Kuhio Beach Improvements
Summary of Beach History and Engineering Design

Through tourism, Waikiki has developed into an 'economic engine' for the State of Hawaii. Waikiki, having long been known for its' vibrant beaches and beach lifestyle, is likely one of the most recognizable images of Hawaii, witnessed around the world for generations. Revenue generated throughout this urban corridor constitutes 44% of the $11.4 billion originating from annual tourism expenditures in Hawaii and is responsible for 140,000 jobs[1]. The thriving economy of Waikiki is directly dependant on the appeal of the sand beach, the cleanliness of the water.

Kuhio Beach has a long history of engineering and beach nourishment having undergone regular beach nourishment to maintain a sandy beach since 1939 when the north section of the Kuhio beach breakwater was built. Past beach nourishment efforts have been carried out regularly but there has been little done to maintain Kuhio Beach since the last major nourishment effort in 1975 (Figure 1). At Kuhio Beach it is necessary to perform regular beach nourishment to maintain an attractive and useful beach for visitors and tourists alike.

Figure 1. Beach Nourishment in Kuhio Beach

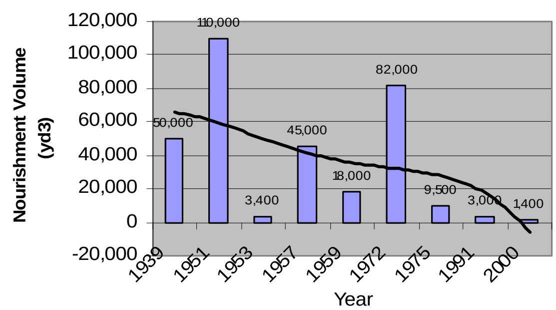
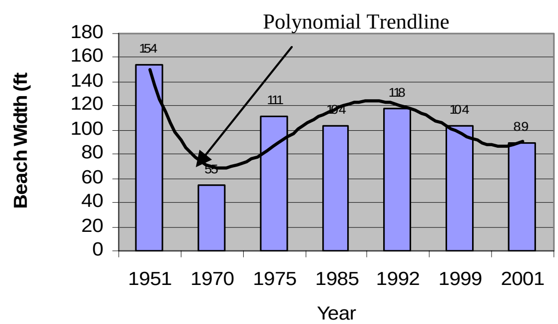


Figure 2. Ave Beach Width Kuhio Beach



Despite these efforts, today major segments of the beach have little to no sand at high tide and few will disagree that overall, the beach here is in a degraded state. Beach loss in Kuhio Beach is characterized by a 65 foot decrease in the average beach width from 1951 to 2001 with the widest beaches in 1951 and the narrowest in 1970 (Figure 2). A recent

[1] *Economic Contribution of Waikiki*. Department of Buisiness Economic Development and Tourism. May, 2003

historical shoreline study[2] conducted for the Department of Land and Natural Resources reveals that despite regular nourishment of the beach (over 300,000 yd^3 collectively), Kuhio Beach has exhibited chronic erosion at an average rate of (-0.7 ± 0.3 ft/yr) for the timer period 1951-2001. A recent economic study for Waikiki revealed, 12.6% of those visitors polled would not return to Hawaii because of overcrowding and congestion. The estimated 249,329 lost visitors represent 3.6% of the 6,948,595 total State visitors in year 2000. Estimated losses in Waikiki are $181 million including more than 5,000 jobs, $111 million in labor income and nearly $21 million in State and local taxes[3].

It is time to reinvest in more efficient and robust modern engineering designs for this important area. Modern coastal engineering designs can restore a more permanent and functional beach system in Waikiki with improved water quality, aesthetic appeal and access. The proposed new design for Kuhio Beach calls for the removal of portions of the shore-parallel offshore breakwater and installing three "tuned T-head groins" in the original footprint of the breakwater (Figure 3).

Figure 3. Kuhio Beach T-Head Conceptual Design

Proposed design of Kuhio Beach. The new design would entail opening up the Kuhio basin using "tuned" T-head groins and adding sand to restore the beach. This is the site of Waikiki's first beach nourishment in 1939 and continues to be an erosion hotspot to this day.

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[2] *Waikiki Analysis of an Engineered Shoreline.* Nov 2002. Prepared for the DLNR by Tara Miller and Charles Fletcher University of Hawaii, Dept of Geology and Geophysics.

[3] Regional *Economic Benefits of Waikik,* Department of Land and Natural Resources May, 2003

Figure 4. Rendition of T-Head Conceptual Design .

These “T-head” groins would improve the existing conditions in several ways: improve water quality by increasing circulation; stabilize the beach face utilizing the predominant wave energy to push sand into the beach; improve access to the swimming and surfing sites; improve public safety by removing the hazardous breakwater offshore; and improve the general aesthetics of the area by reducing the amount of hard structures (Figure 4).

