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BEACH CONDITIONS & STABILIZATION ALTERNATIVES FOR TAMARIND BAY CONDOMINIUM, GRAND CAYMAN

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This report presents the results of field inspections that were performed in May 2003 to investigate the beach erosion problem at the Tamarind Bay Condominium on Seven Mile Beach on Grand Cayman Island, and to determine alternatives that can be considered to restore and stabilize the beach at this site.

Field Investigations

Site investigations were performed on May 26 to 28, 2003. This included inspections and photographs of the beach areas at the property (see Figure 1), and the beach areas to the south and north along Grand Cayman's Seven Mile Beach western shoreline. Historical information and photographs of the shoreline were reviewed.

Figure 1. Views North (left) and South (right) of the Tamarind Bay shoreline.

On May 26 and 27 two beach profile lines were surveyed from the seawall out to a distance of over 300 feet seaward of the seawall to determine the water depths, bottom type, and bathymetry offshore. Underwater inspection of this nearshore area was performed by free diving.

The two profile lines were surveyed from the seawall running perpendicular to the shore at the center and southern areas of the property. The measured water depths were adjusted to reflect the beach and sea bottom elevations relative to normal low tide conditions. The profile line locations are shown in the December 2002 aerial photograph in Figure 2, and the cross-sections for the two profile lines are shown in Figure 3.

Figure 2. December 2002 Aerial Photograph showing the 2 Surveyed Profile Lines

The December 2002 aerial photograph in Figure 2 and cross-sections shown in Figure 3 show the narrow beach depicted in the photographs in Figure 1. The bottom offshore is comprised of sand and rocks, with a natural reef lying approximately 175 feet offshore of the seawall.

The recently completed Reef Ball submerged breakwater offshore of the Marriott can be seen in Figure 2, with a natural reef lying further offshore. The Reef Balls are located approximately 160 feet offshore of the Marriott seawall, and the natural reef is located approximately 220 feet offshore of the seawall.

