FLUCTUATIONS OF WET AND DRY YEARS

PART I

RESEARCH DATA ASSEMBLY AND MATHEMATICAL MODELS

By
Vujica M. Yevdjevich

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HYDROLOGY PAPERS
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Several departments at Colorado State University have substantial research and graduate programs oriented to hydrology. These Hydrology Papers are intended to communicate in a fast way the current results of this research to the specialists interested in these activities. The papers will supply most of the background research data and results. Shorter versions will usually be published in the appropriate scientific and professional journals.

This research is presently sponsored by the U.S. National Science Foundation. Part of the research material is from the project "Water Cycle" sponsored by the U.S. Office of Naval Research. The research on this topic was initiated and carried out partly while the author was associated with the U. S. National Bureau of Standards, and with the U.S. Geological Survey. The research was conducted at Colorado State University Civil Engineering Section, Fort Collins, Colorado.

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PREFACE

This first part of the paper "Fluctuations of Wet and Dry Years" refers only to the assembly of research data and development of mathematical models in the study of patterns in sequence of annual river flow and annual precipitation. The results of the statistical analysis of research data, as well as the interpretation of results, will be the subject of subsequent parts of the paper. These parts will contain: the analysis of patterns in sequence of annual flow and annual precipitation by serial correlation, ranges, runs, and variance spectrum (power spectrum); effects of inconsistency and nonhomogeneity in data on these patterns; the effect of selected beginning of year; and various relationships among statistical characteristics.

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ABSTRACT

The general approach adopted in studying fluctuations of wet and dry years, as defined by the sequence of annual river flow and annual precipitation is described in detail.

Two large samples of data on annual river flow, one on a global and the other on a continental sampling scale, and two large samples of data on annual precipitation, both on the continental sampling scale, constitute the basic research material. The criteria for data selection are described.

A simple mathematical model for the water carryover from year to year in a river basin is developed as a function of annual effective precipitation. Evaporation from river basins and evaporation of rainfall in the air above the river basins are also expressed by simple mathematical models as functions of various physical factors. These three models, respectively, give the simple relationships of annual flow to annual effective precipitation, of annual effective precipitation to annual precipitation at the ground, and of annual precipitation at the ground to annual precipitation at the cloud base. Mathematical models show that the water carryover, the evaporation from the river basin, and the evaporation of rainfall in the air represent the important factors responsible for the dependence in sequence of wet and dry years. Inconsistency and nonhomogeneity in data also produce or increase dependence among the successive wet and dry years.

The procedure used to compile the research data from the available records for the statistical analysis is presented in summary form.

General conclusions from this part of the study are given. Tables of data and statistical parameters for the first large sample of annual river flows are included as appendices.

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PART I

RESEARCH DATA ASSEMBLY AND MATHEMATICAL MODELS

by Vujica M. Yevdjevich*

A. INTRODUCTION

1. Subject. The water yield of a river basin or of the atmosphere above a river basin fluctuates from year to year. The fluctuation is generally and popularly referred to as the sequence of wet and dry years. This problem has intrigued man since the beginning of recorded history. It is a logical step to investigate it from time to time, as new data and new and more effective research techniques become available.

The analysis of fluctuations of annual river flow, of annual effective precipitation**, and of annual precipitation is considered here as representing the fluctuations of annual water yield, and is the subject of this and the subsequent parts of the study.

Three main questions will be answered by the various parts of this study:

(a) Are the sequences of annual flow, annual effective precipitation, and annual precipitation predominantly random*** or nonrandom?

(b) What are the main causes and characteristics of nonrandomness?

(c) What are the simple mathematical models which can be applied to define the nonrandomness?

This investigation is restricted here to the analysis of patterns in sequence of annual water yield of river basins and atmosphere above them.

2. Significance of this investigation. Many efforts have been made in the past to discover the regularities, or to prove the randomness, in the fluctuations of climatic and hydrologic events. The eventual prediction of future events has been the main objective of those efforts.

The average water yield of an area (with no manmade changes, or unusual natural influences, such as landslides with new lakes, fires, and similar) fluctuates in narrow limits for equal periods of sufficient time length. Needs for water, however, increase steadily in most river basins, and the storage of surplus water from wet seasons for dry seasons, and from wet years for dry years is a common practice. Overyear flow regulations will be increased substantially in the near future.

The characteristics of the sequence of wet and dry years in river flow and precipitation determine several design and operation criteria. A typical design problem is the determination of the overyear storage capacity for the given flow regime and water demand. The patterns in fluctuations of total or partial annual flow* are of practical significance in many problems related to water resource development.

Answers to the above three main questions may throw more light on the problem of predictability or nonpredictability of water yield on the basis of one or more years.

3. Selection of phenomena for the study of flow fluctuations. The patterns in fluctuation of annual river flow and annual precipitation can be studied either with the observed data of water flow and precipitation, or with the observed data of other quantities related to them. These are: a) phenomena that cause, or affect in some basic way, the annual flow and annual precipitation; b) phenomena that depend on precipitation and climate as does runoff (tree rings, pollen depositions); c) phenomena that are the result of runoff (varves or sediment deposits).

If the variables that cause and affect the runoff and those that result from runoff follow nearly the same patterns of fluctuations, it can be derived that the sequence of annual flow would have the same fluctuation patterns. This was the way H. E. Hurst [1, 2, 3]** approached the problem of fluctuation of

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** Annual effective precipitation is defined as total annual precipitation minus total annual evaporation and evapotranspiration for a river basin. The annual evaporation and evapotranspiration will be simply referred to as annual evaporation.

***The term "random" is defined here to mean that there is no systematic link between successive values of an infinite time series, or that the members of that time series are independent among themselves. "Nonrandom" means that the members of the time series are dependent among themselves.

* Partial annual flow is defined here as the annual flow for a year that is obtained from all flows equal to or smaller than a given discharge. This discharge may be conceived as the maximum intake flow at a river cross section, and the partial annual flow as total derivable river flow for a year.

** References are given at the end of the publication.

annual flow and of overyear flow regulation. He studied several kinds of recorded data, and suggested an empirical formula for long-term difference of maximum and minimum of the accumulated departures from the mean values.

Rainfall fluctuations are nearest to runoff fluctuations. All other variables (evaporation, air humidity, tree rings, pollen, varves, and others) are less directly or less closely related to runoff. Fluctuations of air temperature, air humidity and other meteorological variables are not closely followed by fluctuations of precipitation, and less so by runoff fluctuations. The tree rings depend on many factors, apart from rainfall, especially on general biological growth patterns, environmental conditions, and water stored underground and in the trees themselves. The annual sediment layer (varve) depends on annual flow in a rather complex way. Large fires and soil conservation measures in a river basin can substantially change the sediment transport without a corresponding effect on the runoff. Fluctuations of lake levels greatly influence the distribution of sediment deposits and, therefore, the thickness of annual layers. The effect of sediment consolidation by overburden restricts the reliability of data on varves, while the freezing and thawing of sediment layers may also alter their thickness and composition.

Precipitation is measured at points and the error of measurement is usually great. The computation of total precipitation on a river basin embodies a still greater error. The river flow essentially integrates the precipitation received on larger areas, but includes evaporation as another important climatic factor, which plays a significant role in many water resource problems.

The study of fluctuations of wet and dry years was carried out for the time series of annual flow, annual effective precipitation, and annual precipitation. They are considered here as the most reliable series for investigation of climatic fluctuations related to water resources.

4. Characteristics of river flow data. Three basic characteristics of runoff records are: a) relatively short periods of flow observations, which actually do not exceed 160 years; b) lack of a sufficient number of stations well distributed on the earth's surface with long and reliable flow records; and c) concentration of data within the same period of time (mostly from 1900 to present). This third characteristic properly points out that patterns in long-term fluctuations of wet and dry years cannot be detected with great reliability, and that some detected regularity inside the short periods may be attributed to sampling fluctuations. The next period of observation of the same length may not show the same properties of time series, as those detected for the past period.

The study of sequence of annual flow is made difficult in some cases by changes made in runoff. The annual flow unaffected by man's activity or by accidents in nature (e.g., fires, filling of lakes by sediment, landslides in river channels with new lakes*) is called here the virgin flow. Storage reservoirs, changes of biological cover, changes in soil treatment, diversions of water from one river basin to another, and different consumptive uses of water affect the annual flow. The actual flow at many river gaging stations is far from the virgin flow.* Sometimes it is possible to correct the records with sufficient accuracy for the changes of flow (taking into account diversions, lake storage, lake evaporation), but often only an approximate value can be obtained for net irrigation loss, and a very rough estimate for influence of changes in treatment of soil and of biological cover.

As longer records become available with time, manmade effects will also increase, and as a result, there will be progressively fewer long-term stations with virgin flows. To await longer records will limit the number of long-term stations considered stationary for the study of fluctuations. Therefore, the results of studies of today may be, in some respects, as proper and reliable as the studies of tomorrow.

5. Types of time series. The river flow time series are either continuous or discrete. A recorded hydrograph is a continuous time series. Mean or total daily, mean or total monthly, and mean or total annual flow represent discrete time series. This study deals exclusively with the discrete time series of annual flow, annual effective precipitation and annual precipitation.

The time series are either stationary or nonstationary. A stationary series of annual flows does not depend on absolute time. In this case, the factors which affect the annual flow or annual precipitation do not change with time. A virgin flow series with no significant change in river basins or in atmosphere for the time of runoff or precipitation records is considered as a stationary time series. If, however, the runoff factors change with time (man's activity in river basin, some large accidents or slow modifications in nature which change flow characteristics, weather modification, some systematic errors in the compilation of annual flows), the time series depends on absolute time, and it is a nonstationary or evaluative series. A depletion or addition of flows by man's activities creates jumps or trends in time series, and such series are nonstationary. A relocation of precipitation gage may introduce nonstationarity. This study deals with the stationary time series, or with those nonstationary time series that can be corrected and reduced to the stationary series. The nonstationary series when used in this study will represent the special case for the analysis of effects of different changes and errors on the properties of time series.

The time series of annual flow and annual precipitation can be either random or nonrandom. The nonrandom series derived from random series by some known stochastic processes** are called stochastic series.

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* There are many more natural factors and processes which suddenly or slowly change the runoff conditions from one period to another.

* The average annual flow of the Upper Colorado River Basin at Lee Ferry, Arizona, during the latter 1950's is only about 85 percent of the average annual flow of this river [4] under virgin conditions.

** The term stochastic process is applied here in the sense that a nonrandom series is derived from random series by some known process like moving average and autoregressive scheme. Random movement is a special case of stochastic processes.

The oscillatory series as nonrandom series may be divided into two groups: a) regular oscillatory series with a definite cycle, following clearly the astronomical time units (i. e., day, year); and b) compound oscillatory series, a composition of several regular oscillatory series, but each of them with an individual cycle and amplitude.

The nonrandomness is often called the persistence, meaning that the successive members of time series are linked among themselves in some persistent manner. The most general case is a compound time series, a combination of oscillatory and stochastic movements.

It can be stated by reviewing hundreds of references on fluctuation of wet and dry years, that the flow and precipitation time series (especially the series of daily and monthly values) are nearly always compound time series. Sometimes they can be approximated by a simple time series (i. e., for annual values). A compound flow series nearly always has a random part, or a random part modified by a stochastic process. By compiling the daily or annual values of runoff and rainfall, the cycles of day and year are eliminated, except that the end effect of cutting a continuous process by a day or year beginning is still present.

6. Practical aspects of random and nonrandom series. If the compound oscillatory sequence existed in annual flows, annual effective precipitation, and annual precipitation, forecasts of annual flow or annual precipitation would be possible by an extrapolation in the future of periodicities determined from past observations.

If randomness predominated in the fluctuations, or if the fluctuations could be approximated by known stochastic processes, it would be possible to apply only the probability theory of random variables for reliable probability statements of future annual flow or annual precipitation and their fluctuations. Then the deterministic prediction of the annual flows of subsequent years would not be possible by extrapolation, except for a portion of future flows which depend on the past flows.

In the case of great persistence in the sequence of annual flow, the overyear flow regulation will demand larger storage space for the same degree of regulation than would be required if randomness predominates, but for the same statistical parameters of the time series.

If the compound oscillatory sequence dominated the annual flow series, the necessary storage volumes for overyear flow regulation could be related to the amplitudes and periods and other characteristics of mathematical models with periodicities.

If the randomness predominated the series, the storage capacities may be determined by applying the theory of probability of random variables. The same would be valid if the observed series (or series derived from observed series) were well approximated by stochastic time series of known processes. In this case, the storage volumes would be related to the parameters of a random variable and of the mathematical model defining the nonrandomness of stochastic process.

7. General approach. The study of the fluctuations of wet and dry years consists mainly of a selection of river gaging and precipitation gaging stations with records sufficiently long, and of analyses of these records by statistical procedures. The statistical properties of time series are then related to the physical and other factors which affect the linkage in the sequence of annual flow and annual precipitation.

The fluctuations of climatic phenomena have generally been analyzed in the past in two basic ways:

(1) Harmonic analysis based on classical methods of Fourier and Schuster. Some of these analyses are well known in Europe (Schuster method in Germany, Labrouste method in France, Vercelli method in Italy). Often the analysis of annual flow and annual precipitation revealed fluctuations with cyclic components of different periods and amplitudes (approach of hidden periodicities). Several hundred references could be cited of the applications of harmonic analysis to the study of fluctuations of climatic and hydrologic phenomena.

(2) Fluctuations of random variables and derived stochastic series. The sequence of observed and derived series of climatic phenomena, whenever there is not a known astronomical cycle involved (day, moon's period of rotation around the earth, year), are analyzed by using probability theory and mathematical statistics to determine the properties of the series. Significance tests are usually applied. The literature on the fluctuation of annual values of the natural phenomena, i. e., precipitation, runoff, temperature, humidity, evaporation, atmospheric pressure, soil moisture, tree rings, varves, pollen, etc., is abundant. Several thousand references could be cited.

A survey of the results and conclusions in this abundant literature reveals two basically opposite views, with many intermediate positions.

A theory is that the physical factors, such as the moon effect, sun-spot fluctuations, and other solar activities; cosmic effects; the persistence in ocean currents and in air-mass movements; etc., create a persistent oscillatory movement of high and low values, which, though combined with random components, make the future values of a time series depend on the previous ones. The hidden periodicities are often ascribed to these effects. This theory is sometimes advocated regardless of the fact that the differences between statistical parameters of observed and random (or stochastic) time series were often statistically nonsignificant.

The other theory is that the natural fluctuations of annual values are very close to random or stochastic time series, with known stochastic processes and their known causes. For example, these processes may be caused by storage of water and heat in oceans, atmosphere, earth; by retardation of water in surface storage spaces in river basins for annual flow fluctuations, etc. Very small departures (considered as nonsignificant) of computed statistical parameters from those of the random series, or series derived from random series by stochastic processes, are emphasized by this theory. The fact that statistical parameters sometimes have consistent departures in the same direction from the statistical parameters of random series is often ignored in this theory, even though the departures can be considered often nonsignificant by the usual procedures of statistical inference.

Many hydrologists agree that the random component of series of annual flow and annual precipitation is large. Some feel, however, that "something exists" beyond the known effects, because of the consistency in departures of statistical parameters between the observed and stochastic series.

The controversy lies mainly in the way that these departures are explained and related to some physical or nonphysical factors.

The approach of this study is the analysis of the mentioned departures between the time series of observed annual flow, derived annual effective precipitation, and observed annual precipitation, and the random time series. The explanations are sought for these departures, whose interpretation divides the two main and opposite viewpoints.

Use of the moving average, which involves the smoothing of the original series in order to study the long-term fluctuations of a phenomenon, is avoided in this study. From the studies of Slutzky [5] and Yale it is known that its use creates, of itself, the nonrandomness or persistence which may lead to erroneous conclusions. The random series becomes a stochastic (nonrandom) series when the method of the moving average or autoregressive scheme is applied. The series will be used here with their unchanged values.

The random series is considered in this study as a bench-mark series. If a large part of the difference between an observed series and the random series can be explained on the basis of known physical causes, the question then arises: How much of the difference remained to be explained on the basis of other less obvious causes? It is of particular interest to see how much of the difference between the observed series and the random series should be explained by factors entirely outside the river basin; for example, upper atmospheric circulation, oceanic circulation, solar activities, cosmic effects, etc.

8. Statistical parameters and methods used in measuring nonrandomness. The statistical parameters for the measurement of dependence between the successive values of a series are many. C. Levert [6] cites nine different statistical parameters to measure the persistence, defined in his study as the internal dependence (nonrandomness) of series:

1. covariance of higher orders or covariance of higher orders in relation to the mean values (cross products of higher order values of successive members of a series); 2. Besson's persistence coefficient; 3. persistence ratio; 4. Von Baur's divergence coefficient; 5. persistence factor; 6. surplus number in statistical model; 7. serial correlation coefficients, and correlogram; 8. Von Bartel's equivalent repeating number; and 9. Kendal's measure of persistence. Apart from these parameters, variance (power) spectrum analysis, and the properties of ranges and runs may be used for measuring the nonrandomness of time series.

The following statistical parameters were selected and used in this study:

a. Serial correlation coefficients and correlograms - The serial correlation coefficients are defined as correlation coefficients of successive values. A correlogram is defined as a graph relating the serial correlation coefficients to the lag between correlated successive values of a series.

b. Ranges - These are defined here for a part of a series as the difference between previous maximum and previous minimum on the cumulative sum of departures of annual values from the average annual value.

c. Runs - They are defined in two basic ways. First, either as the number of consecutive positive or negative departures from the mean, or as the number of values between consecutive maximum and minimum of series, or vice versa. Second, as the total sum of departures from the mean for each consecutive group of positive and negative departures.

d. Variance spectrum analysis - This represents an application of Fourier-series analysis in such a way that an infinite number of small oscillations with a continuous distribution of periods is ascribed to observed variation of a phenomenon [7]; or it is an expression of the second moment of an ensemble process in terms of frequencies [8].

B. SELECTION OF SAMPLES OF DATA

1. Principles used in sampling of stations. Sampling in time of annual flow and annual precipitation is limited to the historical records, which are usually short. Thus wide sampling is possible only by selecting river flow and precipitation stations on an area basis. First the scales of area within which stations would be sampled were selected.

The smaller the area and the greater the number of selected gaging stations, the larger is the average regional correlation coefficient among the data of stations taken pairwise. The larger this average coefficient, the smaller is the effective number* of selected stations, and the less is the information which can be derived. Therefore, there is no advantage in the selection of a very large number of stations within a limited area.

Two scales were selected for the area: global and continental. The global scale meant the use of stations from many parts of the world. The continental scale was limited to Western North America, because the data on both annual flow and annual precipitation was readily available and sufficiently reliable.

This general sampling scheme was thus aimed to compensate as much as possible for the disadvantages of a limited period of observation by sampling stations over large areas.

2. Selection of samples of data from gaging stations with sufficient length of continuous records. A large sample of annual values of flow and precipitation is defined here as containing several thousand station-years. The number of station-years is obtained by summing all observed annual values from the stations of a sample. A small sample is defined here as containing several hundred station-years.

Three types of samples of data from river gaging stations were used in determining the series of annual flow and derived annual effective precipitation:

a. A large sample of streamflow records obtained at gaging stations located throughout the world. This large group representing a sampling of records on a global scale contained 140 river gaging stations with data ending in 1957.

b. A large sample of streamflow records from gaging stations located in Western North America. This group represents sampling on a continental scale. Most of these river gaging stations were located west of the Mississippi River in Western United States and Western Canada. There were data from 446 stations with records ending in 1960.

c. Some small samples of streamflow records obtained from the above two large samples, for regions of homogeneous hydrologic characteristics. The similarity of hydrologic characteristics was determined by the amount of water yield and from climatic factors [arid or humid regions].

Records from 42 stations found in the first sample were also used in the second sample except that these records of the second sample contain 3 more years of observation (1958-1960).

Three types of samples of precipitation gaging stations were used in determining the series of annual precipitation:

a. A large sample of data from precipitation gaging stations in the continental region of Western North America (approximately the same area is covered as by the second sample of river gaging stations), with a total of 1141 stations.

b. Some small samples of data from precipitation gaging stations from the above large sample, but for homogeneous hydrometeorological regions, covering approximately the same areas as the corresponding small samples of data from river gaging stations.

c. A sample of data of nonstationary time series from precipitation gaging stations for the purpose of comparison with the data of stationary time series, with a total of 473 stations.

3. Selection of minimum length of time series The minimum length of continuous records for the river gaging stations from several parts of the world was 40 years, whereas it was 30 years for all other stations. The length of continuous records was selected as a compromise between the larger number of stations for a smaller minimum length of series, and a smaller number of stations for a greater minimum length of series.

4. Analysis of accuracy of data. The data include certain errors. There are a number of reasons for these errors including: inaccuracy of the gaging instruments; inaccuracy in procedures of measurement; inaccuracy in procedures of computation or reduction of the data; changes in observational or computational techniques during the years of observation, etc.

An example of the last type of error is the streamflow records. For a 60-80 year observational period it might include three types of stage measurements: a single daily observation of stage; stage recording; and stage punching. When these errors exist, the data do not represent true values. Sometimes these errors can be recognized by studying the history of the stations providing the records.

A very complex law governs the relation between flow fluctuations and bed level fluctuations. Some earlier observations did not take into account many factors affecting the accuracy of data. Often a mean rating curve was used for a long period, or the rating curve derived from later level and discharge

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* The effective number of stations in the case of correlated stations is the number of uncorrelated stations that would be statistically equivalent. Correlated and uncorrelated stations are those for which simultaneous annual flow or annual precipitation of stations taken pairwise are and are not correlated, respectively.

measurements was used for the flow computation from the previously observed stage levels. Knowledge of river characteristics and station history is needed to explain the possible errors and inconsistencies of past data, and to enable a reliable analysis of data accuracy.

Such an approach is feasible when a limited number of stations is involved; but, when large samples of gaging stations constitute the basic research material, the analysis of each station can be practical only by a general survey of station history during the selection and review of data. Such a survey was made in this study.

5. Criteria for selection of river gaging stations. The criteria used in this study for the selection of series of annual flow have been:

a. Data of the first large sample were in the form of a long uninterrupted sequence; whereas, for the second large sample (Western North America), only the minimum observation period, 1931-1960, was set up as uninterrupted for all stations;

b. Estimated monthly flows by using correlation and regression analysis with neighboring stations did not exceed a small percentage of all monthly values available;

c. Gaging stations with very changeable conditions, with significant continuous changes of virgin flows, were avoided;

d. The records obtained at a station were not used when the diversions into or out of the watershed exceeded one percent of the total river flow and the diversions could not be accounted for by corrections;

e. In the case of large irrigation areas, with the change during the period of observation of net consumptive use of water greater than approximately one to two percent of annual mean flow, the records of such affected stations were not usually selected for the study. Only in exceptional cases, when a large region was not covered by any selected station, the percentage of net consumptive use was allowed to be somewhat greater than one to two percent;

f. Where large storage reservoirs have had a great influence either on overyear flow distribution or on evaporation, and could not be accounted for easily, the downstream stations were not selected for this study;

g. Changes in the land use and in biological cover, usually gradual processes, were not used as criteria for the selection of stations. Since these changes can either increase or decrease the annual flows, they were considered as part of general nonstationarity in data.

h. Effect of large nonstationarity in data was avoided when possible by the proper selection of stations or correction in data;

i. Data of annual flows were taken from the publications or from official records of hydrologic services; and

j. Only stations having records with available monthly or daily flows, which allowed the computation of stored water volumes in the river basin at given times, were used.

6. Criteria for selection of precipitation gaging stations. The criteria used in this study for the selection of series of annual precipitation were:

a. Stations of large sample (Western North America) have the minimum period of observation, 1931-1960, uninterrupted for all stations;

b. Total number of monthly estimates by correlation and regression analysis with neighboring stations is small;

c. Records of large sample are stationary in the practical limits of stationarity tests;

d. Data for the annual precipitation were taken from the publications or from official records of weather services;

e. The sample of nonstationary stations is composed of stations which, by any criteria of nonstationarity have been classified as such.

7. First large sample of river gaging stations and its characteristics. The selection of stations for the study was influenced basically by the data available to the author, and resulted in the following distribution, by countries: United States of America, 72; Canada, 13; Europe, 37; Australia and New Zealand, 11; Africa, 4; and Asia, 3.

The most convenient source of data in the U. S. A. is the Water Resources Division of the Geological Survey (U. S. Department of the Interior), which has a centralized filing system for all hydrologic stations. Included among these publications are compilation reports containing the revised records of streamflow for all stations, up to 1950. Subsequent streamflow records are available in reports or in files. Most of the data for Europe were received from the U. N. Economic Commission for Europe, which has gathered them for a study of the simultaneity of wet and dry years of river flows in Europe. The data for Canada were taken from published reports. All other data were collected either through personal contacts, or through the courtesy of the governmental or other agencies to whom the author addressed himself. To all of them the author is grateful.

The relative frequency distributions of four charactersitics of river gaging stations are given in fig. 1. These variables are: drainage area A of river basin (in sq. miles); average river flow Q (in cfs); average specific water yield q (in cfs/sq. mi.); and the length of observations N (in years). The conversions in metric system are also given in fig. 1.

The river basins for the European stations are on the average larger than for the other regions, because data for the large rivers from Europe were the most readily available. Most large river basins in Western United States are greatly affected by nonhomogeneity in data (manmade influence of river flows), so that many long-term stations have been excluded from this sample of 140 stations.

The average length of observation of these 140 stations is 55 years. There are only 6 stations with a record of about 100 years or more; Göta River at Sjötorp-Vänersborg, Sweden, 150 years; Rhine River at Basle, Switzerland, 150 years; Nemunas River at Smalininkai in Lithuania, U. S. S. R., 132 years; Danube River at Orshava in Iron Gates, Rumania, 120 years; St. Lawrence at Ogdensburg, New York, U. S. A., 97 years; and Mississippi at St. Louis Missouri, U. S. A., 96 years.

8. Second large sample of river gaging stations, and its characteristics. This sample includes the data of 446 river gaging stations in Western North America. The sources of data are the U. S. Geological Survey (Denver office) for the stations in the U. S. A., and Canadian publications on river flows for the stations in Canada.

The relative frequency distributions of four characteristics of these river gaging stations are also given in fig. 1. This permits a comparison of two large samples, one on the global and the other on the continental scale. These variables are: area of river basin (A); average river flow (Q); average specific water yield (q); and length of observation (N).

This large sample will always be treated in two alternatives as far as the length of observations is concerned. The first alternative will be the length of 30 years for all 446 stations, namely the period 1931-1960. The second alternative will be the total available, but unequal and interrupted length of observations for individual stations, with an average length of 37 years.

The second sample is composed of station data in such a way that a station does not include the flows at the upstream stations that are already included in the sample. If, in a river basin, a station A would have stations B, C, and D upstream, the annual flow V, and annual effective precipitation P_e at A have been determined only for the river basin net area, which does not contain the areas of stations B, C, and D. This was computed as $V_n = V_A - (V_B + V_C + V_D)$, where V_n is annual flow at the station A for the net area. Similarly, ${}_nP_e = P_e(A) - P_e(B) - P_e(C) - P_e(D)$, where ${}_nP_e$ is annual effective precipitation at the station A for the net area.

This approach was selected for the purpose of avoiding the high regional correlation of annual flow and annual effective precipitation between the flows of the stations, when the flow of an upstream station passes at a downstream station. In other words, the flow and effective precipitation at the adjacent stations become more independent, if the flows of a station do not contain the flows of the upstream stations.

9. Comparison of two large samples of river gaging stations. The comparison of four characteristics of river basins for the two large samples shows that the average area, average discharge, and average length of observations are greater in the first sample than in the second sample. The specific water yield has approximately the same distribution in the two samples, except that the second sample shows some stations with greater yields, as well as a larger relative frequency for very small yields (up to 0.4 cfs/sq. mi.) than the first sample. The shorter average length of observation in the second sample is compensated in this study by a larger sample size, than for the first sample. The average distance between the stations in the first sample is much greater than in the second sample. The average regional correlation coefficient among the annual flows of stations should therefore be smaller in the first sample than in the second sample.

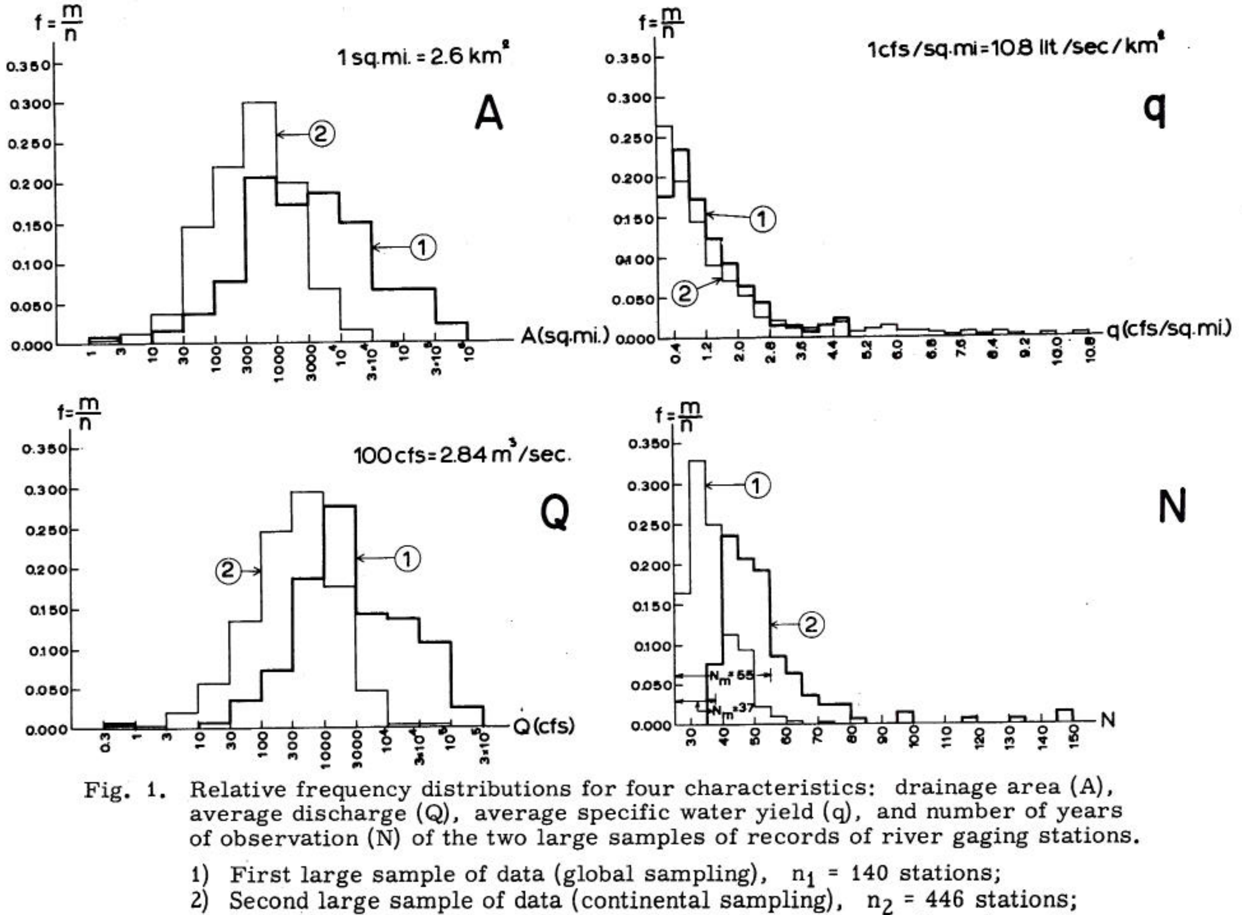

Fig. 1. Relative frequency distributions for four characteristics: drainage area (A), average discharge (Q), average specific water yield (q), and number of years of observation (N) of the two large samples of records of river gaging stations.

1) First large sample of data (global sampling), $n_1 = 140$ stations;
2) Second large sample of data (continental sampling), $n_2 = 446$ stations; with m, number of stations for a class interval; n, total number of stations (140 or 446); and f = m/n, relative frequency.

The first sample has approximately 140 x 55 = 7700 station-years, while the second sample has 446 x 37 = 16502 station-years. Taking into account that the average regional correlation coefficients among the flows is smaller in the first sample, it can be expected that the conclusions about the patterns in sequence of annual flow and annual effective precipitation may be considered of the same order of significance in both samples.

The second sample has the data on flow and effective precipitation of independent river basins (the areas of two river basins never overlap), while this criterion has not been applied to the first sample. This difference between the two samples still further decreases the effect of regional correlation among station data of the second sample, because of the much smaller average distance between the pairs of stations.

It should be stressed, however, that the first sample incorporates several rivers and their stations with large storage reservoirs (St. Lawrence, Göta, Neva, Victoria Lake, Albert Lake, etc.), so that the average dependence of the successive values of annual flow is expected to be somewhat greater in the first sample than in the second one.

The small samples of data of river gaging stations, selected from the two large samples, either refer to specific regions, or are selected according to the other criteria for the specific problems investigated. This will not be specified in this part of the study.

10. Large samples of annual precipitation. The same area covered by the second large sample of river gaging stations is used for the sampling of annual precipitation. The precipitation stations with 30 (1931-1960) or more than 30 years of observations are divided into two groups: a) stations with data considered stationary by either of two tests: by double mass-curve test (Weather Bureau Regional Forecasting Services), or by the test of station moves (either in plan, or by a vertical elevation); and b) stations with nonstationary data by either of the two above criteria of stationarity. The large sample of annual precipitation of stationary records contains 1141 stations. Figure 2 gives the distribution of the average annual precipitation (P_i), and of the number (N) of years of observation for these stations.

The large sample of annual precipitations of nonstationary records contains 473 stations. Figure 2 gives also the distribution of P_i and N for these nonstationary records.

The main objective of the sample of nonstationary records of annual precipitation is the analysis of the effect of nonstationarity in data on the patterns in sequence of annual precipitation.

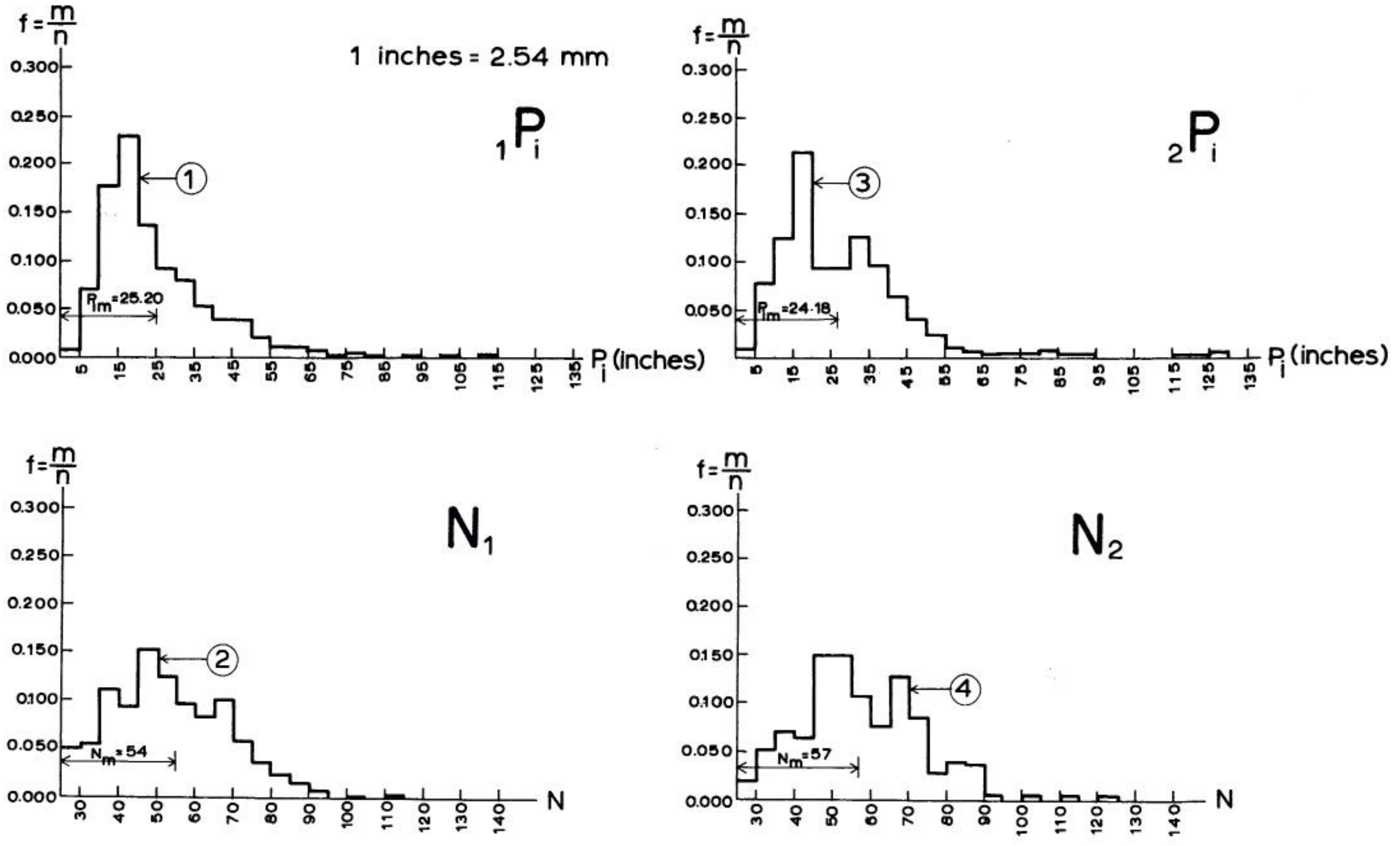

Fig. 2. Relative frequency distributions for two characteristics: average annual precipitation (P_i) and length of observation (N) of the two large samples of records of precipitation gaging stations.
1) Stationary series, average annual precipitation ($_1P_i$), n_1 = 1141 stations; 2) Stationary series, length of observation (N), n_1 = 1141 stations; 3) Nonstationary series, average annual precipitation ($_2P_i$), n_2 = 473 stations; 4) Nonstationary series, length of observation (N), n_2 = 473; with m, number of stations for a class interval; n, total number of stations (1141 and 473); and f = m/n, relative frequency.

C. MATHEMATICAL MODELS

1. Variables used in mathematical models. In order to study the patterns in fluctuations of annual flow, annual effective precipitation, and annual precipitation, these variables were defined as total values for a water year and a river basin. The variables used and referred to the river basin were: V, annual river flow at a gaging station; P_e, annual effective precipitation, or the net annual water yield of atmosphere; P_i, annual precipitation at the ground; E, annual evaporation and evapotranspiration from the ground; P_c, annual precipitation at the cloud base*; E_a, annual evaporation of precipitation between the cloud base and the ground; W_e, total water volume stored at the end of a water year; W_b, total water volume stored at the beginning of a water year; ΔW, annual change in the total water stored; e, random errors in any variable; i, inconsistency (systematic errors) in any variable; h, nonhomogeneity** in data in any variable; q, all types of error in the computed ΔW.

