FEASIBILITY ANALYSIS OF EXISTING WATER DISTRIBUTION NETWORK USING WATER GEMS SOFTWARE

A dissertation submitted in the partial fulfilment of the requirement for the award of the degree of

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IN

HYDRAULICS AND WATER RESOURCE ENGINEERING

BY

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CANDIDATE'S DECLARATION

I do hereby certify that the work presented in the report entitled "**FEASIBILITY ANALYSIS OF EXISTING WATER DISTRIBUTION NETWORK USING WATER GEMS SOFTWARE"** in the partial fulfillment of the requirements for the award of the degree of "Master of Technology" in Hydraulics & Flood Engineering submitted in the Department of Civil Engineering, Delhi technological university ,is an authentic record of my own work carried out from August 2016 to June 2017 under the supervision of Rakesh Mehrotra (Associate Professor),Department of Civil Engineering. I have not submitted the matter embodied in the report for the award of any other degree or diploma.

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CERTIFICATE

This is to certify above statement made by the candidate is correct to best of my knowledge.

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ABSTRACT

In present scenario the major problem related to water distribution system (WDS) is available head and required quantity of water. If consumer remain uncertain about availability of water and reduces their confidence on water distribution network so this will lead to consumer harness water through individual bores and hence exploiting water table. In this we are concern about these problems. To overcome these problems we conducted a study for water distribution system (WDS) with help of software WaterGEMS. After the study of WDS we concluded some result, on the basis of these result we further investigated about present and future requirements of people. Then we suggested some modification to the existing water distribution system (WDS).

WaterGEMS, hydraulic simulation software tool is used to inspect the water demand and available ferrule point in water distribution network of residential area, Dayanand Vihar. Simulation result obtained from the WaterGEMS software is used to redesign or modify the existing water distribution network. So that, sufficient quantity of water is can be supplied at consumer end point at adequate head and adequate volume of water under any condition over a period of time.

Delhi Jal Board is one of the prime water distribution agency in Delhi. A water distribution network for the Dayanand Vihar in East Delhi are is being examined for hydraulic parameter sufficiency and its reliability under various water demands.

ORGANISATION OF THE REPORT

The study and literature described in this report provides an approach for assessing the performance and reliability of a selected water distribution network for urban residential area. The report consists of a selected water distribution network for urban residential area. The report consists of six chapters. Chapter 1 provides a general overview and objectives of our project work. Chapter 2 provides a synopsis of a detailed review of the relevant literature. Chapter 3 gives the brief introduction of the study area. Chapter 4 provides the methodology of the processing of data using WaterGEMS hydraulic simulation software. The reliability of the network under study and associated hydraulic parameters are also depicted. Chapter 5 details the modification of the network. Chapter 6 is about the results and discussion of the hydraulic analysis of the urban residential water distribution network.

KEYWORDS: WaterGEMS, Water Demand, Population Increase, Pumps, Reliability, Water Quality

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LIST ABBREVIATIONS

CPHEEO	Central Public Health and Environmental Engineering Organization
DJB	Delhi Jal Board
GIS	Geographic Information System
LPCD	Liters per Capita per Day
GPCD	Gallons per Capita per Day
LPS	Liters per Second
GPM	Gallons per minute
WDN	Water Distribution Network
WDS	Water Distribution System
WHO	World Health Organization
UGR	Under Ground Reservoir
PHD	Peak Hourly Demand

CHAPTER 1

INRODUCTION

1.1 GENERAL

Water is very precious natural resource for all living beings. A single living being is Impossible to sustain without water. In ancient time people also were concern about water quantity, quality, availability and conservation. People were using many methods and ways to water conservation. There are many factors such as hydraulic and environmental which are governing.

Water distribution network is combination of all appliances which helps in delivering the supply of water from a specific source to consumer point. It comprise of reservoir, main pipes, distribution pipes, different type of valves and pump station etc. Many problem are occurring in water distribution system in terms of capacity, capability and reliability. There are many locality, small area as well as large area are facing problems both in terms of quantity (average demand per capita) and hydraulic head (water head at consumer point).

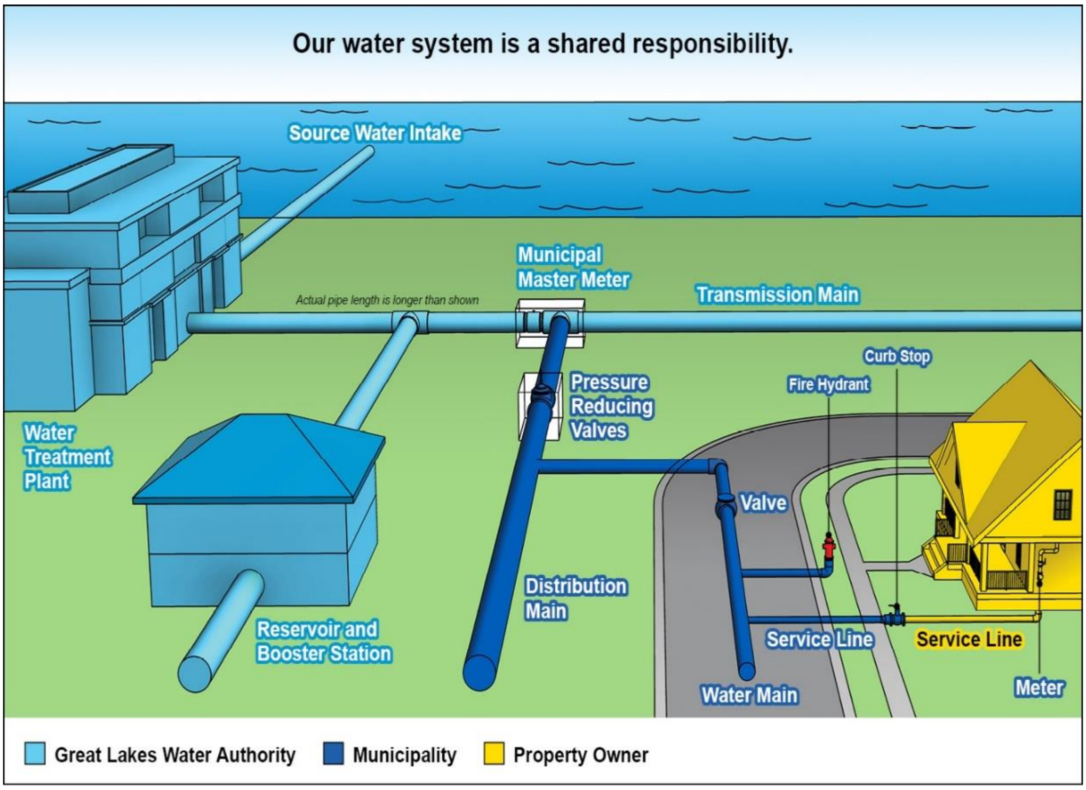

Figure 1.1 Characteristic Layout of Water Distribution System

Delhi Jal Board (DJB) was constituted through a demonstration of Delhi Legislative Assembly on 6th April 1998. Delhi Jal Board is meeting the necessity of drinking water in the National Capital Territory (NCT) of Delhi for more than five decades. Delhi Jal Board has ensured average availability of 50 gallons per capita per day of filtered water through an efficient network of water treatment plants, booster pumping stations and about 9000 kms of water mains & distribution system. Delhi Jal Board is not only responsible for distribution, collection and treatment as well as disposal and treatment of domestic sewage and waste water.

Delhi Jal Board is producing and distributing the drinking water after the treatment of water from different sources such as river Yamuna, Bhakhra Storage, Upper Ganga Canal & Groundwater. The Delhi Jal Board is also provider of water to the NDMC (New Delhi Municipal Corporation) and cantonment area. Sewage from these area is also gathered and disposed by Delhi Jal Board.

Delhi Jal Board is providing about 83% household of Delhi have now water supplied by Distribution mains as well as Delhi Jal Board Water Tanks. Delhi Jal Board supplies water to about 18 million population of Delhi City through a water distribution network comprising of 11540 kms long pipelines and now 117 underground reservoirs (U.G.R) are functioning for rationalized dispersal of water supply in Delhi.

Delhi Jal Board water distribution network (WDN) has been created in a planned manner to cover both arranged and spontaneous zones. Water supply has been discharged in 847 unapproved provinces. Broad quality checks of water supply starting from raw water stage up to the purchaser point end are being done as per standards of BIS 10500-2012. Seven research facilities has introduced at water treatment plants and six zonal labs situated at different location of the city work round the clock to guarantee supply of consumable drinking water at the consumers end.

Delhi Jal Board has additionally dispatched the project “JAL” to make accessible potable drinking water in 20 liter Jar and 250 ml cans to serve consumers. JAL is also certified and approved by Bureau of Indian Standards (B.I.S.), water quality specification and standards. Delhi Jal Board has been provided about 20.65 lakhs water supply connections in the Delhi city till 31.03.2014. Through all endeavours and devotion of D.J.B. staff, the Delhi Jal Board has accomplish considerable increment in Revenue throughout the Years. During last year 2015 about 200 kms of worn out water supply pipelines were changed and 10500 minor and major water spillages were repaired by Delhi Jal Board.

The most basic requirement of water distribution system is supply or quantity. In developed country like U.S.A. France, Israel and Denmark etc., water must be 24 hour supply, but in developing country like India water supply is intermittent and erratic. So consumer is not able to gain sufficient quantity. According to World Health Organisation (W.H.O.) - "It is Possible that the wars of the twenty-first century will be fought for water. SAVE NOW TO PREVENT WAR."

At the launch of the International drinking water supply and sanitation decade (November 1980), Dr H. T. Mahler ,Director – General of world health Organisation ,stated that "…the number of water taps per 1000 population is a much better indicator of a country's health status than the number of hospital beds" (Development Forum, 1987).

The World Health Organisation (WHO Study Group, 1987) declares safe water as "…water that does not contain harmful chemical substances or micro-organisms in concentrations that cause illness in any form". It also defines sufficient water supply as "…one that provides safe water in sufficient quantities for drinking, and for culinary, domestic, and for other household purposes so as to make possible the personal hygiene of member of the household. A significant quantity of water has to be supplied throughout the year to the households and society where the water is to be used."

The most important parameter of water distribution network is Reliability that describes about the performance or consistency of the water network. It is known as ratio of supplied water at consumer end to the designed or required water at consumer end. Delhi Jal Board and all other agencies which are responsible for water distribution network are continuously working towards upgrading the newly designed water network as well as existing water network and optimising the design of up to a great extent in achieving the higher efficiency at the minimum allocation of resources and minimum installation, operational and maintenance cost of water distribution network.

A water distribution network will be called non-reliable or failed if it does not meet consumer demands. So our prime concern should be make water distribution system more reliable by increasing components reliability, which is possible by correct design and proper maintenance of all the components. Water distribution network reliability should be high but not too much increase in capital investment, operational and maintenance cost.

1.2 REQUIREMENT OF WATER DISTIBUTION SYSTEM

In India, the cities are expanding at a very fast rate with the increasing population. The existing water distribution network have been old and unable to face the consumer requirement. So it is necessary to establishment, investigation and up gradation of all the existing networks which must satisfies the following conditions (McGhee, 1991):

- Maintain water quality standards as per suggested by authorities in distribution mains.
- Establish economical design and layout.
- Maintain required design pressure at ferrule point
- Adequate supply of potable drinking water
- Assurance reliability of supply during any period
- Easy maintenance

1.3 OBJECTIVES

- To study the parameter related to water distribution network (WDN) such as:
    1. Inadequacies of designed water supply scheme.
    2. Available head and quantity of water at consumer end point.
    3. Reliability of water supply network.
- To study the water quality parameter and contamination at any point.
- To study the effect of population increment on this existing water distribution network.
- To suggest the modification for existing water distribution network to increase the reliability.

1.4 SCOPPE OF STUDY

- To study the other water distribution network of different regions.
- Finding a reliable solution for forecasting exact demand of consumer.
- To develop an advanced method to solve techno economical solution for water distribution network
- To developing a software with latest technology and making water distribution network smart.

1.5 METHODOLOGY

1. Study area: water distribution network Dayanand Vihar near Anand Vihar, New Delhi.
2. Data collection of Dayanand Vihar Water distribution network that includes network layout, topographical map, installed age of water distribution network, water demand at the consumer end point, water supply duration and pattern, No. of reservoir, pump station details, parameter of installed pumps, pipe type and population etc.
3. Draw water distribution network in WaterGEMS software.
4. Calculate the different parameter of water distribution network with help of WaterGEMS software.
5. Study the water quality standards of water supply for drinking.
6. Reliability of water distribution network in terms of the quantity for the given consumer type, as well as increasing population based on geometric increase method of forecasting effect on the water distribution network reliability.
7. Study of water distribution network for different cases when 1 pump / 2 pump running and design layout.
8. Apply some modification to the water distribution network on the basis of obtained result from the study so that consumer requirement can be fulfilled such as water pressure, quantity and 24×7 water supply.

1.6ASSUMPTIONS

- Assuming flat topography of the study location.
- There is no seismic activity in study location because it can damage the pipe fittings which will leads to breakage of water distribution network.
- All pipe fittings and valves such as isolation valve, reflux valve, sluice valve etc. are functioning properly.
- Adequate quantity of water is available for the consumer needs.
- Water requirement, per capita per day equals to 175 LPCD.
- A plot is defined as 8 persons living in that area with water consumption 180 LPCD.

