

Water Quality Modeling

The main goal is to develop a water resources management plan and study the water quality deterioration, estimates of flow and water quality of the entire Yamuna basin. to develop a mathematical model for easier understanding of flow and water quality trends. The model targeting the entire Yamuna basin is to be formulated for the purpose of estimating the city wise pollution load generation and pollution level forecasting, to provide a decision support system for better management of water resources and control of river pollution etc.

Objectives

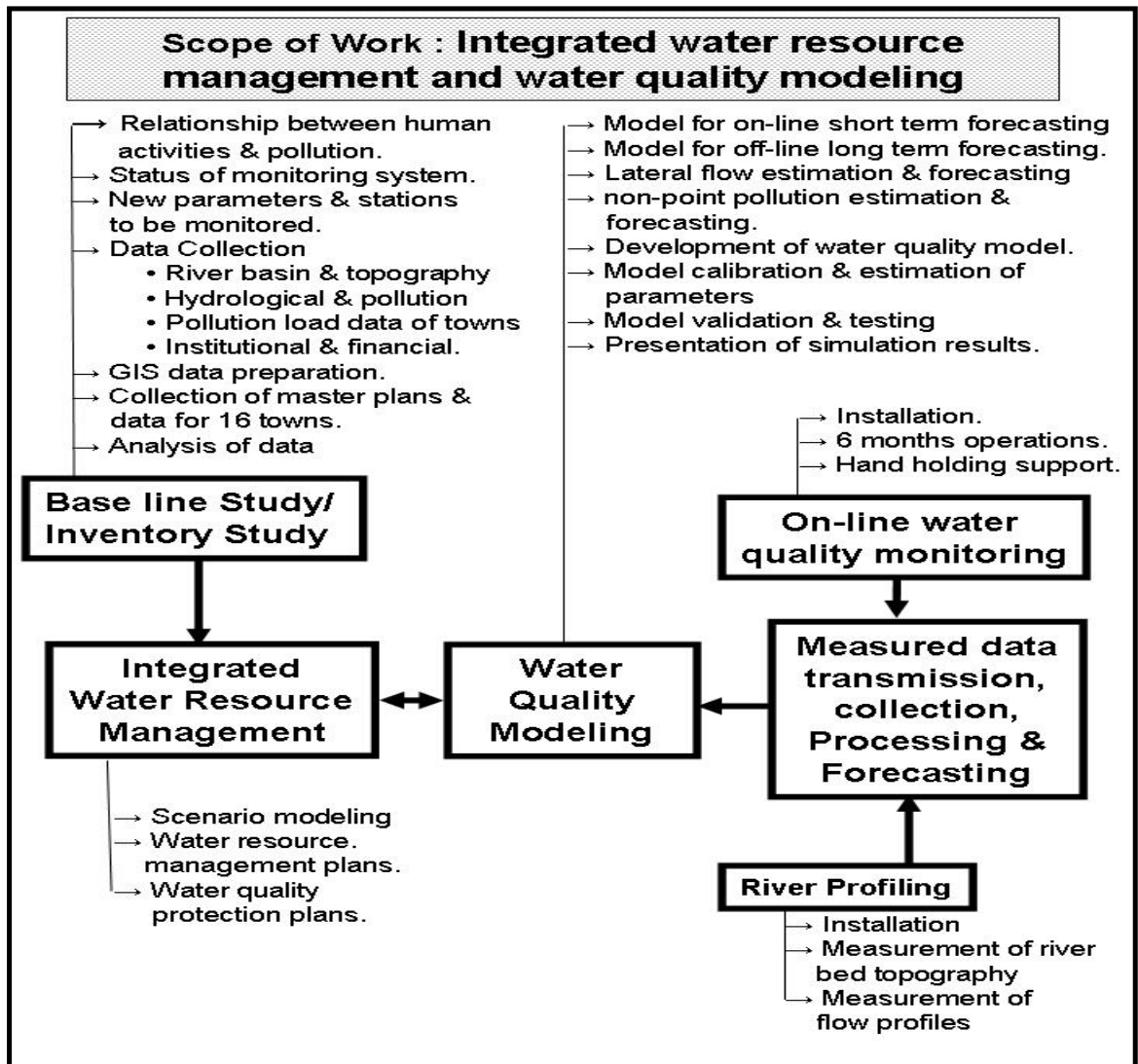
The objectives of the assignment is as follows:

- Base line data collection of the entire existing water monitoring network/ system of river Yamuna, available water quality data of river Yamuna, adequacy of the existing data monitoring stations, geo-positioning of the monitoring points, including estimates of city wise pollution load, industrial pollution generation etc;
- Evaluation and Development of a Monitoring framework and policy initiatives.
- Development of Water Quality Modeling Integrating Water Resources Management including a simulation model for pollution studies and a decision support system for improved management of the water quality of the river Yamuna;
- Development of Water Quality Protection and Dry Weather Flow augmentation proposals including cost estimates including a study of various options to intercept the water flow in the wet season and augment the flows in the dry season;
- Establishment of one on-line water quality monitoring station on a pilot basis; and
- Overseas and Domestic Training with concerned agencies where similar models have been adopted to achieve sustainability of initiatives similar to the Yamuna.

