SUSTAINABLE INTEGRATED RIVER BASIN MANAGEMENT OF UPPER WARDHA PROJECT, INDIA : A CASE STUDY

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ABSTRACT

The close monitoring of reservoir water level necessitates for reservoir scheduling, optimum power generation and safely routing the flood through the spillway gates. The natural tendency of regulating reservoir is to keep the water level in dam lower by safe margin for accommodating the replenishment likely to be received which leads to avoidable water storage loss. Also, early flood warning systems are essentially required for the protection of the population against flood hazards as it allows people to get prepared. Though, in spite of the large investments made in dams and reservoirs across India, most of these structures are still operated on the basis of experience, rules of thumb or static rules established at the time of construction. In present case study, the real time automation system was established for upper Wardha dam located in upper Godavari river basin, Maharashtra, India. The automation system of Upper Wardha project is completed in 1997 and it is first fully automated indigenous project in India. The prime objective of the system is to conserve water efficiently, mitigate the flood at downstream side of the dam and monitoring of reservoir water level for judicious supply of water intended for domestic and industrial water use. The integrated dam automation system was established for upper Wardha project and working successfully since inception in 1997.

Keywords: *Automation; Real time; Inflow forecasting; Reservoir Operation; Upper Wardha*

1. INTRODUCTION

In the recent past, extreme events such as flash floods and droughts are increasingly causing significant damages in terms of human lives, property loss, irrigation productivity, etc. across India. This might be due to erratic behaviour of climatic pattern, land use changes, population burst and subsequently increasing water demand. These circumstance lead to water governance crisis and resource management could become under substantial pressure. Drivers such as demographics and uncertainties further increase the stress on water resources planners and managers. There is a major constraint and a prime cause for lapses in efficient water resources management for non-availability of reliable, real time information from the water infrastructure. The traditional fragmented approach has to give way for adopting more holistic approach for sustainable water resources management.

In spite of the large investments made in dams and reservoirs across India, most of the hydraulic structures are still being operated on the basis of experience, rules of thumb or static rules established at the time of construction. Manual calculations on flood forecasting and water supply, manual operations of dam spillway gates and canal gates. The prevailing limitations in manual measurements of rainfall and hydrological data in the catchment areas, which are crucial for flood forecasting, reservoir management and water use planning. These resulted in serious repercussions and poor ineffective reservoir and canal operation, which leads to unequal distribution of water in command areas have resulting in very poor water use efficiency (WUE) and water crises. The use of excess water results in wastage of water and drainage problems in the downstream area. Hence, the regulations of water through dams, canals and other hydraulic structures are having vital during monsoon as well as dry seasons. Also, the advancement in IT technologies in the field of water resources engineering can be used for real-time inflow forecasting to mitigate flood and regulate water efficiently by functioning short-term and long-term reservoir operations. For real-time applications, forecast information on reservoir inflow is used to optimize short-term benefits by minimizing spills and maximizing the economic value of water for hydropower production and other water uses. To overcome the limitations in present water management scenario, it becomes necessary to use ultra-modern digital technologies for Integrated Water Resources Management (IWRM) System by adopting;

- SCADA integrated with smart devices as well as systems for real time data acquisitions and control
- Smart weather, water level, rainfall and flow measurement systems
- Real time inflow-outflow (flood) forecasting/water demand
- Automated real time operation of dam/reservoir/barrage/canal/water supply schemes for conserving every drop and judicious water distribution to all stake holders
- GIS based Enterprise Management Information System (EMIS) to provide real-time information & data to all stakeholders for managing their resources

There was a Mowad Dam Breach (Maharashtra State) in 1992 and its effects at Upper Wardha Project, Maharashtra, India in terms of major loss of lives and properties. Subsequently, there was a heavy flood during 1994 and the dam endanger situation due to loss of communication, power failure at dam site, regulation of flood flow during adverse conditions because major storage was against gates. These circumstances necessitated to adopt modern technology for overcoming the situation and disaster management, the Government of Maharashtra decided to implement smart integrated Water Resources Management and control system on Upper Wardha Project way back in 1995. In present case study, the real time automation system was established for upper Wardha dam located in upper Godavari river basin, Maharashtra, India. The automation system of Upper Wardha project is completed in 1997 and it is first fully automated indigenous project in India. The prime objective of the system is to mitigate the flood at downstream side of the dam and monitoring of water level in the reservoir, conserve water efficiently and judicious supply of water intended for domestic and industrial water use.

