iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.52871

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Designing of Water Distribution System using EPANET Software

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I. INTRODUCTION

Next to air, the important requirement of human life to exist is water. It is available from various sources such as rivers, lakes, streams, etc. The importance of water in human life is so much that the development of many of the world's ancient cities has taken place near water sources.

The reliance on the monsoon for the supply of water is also significant. Every living thing requires water for its survival, health, and sanitation. Moreover, it is the main raw material for production and many other users outside the home and farm.

In addition to the direct consumption of water at homes and farms, there are many indirect ways water affects our daily lives. For example, water plays a vital role in manufacturing essential commodities, electric power generation, transportation, and recreational and industrial activities. Thus water can be considered as the most important raw material of civilization. The water demand is increasing day by day, and hence every country has to take preventive measures to avoid pollution of the available water resources.

According to the Indian Constitution, legislating regarding matters related to the provision of drinking water supply and sanitation is the responsibility of the State governments as it falls in the state list included in its seventh schedule. The 73rd and the 74th Amendment to the constitution required the state governments to devolve drinking water and sanitation services to the Panchayati Raj Institutions (PRI) in rural areas or municipalities in urban areas, called Urban Local Bodies (ULB).

Various ministries share the responsibility for water supply and sanitation at the central and state level. At the central level, three ministries have responsibilities in this sector. The Ministry of Drinking Water and Sanitation (until 2011, the Department of Drinking Water Supply in the Ministry of Rural Development) is responsible for rural water supply and sanitation. The Ministry of Housing and Urban Poverty Alleviation and the Ministry of Urban Development share the responsibility for urban water supply and sanitation. There are about 100,000 rural water supply schemes in India. At least in some states, responsibility for service provision is in the process of being partially transferred from State 2 Water Boards and district governments to Panchayati Raj Institutions (PRI) at the block or village level. Blocks are an intermediate level between districts and villages.

Water plays a vital role in the life of all living organism. Water used for domestic purposes as well as irrigation and industrial purposes. A water distribution network should be designed such a way that it meets the demand of increased population. An adequate water supply can give better living standards. The water quality should not get deteriorated in the distribution pipes. The deficiencies of water supply in urban regions are becoming a major challenge for authorities. Because most of the water supply scheme are intermittent system. When using an intermittent system the water is distributed to residents for few hours in a day, hence most of the times the pipe lines are empty or partially full. A good water distribution network is the one which provide sufficient pressure at each point of distribution with less loss. A good water distribution network satisfies the consumer demand at required time. The design and analysis of water distribution network is a complex process in metropolitan areas where there is large number of pipes. In general, the layout of a water distribution network can be classified as dead end system, ring system, grid system or radial system. A dead end system has water mains along the roads without a particular pattern for towns that do not have road network patterns. A radial system delivers water into multiple zones. At the center of each zone, the water is delivered radially toward the customers. A grid system follows the general layout of the grid road infrastructure with water mains and branches connected in rectangles. Drawbacks of this topology include difficulties of sizing the system. A ring system is a topology with each water main that go to each road, and there is a sub-main that is branched off the water main to provide a circulation of two directions. This system has many advantages over the grid system. The three methods of water distribution are gravitational system, pumping system and combined gravity and pumping system. In gravity system, the water from a high leveled source is distributed to the consumers at low levels by the mere action of gravity without pumping. This method is the most economical and reliable since no pumping involved. However this method needs lakes or reservoir as a source of supply. In the pumping system the treated water is directly pumped into the distribution mains without storing anywhere.

It is also known as pumping without storage system. In a combined gravity and pumping system, the treated water is pumped at a constant rate and stored into an elevated distribution reservoir. This system helps in operating the pumps at constant speed at their rated capacities, thus increasing their efficiency and reducing their wear and tear. This type of system is invariably and almost universally adopted.

A. EPANET

EPANET was developed by the water supply and water resources division (formally the drinking water research division) of the Environmental Protection Agency's National risk Management Research Laboratory.

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes, pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated. Typical uses for the EPANET model would include hydraulic calibration using chemical tracers (e.g., fluoride), design of sampling programs, evaluation of modified system operation (e.g., altered source utilization or tank operation), selection of satellite treatment locations, and use of targeted pipe clean- ing and replacement to enhance water quality.

EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

1) Places no limit on the size of the network that can be analysed.
2) Computes friction head loss using the Hazen-William, Darcy-Weisbach or ChezyManning formula.
3) Includes minor head losses for bends, fittings, etc.
4) Models constant or variable speed pumps.
5) Computes pumping energy and cost.
6) Models various types of valves including shutoff, check, pressure regulating, and flow control valves.
7) Allows storage tanks to have any shape (i.e., diameter can vary with height).
8) Considers multiple demand categories at nodes, each with its own pattern of time variation.
9) Models pressure-dependent flow issuing from emitters (sprinkler heads).
10) Can perform system operation on both simple tank level and timer controls and on complex rule-based controls.

It can be used for many different kinds of applications in distribution systems analysis. Sampling program design, hydraulic model calibration, chlorine residual analysis, and consumer exposure assessment are some examples. Running under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

B. Aim

To design a water distribution system and analyse it using water simulating software EPANET at Anakkara Grama panchayath.

C. Objectives

The main objective of this project is to plan and design a suitable water supply system for Anakkara panchayath. This includes,

1) Forecasting the population for the design period
2) Estimating the water demand
3) Designing the layout of distribution system
4) Analysis of distribution system using EPANET software.

D. Scope

The other manual methods used for the design of water distribution system consumes more time whereas the EPANET helps to save the time. This is freely downloadable and it does not have any charges. In future this software can make lot of innovations and can make the water distribution system more simplest and easier by installing EPANET in all water distribution network increases the accuracy. This software performs hydraulic and water quality analysis of water distribution network. Also determine the required amount of disinfectant to be used for disinfection of water. In this project, the amount of chlorine required for each node is calculated by using trial and error method.

II. LITERATURE REVIEW

Athulya.T, Anjali.K.Ullas (2020) studied that a water distribution network should be designed such a way that it meets the demand of increased population. An adequate water supply can give better living standard. The deficiencies of water supply in urban regions are becoming a major challenge for authorities. Because most of the water supply scheme are intermittent system. When using an intermittent system the water is distributed to residents for few hours in a day, hence most of the times the pipe lines are empty or partially full.

A good water distribution network is the one which provide sufficient pressure at each point of distribution with less loss. A good water distribution network satisfies the consumer demand at required time. The design and analysis of water distribution network is a complex process in metropolitan areas where there is large number of pipes. The major purpose of providing a good distribution network is to provide sufficient pressure at each point with less loss. A water distribution network consists of pipes, valves, tanks etc. EPANET is a computer programme that tracks the flow of water in each pipe, the pressure at each node and height of water in each tank. Hardy-Cross method is a manual method that makes corrections to initial assumed value by using equations. In this paper it was used to carry out the design and hydraulic analysis of water distribution network using EPANET software and Hardy-Cross method. The method of distribution used here is combined gravity and pumping system. The performance of system designed using EPANET was later compared with manual method. It was obtained that the pressure at all junctions and flow with their velocities at all pipes are feasible.

