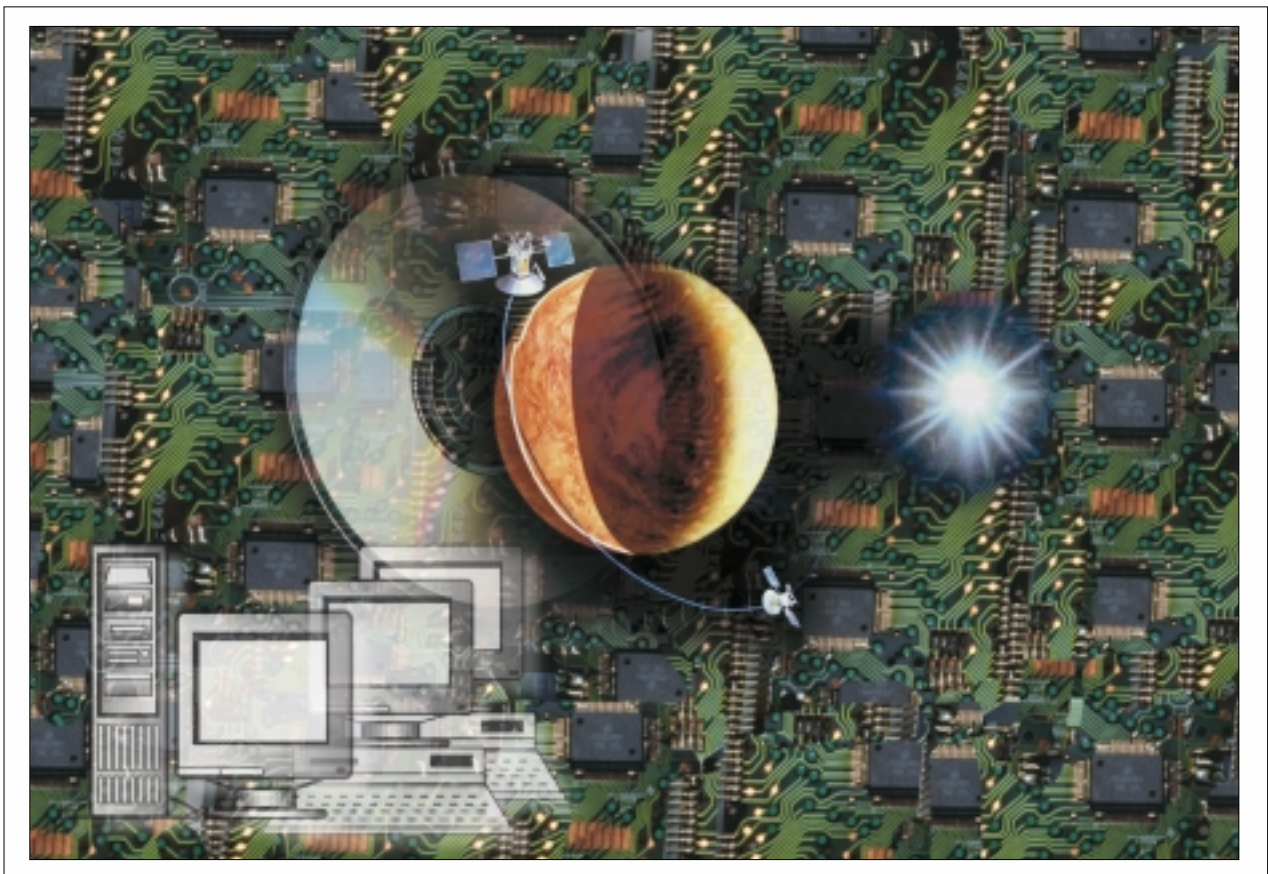


WORLD METEOROLOGICAL ORGANIZATION

OPERATIONAL HYDROLOGY REPORT No. 48

**HYDROLOGICAL DATA MANAGEMENT:
PRESENT STATE AND TRENDS**



By A. Terakawa



WMO-No. 964

Secretariat of the World Meteorological Organization – Geneva – Switzerland

THE WORLD METEOROLOGICAL ORGANIZATION

The World Meteorological Organization (WMO), of which 187* States and Territories are Members, is a specialized agency of the United Nations. The purposes of the Organization are:

- (a) To facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology, and to promote the establishment and maintenance of centres charged with the provision of meteorological and related services;
- (b) To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;
- (c) To promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics;
- (d) To further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities;
- (e) To promote activities in operational hydrology and to further close cooperation between Meteorological and Hydrological Services; and
- (f) To encourage research and training in meteorology and, as appropriate, in related fields and to assist in coordinating the international aspects of such research and training.

(Convention of the World Meteorological Organization, Article 2)

The Organization consists of the following:

The World Meteorological Congress, the supreme body of the Organization, brings together the delegates of Members once every four years to determine general policies for the fulfilment of the purposes of the Organization, to approve long-term plans, to authorize maximum expenditures for the following financial period, to adopt Technical Regulations relating to international meteorological and operational hydrological practice, to elect the President and Vice-Presidents of the Organization and members of the Executive Council and to appoint the Secretary-General;

The Executive Council, composed of 36 directors of national Meteorological or Hydrometeorological Services, meets at least once a year to review the activities of the Organization and to implement the programmes approved by Congress;

The six regional associations (Africa, Asia, South America, North and Central America, South-West Pacific and Europe), composed of Members, coordinate meteorological and related activities within their respective Regions;

The eight technical commissions, composed of experts designated by Members, study matters within their specific areas of competence (technical commissions have been established for basic systems, instruments and methods of observation, atmospheric sciences, aeronautical meteorology, agricultural meteorology, marine meteorology, hydrology, and climatology);

The Secretariat, headed by the Secretary-General, serves as the administrative, documentation and information centre of the Organization. It prepares, edits, produces and distributes the publications of the Organization, carries out the duties specified in the Convention and other Basic Documents and provides secretariat support to the work of the constituent bodies of WMO described above.

* On 31 December 2003.

WORLD METEOROLOGICAL ORGANIZATION

OPERATIONAL HYDROLOGY REPORT No. 48

**HYDROLOGICAL DATA MANAGEMENT:
PRESENT STATE AND TRENDS**

By A. Terakawa



WMO-No. 964

**Secretariat of the World Meteorological Organization – Geneva – Switzerland
2003**

ACKNOWLEDGEMENTS

An Advisory Committee, chaired by Dr Yamada, comprising the following members was established to provide useful information for the preparation of this report.

<i>Name</i>	<i>Affiliation</i>
Dr Tadashi Yamada	Professor, Faculty of Science and Engineering, Chuo University
Mr Yoshiyuki Imamura	Assistant Director, River Planning Division, River Bureau, Ministry of Land, Infrastructure and Transport
Mr Makoto Kaneki	Head, Hydrology Division, River Department, Public Works Research Institute, Ministry of Land, Infrastructure and Transport
Mr Shinichi Kasuya	Director, Research Department, Japan Construction Information Center (JACIC)
Dr Tadahiko Nakao	Director, Institute of River and Basin Integrated Communication System, Foundation of River and Basin Integrated Communications (FRICS)
Mr Eiji Otsuki	Assistant Director, River Information Measures Section, River Planning Division, River Bureau, Ministry of Land, Infrastructure and Transport
Dr Ryosuke Shibasaki	Professor, Center for Spatial Information Science (CSIS), Tokyo University
Dr Kaoru Takara	Professor, Flood Disaster Laboratory, Disaster Prevention Research Institute, Kyoto University

Copyright in this electronic file and its contents is vested in WMO. It must not be altered, copied or passed on to a third party or posted electronically without WMO's written permission.

© 2003, World Meteorological Organization

ISBN: 92-63-10964-8

NOTE

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

CONTENTS

	<i>Page</i>
Foreword	v
Summary (English, French, Russian and Spanish)	vii
CHAPTER 1 — INTRODUCTION	1
1.1 The importance of hydrological data	1
1.2 Structure of this report	1
CHAPTER 2 — HYDROLOGICAL DATABASES	2
2.1 Hydrological databases outlined	2
2.1.1 Need for a database	2
2.1.2 Hydrological observation data: types and units	2
2.1.3 Historical data and real-time data	2
2.2 Selected hydrological databases	3
2.3 Configuration of a hydrological database	3
2.3.1 Flow from data observation to dissemination	3
2.3.2 Methods of data dissemination	4
2.3.3 Present state of the systems	4
2.3.4 Recent trends	4
2.4 Constructing a hydrological database	4
2.4.1 Setting codes and key words	4
2.4.2 Input format	4
2.4.3 Database registration methods	4
2.4.4 Supplement of missing data	4
2.4.5 Managing the quality of data	6
2.4.6 Precautions in constructing a database	6
2.5 Maintaining and updating a hydrological database	6
2.5.1 Maintenance and updating	6
2.5.2 Responding to changes in the hardware and software environments	6
2.5.3 Managing the utilization of a database	7
2.5.4 Need for data base management	7
2.6 Network systems and public release of data	7
2.6.1 Merits of a network system	7
2.6.2 Policies regarding the public release of data	7
2.6.3 Security measures	7
2.6.4 Concept of data copyright	7
2.6.5 Fee charging methods	7
2.6.6 Examples of internet use	7
2.7 Examples of practical hydrological databases	9
2.7.1 Bureau of Meteorology (Australia)	9
2.7.2 Ministry of Land, Infrastructure and Transport (Japan)	9
2.7.3 United States Geological Survey	9
2.7.4 Global Runoff Data Centre	9
2.8 Conclusion	9
CHAPTER 3 — GEOGRAPHICAL INFORMATION SYSTEMS APPLIED TO OPERATIONAL HYDROLOGY 10	
3.1 Geographical Information Systems outlined	10
3.1.1 Definition and special features of GIS	10
3.1.2 History of GIS development	10
3.1.3 GIS standardization trends	10
3.1.4 Introduction of GIS related software	10

3.2	Effectiveness of Geographical Information Systems in operational hydrology	10
3.2.1	Merits of GIS	10
3.2.2	Feasibility of using GIS in operational hydrology	10
3.3	Examples of Geographical Information Systems in operational hydrology	11
3.3.1	Rhine River Geographical Information System	11
3.3.2	River management (Japan)	12
3.3.3	Water quality data management (South Africa)	12
3.3.4	Hydrological models (United States)	12
3.4	Conclusion	12
References		12
APPENDICES		13
Appendix A		13
Questionnaire I		13
Questionnaire I survey field		13
Questionnaire II		14
Questionnaire II survey field		14
Answers to Questionnaire I		16
Answers to Questionnaire II		28
Appendix B		41
The hydrological observation system in Japan		41
Appendix C		43
Examples of practical hydrological databases		43
Bureau of Meteorology, Australia		43
Ministry of land, Infrastructure and Transport, Japan		43
United States Geological Survey		50
Global Runoff Data Centre		52
Appendix D		53
The application of Geographical Information Systems in operational hydrology		53
Rhine River Geographical Information System		53
River management in Japan		53
Water quality data management in South Africa		54
Links with distributed hydrological models (United States)		54

FOREWORD

The key to providing accurate, timely and often life-saving information and forecasts on flooding and drought lie in hydrological data management. With the expansion of computerization and global information networks, recent years have witnessed a consequent increase in the scope and forms of data management undertaken. Geographical information systems (GIS) have evolved since their introduction in the 1960s, to become sophisticated analytical tools, enabling detailed consideration of the many factors affecting river basins and their management. In this application, GIS rely on strong hydrological databases. This important area is the subject of this report.

In order to present a review of the current state of hydrological data management, to offer recommendations on setting up, maintaining and utilizing such databases and to look at likely future trends, the Commission for Hydrology (CHy) of the World Meteorological Organization (WMO), at its tenth session in 1996, requested Mr Akira Terakawa, Director of the Chubu Construction Engineering Office (Nagoya, Japan) and expert in data management, to prepare a report on hydrological data management. A draft report was published in 2000.

The report, which uses as its basis answers to questionnaires sent to members of the Working Group on Basic Systems of the Commission for Hydrology, outlines the establishment and aims of hydrological databases and looks at operational examples from Australia, Japan and the United States. The increasingly important application of GIS to operational hydrology is also reviewed — again making use of research from a range of countries.

I should like to place on record the gratitude of the World Meteorological Organization to Mr A. Terakawa for the time and effort he has devoted to the preparation of this valuable report and to the Advisory Committee who provided valuable information in compiling this report.



(G.O.P. Obasi)
Secretary-General

SUMMARY

The importance of hydrological databases, their basic characteristics and how they are exploited in operational hydrology cannot be underestimated. Forecasting and managing flood and drought events, as well as day-to-day river basin management would be impossible without both real-time and historical databases and the tools, such as Geographical Information Systems (GIS), to analyse them.

This report, prepared for the World Meteorological Organization's Commission on Hydrology (CHy) Working Group on Basic Systems details the present state and trends in constructing databases for hydrological data, the real-time utilization of the data and the application of GIS to operational hydrology in various countries.

Following a brief Introduction, Chapter 2 catalogues the relationship between real-time and historical data. The essential characteristics of a range of countries' hydrological databases are given. Constructing a database involves a number of stages and these are outlined. An effective database also requires making provision for maintenance and updating. The issue of public access is explored, and finally, Chapter 2, describes examples of working hydrological databases from Australia, Japan and the United States.

In Chapter 3 GIS — its development and current trends — are described. The importance of GIS to operational hydrology is outlined and its practical application in various situations, from management of the Rhine River to assessing and disseminating data on water quality in South Africa, is presented.

RÉSUMÉ

L'importance des bases de données hydrologiques, leurs caractéristiques fondamentales et l'utilité qu'elles présentent pour l'hydrologie opérationnelle ne sauraient être sous-estimées. Il serait en effet impossible de prévoir et de gérer les crues et les situations de sécheresse ou même d'assurer la gestion quotidienne des bassins hydrographiques si l'on ne disposait pas de bases de données — actuelles et anciennes — et des outils pour les analyser tels que les systèmes d'information géographique (SIG).

Elaboré à l'intention du Groupe de travail des systèmes de base relevant de la Commission d'hydrologie (CHy) de l'Organisation météorologique mondiale, le présent rapport décrit la situation actuelle et les évolutions constatées en ce qui concerne la constitution de bases de données hydrologiques, l'exploitation en temps réel de ces données et l'application des SIG à l'hydrologie opérationnelle dans divers pays.

Après une brève introduction, le chapitre 2 décrit la manière dont les données obtenues en temps réel se rattachent aux données anciennes. Il énonce aussi les caractéristiques essentielles des bases de données hydrologiques d'un certain nombre de pays. La construction d'une base de données se fait en plusieurs étapes, présentées ici, étant entendu qu'une base de données digne de ce nom doit être mise à jour régulièrement. Le chapitre 2 aborde aussi la question de l'accès du public aux bases de données et décrit enfin des exemples de bases de données hydrologiques exploitées en Australie, au Japon et aux États-Unis d'Amérique.

Le chapitre 3 est consacré aux systèmes d'information géographique et à leur évolution. Il souligne l'importance qu'ils revêtent pour l'hydrologie opérationnelle et présente diverses applications pratiques, qu'il s'agisse par exemple de gérer les eaux du Rhin ou bien d'évaluer la qualité de l'eau en Afrique du Sud et de diffuser les données qui s'y rapportent.

РЕЗЮМЕ

Важность баз гидрологических данных, их основных характеристик, а также того, каким образом они применяются в оперативной гидрологии, нельзя недооценивать. Прогнозирование наводнений и засух и управление при их наступлении, а также повседневное регулирование речных бассейнов было бы невозможным без баз как оперативных, так и исторических данных и таких инструментов, как географические информационные системы (ГИС), применяемые для их анализа.

В данном отчете, подготовленном для рабочей группы по основным системам Комиссии по гидрологии (АГи) Всемирной Метеорологической Организации, подробно описываются существующее состояние и тенденции в таких областях, как создание баз гидрологических данных, оперативное использование данных и применение ГИС в оперативной гидрологии, в различных странах.

После краткого введения в главе 2 систематизируются взаимосвязи между оперативными и историческими данными.

Приводятся важные характеристики ряда баз гидрологических данных, имеющихся в некоторых странах. Создание базы данных требует прохождения ряда этапов, и они также вкратце описываются. Для эффективной базы данных также требуется обеспечение для ее поддержания в рабочем состоянии и обновления. Исследуется проблема общественного доступа к базам и, наконец, в главе 2 приводятся примеры баз гидрологических данных, работающих в Австралии, Японии и в Объединенных Штатах.

В главе 3 описываются ГИС, а также их развитие и современные тенденции. А также характеризуется важность ГИС для оперативной гидрологии, а также предоставляются сведения об их практических применениях в различных ситуациях, начиная от регулирования реки Рейн до описания доступа и распространения информации о качестве воды в Южной Африке.

RESUMEN

No se puede subestimar la importancia de las bases de datos hidrológicos, de sus características básicas ni de la manera en que se explotan en la hidrología operativa. La predicción y la gestión de inundaciones y sequías, así como la ordenación cotidiana de las cuencas fluviales, no serían posible sin bases de datos en tiempo real e históricos y sin instrumentos, como los sistemas de información geográfica (SIG) para analizarlos.

En el presente informe, preparado para el Grupo de trabajo sobre sistemas básicos de la Comisión de Hidrología (CHi) de la Organización Meteorológica Mundial se describen el estado actual y las tendencias de la elaboración de bases de datos con fines hidrológicos, su utilización en tiempo real y la aplicación de los SIG a la hidrología operativa en diversos países.

Tras una breve introducción, en el Capítulo 2 se analiza la relación entre datos en tiempo real e históricos y se resumen las

principales características de las bases de datos hidrológicos de una serie de países. Para elaborar una base de datos hay que seguir varias fases, que también se exponen. Para que una base de datos sea eficaz hay que tomar asimismo disposiciones sobre su mantenimiento y actualización. Se examina la cuestión del acceso público y, por último, en el Capítulo 2 se dan también ejemplos de cómo funcionan bases de datos hidrológicos de Australia, Japón y Estados Unidos.

En el Capítulo 3 se describen dos SIG, su desarrollo y las tendencias actuales. Se señala la importancia de los SIG para la hidrología operativa y se presentan sus aplicaciones prácticas en diversas situaciones, desde la ordenación del río Rin hasta la evaluación y difusión de datos sobre la calidad del agua en Sudáfrica.

CHAPTER 1

INTRODUCTION

1.1 THE IMPORTANCE OF HYDROLOGICAL DATA

Hydrological observations are, in a broad sense, a method of clarifying quantitatively each process in the water cycle, encompassing an extremely wide range of phenomena. The prevention of disasters caused by floods and droughts would be impossible without rational forecasting technology based on an understanding of the rainfall runoff phenomenon and statistical analysis of past hydrological data, which cannot be achieved without hydrological observations.

And whether intentional or not, human, social and economic activities have a great impact on the hydrological cycle. For example, large-scale changes in land use and/or the construction of structures intended to control the hydrological cycle change natural runoff patterns. It is extremely important to collect and to analyse hydrological data continuously over long periods of time in order to evaluate these effects and to take appropriate mitigation measures.

Thanks to the rapid growth of data communication networks in recent years, it is now possible to use these networks to disseminate hydrological data and allow its on-line use by the public. Information of this kind is extremely beneficial, because, when a disaster is forecasted or actually occurs, users can obtain

real-time data and analyse it appropriately in order to prevent or to minimize the disaster.

The accumulation and active use of hydrological data in this way plays an extremely important role in total watershed management, including flood control, water use and environmental conservation.

1.2 STRUCTURE OF THIS REPORT

This report describes hydrological databases and the application of Geographical Information Systems (GIS) to operational hydrology. The report aims to contribute to the effective utilization of hydrological information by giving information on the construction and maintenance of hydrological databases, their control and the formation of networks linking databases of different types for effective dissemination.

It also reports how, in response to recent developments, GIS can be used in the field of operational hydrology to present hydrological information in more easily understandable forms and how to incorporate and integrate pertinent geographical to further the analytical process.

Practical examples of hydrological databases and their operation, from Europe, South Africa, Japan, Australia and the United States, are outlined.

CHAPTER 2

HYDROLOGICAL DATABASES

2.1 HYDROLOGICAL DATABASES OUTLINED

2.1.1 Need for a database

Thanks to rapid advances in computerization in recent years, much topographical and geological data is now digitized. Improved analytical models now permit detailed hydrological analysis of the various physical mechanisms and processes in the hydrological cycle. At the same time, the spread of data communication networks allows hydrological data to be obtained, analysed, and applied to real-time forecasting over large communication networks. The ability to refer to both historical data and real-time observation data facilitates improved forecasting and planning. With improvements in analytical capacity the construction and maintenance of hydrological databases becomes ever more valuable.

To understand present conditions and to forecast future trends not only for the hydrological cycle in a single river basin but also for a much broader watershed, both historical hydrological data and real-time hydrological data should be used to form a database. This data can be made accessible to the public. (Rees, H.G. 1999a).

2.1.2 Hydrological observation data: types and units

Hydrological observation data types, units and quantity vary widely from country to country. They also vary according to the purposes for which the data is collected.

Table 1 is taken from the WMO Guide to Hydrological Practices (Table 4.1, WMO, 1994). It presents items which should be treated as hydrological data.

2.1.3 Historical data and real-time data

Historical data and real-time data differ in that historical data were observed in the past and can be registered in a database at any time, enabling experts to assess accuracy before inclusion, while real-time data is working data whose accuracy is not yet assessed by experts prior to registration.

Real-time data is used by systems that offer instant results such as real-time forecasts of hydrological phenomena etc., while historical data that has been confirmed as reliable is used for the analysis of hydrological phenomena or for research.

