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Hydraulic Analysis of Irrigation Network for the Proposed Taq-Taq Dam Using EPANET Software

Abstract-*Analysis of the pipe network aims to determine the pressure drops and flow rates in the individual parts of the network. In this study, the EPANET software was used for automatically solving problems of the network. The main objective of this study is to analyze the irrigation network of the proposed Taq-Taq dam using hydraulic simulation software. In order to study the distribution of pressure, velocity and head on the pipe network to ensure the operation of the network efficiently and improve quantity of water distributed through the pipelines system. The study explained the velocity, pressure, and head distributions along the pipeline of the proposed irrigation project. The results concluded that the simulated model seems to be reasonably close to those of an actual network system.*

Keywords- *EPANET, Pipe flow, Pipe Network, Simulation, Water Demand.*

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1. Introduction

The aim is to introduce EPANET to model an irrigation network, and to solve any attached problems to an irrigation system. The model contains an optimization technique of network solver EPANET used to reach the proposed scheme. EPANET is chosen due to handle together steady state as well as extend period simulation network of water distribution. This chapter shows discussions the EPANET simulation model by using a sample model of a real irrigation system and sprinkler irrigation system [1].

An irrigation system can be defined as a hydraulic infrastructure that conveys water from the source to the consumers; it consists of five elements: pumps, pipes, valves, tanks, and reservoirs.

2. Description of Project

The purpose of the proposed Taq-Taq Dam is irrigation, hydroelectric power generation and flood control for downstream area. Besides serving the regulating dam for waters released of Dokan Dam power station. The proposed Taq-Taq Dam and Irrigation Project comprise six irrigation systems as shown in Figure (1). These systems are: Taq-Taq irrigation system, Kara Cuge irrigation system, Kanibi irrigation system, Haraba irrigation system, Kotan irrigation system, and Kasgah irrigation system [2].

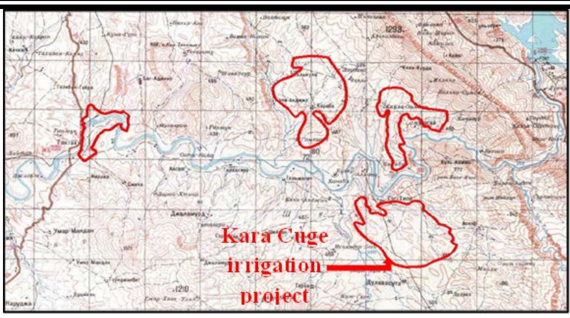

Figure 1: Locations of some irrigation systems (Ministry of Water Resources in Iraq, 2010)

The Kara Cuge irrigation system project was selected as a case study. The system receives water from a reservoir that has a capacity of 5292 $m^3$and connected to the bottom outlet of the proposed Taq-Taq Dam with GRP (Glass Reinforced Polyester) this pipeline (C) Ø700mm dragged that has the length of 3464 m. The main supply line for system is divided into three directions: The first is the GRP pipeline (C-1), (Ø300mm, Ø250mm, and Ø150mm) at a total length of 2047 m. The second is the GRP pipeline (C-2) Ø300mm, and Ø100mm has a length of 1583 m. The last direction is also the GRP pipeline (C-3) within four pipes (Ø600 mm, Ø500 mm, Ø400 mm, and Ø300 mm) and 3933 m is the total length and it go under the bed of the river. Since terrain altitude is not higher than 380 meters above sea level (m.a.s.l) [2], working pressure is assured on entire irrigated area. Figure (2).

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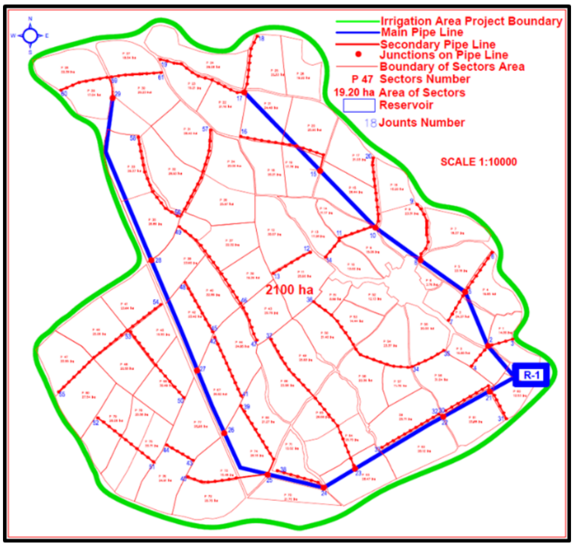

Figure 2: Kara Cuge Irrigation System

3. Hydraulic Analysis of Pipeline Network Using EPANET Software

I. EPANET software description

Pipeline network of the irrigation network was analyzed using EPANET software, which performs the behavior of water quality within a pressurized pipe hydraulic analysis engine which contains the following capabilities [4]:

› Places no limit on the dimension of the network that analyzed

› Computes head loss of friction by using either Darcy-Weisbach, Hazen-Williams, or Chezy-Manning equations

› Contains minor head losses for fittings, bends.

