Hydrologic Monitoring System Assessment

The purpose of the Hydrologic Monitoring System Assessment is to assist a World Bank borrower with the task of preparing technical specifications for tender. Common methods of hydrologic measurement are reviewed. The Assessment requires information that the borrower will provide which will result in developing the overall design of the hydrological information system. A key outcome of this Assessment will be clear, concise specifications which will result in more competitive and cost effective bids. This exercise will also prepare the borrower for the eventual implementation of a highly sustainable hydrologic monitoring system.

Based on the information you provide, a World Bank consultant can more efficiently assist you in defining project needs and help assemble the most appropriate specifications.
Hydrologic Monitoring Systems of HP 2 generally have the following components:

- Data Collection Platform
- Data Communications (Radio, Cable, Antenna)
- Equipment Enclosures
- Solar Panels
- Solar Charger
- Grounding System
- Sensors
- Data Center for:
  - Automatic reception of Data Communication, quality control, and remote station network management
  - Data storage
  - Visualization (Data presented on maps, graphs, tables)
  - Decision Support
    - Alert and alarms based on evaluation of incoming data
    - Forecast models
    - Analytical models

This Questionnaire will provide assistance in assessing the requirements of the respective hydrologic information system. The scale and scope of the hydrologic information system will be much clearly understood. This will result in a better overall understanding of the project and prepare consultants for possible field Missions or to otherwise help in the preparation/review of specifications.
Goal of Hydrologic Measurement System

State the goal of the hydrologic measurement system. By stating the goal, the measurement system will constitute objectives designed to meet the goal of the project.

Goal of the Hydrologic measurement:

Explain the use of the data and how automated data collection, and real-time telemetry will be used. This should include discussion of public safety, protect of property, as well as industrial capacity.
Data Collection Platforms

*Data Collection Platforms (DCP)* are systems that collect and log (store) data automatically. A DCP is synonymous with a Data Logger. A Remote Terminal Unit (RTU) is a device that is generally used with Supervisory Control and Data Acquisition (SCADA), whereby the RTU is used to control and/or supervise a remote device. Data Acquisition System (DAS) is generally synonymous with a DCP, whereby sensors are monitored and stored. For most hydrologic monitoring systems a simple DCP is sufficient, as DCPs offer not only data collection from a wide range of sensors, but also interfaces to radio systems for data communication. Data communication will be addressed later in the Assessment.

Please define the general measurement that will be made and the associated time interval of measurement as well as interval of data transmission.
DCPs can come with displays, and may also be specified without displays. Displays can be quite helpful for the technician, or other interested entity in examining data on-site. Would you prefer a display on the DCP?

DCPs store can store data in addition to transmitting the data in real-time. It is suggested that the data loggers have enough memory to store a year’s worth of data. It is also suggested that the data be stored in non-volatile memory so that in the event there is a power outage, the stored data will be preserved. Are there other capabilities that are required from the DCP?
Sensors

Hydrologic data collection systems usually involve measurements of discharge, precipitation, and meteorological state parameters (temperature, relative humidity, wind speed, wind direction, atmospheric pressure, solar radiation), as well as evaporation/evapotranspiration. Automatic measurements of these parameters are described below:

**Discharge:** Discharge is generally derived by establishing a stage-discharge relationship, whereby water level is measured at various stages and compared to manual discharge measurements at each of these stages. The result is a rating curve, whereby the water level can be measured and referenced to the corresponding discharge. A rating table requires a continuous effort to maintain, though the maintenance of the stage-discharge relationship is extremely simple if the channel is stable. Discharge measurements at stable cross-sections can take place every six to eight weeks. There should be an effort to perform discharge measurements during peak flows. The reason why network operators prefer measuring stage and then deriving discharge through a stage-discharge relationship, is because the stage sensors are considerably less expensive that just measuring stage (water level). There is a strong desire by many operators to use non-contact methods of measuring water level, which is advantageous if there are flood flows that can carry debris that can damage expensive instruments that are in the water.

