

$$\frac{Q_s(\text{after})}{Q_s(\text{before})} = \frac{(0.96)^{2.5}}{(0.82)^{2.5}} = 1.48 \quad (6.2)$$

or a 50% increase in the rate of losses from a beach fill.

Using two different methods, the approximate cost of maintaining the existing shoreline of Florida with beach nourishment was examined in the NRC report "Understanding and Responding to Sea Level Rise" (National Research Council, 1987). For the three different scenarios of sea level rise examined, the annual costs range from \$33 to \$204 per linear meter of shoreline, or between 0.1 and 3.4% of the present day value of beachfront property in Florida. The amount varied by a factor of 2.5 between the two methods - highlighting the need for research in this area.

#### 6.5 RESEARCH NEEDS

Research needs in the area of modifying shoreline response to sea level rise and the effects of sea level rise on the design of protective works lie in the realm of ongoing basic studies of natural shoreline processes, and have little requirement for specific treatment of sea level rise. If engineers had a surf zone sediment transport model capable of reproducing and predicting beach response to storms and structures, including the effects of sea level rise would mean an almost trivial matter of increasing the mean water depth in the model. However, until the knowledge of basic processes has grown considerably and such models are developed, there is little reason to expect accurate prediction of the response of beaches to sea level rise to be possible, and that cost-effective techniques for modifying the response will be available.

There are four major areas requiring research in basic physical processes: 1) wave refraction/diffraction, 2) wave breaking, 3) undertow and longshore currents (nearshore circulation) and 4) sediment entrainment under shoaling and breaking waves. The knowledge gained from research in these areas would then be used as input to beach profile and planform response models.

Once a reasonable expertise in shoreline modeling has been reached, the greatest research need is for the engineering community to analyze and quantify the performance and costs of the available alternatives for dealing