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# Groundwater hydraulics – wells-exercises

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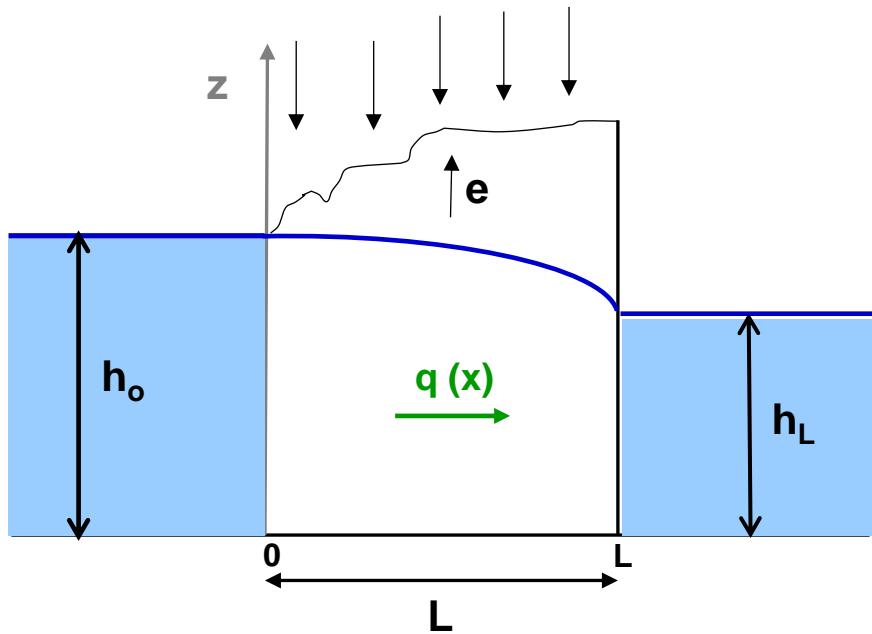
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## Example 1



**General solution:**

$$1. \frac{dq}{dx} + e = 0$$

$$2. q = -Kh(x) \frac{dh}{dx}$$

$$\frac{dq}{dx} + e = 0$$

$$dq = -e \cdot dx \quad \text{after integration} \longrightarrow \quad q = -e \cdot x + c_1$$

$$-K \cdot h \cdot \frac{dh}{dx} = -e \cdot x + c_1$$

$$-K \cdot h \cdot dh = (-e \cdot x + c_1) \cdot dx$$

**Boundary conditions:**

1.  $x = 0 \quad h(x) = h_0$
2.  $x = L \quad h(x) = h_L$

1.  $x = 0 \quad h(x) = h_0$       **the 1st boundary condition**

$$-K \cdot \frac{h^2}{2} = -\frac{e \cdot x^2}{2} + c_1 \cdot x + c_2$$

$$c_2 = -K \cdot \frac{h_0^2}{2}$$

2.  $x = L \quad h(x) = h_L$       **the 2nd boundary condition**

$$-K \cdot \frac{h_L^2}{2} = -\frac{e \cdot L^2}{2} - K \cdot \frac{h_0^2}{2} + c_1 \cdot L$$

