

Hydrology Project

Specification for Dedicated Hydrological Surface Water Data Processing Software

(Draft Document)

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1 Introduction

The objective of the Hydrology Project (India) is to establish a Hydrological Information System (HIS) covering surface water and groundwater quantity and quality data for State and Central agencies for the eight participating peninsular States of the country. An HIS comprises the physical infrastructure and human resources required to sense, collect, process, validate, store and disseminate these data. The physical infrastructure includes observation networks, communication systems, laboratories and data entry, processing and storage centres. Efficiency requires that all activities in the HIS are well tuned to each other, whereas consistency and exchangeability of data demands the use of compatible tools and standardised techniques and procedures.

An HIS provides information on the spatial and temporal characteristics of water quantity and quality variables/parameters describing the water resources/water use system. This information should be tuned to the needs of decision/policy makers, designers and researchers to be able to take decisions, to design or to study the water resources system at large or its components. The establishment of a demand-oriented and reliable HIS requires upgrading and expansion of the physical infrastructure and adoption of standard tools, techniques and procedures. An important activity in the HIS is to efficiently generate reliable information from the collected raw data. This is ensured by bringing the raw data on to the magnetic media and subsequently employing quality checks, carrying out necessary processing activities and finally reporting the information in a most suitable manner.

As such, it is envisaged to have several Data Entry Centres at the lowest level of the system which corresponds to the Sub-Divisional Offices of the State Surface Water Departments (here-in-after referred to as State Agencies) and the Central Water Commission (here-in-after referred to as Central Agency). Further in the system there are Divisional Data Centres which corresponds to the Divisional offices of the State and Central agencies. For the State agencies, it is envisaged to have a State Data Processing Centre which will correspond to the State Level. Similarly, for the Central agency a Regional Data Processing Centre is envisaged at its Regional Offices. The raw data collected at the observation stations would undergo the necessary processing cycle in these three types of Data Centres. Finally, the fully processed data would be properly stored separately in the State Data Storage Centres and Regional Data Storage Centres of State and Central agencies. The Data Storage Centres are to provide the library function only where no further processing is carried out.

Thus for each State and Central agency the following centres in relation to the HIS are to be established:

- Several Data Entry Centres where field data are entered and receive primary validation,
- Several Divisional Data Centres where secondary validation is carried out,
- A Data Processing Centre where comprehensive validation and reporting takes place, and
- A Data Storage Centre to store field and processed data from the state and central agencies working within the state.

For accommodating all the temporary data storage and carrying out all necessary processing activities in the Data Entry, Divisional and State or Regional Data Processing Centres a comprehensive hydrological software system is required.

This specification relates to the requirements for a dedicated hydrological surface water data processing software used at/for:

- **the Data Entry Centres for data entry and primary validation of data,**
- **the Divisional Data Centres for secondary data validation,**
- **the Data Processing Centres for final validation and reporting of processed data,**
- **data transfer between Data Entry Centres and the Divisional Data Centres,**
- **data transfer between Divisional Data Centres and Data Processing Centre, and**
- **data transfer between the Data Processing Centre and the Data Storage Centre.**

To facilitate transfer, the software at Data Entry Centres and Divisional Data Centres are required to be compatible with the software at the Data Processing Centre.

It is to emphasis here that this document does not include the software required for the Data Storage Centres at the State and Central agencies.

2 Application Software

2.1 Objectives

The **Application Software** is expected to facilitate data entry, processing, validation and dissemination of periodic reports, under an integrated software environment that comprises a database and application tools including GIS tools. The system needs to have a modular structure adjustable to the functions carried out at the different levels; a comprehensive package at central offices and headquarters and partial packages for lower level centers.

2.2 Approach

Data entry, processing, validation and dissemination under the HIS are supposed to be carried out and controlled at various types of Data Centers through a dedicated hydrological surface water data processing software system. The requirements for such software are determined by the type and amount of data, by the processing procedures and by the information required by users (State and Central agencies and private sector).

The present section enlists the requirements and specifications for a comprehensive software package to be installed in State SW data processing centers, its divisional and sub-divisional units as well at the national, regional, divisional and sub-divisional offices of the CWC. The comprehensive package will have open architecture using internationally available commercial packages without any proprietary tools. The user interface is to be developed by well known languages and tools. The software will follow an approach that embraces an integrated software environment with standard compatible components and operational procedures. As selected components of the package would be installed at different data processing centers, a modular structure of the package is essential.

2.3 Application Software Requirements

The requirements and specifications for the software package that includes a database, GIS tools and application tools, are presented along the following headings:

- **General requirements**
- **Database requirements**
- **Data types**
- **Data entry and editing**
- **Data validation**
- **Data correction**
- **Data processing and analysis**
- **Data reporting**
- **Data transfer and retrieval**

2.3.1 General Requirements

The items addressed under this heading present general requirements for software and hardware. They describe the working environment requirement, the hardware and software platform support as follows :

- **Hardware platforms** - The software must be supported by commonly used hardware platforms such as : industry standard IBM compatible PCs. The hardware requirements are software-dependent, and therefore, the Bidder will specify the hardware platforms and all peripheral equipment required for the use of the software system. The specifications for hardware will include: CPU requirements, central memory, disk space, and all other technical requirements so as to provide adequate response-time for the users in all operations to be carried out at various data centers - Subdivision Data Centers, Divisional Data Centers and State Data Processing Center in each State and Central agency.
- **Working environment** - The Operating Systems and tools will be based on Client/Server architecture. The software is to operate on the standard working environment and operating systems of MicrosoftTM Windows NT or Windows 95/97. The Bidder will specify the Operating Systems supporting the proposed software, suggesting the operating and maintenance tools required for operation and maintenance of each type of data centers, indicating the Bidder preference based on “value for money” principle. The operating systems specification will include the specific type of operating system required for the database as well as the different “clients” according to the functions carried out different types of data centres
- **Database Tools** - The Bidder will specify the database tools supported and required by the proposed software indicating his preference for the tools based on “value for money” principle. The proposal will include all the database features and tools required for the users, according to the functions of different types of data centres, as part of the software system. The database tools are to be Scalable and open (confirming to ODBC standard and industry standard RDBMS package to be used at Data Storage Centres), and as such fit to all the working environment as well as adaptable for future changes in hardware and software platforms
- **Development tools** - The development tools are to be based on standard application development tools and languages of the leading vendors in the market and industry standards such as C, C++, Visual Basic or other much used and well established programming languages and 4GL (4 Generation Languages) tools. The Bidder will specify the application development tools and programming languages supported and used by the software. The proposal will include all the software features and tools required and used in the software (run-time or other modules if required, such as: report and queries generation tools, programming languages, etc.). All the tools are to be integral part of the proposed software system.
- **Administration, Management and Maintenance Tools** - The Bidder will specify the management tools (database, software administration and configuration) required for the software system management at the various data processing centers, according to the working environment. The proposal will include all the necessary administration, maintenance, and management features and tools required at each type of the data centers.
- **Data Security** - The Bidder will specify the data security standards supported by the software system (database, GIS tools and features), which will be supplied as part of the software. The data security features should comply with the working environment at different types of data centres.
- **Working environment** - The State/Regional Data Processing Centers will be based on Local Area Network (LAN) environment with 6-9 users. Divisional Data Centres would be based on LAN with 2 users or on stand alone environment. All the Sub-Divisional offices will be based on stand alone environment. The application software should be **Scalable** and **Uniform** in all the environments.
- **Communication requirements** - Data will be transferred periodically from lower level to higher level office (subdivision to divisional, divisional to state, etc.). Processed data and feed back will be

transferred periodically from higher level to lower level offices pertaining to respective stations under different offices. The data transfer will be conducted through standard communication means (such as: satellite link, dial-up lines or dedicated lines etc.) where available, or by other means (such as: floppy disk, cartridge, etc.) where communication lines are not available. The Bidder will specify the hardware and software communication requirements, and suggest network tools, protocols, security measurements, to be used for data transfer, communication administration and management. All the application software features which are required for communicating between the centers, will be supplied as part of the proposal (excluding network operating systems and tools required, if any).

