EXHIBIT F

General Introduction and Hydrologic Definitions

Manual of Hydrology: Part 1. General Surface-Water Techniques

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GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1541–A

General Introduction and Hydrologic Definitions

By W. B. LANGBEIN *and* KATHLEEN T. ISERI

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Methods and practices of the Geological Survey

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GENERAL INTRODUCTION AND HYDROLOGIC DEFINITIONS

By W. B. LANGBEIN and KATHLEEN T. ISERI

INTRODUCTION

Hydrologic techniques, capably applied, are essential for the sound development and management of water resources. The population of our country is increasing rapidly but water use outpaces the growth in population and thus creates demands for water that frequently impinge on the available supply. The mounting demands, the increasing areas of conflict, and the rising rate of flood damage impel a need for refined methods of analysis of water problems.

Consider the planning for a water supply for a town or an irrigation project: How much water is available in the river? How does this supply compare with the demand? Is reservoir storage needed? If so, how much? Riverflow varies and therefore reservoirs are built to store water to tide over from times of excess to times of deficiency. The problem is to design the storage reservoir so that the demands for water can be supplied despite variations in riverflow. Reservoirs that are built too large waste money and water; reservoirs built too small cannot do the job expected of them.

Floods pose a different set of hydrologic questions. The height of levees and the size of reservoirs needed to restrain floodwater must be determined if these structures are to be used to reduce flood damage. Flood damage can also be reduced by the proper design of homes and factories which are built on the flood plain, often in ignorance of flood danger. Highway bridges and culverts are other structures that are often damaged by floods. If highways are to cross streams safely and economically, bridges and culverts must be adequate to span the floods expected within their useful life.

Hydraulic engineers with weighty problems of water supply, floods, and pollution control to solve welcome methods that will help them use basic data. The solution of water problems begins with water

data, of which more than 100,000 station-years of streamflow records are available. Collection of basic data, although the essential first step, is only part of the task. Water facts provide the necessary foundation; they do not in themselves give direct solutions to water problems. Sound methods of putting data to practical use in solving water problems are also essential. These problems are increasing in number and complexity, often at a faster pace than the means for solving them.

Another prerequisite to analyzing basic data is that the data be arranged in a form adapted to the methods of analysis. For example, after the development and publication of methods for deriving and using duration curves, there remains the need for presenting the data so that duration curves can be readily prepared. Meeting this need is part of the plan of the Geological Survey for increasing the usefulness of water data for solving water problems. Thus, there are three steps prior to analysis: collection of data; development of methods of using the data; and processing the data into convenient form. This manual discusses the second step: describing hydrologic techniques for the hydraulic engineer.

The general outline of techniques given in engineering textbooks is directed to solving specific problems such as water supply, irrigation, and flood control. In contrast, the purpose of this manual is to describe techniques for analyzing basic river data to give results applicable to many kinds of hydraulic engineering problems concerned with riverflow. Two of the chapters discuss methods of increasing the reliability of short records, a common need in the many uses of streamflow data. Another chapter discusses double-mass curves, and another, duration curves, both useful tools in using records of streamflow. A chapter is devoted to flood-frequency curves, a universal tool for applying flood data to the solution of flood problems. Special problems like flood zoning are included because they afford new opportunities, not yet found in textbooks, for the use of basic data.

This manual began with a series of reports prepared for use within the Geological Survey during the past 10 years. These have been revised and improved for publication in three parts. The first part presents methods of general interest, including a list of definitions; the second part discusses methods of solving low-flow problems found in developing water supply; and the third part discusses flood hydrology.

HYDROLOGIC DEFINITIONS

Surface-water hydrology is the study of the origin and processes of water in streams and lakes, in nature, and as modified by man. It includes such subjects as infiltration, channel storage, floods and

droughts, direct runoff, and base flow. Surface-water hydrology shares with meteorology the study of precipitation and evaporation. Also, surface-water hydrology shares with geomorphology the study of the shape, size, and number of river channels, because river channels are formed as a consequence of the rates and quantities of water they must carry. Some of the tools used in the study and application of surface-water hydrology are unit hydrographs, flow-duration curves, flood-frequency curves, and correlation, all of which are defined in this report.

The definitions in this list are intended to explain the terminology in the "Manual of Hydrology" of which this report is the first chapter. It is, however, more than a glossary of terms used in the manual, as terms are included from the entire field of surface-water hydrology. Terms within some of the definitions are defined in this chapter. Where such terms might affect the meaning of the definition, they are shown in italics.

Excluded from the list are such terms as "river," "lake," "creek," and other names for surface-water features, for which hydrologists have not devised better definitions than are in the dictionaries. In general, therefore, common dictionary terms such as "anomaly" or "abnormal" are not included—but there are exceptions—where a term, like "anabranch," deserves wider usage. Also excluded are those terms, although often used in surface-water hydrology, that are mainly geologic, hydraulic, statistical, or meteorologic. These terms are defined, as necessary, in separate chapters.

The usefulness of a list of definitions is limited by the extent to which the concepts they embody are accepted. To enhance precision and to promote agreement, many of the definitions listed were selected from research papers or reports on field investigations to which appropriate reference is given. Multiple references are cited where they amplify the meaning, and these references can be used as a source of additional information on surface-water hydrology. Where acceptable definitions could not be found in published works, substitutes were written especially for this chapter. Terms defined in this report are grouped by subjects in the section entitled "Topical finding list" to facilitate locating the definitions of related terms.

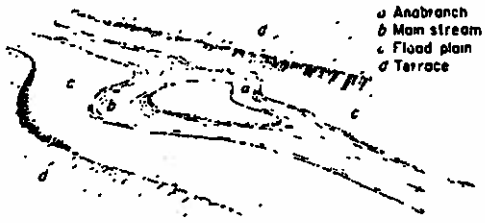
Walter B. Langbein selected or composed the definitions presented in the report, and Kathleen T. Iseri arranged the report for publication, verified references, and prepared the topical finding list.

Ablation. The process by which ice and snow waste away owing to melting and evaporation.

Absorption. The entrance of water into the soil or rocks by all natural processes. It includes the *infiltration* of precipitation or snowmelt, gravity flow of streams into the valley alluvium (*see* **Bank storage**) into sinkholes or other large openings, and the movement of atmospheric moisture.

Acre-foot. A unit for measuring the volume of water, is equal to the quantity of water required to cover 1 acre to a depth of 1 foot and is equal to 43,560 cubic feet or 325,851 gallons. The term is commonly used in measuring volumes of water used or stored.

Anabranch. A diverging branch of a river which reenters the main stream.



Anabranch

Anchor ice. Ice in the bed of a stream or upon a submerged body or structure. (*See also* Schaefer, V. J., 1950, p. 888.)

Annual flood. The highest peak discharge in a *water year.*

Annual flood series. A list of *annual floods.*

Antecedent precipitation index. An index of moisture stored within a drainage basin before a storm. (Linsley and others, 1949, p. 414.)

Area-capacity curve. A graph showing the relation between the surface area of the water in a reservoir and the corresponding volume.

Average discharge. In the annual series of the Geological Survey's reports on surface-water supply—the arithmetic average of all complete water years of record whether or not they are consecutive. Average discharge is not published for less than 5 years of record. The term "average" is generally reserved for average of record and "mean" is used for averages of shorter periods, namely, daily mean discharge.

Backwater. Water backed up or retarded in its course as compared with its normal or natural condition of flow. In *stream gaging,* a rise in *stage* produced by a temporary obstruction such as ice or weeds, or by the flooding of the stream below. The difference between the observed stage and that indicated by the *stage-discharge relation,* is reported as backwater.

Bank. The margins of a *channel.* Banks are called right or left as viewed facing in the direction of the flow.

Bankfull stage. Stage at which a stream first overflows its natural banks. (*See also* **Flood stage.** Bankfull stage is a hydraulic term, whereas flood stage implies damage.)

