ABSTRACT

Title of Thesis: DESIGN WITH CLIMATE: A RETREAT FOR VIEQUES, PUERTO RICO

Sara Salazar Rellihan, Master of Architecture, 2003

Thesis Directed by: Professor Amy Gardner
School of Architecture

One of the main ideas this thesis pursues is the impact of climate on architecture. It involves the exploration of an architecture that is sensitive to the climatic particularities of its site and is able to create a passively comfortable environment for its inhabitants.

The focus of the thesis has been the design of a retreat on the island of Vieques, Puerto Rico. Of particular interest has been the study of 19th century plantation houses in Puerto Rico and their climatic adaptation to the region during a time when climate control mechanisms did not exist. The site is located on the former lands of the United States Navy, which, until May 2003, had occupied most of the island. Due largely to the presence of the Navy, much of Vieques has remained undeveloped. It is a "virgin" island with pristine beaches and a variety of flora and fauna that attract a fair number of tourists.

DESIGN WITH CLIMATE: A RETREAT FOR VIEQUES, PUERTO RICO

By

Sara Salazar Rellihan

Thesis submitted to the Faculty of the Graduate
School of the University of Maryland,
College Park in partial fulfillment of
the requirements for the degree of
Master of Architecture
2003

Advisory Committee:

Professor Amy Gardner, Chair
Professor Carl Bovill
Professor Richard Etlin

TABLE OF CONTENTS

LIST OF FIGURES

I. Introduction

The focus of this thesis has been to address climatic issues, with the goal of creating a series of buildings that are comfortable to their users and that have minimal impact on the surrounding environment. The thesis will consider precedents from a time when environmental control mechanisms did not exists and comfort was attained through simple architectonic means.

In light of the aforementioned goals, the thesis proposes a retreat for the island of Vieques, Puerto Rico. The site on Bahia de la Chiva or Blue Beach, is located within the former lands of the United States Navy, which occupied a large part of the island until May, 2003. Now part of a natural reserve under the jurisdiction of the U.S. Fish and Wildlife Service, Blue Beach is one of the most beautiful beaches on the southern coast of the island and boasts one of the best reef in the Caribbean. The retreat's design is to be sensitive to its surrounding environment, accommodating a relatively few number of guests seeking either ecological activities or simple relaxation on a Caribbean beach.

II. Design with Climate

The Comfort Zone and Bioclimatic Chart

Although subject to variation as well as opinion, the comfort zone for humans in the tropics as determined by C.E.P. Brooks and quoted in Olgyay (1963, p. 17) lies between 74° F and 85° F with relative humidity between 30% and 70%. The comfort zone asdefined by Olgyay, is the conditions under which man succeeds in arriving at "the point at which minimum expenditure of energy is needed to adjust himself to his environment"(1963, p. 14-15). Besides air temperature and humidity, other climatic factors that affect this comfort level are solar radiation and air movement (Olgyay 1963, p. 15). The bioclimatic chart below indicates the comfort zone for humans in relation to air temperature and relative humidity[1]. The processes by which the human body exchanges heat with its environment are radiation, conduction, convection, and evaporation (Olgyay 1963, p. 16).

[1] Relative humidity is defined as the ratio of the absolute humidity to the maximum water vapor capacity of the air at a given temperature. Absolute humidity is the weight of water vapor per unit volume of air (g/m^3).

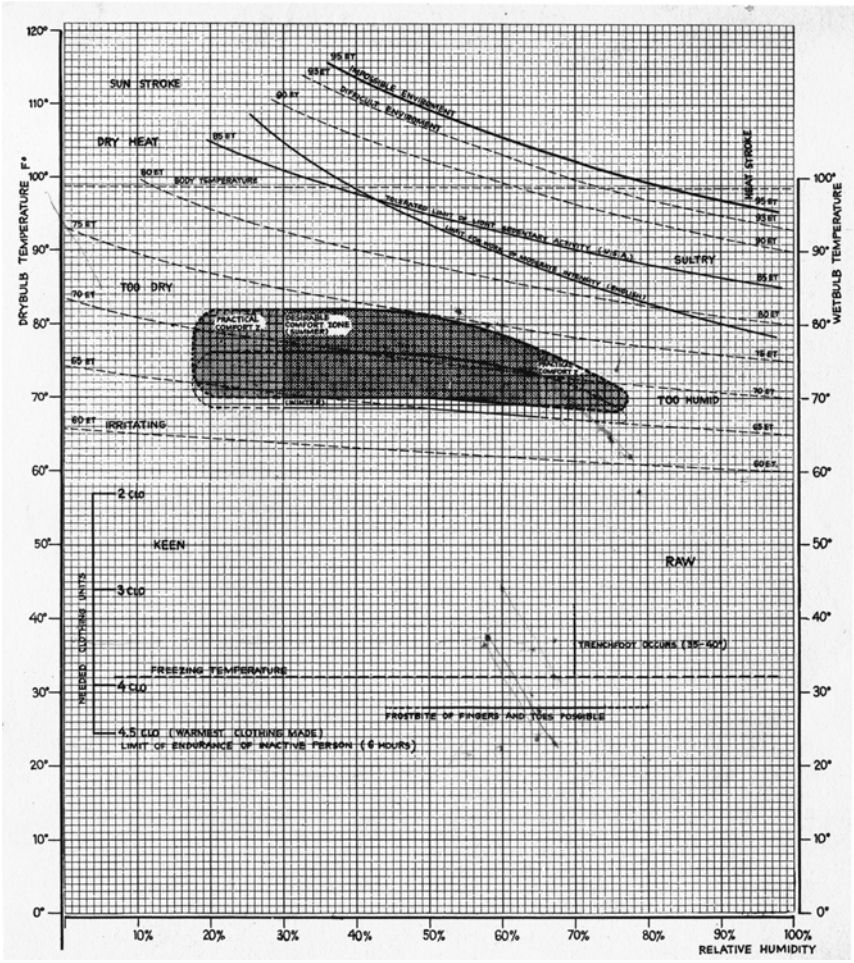

Fig. 1 Bioclimatic chart (Olgyay 1963, p. 19)
The comfort zone for humans is plotted against relative humidity and dry bulb. Extremes are also indicated. With an average temperature of 80º F, ranging from 76º F to 82º F, and a relative humidity of lies within this comfort zone but on the higher end of it. Ventilation and shading can aid in comfort level

Architectural Responses to a Tropical Climate

Fig 2. Caribbean Responses to Climate
(Caribbean Style 1985, p. 23).
Typical Caribbean features such as louvers, screening, jalousies & grills serve to both protect from the sun and allow ventilation

Although Caribbean architecture in general, and Puerto Rican and Vieques architecture in particular, have had numerous influences throughout their history, from pre Columbian to colonial to modern, the climate has been a constant to which each of these architectures has had to adapt, some more successfully than others The tropical temperatures are for the most part comfortable, which allows for many activities to occur out in the open. At the same time, however, the sun can be very intense. Short and sporadic but heavy rains are common. In addition, the danger of hurricanes and tropical storms always exists, requiring a much greater level of protection. Because temperatures outside are relatively

comfortable, most of the effort is spent in preventing the indoor temperature from rising above the outdoor temperature. In order to maintain appropriate comfort levels in the Caribbean, it is essential to reduce the impact of solar radiation and to promote proper ventilation.

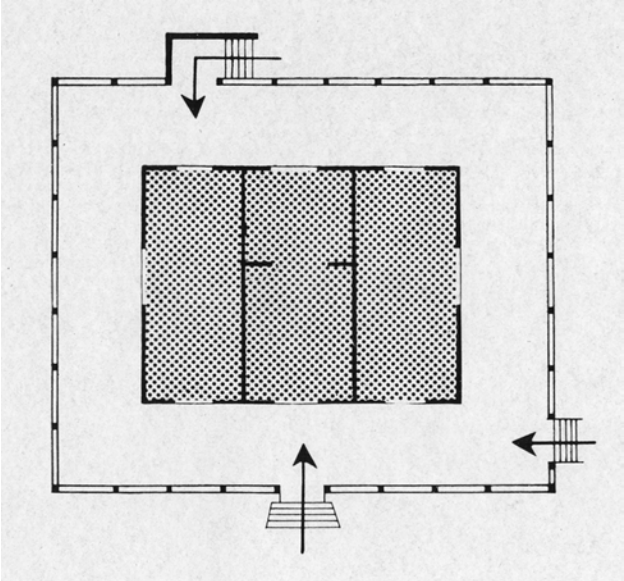

Fig 3. Plan, Typical European colonial house in tropics
Characteristic of these houses were surrounding verandahs leading to inner rooms which were kept cool through shading and which remained poorly lit because of the verandah. Verandahs were occasionally screened to control sunlight (Kureja 1978, p. 38).

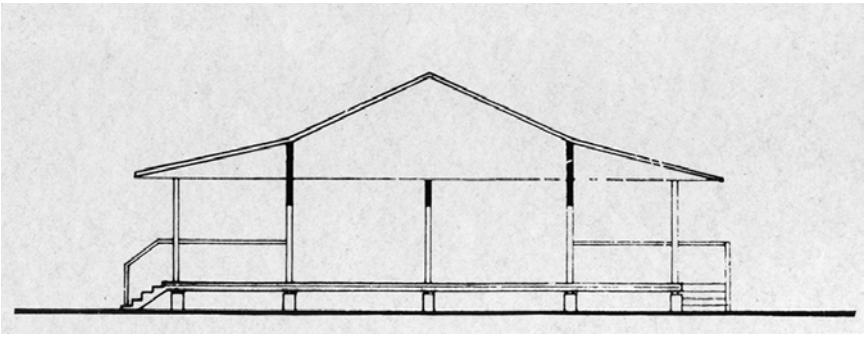

Fig 4. Section, Typical European colonial house in tropics (Kureja 1978, p. 38)

Reducing impact of solar radiation

Several architectural tactics can and have been used in the past in order to moderate the effects of the sun. Orientation of the main facades of a building should be north-south rather than east-west. In general, however, for a building with a light external color, properly shaded windows, and well-insulated walls, effects of orientation with respect to the sun are negligible (Givoni 1976, p. 230-1). Proper choice of materials is also important in order to reduce the amount of radiation that penetrates to the interior of a building. Materials with a low heat capacity[2] are most desirable in order to keep heat from accumulating during the daytime, which would radiate at night when wind speed tends to be the lowest (Givoni 1976, p. 355). Proper shading devices should be employed to both protect exterior walls and windows from direct solar impact and to maintain exterior areas cool. It is important to protect the southern exterior walls from the sun in order to diminish the amount of heat that radiates inside a building from solar exposure. Windows must also be shaded to avoid solar penetration within the building. Any exposed heavy glazing must occur on the northern side of the building to avoid direct sunlight. Reflective light colors are best for avoiding heating up of surfaces. Landscaping can be used to reduce effects of solar radiation. In contrast to most man-made surfaces, plant life tends to absorb heat rather

[2] The heat capacity is the amount of heat required to raise the temperature of a unit volume of material or a unit area of surface by one degree (Givoni, 1976, p. 112).

than radiate it, which helps to maintain cooler surroundings (Kureja 1978, p. 113). Strategic placement of trees can provide shade without blocking winds.

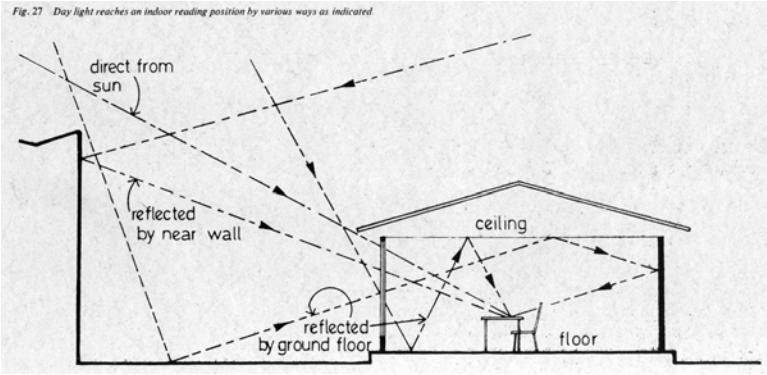

Fig. 5 Sun light Reflection Patterns
Day light penetrating the interior of a building is not only direct sunlight. Much of it is first reflected off of other surfaces in the exterior and the interior (Kureja 1978, p. 37). For this reason, it is important to consider the nature of landscaped and interior surfaces.

Promoting Ventilation

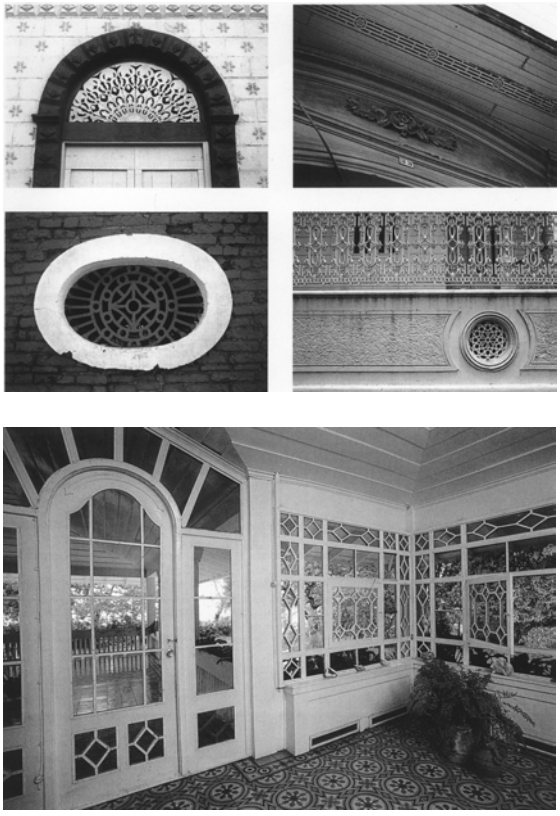

Fig. 6 Ventilation devices
Used in Spanish colonial houses in Puerto Rico, these grills and openings are also decorative.

