamas' natural environments, environmentally based tourism that is sensitive to coastal and marine habitats and enhances their quality is the most compatible development option. Linking "high-end" tourism with nature conservation, through the establishment of protected areas, provides an incentive for environmental standards for facilities and ensures that large areas of nature are protected. The ICM planning and initial planning stages focus resources into assessing which level and type of organizational responsibility, coordination, and implementation is most suitable to the particular places and activities.

One result of the ICM planning is the development of a priority plan for Coastal Investment Projects (CIPs). The identification and selection of CIPs, cost estimates, and the recognition of possible benefits are the result of a process that has five steps.

5.4.4 Elements of an ICM Planning Framework

A general description of the five steps of the ICM formulation and implementation leading to CIPs is described below.

Step one or "<u>scoping</u>" is the identification of priority CIPs by a Steering Committee.

Step two is the establishment of a <u>Management Area Classification System</u>. Its purpose is to classify marine, terrestrial, and wetland biographic units into general management areas to reflect short- and long-term management interventions required for investment projects.

Step three is the preparation of the <u>Integrated Conceptual Management Plan for Priority Coastal Investment Projects</u>. This step more specifically establishes the purpose, objectives, and components for each management category. The "biogeographic footprints" of each management area make the spatial definition of the management category and the investment projects coincide. This process also evaluates the regional economic assets and liabilities through a quantitative industrial cluster analysis. This comprehensive planning effort will ensure the region can competitively supply for the market demand of goods and services. Regional planning integrates an understanding of market forces on regional, national, and local levels to assure that ICM findings have broad, long-term relevance.

Step four is the preparation of a Preliminary Master Plan for Each of the Coastal Investment Projects including sub-project components. Preliminary master plans are based on the management plans and further detail project components for each investment projects mentioned above. The plan establishes an organization and pattern of land use, transportation, and core and indirect service industries.

Step five is the Identification of Potential Investment Options and Preliminary Assessment of the CIPs Costs and Probable Benefits based on the analysis of the detailed project components identified in the preliminary master plans. The project costs consider those investments that could be financed from public sources but do not include the commercial developments (e.g., tourism projects) which would be financed from private sources.

5.5 ICM Planning for Climate Change and Sea Level Rise

ICM planning would also afford the GoB a framework to begin to consider futuristic coastal issues that do not necessitate immediate action but need to be included in long-term planning. One key issue of concern is climate change and the resulting impacts of sea level rise on the coastal zone of The Bahamas. A set of national guidelines for coastal development or a "Code of Practice" for construction in the coastal zone to include futuristic planning for climate change and sea level rise should be included in the ICM plan. Planning for sea level rise includes the following fundamental concepts:

- Protect: reduce the risk of the event by decreasing its probability of occurrence
- Retreat: reduce the risk of the event by limiting its potential effects
- Accommodate: increase society's ability to cope with the effects of the event while considering the variations based on the specific divergence among each island.

5.5.1 Establishing Economic Incentives for Climate Change Initiatives

ICM programs typically seek to establish strong economic benefits to all stakeholders because experience has shown that economic benefits are the strongest incentives to motivate behavior change. However, there are few direct or immediate economic incentives for coastal planning today for the possibility of sea level rise tomorrow. To overcome this barrier, effective ICM planning should focus on indirect economic benefits, such as overcoming disincentives to sea level rise that would inhibit or prevent the use of mitigation/adaptation measures to reduce the impacts of climate change on coastal communities (such as "investments in hazardous zones, inappropriate coastal-defense schemes, sand or coal mining, and coastal habitat conversions). A common cause for avoiding long-term planning issues (climate change and sea level rise) is a lack of available information on the potential external effects of proposed coastal developments on other economic sectors, or a lack of consideration thereof. Therefore, more proactive and integrated planning and management for coastal zones is widely suggested as an effective mechanism for strengthening long-term, sustainable development that can be both environmentally sound and economically efficient.

Another benefit is that ICM planning will address more than climate issues alone and will involve a change in adaptation strategies, i.e., nourishing beaches instead of constructing seawalls, or introducing a building setback instead of allowing construction next to the coast.

In the future, the GoB could more effectively utilize market drivers to their advantage by building collaborative efforts with other public sector authorities. For example, a strong collaborative agreement with the Water and Sewerage Corporation, BELTELCO, and Cable Bahamas could allow for expedited permitting for geographic areas that are willing to implement one or several climate change mitigation/adaptation measures specifically targeted for coastal communities.

5.5.2 Overcoming Institutional Barriers to Managing Sea Level Rise

Critical to a climate change program success is that it overcomes institutional barriers that impede the adaptation of common sense, best management practices in the coastal zone. Having a keen understanding of what factors drive the target audience and influence behavior will help determine the barriers that the GoB face in implementing the desired ICM strategies. Additionally, strong background in and knowledge of the new technologies, industry practices, and opportunities are also important to understanding stakeholders' motivation and barriers.

