REMARKS ON HYDROLOGIC TERMINOLOGY

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When a science is advancing rapidly, as is hydrology today, especially when it is changing from an adolescent or qualitative to an adult or quantitative basis, new terms are needed in particular for the following two purposes: (1) To give expression to new ideas and concepts; (2) to give more definite, specific, quantitative meaning to terms and concepts heretofore chiefly qualitative. The terminology of a growing science is in some respects like the scaffolding of a building or like the false-work of an arch. If the building or arch is enlarged and the plans changed as the work proceeds, the scaffolding or false-work must also be adapted to the new conditions.

The selection of new terms to meet these new conditions in science is often rendered difficult by the fact that many of the best available terms are already preempted and in use--with meanings that are too general and indefinite.

The following principles are suggested for guidance in the selection of specific quantitative terms for use in hydrology or other sciences which are founded, as is hydrology, on physics:

(1) Where a term has an established meaning in the fundamental science in which it originated, and to which it primarily pertains, that meaning should not be changed or a new term substituted when it is applied in some other science.

(2) A term which has a specific meaning should not in general be replaced by a generic or less specific term.

The much overworked word "index" serves to illustrate this point. There are indexes of almost everything, from precocity to pregnancy. Each time the word "index" is used it is necessary to specifically define which and what index is referred to, and how it is determined. In most cases it is better, if possible, to specifically define the quantity and omit the term "index."

(3) In the adoption of new terms, due regard should be had to (a) the background of usage in the same connection, (b) the underlying physical principles involved in the process described, (c) the adequate, accurate, and apt description of what is intended, and the term should not do unnecessary violence to the English language.

It is unfortunate that in hydrology there have been various instances of attempts to introduce new terms without regard to the above principles, in particular without a sufficient knowledge of the background of the subject or the underlying physical principles. Under these conditions a new term may be introduced which amounts to little more than a confession of ignorance on the part of its sponsor.

A few examples will serve not only to illustrate the application of these principles but also the lack of their application in some instances, together with the difficulties which beset any one who attempts to improve existing terminology.

Frequency, recurrence-interval--The term "frequency" originated in and pertains primarily to statistical science. KURTZ and EDGERTON ["Statistical dictionary"] define the term "frequency" as "the number of observations or measures in one of the class-intervals of a frequency-distribution." There has been a tendency in hydrology to use the term "frequency" in the reciprocal sense of the average interval of recurrence of events in a given class. In accordance with the first principle above given, it seems that the term "frequency" should be retained with its original statistical meaning, and the term "recurrence-interval" should be used wherever the latter is referred to.

In this connection a situation exists which serves to illustrate the difficulty of finding adequately specific terms. In hydrology, recurrence-intervals of floods, either equalling or exceeding a given magnitude, are frequently used. For more frequent events there is no appreciable difference between the interval at which floods of a given magnitude will be either equalled or exceeded, and the interval at which the given flood-magnitude will be exceeded. In the case of major floods the difference does, however, become highly significant; and to avoid indefiniteness it seems desirable to limit the use of the words "recurrence-interval" to the average interval of occurrence of quantities (a) from and including a given magnitude to but not including the upper limit of the class interval, (b) including and exceeding a given limit. Where the average interval of floods exceeding a given limit but not including those of precisely that limit is under consideration, the expression "exceedance-interval" should be used.

Conversely, it is often desirable to use some expression to describe the average interval of occurrence of events having a magnitude less than a given quantity. The author has found no term more aptly descriptive of this meaning than the term "subceedance-interval."

Water-losses--The expression "water-losses" has a well-established meaning in English-speaking countries the world over to designate removal of water from a drainage-basin by evaporative processes, that is, interception, transpiration, and direct evaporation. To avoid the indefiniteness of the term "water-losses" it would perhaps be better to use the somewhat more cumbersome term "evaporative losses."

In recent years one finds the word "loss" used in hydrology to designate surface-runoff--this usage being common in connection with soil-conservation. Also a few persons have used the word "loss" to represent that part of the rain which does not produce runoff, including infiltration. It is true that from the viewpoint of agronomy, surface-runoff represents a deduction from water which would otherwise enter the soil; while from the viewpoint of the hydraulic engineer, interested in the quantity of water derived from runoff and available to fill reservoirs or supply water for power, irrigation, etc., infiltration is a deduction from immediate or surface-runoff. It is not, however, wholly or chiefly a deduction from total runoff, since infiltration supplies ground-water, which, in turn, commonly represents one-third to two-thirds of the total runoff of perennial streams. If both these quantities, that is, surface-runoff and infiltration plus interception, are called "losses," then since the sum of these quantities equals the rainfall, the absurd result follows that all rainfall is "loss."

Infiltration, infiltration-capacity, percolation--Infiltration is defined in the Oxford English Dictionary as the flow of a fluid into a substance through pores or small openings. It connotes flow into a substance in contradistinction to the word "percolation," which connotes flow through a porous substance. Infiltration connotes finely subdivided inflow in contradistinction to mass-inflow, such as occurs in ordinary hydraulic flow.

