STREAM FLOW AND PERCOLATION WATER*

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The author, many years ago, commenced investigations of the conditions which govern and control the ever-varying flow of streams and rivers, conceiving that, even were no definite laws established, he might gain a better knowledge of the subject, and information of practical value. The author considers that the agreement between data and facts from widely different sources is such as to fully warrant the statements made in this paper. The subject is treated broadly, and in order to make it clearer many well-known conclusions are repeated.

Fig. 1 is a flow curve showing inconstant rates of discharge for a period of 24 days, and some features characteristic of probably all stream flow curves, the most noticeable being the "peaks" following rainfall, showing immediate increase of flow attributable to surface run-off. Another feature is the slowly falling parts obtaining in rainless periods, when the flow is that of percolation discharge alone. The curve shown represents the flow from a mountain catchment of between 2,000 and 3,000 acres in extent, and is taken from automatically recorded diagrams of depth of

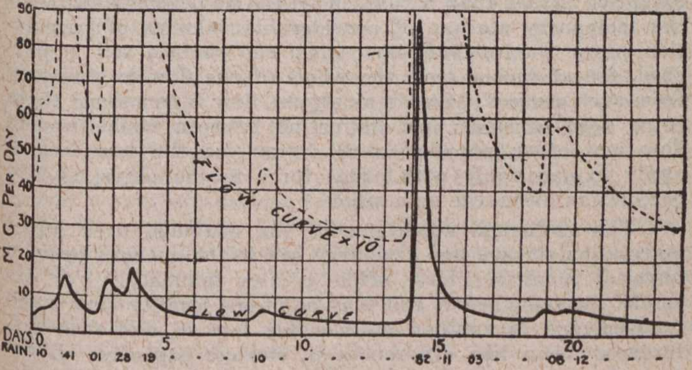

Fig. 1—Stream Flow Curve

water over a weir. It shows quick "run-off" and very marked, yet not exceptional, variations of flow.

Before comparing "peaks" of different streams, it will be interesting to compare those of one stream. They are greatest in proportion to rainfall when the surface soil is moist, always large in winter and after wet weather gradually smaller as summer advances, and smallest near the end of a long period of drought, when they contrast greatly with those of other periods. The rate of rise to a peak, when other conditions are the same, is a rough measure of rainfall intensity, which affects the height of the peak and flood rates. The falling part of the peak curve is generally slightly "slower" than the rising part, and becomes still slower as it descends. It indicates the rate of surface drainage after rain has ceased, and appears to be of some approximately regular form, but is, of course, modified by the amount of percolation discharge. The gently falling and lowest parts of the curve due to percolation discharge are generally gradually higher from the autumn and lower from spring to the end of summer, being lowest at the end of a long drought. One characteristic of these parts is the steady fall of the curve, showing not only that the rate of flow decreases, but that its rate of decrease also diminishes; in other words, the curve gets flatter from day to day throughout a rainless period. Towards the end of a drought the diminution is so small that the curve might appear to have become a horizontal line, yet examination of a greater length of curve will suffice to show such a conclusion is wrong; but it appears probable that a slowly diminishing flow might be continued during perhaps a year of further absolute drought. Some streams in these islands occasionally run dry, yet the larger streams and rivers have substantial discharges in droughts which are but of short duration compared with those which occur in some other countries. Another feature to which attention must be drawn is that the position of these parts of the curve is raised after every peak occurs. To make this clear, let us imagine a prolongation of the curve obtaining before the peak, on the line it would probably have taken had the rainfall not occurred. The produced curve would, apparently in every case, lie some distance below that which actually obtains after the peak, and the amount of difference between the produced and actual curves appears to be roughly proportionate to the extent of the peak. It seems to be clear that not only has there been a large immediate yield as shown by a peak, but that the stream has gained in "staying power." The conclusion drawn is that new supplies of percolation water have increased the amount in store, with the reslut of increased discharge. The effect of frost is, in general, precisely the same as that of absence of rain. Frost does not affect the percolation discharge, except perhaps where such occurs as small surface springs, but it holds up surface "run-off." Snow, of course, does not affect flow until thawing takes place.

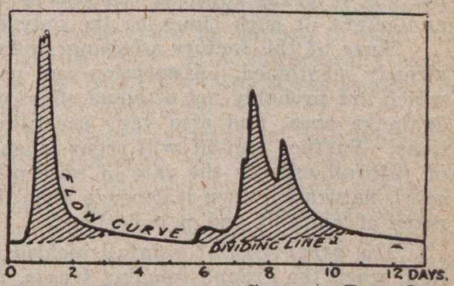

Fig. 2—Estimate of Surface Run-Off

In comparing curves of different streams it may be seen that the slope of the ground is a factor which affects the rates of rise and fall, and also the size of the "peaks," no doubt because less slope and slower "run-off" allows surface water to remain for a longer period under percolation influences. The length and slope of the stream courses are factors influencing chiefly the shape of the peaks, because after water has supplemented the flow in the upper reaches of the stream some time elapses before the effect is recorded at the gauging point. This time, roughly determinable, is a matter of hours for small streams, but of days for large rivers. Every stream course has a slight temporary storage effect, which is increased where the banks are permeable and extensive.

In order to form a rough idea of the extent to which the nature of the drainage area affects the peaks, we may assume the case of a river fed by a number of streams of similar drainage areas at various points. The effects of spates on each stream would be recorded at times, varying roughly according to the distance of the points of confluence from the gauging station. Tracing the flow curve of one stream, and altering the time for each so that if superimposed the peaks would show one after the other, the sum of these stream flow curves representing the total flow of the river, would obviously show less rates of rise and fall, and a less maximum rate in proportion to the total drainage area. Though other factors might modify the curve, the logical conclusion is that increase of size means flatter peaks and smaller maximum or flood rates in proportion to the area, whilst the converse holds for smaller areas.

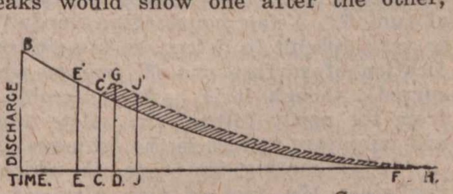

Fig. 3—Tank Discharge Curve

"Dry weather flow" is used by various engineers to mean either minimum known flow, or that for one year (average), or occasionally a supposed irreducible and constant rate which would obtain under any exceptionally adverse conditions. As a term so variously interpreted cannot lead to anything but confusion, what is meant should be expressed in other words. The minimum rate of flow is seldom the same in any different years, and any particular minimum only holds good till a lower one is recorded.

The sources of supply due to precipitation can be classed as: (1) Surface run-off; and (2) percolation discharge.

*From a paper read before the Institution of Water Engineers of Great Britain.