2. General mathematical model. The annual effective precipitation for a river basin may be expressed as:

$$P_e = P_c - (E_a + E) = P_i - E = V + W_e - W_b = V + \Delta W \qquad (1)$$

with

$$P_i = P_c - E_a, \text{ and } \Delta W = W_e - W_b .$$

The variables P_c and E_a are not currently measured. The precipitation P_i over a river basin is usually computed by using the data of a small number of rainfall stations. Any procedure used for the computation of P_i-values by a small number of rainfall stations, produces an annual precipitation which has a large inherent error. The evaporation is measured at points like rainfall, and sometimes only through a quantity (a potential for evaporation), which is related in a complex manner to the real annual evaporation occurring under natural conditions. Also, the measurements during the winter are often discontinued, due to the frost effects.

The variable V represents the measured annual river flow. It is actually the most accurate value available for a river basin of all variables in eq. (1). The change in storage ΔW may be determined approximately by computation of values W_e and W_b. It was concluded for the purposes of this study that the variable P_e would be much more accurate for the majority of river basins with flow measurements, if $P_e = V + \Delta W$ is used instead of $P_e = P_i - E$, with P_i determined from point measurements of rainfall, and E estimated from the meteorological variables measured at some points in the river basins. Determination of the net water yield of atmosphere to a river basin, by using the balance of moisture input and output of air masses over a basin, gives reliable results for very large river basins only.

Seven variables P_c, E_a, P_i, E, P_e, ΔW, and V are characterized by their two basic statistical properties: frequency distribution, and sequential pattern. As all seven variables are related, their two basic statistical properties are interrelated. The simple relationships

$$P_c = P_i + E_a \qquad (2)$$
$$P_i = P_e + E \qquad (3)$$
$$P_e = V + \Delta W \qquad (4)$$

as well as the properties of variables E_a, E, and ΔW determine the relationship of properties among four other variables. In other words and as examples: if the properties of annual flow and annual water carryover, as well as their relationship, are known, the properties of annual effective precipitation can be derived. Or, if the properties of annual evaporation in the air, as well as their relation to precipitation, atmospheric and earth conditions, and the height between cloud base and the earth, were known, the properties of annual precipitation at the cloud base can be derived.

For a long series by neglecting the effect of the ends, $\Sigma\Delta W$ is approximately zero, so that $\overline{V} = \overline{P}_e$.

The variables P_c and P_i are usually closer to a random sequence than the variables P_e and V. The advantage of using the mathematical models of eqs. (1) to (4), and the models relating E_a, E, or ΔW to some of the above four variables, lies in deriving the properties of nonrandom series from those sequences which can be well approximated by random series.

Advances in radar hydrometeorology may, in the future, enable a systematic investigation of the relationship and properties of variables in eq. (2). The available records of precipitation, river flow, and evaporation from the earth's surface enable the investigation for the variables of eqs. (3) and (4).

The computed annual flow at a river cross section generally has: a) a random error, which represents the difference between the true and the computed value; b) inconsistency*, resulting from systematic error made in one direction—positive or negative—due to the methods of measurement or computation (for example, the effect of shifting control, bedshifting effect, or special bed roughness as ripples, dunes, etc., when not followed during the close time intervals and taken into consideration by the computation methods); the values without random errors and inconsistency in data are referred to as true values; and c) nonhomogeneity being produced by the change of virgin flow either by man's influence or by natural phenomena in a river basin (fires,

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* Cloud base is defined as the altitude at which the air is supersaturated with water vapor and at which the raindrops falling from the clouds above it cease to grow and start to evaporate.

** The nonhomogeneity in data is defined here as the difference between the true historical flow or true historical precipitation (random and systematic errors are excluded) and the virgin flow or virgin precipitation, respectively.

* A distinction is made here between inconsistency and nonhomogeneity, though often they are grouped together or interchanged as terms. Inconsistency is defined here as systematic errors, or differences between true flow in nature and the data computed, but with random error excluded.

sedimentation of lake, landslides), and defined as the difference between the true value of computed V, and the true virgin flow. Similar definitions may be applied to measured precipitation or evaporation.*

The true value of annual effective precipitation of virgin nature is expressed as an extension of eq. (4) in the form

$$P_{te} = V \pm e_v \pm i_v \pm h_v + \Delta W \pm g_w \tag{5}$$

where P_{te} is the true and homogeneous value of P_e; e_v, i_v, and h_v refer to the random error, inconsistency, and nonhomogeneity in V, respectively; and g_w represents all types of errors and nonhomogeneity in the computed ΔW.

The true value of the annual effective precipitation, determined from measured precipitation and evaporation is

$$P_{te} = P_i \pm e_p \pm i_p \pm h_p - E \pm e_e \pm i_e \pm h_e \tag{6}$$

where P_{te} is the true and homogeneous value of P_e; e_p and e_e refer to random error in computed values of P_i and E, respectively; i_p and i_e are inconsistency in measuring and computational techniques of P_i and E, respectively; and h_p and h_e represent the nonhomogeneity of data which results from the environmental changes with time for precipitation and evaporation measuring stations, respectively.

The properties of variables ΔW, E, E_a, as well as of e, i, h, and g, determine the relationships among V, P_e, P_i, and P_c.

The hypothetical simple mathematical models for ΔW, E, and E_a variables were analyzed, and their effects on the properties and relationships for V, P_e, P_i, and P_c were discussed. The models are based on the general physical relationships among different variables.

3. Water carryover. The mathematical model of the difference in carryover, ΔW, as related to P_e or V, and to the other variables which affect it, are in general of a very complex nature.

The method by which the water volumes stored in river basins at different times were determined for the purpose of this study is described in detail later. Some general characteristics and a simplified mathematical model for the carryover are dealt with here first.

River basins have three basic types of storage: a) underground storage above the dead storage; b) surface storage in lakes and swamps above the dead storage; and c) surface storage in stream channels. These storage spaces have specific features (for example, stream net storage is affected by unsteady flow of traveling flood waves), and they are in general highly interrelated. The water storage below the ground-water table also is interrelated with the soil moisture or plant moisture above the water table.

The main assumption for the design of the mathematical model is derived here from a general property of water outflows from storage spaces of a river basin. Experience shows that the outflow follows a decay recession curve, if the precipitation and evaporation over the river basin are assumed to have ceased for a sufficiently long period.

A volume-elevation relationship for river basin storage space may often be approximated by an equation of simple power function, as $W_s = aH^m$, with W_s = storage, H = water depth above the reference level of outflow zero, with a and m constants for a given storage space [9, 10]. An outflow rating curve may also be approximated often by a simple power function, of the type $Q_s = bH^r$, with Q_s = = outflow discharge, H = same depth as for storage function, and b and r constants for given outflow geometry [10]. Using the balance equation: inflow minus outflow equals the change in water storage; then, assuming that inflow is zero after a storage space has been filled, at which time the outflow discharge is Q_o, and putting $n = m/r$ (ratio of two exponents in the simple storage and rating curve functions), with $c = bn/a$, a factor connecting the four constants a, b, m, and r, then

$$Q_s^{n-1} = Q_o^{n-1} - c\left(1 - \frac{1}{n}\right) t \tag{7}$$

where t = time [10]. Only in the case when $n = 1$ or $m = r$, is there $Q_s = Q_o e^{-ct}$, or the outflow hydrograph is a simple exponential function; for $n = 2$, the outflow hydrograph follows a straight line. For $n < 2$, the hydrographs are different kinds of decay curves with time. The value n is smaller than two in nearly all natural cases of storage and outflow functions. If the inflow is constant, with the outflow of stored water greater than the inflow, the outflow hydrographs are also decay curves asymptotically approaching the value of constant inflow, but the analytical expressions for recession curves are more complex than those obtained by eq. (7).

As different ground-water basins, lakes and channels have different values of a, b, m, and r, the recession hydrographs are a combination of several individual outflow hydrographs of different decay functions of the type of eq. (7), or still much more complex when the inflow into the storage spaces fluctuates greatly. The unsteady water flow along the river channels further complicates the mathematical analysis of recession curves.

The fitting of a flow recession curve for a river station (with different storage spaces and extensive stream net upstream) by simple mathematical functions of exponential type is always only an approximation of varying accuracy. The functions $Q_s = Q_o e^{-rt}$, or $Q_s = Q_o e^{-kt^s}$, with r, k, and s the constants to be determined by fitting procedures are often used. Equation (7) shows that these two functions are only approximations to the more exact mathematical expressions. Taking into consideration that $W_s = aH^n$, and $Q_s = bH^r$ are also only approximations to the real relationships in nature, then the fitting of recession curves by mathematical functions becomes merely an empirical approach.

The values of annual effective precipitation for n-th, (n + 1)-th,... years are designated here by P_n, P_{n+1}, ... Assuming that the outflows for subsequent years of the total annual effective precipitation are divided by this P_n, the hydrograph $Q/P_n = f(t)$ may be separated according to outflow

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* The nonstationarity of time series of annual flow and annual precipitation is assumed here as being produced mainly by the inconsistency and nonhomogeneity in data.

for years n, n + 1, n + 2, . . . , as shown in fig. 3, upper graph. The constantly decreasing areas which represent the outflows of $P_e = 1$ for the first and following years, are the parts of P_e flowing out of the river basin for the years n, n + 1, n + 2, ... etc.

As it is assumed that the outflow of unit P_e has a constant recession curve, and that a large part of P_e flows out in the year of its occurrence, the portions flowing out starting with n-th year are the coefficients b_o, b_1, b_2, . . . , which have the following six properties:

1) $\sum_{j=o}^{\infty} b_j = 1$; 2) coefficients are all positive; 3) they decrease monotonically; 4) their number extends theoretically to infinity, for the exponential or hyperbolic expressions fitted to the recession curve; 5) they are constants for a river basin only if the rainfall and evaporation distributions of this river basin and within-the-year are approximately equal from year to year; and 6) they do not depend on P_e-values, and each individual b_j depends on the time elapsed since the occurrence of a given annual effective precipitation. The first three properties conform well to the physical properties of river basin recession curves.

The property of infinite time of outflow has only a theoretical meaning. In the practical cases, the last significant coefficient b_m to be used has m only of the order of several years (10 among the largest, usually not more than 1 or 2). The coefficients b_o, b_1, . . . , b_m are not constant in general, especially because of the ratio of b_o to $\sum_{j=1}^{m} b_j$, which changes from year to year. If the values b_1, b_2, . . . , b_m have always the same ratio among themselves, the change in $b_o = 1 - \sum_{j=1}^{m} b_j$ imposes a constant proportional change in all other coefficients. The ratio of b_o to $\sum_{j=1}^{m} b_j$ depends on the time lag between the main amount of outflow of P_e within the year and the end of the water year of the occurrence of P_e. If this time lag fluctuates highly from year to year, then this ratio fluctuates also in the same order of magnitude.

The recession curves are not constant from year to year. The main reason is the nonuniformity of distribution of precipitation and evaporation in river basins and within the water year. Different areas of a river basin have different storage characteristics. The property that the b_j-coefficients are independent of P_e and are constant must be understood only as an average in the statistical sense, and as a simplification introduced here.

The constancy and the independence of b_j-coefficients from P_e are two assumptions used in the development of the following mathematical model relating the change in carryover to the annual effective precipitation. The relation of ΔW to P_e becomes (fig. 3):

$$\Delta W = W_e - W_b = P_n \sum_{1}^{\infty} b_j + P_{n-1} \sum_{2}^{\infty} b_j + P_{n-2} \sum_{3}^{\infty} b_j + \ldots\ldots\ldots - (P_{n-1} \sum_{1}^{\infty} b_j + P_{n-2} \sum_{2}^{\infty} b_j + \ldots.) = P_n - (b_o P_n + b_1 P_{n-1} + b_2 P_{n-2} + \ldots) ,$$

or

$$\Delta W = P_n - \sum_{j=o}^{\infty} b_j P_{n-j} \qquad (8)$$

Equation (8) shows that the relationship of ΔW and the corresponding P_e-values: P_n, P_{n-1}, . . . is described by a multiple linear regression, if b_j-coefficients are assumed to be only the average values of changing b_j-coefficients from year to year.

The simple linear regressions instead of the multiple linear regressions are given here for $\Delta = \Delta W/\overline{V}$ against $\Delta Y = Y - 1 = P_e/\overline{P}_e - 1$, with $\overline{V} = \overline{P}_e$ = average annual flow or average annual effective precipitation, for St. Lawrence River, Göta River, and Neva River are, respectively $\Delta = 0.797 \Delta Y$; $\Delta = 0.701 \Delta Y$; and $\Delta = 0.563 \Delta Y$, and are shown in fig. 4 (a), (b), and (c).

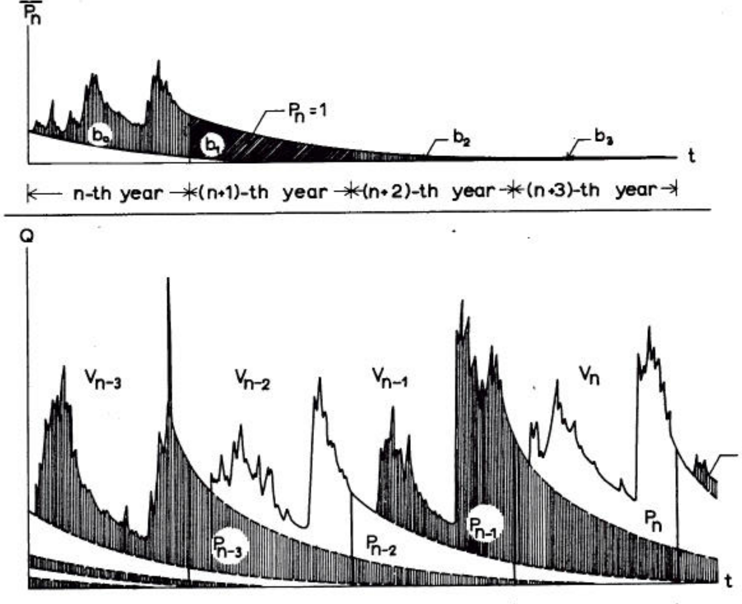

Fig. 3. Proportions (b-coefficients) of an annual effective precipitation which flows out of a river basin for successive years, upper graph. A schematic representation of water carryover from year to year, lower graph.

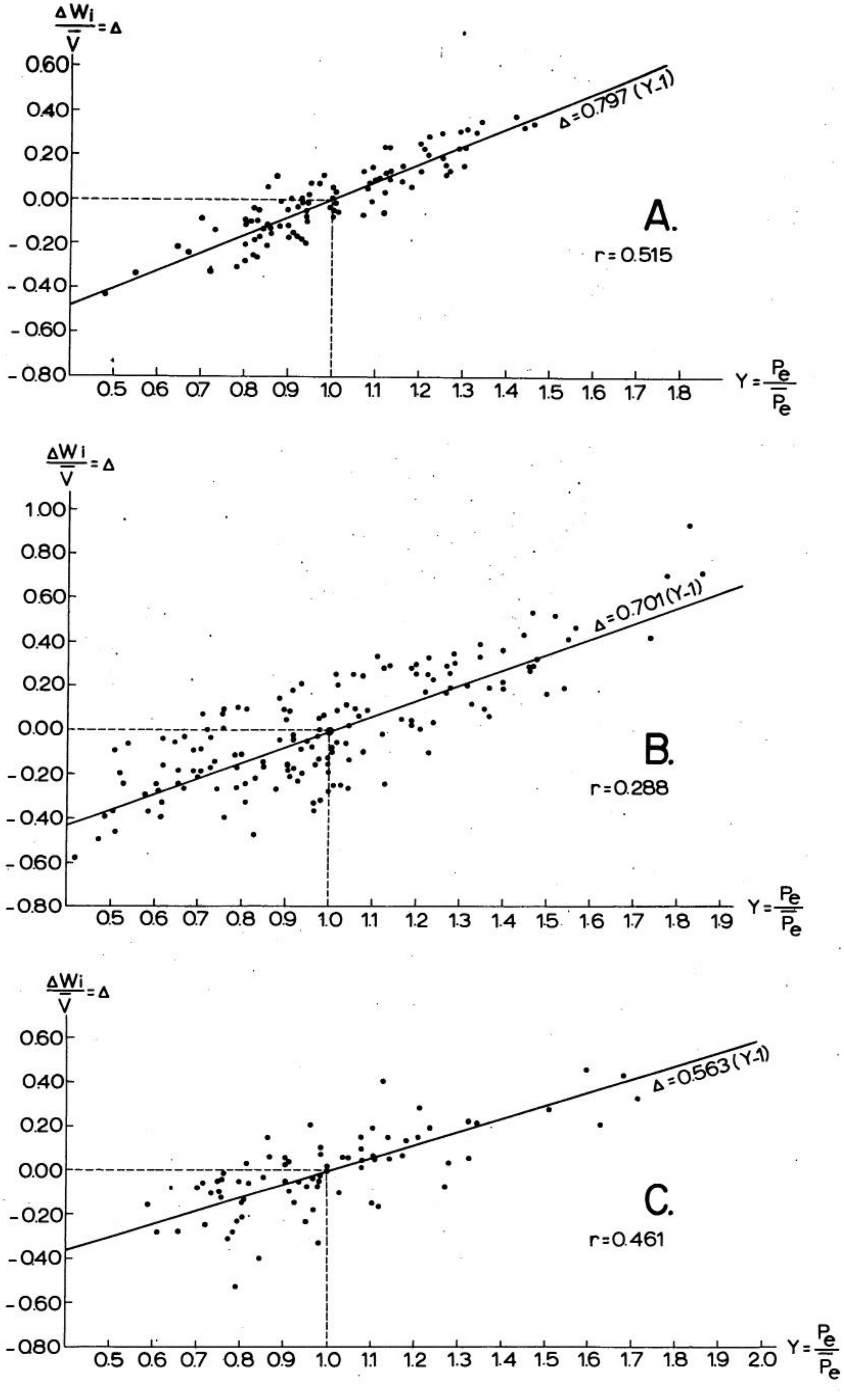

Fig. 4. The simple linear regression of relative change in carryover, $\Delta = \Delta W/\bar{V}$, against relative annual effective precipitation, $Y = P_e/\bar{P}_e$, for three rivers: a) St. Lawrence at Ogdensburg, N. Y., U. S. A.; b) Gōta at Sjöntorp-Vänersburg, Sweden; and c) Neva at Petrokrepost, Russia, U. S. S. R.

The values of the correlation coefficient r are: 0.515, 0.288, and 0.461, respectively. As r^2 is the part of variation of Δ explained by the variable Y, then the simple linear regressions of Δ against Y explain 26.5%, 8.27%, and 21.3%, of the variation of Δ, respectively for the St. Lawrence, Göta and Neva Rivers. This analysis of explained variations shows that the change in carryover is a function also of the previous values of annual effective precipitation, and not only of that for the same year for which ΔW is determined.

Because of simplifying assumptions underlying the properties of b_j-coefficients, eq. (8) should have a component e (assumed random here), which takes care of the differences between the real physical relationship and the assumed properties of b_j-coefficients, so that

$$\Delta W = P_n - \sum_{j=0}^{\infty} b_j P_{n-j} \pm e \tag{9}$$

4. Simple mathematical model for the relationship of annual flow to annual effective precipitation. With the above properties of b_j-coefficients and using eq. (9), the annual flow of the n-th year may be expressed as a function of annual effective precipitation, as shown in fig. 3, lower graph, or by using eqs. (4) and (9)

$$V_n = \sum_{j=0}^{j=\infty} b_j P_{n-j} \pm e \tag{10}$$

where the number of P_e-members theoretically is infinite, but practically can be restricted to m + 1 members, with the assumption that e is a random variable component, normally distributed, with mean zero and standard deviation s_e. Equation (10) with m + 1 members represents a linear mathematical model, a linear autoregressive scheme, or a linear Markov process.

Equation (10) means that if the properties of the P_e-variables are known, namely its probability distribution and the mathematical model of nonrandomness, and if the values of b_0, b_1, ... b_m are determined, as well as s_e^2 (variance of e), the properties of V-variable can be derived analytically.

As V-series are known in general, a similar equation may be derived for P_e-values from V-values as

$$P_n = \sum_{i=0}^{\infty} a_i V_{n+i} \pm d \tag{11}$$

with d a random variable, and a_i-coefficients being related to b_j-coefficients.

The b_j-coefficients in eq. (10), or a_i-coefficients in eq. (11) can be determined in general in two different ways: (a) by using multiple regression analysis from the available sample, and eq. (10) and (11); and (b) by relating the above coefficients to the statistical parameters which describe the nonrandomness of a series.

Assuming in eq. (10) that P_e is random in sequence, and that the number of significant terms is m + 1, and putting s_v = standard deviation of V-series, and s_p = standard deviation of P_e-series, then it can be easily proved by using the expected values in the expression for second moments that

$$s_v^2 = s_p^2 \sum_{j=0}^{m} b_j^2 + s_e^2 \tag{12}$$

The term s_e^2 is related only to the random fluctuations of b_j-coefficients around their mean values, because of the properties assumed for these coefficients. The errors and nonhomogeneity in V and ΔW are not included here in s_e^2. Assuming s_e^2/s_p^2 to be small and negligible, then

$$\frac{s_v^2}{s_p^2} = \sum_{j=0}^{m} b_j^2 < 1 \tag{13}$$

because $\sum_{j=0}^{m} b_j = 1$, or $0 < b_j < 1$. The annual flow has a smaller variance than the corresponding annual effective precipitation.

If b_0, b_1, b_2 ... are relatively small, then the sum Σb_j^2 is much smaller than unity. In most cases, the ratio s_e^2/s_p^2 is much smaller than $(1 - \Sigma b_j^2)$, so that s_v^2/s_p^2 is smaller than unity.

If the carryovers ΔW are large, so that the $\sum_1^m b_j$ is large in relation to b_0, and if b_0 fluctuates in a small range (e is small), then $s_v^2 < s_p^2$.

If ΔW was related only to V, approximately with $\Delta W = b(V - \overline{V})$ with b positive, then

$$V = \frac{P_e + b\overline{P}_e}{1 + b} \tag{14}$$

with $\overline{V} = \overline{P}_e$.

For $P_e > \overline{P}_e$, then $V < P_e$ and for $P_e < \overline{P}_e$, then $V > P_e$, or V is smaller than P_e for large values of P_e, and greater than P_e for small values of P_e.

The difference in carryovers ΔW acts as an attenuator of extremes, so that the standard deviation of V-series is smaller than that of P_e-series. However, if e in eq. (10) is large in comparison with P_e, and as it is either positive or negative, it can occur in some cases that the V-series may have approximately equal or even greater standard deviation than P_e-series.

The same conclusion can be drawn from eq. (12). If s_e^2/s_p^2 is greater than $(1 - \Sigma b_j^2)$, which can occur for large b_0 and small $\sum_{j=1}^{\infty} b_j$, and a large random fluctuating component e, then the ratio of variances s_v^2/s_p^2 may be unity or greater than unity.

In general, however, the greater the carryover for given P_e-values and the more stable the b_0-coefficient, the smaller is s_e^2, and then also s_v is smaller than s_p.

Figure 5 gives the distribution of 140 values s_v/s_p for the first large sample, and of 446 values s_v/s_p for the second large sample of river gaging stations, for computed values s_v and s_p.

The first sample has only 23 values greater than unity, and 117 values smaller or equal to unity. The average ratio is 0.967. This distribution shows that the majority of stations has this ratio close to unity (from 0.98 to 1.02 there are 82 stations or about 60 percent of stations). The carryover in most of the stations is either negligible or is of the same order of magnitude as the e-random component in eq. (10), and there are also the errors in V and ΔW, so that the influence of carryover cannot be clearly distinguished. The rivers with large lake storage have the ratio s_v/s_p from 0.40 to 0.90, and show that a large and substantial carryover has a much greater effect than the random factor e . For three rivers these ratios are: St. Lawrence, 0.44; Göta, 0.59; and Neva, 0.68.

The second example has a similar distribution of s_v/s_p as the first sample, but with the mean value 0.991, because on the average the carryovers in the second sample are much smaller than in the first one.

As the factor e in eq. (10) depends mostly on the rainfall and evaporation distribution in a river basin and within each water year, the problem of the interaction of the b_j-coefficients and the factor e cannot be solved without mathematical and physical models for the sequence of rainfall, evaporation, and runoff within water years of a particular river basin.

As ΔW is estimated with the error g_w , and as V-values have two types of errors and the nonhomogeneity (e, i, and h), as given by eq. (5), the ratio s_v/s_p is further affected by these four factors.

The mathematical models for the difference of carryovers, eq. (9); for the annual flow, eq. (10); for the variance of annual flow, eq. (12); and the ratio of variances, eq. (13); represent only first approximations to the real hydrological model governing the relationship of annual flow and annual effective precipitation.

5. Annual evaporation from river basins. The annual evaporation from a river basin depends on several factors. Among them are: amount of annual precipitation, its distribution within the water year and across the river basin (especially as a function of altitude), solar radiation and its distribution within the water year, stored water from previous years and during different seasons, vegetation cover, and climatic variables (i.e., deficit of moisture in the air, temperature, wind velocities). The complex relationship of annual evaporation to many variables is the main reason that the runoff-rainfall relationship is also complex in the most general case. Since the importance of some variables changes from basin to basin, no general function has yet been developed relating the annual evaporation to the many significant variables of the river basin and its climate.

Simple and multiple correlation and regression analyses show that the annual precipitation is one of the most significant independent variables, which explains a large portion of variation of evaporation. The other significant variable is often the volume of water stored in a river basin. The higher the levels of lakes, rivers, and ground-water tables, and the greater the soil moisture and water stored in plants, the greater is the total annual evaporation. The climatic factors as significant variables determine both the maximum annual moisture which the atmosphere can receive from a river basin, and the real amount of water evaporated and transpired.

A simple linear mathematical model will be assumed here for the evaporation, only for the purpose of showing and discussing the effect of evaporation on nonrandomness of annual effective precipitation, starting from a given sequence pattern of annual precipitation. This simple model is assumed here to be

$$E = aP_i + bW_b \pm \epsilon \tag{15}$$

where: P_i, annual precipitation; W_b, water volume

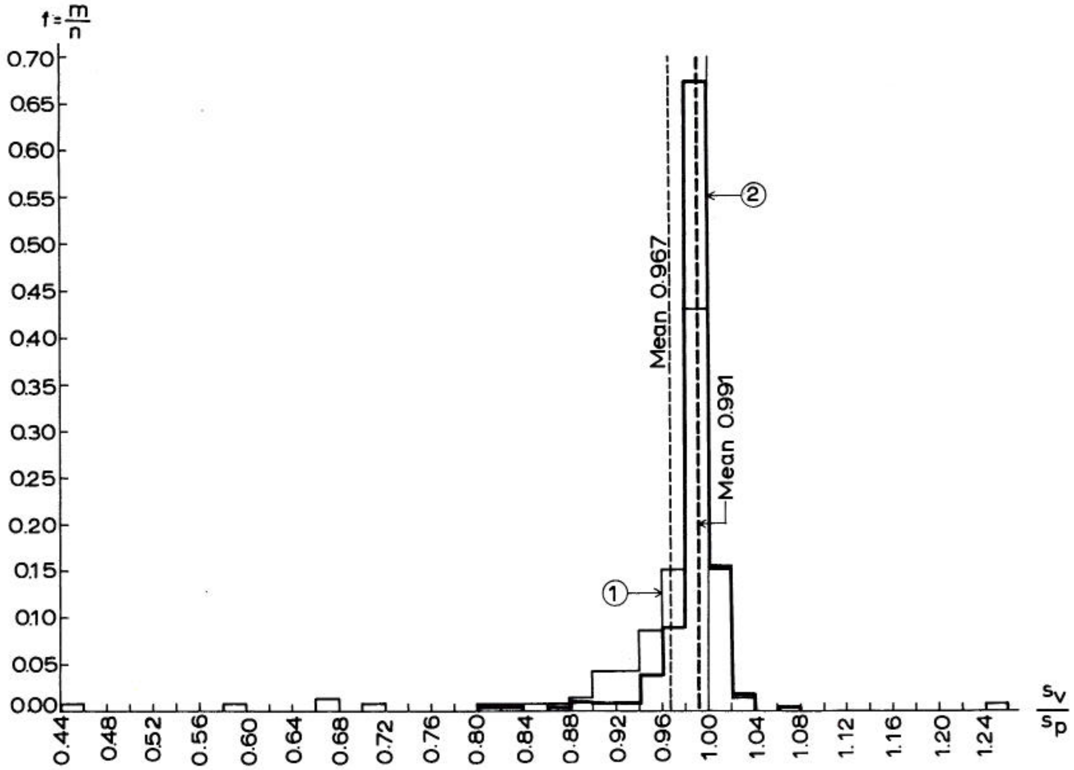

Fig. 5. The relative frequency distributions of the ratio s_v/s_p , which is the ratio of standard deviation of annual flow to standard deviation of annual effective precipitation, for the two large samples of records of river gaging stations: 1) Distribution for the first sample (global scale sampling), with $n_1 = 140$ stations; 2) Distribution for the second sample (continental scale sampling), with $n_2 = 446$ stations; m, number of s_v/s_p values in a class interval; n, number of stations in the samples (140 or 446); $f = m/n$, relative frequency.

and moisture stored in surface and underground spaces and in plants at the beginning of a water year; a and b, coefficients which depend on the climatic factors C_1, C_2, ... C_i; and ϵ, a random factor which embraces the effects of neglected variables, distributions of precipitation, and distribution of stored water and moisture across the river basin and within that water year. Coefficients a and b are functions of all the above factors and are interrelated.

The variable P_i will be considered here as being close to a random sequence, or a value P_i is independent of previous or subsequent values. As the beginning of a water year cuts a continuous meteorological situation, a small dependence among the successive values of P must, however, exist. The variable W_b depends on the previous values of annual effective precipitation. An important climatic variable is the saturation deficit of the air, and it depends partly on the evaporation, and therefore indirectly on P_i and W_b. The net solar radiation in the river basin is also affected by the cloudiness and air moisture, and therefore indirectly by W_b and E.

There is a carryover effect on the annual evaporation and evapotranspiration in a river basin, being produced by the water storage from previous years. This is expressed as the dependence of W_b on previous annual effective precipitations, as well as dependence of saturation deficit in the air on W_b. The factors a and b in eq. (15) may also be partly dependent on the moisture history of the river basin and the surrounding region.

The value W_b at the beginning of n-th water year (fig. 3) is

$$W_b = P_{n-1} \sum_{i=1}^{\infty} b_j + P_{n-2} \sum_{j=2}^{\infty} b_j + \ldots \pm e \qquad (16)$$

where e, a random component, which takes care of fluctuations of b_j-coefficients around their mean values.

The b_j-coefficients here are somewhat different from those in eq. (8), because apart from the water storage, the moisture storage in the soil above the ground-water table and in plants should also be included in W_b.

Putting

$$c_1 = \sum_{i=1}^{\infty} b_j \; ; \quad c_2 = \sum_{j=2}^{\infty} b_j \; ; \quad c_3 = \sum_{j=3}^{\infty} b_j \; ; \ldots.$$

which are all smaller than unity, then

$$W_b = \sum_{i=1}^{\infty} c_i P_{n-i} \pm e \qquad (17)$$

In this way eq. (15) becomes for the annual precipitation of the n-th year

$$E_n = aP_p + b \sum_{i=1}^{\infty} c_i P_{n-i} \pm \eta \qquad (18)$$

with η, a random component, and P_p is the value of P_i for the n-th year.

The fact that a and b are assumed to depend on the climatic variables makes eq. (18) much more complex than it may seem at first glance.

The main property of eq. (18) is that the evaporation E_n of the n-th year in a river basin depends on the annual effective precipitation of previous years, both because of the presence of second term on the right side and because of the complex dependence of a and b on the climatic factors.

6. Simple mathematical model for the relationship of annual effective precipitation to annual precipitation at the ground. Using eq. (3) and (18) then for $P_e = P_i - E$

$$P_n = (1 - a) P_p - b \sum_{i=1}^{\infty} c_i P_{n-i} \pm \eta \qquad (19)$$

Using the recurrence procedure of eq. (19) for P_{n-1}, P_{n-2}, ... and assuming that only first m + 1 values of k_i are significantly different from zero, then

$$P_n = \sum_{i=o}^{m} k_i P_{p-i} \pm \theta \qquad (20)$$

with

$$k_o = 1 - a ; \; k_1 = -bc_1 (1 - a) ; \; k_2 = b(1 - a\,bc_1^2 - c_2) ;$$

$$k_3 = b(1 - a)(b^2 c_1^3 + 2bc_1 c_2 - c_3) ;$$ etc., and θ a random component.

This is also a linear mathematical model or a linear Markov process.

The annual effective precipitation is related to the annual precipitation of the same and previous years, because the annual evaporation is related to the water and moisture stored in a river basin from previous years in both a direct and an indirect way.

Equation (20) shows that if P_i-values are random in sequence, the series of annual effective precipitation is not, because the mathematical model of that equation relates P_e to several preceding values of P_i.

7. Annual evaporation of precipitation in the air. The purpose of the following detailed derivation is to show how the physical-mathematical model derived supports the hypothesis that the evaporation of rainfall in the air affects the nonrandomness of annual precipitation at the ground. Neither precipitation at the cloud base nor evaporation of rainfall in the air is actually measured. The analysis of the physical-mathematical model is thus the only procedure currently available to indicate the validity of this hypothesis.

The rainfall intensity growth through the clouds of falling raindrops is assumed to cease at the cloud base, and the process of evaporation of precipitation in the air occurs between the cloud base and the ground.

A mathematical expression for the average terminal fall velocity of raindrops at elevation Z is

$$V_z = Se^{mZ}(1 - e^{-cr}) \qquad (21)$$

which is simplified expression of those given by A. C. Best [11] with V_z, terminal fall velocity in cm/sec; $S = 950$ cm; $m = 4.0 \times 10^{-5}$ in m^{-1} (meter)$^{-1}$; $c = 10.7\ cm^{-1}$; with Z, altitude in meters; r, raindrop radius in cm (raindrop reduced to a sphere of the same volume), with r = 0-0.30 cm.

A mathematical model for an average density distribution function of raindrops during rainfall is

$$p(r) = \frac{3C_n 2^{n-2}}{\pi B^n} \frac{I^{m}{}_{o}{}^{-nk}}{r^{4-n}} \exp\left[- \left(\frac{2r}{BI^k} \right)^n \right] \qquad (22)$$

which is developed further from the relationships given by A. C. Best [12] where $C = 67$, $m_o = 0.846$, $B = 0.13$, $k = 0.232$, $n = 2.25$; with all these constants given by A. C. Best [12]; $p(r)$, density distribution function; r, raindrop radius in cm; I, rainfall intensity in mm/hr at the elevation Z.

Intensity I in eq. (22) usually refers to the air space immediately above the ground at the altitude approximately $Z_o = 0$. If the value I_g is given for any ground elevation Z_g, then the corresponding value in eq. (22) for the elevation Z would be

$$I = I_g \frac{V_g}{V_z} \tag{23}$$

The temperature gradient is assumed

$$T = T_o - 0.0065\, Z \tag{24}$$

where T_o, temperature at the sea level; and T, temperature at the elevation Z in the air, both in ^{0}C. The water vapor pressure e at the altitude Z is

$$e = e_g \frac{e_s}{e_{gs}} + \frac{Z - Z_g}{Z_b - Z_g} \left(1 - \frac{e_g}{e_{gs}}\right) e_s \tag{25}$$

where e_g, vapor pressure at ground level Z_g; e_s and e_{gs}, saturation vapor pressures at the altitudes Z and Z_g, respectively; with

$$e_s = e + 0.00066\, p_a (T - T_s)\left(1 + \frac{T_s}{928}\right) \tag{26}$$

with p_a, total pressure of moist air; e and e_s in dynes/cm^2; T (dry-bulb temperature, or T_a) and T_s (saturation temperature for e, or wet-bulb temperature T_w) in ^{0}C.

To compute the evaporation of rainfall in air, the following variables should be known: I_g, rainfall intensity at the ground as function of time; Z_g, ground elevation; Z_b, cloud base altitude; T_o, sea level temperature; and e_g, vapor pressure at the ground level. There is a relationship between $\Delta Z = Z_b - Z_g$ (cloud base height above the ground), and the rate of change of T and e with elevation, as well as with e_g and T_o.

The rate of total transfer of heat from the air to an evaporating and ventilated spherical drop occurs at the rate of [13]

$$\frac{d\Omega}{dt} = 4\pi k r (T - T_d)\, f_1(R_e, \sigma) \tag{27}$$

in cal/sec. In this equation $k f_1(R_e, \sigma)$ is heat transfer factor (k, thermal conductivity of air; at 0 ^{0}C it is 5.66×10^{-5} cal/cm/sec ^{0}C); T_d, temperature at the surface of the drop in ^{0}C; $f_1(R_e, \sigma)$, a function of Reynolds number R_e and Prandtl number σ, with $R_e = 2rV/\nu$; V, velocity of the drop relative to the air, ν = kinematic viscosity of air; dry air at 0 ^{0}C has $\nu = 0.13$ cm^2/sec; and $\sigma = \nu/\nu_c$, with ν_c = thermometric conductivity or thermal diffusivity of air, (0.1895 cm^2/sec for air at 0 ^{0}C).

The rate at which the total mass of water vapor M is transferred from a raindrop to the ventilated air is [13]

$$\frac{dM}{dt} = 4\pi \frac{\epsilon D}{RK} r (e - e_d)\, f_2(R_e, \sigma') \tag{28}$$

in gr/sec, where $\rho_w = \epsilon e/RK$ is density of water vapor in gr/cm^3; ϵ, specific gravity of water vapor with respect to dry air (0.622); D, coefficient of diffusion of water vapor in air (cm^2/sec, 0.20 - 0.29 for temperature range $-20\,^0$C to 40 ^{0}C at 1000 mb pressure); R, universal gas constant applicable to any gas per gram of dry air (0.2780×10^7 erg/gm ^{0}C, when e is given in dynes/cm^2); K, absolute or Kelvin temperature in ^{0}C at which the process occurs ($K = 273 + T$); e, vapor pressure in the air sufficiently distant from the drop (in dynes/cm^2); e_d, equilibrium vapor pressure at the boundary of the drop (in dynes/cm^2); and $f_2(R_e, \sigma')$ a function of Reynolds number R_e and number $\sigma' = \nu/D$ equivalent to Prandtl number σ. The approximate values of f_1 and f_2 are

$$f_1(R_e, \sigma) = 1 + 0.246\sqrt{R_e} \tag{29}$$

$$f_2(R_e, \sigma') = 1 + 0.232\sqrt{R_e} \tag{30}$$

The heat balance of the drop, assumed to be governed by the equality of sensible heat transfer and latent heat transfer, as $d\Omega/dt = L\, dM/dt$, with L, latent heat of vaporization of water ($L = 594.9 - 0.51T$, cal/gm, T in ^{0}C) gives

$$\frac{dM}{dt} = \frac{4\pi\epsilon^2 DJLk}{\epsilon^2 L^2 KJe - kR^2K^3}\, e r (T - T_s)\, f_1(R_e, \sigma) \tag{31}$$

with J, mechanical equivalent heat (4.186×10^7 erg/cal).