- **Addition of User modules** - Facility to include user-friendly software interface for addition of user-developed modules must be available as an integral part of the software.
- **Initiation and Integration of external software** - A screen menu for initiation of standard external software processing systems such as EXCEL or GIS software (e.g. Arcinfo) and data exchange with them using clipboard etc. must be available.
- **Gregorian Calander and Year 2000 Compliance** - The software system should follow the Gregorian Calender and be “Year 2000” compliant i.e. all the year fields must include 4 digits. The historical existing data which is of the “two digit” year structure will be converted to full 4 digit year, by the software in the importing process.
- **Drivers for peripherals** - Built-in standard drivers for peripherals such as scanners, printers, plotters and digitisers etc. must be available. Support for HP-GL2 and other HP device drivers must be ensured.
- **Ease of Use** - The software should be easy to learn, intuitive, easy to customise and adjustable to the agency’s needs. A menu-driven help facility must be available.
- **On-line help** - There should be a comprehensive on-line help available for each feature of the software while running it. The complete software documentation should be available on-line with context sensitive help. An animated tutorial for the operation of various modules must also be available on-line for the users.
- **Open and portable (database independent)** - It must be possible to work with various databases and software tools. The software should ensure easy transfer/exchange of data with other database systems.
- **Flexible and modular system** - The system must have a modular strucure which is easily adapted to different environments, flexible to changes or addition of new modules features or functions.
- **Performance** - The software must ensure satisfactory and adequate response times for users in LAN and stand alone environment (both in interactive and batch processing).

2.3.2 Database Requirements

The Dedicated Hydrological Surface Water Data Processing Software would include temporary databases. From these temporary databases the data would be transfered to the industry standard database management system to be made available at each of the Data Storage Centres. The Dedicated Hydrological Surface Water Data Processing Software databases must be structured to ensure data security, integrity, portability and easy maintenance. The system must include:

- A module for establishment and administration of user authorisation - to permit access for authorised users only based on security checks at log-on through username, password, etc.. The users authorisation table has to be kept encrypted.
- Different levels of authorisation, including read, write, edit and special supervisory privilege.
- Simple maintenance modules for database management, back-up and recovery to be used by office personnel (no need for system specialist). A backup strategy shall be maintained and automated

through a hidden logged file. The operator may be forced to take up backups after certain period of times.

- Data integrity function to avoid data corruption and losses.
- Data security and control over access especially in DOS and WINDOWS environment at the entry level to be appropriately provided for.
- The software has to provide for efficient archival facility of raw and processed data distinctly at various levels of data handling stages
- An activity log for audit purposes indicating the date/time, user and activity description.
- Facility to assess the work of individual users specially with respect to the volume of data entered.
- The ability to subdivide the database into basins or groups of basins with responsibility and authorisation for access restricted to named users.
- The database must efficiently operate on voluminous time series data
- The database must have ample capacity to handle all the data associated with the basins under analysis.
- The database must support efficient interfacing with the Data Storage Centre which would include an industry standard relational data base management system.

2.3.3 Data Types

The types of data required to be processed compiled and stored in the HIS include:

1. geographical or space oriented data, i.e. static or semi-static data on catchment features and hydraulic infrastructure
2. location oriented data, including static or semi-static data of the observation stations and hydraulic structures
3. time oriented data, covering equidistant and non-equidistant time series for all types of meteorological, water quantity, quality and sediment data, and
4. relation oriented data on two or more variables/parameters used with respect to meteorological, water quantity, quality and sediment data.

The various types of data are described below.

2.3.3.1 Geographical or Space Oriented Data

Geographical or space oriented data comprise static or semi-static data of the following kind:

- maps of basin features,
- basin descriptive data, and
- hydraulic infrastructure

Maps

Basin features to be stored in the form of maps related to geography, topography (contours), geology, land use, layout of hydraulic infrastructure, catchment boundaries, major administrative and political boundaries, measurement locations, location of structures, industries, etc. The system should have inbuilt GIS tools and also be compatible with commercial GIS-systems. Data are held in layers displayable either in single or multiple layers. Maps must be geographically referenced, and geographically-referenced measurement locations added to the database must be automatically added to the map base.

Basin descriptive data

Basin descriptive data include:

- tables of fixed sets of parameters describing linear, areal and relief aspects of the drainage basin and/or channel network, and
- text files comprising free text on relevant basin features.

Hydraulic infrastructure

Data on the hydraulic infrastructure comprise:

- historical records of survey data on longitudinal and cross-sectional profiles, displayable in graphical and tabular form,
- longitudinal profiles of a fixed set of hydraulic and geomorphologic characteristics of river bed and banks, displayable in graphical and tabular form

Generally, the user must have the option to create a standard template file for a group of parameters.

2.3.3.2 Location Oriented Data

These data comprise a wide range of static and semi-static information at point locations related to:

- observation stations, and
- hydraulic structures.

Observation stations

The software must have the facility to hold data of the following general types:

- **Identification name and code** - by which the station is identified in the catalogue.
- **Summary station data** - on location (e.g. latitude, longitude, altitude, river name, basin name, administrative & political regions and responsible agency), for which a facility must be available to group stations for reports.
- **Station description** - information comprises all relevant data about the site and its surroundings and may include:
 - * site, channel and control (hydraulic and morphological conditions) description
 - * station access
 - * benchmarks locations and levels
 - * facilities and equipment in use
 - * record of repair, maintenance and replacement of equipment
- **Station log** - information related to the interpretation, reliability and processing of a record over specified periods of time. The record can be held in a free format text file.
- **Survey records** - reference to survey data on longitudinal profiles and cross sectional profiles at and adjacent to the gauging station available under hydraulic infrastructure/space oriented data.
- **Catalogue of station series** - a listing of the time series available at a station including a descriptor, units, reference, time interval of measurement, acceptable minimum and maximum values, acceptable rate of rise and rate of fall, identification codes for faulty and missing data and start and end dates. The last dates must be automatically updated.

Hydraulic structures

Features of hydraulic structures (barrages, dams, inlet structures, outfalls, culverts, bridges, etc.) will be stored in a fixed set of parameters such as location, type, geometry, discharge characteristics, type of effluents, etc.

Generally, the user will have the option to create a standard template file for a group of parameters.

2.3.3.3 Time Oriented Data

The software must have the facility to store time oriented data of the following types :

- equidistant time series, and
- non-equidistant time series.

Equidistant time series

Records with a fixed time interval (or with a group of unequal time intervals which repeats in a perfect cyclic manner) are automatically time-labelled and facilities must be available to hold records for a measurement interval of 1 minute to 1 year. Such records must include all possible periodically-measured instantaneous observations (e.g. stage observations), accumulative observations over the time interval (e.g. daily rainfall) and average of observations (e.g. daily mean flow). Facility must be available to distinguish such records. The user must be free to choose an appropriate indicator for missing values.

Non-equidistant time series

Records taken with an unequally spaced time interval must be stored with an entered time label and include:

- event-based observations (e.g. occurrence of a 1 mm tip of a tipping bucket raingauge)
- threshold-based observations (e.g. occurrence of the change in a variable exceeding a specified magnitude).
- constant observations (e.g. gate levels with constant level or fixed number of pumps operating for specified time).

Facility must be available to convert event and threshold based observations to equidistant time series.

Provision must be available to flag the data with respect to whether it is original or estimated and with respect to its quality. These flags must be visible at the time of data validation and reporting.

2.3.3.4 Relation oriented data

The software must have the ability to store relation oriented data of the following kind:

- profile measurement data,
- sets of two or more quantities observed concurrently, and
- the parameters of the relationships between two or more quantities.

Profile measurement data

Profile measurement data include streamflow and sediment transport measurement data obtained by measuring at a number of points in the cross-section. The software shall be able to store the results of streamflow measurements according to the velocity area and float method. Similarly, the software should be able to accommodate for suspended and bed load transport measurement data.

Concurrent observations

Records of this type consist of a time label with two or more concurrently observed/computed quantities at a station, like current meter measurement summary data along with a flag for qualification.

