CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Hydrology is the science that deals with the occurrence and distribution of the waters of the Earth in time and space, both above and below the land surface, including their chemical, biological and physical properties, and their interaction with the physical environment (WMO/UNESCO, 1992). It provides an understanding of various phases of water as it passes from the atmosphere to the Earth and returns to the atmosphere. As such, it forms the basis for water resources assessment and management and the solution of practical problems relating to floods and droughts, erosion and sediment transport and water pollution. Increasing stress on the available water resources in the search for improved economic well-being and concerns for the pollution of surface water and groundwater have highlighted the central role of hydrology in all water and environment initiatives.

To provide guidance in monitoring this vital resource, which is central to the development and well-being of humankind, the World Meteorological Organization (WMO) Commission for Hydrology, at its first session (Washington DC, 1961), recognized the urgent need for the preparation of a guide to the relevant operational practices. As a result, the first edition was published in 1965 as the *Guide to Hydrometeorological Practices*.

The second and third editions of the Guide were published in 1970 and 1974, respectively. The third edition was entitled *Guide to Hydrological Practices* in recognition of the broader scope of its contents. Subsequently, during its fifth session (Ottawa, 1976), the Commission approved the revision of and substantial additions to the Guide to produce a fourth edition, which was issued in two volumes. Volume I dealt with data acquisition and processing and Volume II with analysis, forecasting and other applications. Volumes I and II of the fourth edition were published in 1981 and 1983, respectively. With the evolution of technology and the Hydrology and Water Resources activities within WMO, the fifth edition of the Guide was published in 1994 as one consolidated volume. It was also published on a CD-ROM for easy outreach to a wider water management community beyond the traditional WMO constituency.

In 1999, the World Meteorological Congress adopted "Weather, Climate and Water" as the official subtitle of the Organization. The following year, the Commission for Hydrology, at its eleventh session in Abuja, Nigeria, recommended that the sixth edition of the Guide be published as a live document to be uploaded to the Internet and updated more frequently, as and when required.

1.2 SCOPE

The accepted principles of integrated water resources management dictate that, in order to achieve environmental sustainability and economic productivity, rivers must be managed at the basin level. Today, when water is perceived to be a matter of universal concern, various stakeholders, at the national as well as at international level, participate and play important roles in the process. Many institutions and agencies within a country are engaged in the collection of hydrological data and information. These data may be collected by various agencies using different measurement procedures. The resulting lack of homogeneity in the observations gives rise to a lack of confidence. It is imperative, therefore, that all these partners be made aware of the manner in which the hydrological data are collected, the limitations and the reliability of the data, and how they are to be managed by the responsible organizations in the basin. Transparency in data collection, storage and sharing is an essential element for cooperation among various users. A quality management framework for hydrometry and hydrological information is fundamental in using hydrological information from diverse sources.

The growing demand for freshwater resources has increasingly focused the attention of governments and civil society on the importance of cooperative management. Sharing the benefits of cooperation and even conflict prevention stem from a broad understanding of the principles and mechanisms through which these results can be achieved. Transboundary rivers have the potential to bring countries together both economically and politically or, conversely, they can cause economic and political tensions. The risk factor in decision-making in water resources management is a

function of hydrological variability. The risks can be mitigated through cooperative management of transboundary rivers. Cooperation in transboundary river management is fundamentally a political activity. Allocation of the resources or distribution of the benefits is essentially dependent on the knowledge of water availability and the related hydrological variability. A shared and accepted knowledge of the resources, their projected availability and the confidence in their accuracy greatly help in assessing the feasibility and fairness of alternative management and investment scenarios.

A lack of homogeneity in the data on the land phase of the hydrological cycle limits the scientific capacity to monitor changes relevant to climate and to determine the causes of variability and change in the hydrological regime. River discharge has a role in driving the climate system, as the freshwater flows into the oceans may influence thermohaline circulation. For easy and reliable use, the quality of such data and the procedures for its acquisition, storage and exchange should in general follow certain specified standards and protocols.

All of these factors increased the need for ensuring the quality of hydrological data. WMO, with a vision to provide expertise in international cooperation in weather, climate, hydrology and water resources, issues international guidance material and standards, and it is hoped that this Guide will form an important link in the quality management framework for hydrological practices. To meet such requirements, continuing efforts have been made to expand and improve the Guide, now in its sixth edition. It is expected that this Guide will be useful to agencies – not only to National Hydrological Services, but also to other stakeholders.

This Guide addresses all aspects of the land phase of the hydrological cycle, especially its phases upon and under the surface of the land. In conjunction with the manuals published by WMO, it provides detailed information on those areas that fall within the scope of the hydrology and water resources activities of the Organization designed to support National Hydrological Services and services with a similar mission.

The Guide forms part of an overall framework of recommended practices and procedures provided by *Technical Regulations* (WMO-No. 49) Volume III – Hydrology, as approved by WMO. Members are invited to implement these recommended practices and procedures in developing their Hydrological Services and activities.