› Variable speed pumps or models constant

› Computes cost as well as pumping energy

› Models different types of valves

› Allows the tanks of storage to have many forms (i.e., the diameter that changed with the height)

› Considers a different demand for categories at every node, with its pattern of time variation.

› Models pressure dependent on flow issuing of emitters.

› Can base system operation on both timer controls and simple tank level, and complex rule based controls.

EPANET's simulation model computed the hydraulic heads at junctions and flow rates through links for a fixed set of tank levels, reservoir levels, and water demands over a succession of points in networks and extended period simulation of hydraulic. A network contains pipes, pumps, nodes (pipe junctions), valves and the reservoirs. EPANET tracks the water flow in every pipe, the pressure at every node; the water height in each reservoir, as well as the concentration of chemical species throughout the network during simulation interval included multiple time steps [3]. In addition, chemical species, source tracing and water age have been simulated. Running beneath Windows, EPANET supplies an integrated environment for input data of editing network, water quality simulations and running hydraulic, as well as the results are shown in formats variety. These include data tables, time series graphs, and color-coded network maps in addition to contour plots.

EPANET was developed by both the Supply of water and Resources of Water Division of U.S. Environmental Protection Agency's National Risk Management Sturdy Laboratory. Accurate hydraulic modeling is necessary for doing effective water quantity modeling. EPANET consist of state of the art time. From a one-time step to the next reservoir levels and junction demands are updated according to their prescribed time patterns while tank levels are updated using the current flow solution. The solution for heads and flows at a particular point in time involves solving the conservation of flow equations for each junction and the headless relationship across each link in the network simultaneously. This process, known as hydraulically balancing the network, requires using an iterative technique to solve the nonlinear equations involved. EPANET employs the gradient Algorithm for this purpose.

II. Application the EPANET

The irrigation project for the study area was divided into two main sections through two main pipes from Reservoir (R-1). Each pipe is a 700mm diameter and distributes water to secondary pipes in both sides to deliver water to all parts of the irrigation project, as shows in Figure 3, 4, 5 and 6. The Figures show the results of the distribution of the pipeline, velocity, pressures, and heads along the pipes, respectively. Tables 1 and 2 illustrate the characteristics of nodes and links-pipes, respectively.

