A model for transforming an intermittent into a 24x7 water supply system

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In this case-study, the author presents the award winning project undertaken in Maharashtra's Badlapur city for supplying pure drinking water round the clock. It is unique not only because it is the first such attempt in India but also because of the methods adopted.

The water crisis

Water is indispensable for life but is finite and therefore precious. Serving pure and potable water to the dense populations in developing countries, especially in India, is a daunting task. According to the World Water Development Report, 1.1 billion people worldwide do not have access to safe drinking water. This figure is expected to touch 2 billion by 2050. 1.6 million die every year due to diseases related to poor sanitation and polluted water supply and 160 million are infected with Schistosomiasis while 133 million suffer from high-intensity intestinal helminth infections.

Millennium development goals

Considering the importance of ensuring sustainable water supply in developing countries, the United Nations formulated the famous Millennium Development Goals (MDGs). Member countries adopted the same and mean to achieve the stated goals by 2015.

Access to safe water- Indian scenario

Though 82 % of the urban population has access to safe drinking water, only 63 % of them have access to tap water. Besides, as against a target of 140 liters per capita per day (LPCD), the average per capita water supply in the country varies from 57 to 160 LPCD. In slum areas, the LPCD stands at a mere 27. Some of these statistics are really staggering. For example, the infant mortality ratio in India is 70, which is closer to some of the African countries. One of the main reasons for this state-of-affairs is the inaccessibility of safe drinking water and intermittent water supply. In Asia only 8 cities, Hong Kong, Kualalampur, Changdu, Osaka, Phnum Penh, Seoul, Shanghai and Tashkant get continuous water supply. Currently, no Indian city gets 24x7 water supply.

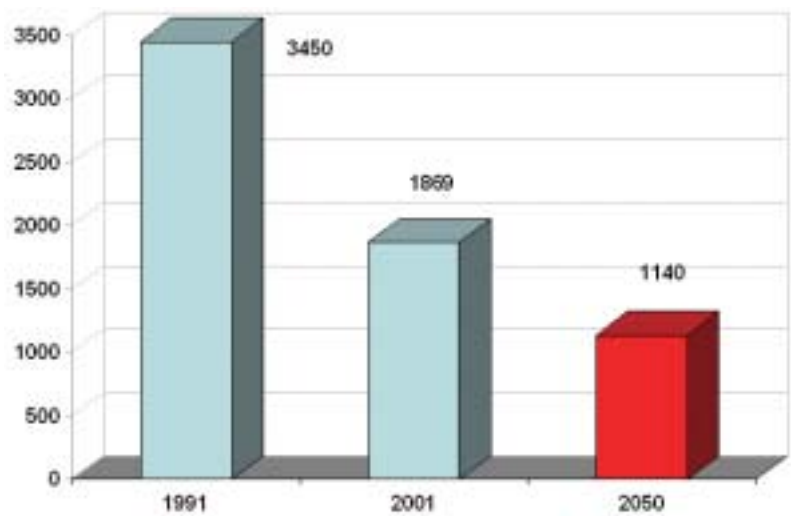


Figure 1.1: Per capita availability of water per year (m^3) in India.

Why is intermittent supply bad?

Water supply systems do not operate as designed. Therefore, reservoir capacities are often underutilised. The valves suffer wear and tear. Since,

water is supplied by zoning the distribution system, more man power is required. During non-supply hours, pipes are empty and dirt water enters pipelines at vulnerable spots and water is contaminated. Large doses of chlorine or other disinfectants are required to make water safe from microbial pollution. Due to limited hours, peak factor is often in the range of 4 to 6 in most of the systems. Therefore, large sizes of pipe mains are required for strengthening the network to meet the hydraulic requirements. Inconvenient supply hours affect poor people. Large size of storage is required and consumers have to pay for pumping. Also, it results in poor sanitation practices leading to increase in health risks and mortality. Due to intermittent water supply, often meters go out of order resulting in loss of revenue. Besides, due to uncertainty consumers store a large quantity of water and waste it before collecting fresh water again. This adds to a huge undue wastage of precious treated water

How 24x7 water supply benefits poor?

