BRISTOL ENGINEERING ADVISORS, INC.
Infrastructure and Water Resources Engineering

July 15, 2016

Attorney William Henchy
165 Cranberry Highway
Orleans, MA 02653

Re: Water System Impact Review
Village at Sudbury Station Development

Dear Mr. Henchy:

Bristol Engineering Advisors, Inc. (Bristol) is pleased to provide you with this Water Impact Report consistent with the requirements outlined in the Sudbury Water District System Rules and Regulations. The rules and regulations require the Water Impact Report to include:

- Estimated impact of the project on the District's water demand;
- Impact of the project to the District's existing supply system including: effects on water flow, speed and direction through existing water mains proximate to the new service line and include maintenance of adequate fire flow;
- Impact of the project with regard to the District's Water Management Act Withdrawal Permit compliance;
- Conditions and water conservation measures that will mitigate the effect of the project's impact.

Project Information

Project Name: The Villages at Sudbury Station

Applicant:

Sudbury Station LLC
Chris Claussen
2134 Sevilla Way
Naples, FL 34105
(239)571-5500

Number of Units:

1 Bedroom Units	116
2 Bedroom Units	109

3 Bedroom Units	25
Total Units	250
Total Bedrooms	409

Estimated Project Start/End Dates:

Estimated Start Date: 2nd Quarter 2017
Estimated Project Duration: 18 Months

Estimated Water Demand:

Title 5

Average Day	44,990 gal	
Maximum Day	56,238 gal	(1.25 x Average Day Demand)

Residents per Unit (1.6)

Average Day	29,000 gal	
Maximum Day	36,250 gal	(1.25 x Average Day Demand)

Background

The Villages at Sudbury Station is proposed to include 250 units of rental housing on 40 acres of land located on Peters Way. The Project includes a total of 409 bedrooms with an estimated water demand of 44,990 gallons per day, based on Title 5 estimates of 110 gallons per day per bedroom. Experience shows that this method of estimating water demand often overstates actual conditions. The methodology used for this analysis is included in Item 2, below, and is based upon data contained in the January 23, 2016 Fiscal Impact Analysis which estimates an average population per unit of 1.6. Using this preferred methodology, the estimated water use is approximately 29,000 gpd. We have used a 1.25 multiplier on average day use to estimate peak day. This is based on the Project not relying on water supplied by the District for landscape irrigation.

The water system is proposed as an 8-inch water main connected to the District system in two locations: the 12-inch main on Concord Road at Peter's Way; and the District's 12-inch main on Hudson Road near Peakham Road.

The District provides water to its customers from nine groundwater supply wells. The water is treated to remove iron and manganese, adjust pH and provide for disinfection of the water and distribution system. The pumped water is stored in four storage tanks, totaling 6.35 million gallons.

The District pumped a total of 689 million gallons (MG) of finished water in 2015, for an average of 1.889 million gallons per day (MGD). The maximum day pumping was approximately 3.6 MG on May 30th. The

prior year (2014), the District produced approximately 612 MG (1.68 MGD). Their 2014 maximum day production was 3.42 MG on June 30th.

This water is distributed to over 6100 water customers through approximately 136 miles of water main ranging from 8-inch up to 16-inch in diameter. In 2015, the District reported 12.6% unaccounted for water (UAW); this is up slightly from 9.4% in 2014. UAW is water that is produced but not accounted for in billing or estimated from normal water uses such as hydrant flushing or fire protection. MassDEP policy is for UAW to be 10% or less.

Like UAW, MassDEP policy is that water suppliers are to strive for a maximum residential consumption of 65 gallons per person per day (RGPCD – residential gallons per capita per day). The District met this goal in 2014, with an RGPCD of 61, but exceeded slightly in 2015 at 69. Exceeding the MassDEP standard imposes additional conditions on a water supplier to reduce demand by restricting "non-essential" water use, and can result in substantial additional requirements in the event that a water supplier desires additional water withdrawal volume under their WMA permit.

The Sudbury Water District has a two-tiered water withdrawal authorization issued by MassDEP under the Water Management Act. The District has a WMA Registration of 1.72 MGD, which is a volume that was grandfathered in 1986 under the provisions of the WMA. District demand has increased since 1986, and they subsequently received a permit under the WMA for an additional 0.36 MGD, bringing their total authorized withdrawal volume to 2.08 MGD. In their permit issued November 10, 2010, MassDEP defined a "baseline" for the District as 2.06 MGD. Even though they have a permitted volume of 2.08 MGD, the District would be required to prepare and submit an "Offset Feasibility Study" should they pump greater than their baseline on an annualized daily average. Thus, the effective permitted volume available to the District should be considered to be 2.06 MGD.