Harshan K G, Keerthana L Madhu & Anjali A (2018) compared Hardy Cross method with results from EPANET software. The distribution layout used here is loop system which is according to the layout of the area. The results were checked for accuracy using Hardy-Cross method for one loop. In manual calculation using Hardy-Cross method, for a single loop it took about forty iterations. It is time consuming and the chance of causing error is high. For a large area, it includes larger number of loops and hence the calculation and design part itself may take many years. The number of professionals needed for the completion of work will also be high.

Future studies are also recommended for more areas for validation of results. The EPANET software is a simple tool for the design of water distribution network. If proper water distribution networks are not laid, it will affect the water supply of the whole areas served by the system. To design a water distribution system a thorough study of the nearby available water resources, existing distribution network, water demand and required discharge etc are necessary. Since manual design becomes difficult, software assisted analysis are nowadays used.

Manoj Nallanathel , B. Ramesh , A P Santhosh(2018) analyzed the flow of water in water distribution network throughout the campus and checked whether there is any shortage of water at particular node. And also explains about the daily usage of water in the campus. From the obtained results, the pressure is quite enough to serve all buildings in campus i.e. the maximum pressure is 33.32 m and the flow is also quite reasonable for transporting the water to the consumers. The velocity will be always low, because of the gravity flow network.

At peak hours also the pressure at the junctions is quite enough to supply the water to the customers. Peak hour 4 am – 5 am, where the water is distributed from main tank to other individual tanks over the building. The water demand in the peak hour is 162.6 m3/h and during non peak hour is 33.6 m3/h. Excess water can be stored in sumps or underground tanks and later it can be used in peak hours. The overall supply of water is 1600 m3in one day but the required demand is around 1200 m3. By considering all the conditions and results obtained from the analysis concluded that there is no shortage of water while distributing the water.

R. K. Rai, and P. S. Lingayat ,(2019)studied that EPANET software is time saving and has no limitation for number of nodes, number of pipes or pumps to be modelled and analysed in it so complex networks can be easily solved. As the number of iterations increase, the value of head loss becomes closer to zero and to verify the obtained answers, balancing of flows at each point is done. The results obtained using Hardy Cross method and EPANET software are nearly equal. Newton-Raphson method is quite difficult to for the analysis of large network, but it gives acceptable result in less number of iteration. This paper aims to develop a simple procedure for analysis of water distribution network using hardy cross method with the help of electronic spreadsheets and EPANET. Engineers may not have enough time to monitor all the hydraulic parameters under different operating conditions. Hence a number of modification attempts to the standard solution methods for the development of a powerful algorithm may help to assess both steady- state solution and particularly time dependent simulations of water distribution systems when the nodal demands change on a daily basis. This paper highlights the effective analysis and distribution of network of pipes using EPANET tool as well as Hardy Cross method and Newton-Raphson method. The findings may help to understand the pipelines system of the study area in a better way. This work deals with the analysis of urban water distribution network in developing countries.

Venkata Ramanaa, Ch. V. S. S. Sudheerb B.Rajasekharc (2017) studied that a numerical model of a water distribution network designed for a town with 50,000 inhabitants was implemented in EPANET. Demonstrated that an efficient method for analysing pipe networks consists in solving the generalized loop equations by means of the Newton-Raphson method combined with the linear theory method as a simple and robust starting procedure. The paper also presents a methodology for computing the chlorine residual concentration in the urban area for 3 days of simulation period. Chlorine concentration of 0.45 mg/l was injected at the source tank. Final data are reported for the third day of the simulation, at three representative time moments, namely: the average daily consumption moment, an off-peak hour and a peak consumption hour.

III. METHODOLOGY

Initially the map of study area was extracted by using Google Earth software. The obtained map was then converted into EPANET file. Elevation, pipe diameter and length had given to each node and pipe for hydraulic analysis by using scale tool from Google earth software. Total area was divided into two grids and demand path is estimated by depending on the number of houses living in the area taken in grid.

A. *Design Considerations*

The layout of the distribution network is drawn based on the existing road pattern. Length of the pipe is taken as the road length. The diameter of the pipe is considered based on the purpose served by the pipe, such as main, sub main, branch pipes. Pipe roughness coefficient is taken 120, since Galvanized Iron pipes are used. The simulation period was set for 24 hours.

B. *Estimating population*

The knowledge of population is essential for designing any water supply scheme, as the supply should be sufficient to satisfy the people's demand during the entire design period. The populations are increased by births, decreased by deaths, increased/decreased by migration, and increased by annexation. These all four factors affect the change in population. The present population may be obtained from the census record. The forecast is done by an appropriate method depending on the nature of the city, its environment, possible development of trade and industries, etc.

C. *Demand Calculation*

Geometrical Increase Method is used for population forecasting. In this method the percentage increase in population from decade to decade is assumed to remain constant. Geometric mean increase is used to find out the future increment in population. Since this method gives higher values and hence should be applied for a new industrial town at the beginning of development for only few decades.

The population at the end of nth decade 'Pn' can be estimated as:

$Pn = P (1+ IG/100)n$

Where, IG = geometric mean (%)

P = Present population

N = no. of decades

The design period for the system is taken as thirty years. After the population forecast the maximum daily demand was calculated using the general equations. Also the minimum required diameter is calculated.

D. *Steps in Using EPANET*

The layout of the distribution network is drawn based on the existing road pattern in an AUTOCAD file. This network is now converted into an EPANET file by using various software such as "EPACAD". EPACAD converts the AUTOCAD file to EPANET file by considering intersections of the lines as nodes and lines as links. Then edit the properties of the objects that make up the system. The input parameters for each nodes and pipes are to be properly assigned. Describe how the system is operated. Then select a set of analysis options. Finally run a hydraulic/water quality analysis. The last step is to view the results of the analysis.

E. *Model Input Parameters*

In order to analyze the water distribution network using EPANET following input data files are needed:

1) *Junction Report:* Junctions are points in the network where links join together and where water enters or leaves the network. The basic input data required for junctions are:

- Elevation above some reference (usually mean sea level)
- Water demand (rate of withdrawal from the network)
- Initial water quality

The output results computed for junctions at all time periods of a simulation are:

- Hydraulic head (internal energy per unit weight of fluid)
- Pressure
- Water quality

2) *Pipe Report:* Pipes are links that convey water from one point in the network to another. EPANET assumes that all pipes are full at all times. Flow direction is from the end at higher hydraulic head (internal energy per weight of water) to that at lower head.