As per CPHEEO ferrule pressure-

NO. of STORY	FERRULE PRESSURE in m
Single	7
Double	12
Triple	17
More than triple	22 (not more than)

Table 1.1 Ferrule Pressure Value as per CPHEEO Recommendation

- There is no water leakage point, no corrosion and water blocks which may affect the performance of the water distribution network.
- Hydraulic friction loss constant as per recommendation:

FLOW(GPM)	CONSTANT (1/2 INCH PIPE)	CONSTANT (3/4 INCH PIPE)
1	2	0.354
2	7.22	1.28
3	15.3	2.71
4	26.0	4.60
5	39.2	6.94
6	55	9.75

Table 1.2 Hydraulic Friction Loss Constant

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Water distribution networks are designed after recognizing the consumption of water that changes according with the summer and winter season, monthly basis, daily and hourly requirement. For designing of water distribution network, we considers the fluctuation that can be occurs during the supply period. Hourly fluctuation are concern for the designing water distribution network because fluctuation are accounted for peak demand of water supply. Hourly fluctuation has higher value than other fluctuations, excluding fire demand fluctuation. The design discharge for water distribution network is calculated by average water supply rate multiplied by peak factor.

The fluctuation in water supply also occurs due to type of gentry, type of supply pattern i.e. continuous or intermittent water supply and local area i.e. residential, educational and industrial area. Water demand will be more in small population area as compared with large population area because in case of large population area demand increases very gradually due to different customs and religions, and different habits of people. All these factors leads to minimising the variation in water demand pattern.

2.2 Type of Water Distribution Network

There are many type or pattern adopted for laying the water mains pipes in ground surface. Each type has its own advantages as well as disadvantage.

2.2.1 Dead End Type Water Distribution Network

In this main distribution pipe runs through the centre of area and sub-mains pipes off from both sides. These sub mains further divides into branch pipes that provides service connection.

It is suitable for old cities that have different pattern of roads.

Advantages

1- Design calculation is fast and easy.

2- A small number of cut off valves are required which reduces the cost of water distribution network.

3-Operational and maintenance cost is very low due to simple laying of pipes.

Disadvantages

1-there is only one main pipeline if it got damaged that will stop the whole water distribution supply i.e. very risky.

2- The network is not successful in maintaining the minimum pressure at remote area points so now-a-days these are not adopted.

3- In this head loss is too large so unable to supply significant amount of water during the fire fighting in localities.

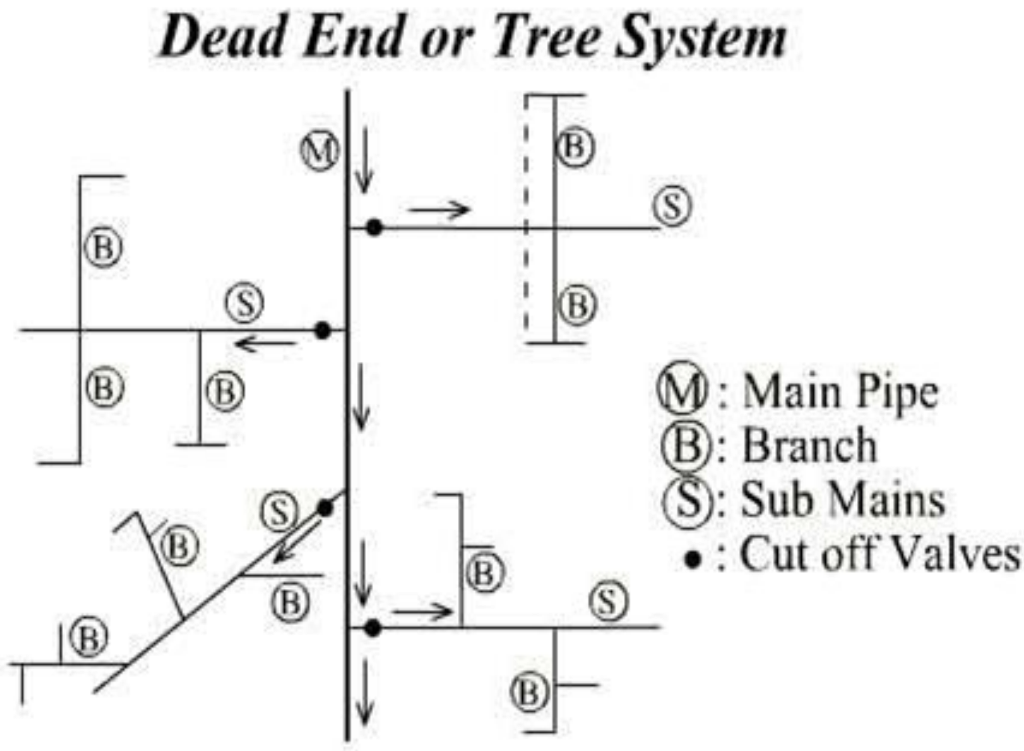

Figure 2.2.1 Dead End or Tree Water Distribution System

2.2.2 Grid Iron Water Distribution Network

In this type or pattern main distribution pipe runs through the centre area and sub-mains are off perpendicular the mains. Again the sub mains interconnect the branches. This type of pattern is adopted for cities which are designed in rectangular layout.

Advantages-

1-In case of repairing the water distribution network only a small area is effected at that time and remaining will get continuous water supply.

2-There is no deposition of sediment and stagnation of water in the water distribution network.

3-Due to interconnectivity, water is available at each nodes thus head loss is minimum so these type of pattern are beneficiary at the time of fire fighting.

Disadvantages-

1- A large number of cut off valve are used that increases the cost of the water distribution network.

2- The analysis of water distribution network is very complex and time consuming.

3- Water distribution network requires a large no of pipes with longer length with large diameter.

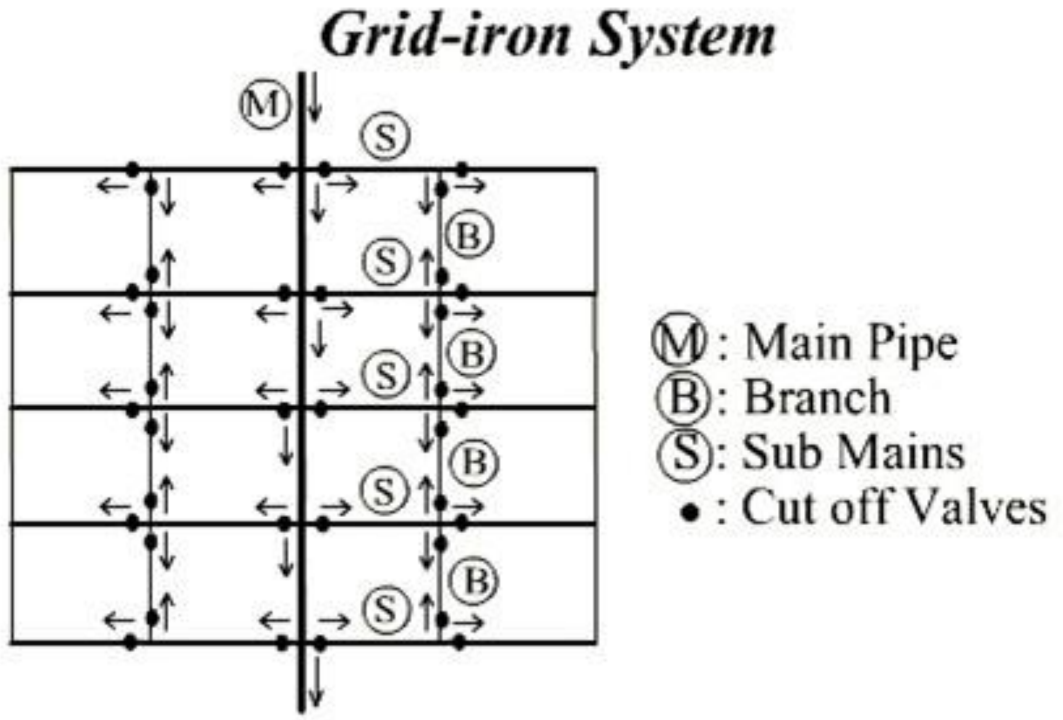

Figure 2.2.2 Grid Iron Water Distribution Network

2.2.3 Circular or Ring Water Distribution Network

In this type or pattern main distribution mains form a ring like shape and sub mains are connected across the main pipes.

Advantages-

1- During the fire fighting a large quantity of water is available in water distribution network.

2-Water supply at a node can supplied from two directions due to ring type of pattern.

Disadvantage-

1- The main distribution pipe have a longer length thus increases Project economy.

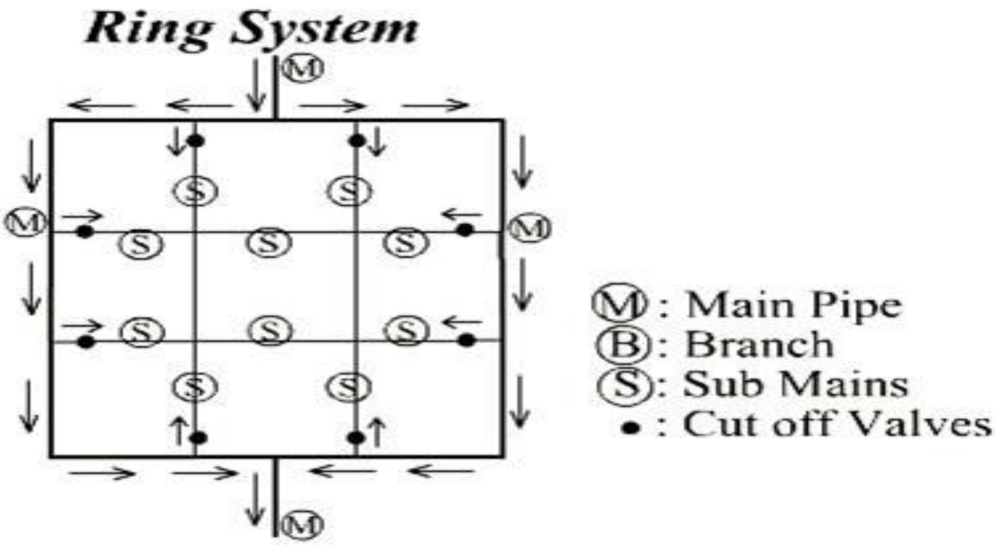

Figure 2.2.3 Ring Water Distribution Network

2.2.4 Radial Water Distribution Network

In this type or pattern whole area is divided into a small area and each small area has a service elevated reservoir. The water is supplied from elevated service reservoir towards the periphery of area.

Advantages-

1- System provides easy swift for service and less head loss.

2-In this water distribution network, calculation are easy.

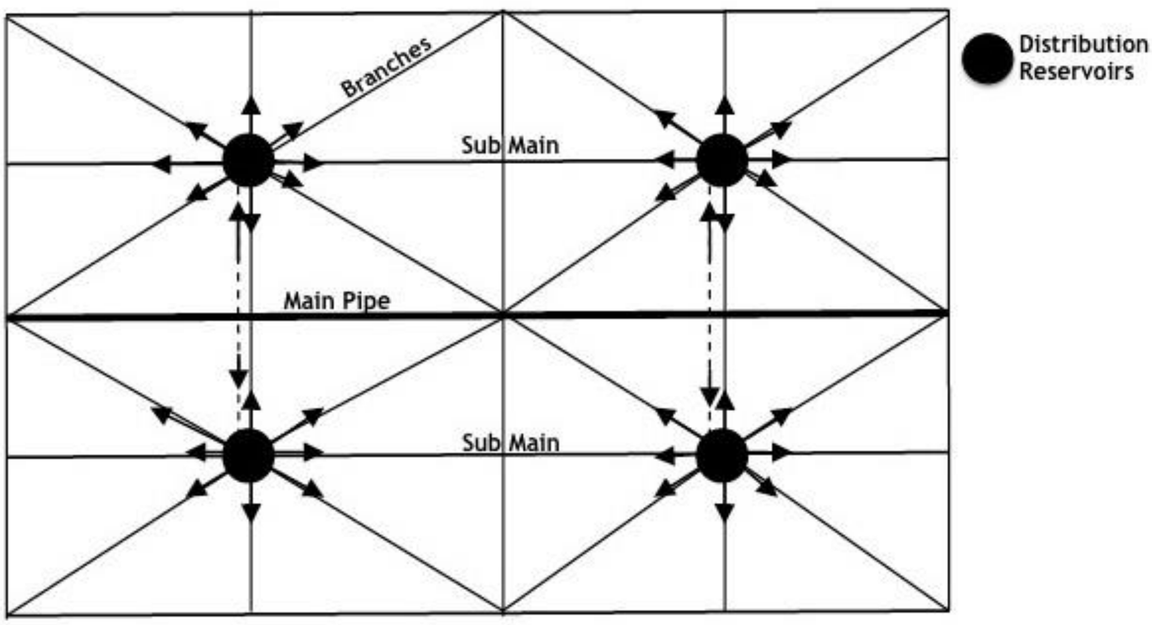

Figure 2.2.4 Radial Water Distribution Network

2.3 DESIGN OF WATER DISTRIBUTION NETWORK (WDN)

A water distribution network must be designed for a long duration for water supply such that it can fulfil consumer demands. In terms of quantity or in terms of available head or both, that should be fulfil by water distribution system. Most of the water system are designed for 30-40 years of span. There must be an alternative approach or method to fulfil design targets. These alternative approaches are chosen on the basis of service coverage during phase period of water distribution network. These alternative approaches consist coverage of increased population with improved water supply conditions, an economical approaches for up gradation of water distribution network and a strategic plan.