Bank storage. The water absorbed into the banks of a stream channel, when the stages rise above the water table in the bank formations, then returns to the channel as effluent seepage when the stages fall below the water table. (After Houk, 1951, p. 179.)

Base discharge (for peak discharge). In the Geological Survey's annual reports on surface-water supply, the discharge above which peak discharge data are published. The base discharge at each station is selected so that an average of about three peaks a year will be presented. (*See also* **Partial-duration flood series.**)

Base flow. *See* **Base runoff.**

Base runoff. Sustained or fair weather runoff. In most streams, base runoff is composed largeiy of groundwater effluent. (Langbein and others, 1947, p. 6.) The term *base flow* is often used in the same sense as base runoff. However, the distinction is the same as that between streamflow and runoff. When the concept in the terms *base flow* and base runoff is that of the natural flow in a stream, base runoff is the logicai term. (*See also* ***Ground-water runoff and*** **Direct runoff.)**

Basic hydrologic data. Includes inventories of features of land and water that vary only from place to place (topographic and geologic maps are examples), and records of processes that vary with both place and time. (Records of precipitation, streamflow, ground-water, and quality-of-water analyses are examples.)

Basic hydrologic information is a broader term that includes surveys of the water resources of particular areas and a study of their physical and related economic processes, interrelations and mechanisms.

Basic-stage flood series. *See* **Partial-duration flood series.**

Braiding of river channels. Successive division and rejoining (of riverflow) with accompanying islands is the important characteristic denoted by the synonymous terms, braided or anastomosing stream. (Leopold and Wolman, 1957, p. 40.) A braided stream is composed of *anabranches.*

Catchment area. *See* **Drainage basin.**

Cfs. Abbreviation of *cubic feet per second.*

Cfs-day. The volume of water represented by a flow of 1 cubic foot per second for 24 hours. It equais

Cfs-day—Continued

86,400 cubic feet, 1.983471 acre-feet, or 646,317 gallons.

Cfsm (cubic feet per second per square miie). The average number of cubic feet of water per second flowing from each square mile of area drained by a stream, assuming that the runoff is distributed uniformly in time and area.

Channel (watercourse). An open conduit either naturaliy or artifically created which periodically o" continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, anabranch, and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided (*see* **Braiding of river channels**). Canal and floodway are some of the terms used to describe artificial channels.

Channel storage. The volume of water at a given time in the *channel* or over the *flood plain* of the *streams* in a *drainage basin* or river *reach.* Channel storage is great during the progress of a *flood event.* (*See* Horton, 1935, p. 3.)

Climate. The sum total of the meteorological elements that characterize the average and extreme condition of the atmosphere over a long period of time at any one place or region of the earth's surface. The collective state of the atmosphere at a given place or over a given area within a specified period of time. (Landsberg, 1945, p. 928.)

Climatic year. A continuous 12-month period during which a complete annual cycle occurs, arbitrariiy selected for the presentation of data relative to hydrologic or meteorologic phenomena. The climatic year is usually designated by the calendar year during which most of the 12 months occur. (*See* **Water year.)**

Cloudburst. A torrential downpour of rain, which by its spottiness and relatively high intensity suggests the bursting and discharge of a whole cloud at once. (Woolley, 1946, p. ii.)

Concentration time. *See* **Time of concentration.**

Concordant flows. Flows at different points in a river system that have the same *recurrence interval*, or the same frequency of occurrence. It is most often applied to flood-flows.

Condensation. The process by which water changes from the vapor state into the liquid or solid state. It is the reverse of evaporation.

Conservation storage. Storage of water for later release for useful purposes such as municipal water supply, power, or irrigation in contrast with storage capacity used for flood control.

Consumptive use. The quantity of water absorbed by the crop and transpired or used directly in the building of plant tissue together with that evaporated from the cropped area. (U.S. Bur. of Reclamation, 1952, p. 3.)

The quantity of water transpired and evaporated from a cropped area or the normal loss of water from the soil by evaporation and plant transpiration. (Blaney, 1951b, p. 190.) (*See also* **Water requirement** *and* Blaney, 1951a, p. 4.)

The quantity of water discharged to the atmosphere or incorporated in the products of the process in connection with vegetative growth, food processing, or an industrial process. (MacKichan, 1957, p. 2.)

Consumptive use, net. The consumptive use decreased by the estimated contribution by rainfall toward the production of irrigated crops. (Simons, 1953, p. 12.) (*See* **Effective precipitation (3).**) Net consumptive use is sometimes called crop irrigation requirement.

Consumptive waste. The water that returns to the atmosphere without benefiting man. (Thomas, 1951, p. 217.)

Contents. The volume of water in a reservoir. Unless otherwise indicated reservoir content is computed on the basis of a level pool and does not include *bank storage*.

Control. A natural constriction of the channel, a long reach of the channel, a stretch of rapids, or an artificial structure downstream from a *gaging station* that determines the *stage-discharge relation* at the gage.

A control may be complete or partial. A complete control exists where the stage-discharge relation at a gaging station is entirely independent of fluctuations in stage downstream from the control. A partial control exists where downstream fluctuations have some effect upon the stage-discharge relation at a gaging station. A control, either partial or complete, may also be shifting. Most natural controls are shifting to a degree, but a shifting control exists where the stage-discharge relation experiences frequent changes owing to impermanent bed or banks.

Correlation. The process of establishing a relation between a variable and one or more related variables. Correlation is simple if there is only one independent variable; multiple, if there is more than one independent variable. For gaging station records, the usual variables are the short-term gaging-station record and one or more long-term gaging-station records. (Searcy, 1960.)

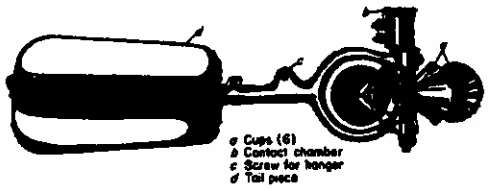
Correlative estimate. A discharge determined by correlation. A correlative estimate represents a likely value of the discharge for any

Correlative estimate—Continued
particular period—commonly a month—according to a specified method of analysis. (After Langbein and Hardison, 1955, [no. 826], p. 826–8.)

Cryology. Science of ice and snow.

Cubic feet per second. A unit expressing rates of discharge. One cubic foot per second is equal to the discharge of a stream of rectangular cross section, 1 foot wide and 1 foot deep, flowing water an average velocity of 1 foot per second.

Current meter. An instrument for measuring the speed of flowing water. The Geological Survey uses a rotating cup meter.



Current meter

Cusec. This abbreviation for cubic foot per second, common in the British Commonwealth countries (except Canada), is not used by the U.S. Geological Survey; instead, *cfs* is used.

Cycle. A regularly recurring succession of events such as the cycle of the seasons. Use of cycle to describe a group of wet years followed or preceded by a group of dry years is to be avoided.

Dead storage. The volume in a reservoir below the lowest controllable level. (Thomas and Harbeck, 1956, p. 13.)

Dependable yield, *n*-years. The minimum supply of a given water development that is available on demand, with the understanding that lower yields will occur once in *n* years, on the average. (Paulsen, 1950, p. 801.)

Depletion. The progressive withdrawal of water from surface- or

Depletion—Continued
ground-water reservoirs at a rate greater than that of replenishment. (*See* **Recession curve** *and* **streamflow depletion.**)

Depression storage. The volume of water contained in natural depressions in the land surface, such as puddles. (After Horton, 1935, p. 2.)

Direct runoff. The runoff entering stream channels promptly after rainfall or snowmelt. Superposed on *base runoff*, it forms the bulk of the hydrograph of a *flood*.

See also **surface runoff.** The terms *base runoff* and *direct runoff* are time classifications of runoff. The terms *ground-water runoff* and *surface runoff* are classifications according to source.