Ventilation helps to evaporate sweat, which in turn helps to cool the body and prevent the discomfort of wet skin. Several factors allow for the best air movement. High elevations generally receive the best breezes. Orientation in relation to the prevailing winds rather than in relation to the sun is probably more important in warm-humid climates. Buildings should be orientated towards the wind or slightly offset (up to 45° angle) (Givoni 1976, p. 231). It is desirable to

maintain unobstructed airflow so exterior walls should have many large openings. Separating buildings from each other allows for utilization of air movements. Raising the building above the ground allows it to be cooler by locating the windows above vegetation that blocks any breezes and by allowing cooling from below (Givoni 1976, p. 353). Tall ceilings (Typical Spanish colonial houses in Puerto Rico have ceiling heights of 16') with vents at the top allow for warm air to rise and exit rooms and for cooler outside air to ventilate in the lower areas. Positioning of windows and other openings can promote or prevent proper ventilation.

Finally, landscaping can be used to control air movements.

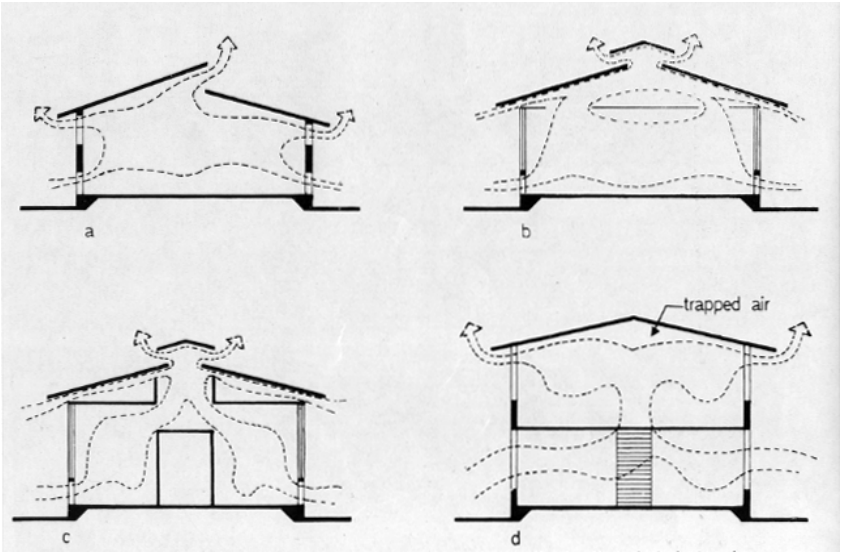

Fig. 7 Air flow patterns within a building
Patterns are dependant on the location of openings (Kureja 1978, p. 92).

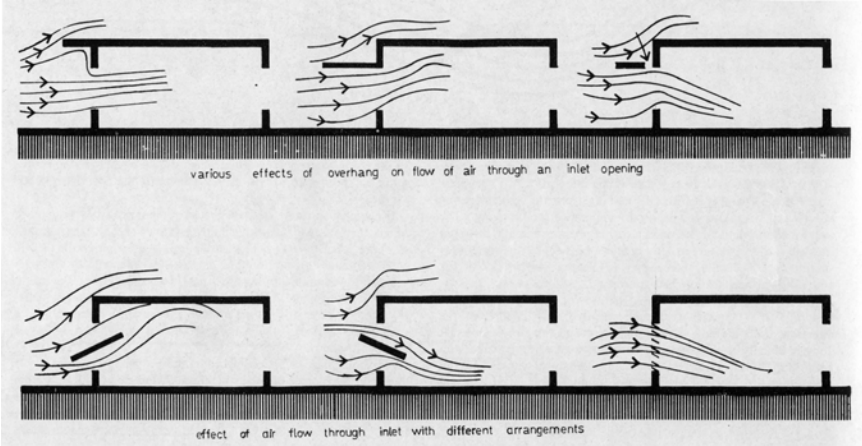

Fig.8 Air flow patterns
Diagrams show the effects that different overhang conditions (top) and different inlets (bottom) have on airflow into a building assuming a constant opening in the rear (Kureja 1978, p. 94).

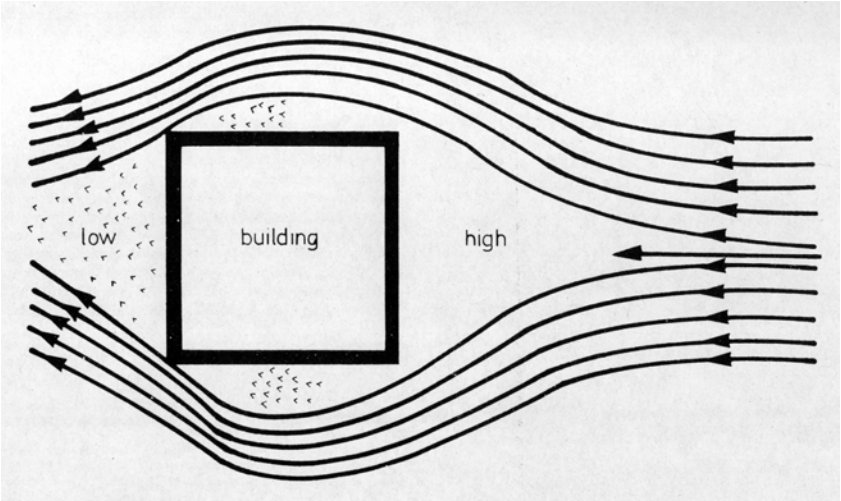

Fig. 9 Diagram, Wind flow around buildings
As the wind flows towards and past a building, it causes pressure differences which aid in ventilation. An area of high pressure is formed in front of the wall towards which the air is flowing. The opposite side, as well as the sides of the building, become areas of low pressure. Because of its low pressure, it helps to suck air out of the building, a very important part of establishing proper ventilation within a building (Kureja 1978, p. 93).

The Typical Rural "Jíbaro" Dwelling

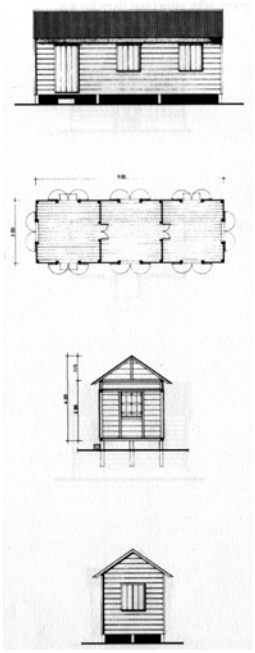

Fig. 10
Typical Puertorrican rural dwelling
The bldg. remains relatively cool by being raised above the warm ground and by allowing for cross ventilation by virtue of its plan and location of openings

The traditional rural dwelling of Puerto Rico is a wooden building with a pitched roof, raised above the ground, and consisting of 10' by 10' square units with openings on all sides at the center. Lifting the building off the ground allows for ventilation beneath the building, keeping it cooler than contact with the warm earth allows. The simplicity of the plan is important. Openings on either side of each unit allow for cross ventilation. Arranging the units enfilade also allows breezes to cross uninterrupted from one end of the building to the other. The pitched roof serves to shed the rains. Wooden shutters protect from heavy winds associated with tropical fronts and even hurricanes.

The Caribbean Sugar Plantation House

The architecture at the former Central Aguirre on the southern part of Puerto Rico is well adapted to the climate. The main house, which would have been the plantation owner's house, sits at the highest point on the site. Besides offering wide views of the entire property, this location captures the best breezes, keeping the house cool. The house is a two-story, American colonial building with a verandah running along the back. Upon entering the house one finds a long hall that connects to the verandah at the back of the house. This plan allows winds to pass through the entire house, maintaining it at a comfortable temperature.

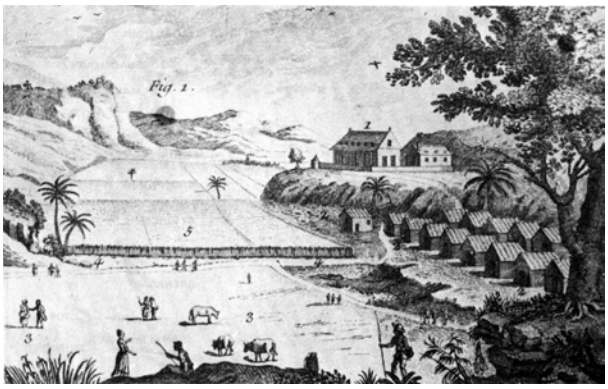

Fig. 11 Caribbean sugar plantation
The French print shows the main house (upper right) located at a high point (Buisseret 1980).

The more modest workers' houses are located down the hill from this main house. They are wooden buildings, raised above the ground on posts to allow for airflow, to separate the building from the warm earth, and to isolate it from insects. They have sloping roofs with openings that allow rising warm air to escape the building. They are double roofs, leaving a gap of air between the outer sloping portion and the flat interior

portion. Although this system creates an insulating barrier between the upper roof, which receives constant solar radiation and the inner ceiling, thereby making the building much cooler, this gap (which must be ventilated) inevitably becomes the home of vermin. The roofs extend beyond the mass of the house to form a screened porch that runs along the entire front end of the building and occasionally one of the sides. As much of the day as possible is spent in this comfortable outdoor room.

Fig. 12 Casa del Francés, Vieques, PR
The only existing plantation house in Vieques is the Casa del Frances, which was built by Don Gustavo Mouraille in 1911 on Central Puerto Real. It now serves as a guest house. It has a pitched roof with openings at the top, a verandah, surrounding the entire building, and many openings along the wall fixed with louvered shutters (Langhorne 1987, plates).

Fig. 13 Typical House of Sugar Plantation worker in Vieques
(Langhorne 1987, plates)

French influenced, the Maud'Huy house in Guadeloupe (1874) has features similar to the Casa del Francés in Vieques: the pitched roof with openings at the top, a verandah that runs along the perimeter of the building, a generous number of openings running to the ground with louvered shutters, etc. Its plan and sections show large interconnecting rooms to allow for maximum cross ventilation.

Fig. 14 Elevation, Le Maud'Huy, Guadeloupe (1873-4)
(Caribbean Style 1985, p. 286)
The façade shows large doors rather than windows all along its 4 very similar sides.

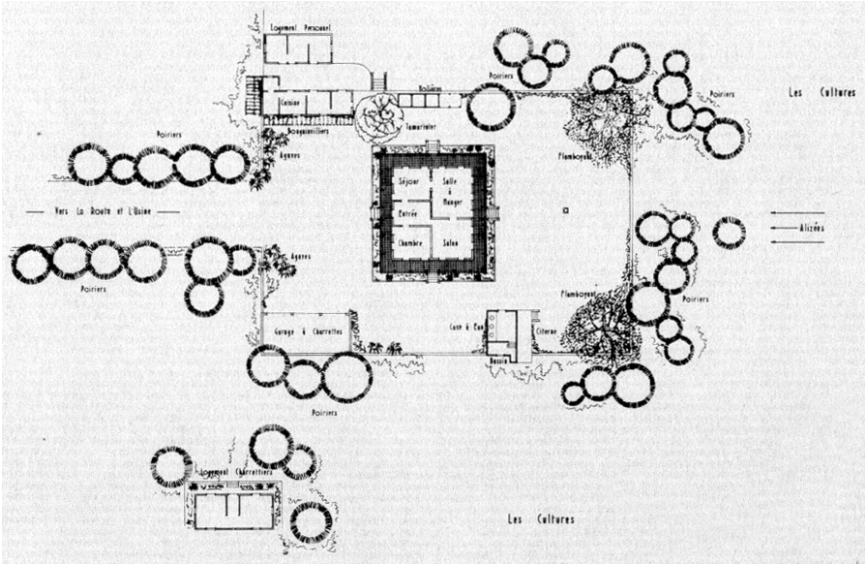

Fig. 15 Plan, Le Maud'Huy
(Caribbean Style 1985, p. 286)

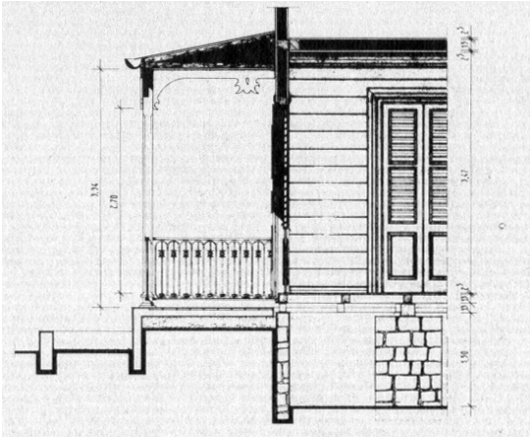

Fig. 16 Section detail, Le Maud'Huy
(Caribbean Style 1985, p. 286)
The porch runs along the entire perimeter of the house, effectively creating a well-ventilated outdoor area that is protected from sun and rain.

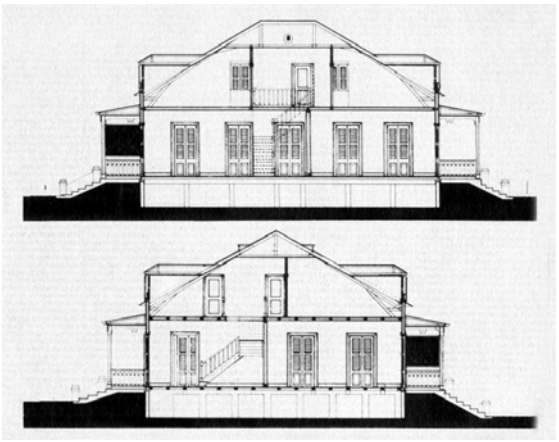

Fig. 17 Sections, Le Maud'Huy
(Caribbean Style 1985, p. 286)

III. Ecotourism and Sustainability

Ecotourism: History and Definition

What is known as nature tourism[3] probably began with the Sierra Club's Outing program in the early 1900's and has since grown rapidly. Unfortunately, this rise in the number of people interested in visiting remote, pristine places has also had adverse environmental effects on these areas, ironically rendering them less attractive to tourism.

In an effort to remedy this unfavorable situation, ecotourism began to take shape between the late 1970's and 1980's (Honey 1999, p. 11). Unlike nature tourism, which is solely defined by the recreation activities of the tourist, ecotourism is also concerned with the conservation of the environment as well as benefiting the people of the host country. In 1991, the Ecotourism Society defined ecotourism as "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (Honey 1999, p.6). It involves "minimization of environmental and cultural consequences," and "contributions to conservation and community projects in developing countries" (Honey 1999, p. 6). The island of Vieques offers many nature related activities. They include turtle watching, night visits to the bioluminescent bay, and snorkeling among the corals reefs. While the community is interested in encouraging tourism in order to improve the economic development, it is

---

Nature tourism is the "travel to pristine places, usually involving physical activity" (Honey 9).

also concerned about conserving the very natural resources that attract tourists in the first place. Therefore, it is important that any further development that occurs on the island will have minimal impact on the environment, particularly on the coasts and marine wildlife.