Recent surveys indicate there is an extensive sand reservoir offshore Waikiki that would provide an excellent source of recycled beach sand through offshore sand pumping. By redesigning some of the shoreline structures in Waikiki, we can improve the efficiency of these structures at retaining sand and enhance the quality of the beach at the same time.

Figure 5. Kuhio Beach and Offshore Sand Fields .

History of Development[4]

1913-1919 Majority of Waikiki has seawalls emplaced to protect roadways and new buildings, beach is lost fronting Kuhio and Queens Beach.

1910 Major sand excavation at Queen Liliokulani residence fronting Royal Hawaiian and Moana beaches causing massive erosion and coral cobble accumulation on beach.

1927 170 foot groin built at West end of Royal Hawaiian Beach. Extended to 368 feet in 1930.

1938-1939 700 foot long, shore-parallel, Kuhio Beach breakwater built. Elevation at mean lower low water (MLLW) known as the "Crib Wall." Area landward of crib wall cleared of coral patches by dragline and 7000 cubic yards of sand added to beach. Cemented sandbag groin built at western end of crib wall. (Figure 6).

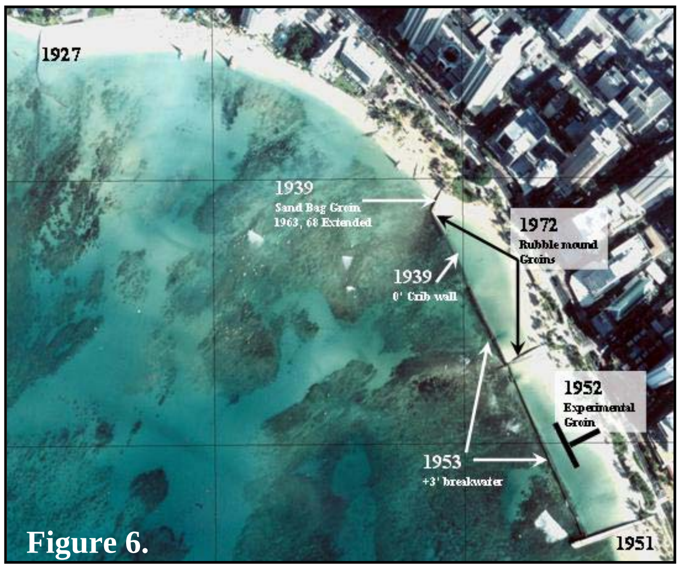

Figure 6.

1951-57 ***Waikiki Beach Development Project***

1951 Kapahulu Storm drain built 355'X 19' X 8.5'. 110, 000 cubic yards of sand added to beach from "Breakers" 1000 feet southeast of storm drain to Kuhio Beach. One report states 107,000 cubic yards added to Kuhio Beach alone.

1952 Experimental T-Head Groin built in what is now the center of the Diamond Head basin. Unknown design and specifications.

[4] Data from *Waikiki, Oahu, Hawaii, An Urban Beach its History from a Coastal Engineering Perspective.* November 2002. Dr. Robert Wiegel University of California Berkely. Hydraulic Engineering Laboratory Technical Report UCB/HEL 2002.

1952-53 730 foot long shore parallel extension built to southeast of crib wall replacing T-head groin, crest at +3 feet. Swimming area dredged and unknown quantity of sand added to beach.

1956-1957 360 foot-long Queens Surf groin/storm drain built.

1957 Kapiolani Park Beach dredged and 35,000 cubic yards of sand placed on beach.

1959 Kuhio Beach 18,757 cubic yards of sand placed.

1963 Cemented Sand bag groin at western end extended. Extended again in 1968.

1972 82, 000 cubic yards of sand delivered to Queens and Kuhio Beach. Highway retaining wall removed. Beachwalk park between Kalakaua Ave and Queens and Kuhio Beaches.

1972 Rubble mound groins at west and central basin incorporated into crib wall replacing sandbags groins and enclosing the basins.