The principal hydraulic input parameters for pipes are:

- Start and end nodes
- Diameter
- Length
- Roughness coefficient (for determining Head-loss)
- Status (open, closed, or contains a check valve)

The output results for pipes include:

- Flow rate
- Velocity
- Head-loss
- Darcy-Weisbach friction factor
- Average reaction rate (over the pipe length)
- Average water quality

The hydraulic head lost by water flowing in a pipe due to friction with the pipe walls can be computed using one of three different formulas:

- Hazen-Williams formula
- Darcy-Weisbach formula
- Chezy-Manning formula

The Hazen-Williams formula is the most commonly used head loss formula in Kerala by Kerala Water Authority.

IV. PRELIMINARY DATA COLLECTION

A. *Study Area*

Anakkara Grama panchayath is the oldest habitations in Palakkad district. Bhararthapuzha is skirting along the boundary of this project. The other local water sources are ponds, open wells and bore wells. Majority of the open wells and ponds go dry during summer season. These are extensively used for irrigation and drinking purposes.

Fig.1 Map of Anakkara Panchayath

Majority of the families are depending on the open wells and bore wells for their drinking water needs. Majority of the open wells dry up during summer. Due to the high density of bore wells and excessive pumping for irrigation/ drinking purpose have resulted in sharp decline of the ground water table, which in turn affected the open wells as well as bore well in the vicinity. At present, no water supply scheme is in use in the selected area. Hence a comprehensive scheme is to be designed. Efficient scheme components and lines are an absolute necessity to satisfy the drinking water needs of these portions .The terrain of the project area is more or less undulating with hard soil.

1) Open Wells

The Grama panchayath have a large number of open wells, most of them with the private owners. Majority of population depend on these open wells for their drinking and other domestic needs. Majority of these wells are non- perennial and dry up during summer months of March to May.

2) Bore Wells

There are few bore wells in the Anakkara Grama panchayath cater a substantial number of households for their domestic and agricultural needs. Indiscriminate and uncontrolled drilling of bore wells and excessive pumping from these wells have resulted in fast depletion of ground water resources and lowering of ground water table.

3) Socio Economic Status

The main occupation of the people in the Scheme area is Agriculture. The main agriculture products are paddy, coconut, Areca nut, rubber, pepper plantation etc. Manufacturing of umbrellas, ceramic wares, garments, surgical materials, bricks, food products such as pappad, tailoring, wood industries etc are the major small scale industries in these panchayath. According to the details collected from the concerned offices, 90 % (average figure) of the total number of houses have sanitary latrines. Hence the sanitary status is satisfactory. The average literacy percentage is about 90 %. There are many LP schools, UP schools and higher secondary schools catering to the basic education needs of the people in the project area and nearby areas. There are many clinics and health centers in this area.

4) Source

To make the scheme successful, it is also necessary to have an adequate source of water supply the aspects of the scheme, namely demand of water, and available quantity of water, should balance each other. The source of the scheme is River Bhrathappuzha (Intake Well cum pump house on the bank of Bhrathappuzha). As per the details received from Water Resource Department (WRD), the source is capable of meeting water requirement of the system for the design period.

B. Forecasting Population

Design of water supply and sanitation scheme is based on the projected population of a particular city or town, estimated for the design period. Any underestimated value will make system inadequate for the purpose intended; similarly overestimated value will make it costly. Change in the population of the city over the years occurs, and the system should be designed taking into account of the population at the end of the design period.

Factors affecting changes in population are:

1) Increase due to births
2) Decrease due to deaths
3) Increase/ decrease due to migration
4) Increase due to annexation.

The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city.

Geometric increase method is used for population forecasting. In this method, percentage increase is assumed to be the rate of growth and the average of the percentage increases is used to find out future increments in population. This method gives higher value and mostly applicable for growing towns and cities having vast scope for expansion.

Water Supply projects are usually designed to meet the requirements over thirty years after their completion.

The time lag between design and completion of the project should also be taken into account, which should not exceed two years to five years, depending on the size of the project. The thirty-year period may, however, be modified regarding certain components of the project depending on their useful life or the facility for earning out extensions when required and the rate of interest so that expenditure far ahead of utility is avoided.

Table shows the ward wise population in 2011 as per census records and expected population of the area at in 2051 and no. of households.

Table 1: Population Forecasting

WARD NO.	POPULATION IN 2011	EXPECTED POPULATION IN 2053	NO.OF HOUSEHOLDS
1	1811	2714	369
2	1531	2295	324
3	1492	2236	313
4	2171	3254	413
5	1650	2473	348
6	1904	2854	433
7	2013	3017	444
8	1526	2287	324
9	1160	1739	261
10	1073	1608	214
11	1612	2416	352
12	1633	2447	358
13	1795	2690	361
14	1858	2784	364
15	1470	2651	336

Average increase in population = 10.64%
Design period taken = 30 years
We are designing the project to satisfy the needs of people for next 30 years, i.e. upto 2053.

Expected population of 2051 $= P\left(1+\frac{r}{100}\right)^n$

Taking 2023 as base year, P = 27663 people
No. of decades, n= 3.2
Expected population of 2051 = 37465 people
The population to be served at the end of the design period is 37465 people.
The distribution network is designed for a population of 37465.

C. Estimation of water demands

After forecasting the population, the quantity of water to be treated and supplied should be calculated, for this we have adopted the standards specified by IS 1172-1971 and from the manual on water supply and treatment prepared by the Central Public Health and Environmental Engineering Organization. In the Code of Basic Requirements of Water Supply, Drainage and Sanitation (IS. 1172 1983) and the National Budding Code, a minimum of 135 lpcd has been recommended for all residences provided with a full flushing system for excreta disposal.

The population at the end of the design period = 37465 people

Recommended per capita water supply levels = 135 lpcd

Quantity of water added for civic and public uses is 5 % of maximum demand of water

Quantity of water added for civic and public uses = $\frac{5}{100} \times 135$

= 6.75 lpcd

Quantity of water required = 37465×(135+6.75) =5310663.75 l/day

Average daily demand = 5310663.75 l/d

Maximum daily demand = 5310663.75 ×1.8 = 9559194 l/day

= 9.56 Mld

Maximum daily demand can be taken as 10 Mld.

