Water supply calculation of Stonegate Arch

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Stonegate Arch water supply system is modeled and calculated using EPANET 2 and AutoCAD based on related regulations, site survey data and waterline layout. In the hydraulic modeling, a reservoir is employed to provide the pressure for the whole on site water supply system. To simplify the modeling, the typical water supply points are assumed to be located at the midpoints of the corresponding pipe segments. One on site outdoor fire hydrant is open to check the whole water supply system so as to maintain an acceptable pressure in the distribution system. Minor loss coefficient for each pipe segment is identified and incorporated in the calculations. Five scenarios of the water supply system are calculated to show the pressure & velocity variations at the control points in Stonegate Arch water supply piping system. The results represent that fire flow has significant impact on the velocity & pressure in the scenarios with fire flow. In addition, water demand and the location of concern determine the value of velocity & pressure variations. For the scenarios without fire flow, domestic water demand and pipe size determine the value of pressure & velocity variation.

Keywords: Water Supply, EPANET 2, Domestic Water Demand, Fire Flow

Introduction

Stonegate Arch Water Supply System is designed to provide adequate flows for domestic uses and fire protection, and to maintain the integrity and reliability of the distribution system.

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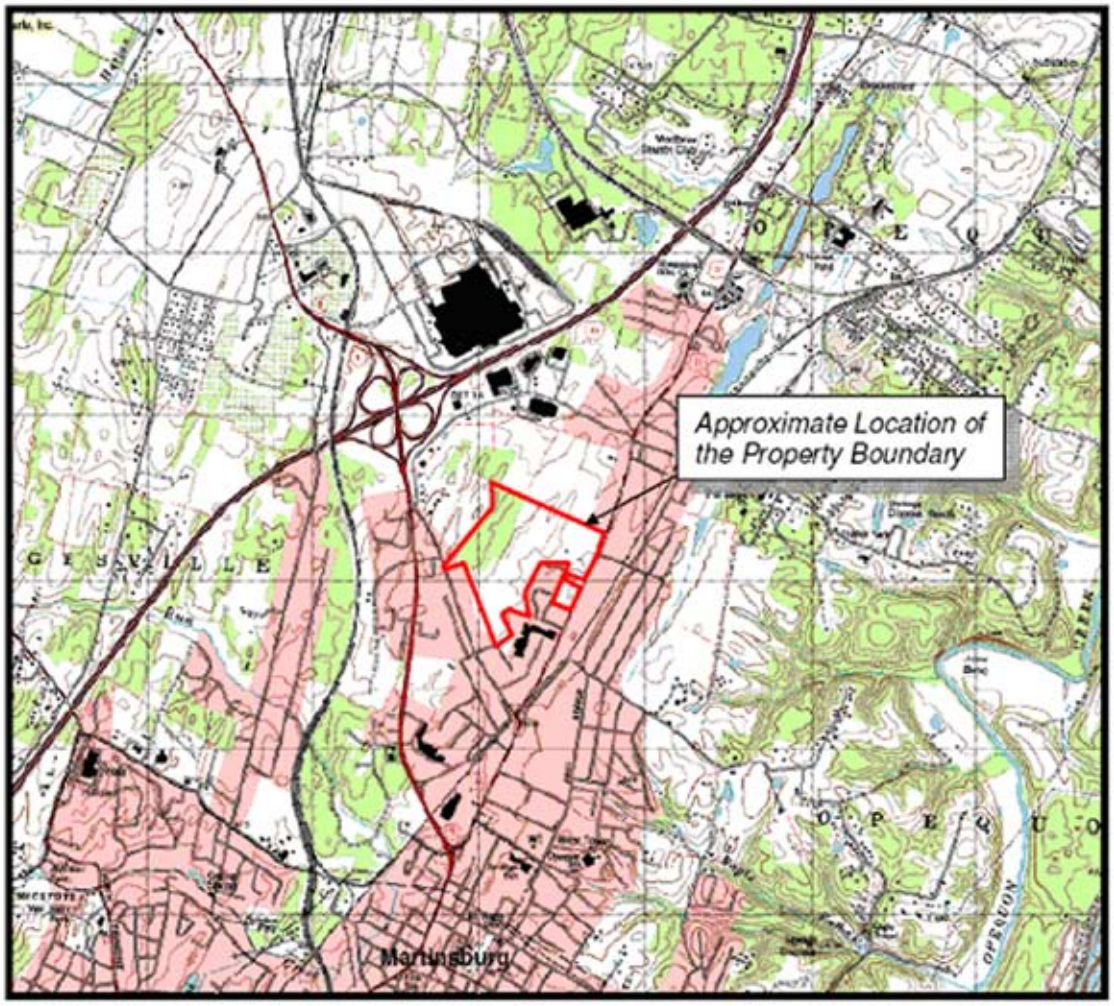

Figure 1. Site Location Map

The Stonegate Arch property (Fig. 1) located on the west side of Williamsport Pike (US Route 11), in Martinsburg, Berkeley County, West Virginia and is developed by American Homes of United Builders. It is approximately 104 acres of agriculture property bordered by residential and light commercial properties.