Discharge. In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean. (*See also* **Streamflow** *and* **Runoff.**)

The data in the reports of the Geological Survey on surface water represent the total fluids measured. Thus, the terms discharge, streamflow, and runoff represent water with the solids dissolved in it and the sediment mixed with it. Of these terms, discharge is the most comprehensive. The discharge of drainage basins is distinguished as follows:

Yield. Total water runout or crop; includes runoff plus underflow.

Runoff. That part of water yield that appears in streams.

Discharge—Continued

Streamflow. The actual flow in streams, whether or not subject to regulation, or underflow.

Each of these terms can be reported in total volumes (such as acre-feet) or time rates (such as cubic feet per second or acre-feet per year). The differentiation between runoff as a volume and streamflow as a rate is not accepted.

Discharge rating curve. *See* **Stage-discharge relation.**

Distribution graph (distribution hydrograph). A *unit hydrograph* of *direct runoff* modified to show the proportions of the volume of runoff that occurs during successive equal units of time. (After Hoyt and others, 1936, p. 124.)

Diversion. The taking of water from a stream or other body of water into a canal, pipe, or other conduit.

Double-mass curve. A plot on arithmetic cross-section paper of the cumulated values of one variable against the cumulated values of another or against the computed values of the same variable for a concurrent period of time. (*See* Searcy and Hardison, 1960.)

Drainage area. The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide. (*See* [U.S.] Federal Inter-Agency River Basin Committee, Subcommittee on Hydrology, 1951, p. 11.)[1]

Drainage basin. A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Drainage density. Length of all *channels* above those of a specified *stream order* per unit of *drainage area.*

Drainage divide. The rim of a *drainage basin.* (*See* **Watershed.**)

Drought. A period of deficient precipitation or runoff extending over an indefinite number of days, but with no set standard by which to determine the amount of deficiency needed to constitute a drought. Thus, there is no universally accepted quantitative definition of drought; generally, each investigator establishes his own definition.

The following paragraph (Hoyt, 1936, p. 2) discusses the problem of defining a drought:

When in an area that is ordinarily classed as humid, natural vegetation becomes desiccated or defoliates unseasonably and crops fail to mature owing to lack of precipitation, or when precipitation is insufficient to meet the needs of established human activities, drought conditions may be said to prevail. Although water for irrigation or other uses in arid areas is always limited, special shortages in such areas are also regarded as droughts. Unsatisfactory distribution of precipitation throughout the year may be as effective a factor in causing a drought as a shortage in the total amount. Temperature and wind may also play an important part, especially in relation to the damage done.

Duration curve. *See* **Flow-duration curve** for one type.

Effective precipitation (rainfall). 1. That part of the precipitation that produces runoff. 2. A weighted average of current and antecedent precipitation that is "effective" in correlating with runoff. 3. As de-

[1] [U.S.] Federal Inter-Agency River Basin Committee, Subcommittee on Hydrology, Inter-Agency coordination of drainage area data, notes on hydrologic activities, Bull. 4, November 1951: Washington, U.S. Geol. Survey, 48 p.

Effective precipitation—Continued
scribed by U.S. Bureau of Reclamation (1952, p. 4), that part of the precipitation falling on an irrigated area that is effective in meeting the *consumptive use* requirements.

Epilimnion. *See* **thermal stratification.**

Evaporation. The process by which water is changed from the liquid or the solid state into the vapor state. In hydrology, evaporation is vaporization that takes place at a temperature below the boiling point.

Evaporation opportunity (relative evaporation). The ratio of the rate of evaporation from a land or water surface in contact with the atmosphere, to the *evaporativity* under existing atmospheric conditions. It is the ratio of actual to potential rate of evaporation, generally stated as a percentage. (Derived from Meinzer, 1923, p. 14.)

The opportunity for a given rate of evaporation to continue is determined by the available moisture supply. (Meyer, 1928, p. 244.)

Evaporation pan. An open tank used to contain water for measuring the amount of evaporation. The U.S. Weather Bureau class *A* pan is 4 feet in diameter, 10 inches deep, set up on a timber grillage so that the top rim is about 16 inches from the ground. The water level in the pan during the course of observation is maintained between 2 and 3 inches below the rim.

Evaporation, total. The sum of water lost from a given land area during any specific time by transpiration from vegetation and building of plant tissue; by evaporation from water surfaces, moist soil, and snow; and by interception. * * * It has been variously termed "evaporation," "evaporation from land areas," "evapotranspiration," "total

Evaporation, total—Continued
loss," "water losses," and "fly off." (Lee, 1949, p. 314.)

Evaporativity (potential rate of evaporation). The rate of evaporation under the existing atmospheric conditions from a surface of water that is chemically pure and has the temperature of the atmosphere. (Meinzer, 1923, p. 13.)

Evapotranspiration. Water withdrawn from a land area by *evaporation* from water surfaces and moist soil and plant *transpiration.* It is a coined word; probably the first recorded use is on page 296 of the Transactions of the American Geophysical Union, part 2, 1934.

Evapotranspiration, potential. *See* **Potential evapotranspiration.**

Excessive rainfall. *See* **Rainfall, excessive.**

Field capacity. *See* **Field-moisture capacity.**

Field-moisture capacity. The quantity of water which can be permanently retained in the soil in opposition to the downward pull of gravity. (Horton, 1935, p. 3.)

Field-moisture deficiency. The quantity of water, which would be required to restore the *soil moisture* to *field-moisture capacity.* (Horton, 1935, p. 3.)

Firn (firn snow). Old snow on the top of glaciers, granular and compact but not yet converted into ice. It is a transitional stage between snow and ice. Also called névé.

Firn line. The highest level to which the fresh snow on a glacier's surface retreats during the melting season. (Matthes, 1949, p. 161.) The line separating the accumulation area from the *ablation* area.

Flood. An overflow or inundation that comes from a river or other body of water (Barrows, 1948, p. 4), and causes or threatens damage.

Any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream.

Flood—Continued

(Leopold and Maddock, 1954, p. 249–251.)

A relatively high flow as measured by either gage height or discharge quantity. (Jarvis and others, 1936, p. 463.)

A glossary of flood terms is given in "The Flood Control Controversy." (Leopold and Maddock, 1954, p. 249–251.) *See* **Annual flood.**

Flood-control storage. Storage of water in reservoirs to abate flood damage. (*See* **Retarding reservoir.**)

Flood crest. *See* **Flood peak.**

Flood event. *See* **Flood wave.**

Flood-frequency curve. 1. A graph showing the number of times per year on the average, plotted as abscissa, that floods of magnitude, indicated by the ordinate, are equaled or exceeded. 2. A similar graph but with *recurrence intervals* of floods plotted as abscissa. (*See* Dalrymple, 1960.)

Flood, maximum probable. The largest flood for which there is any reasonable expectancy in this climatic era. (Leopold and Maddock, 1954, p. 112.)

Flood peak. The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge. Flood crest has nearly the same meaning, but since it connotes the top of the *flood wave*, it is properly used only in referring to stage—thus, crest stage, but not crest discharge.

Flood plain. A strip of relatively smooth land bordering a stream, built of sediment carried by the stream and dropped in the slack water beyond the influence of the swiftest current. It is called a living flood plain if it is overflowed in times of highwater; but a fossil flood plain if it is beyond the reach of the highest flood. (Bryan, 1922, p. 88.)

Flood plain—Continued

The lowland that borders a river, usually dry but subject to flooding. (Hoyt and Langbein, 1955, p. 12.)

That land outside of a stream channel described by the perimeter of the *maximum probable* flood. (After White, 1945, p. 44.)

Flood plain

Flood plane. The position occupied by the water surface of a stream during a particular flood. Also, loosely, the elevation of the water surface at various points along the stream during a particular flood.

Flood profile. A graph of elevation of the water surface of a river in flood, plotted as ordinate, against distance, measured in the downstream direction, plotted as abscissa. A flood profile may be drawn to show elevation at a given time, crests during a particular flood, or to show stages of *concordant flows*.