Energy and Water Sources

In order to achieve a minimal impact on the surrounding site's environment, it will be important to consider energy and water resources. Electricity and water are provided for the island of Vieques from the mainland. Although the site is fairly secluded from Isabel Segunda and Esperanza, it is close enough to provide the site with electricity and water from the mainland. Although this solution does contribute to pollution in the mainland, it would have minimal environmental impact on the actual site. Sewage treatment can be solved by using composting toilets, which would create fertilizer for any number of uses. Greywater from the kitchen, sinks and showers can be collected into a septic tank to separate oils and fats, which can also composted. The remaining effluent can be used for irrigation of an orchard and garden in a leaching field. The orchard and garden could be used to grow local fruits vegetables for consumption by guests.

Another solution for obtaining energy and possibly fresh water is what is known as OTEC (Ocean thermal energy conversion). This process takes advantage of the temperature difference between warm surface waters in tropical regions and that of cool deep waters. A liquid (either

ammonia or water depending on the type of cycle) running through a cycle is pressurized and heated by the warm surface water. This causes it to evaporate and turn a turbine, which produces electricity. Cool water is then used to return the fluid back to its liquid state.

This process is only possible in a few places in the world where a difference of at least 22º F exists between surface water and deep ocean water. Vieques is one of these places. Only about 3 miles off the coast of Bahía de la Chiva, the ocean floor drops dramatically about 2000 ft. Waters at this depth are cold enough to provide the temperature difference required to run the turbine efficiently. The method can also provide fresh water.[4] Although this method does not pollute, it is also still in its research stages, very expensive, and not very popularly known. (National Renewable Energy Laboratory, available on the world wide web at: http://www.nrel.gov/otec/what.html, June 2003).

If salt water is used as the circulating liquid in an open OTEC cycle, the evaporation will desalinate it.

IV. The Site

The Island of Vieques

Fig. 18 Map of Vieques (USGS) indicating the location of the main town, Isabel Segunda on the northern coast of the island and of Esperanza, a fishing village on the southern coast. The site for the resort at Bahia de la Chiva, also on the southern coast is currently accessible by dirt roads from the entrance into former Navy lands indicated on the map.

History

The history of the island of Vieques has been influenced by many different peoples beginning with the Taíno (Arawak) Indians which inhabited many of the Caribbean islands when the Spanish arrived to the New World. Although the Spanish claimed jurisdiction over the island, its seclusion from the main settlements in Puerto Rico made it difficult for the Spanish to prevent other settlers from populating Vieques. As a result, although they were periodically ousted, the French as well as the English and the Danish, inhabited Vieques. In fact, the first governor and true settler of Vieques, Le Guillou, although sanctioned by the Spanish crown,

was French. In an addition, slaves brought form Africa to work in the sugar plantations also formed part of the population. "…demographically Vieques remained (in 1862) a melting pot of nations and races" (Langhorne 1987, p. 34).

Among Le Guillou's contributions to the island in the early 19th century, were the introduction of sugar cane and the construction of two sugar mills. Sugar cane production accelerated, particularly in the first decades after the US invasion in 1898. In 1941, the United States Navy took much of the land that had once been used for sugar cane production. However, by the time these lands were expropriated, sugar production was essentially dead.

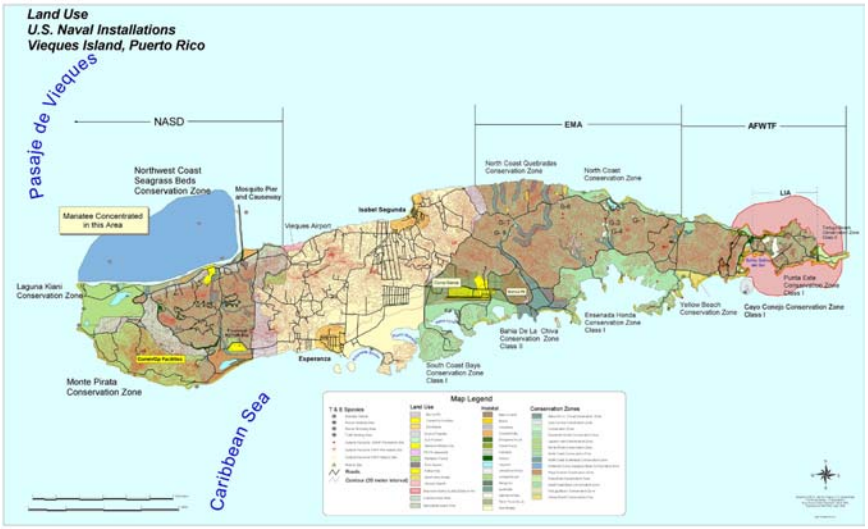

Fig. 19 Map of Vieques showing land distribution and use. Until May this year, the US Navy controlled most of the eastern part of the island as well as a large portion of the western part

The modern history of Vieques is marked by the presence of the Navy on the island. The 24, 762 acres of land (72.8% of total land area of

the island) that have been in the hands of the Navy for over 60 years have been used for different military practices. Due to this, much of the development of the island has been retarded. On the one hand, this has left untouched much of the land. There is only a small town, Isabela II on the northern coast and a small fishing village, Esperanza, on the South-west coast. The rest of the island is fairly uninhabited. At the same time, however, many of the lands held by the Navy have felt the effects of military exercises and pollution. The Navy has fueled part of the economy of the island, but industries such as tourism have not been able to flourish, despite the island's attractive beaches and other natural features.

The accidental death by Navy fire of a local Navy guard, has prompted the military to leave the island. On the 1st of May, 2003, all the lands owned by the Navy went into the hands of the US Fish and Wildlife Service, which will be in charge of their decontamination. A large part of these lands will be protected as a natural reserve including the site at Bahía de la Chiva.

The Future of Vieques

Once the Navy leaves Vieques, the question of the island's development will be the task at hand. The Comité Pro Rescate y Desarrollo de Vieques (Comitee for rescue and development of Vieques) backed by the Grupo de Apoyo Técnico y Profesional (GATP) (Group for technical and professional support) are among the groups that have already taken on this duty. The GATP had issued the Guías para el Desarrollo

Sustentable de Vieques (Guides for the sustainable development of Vieques). They call for development that prioritizes the conservation of the natural environment as well as the progress of the local population in terms of education, housing, and the economy. Tourism is to be promoted to fuel the economy, especially eco-tourism and tourism associated with the island's cultural treasures (architectural ruins and archaeological digs). Vieques offers a variety of activities for those who are interested in the natural environment. The island has two bioluminescent bays, several coral reefs, and beaches that serve as nesting grounds for sea turtles.

Climate and Topography

The island of Vieques is located about 6 miles (10 km) off the northeastern coast of the mainland Puerto Rico. It is approximately 51 square miles (136 km), or 33,000 acres, and measures approximately 20 miles (33 km) in length by 4.5 miles (7.2 km) at its widest point. Its location (Lat. 18°08′N, Lon. 65°26′W) among the Leeward islands of the Lesser Antilles, affords it a favorable position in relation to the Trade Winds which hit the island from the east. The wind direction varies, however, from northeast to southeast and changes from one season to the next. The prevailing direction during winter is from the east while during the summer it tends to be from the east/southeast. Winds tend to pick up in the morning and die down during the late afternoon. In addition, local

coastal breezes also affect the island. Diurnal breezes flow from sea to land while nocturnal breezes flow from land out to sea.

Vieques' topography consists primarily of a series of low hills and shallow valleys. Because of this relative shallow topography, the winds are allowed to pass virtually uninterrupted along the length of the island. The GATP (Guides for the Sustainable Development of Vieques) suggest that it may be possible to harness this wind power by windmills in order to produce electricity.

In general, Vieques' climate may be classified as tropical marine. However, it is important to note that Vieques' minimal elevation prevents it from fully benefiting from the moisture that the Trade Winds bring. A larger island with a substantial mountain range, such as Puerto Rico, allows for a change in temperature and pressure as winds hit and flow over the mountains resulting in rain. Vieques, therefore, has a relatively low average annual precipitation of 36 inches, but rainfall varies between 26 and 72 inches for the entire island. The island's dry season extends from December to July and its rainy season from August to November. Rainstorms tend to be short except for tropical storms and depressions. In addition, there is the threat of major fronts and hurricanes, always a possibility between the later summer months and November. The GATP suggests that a water catchment system with cisterns might serve to collect these rains during the rainy season and provide at the least part of the water supply.

Vieques' climate in general is fairly hot, with an average temperature of 80º degrees F. August tends to be the warmest month, averaging about 82º F, while February tends to be the coolest, averaging 76º F. The sun is intense during the day due to little cloud coverage. During the evenings, a rapid drop in temperature renders nights cool and comfortable.

Blue Beach (Bahía de la Chiva)

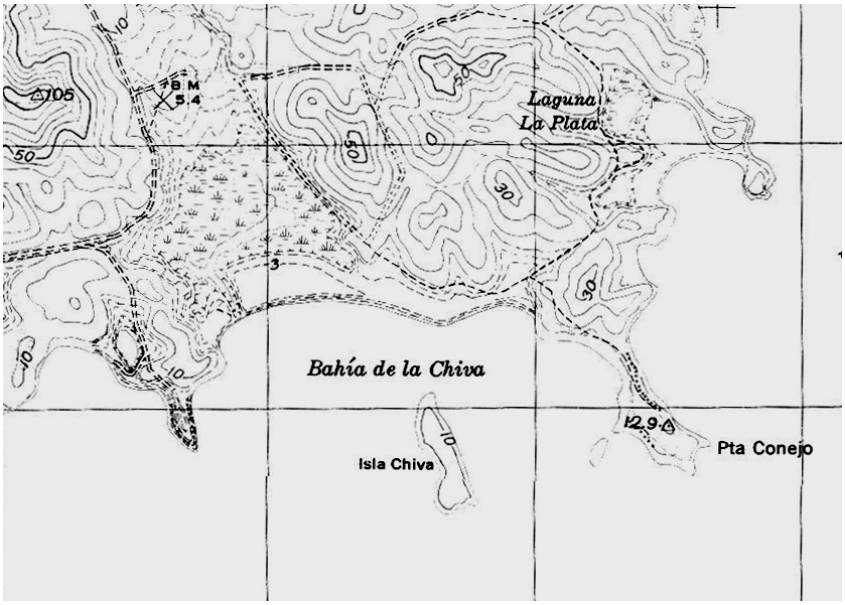

Fig. 20 Topographic Map, Bahia de la Chiva (USGS)

Blue Beach or Bahía de la Chiva, located within the former lands of the US Navy (now under the jurisdiction of Fish and Wild Life), was once the site of amphibious navy landings. It is one of the several bays that form the southern coast of Vieques. It is a shallow bight to the west of Punta Conejo (highest point is 12.9m). At the entrance to the bight is a cay, Isla

de la Chiva, which reaches a height of 30' above sea level. The site was chosen for its beautiful beaches and for Blue Tang Reef just off its coast, which is intended to be one of the main attractions to the resort.

Site Access

Current access to the site is via former Navy dirt roads which stem off of route 997, which connects the town of Isabel Segunda on the north coast with Esperanza on the south coast. Access to the island is by airplane or boat. The Vieques airport is located just west of Isabel Segunda and has regular flights from the mainland. There is also a ferry that arrives at the port in Isabel Segunda from Fajardo on the East coast of the Puerto Rico. It makes several trips daily.

Flora and Fauna

Woodbury (1972) as quoted in the GATP estimates that about 80% of the vegetative cover of Vieques has been altered due to either agriculture or to practices of the Navy (3.3). The vegetation that is found on and around the site, is for the most part beach underbrush which consists of plants that can tolerate high concentrations of salt and strong winds. Towards the west end of the site is an area of mangroves. Trees that are found on the island include Acacia, Prosopis & Ziziphus (Woodbury, 1972 quoted in GATP, 3.3)

Coral Reef

Just beyond Isla de la Chiva and extending 1.5 to 2.1 miles west of punta Conejo, is a coral reef which lies about 0.5 miles off shore. It is

covered with between 2 and 18 ft of water. (http://chartmaker.ncd.noaa.gov/nsd/cp5/CP5v1-chp13.pdf) Blue Tang Reef, as it is called, is considered to be one of the best snorkeling sites on the island. Coral reefs grow very slowly, so any damage done to them has long-term effects. They harbor a variety of fish and other animals such as marine turtles (GATP 3.3). Its protection, along with other coral reefs on the island, is very important.

V. Precedents

Little Dix Bay, Virgin Gorda, BVI
Tippetts-Abbett-McCarthy-Stratton, 1958

Fig. 21 View of Little Dix Bay from the Beach (www.littledixbay.com) The separate buildings with their Polynesian-style roofs and integrated with the vegetation along the cove and surrounding hills makes for a very unobstrusive resort that complements the natural landscape. The resort was intended by the Rockefellers (who's project it was along with Caneel Bay in St. John, USVI) to be environmentally friendly.

Little Dix Bay Resort is one of two island resorts built in the late 1950's by Laurence Rockefeller.[5] It is a typical "casita"style tropical resort which opened with 50 units but has since grown to 98 suites. The casita's or cottages are scattered along the length of the cove formed by Little Dix Bay. Thirty of the original guest rooms (Deluxe Cottages) are housed in pairs within hexagonal buildings located up against the hill and hidden within coconut palm trees and sea grapes. They are raised on stilts so that guests can rise up above the vegetation and get views of the bay. This also creates a sun deck below. The remaining 20 units (premium cottages) are located in low buildings near the beach in groups of four.

[5] Laurence Rockefeller also sponsored a resort at Caneel Bay in St. John (USVI) with similar objectives.

The dining room and terrace consist of a series of Polynesian-style pyramidal roofs covering an amorphous area which is completely open to the outside. These buildings (as well as the guest rooms) benefit from wide overhangs which shade the sun and rain while still allowing most activities to occur outside. Canvas draw draperies aid in blocking sudden rain showers and direct sunlight at certain times of the day. Directly behind this area is a block which holds the kitchen and service areas, restrooms, front desk, bar and shop. Besides the main restaurant there is also the Beach Grill and the Sugar Mill Italian restaurant.

