Simulation of Groundwater Flow and Chloride Transport in the “1,500-Foot” Sand, “2,400-Foot” Sand, and “2,800-Foot” Sand of the Baton Rouge Area, Louisiana

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Abstract

Groundwater withdrawals since the 1940s have lowered water levels, altered groundwater-flow directions, and caused saltwater to intrude within some freshwater-containing sands of the fluvial-deltaic Southern Hills regional aquifer system beneath Baton Rouge, Louisiana. New interpretations of stratigraphic correlations amongst geophysical well logs were utilized to revise a hydrogeologic framework that delineates the depth and thickness variations of aquifers and confining units in the Southern Hills regional aquifer system. A groundwater-flow and chloride-transport model incorporating the revised framework was constructed to assess the effects of groundwater withdrawals on the rate and pathways of saltwater migration in the “1,500-foot” sand, “2,400-foot” sand, and the “2,800-foot” sand. Groundwater withdrawals reported since 1940 were compiled to specify annual average withdrawal rates through 2016 for 722 wells. Regional groundwater flow throughout the Southern Hills regional aquifer system was first simulated with MODFLOW, and flow-model parameters were calibrated to 8,810 water levels observed through 2016 by using the parameter-estimation code PEST++. Saltwater transport was subsequently simulated for the “1,500-foot” sand, “2,400-foot” sand, and the “2,800-foot” sand by using the variable-density code, SEAWAT. Chloride-concentration measurements were used as a proxy for saltwater to formulate the concentration initial conditions and calibrate the transport-model parameters.

Three groundwater-management scenarios were simulated to evaluate the effects of different groundwater withdrawals on future groundwater levels and saltwater

concentrations in the “1,500-foot” sand, “2,400-foot” sand, and “2,800-foot” sand. All three scenarios simulated the period from 2017 through 2112 (96 years), and the water levels and concentrations simulated for 2047 and 2112 were compared among the scenarios. The first scenario simulated a continuation of groundwater withdrawals at 2016 rates and represents the “status quo” of groundwater withdrawals. The second scenario simulated the effects of discontinuing 10,620 gallons per minute (gal/min) of withdrawals from the “2,800-foot” sand, and the third scenario simulated reallocating 2,000 gal/min of withdrawals from the “1,500-foot” sand to the “2,800-foot” sand. Continuation of the “status quo” withdrawals results in lower water levels by 2047 around groundwater-withdrawal locations in the “1,500-foot” sand, “2,400-foot” sand, and “2,800-foot” sand. By 2112, water levels recover to higher levels as flow in the aquifer approaches equilibrium. Saltwater within the “1,500-foot” sand would continue migrating toward public-supply wells located 2.4 miles (mi) north of the Baton Rouge Fault, but a “scavenger well” that removes relatively concentrated water from the base of the “1,500-foot” sand attenuates chloride concentrations at the public-supply wells. Saltwater within the “2,400-foot” sand would continue to encroach on a well with large withdrawals and farther east within an area about 1 mi north of the Baton Rouge Fault. Saltwater within the “2,800-foot” sand would migrate northward toward withdrawal wells located about 3 mi north of the industrial district. Cessation of 10,620 gal/min of industrial withdrawals from the “2,800-foot” sand about 12 mi northwest of the industrial district (scenario 2) would cause a substantial water-level recovery in the “2,800-foot” sand in the area of discontinued withdrawals. Groundwater levels 3 mi north of the industrial district would be 25–30 feet higher in 2047 than predicted for the “status quo” withdrawals. Saltwater encroachment toward wells north of the industrial district would be slowed because of the decreased hydraulic gradient. Reallocating 2,000 gal/min of withdrawals from the “1,500-foot” sand to the “2,800-foot” sand 12 mi northwest of the industrial district (scenario 3) would have a negligible effect on water levels and chloride concentrations in the “1,500-foot” sand 15 mi to the south-southeast where saltwater is encroaching toward wells in the “1,500-foot” sand. Within the “2,800-foot” sand, the area of saltwater encroachment is only 3 mi from increased withdrawals in the “2,800-foot” sand, and water levels would be about 5 feet lower in 2047 than for the “status quo” scenario. A larger hydraulic gradient would cause slightly faster saltwater transport and higher chloride concentrations within this area of the “2,800-foot” sand.