A
MINI PROJECT
ON

DESIGN OF WATER DISTRIBUTION PIPE NETWORK OF HASILA BILL NOTUN BASTI, GOALPARA PWSS WATER SUPPLY SCHEME USING EPANET

Submitted in partial fulfillment of the requirements for the award of the

Degree of

MASTERS OF TECHNOLOGY

in

CIVIL ENGINEERING

(*With Specialization in Water Resources Engineering*)

ASSAM ENGINEERING COLLEGE

UNDER

ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY

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CANDIDATE DECLARATION

I hereby certify that the work presented in the dissertation report entitled **"DESIGN OF WATER DISTRIBUTION PIPE NETWORK OF HASILA BILL NOTUN BASTI, GOALPARA PWSS WATER SUPPLY SCHEME USING EPANET"** is accorded for the award of degree of **MASTER OF TECHNOLOGY** with specialization in water resources engineering, submitted in the department of Civil Engineering, Assam Engineering College, Guwahati, Assam has been carried out by me under the guidance of **DR.BIBHASH SARMA**, Professor, Department of Civil Engineering, Assam Engineering College, Guwahati.

The content of this report has not been submitted to any other university for the award of any degree.

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CERTIFICATE OF APPROVAL FROM GUIDE

This is to certify that the dissertation report entitled **“DESIGN OF WATER DISTRIBUTION PIPE NETWORK OF HASILA BILL NOTUN BASTI, GOALPARA PWSS WATER SUPPLY SCHEME USING EPANET”** is submitted by **BARASHA KAKOTI**, Roll No.- 203620061007, a student of 3rd semester in the Department of Civil Engineering, Assam Engineering College, Guwahati in partial fulfillment for the award of degree of **MASTER OF TECHNOLOGY** in Civil Engineering with specialization in Water Resources Engineering under **ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY** has been carried out under my guidance.

The content of this report has not been submitted to any other university for the award of any degree.

Dated- **Dr. Bibhash Sarma**

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This is to certify that the dissertation report entitled **“DESIGN OF WATER DISTRIBUTION PIPE NETWORK OF HASILA BILL NOTUN BASTI, GOALPARA PWSS WATER SUPPLY SCHEME USING EPANET”** is submitted by **BARASHA KAKOTI**, Roll No.- 203620061007, a student of 3rd semester in the Department of Civil Engineering, Assam Engineering College, Guwahati in partial fulfillment for the award of degree of **MASTER OF TECHNOLOGY** in Civil Engineering with specialization in Water Resources Engineering under **ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY** has been carried out and presented in required manner.

The content of this report has not been submitted to any other university for the award of any degree.

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ABSTRACT

A water distribution network is a part of water supply network with components that carry potable water from a centralized treatment plant or well or any source of clean water to consumers to satisfy residential, commercial, and industrial and firefighting requirements. Water is one of the basic necessities of human beings in the world. The demand of water in various purpose of livelihood like domestic, industrial, agriculture etc is increasingly high in recent scenario. To mitigate the need for every purpose with limited water source water distribution network is the highly workable system. A water distribution network consists of infrastructure that collects, treats, stores, and distributes water between water sources and consumers. Efficient water distribution systems play a crucial role in protecting public health by ensuring that clean and safe drinking water is delivered to communities. Reliable water distribution systems are crucial for economic growth. They support numerous industries and agricultural operations by assuring access to water for production processes, ultimately contributing to job creation and community development. The main factor is supply reliability. Designing a new water distribution network or upgrading the current one is required to address this issue. A variety of computation tools, including LOOP 4.0, MIKENET, STANET, EPANET 2.0 and EPANET 2.2 software can be used to solve this kind of problem in addition to being solved manually. The evaluation of the current water distribution network using EPANET served as the foundation for this investigation.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Water is the most valuable gift from nature. It is the most important for supporting life and is necessary in practically all human activities, including household and industrial use, irrigation to fulfill expanding food and fiber needs, power generation, navigation, recreation, and animal consumption. The most prevalent sources of water are rainwater, surface water, ground water, and water obtained by reclamation. Water development, conservation, and utilization are key components of a country's development plan. As the population has grown, so has the demand for water supply in municipal amenities such as home, irrigation, and industrial use. As a result, identifying water supply sources, conserving them, and maximizing their use is necessarily important factor.

A water distribution system is a complicated network of infrastructure that transports clean, potable water from treatment plants to residences, businesses, and other end consumers. By delivering a consistent supply of safe drinking water, this system contributes significantly to community health and well-being. The World Health Organization (WHO) defines a water distribution system as a network of pipes in a tree-like structure that transports water from water treatment plants to service reservoirs, whereas a water distribution system is a network of pipes in a loop structure that supplies water from service reservoirs and balancing reservoirs to consumers. The component of distribution system consists of distribution mains, arterial mains, storage reservoirs, and system accessories (valve, hydrant, mainline meters, service connections, and backflow preventers). Distribution mains are the pipelines that comprise the distribution system. Their purpose is to transport water from the water source or treatment facility to customers.

A distribution network can eventually fail or the existing design may not be efficient for better working life, in such cases resigning of the network is proposed using effective software for sustainability as well as longer working life. A water distribution network's design is typically determined by the geography and the suggested roadway layout. The modeler simulates network pressures and flows, as well as inflows and outflows to and from the tank for necessary loading, using commercial software such as EPANET

1.2 BACKGROUND STUDY OF WATER DISTRIBUTION NETWORK

Water distribution dates back to antiquity. Urban water distribution systems (WDSs) have been around since the Bronze Age (3200-1100 B.C.), with notable instances dating back to the mid-third millennium B.C. (Mays et al). These include, for example, a network of hundreds of wells that feed water to homes, as well as private and public baths (Mays et al). Crouch, who investigated water management in ancient Greece, discovered that the first piped water supply, including pressure pipes, existed as early as the second millennium B.C.

One of the earliest theories for solving water flow and pressure problems in water distribution networks is the popular Hardy Cross method, which is an iterative method for determining the flow in pipe network systems where the inputs and outputs are known but the flow within the network is unknown. The Hardy Cross approach is an adaption of the Moment distribution method, which was also developed by Hardy Cross to calculate moments in indeterminate structures. The method was later rendered obsolete by computer-solving algorithms that used the Newton-Raphson method or other solution methods, eliminating the need to solve nonlinear systems of equations manually.

1.3 STUDY AREA

The water distribution network we will be designing and analyzing in this project work is for the area named Hasila Bill Notun Basti situated in the Goalpara District of the state Assam, India. The distribution network is under PWSS Scheme of Public Health Engineering Department (PHED), Govt. of Assam which we will be redesigning using a new software called EPANET 2.2.

Goalpara is a town and the district headquarters of Goalpara District in Assam, India. It is located 134 kilometers (83 miles) to the west of Guwahati. The geographical coordinates are between Latitude 25053' - 26030' North and Longitude 9007' - 9105' East and its Boundary is shared to the North of the Brahmaputra, South East Garo Hill District of Meghalaya, East Kamrup District, and West Dhubri District occupying a total area of about 1824 square kilometers. **Hasila Bill Notun Basti** is a place under which the proposed project of Gobindapur (CT) village which lies under Balijana block with Gram Panchayat Baladmari of Goalpara sub division, Assam, India, located 0.5 kilometres from Balijana. This project is done under Jal Jeevan Mission (JJM) under PHED, Goalpara Division which covers two habitations namely Hasilabeel and Hasilapara. The overall geographical area of the village is 296.51 hectares. For the purpose of giving a proper idea of the location the map has been attached for the same.

