TECHNICAL MEMORANDUM

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Subject:	Tamarack Development Hydraulic Analysis		

DAVID SCHAEFFER ENGINEERING LTD.

Tamarack Development Hydraulic Analysis

C3 WATER INC.

August 5, 2021

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	June 28, 2021	First Draft	Jeffrey Stevens Emma Thompson	Sam Ziemann
2	August 5, 2021	Final	Jeffrey Stevens Emma Thompson	Sam Ziemann

SIGN OFF (final version only)

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DATE: August 5, 2021

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1.0 INTRODUCTION

C3 Water Inc. (C3W) has been requested to evaluate the capacity of the existing communal wells to supply the proposed Tamarack development in the southeast quadrant of the village of Richmond. This hydraulic analysis includes a review of available water supply, pumping, storage, and watermain capacity to meet drinking water and fire flow needs in the proposed Tamarack development. The proposed development, located at 6012 Ottawa Street, will consist of a mix of residential, commercial and institutional uses.

1.1 System Background

The Village of Richmond is primarily serviced through individual private wells, with the exception of developments on the edges of the village that are serviced by communal wells. The King's Park Subdivision on the eastern side of the village is serviced by the King's Park Communal Well System, which is operated by the City of Ottawa. The Richmond West Pumping Station is designed to service existing and future developments in the Western Development Lands, and eventually the entire village. The design of the station was influenced by a 2011 report completed by Stantec, titled The Village of Richmond Water & Sanitary Master Servicing Study (MSS). The MSS outlines future demand projections and provides recommendations for future servicing infrastructure.

1.2 Proposed Servicing Strategy

The preferred servicing strategy for the Tamarack development based on the Preliminary Servicing Alternatives report produced by Stantec located in the appendix of the Functional Servicing Report (FSR) from DSEL included connections to both the Richmond West Pumping Station and the King's Park Communal Well System. The proposed layout is illustrated in Figure 1-1 below.

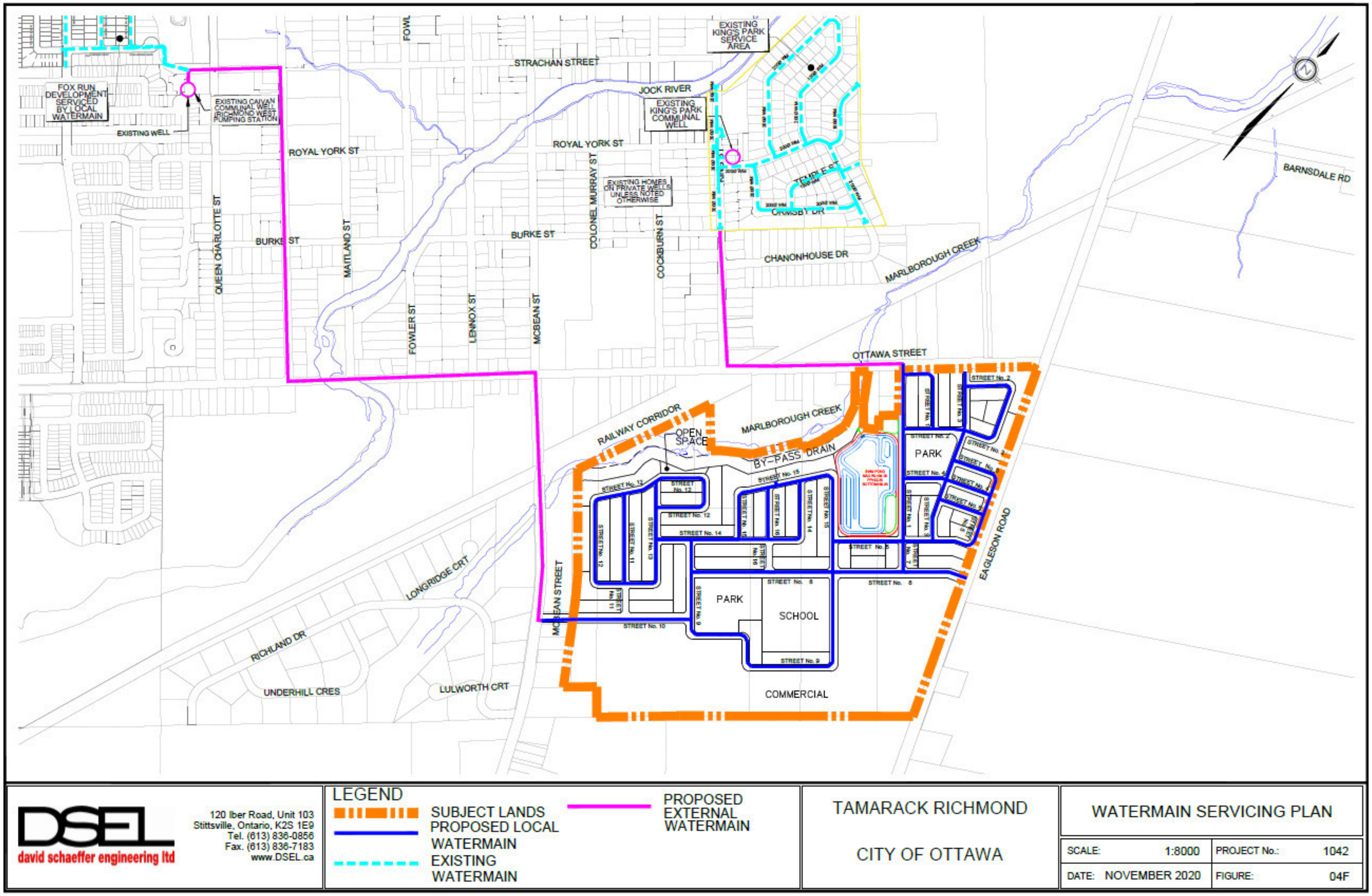

Figure 1-1 Proposed Development Configuration and Servicing Plan

1.3 Development Demands

Demand calculations for the Tamarack development were completed by Stantec and are summarized in Table 1-1 below. Average day demands (ADD) were calculated based on a single-family house water usage of 180 L/person/day and a townhouse water usage of 198 L/person/day. These values are to be used for developments greater than 3000 people in areas outside the City's greenbelt. Maximum day demands (MDD) were calculated by adding 1049 L/day for each single-family house. Peak hour demands (PHD) were calculated by applying a peaking factor of 2.2 to the MDD. This method of demand calculation is outlined in the City of Ottawa 2013 Water Master Plan completed by Stantec in support of the 2013 Infrastructure Master Plan for the City. This method supersedes the 350 L/person/day consumption rate shown in the Ottawa Design Guidelines for Water Distribution, which was published in 2010.

It should be noted that demands for potential future institutional and commercial sections of the development were not included in this calculation. An extension to the existing demands was calculated by C3W to represent potential industrial, commercial and institutional (ICI) growth in the lands south of the Tamarack development and presented as a separate development scenario. For this calculation, the 18.69 ha of employment land described in the FSR was given a water usage rate of 28,000 L/ha/day as outlined in the 2013 Water Master Plan. The MDD was determined by applying a peaking factor of 1.5 to the ADD, and the PHD was found by applying a factor of 1.8 to the ADD. Detailed demand calculations can be found in Appendix A.

Table 1-1 Development Demands

Type	Number of Units or Ha	Population	ADD (L/s)	MDD (L/s)	PHD (L/s)
Single Family	660	2,244	4.68	12.69	27.91
Townhouse	380	1,026	2.35	2.35	5.17
Total Res Only	**1,040**	**3,270**	**7.03**	**15.04**	**33.09**
ICI	18.69 ha	-	6.06	9.09	10.90
Total With ICI	**-**	**3,270**	**13.09**	**24.11**	**43.99**

1.4 Fire Flows

Fire flow calculations for the proposed residential buildings were completed by Stantec using the Fire Underwriters Survey (FUS) method, and aligned with other recent residential developments in the Western Development Lands. The highest fire flow was required for townhouses at a rate of 133 L/s for two hours.

An additional FUS fire flow was calculated by C3W to better represent the long-term requirement of the development area. Although there is currently no planned development in the ICI land south of the residential area, it is important to size watermains in early phases to the ultimate requirements. The required flow for a large school was calculated based on a typical example in Richmond and was found to be 217 L/s for 2.75 hours. The fire flow calculations can be found in Appendix A, and the fire flow requirements for the development are summarized in Table 1-2 below.

Table 1-2 Development Fire Flow Requirement

Building Type	FUS Requirement (L/s)	Time Requirement (hours)
Single Family	67	1.50
Townhouse	133	2.00
School	217	2.75

2.0 DESKTOP CAPACITY ANALYSIS

A desktop capacity analysis was carried out to confirm the results of previous analysis completed by Stantec. Supply, storage and pumping capacity were reviewed to determine if the existing and planned infrastructure is sufficient to adequately service the site and existing customers. Capacity conditions were considered for six development scenarios, as follows:

1. Total Existing: The first scenario consisted of all existing (or under construction) developments connected to the communal well systems. This was assumed to be the King's Park Subdivision, and Fox Run Phases 1 & 2.

2a. Existing + Tamarack (Residential Only): This scenario included the above existing demands plus the proposed residential demands from the Tamarack development.

2b. Existing + Tamarack (With ICI): This scenario included the existing demands plus the proposed residential and ICI demands from the Tamarack development

3a. Existing + Western Development Lands + Tamarack (Residential Only): This scenario included the buildout of the Western Development Lands. It included the completion of development in the Mattamy Development Lands, the Richmond Village Development Company (RVDC) development, and miscellaneous other developments described in the FSR for the Mattamy Homes development completed by DSEL. The proposed residential Tamarack demands were added to this scenario.

3b. Existing + Western Development Lands + Tamarack (With ICI): This scenario included the demands described in Scenario 3a, plus the Tamarack ICI demands.

4. Ultimate Buildout with Tamarack (With ICI): The final scenario considered the full buildout of the village where all properties are connected to a communal drinking water system. This full buildout scenario was originally outlined in the MSS. When the MSS was written in 2011, the Tamarack development area was zoned for ICI use, and was given projected demands far lower than the new calculated demands for the planned residential use. For the post-development conditions in the final scenario, the projected ICI demands were replaced with the calculated Tamarack residential and ICI demands.

2.1 Available Supply and Required Demand

The Richmond West Reservoir and PS is supplied by two wells: PW09-1 and PW08-1 with capacities of 40.2 L/s and 28 L/s, respectively. The current Permit to Take Water (PTTW) for each well is 26.85 L/s, for a total of 53.7 L/s. An additional well, PW09-2, has a capacity of at least 10 L/s, but is not operational or included in the site's PTTW. It is expected that this well will be incorporated into the system as demands grow. Since the City of Ottawa requires that maximum day demands can be serviced with the best well out of service, the current firm capacity of the wells is stated to be 28 L/s. With the future 10 L/s well, the firm capacity could be increased to 38 L/s, which was used to represent the buildout capacity. It is expected that additional wells may be drilled as needed to increase the available supply, but no specific plans have been presented at this time.

The King's Park Communal Well system is supplied by two wells, KP1 and KP2. The wells are capable of pumping at 17.67 L/s and 18.6 L/s, respectively at a TDH of 48m. However, to conform to the site's PTTW, both pumps are throttled to 15.16 L/s each for a total maximum flow of 30.3 L/s. A 1991 study completed by Jacques Whitford indicated that the safe aquifer yield was found to be 56 L/s. Due to a lack of available flow test data to confirm this higher capacity, the flow rate of these wells was kept constant across all scenarios. It was assumed that since the Tamarack development will link the Richmond West and King's Park systems, only the largest well out of the combined system must be removed to represent firm capacity. The existing and future water demands compared to the available supply are shown in Table 2-1 and Figure 2-1 below.

Table 2-1 Existing and Future Water Supply and Demand Comparison

		Total Demand (L/s)			Total Supply (L/s) (King's Park + Richmond West PS)	
	Scenario	**ADD**	**MDD**	**PHD**	**Largest well offline**	**All wells online**
1	Total Existing	5.6	12.7	28.0	58.3 (30.3 + 28)	84.0 (30.3 + 53.7)
2a	Existing + Tamarack (Res Only)	12.7	27.8	61.1		
2b	Existing + Tamarack (With ICI)	18.7	36.9	72.0		
3a	Existing + WDL + Tamarack (Res Only)	24.1	53.5	117.7		
3b	Existing + WDL + Tamarack (With ICI)	30.2	62.6	128.6		
4	Ultimate Buildout with Tamarack (With ICI)	59.3	142.3	332.3	68.3 (30.3 + 28 + 10)	94.0 (30.3 + 53.7 + 10)

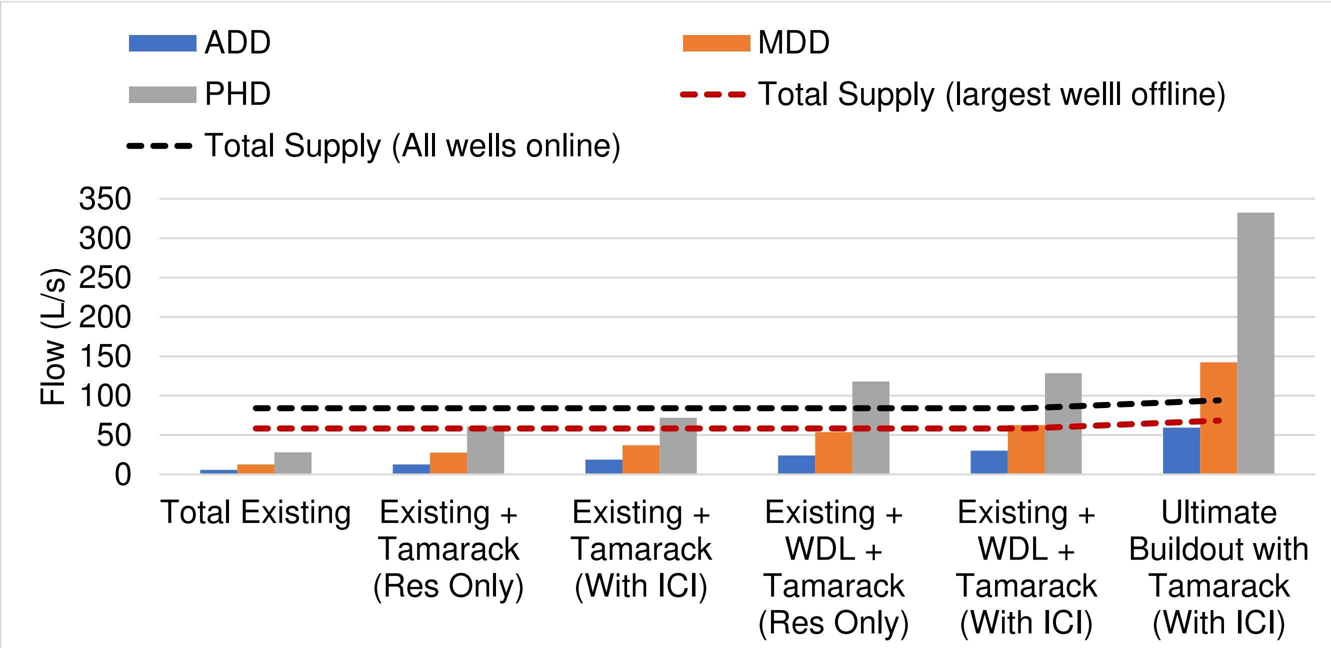

Figure 2-1 Existing and Future Water Supply and Demand Comparison

The supply capacity should be sized to meet MDD with the PHD to be supplied by a combination of well and storage (see Section 2.2). Based on the desktop analysis, there is sufficient capacity between the two well systems to meet MDD demands for the Tamarack development in addition to existing demands (scenarios 1, 2a, and 2b). If the Tamarack development remains only residential, there is sufficient well capacity to meet projected future demands at the buildout of the Western Development Lands (scenario3a). An additional 4.3 L/s of well capacity will be required to meet the Tamarack ICI demands included in scenario 3b. To meet MDD demands for the entire village with the Tamarack development and potential ICI growth, significant additional well capacity will be needed. PHD is typically supplied from storage if sufficient storage is available, which will be discussed in the next section.

2.2 Available and Required Storage

The Richmond West PS currently has 1,175 m^3 of in-ground storage capacity, of which 148 m^3 is used for chlorine contact time. There is no available storage in the King's Park System. Combining the existing Richmond West and King's Park systems lead to the current system being deficient in storage as show in Table 2-2.

The station is designed to support several storage upgrades. At the buildout of the Western Development Lands, additional storage of 1,100 m^3 is planned for a total storage of 2,152 m^3. To eventually service the entire village, an additional 2,150 m^3 is planned for a total storage of 4,307 m^3. It should be noted that the available storage volumes were originally recorded in the Richmond Pump Station – Design Brief report without an adjustment for the in-reservoir chlorine contact chamber. The storage capacity recommendations were based on the MECP storage volume equation *Volume = (MDD / 4 + Fire) * 1.25*. These calculations should be updated based on the required chlorine contact time based on a higher flowrate. A FUS fire flow for typical townhouses of 133.33 L/s for 2 hours was used for this calculation. These values are listed as the current and future available storage in Table 2-2 and Figure 2-2 below.

The required fire flow for all scenarios was estimated by C3W and is listed below. The previously completed calculations did not take into account a higher fire flow requirement for an institutional or commercial development that may later be built to the south of the Tamarack development. Therefore, the storage requirement for all scenarios including the potential ICI growth included the FUS fire flow for a school, which was found to be 217 L/s for 2.75 hours. For scenarios considering only the residential Tamarack demands, the previously calculated 133 L/s for 2 hours was used. To represent the fire flow requirement at the buildout of the village, the MECP suggested fire flow for a community of 19,650 was used. This was found to be 267.2 L/s for 4.1 hours.

Table 2-2 Existing and Future Storage Capacity and Requirement Comparison

					Required Storage (m^3)				Available Storage (m^3)
	Scenario	**Total Pop.**	**Fire Flow (L/s)**	**Length (hrs)**	**Fire Storage**	**Equalization Storage**	**Emergency Storage**	**Total**	**Total Available**
1	Total Existing	2,478	133	2	960	275	309	1,544	1,027
2a	Existing + Tamarack (Res Only)	5,727	133	2	960	600	390	1,950	1,027
2b	Existing + Tamarack (With ICI)	5,727	217	2.75	2,145	796	735	3,676	1,027
3a	Existing + WDL + Tamarack (Res Only)	10,609	133	2	960	1,156	529	2,645	2,152
3b	Existing + WDL + Tamarack (With ICI)	10,609	217	2.75	2,145	1,352	874	4,371	2,152
4	Ultimate Buildout with Tamarack (With ICI)	19,650	267	4.1	3,932	3,073	1,751	8,757	4,307

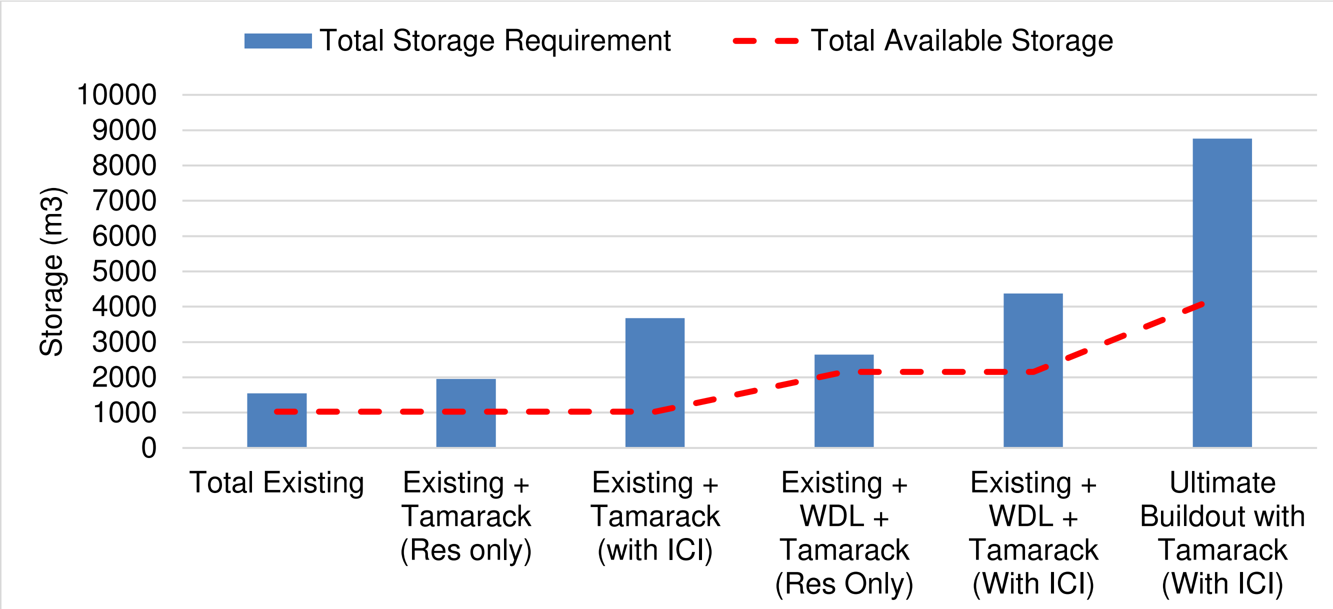

Figure 2-2 Existing and Future Storage Capacity and Requirement Comparison

To provide adequate fire, emergency and equalization storage for both the existing developments and the residential Tamarack development, roughly 923m^3 should be added to the existing 1,027 m^3 storage capacity. If the potential ICI demands are considered, approximately 2,650 m^3 should be added. Since the village of Richmond is currently not fully serviced by a communal drinking water system, it is assumed that tanker trucks are utilized to combat fires where there are no hydrants. Until additional storage can be included at the Richmond West PS, this protection method may be required to supplement a larger fire.

If the Western Development Lands are built out in the same timeline as the Tamarack residential development, roughly 493 m^3 should be added to the planned 2,152 m^3. If the potential ICI demands are considered as well, 2,219 m^3 should be added. Finally, 4,450 m^3 should be added to the planned 4,307 m^3 storage capacity if the entire village is to be supplied on one drinking water system and meet the higher MECP fire flow guidelines.

2.3 Available and Required Pumping

The Richmond West PS currently consists of five pumps, with a firm capacity of 221 L/s.

- 7.5 HP jockey pump with a design point of 6 L/s at 55 m TDH
- 40 HP pump with a design point of 25 L/s at 55m TDH
- 50 HP pump with a design point of 45 L/s at 55 m TDH
- 2x 150 PH fire pump with a design point of 145 L/s at 55 m TDH

According to the Richmond West PS Design Brief report, all pumps except one of the two fire pumps are equipped with variable frequency drives (VFD). The station is designed to be upgraded with larger pumps as needed to meet future demands. The ultimate future scenario outlined in the Design Brief considered a pumping requirement for the station of 291.66 L/s. This design flow was used to represent the station's future capacity for Scenario 4.

Both King's Park wells KP1 and KP2 are equipped with submersible well pumps designed to operate at 17.7 L/s and 18.6 L/s, respectively at a TDH of 48 m. They are both throttled to 15.6 L/s to conform to the site's PTTW. Therefore, the current firm capacity of the King's Park system is 15.6 L/s. There are no known plans to upgrade the pumps or valve discharge positions. The total firm capacity of the combined King's Park and Richmond PS pumps is compared to the pumping requirements for all scenarios in Table 2-3 and Figure 2-3.

Table 2-3 Existing and Future Pumping Capacity and Requirement Comparison

		Required Pumping (L/s)				Available Pumping (L/s)
	Scenario	ADD	MDD	PHD	MDD + Fire	Total Firm Capacity
1	Total Existing	5.6	12.7	28.0	146.1	236.2
2a	Existing + Tamarack (Res Only)	12.7	27.8	61.1	161.1	236.2
2b	Existing + Tamarack (With ICI)	18.7	36.9	72.0	253.5	236.2
3a	Existing + WDL + Tamarack (Res Only)	24.1	53.5	117.7	186.8	236.2
3b	Existing + WDL + Tamarack (With ICI)	30.2	62.6	128.6	279.3	236.2
4	Ultimate Buildout with Tamarack	53.2	133.2	321.4	349.9	306.8

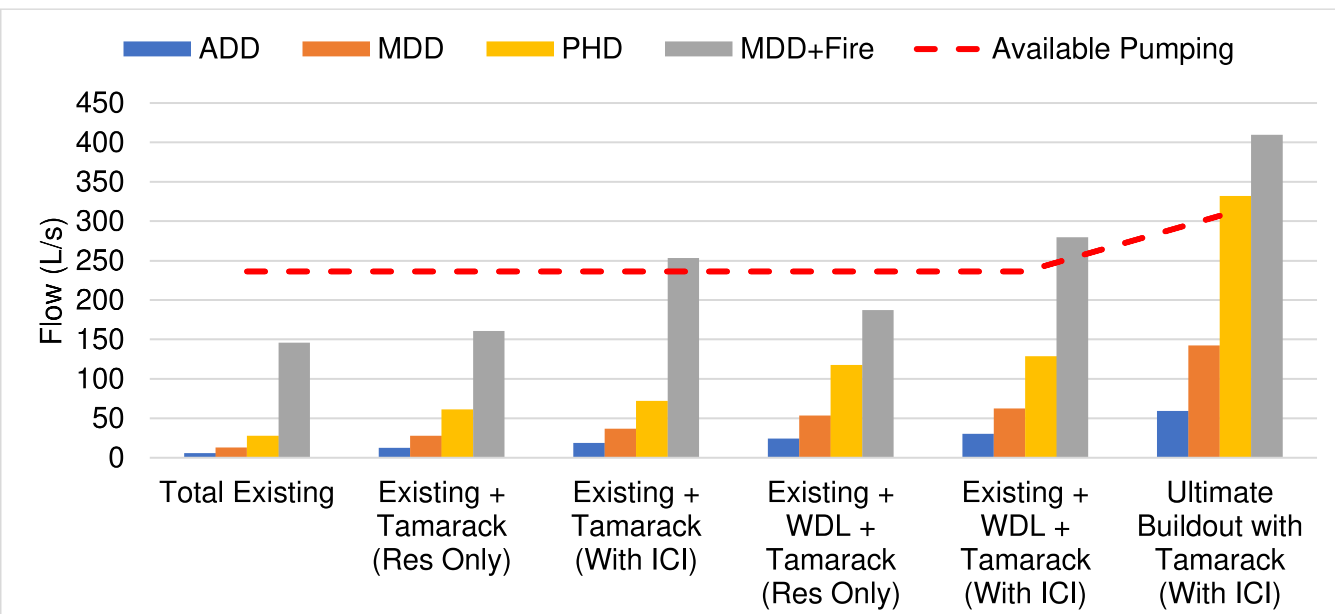

Figure 2-3 Existing and Future Pumping Capacity and Requirement Comparison

When the Tamarack residential development is considered in addition to both the existing and the buildout of the Western Development Lands, there is sufficient capacity to meet MDD + fire pumping requirements. When an ICI fire flow of 217 L/s is considered, the station is not able to meet MDD + fire pumping requirements for the existing developments plus Tamarack. The Richmond West PS is designed to be upgraded as needed to eventually supply the whole village. 103 L/s will be needed in addition to the current planned 291.66 L/s capacity of the station and the 15.16 L/s from the King's Park system to supply the built-out village with the Tamarack development.

3.0 MODELLING RESULTS

3.1 Model Development

An InfoWater model previously built to analyze developments in the Western Development Lands was used as a base to assess the proposed Tamarack development. The development was added to the model utilizing site plans provided in the FSR. Because detailed site layouts are not yet available, the calculated residential demands were divided equally between the development's nodes in the model. For scenarios considering ICI water use, the ICI demands were placed on the southeastern nodes of the development. Existing model demand patterns for single-family, townhouse, institutional and outdoor water use were used in the new development.

The King's Park Communal Well System and King's Park Subdivision were also added to the model based on drawings provided in the FSR. The well pumps were defined using design points specified in the MSS. Existing King's Park demands were assigned based on usage statistics outlined in the 2018 Annual Report for the system. For future scenarios, demands from the MSS for village infill growth east of the Jock River were added to the relevant King's Park nodes.

King's Park and Richmond pumps were regulated as outlined in the MSS and PS Design Brief. Pump settings are summarized in Table 3-1 below. For ADD and MDD scenarios, system pressures were maintained at a HGL of 140 m with variable frequency drive (VFD) controls. Since the elevation of the system ranges between 94 – 100 m, the expected system pressure is 40 – 46 m or 57 – 65 psi. This setting produces slightly higher pressures in the King's Park system than the current operating pressure of 60 psi, but is consistent with the 135 – 145 m HGL range of the Richmond West PS system. For increased reliability during fire flow scenarios, a pressure sustaining valve (PRV) was added to the outlet of the Richmond West PS and set to maintain 60 psi (140 m HGL) in the system.

It should be noted that the Richmond West PS was not modelled with individual well pumps or a tank. For added simplicity, it was modelled with one fixed head reservoir that is able to supply more water than specified in the site's PTTW, and is not limited by any tank capacity. Therefore, the following results were used primarily to confirm watermain sizing and not pump station or well capacity.

Table 3-1 Model Pump Settings

Pump	Setting			
	Scenario 2a/2b ADD, MDD	**Scenario 2a/2b Fire**	**Scenario 3a/3b ADD, MDD**	**Scenario 3a/3b Fire**
Richmond HLP-1 (Jockey)	VFD set to 60 psi	PRV set to 60 psi	VFD set to 60 psi	PRV set to 60 psi
Richmond HLP-2	VFD set to 60 psi	PRV set to 60 psi	VFD set to 60 psi	PRV set to 60 psi
Richmond HLP-3	Closed	PRV set to 60 psi	VFD set to 60 psi	PRV set to 60 psi
Richmond HLP-4 (Fire)	Closed	PRV set to 60 psi	Closed	PRV set to 60 psi
Richmond HLP-5 (Fire)	Closed	Closed	Closed	Closed
King's Park Well Pump 1	VFD set to 64 psi, throttled to 15.16 L/s	Throttled to 15.16 L/s	VFD set to 64 psi, throttled to 15.16 L/s	Throttled to 15.16 L/s
King's Park Well Pump 2	VFD set to 64 psi, throttled to 15.16 L/s	Throttled to 15.16 L/s	VFD set to 64 psi, throttled to 15.16 L/s	Throttled to 15.16 L/s

The watermain connecting the development to the King's Park system was given an initial diameter of 250 mm. The watermain linking the Richmond West PS to the development was given a diameter of 350 mm, since during a fire flow event, the majority of the flow is expected to be provided by the pumping station. Most watermains inside the development were given an initial diameter of 150 mm, except for a path linking the two systems, which was set to 250 mm. The watermain sizing can be seen in Figure 3-1 below. All roughness values (or C-factors) were assigned based on the City of Ottawa's Water Design Guidelines, shown Table 3-2.

Table 3-2 City of Ottawa Water Design Guidelines for C-Factors

Watermain Diameter (mm)	C-Factor
150	100
200 - 300	110
350 - 600	120
> 600	130

The model was run under Scenarios 2a, 3a and 3b to represent the Tamarack residential development under approximate existing/near future conditions with Fox Run Phases 1 & 2 completed, and future conditions at the buildout of the Western Development Lands, both with and without the potential ICI growth to the south of the Tamarack development. For each scenario, ADD, MDD and MDD plus fire conditions were tested.

3.2 Pressure Results

The pressures within the Tamarack development were found to closely match the expected range. Due to the high capacity of the Richmond West PS, pressures did not drop despite the difference in demands between scenarios 2a, 3a and 3b.

