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Feasibility Analysis of Water Distribution System for Yavatmal City using WaterGems Software

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ABSTRACT: Water supply in Yavatmal city is not properly laid and managed due to its undulating terrain and scarcity of rainfall harvesting in the city and its nearby area. A study was undertaken to suggest measures for the improvement to the distribution system, which can easily fulfil the demand for water in the city and can lead to development of the city in near future. The paper presents results of analysis carried out using Bently systems Water gems for basic design of distribution system which consist of reservoir, pipe network and ESR. The design has been done for 2047 water needs for drinking purpose. As per records, existing distribution system will not be able to take the load of the same a new pipelines are to be proposed to ensure basic water for drinking is easily available for the fast growing population of Yavatmal city.

KEYWORDS: Water supply, Networking, Water GEMs.

I. INTRODUCTION

Yavatmal city is district headquarters of theYavatmal district in Maharashtra. The city is basically formed by integration of six densely populated town namely Lohara, Pimpalgaon, Umarasa, Wadgaon Rd., Waghapur and Yavatmal R. The distribution network system is serving for longer period and due to aging, network components like CI pipes are corroded and AC mains are incursion condition and thus leaking. Furthermore there is no scope for the existing system to hold the future load of water demand. Hence considering the need of the town remodelling distribution system and construction of overhead tanks in Yavatmal city at various locations based on the demand of that area.

The project is being implemented to improve the water supply system, to minimize the leakage and to optimise the water availability to the consumers. It was also intended to check the various demand that need to fulfil if various per capita demand is to be satisfied including 24 x 7 water supply.

Remodelling plan of water distribution system has considered every factor such as geographical conditions, demand assessment for entire town, future growth considering population density of each zone or town, pressure, losses, pipe size etc. using sophisticated software 'WaterGEMS'.

II. RELATED WORK

Sajedkhan S. Pathan et.al. (2013) have done optimization on Water supply network are costly infrastructure designed with an objective of minimizing the overall cost while meeting the water demand requirements in the sufficient quantity, quality and at satisfactory pressure i.e. finding out such an optimal geometrical layout which delivers known

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demands from source to all individual consumers for a long period. In this paper design of water supply network duly considering optimization in addition to the cost minimization, minimum head requirement and minimum chlorine requirement is presented. Gradient method is one in which the pipe discharges and nodal heads are taken as the basic unknowns in formulating the Q-H equations. The non linear Q-H equations for the pipe head loss are linearised and solved by Gradient method. WaterGEMS software algorithm is based on Gradient method gives optimal solution for the design of new as well as expansion of existing water supply network. The software also gives how the chlorine concentrations changes throughout the network. Water quality results are represented either using colour coding, tables or graphs and helps to discover what better initial values for chlorine concentration might be set in the network. Decision variables involves are pipe diameter, reservoir elevations and reservoir capacity etc. with flow as primary variable. A design is obtained duly considering minimum and maximum head and velocity criteria in order to determine the actual supply form each node to all consumers. In this paper a part of Aurangabad city is designed and its water quality (chlorine) analysis is done by WaterGEMS software.

Abhay Tawalare et.al (2016) have study on Indian government implementation of 24x7 water supply projects in few selected cities. These projects were implemented either under Public Private Partnership (PPP) or direct funding by government. However, many projects witnessed failure during later stage of project life cycle. The paper aimed to carry out performance evaluation of implementation of continuous water supply projects against the various risks. The case study research methodology was adopted for the study. Initially, various risks in water supply projects were identified through literature review. Two polar cases were selected for the study, one was implemented under Public Private Partnership (PPP) and other was implemented under direct funding from government budget. The cross case analysis of both cases against the identified risks is presented in the paper. The project under PPP mode could not perform well against risks like consumer risk, revenue risk, financial risk and socio political risk. The result showed that both the projects could not achieve the desired success as planned initially still it can be concluded that continuous water supply projects under government funding performed better.