Flood routing. The process of determining progressively the timing and shape of a *flood wave* at successive points along a river. (*See* Carter and Godfrey, 1960.)

Floods above a base. *See* **Partial-duration flood series.**

Flood stage. The gage height of the lowest bank of the reach in which the gage is situated. The term "lowest bank" is, however, not to be taken to mean an unusually low place or break in the natural bank through which the water inundates an unimportant and small area. (Linsley, 1942, p. 89.)

The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured. (U.S. Weather Bur.)

See also **Bankfull stage.**

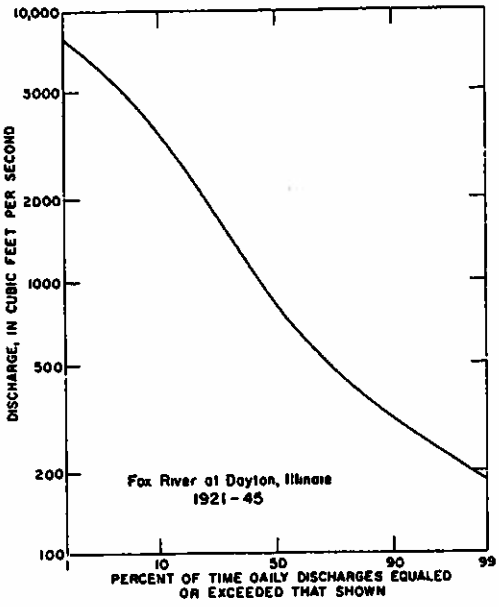
Flood wave. A distinct rise in stage culminating in a crest and followed by recession to lower stages.

Floodway. A part of the flood plain, otherwise leveed, reserved for emergency diversion of water during floods. A part of the flood plain which, to facilitate the passage of floodwater, is kept clear of encumbrances.

The channel of a river or stream and those parts of the flood plains adjoining the channel, which are reasonably required to carry and discharge the floodwater or floodflow of any river or stream (Erbe and Flores, 1957, p. 443).

Flood zone. The land bordering a stream which is subject to floods of about equal frequency; for example, a strip of the *flood plain* subject to flooding more often than once but not as frequently as twice in a century. (*See* White, 1945, p. 44.)

Flow-duration curve. A cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded. (*See* Searcy, 1959.)



Flow-duration curve

Forest influences. Effects resulting from the presence of forest or brush upon climate, soil water, runoff, streamflow, floods, erosion, and soil productivity. (Kittredge, 1948, p. 1.)

Frazil (frazil ice). A French-Canadian term for fine spicular ice, derived from the French for cinders which this variety of ice most resembles. When formed in salt water, it is known as lolly ice. It is composed of fine particles which, when first formed, are colloidal and not seen in the water in which they are floating. (Barnes, 1928, p. 108; *see also* Schaefer, 1950, p. 888.)

Gage height. The water-surface elevation referred to some arbitrary gage datum. Gage height is often used interchangeably with the more general term *stage* although gage height is more appropriate when used with a reading on a gage.

Gaging station. A particular site on a stream, canal, lake, or reservoir where systematic observations of *gage height* or *discharge* are obtained. (*See also* Stream-gaging station.)

Glacier. Bodies of land ice that consist of recrystallized snow accumulated on the surface of the ground (Matthes, 1949, p. 150), and that move slowly downslope.

Ground water. Water in the ground that is in the *zone of saturation*, from which wells, springs, and *ground-water runoff* are supplied. (After Meinzer, 1949, p. 385.)

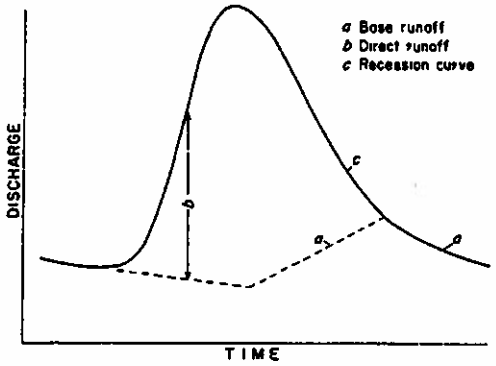
Ground-water outflow. That part of the discharge from a drainage basin that occurs through the ground water. The term "underflow" is often used to describe the ground-water outflow that takes place in valley alluvium (instead of the surface *channel*) and thus is not measured at a *gaging station*.

Ground-water runoff. That part of the runoff which has passed into the ground, has become ground water, and has been discharged into a stream channel as spring or seepage water. *See also* **Base runoff** *and* **Direct runoff.**

Guttation. The loss of water in liquid form from the uninjured leaf or stem of the plant, principally through water stomata. (Lee, 1949, p. 260.)

Heat budget, annual (of a lake). The amount of heat necessary to raise the water from the minimum temperature of winter to the maximum temperature of summer. (Welch, 1952, p. 65.)

Hydrograph. A graph showing stage, flow, velocity, or other property of water with respect to time.



Hydrograph

Hydrologic budget. An accounting of the inflow to, outflow from, and storage in, a hydrologic unit, such as a drainage basin, aquifer, soil zone, lake, reservoir, or irrigation project.

Hydrologic cycle. A convenient term to denote the circulation of water from the sea, through the atmosphere, to the land; and thence, with many delays, back to the sea by overland and subterranean routes, and in part by way of the atmosphere; also the many short circuits of the water that is returned to the atmosphere without

Hydrologic cycle—Continued

reaching the sea. (After Meinzer, 1949, p. 1.)

Hydrologic equation. The equation balancing the *hydrologic budget.*

Hydrology. The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground. (Am. Soc. Civil Engineers, 1949, p. 1.)

The science that relates to the water of the earth. (Meinzer, 1923, p. 9.)

The science treating of the waters of the earth, their occurrence, distribution, and movements. (Jarvis and others, 1936, p. 464.)

In practice the study of the water of the oceans and the atmosphere is considered part of the sciences of oceanography and meteorology.

Hyetograph. Graphical representation of rainfall intensity against time.

Hypolimnion. *See* **Thermal stratification.**

Infiltration. 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. (Horton, 1942, p. 480.) *See also* Schiff and Dreibelbis (1949, p. 76) and Musgrave (1946, p. 726–747).

Infiltration capacity. The maximum rate at which the soil, when in a given condition, can absorb falling rain or melting snow. (After Horton, 1935, p. 2.)

Infiltration index. An average rate of infiltration, in inches per hour, equal to the average rate of rainfall such that the volume of rainfall at greater rates equals the total direct runoff. (Langbein and others, 1947, p. 11.)

Interception. The process and the amount of rain or snow stored on

Interception—Continued
leaves and branches and eventually evaporated back to the air. Interception equals the precipitation on the vegetation minus *stemflow* and *throughfall* (after Hoover, 1953, p. 1.)

Irrigated area. The gross farm area upon which water is artificially applied for the production of crops, with no reduction for access roads, canals, or farm buildings. (Simons, 1953, p. 8.)

Irrigation. The controlled application of water to arable lands to supply water requirements not satisfied by rainfall. (After Houk, 1951, p. 1.)

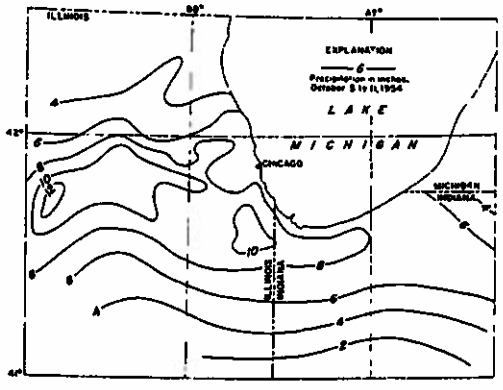
Irrigation efficiency. The percentage of water applied that can be accounted for in soil-moisture increase. (Pillsbury, Compton, and Picker, 1944, p. 7.)

