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MODELLING OF WATER DISTRIBUTION NETWORK USING EPANET

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Abstract:
The main objective of this study is to design the water distribution network for Nandimangalam village, Kattumannarkoil Taluk of Cuddalore District using EPANET Software. The principal parameters required to run the software for the study are area contour map, road network map, population and water demand. The performance of EPANET software simulates the hydraulic behavior of the pipe line junctions, nodes, reservoirs, pumps and valves. The simulation of software on hydraulic behavior to design and analyze the water distribution network endow with the information on various demands, losses, pressures, head and flow of water in each pipe etc. Using EPANET the water distribution network was carried out in this study. The performance of EPANET software provides sufficient water to the distribution network.

Keywords: Demand, design, EPANET, flow, pressure, water distribution network.

1. INTRODUCTION

Water is one of the most important factors for the sustainability of life. Water covers about 70% of earth's surface and the fresh water available is about 1.7% as surface and ground water sources. It is important to monitor the adequate supply of potable water for specific area not only in terms of quantity but also the quality.

All developing countries are finding a new resource of water through underground and surface water to fulfill the water requirement, but they unable to succeed in supplying both quantity and quality aspects. A versatile supply of water management is necessitated due to the escalation of water demand. In the previous decade, global warming resulted in water scarcity almost in all countries. The resulted water loss showed great impact on the economic, social and environmental costs. The most important mission of the water management body is to supply water of essential quantity to each customer with adequate pressure. The distribution of water through a network is not an easy task to supply with quantity and quality aspects. While designing the water distribution network parameters with respect to quantity and quality must be considered invariably with flow of water. Only for few hours per day most of the cities in India are acquiring water. The most common problems faced by the customers are irregular pressure with sporadic water supply.

This study aims to design the water distribution network using EPANET. With this focus the specific objectives of the present study are to generate the thematic layers for village map using ILWIS and to design the pipe network for the future demand.

2. LITERATURE REVIEW

Harshan et al., 2018 designed a water distribution network using EPANET software, for a small area in vettompanchayat and it is validated using Hardy-cross method. The results inferred that Hardy-cross method took about 40 iterations to complete single loop. The results of EPANET and Hardy-cross methods are almost same. The results proved that EPANET software is an uncomplicated tool for the design of water distribution network. **Alkali et al., 2017** proposed a water supply network using EPANET software and conformed to the design criteria established by the previous designers of the Scheme. The anticipated water demand for the year 2031 was 450 LPS with 1.24 m/s flow velocity was predicted using the EPANET software which has been proved to be an efficient tool for hydraulic analysis and in design of water distribution network (**Singh and Turkiya 2013**). Due to Pressure/head dependent and Demand driven the consumers are suppose to go for illegitimate tapping of water to accomplish their water demand, which in turn frequently exerts surplus demand and enhanced recontamination probability towards consumer side (**Karadirek, et al., 2012).** Irregular supply of water may results in intrusion of contamination into the pipes during non-supply hours (**Kelkar, et al., 2002**). Water quality related problems within water distribution network includes interaction between the pipe wall and the water and reactions within the bulk water itself (**Brown, et al., 2011**).

3. EPANET

EPANET is a software package published by the National Risk Management Research Laboratory of United State Environment Protection Agency in 2000. Normally, it is used in water system simulation and hydraulic behaviour design with pressurized pipe networks. Constructing the distribution of water systems, calibrating and tuning the coefficients of water systems are the main functions of EPANET. EPANET is a 3rd generation software package for modelling water

distribution networks. This programme performs extended period simulation of hydraulic and water quality conditions within pressurized pipe networks.

This study aims to Design the water distribution network using EPANET. With this focus the specific objectives of the present study are to generate the thematic layers for village map using ILWIS and to design the pipe network for the future demand.

4. WATER DISTRIBUTION NETWORK

The components of water distribution network are reservoirs, pipes valves pumps etc. The most the components are exposed to internal pressure, corrosion and stress through soil and environment. The primary task in designing a water distribution network must distribute the preferred quantity of water to the consumer end with reasonable pressure. Through this network design components of water distribution network confirms the competence of water distribution network (**Mays 2000).** The optimal design approach in distribution of network has been identified for effective design. The network system have to be modeled, analyzed, and its performance is evaluated under the various physical and hydraulic parameters or conditions (**Amir et al., 2008 and Ioan et al., 2011**).

