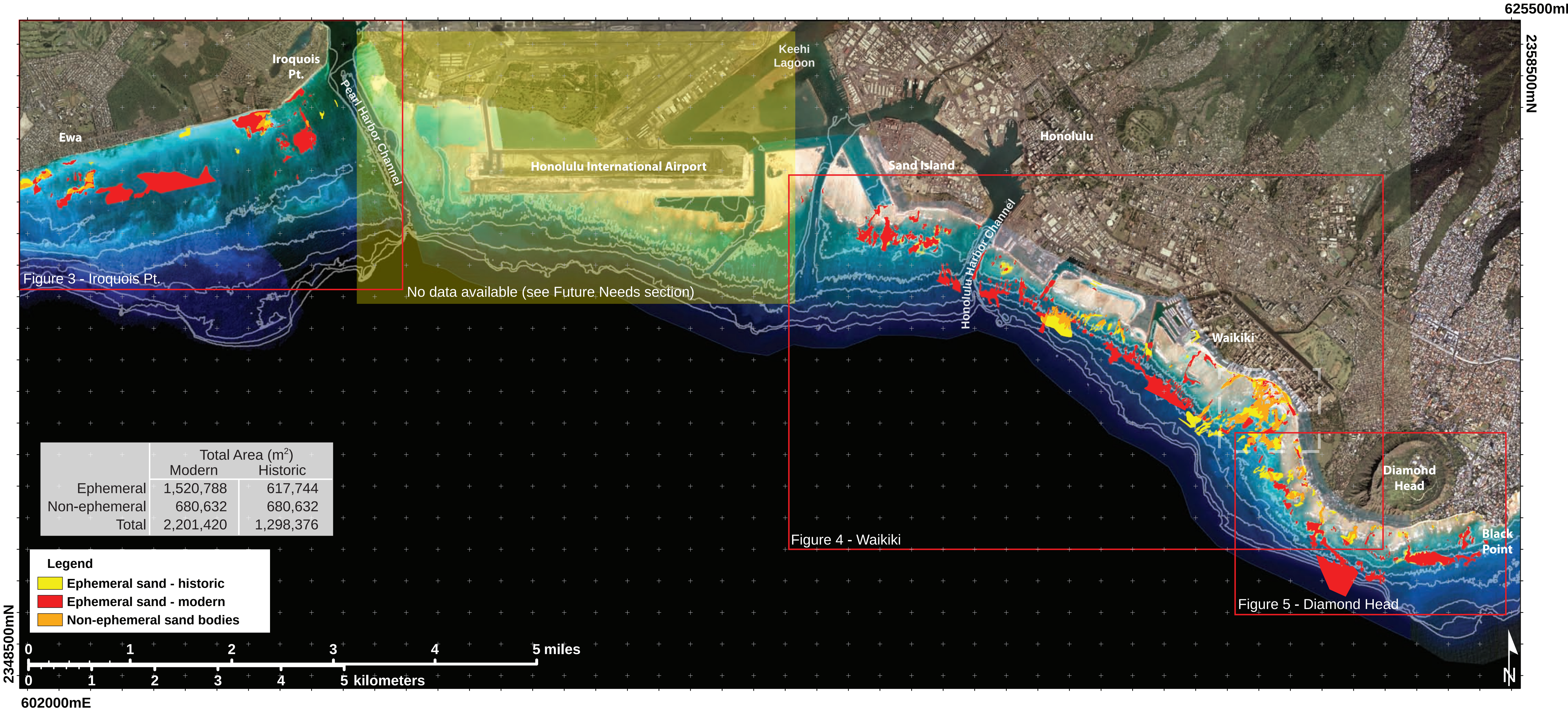
South Oahu Reeftop Sand Bodies



	Total Area (m^2)	
	Modern	Historic
Ephemeral	1,520,788	617,744
Non-ephemeral	680,632	680,632
Total	2,201,420	1,298,376

Figure 1 Digitized modern sand bodies (red) and historic (yellow) with intersecting (presumed non-ephemeral) bodies in orange. Base map is a 2005 Quickbird satellite image mosaic.

