Government of India & Government of The Netherlands

Technical Assistance
HYDROLOGY PROJECT

DHV CONSULTANTS &
DELFT HYDRAULICS
with HALCROW, TAHAL,
CES, ORG & JPS

AN OVERVIEW
OF
HYDROLOGICAL INFORMATION SYSTEM
(HYDROLOGY PROJECT – INDIA)

Summary

Planning of water resources projects requires adequate information on the hydro-meteorological regime. Poor availability of comprehensive and good quality data often leads to unsound design and operation. The existing systems in many countries including India are inadequate in terms of reliability, accessibility, compatibility, and presentation. The main causes are manual processing of voluminous information, a wide gap between the tools available and employed, and involvement of number of agencies often lacking desired integration. A comprehensive computerised hydrological database linked with a geographic database is a basic requirement for efficient water management.

An attempt to improve and upgrade the existing hydrological system in nine peninsular states of India is being made through the Hydrology Project (HP). The prime objective of HP is to develop an effective HIS and modernise the system of collection, and processing of hydrological and allied data. Dedicated softwares have been developed for surface water and groundwater data entry and processing and procedures for data observation and validation have been standardized. Aspects like infrastructure development, maintenance support, and availability of trained personnel are being ensured for system's sustainability. Countries like India can benefit immensely by judicious use of emerging technology. Revitalising the existing HIS for a vast region covering more than 1.7 million sq. km is a unique challenge. This note highlights the key features of the dedicated hydrological data observation, multi-level processing, and geographically-distributed storage system. The key features of HIS and experiences from the Hydrology Project are also discussed.

1 Introduction

Fresh water is one of the most critical natural resources for the continuance of life on earth. The pressure on freshwater resources has increased dramatically during the 20th century. By 1997, one-third of the world's population was living under medium to high water-stress conditions. It is expected that by 2025, two-thirds of the population will be affected by water shortages *(HWRP home-page, WHYCOS project)*. Sharp population growth in most parts of the developing world has lead to greater pressure on producing sufficient food and this requires more water. Inefficient irrigation practices compound the problem of freshwater availability in many parts of the world. The available amount of suitable water is further reduced due to contamination of water resources caused by the discharge of untreated/partially treated wastewater and recharge from irrigated fields into natural water bodies. The looming water crisis with competition for water among neighbouring countries will become a source of conflict, as about 300 river basins and numerous aquifers are shared among two or more nations. Recurring floods and droughts in several parts of the world, including India, are causes of concern for the society. Unless water resources are wisely managed, water shortages and hazards are bound to become serious obstacles for economic and social progress, particularly in the developing countries.

A necessary pre-requisite for wise water resources management is accurate, comprehensive and timely availability of hydrological data along with information about the economic, social and environmental dimensions. Unfortunately, in many parts of the world, the systems for collecting and managing water-related information are inadequate and often deteriorating. Difficulties arise due to lack of financial resources to maintain networks compounded by non-standard procedures for data collection and quality assurance among responsible agencies, inadequate and unreliable telecommunication systems, and outdated procedures for information management and dissemination. India is also facing serious problems in the water sector due to rapid rise in population and industrial activities.

To improve the existing Hydrological Information System (HIS) in India, a giant step forward has been taken by launching the ambitious Hydrology Project (HP). HP aims at developing and improving the existing set-up of (geo-) hydrometeorological information systems available in various government agencies in nine peninsular states of India. These states are Andhra Pradesh, Gujarat, Chhattisgarh, Madhya Pradesh, Maharastra, Karnataka, Kerala, Orissa and Tamil Nadu (Fig. 1). This will assist in gathering reliable and spatially intensive data on the quantity and quality of water of hydro-meteorological, hydrological and hydro-geological systems, and in utilizing computerised databases for planning, design and management of water resources systems. Special attention is being paid to standardisation of procedures for observation and validation of data, so that it is of acceptable quality and compatible between different agencies and states. Adequate facilities are being built up for proper storage, archival and dissemination of data. Infrastructure and human resources development aspects are emphasised and ensured for the sustainability of such a system, which should keep pace with the developments in technology and at the same time in hydrology and allied sciences.

Figure 1: HP Area of 9 Indian States

This note presents the salient features of the improved Hydrological Information System (HIS) in the project area and highlights the benefits and opportunities it provides for better water resources management. The ambitious Hydrology Project is in an advanced stage of implementation and the analysis presented here was made on the basis of the experiences gained in setting up the comprehensive and reliable hydrological information system. Also highlighted are some of the future plans that are to be effected as a natural follow-up of such a project.

2 Existing Hydrological Information System in India

Hydrological Information in India is primarily provided by various Central and State Government's meteorological, surface water and groundwater agencies. Information on surface water bodies is provided by the Central Water Commission (CWC) and the state water resources/irrigation departments. Similarly, information on groundwater is the responsibility of the Central Ground Water Board (CGWB) and the respective State groundwater agencies. The systems for gathering water quality information is the responsibility of Central and State Pollution Control Boards, State Public Health Engineering Departments, CWC and CGWB.

2.1 Observation Networks

Rainfall stations constitute the bulk of the hydro-meteorological network and are predominantly owned by the state departments, under the supervision of the India Meteorological Department (IMD). IMD collects and archives data, from selected stations of this network. Climate stations, for hydro-meteorological variables, are mainly maintained by the IMD; only a few states have substantial network of climatic stations. Most of the rainfall and climate stations owned by IMD and the state departments were set up long ago (ranging from 20 to 100 years); most of these have not been maintained and upgraded adequately. This has often resulted in gaps in data series and quality of observations.

River gauging stations have primarily been setup with the objective to collect water level and discharge data at river and reservoir stations/locations. At some of these stations, sediment and water quality is also observed. Stations belonging to the CWC are located on the major river courses whereas those of the States are located on the smaller rivers and tributaries of the major rivers. The network of the CWC focuses primarily on gathering information on the overall water resources of the country, to resolve interstate water sharing disputes, and enable basin-wise flood forecasting. The observation networks of various states cover the basins more intensely with the aim to provide hydrological data for planning and designing of water resources projects.

The availability of observers at river gauging and hydro-meteorological stations has gradually declined. Coupled with ever reducing financial support, this rendered most of the river gauging and meteorological networks (except CWC and a few states) non-operational. The observation process on most hydro-meteorological stations is manual with few automatic equipment installed in recent years. The discharge measurements is mainly by current meters in CWC stations; the use of non-standard floats has been in vogue in many states.

The assessment of groundwater resources in India is based on annual recharge and discharge using a simple form of water balance equation. Among the different inputs, water levels, aquifer parameters, rainfall and evaporation are observed directly while others are estimated indirectly. Most groundwater observations have been at open dug wells tapping the upper unconfined aquifers. The water levels measured reveal the piezometric head/water table elevation of the semi-confined/unconfined aquifers. However, the necessary hydraulic well-aquifer connection was not always beyond suspicion. The frequency of monitoring was limited to four times in a year: pre-monsoon, monsoon, post-monsoon, and winter seasons. Presumably, these water levels represent the troughs and peaks of the water table hydrograph, though many times these data points are too sparse to yield reliable and credible conclusions. Limited monitoring of the piezometric head of the deeper confined/leaky confined aquifers has been carried out by some agencies by observing water levels in deep production tube wells.

Awareness on the need for collecting information on water quality has grown only in the last decade, primarily due to deteriorating quality of already dwindling water resources. Whereas the river gauging authorities usually try at least to obtain basic water quality variables for selected river gauging station/locations, the pollution control boards take observations with the aim of surveillance near the industrial or urban centers. In the past, water quality labs were inadequate in numbers and analytical capabilities. Insufficient finances have also marred operations.

Though the observation networks of the central and state agencies are expected to have complementary roles, the actual networks often have many duplications/gaps.

2.2 Data processing and dissemination

Agencies providing hydrological services have been using computerised methods of data handling for several years, with different levels of sophistication ranging from simple ASCII based data files to more user friendly spreadsheet files and dBase databases. However, there is a total lack of uniformity in the formats and software being used in different agencies and even in different offices of the same agencies. There have been a few efforts in the past in some agencies to improve the data processing systems, but these were not designed to yield objective solutions. Users faced difficulties in getting hydrological data, specially due to difficulties in locating the source, unavailability of all data on computer media and long delays in data supply. Thus, the overall status of data availability and accessibility of the information has not been satisfactory in the past, which in the end led to the need and formulation of the Hydrology Project for upgradation and improvement of the existing scenario. The next few sections highlight the paradigm change that is being brought about through the implementation of the HP.