5. STUDY AREA

The present study is undertaken as a part of proposed water distribution network project to quantify existing intermittent and proposed continuous supply scenario for Nandimangalam village, Kattumannarkoil Taluk of Cuddalore District. Fig. 1 presents the location map of the study area, Nandimangalam village, Kattumannarkoil Taluk of Cuddalore District. Nandhimangalam is a small village having area of about 274.69 hectares near Chidambaram. It is about 15 km from Chidambaram. It comes under Kattumannarkoil Taluk of Cuddalore district. Nearly 1248 people live here. Agriculture is the main activity in the village. The study area is situated at the coordinates 11.27°N 79.66°E , and located along the banks of the River Kollidam. The study area receive water supply for about 1 hour per day from 6:30 a.m. to 7:30 a.m. Water is supplied from Elevated Service Reservoir (ESR).

The total number of houses in the village counted through topography map of study area is about 312. A total of 1248 members per house has been accounted and consumption per person has been taken as 135+10 lpcd, 10 lpcd taken into account for unaccounted flow. Total lpcd comes around 180960lpcd for the chosen study area.

Fig. 1 Study Area Map

6. METHODOLOGY

The data required for this study are contour map, water supply network map, node map, water demand, population and finally EPANET software. For EPANET model application, the water supply network map, node map and elevation map were generated and geo-referenced using ILWIS software. EPANET, in general operates under "Demand-driven"

assumption - wherein, the nodal demands are assigned fixed values and the problem is to find pipe flows and nodal pressures that are hydraulically consistent with the nodal demands (Rossman, 2004). The Hazen-Williams formula as given below was used to calculate the hydraulic head loss

$$h_L = 4.727C^{-1.852}d^{-4.871}q^{1.852}L$$

Where,

hL - head loss
C - hazen-williams roughness coefficient
d - pipe diameter
q - flow rate
L - pipe length

The steps involved in hydraulic modeling are as follows:

1. Satellite Image of study area from Google Earth Collection.
2. Geo-referencing of satellite image of study area using ILWIS.
3. Preparation of Base Map
4. Collection of Population data and Water Demand Associated with Geometry of Network
5. Collection of Pipe, Node, Reservoir, Valve Data for Network
6. Simulation of Network
7. Run the hydraulic analysis
8. Hydraulic Report Analysis

7. RESULTS AND DISCUSSION

In the study area it has been observed that some of the critical areas have been identifies and variation in parameter is observed. Hydraulic parameters such as velocity, head, and flow unit head loss for each node and link which are presented in the following figures. Figures 2 to 4 represents the results of ILWIS software to prepare a base map for network analysis. The results of hydraulic analysis (Figs. 5 to 11) using EPANET software are being represented by graph plotted between the following outputs such as flow, velocity, pressure, elevation, demand and head.

At the end of the hydraulic analysis Figs. 5 to 11 inferred that the resulting pressures at all the junctions and the flows with their velocities at all pipes are adequate enough to provide water to the study area. The hydraulic analysis results inferred that the pipes connected to the tanks as distribution pipes to the other pipes have smaller diameters. It was observed that the network on the topographical map have wide coverage of water distribution system to all parts of the study area.

The results inferred that the entire network has uniform flow and velocity and every node receives enough pressure and there is no deficiency in demand. However, some of the area has to be improved to achieve desired pressure levels.

Fig.2 Satellite Image of study area from Google Earth Collection.