Table 2: Maximum expected daily demand of water

WARD NO.	EXPECTED MAX.DAILY DEMAND(Mld)
1	0.69
2	0.58
3	0.57
4	0.83
5	0.63
6	0.73
7	0.77
8	0.58
9	0.44
10	0.41
11	0.62
12	0.62
13	0.68
14	0.71
15	0.70

D. Layout of Distribution System

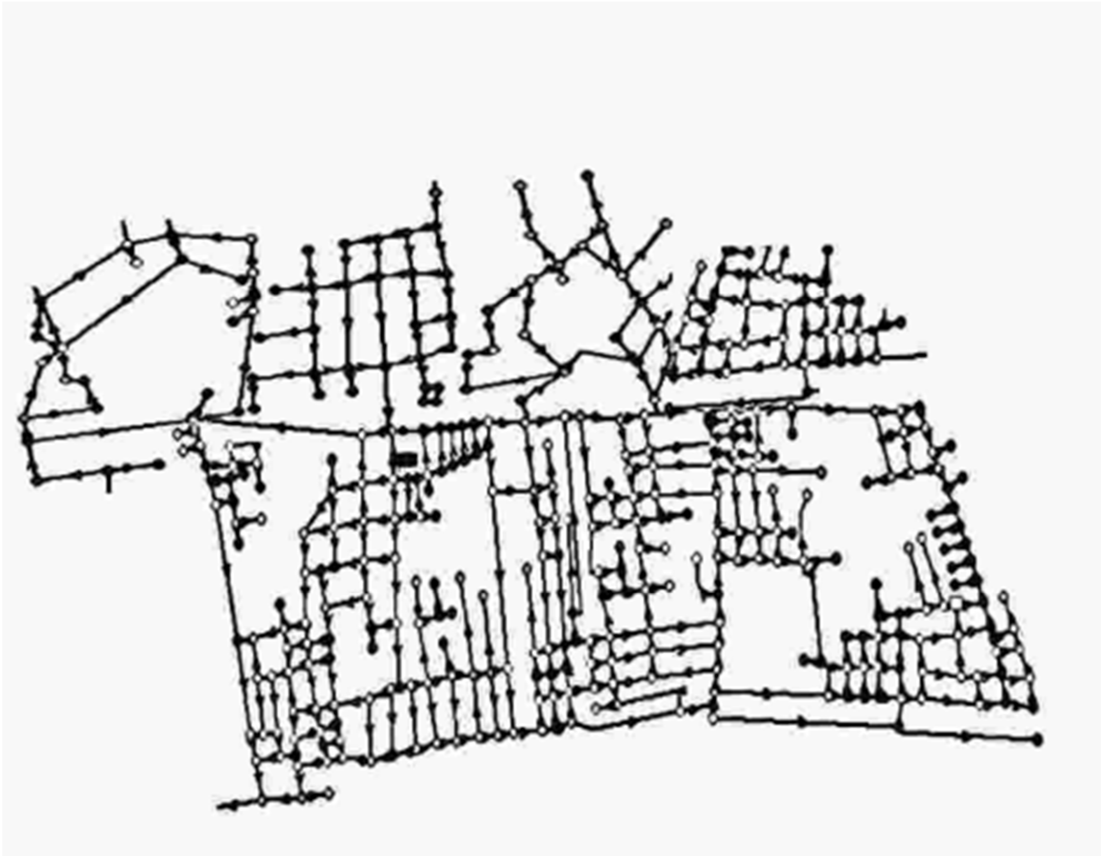

Fig. 2: General layout of proposed water distribution network

E. Analysis of water distribution system in EPANET

1) Result of Nodes

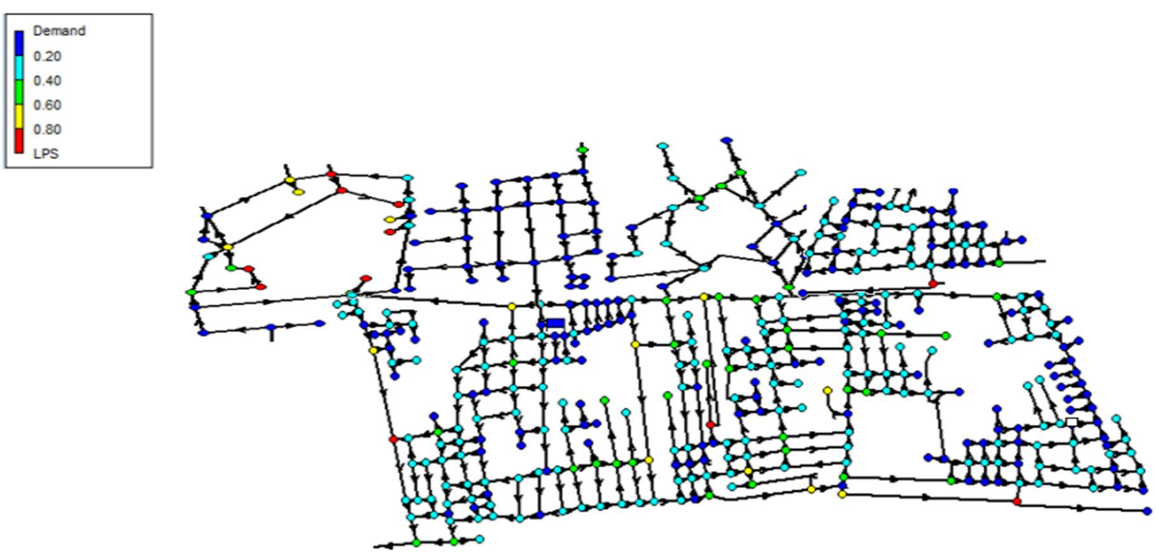

Fig 3: Demand Distribution Network Diagram

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Table 3: Result of nodes

	Elevation	Head	Pressure
Node ID	m	m	m
n1	20.33	29.46	9.13
n2	16.26	29.46	13.2
n4	15.78	29.46	13.68
n5	19.46	29.46	10
n6	21.34	29.49	8.15
n7	19.13	29.44	10.31
n8	15.78	29.46	13.68
n9	20.99	29.66	8.67
n10	22.5	29.69	7.19
n11	23.48	29.7	6.22
n12	22.29	30.1	7.81
n13	21.93	29.71	7.78
n15	21.34	29.77	8.43
n16	26.84	29.65	2.81
n17	17.28	29.2	11.92
n18	16.88	29.19	12.31
n20	5.81	29.2	23.39
n21	15.1	29.19	14.09
n22	15.07	29.19	14.12
n23	16.26	29.18	12.92
n24	16.05	29.18	13.13
n26	16.29	29.18	12.89
n27	15.33	29.17	13.84
n29	15.93	29.19	13.26
n30	20.28	29.43	9.15
n31	16.62	29.43	12.81
n32	22.89	29.55	6.66
n33	20.52	29.78	9.26
n35	20.93	29.55	8.62
n36	20.8	29.82	9.02
n37	17.69	29.8	12.11
n38	17.66	29.79	12.13
n39	18.55	29.79	11.24
n40	12.14	29.8	17.66
n41	11.68	30.21	18.53
n42	17.23	30.4	13.17
n43	16.98	30.63	13.65
n44	15.04	30.62	15.58

