APPENDIX C

DERIVATION OF HYRAULIC CONDUCTIVITY

Horizontal and vertical hydraulic conductivity were derived from (1) measured estimates of hydraulic conductivity compiled by Mace and others (2000), (2) maps of sandstone thickness (Bebout and others [1982], Ayers and Lewis [1985], Fogg and others [1983b], Xue [1994]), and (3) structural information on layer elevations and thickness. This appendix documents how values of horizontal and vertical hydraulic conductivity were derived and assigned to model grid cells.

Our approach to mapping hydraulic conductivity followed these steps:

(1) We used ArcView to post the field-estimates of hydraulic conductivity compiled by Mace and others (2000). Additional work was needed to assign the Mace and others (2000) data to specific model layers on the basis of well depth, screened interval, and designated aquifer code. Data were posted on maps as the logarithm (base 10) of the reported hydraulic conductivity.

(2) On top of the posted values of hydraulic conductivity, we overlaid maps of the net thickness of sandstone in the aquifer layers. To account for the entire study area we used sandstone-thickness maps from Bebout and others (1982), Ayers and Lewis (1985), Fogg and others (1983b), and Xue (1994). To supplement these maps, we posted and contoured values of sandstone thickness for part of Gonzales County inferred from additional logs.

(3) We contoured hydraulic conductivity by hand using the thickness of sandstones as an interpretive guide. Our conceptual model was that hydraulic conductivity is greatest along the axes of sand channels because (a) that is where the coarse-grained sands are

concentrated and low-permeability silts and clays tend to be absent and (b) thick sandstones tend to be better interconnected and have a higher effective hydraulic conductivity (Fogg and others, 1983a). We found qualitative but mappable local correlation between sandstone thickness and hydraulic conductivity.

(4) We traced and digitized the contoured maps of hydraulic conductivity and sandstone thickness.

(5) We used Surfer to interpolate values of hydraulic conductivity (still in log–base 10 units) and sandstone thickness for each active cell of model grid for the Hooper aquitard (layer 6), Simsboro aquifer (layer 5), Calvert Bluff aquitard (layer 4), and Carrizo aquifer (layer 3).

(6) We calculated an average value of horizontal and vertical hydraulic conductivity (K_h and K_v, respectively) for each active cell in the Hooper aquitard (layer 6), Simsboro aquifer (layer 5), Calvert Bluff aquitard (layer 4), and Carrizo aquifer (layer 3). We used equations A-1 and A-2 to weight hydraulic conductivity by sand thickness. Equation A-1 gives an arithmetic average for horizontal hydraulic conductivity and equation A-2 gives a harmonic mean for vertical hydraulic conductivity

$$K_h = (K_{hs} \times b_s + K_{hc} \times b_c)/B \tag{A-1}$$

$$K_v = B/[(b_s/K_{vs}) + (b_c/K_{vc})] \tag{A-2}$$

where K_{hs} and b_s are the horizontal hydraulic conductivity and total cell thickness of sand, respectively; K_{hc} and b_c are horizontal hydraulic conductivity and total cell thickness of non-sand (clay, silt, and lignite) materials, respectively; and B is total cell thickness. The values of K_{hs} and b_s were determined in step (5) above; b_c was determined from total cell thickness minus sand thickness. Total cell thickness (B) was calculated from the top and bottom of grid cells. We assumed that K_{hc} was 9 x 10^{-4} ft/d. We assumed that local anisotropy is 0.1 for sandstone beds and 0.01 for clay, silt, and lignite beds.

Adjustments were made to the initial cell estimates of horizontal and vertical hydraulic conductivity during model construction and calibration.

(1) We smoothed the values of hydraulic conductivity in the outcrop of layer 5 representing the Simsboro aquifer. If the value in row *i* was less than 20 percent of the value in row *i+1* in the outcrop, for any given column, we set the hydraulic conductivity of the cell in row *i* to the value for the cell of row *i+1*.

(2) Another correction for the outcrop of the Hooper and Calvert Bluff aquitards (layers 6 and 4, respectively) was where too large a value of vertical hydraulic conductivity was calculated because sand makes up most or all of the section. If the estimated K_v was more than twice the assigned value of K_{hc}, we limited K_v for the cell to the mean value for the layer.

