STREAM FLOW AND PERCOLATION WATER

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(Continued from last week's issue)

LET us now assume that before and after a particular rainfall the stream flow curve has assumed the basic curve form, and at particular times before and after the peak the rate of 2 M.G. per day is recorded; the gain is the total discharge between those two times, because the available amount of percolation water, as indicated by the basic curve, was the same at both times; thus the benefit accruing from a particular rainfall is measured. In this case, should the stream flow curve assume the basic curve form, but not continue so far as to show the rate of 2 M.G., but only, say, 4 M.G. per day, the basic curve can be applied to the flow curve to continue the latter to the time at which the rate of 2 M.G. per day is shown. Then the total discharge, as shown by the flow curve and its continuation, between the two times represents the amount of gain.

Supply and Discharge

This case is illustrated by Fig. 5, which shows an inserted curve EF, which is a reproduction of a part of the basic curve. The time J is fixed by the rate IJ, which is the same as GH. A, B and C show the total gain due to the particular rainfall. A is the estimated surface run-off, whilst B and C show the gain of percolation water. The curve at G must be of basic form, otherwise the principles are not applicable to this case. It was not necessary to draw the portion C, as its equivalent was measurable between ordinates of the basic curve, in this case representing 4 and 2 M.G. per day, but it suffices to illustrate plainly how much more percolation water was in store at the time K than at the time H, and shows what might be called the "correction" for percolation storage. It is suggested that this correction be made in figures representing calculated evaporation loss; and as in cases where these figures are taken over a period the correction might be equivalent to two inches of rainfall, it is plain that uncorrected figures may be inaccurate. Were the basic curve only approximately obtained, it would be of some value for making this correction. The basic curve serves to illustrate the fact that over a period when percolation supply becomes reduced, "depletion" of percolation storage takes place, and this will continue until the average rate of supply and the average discharge are roughly balanced, though neither is actually constant. Conversely, when percolation supply over a period becomes increased, the "filling up" of percolation storage takes place before supply and discharge roughly balance. From another point of view, it might be seen that the average rate of discharge does not immediately change to equal an average rate of supply, but the difference goes to, or is taken from, storage, until the surface of saturation is at such a level that average supply and discharge are about balanced; thus a year's minimum can only occur after a period of small supplies, and a year's maximum only after a period of large supplies.

Maintaining Constant Supply

It occurred to the author originally that if one could determine the available percolation water stored in a drainage area at the end of a winter period, there would be something of value in estimating the amount of artificial storage required to maintain a constant supply, because with a greater amount of natural storage less artificial storage would apparently be necessary. The available percolation storage can be ascertained with the assistance of a basic curve, no doubt in many cases within near limits; yet the author thinks this figure would be of doubtful value, for it is obvious that before percolation discharge can become equal to its average rate, supplies from subsequent rainfall must first replenish the depleted percolation storage according to the amount which has been temporarily available from that source. And for the same reason it is doubtful whether the figure of minimum rate of flow is of much value where a large proportion of the mean flow is required for a constant supply.

The author suggests another use for the basic curve in which it might be of more value. As evaporation during the winter is small and the gains from rainfall should nearly equal the rainfall, the former is the discharge, plus or minus the difference in percolation storage at the beginning and end of a test period. If the difference between the rainfall and the total gain could be accounted for by evaporation, it would be safe to presume that the drainage area was water-tight; if not, there might be proof that percolation water from outside sources was feeding the stream, or, on the other hand, indications of a serious loss of percolation water from the drainage area. In the latter case there would be warning that the installation of a dam might be unfortunate, or even disastrous. There has been sufficient evidence put forward by observers to show that the percolation drainage area is in some cases considerably different from the topographical drainage area, and to consider them as equivalent without satisfactory evidence that such was the case might be an unsound presumption.

Evaporation

The rate of evaporation from water surfaces appears to follow an ill-defined relation to the power of the sun and the duration of sunshine, whilst wind also has a slight influence; but evaporation from a drainage area is influenced by other conditions, such as the soil, percolation rate, elevation and vegetation. The most important factor other than the sun is probably the capacity of the surface soil for moisture. The power of the soil to retain water is known as capillary attraction, and it is a power which defies to some extent the force of gravity. When these conflicting forces are balanced, the amount of water retained in the soil is relatively large (no doubt often equivalent to three inches of rainfall), but very variable, according to depth and fineness, and perhaps also variable with weather conditions. The power of evaporation, due largely to the influence of the sun, appears to be a stronger force than that of the capillary attraction of the soil, for the soil is robbed of part of its moisture, and therefore makes a toll of subsequent rainfall. It is doubtful whether the soil can take its full share from a particularly heavy fall as it requires too much time to do so, and consequently part of the rainfall percolates before the soil is fully satisfied. Though this latter point remains in doubt, it is quite clear that a large part of the evaporation loss in a dry period is replaced from subsequent rainfall, and at times there is but a small balance available to supplement stream flow. In hot, dry months evaporation loss from a drainage area is smaller in the absence of rain than it would otherwise be, because the moisture is not available for evaporation. The surface soil probably draws to some extent upon the subsoil immediately below it, for even vegetation which derives supplies from some depth below the surface has at such times difficulty in maintaining life. Evaporation cannot reduce the percolation storage where the latter is in deep subsoil, but may reduce very slightly the discharge from such a source by evaporation from the stream surface.

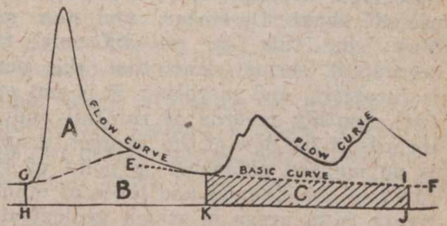

Fig. 5—Flow and Basic Curves

Figures quoted as calculated evaporation losses from drainage areas, though amended by the correction already suggested, would also include losses due to percolation water escaping from the drainage area, and for these reasons they are of doubtful value. The same remarks apply to the figures given in certain text-books to represent evaporation losses due to different forms of vegetation, as they are probably based on differences between rainfall and stream flow.

Investigations of loss by evaporation have been made by means of percolation gauges, but there does not appear to be such definite agreement between the records as might enable accurate conclusions to be deduced therefrom. It is difficult to see how soil and subsoil can be disturbed and placed in a percolation gauge in a condition equivalent to