Irrigation requirement. The quantity of water, exclusive of precipitation, that is required for crop production. It includes surface evaporation and other economically unavoidable wastes. Blaney, 1951a, p. 4.)

Irrigation, supplemental. *See* **Supplemental irrigation.**

Isohyet. *See* **Isohyetal line.**

Isohyetal line (isohyet). A line drawn on a map or chart joining points that receive the same amount of precipitation.



Isobyetal lines

Lag. Variously defined as time from beginning (or center of mass) of rainfall to peak (or center of mass) of runoff. (After Am. Soc. Civil Engineers, 1949, p. 106.)

Limnology. That branch of hydrology pertaining to the study of lakes.

Long-period variations. Secular when a cycle or a change in trend is completed within a century: climatic when the period of change runs through centuries or a few millenia; geologic when the period runs into geological time. (Willett, 1948, p. 806.) (*See* **Trend.**)

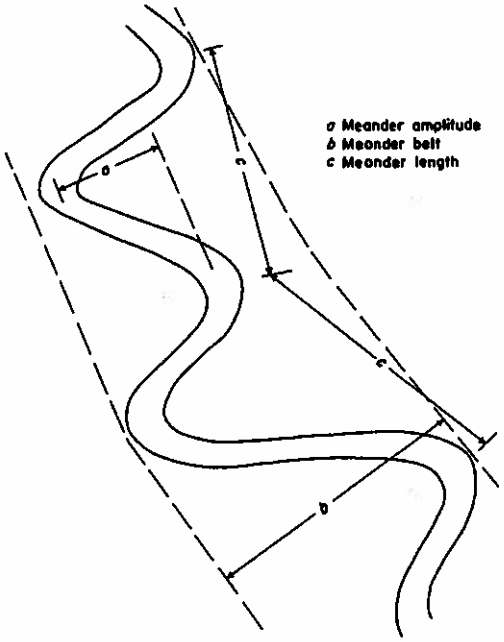
Low-flow frequency curve. A graph showing the magnitude and frequency of minimum flows for a period of given length. Frequency is usually expressed as the average interval, in years, between recurrences of an annual minimum flow equal to or less than that shown by the magnitude scale.

Lysimeter. Structure containing a mass of soil, and designed to permit the measurement of water draining through the soil. (Harrold and Dreibelbis, 1951, p. 3.) (*See also* Kohnke, Dreibelbis and Davidson, 1940, p. 1–67.)

Mass curve. A graph of the cumulative values of a hydrologic quantity (such as precipitation or runoff), generally as ordinate, plotted against time or date as abscissa. (*See* **Double-mass curve,** *and* **Residual-mass curve.**)

Maximum probable flood. *See* **Flood, maximum probable.**

Meander. The winding of a stream channel.



Meanders

Meander amplitude. Distance between points of maximum curvature of successive meanders of opposite phase in a direction normal to the general course of the meander belt, measured between centerlines of channels.

Meander belt. Area between lines drawn tangential to the extreme limits of fully developed meanders.

Meander breadth. The distance between the lines used to define the *meander belt.*

Meander length. Distance in the general course of the meanders between corresponding points of successive meanders of the same phase.

Twice the distance between successive points of inflection of the meander wave. (Leopold and Wolman, 1957, p. 55.)

Meromictic lake. A lake in which some water remains partly or wholly unmixed with the main water mass at circulation periods is said to be meromictic. The process leading to a meromictic state is termed meromixis. The perennially stagnant deep layer of a meromictic lake is called the monimolimnion. The part of a meromictic lake in which free circulation can occur is called the mixolimnion. The boundary between the monimolimnion and the mixolimnion is called the chemocline. (Hutchinson, 1957, p. 480.)

Moisture. Water diffused in the atmosphere or the ground.

Moisture equivalent. The ratio of (a) the weight of water which the soil, after saturation, will retain against a centrifugal force 1,000 times the force of gravity, to (b) the weight of the soil when dry. The ratio is stated as a percentage. (Meinzer, 1923, p. 25; *see also* Briggs and McLane, 1907, p. 5)

Mudflow. A well-mixed mass of water and alluvium which, because of its high viscosity and low fluidity as compared with water, moves at a much slower rate, usually piling up and spreading over the fan like a sheet of wet mortar or concrete. (Woolley, 1946, p. 75.)

Normal. A central value (such as arithmetic average or median) of annual quantities for a 30-year period ending with an even 10-year, thus 1921–50; 1931–60, and so forth. This definition accords with that recommended by the Subcommittee on Hydrology of the Federal Inter-Agency Committee on Water Resources.

Overland flow. The flow of rainwater or snowmelt over the land surface toward stream channels. After it enters a stream, it becomes *runoff.*

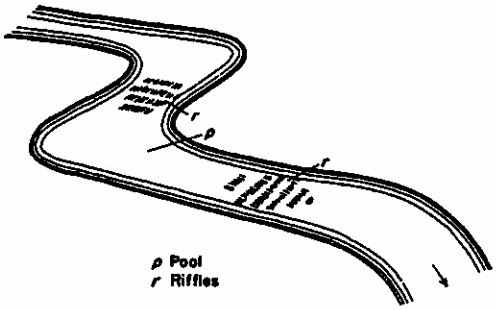
Partial-duration flood series. A list of all flood peaks that exceed a chosen base stage or discharge, regardless of the number of peaks occurring in a year. (Also called *basic-stage flood series,* or *floods above a base.*)

Percolation. The movement, under hydrostatic pressure, of water through the interstices of a rock or soil, except the movement through large openings such as caves. (Meinzer, 1923, p. 42; *see also* Rorabaugh, 1951, p. 165.

Percolation, deep. In irrigation or farming practice, the amount of water that passes below the root zone of the crop or vegetation. (Barrett and Milligan, 1953, p. 24.)

Pondage. Small-scale storage at a waterpower plant to equalize daily or weekly fluctuations in riverflow or to permit irregular hourly use of the water for power generation to accord with fluctuations in load. (After Barrows, 1943, p. 166.)

Pool. A deep reach of a stream. The reach of a stream between two riffles. Natural streams often consist of a succession of pools and riffles.



Pool and riffles

Potential evapotranspiration. *Water loss* that will occur if at no time there is a deficiency of water in the soil for use of vegetation. (Thornthwaite, 1944, p. 687.)

Potential natural water loss. The *water loss* during years when the annual precipitation greatly exceeds the average water loss. It represents the approximate upper limit to water loss under the type and density of vegetation native to a basin, actual conditions of moisture supply, and other basin characteristics, whereas *potential evapotranspiration* represents the hypothetical condition of no deficiency of water in the soil at any time for use of the type and density of vegetation that would develop. (After Troxell and others, 1954, pl. 11*B*.)

Potential rate of evaporation. *See* **Evaporativity.**

Precipitation. As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface. It is the common process by which atmospheric water becomes surface or subsurface water * * *. The term "precipitation" is also commonly used to designate the quantity of water that is precipitated. (Meinzer, 1923, p. 15.)

Precipitation includes rainfall, snow, hail, and sleet, and is therefore a more general term than rainfall.

Rain. Liquid *precipitation.*

Rainfall. The quantity of water that falls as rain only. Not synonymous with *precipitation.*

Rainfall excess. The volume of rainfall available for direct runoff. It is equal to the total rainfall minus *interception, depression storage,* and *absorption.* (*See* Am. Soc. Civil Engineers, 1949, p. 106.)

Rainfall, excessive. Rainfall in which the rate of fall is greater than certain adopted limits, chosen with regard to the normal precipitation (excluding snow) of a given place or area. In the U.S. Weather Bureau, it is defined, for States along the southern Atlantic coast and the Gulf coast, as rainfall in which the depth of precipitation is 0.90 inch at the end of 30 minuties and 1.50 inches at the end of an hour, and for the rest of the country as rainfall in which the depth of precipitation at the end

Rainfall, excessive—Continued
of each of the same periods is 0.50 and 0.80 inch, respectively.

