LAND SUBSIDENCE AS A RESOURCE MANAGEMENT OBJECTIVE IN ANTELOPE VALLEY, CALIFORNIA

Steven P. Phillips (U.S. Geological Survey, Sacramento, California)

Ground water is an important component of the water supply in Antelope Valley (see Londquist abstract for information on the hydrogeology of Antelope Valley), comprising about 85 percent of the total supply in 1992. Water demand is expected to increase rapidly with the projected increase in population from the current (1994) level of about 310,000 to over 690,000 by the year 2010 (Templin and others, 1994). The combination of about 6.6 ft of land subsidence (4.9 ft from 1961–92; Ikehara and Phillips, 1994) attributable to ground-water withdrawal (Londquist and others, 1993), and the unpredictable nature of surface-water supply, underscores the need for management of Antelope Valley water resources (see Ikehara #1 and Blodgett abstracts for additional information on the measurement of land subsidence in the Antelope Valley).

Although land subsidence is generally considered a negative effect of development, it does have positive attributes. The primary benefit from land subsidence is the water released from compaction of sediments. In some areas of the San Joaquin Valley, it is estimated that as much as 60 percent of ground water applied as irrigation over a 4-year period was derived from compaction (Poland and others, 1975, fig. 42) (see Pool abstract for additional estimates of water derived from compaction in the Picacho Basin, Arizona). Another potential benefit is the creation of a precompacted zone ideal for storage and recovery of surface, imported, or reclaimed water. Water artificially recharged into a precompacted zone can be withdrawn effectively, as heads can be drawn down to their historic low without inducing additional subsidence.

Negative aspects of land subsidence include detrimental effects on man-made structures, geomorphology, ground-water quality, and the hydraulic properties of the aquifer system. Differential subsidence causes tensional forces at the outer boundaries of the subsidence area, and compressional forces at the center (see Helm abstract). Linear engineered structures are particularly susceptible to damage from strain events related to these forces. Canals, sewers, water delivery systems, drainage works, flood-control facilities, transportation grids, well casings, and other engineered structures have all been damaged in subsiding areas (Poland, 1984) (see Schumann abstract for related damages experienced at Luke Air Force Base near Phoenix, Arizona).

Differential land subsidence can affect the geomorphology of an area. Drainage patterns, for example, can be altered substantially by a change or reversal of gradient. Subsidence-related alterations in drainage patterns and local topography can cause severe flooding (see Schumann abstract). Associated problems include increased rates of erosion, as on Rogers Lake, a dry lakebed at Edwards Air Force Base (see Blodgett abstract). Farmland is also susceptible to damage from altered drainage patterns and associated increases in erosion, requiring more frequent grading.

Ground-water quality can be affected by subsidence-related processes. Earth fissures, which are vertically oriented fractures often related to land subsidence, can act as conduits from the surface to the ground-water system. These fissures can provide preferential pathways for the transport of surface or subsurface contaminants to the water table. Another potential effect on ground-water quality is the mixing of relatively poor-quality water from compaction with ground water of better quality. Pore water in clay deposits, which would be released during compaction, is generally higher in dissolved solids than pore water in coarse-grained deposits.

The hydraulic properties of the aquifer system are also affected by land subsidence. Compaction often results in a permanent loss of storage; most of the loss occurs in the compressible fine-grained units. Compaction also can result in a permanent decrease in the ability of the compacted unit to transmit water. If the fine-grained units are areally extensive and subhorizontal, which is common in alluvial basins of the United States, this could have an effect on the characteristics of vertical flow in the ground-water system.

The optimal management of a water supply generally emphasizes a balance between supply and demand, and a minimization of physical, economic, and environmental consequences. In Antelope Valley and other western basins where land subsidence is occurring, the potential positive and negative consequences of subsidence should be a key management consideration. The experience in Antelope Valley and other semi-arid and arid basins with subsidence shows that land subsidence generally is not included in water-resource management plans. The challenge ahead is to quantify the physical, economic, and environmental effects of subsidence in Antelope Valley and other basins on an areal basis so they can be used in the management process.