Figure 2. AutoCAD Conceptual Plan of Water Supply System

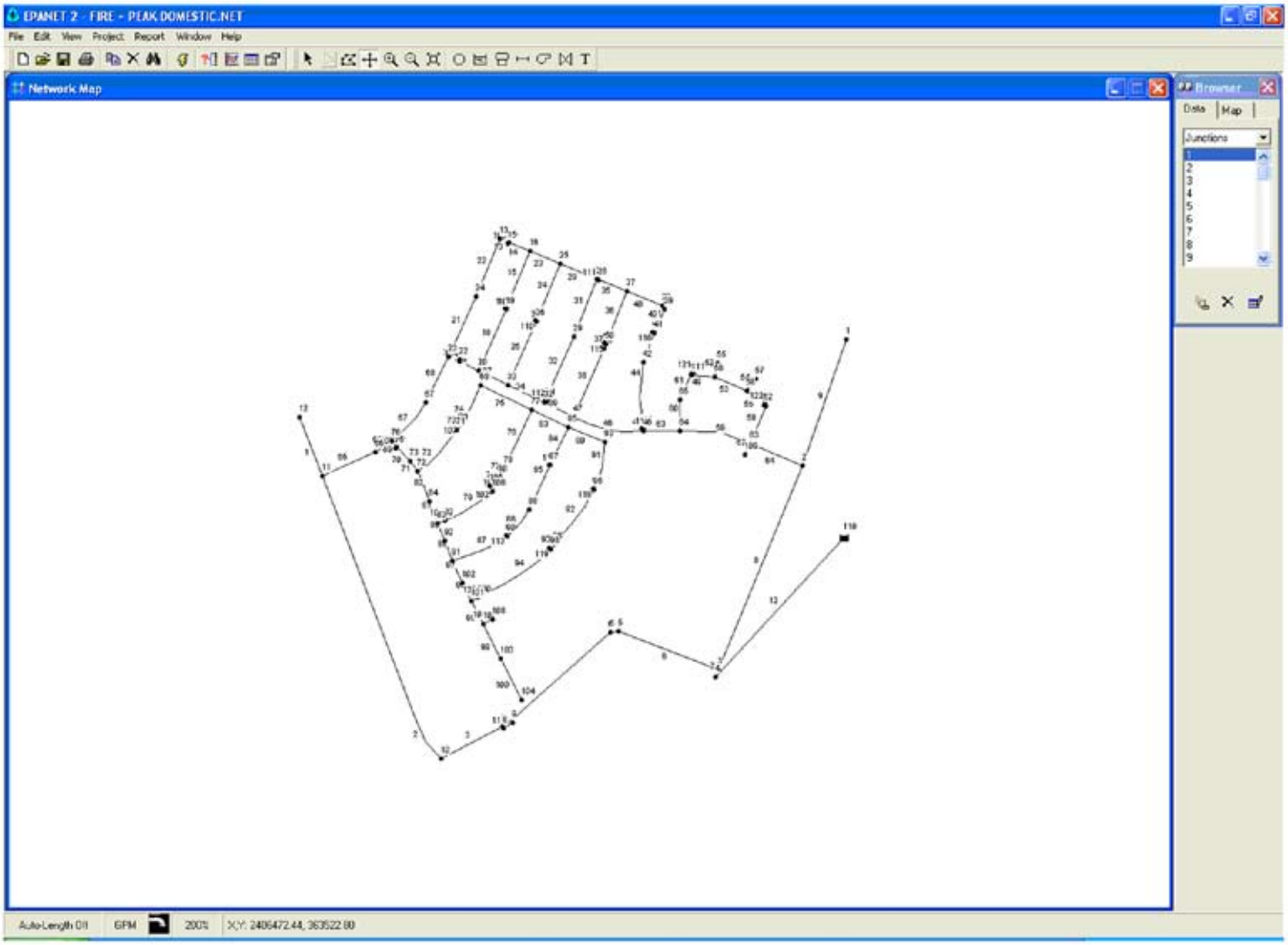

Figure 3. EPANET 2 Calculation Map of Water Supply System

Hydraulic calculations of water supply system were performed by EPANET 2, which was developed by EPA's Water Supply and Water Resources Division. Fig. 2 and 3 show the conceptual and calculation maps of the water supply system in AutoCAD and EPANET 2, respectively. For all proposed Stonegate Arch site, the total peak design domestic water demand is 326 gpm (use 0.5 gpm per home for 386 house units and 250 condos units, water demands of both retail and a couple of parks included as well) and the design fire demand for each outdoor fire hydrant is 500 gpm on the site. In the hydraulic modeling, a reservoir is employed to provide the pressure for the whole onsite water supply system. The result of existing fire hydrant outlet water pressure test was provided by Chris Thiel, from Berkeley County Public Service District. At the flow rate of 1300 gpm, the pressure drops from 78 psi to 60 psi at the location of the existing fire hydrant right beside the site.

The water lateral is located in front of each house. To simplify the modeling, the typical water supply points are assumed to be located at the midpoints of the corresponding pipe segments. One onsite fire hydrant is open to check the whole water supply system so as to maintain an acceptable pressure in the distribution system. Minor loss coefficient for each pipe segment is identified and incorporated in the calculations.

The hydraulic modeling is accomplished using the Hardy Cross method and the Hazen-Williams formula with a selection of roughness coefficient (C=145, PVC C909 CLASS 200 is selected for D<=8 inches; C=120, DIP CLASS 52 is selected for D>8 inches). Minimum water main size is 8 inches in diameter for the residential areas. One 6 inch PVC waterline is designed to serve each condo building and 1 inch water lateral is used for each family unit.

Water mains located in public or private residential streets should be placed outside of the roadway. Permanent easements are required for all water mains

not located within the public street right-of-way. Flexible coupling will be used wherever the pipe runs into or out of concrete structures, at bends or miters, and at other points where differential settlement or normal expansion and contraction of the pipe are anticipated.

Results and Discussion

Five scenarios are calculated to describe the velocity & pressure variations at the control points in Stonegate Arch water supply system (636 units + other customers). The following are the results of the water supply system calculations for Stonegate Arch.

Scenario 1

Static (no fire flow & domestic water demand)

No fire-fighting & domestic water demand, onsite system pressures would range from 73.54 psi to 82.51 psi based on the 78.00 psi static pressure for the existing fire hydrant.

Scenario 2

Average Daily Water Demand (150 gpd per unit)

Time pattern is set in the EPANET 2 hydraulic modeling of this scenario and average daily water demand (150 gpd per unit) is applied.

Fig. 4 shows the changes of pressure (77.92 psi ~ 77.99 psi) in 24 hr at the location of the existing municipal fire hydrant. The pressure does not change much because of the low domestic water demands.