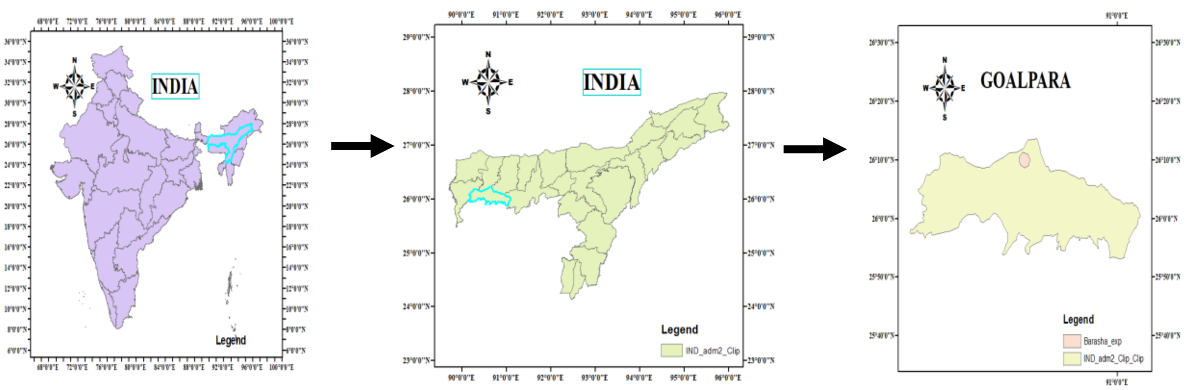
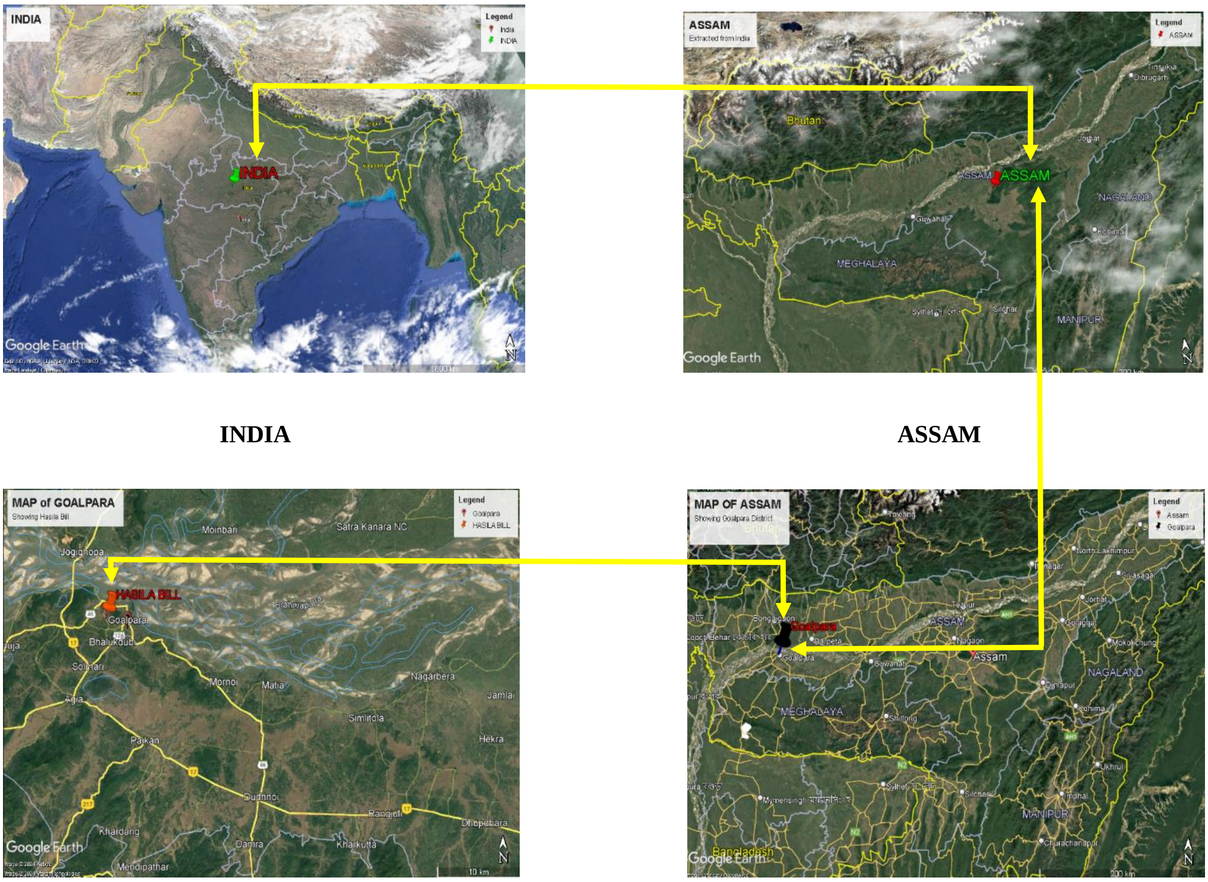


Fig. 1 – Study Area



INDIA

ASSAM

HASILA BILL

GOALPARA

Fig. 2 – Map of Study Area

1.4 SOURCE OF WATER

The source of water we are taking into consideration for this project work is groundwater with HFL 37.43m which contains 0.24 mg/l of Iron. The source is set up with two submersible pumps (1 installed and 1spare) having Horse Power 3 Watt with a discharge of 100 LPM and head 60m. There is one Tube well which is constructed along the source with a depth of 175m and diameter of 150m.

1.5 ROAD NETWORK AND HOUSING MAP OF THE STUDY AREA

The roads connecting Hasila Bill to the main town is basically connected to Goalpara Sub Division through bitumen roads. We have attached the road and housing map of our study

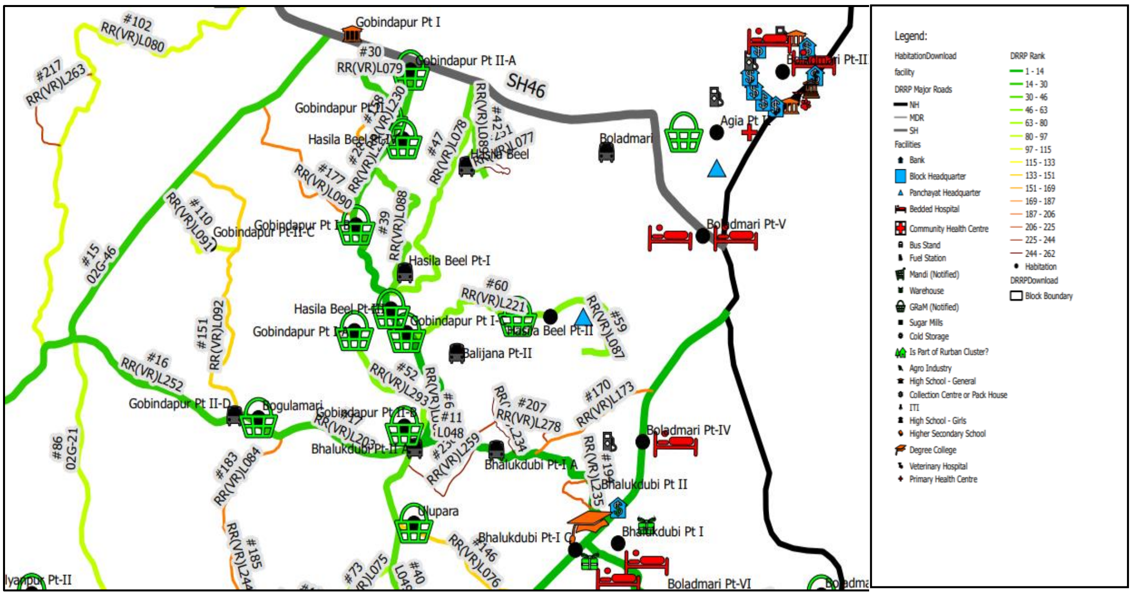


Fig. 3 – Road and Housing Map of the Study Area

1.6 DISTRIBUTION SYSTEM

Water distribution network is the term for the portion of a water that is being distributed through pipes that creates that creates a network using pumps, reservoir, valves, nodes etc. Distribution network needs a centralized treatment plant of water that can satisfy the consumers to satisfy residential, commercial, industrial and firefighting requirements.

Components of a water distribution system –

a. **Pipelines** – The pipes are the ways through the water gets conveyed to every consumer from the service reservoirs. The pipes joining the pump or reservoir to other pipes are termed as **mains**. The pipes with larger diameters are termed as **primary feeders** and the pipes connecting primary feeders to distributors are called **secondary feeders**.

b. **Valves** – The valves are the objects that controls the flow of water in a water distribution network and regulate pressure.

c. **Hydrants** – Fire hydrants provide a means of accessing water for firefighting purposes.

d. **Reservoirs** – These are storage models that stores clean water which is then transferred to the consumers through pipes. There are several types of reservoirs such as –

Underground storage reservoir which is ground excavated and is fully covered.

Surface reservoir is basically constructed on the ground with concrete lining to store clean water and are covered with lids to prevent contamination.

Water Tower reservoir is the one which is elevated in structure which may be rectangular or spherical.

Standpipe is that kind of reservoir which is a combination of both ground storage and water tower reservoir.

Sump is also a type of reservoir which is not used for direct distribution of water, instead it is a typically underground reservoir from which water is pumped to the service reservoir when needed.

e. Pump – Pumps are devices that transport water from treatment plants or reservoir to storage tanks or directly to distribution pipes.

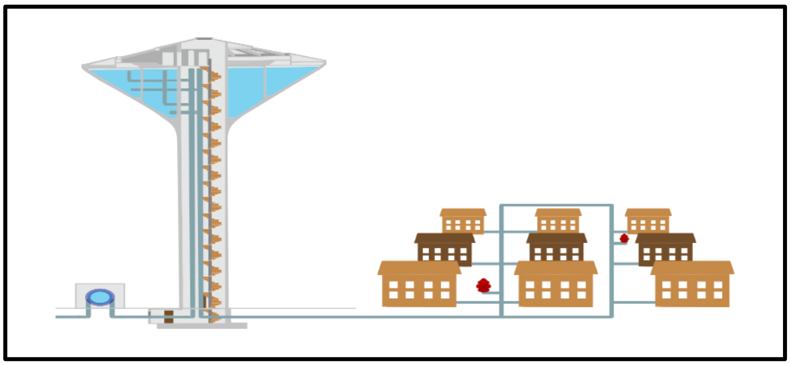


Fig. 4 – General Layout of a normal distribution system

Distribution system layout –

There are four types of water distribution system layout that are commonly used. They are –

a. Dead-End System – In this system the main pipeline runs through the central part of an area. This system is also termed as the tree distribution system. In this system the sub mains branch off from both sides of the mains.

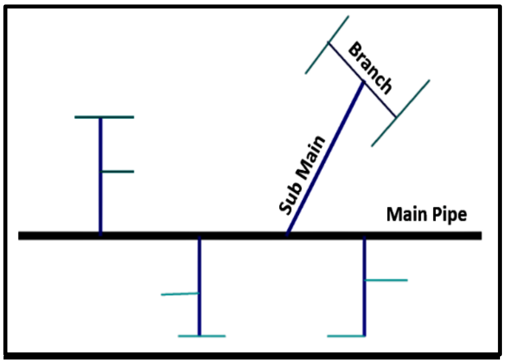


Fig. 5 – Dead-End System

b. Grid-Iron System – This type of distribution system does not have any dead end because the because the main, sub mains, and branch lines are all interconnected. The main is connected at the central area and the submains are branch out at right angles. The water in this system flow continuously without any sediment deposition.

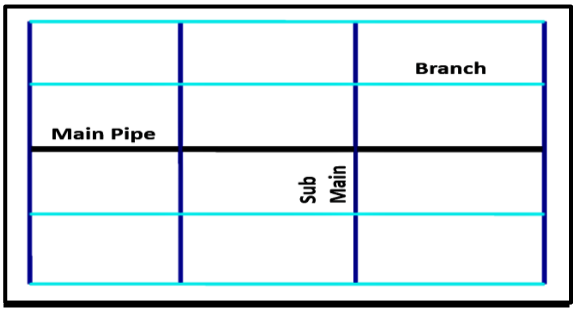


Fig. 6 – Grid-Iron System

c. **Ring-Water System** – This system is also called circular distribution system where the main water supply line is formed around the area of distribution, essentially forming a ring shape. In this system there is no stagnation of water, branch lines are projected perpendicularly from the main line as well as to each other.