2. THE UPPER WARDHA PROJECT:

The Wardha River, across which the Upper Wardha Dam is built, is a tributary of the Godavari River in Maharashtra, India. From its origin, at an altitude of 785 m above mean sea level in Satpura range from the Multai Plateau in Betul District of Madya Pradesh, the river flows 32 km in Madhya Pradesh and then enters into Maharashtra near the Multai plateau of the Satpuda range. The river drains a catchment area of 4,302 km^2 up to the upper Wardha dam site. It flows along the entire northern and western border of the Wardha district. After traversing 528 km, it joins Wainganga River, which ultimately flows into the Godavari River. Kar, Wena, Jam and Erai are its left-bank tributaries whereas Madu, Bembla and Penganga are the right-bank tributaries. The topography is hilly and dominant land use is forest in its upper reaches from its source and the lower reaches are flat wide valleys. The project is located near Morshi town, about 8 km towards to the east of Morshi and 56 km from the Amaravati town, in the Godavari River Basin. The total storage of dam is about 786 Mm^3. There are thirteen number of gates on the dam having size of 18 m x 12 m. The water storage against gates is about 663 Mm^3. The design flood capacity is about 19457 m^3/s of the dam. Fig. 1 shows the index map of upper Wardha project.

Fig. 1 : Index map of upper Wardha project

3. PRE-IMPLEMENTATION SCENARIO AT UPPER WARDHA PROJECT

The following points were identified before implementation of real time automation technology within the upper Wardha project for sustainable management of water resources.

(a) The rainfall and weather parameters were manually measured in the catchment area;

(b) The water level and discharge along the rivers, were measured manually within the upper Wardha command area;

(c) There was no robust communication system available between the gauging recorders and authorities for decision making, particularly, during monsoon season;

(d) There was no centralized real time reservoir operation and water management system for decision making to supply and regulate water judiciously, timely and equitably;

(e) The reservoir gates were operated manually which leads to severe situation during monsoon season;

(f) The canal gates were operated physically, hence, there was no regulation on water usage which resulted huge water loss within the command area;

(g) The calculations and estimation of various database, i.e. inflow-outflow, discharge and water level time series, rainfall and other weather parameters were recorded manually;

(h) There was no system available for leakage detection within the dam;

(i) The drainage gallery pumps were operated physically;

(j) There were manual operation of drainage gallery area and power management.

4. ESTABLISHMENT OF PROJECT SET UP AND THEIR IMPLEMENTATION

Automation provides real time measurements and data communication system for better management practices. IT based automation system records automatic calculations and estimation of various parameters, such as, rainfall, discharge, water level, weather, reservoir water level, etc. The decision support system can be established by using real time reservoir operating and monitoring policy. Keeping in view of aforesaid scenario, the following project implementation strategy and solutions were planned to overcome deficiency in the system and become sustainable solution for the concerned stakeholders within the upper Wardha project. The following points were integrated within the system for sustainable water resources management in Upper Wardha catchment area.

(a) Monitoring of rainfall data from 9 field station at catchment area;

(b) Monitoring of river gauge water level from 4 river gauge stations;

(c) Real time monitoring of reservoir level and gate opening;

(d) Real time control gate operation following gate operating schedule;

(e) Regulate water supply for hydropower generation, domestic and industrial usage;

(f) Monitoring and control Left Bank Head Regulator (LBHR) & Right Bank Head Regulator (RBHR) Canal gates;

(g) Determine discharge rate, inflow rate, contents, % contents etc.;

(h) Monitoring flow and providing billing for usage of water to MIDC, MJP and Morshi Town for better management of revenue generation;

(i) Estimation of expected inflow into the reservoir;

(j) Monitoring and control of area lighting with drainage gallery;

(k) Monitor & Control dewatering pump;

(l) Remote monitoring at sub-division, division and circle level.

The step by step establishments of project set up and implementation strategy have been deliberated in succeeding paragraph for smooth functioning and execution of centralized integrated water resources management system within the upper Wardha project. The schematic diagram of established system is depicted in Fig. 2.