P.H.Bhagwat , S.E.Bhandarkar (2012) Analysed the study on Bemal Dam water can it be used for drinking water The Physico chemical parameter of surface water from Bemla dam of Bhabhulgaon DistYavatmal is determined during March 2012 for 20 different points . The Physico -chemical parameters are pH, electrical conductance, DO, BOD, COD, TDS, total hardness, total alkalinity, turbidity; anions includes chlorides, sulphates , nitrates etc.. All the parameters are found to be within the permissible limit. Hence, water is safe and suitable for domestic, irrigation and drinking purposes.

III. STUDY AREA DESCRIPTION

Yavatmal is a city and municipal council in the Indian state of Maharashtra. It is the administrative headquarters of Yavatmal District. Yavatmal is around 150 kilometres away from regional headquarter Maharashtra while it is 670 km away from the state capital Mumbai. The name is derived from the Marathi Yavat (mountain) and mal (row).

During British rule, Yavatmal city was classified as a hill station. Both cotton-ginning and pressing are carried on in Yavatmal while the town is also the chief trading centre in the district, and connected by road with Dhamangaon station, 47 km away. Major business establishments in Yavatmal include the Raymonds factory which produces special fibre for jeans. The establishments related to cotton, and textile industries has earned the city its nickname "Cotton city". There is a 106-acre (0.43 km²) textile Special Economic Zone (SEZ) under construction while HLL Unilever has also decided to restart the plant they currently have in the city. Other local businesses in the town are dominated by the presence of agricultural supply facilities used by the nearby farming community. Banking services are available in the Yavatmal, Ner, Pusad, Digras, Ghatanji and Pandharkawada and Wani areas. The major industrial centres are at MIDC Lohara, Darwha, Digras, Pusad, Umerkhed, Wani, Umari, Pandharkawada, Ralegaon and Bhabhulgaon, Ner, and Wani-Maregaon with the main market places in Yavatmal City, Wani, Darwha, Digras, Akola Bazar, Ghatanji, Mohada, Pusad, Umerkhed, Arni and Pandharkawada. This shows that Yavatmal city plays a vital role in development of the area as large no. of industries are established here.

Yavatmal city is administered by a municipal council. According to census 2011, its population is nearly 116,551. But this figure is number of inhabitants within municipal boundaries. Urbanization has crossed municipal boundaries and

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neighbouring villages have become part of urban agglomeration having population nearing 3 Lacks; the villages are Wadgaon road, Lohara, Umarsara, Waghapur, Moha, Bhos, Pimpalgaon, Pangari, Bhoyar, Parwa, Bhari, and Madkona. Yavatmal is a fifth most populous city and the largest municipal council of Vidarbha.

The city has elevation of 450 m from the sea level, attracting average rainfall of 700mm to 1000mm annually. Therefore it becomes necessary to manage this resource and utilise it for the development of the city.

For the design and analysis purpose the city was divided into various zones based on the population and the ultimate population for the year 2047 was predicted to be of 1, 43,475 in the municipal area itself. Different demand for this population was evaluated but the basic study is done only for drinking demand water supply.

IV. WATER DISTRIBUTION SYSTEM

The existing water distribution system of Yavatmal was from a small reservoir named Nilona which is insufficient to fulfil the fast growing demand of the city. Therefore a feasibility check for new source has been checked in this study. The new suggested reservoir based on which the study is performed is Bemla dam, which is 22km north to the Yavatmal city.

Water supply distribution system should adopt network design and operation strategies that prioritize issues closely linked to water supply hygiene. The following factors should be considered in the design:

- Identify and prevent low pressures, especially negative pressures, in the system;
- Prevent pressure surges in the network;
- Design the network to minimize the risks of contamination during operational activities and to avoid water stagnation;
- Design and operate service reservoirs to avoid contamination by ingress and to avoid stagnation;
- Control disinfectant residuals in distribution systems;
- Assess the effect of different supplies entering the network;
- Determine the benefits and problems of zoning the network;
- Select construction materials that do not promote microbial growth;
- Prevent cross-connections and backflow.
- The distribution layout should be such as to facilitate hydraulic isolation of section, metering for assessment and control of leakage and wastage.

