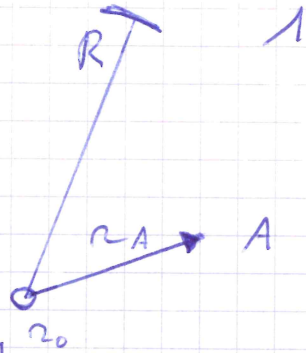
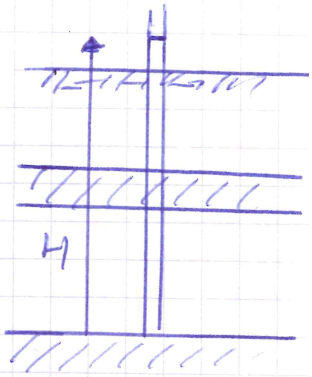
Multiple well extraction

15/11/2024

CONFINED AQUIFER





SINGLE WELL:

$$H - h_A = \frac{Q}{2\pi k D}\left[\ln R - \ln r_A\right]$$

MULTIPLE WELLS

well 1 $\quad H - h_A = \dfrac{Q}{2\pi k D}\left[\ln R_1 - \ln r_{A,1}\right]$

well 2 $\quad H - h_A = \dfrac{Q}{2\pi k D}\left[\ln R_2 - \ln r_{A,2}\right]$

⋮

well n $\quad H - h_A = \dfrac{Q}{2\pi k D}\left[\ln R_n - \ln r_{A,n}\right]$

SUPERPOSITION

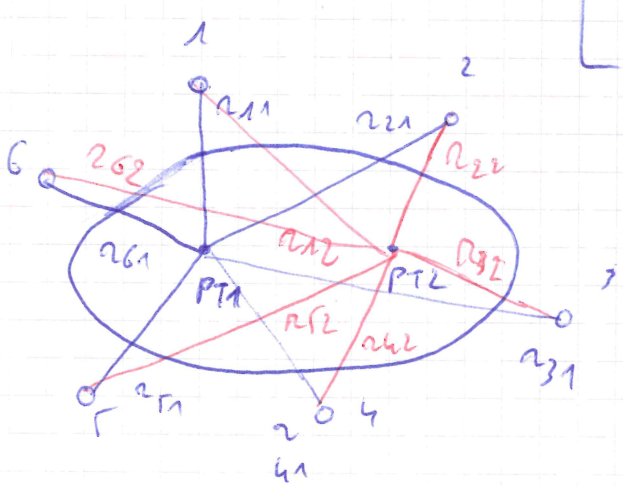
$$H - h_A = \frac{Q}{2\pi k D}\left[\ln R_1 \cdot R_2 \dots R_n - \ln r_{A,1} \cdot r_{A,2} \dots r_{A,n}\right]$$

GENERAL EQUATION - RELATIONSHIP BETWEEN 2 POINTS

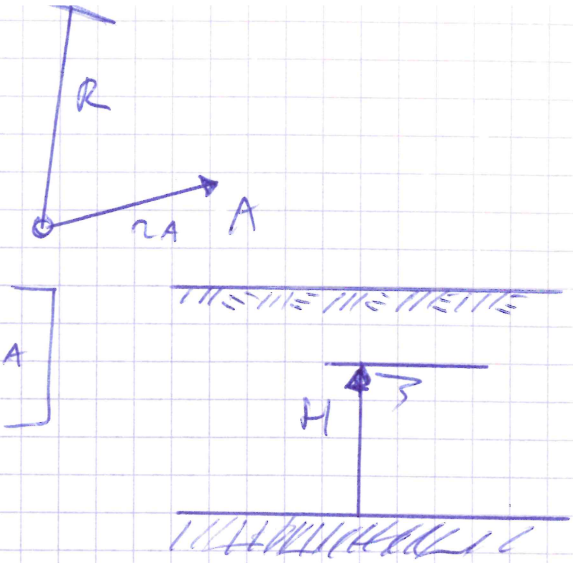
$$h_2 - h_1 = \frac{Q}{2\pi k D}\left[\ln r_{12} \cdot r_{22} \dots r_{n2} - \ln r_{11} \cdot r_{21} \dots r_{n1}\right]$$