US Army Corps of Engineers

United States Army Corps of Engineers, Honolulu Engineering District
Department of Land and Natural Resources, Office of Conservation and Coastal Lands
University of Hawaii at Manoa, School of Ocean and Earth Science and Technology

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Reeftop Sand Body Analysis

Coastal high-resolution (0.5 m) ortho-photomosaics were selected as base maps to examine nearshore submarine sand fields. Changes in the extent of these sand bodies over time help differentiate ephemeral and non-ephemeral sand volumes that may indicate potential sand resources. A selection criterion for mosaic use was based on the date of the mosaicked photo base maps, and the quality of the water surface and water column properties for imaging the seafloor. Five years of orthophotomosaic coverage were identified for this study; four of these years constitute "historic" coverage while one year is used to delineate modern sand extent. Changes in sand surface area between historic and modern images are used to represent "ephemeral" vs "non-ephemeral" sand bodies.

Mosaics from 1949, 1950, 1967, and 1970 were selected as base maps to quantify historical sand body extent. Mosaic coverage from 2005 was chosen for the modern base map. All imagery was processed to map quality with Root Mean Square Error of < 2 m. Continuous sand bodies visible in each mosaic were manually digitized using ArcMap. ArcToolbox was used to extract the overlapping spatial extent of modern and historical sand body data; these provide sand body surface areas. The extent of mosaic coverage varies both within historical mosaic years and between historical and modern coverage. Historic coverage is compiled to approximate modern coverage bounds.

Sandy area that is unchanging between historical and modern datasets is inferred to represent relatively stable, 'non-ephemeral' areas of sand that may be of potentially significant volume. Sandy area with no spatial overlap indicates sand that has been transported within the past 50 years (the temporal extent of map coverage) and is not likely to be of sufficient thickness for use as a resource because it is ephemeral.

Water column clarity in portions of the historical mosaics varies significantly. Visual analysis of image data and bathymetry yielded a good correlation between depth and clarity (i.e. light attenuation through water increases with depth) except where surface glint (water surface reflectance) and suspended sediments in shallower water (< -5 m depth) obscure potential sandy substrate identification. These two sources of uncertainty affected sand body identification offshore of Ewa Beach Park to the west of Pearl Harbor Channel (see Figure 2). Modern coverage in these areas indicates significant sand (~350,000 m^2). However, no apparent bottom is visible in historic imagery due to large amounts of suspended sediment.