Alternatively, if there is the consideration of backwater effects. Backwater effects are conditions whereby a downstream condition causes the water to back-up to the stage measurement site, thus making it impossible to derive a stage-discharge relationship. In these cases, the use of an Acoustic Doppler Current Profiler (ADCP) is the only solution that can be applied. The ADCP must be placed in the water (contact sensor), making it subject to damage during flood flows that carry debris in the water. ADCP’s can range from $7,000 - $18,000 USD, so the use of these devices should be judicious.

Prior to determining the discharge measurement method, the operator should understand the limitations of contact sensors and the threat to these sensors from debris being carried by flood waters. The operator or an agent of the operator should perform a survey of all discharge sites so that the correct technology can be recommended.

**Stream Gauging Measurements:** Stream gauging measurements are made in order to develop a stage-discharge relationship. The stream gauging measurements can be made as follows:

- Cableway Measurement
- Bridge Measurement
- Boat Measurement
- Remote control boat (w/ADCP)
- Wading

The different methods of measurement allow for measurement in different cross-sections.

Cableway Measurements: Cableway measurements require a steel cableway to be installed which will span the river cross-section. Historically, hydrographers (people who make stream gauging measurements) would climb into a cable car and make measurements from the cable car which moves from one bank to the opposite bank. There have been significant advances in this area, with the automatic cableway systems. The automatic cableway systems allow the hydrographer to stay on the cross-section bank and remotely control a device which travels across the cableway. ADCPs and typical current meters can be used with the automatic cableway systems. These types of systems are highly recommended over the legacy cableway and cable car system. This is a good method of measurement in high velocity water.

Bridge Measurement: Bridge measurements can utilize either ADCPs or typical current meters. Bridge measurements are very popular and are safer than making measurements from a cableway, boat, or wading. Unfortunately, bridges are not available at all cross-sections. And although bridge measurements may be somewhat safer than other measurements, and more cost effective, there is danger in making bridge measurements from vehicle traffic on the bridge. This is a good method of measurement in high velocity water.

Boat Measurement: Boat measurements can utilize either ADCP or typical current meters. The boat is used with a tag line that is temporarily placed across the cross-section. The tag line helps the hydrographer to determine measurement points and keeps the boat tethered to the cross-section being measured. Boat measurements do not require the use of a cableway, which saves the initial cost of the cableway. However, the measurements can only be made from the boat in lower velocity water.

Remote Control Boat Measurement: Remote control boat measurements are usually restricted to use with the ADCP. The ADCP is placed on a small boat and the boat is remotely controlled to make the measurement across the cross-section. This method is only suggested on smooth, low velocity water. In routine practice in open channels, the boat measurement might be most suitable for canals.

Wading: In conditions of low flow, discharge can be measured by having the hydrographer wade across the channel. A rule of thumb for the upper limit where wading measurements can be made is given by the product of the depth of water and the velocity of water. If the product of the water velocity in ft per second and the depth of water in ft is greater than 10, measurement of discharge by wading the river should be discouraged.
**Water Level:** The water level measurement is necessary if the desire is to use the stage-discharge relationship. The stage-discharge method of determining water level is considered to be more cost effective than using ADCPs for continuous discharge measurements. The most popular water level sensors consist of the following:

- Shaft encoder with pulley, tape and float
- Bubbler system with non-submersible pressure transducer
- Radar water level measurement
- Ultrasonic water level measurement
- Submersible pressure transducer

The proper solution for the operator can only be suggested once a thorough survey of the sites has been completed. The Agency should have a clear idea where the measurement points should be along a given river reach and not leave this up to the supplier.

**Precipitation:** Precipitation measurements are usually made with either a storage gauge or a tipping bucket rain gauge. The tipping bucket rain gauges have been generally preferred because of the minimal maintenance requirements.

