هندسة الموارد المائية والهيدروليكا

ماجستير العلوم الهندسية (M. Sc.)

ادارة الموارد المائية

مدع 609 – مقرر اجبارى - 3 ساعات معتمدة

أعمال السنة: 40 – التحريرى: 60 – الاجمالى: 100 درجة

Water Resources Management

Contents:

- Planning and measurement concepts for control, conservation and use for water resources by emphasizing interdisciplinary approaches.
- Alternatives to minimize flood damages.
- Egypt water rights, multipurpose projects, environmental impacts, policies for the future.
- Systems approach to planning.

Report 1: Minimizing flood damages, especially in Egypt.

Report 2: Rain gauge stations, especially in Egypt.

Report 3: Egypt water rights, multipurpose projects, and policies for the future.

Dr. Alaa Nabil El-Hazek

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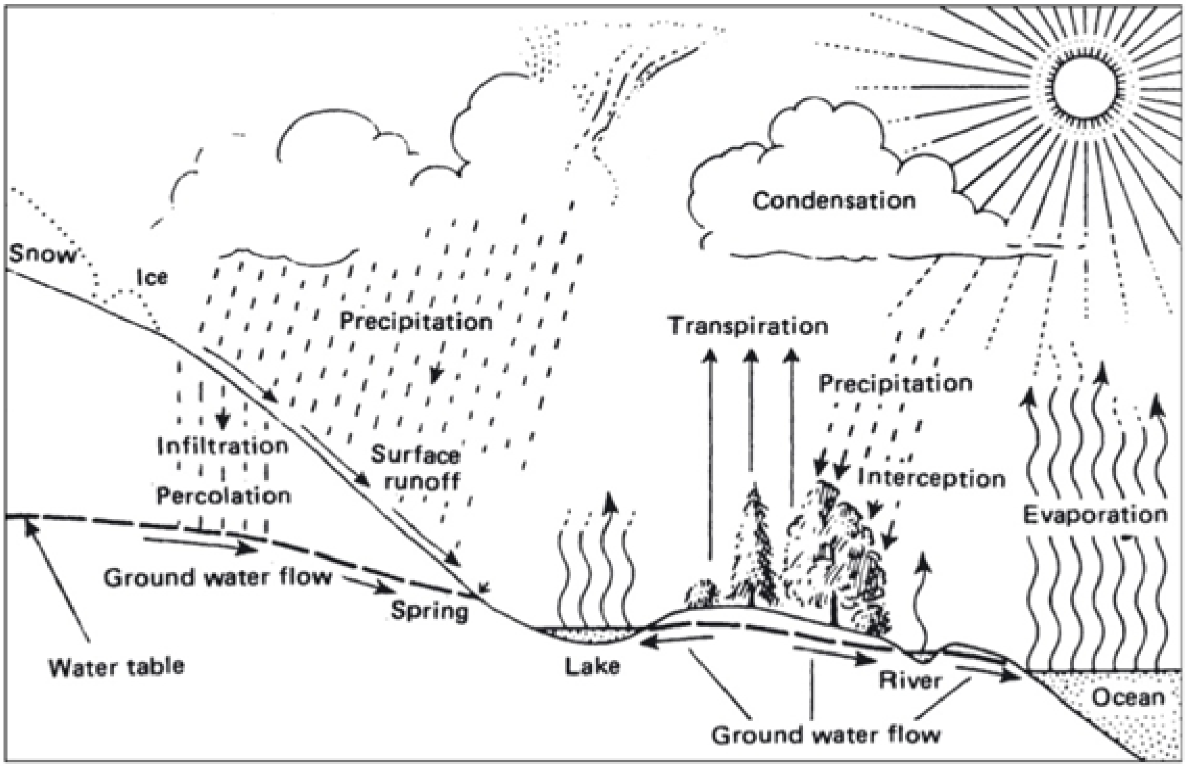
Ch. 1 – Introduction