Relationship parameters

These records store the parameters of a relation e.g. stage-relation curves, current meter ratings, stage-discharge rating curves. Not less than four equations must be available for a relation to cover the full range of the independent variable. The records must include a station name/instrument code, validity period of the relation, type of equation, equation boundaries, parameter values and summary error statistics for each equation. Facility for flagging a relationship for making a distinction between a good quality and a doubtful relationship must be available.

2.3.4 Data Entry and Editing

The software system must include user-friendly data entry screens and menus for all types of data mentioned above. Data entry screens for field data must fully resemble the standard layouts of the field note books. Facility must be available to prompt at faulty data entry of any value and reject them (e.g. alpha character in a numeric field, negative rainfall, day number above 31, etc.). The screen must have calculator functions associated with entry of numeric data. There should also be an option of entering a mathematical expression instead of a single value.

Facility must be available for entry of time series data from a variety of sources including:

- keyboard
- ASCII data held on computer disk file in fixed and free formats.
- digital data originating from a variety of digital loggers and recorders and the ability to customise input from new logger formats assisted by user prepared data entry templates.
- digital data originating from a chart digitising tablet including water level charts and chart records of rainfall recorded on siphon recorders.
- comma separated variable (CSV) files originating from data entered to standard spreadsheet packages (LOTUS, EXCEL, etc.)
- data capture from remote sites through telemetry interfaces for radio, satellite or telephone-based systems

With respect to time series, the software must permit either simultaneous display in tabular and graphical format or toggle switching between them. Batch entry of data must permit automatic entry of data to multiple stations in a single operation.

For convenience in accessing a particular data set for keyboard entry or editing, the user must have ready access to a list and map of the region showing the stations, and from each station a list of time series. The user must have the option to specify a start date or start and end dates for display.

A specific requirement of the software is for the ability to select a station or group of stations of interest from a map on which the measurement points are located, by clicking on the stations with the mouse or by encircling a group of stations with a polygon. Maps must be rescalable with increasing detail presented at increasing levels of resolution. Facility must be available to import the graphical outputs into the standard text editors such as MS-WORD etc.

The software must allow relation-oriented and survey data to be entered from ASCII data files or directly from keyboard for which templates must be available. There must also be a facility to transfer directly the parameters of stage-discharge and sediment-discharge relations from the modules in which these are computed. Facility for obtaining information, graphically, for the availability of data must be available.

2.3.5 Data Validation

2.3.5.1 Validation categories

The software must provide wide-ranging facilities for the validation of measured and derived variables, including methods to perform the following categories of validation:

- (1) Comparison of observations against physical or previous numerical limits for a variable
- (2) Comparison of observations against preceding or following observations of a variable (limits in rate of rise and rate of fall).
- (3) Comparison of time series against known (hydrological) behaviour of a station.
- (4) Comparison of measurements of the same variable at a station made by different methods or instruments
- (5) Comparison of a variable against related variables measured at the same station (flow, velocities, water quality parameters)
- (6) Comparison of records between adjacent stations measuring the same variable (e.g. successive gauging stations on the same river reach, rainfall measured at stations located nearby).
- (7) Comparison of records between different variables within a basin (e.g. rainfall and runoff, climatic variables).

Validation is a multi-stage process and several tests will be performed sequentially on the same record at different stages of processing. Facilities for performing validation of the first five categories must be available within the module supplied to the Data Entry Centre. All seven categories be available to the Data Processing Centre. In the next sub-section the required validation procedures are listed (see also Table 2.5.1).

The original data, as retrieved from the field and entered into computer file, may not be altered except for repair of gross errors such as typing errors. All other repairs and adaptations can only be executed on descendants of the original data.

2.3.5.2 Validation procedures

The software must provide both objective validation rules and graphical screening methods, each of which may be applied to the above seven categories. *Inter alia* the following procedures must be available :

Maps

It must be possible to display, whenever needed, the area of interest alongwith the necessary attributes like the location of various observation stations and river layout etc. as a necessary help while carrying out data validation.

Listing of data

For easy reference during validation the software must have the facility to display in appropriate tables:

- all station information
- time series records,
 - * in tables resembling the field note book layout, and
 - * dedicated tables for data having hourly, daily, weekly, 10-daily, monthly or any other user defined time interval; optionally a tables should display following statistics: number of data, number of missing data, minimum and maximum, sum, mean, standard deviation and coefficient of variation
- relation oriented data

Test on extremes

Flagging and listing of input data if values exceed pre-set seasonal numerical or physical limits. Values may refer to:

- upper and lower limits: absolute limits and statistically determined limits
- limits in rise and fall between successive values

Test on timing errors

There must be a facility to display a data table of a restricted length of time series for a defined period for several stations simultaneously (e.g. monthly records of daily rainfall) to detect timing errors.

Checks on physical and chemical consistency

- Balance checks, e.g. water balances and ion balances. Facilities must be available for the calculation and graphical display of the difference between two data sets or between a single series and the sum of several series (e.g. the flow at junctions).
- Comparison of series: climatological data (e.g. maximum temperature \geq minimum temperature, dry bulb temperature \geq wet bulb temperature), water quality data (e.g. COD \geq BOD, totals \geq dissolved equivalent, like TDS \geq DS, $Cd_{tot} \geq Cd_{dis}$, etc)
- The software should include tools to perform conditional checks on time series, i.e. acceptable values for a variable are bounded given that a related variable have exceeded certain limits (e.g. if $DO > 7$ then $Fe^{2+} = 0$, if $pH > 6$ then Al^{3+} and manganese should be below the detection limit, etc.)

The system must be able to flag the data points whenever the physical or chemical consistency is violated.

Inspection of temporal variation

- Graphical display of a time series and its time derivative, showing also limits of rise and fall
- Graphical display of time series (≥ 5 series) of the same type, with options for lagging and/or shifting of one or more series.
- Graphical display of time series (≥ 5 series) of different types; the vertical axis shall accommodate for at least two different scales
- Graphical display of residual series (time series plotted relative to its mean), residual mass curves (time series plot of accumulated differences from the mean) and moving average plots.
- It must be possible to detect periods of identical readings which are sometimes present in the data set.

The horizontal axis shall have clear date/time labels. For the vertical axis linear and logarithmic scales should be available. Series can be plotted as lines and/or bars (in different styles/colours). Different grids must be available and addition of text to axes, series and legends shall be possible.

Inspection of longitudinal/spatial variation

- Tabular and graphical display of one or more variables/parameters at a moment in time as a function of location.
- Graphical display of variables/parameters (e.g. by bars) on a geographical map at the measuring locations.
- Spatial correlation analysis including computation of correlation structure with graphical facilities to describe correlation with respect to distance and direction for various hydrometeorological parameters.

Inspection of cross-sectional variation

- Graphical display of vertical and horizontal variation of flow velocity measurements, in vector and contour forms.
- Graphical display of variation of flow velocities with sediment measurements simultaneously at their location in the cross-section.

Test on relations

Test of time series data against known relations at a station or between stations. The software must include:

- Scatter plots and scatter plot matrix up to five variables (e.g scatter plot matrix of flow, conductivity, TON, SiO₂, SO₄)
- Procedures to establish relations between time series with confidence limits, valid for a time period, including regression techniques (simple linear, multiple linear and polynomial regression) optional shift in time of series must be available with graphical plotting of the relation curve. Examples of relations are: water levels observed at neighbouring stations adjusted for travel time, discharge rating curves, sediment transports against Shields parameter, EC versus sum of cat-ions and an-ions, TDS versus EC, Na and Cl, Total nitrogen and phosphorus, etc.
- Options to display new data against established relations and listing of data outside the confidence limits
- Facilities for graphical and statistical comparison of relation curves valid for different time periods.

Double mass analysis

Facility for double mass analysis must be available in which one series is compared with one or a weighted average of a number of other series. A flexible composition of series elements (aggregates or averages of observations/computed values of variable duration, adjusted for missing values and laying within given boundaries) shall be possible. The method must allow for incomplete series, with the gaps properly annotated in the double mass curve.

Nearest neighbour check

For climatic data the near neighbour test must be available in which observations at a station are compared with the weighted mean of observations on the same variable at surrounding stations. Surrounding stations will be selected automatically, based on distance and orientation to the station under investigation. The weighted mean can be obtained through regression or can be derived from the inverse of some power of the distance between observation stations. Observations can be flagged if the difference between observed and computed values exceeds some constant or statistically derived value (based on the average of surrounding stations and their variation).