V. HYDRAULIC CONSIDERATION

The purpose of a pipe system is to supply water at adequate flow and pressure. However, the action at the pipe wall reduces pressure. Water demand, pipe length, gradient and diameter also affects adversely on the pressure. Several established empirical equations Hazen's Williams and these have been incorporated into network (Hwang & Houghtalen, 1996).

Modelling software packages to facilitate their solution and use. While designing a piped system, the purpose is to ensure sufficient pressure at the point of supply to provide an adequate flow to the consumer. This pressure increases as the number of properties supplied through a single service pipe increases (Colebrook, 1939). In order to maintain microbial quality, it is important to minimize transit times and avoid low flows and pressures. These requirements need to be balanced against the practicalities of supplying depending upon consumer's location and where pipes can be laid. The system capacity should not be excessive since it results in long transit times, unless this excess capacity is required to meet increase in future demand.

Theoretically, loops, low-flow and dead-ends should be avoided, however this practically impossible. Low-flow sections of dead-ends should be as short as possible. Both loops and dead-ends in the system may cause problems by creating long residence times and sections where sediments can collect. In loops, the change in flow direction may disturb any deposits in the pipes.

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Present scenario:

Present scenario in Yavatmal city is not adequate to cover whole city. As per authorities, many locations in the city are deprived of municipal connections and those areas which are connected usually get water in 3-4 days for few hours. So there is an urgent requirement to improve and upgrade the supply system so that it can sustain the future load. This study suggest some alternative which can be considered during upgradation.

Software Tools:

Water GEMS is a comprehensive and easy to use water distribution modelling application. Water GEMS can run from within ArcGIS, AutoCAD, and Micro Station, or as a Standalone application. From fire flow and water quality simulations, to criticality and energy cost analysis, to advance genetic equipped with everything you need in a flexible multi-platform environment.

VI. RESULTS AND DISCUSSION

Water Gems Software:

Water distribution system Analysis aims at demarcating the project boundary based on the contour levels. These types of levels were derived the existing toposheets of Yavatmal city. For water distribution, levels of contour will be the criteria. Zoning of the distribution system is given in fig. 1