24x7 continuous, pressurised water supply overcomes shortcomings of intermittent supply and ensures customer convenience and benefits the poor. Continuous high quality water supply system reduces contamination level as the pipes are under positive pressure and entry of contaminants into the pipes is restricted. Life of distribution networks increases as steady pressure in the pipes causes less damage to the pipes. A better demand management is possible due to elaborate metering and effective leakage control. It also results in less storage of water or none at all, which in turn reduces wastage of water. Continuous supply of pure water boosts the economy and attracts more industries and businesses.

Objectives of the present study

Usually, water supply systems are designed as continuous water supply systems. Due to inadequate funding, improper implementation coupled with complications caused by unprojected urbanisation, increased population and rise in demand for water, distribution systems are expanded without taking cognizance of the hydraulic design. Second law of thermodynamics on entropy, i.e., orderly systems become disorderly as time moves on, applies to the ever expanding water supply distribution systems as well. Transforming the disorderly distribution system into a well disciplined and properly designed system (pressurised pipelines with optimum pressures) is the task of 24x7 supply system. For that, it needs to meet the present and future requirements. Unless a proper

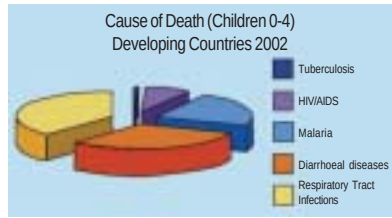


Figure 1.2: Diarrhoeal diseases- major cause of death among children under the age of four in developing countries.

hydraulic model is prepared, it is not possible to convert old intermittent system into a 24x7 system.

Attempts have been made to achieve 24x7 water supply. The approach adopted is of the category *Part to Whole*. In this approach, small DMAs are prepared. These DMAs are then converted to 24x7 with various measures. Such DMAs are clubbed to create an *operational zone*. The main drawback of this approach is that the problems as well as their solutions are studied in isolation. The success of one DMA or operational zone could be at the cost or at the services of the other consumers. There is also the danger of selecting an isolated DMA or operational zone with relatively fewer complications to achieve early success.

In our approach, the problem is looked at from a different perspective called the *Whole to Part* as opposed to the *Part to Whole*. Here, the hydraulic model for the entire city is prepared. This model of the entire water supply system of a city is essential to study