Table 3-3 Tamarack Development Pressure Results

Scenario	Pressure (psi)		
	Min	Max	Average
Scenario 2a ADD	58	64	63
Scenario 2a MDD	58	64	63
Scenario 3a ADD	58	64	63
Scenario 3a MDD	58	64	63
Scenario 3b ADD	58	64	63
Scenario 3b MDD	58	64	63

3.3 Fire Flow Results

The available fire flow was determined at several points in the model, shown in Figure 3-1 below. Fire flows were determined by allowing the residual system pressure to drop to 20 psi while increasing the fire flows under MDD conditions for each scenario. For the fire flow modelling, the VFD controls were removed from the Richmond West PS and King's Park wells. A PRV was inserted at the outlet of the Richmond West PS and set to maintain a downstream pressure of 60 psi. The station was run at firm capacity with one of the two largest pumps off.

The fire flow results predicted by the model are representative of the amount of water available in a watermain and not the extent of flows available from a hydrant. Several hydrants may need to be operated to provide desired fire flows but may not be equivalent to model results.

The modelling results are summarized in Table 3-4 below. When the model was run under scenario 2a with standard internal watermains set to a diameter of 150 mm, several areas of the development were not able to meet the flow required to support a townhouse. When all 150 mm watermains were upgraded to a diameter of 200 mm, most areas were able to meet the required flow. Those that were not able to meet the flow are located along the edges of the development, far from the 250 mm watermains. To fix this issue, a 250mm watermain could be added on the proposed 11th Street, providing an additional connection to the isolated southwest section of the development. When this watermain was added and the model was run under Scenario 3a conditions, all tested nodes were able to achieve 133 L/s except at the dead end at the eastern edge of the development. It is recommended that single-family units be considered in that area rather than townhouses so that watermains do not have to be oversized and cause potential long term water quality issues.

Along the south side of the development, a maximum fire flow of 191 L/s was achieved. This is below the FUS flow of 217 L/s required to support a typical school. To meet increased ICI demands and fire flows, the 250mm watermains were increased to 300mm, and the watermain linking the development to the Richmond West PS was increased to 400mm. Under this configuration all areas in the development were able to meet the required 133 L/s without the additional 11th Street watermain. The south side of the development along with several other points were able to meet the larger 217 L/s requirement. The available flow under this configuration is shown in Figure 3-4.

Table 3-4 Available Fire Flow with Various Watermain Configurations

Node	Available Flow				
	Phase 2 150mm	Phase 2 200mm	Ultimate 200mm	Ultimate 200mm with Extra Watermain	Ultimate 200mm, 300mm and 400mm pipes
J_41	133	160	158	160	209
J_12	177	180	178	190	246
J_13	96	152	150	155	179
J_17	105	158	156	161	190
J_21	71	127	126	186	144
J_24	65	121	120	161	135
J_26	76	132	130	169	151
J_30	165	171	169	172	234
J_32	162	171	168	171	231
J_34	111	151	149	151	189
J_43	118	153	150	153	195
J_45	88	136	134	136	162
J_5	194	193	191	191	260
J_51	74	127	125	127	145
J_9	176	177	175	177	249

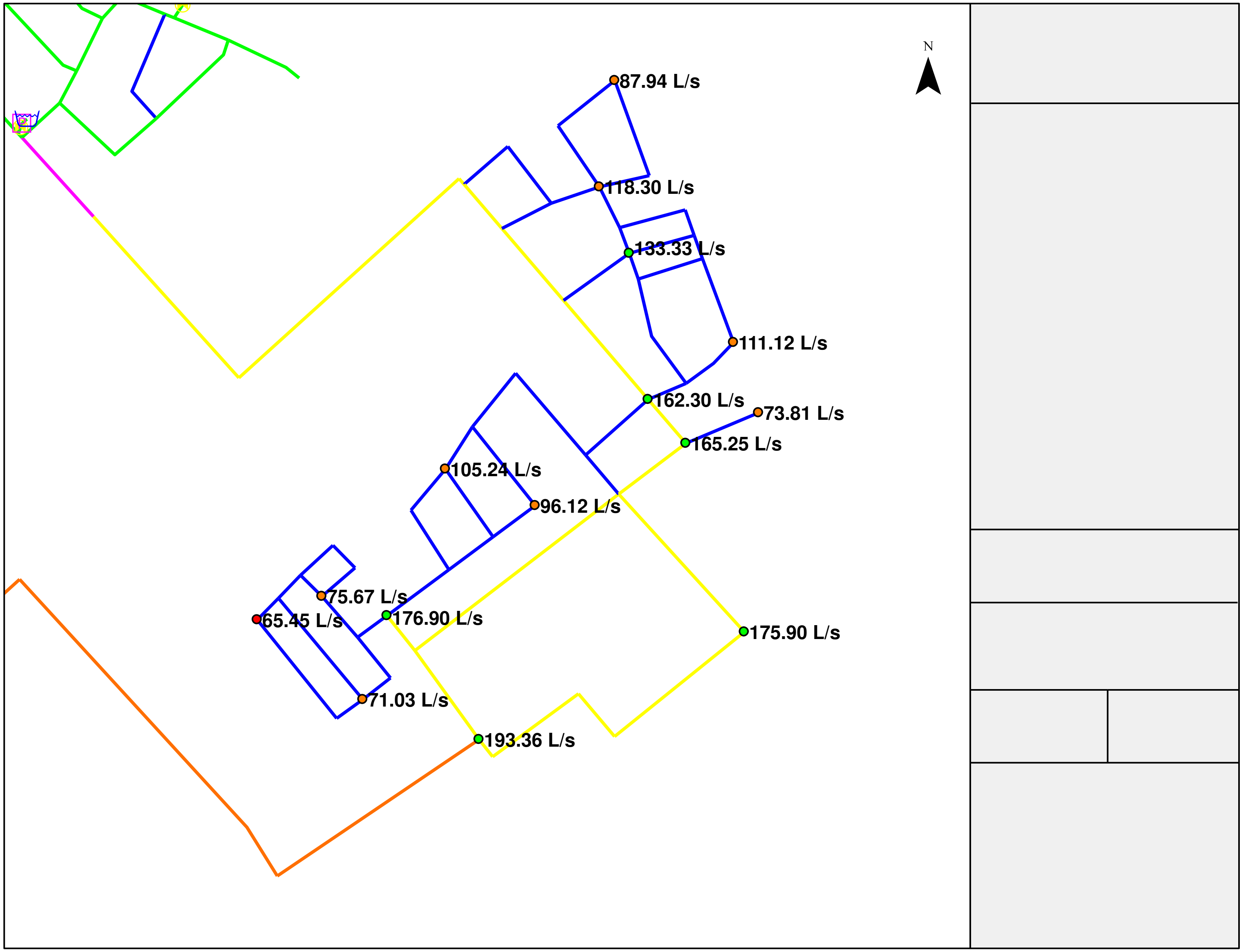

Figure 3-1 Scenario 2a (Res Only) Available Fire Flow with 150 mm Internal Watermains