Contour maps

Facility must be available for making contours from point values showing isolines for a parameter such as rainfall, pressure etc.. The isoline maps prepared for different time intervals can be used to visualise and check the spatial variability of the parameter. Facility must also be available to obtain 3D effect from the isoline maps and navigating in time and space domain using easy keyboard controls.

Hydrological validation

The facility to make volume and time distribution comparisons between observed runoff and basin rainfall and between observed and computed runoff must be available. This implies the need for methods of computation of areal rainfall, evaporation and of runoff by rainfall-runoff models. The software must include at least one well known regime type conceptual rainfall-runoff model, which may be suitable for Indian conditions.

2.3.6 Data Correction

Except for the rejection of spurious values created at data entry, objective tests will be used for data correction only with initial user intervention. The various tests must create temporary tabular outputs flagging suspect values and the reason for suspicion. The following data correction, replacement or infilling methods for missing or suspect data must be available:

- (1) Simple procedures must be available to scroll through data sets (graphs and tables) and to rescale to inspect suspect values. For clearly erroneous values, (e.g. a spike due to mis-entry) correction must be available either through graphical editing or via a table showing the graphed data in tabular form, simultaneously displayed or accessed by toggle.
- (2) Linear interpolation over periods of missing data
- (3) Use of regression relations
- (4) Spatial interpolation using near neighbour relationships for climatic variables, including corrections for orographic inhomogeneity
- (5) A constant correction can be applied to a range of values to adjust for zero and scale
- (6) A drift correction can be applied to a range of values
- (7) Correction of ARG (Automatic Rain Gauge) data by means of daily and twice daily SRG (Standard Rain Gauge) data
- (8) Filling in missing ARG data at one site by means of SRG data at the same site and/or ARG data at a nearby site.
- (9) Data can be time-shifted.
- (10) Filling in missing runoff data by means of rainfall-runoff simulation.

2.3.7 Data Processing and Analysis

The software must provide hydrological processing and analysis facilities to enable the field data to be transformed to useful values, formats and time scales, in order to perform hydrological validation, to prepare data for reporting, response to queries and subsequent analysis.

2.3.7.1 Processing of flow measurements and stage discharge data

For the processing of streamflow measurements and stage discharge data the dedicated software must include the following facilities.

Processing of flow measurements

- For entry of flow measurement data templates must be available which resemble the standard field discharge measurement notes
- For validation purposes facilities should be available to display the observed flow velocities in the cross-section
- Facilities should be available to compute the discharge from current meter measurements (mid-section method) and from float measurements, etc. according to International Standards. The computation should generate the summary flow measurement information.
- Facilities should also be available to compute the discharge by means of the slope-area method according to International Standards.

Entry of stage discharge data

The template for the input of summary flow measurement information must include fields for: station identification, date, start time, finish time, gauging number, mean gauge height, discharge, cross sectional area, channel width, mean velocity, change of stage during gauging, fall between gauges, surface slope, method of suspension, meter number and rating number, observer and remarks. Facility should be available for making the list of data available in the database.

Establishment and verification of discharge rating equation

- **Fitting of rating equations:**

Rating curves must be fitted using three parameter power type equations. Other equation types must optionally be available. At least 4 equations must be available for each station period (including one for zero flow with non-zero water level). An effectively unlimited number of rating curves can be stored in the database corresponding to different validity periods. Provision must be made for the following:

- * Simple rating equation
- * Complex relations due to backwater, including normal and constant fall methods
- * Complex relations due to unsteady flow, including modelling of the Jones correction
- * Corrections for “shift” under conditions of scour and deposition using Stout’s method.
- * Determination of stage discharge relationships for standard weirs and flumes from structure dimensions according to International Standards.

A least squares procedure must be used to fit the rating equation and an error of fit statistic must be calculated for the overall fit and for individual ranges. The software must allow the user to select or exclude the gaugings to be fitted and select and test the number of segments to be used. Where the stage level of zero flow is known, a procedure to force fit the bottom segment must be available. Graphical presentation of relationships with the gaugings time (or sequence) labelled is required in both linear and logarithmic form. It should also be possible to get the summary current metering data in tabular form simultaneously with the graphics. The cursor in the tabular form must correspond to a marker locating the data in the graph.

- **Extrapolation of rating equations:**

Procedures are required to extrapolate ratings beyond the limits of observed discharge measurements. These must include logarithmic extrapolation, combined extrapolation of stage-area and stage-velocity relationships, and extrapolation based on Chezy or Manning equations. A facility is required to determine hydraulic parameters from a cross sectional profile and the stage discharge database.

- **Validation of rating equations:**

A procedure is required to make statistical tests with necessary graphics to check that additional gaugings are satisfactorily fitted by an existing rating curve. It must also be possible to compare the ratings pertaining to different time periods graphically and statically.

Hydraulic computations

Many rivers in India have low slopes and many gauging sites have channel control. This combination results in vulnerability of gauging stations to variable backwater effects. Provision is required for the user to determine the impact on water level at the station of a range of set up levels at downstream points, given the availability of survey data on the longitudinal profile of the river and sufficient cross sections through the reach.

Stage-discharge transformation

Provision must be available for the transformation of river level to discharge for each of the categories of rating relations described under 3.1. For a discharge series the appropriate water level time series (single or twin) and rating equation will be selected automatically based on the validity period of the rating equations. In the case of structures, provision must be made for both modular and submerged flow conditions.

2.3.7.2 Sediment data

For the processing of sediment data the dedicated software must include the following facilities.

Processing of sediment data

- For entry of sediment transport measurement data templates must be available which resemble the standard field sediment transport measurement notes
- For validation purposes facilities should be available to display the observed sediment data with the flow velocities in the cross-section
- Facilities should be available to compute the suspended, bed and total load per fraction or for combination of fractions
- Templates must be available for entry of summary sediment information including: station, date, start time, finish time, gauging number, mean gauge height, change of stage during measurement, discharge, cross sectional area, channel width, type of sediment load measured, type and number of instrument, specific features or layout of the instrument (e.g. type, size or model of intake nozzle), way of operation, instrument coefficient, observer and remarks.
- Sediment information will be processed according to the type of sampling and method of analysis. The sizes will be given with the original parameters and units of the size measurement method and equipment used. The procedure for transforming these sizes in equivalent particle diameters will be indicated.

Establishment and verification of sediment rating equation

- Fitting of rating equation : Procedures similar to those for discharge rating equation (simple rating curve) must be available to establish flow-sediment relationships for the entire suspended load, or for each fraction or combination of fractions. Different curves for different seasons or flow conditions should be available. For measurements of suspended sediment transport rates in sand bed rivers, the flow sediment relationship should allow for separate relationship for near bed transport.

- Extrapolation of rating curve : Procedures are required to identify the kind of flow-sediment relationship and to determine the best possible method for extrapolating transport rates or concentrations to extreme discharges

Sediment transport computations

Bed load rates, if not measured, must be computed by the software making use of the most current formulas: Einstein, Meyer-Peter and Mueller, Van Rijn, Bagnold, Ackers and White, Tofaletti. Their range of applicability must be indicated and clear explanations must be given on how the coefficients, parameters and variables are defined and determined.

Reservoir Sediment Data

The software must have the facility to handle the reservoir sedimentation data originating from reservoir surveys and to process the same for making the area-capacity curve and keeping the information related to the bottom topography of the reservoir.

2.3.7.3 Data Compilation

The software should include the following general data compilation facilities:

Aggregation and dis-aggregation options

Facilities are required to aggregate or average data from the interval of measurement to longer time intervals, specifically from hourly or less to daily, 10-daily, monthly, seasonally and yearly. Dis-aggregation options should be available from monthly and 10-daily to daily data and from monthly to 10-daily data with and without interpolation. Facility must also be available for converting the event data originating from the data loggers to equidistant time series data at user defined intervals.

Series transformation

The software should allow for user defined transformation options including standard mathematical operations.