Table 1 – Recommended symbols, units and conversion factors

I Item	II Element	III Symbol	IV		VI Conversion factor*	VII Remarks
			V Units			
			Recommended	Also in use		
3	Area (cross-sectional) (drainage basin)	A	m ²	ft ²	0.0929	ISO
			km ²	acre	0.00405	ISO
				ha	0.01	
				mile ²	2.59	
9	Depth, diameter, thickness	D	m	ft	0.305	ISO
			cm	in	2.54	
10	Discharge (river flow) (wells) (unit area-Q A ⁻¹ , or partial)	Q Q _{we} Q	m ³ s ⁻¹	ft ³ s ⁻¹	0.0283	ISO
			1 s ⁻¹	gal (US) min ⁻¹	0.063	
			m ³ s ⁻¹ km ²	1	0.0109	ISO
			1 s ⁻¹ km ²	ft ³ s ⁻¹ mile ⁻²	10.0	
18	Head, static (water level) = z + h _p	h	cm	ft	30.5	ISO
			m		0.305	
33	Precipitation	P	mm	in	25.4	
34	Precipitation Intensity	I _p	mm h ⁻¹	in h ⁻¹	25.4	
42	Runoff	R	mm	in	25.4	
63	Velocity (water)	V	m s ⁻¹	ft s ⁻¹	0.305	ISO
64	Volume	V	m ³	ft ³	0.0283	ISO
				acre ft	1230.0	

NOTE: Where international symbols exist these have been used where appropriate and indicated as ISO in the last column.

* Column IV = Conversion factor (Column VI) × Column V

The only communication tools that can be used to supply real-time data are on-line (telephone lines, LAN, WAN, the internet, etc.), but historical data can be supplied in other ways too – via publications or electronic media (FD, CD, MO, ZIP, etc.).

2.2 SELECTED HYDROLOGICAL DATABASES

Table 2 catalogues the current provision of hydrological databases in several countries based on a survey (see Appendices).

2.3 CONFIGURATION OF A HYDROLOGICAL DATABASE

2.3.1 Flow from data observation to dissemination

The route from observation stage to data dissemination varies according to the aims of the organization, but a standard flow can be identified. Hydrological data observed at an observation station is collected and processed as real-time data and then released to the public as unverified data. Since the real-time data collected

Table 2 – State of the provision of hydrological databases in selected countries

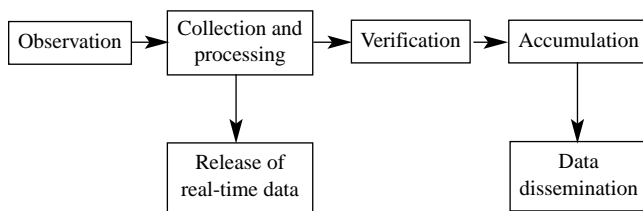
Country	Australia
Organization	Bureau of Meteorology (BOM) State government agency (for example, Department of Natural Resources and Environment, Victoria)
System name	HYDSYS, HYDROL, ADAM
Online data	Real-time data is not provided
Data verification	Related organizations have obtained ISO 9002 quality assurance systems
Country	Brazil
Organization	Ministry of Mines and Energy (MME) Electricity Regulatory Agency (ANEEL)
System name	Micro Systems of Hydrological Data (MSDHD)
Online data	It is released on the internet (including real-time data)
Data verification	A quality assurance system is applied to the observation instruments
Country	France
Organization	Direction Regionale de l'Environment (DIREN), Cemagref
System name	Unconfirmed
Online data	Information provided by dedicated terminals excluding real-time data
Data verification	Correlation analysis with nearby observation stations
Country	Germany
Organization	State governments
System name	Various
Online data	All data is converted to electronic form and released including real-time data
Data verification	Observation stations confirm the accuracy of the data
Country	Japan
Organization	Ministry of Land, Infrastructure and Transport
System name	WISEF
Online data	Released on the internet including real-time data
Data verification	Automatic and manual quality checks are done to correct abnormal and missing values. Abnormal or missing values in online data are to be supplemented by offline data
Country	New Zealand
Organization	National Institute of Water and Atmospheric Research (NIWA)
System name	Water Resources Archive (WRA)
Online data	Provision through the internet based on a cost sharing basis is growing
Data verification	ISO 9002 quality assurance system has been obtained for the observation equipment and database system
Country	Slovenia
Organization	Hydro Meteorological Institute of Slovenia
System name	VMS (Improved HOMS G06)
Online data	Real-time data is provided over the internet
Data verification	QA treatment, QC treatment, balance method and regression method
Country	United States
Organization	United States Geological Survey (USGS)
System name	STORET-X
Online data	Released over the internet (release of real-time data)
Data verification	Hydrological technologists check for abnormal and missing values Detailed information regarding observation and analytical methods are stored in the database
Country	Zambia
Organization	Zambia Meteorological Department (ZMD) Department of Water Affairs (DWA)
System name	HYDATA
Online data	Unconfirmed
Data verification	The data processing division confirms accuracy

and processed includes observation errors, it is verified, then registered in the database as verified data and also released to the public (FRICS, 1996, 1997).

2.3.2 Methods of data dissemination

There are online and offline methods for disseminating data. Online dissemination of data is carried out to provide both real-time data and historical data, the standard methods for this are the internet and dedicated terminals. Offline data dissemination is usually performed to distribute historical data such as via publications or other electronic media (FD, CD, MO, ZIP, etc.).

2.3.3 Present state of the systems



The quantity of data to be accumulated and handled by each system in each country dictates the size of the database. The system environment is often a client/server system and it is frequently the case that the server is a UNIX based work station and the clients are personal computers.

The database software may be independently developed by the operating organization or it may be off-the-shelf software. However, off-the-shelf software is considered beneficial given the time and cost of developing independent software.

The following list shows the database software used by the organizations that responded to the questionnaires.

The home page addresses of the software manufacturers are shown below and Table 3 describes the features of each.

Country	System name	Software
Australia	ADAM	Oracle
Brazil	MSDHD	SQL server
China		Sybase
Japan	WISEF	Oracle
United States	STORET-X	Oracle
Zambia	HYDATA	Sybase

Software name	Home page address
Oracle	http://www.oracle.com
Sybase	http://www.sybase.com
SQL	http://www.microsoft.com/sql/default2.htm

2.3.4 Recent trends

A hydrological database must be able to accumulate and manage the target data and provide data services quickly and accurately. It should also permit comprehensive automated reporting. Rapid progress in computer hardware technology now permits a database to accumulate and manage an infinite quantity of data, for multi-purpose applications.

The system should be an electronic system fully integrated from the observation stage to the data dissemination stages and should be designed so that observed data can be easily obtained online.

With increasing international standardization, database specifications should be established using a standard data format to permit use both domestically and internationally. The system should also permit users to perform centralized searches of a number of databases (Rees, H.G., 1999a).

2.4 CONSTRUCTING A HYDROLOGICAL DATABASE

2.4.1 Setting codes and key words

When constructing a hydrological data base it is possible to simplify data management and the search function by preparing codes and key words linked to the hydrological data. It is also possible to prepare a data dictionary, which can include specifications of all observation stations and explanations of terminology, again linked to the hydrological data. By incorporating GIS, the locations of observation stations can be presented visually which is helpful.

2.4.2 Input format

In advance of constructing a hydrological database, input formats for all types of data must be determined and the units etc. for all observations standardized. If information is to be exchanged with other organizations, integration of input formats can ease the exchange of data and manipulation opportunities.

2.4.3 Database registration methods

Thanks to the introduction of telemetry systems, it is now possible to automatically register online data in a database. There are two methods of registering offline data in a database: reading it from recording paper and registering digital data with a data logger etc. A comparison of the costs of reading from recording paper and using a data logger has revealed that installation and recovery costs are about the same, but it is possible to sharply reduce the reading costs by using the data logger method. The digitization of observation data using a data logger etc. also prevents human errors at the data input stage (FRICS, 1997).

2.4.4 Supplement of missing data

Malfunctioning of observation instruments and other problems sometimes result in incomplete data. Because real-time data is used immediately, missing data are not usually supplemented.

But if observation data obtained offline are available for the same location as the missing data at the verification stage, the offline data is often added to complete the data, alternatively hydrological data can be corrected on the basis of expert opinion (FRICS, 1996, 1997).

Table 3 – Features of the database software

<i>Product</i>	<i>ORACLE</i>	<i>Sybase</i>	<i>Microsoft SQL server</i>
<i>Developer</i>	Oracle Corporation	Sybase	Microsoft Corporation
<i>Version (1995)</i>	Oracle 7 (7.2)	Sybase11	MS-SQL server 6.0
<i>Basic specifications</i>	ANSI/ISO SQL92 entry level 254 Depends on memory device Depends on memory device Depends on memory device Depends on memory device Unlimited	ANSI/ISO SLQ92 entry level 250 2 000 000 000 32 767 251 2 000 Depends on memory device 32 000	ANSI/ISO SLQ92 entry level 250 Depends on memory device 32 767 251 1 962 8 000 000 000 32 767
<i>DB engine</i>	Client/server — It is compatible with the symmetric multi-processor (SMP), cluster type multi-processor, and parallel multi-processor (MPP), and many others.	Client/server — It is equipped with virtual server architecture so it can use the parallel processing function of symmetric multi-processor (SMP). Its loosely coupled multi-processor is compatible with the Sybase Navigation Server.	Client/server — It uses the parallel processing function of the Windows NT symmetric multiprocessor (SMP).
<i>Operation management functions</i>	Language, compiler — Direct SQL text is incorporated in its C/C++, COBOL, and FORTRAN sources, and it is equipped with a pre-compiler that can be used to develop applications. It supports all SQL text of Oracle 7. It is also possible to embed PL/SQL commands.	— (Roll back and roll forward) — — Sybase SQL monitor	It is possible to develop client applications compatible with ODBC using Visual Basic 4.0 and Visual C++4.0. — None (can be handled with alert and trigger) (Roll back and roll forward) Backup — SQL enterprise manager
<i>Networks</i>	Log switching during operation Restoration from malfunction function On-line backup/recovery Tuning function Data base management tools — Client/server functions	— (Roll back and roll forward) — — Sybase SQL monitor	— It uses DB library or ODBC. It uses Net-library for its server and client. Net-library supports TCP/IP, IPX/SPX, named pipes, and DECnet, etc. Third party provision. Unnecessary.
<i>Others</i>	Gateway functions to other DB Protocol conversion function — Multi-media compatibility — Object oriented compatibility —	— With open client/open server, it achieves an C/S environment. — (It uses the OmniSQL gateway) — It supports variable length binary data (maximum 4G byte). — It provides a C++ class library as the API of an open server and open client.	— Image type data can be stored as maximum 2G byte variable length binary data. —

2.4.5 Managing the quality of data

Hydrological observation data includes abnormal values and observation errors caused by malfunctioning observation instruments. Hydrological data obtained indirectly through a process of conversion also includes errors caused by the analysis. Problems arise if users utilize hydrological data without being aware of the possibility of these observation errors (particularly when performing statistical analyses).

The quality of hydrological data is managed by performing reliability checks and by correcting missing data and abnormal values. Methods of managing quality that are widely used include obtaining ISO certification of observation instruments, systems, and organizations and having experts verify the hydrological data. Reliability checks with related data would be desirable, for runoff, for example, catchment areas and specific characteristic data such as annual runoff depth and annual runoff coefficients can be used.

It is possible to define a missing data detection function in a system, and although the detection of abnormal values can be partially automated, ultimately it must be done by expert check. It is essential to construct a data quality management system that can perform this task efficiently.

And if an expert is to verify, supplement and correct the hydrological data, an extremely important aspect of the data quality management is the registration of auxiliary data in the database, defining when, how, by whom and why these tasks are performed. Because real-time data is used immediately without verification, it should be stored in the database in a way that distinguishes it from verified historical data (FRICS, 1996, 1997).

2.4.6 Precautions in constructing a database

An effective way to construct a database is first to clarify its objectives and how it will be used; begin actual operations with a simple system; then gradually expand the system through incremental modifications based on actual experience of operational use of the database.

And it is possible to guarantee the quality of the data base by registering not only observed data in the data base, but also information related to the qualities of the instruments, measurement techniques, and verification methods (FRICS, 1996).

2.5 MAINTAINING AND UPDATING A HYDROLOGICAL DATABASE

2.5.1 Maintenance and updating

Table 4 lists the maintenance and updating tasks that are part of the operation of a hydrological database. At the first stage of database construction planning, it is essential to make budget provisions to cover the cost of maintenance and updating (FRICS, 1997).

2.5.2 Responding to changes in the hardware and software environments

The following tasks are necessary when new hardware is introduced or a new version of the software is released:

- (a) Preparatory study
The present system environment and the state of its maintenance are studied to prepare a plan for the change-over and all system users kept informed of the process. Documents concerning policy decisions such as the organization of software resources and the operating system are to be prepared.
- (b) Policy decisions
Decisions are made regarding the replacement of hardware, replacement of the operating system or database application software, the modification of the working system, system reconstruction and so on.
- (c) Modification and reconstruction
The operating system, database application software etc. are replaced, the working programmes modified and data files corrected, to reconstruct the system.

Table 4 – Maintenance and updating tasks

<i>Category</i>	<i>Management item</i>	<i>Tasks</i>	<i>Task description</i>
System integration management	Overall management of the system	Overall management of the system	Discovery of malfunctions and specification of location of the problems
System management	Hardware management Software management	Responding to instrument malfunctions Responding to abnormal processing Installation Version management	Instrument repair Study and restoration of abnormality Introduction and coordination of software in the instruments Compatibility survey
Database management	Data management	Data quality checking and registration Backup Restoration Security	Checking and registration by the quality control system Database backup Database restoration Monitoring for illegal use, viruses, etc., ID control, log-on control
Ordinary users	Information provision	Offline data provision Responding to inquiries Release on the web Release by FTP Search agents	Loading in magnetic media Response by telephone, fax, mail, etc. Updating of home page File maintenance Integrated item searching

(d) Testing

The environment to test the modified programmes is established and test data prepared for a trial operation to verify the results of the changes that have been introduced.

(e) Final transfer

After establishment of the operating environment, the programmes and data files are transferred to the new system and the results of its operation are confirmed.

2.5.3 Managing the utilization of a database

When hydrological data is released to the public online, there is always a chance that the system might be shut down or be destroyed by improper access or by illegal access. It is, therefore, essential to take precautions to make sure that the system always operates properly by, for example, managing access to the port number allowing outside access is and/or by keeping a record of the communication log.

2.5.4 Need for database management

It is necessary to train the personnel who will maintain and manage the hydrological database. A system manager, who is responsible for the maintenance and management of the network and its computers, must basically be an expert on the system, but need not be an expert on hydrology. The database manager, who is responsible for the maintenance and management of the network, its computers and for the quality of the hydrological data, must possess experience in both system technology and hydrology (FRICS, 1996).

2.6 NETWORK SYSTEMS AND PUBLIC RELEASE OF DATA**2.6.1 Merits of a network system**

A data communication network removes temporal and spatial restrictions on access to data so that users around the world can access and exchange data at any time.

The construction of a hydrological database and its incorporation in a network allows users to monitor the state of hydrological cycles in a river basin or globally in real-time or obtain accumulated data online, providing them with the means to refer to historical cases and perform real-time forecast analysis.

The internet makes it possible for users to obtain hydrological data easily via connections to a database whenever they need. It is an effective way to widely disseminate flood and drought information and to facilitate research.

2.6.2 Policies regarding the public release of data

Data is released to the public via the internet, and offline for high volume data. There are two ways to release hydrological data over the internet: by allowing anyone to search for and download data without restriction and by providing authorized users with ID and passwords to allow access.

Data provided to the public over the internet should be processed to meet users' needs. The internet is a very effective way to provide real-time data on specific locations, which can then be used to prevent or to minimize flood damage.

For users who wish to use unmodified data for analysis purposes, raw data should be accompanied by supplementary information such as explanations of measurement methods. When releasing unverified real-time data to the public, it is advisable to clearly indicate that the observed data could include errors, thus avoiding misconceptions regarding the nature of the data (FRICS, 1996, 1997).

2.6.3 Security measures

The release of data to the general public must be accompanied by adequate security measures to deal with the risk of damage to the database system by unauthorized access.

The fundamental concept of security is the refusal of access to anyone not clearly authorized. This involves blocking everything but essential network protocols to minimize the opportunities for unauthorized access in order to guarantee a high degree of overall system safety. Security controls to prevent unauthorized access from the internet can be provided by a firewall or by screening users based on their ID codes and passwords. Another security management method is to employ multiple layers of verification by the above means (FRICS, 1999*b*).

2.6.4 Concept of data copyright

It is assumed that once hydrological data is released, users may use them for a variety of purposes, but it is generally agreed that copyright of the data belongs to the data providing organization.

Copyright of publicly released data is to be handled, case by case, in the following way:

- (a)* Free: no restrictions are applied to the way that users utilize the data.
- (b)* Authorization system: restrictions are applied depending on the purpose of each user.
- (c)* Charging for copyright use: users are charged for the use of the copyright without restrictions for utilizing data.
- (d)* Charging for copyright use with an authorization: users are charged for use of the copyright and their use of the data is restricted to a specified purpose.

2.6.5 Fee charging methods

How to charge database users in order to cover the cost of data base management is an important issue. Hydrological data can either be provided free of charge or for a fee. A free provision method is to allow users to download the data through the network.

Fee paying methods include transmitting data to dedicated terminals and providing it via the internet to authorized users only who require passwords to access the data. The usual methods of providing data offline with a charge are selling printed data or electronic media (FD, CD, MO, ZIP, etc.) or providing them at cost plus a service charge.

2.6.6 Examples of internet use

Data can be provided online and released to the public via the internet. Table 5 presents the example of sites supplying hydrological data through the internet.

Table 5 – Examples of websites for hydrological databases surveyed (in alphabetical order)

Home page name	Names and home page addresses (including links)	Principal link pages	Description	Country
CMC	Canadian Meteorological Centre http://www.cmc.ec.gc.ca/indexe.html		A meteorological information organization operated by the Canadian Meteorological Agency. It provides meteorological analysis, weather forecasts, radar data, river flow volumes (levels), etc. It also supplies free weather maps and radar data etc. in real-time. It sells CD-ROM records of annual river and hydrological information (HYDAT) to single users for \$750. The CD-ROM includes analysis software.	Canada
EPA	Environmental Protection Agency http://www.epa.gov/		The US Environmental Protection Agency operates databases of air, water, and soil pollution information. In addition to numerical data, it manages and release large quantities of text data concerning environmental pollution.	United States
MET	Meteorological Office http://www.metoffice.gov.uk/		The national meteorological bureau of the United Kingdom provides weather data on the web, by telephone and by fax. It is operates an automatic data collection system called Automatic Weather Measurements (AWS).	United Kingdom
MOC	Ministry of Land, Infrastructure and Transport http://wdb-kk.river.or.jp/e/zenkoku/		A hydrological database operated by the Ministry of Land, Infrastructure and Transport of Japan. It can be used to download real-time and historical data. Data registered in the database, includes river levels, flow volumes, water quality and precipitation.	Japan
NCDC	National Climatic Data Center http://www.ncdc.noaa.gov/ol/ncdc.html http://www.noaa.gov/ http://ns.noaa.gov/NESDIS/NESDIS_Home.html	NOAA, NESDIS	An organization linked to the Department of Commerce, NOAA, and NESDIS (National Environment Satellite, Data and Information Service). It manages huge meteorological data bases. At the same time as it provides real-time radar weather data and satellite weather data, it publishes CD-ROM etc. and operates databases such as a database of satellite weather images obtained since 1960.	United States
NGDC	National Geophysical Data Center http://www.ngdc.noaa.gov/ http://www.noaa.gov/ http://ns.noaa.gov/NESDIS/NESDIS_Home.html	NOAA, NESDIS	Like the NCDC, it is linked to the Department of Commerce, NOAA and NESDIS and operates databases containing a huge quantity of data obtained from global observation satellites (more than 300 databases). It provides it to users as public domain data.	United States
NIWA	National Institute of Water & Atmospheric Research http://www.niwa.cri.nz/index.html		New Zealand's weather information bureau, its services can be used by first purchasing the right to access its data base then using a password to obtain data on the web, from Europe, South Africa, Japan and the United States.	New Zealand
NWS	National Weather Service http://fgsv5.nws.noaa.gov/index.html http://www.noaa.gov/	NOAA	This is the National Weather Service of the United States. It can be used for real-time searches for weather information not only for the United States, but also for the entire world. It is linked to global observation data from NOAA. It also provides visual files that can be used for various types of weather analysis. River flooding forecasts are prepared and provided by the NWSRFS (NWS River Forecast System).	United States
USGS	US Geological Survey http://water.usgs.gov/ http://water.usgs.gov/pubs/FS/FS-027-98/ http://edcwwww.cr.usgs.gov/eros-home.html	NWIS, EROS	The United States Geological Survey (USGS), it operates a river water level observation network and publishes river water level records. The National Water Information System (NWIS) handles all information about above ground water and supplies real-time river flow volume and water level data through the internet. The Earth Resources Observation System (EROS) controls global observation data obtained by observation satellites.	United States
WMO	World Meteorological Organization http://www.wmo.ch/home.html http://www.wmo.ch/web/gcoss/gcoss/home.html http://www.wmo.ch/web/homs/ihnets.html http://www.bafg.de/html/internet/grdc/grdc.html	GCOS, INFOHYDRO, GRDC	It is a specialized United Nations body. It supplies hydrological data and water resource information from around the world. The Global Runoff Data Centre (GRDC), a database of flow volumes of principal rivers in various nations, is operated by Germany. Its catalogue and tools can be downloaded for free. INFOHYDRO is a database of hydrological observation conditions and tables of principal rivers, lakes and marsh drainage basins in various countries.	Switzerland GRDC is in Germany

2.7 EXAMPLES OF PRACTICAL HYDROLOGICAL DATABASES

2.7.1 Bureau of Meteorology (Australia)

In Australia, responsible organizations for hydrology or the environment in state governments collect hydrological data. The Bureau of Meteorology (BOM) collects some hydrological data. Precipitation databases and hydrological databases include HYDSYS (Hydrometric Data Processing and Archive System), HYDROL (Flexible Hydrological Archiving System) and ADAM (Australian Data Archive for Meteorology). Information that is publicly released includes flood forecasts prepared by analysing hydrological data. River water level data is provided through the internet after verification process.

