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MEMORANDUM

TO: Jeffrey Crane, Water & Sewer Superintendent

CC: Christopher Cronin, Arthur Martineau, Jacki Byerley, Town Of Andover
Todd Prokop, P.E., Adam Moskal, P.E., Jim Rivard, P.E., and Srivalli Sukuru, P.E., Woodard & Curran

FROM: Rachel Jacques, P.E., Woodard & Curran

DATE: September 9, 2022

RE: DRAFT – 3000 Minuteman Road Hydraulic Analysis

The following memorandum summarizes the results of the hydraulic analysis of the Town of Andover's (Town) water system based on water demands from the proposed development at 3000 Minuteman Road. This memorandum has been prepared in accordance Task Order 18 of our general Consulting Services Agreement dated December 10, 2020.

PURPOSE

The purpose of this hydraulic analysis was to evaluate impacts to pressure and available fire flow in the vicinity of 3000 Minuteman Road (the Site) due to the proposed development by utilizing the Town's existing water distribution system hydraulic model. The hydraulic model simulations were performed under steady-state and extended period simulation (EPS) conditions utilizing InfoWater hydraulic modeling software by Innovyze.

In addition, a description of work and budgetary cost estimate is provided for proposed sewer rehabilitation in and around the Site.

BACKGROUND

The proposed development will be located at 3000 Minuteman Road. Based on information provided by Alexandria Real Estate Equities, Inc. (Alexandria), the development will occur in three phases (Phase A, Phase B, and Phase C). Table 1 summarizes the demand and fire flow information provided by Alexandria for each phase.

TABLE 1: DEMANDS BY PHASE OF DEVELOPMENT

Phase	Demand
Phase A	
Total Daily Domestic Demand	104,535 gpd
Max. Instantaneous Peak Demand	550 gpm
Phase B	
Total Daily Domestic Demand	173,045 gpd
Max. Instantaneous Peak Demand	700 gpm
Phase C	
Total Daily Domestic Demand	396,930 gpd
Max. Instantaneous Peak Demand	903 gpm
Sprinkler System Flow	2,162 gpm
Notes: gpd = gallons per day gpm = gallons per minute	

In addition, Alexandria provided an hourly instantaneous peak demand curve for Phase C, as shown in Figure 1 below, and noted that the average hourly demands for each phase would follow a similar curve with adjustments for the scale of the demands. Woodard & Curran developed the average hourly demands for Phase C by multiplying the hourly peak instantaneous demands by the ratio of total daily domestic demand to total daily peak instantaneous demand. After development, the curve was provided to Alexandria for review and upon review Alexandria provided approval of the curve. Table 2 summarizes the hourly peak instantaneous demands and the average hourly demands.

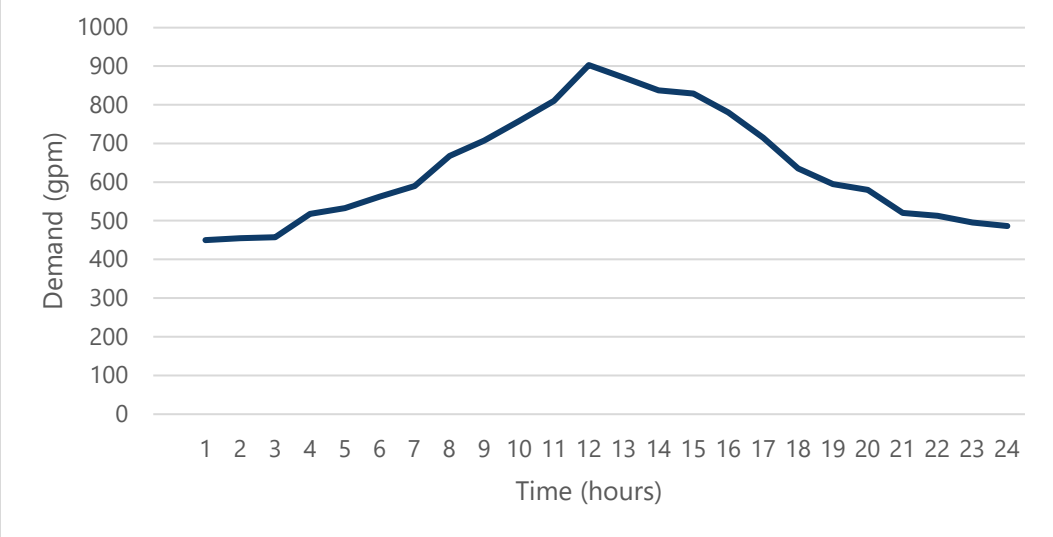

FIGURE 1: PHASE C PEAK HOURLY INSTANTANEOUS DEMANDS

TABLE 2: HOURLY PEAK INSTANTANEOUS AND AVERAGE DEMANDS

Time (Hour)	Peak Instantaneous Demand (gpm)	Average Demand (gpm)
1	450	195
2	455	197
3	458	198
4	518	224
5	533	231
6	563	244
7	590	256
8	668	289
9	708	307
10	758	328
11	810	351
12	903	391
13	870	377
14	838	363
15	829	359
16	780	338
17	715	310
18	635	275
19	595	258
20	580	251
21	520	225
22	513	222
23	495	215
24	486	211