Hydrologic Cycle

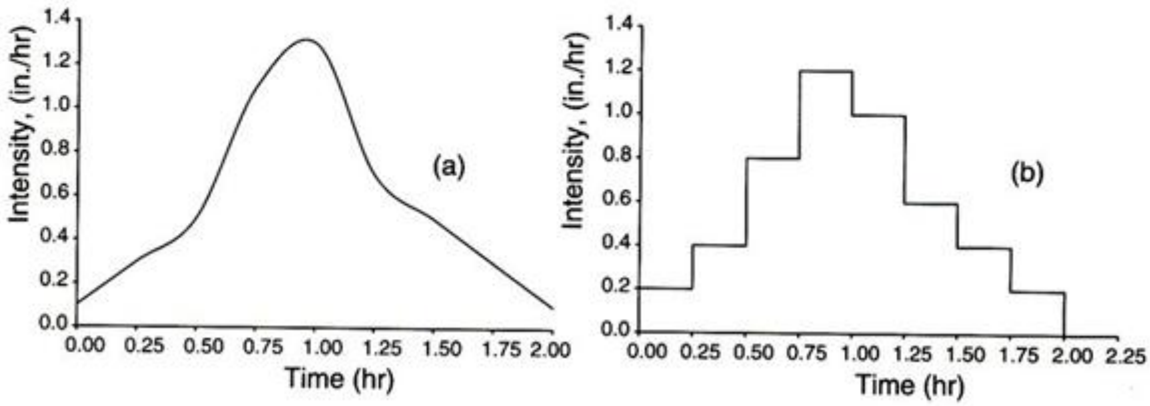


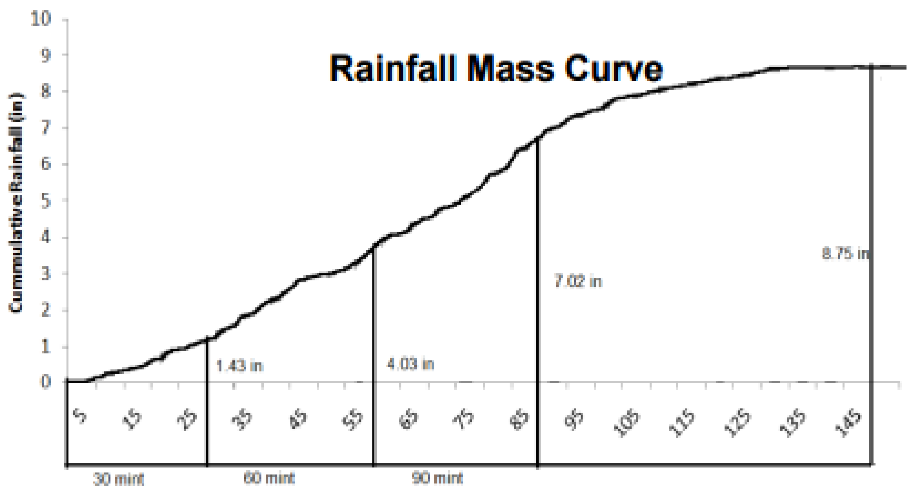
(climateofindia.pbworks.com)

Presentation of rainfall data

Rainfall Hyetographs

***Hyetographs* describe the varying rainfall intensity during a storm**





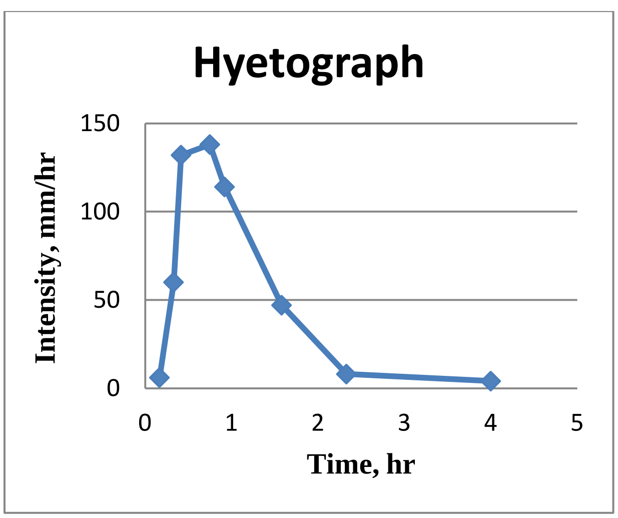
Example (1):

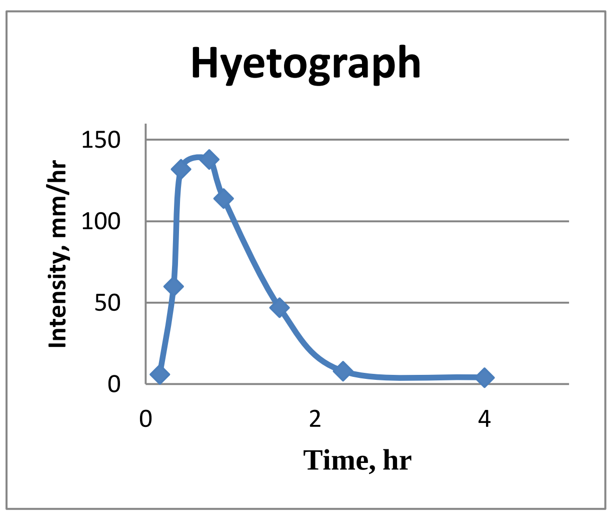
From the cumulative depth of rain fall, draw the hyetograph?

Time	Accumulated Depth (mm)
6:50	0
7:00	1
7:10	11
7:15	22
7:35	68
7:45	87
8:25	118
9:10	124
10:50	130

Solution:

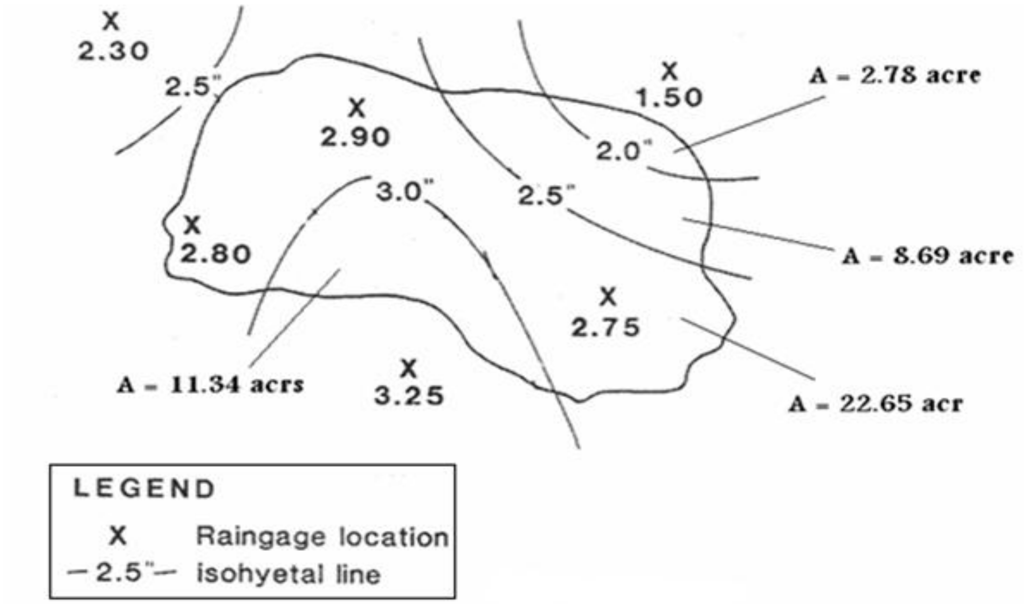
Time	Accumulated Depth, mm	Interval Depth, mm	Interval Time, hr	Intensity, mm/hr	Time from Start, hr
6:50	0			0	0
7:00	1	1	0.167	6	0.167
7:10	11	10	0.167	60	0.33
7:15	22	11	0.0833	132	0.417
7:35	68	46	0.33	138	0.75
7:45	87	19	0.167	114	0.92
8:25	118	31	0.67	47	1.58
9:10	124	6	0.75	8	2.33
10:50	130	6	1.67	4	4.00





Example (2):

Compare between the Isohyetal method and Arithmetic Mean method?



Area	Boundary Contour		
	Contour 1	Contour 2	Average Contour
2.78	1.5	2	1.75
8.69	2	2.5	2.25
22.65	2.5	3	2.75
11.34	3	3.25	3.125
Total Area = 45.46 acre			

Isoheytal Method:

P = (1.75*2.78) + (2.25*8.69) + (2.75*22.65) + (3.125*11.34) / 45.46 = 2.69 mm

Arithmetic Mean:

P = (1.75+2.25+2.75+3.125) / 4 = 2.47 mm

<u>Chapter 3</u> - <u>Evapotranspiration</u>

<u>Example 1:</u>

The six-month seasonal precipitation is 70 cm, runoff is 20 cm, the change in storage is 15 cm and there is no change in groundwater.
What are the monthly evapotranspiration rates?

<u>Solution:</u>

Change in storage = inputs – outputs

ΔS = P – R – G – ET

15 = 70 – 20 – 0 – ET

ET = 35 cm/6 months

<u>Pan evaporation</u> *(E_P)* is used to estimate lake evaporation. The lake evaporation *(E_L)* is usually calculated for *yearly time period* using a pan coefficient *(p_c)*.

$$\boldsymbol{E_L = p_c \times E_p}$$

The pan coefficient on an *annual basis* has been reported to vary between *0.65 and 0.82 (Kohler et al., 1955).* For *short time period*, the coefficient has been reported for well-watered grass to vary between *0.35 and 0.85 (Shih et al., 1983).*

<u>Example 2:</u>

For a class A pan, the precipitation and water added to bring the level of water in the pan to a fixed level are as follows:

Week	1	2	3	4	*Water taken from the pan.
Rainfall (in)	0.00	1.04	1.84	0.42	
Water added (in)	0.90	0.04	- 0.70*	0.97	

a) Compute the weekly evaporation?

b) If the pan evaporation coefficient for this period of time is 0.80 and an adjacent lake has a surface area of 150 acre, what is the evaporation from the lake expressed in inches and cubic feet for 4-week period of time?

<u>Solution:</u>

a) Evaporation = rainfall + water added

E_{Weekly} = [(0+0.9) + (1.04+0.04) + (1.84 – 0.7) + (0.42+0.97)] / 4 = 1.118 in/week

b) $\boldsymbol{E_L =}$ $\boldsymbol{p_c}$ x $\boldsymbol{E_p}$ = 0.8 * (1.118*4) = 3.578 in