2.7.2 Ministry of Land, Infrastructure and Transport (Japan)

In Japan, the Ministry of Construction which is in charge of operational river management, has constructed databases, unifying data specifications and transforming hydrological data, including water quality data, into electronic form. The Water Information Standard Exchange Format (WISEF) has been proposed and introduced as a standard data format.

The system can provide real-time data and historical data through the internet and it can be used to verify the quality of data to be provided as historical data (FRICS, 1997, 1998).

2.7.3 United States Geological Survey

The USGS (United States Geological Survey) has established databases of hydrological data at each regional office as part of the National Water Information System (NWIS) and has linked them with an online network including the USGS headquarters and all its regional bureaus and branch offices in the nation, permitting the real-time exchange of hydrological information.

This system stresses the exchange of information over the internet and the registration of hydrological data quality information (FRICS, 1996).

2.7.4 Global Runoff Data Centre

The Global Runoff Data Centre (GRDC) serves under the auspices of the WMO as one of their global data centres. It operates with the financial support of the Federal Republic of Germany from an administrative office established at the Federal Institute of Hydrology, Germany. The goal of GRDC is to acquire and provide data required for comparative analysis on a global scale and to provide decision makers with the hydrological data needed to perform global scale water resources assessments.

Due to GRDC's data policy of unrestricted but identified access, limited to non-commercial applications, GRDC data are presently not available online. An applicant has to identify himself and his purpose and to agree upon the data policy by signing a declaration. The data policy takes into account the considerable reluctance of data providers to let their data circulate freely and is determined by an international steering committee.

After identification, GRDC's basic data provision method is to disseminate the requested data non-bureaucratically as an e-mail attachment or, if the requester does not provide an e-mail address, by mailing floppy disks. Users can request monthly or daily discharge data which they may comfortably select by using the catalogue tool which is freely available from the download section of the web page of the centre.

2.8 CONCLUSION

The rapid improvement in the capabilities of computers, the growth of communication networks, improvements in hydrological analysis technology and the demand for public access to information, have led to the construction of hydrological databases and the formation of hydrological data networks, for example, through the internet.

As a result, future hydrological databases will be constructed to handle all hydrological data in electronic form and network systems will be formed, permitting the public release of real-time data and allowing users to perform real-time monitoring of hydrological cycles in individual river basins or on a broader watershed scale.

It is also expected that due to the international standardization of database specifications, it might become possible to use a standard format to integrate and search a wide range of data bases.

CHAPTER 3

GEOGRAPHICAL INFORMATION SYSTEMS APPLIED TO OPERATIONAL HYDROLOGY

3.1 GEOGRAPHICAL INFORMATION SYSTEMS OUTLINED

3.1.1 Definition and special features of GIS

Geographical Information Systems (GIS) are tools used to link data including maps, text, numerical data, and images, etc. The concept allows searching, integration and analysis functions to be performed on information of various types by computer. Because hydrological data are, in most cases, spatial data the introduction of GIS for their effective management is a smart way to respond to user needs.

3.1.2 History of GIS development

During the 1960s, computer use in the United States expanded to universities, governmental bodies and private companies. During this period, various innovations were introduced in the field of GIS. In 1966, the Canada Geographic Information System (CGIS) was completed and began to operate as a grid/cell type land information system.

In the 1970s, the foundation technologies of today's GIS were almost complete with the spreading use of the vector overlay method (which had replaced the grid/cell method), CAD technology, automated cartography, the digitalization of measurement results, graphic devices and database technology.

In the 1980s, GIS was influenced far more by transformations in the computer world than by theoretical and technological progress within the GIS field itself. Progress in both packages of specialized GIS and related software has permitted users to establish systems at lower cost and in a shorter time than developing their own systems.

Consequently, GIS systems are now used by many organizations. GIS systems used for planning, analysis and decision making support include systems for statistical data or natural resource data, systems for individual project development and planning and systems for risk management. Those used to continuously maintain data to manage specific geographical matters include facility management, land and building management and residential registration management (JACIC, 1993).

3.1.3 GIS standardization trends

The ISO/TC211 is a specialized committee established by the International Organization for Standardization (ISO); the Open GIS Consortium (OGC) is an organization established by leading American GIS vendors and computer vendors. Both were established in 1994 aiming at standardization in the field of numerical geographical data.

Standardization is essential to protect users from making unnecessary investment and to allow users to use data more effectively. Thanks to such organizations, efforts to standardize geographical information can now be seen in many countries.

3.1.4 Introduction of GIS related software

Many organizations are using off-the-shelf software for GIS. Available software is described in *GIS world sourcebook* (GIS World, Inc., 1999) and *GIS data book* (JACIC, 1999). Detailed information can be found in these publications.

The following list shows the GIS related software being used by organizations which responded to the questionnaires.

Country	Software
Australia	ArcView, ArcInfo, Mapinfo
Brazil	ArcView
Germany	ArcInfo, ArcView
New Zealand	ArcView, ArcInfo
South Africa	ArcInfo (the future use of ArcView3 is now under consideration)
United States	ArcInfo

The following are the home page addresses for the software products listed above with their main characteristics, which are summarized in Table 5.

Software name	Home page address
ArcInfo	http://www.esri.com
ArcView	http://www.esri.com
Mapinfo	http://www.mapinfo.com

3.2 EFFECTIVENESS OF GEOGRAPHICAL INFORMATION SYSTEMS IN OPERATIONAL HYDROLOGY

3.2.1 Merits of GIS

Because almost all hydrological data is spatial, the introduction of GIS is an effective tool to manage it. It can be used to easily compare and analyse large quantities of information and to display the results visually in easily understandable forms.

Incorporating three-dimensional numerical geographical information provided by GIS in the analysis of hydrological data permits detailed analysis accounting for the areal distribution of land use, ground cover, soil properties and surface slope etc.

3.2.2 Feasibility of using GIS in operational hydrology

Hydrological data can be managed more efficiently by linking it to GIS spatial information. Possible applications include (JACIC, 1998d):

- (a) Drainage basin environment management
By linking precipitation, river water level and discharge, water quality and other forms of hydrological data with map data showing the distribution of population in the drainage basin, plant and animal ecosystems, industry, land use and so on, it is possible to spatially monitor changes in the environment of the watershed and in the hydrological data. This will

Table 6 – Characteristics of GIS-related software

Software	ArcInfo
Developer	ESRI (Environmental Systems Research Institute, Inc.)
Characteristics	An integrated tool with a full selection of GIS functions, it is fully equipped for all GIS uses from map drawing to analytical processing. It can prepare data with topological structures and perform many kinds of vector type map data analysis. Able to use both raster and vector data for analysis tasks, it can be used to prepare elevation raster models (GRID) from topographical map data to perform hydrological analysis. Work processes can be handled by a command base and a customized system can be constructed using a macro-language etc.
Platform	Sun SPARCstation (Solaris2), HP9000, IBM RS/6000, NEC EWS4800, Silicon Graphics, DEC Alpha AXP, Windows NT4.0
Software	ArcView
Developer	ESRI (Environmental Systems Research Institute, Inc.)
Characteristics	Thanks to its Windows menu interface, intuitive and easily performed procedures can be used to display maps. With its easy-to-use operating menu presented by Map Data Preparation, Spatial Analysis and other Dialog Boxes, it can be used for centralized control of maps documents, graphs, output image, script language and for creating presentations through unrestricted data manipulation by Hot Link, Draw Graph, and Layout (printed map preparation function). Other features are topographical and hydrological analysis, route searching, 3-D display, time series analysis, image processing, and Web distribution possible thanks to its expansion function.
Platform	Windows NT4.0, Windows NT3.51, Windows 95, Windows 98
Software	Mapinfo Professional
Developer	Mapinfo
Characteristics	It can be used to perform graph analysis based on interactive operations made possible by its 3-D graph drawing function. Prepared by the Defense Mapping Agency (DMA), it automatically converts DEM (Digital Elevation Model) data files of digital landform data provided by USGS and EROS Data Center into Mapinfo grid maps. It calculates distances and surface areas accounting for curved and flat surfaces. It can obtain coordinates within the range of the boundaries of coordinates for Mapinfo Tables that can be used to prepare maps.
Platform	Windows 95, Windows 98
Remarks	There are versions in 20 languages for 58 countries.

give a clear view of the spatial relationships between these phenomena. This analysis can be used for watershed basin environmental planning.

(b) Inundation risk management

By linking information about the submersion of land during past flooding and submersion information from flood simulations based on hypothetical flood period water levels to map data, it is possible to provide risk management during floods by indicating the locations of routes to evacuation sites and the locations of emergency equipment and facilities. And by also performing simulations to forecast flood conditions based on real-time hydrological data, it is possible to prepare maps that show the extent of likely future disasters likely and use these maps for the advance study of plans to respond to such disasters.

(c) Flood and drought management

Linking real-time hydrological data and the results of forecasting simulations to map data permits the spatial clarification of future flood conditions and drought conditions and the high risk locations in a watershed.

(d) River facility management

By preparing electronic records of hydrological data along with cross-section and longitudinal sections of a river and other data representing its specifications with facility specifications for dams, sluice gates, water intake facilities, bridges etc. and linking this data to geographical information, it is

possible to refer to relationships between spatial hydrological data and river facility specifications at any time. It is also an aid in effective preparation of plans for the renovation and reconstruction of facilities.

(e) Information management

Displaying hydrological data in tables and graphs for each data item and linking them to map data to clearly display large quantities of information spatially in a drainage basin enables users to more intuitively and easily understand just what phenomena are occurring at a given time and place. This is an effective tool in emergencies.

When constructing a system for releasing hydrological data to the public, it should be integrated so that, instead of having to perform searches using only observation station names or code numbers, users can click on map data.

3.3 EXAMPLES OF GEOGRAPHICAL INFORMATION SYSTEMS IN OPERATIONAL HYDROLOGY

3.3.1 Rhine River Geographical Information System

In the River Rhine catchment, a region that has suffered from major flood disasters in recent years, the International Commission for the Hydrology of the River Rhine (CHR) has used RHINE-GIS to start developing a practical system for

constructing water balance models and precipitation runoff models. The models are used for climate change studies as well as for calibration of flood forecasting systems. (Krahe, P., *et al.*, 1997). This system uses GIS to set various model parameters necessary for a model calibration.

The hydrological atlas of Germany provides a modern and up-to-date source of information. New technological options such as digital data and application of GIS are used. The atlas supplies basic information, offers a general overview, represents the latest knowledge available and gives information on data sources and methodologies. Essential topics concerning hydrology, water resources management and the environment in Germany are treated. Switzerland has also published a digital hydrological atlas.

3.3.2 River management (Japan)

Typical examples of the application of GIS in Japan include the Kasumigaura GIS (Ministry of Land, Infrastructure and Transport), Digitized Basin Map (FRICS) and the Flood Damage Statistical Survey Support System (JACIC). These systems, which can be used to combine and represent various kinds of data as map information as well as to calculate the state of damage that flooding would cause, are to be used for river watershed management (Terakawa, A., *et al.*, 1999).

3.3.3 Water quality data management (South Africa)

In South Africa, WATER MARQUE has been constructed as a joint project of several related organizations. This system is a multiple menu tool developed using GIS technology and intended to be used to evaluate, reference, display and report water quality data. Users trained in water quality evaluation can access water quality and related data, analyze the data and prepare output maps.

3.3.4 Hydrological models (United States)

The Task Committee on GIS Modules and Distributed Models of the Watershed established by the American Society of Civil Engineers (ASCE) has studied and prepared a report on the present state and trends in GIS modules from the point of distributed hydrological modelling technology.

This report contains the names and outlines of specific software products that can perform spatial hydrological calculations using digital data that include topographical and land use conditions (ASCE, 1998).

3.4 CONCLUSION

Geographical Information Systems are clearly extremely important tools in integrated river basin management. They are now being introduced in various fields in response to the increasing compatibility, improvement and international standardization in GIS software. By applying GIS to operational hydrology, spatial hydrological data can be clearly integrated with three-dimensional numerical map data provided directly by GIS in the analysis of hydrological data, thus contributing to more effective data management.

REFERENCES

- ASCE Task Committee, ed., (to be published). *GIS modules and distributed models of the watershed*.
- FRICS, ed., 1996. *Water data bases in the United States: fact-finding survey report* (in Japanese).
- FRICS, ed., 1997. *The Ministry of Construction Hydrology and Water Quality Data Base System* (in Japanese).
- FRICS, ed., 1998. *Water Information Standard Exchange Format Ver2.0* (in Japanese).
- FRICS, ed., 1999a. *Report on the construction of the Hydrology and Water Quality Data Base* (in Japanese).
- FRICS, ed., 1999b. *Report on the public information service of the Hydrology and Water Quality Data Base in 1998* (in Japanese).
- GIS World, Inc. ed., 1999. *GIS World Sourcebook*.
- Grabs, W. E., *Integrative management of data and information at the Global Runoff Data Centre (GRDC)*. Proceedings of the international conference on quality, management and availability of data for hydrology and water resources management, Koblenz, Germany, 22–26 March 1999.
- JACIC, ed., 1993. *GIS introduction and operation manual* (in Japanese).
- JACIC, ed., 1998a. *Geographical information system – utilization and example* (in Japanese).
- JACIC, ed., 1998b. *GIS data book* (in Japanese).
- JACIC, ed., 1998c. *Use of GIS in the near future* (in Japanese).
- JACIC, ed., 1998d. *Use of GIS in the river field* (in Japanese).
- JACIC, ed., 1999. *GIS data book* (in Japanese).
- Krahe, P., Daamen, K., Mülders, R. and Wilke, K., 1997. *GIS-related baseflow simulation for water balance and precipitation-runoff modelling in the River Rhine basin*. Proceedings of the IAHS, Publication No. 242.
- Rees, H. G., *Issues of hydrological database management*. Proceedings of the international conference on quality, management and availability of data for hydrology and water resources management, Koblenz, Germany, 22–26 March 1999a.
- Rees, H. G., *The management of the FRIEND European Water Archive*. Proceedings of the international conference on quality, management and availability of data for hydrology and water resources management, Koblenz, Germany, 22–26 March 1999b.
- Terakawa, A. and Abe, K., *Lake watershed GIS data base for lake water quality management*. Proceedings of the international conference on quality, management and availability of data for hydrology and water resources management, Koblenz, Germany, 22–26 March 1999.
- WMO, 1994. *Guide to hydrological practices*. WMO-No. 168, WMO, Geneva.
- Yoshino, F., 1996. *Final report on the areal modeling using remote sensing data and GIS*. WMO, Geneva.
- Introductory information on the following systems were also used as for reference.
- ADAM (Australia)
 - HYDROL (Australia)
 - HYDSYS (Australia)
 - WATER MARQUE (South Africa)

APPENDIX A
QUESTIONNAIRE I

QUESTIONNAIRE I SURVEY FIELD

In April 1998, the first questionnaire was sent to the Commission for Hydrology Working Group Members and Advisory Members introduced from the WMO secretariat. The following countries responded: Australia, Brazil, China, France, Germany, New Zealand, Slovenia, South Africa, Uzbekistan, Vietnam and Zambia.

QUESTIONNAIRE I

Section 1. Hydrological database

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

QUESTIONNAIRE II

QUESTIONNAIRE II SURVEY FIELD

Additional information was requested via a second questionnaire, sent in May 1999. Responses were collected from the following countries: Australia, Brazil, New Zealand, Slovenia and the United States.

QUESTIONNAIRE II

We would like to ask your cooperation in answering the following questions regarding the hydrological data and database system, with descriptions in English and selecting relevant answers with a cross []. The hydrological data refer to those of climate, rainfall, runoff, sediment, water quality, etc. If the question relates to material you consider confidential please write "Confidential" on the relevant item.

Section 1. Standardization of hydrological data

- Q1.1 In the course of recording and processing data, two types of data, analog and digital data, are prepared. The analog data includes manually recorded data, recording sheets of automatic recorders, etc., and the digital data are those recorded by electronic media such as telemeter, data logger, etc. Regarding the analog and digital data, please answer the following.
- (a) Which data are treated as official or formal?
 analog data digital data depends on the kind of data
- (b) If the last answer is selected, please specify.
- Q1.2 In the case of international rivers which flow through more than two countries, it would be beneficial to share the hydrological data mutually among the countries concerned. In this regard, please answer the following.
- (a) Do you have international river(s)?
 yes no
- (b) If yes, is there any activity to standardize the hydrological database among the countries concerned?
 yes no
- (c) If yes, please give the following.
- (i) Name of the international river.
 - (ii) Name of the organization for promoting standardization of the database.
 - (iii) Names of member countries of the organization.

Section 2. Hydrological database

- Q2.1 Regarding the features of your hydrological database system, please answer the following.
- (a) Name or type of database.
 - (b) Kinds of data handled.
 - (c) Time intervals of updating.
 - (d) Type and name of computer system (hardware).
 - (e) Operating system.
 - (f) Name of database application.
 - (g) Name of GIS application.
 - (h) Protocol of database network.
 - (i) Configuration (or system diagram) of database system. Please provide a copy.
- Q2.2 Regarding the services of your database system, please answer the following.
- (a) Are the real-time hydrological data offered to external clients?
 yes with charge yes without charge no
- (b) Are the historical data offered to external clients?
 yes with charge yes without charge no
- (c) If you charge for offering data, please describe the charging system or provide the tariff for reference.
- Q2.3 Regarding the use of your data, please answer the following.
- (a) Is the copyright reserved in your hydrological data?
 yes no
- (b) Are there any conditions or regulations to follow when using your data?
 yes no
- (c) If yes, please describe below.
- (d) Please describe the general features of the database application used in your database system.

- Q2.4 Regarding the real-time hydrological data system, please answer the following.
- (a) How do you adjust and/or correct for the lack of observation and abnormal records in your real-time hydrological data system?
 - (b) Do you have any established measures to adjust/correct real-time data automatically?
[] yes [] no
 - (c) If yes, please outline the system.
- Q2.5 Regarding the quality control of hydrological data, please answer the following.
- (a) Please outline your quality control system for hydrological data.
 - (b) Is any international standard such as ISO applied to the quality control of data?
[] yes [] no
 - (c) If yes, which standards (ISO 9002 for instance) are applied to which part of the quality control system?
- Q2.6 Regarding the training of database-keeping staff and clients, please answer the following.
- (a) Do you carry out training of database-keeping staff and clients?
[] yes for both the database-keeping staff and clients [] yes for database-keeping staff only
[] yes for clients only [] no
 - (b) If yes, please outline your training programme.
- Q2.7 Regarding the network system for the hydrological database, please answer the following.
- (a) Do you classify clients depending on the degree of accessibility (full or partial access) to the data?
[] yes [] no
 - (b) If yes, what are the criteria for classification?
 - (c) Do you have any regulation for regular change and control of the password to secure your database system?
[] yes [] no
 - (d) Do you separate data for public use from other data?
[] yes [] no
 - (e) If yes, what are the principles or criteria for the separation?
 - (f) Do you establish a separate database system for public use?
[] yes [] no
 - (g) What measures are you taking to protect the system from computer viruses and hackers?
 - (h) What is the backup system to secure the database from losses due to hardware crashing, earthquake, fire and other troubles?

Section 3. Application of GIS to hydrological database

- Q3.1 Regarding the application of GIS to the hydrological database system, please answer the following.
- (a) Do you have GIS linked to the hydrological database?
[] yes [] no
 - (b) If yes, is the GIS standardized, for example, in compliance with ISO or TC211?
[] yes [] no
 - (c) If yes, please describe the applied standards.
 - (d) Please outline the features of the GIS application you are using.
 - (e) If you establish GIS with the hydrological database, what advantages do you expect in hydrological data management in practice?

ANSWERS TO QUESTIONNAIRE I

AUSTRALIA

Section 1. Hydrological database

Q1.1 In your country which organization is in charge of constructing the hydrological database?

In Australia, water resources management is a State Government responsibility. Therefore, most hydrological data are collected by State Government water or environmental agencies. Because flood warning is a national responsibility of the Bureau of Meteorology (a Federal Government agency), the Bureau also collects some hydrological data, however this is usually a joint responsibility with the State agencies. A list of some of the agencies who collect and store hydrological data is given below:

- *Federal Government agencies: Bureau of Meteorology*
- *State Government agencies: Department of Natural Resources and Environment – Victoria, Department of Land and Water Conservation – New South Wales; Department of Lands, Planning and Environment – Northern Territory; Department of Natural Resources – Queensland; Water and Rivers Commission – Western Australia; Ecowise Environmental – Australian Capital Territory; Department of Environment, Heritage and Aboriginal Affairs – South Australia; Department of Primary Industries and Fisheries – Tasmania*
- *Other State-based Agencies: Hydro-Electric Commission – Tasmania, Melbourne Water, Murray-Darling Basin Commission, Snowy Mountains Hydro-Electric Authority, Sydney Water, Brisbane City Council*

Q1.2 Is the operational hydrological database computerized? If so, describe the system?

The following computerised precipitation database and hydrological databases are used in Australia:

- *HYDSYS (information attached)*
- *HYDROL (information attached)*
- *ADAM (information attached)*

Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?

There are a variety of answers to this question. Currently, there is no direct access for the general public to the databases (for example via the internet). However, some examples of what is occurring include:

- *The Bureau of Meteorology is currently developing an internet based access regime for obtaining rainfall data, this system will be on a charge for use basis (see attachment).*
- *The NSW DLWC has produced a CD-ROM of their data which can be purchased.*
- *Most agencies charge for data, but the charge is usually only related to the handling of the data.*
- *Most agencies can provide data via ftp facilities once it has been purchased.*

Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?