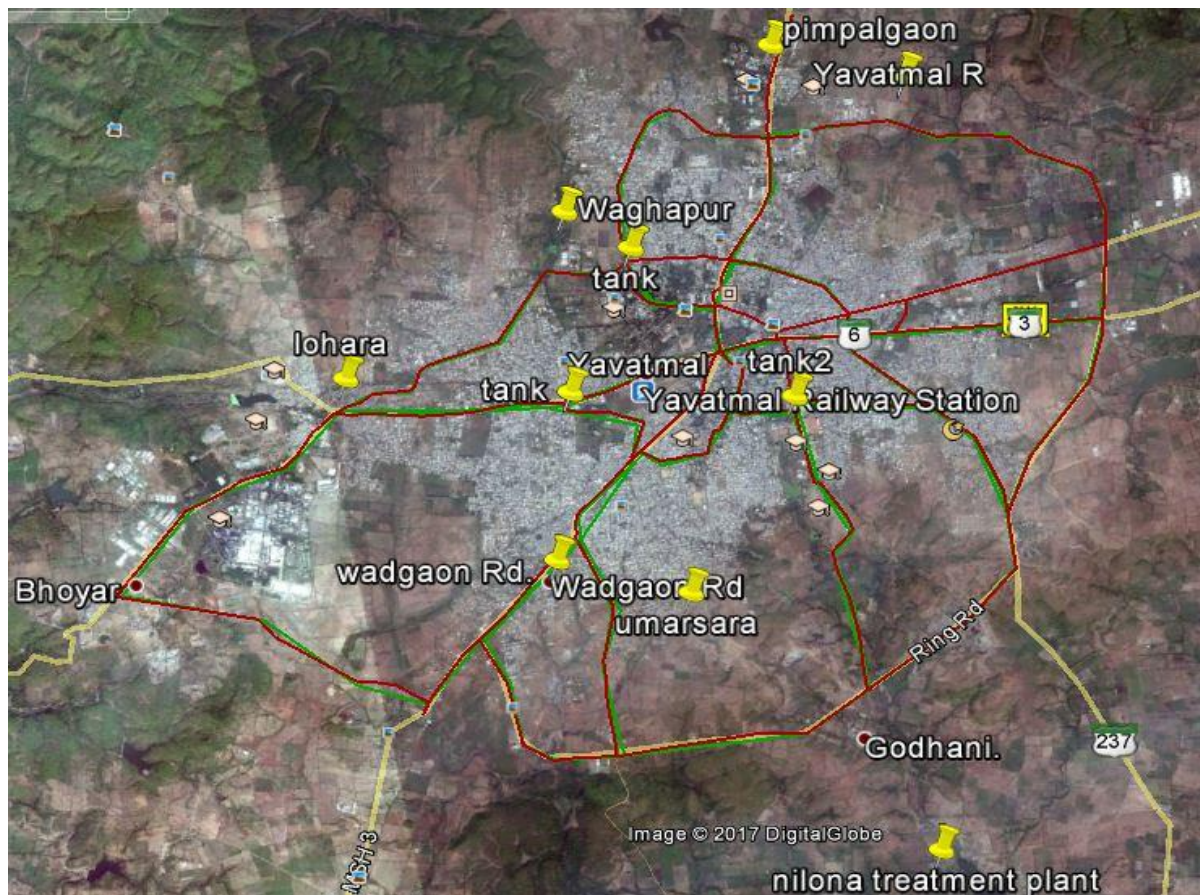


Fig. 1. Zoning of the distribution system

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Primarily, reservoir was a focal point from where the pipes and nodes will be drawn through water gems software. Elevation and flow direction were automatically taken from the input parameters by the software. While digitizing the pipe line and the nodes care were taken elevation was considered from the previous level was considered.