Creation of derived series

Facilities are required to extract and store the following characteristics of series:

- minimum, maximum and mean values for different time periods from a record
- peaks (instantaneous values) or totals (accumulated values) over a threshold (POT) and time span between successive POT's

Computation of Areal Rainfall

The software must provide methods of computing areal rainfall or other variable over a basin from point measurements within the catchment or close to its boundary. The following methods of deriving weights are required:

- Equal station weights
- User specified weights (say, based on orography or mean annual rainfall)
- Thiessen polygon derived weights
- Kriging (also capable of considering orographical effects).

The methods are to be applied to a range of data intervals including daily, storm (1 to 10 days), monthly or annually. Plotting of isohyets must be possible for the same periods using graphical interface.

Evapotranspiration

The software must provide procedures for estimating daily potential evapotranspiration from measurement of meteorological variables. The primary requirement is for estimation using the Penman method, both in the standard form and with the FAO correction; other options may be offered as optional extras.

Options must be available for computation using a full range of meteorological measurements but also for the measurements more typically at Indian Meteorological Department stations:

- Daily maximum and minimum temperature
- Twice daily dry bulb and wet bulb temperatures
- Daily wind run at 2 metres above ground level (with conversion facility to/from other heights)
- Daily bright sunshine hours

2.3.7.4 Statistical analysis

The software should include the following statistical analysis tools:

Statistical tests

Statistical tests for stationarity, homogeneity and randomness must be available including Student t-test, Fisher F-test and Wilcoxon W-test, Spearman rank correlation test, run tests and linear trend tests.

Basic statistics

Facilities should be available to compute of any part of time series basic statistics like minimum, maximum, mean, median, mode, standard deviation, skewness, kurtosis and empirical frequency and cumulative frequency distributions. The latter two options should be supported by graphical output.

Fitting of frequency distributions

Facilities should be available to fit at least the following theoretical frequency distribution to data sets: Normal, Log-normal, Pearson III, Log-Pearson III, Exponential, Extreme Types I, II and III and POT-distributions.

The facility should include efficient parameter estimation procedures with and without censoring of data, goodness of fit tests, graphical display of frequency distribution with confidence limits and tabular output showing extremes for user defined distinct return periods with confidence limits.

Auto and cross correlation analysis

Facility should include the computation of auto and cross-covariance function and auto and cross-correlation function and also to present the same in tabular and graphical form with necessary confidence band for zero correlation with user defined significance levels.

Spectral analysis

It must be possible to compute spectral density function and present the same in tabular and graphical form with limit for white noise.

Range and Run analysis

Facility for making computations of deficit, surplus, range and rescaled adjusted range must be available and to present the same in tabular and graphical forms.

Duration Curves

It is required to produce a duration analysis of a time series over a given time period, giving the percentage of time that a particular value is exceeded. Duration analysis will normally be applied to flow (flow duration curves) but it may equally be applied to other variables. The following options are required:

- The analysis must be available both on the basis of flow and expressed as a percentage of average flow (to permit comparison between basins). The time period over which the analysis is applied must be available for the full year, for seasonal analysis (monsoon months only) or for a particular month. Duration analysis is usually performed with daily data but analysis for alternative durations (e.g. 10 days, 15 daily and monthly) is also required.
- Tabular output must give data values corresponding to percentiles and probability scales. In particular there is a requirement for the median (50%ile) and 5, 10, 20, 80, 90 and 95%iles. Alternately, the percentiles may be selectable by the user.
- Graphical displays and reports must be available to provide comparisons for a single site for different periods of record, for different months or seasons, or for different sites. Graphs must be displayed using a linear and logarithmic scales for the flow axis and a linear and normal probability scale for the frequency axis.

Frequency Curves

It is required to compute frequency curves and display graphically as a means of showing the variation in hydrological quantities through the year. The frequency curve indicates the magnitude of the quantity for a specific probability of non-exceedence, with time through the year on the x-axis, the quantity on the y-axis and probability as a parameter. The probabilities may be fixed (but include 10, 50 and 90%) or selectable by the user. Besides the frequency curves the actual variation as well as the overall minimum and maximum values for the selected variable through the year must be displayed. Tabular output is also required.

Depth-Area-Duration and Intensity-Frequency-Duration analysis

Facility must be available for getting the Depth-Area-Duration and Intensity-Frequency-Duration analysis done by inputting the basic rainfall series alongwith the locational details of the rainfall stations. It must be possible to obtain the output in tabular and graphical form giving the necessary curves.

2.3.8 Data Reporting

The software must provide a wide range of graphical and tabular reporting options, to screen, output to file, printer or colour plotter. Many of these have already been implied by requirements of processing and validation. Facility must also be available for combining the graphical output with the tabular output. It must be possible to generate report in user defined formats for all types of climatic, flow, sediment and water quality data. It must be possible to define the number of significant digits for different variables by the user for reporting. The tabular outputs must include the following :

- monthly summary of hourly values (e.g. short period rainfall, water level etc.) for a single station.
- monthly summary of daily mean, maximum and minimum flow, daily runoff, with summary statistics for the month of mean flow, total runoff, total volume maxima and minima for a single station

- monthly summary of daily measured suspended sediment discharge and concentration for coarse, coarse+medium and fine fractions, with monthly mean values; same structure to be applied for total loads
- semestrial summary of decadal suspended sediment discharge and concentration for coarse, medium and fine fractions
- annual summary of daily values with summary statistics for each month and for the year (including maxima, minima, means, 50%ile, number of rainy days, total volume, runoff, as appropriate) for a single station
- annual summary of monthly, seasonal and annual suspended sediment discharge, total load and fraction wise, with the annual mean and maximum sediment concentrations
- long term summary of monthly values with summary statistics for the entire record
- monthly report of daily values for multiple stations in a group to permit comparison, with monthly statistics for each station.
- tabular output of stage-discharge summary data for a selected period
- tabular output of stage-discharge and discharge-concentration parameters for a selected period
- tabular outputs for pre- post- and monsoon summaries of bed material composition and suspended sediment samples
- listing of information held under station characteristics, station description and history and station log.
- inventory of the data available in the database at every level of data handling.

Graphical outputs must include standard set-ups in which there must be flexibility to select the output size, the scale (including autoscaling), gridlines, headings and axes text. Line and bar and scatter graph formats must be available and there must be the option to choose the type of line (coded or coloured). It must be possible to display different variables on the same graph and to mix line and bar graphs (e.g. hydrograph as line; hyetograph as bar). The software must also permit user configuration and storage of new graph types.

Following graphical output must be possible on the screen, plotters and printers :

- time series for single or multiple stations for a selected period, including month and year.
- residual series, residual mass curves and moving averages
- relation curves and double mass curves
- stage discharge or sediment rating curves (with individual plotted points)
- flow duration and frequency curves
- depth-area-duration and intensity-frequency-duration curves
- areal (map) reports of location of stations
- areal reports of isolines and other mapped variables.
- availability of time series, stage-discharge and other types of data over a selected period in barchart or other format
- time axes must be in common date and time units (human) and easily understandable
- vertical and horizontal axes must be in clear and rounded increments, easily understandable.

In addition to the above defined tabular and graphical output the system must facilitate the user with efficient tools for design of document layout for text, tables and graphics. It must be possible to mix text, tables and graphics on a single page at the user's convenience. Output to file is required in both text and spreadsheet compatible format. The processing history of analyses must be traceable and available for reporting.

2.3.9 Data transfer and retrieval

The data would be transferred from the Sub-Divisional offices to Divisional offices and from Divisional to State/Regional level Data Processing Centres. From State/Regional Data Processing Centres the data would be transferred to the corresponding Data Storage Centres. Adequate facility should be available for avoiding any duplication or cluttering of data files when transferred from one level to another. The transfer of data should be supported by suitable modules for transferring the data through different means like MODEM or Ethernet network using TCP/IP - FTP or IPX/SPX etc. or transfer on floppies or other magnetic media. The software shall transparently cater to the different aspects through dialogue boxes and forms. Simple export and import formats are required to permit easy transfer from one location of the software to another within the HIS.

Also, the software must have a data translator utility built in for retrieving the fully processed data from the databases for standard hydrological modelling softwares.

