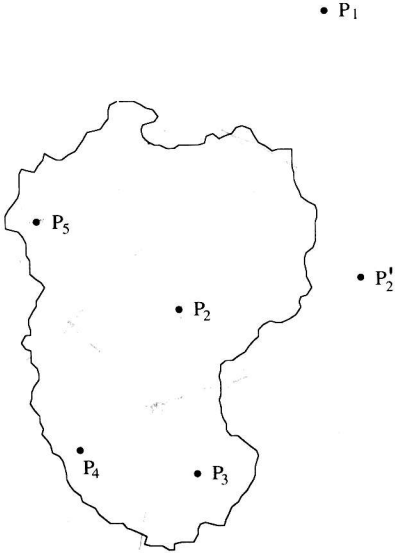
Areal Rainfall

The *arithmetic-mean method* is the simplest method of determining areal average rainfall. It involves averaging the rainfall depths recorded at a number of gages [Fig. 3.4.3(*a*)]. This method is satisfactory if the gages are uniformly distributed over the area and the individual gage measurements do not vary greatly about the mean.

If some gages are considered more representative of the area in question than others, then relative weights may be assigned to the gages in computing the areal average. The *Thiessen method* assumes that at any point in the watershed the rainfall is the same as that at the nearest gage so the depth recorded at a given gage is applied out to a distance halfway to the next station in any direction. The relative weights for each gage are determined from the corresponding areas of application in a *Thiessen polygon* network, the boundaries of the polygons being formed by the perpendicular bisectors of the lines joining adjacent gages [Fig. 3.4.3(*b*)]. If there are J gages, and the area within the watershed assigned to each is A_j, and P_j is the rainfall recorded at the jth gage, the areal average precipitation for the watershed is

$$\bar{P} = \frac{1}{A} \sum_{j=1}^{J} A_j P_j \tag{3.4.1}$$

where the watershed area $A = \Sigma_{j=1}^{J} A_j$. The Thiessen method is generally more



Station	Observed rainfall within or close to the area (mm or in)
P_2	20.0
P_3	30.0
P_4	40.0
P_5	50.0
	140.0

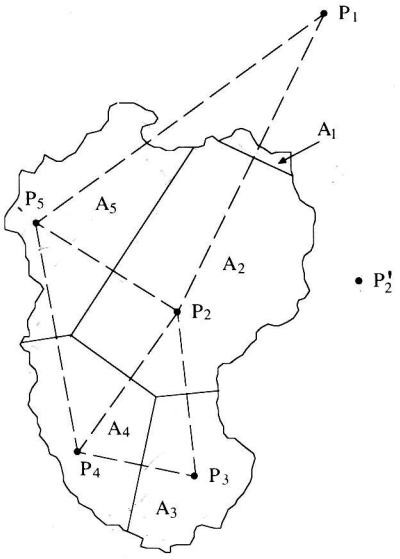
Average rainfall = 140.0/4 = 35.0 mm or in

FIGURE 3.4.3(*a*)
Computation of areal average rainfall by the arithmetic-mean method.

accurate than the arithmetic mean method, but it is inflexible, because a new Thiessen network must be constructed each time there is a change in the gage network, such as when data is missing from one of the gages. Also, the Thiessen method does not directly account for orographic influences on rainfall.

The *isohyetal method* overcomes some of these difficulties by constructing isohyets, using observed depths at rain gages and interpolation between adjacent gages [Fig. 3.4.3(*c*)]. Where there is a dense network of raingages, isohyetal maps can be constructed using computer programs for automated contouring. Once the isohyetal map is constructed, the area A_j between each pair of isohyets, within the watershed, is measured and multiplied by the average P_j of the rainfall depths of the two boundary isohyets to compute the areal average precipitation by Eq. (3.4.1). The isohyetal method is flexible, and knowledge of the storm pattern can influence the drawing of the isohyets, but a fairly dense network of gages is needed to correctly construct the isohyetal map from a complex storm.

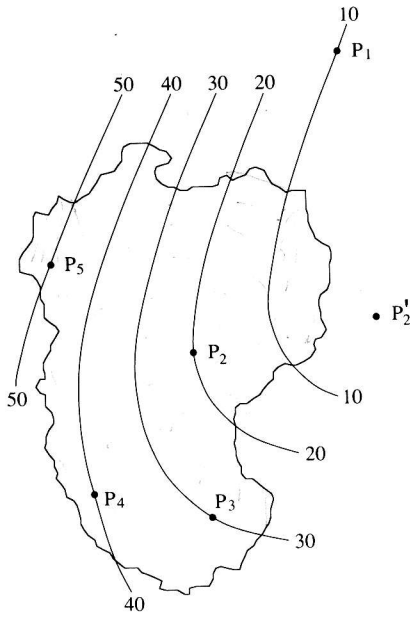
Other methods of weighting rain gage records have been proposed, such as the *reciprocal-distance-squared method* in which the influence of the rainfall at a gaged point on the computation of rainfall at an ungaged point is inversely proportional to the distance between the two points (Wei and McGuinness, 1973). Singh and Chowdhury (1986) studied the various methods for calculating areal average precipitation, including the ones described here, and concluded that all the methods give comparable results, especially when the time period is long;



Station	Observed rainfall (mm or in)	Area (km^2 or mi^2)	Weighted rainfall (mm or in)
P_1	10.0	0.22	2.2
P_2	20.0	4.02	80.4
P_3	30.0	1.35	40.5
P_4	40.0	1.60	64.0
P_5	50.0	1.95	97.5
		9.14	284.6

Average rainfall = 284.6/9.14 = 31.1 mm or in

FIGURE 3.4.3(*b*)
Computation of areal average rainfall by the Thiessen method.



Isohyets (mm or in)	Area enclosed (km^2 or mi^2)	Average rainfall (mm or in)	Rainfall volume
	0.88	5*	4.4
10			
	1.59	15	23.9
20			
	2.24	25	56.0
30			
	3.01	35	105.4
40			
	1.22	45	54.9
50			
	0.20	53*	10.6
	9.14		255.2

*Estimated.

Average rainfall = 255.2 / 9.14 = 27.9 mm or in

FIGURE 3.4.3(*c*)
Computation of areal average rainfall by the isohyetal method.

that is, the different methods vary more from one to another when applied to daily rainfall data than when applied to annual data.