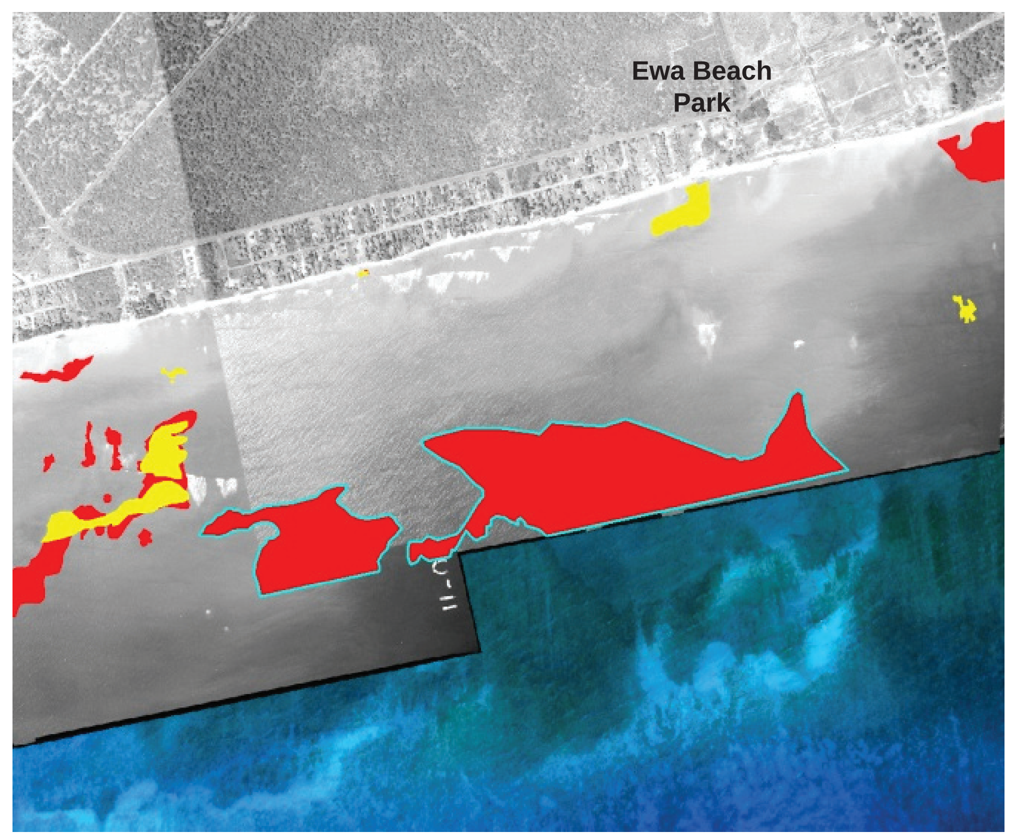

Figure 2 Modern sand bodies (red) and historic sand bodies (yellow); two modern sand bodies (red outlined with blue) are not visible in historic imagery (used as the base photo here). This is likely due to significant suspended sediment in the shallow water.

Sand body analysis of the south shore of Oahu between Ewa Beach and Black Point indicates approximately 680,000 m^2 of non-ephemeral sand. The Iroquois Pt. portion of the study area (Figure 3) between Pearl Harbor Channel and Ewa Beach contains approximately 100,000 m^2 of stable sand. The nearshore area is characterized by shallow (< -5 m) reef flat within the extents of available base map data. The water in this area is turbid with suspended sediments obscuring positive bottom identification in many of the historical base maps. Stable sand bodies are located within ~600 m of shore towards the east and west sections of the area near hard shoreline structures.

The central portion of the study area between the airport runway and Diamond Head (Figure 4) contains approximately 490,000 m^2 of apparently stable sand. The nearshore area is characterized by reef and hard bottom interspersed with sand pockets and fields in 0 - 15 m water depth. The remaining section of the study area between Black Point and Diamond Head (Figure 5) contains approximately 87,000 m^2 of apparently stable sand. The majority of this sand (75,000 m^2) is a single sand body between 5 and 10 m water depth.

Jet Probing

Reef-top sand resources at Waikiki were investigated using a "jet probe." Sediment thickness measurements (Figure 6) were obtained with a jet probe deployed from a small boat and operated by a researcher using SCUBA. The jet probe is built from a small diameter pipe connected to a shipboard water pump via fire hose. High-pressure water is pumped out of the pipe to displace sediment as the diver pushes it into sandy substrate. A volume of sediment is washed out of the hole by water pressure (called "outwash") affording observations of buried sediment texture, composition, and color. The probe stops penetrating when it contacts a boundary with bedrock or an impenetrable layer of consolidated sediment. Depth of penetration provides a measure of unconsolidated sediment thickness. The probe length is 3.0 m; if sand body thickness exceeds 3.0 m, a value of 3.1 m is recorded. Among reef-top sand bodies, few fields exceed the 3.0 m length of the probe. These sand bodies could be considerably thicker; hence all thickness interpolation labeled as 3.0 m and should be considered a minimum estimate. At each sample location three thickness measurements were taken within a 20 m radius of the anchored boat and the average is reported as the thickness at the site (see Bochicchio et al., 2009 for volume calculation methods).

