Design Criteria for Rainfall Catchment Areas for Watering Wildlife and Livestock

JOEL E. VERNER
Lands Examiner, Bureau of Land Management, Rock Springs, Wyoming

As a rule the design of areas for the collection of rainfall is based on the average rainfall for a given area. This creates a problem because the figure does not give a true picture of rainfall distribution (Wisler and Brater, 1959). To partially demonstrate this, rainfall data for 1915, 1916 and 1924 through 1962 from the Eden Project in Eden Valley, Wyoming are presented here. For proper evaluation at least thirty years of rainfall data should be required (Wisler and Brater, 1959).

The data were first grouped into eleven class intervals for ease of computation (Table 1). The class intervals are of equal size and eleven groups, in descending order are shown, so that correct computations can be obtained (Remmers, Gage and Rummel, 1960). The arithmetic mean was computed at 7.48 inches and occurred in the 61 percentile rank.

The formula for determining the percentile rank (Remmers, Gage and Rummel, 1960) of the arithmetic mean is:

$$\left[\frac{\left[\frac{(\bar{x} - L')}{C'}\right] f + cf}{N}\right] 100 = \text{Percentile rank of a arithmetic mean}$$

Where:

$\bar{x}$ = Arithmetic mean.

L' = Lower limit of interval in which arithmetic mean occurs.

C′ = Class interval size, in this case 0.99.

f = Number of frequencies in the interval in which x occurs.

cf = Cumulative frequency up to and including the interval occurring just below the x interval.

N = Total number of occurrences.

Occurrence of the average rainfall in the 61 percentile rank means that rainfall equal to or less than the average should occur 61 percent of the time (Remmers, Gage and Rummel, 1960). If the catchment areas are designed according to average rainfall, water shortage should not be a problem in at least forty out of every 100 years. In the case of watering devices that rely on catchment areas there could be inadequate water as much as sixty percent of the time, which could result in costly water hauling to keep the devices filled. All this would then be erroneously attributed to "so-called" drought years when actually it would be the result of basing a design on a 61 percentile ranked average.

Next, how aften can water be hauled to these devices economically and how often can the water supply be allowed to become inadequate? If the answer is ten percent of the time, then for convenience, we determine the ten percentile ranked rainfall. The same procedure can be used for five, 15, 20, 25, 50 or any other percentile ranked rainfall that is desired. Table 1 was used to determine the ten percentile ranked rainfall which was computed to be 4.52 inches.

The formula for determining the ten percentile (Remmers, Gage and Rummel, 1960) ranked rainfall is:

$$\left[\frac{\left(\frac{N \times \%}{100}\right) - cf'}{f'}\right] C' + L'' = \text{Percentile rank}$$

Where:

% = Percentile rank that is to be determined.

cf′ = The cf of the next lower interval to that interval that contains the cf as derived from $\frac{N \times \%}{100}$

f′ = Number of occurrences in the interval that contains the cf as derived from $\frac{N \times \%}{100}$

L″ = Lower limit of the interval in which f′ is found.

Once the desired percentile ranked rainfall is determined then it is possible to determine the size of the collection area. In order to do this it is necessary to know the capacity of the storage area in gallons. Theoretically twelve inches of rainfall falling on an impervious surface will yield 7.48 gallons of runoff per square foot (Humphrey and Shaw, 1957). However, the percentile ranked rainfall is usually less than twelve inches; therefore, the percentile ranked rainfall is divided by twelve inches and then multiplied by 7.48 gallons per square foot to give the gallons of runoff yield for each square foot of the percentile ranked rainfall.

To determine the area needed for collecting rainfall to fill a known storage capacity it is necessary to divide the storage capacity gallons by the gallons yielded per square foot. However, storage requirements are dependent on the number of days and the daily requirements of the kind and number of animals that are to be watered (Humphrey and Shaw, 1957).

These calculations for catchment areas do not take evaporation into consideration. With covered storage areas evaporation is negligible, but with open storage, the collection area must be increased to compensate for this loss. With an evaporation loss of 20 percent the collection area would only provide 80 percent of the storage capacity; therefore, the area would have to be increased 25 percent. For a 33 percent evaporation loss, a 50 percent increase would be necessary and for a 25 percent evaporation loss the area would have to be increased 33 percent. If the evaporation loss is determined in percentage the necessary increase of the catchment area can be obtained by the following formula:

$$\text{Percent increase of catchment area} = 100\left[\frac{\text{Evaporation loss percentage}}{100 - \text{Evaporation loss percentage}}\right]$$

Table 1. Rainfall intervals and their frequencies, Eden Valley, Wyoming.

Class intervals	x[1]	f	cf	fx
13.00-13.99	13.50	2	41	27.00
12.00-12.99	12.50	1	39	12.50
11.00-11.99	11.50	3	38	34.50
10.00-10.99	10.50	2	35	21.00
9.00- 9.99	9.50	2	33	19.00
8.00- 8.99	8.50	4	31	34.00
7.00- 7.99	7.50	4	27	30.00
6.00- 6.99	6.50	10	23	65.00
5.00- 5.99	5.50	7	13	38.50
4.00- 4.99	4.50	4	6	18.00
3.00- 3.99	3.50	2	2	7.00
Sum		41		306.50

[1]x = Midpoint of the class interval
f = Number or frequency of occurrences within each interval
cf = Cumulative frequency

Discussion

The percentile rank for average rainfall at a given location provides a good basis for design of catchment areas. These may be most economical for water availability and at the same time decrease the need for hauling water. In some instances a smaller collection area than that originally specified may be possible. This would result in lower construction costs. An overflow from the storage area is needed for years that have higher rainfall than that for which the collection area was designed.

In some cases seasonal rainfall can be used as a base instead of data for the whole year. A very dry period or one of heavy use might well be such a case. In this situation only rainfall data for that particular season would be used for the catchment design and percentile rank. At least a thirty year record is needed.

Another use of the percentile rank of rainfall average is in agricultural or livestock operations. The fifty percentile rank, usually called the median, is a more useful rainfall figure for a farming or livestock operation. With the median figure all rainfall equal to it or less should occur fifty percent of the time and any rainfall above the median should occur the other fifty percent of the time. This gives a more realistic approach to the evaluation of rainfall data as a basis for an agricultural operation.

LITERATURE CITED

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