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Professional drinking water supply with Supervisory Control And Data Acquisition (SCADA) system

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ABSTRACT

The planning and design of water supply network requires great attention to these days because ineffective water distribution leads to various losses due to which the ultimate goals of water supply such as quality, quantity and timeliness are not being achieved. So the planning and design requires the expertise of city planners and civil engineers.

Vijayawada city has five piped water supply systems starting from 1907 and out of which three pumping main lines are located at head water works near Prakasham barrage of river Krishna and other two from intake gallery in river Krishna and Pushkarghat water works. The original water supply scheme comprising one infiltration well of capacity 5 Million Gallon per Day (MGD) could not meet the demand due to increase in population and hence Dr. K.L.Rao head waterworks located upstream of the Prakasam barrage had been augmented to meet the increasing population.

The main objectives of study area are to supply safe and clean water in adequate quantity, conveniently and optimizing unit cost of production as possible, to reduce Unaccounted For Water (UFW) by identifying the leakages, overflows, bypasses and direct distribution points and to implement online information, historical data and automated reports to help in taking timely decision and managing demand variations.

The specific conclusions drawn from the present study is as unit cost of water production has been optimized to Rs 2.17/- per kilo liter by using SCADA process, the chlorine dosage of 0.02 to 0.05 mg per liter has been maintained throughout the water supply as per the standards of drinking water using SCADA process whereas in the previous was not maintained as per IS code, SCADA process is able meet the demand of 150 liters per capita per day for the entire population of the city whereas it was not met by the previous system, SCADA ensured the supply of water at the required point of the time whereas in the previous method there were delays due to uncontrolled monitoring, the amount of Unaccounted For Water (UFW) has been brought down from 50% to 20% by controlling the leakages and overflows in SCADA process, by using SCADA process we could generate reports and graphs with all the information such as flow rates, level, UFW whereas in the previous case we cannot know all the details.(6).

Key words: Intelligent Electronic Device, Unaccounted For Water (UFW), Overflow alert system, Chlorine analyzer, Flow meter

INTRODUCTION

Water distribution and its usage in present days is being influenced by many factors such as population, food production, nature of distribution system, power generation, industrial growth wild life etc. (1) The present available water sources are not sufficient to meet the demand of enormously increasing population which is expected to increase for about 1500 to 1800 million by the year 2050 (12). As a global

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water crisis threatens, modern civilization must know how world water supply effects the food consumption. (7) Regional variations in the rainfall lead to situations when some parts of the country do not have enough water even to raise a single crop, which effects the food production. To meet the requirement of food production, every water source must be utilized in a proper and effective manner without any wastage (3).

The planning and design of water supply network requires great attention to these days because ineffective water distribution leads to various losses due to which the ultimate goals of water supply such as quality, quantity and timeliness are not being achieved. (5) So the planning and design requires the expertise of city planners and civil engineers (8). Public drinking water works aims to provide safe potable water to every person. To achieve this they pump raw water from various sources like river and bore wells, process the raw water and then distribute to the public through various service reservoirs present across the city. (9) Both quantity and quality of water is very much important for public drinking water works. Powerful software and measuring instruments can help in optimization of the water supply and improving service delivery to the public.

Water management system aims to provide quality and quantity auditing in public drinking water systems. The system logs data related to various parameters like flow rate, volume accumulated, quality assurance by measuring the dosage of chlorine in various parts of the city.

OBJECTIVES OF THE PRESENT STUDY

To achieve the above requirements this study is taken with the following objectives.

1. To supply safe and clean water in adequate quantity, conveniently and optimizing unit cost of production as possible.
2. To reduce Unaccounted For Water (UFW) by identifying the leakages, overflows, bypasses and direct distribution points (4).
3. To implement online information, historical data and automated reports to help in taking timely decision and managing demand variations.