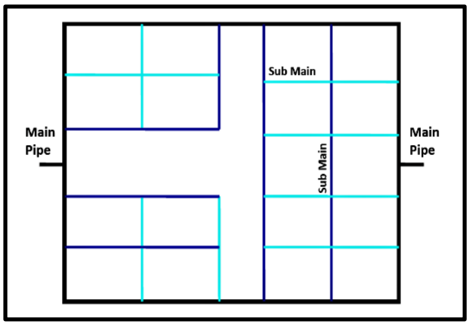


Fig. 7 – Ring-Water System

d. **Radial-Water System** – In this system the area is divided into small distribution zones. Each zone receives its own centrally located elevated reservoir where pipelines are laid radially to the surrounding streets. This distribution system is ideal for areas with radially designed roads.

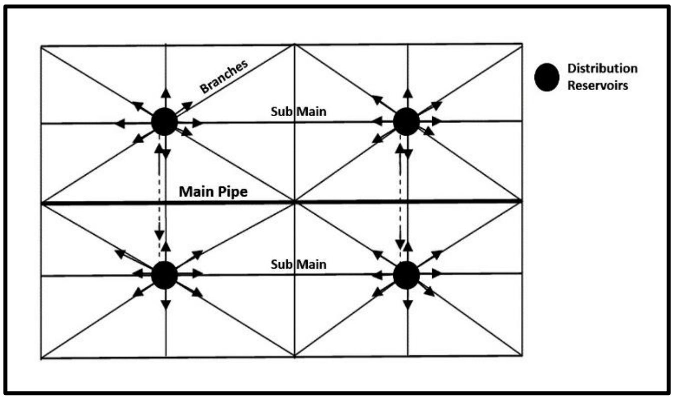


Fig. 8 – Radial-Water System

1.7 OBJECTIVE OF THE PROJECT

The project aims to fulfill the water demand of the study area taking 2024 as the base year of designing the water distribution network, taking 2037 as intermediate year and 2052 as the ultimate year for the project we are taking on interest. The basic objectives of the project are the following ones: -

- To design and analyze the data regarding water distribution network of Hasila Bill Notun Basti Piped Water Supply Scheme (PWSS) under PHE department, Goalpara Division using EPANET 2.2 software.

- To analyze the data by using EPANET software.

- To determine a water demand and water pressure across the network during a simulation period made up of several time steps in the designed network.

- To compare the analyzed result with the actual result.

CHAPTER 2

POPULATION FORECAST

2.1 POPULATION OF THE STUDY AREA

Hasila Bill has a population of 650 people and 130 households as per Integrated Management Information System (2020). Also, as per 2011 population survey the population of our study area is of 650 people with 130 households. Here the rural population forecast has been done for the required project.

2.2 RURAL POPULATION PROJECTION

The population to be served in the various stages of the project has been worked out by different methods. We have separately calculated the population variation in the required years through various population forecasting method.

a) Arithmetic Progression Method
b) Geometrical Progression Method
c) Incremental Increase Method
d) Graphical Method
e) National Water Development Agency's Method

Proposed Period	2021
Execution Period	3
Present Year	2024
Immediate Year	2037
Ultimate Year	2052

The below table shows the Rural Population Forecast: -

SL. No.	YEAR	POPULATION	INCREASE IN DECADE X	INCREMENTAL INCREASE (I)	RATE OF GROWTH	GEOMETRIC MEAN
1	1971	403170				0.209
2	1981	507268	104098		0.2582	
3	1991	616042	108774	4676	0.2144	
4	2001	755133	139091	30317	0.2258	
5	2011	870121	114988	-24103	0.1523	
		Average =	116737.78	= 3630		

Table 1 – Rural Population Forecast till 2011

Arithmetic Progression Method -

Increase in three Decades (2011-1971) = (870121 - 403169.88)

= 466951.12

= 466951.12

Average Increase in Population per decade = 466951.12 / 4

= 116738

The formula used for Arithmetic Progression Method is –

$$P_n = P_{2011} + n\bar{x}, \text{ where,}$$

P_n = Population required,

P_{2011} = last known population

n = number of decades between P_{2011} and P_n and,

$\bar{x}$ = the rate of population growth.

Population for year 2021 = Population in 2011 + Average increase for 1.0 decade

$$P_{2021} = \text{Population in 2011} + 1\times116738$$

$$P_{2021} = 870121 + \frac{2021-2011}{10} \times 116738$$

$$P_{2021} = 986858.78$$

Population for the current year 2024 = Population in 2011 + Average increase for 1.2 decade

$$P_{2024} = \text{Population in 2011} + 1.2\times116738$$

$$P_{2024} = 870121 + \frac{2024-2011}{10} \times 1.2\times116738$$

$$P_{2024} = 1067407.848$$

Now,

Population for Intermediate year 2037 = Population in 2011 + Average increase for 2.6 decade

$$P_{2037} = \text{Population in 2011} + 2.6\times116738$$

$$P_{2037} = 870121 + \frac{2037-2011}{10} \times 2.6 \times 116738$$

$$P_{2037} = 1659268.393$$

Population for the Ultimate year 2052 = Population in 2011 + Average increase for 4.1 decade

$$P_{2052} = \text{Population in 2011} + 4.1 \times 116738$$

$$P_{2052} = 870121 + \frac{2052-2011}{10} \times 4.1 \times 116738$$

$$P_{2052} = 2832483.082$$

The above population forecast is shown in a tabular format: -

YEAR	POPULATION
2021 (Proposed Year)	986858.78
2024 (Current Year)	1067407.848
2037 (Intermediate Year)	1659268.393
2052 (Ultimate Year)	2832483.082

Table 2 – Population Using Arithmetic Progression method

Geometric Progression Method –

Assuming that the future growth follows geometric mean of period 1981-2011, i.e. $\mathbf{r_g} = \mathbf{0.209}$

The formula for the geometric forecast is

$$P_n = P_{2011} \times (1+rg)^{\frac{[(n-1)-2011]}{10}}, \text{ where,}$$

P_n = Population required,

P_{2011} = last known population

r_g = Geometrical Mean

n = Required population year

Here, using the above formula –

Population for year 2021 = $870121 \times (1+0.209)^{(2020-2011)/10}$

$$P_{2021} = 1032198.732$$

Similarly, population for the current, intermediate and ultimate year was calculated respectively-

YEAR	POPULATION
2021 (Proposed Year)	1032198.732
2024 (Current Year)	1092675.515
2037 (Intermediate Year)	1398445.038
2052 (Ultimate Year)	1859023.389

Table 3 – Population using Geometric Progression Method

<u>Incremental Increase Method</u> –

Assuming that the future growth follows geometric mean of period 1981-2011, i.e. $\mathbf{r_g = 0.209}$

The formula used for calculating population through Incremental Increase Method is –

$$P_n = P_{2011} \times Nx + \frac{n(n+1) \times Y}{2} \times r_{g,}, \text{ where,}$$

P_n = Population required,

P_{2011} = last known population

n= Decades

X = Average increase in decade – 116738

Y = Average incremental increase in decade – 3630

r_g = Geometrical mean

Here, using the mentioned formula we get –

$P_{2021} = 870121 + 1 \times 1166737.78 + [\frac{1 \times (1+1) \times 3630}{2}] \times 0.209$

$P_{2021} = 987617.45$

Similarly, population for the current, intermediate and ultimate year was calculated respectively-

YEAR	POPULATION
2021 (Proposed Year)	987617.45
2024 (Current Year)	1023014.326
2037 (Intermediate Year)	1177189.804
2052 (Ultimate Year)	1356677.793

Table 4 – Population using Incremental Increase Method

<u>GRAPHICAL METHOD</u>: -

Linear Graph Method: -

Here the population forecasting is done using graphical representation where we have got predictable population for the 2021 (execution year), 2024 (current year), 2037(intermediate year), 2052 (ultimate year).

Year	Population	Forecast(population)
1971	403170	
1981	507268	
1991	616042	
2001	755133	
2011	870121	870121
2021		989196.2102
2024		1024829.646

Table 5 – Population Forecast for the Year 2021 and 2024 using Simple Graphical Method

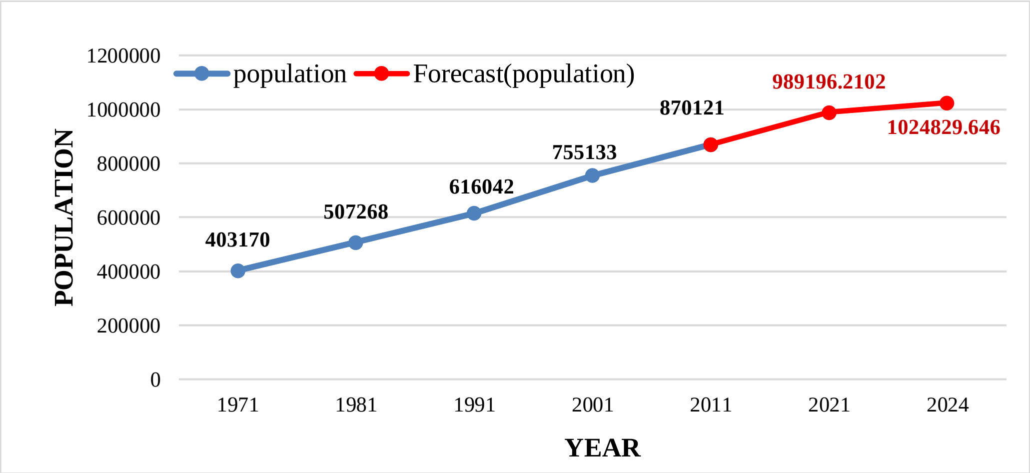


Fig. 9 – Population Graph for 2021and 2024

Year	Population	Forecast(population)
1971	403170	
1981	507268	
1991	616042	
2001	755133	
2011	870121	870121
2021		989196.2102
2031		1107974.33
2037		1179241.203