2.4 Data Volume

The variety of data types which the software is to cater have been indicated in section 2.3.3. It has also been indicated that the software should be able to handle very large amount of data, both static and time series data. To give a rough estimate of the volume of time series data flowing into the HIS an overview of the Hydrometeorologic and Hydrometric stations in each of the State under different agency has been given here.

There are two kinds of Hydrometeorologic stations - one is rainfall station and other is full climatic station. The rainfall station may be of Standard (SRG) or Automatic (ARG) type. The SRG station is read once or twice a day whereas the data from ARG may be at 15 minutes or less time intervals. The full climatic station is also of two kinds - one requiring manual observations and other which is automatic. At both the stations the variables observed are the rainfall, wind direction and speed, temperature, relative humidity, pan evaporation, sunshine duration and atmospheric pressure (only at few climatic stations). At the manually observed climatic stations observations are taken twice a day from SRG, anemometer and wind vane, dry, wet, minimum and maximum thermometers, barometer and evaporimeter. Continuous chart records are obtained for dry bulb temperature (thermograph), relative humidity (hygrograph) and sunshine duration. Later on, the information from the chart records can be coded in digital form at time intervals of 15 minutes. Intervals finer than 15 minutes may also be sometimes necessary, atleast for variables like rainfall, temperature etc. The data at the automatic climatic station is also collected at similar time intervals with higher level of automation.

Hydrometric stations are broadly of four types - only gauge and discharge observation stations (GD), gauge, discharge and sediment station (GDS), gauge, discharge and water quality observation stations (GDQ) and gauge, discharge, water quality and sediment station (GDSQ). The frequency of measurement of various variables at these stations vary from station to station and from season to season and on the other factors like variability of flow variables etc. Normally, gauges are observed at hourly intervals manually and at shorter intervals like 15 minutes when observed using a chart type or digital recorder. The frequency of gauge measurement in lean season at many location is brought to a day. Discharge observations are made according to the type of control available at the sites. Frequent discharge observations like 2-3 times a day in monsoon season is made at locations where permanent control is not present. At some of the stations where stable stage-discharge relationship exist fewer discharge observations are made. Sediment and water quality samples are taken and analysed at some

sites at an interval of a day or more. For water quality, field and laboratory analyses is carried out to find out many variables like colour, odour, turbidity, dissolved oxygen, electric conductivity, pH, water temperature, dissolved and suspended solids, alkalinity (carbonate/bicarbonate), chloride, sulphate, calcium, magnesium, potassium, sodium, nitrogen, phosphate, boron, fluoride, iron, manganese, silica, COD, BOD, coliform bacteria, trace heavy metals, cyanide and trace organics etc.

Table 2.4.1 gives the details about the number and type of hydrometeorologic and hydrometric stations envisaged under the project. These numbers, though indicative, must only be taken for a gross estimate of the volume of data which is expected to be generated. Since the HIS is to be of self evolutionary type it is expected that it is upgraded frequently in future to satisfy future demands of the data users. Thus the software should have immense potential to cater to increased requirement with respect to data volume in future. Also, during validation and processing of data the original data is converted into many other forms, estimates and compiled data series at different time intervals, the actual data volume to be handled by the software will be much more than is indicated by the raw data volume.

Table : 2.4.1 : Hydrometeorologic and hydrometric network envisaged under the project.

State	Agency	Data Type							
		Rainfall		Climatic		Hydrometric			
		SRG	ARG	Mann-ed	Auto-matic	GD	GDS	GDQ	GDSQ
Orissa	IMD	39	-	18	-	-	-	-	-
	CWC	37	18	-	-	10	2	-	9
	ID	75	15	9	3	46	19	0	11
	Other	366	-	-	-	-	-	-	-
Andhra Pradesh	IMD	23	-	11	-	-	-	-	-
	CWC	53	36	12	-	12	0	9	13
	ID	-	-	-	-	203	22	0	34
	Other	681	80	8	-	-	-	-	-
Karnataka	IMD	-	7	16	-	-	-	-	-
	CWC	25	5	-	-	9	9	0	17
	ID	-	-	-	-	-	-	-	-
	Other	893	183	78	-	-	-	-	-
Maharastra	IMD	-	14	14	-	-	-	-	-
	CWC	15	-	-	-	32	0	6	24
	CAD	648	547	131	-	261	2	0	31
	Other	333	-	-	-	-	-	-	-
Gujrat	IMD	1	15	12	-	-	-	-	-
	CWC	1	9	-	-	9	0	1	6
	WRD	-	-	-	-	11	73	0	70
	Other	418	249	300	5	-	-	-	-
Madhya Pradesh	IMD	36	13	18	-	-	-	-	-
	CWC	71	44	-	-	9	0	2	17
	WRD	160	39	-	-	100	3	0	0
	Other	196	-	13	-	-	-	-	-
Tamil Nadu	IMD	15	25	17	-	-	-	-	-
	CWC	-	-	5	-	12	-	-	8
	WRD	330	151	33	3	60	5	0	35
	Other	604	4	-	-	-	-	-	-
Kerala	IMD	60	-	10	-	-	-	-	-
	CWC	19	19	2	-	-	-	3	16
	ID	102	20	9	-	80	-	-	30
	Other	-	-	11	-	-	-	-	-
Total		5201	1493	727	11	854	135	21	321

- CWC - Central Water Commission
- IMD - India Meteorologic Department
- ID - Irrigation department of State
- WRD - Water Resources Department
- AD - Agriculture Department
- CAD - Command Area Development Department

2.5 Functionality Model

For the State and Central agencies all the data processing activities before the archival of the fully processed data at the State/Regional Data Storage Centre would take place at Sub-Divisional, Divisional Data Centres and State Data Processing Centres. The functions carried out at these offices are given here under.

The functions of the Data Entry Centres include :

- Collection of the field data in manuscript and/or digital form and maintaining a record of its receipt,
- Manual and/or automatic digitisation of analogue records from strip and drum charts,
- Entry of field and digitised data in computer files and carrying out primary data validation,
- Feed back to the field stations in case of discrepancies found during checking and for delays in receiving the field data,
- Transfer of data to the Divisional Data Centre and maintaining a record of the transfer, and
- Archiving of original field registers with proper documentation.

The functions of the Divisional Data Centres include :

- Collection of data from Data Entry Centres and maintaining a record of its receipt,
- Additional automatic digitisation of analogue records from strip and drum charts,
- Entry of additional field and digitised data in computer files,
- Carrying out secondary data validation,
- Feed back to the Data Entry Centres if necessary as a follow up of validation exercise,
- Transfer of data to the Data Processing Centres and maintaining a record of the transfer,
- Backing up the necessary data records and archiving on proper magnetic media, and
- Archiving the field records, if any, with proper documentation.

The functions of the State Data Processing Centre include :

- Collection of digitised data from the Divisional Data Centres ,
- Loading of data in the state or agency database within the dedicated hydrological surface water data processing software,
- Transfer and retrieval of field data to/from the Data Storage Centre,
- Validation, correction, processing and compilation of field data relating to the surface water component of the hydrological cycle, including, precipitation, evaporation, evapotranspiration (and the climatic variables required for their computation), streamflow, sediment transport and water quality parameters (also making use of GIS tools available in the software).
- Preparation of yearbooks, reports and documents in tabular and graphical format.
- Transfer of processed data to the Data Storage Centre.
- Exchange of information from within the state between state and central organisations, either directly or through the State Data Storage Centre.
- Hydrological analysis as is required for the thorough validation of the data and for preparation of yearbooks, reports and documents.

Based upon the functions mentioned above three types of modules are required for each type of offices respectively. For Sub-Divisional offices Primary Module, for Divisional offices Secondary Module and for State/Regional offices Full package is required. Also for the National Data Centre of the CWC a full

package is required. A complete checklist of the features available in each of these modules is given in Table 2.5.1. The important requirement is that the secondary package would include all the features available in the primary module and similarly the full package will include all the features of the secondary and primary modules.

Table 2.5.1 : Availability of options in different types of packages.