A general contact for information on ADAM (Bureau of Meteorology) and general information on the hydrological databases held by agencies throughout Australia is:

*Ross James
Supervising Engineer Water Resources
Hydrology Unit
Bureau of Meteorology
GPO Box 1289K
Melbourne Vic. 3001
Australia
Tel: +61 3 9669 4605
Fax: +61 3 9669 4725
E-mail: rjames@bom.gov.au*

Contacts for the two hydrological databases are:

*HYDSYS: Peter Heweston (Manager)
HYDSYS Pty Ltd
PO Box 3476
Western Creek ACT 2611
Australia
Tel: 61 6 288 2302
Fax: 61 6 288 9061
E-mail: 100032.503@compuserve.com
HYDROL: Mark Willis (Database Manager)
Phone: +61 3 6230 5687
Fax: +61 3 6234 2360
E-mail: mark.willis@oa.hydro.com.au*

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
All of the organizations listed in 1.1 would also collect data in real-time. The availability of this data depends to a large extent on the purpose for which it is required. The data themselves are not necessarily disseminated, rather the products, for example, forecasts and warning are disseminated. Some general comments are as follows:
- *Dissemination is usually within organizations, by communications and computer linkages.*
 - *Data telemetry systems make use of radio, telephone and satellite transmission systems.*
 - *Some databases interrogate data sources and update databanks in real-time.*
 - *The Bureau of Meteorology has river height bulletins accessible by facsimile and able to be viewed over the internet.*
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
See also 1.3.
- *Some agencies allow user to access data sites themselves (e.g. by telephone for flood height information).*
 - *Bureau of Meteorology river height bulletins can be accessed over the internet.*
 - *Bureau of Meteorology data is available free of charge, as this is a basic service.*
 - *Most other agencies would charge a handling fee for access to their real-time data.*
 - *I am not aware of any other agencies making their real-time data readily available to the general public, it is usually collected for specific purposes.*
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
There are plans to provide a range of services over the internet (e.g. the river height bulletins) are one example. However, they are presented more in the form of products (e.g. river height forecast/warning), rather than real-time information. The main reasons for not making extensive use of the internet are as follows:
- *Not all users have easy access to the internet.*
 - *The security of computer systems must be protected.*
 - *Real-time data is often not subject to the stringent accuracy/quality checks applied to other data and therefore have a higher possibility of error.*
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
Real-time data are not necessarily being included in the official data base until strict operational procedures and data checks are in place. The accuracy and reliability depend on a number of factors. The first is instrument reliability, this is accepted provided there is an adequate inspection and maintenance programme, carried out by suitably qualified staff. Secondly, the data recorded can be subject to a number of internal consistency tests (for example acceptable ranges, etc.). Finally, the data can be viewed in the office on receipt and any other obvious problems. Many agencies now have obtained quality control standards (e.g. ISO Standards).
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
A general contact for information held by agencies throughout Australia is:
- Ross James
 Supervising Engineer Water Resources
 Hydrology Unit
 Bureau of Meteorology
 GPO Box 1289K
 Melbourne Vic. 3001
 Australia
 Tel: +61 3 9669 4605
 Fax: +61 3 9669 4725
 E-mail: rjames@bom.gov.au*

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

Copies of the following case studies provided:

- *GIS as a tool in predicting Urban Catchment Response*
- *GIS – Display Tools or Analytical Tools for Hydrologists?*
- *Application of GIS and Remote Sensing in Stream Turbidity Modelling.*
- *GIS and Hazard Management.*
- *UNESCO New Technologies, Remote Sensing and GIS.*

BRAZIL**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
According to the internal structure of the Ministry of Mines and Energy (MME) the responsibilities of the National Agency of Electric Energy (ANEEL) are:
- *To plan and coordinate the implementation of the national basic hydrologic network, establishing and defining priorities.*
 - *To organize constructing the hydrological database.*
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
Part of our hydrologic network is automatic – we can say that it represents 7% of our network (3 200 points of measurement that represent 4 800 stations). The operational hydrological database is computerized, using the microcomputer (MSDHD) – micro systems of hydrological data; version DOS; in the future Windows.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
Yes, all of our hydrologic network information is free to everyone. Access to the database is public and the service is free – you can get information by letter, fax or e-mail. Our automatic hydrologic network is at <http://www.aneel.gov.br> in “Dados On-line”. Or contact:
- Agencia Nacional de Energia Eletrica (ANEEL)
 Mauro Silvio Rodrigues
 Hydrologic Telemetry
 Tel: 55 61 312 5884/5883
 Fax: 55 61 312 5881
 E-mail: mauro@aneel.gov.br*
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
*Marcos Vasconcelos de Freitas
 E-mail: mfreitas@aneel.gov.br*

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
ANEEL via the internet. All the stations in Brazil can be accessed and the service is free of charge.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
Yes, free of charge.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
Answered above.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
Telemetry.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
*Mauro Silvio Rodrigues (Telemetry)
 E-mail: mauro@aneel.gov.br*

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

Actually, many agencies in Brazil are developing GIS programmes for rivers. For more information contact:

*Mr J. Clayton
 E-mail: clayton@aneel.gov.br*

Information supplied by:

Mauro Silvio Rodrigues and Valdemar Santos Guimaraes
 Agencia Nacional de Energia Eletrica (ANEEL)
 Tel: +55 61 312 5884/5883
 Fax: +55 61 312 5881
 E-mail: mauro@aneel.gov.br

CHINA**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
Department of Hydrology, Ministry of Water Resources
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
Yes. The system is SYBASE, POWERBUILD in Vax type computer.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
I am not sure. You may contact them.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
*Mr Desheng Jiao (Director)
Department of Hydrology
Ministry of Water Resources
2, Lane 2, Baiguang Road
Beijing 100053
People's Republic of China
Tel: +86 10 63202620
Fax: +86 10 63202978*

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
Information Centre, Ministry of Water Resources
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
I am not sure. You may contact them.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
No. It is not open to public.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
Sorry, I have no information this.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
*Mr Dekun Chen (Director)
Information Centre
Ministry of Water Resources
2, Lane 2, Baiguang Road
Beijing 100053
People's Republic of China
Tel: +86 10 63202419
Fax: +86 10 63202407*

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

China has done some of work on operational applications of GIS, however the papers are mostly in Chinese. Herewith please find one paper. If you want to know more information please ask the authors.

Information supplied by:

Xiaoqing Yang
International Research and Training Center on Erosion and Sedimentation (IRTCES)
P.O. Box 366
Beijing 100044
Tel: +86 10 68413372
Fax: +86 10 68411174
E-mail: irtces@public.bta.net.cn

FRANCE**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
Direction Regionale de l'Environnement (DIREN). Other hydrological data are collected by Electricite de France, Cemagref etc. Each organization is responsible for the quality of the data: water level, calculated instantaneous flow, calibration etc. These data are collected by the French Environment Ministry/Water Headquarters and stored in a national database (called "hydro"). Some quality tests are performed. There are about 3 500 limnigraphs: 3 000 managed by DIREN, 500 by other semi-public organizations. (NB There is also a flood alert service managed by the French Ministry of Equipment.)
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
Yes – French system.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
No, organizations can take a subscription to the database: the initial charge is US\$200, thereafter charges are calculated by quantity of data.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
M. Cherer (hydro@environnement.gouv.fr)

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
No, real-time data are disseminated, only flood announcements where the time delay is from a few days to a week.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
No.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
No, the situation is not clear: data are considered products to be sold.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
DIREN. Classical methodology: test the data capture, coherence test with other gauge-stations, double cumuls.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
M. Cherer (hydro@environnement.gouv.fr)

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

See Cemagref internet site (www.cemagref.fr)

Information supplied by:

Marc LOINTIER
 Hydrologue Responsable du Laboratoire ORSTOM
 Maison de la Teledetection en Languedoc Roussillon
 500 rue J.F. Breton
 34093 Montpellier cedex 05
 Tel: +33 4 67 54 87 03
 Fax: +33 4 67 54 87 00

GERMANY**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
Hydrological data are managed in Germany at different levels. According to our federal state system each individual state (total of 16) is responsible for all water affairs within the state. The Federal Republic of Germany itself deals with waterways for navigation and coastal water systems. Therefore in Germany more than one hydrological database exists. A hydrological database exists in each federal state (called Länder) and an additional one at the Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology). The latter is responsible for waterways of navigation.
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
All hydrological databases in Germany are computerized. The systems used are UNIX and DOS.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
The general public has access to the database on request. The charge of the service depends on the service required. Usually the costs are very low or the service is rendered without any charge.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
The person responsible for the data base of the Bundesanstalt für Gewässerkunde is:
Dr R. Neuhaus
Bundesanstalt für Gewässerkunde
Postfach 309, 56003 Koblenz
Germany
Tel: +49 261 1306 5212
Fax: +49 261 1306 5280
E-mail: neuhaus@koblenz.bfg.bund400.de

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
Real-time data are available via internet, videotext, telephone, etc.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
The general public has also access via internet.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
See Q2.1.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
The hydrological service dealing with the measuring station concerned is responsible for checking the data.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
Depending on the measuring station concerned the hydrological service is responsible for further information.

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

Please find enclosed three reports on operational applications of GIS in Germany. GIS is widely used in various projects in Germany. For further information a report Abnormalities of the weather in Germany in 1997, including the flood event on the River Oder is also attached.

Information supplied by:

Professor Dr K. Hofius
 Commission for Hydrology, Office of the President
 Bundesanstalt für Gewässerkunde
 (Federal Institute of Hydrology)
 Postfach 309, D-56003 Koblenz
 Germany
 Tel: +49 1306 5313
 E-mail: hoflus@koblenz.bfg.bund400.de

NEW ZEALAND**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
In New Zealand, the National Institute of Water and Atmospheric Research Ltd (NIWA) is responsible for maintaining and enhancing national water quality and quantity databases. The national databases and data collection networks are collectively referred to as the Water Resources Archive (WRA). The primary data source for the WRA is NIWA's field offices in 14 locations around New Zealand. Local government agencies have their own local networks and databases and contribute their data to the WRA.
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
The Hydrometric Database, a component of the WRA, is computerized. The software, called "Tideda", was developed by NIWA and its predecessors, for storage and analysis of hydrological data. Please see the HOMS description of Tideda.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
Most of the data in the WRA are available to the public since their collection and storage was funded (mostly) by the New Zealand government. Data is mainly sent by mailing disks or by e-mail. Direct access by internet is being established. A CD-ROM of WRA data (1905-95) was very popular. Minimal costs are charged for NIWA staff time required to process data requests.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
*Charles Pearson
 Project Director of Hydrology
 National Institute of Water and Atmospheric Research Ltd (NIWA)
 Tel: +64 3 348 8987
 Fax: +64 3 348 5548
 E-mail: c-pearson@niwa.cri.nz*

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
NIWA and regional councils operate hydrometric networks on a real-time basis. The New Zealand Meteorological Service Ltd operates three radars for storm rainfall warnings. Most transfer of data is by radio telemetry, although there is now a move to include use of the internet. Data are only disseminated during flood events or upon request. Otherwise real-time data are used internally for checking operation of hydrometric recorders.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
If particular clients require real-time data, they must pay for this to be set up (e.g. hydropower companies pay for real-time hydro reservoir data for selling electricity on NZ's deregulated electricity market).
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
The internet is now being used for automatically transferring real-time data to paying clients. By 2001 users will be able to extract provisional (unchecked) real-time data using an internet interface to the Water Resources Archive.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
We have a Telarc-accredited ISO 9002 quality assurance programme for data collection and database activities. New methods are being developed using neural networks for real-time data checking.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
See Q1.4.

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

GIS is used extensively in New Zealand by staff of central government, local government, universities and private companies, for catchment resource management.

Information supplied by:

Charles Pearson
 Project Director of Hydrology
 National Institute of Water and Atmospheric Research Ltd (NIWA)
 PO Box 8602, Christchurch
 New Zealand
 Tel: +64 3 348 8987
 Fax: +64 3 348 5548
 E-mail: c-pearson@niwa.cri.nz

SLOVENIA

Section 1. Hydrological database

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
Republic of Slovenia, Ministry of the Environment and Physical Planning Hydrometeorological Institute of Slovenia, Vojkova lb, 1001 Ljubljana p.p. 2549, Tel: +386 61 327 461, Fax: +386 61 133 13 96
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
Yes, interface with procedures for encoding, listing inquiring and producing simple statistics and reports. Database consists of several RMS files containing hourly and daily values (water levels, discharges, water temperature, suspended material), data on the network, hydrometry data, rating curves. Database is in operation since 1989 and is written in FORTRAN running under VMS. It is a Slovenian product based on HOMS G06 data architecture with several modifications.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
Not directly. Requests need to be sent in writing. The service is charged for according to the costs.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
- | | | |
|-------------------------------------|-----------|---|
| <i>Anton Muzic</i> | <i>or</i> | <i>Joze Miklavcic</i> |
| <i>Adviser to the Director</i> | | <i>Expert Assitant</i> |
| <i>Tel: +386 61 327 461</i> | | <i>Tel: +386 61 327 461</i> |
| <i>Fax: +386 61 133 13 96</i> | | <i>Fax: +386 61 133 13 96</i> |
| <i>E-mail: tone.muzic@rzs-hm.si</i> | | <i>E-mail: joze.miklavcic@rzs-hm.si</i> |

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
Republic of Slovenia, Ministry of the Environment and Physical Planning Hydrometeorological Institute of Slovenia, Vojkova lb, 1001 Ljubljana p.p. 2549, Tel: +386 61 327 461, Fax: +386 61 133 13 96, (<http://www.rzs-hm.si/podatki/vode.html>), TELETEXT, computer network for water quality and quantity.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
The service is free of charge.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
Yes.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
The Department for Observations and Measurements and the Department for Basic Processing of Hydrological Data of the Hydrometeorological Institute of Slovenia. QA procedures, QC procedures, balance method, regression method control.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
- | | | |
|-------------------------------------|-----------|-------------------------------------|
| <i>Anton Muzic</i> | <i>or</i> | <i>Marjan Bat</i> |
| <i>Adviser to the Director</i> | | <i>Adviser to the Director</i> |
| <i>Tel: +386 61 327 461</i> | | <i>Tel: +386 61 327 461</i> |
| <i>Fax: +386 61 133 13 96</i> | | <i>Fax: +386 61 133 13 96</i> |
| <i>E-mail: tone.muzic@rzs-hm.si</i> | | <i>E-mail: marjan.bat@rzs-hm.si</i> |

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

There are no operational GIS in use. At this moment we use only digitized pictures of the drainage network and watersheds, as ACAD DWG FILES (digitized maps – scale 1:25 000).

UZBEKISTAN**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
The main administration of Hydrometeorology of the Cabinet of Ministers of the Republic of Uzbekistan (Glavgidromet)
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
Glavgidromet has an operative hydrological database prepared partially on PC in DOS and partially on paper.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
General public cannot access the real-time data. There is no free of charge access to database services.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
Lyudmila Vasilina (Tel: 7 3712 35-87-55) and Mikhail Torsky (Tel: 7 371 133-43-47) can give more detailed information concerning the hydrological database. The information about water resources quality parameters can be obtained from Tatiana Ososkova (Tel: 7 371 133-61-17).

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
In the Republic of Uzbekistan Glavgidromet distributes the hydrological data on quantitative and qualitative parameters by the publication of yearbooks on the rivers and reservoirs regime and materials on the hydrochemical regime of surface water bodies. Glavgidromet also issues forecasts of rivers as well, free of charge and charged, depending on the status of organizations being served.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
For access to the real-time hydrological databases the computing system "ARM-Gydrolog" has been developed in Glavgidromet. But access to the real-time data on qualitative parameters does not exist.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
The internet network is not widely used in Glavgidromet because of financial embarrassment.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
The accuracy and reliability of the rivers and reservoirs regime data are controlled by the Department of Hydrology of the Surface System Administration. The accuracy and reliability of the hydrochemical regime and surface water pollution data are checked by the Laboratory of the Surface Water Pollution of the Environmental Pollution Monitoring Administration of Glavgidromet.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
Nail Sagdeev (Tel: 7 371 235-82-25) and Tatiana Ososkova (Tel: 7 371 133-61-17).

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

Unfortunately, we have no publications on GIS application in Glavgidromet. Consultations on operative application of GIS can be given by Mikhail Arushanov – Chief of the Information Technologies Development Service of Information Communication and Processing Administration of Glavgidromet (Tel: 7 371 235 81 04).

VIETNAM**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
In Vietnam, the Hydrometeorological Service (HMS) is in charge of constructing the hydrological database (including quantity and quality)
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
Some of them are computerized.
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
Some can be accessed. The service is charged.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?
Mr Phung Ngoc Diep, Director, International Cooperation Department, HMS.

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
The Hydrometeorological Service (HMS).
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
See Q1.3.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
Not yet, access to the internet is not widespread.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
Department of Network Operation in HMS.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
Mr Phung Ngoc Diep, Director, International Cooperation Department, HMS.

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

Information supplied by:

Vvtuan@netnam.org.vn

ZAMBIA**Section 1. Hydrological database**

- Q1.1 In your country which organization is in charge of constructing the hydrological database?
In our country there are four organizations in charge of constructing hydrological databases. However, the Department of Water Affairs (DWA) is the main custodian of the hydrological data and the Zambia Meteorological Department (ZMD) is responsible for rainfall data and other climatological data. The other two, the Zambezi River Authority (ZRA) and the Zambia Electricity Supply Corporation (ZESCO) only cover areas of their interest i.e., the Kariba Dam and the Zambezi Basin.
- Q1.2 Is the operational hydrological database computerized? If so, describe the system?
The operational hydrological databases in these organizations are all computerized.
- ZESCO and DWA uses HYDATA
 - ZRA uses HYDATA and SYBASE which is a SADC regional database which ZRA is hosting on its behalf
 - ZMD uses CLICOM and HOMS component G06.3.01 (still on trial)
- HYDATA is a hydrological database designed for use on modern PCs. The system incorporates its own integrity checking and backup facility where by all the database files are interrogated and copied onto floppy diskettes. The database has the capacity to store data for up to 1 000 stations. Each station may be one of the six types: (a) event, (b) gauging and rating, (c) flow, (d) general, (e) rainfall and (f) storage.*
- CLICOM is designed in almost the same way as HYDATA except it is for climatological and rainfall parameters.*
- Q1.3 Can the general public access the database? How? Is the service free of charge or is a fee charged?
The data and information is given out free of charge by ZRA, DWA, ZESCO and ZNM. However, they all reserve the right to decide which data can be given out. An enquirer therefore has to put his/her request in writing explaining what type of data and information is required and giving reasons why they they need the data. For data in the regional database, SYBASE, the enquirer is expected to obtain permission from the respective riparian country who will authorise ZRA to give out the data.
- Q1.4 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on this matter?

*The Chief Executive
 Zambezi River Authority
 P.O. Box 130233
 0101 Lusaka
 Tel: 260-1-228 401
 Fax: 260-1-227 498
 E-mail: zaraho@zamnet.zm*

*The Officer in Charge
 DWA
 Shekiabeki Road
 Lusaka
 Tel: 260-1-223 135
 E-mail: hydro@zamnet.zm*

*SADC Project Manager
 ZESCO Ltd
 P.O. Box 33304
 Lusaka
 Tel: 260-1-228 084/5/6
 Fax: 260-1-229 542
 E-mail: sadcaaa@zamnet.zm*

Section 2. Real-time hydrological data availability

- Q2.1 In your country by which organization and how are real-time hydrological data (including quantity and quality) disseminated?
Some institutions have subscriptions to, ZRA, ZMD and DWA and the information is disseminated by telephone, fax, e-mail and by mail on a weekly or ten day basis.
- Q2.2 Can the general public access the real-time data? How? Is the service free of charge or is a fee charged?
The general public can not access the real-time data; most of the reporting stations are not in a network neither does the telemetry system function properly in the organizations.
- Q2.3 Is the internet network used for disseminating real-time hydrological data? Is there a plan to use the internet for this purpose in the near future? If not, what is the main reason?
Although all the organizations are connected to the internet, the internet is not yet used for disseminating real-time data. Yes, future plans are to use it. The problems as of now is that the telemetry system is not in good order and it is quite costly to introduce the system, since most of the reporting stations are in remote locations.
- Q2.4 Who is checking the accuracy and reliability of data before accepting them as officially recorded data and storing in the data base? Describe the process?
The accuracy and reliability of the data is checked by the data processing section within the organization especially for HYDATA. For the SYBASE the quality control of the data is the responsibility of the respective riparian countries of the Zambezi River Basin.
- Q2.5 Who do you recommend is the suitable person (name, position, tel, fax and/or e-mail address) to ask for more details on the matter?
 (No answer)

Section 3. Operational application of Geographical Information Systems

If available, please send a copy of relevant papers or reports on operational applications of Geographical Information Systems (GIS) for river/watershed management in your country.

There are no report or papers on the case of operational applications of GIS for rivers/watershed management. The system has just been introduced in Zambia. The GIS and remote sensing equipment and software is ready in place and literature is being procured. The development of a GIS database commenced through the ZACPRO 6 Project, phase 1.2: Sector studies at ZRA. ZMD has METEOSAT and NOAA satellite receivers and some GIS software which could be used for operational applications in watershed management. However, there are also no reports or papers on this.

Information supplied by:

Z. P. Daka
Hydrometeorologist
Meteorological Department
P.O. Box 30200
10101 Lusaka
Zambia

ANSWERS TO QUESTIONNAIRE II

AUSTRALIA

Please note where possible the answers to the questions cover the meteorological data collection by the national meteorological organization and the hydrometeorological data collection by the eight main state government water agencies.

