

Applied Hydrogeology | (4th Edition)

Chapter 8, Problem 6P

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Problem

Answers to odd-numbered problems appear at the end of the book.
The aquifer beneath an infinite-strip oceanic island has a mean hydraulic conductivity of 312 ft/d. The amount of recharge is 0.00831 ft/d. The density of fresh water is 1.000 g/cm³ and the density of underlying saline water is 1.024 g/cm³. If the island is 8715 ft in width, what is the depth to the salt-water interface in the center of the island?

Step-by-step solution

Step 1 of 12

Determine the specific gravity G using the formula;
$$G = \frac{\rho_s}{\rho_w - \rho_s}$$
Here, ρ_w is the density of fresh water and ρ_s is the density of saline water.
Substitute 1.000 g/cm³ for ρ_w and 1.024 g/cm³ for ρ_s .
$$G = \frac{1.000}{1.024 - 1.000}$$
$$= 41.7$$

Comment

Step 2 of 12

Determine the half width a of an infinite strip oceanic island using the formula;
$$a = \frac{d}{2}$$
Here, d is the diameter of the island.
Substitute 8,715 ft for d .
$$a = \frac{8,715}{2}$$
$$= 4,357.5 \text{ ft}$$

Comment

Step 3 of 12

Determine the elevation n of the water table above sea level using the formula;
$$h^2 = \frac{w[a^2 - (a-x)^2]}{K(1+G)}$$
Here, w is the recharge rate, x is the distance from the coast, and K is the hydraulic conductivity.
The distance from the coast varies from 4,357.5 ft to 0 ft.
To calculate the head above the sea level, drop the half width of an infinite strip oceanic island value by 100 ft consecutively and take the drop value as distance from the coast.

Comment

Step 4 of 12

Determine the elevation of the water table above sea level using the formula;
$$h^2 = \frac{w[a^2 - (a-x)^2]}{K(1+G)}$$
Substitute 0.00831 ft/day for w , 4,357.5 ft for a , 4,257.5 ft for x , 312 ft/day for K , and 41.7 for G .
$$h^2 = \frac{0.00831[4,357.5^2 - (4,357.5 - 4,257.5)^2]}{312(1+41.7)}$$
$$h = 3.44 \text{ ft}$$
Similarly calculate and tabulate the elevation of the water table above sea level as in Table (1), (2), (3), and (4).

Comment

Step 5 of 12

Determine the depth z to the salt-water interface in the center of the island using the formula;
$$z = Gh$$
Substitute 41.7 for G and 3.4 ft for h .
$$z = 41.7 \times 3.44$$
$$= 143.5 \text{ ft}$$
Similarly calculate and tabulate the depth to the salt-water interface in the center of the island as in Table (1), (2), (3), and (4).

Comment

Step 6 of 12

Show the radius, radial distance, amount of recharge, hydraulic conductivity, specific gravity, depth above the sea level, and depth to the salt-water interface in the center of the island as in Table (1).

a (ft)	x (ft)	w (ft/day)	K (ft/day)	G	h (ft)	z (ft)
4357.5	4257.5	0.00831	312	41.7	3.44	143.5
4357.5	4157.5	0.00831	312	41.7	3.44	143.4
4357.5	4057.5	0.00831	312	41.7	3.43	143.2
4357.5	3957.5	0.00831	312	41.7	3.43	142.9
4357.5	3857.5	0.00831	312	41.7	3.42	142.6
4357.5	3757.5	0.00831	312	41.7	3.41	142.1
4357.5	3657.5	0.00831	312	41.7	3.40	141.6
4357.5	3557.5	0.00831	312	41.7	3.38	141.1
4357.5	3457.5	0.00831	312	41.7	3.37	140.4
4357.5	3357.5	0.00831	312	41.7	3.35	139.7

Comment

Step 7 of 12

Show the radius, radial distance, amount of recharge, hydraulic conductivity, specific gravity, depth above the sea level, and depth to the salt-water interface in the center of the island as in Table (2).

a (ft)	x (ft)	w (ft/day)	K (ft/day)	G	h (ft)	z (ft)
4357.5	3257.5	0.00831	312	41.7	3.33	138.9
4357.5	3157.5	0.00831	312	41.7	3.31	138.0
4357.5	3057.5	0.00831	312	41.7	3.28	137.0
4357.5	2957.5	0.00831	312	41.7	3.26	135.9
4357.5	2857.5	0.00831	312	41.7	3.23	134.7
4357.5	2757.5	0.00831	312	41.7	3.20	133.5
4357.5	2657.5	0.00831	312	41.7	3.17	132.1
4357.5	2557.5	0.00831	312	41.7	3.13	130.7
4357.5	2457.5	0.00831	312	41.7	3.10	129.1
4357.5	2357.5	0.00831	312	41.7	3.06	127.5