Features	Sub-features	Primary Module	Secondary Module	Full Package
Data Entry and Editing	Space Oriented Data	No	No	Yes
	• maps of basin features	No	No	Yes
	• basin descriptive data	No	No	Yes
	• hydraulic infrastructure	No	No	Yes
	Location Oriented Data	No	No	Yes
	• Observation stations	No	No	Yes
	• Hydraulic structures	No	No	Yes
	Time Oriented Data	Yes	Yes	Yes
	• Equidistant time series	Yes	Yes	Yes
	• Non-equidistant time series	Yes	Yes	Yes
Relation Oriented Data	• Profile measurement data	Yes	Yes	Yes
	• Concurrent Observations	Yes	Yes	Yes
	• Relationship parameters	No	Yes	Yes
Primary Validation	• Listing of Data	Yes	Yes	Yes
	• Test on Extremes	Yes	Yes	Yes
	• Test on Timing Errors	Yes	Yes	Yes
	• Inspection of Temporal Variation	Yes	Yes	Yes
	• Inspection of Cross-sectional Variations	Yes	Yes	Yes
Secondary Validation	• Checks on Physical & Chemical Consistency	No	Yes	Yes
	• Inspection of Longitudinal/Spatial Variation	No	Yes	Yes
	• Test on Relations	No	Yes	Yes
	• Double Mass Analysis	No	Yes	Yes
	• Nearest Neighbour Check	No	Yes	Yes
Hydrological Validation	• Rainfall-runoff Simulation	No	No	Yes
Data Correction & Completion	• Time Shifting of Data	No	Yes	Yes
	• Interpolation	No	Yes	Yes
	• Regression	No	No	Yes
	• For ARG Data	No	No	Yes
Flow Measurements	• Discharge Computations	Yes	Yes	Yes

	<ul style="list-style-type: none"> • Fitting of Rating Curve • Shift Adjustment • Validation of Rating Curve • Extrapolation of Rating Curve • Stage-Discharge Transformation • Hydraulic Computations 	Yes No No No No No	Yes Yes Yes No No No	Yes Yes Yes Yes Yes Yes
Sediment Data	<ul style="list-style-type: none"> • Sediment Load Computations • Fitting of Sediment Rating • Processing of Reservoir Sediment Data • Validation of Sediment Rating • Extrapolation of Sediment Rating • Sediment Transport Computations 	No No No No No No	No No No No No No	Yes Yes Yes Yes Yes Yes
Data Compilation	<ul style="list-style-type: none"> • (Dis-) Aggregation of Series • Series Transformation • Creation of Derived Series • Computation of Areal rainfall • Computation of Evapotranspiration 	No No No No No	Yes Yes No No No	Yes Yes Yes Yes Yes
Statistical Analysis	<ul style="list-style-type: none"> • Statistical Tests • Basic Statistics • Fitting Frequency Distributions • Correlogram Analysis • Spectral Analysis • Range and Run Analysis • Flow Duration Curves • Frequency Curves • DAD and IDF Curves 	No Yes No No No No No No No	Yes Yes Yes Yes Yes No No No No	Yes Yes Yes Yes Yes Yes Yes Yes Yes
Data Reporting	<ul style="list-style-type: none"> • Standard outputs primary used for validation purposes • Customised tabular and graphical Outputs for preparing reports 	Yes No	Yes No	Yes Yes
Data Transfer	<ul style="list-style-type: none"> • Data transfer utilities 	Yes	Yes	Yes
Data Retrieval	<ul style="list-style-type: none"> • Data translator utilities 	No	No	Yes
Developmental Tools	<ul style="list-style-type: none"> • Report generation tools • Programming languages 	No No	No No	Yes Yes

2.6 Users & Working Environment

The dedicated software package will be used by the Central Water Commission (CWC) and the Surface Water Departments in the States of Gujarat, Madhya Pradesh, Orissa, Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala. The CWC is a national agency having its headquarters at Delhi. It operates through a network of regional offices. The regional offices are supported in turn by Circle, Divisional and Sub-Divisional Offices. There are 5 regional, 11 Divisional and 42 Sub-Divisional offices of CWC covered under the HIS.

The State Surface Water Departments operates within the respective states through 2-5 Divisional and 6-21 Sub-Divisional offices in the various States respectively. The professional staff who will work with the software at Sub-Divisional, Divisional and State Data Centres would be Graduates in Civil Engineering. These staff members would be assisted by persons having Diploma in Civil Engineering and/or Degree in Sciences. The number of staff members working for HIS are estimated to range between 2-3 at Sub-Divisional, 3-4 at Divisional and 10-12 at State or Regional level offices.

At the Data entry centres of CWC and state agencies only one or two stand alone personal computers are expected to be available. At this level one copy of the software is required which would be used by one stand alone PC. At the Divisional offices two PCs would be available and are to function with only one copy of the software by either using only one PC or using both with the help of a LAN. At Regional offices of the CWC there would be two PCs and would function with a single copy of the software as in Divisional offices. The Data Processing Centres of state agencies there would be 6 PCs which would be used in a LAN making use of a single copy of the software. Similarly, at head office of CWC at Delhi there would be nine PCs and are expected to function in a LAN making use of one copy of the software.

Based upon the above users and working environment and the structure of State and Central agencies in each states the quantitative requirement for each type of package have been worked out and the same are given in section 4.1.

3 Selection and Implementation

3.1 Working Prototype (Demo)

The Bidder will demonstrate his software and tools by constructing a working prototype (DEMO) of the proposed software system. The Purchaser will supply field data to be used in the DEMO. The demonstration would aid the purchaser and would be a part of the selection process. The working prototype would be available to the Bidder for the entire period of evaluation. The DEMO will include the following items :

- construction of a Demo Database containing tables for time series data, stage-discharge data and spatial information
- demonstration of all the software functions as outlined in the specifications
- demonstration of GIS tools and its integration with the database, manipulation of contour maps based on the database
- import/export of spreadsheet, dBASE3 and MS-Access files (supplied by the Purchaser) into and out of the DEMO database

3.2 Pilot

3.2.1 Pilot Hardware Procurement

As stated in section 2.3.1 the Bidder must supply the specifications for every hardware item required for the proposed software. The Bidder shall also quote for the prices of each of these items in the price tables in section 4. The Purchaser would decide and has full rights for purchase of the hardware items required for the implementation of the pilot.

3.2.2 System Tailoring, Development & Customization

The software development and customization, will be conducted by the Bidder, along the steps and milestones, and will be part of the agreement. Each step will be monitored, tested and approved by the Purchaser. The final system “tailoring” will be authorized by the Purchaser before the start of customization and development by the Bidder.

3.2.3 Acceptance Tests

The system will be tested and approved by the Purchaser according to acceptance tests. The acceptance tests for the software, will include all the features of the software including:

- Data entry and editing
- Data validation
- Data processing
- GIS tools
- Reports production
- Importing and exporting of data, figures and maps.
- Data transport

- Database management, software configuration, and administration
- Response-time
- Error handling (for hardware and software malfunctioning)

3.2.4 Pilot Implementation

The Bidder will install, customize and configure the software and all proposed items, at the pilot sites, accompany and assist in the implementation process during the pilot testing, as specified in the Time Table. The pilot would be implemented in the CWC and one of the state agency. During the pilot the software would be installed at every level so as to cover the whole range of activities as anticipated in the HIS. As such one set of software would be installed at one Sub-Divisional, one Divisional and one Regional Office of the CWC within the same city. Similarly, another set would be installed at one Sub-Divisional, one Divisional and the State Data Processing Centre, within the same city, of an state agency which would be identified by the purchaser.

3.3 Performance

The proposed software system will have adequate response-times for all the operations for both - online users and batch processing. For all the stand alone computers the response times for features on data entry/editing, retrieval and simple processing activities must be negligible (almost instantenous). The response time for carrying out any other processing activity must also be very small (say a few seconds). For the LAN environment the Bidder is responsible for providing solution for response time issues, if any. It is recognized that response-time is dependent on the hardware as well as on the software. Hence the proposing Bidder will assist in all issues on this subject.

