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To cite this article: J.R Lim *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **849** 012094

IOP Conf. Series: Materials Science and Engineering **849** (2020) 012094 doi:10.1088/1757-899X/849/1/012094

Development of dead-end system calculation model for water reticulation design using Microsoft Excel with optimized algorithm: a case study at regional operations center (ROC) Melaka, Malaysia

J.R Lim*, S.R.M Kutty, A.A.S Ghaleb, N.M.Y Almahbashi, A.M. Al-Sabaeei

[1] Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia

Abstract. This paper presents computation of Dead-End System for Water Reticulation using Excel Spreadsheet. An on-going project entitled Regional Operations Center (ROC) located in Melaka, Malaysia was taken as a case study for this research in which all the information needed such as water demand, tapping pressure and location were referred. In a Civil and Structural consulting firm, a great amount of time (approximately 5 hours) had been taken in performing Dead- End analysis. Furthermore, the computation of design by the engineers is a tedious process as the previous spreadsheet contains wrong and insufficient information. With that, this research is aimed to design a Dead-End System Calculation which can compute the necessary information needed in Water Reticulation. As well, the study aims to verify the accuracy of the above said calculation spreadsheet by using EPANET which is a modelling tool for drinking water distribution. This research was done first by designing the calculation spreadsheet using preliminary information from ROC. Then, the exact same design was computed by using EPANET. Next, comparison of results taken from both methods was carried out. Lastly, the comparison on time taken to compute water reticulation design between the previous available spreadsheet and the calculation spreadsheet designed through this research was done. The verified calculation spreadsheet will allow users to get hydraulic information such as velocity, optimum pipe size, residual pressure and total head loss.

1. Introduction

Water is one of the renewable resources because of its natural life cycle. Water is widely but irregularly distributed in the space and Earth [1]. However, 97% of water comes from the seas and oceans which do not support our daily usage. With its large volume, it created the illusion that water is ample and abundant. In reality, we only have about 3% of our planet's fresh water that can be used for drinking, and other daily usages for both humans and nature. Fresh water is a limited resource on the Earth and it is precious considering its function. Not only for consumption, human and other living things on this planet need water for living and continuing their daily activities. Most of it (about 69%) are found in glaciers and icecaps while around 30% is stored in groundwater. The rest of the water is found in rivers, swamps, lakes and others which only contribute to small portion (0.3%) of fresh water of the Earth [2].

To support on-going human activities and also the natural water cycle without being disrupted, a proper water reticulation is needed. We should not take advantages that water is inexhaustible resource and use it foolishly. In recent year, with the increasing growth in the population and with the demand of higher quality and standard of living, problems related to water has been raised and have caught people's attention [3]. People need a proper water reticulation system to support good health especially. In South Africa, Australia and New Zealand, water reticulation system is referring to the piped water network [4]. However, this terminology is now widely used to mean water supply system. Mostly every city has a water reticulation system either complete or imperfect one to serve the needs of the citizens. We are said to be served with well water reticulation system when we turn on the tap in kitchen or bathroom and we get immediate access to a clean and treated water supply [5].

In any development such as residentials, factories or commercials, water reticulation must be included as a part of the development. This project deals only with external water reticulation work. For the source of water, it can either be tapped from the water supply mains or from the water reservoir directly. In order to start designing for water reticulation works, the engineers have to seek for states' water agencies for tapping point information. Prior to submission, the engineers have to compute water demand for the proposed development. The officers will then provide tapping information that fulfill the demand requirement from the nearest supply mains or reservoirs. The tapping information normally includes the tapping location, size and type of existing pipes and the residual head in it. From the information given, engineers can start designing for external water reticulation to deliver water from the source to different storage tanks available in the development complying to different hydraulic requirements from the authorities. Originally, spreadsheet is used by the engineers to compute for water reticulation design.

There are two major problems in designing water reticulation system. First, traditionally, engineers often took long time (approximately 5 hours) in designing water reticulation system. They have to source for different information in order to get the design done. For example, they have to get the schedule of area from architect or planner, and then compute the water demand based on Uniform Technical Guidelines Water Reticulation and Plumbing. With the water demand, only the engineers can start design for water reticulation design provided that the details and location of tapping point are given. Second, previously, there is no single spreadsheet to compute water reticulation design perfectly. The available spreadsheet was confusing and contained wrong formulas. This results in additional efforts from the users to amend the spreadsheet prior using. Repetitive amendments by engineers will also result in inefficiency of performance.

The objectives of this study are to propose a viable solution to the issue of tedious process needed for computing water reticulation design by developing a calculation spreadsheet that can be used repeatedly for different projects for water reticulation design using Dead End or Tree System and to evaluate the accuracy of the calculation spreadsheet by verifying the result against computerized analysis using EPANET.

2. Case Study of Regional Operations Center (ROC) in Melaka

2.1. Project Description
Edaran SWM SDN BHD is proposing to develop 47.69 acres of land for a regional operations centre at Lot 22337 (Grn 56241), Mukim Tanjong Minyak, Daerah Melaka Tengah, Negeri Melaka, Malaysia. Generally, the proposed development is consisting of administrative offices, maintenance facility, operations deployment facility, staff quarters area & fleet parking area. The proposed development is located nearby Lebuh SPA, and Kampung Bertam Ulu. It is easily accessible from Lebuh SPA. Figure 1 shows the location plan of the project.

Figure 1. Location plan of ROC

2.2 Water Demand Estimation
There are diverse demand of water depending on the type of development constructions. The daily demand

changes according to climate and festival events [6]. In many states in Malaysia, January and February have higher water demand, most probably caused by the hot weather starting of the year. The demand in some urban areas experiences lower water demand during festive seasons as most of the factories shut down. On the other hand, rural areas will have higher water demand during that period as people leaving their workplaces and back to hometowns.

The breakdown of the water demand is summarized in Table 1. The water demand has been estimated based on Uniform Technical Guidelines Water Reticulation and Plumbing in Malaysia. The total water demand required is 172620 lpd / 45601 gpd.

Table 1. Water demand estimation

No.	Type of Building	Water Demand (Litres)		Quantity		Total Water Demand (litre/day)	Total Water Demand (gallon/day)
1.	Administration Office	1000/100	m^2	3,010	m^2	30,100	7,952
2.	Maintenance Facilities	1500	per unit	7	Unit	10,500	2,774
	-Workshop Office	1000/100	m^2	240	m^2	2,400	634
	-Meeting Room and Pantry	1000/100	m^2	70	m^2	700	185
	-Workers Surau	50	per person	200	Person	10,000	2,642
	-Workers Toilet	50	per person	200	Person	10,000	2,642
	-Operation / Mechanics Shower Room	50	per person	200	Person	10,000	2,642
	-Vehicles Washing Bay	40000	per unit	1	unit	40,000	10,567
3.	Operations Deployment Facility	1000/100	m^2	282	m^2	2,820	745
4.	Staff Quarters Area	1100	per unit	51	unit	56,100	14,820
Total						**172,620**	**45,601**

2.3 Proposed Tapping Location of Water Supply

The water supply tapping shall be obtained from the existing 200 mm diameter MSCL water pipe near Lebuhraya SPA obtained from SAMB which is shown in the figure below:

Figure 2. Tapping Location from SAMB

3.0 Water Reticulation Design

In this water supply reticulation design, Dead-End water supply pipe design is adopted for both domestic pipe and hydrant pipes. The design including all the formula and tables are based on SPAN Uniform Technical Guidelines. Major friction losses are computed based on Hazen – William Pipe Formula. Hazen William Coefficient, C for various pipe material is shown in Table 2:

Table 2. Hazen William Coefficient, C

Type of Pipe	Hazen William Coefficient, C
Ductile Iron (cement Lined)	100
Steel (Cement Lined)	100
HDPE/ ABS/ GRP/ uPVC	120

The proposed water pipe after the suction tank / elevated tank is under Mechanical & Electrical (M&E)'s scope of works (Internal Water Reticulation). The highest supply level (TWL/HSL) of the development is 35.20 m ODL. Bottom water level is 30.70 m ODL. ½ of Top Water Level is 32.95 m ODL. The Highest Supply Level is the summation of Floor Finish Level (30.70 m) and Water Tank Height (4.5 m). Different sizes of MSCL pipes have been adopted in this proposed water supply system which are having internal diameter of 100, 150 and 200 mm. Also, the selection of pipe is based on advises of local water technical department and also based on the Uniform Technical Guidelines. Lastly, all piping materials, valves, hydrants, and specials shall be in accordance with SPAN's requirement and approval. There are 9 nodes and 8 pipes altogether in this project.

3.1 Functions and Criteria of this Calculation Spreadsheet

The calculation spreadsheet should be able to calculate water demand, velocity of water in pipe, total head loss, residual head, optimum pipe sizes and some other hydraulic parameters. The water reticulation design is semi-automated such that users are required to provide some necessary information as input to obtain desirable solution. For example, the users can input the desired and available pipe size in the spreadsheet, but software will perform the calculation and show the pipe size that might not available in the market. Besides, no transferring of data needed from the calculation of water demand up until getting the desired information. One single spreadsheet is able to perform the whole Water Reticulation Design. However, for instant EPANET, the users have to manually calculate the water demand before the information can be used in EPANET. Also, all the design parameters and design criteria can be set in the spreadsheet and it will tell whether the calculated output follows the design criteria imposed for external water reticulation in Malaysia.

3.2 Algorithm of Calculation Spreadsheet

There are different tabs in the calculation spreadsheet to compute water reticulation. First of all, the spreadsheet starts by computing the total water demand through the water demand stated in SPAN Uniform Technical Guidelines Water Reticulation and Plumbing. After that, the spreadsheet is able to compute the water demand for each node which will eventually equal to the total water demand computed in the first tab. Then, in tab 3, the water reticulation design starts. In the first page of the tab, all the design criteria had been set with specific colour wordings and some with highlighted cells. In page 3 until the pages required, the spreadsheet is able to compute the water reticulation design for each node depending on the number of nodes available in the project. By doing that, the users need to input the desired diameter of pipe and the length of pipe connecting from the node to its subsequent node which the cells will be filled in yellow colour for prompting function. For the subsequent page, it is for pressure checking. It starts by inputting the ground level of node. Then, the users need to input the approved total tapping pressure obtained from the water agency. After that, the Highest Supply Level is needed to be inputted. Lastly, in page 2, the summary of the analysis will be given consisting pipe and node details. Figure 3 shows the algorithm of the calculation spreadsheet.

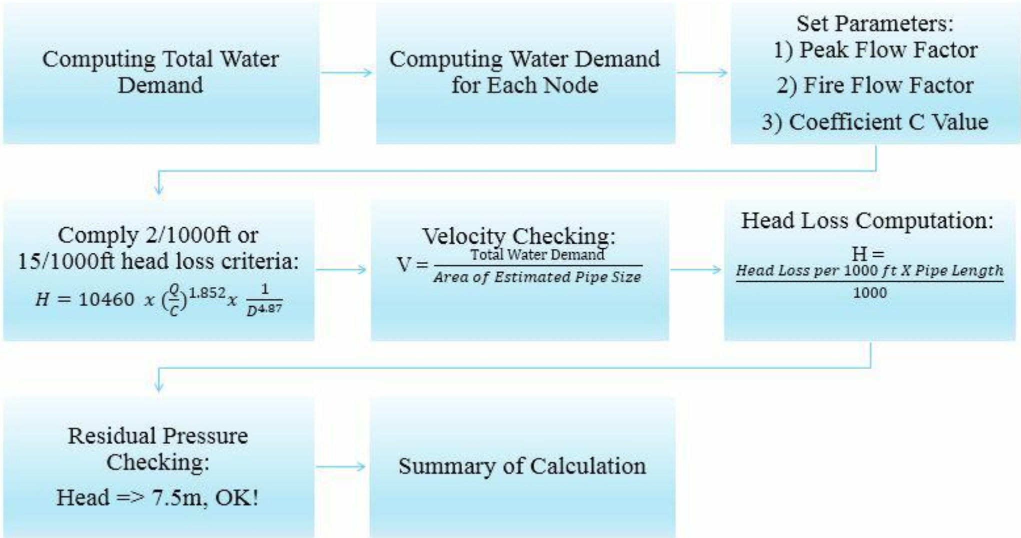


Figure 3. Algorithm of Calculation Spreadsheet

3.3 From the Spreadsheet

Head Loss checking is done by using formula,

$$\boldsymbol{H = 10460\ x\ \left(\frac{Q}{C}\right)^{1.852} x \frac{1}{D^{4.87}}} \tag{1}$$

Velocity checking is done using formula,

$$\boldsymbol{v = \frac{Total\ Water\ Demand}{Area\ of\ Estimated\ Pipe\ size}} \tag{2}$$

Total Head Loss is calculated by,

$$\boldsymbol{H = \frac{Head\ Loss\ per\ 1000ft\ x\ Pipe\ Length}{100}} \tag{3}$$

Residual pressure checking is done by ensuring that enough pressure head is supplied to the end users while complying the minimum pressure head required stated in design criteria.

4. Results and Discussion

4.1 File Type Conversion
In this project, EPACAD software was utilized to convert pipes and nodes of drawing in AutoCAD file into EPANET file. EPACAD is a free programming software which effectively converts an AutoCAD file into an EPANET acceptable file (.dxf) which is the most generally utilized free programming for modelling of pressurized water systems [7]. EPACAD can consequently import the principle properties of components, giving the expected data to construct a system. It was done for time saving and to get the exact drawing from AutoCAD file.

4.2 Building the Model
4.2.1 Peak Flow
For peak flow, some modifications were done on the pipes arrangement to simplify the analysis which can be seen below in Figure 4. Besides, all the nodes and pipes were named accordingly to ease result comparision later. The symbol of Node 1 is different with other nodes (junctions) as it was tapping point location. The tank symbol was used as an representation for tapping point location.

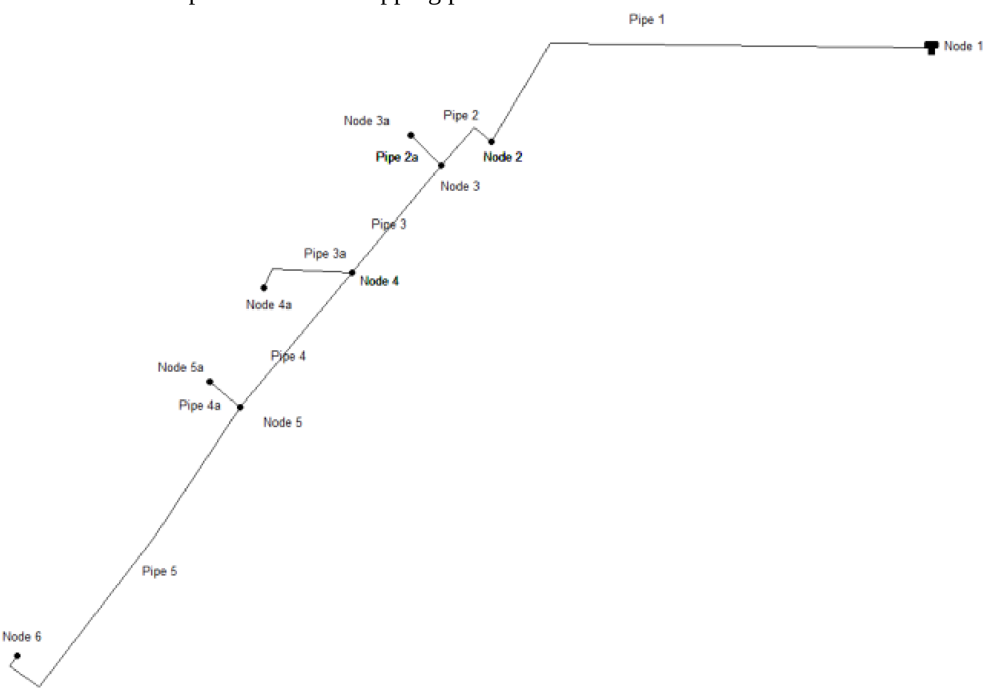
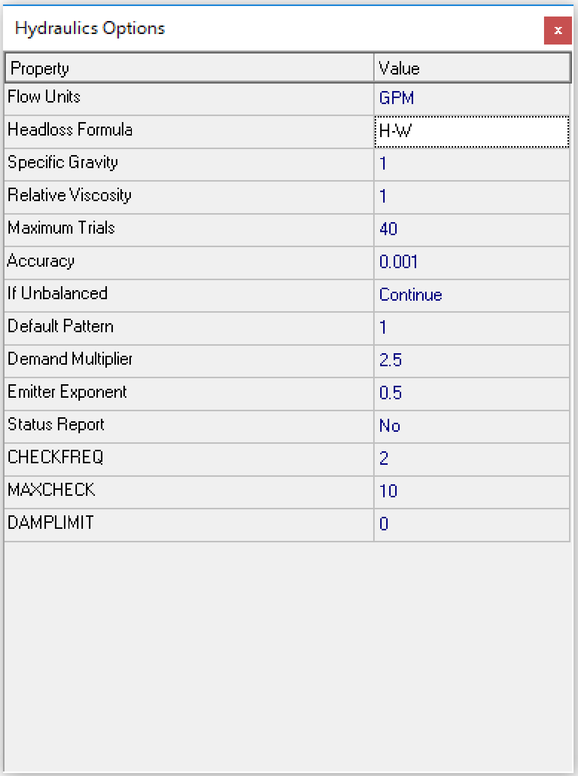


Figure 4. Modifications and Naming of Junctions and Pipes for Peak Flow

In EPACAD, 5 analysis options are available which are Hydraulics Options, Quality Options, Reactions Options, Time Options and Energy Options. However, only the Hydraulics Options was done as a comparion with manual calculation method. The other options are not under scope of works of this project. In the parameters of Hydraulics options, Flow Unit GPM (gallons per minute) and Headloss Formula H-W (Hazen William Formula) were selected. This selection will automatically set all the unit of length into feet, and diameter into inches. It was done so to tally the unit measurements used in manual calculation spreadsheet. Another parameter to be changed was Demand Multiplied. As discussed in earlier part of this paper, in order to calculate the Peak Demand, the demand should times with a factor of 2.5 as shown in Figure 5.



Hydraulics Options

Property	Value
Flow Units	GPM
Headloss Formula	H-W
Specific Gravity	1
Relative Viscosity	1
Maximum Trials	40
Accuracy	0.001
If Unbalanced	Continue
Default Pattern	1
Demand Multiplier	2.5
Emitter Exponent	0.5
Status Report	No
CHECKFREQ	2
MAXCHECK	10
DAMPLIMIT	0

Figure 5. Parameters Taken as Input for Hydraulic Options of Peak Flow

4.2.2 Data Conversion for Peak Flow

In the calculation spreadsheet, Highest Supply Level (HSL) was indicated as the summation of Elevation (Platform Level) and Supply Level which is the same as Elevation parameter in EPANET. On the other hand, even though the demand in gallons per minute (gpm) was calculated in calculation spreadsheet as well, but the demand needed in EPANET is different. EPANET required only the nodes with demand output. Nodes with no demand output need to be inputted as zero demand. Table 3 shows data conversion of nodes information for peak flow while Table 4 shows data conversion of tapping pressure for peak flow.

Table 3. Data Conversion of Nodes Information for Peak Flow

	HSL (m)	Elevation (ft)	Demand (gpd)	Peak Flow Base Demand (gpm)
Node 2	35.10	115.16	0	0.0000
Node 3	30.45	99.90	0	0.0000
Node 3a	35.20	115.49	19469	13.5205
Node 4	30.35	99.57	0	0.0000
Node 4a	32.10	105.31	10567	7.3381
Node 5	29.45	96.62	0	0.0000
Node 5a	32.70	107.28	14820	10.2917
Node 6	19.85	65.12	745	0.5173

**yellow columns denote data to be inputted into EPANET.*

Table 4. Data Conversion of Tapping Pressure for Peak Flow

	Elevation (m)	Elevation (ft)	Tapping Pressure (m)	Maximum Level (ft)	Tank Diameter (m)	Tank Diameter (inches)
Node 1	29.00	95.14	15.00	49.21	7.46	293.5184

**yellow columns denote data to be inputted into EPANET.*

4.2.3 Fire Flow

For fire flow demand, the same file was extracted from peak demand, but the extra pipes and nodes were deleted besides adding new pipes. It was done so as only the longest pipe (considered as one pipe) should be taken for analyzing process. Other than that, the pipes and nodes were renamed as well. Figure 6 shows the modifications and naming of junctions and pipes of fire flow. The parameters set for fire flow were the same as peak demand flow expect for Demand Multiplier. In demand multiplier, the factor is taken as 1.0 as shown in Figure 7.

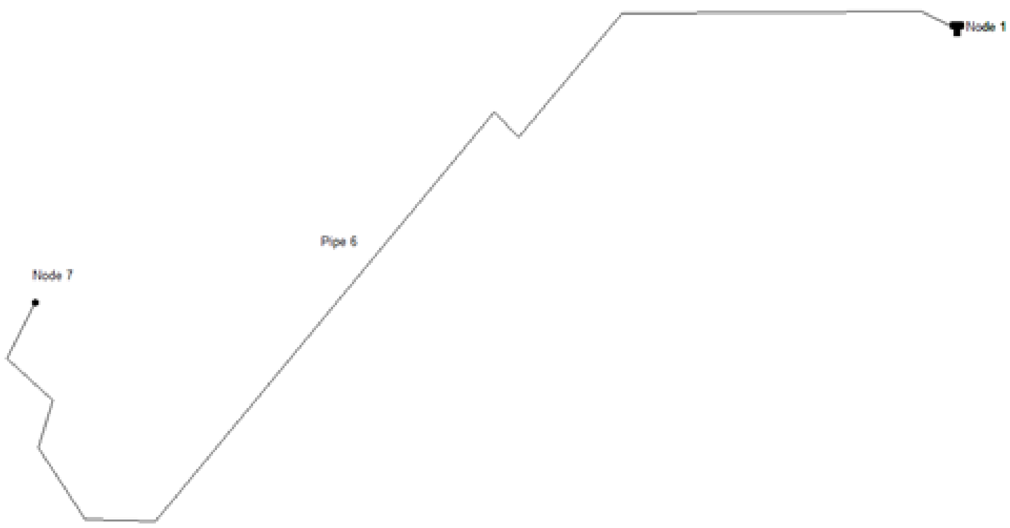


Figure 6. Modifications and Naming of Junctions and Pipes of Fire Flow

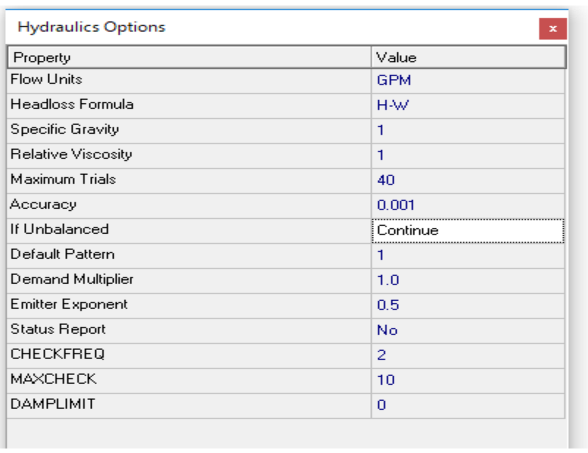


Figure 7. Parameters Taken as Input for Hydraulic Options of Fire Flow

4.2.4 Data Conversion for Fire Flow

The demand needed in fire flow is taken as 30000 gpm plus the domestic demand of the entire development.

477601 gpd = Fire Demand + Water Demand
= 300 gpm + 45601 gpd
= 432000 gpd + 45601 gpd

Table 5 shows the data conversion for node information for fire flow while Table 6 shows the data conversion for tapping pressure information for fire flow.

Table 5. Data Conversion for Node Information for Fire Flow

	HSL (m)	Elevation (ft)	Demand (gpd)	Peak Flow Base Demand (gpm)
Node 7	29.35	96.29	477601	331.67

**yellow columns denote data to be inputted into EPANET.*

Table 6. Data Conversion for Tapping Pressure Information for Fire Flow

	Elevation (m)	Elevation (ft)	Tapping Pressure (m)	Maximum Level (ft)	Tank Diameter (m)	Tank Diameter (inches)
Node 1	29.00	95.14	15.00	49.21	7.46	293.5184

**yellow columns denote data to be inputted into EPANET.*

4.3 Results of Dead-End Design Using EPANET

4.3.1 Peak Flow

Table 7 shows the results of junctions for peak flow extracted from EPANET while Table 8 shows the results of pipes for peak flow extracted from EPANET.

Table 7. Results of Junctions for Peak Flow Extracted from EPANET

Node ID	**Demand (GPM)**	**Head (ft)**	**Pressure (psi)**
Junc Node 2	0.00	142.72	142.72
Junc Node 3	0.00	142.47	18.45
Junc Node 4	0.00	142.30	18.52
Junc Node 6	1.29	141.75	33.20
Junc Node 5	0.00	141.75	19.55
Junc Node 3a	33.80	142.45	11.68
Junc Node 5a	25.73	141.67	14.90
Junc Node 4a	18.34	142.16	15.97
Tank 1	-79.17	144.35	21.32

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Table 8. Result of Pipes for Peak Flow Extracted from EPANET

Link ID	Flow (GPM)	Velocity (fps)	Unit Headloss (psi)
Pipe 2	79.17	0.93	1.19
Pipe 3	45.37	0.53	0.42
Pipe 4	27.02	0.71	1.17
Pipe 5	1.29	0.03	0.00
Pipe 2a	33.80	0.89	1.77
Pipe 4a	25.73	0.68	1.07
Pipe 1	79.17	0.93	1.19
Pipe 3a	18.34	0.48	0.57

4.3.2 Fire Flow

Table 9 shows the results of junctions for fire flow extracted from EPANET while Table 10 shows the results of pipes for peak flow extracted from EPANET.

Table 9. Results of Junctions for Fire Flow Extracted from EPANET

Node ID	Elevation (ft)	Demand (GPM)	Head (ft)	Pressure (psi)
Node 7	96.29	331.67	130.53	14.83
Node 1	95.14	-331.67	144.35	21.32

Table 10. Result of Pipe for Fire Flow Extracted from EPANET

Link ID	Flow (GPM)	Velocity (fps)	Unit Headloss (ft/Kft)
Pipe 6	331.67	2.19	4.16

4.4 Results Comparison and Discussion for both Methods

4.4.1 Peak Flow

4.4.1.1 Comparison of Junctions

Table 11 shows results comparison of node information for peak flow. For junctions, only the results of HGL (Head) and Residual Head (Pressure) are being compared. HGL is known as Hydraulics Grade Line which is a graphical representation of static head. It lies one velocity head below the Energy Grade Line (EGL) [8]. In our project, HGL can be calculated by adding elevation (platform level) and the approved tapping pressure from SAMB. However, stating from Node 2, total head loss of pipe from friction needs to be deducted from HGL. From the comparison of EPANET and calculation spreadsheet, we can conclude that the results are almost 100% similar.

On the other hand, Residual Head means internal pressure left in a pipe after supplying the demands needed. In this case, the demands will be deducted in the form of Highest Supply Level (HSL). HSL is the summation of platform level and the supply level. Similar to HGL, results from calculation spreadsheet have more than 99.9% similarity to the results generated from EPANET. The results prove that the calculation spreadsheet is computed correctly.