Fig. 22 Dining Pavilion
The pavilion consists of roofs that are held up by stone columns without any walls. This allows for a very well-ventilated, and comfortable area with spectacular views out to the ocean. The great overhangs from the roof also prevent rain from entering the area. Some areas of the pavilion have pivoting, glass doors that can be open or closed.

Little Dix Bay succeeds in being a fairly unintrusive resort which enhances the landscape instead of disrupting it. This is achieved through massing, by creating several low, small buildings (rather than one large building) that follow the curvature of the bay and by employing natural materials such as woods (wallaba roof shingles and purpleheart framing both from British Guina), stone, tile, shingle, wicker and cane.

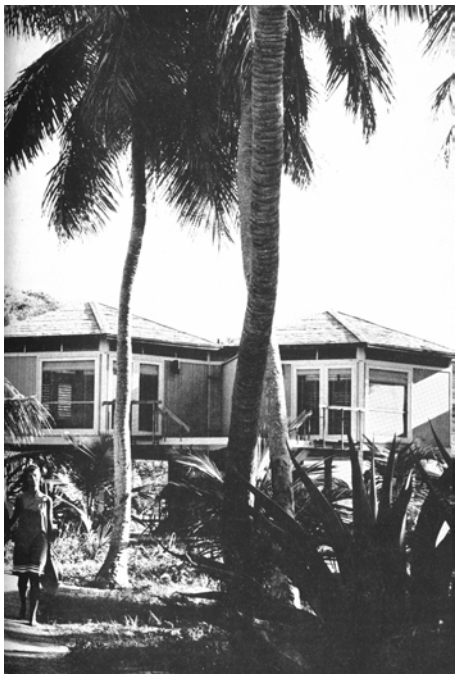

Fig. 23 Little Dix Bay
View of Cottages on stilts

Because when it was first built there was no water, power or telephone in the area, the architects had to find alternative ways of supplying these provisions. Water was obtained from low-temperature, low pressure sea water evaporation process and from rain water collection. Sewage was

treated in a plant on site, which permitted the use of effluent for irrigation. Power was produced by diesel-powered generators.

The hotel was intended to accommodate people looking for a relaxing time in a secluded beach. The resort also offers a pool, tennis courts and trails for walks and jogging.

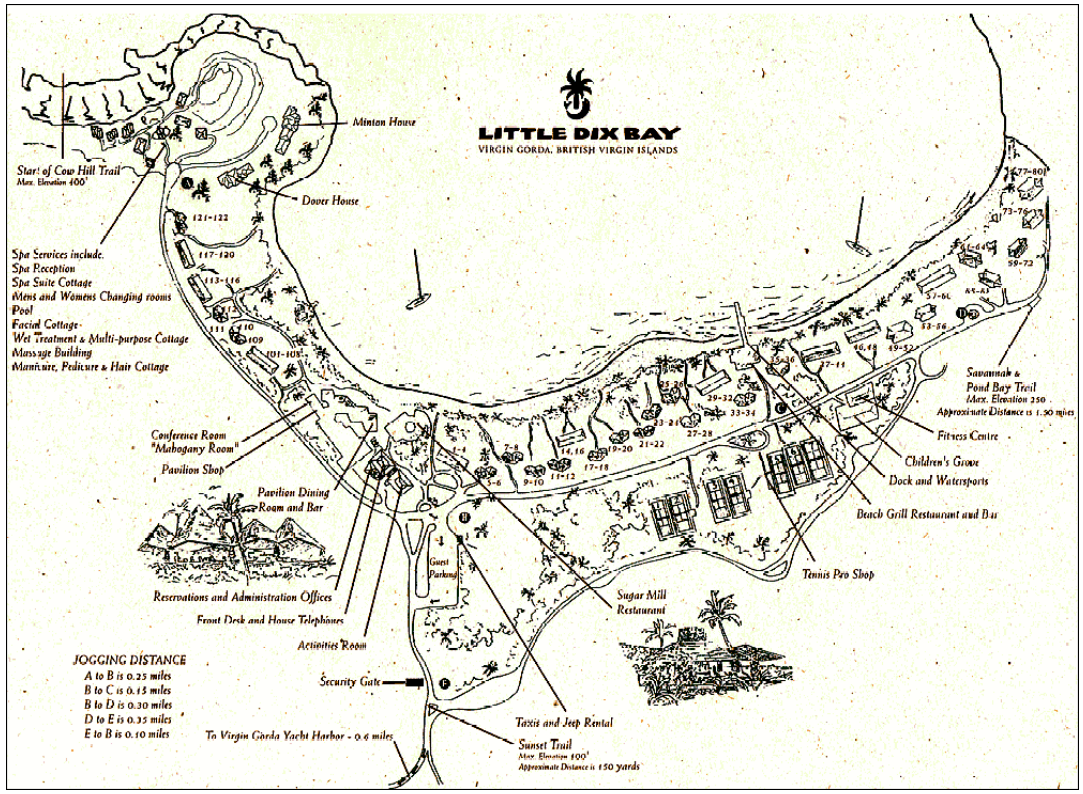

Fig. 24 Site Plan, Little Dix Bay

Fig. 25 Landscape, Little Dix Bay
Landscaping helps to complement the resort's grounds and provides paths for strolls.

Fig. 26 Little Dix Bay
View of pool overlooking the ocean

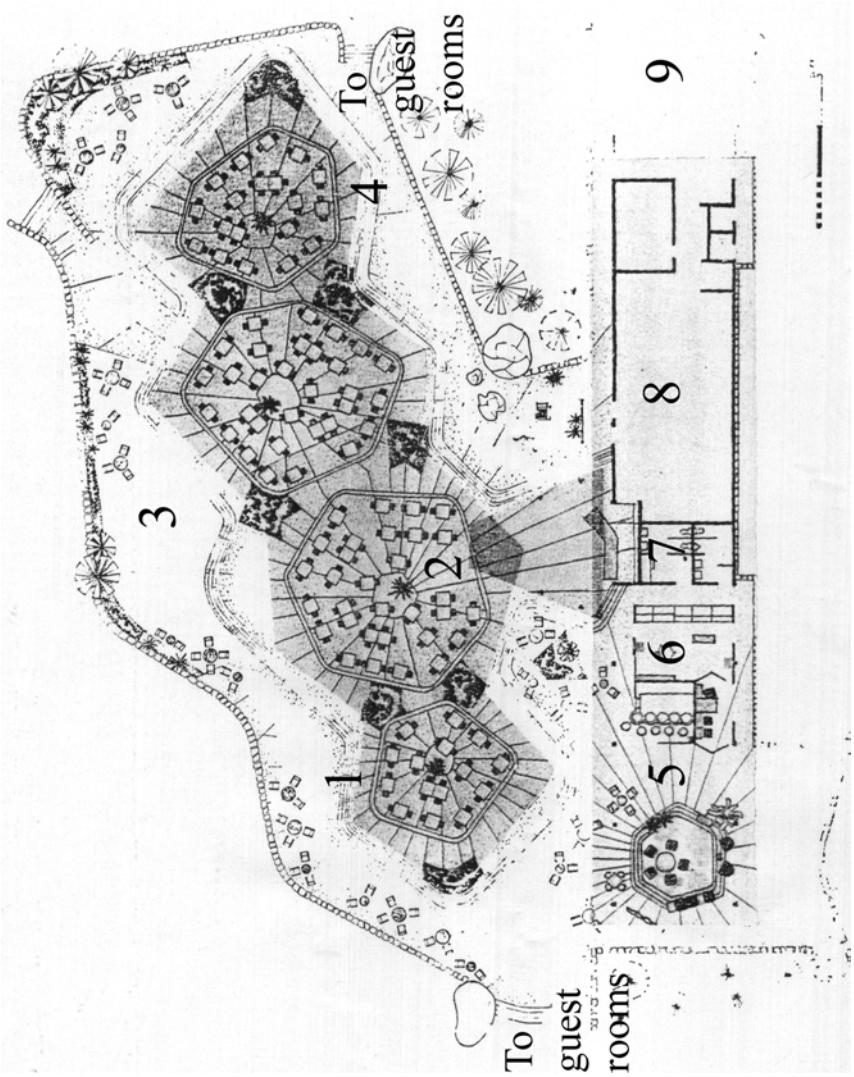

Fig. 27 Plan of Dining Pavilion, Little Dix Bay
The dining pavilion consists of a group of amorphous areas covered by Polynesian-style roofs, with a block of services behind it.
1) Cocktails, 2) Dining & buffet below, 3) Dancing, 4) Terrace, 5) Bar & lounge, 6) Gifts, 7) Restrooms, 8) Kitchen & services, 9) Service court

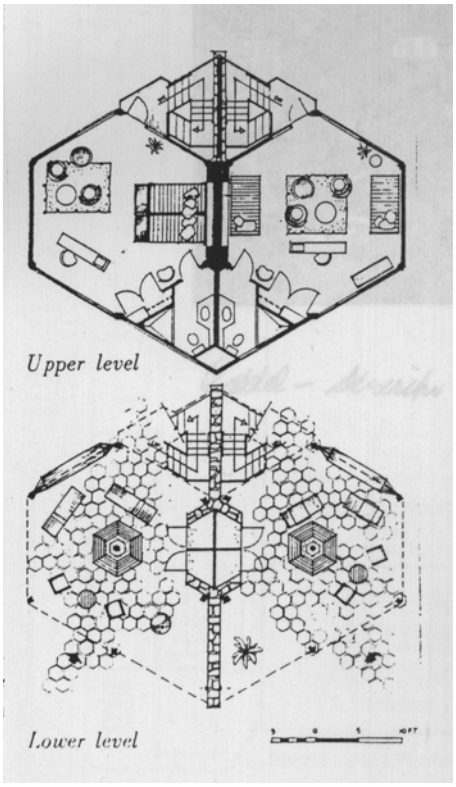

Fig. 28 Unit Plan, Little Dix Bay
These cottages, each with two units, are elevated above the ground, which cools them down, allows for unblocked breezes to penetrate into the units, and makes for an outdoor shaded sitting area below.

The Serai
Bali, Indonesia
Kerry Hill Architects, 1991-1994

Fig. 29 Serai Hotel
View towards hotel from pool area
(Mostaedi 1999, p. 29)

Located on a 2 hectare site in a secluded beach on the east coast of Bali, the Serai benefits from a simple program not dissimilar to what this thesis intends to propose. It consists of 56 standard guest rooms and two suites, one restaurant and bar, one shop, a lobby, a pool, and the service areas.

The Serai, which is located in the tropics had to tackle many of the climatic issues which must be addressed for a hotel in the Caribbean. "Hill seeks to evolve an architecture that is both climate-and site-specific, drawing on the indigenous forms of tropical building," (Tropical Paradigm A + U Feb. 1997 p. 65). Its location in a hot and humid tropical climate has allowed the hotel to be very open in order to allow breezes to circulate within the structures. It consists of several buildings joined by open

walkways. The four guest room wings are only one room deep, allowing for the possibility of using cross ventilation to cool the rooms. All public areas are unwalled pavilions consisting of a roof held up by slim columns. Wide overhangs provide plenty of shade and grass thatch roofing[6] helps to keep the buildings cool. Inspired by traditional Balinese architecture, the hotel is constructed with local materials such as coconut wood, ochre colored stones, bamboo, teak wood and a more modern but widely-used material, concrete.

The buildings/pavilions are organized within an orthogonal grid which is skewed in relation to the beach line in order to allow every room to have a view of the ocean. This configuration also allowed for the buildings to surround a pre-existing coconut grove without damaging it. In the center of this grove, is the pool which seems to act as the pivot for the other structures.

Before descending to the porte cochere of the Serai, guests get an overview of the entire hotel. They are greeted by a colonnaded open corridor leading to the lobby towards the right beyond which they can get a glimpse of the ocean. Once in the lobby, guests can either go to the bed rooms which are accessed beyond the lobby towards the right or proceed to the lounge and restaurant towards the left.

[6] Thatch is a very good insulator.

Fig. 30 Serai Hotel, Bali
View from porte cochere area to lobby and ocean at the end of the corridor. The area to the left is administration.
(Mostaedi 1999, p. 31)

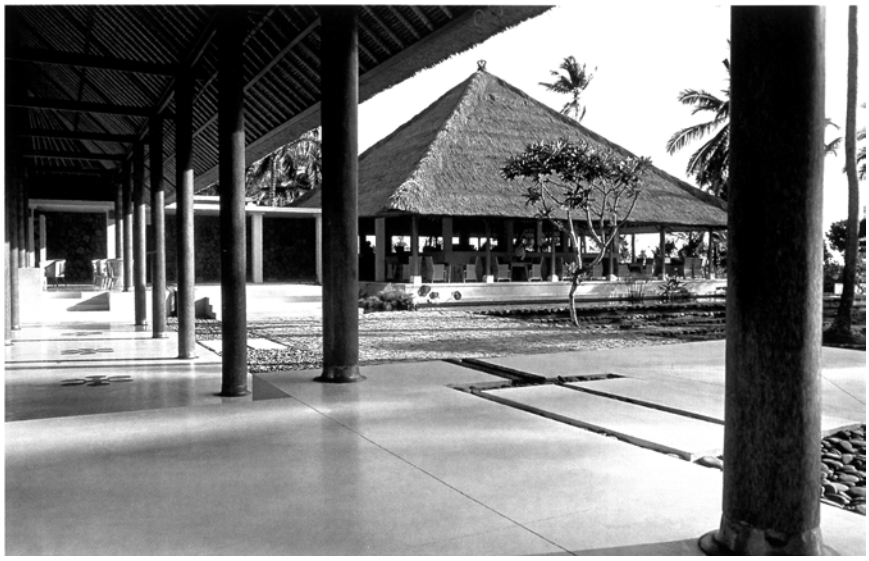

Fig. 31 Serai Hotel, Bali
View from colonnaded lobby towards restaurant pavilion.
(Mostaedi 1999, p. 30)

The administration areas are accessed from the porte cochere and entry corridor by way of a separate entrance. The main service areas, which have independent access from the road, are housed in two separate structures with direct access to the guest rooms. There is another small service area near the restaurant and administration areas, which has the kitchen. It also has a discrete entrance from the main road and an area for arrival of supplies and removal of trash. The simplicity of the plan allows for a very clear sequence of spaces for both guests and service personnel. Private and public guest areas can be easily distinguished from each other as wells as from service. This results in an efficient circulation of service to main public areas without overlapping with guest activities.