The evaporation of all raindrops in a unit volume of air (1m^3) is given by

$$\frac{dM}{dt} = \int_{r=o}^{\infty} \frac{a_o \alpha\, e(T - T_s)}{e - b_o}\, p(r)\, r \left(1 + 0.246\sqrt{R_e}\right) dr \tag{32}$$

with α, a factor greater than unity taking care of nonsphericity of drops; $a_o = 4\pi k/L = 1.21 \times 10^{-6}$; $b_o = kR^2k^3/\epsilon^2 L^2 DJ \approx 7200$ dynes/cm^2; $R_e = 2rV_z/\nu$, and $p(r)$ is given by eq. (22). The values e, T, T_s, $p(r)$, and R_e are functions of time and altitude.

The evaporation of rainfall for a given rainfall event is

$$E = a_o \alpha g \int_{r=o}^{\infty} \int_{Z=Z_g}^{Z_b} \int_{t=o}^{t_o} \frac{e(T - T_s)}{e - b_o}\, r \left(1 + 0.246\sqrt{R_e}\right) p(r)\, dr\, dZ\, dt \tag{33}$$

where g, gravity constant; t_o, duration of a rainfall event.

The annual evaporation of rainfall in the air over a place is the summation of E-values for all rainfall events during a year, and the total annual evaporation above a river basin surface is the sum of annual evaporation over the river basin area.

Evaporation thus depends on e (vapor pressure at Z), T (temperature at Z), and Z_b = cloud base altitude. These three variables in turn depend on the climatic factors of a region, and indirectly also on water evaporation from the ground and ground conditions. The evaporation of rainfall in air depends, therefore, also on the moisture and water stored in river basins in different forms and at different places.

The greater the water storage in a river basin in comparison with river flows, the more influential is the effect of water evaporation from the river basin on the atmosphere (temperature, vapor pressure, cloud base height). There is, therefore, a carryover effect of moisture stored from previous years in river basin on the evaporation of rainfall above it, between the ground and the cloud base. However, the climatic factors of the region in which the particular river basin is located play a dominant role for the evaporation of rainfall in the air.

8. Simple mathematical model for the relationship of annual precipitation at the ground to annual precipitation at the cloud base. Assuming that the evaporation of rainfall in air is a function of rainfall and environmental climatic conditions, then

$$E_a = cP_c + dW_b \pm \epsilon \tag{34}$$

where P_c, annual precipitation at the cloud base; W_b, annual storage of water or moisture in the river basin, at the beginning of a year; and c and d, factors which depend on climatic variables. Similarly as in eq. (18)

$$E_a = cP_c + d \sum_{j=o}^{\infty} a_j P_{n-j} \pm \epsilon \tag{35}$$

with P_{n-j}, annual effective precipitations of the current and the previous years, with ϵ a random component.

As $P_i = P_c - E_a$, then

$$P_i = (1 - c) P_c - d \sum_{j=o}^{\infty} a_j P_{n-j} \pm \epsilon \tag{36}$$

If the annual precipitation at the cloud base is a random variable, the fact that E_a depends to some extent on the annual effective precipitation for previous years, makes the annual precipitation a nonrandom variable. The greater the carryover, the smaller E_a should be. The significance of the nonrandomness introduced by the changing carryover depends on the order of magnitude of second term at the right side of eqs. (35) and (36) in comparison to the other two terms.

It should be expected that the mathematical model, eqs. (35) and (36) would be very complex in a detailed study, because there is a constant interaction between the atmosphere and the river basin surface, as well as a continuous or discontinuous replacement of air masses above a river basin and during a water year.

It is not possible to tell in advance how the evaporation of rainfall in the air would affect the time series of annual precipitation at the ground, once the sequence pattern of annual precipitation at the cloud base is assumed. However, there is a legitimate expectation that some difference in sequence pattern would usually exist between the two series of annual precipitation.

9. Physical factors and nonstationarity that are causes of nonrandomness of annual river flows. Simplified mathematical models for the relationships of annual river flow to annual effective precipitation, of annual effective precipitation to annual precipitation at the ground, and of annual precipitation at the ground to annual precipitation at the cloud base, show that the important physical reasons for nonrandomness in the sequence of annual flows are:

(1) Different carryovers of water in river basins from year to year (water storage effect);

(2) Evaporation from river basins, which are related to different amounts of moisture stored in river basins from year to year (so indirectly again it is an effect of water and moisture storage in river basin); and

(3) Evaporation of rainfall in air above river basins, which depends on the values and gradients of relative humidity and temperature, and on the altitudes of cloud base above a river basin and in a water year. They, in turn, also depend to some extent on the moisture stored in river basins from previous years (so indirectly again it is an effect of water and moisture storage in river basin), apart from the main dependence on the climatic factors.

(4) Inconsistency and nonhomogeneity in data. Inconsistency and nonhomogeneity in annual values of flow and precipitation increase on the average the nonrandomness of time series. They create nonrandomness if the true virgin values are random in sequence. Both phenomena are more or less present in the series of annual flow, annual effective precipitation, and annual precipitation at the ground. The nonrandomness in sequence of annual flow and annual precipitation is, therefore, partly affected by any substantial amount of inconsistency and nonhomogeneity in data.

10. Investigation of nonrandomness. To investigate the nonrandomness in sequence of annual values of runoff and rainfall, corresponding reliable samples of data are essential. One station may show a type of nonrandomness which the adjacent stations may not prove; or if they support it, the reason can be the regional correlation of annual values among the adjacent stations.

The sampling of stations in a very large area has such properties that the average intrastation correlation of annual values is expected to be a minimum, because of sufficient distances between stations. This is particularly true for the first sample of river gaging stations, selected on a global scale. The second sample of river gaging stations and the large sample of precipitation gaging stations of Western North America are expected to have somewhat greater average correlation coefficients of annual flow or annual precipitation of all stations taken pairwise, than the first large sample of river gaging stations. However, this area is large, and the average coefficient is not expected to be much greater than zero. A special investigation of this intrastation correlation will be carried out later, in order to test the significance of statistics derived for such large samples from large areas.

The results of investigation of nonrandomness in sequence of annual values of runoff and rainfall for the samples described in chapter B are the subject of subsequent parts of this study.

D. COMPILATION OF SAMPLE DATA

1. Annual river flow. Observed hydrographs of river flows and the sequence of average monthly flows* show in general that the within-the-year flow fluctuation follows the annual cycle in most cases. The astronomical cycle of the year is the reason that many phenomena which produce or affect the runoff have regular seasonal variations. Examples of these oscillations are: regular seasonal fluctuations of rainfall and evaporation; regular sequence of cold and hot seasons, with snow and ice accumulation and melting, respectively; regular occurrence of vegetation growth seasons; and similar.

The effect of this annual cycle is excluded by the computation of annual flows on the basis of a selected beginning of the water year. October 1 was used almost exclusively as the beginning for the Northern Hemisphere (November 1 for some European rivers), and January 1, April 1, or May 1 for the rivers of Australia, Africa, New Zealand, and Asia. The termination of the low flow season is used as the end of the preceding and the beginning of the following water year.

The selection of the most appropriate beginning of the water year for the study of fluctuations of annual river flow and annual precipitation was a problem specially studied. The results will be discussed in one of the future parts of this paper. The approach and analysis of this problem is briefly outlined here.

Twelve beginnings of year were used for several stations and twelve time series of annual values were obtained from the same time series of monthly flows. Beginnings were January 1, February 1, March 1, and so on until December 1. The selected beginning for this study of October 1 for most stations was thus also included. The statistical parameters which measure the nonrandomness as well as those which describe frequency distributions of these time series were computed. The comparison among these statistics for the twelve series have given the idea of the effects of a year beginning, on characteristics of time series. Nonrandomness of time series with the water year beginning on October 1 was among the smallest of all twelve series with various beginnings of the year.

2. Compilation of carryover. The compilation of water carryover in river basins is not usually simple. A great amount of work is necessary, if it is to be determined with a sufficient accuracy, especially for large river basins. An approximate method was used in this study, which is more accurate for small river basins than for large ones.

The daily flow at the lower part of flow recession curve of a river station at the beginning of a water year was considered to be an index of stored water in the river basin at that time. Daily flows in the two months preceding and following the beginning of a water year (usually September and October) were normally used to determine the mean recession curve for the time around the beginning of a water year. The total water volume stored in the river basin was computed by using the determined mean recession curve and the index flow.

The average of the two mean monthly flows, of the months preceding and following the beginning of a water year, was used as the index flow when only the monthly flows for a station were available to the author. The recession curve of highest slope from the recession of monthly flows was used in this case.

The index flow obtained as the average from the two mean monthly flows is only an approximation of the daily flow at the beginning of a water year. The average of the two mean monthly flows was used as the index flow for nearly half of the 140 stations of the first large sample, because the daily flows of these stations were not available to the author. It was also used for some years in the second large sample when daily flows were missing. The computed water storage in river basins has substantial error in these cases. In general, the daily flow was more often used as index flow for small river basins. The average of the two mean monthly flows was used as the index flow usually for the large river basins.

When very high flows occurred at the beginning of a water year, the storage volume was computed as the sum of the flood volume that passed the station from October 1 up to and including a selected low flow on the recession curve, which flow was occurring later in October, and the water volume determined from the recession curve which starts from this selected low flow. This low flow was used as the index flow. The computation of the second part of storage volume in a river basin is determined from the lower part of the recession limb of the hydrograph [9]. Most of the index flows were thus taken from the mid or lower part of the recession curve. This accommodation in the case of occurrence of a peak flow at or near the beginning of a water year has been justified by the assumption, that the flood peak at and immediately after the beginning of a water year was produced by the rainfall preceding that beginning and should be the part of annual flow of the preceding year.

The accurate computation of the difference of carryovers, ΔW, is complex. It was practical for the purposes of this study to determine ΔW only as an approximation. The majority of values of computed ΔW are under 0.1 percent of the mean annual flow. The greatest absolute values of ΔW are the most significant for the determination of the series P_e, which is determined by the equation $P_e = V \pm \Delta W$.

The fitting of the mean recession curves was done by the exponential functions of two forms, either as $Q = Q_o e^{-ct}$ or as $Q = Q_o e^{-ct^n}$. Semi-log paper was used to plot many recession curves for a river station, and from them the mean recession curve was determined. The coefficient c was then computed

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* See "Water", the yearbook of Agriculture, 1955, U.S. Department of Agriculture, page 60, for the sequence of average monthly flows for some key river gaging stations in the United States of America.

for the first function, and the mean recession curves in graphical form for the second type of exponential function were used. The mean value of the coefficient c for a river basin was computed as

$$c = Q_o/W \quad \text{for} \quad Q = Q_o e^{-ct}$$

Figure 6 shows an example of the mean recession curve with the approximate fit by the function $Q = Q_o e^{-ct}$. Several recession curves of daily flows in the months of September and October were plotted and the mean slope in the semi-log scale diagram was determined. The relationship of W against Q_o given as relationship $W = (1/c)\, Q_o$ is a straight line. The water stored in the river basin was thus simply determined from the index flow Q_o by dividing it by c.

Figure 7 shows an example of the mean recession curve with the approximate fit by the function $Q = Q_o e^{-ct^n}$. Several recession curves of daily flows in the months of September and October were plotted and the mean slopes for given ranges of Q_o were determined. These slopes are given also in fig. 7. Figure 8 gives the relationship of W against Q_o, with the approximations of their nonlinear relationship by several straight lines for the selected ranges of Q_o. The values W were determined from this polygon line for given values of Q_o.

Mean recession curves were determined for each of the 140 stations in the first large sample and each of 446 stations in the second large sample, which were used in this study, and the corresponding series of W values were computed. The annual effective precipitation was computed by the equation $P_e = V + W_e - W_b = V + \Delta W$, with P_e and V the annual effective precipitation and annual flow for a water year and a river gaging station, respectively, and W_e and W_b, the water volumes stored in a river basin at the end and at the beginning of that water year, respectively.

The water storage in the river basin was computed from the recession curve that has been extrapolated beyond Q_{min} (minimum index flow and minimum flow at the recession curves). This extrapolation has small influence on the difference ΔW. If an error ΔW_o is introduced into both W_e and W_b by the extrapolation of recession curve beyond the lowest flow index, then $\Delta W = (W_e \pm \Delta W_o) - (W_b \pm \Delta W_o) = W_e - W_b$. Therefore, the recession curve in the range of the used index flows should be a good approximation only.

The question of the index flow to be used for the compilation of the stored water in a river basin became a problem, when the outflow from large lakes had considerable influence on the flows (St. Lawrence River, Neva River, Gõta River, etc.). Two methods were used to determine the water storage. In some cases the approach of index flow at the beginning of a water year was used (Neva, Gõta). In the other cases (St. Lawrence River) the total water storage in large lakes was computed, using the surface areas and levels of lakes at the end of each water year, and the computed stored volume was considered to be approximately the same as the total water volume stored in the river

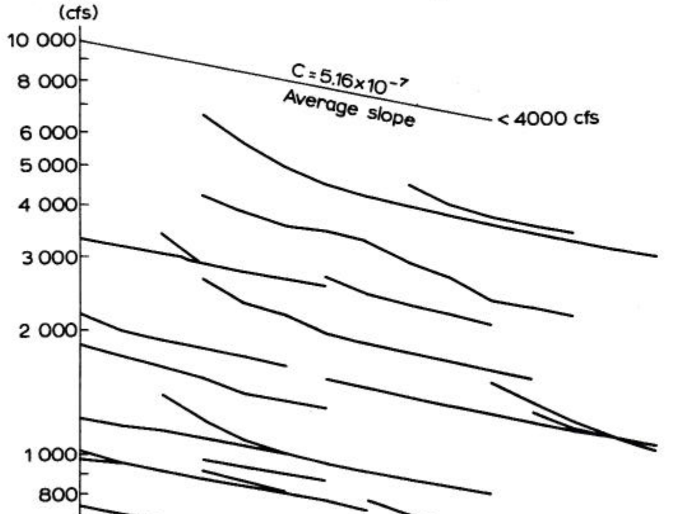

Fig. 6. Determination of the mean recession curve for Sabine River near Ruliff, Texas, U. S. A., as an example of fitting the exponential function $Q = Q_o e^{-ct}$ to observed recession curves in September and October, with $C = 5.16 \times 10^{-7}$ for the low flows below 4000 cfs.

basin. It was supposed that the total water stored in all other bodies of water in the river basin was small in comparison with the total water stored in large lakes.

3. Dimensionless and standardized variables. The annual flow, or V-values, and the annual effective precipitation computed by using eq. (4), as P_e-values, have been reduced to dimensionless variables (modular coefficients) as $U = V/\overline{V}$, and $Y = P_e/\overline{P}_e$ in both the first and the second large samples. In the second sample the standardized variables $(V - \overline{V})/s_v$, and $(P_e - \overline{P}_e)/s_p$ were also determined for the particular purposes of using the second sample also for regional correlation studies and synoptic studies of wet and dry years in a large region.

The procedures used for the computation of values of ΔW do not take into consideration the following factors: (1) unsteady movement of water along the channels; (2) flow concentration time in large river basin; (3) effects of snow and glaciers either on the index flows or on ΔW; (4) differences in recession curves from year to year (departures from the mean recession curve), which are caused by variable evapotranspiration losses around the beginning of a water year, because of different climatic and biologic cover conditions; and (5) effects of evaporation within the year on recession curves (assumption that $P_e = P_i - E$ always has a positive value for each year, or $P_i > E$). In some river basins, therefore, substantial errors occur in the computed ΔW-values.

4. Annual precipitation. The series of annual precipitation in Western United States and Western Canada were computed for the calendar years. The selection of stations was affected by the test of homogeneity, which was done either by double-mass curves in some regional weather services, or the homogeneity was estimated directly from the station history, mostly from the vertical and horizontal displacements of stations with time.

The series of annual precipitations P_i have also been made dimensionless, or have been standardized by computing $(P_i - \overline{P}_i)/s_i$, with s_i standard deviation of P_i.

The reduction of data on dimensionless or standardized variable has been made by using the digital computer.

The annual precipitation is given for calendar years instead of for water years, because data in the first form was readily available for punching on cards. The assumption has been made that the analyses of sequence of annual precipitation by serial correlation, ranges, runs, and variance spectrum will not give substantially different results for various beginnings of year. This selection was not considered as an important factor in deriving the conclusions about the patterns in sequence of annual precipitation.

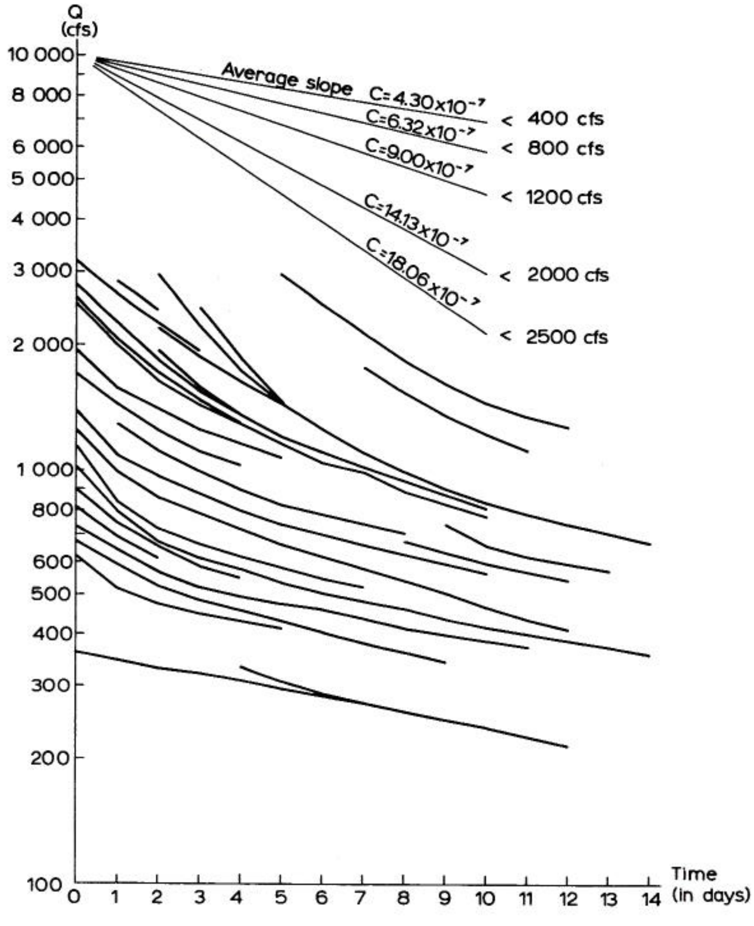

Fig. 7. Determination of the mean recession curve in the form of straight lines approximation for various ranges of low flows of South Fork Skykomish River, near Index, Washington, as an example of fitting the exponential function $Q = Q_o e^{-ct^n}$ to the observed recession curves in September and October.

5. Data of the first sample. As the first sample of data of river gaging stations has 68 long record stations outside the United States, it was considered useful for the researchers in the States to reproduce data of the first sample in a condensed form.

Table 1, Appendix 1 gives the names and locations of 140 stations, basin area, and several statistics which characterize annual river flows and its series expressed in modular coefficients (U_i), and annual effective precipitation and its series expressed in modular coefficients (Y_i). The index of variability is defined here as the coefficient of variation of logarithms of the corresponding U- and Y-variable.

Table 2, Appendix 2, gives the series of U- and Y-variable in modular coefficient (means are unities) for all 140 river gaging stations.

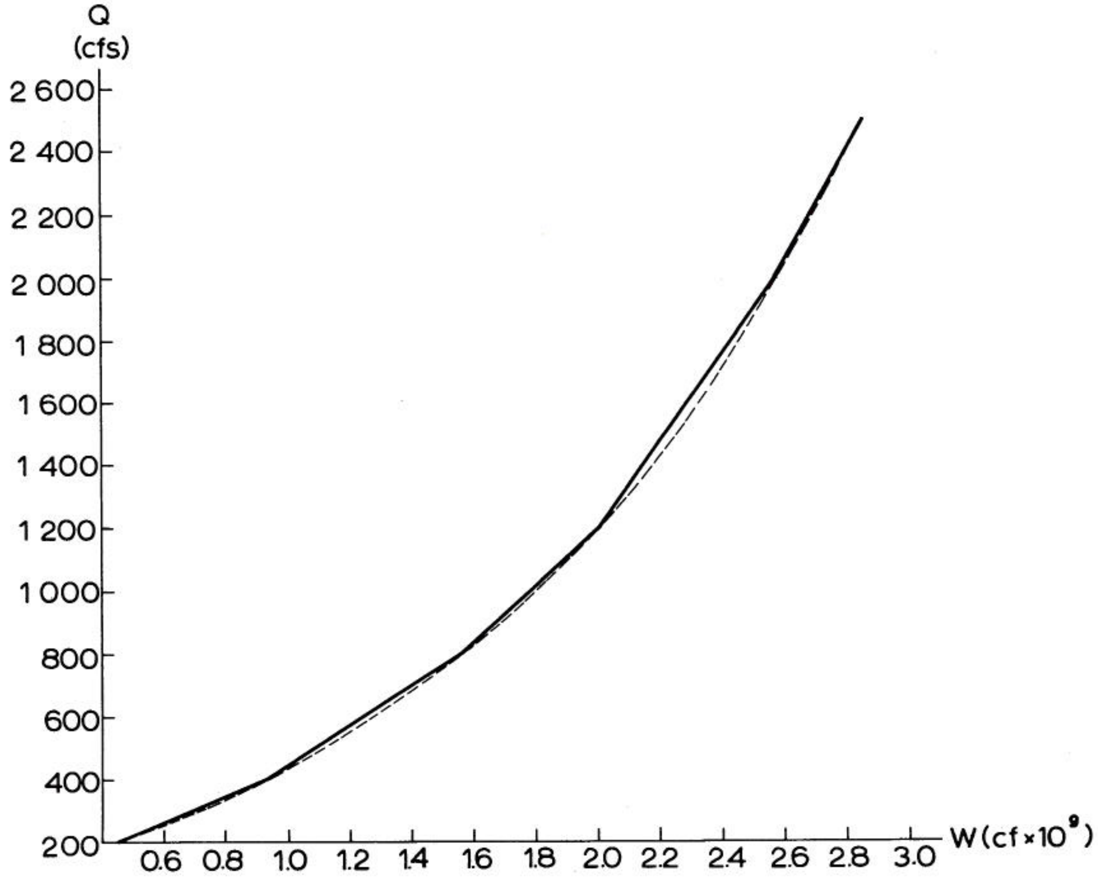

Fig. 8. Relationship of water volume stored in a river basin (W) and the index flow (Q_o) for the example given in fig. 7. Straight lines fitted to various ranges of low flows of the recession curve give $W = f(Q_o)$ relationship which approximates well the nonlinear function.

E. ERRORS AND NONHOMOGENEITY

1. Random errors of annual flows. The ratio of the standard deviation of random errors to a discharge is called the relative error. Multiplied by 0.67 it is called the probable relative error.

The data published by some hydrologic services is accompanied by an estimate of the probable error of individual daily discharges. In the U. S. Geological Survey (Water Resources Division), the words excellent, good, fair, and poor are used to describe the errors in the data–the estimate being that the probable error is up to 5%, 10%, 15%, and greater than 15%, respectively, in comparison with the computed discharge. Very little information is available for the quantitative analysis of errors in computed annual flows. Many factors make this problem complex: the errors in measurement of discharge and gage height; the use of rating curve, with loops created by unsteady flow and some changes in bed roughness (plainbed, ripples, dunes, antidunes); the shifting of bed; the manner of discharge computation, etc. Actually, there are two different problems: a) the error of any individual discharge, estimated from the rating curve and gage height; b) the error of computed mean value of an annual flow.

The probable error of the mean annual flow is much smaller than the probable errors of its individual daily discharges, if a sufficient number of discharge measurements and estimated discharges are used for computing the annual flow. There are three main sources of random errors in the annual flow: 1) Sampling error, which depends on the number of individual discharges taken for the computation of the annual flow; 2) measurement error, which comes from the errors in measured discharges; and 3) rating curve effect, which depends on the way the rating curves are obtained, plotted, and used. The probable error of an annual flow is a function of these basic factors: the number N of discharges taken for the computation of annual flow (i. e., 365 mean daily discharges), the number n of measured discharges, the probable error of measured individual discharges, the coefficient of variation for N discharges, and the goodness of rating curve.

The nonrandomness of a time series is decreased, on the average, by the presence of these random errors. The effect of random errors on the sequential patterns of annual flow and annual effective precipitation may be considered small, except under special conditions.

2. Inconsistency in annual flows. Inconsistency has been defined as a systematic error, sometimes on one side of the true value and sometimes on the other along the series, with fluctuations around the true value. Inconsistency is introduced by any kind of systematic errors which change from time to time.

The case of the River Nile at Aswan Dam, fig. 9, is analyzed here as an example of inconsistency. Before the construction of Aswan Dam in 1903, the observations were made by stage gagings downstream of the dam. From 1903-1939, discharges were determined accurately enough by relating sluice measurements in the 1903-1939 period to the gage-stages downstream; and that rating curve was then applied for the determination of discharges before 1903, from 1869 to 1902 [14, pages 125-147]. The degradation downstream, after the dam was put into operation by a removal of sediment islands and some bank erosion, has changed the rating curve in comparison with the

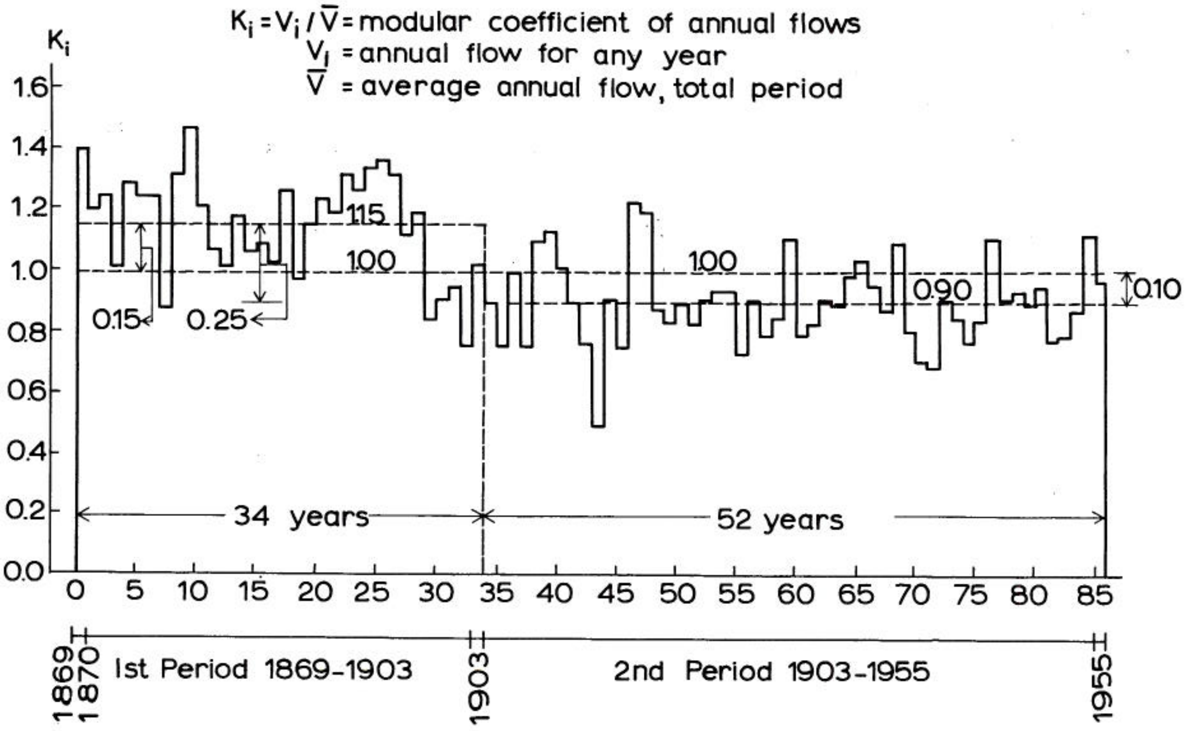

Fig. 9. Fluctuations of annual flow of River Nile as an example of inconsistency in data of time series.

true rating curve before the dam was built. The results are that the mean discharge for 34 years before 1903 is 3380m^3/s (1869-1903), and the mean discharge for 52 years after 1903 is 2650m^3/s (1903-1955). Though the created reservoir increased the losses by evaporation and eventually by seepage, the difference of the mean discharges of 730m^3/s cannot be chiefly explained in that manner. Both inconsistency and nonhomogeneity effects are inherent in the data, but inconsistency seems prevailing.

The first period has a mean discharge 27.7% higher than the mean of the second period, which will be shown below as significantly different from zero for the two periods of 34 and 52 years.

Table 3 gives the mean discharges for 2 or 3 periods—each between 34 and 52 years long—for 19 river gaging stations, the Nile included. The means of the short periods of the 34- to 52-year span are given in modular coefficients K with respect to the general mean as unity. The difference $\Delta K = K_{max} - K_{min}$ for 2 or 3 periods is considered here as a rough measure of the sampling deviation of the means. This difference for the Nile River is 0.250. Assuming as an approximation that the distribution of annual flows for each station is normal, the level of significance that the maximum difference ΔK is not different from zero can be determined. The variance of the mean was computed for the Nile by the formula

$$\text{var}(\Delta K) = s^2 \left(\frac{1}{N_1} + \frac{1}{N_2}\right)$$

where s^2 = variance of annual flows for the period $N = N_1 + N_2$, and N_1 and N_2 are the parts of the total period. With $\Delta K/\sqrt{\text{var}(\Delta K)}$, the standardized variable for ΔK is obtained and the level of significance determined from the normal function tables.

The majority of rivers, 14 out of 19, have ΔK-values which are not significantly different from zero on 95% level. Among all stations, the Nile River has the greatest level of significance of 99.99%, which would lead to the conclusion that the mean annual flows for two periods of 34 and 52 years are significantly different from zero. In this case, inconsistency in data may be assumed as likely, with the chance of 1 in 100,000 that the difference of $\Delta K = 0.250$ for the Nile River might be produced by a sampling deviation. This significance level would be somewhat smaller if the interdependence of successive annual flows would be introduced into the test of significance for $\Delta K = 0.250$. However, this interdependence is largely produced by the jump in the mean of the time series around 1903, because the interdependence for each of two periods is much smaller than that for the total period of 86 years. Therefore, the test under the condition of independence may be justified.

The values of level of significance of 99.94 for the St. Lawrence River should be viewed from the fact that the large water carryover in Great Lakes makes the means of the two periods of 49 years highly interdependent, which deviates from the assumption that the means are independent. The effective sample sizes of two 49-year half-periods would be much smaller than 49, as would the level of significance, if this interdependence of means would be taken into account.

3. Nonhomogeneity in annual flows. Nonhomogeneity has been defined as the change of virgin flow with time. As an example of nonhomogeneity, the annual flow of the Colorado River at Lee Ferry station, Arizona, is given here and briefly analyzed. Figure 10 shows the graph of 64 years of historical annual flows, the computed annual virgin flows, and reduced annual homogeneous flows at the period 1954-1957, by taking into account the depletions acting on river flows at that time. The depletion model [4] shows that the average annual flow was constantly decreased from 1896 to 1959.

The virgin annual flows have for 64 years the coefficient of variation of $C_v = 0.278$. The ratio of mean for each of the two periods of 32 years (1896-1927, 1928-1959) to the mean for the whole period of 64 years of historical flows are: $K_1 = 15.30/13.53 = 1.13$, and $K_2 = 11.75/13.53 = 0.87$, respectively. The difference $\Delta K = 0.260$. Using the expression $\text{var}(\Delta K) = 4C_v^2/N$, then the level of significance is more than 99.99% that the difference $\Delta K = 0.260$ is significantly different from zero (K_1 and K_2 are assumed independent, and annual flows normally distributed).

Both the physical factors of depletion and the test of significance show clearly in this example that the two means are from a nonhomogeneous sample, or that the time series of annual flow is not a stationary time series. Nonhomogeneity is, therefore, a complex trend function which depends on the sequence of major depletion factors (water diversion out of river basin, beginning of large irrigation projects, of storage reservoirs, etc.). It is quite evident that there is sampling difference among the two half-period means, but the real difference is substantially increased by the nonhomogeneity in data.

The last 40 to 150 years was a period of settlement or of vast agricultural and industrial development in many areas of the world. These developments surely produced continuous or at least discontinuous changes of the virgin flows.

4. Discussion of inconsistency and nonhomogeneity. The low degree of inconsistency and nonhomogeneity is difficult to detect, although the trend in increase or decrease of annual flows can be estimated in some cases. As certain changes which cause systematic errors occur during a long period of observations (such as changes in instrumentation used, in methods of measurement and computation, changes due to the uncontrolled shifting of bed), it is quite probable that a high percentage of the river gaging stations selected for this study have more or less inconsistent and nonhomogeneous data. It is certain that many European and American river basins whose data is analyzed in this study have undergone substantial changes in the periods of flow observations.

The systematic errors can be of both signs, with flows in short periods either above or below the true values. They create a type of fluctuation, with trends and jumps as the main elements of these errors.

The individual values of inconsistency or nonhomogeneity are difficult to detect from year to year along the series. It is possible, however, to estimate the change from time to time with the positive or negative sign (as was shown for the Nile and Colorado Rivers) by detailed study of historical records and data of each river basin and station, and by statistical significance tests of different parameters.

The departures of the short-period means from the general mean can be produced by: a) the sampling fluctuations of means; b) the shifting due to the oscillatory phenomena, to the long-range

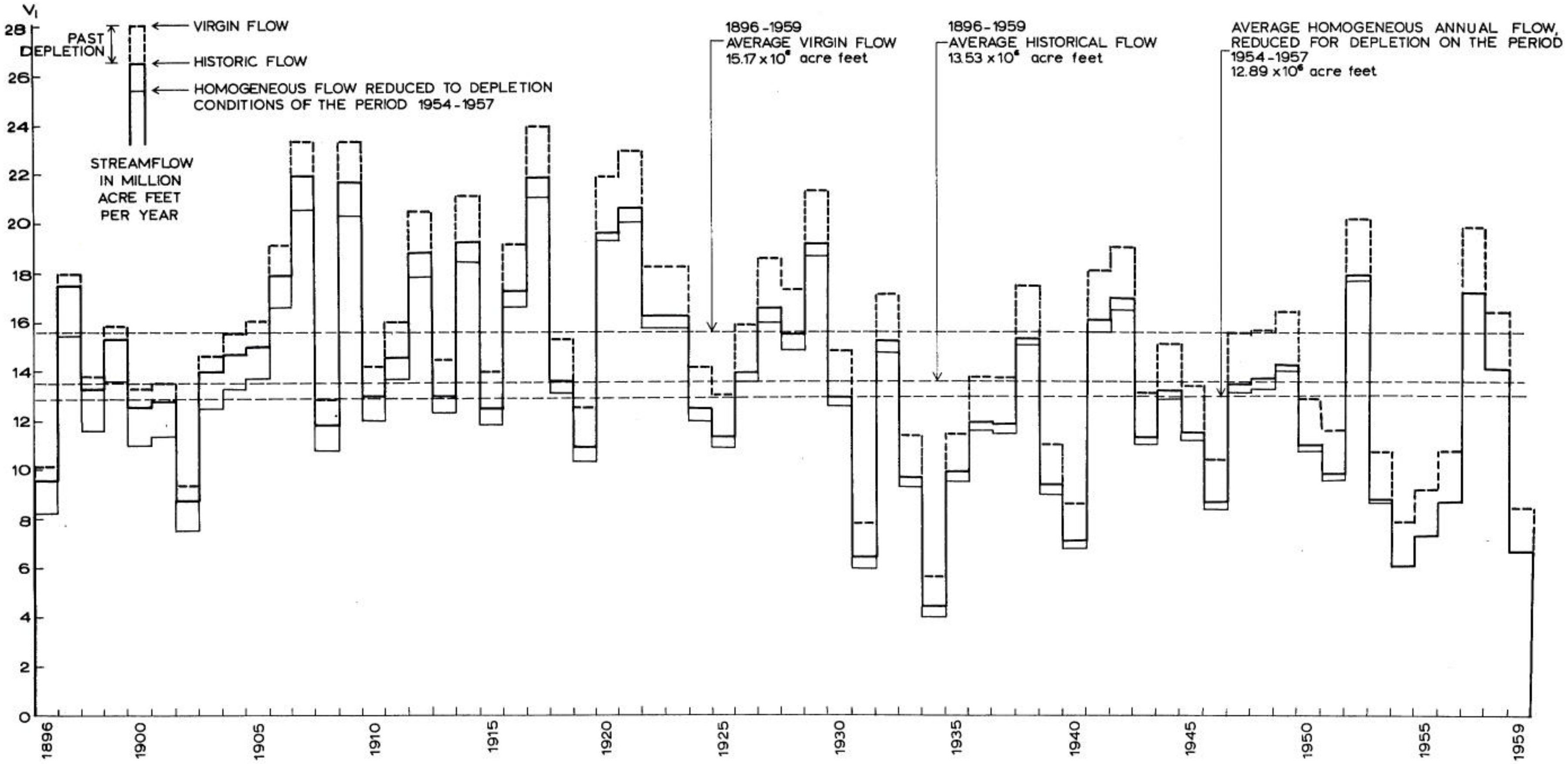

Fig. 10. Fluctuations of annual flow of Colorado River at Lee Ferry Station, Arizona, with historical, virgin, and homogeneous annual flows reduced at the period 1954-1957; an example of nonhomogeneity in data of time series.

persistence or regression effect; c) shifting due to inconsistency and nonhomogeneity. Two aspects of inconsistency and nonhomogeneity are of practical interest: 1) how to detect them, and 2) how they influence the statistics which describe the patterns in sequence of a time series. Their influence can be indicated by the study of different statistics which point to the possible sources of inconsistency and homogeneity (cases of the Nile and Colorado Rivers, respectively). The statistical indication of possible inconsistency and nonhomogeneity should always coincide with the physical sources of inconsistency and nonhomogeneity determined by characteristics of available data, peculiarities of river gaging station, and from the river basin and gaging station history.

The study of effects of inconsistency and nonhomogeneity in data on patterns in sequence of annual flow, annual effective precipitation and annual precipitation will be the subject of a special part of this paper. It is difficult to distinguish in practice between the effects of inconsistency and nonhomogeneity, although they are two different phenomena.

5. *Errors in computation of the difference in carryover.* The errors in the quantity ΔW point out that the effect of water storage in a river basin on the annual flow is not fully eliminated by the ΔW-values as they were determined in this study. The greater these errors, the larger are the corresponding effects still remaining in the computed annual effective precipitation. Since an approximate method was used here for the computation of ΔW, these errors are always present. They are expected to be greater for the large river basins, where the flow concentration time is long and precipitation distribution over area or in time is quite non-uniform from year to year, than for the small river basins where concentration time is short and distribution of rainfall is much more uniform both in area and in time. The errors will be greater with a high percentage of snow and ice carryover from year to year, than in the case where this is negligible.

6. *Errors and nonhomogeneity in annual precipitation.* A computed value of annual precipitation has random errors, systematic errors (inconsistency), and nonhomogeneity in data.

Inconsistency is created mostly by changes in instruments, method and time of measurements, etc. Nonhomogeneity comes mostly from three sources: (a) movement of precipitation station by a substantial horizontal distance; (b) movement of station by a substantial vertical distance; and (c) changes in the environment of a station, i.e., tree growth, building of houses, or any other substantial change around the station which affects the flow pattern of air.

Precipitation data must be considered, therefore, as having relatively large errors and nonhomogeneity in its annual values, nonhomogeneity being the more important for the purpose of this study.