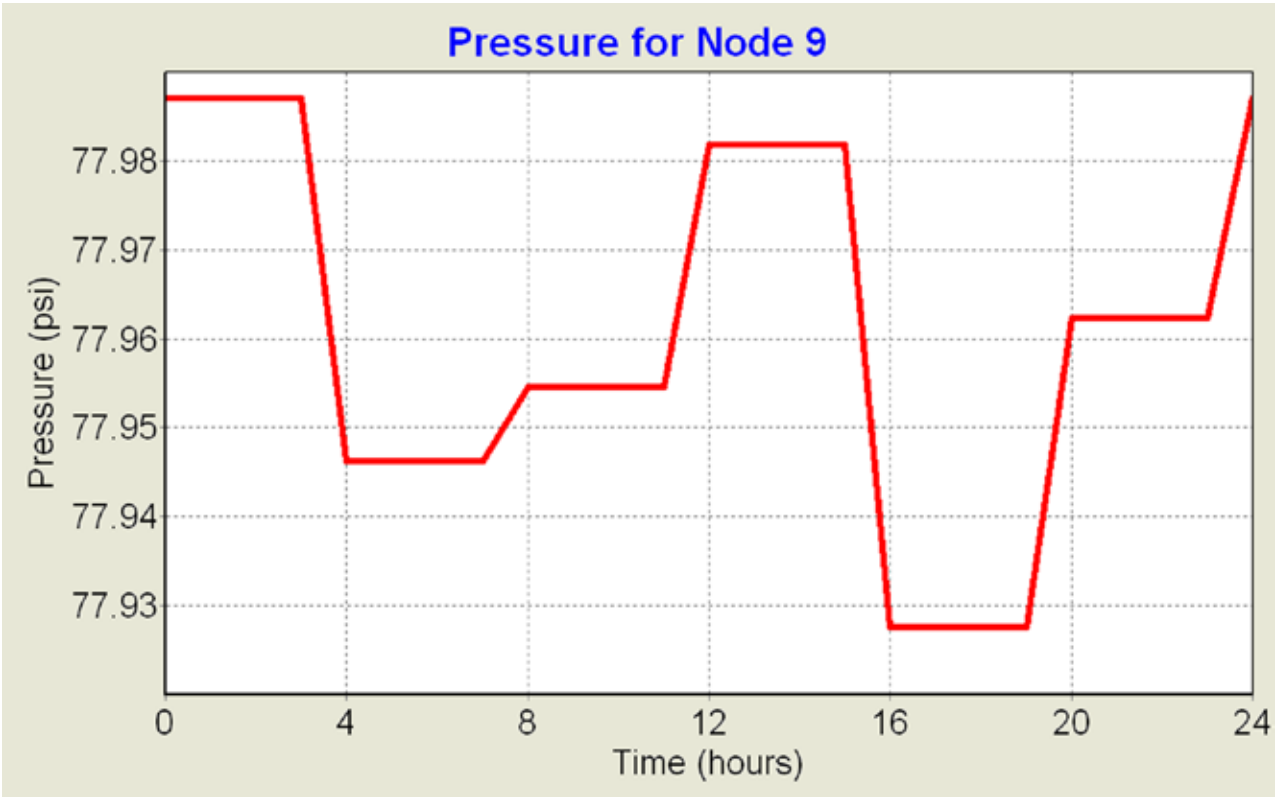

Figure 4. Pressure Variation for Existing Fire Hydrant (Node 9)

Figure 5. shows the daily pressure fluctuations (73.41 psi ~ 73.52 psi) at the control point.

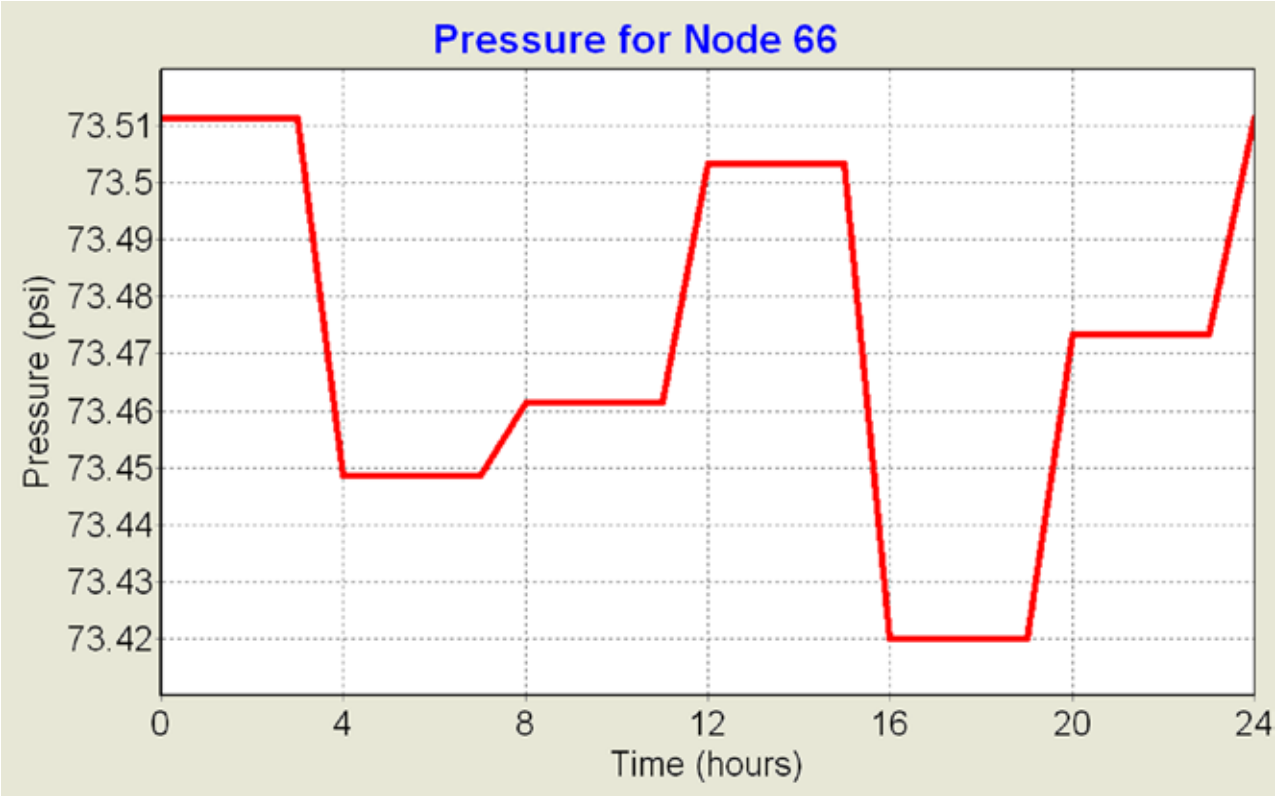

Figure 5. Pressure Variation for Control Point (Node 66)

