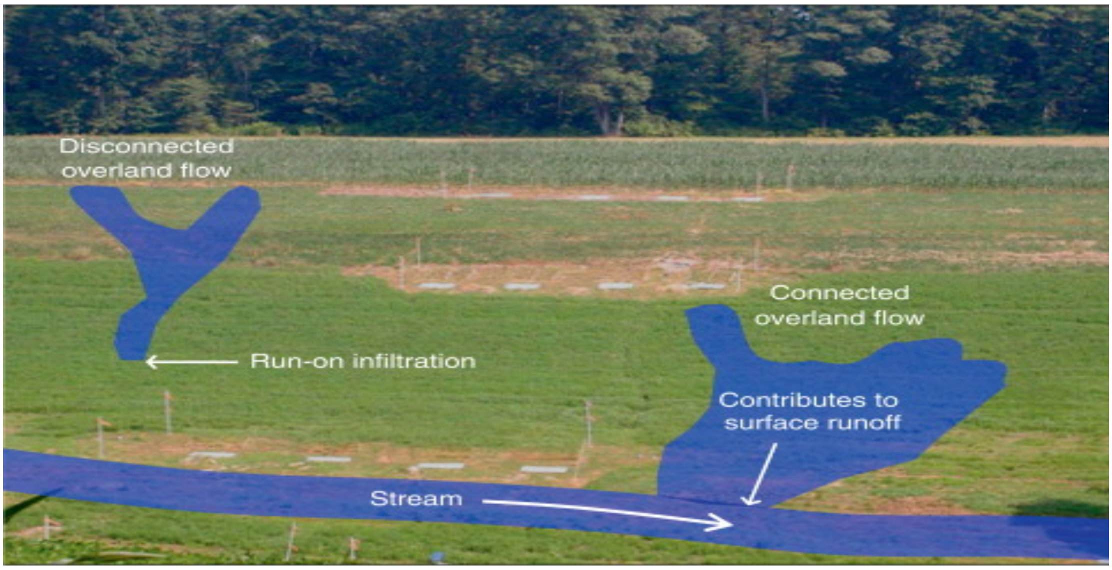
Lecture six

The Runoff



It is the flow or the discharge of precipitation on a catchment area or through a surface channel during a time till it reaches the surface water.It thus represents the catchment output in a given unit of time. The flow over land occurs when soil is infiltrated to full capacity and excess water from rain. The portion of runoff is called *overland flow*

During a precipitation a mass of a total volume of rainfall onto and flows on soil . Initial abstraction is water intercepted by vegetation IA, also there are evaporation, transpiration, infiltration F, and initial abstraction, and then the storage change is written as

R (rainfall excess)=P-E-T-F-Ia

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1- Some definitions related to the runoff :

1.1-Over land flow: the flow of water over the surface of the land.

1.2-Inter flow: the lateral flow of water under the surface of the soil.

1.3-Flow open channel: the flow of water through many channels to the stream.

1.4-Direct runoff: the sum. Of overland flow and interflow.

1.5-Base flow: interflow and groundwater. It is the delayed flow that reaches the stream as groundwater.

2-Volume of runoff

More complex methods for the determination of runoff are available.They require a more detailed mathematical description of the watershed characteristics.The volume of runoff may estimate as an annual or monthly or daily or even for some hours.

The mean methods to estimate the runoff volume:

2.1--Relation between precipitation and runoff.

2.2-Emprircal equations.

1& 2 through many relations between R&P like:

$R=CP$ or $R=aP+b$ or $R=0.85P-30.5$

2.3-Catchment area.

It depends on the budget equation.

2.4-Infiltration indices.

(Have studied previously)

2.5-Rational equation.

(This lecture)

2.6-The Hydrograph.(next lecture))

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2.5- Rational equation (CIA)

The rational methods are one of the oldest and were originally used to estimate the peak discharge. The simplest model of watershed runoff is the rational equation (Q=CIA).

Q: peak discharge (m^3/s)

C: runoff coefficient,(in fig.)

I: rainfall intensity(mm/hr.)