- **2.3.1 PIPELINES -** Mostly pipelines follow the profile of ground surface. Gravity pipelines are laid below the H.G.L. (Hydraulic Gradient Line).Pipes are made of cast iron (C.I.), ductile iron (D.I.), mild steel, prestressed concrete, asbestos cement and plastics etc.
- **2.3.2 CONDUIT HYDRAULICS THEORY-** The design of fluid supply depends upon a number of parameter are resistance to flow, sediment transport, scour, available pressure, allowable velocities of flow, water quality and relative cost.
- **2.3.3 FORMULAE -** There are many formula used for conduits design for calculating flow velocity. However, Darcy Weisbach's formula, Manning's formula, Hazen-Williams formula and Colebrook White formula.

(a) Darcy Weisbach's Formula

First of all Darcy and Wiesbach Suggested dimensionless formula for pipe flow as,

$$S = \frac{H}{L} = \frac{f\ v^2}{2\ g\ D}$$

Where,

H = head loss due to friction in m

L = length of pipes in m

V = velocity in m/s

g = gravity acceleration in m /s ^{2}

D= diameter of pipe in m

f= friction factor dimensionless

(b)Hazen- William Formula

Hazen- William formula is expressed as-

$$V = 0.849CR^{0.63}S^{0.54}$$

Where,

C= Hazen-Williams Coefficient

R= Hydraulic radius in m

S= Slope of H.G.L.

V= velocity in m/s

(c)Manning's Formula

The Manning's formula given as,

$$V = \frac{1}{n} R_3^2 S_2^1$$

Where,

N= Manning's coefficient

R= hydraulic radius in m

S= slope of hydraulic gradient

V= velocity in m/s

(d) Colebrook White Formula

This formula is used for calculation of friction factor

$$\frac{1}{\sqrt{f}} =- 2\log_{10}\left[\left(\frac{k}{3.7d}\right) + \frac{2.51}{R_e\sqrt{f}}\right]$$

Where,

f= Darcy friction factor

k= roughness projection

d= diameter of pipe

R_e = Reynolds number

- **2.3.4 ROUGHNESS COEFFICENT-**

  The coefficient of roughness depends upon the Reynolds number and roughness of pipes. If $R_e > 10^7$ friction factor f is independent of velocity of flow and pipe diameter.

Pipe material	Recommended value	
	New Pipes	Design Purpose
Cast Iron	130	100
Ductile iron	130	100
Mild Steel	140	100
Galvanised Iron above 50 mm dia.	120	100
Galvanised Iron upto50 mm dia. Used for house service connections	120	55

Table 2.3.1 Roughness coefficient (C)

2.4 WATER DISTRIBUTION SYSTEM ANALYSIS METHODS

In water distribution system, pipe network analysis is the analysis of the fluid flow through a hydraulic network, containing several or many interconnected branches. The aim is to determine the flow rates and pressure drops in the individual sections of the network. This is a common problem in hydraulic design. To direct water to many users, municipal water supplies often route it through a water supply network. A major part of this network will consist of interconnected pipes. This network creates a special class of problems in hydraulic design, with solution methods typically referred to as pipe network analysis. Water utilities generally make use of specialized software to automatically solve these problems. However, many such problems can also be addressed with simpler methods, like a spreadsheet equipped with a solver, or a modern graphing calculator.

2.4.1 DETERMINISTIC NETWORK ANALYSIS

Once the friction factors of the pipes are obtained (or calculated from pipe friction laws such as the Darcy-Weisbach equation), we can consider how to calculate the flow rates and head losses on the network. Generally the head losses (potential differences) at each node are neglected, and a solution is sought for the steady-state flows on the network, taking into account the pipe specifications (lengths and diameters), pipe friction properties and known flow rates or head losses.

The steady-state flows on the network must satisfy two conditions:

1. At any junction, the total flow into a junction equals the total flow out of that junction (law of conservation of mass, or continuity law, or Kirchhoff's first law)
2. Between any two junctions, the head loss is independent of the path taken (law of conservation of energy, or Kirchhoff's second law). This is equivalent mathematically to the statement that on any closed loop in the network, the head loss around the loop must vanish.

If there are sufficient known flow rates, so that the system of equations given by (1) and (2) above is closed (number of unknowns = number of equations), then a deterministic solution can be obtained.

The classical approach for solving these networks is to use the Hardy Cross method. In this formulation, first you go through and create guess values for the flows in the network. These initial guesses must satisfy the Kirchhoff laws (1). That is, if Q_7 enters a junction and Q_6 and Q_4 leave the same junction, then the initial guess must satisfy $Q_7 = Q_6 + Q_4$. After the initial guess is made, then, a loop is considered so that we can evaluate our second condition. Given a starting node, we work our way around the loop in a clockwise fashion, as illustrated by Loop 1. We add up the head losses according to the Darcy–Weisbach equation for each pipe if Q is in the same direction as our loop like Q_1, and subtract the head loss if the flow is in the reverse direction, like Q_4. In other words, we add the head losses around the loop in the direction of the loop; depending on whether the flow is with or against the loop, some pipes will have head losses and some will have head gains (negative losses).

To satisfy the Kirchhoff's second laws (2), we should end up with 0 about each loop at the steady-state solution. If the actual sum of our head loss is not equal to 0, then we will adjust all the flows in the loop by an amount given by the following formula, where a positive adjustment is in the clockwise direction

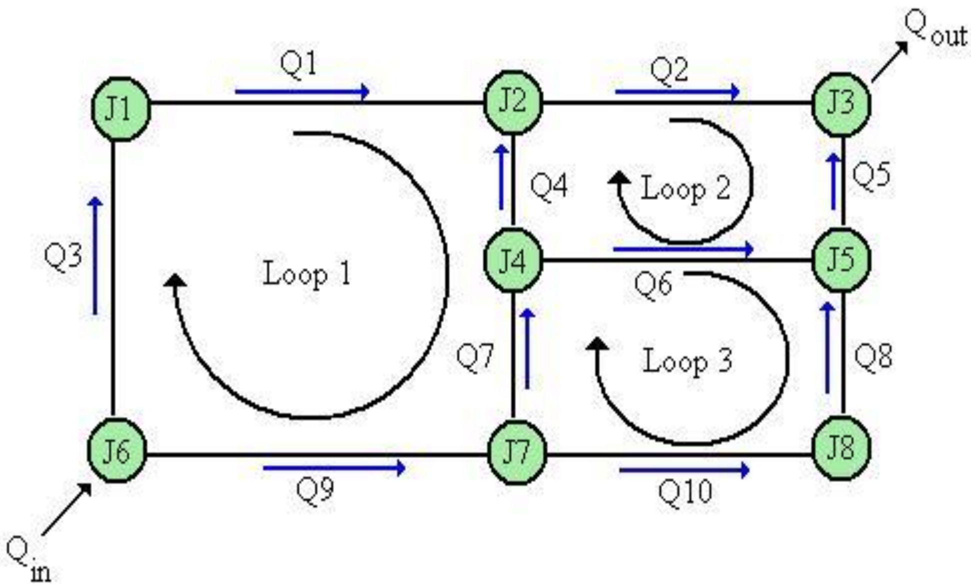

Figure 2.4.1 Loop Diagram of a Network

$$\mathbf{\Delta Q} = -\frac{\sum \mathbf{head\ loss_c} - \sum \mathbf{head\ loss_{cc}}}{\mathbf{n}.\left(\sum \frac{\mathbf{head\ loss_c}}{\mathbf{Q_c}} + \sum \frac{\mathbf{head\ loss_{cc}}}{\mathbf{Q_{cc}}}\right)}$$

Where,

a) n is 1.85 for Hazen-Williams.
b) n is 2 for Darcy–Weisbach.

- The clockwise specifies (c) means only the flows that are moving clockwise in our loop, while the counter-clockwise specifies (cc) is only the flows that are moving counter-clockwise.
- This adjustment doesn't solve the problem, since most networks have several loops. It is okay to use this adjustment, however, because the flow changes won't alter condition 1, and therefore, the other loops still satisfy condition 1. However, we should use the results from the first loop before we progress to other loops.

- An adaptation of this method is needed to account for water reservoirs attached to the network, which are joined in pairs by the use of 'pseudo-loops' in the Hardy Cross scheme. This is discussed further on the Hardy Cross method site.
- The modern method is simply to create a set of conditions from the above Kirchhoff laws (junctions and head-loss criteria). Then, use a Root-finding algorithm to find Q values that satisfy all the equations. The literal friction loss equations use a term called Q^2, but we want to preserve any changes in direction. Create a separate equation for each loop where the head losses are added up, but instead of squaring Q, use $|Q|\cdot Q$ instead (with $|Q|$ the absolute value of Q) for the formulation so that any sign changes reflect appropriately in the resulting head-loss calculation.

2.4.2 PROBABILISTIC NETWORK METHOD

In many situations, especially for real water distribution networks in cities (which can extend between thousands to millions of nodes), the number of known variables (flow rates and/or head losses) required to obtain a deterministic solution will be very large. Many of these variables will not be known, or will involve considerable uncertainty in their specification. Furthermore, in many pipe networks, there may be considerable variability in the flows, which can be described by fluctuations about mean flow rates in each pipe. The above deterministic methods are unable to account for these uncertainties, whether due to lack of knowledge or flow variability.

For these reasons, a probabilistic method for pipe network analysis has recently been developed, based on the maximum entropy method of Jaynes. In this method, a continuous relative entropy function is defined over the unknown parameters. This entropy is then maximized subject to the constraints on the system, including Kirchhoff's laws, pipe friction properties and any specified mean flow rates or head losses, to give a probabilistic statement (probability density function) which describes the system. This can be used to calculate mean values (expectations) of the flow rates, head losses or any other variables of interest in the pipe network. This analysis has been extended using a reduced-parameter entropic formulation, which ensures consistency of the analysis regardless of the graphical representation of the network. A comparison of Bayesian and maximum entropy probabilistic formulations for the analysis of pipe flow networks has also been presented, showing that under certain assumptions (Gaussian priors), the two approaches lead to equivalent predictions of mean flow rates.

2.4.3 GRADIENT METHOD

The gradient method directly obtains the improve discharge Q and head H values instead of computing corrections to them. In iterative procedure, that is continued till no further improvement is observed. This method also does not need balancing the node flow continuity equations at each node to be begin the process. The pipe discharge and nodal heads are taken as the basic unknown in formulating the Q-H equations for different situations as described above. The advantage of gradient method over other methods is that number of iterations required for convergence is minimum, whereas Newton Raphson method has maximum iterations.

The typical optimization approach for water distribution system is that considering a single design scenario with prefixed nodal demands representing the peak values at the end of the life cycle of the construction. Instead, this paper presents a different approach for the design of water distribution mains aimed at considering the phasing of construction. It makes it possible to identify, on prefixed time steps or intervals (for instance 40 years), the upgrade of the construction rendering the network able to satisfy, during the expected life of the system, growing nodal demands related to the increment in the population served. To show the benefits of this approach in comparison to using a single design flow, an optimization methodology, aimed at introducing new pipes in the network as needed at each time step, was set up and applied to a simple case study, where two different scenarios were considered concerning the growth of the network. Results showed that this approach is able to yield better results when compared with the single flow design, because it enables short-term construction upgrades to be performed while keeping a vision of the expected long term network growth.

In situations where nodal demands increase in time without uncertainty, this approach entails identifying, on prefixed time steps, the optimal network upgrades that allow the network to keep supplying water with acceptable service pressure to users. Designing in a single phase without considering long-term implications results in a system that may need inefficient upgrades at the end of the design period or excessive initial investments in capacity that may not be required for a long (uncertain) time in the future.

2.5 OPERATION OF WATER DISTRIBUTION NETWORK

2.5.1 Leak Detection and Monitoring

Increasing the pressure from the supply source was one way to address the service level problem. However, because of high losses in the pipe system, increasing the pressure would also increase non-revenue water (NRW). Leak detection was conducted and hundreds of service pipe leaks were reported, however, their repair did not contribute to the improvement of pressure in the area.

Like the larger pipes, older service lines made out of ferrous materials will tend to corrode over a long period of time. Galvanic corrosion is a particular kind of corrosion that is caused by corrosive water that can lead to a problem known as tuberculation. Tuberculation is an electrochemical phenomenon where metal ions given up by the pipe wall are deposited inside the pipe eventually building a mass that restricts the flow of water to the customer's home. Once the mass builds up to a size that restricts flow, it cannot be removed and the pipe must be replaced.

Zheng Yi Wu et al. (2012) have suggested a new optimization methodology for leakage detection in water distribution systems. It pinpoints where leakages are and predicts how much a leakage is as orifice flow that is modelled as flowing emitter flow dependent on the nodal pressure in addition to the volume-based demand at node. The new method then minimises the differences between the model predicted and the field observed values of flows and pressures. The optimization problem is solved by using a competent genetic algorithm. The methodology is developed as a user-friendly integrated optimization modelling tool so that engineers can readily execute leakage hotspot identification optimization as an independent task. The integrated optimization framework also permits the engineer to carry out combined leak detection and hydraulic calibration tasks. The results obtained illustrate the robustness and effectiveness of the developed method at predicting leakage hotspots.

Buchberger and Nadimpali et al. (2004) proposed a new method for detecting the magnitude of leaks in small residential service zones of a drinking water distribution network is proposed. Several examples, based on observed and simulated pipe flows are presented to demonstrate the application of the leak detection method in a very effective and efficiently.