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Table 11. Results Comparison of Node Information for Peak Flow

	Head (ft)	Head (m)	HGL (m)	Pressure (psi)	Pressure (m)	Residual Head (m)
Node 1(Tank 1)	144.35	44.00	44.00	21.32	14.99	15.00
Node 2	142.72	43.50	43.50	11.94	8.40	8.40
Node 3	142.47	43.42	43.43	18.45	12.97	12.98
Node 3a	142.45	43.42	43.42	11.68	8.21	8.22
Node 4	142.3	43.37	43.38	18.52	13.02	13.03
Node 4a	142.16	43.33	43.33	15.97	11.23	11.23
Node 5	141.75	43.21	43.21	19.55	13.75	13.76
Node 5a	141.67	43.18	43.18	14.90	10.48	10.48
Node 6	141.75	43.21	43.21	33.20	23.35	23.36

**Green columns denote results from calculation spreadsheet while yellow columns denote results from EPANET.*

4.4.1.2 Comparison of Pipes

Table 12 shows results comparison for pipe information for peak flow. For pipes, the volume of water flow in pipes, its velocity and unit head loss are the parameters taken by the author as a comparison between calculation spreadsheet and EPANET. The results of flow of pipes generated from both methods should be equally the same as both had taken 2.5 as the peak demand multiplier. The 0.01gpm difference in Pipe 3a is probably because of difference in decimal numbers taken during the computation.

For the velocity of pipes, the results generated from calculation spreadsheet are 100% similar to the results generated from EPANET. Once again, the author proved that the calculation spreadsheet is workable. Besides, the results of unit head loss of calculation spreadsheet are also 100% similar to that of EPANET.

Table 12. Results Comparison for Pipe Information for Peak Flow

	Flow (GPM)	Flow (GPM)	Velocity (fps)	Velocity (m/s)	Velocity (m/s)	Unit Headloss (ft/Kft)	Unit Headloss (ft/Kft)
Pipe 1	79.17	79.17	0.93	0.28	0.28	1.19	1.19
Pipe 2	79.17	79.17	0.93	0.28	0.28	1.19	1.19
Pipe 2a	33.80	33.80	0.89	0.27	0.27	1.77	1.77
Pipe 3	45.37	45.37	0.53	0.16	0.16	0.42	0.42
Pipe 3a	18.34	18.35	0.48	0.15	0.15	0.57	0.57
Pipe 4	27.02	27.02	0.71	0.22	0.22	1.17	1.17
Pipe 4a	25.73	25.73	0.68	0.21	0.21	1.07	1.07
Pipe 5	1.29	1.29	0.03	0.01	0.01	0.00	0.00

**Green columns denote results from calculation spreadsheet while yellow columns denote results from EPANET.*

4.4.1 *Fire Flow*

4.4.2.1 Comparison of Junctions

Table 13 shows results comparison for node information for fire flow. For fire flow, only two nodes are being computed as only the longest distance of pipe (which is only one pipe) is needed as a representative. The results of HGL from calculation spreadsheet are 100% similar to that of EPANET. On the other hand, Residual Head from EPANET system has a slight difference which is 0.01m lesser to that of calculation spreadsheet. By right, EPANET computation should get 15.00m of Residual Head at Node 1 as it is the tapping location which has no output of water yet. The Residual Head should be the tapping pressure obtained from SAMB which is 15.00m.

Table 13. Results Comparison for Node Information for Fire Flow

	Head (ft)	Head (m)	HGL (m)	Pressure (psi)	Pressure (m)	Residual Head (m)
Node 1(Tank 1)	144.35	44.00	44.00	21.32	14.99	15.00
Node 7	130.53	39.79	39.78	14.83	10.43	10.43

**Green columns denote results from calculation spreadsheet while yellow columns denote results from EPANET.*

4.4.2.2 Comparison of Pipes

Table 14 shows the results comparison for pipe information for fire flow. For all three parameters in pipe which are flow, velocity and unit head loss, the author got exact similar result for both the calculation spreadsheet and EPANET. As both had used 1.0 and the demand multiplier and both had used same formulas for computation, the results should be the same as well.

Table 14. Results Comparison for Pipe Information for Fire Flow

	Flow (GPM)	Flow (GPM)	Velocity (fps)	Velocity (m/s)	Velocity (m/s)	Unit Head Loss (ft/Kft)	Unit Head Loss (ft/Kft)
Pipe 6	331.67	331.67	2.19	0.67	0.67	4.16	4.16

**Green columns denote results from calculation spreadsheet while yellow columns denote results from EPANET.*

4.5 Time Taken Reduction Using the Designed Spreadsheet

Time taken used to compute the Dead-End analysis is one of the comparisons needed in this project. The author recorded the time taken needed for each process to calculate the time needed while using previous spreadsheet and the spreadsheet with optimized algorithm through ROC Project. Table 15 shows the time taken reduction using the designed spreadsheet.