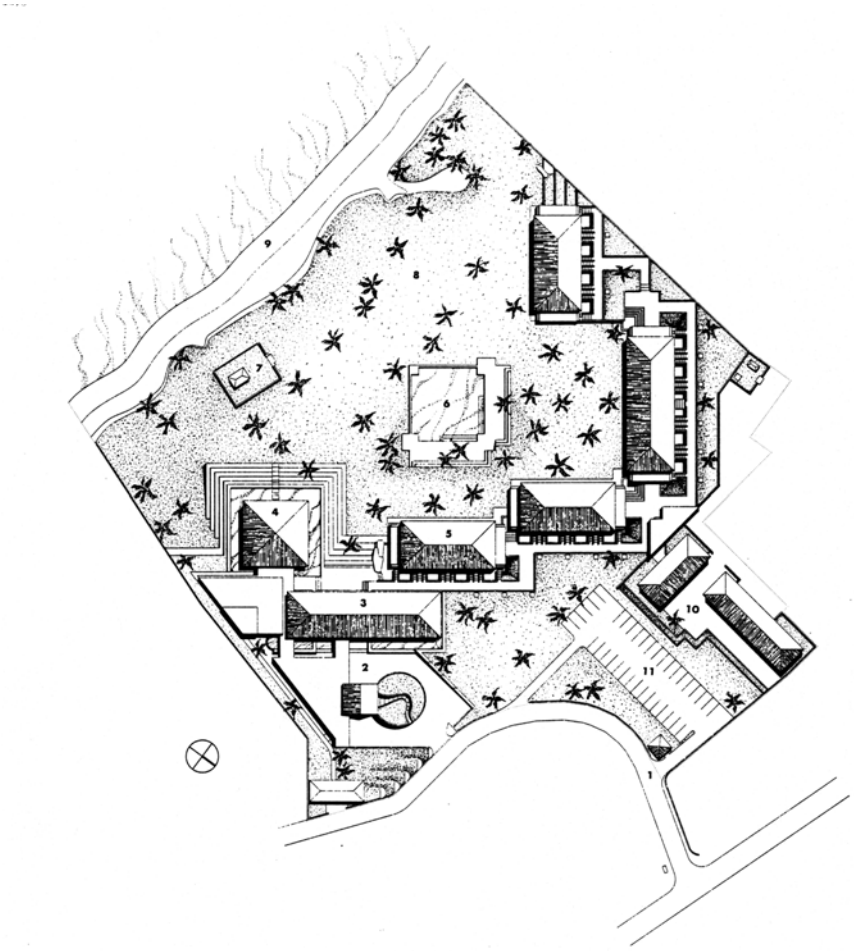

Fig. 32 Serai Hotel, Bali
Site Plan: 1) Guard, 2) Porte Cochere, 3) Lobby, 4) Restaurant, 5) Guest room block, 6) Swimming pool, 7) Temple, 8) Coconut grove, 9) Beach, 10) Service Yard, 11) Parking (A+U Feb. 1997, p.)

Guestroom Analysis

The Serai, Bali, Indonesia

The 56 guestrooms and two suites of the Serai hotel in Bali are housed in four separate buildings. The buildings are two stories high so that half of the rooms are on the ground and half are above. They are entered in pairs from an open walkway which runs midway between the two floors and is detached from the buildings. Stairs from the walkway lead either up or down. Bottom units have enclosed exterior sitting areas while top units have balconies. Because the buildings are one unit deep, cross ventilation is possible and bathrooms have windows.

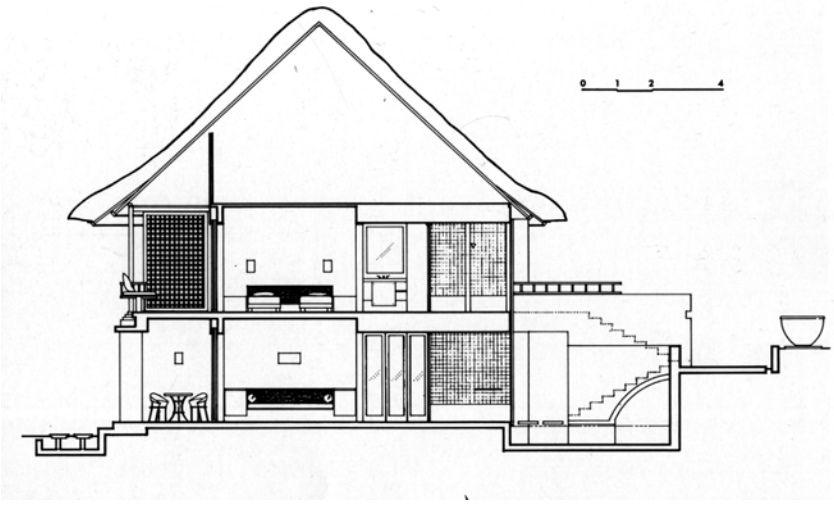

Fig. 33 Serai Hotel, Bali
Section through guest room building with detached walkway and entries
(Mostaedi 1999, p. 32)

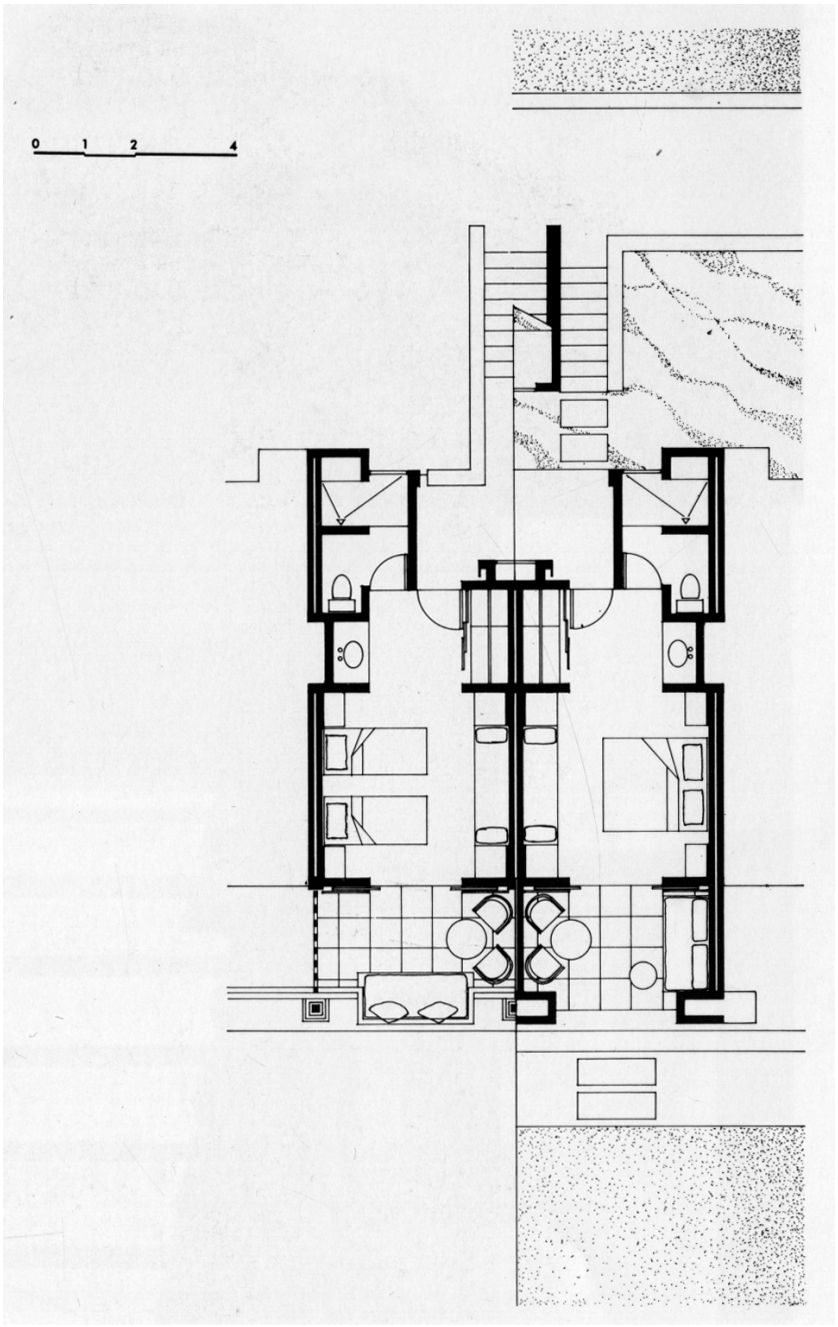

Fig. 34 Serai Hotel, Bali
Standard guest room plan

Little Dix Bay, Virgin Gorda, BVI

The hexagonal cottages hold two units with living areas. Lifting the cottages above the ground allows for a private sun deck/ lounging area beneath each unit.

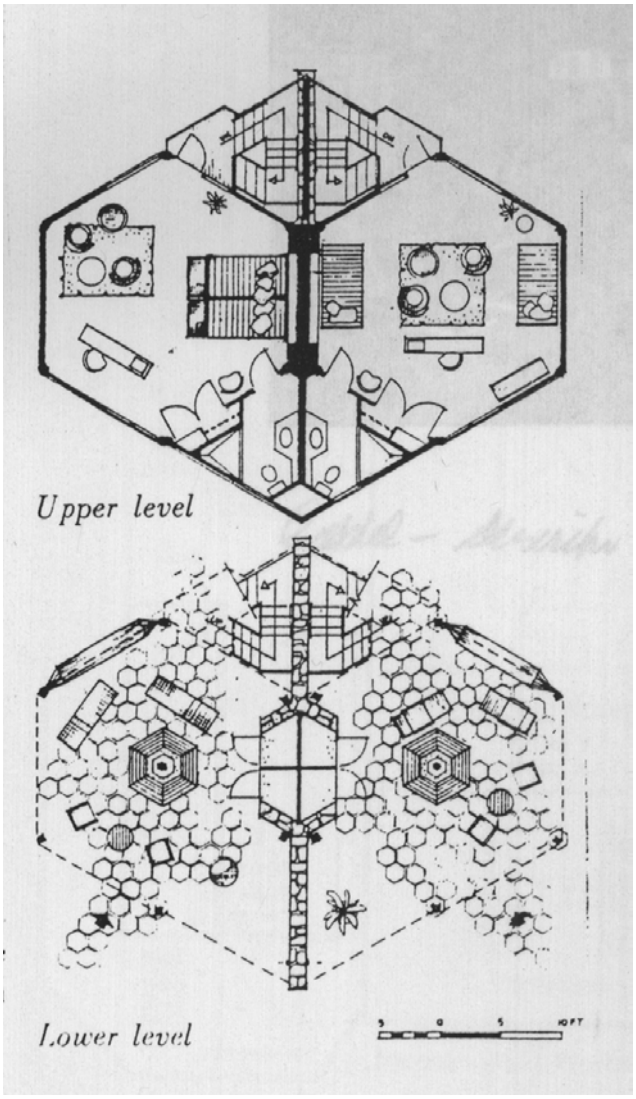

Fig. 35 Plan of hexagonal cottage, Little Dix Bay

Biras Creek, Virgin Gorda, BVI

Biras Creek offers a total of 33 suites for about 60 guests. There are 30 simple suites. Ocean-side suites are located along the Bay while Garden suites are scattered about the foliage and their landscaped garden. There are 2 suites per cottage and three of these duplexes can be interconnected. Each unit is 475 ft² including a 135 ft² outdoor sitting area, separate bedroom and sitting area, and a bathroom with an outdoor garden shower.

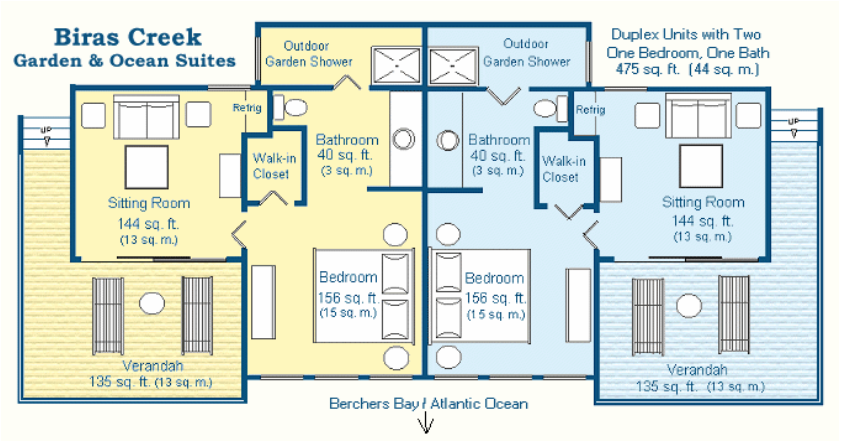

Fig. 36 Garden and Ocean suites, Biras Creek
(www.biras.com)

In addition to the ocean-side and garden suites, there are also two grand suites with panoramic views of the ocean. The two suites, which are identical in size (1325 ft²), are located in the same cottage and can be interconnected. Each includes 2 private verandahs (one off the living area and one off the bedroom), a separate entry with a half bath, a large living area, a separate bedroom, and an oversize indoor/outdoor bathroom with a

large soaking tub and an outdoor shower.

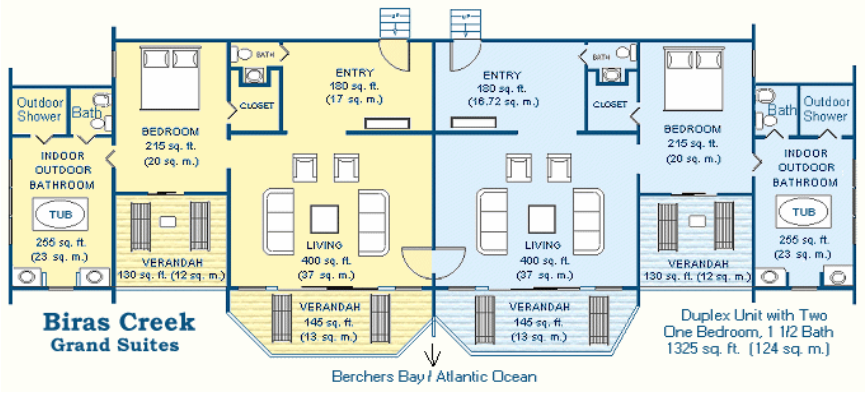

Fig. 37 Grand Suites, Biras Creek
(www.biras.com)

Finally, there is the Premier suite, a very spacious (900 ft² not including verandahs) two-bedroom cottage located near the beach front. It has a large central sitting room with a covered verandah between the two bedrooms. Each bedroom has its own bathroom and a private verandah. Each bedroom can be privately accessed from the verandah.