There are a lot of method to calculate loss water through the pipe distribution network. But due to leaking loss water is calculated as:

Water lost = (A+L+R) X flow rate

A = awareness time: that a leak has been occur

L = location time: time spent to find the leakage point

R = repair time: time between issue arise and completion of repair

Flow rate= discharge m^3/ day

2.5.2 PIPE BREAKAGE

The rates of pipe breakage with increasing pipe diameter and times are investigated. Failure rates for cast-iron pipe are found to decrease with increasing diameter. Changes in pipe failure rates for the various modes of failures are examined in detail. Asbestos-cement and cast-iron pipe overall failure rates are found to increase with time, but for different reasons. Analysis of the modes of failure shows that joint failure is predominant for cast-iron pipe systems with bolted and universal joints whereas the predominant mode of failure for asbestos-cement pipe systems is circumferential cracking

2.5.3 WATER HAMMER

Water hammer phenomenon in water supply pipe network in order to provide an acceptable level of protection against system failure due to pipes collapse or bursting. Water Hammer and Mass Oscillation WHAMO software is used in the analysis which uses the implicit finite difference scheme for solving the momentum and continuity equations at unsteady state case.

R. Wang et al (2014) described about water hammer that water hammer hazards are mainly in four aspects: the high water pressure bursting pipes, the vacuum flattening pipes and leading to water pollution, the cavitation damaging the pipes and pump impellers, as well as the transient force losing the pipe joints. We presented a method to calculate five risk factors: the above four factors plus a composite risk factor.

The pipe rupture risk assessment method and procedure were proposed through a water supply pipe network risk prediction flow chart. A real engineering case of CD city of China was used to illustrate the assessment method. The technology was proved correct, and the pipe rupture risk prediction and classification maps can be used to provide a technical guidance for the water distribution network (WDN) design and operation maintenance.

2.5.4 PUMPING MAINS OPERATIONS

Pumping stations in a water distribution network are necessary where water is pumped directly in to a system or where pressure can be increased so that there is an insufficient difference in water levels in gravity flow distribution systems.

Buchleiter and Heermann et al (1986, 1990), Moradi-Jalal et al (2003) and Planells et al (2005) have developed methods to optimize the type and number of pumps as well as scheduling the operation of pumps, considering both the initial investment and the cost of consumed energy.

Chen et al (1988) considered a network without tanks and determined the optimal allocation of supply between the pump sources. Dynamic programming approach was used to select the actual pumps given the continuous outflows. Kim and Mays (1994) described how to minimize the pumping costs by including the rehabilitation action for each main of the hydraulic model as a decision variable. This system cost, subject to a hydraulic constraint formulation is minimized using a nonlinear optimization package.

Klempous et al (1997) presented a multilevel two algorithms for finding optimal control in a static water distribution system based on the idea of aggregation technique. The first is a simulation algorithm of the pipeline network and the other is an algorithm for finding optimal control at the pumping station.

CHAPTER-3

STUDY AREA

3.1 LOCATION

Water distribution network under study is situated in East Delhi near Anand Vihar and Arya Nagar as Shown in the figure3.1.1and 3.1.2. This Water Distribution Network Is Conserved By Delhi Jal Board. The residential area is known as **DAYANAND VIHAR**. For distribution of water in network, water is firstly stored in underground reservoir (UGR) from Bhagirathi Water Treatment Plant which is approximately 12.0 kms far away from the Dayanand Vihar residential area. The diameter of pipe connecting Bhagirathi Water treatment plant and Dayanand Vihar is 700 mm. The geographical area of our residential water distribution network is flat with having slope about 1% -2.5%. Figure 3.1.1 shows the Google map of Dayanand Vihar.

The climate of Dayanand Vihar is humid subtropical. In area, there is a very high difference between summer and winter temperature. The area also experiences high humidity during the rainy season.

Figure 3.1.1 Dayanand Vihar Google Map

Figure 3.1.2 Layout of Plots of Dayanand Vihar Residential Area

3.2 SALIENT DATA

The water distribution network under our area of scope is dead end type system. The salient data of the network are:-

ITEM	**VALUE**
AREA	9 Hectares
NO OF PUMPS	1+1(Stand by)
DISCHARGE AND HEAD OF PUMP	2MGD and 28 m
HORSE POWER OF PUMP	100HP
NO OF OVER HEAD TANK	0
NO OF UNDER GROUND RESERVOIR	1
SIZE/VOLUME OF UGR	10Mi L
NO OF CURRENT CONSUMERS	2370
NO OF PIPES	58
MATERIAL OF PIPE	CAST IRON
DIAMETER OF PIPE LINE	100,150,200 mm
AGE OF WATER SUPPLY NETWORK	5 year
DESIGN PERIOD OF NETWORK	40 year
NO OF NODES	50
NO OF PLOTS	270
MAXIMUM HEIGHT ALLOWED TO BE CONSTRUCTED	15m

Table 3.2- Salient data of Dayanand Vihar WDN

CHAPTER 4

DAYANAND VIHAR WATER DISTRIBUTION NETWORK

4.1 WATER DISTRIBUTION NETWORK (WDN)

Distribution system is a network of pipelines that distribute water to the consumers, it also consists pipes, pumps, reservoirs, type of valves, and hydraulic elements. For study of water distribution network, we represent this all apparatus in a network representation form.

The improvement and augmentation of consumable drinking water supply in Delhi is one of the mission of for urban infrastructure of cities focused under Jawaharlal Nehru National Renewal Mission (JNNURM), city development plan, department of urban development, Govt. of Delhi; 2006 since inadequacy of water supply has been identified as one of the weak area.

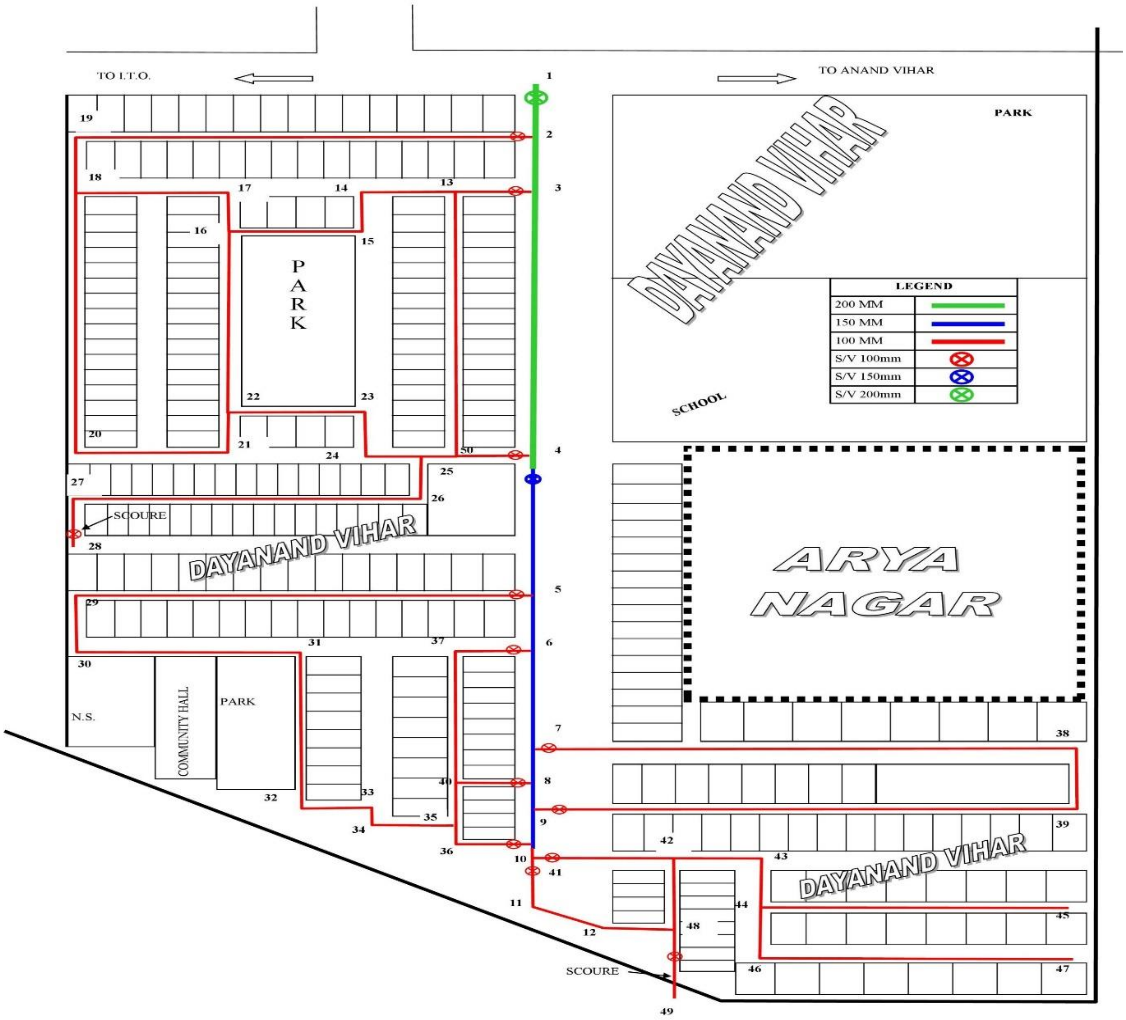

Figure 4.1 Pipe Layout of Dayanand Vihar Water Distribution Network

4.2 WaterGEMS -WATER DISTRIBUTION NETWORK TOOL

WaterGEMS provide a comprehensive approach to solve a water distribution network and easy to use decision support tool for water networks. WaterGEMS helps in understanding the behaviour and information of a system, how it responds to operational strategies, and how should grow as population and increase in consumer demand.

WaterGEMS simulates about fire flow as well as water quality, to criticality analysis and energy cost analysis. WaterGEMS has a whole solution of everything whatever we need in a workable environment.

WaterGEMS provide different software tool for-

- **Intelligent planning for system reliability:** The capability of water distribution network to adequately serve water to the consumers must be evaluated whenever system growth is predicted. WaterGEMS also identified problem area and plan capital investments.
- **Optimised operation for system efficiency:** Pragmatic modelling of complex operation of water distribution network is very difficult. But with help of WaterGEMS optimise pumping strategies, and plan shutdowns and routine operations to minimise disruption.
- **Reliable asset renewal decision support for system sustainability:** In a water distribution network, when we renew or replace water infrastructure, a lot of information regarding network we required and analysis is very complex and tedious. WaterGEMS tool is used as Pipe Renewal Planner makes very easier and fast by analysing and comparing a broad range of prioritise the renewal approach.

  In our analysis we uses WaterGEMS V8i series for our case study area. The results obtained from WaterGEMS are used to compare the performance of water distribution network based on its consistency.

WaterGEMS uses the “Gradient Method” for solving the water distribution network. The solutions obtained from the WaterGEMS software are matched with the actual performance of the system. Cast Iron pipes are used in our water distribution network, hence C = 100 is adopted for the pipes.

4.3 POPULATION

In India Census is conducted at an interval of 10 years. That provide the present population data as well as prediction about future population. This data is helps the design engineer during the design of water distribution network. There are many math formula which are used for forecasting of population such as Arithmetic mean method, Geometric increase method and incremental method. But in our study we adopted Geometric increase method. Accordingly,

$$P_n = P_0\left(1 + \frac{r}{100}\right)^n \qquad ....4.4.1$$

Where,

P_0 = Initial population

P_n = Future population

r = assumed rate of growth

n = number of decade

The rate of growth of India is calculated with help of census of year 2011and our population growth is about 17.69 %. But population growth of Delhi is too high as compare with country rate of growth. The census of Delhi is given in Table 4.3.1, that provides the rate of growth of population of Delhi.

S.NO.	CENSUS YEAR	POPULATION	% CHANGE
1	1951	1744500	-
2	1961	2669990	34.41
3	1971	4066400	34.58
4	1981	6220973	34.63
5	1991	9421311	33.96
6	2001	13851503	31.98
7	2011	16753235	17.32

Table 4.3.1 Census of Delhi

Rate of growth ‘r’ is calculated by two methods:

1. Empirical relation

$$r = \sqrt[t]{\frac{P_2}{P_1}} - 1$$

Where

P_1 = Initial known population

P_2= Future known population

t= number of decades between P_1 and P_2

from the table 4.3.1:

P_1 = 13851503

P_2 = 16753235

t = 1

$r = \sqrt[1]{\frac{16753235}{13851503}} - 1$ = 1.2094 - 1 =0.2094

r = 20.94%

2. Average rate of increase:

$$r = \frac{r_1 + r_2 + r_3 + ...r_t}{t}$$

$$r = \frac{34.41 + 34.58 + 34.63 + 33.96 + 31.98 + 17.32}{6}$$

r = 31.14

‘r’ value obtained from the empirical method is approximate such as given in Delhi population census survey but obtained from average rate of increase is too higher so we do not use it. So r = 20.94 % is adopted for population increase in Delhi for next 40 years. Now population is divided in plots of Dayanand Vihar.

Decade	Population	% Increase	New Population	NO. of Person Per Plot
1	2370	20.94	2866	11
2	2866	20.94	3466	13
3	3466	20.94	4191	15
4	4191	20.94	5068	18

Table 4.3.2 Estimated Population Growth with Constant ‘r’

In population census, it is realised that there is decline in population census growth rate so we will assume decline rate of growth ‘r’. So after analysing current trend of population with help of Delhi population census there will be a constant decline of approximate 3% per decade then population accordance with decline growth rate ‘r’ are shown in table 4.3.3.