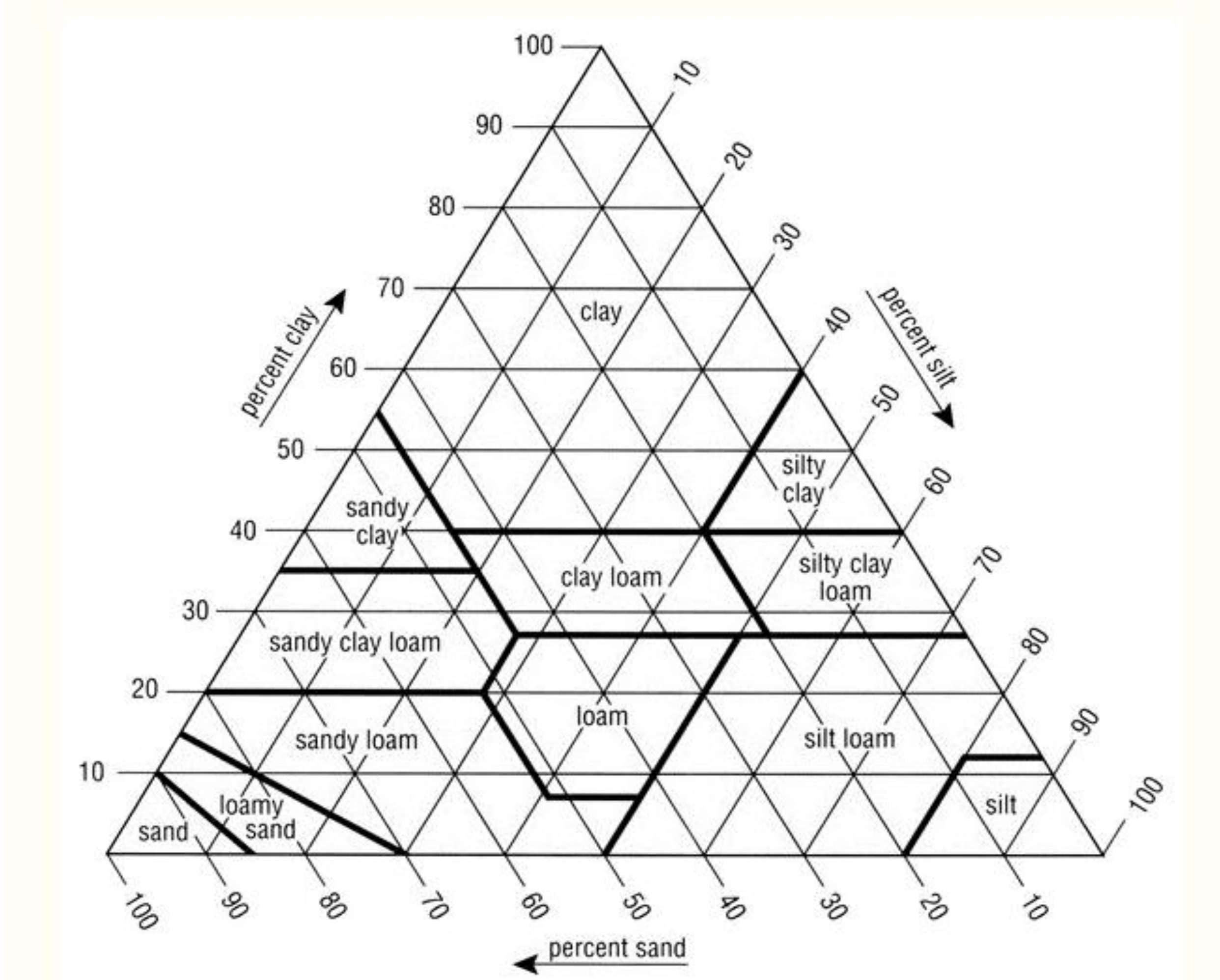
= (3.578/12) * (150*43,055.6) = 1,925,663.5 ft^3

(1 acre = 43,055.6 ft^2)

*(1 acre = 4,000 * $(3.28)^2$ = 43,055.6 ft^2)*

Chapter 4 - Infiltration

Types of Soils:



Soil Survey Division Staff (1993). United States Department of Agriculture. pp. 63–65.
http://www.had2know.com/garden/classify-soil-texture-triangle-chart.html

Example:

Use a soil texture triangle to calculate the soil texture for the following combinations of sand, silt and clay

a. *25% sand, 30% silt, 45% clay*
clay

b. *40% sand, 30% silt, 30% clay*
clay loam

c. *60% sand, 10% silt, 30% clay*
sandy clay loam

d. *70% sand, 12% silt, 18% clay*
sandy loam

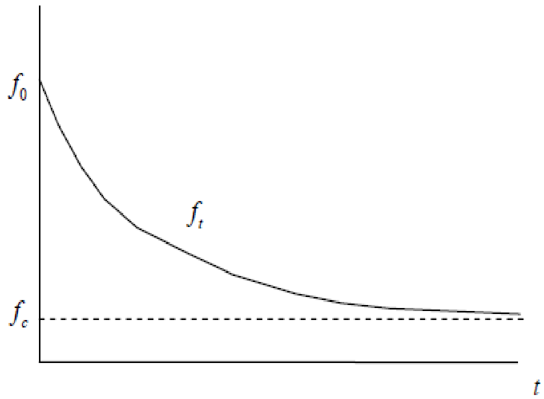
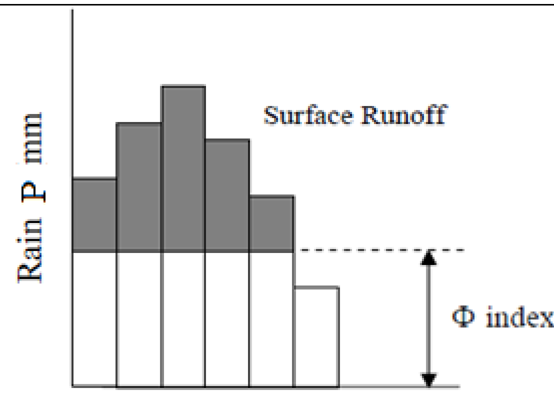
e. *90% sand, 5% silt, 5% clay*
sand