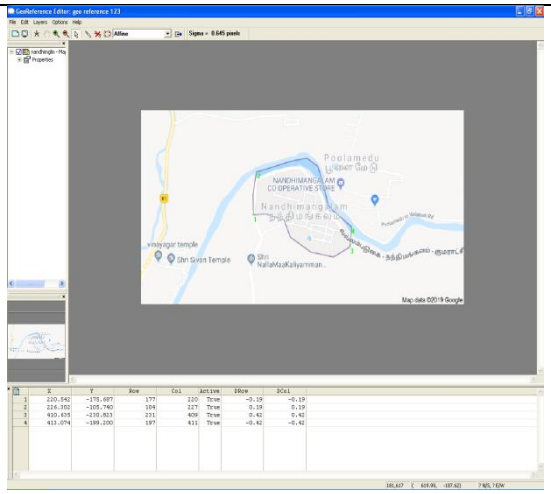

Fig.3 Geo-referenced image of study area using ILWIS

Fig. 4 Prepared Base Map

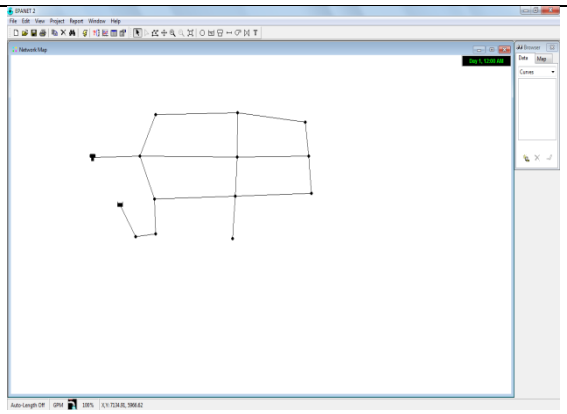

Fig. 5 Pipe line Network

Network Table - Nodes

Node ID	Elevation ft	Base Demand GPM	Initial Quality
Junc 1	30	0	0
Junc 2	25	60	0
Junc 3	20	40	0
Junc 4	20	30	0
Junc 5	20	30	0
Junc 6	22	50	0
Junc 7	30	40	0
Junc 8	25	36	0
Junc 9	25	40	0
Junc 10	20	35	0
Junc 14	22	50	0
Junc 15	22	50	0
Resvr 12	800	#N/A	0
Tank 11	850	#N/A	0

Fig. 6 Network Table Representing Nodes

Network Table - Links

Link ID	Length ft	Diameter in	Roughness	Bulk Coeff.	Wall Coeff.
Pipe 1	118.11	14	100	0	0
Pipe 2	448.622	14	100	0	0
Pipe 3	229.133	12	100	0	0
Pipe 4	160.170	14	100	0	0
Pipe 5	158.989	14	100	0	0
Pipe 6	1000	12	100	0	0
Pipe 7	346.784	14	100	0	0
Pipe 8	249.344	12	100	0	0
Pipe 9	160.170	12	100	0	0
Pipe 10	158.989	12	100	0	0
Pipe 11	453.838	16	100	0	0
Pipe 12	242.257	16	100	0	0
Pipe 13	151.673	14	100	0	0
Pipe 14	131.234	12	100	0	0
Pipe 16	106.62	18	100	0	0
Pipe 17	73.162	18	100	0	0
Pipe 18	86.459	18	100	0	0