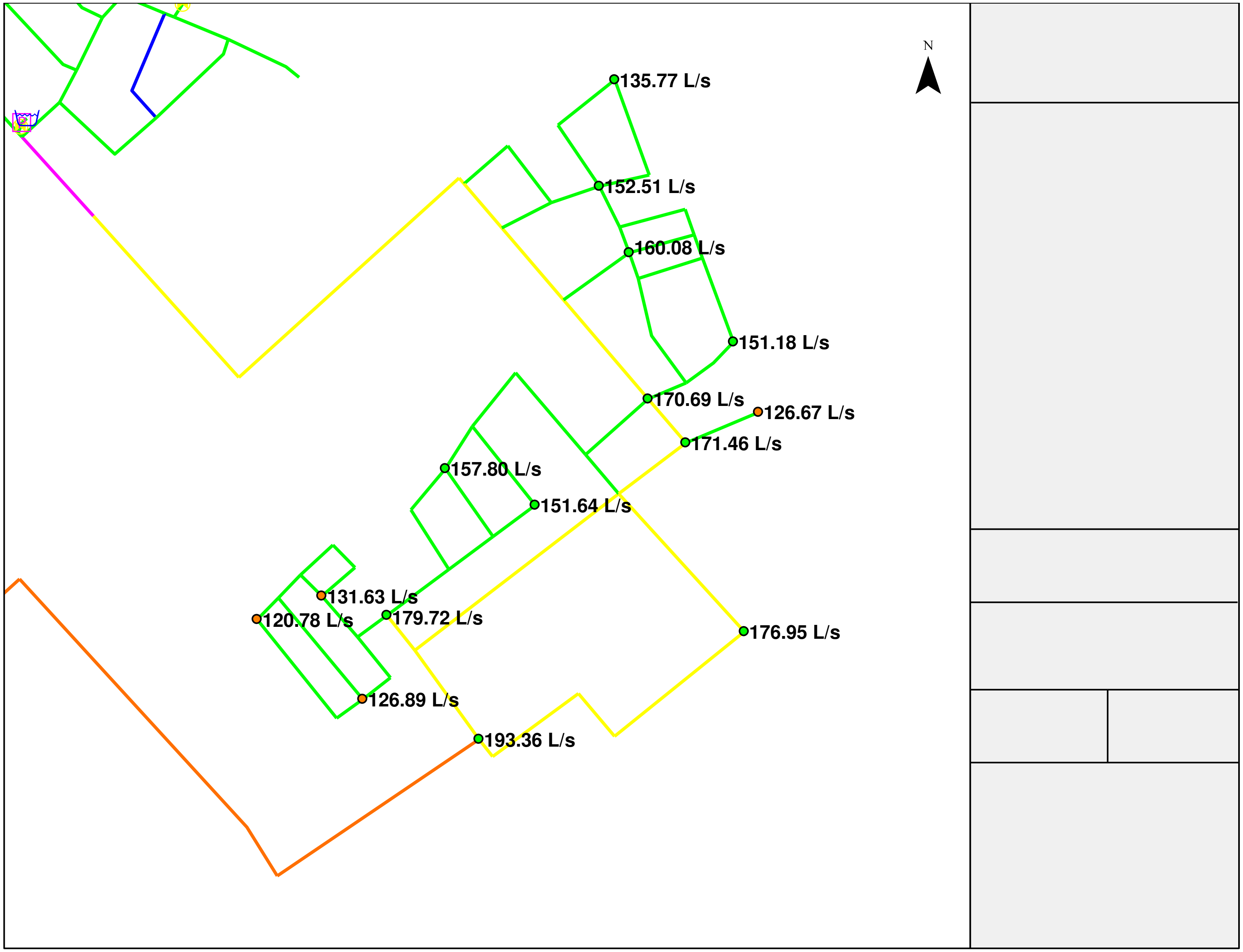

Figure 3-2 Scenario 2a (Res Only) Available Fire Flow with 200 mm Internal Watermains

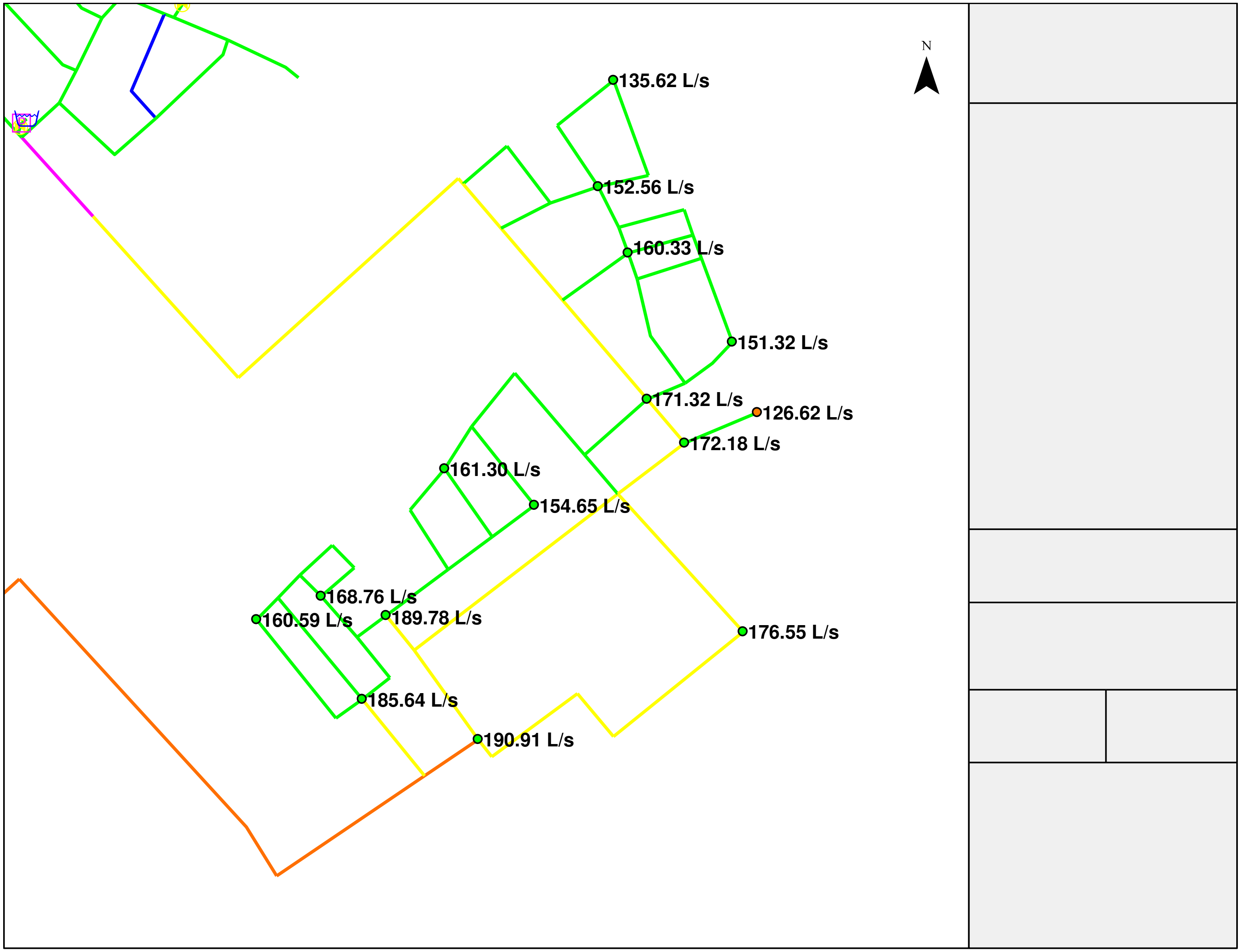

Figure 3-3 Scenario 3a (Res Only) Available Fire Flow with 200 mm Internal Watermains and Extra 11th Street Watermain