A comparison of annual precipitations of two large samples of precipitation stations: (a) homogeneous stations and (b) nonhomogeneous stations, is intended to show an order of magnitude of nonrandomness which can be introduced in the series of annual precipitation by nonhomogeneity in data.

Table 3

Comparison of mean annual flows of 19 rivers for periods of 34 to 52 years (see data, Tables 1 and 2) showing K ratio of the means of shorter period to the mean of total period, and N number of years in short periods.

River	I Period			II Period			III Period			ΔK
		N	K		N	K		N	K	$K_{max} - K_{min}$
Gŏta	1807-1857	50	1.021	1857-1907	50	1.005	1907-1957	50	0.968	0.053
Rhine, Basle	1807-1857	50	1.005	1857-1907	50	0.966	1907-1957	50	1.027	0.061
Nemunas (Sm)	1811-1855	44	0.974	1855-1899	44	0.996	1899-1943	44	1.011	0.037
Danube (Orsh.)	1837-1877	40	0.987	1877-1917	40	1.012	1917-1957	40	0.998	0.025
St. Lawrence	1860-1909	49	1.030	1908-1957	49	0.969				0.061
Mississippi (St. Louis)	1861-1909	48	1.027	1909-1957	48	0.972				0.055
Tennessee	1874-1915	41	1.058	1815-1956	41	0.943				0.115
Mississippi (Koekuk)	1878-1918	40	1.066	1817-1957	40	0.929				0.137
Nile (Aswan Dam)	1869-1903	34	1.150	1903-1955	52	0.900				0.250
Kanawha	1877-1917	40	1.071	1917-1957	40	0.924				0.147
Neva	1859-1897	38	0.977	1897-1935	38	1.020				0.043
Mures	1877-1916	38	1.019	1916-1945	38	0.963				0.056
Dnieper	1881-1918	37	1.000	1918-1955	37	1.000				0.000
Goulburn	1881-1918	37	1.000	1917-1954	37	1.021				0.021
Kiewa	1885-1921	36	1.022	1921-1957	36	1.977				0.045
Thames	1883-1919	36	0.949	1918-1954	36	1.059				0.110
Susquehanna	1890-1925	35	1.024	1922-1957	35	0.960				0.064
Drina	1890-1925	35	0.984	1922-1957	35	1.011				0.027
Dal	1852-1887	35	1.030	1887-1922	35	0.971				0.059

F. CONCLUSIONS

The preceding discussion and the mathematical models derived above show that variations in water carryover in river basins from year to year (moisture in the soil and plants included), evaporation from the river basin, and evaporation of rainfall in the air are the three significant factors that produce and/or affect the nonrandomness in sequence of annual flow and annual precipitation. Inconsistency and nonhomogeneity in data also produce and/or affect dependence in time series of annual flow and annual precipitation.

Subsequent parts of this study deal primarily with the effects of these factors on the patterns in sequence of annual values of runoff and rainfall. For this purpose, the samples already described in detail, as well as the statistical techniques outlined in Chapter A, are used.

Many attempts have been made in the past to explain the nonrandomness of annual flow and annual precipitation partly, or fully, as direct results of occurrences in the upper atmosphere and the oceans, and by solar and cosmic activities. The author's preliminary investigations have led to a step-by-step approach to the analysis of patterns in sequence of annual flow and annual precipitation. First, the effects on these patterns of water carryover, evaporation from the ground, evaporation of rainfall in the air and inconsistency and nonhomogeneity in data should be investigated and accounted for. If the nonrandomness in time series, which has not been accounted for by these factors, remains significant, further steps in searching for the causal factors of nonrandomness will become justified.

Factors associated with the upper atmosphere, then the oceans, then solar and cosmic activities are logical steps in the search for the sources of nonrandomness in the sequence of wet and dry years.

The mathematical models in Chapter C are only an indication of causal factors of nonrandomness. Serial correlation analysis, analysis by range and runs, and variance spectrum analysis of time series of annual flow and annual precipitation are foreseen as subsequent parts of this study. They will serve to determine the effects of the above factors (carryover, evaporation at the ground, evaporation in the air, and inconsistency and nonhomogeneity in data) on nonrandomness. They will also show how good a simplified mathematical model is in describing the time dependence of wet and dry years.

REFERENCES

1. Hurst, H. E., Long-term storage capacity of reservoirs: Am. Soc. Civil Engineers Trans., 1951, v. 116, no. 2447, p. 776.

2. Hurst, H. E., Methods of using long-term storage in reservoirs: Institution of Civil Engineers Proc., London, 1956, pt. 1, v. 5, p. 519.

3. Hurst, H. E., The problem of long-term storage in reservoirs: Intern. Union Geophysics and Geodesy Information Bull., London, 1956, no. 15, p. 463.

4. Yevdjevich, V. M., Some general aspects of fluctuations of annual runoff in the Upper Colorado River Basin: Civil Eng. Section, Colorado State University, Fort Collins, Colo. Oct. 1961, No. CER61VMY54, p. 48.

5. Slutzky, E., The summation of random causes as the source of cyclic processes: Econometrica, 1937, no. 5.

6. Levert, C., Das Phaenomen der Persistanz und dessen Auswirkungen bei Statistischen Bearbeitungen (Persistence phenomenon and its effect in the statistical computations): La Météorologie, Paris, 1957, p. 165.

7. Panofsky, H. A., Meteorological Applications of Power Spectrum Analysis: Amer. Meteor. Soc. Bull., v. 36, no. 4, April 1955, p. 163-166.

8. Blackman, R. B., and Tukey, J. W., The Measurement of Power Spectra: Dover Publications, New York, 1958.

9. Langbein, W. B., Some channel-storage studies and their application to the determination of infiltration: Amer. Geophys. Union Trans., pt. 1, Aug. 1938, p. 435-447.

10. Yevdjevich, V. M., Analytical integration of differential equation for water storage: U. S. National Bureau of Standards Research Journal, Mathematics and Mathematical Physics, v. 63B no. 1, July-Sept. 1959, p. 43.

11. Best, A. C., Empirical formulae for the terminal velocity of water drops falling through atmosphere: Royal Meteorol. Soc. Quart. Jour., v. 76, no. 329, 1950, p. 302-311.

12. Best, A. C., The size distribution of raindrops: Royal Meteorol. Soc. Quart. Jour., v. 76, no. 327, 1950, p. 16-36.

13. Squires, P., The growth of cloud drops by condensation I, General characteristics: Australian Jour. of Sci. Research, Series A, Physical Sci., v. 5, no. 1, 1952, p. 59-86.

14. Hurst, Black, Simaika, The Nile Basin; v. 7, The Future Conservation of the Nile: S. O. P. Press, Cairo, Egypt. 1946.

APPENDIX 1

TABLE 1

DATA ON STREAM GAUGING STATION AND ANNUAL FLOWS OF THE FIRST

Number of Station	Name of River	Name of Station	State or Country	Basin Area A sq.mi.* (1)	Mean Discharge Q cfs** (2)
		I. The U. S. A.			
1	Piscataquis	near Dover-Foxcroft	Maine	297	578
2	Pemigewasset	Plymouth	New Hampshire	622	1 368
3	Susquehanna	Harrisburg	Pennsylvania	24 100	34 555
4	Potomac	Point of Rocks	Maryland	9 651	9 283
5	Rappahannock	near Fredericksburg	Virginia	1 599	1 663
6	Roanoke	Roanoke	Virginia	388	382
7	Chattahoochee	near Norcross	Georgia	1 170	2 222
8	French Broad	Asheville	North Carolina	945	2 048
9	Tennessee	Chattanooga	Tennessee	21 400	36 876
10	Little Wabash	Wilcox	Illinois	1 130	900
11	Kentucky	Lock 10 near Winchester	Kentucky	3 960	5 165
12	Kanawha	Kanawha Falls	West Virginia	8 367	12 712
13	Tygart	Belington	West Virginia	408	799
14	Allegheny	Red House	New York	1 690	2 804
15	St. Regis	Brasher Center	New York	616	1 067
16	St. Lawrence	Ogdensburg	New York	295 200	240 820
17	Wolf	New London	Wisconsin	2 240	1 708
18	Fox	Berlin	Wisconsin	1 430	1 104
19	Rock	Afton	Wisconsin	3 300	1 751
20	Sanganmon	Monticello	Illinois	550	397
21	Mississippi	Keokuk	Iowa	119 000	61 177
22	Cedar	Cedar Rapids	Iowa	6 510	3 038
23	Red of the North	Grand Forks	North Dakota	30 100	2 282
24	Missouri	Fort Benton	Montana	24 000	7 635
25	Yellowstone	Corwin Springs	Montana	2 630	2 987
26	Middle Boulder Creek	Nederland	Colorado	35.5	53.6
27	Missouri	Sioux City	Iowa	314 600	33 651
28	Osage	near Bagnell	Missouri	14 000	8 843
29	Mississippi	St. Louis	Missouri	701 000	175 119
30	Current	Van Buren	Missouri	1 667	1 885
31	Petit Jean Creek	Danville	Arkansas	741	849
32	Sabine	Logansport	Louisiana	4 858	3 294
33	Neches	near Rockland	Texas	3 539	2 323
34	Little River	Cameron	Texas	7 034	1 746
35	Brazos	Waco	Texas	28 500	2 717
36	North Llano	near Junction	Texas	914	68.3
37	Colorado	Bellinger	Texas	16 840	393
38	Pecos	near Anton Chico	New Mexico	1 050	144.5
39	Little Beaver Creek	near Pikes Peak	Colorado	1.0	0.563
40	Arkansas	Salida	Colorado	1 218	588
41	Fraser	near Winter Park	Colorado	27.6	40.6
42	White River	near Meeker	Colorado	762	636
43	San Juan	Bosa	New Mexico	1 990	1 235
44	Ashley Creek	near Vernal	Utah	101	106.2
45	Verde	below Barlett Dam	Arizona	6 160	778
46	Virgin	Virgin	Utah	934	217.3
47	Beaver	near Beaver	Utah	82	51.9
48	City Creek	near Salt Lake City	Utah	19.2	16.4
49	Blacksmith Fork	above U.P.&L.Co. near Hyrum	Utah	260	126.7
50	Humbolt	Palisade	Nevada	5 010	356.3
51	Carson	near Fort Churchill	Nevada	1 450	370.5
52	Kern	near Bakersfield	California	2 420	968.6
53	Kaweah	near Three Rivers	California	520	570
54	Kings	Piedra	California	1 694	2 304
55	Arroyo Seco	near Soledad	California	241	165.8
56	Tenaya Creek	near Yosemite	California	47	105
57	Cherry Creek	near Hetch Hetchy	California	111	368.6
58	Cosumnes	Michigan Bar	California	537	489
59	Feather	Bidwell Bar	California	1 353	1 872
60	Trinity	Lewiston	California	727	1 608
61	Quinault	at Quinault Lake	Washington	264	2 762
62	South Fork Skykomish	near Index	Washington	355	2 403
63	Wenatchee	Plain	Washington	591	2 194
64	Kootenai	Libby	Montana	10 240	11 848
65	Clearwater	Kamiah	Idaho	4 850	8 121
66	Big Wood & Big Wood. Slough	Hailey	Idaho	640	427
67	Boise	Twin Springs	Idaho	830	1 174
68	John Day	McDonald Ferry	Oregon	7 580	1 996
69	Clackamas	Cazadero	Oregon	657	2 687
70	Willamette	Albany	Oregon	4 840	13 659
71	Umqua	near Elkton	Oregon	3 680	7 418
72	Rogue	Raygold	Oregon	2 020	2 904

* 1 sq.mi. = $2.59 km^2$

** 1 c.f.s. = $0.0283 m^3/s$

*** 1 cfs/sq mi = $10.93 lit/sec/km^2$

**** From 1 Oct. of first year to 1 Oct. of last year or the same for any other beginning of water year.

SAMPLE (GLOBAL SCALE SAMPLING)

Mean Yield	Number of Years	Period of Records	Coefficient of Variation		Skew Coefficient		First Serial Correlation Coefficient		Index of Variability	
q cfs/sq. mi. ***	N	From-To****	U_1	Y_1	U_1	Y_1	U_1	Y_1	U_1	Y_1
(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1.95	54	1902-1956	0.216	0.216	0.009	0.012	0.064	0.082	0.233	0.233
2.20	53	1903-1956	0.163	0.162	0.001	0.027	0.082	0.095	0.169	0.167
1.43	67	1890-1957	0.207	0.201	0.266	0.240	0.181	0.166	0.206	0.206
0.962	61	1896-1957	0.299	0.299	0.303	0.302	0.034	0.032	0.307	0.307
1.04	50	1907-1957	0.319	0.327	0.257	0.425	0.026	0.002	0.361	0.363
0.984	58	1899-1957	0.348	0.353	0.634	0.631	0.152	0.155	0.362	0.368
1.90	53	1903-1956	0.292	0.299	0.259	0.325	0.154	0.121	0.306	0.311
2.17	62	1895-1957	0.288	0.299	0.628	0.656	0.212	0.162	0.286	0.296
1.72	82	1874-1956	0.241	0.240	0.100	0.084	0.186	0.191	0.253	0.252
0.796	43	1914-1957	0.488	0.486	0.117	0.131	0.099	0.101	0.625	0.619
1.30	49	1907-1956	0.301	0.298	0.084	0.050	-0.006	-0.004	0.337	0.335
1.53	80	1877-1957	0.241	0.241	0.538	0.516	0.039	0.037	0.240	0.242
1.96	50	1907-1957	0.211	0.210	0.181	0.110	-0.064	-0.073	0.216	0.215
1.66	53	1903-1956	0.212	0.215	0.380	0.388	0.122	0.077	0.212	0.214
1.73	46	1910-1956	0.223	0.223	0.781	0.764	0.045	0.0002	0.221	0.221
0.816	97	1860-1957	0.087	0.197	-0.286	0.141	0.705	0.094	0.089	0.204
0.762	61	1896-1957	0.278	0.276	0.366	0.418	0.401	0.400	0.284	0.279
0.772	59	1898-1957	0.225	0.235	0.184	0.578	0.404	0.259	0.230	0.233
0.531	42	1914-1956	0.359	0.354	0.322	0.305	0.214	0.218	0.391	0.386
0.722	43	1914-1957	0.546	0.543	0.846	0.833	0.252	0.253	0.643	0.639
0.514	79	1878-1957	0.295	0.291	0.467	0.413	0.415	0.425	0.312	0.308
0.467	54	1903-1957	0.419	0.419	0.327	0.418	0.239	0.236	0.492	0.481
0.076	56	1901-1957	0.662	0.668	0.971	1.08	0.515	0.493	0.779	0.776
0.318	65	1890-1955	0.274	0.276	0.084	0.076	0.593	0.582	0.291	0.293
1.14	45	1910-1955	0.218	0.227	0.130	0.137	0.164	0.077	0.225	0.235
1.51	50	1907-1957	0.240	0.242	0.205	0.236	-0.239	-0.240	0.248	0.249
0.107	58	1897-1955	0.277	0.280	-0.187	-0.279	0.590	0.532	0.307	0.319
0.632	50	1880-1930	0.501	0.499	0.682	0.681	0.068	0.068	0.558	0.557
0.250	96	1861-1957	0.299	0.293	0.291	0.175	0.294	0.302	0.317	0.313
1.13	45	1912-1957	0.395	0.406	0.456	0.489	0.302	0.273	0.408	0.420
1.14	41	1916-1957	0.556	0.559	0.851	0.914	-0.076	-0.085	0.624	0.618
0.678	54	1903-1957	0.560	0.561	0.534	0.532	0.218	0.216	0.667	0.670
0.656	54	1903-1957	0.584	0.585	0.320	0.321	0.134	0.133	0.739	0.741
0.248	40	1917-1957	0.749	0.750	0.856	0.861	0.288	0.281	0.917	0.917
0.0953	43	1898-1941	0.675	0.693	1.110	1.140	0.031	0.014	0.664	0.677
0.0747	42	1915-1957	1.100	1.110	1.610	1.660	0.237	0.238	1.255	1.248
0.0233	50	1907-1957	0.752	0.757	0.943	0.932	-0.049	-0.052	0.872	0.905
0.138	46	1911-1957	0.709	0.712	1.49	1.48	0.127	0.132	0.749	0.776
0.563	48	1909-1957	0.481	0.514	0.909	0.864	0.037	-0.047	0.509	0.551
0.483	47	1909-1956	0.213	0.220	-0.407	-0.359	0.377	0.335	0.234	0.241
1.47	47	1910-1957	0.247	0.249	0.288	0.218	0.239	0.228	0.253	0.258
0.836	48	1909-1957	0.220	0.233	0.529	0.611	0.164	0.122	0.220	0.231
0.621	47	1910-1957	0.431	0.433	0.296	0.325	0.098	0.089	0.468	0.469
1.05	43	1914-1957	0.311	0.324	0.488	0.483	0.274	0.194	0.319	0.334
0.126	50	1888-1938	0.639	0.639	1.30	1.28	0.161	0.164	0.625	0.628
0.233	42	1909-1951	0.408	0.409	1.13	1.13	0.311	0.309	0.376	0.377
0.633	43	1914-1957	0.348	0.359	-0.360	-0.376	0.483	0.433	0.431	0.455
0.854	59	1898-1957	0.274	0.302	0.629	0.438	0.377	0.274	0.277	0.322
0.499	44	1913-1957	0.343	0.355	0.247	0.245	0.514	0.468	0.367	0.382
0.0711	46	1911-1957	0.641	0.642	0.875	0.871	0.221	0.219	0.726	0.729
0.256	46	1911-1957	0.546	0.547	0.830	0.833	0.099	0.098	0.564	0.564
0.400	60	1893-1953	0.571	0.586	1.29	1.33	0.174	0.137	0.541	0.553
1.10	53	1903-1956	0.515	0.520	1.06	1.06	0.120	0.108	0.514	0.522
1.36	61	1895-1956	0.444	0.449	0.774	0.775	0.092	0.076	0.462	0.469
0.688	53	1902-1955	0.749	0.749	1.00	1.00	0.168	0.167	0.849	0.850
2.23	44	1912-1956	0.338	0.338	0.065	0.059	-0.063	-0.062	0.387	0.389
3.32	45	1910-1955	0.323	0.324	0.203	0.200	0.013	0.012	0.350	0.352
0.91	49	1907-1956	0.583	0.583	0.543	0.543	0.074	0.074	0.709	0.710
1.38	45	1911-1956	0.493	0.498	0.554	0.532	0.056	0.047	0.540	0.554
2.21	45	1911-1956	0.473	0.474	0.548	0.545	0.180	0.178	0.508	0.509
10.50	46	1911-1957	0.172	0.172	-0.176	-0.073	0.189	0.193	0.180	0.177
6.78	46	1911-1957	0.208	0.208	-0.055	-0.007	0.312	0.315	0.219	0.218
3.71	47	1910-1957	0.243	0.243	0.103	0.098	0.284	0.278	0.254	0.255
1.16	47	1910-1957	0.227	0.230	-0.093	-0.014	0.048	0.020	0.241	0.242
1.67	46	1910-1956	0.249	0.248	0.168	0.138	0.228	0.224	0.257	0.256
0.667	42	1915-1957	0.345	0.359	0.374	0.330	0.068	0.006	0.366	0.388
1.41	45	1911-1956	0.281	0.285	0.165	0.155	-0.044	-0.068	0.297	0.302
0.263	53	1904-1957	0.408	0.410	0.366	0.365	0.163	0.155	0.440	0.444
4.09	49	1908-1957	0.214	0.218	0.205	0.183	0.084	0.021	0.219	0.224
2.82	48	1893-1941	0.236	0.238	0.007	0.001	-0.046	-0.056	0.247	0.250
2.02	52	1905-1957	0.303	0.305	0.251	0.214	-0.004	-0.014	0.325	0.330
1.44	52	1905-1957	0.294	0.305	0.231	0.190	0.153	0.114	0.312	0.328

Number of Station	Name of River	Name of Station	State or Country	Basin Area A sq.mi.* (1)	Mean Discharge Q cfs** (2)
		II. Canada			
1	Columbia	Nicholson	British Columbia	2 570	3 743
2	Capilano Creek	near North Vancouver	British Columbia	68	693.8
3	Thomson	near Spences Bridge	British Columbia	21 600	26 658
4	Bridge	near Shalalth	British Columbia	1 350	3 554
5	North Saskatchewan	Edmonton	Canada	10 500	7 830
6	Belly	Mountain View	Canada	121	312.2
7	Bow	Banff	Canada	852	1 405
8	Spray	Banff	Canada	289	461.6
9	Milk	Milk River	Canada	1 104	294.1
10	Lahave	West Northfield	Canada	497	478
11	St. Mary	Stillwater	Canada	523	1 452
12	Saugeen	Walkerton	Canada	850	1 059
13	Magnetawan	Burks Falls	Canada	241	392.7
		III. Europe			
1	Thames	Teddington	Great Britain	3 812	2 223
2	Garonne	Mas d'Argenais	France	19 760	22 280
3	Rohne	Brig	Switzerland	316	1 486
4	Luetschine	Gsteig	Switzerland	144	667
5	Birs	Muenchenstein	Switzerland	346	526
6	Rhine	Basle	Switzerland	13 867	36 253
7	Rhine	Maxau	Germany	19 130	42 748
8	Inn	Reisach	Germany	3 717	10 943
9	Danube	Hofkirchen	Germany	18 034	22 267
10	Main	Schweinfurt	Germany	4 656	3 565
11	Ems	Rheine	Germany	1 420	1 161
12	Weser	Hann-Muenden	Germany	4 740	3 668
13	Elbe	Darchau	Germany	50 140	24 138
14	Danube	Vienna-Nussdorf	Austria	38 600	67 670
15	Drau	Newbruecke	Austria	4 011	10 022
16	Drina	Zvornik	Yugoslavia	6 620	13 516
17	Danube	Orshava	Romania	216 300	189 455
18	Mures	Arad	Romania	10 400	5 906
19	Vistula	Jorun	Poland	66 500	35 300
20	Göta	Sjötorp-Vänersburg	Sweden	18 076	18 921
21	Dal	Norslund	Sweden	9 610	12 249
22	Indals	Ostersund	Sweden	4 678	8 511
23	Angerman	Forsmo	Sweden	11 560	11 720
24	Lule	Trangfors	Sweden	3 789	9 354
25	Lule	Porjus	Sweden	9 310	17 750
26	Nemunas	Smalininkai	U.S.S.R.	30 900	19 253
27	Nemunas	Birstonas	U.S.S.R.	16 570	9 718
28	Nemunas	Grodno	U.S.S.R.	12 570	7 053
29	Danguva	Vitebsk	U.S.S.R.	10 360	8 084
30	Neva	Petrokrepost	U.S.S.R.	105 000	91 462
31	Volkhov	Gustinopolie	U.S.S.R.	30 260	20 912
32	Svir	Miatusovo	U.S.S.R.	25 100	21 988
33	S. Dvina	Ust-Pinega	U.S.S.R.	133 000	121 220
34	Kama	Berezniki	U.S.S.R.	31 800	31 657
35	Volga	Gorkii	U.S.S.R.	181 900	102 970
36	Don	Kalach	U.S.S.R.	81 700	23 647
37	Dnieper	Dnieperpetrovsk	U.S.S.R.	161 000	56 904
		IV. Australia and New Zealand			
1	Avoca	Coonoorer Bridge	Victoria	1 000	77.2
2	Broken	Goorambat	Victoria	740	274.4
3	Banyip	Banyip	Victoria	268	167.1
4	Glenelg	Balmoral	Victoria	606	160.5
5	Goulburn	Murchison	Victoria	4 140	3 175
6	Kiewa	Kiewa	Victoria	450	729.7
7	Murray	Jingellic	Victoria	2 520	2 683
8	Owens	Wangaratta	Victoria	2 100	1 586
9	Snowy	Jarrahmond	Victoria	5 100	2 321
10	Thomson	Cowwar	Victoria	450	446.6
11	Lake Taupo	Inflows	New Zealand	1 270	4 491
		V. Africa			
1	Lake Victoria	Outflow	Uganda	99 600	23 407
2	Lake Albert	Mongalla	Sudan	171 000	25 384
3	Nile	Aswan Dam	Egypt	710 000	93 510
4	Niger	Koulicoro	French Sudan	46 320	54 362
		VI. Asia			
1	Tigris	Baghdad	Irak	21 066	44 654
2	Tama	Atsumi	Japan	98	406
3	Tone	Iwamoto	Japan	656	2 937

Mean Yield q cfs/sq.mi.***	Number of Years N	Period of Records From-To****	Coefficient of Variation		Skew Coefficient		First Serial Correlation Coefficient		Index of Variability	
			U_i	Y_i	U_i	Y_i	U_i	Y_i	U_i	Y_i
(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1.46	41	1913-1954	0.150	0.159	-0.070	-0.090	0.085	-0.025	0.154	0.164
10.2	40	1914-1954	0.166	0.163	0.037	-0.023	0.0002	0.022	0.169	0.167
1.23	43	1911-1954	0.144	0.155	1.19	1.22	0.221	0.157	0.138	0.148
2.63	41	1913-1954	0.142	0.145	0.381	0.333	-0.153	-0.188	0.141	0.144
0.746	44	1911-1955	0.230	0.234	0.558	0.627	0.158	0.119	0.225	0.228
2.58	44	1911-1955	0.244	0.252	0.134	0.087	0.105	0.049	0.257	0.270
1.65	44	1910-1954	0.136	0.139	0.034	-0.065	-0.061	-0.112	0.139	0.142
1.60	45	1910-1955	0.293	0.295	-0.942	-0.930	0.438	0.437	0.404	0.406
0.266	44	1911-1955	0.357	0.357	0.592	0.565	0.568	0.563	0.384	0.386
2.37	40	1914-1954	0.162	0.158	-0.022	-0.016	0.059	0.075	0.166	0.164
2.78	40	1914-1954	0.126	0.129	0.250	0.263	-0.161	-0.138	0.126	0.129
1.24	40	1913-1953	0.263	0.261	0.640	0.634	0.178	0.180	0.264	0.262
1.63	40	1913-1953	0.235	0.235	0.867	0.863	0.216	0.209	0.229	0.229
0.583	71	1883-1954	0.366	0.365	0.172	0.123	0.140	0.179	0.402	0.406
1.13	42	1913-1955	0.319	0.321	-0.156	-0.159	0.438	0.450	0.395	0.402
4.70	41	1916-1957	0.099	0.100	0.269	0.220	0.283	0.271	0.098	0.100
4.63	40	1917-1957	0.096	0.096	0.384	0.356	-0.131	-0.126	0.095	0.095
1.52	41	1916-1957	0.271	0.271	-0.156	-0.155	0.168	0.170	0.299	0.302
2.61	150	1807-1957	0.159	0.173	0.143	0.229	0.077	0.015	0.162	0.176
2.23	55	1900-1955	0.190	0.207	0.075	-0.071	0.029	-0.056	0.196	0.219
2.94	55	1900-1955	0.106	0.117	-0.070	0.053	-0.348	-0.401	0.108	0.119
1.23	55	1900-1955	0.208	0.217	0.338	0.224	0.177	0.018	0.211	0.224
0.766	45	1910-1955	0.301	0.202	0.334	0.411	0.210	0.218	0.315	0.316
0.818	55	1900-1955	0.291	0.303	0.129	0.328	0.113	0.067	0.308	0.316
0.774	55	1900-1955	0.256	0.265	-0.027	0.048	0.171	0.124	0.274	0.282
0.480	55	1900-1955	0.276	0.276	0.980	1.03	0.371	0.360	0.263	0.262
1.75	64	1893-1957	0.155	0.164	0.152	0.167	0.016	-0.056	0.156	0.166
2.50	55	1901-1956	0.230	0.178	0.717	0.730	0.389	0.390	0.221	0.223
2.04	67	1890-1957	0.279	0.280	0.709	0.712	-0.034	-0.038	0.278	0.279
0.876	120	1837-1957	0.192	0.214	0.270	0.226	0.096	0.001	0.193	0.220
0.568	79	1876-1955	0.401	0.404	0.900	0.982	0.247	0.245	0.398	0.396
0.531	40	1900-1940	0.202	0.208	0.163	0.423	0.033	0.018	0.206	0.210
1.05	150	1807-1957	0.182	0.308	-0.058	0.392	0.463	0.009	0.189	0.323
1.27	70	1852-1922	0.218	0.245	0.596	0.564	0.093	-0.047	0.214	0.244
1.82	64	1893-1957	0.148	0.184	0.221	-0.482	0.021	-0.124	0.149	0.209
1.01	48	1909-1957	0.205	0.205	0.091	0.071	0.065	0.090	0.213	0.213
2.47	46	1911-1957	0.143	0.157	0.764	1.18	0.081	-0.022	0.108	0.114
1.91	57	1900-1957	0.107	0.114	0.188	0.177	0.013	-0.126	0.138	0.148
0.623	132	1811-1943	0.177	0.192	0.465	0.607	0.185	0.118	0.176	0.189
0.586	63	1880-1943	0.155	0.158	0.440	0.381	0.178	0.121	0.154	0.158
0.561	67	1876-1943	0.190	0.220	0.739	0.724	0.252	0.121	0.184	0.214
0.780	58	1877-1935	0.263	0.272	0.135	0.404	0.218	0.207	0.279	0.282
0.871	76	1859-1935	0.163	0.241	0.427	0.993	0.534	0.090	0.161	0.229
0.691	52	1881-1933	0.260	0.256	0.272	0.213	0.016	0.103	0.269	0.267
0.876	54	1881-1935	0.162	0.230	0.746	0.795	0.394	0.141	0.157	0.221
0.911	53	1882-1935	0.181	0.266	0.094	0.301	0.355	0.004	0.188	0.296
0.996	57	1881-1938	0.210	0.231	0.035	0.072	0.326	0.183	0.220	0.242
0.566	58	1877-1935	0.212	0.221	-0.005	0.120	0.139	0.163	0.225	0.235
0.289	48	1881-1929	0.330	0.336	0.668	0.658	0.057	0.047	0.331	0.338
0.353	74	1881-1955	0.274	0.276	0.308	0.275	0.112	0.144	0.284	0.289
0.077	59	1889-1948	0.846	0.844	0.696	0.704	0.127	0.133	1.090	1.094
0.371	62	1886-1948	0.783	0.777	1.73	1.74	0.288	0.305	0.834	0.838
0.624	41	1907-1948	0.354	0.372	0.910	1.44	0.110	0.075	0.344	0.340
0.265	44	1888-1932	0.721	0.723	1.45	1.44	0.089	0.088	0.921	0.921
0.767	73	1881-1954	0.454	0.452	0.933	0.957	0.169	0.179	0.469	0.465
1.62	72	1885-1957	0.497	0.500	1.54	1.54	0.290	0.294	0.473	0.475
1.06	67	1890-1957	0.461	0.463	1.19	1.15	0.212	0.215	0.451	0.458
0.755	62	1886-1948	0.577	0.578	1.42	1.40	0.179	0.189	0.626	0.642
0.455	42	1906-1948	0.361	0.374	0.713	0.715	0.137	0.115	0.356	0.367
0.992	48	1900-1948	0.290	0.298	0.458	0.618	0.051	0.023	0.302	0.305
3.54	51	1904-1955	0.164	0.176	0.618	0.702	0.174	0.105	0.161	0.172
0.235	54	1898-1952	0.218	0.264	0.422	0.798	0.649	0.416	0.218	0.257
0.148	48	1904-1952	0.301	0.352	1.65	1.64	0.638	0.486	0.273	0.317
0.132	52	1903-1955	0.155	0.167	0.119	0.054	0.162	0.099	0.161	0.176
1.17	51	1906-1957	0.242	0.243	0.311	0.488	0.554	0.548	0.246	0.247
2.12	40	1906-1946	0.279	0.282	0.507	0.460	0.339	0.312	0.287	0.293
4.14	37	1918-1955	0.401	0.409	1.54	1.51	-0.017	-0.020	0.355	0.366
4.48	38	1918-1956	0.121	0.119	-0.152	-0.292	0.115	0.078	0.124	0.123

APPENDIX 2

TABLE 2

ANNUAL FLOWS OF 140 RIVER GAUGING STATIONS FROM DIFFERENT PARTS OF THE WORLD

1.	The United States of America	72 stations
2.	Canada	13 stations
3.	Europe	37 stations
4.	Africa, Asia, New Zealand	8 stations
5.	Victoria, Australia	10 stations
	Total	140 stations

UNITED STATES

1.River Piscataquis
near Dover-Foxcroft,
Me., 1902-1956

U	Y
1.042	1.038
0.739	0.762
0.682	0.660
0.904	0.903
1.232	1.248
1.447	1.432
1.011	1.050
0.948	0.909
0.412	0.412
1.224	1.225
1.106	1.106
1.115	1.113
0.890	0.893
0.974	0.974
1.450	1.449
0.964	0.972
1.269	1.260
1.090	1.091
1.013	1.013
1.206	1.206
0.916	0.914
0.831	0.831
0.741	0.744
1.141	1.138
0.876	0.876
1.457	1.462
1.023	1.018
0.814	0.814
0.871	0.872
0.950	0.956
0.980	0.972
0.930	0.930
0.936	0.937
1.241	1.239
1.071	1.072
1.149	1.155
0.869	0.863
0.976	0.978
0.580	0.578
0.883	0.884
0.860	0.859
0.919	0.922
1.116	1.116
0.919	0.918
1.250	1.248
0.710	0.709
0.694	0.695
0.852	0.851
1.343	1.344
1.134	1.132
1.078	1.079
1.052	1.060
1.291	1.284
0.826	0.827

2.Pemigewasset near
Plymouth, N.H.
1903-1956

U	Y
1.009	1.050
0.972	0.939
0.936	0.927
0.819	0.846

River No. 2 cont'd

U	Y
1.316	1.290
0.958	0.967
0.891	0.888
0.746	0.753
1.005	0.998
1.097	1.090
1.023	1.022
0.943	0.948
1.140	1.149
1.081	1.069
0.826	0.847
1.023	1.006
1.220	1.226
0.936	0.927
1.228	1.227
0.833	0.832
1.074	1.081
1.060	1.060
0.943	0.939
0.768	0.766
1.383	1.386
0.972	0.968
0.921	0.920
0.602	0.608
0.928	0.936
0.965	0.951
0.901	0.914
0.929	0.918
1.158	1.155
1.134	1.134
1.157	1.176
1.036	1.018
0.878	0.881
0.677	0.672
0.883	0.889
1.057	1.054
0.917	0.923
1.085	1.084
1.110	1.131
1.129	1.097
0.713	0.712
0.834	0.839
0.924	0.921
1.195	1.200
1.217	1.211
1.126	1.125
1.311	1.322
1.014	1.018
0.994	0.989

3.River Susquehanna,
Harrisburg, Pa.
1890-1957

U	Y
1.522	1.517
1.328	1.326
1.091	1.095
1.129	1.128
0.972	0.966
0.854	0.862
0.987	0.984
1.117	1.113
1.039	1.040
0.813	0.810
1.158	1.163
1.282	1.290

River No. 3 cont'd

U	Y
1.279	1.271
1.120	1.120
0.883	0.884
0.984	0.980
0.914	0.918
1.294	1.291
0.859	0.857
0.845	0.849
0.712	0.715
1.129	1.149
1.001	0.976
1.091	1.090
0.969	0.974
1.294	1.294
0.877	0.875
1.027	1.040
0.932	0.919
0.969	0.976
0.883	0.880
1.048	1.044
0.625	0.627
1.085	1.115
0.703	0.673
0.833	0.847
1.218	1.204
1.473	1.474
0.891	0.890
0.859	0.859
0.584	0.585
0.715	0.713
1.065	1.073
0.650	0.657
0.983	0.970
1.085	1.085
1.074	1.076
0.940	0.946
0.831	0.821
0.927	0.932
0.683	0.678
0.830	0.849
1.278	1.259
0.848	0.850
1.112	1.132
1.243	1.227
1.027	1.024
0.964	0.962
0.855	0.858
1.031	1.032
1.325	1.322
1.148	1.149
1.004	1.003
0.718	0.718
0.820	0.822
1.242	1.248
0.930	0.923

4.Potomac River, near
Point of Rocks, Md.
1896-1957

U	Y
1.267	1.248
1.030	1.031
1.390	1.390
0.689	0.688
1.321	1.330
1.642	1.629

River No. 4 cont'd

U	Y
1.480	1.481
0.710	0.708
0.719	0.721
0.997	0.998
1.496	1.500
1.508	1.507
0.693	0.689
0.835	0.835
0.700	0.703
0.685	0.691
0.854	0.847
1.099	1.098
1.048	1.051
1.120	1.121
0.849	0.846
1.012	1.017
0.904	0.901
1.099	1.102
0.758	0.758
0.879	0.876
0.542	0.544
1.465	1.479
0.745	0.730
0.858	0.863
1.239	1.235
1.293	1.298
0.921	0.917
0.699	0.698
0.530	0.533
0.745	0.743
1.368	1.372
0.523	0.528
1.149	1.143
1.448	1.447
1.365	1.366
0.936	0.936
0.970	0.969
0.981	0.986
0.788	0.784
0.726	0.736
1.452	1.444
0.738	0.739
0.961	0.976
0.951	0.937
0.562	0.561
0.847	0.849
1.423	1.424
0.920	0.926
1.404	1.396
1.186	1.188
1.168	1.167
0.502	0.503
1.223	1.226
0.755	0.757
0.829	0.824

5.River Rappahannock
near Fredericksburg,
Va., 1907-1957

U	Y
1.449	1.452
1.094	1.082
0.794	0.794
0.590	0.592
1.239	1.249
1.034	1.023

River No. 5 cont'd

U	Y
0.764	0.764
1.118	1.129
1.197	1.187
0.902	0.902
1.173	1.173
1.016	1.016
0.950	0.962
1.016	1.004
0.872	0.872
0.746	0.752
1.732	1.885
0.992	0.833
0.770	0.776
1.040	1.035
1.293	1.305
1.004	0.992
0.673	0.672
0.264	0.266
0.559	0.558
1.395	1.399
0.756	0.776
1.230	1.211
1.189	1.187
1.570	1.576
1.049	1.044
0.908	0.907
0.928	0.931
0.866	0.864
0.726	0.741
1.455	1.440
0.660	0.674
1.026	1.030
1.136	1.122
0.643	0.643
1.275	1.280
1.844	1.844
0.912	0.910
1.221	1.216
1.159	1.162
1.136	1.134
0.403	0.403
0.949	0.952
0.479	0.483
0.798	0.791

6.River Roanoke,near
Roanoke, Va.
1899-1957

U	Y
0.940	0.939
2.189	2.214
1.398	1.370
1.587	1.589
0.644	0.641
1.071	1.072
0.895	0.891
1.526	1.532
1.223	1.270
1.443	1.384
0.867	0.893
0.822	0.818
1.458	1.449
0.851	0.844
0.924	0.915
1.236	1.330

The annual flows are expressed in modular coefficients which are the ratios of annual flows to the mean annual flow of a station. Three significant figures are given after the decimal point, taken from the five figures, which were computed by the IBM-704 computer at the U.S. National Bureau of Standards. Data on two series of annual river flows will follow: 1) Series U_i, which is the sequence of the modular coefficients of observed and computed annual flows for water years; 2) Series Y_i, which is the sequence of modular coefficients of annual flows corrected by removing from the individual annual flows the overyear carrying quantity of water. The appendix 1, Table 1, gives the first and the last water year for each station. This locates the data of Table 2 in time.