Fig. 7 Network Table Representing Links

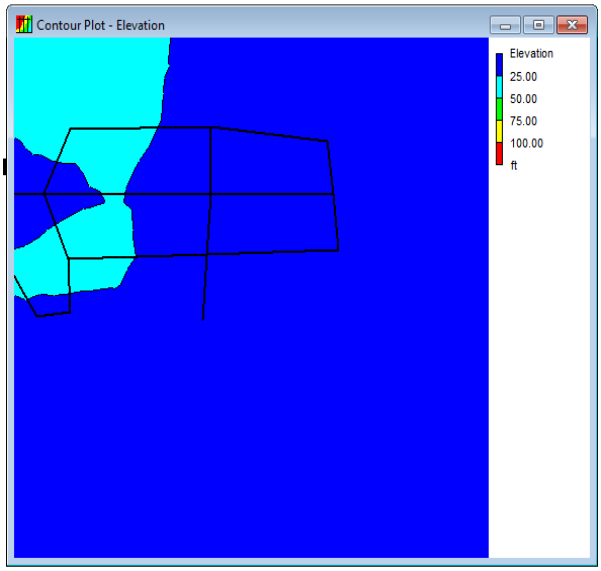

Fig. 8 Contour Plot of Elevation

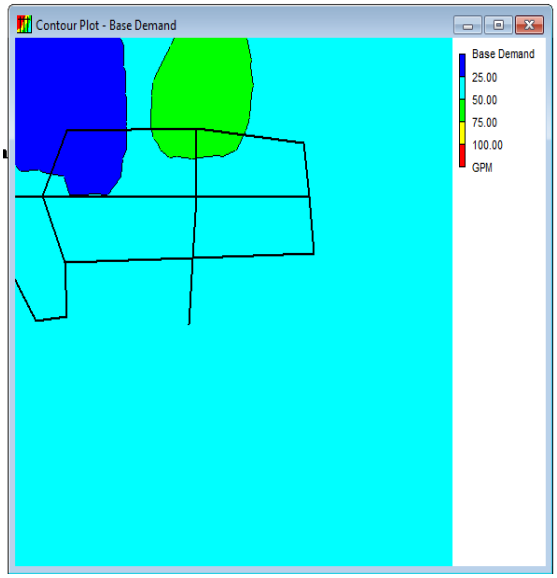

Fig. 9 Contour Plot of Base Demand

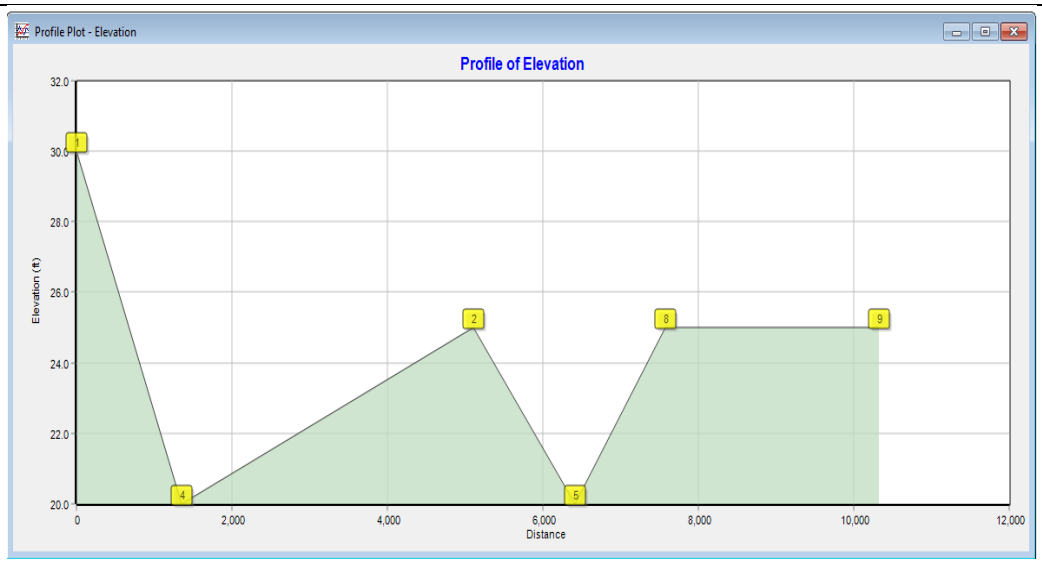

Fig. 10 Profile of Elevation

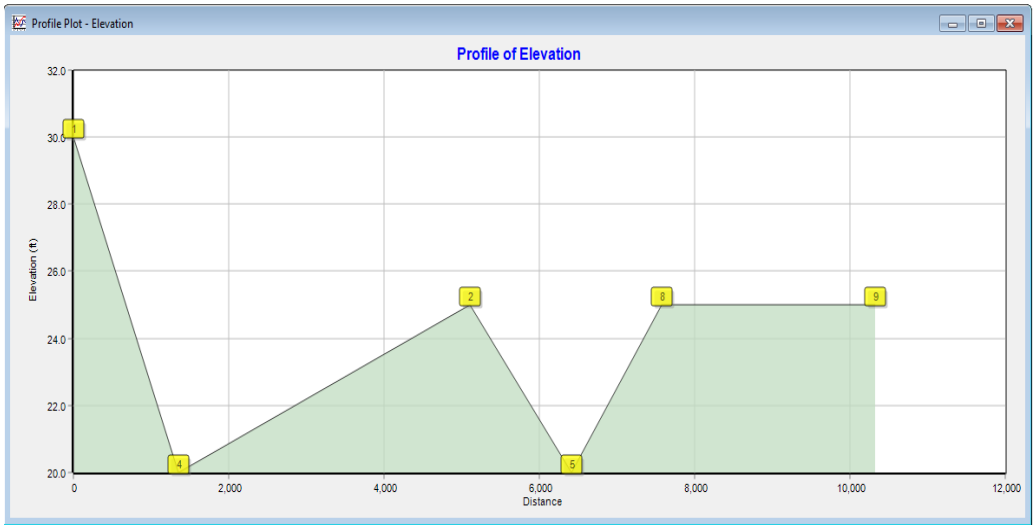

Fig. 11 Profile of Elevation

8. CONCLUSIONS

The hydraulic analysis using the EPANET software provides the information about various demands, losses, pressures and head of the network. The proposed design of water distribution system in the study area meets the daily requirement of water for the domestic demand. The entire network has uniform flow and velocity and every node receives enough pressure and there is no deficiency in demand. Nevertheless, some of the area has to be improved to achieve desired pressure levels. EPANET software would help to design the pipe network under the conditions of uncertainty in input parameters.

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