When measuring precipitation, there are two generally competing considerations that must be understood. These considerations consist of the desire to measure precipitation rate versus total precipitation. It is very difficult to obtain instantaneous precipitation rates with a tipping bucket rain gauge. As well, the tipping bucket rain gauge cannot accurately resolve cumulative precipitation unless the results are corrected by accounting for the precipitation rate. These inaccuracies are due to the tipping bucket method of the buckets tipping during rainfall. Fortunately, most hydrology projects require accurate measurement of precipitation accumulation over 15 minutes to an hour. The need for rainfall intensities may only exist with an entity such as IMD. In most hydrologic measurement projects a high quality tipping bucket with a siphon arrangement or software applied corrections to the rainfall rates will produce reasonable cumulative precipitation values. Upon filling out the station survey table, a proper solution for precipitation will be provided.

**Meteorological State Parameters and Climate Stations:** Meteorological state parameters and measurements are one of the most straightforward measurements in a hydrologic measurement network. The major consideration for these types of stations is exposure. Obstructions and anthropogenic sources of measurement influences should be eliminated. Sites for Climate Stations especially should be very carefully examined prior to selecting the site for consideration for instrumentation. Each meteorological sensor has exposure requirements that

In order for your hydrologic network to be properly evaluated the operator should provide information in table format of the following:

**Table 1: Discharge sites**

- Name of site
- Latitude of Site in decimal degrees to the 4th decimal point
- Longitude of the site in decimal degrees to the 4th decimal point
- Elevation of the Site
- Width of channel at peak and low flow
- Maximum and minimum water level height from the bottom of the channel
- Maximum velocity of water
- Backwater effects
- Natural or lined channel (lined, i.e. canal)
- Closest bend in the channel upstream and downstream of measurement site
- Knowledge or evidence of debris during high flow (high, moderate, low, none)
- Closest bridge upstream or downstream

**Table 2: Reservoir elevation sites**

- Name of site
- Latitude of Site in decimal degrees to the 4th decimal point
- Longitude of the site in decimal degrees to the 4th decimal point
- Elevation of the Site
- Range of reservoir elevations

**Table 3: Precipitation sites**

- Name of site
- Latitude of Site in decimal degrees to the 4th decimal point
- Longitude of the site in decimal degrees to the 4th decimal point
- Elevation of the Site
- The height and distance of the closest object to the precise precipitation gauge site. Anything that is greater in height than twice the distance to the proposed gauge site should be noted.

**Table 4: Climate station or all weather station sites**
• Name of site
• Latitude of Site in decimal degrees to the 4th decimal point
• Longitude of the site in decimal degrees to the 4th decimal point
• Elevation of the Site
• Distance and height of closest buildings to the site
• Available area for site (i.e. 400 m²)

**Table 5: Snow depth and snow pack water content sites**

• Name of site
• Latitude of Site in decimal degrees to the 4th decimal point
• Longitude of the site in decimal degrees to the 4th decimal point
• Elevation of the Site
• Maximum depth of snow
• Maximum snow pack water content

**Table 6: Cooperative sites, where you may desire data or you may be willing to add sensors to the sites**

• Name of site
• Latitude of Site in decimal degrees to the 4th decimal point
• Longitude of the site in decimal degrees to the 4th decimal point
• Elevation of the Site
• Cooperating Agency (i.e. IMD, CWC, SASE)

**Schematics and Diagrams**

• Prepare a schematic of your river system and include the reservoirs and proposed gauging stations in this schematic.
• Prepare a map in Google Earth that identifies all of your measurement stations. Examine these points to assure the coordinates are reasonably correct. Export the file as a KMZ.
Do you need assistance designing a hydrologic monitoring network, or have you already determined all of your sites and the parameters that you would like to measure?
Data Communication

An important capability of any modernized hydrologic monitoring network is the real-time relay of measurements from the field to the operations center where the data can be made available to support decisions.

What is your preferred method of data communication? If you have no preference a suitable method of data communication will be recommended based on the requirements of the information being collected as well as radio propagation considerations.

