Appendix 5

Horizontal Travel Distance

The horizontal travel distance (X) is defined in this analysis as the distance of horizontal migration corresponding to the vertical travel time. The horizontal travel distance of the injected wastewater can be estimated by multiplying the seepage velocity (v_s) in the horizontal direction by the vertical travel time (t) estimated earlier (Eqn. 13). Seepage velocity is defined as the velocity representing the average rate at which ground water moves (Fetter, 1994) and is estimated by dividing the Darcy flow (q) by the porosity (n) of the hydrologic unit (Eqn. 14). Porosity represents the ratio between the volumes of voids over the total volume of the media (Freeze and Cherry, 1979). In this analysis, published porosity values were used. Darcy flow is defined as fluid flow through porous media (e.g. sand) (Freeze and Cherry; 1979), taking into consideration that ground water flows through porous media, Darcian assumptions must be applied. Darcy flow takes into account horizontal hydraulic conductivity (K_h) and the horizontal hydraulic gradient (i) (Eqn. 15). Hydraulic conductivity represents the ability of the media to transmit water (Fetter, 1994). Simple substitution of the seepage velocity and Darcy flow equations into Equation 13, will result in Equation 16.

$$X = v_s \times t \quad \text{(Eqn. 13)}$$

$$v_s = \frac{q}{n} \quad \text{(Eqn. 14)}$$ [1]

$$q = K_h \times i \quad \text{(Eqn. 15)}$$

$$X = \frac{K_h i}{n} t \quad \text{(Eqn. 16)}$$

As in the analysis of vertical travel time, two scenarios were considered: 1) porous media flow and 2) bulk flow through preferential flow paths. To assess the two scenarios, vertical travel times respective to the two scenarios were used in estimating the horizontal travel distances.

In Dade and Brevard Counties, a horizontal hydraulic gradient of 0.001 was assumed for all the hydrologic units. In Pinellas County, a horizontal hydraulic gradient of 0.05 was assumed in the injection zone and 0.001 in the overlying units. A greater horizontal hydraulic gradient in the injection zone accounts for the effects of injection pressure due to the injection of millions of gallons of wastewater a day.

Primary porosities were used in this analysis (Eqn. 16) however, in the Boulder Zone a porosity of 0.5 was assumed in Dade and Brevard Counties. A larger porosity in the Boulder Zone takes into account cavernous pores or large fractures found in the Boulder Zone (Meyer, 1984, Maliva and Walker, 1998).

The results of this analysis and a summary of the assumptions made are presented in the following tables for Dade, Pinellas and Brevard Counties (Table 5-1, 5-2 and 5-3).

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[1] Same equation used in Appendix 4 (Eqn. 4)

Appendix Table 5-1 Horizontal Migration
(Scenario 1: Porous Media Flow)

Dade

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Biscayne Aquifer	1,524	0.001	0.31	2	9
Intermediate Confining Unit	90.0	0.001	0.31	246082	71443
Upper Floridan Aquifer	42	0.001	0.32	61270	8042
Middle Confining Unit	5	0.001	0.43	114671	1253
Lower Floridan Aquifer	0.10	0.001	0.40	10984	3
Boulder Zone	6,538	0.001	0.50	16	209
				Total Horizontal Distance	**80,959**

Pinellas

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	29	0.001	0.31	297	28
Intermediate Confining Unit	4	0.001	0.31	6806	88
Upper Floridan Aquifer	22	0.05	0.226	1306	6355
				Total Horizontal Distance	**6,471**

Brevard

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	56	0.001	0.31	172	31
Intermediate Confining Unit	20.00	0.001	0.31	87494	5645
Upper Floridan Aquifer	20	0.001	0.26	22406	1724
Middle Confining Unit	1	0.001	0.43	109982	205
Lower Floridan Aquifer	0.1	0.001	0.40	187918	47
Boulder Zone	650	0.001	0.50	6	7
				Total Horizontal Distance	**7,658**

Appendix Table 5-2 Horizontal Migration (Scenario 2: Preferential Flow Paths)

Dade

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Biscayne Aquifer	1,524	0.001	0.31	2	9
Intermediate Confining Unit	90.0	0.001	0.10	3,335	3,002
Upper Floridan Aquifer	42	0.001	0.10	3,379	1,419
Middle Confining Unit	5	0.001	0.10	711	33
Lower Floridan Aquifer	0.10	0.001	0.10	2,746	3
Boulder Zone	6,538	0.001	0.20	16	522
				Total Horizontal Distance	**4,988**

Pinellas

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	29	0.001	0.31	297	28
Intermediate Confining Unit	4	0.001	0.1	1,756	70
Upper Floridan Aquifer	22	0.05	0.1	290	3,195
				Total Horizontal Distance	**3,293**

Brevard

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	56	0.001	0.31	172	31
Intermediate Confining Unit	20.00	0.001	0.10	3	1
Upper Floridan Aquifer	20	0.001	0.10	724	145
Middle Confining Unit	1	0.001	0.10	682	5
Lower Floridan Aquifer	0.1	0.001	0.10	46980	47
Boulder Zone	650	0.001	0.20	6	18
				Total Horizontal Distance	**247**

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