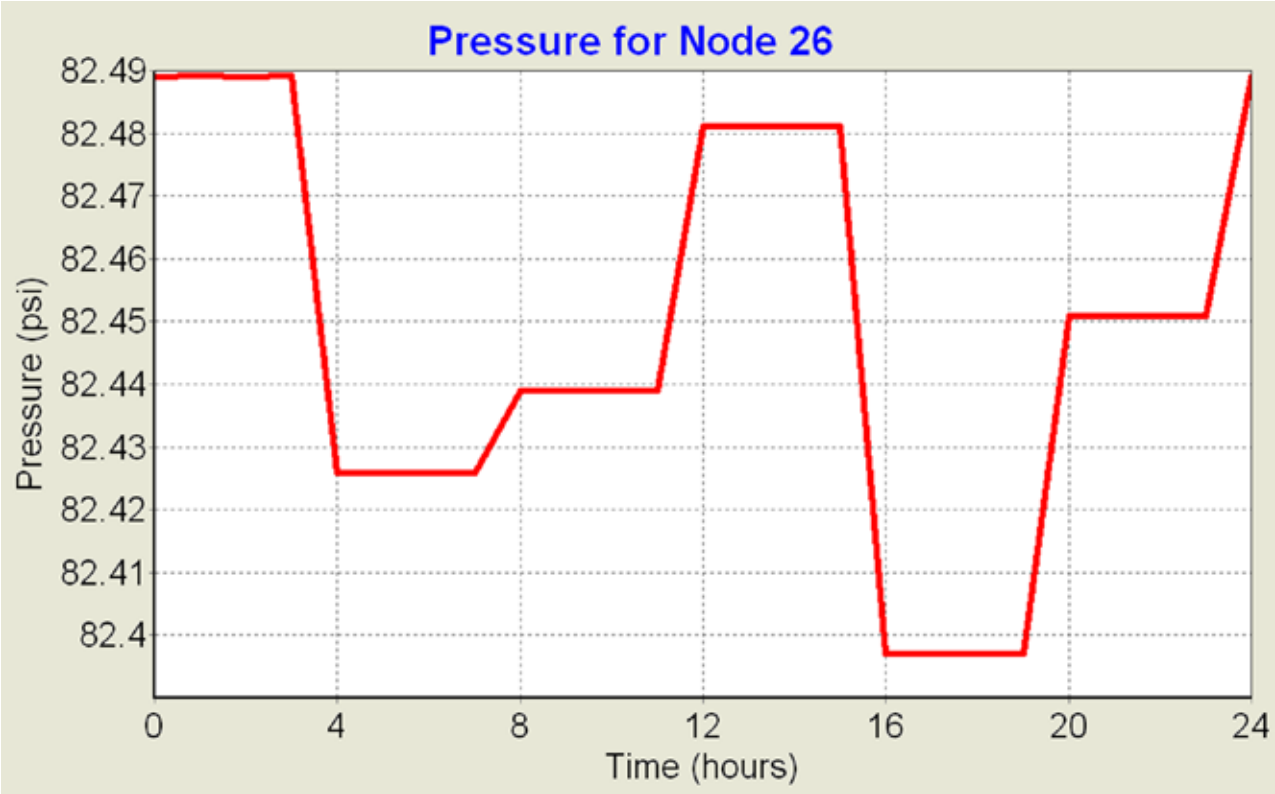

Figure 6. Pressure Variation for Highest Pressure Point (Node 26)

The daily changes of maximum pressure (82.39 psi ~ 82.49 psi) are shown in Figure 6.

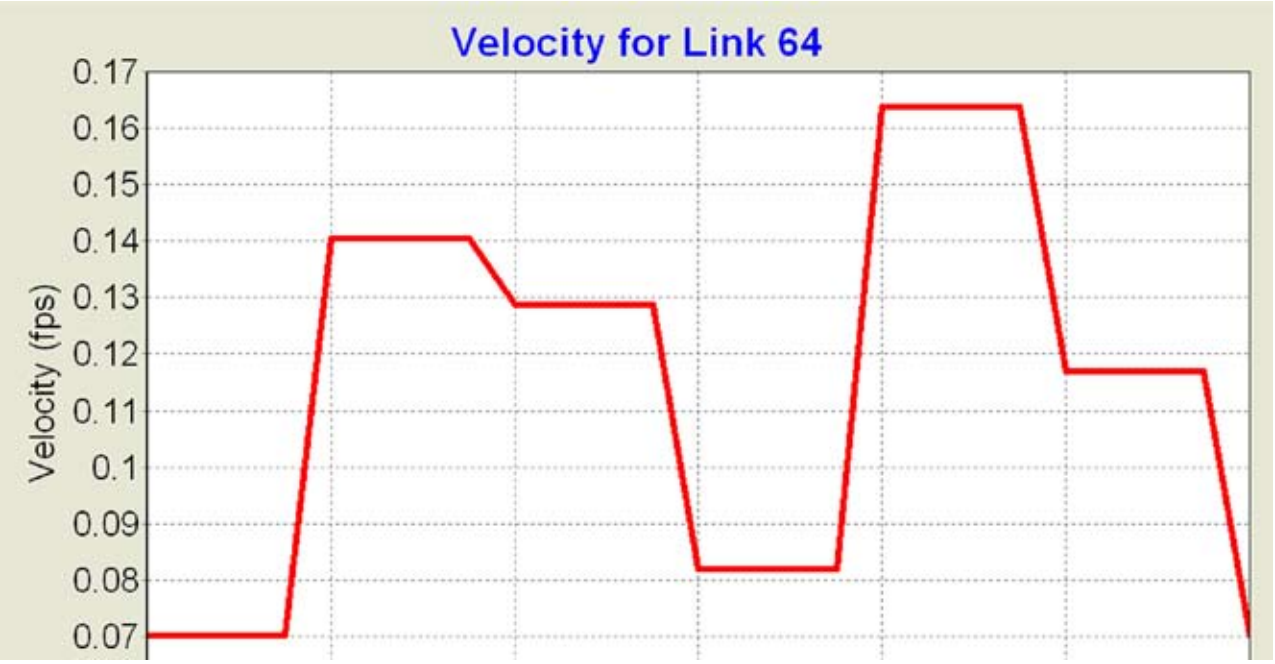

Figure 7. Velocity Variation for The Waterline with Highest Velocity (Link 64)

Figure 7. describes that the velocity varies between 0.06 fps and 0.17 fps at the waterline with general highest velocity.