For the water modeling works the target area is the entire stretch of the Yamuna River Basin from Tajewala /Yamuna Nagar to Allahabad, Western Yamuna canal, Eastern Yamuna Canal, Nazafgarh Drain and Hindon River shall be assimilated. The scope of work is described in detail under the following six headings:

- Base Line Data Collection / Inventory Study.
- Measured Data Collection , Processing and Forecasting
- Integrated Water Resource Management and Water Quality Modeling of River Yamuna Basin
- Water Quality Protection and Dry Weather Flow Augmentation Proposals.
- Setting Up of On-Line Monitoring Station.
- Overseas and Domestic Training

The entire work program is shown schematically in the following scope of work activity flowchart:



Base Line Data Collection / Inventory Study

Adequate knowledge of the existing nature, magnitude and sources of various pollution loads in water is much needed for any rational formulation of water pollution control measures and integrated water resource management. The need and importance of a basin wise study of water quality and the various factors that determine the pollution load generation and its runoff is required as the basic information for river water pollution control and water resource management.

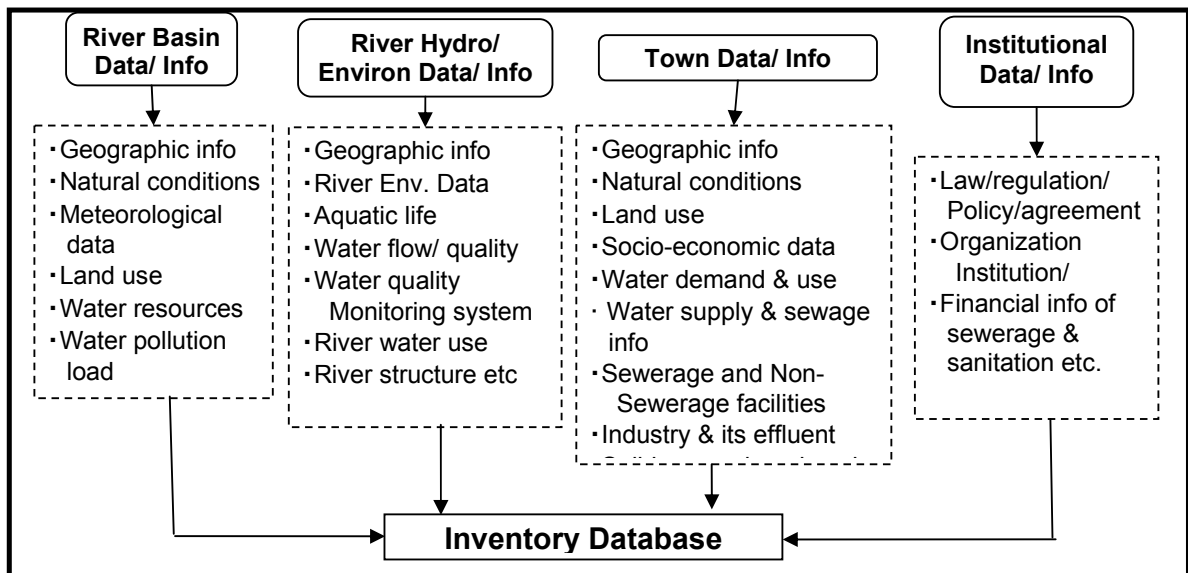
The consultant should carry out the task of baseline data collection for the entire Yamuna basin (including tributaries). This study shall include all the current and past water quality data of river Yamuna which also is to be documented.

Main Objectives of the Inventory Study:

The main objectives of the inventory study are listed and shown graphically below:

- To collect detailed data relevant to integrated water resources management and water pollution for the entire Yamuna basin such as hydrological, climatic, demographic, land-use, agriculture, water supply, wastewater disposal, etc.
- To estimate city wise pollution load generation, pollution source identification, data forecasting etc.
- To assess the auto oxidation of pollutants from the points of discharges so as to determine the assimilative/ regenerative capacity.
- To assess the possibilities and methods for recycling and reuse of waste water for industrial, irrigation and other uses.
- To analyze the data with a view of assessing the relationship between human activities and different aspects relating to water quality in Yamuna Basin.
- To study and analyze the entire present water monitoring system, available river quality data, additional parameters to be analyzed etc.
- To geo-position all the present monitoring stations.
- To study and analyze industrial pollution management in Yamuna Basin.
- To develop monitoring framework and recommend legislative and regulatory initiatives.
- To use the inventory data during water quality modeling (described in subsequent sections) to get accuracy in modeling results.

Inventory Study: Scope of work



Inventory Study of Existing Water Supply and Wastewater Treatment Systems, Facilities, Master Plans and Problems.