Comment

Step 8 of 12

Show the radius, radial distance, amount of recharge, hydraulic conductivity, specific gravity, depth above the sea level, and depth to the salt-water interface in the center of the island as in Table (3).

a (ft)	x (ft)	w (ft/day)	K (ft/day)	G	h (ft)	z (ft)
4357.5	2257.5	0.00831	312	41.7	3.02	125.7
4357.5	2157.5	0.00831	312	41.7	2.97	123.9
4357.5	2057.5	0.00831	312	41.7	2.92	121.9
4357.5	1957.5	0.00831	312	41.7	2.87	119.8
4357.5	1857.5	0.00831	312	41.7	2.82	117.5
4357.5	1757.5	0.00831	312	41.7	2.76	115.2
4357.5	1657.5	0.00831	312	41.7	2.70	112.6
4357.5	1557.5	0.00831	312	41.7	2.64	110.0
4357.5	1457.5	0.00831	312	41.7	2.57	107.1
4357.5	1357.5	0.00831	312	41.7	2.50	104.1

Comment

Step 9 of 12

Show the radius, radial distance, amount of recharge, hydraulic conductivity, specific gravity, depth above the sea level, and depth to the salt-water interface in the center of the island as in Table (4).

a (ft)	x (ft)	w (ft/day)	K (ft/day)	G	h (ft)	z (ft)
4357.5	3100	0.00831	312	41.7	2.42	100.9
4357.5	3200	0.00831	312	41.7	2.34	97.4
4357.5	3300	0.00831	312	41.7	2.25	93.7
4357.5	3400	0.00831	312	41.7	2.15	89.8
4357.5	3500	0.00831	312	41.7	2.05	85.5
4357.5	3600	0.00831	312	41.7	1.94	80.9
4357.5	3700	0.00831	312	41.7	1.82	75.8
4357.5	3800	0.00831	312	41.7	1.68	70.2
4357.5	3900	0.00831	312	41.7	1.54	64.0
4357.5	4000	0.00831	312	41.7	1.37	56.9
4357.5	4100	0.00831	312	41.7	1.17	48.6
4357.5	4200	0.00831	312	41.7	0.92	38.2
4357.5	4300	0.00831	312	41.7	0.56	23.2
4357.5	4400	0.00831	312	41.7	0.00	0.0

Comment

Step 10 of 12

The fresh water lens thins very rapidly in the last 100 m as the shoreline is approached. As the Dupuit assumptions may not be valid near the coastline the profile of the interface close to the coast can be calculated using the below formula,
$$z = \frac{Gq'}{K} + \sqrt{\frac{2Gq'x}{K}}$$
Here, q' is the outflow per unit width.
The outflow per unit width is equal to the recharge rate times the half width.
Determine the outflow rate using the formula;
$$q' = w \times \frac{d}{2}$$
Substitute 0.00831 ft³/day for w and 8,715 ft for d .
$$q' = 0.00831 \times \frac{8,715}{2}$$
$$= 36.21 \text{ ft}^3/\text{day/ft}$$

Comment

Step 11 of 12

The distance from the coast varies from 0 ft to 100 ft.
To calculate the depth to the salt-water interface in the center of the island, increase the width of an infinite strip oceanic island value by 20 ft consecutively and take the drop value as distance from the coast.
Determine the profile z of the interface close to the coast using the formula;
$$z = \frac{Gq'}{K} + \sqrt{\frac{2Gq'x}{K}}$$
Substitute 41.7 for G , 36.21 ft³/day/ft for q' , 312 ft/day for K , and 0 ft for x .
$$z = \frac{41.7 \times 36.21}{312} + \sqrt{\frac{2 \times 41.7 \times 36.21 \times 0}{312}}$$
$$= 4.70 \text{ ft}$$
Similarly calculate and tabulate the profile of the interface close to the coast for the remaining values as in Table (5).

Comment

Step 12 of 12

Show the specific gravity, discharge per unit width, hydraulic conductivity, distance from the coast, and profile of the interface close to the coast as in Table (5).

G	q' (ft ³ /day/ft)	K (ft/day)	x (ft)	z (ft)
41.7	36.21	312	0	4.70
41.7	36.21	312	20	18.6
41.7	36.21	312	40	24.4
41.7	36.21	312	60	28.8
41.7	36.21	312	80	32.5
41.7	36.21	312	100	35.8

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