O 45. FIRE SCENARIOS-BASED ANALYSIS IN WATER SUPPLY NETWORK: CASE STUDY AKYURT, ANKARA

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ABSTRACT: Water is an important need to realize fundamental activities of people. With the growth of the settlements, the combined pipeline systems that distribute water brought from natural sources to settlements have become complicated. Damage to water networks due to natural disasters creates many problems. Computer programs are frequently used to examine the impact of disasters on water networks. The EPANET developed by the United States Environmental Protection Agency is highly preferred for optimizing water networks, revealing behaviors under different scenarios and solving design problems. With the EPANET program, it is possible to observe hydraulic characteristics (flow rate, pressure, velocity etc.) easily under changing conditions. Akyurt district in Ankara, one of Turkey's crowded cities, has been chosen as the study area. In this study, 5 different fire scenarios were determined for the Akyurt district water network and the behavior of the system was investigated under these scenarios. The pressure and flow behaviors were evaluated under changing conditions in the water distribution network. The behaviors of common areas, public buildings and residential in terms of water transmission under fire scenarios were investigated.

Keywords: Akyurt, EPANET, Fire Scenarios, Water Network

1. INTRODUCTION

Water is one of the basic requirements for a region to be suitable for life. The lack of fresh water means that its use, storage and transmission must be done with great importance. Network systems are used for the distribution of drinking water. Drinking water network is a system in which water is distributed over a main transmission line in order to meet the water needs of the people. With the development of technological possibilities, the ways of supply and transmission of water have improved. In addition, with the increase in population, the complexity of water networks necessitated the use of computer programs for network solutions.

One of the frequently used computer programs in water network solutions is EPANET. EPANET is a public water distribution system modeling software package developed by the Water Supply and Water Resources Department of the United States Environmental Protection Agency (Rossman and Van Zyl, 2009).EPANET is used to design and dimension new water infrastructure, to optimize the operation of tanks and pumps, to reduce energy use, to investigate water quality problems and to make scenario-based studies (Polat et al. 2018; Dunca et al. 2018; Stillwell et al. 2011;Davis et al. 2018).

Estimation and preparing for the disasters that may occur for the people reduce the loss of life and property. Fire is one of the most damaging disasters in the settlements. Fires have significantly negative effects on the living things and the balance of the environment.

In case of a fire in the drinking water network, serious damage to the network occurs. The fire must be extinguished before damage occurs. The required water is supplied from the water network to extinguish the fire (Sarptaş et al. 2017).

EPANET, which enables the solution of different hydraulic problems, was invented by Rossman (2009).Besides, it provides solutions water quality problems besides hydraulic. For Calabar Metropolis in South Nigeria, EPANET has simulated real-time hydraulic behavior for water distribution networks (Njoku et al. 2017). Thus, it is aimed to understand the movement and properties of water in the water distribution system (Sarptaş et al. 2017). With the help of EPANET program, the effects of the

equipments (pump, frequency converter, etc.) used in the system on energy efficiency has been investigated. As a result of this study, 16% energy savings were achieved for the organized industrial zone with 134 nodes.
According to the literature review, there is not enough research on in case of disasters the behavior of water networks. In this study, it is aimed to investigate the behavior of the water network on a scenario basis in the event of a fire disaster, which causes huge losses. Fire scenarios have been established in accordance with the Technical Specification for Surveying, Feasibility and the Preparation of Projects of Drinking Water Facilities. The fire scenarios created for a certain part of the water network of Akyurt district of Ankara province were examined with the help of EPANET program. In case the system operates under the most unfavorable conditions, it is thought that the changes in the pressure and flow characteristics of the water network can give information about the sensitive points of the system. In addition, the fact that Akyurt district has a developing population increases the importance of the study.

2. MATERIAL METOD

2.1. Study Area

Akyurt is a district established on a large and flat land within the borders of Ankara.It's surface area is 258 km^2 and its altitude is 960 m (Figure 1).