STUDY AREA: Vijayawada, the third largest city in the state of Andhra Pradesh after Hyderabad and Visakhapatnam, also it is one of the important commercial and transport centers of the state. Over years the city has grown as a major economic, cultural and administrative nerve centre of coastal Andhra due to its nodal location as an important railway junction of and, also because of National Highway-5 and National Highway-9 traversing the city. The city also has a few places of historic importance. The city is situated at the foot of a low range hills on the northern bank of the river Krishna with its cardinal points as 16° 31’ North latitude and 80° 37’ East longitude, around 70 km away from the coast.

HISTORY & GROWTH OF THE VIJAYAWADA CITY

The growth of the town during 1855 AD was along the banks of the river Krishna abutting Indrakiladri hills around the temple of lord Malleswara. During 1905 AD, the growth started along the canals and areas abutting Indrakiladri and Gandhi hills. The city grew further along the three canals with more growth along the Bandar canal.

CLIMATIC CONDITIONS OF VIJAYAWADA CITY

Vijayawada and the surrounding areas experience high temperature. The mean daily maximum temperature is 47^0 C, while minimum is 27.7^0 C in this region. The temperature begins to rise in mid February; April and May are the hottest months. December and January are usually the months with the lowest temperatures during the year. During these two months, the

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mean daily maximum temperature is about 29^0 C while minimum is about 19^0 C. Cold weather period in Vijayawada is normally found in rainy seasons. The city receives an average annual rainfall of 965 mm and the build of the rainfall is received during south-west monsoon period.

WIND DIRECTION IN THE CITY REGION

The direction of wind in the region around Vijayawada in the hottest months of April and May is from south to east in the morning hours and, in the evening from southeast to northeast. In warm months from October to March, the wind blows in the morning from east and north and, in the evenings mostly from southeast and east.

TOPOGRAPHY AND LANDSCAPE OF CITY

The land lay of Vijayawada is characterized by four canals, four hills and the holy river Krishna. Vijayawada when approached from Guntur is welcomed by the historic gates across the holy river Krishna. The way to Machilipatnam runs parallel to Budameru canal and across two other canals. The natural slope of the old town is falling from north to south whereas the new town slopes down from west to east.

INTAKE SYSTEMS

Vijayawada city has five piped water supply systems starting from 1907 and out of which three pumping main lines are located at head water works near Prakasham barrage of river Krishna and other two from intake gallery in river Krishna and Pushkarghat water works. The original water supply scheme comprising one infiltration well of capacity 5 Million Gallon per Day (MGD) could not meet the demand due to increase in population.

Table 1: Capacities of plants

S. No.	System	Design capacity in MGD	Year of incorporation	Present condition
1	Head water works, behind Kanakadurga temple	5	1965	Working
2	Head water works, behind Kanakadurga temple	8	2003	Working
3	Head water works, behind Kanakadurga temple	16	1994, 2003	Working
4	Intake gallery (3 wells)	10		Working
5	Head water works, behind Kanakadurga temple	11	2010	Working

DISTRIBUTION SYSTEM

The city is divided into 54 hydraulic zones; each having a separate elevated storage reservoirs and distribution systems. Out of 54 zones 27 zones are fully covered and 18 zones are partly covered and have been approved in phase II under JNNURM for full coverage of distribution system. VMC is preparing detailed project report for the balance component of water supply system.

Surface water is pumped into the service reservoirs after primary treatment. The water from the bore wells is pumped into the Over Head Tanks (OHT) directly. There are 6 OHTs with ground water as source and a total capacity of around 4 ML. The reservoirs have a total supply capacity of around 50 ML. Boosters are used at places to meet the required pressure. (11) For example here reservoir with capacity for

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Krishna water source is shown in below table 2 which is under 16 MGD plant.