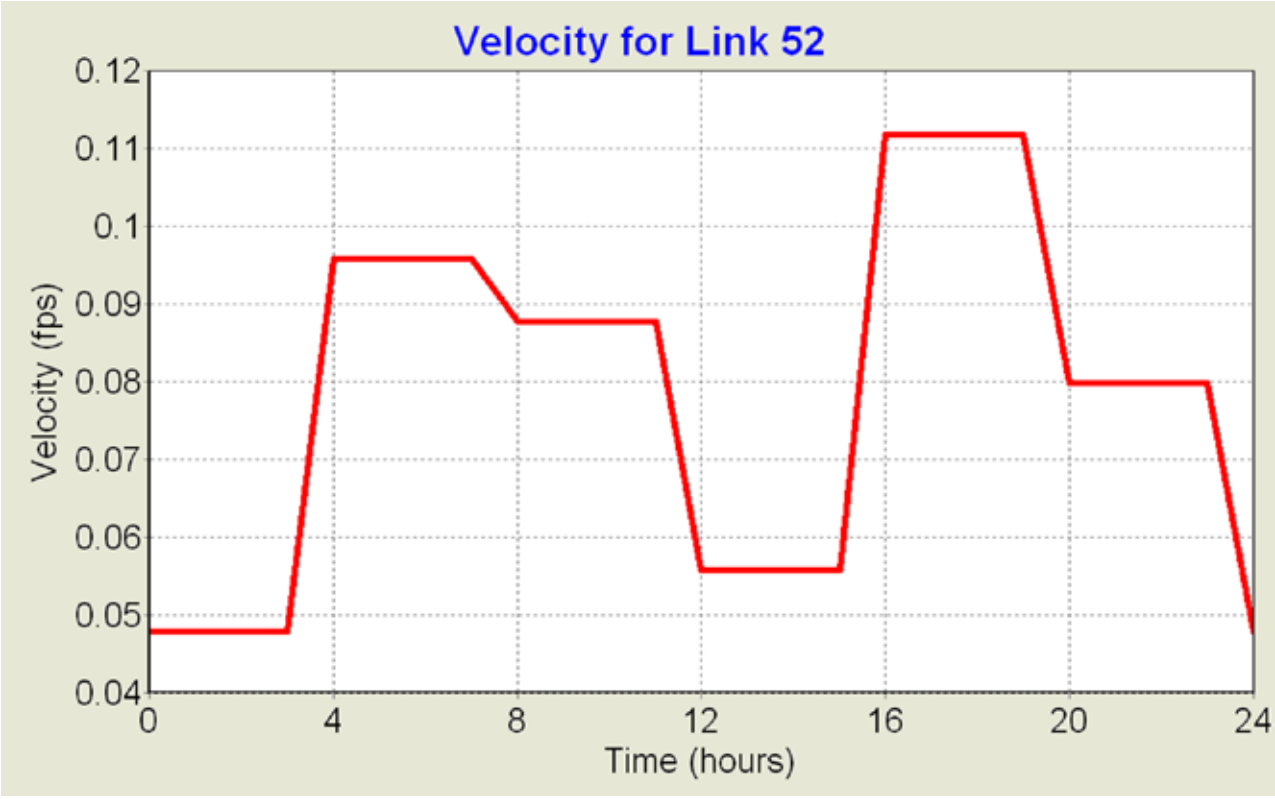

Figure 8. Velocity Variation for Water Supply Point with Highest Velocity (Link 52)

Figure 8. describes that the velocity varies between 0.04 fps and 0.12 fps at the water supply point with highest velocity (to each condo).

From the above figures, it is obvious that water demand and pipe size determine the value of pressure & velocity variations. The pressure in the main are altered little because of the trivial water demand, while the velocity at the water supply point is changed relatively significant due to the changing water demand and small pipe size.

Scenario 3
Peak Domestic Water Demand (0.5 gpm per unit)
The water supply system is designed to provide a residential peak demand flow (no fire flow). The EPANET 2 hydraulic calculation shows the pipe pressures range from 72.31 psi to 81.28 psi. The pressure at the existing fire hydrant is 77.21 psi. In this case, 2.08 fps is the maximum flow velocity for all the pipes.

Scenario 4
Most Distant Outdoor Fire Hydrant (500 gpm) + Average Daily Water Demand (150 gpd per unit)
Time pattern is set in the EPANET 2 hydraulic modeling of this scenario and average daily water demand (150 gpd per unit) is applied. More importantly, the 500 gpm flow requirement of the most distant onsite fire hydrant through the first continuous 4 hours is considered.

Figure 9 shows the changes of pressure (75.90 psi ~ 77.99 psi) in 24-hour at the location of the existing fire hydrant.