1975 Kuhio Beach, 9,500 cubic yards of sand added.

1991 Kuhio Beach 3000 cubic yards of sand added.

2000 Kuhio Beach. Pilot offshore sand pumping project 1,400 cubic yards delivered from offshore Queens (Figure 7).

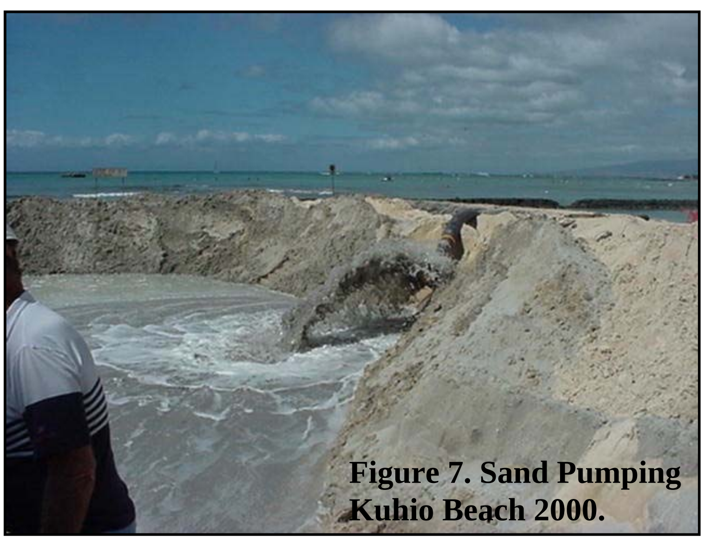

Figure 7. Sand Pumping Kuhio Beach 2000.

Summary of Facts

1. ***Water Quality:***

   Completion report by Fujioka and Morens[5] found that storm drain water contains high levels indicator bacteria likely from the soil. They conclude that although there is no immediate health risk due mixing with the ocean of the storm water discharge at Kapahulu drain, "prudence states that it is not a good decision to allow a storm drain to discharge so close to a swimming area." They recommend that the water within Kuhio Beach should have better circulation and that the storm water discharge be relocated by extension or by changing the walls and jetties.

2. ***Erosion and sand loss:***

   Evidence shows that the current breakwater design is not effective at retaining sand. Since 1953, when the main breakwater section was completed a total of nearly 160,000 cubic yards of sand has been added to Kuhio Beach. **This averages to a loss of about 3,200 cubic yards of sand per year for the last 50 years.** This is in addition to regular beach scraping that the City and County carries out to reshape the beach face. The current breakwater design fails in several ways:

   a. Ineffective at retaining placed sand. Closed off to wave energy that would normally deliver sand onto beach from nearshore. Wave overtopping causes increased water levels inside of walls and accelerate currents that remove sand on a one-way trip through narrow openings.
   b. Poor circulation of ocean water, increased potential for health hazards from storm water discharge.
   c. Breakwall causes reflection of incoming waves disrupting the nearshore surf.
   d. Current design presents significant safety hazard to the public with wave overtopping of a slippery surface and heavy public use of the breakwater.

3. ***Previous T-Head Groin:***

   Although very little information exists on the previous T-Head groin, it appears that it was in place for about 1 year and may have been an experimental design before installing the existing breakwater. It appears the design was faulty in several ways:

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[5] Fujioka, J.R., Morens, M. D. March 1994. *Assessing the Impact of the Kapahulu Storm Drain System on the Quality of Water at Kuhio Beach and the Health of the Swimmers using the Beach.* Project Completion Report. Prepared for State of Hawaii, Department of Health. Water Resources Research Center, University of Hawaii at Manoa.

a. Shore parallel breakwall design was an incorrect orientation to allow wave energy to transport sand to beach. Unknown breakwater height but may have been too low to protect from incoming waves.
b. Groin fields are more effective in a series or with defining boundary conditions. The predicted shoreline position is based on a general rule that the low water shoreline will be a distance from the structures of about 45% of the gap distance between headlands (The distance between the shoreline and the gap offshore is more or less linear to the width of the gap). In this case the "gap" between headlands was far too wide.

Proposed T-Head Design

4. Design consists of 4 stabilizing headlands, producing a scalloped shoreline (Figure 8). This would produce 4 beach cells with gap widths of 160 to 200 feet. The design principle is to create breakwater gaps that are parallel to the incoming wave energy thus allowing sand to be brought into the beach.

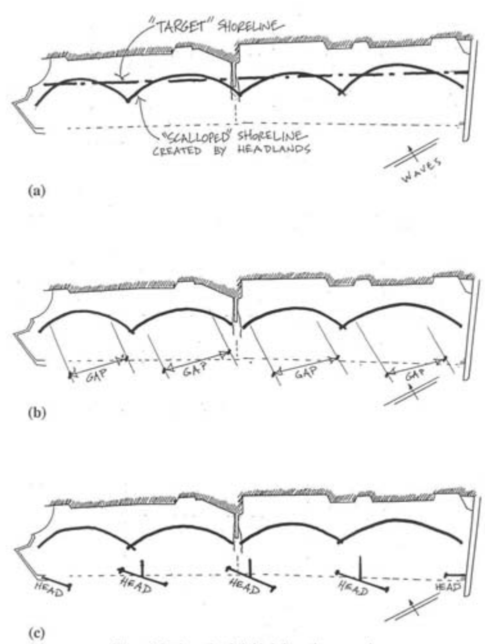


Figure 3: Design rationale behind alternative approach.

   a. Plans allows for adjustments to the design height and width of revetments. The existing revetments have an elevation of +3.0 feet. While a +5 foot design would be desirable from an engineering standpoint to reduce wave overtopping, it may be more practical to consider + 4.0 foot elevations.
   b. Typical Dimensions:

      Length: 180' (~ shore parallel).