Table 2 Reservoirs with capacities under 16 MGD plant

S. No.	Name of reservoir	Capacity in lakh gallons	Supply in LGD
1	Mallikarjuna pet	3.25	6.5
2	Brahumam gari matam	1.5	3
3	Gollapalem gattu	1	2
4	Labbipet stadium	3.25	6.5
5	Rahman park	2.75	5.5
6	Gulamohiddin nagar	1.5	3
7	Machavaram – 1 & 2	2.25	4.5
8	Satyanarayanapuram	3.25	6.5
9	H.B.colony – 1 & 2	2	4
10	Gandhi nagar – 1 & 2	6.5	13

The figures 1, 2, 3, 4, 5, 6 are illustrate location maps of Satellite view of Vijayawada city, base map, contour map, soil map of Krishna river, land use/land cover map & Triangulated Irregular Network (TIN) map.

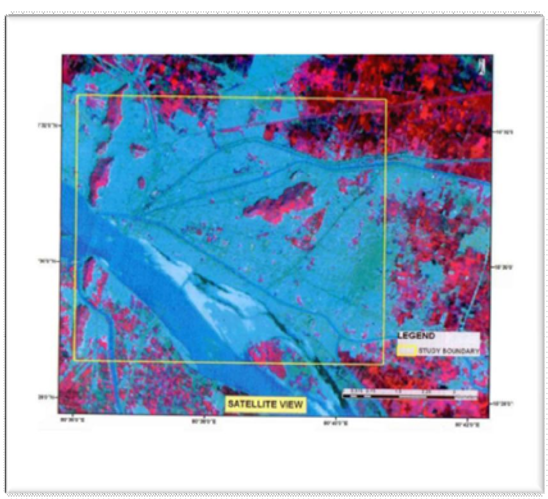

Fig. 1 Satellite image of Vijaywada city

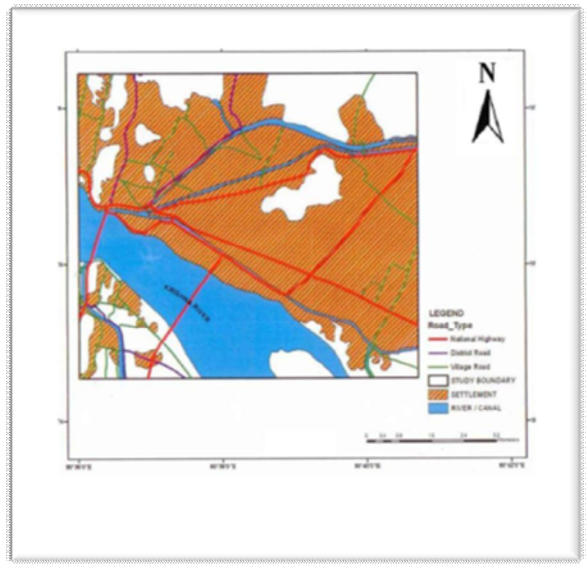

Fig. 2 Base map of river Krishna

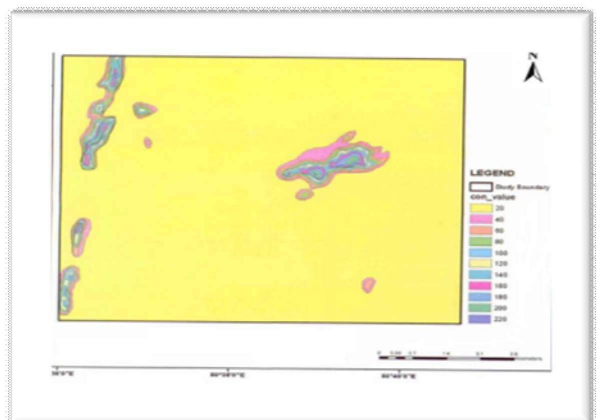

Fig. 3. Contour map of study area

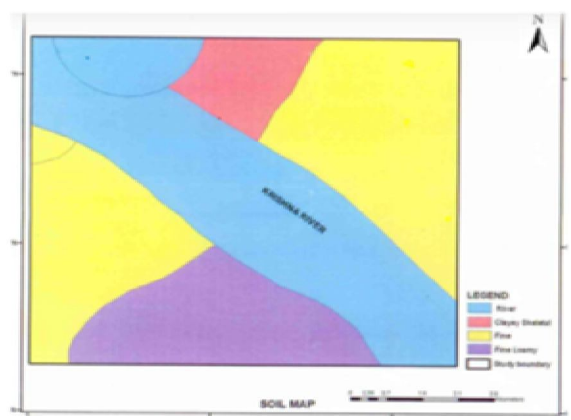

Fig. 4. Soil map of study area

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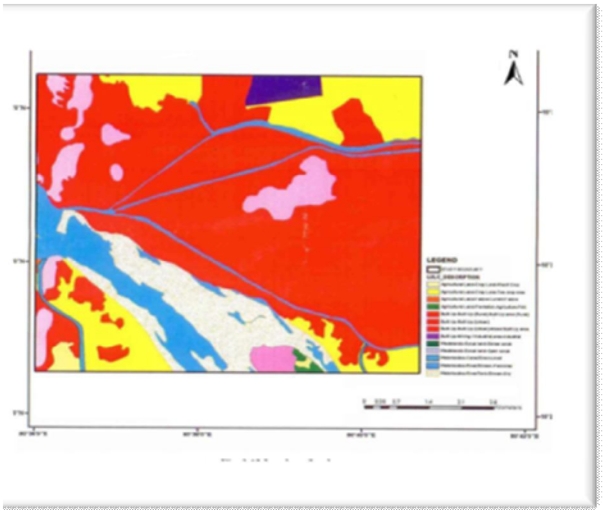

Fig. 5. Land use/land cover map of study area

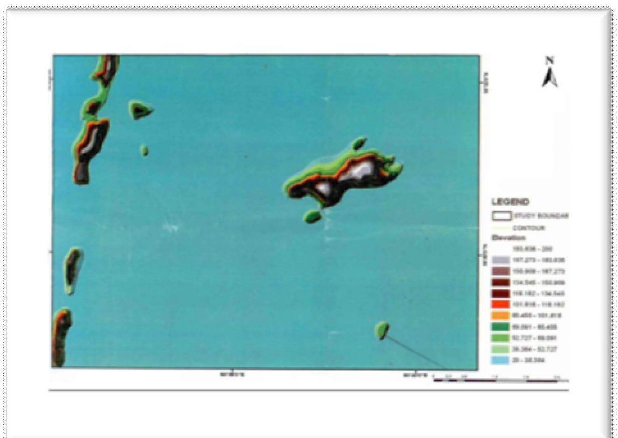

Fig. 6. TIN map of study area

METHODOLOGY