Section 1. Standardization of hydrological data

- Q1.1 In the course of recording and processing data, two types of data, analog and digital data, are prepared. The analog data includes manually recorded data, recording sheets of automatic recorders, etc., and the digital data are those recorded by electronic media such as telemeter, data logger, etc. Regarding the analog and digital data, please answer the following.
- (a) Which data are treated as official or formal?
 analog data digital data depends on the kind of data
- (b) If the last answer is selected, please specify.
From some stations digital data is received for real-time operational purposes. The analog data is received later and after quality control may replace the digital data in the data archive.
- Q1.2 In the case of international rivers which flow through more than two countries, it would be beneficial to share the hydrological data mutually among the countries concerned. In this regard, please answer the following.
- (a) Do you have international river(s)?
 yes no
- (b) If yes, is there any activity to standardize the hydrological database among the countries concerned?
 yes no
- (c) If yes, please give the following.
- (i) Name of the international river.
 - (ii) Name of the organization for promoting standardization of the database.
 - (iii) Names of member countries of the organization.

Section 2. Hydrological database

- Q2.1 Regarding the features of your hydrological database system, please answer the following.
- (a) Name or type of database.
Meteorology: Oracle
Hydrology: most agencies use a proprietry package called HYDSYS
- (b) Kinds of data handled.
Meteorology: all meteorological variables
Hydrology: rainfall, surface water data, groundwater data and water quality data
- (c) Time intervals of updating.
Meteorology: regular and ongoing
Hydrology: regular and ongoing
- (d) Type and name of computer system (hardware).
Meteorology: HP 9000 Series 800 servers
Hydrology: Intel based desktop computers
- (e) Operating system.
Meteorology: HP Unix
Hydrology: MS Windows
- (f) Name of database application.
Meteorology: Oracle
Hydrology: proprietry system using DB III files
- (g) Name of GIS application.
Meteorology: no GIS linked to the database system but ArcInfo and ArcView are used.
Hydrology: simple proprietry mapping package in the database system. ArcInfo, ArcView and MapInfo are also used to display data and network information
- (h) Protocol of database network.
Meteorology: TCP/IP and SQL
Hydrology: Windows networking and proprietry HYDSYS file and record control management
- (i) Configuration (or system diagram) of database system. Please provide a copy.
Too large and complex to provide.
- Q2.2 Regarding the services of your database system, please answer the following.
- (a) Are the real-time hydrological data offered to external clients?
 yes with charge yes without charge no
Yes, but arrangements and possible charges vary between organizations.

- (b) Are the historical data offered to external clients?
 yes with charge yes without charge no
Depends on the different agencies and the use of the data.
- (c) If you charge for offering data, please describe the charging system or provide the tariff for reference.
*If a charge is applied then it is usually just to cover the cost of extracting and preparing the data in the format required.
 Charging rates vary between agencies providing the data.*
- Q2.3 Regarding the use of your data, please answer the following.
- (a) Is the copyright reserved in your hydrological data?
 yes no
- (b) Are there any conditions or regulations to follow when using your data?
 yes no
- (c) If yes, please describe below.
Data are not to be sold or passed on to a third party without permission of the copyright holder.
- (d) Please describe the general features of the database application used in your database system.
- *Extracts data;*
 - *Range of standard analyses: hourly totals, daily totals, monthly totals;*
 - *Storm events, annual series, distribution fitting, flow duration;*
 - *Statistical summaries, intensity frequency duration, double mass curves;*
 - *Range of presentations: tabulations, graphs;*
 - *Export of data in a range of formats.*
- Q2.4 Regarding the real-time hydrological data system, please answer the following.
- (a) How do you adjust and/or correct for the lack of observation and abnormal records in your real-time hydrological data system?
Manual intervention
- (b) Do you have any established measures to adjust/correct real-time data automatically?
 yes no
- (c) If yes, please outline the system.
Simple bounds checking and rate of change checks to highlight possible values in error.
- Q2.5 Regarding the quality control of hydrological data, please answer the following.
- (a) Please outline your quality control system for hydrological data.
- *Varies between the agencies but will often include some or all of the following:*
 - *Check against neighbouring station;*
 - *Use of long-term check gauges to verify TBRG operation;*
 - *Double mass curves;*
 - *Reasonable value checks based on long term station statistics;*
 - *Volume balance between neighbouring flow stations;*
 - *Visual inspection of plotted data.*
- (b) Is any international standard such as ISO applied to the quality control of data?
 yes no
Some State water agencies have ISO certification for their data management others do not. The national meteorological agency does not apply ISO standards.
- (c) If yes, which standards (ISO 9002 for instance) are applied to which part of the quality control system?
Information is not available.
- Q2.6 Regarding the training of database-keeping staff and clients, please answer the following.
- (a) Do you carry out training of database-keeping staff and clients?
 yes for both the database-keeping staff and clients yes for database-keeping staff only
 yes for clients only no
- (b) If yes, please outline your training programme.
Varies between agencies but consists of:
- *In-house training;*
 - *External course provided by educational institutions;*
 - *Courses provided by the database developers and software suppliers.*
- Q2.7 Regarding the network system for the hydrological database, please answer the following.
- (a) Do you classify clients depending on the degree of accessibility (full or partial access) to the data?
 yes no
- (b) If yes, what are the criteria for classification?
*External clients do not have direct access to the database.
 Internal users are classified depending on their need to read, update or create data files.*
- (c) Do you have any regulation for regular change and control of the password to secure your database system?
 yes no

- (d) Do you separate data for public use from other data?
 yes no
- (e) If yes, what are the principles or criteria for the separation?
Some water agencies collect data for commercial operations or for use in operational water supply management. This data may be confidential and may not be made available to the public.
- (f) Do you establish a separate database system for public use?
 yes no
But data products may be generated from the main database system made available to the public, e.g. by the internet.
- (g) What measures are you taking to protect the system from computer viruses and hackers?
Firewalls to exclude external access, regular backups and regular software checks.
- (h) What is the backup system to secure the database from losses due to hardware crashing, earthquake, fire and other troubles?
This will vary from agency to agency but will generally consist of:
 - *Backup to tape and CD;*
 - *Some organizations hold hold backups at another secure location;*
 - *Some organizations run duplicate databases.*

Section 3. Application of GIS to hydrological database

Q3.1 Regarding the application of GIS to the hydrological database system, please answer the following.

- (a) Do you have GIS linked to the hydrological database?
 yes no
But GIS systems are used to display data and network information extracted from the databases.
- (b) If yes, is the GIS standardized, for example, in compliance with ISO or TC211?
 yes no
- (c) If yes, please describe the applied standards.
Standard GIS packages are used such as ArcInfo, ArcView and MapInfo. So the standards applied are whatever standards are built into them.
- (d) Please outline the features of the GIS application you are using.
 - *Standard mapping and spatial presentation features;*
 - *Rainfall and runoff analyses such as isohyetal type analyses or polygon analyses.*
- (e) If you establish GIS with the hydrological database, what advantages do you expect in hydrological data management in practice?
 - *Network design;*
 - *Presentation and analysis of data for quality control purposes;*
 - *Improved and more rapid presentation of data;*
 - *Presentation of real-time data.*

BRAZIL**Section 1. Standardization of hydrological data**

- Q1.1 In the course of recording and processing data, two types of data, analog and digital data, are prepared. The analog data includes manually recorded data, recording sheets of automatic recorders, etc., and the digital data are those recorded by electronic media such as telemeter, data logger, etc. Regarding the analog and digital data, please answer the following.
- (a) Which data are treated as official or formal?
 analog data digital data depends on the kind of data
- (b) If the last answer is selected, please specify.
- Q1.2 In the case of international rivers which flow through more than two countries, it would be beneficial to share the hydrological data mutually among the countries concerned. In this regard, please answer the following.
- (a) Do you have international river(s)?
 yes no
- (b) If yes, is there any activity to standardize the hydrological database among the countries concerned?
 yes no
- (c) If yes, please give the following.
- (i) Name of the international river.
Prata (Paraná) River and some of its tributaries.
- (ii) Name of the organization for promoting standardization of the database.
Comite Internacional de Cooperação (CIC).
- (iii) Names of member countries of the organization.
Argentina, Brazil, Bolivia, Paraguay and Uruguay.

Section 2. Hydrological database

- Q2.1 Regarding the features of your hydrological database system, please answer the following.
- (a) Name or type of database.
SQL server
- (b) Kinds of data handled.
Level, discharge, rain, water quality and sediment
- (c) Time intervals of updating.
Approximately three months
- (d) Type and name of computer system (hardware).
ALR – Intel Pentium II dual processors
- (e) Operating system.
Windows NT server
- (f) Name of database application.
Hidro-1.0
- (g) Name of GIS application.
ArcView
- (h) Protocol of database network.
TCP/IP
- (i) Configuration (or system diagram) of database system. Please provide a copy.
- Q2.2 Regarding the services of your database system, please answer the following.
- (a) Are the real-time hydrological data offered to external clients?
 yes with charge yes without charge no
- (b) Are the historical data offered to external clients?
 yes with charge yes without charge no
- (c) If you charge for offering data, please describe the charging system or provide the tariff for reference.
- Q2.3 Regarding the use of your data, please answer the following.
- (a) Is the copyright reserved in your hydrological data?
 yes no
- (b) Are there any conditions or regulations to follow when using your data?
 yes no
- (c) If yes, please describe below.
- (d) Please describe the general features of the database application used in your database system.
Georeferenced hydrometeorological data, consist data, cross link regular data and geographical data, tabular input and output, statistical data.
- Q2.4 Regarding the real-time hydrological data system, please answer the following.
- (a) How do you adjust and/or correct for the lack of observation and abnormal records in your real-time hydrological data system?
Through comparison graphics.

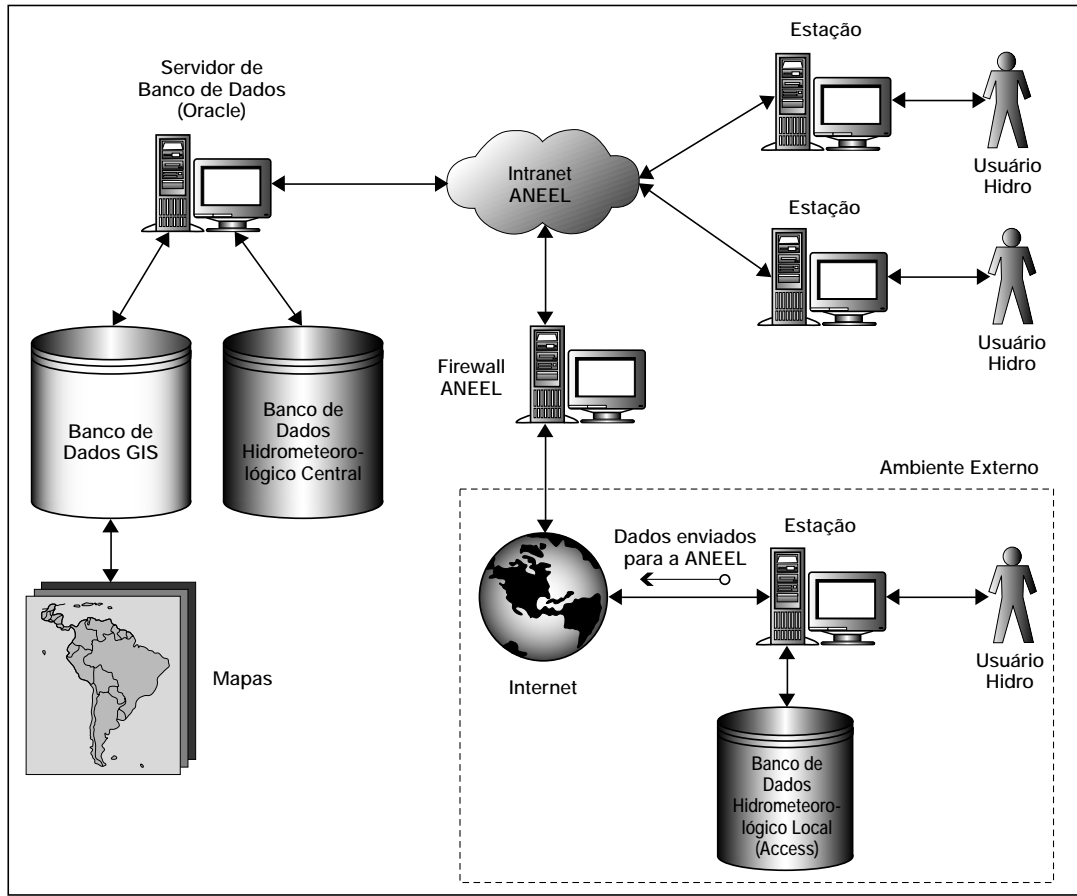


Figure 1 – Overview of Brazil’s hydrological database

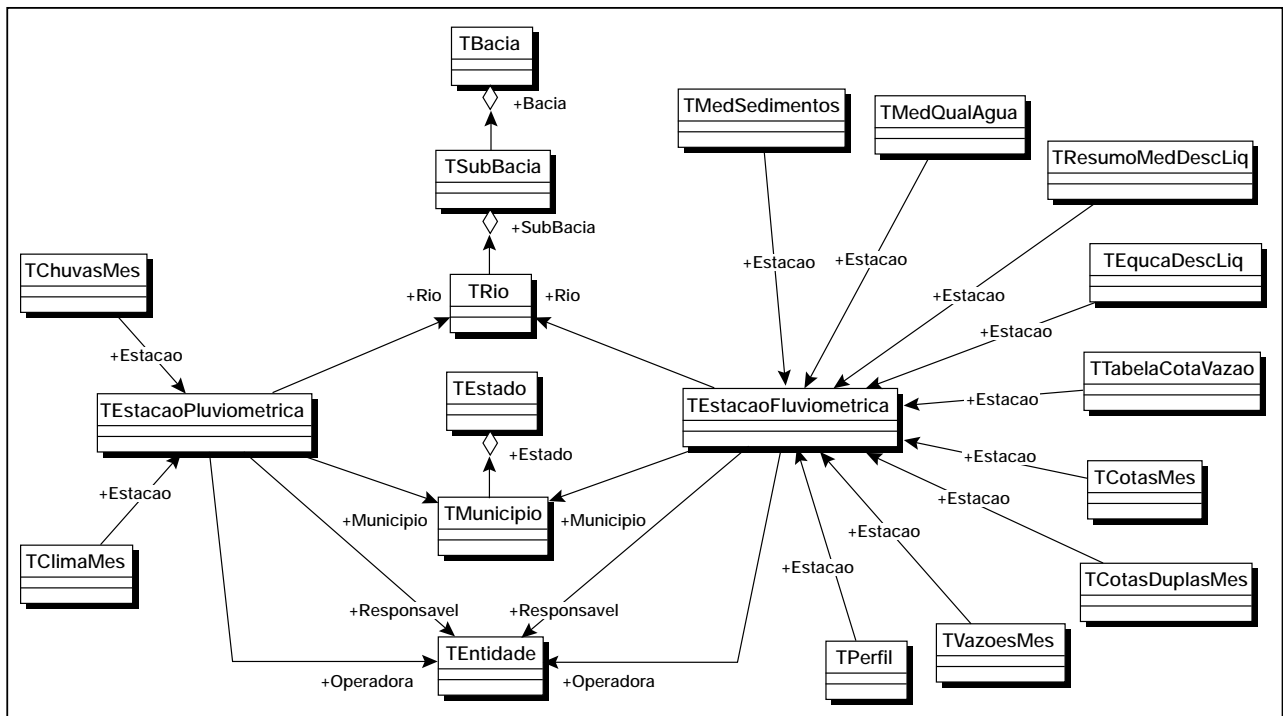


Figure 2 – Brazil’s hydrological database configuration

- (b) Do you have any established measures to adjust/correct real-time data automatically?
[x] yes [] no
- (c) If yes, please outline the system.
- Q2.5 Regarding the quality control of hydrological data, please answer the following.
- (a) Please outline your quality control system for hydrological data.
Historical data quality is being analysed.
- (b) Is any international standard such as ISO applied to the quality control of data?
[x] yes [] no
- (c) If yes, which standards (ISO 9002 for instance) are applied to which part of the quality control system?
In implementation.
- Q2.6 Regarding the training of database-keeping staff and clients, please answer the following.
- (a) Do you carry out training of database-keeping staff and clients?
[] yes for both the database-keeping staff and clients [x] yes for database-keeping staff only
[] yes for clients only [] no
- (b) If yes, please outline your training programme.
- Q2.7 Regarding the network system for the hydrological database, please answer the following.
- (a) Do you classify clients depending on the degree of accessibility (full or partial access) to the data?
[x] yes [] no
- (b) If yes, what are the criteria for classification?
Government bodies have free access to the database.
- (c) Do you have any regulation for regular change and control of the password to secure your database system?
[] yes [x] no
- (d) Do you separate data for public use from other data?
[x] yes [] no
- (e) If yes, what are the principles or criteria for the separation?
Government bodies have free access to the database.
- (f) Do you establish a separate database system for public use?
[] yes [x] no
- (g) What measures are you taking to protect the system from computer viruses and hackers?
Firewall, proxy server and virus protection software.
- (h) What is the backup system to secure the database from losses due to hardware crashing, earthquake, fire and other troubles?
Backup on CD-ROM, DAT tape and use of a safe room.

Section 3. Application of GIS to hydrological database

- Q3.1 Regarding the application of GIS to the hydrological database system, please answer the following.
- (a) Do you have GIS linked to the hydrological database?
[x] yes [] no
- (b) If yes, is the GIS standardized, for example, in compliance with ISO or TC211?
[x] yes [] no
- (c) If yes, please describe the applied standards.
ArcView
- (d) Please outline the features of the GIS application you are using.
Spatial analysis, river analysis
- (e) If you establish GIS with the hydrological database, what advantages do you expect in hydrological data management in practice?
Publish online data on internet and other media.

NEW ZEALAND

Section 1. Standardization of hydrological data

- Q1.1 In the course of recording and processing data, two types of data, analog and digital data, are prepared. The analog data includes manually recorded data, recording sheets of automatic recorders, etc., and the digital data are those recorded by electronic media such as telemeter, data logger, etc. Regarding the analog and digital data, please answer the following.
- (a) Which data are treated as official or formal?
 analog data digital data depends on the kind of data
- (b) If the last answer is selected, please specify.
- Q1.2 In the case of international rivers which flow through more than two countries, it would be beneficial to share the hydrological data mutually among the countries concerned. In this regard, please answer the following.
- (a) Do you have international river(s)?
 yes no
- (b) If yes, is there any activity to standardize the hydrological database among the countries concerned?
 yes no
- (c) If yes, please give the following.
- (i) Name of the international river.
- (ii) Name of the organization for promoting standardization of the database.
- (iii) Names of member countries of the organization.

Section 2. Hydrological database

- Q2.1 Regarding the features of your hydrological database system, please answer the following.
- (a) Name or type of database.
"Tideda"
- (b) Kinds of data handled.
Water levels (groundwater, lake, river, estuary, sea), discharges, sediment concentrations, rainfall.
- (c) Time intervals of updating.
Various, but usually three-monthly. Some data are updated to the (raw) databases in real-time (every 15 minutes or one hour).
- (d) Type and name of computer system (hardware).
Dell Pentium Optiplex GX1 PII 350, 64 Mhz, memegory, 9 Gb
- (e) Operating system.
Windows NT
- (f) Name of database application.
"Tideda"
- (g) Name of GIS application.
ArcView
- (h) Protocol of database network.
TCP/IP
- (i) Configuration (or system diagram) of database system. Please provide a copy.
Not available
- Q2.2 Regarding the services of your database system, please answer the following.
- (a) Are the real-time hydrological data offered to external clients?
 yes with charge yes without charge no
- (b) Are the historical data offered to external clients?
 yes with charge yes without charge no
- (c) If you charge for offering data, please describe the charging system or provide the tariff for reference.
Charging for historical data is only for the time taken for the database operator to copy the data onto a file and send it to the client by either internet or by copying the file to a diskette or CD-ROM and posting it to the client. For real-time data, clients usually have a contract whereby they pay for the whole package of the costs for the time associated with collection and transmission of the data to their offices.
- Q2.3 Regarding the use of your data, please answer the following.
- (a) Is the copyright reserved in your hydrological data?
 yes no
- (b) Are there any conditions or regulations to follow when using your data?
 yes no
- (c) If yes, please describe below.
Data funded by commercial operators are owned by those agencies and their permission must be obtained by a third party wishing to use the data.
Data funded by the New Zealand Government are owned by the New Zealand Government and are freely available for the good of all. Acknowledgement of this is is often required when using the data for commercial and scientific purposes.

- (d) Please describe the general features of the database application used in your database system.
Data are transferred by radio to local field offices, and then by internet automatically to the central raw hydrological database. These data are disseminated to real-time users. After quality assurance procedures carried out at the central and local offices, the data are transferred to a confirmed hydrological database.
- Q2.4 Regarding the real-time hydrological data system, please answer the following.
- (a) How do you adjust and/or correct for the lack of observation and abnormal records in your real-time hydrological data system?
A gap is left as a gap, unless a client specifically wishes for it to be detected and corrected. This is done manually by correlation with neighbouring stations. Some research has been done here on automating this using neural network procedures.
- (b) Do you have any established measures to adjust/correct real-time data automatically?
[] yes [x] no
- (c) If yes, please outline the system.
But we are working towards this using neural networks.
- Q2.5 Regarding the quality control of hydrological data, please answer the following.
- (a) Please outline your quality control system for hydrological data.
This will be too long. I will send you a separate document about this. You can also read about our QA system in a paper in the Hydrological Sciences Journal in 1987 by Mosley and Mc Kerchar.
- (b) Is any international standard such as ISO applied to the quality control of data?
[x] yes [] no
- (c) If yes, which standards (ISO 9002 for instance) are applied to which part of the quality control system?
ISO 9002 to the whole system.
- Q2.6 Regarding the training of database-keeping staff and clients, please answer the following.
- (a) Do you carry out training of database-keeping staff and clients?
[x] yes for both the database-keeping staff and clients [] yes for database-keeping staff only
[] yes for clients only [] no
- (b) If yes, please outline your training programme.
Occasional courses and in-house training programmes.
- Q2.7 Regarding the network system for the hydrological database, please answer the following.
- (a) Do you classify clients depending on the degree of accessibility (full or partial access) to the data?
[] yes [x] no
- (b) If yes, what are the criteria for classification?
- (c) Do you have any regulation for regular change and control of the password to secure your database system?
[x] yes [] no
- (d) Do you separate data for public use from other data?
[x] yes [] no
- (e) If yes, what are the principles or criteria for the separation?
Based on data ownership – private versus government.
- (f) Do you establish a separate database system for public use?
[x] yes [] no
Planned for WWW access only. Otherwise we provide the data.
- (g) What measures are you taking to protect the system from computer viruses and hackers?
We have firewalls established by our IT group.
- (h) What is the backup system to secure the database from losses due to hardware crashing, earthquake, fire and other troubles?
Regular backups are made. Data are stored in different buildings also.