n45	17.94	29.44	11.5
n46	16.75	29.4	12.65
n48	14.74	29.43	14.69
n49	13.31	29.26	15.95
n50	12.05	29.19	17.14
n51	15.41	29.32	13.91
n52	11.27	29.21	17.94
n53	13.29	29.15	15.86
n54	15.12	29.15	14.03
n55	16.97	29.04	12.07
n56	13.25	29.04	15.79
n57	16.94	29.1	12.16
n58	16.96	29.15	12.19
n59	16.03	29.15	13.12
n60	16.5	29.2	12.7
n62	14.34	29.2	14.86
n63	15.95	29.3	13.35
n64	15	29.5	14.5
n66	16.77	29.17	12.4
n67	18.22	29.17	10.95
n68	17.04	29.07	12.03
n69	21.75	29.04	7.29
n70	12.68	29.04	16.36
n71	17.39	29.01	11.62
n72	15.56	29.43	13.87
n73	17.68	29.32	11.64
n74	15.53	29.01	13.48
n75	13.96	29.03	15.07
n76	15.32	29.05	13.73
n77	20.67	28.99	8.32
n79	22.46	28.99	6.53
n80	21.71	28.99	7.28
n81	21.71	29	7.29
n82	22.4	29	6.6
n84	23.08	28.99	5.91
n85	22.39	29	6.61
n86	21.81	29	7.19
n87	20.57	29.01	8.44
n89	13.51	29.17	15.66
n90	22.31	29.02	6.71
n91	21.85	29	7.15

n92	14.08	28.98	14.9
n94	12.46	28.98	16.52
n95	18.43	28.99	10.56
n96	12.29	28.98	16.69
n97	18.74	28.99	10.25
n98	19.82	28.99	9.17
n99	19.5	28.99	9.49
n101	20.4	29.07	8.67
n102	17.04	29.06	12.02
n103	17.78	28.99	11.21
n104	18.51	28.99	10.48
n105	20.32	28.99	8.67
n106	22.79	28.99	6.2
n107	18.51	28.98	10.47
n108	17.03	30.91	13.88
n110	16.7	32.85	16.15
n111	19.24	33.16	13.92
n114	18.01	33.41	15.4
n115	17.28	32.88	15.6
n116	16.93	30.69	13.76
n118	21.11	29.73	8.62
n119	20.03	29.74	9.71
n120	21.27	29.76	8.49
n122	15.73	30	14.27
n123	17.69	30.03	12.34
n124	16.98	30.07	13.09
n125	18.2	29.99	11.79
n127	15.44	30.01	14.57
n128	16.05	30.01	13.96
n129	14.31	30.01	15.7
n130	16.01	30.02	14.01
n131	15.55	30.45	14.9
n133	16.93	30.55	13.62
n134	16.91	30.51	13.6
n135	16.19	30.49	14.3
n136	15.9	30.45	14.55
n137	17.81	30.47	12.66
n138	25	30.44	5.44
n139	17.7	32.4	14.7
n140	17.96	32.83	14.87
n141	19.72	33.55	13.83

n142	17.29	33.42	16.13
n143	20.32	34.36	14.04
n144	28	36.45	8.45
n145	18.21	33.56	15.35
n150	15.94	30.61	14.67
n152	12.79	29.92	17.13
n153	17.96	32.48	14.52
n154	18.1	32.76	14.66
n156	21.18	33.6	12.42
n157	21.11	33.6	12.49
n161	22.76	29	6.24
n162	14.76	28.99	14.23
n163	19.32	30.43	11.11
n164	30	30.42	0.42
n165	17.72	30.42	12.7
n167	17.38	30.43	13.05
n168	14.84	30.44	15.6
n169	30	30.44	0.44
n171	33.78	41.54	7.76
n173	40	45.03	5.03
n176	14.48	30.03	15.55
n177	13.75	30.03	16.28
n178	10.53	30.03	19.5
n179	12.7	30.01	17.31
n180	14.06	30.02	15.96
n181	30	41.65	11.65
n183	30.34	41.83	11.49
n184	32.69	41.37	8.68
n185	26.6	35.52	8.92
n188	23.35	34.57	11.22
n189	26.75	35.11	8.36
n190	26.73	34.98	8.25
n191	17.82	34.94	17.12
n192	22.69	34.95	12.26
n193	15.45	34.95	19.5
n194	33	44.09	11.09
n196	16.34	30.06	13.72
n199	16	30.06	14.06
n201	16.34	30.11	13.77
n202	50	65.4	15.4
n204	17.93	34.91	16.98

n205	15.71	34.88	19.17
n206	17.18	34.86	17.68
n207	17.9	34.86	16.96
n208	17.85	34.86	17.01
n209	16.52	34.86	18.34
n210	18.82	34.87	16.05
n211	19.29	34.87	15.58
n214	21.59	34.87	13.28
n215	22.28	34.9	12.62
n216	19.97	34.89	14.92
n219	22.12	34.89	12.77
n220	15.94	34.89	18.95
n221	16.72	34.89	18.17
n222	21.6	34.89	13.29
n223	16.07	34.89	18.82
n224	30.42	43.11	12.69
n225	36	44.37	8.37
n226	16.66	29.46	12.8
n227	15.4	30.45	15.05
n229	21.87	30.23	8.36
n230	31.56	42.88	11.32
n231	28.27	36.51	8.24
n232	19.56	29.79	10.23
n233	22.76	29.79	7.03
n234	21.73	29.76	8.03
n235	16.8	29.11	12.31
n236	21.28	28.99	7.71
n237	17.62	28.99	11.37
n238	16.84	28.99	12.15
n239	17.39	29.24	11.85
n241	23	30.1	7.1
n242	24.55	34.46	9.91
n244	15.22	34.89	19.67
n246	15.73	29.19	13.46
n247	16.81	29.2	12.39
n249	10.32	29.17	18.85
n250	10	29.16	19.16
n252	15.5	29.18	13.68
n253	16.91	29.22	12.31
n255	14.93	30.01	15.08
n256	19.32	29.94	10.62

n257	16.2	29.97	13.77
n260	19.08	29.79	10.71
n261	15	29.46	14.46
n263	11.64	29.19	17.55
n264	9.66	29.2	19.54
n265	15.71	29.19	13.48
n266	11.95	29.19	17.24
n267	14.87	29.18	14.31
n268	12.96	29.45	16.49
n269	16.54	30.01	13.47
n270	11.12	30.01	18.89
n272	12.76	29.04	16.28
n273	20.01	33.38	13.37
n274	20.22	33.38	13.16
n275	12.06	29.43	17.37
n276	17.76	29.99	12.23