Item 1 – Impact on District's Water Demand

The Project will be incorporating water saving faucets and showerheads, as required for new developments. In addition, each unit will include horizontal axis washing machines and high efficiency dishwashers. The District Rules and Regulations assign a water savings for the washing machines of 7,300 gallons per unit per year. Water efficient dishwashers can save about 2 gallons per cycle – about a $^1/_3$ reduction compared to a traditional appliance. Assuming one load of laundry and one dishwasher cycle per day, use of these appliances will save approximately 8,000 gallons per unit per year, or a total of over 2,000,000 gallons per year for the entire Project. This equates to greater than 10% of the total water demand for the Project.

Additionally, the Project is proposing two on-site irrigation wells to avoid the use of District water for landscaping. This will avoid the use of several million gallons per year of District water during periods of peak District demand.

Finally, the new construction of the water system and units means that leaks will be minimal to non-existent for a number of years, essentially eliminating UAW from this development. Furthermore, because of the lack of irrigation demand and the inclusion of water efficient infrastructure throughout, it is likely that RGPCD will be substantially below the MassDEP regulatory threshold of 65. Both of these attributes will have a beneficial impact on the District water accounting, and will assist the District in meeting its permit requirements.

Item 2 – Impact on Existing Supply System

Fire Flow Test

On Friday, July 8, personnel from Bristol met with personnel from the District to conduct a series of fire flow tests in the vicinity of the proposed District interconnections. The locations were selected due to their proximity to the proposed access road for the proposed development. They were: Hudson Road at Peakham Road and Concord Road at Candy Hill Road-Peters Way. The tests were conducted mid-morning in order to provide normal system flows and pressures.

Test 1 was conducted on Hudson Road. The flow hydrant was located near the intersection of Concord Road; the residual (reporting) hydrant was located near Peakham Road. Recorded static pressure was 90 pounds per square inch (psi). Both hydrants are served off of a 12-inch water main.

Fire flow testing at this location shows an available fire flow of approximately 2500-3200 gallons per minute (GPM) at a 20 psi residual pressure. The flow ranges are due to flow velocities causing the pitot flow gauge to oscillate during the test. A copy of the field test data is attached.

Test 2 was performed on Concord Road. The flow hydrant was located adjacent to the cemetery; the residual hydrant was located at the intersection of Concord Road – Candy Hill Road. Recorded static pressure was 79 psi. Both hydrants are served off of a 12-inch water main.

Fire flow testing at this location resulted in available fire flow of 2000-2800 GPM at a residual pressure of 20 psi. Like test 1, the test flow resulted in the pitot flow gauge oscillating during the test. A copy of the field test data is attached.

Based on the fire flow testing, the existing water distribution system, as designed, is capable of providing water supply to the proposed development for both fire flow and domestic demands.

Proposed Water Usage – Village at Sudbury Station

The proposed development consists of 10 building units ranging in size from two stories to four stories. The units will consist of a total of 250 residential units comprised of 116 1-bedroom apartments, 109 2-bedroom apartments and 25 3-bedroom apartments.

Utilizing data from 9 similar residential complexes located in Sutton, Danvers and Abington, MA, the Average Water Usage in Gallons per Day per bedroom was 59 GPD. The Average Water Usage per residential unit was 116 GPD. Using these average values, the Village at Sudbury Station is expected to utilize approximately 24,131 GPD based on the Average Usage per Bedroom value and 29,000 GPD based on the Average Usage per unit value. The usage values listed represent approximately 12% and 15%, respectively, of the District's current remaining WMA allocation.

Estimating the population of the development is based on the number of persons occupying each bedroom. For the purpose of this evaluation, we will assume the population projections included in the January 23, 2016 Fiscal Impact Analysis for the project that assumed 1.6 persons per unit, or 400 residents at full utilization.

Utilizing the 2015 Residential Gallons Per Capita Day value of 69 gallons per capita day as reported in the District's 2015 MassDEP Annual Statistical Report, the above estimated population will require 27,600 gpd. This usage, which is expected to be higher than what will actually occur at the Village due to limitations on landscape watering, washing vehicles, etc., and use of water conservation low flow fixtures in the development, represents approximately 15% of the District's current remaining WMA allocation. Allowing a 5% contingency for excess demand, we estimate the average daily usage will be approximately 29,000 gpd based on the Fiscal Impact Analysis.

This value equates to average daily flow rate of 20 gallons per minute based on a 24-hour day. A more conservative 16-hour day usage period realizes an average daily flow rate of 30 gpm to the complex.

The District has reported a maximum day peaking factor of 2.0. For a proposed development like the Village, the peaking factor will be less than average due to the lack of landscape care be each residence, water conservation plumbing fixtures such as low flow showers and faucets. Typical estimated maximum day usage factor for a development like the Village is approximately 1.25. Using this value, the maximum day usage at the complex will be 36,250 gpd. This equates to 38 gpm average flow rate.