River No. 6 cont'd

U	Y
1.160	1.081
0.775	0.756
1.126	1.131
1.257	1.250
0.652	0.656
0.812	0.807
1.196	1.196
0.757	0.816
1.084	1.080
0.516	0.462
0.445	0.442
0.922	0.922
1.223	1.243
1.215	1.320
0.793	0.663
0.526	0.526
0.568	0.568
1.139	1.138
0.492	0.494
1.244	1.241
1.257	1.267
1.170	1.162
1.134	1.130
0.762	0.760
1.160	1.161
0.508	0.503
0.579	0.587
1.039	1.030
0.644	0.668
0.856	0.847
1.034	1.018
0.830	0.832
1.362	1.363
1.733	1.731
1.089	1.089
1.034	1.027
0.929	0.929
0.835	0.832
0.461	0.460
0.984	0.985
0.461	0.465
1.162	1.208

7.Chattahoochee River
near Norcross, Ga.
1903-1956

U	Y
0.634	0.630
0.788	0.790
1.373	1.474
1.112	1.016
1.224	1.220
1.355	1.358
0.896	0.898
0.760	0.750
1.350	1.360
0.900	0.899
0.504	0.496
1.030	1.050
1.256	1.242
1.188	1.197
0.729	0.717
1.332	1.332
1.584	1.595
1.076	1.071
1.238	1.231

River No. 7 cont'd

U	Y
1.044	1.044
0.867	0.878
0.667	0.653
0.771	0.774
0.758	0.755
1.028	1.038
1.482	1.531
1.073	1.018
0.657	0.653
1.152	1.159
1.405	1.401
0.788	0.790
0.876	0.873
1.414	1.468
1.200	1.149
0.927	0.928
0.964	0.962
0.658	0.658
0.557	0.554
0.750	0.759
1.086	1.082
1.041	1.046
0.773	0.769
1.508	1.506
0.824	0.821
1.040	1.044
1.652	1.657
0.990	0.985
0.724	0.721
1.125	1.125
0.911	0.915
0.896	0.889
0.648	0.649
0.413	0.413

8.French Broad River
near Asheville, N.C.
1895-1957

U	Y
0.693	0.695
1.021	1.008
0.889	0.912
1.543	1.524
1.187	1.201
1.792	1.850
1.245	1.167
1.411	1.417
0.601	0.592
0.899	0.913
1.411	1.594
1.035	0.855
1.152	1.153
1.387	1.389
0.982	0.981
0.742	0.730
1.084	1.094
1.016	1.015
0.508	0.490
1.402	1.459
1.704	1.644
0.933	0.954
0.801	0.783
1.499	1.498
1.089	1.111
1.109	1.104
1.070	1.045

River No. 8 cont'd

U	Y
0.928	0.937
0.982	1.009
0.640	0.592
0.591	0.602
0.703	0.696
1.236	1.270
1.206	1.303
0.899	0.769
0.659	0.649
0.801	0.820
1.216	1.217
0.801	0.819
1.011	0.983
1.114	1.139
1.206	1.185
0.878	0.877
0.934	0.930
0.773	0.776
0.649	0.631
0.924	0.962
1.149	1.120
0.795	0.806
0.728	0.725
1.143	1.131
0.751	0.741
0.988	1.006
1.525	1.538
1.116	1.102
0.824	0.806
0.996	0.996
0.762	0.766
0.712	0.694
0.675	0.690
0.569	0.567
0.912	0.963

9.Tennessee River
near Chattanooga,Tenn.
1874-1956

U	Y
1.483	1.482
1.280	1.272
0.862	0.856
0.814	0.811
0.906	0.894
1.155	1.176
0.968	0.964
1.586	1.596
1.052	1.034
1.396	1.387
0.767	0.802
1.529	1.506
1.093	1.102
0.954	0.955
1.142	1.154
1.207	1.221
1.388	1.349
1.125	1.130
1.025	1.033
0.738	0.714
0.903	0.902
0.778	0.794
1.196	1.178
0.808	0.825
1.323	1.310
0.811	0.819

River No. 9 cont'd

U	Y
1.307	1.319
1.150	1.146
1.180	1.154
0.594	0.594
0.838	0.844
1.025	1.142
1.177	1.078
1.092	1.075
1.348	1.358
0.800	0.802
0.846	0.838
1.161	1.169
0.976	0.959
0.607	0.602
0.938	0.946
1.212	1.218
1.199	1.207
0.781	0.768
1.093	1.082
1.337	1.351
0.998	0.997
1.188	1.175
1.150	1.153
0.930	0.956
0.602	0.565
0.710	0.714
1.172	1.171
1.158	1.172
1.315	1.321
0.865	0.849
0.616	0.607
0.989	1.000
1.174	1.173
0.731	0.737
0.998	0.980
1.024	1.050
0.998	0.988
0.969	0.978
0.885	0.883
0.533	0.545
0.533	0.514
0.566	0.609
1.043	1.022
0.894	0.906
0.881	0.883
1.118	1.121
0.917	0.891
0.825	0.840
1.150	1.192
1.274	1.261
0.993	0.970
0.961	0.941
0.751	0.738
0.710	0.708
0.793	0.818
0.630	0.650

10.Little Wabash River
near Wilcox, Ill.,
1914-1957

U	Y
1.410	1.412
1.188	1.186
0.816	0.816
1.122	1.124
1.003	1.000

River No. 10 cont'd

U	Y
1.388	1.388
0.546	0.547
1.288	1.277
0.765	0.767
0.913	0.912
0.385	0.384
0.831	0.847
1.699	1.687
1.333	1.329
1.666	1.666
1.155	1.155
0.222	0.222
0.946	0.948
1.544	1.542
0.222	0.243
1.395	1.373
0.389	0.389
1.043	1.043
1.058	1.057
0.905	0.905
0.331	0.331
0.201	0.201
1.153	1.153
1.425	1.424
0.503	0.504
1.575	1.615
1.268	1.228
0.944	0.944
0.995	0.994
1.527	1.527
2.266	2.266
1.147	1.146
1.013	1.012
0.318	0.317
0.325	0.326
0.435	0.451
0.644	0.628
1.708	1.708

11.Kentucky River near
Winchester,Ky
1907-1956

U	Y
1.071	1.069
1.016	1.016
0.903	0.906
0.956	0.954
1.328	1.328
0.957	0.955
0.662	0.664
0.914	0.965
1.363	1.311
1.248	1.250
0.820	0.818
0.766	0.765
1.547	1.550
0.658	0.660
1.140	1.135
1.107	1.108
1.148	1.175
0.801	0.774
0.894	0.913
1.765	1.749
1.060	1.060
1.211	1.212

River No. 11 cont'd

U	Y
0.590	0.587
0.427	0.430
1.034	1.032
0.988	0.989
0.676	0.687
1.540	1.529
0.921	0.910
1.078	1.078
0.965	0.967
1.296	1.296
0.546	0.547
0.385	0.382
0.726	0.733
1.254	1.248
0.765	0.767
0.940	0.939
0.994	0.995
0.992	0.992
0.956	0.954
0.929	0.930
1.454	1.457
1.278	1.278
1.366	1.364
0.846	0.845
0.390	0.392
1.162	1.160
1.166	1.166

12.Kanawha River, near
Kanawha Fall, W.Va.
1877-1957

U	Y
1.361	1.370
1.054	1.044
0.869	0.894
0.826	0.824
1.353	1.367
0.960	0.946
1.298	1.294
0.742	0.742
1.432	1.434
1.054	1.065
0.834	0.832
1.424	1.436
1.306	1.296
1.550	1.540
1.117	1.117
1.030	1.039
0.842	0.830
0.928	0.927
0.912	0.957
1.290	1.246
0.960	0.967
1.424	1.418
0.802	0.801
1.668	1.688
1.180	1.161
1.093	1.091
0.597	0.596
0.810	0.812
1.006	1.034
1.440	1.421
1.306	1.299
1.015	1.014
0.810	0.813
0.834	0.830
1.062	1.067
0.905	0.900
0.881	0.877
0.873	0.923
1.172	1.144
0.960	0.938
0.936	0.940
1.188	1.184

River No. 12 cont'd

U	Y
1.030	1.043
0.706	0.692
1.038	1.037
0.881	0.883
1.054	1.107
0.672	0.616
0.707	0.712
1.180	1.177
0.999	1.010
0.975	1.022
0.742	0.682
0.621	0.627
0.857	0.853
0.983	0.982
0.615	0.629
1.273	1.261
1.089	1.098
0.903	0.894
1.036	1.038
0.805	0.800
0.872	0.876
0.557	0.552
0.668	0.705
1.086	1.070
0.739	0.753
0.964	0.970
0.949	0.927
0.668	0.669
0.971	0.973
1.192	1.198
1.120	1.115
1.009	1.004
0.876	0.875
1.512	1.512
0.682	0.682
1.015	1.014
0.772	0.785
1.038	1.034

13.Tygart River, near
Belington, W.Va.
1907-1957

U	Y
1.440	1.433
0.689	0.692
0.984	0.985
1.010	1.061
1.315	1.266
0.969	0.967
1.187	1.183
0.679	0.682
1.129	1.136
1.020	1.012
1.018	1.020
0.819	0.818
1.133	1.141
0.715	0.710
1.166	1.161
0.882	0.884
1.340	1.373
0.760	0.727
1.098	1.138
1.502	1.461
1.247	1.251
0.997	0.992
0.735	0.734
0.717	0.724
1.020	1.014
1.142	1.146
0.774	0.782
1.231	1.221
1.151	1.150
1.018	1.019
1.093	1.094

River No. 13 cont'd

U	Y
0.970	0.969
0.851	0.857
0.645	0.640
0.795	0.803
1.174	1.167
0.871	0.878
1.104	1.104
0.906	0.900
0.696	0.697
1.025	1.030
1.067	1.069
1.298	1.296
1.148	1.144
0.880	0.880
0.801	0.801
0.676	0.678
1.010	1.009
1.184	1.190
0.913	0.908

14.Allegheny River, near
Red House, N.Y.
1903-1956

U	Y
1.258	1.271
0.842	0.826
0.810	0.817
1.070	1.064
1.280	1.278
1.020	1.021
1.088	1.090
1.080	1.130
1.080	1.052
1.191	1.168
0.927	0.926
0.902	0.906
1.487	1.484
1.034	1.035
1.020	1.028
0.977	0.969
0.767	0.776
0.767	0.765
0.970	0.961
0.706	0.705
0.927	0.979
0.728	0.679
0.916	0.926
1.163	1.149
1.287	1.288
1.227	1.227
0.956	0.954
0.636	0.636
0.934	0.934
0.799	0.800
0.663	0.664
0.836	0.835
0.917	0.912
1.210	1.211
0.950	0.954
0.788	0.789
1.046	1.044
0.734	0.729
1.052	1.067
1.422	1.408
0.772	0.777
1.264	1.361
1.113	1.016
1.255	1.253
1.031	1.028
0.754	0.755
0.994	0.994
1.287	1.286
1.146	1.146
0.910	0.910

River No. 14 cont'd

U	Y
0.787	0.788
0.752	0.751
1.468	1.473

15.St.Regis River,near
Brasher Center, N.Y.
1910-1946

U	Y
1.087	1.096
1.218	1.241
1.293	1.263
0.946	0.946
0.710	0.717
1.012	1.014
0.778	0.774
1.040	1.056
1.218	1.202
0.975	1.009
0.901	0.859
1.051	1.050
0.794	0.797
0.984	1.074
1.087	1.012
1.284	1.278
0.918	0.907
1.406	1.414
1.162	1.159
1.190	1.187
0.604	0.610
1.096	1.094
1.012	1.008
0.763	0.760
0.910	0.922
0.927	0.961
1.297	1.257
0.942	0.957
0.855	0.853
0.738	0.722
0.544	0.538
0.782	0.806
1.123	1.109
0.837	0.846
0.938	1.012
0.923	0.842
1.766	1.767
0.863	0.852
0.883	0.895
0.877	0.875
1.082	1.079
0.813	0.810
0.985	0.988
1.223	1.313
1.280	1.192
0.880	0.877

16.St.Lawrence(Main Stem)
near Ogdensburg, N.Y.
1860-1957

U	Y
1.142	1.269
1.179	1.109
1.134	0.935
1.104	0.922
1.104	1.262
1.021	0.938
1.129	1.183
1.005	0.816
1.034	1.333
1.158	1.303
1.075	0.901

River No. 16 cont'd

U	Y
0.930	0.830
0.984	1.214
1.084	1.076
0.959	0.956
1.092	1.430
1.046	0.718
1.046	1.000
1.075	0.817
1.013	1.216
0.963	1.002
1.063	1.203
1.042	1.129
1.121	0.988
1.050	1.278
1.154	1.070
1.117	0.973
1.001	0.990
1.021	0.900
1.088	1.122
1.075	0.769
0.951	1.073
1.005	1.074
1.005	1.071
0.897	0.663
0.884	0.876
0.905	0.800
0.947	1.201
0.947	1.086
0.938	0.949
0.942	0.893
0.947	0.908
1.005	1.164
1.013	1.125
0.988	0.990
1.001	0.879
1.013	1.135
1.088	1.006
1.000	0.830
0.959	0.843
0.909	0.803
0.951	1.252
1.071	1.158
1.001	0.877
0.918	0.796
0.996	1.303
1.001	0.938
1.026	1.075
1.042	0.943
0.938	0.930
0.972	0.839
0.951	0.996
0.901	0.683
0.918	0.916
0.889	0.550
0.864	0.976
0.938	1.223
0.988	1.335
1.059	1.250
1.092	0.827
0.905	0.473
0.905	0.915
0.864	0.820
0.781	0.698
0.760	0.862
0.797	0.850
0.889	0.952
0.905	1.129
0.897	0.962
0.872	0.729
0.884	0.831
0.889	1.125
1.030	1.404
1.026	0.864
1.005	1.079
1.067	0.907
1.067	1.298
1.071	0.793
1.001	0.792

River No. 16 cont'd

U	Y
0.980	1.288
1.121	1.460
1.142	1.261
1.075	0.905
1.055	0.997
1.063	0.852
1.071	1.008
1.001	0.856

17.Wolf River near
New London, Wisc.
1896-1957

U	Y
0.784	0.780
0.610	0.621
0.773	0.764
0.606	0.656
1.149	1.119
0.790	0.776
0.906	0.942
0.957	0.956
1.090	1.080
1.200	1.194
1.213	1.219
0.826	0.787
0.748	0.760
0.619	0.635
0.617	0.634
1.664	1.702
1.428	1.410
1.113	1.090
1.042	1.043
1.382	1.409
1.241	1.193
1.048	1.053
1.206	1.210
1.212	1.202
1.007	1.011
1.376	1.382
1.072	1.062
1.206	1.235
0.790	0.760
1.031	1.090
1.183	1.141
1.276	1.323
1.593	1.529
0.738	0.720
0.506	0.525
0.814	0.792
0.703	0.703
0.566	0.589
1.099	1.099
0.847	0.843
0.922	0.905
1.218	1.300
1.230	1.176
0.956	0.960
1.174	1.214
1.645	1.667
1.445	1.378
0.870	0.859
1.002	1.015
1.185	1.175
1.883	0.889
0.724	0.692
0.666	0.669
0.860	0.875
1.002	1.024
1.236	1.210
0.909	0.907
0.741	0.766
0.935	0.906

River No. 17 cont'd

U	Y
0.774	0.777
0.590	0.593

18.Fox River, near
Berlin, Wisc.
1898-1957

U	Y
0.712	0.717
0.641	0.656
0.857	0.850
0.713	0.726
0.970	1.040
1.087	1.038
1.414	1.407
1.250	1.236
1.142	1.181
1.051	0.981
0.854	0.863
0.736	0.748
0.763	0.782
1.314	1.407
1.223	1.134
0.829	0.821
0.988	1.092
1.377	1.292
1.396	1.387
1.241	1.203
0.988	1.002
1.115	1.111
0.898	0.902
1.368	1.386
0.997	0.954
1.142	1.231
0.844	0.787
0.942	0.979
1.106	1.111
1.214	1.197
1.468	1.458
0.915	0.891
0.609	0.629
0.734	0.695
0.747	0.766
0.574	0.574
1.039	1.043
0.789	0.783
0.864	0.860
1.398	1.724
1.244	0.911
0.988	1.036
1.066	1.046
1.141	1.217
1.114	1.013
0.836	0.864
0.969	1.041
1.179	1.103
1.039	1.036
0.879	0.852
0.705	0.696
0.806	0.808
1.088	1.136
1.179	1.149
1.050	1.051
0.739	0.827
1.025	0.932
0.907	0.925
0.734	0.711

19.Rock River, near
Afton, Wisc.
1914-1956

U	Y
1.342	1.399
1.685	1.566
1.462	1.464
1.394	1.385
0.605	0.630
1.262	1.246
0.902	0.960
1.548	1.500
1.028	1.023
1.154	1.177
0.662	0.638
0.731	0.778
1.217	1.206
1.274	1.249
1.759	1.769
0.845	0.839
0.344	0.344
0.754	0.745
0.992	1.002
0.339	0.336
0.834	0.836
0.531	0.540
0.921	0.913
1.238	1.436
1.177	0.981
0.560	0.575
0.848	0.858
0.795	0.808
1.318	1.300
0.817	0.816
0.668	0.694
1.097	1.077
0.797	0.801
0.956	0.947
0.613	0.612
1.084	1.126
1.227	1.212
1.776	1.775
1.012	1.002
0.641	0.661
1.088	1.072
0.700	0.701

20.Sangamon River, near
Monticello, Ill.
1914-1957

U	Y
0.650	0.672
0.928	0.908
0.575	0.575
0.802	0.805
0.930	0.927
1.044	1.043
0.492	0.503
1.560	1.549
0.875	0.884
1.825	1.821
0.678	0.674
1.447	1.570
2.798	2.772
1.502	1.407
1.729	1.728
0.976	0.974
0.189	0.197
0.451	0.443
1.081	1.089
0.171	0.170
1.122	1.117
0.655	0.661
1.162	1.158
1.220	1.219

River No. 20 cont'd

U	Y
1.212	1.212
0.335	0.334
0.358	0.360
1.596	1.599
1.787	1.784
1.011	1.010
0.602	0.649
1.210	1.163
0.966	0.966
0.842	0.842
0.910	0.910
2.012	2.014
1.316	1.317
1.245	1.241
0.439	0.437
0.174	0.174
0.436	0.437
0.663	0.663
1.021	1.021

21.Mississippi River,
near Keokuk, Iowa
1878-1957

U	Y
0.810	0.806
1.237	1.262
1.300	1.327
2.076	2.030
1.353	1.354
1.139	1.187
1.467	1.435
1.128	1.115
0.879	0.874
1.365	1.362
0.697	0.694
0.825	0.831
0.820	0.810
1.282	1.290
1.039	1.033
0.794	0.793
0.510	0.511
0.728	0.731
1.148	1.150
0.696	0.691
0.908	0.914
0.777	0.798
0.993	0.968
0.899	0.913
1.420	1.489
1.206	1.136
1.325	1.340
1.434	1.428
1.320	1.326
1.257	1.232
1.106	1.111
0.812	0.807
0.581	0.602
1.181	1.168
0.885	0.878
0.809	0.820
1.137	1.168
1.442	1.405
1.013	1.005
0.839	0.838
1.075	1.116
1.168	1.130
0.757	0.770
0.976	0.960
0.637	0.645
0.834	0.833
0.612	0.605
0.742	0.802
1.231	1.193

River No. 21 cont'd

U	Y
1.040	1.048
1.320	1.292
0.668	0.667
0.404	0.409
0.841	0.834
0.694	0.694
0.352	0.353
0.936	0.941
0.779	0.782
0.816	0.807
1.070	1.132
0.959	0.897
0.569	0.572
0.893	0.940
1.238	1.262
1.360	1.295
1.227	1.227
1.157	1.186
1.128	1.104
1.256	1.250
0.847	0.840
0.722	0.722
1.013	1.024
1.359	1.375
1.467	1.447
1.053	1.051
0.891	0.900
0.892	0.886
0.684	0.678
0.689	0.695

22.Cedar River, near
Cedar Rapids, Iowa
1903-1957

U	Y
0.889	0.829
1.070	1.082
1.251	1.289
1.488	1.487
1.155	1.115
1.346	1.354
1.083	1.074
0.428	0.479
1.175	1.137
0.793	0.785
0.553	0.567
1.807	1.918
1.462	1.346
1.010	1.014
1.050	1.057
1.455	1.458
1.148	1.158
0.948	0.971
0.879	0.840
0.530	0.554
1.066	1.093
0.573	0.534
0.622	0.659
1.044	1.024
1.076	1.081
1.745	1.725
0.589	0.581
0.262	0.287
1.284	1.265
0.869	0.863
0.227	0.238
0.846	0.839
0.842	0.872
1.099	1.071
0.895	0.945
0.771	0.718
0.376	0.388
0.992	1.018

River No. 22 cont'd

U	Y
1.715	1.739
1.197	1.156
1.207	1.211
1.541	1.554
1.174	1.179
1.786	1.764
0.884	0.877
0.688	0.686
0.874	0.888
2.091	2.114
1.323	1.297
0.806	0.806
0.728	0.744
0.602	0.584
0.295	0.294
0.387	0.392

23.
Red of the North River, near Grand Forks, N.D.
1901-1957

U	Y
1.393	1.386
1.273	1.277
2.101	2.098
1.539	1.606
2.097	2.039
1.608	1.612
1.386	1.364
1.056	1.073
1.235	1.174
0.320	0.318
0.328	0.390
0.591	0.546
0.740	0.755
1.253	1.265
2.441	2.476
1.184	1.113
0.420	0.411
0.916	0.952
1.338	1.337
0.686	0.659
0.973	0.966
0.583	0.582
0.320	0.318
0.548	0.547
0.534	0.532
1.998	2.025
0.784	0.799
0.758	0.708
0.539	0.528
0.154	0.148
0.273	0.272
0.176	0.176
0.107	0.106
0.192	0.197
0.259	0.254
0.259	0.287
0.392	0.374
0.254	0.260
0.334	0.329
0.698	0.778
1.012	0.992
1.790	1.776
1.191	1.215
1.588	1.572
1.158	1.147
1.897	1.900
1.494	1.464
0.929	0.936
3.321	3.456
1.612	1.488

River No. 23 cont'd

U	Y
1.608	1.601
1.036	1.029
0.774	0.770
0.662	0.662
0.850	0.848
1.041	1.103

24. Missouri River, near Fort Benton, Mont.
1890-1955

U	Y
1.080	1.102
1.288	1.294
1.170	1.174
1.549	1.548
0.982	0.975
1.124	1.146
1.109	1.077
1.254	1.258
1.392	1.397
1.011	1.007
0.911	0.904
0.853	0.840
0.939	0.953
1.092	1.086
0.666	0.647
0.784	0.806
1.362	1.378
1.505	1.511
1.369	1.368
1.084	1.060
0.987	0.992
1.204	1.218
1.382	1.370
1.144	1.139
1.183	1.204
1.481	1.475
1.486	1.483
1.008	1.009
0.664	0.625
0.985	1.009
1.032	1.031
1.088	1.085
1.003	0.989
0.846	0.857
1.020	1.057
0.956	0.928
1.414	1.429
1.298	1.287
0.901	0.896
0.720	0.712
0.543	0.526
0.700	0.720
0.771	0.760
0.648	0.640
0.564	0.581
0.597	0.596
0.474	0.466
0.787	0.780
0.715	0.726
0.566	0.561
0.536	0.553
1.045	1.037
1.242	1.245
0.895	0.892
0.786	0.786
0.777	0.781
1.159	1.169
1.404	1.394
0.879	0.866
0.950	0.963

River No. 24 cont'd

U	Y
1.126	1.130
1.084	1.073
1.009	0.999
0.684	0.689
0.727	0.738

25. Yellowstone River, near Corwin Spring, Mont.
1910-1955

U	Y
1.236	1.265
1.065	1.071
1.400	1.400
1.038	1.043
0.874	0.868
1.232	1.248
1.296	1.315
1.326	1.304
0.700	0.636
1.011	1.061
1.051	1.025
0.884	0.888
0.881	0.891
0.786	0.771
1.336	1.394
0.907	0.846
1.252	1.306
1.400	1.361
0.887	0.874
0.867	0.867
0.686	0.657
0.954	0.973
0.847	0.830
0.636	0.632
0.870	0.889
0.902	0.890
0.705	0.710
1.055	1.073
0.926	0.908
0.782	0.790
0.698	0.760
0.981	0.918
1.380	1.419
0.837	0.810
0.967	1.014
0.990	0.931
1.133	1.182
1.120	1.090
1.016	1.021
1.110	1.141
1.267	1.257
1.193	1.158
0.902	0.896
1.067	1.080
0.545	0.534

26. Middle Boulder Creek, near Nederland, Colo.
1907-1957

U	Y
0.834	0.832
1.328	1.334
0.686	0.674
0.890	0.899
1.238	1.234
0.776	0.801
1.319	1.296

River No. 26 cont'd

U	Y
1.017	1.028
0.849	0.835
1.035	1.027
1.377	1.392
0.789	0.772
1.179	1.185
1.418	1.411
0.740	0.739
1.211	1.226
1.115	1.106
0.668	0.673
1.412	1.405
1.052	1.066
1.136	1.131
1.000	1.006
0.933	0.920
0.690	0.685
0.858	0.854
0.964	0.970
0.601	0.597
1.046	1.046
1.158	1.169
0.845	0.840
1.227	1.229
0.798	0.788
0.791	0.813
0.940	0.930
1.022	1.008
0.996	1.000
0.869	0.877
1.115	1.120
0.763	0.750
1.220	1.238
0.843	0.826
1.226	1.227
0.761	0.759
1.203	1.200
1.349	1.347
0.946	0.944
0.489	0.511
0.750	0.726
0.976	0.976
1.552	1.573

27. Missouri River, near Sioux City, Iowa
1897-1955

U	Y
1.186	1.187
1.370	1.377
0.998	0.989
1.052	1.101
0.882	0.848
1.022	1.082
1.105	1.034
0.832	0.796
1.129	1.267
1.417	1.338
1.358	1.330
1.474	1.524
0.990	0.902
0.882	0.987
1.290	1.314
1.260	1.214
1.129	1.094
1.343	1.428
1.400	1.293
1.367	1.383
1.150	1.131
0.582	0.504
1.159	1.209

River No. 27 cont'd

U	Y
0.972	0.962
0.960	0.959
1.090	1.150
1.245	1.192
1.108	1.098
0.894	0.963
1.507	1.540
1.266	1.196
1.037	0.991
0.758	0.789
0.466	0.408
0.793	0.808
0.734	0.781
0.475	0.404
0.591	0.608
0.565	0.568
0.603	0.589
0.764	0.858
0.753	0.670
0.462	0.487
0.592	0.642
0.869	0.860
1.040	1.067
1.179	1.168
0.905	0.883
0.741	0.778
1.126	1.136
1.143	1.131
1.031	1.027
1.091	1.103
1.124	1.207
1.404	1.300
0.930	0.949
0.739	0.726
0.661	0.671

28. Osage River, near Bagnell, Mo.
1880-1930

U	Y
0.428	0.430
1.260	1.261
0.696	0.692
0.775	0.800
1.910	1.897
0.473	0.465
0.201	0.199
0.587	0.588
1.290	1.294
0.868	0.875
1.229	1.215
1.494	1.496
0.945	0.949
0.498	0.495
0.586	0.586
1.473	1.474
1.026	1.021
1.057	1.066
0.880	0.870
0.453	0.473
0.604	0.590
0.817	0.828
1.351	1.338
1.768	1.769
1.026	1.036
0.916	0.916
0.938	0.933
1.412	1.416
1.199	1.188
1.077	1.080
0.483	0.482

River No. 28 cont'd

U	Y
1.280	1.278
0.569	0.569
0.636	0.639
2.083	2.101
1.605	1.583
0.292	0.299
0.226	0.219
0.723	0.723
1.005	1.020
1.250	1.244
1.443	1.433
0.560	0.562
1.199	1.200
0.656	0.673
0.736	0.735
2.499	2.491
1.382	1.372
1.737	1.736
0.398	0.399

29.Mississippi River, near St. Louis, Mo.
1861-1957

U	Y
1.150	1.168
0.708	0.660
0.502	0.476
0.927	1.031
1.074	1.102
1.341	1.279
0.712	0.697
1.180	1.298
0.945	0.840
0.787	0.734
0.781	0.820
1.020	1.022
0.724	0.751
1.067	1.115
1.427	1.454
1.159	1.075
1.187	1.199
0.784	0.764
0.969	1.002
1.325	1.415
1.742	1.635
1.348	1.346
1.148	1.232
1.365	1.346
1.070	0.983
0.829	0.839
1.249	1.241
0.689	0.671
0.773	0.799
0.899	0.879
1.505	1.519
1.058	1.020
0.638	0.636
0.465	0.492
0.830	0.847
1.132	1.108
0.898	0.922
0.976	0.963
0.726	0.769
0.760	0.701
0.871	0.996
1.491	1.536
1.280	1.153
1.038	1.126
1.109	1.029
1.185	1.198
1.290	1.248

River No. 29 cont'd

U	Y
1.165	1.179
0.950	0.940
0.545	0.545
1.186	1.209
0.833	0.796
0.692	0.757
1.462	1.540
1.440	1.303
0.960	0.952
0.714	0.723
0.982	1.005
1.264	1.265
0.852	0.888
1.146	1.080
0.758	0.798
1.067	1.087
0.858	0.830
0.962	1.194
1.853	1.682
1.166	1.146
1.511	1.438
0.715	0.708
0.450	0.462
0.912	0.896
0.780	0.780
0.386	0.387
1.071	1.072
0.649	0.665
0.838	0.795
0.895	0.999
0.845	0.737
0.452	0.472
0.685	0.748
1.349	1.370
1.340	1.285
1.194	1.218
1.274	1.291
0.989	0.972
1.356	1.330
0.930	0.917
0.970	1.004
1.136	1.134
1.512	1.627
1.332	1.194
0.806	0.797
0.648	0.696
0.744	0.680
0.537	0.532
0.703	0.735

30.Current River, near Van Burean, Mo.
1912-1957

U	Y
0.546	0.549
0.732	0.760
1.421	1.428
1.193	1.174
0.650	0.624
0.857	0.895
0.682	0.668
1.188	1.236
1.209	1.208
1.230	1.185
1.183	1.184
0.679	0.670
0.527	0.527
0.764	0.737
1.931	2.012
1.618	1.606
1.305	1.292

River No. 30 cont'd

U	Y
0.854	0.826
0.690	0.665
0.557	0.530
1.040	1.085
0.460	0.441
1.212	1.244
0.504	0.484
0.996	0.976
1.087	1.100
0.973	0.959
0.627	0.620
0.560	0.585
1.064	1.066
1.246	1.238
0.682	0.667
1.705	1.771
1.363	1.348
1.158	1.134
0.919	0.898
1.359	1.432
1.893	1.872
1.344	1.368
1.445	1.388
0.638	0.606
0.424	0.410
0.623	0.620
0.540	0.534
1.322	1.364

31.Petit Jean Creek,near Danville, Ark.
1916-1957

U	Y
0.563	0.563
0.314	0.318
0.712	0.710
1.310	1.310
0.786	0.788
0.850	0.846
1.264	1.265
0.768	0.766
0.226	0.240
0.744	0.737
2.301	2.368
1.147	1.073
1.112	1.112
0.915	0.915
0.619	0.619
1.025	1.024
0.846	0.847
0.526	0.548
2.326	2.303
0.238	0.241
1.159	1.157
1.503	1.502
1.162	1.162
0.224	0.224
0.642	0.644
1.055	1.053
0.691	0.691
1.019	1.019
2.408	2.454
1.338	1.292
0.763	0.763
1.006	1.006
1.262	1.263
1.748	1.749
0.644	0.646
1.319	1.316
1.364	1.364
0.317	0.317

River No. 31 cont'd

U	Y
0.643	0.643
0.261	0.261
1.878	1.880

32.Sabine River, near Logansport, La.
1903-1957

U	Y
0.367	0.366
1.928	1.930
1.309	1.309
0.889	0.886
1.325	1.328
0.240	0.238
0.325	0.324
0.204	0.206
0.763	0.766
0.534	0.538
1.447	1.444
1.527	1.530
0.758	0.754
0.313	0.314
0.262	0.262
0.974	0.982
1.836	1.830
1.184	1.182
1.187	1.186
0.735	0.741
1.074	1.070
0.129	0.126
1.102	1.102
1.129	1.131
0.556	0.555
1.093	1.093
0.935	0.934
0.558	0.558
1.645	1.646
1.072	1.074
0.750	0.746
1.116	1.120
0.352	0.348
0.708	0.710
1.323	1.322
0.556	0.555
0.545	0.549
2.044	2.050
1.601	1.596
0.720	0.716
1.753	1.754
2.514	2.516
2.154	2.154
1.392	1.392
1.179	1.176
0.789	0.792
1.772	1.780
0.433	0.422
0.759	0.758
1.212	1.215
0.425	0.422
0.693	0.700
0.314	0.307
1.493	1.497

33.Neches River,near Rockland, Tex.
1903-1957

U	Y
0.359	0.357
1.649	1.650
0.895	0.901
0.956	0.952
1.954	1.956
0.263	0.258
0.443	0.443
0.273	0.274
0.999	1.000
0.482	0.489
1.347	1.342
1.132	1.133
0.938	0.936
0.248	0.246
0.170	0.170
1.055	1.065
1.446	1.439
1.511	1.508
1.795	1.794
1.214	1.217
1.804	1.802
0.098	0.097
1.498	1.498
1.300	1.299
0.366	0.366
1.102	1.103
0.809	0.809
0.887	0.886
1.520	1.521
0.831	0.831
0.921	0.921
1.492	1.493
0.617	0.616
0.552	0.552
0.832	0.832
0.508	0.508
0.651	0.652
2.128	2.136
1.500	1.496
0.445	0.440
1.916	1.918
2.022	2.022
2.102	2.106
1.936	1.933
0.741	0.738
0.697	0.699
1.679	1.682
0.234	0.231
0.531	0.529
1.210	1.210
0.320	0.319
0.578	0.579
0.198	0.197
0.842	0.844

34.Little River,near Cameron, Texas
1917-1957

U	Y
0.210	0.213
1.695	1.710
2.119	2.114
2.016	2.014
1.775	1.765
0.456	0.457
1.151	1.150
0.102	0.103
1.426	1.425
0.790	0.791
0.460	0.460

River No. 34 cont'd

U	Y
0.779	0.779
0.601	0.601
1.025	1.024
1.014	1.016
0.373	0.371
0.506	0.506
1.325	1.385
1.610	1.727
1.511	1.362
1.849	1.850
0.279	0.277
0.751	0.752
3.359	3.361
1.523	1.526
0.582	0.578
1.874	1.876
1.935	1.963
1.232	1.212
1.059	1.050
0.224	0.223
0.545	0.544
0.306	0.307
0.109	0.108
0.214	0.213
0.435	0.435
0.322	0.322
0.354	0.355
0.113	0.113
1.960	1.962

35.Brazos River, near
Waco, Texas
1898-1941

U	Y
0.795	0.785
1.759	1.845
0.482	0.389
0.890	0.922
0.835	0.847
0.486	0.442
1.369	1.379
0.865	0.856
0.530	0.510
1.829	1.821
0.245	0.242
0.308	0.306
0.379	0.380
0.333	0.332
0.353	0.363
2.650	2.630
2.035	2.060
0.960	0.920
0.210	0.214
0.375	0.372
2.263	2.271
2.422	2.406
0.699	0.686
1.487	1.479
0.559	0.557
1.001	1.004
0.537	0.554
1.064	1.082
0.894	0.893
0.747	0.692
0.662	0.665
0.798	0.792
0.949	0.943
1.708	1.711
0.637	0.626
0.354	0.353
1.557	1.561
1.010	1.138
0.756	0.609
1.358	1.353

River No. 35 cont'd

U	Y
0.455	0.453
0.606	0.608
2.786	2.946

36.North Llano River
near Junction, Tex.
1915-1957

U	Y
0.372	0.308
0.151	0.150
1.217	1.220
2.021	2.139
1.035	0.964
0.277	0.236
0.833	0.835
1.012	1.025
2.446	2.452
2.299	2.296
0.472	0.463
0.151	0.687
1.479	0.971
0.187	0.162
0.151	0.150
1.582	1.584
3.559	3.618
1.069	1.019
0.205	0.203
3.969	4.030
3.149	3.189
0.625	0.542
4.364	4.393
1.084	1.064
0.593	0.597
0.669	0.679
0.893	0.913
0.599	0.598
0.589	0.563
0.291	0.284
0.124	0.128
0.385	0.384
1.314	1.331
0.507	0.504
0.313	0.305
0.164	0.160
0.114	0.113
0.069	0.069
0.012	0.012
0.184	0.210
0.120	0.095
1.349	1.356

37.Colorado River,near
Bellinger, Tex.
1907-1957

U	Y
2.522	2.521
0.246	0.248
0.496	0.497
1.020	1.019
0.689	0.688
1.655	1.665
2.771	2.760
1.090	1.102
0.178	0.168
0.238	0.236
0.292	0.292
2.670	2.674
1.706	1.704
0.325	0.323

River No. 37 cont'd

U	Y
1.968	1.968
1.007	1.007
0.750	0.751
1.340	1.347
1.360	1.354
0.651	0.684
1.541	1.507
0.666	0.666
1.065	1.064
0.437	0.437
2.464	2.477
0.336	0.322
0.204	0.205
2.756	2.761
1.617	1.639
0.425	0.398
0.961	0.959
1.098	1.100
0.547	0.545
1.820	1.920
0.925	0.828
0.243	0.240
0.483	0.483
0.814	0.840
0.437	0.413
0.979	0.976
1.009	1.011
0.793	0.792
0.423	0.434
0.302	0.300
0.080	0.081
0.430	0.429
1.182	1.182
0.763	0.796
0.085	0.051
2.128	2.130

38.Pecos River, near
Anton Chico, N. Mex.
1911-1957

U	Y
1.301	1.299
0.844	0.850
1.163	1.164
1.765	1.758
1.904	1.904
0.985	0.976
0.550	0.550
3.004	3.029
1.207	1.176
1.422	1.420
0.439	0.452
0.097	0.083
1.195	1.207
0.212	0.198
2.148	2.165
0.797	0.775
0.602	0.601
0.966	0.990
1.181	1.155
1.177	1.236
1.253	1.221
0.601	0.642
0.187	0.124
1.052	1.041
0.577	0.580
1.668	1.677
0.602	0.598
0.782	0.780
0.748	0.745
3.385	3.382
2.620	2.521
0.577	0.769

River No. 38 cont'd

U	Y
0.720	0.525
0.955	0.950
0.433	0.427
0.445	0.444
0.789	0.794
1.350	1.339
0.362	0.364
0.253	0.279
0.907	0.880
0.438	0.435
0.343	0.348
0.858	0.853
0.190	0.196
1.045	1.094