Sand Body Research

The State of Hawaii and the island of Oahu (in particular), have a long history of offshore sand research. The primary references describing this work are Dollar (1979), who summarizes the early work, and Barry (1995) and Sea Engineering (1993) who update the summary to 1995. Sea Engineering (1993) also includes an analysis of sand samples from certain offshore sand fields.

(Continued on p. 6)

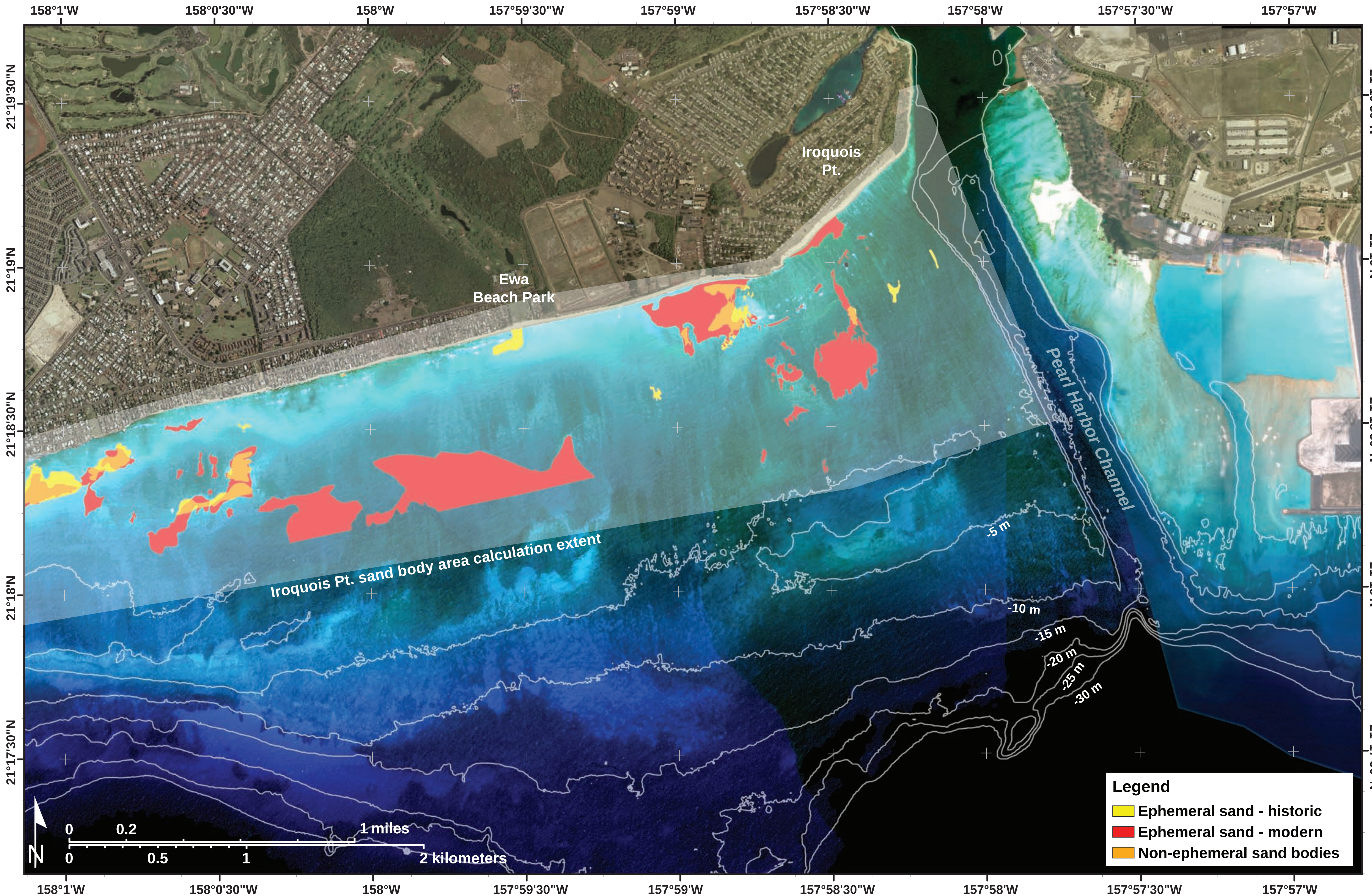

Figure 3 Iroquois Pt. reeftop sand resources. Results indicate approximately 100,000 m^2 of non-ephemeral sand within the Iroquois Pt. sand body area calculation extent (light shaded area).