Flow Impacts to Existing System

The proposed Village at Sudbury Station will connect to existing 12-inch diameter mains in Hudson Road – Peakham Road and in Concord Road at Peter's Way. An 8-inch water main will be installed for the distance of approximately 2,630 feet between the connection points to service the development. An additional 1,050 feet of 8-inch main will be installed to serve buildings 1, 2 and 3. Six fire hydrants are planned to be installed.

For this report, we have estimated a fire flow rate of 1,000 gpm to be located at approximately Station 10+00 of Access Drive 1 in front of Building 12. Using a Hardy Cross methodology, headloss flow tables based on Darcy Weisbach flow formula as contained in Cameron Hydraulic Data book and Hazen-Williams flow formula, it was determined that a flow of 1,000 gpm will result in an increase in flow of 560 gpm in Hudson Road and 440 gpm flow increase in Concord Road.

Calculating for velocity increases in the two existing 12-inch mains results in a maximum increase of 1.58 $^{ft}/_{sec}$ in the Hudson Road main and a 1.24 $^{ft}/_{sec}$ increase in the Concord Road main. Since flow is expected to arrive at each proposed 8-inch connection point from two directions, the actual expected flow increase will be about 50% of the total velocity increase. This will result in velocity increase of 0.79 $^{ft}/_{sec}$ in Hudson Road and velocity increase of 0.62 $^{ft}/_{sec}$ in Concord Road.

As can be seen, the increase in velocity to the existing 12-inch mains is negligible at a "fire flow" rate of 1,000 gpm, we have not calculated the velocity for average or maximum day residential usage (30 – 38 gpm, respectively) since the increase in velocity value will be essentially zero.

Item 3 – Impact of the Project on the District's WMA permit

As stated above, the District's WMA authorized withdrawal volume is 2.08, though given the regulatory consideration given to "baseline" in the recently promulgated regulations (310 CMR 36.00), it is appropriate to consider the value of 2.06, as defined as baseline in the District's 2010 WMA permit, as the regulatory threshold against which future water supply obligations are considered.

The District reported 1.88 MGD as their annual daily average production in 2015, and 1.68 in 2014. Records for prior years were not examined, but if the higher year usage of 1.88 MG reported in 2015 is to continue, there remains 0.2 MGD under the WMA permit and 0.18 MGD under the baseline available before consideration would be given to seeking additional withdrawals under the WMA.

The Project has been designed to have Title 5 wastewater design flows of just under 45,000 gallons per day (0.045 MGD). Assuming this is the annual average daily rate for water supply, this would result in the 2015 raw water pumping increasing to 1.925 MGD. This leaves an additional 0.155 MGD available under the permit, and 0.135 under the baseline amount to meet demand growth.

Water consumption data for years 2014 and 2015, as reported on the Massachusetts Department of Environmental Protection Annual Statistical Reports, is shown in Table 1 below.

Usage Category	2014 Services	Usage - MGY	2015 Services	Usage - MGY
Residential	5741	408.748	5796	458.701
Commercial/Business	232	79.226	234	62.966
Agricultural	7	9.528	7	7.115
Industrial	8	9.644	7	5.318
Municipal/Institutions	67	15.904	64	13.50
Totals	**6055**	**523.09**	**6108**	**547.6**

The newly promulgated WMA regulations require that permittees seeking increases above their baseline volume offset or mitigate the impacts of the requested increase. Examples of offsets include projects that

return water to the basin, such as infiltration and inflow (I&I) reduction projects, increasing stormwater recharge and wastewater returns to the basin via groundwater discharge projects. Given that this project is proposing on-site treatment and disposal, it is likely that much of the projected water demand will be offset by the on-site groundwater discharge of the treated effluent (minus some consumptive losses). Therefore, the net effect of the Project on the District's long-term ability to meet its water supply obligations may at worst be minimal, and potentially a net positive.

Item 4 –Water Conservation Measures

The Project is taking several steps to reduce its impact on the Sudbury Water District. These actions include using low-flow fixtures throughout the development. Furthermore, the Project is proposing a dedicated irrigation supply well, eliminating essentially all outdoor water use for landscaping purposes. The Project will include backflow preventers located in dedicated mechanical rooms to which the District personnel will have access for inspection purposes.

Together, the water conservation measures to be implemented for this project will reduce the Project's water consumption by more than 10% compared to a similarly sized project.

Respectfully,

BRISTOL ENGINEERING ADVISORS, INC.