- Identify and characterize existing water supply and wastewater treatment systems and their use profiles.
 - Review local water supply and wastewater treatment plans and system documents.
 - Describe water sources, wastewater generation, treatment plant capacity, reservoir yields and other raw water storage capacity.
 - Identify major transmission lines and interconnections with other systems.
 - Provide maps.
 - Water use and wastewater generation data: current and historical (average and peak demand).
 - Unaccounted for water use and exfiltration: leakage and other non metered uses
 - Using information collected to develop mass balance of water in towns on Yamuna basin.
 - Summarize planned facilities and sources and identify problems, provide summary matrix which can be linked to GIS maps of the facilities and transmission lines.
- Identify and provide information on other permitted and significant non-permitted users such as private systems, industrial and agricultural withdrawals. Provide data on water usage as available. Describe plans and problems.
- Quantify and summarize the extent of individual wells and other small users to the extent possible.
- In addition to providing all this information by system, summarize data by major basins.

Water supply and waste water treatment analysis data for 8 towns of Uttar Pradesh and 8 towns of Haryana will be provided by the other consultants, who are carrying out the Master Plan, Feasibility Studies and DPR preparation for Haryana and Uttar Pradesh.

Industrial Pollution Management Study of River Yamuna basin

This study will focus on identification of polluting industries along the river, city/sub basin wise industrial pollution contribution to the river, study of the industrial discharge permit system and policy initiatives to minimize industrial pollution etc,. The relevant data such as Geographical distribution and category wise distribution of Industrial Pollution can be collected from state pollution control boards, Central Pollution Control Boards etc, and is to be incorporated in the model and any future industrial pollution scenarios for the Yamuna Basin to be developed.

Evaluation and Development of Pollution Load Trading program.

The consultants are required to evaluate the development of a pollution load trading program, between authorities, agencies, municipalities, state governments etc, which will be based on the river classification standards and will serve as establishing the baseline for Yamuna River protection. This task will facilitate an assessment of pollution trading opportunities as an innovative approach to achieve water quality loads established on baseline criteria. Trading can be based on the fact that different sources in a basin can face different costs to control the same pollutant. The trading program should be flexible to allow facilities facing higher pollution control costs to meet the reduction requirements by purchasing credits from another source at lower cost. Pollution trading also provides an important mechanism to accommodate increases in pollution load from new growth, including increased Stormwater

In this task, the following shall be accomplished:

- The water quality “problem”- current impairment, the cause of the problem or threat, the contributing pollutants and pollutant loadings, the contributing sources, their relative contribution etc,.
- Setting up pollution load permissible limits per region/area/state/municipality.

- Evaluate, if the trading is a technically and legally feasible solution.

Flow and River Bed Topographical Data.

In the planned programme it is required to measure and collect the data of flow, river bed topography and river cross section data and to incorporate in the model. The flow data of the river, tributaries and nallahs of the target area of Yamuna Basin and river bed topography and cross section data of the river shall be collected.

Development of Monitoring Framework and Policy Initiatives

Government of India constituted the Water Quality Assurance Authority (WQAA) to exercise powers under various sections of the Environment Protection Act 1986. The WQAA is authorized to issue directions and take measures to reduce pollution in surface and ground water bodies. The enforcement of pollution control norms and measures require routine and reliable monitoring of water quality in water bodies. With a view to standardizing the methods of water quality monitoring and to ensure the quality of measured data, MoEF has brought out a Uniform Protocol on Water Quality Monitoring order 2005 vide gazette notification S.O 2151 dated June 17, 2005 (annexure-I).

The consultant is required to study the existing framework for river pollution control from the adequacy and enforcement point of view in the states in Yamuna Basin. The consultant shall develop/modify/recommend a new monitoring framework for enforcement of river pollution control standards, norms, rules and guidelines etc including enforcement on and by the Local Urban Bodies, Municipalities, Industries and State governments in the Yamuna Basin through WQAA.

It is required to evaluate whether the framework can be used to establish protocols and the unit cost for load. Penalty for exceeding pollution load by any region in the river basin should be managed by the framework.

The study shall broadly consist of:

- Development of Institutional framework for Water Pollution Management
- Development of Enforcement Mechanism
- Recommending Policy Initiatives, such as Review and modification (if any) of polluters pay principle etc.

Measured Data Collection, Processing and Forecasting.

Present Status.

There are three zonal laboratories that are involved in the water quality monitoring program in Yamuna Basin. The zonal laboratory at CPCB New Delhi collects grab samples from 15 - 25 stations along the main stretch of river Yamuna once a month (on same day). Similarly, water samples are collected and tested from 8 sites/ stations in Hindon river by IIT Roorkee and 11 sites/ stations on Western Yamuna Canal by PCRI Haridwar once a month (on same day).

Measured Data Collection.

It is required to develop a system to collect on-line all measured flow and water quality data from all measuring stations and laboratories at central server via-email.

Measured Data Processing.

The measured data collected shall be processed & converted into ASCII file format and uniform measurement protocol format (refer Annexure-I) brought out by the MoEF.

Data Forecasting.