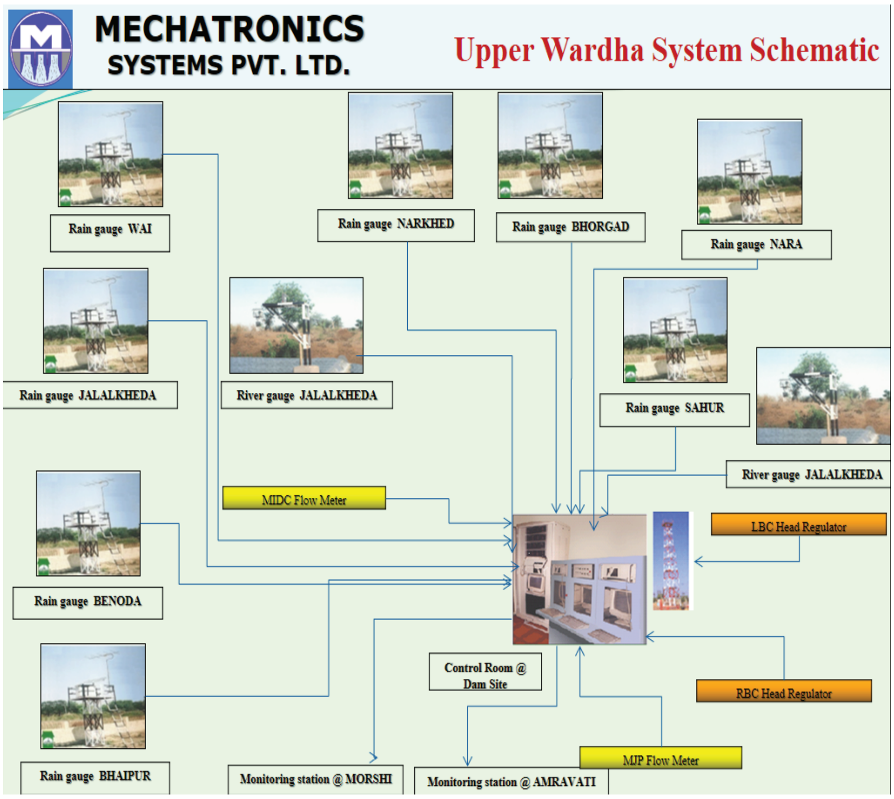

Fig. 2 : Schematic diagram of established system in upper Wardha catchment

4.1 Measurement of Weather Parameters, Stage-Discharge along River and Reservoir Water Level

The weather station unit is designed for collection, storage and transmission of weather data, such as, rainfall, air temperature, relative humidity, wind speed, wind direction, air pressure, solar radiation from remote Stations to control room. There are nine automatic rain gauges, i.e. Bhaipur, Sahur, Wai, Narkhed, Katol, Benoda, Nara, Jalalkheda, and Etava locations, were installed within the catchment area which represents approximately equal area for each station. The areas of respective rain gauge station were approximated using Thiessen polygon method. The six instruments, i.e., Tipping Bucket, weather sensor, solar power supply, Data logger, Telemetry system, Battery backup were used for recording rainfall at particular station. The data logger measures rainfall and send data to the data center after every 15 minutes. The rainfall of current hour, daily, weekly, cumulative rainfall from defined date at start of monsoon, i.e. 1st June of every year, air temperature, relative humidity, wind speed, wind direction, air pressure, solar radiation, water level, are continuously displayed.

FCS Sensor

Tipping Bucket

Full Climate Station

Data Logger

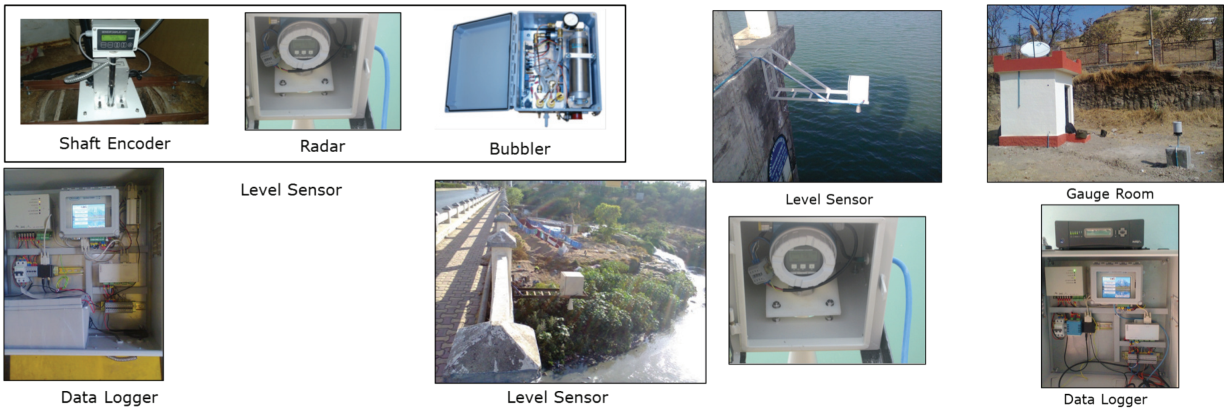

Fig. 3 : Instrumentation set-up for measurement of weather parameters, stage-discharge along river and reservoir water level

Further, the water level gauges were installed at four locations along the river, i.e., Jalalkheda, Chargadh, Salbardi and Barshingi stations. While flow measurement system was established at three locations, i.e., MJP Amravati, MIDC Morshi and Morshi for water supply. The five instruments, i.e., level sensor, solar power supply, data logger, telemetry system, and battery backup, were used for reservoir water level measurement. The data logger measures river level, accordingly calculate discharge and send data to the data center at every 15 minutes. Level sensor is used as per site condition such as radar, shaft encoder, bubbler sensor. All data is stored locally at every 15 minutes interval. The records of weather parameters, river water levels and discharges were used for real time inflow forecasting at upper Wardha dam intended for mitigation of flood and regulate water supply through efficient reservoir operation. This system also provides computerized water billing, which lead to rise in revenue generation by 25-30%. Also, water losses were significantly reduced due to human negligence.