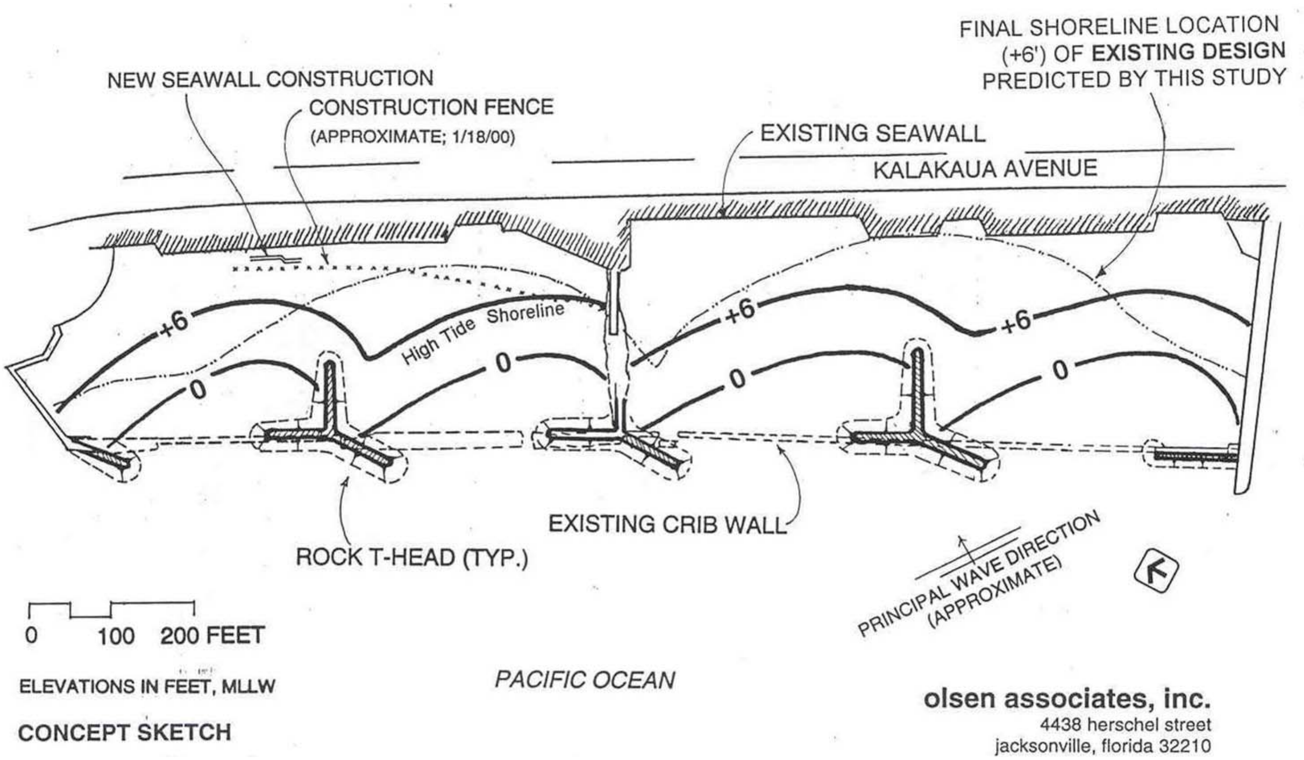
      Width: 30-40' base; 6-8' top. (or less).

      Gaps: 160 to 200 feet.

      Height: +4.0- 4.5'. Trunk or stems at +3.0'

   c. Rock armor for T-Heads roughly similar size to existing structures.

Figure 8. Proposed alternative design. Shaded areas of structures depict new construction.



5. *Advantages of proposed design include*:
   a. Shore parallel design will reduce or eliminate the existing “pinch points” where the beach is nonexistent and produce 3.2 acres of dry beach area.
   b. Reasonable to expect that the project will improve public safety.
      1.Size of gaps (200’) wide enough to ensure no fixed rip currents.
      2.Elimination of “Slippery Wall” hazard with wave overtopping.
      3.Allows rapid lifeguard access to outer surf areas, increases public access to the surf.
      4.Design will still provide quite water suitable for small children and non-swimmers in the lee of headland structures. Possible to retain a pool-like condition behind T-Head by retaining crib wall between one of the T-Heads but will degrade beach condition.

Please feel free to contact Sam Lemmo, of the Office of Conservation and Coastal Lands at 587-0381 or Dolan Eversole of the University of Hawaii Sea Grant Program 587-0321 if you have any further questions. Or visit us online at http://www.hawaii.gov/dlnr/occl/index.php

Existing Kuhio Beach Conditions: