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A REVIEW OF MODELING AND APPLICATION OF WATER DISTRIBUTION NETWORKS (WDN) SOFTWARES

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***Abstract*- Water is an essential element required for the sustenance of life. Demand for drinking water is increasing on continual basis with corresponding increase in population. This ever increasing demand can be fulfilled by designing efficient water distribution networks based on advance computing systems include modern hydraulic modeling and designing softwares. Extensive review has been carried out for softwares used in designing water distribution networks and data management of hydraulic properties of networks. Softwares for water distribution include public domain softwares like EPANET, Branch and Loop as well as commercial softwares like Aquis, WaterGEMS, WaterCAD, etc. Water distribution system designing softwares differ from each another in various aspects include their functionality, compatibility to different computational systems; graphical user interfaces (GUIs), searching and optimizing algorithms, languages and programs used in their developments. The choice of water distribution network software is based on the availability of the data, time, financial implications, resources, applicability and overall purview of the project.**

***Keywords*-** Water Distribution Networks (WDN), Graphical User Interface (GUI), Modeling, Optimization, Software.

I. INTRODUCTION

Drinking water is one of the fundamental elements required for almost all biotic components to carry out their different fundamental activities of life. Water required for drinking purpose is further stressed by continuously increasing population and in order to fulfill this ever increasing demand at urban as well as rural level, there is a need to replace the traditional and obsolete methods of designing water distribution networks with accurate, speedy and computer based softwares and methods. Designing of water distribution networks is a critical part of the water supply system which contributes for the major share of overall expenditures incurred in it so as to systematic and proper design as well as modeling becomes the crucial one. Advancements in the field of water supply and the usage of computers in it has urged field experts, scientists, research scholars, developers and programmers to develop number of softwares for the design and modeling of water distribution networks including public domain softwares like EPANET, Branch, and LOOP as well as commercial softwares like Aquis, H2O map, KYPipe, WaterCAD, WaterGEMS, etc. The present paper undertakes the review of various softwares available for designing and modeling of the water distribution networks (WDN) developed over the period of time and advancements in them with respect to design algorithms, modeling efficiencies, compatibility to different computing systems, flexible inputoutput systems, etc.

To review the various softwares and its applications, the paper is divided into two groupd viz., modeling softwares and its applications.

II. REVIEW OF MODELLING SOFTWARES

The various modeling softwares are available in market are of freewares as well as commercial. It can be used for designing of water distribution network with an appropriate ways. These are classified as below,

WaterCAD V8*i* (2014) is a hydraulic modeling software package comprised of wide range of functionality includes graphical and profiling advancements, flexibility in data archiving and representations, advancements in GUI and its customization, etc. Many features like hydraulic and water quality analysis, steady state and extended period simulations are also made to function with enhanced capabilities, strong data management along with AutoCAD and GIS integrations. The advantages of WaterCAD V8*i* over other softwares include simplified model building with geospatial modules and tools like LoadBuilder and TRex, water quality modeling, fire flow analysis, optimization and scenario management, etc. WaterCAD V8*i* is thus easy to use and versatile water distribution as well as quality modeling software packages accepted for variety of applications [17].

WaterGEMS V8*i* (2014) is a versatile hydraulic modeling software package with the advancements in the interoperability, optimization of networks; model building supported with geospatial tools and asset management tools. WaterGEMS V8*i*

is highly efficient and dynamic modeling software which provides the wide regime of analysis and solutions for fire-flow analysis, water quality modeling, energy and capital cost management, etc. Many of the features and functions are common in WaterCAD V8*i* and WaterGEMS V8*i* which are streamlined model building, integration with the GIS and AutoCAD functionalities, optimized model calibration, design and its operations. The best part in the WaterGEMS V8*i* is the presentation of obtained results which is very attractive and appealing and can be presented with variety of graphical tools include ArcMap visualization, thematic mapping, contouring, profiling with color coding and symbology. With the ever increasing number of users WaterGEMS V8*i* has proved that WaterGEMS V8*i* is one of the most popular and user friendly hydraulic modeling and optimization software package. WaterGEMS V8*i* has strong design algorithm to meet the criteria of accuracy in design of water distribution networks, control of distribution network variables like flow, pressure, and velocity along with their optimization [18].

Branch (2014) is public domain optimization software in which program is developed to design the branched water distribution networks. Branch software takes certain parameters like elevation data, pipe lengths, coefficient of friction and demand of nodes as inputs over the cost as function. The output is optimized length and diameters of pipes so that overall cost of network is the least one [16].

DisNet (2014) is powerful and efficient water distribution software and offers great simplicity in building water distribution networks. Key strengths of DisNet include its simplicity and appealing user interface with maximum accuracy in output with optimum input details. Along with design of water distribution, DisNet is used in the modeling of stream hydrology, generation of unit hydrographs and establishing interrelationships between them. DisNet is integrated with CAD as its inbuilt management tool and used in modeling different types of water distributions networks for different topographical conditions [12].

EPANET (2014) is public domain software which can be efficiently used to design any sort of network. It provides variety of advantages like water quality analysis, extended period simulation, residual chlorine calculations for disinfection, etc. It can also be used to renovate or restore the existing water supply systems. It is available as public domain softwares with the relative nomenclature as EPANET 2.0, EPANET 2d-2w [15].

HydrauliCAD (2014) is AutoCAD based water distribution software integrated with EPANET hydraulic analysis program. Fundamental understanding serves the purpose of building hydraulic model with it. HydrauliCAD possesses a feature of building query for addition and editing of different hydraulic parameters like head-loss, pressure, flow of distribution networks. HydrauliCAD provides inbuilt pipe catalogue comprises of detailed information about pipe material, classes and sizes. Along with water distribution HydrauliCAD is also used for fire-flow analysis.

HydrauliCAD is versatile software used by the modelers, field professionals and engineers [11].

WATSYS (2014) is water distribution simulation and modeling software based on Geographical Information System (GIS). WATSYS is efficiently used for designing new water distribution as well as for up-gradation of existing distribution network. WATSYS uses EPANET program as basis for water distribution and water quality analysis scenarios. WATSYS is easily integrated with AutoCAD to use CAD based drawings to develop and build hydraulic networks. WATSYS comprises of features like color-coded plans for making colorful visualizations of pressure, elevations and flows at different nodes, easy importing and exporting data files, in-built pipe catalogue, etc. WATSYS is efficiently used for simulation and modeling variety types of distribution networks [19].

Pipe2014 is the recent version of KYPipe hydraulic modeling software package which has a strong computational algorithm for the fluids essentially water. Pipe2014 can be used for the designing and selection of pumps, valves, tanks as well as pipes. It also includes the features like sizing of pipes and optimization of pump operations. Pipe2014 provides a very interactive and user friendly interface which offers extensive flexibility to users for the designing and optimization of distribution networks. Pipe2014 is compatible to integrate with GIS and variety of formats of images used for designing distribution networks [23].

Synergi Water (2014) is hydraulic modeling and simulation software package with the strong database management used for increasing the efficiency of existing distribution network as well as in the design and development of the newer one. Synergi Water provides the variety of advantages over other public domain softwares, as it provides versatile environment of tools for detailed and comprehensive modeling, performs speedy and accurate analysis of extremely large systems comprising of more than one lakh system components, water quality modeling and designing of complex systems with proper arrangements of pump, valves and tanks. Its integrity with the GIS and SCADA is extremely flexible which makes the remote operations simple and trouble free [20].

H2Onet and H2Omap (2015) are commercial softwares which are integrated with the GIS and used for design, analysis and optimization of different types of water distribution networks. It is advantageous for leakage detection and assessment, analysis of fire-flow and hydrant, costoptimization, etc. The most important feature which makes this software stand-out includes programmed and automated online SCADA interface. Its integration with GIS software provides different vector and

raster tools which supports wide range of spatial analysis, sampling, planning, evaluation and assessment of existing as well as newly developed water supply system [21, 22].

HYDROFLO3 (2015) is advanced version of HYDROFLO series and used to design variety of the distribution systems includes pumped flow, gravity fow, flow through pipes as well as open channel flows. HYDROFLO3 offers advantages of easy conversions between Metric and SI units, calibration and validation of existing networks, easy addition and editing of hydraulic parameters of entire distribution network. HYDROFLO3 provides a unique feature as Pump base used for the calculation of pump hydraulic characteristics required in forced flow systems. Along with water distribution networks HYDROFLO3 is used for simulation of treatment plants, chemical dosing systems, industrial applications, fireflow analysis, etc. It is comprehensive software package used to design variety of distribution networks with strong data management capacity [14].

Apart from these softwares large number of other hydraulic modeling and optimization softwares are available in the market which essentially include Archimede, Cross, Eraclito, Helix delta-Q, Netis, OptiDesigner, Wadiso SA, etc.

III. REVIEW OF APPLICATION OF MODELLING SOFTWARES

After reviewing of the various freewares and commercial softwares, it is essential to review their applications. Few of the applications are reviewed as below.

Ingeduld P. *et. al.* (2006) studied the intermittent water supply scheme with two case studies of Shillong, India and Dhaka, Bangladesh using **EPANET** software. The alternate emptying and refilling of water pipelines makes it difficult to apply standard EPANET based hydraulic models because of low pressure and empty pipes. The intermittent water supply systems are highly influenced by the low pressure and "dry pipe" situations and hence adjustment in basic EPANET source code has been carried out so as to design of water distribution network. Authors had developed a configurable tool for incorporating roof tanks into the water supply analysis and for better formulation and schematization of the system hydraulics. Results obtained from the hydraulic model of these two case studies, are incorporated in the algorithm of water distribution software packages, MIKE NET and MIKE URBAN of DHI hydro-informs [4].