Peter L. Newton

Peter Newton

Attachments:

Fire Flow Test 1 Data – Hudson Road|Peakham Road
Fire Flow Test 2 Data – Concord Road|Peters Lane
Flow-Velocity Calculations at 1,000 gpm Flow Rate

FLOW TEST DATA SHEET

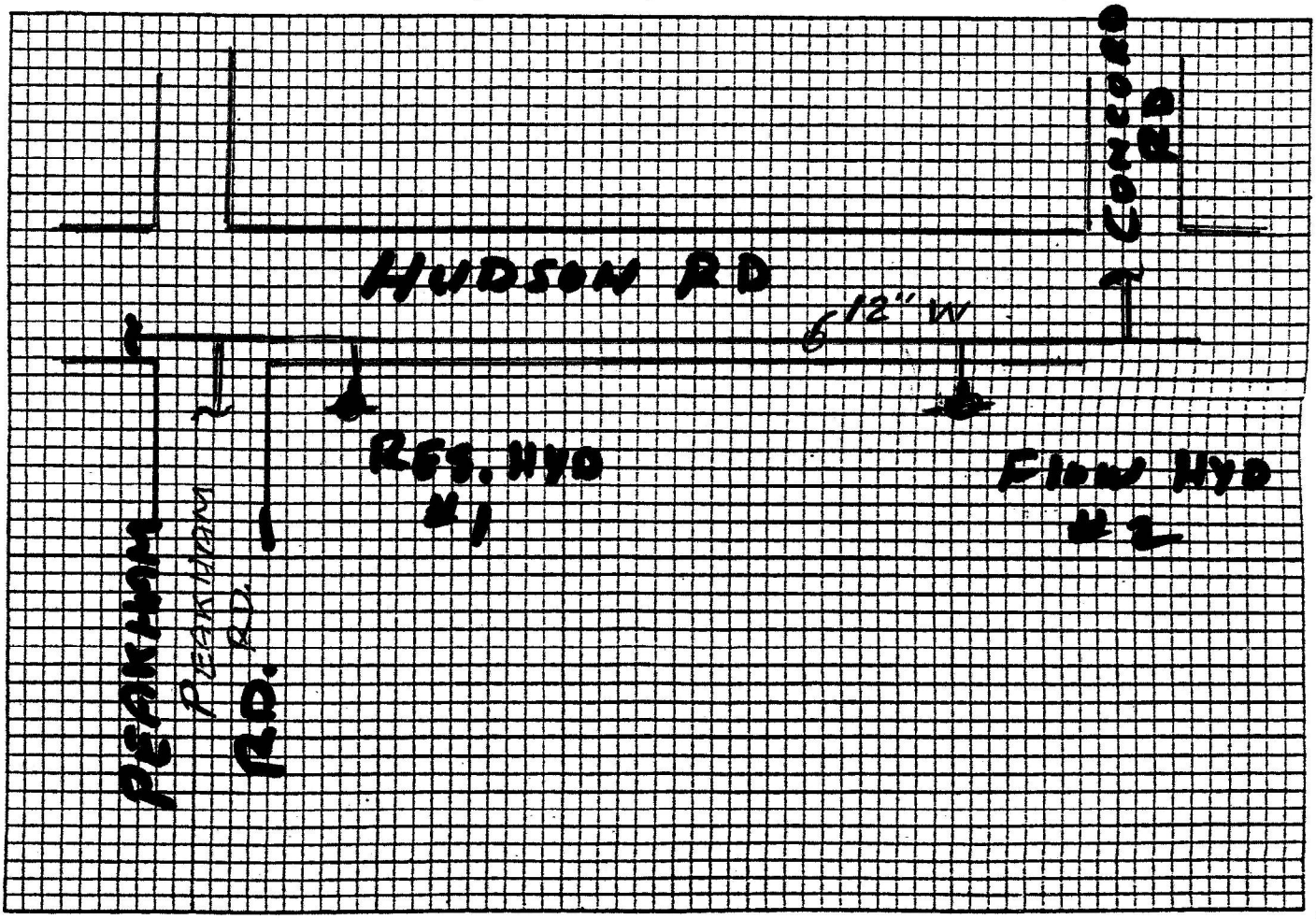
INSURED VILLAGE AT SUDBURY STATION. 7/8/2016

LOCATION HUDSON - PEAKHAM RD BY TMS/PN/PAT CARROLL

DATE	TIME (AM / PM)	TEST HYD		FLOWING HYD 2					FLOWING HYD 3					TOTAL FLOW	
		STATIC (psi)	RESI-DUAL (psi)	PITOT (psi)	DIA (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	PITOT (psi)	DIA (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	ACTUAL (gpm)	AT 20 psi (gpm)
7/8	10:45	90	83	20	2 1/2	–	–	750	–	–	–	–	–	750	* 2680
		90	83	30	2 1/2	–	–	920	–	–	–	–	–	920	* 3191
		90	86	10	2 1/2	–	–	530	–	–	–	–	–	530	* 2492

* CALCULATED VALUES

SKETCH FLOW TEST LOCATION: ~~Flow~~ RESIDUAL (Test) Hydrant is always #1



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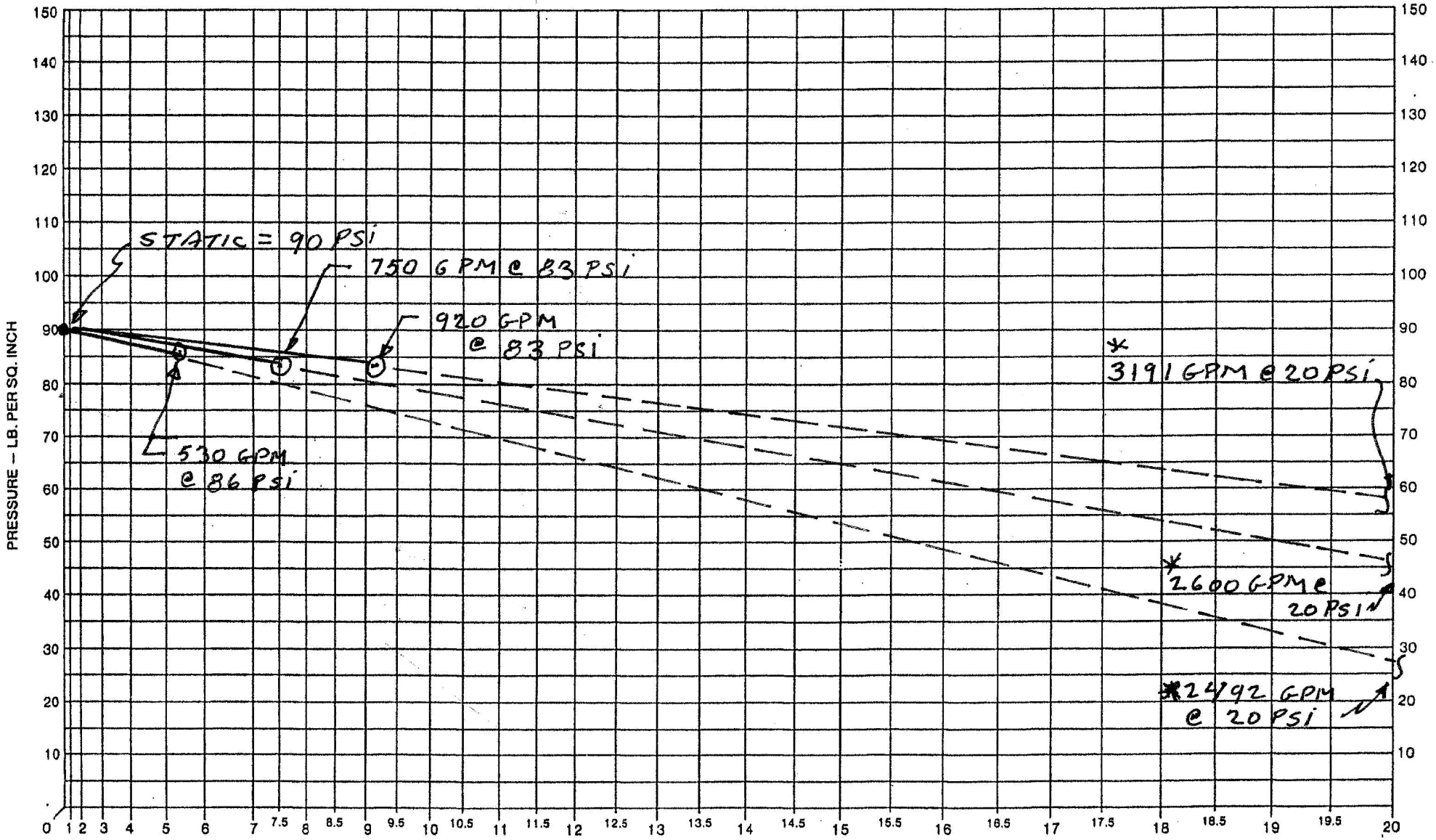
FIRE PROTECTION WATER SUPPLY ANALYSIS