2) Results of Pipes

Fig 4: Pressure Distribution Network Diagram

Table 4: Result of pipes

	Length	Roughness coefficient	Flow	Velocity	Unit Headloss	Friction Factor
Link ID	m		LPS	m/s		
Pipe p1	69.04	130	0.29	0.04	0.03	0.039
Pipe p3	43.76	130	1.69	0.22	0.71	0.03
Pipe p4	39.24	130	1.34	0.17	0.46	0.031
Pipe p5	45.47	130	0.12	0.02	0.01	0.044
Pipe p6	86.91	130	1.12	0.14	0.33	0.032
Pipe p10	153.27	130	1.78	0.23	0.78	0.03
Pipe p11	67.52	130	0.59	0.08	0.1	0.035
Pipe p14	87.14	130	0.04	0	0	0.054
Pipe p15	97.68	130	0.21	0.03	0.01	0.041
Pipe p17	141.26	130	0.49	0.06	0.07	0.036
Pipe p18	131.64	130	0.37	0.05	0.04	0.038
Pipe p19	70.03	130	0.45	0.06	0.06	0.037
Pipe p21	78.26	130	-0.58	0.07	0.1	0.035
Pipe p22	89.82	130	0.48	0.06	0.07	0.036
Pipe p23	82.23	130	1.75	0.22	0.76	0.03
Pipe p26	68.55	130	1.03	0.13	0.28	0.032
Pipe p27	56.87	130	0.89	0.11	0.22	0.033
Pipe p28	51.82	130	0.28	0.04	0.03	0.039
Pipe p29	92.2	130	0.04	0	0	0.053
Pipe p30	105.87	130	2.76	0.35	1.76	0.028
Pipe p31	61.14	130	0.87	0.11	0.21	0.033
Pipe p32	46.64	130	0.68	0.09	0.13	0.034
Pipe p33	121.6	130	0.95	0.12	0.24	0.033
Pipe p35	50.69	130	0.02	0	0	0.055
Pipe p36	141.7	130	1.33	0.17	0.45	0.031
Pipe p37	263	130	1.3	0.17	0.43	0.031
Pipe p38	114.2	130	0.05	0.01	0	0.049
Pipe p39	123.5	130	0.31	0.04	0.03	0.039
Pipe p40	85.47	130	1.49	0.19	0.56	0.031
Pipe p41	157.8	130	0.07	0.01	0.01	0.047
Pipe p45	104.3	130	1.99	0.25	0.96	0.029
Pipe p48	85.83	130	0.04	0.01	0	0.051
Pipe p49	214	130	0.68	0.09	0.13	0.034
Pipe p50	180	130	0.18	0.02	0.01	0.042
Pipe p51	165.19	130	0.91	0.12	0.23	0.033
Pipe p52	119.9	130	1.91	0.24	0.89	0.029
Pipe p54	195.9	130	0.67	0.09	0.13	0.034

Pipe p55	108.6	130	0.81	0.1	0.18	0.033
Pipe p56	203	130	0.48	0.06	0.07	0.036
Pipe p58	140.84	130	0.07	0.01	0.01	0.047
Pipe p60	41.92	130	0.15	0.02	0.01	0.043
Pipe p62	83.37	130	0.51	0.06	0.08	0.036
Pipe p63	45.84	130	0.56	0.07	0.09	0.035
Pipe p64	47.11	130	0.94	0.12	0.24	0.033
Pipe p65	98.7	130	1	0.13	0.27	0.032
Pipe p68	83.61	130	0.88	0.11	0.21	0.033
Pipe p69	141.9	130	0.78	0.1	0.17	0.034
Pipe p72	85.16	130	0.15	0.02	0.01	0.043
Pipe p73	49.63	130	0.02	0	0	0.057
Pipe p74	53.89	130	0.12	0.01	0	0.045
Pipe p75	17.67	130	0.09	0.01	0	0.046
Pipe p77	122.3	130	0.06	0.01	0	0.048
Pipe p78	48.13	130	0.04	0.01	0	0.051
Pipe p79	135.3	130	0.24	0.03	0.02	0.04
Pipe p80	137.83	130	0.09	0.02	0.02	0.044
Pipe p81	48.93	130	0.19	0.04	0.04	0.04
Pipe p82	85.85	130	3.86	0.49	3.27	0.027
Pipe p84	110.4	130	3.59	0.46	2.85	0.027
Pipe p89	220.46	130	3.44	0.44	2.64	0.027
Pipe p91	89.67	130	0.79	0.1	0.17	0.034
Pipe p92	66.23	130	0.85	0.11	0.2	0.033
Pipe p93	65.55	130	0.91	0.12	0.22	0.033
Pipe p94	58.11	130	0.97	0.12	0.25	0.033
Pipe p96	148.4	130	0.83	0.11	0.19	0.033
Pipe p97	61.6	130	2.38	0.3	1.33	0.029
Pipe p99	78.53	130	0.28	0.04	0.02	0.039
Pipe p100	36.88	130	0.08	0.02	0.01	0.046
Pipe p101	106.4	130	0.6	0.08	0.11	0.035
Pipe p103	95.74	130	1.36	0.17	0.47	0.031
Pipe p104	46.48	130	1.29	0.16	0.43	0.031
Pipe p105	161.2	130	0.61	0.08	0.11	0.035
Pipe p107	109.04	130	0.99	0.13	0.26	0.032
Pipe p108	75.92	130	5.19	0.66	5.66	0.025
Pipe p109	74.72	130	2.76	0.35	1.76	0.028
Pipe p111	59.56	130	13.92	1.77	35.15	0.022
Pipe p112	77.83	130	7.17	0.91	10.28	0.024
Pipe p117	97.04	130	3.79	0.48	3.16	0.027
Pipe p120	64.92	130	4.45	0.57	4.26	0.026

Pipe p123	133.9	130	0.06	0.01	0	0.049
Pipe p128	81.48	130	0.71	0.09	0.14	0.034
Pipe p129	184.97	130	0.09	0.01	0	0.047
Pipe p132	78.29	130	0.45	0.06	0.06	0.036
Pipe p133	148.52	130	0.13	0.02	0.01	0.044
Pipe p135	142.92	130	14	1.78	35.55	0.022
Pipe p140	91.23	130	0.11	0.01	0	0.045
Pipe p141	76.96	130	0.04	0	0	0.053
Pipe p143	63.05	130	0.57	0.07	0.1	0.035
Pipe p144	69.01	130	2.62	0.33	1.59	0.028
Pipe p147	25.67	130	9.75	1.24	18.19	0.023
Pipe p151	92.66	130	2.51	0.32	1.47	0.028
Pipe p152	120.3	130	1.08	0.14	0.31	0.032
Pipe p153	59.07	130	1.31	0.17	0.44	0.031
Pipe p154	63.08	130	0.03	0	0	0.055
Pipe p161	127.52	130	1.16	0.15	0.35	0.032
Pipe p166	144.3	130	0.12	0.02	0.01	0.045
Pipe p167	54.85	130	0.03	0.01	0	0.052
Pipe p168	147.5	130	0.05	0.01	0	0.049
Pipe p169	47.36	130	0.14	0.02	0.01	0.044
Pipe p170	191	130	0.43	0.05	0.06	0.037
Pipe p171	102.11	130	0.05	0.01	0	0.05
Pipe p175	150.6	130	1.15	0.15	0.35	0.032
Pipe p177	59.95	130	0.55	0.07	0.09	0.035
Pipe p179	88.07	130	0.16	0.02	0.01	0.042
Pipe p180	166.9	130	-0.05	0.01	0	0.05
Pipe p181	28.25	130	0.4	0.05	0.05	0.037
Pipe p182	97.47	130	0.04	0.01	0	0.051
Pipe p184	33.79	130	6.35	0.81	8.21	0.025
Pipe p185	30.64	130	0.54	0.07	0.09	0.035
Pipe p186	37.69	130	0.3	0.04	0.03	0.039
Pipe p190	168.74	130	4.09	0.52	3.63	0.026
Pipe p191	257.76	130	1.73	0.22	0.74	0.03
Pipe p193	27.42	130	6.36	0.81	8.23	0.025
Pipe p196	84.22	130	0.6	0.08	0.1	0.035
Pipe p198	223.3	130	0.95	0.12	0.24	0.033
Pipe p202	39.19	130	0.04	0.01	0	0.051
Pipe p203	26.31	130	-0.01	0	0	0
Pipe p205	64.83	130	2.08	0.27	1.04	0.029
Pipe p206	217.76	130	0.32	0.04	0.03	0.038
Pipe p209	236.11	130	0.1	0.01	0	0.045