1.3 CONTENTS OF THE GUIDE

It is difficult to set a clear dividing line between the science of hydrology and the practice of water resources planning and management. Nevertheless, for practical reasons, it was necessary to split the Guide into two volumes as shown in Figure II.1.1.

Volume I, entitled Hydrology – From Measurement to Hydrological Information, deals with networks, instruments, methods of observation and primary data processing and storage. It contains ten chapters, beginning with an introduction and an outline of the contents in Chapter 1.

Chapter 2, entitled Methods of observation, deals with the design and evaluation of hydrological networks and provides an overview of instruments and methods of observation for various hydrological elements that are described in detail in the subsequent chapters. Precipitation measurement in Chapter 3 is covered in all its aspects, ranging from the location of raingauges to the observation of precipitation by remote-sensing. The chapter covers liquid and solid precipitation, including their quality. Chapter 4, Evaporation, evapotranspiration and soil moisture, addresses both direct and indirect methods and also briefly reviews methods for evaporation reduction.

Chapter 5, Surface water quantity and sediment measurement, is pivotal and deals with measurement of flow in rivers and the capacity of lakes and reservoirs. It is also concerned with the measurement of sediment discharge. This subject matter is discussed in greater detail in the *Manual on Stream Gauging* (WMO-No. 519) and the *Manual on Operational Methods for the Measurement of Sediment Transport* (WMO-No. 686), to which the reader is invited to refer for more information.

Chapter 6, which is entitled Groundwater, is concerned with measurements from wells and the hydraulic properties of aquifers. It also looks in some detail at various remote-sensing techniques for groundwater observation.

The development of water resources is not only constrained by their quantity but also by their quality. Accordingly, Chapter 7, Water quality and aquatic ecosystems, addresses subjects ranging from sampling methods to remote-sensing. Chapter 8, Safety considerations in hydrometry, discusses topics ranging from the safety of personnel performing the measurements to safeguarding recording stations and the samples collected.