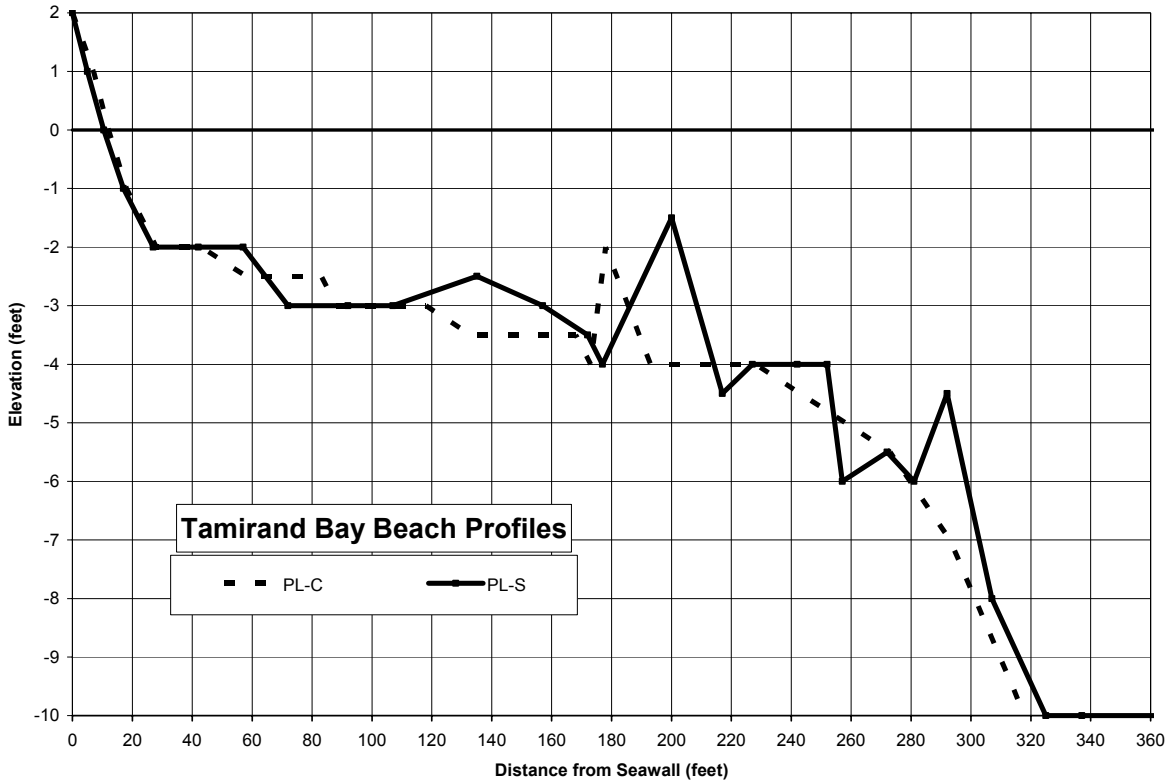

Figure 3. Beach Profile Lines Surveyed May 2003

The beach profiles shown in Figure 3 show relatively shallow water depths predominantly 3 to 3.5 deep from 75 feet offshore to the reefs that start at 175 feet offshore. The three beach profiles surveyed offshore of the Marriott in February 2002 (labeled north, center and south and shown in color) are shown together with the two Tamarind Bay beach profiles surveyed in May 2003 (labeled PL-C and PL-S and shown in bold and dashed black lines) in Figure 4, to show the differences in water depths and offshore reefs in these 2 locations.