Pipe p210	159.7	130	1.7	0.22	0.72	0.03
Pipe p211	160.3	130	1.56	0.2	0.61	0.03
Pipe p212	125.81	130	2.86	0.36	1.88	0.028
Pipe p214	39.34	130	2.93	0.37	1.96	0.028
Pipe p215	120.1	130	1.44	0.18	0.53	0.031
Pipe p216	249.6	130	1.16	0.15	0.35	0.032
Pipe p217	185.1	130	1.12	0.14	0.33	0.032
Pipe p218	229.9	130	0.85	0.11	0.2	0.033
Pipe p221	121.25	130	0.16	0.02	0.01	0.042
Pipe p226	364.1	130	0.16	0.02	0.01	0.042
Pipe p232	94.08	130	0.82	0.1	0.19	0.033
Pipe p233	67.56	130	0.27	0.03	0.02	0.039
Pipe p234	66.12	130	1.57	0.2	0.62	0.03
Pipe p237	44.27	130	0.29	0.04	0.03	0.039
Pipe p238	86.16	130	2.88	0.37	1.9	0.028
Pipe p241	216.53	130	0.8	0.1	0.18	0.034
Pipe p242	46.6	130	2.24	0.28	1.19	0.029
Pipe p245	167	130	1.88	0.24	0.87	0.03
Pipe p246	61.58	130	0.03	0	0	0.056
Pipe p247	48.57	130	0.66	0.08	0.12	0.035
Pipe p248	209.84	130	0.17	0.02	0.01	0.042
Pipe p250	145.9	130	0.07	0.01	0.01	0.047
Pipe p251	106.78	130	0.05	0.01	0	0.05
Pipe p253	107.96	130	0.05	0.01	0	0.051
Pipe p256	86.6	130	0.07	0.01	0.01	0.047
Pipe p257	78.24	130	0.02	0	0	0.056
Pipe p258	79.61	130	0.52	0.07	0.08	0.036
Pipe p259	125.81	130	0.06	0.01	0	0.048
Pipe p260	153.04	130	0.48	0.06	0.07	0.036
Pipe p262	68.03	130	0.63	0.08	0.11	0.035
Pipe p263	142.5	130	2.11	0.27	1.07	0.029
Pipe p264	113.4	130	0.05	0.01	0.01	0.049
Pipe p265	108.68	130	0.52	0.07	0.08	0.036
Pipe p266	89.97	130	0.21	0.03	0.02	0.041
Pipe p267	73.96	130	0.81	0.1	0.18	0.033
Pipe p268	103.6	130	4.35	0.55	4.08	0.026
Pipe p269	113.7	130	0.94	0.12	0.24	0.033
Pipe p270	86.72	130	0.04	0	0	0.054
Pipe p271	104	130	0.05	0.01	0.01	0.049
Pipe p272	200.2	130	1.77	0.23	0.77	0.03
Pipe p274	75.9	130	0.63	0.08	0.11	0.035

Pipe p275	100.5	130	0.05	0.01	0	0.05
Pipe p276	82.29	130	0.12	0.02	0.01	0.044
Pipe 3	36	130	0.27	0.03	0.02	0.039
Pipe 4	86	130	0.04	0.01	0	0.05
Pipe 6	126.12	130	0.37	0.05	0.04	0.038
Pipe 8	70.48	130	0.45	0.06	0.06	0.037
Pipe 10	32.56	130	1.06	0.14	0.3	0.032
Pipe 11	120.21	130	0.43	0.06	0.06	0.037
Pipe 12	59.93	130	1.08	0.14	0.31	0.032
Pipe 13	168.57	130	2.29	0.29	1.25	0.029
Pipe 14	61.66	130	0.61	0.08	0.11	0.035
Pipe 15	179.53	130	2.11	0.27	1.07	0.029
Pipe 16	155.14	130	0.07	0.01	0.01	0.047
Pipe 17	135.73	130	0.33	0.04	0.03	0.038
Pipe 20	81.64	130	3.66	0.47	2.97	0.027
Pipe 22	189	130	4.93	0.63	5.13	0.026
Pipe 23	155.95	130	0.07	0.01	0.01	0.047
Pipe 24	38.61	130	0.13	0.02	0.01	0.044
Pipe 25	71.79	130	0.03	0.01	0	0.054
Pipe 26	102.11	130	0.46	0.06	0.06	0.036
Pipe 27	158.57	130	0.83	0.11	0.19	0.033
Pipe 28	99.5	130	0.53	0.07	0.08	0.036
Pipe 29	130.49	130	7.79	0.99	12	0.024
Pipe 30	136.03	130	3.48	0.44	2.7	0.027
Pipe 31	210.78	130	1.52	0.19	0.58	0.03
Pipe 32	112.65	130	2.69	0.34	1.68	0.028
Pipe 33	140.6	130	11.54	1.47	24.83	0.023
Pipe 34	57.67	130	6.81	0.87	9.35	0.024
Pipe 35	24.04	130	9.39	1.2	16.97	0.023
Pipe 37	149.84	130	0.07	0.01	0.01	0.047
Pipe 38	82.88	130	1.24	0.16	0.4	0.031
Pipe 39	59.07	130	0.6	0.08	0.1	0.035
Pipe 40	151.14	130	6.26	0.8	8.01	0.025
Pipe 41	36.16	130	12.52	1.59	28.91	0.022
Pipe 42	57.13	130	9.48	1.21	17.25	0.023
Pipe 43	274.11	130	9.62	1.22	17.74	0.023
Pipe 46	48.82	130	0.95	0.12	0.24	0.033
Pipe 48	123.97	130	0.95	0.12	0.24	0.033
Pipe 49	89.49	130	0.64	0.08	0.12	0.035
Pipe 50	229.2	130	0.33	0.04	0.03	0.038
Pipe 18	187.85	130	0.33	0.04	0.03	0.038