Decade	Population	% Increase	New Population	No. of Person Per Plot
1	2370	20.94	2866	11
2	2866	18	3381	12
3	3381	15	3888	14
4	3888	12	4354	16

Table 4.3.3 Estimated Population Growth with changing ‘r’

4.4 RELIABILITY

In our analysis of project work we are concerned about the reliability of the water distribution network in terms of quantity of water that is being deliverable to the consumer end point. It is kept in mind about reliability factor while designing the water distribution network. Reliability on the basis of quantity is described below:

- **Water Demand Reliability:**

  “As per BIS 1172:2007 – 135 to 255 LPCD of water is to be supplied at a consumer end per day. According to CPHEEO 227 LPCD was the requirement of water in India during year 2011. The economic survey of state Govt. of Delhi has declared the current water supply is 172 LPCD and 180 LPCD by 2021.” For network Analysis our assumption for water demand is 175 LPCD i.e. quantity of water should be available to the consumer having metered supply. Hence, Reliability

$$R_Q = \frac{total\ amount\ of\ water\ is\ available\ at\ one\ consumer\ end}{toatal\ amount\ of\ water\ shold\ be\ available\ at\ one\ consumer\ end}$$

4.5 NETWORK APPRAISAL

The given water distribution network of Dayanand Vihar is tested for network capacity in terms of quantity of water for given operating conditions which is an intermittent water distribution supply from UGR.

4.5.1 DAYANAND VIHAR WDN NODE DETAILS

In water distribution network of Dayanand Vihar, there are 50 no. of nodes which have Zero elevation value due to flat topography of the area.

The node details of water distribution network are shown in table 4.5.1

Label	Elevation (m)	Hydraulic Grade (m)	Pressure (m H2O)
J-2	0	21.57	21.52
J-3	0	21.18	21.14
J-4	0	20.26	20.21
J-5	0	19.78	19.74
J-6	0	19.31	19.27
J-7	0	18.78	18.74
J-8	0	18.73	18.69
J-9	0	18.7	18.66
J-10	0	18.44	18.4
J-11	0	18.33	18.3
J-12	0	18.3	18.26
J-13	0	20.59	20.55
J-14	0	20.46	20.42
J-15	0	20.33	20.29
J-16	0	20.1	20.06
J-17	0	20.06	20.02
J-18	0	20	19.96
J-19	0	20.01	19.97
J-20	0	19.98	19.94
J-21	0	20.03	19.99
J-22	0	20.06	20.02
J-23	0	20.09	20.05

J-24	0	20.11	20.07
J-25	0	20.13	20.09
J-26	0	20.02	19.98
J-27	0	19.5	19.46
J-28	0	19.5	19.46
J-29	0	18.26	18.23
J-30	0	18.26	18.23
J-31	0	18.27	18.23
J-32	0	18.39	18.36
J-33	0	18.42	18.39
J-34	0	18.43	18.39
J-35	0	18.47	18.43
J-36	0	18.44	18.4
J-37	0	19.06	19.02
J-38	0	18.38	18.35
J-39	0	18.38	18.34
J-40	0	18.72	18.68
J-41	0	18.36	18.33
J-42	0	18.25	18.21
J-43	0	18.12	18.09
J-44	0	18	17.96
J-45	0	17.89	17.85
J-46	0	17.98	17.94
J-47	0	17.94	17.9
J-48	0	18.26	18.22
J-49	0	18.26	18.22
J-50	0	20.22	20.18

Table 4.5.1 Dayanand Vihar WDN Node Details

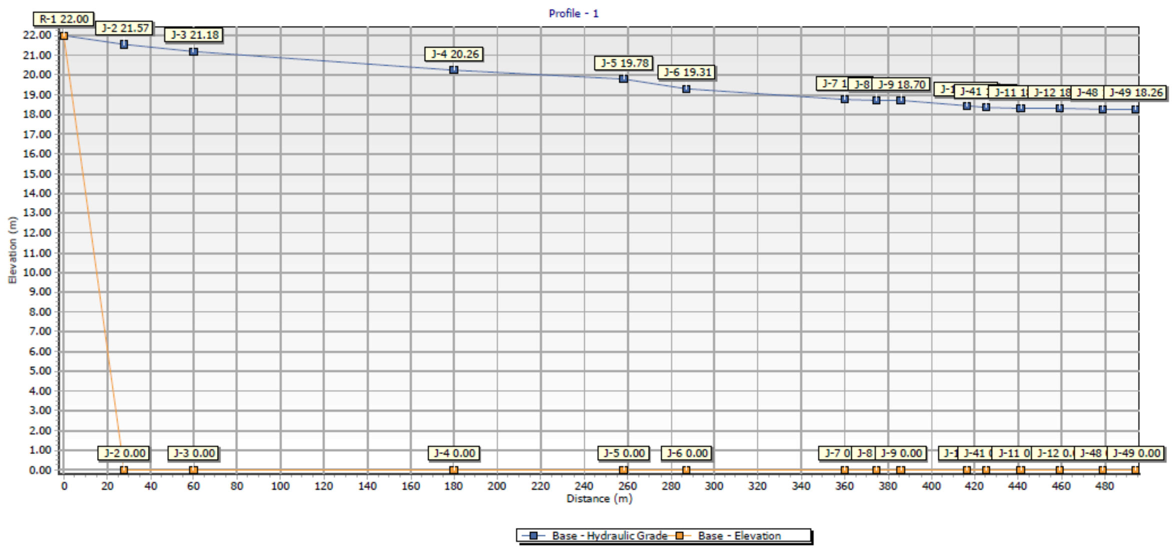

Figure 4.5.1 Hydraulic Grade Profile.

4.5.2 DAYANAND VIHAR WDN PIPE DETAILS

In water distribution network, there are 58 pipes of Cast Iron material whose C value is assumed to be C=100. These pipes have different diameter of 200 mm, 150 mm and 100 mm. The length scaled itself with the help of WaterGEMS software

Label	Length (Scaled) (m)	Diameter (mm)	Material
P-1	89	200.0	Cast iron
P-2	117	200.0	Cast iron
P-3	559	200.0	Cast iron
P-4	296	200.0	Cast iron
P-5	118	150.0	Cast iron
P-6	210	150.0	Cast iron
P-7	71	150.0	Cast iron
P-8	57	150.0	Cast iron
P-9	75	100.0	Cast iron
P-10	117	100.0	Cast iron
P-11	124	100.0	Cast iron
P-12	144	100.0	Cast iron
P-13	83	100.0	Cast iron
P-14	204	100.0	Cast iron

P-15	82	100.0	Cast iron
P-16	236	100.0	Cast iron
P-17	117	100.0	Cast iron
P-18	708	100.0	Cast iron
P-19	550	100.0	Cast iron
P-20	234	100.0	Cast iron
P-21	85	100.0	Cast iron
P-22	211	100.0	Cast iron
P-23	92	100.0	Cast iron
P-24	85	100.0	Cast iron
P-25	90	100.0	Cast iron
P-26	536	100.0	Cast iron
P-27	102	100.0	Cast iron
P-28	383	100.0	Cast iron
P-29	705	100.0	Cast iron
P-30	119	100.0	Cast iron
P-31	344	100.0	Cast iron
P-32	329	100.0	Cast iron
P-33	108	100.0	Cast iron
P-34	37	100.0	Cast iron
P-35	131	100.0	Cast iron
P-36	39	100.0	Cast iron
P-37	116	100.0	Cast iron
P-38	120	100.0	Cast iron
P-39	837	100.0	Cast iron
P-40	126	100.0	Cast iron
P-41	837	100.0	Cast iron
P-42	280	100.0	Cast iron
P-43	89	100.0	Cast iron
P-44	119	100.0	Cast iron
P-45	27	100.0	Cast iron
P-46	106	100.0	Cast iron

P-47	215	100.0	Cast iron
P-48	135	100.0	Cast iron
P-49	103	100.0	Cast iron
P-50	475	100.0	Cast iron
P-51	107	100.0	Cast iron
P-52	482	100.0	Cast iron
P-53	151	100.0	Cast iron
P-54	147	100.0	Cast iron
P-55	107	100.0	Cast iron
P-56	559	100.0	Cast iron
P-57	54	100.0	Cast iron
P-58	119	100.0	Cast iron

Table 4.5.2 Dayanand Vihar WDN Pipe Details

4.5.3 PUMPING FOR INTERMITTENT WATER SUPPLY

Delhi Jal Board is supplying water in Dayanand Vihar currently. The water is supplied for three times in a day for Morning 6 am to 9 am, evening 5pm to 7 pm and night 10:30 pm to 11:30 pm.

Figure 4.5.3 Water Demand Pattern of Dayanand Vihar

4.6 DESIGN OF NETWORK IN WaterGEMS

The simulation is performed for the current population of Dayanand Vihar 2370 people, who lives in 270 plots. There are 50 nodes in network, each node have different demand corresponding to available head. So we have to identify the critical point where required amount of water is not available.

The Network Provided Us by Delhi Jal Board was originally only layout of society so we draw a network in WaterGEMS. The layout of Daynand Vihar is shown. The nodes at junctions are identified and pipes layout is shown in Fig. (4.5.9)

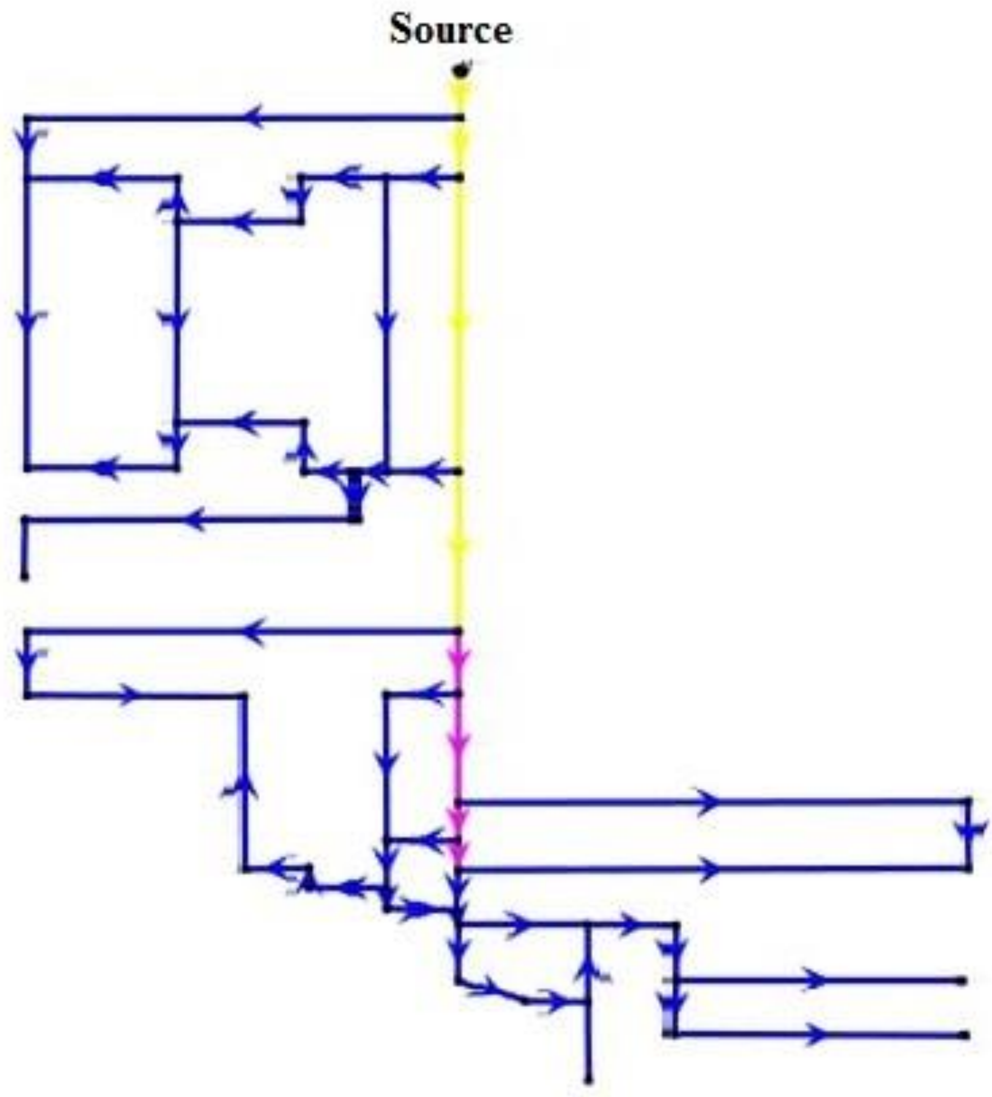

Figure 4.6.1 WaterGEMS Water Distribution Network of Dayanad Vihar

4.6.1 INTERMITTENT WATER SUPPLY FROM UGR

Currently only 1 pump is running and this is used for pumping water in the network. The calculations for water supply are shown below:-

Demands at each nodes are different as data given by Delhi Jal Board-

Demands at the node as per Delhi Jal Board ⟶ 0.26 L/S

Water delivered at the node in 1 hour ⟶ 0.26 X 3600 =936 L

Total amount for water at 50 nodes ⟶ 936 X 50 =46800 L

Total water in a day for 50 nodes ⟶ 46800 X 6=280800 L

Quantity of water per capita per day ⟶ 280800/2370=118.48 L

WaterGEMS simulation is done for 0.26 LPS demand at each nodal point as shown in figure 4.5.1.