It is required to obtain accurate forecasts of hydrological and pollution data of all measuring stations in Yamuna basin.

- Short term forecasts of measured data are to be linked with the on-line simulation model version for the online flood and pollution warning system discussed below.
- Long term forecasted data would be used for the off-line simulation model version for the purpose of scenario modeling in the decision support system for integrated water resource management and pollution control.
- There are several other forecasts of estimated data that are to be obtained. These include the short forecasts of lateral flow and non-point pollution load entering into various streams, water courses and rivers in Yamuna basin. This is to be linked with on-line and off-line simulation models respectively.

Development of Software and Data Servers.

It is required to develop the source code for long term and short term forecasts.

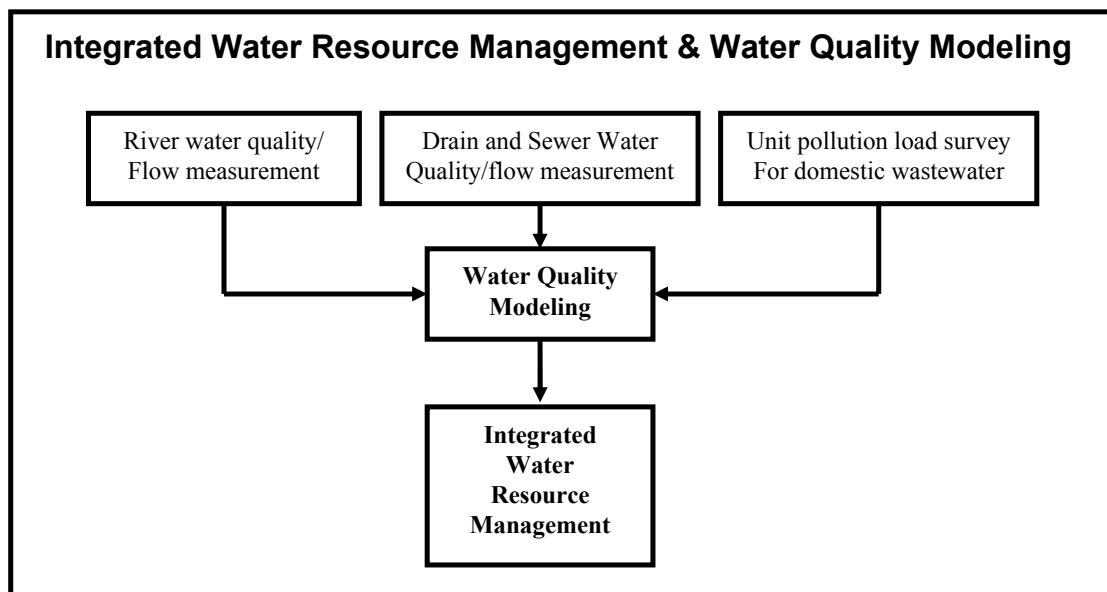
Integrated Water Resource Management and Water Quality Modeling of River Yamuna Basin

A decision support system for integrated water resources management is to be developed and coupled with water quality modeling.

Development of Water Quality Simulation Model

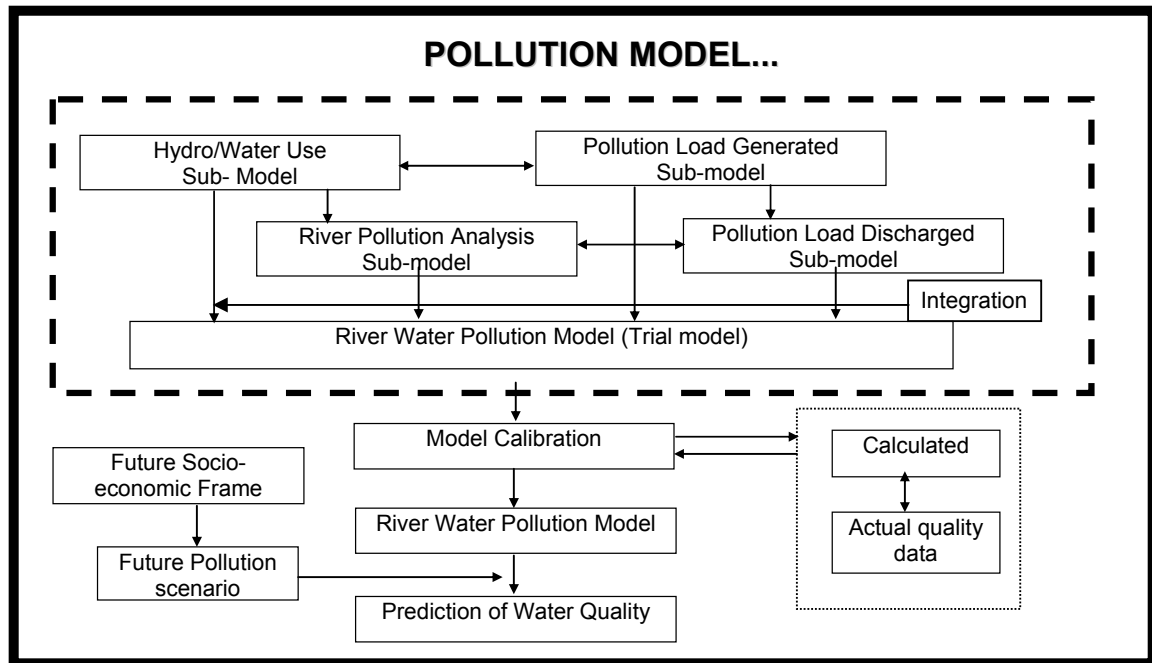
It is required to undertake water quality modeling work under YAP-II using water quality, river discharge and river hydrological data to simulate pre and post action plan scenarios. Varying conditions of flow, river bed topography data etc. can be used to predict different situations. This process is shown graphically in the flow chart below.