Table 6 - Population Forecast for the Year 2037 using Simple Graphical Method

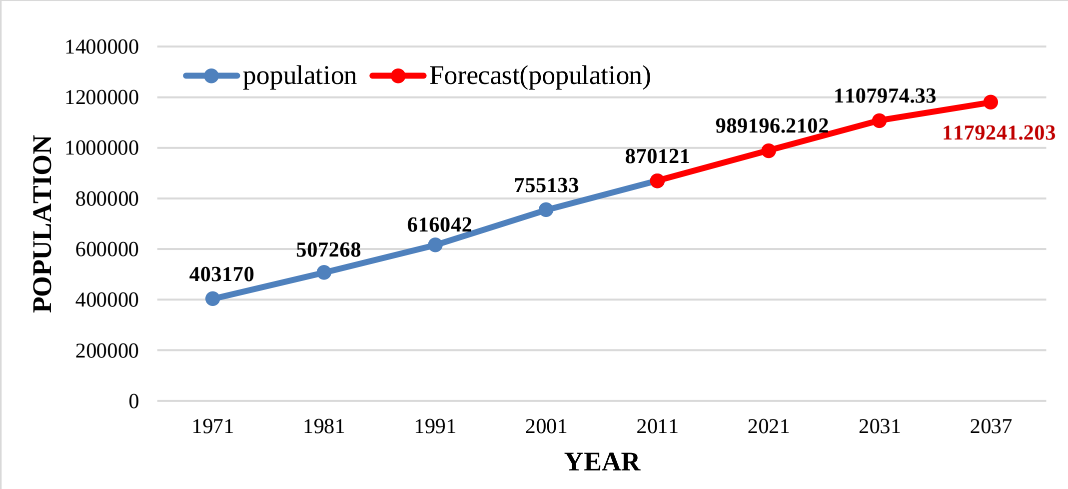


Fig. 10 –Population Graph for the year 2037

Year	Population	Forecast(population)
1971	403170	
1981	507268	
1991	616042	
2001	755133	
2011	870121	870121
2021		989196.2102
2031		1107974.33
2041		1226752.451
2051		1345530.571
2052		1357408.383

Table 7 - Population Forecast for the Year 2052 using Simple Graphical Method

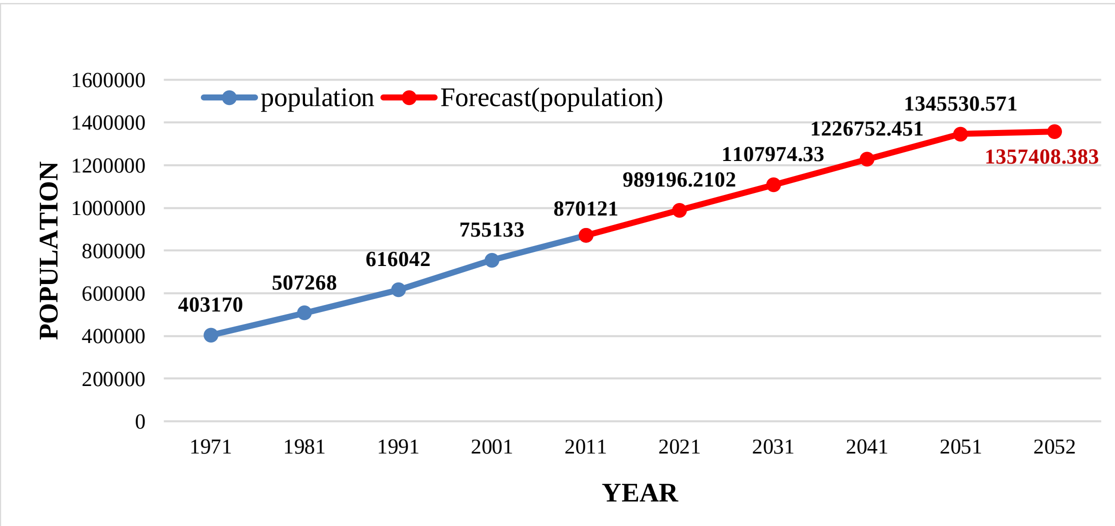


Fig. 11 - Population Graph for the year 2052

Results of the graphical method is given below: -

YEAR	POPULATION
2021(Proposed year)	989196.2102
2024 (Current year)	1024829.646
2037 (Intermediate year)	1179241.203
2052 (Ultimate year)	1357408.383

Table 8 – Population using Simple Graphical Method

NATIONAL WATER DEVELOPMENT AGENCY (NWDA) METHOD FOR POPULATION CALCULATION: -

According to NWDA, the rural population of a basin is assessed on proportionate area basis from the latest available district- wise census data using the following formula and as per latest revision of UN Publication, "World Population Prospectus" on medium variant growth rate –

$$P_n = P_{2011} \times (1+r)^n, \text{ where,}$$

r = annual compound rate of growth (geometrical mean)

n = number of decades

Here, using the above formula –

Population for year 2021 = $870121 \times (1+0.209)^1$

$$P_{2021} = 1051976.289$$

Similarly, population for the current, intermediate and ultimate year was calculated respectively-

YEAR	POPULATION
2021 (Execution Year)	1051976.289
2024 (Current Year)	1113611.844
2037 (Intermediate Year)	1425240.098
2052 (Ultimate Year)	1894643.411

Table 9 – Population using NWDA Standard Method

The Figures of Population Forecast by Above Five Methods are summarized as below:

YEAR	ARITHMETIC INCREASE METHOD	GEOMETRICAL PROGRESSION METHOD	INCREMENTAL INCREASE METHOD	GRAPHICAL METHOD	NWDA METHOD
2021	986858.78	1032198.732	987617.45	989196.2102	1051976.289
2024	1067407.848	1092675.515	1023014.326	1024829.646	1113611.844
2037	1659268.393	1398445.038	1177189.804	1179241.203	1425240.098
2052	2832483.082	1859023.389	1356677.793	1357408.383	1894643.411

Table 10 – Resultant Population of every method used

According to NWDA Guidelines for preparation of preliminary Water Balance Reports we have considered their way of calculating population as the standard one and calculation of other parameters is performed using those values.

CHAPTER 3
LITERATURE REVIEW

3.1 GENERAL

A literature review is a fundamental component of academic research, representing a systematic aspect of creative scholarship on a certain topic. This is a systematic method of searching, choosing, and synthesizing all relevant research, journals, and books to uncover trends, gaps, and essential insights. The literature review is an important aspect of a research article since it not only contextualizes the current study but also throws light on the contributions and limits of prior efforts. The significance of carrying out this process is twofold: it informs the methodology of earlier research in the topic, which helps build the foundations of credibility for both the study itself and the process in which the research questions and methodologies are developed in order to perform a thorough and comprehensive investigation. Several studies have addressed the following: -

3.2 REVIEW OF THE JOURNALS STUDIED

Payal Lungariya *et.al* (2016) in their study presents the analysis of continuous water distribution system in Surat City, Gujarat using EPANET software. In this study they collected the data of existing water distribution from Municipal Corporation and Multimedia Consultancy. The analysis resulted in elevation and pressure at different nodes and head loss at different pipes too. The new results were compared with the existing actual data and at the end it was concluded that the resultant pressure at the junctions and velocities of the flow at all the pipes are enough to meet the water need of the area of interest. It was also concluded that the diameters of the pipes the tanks are connected to other pipes have smaller diameters. The compared results showed up that the simulated model was close to existing one, discharge should be increased to achieve the base demand.

G. Anisha *et.al* (2016) had considered a present system of water supply in Chirala municipality, Andhra Pradesh for their study which is a dead-end system. Their research work is everything about the study and analysis of the existing network and concluding it about the reliability on the network for the upcoming years. They analyzed the system based on various public demands, quantities of inflows and outflows of the over- head reservoir. Their study provides us the data of demands, head losses and uses of water of the public. They had redesigned the actual system, here it analyzing and redesigning the actual system, here it is concluded that the new designed contains new additional sites for additional reservoirs to meet the water demand till 2041 and had planned it according to road plan and help the municipality and people of Chirala.

Brinda H. Dave *et.al* (2015) analyzed the Indian Remote Sensing (IRS) LISS-IV data covering Gandhinagar city of Gujarat for studying transport network, study area and various infrastructure in the city. CAROSAT Digital Elevation Model (DEM) data and LISS-IV data were used to generate 3-D visualization image of LISS-IV image of Gandhinagar city. The main aim of their analysis was the effective planning of a water distribution system and its proper analysis using EPANET 2.0 software. The present data of water distribution system was collected from Gandhinagar Municipal Corporation (GMC), Road and Building Department and Town Planning Department; Government of Gujarat. The Google Earth image of the city was collected and elevation of nodes, length of pipe was recorded for 285 nodes including elevation at nodes and head losses at pipes. The gained data was utilized in EPANET software to analyze pressure, head loss and elevation. This study indicated that result from the EPANET designed network were checked with hydraulic equation and found to be in agreement which can be used for modelling the water distribution network in Gandhinagar, Gujarat.

G. Venkata Ramana *et.al* (2018) in this study analyzed the validation and sustainability of the water distribution system of Dire Dawa, largest city of Ethiopia. It was observed that the current water demand surpassed the present water supply by about 65%. Therefore, to provide adequate quantity of water Dire Dawa Water Supply & Sewage Authority took the decision to validate and examine the existing water distribution system. After proper study considering the future needs of the study area, it was suggested that 2 GLRs with 2.7Mm^3 each would be installed. Based on the output, the diameter of the existing system was revised. Using software like EPANET, AutoCAD and Water GEMs frictional losses, velocity of flow, residual head and pressure at nodes were examined and a proper continuous water distribution system was designed for the Dire Dawa city of Ethiopia.