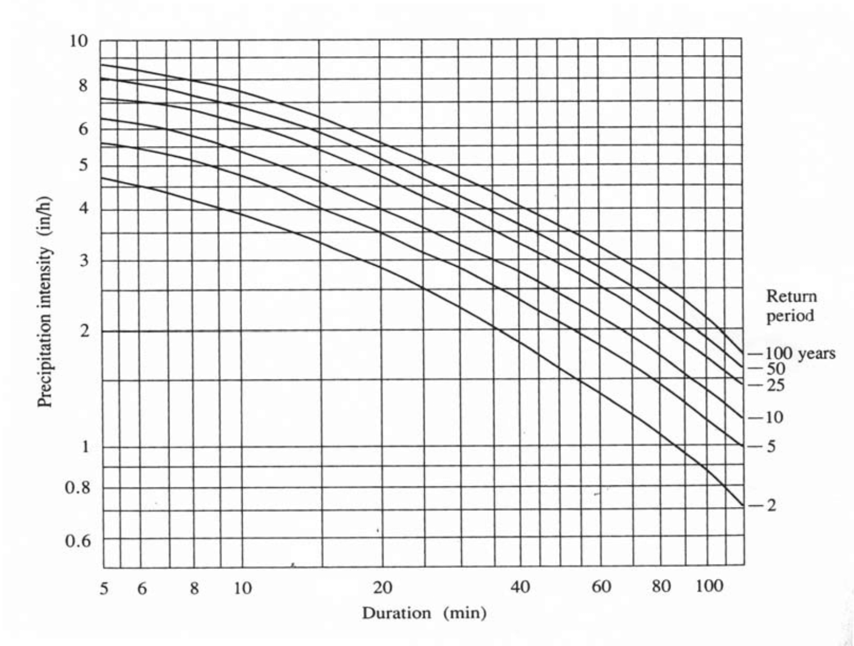
A: watershed area.(m^2)

Runoff coefficient C

Ground Cover	**Runoff Coefficient, c**
Lawns	0.05 - 0.35
Forest	0.05 - 0.25
Cultivated land	0.08-0.41
Meadow	0.1 - 0.5
Parks, cemeteries	0.1 - 0.25
Unimproved areas	0.1 - 0.3
Pasture	0.12 - 0.62
Residential areas	0.3 - 0.75
Business areas	0.5 - 0.95
Industrial areas	0.5 - 0.9
Asphalt streets	0.7 - 0.95
Brick streets	0.7 - 0.85
Roofs	0.75 - 0.95
Concrete streets	0.7 - 0.95

2.5.1-The intensity could be calculated using

a-I-D-F curves (fig.)



b- The relation between the rainfall intensity and the duration

$$i(cm/hr)=\boxed{\frac{424}{(tmin.+21)}}$$

c- The relation between the rainfall depth and the duration

i= depth/duration

In the watershed area the infiltration and depression storage is incorporated into the value of (c) so the volume of runoff will depend on the watershed area,it is: the total surface area of the drainage basin. This area can subdivide into two areas: pervious area and the impervious area. The pervious area allows for soil infiltration whereas the impervious does not. If the area were 100%impervoius, then the mass balance's infiltration term would be zero.

2.5.2-Time of concentration:

The time of concentration is the longest travel time it takes a particle of water to reach a discharge point in a watershed.

a-lizard's formula

$Tc=41KL/i$

Tc: time (min) , L: overflow distances(ft.) , i: rainfall intensity(in/hr.)

$K=0.0007\ i + cr\ /s$

S: slope, ce: retardance coef.(kind of surface)

b-**Kerby´s equation**

$Tc=c(Lns^{-0.5})$

Tc:time ,L:length of flow(ft) , s: slope , c:0.83(when using ft)1.44(when using m)

N:retardness roughness coef.

***c-Kirpich´s equation**

$tc=0.0078(L^{0.77}/S^{0.385})$
tc;time(min)
L:length of travel(ft,m)
S:slope (m/m)

Examples

Ex.1:

Design a pipe of the storm sewer system that receive drainage water from an area of 10000 m^2. the length =189m.slope channel=0.004m/ rainfall depth=28.7mm, runoff coef.=0.6,relevant slope=0.005m/m,?

$Tc=0.02*(189)^{0.77}(0.004)^{-0.365}$

$=9.487$ min

I=p/t==181.5 mm/hr

$I=\frac{p}{t} = \frac{28.7}{9.487/60} = 181.5$ mm/hr

Q=CIA

$=0.6*\frac{181.5}{1000}*\frac{1}{3600}*10000=0.302\ m^3/s$

$Q=\frac{1}{n} R^{2/3}\ S^{1/2}\ A$

$=\frac{1}{n}\ (A/P)^{2/3}\ S^{1/2}\ A$

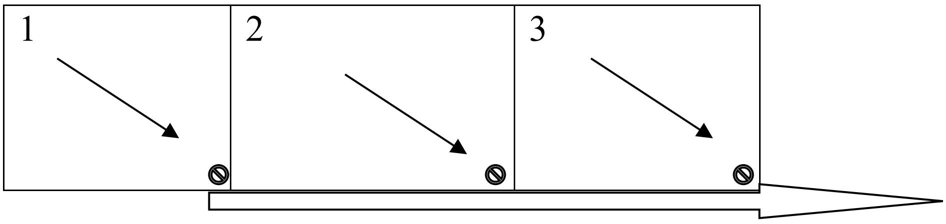
R=A/P=D/4

$Q=\frac{1}{n}*(\frac{D}{4})^{2/3}\ S^{1/2}$ D=0.52 m

Ex.2 :

For the watershed (fig.)find the peak discharge from the outfall,use 50 yr. return period and IDF curve below?