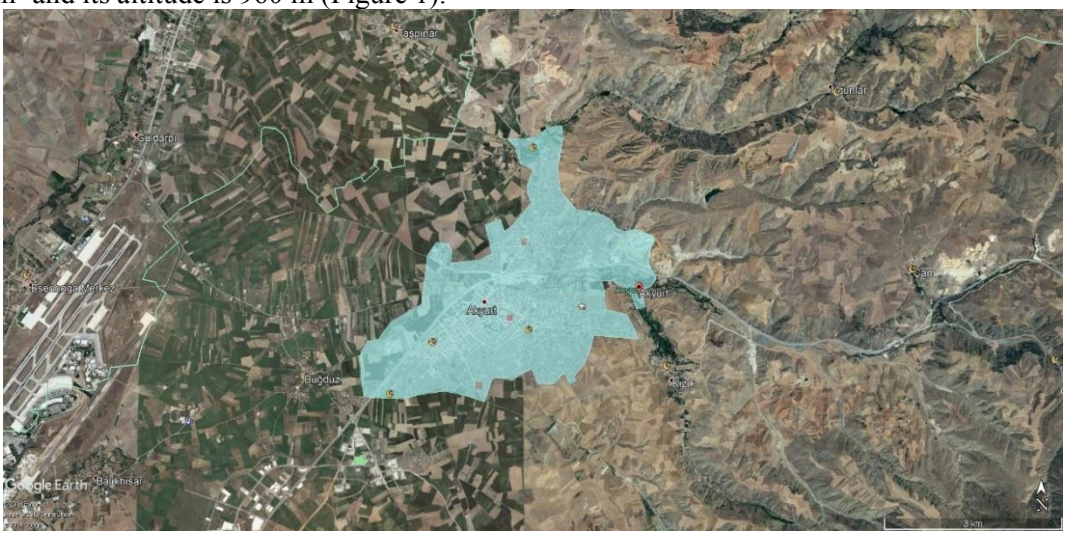


Figure3. Study area

Akyurt district, where the typical continental climate of Central Anatolia is experienced, is hot and dry in summers and cold and rainy in winters. Air temperatures rise to 37 °C in summer and fall to -24 °C in winter.

2.2. EPANET

EPANET software, developed by the US Environmental Protection Agency, is one of the most important software used today to simulate hydraulic and water quality behavior in pressurized water networks (Ramana et al. 2015).
Today, many countries in arid climates face water shortages and consequently pressure problems in water distribution systems. In such countries, the EPANET software makes the necessary improvements in network infrastructure and operating conditions in order to increase the quality and quantity of water supplied and distributed to the consumer. In the simulations performed with EPANET software, hydraulic parameters such as head loss, pressure, flow and velocity in the system can be determined accurately in time-dependent manner throughout the network (Ramana et al. 2015)
EPANET is also used in water distribution systems to determine the operating program of the pumps and to calculate the total energy consumption of the network (Georgescu et al. 2014).

2.3. Hazen-Williams

Hazen-Williams formula is one of the formulas that EPANET uses to find the head loss in pipes. In Equation 1, the Hazen Williams head loss formula is given (Eck and Mevissen, 2012).

$$h_f = 10.65\, C^{-1.852} D^{-4.871} L Q^{1.85} \quad (1)$$

In Equation 1, organized according to SI unit, h_f is head loss (m); D is the inside diameter (m); Q is the discharge (m^3/s); L is the length of pipe (m), C is the friction coefficient of Hazen-Williams formula.

2.4. Fire Scenarios

In addition to the successful operation of the system, the network is required to operate stable in case of a disaster. In this study, various scenarios were tested to investigate the problems that may occur in case of fire (Table 1). Figure 2 shows the fire locations of the scenarios.

Table2. Fire Scenarios

Fire 1	Farthest points to reservoir
Fire 2	The lowest flow points
Fire 3	Points on the main pipes
Fire 4	The two furthest points on the East-West axis
Fire 5	The points where there are public buildings