3 Salient features of new HIS

The prime objective of the HP is to develop a comprehensive, reliable, easily accessible, user friendly and sustainable HIS in the concerned agencies. A HIS comprises of physical infrastructure and human resources to collect, process, store and disseminate water resources data. The overall objective of HIS under HP is to realize part of the Govt. of India's policies and strategies in the water sector. Article 2 of the National Water Policy (1987) of India, which is pertinent to HIS, stipulates: "*The prime requisite for resources planning is a well-developed information system. A standardised national information system should be established with a network of data banks and data bases, integrating and strengthening the existing Central and State level agencies and improving the quality of data and the processing capabilities. There should be free exchange of data among the various agencies and duplication of data collection should be avoided".*

The primary role of the HIS is to provide reliable data sets for long-term planning and design, and to frame rules for management of water resource systems. The system should provide the information to users in time and in proper form. The scope of HIS is not intended to provide data to users on a real-time basis for short-term forecasting or for operational use.

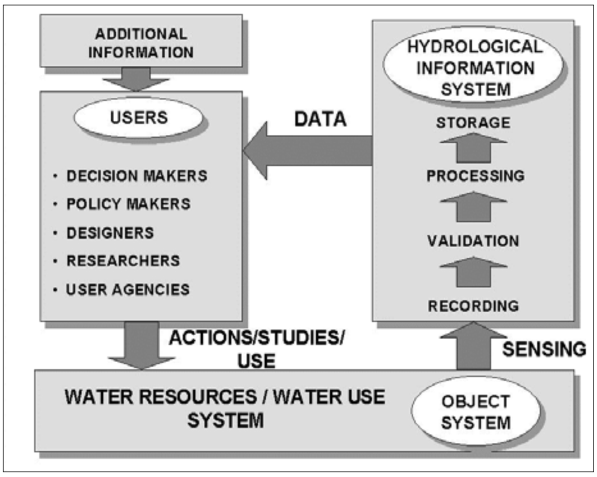

Figure 2: Role of Hydrological Information System

The first step is to obtain information on temporal and spatial characteristics of the object system through a network of observational stations. The basic data collected for different hydro-meteorological parameters are called observed or field data. Such observed data have to be processed to ensure their reliability. Both field and processed data sets have to be properly stored, i.e. processed data for dissemination and field data to permit inspection and revalidation in response to queries from users. This role of HIS is illustrated in Fig. 2.

The new HIS has the following characteristics:

- it is demand driven, i.e., output is tuned to the user needs,
- it ensures use of standardised equipment and procedures for data collection,
- it employs (computerised) processed and validated databases for efficient dissemination, and
- proper institutional support to ensure sustainability.

The scope of various activities under HIS is briefly outlined in what follows.

3.1 Review of observational network

The objectives of the system need to be laid down and the existing observational network is reviewed and augmented. The observation networks have been thoroughly reviewed from three specific view points: (a) to open new stations in areas hitherto poorly represented or sparsely covered or to replace non-representative stations with dedicated sites, (b) to avoid duplication of stations across various agencies and (c) to improve frequency and accuracy of observations through automated equipment and standard procedures. Old and defunct equipment has been replaced with new and standard equipment.

3.1.1 Surface water monitoring network

A major improvement in the hydro-meteorological network has been the reactivation of many old rainfall stations, that had become non-functional due to inadequate monitoring and shortage of funds. Many new full climatic stations have been established comprising standard and autographic raingauges, dry and wet bulb, minimum and maximum thermometers, anemometer, sunshine recorder and pan evaporimeter. There were about 7200 rainfall and 640 climatic stations in the project area. The field inspections revealed that improperly located stations, ill maintained or defunct equipment and sub-standard observation practices were common features at existing stations. To revitalise the meteorological network about 500 new stations have been setup and another 1700 stations upgraded to meet the standards.

The main improvements of river gauging stations have been the introduction of digital recorders. The practice of employing floats has been replaced by current meter measurements. Most of the reservoirs monitoring stations have also been provided with automatic water level recording. Sophisticated techniques for discharge measurements like the Acoustic Doppler Current Profilers (ADCPs) have also been employed at a few stations, where gauging is extremely difficult with conventional means. Under HP, about 265 existing stations have been upgraded and another 650 new gauge-discharge stations have been established.

3.1.2 Groundwater monitoring network

The main objective of the groundwater component of HP is the establishment of the required infrastructure for improving the understanding of groundwater systems, both in the terms quantity and quality. The water level and water quality monitoring networks have been expanded and upgraded by replacing non-representative observation wells with scientifically designed piezometers. There have been about 27,000 observation wells in the project area before the project. Only 6% of these were tubewells, while others were hand dug open wells. These open dug wells were not owned by the agencies and were also not maintained adequately. Under the project the network has been strengthened by constructing about 7,900 new piezometers. Piezometers are purpose-built observation wells which are designed to measure the vertically averaged piezometric head of a single layer, and cannot be used for groundwater exploitation. The piezometer have been designed to provide for sampling of groundwater from the tapped aquifer for water quality monitoring.

The design of the network has been optimized by integrating the monitoring piezometers of the different agencies. The improved network has been designed to get a good spatial and vertical coverage and representation of all the hydro-geological setups, considering the present and projected status of groundwater development and water quality variations. As many as 6400 piezometers have been provided with Digital Water Level Recorders (DWLR's), to ensure measurement of undistorted piezometric head at the desired frequency (ranging from 10 minutes to 6 hours). The accurate and high frequency piezometric head data will enhance the technical content of the data and also facilitate many new analyses. The improved groundwater monitoring network would provide:

- long-term hydrogeologic information and groundwater quality data,
- characterisation of different groundwater flow regimes,
- recommendations for regulations related to use and conservation of groundwater resources,
- a baseline for control of groundwater over-pumping
- information necessary for conjunctive use planning

3.1.3 Water quality monitoring network

An extensive network for monitoring of the quality of surface water (SW) at about 675 locations and groundwater (GW) at about 29,000 locations have been established. The stations are categorized into "Baseline", "Trend" and "Flux"/"Surveillance" stations based on the guidelines of the World Health Organisation. The frequency of sampling and water quality parameters to be analysed for each category of stations have been defined and documented in the "*Protocol for Water Quality Monitoring*", to achieve uniform monitoring procedure of all the participating agencies for comparable results.

3.2 Assessing the needs of users

Hydrological Data User Groups (HDUGs) have been constituted in each state and at the central level to ascertain and respond to the needs of users. A wide array of potential hydrological data users are represented in these groups, whose main aim is to review hydrological information needs, identify shortfalls in content and services provided, and make suggestions for improvements. This forum has given a unique opportunity to bring the HIS closer to the users and fulfil their aspirations.

3.3 Data collection

A comprehensive list of all monitoring equipment to be employed in the HIS has been elaborated as listed in **Appendix A**. The equipment varies from a simple raingauge, a fully automated tipping bucket raingauge or ADCPs to digital water level recorders, Atomic Adsorption Spectrophotometer (AAS) and Gas Chromatograph (GC). Detailed specifications for all equipment have been drawn up and are being utilised by all agencies. This step would reduce variability in observations, at different locations and by different agencies.

3.4 Water quality analysis

A comprehensive water quality laboratory development programme has been completed by establishing or upgrading 290 laboratories under three categories: Level I, Level II and Level II+, with varying levels of sophistication. Level I laboratories (215) cover six parameters (colour, temperature, pH, dissolved oxygen, conductivity and turbidity) for analysis at the site of sampling. The analysis of other parameters is done at Level II or Level II+ laboratories. There are about 50 Level II laboratories for the analysis of physico-chemical and microbiological parameters and 20 level II+ laboratories for the additional analysis of heavy metals and pesticides. Special instruments, like UV-visible spectrophotometer, Atomic absorption spectrophotometer (AAS) and Gas chromatograph (GC) have been provided in the Level II and level II+ laboratories for analysis of pollution related parameters including toxicants, like trace metals and pesticides.