39.Little Beaver Creek
near Pikes Peak,Colo.
1909-1957

U	Y
1.510	1.433
0.995	1.058
0.853	0.810
0.729	0.796
2.008	1.995
1.510	1.508
0.480	0.439
0.729	0.800
0.871	1.123
1.137	0.824
0.835	0.918
1.457	1.467
0.640	0.556
1.262	1.418
1.137	0.947
0.409	0.470
1.191	1.160
0.872	0.830
0.800	0.732
1.635	1.899
0.924	0.738
0.746	0.668
0.498	0.499
1.297	1.412
0.586	0.439
1.031	1.170
1.137	1.182
0.586	0.452
1.155	1.333
0.764	0.552
0.391	0.410
1.422	1.522
1.457	1.447
0.746	0.680
1.191	1.195
1.155	1.250
0.729	0.769
2.381	2.416
1.351	1.195
0.658	0.623
0.249	0.191
0.390	0.434
1.084	1.094
0.498	0.481
0.266	0.252
0.835	0.960
1.155	1.036
2.346	2.413

River No.40.
Arkansas River,
near Salida,Colo.
1909-1956

U	Y
1.011	0.990
1.162	1.219
1.181	1.146
0.923	0.929
1.283	1.292
0.884	0.861
1.315	1.337
1.308	1.286
1.222	1.252
1.021	1.015
1.283	1.273
1.210	1.224
1.181	1.155
1.188	1.240
1.218	1.157
0.838	0.863
1.043	1.017
1.133	1.182
1.130	1.098
1.130	1.194
0.997	0.930
0.561	0.530
0.878	0.897
0.795	0.788
0.581	0.580
0.890	0.918
1.183	1.193
0.768	0.733
0.948	0.996
0.856	0.806
0.516	0.520
0.838	0.861
1.036	1.027
1.088	1.113
0.877	0.854
0.800	0.834
0.863	0.816
1.150	1.212
1.170	1.124
1.189	1.211
0.843	0.815
0.965	0.981
1.330	1.350
1.002	0.978
0.649	0.641
0.678	0.693
0.878	0.866

41.Fraser River,near
Winter Park, Colo.
1910-1957

U	Y
1.074	1.136
1.372	1.353
0.894	0.931
1.520	1.493
1.390	1.366
1.074	1.075
1.087	1.066
1.506	1.537
0.826	0.809
1.030	1.029
1.343	1.338
0.877	0.856
1.161	1.183
1.069	1.043
1.005	1.077
1.350	1.300
1.087	1.116
1.410	1.363

River No. 41 cont'd

U	Y
1.237	1.280
1.136	1.104
0.729	0.706
0.880	0.882
1.146	1.168
0.724	0.671
0.919	0.948
0.727	0.754
0.786	0.764
1.114	1.128
0.890	0.850
0.707	0.733
0.818	0.806
1.008	1.010
0.724	0.707
0.688	0.676
0.902	0.930
0.754	0.757
1.138	1.130
0.860	0.861
1.207	1.196
0.769	0.754
0.931	0.946
1.057	1.060
0.759	0.734
0.456	0.459
0.717	0.732
0.850	0.822
1.289	1.361

42.White River near
Meeker, Colo.
1909-1957

U	Y
0.880	0.860
0.931	0.937
1.258	1.246
0.796	0.802
1.042	1.035
0.744	0.742
1.050	1.097
1.277	1.260
1.038	1.009
0.796	0.795
1.239	1.253
1.538	1.564
1.055	1.025
1.039	1.032
0.910	0.906
1.000	1.026
1.086	1.064
1.069	1.091
1.306	1.340
1.549	1.557
1.053	1.008
0.786	0.757
1.178	1.195
1.053	1.038
0.533	0.502
0.794	0.824
0.907	0.888
0.715	0.712
1.075	1.103
0.808	0.794
0.780	0.773
0.976	0.996
1.034	1.009
0.819	0.815
0.862	0.8588
1.002	1.019
0.789	0.769
1.203	1.260
0.995	0.951

River No. 42 cont'd

U	Y
1.135	1.149
0.932	0.926
0.956	0.946
1.313	1.343
0.989	0.944
0.654	0.669
0.748	0.736
0.854	0.836
1.451	1.541

43.San Juan River, near
Rosa, N. Mex.
1910-1957

U	Y
1.669	1.700
1.531	1.502
0.737	0.739
1.174	1.185
1.418	1.409
1.531	1.544
1.604	1.586
0.718	0.720
1.004	1.004
1.847	1.846
1.183	1.185
1.127	1.119
1.016	1.031
1.097	1.082
0.701	0.713
0.880	0.871
1.443	1.464
0.732	0.710
1.257	1.276
0.729	0.713
0.505	0.511
1.563	1.555
0.591	0.593
0.359	0.353
1.278	1.286
0.827	0.827
1.285	1.286
1.226	1.224
0.646	0.646
0.474	0.488
1.989	2.038
1.493	1.425
0.696	0.698
1.030	1.034
0.848	0.843
0.383	0.383
0.611	0.617
1.033	1.027
1.190	1.195
0.534	0.528
0.367	0.365
1.378	1.383
0.514	0.506
0.485	0.494
0.486	0.480
0.518	0.514
1.290	1.297

44.Ashley Creek, near
Vernal, Utah
1914-1957

U	Y
1.365	1.378
1.186	1.191

River No. 44,cont'd

U	Y
1.045	1.030
1.553	1.550
0.829	0.826
0.659	0.643
1.186	1.191
1.676	1.713
1.647	1.637
1.318	1.285
0.739	0.717
0.760	0.831
0.941	0.877
1.120	1.269
1.139	0.991
1.261	1.320
1.092	1.082
0.554	0.483
0.960	1.001
0.629	0.588
0.407	0.412
0.832	0.828
0.540	0.571
1.026	1.020
0.998	1.045
0.864	0.855
0.699	0.674
1.196	1.272
1.356	1.274
0.870	0.837
1.261	1.280
0.860	0.882
0.662	0.643
1.196	1.220
0.841	0.785
1.026	1.052
1.130	1.106
0.974	0.962
1.713	1.775
0.751	0.687
0.756	0.767
0.698	0.697
0.757	0.739
0.925	1.012

45.Verde River below
Barlett Dam, Ariz.
1888-1938

U	Y
1.380	1.383
1.739	1.780
3.086	3.048
0.239	0.234
0.527	0.538
0.342	0.334
1.310	1.312
0.540	0.547
0.961	0.967
0.419	0.403
0.352	0.360
0.225	0.213
0.556	0.555
0.375	0.395
0.745	0.738
0.490	0.486
2.785	2.298
1.602	1.583
1.527	1.540
0.807	0.800
1.355	1.355
0.842	0.837
1.180	1.196
0.798	0.791
0.672	0.666
0.702	0.702

River No. 45 cont'd

U	Y
1.545	1.541
2.261	2.295
1.586	1.558
0.887	0.882
0.963	0.980
2.242	2.226
0.550	0.557
1.391	1.383
0.954	0.988
0.969	0.935
0.468	0.498
0.910	0.883
1.452	1.483
0.555	0.522
0.693	0.695
0.509	0.508
0.716	0.718
1.478	1.475
0.389	0.390
0.292	0.290
0.897	0.904
0.509	0.506
1.454	1.450
0.774	0.773

46.Virgin River, near
Virgin, Utah
1909-1951

U	Y
1.422	1.424
2.029	2.033
0.860	0.852
1.003	1.004
1.371	1.369
1.182	1.189
1.790	1.788
1.035	1.030
1.063	1.068
0.851	0.849
1.072	1.069
1.017	1.020
2.139	2.145
1.762	1.755
0.635	0.637
0.727	0.724
0.782	0.782
1.017	1.026
0.722	0.712
0.856	0.864
0.713	0.709
0.543	0.540
1.426	1.428
0.722	0.724
0.497	0.496
0.897	0.896
0.755	0.756
1.348	1.349
1.288	1.289
0.768	0.774
0.782	0.779
1.569	1.566
1.104	1.102
0.824	0.825
0.902	0.901
0.764	0.766
0.552	0.550
0.745	0.747
0.584	0.583
0.759	0.762
0.644	0.642
0.474	0.474

47.Beaver River near
Beaver,Utah
1914-1957

U	Y
1.214	1.188
1.306	1.343
1.036	0.988
0.850	0.848
0.934	0.930
1.327	1.349
1.418	1.435
1.543	1.532
1.372	1.372
0.770	0.725
0.980	1.027
1.181	1.162
0.959	0.988
1.084	1.073
1.223	1.235
0.977	0.962
0.497	0.440
1.002	1.037
0.894	0.902
0.439	0.393
0.961	1.004
1.387	1.332
1.493	1.467
1.167	1.163
0.668	0.660
0.992	1.003
1.653	1.688
1.258	1.224
0.928	0.930
1.364	1.360
1.140	1.158
0.832	0.805
1.341	1.382
0.950	0.909
1.229	1.248
0.645	0.608
0.387	0.401
0.659	0.702
0.320	0.266
0.347	0.349
0.331	0.325
0.701	0.714
1.339	1.369

48.City Creek near
Salt Lake City,
Utah,1898-1957

U	Y
1.196	1.202
0.647	0.566
0.769	0.777
0.756	0.757
0.762	0.804
1.043	1.059
0.775	0.748
1.141	1.213
1.751	1.802
1.238	1.262
1.562	1.539
1.184	1.085
0.762	0.714
1.019	1.064
0.830	0.801
1.092	1.122
0.799	0.757
1.086	1.125
1.403	1.441
0.878	0.836
0.927	0.968
1.049	1.034
1.678	1.740
1.501	1.465

River No. 48 cont'd

U	Y
1.269	1.306
0.805	0.686
0.903	0.930
0.897	0.928
1.122	1.210
1.110	1.010
1.232	1.341
0.714	0.594
0.531	0.477
0.958	0.985
0.866	0.884
0.415	0.324
0.811	0.870
1.196	1.239
1.049	1.059
1.037	1.041
0.762	0.747
0.805	0.810
1.013	1.062
1.287	1.330
0.970	0.893
0.988	1.028
0.824	0.857
0.836	0.741
0.921	0.922
1.013	1.042
1.159	1.140
1.177	1.236
0.982	0.936
1.562	1.617
1.086	1.069
0.610	0.478
0.628	0.667
0.720	0.718
0.890	0.938

49.Blacksmith Fork above
Utah Power & Light Co,
Utah, 1913-1957

U	Y
1.278	1.308
0.741	0.700
1.302	1.351
1.618	1.630
1.144	1.100
0.805	0.794
1.192	1.215
1.681	1.719
1.539	1.531
1.500	1.499
1.010	0.960
0.939	0.940
0.732	0.716
0.963	0.982
0.987	0.984
0.963	0.961
0.726	0.712
0.471	0.442
1.113	1.156
0.813	0.803
0.459	0.422
0.570	0.578
1.200	1.238
0.947	0.940
0.963	0.967
0.688	0.658
0.494	0.482
0.418	0.415
0.492	0.501
0.924	0.956
0.659	0.644
0.784	0.796
1.366	1.392
0.892	0.868

River No. 49 cont'd

U	Y
1.105	1.121
1.073	1.075
1.523	1.568
1.492	1.478
1.610	1.612
0.995	0.947
0.761	0.741
0.759	0.770
1.184	1.206
1.113	1.120

50. Humboldt River, near
Palisade, Nevada
1911-1957

U	Y
1.187	1.192
1.008	1.002
2.119	2.118
0.373	0.368
0.935	0.935
1.782	1.784
0.362	0.361
0.688	0.686
0.497	0.497
2.419	2.421
1.720	1.720
0.912	0.918
0.452	0.444
1.221	1.231
0.354	0.344
0.951	0.952
0.550	0.549
0.449	0.450
0.412	0.413
0.143	0.141
1.204	1.207
0.510	0.509
0.098	0.097
0.620	0.621
1.044	1.045
0.735	0.734
0.887	0.888
0.674	0.674
0.601	0.599
1.022	1.026
2.189	2.187
2.313	2.312
1.125	1.126
2.282	2.288
1.504	1.501
0.682	0.680
0.561	0.561
0.906	0.907
0.991	0.992
1.271	1.271
2.461	2.462
0.679	0.677
0.279	0.278
0.248	0.248
1.356	1.357
1.221	1.222

51.Carson River, near
Fort Churchill, Nev.
1911-1957

U	Y
0.648	0.645
0.599	0.600
2.302	2.303
1.109	1.107

River No. 51 cont'd

U	Y
2.040	2.044
1.741	1.738
0.831	0.832
0.955	0.954
0.540	0.540
1.109	1.109
1.714	1.715
1.225	1.224
0.340	0.340
0.996	0.997
0.426	0.425
1.268	1.269
0.632	0.631
0.340	0.340
0.556	0.556
0.243	0.242
1.142	1.142
0.453	0.453
0.283	0.283
0.783	0.783
1.020	1.020
0.977	0.977
2.162	2.165
0.521	0.518
1.036	1.036
0.910	0.910
1.503	1.503
1.503	1.503
0.629	0.629
1.155	1.155
0.977	0.977
0.615	0.615
0.564	0.564
0.623	0.624
0.969	0.969
1.579	1.579
2.181	2.184
0.896	0.893
0.658	0.658
0.426	0.426
1.984	1.987
0.834	0.830

52.Kern River, near
Bakersfield, Calif.
1893-1953

U	Y
0.810	0.786
1.452	1.466
0.891	0.883
1.259	1.262
0.410	0.388
0.472	0.471
0.454	0.458
1.242	1.264
0.811	0.796
0.794	0.792
0.659	0.685
0.780	0.761
2.610	2.652
1.548	1.525
0.768	0.761
2.478	2.585
1.053	0.950
1.429	1.452
0.598	0.557
0.510	0.517
1.559	1.588
0.947	0.920
2.746	2.796
1.244	1.208
0.734	0.757
0.760	0.729
0.839	0.834

River No. 52 cont'd

U	Y
0.739	0.736
1.198	1.210
0.745	0.748
0.271	0.246
0.665	0.676
0.487	0.480
1.136	1.150
0.482	0.469
0.470	0.471
0.494	0.500
0.262	0.252
1.043	1.066
0.630	0.611
0.331	0.331
0.671	0.684
1.116	1.123
1.744	1.745
1.948	1.972
0.706	0.684
1.102	1.098
1.950	1.968
1.155	1.140
1.730	1.736
0.895	0.885
1.244	1.256
0.981	0.986
0.644	0.622
0.483	0.481
0.429	0.427
0.639	0.645
0.808	0.808
2.103	2.138
0.837	0.810

53.Kaweah River,near
Three Rivers, Calif.
1903-1956

U	Y
0.909	0.933
0.837	0.810
2.686	2.698
1.452	1.446
0.620	0.619
1.948	1.959
0.992	0.976
1.325	1.335
0.500	0.489
0.535	0.539
1.180	1.183
0.897	0.893
1.843	1.879
1.143	1.107
0.553	0.583
0.628	0.607
0.846	0.839
0.844	0.840
1.120	1.124
0.879	0.887
0.246	0.226
0.790	0.800
0.530	0.523
1.172	1.177
0.491	0.484
0.541	0.546
0.526	0.527
0.277	0.272
1.255	1.265
0.686	0.683
0.318	0.310
0.867	0.875
1.178	1.180
1.640	1.645
2.112	2.117
0.599	0.589

River No. 53 cont'd

U	Y
1.239	1.238
1.555	1.558
1.190	1.189
1.627	1.627
0.762	0.760
1.336	1.338
0.863	0.871
0.642	0.627
0.632	0.635
0.530	0.527
0.730	0.733
1.022	1.023
1.994	2.001
0.748	0.741
0.742	0.740
0.669	0.667
1.752	1.758

54.Kings River, near
Piedra, Calif.
1895-1956

U	Y
0.920	0.916
1.168	1.166
0.530	0.539
0.764	0.750
0.786	0.790
1.771	1.777
0.903	0.895
0.981	0.982
1.007	1.066
0.868	0.812
2.340	2.348
1.636	1.631
0.595	0.597
1.689	1.688
1.063	1.057
1.693	1.704
0.577	0.564
0.564	0.566
1.528	1.541
1.090	1.078
1.819	1.846
1.133	1.106
0.816	0.864
0.721	0.675
0.838	0.834
0.920	0.920
1.315	1.318
0.933	0.939
0.234	0.219
0.773	0.779
0.621	0.618
1.189	1.195
0.582	0.576
0.508	0.509
0.516	0.518
0.280	0.277
1.246	1.255
0.708	0.700
0.394	0.393
0.972	0.976
1.122	1.122
1.403	1.404
1.963	1.981
0.584	0.570
1.070	1.066
1.524	1.529
1.202	1.201
1.215	1.214
0.698	0.697
1.237	1.240
0.967	0.978
0.664	0.649

River No. 54 cont'd

U	Y
0.595	0.594
0.576	0.576
0.768	0.771
0.960	0.959
1.708	1.716
0.692	0.685
0.760	0.760
0.685	0.687
1.611	1.616

55.Arroyo Seco River
1902-1955

U	Y
0.868	0.868
0.497	0.501
1.019	1.016
1.677	1.679
2.630	2.631
0.621	0.618
1.984	1.987
0.700	0.697
2.412	2.415
0.308	0.304
0.119	0.118
2.177	2.180
1.743	1.745
2.147	2.149
1.514	1.510
0.633	0.636
0.570	0.566
0.439	0.439
0.700	0.700
1.821	1.823
1.055	1.055
0.138	0.136
0.446	0.447
1.333	1.332
1.508	1.508
0.621	0.621
0.430	0.430
0.390	0.390
0.101	0.101
1.098	1.098
0.162	0.162
0.645	0.645
0.766	0.766
1.001	1.001
1.236	1.237
2.696	2.698
0.201	0.198
1.550	1.552
3.166	2.168
1.411	1.410
1.104	1.102
0.736	0.735
0.874	0.874
0.657	0.657
0.266	0.266
0.186	0.186
0.434	0.434
0.414	0.414
0.749	0.748
1.737	1.738
0.601	0.601
0.366	0.365
0.341	0.341

56.Tenaya Creek near Yosemite, Calif.
1912-1956

U	Y
0.671	0.678
1.523	1.523
1.124	1.122
1.314	1.320
1.085	1.079
0.764	0.780
0.971	0.954
0.929	0.930
1.066	1.079
1.333	1.316
0.945	0.954
0.343	0.336
1.190	1.190
0.731	0.731
1.323	1.324
0.801	0.800
0.617	0.615
0.716	0.719
0.315	0.312
1.190	1.192
0.708	0.707
0.411	0.409
1.276	1.278
1.219	1.220
1.162	1.160
1.704	1.707
0.555	0.552
1.085	1.082
1.133	1.135
1.247	1.248
1.181	1.180
0.775	0.775
1.171	1.173
1.085	1.092
0.724	0.716
0.981	0.981
0.730	0.729
0.962	0.961
1.362	1.361
1.571	1.575
0.832	0.813
0.777	0.774
0.671	0.673
1.723	1.724

57.Cherry Creek near Hetch Hetchy, Calif.
1910-1955

U	Y
1.728	1.728
0.657	0.656
0.613	0.613
1.468	1.468
1.148	1.147
1.275	1.295
1.169	1.149
0.860	0.869
0.781	0.778
0.781	0.776
1.126	1.126
1.313	1.313
1.015	1.025
0.366	0.356
1.118	1.118
0.689	0.689
1.145	1.145
0.833	0.833
0.619	0.619
0.746	0.751
0.423	0.418
1.158	1.159

River No. 57 cont'd

U	Y
0.667	0.667
0.559	0.559
1.191	1.194
1.142	1.140
1.015	1.015
1.698	1.705
0.602	0.602
1.254	1.247
1.327	1.327
1.332	1.332
1.237	1.237
0.814	0.814
1.221	1.221
1.102	1.101
0.673	0.683
0.876	0.867
0.803	0.802
0.998	0.998
1.316	1.316
1.563	1.563
0.955	0.955
0.882	0.881
0.738	0.738

58.Cosumnes River,near Michigan Bar, Calif.
1907-1956

U	Y
0.405	0.403
1.684	1.685
1.306	1.306
2.473	2.474
0.390	0.390
0.360	0.359
1.541	1.541
1.154	1.155
1.609	1.611
1.173	1.171
0.633	0.634
0.731	0.732
0.480	0.480
1.149	1.149
1.204	1.204
1.239	1.239
0.114	0.113
1.075	1.076
0.417	0.417
1.277	1.278
0.889	0.889
0.325	0.325
0.466	0.466
0.129	0.129
0.885	0.885
0.319	0.319
0.345	0.345
1.042	1.042
1.472	1.472
1.128	1.128
1.930	1.930
0.260	0.259
1.412	1.412
1.134	1.135
1.441	1.441
1.864	1.864
0.529	0.529
1.008	1.008
1.102	1.102
0.409	0.408
0.758	0.759
0.670	0.670
0.936	0.937
2.152	2.153

River No. 58 cont'd

U	Y
2.201	2.202
0.746	0.746
0.646	0.646
0.505	0.505
1.878	1.879

59.Feather River, near Bidwell Bar, Calif.
1911-1956

U	Y
0.473	0.461
0.641	0.640
1.833	1.841
1.245	1.244
1.549	1.551
1.154	1.147
0.598	0.611
0.871	0.858
0.510	0.502
1.421	1.432
1.314	1.317
0.796	0.796
0.227	0.210
0.743	0.759
0.694	0.684
1.517	1.525
1.026	1.022
0.398	0.392
0.994	1.015
0.283	0.259
0.887	0.894
0.429	0.426
0.440	0.440
1.034	1.042
1.070	1.069
0.737	0.734
2.200	2.214
0.373	0.357
1.396	1.400
1.517	1.526
1.568	1.568
1.410	1.407
0.590	0.583
0.923	0.927
1.015	1.012
0.558	0.554
0.892	0.901
0.601	0.594
0.962	0.965
1.483	1.514
2.039	2.018
1.185	1.181
0.910	0.907
0.516	0.509
1.976	1.988

60.Trinity River, near Lewiston, Calif.
1911-1956

U	Y
0.883	0.884
0.921	0.919
1.742	1.742
1.854	1.854
1.288	1.287
0.560	0.560
0.518	0.518
0.989	0.990
0.350	0.347

River 60 cont'd

U	Y
1.543	1.543
0.672	0.671
0.590	0.592
0.228	0.225
1.288	1.292
0.697	0.694
1.568	1.569
0.908	0.907
0.454	0.453
0.697	0.698
0.345	0.344
0.618	0.618
0.690	0.691
0.586	0.586
0.830	0.830
0.878	0.879
0.858	0.859
1.808	1.810
0.493	0.490
1.382	1.384
2.189	2.189
1.550	1.549
0.952	0.951
0.560	0.560
0.901	0.901
1.215	1.216
0.629	0.629
1.032	1.035
0.937	0.935
0.733	0.733
1.383	1.387
1.558	1.554
1.385	1.386
1.370	1.370
0.631	0.630
1.737	1.737

61.Quinault River,near Quinault Lake, Wash.
1911-1957

U	Y
0.818	0.819
1.028	1.024
1.133	1.140
0.891	0.869
1.170	1.177
0.735	0.743
1.064	1.050
1.162	1.170
0.894	0.921
1.249	1.254
1.064	1.056
0.902	0.882
0.836	0.882
1.151	1.095
0.746	0.762
1.072	1.077
0.996	0.975
0.706	0.703
0.644	0.666
0.927	0.921
1.061	1.054
1.115	1.132
1.231	1.213
1.227	1.237
0.870	0.860
0.819	0.838
1.018	0.998
0.904	0.904
1.043	1.043
0.895	0.910
0.849	0.833
0.806	0.807

River No. 61 cont'd

U	Y
0.658	0.670
0.963	0.958
1.113	1.109
0.923	0.922
1.104	1.128
0.989	0.976
1.293	1.292
1.198	1.243
0.940	0.883
1.088	1.139
1.289	1.253
1.126	1.119
1.276	1.304
1.011	0.986

62. South Fork of Skykomish, near Index, Wash.
1911-1957

U	Y
0.978	0.978
1.103	1.106
0.970	0.974
0.612	0.609
1.182	1.178
1.036	1.038
1.248	1.243
1.128	1.130
0.924	0.952
1.253	1.251
0.882	0.881
0.928	0.908
0.882	0.893
1.078	1.063
0.687	0.704
0.970	0.982
1.132	1.126
0.716	0.691
0.666	0.669
0.745	0.757
1.099	1.089
1.395	1.431
1.408	1.373
1.103	1.102
0.891	0.891
0.821	0.822
0.931	0.925
0.998	1.000
0.777	0.776
0.563	0.598
0.835	0.799
1.041	1.046
0.699	0.713
0.878	0.874
1.086	1.075
1.067	1.069
1.182	1.197
1.048	1.039
1.360	1.362
1.155	1.187
0.816	0.770
0.975	1.001
1.273	1.261
1.072	1.067
1.329	1.342
1.077	1.056

63. Wenatchee River, near Plain, Wash.
1910-1957

U	Y
0.989	0.989
0.943	0.942
1.139	1.146
0.952	0.954
0.620	0.608
1.281	1.289
0.984	0.984
1.139	1.139
1.130	1.130
0.811	0.827
1.381	1.371
0.998	0.985
1.021	1.016
0.907	0.908
1.103	1.100
0.661	0.664
0.994	1.008
1.162	1.150
0.620	0.612
0.615	0.614
0.679	0.685
1.021	1.021
1.217	1.239
1.524	1.500
1.187	1.192
0.845	0.840
0.806	0.806
1.001	1.000
0.834	0.832
0.768	0.772
0.577	0.588
0.746	0.729
1.051	1.058
0.577	0.582
0.781	0.776
1.053	1.050
1.018	1.021
1.124	1.134
1.080	1.073
1.391	1.393
1.356	1.366
0.854	0.835
0.990	1.007
1.331	1.327
1.137	1.128
1.501	1.515
1.101	1.087

64. Kootenai River, near Libby, Mont.
1910-1957

U	Y
1.182	1.185
0.844	0.844
1.106	1.113
1.063	1.068
0.861	0.849
1.392	1.402
1.013	1.004
0.979	0.977
1.046	1.043
0.937	0.944
1.165	1.165
0.861	0.850
1.004	1.005
0.652	0.646
1.114	1.131
0.554	0.558
1.173	1.197
1.224	1.184
0.789	0.783
0.841	0.849

River No. 64 cont'd

U	Y
0.627	0.622
1.004	1.014
1.148	1.162
1.332	1.310
1.009	1.015
0.753	0.739
0.693	0.704
1.050	1.055
0.804	0.803
0.757	0.764
0.645	0.668
1.133	1.118
1.081	1.073
0.580	0.583
0.746	0.742
1.121	1.132
1.115	1.119
1.382	1.374
0.846	0.837
1.154	1.162
1.400	1.464
1.105	1.044
1.014	1.016
1.381	1.393
1.052	1.040
1.352	1.358
0.912	0.888

65. Clearwater River, near Kamiah, Idaho
1910-1956

U	Y
0.997	0.994
1.268	1.273
1.293	1.290
0.903	0.903
0.733	0.733
1.196	1.201
1.318	1.314
1.280	1.278
0.738	0.732
0.963	0.985
1.428	1.412
1.024	1.018
0.893	0.894
0.777	0.778
1.177	1.186
0.722	0.722
1.342	1.358
1.564	1.540
0.747	0.746
0.724	0.727
0.640	0.636
1.064	1.066
1.104	1.108
1.070	1.065
0.757	0.756
0.907	0.908
0.599	0.598
0.890	0.892
0.771	0.768
0.719	0.737
0.586	0.587
0.906	0.890
1.261	1.262
0.597	0.600
0.802	0.807
0.940	0.938
1.238	1.242
1.375	1.371
1.124	1.124
1.254	1.254
1.124	1.122
1.009	1.004

River No. 65 cont'd

U	Y
0.916	0.917
1.001	1.005
0.993	0.995
1.263	1.265

66. Big Wood (And Slough) River, near Hailey, Idaho
1915-1957

U	Y
1.335	1.343
1.326	1.324
0.960	0.968
0.764	0.752
0.731	0.731
1.461	1.500
1.365	1.330
1.155	1.179
0.518	0.464
1.295	1.334
0.600	0.569
1.216	1.255
0.925	0.888
0.527	0.522
0.813	0.834
0.398	0.361
1.019	1.054
0.728	0.705
0.414	0.398
0.810	0.829
0.775	0.782
0.527	0.511
1.691	1.743
0.688	0.641
0.827	0.893
0.984	0.952
1.150	1.145
1.787	1.802
0.925	0.903
0.845	0.840
1.087	1.114
1.026	1.008
0.962	0.974
0.836	0.806
0.974	1.009
1.351	1.367
1.668	1.651
1.094	1.084
0.956	0.953
0.740	0.724
1.525	1.552
1.222	1.205

67. Boise River, near Twin Springs, Idaho
1911-1956

U	Y
1.210	1.207
1.082	1.089
1.090	1.097
0.636	0.624
1.304	1.315
1.142	1.130
1.133	1.131
0.844	0.855
0.869	0.873
1.482	1.479
1.150	1.138
0.903	0.905
0.489	0.480
1.176	1.186

River No. 67 con

U	Y
0.577	0.570
1.295	1.325
1.252	1.228
0.699	0.695
0.715	0.717
0.534	0.526
0.980	0.985
0.847	0.847
0,624	0.618
0.851	0.853
0.984	0.986
0.604	0.599
1.223	1.236
0.695	0.684
0.860	0.871
0.733	0.731
0.887	0.882
1.657	1.670
0.661	0.649
0.935	0.942
1.176	1.195
1.102	1.080
1.005	1.006
0.993	0.990
1.207	1.222
1.286	1.298
1.337	1.313
1.159	1.157
1.167	1.171
0.852	0.848
1.591	1.598

68. John Day River, near McDonald Ferry, Oreg.
1904-1957

U	Y
0.646	0.641
0.997	0.999
1.478	1.477
0.676	0.677
0.686	0.684
1.037	1.035
0.666	0.670
1.663	1.666
1.222	1.217
1.057	1.061
0.506	0.500
1.643	1.650
1.558	1.565
0.947	0.935
0.881	0.880
1.047	1.060
1.803	1.797
1.503	1.494
0.981	1.010
0.551	0.523
1.042	1.049
0.531	0.526
1.122	1.151
1.332	1.305
0.671	0.668
0.367	0.366
0.401	0.400
1.137	1.139
0.801	0.806
0.319	0.312
0.460	0.459
0.604	0.606
0.731	0.734
1.117	1.118
0.653	0.649
0.708	0.718

River No. 68 cont'd

U	Y
0.801	0.810
1.412	1.402
1.690	1.691
0.430	0.426
0.844	0.847
1.078	1.080
0.844	0.842
1.842	1.864
1.122	1.101
1.088	1.087
1.355	1.354
1.192	1.193
1.275	1.278
0.846	0.847
0.609	0.604
1.808	1.820
1.218	1.209

69.Clackamas River,near
Cazadero, Oreg.
1908-1957

U	Y
0.949	0.968
1.135	1.145
0.834	0.802
1.012	1.025
1.023	1.023
0.867	0.875
0.692	0.664
1.418	1.444
1.072	1.073
1.202	1.176
1.005	1.059
0.912	0.916
1.425	1.396
0.979	0.964
1.064	1.068
0.752	0.764
1.068	1.048
0.618	0.622
1.053	1.139
1.087	0.996
0.785	0.778
0.692	0.684
0.688	0.688
0.945	0.951
1.083	1.122
0.971	0.929
0.943	0.951
0.901	0.905
0.891	0.912
1.169	1.154
0.801	0.792
0.777	0.794
0.631	0.624
0.818	0.802
1.325	1.351
0.652	0.634
0.823	0.830
1.081	1.082
1.030	1.033
1.219	1.244
1.180	1.168
1.245	1.253
1.362	1.386
1.032	0.993
1.105	1.138
1.276	1.256
0.975	0.973
1.457	1.448
0.972	0.955

70.Willamette River,near
Albany, Oreg.
1893-1941

U	Y
1.266	1.280
1.332	1.336
0.878	0.873
1.347	1.362
1.106	1.089
1.157	1.162
1.062	1.056
1.157	1.166
1.391	1.384
0.668	0.655
0.805	0.816
1.135	1.134
0.937	0.931
0.952	0.963
1.018	1.006
0.813	0.825
1.054	1.052
1.032	1.032
0.849	0.848
0.640	0.630
1.281	1.292
1.032	1.029
1.054	1.040
1.047	1.058
0.849	0.896
1.369	1.325
1.032	1.031
0.981	0.980
0.646	0.643
1.288	1.286
0.682	0.673
1.230	1.296
1.106	1.041
0.754	0.754
0.674	0.674
0.584	0.578
1.135	1.138
1.171	1.192
0.721	0.696
1.059	1.062
0.936	0.937
0.951	0.964
1.309	1.304
0.790	0.777
0.707	0.724
0.598	0.595
0.928	0.922
1.484	1.492

71.Umpqua River,near
Elkton, Oreg.
1905-1957

U	Y
0.928	0.926
1.322	1.325
1.050	1.049
1.128	1.142
1.035	1.014
0.852	0.858
1.073	1.069
0.970	0.976
0.902	0.899
0.646	0.639
1.283	1.288
1.152	1.153
0.950	0.945
1.196	1.203
0.914	0.938
1.631	1.609
1.201	1.196
0.868	0.869
0.532	0.526

River No. 71 cont'd

U	Y
1.294	1.301
0.544	0.536
1.175	1.203
0.906	0.878
0.576	0.570
0.596	0.605
0.425	0.413
1.015	1.024
1.023	1.030
0.443	0.431
1.002	1.006
0.912	0.912
0.798	0.804
1.436	1.435
0.763	0.752
0.749	0.773
0.615	0.598
0.894	0.889
1.512	0.521
0.591	0.586
0.823	0.826
1.165	1.166
0.854	0.855
1.192	1.203
0.973	0.964
1.109	1.112
1.483	1.491
1.295	1.284
1.242	1.248
1.336	1.335
0.810	0.803
1.800	1.801
1.015	1.023

72.Rogue River, near
Raygold, Oreg.
1905-1957

U	Y
0.943	0.939
1.463	1.469
1.081	1.084
1.222	1.224
1.264	1.244
1.071	1.071
1.215	1.228
1.050	1.054
0.981	0.972
0.658	0.632
0.978	0.996
1.071	1.082
0.837	0.819
0.971	0.976
0.706	0.714
1.415	1.428
0.992	0.986
0.771	0.756
0.575	0.551
1.098	1.128
0.523	0.491
1.184	1.231
0.957	0.940
0.627	0.602
0.613	0.604
0.399	0.387
0.923	0.943
0.954	0.983
0.524	0.484
0.940	0.955
0.920	0.922
0.842	0.857
1.421	1.434
0.810	0.784
0.824	0.837
0.672	0.647

River No. 72 cont'd

U	Y
0.902	0.904
1.510	1.550
0.719	0.702
0.878	0.870
1.137	1.148
0.785	0.773
1.103	1.127
0.982	0.973
1.059	1.064
1.470	1.488
1.465	1.454
1.361	1.368
1.399	1.390
0.729	0.709
1.693	1.723
1.308	1.302

CANADA RIVERS

1.Columbia River,at
Nicholson, Canada
1913-1954

U	Y
1.298	1.254
1.034	1.028
1.111	1.127
1.047	1.046
1.162	1.200
1.082	1.014
1.007	0.998
1.037	1.067
1.023	1.031
1.018	0.999
0.820	0.810
1.125	1.162
0.759	0.730
1.074	1.142
1.082	1.015
0.850	0.824
1.028	1.066
0.852	0.836
1.047	1.065
1.143	1.157
1.248	1.213
1.002	1.011
0.876	0.866
0.783	0.786
1.079	1.130
0.927	0.885
0.954	0.980
0.775	0.759
0.967	0.978
0.919	0.902
0.724	0.730
0.732	0.705
1.015	1.052
1.047	1.070
1.111	1.073
0.743	0.746
1.031	1.038
1.173	1.209
0.999	0.998
0.959	0.925
1.336	1.374

2.Capilano Creek,near
No.Vancouver,Canada
1914-1954

U	Y
1.034	1.024

River No. 2 cont'd

U	Y
1.296	1.297
0.856	0.860
1.208	1.204
1.120	1.124
1.088	1.112
1.322	1.302
1.176	1.183
0.773	0.759
0.970	1.013
1.186	1.143
0.819	0.834
1.218	1.208
0.862	0.860
0.801	0.798
0.807	0.809
0.912	0.924
1.127	1.116
1.091	1.096
0.908	0.900
1.237	1.238
0.878	0.877
0.866	0.889
1.038	1.014
0.918	0.919
1.127	1.128
1.006	1.013
0.874	0.869
0.748	0.747
0.660	0.662
1.050	1.050
1.121	1.122
0.807	0.808
0.980	0.982
0.819	0.816
1.166	1.168
1.062	1.082
0.957	0.938
0.954	0.983
1.152	1.124

3.Thompson River,near
Spences Bridge,B.C.
Canada, 1911-1954

U	Y
0.968	0.949
1.050	1.062
0.990	1.001
1.013	0.971
1.084	1.117
1.002	1.002
1.050	1.053
0.953	0.920
1.016	1.101
1.144	1.144
0.979	0.968
1.020	0.958
0.885	0.902
1.058	1.037
0.780	0.710
0.983	1.129
1.095	0.966
0.728	0.707
0.746	0.804
0.878	0.866
1.032	1.030
1.560	1.589
1.155	1.144
1.167	1.165
1.039	1.065
0.848	0.820
0.859	0.869
0.972	0.954
0.990	0.997
0.870	0.919

River No. 3 cont'd

U	Y
1.024	0.953
0.960	0.966
0.840	0.909
0.979	0.890
1.092	1.089
0.990	1.022
1.257	1.301
1.013	0.954
0.975	0.980
0.949	0.886
0.945	1.000
0.848	0.853
1.212	1.276

4.Bridge River near
Shalalth, B.C.,Canada
1913-1954

U	Y
1.100	1.105
1.187	1.192
1.128	1.117
0.847	0.846
1.258	1.276
0.968	0.951
0.864	0.864
1.021	1.034
1.230	1.211
1.097	1.097
1.106	1.115
1.075	1.066
0.827	0.820
1.019	1.041
1.168	1.160
0.799	0.789
0.931	0.952
0.844	0.829
0.928	0.942
0.872	0.860
1.142	1.143
1.055	1.054
0.878	0.885
0.960	0.954
1.021	1.036
0.920	0.912
1.154	1.161
1.041	1.022
1.128	1.146
0.836	0.822
0.872	0.875
0.875	0.870
0.971	0.973
0.824	0.836
1.317	1.308
0.819	0.804
1.227	1.239
0.917	0.913
0.889	0.888
0.836	0.834
1.047	1.054

5.No.Saskatchewan River,
Edmonton, Canada
1911-1955

U	Y
1.328	1.330
1.101	1.083
0.903	0.902
1.488	1.499
1.262	1.273
1.254	1.240

River No. 5 cont'd

U	Y
0.944	0.956
0.719	0.704
1.056	1.045
0.807	0.802
0.787	0.804
1.130	1.141
0.926	0.913
1.220	1.292
1.066	1.082
1.332	1.285
1.292	1.256
0.710	0.707
0.780	0.790
0.806	0.805
1.040	1.033
0.940	0.939
0.728	0.731
1.056	1.053
0.930	0.930
0.733	0.758
0.960	0.968
0.805	0.784
0.812	0.814
0.651	0.649
0.977	0.995
0.944	0.923
1.161	1.183
0.748	0.735
0.939	0.932
0.927	0.944
1.438	1.427
0.660	0.647
0.826	0.833
0.948	0.962
1.206	1.216
1.106	1.088
1.554	1.616
0.998	0.928