(3) We made sure default values were assigned to additional cells in layers between the active cells representing alluvium in layer 1 and the uppermost active cell of bedrock layers 6 through 3.

(4) Maximum hydraulic conductivity of thick deposits of Simsboro sandstone in the Rockdale Delta was limited to 30 ft/d, giving a maximum transmissivity of 15,200 ft^2/d.

(5) We selectively adjusted hydraulic conductivity in four zones of layer 5 representing the Simsboro aquifer where model-calculated values of transmissivity, or the range in transmissivity, were deemed too high in

comparison to field data. These adjustments decreased the range of assigned values in the targeted zones These zones included:

(a) The area within columns 164 to 168 and rows 27 to 29 in the vicinity of the Walnut Creek Mine in Robertson County,

(b) The area within columns 145 to 153 and rows 46 to 54 in the vicinity of the Bryan-College Station well field in Brazos and Robertson Counties,

(c) The area within columns 117 to 140 and rows 29 to 33 in the vicinity of the Sandow Mine in Milam County, and

(d) The area within columns 101 to 105 and rows 27 to 33 in the vicinity of the Three Oaks Mine in Bastrop and Lee Counties.

Transmissivity for each cell in zone (a) was decreased by 30,000 ft^2/d to no less than 30,000 ft^2/d. In zone (b), transmissivity was increased by 30,000 ft^2/d to as much as approximately 113,700 ft^2/d. In zone (c) and (d), the adjustment of transmissivity was linearly scaled. In zone (c) the maximum decrease in transmissivity of -50,000 ft^2/d was assigned to cells with an initial transmissivity of as much as 113,000 ft^2/d; the decrease in transmissivity was scaled to 0 for cells with an initial transmissivity of less than 40,000 ft^2/d. For zone (d) we increased transmissivity, again by scaling the adjustment. The maximum increase in transmissivity of +30,000 ft^2/d was assigned to cells with an initial transmissivity as small as 5,000 ft^2/d; the increase in transmissivity was scaled to 0 for cells with an initial transmissivity of more than 40,000 ft^2/d. The recalculated transmissivities were then divided by cell thickness to provide hydraulic conductivity as the model input parameter.

(6) We increased K_v of layer 6 representing the Hooper aquitard in all cells by a factor of 10 to improve the model calibration of simulated and observed water levels. And (7), we globally adjusted vertical hydraulic conductivity by layer by slightly shifting the average and decreasing or increasing the standard deviation of vertical hydraulic conductivity to better reproduce the expected ratio of K_v/K_h from the conceptual model (Table C-1).

Table C-1. Comparison of initial and adjusted values of hydraulic conductivity (horizontal [K_h] and vertical [K_v]) assigned in the model

		K_h		K_v		K_v/K_h	
		initial	adjusted	initial	adjusted	initial	adjusted
Carrizo (Layer 3)	$10^{\mu log[-]}$	6.4	6.2	5.5×10^{-4}	1.3×10^{-3}	8.6×10^{-5}	2.1×10^{-4}
	$\sigma_{log[-]}$	0.62	0.60	0.78	0.62	0.75	0.49
Calvert Bluff (Layer 4)	$10^{\mu log[-]}$	0.91	0.91	2.8×10^{-5}	9.7×10^{-5}	3.1×10^{-5}	1.1×10^{-4}
	$\sigma_{log[-]}$	0.51	0.51	0.09	0.12	0.49	0.48
Simsboro (Layer 5)	$10^{\mu log[-]}$	2.6	2.6	1.4×10^{-4}	9.5×10^{-4}	5.5×10^{-5}	3.7×10^{-4}
	$\sigma_{log[-]}$	0.80	0.80	0.62	0.58	0.76	0.53
Hooper (Layer 6)	$10^{\mu log[-]}$	0.91	0.49	1.1×10^{-5}	3.5×10^{-5}	1.2×10^{-5}	7.1×10^{-5}
	$\sigma_{log[-]}$	1.7	1.5	0.12	0.38	1.6	1.1

$10^{\mu log[-]}$ Mean value calculated as geometric mean of log-transformed variable

$\sigma_{log[-]}$ Standard deviation calculated from log-transformed variable

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