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DESIGN OF KANO METEROPOLITAN WATER DISTRIBUTION SYSTEM USING EPANET SOFTWARE

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ABSTRACT — Kano state is the second must populated city in Nigeria which is created in 1967. The present water distribution system of Kano state metropolitan was design and constructed since 1980 when the population was less compared to the present. The current population of the state metropolitan is about 3,658,895 with no significant improvement made to the water distribution network. EPANET is a computer program that performs extended period simulation of hydraulic and water quality behaviour within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network. The results obtained verified that the pressures at all junctions and the flows with their velocities at all pipes are enough to provide adequate water to the design network and the design pipes diameters are economically suitable.

KEYWORD: Water Demand, water supply, Distribution Networks, EPANET

1. INTRODUTION

The system of water supply in Kano is traditionally oriented, local and outdated equipments are still in used for water supply. As such, private individuals also engaged in water supply by using distribution tankers and water vendors. Similarly, the existing infrastructural facilities used for water supply are not maintain regularly and erratic power supply to run the machinery for better supply, even the places with pipe borne water supply, the supply is irregular (Olokesusi, 2004).The public water Supply in Kano state was started by Kano Native Authority (NA) during colonial administration before creation of the state in 1967. The water supply is control by water division of ministry of work and survey after Kano state creation In 1975, water resources development agency was created by Kano state named it as water resources and engineering construction agency popularly known as WRECA, which carry out research on water resources development and supply water to the State. WRECA was able to realize over 90% of water supply facilities and infrastructure in the state. Three water bodies were resulted after WRECA was spitted in 1990; namely, Kano State Ministry of Water Resources, Kano State Water Board and the newly established WRECA. The new WRECA take care of developing and maintaining water resources facilities in the state. The Water Board is control process of water supply in urban and semi-urban centres while the water board activities over see by ministry of water resources.

Water distribution Network is a hydraulic infrastructure consisting of elements such as pipes, tanks, reservoirs, pumps and valves e.t.c. It is crucial to provide water to the consumers; effective water supply is of paramount importance in designing a new water distribution network or in expanding the existing one. It is also essential to investigate and establish a reliable network ensuring adequate head.

1.1 History of Water Source to KANO Metropoltan

METEROPOLITAN Up to date, there are three (3) water treatment plants that serve kano metropolitan namely; Chalawa, Tamburawa and bagwai Treatment plants. These treatment plants were used to provide portable water to the state metropolitan. Based on the state demand and population, the water treatment plants were constructed and expanded in different time interval. These constructions were started since 1930s when the state population was growing with civilization.The urban area of Kano comprises of six local government areas. Namely; Tarauni, Dala, Fagge, Kano Munincipal, Gwale and Nassarawa, with population of 2, 163, 2225 (NPC, 2006), while the metropolitan comprises of eight local government area, the above six mentioned, with addition of Ungogo and Kumbotso with total population of 2,828,861 (NPC, 2006). A Challawa water works was constructed by the Water Resources and Engineering Construction Agency, Kano between the years of 1990 to 1992. It has 42m high and 7.8 km length, with storage capacity of 904,000,000 m3. It has direct catchment area of 3857 km2. The water is currently used only to supply Kano city.The water work has three distinct phases, namely first, second and third Challawa water work. The first water work started in 1932 with capacity of supplying 20 million litres to the metropolitan of Kano. The second and third Challawa water projects work were established in the year 1974 and 1992 respectively with capacity of supplying 90 million liters to greater Kano per day.

The Tamburawa water work are named as old and new Tamburawa, Old Tamburawa water works commenced in 1986 with capacity of 9.6 million liters of water and then it was upgraded to supply 20 Million litres, and New Tamburawa water treatment plants has the capacity to supply 150 million liters of water to the Kano city and its surrounding environment.

Watari water Treatment Plant was located in Bagwai Local Government, which is about 18km, North-western part of Kano between latitudes 1206’ 54.54’’N and 120 9’ 17.8’’N and longitudes 08011’ 50.62’’E and 080 16’ 28.05’’E and its play significant roles in water supply to Kano city. It has the capacity of producing 45 million litres of water per day.

2. LITERATURE REVIEW

Many computer software were developed to ease water distribution network design. Among them are; WADISO, WATERCAD, EPANET, AQUANET, ARCHIMEDE, BRANCH/LOOP, CROSS, ERACLITO, H2ONET/H2OMAP, HELIX DELTA-Q, MIKE NET, NETIS, OPTIDESIGNER, PIPE2000, STANET. One of the first and probably the most widely used method of analysis is the Hardy Cross Technique (1936). This method makes corrections to initial assumed value by using a first order expansion of the energy equation in terms of selection factor for the flow rate in each loop. The process is of course repetitive and is dependent on the accuracy of the initial given which must be reasonably good. If an aimer is to be obtained, reportedly, however the method is suitable for both hand calculation, and also a number of digital programs have been prepared for network flow analysis suing this procedure. In certain cases it has been found that the Hardy Cross method converges very slowly or not at all. This lead Mc corale and Deliany (1960) to suggest special measures to improve convergence. The method described by Newton and Peter (1963) have also been used by Gludice problems. This method adjusts the flow rate in all the loops simultaneously. Convergence using Newton-Rapson approach is much quicker than that obtained using Hardy Cross analysis. This is especially important when analyzing networks involving large number of pipes. Direct (1965) and Pitchal (1966) for studied for hydraulic networks. The method has been extended by Shanny and Howard (1968) to include various hydraulic components in the network. Epp and Fowler (1970) late reported an approach to solving hydraulic network problems utilizing the Newton-Rapson method have offered some details pertaining to a general digital computer program available for this.

However, pressure is lost by the action of friction at the pipe wall. The pressure loss is also dependent on the water demand, pipe length, gradient and diameter of Pipe. Network analysis of water distribution systems has evolved from a time consuming process done infrequently to a quick and easy process done regularly on systems of all sizes. Consequently, two network analysis programs were introduced by Shamir and Howard (1968) and Epp and Fowler (1970). Both renditions used the Newton-Raphson method to linearize the nonlinear mass and energy equations.

2.1. Overview of EPANET software

EPANET was developed by the water supply and water resources division (formerly the drinking water research division) of the U.S Environmental protection agency's national risk management research laboratory. EPANET is a computer program that performs extended period simulation of hydraulic and water quality behaviour within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated. Running under windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include colour-coded network maps, data tables, time series graphs, and contour plots.

Hydraulic Modelling Capabilities Full- featured and accurate hydraulic modelling is a prerequisite for doing effective water quality modelling. EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

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

Model Input Data In order to analyze the Water Distribution Network using EPANET, The following input data files are needed.

- Junction report (NODE)
- Pipe report (LINK)

2.2. Junction Report (NODE)

Junctions are points in the network where links join together and where water enters or leaves the network.

The basic input data required for junctions are:

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

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

> Hydraulic head (internal energy per unit weight of fluid)
> Pressure
> Water quality Junctions can also:
> Have their demand vary with time
> Have multiple categories of demands assigned to them
> Have negative demands indicating that water is entering the network
> Be water quality sources where constituents enter the network
> Contain emitters (or sprinklers) which make the outflow rate depend on the pressure.

2.3. Pipe Report (LINKS)

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

The principal hydraulic input parameters for pipes are:

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

Computed outputs for pipes include:

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

3. METHODOLOGY

3.1. PROJECTED AREA

Kano State is situated in the north-west region of Nigeria. It has a total land area of 20,131 km2 (7,773 sq mi), which represents 3.13% of the entire total area of the country. Kano State is bounded to the west by Katsina State, to the south-west by Kaduna State, to the east by Jigawa State and southeast by Bauchi State. It was part of the Sudano-sahelian region of the country and comprises of 44 local government areas, which divide into three geopolitical zones, namely Kano Central, Kano South and Kano North.

Kano has a total population of 9,383,682 and population density of 470 per/sq km. Kano metropolitan has population of 2,163,225 (NPC, 2006). Almost 75% of the people living in Kano were living in rural areas.

Currently the rate of population growth observed to be 2.9% per annum in Kano State.