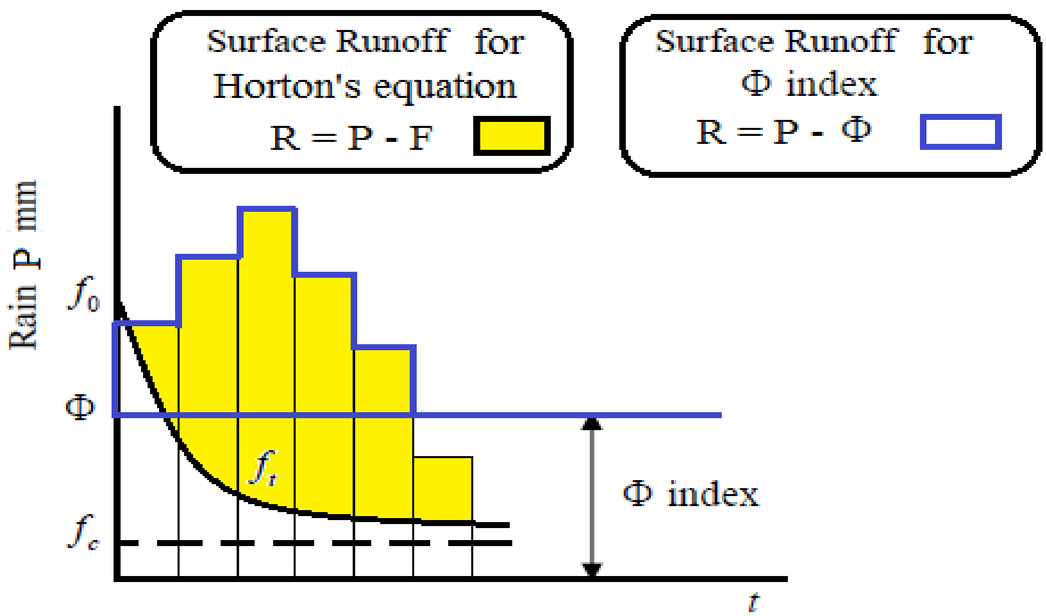
f. *80% sand, 15% silt, 5% clay*
loamy sand

g. *10% sand, 85% silt, 5% clay*
silt

h. *5% sand, 75% silt, 20% clay*
silt loam

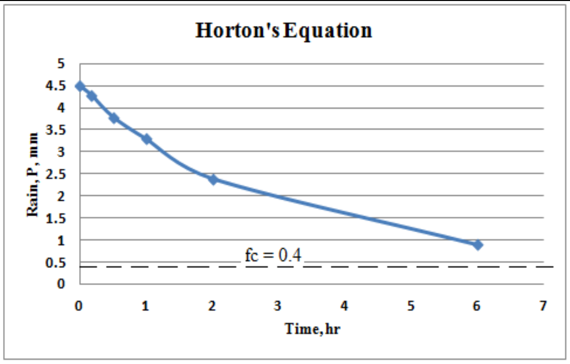
Estimation of Infiltration Rates:

(1) **Horton's Equation:**	(2) **ϕ - Index:**
	



Horton's Equation

Practice 1, Page 56



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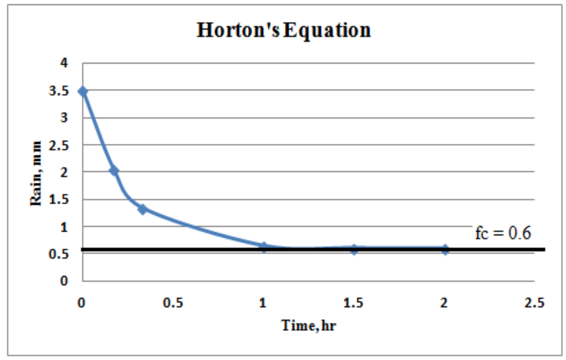

ϕ - Index

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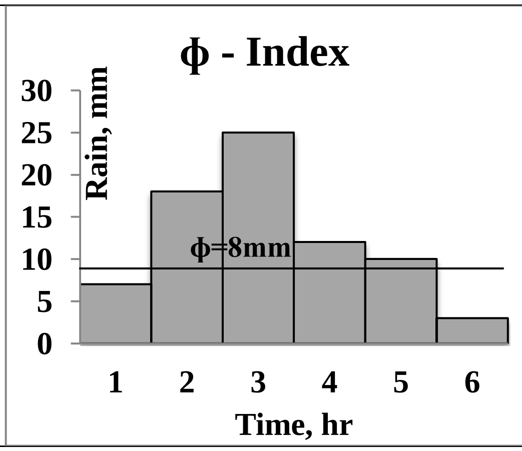
Time (hr)	1	2	3	4	5	6
Rain (mm)	7	18	25	12	10	3



(7-ϕ) + (18-ϕ) + (25-ϕ) + (12-ϕ) + (10-ϕ) + (3-ϕ) = 33

Try & Error

ϕ = 7   11+18+5+3 = 37

ϕ = 8   10+17+4+2 = 33

ϕ = 8 mm/hr

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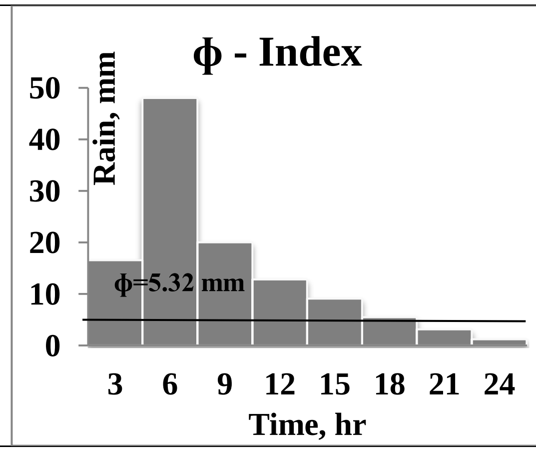
Time (hr)	3	6	9	12	15	18	21	24
Rain (mm)	16.5	48.0	20.0	12.8	9.1	5.5	3.1	1.2