In this project, for the above objectives, it is required, to get the source code developed by firms involved in application software development. The ownership and other rights over the source code shall be of NRCDD and governed by rules and regulations framed by the MoEF.



Model Deliverables

- Menu Driven User Interface
- Short term and long term pollution forecasts
- Decision support system for Integrated Water Resource management
- Linkage with GIS
- Performance evaluation of pollution abatement infrastructures
- Comparative polluto-graphs etc



Calibration of the Model

Using past records of measured flow and water pollution data of every year say from 1990 onwards, the data shall be used to calibrate the model for each year separately. This calibration is similar to the conventional simulation model calibration. This would be needed to estimate lateral flow and non-point pollution loads entering along all stretches of river Yamuna.

In a conventional approach for modeling and simulation, conservation laws of physics & chemical processes called governing equation are solved numerically at grid and node points. The simulated model results are then compared with observed data and values of model coefficients (conceptual parameters) are fine tuned (adjusted/ estimated) so that the difference between simulated response and observed response is minimized. This process is called model calibration. The simulation model shall be calibrated based on the present water quality data.

Water Quality Forecasting

The processed data shall be used by forecasting model/ software for making accurate forecasts using standard (well tested) methods.

- Initial forecasts refer to computing parameter values at monthly intervals for a user specified lead time say 30 days and one year ahead.
- For the purpose of scenario modeling, forecasts refer to computing parameter/variable values at one month intervals for a user specified lead time say 1 year, 30 years ahead.

- The above forecasts are to be made from estimated lateral flow and non-point pollution load entering into various streams, water courses and rivers in Yamuna basin.

Model Validation and Testing.

The model shall be tested by comparing the simulated and observed results for the past records of the measured data and by comparing them with standard (bench mark) test results.

- The efficacy of forecasting capabilities of the simulation model for Yamuna basin will be tested using the following procedure:
 - From the date of successful installation of the model & software, the software will start producing future forecasts every 30 days. These forecasted results will be compared with measured data as and when it comes.
 - The measurements shall also be compared with corrected/ modified forecasts as the recursive simulations progress. The same shall be displayed in the form of graphs for all measuring stations. This shall be done for one month (30 days predictions at each time step) in each quarter of the year involving dry and wet weather flows.
- The efficacy of long - term forecasting capabilities of the simulation model for Yamuna basin will be tested using the following procedure:
 - Start the model from the past date say 1990 using the base GIS layer data for that year. Make the long term forecasts for all 12 months in 2007 using the calibrated parameters for same year 1990 and forecasted values of flow, water quality, lateral flow and non-point pollution and possibly river bed topography data also. Evaluate the long term forecasting efficacy of the model by comparing simulated results with forecasted results