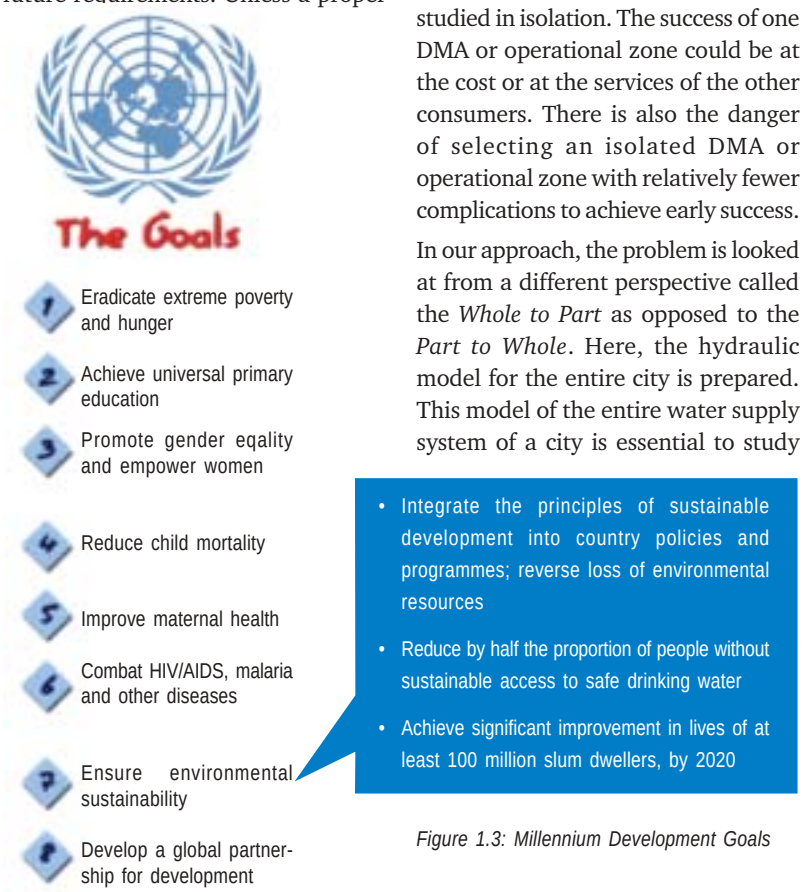


Figure 1.3: Millennium Development Goals

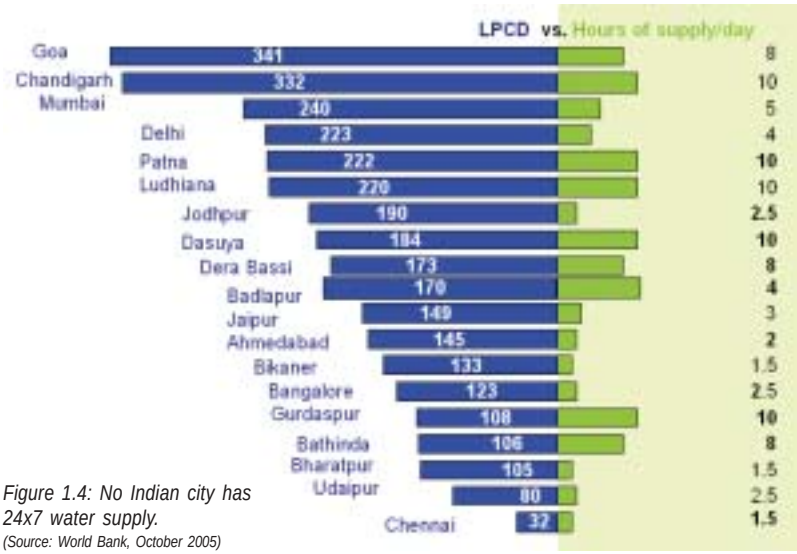


Figure 1.4: No Indian city has 24x7 water supply.
(Source: World Bank, October 2005)

and adopt various strategies to ensure equitable water supply to all parts of the city. The first key to convert an intermittent water supply system into 24x7 continuous systems is to understand the water balance, i.e., inflow of water into the system, its consumption and loss in the system. For most of the cities, quantum of water is finite and hence requires judicious demand management through proper design and operation strategies. Regular water audit of the system and its proper recording is necessary to determine effective usage of water. It is very pertinent for identification of key parameters for improvements and also to assess the changing consumer withdrawal pattern. Reliable data of water distribution infrastructure along with GIS network plans, data of bulk supply and accurate consumer records are necessary for a study of converting an intermittent supply to the 24x7 supply system. The study involves dividing city into a number of various operational zones with respect to available storage capacities and they can be further divided into District Metering Areas (DMA), if required. Two cases are involved: (i) OZ is self sufficient and does not require further division into DMA; (ii) OZ is sufficient with respect to storage but operation wise certain pockets are still to attain 24x7 in totality. In such case, DMA will be demarcated with respect to the problems reported through water audit. These DMAs will be further studied for fine tuning with view point of leakage control, equitable water supply through controls. Each DMA is hydraulically discrete (isolable) from adjoining area. It is fed with water from single point, the flow and pressures at key locations are continuously metered and measured which then give indication of the extent of leakages as well as high flow rates. Leakages are then repaired. Some pipes and ailing valves and old property connections in worst part of the distribution networks are replaced. Suitable control measures are adopted to keep check on high flow rates. The DMA is then set for 24x7 continuous water supplies.

Objective of the present study is to describe the elaborate hydraulic model prepared using WaterGems, Darwin Designer and other advanced utilities of WATERCAD. The approach of *Whole to Part* and the hydraulic model shall be a showcase study for other cities in India and also for cities in developing countries to enhance public health of the poor masses and thus attain Millennium Development Goals set by the United Nations.

Simulation of the real world network involves modelling of the entire city network, its complex operations and the present behaviour of the hydraulic systems. Further it is essential to study the entire networks for suitable zoning and sub-zoning. Thereafter, the critical analysis for improving the system through various measures needs to be modelled under numerous scenarios and alternatives. Also the field results are to be used in proper manner to understand and then to enhance the network performance. Since, the entire exercise involves management of vast data, comparison of permutation and combination of a large number of scenarios resulting from various alternative measures representing real world system, a comprehensive model is required. This model prepared on a advanced platform like WaterGems shall certainly be the most crucial to take engineering as well as management decisions to transform the system into 24x7 today as well as for meticulous planning for future.

