

KEY 1 of 3

- Well Data and Groundwater Contour Maps. Examine Figure 1 location map showing a hypothetical well field and a generalized well log. The wells are set in an unconsolidated sand-gravel bed, underlain by clay layer. Table 1 below lists the wells, surface elevation, riser stick-up (above ground surface), depth-to-water, and total depth of the well screen. The bore holes were drilled to the base of the sand-gravel layer, and screen set at TD of well (i.e. well TD = depth to top of underlying clay layer)

A. Examine the well data in Table 1 and Monitoring Well Location Map on Figure 1. Fill in Table Below.

Table 1. Well Data - Hydrology practice problem (March 2016)

SEE ATTACHED TABLE

ID	Surf_elev_ft	stickUP_ft	DTW_ft	Elev_top_casing_ft	SWL_Elev_ft	TD_ft	Well_column_ft	T ft ² /day
MW-1	172	1.3	68.2	173.3	105.1	118	57.1	14485
MW-2	158	2	55.5	160	104.5	115	61.5	17433
MW-5	154	1.2	58	155.2	97.2	110	53.2	15080
MW-6	157	2.1	56.1	159.1	103	115	61.0	17291
MW-7	163	1.8	67.5	164.8	97.3	110	44.3	12557
MW-8	165	1.9	63.7	166.9	103.2	115	53.2	15080
MW-9	154	2.1	55.3	156.1	100.8	115	61.8	17518
MW-10	159	1.6	58.8	160.6	101.8	115	57.8	16384
MW-11	156	1.5	62.4	157.5	95.1	110	49.1	13918
MW-12	168	0	64.4	168	103.6	116	57.6	14626
MW-13	172	0	69.8	172	102.2	116	46.2	13096
MW-14	174	1.8	77	175.8	98.8	110	34.8	9864
MW-15	163	2.1	64.5	165.1	100.6	112	49.6	14059
MW-16	153	2	59.2	155	95.8	110	52.8	14967

AVG. T = 14,740 ft²/DAY

- Label monitoring wells with SWL, and draw groundwater contour map using a 1 ft contour interval.
- Determine the hydraulic gradient (ft/ft) between the Children Farm Home and Chemical Plant. Which direction is groundwater flow? Show all of your math work.

SEE ATTACHED MAP

- Does this scenario represent a confined or unconfined aquifer? Artesian or non-artesian? Water table or potentiometric surface under artesian pressure?

SEE ATTACHED
GRAD = 0.003 TO SOUTH
UNCONFINED SAND + GRAVEL, NON-ARTESIAN, WATER TABLE

- Note the groundwater contour patterns. What hydrogeologic phenomena is likely represented at MW-11?

CONE OF DEPRESSION

- Given the hydraulic data listed on your contour map, calculate the transmissivity (ft²/day) for each well, and determine an average. Fill in the last column in Table 1 above. (Hint: use K from Figure 1, convert to ft/day, and calculate T in ft²/day). Show all of your math work.

SEE ABOVE & ATTACHED
AVG. T = 14,740 ft²/DAY

- Using Darcy's Law, calculate the approximate average annual groundwater discharge from the aquifer across line X-Y. Show all of your math work; answer in units of MGal/year.

$Q = \frac{7.9 \times 10^7 \text{ ft}^3}{\text{yr}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = 591 \frac{\text{MGal}}{\text{yr}}$
 $Q = \left(\frac{0.1 \text{ cm}}{\text{sec}} \right) \left(\frac{3.15 \times 10^7 \text{ sec}}{\text{yr}} \right) \left(\frac{1 \text{ ft}}{30.5 \text{ cm}} \right) (0.003) (5200 \text{ ft} \times 49 \text{ ft})$
 $Q = 49 \text{ ft} \times \frac{61.8 \text{ ft} + 34.8 \text{ ft} + 49.6 \text{ ft}}{3} \times \frac{1 \text{ ft}}{30.5 \text{ cm}} \times 0.003 \times 5200 \text{ ft} = 5200 \text{ ft}$
 Avg. SANDWATER THICKNESS = 49 ft
 MW 14 + MW 15 + MW 9
 $K = 1 \times 10^{-1} \frac{\text{cm}}{\text{sec}}$
 $I = 0.003$
 $\text{Dist. XY} = 6.5 \text{ mi} \left(\frac{800 \text{ ft}}{1 \text{ mi}} \right) = 5200 \text{ ft}$
 SEE ATTACHED

G. Darcy's Law $Q = KIA$
 $K = 1 \times 10^{-1} \text{ cm/sec}$ (GIVEN)
 $I = 0.003$ (CALCULATED IN PART C)

$A = (\text{LENGTH}) \times (\text{AVG. SAMPLING THICKNESS})$
 MW-14, MW-15, MW-9