Sandeep Thakur *et.al* (2020) have designed a pipe network for NIT Srinagar using EPANET software for 30 years of population as its design period. The designed network is a hydraulic design. They used the EPANET software to calculate water demand. They concluded their research by examining plan of water supply pipe networks. After analyzing, their point of the study was to guarantee that water get supplied to all zones in great quality and amount, with the end goal of investigation and reenactment to acquire least and most power, speed of stream in the pipe arrange framework.

R.K. Rai *et.al* highlighted the proper analysis and distribution of water supply network using EPANET tool along with the use of Hardy- Cross Method and Newton – Raphson Method. The work of the researchers here is based on a random urban model of distribution system in developing countries. The main objective was to analyze existing water distribution system and to suggest some measurement if present network does not fulfil the present and future demand. Their study found out that using EPANET tool is time saving and affordable with so limitation of nodes, pipes or pumps to be modelled. EPANET software is effective in solving complex network with ease. It was concluded that results obtained from Hardy-Cross and Newton-Raphson Methods and EPANET software are almost equal and hence acceptable.

Arjun Kumar *et.al* (2015) have designed a water distribution system using EPANET software for an area called Kathgarh, Indora, Himachal Pradesh. They designed the supply system in order to fulfil the water demand of the continuously growing population in their area of interest. For the purpose of the study and design they collected the details from the Irrigation and Public Health Department (IPH), Indora, Himachal Pradesh. The collected details include the information about the main water source, population of the study area, water demand, pump requirement along with number of required water tanks. In the designed system using EPANET software 2 centrifugal pumps with 10HP were used with 2 overhead tanks of capacity 88700 liters. The distribution method used by them is the combination of gravity and pumping system, which supplies water for 8 hours per day. The results from the EPANET tool were concluded in the form of graphs which showed demand is maximum during the peak hours.

Rasooli Ahmedullah *et.al* (2016) had the objective of designing and balancing Water Distribution Network (WDN) based on loops hydraulically balanced method as well as Geographical Information System (GIS) methodology with the help of EPANET software. To acquire the objective, they set they analyzed water flows in each pipe and performed the iteration process on loops and at each iterations reasonable changes occurred in the flows until the head was minimum changes occurred in the flows until the head was minimum or zero. Since the method is confirmed to be effective, simulations were performed by using GIS and EPANET software. The analysis was for the Kabul City and the WDN for the area was accomplished and found that the used method can be used for complex networks. The result of the balanced method was effective which was then compared to EPANET hydraulic status simulation which was precise. Hence, as a context these principles have been applied to each pipe and each node in closed-loops pipe network until they have gotten corrected flows and successful result and concisely found the required parameters such as the pressure of nodes, discharges, and water flows and flows direction in the network.

Ishani Gupta *et.al* (2013) made an attempt to simulate the Water Distribution Network (WDN) of urban estate phase II, city of Punjab, India. The Municipal Corporation of the study area relies on groundwater extracted by the deep bore tube wells. The researchers hence decided to develop a WDN using EPANET software as a tool to simulate the hydraulic behavior of the hydraulic parameters. For creating the EPANET model- junction, pumps, valves, reservoir, pipes were used. The EPANET designed WDN has four deep bore tube wells to serve the study area. The simulation of the newly designed distribution network was carried out for 24 hours' period water supply. The comparison of existing and newly designed WDN were reasonably close and thus the study was a successful one.

Biprodip Mukherjee *et.al* (2017) did a case study to analyze water supply system of clean water of a Water Treatment Plant in Assam, India. Water under this treatment plant was supplied in three different routes in 42 numbers of elevated storage reservoirs. According to the researchers the loss of the water in such pipelines can be a foundation for pressure transiency and can create stress on the piping system. These all are revealed by using various pipeline hydraulic software like EPANET, LOOP, HAMMER etc. The Public Health Engineering Department (PHED) one of the oldest departments of India which is responsible for the supply. According to this study, a good design is only possible when all the advantages of the software could be clubbed together. Here in this case study, the survey drawing is viewed and an optimized design is simulated in LOOP software where the optimized diameter of the pipe is obtained. Again, as it is a pressured pipeline the whole system is modelled in EPANET software where all the hydraulic parameters are obtained. This analysis concluded that this type of designed study is hoped to open many possibilities for different usage of water with several fittings and management techniques to provide undisturbed water supply to the people of Assam.

CHAPTER 4

METHODOLOGY

4.1 GENERAL

In this project work we have redesigned an existing water distribution network in the Hasila Bill area of Goalpara District under Balijana block. Here we have deigned the network using **EPANET 2.2** software where the water demand, velocity, and pressure distribution of the study area is evaluated. The execution period of the project was 2021 and we have analyzed the network according to the rural population forecast of the Goalpara district taking 2024 as current year and 2037 and 2052 as the intermediate and ultimate year respectively.

4.2 EPANET

The National Risk Management Research Laboratory of the U.S. Environmental Protection Agency's Water Supply and Water Resources Division (previously the Drinking Water Research Division) created EPANET. It is a software that is in the public domain and can be distributed and copied without restriction. EPANET simulates the hydraulic and water quality behaviour of pressurised pipe networks over lengthy periods of time. Pipes, nodes (pipe junctions), pumps, valves, and storage tanks or reservoirs make up a network. During a simulation period made up of several time steps, EPANET measures the water flow in each pipe, the pressure at each node, the water height in each tank, and the concentration of a chemical species across the network. Along with chemical species, source tracing and water age can also be stimulated.

EPANET can help assess alternative management strategies for improving water quality throughout a system. These can include:

- Altering source utilization within multiple source systems,
- Altering pumping and tank filling/emptying schedules,
- Use of satellite treatment, such as re-chlorination at storage tanks,
- Targeted pipe cleaning and replacement.

  EPANET, which runs on Windows, offers a unified interface for modifying network input data, simulating hydraulic and water quality, and viewing the output in many forms. These consist of contour plots, time series graphs, data tables, and network maps with colour coding. In order to analyze the WDN 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:

a. Elevation above some reference (usually mean sea level)

b. Water demand (rate of withdrawal from the network)

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

a. Hydraulic head (internal energy per unit weight of fluid)

b. Pressure

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. The principal hydraulic input parameters for pipes are:

a. start and end nodes

b. diameter

c. length

d. roughness coefficient (for determining Head-loss)

e. Status (open, closed, or contains a check valve)

Computed outputs for pipes include:

a. flow rate

b. velocity

c. Head-loss

Following are the steps carried out to model water distribution network using EPANET: -

Step 1: Draw a network representation of distribution system or import a basic description of the network placed in a text file.

Step 2: Edit the properties of the objects that make up the system. It includes editing the properties and entering required data in various objects like reservoir, pipes, nodes and junctions.

Step 3: Describe how the system is operated.

Step 4: Select a set of analysis option.

Step 5: Run a hydraulic/water quality analysis

Step 6: View the results of the analysis which can be viewed in various form i.e. in form of tables and graphs.

Step 7: Repeat the procedure for other distribution networks.

Step 8: The pipe head loss is calculated by using Hagen-William's formula in the software itself –

$$h = 4.72C^{-1.85}d^{-4.87}L, \text{ where}$$

C = Hagen-William's Roughness Coefficient

d = Pipe diameter in m

L = Length of the pipe in m

4.3 WORK DONE PHE DEPARTMENT

Public Health Engineering Department (PHED), Goalpara Division under PWSS aimed to provide tapped water to every household at the rate of 55 lpcd up to its ultimate design period. The execution year for their proposed network was 2021. The following parameters were considered by the PHE Department which is also considered for the redesigned network also –

Minimum Residual Head	7m
Design LPCD	55 lpcd Institutional Demand - 5% UFW – 15% Demand – 67 lpcd
Minimum Size of Pipe	63 HDPE
Frictional Losses	4m/km
Transmission from Borewell to Elevated Service Reservoir (ESR) – GI Pipe	38m length (RWRM = 20m & PWRM = 18m)
Pimping Hours	24 hours (16 hours for electricity and 6 hours Solar Based)
Bore Size	100mm x 150mm
ESR	1/3rd capacity of Intermediate Stage Demand
Treatment	Chlorinator
Electric Connection	From nearest pole as per survey

Table 11 – Project Details

The layout and designed network by PHE department using WaterGEMS is attached below –