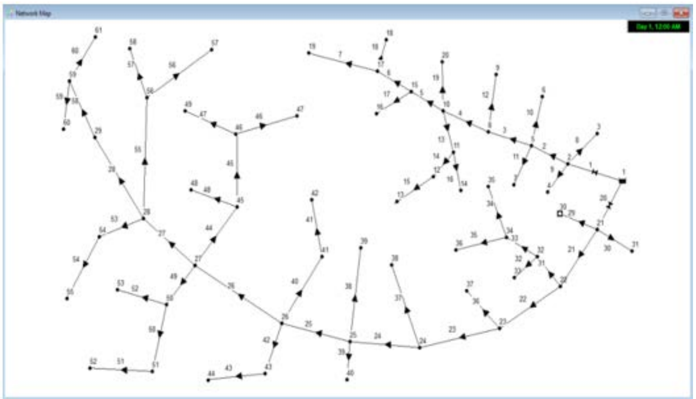

Figure 3: Distribution of the pipeline in the irrigation project

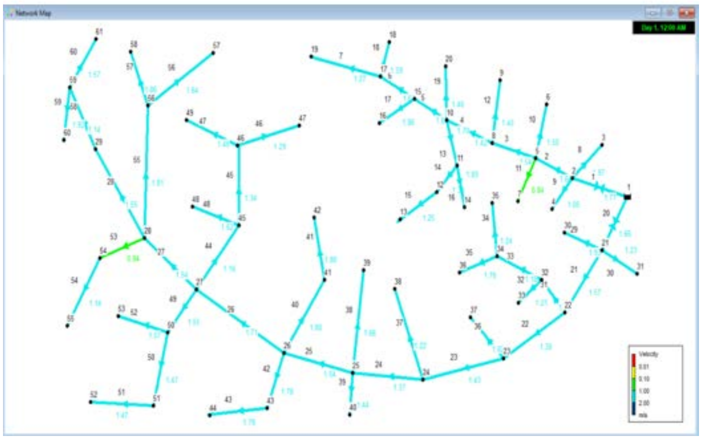

Figure 4: Velocity distribution along the pipeline in the irrigation project

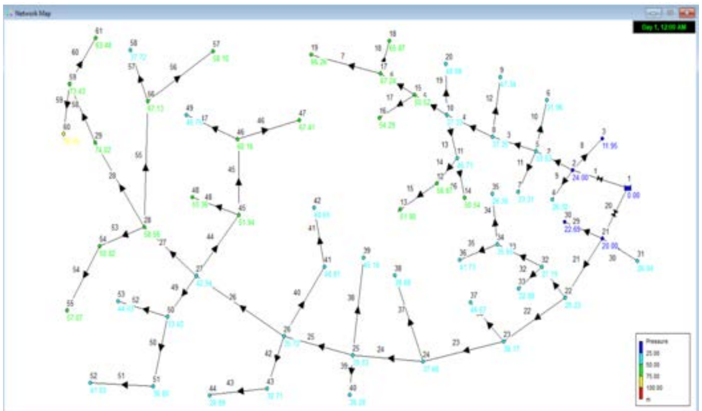

Figure 5: Pressure distribution along the pipeline in the irrigation project

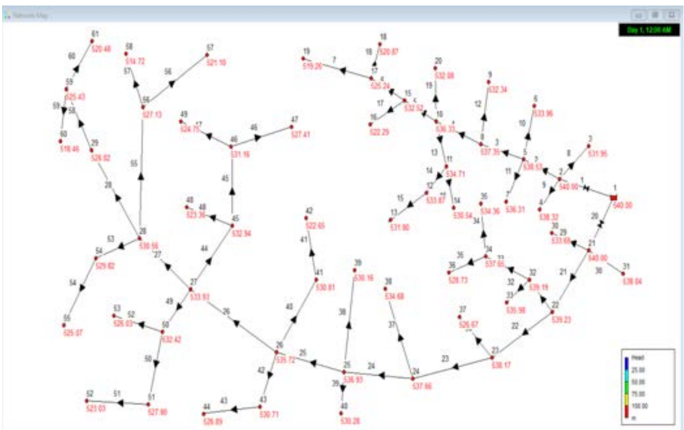

Figure 6: Head distribution along the pipeline in the irrigation project

Table 1: Results and characteristics in nodes-junctions of irrigation project for study area

Node ID	Elevation (m)	Demand (l/sec)	Head (m)	Pressure(m)
Junc. 2	516	0	540	24
Junc. 3	520	15.5	531	11.95
Junc. 4	512	18.54	538	26.32
Junc. 5	505	0	538	33.53
Junc. 6	502	47.12	533	31.96
Junc. 7	503	6.58	536	33.31
Junc. 8	500	0	537	37.35
Junc. 9	485	45.47	532	47.34
Junc. 14	480	33.33	530	50.54
Junc. 12	477	145.93	533	56.87
Junc. 13	480	61.57	531	51.8
Junc. 10	499	0	536	37.33
Junc. 11	488	28.86	534	46.71
Junc. 16	468	91.27	522	54.29
Junc. 17	458	0	525	67.24
Junc. 18	455	77.89	520	65.87
Junc. 19	453	40.01	519	66.26
Junc. 15	482	0	532	50.52
Junc. 20	484	68.93	532	48.08
Junc. 21	520	0	540	20
Junc. 22	513	0	539	26.23
Junc. 23	500	0	538	38.17
Junc. 24	500	0	537	37.66
Junc. 25	497	0	536	39.93
Junc. 26	500	0	535	35.72
Junc. 27	491	0	533	42.94
Junc. 28	472	0	530	58.56
Junc. 30	511	34.14	533	22.69
Junc.31	512	38.73	538	26.04
Junc. 32	512	0	539	27.19
Junc. 33	503	59.21	535	32.98
Junc. 35	508	22	534	26.36
Junc. 36	487	125.9	528	41.73
Junc. 37	480	114.61	526	46.67
Junc. 38	496	38.19	534	38.68
Junc. 40	494	45.36	530	36.28
Junc. 41	482	0	530	48.81
Junc. 42	482	56.62	522	40.65
Junc. 43	498	0	530	32.71
Junc. 44	498	55.98	526	28.89
Junc. 45	481	0	532	51.94
Junc. 46	471	0	531	60.16
Junc. 47	460	22.87	527	67.41
Junc. 49	478	71.81	524	46.75
Junc. 48	468	50.91	523	55.36
Junc. 50	499	0	532	33.42
Junc. 51	491	0	527	36.8
Junc. 53	482	77	526	44.03
Junc. 54	479	0	529	50.82
Junc. 55	468	80.91	525	57.07
Junc. 57	463	115.83	521	58.1
Junc. 58	477	58.56	514	37.72
Junc. 59	452	0	525	73.43
Junc. 61	457	49.24	520	63.48
Junc. 60	440	60.41	518	78.46
Res. 1	540	1983.55	540	0