Water is pumped from its source through pumping station or booster and then sent to water treatment plants where the treatment is carried out. The treated water is then distributed for its end usage. Fig. 4.1 illustrates the typical distribution system of water (10).

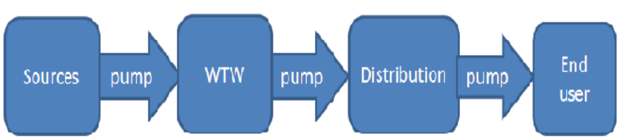

Fig. 7 Typical water distribution system

SYSTEM OVERVIEW

The system contains sensors to measure flow and level. These sensors give analog output corresponding to the flow and level. Flow sensor is a clamp on type which is attached to inlet pipe and ultrasonic level sensor is installed on top of the reservoir. Intelligent Electronic Device (IED) captures processes and stores the online data for further processing. Location of reservoir: Governerpet, Capacity of the reservoir: 2.75 L gal, Type of reservoir: ELSR Depth of water level: 4.43 meters, Dead storage: 0.10 meters, Source of reservoir filling: Pushkar ghat This reservoir is supplying water to the following areas: Labbipet, Punnamma tota, Police quarters, Governerpet, Suryaraopet, Newgiripuram. Table 3 illustrates the equipment installed and the purpose of each equipment.