Case study

The case study covers the application of the approach to convert its old intermittent system into the 24x7 continuous water supply system of Badlapur city. The experimentation and implementation of Ward No 34 has been presented with all aspects. So far in Badlapur city 10 wards out of 34 wards having 3 Operation Zones have been successfully transformed into 24x7 continuous water supply using critical hydraulic modelling presented in this study report.

Badlapur city in Mumbai Metropolitan Area has been selected to convert its existing intermittent system into the 24x7 continuous water supply system.

The reasons for selecting this city are that the water supply system is owned and maintained by the author's department, i.e., Maharashtra Jeevan Pradhikaran (MJP).

It has an assured water source in the form of the river Ulhas and is part of the JNNRUM programme, which makes the project sustainable.

Present water supply arrangement of Badlapur is schematically shown in Figure 2.2. The city has a population of 0.14 million spread over an area of 68 square kilometers. There are 10,700 water connections in the 34 wards of the city. Currently, the system is operated in intermittent mode and water is supplied in various zones for 4 hours a day.

Stages adopted for transformation into 24x7 water supply system

The scheme is under intermittent operation mode for the past ten years. A large number of property connections have been issued without verifying the adaptability of design or a proper hydraulic study of the network. As a result, daily operation of water supply is done by operating valves zone wise. A fleet of valve operators are required to perform this job. The system which is, therefore, being operated as an intermittent supply mode is deteriorating fast.

When it was decided to convert this intermittent system into 24x7 system, a holistic approach was adapted. Achieving continuous water supply is the result of the combined efforts of various strategies adopted for improving the water supply. The action plan of transformation is shown in Figure 2.3.

System analysis of the present system

(a) Water infrastructure mapping

Under this, water infrastructure utility is studied and its operation mapping is recorded. Base Map is prepared with the help of topology survey, GIS, Mobile Mapper etc. Information of all-important features of water supply system, i.e., pipe (material, age, diameter, physical, structural etc), junctions, valves (Type, setting, Age, Physical etc), Reservoirs (capacities, levels, age, structural etc), pumping system etc. is collected. This information provides the basic ingredients to the hydraulic model. This model is suitably calibrated to match with the field observations

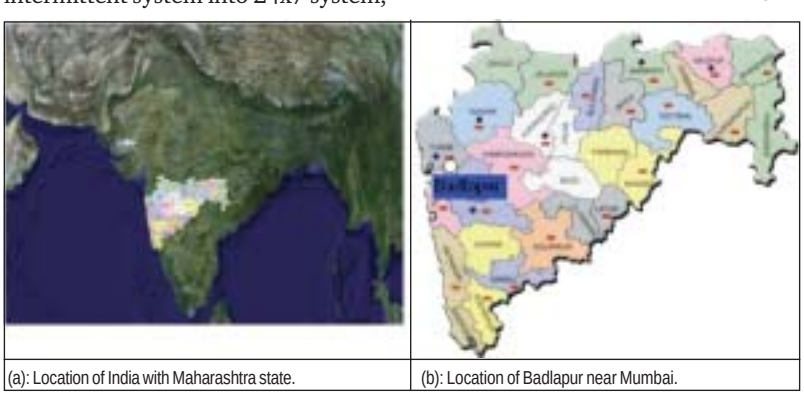
Operation mapping: Information on present operation in the form of sub-zones, hours of supply, water with-drawls, leakages, valve operations over a day etc. is collected. Network components are then calibrated with respect to field results. This information is modeled to simulate the network behavior over a day and it is kept ready for further exercise. The information on with-drawls, leakages, also the valve operation is suitably modeled.

Population forecast

The Badlapur town has been bifurcated in East and West zones. Fifteen wards out of thirty four are situated at west side, whereas remaining nineteen wards are situated on east side. Badlapur town is very nearer to Mumbai, it has grown up rapidly. The area nearer to the railway station has developed beyond imagination where as some area is under development. Since the development of the city is not uniform, *population density method* has been used. The population growth in one area is exorbitant whereas it is negligible in other area. Hence the population needs to be forecasted by taking development plan of the town into consideration. The population arrived by this method is found as reasonable and realistic.