VI. Program

The Caribbean retreat is designed for a relatively small number of guests (50-60), who wish to enjoy the tranquility of a Caribbean vacation in a natural setting characterized by beautiful beaches, wonderful views, soothing breezes, and one of the best reefs in the Caribbean. The retreat will also provide access to the many ecological activities that attract people to the island of Vieques, particularly the Blue Tang Reef located just off its shores. The type of guests that are expected to stay at the resort are of two kinds:

1) Guests attracted to nature tourism who are interested in physical activities, such as turtle watching, scuba diving and snorkeling on the reef, kayaking in the bioluminescent bay. Access to these activities will be made available by boat to Esperanza. These guests are expected to be either couples or families with older children who are interested in these types of activities. 2) Guests who wish to relax, sun bathe, take advantage of the beach and activities provided by the hotel.

Guest travel, arrival, and stay at retreat

- Typical guests will either arrive at the airport in Isabel II from San Juan, Puerto Rico or at the ferry dock from Fajardo (on the east coast of PR) where they will be picked up by a car service hired by the retreat. Guests must inform the retreat of their

travel plans prior to their arrival on the island so arrangements for pick up can be coordinated.

- Guests will be taken to a marina in Esperanza (20 minute drive) from where they will be taken by boat (run by an employee who is also in charge of running the regularly scheduled shuttle service) to the shores of the retreat.
- At the dock, guests will be welcomed by a "bellhop". This person will be in charge of receiving guests, delivering luggage to their room, and keeping of the activities and guest pickup schedule.
- Guests may choose to walk or be driven by bellhop in a golf cart (Five-passenger golf cart with trunk for luggage) up to the lobby area where they will check in. Guests may enjoy a drink at the lobby bar or purchase local crafts at the shop before proceeding to their cabin.
- From the lobby, guests may continue on to their cabin. They may choose to walk or be driven by golf cart. Luggage will be delivered to their room by golf cart to their central cluster area, and then by foot or wagon through wooden walkways to cabins.
- Once they have settled in, guests may choose to explore the site (by foot), head for Blue Beach (Bahia de la Chiva) for the rest of the day with snorkeling gear (provided for each cabin), sign up for the day's trip to the reef for a lesson in scuba diving, take

the shuttle to Esperanza for lunch, make arrangements for a night trip to the phosphorescent bay or turtle watching, or simply grab a book at the reading pavilion and relax on their deck. Access to the reef will be through a local diving company, which will take interested guests out to the reef for snorkeling or scuba diving. The retreat will be in charge of making arrangements for the guests as part of a schedule of activities. Other activities offered on the island like tours of and kayaking in the phosphorescent bays near the site on the south coast of the island and turtle watching, will also be arranged for by the retreat. On a regular basis, a shuttle will also travel to and from the town of Esperanza, where guests can enjoy lunch at some of the oceanfront restaurants or make arrangements to visit and explore other parts of the island, such as the fort and lighthouse in Isabel II.

- For meals, guests can choose to either go to the main restaurant, located at the central cluster, or have a sandwich or quick pre-prepared meal at one of the other two clusters: the lobby bar or reading pavilion café. Room service will not be provided, but food outlets will be open late. The restaurant, which will serve local dishes as well as continental food, will open for all meals. During hours when it is closed, its bar will remain open.

Service Areas

Service to the retreat will be by land along already existing roads. This land access to and from the retreat will also serve for any medical emergencies that may arise. Back-of-the-house services will be: administration, receiving and trash collection, housekeeping & laundry (laundry room and linen storage, housekeeping executive/manager's office, housekeeping storage and workroom) employee areas (personnel/ timekeeping/ security office, locker rooms, lounge/ dining area), and engineering/ mechanical.

Administration offices will be located near the lobby. They will include the business manager's office, an accounting office, front desk and a front office work room (separate room for use by staff with enough space for copy machine, filing, safety deposit box and storage). Because of the small size of the hotel, reservations will be taken by front desk attendants.

The remaining elements of the service program will be located in a separate building away from guest areas and accessible by paths from main roads leading to the site as well as from central areas of all three clusters. These back-of-the-house areas will be run by the general manager. The area must allow for access by trucks for the delivery of goods and the removal of trash. The receiving area will have one loading dock, a receiving office, and an area for receiving, inspecting and temporary storage of food and supplies. From here, goods will be taken to

either general storage room or to refrigerated/ frozen storage areas in the service building & to storage throughout the retreat (restaurant, shop, lobby bar, reading pavilion café). Trash will be collected in an area away from the receiving area. It will include a loading dock, a trash collection room and a recycling room with separate storage for different items: cans, glass bottles, plastic bottle, paper, cardboard. The retreat will make arrangements with companies in the mainland (Puerto Rico) for the collection of these items. Trash collection, recycling, and composting will be handled by the grounds person, who will also be in charge of maintaining retreat grounds, including trails, the garden and orchard, which will provide fresh fruit & vegetables for use by restaurant.[7]

Employee travel, arrival, and work

- Employees will travel to the retreat by a hired van service that will pick up employees at key locations in Isabel II and Esperanza at the beginning of work shifts. Limited parking will be provided for certain employees as well as for other visitors to the site, such as outside service companies employed for specific work.
- Employees will enter through the employee entrance, check in at the security/ timekeeping/ personnel office (person doubles as general manager's secretary) pick up their clean uniform, and

[7] Gray water from the kitchen will be used for irrigation and compost (from kitchen scraps & toilets) will be used for fertilizing.

proceed to the locker rooms. These will have showers and changing rooms.

- From the locker rooms, employees will proceed to their respective job positions throughout the retreat.
- There will be a laundry attendant in charge of running the machines, receiving soiled laundry, preparing and distributing employee uniforms, and preparing clean linen for delivery to cabins and public guest areas.
- Front-of-the-House employees such as restaurant, café and bar attendants, cooks, and servers and front desk and administration personnel will travel to each cluster by a golf cart assigned to each cluster (the golf cart will remain at the central cluster area for use by employees and for emergencies).
- Housekeeping will be done by three teams of two employees each. Each team will be in charge of one cluster of cabins and central public building. Each team will have its own utility golf cart to take linen, cleaning supplies, and room amenities from laundry housekeeping storage and workroom at main service building and bring back garbage from rooms and public areas. Each cluster of cabins will have a housekeeping storage room located at the central area, with cleaning supplies and equipment.

- The maintenance/ engineer person will have an office and workshop. This person will be in charge of general maintenance of buildings such as repairing of fixtures, railings, dock, etc.
- During their breaks, employees may rest or eat at the employee dining room/ lounge. The café, with small kitchen, will serve simple food prepared by the restaurant that can be easily reheated. The task of preparing and serving employees will be done by restaurant staff.
- The restaurant, which will require a larger amount of supply and trash collection than the other centers, will be serviced regularly. Employee in charge of receiving and supply distribution will restock china as well as food and beverage storages in restaurant (as well as in shop, café and lobby bar). The vehicle used for this task should be a medium sized utility vehicle (larger than regular golf cart, maybe utility golf cart with attached trailers) that may be able to restock restaurant. Trash from the restaurant will be removed, on a regular basis to avoid accumulation during the course of the day, by employee in charge of trash collection. This may require a similar vehicle to the one mentioned above for supply distribution. Central public areas will provide separate trash containers for recycling.
- The restaurant will have a chef and two cooks in charge of preparation of all of the day's food, including what will be sent to

the library café, lobby bar, and employee café. The restaurant will have two to three servers, including a bar tender.

- At the end of their shift, employees will take the van back to Isabel II or Esperanza where they were picked up. The total number of employees is expected to be about 25.

Programmatic Elements:

Reception/ Lobby

Front Desk (Reception desk): Located within the lobby, the front desk should be set back from main circulation yet be readily visible by arriving guests. It should allow unobstructed views of lobby and main entry.

Concierge: A desk, which can be an extension of the reception desk, should be provided for the concierge in the lobby

Bell Captain's Station: Handling of luggage should be separate from the main lobby. There should be a storage area for luggage carts.

Lobby: The lobby acts as the central focal point of the hotel. It is where guests are received, where they can gather, and from where all other areas of the hotel can be accessed. Because it is the main organizer of guest traffic, it is important for it to have an efficient circulation pattern.

Lounge: The Lounge, which acts as the hotel's living room, can either form part of the lobby or be a separate area. If separate, it should be seen from lobby and front desk. Proximity to the bar is also essential.

Shop: General supplies and local craft shop

Reading Pavilion and Café: Reading Pavilion: This is meant to be an informal room or area where guests can borrow books and board games and/or read. It will house not only a variety of novels for casual reading but also informative books to enhance the visitor's stay in Vieques. These would include books on the history of Vieques, its flora, and its fauna. Café: The café is intended to serve drinks and snacks during the day for take-out or informal meals. It will serve snacks, sandwiches, and other simple, pre-prepared meals. It should have a seating area, restrooms nearby, a small preparation area, and storage area with chiller and freezer. The space allowance per person for a coffee shop is about 15 ft² (Huffadine 2000, p. 179).

Main Restaurant:

Restaurant: should be able to support lunch and dining for not only guests but other occasional visitors to the retreat. It will serve local as well as international food. The area per person for a formal dining room is about 20 ft² (Huffadine 2000, p. 179).

Bar: The bar must accommodate both standing and seated customers. The design of a bar with one attendant usually requires an area for 8 to 10 stools and a counter about 16 to 20 feet long (Huffadine 2000, p.191). Space allocation for a public bar is about 16 ft² per person (Huffadine 2000, p. 179)

Main Kitchen: Although the kitchen should be located next to the restaurant, it must also prepare food for the lobby bar and cafe. It should

consist of several work spaces for different stages and kinds of food preparation. It should have walk-in freezers and chillers and dish and pot washing areas. Directly associated with the kitchen are:

Storage: a) Dishes, glassware & utensils, b) Cold foods, c) Dry foods, d) Beverages and liquor

Service Areas

Housekeeping: Although rarely confined in just one building, this department usually has one central area. It is in charge of cleaning, checking, and restocking guestrooms, public guest and circulation areas, and back-of-the-house. It is in charge of minor maintenance repairs and laundry (Huffadine 2000, p. 245).

Executive Offices: They should be located centrally near delivery dock and laundry and next to the main storage area (Huffadine 2000, p. 245).

General Storage: Storage of housekeeping supplies

Laundry: The laundry is done by housekeeping

Main storage: Storage for restaurant linen, rooms, employee uniforms, etc. should be located near executive housekeeping office and next to the laundry

Supplementary storage rooms: located on guest room floors or within or next to cottages. These should be 3.5 to 5 ft^2 per guest room (Huffadine 2000, p. 246).

Employee rooms: restrooms, locker rooms and eating lounge

Loading dock: Area for truck to park, load and unload cargo.

Receiving & handling: Area right next to loading dock where incoming materials are received and separated to be taken to storage areas in different parts of the hotel.

Trash storage/management: This area should be right next to loading dock for easy removal. Trash will be sorted for recycling of cans, glass, plastic and paper products which will be removed from the site. All organic material will be made into compost and used as fertilizer.

Diagrams: Relationship of Programmatic Elements and Circulation Patterns

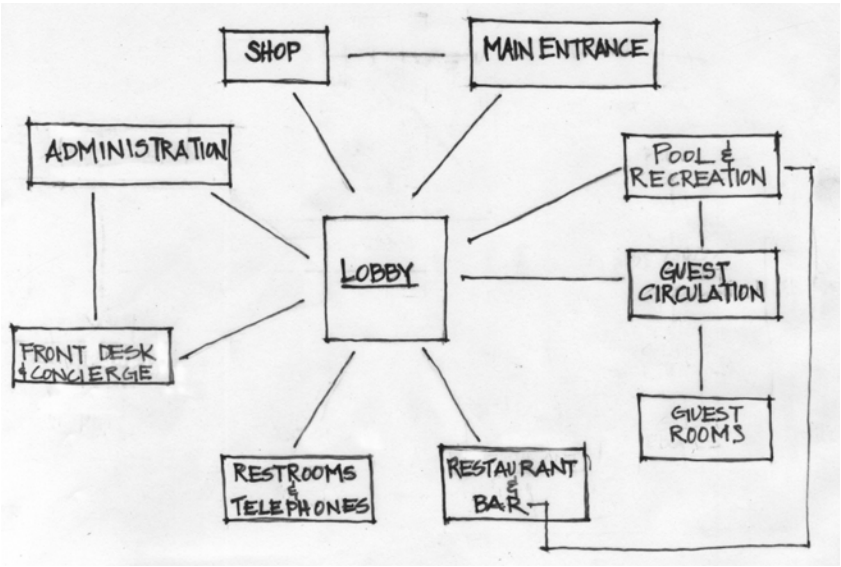

Fig. 38 Program Diagram
Diagram showing the relationship of lobby to other programmatic elements. The lobby acts as a central distribution and gathering area.