Table 3 Installed equipment

S. No.	Equipment	Make - Model	Purpose of equipment
1	Ultra sonic level meter	Nevelco – SGP-370-2.	For level measurement
2	Ultra sonic clamp on flow meter	GE – AT 868	For flow measurement
3	Intelligent Electronic Device	Efftronics- DL 99/2001	For data recording
4	Lightning arrestor	-	For protection from lightning
5	Earthing	-	For protecting equipment from unnecessary current

ANALYSIS AND INTERPRETATION

The data collected by the Intelligent Electronic Device (IED) is ported into the system for further analysis. Connection between Intelligent Electronic Device and Personal

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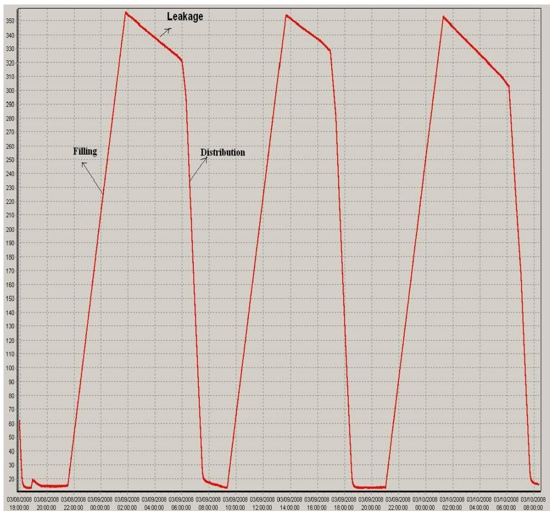
Computer (PC) is established using an RS-232 cable. Reports and graphs of flow and level are taken. Graph 1 shows Flow graph made by plotting the flow rate on Y-axis Vs Time on X-axis. Graph 2 shows Level graph made by plotting level on Y – axis and Time on X – axis.



Graph 1 Level graph

Graph 2 Flow graph

OBSERVATIONS

Based on the study made at the ELSR–1, Governerpet the following observations are made on water wastages which are illustrated in table 5.1. The listed also contains observations on security and hygiene of the reservoir. Solutions and details of the recommendations are listed under recommendations.

Table 4 Consolidated report of UFW

Month	Total amount of water filled (kilo liters)	Total amount of water pumped (kilo liters)	Water over-flow (kilo liters)	Leakage into distribution lines (kilo liters)	Total UFW (kilo liters)	Percentage of UFW
September	64533	46497	4699	13337	18036	27.95
October	44385	34127	1607	8651	10258	23.11
November	51126	38106	1112	11908	13020	25.47

ESTIMATION OF OVERFLOWS

There were 24 overflow instances found in September 2010 and 4,700 kilo liters of purified water are lost in these overflows. The total over flow throughout the year will be 56,400 kilo liters. Cost of water loss for 1 year = Rs 1, 42,692/-. Reasons for overflow are no overflow indication or alert mechanism available and valves are not closed timely.

ESTIMATION OF INFLOW AND OUTFLOW LEAKAGES AT RESERVOIRS

Rate of leakage is 30 kilo liters/hour. Leakages at the outlet account for 13,138 kilo liters of purified water per month. This results in net loss of Rs. 3, 98,870/- per reservoir per year.

RECOMMENDATIONS

The following recommendations are to be implemented to avoid wastage of water at reservoirs like leakages at inflow, outflow and overflows.

Direct wastage: Over flow warning system would control overflows. This system will produce beeps before water in the reservoir reaches overflow level.

Mechanical : Valves need to be monitored and timely maintenance schedule to be designed. Replace aged and partially damaged valves.

Hygiene : Monitoring and alert mechanism for reservoir cleaning is required.

Optimization: Monitoring and optimization of the reservoir filling is required. Online assessment of level in various reservoirs may help in palling for proportionate distribution of water.

Disinfectant: Timely monitoring of chlorine levels will help in taking corrective actions.

Security: Alertness of the employee present at the reservoir can prevent security threats to some extent. In duly person may be asked to press a present button for every 15 min which will ensure his presence at the reservoir and his alertness. Opening of the reservoir gate to the top can be monitored from a central place.