The five instruments, i.e., Level sensor, Solar/mains power supply, Data logger, Telemetry system, Battery backup were used for reservoir water level measurement. This unit is designed for collection, storage and transmission of reservoir water level from remote station to control room. The system integrates micro controller based digital water level recorder with in-built internal memory in consort with a real time clock in LCD for demonstrating the instrument status. The digital water level recorder consists of a weatherproof data logger and level sensor with solar paneled power supply.

The three different sensor input combinations, such as Ultrasonic, Radar Shaft Encoder, Bubbler type Level Sensor embedded within the system, which was used depending upon site condition. The data logger measures reservoir level and send data to the data center at rate of 15 minutes. The user can able assess the data locally as well. The system is powered by rechargeable sealed maintenance free batteries integrated with solar panel.

4.2 Gate Control System

The positions of the dam gates i.e., spillway, irrigation, hydropower outlets, should be measured discharge through gates and corresponding positions of gates can effectively be operated depending upon inflow-outflow requirement for flood mitigation and domestic/industrial water supply by concerned authorities. MECH-GMS is specially designed measurement system installed in this project for radial, vertical and screw type gates. These can be interfaced with various types of sensors such as, leaner encoders, rotary encoders, absolute encoders and optical encoders. There is special function also available for conversion of radial gate opening to vertical opening.

Fig. 4 : Instrumentations for gate control system

The centralized gate operation system was established to regulate discharge outflow through spillway radial gates from the control room, which enables centralized hoist motor control cubicle integrated with automatic and manual interlocking. The system can be operated from the master control station through the VSAT network, which is a two-way communication media. The gates can also be operated manually from the dam control station, using the control system. Further, more ancillary automatic/computerized control system equipments were installed for area-Lighting, Gallery Dewatering Pumps and low voltage gallery illumination with back-up power source.

Fig. 5 : SCADA based gate control panel set-up

4.3 Real Time Data Acquisition, Monitoring and Control Software:

The MECH SCADA/ MMI Software is established for a complete automation solution providing graphical visualization, data acquisition and supervisory control for field instrumentation program. The MECH SCADA system incorporates host software automation solutions comprising remote telemetry systems, remote terminal units (RTU), programmable logic controllers (PLCs) which were typically installed in remote areas. Fig. 6 depicts explicit measurements monitoring and controlled data in the database for exhibiting real time data. Furthermore, multiple colours were used to demonstrate alarming situation whether the parameters are in controlled conditions or not. The computerized remote control system is utilized for monitoring the flood routing by controlling and operating the spillway, irrigation, hydropower gate outlets without affecting dam safety. All measured parameters, such as, rainfall in the catchment area, inflow, travel time, levels in the dams on u/s and d/s, etc. are being taken into account for successful operation of flood routing. The Decision Support Software (DSS) is automatically adjusting the gate openings of spillway radial gates. The gate positions are being periodically modified on the basis of signals of data acquired from various sites. Accordingly, the DSS is being operated the spillway gates with taking into account of gate operation schedule.

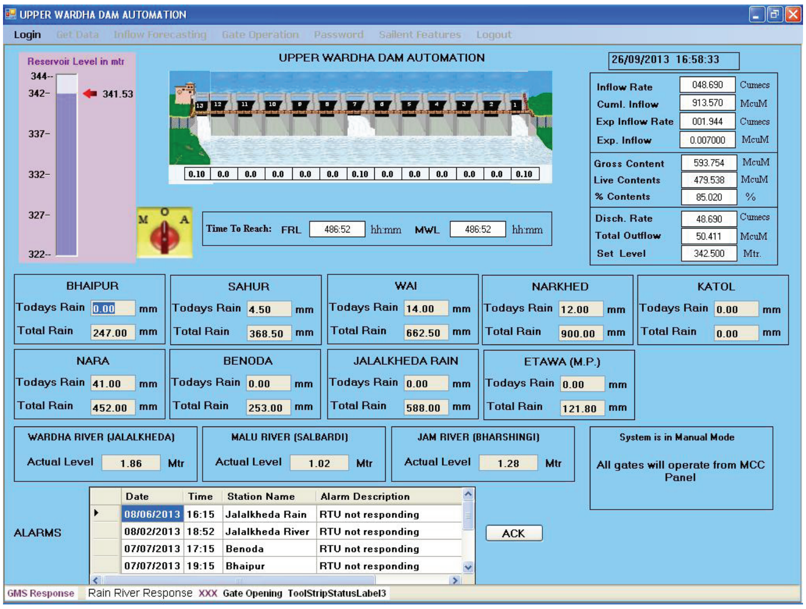

Fig. 6 : Dam Automation window display in computer for controlling the entire system