Section 3. Application of GIS to hydrological database

- Q3.1 Regarding the application of GIS to the hydrological database system, please answer the following.
- (a) Do you have GIS linked to the hydrological database?
[x] yes [] no
- (b) If yes, is the GIS standardized, for example, in compliance with ISO or TC211?
[x] yes [] no
- (c) If yes, please describe the applied standards.
ArcView and ArcInfo
- (d) Please outline the features of the GIS application you are using.
ArcView and ArcInfo
- (e) If you establish GIS with the hydrological database, what advantages do you expect in hydrological data management in practice?
Easier to visualize location of monitoring stations and to make network decisions.

SLOVENIA

Section 1. Standardization of hydrological data

Q1.1 In the course of recording and processing data, two types of data, analog and digital data, are prepared. The analog data includes manually recorded data, recording sheets of automatic recorders, etc., and the digital data are those recorded by electronic media such as telemeter, data logger, etc. Regarding the analog and digital data, please answer the following.

- (a) Which data are treated as official or formal?
 analog data digital data depends on the kind of data
- (b) If the last answer is selected, please specify.

Q1.2 In the case of international rivers which flow through more than two countries, it would be beneficial to share the hydrological data mutually among the countries concerned. In this regard, please answer the following.

- (a) Do you have international river(s)?
 yes no
- (b) If yes, is there any activity to standardize the hydrological database among the countries concerned?
 yes no
- (c) If yes, please give the following.
- (i) Name of the international river.
The Soča in the Adriatic basin and the Sava, Drava and Mura rivers in the Danube basin.
- (ii) Name of the organization for promoting standardization of the database.
NEDHYCOS, Danube Commission
- (iii) Names of member countries of the organization.
Mediterranean countries and the Danube basin countries.

Section 2. Hydrological database

Q2.1 Regarding the features of your hydrological database system, please answer the following.

- (a) Name or type of database.
 INDEX FILES
- (b) Kinds of data handled.
Hourly data (water levels), daily data (water levels, discharges, water temperatures, concentrations of suspended material, quantities of transported material), rating curves, hydrometric measurements, inventory of gauging stations
- (c) Time intervals of updating.
12 months (official – controlled data)
- (d) Type and name of computer system (hardware).
MicroVAX 3100 - 80
- (e) Operating system.
Open VMS VAX V5.5-1
- (f) Name of database application.
Hydrological Data Bank (BHP)
- (g) Name of GIS application.
- (h) Protocol of database network.
- (i) Configuration (or system diagram) of database system. Please provide a copy.
Attached

Q2.2 Regarding the services of your database system, please answer the following.

- (a) Are the real-time hydrological data offered to external clients?
 yes with charge yes without charge no
- (b) Are the historical data offered to external clients?
 yes with charge yes without charge no
- (c) If you charge for offering data, please describe the charging system or provide the tariff for reference.
Although "without charge", the HMZ charges data users for the staff time used for carrying out services and for the costs of materials, handling and mailing.

Q2.3 Regarding the use of your data, please answer the following.

- (a) Is the copyright reserved in your hydrological data?
 yes no
- (b) Are there any conditions or regulations to follow when using your data?
 yes no
- (c) If yes, please describe below.
According to the policy guidelines for the dissemination of data and costing of services (GRDC — Global Runoff Data Centre, Federal Institute of Hydrology, Koblenz, Germany).
- (d) Please describe the general features of the database application used in your database system.
H–Q transformations; monthly and yearly tables, graphics; statistical analyses of time series.

- Q2.4 Regarding the real-time hydrological data system, please answer the following.
- (a) How do you adjust and/or correct for the lack of observation and abnormal records in your real-time hydrological data system?
We do not! We use only logical controls of data.
- (b) Do you have any established measures to adjust/correct real-time data automatically?
[] yes [x] no
- (c) If yes, please outline the system.
- Q2.5 Regarding the quality control of hydrological data, please answer the following.
- (a) Please outline your quality control system for hydrological data.
Water balance, correlation to the neighbouring gauging station.
- (b) Is any international standard such as ISO applied to the quality control of data?
[] yes [x] no (*WMO recommendations*)
- (c) If yes, which standards (ISO 9002 for instance) are applied to which part of the quality control system?
- Q2.6 Regarding the training of database-keeping staff and clients, please answer the following.
- (a) Do you carry out training of database-keeping staff and clients?
[] yes for both the database-keeping staff and clients [] yes for database-keeping staff only
[] yes for clients only [x] no
- (b) If yes, please outline your training programme.
- Q2.7 Regarding the network system for the hydrological database, please answer the following.
BHP is not connected to the network system!
- (a) Do you classify clients depending on the degree of accessibility (full or partial access) to the data?
[] yes [x] no
- (b) If yes, what are the criteria for classification?
- (c) Do you have any regulation for regular change and control of the password to secure your database system?
[] yes [x] no
- (d) Do you separate data for public use from other data?
[] yes [x] no
- (e) If yes, what are the principles or criteria for the separation?
- (f) Do you establish a separate database system for public use?
[] yes [x] no
- (g) What measures are you taking to protect the system from computer viruses and hackers?
- (h) What is the backup system to secure the database from losses due to hardware crashing, earthquake, fire and other troubles?
We use OPEN WMS – backup utility and we keep three copies of the database on different media and in different locations.

Section 3. Application of GIS to hydrological database

- Q3.1 Regarding the application of GIS to the hydrological database system, please answer the following.
- (a) Do you have GIS linked to the hydrological database?
[] yes [x] no
- (b) If yes, is the GIS standardized, for example, in compliance with ISO or TC211?
[] yes [x] no
- (c) If yes, please describe the applied standards.
- (d) Please outline the features of the GIS application you are using.
- (e) If you establish GIS with the hydrological database, what advantages do you expect in hydrological data management in practice?

At this moment we run two separate systems:

- *controlled, official data (in databank);*
- *real-time data which are used in prognostic services (flood forecasting and warning system) and are disseminated to the public through the internet and TV. In exceptional cases real-time data could be used to fill gaps in the analog data series. As a rule, real-time data are not offered to external clients.*

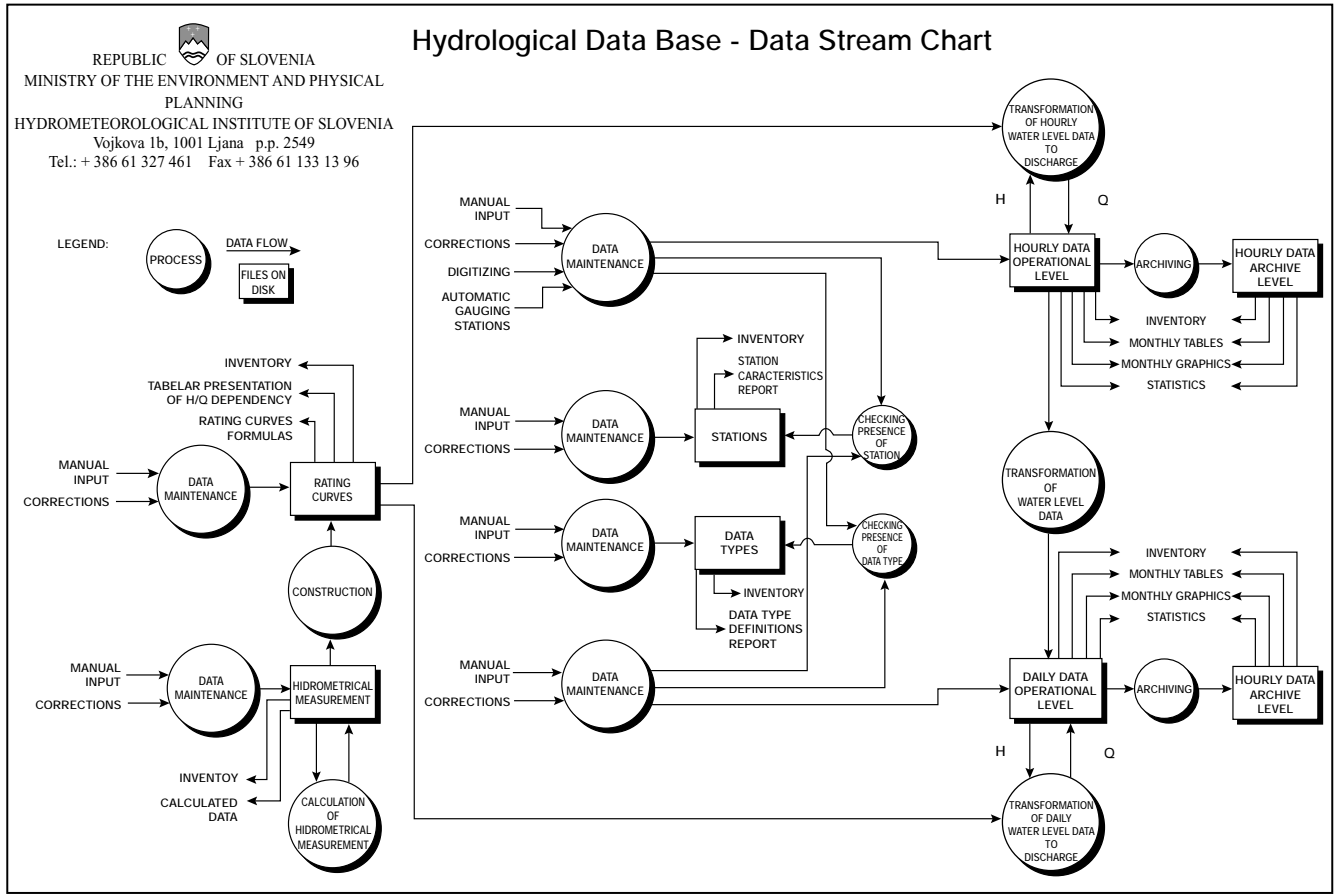


Figure 3 – Slovenia’s hydrological database

UNITED STATES

Section 1. Standardization of hydrological data

- Q1.1 In the course of recording and processing data, two types of data, analog and digital data, are prepared. The analog data includes manually recorded data, recording sheets of automatic recorders, etc., and the digital data are those recorded by electronic media such as telemeter, data logger, etc. Regarding the analog and digital data, please answer the following.
- (a) Which data are treated as official or formal?
 analog data digital data depends on the kind of data
- (b) If the last answer is selected, please specify.
Both analog and digital data are official. All field notes and digital films are archived.
- Q1.2 In the case of international rivers which flow through more than two countries, it would be beneficial to share the hydrological data mutually among the countries concerned. In this regard, please answer the following.
- (a) Do you have international river(s)?
 yes no
- (b) If yes, is there any activity to standardize the hydrological database among the countries concerned?
 yes no
- (c) If yes, please give the following.
- (i) Name of the international river.
Many rivers between the US, Canada and Mexico.
- (ii) Name of the organization for promoting standardization of the database.
International Joint Commission (US, Canada)
- (iii) Names of member countries of the organization.

Section 2. Hydrological database

- Q2.1 Regarding the features of your hydrological database system, please answer the following.
- (a) Name or type of database.
National Water Information System (NWIS)
- (b) Kinds of data handled.
River stage, river discharge, precipitation, groundwater levels, water chemistry, suspended sediment, biology
- (c) Time intervals of updating.
15 minutes, daily and periodic
- (d) Type and name of computer system (hardware).
*Data General and Sun servers
 Personal computer desktops (many brands)*
- (e) Operating system.
DG and Sun mix
- (f) Name of database application.
Ingres
- (g) Name of GIS application.
ESRI, ArcInfo
- (h) Protocol of database network.
Operational database distributed on 46 servers nationwide
- (i) Configuration (or system diagram) of database system. Please provide a copy.
- Q2.2 Regarding the services of your database system, please answer the following.
- (a) Are the real-time hydrological data offered to external clients?
 yes with charge yes without charge no
- (b) Are the historical data offered to external clients?
 yes with charge yes without charge no
- (c) If you charge for offering data, please describe the charging system or provide the tariff for reference.
- Q2.3 Regarding the use of your data, please answer the following.
- (a) Is the copyright reserved in your hydrological data?
 yes no
- (b) Are there any conditions or regulations to follow when using your data?
 yes no
- (c) If yes, please describe below.
- (d) Please describe the general features of the database application used in your database system.
The NWIS database is an internal system for day-to-day processing. Public access of real-time and historical data is via the internet.
- Q2.4 Regarding the real-time hydrological data system, please answer the following.

(a) How do you adjust and/or correct for the lack of observation and abnormal records in your real-time hydrological data system?
We do not estimate missing data real-time. We use various thresholds to check for anomalies.

(b) Do you have any established measures to adjust/correct real-time data automatically?
 yes no

(c) If yes, please outline the system.

Q2.5 Regarding the quality control of hydrological data, please answer the following.

(a) Please outline your quality control system for hydrological data.

All data are checked and reviewed at the state office. A subset of data are reviewed every three years at the national level.

(b) Is any international standard such as ISO applied to the quality control of data?

yes no

(c) If yes, which standards (ISO 9002 for instance) are applied to which part of the quality control system?

Q2.6 Regarding the training of database-keeping staff and clients, please answer the following.

(a) Do you carry out training of database-keeping staff and clients?

yes for both the database-keeping staff and clients yes for database-keeping staff only

yes for clients only no

Some informal training for major clients.

(b) If yes, please outline your training programme.

Training courses programme is offered periodically at the regional and national level, usually when the software is upgraded.

Q2.7 Regarding the network system for the hydrological database, please answer the following.

(a) Do you classify clients depending on the degree of accessibility (full or partial access) to the data?

yes no

All clients have equal access through the internet.

(b) If yes, what are the criteria for classification?

(c) Do you have any regulation for regular change and control of the password to secure your database system?

yes no

(d) Do you separate data for public use from other data?

yes no

(e) If yes, what are the principles or criteria for the separation?

Public access is through the internet.

(f) Do you establish a separate database system for public use?

yes no

(g) What measures are you taking to protect the system from computer viruses and hackers?

(h) What is the backup system to secure the database from losses due to hardware crashing, earthquake, fire and other troubles?

Daily backups, weekly and monthly backup tapes secured offsite. We are in the process of installing redundancies, servers for processing and survey data.

Section 3. Application of GIS to hydrological database

Q3.1 Regarding the application of GIS to the hydrological database system, please answer the following.

(a) Do you have GIS linked to the hydrological database?

yes no

(b) If yes, is the GIS standardized, for example, in compliance with ISO or TC211?

yes no

(c) If yes, please describe the applied standards.

(d) Please outline the features of the GIS application you are using.

(e) If you establish GIS with the hydrological database, what advantages do you expect in hydrological data management in practice?

APPENDIX B

THE HYDROLOGICAL OBSERVATION SYSTEM IN JAPAN

INTRODUCTION

In Japan, the national government and regional governments that manage the country's rivers acquire data from hydrological observations and utilize this data in information systems constructed for a variety of purposes. Table 7 shows the numbers of telemetry observation stations operated by the Ministry of Land, Infrastructure and Transport

The Foundation of River and Basin Integrated Communications (FRICS), a non-profit organization for the public dissemination of hydrologic data, processes the precipitation, radar data and data from telemetry observation stations so that it can be easily understood. It provides the processed data to a wide range of users through its dedicated terminals. With the present observation system, data can be obtained online or offline depending on the purpose for which it is to be used.

Table 7 – Radar sites and telemetry observation stations operated by the Ministry of Land, Infrastructure and Transport

	<i>Radar</i>	<i>Precipitation observation stations</i>	<i>Water level observation stations</i>	<i>Water quality observation stations</i>	<i>Snow depth observation stations</i>
Hokkaido	4	210	168	13	–
Tohoku	3	225	208	22	21
Kanto	4	196	185	20	–
Hokuriku	3	133	78	9	21
Chubu	2	212	148	15	–
Kinki	2	153	113	18	3
Chugoku	2	161	111	13	19
Shikoku	2*	124	55	–	–
Kyushu	3	244	208	2	–
Okinawa	1	15	7	–	–
National total	26*	1 653	1 281	112	64
Prefectures	–	1 139	1 148	0	0
Total	26*	2 792	2 429	112	64

* Including 1 under construction

(April 1999)

SYSTEM CONFIGURATION AND FUNCTIONS

Administration centre

The heart of the system is the administration centre (Ministry of Land, Infrastructure and Transport) where real-time data from the main river networks is monitored. The centre edits and prints the data collected from the regional control centres.

Regional construction bureau (control centre)

The control centre collects data for river networks from the sub-centre in its administrative area, then edits and prints the collected data.

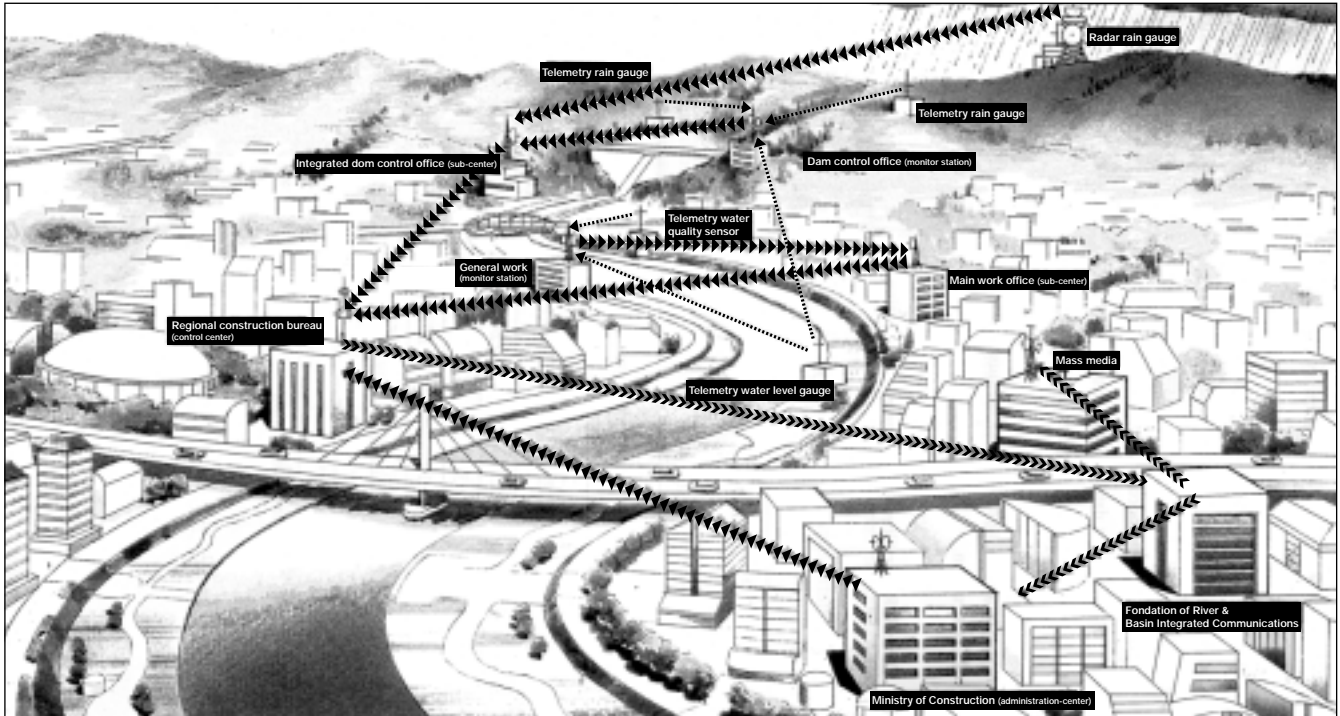
Sub-centre (general works office or integrated dam control office)

A sub-centre controls several monitoring stations for integrated management of a single river network. The sub-centre also collects data directly from its gauging station. The sub-centre then processes, displays, and records the collected data.

Monitoring station (general works office or dam operation office)

A work office or dam operation office not assigned as a sub-centre serves as a monitoring station. The monitoring station collects data from its administration area and transmits the data to the sub-centre.

Figure 4 – Configuration of Japan’s river information system



The system collects data, including rainfall and water levels, using special equipment (radar rain gauges and telemetry devices) positioned along a river or in a river basin. Data is relayed to specified destinations through a dedicated microwave line linking the Ministry of Land, Infrastructure and Transport and the regional construction bureaus. Through the system, hydrological data can be transmitted quickly to support action against floods and drought. The system also assists in daily river administration. Rainfall, water levels and other hydrological data are disseminated to municipalities along the river and to mass media via FRICS. The data are helpful in flood prevention activities, issuing warnings and preparing for evacuations.

Gauging station

A radar rain gauge measures rainfall from radio waves reflected on raindrops. The intensity of reflected waves (echoes) from raindrops in the air is measured to monitor the actual rainfall amount.

Telemetry rain gauge network

As instructed by the monitoring station, measured rainfall data is encoded and transmitted through a telemetry line. Rain gauges are installed at appropriate points in a watershed, to collect detailed rainfall information.