INSURED Village AT SUDBURY STA. POLICY NO. — BY TMS | PN | PAT CARROLL

LOCATION HUDSON - PEAKHAM RD. DATE 7/8/2016 TIME 10:45 (AM) PM



MULTIPLY SCALE BY 100

* calculated values

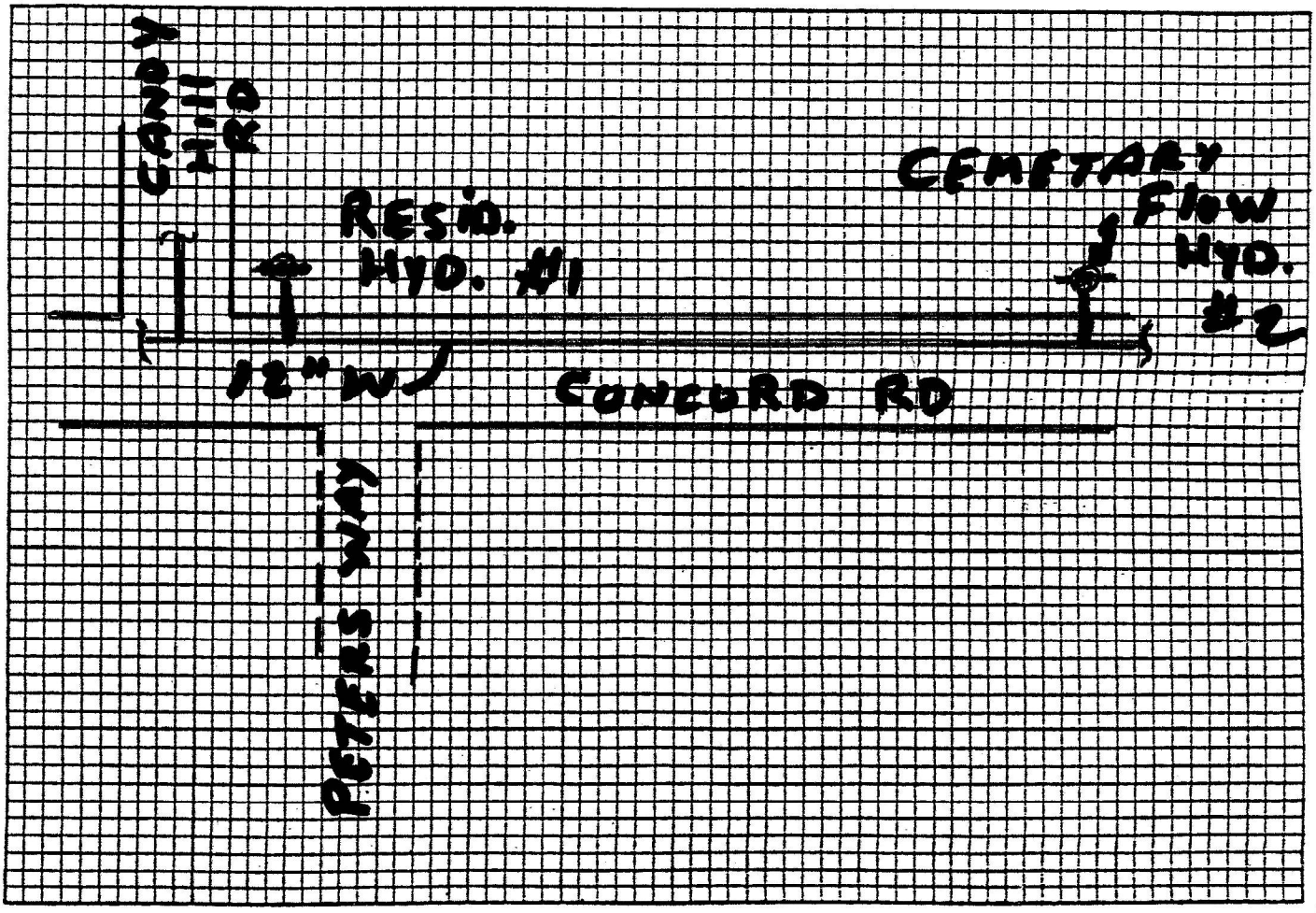
FLOW TEST DATA SHEET

INSURED VILLAGE AT SUDBURY STATION 7/8/2016

LOCATION CONCORD RD – PETER'S LANE BY TMS/PN/PAT CARROLL

DATE	TIME (AM) PM	TEST HYD		FLOWING HYD 2					FLOWING HYD 3					TOTAL FLOW	
		STATIC (psi)	RESI-DUAL (psi)	PITOT (psi)	DIA (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	PITOT (psi)	DIA (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	ACTUAL (gpm)	AT 20 psi (gpm)
7/8	11:00	79	74	10	2½	–	–	530	–	–	–	–	–	530	2004
	11:05	79	74	20	2½	–	–	750	–	–	–	–	–	750	2837

