Hydrogeology, Water-Level Altitudes and Changes in the Chicot, Evangeline, and Jasper Aquifers; Land-Surface Subsidence (Clay Compaction) in the Chicot and Evangeline Aquifers; and Faulting in the Houston-Galveston Region, Texas

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The Chicot aquifer (in Holocene- and Pleistocene-age sediments), Evangeline aquifer (in Pliocene- and Miocene-age sediments), and Jasper aquifer (in Miocene- and Oligocene-age sediments) are the three primary aquifers in the Gulf Coast aquifer system in Texas. The lowermost Jasper aquifer is separated from the Evangeline aquifer by the Burkeville confining unit. The hydrogeologic units are laterally discontinuous, fluvial-deltaic lenticular deposits of gravel, sand, silt, and clay that dip and thicken from northwest to southeast. The units thus crop out in bands inland from and approximately parallel to the coast and become progressively more deeply buried and confined toward the coast as the clay percentages of the sediments increase.

The Chicot aquifer outcrop, which comprises the youngest sediments, is the closest of the aquifer outcrops to the coast, followed farther inland by the Evangeline aquifer outcrop and then farthest inland by the Jasper aquifer outcrop. The Chicot aquifer can be differentiated from the geologically similar Evangeline aquifer on the basis of hydraulic conductivity. The Jasper aquifer can be differentiated from the Evangeline aquifer in the outcrops on the basis of water levels (higher in the Jasper aquifer than in the Evangeline aquifer) and in the downdip parts of the aquifers on the basis of position relative to the Burkeville confining unit. Water in the aquifers is fresh (less than 1,000 milligrams per liter dissolved solids concentration) in the region but becomes more saline in the downdip and deeply buried parts of the aquifers near the coast. In the natural ground-water-flow system, water recharges the aquifers in the unconfined outcrop areas, moves downward and coastward, and discharges upward as diffuse upward leakage in the confined downdip areas.

The U.S. Geological Survey, in cooperation with the Harris-Galveston Subsidence District, the City of Houston, the Fort Bend Subsidence District, and the Lone Star Groundwater Conservation District, publishes an annual report on the water-level altitudes and water-level changes for the Chicot, Evangeline, and Jasper aquifers and compaction of subsurface sediments in the Chicot and Evangeline aquifers in the Houston-Galveston region. The Houston-Galveston region comprises Harris, Galveston, Fort Bend, Waller, and Montgomery Counties and adjacent parts of Brazoria, Grimes, Walker, San Jacinto, Liberty, and Chambers Counties. The 2007 report (Scientific Investigations Map 2968) shows potentiometric surfaces as low as 200 feet below sea level for the Chicot aquifer in central Harris County; 300 feet below sea level for the Evangeline aquifer in northern Harris County, and 125 feet below sea level for the Jasper aquifer in southern Montgomery County. Additionally, for the period 1977–2007, the report shows water-level rises of as much as 200 and 260 feet in the Chicot and Evangeline aquifers, respectively, in southeast Harris County.

The Houston-Galveston region is the largest urban area in the United States affected by land-surface subsidence caused by ground-water withdrawals. Sustained withdrawals cause water levels in the aquifers to decline, which in turn causes depressurization and dewatering of the clay lenses. Subsequently, the individual grains of the clay lenses begin to realign and compress. In areas of southeast Harris County near the Houston Ship Channel, land-surface altitude has declined as much as 10 feet. Land-surface declines caused by extraction of hydrocarbons have been documented in other areas, although these areas are small. Land-surface subsidence is especially problematic for coastal areas of low topographic relief. Impervious land-surface cover, near-surface clay in the Chicot aquifer, proximity to the Gulf of Mexico, and periodic low-pressure weather systems with storm surge and high rainfall combine to make areas affected by subsidence more flood prone. Approximately 25 percent of the Houston-Galveston region is within the established 100-year flood plain.

More than 150 historically active faults have been identified in the Houston-Galveston region. Some of the better known faults are the Eureka Heights, Hardy, Long Point, Pecore, and Clodine. Fault scarps that are monitored increase in height at rates that range from 0.2 to 1.1 inches per year with the average rate of 0.4 inches per year. Fault movement has caused substantial, costly damage to buildings, roadways, and utilities. Numerous subsurface faults at depths from 3,200 to 13,000 feet have been documented. These faults have been delineated through studies of geophysical well logs and from results of deep seismic surveys. Some of these subsurface faults penetrate younger sedimentary deposits at shallower depths (less than 3,000 feet) and have offset the present land surface, producing recognizable fault scarps.

Many identifiable faults at land surface can be traced to appreciable depths. Faults in the region are not a surficial phenomenon, but rather, are part of deep and complex overall geologic structure of the upper Texas Gulf Coast. Connections between fault scarps at land surface and subsurface faults have been verified for at least 40 faults for which sufficiently detailed information is available for the shallow subsurface. The subsurface faults in the area are considered growth faults with a definitive characteristic of increasing displacement with depth. This specific characteristic is considered evidence of a long history of continual fault movement. This continual movement occurs contemporaneously and continuously as sediments are deposited on both sides of the fault scarp, such that the sediment thickness on the downthrown side is thicker than on the upthrown side. Evidence exists that these faults are natural geologic features with histories of movement spanning tens of thousands to millions of years. Current identifiable scarps reflect only the most recent displacements of faults that were historically active long before the formation of the present-day land surface or the occurrence of anthropogenic activity.

References

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