The procedures for analyses of various parameters have been identified and documented as "*Guidelines on Standard Analytical Procedures for Water Analysis*" with illustrations/examples and sample calculations for the reference of the laboratory chemists.

In view of the multiplicity of the water quality monitoring agencies and the large number of analytical laboratories participating in the process of sampling and analysis, it is imperative to conduct Analytical Quality Control (AQC) exercises for reliability and reproducibility of data. Two types of AQC exercises viz. "Within-laboratory AQC" and "Inter-laboratory AQC" have been formulated. While the first exercise is a routine exercise for individual laboratories, internally to be conducted regularly to gain confidence in analysis, the latter provides an opportunity to test the analytical skills of the chemists across various participating laboratories. The inter-laboratory AQC exercises are proposed to be conducted at least once a year. Two-rounds of "Within Laboratory AQC" and two annual rounds of "Inter-laboratory AQC" exercises conducted among the participating laboratories showed marked improvements in the generation of better quality data.

3.5 Data processing, analysis and reporting

The existing system of manual or very limited computerised data processing is being replaced by fully computerised data processing using dedicated and user-friendly software. The raw data are in a variety of formats such as hand-written records, charts and digital records. Raw data as observed and recorded may contain many gaps and inconsistencies and are passed through a series of operations, typically: data entry, validation checks, in-filling of missing values, processing to estimate derived variables, compilation in different forms, and analysis for commonly required statistics etc. Of particular importance is assuring the quality and reliability of the data through a variety of validation procedures. Reports are prepared to bring out the salient characteristics of the hydrological regime of the region.

Both surface water and ground water agencies would employ dedicated hydrological data processing software. HYMOS, a hydrological data processing software and a product of Delft Hydraulics of The Netherlands is employed for all surface water quantity and quality and hydro-meteorological data processing activities. Similarly, a comprehensive groundwater data processing software is being prepared. Both surface and groundwater data processing software are modular in nature and are being implemented with varying levels of sophistication. The first module, also called the primary module, is dedicated to the purpose of entry of all types of data and for carrying out the preliminary data validation. The second module is oriented towards performing spatial consistency checks and having different types of data correction, data compilation and analyses procedures. The third or the highest level module will have the necessary options for hydrological validation and comprehensive reporting. The dedicated groundwater data processing software also includes GIS support, to visualise and analyse spatial data.

The primary modules of surface and groundwater data processing systems (including water quality) are called Surface Water Data Entry System (SWDES) and Ground Water Data Entry System (GWDES) respectively. These software have a Microsoft Access database structure at the back end and the front end has been built using Visual Basic for Application (VBA). These systems are customised to provide a user-friendly environment. The computer screens look alike the manuscripts used by observers for recording the observed data. Comprehensive and easy scrutiny of data is provided by graphical visualisation. Application of these data processing systems throughout the project area and at all the agencies has, for the first time, provided a unique scenario at a gigantic scale, in which all the hydrological data processers use standard and uniform tools.

3.6 Management of historical data

All the State and Central agencies have been maintaining their observational networks for many years and thus a huge volume of historical data is available. Most of this data is in manuscript or chart forms. Some of this data is even becoming physically inaccessible due to gradual decay of older manuscripts. Often these are of variable or "unknown" quality since in many cases the recorded data were seldom scrutinised. A comprehensive program of historical data entry is established in each agency holding such data, for organising this valuable information in the uniform databases of SWDES and GWDES. Subsequent to entry into the computer, the data will be scrutinised for obvious data entry mistakes and thereafter for desired hydrological consistency. Most of the available groundwater related data have already been organised and surface water data are also expected to be completed soon. Such a mammoth organisation of hydrological data are being accomplished for the first time for a substantial part of the country. It is expected that this would provide the water resources engineers and planners of the country with an excellent opportunity to easily access the required historical hydrological information and use it.

3.7 Data storage and dissemination

All historical and currently observed data sets are proposed to be stored and maintained in well-defined computerised databases, using industry standard relational database management systems like ORACLE. This is essential for long-term sustainability of the data sets and their efficient dissemination to the end users. Both, raw and processed data sets will be stored and archived with specified standards so that there is no loss of information. Necessary features of data administration and management like data security, protection from data corruption and provision of controlled accessibility would be part of the system design. An efficient and user-friendly query system aided with graphical visualisation on the maps for identifying the data required, also through Internet, is envisaged to be used for making data request.

3.8 Overall structure of HIS

The structure of HIS at State/Regional level, as set up by various participating State and Central agencies respectively, emphasising the distributed approach to carry out data processing, data exchange and dissemination processes is illustrated in Fig. 3. Being a distributed data processing and management system, each data processing centre is provided with adequate communication links for exchange of data to and from other data processing centres.

HIS operates at different levels from measurement in the field to comprehensive validation and data processing at three levels of Data Processing Centres and storage at Data Storage Centres as follows:

a) **Observation stations/wells:** Observations on different hydro-meteorological, hydrological and hydrogeological variables and collection of water quality samples is done at the surface water and groundwater observation networks. The field data are submitted to the Sub-divisional/District Data Processing Centres within the month of observation. The water samples are collected and send to designated water quality laboratories on a regular basis.

b) **Water Quality Laboratories:** Samples arriving from observation stations are analysed within the prescribed time frame. The results are entered in the computer and subjected to primary validation. At regular intervals, the laboratory passes the information to the Divisional or Regional Data Processing Centre.

c) **Sub-divisional/District Data Processing Centres (SDDPC/dDPC):** Here, all field data are entered in the computer and preliminary validation is carried out. Computerised data are passed on to the Divisional/Regional Data Processing Centre within 10 days after the month of observation.

d) **Divisional/Regional Data Processing Centres (DDPC/rDPC):** Given their larger areal coverage, data is organised in basin/sub-basin wise databases and secondary data validation (spatial consistency checks) is carried out. Validation at Divisional Data Processing Centres is completed within 15 days of receipt of data and thereafter surface and groundwater data are transferred to the respective State Data Processing Centres.

e) **State/Regional Data Processing Centres (SDPC/RDPC):** Their main activity is final data validation, completion, analysis, and reporting. Since these centres cover a whole river basin or a very large part thereof, it is appropriate to ensure hydrological consistency between inter-related variables like rainfall, runoff, recharge etc. The data arriving from various Divisional Data Processing Centres are organised in basin wise databases and hydrological validation is carried out. With the procedure, the need for exchange of data among different agencies, for the purpose of validation has been realized and a formal data exchange process has been established. The inter-agency data validation exercises are scheduled twice-a-year, in the months of February and August, for the data of monsoon and non-monsoon months respectively. After the data is thoroughly validated, the (authenticated) processed data are transferred to the respective Data Storage Centres.

(f) **State/National Data Storage Centres (SDSC/NDSC):** For six out of eight States there is a common Data Storage Centre for surface and groundwater data. Central agencies have separate Data Storage Centres for each of the regions. Each central agency also has one National Data Storage Centre for bringing desired information from various state and regional data centres to have an overall perspective of hydrological regime at the national level. All the State and Regional Data Storage Centres store and administer the storage of field (or raw) and processed (or authenticated) hydrological data and ensure smooth and efficient dissemination of data to the users. For an effective dissemination of available information, Data Storage Centres also maintain a catalogue of data stored in its own database and those stored in the databases of other agencies.