Telemetry water level station

Water level information is important for flood forecasting and flood prevention activities. The data is also necessary for water supply control at the drought season. A telemetry water level station continuously collects water level data from gauges and transmits the data to the monitoring station or sub-centre.

Telemetry water quality observation network

This system transmits encoded water quality data through a telemetry line as instructed by the monitoring station. Telemetry stations are installed at important points in each river network. The stations periodically collect and transmit water quality data (temperature, pH, conductivity and dissolved oxygen).

APPENDIX C

EXAMPLES OF PRACTICAL HYDROLOGICAL DATABASES

BUREAU OF METEOROLOGY, AUSTRALIA

In Australia, bodies responsible for hydrology or the environment in state governments acquire hydrological data. The public release of data not only involves the direct provision of hydrological data; it is also analysed and released as flood level warning data. After river water level information has been verified, it is provided over the internet.

HYDSYS, HYDROL and ADAM have been constructed as precipitation databases and hydrological databases. The following are the special features of these databases.

Hydrometric Data Processing and Archive System (HYDSYS)

- Import data from any logger;
- Keep 25 000 station years of data online;
- Analyse a year of continuous data in 3 seconds;
- Edit and review data with a powerful graphical data editor;
- Produce powerful reports and graphs;
- Compute flows, loads, runoff and much more;
- Use a standard Pentium PC.

Australian Data Archive for Meteorology (ADAM)

There are four ORACLE databases set up on UNIX servers in head office that go together and provide differing functionality for ADAM. These are:

- ADAM – This database is the entry point for users to access the climatological data. It is a read only database in so far as there are no routine updating processes for tables. There are some tables in ADAM, but it is generally used as a way of accessing the corporate database CADAM, which retains all of the data.
- CADAM – Contains all of the quality controlled data, as well as being the initial repository for data collected from real-time sources which are awaiting quality control.
- QADAM – The quality control of climatological data is performed in QADAM. The processes usually involve extraction of data from CADAM, reference to documents, analysis, charts, etc., for quality purposes, rectification of incorrect data, resetting of quality flags, and then transference of quality controlled data back to CADAM.
- DADAM – It is used for developing new forms, menus, applications etc.

Flexible Hydrological Archiving System (HYDROL)

This is a totally integrated time-series database management, analysis and modelling tool. The system combines the utility of real-time data acquisition and archiving, with easy-to-use data editing and maintenance functions and powerful analysis and modelling capabilities.

MINISTRY OF LAND, INFRASTRUCTURE AND TRANSPORT, JAPAN

In Japan, the Ministry of Land, Infrastructure and Transport that manages rivers considered to be of national importance is increasing the efficiency of domestic use of hydrological and water quality databases by carrying out national integration of databases and data specifications, preparing electronic hydrological and water quality data, retaining high quality hydrological and water quality data, speeding up its acquisition and statistical processing and making more advanced use of hydrological and water quality data.

Water Information Standard Exchange Format (WISEF) has been proposed as a format to be used to provide an integrated database format.

In addition to its internal use, this system is intended to provide data to a wide range of users outside the ministry by offering data both online (internet) and offline, providing both real-time and historical data, verifying the quality of the data, speeding up data provision and serving as an outlet for river related data including that obtained by other ministries, agencies and organizations (construction of hydrological and water quality databases as standards for Japan).

To introduce this system, the following pages present the system configuration (Figure 5), the data quality confirmation procedure (Figure 6), the public database (Table 8), the database entry format (Table 9), and the Ministry of Land, Infrastructure and Transport Hydrological and Water Quality Database homepage and sample pages (Figures 7 to 11).

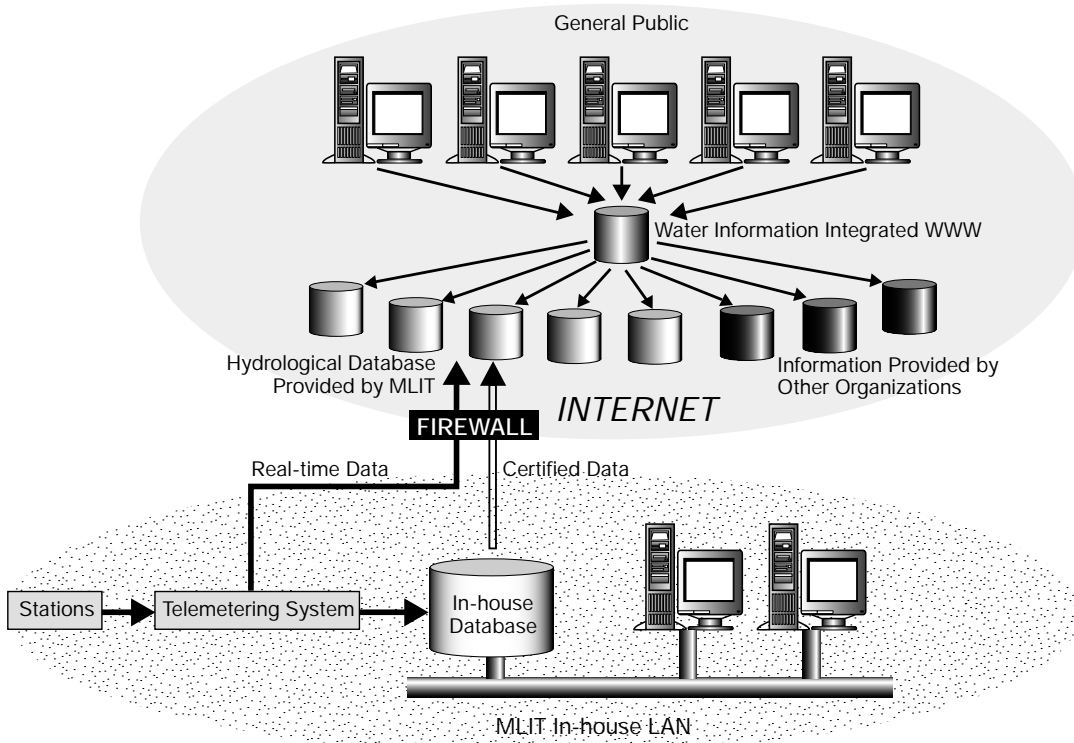


Figure 5 – System configuration

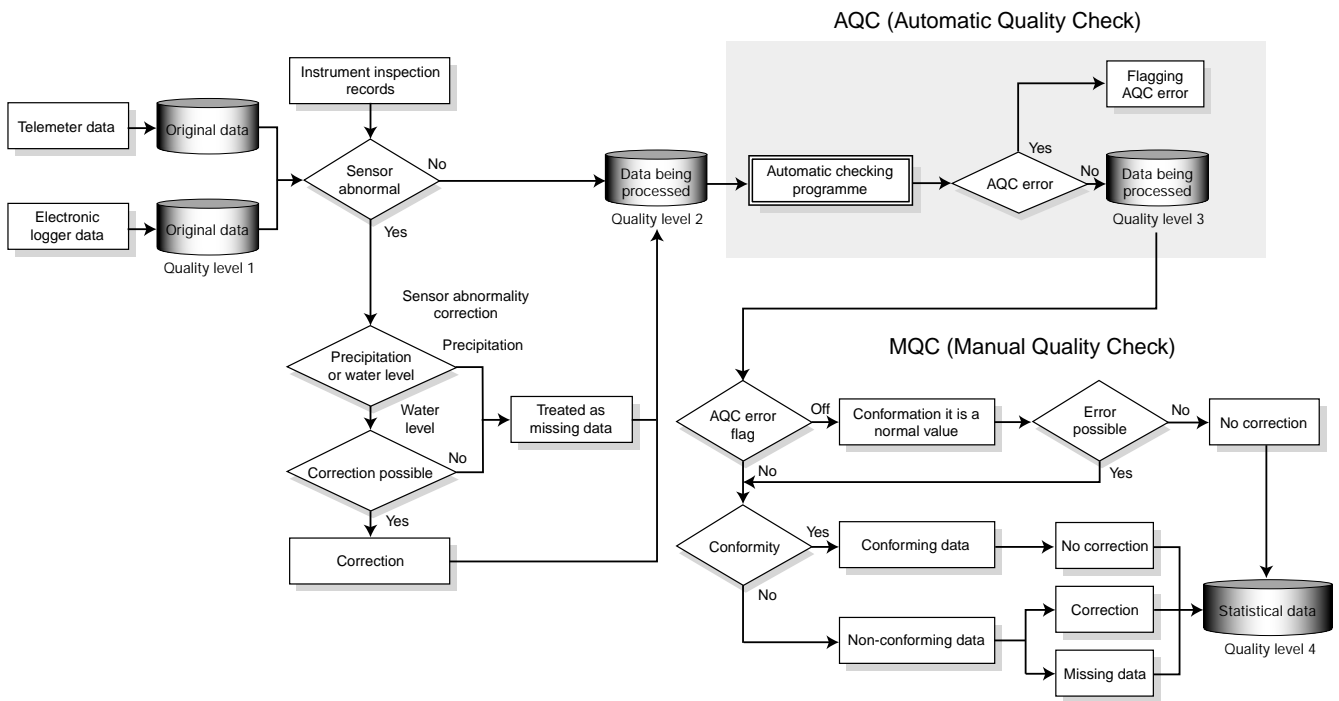


Figure 6 – Data quality confirmation procedure

Table 8 – Public database**Publicly released verified data**

	<i>Observation station</i>	<i>Observed values</i>
Water level, flow volume	Name of water level/discharge observation station, river system name, river name, location (region, latitude/longitude, kilometre post), elevation of gauge datum zero (historical), standard water level (high water level, present designated water level).	Verified hourly water level, daily peak water level. Water level duration data*, verified hourly discharge, daily average discharge, daily peak discharge, flow regime. For the time being, representative observation stations; as plans are completed, the number of stations whose data is released will increase.
Precipitation	Name of precipitation observation station, river system name, river name, location (region, latitude/longitude), elevation.	Verified hourly precipitation, daily precipitation, annual statistical precipitation data. For the time being, representative observation stations; as plans are completed, the number of stations whose data is released will increase.
Water quality (sampling)	Name of water quality observation station, river system name, river name, location (region, latitude/longitude, kilometre post), environmental standard values.	Verified water quality measurement item observation data, daily data. Annual statistical water quality data. As plans are completed, the number of stations whose data is released will increase.
Groundwater level/quality	Name of groundwater level/quality observation station, river system name, river name, location (region, latitude/longitude).	Verified daily data, annual statistical data. As preparations are completed, the number of stations whose data is released will increase.
Dams, etc.	Dam name, river system name, river name, location (region, latitude/longitude).	Verified reservoir level, inflow discharge, outflow discharge, percentage of storage. As preparations are completed, the number of dams whose data is released will increase.
Weather, etc.	Observation station name, location (region, latitude/longitude).	Temperature, atmosphere pressure, wave height, wave direction, tide level, accumulated snow depth, daily sunlight, wind direction, wind speed. As preparations are completed, the number of stations whose data is released will increase.

* The discharge is prepared after H-Q type verification, so its release is delayed between six months and a year and a half.

Publicly released real-time data

	<i>Observation station</i>	<i>Observed values</i>
Water level, flow volume	Name of water level/discharge observation station, river system name, river name, location (region, latitude/longitude, kilometre post), elevation of gauge datum zero (historical), standard water level (high water level, present designated water level).	Hourly water levels. For the time being, representative observation stations; as plans are completed, the number of stations whose data is released will increase.
Precipitation	Name of precipitation observation station, river system name, river name, location (region, latitude/longitude), elevation.	Hourly precipitation. For the time being, representative observation stations; as plans are completed, the number of stations whose data is released will increase.
Water quality	Name of water quality observation station, river system name, river name, location (region, latitude/longitude, kilometre post), environmental standard.	Water quality (automatic water quality monitoring systems) As plans are completed, the number of stations whose data is released will increase.
Dams, etc.	Dam name, river system name, river name, location (region, latitude/longitude).	Reservoir level, inflow discharge, outflow discharge, percentage of storage. As plans are completed, the number of dams whose data is released will increase.
Weather, etc.	Observation station name, location (region, latitude/longitude).	Tide levels. As plans are completed, the number of stations whose data is released will increase.

Table 9 – Database entry format

- 1) Basic specifications
 - Text shall be ASCII code;
 - It must be possible to enter and output data with spreadsheet software;
 - The format must have high extensibility and flexibility.
- 2) File specifications
 - The file specifications: DOS standard text file;
 - The text code: half size text ASCII;
 - Extension: wsf.
- 3) Data specifications
 - Date, time: western calendar years: month, day, hour, minute;
 - Water level: recorded as values in metre units based on the reference elevation (zero level);
 - Precipitation: recorded in mm;
 - Discharge: recorded in m³/s.
- 4) Basic configuration

The observation station category, data quality information etc. are registered as station text while the observation values are registered as data text. Hydrological data is registered by a repetitive station text + data text registration process.

FILE, EOF and OED text are fixed form data attached to the beginning and end of each datum.

<i>Header</i>	<i>Description</i>
FILE	Only one is recorded at the beginning of the file. It corresponds to EOF.
EOF	Only one is recorded at the end of the file. Lines coming after EOF are invalid.
COM	Comment line. It can be recorded on all lines within a file. It has no effect ory processing.
STATION	<p>Station: enter in the sequence:</p> <p>[1] observation station category.</p> <p>[2] database registration code.</p> <p>[3] quality code.</p> <p>[4] sensor code.</p> <p>Following station: enter the following codes and values (they are effective until the next station):</p> <p>[1] observation station category – water level/discharge observation station: (H), precipitation observation station: (R), water quality observation station: (WQ), groundwater level observation station: (GH), groundwater quality observation station: (GWQ), dam: (DAM), intake volume: (PUMP), meteorological observation station: (MET), oceanographic phenomena: (OCE).</p> <p>[2] Database registration code.</p> <p>[3] Quality code – original: (1), sensor corrected: (2), AQC complete: (3), verified: (4), publication approved: (5).</p> <p>[4] Sensor code – telemeter (1), electronic logger: (2), self-recorder: (3), normal: (4), other (5).</p>
DATA	<p>Data set name</p> <p>Lines following the data line and preceding the OED line are data recording lines. (Input in the sequence: year, month, day, hour, minute, observed value.</p>
EOD	Recorded on the line following the final data recording line.

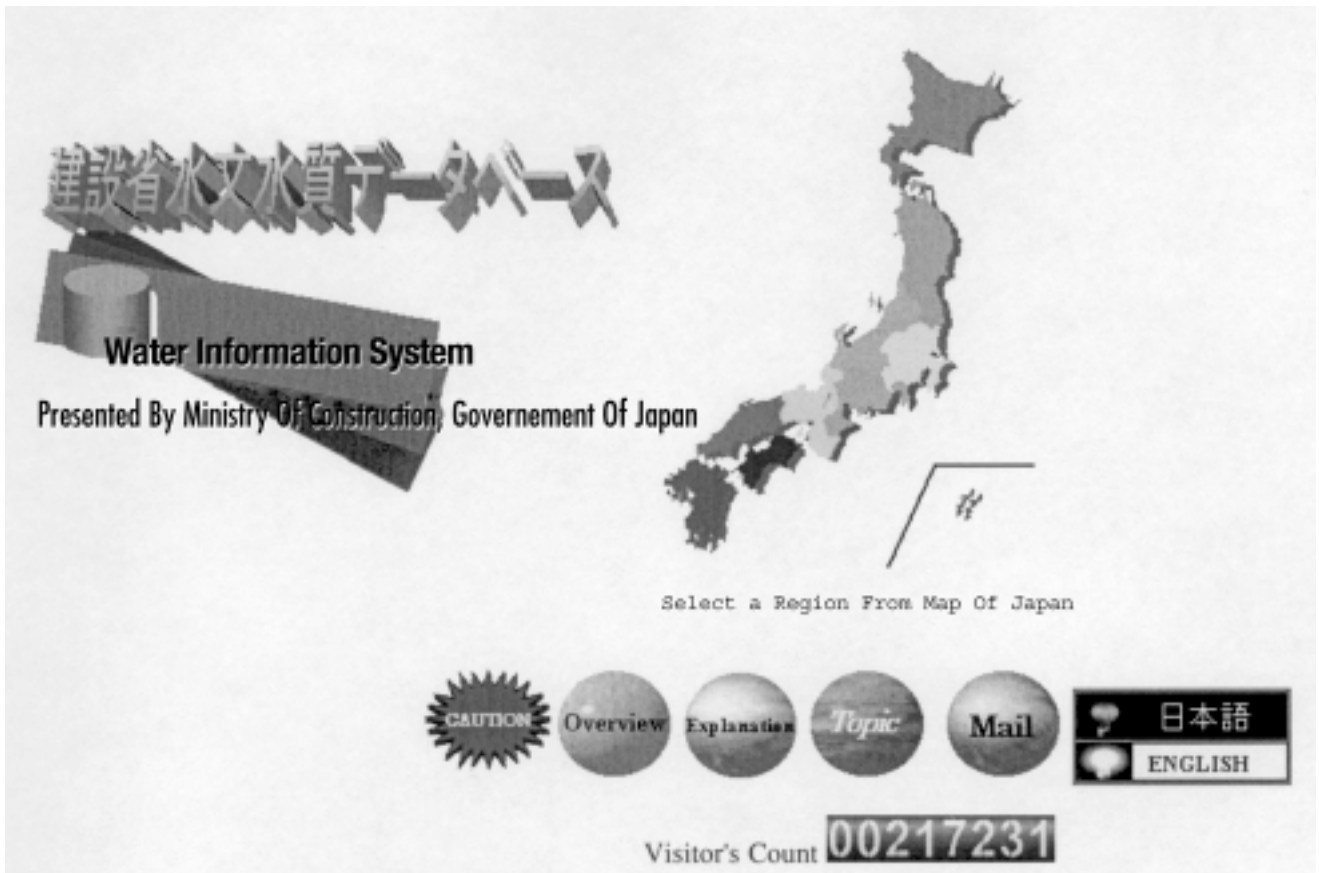


Figure 7 – Water information system homepage

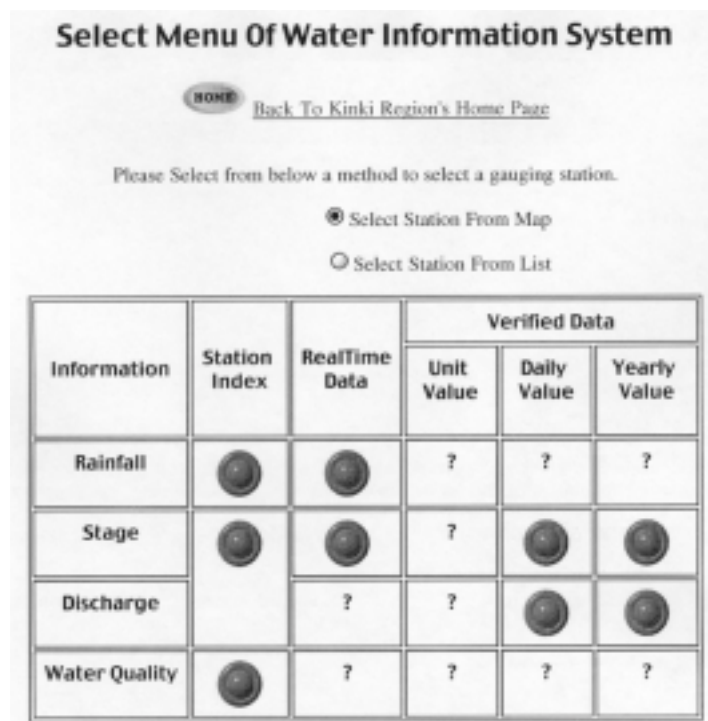


Figure 8 – Water information system menu

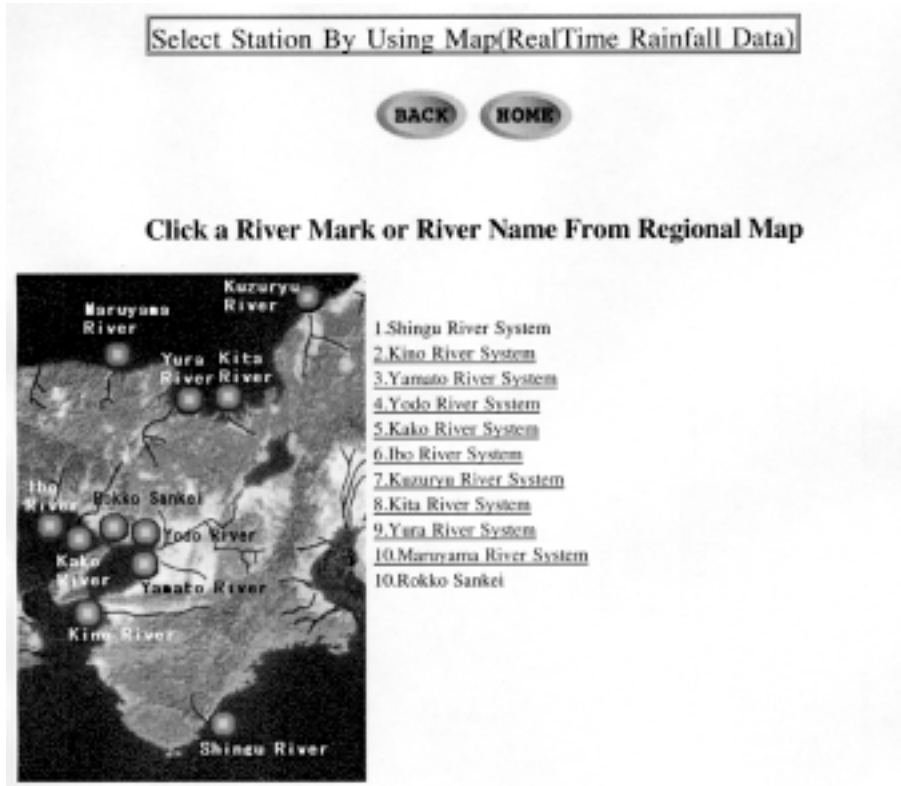


Figure 9 – Water information system rainfall (real-time)



Figure 10 – Water information system rainfall (real-time)

Realtime Rainfall

BACK HOME MENU

Please refer to "Precaution On RealTime Data" when using the real-time data.