Notes:
gpm = gallons per minute

EVALUATION CRITERIA

Typical and recommended operating standards, such as those listed by the American Water Works (AWWA), are used to ensure that an adequate level of service is provided to all customers at all times. These criteria were used to evaluate the results obtained from the hydraulic model. The evaluation criteria are listed below.

Fire Protection

Guidance from the Insurance Services Office stipulates that needed fire flow shall not be less than 500 gallons per minute (gpm), with increasing values based on the type of building being assessed. The AWWA recommends that fire flows be evaluated for maximum daily demand conditions. We used the hydraulic model to predict Available Fire Flow (AFF) within the distribution system in the vicinity of the development.

System Pressure

The AWWA recommends maintaining a minimum pressure above 20 pounds per square inch (psi) under all operating conditions. In addition, the Massachusetts Department of Environmental Protection (MassDEP) Bureau of Resource Protection Drinking Water Program states the following pressure requirements in Part 9.3 of "Guidelines for Public Water Systems":

1. *The normal working pressure in the distribution system should be approximately 60 – 80 psi and not less than 35 psi.*

    a. *Pressure – All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. All service connections shall have a minimum residual water pressure at street level of at least 20 psi under all design conditions of flow.*

Based on this guidance, for model scenarios which represented non-emergency conditions, a minimum of 35 psi was maintained in the system. For scenarios that represented emergency conditions (fire flow), a minimum pressure of 20 psi was used.

HYDRAULIC ANALYSIS

Four evaluation scenarios were developed to assess the effects of the proposed development compared to maximum daily demand (MDD) with existing distribution system configuration (Baseline Scenario – no development).

- Baseline Scenario – Steady State and EPS: MDD and existing distribution system configuration with no additional demands. Pressure and available fire flow were reviewed under this scenario.
- Phase A – Steady State: Baseline Scenario modeled with the addition of the proposed maximum peak instantaneous demand for Phase A of the development applied at the junction representing 3000 Minuteman Road (J278). Pressure and available fire flow within the vicinity of the Site were reviewed under this scenario.
- Phase B – Steady State: Baseline Scenario modeled with the addition of the proposed maximum peak instantaneous demand for Phase B of the development applied at the junction representing 3000 Minuteman Road (J278). Pressure and available fire flow within the vicinity of the Site were reviewed under this scenario.
- Phase C – Steady State: Baseline Scenario modeled with addition of the proposed maximum peak instantaneous demand for Phase C of the development applied at the junction representing 3000 Minuteman Road (J278). Pressure and available fire flow within the vicinity of the Site were reviewed under this scenario.
- Phase C – EPS: Baseline Scenario modeled with the proposed average hourly demand curve for Phase C of the proposed development applied at the junction representing 3000 Minuteman Road (J278), evaluated for a period of one week. Wood Hill Storage Tank water levels and water treatment plant operation were reviewed under this scenario.

All scenarios were evaluated using the system wide MDD of approximately 13.2 million gallons per day (MGD). Results were evaluated at various locations within the West High Pressure Zone.

For comparison purposes, the pressure and Available Fire Flow (AFF) are summarized in Table 3 below for three locations within the vicinity of the Site (JP6574, JP4066, and HYD-725) and three locations representative of conditions within the West High Pressure Zone (HYD-612, HYD-622, and HYD-926). For the purposes of this analysis, additional demands were added at the junction representing the Site (J278). Junction J278 is located on the 12-inch water main on Minuteman Road as shown in Figure 2, attached. An analysis was not conducted at any locations within the campus of 3000 Minuteman Road. In addition, analysis of the sprinkler system flow provided for Phase C was limited to confirming AFF at the Site was greater than the provided sprinkler system flow during all scenarios.

Woodard & Curran compared predicted model results to fire flow tests provided by the Town on August 2, 2022. The fire flow tests were conducted by Cameron & Davis Fire Protection Engineering on February 12, 2022. AFF shown in the tests and predicted by the hydraulic model are both high, but the values produced by the model are slightly more conservative. For this analysis, the model was not updated and therefore, the more conservative predictions were used for the evaluations below.