6.Belly River,near
Moutain View,Canada
1911-1955

U	Y
0.814	0.807
1.095	1.100
0.964	0.974
1.089	1.095
1.416	1.401
1.050	1.050
0.919	0.918
0.775	0.768
1.031	1.047
1.111	1.117
1.060	1.043
1.028	1.028
0.964	0.968
1.191	1.206
0.650	0.652
1.601	1.611
1.323	1.300
0.858	0.853
0.954	0.960
0.599	0.601
0.958	0.946
1.034	1.052
1.275	1.265
0.945	0.947
0.705	0.701
0.823	0.828
1.025	1.022
0.679	0.677
0.637	0.654
0.560	0.568
1.079	1.078
1.111	1.180

River No. 6 cont'd

U	Y
0.528	0.443
0.874	0.882
0.993	1.016
1.018	1.005
1.342	1.321
0.743	0.754
1.159	1.226
1.457	1.501
0.954	0.834
1.291	1.297
1.236	1.253
1.076	1.050

7.Bow River,near
Banff,Canada
1910-1954

U	Y
0.975	0.990
1.124	1.127
1.131	1.140
1.067	1.051
1.124	1.122
0.968	0.962
1.032	1.046
0.932	0.911
1.010	1.022
0.946	0.933
1.010	1.024
1.060	1.067
0.939	0.921
1.146	1.166
0.868	0.849
1.138	1.161
1.345	1.319
0.811	0.806
1.110	1.124
0.889	0.884
1.153	1.156
1.096	1.095
1.081	1.077
1.096	1.095
0.840	0.838
0.761	0.767
1.024	1.046
0.882	0.866
0.989	0.999
0.768	0.756
0.946	0.955
0.918	0.903
0.861	0.877
0.768	0.752
0.982	1.001
1.024	1.027
1.181	1.163
0.706	0.705
0.992	0.992
1.089	1.099
1.010	1.015
0.971	0.969
1.275	1.281
0.959	0.938

8.Spray River, near
Banff, Canada
1910-1955

U	Y
1.259	1.252
1.116	1.130
1.254	1.267
1.337	1.336
1.200	1.185

River No. 8 cont'd

U	Y
1.532	1.550
1.116	1.088
1.118	1.117
1.100	1.101
1.027	1.038
1.124	1.114
0.899	0.898
1.150	1.160
0.958	0.961
1.198	1.216
0.791	0.789
1.285	1.297
1.367	1.340
0.947	0.949
1.129	1.137
0.942	0.935
1.213	1.215
1.308	1.318
1.092	1.084
1.100	1.101
0.836	0.825
0.869	0.887
1.111	1.105
0.875	0.885
0.925	0.917
0.765	0.775
1.033	1.033
0.970	0.953
0.713	0.734
0.869	0.857
1.111	1.123
1.209	1.228
1.354	1.333
0.793	0.764
0.284	0.299
1.235	1.247
0.466	0.449
0.420	0.424
0.349	0.337
0.251	0.244

9.Milk River, near
Milk River, Canada
1911-1955

U	Y
0.537	0.534
0.524	0.521
0.265	0.262
0.558	0.568
1.115	1.114
1.234	1.231
0.697	0.694
0.643	0.649
0.996	0.987
0.534	0.534
0.670	0.679
0.649	0.640
0.775	0.775
1.057	1.083
0.687	0.663
1.299	1.307
1.346	1.343
1.122	1.126
1.010	1.003
0.704	0.699
1.040	1.041
1.061	1.061
1.231	1.234
1.078	1.076
0.887	0.891
0.969	0.970
1.037	1.030
0.894	0.894
0.721	0.721
0.721	0.724

River No.9 cont'd

U	Y
1.122	1.136
1.061	1.066
0.656	0.635
0.959	0.978
1.588	1.592
2.085	2.076
1.465	1.466
1.034	1.022
1.125	1.149
1.639	1.630
1.258	1.267
1.663	1.662
1.149	1.130
1.136	1.134

10.Lehave River,near
W.Northfield,Canada
1914-1954

U	Y
0.968	0.974
1.103	1.099
1.103	1.098
0.968	1.013
1.061	1.018
1.027	1.022
0.717	0.716
0.942	0.956
1.163	1.153
0.883	0.894
0.702	0.688
1.154	1.154
1.095	1.105
0.993	0.984
0.976	0.996
0.787	0.764
0.874	0.892
0.805	0.809
1.069	1.090
1.298	1.258
1.086	1.096
0.959	0.979
0.968	0.942
0.968	0.996
0.959	0.926
0.699	0.706
0.818	0.812
0.917	0.953
1.307	1.278
0.775	0.769
1.205	1.204
1.180	1.182
0.900	0.901
1.112	1.108
0.831	0.880
0.968	0.931
1.290	1.294
1.154	1.139
1.035	1.057
1.180	1.161

11.St.Mary River,near
Stillwater, Canada
1914-1954

U	Y
0.999	0.999
0.944	0.934
0.896	0.895
1.082	1.100
0.902	0.890
1.020	1.017
0.758	0.753
1.013	1.020

River No. 11 cont'd

U	Y
1.150	1.237
1.109	1.027
0.840	0.834
1.061	1.058
1.088	1.099
1.192	1.192
1.088	1.091
0.840	0.830
1.082	1.096
0.847	0.850
1.067	1.067
1.061	1.044
1.088	1.106
0.971	0.974
0.896	0.900
0.964	0.985
1.047	1.007
0.875	0.886
1.026	1.015
0.930	0.948
1.323	1.312
0.882	0.880
1.192	1.188
0.827	0.838
0.847	0.867
1.067	1.039
0.999	1.061
0.875	0.821
0.868	0.869
0.951	0.940
1.164	1.175
1.165	1.154

12.Sangeen River,near Walkerton,Canada

1913-1953

U	Y
0.850	0.851
0.639	0.656
1.234	1.218
1.042	1.043
0.790	0.795
0.998	0.991
0.945	0.948
1.067	1.065
0.836	0.834
0.869	0.871
0.930	0.935
0.680	0.675
1.143	1.149
1.001	0.998
1.105	1.114
1.766	1.752
1.030	1.028
0.486	0.489
1.256	1.276
1.077	1.060
0.831	0.825
0.576	0.577
0.675	0.691
0.935	0.926
0.874	0.869
0.732	0.729
0.855	0.864
0.869	0.865
1.209	1.230
1.540	1.520
0.850	0.848
1.001	0.998
1.067	1.068
1.417	1.422
0.924	0.920
0.874	0.874
1.285	1.282
1.407	1.437

River No. 12 cont'd

U	Y
1.275	1.246
1.058	1.057

13.Megnetawan River,near Burks Falls, Canada

1913-1953

U	Y
1.146	1.182
0.993	0.980
1.321	1.319
1.339	1.346
0.822	0.814
1.085	1.077
0.909	0.920
1.069	1.048
1.024	1.026
0.822	0.821
0.817	0.814
0.766	0.766
0.912	0.925
1.039	1.042
1.591	1.691
1.706	1.599
0.782	0.780
0.524	0.523
1.006	1.048
1.225	1.171
0.789	0.790
0.822	0.834
0.812	0.819
1.158	1.162
1.006	1.002
0.863	0.848
0.680	0.740
0.889	0.822
1.006	1.007
1.133	1.155
0.685	0.687
0.980	0.983
0.978	0.966
1.286	1.314
0.891	0.853
1.113	1.109
0.914	0.934
1.105	1.098
1.141	1.163
0.848	0.819

EUROPE

1.Thames River,near Teddington, England

1883-1954

U	Y
0.864	0.837
0.639	0.647
1.080	1.080
0.985	0.977
0.720	0.742
1.030	1.016
0.648	0.638
0.448	0.477
1.120	1.102
0.855	0.835
0.634	0.660
1.264	1.246
0.661	0.727
1.224	1.191
0.504	0.454
0.738	0.744
0.873	0.879

River No. 1 cont'd

U	Y
0.639	0.640
0.445	0.451
1.026	1.095
1.507	1.444
0.472	0.464
0.702	0.689
0.675	0.686
1.179	1.214
0.580	0.556
1.170	1.175
1.021	1.006
1.350	1.447
1.395	1.316
0.823	0.808
1.480	1.511
1.660	1.662
1.287	1.340
1.071	1.026
1.530	1.534
1.120	1.114
0.643	0.592
0.594	0.622
1.003	1.003
1.197	1.255
1.606	1.574
1.300	1.270
1.318	1.539
1.656	1.432
0.648	0.623
1.386	1.426
1.224	1.314
1.111	1.031
1.125	1.094
0.329	0.310
0.710	0.740
1.552	1.574
1.696	1.687
0.666	0.634
1.206	1.228
1.300	1.282
1.345	1.378
0.841	0.816
0.958	0.946
0.304	0.297
0.814	0.823
0.819	0.956
1.584	1.453
0.553	0.558
0.657	0.632
0.904	0.952
1.701	1.726
1.192	1.142
0.864	0.867
0.774	0.790

2.Garonne River,near Mas D'Argenais,France

1913-1955

U	Y
1.275	1.279
1.545	1.539
1.250	1.243
1.166	1.160
0.985	0.984
1.366	1.372
1.052	1.143
0.962	0.856
1.133	1.144
1.069	1.054
0.952	0.962
0.667	0.657
0.987	0.992
1.027	1.068
1.245	1.212
0.702	0.719

River No. 2 cont'd

U	Y
1.537	1.565
1.458	1.453
1.231	1.251
0.971	0.972
0.993	0.935
1.174	1.190
1.687	1.678
1.031	1.058
0.881	0.884
1.107	1.083
1.085	1.109
1.424	1.408
0.856	0.845
0.477	0.490
0.668	0.683
0.992	0.947
0.447	0.446
0.545	0.555
0.648	0.650
0.206	0.188
0.591	0.595
1.228	1.248
0.841	0.834
0.688	0.694
0.879	0.893
0.971	0.959

3.Rhone at Brig, Switzerland

1916-1957

U	Y
1.074	1.090
0.973	0.954
0.988	1.021
1.229	1.226
1.015	1.007
0.946	0.928
0.988	0.992
0.954	0.947
0.846	0.847
0.996	0.992
1.033	1.043
1.162	1.153
1.105	1.118
0.885	0.869
1.051	1.049
0.880	0.904
0.823	0.819
0.942	0.951
1.067	1.064
1.154	1.139
1.065	1.072
0.904	0.906
0.916	0.903
0.951	0.976
1.008	0.991
0.963	0.971
1.033	1.022
0.949	0.929
1.188	1.205
1.086	1.104
1.115	1.105
0.915	0.923
0.956	0.954
1.076	1.063
1.087	1.093
1.096	1.084
1.016	1.039
0.876	0.865
0.942	0.939
0.906	0.917
0.836	0.825

4.Luetschine River,at Gsteig,Switzerland

1917-1957

U	Y
0.927	0.925
1.089	1.113
1.233	1.212
0.881	0.874
1.132	1.133
0.952	0.954
1.102	1.097
0.858	0.871
1.092	1.071
1.054	1.069
1.028	1.029
1.071	1.070
1.000	0.998
1.129	1.116
0.923	0.934
0.898	0.916
0.900	0.886
1.054	1.066
1.129	1.126
1.063	1.059
0.900	0.898
0.962	0.948
1.130	1.150
0.946	0.934
0.974	0.992
0.976	0.953
0.919	0.916
1.172	1.188
0.952	0.950
0.943	0.932
0.931	0.941
0.816	0.819
0.919	0.907
1.005	1.012
0.980	0.963
1.046	1.067
0.964	0.987
1.092	1.059
0.949	0.959
0.905	0.906

5.Birs River,near Muenchenstein,Switz.

1916-1957

U	Y
1.078	1.094
0.836	0.836
1.080	1.064
0.737	0.758
0.399	0.382
1.130	1.138
1.102	1.087
1.232	1.254
0.714	0.715
1.042	1.019
1.122	1.146
0.770	0.748
0.828	0.824
1.066	1.068
1.374	1.382
0.963	0.958
0.763	0.756
0.587	0.591
1.144	1.187
1.313	1.295
1.358	1.336
0.970	0.979
1.388	1.388
1.504	1.558
1.370	1.295
0.887	0.909
0.647	0.621
0.690	0.720

River No. 5 cont'd

U	Y
1.000	1.081
1.052	1.044
0.576	0.562
1.087	1.101
0.672	0.656
0.640	0.662
1.450	1.454
1.073	1.077
1.140	1.125
0.720	0.752
1.216	1.180
1.106	1.111
1.074	1.092

6.Rhine River,near Basle,Switzerland

1807-1957

U	Y
0.843	0.856
1.007	0.984
0.806	0.801
0.993	0.978
1.090	1.141
1.073	1.076
0.954	0.908
1.104	1.115
1.259	1.315
1.429	1.406
0.940	0.920
0.799	0.766
0.930	0.958
1.065	1.114
0.922	0.871
1.011	1.025
1.115	1.146
1.084	1.048
0.873	0.844
1.048	1.053
1.017	1.038
0.866	0.926
1.018	0.967
1.239	1.284
0.789	0.689
0.895	0.945
0.937	0.900
0.823	0.848
0.868	0.871
1.134	1.121
0.962	0.967
1.028	1.038
0.873	0.880
1.070	1.066
0.892	0.861
1.150	1.188
1.091	1.100
1.017	1.011
1.206	1.213
1.151	1.123
0.850	0.817
0.933	0.939
1.052	1.074
1.144	1.200
1.056	1.069
1.208	1.144
0.830	0.798
1.148	1.194
0.930	0.909
0.764	0.730
0.684	0.709
0.850	0.830
1.197	1.321
1.017	0.902
0.830	0.859
0.881	0.880
0.937	0.903

River No. 6 cont'd

U	Y
0.743	0.738
0.936	0.975
1.229	1.238
0.981	0.962
0.985	0.968
0.775	0.779
0.979	0.972
0.892	0.908
0.996	1.009
0.815	0.771
0.825	0.860
1.313	1.305
1.135	1.116
1.111	1.156
1.110	1.094
0.896	0.930
1.141	1.156
0.849	0.864
1.225	1.157
0.881	0.862
0.662	0.687
0.954	0.937
0.828	0.808
1.103	1.209
1.036	0.972
0.973	1.009
0.981	0.936
1.021	1.029
0.785	0.749
0.778	0.801
0.825	0.776
1.100	1.209
1.320	1.340
0.948	0.838
0.931	0.950
0.925	0.910
0.991	1.040
1.028	1.010
0.948	0.933
0.993	0.980
0.979	1.048
1.087	0.995
0.942	0.955
0.925	0.960
0.798	0.792
1.334	1.364
0.950	0.892
1.042	1.088
1.040	1.022
1.271	1.280
1.073	1.054
1.166	1.201
1.120	1.116
0.912	0.891
1.095	1.053
1.083	1.118
0.595	0.555
1.123	1.202
1.076	1.032
1.233	1.242
0.776	0.773
1.149	1.124
1.177	1.246
0.921	0.856
0.905	0.882
1.006	1.071
1.360	1.351
0.959	0.919
0.902	0.902
0.785	0.786
1.054	1.056
1.298	1.387
1.211	1.163
0.971	0.941
1.064	1.043
1.360	1.490
1.143	1.004
0.897	0.931
0.789	0.769

River No. 6 cont'd

U	Y
0.846	0.859
1.203	1.243
1.031	0.979
0.740	0.699
1.058	1.094
0.637	0.602
0.757	0.792
1.151	1.149
0.952	0.959
1.163	1.152
0.916	1.048
1.255	1.134
1.043	1.072
1.033	1.062

7.Rhine River,near Maxau, Germany

1900-1955

U	Y
0.884	0.955
0.938	0.899
0.807	0.798
0.898	0.871
0.843	0.935
0.925	0.809
0.824	0.843
0.878	0.940
0.847	0.842
1.279	1.297
0.871	0.781
0.974	1.071
1.007	0.971
1.250	1.281
1.053	1.008
1.147	1.209
1.133	1.130
0.915	0.876
1.109	1.057
1.131	1.181
0.602	0.539
1.164	1.282
1.122	1.057
1.281	1.296
0.777	0.764
1.156	1.118
1.166	1.293
0.924	0.808
0.861	0.746
0.975	1.156
1.360	1.352
0.941	0.876
0.888	0.882
0.708	0.726
0.982	0.993
1.262	1.299
1.224	1.202
0.924	0.903
1.046	1.137
1.412	1.431
1.246	1.137
0.926	0.901
0.806	0.782
0.833	0.898
1.115	1.117
1.048	1.029
0.710	0.623
1.067	1.136
0.618	0.559
0.714	0.772
1.151	1.136
0.958	0.986
1.178	1.130
0.852	0.964
1.284	1.213

8.Inn River,near Reisach, Germany

1900-1955

U	Y
0.984	1.003
1.035	1.030
0.984	0.989
1.022	1.005
1.074	1.090
1.010	0.985
1.055	1.062
0.945	0.957
0.797	0.780
1.164	1.188
0.952	0.926
1.080	1.096
0.939	0.934
1.084	1.079
0.945	0.924
0.968	1.007
1.038	1.023
0.922	0.945
1.058	1.017
1.222	1.280
0.829	0.773
0.964	1.000
0.964	0.940
1.116	1.137
0.868	0.842
1.110	1.112
1.116	1.148
1.000	0.987
0.990	0.966
0.929	0.950
1.132	1.138
0.852	0.891
0.903	0.850
0.948	0.953
1.087	1.096
1.064	1.037
1.161	1.222
0.997	0.936
0.897	0.915
1.084	1.073
0.942	0.941
0.900	0.916
0.958	0.932
0.971	0.986
1.116	1.110
0.971	0.967
0.797	0.756
1.110	1.138
0.735	0.733
1.238	1.250
1.019	1.001
0.890	0.925
0.971	0.940
0.977	1.012
1.116	1.105

9.Danube River,near Hofkirchen,Germany

1900-1955

U	Y
0.908	0.912
0.940	0.935
0.873	0.863
0.881	0.887
0.956	0.992
1.206	1.181
1.030	1.005
0.886	0.921
0.812	0.796
1.279	1.315
0.918	0.846
1.053	1.164
1.135	1.072

River No. 9 cont'd

U	Y
1.267	1.267
1.034	1.033
1.167	1.197
0.937	0.907
0.793	0.762
0.935	0.922
1.159	1.208
0.552	0.491
0.942	1.058
1.143	1.051
1.213	1.257
0.788	0.764
1.222	1.215
1.060	1.125
0.850	0.773
0.728	0.711
0.808	0.864
1.233	1.244
0.997	0.955
0.881	0.878
0.672	0.683
0.913	0.900
1.113	1.155
1.208	1.211
1.026	1.010
1.035	1.094
1.579	1.595
1.468	1.438
1.152	1.076
0.774	0.758
1.083	1.140
1.328	1.317
0.968	0.948
0.800	0.753
1.182	1.219
0.678	0.657
0.650	0.670
0.932	0.918
0.810	0.834
0.980	0.948
0.820	0.887
1.241	1.211

10.Main River,near Schweinfurt, Germany

1910-1955

U	Y
1.059	0.918
0.769	0.858
1.090	1.037
1.253	1.285
1.186	1.156
1.067	1.096
0.950	0.932
0.698	0.690
0.784	0.773
1.247	1.263
0.497	0.474
0.804	0.902
1.222	1.208
1.342	1.393
1.003	0.940
1.393	1.393
1.205	1.260
1.112	1.028
0.669	0.658
0.788	0.896
1.400	1.362
0.890	0.848
0.837	0.821
0.474	0.459
0.908	0.929
1.034	1.075
1.390	1.356
0.697	0.695

River No. 10 cont'd

U	Y
0.910	0.978
1.603	1.648
1.813	1.840
1.328	1.222
0.710	0.673
0.957	0.995
1.333	1.347
0.989	0.982
0.786	0.746
1.186	1.210
0.494	0.475
0.571	0.597
0.898	0.884
0.908	0.946
1.049	1.018
0.596	0.683
1.101	1.048

11.Ems River, near Rheine, Germany
1900-1955

U	Y
0.996	0.978
1.408	1.415
1.181	1.227
0.868	0.798
0.659	0.674
1.074	1.065
0.829	0.846
0.847	0.844
0.583	0.597
1.326	1.346
0.662	0.607
0.701	0.771
1.202	1.141
1.214	1.232
1.208	1.194
1.169	1.170
0.795	0.787
0.807	0.840
0.835	0.797
1.026	1.062
0.625	0.590
0.598	0.606
1.302	1.317
1.606	1.808
1.102	0.889
1.502	1.502
1.457	1.527
0.986	0.916
0.850	0.837
0.677	0.683
1.269	1.286
0.810	0.798
0.738	0.733
0.452	0.451
0.750	0.751
1.050	1.093
1.560	1.519
0.653	0.671
1.111	1.095
1.029	1.048
1.266	1.263
1.193	1.180
0.947	0.954
1.044	1.037
1.463	1.479
1.311	1.298
0.640	0.624
1.257	1.276
0.464	0.450
0.932	0.938
1.117	1.119
0.956	0.944

River No. 11 cont'd

U	Y
0.902	0.911
0.725	0.771
1.263	1.244

12.Weser River,near Hann-Muenden,Germany
1900-1955

U	Y
1.203	1.200
1.188	1.162
0.856	0.878
1.032	0.989
0.982	1.019
1.322	1.308
1.079	1.070
1.069	1.088
0.722	0.707
1.181	1.196
0.769	0.729
0.760	0.875
1.234	1.141
1.190	1.195
1.119	1.114
1.100	1.130
0.969	0.948
0.841	0.846
0.780	0.758
0.749	0.765
0.531	0.506
0.917	0.960
1.251	1.225
1.368	1.567
1.078	0.939
1.524	1.485
1.179	1.224
0.982	0.917
0.669	0.656
0.636	0.664
1.228	1.264
0.816	0.770
0.865	0.877
0.535	0.497
0.895	0.915
0.877	0.899
1.290	1.271
0.700	0.699
1.016	1.026
1.379	1.434
1.519	1.521
1.266	1.215
0.748	0.723
0.899	0.908
1.326	1.337
1.247	1.255
0.788	0.746
1.147	1.192
0.587	0.557
0.762	0.780
1.063	1.054
0.909	0.908
1.077	1.085
0.503	0.531
1.276	1.275

13.Elbe River, near Darchau, Germany
1900-1955

U	Y
0.939	0.938
1.003	1.006

River No. 13 cont'd

U	Y
0.822	0.822
0.825	0.786
0.873	0.950
1.192	1.195
1.321	1.283
0.937	0.918
0.839	0.845
1.019	1.085
1.034	0.935
0.709	0.789
0.905	0.858
0.934	0.935
1.126	1.186
1.360	1.310
1.104	1.067
0.712	0.723
0.815	0.803
1.309	1.352
0.720	0.668
0.842	0.921
1.275	1.224
1.112	1.155
0.818	0.814
1.534	1.542
1.356	1.348
0.971	0.914
0.768	0.758
0.627	0.669
1.199	1.230
0.987	0.934
0.693	0.675
0.524	0.521
0.798	0.793
0.806	0.825
1.092	1.129
1.110	1.155
1.177	1.153
1.705	1.744
1.913	1.921
1.366	1.261
0.756	0.713
0.994	1.002
1.037	1.065
1.141	1.137
0.832	0.783
1.084	1.123
0.749	0.725
0.763	0.763
0.768	0.768
0.692	0.713
1.005	0.978
0.677	0.743
1.328	1.322

14.Danube River,at Vienna-Mussdorf, Austria, 1893-1957

U	Y
0.830	0.884
0.890	0.821
1.194	1.252
1.172	1.158
0.858	0.799
0.959	1.025
1.028	0.978
0.810	0.816
0.928	0.919
0.888	0.904
0.862	0.865
1.001	1.005
1.133	1.162
1.124	1.072
0.830	0.847
0.786	0.811

River No. 14 cont'd

U	Y
1.265	1.253
0.895	0.854
1.078	1.126
1.020	1.009
1.249	1.277
1.051	1.006
1.140	1.172
0.977	0.935
0.860	0.882
1.018	0.993
1.215	1.255
0.741	0.697
0.946	1.023
1.143	1.080
1.187	1.208
0.846	0.845
1.260	1.251
1.028	1.067
0.888	0.843
0.820	0.792
0.835	0.873
1.095	1.122
0.930	0.880
0.915	0.924
0.775	0.764
0.966	0.962
1.001	1.037
1.194	1.212
1.046	1.004
0.933	0.940
1.286	1.328
1.222	1.180
1.074	1.074
0.862	0.867
1.156	1.164
1.238	1.274
1.021	0.942
0.703	0.660
1.205	1.246
0.788	0.786
0.761	0.782
0.932	0.920
0.902	0.905
0.950	0.937
0.909	0.985
1.237	1.189
1.036	1.028
1.101	1.126

15.Drau River at Neubruecke,Austria
1901-1956

U	Y
0.880	0.863
0.828	0.850
1.032	1.034
0.732	0.710
0.754	0.750
0.810	0.820
0.803	0.803
0.817	0.838
1.328	1.328
0.968	0.957
1.113	1.125
0.947	0.942
1.152	1.134
0.954	0.992
1.071	1.071
1.398	1.367
1.018	1.054
1.243	1.225
1.067	1.075
0.722	0.679
0.718	0.754

River No. 15 cont'd

U	Y
0.968	0.966
1.278	1.298
1.194	1.184
1.271	1.264
1.469	1.485
0.979	0.958
0.962	0.943
0.997	1.026
1.141	1.124
0.796	0.787
0.859	0.886
1.564	1.568
1.275	1.240
1.543	1.562
1.426	1.462
1.120	1.090
0.905	0.892
0.845	0.870
1.081	1.053
0.775	0.810
0.732	0.731
0.792	0.756
1.039	1.049
0.775	0.757
0.796	0.798
0.958	0.968
0.613	0.602
0.814	0.818
1.261	1.266
0.810	0.824
0.873	0.872
1.021	1.025
0.895	0.880
0.814	0.810

16.Drina River at Zvornik, Yugoslavia
1890-1957

U	Y
1.324	1.324
1.431	1.441
1.152	1.158
1.045	1.026
1.491	1.492
0.964	0.975
1.972	1.976
0.721	0.705
0.966	0.984
1.256	1.237
1.214	1.230
1.013	0.999
0.671	0.648
0.940	0.928
0.770	0.779
1.034	1.052
0.998	0.968
0.658	0.659
0.577	0.610
0.992	1.010
0.789	0.784
0.841	0.848
0.914	0.917
0.770	0.766
0.925	0.930
0.940	0.941
0.979	0.929
0.499	0.499
0.987	1.092
0.943	0.872
0.692	0.688
1.081	1.132
1.097	1.035
1.246	1.264
0.582	0.598

River No. 16 cont'd

U	Y
1.397	1.382
0.818	0.826
1.047	1.042
1.123	1.131
1.188	1.187
0.925	0.934
0.922	0.883
0.786	0.789
1.651	1.682
1.008	0.970
1.071	1.139
1.361	1.353
1,264	1.219
0.734	0.757
1.228	1.232
1.272	1.256
1.170	1.199
0.642	0.633
0.773	0.794
0.799	0.804
0.663	0.579
0.998	1.031
1.047	1.026
0.585	0.601
0.781	0.754
1.102	1.184
0.859	0.878
1.329	1.259
0.637	0.654
1.235	1.284
1.369	1.274
0.734	0.762

17.Danube River,at Orshava, Romania
1837-1957

U	Y
1.178	1.185
1.122	1.085
0.844	0.941
1.000	0.887
0.796	0.821
1.092	1.196
1.094	1.090
1.315	1.349
1.122	1.089
1.109	1.124
0.954	0.806
0.892	0.981
1.092	1.087
1.135	1.334
1.142	0.925
1.396	1.407
0.813	0.762
1.152	1.211
0.846	0.791
0.809	0.749
0.732	0.865
0.913	0.914
1.161	1.186
0.984	0.792
0.773	0.822
0.604	0.579
0.876	1.026
0.948	0.774
0.641	0.726
1.030	1.038
0.969	0.906
0.833	0.873
1.079	1.229
1.295	1.142
0.891	0.943
0.932	0.840
0.768	0.819

River No. 17 Cont'd

U	Y
0.807	0.779
1.241	1.336
1.124	1.086
0.986	1.065
1.461	1.338
0.939	1.081
1.246	1.166
0.799	0.927
1.220	1.050
0.904	0.967
0.831	0.794
1.000	0.929
0.796	0.799
1.124	1.235
0.878	0.912
0.842	0.747
0.924	0.894
0.976	0.988
0.859	0.814
0.756	0.818
1.125	1.033
0.995	1.248
1.342	1.268
0.810	0.621
0.847	1.049
1.120	0.908
0.922	1.062
1.079	0.999
0.844	0.839
0.833	0.882
0.915	0.894
1.178	1.218
1.120	1.020
0.788	0.771
0.762	0.840
1.178	1.294
0.976	0.774
1.019	1.027
1.226	1.469
1.155	1.094
1.342	1.411
1.319	1.219
1.140	0.974
0.736	0.862
1.206	1.141
1.164	1.269
0.704	0.473
0.874	1.171
1.133	0.917
1.185	1.319
0.792	0.823
1.356	1.313
1.006	1.041
0.870	0.757
0.866	0.813
0.810	0.912
1.071	1.152
1.056	0.869
0.883	1.002
0.911	0.916
0.913	0.777
0.986	1.124
1.252	1.419
1.194	1.043
0.870	0.798
1.343	1.507
1.433	1.444
1.300	1.039
0.671	0.599
1.025	1.220
1.138	1.094
0.801	0.694
0.786	0.703
1.000	1.120
0.704	0.690
0,712	0.617
1.062	1.149
0.812	0.861

River No. 17 Cont'd

U	Y
1.066	1.023
0.818	0.884
1.237	1.377
1.219	1.054
0.943	1.026

18.Riul Mures River,at Arad, Romania
1876-1955

U	Y
0.909	0.943
1.393	1.368
1.590	1.618
2.260	2.387
0.837	0.696
1.273	1.262
0.843	0.857
0.700	0.694
1.351	1.343
0.909	0.908
1.321	1.308
0.885	0.943
0.843	0.784
0.753	0.748
0.903	0.924
0.957	0.939
0.402	0.400
1.010	1.008
0.499	0.502
1.231	1.229
0.435	0.433
0.403	0.436
0.610	0.580
0.891	0.920
0.998	0.993
1.118	1.104
0.438	0.452
0.700	0.691
1.034	1.036
0.968	0.958
0.694	0.695
0.837	0.847
0.783	0.785
0.998	1.000
1.800	2.071
2.104	1.863
1.375	1.361
1.393	1.408
1.507	1.464
0,723	0.714
0.400	0.420
1.357	1.355
1.447	1.447
0.628	0.617
1.070	1.100
1.124	1.093
1.136	1.159
0.682	0.706
1.668	1.640
0.658	0.661
0.998	0.987
0.855	0.857
0.735	0.725
0.957	1.005
1.734	1.680
1.250	1.282
0.825	0.823
0.962	0.932
0.532	0.562
0.980	0.985
1.058	1.034
0.801	0.808
1.519	1.509
1.644	1.770

River No. 18 Cont'd

U	Y
1.871	1.736
0.493	0.489
0.723	0.763
1.052	1.033
0.873	0.853
0.837	0.850
1.034	1.037
0.783	0.790
0.523	0.502
0.771	0.785
0.598	0.594
1.094	1.098
0.646	0.639

19.Vistule River,near Jorun, Poland
1900-1940

U	Y
0.899	0.863
1.041	1.077
1.192	1.186
0.688	0.644
0.804	0.821
0.961	0.986
1.024	1.021
1.125	1.137
0.890	0.842
0.801	0.836
0.870	0.808
0.761	0.856
1.446	1.568
1.220	1.079
0.964	0.937
1.244	1.256
1.075	1.018
0.818	0.861
1.320	1.309
1.164	1.191
0.637	0.555
0.719	0.822
1.178	1.125
1.233	1.249
0.848	0.902
1.162	1.129
1.384	1.384
0.972	0.905
0.783	0.783
0.702	0.750
1.189	1.293
1.112	0.966
0.752	0.803
1.012	1.053
1.045	0.980
0.894	0.924
1.096	1.047
0.957	0.981
0.903	0.862
1.137	1.188

20.Göta River,near Sjötop-Vännersburg, Sweden, 1807-1957

U	Y
0.767	0.730
0.724	0.722
0.701	0.647
0.780	1.033
1.007	1.236
1.013	0.745
0.793	0.703

River No. 20 Cont'd

U	Y
0.991	1.284
1.044	1.403
1.310	1.372
1.276	1.025
0.966	0.474
0.828	1.081
0.953	0.786
0.933	0.890
1.020	1.450
1.186	1.084
1.145	1.185
1.119	0.910
0.929	1.040
0.963	0.920
1.048	1.224
1.121	1.320
1.343	1.234
1.160	0.928
1.009	0.972
1.216	1.403
1.011	0.613
0.944	1.291
1.104	1.043
1.104	1.274
1.216	1.214
1.138	0.941
1.179	1.467
1.323	1.048
0.880	0.506
0.746	0.887
0.922	0.979
1.186	1.462
1.063	0.789
0.983	1.230
1.129	0.967
0.989	0.981
1.140	1.552
1.276	0.996
1.276	1.362
0.955	0.327
0.683	0.758
0.744	0.755
0.825	0.906
0.714	0.524
0.660	0.618
0.905	1.831
1.379	1.134
1.101	1.016
1.153	1.133
1.073	0.905
0.880	0.690
0.942	1.472
1.315	1.496
1.298	0.983
1.114	1.017
1.019	0.834
0.905	0.791
0.852	1.129
1.326	1.744
1.343	0.968
1.047	0.808
0.776	0.686
0.910	1.234
1.114	0.982
0.936	1.024
0.961	0.592
0.726	0.937
1.106	1.565
1.190	1.046
1.190	1.005
1.009	1.073
1.099	0.920
0.843	0.605
0.808	1.060
0.899	0.708
0.910	1.198
1.009	0.954
1.026	0.941

River No. 20 Cont'd

U	Y
0.897	0.741
1.020	1.350
1.088	1.275
1.151	0.883
1.035	1.051
1.158	1.482
1.267	1.016
1.013	0.846
0.935	0.673
0.662	0.756
0.950	1.196
1.121	1.166
0.880	0.489
0.802	0.895
0.856	1.144
1.080	1.019
0.959	1.058
1.345	1.538
1.153	0.755
0.929	0.992
1.158	1.186
0.957	0.624
0.705	0.757
0.905	1.187
1.000	0.850
0.948	0.922
0.907	0.799
0.991	1.515
0.994	0.419
0.701	0.671
0.692	0.791
1.086	1.871
1.306	0.831
0.895	0.728
1.149	1.862
1.297	0.969
1.168	1.006
1.218	1.334
1.209	1.242
0.974	0.511
0.834	0.655
0.638	0.714
0.991	1.290
1.198	1.408
1.091	0.912
0.892	0.654
1.020	1.279
0.869	0.578
0.772	0.617
0.606	0.516
0.739	0.921
0.813	1.019
1.173	1.366
0.916	0.702
0.880	0.613
0.601	0.540
0.720	0.813
0.955	1.350
1.186	1.462
1.140	0.813
0.992	1.085
1.048	0.964
1.123	0.997
0.774	0.530
0.769	1.110

21.Dal River,near Norslund, Sweden
1852 - 1922

U	Y
1.155	1.219
0.645	0.554
0.873	0.924
0.902	0.917

River No. 21 Cont'd

U	Y
0.899	0.919
0.864	0.830
0.732	0.731
1.530	1.671
1.273	1.173
0.991	0.910
1.028	1.194
1.057	0.945
0.778	0.723
1.196	1.450
1.250	1.047
0.985	0.989
1.198	1.251
0.997	0.908
0.827	0.806
1.098	1.370
1.556	1.498
0.836	0.721
0.910	0.818
0.749	0.893
1.078	1.032
1.031	0.923
1.103	1.209
0.732	0.586
0.856	1.030
1.386	1.370
1.227	1.292
1.083	0.910
1.184	1.437
0.965	0.664
1.014	1.102
0.925	0.900
0.752	0.778
1.219	1.182
0.942	0.998
0.905	0.837
0.735	0.862
1.233	1.118
1.265	1.422
1.268	1.192
1.080	1.055
1.593	1.576
1.187	1.137
0.876	0.823
0.694	0.666
0.789	1.000
0.925	0.868
0.985	0.835
0.660	0.788
1.060	0.960
1.054	1.118
0.867	0.805
0.867	1.036
1.299	1.108
0.795	0.760
0.841	1.059
1.089	0.945
0.651	0.562
0.712	0.833
1.216	1.145
0.887	1.001
0.954	0.984
0.896	0.755
1.147	1.298
0.749	0.688
0.890	0.878

22. Indals River,near Ostersund,Sweden
1893-1957

U	Y
1.140	1.024
1.020	1.068
1.315	1.214

River No. 22 Cont'd

U	Y
0.929	0.932
1.078	1.120
1.319	1.395
1.103	1.071
0.892	0.783
1.041	1.240
1.281	1.211
0.990	0.790
1.095	1.130
1.037	1.025
1.041	1.088
0.912	0.858
0.904	1.048
0.916	1.273
0.867	0.374
0.771	0.791
0.912	0.887
0.966	0.975
0.888	0.938
0.970	0.938
0.888	0.907
1.020	1.058
0.759	0.731
0.941	0.896
1.045	1.255
1.186	0.993
1.049	1.146
1.107	1.068
1.020	1.015
1.107	1.113
1.103	1.094
0.858	0.848
1.008	1.074
0.871	0.754
0.863	0.960
1.124	1.077
0.896	0.933
1.124	1.096
1.211	1.225
0.937	0.943
0.709	0.645
1.302	1.406
0.950	0.839
0.829	0.930
1.024	1.076
0.937	0.856
1.236	1.191
1.070	1.143
1.120	1.069
1.136	1.149
0.734	0.687
0.850	0.881
1.232	1.220
0.987	1.002
0.734	0.736
0.941	0.969
1.120	1.112
0.792	0.775
0.850	0.842
1.028	1.066
0.999	1.044

23.Angerman River,near Forsmo, Sweden
1909-1957

U	Y
0.922	0.748
0.636	0.644
0.705	0.720
1.018	1.011
0.868	0.883
0.825	0.864
0.976	0.936
0.822	0.890

River No. 23 Cont'd

U	Y
1.078	1.162
1.084	1.003
1.241	1.187
1.076	1.208
1.112	1.013
0.886	0.973
1.256	1.242
1.286	1.242
1.076	1.030
1.284	1.417
1.039	0.930
0.994	1.090
1.115	0.970
1.009	1.095
0.907	0.894
0.762	0.742
0.795	0.805
1.048	1.068
1.449	1.417
0.708	0.717
1.223	1.268
1.066	0.982
0.596	0.712
0.967	0.964
0.618	0.571
1.148	1.118
0.943	1.021
1.473	1.390
0.976	1.015
0.684	0.634
0.976	1.031
1.133	1.083
1.211	1.287
1.021	0.997
1.039	1.062
1.301	1.292
0.886	0.885
0.910	0.856
0.852	0.890
0.997	1.038