Station Data	
NAME OF STATION	: Kumogahata
NAME OF RIVER SYSTEM	: Yodo
NAME OF RIVER	: Katsura
SITE MANAGE OFFICE	: Yodo Work Office
SITE ADDRESS	: Kumogahata Kita Ward Kyoto
Pref.	
LATITUDE	: 35.06.41 N
LONGITUDE	: 135.44.49 E
ALTITUDE	: 250m
TERM OF DATA	: FROM 1 WEEK AGO

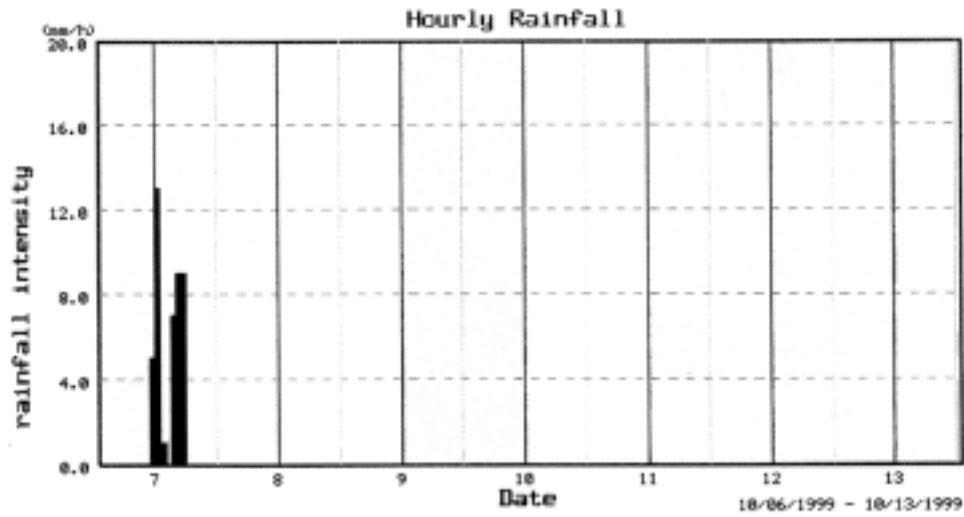


Figure 11 – Water information system rainfall (real-time)

UNITED STATES GEOLOGICAL SURVEY

The USGS constructed the WATSTORE and NAWDEX at its Reston Headquarters in order to acquire hydrological observation data, beginning in 1971. Later it constructed NWIS-I (National Water Information System) hydrological database system in order to boost the efficiency of the hydrological work of its regional offices, but as the system aged it became difficult to maintain and it could not be used to integrate other kinds of hydrological data. It was incompatible with advanced information technology and had other problems. In 1988 the USGS began to develop NWIS-II.

The USGS plans to store observed data in the NWIS-II. The data will be stored in databases at its regional offices and an online network linking the USGS headquarters, its regional offices and its regional branches will be established so they can exchange data in real-time. This system puts top priority on registering hydrological data quality information.

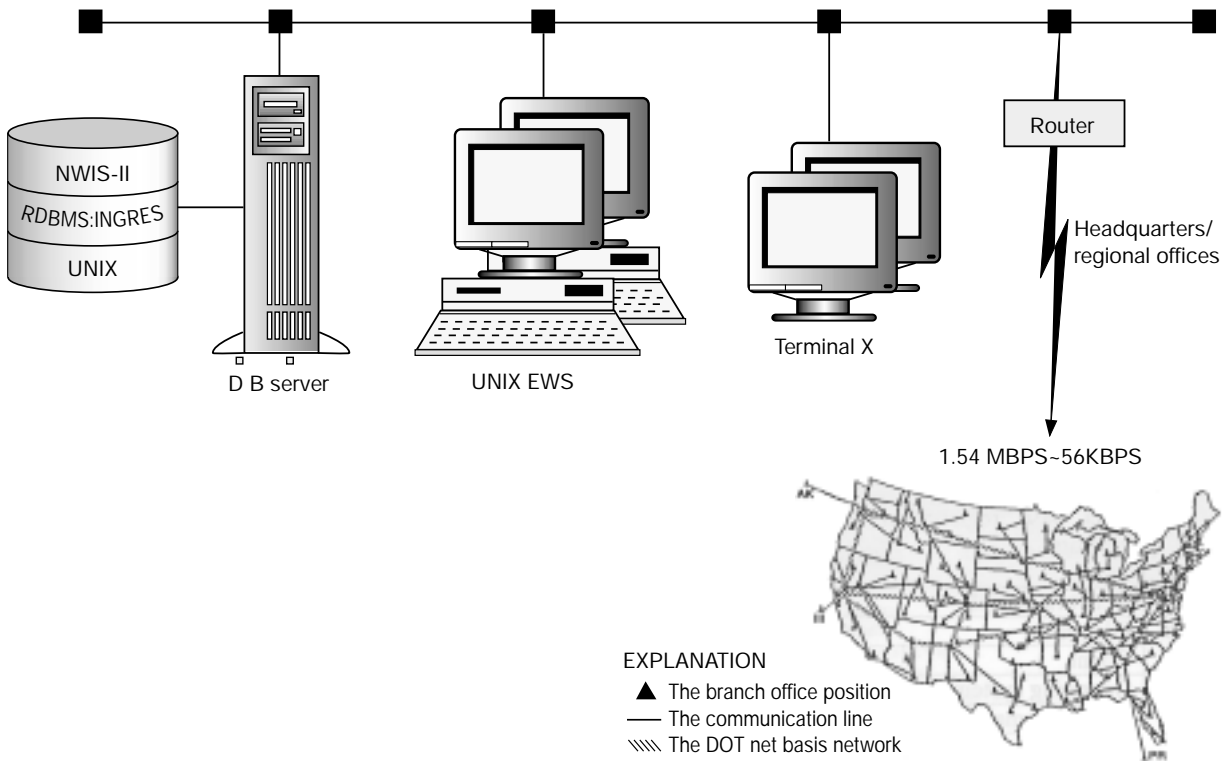


Figure 12 – Configuration of the NWIS-II regional office system (proposed)

Table 10 – Features of NWIS-II

<i>Item</i>		<i>NWIS-II (USGS)</i>
Purpose of data observation		Water management
Purpose of including it in the database		Support for acquisition, organization, analysis and other tasks
Construction of the database	<p>Coordination of coded items with related government departments and agencies</p> <p>Observation station and sensor locations</p> <p>Definition of observation timing</p> <p>Observation station (site) locations</p> <p>Time intervals</p> <p>Recording water quality analysis method, processes</p> <p>Short term observations outside of the set locations</p>	<p>This is being done.</p> <p>They are distinguished.</p> <p>Local time + Greenwich mean time.</p> <p>Latitude, longitude, etc.</p> <p>Optimal times.</p> <p>Done very strictly.</p> <p>Registration if possible.</p>
Data preparation related items	<p>Data items</p> <p>Data registered to the database</p> <p>Data checking</p> <p>Preparation of magnetic media data</p> <p>Supplementing missing data</p> <p>Correcting abnormal values</p> <p>Inspector qualification system</p> <p>Verification support applications</p> <p>Period from observation to preparation confirmed values</p> <p>Database registration of observers</p> <p>Database registration of water quality analysts</p> <p>Database registration of data creators</p>	<p>Water level, discharge, water quality, groundwater (level and quality), river bottom quality. Online telemetry values electronic logger tape.</p> <p>The inspection is systematized.</p> <p>Automatic entry.</p> <p>It is done (by a hydrologist).</p> <p>It is done (by a hydrologist).</p> <p>No.*</p> <p>Yes.</p> <p>2 to 3 weeks</p> <p>It is done.</p> <p>It is done.</p> <p>It is done.</p> <p>Distributed (model (C/S).</p>
System configuration	<p>Network model</p> <p>File server</p> <p>Client</p> <p>Operating system</p> <p>Database management system</p> <p>Application development language</p> <p>Graphic user interface</p> <p>GIS software</p> <p>GIS data</p> <p>Mechanism of release of data to third parties</p>	<p>Unix file server</p> <p>UNIX EWS, X terminal</p> <p>UNIX</p> <p>RDBMS:INGRES</p> <p>C, FORTRAN, 4GL, FRAMEMAKER</p> <p>X11, MOSAIC</p> <p>ARC/INFO</p> <p>1:100 000 prepared by the USGS</p> <p>Each regional office is linked to the internet</p>

* At the USGS, members who specialized in hydrology at university and who have many years of practical experience are called hydrologists, and can correct hydrological data based on their personal judgement.

GLOBAL RUNOFF DATA CENTRE

The Global Runoff Data Centre (GRDC), an organization established by the World Meteorological Organization, is operated from an administration office established at the Federal Institute of Hydrology, Germany. The goal of the GRDC is to provide data required for comparative analysis of hydrological observations on a global scale and to provide decision makers with the hydrological data needed to perform global scale water resource assessments.

The GRDC has established databases of discharge data of principal rivers in various countries around the world and has formed an international committee to smoothly manage a system intended to provide mutual benefits for participating nations by providing each nation contributing data with data from other countries if it requests such data.

Basic data is provided via floppy disk. Any user can request monthly or daily discharge data by mail by referring to a catalogue of data on the internet and providing its code number and other necessary information online.

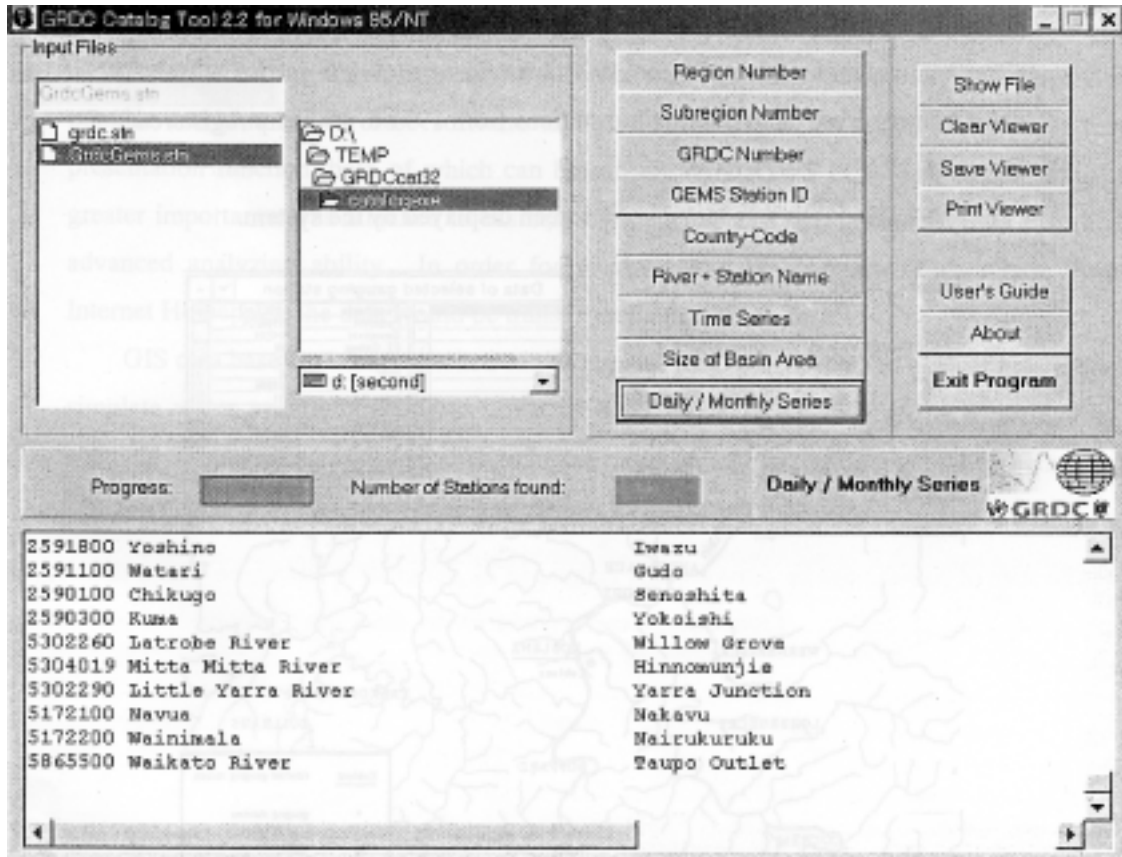


Figure 13 – Catalogue of data presented

APPENDIX D

THE APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEMS IN OPERATIONAL HYDROLOGY

RIVER RHINE GEOGRAPHICAL INFORMATION SYSTEM

Organization name:	International Commission for the Hydrology of the River Rhine (CHR/KHR)
GIS name:	RHINE-GIS
Features of the system:	<p>The drainage basin of the Rhine River has suffered severe flood disasters in recent years. In response, CHR/KHR began to develop a practical system to calculate water balance models and precipitation runoff models using GIS. This system uses GIS to set the constants needed to perform hydraulic calculations.</p> <p>In the Rhine River basin, topographical and hydrological data have been digitized to develop a GIS system with the cooperation of neighbouring nations.</p> <p>RHINE-GIS registers monthly average precipitation and precipitation at monthly, daily, three-hour, and six-hour precipitation intervals, and meteorological and weather data such as air temperature, humidity, wind speed, hours of sunlight etc.</p> <p>And in the Rhine River basin in Germany, daily and hourly data observed at 500 observation stations from 1961 to 1990 have been registered, while in the Moselle River basin, daily data observed at 90 observation stations between 1971 and 1980 have been registered.</p>

RIVER MANAGEMENT IN JAPAN

In Japan, the Ministry of Land, Infrastructure and Transport, JACIC, and FRICS have developed a number of systems including the following.

Kasumigaura GIS (Ministry of Land, Infrastructure and Transport)

A GIS database for the Lake Kasumigaura basin has been developed, as a research project, aimed at sharing data among related national, prefectural and municipal administrative organizations. The system was designed so that users can retrieve various types of information concerning quantity and quality of water by clicking on the location on the map shown on the monitor display, thus providing an overview of current watershed conditions.

Mesh geographical data for a base map is based on a digital map prepared by the Geographical Survey Institute, which covers the area with a 50 m mesh for elevation, 100 m for land use and 1 km for surface soil and geology. Point data such as hydrological data are entered against the location of the observation point, while the area data such as amount of municipal water supply in each municipality are entered against the municipal location.

The framework of the GIS database utilizes EXCEL (Microsoft) and ArcView3 (ESRI), both of which can be run on Windows. Great importance is attached to ease of operation and data updating rather than having a highly advanced analysing capability. In order to disseminate the contents of the database through the internet the data is transformed into HTML format.

This GIS database can be used in constructing and evaluating a model to simulate water and pollutants movement in the watershed. This is a useful tool in estimating the impact of land use changes in the basin on lake water quality and to compare the effects of various measures for reducing the pollutants load in the basin.

Water damage statistical survey support system (JACIC)

This system has been established to quickly survey the state of flood damage immediately after a flood has occurred. A user can draw the inundated district with a mouse to use numerical information for pre-recorded 100 m meshes to estimate the total number of victims, effected households and value of the damage.

Digitized basin map (FRICS)

This system, which converts information about the ground in a river watershed into numerical form that can be used by GIS, can be used to display maps presenting freely combined information of many kinds.

The watershed environment data that is handled includes regulations concerning urban planning districts and housing land preparation, flood hazard maps and inundation analysis results, maps of past inundation areas, locations of past liquefaction, hydrogeological maps, groundwater level observation wells, past land use, and topographical categorizations, and so on. This data can be applied as basic data for the preparation of river improvement: measures and to clarify the links between ground conditions and both flooding and liquefaction that occurs during earthquakes.

WATER QUALITY DATA MANAGEMENT IN SOUTH AFRICA

Organization name:	Developed as a joint project by the Institute for Water Quality Studies of the Department of Water Affairs and Forestry, CSIR, Stewart Scott Incorporated, GIS lab at the University of Pretoria, and GIMS (Pty).
Name of GIS:	WATER MARQUE
Characteristics of the system:	<p>This system is a multiple menu tool developed using GIS technology and intended to be used to evaluate, reference, display and report on water quality data. Users trained in water quality evaluation can access water quality and related data, analyse the data and produce output maps.</p> <p>And it is possible for a water supply management bureau to obtain almost all defined water quality standards from this system.</p> <p>The following are the principal function modules of the system.</p> <ul style="list-style-type: none"> • Selection of collection sites; • Selection and display of spatial characteristics; • Selection of monitoring points; • Referencing data; • Output. <p>One example is its ability to display a red box if, when selecting standards for agriculture and sodium ions, the concentration of sodium ions in river water exceeds the level that is recommended for irrigation water.</p>
Future challenges:	The system is useful for data mapping, but because a UNIX platform is expensive and AMLs lacks flexibility, the next version will include a system permitting users to access main frame computer or UNIX server data from a personal computer.

LINKS WITH DISTRIBUTED HYDROLOGICAL MODELS (UNITED STATES)

A final draft report from the American Society of Civil Engineers (ASCE) Task Committee on GIS Modules and Distributed Models of the Watershed.

Activities

This Committee has studied and prepared a report on the present state of and trends in GIS modules and distributed model technology used for hydrology.

The application of GIS to the field of hydrology

GIS is applied to distributed hydrological models by calculating loss discharge accounting for the setting of the drainage basin boundaries, for land use and for geological conditions using digital elevation data that includes topographical conditions and land use conditions.

Because there is a correlation between soil and the water balance, it is possible to use GIS to calculate the loss precipitation by dividing a drainage basin into small sections.

With GIS, the soil – water balance relationship data is completely handled at the database level and maps are treated as mere display devices rather than as the actual analysis tools.

And if precipitation values obtained by radar and remote sensing data are utilized, it is possible to quantify meteorological parameters such as precipitation even in regions without observation instruments, permitting the increased precision of models used in conjunction with GIS.

Software used for hydrology

The following are the GIS related software used for hydrology referred to in this report.

- Modular Modelling System;
- Precipitation Runoff Modelling System (MMS/PRMS);
- A Gis/Hec-1 Interface Module;
- Application for Hydrological and Water Quality Modelling (GRASS);
- A digital landscape analysis tool for hydrologic modelling application (TOPAZ);
- Watershed Modelling System (WMS);
- Hydrological Model CASC2D.

OPERATIONAL HYDROLOGY REPORTS

WMO No.	Report No.	
332	No. 1	— Manual for estimation of probable maximum precipitation (Second edition)
337	No. 2	— Automatic collection and transmission of hydrological observations*
341	No. 3	— Benefit and cost analysis of hydrological forecasts. A state-of-the-art report
356	No. 4	— Applications of hydrology to water resources management*
419	No. 5	— Meteorological and hydrological data required in planning the development of water resources*
425	No. 6	— Hydrological forecasting practices*
429	No. 7	— Intercomparison of conceptual models used in operational hydrological forecasting
433	No. 8	— Hydrological network design and information transfer
461	No. 9	— Casebook of examples of organization and operation of Hydrological Services
464	No. 10	— Statistical information on activities in operational hydrology*
476	No. 11	— Hydrological application of atmospheric vapour-flux analyses*
513	No. 12	— Applications of remote sensing to hydrology
519	No. 13	— Manual on stream gauging — Volume 1: Field work — Volume 2: Computation of discharge
559	No. 14	— Hydrological data transmission
560	No. 15	— Selection of distribution types for extremes of precipitation
561	No. 16	— Measurement of river sediments
576	No. 17	— Case studies of national hydrological data banks (planning, development and organization)
577	No. 18	— Flash flood forecasting
580	No. 19	— Concepts and techniques in hydrological network design
587	No. 20	— Long-range water-supply forecasting
589	No. 21	— Methods of correction for systematic error in point precipitation measurement for operational use
635	No. 22	— Casebook on operational assessment of areal evaporation
646	No. 23	— Intercomparison of models of snowmelt runoff
650	No. 24	— Level and discharge measurements under difficult conditions
655	No. 25	— Tropical hydrology
658	No. 26	— Methods of measurement and estimation of discharges at hydraulic structures
680	No. 27	— Manual on water-quality monitoring
683	No. 28	— Hydrological information referral service — INFOHYDRO Manual
686	No. 29	— Manual on operational methods for the measurement of sediment transport
704	No. 30	— Hydrological aspects of combined effects of storm surges and heavy rainfall on river flow
705	No. 31	— Management of groundwater observation programmes
717	No. 32	— Cost-benefit assessment techniques and user requirements for hydrological data
718	No. 33	— Statistical distributions for flood frequency analysis
740	No. 34	— Hydrological models for water-resources system design and operation
749	No. 35	— Snow cover measurements and areal assessment of precipitation and soil moisture
773	No. 36	— Remote sensing for hydrology — Progress and prospects
754	No. 37	— Hydrological aspects of accidental pollution of water bodies
779	No. 38	— Simulated real-time intercomparison of hydrological models
804	No. 39	— Applications of remote sensing by satellite, radar and other methods to hydrology
803	No. 40	— Land surface processes in large-scale hydrology
806	No. 41	— An overview of selected techniques for analysing surface-water data networks
813	No. 42	— Meteorological systems for hydrological purposes
884	No. 43	— Current operational applications of remote sensing in hydrology
885	No. 44	— Areal modelling in hydrology using remote sensing data and geographical information system
886	No. 45	— Contaminants in rivers and streams — Prediction of travel time and longitudinal dispersion
887	No. 46	— Precipitation estimation and forecasting
948	No. 47	— Manual on sediment management and measurement

* Out of print