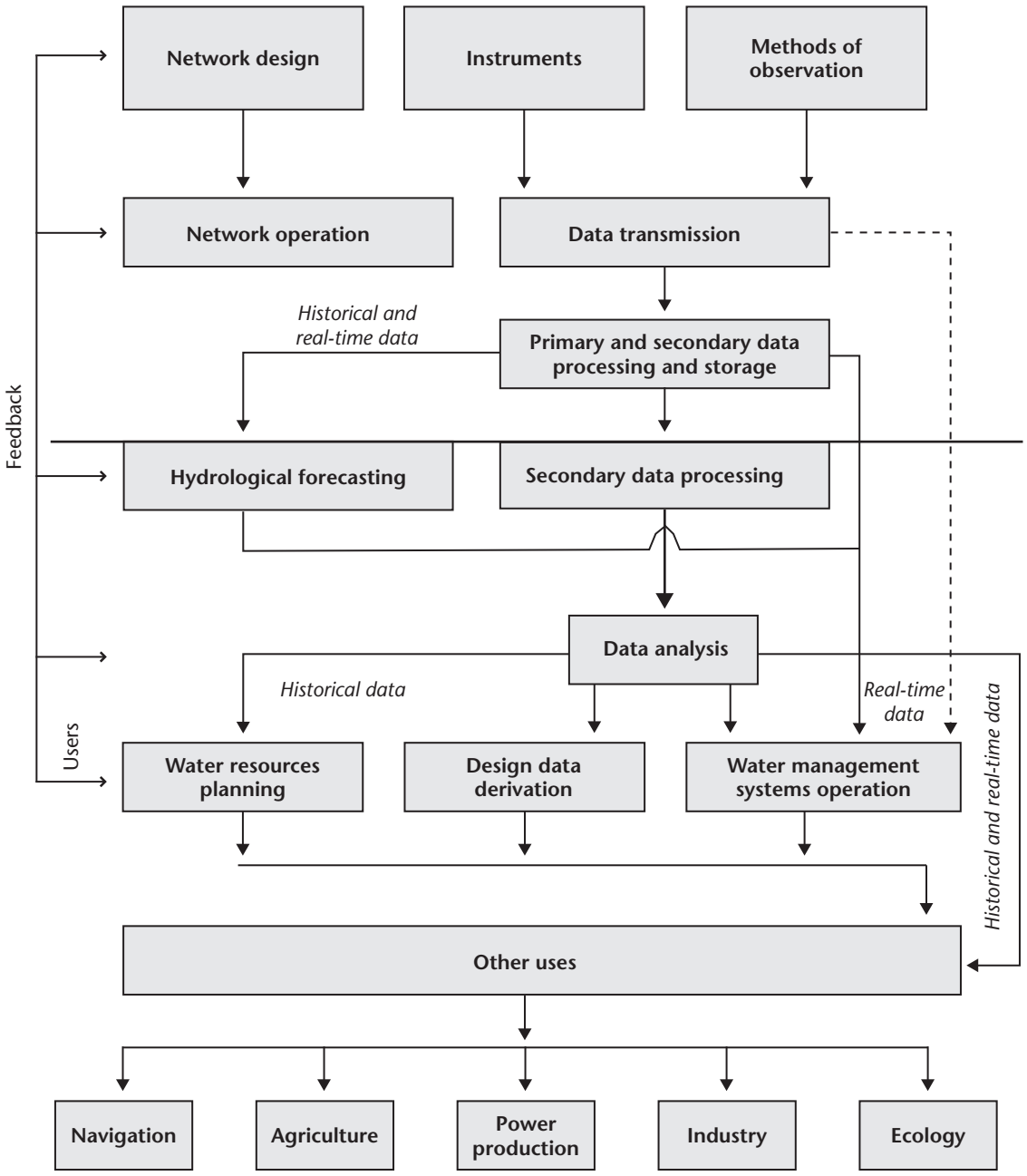

Figure II.1.1. Hydrological system

Lastly, Chapters 9 and 10, Data processing and quality control and Data storage, access and dissemination, respectively, include the dissemination of data for use by the wider water community.

Volume II deals with the application of the information referred to above in hydrological forecasting and the planning and design of various water projects. Accordingly, the volume is entitled Management of Water Resources and Application of Hydrological Practices. It consists of seven chapters beginning with an introduction and outline of the contents in Chapter 1.

Chapter 2 provides guidance on the management of hydrological services, including human resources aspects and financial and asset management. Chapter 3 introduces integrated water resources management and emphasizes the vital role of quality hydrological data in addressing various complex water management issues. Chapter 4 highlights the use of hydrological information in applications to water management, namely estimating reservoir

capacity and yield, flood management, irrigation and drainage, hydropower and energy-related projects, navigation and river training, urban water resources management, sediment transport and river channel morphology and environmental issues. Chapter 5 deals with extreme value analysis, and Chapters 6 and 7 address the modelling of hydrological systems and hydrological forecasting, respectively, as two of the key functions of Hydrological Services in water management.

While a measure of standardization is desirable and can be achieved with respect to instruments, methods of observation and publication practices, this is rarely the case with respect to hydrological analysis and applications. Therefore, the emphasis in Volume II is on presenting alternative approaches to the solution of selected problems, which have been demonstrated through experience to be both practical and effective. Rather than recommending one approach or technique in preference to another, attention is drawn to the principal features and advantages of each approach. The final choice will depend on a multitude of factors, including the relevant hydrological and climatic regimes, available data and information and the purposes to be served, and can only be made in the light of a full understanding of a specific situation. During the past few years, the increasing availability of microcomputers has permitted the introduction of more sophisticated analytical methods and techniques. Some of these have now been widely adopted and have therefore been introduced into this Guide.

The space limitations of this Guide restrict the amount of material that can be presented. For more detailed information on the subjects discussed, the reader should consult the following publications: for discharge measurement, the *Manual on Stream Gauging* (WMO-No. 519, Volumes I and II) and on sampling, the *GEMS/Water Operational Guide* (UNEP, 2005). The reader is also referred to international standards dealing with methods for liquid flow measurements in open channels prepared by member countries of the International Organization for Standardization (ISO). ISO has developed more than 50 standards for various types and methods of measurement. Valuable references can also be found in the proceedings of the international symposiums, seminars and workshops on hydrometry organized by the International Association of Hydrological Sciences (IAHS), WMO and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

A full description of the theoretical base for the recommended practices and detailed discussion of their methods of application are beyond the scope of this Guide. For such details, the reader is referred to appropriate WMO manuals and technical reports, as well as to other textbooks, handbooks and technical manuals of national agencies. In particular, further detailed guidance on instruments and methods of observation is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and the *Guide to Climatological Practices* (WMO-No. 100).

References and suggestions for further reading appear at the end of each chapter.

1.4 THE HYDROLOGICAL OPERATIONAL MULTIPURPOSE SYSTEM

In recent decades, hydrological science and technology have made substantial progress and significant contributions have been made by field hydrologists to the development and management of water resources. So as to facilitate the sharing of hydrological practices among the National Hydrological Services, a technology transfer system known as the Hydrological Operational Multipurpose System (HOMS) was developed by WMO and has been in operation since 1981. It offers a simple but effective means of disseminating information on a wide range of proven techniques for the use of hydrologists. HOMS transfers hydrological technology in the form of separate components. These components can take any form, such as a set of drawings for the construction of hydrological equipment, reports describing a wide variety of hydrological procedures and computer programs covering the processing and storage of hydrological data, as well as modelling and analysis of the processed data. To date, over 180 components have been made available, each operationally used by their originators, thus ensuring that every component serves its purpose and has been proved in practice. These descriptions appear in the *HOMS Reference Manual* (HRM) which is available online at http://www.wmo.int/pages/prog/hwrp/homs/homs_en.html in English, French, Russian and Spanish. The present Guide is further enriched through cross-references to the relevant HOMS components, which are included at the beginning of the relevant sections of this Guide.

References and further reading

United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme, 2005: *Global Environment Monitoring System (GEMS)/Water Operational Guide*. Fourth

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