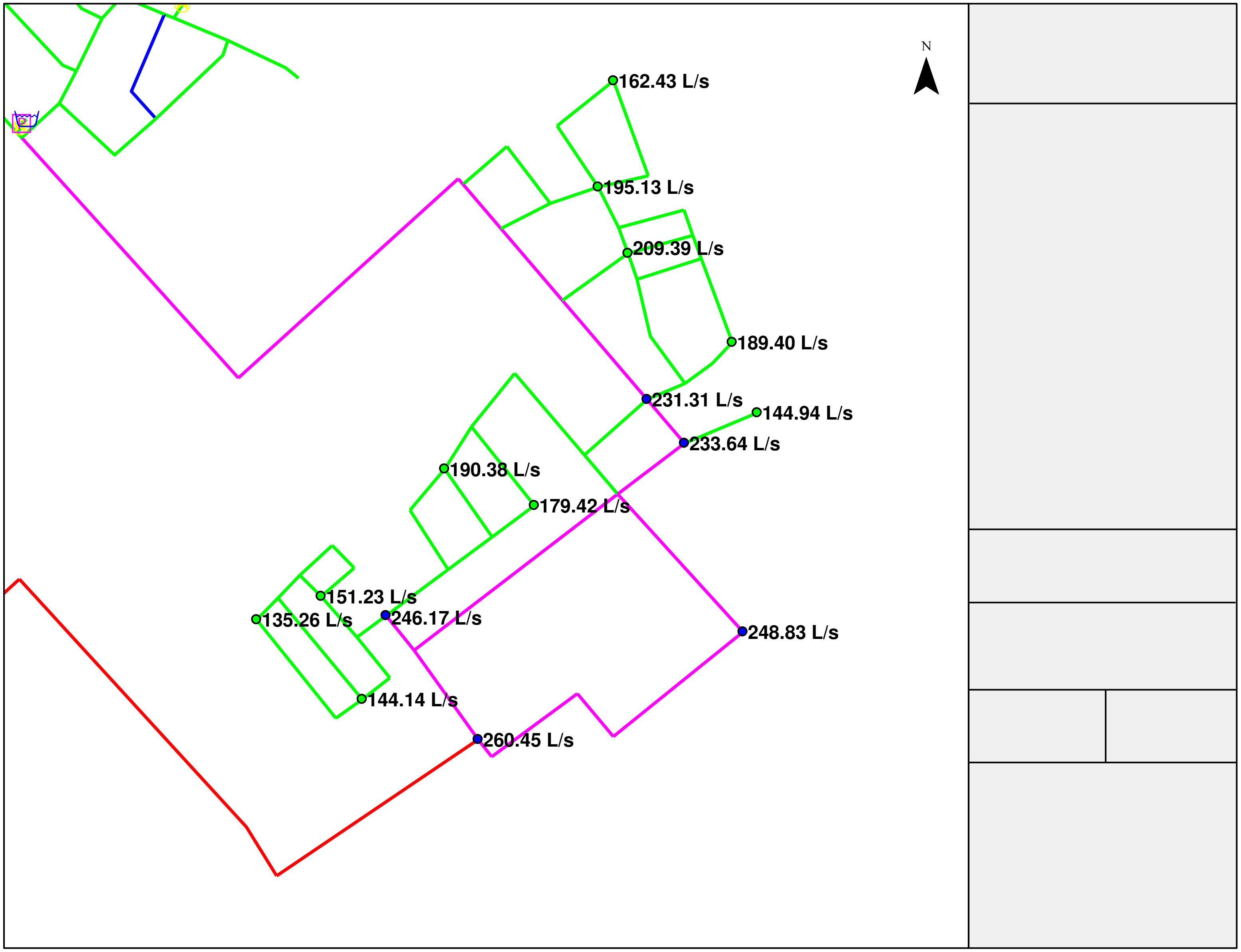

Figure 3-4 Scenario 3b (With ICI) Available Fire Flow with 300mm Backbone and 400mm Connection to Richmond PS

4.0 SUMMARY AND CONCLUSIONS

1. When the Tamarack residential-only demands are considered, there is sufficient capacity between the King's Park and Richmond West systems to meet MDD demands for the Tamarack development in addition to existing and projected future demands at the buildout of the Western Development Lands.
    a. When demands for the ICI area south of the Tamarack development are considered in addition to the residential demands, there is sufficient capacity to meet MDD demands in addition to the existing demands. An additional 4.3 L/s of well capacity would have to be added to meet the projected future MDD demands at the buildout of the Western Development Lands.
    b. To supply the development in the full village buildout scenario, additional well capacity will be needed.
    c. The details of operating both water systems interconnected should be considered. Ensuring that both work at the same HGL will help balance the systems and ensure that one system isn't being unduly stressed.
    d. Water quality impacts should be considered and may be very sensitive to the operating HGL of both systems.

2. When combined, the existing system has a storage deficiency. The Tamarack development would further increase the required amount of storage for the existing and WDL buildout scenarios, especially if institutional and commercial fire requirements are considered. To provide adequate storage for both the existing developments and the Tamarack residential development, roughly 923m^3 should be added to the existing 1,027 m^3 available storage capacity. To supply an institutional fire flow of 217 L/s, 2,650 m^3 of storage would need to be added.
    a. If the Western Development Lands are built out in the same timeline as the Tamarack residential development, roughly 493 m^3 should be added to the planned 2,152 m^3.
    b. If the institutional and commercial area south of the Tamarack development are built on the same timeline, 2,219 m^3 of storage should be added.
    c. In order to meet the village buildout demands, approximately 4,450 m^3 should be added to the planned 4,307 m^3 storage capacity if the entire village is to be supplied on one drinking water system based on estimated MECP fire flows.

3. There is an approximate 17.4 L/s pumping deficiency to meet MDD + fire pumping requirements of existing demands plus Tamarack when a fire flow of 217 L/s is considered to represent institutional and commercial requirements. There is a shortfall of 43.1 L/s when considering the buildout of the Western Development Lands in addition to the Tamarack development with the potential institutional and commercial growth. There is sufficient pumping capacity if only a residential fire is considered and the ICI component of the development is deferred.
    a. To supply the built out village plus the Tamarack Development, an additional 102.7 L/s will need to be added to the planned 291.66 L/s capacity.

4. The model results show that the existing system can maintain pressures ranging from 58-64 L/s in the Tamarack development area with institutional and commercial demands under existing and WDL buildout conditions.

5. Watermains of 200 mm are recommended to supply sufficient fire flow to the internal residential portions of the development to support 133 L/s fire flows for townhouses. An additional 250mm watermain on 11th Street is recommended to supplement flows the western edge of the development. When institutional and commercial demands are applied, A maximum fire flow of 249 L/s can be achieved in the south part of the system if the connection to the Richmond West PS is sized at 400mm, with a 300mm watermain running through the development and connecting to the King's Park system.
    a. If these watermains sizes are not feasible, it is recommended that future institutional and commercial buildings along the south side of the development be designed to meet maximum available flows shown in Figure 3-3.

5.0 REFERENCES

Stantec Consulting Ltd. (2011). *Village of Richmond Water & Sanitary Master Servicing Study*

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Government of Ontario (MECP). (2021). *Map: Permits to Take Water.* Accessed at https://www.ontario.ca/page/map-permits-take-water

City of Ottawa (2018). *2018 Summary Report King's Park Well System.*

Stantec Consulting Ltd. (2017). *Richmond Pump Station – Design Brief.*

APPENDIX A –

Demand and Fire Flow Calculations

Table 8-1: Fire Flow Requirements

EQUIVALENT POPULATION[1]	SUGGESTED FIRE FLOW (L/s)	DURATION (HOURS)
500 – 1 000	38 (10 ft/s)	2
1 000	64 (17 ft/s)	2
1 500	79 (21 ft/s)	2
2 000	95 (25 ft/s)	2
3 000	110 (29 ft/s)	2
4 000	125 (33 ft/s)	2
5 000	144 (38 ft/s)	2
6 000	159 (42 ft/s)	3
10 000	189 (50 ft/s)	3
13 000	220 (58 ft/s)	3
17 000	250 (66 ft/s)	4
27 000	318 (84 ft/s)	5
33 000	348 (92 ft/s)	5
40 000	378 (100 ft/s)	6

Note [1]: When determining the fire flow allowance for commercial or industrial areas, it is recommended that the area occupied by the commercial/industrial complex be considered at an equivalent population density to the surrounding residential lands.