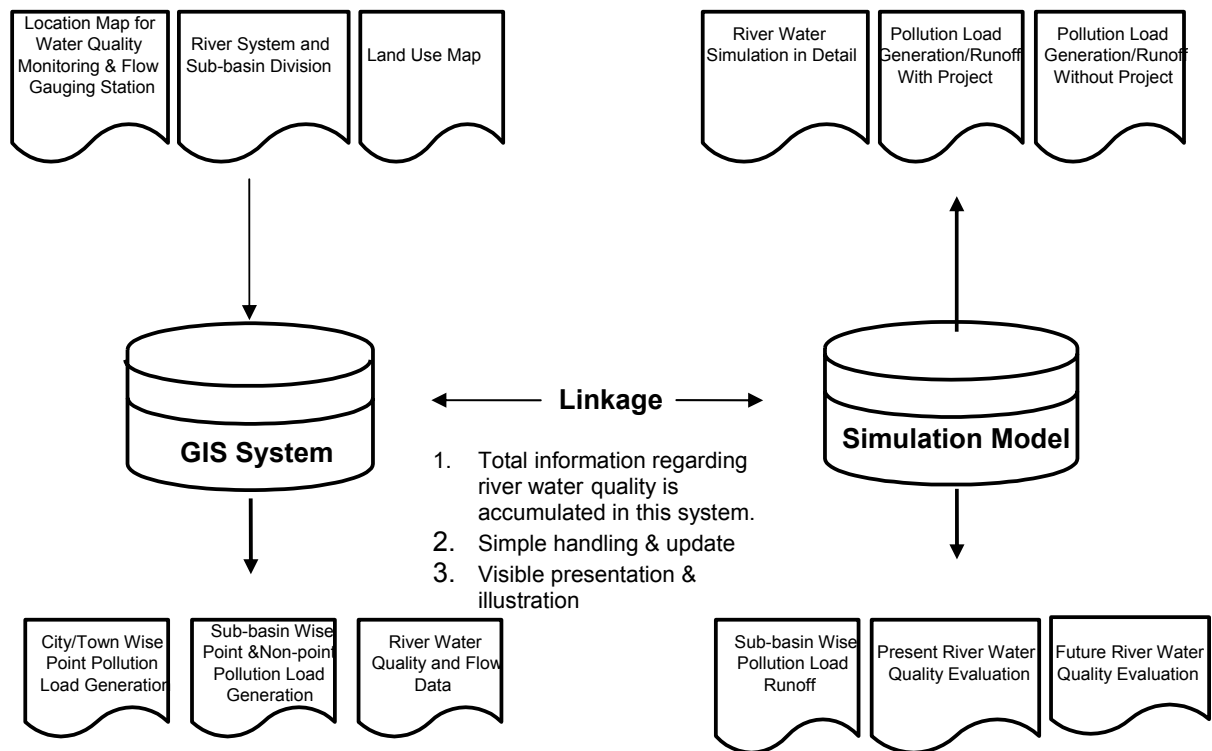
Linking Simulation Model with GIS and MP/FS/DPR Preparation in Project Towns

Following, GIS data layers shall be prepared using the satellite imagery in Yamuna basin.

- GIS data layer of all watercourses, streams, tributaries and Main River in complete Yamuna basin shall be prepared.
- GIS data layer of contours shall be prepared to develop a Digital Terrain Model (DTM) to map the flooded area maps for the complete Yamuna basin.
- GIS data layer associated with point sources of pollution such as STP outfalls, Industrial outfalls, thermal power station outfalls, etc along with their names shall also be prepared.
- To make results readable and useful (self contained), it is necessary to prepare a GIS layer consisting of city names and their geo - referenced co-ordinates.
- Similarly other GIS layers of data required for modeling work such as grid points, cross-section data, etc shall also be prepared for Yamuna basin. The grid spacing in Yamuna basin shall be variable and shall not exceed 500m to 1000 m.

Satellite Images (0.6 m quick bird) of all the towns in Yamuna Basin will be procured by the consultants carrying out Master Plan (MP) Preparation, Feasibility Study (FS) and Detailed Project Report (DPR) Preparation of YAP towns of Uttar Pradesh and Haryana which can be used during Linking of GIS with the model. The remaining satellite images of Yamuna Basin (if any) will be procured by the consultant for Integrated Water Resource Management and Water Quality Modeling of Yamuna Basin. The model under this assignment should be linked to the MP/FC/DPR base year of 2010 and the design year 2040.

SIMULATION MODEL AND GIS SYSTEM



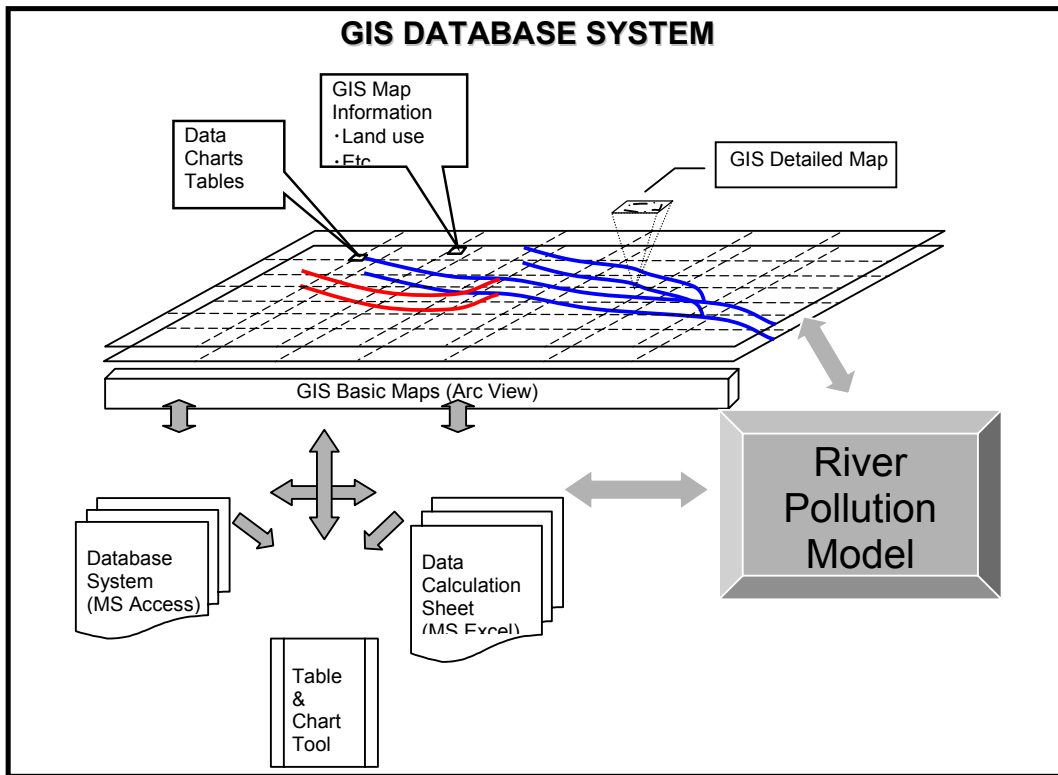
Note: *It shall be automatic not manual*

