

started in 1961 have since raised the groundwater table and arrested the subsidence. In Niigata the most severe subsidence has also occurred right on the coast. In all of these cases, regulations controlling groundwater pumping have since been enacted, plus recharge has been practiced in several of the regions where the subsidence is particularly acute. These measures have always proved successful in at least slowing the rate of compaction. In the Tokyo region however, 253 km of embankments, 41 sluice units, and 9 pumping stations were required to protect against typhoon flooding and extreme tides, and to provide drainage for rainwater (Ukena et al., 1970; Tagami et al., 1970). These are precisely the types of measures that may be required in many coastal cities within the next century.

3.6 RESEARCH NEEDS

One important aspect of compaction that requires investigation is its effect on the tide gage measurements used to determine sea level rise, as noted in section 2. Although gage elevations are often surveyed in relation to bench marks that are anchored to bedrock, the error inherent in leveling over possibly long distances would favor a more direct indication of any local compaction. It is recommended that a few experimental groundwater table/compaction devices be installed near selected tide gages. These would be located in communities where demand for the local groundwater is high, and compressibility of the underlying strata significant. If these devices prove useful, more should be added until, ideally, every tide gage used in making sea level rise estimates has at least one accompanying compaction device.

Another task necessary to resolve the eustatic component of sea level rise is to survey each tide gage in relation to orbiting satellites. Once each gage is tied-in to an absolute datum and compaction devices installed, the relative rise (or fall) in sea level at any particular site can be separated into its compaction, tectonic, and eustatic components.

A program is also needed to document compaction rates in those coastal areas currently experiencing high rates of erosion and shoreline retreat to see if compaction is playing a role, and to determine if remedial measures can be implemented. Installing arrays of compaction measuring devices will also permit study of the long-term behavior of the local subsidence as well as its relation to fluctuations and secular depletion of the water table. By sinking