r_{22} : distance well 2 to point 2

r_{12} : distance well 1 to point 2



UNCONFINED AQUIFER



SINGLE WELL

$$H^2 - h_A^2 = \frac{Q}{\pi k}\left[\ln R - \ln r_A\right]$$

MULTIPLE WELLS

well 1 $\quad H^2 - h_A^2 = \frac{Q}{\pi k}\left[\ln R_1 - \ln r_{A,1}\right]$

well 2 $\quad H^2 - h_A^2 = \frac{Q}{\pi k}\left[\ln R_2 - \ln r_{A,2}\right]$

⋮

well n $\quad H^2 - h_A^2 = \frac{Q}{\pi k}\left[\ln R_n - \ln r_{A,n}\right]$

SUPERPOSITION $\quad H^2 - h_A^2 = (H - h_A)(H + h_A)$

$\hookrightarrow \simeq$ cte when $(H + h_A) \simeq$ cte

$$(H^2 - h_A^2) = \frac{Q}{\pi k}\left[\ln R_1 \cdot R_2 \cdots R_n - \ln r_{A,1} \cdot r_{A,2} \cdots r_{A,n}\right)$$

GENERAL EQUATION – RELATIONSHIP BETWEEN 2 POINTS

$$(h_2^2 - h_1^2) = \frac{Q}{\pi k}\left[\ln r_{12} \cdot r_{22} \cdots r_{n2} - \ln r_{11} \cdot r_{21} \cdots r_{n1}\right]$$

(FIG ≡ FIG p.1)

$R_1 = 3000 s\sqrt{k} = 3000 (H - h_A)\sqrt{k}$

$\hookrightarrow$ unknown !

$R_2 = 3000 s\sqrt{k} = 3000 (H - h_2)\sqrt{k}$

$R_n = 3000 s\sqrt{k} = 3000 (H - h_n)\sqrt{k}$

STEP 1 CRITICAL POINT

= POINT FOR WHICH Q is maximum

$$(h_2^2 - h_1^2) = \frac{Q}{\pi k}\left[\ln r_{12}\cdot r_{22}\cdots r_{n2} - \ln r_{11}\cdot r_{21}\cdots r_{n1}\right]$$

(A) (A)

MAX WHEN (A) IS MAXIMUM

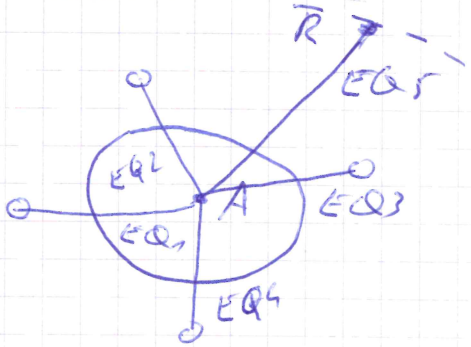
most critical point = point for which $r_{11}\cdot r_{21}\cdots r_{n1}$ is MAX

STEP 2: SOLVE EQUATIONS

- unknowns - $h_1, h_2 \ldots h_n$: the height in the individual wells (n)

$$-\frac{Q}{n+1 \text{ unknowns}} \quad (1)$$

- because of symmetry the number of unknowns will be reduced
- equations: for example for 4 wells



(A most critical point)

STEP 3 - OPTIMIZE

* MINIMUM NUMBER OF WELLS : 3
* h in each well ≈ the same height
  when h_i is ↑ : modify the location in a way that $h_i \approx$ the
  when h_i is ↓ : modify
* $Q_{OPT} = Q_{MAX} = 2\pi h_i \cdot h\frac{1}{15\sqrt{h}} = 2\pi \cdot h_i \cdot \frac{\sqrt{h}}{15}$; $Q' > Q_{MAX} \Rightarrow$ ADD MORE WELLS ; $Q < Q_{MAX} \Rightarrow$ LESS WELLS

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