In spite of the accepted meaning of the term "infiltration," which precisely describes the manner of entrance of rainfall into the soil, other terms are sometimes used, such as "absorption," "intake," and "percolation." "Absorption" has quite a different meaning, and infiltration in general is not absorption in the accepted sense. It is a particular form of inflow.

The word "intake" has been used in a recent paper to include surface-detention, depression-storage, and infiltration. The authors of the paper state that "intake," so defined, is not infiltration, yet they frequently use the words "infiltration" and "intake" interchangeably. On the other hand, the "intake" as above defined can very readily be obtained from the results of an infiltrometer-experiment by merely subtracting the runoff-intensity from the rainfall-intensity, whereas the determination of the true infiltration-capacity during runoff is somewhat more laborious. It is probably for this reason that the term "intake" has sometimes been used. Actually if, as is often the case, it is assumed to be equivalent to infiltration-capacity during runoff, gross errors may result, since in reality the difference between rain-intensity and runoff-intensity represents the sum of the infiltration-capacity and the rate of accumulation of surface-detention. The latter rate may be, and frequently is, equivalent to 25 to 50 per cent of the infiltration-capacity in the earlier stages of runoff.

The author has defined infiltration-capacity [Trans. Amer. Geophys. Union, 1933, p. 447] as "the maximum rate at which a given soil can absorb rainfall when the soil is in a specified condition." There has been a tendency to substitute the words "infiltration-rate" or "infiltration-rates" for "infiltration-capacity," the reason given being that, to the minds of some, the word "capacity" connotes a volume, whereas infiltration-capacity is a rate. The word "capacity" is, however, commonly used with two different well-established meanings in the fundamental science of physics, namely, (1) to define a volume, (2) to define a maximum or limiting rate as, for example, the capacity of a pipe to carry a fluid under specified conditions, or the capacity of an electric conductor. These two meanings need never be confused. The term "infiltration-capacity" conforms to the second of these well-established usages. Substitution of the words "rate" or "rates" where capacity is intended leads to serious confusion in some cases, as it so happens that whenever rain-intensity is less than infiltration-capacity, infiltration takes place at a definite rate but not at the capacity-rate, whereas when rainfall-excess occurs, infiltration takes place at capacity-rate. Use of the single term "rate" indiscriminately in both cases leads to serious confusion and gross inaccuracy.

As to the word "percolation," not only does this word have an established usage different from "infiltration" or "infiltration-capacity," but its use to denote the latter has evidently arisen

from ignorance of the fact that when percolation occurs the soil is saturated, whereas when infiltration takes place, the soil is not fully saturated as a rule, but only saturated to or slightly above its field- or capillary-moisture-capacity. "Infiltration-capacity" and "percolation-capacity" or, as it is more commonly described in ground-water hydrology, "transmission-capacity," are related but they are not identical.

The compounding of confusion which may result by indefiniteness and lack of recognition of physical principles in such cases is illustrated by the following quotation given to the author and which purports to have been taken from a recently published paper:

> "The infiltration-rate is ordinarily at its maximum when water is first applied to the soil, and then as the pore-spaces become filled and wetting occurs, it decreases until a more or less stable minimum is reached. This minimum is the field percolation-rate, that is, the rate at which water moves through the saturated soil-profile, and it is governed largely by the permeability of the least pervious horizon. This minimum or stable infiltration-rate or percolation-rate, being a quantitative determination of the rapidity with which water can move through a saturated profile, is a measure of the internal drainage." (Underscored words are the author's.)

The author does not need to point out the inaccuracies in this statement.

The term "infiltration-index" has sometimes been used in place of "infiltration-capacity" on the ground that determinations of infiltration-capacity are always subject to some error. This is, however, also true of all measurements of quantities, direct or indirect. The substitution of the indefinite term "infiltration-index" for the specific, definite term "infiltration-capacity" on this ground is not justified and it is otherwise undesirable.

Detention, retention--The words "detention" and "retention" have been used in connection with the surface-phase of the hydrologic cycle with various meanings. The word "retention" seems objectionable as none of the rain falling on a drainage-basin is permanently retained. Either it is lost by evaporative processes or else it is temporarily detained by various forms of storage in its course through the hydrologic cycle. The author has defined "surface-detention" as "that part of the rain which remains on the ground-surface during rain and either runs off or is absorbed by infiltration after rain ends." While surface-runoff is taking place, it is water in transit as sheet-flow. The above definition is specific and less objectionable than the use of the term "retention" in a similar sense.