After each phase of the development occurs, Woodard & Curran recommends confirming that the actual demands match the estimates provided by Alexandria and that the impacts on the distribution system are similar to the conditions predicted by the hydraulic model. If major adjustments need to be made, we recommend updating the predicted usage and the hydraulic model analysis prior to the next phase of development at the Site. In addition, if demands or impacts to the distribution system are different than anticipated in any phase, at that time the need for on-site water storage should be evaluated.

Baseline

Under baseline conditions, pressures and AFF within the vicinity of the Site were predicted to be approximately 100 psi to 130 psi and 3,300 gpm to 4,300 gpm, respectively. In addition, pressures and AFF beyond the area of the Site but within the West High Pressure Zone (represented by locations HYD-612, HYD-622, and HYD-926) were predicted to be approximately 45 psi to 115 psi and 1,300 gpm to 3,700 gpm, respectively. Refer to Table 3 for approximate pressure and AFF at representative locations in the West High Pressure Zone.

Water levels within the Wood Hill Storage Tank were predicted to fluctuate daily between approximately 14.5 feet to 20 feet. The Wood Hill Pumps at the water treatment plant, which supply the West High Pressure Zone, were predicted to operate for approximately 18 hours each day and supply an average of approximately 2,620 gpm while pumping (suppling an average of approximately 2.8 MGD into the West High Pressure Zone).

Phase A – Steady State

Minimal change (from baseline) in pressures within the vicinity of the development (decrease of approximately 8 psi or less) was predicted near the Site under Phase A and all locations analyzed remained above approximately 45 psi. The addition of the proposed development resulted in a modest reduction (approximately 300 gpm to 500 gpm) in predicted AFF in the vicinity of the Site and lesser impacts in other areas of the system. No locations are predicted to decrease to an AFF of less than 500 gpm. Refer to Table 3 for approximate pressure and AFF at representative locations in the West High Pressure Zone.

Phase B – Steady State

Pressures within the vicinity of the Site were predicted to decrease approximately 10 psi or less under Scenario 2 and all locations analyzed remained above approximately 40 psi. The addition of the proposed development resulted in a reduction (approximately 615 gpm or less) in predicted AFF in the vicinity of the Site, with no locations predicted to decrease to an AFF of less than 500 gpm. Refer to Table 3 for approximate pressure and AFF at representative locations in the West High Pressure Zone.

Phase C – Steady State

Pressures within the vicinity of the Site were predicted to decrease approximately 15 psi or less under Scenario 3A and all locations analyzed remained above approximately 40 psi. The addition of the proposed development resulted in a reduction in predicted AFF in the vicinity of the Site of approximately 1,000 gpm or less, with no locations predicted to decrease to an AFF of less than 500 gpm. Refer to Table 3 for approximate pressure and AFF at representative locations in the West High Pressure Zone.

TABLE 3: APPROXIMATE PRESSURE AND AVAILABLE FIRE FLOW AT PEAK DEMAND

Junction ID	Parameter	Baseline	Phase A	Phase B	Phase C
J278 (Site)	Pressure (psi)	125	120	115	110
	AFF (gpm)	3,980	3,430	3,280	3,080
JP4066	Pressure (psi)	100	95	90	90
	AFF (gpm)	3,325	2,940	2,830	2,680
JP6574	Pressure (psi)	130	125	125	120
	AFF (gpm)	3,715	3,265	3,145	2,975
HYD-622	Pressure (psi)	95	90	88	85
	AFF (gpm)	1,325	1,230	1,200	1,155
HYD-725	Pressure (psi)	130	122	120	118
	AFF (gpm)	4,300	3,890	3,775	3,615
HYD-926	Pressure (psi)	45	45	44	44
	AFF (gpm)	1,795	1,655	1,620	1,565
HYD-612	Pressure (psi)	115	110	105	100
	AFF (gpm)	3,710	3,350	3,250	3,110

Notes:
AFF = Available Fire Flow
gpm = gallons per minute
psi = pounds per square inch

1. Locations are depicted on Figure 2, attached.

Phase C – Extended Period

Under Phase C, with the full build-out of the development, it is predicted that the Town would be able to maintain the water level in the Wood Hill Tank within their normal operating ranges; however, this may require operational changes at the water treatment plant such as increasing the Wood Hill Tank low level. The Wood Hill Pumps were predicted to operate for approximately 22 hours each day and supply an average of approximately 2,440 gpm while pumping (supplying an average of 3.2 MGD into the West High Pressure Zone).