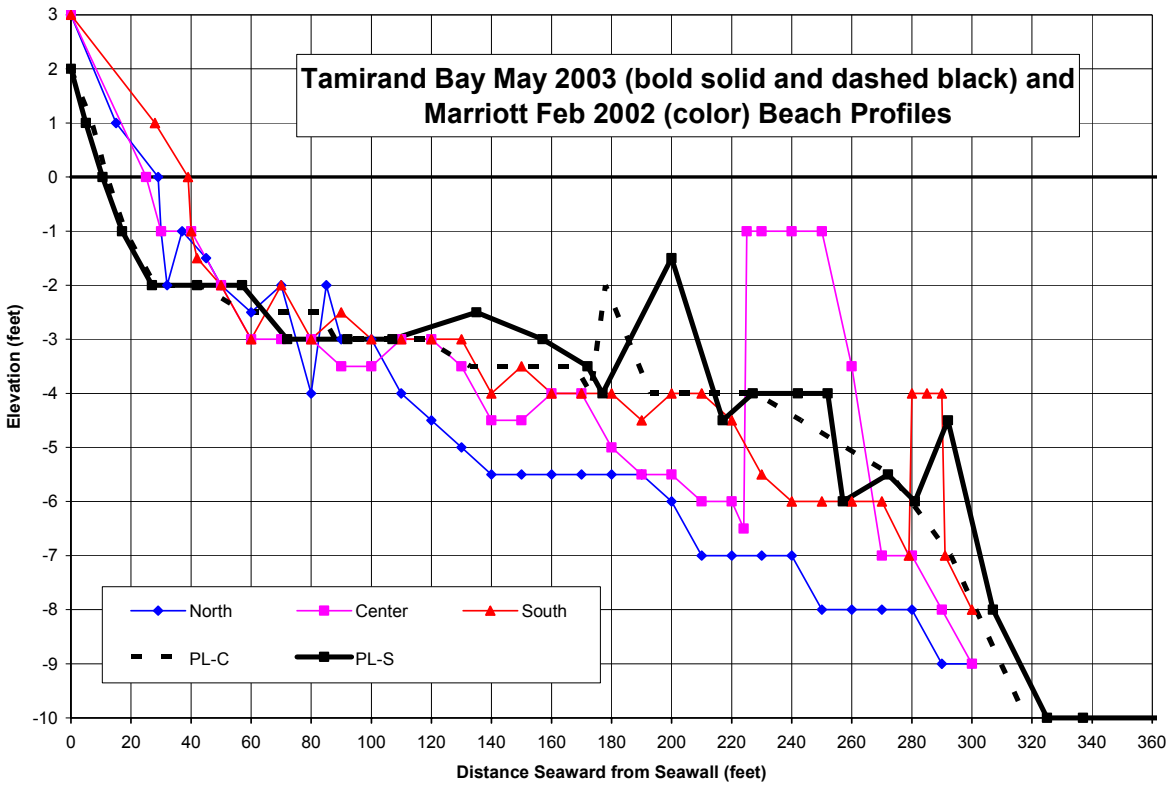

Figure 4. Tamarind Bay and Marriott Beach Profile Lines

Figure 4 shows that landward of the natural reef (distances 140 to 170 feet from the seawall), the water depths are 4 to 6 feet at the Marriott, but only 2.5 to 3.5 feet deep at Tamarind Bay. This indicates that the 4'-high Ultra Ball size Reef Ball units used for the Marriott are too tall to be deployed as submerged breakwater units at the same offshore distance at Tamarind Bay. Therefore smaller 3'-high Pallet size Reef Ball units could be used if a similar submerged breakwater system is installed for the Tamarind Bay and/or adjoining properties.

Figure 5 shows the plan view of the Marriott beach profile survey data taken in February 2002. The natural reef and water depths offshore of the Marriott are shown, as is the location of the Reef Ball artificial reef submerged breakwater.

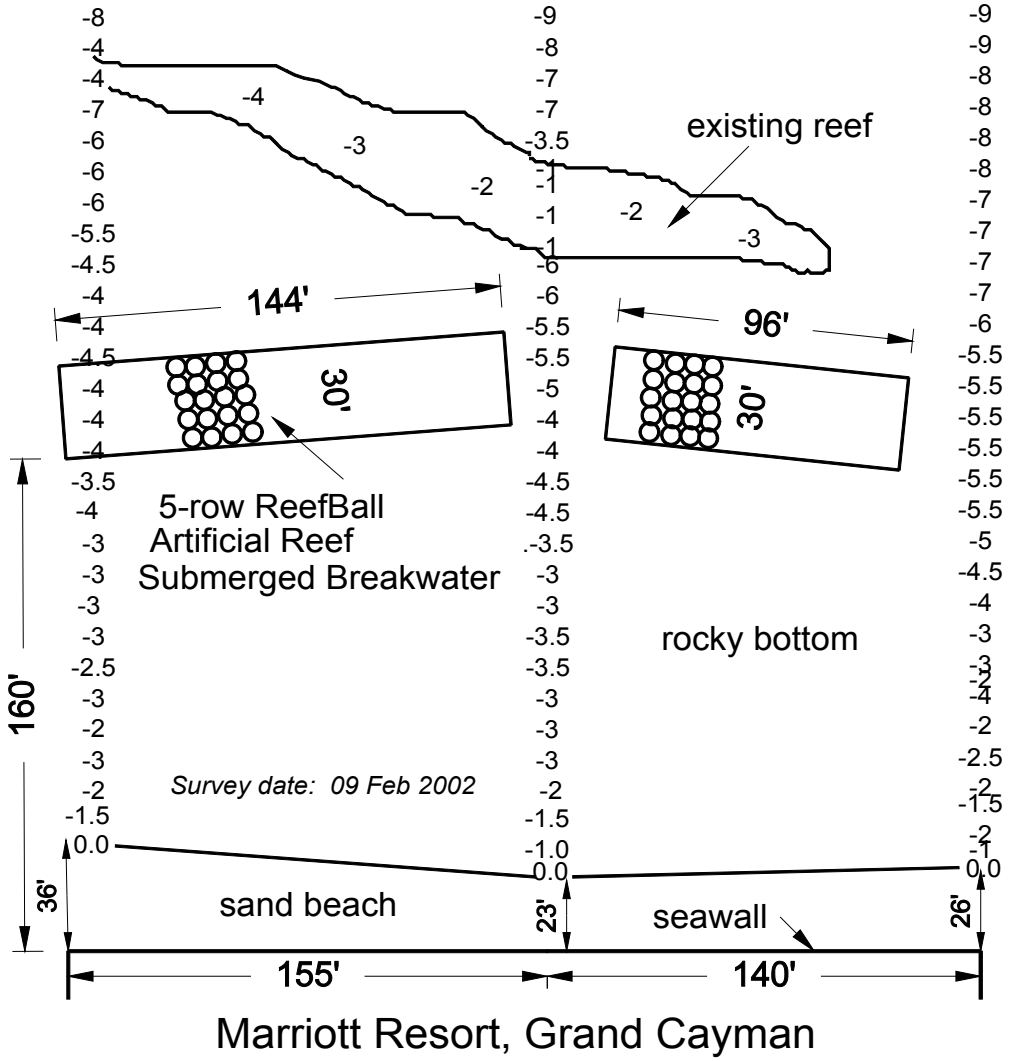

Figure 5. Plan View of the Marriott Profile Lines and Original Conceptual Design for the Reef Ball Artificial Reef Submerged Breakwater (north is to the right)