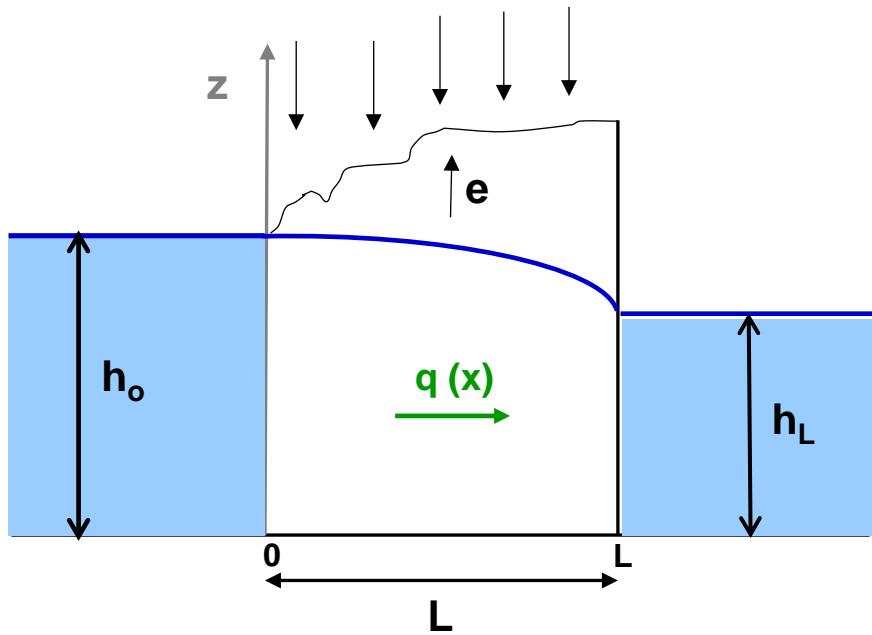
$$c_1 = -K \cdot \frac{h_L^2}{2} + \frac{e \cdot L^2}{2} + K \cdot \frac{h_0^2}{2} = K \left( \frac{h_0^2}{2 \cdot L} - \frac{h_L^2}{2 \cdot L} \right) + \frac{e \cdot L}{2}$$

**Specific flow  $q$ :**       $q = \frac{e \cdot L}{2} - e \cdot x + K \cdot \left( \frac{h_0^2 - h_L^2}{2 \cdot L} \right)$

$$x = 0 \quad q_o = \frac{e \cdot L}{2} - K \cdot \left( \frac{h_L^2 - h_0^2}{2 \cdot L} \right)$$

$$x = L \quad q_L = -\frac{e \cdot L}{2} - K \cdot \left( \frac{h_L^2 - h_0^2}{2 \cdot L} \right)$$

## Example 1



**General solution:**

$$h_o = 100 \text{ m}$$

$$h_L = 80 \text{ m}$$

$$e = 1 \text{ cm/hod}$$

$$L = 50 \text{ m}$$

$$K = 0.1 \text{ m/hod}$$

$$q = ?$$

$$\frac{dq}{dx} + e = 0$$

$$dq = -e \cdot dx \quad \text{after integration} \longrightarrow \quad q = -e \cdot x + c_1 = -(-1)x + c_1$$

$$-K \cdot h \cdot \frac{dh}{dx} = -e \cdot x + c_1$$

$$-K \cdot h \cdot dh = (-e \cdot x + c_1) \cdot dx$$

**Boundary conditions:**

1.  $x = 0 \quad h(x) = h_0$
2.  $x = L \quad h(x) = h_L$

$$1. \quad x = 0 \quad h(x) = 100 \text{ m}$$

$$-K \cdot \frac{h^2}{2} = -\frac{e \cdot x^2}{2} + c_1 \cdot x + c_2$$

$$c_2 = -0.1 \cdot \frac{100^2}{2} = -500$$

$$2. \quad x = 50 \text{ m} \quad h(x) = 80 \text{ m}$$

$$-0.1 \cdot \frac{80^2}{2} = -\frac{(0.01) \cdot 50^2}{2} - 0.1 \cdot \frac{100^2}{2} + c_1 \cdot 50$$