Fig.1 A map showing of Kano state metropolitan roads network

3.2. MATERIALS

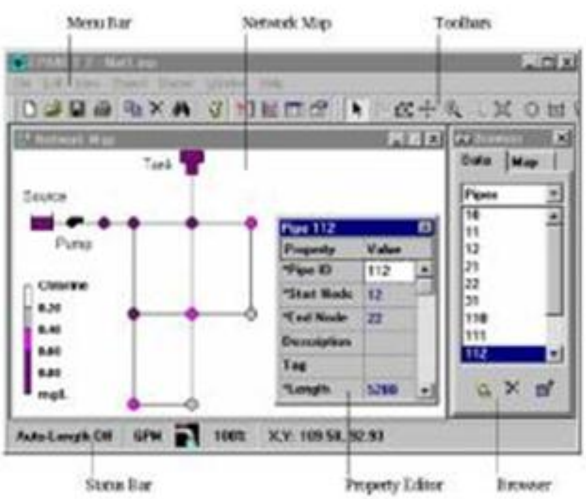
The materials used for this study includes; topographical map, then water distribution parameters such as; water demand, Kano metropolitan population, and also distribution network parameters such as; elevations, pipe diameter, pipe length, finally EPANET software.

3.3. METHOD

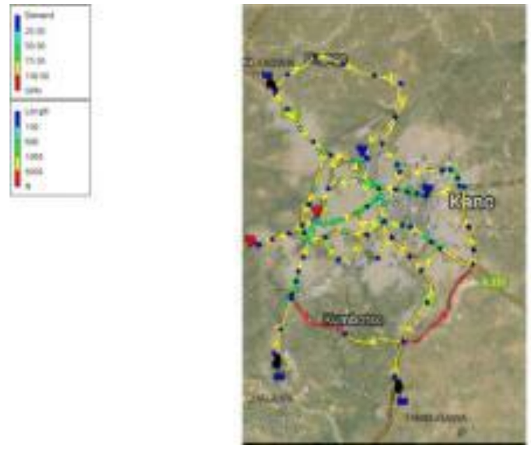
The demand was obtained after considering the population of the study area as 3,658,895, also the study area falls under the category of urban settlement, as a result of this development, the standard from the Federal Ministry of Water Resources manual on water demand was used, for this research 180 L/C/D was considered. The demand at particular junction was obtained by dividing (the total population by the number of junctions and multiplying by 180L/C/D. After that, the following steps were carried out to analyze the state metropolitan water distribution network:

The following are the step by step method that would be used during the Design

1- Lunch the software
2- Calibrate the software e.g. S.I. units, e.t.c
3- Importation of the background map
4- Place the NODES i.e. Reservoir, Tanks and junctions
5- Edit the appropriate Data in Step 4
6- Draw the links(pipe, pump and valves) to connect all the nodes in step 4
7- Edit links parameters appropriately
8- Run the system and check the pressure drop. Add pumps if necessary in order to archive a design pressure throughout the Distribution network
9- Add the pump curve to each pump
10- Add Demand Pattern to all NODES
11- Apply the Time series Analysis
12- Run the network and check for errors
13- Display the Legend
14- Apply Simple Control



15-Display the Result in Tabular and Graphical form



^ water tank

Fig. 2 Kano State metropolitan water distribution network

4. RESULTS AND DISCUSSION

The analysis of any water distribution network includes determining quantities of flow and head losses in the various pipe lines, and resulting residual pressure at various demands in the network junctions. The results obtain for the network of Kano Metropolitan water supply systems were described below:

4.1.SUMMARY OF 24 HOURS SUPPLY

The following are the summary of the 24hrs supply Water distribution Network of Study area.

- Number of Junctions 106
- Number of Reservoirs 3
- Number of Tanks 4
- Number of Pipes 129
- Number of Pumps 3
- Flow Units LPS
- Headloss Formula H-W

NETWORK (NODES JUCTIONS) at 0:00 Hrs

The table below is the output of NODES (JUNCTION) from EPANET after Extended Period Simulation; Demand, Head and Pressure were the desired output.