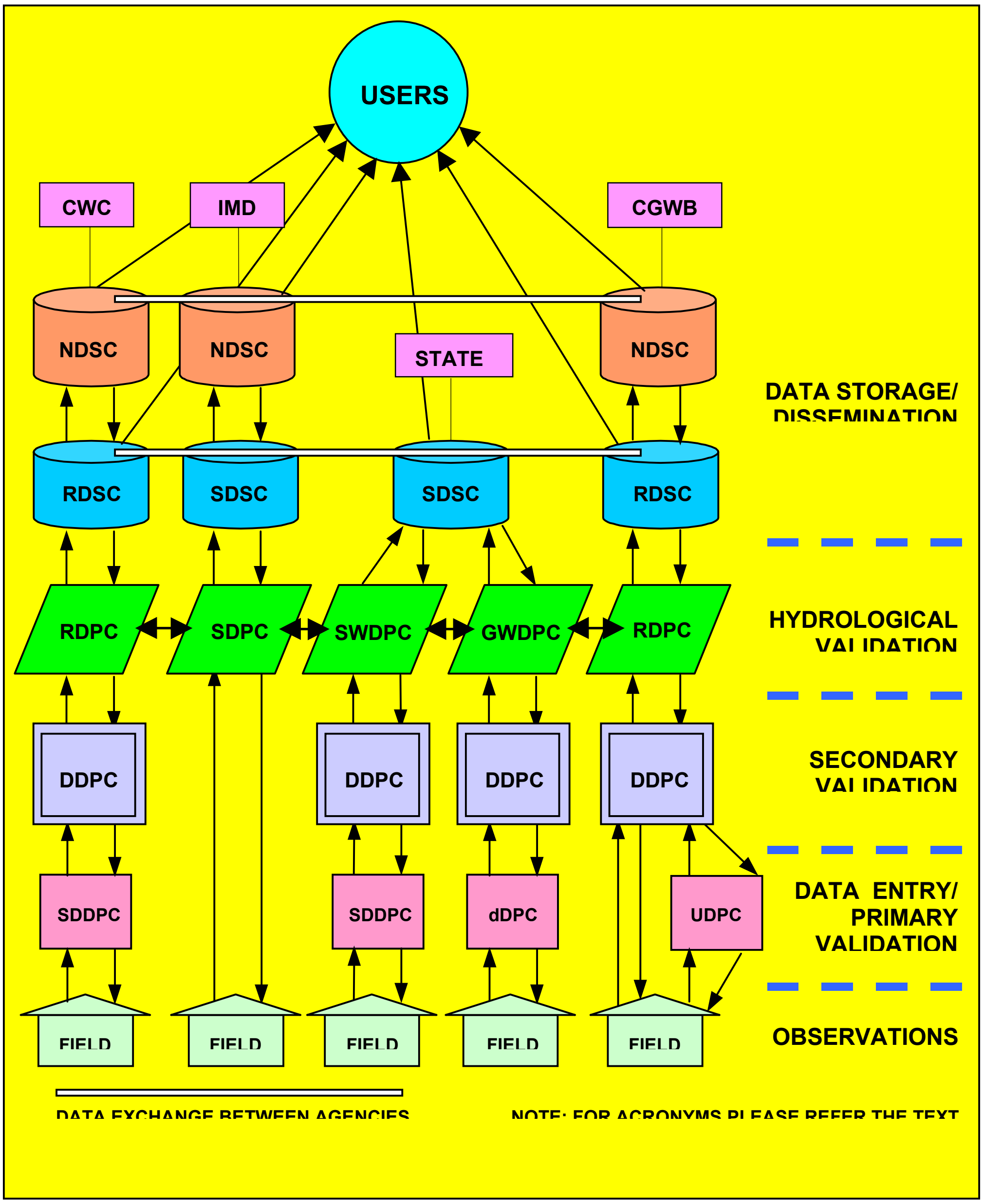

Figure 3: Structure of HIS at State/Regional levels

4 Sustainability of HIS

An extensive training program has been planned under HP and is being implemented throughout the project area. It is envisaged to ensure necessary skill building and provide training to all the personnel involved at different levels in various activities of HIS. A whole range of subjects, issues and activities are covered under the well-planned training program that includes training courses (**as listed in Appendix B**) covering aspects such as:

- Observation practices on hydrological and allied data,
- Standard water quality sampling and analysis procedures,
- Basic know how for working on computers,
- Surface water, groundwater and water quality data entry procedures,
- Surface water, groundwater, and water quality data processing and interpretations using dedicated software,
- Geographical information system,
- Database management systems including aspects of latest information technology,
- Sophisticated equipment and installations like DWLRs, ADCPs, AASs and GCs etc.,
- Analyses of pollution related parameters,
- Procurement procedures for equipment and other infrastructural facilities,
- Installation and acceptance protocols for specialised equipment,
- Training and communication skills for in-house trainers.

Most of these training courses have been institutionalised through the services of a few designated research and academic institutions called the Central Training Institutes (CTIs). Courses are developed and refined by the in-house faculty members of such institutions and the consultants to the project. A three pronged approach is adopted for imparting training to a very large number (about 10,000) of trainees on a variety of issues as mentioned above. A concept called “training of trainers (ToT)” is employed by which a core group of a substantial number of motivated officers of each state and/or CTIs are trained. These are then expected to conduct further training courses for the actual trainees with or without the help of faculty members from the CTIs or the Consultants. After the formal training courses the trainees are further assisted at their own working place by what is called as hands-on-coaching sessions.

Comprehensive and well-laid out training documents (**as listed in Appendix C**) have been prepared covering the contents of the course, the exercises and the presentation material so as to ensure uniformity and standardisation in transfer of knowledge and delivery of training courses. Scores of training courses have been conducted regularly by the CTIs and the Consultants throughout the project period. It is also planned that these CTIs would continue to provide training facilities even after the project ends, specially to address the problem of frequent transfers of trained staff members out of the project area.

5 Institutional Strengthening

Information on hydrological processes would be required by the society on a continuous basis for a sufficiently long period of time in the future also. Since HIS is a vast system, institutional and human resource development aspects need to be paid adequate attention. This is particularly required in view of the absence of objective planning and maintenance of HIS in the recent past, specially by most of the state agencies. Many water resources projects have been launched and successfully completed earlier, but there is always a fear that the created facilities would wither away, the trained staff will move elsewhere and the things would gradually return to pre-project stage. This has been experienced in case of many other projects funded by internal or external agencies and specially in developing countries. HIS is re-vitalised by way of this project and it is, therefore, of utmost importance to ensure that the institutional strength required for HIS and created under the project is maintained and enhanced in the future.

There have been significant institutional problems in making the evolving HIS efficient and objective. First of all, in a few states the HIS was not independent and was getting least attention for budgetary and personnel support. It required perusal at the highest level of governance, in some cases, to make the hydrological services independent, within the broad umbrella of the department. Secondly, in view of the tremendous water quality monitoring programme being introduced, there were serious problems of unavailability of suitable staff in the water quality laboratories. Similar is the case for database administration and information technology. Since application of emerging information technology tools is a recent phenomenon, not only in the water sector but in general also, it was expected to face such situation. Further, in this era of privatisation and shedding public funding by reducing staff, it was very difficult to deploy adequate number of observers and helpers on new and existing observation stations. All such problems have been highlighted at the appropriate level of decision making to ensure suitable solutions. Steps have been taken for fresh recruitment, re-deployment from other projects or deputation from other departments etc. to overcome such difficulties.

Though it is not to suggest that most of these obstacles have already been resolved to the desired level of satisfaction, the suggested solutions have been followed up in right earnest. The in-house capacity building by a strong training component would also go a long way in bridging the remaining gaps. Furthermore, a whole set of manuals (**table of contents given as Appendix D**), reports and guidelines (**as listed in Appendix E**) prepared on various aspects of HIS has been made available to each office/location and would go a long way in institutionalising various HIS activities. Establishment of HDUGs and advisory role it would play would further make the system vivid and responsive.

6 Project Implementation

Implementation of any wide spread project as the HP, involving participation of more than 20 independent government agencies, its bureaucratic way of functioning and variety of technical and institutional matters, would definitely not be an easy task. It is obvious that such projects must be meticulously planned and structurally implemented. As most of the activities are closely linked with each other, it becomes extremely important to rationally sequence and execute them within the stipulated time frame. When such a large existing HIS is being upgraded and standardised, it is very important that the required specifications, guidelines and training documents are prepared with utmost precision and clarity. Any shortcuts in these often lead to non-optimality, non-uniformity, inefficiency and wasteful use of resources in the long run. Also, the project must be phased such that activities are sequentially and/or concurrently initiated and completed as planned. Proper categorisation and sequencing of activities would ensure that due emphasis and efforts are given to various aspects.