Thus reliability calculation for 0.26 LPS demand-

- R_Q

  Total amount of water available for per person per day = 118.27 L

  Total required amount of water for per person per day = 175.00 L

$$R_Q = \frac{118.27}{175}$$

$$= 67.58\ \%$$

From the above calculation it is very clear that required demand of water in not satisfied by current pattern of water supply or we can say our network is not well designed to make the system reliability 100%.

If we assume that population is constant and water demand is increased, then we have to increase the quantity of water LPCD, we fed the increase demand in the WaterGEMS water distribution network. After increasing the demand at nodes we realise in simulation available head or water pressure at consumer end start to decreasing. Table 4.5.1.1 shows the water demand at each node and corresponding the water distribution network reliability.

Table 4.5.1.1 shows that initially 118.48 LPCD water is supplied to the residential area but when we increases the water supply at 132.15 there are many pipes which shows the water pressure below 7 m as standardised by CPHEEO. Hence reliability increases but not for whole water supply system. So we have to change the current scenario of water supply pattern.

Water per capita (l)	Total water for network (l)	Demand at node (lps)	R_H
118.48	280797.6	0.26	67.70
123.03	291597.5	0.27	70.30
127.59	302397.4	0.28	72.90
132.15	313197.3	0.29	75.51
136.70	323997.2	0.30	78.11
141.26	334797.1	0.31	80.72
145.82	345597.0	0.32	83.32
150.37	356396.9	0.33	85.92
154.93	367196.8	0.34	88.53
159.49	377996.7	0.35	91.13
164.04	388796.6	0.36	93.73
168.06	399596.5	0.37	96.03
173.16	410400.0	0.38	98.94

Table 4.6.1.1 Variation of Water Demand at Each Node

For various water demand in water distribution network nodes, WaterGEMS simulation is run for different value of demand flow such as 0.26LPS, 0.28LPS, 0.30LPS, 0.32LPS, 0.34LPS, 0.36 LPS, 0.38LPS etc. We observe that as water demand start increasing many pipes in water distribution network start facing negative pressure this is shown by black colour

WaterGEMS simulation is done and the obtained result is shown below

- **COLOUR CODING FOR WATER DISTRIBUTION NETWORK**

Discharge flow in pipes above 0.38 LPS (Q > 0.38)

Discharge flow in pipes below 0.38 LPS to 0 LPS (0< Q < 0.3)

Discharge flow in pipes below 0LPS (Q < 0 LPS)

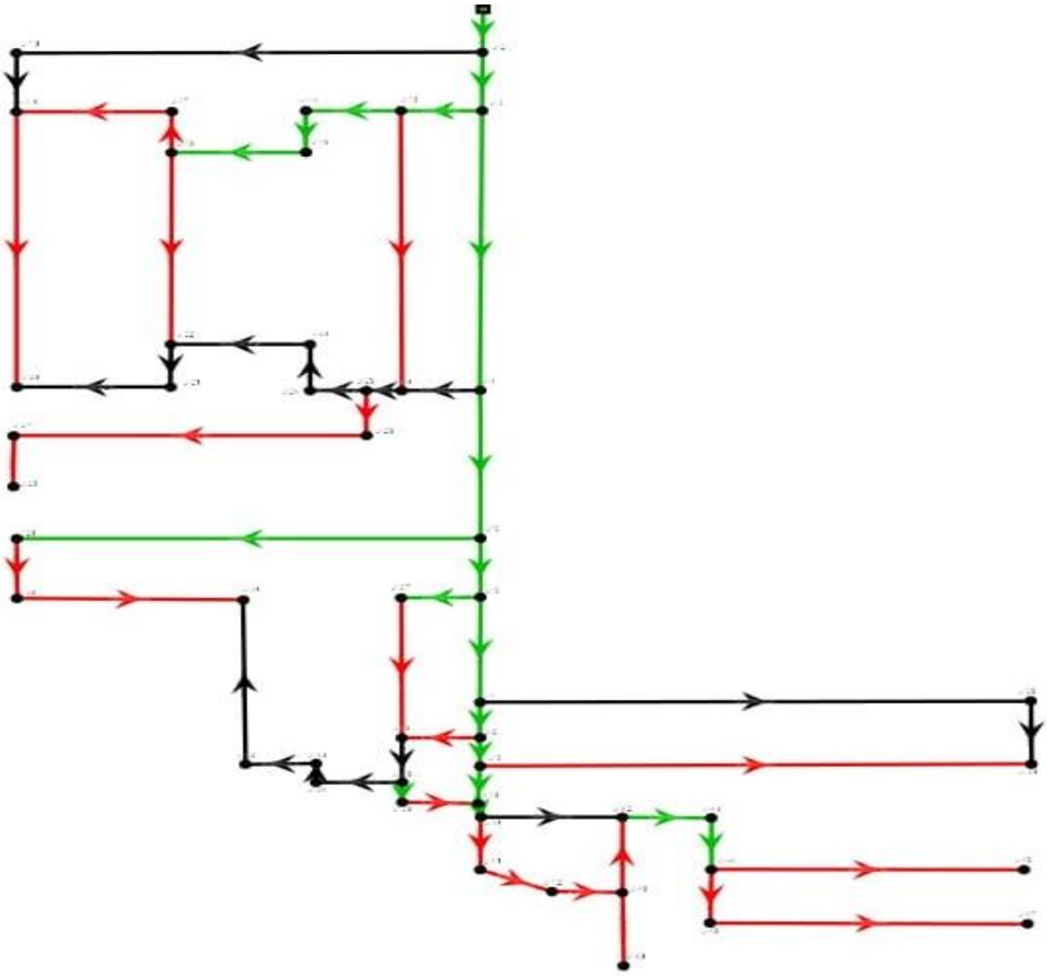

Figure 4.6.1.1 WDN Simulation Run at Water Demand 0.26 LPS

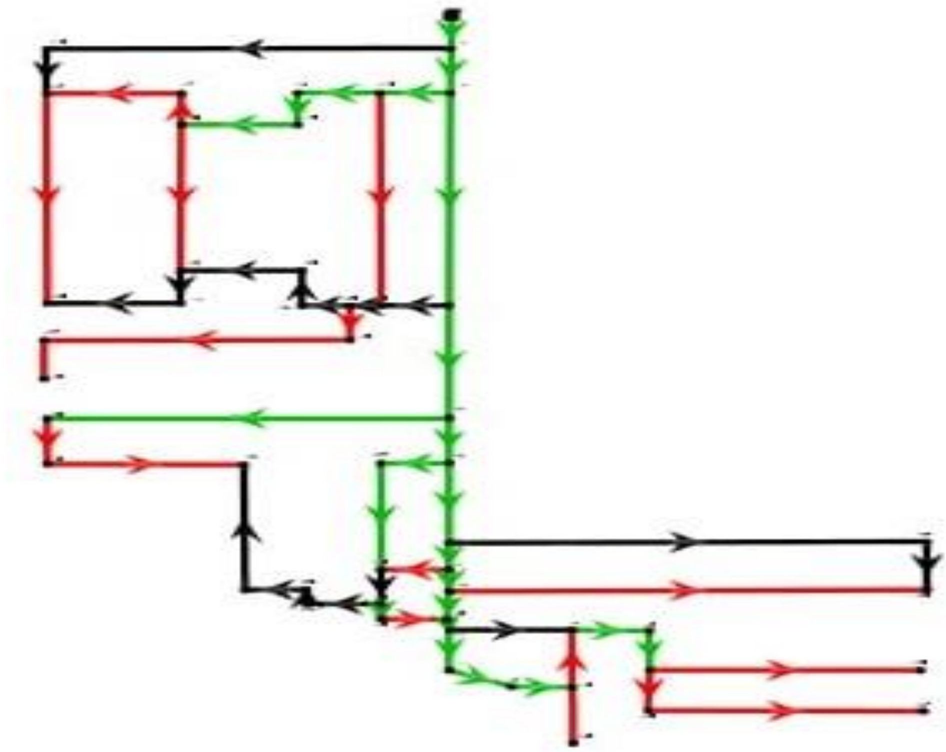

Figure 4.6.1.2 WDN Simulation Run at Water Demand 0.27 LPS

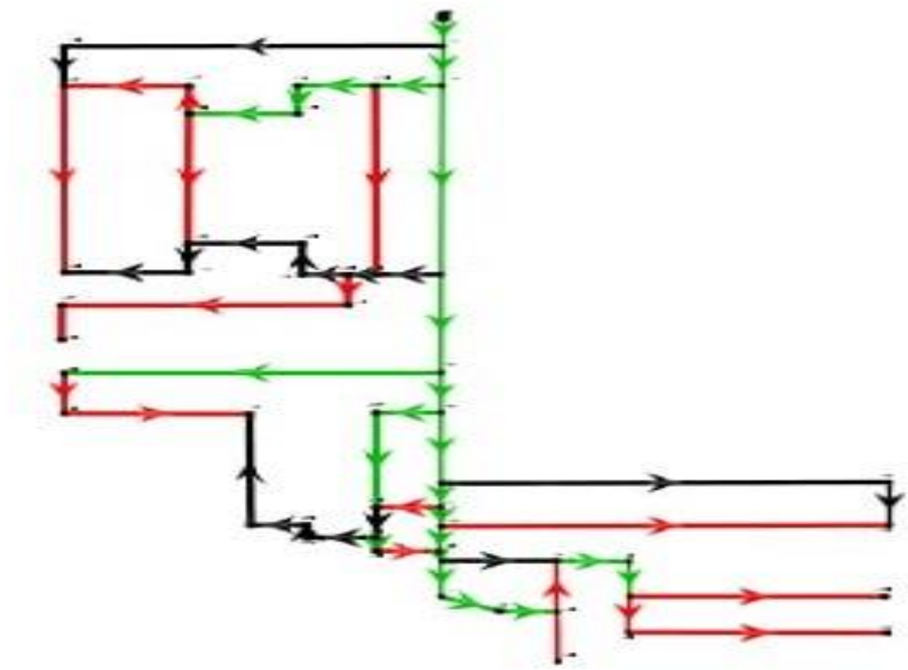

Figure 4.6.1.3 WDN simulation run at water demand 0.28 LPS

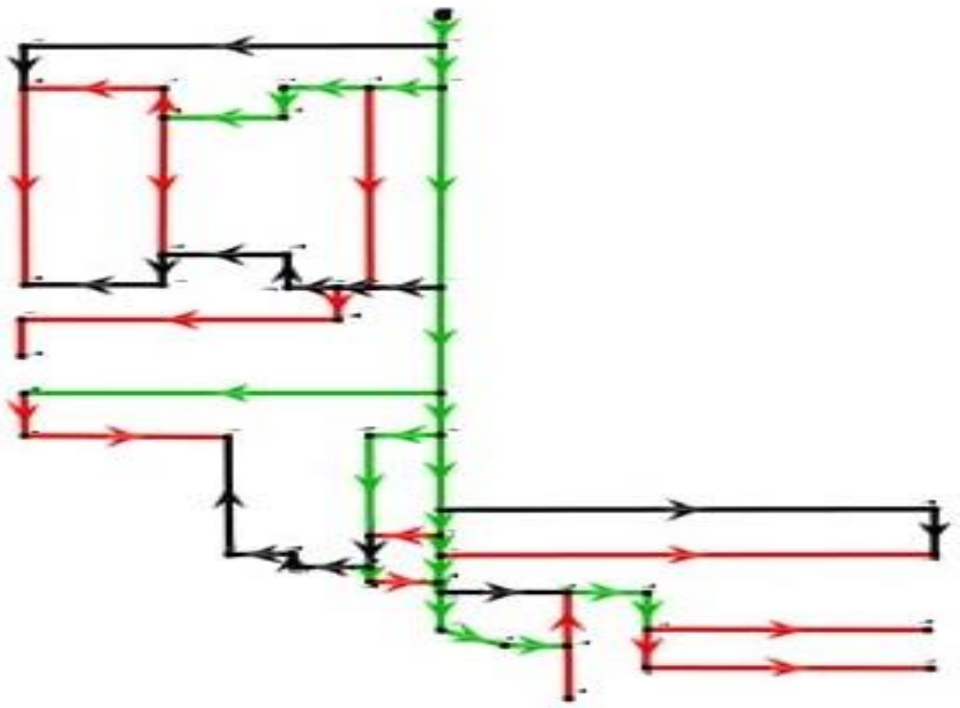

Figure 4.6.1.4 WDN Simulation Run at Water Demand 0.30 LPS

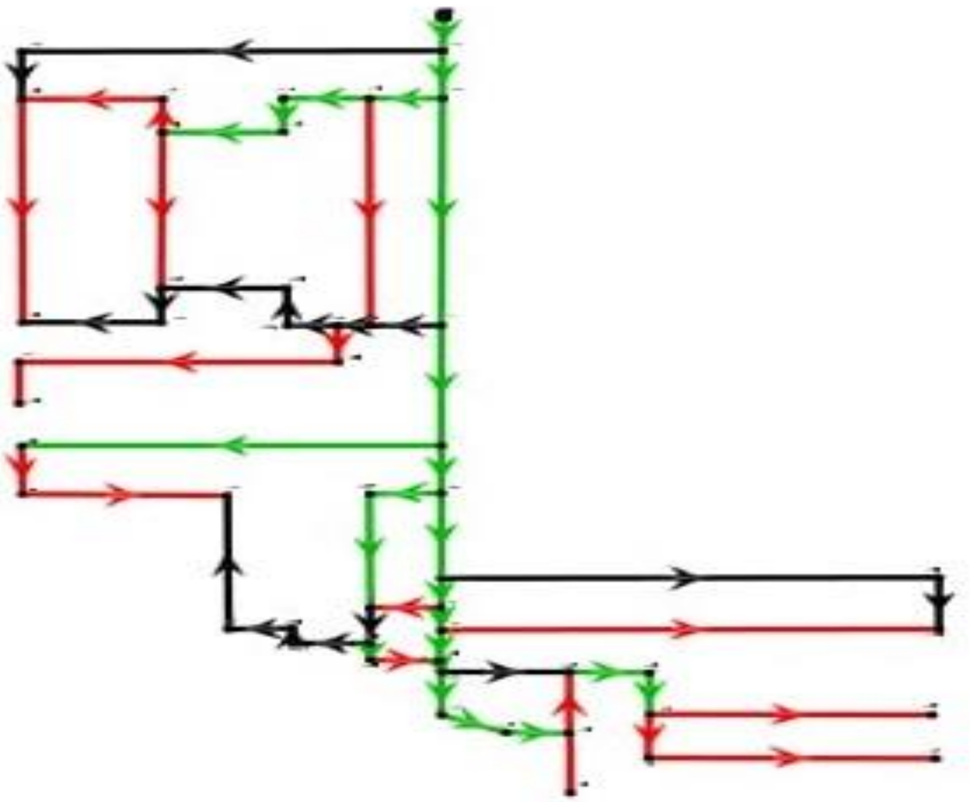

Figure 4.6.1.5 WDN Simulation Run at Water Demand 0.32 LPS

Now Figure 4.6.7 shows graph between realiabilty and incresing water demand is plotted which describes that as water demand at each node is satisfied realibility R_Q of water distribution network starts to increseing.