The gate is being operated either fully automatic mode or semi-automatic mode or operator override with password security. In full automatic mode, SCADA software commands all decisions. Based on the inputs received from the monitoring equipments and pre-programmed commands, the algorithm estimates discharge rate at pre-programmed time interval based on reservoir operation schedule. The software incessantly estimates actual inflow using change in reservoir level, expected inflow based on the rainfall and corresponding runoff relationship. The system exhibits inflow and estimated data on the monitor along with the graphical representation of spillway gates. The inflow rate is to be forecasted by considering the time to reach MWL and FRL. The system estimates discharge required to be release and accordingly repositions the gate taking into considerations gate operation schedule. Based on forecasted inflow and travel time to reach to reservoir, system provide automatic decision considering downstream conditions, reservoir operation schedule for mitigating flood damage in terms of lives or properties. For accommodating capacity for impinging flood discharge, the system is activated to adjust the extent of gate opening to release the water at moderate rate for effective flood routing.

In semi-automatic mode, the software provides to operator override after checking security password and confirmation from central control station at the Dam. In this mode, the operation integrates four types of various options, such as, gate opening against time option; discharge rate against time option; Level to be maintained option; anticipatory option. The software provides access to all these options only after the confirmation of security password. In gate opening option, operator can open the gates for a particular time interval. The gate operation schedule is also provided override for the higher password levels. In the discharge rate option, the operator can enter the required discharge rate or a quantum of water to be released within a time interval. Accordingly, extent of gate is opened considering gate operation schedule. In level to be maintained option, the operator can enter the level required to be maintained and entered level will be maintained during entire operation. Accordingly, extent of gate is controlled the discharge considering gate operation schedule. This option is available with higher password levels only. Finally, the estimation of expected inflow after a pre-determined time interval is done based on rainfall in the catchment and the provided rainfall run-off relationship in anticipatory option. Also, the system estimates the status of the reservoir after particular time interval. Based on these estimation, operator can operate the gates manually to create accommodation capacity by releasing the water at moderate rate.   The relevant data is stored after a pre-defined time interval. Fig. 7 shows the few screenshots of gate operation, inflow forecasting, and drainage galley pump operation using integrated established dam automation system. Also, comparison of expected (forecasted) and actual inflow water yield into the upper Wardha reservoir at 10 daily time scale for monsoon 2006 in graphical format and tabular form, are depicted in Fig. 7 and Table 1 respectively. The same practice as inflow forecasting is followed by concerned authorities.