5.5.3 Define Tangible ICM Climate Change and Sea Level Rise Program Goals

Climate Change planning should be undertaken during the ICM Implementation phase focused on the preparation of a series of plans both at the national level and at the island level based on the framework jointly developed by GoB, the national Climate Change Steering Committee, and the local communities.

A successful ICM program will clearly define a set of program goals that offer tangible benefits to society by planning now to avoid areas prone to future sea level rise. Secondary benefits should also be addressed through communicating public awareness and increase public buy-in by demonstrating the value of this long-term environmental stewardship. Furthermore, a climate change program should be relayed in simple, focused messages that clearly state the problem, the proposed solution, and the outcome. The messages should consist of easy to understand language to facilitate comprehension among both experts and lay-people.

The plan may include the following components.

- Increase the area where wetlands and beaches, through protection and restoration, will survive rising sea level and decrease the future costs of sea level rise defenses by: (a) prompting the central GoB and Local Town Councils to start to decide now which areas will be protected from the rising sea and which areas will retain wetlands and beaches, (b) prompting the GoB and Local Town Councils to consider how they might increase the area of natural shores where community plans imply too-little protection, and (c) prompting incentives for development and construction interests to look for opportunities to gain “credit” for efforts that allow wetlands and beaches to survive rising sea level.

- Decrease the cost of sea level rise in areas likely to be abandoned to a rising sea by: (a) encouraging timely signals to the tourism market so that private investors do not over invest, (b) encourage private and public purchase of rolling easements, and (c) prompt development and infrastructure to take place consistent with this long-term ICM plan.

- Decrease the cost of sea level rise in areas likely to be protected by: (a) prompting communities to decide whether to replenish beaches, use dikes/seawalls and pumping or elevate land surfaces and (b) prompting development and infrastructure improvements to take place consistent with this long-term ICM plan.

- Increase environmental functioning and quality in areas likely to be protected by promoting measures that retain natural wetlands, beaches, and public access along the shore.

- Promote county/local climate outreach projects (e.g., school curricula, demonstration awareness, and arts).

5.6 Recommendations

The following strategy is suggested to initiate the national ICM program over the short-term.

5.6.1 Case Study for a selected Bahamian island focusing on flood prone areas and “no development zones: integrating the coastal engineering principles and analytical models described in Section Four and the Integrated Coastal Planning Principles described in Section Five.

5.6.2 Apply ICM and EIA planning principles to the review of the New Providence Road Improvement Project.

5.6.3 Establish a national coastal GIS database by engaging, collaborating, and gaining cooperation of all relevant ministries, NGOs, and international organizations (IMO). The database will contain critical coastal information that is readily available and will be useful for planning and review purposes (e.g., EIA). Examples of the data follow.

- Areas vulnerable to flooding (flood prone zones) based on past series of storms. This information is essential for the national Emergency Response group, for Physical Planning to determine “no build zones” because of potential flooding.
- Input national map series produced by ODA for the nation indicating land capability.
- Input national bathymetric maps and nautical charts as a foundation for establishing critical marine habitats.

- Determine if World Conservation Monitoring Center (WCMC) in Cambridge has a useful coral reef database of The Bahamas coral reef. If so, incorporate it.
- Digitize the existing and proposed terrestrial and marine protected areas available from the BNT.
- Digitize the existing and proposed fishery reserves proposed by the Department of Fisheries.
- Digitize and incorporate the national crown lands.
- Digitize and incorporate major shipping lanes for hazardous and petroleum products. This will serve as a foundation for preparing an oil spill contingency plan for vulnerable coastal areas.
- Digitize critical coastal and marine habitats such as mangroves, seagrass beds, sand beaches and dune systems, coral reefs, and areas of high coastal biodiversity.
- Work with the Ministry of Tourism to digitize major priorities for coastal and marine tourism.
- Digitize preferred cruising anchorages and dive sites.

5.6.4 Working with an interdisciplinary team of coastal geomorphologists, coastal engineers, and coastal planners, establish standard methodologies to prepare coastal hazard zones and setbacks based on the characteristics and dynamics of different coastal types, e.g., sandy beach and dune coasts, iron coasts, and mangrove coasts.

5.6.5 Working within a multi-agency team, prepare a handbook or a "Code of Practice" for construction in the coastal zone for wide distribution.

5.6.6 Undertake a comprehensive coastal zone management workshop, based on the upcoming ICM workshop and further field investigations and interviews. Based on the above, prepare an issues paper on coastal zone management in The Bahamas and further elaborate the strategy to achieve sustainable management of Bahamian coastal resources. Since ICM planning is the "resolution of issues in context," this issues paper will provide the foundation for the ICM strategy, plan, and investment program (Coastal Investment Program – [CIP]).

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