$\text{LENGTH } \bar{xy} = 6.5 \sin\left(\frac{800 \text{ ft}}{17}\right) = 5200 \text{ ft}$

$\text{AVG. SAMPLING THICKNESS} = \frac{61.8 \text{ ft} + 34.8 \text{ ft} + 49.6 \text{ ft}}{3} = 49.0 \text{ ft}$

$A = (49.0 \text{ ft})(5200 \text{ ft}) = 254,800 \text{ ft}^2$

$Q = KIA =$

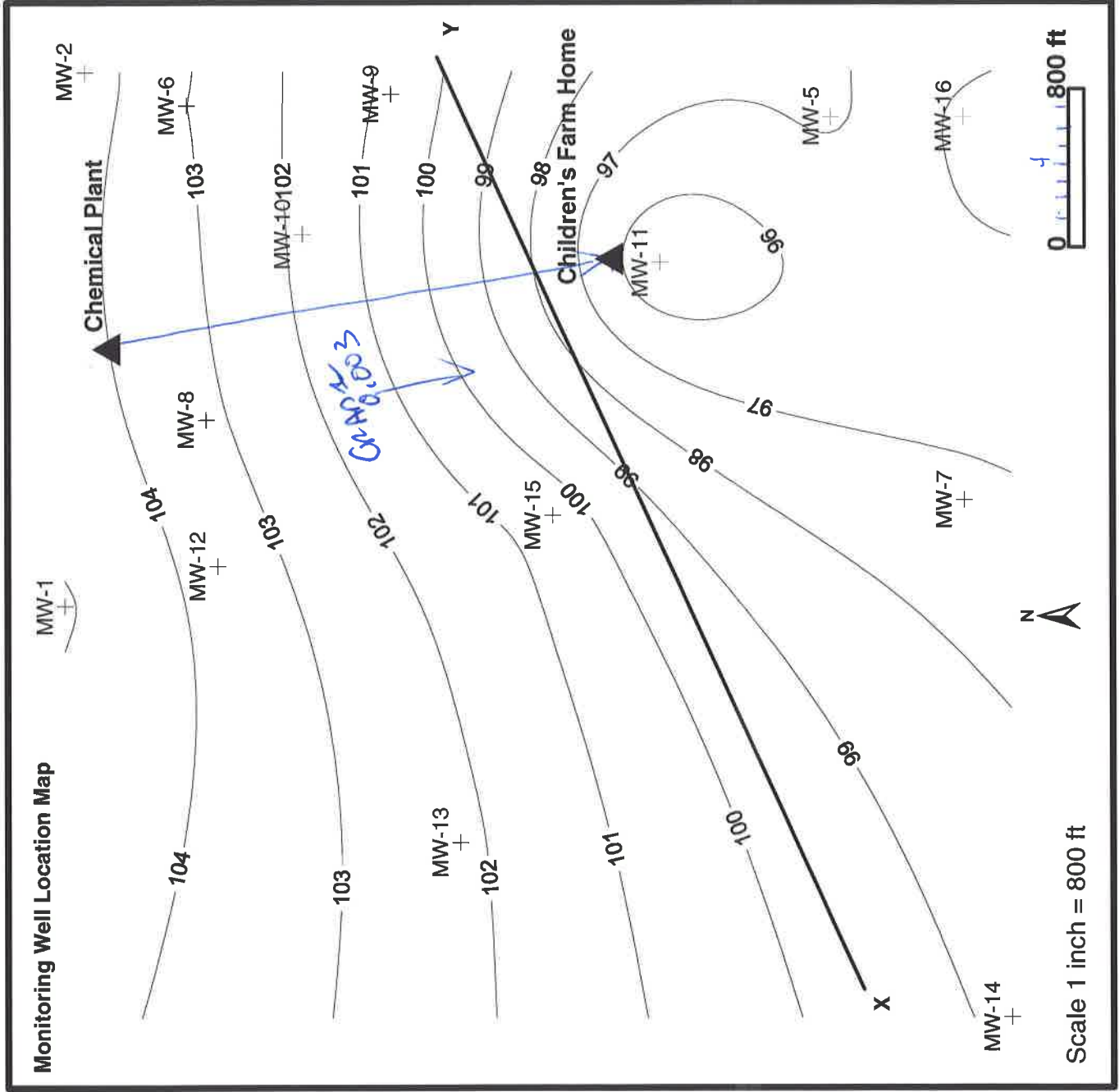
$Q = \left(\frac{0.1 \text{ cm}}{\text{sec}}\right) \frac{3.15 \times 10^7 \text{ sec}}{\text{yr}} \left(\frac{1 \text{ ft}}{30.5 \text{ cm}}\right) (254,800 \text{ ft}^2) (0.003) =$