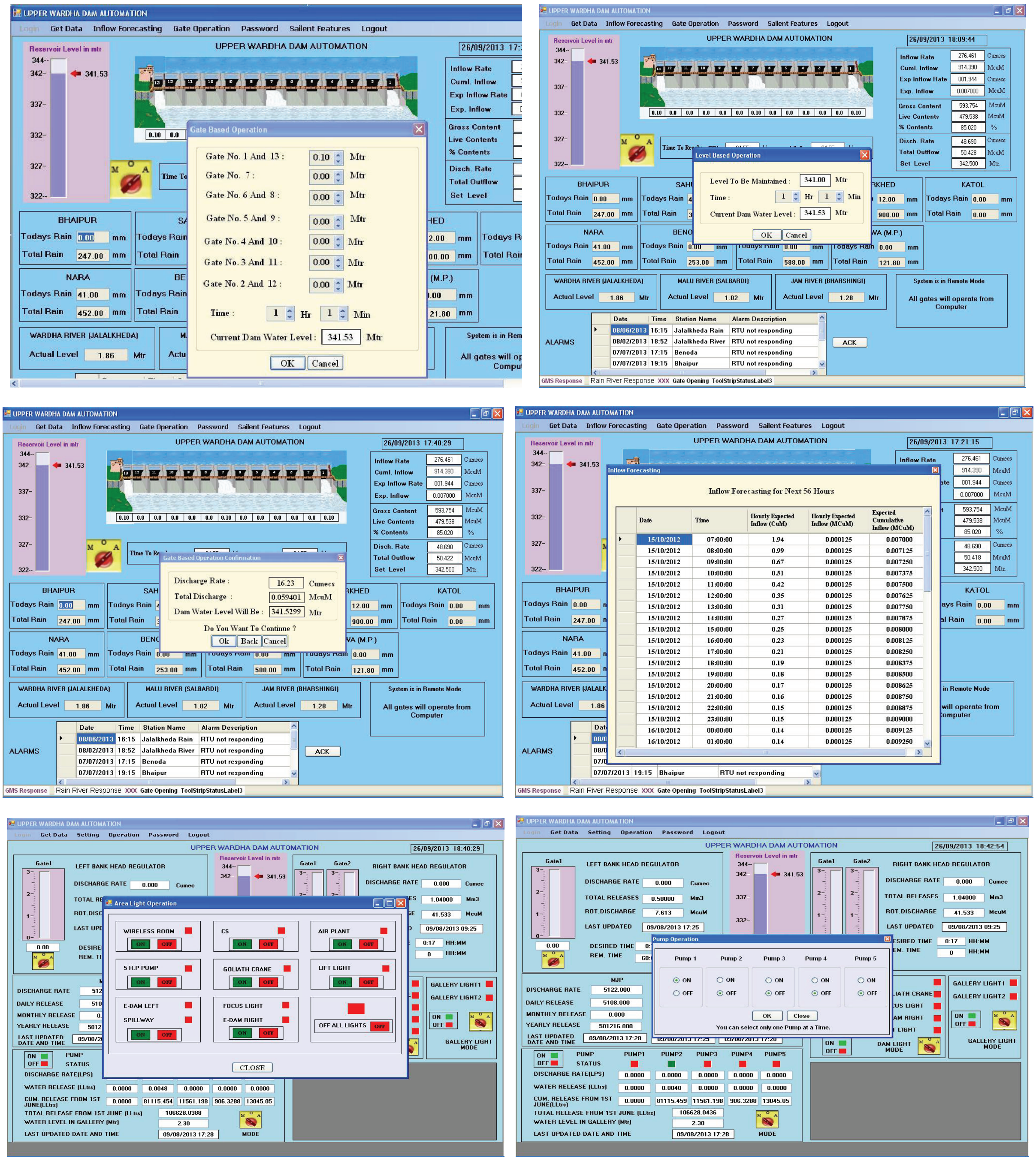

Fig. 7 : Gate operation, Inflow forecasting and drainage gallery pump operation

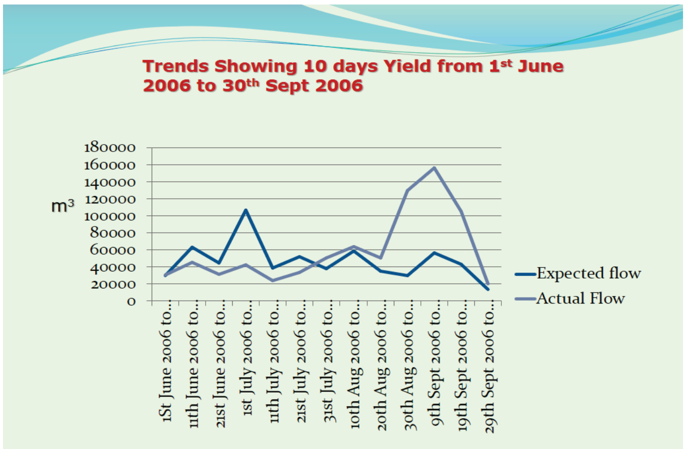

Fig. 8 Comparison of expected & actual inflow yield at 10 daily time scale for monsoon 2006

4.4 Water Audit Reports:

The software summarises water audit reports in terms of water bill, spillway gate operations, outflow releases, pump operations, etc. for effective management of water resources within the project. This information is immensely helpful for the stakeholders within the system for future planning and schedule of flood control, irrigation, and water supply. Fig. 9 depicts few reports generated from the established monitoring software.

Table 1 : Comparison of expected & actual inflow yield at 10 daily time scale for monsoon 2006

Duration	Per 10 days yield (Expected)	Per 10 days yield (Actual)
1St June 2006 to 10th June 2006	30125.00	30250.50
11th June 2006 to 20th June 2006	63147.37	45087.30
21st June 2006 to 30th June 2006	44941.51	31436.00
1st July 2006 to 10th July 2006	107103.18	42499.20
11th July 2006 to 20th July 2006	38346.31	24072.10
21st July 2006 to 30st July 2006	51794.97	33219.10
31st July 2006 to 9th Aug 2006	37639.33	50422.00
10th Aug 2006 to 19th Aug 2006	58364.26	64145.80
20th Aug 2006 to 29th Aug 2006	35302.48	50393.50
30th Aug 2006 to 8th Sept 2006	30123.45	129701.00
9th Sept 2006 to 18th Sept 2006	56719.84	156451.30
19th Sept 2006 to 28th Sept 2006	43116.77	105291.60
29th Sept 2006 to 30th Sept 2009	13290.50	19999.00
Total	**610015.02**	**782968.4**
Average Accuracy of the Result is :- 77.03 %		