24.Lule River,near Trangfors, Sweden
1911-1957

U	Y
0.927	0.869
0.839	0.925
1.032	1.022
1.018	1.007
1.052	1.011
1.030	1.020
1.074	1.129
0.899	0.841
1.004	1.098
1.086	0.969
0.931	1.026
0.931	0.910
0.929	0.866
1.070	1.114
0.963	0.929
0.939	0.928
0.776	0.830
0.975	0.921
0.927	0.999
0.947	0.922
1.166	1.214
1.114	1.076
1.146	1.170
0.940	0.942
0.961	0.924
1.255	1.260
0.929	0.930
1.006	0.984
0.951	1.020

River No. 24 Cont'd

U	Y
0.955	0.870
1.114	1.168
0.982	1.015
1.174	1.121
1.022	1.051
1.130	1.100
1.106	1.087
1.146	1.122
0.853	0.898
1.150	1.112
0.935	1.059
0.839	0.803
0.982	0.961
0.929	0.896
1.162	1.188
1.012	0.971
1.126	1.176
0.917	0.867
0.909	0.912
0.931	0.963
1.191	1.151
1.022	1.037
0.802	0.779
1.030	1.078
1.058	1.052
1.010	0.977
0.833	0.810
0.861	0.921

25.Lule River,near Porjus, Sweden
1900-1957

U	Y
0.905	0.888
0.931	0.873
1.025	1.084
0.852	0.782
0.765	0.796
0.950	0.974
0.927	0.864
0.837	0.918
1.138	1.142
1.266	1.315
0.995	0.920
0.897	0.914
0.829	0.846
1.274	1.252
0.946	0.977
0.988	0.942
0.893	0.896
1.018	1.081
1.055	0.975
0.927	0.990
1.312	1.394
1.127	1.044
1.210	1.211
1.048	1.016
0.942	0.952
0.890	0.843
1.229	1.282
0.848	0.832
0.893	0.958
0.927	0.948
0.995	0.977
1.206	1.157
1.037	1.065
1.055	1.018
0.988	1.012
0.961	0.953
1.003	0.992
1.372	1.486
1.014	0.871
0.761	0.819
1.048	0.993

River No. 25 Cont'd

U	Y
1.029	1.069
1.037	1.044
0.829	0.836
0.893	0.838
0.924	0.962

26.Neumunas River,at
Smalininkai,Lituania,
USSR, 1811-1943

U	Y
0.715	0.750
0.854	0.963
0.931	0.805
0.812	0.826
1.072	1.173
1.243	1.122
0.893	0.899
0.748	0.744
0.940	1.052
1.089	1.066
1.135	1.087
1.036	1.020
0.953	0.980
0.957	0.948
0.869	0.802
0.886	0.875
1.126	1.260
1.480	1.490
0.970	0.914
0.893	0.840
0.752	0.804
0.843	0.823
1.208	1.214
0.766	0.682
0.777	0.825
1.128	1.145
0.772	0.752
0.898	0.865
1.047	1.250
1.021	0.861
0.632	0.626
0.829	0.817
1.327	1.474
1.194	1.204
1.106	0.932
0.746	0.765
0.632	0.625
0.874	0.986
0.918	1.048
1.258	1.054
1.054	1.048
1.261	1.334
1.001	0.941
1.245	1.342
0.926	0.798
1.150	1.127
0.724	0.710
0.798	0.864
0.889	0.868
1.008	1.012
0.992	0.989
0.697	0.652
0.953	1.087
0.891	0.785
0.950	0.932
1.404	1.526
1.135	1.056
0.977	1.020
1.063	1.105
1.102	1.021
0.891	0.912
0.994	0.941
0.898	0.887
0.763	0.793

River No. 26 Cont'd

U	Y
1.016	1.033
1.060	1.078
1.027	1.040
1.195	1.218
1.287	1.313
1.072	0.985
0.847	0.822
1.184	1.296
1.206	1.132
1.083	1.205
1.093	0.925
0.970	1.078
0.988	0.868
0.948	1.011
0.810	0.832
1.034	0.945
0.944	0.955
0.867	0.994
1.062	1.013
0.979	1.016
0.961	0.833
1.008	0.990
0.878	0.959
1.071	1.076
0.992	0.944
0.999	0.938
1.140	1.293
1.232	1.236
1.003	0.927
1.091	1.147
1.161	1.090
0.952	0.899
1.084	1.123
0.884	0.857
1.028	1.027
0.867	0.848
0.763	0.837
1.082	1.074
1.155	1.142
0.803	0.724
1.408	1.550
1.049	1.049
1.008	0.959
0.928	0.865
0.827	0.821
0.724	0.702
0.952	1.018
0.873	0.985
1.393	1.275
0.948	1.071
1.326	1.291
1.151	1.222
1.150	1.015
0.818	0.786
0.904	1.029
1.544	1.520
1.234	1.278
1.302	1.287
1.054	0.968
1.034	1.086
1.118	1.085
1.008	0.896
0.732	0.783
0.847	0.828
0.930	1.028
1.172	1.094
0.803	0.738
0.842	0.924

27.Neumunas River,at
Birstonas,Lithuania,
USSR, 1880-1943

U	Y
0.966	0.904

River No. 27 Cont'd

U	Y
0.737	0.718
1.170	1.235
1.013	0.952
0.988	1.136
1.086	0.936
0.912	0.969
0.974	0.918
1.013	1.056
0.828	0.818
1.002	0.980
0.806	0.795
0.872	0.929
0.999	0.975
0.926	0.927
0.966	0.953
0.966	0.954
0.777	0.813
0.941	0.949
1.028	0.998
1.104	1.100
1.155	1.174
1.184	1.223
0.890	0.844
1.072	1.123
1.159	1.121
1.028	0.999
1.053	1.071
0.970	0.961
0.944	0.969
0.894	0.858
0.803	0.855
0.992	0.980
1.115	1.121
0.745	0.715
1.148	1.203
1.035	1.018
1.082	1.071
0.915	0.891
0.886	0.880
0.668	0.657
0.988	1.056
0.981	0.999
1.224	1.163
0.886	0.923
1.180	1.221
1.228	1.203
1.032	1.002
0.810	0.808
0.879	0.981
1.508	1.477
1.213	1.206
1.308	1.355
1.148	1.056
1.050	1.067
1.177	1.180
1.046	0.987
0.796	0.801
0.853	0.853
1.002	1.051
1.199	1.171
0.817	0.780
0.857	0.904

28.Nemunas River,at
Grondno,Lithuania,
USSR, 1876-1943

U	Y
1.391	1.392
0.901	0.879
1.146	1.224
0.876	0.816
0.881	0.906
0.666	0.627
1.266	1.244

River No. 28 Cont'd

U	Y
0.986	1.078
1.021	0.923
1.036	1.245
0.911	0.706
0.941	1.026
0.961	0.884
0.771	0.825
0.936	0.925
0.686	0.639
0.796	0.778
0.946	1.034
0.866	0.825
1.011	1.008
0.871	0.877
0.731	0.690
0.880	0.922
0.996	1.029
0.936	0.880
1.066	1.058
1.231	1.269
0.816	0.877
0.936	0.855
1.031	1.121
0.881	0.796
0.931	0.895
0.776	0.781
0.821	0.822
0.841	0.902
0.801	0.738
1.066	1.170
0.996	0.948
0.776	0.774
1.216	1.182
1.086	1.190
1.161	1.138
0.951	0.936
0.921	0.888
0.701	0.685
1.046	1.033
1.006	1.096
1.296	1.327
0.876	0.793
1.221	1.259
1.316	1.397
1.071	1.013
0.916	0.881
0.900	0.897
1.607	1.736
1.261	1.230
1.396	1.388
1.226	1.279
1.146	1.026
1.281	1.312
1.091	1.092
0.866	0.781
0.916	0.921
1.066	1.072
1.271	1.336
0.901	0.865
0.906	0.855

29.Danguva River at
Vitebsk, USSR
1877-1935

U	Y
1.358	1.350
1.577	1.567
1.035	1.002
1.166	1.168
0.712	0.640
0.808	0.886
1.061	1.026
0.563	0.538
0.926	0.976

River No. 29 Cont'd

U	Y
0.817	0.854
1.101	1.030
0.799	0.793
0.511	0.574
0.904	0.897
1.031	1.016
0.725	0.755
0.983	0.991
1.149	1.117
1.122	1.119
0.760	0.691
0.694	0.721
1.122	1.206
1.170	1.080
0.961	0.948
1.476	1.618
1.074	1.048
0.812	0.784
1.223	1.260
1.170	1.132
1.070	1.037
1.402	1.580
1.210	1.054
0.690	0.693
0.935	0.898
0.721	0.756
0.812	0.773
0.987	0.953
0.821	0.874
0.991	1.050
1.454	1.461
1.057	1.037
0.712	0.690
0.664	0.607
0.428	0.418
1.000	1.041
0.795	0.849
1.271	1.222
0.677	0.765
1.052	0.995
1.367	1.428
1.424	1.405
1.214	1.130
0.751	0.830
1.293	1.225
1.057	1.078
1.463	1.571
0.970	0.854
0.900	0.936

30.Neva River, at
Petrokrepost,USSR
1859-1935

U	Y
0.868	0.818
0.857	0.904
0.880	0.903
0.841	0.797
1.027	1.325
1.127	1.027
1.023	0.984
1.058	1.344
1.266	1.105
0.980	0.794
1.073	1.138
1.092	1.127
1.046	0.977
1.004	1.008
1.092	1.176
1.004	0.782
0.787	0.615
0.730	0.863
0.992	1.235
1.293	1.628

River No. 30 Cont'd

U	Y
1.308	0.981
1.069	1.080
1.023	0.776
0.768	0.718
0.969	1.077
0.861	0.756
0.872	0.857
0.791	0.710
0.934	1.214
1.038	1.086
0.942	0.659
0.799	0.749
0.756	0.963
0.988	1.035
1.054	1.186
1.069	0.921
0.984	0.934
0.930	0.806
0.811	0.870
1.139	1.596
1.343	1.269
1.177	0.948
0.911	0.983
1.235	1.511
1.324	0.787
1.270	1.684
1.282	1.120
0.965	0.719
0.791	0.761
0.876	0.916
0.930	0.904
0.872	0.981
1.062	1.109
1.011	0.912
0.888	0.752
0.776	0.762
0.780	0.815
0.926	1.084
1.069	1.214
1.023	0.806
0.838	0.733
0.737	0.589
0.730	1.132
1.004	1.046
1.393	1.714
1.243	0.844
1.015	1.006
1.004	0.977
0.980	1.138
1.266	1.325
1.166	0.968
1.042	1.102
1.038	0.957
1.042	0.985
0.922	0.811
0.919	1.108

31.Volkhov River at
Gustinopolic,USSR
1881-1933

U	Y
0.770	0.713
0.604	0.717
1.180	1.127
0.608	0.570
0.917	0.930
0.684	0.694
1.118	1.112
0.898	0.892
0.574	0.540
0.696	0.723
0.846	0.917
0.937	0.957
1.249	1.324

River No. 31 Cont'd

U	Y
1.144	1.017
0.905	0.936
0.863	0.763
0.729	0.777
1.501	1.536
1.111	1.074
0.974	0.943
1.114	1.385
1.480	1.325
0.972	0.935
1.175	1.176
1.067	0.992
0.793	0.795
0.744	0.981
1.234	1.052
0.881	0.906
1.197	1.155
1.014	0.987
0.908	0.895
1.153	1.152
0.896	0.914
0.888	0.958
1.334	1.400
1.273	1.206
0.839	0.779
0.662	0.596
0.491	0.504
1.237	1.341
1.042	1.113
1.653	1.534
0.746	0.766
1.318	1.312
1.072	1.083
1.312	1.491
1.438	1.249
0.709	0.720
1.057	1.046
0.920	0.909
1.072	1.082

32.Svir River at
Miatusovo, USSR
1881-1935

U	Y
0.979	0.723
0.785	0.865
1.042	0.983
0.918	0.911
0.946	0.934
0.913	0.942
1.204	1.573
1.241	1.111
1.047	0.694
0.775	0.687
0.819	1.193
1.014	0.901
1.011	1.060
0.912	0.818
1.069	1.123
0.881	0.630
0.796	0.896
1.135	1.509
1.161	0.940
0.997	0.796
0.865	1.194
1.273	1.565
1.401	1.282
1.287	1.168
1.182	0.925
0.888	0.840
0.828	0.827
0.891	0.940
0.998	0.895
0.921	1.073

River No. 32 Cont'd

U	Y
1.125	1.098
0.946	0.766
0.777	0.724
0.806	0.947
0.897	0.982
1.022	1.000
1.043	1.067
0.965	0.780
0.838	0.785
0.738	0.737
0.883	1.135
1.039	1.164
1.451	1.423
0.982	0.777
0.962	0.975
0.994	0.997
0.886	0.935
1.233	1.419
1.217	1.164
1.164	1.207
1.069	0.838
0.926	0.884
0.886	0.798
0.978	1.408

33.S.Dvina River, at
Ust-Pinega, USSR
1882-1935

U	Y
0.710	0.856
0.908	0.725
0.713	0.691
0.632	0.693
0.981	1.113
1.194	1.224
1.025	0.902
0.725	0.680
0.990	1.034
1.051	1.096
1.127	1.379
1.074	0.986
1.095	1.024
1.089	0.918
0.777	0.766
0.769	0.716
1.270	1.501
1.121	1.022
1.086	0.952
0.996	1.105
1.243	1.298
1.153	1.086
0.984	1.101
1.010	0.837
0.868	0.882
0.824	0.916
1.080	0.989
0.935	0.939
0.993	0.930
1.004	0.950
0.629	0.660
0.996	1.061
1.121	1.185
1.205	1.211
1.054	0.906
1.036	1.389
0.885	0.582
0.821	0.750
0.684	0.715
1.069	1.097
1.322	1.508
1.284	1.046
0.943	0.944
0.874	0.917
1.083	1.104

River No. 33 Cont'd

U	Y
1.136	1.203
1.529	1.561
1.162	1.026
0.938	0.917
0.993	1.731
0.926	0.270
0.879	0.753
1.002	1.152

34.Kama River, at
Berczniki, USSR
1881-1938

U	Y
1.126	1.164
0.766	0.774
1.106	1.106
0.872	0.822
1.181	1.282
0.957	0.888
1.091	1.106
0.964	1.012
0.780	0.679
1.102	1.193
1.102	1.112
1.170	1.195
1.204	1.148
1.270	1.356
0.826	0.738
0.946	0.971
0.918	0.879
1.426	1.488
1.091	1.113
0.996	0.902
1.074	1.103
1.010	1.007
1.035	1.067
1.010	1.031
0.988	0.933
0.616	0.604
0.879	0.924
1.315	1.292
0.815	0.789
0.914	0.923
0.967	0.907
0.698	0.762
1.259	1.299
0.957	0.982
1.348	1.420
1.078	0.903
1.018	1.196
1.074	0.974
0.897	0.816
0.702	0.732
0.727	0.700
1.021	1.090
1.159	1.179
1.159	1.116
1.371	1.437
1.215	1.195
1.482	1.426
1.181	1.179
1.048	1.075
0.836	0.796
0.936	0.934
0.811	0.843
0.801	0.756
0.889	0.940
0.642	0.598
0.616	0.632
0.553	0.501

35.Volga River at
Gorkii, USSR
1877-1935

U	Y
1.299	1.289
1.296	1.314
1.062	1.039
1.436	1.449
0.816	0.750
0.809	0.826
1.114	1.149
0.850	0.819
0.932	0.932
0.912	0.934
1.443	1.516
1.206	1.161
0.799	0.721
0.603	0.611
0.891	0.891
0.932	0.987
0.960	0.997
1.254	1.157
0.973	0.993
0.764	0.709
0.665	0.685
1.292	1.449
1.158	1.024
1.069	1.038
1.004	1.087
1.059	1.004
0.812	0.820
0.936	0.975
1.104	1.071
0.960	0.986
1.189	1.300
1.066	0.941
0.723	0.692
0.795	0.790
0.970	0.955
0.884	0.889
0.977	0.989
1.186	1.194
1.093	1.183
1.302	1.204
0.946	1.033
0.987	0.916
0.840	0.756
0.456	0.414
0.850	0.919
0.970	1.026
1.227	1.174
0.692	0.755
1.320	1.275
1.100	1.093
1.292	1.420
1.230	1.109
0.706	0.747
1.141	1.090
0.997	0.938
0.888	1.071
0.942	0.834
0.821	0.910

36.Don River, at
Kalach, USSR
1881-1929

U	Y
0.842	0.822
1.090	1.098
1.287	1.304
0.819	0.810
0.824	0.820
0.999	0.980
1.362	1.381
1.339	1.329
0.680	0.652

River No. 36 Cont'd

U	Y
0.484	0.471
0.782	0.787
1.210	1.225
0.607	0.611
1.179	1.166
1.240	1.278
1.034	1.009
0.885	0.876
1.124	1.155
0.828	0.799
0.977	0.974
1.007	1.009
0.832	0.828
0.936	0.939
0.651	0.642
0.717	0.719
0.983	0.981
1.049	1.062
0.469	0.459
0.717	0.729
0.506	0.492
0.868	0.884
1.037	1.037
0.565	0.549
1.769	1.817
1.220	1.217
1.785	1.791
0.815	0.800
1.069	1.074
1.680	1.663
0.861	0.844
1.013	1.016
0.694	0.700
1.003	0.995
0.616	0.645
1.621	1.621
1.231	1.237
1.040	1.053
1.650	1.636

37.Dnieper River,at Dnieperpetrovsk,USSR
1881-1955

U	Y
0.627	0.609
0.988	1.016
0.817	0.798
0.682	0.689
1.326	1.306
0.720	0.754
1.375	1.350
1.089	1.103
0.866	0.845
0.900	0.918
0.694	0.668
1.024	1.092
0.868	0.856
1.522	1.495
1.263	1.283
1.005	0.961
0.712	0.708
0.676	0.714
1.102	1.056
0.791	0.807
1.004	1.064
0.955	0.947
0.702	0.640
0.952	0.969
1.284	1.321
1.390	1.387
1.334	1.332
1.073	1.048
0.688	0.703
0.837	0.810

River No. 37 Cont'd

U	Y
0.992	1.054
1.073	1.102
1.075	0.980
1.118	1.130
1.171	1.192
1.503	1.515
0.802	0.822
1.180	1.164
0.978	0.922
0.448	0.428
0.955	0.995
1.014	1.026
1.204	1.190
0.493	0.499
1.082	1.092
1.140	1.137
1.064	1.070
1.211	1.182
0.675	0.695
1.481	1.483
1.596	1.592
1.411	1.649
1.504	1.293
1.021	1.010
0.965	0.928
1.022	1.029
1.003	0.980
0.667	0.658
1.029	1.067
1.312	1.387
1.635	1.531
0.604	0.630
0.862	0.847
0.862	0.905
0.850	0.797
0.963	0.986
0.833	0.847
0.802	0.814
0.658	0.620
1.006	0.996
0.640	0.646
1.284	1.321
0.574	0.541
0.969	0.990

AFRICA,ASIA, and NEW ZEALAND

1.Outflow from Lake Victoria,Nile Basin, Africa, 1898-1952

U	Y
1.232	0.973
0.873	0.804
0.875	0.899
0.727	0.646
0.989	1.332
1.276	1.238
1.194	1.118
1.418	1.751
1.390	1.175
1.093	0.992
1.024	0.942
0.903	0.888
0.792	0.687
0.691	0.704
0.787	0.844
0.783	0.786
0.893	0.941
1.072	1.288
1.446	1.770
1.553	1.219
1.083	0.962

River No. 1 Cont'd

U	Y
0.905	0.802
0.781	0.721
0.606	0.524
0.623	0.731
0.771	0.763
0.722	0.694
0.932	1.252
1.210	1.133
0.950	0.901
0.832	0.718
0.973	1.186
1.166	1.238
1.220	1.244
1.228	1.146
0.989	0.859
0.924	0.928
1.050	1.170
1.225	1.345
1.268	1.221
1.092	0.991
1.036	1.064
1.003	0.983
1.267	1.455
1.098	0.900
0.825	0.700
0.807	0.852
0.739	0.701
1.012	1.303
1.128	1.056
0.956	0.816
0.817	0.797
0.834	0.838
0.914	1.004

2.Lake Albert at Mongalla, Africa
1904-1952

U	Y
1.350	1.223
1.357	1.540
1.446	1.306
1.121	0.984
1.178	1.294
1.150	1.044
0.978	0.827
0.777	0.759
0.830	0.878
0.844	0.870
1.001	1.050
1.022	1.248
1.724	2.419
2.239	1.858
1.330	0.905
0.992	0.894
0.804	0.621
0.562	0.464
0.556	0.650
0.761	0.826
0.720	0.635
0.712	0.919
1.071	1.151
0.916	0.810
0.819	0.756
0.815	0.920
1.025	1.193
1.163	1.234
1.242	1.181
1.026	0.867
0.857	0.772
0.820	0.899
0.965	1.080
1.104	1.144
1.050	0.930
0.851	0.766

River No.2 Cont'd

U	Y
0.786	0.780
1.071	1.528
1.193	0.897
0.820	0.616
0.627	0.608
0.649	0.674
0.915	1.296
1.193	1.207
1.089	0.885
0.810	0.681
0.698	0.644
0.966	1.263

3.Nile (Second Half), at Aswan Dam, Egypt
1903-1955

U	Y
0.993	0.974
0.842	0.837
1.106	1.127
0.831	0.810
1.227	1.256
1.261	1.273
1.155	1.151
0.993	0.982
0.849	0.823
0.547	0.498
1.008	1.090
0.831	0.823
1.359	1.408
1.336	1.327
0.974	0.926
0.929	0.928
0.985	0.995
0.914	0.910
1.016	1.013
1.038	1.050
1.038	1.039
0.812	0.798
1.012	1.028
0.872	0.843
0.944	0.967
1.234	1.246
0.887	0.856
0.929	0.946
1.019	1.027
0.989	1.001
1.095	1.084
1.159	1.166
1.057	1.038
0.966	0.968
1.212	1.232
0.898	0.884
0.793	0.761
0.763	0.782
1.000	1.006
0.948	0.936
0.861	0.852
0.936	0.968
1.234	1.248
1.008	0.992
1.038	1.023
0.993	1.007
1.061	1.052
0.864	0.874
0.880	0.854
0.974	0.983
1.246	1.264

4.Niger River at Koulicoro, Africa
1906-1957

U	Y
0.732	0.731
0.789	0.791
1.270	1.269
0.803	0.801
1.043	1.045
0.846	0.844
0.529	0.530
0.605	0.603
0.900	0.901
0.892	0.892
0.957	0.962
1.035	1.032
0.902	0.900
0.803	0.803
0.677	0.675
0.961	0.967
1.008	1.006
1.427	1.428
1.529	1.530
1.091	1.087
1.276	1.278
1.401	1.404
1.341	1.340
1.311	1.311
1.132	1.132
1.151	1.150
1.057	1.054
0.949	0.948
0.936	0.935
1.120	1.123
0.832	0.830
0.956	0.955
0.883	0.884
0.761	0.759
0.804	0.805
0.645	0.644
0.772	0.772
0.646	0.645
0.802	0.803
0.996	0.996
0.817	0.817
1.085	1.089
0.899	0.896
0.980	0.984
1.385	1.389
1.060	1.056
1.280	1.285
1.352	1.356
1.333	1.330
0.883	0.874
1.355	1.358

5.Tigris River, at Baghdad, Iraq
1906-1946

U	Y
1.769	1.752
1.394	1.381
1.061	1.053
1.056	1.055
0.924	0.927
0.894	0.890
0.842	0.842
0.860	0.864
1.602	1.626
1.302	1.292
0.792	0.776
0.925	0.934
1.302	1.309
0.937	0.933
0.807	0.799
1.114	1.123

River No. 5 Cont'd

U	Y
1.250	1.263
0.832	0.808
0.499	0.497
1.162	1.180
0.817	0.807
0.741	0.743
1.060	1.071
0.431	0.409
0.768	0.777
0.704	0.703
0.732	0.735
0.709	0.706
0.725	0.727
0.883	0.895
0.915	0.906
1.128	1.136
1.090	1.091
1.204	1.217
1.279	1.268
1.175	1.182
1.211	1.208
0.923	0.919
0.826	0.826
1.350	1.372

6.Lake Taupo inflows,
New Zealand,
1904-1955

U	Y
1.075	1.076
1.325	1.386
1.098	1.045
0.946	0.943
1.423	1.453
0.864	0.800
0.948	1.001
1.149	1.126
0.904	0.905
0.679	0.656
0.997	0.996
0.993	0.983
1.162	1.222
1.176	1.140
0.900	0.920
1.038	0.988
1.004	1.057
0.884	0.850
0.853	0.874
1.084	1.083
1.153	1.149
1.425	1.452
1.046	1.000
1.153	1.205
1.191	1.166
0.804	0.794
0.913	0.902
0.844	0.891
0.837	0.790
0.922	0.951
1.307	1.326
1.064	1.042
0.819	0.789
0.942	0.943
0.977	1.019
0.844	0.873
0.988	0.954
1.040	0.962
1.209	1.277
0.964	0.994
0.973	0.925
0.962	0.928
0.913	0.909

River No. 6 Cont'd

U	Y
0.926	0.946
0.913	0.884
0.719	0.746
0.859	0.850
1.031	1.040
1.046	1.062
0.721	0.691
0.991	1.022

7.Tama River,near
Atsumi, Japan
1918-1955

U	Y
1.144	1.133
1.490	1.514
1.412	1.366
0.875	0.872
1.646	1.665
0.758	0.729
1.031	1.060
0.486	0.447
0.757	0.765
2.460	2.485
0.901	0.932
1.152	1.143
0.769	0.750
0.800	0.815
0.720	0.712
0.647	0.630
1.118	1.110
0.901	0.962
0.927	0.869
1.464	1.488
0.849	0.828
0.551	0.540
1.152	1.194
0.718	0.681
0.927	0.912
0.598	0.604
0.866	0.901
0.640	0.640
1.473	1.451
0.953	1.002
1.680	1.693
1.395	1.393
0.797	0.747
0.631	0.608
0.792	0.798
0.823	0.838
0.696	0.725

8.Tone River,at
Iwamato, Japan
1918-1956

U	Y
0.958	0.984
1.008	0.991
1.108	1.094
1.046	1.045
1.188	1.187
0.717	0.710
1.006	1.027
0.944	0.936
1.043	1.050
1.071	1.061
1.131	1.128
0.994	0.992
0.841	0.840
1.011	1.015

River No. 8 Cont'd

U	Y
0.822	0.817
1.115	1.119
1.061	1.062
1.066	1.067
0.971	0.979
1.102	1.094
0.910	0.899
0.863	0.874
0.892	0.892
0.826	0.814
0.961	0.964
0.871	0.867
1.033	1.040
0.949	0.981
1.118	1.143
1.214	1.214
1.238	1.192
1.134	1.111
0.803	0.823
1.016	1.004
1.130	1.137
0.910	0.892
0.943	0.943
0.985	1.006

VICTORIA,AUSTRALIA

1.Avoca River at
Coonover Bridge,
Victoria,Australia
1889-1948

U	Y
1.980	1.942
0.112	0.116
1.385	1.381
2.990	2.994
2.058	2.059
0.255	0.258
0.327	0.319
0.413	0.411
0.786	0.788
0.358	0.359
0.290	0.288
0.260	0.260
0.098	0.104
1.773	1.771
0.352	0.352
0.439	0.438
1.760	1.760
0.154	0.154
0.558	0.559
2.718	2.736
2.757	2.761
0.878	0.872
1.019	1.021
0.314	0.308
0.069	0.062
1.142	1.143
2.343	2.343
2.472	2.493
1.709	1.694
0.102	0.099
1.734	1.740
1.657	1.660
0.207	0.203
2.628	2.655
1.215	1.193
0.280	0.283
0.570	0.564
0.493	0.496
0.412	0.411
0.090	0.087
0.739	0.759

River No. 1 Cont'd

U	Y
2.149	2.239
1.283	1.202
1.980	1.954
0.318	0.319
1.372	1.373
1.320	1.321
0.177	0.177
0.874	1.593
1.980	1.264
0.100	0.100
0.291	0.291
1.838	1.843
0.085	0.083
0.128	0.128
1.227	1.246
0.479	0.473
0.966	0.955
0.535	0.540

2.Broken River at
Goorambeet,Victoria
1886-1948

U	Y
1.567	1.549
0.561	0.557
2.318	2.324
1.961	1.981
0.685	0.657
1.064	1.070
2.121	2.151
2.690	2.672
0.718	0.723
0.437	0.418
0.579	0.580
0.791	0.801
0.623	0.624
0.809	0.800
0.670	0.666
0.156	0.170
0.875	0.861
1.141	1.151
1.050	1.045
1.658	1.669
0.368	0.349
0.503	0.513
1.738	1.734
0.984	0.999
0.802	0.786
0.594	0.599
0.554	0.554
0.077	0.069
1.090	1.095
2.241	2.263
4.446	4.445
2.303	2.294
0.256	0.246
1.502	1.510
1.589	1.588
0.386	0.380
1.348	1.383
1.261	1.243
0.499	0.500
1.363	1.352
0.379	0.394
0.842	0.835
0.236	0.224
0.488	0.502
1.848	1.926
1.075	0.990
0.769	0.775
0.762	0.771
1.122	1.112
0.933	0.927

River No. 2 Cont'd

U	Y
0.270	0.269
0.627	0.972
2.161	1.821
0.145	0.143
0.184	0.180
1.414	1.416
0.263	0.262
0.113	0.113
0.302	0.308
0.475	0.472
0.842	0.841
0.372	0.374

3.Bungyip River at
Bungyip,Victoria
1907-1948

U	Y
0.646	0.626
0.862	0.855
0.694	0.743
1.275	1.294
0.886	0.897
1.119	1.067
0.472	0.479
0.688	0.681
1.059	1.124
1.359	1.317
1.030	1.035
0.634	0.631
1.155	1.126
0.682	0.681
0.916	0.909
1.688	1.949
1.748	1.539
0.862	0.866
0.856	0.816
0.832	0.836
0.880	0.943
1.059	1.000
1.131	1.203
1.281	1.315
1.401	1.309
0.766	0.794
2.041	2.312
1.436	1.179
1.071	1.051
1.018	0.979
0.460	0.488
1.586	1.591
0.736	0.739
1.006	0.982
0.808	0.827
0.616	0.606
0.712	0.674
0.574	0.686
0.892	0.813
1.149	1.156
0.910	0.879

4.Glenelg River at
Balmoral,Victoria
1888-1932

U	Y
2.211	2.198
0.642	0.641
0.238	0.238
0.897	0.897
1.850	1.850
1.264	1.265

River No. 4 Cont'd

U	Y
0.909	0.910
0.191	0.191
0.161	0.161
0.349	0.350
0.560	0.561
0.766	0.766
0.519	0.520
0.141	0.141
2.248	2.249
0.716	0.716
0.878	0.878
3.774	3.776
1.115	1.115
0.804	0.804
1.763	1.763
1.856	1.901
0.847	0.803
0.866	0.866
0.440	0.440
0.021	0.022
1.451	1.452
1.277	1.277
1.989	1.988
0.984	0.984
0.394	0.394
1.158	1.159
0.560	0.561
0.510	0.510
1.501	1.502
1.625	1.626
0.666	0.667
1.246	1.246
0.209	0.209
0.481	0.481
0.679	0.679
0.618	0.619
1.557	1.577
1.065	1.044

5.Goulburn River,near
Murchison,Victoria
1881-1954

U	Y
0.882	0.865
1.244	1.245
0.494	0.505
0.857	0.842
0.651	0.678
1.688	1.668
0.750	0.748
1.552	1.552
1.329	1.344
0.721	0.702
0.995	0.995
1.251	1.267
1.518	1.514
0.731	0.744
0.554	0.536
0.548	0.544
0.687	0.698
0.680	0.700
0.910	0.908
0.901	0.877
0.289	0.306
0.992	0.976
0.961	0.959
1.027	1.032
1.716	1.720
0.504	0.493
0.526	0.529
1.357	1.358
1.058	1.074
1.039	1.024
0.668	0.688

River No. 5 Cont'd

U	Y
0.636	0.615
0.224	0.223
1.159	1.162
1.713	1.748
2.668	2.646
1.527	1.523
0.510	0.507
1.310	1.308
1.288	1.292
0.526	0.526
1.562	1.604
1.294	1.262
0.589	0.587
1.017	1.006
0.705	0.735
1.039	1.039
0.636	0.614
1.046	1.088
1.896	2.010
1.200	1.054
1.033	1.046
1.162	1.205
1.276	1.227
0.964	0.957
0.403	0.405
0.570	0.739
1.694	1.530
0.409	0.410
0.595	0.593
1.402	1.417
0.664	0.649
0.494	0.490
0.646	0.662
0.790	0.782
1.077	1.081
0.778	0.774
0.976	1.008
0.693	0.666
1.310	1.304
2.098	2.100
1.439	1.438
0.888	0.886

6.Kiewa River, at
Kiewa, Victoria
1885-1957

U	Y
0.707	0.738
1.174	1.144
0.647	0.650
1.133	1.128
1.130	1.154
0.598	0.569
0.825	0.829
1.063	1.098
1.264	1.256
0.825	0.832
0.563	0.527
0.569	0.576
0.802	0.823
0.608	0.634
0.798	0.743
0.593	0.597
0.319	0.336
0.778	0.758
0.841	0.840
1.169	1.189
1.987	1.978
0.795	0.782
0.643	0.648
1.494	1.487
1.384	1.424
0.847	0.820
1.236	1.265

River No. 6 Cont'd

U	Y
0.676	0.647
0.275	0.263
1.236	1.245
1.905	1.945
3.179	3.156
1.507	1.497
0.702	0.693
1.285	1.294
1.210	1.203
0.559	0.552
1.535	1.576
1.521	1.492
0.899	0.930
1.727	1.687
0.987	1.017
0.984	0.971
0.717	0.699
1.080	1.130
1.823	1.888
0.841	0.724
0.732	0.777
0.987	1.000
0.920	0.874
0.911	0.904
0.431	0.430
0.486	0.570
1.303	1.226
0.388	0.395
0.438	0.422
1.074	1.111
0.666	0.632
0.332	0.328
0.618	0.651
0.959	0.945
1.180	1.167
0.743	0.754
0.713	0.723
0.606	0.598
1.030	1.032
1.480	1.466
1.124	1.129
0.802	0.805
2.014	2.316
2.083	1.776
0.537	0.532

7.River Murray at
Jingellic,Victoria
1890-1957

U	Y
0.824	0.790
0.853	0.862
1.364	1.428
1.658	1.593
0.838	0.872
0.648	0.607
0.585	0.584
0.812	0.873
0.689	0.721
0.954	0.850
0.756	0.757
0.282	0.300
0.734	0.720
0.805	0.806
1.077	1.155
1.629	1.576
0.604	0.576
0.648	0.682
1.133	1.096
0.838	0.896
0.689	0.636
0.771	0.821
0.753	0.730
0.313	0.272

River No. 7 Cont'd

U	Y
1.222	1.256
1.476	1.516
2.560	2.564
1.051	1.019
0.686	0.684
1.185	1.235
1.126	1.072
0.663	0.633
1.476	1.562
1.271	1.240
0.794	0.805
1.159	1.112
0.801	0.885
0.734	0.685
0.596	0.559
0.887	0.968
1.625	1.641
0.991	0.901
0.846	0.891
1.394	1.432
1.084	1.043
1.096	1.070
0.522	0.512
0.440	0.529
1.450	1.397
0.428	0.396
0.447	0.432
1.334	1.424
0.798	0.728
0.364	0.360
0.667	0.707
1.137	1.135
1.319	1.320
0.909	0.880
0.883	0.961
0.909	0.870
1.234	1.242
2.083	2.050
1.375	1.373
0.689	0.679
2.027	0.317
2.340	2.061
0.656	0.652

8.Owens River at
Wangaratta,Victoria
1886-1948

U	Y
1.085	1.058
0.501	0.503
1.211	1.211
1.122	1.142
0.543	0.511
0.978	0.983
1.444	1.470
1.671	1.650
0.858	0.895
0.559	0.515
0.547	0.548
0.795	0.822
0.591	0.600
0.908	0.872
0.643	0.642
0.122	0.129
0.681	0.674
0.996	1.001
1.022	1.037
1.722	1.717
0.572	0.557
0.504	0.526
1.488	1.467
1.223	1.270
0.889	0.845
0.820	0.839

River No. 8 Cont'd

U	Y
0.491	0.477
0.152	0.143
1.255	1.264
2.012	2.055
3.475	3.454
1.633	1.617
0.439	0.430
1.293	1.303
1.520	1.514
0.502	0.497
1.450	1.504
1.337	1.311
0.650	0.648
1.507	1.487
0.681	0.731
1.091	1.058
0.574	0.557
0.807	0.840
2.182	2.333
1.085	0.904
0.864	0.889
1.268	1.280
1.261	1.233
1.091	1.090
0.346	0.341
0.536	0.802
2.018	1.834
0.265	0.200
0.383	0.366
1.677	1.696
0.662	0.685
0.236	0.194
0.607	0.643
1.053	1.027
1.350	1.348
0.750	0.758

9.Snowy River at
Jarrahmond, Victoria
1906-1948

U	Y
0.457	0.440
0.685	0.693
0.883	0.876
1.353	1.408
1.069	1.027
1.017	1.039
1.685	1.689
0.616	0.582
1.013	1.013
1.336	1.365
1.426	1.420
0.900	0.887
1.814	1.832
1.237	1.292
0.905	0.824
0.788	0.780
1.008	1.026
0.625	0.624
1.495	1.501
0.707	0.691
1.245	1.328
0.832	0.769
0.646	0.621
0.737	0.759
0.836	0.837
0.888	0.865
1.538	1.634
1.935	1.929
1.099	1.047
1.206	1.172
0.608	0.619
0.547	0.591
1.034	0.998

River No. 9 Cont'd

U	Y
0.543	0.528
0.560	0.557
1.172	1.217
0.819	0.784
0.676	0.726
0.720	0.688
1.306	1.304
1.082	1.148
0.952	0.869

**10. Thomson River at
Cowwarr, Victoria
1900-1948**

U	Y
0.949	0.936
0.616	0.622
0.978	1.016
0.649	0.594
1.070	1.093
1.140	1.124
0.665	0.657
0.535	0.534
1.462	1.462
0.985	1.006
1.180	1.159
0.824	0.856
1.106	1.078
0.439	0.435
0.822	0.830
1.258	1.290
1.661	1.633
1.341	1.349
1.285	1.285
0.952	0.936
1.030	1.031
0.846	0.883
1.708	1.696
0.956	0.941
1.151	1.159
0.842	0.826
1.066	1.084
0.965	0.955
0.938	0.932
1.016	1.028
1.023	1.057
1.025	0.981
1.012	1.061
1.697	1.865
1.155	0.962
1.211	1.205
0.537	0.527
0.555	0.587
1.330	1.298
0.672	0.678
0.719	0.712
1.160	1.188
0.797	0.775
0.896	0.895
0.754	0.784
1.019	0.994
1.030	1.031
0.972	0.970

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