Reframing of suitable water operational zones

With respect to study of present operation, new water operational zones are demarcated for effective operation. The proper reframing of the zones itself improves the water supply considerably. This needs to be carried out taking the cognizance of behaviors of peaking flow rates under the transforming phases which basically reflect the change in the consumer



(a): Location of India with Maharashtra state. (b): Location of Badlapur near Mumbai.

Figure 2.1: Location of Badlapur near Mumbai in India.

Figure 2.2: Water supply arrangement of Badlapur city.

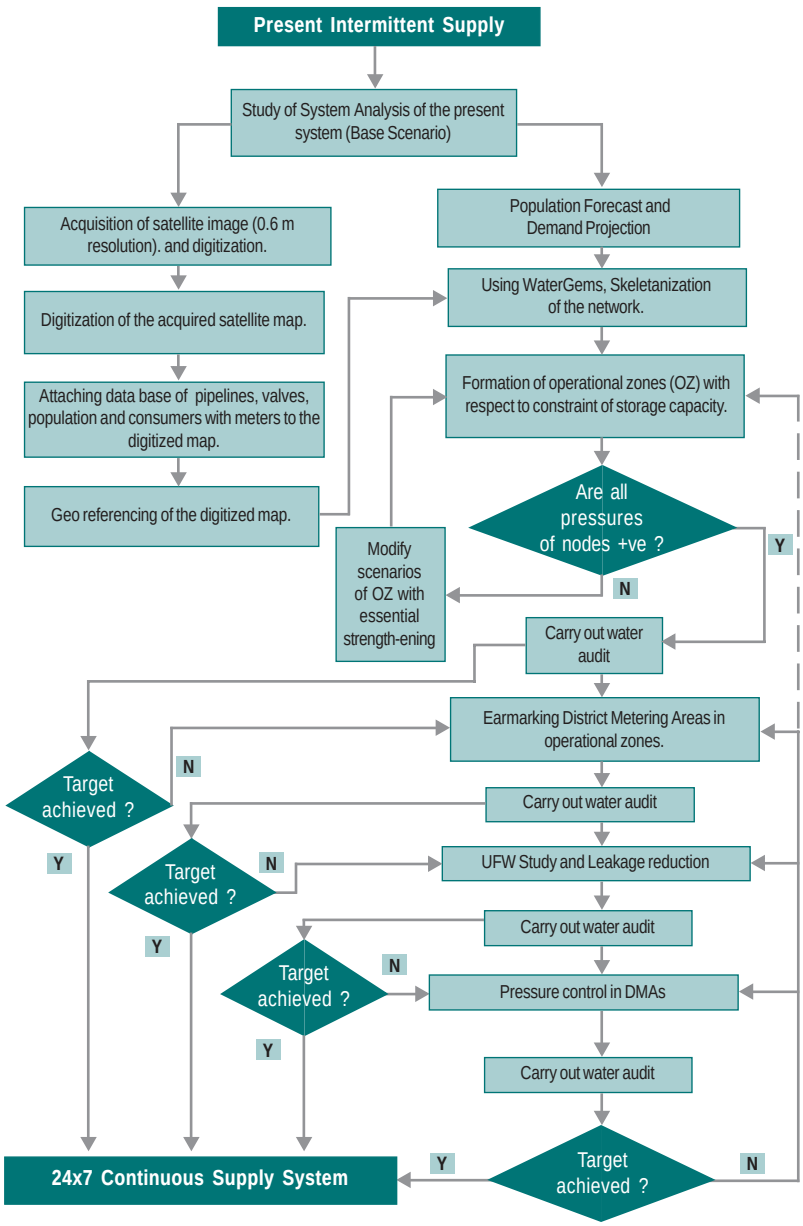


Figure 2.3: Action Plan for Transformation into 24x7 Water Supply System.

Table 2.1: Present and future service reservoirs

	Present Service Reservoirs		*Future Service Reservoirs*	
	Name	Capacity (ML)	Name	Capacity (ML)
1	Shirgaon	3.55	Gandhi Chowk	1
2	Gandhi Chowk	1	Mhada Colony	2
3	Kharvai	0.12	Kirti Police Colony	2
4	Badlapur Village	0.5	Datta Chowk	1.6
5	Belavli	4.5	Vadavli	0.85
	Total	9.67	Total	7.45

habits. The reframing involves introducing isolation valves to segregate operation zones, proper regulation of reservoir outlet valve and assigning the peak demands with respect to water audit study. Then the networks are critically analyzed. The Baldapur city has been divided in 10 operational zones for the present study purpose.