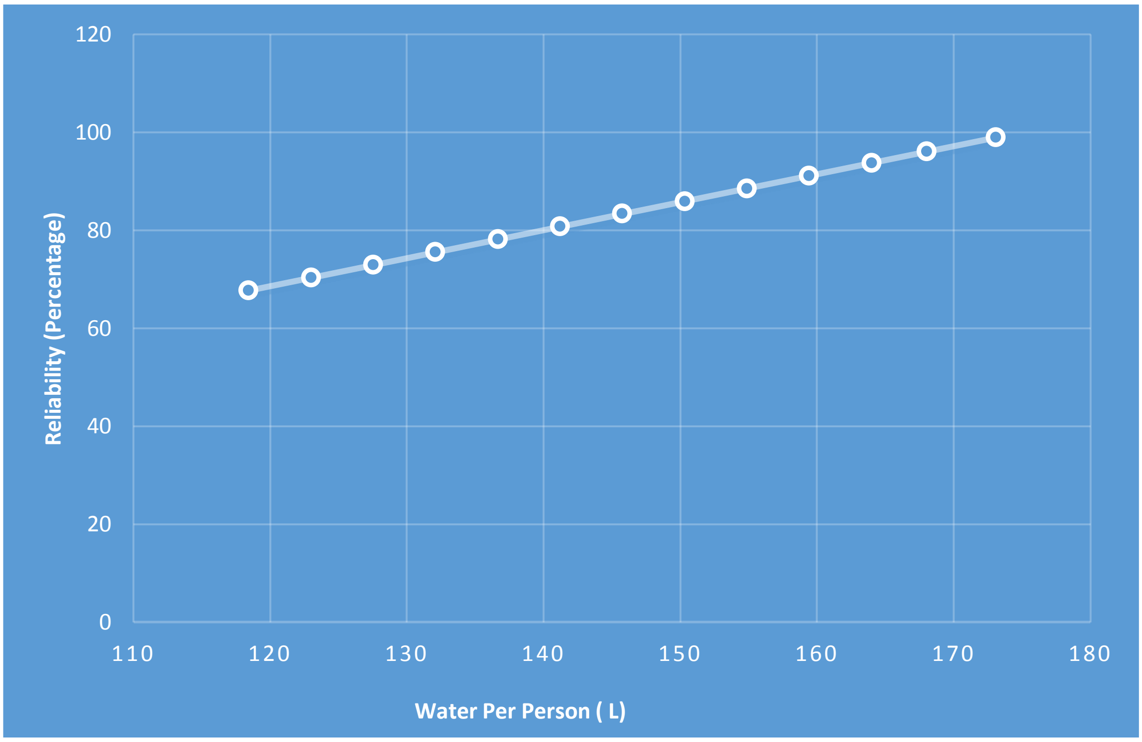

Figure 4.6.1.6 Variation of Realiablity With Increseing Water Demand

4.6.2 POPULATION INCREASE EFFECT ON DEMAND

In previous analysis water demand was assumed for constant population of the area .But now, the population of the area is increasing and water demand is also increasing. So population forecasting is done for next 40 years from current population of the residential area, and studied the water distribution network with help of WaterGEMS tool.

Referring from section 4.3 population increment is calculated. Table 4.3.3 indicate population growth for next 40 years.

Decade	New population	No. of Person per plot
1	2866	11
2	3381	12
3	3888	14
4	4354	16

Table 4.6.2.1 Population Forecasting

As the population increases, the water supply demand at node will be also increase. Number of people per plot is now increase from 8 people per plot to 11 people per plot. So corresponding to 11 people per plot will calculate the water demand.

Daily consumption of water → 180LPCD

Total quantity of water per day → 180 X 2866 = 425880 L per day

Water supplied at one node → 425880/50 = 8517.6 L per day

Water supplied for 1 hour supply → 8517.61/6 = 1419.60 L per hour

Water demand at each node → 1419.60/ (60X60) = 0.394 L/S

Table 4.6.2.2 further shows population increase over 4 decades

Decade	No. of Person per plot	Supply LPCD	Total Water per plot	Total water (L)	Nodal demand for 6 hr. supply
1	11	180	1980	534600	0.394
2	12	180	2160	583200	0.484
3	14	180	2520	680400	0.534
4	16	180	2880	777600	0.583

Table 4.6.2.2 Population Growth Effect on Nodal Demand

From table 4.6.2.2, it is very clear that nodal demand of first decade 0.394 LPS is not possible to running by 1pump so when 1 stand-by pump also have to be started for 6 hour per day water supply. Even if it is possible to satisfied the consumer water demand up to some extent.

For various water demand in water distribution network nodes, WaterGEMS simulation is run for different value of demand flow such as 0.394LPS, 0.484LPS, 0.534LPS, 0.583LPS, etc. We observe that as water demand start increasing many pipes in water distribution network start facing negative pressure this is shown by black colour.