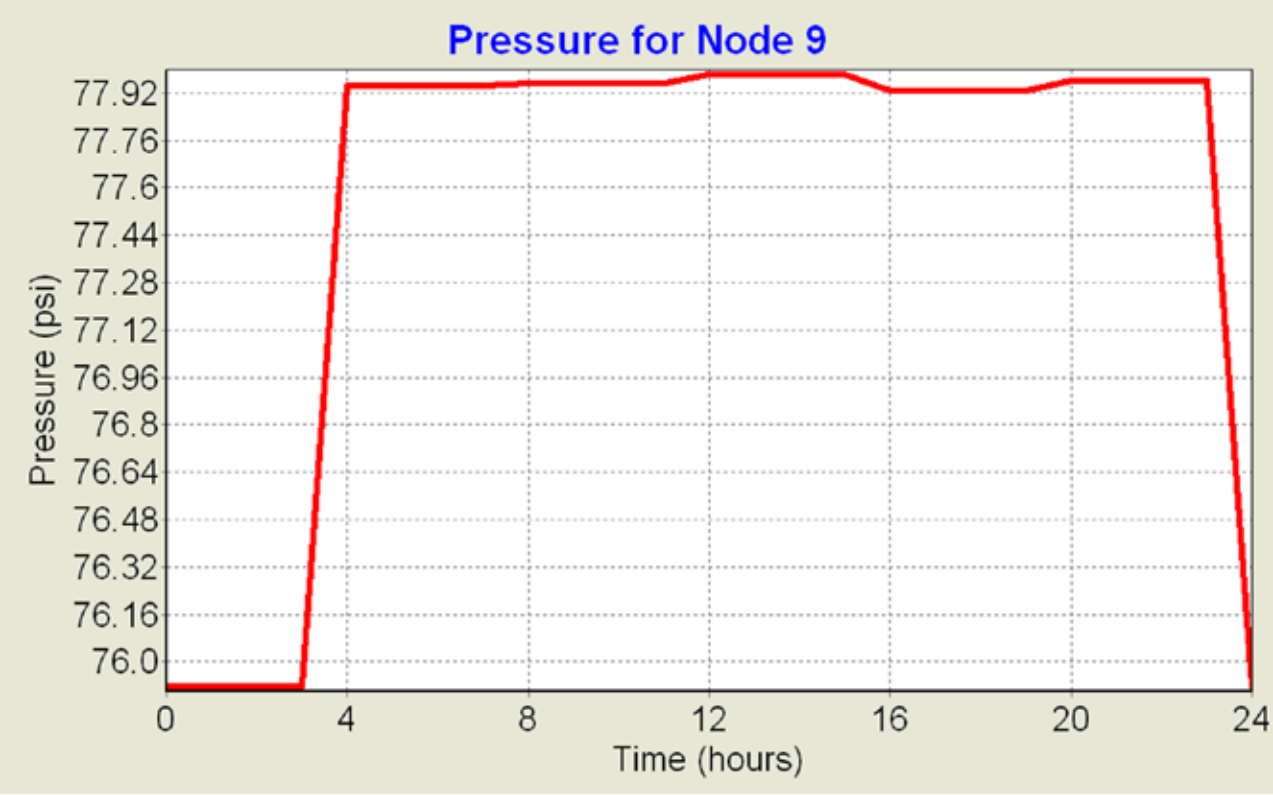

Figure 9. Pressure Variation for Existing Fire Hydrant (Node 9)

Figure 10. shows the daily pressure fluctuations (70.10 psi ~ 74.10 psi) at the control point.

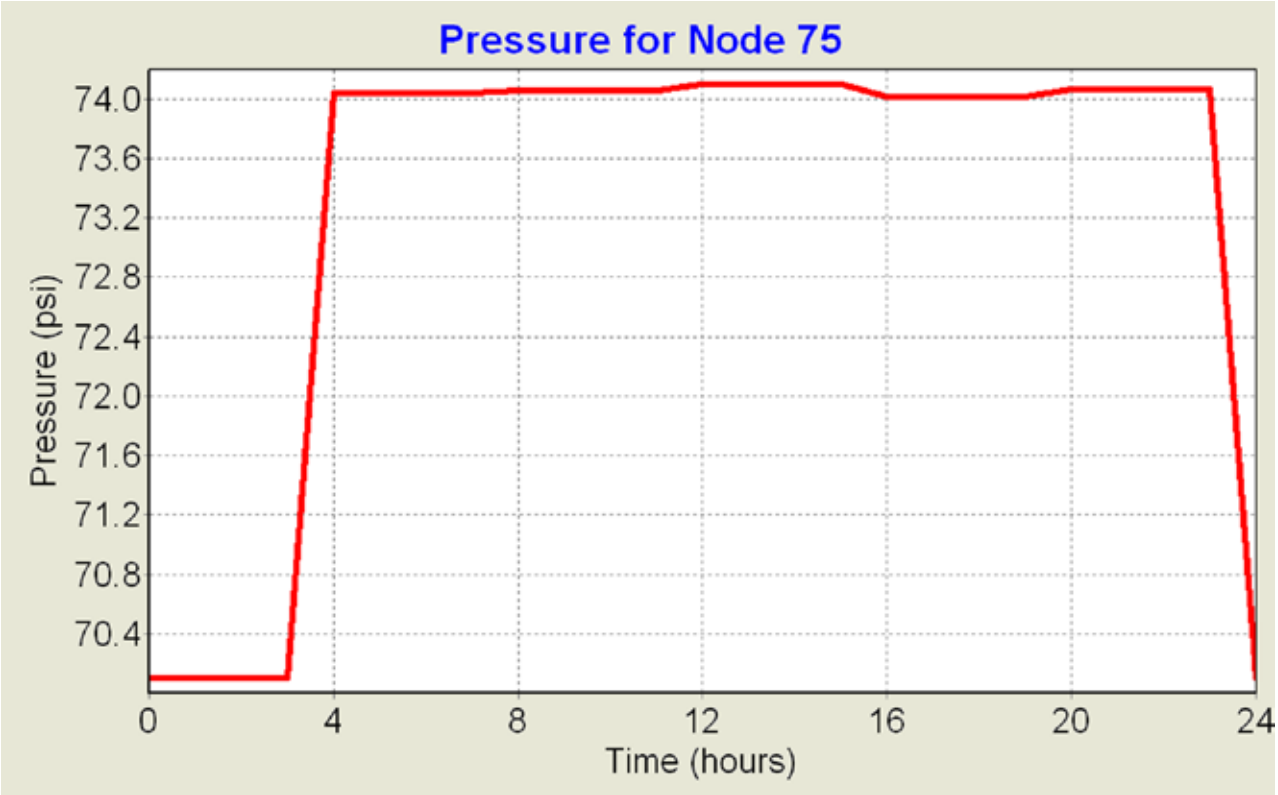

Figure 10. Pressure Variation for Control Point (Node75)