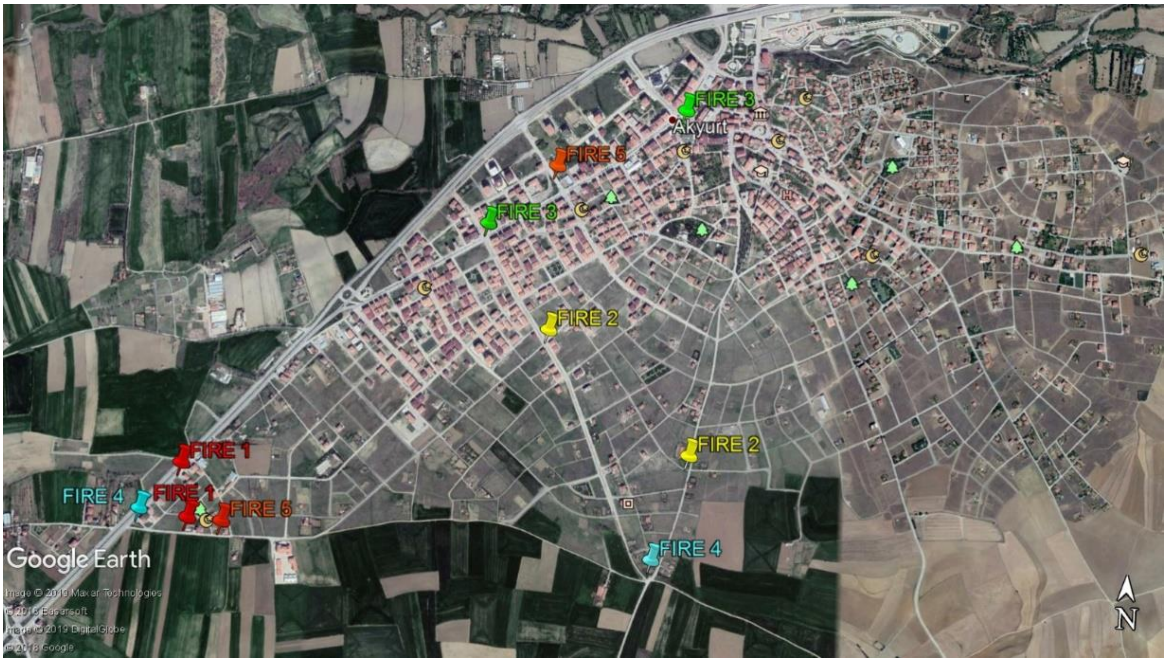


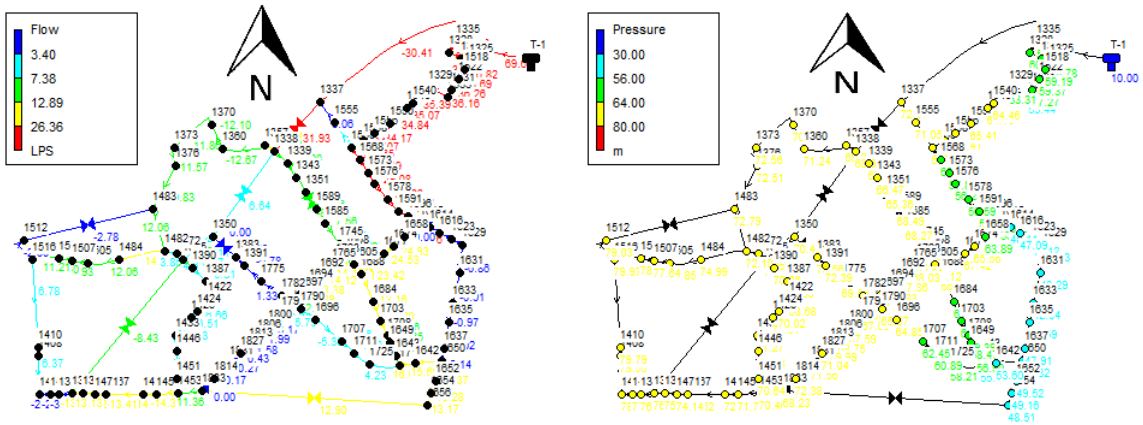
Figure 2. Fire scenarios used in the study

3. RESULTS AND DISCUSSION

Within the scope of the study, scenario based analysis was performed with EPANET program for a certain part of the water network of Akyurt district. The behavior of the system was investigated in case of 5 different scenarios for the water network against fire disaster causing loss of life and property. Sensitive zones were determined by observing the flow and pressure changes of the network. In Figure 3, flow and pressure values related to the present status of the water network of the study area are given. Figure 4-8 shows the flow and pressure values of the water network according to 5 different fire scenarios.