(16.5-ϕ) + (48-ϕ) + (20-ϕ) + (12.8-ϕ) + (9.1-ϕ) + (5.5-ϕ) + (3.1-ϕ) + (1.2-ϕ) = 80

Try & Error

ϕ = 2   14.5+46+18+10.8+7.1+3.5+1.1 = 101

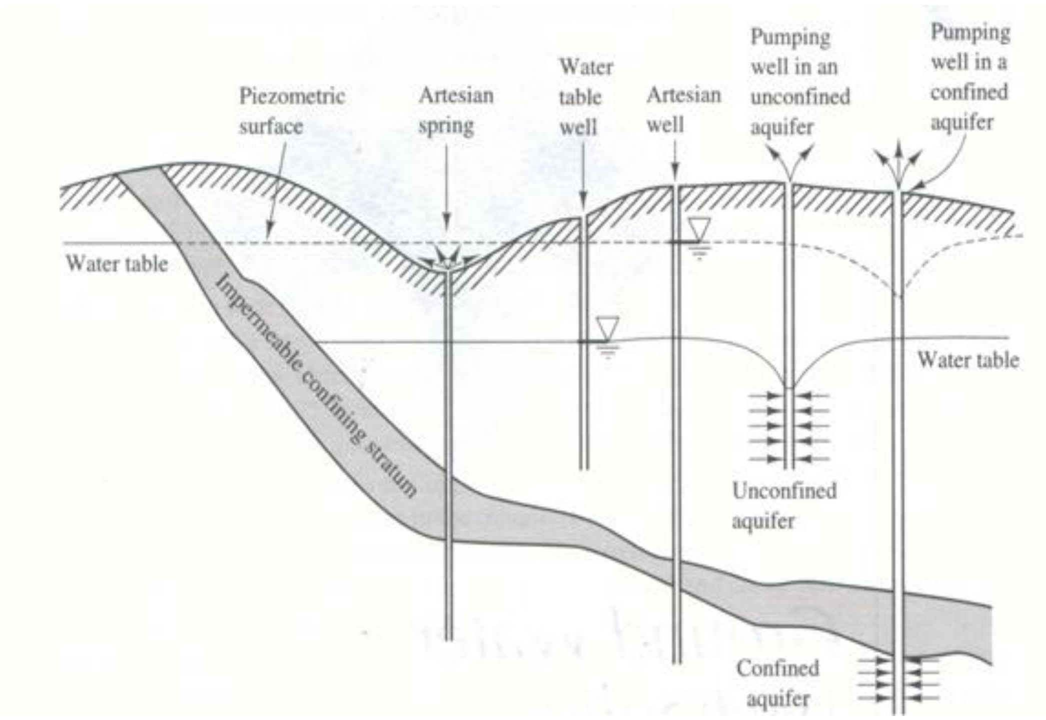
ϕ = 1   15.5+47+19+11.8+8.1+4.5+2.1+0.2 = 108.2

ϕ = 5.5 11+42.5+14.5+7.3+3.6 = 78.9

ϕ = 5.3 11.2+42.7+14.7+7.5+3.8 = 79.9

ϕ = 5.3 mm/3 hr = 1.77 mm/hr

Chapter 5 – Groundwater



Notes

- An artesian spring is formed when the impermeable confining stratum is perforated at a location where the ground surface falls below the piezometric surface.
- It becomes an artesian well if the ground surface rises above the piezometric surface.
- The water table of an unconfined aquifer is usually unrelated to the piezometric surface of a confined aquifer in the same region.
- The pressure head in a confined aquifer is represented by the piezometric surface that usually originates from a distant source such as the water table of a recharging area.

Hydraulic conductivity, K, is a property of vascular plants, soils and rocks that describes the ease with which a fluid (usually water) can move through pore spaces or fractures.
It depends on the permeability of the material, the degree of saturation, and on the density and viscosity of the fluid.
By definition, hydraulic conductivity is the ratio of velocity to hydraulic gradient.

$$K = \frac{Q/A}{\Delta h/\Delta s}$$

- K is the hydraulic conductivity, m/s
- Q is the discharge, m^3/s
- A is the area, m^2
- $\Delta h/\Delta s$ is the head loss per unit length
- q = Q/A is the flux, (m/s)

Permeability, k, is a portion of the flow of water through a porous media, and is a property of the porous media only, not the fluid.
Given the value of hydraulic conductivity for a subsurface system, the permeability can be calculated *as follows:*

$$k = K\frac{\mu}{\rho g}$$

- k is the permeability, m^2
- K is the hydraulic conductivity, m/s
- μ is the dynamic viscosity of the fluid, kg/(m.s)
- ρ is the density of the fluid, kg/m^3
- g is the acceleration due to gravity, m/s^2

Example (1):

A small sample of an aquifer (uniform sand) is packed in a test cylinder (Darcy-tube) to form a column 30 cm long and 4 cm in diameter. At the outlet of the test cylinder, 21.3 cm^3 of water is collected in 2 min. During the testing period a constant piezometric head difference of Δh = 14.1 cm is observed. Determine the hydraulic conductivity of the aquifer sample?