The Hydrology Project has been implemented by most of the agencies to the satisfaction of all partners. However, it is apparent, retrospectively though, that there are certain factors which, if considered adequately, would have resulted in better implementation. Some of these factors are: (a) allowing adequate time period for preparation of standard specifications before initiation of procurement of sophisticated equipment, (b) accounting for longer time required for standard government procurement processes, (c) ensuring availability of infrastructural facilities before delivery of equipment, (d) synchronising training component with the availability of staff and computers in the offices and readiness of observation stations, (e) training existing staff for specialised jobs rather then expecting and waiting for recruitment of new staff in this era of slimming down government agencies.

The project has given a unique experience of standardising equipment specifications, setting uniform and standard data collection procedures, providing training in structured manner and implementing uniform and dedicated software for hydrological data processing and management at such a huge scale. However, rather then its successful implementation during the project period, it is more crucial to ensure continuance and sustenance of HIS activities, as prescribed under the project, in the future. Two major factors which may impede this continuity are the frequent transfers of government officials out of the project domain and lack of commitment from government side to continually provide adequate budgetary support.

7 Conclusions

In many countries, hydrological services receive inadequate funding to carry out even basic monitoring and assessment of national water resources. The situation is exacerbated by the existence of several monitoring networks with different purposes and standards; these are often independently operated. Computer archives are maintained on obsolete equipment or do not exist, and paper records are fast deteriorating, resulting in long gaps in records and unknown quality of data. This drastically reduces their value for planning, design, and management, restricting the ability of the nation to address the issues in the right perspective. Better (not necessarily more) information directly useful to data users in an open and participatory decision making process is urgently needed.

The expansion of water-development projects has slowed down in the recent past due to environmental and other considerations. The emphasis has shifted towards developments of management strategies that make optimal use of the existing infrastructure. The pre-requisite for any water resources developmental and management plan is the availability of a comprehensive, reliable and easily accessible hydrological information system. India has already established itself in the information technology area. There is no reason why this technology can't be extensively applied in the water sector. There are great challenges in the water sector and unless these are faced head-on with the best tools, a similar opportunity may not come in the foreseeable future.

The Hydrology Project is a concerted effort for improving and developing computerised hydrological data processing and management systems. It has promoted interaction between different state and central agencies and different states. The procedures of observation, processing and dissemination of water resources data have been standardised. Special attention has been paid to the critical elements such as institutional capacity building and establishment of Data User Groups to enable sustainability of the system on a long-term basis. It would only be fitting to carry the experience gained in the Hydrology Project to the remaining areas in India and other countries, at least these in the SAARC region.

EQUIPMENTS FOR WHICH DETAILED SPECIFICATIONS HAVE BEEN PROVIDED UNDER HP

S. NO. CATEGORY/NAME OF EQUIPMENT

1. HYDROLOGICAL EQUIPMENT

1.1 STAFF GAUGE
1.2 LEVEL INDICATOR TAPE
1.3 ELECTRICAL LEVEL INDICATOR TYPE
1.4 AWLR (FLOAT TYPE)
1.5 DWLR (PRESSURE TYPE)
1.6 DWLR (BUBBLER TYPE)
1.7 DWLR (FLOAT WITH SHAFT ENCODER)
1.8 CURRENT METER (CUP-TYPE)
1.9 CURRENT METER (PYGMY-TYPE)
1.10 CURRENT METER (PROPELLER TYPE)
1.11 ELECTROMAGENTIC – CURRENT METER FOR WADING USE
1.12 ELECTROMAGNETIC CURRENT METER
1.13 PULSE COUNTER
1.14 ELECTRONIC STOPWATCH
1.15 PORTABLE ECHO-SOUNDER
1.16 DISCHARGE MEASURING SYSTEM
1.17 ACOUSTIC DOPPLER CURRENT PROFILER
1.18 CABLE WAY
1.19 BRIDGE OUTFIT
1.20 BOAT OUTFIT
1.21 FRP BOAT
1.22 FRP CATAMARAN
1.23 ALUMINIUM BOAT
1.24 OUTBOARD ENGINE
1.25 BOAT TRAILER
1.26 STEEL BOAT
1.27 MOTOR LAUNCH
1.28 SUBMERSIBLE PUMP, PORTABLE
1.29 INTEGRATED BATHYMETRIC SYSTEM (FOR RESERVOIR SEDIMENTATION SURVEY)
1.30 HYDROGRAPHIC ECHO SOUNDER
1.31 SOUND VELOCITY CALIBRATOR

2. SEDIMENT EQUIPMENT

2.1 BED MATERIAL SAMPLER
2.2 POINT INTEGRATING BOTTLE
2.3 DEPTH INTEGRATING (HAND HELD)
2.4 DEPTH INTEGRATING (WINCH OPERATED)
2.5 VISUAL ACCUMALATION TUBE
2.6 ELECTRONIC PRECISION BALANCE
2.7 (TOP LOADED)
2.8 OPTICAL PARTICLE SIZER (PC CONTROLLED)
2.9 TEST SIEVES WITH SHAKER

3. METEOROLOGICAL EQUIPMENT

3.1 DIGITAL WEATHER STATION
3.2 COUNTER TYPE ANEMOMETER
3.3 WIND DIRECTION INDICATOR
3.4 RAIN GAUGE (NON RECORDING)

3.5 RAIN GAUGE (AUTOGRAPHIC SIPHON TYPE)
3.6 RAIN GAUGE (TIPPING BUCKET TYPE)
3.7 SUNSHINE RECORDER
3.8 LIQUID-IN-GLASS THERMOMETERS
3.9 THERMOGRAPH (BIMETALLIC TYPE)
3.10 HYDROGRAPH (HAIR STRING TYPE)
3.11 STEVENSON SCREEN
3.12 EVAPORIMETER (US CLASS A PAN)

4. WATER QUALITY EQUIPMENT

4.1 ANALYSIS KIT WQ FIELD MEASUREMENTS (PORTABLE)
4.2 STERLISER, AUTOCLAVE
4.3 ANALYTICAL BALANCE (ELECTRONIC)
4.4 ANALYTICAL BALANCE (MECHANICAL)
4.5 ANALYTICAL BALANCE (ELECTRONIC-HIGH ACCURACY)
4.6 CENTRIFUGE
4.7 COD DIGESTOR (OPEN REFLUX)
4.8 CONDUCTIVITY METER (DIGITAL)
4.9 DEEP FREEZER
4.10 DISSOLVED OXYGEN METER (PORTABLE)
4.11 SAMPLER (DISSOLVED OXYGEN)
4.12 DISTILLATION APPRATUS (CYANIDE)
4.13 DISTILLATION APPRATUS (FLUORIDE)
4.14 FILTRATION ASSEMBLY FOR MEMBRANE FILTERS
4.15 FLAME PHOTOMETER (MICROPORCESSOR BASED)
4.16 FUME CUPBOARD
4.17 GAS CHROMOTOGRAPH (PC-CONTROLLED)
4.18 INCUBATOR (BACTERIOLOGICAL)
4.19 INCUBATOR (BOD)
4.20 ION METER
4.21 DIGESTION AND DISTILLATION UNIT, KJELDAHI
4.22 pH METER (DIGITAL)
4.23 pH METER (FIELD-PORTABLE)
4.24 SHAKER (OSCILATORY)
4.25 SILTO METER
4.26 SOXHLET EXTRACTION UNIT
4.27 SPECTROPHOTOMETER (ATOMIC ABSORPTION)
4.28 SPECTROPHOTOMETER (UV VISIBLE – PC CONTROLLED)
4.29 SPECTROPHOTOMETER (UV VISIBLE – MANUAL)
4.30 THERMOMETERS (SET OF)
4.31 TURBIDY METER (NEPHELOMETER)
4.32 WATER BATH (BACTERIOLOGICAL)
4.33 WATER BATH (GENERAL PURPOSE)
4.34 WATER PURIFIER (DISTILLATION UNIT – AUTOMATIC)
4.35 WATER PURIFIER (DOUBLE DISTILLATION UNIT)
4.36 WATER PURIFIER (ION EXCHANGE REISN COLUMN)
4.37 TOC ANALYSER (MICROPROCESSOR CONTROLLED)
4.38 MICROWAVE DIGESTOR (MICROPROCESSOR CONTROLLED)
4.39 WATER PURIFIER (REVERSE OSMOSIS AND ION EXCHANGE)
4.40 CONDUCTIVITY METER (FIELD – PORTABLE)
4.41 GAS CHROMOTOGRAPH
4.42 LAMINAR FLOW