ALL RAIN GAUGE STATION DETAILS

FROM 27/08/2012 TO 27/08/2012 Date 27/09/2013

Date	Time	BHAIPUR		SAHUR		WAI		NARKHED		KATOL		NARA		BENODA		JALALKHEDA RAIN		ETAWA (M.P.)	
		Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain	Todays Rain	Total Rain
27/08/2012	08:00	0.00	314.50	0.50	246.00	0.00	603.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	0.00	280.50	0.00	310.80
27/08/2012	09:00	0.00	314.50	0.00	246.00	0.00	603.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	0.00	280.50	0.00	310.80
27/08/2012	10:00	0.00	314.50	0.00	246.00	0.00	603.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	0.00	280.50	0.00	310.80
27/08/2012	11:00	0.00	314.50	0.00	246.00	0.00	603.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	0.00	280.50	0.00	310.80
27/08/2012	12:00	0.00	314.50	0.00	246.00	0.00	603.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	1.50	282.00	0.00	310.80
27/08/2012	13:00	0.00	314.50	0.00	246.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	3.50	284.00	0.00	310.80
27/08/2012	14:00	0.00	314.50	0.00	246.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	3.50	284.00	0.00	310.80
27/08/2012	15:00	0.00	314.50	0.00	246.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	3.50	284.00	0.00	310.80
27/08/2012	16:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	3.50	284.00	0.00	310.80
27/08/2012	17:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
27/08/2012	18:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
27/08/2012	19:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
27/08/2012	20:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
27/08/2012	21:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
27/08/2012	22:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
27/08/2012	23:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
28/08/2012	00:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
28/08/2012	01:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
28/08/2012	02:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80
28/08/2012	03:00	0.00	314.50	2.00	248.00	2.00	605.50	0.00	522.00	0.00	0.00	0.00	468.00	0.00	260.50	4.00	284.50	0.00	310.80

Total Page No.: 1 Zoom Factor: 100%

Upper Wardha Dam Automation

FROM 03/09/2012 TO 04/09/2012 DATE 27/09/2013

Date	Time	Dam Level	Contents			Inflow		Exp. Inflow	Discharge		Total Flow	Time to Reach FRL	Time to Reach MWL	GATE OPENING IN METER												
			Live	%	Total	Rate	Cum		Rate	Cum				1	2	3	4	5	6	7	8	9	10	11	12	13
03/09/2012	08:00	341.72	495.3805	87.8300	609.5961	233.327	1,178.560	0.012	0.000	0.000	0.000	81:45	81:45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	13:00	341.75	497.9067	88.2700	612.1223	699.980	1,181.080	0.010	0.000	0.000	0.000	26:15	26:15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	14:00	341.76	498.7403	88.4200	612.9559	233.327	1,181.920	0.010	0.000	0.000	0.000	77:45	77:45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	15:00	341.77	499.5947	88.5700	613.8103	236.105	1,182.770	0.011	0.000	0.000	0.000	75:50	75:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	16:00	341.78	500.4398	88.7200	614.6554	236.105	1,183.620	0.011	0.000	0.000	0.000	74:50	74:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	17:00	341.78	500.4398	88.7200	614.6554	0.000	1,183.620	0.012	0.000	0.000	0.000	999:99	999:99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	18:00	341.78	500.4398	88.7200	614.6554	0.000	1,183.620	0.013	0.000	0.000	0.000	999:99	999:99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	19:00	341.79	501.2856	88.8700	615.5012	233.327	1,184.460	0.014	0.000	0.000	0.000	74:43	74:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	20:00	341.80	502.1323	89.0200	616.3479	236.105	1,185.310	0.015	0.000	0.000	0.000	72:50	72:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	21:00	341.82	503.8278	89.3200	618.0434	469.431	1,187.000	0.017	0.000	0.000	0.000	35:38	35:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	22:00	341.84	505.5263	89.6200	619.7419	472.209	1,188.700	0.018	0.000	0.000	0.000	34:25	34:25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/09/2012	23:00	341.87	508.0798	90.0800	622.2954	711.091	1,191.260	0.020	0.000	0.000	0.000	21:51	21:51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/09/2012	00:00	341.88	508.9325	90.2300	623.1481	236.105	1,192.110	0.022	0.000	0.000	0.000	64:50	64:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/09/2012	01:00	341.89	509.7860	90.3800	624.0016	236.105	1,192.960	0.025	0.000	0.000	0.000	63:50	63:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/09/2012	02:00	341.90	510.6402	90.5300	624.8558	238.882	1,193.820	0.028	0.000	0.000	0.000	62:6	62:6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/09/2012	03:00	341.91	511.4952	90.6800	625.7108	236.105	1,194.670	0.032	0.000	0.000	0.000	61:50	61:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Total Page No.: 1 Zoom Factor: 100%