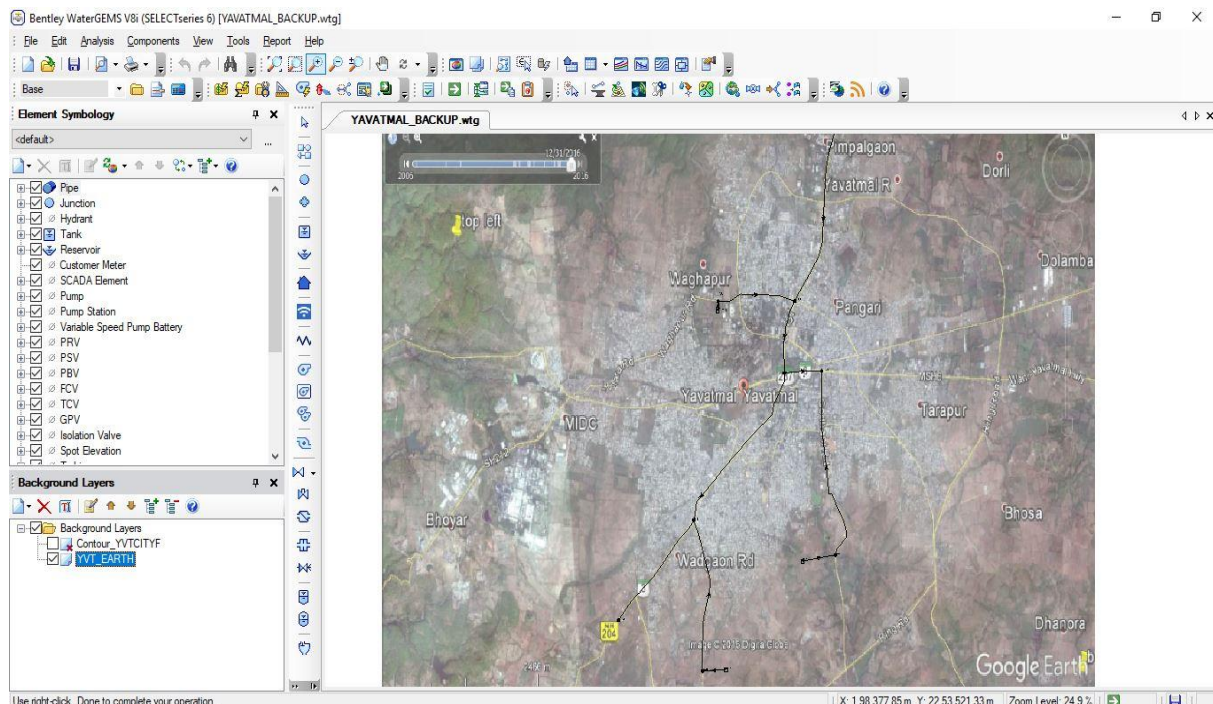


Fig. 2. Output of flow of distribution system

The figure above shows the network design for the city area from the Bemla Dam passing through the city. There is sub line taken from main line to each area zones till their respective new ESRs. From this ESRs the distribution can be done. The end point is left open for future extension of the system, but it should have a closed valve.

Table 1. Junction Data from Water Gems

FlexTable: Junction Table (Current Time: 0.000 hours) (YAVATMAL_BACKUP.wtg)								
	ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
97: J-34	97	J-34	440.00	<None>	<Collection:	67	463.26	228
103: J-35	103	J-35	455.00	<None>	<Collection:	67	469.50	142
106: J-36	106	J-36	425.00	<None>	<Collection:	67	469.78	438
111: J-38	111	J-38	445.00	<None>	<Collection:	67	466.61	211
114: J-39	114	J-39	440.00	<None>	<Collection:	67	466.61	260
116: J-40	116	J-40	430.00	<None>	<Collection:	67	468.61	378
126: J-45	126	J-45	450.00	<None>	<Collection:	67	467.37	170
127: J-46	127	J-46	440.00	<None>	<Collection:	67	469.01	284

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After completing everything, all pipes and the nodes, software will be provided with inputs like demand and the pipe materials. Elevation, contour, demand, pipe material and other parameters will be considered by the software. A simulation was done by the software, where it decides the diameter of the pipe and flow direction and flow quantity.

Table. 2. ESR data provided by water GEMS.

	ID	Label	Zone	Elevation (Base) (m)	Elevation (Minimum) (m)	Elevation (Initial) (m)	Elevation (Maximum) (m)	Volume (Inactive) (ML)	Diameter (m)	Flow (Out net) (L/s)	Hydraulic Grade (m)
109: T-1	109	T-1	<None>	430.00	465.00	470.00	480.00	0.00	5.00	102	470.00
118: T-2	118	T-2	<None>	440.00	443.00	470.00	480.00	0.00	5.00	133	470.00
130: T-3	130	T-3	<None>	440.00	455.00	470.00	480.00	0.00	5.00	134	470.00

Such simulation study by water gems software for Yavatmal city seems to be promising in deciding the pipe material taking into consideration of the feasibility of the cost of the material and also the shortest path through which water distribution system was drawn for the benefit of the society

Table 3: Pipe data in water GEMS.

	ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C
104: P-39	104	P-39	2,539	R-1	J-35	400.0	Cast Iron	130.0
107: P-41	107	P-41	1,223	J-35	J-36	400.0	Cast Iron	130.0
110: P-42	110	P-42	137	J-36	T-1	400.0	Cast Iron	130.0
112: P-43	112	P-43	1,043	J-35	J-38	400.0	Cast Iron	130.0
113: P-44	113	P-44	4,422	J-38	J-34	400.0	Cast Iron	130.0
115: P-45	115	P-45	577	J-38	J-39	400.0	Cast Iron	130.0
117: P-46	117	P-46	2,744	J-39	J-40	400.0	Cast Iron	130.0
119: P-47	119	P-47	517	J-40	T-2	400.0	Cast Iron	130.0
128: P-50	128	P-50	2,175	J-45	J-46	400.0	Cast Iron	130.0
131: P-51	131	P-51	362	J-46	T-3	400.0	Cast Iron	130.0

Pipe of size 400mm is given to make the system future proof for 24 x 7 water supply scheme.

VII. RESULTS

Bembla dam capacity = 322 MCM

Yavatmal population projected in year 2047 = 143475 souls.

- Demand at 200 LPCD for 24 X 7 supply
Total requirement = 28.675 MLD
= 10.5 MCM

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- ii) Demand at 135 LPCD
Total requirement = 19.37 MLD
= 7.07 MCM
- iii) Demand at 40 LPCD only for drinking and cooking purpose
Total requirement = 5.8 MLD
= 2.1 MCM

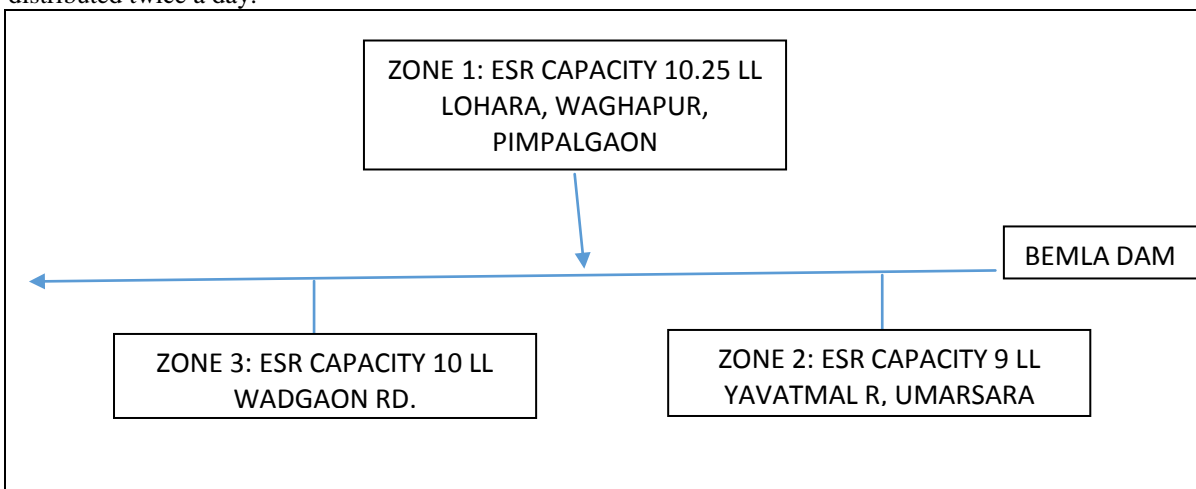
Pipe size of 400mm is suggested which can sustain the future load on the system if 24 X 7 water supply scheme is approved.

Three water tank is suggested by dividing the city area into 3 zones based on population distribution.

Each have capacity of 10 lakh litres. But it is suggested that the supply should be twice a day to overcome the stress on the supply system.

VIII. CONCLUSION

Based on this study it can be concluded that the Bemla dam which is 22km north of the city can easily take the load of the Yavatmal city by its own, whereas existing system can also use at the same time to decrease the pressure on new system. The city has been divided into 3 zones having ESR of 10 lakh litre capacity from where water can be distributed twice a day.



WATER GEMS SOFTWARE is more efficient and changes can be done very easily. Various material's costs can be marked and cost estimation is not considered in this study as it depends on the authority to approve, but PVC cost is the lowest among the all materials and durable as well. Hence, PVC is suggested for adoption.

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