Network Table - Nodes at 0:00 Hrs

Node ID	Demand LPS	Head m	Pressure m
Junc JU3	51.6	205.67	204.67
Junc JU4	52.2	159.02	158.02
Junc JU5	72.0	117.48	116.48
Junc JU6	84.0	67.82	66.82
Junc JU7	96.0	61.2	60.2
Junc JU8	113.4	55.42	55.31
Junc JU9	100.8	58.62	58.51
Junc JU10	168	63.54	63.43
Junc JU11	126	57.57	57.46
Junc JU12	132	61.45	60.45
Junc JU13	138	65.24	64.24
Junc JU14	139.2	72.41	71.41
Junc JU15	156	81.18	80.18
Junc JU16	135.6	92.45	91.45
Junc JU17	120	52.34	52.34
Junc JU18	108	49.1	49.1
Junc JU19	111	46.95	46.95
Junc JU20	114	45.91	45.91
Junc JU21	180	43.86	43.75
Junc JU22	180	38.79	38.68
Junc JU23	180	36.26	36.15
Junc JU24	180	35.86	35.75
Junc JU25	180	36.31	36.31
Junc JU26	180	38.25	38.25
Junc JU27	144	38.85	38.85
Junc JU28	126	43.49	43.38
Junc JU29	108	43.44	43.33
Junc JU30	118.8	56.08	55.97
Junc JU31	96	48.67	48.56
Junc JU32	113.4	40.23	40.12
Junc JU33	114	38	37.89
Junc JU34	111.6	36.78	36.67
Junc JU35	132	36.47	36.36
Junc JU36	126.6	36.04	35.93
Junc JU37	192	35.49	35.38
Junc JU38	174	35.48	35.37
Junc JU39	179.4	41.54	41.54
Junc JU40	174	40.23	40.23
Junc JU41	186	40.11	40.11
Junc JU42	192	40.31	40.31
Junc JU43	168	40.9	40.9
Junc JU44	180	40.63	40.63
Junc JU45	180	41.81	41.81
Junc JU46	174	39.6	39.6
Junc JU47	0	187.49	185.49
Junc JU48	96	144.51	142.51
Junc JU49	108	107.73	105.73
Junc JU50	113.4	90.73	88.73
Junc JU51	112.8	76.65	74.65
Junc JU52	118.8	64.14	62.14
Junc JU53	132	52.3	50.3
Junc JU54	126	45.63	45.63
Junc JU55	127.2	42.53	42.53
Junc JU56	117	42.22	42.22
Junc JU57	119.4	42.21	42.21
Junc JU58	139.2	40.23	38.23
Junc JU59	132	39.03	37.03
Junc JU60	144	38.89	36.89
Junc JU61	142.8	38.74	36.74
Junc JU62	138	38.91	36.91
Junc JU63	126.6	39.8	37.8
Junc JU64	118.8	42.68	40.68
Junc JU65	126	50.35	48.35
Junc JU66	114	67.55	65.55
Junc JU67	108	86.97	84.97
Junc JU68	132	39.32	37.32
Junc JU69	126.6	46.08	46.08
Junc JU70	132	52.28	52.28
Junc JU71	112.2	44.33	44.33
Junc JU72	114	43.74	41.74
Junc JU73	126	44.25	42.25
Junc JU74	156	37.2	37.2
Junc JU75	118.8	51.04	49.04
Junc JU76	133.2	57.63	55.63
Junc JU77	120	70.48	67.48
Junc JU78	118.8	67.89	64.89
Junc JU79	144	47.3	44.3