Overflow alert system: Overflow alert mechanism alerts the operator to close the valve immediately, restricting the over flows. An overflow sensor will sense the level of the water and an electronic circuit attached to it will actuate the alarm.

SCADA for water supply system: To mitigate the above water losses and to provide truthful information of the field parameters like flow, water level, chlorine level to the authorities for better controlling of the field operations and systematic documentation of maintenance works SCADA a computerized maintenance management system is implemented(2).

EQUIPMENT IN SCADA SYSTEM

The instruments which are used to carry out SCADA process successfully are flow meter, level meter, chlorine analyzer, Intelligent Electronic Device (IED) and Front End Processor (FEP).

Flow meter: The flow meter is used to measure the velocity of the flowing water and thereby knowing the velocity, flow can be calculated. Flow measurement is basically requires at water production plant, service reservoirs and bulk water supply lines. The ultrasonic flow meter is designed to measure the fluid velocity of liquid within a closed type. (13) The transducers are non-invasive, clamp-on type, which will provide benefits of non-fouling operation and easy installation. Fig. 8 shows ultrasonic flow meter, Fig. 9 shows installation of flow meter & Fig.10 shows digital flow meter respectively.

Fig. 8 Ultrasonic flow meter

Fig. 9 Installation of flow meter

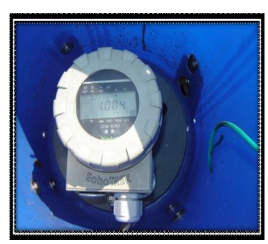


Fig. 10 Digital flow meter

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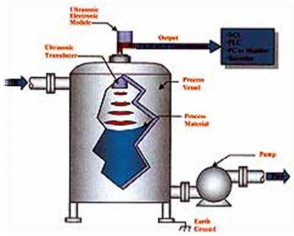

Fig. 11 Ultra sonic level meter

Fig 12 Installation of digital level meter

Fig.13 Chlorometric meter

Level meter

Level meter is an ultrasonic device which is used to measure the level of the water in the reservoirs during the time of filling and also distribution. Level measurement of water is required at all service reservoirs and all underground sumps. Hence the level of water in the reservoir can be found out. Fig. 11 shows the Ultrasonic level meter and Fig.12 illustrates the digital level meter's installation.

Chlorine analyzer

Chlorine analyzer helps us to find the amount of chlorine present in the water. Chlorine measurement is required at water production centre, service reservoirs and areas where chlorine recharge is carried out. Fig. 13 shows the chlorometric meter.

Fig. 14 Intelligent Electronic Device

Fig. 15 Front End Processor

Fig. 16 Central Monitoring Unit

Intelligent Electronic Device (IED): Intelligent Electronic Device (IED) provides us the data collected from various equipments and transmits the processed data to the central place. It generates various configurable alarms like, tank overflow, leakages, insufficient flow rate etc. Fig. 14 shows the Intelligent Electronic Device.

Front End Processor (FEP): IED transmits the processed data to the central device known as FEP which is front end processor. It provides controlling by means of digital outputs. The data collected by FEP is then transferred to the central monitoring unit to generator output. Fig. 15 shows FEP.

Central Monitoring Unit (CMU): Central Monitoring Unit validates by sequencing the data received from all the IEDs. It is well equipped to store large amount of data for historical trends. This helps in providing

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supervisory control from central place. Fig. 16 shows Central Monitoring Unit.

The output parameters like water level, flow rate, chlorine level and various other information is displayed through Liquid crystal digital display. Hence we can get overall idea about the information of all the reservoirs at a single glance. Fig.17 illustrates LCD display of water level, flow rate and chlorine level.