VIDHARBHA IRRIGATION DEVELOPMENT CORPORATION (V. I .D. C.) , NAGPUR
UPPER WARDHA PROJECT DIVISION, AMRAWATI

WATER SUPPLY BILL

NO. . /UWDD/AB2/

1.	CUSTOMER	:	**MAHARASHTRA INDUSTRIAL DEVELOPMENT CORPORATION**
2.	SOURCE OF WATER	:	UPPER WARDHA DAM
3.	DATE OF AGGRIMENT	:	19/11/2008
4.	MONTH & YEAR OF CONSUMPTION	:	9 - 2012
5.	TOTAL CONSUMPTION OF WATER	:	26550.00 UNITS (1 UNIT = 10,000 LTRS.)
6.	UNIT RATE	:	RS. 38.00 PER UNIT (1 UNIT = 10,000 LTRS.)
7.	AMOUNT	:	**RS** 1,008,900.00
8.	LOCAL TAXES (20 PERCENT)	:	**RS** 201,780.00
9.	GRAND TOTAL	:	**RS** 1,210,680.00

IN WORDS RS. **Rupees Twelve Lakh Ten Thousand Six Hundred Eighty Only**

C.C. TO : 1) Executive Engineer , Maharashtra Jeevan Pradhikaran Div. No. 2 , Amrawati for payment
2) T.S. -3 , Divisional Office .

Sub Divisional Engineer
Upper Wardha Dam Sub Div. II ,
Morshi

Executive Engineer
Upper Wardha Dam Division,
AMRAWATI

Pumps Report: Daily
FROM 27/09/2012 TO 27/09/2012
Date: 27/09/2013

Date	Time	Sump Level (Mtr)	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Total Cummulative Discharge (LLtr)
			Cumulative Discharge (LLtr)	Cumulative Discharge (LLtr)	Cumulative Discharge (LLtr)	Cumulative Discharge (LLtr)	Cumulative Discharge (LLtr)	
27/09/2012	08:00	2.55	0.00	356.47	432.05	0.00	0.00	788.52
27/09/2012	09:00	2.55	0.00	358.06	436.19	0.00	0.00	794.25
27/09/2012	10:00	2.55	0.00	359.15	440.91	0.00	0.00	800.06
27/09/2012	11:00	2.55	0.00	363.46	445.13	0.00	0.00	808.59
27/09/2012	12:00	2.55	0.00	367.80	445.80	0.00	0.00	813.59
27/09/2012	13:00	2.55	0.00	369.88	450.87	0.00	0.00	820.76
27/09/2012	14:00	2.55	0.00	372.98	455.59	0.00	0.00	828.58
27/09/2012	15:00	2.55	0.00	376.88	460.31	0.00	0.00	837.19
27/09/2012	16:00	2.55	0.00	381.42	460.48	0.00	0.00	841.90
27/09/2012	17:00	2.55	0.00	383.51	465.56	0.00	0.00	849.07
27/09/2012	18:00	2.55	0.00	386.47	470.28	0.00	0.00	856.74
27/09/2012	19:00	2.55	0.00	390.30	475.52	0.00	0.00	865.82
27/09/2012	20:00	2.55	0.00	395.05	475.55	0.00	0.00	870.60
27/09/2012	21:00	2.55	0.00	397.14	480.24	0.00	0.00	877.38
27/09/2012	22:00	2.55	0.00	400.03	484.96	0.00	0.00	884.99
27/09/2012	23:00	2.55	0.00	404.13	489.18	0.00	0.00	893.31
28/09/2012	00:00	2.35	0.00	408.47	489.76	0.00	0.00	898.23
28/09/2012	01:00	2.35	0.00	410.70	493.90	0.00	0.00	904.60

Total Page No.: 1 Zoom Factor: 100%

Fig. 9 : Audit reports for various operations from the developed software

5. CONCLUSIONS

The integrated dam automation system was established for upper Wardha project and working successfully since inception. It is a pioneering achievement of Mechatronics System Pvt Ltd., Pune that

the established system is the first kind of real time dam automation system in India when automation/

SCADA technology was in just initial stage at that time. The following benefits were concluded at the end of successfully implementation of project.

(1) Optimization of water storage

(2) Real time remote reservoir monitoring and control

(3) Instantaneous decision making support system

(4) Inflow-outflow flood forecasting

(5) Efficient flood routing

(6) Increase in hydro-power generation

(7) Safety of dam structures

(8) Reduction and/or elimination of man-made errors

(9) Single room control for reservoir operation

(10) Reduction in operational costs

(11) Increased crop production within the catchment area

(12) Water allocation provided to water users as timely, judiciously and equitably

(13) Efficient management of the water resources system

(14) Reduced maintenance requirements and increased water revenue generation

(15) Decreased flood damage at downstream of the dam

(16) Better response provided in emergencies

(17) Fish and wildlife enhancement

REFERENCE

http://msplautomationprojects.com/Pages/Dams/Upperwardha/PageUpperWardhaLiveData.aspx