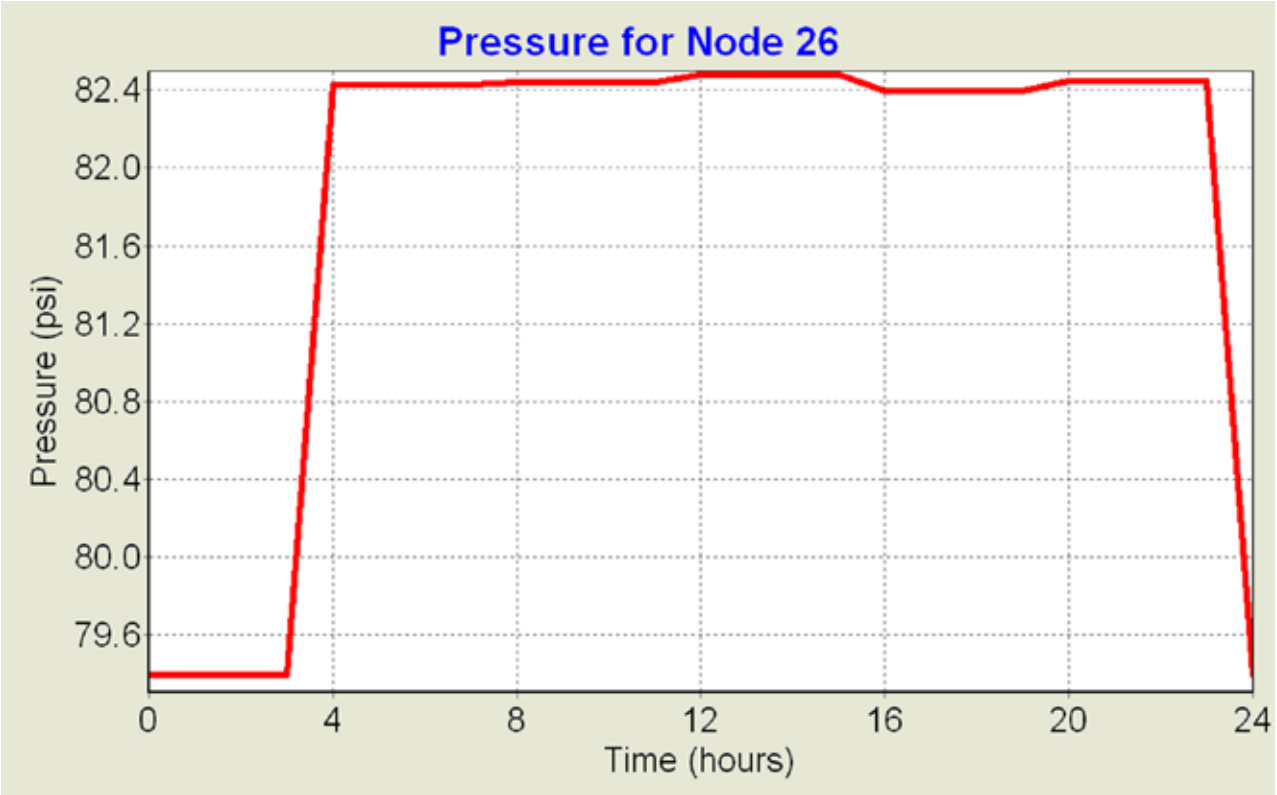

Figure 11. Pressure Variation for Highest Pressure Point (Node 26)

The daily changes of maximum pressure (79.30 psi ~ 82.50 psi) are shown in Figure 11.