Linkage with GIS

Calculation of sub-basin wise pollution load generation is ambitious, extremely extensive and complex; therefore, efficient data management, accumulation and assembly are necessary. In this circumstance, linkage with GIS is useful for the basin runoff model as shown in the figure below.

The water quality data derived from the simulation model would be integrated and will use a GIS platform for its proper display. GIS data would use automated queries and display for:

- Temporal display of pollution
- Tabulated pollution data at a station
- Buffer analysis of industrial pollution at stations
- Area wise distribution of different clutters contributing to pollution



Integrated Water Resource Management

A decision support system is to be developed for integrated water resource management. It shall provide cost benefit results.

- **Objectives of the Decision Support System**

The decision support system is to be developed to facilitate decision making by planners, designers and environmental law enforcement agencies, for implementation of water resource management measures.

- **Functions of the Decision Support System**

- To analyze various water resource management scenarios or alternate plans for optimal utilization of water in Yamuna basin especially flow augmentation involving construction of water storage structures, upstream water storage, ground water recharge, rain water harvesting and preparing storage areas for storing excess water during the wet season, etc.
- To develop an integrated water resources management plan to augment the river flow so that future water supply needs are met; future pollution load is minimized; water quality is improved and river ecology is restored.
- To evaluate the efficacy and impact of planned works being done during Yamuna action Plan and suggest corrective actions for better management and control of river pollution.
- To estimate the water retention capacity of the river (amount of rain water can be stored in the catchments) and action plan for the same.
- To develop an implementation plan that outlines various projects that are needed for improvement of river water quality.
- To establish a baseline loading allocation to the various sources in the basin based on a River classification index.

- To establish a unit load cost criteria for penalties if an entity discharges exceed their allocated load to the river, and these funds can be used for clean-up of the river. The future Yamuna River basin Management Agency will likely establish protocols and unit load costs as well as managing the penalties.

Water Quality Protection and Dry Weather Flow Augmentation Proposals

The water quality protection and dry weather flow augmentation proposals should include:

- Identification of alternative proposals for different reaches of the Yamuna River Basin including detailed descriptions for different implementation scenarios of water quality reflecting the influence of flow augmentation measures created for use during the dry season at strategic locations.
- Predict the pollution load reductions required for compliance with national standards and guidelines. This is particularly critical in the heavily polluted Delhi and Agra stretches of the Yamuna River Basin.
- Preparation of indicative capital investment and annual O &M cost estimates for the alternative proposal presented.
- Comparative analyses of the proposals presented including the preparation of final conclusions and specific recommendations.

Forecast Future Demands

Project water supply and wastewater treatment needs to the year 2040 for towns in Yamuna basin including projections given differing population growth scenarios. The forecasts should be graphed out in five year increments.

Identify and Evaluate Opportunities to Expand Water Supply and Wastewater Treatment Resources

Opportunities should include but not be limited to: potential new surface water sources; expansion of existing sources; groundwater and direct or indirect reuse; wastewater treatment technologies, potential wastewater reclamation uses etc,

Development and Evaluation of Water Supply and Wastewater Treatment Alternatives

- Combine individual water supply and wastewater treatment options in an integrated approach to provide long-range alternatives for towns in Yamuna basin. The options should consist of different resource combinations, regional vs. local alternatives, and mixes of water conservation, demand reduction, public education and efficiency. Options can include programs, policies and projects. The alternatives should be developed to provide and evaluate different approaches to satisfying future water demands and wastewater treatment needs.
- Provide for a process to identify which options should be dropped and which options should receive further consideration to keep the number of options within reason.

Setting up of On-line Monitoring Station

In the planned water monitoring program, one on-line monitoring station on pilot basis is to be setup on the Yamuna Basin.