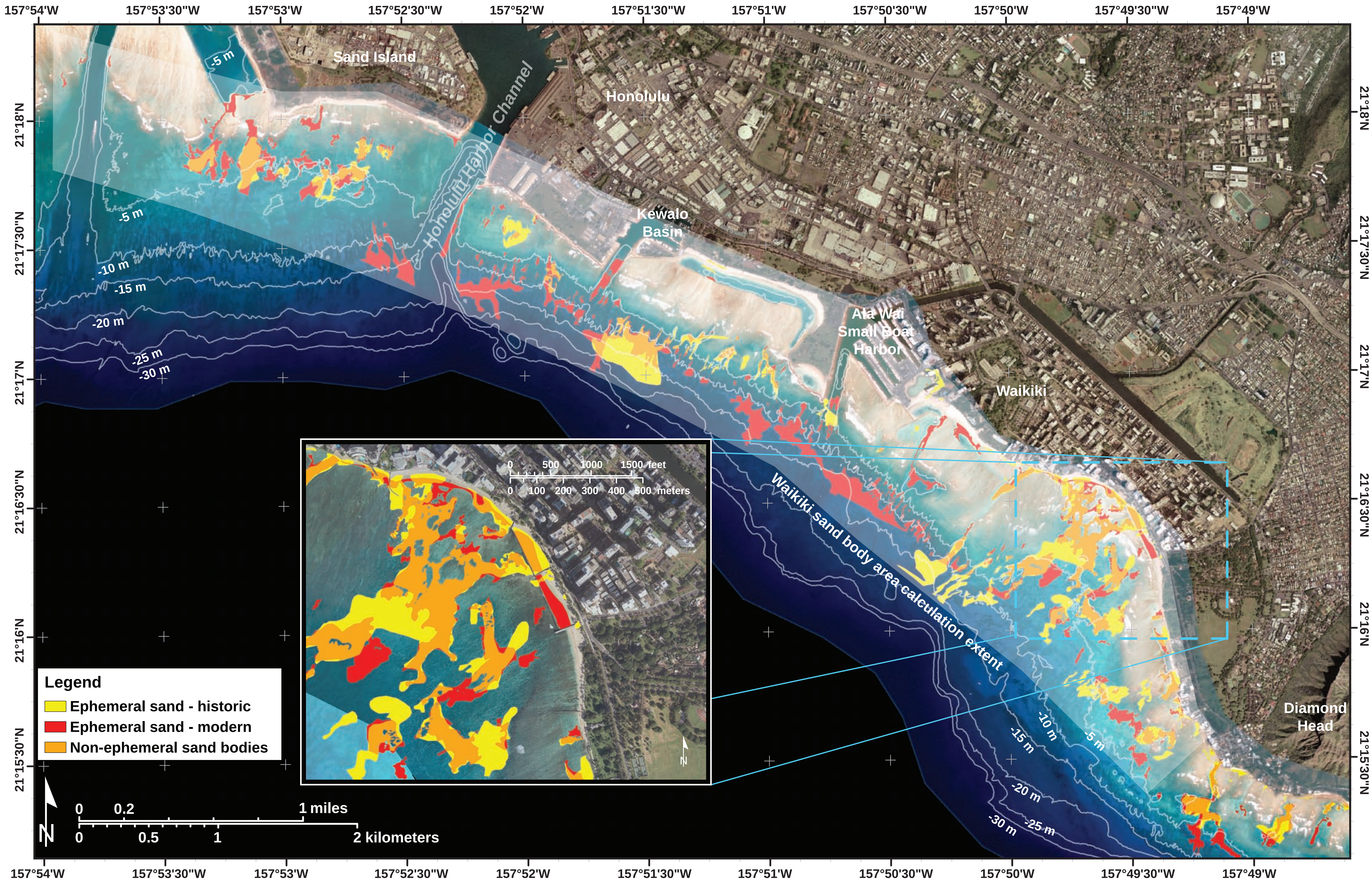

Figure 4 Waikiki reeftop sand resources. Results indicate approximately 490,000 m^2 of non-ephemeral sand within the Waikiki sand body area calculation extent (light shaded area).