Junc JU80	96	56.67	53.67
Junc JU81	0	52.59	49.59
Junc JU82	93.6	50.14	47.14
Junc JU83	113.4	40.34	37.34
Junc JU84	120	38.63	35.63
Junc JU85	126	38.26	35.26
Junc JU86	162	36	35.89
Junc JU87	138	36	35.89
Junc JU88	156	38.16	35.16
Junc JU89	160.8	35.88	32.88
Junc JU90	160.8	38.5	37.5
Junc JU91	156	42.01	41.01
Junc JU92	108	57.61	56.61
Junc JU93	113.4	56.01	55.01
Junc JU94	144	45.51	44.51
Junc JU95	133.2	54.07	53.07
Junc JU96	144	40.34	37.34
Junc JU97	108	49.44	46.44
Junc JU98	100.8	60.05	57.05
Junc JU99	59.4	55.51	52.51
Junc JU100	53.4	66.1	63.1
Junc JU101	118.8	69.72	66.72
Junc JU102	132	67.84	66.84
Junc JU103	153.6	35.92	33.92
Junc JU104	118.8	37.66	34.66
Junc JU105	72	112.45	109.45
Junc JU106	60	163.06	160.06
Junc JU107	0	206.51	203.51
Junc JU108	147.6	35.95	32.95
Resvr R1	-1351.37	0	0
Resvr R2	-1383.3	0	0
Resvr R3	-2102.22	0	0

Tank NEWSITE	-1151.43	110	100
Tank BADAWA	-1929.98	110	100
Tank SABONGARI	-2607.78	110	100
Tank GORONDUTSE	-2804.72	111	100

4.3. NETWORK (LINKS) AT 0:00 HRS The table below is the output of Links (Pipe) from EPANET after Extended Period Simulation; Length, Diameter, Flow, Velocity, Unit Head loss and Friction factor were the output.

Network Table - Links at 0:00 Hrs

Link ID	Length m	Dia. mm	Flow LPS	Vel. m/s	Unit Head loss m/km	Friction Factor
Pipe PI1	6307.18	780	1876.2	3.93	13.96	0.014
Pipe PI2	6048.37	780	1824.0	3.82	13.25	0.014
Pipe PI3	8048.12	780	1752.0	3.67	12.29	0.014
Pipe PI4	1203.47	780	1726.1	3.61	11.96	0.014
Pipe PI5	5080.33	780	728.86	1.53	2.42	0.016
Pipe PI6	4237.9	780	620.86	1.3	1.8	0.016
Pipe PI7	4350.64	780	507.46	1.06	1.24	0.017
Pipe PI8	2299.76	780	-573.04	1.2	1.55	0.017
Pipe PI9	2583.44	780	-673.84	1.41	2.09	0.016
Pipe PI10	1913.17	780	112.81	0.24	0.08	0.021
Pipe PI11	2123.15	780	-5.99	0.01	0	0.032
Pipe PI12	3902.81	780	-13.62	0.03	0	0.029
Pipe PI13	2367.74	780	-145.62	0.3	0.12	0.02
Pipe PI14	3024.18	780	-283.62	0.59	0.42	0.018
Pipe PI15	2663.69	780	-422.82	0.88	0.88	0.017
Pipe PI16	2516.02	780	-578.82	1.21	1.58	0.016
Pipe PI17	3434.55	780	-766.16	1.6	2.66	0.016
Pipe PI18	2172.51	780	854.29	1.79	3.25	0.016
Pipe PI19	2111.62	780	758.29	1.59	2.61	0.016
Pipe PI20	1544.04	780	99.99	0.21	0.06	0.021
Pipe PI21	1716.24	780	-26.01	0.05	0.01	0.026
Pipe PI22	2462.09	780	618.9	1.3	1.79	0.016
Pipe PI23	3489.67	780	901.28	1.89	3.59	0.015
Pipe PI24	6340.63	780	768.08	1.61	2.67	0.016
Pipe PI25	4660.14	780	624.08	1.31	1.82	0.016
Pipe PI26	3913.22	780	491.91	1.03	1.17	0.017