Table 2: Results and characteristics in links-pipes of irrigation project

Link ID	Length (m)	Diameter (mm)	Roughness, C	Flow (l/sec)	Velocity (m/sec)	Unit Head loss (m/km)	Friction Factor, f
Pipe. 2	620.3	700	155	646.96	1.68	2.38	0.012
Pipe. 3	580.23	700	155	593.26	1.54	2.02	0.012
Pipe. 4	585.84	700	155	547.79	1.42	1.75	0.012
Pipe. 7	975	200	155	40.01	1.27	6.13	0.015
Pipe. 8	260	100	155	15.5	1.97	30.98	0.016
Pipe. 9	280	150	155	18.54	1.05	5.99	0.016
Pipe.10	550	200	155	47.12	1.5	8.3	0.014
Pipe.11	350	100	155	6.58	0.84	6.34	0.018
Pipe.12	645	200	155	45.47	1.45	7.77	0.015
Pipe.13	400	450	155	269.69	1.7	4.04	0.012
Pipe.14	340	450	155	207.5	1.3	2.49	0.013
Pipe.15	450	250	155	61.57	1.25	4.59	0.014
Pipe.16	235	150	155	33.33	1.89	17.75	0.015
Pipe.17	1075	250	155	91.27	1.86	9.52	0.014
Pipe.18	615	250	155	77.89	1.59	7.1	0.014
Pipe.19	750	250	155	68.93	1.4	5.66	0.014
Pipe.22	1087.4	1000	155	1022.57	1.3	0.98	0.011
Pipe.23	386.83	900	155	907.96	1.43	1.31	0.011
Pipe.24	610.7	900	155	869.77	1.37	1.21	0.011
Pipe.25	702.32	800	155	772.23	1.54	1.72	0.011
Pipe.26	723.85	700	155	659.63	1.71	2.46	0.012
Pipe.27	1266.8	550	155	364.95	1.54	2.66	0.012
Pipe.28	825.18	300	155	109.65	1.55	5.5	0.013
Pipe.29	340	150	155	34.14	1.93	18.55	0.015
Pipe.30	340	200	155	38.73	1.23	5.77	0.015
Pipe.31	10	400	155	207.11	1.65	4.4	0.013
Pipe.32	750	250	155	59.21	1.21	4.27	0.014
Pipe.33	652.5	400	155	147.9	1.18	2.36	0.013
Pipe.34	400	150	155	22	1.24	8.22	0.016
Pipe.35	1255	300	155	125.9	1.78	7.11	0.013
Pipe.36	1925	300	155	114.61	1.62	5.97	0.013
Pipe.37	530	200	155	38.19	1.22	5.62	0.015
Pipe.38	675	200	155	52.18	1.66	10.02	0.014
Pipe.39	860	200	155	45.36	1.44	7.73	0.015
Pipe.40	420.5	200	155	56.62	1.8	11.66	0.014
Pipe.41	700	200	155	56.62	1.8	11.66	0.014
Pipe.42	438.37	200	155	55.98	1.78	11.42	0.014
Pipe.43	335	200	155	55.98	1.78	11.42	0.014
Pipe.44	434.02	400	155	145.59	1.16	2.29	0.013
Pipe.45	423.73	300	155	94.68	1.34	4.19	0.014
Pipe.46	425	150	155	22.87	1.29	8.83	0.016
Pipe.47	1050	250	155	71.81	1.46	6.11	0.014
Pipe.48	1000	200	155	50.91	1.62	9.58	0.014
Pipe.49	329.55	350	155	149.09	1.55	4.59	0.013
Pipe.50	752.11	250	155	72.09	1.47	6.15	0.014
Pipe.51	775	250	155	72.09	1.47	6.15	0.014
Pipe.52	920	250	155	77	1.57	6.95	0.014
Pipe.53	502.8	350	155	80.91	0.84	1.48	0.014
Pipe.54	1515	300	155	80.91	1.14	3.13	0.014
Pipe.55	558.77	350	155	174.39	1.81	6.13	0.013
Pipe.56	990	300	155	115.83	1.64	6.09	0.013
Pipe.57	1000	200	155	58.56	1.86	12.41	0.014
Pipe.58	226.93	350	155	109.65	1.14	2.6	0.014
Pipe.59	530	200	155	60.41	1.92	13.15	0.014
Pipe.60	550	200	155	49.24	1.57	9	0.014

4. Conclusions

i. In this paper, the researcher succeeded in modeling the water distribution system using EPANET2.0 software as a tool for improving the simulation of the hydraulic behavior of the water supply distribution network. After analyzing the water distribution network of the proposed Taq-Taq dam, we can obtain any value of variables.

ii. A Comparison of the results that the researcher obtained indicates that the simulated model seems to be reasonably close to the same network.

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