Beach Erosion Problem

The Tamarind Bay Condominium lies at the southern end of Seven Mile Beach. The beaches in this area currently are very narrow, having last been stripped of sand during the past winter/spring of 2003. The area was severely eroded by previous tropical storms and hurricanes, most notably the recent Hurricane Michelle in November 2001. The beaches do become wider as you go further north along Seven Mile Beach.

To the south of Tamarind Bay, there is a short stretch of sand beach followed by a rocky shoreline as you approach the Treasure Island Resort. There are some rock groins that were constructed in this area, and the shoreline here curves around to the east. This rocky shoreline to the south and reorientation of the shoreline effectively blocks any potential transport of sand from the south to the southern Seven Mile Beach area.

Therefore the Tamarind Bay beach area is particularly susceptible to erosion from waves coming from the southwest, due to the lack of sand along the coast to the south. Waves from the southwest, especially during storm events, transport sand to the north. Waves from the northwest tend to transport sand to the south along the Seven Mile Beach area, but this occurs at a much slower rate, and recurring southwest waves over the past few years have prevented the beach from accreting out to the beach width that the area had prior to 1996. Due to the erosion of the beaches along the southern reach of the Seven Mile Beach area, natural sand accretion and return of the beach width to that in the mid 1990's could take several years, if at all, and any future southwest wave events will further erode the beaches in this area, and slow this natural recovery.

Alternatives for Beach Restoration and Stabilization

Based on the field investigations of the Tamarind and surrounding areas, alternative methods for restoring the beach and stabilizing the shoreline were developed. For the Tamarind Bay beach, beach restoration and stabilization alternatives include beach renourishment with sand fill, shore perpendicular groins to stabilize this beach sand fill, a shore parallel sill to perch the beach sand fill, and an offshore submerged artificial reef breakwater. These alternatives are discussed in the following sections.

Beach Renourishment with Sand Fill

Beach nourishment with sand fill has been performed along Seven Mile Beach in the past by trucking sand in from an upland sand source. Hydraulically pumping sand from offshore to renourish the beach is another method that can be considered for this site. Beach renourishment with sand fill is the most direct way to restore the beach, but with no structures to hold this sand in place, the sand will be easily eroded and redistributed along the shoreline.

Shore Perpendicular Groins

Shore perpendicular groins can be used to hold sand on the beach, preventing it from being washed along the shoreline. By themselves, groins can trap sand on one side, while causing erosion of the beach on the other side. This can be minimized by using short groins, and adding sand to the beach to fill the groins immediately after they are installed. The use of groins as terminal structures to stabilize sand fill placed on the beach by Alternative 1 would increase the longevity of the beach fill, but could adversely affect adjacent beaches. Rock

groins can impede pedestrian travel along the beach, so that the use of a design such as sand-filled containers shown in Figure 6 to form the groins should be considered to allow pedestrian travel across them.

Figure 6. Sand-filled Groins Stabilizing a Florida Beach

Perched Beach

Another method to assist with holding sand on the beach is to install a shore parallel structure seaward of the seawall, and fill the area between this structure and the seawall with fill. The ends of the sill structure must curve back to the seawall at the north and south ends of the property. This shore parallel structure functions as a sill to hold the sand on the beach.. The use of a step-faced sand-filled container such as that shown in Figure 7 allows pedestrian traffic along and up and down the structure when it is exposed.

Figure 7. Sand-filled Container with Step-face

Submerged Breakwater

A submerged breakwater reduces the wave action that reaches the beach, thereby assisting to stabilize the shoreline. The use of artificial reef units for a submerged breakwater also provides underwater habitat, enhancing the environment.

Unlike traditional breakwaters that project above the water surface and stop all wave action, submerged breakwaters allow the smaller waves to pass over the structure so that sand transport along the coast is maintained during normal conditions. During large wave events, the larger waves are forced to break on the submerged breakwater, thereby reducing the wave energy reaching the beach from large waves, and reducing the associated beach erosion. The disadvantage of submerged breakwaters is that they become less effective as their depth of submergence increases, so that they are less effective at reducing wave action during elevated water levels due to storm surge.