Demand Calculations (Stantec, 2019)

Unit Type	Unit Count	PPU	Population	2013 WMP Consumption Rates (L/d/cap)	BSDY (L/min)	MXDY (L/min)	PKHR (L/min)
Single-family	660	3.4	2,244	180	281	761	1,674
Townhouse	380	2.7	1,026	198	141	141	310
Total	***1,040***		***3,270***		***422***	***902***	***1,984***
				Minimum Required Fire Flow	8,000 L/min for 2.0 hrs		

Demand Calculations (C3W, 2021)

Unit Type	Unit Count	PPU	Population	2013 WMP Consumption Rates (L/d/cap)	ADD (L/s)	MDD (L/s)	PHD (L/s)
Single-family	660	3.4	2,244	350	9.09	17.10	37.63
Townhouse	380	2.7	1,026	350	4.16	4.16	9.14
Total	***1,040***		***3,270***		***13.25***	***21.26***	***46.77***

Stantec

FUS Fire Flow Calculation

Calculations based on: "*Water Supply for Public Fire Protection*" by Fire Underwriters' Survey, 1999

Stantec Project #: 163401545
Project Name: Richmond Mattamy Water Distribution System Analysis
Date: June 14, 2019
Data inputted by: J. Sidhu
Data reviewed by: K. Alemany

Fire Flow Calculation #: 1
Building Type/Description/Name: Residential

Notes:

Table A: Fire Underwriters Survey Determination of Required Fire Flow - Long Method

Step	Task	Term	Options	Multiplier Associated with Option	Choose:	Value Used	Unit	Total Fire Flow (L/min)
		Framing Material						
1	Choose Frame Used for Construction of Unit	Coefficient related to type of construction (C)	Wood Frame	1.5	Ordinary construction	1	m	
			Ordinary construction	1				
			Non-combustible construction	0.8				
			Fire resistive construction (< 2 hrs)	0.7				
			Fire resistive construction (> 2 hrs)	0.6				
		Floor Space Area						
2	Choose Type of Housing (if TH, Enter Number of Units Per TH Block)	Type of Housing	Single Family	1	Single Family	1	Units	
			Townhouse - indicate # of units	5				
			Other (Comm, Ind, Apt etc.)	6				
2.2	# of Storeys	Number of Floors/Storeys in the Unit (do not include basement if 50% below grade):			2	2	Storeys	
3	Enter Ground Floor Area of One Unit	Average Floor Area (A) based total floor area of all floors (non-fire resistive construction):			1,100 Square Feet (ft2)	204	Area in Square Meters (m^2)	
4	Obtain Required Fire Flow without Reductions	Required Fire Flow (without reductions or increases per FUS) (F = 220 * C * √A) Round to nearest 1000L/min						3,000
5	Apply Factors Affecting Burning	**Reductions/Increases Due to Factors Affecting Burning**						
5.1	Choose Combustibility of Building Contents	Occupancy content hazard reduction or surcharge	Non-combustible	-0.25	Limited combustible	-0.15	N/A	2,550
			Limited combustible	-0.15				
			Combustible	0				
			Free burning	0.15				
			Rapid burning	0.25				
5.2	Choose Reduction Due to Presence of Sprinklers	Sprinkler reduction	Adequate Sprinkler conforms to NFPA13	-0.3	None	0	N/A	0
			None	0				
		Water Supply Credit	Water supply is standard for sprinkler and fire dept. hose line	-0.1	Water supply is not standard or N/A	0	N/A	0
			Water supply is not standard or N/A	0				
		Sprinkler Supervision Credit	Sprinkler system is fully supervised	-0.1	Sprinkler not fully supervised or N/A	0	N/A	0
			Sprinkler not fully supervised or N/A	0				
5.3	Choose Separation Distance Between Units	Exposure Distance Between Units	North Side	0 to 3.0m	0.25	0.75	m	1,913
			East Side	3.1 to 10.0m	0.2			
			South Side	0 to 3.0m	0.25			
			West Side	3.1 to 10.0m	0.2			
6	Obtain Required Fire Flow, Duration & Volume	*Total Required Fire Flow, rounded to nearest 1000 L/min, with max/min limits applied:*						**4,000**
		Total Required Fire Flow (above) in L/s:						**67**
		Required Duration of Fire Flow (hrs)						**1.50**
		Required Volume of Fire Flow (m^3)						**360**

Stantec

FUS Fire Flow Calculation

Calculations based on: "*Water Supply for Public Fire Protection*" by Fire Underwriters' Survey, 1999

Stantec Project #: 163401545
Project Name: Richmond Mattamy Water Distribution System Analysis
Date: June 14, 2019
Data inputted by: J. Sidhu
Data reviewed by: K. Alemany

Fire Flow Calculation #: 2
Building Type/Description/Name: Residential

Notes:

Table A: Fire Underwriters Survey Determination of Required Fire Flow - Long Method

Step	Task	Term	Options	Multiplier Associated with Option	Choose:	Value Used	Unit	Total Fire Flow (L/min)
		Framing Material						
1	Choose Frame Used for Construction of Unit	Coefficient related to type of construction (C)	Wood Frame	1.5	Ordinary construction	1	m	
			Ordinary construction	1				
			Non-combustible construction	0.8				
			Fire resistive construction (< 2 hrs)	0.7				
			Fire resistive construction (> 2 hrs)	0.6				
		Floor Space Area						
2	Choose Type of Housing (if TH, Enter Number of Units Per TH Block)	Type of Housing	Single Family	1	Townhouse - indicate # of units	5	Units	
			Townhouse - indicate # of units	5				
			Other (Comm, Ind, Apt etc.)	6				
2.2	# of Storeys	Number of Floors/Storeys in the Unit (do not include basement if 50% below grade):			2	2	Storeys	
3	Enter Ground Floor Area of One Unit	Average Floor Area (A) based total floor area of all floors (non-fire resistive construction):			4,500 Square Feet (ft2)	836	Area in Square Meters (m^2)	
4	Obtain Required Fire Flow without Reductions	Required Fire Flow (without reductions or increases per FUS) (F = 220 * C * √A) Round to nearest 1000L/min						**6,000**
5	Apply Factors Affecting Burning	**Reductions/Increases Due to Factors Affecting Burning**						
5.1	Choose Combustibility of Building Contents	Occupancy content hazard reduction or surcharge	Non-combustible	-0.25	Limited combustible	-0.15	N/A	**5,100**
			Limited combustible	-0.15				
			Combustible	0				
			Free burning	0.15				
			Rapid burning	0.25				
5.2	Choose Reduction Due to Presence of Sprinklers	Sprinkler reduction	Adequate Sprinkler conforms to NFPA13	-0.3	None	0	N/A	**0**
			None	0				
		Water Supply Credit	Water supply is standard for sprinkler and fire dept. hose line	-0.1	Water supply is not standard or N/A	0	N/A	**0**
			Water supply is not standard or N/A	0				
		Sprinkler Supervision Credit	Sprinkler system is fully supervised	-0.1	Sprinkler not fully supervised or N/A	0	N/A	**0**
			Sprinkler not fully supervised or N/A	0				
5.3	Choose Separation Distance Between Units	Exposure Distance Between Units	North Side	3.1 to 10.0m	0.2	0.65	m	**3,315**
			East Side	10.1 to 20.0m	0.15			
			South Side	10.1 to 20.0m	0.15			
			West Side	10.1 to 20.0m	0.15			
6	Obtain Required Fire Flow, Duration & Volume	*Total Required Fire Flow, rounded to nearest 1000 L/min, with max/min limits applied:*						**8,000**
		Total Required Fire Flow (above) in L/s:						**133**
		Required Duration of Fire Flow (hrs)						**2.00**
		Required Volume of Fire Flow (m^3)						**960**

Required Fire Flow Calculation

Calculations performed in accordance with Water Supply for Public Fire Protection, Fire Underwriters Survey, 1999

Project Name:	Tamarack Development School
File Number:	211554
Date:	22-Jun-21

Theoretical School			**Comments**
Construction Coefficient:		0.8	
			non-combustible construction (unprotected metal structural component, masonry or metal walls)
Gross Area for Analysis (m^2):		15,000	100m x 150m x 1 floors
1. Preliminary Flow (Lpm)		21,556	F = 220*C*sqrtA
2. Occupancy Hazard Charge/Credit:		-15%	Limited Combustible
3. Sprinkler System Credit:		-30%	
4. Exposure Charges:			
	north	0%	
	east	0%	
	south	0%	
	west	0%	
	Exposure Total:	0%	
5. FUS Required Fire Flow:			
	Step 2 Flow (Lpm):	18,322	
	Step 3 & 4 Net Charge:	-30%	
	Fire Flow (Lpm):	13,000	2.75 hours
	Fire Flow (Lps):	**216.7**	