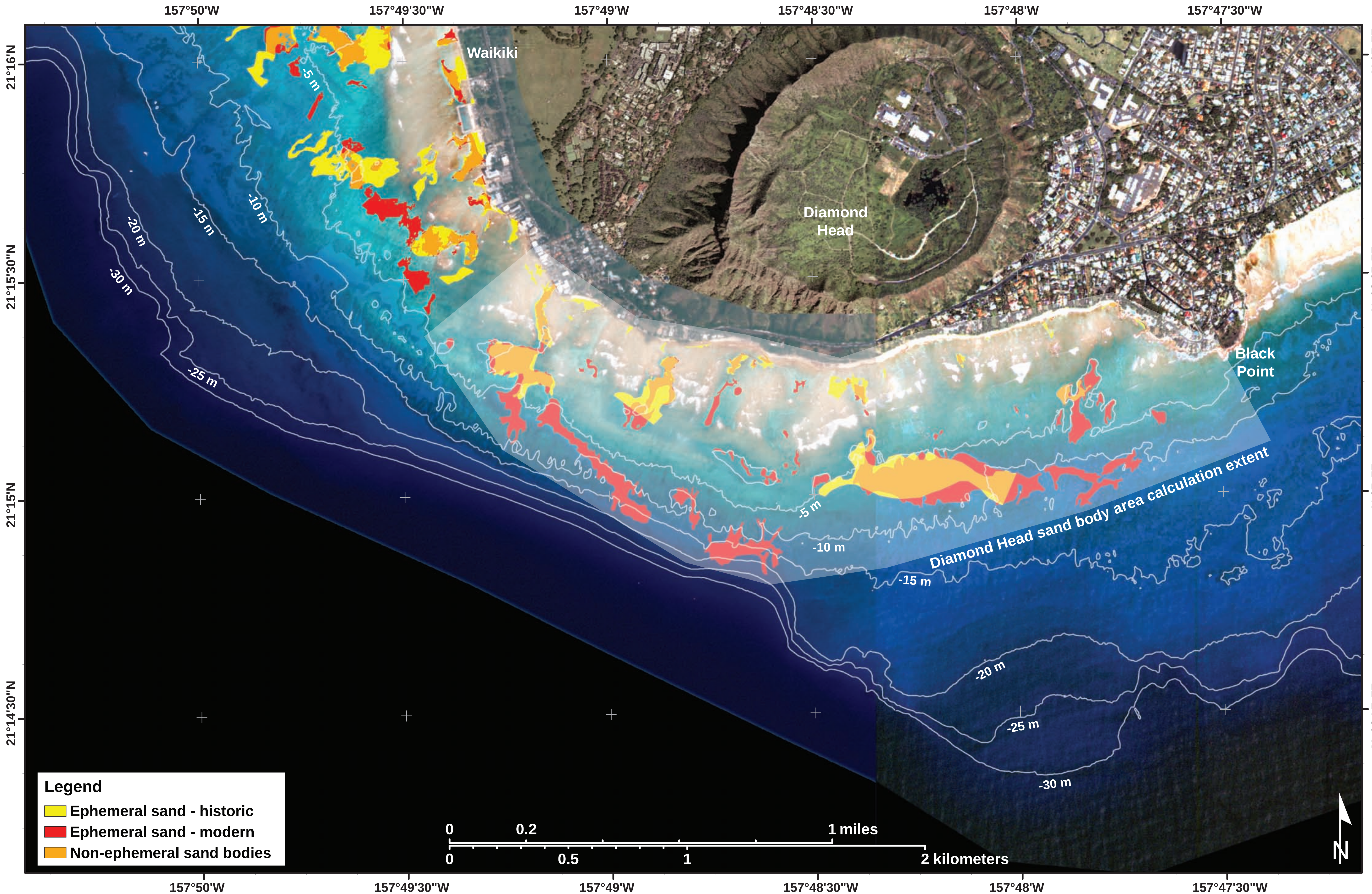

Figure 5 Diamond Head reeftop sand resources. Results indicate approximately 87,000 m^2 of non-ephemeral sand within the Diamond Head sand body area calculation extent (light shaded area).