Reach. 1. The length of channel uniform with respect to discharge, depth, area, and slope. 2. The length of a channel for which a single gage affords a satisfactory measure of the stage and discharge. 3. The length of a river between two gaging stations. 4. More generally, any length of a river.

Recession curve. A hydrograph showing the decreasing rate of *runoff* following a period of rain or snowmelt. Since direct runoff and base runoff recede at different rates, separate curves, called direct runoff recession curves or base runoff recession curves, are generally drawn. The term "depletion curve" in the sense of base runoff recession is not recommended.

Recurrence interval (return period). The average interval of time within which the given flood will be equaled or exceeded once. (Am. Soc. of Civil Engineers, 1953, p. 1221.)

Regime. "Regime theory" is a theory of the forming of channels in material carried by the streams. As used in this sense, the word "regime" applies only to streams that make at least part of their boundaries from their transported load and part of their transported load from their boundaries, carrying out the process at different places and times in any one stream in a balanced or alternating manner that prevents unlimited growth or removal of boundaries. A stream, river, or canal of this type is called a "regime stream, river, or canal." A regime channel is said to be "in regime" when it has achieved average equilibrium; that is, the average values of the quantities that constitute regime do not show

Regime—Continued
a definite trend over a considerable period—generally of the order of a decade. In unspecialized use "regime" and "regimen" are synonyms. (After Blench, 1957, p. 2.)

Regimen of a stream. The system or order characteristic of a stream; in other words, its habits with respect to velocity and volume, form of and changes in channel, capacity to transport sediment, and amount of material supplied for transportation. The term is also applied to a stream which has reached an equilibrium between corrosion and deposition or, in other words, to a graded stream. (Bryan, 1922, p. 89.)

Regulation. The artificial manipulation of the flow of a stream.

Re-regulating reservoir. A reservoir for reducing diurnal fluctuations resulting from the operation of an upstream reservoir for power production.

Reservoir. A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.

Residual-mass curve. A graph of the cumulative departures from a given reference such as the arithmetic average, generally as ordinate, plotted against time or date, as abscissa. (*See* **Mass curve.**)

Retarding reservoir. Ungated reservoir for temporary storage of flood water. Sometimes called detention reservoir.

Return flow. That part of irrigation water that is not consumed by evapotranspiration and that returns to its source or another body of water. The term is also applied to the water that is discharged from industrial plants. Also called return water.

Riffle. A rapid in a stream.

Riparian. Pertaining to the banks of a stream.

Runoff. That part of the precipitation that appears in surface streams. It is the same as *streamflow* unaffected by *artificial diversions, storage*, or other works of man in or on the stream channels. Runoff may be classified as follows:

Classification as to speed of appearance after rainfall or snow melting:
- Direct runoff
- Base runoff

Classification as to source:
- Surface runoff (*see* Overland flow)
- Storm seepage
- Ground-water runoff (*see* Stream, gaining)

Runout. *See* Water yield.

Second-foot. Same as *cfs*. This term is no longer used in published reports of the U.S. Geological Survey.

Sediment. Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water or air or is accumulated in beds by other natural agencies. (Colby, Hembree, and Jochens, 1953, p. 24.)

Sediment discharge. The rate at which dry weight of sediment passes a section of a stream or is the quantity of sediment, as measured by dry weight, or by volume, that is discharged in a given time. (Colby, Hembree, and Jochens, 1953, p. 24.)

Seiche. The free oscillation of the bulk of water in a lake and the motion caused by it on the surface of the lake. (Bergsten, 1926, p. 1.)

Shifting control. *See* Control.

Skimming. The diversion of water from a stream or conduit by a shallow overflow used to avoid diversion of sand, silt, or other debris carried as bottom load.

Snow. A form of precipitation composed of ice crystals.

Snow course. A line or series of connecting lines along which snow samples are taken at regularly spaced points. (U.S. Dept. Agriculture, Soil Conserv. Service and Nevada State Engineer, 1948, p. 2.)

Snow density. Ratio between the volume of melt water derived from a sample of snow and the initial volume of the sample. This is numerically equal to the specific gravity of the snow. (Linsley, Kohler, and Paulhus, 1949, p. 127.)

Snowline. The general altitude to which the continuous snow cover of high mountains retreats in summer, chiefly controlled by the depth of the winter snowfall and by the temperature of the summer.

Snowline, temporary. A line sometimes drawn on a weather map during the winter showing the southern limit of the snow cover.

Snow, quality of. The ratio of heat of melting of snow, in calories per gram to the 80 calories per gram for melting pure ice at 0°C. (Bernard and Wilson, 1941, p., 178–179.) (*See also* Wilson, 1942b, p 553–556.)

Percentage by weight which is ice (Linsley, Kohler, and Paulhus, 1949, p. 129).

Soil moisture (Soil water). Water diffused in the soil, the upper part of the *zone of aeration* from which water is discharged by the *transpiration* of plants or by soil evaporation. *See* Field-moisture capacity *and* Field-moisture deficiency.

Stage. The height of a water surface above an established datum plane; also *gage height*.

Stage-capacity curve. A graph showing the relation between the surface elevation of the water in a reservoir, usually plotted as ordinate, against the volume below that elevation, plotted as abscissa.

Stage-discharge curve (rating curve). A graph showing the relation between the gage height, usually plotted as ordinate, and the amount of water flowing in a channel, ex-

Stage-discharge curve—Continued
pressed as volume per unit of time, plotted as abscissa.

Stage-discharge relation. The relation expressed by the *stage-discharge curve.*

Stage, flood. *See* **Flood stage.**

Stemflow. Rainfall or snowmelt led to the ground down the trunks or stems of plants (Hoover, 1953, p. 1).

Storage. 1. Water artificially impounded in surface or underground reservoirs, for future use. The term *regulation* refers to the action of this storage in modifying *streamflow.* *See also* **Conservation storage, Total storage, Dead storage,** *and* **Usable storage.** 2. Water naturally detained in a drainage basin, such as *ground water, channel storage,* and *depression storage.* The term "drainage basin storage" or simply "basin storage" is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin.

Storage, bank. *See* **Bank storage.**

Storage, conservation. *See* **Conservation storage.**

Storage, dead. *See* **Dead storage.**

Storage, depression. *See* **Depression storage.**

Storage ratio. The net available storage divided by the mean flow for 1 year. (Hazen, 1930, p. 1446.) (*See also* Thomas and Harbeck, 1956, p. 14.)

Storage-required frequency curve. A graph showing the frequency with which storage equal to or greater than selected amounts will be required to maintain selected rates of regulated flow.

Storage, total. *See* **Total storage.**

Storage, usable. *See* **Usable Storage.**

Storm. A disturbance of the ordinary average conditions of the atmosphere which, unless specifically qualified, may include any or all meteorological disturbances, such

Storm—Continued
as wind, rain, snow, hail, or thunder.

Stormflow. *See* **Direct runoff.**

Storm seepage. That part of precipitation which infiltrates the surface soil, and moves toward the streams as ephemeral, shallow, perched ground water above the main ground-water level. Storm seepage is usually part of the *direct runoff.*

Stream. A general term for a body of flowing water. In hydrology the term is generally applied to the water flowing in a natural *channel* as distinct from a canal. More generally as in the term *stream gaging,* it is applied to the water flowing in any channel, natural or artificial.

Streams in natural channels may be classified as follows (after Meinzer, 1923, p. 56–58):

Relation to time.
- **Perennial.** One which flows continuously.
- **Intermittent or seasonal.** One which flows only at certain times of the year when it receives water from springs or from some surface source such as melting snow in mountainous areas.
- **Ephemeral.** One that flows only in direct response to precipitation, and whose channel is at all times above the water table.

Relation to space.
- **Continuous.** One that does not have interruptions in space.
- **Interrupted.** One which contains alternating reaches, that are either perennial, intermittent, or ephemeral.