5. AUTOMATION AND COMMUNICATION

5.1 PERSONAL COMPUTER (PENTIUM IV)
5.2 LAPTOP PC
5.3 SERVER WITH RAID DISK
5.4 NETWORKING
5.5 LASER PRINTER (B/W 8 AND 16 PPM) A4 SIZE
5.6 LOW VOLUME INKJET PLOTTER

5.7 COLOUR LASER PRINTER (A4 SIZE)
5.8 SCANNER
5.9 DIGITISER
5.10 CD WRITER
5.11 DAT TAPE DRIVE
5.12 UPS (I AND 5 KVA)
5.13 WIRELESS SET
5.14 VHF FM TRANSDUCER (WALKIE-TALKIE)
5.15 POWER SUPPLY FOR TRANSRECEIVER

6. SURVEY EQUIPMENT

6.1 COMPOSS
6.2 THEODOLITE
6.3 LEVELLING STAFF
6.4 AUTO LEVEL
6.5 DIGITAL LEVEL
6.6 LASER DISTANCE METER
6.7 TOTAL STATION
6.8 GPS L1 RECEIVER
6.9 DIFFERNTIAL GPS

TRAINING COURSES DEVELOPED AND ORGANISED UNDER HP

S. NO. TRAINING COURSES

1. DATA COLLECTION PROCEDURES

1.1 DATA COLLECTION AT RAINFALL STATIONS
1.2 DATA COLLECTION AT FULL CLIMATIC STATIONS
1.3 HYDROMETRY FOR HELPERS
1.4 HYDROMETRY FOR GAUGE READERS/OBSERVERS
1.5 HYDROMETRY FOR SUPERVISORS
1.6 GROUNDWATER DATA COLLECTION
1.7 O & M OF AWLR/DWLR
1.8 O & M OF BANK OPERATED CABLE WAYS
1.9 SEDIMENT EQUIPMENT – SAMPLING AND MAINTENANCE
1.10 O & M OF RESERVOIR SEDIMENTATION SURVEY EQUIPMENT

2. WATER QUALITY SAMPLING AND ANALYSIS PROCEDURES

2.1 WQ SAMPLING AND FIELD PARAMETERS
2.2 WQ ANALYTICAL PROCEDURES
2.3 ANALYTICAL PROCEDURES FOR POLLUTION RELATED PARAMETERS
2.4 ADVANCE WQ EQUIPMENT (AAS, GC, UV-VIS)
2.5 WQ LABORATORY MANAGEMENT
2.6 LABORATORY NETWORKING AND ANALYTICAL QUALITY CONTROL

3. HYDROLOGICAL DATA ENTRY AND PROCESSING

3.1 SURFACE WATER DATA ENTRY SYSTEM
3.2 BASIC SW DATA PROCESSING (HYMOS)
3.3 ADVANCE SW DATA PROCESSING (HYMOS)
3.4 WQ DATA ENTRY SYSTEM (SWDES)
3.5 WQ DATA PROCESSING
3.6 GROUNDWATER DATA ENTRY (GWDES)
3.7 DWLR DATA ANALYSIS
3.8 GROUNDWATER DATA PROCESSING (UNDER PREPARATION)
3.9 GEOGRAPHICAL INFORMATION SYSTEM
3.10 REMOTE SENSING APPLICATIONS

4. IT & HIS MANAGEMENT

4.1 BASIC COMPUTER OPERATIONS
4.2 MS OFFICE
4.3 COMPUTER SYSTEM MANAGEMENT
4.4 DATABASE ADMINISTRATION (ORACLE, VB)
4.5 HIS OPERATIONALISATION WORKSHOP (SW & GW)
4.6 HIS MANAGEMENT TRAINING
4.7 HIS DATABASE ADMINISTRATION

5. POST GRADUATE TRAINING AND STUDY TOURS

5.1 BASIC HYDROLOGY COURSE
5.2 POST GRADUATE HYDROLOGY COURSE
5.3 STUDY TOURS IN INDIA (VISITS TO FIELD, DATA CENTRES & WQ LABORATORIES)
5.4 OVERSEAS TRAINING AND STUDY TOURS

TRAINING MODULES PREPARED UNDER HP

S.NO.	TRAINING MODULES
	WATER QUALITY DOMAIN
1	BASIC WATER QUALITY CONCEPTS
2	BASIC CHEMISTRY CONCEPTS
3	GOOD LABORATORY PRACTICES
4	HOW TO PREPARE STANDARD SOLUTIONS
5	HOW TO MEASURE COLOUR, ODOUR AND TEMPERATURE
6	UNDERSTANDING HYDROGEN ION CONCENTRATION (PH)
7	HOW TO MEASURE PH
8	UNDERSTANDING ELECTRICAL CONDUCTIVITY
9	HOW TO MEASURE ELECTRICAL CONDUCTIVITY
10	HOW TO MEASURE DISSOLVED, SUSPENDED AND TOTAL SOLIDS
11	CHEMISTRY OF DISSOLVED OXYGEN MEASUREMENT
12	HOW TO MEASURE DISSOLVED OXYGEN (DO)
13	HOW TO SAMPLE SURFACE WATER FOR WATER QUALITY ANALYSIS
14	HOW TO SAMPLE GROUNDWATER FROM BORE-WELLS FOR WQ ANALYSIS
15	UNDERSTANDING BIOCHEMICAL OXYGEN DEMAND TEST
16	UNDERSTANDING DILUTION AND SEEDING PROCEDURES IN BOD TEST
17	HOW TO MEASURE BIOCHEMICAL OXYGEN DEMAND
18	UNDERSTANDING CHEMICAL OXYGEN DEMAND TEST
19	HOW TO MEASURE CHEMICAL OXYGEN DEMAND (COD)
20	INTRODUCTION TO MICROBIOLOGY
21	MICROBIOLOGICAL LABORATORY TECHNIQUES
22	COLIFORMS AS INDICATOR OF FAECAL POLLUTION
23	HOW TO MEASURE COLIFORMS
24	BASIC AQUATIC CHEMISTRY CONCEPTS
25	OXYGEN BALANCE IN SURFACE WATERS
26	BASIC ECOLOGY CONCEPTS
27	SURFACE WATER QUALITY PLANNING CONCEPTS
28	MAJOR IONS IN WATER
29	ADVANCED AQUATIC CHEMISTRY: SOLUBILITY EQUILIBRIA
30	ADVANCED AQUATIC CHEMISTRY CONCEPTS: REDOX EQUILIBRIA
31	BEHAVIOUR OF TRACE COMPOUNDS IN AQUATIC ENVIRONMENT
32	POTENTIOMETRIC ANALYSIS
33	USE OF ION SELECTIVE PROBES
34	ABSORPTION SPECTROSCOPY
35	EMISSION SPECTROSCOPY AND NEPHELOMETRY
36	HOW TO MEASURE FLUORIDE
37	HOW TO MEASURE NITROGEN - NITRATE BY UVS AND CD REDUCTION METHOD
38	HOW TO MEASURE NITROGEN, AMMONIA AND ORGANIC
39	HOW TO MEASURE NITROGEN, AMMONIA BY DIRECT PHENATE METHOD
40	HOW TO MEASURE CHLOROPHYLL
41	HOW TO MEASURE PHOSPHORUS
42	HOW TO MEASURE BORON

43 HOW TO MEASURE IRON
44 HOW TO MEASURE SODIUM
45 HOW TO MEASURE SULPHATE
46 HOW TO MEASURE SILICATE
47 INTRODUCTION TO ADVANCED INSTRUMENTAL ANALYSIS – AAS
48 PERFORMING ANALYSIS BY AAS – GETTING STARTED
49 INTRODUCTION TO ADVANCED INSTRUMENTAL ANALYSIS – GC
50 PERFORMING ANALYSIS BY GC - GETTING STARTED