Artificial Reef Submerged Breakwater Project Design

To stabilize and enhance the beach at the Grand Cayman Marriott Resort, an artificial reef submerged breakwater was installed to reduce the wave action reaching the beach. This has assisted in stabilizing the shoreline by reducing the wave action that impacts and erodes the beach, especially when the waves strike and reflect from the vertical seawall. The existing reef offshore of the hotel is only sufficiently wide and high enough to assist with wave attenuation over a short distance, which is where the gap between the two breakwaters was installed.

The recommended design for beach stabilization for Tamarind Bay using Reef Ball™ artificial reef units is presented in this section. Due to the shallower water depths, Pallet Ball reef units are recommended to provide a 30-foot wide submerged breakwater. The 3-foot high artificial breakwater units should be installed in low tide water depths of 3.5 to 4 feet, so that the top of the units will be slightly below the lowest normal water level (0.5 to 1.0 feet). The base width of the Pallet Balls is 4 feet, so that 7 rows of Pallet Ball units would be necessary to achieve the same width as the 5 rows of the 6-foot wide Ultra Ball units used for the Marriott.

Table 1 shows the various sizes and weights of Reef Ball™ artificial reef units that are available. Microsilica and other additives are used in the concrete to increase the strength and workability plus decrease the pH of the concrete to that of marine environment.

Table 1. Reef Ball™ Sizes, Weights, Volume & Number of Holes

Style	Width	Height	Weight	Concrete Volume	No. of Holes
Ultra Ball	6 feet (1.83m)	4.5 feet (1.37m)	4000-6000 lbs (1814-2722 kg)	1 yard 0.76m^3	29-34
Reef Ball	6 feet (1.83m)	4 feet (1.22m)	3000-6000 lbs (1360-2722 kg)	0.75 yard 0.57m^3	29-34
Pallet Ball	4 feet (1.22m)	3 feet (0.91m)	1500-2200 lbs (680-998 kg)	0.33 yard 0.25m^3	17-24
Bay Ball	3 feet (0.91m)	2 feet (0.61m)	375-750 lbs (170-340 kg)	0.10 yard 0.08m^3	10-16

The sea bottom where the submerged breakwater is proposed consists primarily of barren rock with some patches of sand, so that scour and settlement of the artificial reef units are not a problem. For increased stability of the structure, sleeves for fiberglass rebar will be pre-cast into the Reef Ball™ units, with fiberglass rebar driven or drilled into the bottom to provide additional resistance to sliding of the units as they are deployed. Due to the smaller

size and hence smaller weights of the Pallet Ball units, the anchoring to the bottom is extremely important to ensure stability and longevity of the breakwater. If desired, the central cavities of the Pallet Ball units can be filled approximately one-third full with small rocks to provide additional weight and habitat.

The field work performed for this report was adequate to determine the viable options for shoreline stabilization, to evaluate the suitability and effectiveness of various alternatives, and to develop conceptual designs. A more accurate and thorough survey of the offshore bathymetry is required to more precisely define the exact location of the breakwater.

Conclusions

The southern end of Seven Mile Beach, including Tamarind Bay, has a beach erosion problem. At the time of the site inspection for this report, the sand beach is gone, and although it is expected to recover by sand transport into the area from the north, the beach continues to be eroded away by waves coming from the southwest each year.

As discussed in this report, there are several alternatives that can be used to stabilize and restore the beach. The most direct approach is to add sand to the beach, and this method has been employed in the past, but the sand is easily eroded away by southwest waves. Structures such as groins or a nearshore sill can be employed to assist in holding the sand in place, but these structural elements can affect the adjacent beaches, and impede the natural transport of sand as well as pedestrian traffic along the beach.

The recommended and most environmentally friendly option is an offshore submerged breakwater to reduce the wave action reaching the beach. The use of artificial reef units to form a submerged breakwater provides marine habitat, as well as allowing some of the wave action to pass through and over the breakwater so that the natural flow of sand along the beach can continue. The conceptual design of a 7-row Pallet Ball^{TM} artificial reef submerged breakwater is presented in this report.