Machell J., *et. al.*, (2010) has discussed about the data which is collected manually and do not reflect the exact scenario when the modeling is carried out. They attempted to simulate the water distribution network online with help of AQUIS 7T by accessing real time data from different sensors in water supply system. The online hydraulic simulation model demonstrates its potential by showing details of a flow event detected in the DMA (Distribution Management Areas). It is also discussed that the simulation of various DMAs have shown appropriate results for pressures at different nodes and provided early warnings in case of any problem for each pipe of model. Authors has concluded that the AQUIS 7T is very efficient online simulation software which results in realistic benefits at the managerial as well as at the consumer levels [6].

Arunkumar M., Nethaji Mariappan V.E. (2011) evaluated and assessed public water supply system with the help of EPANET 2.0 software for the systematic planning and operation of distribution system over the design period of 30 years. Hydraulic model is built and run with EPANET 2.0 for the "A" Zone, Thirumullaivoyal, Avadi city of Tamilnadu, India. The model testing and run has been carried out for 24 hrs supply and the intermittent supply of 6 hrs and resulting pressure at different nodes are checked. Pressure for intermittent supply has been observed almost double (24.03 m) that to pressure observed with 24 hrs supply (12.02 m). Equal pressure has been achieved throughout the model by providing pressure break and pressure release valves. EPANET 2.0 software has been efficiently used for the comparison of 24 hrs supply and intermittent supply of 6 hrs for public water supply system [1].

Ramesh H., *et. al.*, (2012) worked on generation of satellite based thematic layers, town and ward boundary maps and Geospatial Information System (GIS) based census data to estimate water demand, design of transmission lines and main pipe lines to meet the requirement of future demand for the case study area of Alnavar, Karnataka, India. They have also used GIS to integrate and estimate quantity of earth work through Digital Elevation Model (DEM). The pipe network system is simulated to understand its behavior for different inputs of demands using EPANET 2.0. The results obtained from EPANET 2.0 software are cross-checked against calculation with hydraulic equations and found accurate. The research work proved that present software is less tedious in nature and easily allows incorporating changes [9].

Mohapatra S. *et al.*, (2012) studied the efficiency of water supply system using EPANET and ArcGIS softwares. They had carried out the study at Untkhana, Nagpur, India for leakages in continuous as well as intermittent water supply system and the simulated results were reviewed. With continuous water supply system more pressure has been observed but it is less than 12.0 m. EPANET has successfully been used for simulation of both intermittent and continuous supply providing conclusion that avoidance of direct tapping to transmission mains and immediate repair of leakages can improve the system [8].

Gupta I., *et. al.*, (2013) has thoroughly studied the water distribution network of a small area from Punjab city, India. The

work basically includes design of water distribution network with help of EPANET software along with the study of hydraulic parameters required in design and corresponding variations in their functions and values. Design and development of network comprises of data collection, building water distribution model and calibration of it with bore-well as source of water supply. Comparison of pressure has also been carried out between results obtained from field survey and from the build model. The study showed that results obtained from EPANET based model and actual network are close enough to each other [3].

Elsheikh M. A., *et. al.*, (2013) has studied water distribution network of Tanta city, Egypt, for the design period of 10 years with the help of WaterCAD software to check the feasibility of existing distribution network with additional network of new pipes to serve new and additional areas. The WaterCAD software is applied to design and optimize the water distribution network considering severe problem of aging of pipes as well as to address the quality of water supplied. The application of various tools of WaterCAD like Darwin Designer, Pipe catalogue tools are found to be very effective in overall design and optimization of water distribution network [2].

Sumithra R.P., *et. al.*, (2013) has carried out the feasibility analysis of water distribution system of Tirunelveli Municipal Corporation, Tamilnadu, India with the help of LOOP and WaterGEMS softwares packages for design period of 30 years. The variety of analysis has been carried out yielding wide range of results for diameter of pipes, pressure at different nodes, cost analysis, etc. The network analysis has been done pertaining to the criteria of 135 lpcd water supply with the minimum head of 7.0 m. It has also been discussed as a result that LOOP and WaterGEMS softwares are highly efficient to do various hydraulic and costing analysis. WaterGEMS found extremely user friendly with variety of hydraulic and graphical analysis options. It is also less time consuming for the renovating and reanalyzing the network [10].