Relation to ground water.
- **Gaining.** A stream or reach of a stream that receives water from the *zone of saturation.*
- **Losing.** A stream or reach of a stream that contributes

Stream—Continued

water to the *zone of saturation.*

Insulated. A stream or reach of a stream that neither contributes water to the *zone of saturation* nor receives water from it. It is separated from the zones of saturation by an impermeable bed.

Perched. A perched stream is either a losing stream or an insulated stream that is separated from the underlying ground water by a *zone of aeration.*

Streamflow. The discharge that occurs in a natural *channel.* Although the term *discharge* can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than *runoff,* as streamflow may be applied to discharge whether or not it is affected by *diversion* or *regulation.*

Streamflow depletion. The amount of water that flows into a valley, or onto a particular land area, minus the water that flows out the valley or off from the particular land area. (Blaney, 1951a, p. 4.)

Stream gaging. The process and art of measuring the depths, areas, velocities, and rates of flow in natural or artificial channels. (*See* Corbett and others, 1943.)

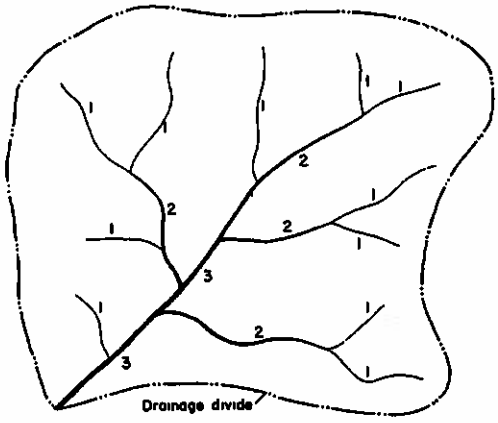
Stream-gaging station. A *gaging station* where a record of discharge of a stream is obtained. Within the Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained.

Stream order. A method of numbering streams as part of a drainage basin network. The smallest unbranched mapped tributary is called first order, the stream receiving the tributary is called second order, and so on. It is usually necessary to

Stream order—Continued

specify the scale of the map used. A first-order stream on a 1 : 62,500 map, may be a third-order stream on a 1 : 12,000 map. (After Leopold and Miller, 1956, p. 16.)

Tributaries which have no branches are designated as of the first order, streams which receive only first-order tributaries are of the second order, larger branches which receive only first-order and second-order tributaries are designated third order, and so on, the main stream being always of the highest order. (Horton, 1932, p. 356.)



Stream orders

Submeander. Small meander contained with banks of main channel, associated with relatively low discharges.

Subsurface runoff. *See* **Storm seepage.**

Supplemental irrigation. Commonly, irrigation as carried on in humid areas. The term means that the irrigation water is supplementary to the natural rainfall rather than being the primary source of moisture as in the arid and semiarid West. Supplementary irrigation is used generally to prevent retardation of growth during periods of drought. (Huffman, 1953, p. 231.)

Supplemental sources. When irrigation water supplies are obtained

Supplemental sources—Continued from more than one source, the source furnishing the principal supply is commonly designated the primary source, and the sources furnishing the additional supplies, the supplemental sources. (Houk, 1951, p. 396.)

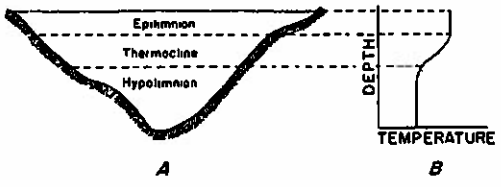
Surface runoff. That part of the runoff which travels over the soil surface to the nearest stream channel. It is also defined as that part of the runoff of a drainage basin that has not passed beneath the surface since precipitation. The term is misused when applied in the sense of direct runoff. *See also*, **Runoff, Overland flow, Direct runoff, Ground-water runoff,** *and* **Surface water.**

Surface water. Water on the surface of the earth.

Tank. An artificial reservoir for stock water; local in Southwest.

Terrace. A berm or discontinuous segments of a berm, in a valley at some height above the *flood plain*, representing a former abandoned flood plain of the stream.

Thermal stratification (of a lake). Vertical temperature stratification that shows the following: The upper layer of the lake, known as the epilimnion, in which the water temperature is virtually uniform; a stratum next below, known as the thermocline, in which there is a marked drop in temperature per unit of depth; and the lowermost region or stratum, known as the hypolimnion, in which the temperature from its upper limit to the bottom is nearly uniform. (Welch, 1952, p. 51.)



Thermal stratification. *A*. Cross section. *B*. Graph showing variation in temperature with depth

Thermocline. *See* **Thermal stratification.**

Throughfall. In a vegetated area, the precipitation that falls directly to the ground or the rainwater or snowmelt that drops from twigs or leaves. (After Hoover, 1953, p. 1.) (*See* **Stemflow.**)

Time of concentration. The time required for water to flow from the farthest point on the watershed to the gaging station. (Ramser, 1927, p. 804.)

Total storage. The volume of a reservoir below the maximum controllable level including dead storage. (Thomas and Harbeck, 1956, p. 13.)

Transpiration. The quantity of water absorbed and transpired and used directly in the building of plant tissue, in a specified time. It does not include soil evaporation. (After Blaney, 1951a, p. 4.)

The process by which water vapor escapes from the living plant, principally the leaves, and enters the atmosphere. * * * As considered practically, transpiration also includes *guttation*. (Lee, 1949, p. 260.)

Trend. A statistical term referring to the direction or rate of increase or decrease in magnitude of the individual members of a time series of data when random fluctuations of individual members are disregarded.

Underflow. The downstream flow of water through the permeable deposits that underlie a stream and that are more or less limited by rocks of low permeability.

Unit hydrograph. The *hydrograph* of *direct runoff* from a storm uniformly distributed over the *drainage basin* during a specified unit of time; the hydrograph is reduced in vertical scale to correspond to a volume of runoff of 1 inch from the drainage basin. (After Am. Soc. Civil Engineers 1949, p. 105.)

Unit hydrograph—Continued
The hydrograph of surface runoff (not including ground-water runoff) on a given basin due to an *effective rain* falling for a unit of time. (Sherman, 1949, p. 514.) (*See also* Hoyt and others, 1936, p. 124.)

Usable storage. The volume normally available for release from a reservoir below the stage of the maximum controllable level. (Thomas and Harbeck, 1956, p. 13.)

Water balance. *See* **Hydrologic budget.**

Water content of snow. *See* **Water equivalent of snow.**

Water crop. *See* **Water yield.**

Water equivalent of snow. Amount of water that would be obtained if the snow should be completely melted. Water content may be merely the amount of liquid water in the snow at the time of observation. (Wilson, 1942a, p. 153–154.)

Water loss. The difference between the average precipitation over a drainage basin and the *water yield* from the basin for a given period. (After Williams and others, 1940, p. 3.) The basic concept is that water loss is equal to *evapotranspiration*, that is, water that returns to the atmosphere and thus is no longer available for use. However, the term is also applied to differences between measured inflow and outflow even where part of the difference may be seepage.

Water requirement. The quantity of water, regardless of its source, required by a crop in a given period of time, for its normal growth under field conditions. It includes surface evaporation and other economically unavoidable wastes. (Blaney, 1951a, p. 4.)

Watershed. The divide separating one *drainage basin* from another and in the past has been generally used to convey this meaning.

Watershed—Continued
However, over the years, use of the term to signify drainage basin or catchment area has come to predominate, although drainage basin is preferred. *Drainage divide*, or just divide, is used to denote the boundary between one drainage area and another. Used alone, the term "watershed" is ambiguous and should not be used unless the intended meaning is made clear.

Water table. The upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body. (Meinzer, 1923, p. 22.)

Water year. In Geological Survey reports dealing with surface-water supply, the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ended September 30, 1959, is called the "1959 water year."