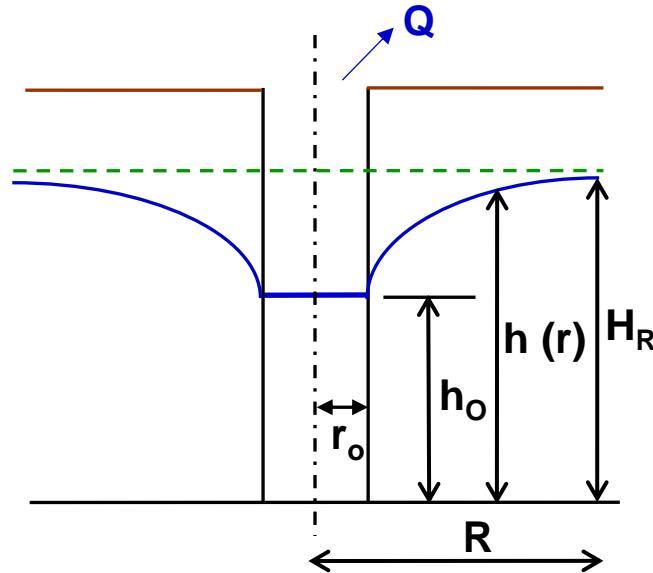
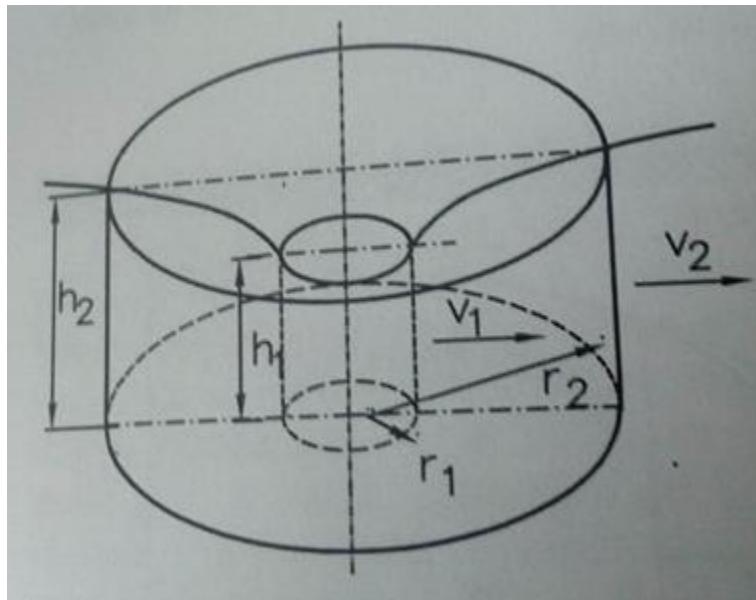
$$c_1 = 3.85$$

Specific flow  $q$ :

$$x = 0 \quad q_o = \frac{e \cdot L}{2} - K \cdot \left( \frac{h_L^2 - h_o^2}{2 \cdot L} \right)$$

$$x = L \quad q_L = -\frac{e \cdot L}{2} - K \cdot \left( \frac{h_L^2 - h_o^2}{2 \cdot L} \right)$$

# Wells - 1



$$Q = 2 \cdot \pi \cdot r \cdot h(r) \cdot v$$

$$Q = 2 \cdot \pi \cdot r \cdot h(r) \cdot \left( -K \cdot \frac{dh}{dr} \right)$$

$$h(r)=?$$

# Wells - 1

$$Q = 2 \cdot \pi \cdot r \cdot h(r) \cdot v \quad h(r) = ?$$

$$Q = 2 \cdot \pi \cdot r \cdot h(r) \cdot \left( -K \cdot \frac{dh}{dr} \right)$$