SURFACE WATER DOMAIN

1 UNDERSTANDING HIS CONCEPT AND ITS SET-UP
2 UNDERSTANDING DATA PROCESSING ACTIVITIES UNDER HIS
3 UNDERSTANDING DATA PROCESSING PLAN
4 DIFFERENT TYPES AND FORMS OF DATA IN HIS
5 HOW TO RECEIVE DATA AT DIFFERENT LEVELS
6 HOW TO ORGANISE DATA INTO TEMPORARY DATABASES
7 HOW TO MAKE DATA ENTRY FOR RAINFALL DATA
8 HOW TO CARRY OUT PRIMARY VALIDATION FOR RAINFALL DATA
9 HOW TO CARRY OUT SECONDARY VALIDATION OF RAINFALL DATA
10 HOW TO CORRECT AND COMPLETE RAINFALL DATA
11 HOW TO COMPILE RAINFALL DATA
12 HOW TO ANALYSE RAINFALL DATA
13 HOW TO REPORT ON RAINFALL DATA
14 HOW TO PROCESS EVAPORATION DATA
15 HOW TO MAKE DATA ENTRY OF CLIMATIC DATA
16 HOW TO CARRY OUT PRIMARY VALIDATION OF CLIMATIC DATA
17 HOW TO CARRY OUT SECONDARY VALIDATION OF CLIMATIC DATA
18 HOW TO CORRECT AND COMPLETE CLIMATIC DATA
19 HOW TO ANALYSE CLIMATIC DATA
20 HOW TO REPORT ON CLIMATIC DATA
21 HOW TO MAKE DATA ENTRY FOR WATER LEVEL DATA
22 HOW TO CARRY OUT PRIMARY VALIDATION OF WATER LEVEL DATA
23 HOW TO CARRY OUT SECONDARY VALIDATION OF WATER LEVEL DATA
24 HOW TO CORRECT AND COMPLETE WATER LEVEL DATA
25 HOW TO ANALYSE WATER LEVEL DATA
26 HOW TO REPORT ON WATER LEVEL DATA
27 HOW TO MAKE DATA ENTRY AND PROCESSING OF FLOW MEASUREMENT DATA
28 HOW TO CARRY OUT PRIMARY VALIDATION OF STAGE-DISCHARGE DATA
29 HOW TO FIT RATING CURVE TO STAGE-DISCHARGE DATA
30 HOW TO VALIDATE RATING CURVE
31 HOW TO EXTRAPOLATE RATING CURVE
32 HOW TO CARRY OUT SECONDARY VALIDATION OF STAGE-DISCHARGE DATA
33 HOW TO REPORT STAGE-DISCHARGE DATA
34 HOW TO COMPUTE DISCHARGE DATA
35 HOW TO CARRY OUT PRIMARY VALIDATION OF DISCHARGE DATA
36 HOW TO CARRY OUT SECONDARY VALIDATION OF DISCHARGE DATA
37 HOW TO DO HYDROLOGICAL DATA VALIDATION USING REGRESSION
38 HOW TO DO HYDROLOGICAL DATA VALIDATION USING HYDROLOGICAL MODEL
39 HOW TO CORRECT AND COMPLETE DISCHARGE DATA
40 HOW TO COMPILE DISCHARGE DATA

41 HOW TO ANALYSE DISCHARGE DATA
42 HOW TO REPORT ON DISCHARGE DATA
43 HOW TO TRANSFER RAW AND PROCESSED DATA SETS BETWEEN TEMPORARY DATABASES
44 HOW TO TRANSFER RAW AND PROCESSED DATA SETS FROM TEMPORARY TO PERMANENT DATABASES

Appendix D

Manuals Produced under the Hydrology Project (Same as HP Library)

Appendix E

LIST OF REPORT AND MANUALS

NETWORK AND EQUIPMENT: SURFACE WATER

1. NETWORK DESIGN FOR RIVER FLOW MEASUREMENTS FOR ALL STATES (JULY 1997)
2. GUIDELINES FOR SW SITE SELECTION AND INSTALLATION PLANNING (DECEMBER 1998)
3. SPECIFICATIONS OF SW EQUIPMENT (UPDATED AS REQUIRED)
4. MODEL BIDDING DOCUMENT AND SPECIFICATIONS FOR PROCUREMENT OF DWLR (MARCH 1998)
5. DESIGN OF BANK-OPERATED CABLEWAYS (OCTOBER 1998)
6. MODEL BIDDING DOCUMENT FOR BANK-OPERATED CABLEWAYS (OCTOBER 1999)
7. BIDDING DOCUMENT FOR PROCUREMENT OF RESERVOIR BATHYMETRY SYSTEMS (APRIL 2000)
8. HIS MANUAL (JANUARY 2001)
9. SW MONITORING; PROCEDURES FOR OPERATION AND MAINTENANCE NORMS (FEBRUARY 2001)

NETWORK AND EQUIPMENT: GROUNDWATER

1. POSITIONING AND LEVELLING OF OBSERVATION WELLS TO GEOGRAPHICAL AND MSL (JUNE 1997)
2. SPECIFICATIONS OF GW EQUIPMENT
3. SPECIFICATION FOR DWLR EQUIPMENT (FEBRUARY 1998)
4. MODEL BIDDING DOCUMENTS FOR DWLR EQUIPMENT (MARCH 1998)
5. GUIDELINES FOR IMPLEMENTATION OF PIEZOMETERS (JULY 1998)
6. MANUAL ON DWLR OPERATION, MAINTENANCE AND DATA USE (JANUARY 1999)
7. DWLR SPECIFICATIONS AND ACCEPTANCE PROTOCOL (CHENNAI WORKSHOP, SEPTEMBER 1998)
8. REDUCED LEVELS OF MONITORING NETWORK STATIONS (DECEMBER 1998)
9. MANUAL FOR DRILLING OF LITHO-SPECIFIC PIEZOMETERS (UPDATE IN 2001)

NETWORK AND EQUIPMENT: WATER QUALITY

1. GUIDELINES FOR LABORATORY DESIGN (VOLUME I, DECEMBER 1996)
2. SURFACE WATER QUALITY NETWORK DESIGN GUIDELINES (JUNE 1997)
3. GROUNDWATER QUALITY MONITORING: OBJECTIVES, NETWORK DESIGN, DATA ACQUISITION (MARCH 1998)
4. NETWORKS AND MANDATES OF WATER QUALITY MONITORING (JANUARY 1999)
5. SPECIFICATIONS OF LABORATORY EQUIPMENT (UPDATED AS REQUIRED)

DATA COLLECTION: SURFACE WATER

1. STANDARDS FOR COLLECTION, STORAGE AND PROCESSING OF SW DATA (JUNE 1997)
2. TRAINING MODULES FOR SURFACE WATER AND HYDRO-METEOROLOGICAL DATA COLLECTION
3. HIS MANUAL (JANUARY 2001)

DATA COLLECTION: GROUNDWATER

1. MANUAL ON GW FIELD MEASUREMENTS (JANUARY 1997)
2. TRAINING MODULES FOR GW DATA COLLECTION
3. GIS – METHODOLOGY MANUAL (MARCH 2001)

DATA COLLECTION: WATER QUALITY

1. GUIDELINES FOR ANALYTICAL QUALITY CONTROL: AQC (MAY 1997)
2. GUIDELINES ON STANDARD ANALYTICAL PROCEDURES (SAP) FOR WATER ANALYSIS (MAY 1999)
3. PROTOCOL FOR WQ MONITORING (AUGUST 1999)

4. WQ SAMPLING AND LABORATORY ANALYSIS TRAINING MODULES (50 TITLES AVAILABLE)
5. WORKBOOK ON OPERATION OF ATOMIC ABSORPTION SPECTROPHOTOMETER (MARCH 2001)
6. WORKBOOK ON ANALYSIS OF PESTICIDES IN WATER SAMPLES BY GAS CHROMATOGRAPHY (JAN.'01)
7. HIS MANUAL (JANUARY 2001)
8. MAINTENANCE NORMS AND LOGBOOKS FOR WQ LABORATORIES (FEBRUARY 2001)

DATA ENTRY: SURFACE WATER

1. SURFACE WATER DATA ENTRY SYSTEM SOFTWARE SWDES (REGULAR UPDATES)
2. SWDES USER MANUAL (REGULAR UPDATES)
3. SWDES TRAINING MODULES (OCTOBER 1999 AND UPDATED)

