Plate 5.6 Flood Discharge

Introduction

Despite their destructive effect floods are a phenomenon which never fails to fascinate. It is no coincidence that flood processes as well as flood protection have been central themes of hydrological research for a long time. The fact that the older measurement networks were set up with a view to mean and high flow underlines the importance of this field of hydrology. Knowledge concerning flood discharge is in fact a basic factor in planning hydro-engineering projects, optimum use of resources, economic use of installations and protection of waters.

High quality discharge data are necessary for solving many problems of water management, protection of waters and calibration of runoff models. In view of the mountainous character of Switzerland, flood discharge in steep slopes causes high flow velocity. The results are changes in the channel through erosion and silting-up, as well as the transport of large amounts of bed load, suspended load and floating material. Most of the methods of discharge measurement currently used necessitate the presence of specialists. It often happens, however, that floods occur within short periods of time in a matter of minutes or hours – or at night. In addition, floods are often difficult to predict, a fact which makes it difficult or even impossible to maintain a stand-by service. For this reason it is sometimes essential to extrapolate extreme flood discharge figures by means of hydraulic procedures based on discharge measurements, which leads to an additional lack of accuracy. This must be taken into account in the interpretation of extreme flood discharge.

Flood characteristics

The term flood is used when the baseflow is considerably exceeded over a given period of time. The definition of considerably exceeded must be decided in each individual case. Quite often a multiple of the mean discharge is used as a threshold value.

The following parameters are used to characterise floods: flood level, flood peak, volume and duration of flood. The flood hydrograph shows the relationship between peak flow, volume and duration. Together with data concerning flood frequency, the flood hydrograph is a very important factor in calculation methods. The design flood is that used for planning and designing flood protection measures. In Switzerland common practice so far has been to base the design of hydro-engineering projects on the so-called 100-year flood. The design of a dam was based on the statistically estimated flood which had ten times less occurrence probability (i.e. the 1000-year flood). Today more differentiated methods are used.

Knowledge concerning floods of selected return periods is an essential element in the design procedure. Problems arise in ascertaining the return period of floods owing to the fact that measurement series are too short, flood events have different processes of formation, errors are made in the measurement, homogeneity is lacking, or there is uncertainty regarding the determination of rating curves. Nevertheless, flood statistics are an important aid in planning and designing hydro-engineering projects.

Analysis of flood measurement series

Over the last few years the Swiss National Hydrological and Geological Survey has analysed its discharge measurement gathered over a minimum period of 10 years and parallel data supplied by cantonal offices, universities and private institutions, and has published the results of these analyses [4,5]. The aims were the following: to check and adjust flood observations, to draw up graphs to illustrate the data, to obtain information on flood frequency, to analyse changes in flood discharge over the measurement period and to estimate changes brought about by human intervention. This research has provided a stock of comprehensive basic material which can be used to solve a variety of problems.

The statistical analysis included monthly flood peaks. Flood probability was calculated for the highest annual flood peaks as well as for the highest summer and winter peaks. Calculations were based on recommendations for calculating flood probability as given in [3]. The distribution functions used were log-Pearson Type III, Pearson Type III and gamma distribution.

Information given on the map

The present map shows extreme flood discharge peaks, statistical characteristics and flood frequency for selected catchments throughout Switzerland. All measuring stations from which data was used are shown on the map. The symbol for the measuring station indicates the period of observation during the timespan indicated while the colour shows the degree of human influence on the flood regimen. A distinction has been made between stations which report little or no human influence, stations with moderate influence and stations with a high degree of influence. The number of the measuring station refers to the table which includes further flood characteristics and to map 5.1 which contains general information on measuring stations. The number in bold print corresponds to the mean value of the annual flood peaks during each of the most recent homogenous periods. These mean values are based on different periods according to the length of time the measuring station has been in operation. For purposes of comparison mean values and coefficients of variation have been calculated for suitable stations (area < 200 km^2, little or no human influence on the flood regimen) over a standard period (1971–1990). The results obtained have been classified and are shown by area on the map. The colour corresponds to the specific discharge of the mean annual flood peak and the type of shading indicates the coefficient of variation (quotient from standard deviation and mean value).

Apart from general information about the stations, the table of flood characteristics contains the following statistical values: mean annual discharge, mean value, standard deviation and skewness of annual flood peaks, the highest flood peak observed and the 50-year and 100-year flood peak values (flood peaks which, statistically, are expected to occur at an average rate of once every 50 or 100 years). In cases of heterogeneity (e.g. construction of alpine reservoirs), several measurement series were evaluated for one measuring station.

The graphic illustration shows the time series for 1921–1990 and 1961–1990 of flood peaks, provided by selected measuring stations. These peaks are differentiated according to whether they occurred in the summer or winter half-year. All flood peaks above a certain threshold value are shown using a dash-code. The lowest flood peak of the measurement series is usually taken as the threshold value, whereas here we had to deviate from this principle in one or two cases to avoid having an illegible accumulation of minor floods close to the threshold value. On the basis of these illustrations it is possible to ascertain whether there has been any change in the frequency of floods.

Final remarks

As a result of a series of heavy floods many interesting studies have been carried out in this field in Switzerland over the last few years. Reference [6] provides a summary of the present situation in this respect. Despite ongoing intensive research many questions remain unanswered, a fact which was underlined by a cause and effect analysis of the 1987 floods [1]. The charts on this page give an idea of the problem. They attempt to show the relationship between various catchment characteristics and the specific discharge of the mean annual flood peaks for the period 1971–1990. It is obvious that even trends are difficult to make out. Flood discharge from a catchment is a result of highly complex interplay between precipitation and the basin characteristics. It is not surprising that, despite great improvements in the basic data available and the use of a geographical information system, the conclusion of a new Swiss study on this subject casts doubt upon the possibility of regionalising flood discharge [2]. Within process research and modelling in the field of flood hydrology, in particular in measuring, every effort must therefore be made to ensure future access to the basic information necessary to provide reliable protection from floods, especially in view of the changing climatic conditions.

References

[1] **Bundesamt für Wasserwirtschaft, Landeshydrologie und -geologie (1991):** Ursachenanalyse der Hochwasser 1987. Mitteilung der Landeshydrologie und -geologie Nr. 14, Bern.

[2] **Düster, H. (1994):** Modellierung der räumlichen Variabilität seltener Hochwasser in der Schweiz. Geographica Bernensia G44, Bern.

[3] **DVWK (1979):** Empfehlungen zur Berechnung der Hochwasserwahrscheinlichkeit. DVWK-Regeln zur Wasserwirtschaft, Nr. 101, Hamburg.

[4] **Spreafico, M., Aschwanden, H. (1991):** Hochwasserabflüsse in schweizerischen Gewässern. Mitteilungen der Landeshydrologie und -geologie Nrn. 16 und 17, Bern.

[5] **Spreafico, M. Stadler, K. (1986):** Hochwasserabflüsse in schweizerischen Gewässern. Mitteilungen der Landeshydrologie und -geologie Nrn. 7 und 8, Bern.

[6] **Weingartner, R., Spreafico, M. (1990):** Analyse und Abschätzung von Hochwasserabflüssen – Eine Übersicht über neuere schweizerische Arbeiten. In: Deutsche Gewässerkundliche Mitteilungen, 34. Jg., Heft 1/2:42–45, Koblenz.

Relazione tra alcune caratteristiche del bacino e i contributi di punta medi annuali di piena (mHq)
Relationship between particular catchment characteristics and the specific discharge of the mean annual flood peak (mHq)