Many DCPs can accommodate multiple data communication links. This is quite useful in the event a data communication path fails. Two communication paths (dual-path) data is becoming more common for information systems that need data reliably and promptly. How critical is your information. How long can you be without data in the most critical situation? Would you like to employ dual-path communication?
Warranty Period

Warranty period is a period where if the equipment fails due to manufacturer defect, the unit is replaced at no charge to the agency. However, if the equipment fails by any other means, such as vandalism, or a force majeure, then the responsibility for replacement will be up to the agency, though contractor usually replaces the equipment under the maintenance contract that is tied to the warranty period. Some agencies would like to include all equipment failures, including vandalism or force majeure in the warranty period. It is not recommended that vandalism or force majeure be included in the warranty period, as if the supplier is expected to take on all risk, the agency will certainly overpay for the contract.

How many year(s) of warranty are desired?
Maintenance Period

The maintenance period follows the warranty period. During the maintenance period, all equipment failures are generally the responsibility of the agency, as the supplier performs the field work necessary to restore the station. Again, as in the Warranty Period, it is not advisable to include equipment losses and replacement as a requirement of the supplier. The supplier will take the worst case scenario, and need to add to the contract in a way where the contractor will not assume any risk, thus over pricing the offer. Hardware costs during the maintenance period can be offset with a large supply of spare equipment. During the maintenance period, one can assume that 10% of the equipment will need to be replaced annually. If high quality equipment is specified, this can reduce down to less than 5%. It is important that station security be well thought out during the specification and tendering process, as this will certainly save resources during the warranty and maintenance periods.

Maintenance contracts should require regular reporting which provides a summary of all maintenance activities. These activities should include the following:

- Emergency Maintenance activities, including dates, time, action performed, and number of hours required to resolve the situation
- Preventative maintenance activities, including dates, time, actions performed, and number of hours required per site
- Status of all hardware components, whether in operation or held in spare. This report should provide the operational readiness of all hardware components, and should identify where all equipment is located, whether it be in the field, in the warehouse, or back at the manufacturers facility for repair or calibration. Equipment identification should be referenced my model and serial number.

What length of maintenance period is required? Some entities have specified up to 8 years for the maintenance period.
Do you have field offices that the maintenance crew can share with your staff? Having the maintenance crew alongside your staff is a good way to learn and manage the maintenance contract.

Do you intend to one day having your staff maintain this equipment?
If you do not intend to maintain your equipment one day, then it is necessary that the outsourced group be subject to a Quality Assurance Program. Quality Assurance means that the outsourced group performing the maintenance will need to be audited at regular intervals to make certain the equipment being operated is within specification, and to also assure the data is of high quality. The Quality Assurance program can also be outsourced or performed in house. Would you prefer to outsource the Quality Assurance program or have it done in house?
Data Center

The hydrologic monitoring network will transmit data to the Data Center in real-time. The Data Center will have the necessary data receivers and a computer system to act as the first level repository of the information. The computer will also be used to validate information and track erroneous measurements, being used to direct the maintenance staff to tend to station outages.

The space for the Data Center is required to contain the necessary computer systems under proper environmental conditions. It is suggested that the space for the Data Center be provided with easy access to external data communication facilities, such as radio antenna. Components of a Data Center consist of the following:

- A computer for the automatic reception of Data Communication, quality control, and remote station network management
- A computer for Data storage
- A computer for Data Visualization (Data presented on maps, graphs, tables)
- A computer for hosting Web services
- A computer for decision Support
  - Alert and alarms based on evaluation of incoming data
  - Forecast models
  - Analytical models

The various components can share computers, though the use of multiple computers will help in sharing the load. These computers are usually “Server” grade computers. By no means should a “Server” grade computer be used by the office staff for typical office productivity tasks, such as word processing, browsing the Internet, CAD applications, or other activities normally reserved for a personal work station.

A Data Center is normally equipped with the following:

- Computer Servers
- Computer Workstations with Monitors (Multiple monitors are very useful)
- Software (Operating System, Data base, Data Collection, Decision Support, Visualization, Web Services, etc.)
- Uninterruptable Power Supply
- Backup Power (for outages greater than 30 minutes)
- Computer furniture (equipment racks, desks, bookshelves, etc.)
Do you have a facility that can be used as the Data Center? This area will be modernized through the Tender process to accept the necessary equipment.

Describe products or functions that you would like to have as part of your Data Center.