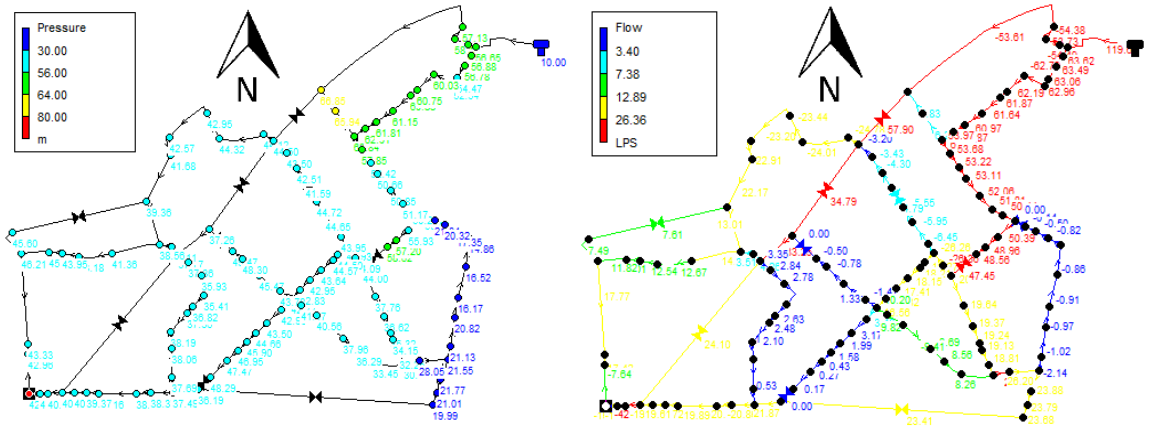
- In present status, since the north of the network is close to the reservoir, the flow values are above 30 l/s. As the usage towards the southern parts increased, the flow values decreased. It has been calculated that the pressure in most of the network is around 64 mss.

- In the case of Fire 2 scenario, pressures in the eastern part of the network have been greatly reduced. Because there are many elbows around the points where the fire is simulated, the sensitivity of the region increases more.
- In the fire 3-4-5 scenario, although the flow directions within the water network change, the flow rates do not vary significantly. However, in Fire 5 scenario, greater pressure values were determined in the entire network compared to Fire 3-4.



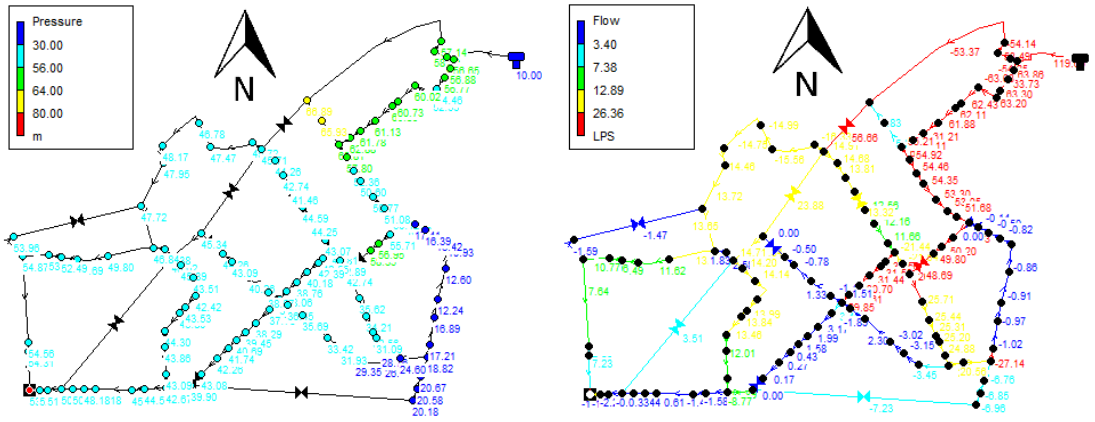
(a) (b)

Figure 3. (a)Flow and (b) pressure values of the present status



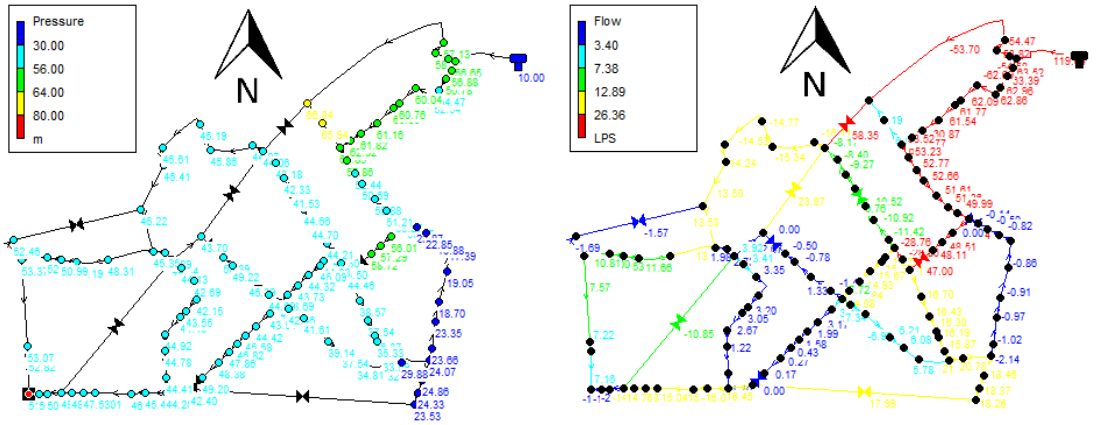
(a) (b)