$Q = \frac{7.9 \times 10^7 \text{ Ft}^3}{\text{yr}} \left(\frac{7.48 \text{ GAL}}{\text{Ft}^3}\right) \left(\frac{1 \text{ MGal}}{10^6 \text{ GAL}}\right) = 590.5 \frac{\text{MGal}}{\text{yr}}$

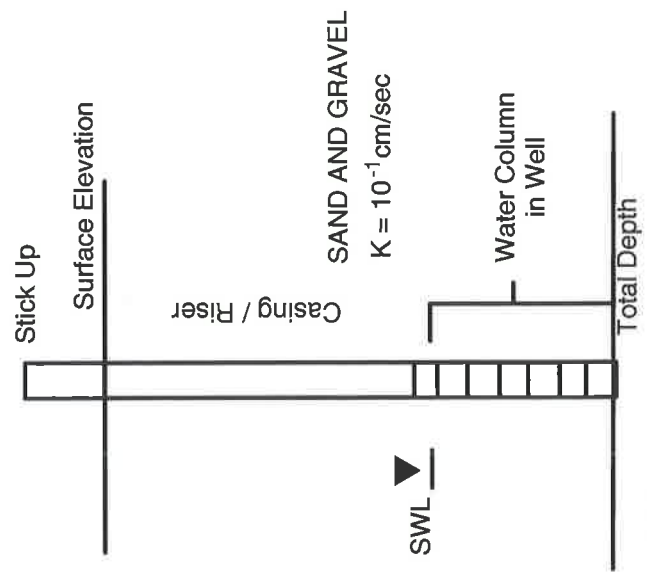
$Q \approx 591 \frac{\text{MGal}}{\text{yr}}$

KEY

Figure 1. ES476 Hydrology - Well Field Problem / Aquifer Analysis



3 of 3



$$\text{CFT} = \frac{\Delta h_{\text{neto}}}{\text{H.D.}} = \frac{104 \text{ ft} - 96 \text{ ft}}{\frac{8 \text{ ft}}{2560 \text{ ft}}} = 0.003$$

$$\text{H} = 104 \text{ ft} \text{ (at CP)}$$

$$\text{Distance CP} \rightarrow \text{CFT} = (3.2 \text{ mi}) \frac{800 \text{ ft}}{1 \text{ mi}} = 2560 \text{ ft}$$

SURF-ELEV + STICK-UP =

KEY

T

FE/OAY

X_east	Y_north	SWL_elev	ID	sort	Surf_elev	stickUP	DTW	Elev_top_casing	SWL_Elev	TD	Water_column
8.898453	18.21669	105.1	MW-1	1	172	1.3	68.2	173.3	105.1	118	51.1
18.38745	17.84916	104.5	MW-2	2	158	2	55.5	160	104.5	115	61.5
17.58556	4.651437	97.2	MW-5	5	154	1.2	58	155.2	97.2	110	53.2
17.78603	16.04491	103	MW-6	6	157	2.1	56.1	159.1	103	115	61.0
10.76952	2.312603	97.3	MW-7	7	163	1.8	67.5	164.8	97.3	110	44.3
12.20624	15.71079	103.2	MW-8	8	165	1.9	63.7	166.9	103.2	115	53.2
17.9865	12.43642	100.8	MW-9	9	154	2.1	55.3	156.1	100.8	115	61.8
15.51402	14.00678	101.8	MW-10	10	159	1.6	58.8	160.6	101.8	115	57.8
15.01284	7.691927	95.1	MW-11	11	156	1.5	62.4	157.5	95.1	110	49.1
9.600107	15.51032	103.6	MW-12	12	168	0	64.4	168	103.6	116	57.6
4.68855	11.23359	102.2	MW-13	13	172	0	69.8	172	102.2	116	46.2
1.581237	1.477303	98.8	MW-14	14	174	1.8	77	175.8	98.8	110	34.8
10.50223	9.596407	100.6	MW-15	15	163	2.1	64.5	165.1	100.6	112	49.6
17.58556	2.312603	95.8	MW-16	16	153	2	59.2	155	95.8	110	52.8

MW1 $T = (Kb) \left(\frac{10^{-6} \text{ cm}}{\text{Sec}} \right) \left(\frac{24 \text{ hrs}}{\text{day}} \right) \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) \left(\frac{1 \text{ ft}}{2.54 \text{ in}} \right) \left(\frac{1 \text{ ft}}{12 \text{ in}} \right)$

$T = 14,485 \frac{\text{ft}^2}{\text{DAY}}$

SURFACE ELEVATION

DTW

STICK-UP

WATER COLUMN

SWL ELEV. = (SURFACE + STICK-UP) - DTW

SAND + GRAVEL $K = 10^{-1} \text{ cm/sec}$

CLAY $K = 10^{-6} \text{ cm/sec}$

$T = Kb = (K)(\text{WATER COLUMN})$