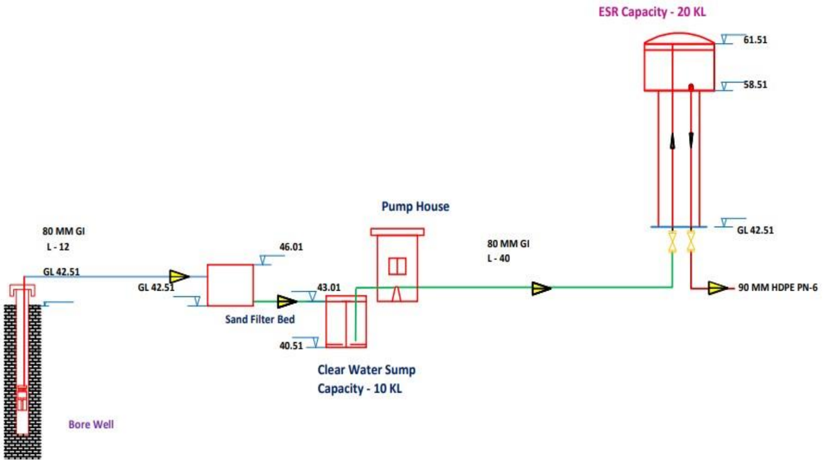


Fig. 12 – Layout of the source of the project

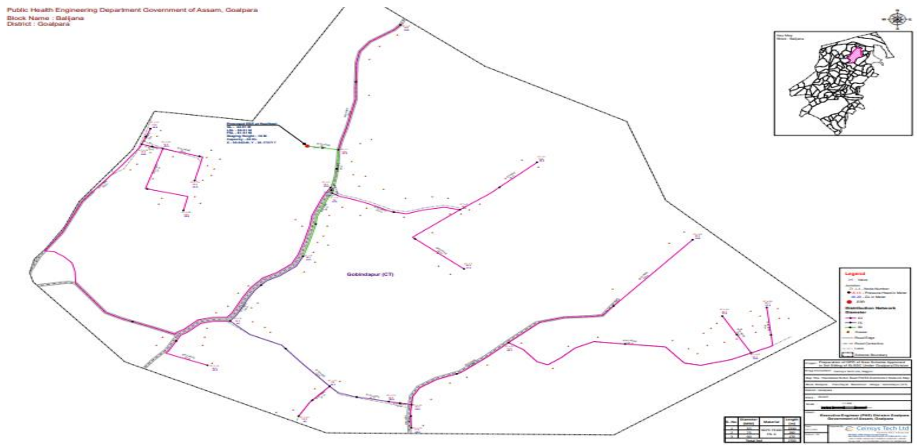


Fig 13 – Old Distribution Network

The link results of the network designed by PHED; Goalpara is given below –

SL No.	Start Node	End Note	Diameter (mm)	Length (m)	Flow (L/m)	Velocity (m/s)	Head loss (m/km)
	Tank	1	80.9	28	124.04	0.41	2.394
1	1	3	80.9	49	114.36	0.37	2.029
2	3	4	80.9	7	75.9	0.25	0.95
3	4	8	67.4	86	56.04	0.18	0.542
4	8	9	67.4	108	53.28	0.25	1.2
5	9	11	67.4	124	43.26	0.2	0.816
6	11	13	56.7	58	36.42	0.17	0.593
7	13	14	56.7	21	34.98	0.23	1.28
8	14	21	56.7	122	30.06	0.2	0.983
9	3	16	56.7	582	23.6	0.16	0.62
10	4	5	56.7	120	12.42	0.08	0.188
11	21	23	56.7	250	11.52	0.08	0.164
12	16	18	56.7	20	8.7	0.06	0.098
13	21	22	56.7	220	5.1	0.03	0.036
14	1	2	56.7	178	4.14	0.03	0.024
15	9	10	56.7	117	2.17	0.02	0.011
16	5	7	56.7	116	2.17	0.02	0.011
17	18	20	56.7	111	2.58	0.02	0.01
18	5	6	56.7	92	2.1	0.01	0.007
19	23	25	56.7	70	1.62	0.01	0.004
20	18	19	56.7	68	1.56	0.01	0.004
21	23	24	56.7	54	1.26	0.01	0.003
22	11	12	56.7	47	1.08	0.01	0.002
23	14	15	56.7	30	0.66	0	0.001
24	16	17	56.7	22	0.48	0	0

Table 12 – Link Results of old Distribution Network

The node results of the Distribution Network by PHED, Goalpara is given below-

Node ID	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure Head (m)
1	41.92	0.110	58.54	16.62
2	38.90	0.069	58.54	19.64
3	42.29	0.246	58.44	16.15
4	42.48	0.124	58.44	15.96
5	43.00	0.127	58.41	15.41
6	39.60	0.035	58.41	18.81
7	37.46	0.045	58.41	20.95
8	42.25	0.046	58.39	16.14
9	41.96	0.122	58.26	16.30
10	42.91	0.045	58.26	15.35
11	40.20	0.096	58.16	17.96
12	42.00	0.018	58.16	16.16
13	39.88	0.023	58.13	18.25
14	39.77	0.066	58.10	18.33
15	40.64	0.011	58.10	17.46
16	45.84	0.241	58.08	12.24
17	41.50	0.008	58.08	12.58
18	43.57	0.077	58.08	14.51
19	39.91	0.026	58.08	18.17
20	39.17	0.043	58.08	18.91
21	43.09	0.229	57.98	14.89
22	35.80	0.085	57.97	22.17
23	36.84	0.144	57.94	21.10
24	37.64	0.021	57.94	20.30
25	37.80	0.027	57.94	20.14

Table 13 - Node Results of old Distribution Network

4.4 PRESENT WORK

In this project work we have redesigned the above water distribution network using EPANET 2.2 software. Our main objective was to calculate the water demand, pressure distribution and flow velocity of the designed network for the current year. The EPANET 2.2 tool is capable of the simulation all the parameters we have objectified. The following steps are followed in designing the new network –

Step I: The road and locality map were collected from Public Works Department (PWD), Goalpara Division.

Step II: The required pump and source details were collected from the PHE Department, Goalpara Division.

Step III: The elevation data where the junctions (nodes) were to be setup was collected from the PHE Department as well.

Step IV: We have loaded the road map of the study area and have designed the network according to the road expansion so that each household get optimum water supply.

Step V: The water demand in each junction is calculated according to the number of houses in each junction.

Step VI: After the calculation of water demand in each junction we have run the network and the flow LPS, velocity, unit head loss, status of the links, head and pressure t each junction.

Step VII: Each variation in the links (pipelines) and nodes has been shown using the diagram of the network as well.

Step VIII: Repeat the procedure for other distribution networks.
Step IX: The pipe head loss is calculated by using Hagen-William's formula in the software itself –

$$h = 4.72C^{-1.85}d^{-4.87}L, \text{ where}$$

C = Hagen-William's Roughness Coefficient

d = Pipe diameter in m

L = Length of the pipe in m

4.4 DESIGNED NETWORK

By considering the collected data we have redesigned the network which is attached below-

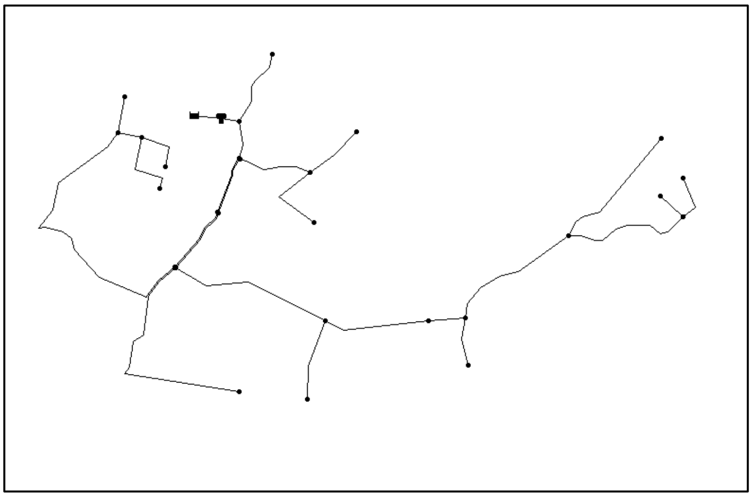


Fig. **14** – Newly Designed Distribution Network in EPANET 2.2

The demand calculation against the numbers of houses under each pipeline, pressure distribution and flow velocity are performed after designing the preliminary water distribution network. The formula used to calculate the water demand in each junction (nodes) is –

Water Demand = Number of Houses falling under each node × ($\frac{\mathbf{5 \times 67 \times 1.11 \times 3}}{\mathbf{24 \times 60}}$), where

5 is the average number of family members in each household

67 is the designed water demand lpcd

1.11 is the population forecast for the year 2024 according to NWDA method of population forecast

3 is the peak flow factor

24 is the pumping hour converted to minutes.

The diameters and length of the pipes used in the project are shown in the below table –

SL. No.	Start Node	End Node	Length (m)	Diameter (mm)
1	1	2	28	110
2	2	24	178	110
3	2	23	49	63
4	23	13	7	63
5	13	9	86	75
6	23	3	86	75
7	3	4	108	75
8	4	26	582	110
9	26	27	22	63
10	26	28	20	75
11	28	30	111	75
12	28	31	66	63
13	10	11	124	90
14	11	21	47	63
15	11	14	58	63
16	10	22	117	75
17	14	12	21	63
18	12	15	30	63
19	12	16	122	110
20	16	18	250	110
21	16	17	220	110
22	18	19	54	75
23	18	20	70	75

Table 14 – Length and Diameter of the pipelines provided in the designed network

CHAPTER 5

RESULTS

5.1 GENERAL

The redesign of the Hasila Bill PWSS project was successfully run for the time period of 24 hours as per the project and area requirement. The redesigned network is similar to the original one because of the road and housing plan of the area of interest. The pipelines are meant to be setup according to the roadways of the study area. Here the final results after the changes made during redesign is given in this chapter.