Subsurface and concealed-surface runoff--Cases arise where surface-runoff may take place in such a manner as not to be visible, as, for example, where it occurs through a layer of coarse material, sometimes through a thick matting of grass or mulch-cover; through a layer of plant-roots close to the soil-surface and under forest-litter; or even, in some cases, through a network of sun-cracks in the soil-surface. This has sometimes been called "subsurface-runoff," sometimes "ground-water flow." The term "subsurface-runoff" would not be objectionable were it not for the fact that it is likely to be confused with true ground-water flow. The term "ground-water flow" applied to this class of flow is highly objectionable on several counts; flow occurring close to the surface in the manner described has little in common with true ground-water flow. It is mostly turbulent flow, while true ground-water flow is mostly laminar. It persists only during rainfall-excess or for a short time thereafter, measured in hours or at the most in days, whereas ground-water flow persists on perennial streams at all times. Furthermore, surface-runoff follows the same laws and behaves in the same manner whether it actually occurs visibly on the ground surface, or is concealed and invisible, taking place just below the soil-surface where it is sustained by temporary detention below the soil-surface. Nevertheless, it may be desirable to distinguish between the two cases and, if so, flow which is essentially surface-runoff but which is concealed from view in some one of the ways described, may appropriately be called "concealed-surface runoff."

Channel-storage, valley-storage--The terms "channel-storage" and "valley-storage are both in use to describe water in transit in a system of stream-channels or within the channels and over adjacent flood-plains. The use of the term "channel-storage," where there is also flow outside the channels, is perhaps justified by the fact that when this occurs, the adjacent flood-plain becomes a part of the channel, in a hydraulic sense. The term "valley-storage" includes "channel-storage," whereas the term "channel-storage may or may not include flood-plain storage, dependent on the meaning assigned to the word "channel." In the great majority of stream-rises, channel-storage alone is present, using the word "channel" in a restricted sense. While the term "valley-storage" seems preferable in general, there seems to be no valid objection to the

use of the term "channel-storage" where the water in transit is definitely confined to the stream-channel exclusive of the flood-plain.

Darcy's or Poiseuille's law--The law expressing the relation of rate-of-flow to hydraulic gradient in cases of capillary or laminar flow is generally described in physics as "Poiseuille's law." The fact that this law also applies to ground-water flow was discovered by DARCY, who recognized and pointed out his indebtedness to POISEUILLE. In ground-water hydrology the same law is commonly referred to as "Darcy's law," apparently for no better reason than that some who use this law have found difficulty in either spelling or pronouncing POISEUILLE'S name. It is well established that credit for a general law or principle belongs to the man who developed it on a definite quantitative basis, as did POISEUILLE--not to one who subsequently applied the same law in some particular case.

Recharge--This term has been extensively used to describe replenishment of ground-water. Apparently borrowed from ballistics, the term "recharge" connotes complete replenishment by more or less definite quanta. That is not the manner in which ground-water storage is refilled. The restoration generally takes place by isolated quanta, varying, however, greatly in amount and duration. Furthermore, there may be, and frequently is, addition to the ground-water storage without bringing about an increase in the amount of storage above that existing when restoration began. This happens whenever the rate of accretion to an aquifer through infiltration is less than the rate of ground-water outflow. This condition is not reflected in the word "recharge," which certainly connotes an increase over the preexisting quantity. In view of these defects the author prefers the word "accretion," although there is much to support the earlier term "replenishment"--the principal objection to "replenishment" being that it is a more cumbersome word. It has, however, the background of usage by such distinguished pioneer hydrologists as Sir ALEXANDER BINNIE, CORNELIUS C. VERMEULE, and GEORGE W. RAFTER.

Plat, plot--The term "plot" has recently come into quite general use to specify a restricted parcel of ground on which, for example, a runoff-experiment is conducted. English usage, as may be seen from consulting, for example, the Oxford Dictionary, favors the word "plat" in this connection, a plat being a subdivision of the land-surface. No adequate justification for the use of the word "plot" has been offered.

In the preceding notes, references to persons and specific papers have been purposely omitted. The objective in this paper is to call attention to principles which may serve as guides in revision of hydrologic terminology and to give a few examples where standardization seems to be urgently needed. It seems necessary to state that these examples have not been chosen with reference to any particular person or paper but merely to bring to a focus the objections to certain terms and usages now more or less in vogue. The reader will undoubtedly notice various confessions of ignorance.

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DISCUSSION

O. E. MEINZER (U. S. Geological Survey, Washington, D. C.)--In regard to the important concept that is expressed by different authors by the terms loss, evaporative loss, evaporation, evaporation and transpiration, evapo-transpiration, consumptive use, or fly-off; I have never used the term fly-off but am wondering whether we might not do well to adopt that term for this concept. It is a short, simple term that would not be misunderstood and would be appropriate to designate the concept that is correlative to that expressed by the term runoff. (President GROVER pointed out that the term fly-off was suggested many years ago by W. J. McGEE.)

In regard to the different kinds of runoff, some of the authors of the forthcoming volume on Hydrology agreed to the use of the following terms: Surface-runoff and ground-water runoff, to make up total runoff; overland runoff, to designate the running surface-water before it reaches a stream-channel; and direct runoff, to designate the precipitated water that gets into the streams without retardation.