Figure 4.(a)Flow and (b) pressure values of Fire 1



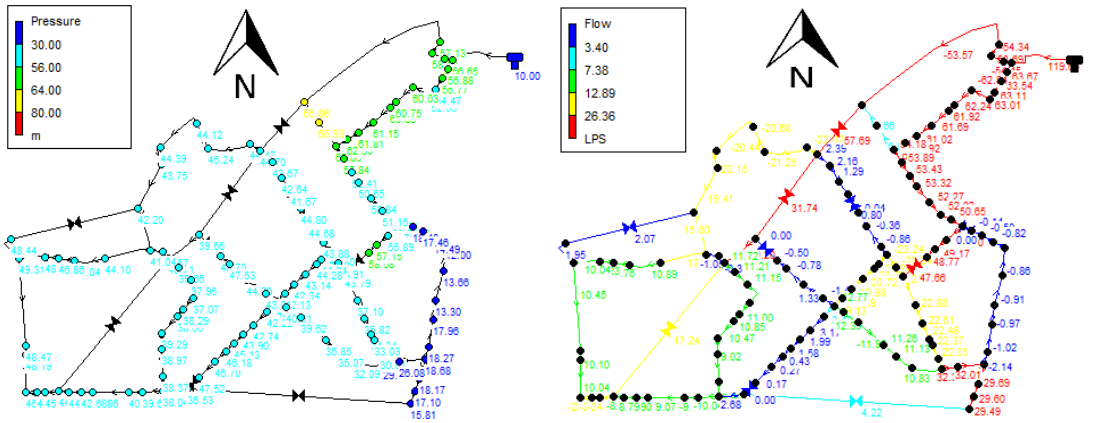
(a) (b)

Figure 5.(a)Flow and (b) pressure values of Fire 2



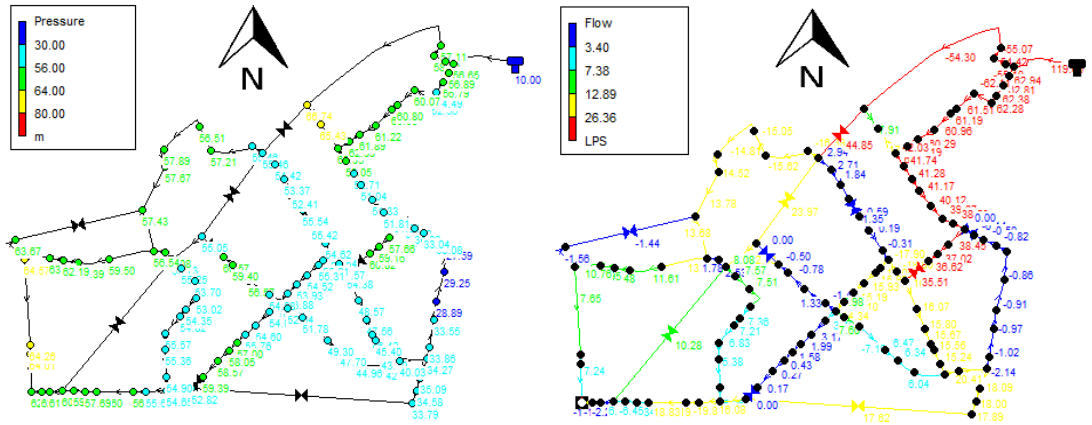
(a) (b)

Figure 6.(a)Flow and (b) pressure values of Fire 3



(a) (b)

Figure 7.(a)Flow and (b) pressure values of Fire 4



(a) (b)

Figure 8.(a)Flow and (b) pressure values of Fire 5

4. CONCLUSION

For Akyurt where rapidly growing population, the behavior of the water network against to a fire disaster was investigated based on the scenarios. EPANET was used to examine the change of flow and pressure characteristics of the system. For the present situation, pressure and flow values of the water network have been determined and changes have been observed according to fire scenarios.

In the Fire 2 Scenario, the lowest pressure values were observed. On the other hand, the highest pressure values were observed in the Fire 5 Scenario.

If the flow increases from anywhere in the network for fire, pipes near the reservoir carry high flow. If these pipes fail or become unable to function, alternative plans should be developed to solve the problems that may occur. It was also observed that in all fire scenarios, the pressures in the east of the network fell below critical values. In order to assess the capacities of water distribution system, it is recommended to evaluate their performance according to different disaster scenarios.

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