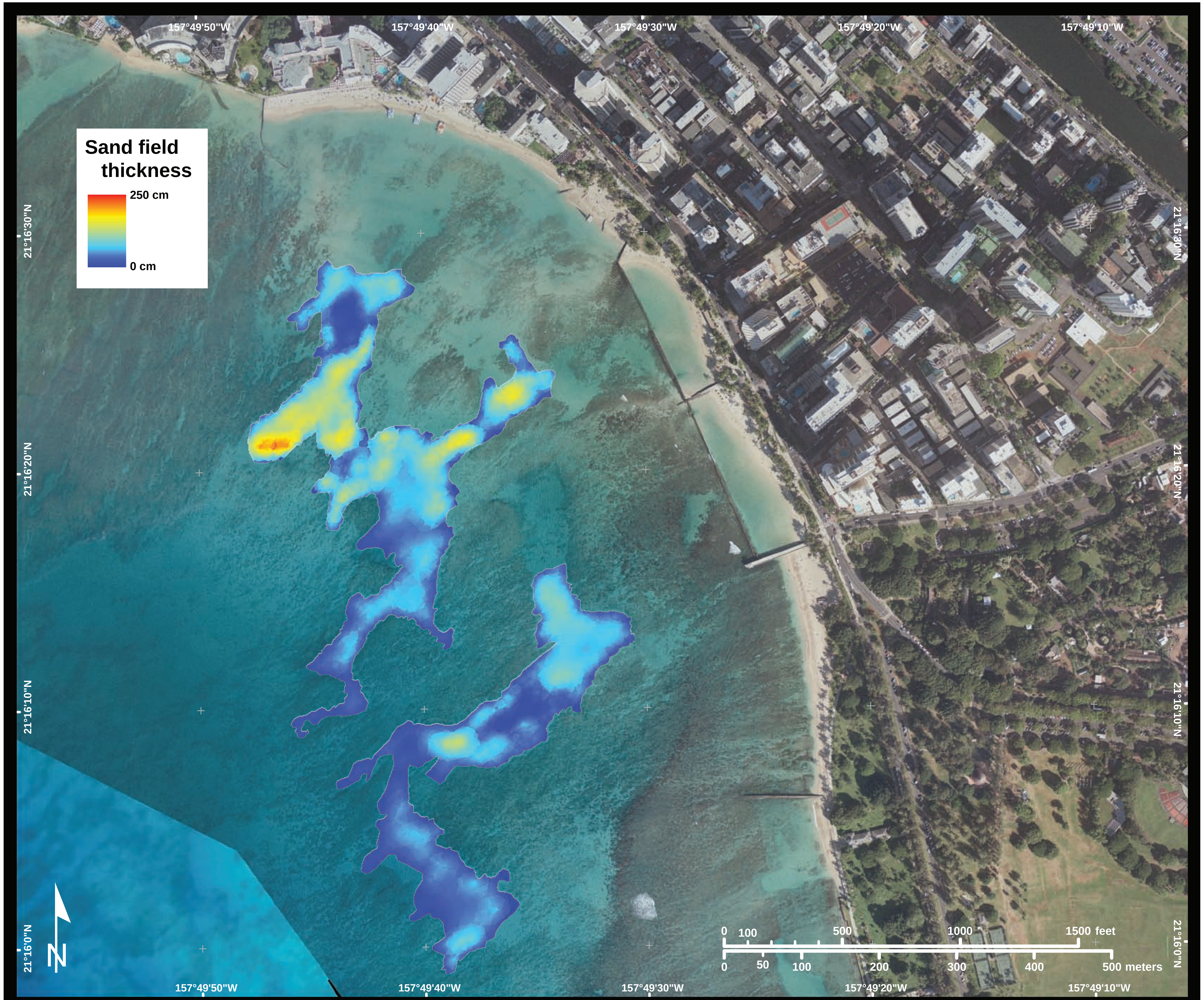

Figure 6 Jet probing of sand bodies in Waikiki reveals sand thickness from which sand body volumes may be calculated.

Monty Hampton with the U.S. Geological Survey conducted offshore sand body research for several years in the late 1990's and early 2000's. His Open File Report No. 03-441 (Hampton et al., 2003) provides original research on sand fields using sub bottom geophysical data and vibra-cores. The report includes photographs of cores and places emphasis on the need for sand resources to maintain Waikiki Beach – this is a valuable reference that can be accessed here: http://walrus.wr.usgs.gov/reports/ofr03-441.html; last viewed 12/17/09. This research provides seismic data and cores from fields around the entire island of Oahu.

Since Hampton et al, remote sensing and jet-probing have been employed to assess reef-top sand fields. An analysis of reef-top sand field resources at Waikiki, performed for the Hawaii State Department of Land and Natural Resources, was conducted by the University of Hawaii Coastal Geology Group. The data are provided in map form in this report. This data informed the decision-making with regard to the Kuhio Beach renourishment project (Eversole, 2004). Similar (though more extensive) work was published by Bochicchio et al (2009) for the windward region of Kailua, Lanikai, and Waimanalo. They probed over 200 sand fields to assemble a comprehensive database of reef-top sand resources. Another unpublished probing effort was performed on Maui where a dozen fields were probed along the West Maui coast between Napili Bay and Kaanapali.

This report builds on the work of Conger et al (in press) by extending the remote sensing identification of reef-top sand fields on the Oahu south shore between Ewa and Black Point. The map of these sand resources is provided herein. Additional work has been performed under commercial contract, largely with the Waimanalo company Sea Engineering, Inc. but this information is not publically available.