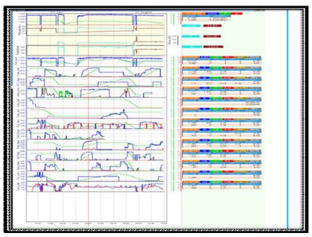

Fig. 17 LCD display of water, flow rate, chlorine level

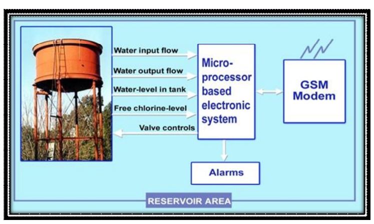

Fig. 18 Microprocessor based electronic system

DESCRIPTION OF SCADA PROCESS

Water input flow and water output flow are measured by using flow meter, water level in the tank is known by using level meter and amount of chlorine present in water can be known from chlorine analyzer. All these three instruments are placed at every reservoir and this data will be collected by the micro-processor based electronic system which is nothing but intelligent electronic device. Each plant is provided with IED. Each IED is provided with a unique identification number. IED is equipped with a GSM modem. A GSM modem is a special type of modem which accepts a SIM card and operates just like a mobile phone. A GSM modem looks just like a mobile phone. At the FEP, there will be as many modem as there are number of plants. Each modem here is given the same number as given to the mode for the IED of the plant. So, the FEP collects the information from all the plant.

Central Monitoring Unit receives the data from FEP and communicates with local units for any missing information. It helps in sequencing the data and provides large amount of data for historical trends. It generates various required reports and graphs and provides centralized monitoring which helps in SUPERVISORY CONTROL from central place. The output may be shown on LCD monitor. The output may be shown on LCD monitor. The data is sent to the associated circle offices so as to make a better control of the water treatment and distribution.

The Microprocessor based electronic system process is involved in SCADA has been shown in the Fig. 18 and schematic diagrams of SCADA are shown in Fig. 19 & Fig. 20.

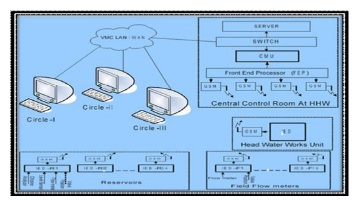

Fig. 19 Schematic diagram of SCADA

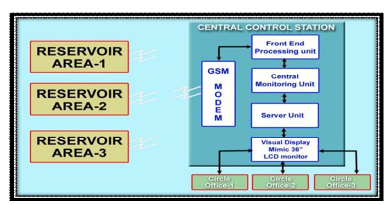

Fig. 20 Schematic diagram of SCADA

IMPORTANT FEATURES OF SCADA SOFTWARE

The software system of SCADA plays a vital role in the administration of the entire water distribution process (2). This is based on the oracle database management system. The entire particulars of all the reservoirs collected by the FEP through the IESs is monitored by the

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software system tough different commands and executed in a proper manner (3).

Some of the important executions that can be done by the software are:

1. Different parameters relating to the reservoir and their dimensions, low rates and capacities of the plants can be given as inputs.
2. Addition of new reservoirs or plants under the control of SCADA can be done by this.
3. Filling and distribution schedules of all the plants and reservoirs of different capacities can be framed easily and accurately.
4. The energy consumed by the pumps and the plants can be known and informed.

CONCLUSIONS

The specific conclusions drawn from the present as follows

1. Unit cost of water production has been optimized to Rs 2.17/- per kilo liter by using SCADA process.
2. The chlorine dosage of 0.02 to 0.05 mg per liter has been maintained throughout the water supply as per the standards of drinking water using SCADA process whereas in the previous was not maintained as per IS code.
3. SCADA process is able meet the demand of 150 liters per capita per day for the entire population of the city whereas it was not met by the previous system.
4. SCADA ensured the supply of water at the required point of the time whereas in the previous method there were delays due to uncontrolled monitoring.
5. The amount of Unaccounted For Water (UFW) has been brought down from 50% to 20% by controlling the leakages and overflows in SCADA process.
6. By using SCADA process we could generate reports and graphs with all the information such as flow rates, level, UFW whereas in the previous case we cannot know all the details.

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