Storage capacities

There are existing 5 storage tanks total storage of which is 9.67 million liters (ML) as shown in Table 2.1. Considering the future demand and transformation of intermittent system into continuous systems, the work of construction of future reservoirs as shown in Table 2.1 are being taken up.

Water audit

This activity measures the total inflows and outflows of the system with the help of various methods, which involve use of instruments like pressure gauges, flow meters. The activity is like a pathology test, which reflects the health of water supply system in terms of its components under different parameters recording the transformation. The water audits need to be repeated several times after every experimentation to evolve the appropriate decision making and to document the progress of the improvements.

Accurate metering of the retail consumers is an important job to be carried out in order to achieve 24x7 continuous water supplies. It is an essential prerequisite for demand management. A water balance is required to be achieved by ascertaining –

1) the total quantum of water entering the system by installing bulk meters 2) total quantum of water consumed by taking readings of retail meters installed at consumer's end. The water audits provide leads for leakage

studies, for ascertaining the changing flow rates during transformations towards 24 x7, for throttling exercise for equitable pressures and also for assessing the progress achieving of 24 x 7.

UFW study and leakage reduction

This involves the activities of carrying out of various leak detection exercises. Also implementing various leak reduction measures to minimize the leakages. The information shall be stored as a demand alternative along with the with-drawls pattern. Upon implementation of various leakages measures and there upon conducting critical water audits studies various alternatives representing the changes shall be created and appropriately used for further study. A typical leak detection exercise is shown in Figure 2.3.

Pressure reduction

This involves identification of high pressure pockets in an operation zones or DMAs. These pockets are critically studied for applying suitable pressure reducing measures which help both ways, maintaining the desired flow rates and also reduction of leakages. The valve operation information essential to achieve the desired results are studied and then appropriately used for further improvements.

Phasing of transformation

Though the M.J.P. has decided to transform the existing intermittent system of the town into 24x7 continuous systems, it is proposed to implement this transformation in phases.

Further activities

With the *Whole to Part* approach the city has been first divided in to 10 operational zones after critical study. So far 30% of the entire city has attained the transformation from intermittent water supply to 24x7 continuous water supply. It has been achieved through 3 operation zones. Further activities involved attaining the transformation from intermittent water supply to 24x7 for the remaining part of the city. Also, in parallel for the sustained Operation Zones, they shall be critically studied and as required shall be divided in DMAs for further improvements with the help of modelling exercise.

Figure 2.3: Leak detection exercise.

Antrix to launch large commercial satellites

Hyderabad: Eyeing the lucrative global commercial satellite launch market, Antrix Corporation Ltd is targeting at least one satellite launch every year on a commercial basis.

The commercial arm of the Indian Space Research Organisation (ISRO) is currently in talks for contracts to launch of two to three large satellites in the 2.2 to 2.4 tonne range while it is also likely to conclude deals for 2-3 smaller satellites.

Apart from satellite launches, Antrix is in the market for remote-sensing services, satellite transponder rentals and design development and management of satellite systems.

Antrix is targeting the emerging market for small scientific and commercial satellites of up to the 600 kg class, a segment from which the Europeans and the US launch majors like Arianespace, Lockheed Martin and Boeing have moved out.

Satellite survey of tea gardens in Assam, Bengal

Kolkata: IIT-Kharagpur will prepare a comprehensive satellite survey of all the small growers in Bengal and Assam and a land-use atlas of these two states.

Union Minister of State for Commerce & Industry Jairam Ramesh said the two surveys would be completed by this December and March, 2008 respectively. "The survey of the small growers will help the Centre to get a comprehensive picture of the small growers in these two states. We will get a detailed picture of the status of the small growers through this survey that will help us intervene into the matter," he said.

Of the total tea grown in the state, around 10 per cent comes from small growers in Assam and 25 per cent comes from the small growers of Bengal. "Small growers have changed the face of tea industry in the recent past. However, they lag behind in various areas including R&D and engineering processes," he said. The land-use atlas would be prepared by March next.