Solution

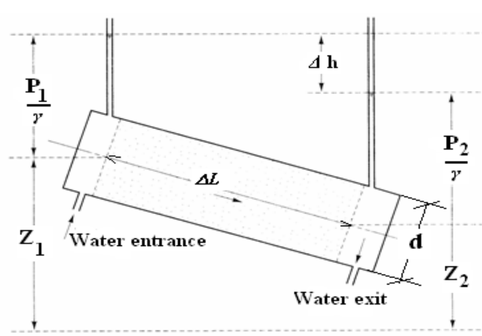
$$A = \frac{\pi d^2}{4} = \frac{\pi \quad 4^2}{4} cm^2 = 12.56 cm^2$$

$$\frac{dh}{dL} = \frac{14.1}{30} = 0.47$$

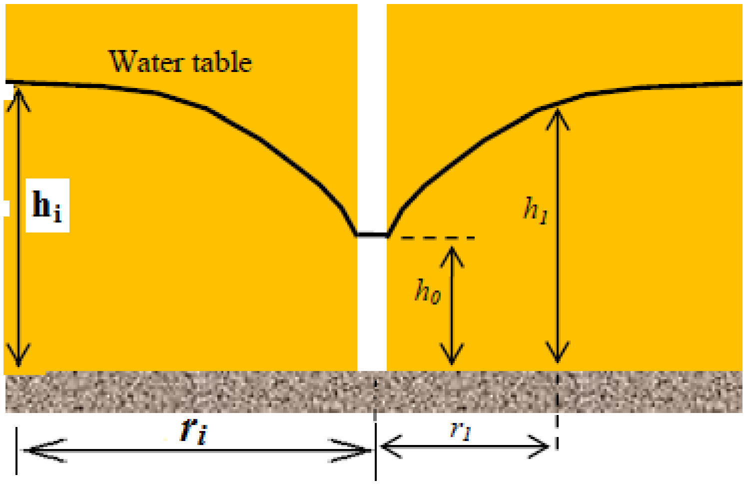
(Velocity head is negligible in ground water flow)

$$Q = \frac{21.3 \quad cm^3}{2 \quad \min} = \frac{21.3 \quad cm^3}{2 \quad x \quad 60\sec} = 0.1775 cm^3/\sec$$

$$K = \frac{\mathbf{Q/A}}{\boldsymbol{\Delta h/\Delta s}} = \frac{0.1775/12.56}{0.47} = 0.03\ cm/s$$



Unconfined Aquifer:



$$Q = (\pi K)\frac{(h1^2 - ho^2)}{ln\frac{r1}{ro}}$$

- The selection of the radius of influence, r_i, is somewhat arbitrary.
- The variation of Q is rather small for the wide range of r_i, because the influence on the well by the water table at great distance is small.
- In practice, approximate values of r_i may be taken between 100 and 500 m, depending on the nature of the aquifer and the operation of the pump.

Example (2):

A 95 ft-thick unconfined aquifer is penetrated by an 8-inch diameter well that pumps at a rate of 50 gpm. Assume hydraulic conductivity of $4x10^{-4}$ ft/sec.

If the radius of influence is 500 ft, determine the drawdown at the well?

Solution:

Q = 50 / 449 = 0.1114 cfs $K = 4x10^{-4}$ ft/sec

h_i = 95 ft r_i = 500 ft r_o = 4/12 = 0.33 ft

$$Q = (\pi K)\frac{(h1^2 - ho^2)}{ln\frac{r1}{ro}}$$

$$0.1114 = \frac{\pi * 4 * 10^{-4}\,(95^2 - ho^2)}{ln\frac{500}{0.33}}$$

h_o = 91.5 ft

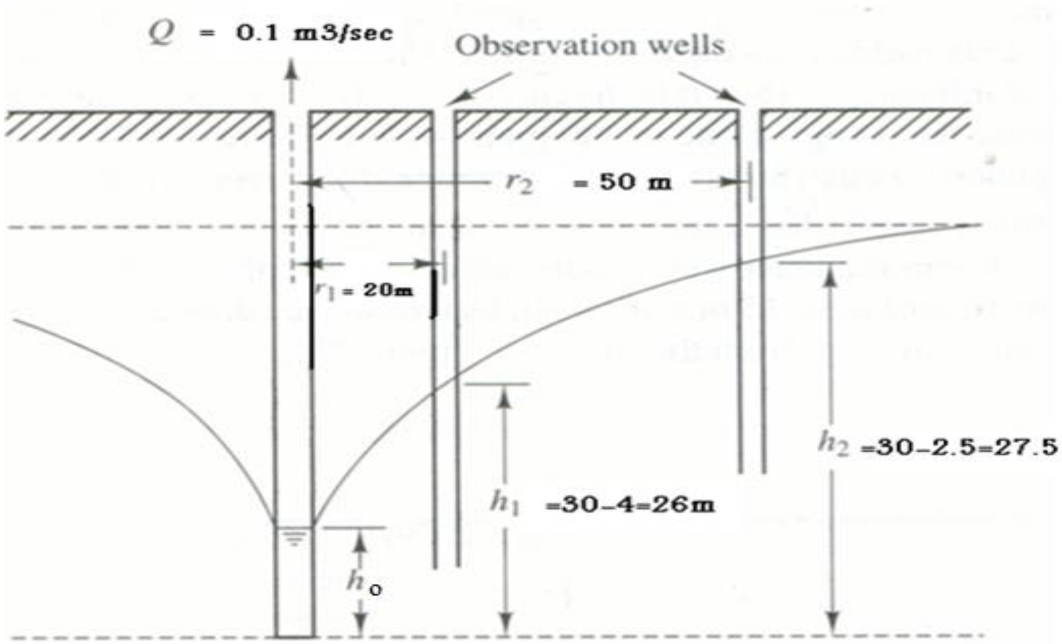
Drawdown = $h_i - h_o$ = 95 – 91.5 = 3.5 ft