SKETCH FLOW TEST LOCATION: RESIDUAL (TEST) Hydrant is always #1



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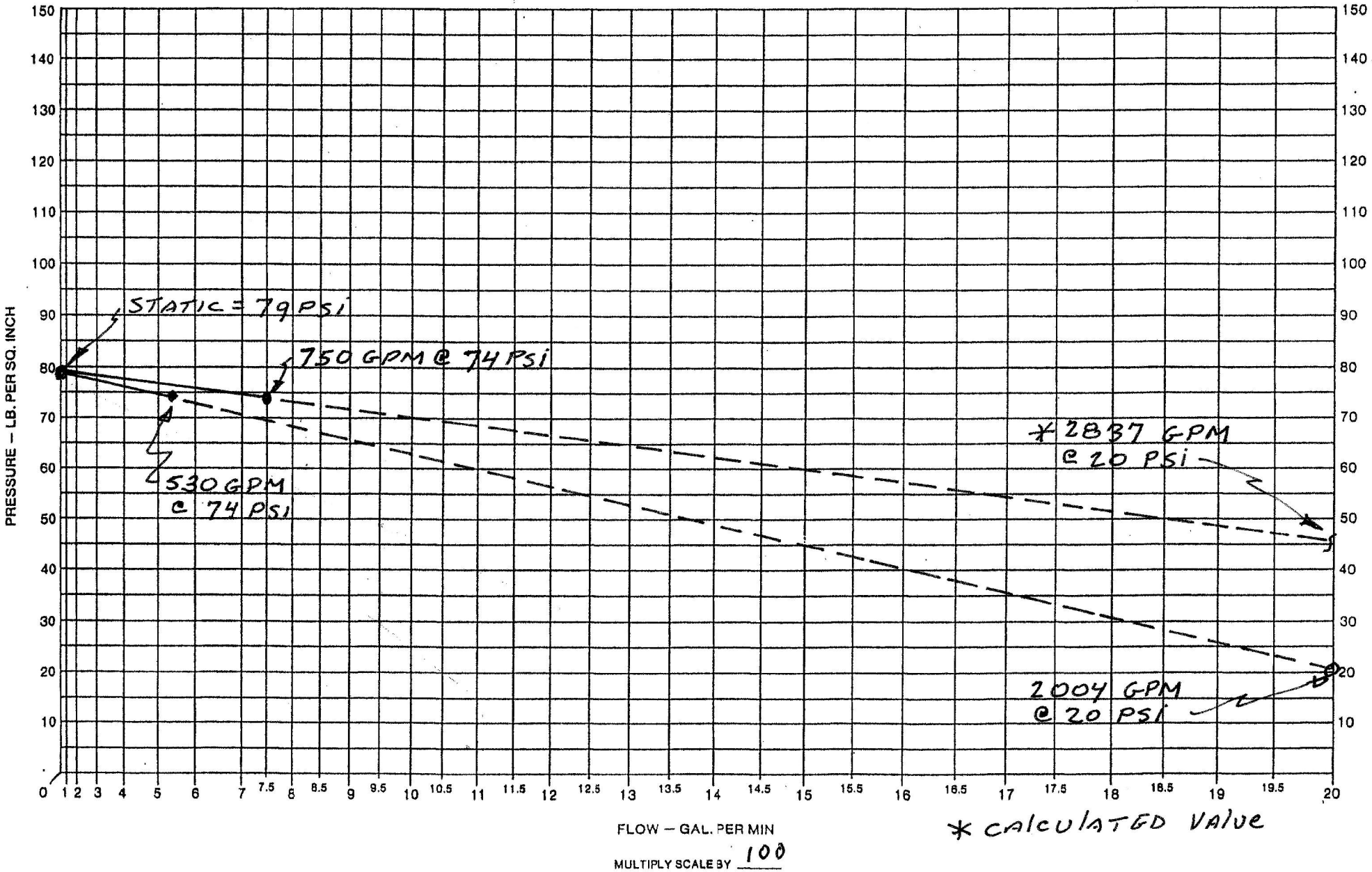
FIRE PROTECTION WATER SUPPLY ANALYSIS

INSURED VILLAGE AT SUDBURY STA. POLICY NO. _____ BY TMS/PN/PAT CARROLL

LOCATION CONCORD RD - PETER'S WAY DATE 7/8/2016 TIME 11:00 (AM) PM



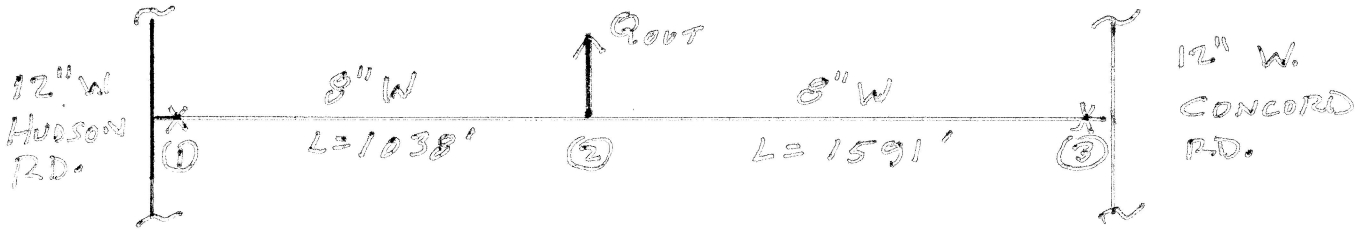
* CALCULATED VALUE

VILLAGE AT SUDBURY STATION
FLOW – VELOCITY CALCULATIONS

BY: TMS
7-14-16
P1 OF 3

GIVEN:
CONNECT 2629 LIN. FT. OF 8" MAIN TO EXISTING 12" MAINS IN HUDSON RD. AND CONCORD RD. TO SERVE PROPOSED DEVELOPMENT.

DETERMINE:
FLOW IN PROPOSED 8-INCH MAIN IN ORDER TO DETERMINE VELOCITY INCREASES IN EXIST. MAINS.