	1	2	3
Area(acre)	3.9	7.1	8.9
C	0.4	0.4	0.4
Time(min)	5	6	7
Length(ft)		600	720
Velocity(ft/s)		2	2.5



T_2=L/V=600/2=300 s = 5 min

T_3=720/2.5=200 s= 4.8 min

Max. t =5+5+4.8=14.8 min

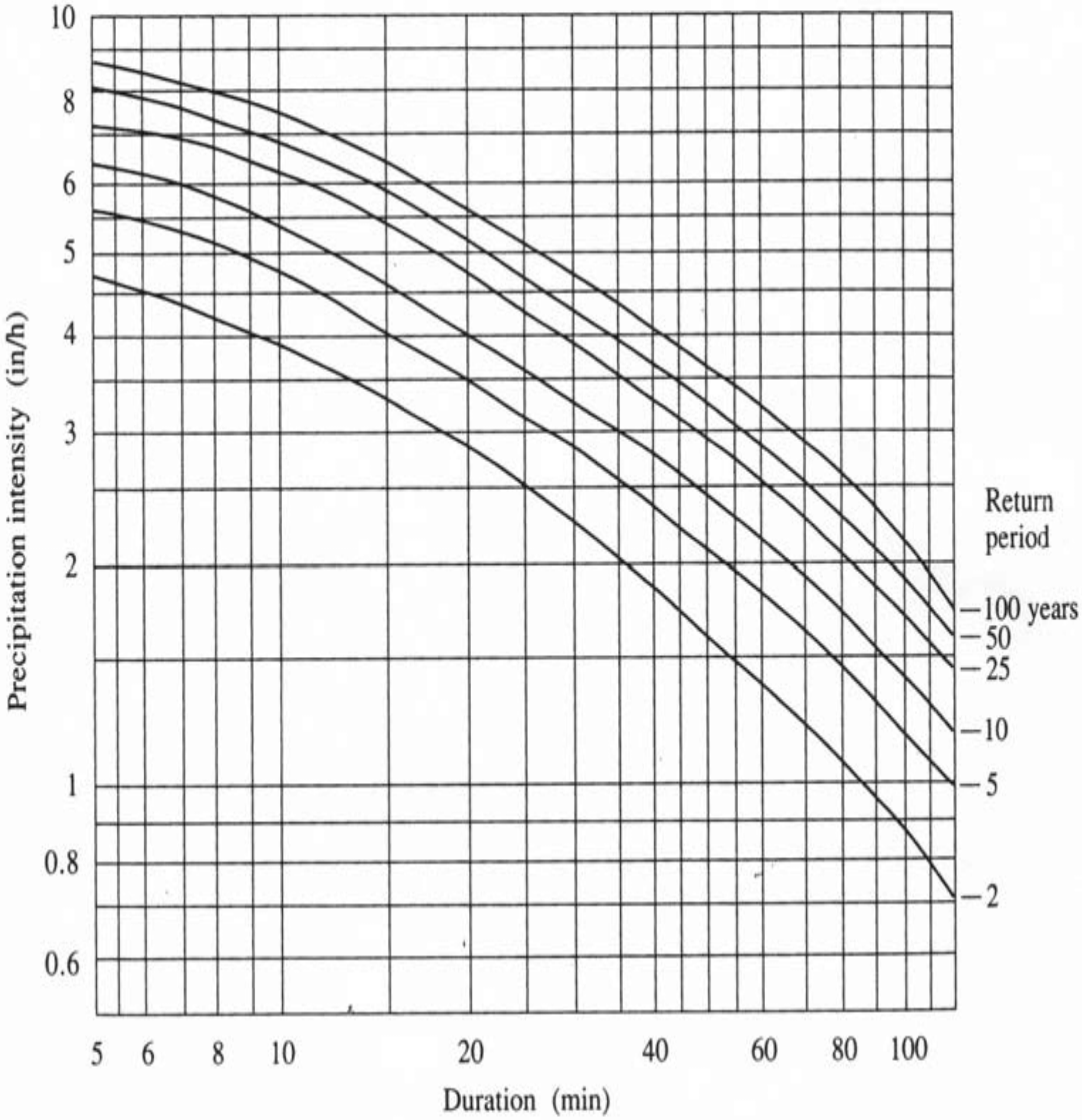
From chart i=7 in/hr

=7/12*0.3048/3600=0.00005 m/s

Q=CIA

=0.4*0.00005*4000(3.9+7.1+8.9)

=1.592 m^3/s


10
8
6
5
4
3
2
1
0.8
0.6
Precipitation intensity (in/h)
5
6
8
10
20
40
60
80
100
Duration (min)
Return
period
100 years
50
25
10
5
2