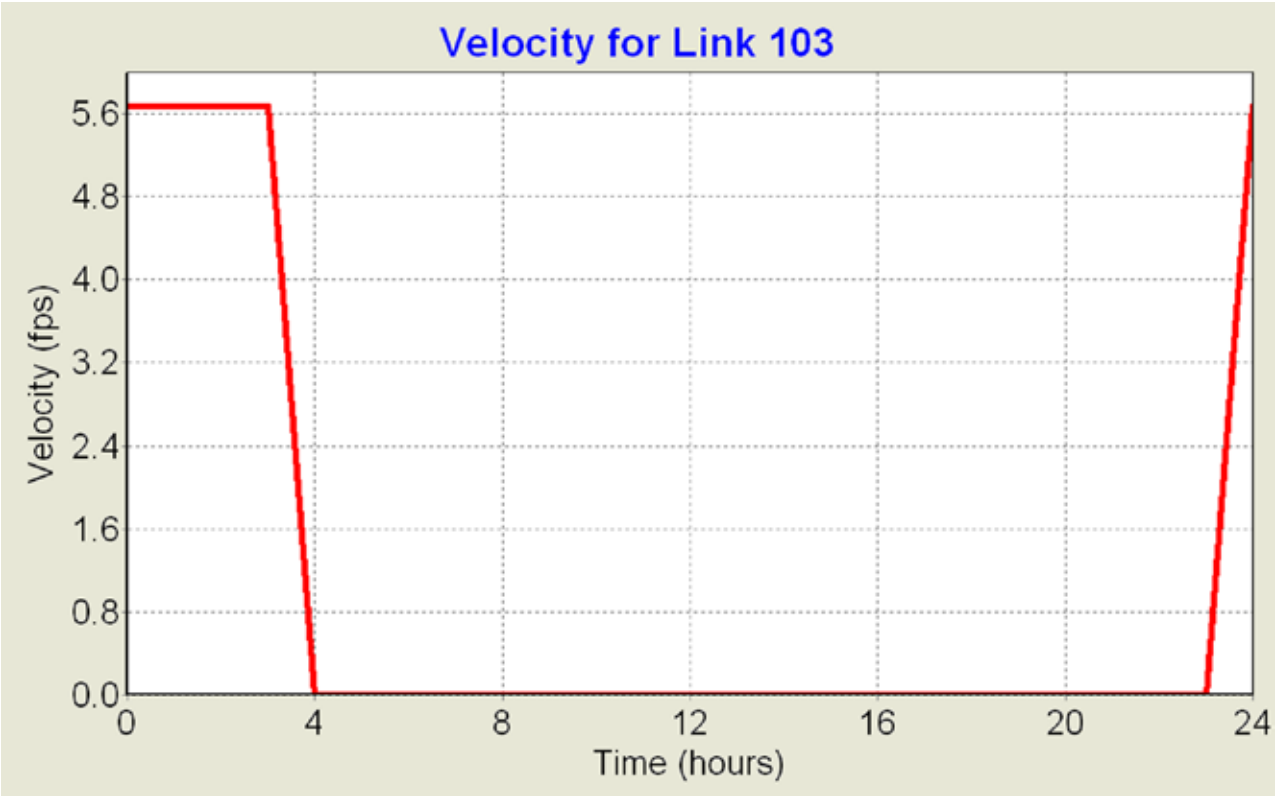

Figure 12. Velocity Variation for Waterline with Highest Velocity Pipe (Link 103)

Figure 12 describes that the velocity varies between 0.00 fps and 6.00 fps at the location of the most distant fire hydrant.

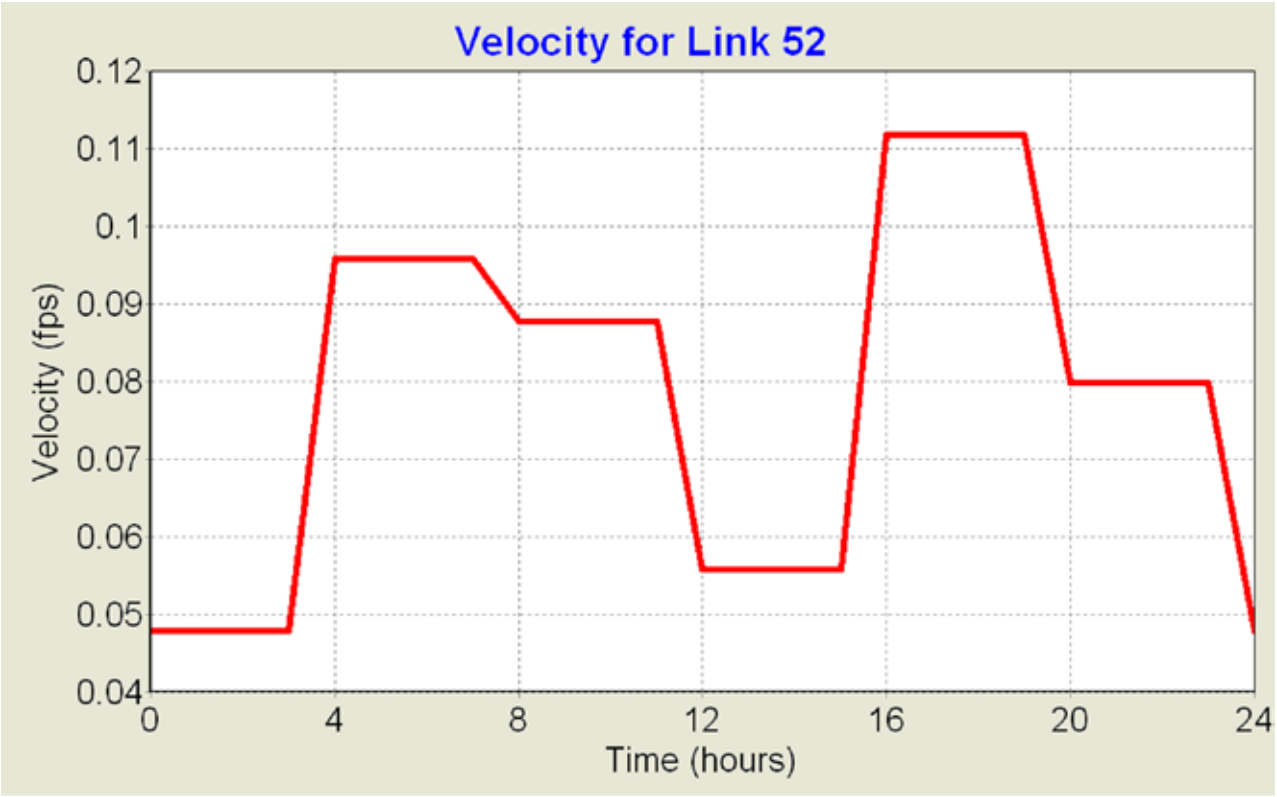

Figure 13. Velocity Variation for Water Supply Point with Highest Velocity (Link 52)

Fig. 13 describes that the velocity varies between 0.04 fps and 0.12 fps at the water supply point with highest velocity (to each condo). It seems that the fire flow has less effect on the velocity of the point than those of the points closer to the most distant fire hydrant at the first 4 hours.

From the above figures, it is obvious that water demand as well as the location of the pipe segment determine the value of pressure & velocity variations. And the velocity in the water main is changed significant due to the fire flow.

Scenario 5
Most Distant Outdoor Fire Hydrant (500 gpm) + Peak Domestic Water Demand (0.5 gpm per unit)
Furthest fire hydrant (500 gpm) is open and 0.5 gpm water demand is provided for each unit, the pipe pressures range from around 66.30 psi (at the location of most distant fire hydrant) to 75.60 psi on the site and the pressure for the existing fire hydrant is 73.48 psi at this condition. All flow velocities in the pipes are not more than 5.67 fps.

Conclusion
Stonegate Arch Water Supply System is modeled using EPANET 2 and AutoCAD. Five water supply scenarios are calculated to analyze the hydraulic conditions at the control points. As of the scenarios with fire flow, fire flow has significant impact on the velocity & pressure. In addition, water demand and the location under investigation determine the value of velocity & pressure variations. For the scenarios without fire flow, domestic water demand and pipe size determine the value of pressure & velocity variation.

Reference
International Plumbing Code 2003 (International Plumbing Code). International Code Council.

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Subdivision Regulations. Berkeley County, West Virginia.