3.4 Full-scale Implementation (in all the states and agencies sites)

The Bidder will install, customize and configure the software at all the State Data Processing Centres of the participating states and at the National Data Centre and Regional Data Processing Centres of the CWC. The purchaser would arrange to install the software at all the other remaining sites at Sub-Divisional and Divisional offices of the participating state and CWC agencies. The necessary advice for such installation exercise would be given to the purchaser by the Bidder.

3.5 Documentation & Manuals

The software system will be supplied with all the documents required to operate, maintain, configure and develop the system at the user's specific environment. The manuals should cover all aspects of the software, specifically dealing in detail about various processing features. The documents will be in English and include at least :

- general description of the software system
- list of modules included, and a description of each module, specifying inputs and outputs for each module and cross reference and module dependencies
- error handling and trouble-shooting - message list and error handling specifications for all error encountered
- system installation and maintenance guide - containing all the information required to operate and maintain the system by the data center staff

- manual giving in detail the contents of each and every computational procedure used in the software.
- manual and user guides for the databases, developmental and GIS tools used by the software
- advanced customisation guide - for plugging in user developed modules including programming interface references.

Each of the documentation mentioned above, shall be provided in printed form duly bound. In addition, the documents shall be made available on CD-ROM also.

3.6 Training

An in-depth training in the use of the software for around 20 persons will be provided by the Bidder. The training will take place in India and the exact place of training would be decided by the Purchaser. The logistics for the training with respect to place of training and arrangements for trainees would be the responsibility of the Purchaser. The training would be conducted in two batches of 10 persons each at the two pilot sites. The training program should strictly cover all the feature of the software, GIS, database and developmental tools and all other aspects covered under the specification of the software. The text to be supplied to the trainees would be prepared by the Bidder and would be included as a part of the full training package. Time table for the training would be prepared by the Bidder in consultation with the Purchaser.

3.7 Bidder's Experience

The Bidder is to be a well known and established company, with at least 10 years of experience in the specific field of software development in hydrological data processing. The Bidder should be able to prove wide experience which include : world-wide software supply and support, developing and installing new versions containing new features required by the users. The bidder must be able to prove previous reliable use of the proposed software (or its earlier versions) over a period of at least 5 years with preferably international performance record. The Bidder will provide the relevant information of its company and staff experience, a User List and reference information.

3.8 Service & support

3.8.1 Software Support

Service and support will be provided by the Bidder for all the proposed items. The Bidder has to prove the ability to provide service and support, in all the participating states for the support duration specified, and according to the requirements. The supporting company can be a locally-based and well-established Indian company (possibly acting as a software service organization for the Bidder). The Bidder should be able to provide sufficient and efficient supporting technicians which have experience in software support. The Bidder will provide traceable information of the supporting company staff experience. All the support and service are directly required for the Data Processing centres of CWC and state agencies. The requirement of any support for other locations of the software i.e. the Sub-Divisional and Divisional offices of CWC and State agencies would normally be provided by the staff members of the respective Data Processing Centres. In case it is so required, advice from the help desk may be sought by the staff at the Data Processing Centres in satisfying the needs of the Sub-Divisional and Divisional Data Centres.

The support and service for the software will include:

- installation and customization of the software system (all items supplied according to the price tables) in all the Data Processing Centres in the states and the CWC
- software support by phone - the supporting company will establish “help desk” services for the Purchaser in each participating State
- The software support will include remote servicing through dial up modem and adequate software for remote service, where such means are available
- software support on-site whenever required at the local data centers
- providing and installing required software modifications for problems caused by software bugs
- installation and customization of new versions of software, database and other tools
- developing new features whenever required by the Purchaser
- adaptation of the software for new versions of operating systems and hardware platforms whenever required
- advising the users about working environment and performance issues
- service response time:
 - * phone service - help-desk services by phone will be initiated within 4 hours
 - * on-site service for problems - will be supplied within 24 hours since the customer complaint for **regular service**
 - * on-site service for urgent problems - special service, will be supplied within 8 hours since complaint for **special service**
 - * **regular service** will be provided for “**one computer**” problems in which only one computer is not functioning
 - * **special service** will be provided for “**all network**” problems in which all the network and computerized systems are not functioning in the State/Regional Data Processing Centres
 - * for special service, the problems are to be attended until solved
- service and support company “help desk” office hours for calls will be 0800 to 1800 hrs.

3.8.2 Support Duration

The Bidder is solely responsible for installation, service and support through the time stipulated in the contract. The Bidder will be prepared to maintain and support the software at least for **7 years** after the completion of implementation. The Purchaser maintains the right to replace the supporting company one year after the completion of the implementation, or sign a new agreement for maintenance and support with the supporting company.

3.9 Agreements

The Bidder will keep the time schedule for software products delivery (as specified in the Time Table), which will be part of the agreement. The agreement will include all the steps mentioned in various clauses of the document. It will include the service particulars, service response time, warranties and responsibilities of the Bidder. The support period is to be as required by the Purchaser.

4 Cost

4.1 Quantitative requirement of different Package types

As stated earlier in the document, the software has to be of modular character so that a scaledown version of the same software may be installed at the Sub-Divisional and Divisional offices. The number of copies of various types of packages, as described in section 2.4, required for all the state agencies and CWC are given in Table 2.6.1 below :

State/Central agency	Quantitative Requirement for :		
	Sub-Divisional Data Centre (Primary Module)	Divisional Data Centre (Secondary Module)	State/Regional/National Data Processing Centre/NIH (Full Package)
Andhra Pradesh	11	3	1
Gujrat	6	1	1
Karnataka	18	5	1
Kerala	6	2	1
Madhya Pradesh	14	5	1
Maharastra	21	5	1
Orissa	9	3	1
Tamilnadu	12	4	1
CWC	43	12	6
NIH	-	-	1
Total	140	40	15

4.2 Price Tables

The evaluation of the proposal will include the proposed software cost required for it. Following are price tables including the items to be filled out by the Bidder. The tables include the information required for proposal evaluation. The Bidder will fill the following tables for each of the supplied items including software items, hardware and peripherals, manuals, training, maintenance service and support etc.:

Software Price Table (for all required software tools)

Item Number	Name	Software Vendor	Warranty Period	Price Per Unit	Yearly Maintenance Charge
1.					
2.					
3.					
etc.					

Package Price Table (including all the required software tools)

Complete software	Stand Alone system		LAN (2 Users)		LAN (6 Users)		LAN (10 Users)	
Functionality model (including all tools)	Price	Annual Maintenance charge	Price	Annual Maintenance charge	Price	Annual Maintenance charge	Price	Annual Maintenance charge
Primary Module								
Seconadry Module								
Full Package								

Hardware Price Table (for all required hardware items)

Item Number	Name	Hardware Vendor	Warranty Period	Price Per Unit	Yearly Maintenance Charge
1.					
2.					
3.					
etc.					

Miscellaneous Price Table

Item Name	Price Per Unit
Manuals (specify separately for all types)	
Training (specify for 20 persons)	
Other (specify)	

5 Time Table

The time table for different activities for the procurement of the Dedicated Hydrological Surface Water Data Processing Software and necessary hardware and carry out the required customization and finally implementing it at all the required locations is suggested here under :

STEP	TIME TABLE IN MONTHS (Starting: 1 October, 1997)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WB approval: procurement process & notice	■																	
Notice for Invitation for Prequalification	■																	
Sale of Prequalification document		■	■															
Clarification meeting		■																
Submission of Prequalification applications		■	■															
Evaluation of Prequalification applications			■															
Approval of WB on Evaluation report				■														
Sale of Bid Document to Qualified Bidders				■	■	■												
Submission of Bids				■	■	■												
Technical evaluation of Bids including DEMO						■	■											
Financial Evaluation of Bids and Selection							■											
Contract Finalisation								■	■									
Pilot Hardware & Software Procurement									■	■								
Pilot Implementation																		
Installation of the Hardware and Software										■	■							
Software Customizing										■	■	■	■					
Finalizing, Integrating and Stabilizing												■	■					
Field Tests														■	■			
Acceptance Tests															■	■		
Training of Trainers																■	■	
Approval of Tests reports to HLTG (SW)																■		
Full-scale Implementation																		
Hardware & Software Procurement																	■	■
Installation of the Hardware and Software																		■
Integrating and Stabilizing																		■