Pipe 19	44.94	130	-0.05	0.01	0	0.05
Pipe 36	140.62	130	4.55	0.58	4.43	0.026
Pipe 51	47.25	130	4.71	0.6	4.72	0.026
Pipe 52	184.3	130	0.66	0.08	0.13	0.034
Pipe 53	128.91	130	0.09	0.01	0	0.047
Pipe 54	55.54	130	1.4	0.18	0.5	0.031
Pipe 55	159.27	130	1.61	0.2	0.64	0.03
Pipe 56	161.23	130	4.46	0.57	4.28	0.026
Pipe 57	228.07	130	0.1	0.01	0	0.045
Pipe 58	202.29	130	24.57	3.13	100.73	0.02
Pipe 59	169.26	130	2.32	0.3	1.27	0.029
Pipe 60	117.87	130	0.92	0.12	0.23	0.033
Pipe 61	116.47	130	0.16	0.02	0.01	0.043
Pipe 5	128.2	130	0.83	0.11	0.19	0.033
Pipe 7	172.99	130	0.43	0.06	0.06	0.037
Pipe 44	109.16	130	1.23	0.16	0.39	0.031
Pipe 45	108.37	130	0.37	0.05	0.04	0.038
Pipe 62	71.27	130	0.03	0	0	0.058
Pipe 63	84.87	130	0.47	0.06	0.06	0.036
Pipe 64	72.61	130	-0.61	0.08	0.11	0.035
Pipe 65	128.11	130	0.36	0.05	0.04	0.038
Pipe 66	90.86	130	0.13	0.02	0.01	0.044
Pipe 47	249.45	130	2.6	0.33	1.57	0.028
Pipe 67	124.23	130	1.36	0.17	0.47	0.031
Pipe 68	31.96	130	1.68	0.21	0.7	0.03
Pipe 69	42.19	130	1.78	0.23	0.78	0.03
Pipe 79	72.9	130	0.28	0.04	0.02	0.039
Pipe 80	61.02	130	0.03	0.01	0	0.054
Pipe 81	142.53	130	0.07	0.01	0.01	0.047
Pipe 82	20.56	130	0.19	0.02	0.01	0.041
Pipe 83	51.34	130	0.37	0.05	0.04	0.038
Pipe 84	61.81	130	8.15	1.04	13.04	0.024
Pipe 85	124.94	130	5.28	0.67	5.83	0.025
Pipe 86	56.66	130	3.25	0.41	2.38	0.027
Pipe 87	109.86	130	1.78	0.23	0.78	0.03
Pipe 88	112.04	130	2.74	0.35	1.74	0.028
Pipe 71	59.59	130	2.66	0.34	1.63	0.028
Pipe 72	121.68	130	3.37	0.43	2.54	0.027
Pipe 75	44.12	130	1.38	0.18	0.48	0.031
Pipe 76	30.52	130	2.18	0.28	1.14	0.029
Pipe 77	73.93	130	6.01	0.76	7.41	0.025

Pipe 78	55.12	130	3.33	0.42	2.49	0.027
Pipe 89	49.72	130	3.76	0.48	3.11	0.027
Pipe 90	75.18	130	11.01	1.4	22.76	0.023
Pipe 91	66.55	130	5.91	0.75	7.2	0.025
Pipe 92	47.72	130	0.56	0.07	0.09	0.035
Pipe 93	49.73	130	1.06	0.13	0.3	0.032
Pipe 94	27.01	130	1.44	0.18	0.53	0.031
Pipe 95	21.66	130	12.88	1.64	30.43	0.022
Pipe 96	150.03	130	6.43	0.82	8.41	0.025
Pipe 97	49.27	130	0.45	0.06	0.06	0.036
Pipe 1	117.36	130	24.66	2.18	41.71	0.021
Pipe 2	203.02	130	0.07	0.01	0.01	0.047

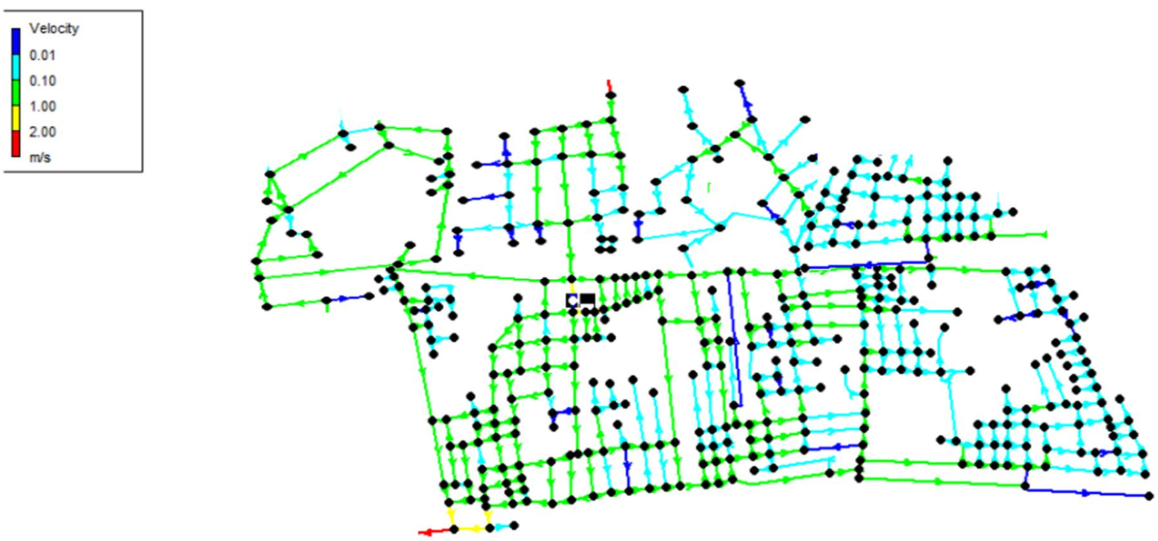

Fig 5: Velocity Distribution Network Diagram

V. CONCLUSION

The project aims to design a water supply distribution system in Anakkara Grama panchayath in Palakkad District. Since there does not exist any water supply schemes the area there is a scarcity of potable water during the non-monsoon period. Hence, it has to be supplemented by a new scheme that can fulfil the requirements of providing safe potable water for the people in the area. With this in mind, we have decided to plan and design an efficient water supply scheme for the ward. The different components of the water supply scheme including Overhead water tank, and pumping units have to be effectively and economically planned and designed. The network designed has to be modelled using Epanet and checked for its viability.

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