5.2 LINK RESULT

The results at each link/pipeline are shown below –

Link ID	Flow LPM	Velocity (m/s)	Unit Head Loss (m/km)	Status
1	156	0.27	1.61	Open
2	33	0.12	0.58	Open
3	30	0.11	0.49	Open
4	13	0.02	0.02	Open
5	70	0.26	2.35	Open
6	57	0.22	1.61	Open
7	48	0.13	0.48	Open
8	41	0.22	2.04	Open
9	39	0.21	1.86	Open
10	2	0.01	0.01	Open
11	35	0.06	0.10	Open
12	4	0.01	0.00	Open
13	18	0.03	0.03	Open
14	4	0.02	0.01	Open
15	9	0.03	0.05	Open
16	4	0.02	0.03	Open
17	5	0.02	0.02	Open
18	132	0.71	17.81	Open
19	12	0.02	0.01	Open
20	96	0.51	9.87	Open
21	25	0.04	0.05	Open
22	4	0.02	0.03	Open
23	17	0.06	0.17	Open
24	-3.11	0.46	52.50	Open
25	-5	0.02	0.02	Open
26	9	0.05	0.12	Open
27	3	0.02	0.02	Open
28	3	0.01	0.00	Open

Table 15 – Link Results

5.3 JUNCTION RESULT

The results at each junction are shown in the below table –

Node ID	Demand LPM	Head (m)	Pressure (m)
2	7	52.46	10.56
3	2	51.55	9.25
4	5	51.50	9.50
6	7	51.53	8.53
7	3	51.53	11.93
8	3	51.53	14.03
9	13	51.33	9.03
10	4	51.55	9.15
11	3	51.09	10.89
12	2	50.94	11.14
13	13	51.33	9.03
14	2	50.97	11.07
15	2	50.94	10.34
16	13	50.92	7.82
17	4	50.92	14.12
18	5	50.92	14.12
19	4	50.92	13.32
20	9	50.91	13.11
21	4	51.09	9.09
22	5	51.15	8.25
23	3	51.60	9.30
24	12	52.46	13.56
26	4	51.47	5.67
27	4	51.47	5.97
28	3	51.46	7.86
30	5	51.46	12.26
31	9	51.45	11.55