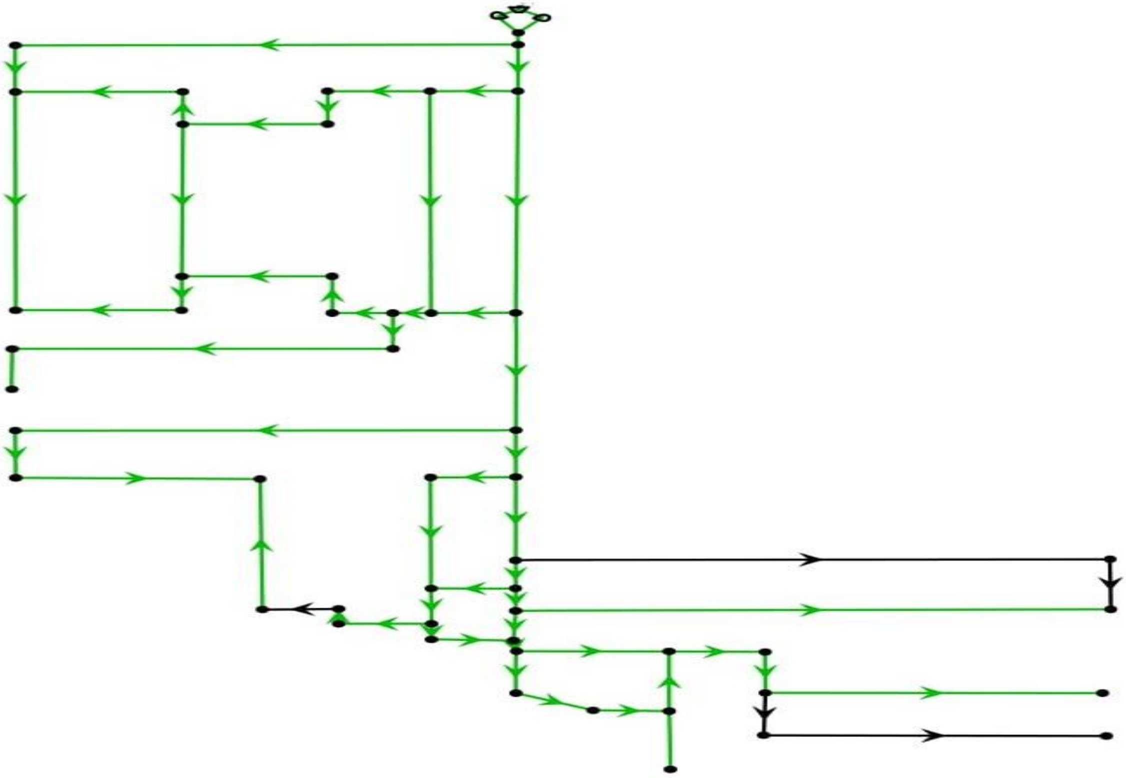

Figure 4.6.2.1 WDN Simulation Run at Water Demand 0.394 LPS

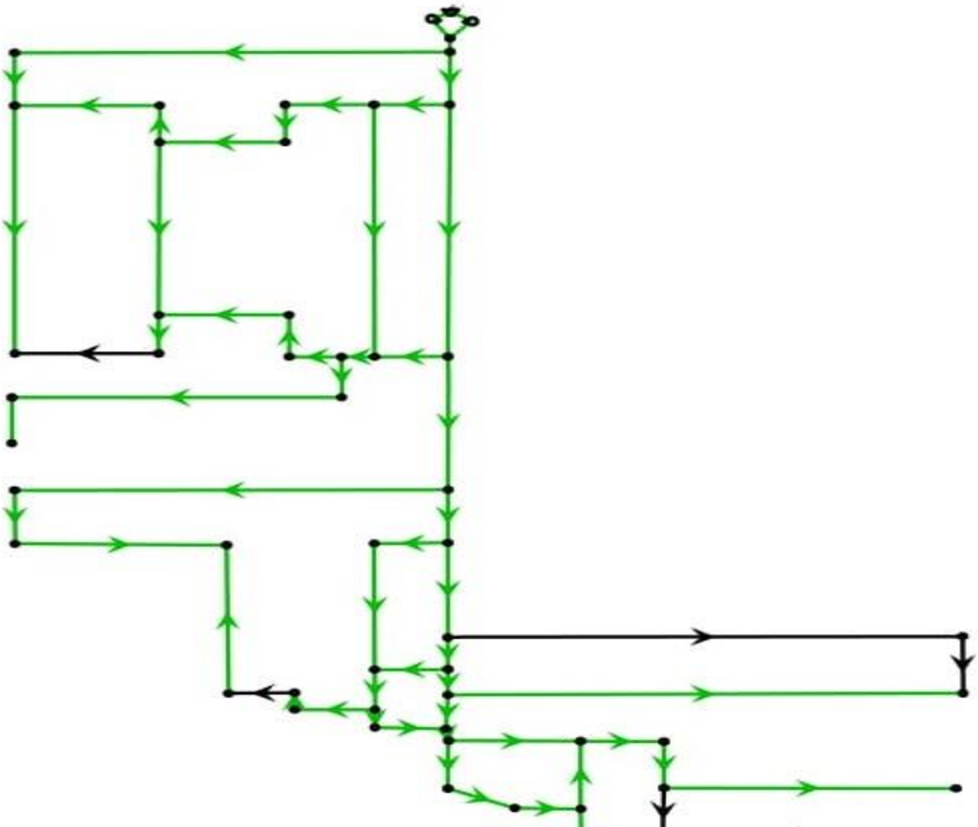

Figure 4.6.2.2 WDN Simulation Run at Water Demand 0.484 LPS

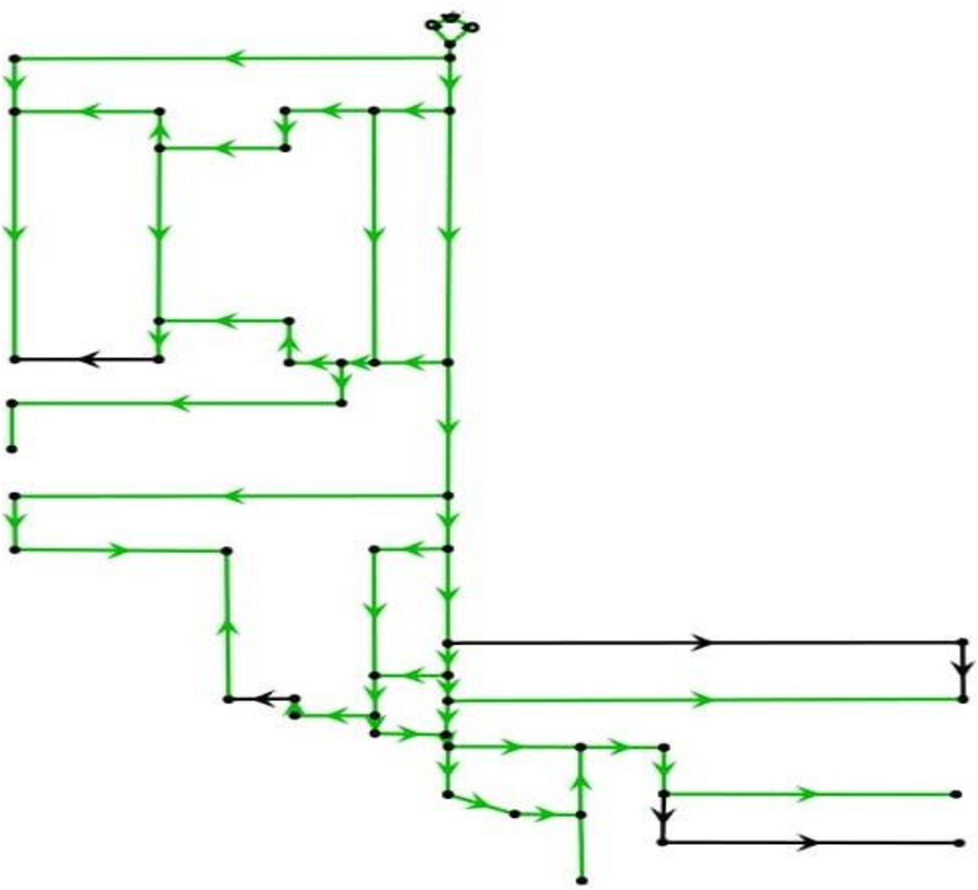

Figure 4.6.2.3 WDN Simulation Run at Water Demand 0.534 LPS

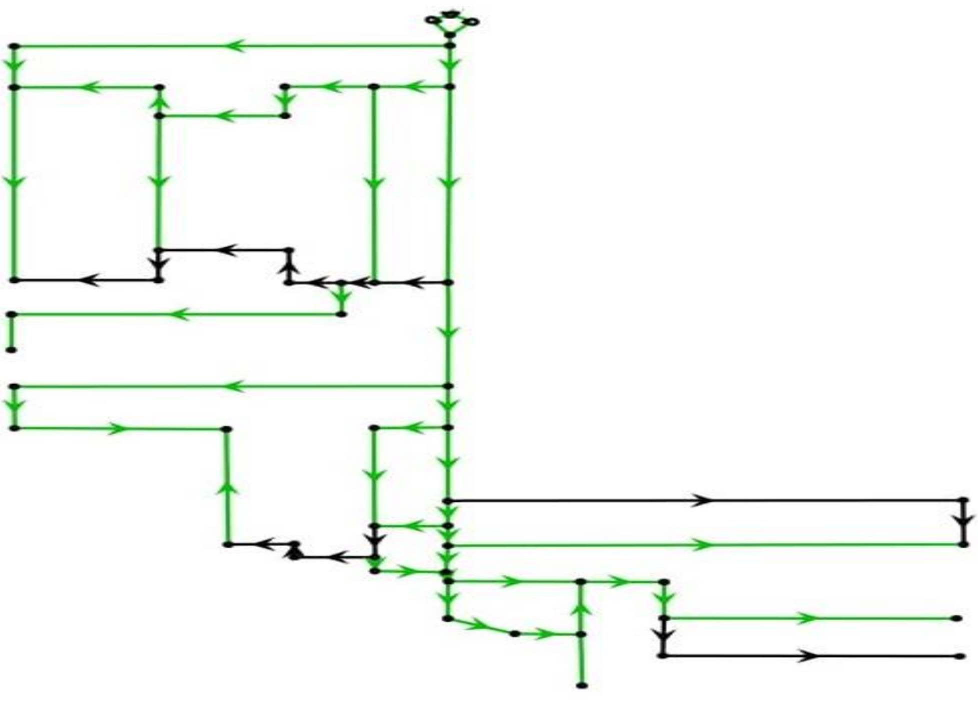

Figure 4.6.2.4 WDN Simulation Run at Water Demand 0.58 LPS

CHAPTER -5

IMPROVEMENT BASED ON ANALYSIS OF EXISTING SYSTEM

The designed water distribution network of residential area Dayanand Vihar has been analysed for 6 hour water supply for both one pump running and two pump are running. From the section 4.6.1 and 4.6.2, it is observed that consumer demands are not satisfying so it is necessary to modify the current water distribution network of Dayanand Vihar. So that existing network can fulfil consumer current demand with increased reliability of water distribution network and to satisfy future water demand on basis of growing population.

5.1 CONTINUOUS WDN IMPLEMENTAION

From Figure 5.1, it is observed how water demand changes if no. of water supply duration in hours are increased from 6 hour supply to 9 hour supply, 12 hour supply and 24 hour supply. As we increased supply duration our water demand start decreasing, so 6 hour supply for 180 LPCD water in a day cannot fulfil consumer demand and we increases supply duration.

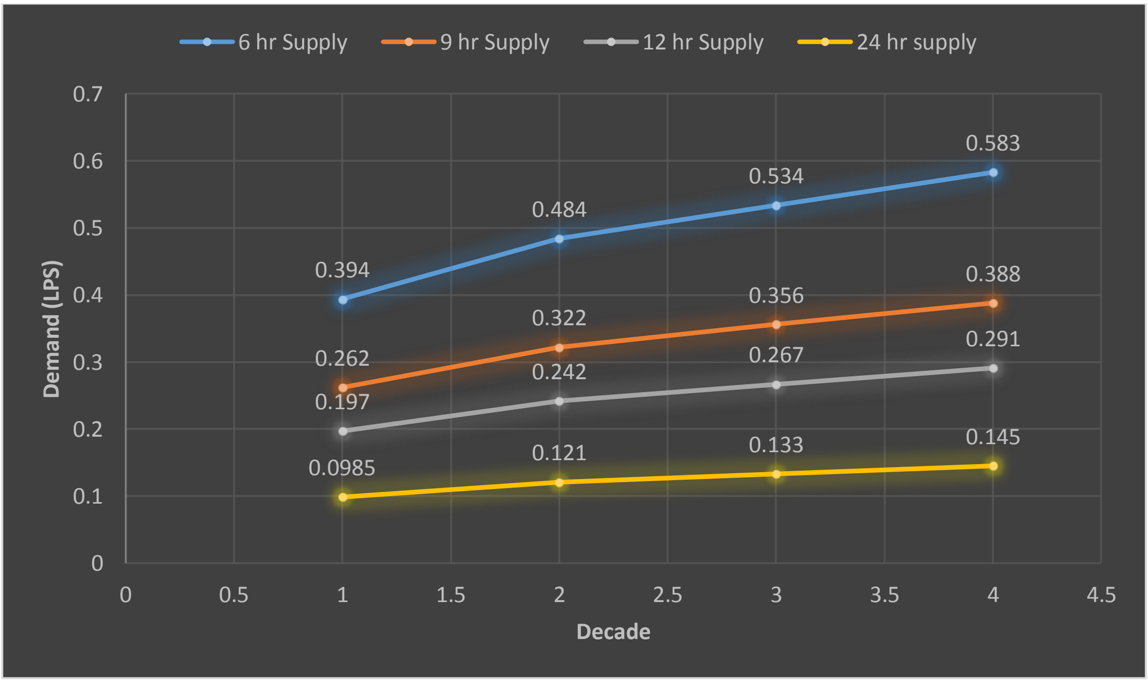

Figure 5.1 Water Demand on Basis of Supply Duration

Time	Population	Supply (LPCD)	Total Water Required	Demand at a node for24 hour supply (LPS)
Decade 1	2866	180	515880	0.098
Decade 2	3381	180	608580	0.121
Decade 3	3888	180	699840	0.133
Decade 4	4354	180	783720	0.145

Table5.1 Demand Variation for Continuous Water Supply System

5.2 MODIFIED GRID IRON TYPE WDN DAYANAND VIHAR

Colour coding for water distribution network

Existing Diameter = 200 mm

Existing Diameter = 150 mm

Existing Diameter = 100 mm

New Diameter = 100 mm

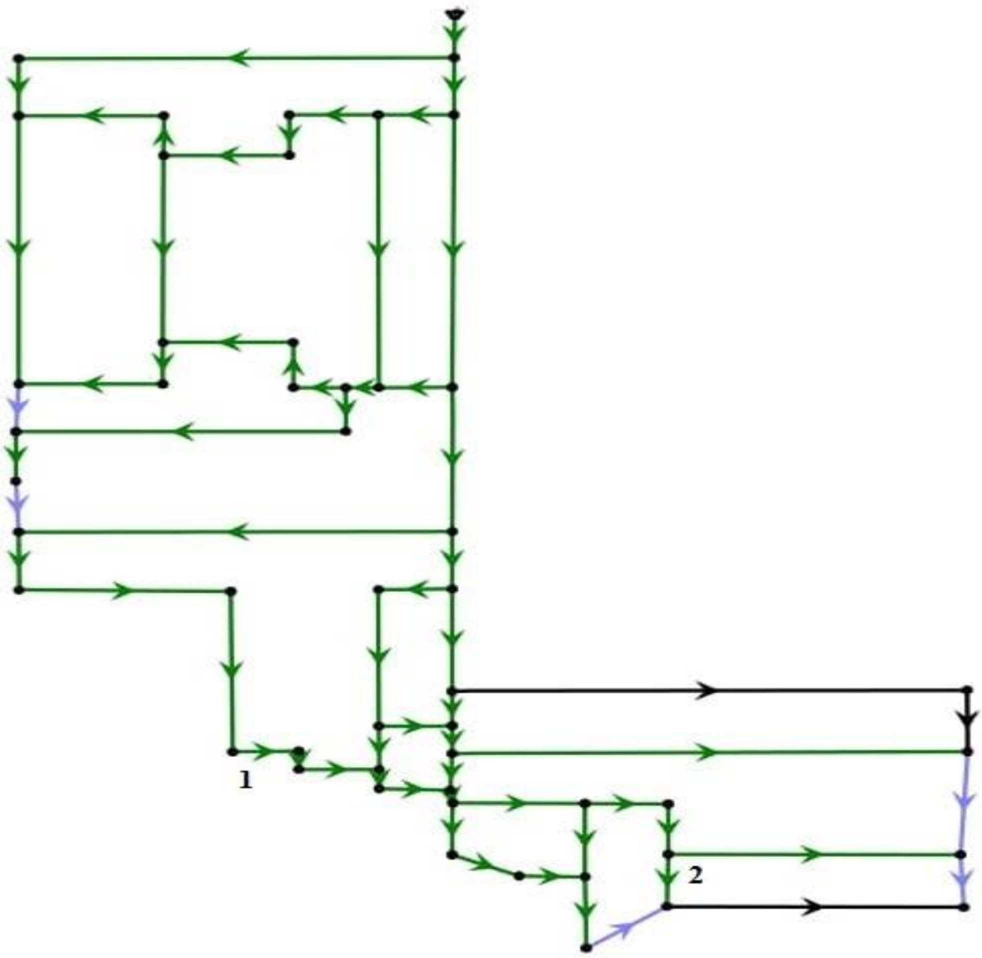

Figure - 5.2 Modified Grid Iron Type WDN of Dayanand Vihar

WaterGEMS simulation is run with demand value 0.098 LPS as per given in table 5.1 and water supply demand is fed in water distribution network but it is unable to satisfied all consumer so further we applied some modification so that our design parameter can be achieved. Then we make some layout modification in water network and make Dead end type water distribution network to Grid iron type water distribution network. Again simulation is done for 0.098 LPS 24 hour supply with modified Grid iron water distribution network, then we were able to achieve water demand criteria up to an extent as shown in Figure 5.2. In Figure 5.2, pipe 1 and pipe 2 are shown which are getting water demand due to modified layout. But there were also some area or nodes which are not be getting sufficient water, so this error cannot be solved by such modification. If such water distribution network is used then consumer should take care of water leakage and wastage to reduce water loss. Also water supply in society under study is metered so wastage will be less in 24 hour water supply. This will help in reducing peak demand and water to people should have access to get water from such as water tankers and bore well etc. which is mandatory.

CHAPTER – 6

CONCLUSION

Water distribution network of Dayanand Vihar has been analysed using WaterGEMS simulation software tool for the following:

1. Capacity of water distribution network to water supply, its capability to satisfy the purchaser demand for their present and future water needs till 4 decades.
2. Population growth effect as well as its responses for maintaining water distribution network reliability.

The literature review regarding this matter underscored that water distribution network in the urban areas have been considered extensively by the analysts amid the past 2 decades using the specialized simulation software and has helped in growing more dependable and effective water conveyance arrangement of present circumstances. Based. In view of the examination and discussion in this report, following in concluded:-

- Water supply demand at a node taken as 0.26 LPS by Delhi Jal Board come into sight i.e. Inadequate considering expected population increment as per town planning in Delhi.
- The present water distribution system is being utilised as intermittent water supply system so this system can be utilised as only till 150.37 LPCD demand.
- This water distribution network can satisfy 0.394 LPS water demand till one decade as intermittent water distribution system from present as per growth rate of population forecast.
- This existing water distribution network is recommended for continuous water supply system so as to fulfil current water demand 175LPCD and shall thus fulfil water demanded by consumer up to 3 decade.
- The reliability of the existing water distribution network when used as 24 hour continuous water supply will be above 90 % up to 3 decade and shall remain above 70 % in the fourth decade as per the water demands at nodes.
- In case this system is expanded it cannot be used as current water distribution network in spite of 24 hour continuous supply.
- As losses are increasing in consumer service pipe so 3/4 inch pipe should recommended because of 6 times less losses as compare with 1/2 inch pipe.

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