Example 7.1 A watershed has a runoff coefficient of 0.20, area 150 ha with the general slope of 0.001 and maximum length of travel of overland flow of 1.25 km. Information on the storm of 50 years return period is given as follows:

Duration (min)	15	30	45	60	80
Rainfall (mm)	40	60	75	100	120

Estimate the peak flow to be drained by a culvert for a 50-year storm.

The SCS-CN method

The SCS-CN method

- Method developed by Soil Conservation Service (1972) for computing abstractions from storm rainfall
- This method is widely used for estimating floods on small to medium-sized ungaged drainage basins around the world.

The SCS-CN method

- For the storm as a whole, the depth of excess precipitation or direct runoff *Pe* is always less than or equal to the depth of precipitation P;
- likewise, after runoff begins, the additional depth of water retained in the watershed,*Fa*, is less than or equal to some potential maximum retention *S*

The SCS-CN method

- There is some amount of rainfall *Ia* (initial abstraction before ponding) for which no runoff will occur, so the potential runoff Pe is *P — Ia.*
- The hypothesis of the SCS method is that the ratios of the two actual to the two potential quantities are equal, that is,

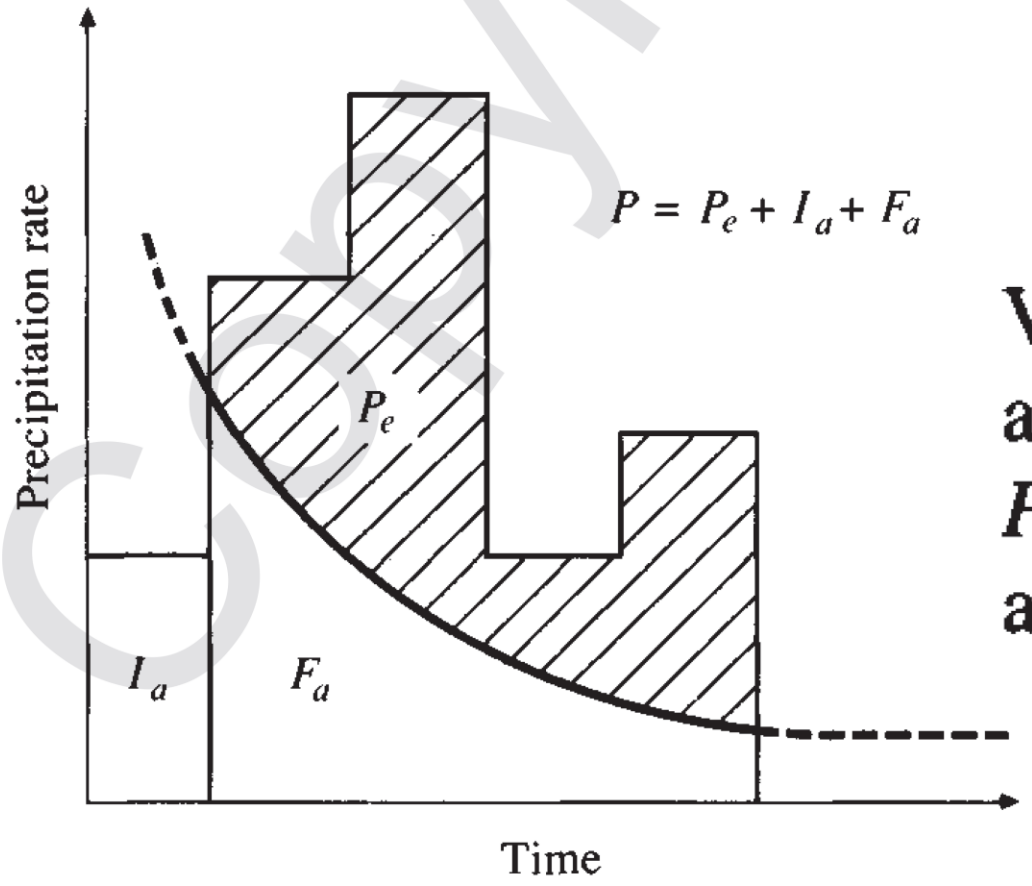
$$\frac{F}{S} = \frac{r_d}{P_e}$$

+

Continity eqn → $P = P_e + I_a + F_a$

→ $$P_e = \frac{(P - I_a)^2}{P - I_a + S}$$

The SCS-CN method

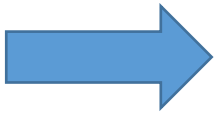


Variables in the SCS method of rainfall abstractions: I_a = initial abstraction, P_e = rainfall excess, F_a = continuing abstraction, P = total rainfall.

By study of results from many small experimental watersheds, an empirical relation was developed