Example (3):

A well 20 cm in diameter penetrates 30 m deep into the undisturbed water table of an unconfined aquifer. After a long period of pumping at a constant rate of 0.1 m^3/sec, the drawdown at distances of 20 m and 50 m from the well were observed to be 4 m and 2.5 m, respectively.

1. Determine the hydraulic conductivity of the aquifer?
2. What is the drawdown at the pumped well?

Solution



$Q = 0.1\ m^3/s$ $\quad$ $h_1 = 30 - 4 = 26$ m $\quad$ $h_2 = 30 - 2.5 = 27.5$ m

$r_1 = 20$ m $\quad$ $r_2 = 50$ m

1. $Q = (\pi K)\frac{(h2^2 - h1^2)}{ln\frac{r2}{r1}}$

$$K = \frac{Q}{\pi\ (h2^2 - h1^2)}\ ln\frac{r2}{r1}$$

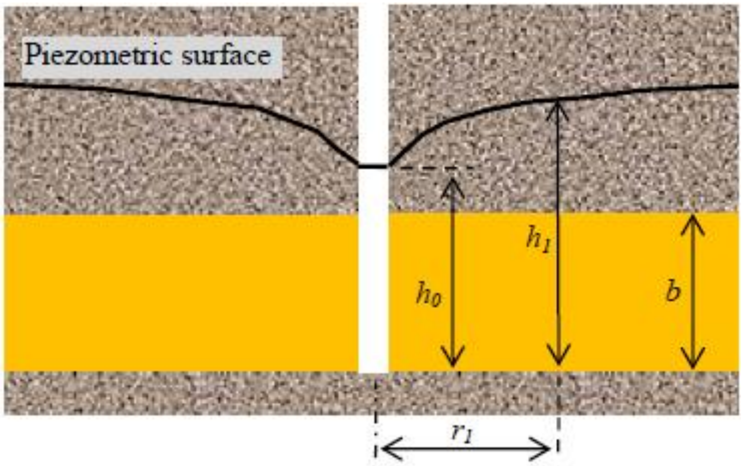
$K = \frac{0.1}{\pi\ (27.5^2 - 26^2)}\ ln\frac{50}{20}$ = 3.63*10^{-4} m/s

2. $Q = (\pi K)\frac{(h1^2 - ho^2)}{ln\frac{r1}{ro}}$

$$0.1 = (\pi * 3.6 * 10^{-4})\frac{(26^2 - ho^2)}{ln\frac{20}{0.1}}$$

$h_o = 14.5$ m $\quad$ & $\quad$ Drawdown = 30 –14.5 = 15.5 m

Confined Aquifer:



$$Q = (2\pi bK)\frac{(h1 - ho)}{ln\frac{r1}{ro}}$$

$$Q = (2\pi T)\frac{(h1 - ho)}{ln\frac{r1}{ro}}$$

Note: The transmissivity of 1 m^3/hr.m represents a flow rate 1 m^3/hr per meter of aquifer depth (or height) flowing towards the well.

Example (4):

A well fully penetrates a 25 m thick confined aquifer. After a long period of pumping at a constant rate of 0.05 m^3/sec, the drawdown at distances of 50 m and 150 m from the well were observed to be 3 m and 1.2 m, respectively.

1. Determine the hydraulic conductivity of the aquifer?
2. What is the transmissivity?

Solution

Q = 0.05 m^3/s　　　　$h_2 - h_1 = 3 - 1.2 = 1.8$ m

r_1 = 50 m　　　　r_2 = 150 m

1. $Q = (2\pi bK)\frac{(h1-ho)}{ln\frac{r1}{ro}}$

$K = \frac{Q}{2\,\pi\,b\,(h2-h1)}\;ln\frac{r2}{r1}$

$K = \frac{0.05}{2\,\pi*25\,(1.8)}\;ln\frac{150}{50}$ = 1.9*10^{-4} m/s

2. T = K * b = 1.9*10^{-4} * 25 = 0.00475 m^2/s

References

1. David A. Chin, 2007, *"Water-Resources Engineering, 2/E "*, Prentice Hall, ISBN: 0131481924
2. Dawei Han, 2010, "*Concise Hydrology*", www.Bookboon.com
3. Richard H. McCuen , 2005, *"Hydrologic Analysis and Design, 3/E"*, Prentice Hall, ISBN: 0131424246