DATA ENTRY: GROUNDWATER

1. GROUND WATER DATA ENTRY SYSTEM SOFTWARE GWDES (REGULAR UPDATES)
2. GWDES USER MANUAL (REGULAR UPDATES)

DATA ENTRY: WATER QUALITY

1. SWDES SOFTWARE EXTENSION FOR WQ PARAMETERS (JANUARY 2001)
2. GWDES SOFTWARE EXTENSION FOR WQ PARAMETERS (MARCH 2001)

DATA PROCESSING: SURFACE WATER

1. LAY-OUT AND STAFFING OF DATA PROCESSING CENTERS (MARCH 1998)
2. REVIEW OF STANDARDS FOR COLLECTION, STORAGE AND PROCESSING OF SW DATA (JUNE 1997)
3. SPECIFICATIONS FOR DEDICATED SW DATA PROCESSING SOFTWARE (DECEMBER 1997)
4. CUSTOMISED HYMOS SOFTWARE (IMPLEMENTATION FROM NOVEMBER 1999 ONWARDS)
5. BASIC HYMOS TRAINING MODULES (38 TITLES) (NOVEMBER 1999)
6. ADVANCED HYMOS TRAINING MODULES (6 TITLES) (JANUARY 2001)
7. HIS MANUAL (JANUARY 2001)
8. EXAMPLE YEAR BOOK (2001)

DATA PROCESSING: GROUNDWATER

1. LAY-OUT AND STAFFING OF DATA PROCESSING CENTRE (MARCH 1998)
2. APPROACH TO COMPUTERISATION OF GW DATA UNDER THE HP (JULY 1997)
3. STANDARDS FOR GW DATA ACQUISITION, PROCESSING AND DISSEMINATION (MARCH 1997)
4. SPECIFICATIONS AND TENDER DOCUMENTS FOR DEDICATED GW DATA PROCESSING 5. SOFTWARE AND HARDWARE (JANUARY 1998)
5. APPLICATION GUIDELINES FOR GW DATA PROCESSING, INCL. RESOURCE EVALUATION (NOV. 1998)
6. TRAINING MODULES FOR GW DWLR DATA HANDLING (MARCH 2000)
7. EXAMPLE YEAR BOOK (EARLY 2001)

DATA PROCESSING: WATER QUALITY

1. HIS MANUAL (JANUARY 2001)

DATA STORAGE AND DISSEMINATION

1. LAYOUT AND STAFFING OF DATA STORAGE CENTRES (MARCH 1998)
2. PROVISIONAL DATA DICTIONARY FOR THE DATA BASE SYSTEM (JANUARY 1998)
3. HARDWARE AND SOFTWARE SPECIFICATIONS FOR DATA STORAGE CENTRES (JUNE 2000)
4. BIDDING DOCUMENT FOR PROCUREMENT OF DATA STORAGE SOFTWARE (OCTOBER 2000)

DATA USER ESTABLISHMENT

1. MODEL HIN DOCUMENT (2001)
2. QUESTIONNAIRE HYDROLOGY INFORMATION NEEDS (UPDATED IN 2000)
3. TERMS OF REFERENCE FOR HDUG (JANUARY 2000)

APPLIED HIS STUDIES

1. MODEL FORMAT FOR R&D STUDY PROPOSALS (MARCH 1998)
2. FLOOD FORECASTING MODELING AND TELEMETRY IN THE BRAHMANI AND BAITARANI RIVER BASINS (NOVEMBER 1998)
3. HIS-WRM APPLICATION STUDY FOR SABARMATI BASIN (STARTED IN APRIL 2000)

HIS MANAGEMENT: ORGANIZATIONAL

1. HIS DESCRIPTION, MISSION STATEMENT & PRESENTATION PACKAGE (LATEST UPDATE: JULY 1999)
2. AGENCY HIDAPS (1998/1999) AND MODEL HIDAP (JUNE 1998)
3. DETAILED ORGANIZATIONAL ASSESSMENTS MAHARASHTRA SW & GW DEPARTMENTS (1999)
4. DETAILED ORGANIZATIONAL ASSESSMENTS ANDHRA PRADESH SW & GW DEPARTMENTS (1999)
5. DETAILED ORGANIZATIONAL ASSESSMENTS TAMIL NADU SW & GW DEPARTMENTS (1999)

HIS MANAGEMENT: HUMAN RESOURCE DEVELOPMENT AND TRAINING

1. STAFF REQUIREMENTS AND JOB DESCRIPTIONS FOR ALL HIS OPERATIONS (APRIL 1998)
2. DETAILED STAFFING PLANS FOR ALL AGENCIES (1998 ONWARDS)
3. TRAINING CO-ORDINATION TASKS (1997)
4. TRAINING MANAGEMENT WORKSHOP SCENARIO FOR IN-HOUSE TRAINERS AND CO-ORDINATORS (1998)
5. TRAINING TARGETS, IMPLEMENTATION PLANS AND BUDGETS FOR FY 1999 - 2000 (APRIL 1999).
6. TRAINING TARGETS, IMPLEMENTATION PLANS AND BUDGETS FOR FY 2000 - END OF PROJECT (MAY'00).
7. CATALOGUE OF POSTGRADUATE TRAINING IN INDIA (APRIL 1999, APRIL 2000 ETC)
8. CATALOGUE OF STUDY TOUR LOCATIONS IN INDIA (APRIL 1999, APRIL 2000 ETC)
9. DIRECTORY OF HP IN-HOUSE TRAINERS AND FACULTY (SEPTEMBER 1998, ANNUALLY UPDATED)
10. DIRECTORY OF HP TRAINING INSTITUTES (SEPTEMBER 1998, ANNUALLY UPDATED)
11. COURSE SPECIFICATIONS FOR ALL PROJECT TRAINING (MARCH 98, REGULARLY UPDATED)
12. TRAINING HISTORY (REGULAR COMPILATION AND DISTRIBUTION FROM NOVEMBER 1997 ONWARDS)
13. TRAINING OF TRAINERS MODULES (4 TITLES, SINCE 1997)
14. TRAINING SUSTAINABILITY CONCEPTS, WORKSHOP SCENARIO AND FINDINGS (MARCH 1999)
15. OVERSEAS TRAINING AND STUDY TOUR PROGRAMS AND SUBCONTRACTS (1998, 1999)
16. HUMAN RESOURCE REQUIREMENT FOR WATER QUALITY SAMPLE ANALYSIS IN HP-LABORATORIES (JANUARY 2001).

HIS MANAGEMENT: MIS DEVELOPMENT AND REPORTS

1. MIS-1 DEVELOPMENT: CONSOLIDATION OF HP MONITORING CONCEPTS (1998)
2. MIS-1 DEVELOPMENT: SW AND GW REPORTING FORMATS ON PROJECT PROGRESS (SEPTEMBER 1998)
3. MIS-1 DEVELOPMENT: SYSTEM MANUAL AND USER GUIDE (1998)
4. MIS-1 REPORTS: PROJECT PROGRESS REPORTS (QUARTERLY)
5. MIS-1 / HIDAP REPORTS: PROGRESS AGAINST SELECTED PERFORMANCE INDICATORS (1999/2000)
6. MIS-1 / HIDAP REPORTS: ABBREVIATED ASSESSMENTS (JAN. 1999, JAN. 2000)
7. MIS-2 DEVELOPMENT: EXECUTIVE BALANCED HIS SCORECARD FORMATS (DEC. '99)

8. MIS-2 DEVELOPMENT: USER MANUAL FOR MIS/GIS DATA ENTRY SOFTWARE (MAY 1999)
9. MIS-2 DEVELOPMENT: AGENCY PERFORMANCE INDICATORS AND REPORTING FORMATS (APRIL 2000)
10. MIS-2 DEVELOPMENT: MILESTONE PLANNING AND REVISED PHYSICAL/FINANCIAL TARGETS FOR 2000-2001 FOR ALL AGENCIES (APRIL 2000)
11. MIS-2 REPORT: PROJECT PROGRESS REPORTS (QUARTERLY FROM 2ND QUARTER 2000)

HIS MANAGEMENT: PUBLIC RELATIONS

1. QUARTERLY NEWSLETTER (FROM 1998 ONWARDS)
2. CONTRIBUTIONS TO THIRD PARTY SEMINARS AND CONFERENCES (ONGOING)
3. WEB SITE AND HP LEAFLET (2000 ONWARDS)