Pipe PI27	5451.92	780	331.11	0.69	0.56	0.018
Pipe PI28	6774.66	780	-23.83	0.05	0	0.026
Pipe PI29	2597.18	780	526.47	1.1	1.33	0.017
Pipe PI30	2892.15	780	413.07	0.86	0.85	0.017
Pipe PI31	2998.51	780	299.07	0.63	0.47	0.018
Pipe PI32	1947.23	780	187.47	0.39	0.2	0.019
Pipe PI33	2453.81	780	274.56	0.57	0.4	0.018
Pipe PI34	6214.98	780	41.58	0.09	0.01	0.024
Pipe PI35	5890.25	780	-112.02	0.23	0.08	0.021
Pipe PI36	5717.81	780	1722.17	3.6	11.91	0.014
Pipe PI37	7243.88	780	1662.17	3.48	11.15	0.014
Pipe PI38	6801.09	780	1590.17	3.33	10.27	0.014
Pipe PI39	4678.44	780	885.57	1.85	3.47	0.015
Pipe PI40	6947.55	780	784.77	1.64	2.78	0.016
Pipe PI41	8801.94	780	676.77	1.42	2.11	0.016
Pipe PI42	4344.79	780	454.92	0.95	1.01	0.017
Pipe PI43	6086.59	780	418.9	0.88	0.87	0.017
Pipe PI44	1468.41	780	229.73	0.48	0.29	0.019
Pipe PI45	3372.25	780	68.93	0.14	0.03	0.023
Pipe PI46	2753.8	780	147.96	0.31	0.13	0.02
Pipe PI47	1130.25	780	268.26	0.56	0.38	0.018
Pipe PI48	3489.38	780	254.09	0.53	0.34	0.019
Pipe PI49	2683.36	780	80.09	0.17	0.04	0.022
Pipe PI50	1626.17	780	-111.91	0.23	0.08	0.021
Pipe PI51	6543.72	780	-361.34	0.76	0.66	0.018
Pipe PI52	6260.56	750	-224.65	0.51	0.33	0.019
Pipe PI53	2778.8	750	-464.63	1.05	1.27	0.017
Pipe PI54	8355.66	780	395.75	0.83	0.78	0.017
Pipe PI55	9974	600	342.35	1.21	2.15	0.017
Pipe PI56	8687.85	600	282.95	1	1.51	0.018

Pipe PI57	15600.08	780	190.05	0.4	0.2	0.019
Pipe PI58	16370.86	780	58.05	0.12	0.02	0.023
Pipe PI59	3400.71	750	-310.83	0.7	0.6	0.018
Pipe PI60	9164.89	750	500.18	1.13	1.46	0.017
Pipe PI61	5666.35	750	-310.83	0.7	0.6	0.018

Pipe PI62	6966.75	780	77.85	0.16	0.04	0.022
Pipe PI63	6868.24	780	-119.98	0.25	0.09	0.021
Pipe PI64	9844.79	750	-406.83	0.92	1	0.017
Pipe PI65	1454.49	750	-525.63	1.19	1.6	0.017
Pipe PI66	8573.48	750	783.83	1.77	3.35	0.016
Pipe PI67	7253.42	600	258.34	0.91	1.27	0.018
Pipe PI68	4173.82	780	102.04	0.21	0.06	0.021
Pipe PI69	7230.88	750	645.54	1.46	2.34	0.016
Pipe PI70	6157.69	750	512.34	1.16	1.53	0.017
Pipe PI71	4239.58	600	393.54	1.39	2.78	0.017
Pipe PI72	4354.15	600	30.3	0.11	0.02	0.025
Pipe PI73	4096.8	780	24.13	0.05	0	0.026
Pipe PI74	2171.27	780	-131.87	0.28	0.1	0.021
Pipe PI75	2494.91	780	1978.2	4.14	15.39	0.014
Pipe PI76	2327.89	780	1882.2	3.94	14.04	0.014
Pipe PI77	7220.77	780	756	1.58	2.59	0.016
Pipe PI78	8834.35	780	648	1.36	1.95	0.016
Pipe PI79	10921.74	780	534	1.12	1.36	0.017
Pipe PI80	7678.56	780	408	0.85	0.83	0.017
Pipe PI81	5074.55	780	289.2	0.61	0.44	0.018
Pipe PI82	3283.47	780	1018.2	2.13	4.5	0.015
Pipe PI83	3326.55	780	904.89	1.89	3.62	0.015
Pipe PI84	3702.75	780	792.09	1.66	2.83	0.016
Pipe PI85	4594.2	780	673.29	1.41	2.09	0.016
Pipe PI86	3699.46	780	541.29	1.13	1.4	0.017
Pipe PI87	1815.32	780	610.08	1.28	1.74	0.016
Pipe PI88	2866.72	780	242.62	0.51	0.32	0.019
Pipe PI89	3308.16	780	125.62	0.26	0.09	0.021
Pipe PI90	3004	780	355.56	0.74	0.64	0.018