In general, offshore sand resources are found to be thin and generally unsuitable for large-scale nourishment projects. However, there are exceptions: a large field of thick coarse carbonate sand in 40 ft of water offshore of West Maui has been identified; a large field of carbonate sand in 60-110 ft of water offshore of the Honolulu Airport is described in Barry (1995); Barry also reports that the Penguin Bank plateau holds viable deposits (though Whale Sanctuary status and heavy fishing use likely prevent mining this area); and a moderate field of thick carbonate sand in 40 ft of water between Lanikai and Waimanalo is described in Bochicchio et al (2009). Additionally, it has been reported that Sea Engineering is using the Halekulani sand channel in Waikiki as a resource for nourishing Greys Beach, Waikiki with approximately 15,000 yd^3 of sand.

Future Needs

Several recommendations emerge from this review:

1. Given the continued need to nourish Waikiki, research to identify sand resources in waters fronting the fringing reef there (in depths of 15 to 80 ft) would be justified.
2. The "Reef Runway" sand field fronting the Honolulu airport has been identified as a potential resource. Further work assessing this location and sand quality is justified.
3. Offshore sand assessment for fields on the leeward coast (pending the analysis in Hampton et al), and Maunalua Bay are justified as these locations are proximal to Waikiki.
4. Sand needs on Maui are significant. Further assessment is justified at West Maui and the north shore.
5. Sand fields deemed viable as a beach resource using preliminary tactics (i.e., diver surface samples, jet probing) will need vibracore analysis to confirm the character of the deposit.

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