ASSUME FLOW OUT = 1,000 GPM.
C-VALUE = 120 or ROUGHNESS FACTOR = 0.0004
H_L ①-② = H_L ②-③
USE CAMERON TABLES (DARCY-WEISBACH FORMULA).

TRIAL 1.
ASSUME HIGHER FLOW IN ①-②
①-② = 600 GPM
②-③ = 400 GPM

HEADLOSS:
600 GPM, L=1038', H_L = 0.661 FT/100FT = 6.9 FT.
400 GPM, L=1591', H_L = 0.303 FT./100 FT. = 4.8 FT.

TRIAL 2
①-② = 550 GPM
②-③ = 450 GPM
HEADLOSS:
550 GPM, L=1038', H_L = 0.559 FT/100 FT. = 5.8 FT.
450 GPM, L=1591', H_L = 0.38 FT./100 FT. = 6.0 FT.

VILLAGE AT SUDBURY STATION
Flow - velocity calculations

Try HAZEN-WILLIAMS to obtain closer flow values.

$$H_f = 0.002083\, L \left(\frac{100}{C}\right)^{1.85} \frac{GPM^{1.85}}{d^{4.8655}}$$

Where:
L = Length Pipe, Ft.
C = H-W Pipe coefficient = 120
GPM = Flow, GPM
d = Pipe Nominal ID, Inches
H_f = Friction loss, Ft.

TRIAL 1:

Assume $Q_{①-②} = 600$ GPM; $Q_{②-③} = 400$ GPM

$$H_{f①-②} = 0.002083(1038)\left(\frac{100}{120}\right)^{1.85} \frac{600^{1.85}}{8^{4.8655}}$$

$H_{f①-②} = 8.6$ Ft.

$$H_{f②-③} = 0.002083(1591)\left(\frac{100}{120}\right)^{1.85} \left(\frac{400^{1.85}}{8^{4.8655}}\right)$$

$H_{f②-③} = 6.2$ Ft.

TRIAL 2

Assume $Q_{①-②} = 560$ GPM $Q_{②-③} = 440$ GPM

$$H_{f①-②} = 0.002083(1038)\left(\frac{100}{120}\right)^{1.85}\left(\frac{560^{1.85}}{8^{4.8655}}\right)$$

$H_f = 7.6$ Ft.

$$H_{f②-③} = 0.002083(1591)\left(\frac{100}{120}\right)^{1.85}\left(\frac{440^{1.85}}{8^{4.8655}}\right)$$

$H_{f②-③} = 7.4$ Ft.

$H_{f①-②} = \underline{7.6}$ Ft. $H_{f②-③} = \underline{7.4}$ Ft. OK

Use $Q_{1-2} = 560$ GPM, $Q_{2-3} = 440$ GPM

VILLAGES AT SUDBURY STATION
FLOW-VELOCITY CALCS.

BY: TMS
7-14-11
P. 3 OF 3

FOR 1000 GPM FLOW,
FLOW FROM HUDSON RD = 560 GPM
FLOW FROM CONCORD RD = 440 GPM.
FLOW IN EXISTING 12" MAINS WILL INCREASE BY 560/440 GPM.

12" MAIN - VELOCITY @ 560 GPM

$Q = VA$
V = velocity = Ft./Min
A = Area of Pipe, $Ft^2 = 0.79\ Ft^2$
Q = Flow, Ft^3/Min.

$$560 \frac{Gal}{Min} \Big/ 7.49 \frac{Gals}{Ft^3} = 74.8\ Ft^3/Min = \underline{1.25\ Ft^3/sec}$$

$$V = Q/A \Rightarrow \frac{1.25\ Ft^3/sec}{0.79\ Ft^2} = 1.58\ Ft/sec - \text{INCREASE IN VELOCITY.}$$

VELOCITY @ 440 GPM

$$440 \frac{Gal}{Min} \Big/ 7.49 \frac{Gal}{Ft^3} = 58.7\ Ft^3/Min = \underline{0.98\ Ft^3/sec}$$

$$V = Q/A \Rightarrow \frac{0.98\ Ft^3/sec}{0.79\ Ft^2} = 1.24\ Ft./Sec - \text{INCREASE IN VELOCITY.}$$

ASSUME FLOW IN 12" MAINS FROM 2 DIRECTIONS
$V_{/2}$ HUDSON RD = $\frac{1.58\ Ft/sec}{2} = 0.79\ Ft./sec.$

$V_{/2}$ CONCORD RD = $\frac{1.24\ Ft./sec}{2} = 0.62\ Ft/sec$

INCREASE IN VELOCITIES DUE TO 1000 GPM FLOW WILL BE APPROX. 0.7 Ft/sec.
INCREASE IN VELOCITIES DUE TO EXPECTED DOMESTIC DEMANDS (38 GPM AVERAGE) = NEGLIGIBLE