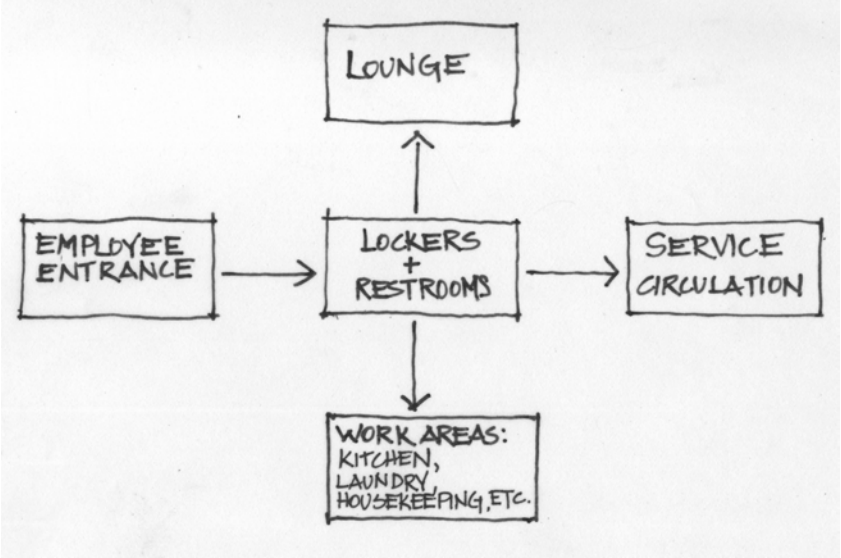

Fig. 39 Program Diagram
Diagram shows employee circulation beginning at the employee entrance, which is distinct from main guest entrance. This circulation is meant not to interfere with guests and their activities.

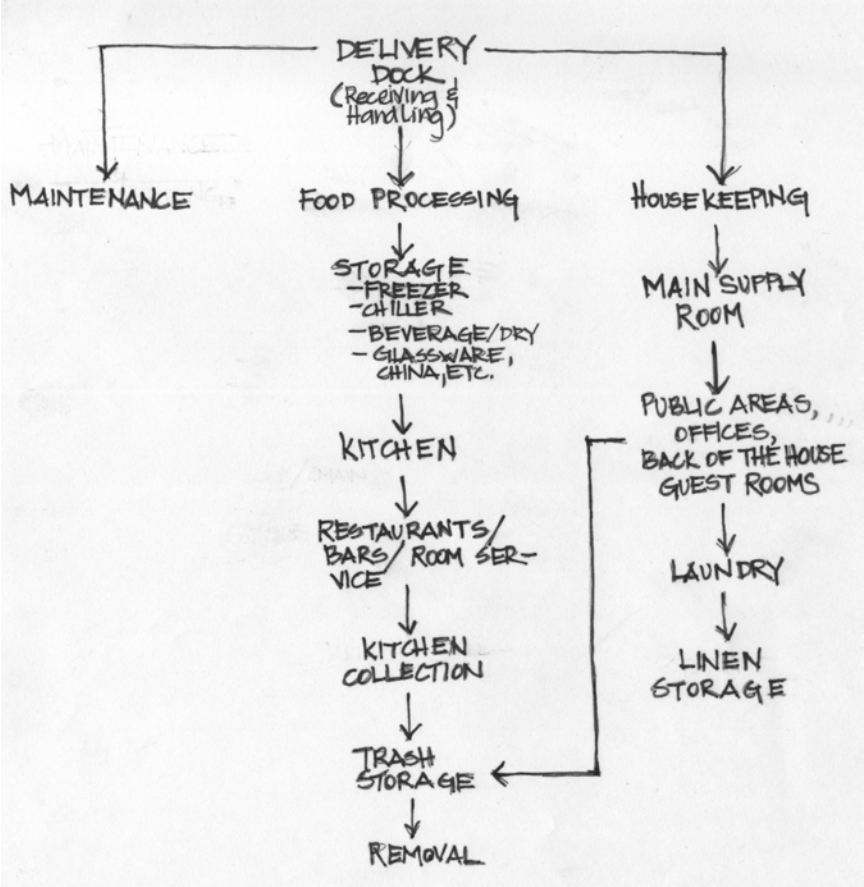

Fig. 40 Program Diagram
Diagram shows back-of-house circulation.
Based on diagram by Huffadine (2000, p. 224).

VII. Final Design

Fig. 41 Perspective
View of retreat from water.