Table 16 – Junction Results

5.4 DIAGRAMS OF THE DESIGNED NETWORK SHOWING DIFFERENT PARAMETERS

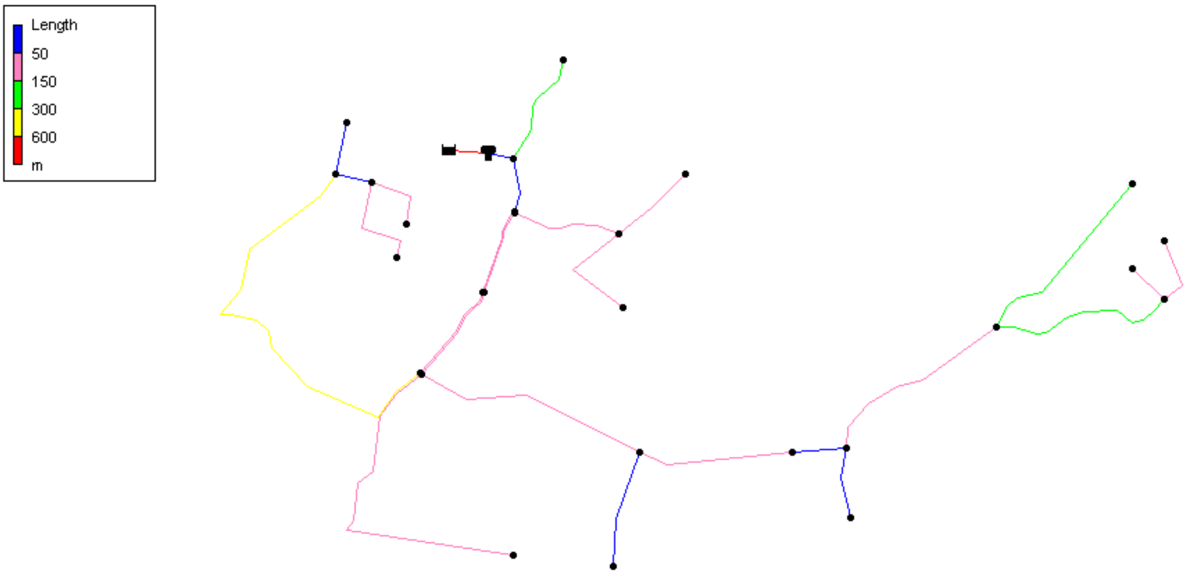


Fig. 15 – Length of Distribution Network Diagram

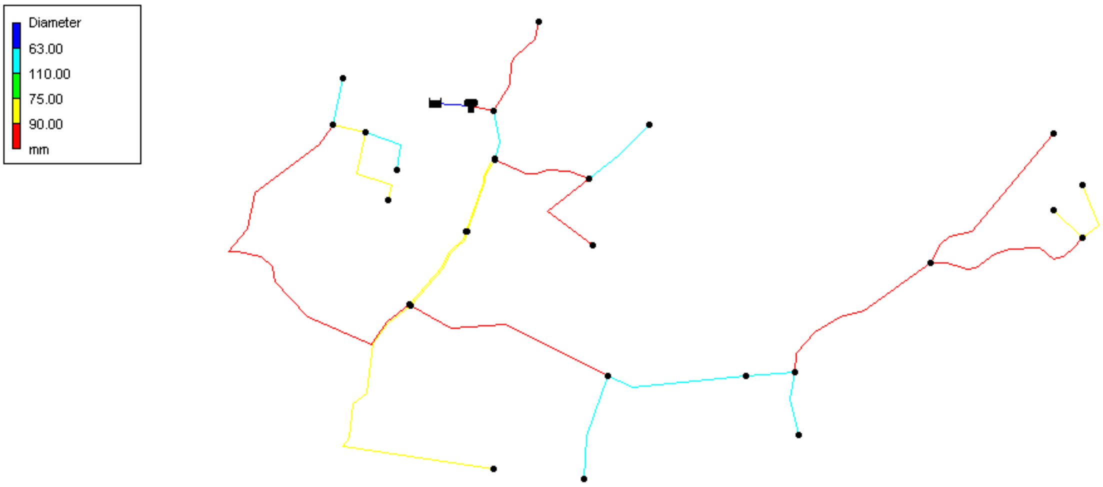


Fig. 16 – Diameter of Distribution Network Diagram

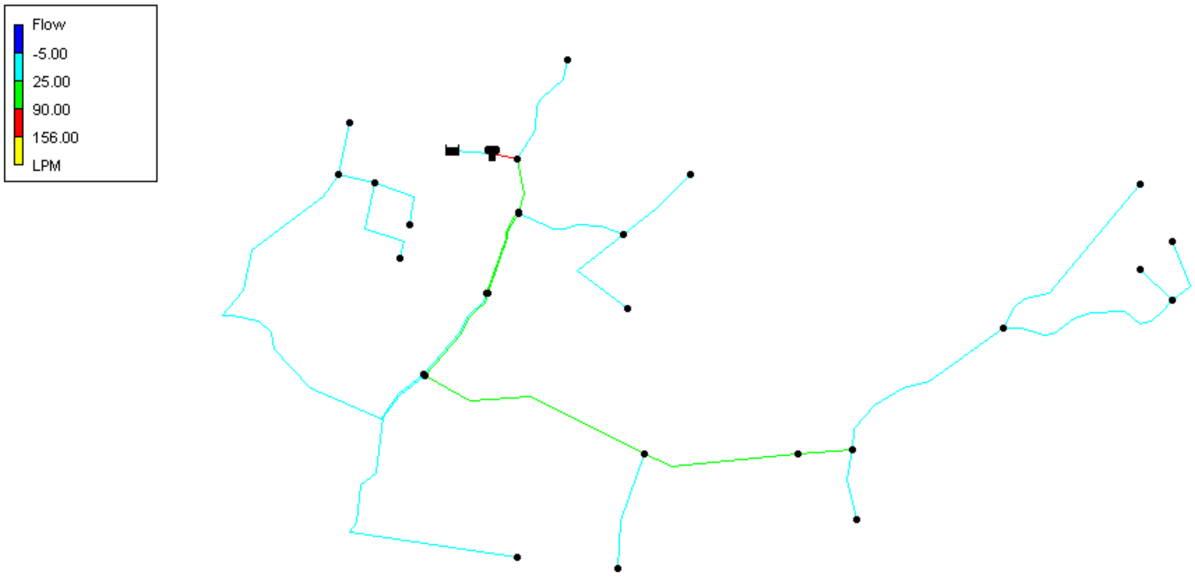


Fig 17 – Flow Distribution Network Diagram

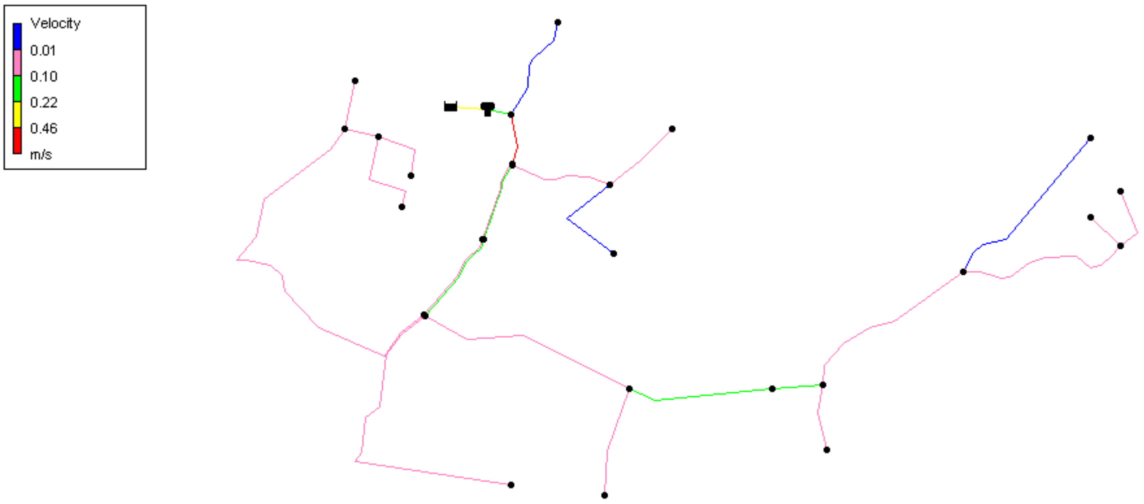


Fig. 18 – Velocity Distribution Network Diagram

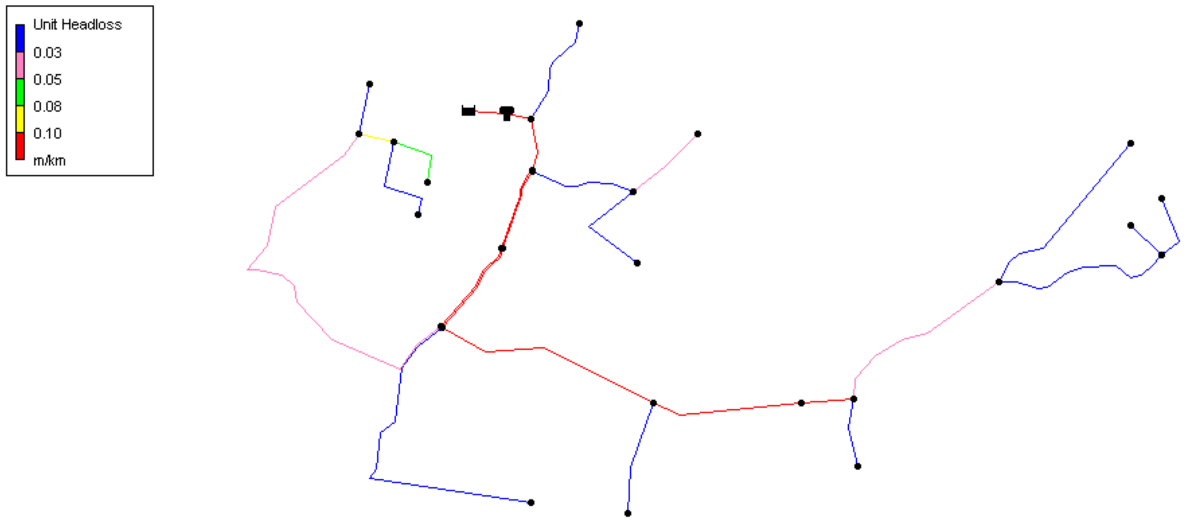


Fig. 19 – Unit Head loss Distribution Network Diagram

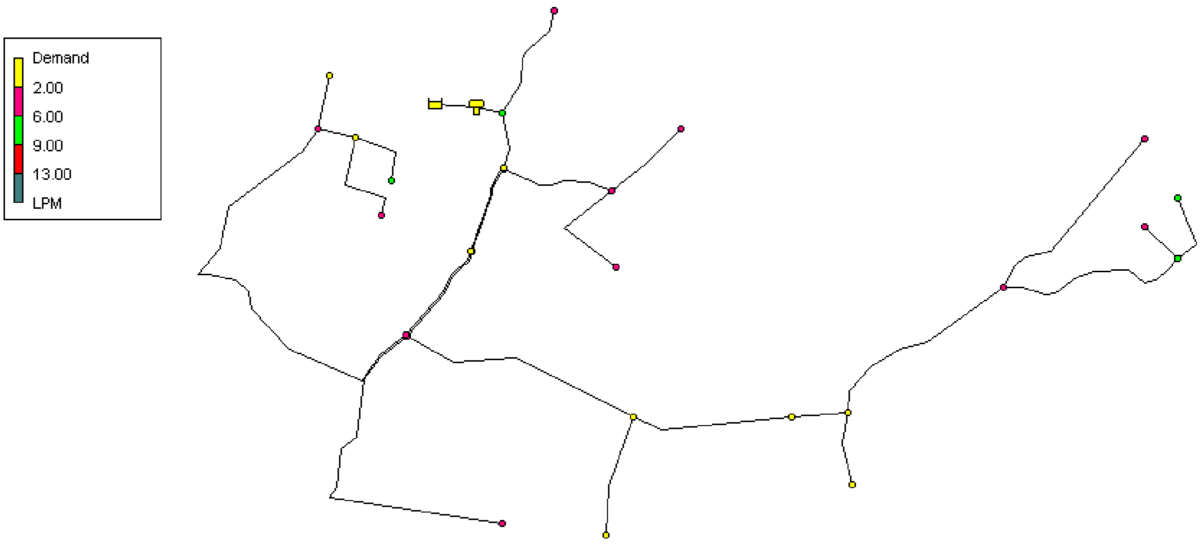


Fig. 20 – Demand Distribution Network Diagram

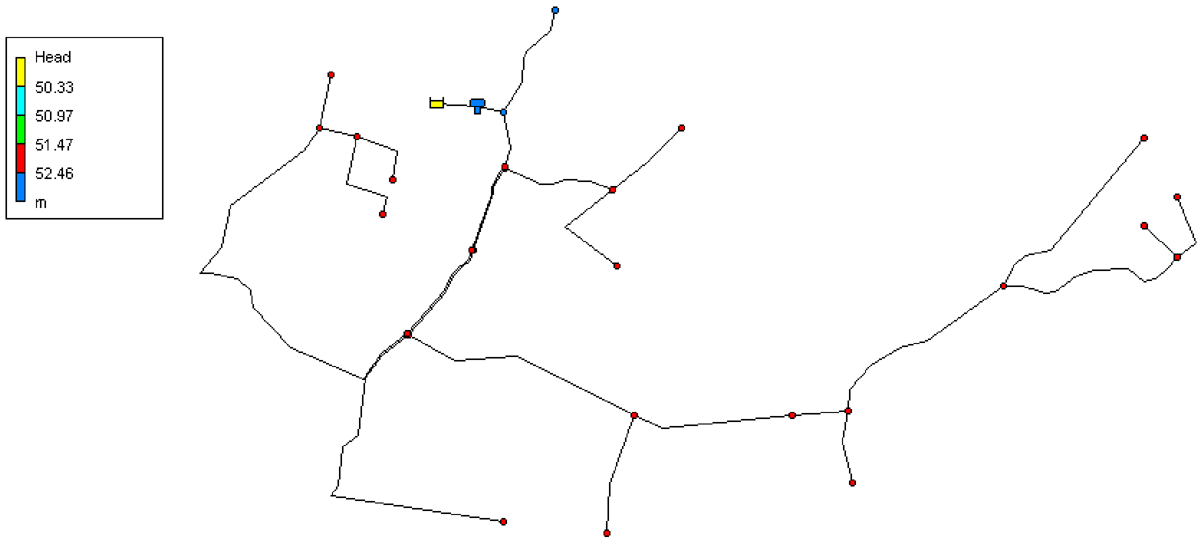


Fig. 21 – Head of Distribution Network Diagram

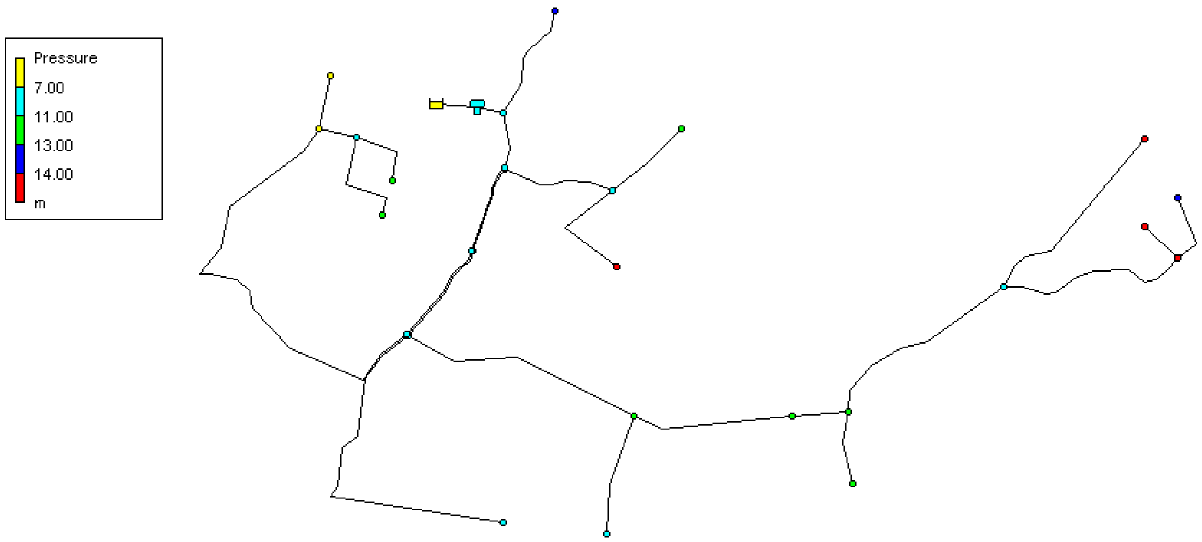


Fig 22– Pressure Distribution Network Diagram

CHAPTER 6

CONCLUSION

6.1 GENERAL

The design of Water Distribution Network of Hasila Bill area is successfully completed. The following conclusions have been summarized –

1. The main purpose of this design is to make it sustainable to its ultimate period year. The pipe material we have recommended to use for this network is High Density Polyethylene (HDPE) which is cost effective.
2. The design is laid according to the master plan of the roadways of the study area in view of the extension of the area in future so that extension of the network can be done easily without changing the previous layout.
3. We have calculated the pressure, velocity and demand of the new design and shown it for a better understanding of the readers as well.
4. We have compared the results of both the networks and found out that the new network results are more effective as we have provided large diameter pipes and extra nodes.
5. We have got effective demand, flow, velocity and pressure results as compared to existing network.
6. The network has been designed to maintain sufficient pressure and flow rates across all nodes under normal and peak demand conditions, ensuring reliable water delivery to consumers.
7. The layout minimizes energy consumption and reduces operational costs by optimizing pipe diameters, pump placements, and storage capacities.
8. This network accounts for potential population growth, land-use changes, and future demand increases, incorporating flexibility for expansion.
9. Environmental impacts were considered, with efforts to reduce water loss through leak-proof materials and efficient distribution practices.
10. Such Water Distribution System design help us to get proper idea of the planning and management of areas with a better view and encourages us to design such networks in the future.

6.2 FUTURE SCOPE

The future of water distribution network design stresses innovation, sustainability, and agility to address shifting issues and possibilities. EPANET is used to do more complex dynamic assessments, such as modelling changes in water quality, pressure transients, and time-varying demands, in future EPANET can be used to design complex networks for large cities as well. EPANET is highly recommended software for the distribution network design purpose in the future because it gives the velocity, demand, pressure and values of other required parameters with minimum input data.

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