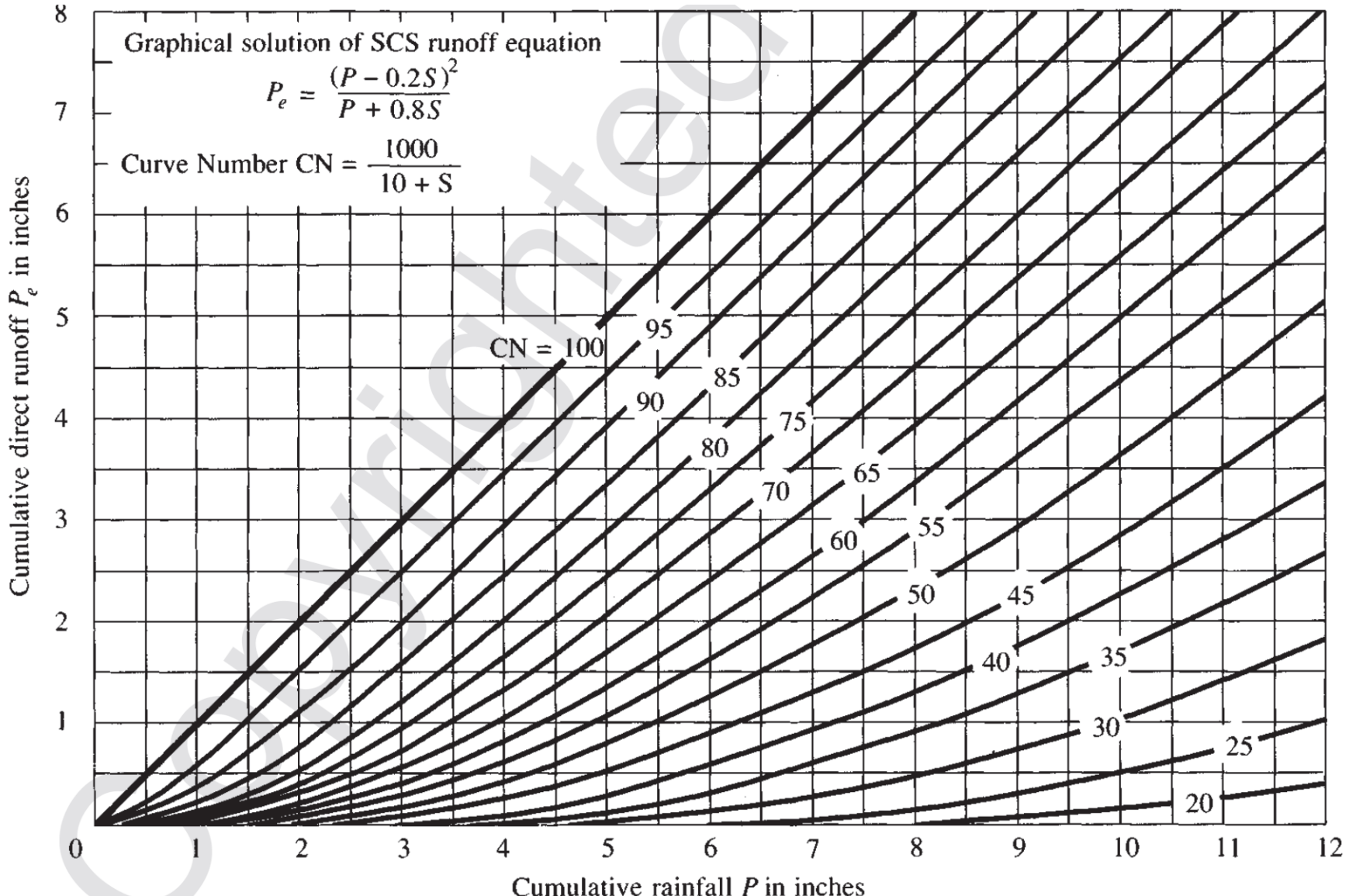
$$I_a = 0.2S$$

Resulting in



$$P_e = \frac{(P - 0.2S)^2}{P + 0.8S}$$

SCS-CURVE



- To standardize these curves, a dimensionless curve number CN is defined such that $0 < CN < 100$. For impervious and water surfaces $CN = 100$; for natural surfaces $CN < 100$.

The curve number and S are related by

$$S = \frac{1000}{CN} - 10$$

- where **S** is in inches. The curve numbers shown in the Fig apply for normal *antecedent moisture conditions* (AMC II). For dry conditions (AMC I) or wet conditions (AMC III), equivalent curve numbers can be computed by

$$CN(I) = \frac{4.2CN(II)}{10 - 0.058CN(II)}$$

$$CN(III) = \frac{23CN(II)}{10 + 0.13CN(II)}$$

Classification of antecedent moisture classes (AMC) for the SCS method of rainfall abstractions

AMC group	Total 5-day antecedent rainfall (in)	
	Dormant season	Growing season
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	Over 1.1	Over 2.1

(*Source:* Soil Conservation Service, 1972, Table 4.2, p. 4.12.)

- Curve numbers have been tabulated by the Soil Conservation Service on the basis of soil type and land use. Four soil groups are defined:

Group A: Deep sand, deep loess, aggregated silts

Group B: Shallow loess, sandy loam

Group C: Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay

Group D: Soils that swell significantly when wet,heavy plastic clays, and certain saline soils

- The values of CN for various land uses on these soil types are given in a Table For a watershed made up of several soil types and land uses, a composite CN can be calculated

TABLE 5.5.2

Runoff curve numbers for selected agricultural, suburban, and urban land uses (antecedent moisture condition II, $I_a = 0.2S$)

Land Use Description		Hydrologic Soil Group			
		A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[3]:					
Average lot size	Average % impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

[1]For a more detailed description of agricultural land use curve numbers, refer to Soil Conservation Service, 1972, Chap. 9

[2]Good cover is protected from grazing and litter and brush cover soil.

[3]Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[4]The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5]In some warmer climates of the country a curve number of 95 may be used.

example

- A certain watershed experienced 12.7 cm heavy storm in a single day. The watershed is covered by pasture with good grazing, and 32 % of B soils and 68 % of C soils. Following the SCS methodology, determine the direct runoff for the 12.7 cm rainfall event.