SUMMARY OF ANALYSIS

Based on the information provided by Alexandria and a review of the Town's hydraulic model, it appears that existing infrastructure within Andover's water distribution system is capable of providing water at the 3000 Minuteman Road development during the maximum predicted usage of 903 gpm peak instantaneous flow and 396,930-gallon maximum daily flow. The additional demand at 3000 Minuteman Road will cause decreases in pressure and available fire flow within the West High Pressure Zone, but it does not appear that these impacts will have major detrimental effects on the level of service, largely because existing pressures and fire flows in this zone are relatively high.

As noted above, Woodard & Curran recommends using actual billing records and field-collected data after each stage of development to confirm impacts are similar to the model predictions.

In addition, a single connection to the Town's water distribution system could be a vulnerability for the development; therefore, Woodard & Curran recommends evaluating if there are two locations at which the development can connect to the distribution system.

Chandler Road Water Main Replacement

Based on discussions with the Town, the existing 8-inch water main on Chandler Road between Route 93 and the Shattuck Road easement (approximately 221 Chandler Road) is unlined cast iron and prone to breaks. This is a crucial water main serving the area south of the development and impacts to this water main may subsequently affect water supply to the development. Therefore, as part of the improvements for this development the Town recommends that the approximately 2,300 linear feet of water main on Chandler Road be replaced with a new 12-inch ductile iron water main. Table 4 summarizes the preliminary estimate for the replacement of the water main on Chandler Road. The construction cost is based on $275 per linear foot of new 12-inch ductile iron water main.

TABLE 4: CHANDLER ROAD WATER MAIN REPLACEMENT PRELIMINARY ESTIMATE

Item	Cost
Construction Cost	$633,000
Design (10%)	$63,000
Police (13%)	$82,000
Construction Administration (15%)	$95,000
Contingency (20%)	$127,000
Total	**$1,000,000**

Wood Hill Pump Replacement

As noted above, the Site is in the West High Pressure Zone. The Wood Hill Pumps, located at the Andover Water Treatment Plant, pump water into this pressure zone. These pumps were predicted to operate for approximately 22 hours per day to meet the increased demand of the proposed development. Based on information from the Town, these pumps are old and periodically overheat if run for an extended period of time. In order to provide reliable service, the Town recommends that these pumps be replaced with appropriate size pumps that meet the anticipated increased demand. The preliminary estimate to replace these pumps is $1.8 Million.

SEWER REHABILITATION SUMMARY

At the request of the Town, Woodard & Curran has developed a preliminary plan for the sanitary sewer infrastructure in the vicinity of the Site. This work includes lining of approximately 1,400 linear feet (LF) of 18-inch sewer gravity mains and sealing of five sewer manholes. Lining of the gravity mains shall be accomplished by Cured-In-Place-Pipe (CIPP) lining and will be designed in accordance with ASTM F1216. It is assumed that the segments intended for lining have been inspected via Closed-Circuit Television (CCTV) inspection in the past 5 years, do not contain defects requiring excavation, and there is no more than 400 LF between access manholes of sufficient size to accept an 18-inch liner and appurtenances. Sealing and restoration of the sewer manholes shall be accomplished via curtain grouting to stop active infiltration and dry the substrate to accept interior lining. Cementitious lining of the manhole is recommended following curtain grouting except in cases where manholes are subject to excessive corrosion and/or display evidence of corrosion. Should the manholes display evidence of corrosion, it is recommended to line the interior surfaces of the manhole via Epoxy lining. The preliminary estimate for the proposed sewer rehabilitation work is presented in Table 5.

TABLE 5: SEWER REHABILITATION PRELIMIANARY ESTIMATE

Item	Cost (Cementitious Lining)	Cost (Epoxy Lining)
Construction	$225,000	$270,000
Police (13%)	$29,000	$35,000
Design (10%)	$23,000	$27,000
Construction Administration (15%)	$34,000	$41,000
Contingency (20%)	$45,000	$54,000
Total	**$356,000**	**$427,000**

Infiltration/Infiltration Removal

In accordance with MassDEP's regulations, prior to new development sewer flows entering the system, Infiltration/Inflow (I/I) should be removed from the sewer system. The amount of I/I to be removed is four times the amount of flow the development will be adding to the sewer system. It is anticipated that the amount of sewer flow that will be generated by the development is 225,000 gallons per day. At the 4:1 I/I removal ratio that would result in the need to remove 900,000 gallons of I/I. In lieu of actually removing I/I flow, a fee paid to the Town to be used to remove I/I from the sewer system is an option. This fee would be $3.50 times 900,000 gallons or $3.15 Million.

FIGURE 2
LOCATIONS WITHIN WEST HIGH PRESSURE ZONE