Water yield (water crop or runout). The runoff from the drainage basin, including *ground-water outflow* that appears in the stream plus ground-water outflow that bypasses the gaging station and leaves the basin underground. Water yield is the *precipitation* minus the *evapotranspiration*.

Withdrawal use of water. The water removed from the ground or diverted from a stream or lake for use. (MacKichan, 1957, p. 2.)

Year. *See* **Climatic year; Water year.**

Zone of aeration. The zone above the water table. Water in the zone of aeration does not flow into a well.

Zone of saturation. The zone in which the functional permeable rocks are saturated with water under hydrostatic pressure. (Meinzer, 1923, p. 21.) Water in the zone of saturation will flow into a well, and is called *ground water*.

TOPICAL FINDING LIST

With terms arranged in alphabetical order as they are in the previous section, it is difficult to find the definitions of related terms. For convenience in finding such terms, the following list is organized by major topics, with related terms grouped. The main headings are alphabetized, and the subheadings are arranged approximately in the order of their association with the main headings. The terms that are grouped with the subheadings are similarly arranged. All terms defined in this manual are included, and some may appear under more than one heading. Page numbers are given for ready reference to the definitions.

Floods—Continued

Flood profile, 10; flood plane, 10; concordant flows, 6; flood routing, 10; channel storage, 5; lag, 13; time of concentration, 20.

Flood-frequency curve, 10; annual flood, 4; annual flood series, 4; partial-duration flood series, 14; basic-stage flood series, 5; base discharge, 4; floods above a base, 10; recurrence interval, 16.

Flood plain, 10; flood zone, 11.

Floodway, 11; flood-control storage, 10; retarding reservoir, 16.

Unit hydrograph, 20; distribution graph, 8; antecedent precipitation index, 4; rainfall excess, 15; lag, 13.

Geomorphology

Drainage area, 8; drainage basin, 8; catchment area, 5; drainage divide, 8; watershed, 21.

Bank, 4; riparian, 16; bankfull stage, 4: flood stage, 10; stream, 18; stream, perennial, 18; stream, intermittent or seasonal, 18; stream, ephemeral, 18; stream, continuous, 18; stream, interrupted, 18; regimen of a stream, 16; stream order, 19.

Channel, 5; braiding of river channels, 5; anabranch, 4; drainage density, 8; reach, 16; riffle, 16; pool, 15; control, 6; stage-discharge relation, 18.

Meander, 14; meander amplitude, 14; meander belt, 14; meander breadth, 14; meander length, 14; submeander, 19.

Flood plain, 10; terrace, 20.

Runoff, 17; concordant flows, 6; lag, 13; depression storage, 7.

Sediment, 17; sediment discharge, 17; mudflow, 14; regime, 16.

Ground water

Ground water, 11; ground-water outflow, 11; underflow, 20.

Runoff, 17; base runoff, 5; base flow, 5; ground-water runoff, 12; storm seepage, 18; recession curve, 16.

Zone of aeration, 21; percolation, 15; percolation, deep, 15; zone of saturation, 21; water table, 21.

Stream, gaining, 18; stream, losing, 18; stream, insulated 19; stream, perched, 19.

Hydrology

Hydrology, 12; hydrologic cycle, 12; hydrologic budget, 12; hydrologic equation, 12; water balance, 21; water yield, 21; water loss, 21.

Surface water, 20; ground water, 11; precipitation, 15; evaporation, 9; transpiration, 20; limnology, 13.

Basic hydrologic data, 5; water year, 21; climatic year, 5.

Climate, 5; storm, 18; drought, 8; cycle, 7; long-period variations, 13; normal, 14; trend, 20.

Lakes

Limnology, 13; surface water, 20; evaporation, 9.

Thermal stratification (epilimnion, hypolimnion, thermocline), 20; meromictic lake, 14.

Heat budget, annual, 12.

Seiche, 17.

Storage, 18; area-capacity curve, 4; stage-capacity curve, 17; contents, 6.

Land surface

Absorption, 4; infiltration, 12; infiltration capacity, 12; infiltration index, 12.

Overland flow, 14; surface runoff, 20; lag, 13.

Depression storage, 7; streamflow depletion, 19.

Low flow

Base flow, 5; base runoff, 5; ground-water outflow, 11; ground-water runoff, 12; recession curve, 16; dependable yield, *n*-years, 7.

Climatic year, 5; drought, 8.

Low-flow frequency curve, 13; recurrence interval, 16; flow-duration curve, 11; storage-required frequency curve, 18.

Snow, ice, and glaciers

Cryology, 7.

Snow, 17; snowline, 17; snowline, temporary, 17; snow course, 17; snow density, 17; snow, quality of, 17; water equivalent of snow, 21; water content of snow, 21.

Anchor ice, 4; frazil, 11.

Glacier, 11; ablation, 4; firn, 9; firn line, 9.

Soil water

Soil moisture, 17; field-moisture capacity, 9; field-moisture deficiency, 9; moisture equivalent, 14; zone of aeration, 21.

Absorption, 4; infiltration, 12; infiltration capacity, 12; infiltration index, 12; percolation, 15; irrigation efficiency, 13.

Storm seepage, 18.

Stream gaging

Stream gaging, 19; basic hydrologic data, 5.

Gaging station, 11; stream-gaging station, 19; current meter, 7.

Discharge, 7; streamflow, 19; runoff, 17; average discharge, 4.

Stage, 17; gage height, 11.

Stage-discharge curve, 17; discharge rating curve, 8; stage-discharge relation, 18; stage-capacity curve, 17; area-capacity curve, 4; control, 6; shifting control, 17.

Reach, 16; backwater, 4.

Drainage area, 8; drainage basin, 8; catchment area, 5.

Streamflow, runoff, and water yield

Streamflow, 19; discharge, 7; average discharge, 4; normal, 14; diversion, 8; regulation, 16; skimming, 17; streamflow depletion, 19; stream-gaging station, 19.

Runoff, 17; direct runoff, 7; stormflow, 18; overland flow, 14; base runoff, 5; base flow, 5; surface runoff, 20; subsurface runoff, 19; ground-water runoff, 12; storm seepage, 18; depression storage, 7; effective precipitation, 8; rainfall excess, 15; time of concentration, 20.

Water yield, 21; water crop, 21; runout, 17; hydrologic budget, 12; water balance, 21; hydrologic equation, 12; water loss, 21; long-period variations, 13; trend, 20; normal, 14.

Drainage basin, 8; drainage area, 8; catchment area, 5; drainage divide, 8; watershed, 21; stream, 18.

Tools of analyses, instruments

Basic hydrologic data, 5; average discharge, 4; normal, 14; recurrence interval, 16; climatic year, 5; water year, 21; gaging station, 11; current meter, 7; lysimeter, 13.

Stage-discharge curve, 17; stage-capacity curve, 17; storage ratio, 18.

Flow-duration curve, 11; duration curve, 8; recession curve, 16.

Mass curve, 13; residual-mass curve, 16; double-mass curve, 8.

Low-flow frequency curve, 13; storage-required frequency curve, 18; recurrence interval, 16.

Flood-frequency curve, 10; annual flood series, 4; partial-duration flood series, 14; recurrence interval, 16; base discharge (for peak discharge), 4.

Correlation, 6; correlative estimate, 6.

Unit hydrograph, 20; distribution graph, 8; rainfall excess, 15; time of concentration, 20; lag, 13.

Hydrograph, 12; hyetograph, 12; isohyetal line, 13; antecedent precipitation index, 4; effective precipitation, 8; trend, 20; stream order, 19.

Units and abbreviations

Acre-foot, 4.

Cfs, 5; cubic feet per second, 7; second-foot, 17; cusec, 7.

Cfs-day, 5.

Cfsm (cubic feet per second per square mile), 5.

Vegetation

Interception, 12; throughfall, 20; stemflow, 18.

Transpiration, 20; evapotranspiration, 9; consumptive use, 6; guttation, 12; water loss, 21.

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