IV. SUMMARY

From the above review of the softwares and researchers analysis, it can be summarized that there are different commercial softwares and free-wares available in the market to design and optimize variety of water distribution networks ranging from simple to complex, realistic or even hypothetical. These designing and modeling softwares differ from each other in various aspects include their functionality, compatibility to different computational systems and requirements, graphical user interfaces (GUIs), searching and optimizing algorithms, languages and programs that are used in their designing and development. Some advanced softwares like Aquis2014, Synergi Water, H2Onet and H2Omap can be integrated with GIS and SCADA but still many other freewares like EPANET, Branch, etc., lacks these functionalities. Commercial softwares offer great flexibility in building different types of hydraulic models with variety of the features over public domain softwares. Thus, choice of softwares for water distribution networks design is based on the overall cost of project, data required by softwares, specificity of software related to types of distribution networks it can handle as well as its computational requirements.

V. CONCLUSION

This extensive review of softwares for designing and modeling water distribution networks concludes that the choice of design softwares are entirely depends upon the availability of the data, time, financial implications, resources, applicability, compatibility and overall purview of the project. Designing of Water Distribution Networks (WDNs) requiring modest accuracy can opt for free-wares but for the speedy and accurate designing of water distribution networks commercial softwares are needs to be adopted.

REFERENCES

[1] Arunkumar M., Nethaji Mariappan V.E. (2011), "Water demand analysis of municipal water supply using EPANET", *International Journal on Applied Bioengineering*, Vol. 5, No.1.

[2] Elsheikh M. A., Salem H.I.,Rashwan I.M. and El-Samadoni M.M. (2013), "Hydraulic modelling of water supply distribution for improving its quantity and quality", Sustain. Environ. Res., 23(6), 403-411.

[3] Gupta I., Dr. R.K. Khitoliya, Dr. Shakti Kumar (2013), "Study of water distribution network using EPANET", *International Journal of Computational Engineering Research,* Vol. 03, Issue 6.

[4] Ingeduld P., Zdenek Svitak (2006), "Modeling intermittent water supply systems with EPANET", 8th annual WD symposium EPA Cincinnati.

[5] IS 1172:1993 (2010), "Code of basic requirements for water supply, drainage and sanitation", fourth reprint, *Bureau of Indian Standards* as retrieved on 28 March 2015 from: https://law.resources.org/

[6] Machell J., S. R. Mounce, and J. B. Boxall (2010), "Online modelling of water distribution systems: a UK case study", *Drinking Water Engineering and Science*, 3, 21–27.

[7] Mahmoud A. Elsheikh, Hazem I. Saleh, Ibrahim M. Rashwan and Mohammed M. El-Samadoni Mohammed M. El-Samadoni (2013), "Hydraulic modelling of water supply distribution for improving its quantity and quality", *Sustain. Environ. Res.*, 23(6), 403-411.

[8] Mohapatra S., S. Kamble, A. Sargaonkar & P. K. Labhasetwar (2012), "Efficiency study of a pilot water distribution system using EPANET and ArcGIS10", *Conference CSIR-NEERI*.

[9] Ramesh H., Santhosh L.and Jagadeesh C. J. (2012), "Simulation of hydraulic parameters in water distribution network using

EPANET and GIS", International Conference on Ecological, Environmental and Biological Sciences (ICEEBS).

[10] Sumithra R.P. Nethaji Mariappan V. E., Joshua Amarnath (2013), "Feasibility analysis and design of water distribution system for tirunelvelli corporation using Loop and Watergems software", *International Journal of Applied Bioengineering*", Vol.7, No.1.

[11] http://hydraulicad.com as retrieved on August 21, 2014.

[12] http://techsoftglobal.com/disnetpage.aspx as retrieved on September 15, 2014.

[13] http://www.mikepoweredbydhi.com/products/mikeURBAN as retrieved on October 10, 2014.

[14] http://www.tahoesoft.com/html/hydroflo.html as retrieved on May 15, 2015.

[15] http://www2.epa.gov/water-research/epanet as retrieved on November 6, 2014.

[16] water.usgs.gov/software/branch.html as retrieved on December 15, 2014.

[17] www.bentley.com/WaterCAD-Spec as retrieved on January 6, 2015.

[18] www.bentley.com/WaterGEMS-Spec as retrieved on January 24, 2015.

[19] www.civilsystems.com/watsys.html as retrieved on February 15, 2015.

[20] www.dnvgl.com/software/synergi as retrieved on March 21, 2015.

[21] www.innovyze.com/products/h2omap_water/features.aspx as retrieved on April 20, 2015.

[22] www.innovyze.com/products/h2onet_water/features.aspx as retrieved on May 15, 2015.

[23] www.kypipe.com as retrieved on June 21, 2015.

[24] www.schneider-electric.com/product/aquis2014-us-web.pdf as retrieved on July 6, 2015.