Pipe PI91	3792.48	780	162.6	0.34	0.15	0.02
Pipe PI92	5817.37	780	24.6	0.05	0	0.026
Pipe PI93	4213.42	780	-118.2	0.25	0.08	0.021
Pipe PI94	2848.25	780	-84.36	0.18	0.04	0.022
Pipe PI95	4479.87	780	-216.36	0.45	0.26	0.019

Pipe PI96	4455.74	780	-177.83	0.37	0.18	0.02
Pipe PI97	3403.92	600	-309.83	1.1	1.78	0.017
Pipe PI98	3761.07	780	-349.35	0.73	0.62	0.018
Pipe PI99	3829.15	780	-475.95	1	1.1	0.017
Pipe PI100	1978.32	780	570.33	1.19	1.54	0.017
Pipe PI101	1947.23	780	-560.17	1.17	1.49	0.017
Pipe PI102	3699.46	780	439.5	0.92	0.95	0.017
Pipe PI103	2786.12	780	265.5	0.56	0.37	0.019
Pipe PI104	3159.58	780	79.5	0.17	0.04	0.022
Pipe PI105	2797.77	780	240.26	0.5	0.31	0.019
Pipe PI106	3622.78	780	72.26	0.15	0.03	0.022
Pipe PI107	3602.63	780	-40.24	0.08	0.01	0.024
Pipe PI108	2462.09	780	-220.24	0.46	0.26	0.019
Pipe PI109	2738.99	780	-667.05	1.4	2.06	0.016
Pipe PI110	2252.14	780	266.82	0.56	0.38	0.018
Pipe PI111	3409.9	780	92.82	0.19	0.05	0.022
Pipe PI112	1701.96	780	284.3	0.59	0.42	0.018
Pipe PI113	2467.45	780	1459.7	3.05	8.77	0.014
Pipe PI114	3265.9	780	634.79	1.33	1.88	0.016
Pipe PI115	3283.47	780	454.79	0.95	1.01	0.017
Pipe PI116	1626.17	780	274.79	0.58	0.4	0.018
Pipe PI117	2677.4	780	-17.12	0.04	0	0.028
Pipe PI118	3085.45	780	-197.12	0.41	0.21	0.019
Pipe PI119	3513.33	780	647.79	1.36	1.95	0.016
Pipe PI120	3397.12	780	527.79	1.1	1.33	0.017
Pipe PI121	3793.93	780	419.79	0.88	0.87	0.017
Pipe PI122	3920.5	780	308.79	0.65	0.49	0.018
Pipe PI123	3929.82	780	-194.79	0.41	0.21	0.019
Pipe PI124	8880.52	750	-381.49	0.86	0.88	0.017
Pipe PI125	5916.54	750	118.8	0.27	0.1	0.021
Pipe PI126	1827.18	800	-3067.7	6.1	30.66	0.013
Pipe PI127	2248.09	780	-1845.3	3.86	13.53	0.014
Pipe PI128	3040.62	800	-2075	4.13	14.87	0.014
Pipe PI129	3106.8	780	-714.42	1.5	2.33	0.016
Pump P1	#N/A	#N/A	1722.17	0	-196	0
Pump PU2	#N/A	#N/A	1927.88	0	-191	0
Pump PU3	#N/A	#N/A	1978.29	0	-190	0

5. CONCLUSION AND RECOMMENDATION

The aim and objective of this research is to design a water distribution network for kano Metropolitan. Based upon the population forecasted, the Based Demand was calculated and the entire network Hydraulic were analysed. The Water Head and pressure calculated were sufficient to withdrawn the actual demand at all the junctions (Nodes) within 24hrs of the Design. The Negative flows in some of the pipes indicate the flow is in opposite direction and also all the velocities were within the safe limits.

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