Table 15. Time Taken Deduction Using the Designed Spreadsheet

No.	Process	Time Taken (minutes)	Time Taken (minutes)	Overall Reduction in Time Taken (minutes)
1.	Water Demand Calculation	60	60	-
2.	Water Demand Break Down for Each Node	-	15	-
3.	Design Calculation	180	60	-
4.	Summary of Pipes and Hydraulic Information	-	20	-
5.	Presentation of Data	60	5	-
	Total	**300**	**160**	**140 (46.67%)**

**Blue column denote time taken using previous spreadsheet while yellow column denote time taken using spreadsheet with optimized algorithm.*

Based on the table, it can be seen that the total time taken to compute Dead-End System using the previously available spreadsheet was 300 minutes (5 hours). However, the total time taken to compute the exact analysis using calculation spreadsheet designed by the author only took 160 minutes (2.67 hours). The total reduction in time taken to perform the analysis is 140 minutes (2.33 hours) which is equivalent to 46.67%. Through the percentage of reduction, the author can conclude that the objective is achieved that the designed spreadsheet is a time efficient calculation model.

5. Suggestions on Water Management

5.1 Water Distribution System

Water loss can happen in all reticulation systems which only different in the volume of loss. The difference can be rely on the attributes of the pipe arrangement and other local causes, the state's water authority standard operating procedure, and the technology implied in the system. Besides, the volume and components lost can be different between countries and regions. One of the foundations of a water lost master plan is to comprehend the characteristic and details of every components to make sure that each of the components is estimated and evaluated as precisely as possible. With that, the action plans can then be transformed into real results.

5.2 Leakage monitoring

Leakage monitoring is identified as the main effective technique to cost saving and management of leakage. Leakage monitoring is done through measuring leakage and detecting leakage activities by observing water that flow into different zones and regions for better leakage management. Not forgetting flow at zones and districts, a flow measuring system in water supply should as well incorporate total flow measurements from reservoir or treatment plant. With that, engineers and designers can comprehend better and work the framework in smaller regions. It is believed that the actions can permit more accurate demand calculation and leakage management. Leakage monitoring can be done through installation of flow meters at specific locations throughout the water supply system which sometimes will consolidate a pressure reducing valve.

5.3 Pressure monitoring

Water reticulation systems distribute water from the water source to the end users. This system is managing water demand that fluctuates throughout the day. Water consumption is highest when it is utilized for individual cleaning, and when during meal preparation and washing clothes. Water consumption is least when most of the people are sleeping at night. It is important to keep up adequate pressure in the supply system to secure it from contamination by the entrance of dirtied seepage water [9].

5.4 Knowledge and Technology Transfer

Even though Malaysia is rich with natural resources, but there are still rooms for improvement on its management on natural resources especially water supply. Through knowledge sharing and technology transfer with our countries, surely water supply management can be improved. For example, as per World Bank on 2007, Singapore is well-known for its water supply system with only 5% of non-revenue water. Engagement can always be held to learn the betterment of others allowing enhancement of our current technology and information. Furthermore, it can result in water management practices which is more advance and also more sustainable as well.

5.5 Raising Public Awareness

No matter how perfect a country's water supply management is, it could not portray the best result if the citizens' awareness is shallow. Citizens should not tap the water illegally. A stricter law should be implemented, and more fine amounts should be imposed to those who violate the laws. Besides that, education about conserving water should be started in schools and homes itself. To a bigger extend, government and non-governmental organizations as well as all other stakeholders should corporate in providing schemes and strategic awareness in raising the public awareness about water conservation. Therefore, it is vital to have public awareness involved in while implementing water conservation activities to achieve better water management system.

6.0 Conclusion

The first objective in Section 3.0 in this paper is met where a calculation software that can manually design for water reticulation that used Dead-End or Tree System had been developed. With its semi-automated function in the designed spreadsheet, it has roughly 46.67% deduction of time compared to the previous spreadsheet by not having to amend the formulas and conversion factors prior computation. With that, it serves its purpose of reducing the tedious process while doing water reticulation design.

Moreover, second objective of this project is achieved as well. The programming spreadsheet is proved to be accurate through the results comparison against computerized analysis using EPANET. The calculation spreadsheet is able to calculate water demand, velocity, unit head loss, residual head, flow and others complying with latest SPAN requirements. The spreadsheet is also able to decide the optimum pipe sizes to the users.

With the spreadsheet developed, it could solve the problem of not having full detailed Dead-End Analysis Spreadsheet. Besides that, it eases the engineers to do preliminary study regarding water reticulation. The users only have to key in some details and will get to know the basic information for pre-consultation purpose. As all the formulas and unit conversion are already keyed-in before-hand, the users do not need to do the conversion anymore. In contrast, one will need to have EPANET or any other water reticulation software downloaded before using. The user will also need to study the manual before using the software if the user is new to the software. As no downtime is allowed, the calculation spreadsheet will be a good choice for doing water reticulation design.

This spreadsheet can be used in any consulting company that provides infrastructure consulting service. The language used in Excel Spreadsheet is English which a universal language. Furthermore, full sentences had been incorporated into the Spreadsheet to ease understanding.

Acknowledgement

The authors acknowledge the support of UTP, Malaysia for successful completion of this study.

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