- It shall be capable of measuring and transmitting data (to reach central server at CPCB/NRCD) continuously.
- Objective is to measure and transmit flow and water quality parameters for which on-line measuring probes are available in the market.
- The telemetry system of the procured instrument(s) shall be capable of transmitting 70 – 100 real numbers per minute & shall allow for addition of new probes in future.
- Measuring equipment with in built data transmitter/ without data transmitter, separate data transmitter that can be interfaced with any digital measuring device or such probes are required to be installed and setup at remote location.
- The installation would be said to have been completed only after the system starts getting data at central and zonal data servers routinely (say for 30 days).
- Active involvement and support of equipment supplier(s) would also be necessary during the data processing, operation and maintenance training, and hand holding support component.
- Parameters such as pH, DO, Conductivity, Turbidity etc shall be measured at the On-Line Monitoring Station.
- The data transmission network shall be capable of handling above said data in real time. On-line monitoring station for which telemetry/ data transfer link to central server will be established by the consultant.
- The processed (raw) data shall be posted in the form of graphs (along with simulation model results) and get systematically (cataloged) and stored in NRCD server for downloading.

Training of Staff

For the water quality monitoring to be sustainable, longer hand holding support is mandatory.

On the Job Training

The Consultant shall provide On -the-Job Training to the staff & operators involved in the water quality modeling and monitoring on the aspects of the water modeling system. The nature of hand-holding support shall be that the staff can successfully and efficiently operate and maintain different components of the water quality monitoring system. It is anticipated that hand-holding support will extend to December, 2009

Key Personnel and Team Members

The project requires the consultant to provide an adequate number of experienced International and domestic staff in the relevant field. The table below indicates and summarizes the time estimated for various key positions. The consultants are required to submit their own manning schedule and key staff assignment for the project.

Designation	Qualifications		Nos. of Staff	Total Staff months*
Team Leader/ Basin Manager	Masters/Ph.D in relevant discipline. Total minimum work experience of 15 years. Having minimum 8 years of International experience in relevant projects and in the development and application of water quality models	International	1	6
Environmental Policy Expert	Masters in relevant discipline. Total minimum work experience of 10 years. Having minimum 5 years of International Experience in Environmental Policy.	International	1	1
Water Resource Management Expert	Masters/Ph.D in relevant discipline. Total minimum work experience of 10 years. Having minimum 5 years experience in relevant projects in India and Abroad in Hydrology, Hydraulics, and Water Quality Modeling.	International	1	6
Water Quality Modeler	B.E./M.Tech or other relevant qualification. Total minimum work experience of 10 years. Having minimum 5 years experience in relevant projects.	International	1	6
Hydraulic Modeler	B.E/ B.Tech or other relevant qualification. Total minimum work experience of 10 years. Having minimum 5 years experience in relevant projects.	International	1	6
Environmental Policy Expert	Masters in relevant discipline. Total minimum work experience of 10 years. Having minimum 5 years experience in Environmental Policy.	Domestic	1	4
Water Quality Modeler	B.E./M.Tech or other relevant qualification. Total minimum work experience of 10 years. Having minimum 5 years experience in relevant projects.	Domestic	1	12
Hydraulic Modeler	B.E/ B.Tech or other relevant qualification. Total minimum work experience of 10 years. Having minimum 5 years experience in relevant projects.	Domestic	1	12
GIS Database Analyst	B.Sc/ M.Sc in Geography or Planning. Total minimum work experience of 10 years. Having minimum 5 years experience in relevant projects	Domestic	1	12
Support Persons	As required by the consultant	Domestic		

**Positions and Man Months are only tentative.*

Coordination with Project Management Consultants (PMC)

The primary role of the PMC includes that of technical secretariat to the steering Committee/ NRCD to ensure a well organized and smoothly flowing project, transferring appropriate international experience, and searching out a common understanding and assessment of viable alternatives. The PMC will monitor the project activities to ensure that the work is completed in time, within budget, and within the framework of all the other work that is being undertaken concurrently, and to provide technical and management guidance and direction to the employer and the consultants. Upon completion of each phase, the NRCD/ PMC will approve the work before proceeding to the next phase.

Regular monitoring of the consultants work will be done by the Employer assisted by the PMC professionals. The basic mechanism for monitoring the work would be by means of a monthly status report in which the current month's activities, milestones achieved, administrative issues, and potential variances are set out and described. Quarterly meetings are also held between the consultant project manager, the Steering Committee and the PMC professional staff. At these meeting a more thorough discussion of progress, and variances would take place.

The process described above will ensure that each report will adhere to a common framework for execution and reporting, and that a high level of quality in the final deliverables will be achieved. The PMC will review the draft and final documents.

Project Office

The consultants should have project office at Delhi for day to day activities, data collection, planning and designing and coordination with PMC, NRCD, and JBIC.

Deliverables and Time Schedule

The consulting services shall be carried over a period of 12 months for each state from date of award of contract and shall include the following deliverables:

S.No.	Deliverable/ Report	Time-frame
1.	Inception Report	1 month
2.	Monthly Report	Before 10 th of Every month
3.	Interim Report	6 th Month
4.	Draft Final report	11 th Month
5.	Final Report	12 th Month
6.	Handholding	Up to Dec 2009

The monthly progress reports will provide general information on the progress of implementation of the programme, giving details of work done and work to be done, and will provide updated information about the Consultant's activities for the month and the present status of contract.