Up-Gradient Wells

The region from which a pumping well produces water is called the capture zone. The capture zone for a well has a parabolic shape, opening in the up gradient direction. The down gradient limit of the capture zone is defined by the stagnation point, the point where the groundwater flow rate in the aquifer and flow rate to the well have equal magnitude, but opposite direction. For a uniform flow field, the down gradient distance from the well to the stagnation point can be determined using the equation shown in Figure 9(b) of Cohen et al (1997). The pumping rate of the well, transmissivity of the aquifer, and hydraulic gradient of the aquifer are needed for this calculation.

The base case pumping rate for a rural domestic well was selected based upon county specific data. Initially, we contacted Kevin Kluge of the Texas Water Development Board (Board) to attempt to get a state sanctioned estimate of rural/domestic per capita groundwater use. Mr. Kluge stated that the Board does not calculate such a per capita estimate. Instead, the Board estimates per capita use based upon municipal use and municipal population. Their number for Goliad County is 119 gpd/person.

We estimated the average household size in Goliad County, by consulting the Goliad County website at http://www.goliadcc.org/index.php/re-location-info.html. There it is reported that the average Goliad County household has 2.6 people. Taking 2.6 people multiplied by 119 gpd/person, one gets a daily use of 309.4 gpd/household. This equates to a pumping rate of 41.4 ft^3/day.

The transmissivity of the aquifer, the product of the aquifer hydraulic conductivity and the aquifer thickness, was based on an average hydraulic conductivity determined from the pump tests conducted at the site and a thickness of 36 feet, the smallest average thickness for any of the sands (Table 6.1 of the Mine Permit Application). UEC used minimum thickness since reducing thickness increases the distance to the stagnation point. The gradient used for the base case was an average value developed from the September 2008 water level measurements for the B-sand production area monitor well ring.

Under the base case conditions, the capture zone for a pumping well would extend less than 16 feet in the down gradient direction. We evaluated three additional scenarios: 1) five times the average rural domestic pumping rate, 2) the 5th percentile B-sand gradient, and 3) hydraulic conductivity reduced by 50%. These changes increase the down gradient distance of the stagnation point, but the stagnation point remains far up gradient of the proposed aquifer exemption boundary for all up gradient wells. Results are presented in the following table.

Scenario	Pumping Rate	Hydraulic Conductivity	Sand Thickness	Transmissivity	Gradient	Stagnation Point
	Q (ft3/d)	K (ft/d)	b (ft)	T (ft2/d)	i (ft/ft)	(ft)
Average conditions (B-sand)	41.366	19.2	36	691.2	0.00061	15.61

Five times average water use / household	206.83	19.2	36	691.2	0.00061	78.07
5th percentile graben gradient	41.366	19.2	36	691.2	0.00035	27.21
Hydraulic conductivity reduced by 50%	41.366	9.6	36	345.6	0.00061	31.23

Reference

Cohen, Robert M., James W. Mercer, Robert M. Greenwald, and Milovan S. Beljin, 1997. Design Guidelines for Conventional Pump-and-Treat Systems, EPA/540/S-97/504, September 1997