$$-\frac{Q}{2 \cdot \pi \cdot K} \cdot \frac{1}{r} dr = h \cdot dh$$

$$-\frac{Q}{2 \cdot \pi \cdot K} \cdot \int \frac{1}{r} dr = \int h \cdot dh$$

$$-\frac{Q}{2 \cdot \pi \cdot K} \cdot \ln r + c = \frac{h^2}{2}$$

$$c = \frac{H_R^2}{2} + \frac{Q}{2 \cdot \pi \cdot K} \cdot \ln R$$

$$h^2 = H_R^2 + \frac{Q}{\pi \cdot K} \cdot \ln \frac{r}{R}$$

$$h = \sqrt{H_R^2 + \frac{Q}{\pi \cdot K} \cdot \ln \frac{r}{R}}$$

$$Q = \pi \cdot K \cdot (H R^2 - h_o^2) \cdot \ln \frac{r}{R}$$

## Wells - 1

$$h(r) = ?$$

$$r = 0.5 \text{ m}$$

$$H_R = 15 \text{ m}$$

$$h_o = 10 \text{ m}$$

$$K = 0.001 \text{ m/s}$$

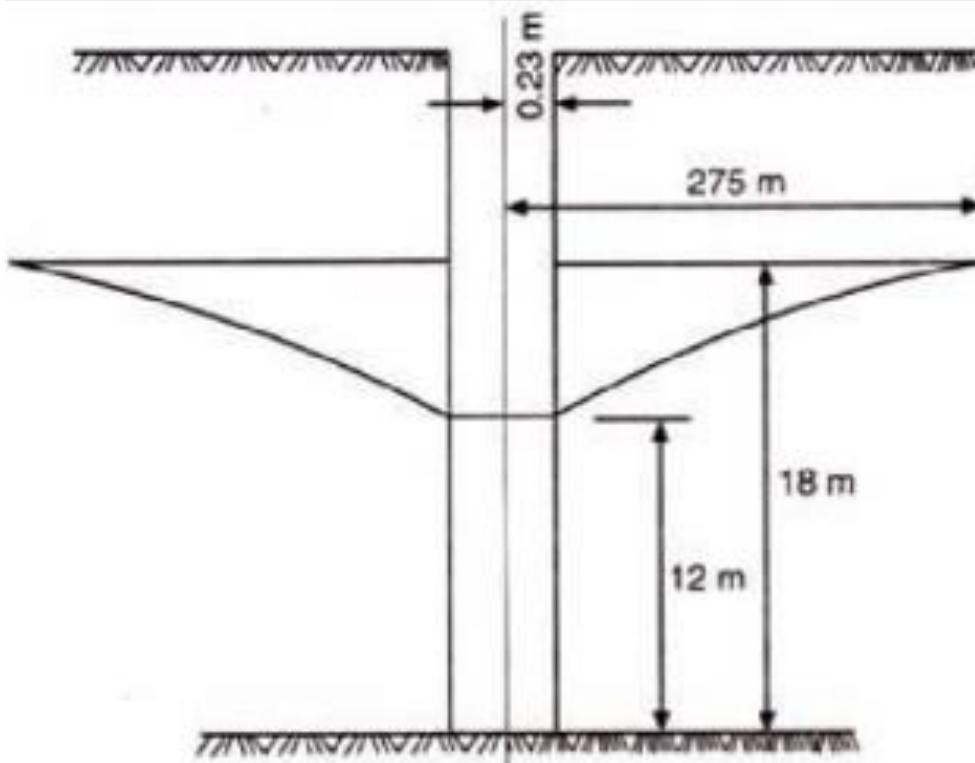
$$Q = 10 \text{ m}^3/\text{s}$$

$$h^2 = H_R^2 + \frac{Q}{\pi \cdot K} \cdot \ln \frac{r}{R}$$

$$h = \sqrt{H_R^2 + \frac{Q}{\pi \cdot K} \cdot \ln \frac{r}{R}}$$

$$Q = \pi \cdot K \cdot (H R^2 - h_o^2) \cdot \ln \frac{r}{R}$$

A tube well is 0.46 m in diameter. The unconfined aquifer is of 18 m depth. After drawdown depth of water is 12 m in the well. Permeability of soil is 24.50 m/day. Radius of circle of influence is 275 meters. Calculate discharge of the tube well.



$$Q = \frac{\pi \cdot K \cdot (H R^2 - h_o^2)}{2.303 \log_{10} R/r}$$

$$Q = ?$$