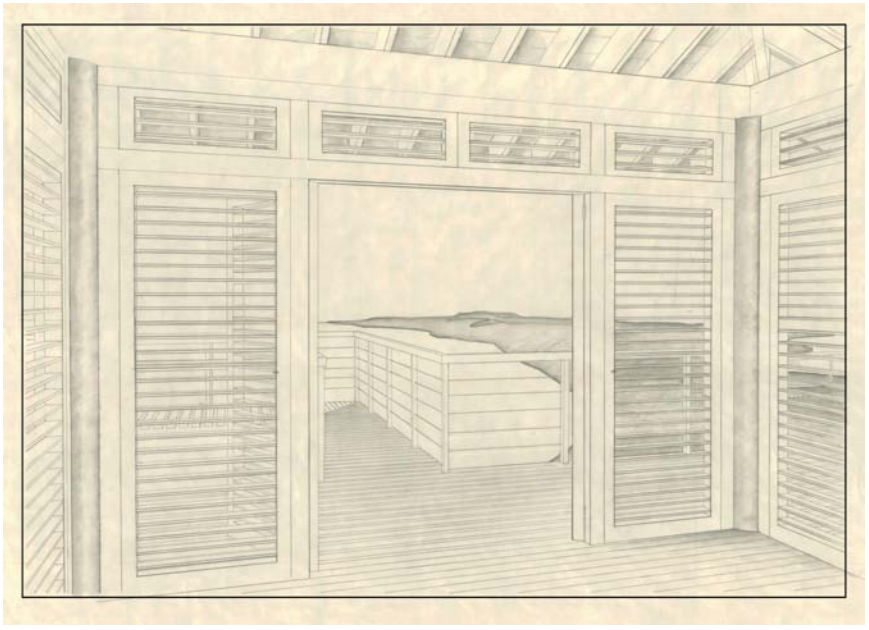

Fig. 42 Perspective
View from cabin looking out to landscape

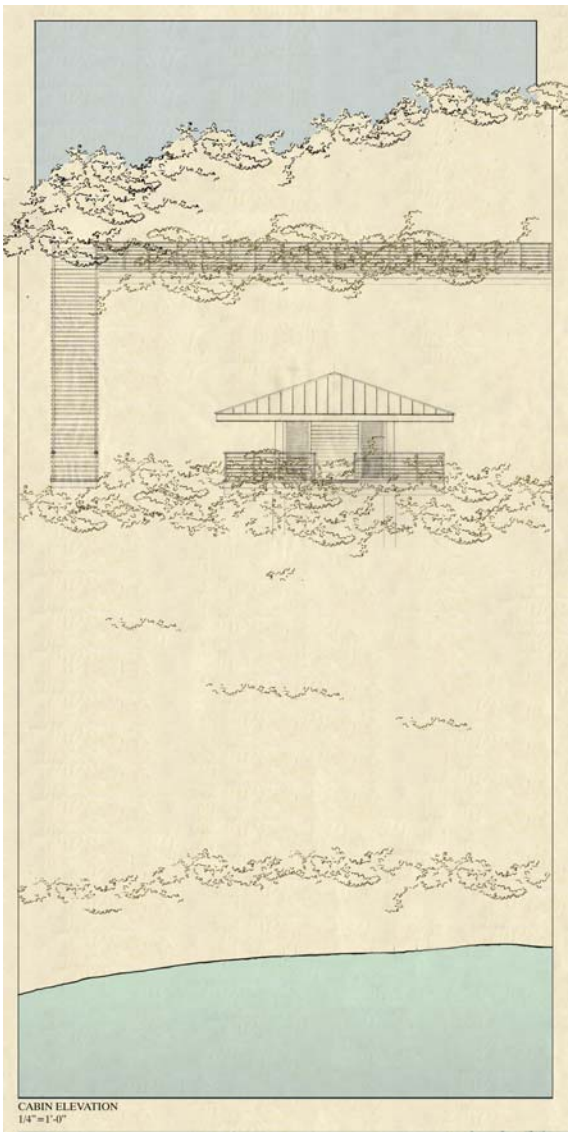

Fig. 43 Cabin Elevation

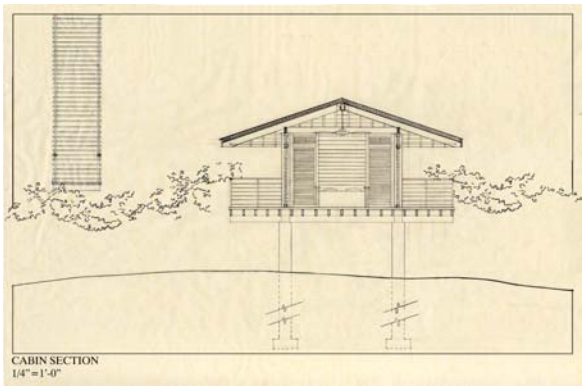

Fig. 44 Cabin Section

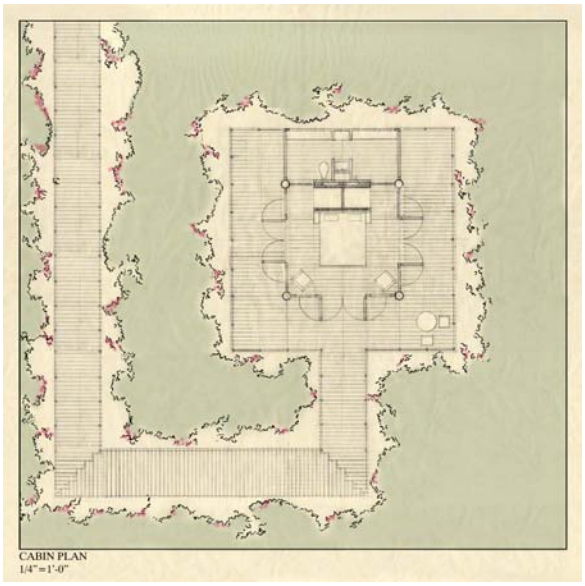

Fig. 45 Cabin Plan

Fig. 46 Cabin Wall Section and Elevation

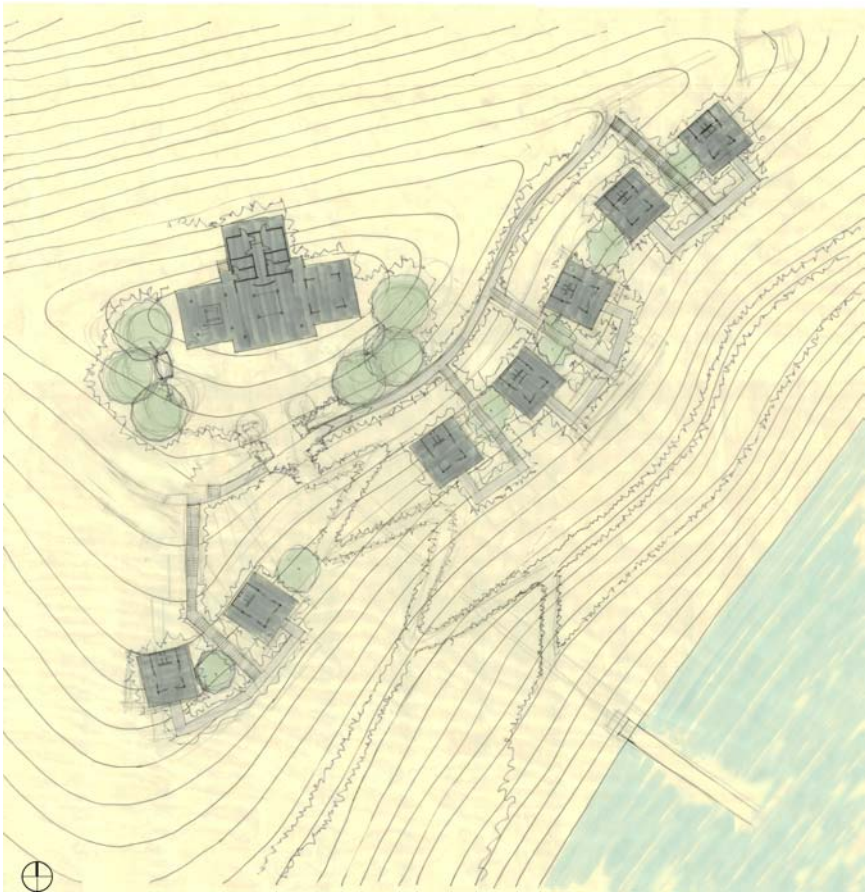

Fig. 47 Lobby Siteplan

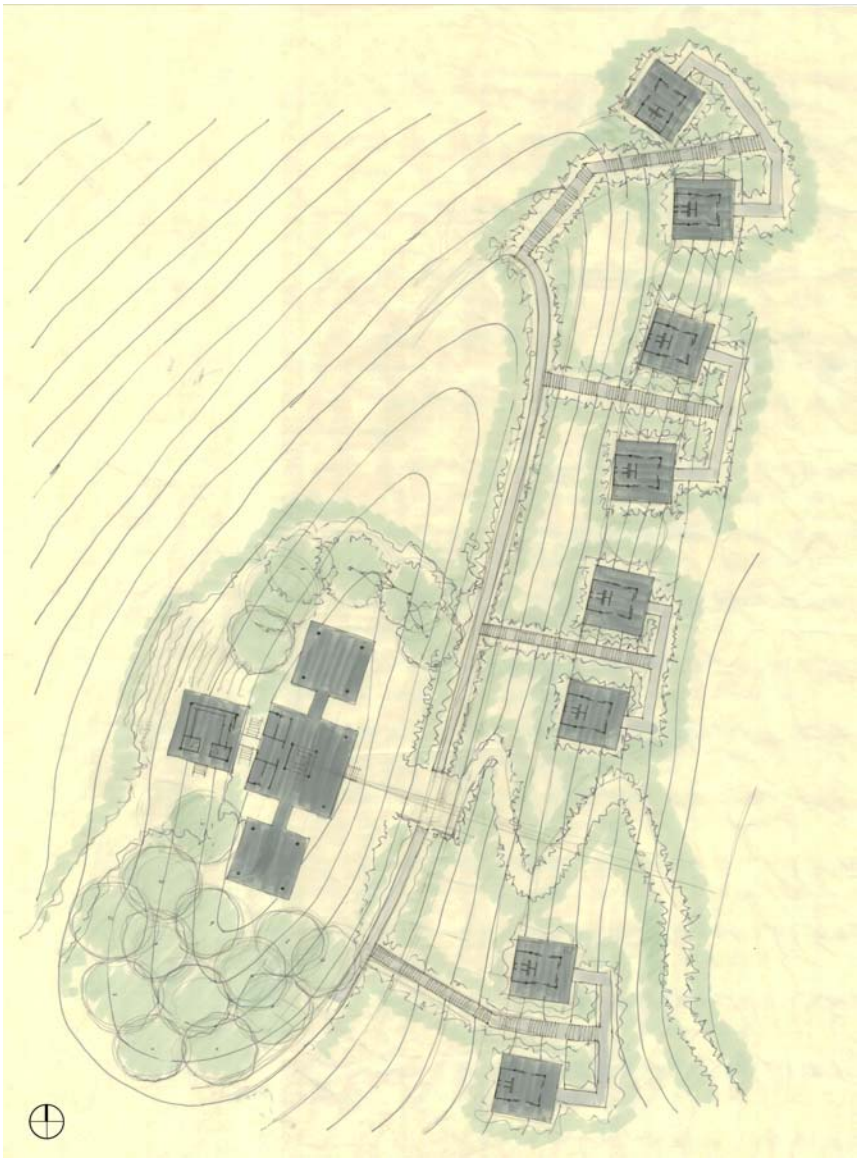

Fig. 48 Restaurant Siteplan

Fig. 49 Café/ Reading Pavilion Siteplan

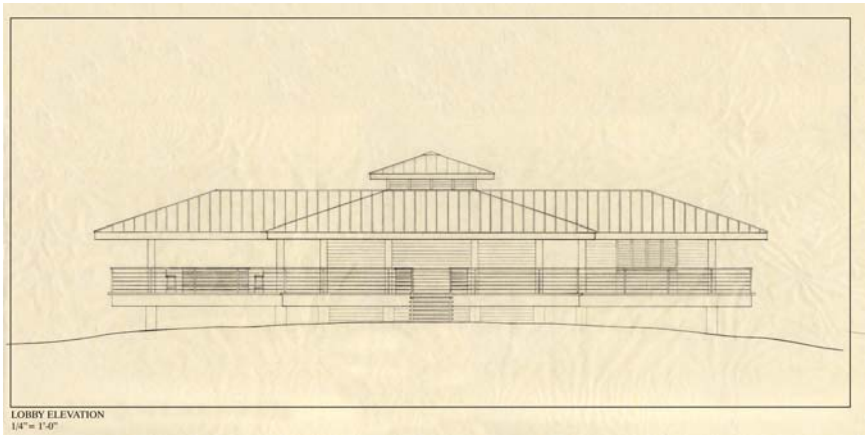

Fig. 50 Lobby Elevation

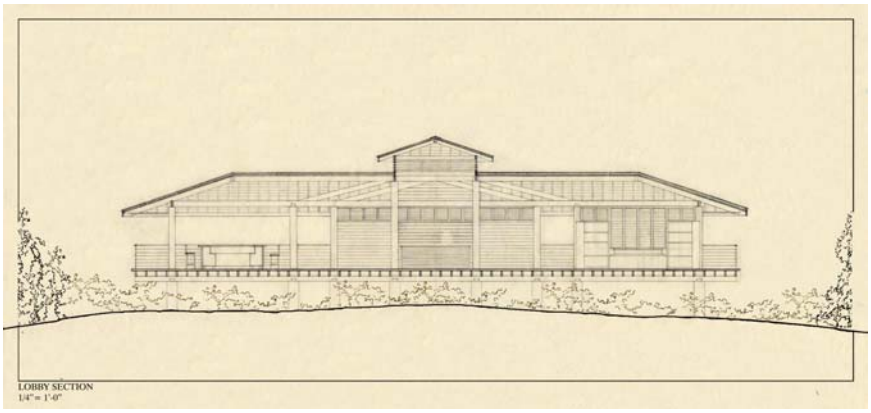

Fig. 51 Lobby Section

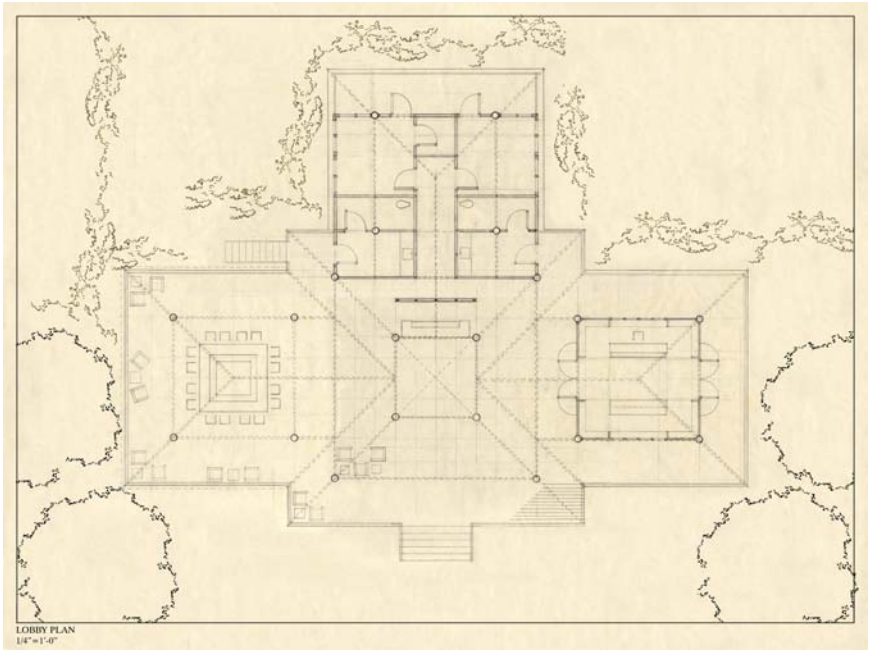

Fig. 52 Lobby Plan

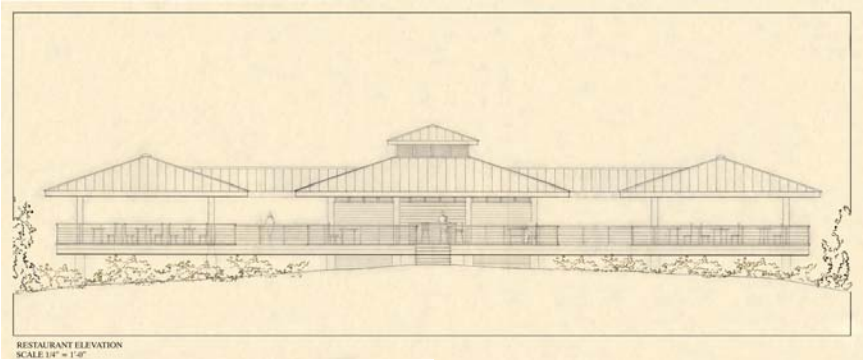

Fig. 53 Restaurant Elevation

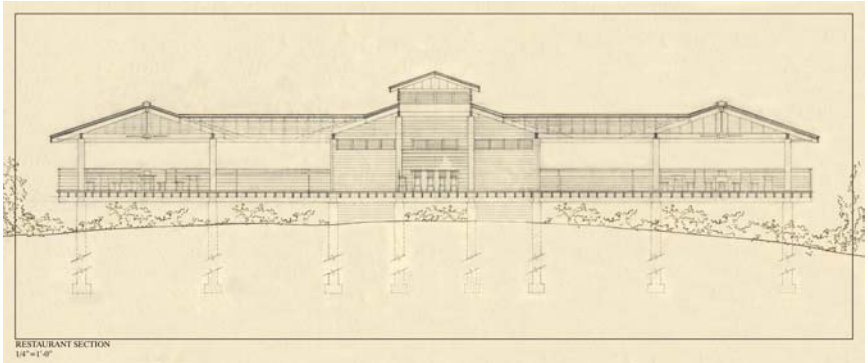

Fig. 54 Restaurant Section

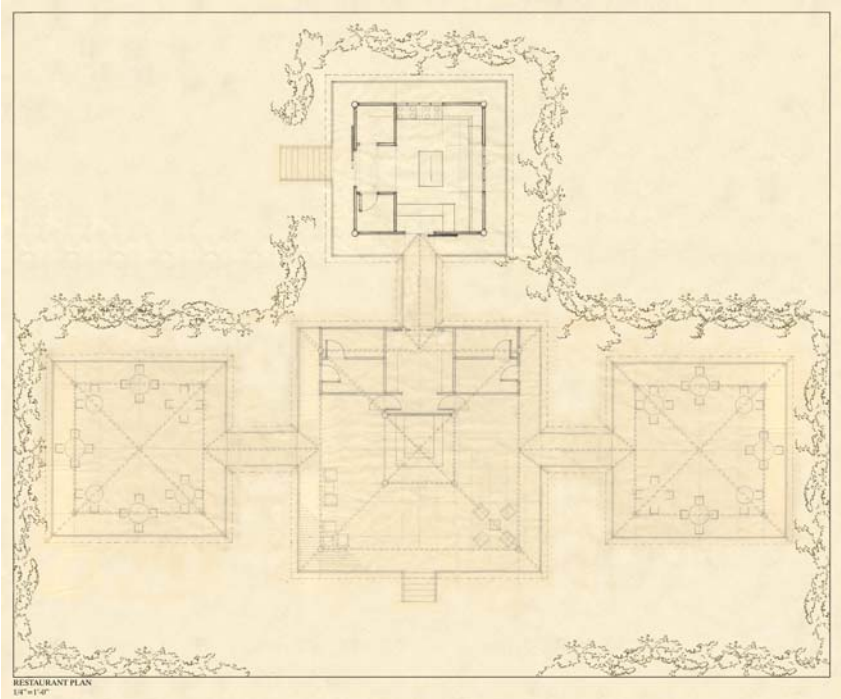

Fig. 55 Restaurant Plan

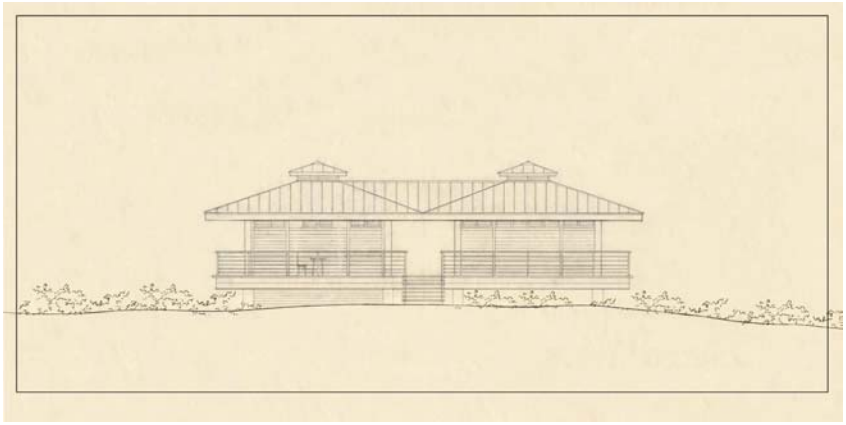

Fig. 56 Café/ Reading Pavilion Elevation

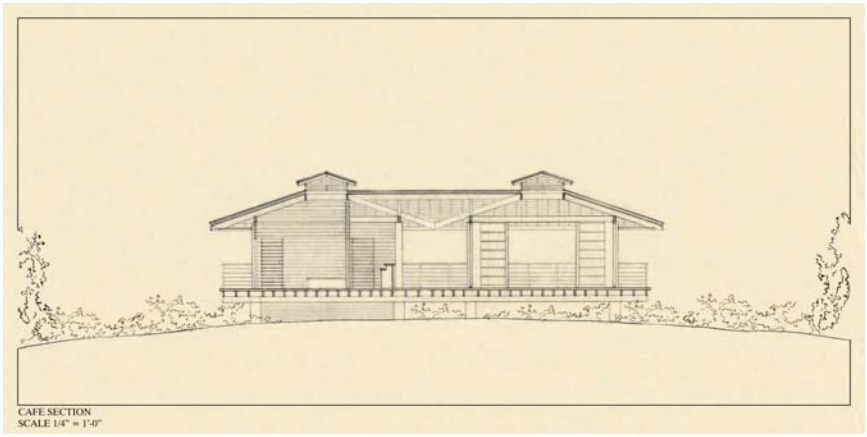

Fig. 57 Café/ Reading Pavilion Section

BIBLIOGRAPHY

Aronsson, Lars. The Development of Sustainable Tourism. New York: Continuum, 2000.

Buisseret, David. Historic Architecture of the Caribbean. Kingston: Heinemann, 1980.

Bonnet Benítez, Juan A. Vieques en la Historia de Puerto Rico. San Juan: F. Ortiz Nievas, 1976.

"Centro per le Vacanze, nelle Virgin Islands" Domus Aug. 1965:12-13.

Crain, Edward E. Historic Architecture in the Caribbean Islands. Gainesville, Fl: Florida University Press, 1994.

Dixon, John M. "The Art of Accomodation" Progressive Architecture Apr. 1994: 92-95.

The Encyclopedia of Ecotourism. Ed. David B. Weaver. New York: CABI Publishing, 2001.

Givoni, B. Man, Climate and Architecture. London: Applied Science Publishers LTD, 1976.

Gravette, Andrew. Architectural Heritage of the Caribbean. Princeton: Markus Wiener Publishers, 2000.

Guias para el desarrollo Sustentable de Vieques: Grupo de Apoyo Tecnico y Profecional

Honey, Martha. Ecotourism and Sustainable Development. Washington, DC: Island Press, 1999.

Huffadine, Margaret. Resort Design: Planning, Architecture, and Interiors. Washington, DC: McGraw-Hill, 2000.

"Inviting Virgin" Progressive Architecture Sept. 1965: 191-195.

Jopling, Carol F. Puerto Rican Houses in Sociohistorical Perspective. Knoxville: The University of Tenessee Press, 1988.

Kureja, C.P. Tropical Architecture. New Delhi: Tata McGraw-Hill, 1978.

Langhorne, Elizabeth. Vieques: History of a Small Island. Vieques, PR: The Vieques Conservation and Historical Trust, 1987.

Olgyay, Aladar and Victor. Solar Control and Shading Devices. Princeton, NJ: Princeton University Press, 1957.

Olgyay, Victor. Design with Climate. Princeton: Princeton University Press, 1963

Rivera Martínez, Dr. Antonio Así Empezó Vieques. Rio Piedras: UPR, 1963.

Rutes, Walter A., Richard H. Penner, and Lawrence Adams. Hotel Design: Planning & Development. New York: W.W. Norton & Co., 2001.

Slesin, Susan et al. Caribbean Style. New York: Clarkson N. Potter, Inc., 1985.