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Technical Memorandum

To: Bill Stewart, Town of New Castle
From: Erik Nichols, EIT and Andrew Sharpe, PE
Date: 01/14/21
Subject: Hydrant Flow Evaluation

The Town of New Castle owns, operates, and maintains a water distribution system serving the village area of New Castle from Shapleigh Island/Sawtelle Bridge to the Coast Guard Station. This system includes 31 fire hydrants (see Figure 1). The Town has recently completed the Water Transmission Main Improvements Project between Peirce Island and the intersection of Main Street and Wentworth Road in New Castle near the Coast Guard Station. This project replaced the existing 8-inch diameter DI water main with 12-inch diameter DI, HDPE, and PVC main. This project is the first phase of a water main improvements program recommended by Underwood Engineers (UE) to increase the available fire flows in New Castle (Water System Evaluation, 2016). Other improvements identified include replacing the existing transmission mains in the City of Portsmouth's distribution system with larger diameter mains (e.g. Wentworth Road, Peirce Island, and near Marcy Street) which have yet to be designed and constructed.

With the first phase completed, the Town has tasked UE with evaluating the current available fire flows for the Town. This will establish the degree of improvement resulting from the construction of the 12-inch diameter transmission main. Using the updated fire flows from this evaluation, The Town plans to paint their hydrants using the National Fire Protection Association's (NFPA) color code for available fire flow. The City of Portsmouth also uses this color code system for their hydrants, so it will be consistent for the municipal hydrants throughout the Town. The following describes the work completed and the results of the evaluation.

Available Fire Flows within the Town's Distribution System

In 2016, UE performed hydrant flow testing during the Town's annual flushing program. Static pressure, residual pressure, and pitot readings were obtained at each of the Town's thirty (30) hydrants. It is noted that a hydrant was added during the recent Water Transmission Main Improvements Project (Hydrant 10A). In November 2020, UE again performed hydrant flow testing. Working with Town Staff, static pressure, residual pressure, and pitot readings were obtained on thirty (30) hydrants within the New Castle distribution system and five (5) hydrants in the Portsmouth distribution system. In addition, static and residual pressures of nearby hydrants within the system were obtained to calculate available fire flows. Using the data collected in the field, UE observed actual flows and calculated the available fire flows of each hydrant based on maintaining a minimum residual pressure of 20 psi. Table 1 below summarizes those results and compares them with the 2016 information:

Table 1: Available Fire Flows within the Town's Distribution System

Hydrant #	Hydrant Location	Static Pressures		Residual Pressures		Observed Flows		2016 to 2020 Observed Flow Improvement Multiplier	2020 Available Fire Flows @ 20 psi (gpm)
		2016 Observed Static Pressure (psi)	2020 Observed Static Pressure (psi)	2016 Observed Residual Pressure (psi)	2020 Observed Residual Pressure (psi)	2016 Observed Flows (gpm)	2020 Observed Flows (gpm)		
1*	Goat Island	64	64	20	33	650	1,030	1.58	1,240
2*	KPYC	64	64	22	33	670	1,010	1.51	1,230
3*	167 Portsmouth Ave	54	55	16	26	590	870	1.47	960
4*	Riverview and Portsmouth Ave	51	54	18	26	550	830	1.51	920
5*	Oliver Street and Portsmouth Ave	55	57	18	27	590	890	1.51	1,000
6	Oliver Street	56	59	18	27	590	610	1.03	680
7	Oliver Street and Cape Road	63	65	20	28	590	830	1.41	920
8	End of Cape Road	64	65	20	26	610	850	1.39	920
9	Laurel Lane	56	57	11	19	520	810	1.56	800
10*	Ritson Street and Portsmouth Ave	60	60	20	30	610	890	1.46	1,040
10A*	Grist Mill and Portsmouth Ave	NA	61	NA	30	NA	890	NA	1,040
11*	Portsmouth Ave and Walton Road	55	58	18	27	630	870	1.38	970
12	Locke Road	56	56	15	16	520	610	1.17	580
13	Walton Road	59	64	13	14	500	640	1.28	600
14	Mainmast Circle	45	49	8	9	420	550	1.31	460
15	Quarter Deck and Mainmast	58	62	10	NA	480	NA	NA	580
16	Quarter Deck Lane	58	62	10	10	480	550	1.15	490
17*	Cranfield Street and Colonial Lane	56	57	20	27	670	890	1.33	1,000
18*	Cranfield Street and Main Street	60	61	20	27	650	870	1.34	960
19*	133 Main Street	55	60	15	28	550	890	1.62	1,000
20*	Main Street and Verand Court	53	57	16	26	570	870	1.53	960
21*	Main Street across from Town Hall	55	58	17	27	610	870	1.43	970
22*	Main Street and Wentworth	55	58	12	24	550	850	1.55	900
23	Ocean Street	58	60	16	22	610	830	1.36	850
24	Wentworth Road at USCG	56	60	16	25	590	830	1.41	890
25	Walbach Street	60	61	20	25	590	850	1.44	910
26	Piscataqua Street and Walbach Street	63	60	19	23	630	850	1.35	890
27	Piscataqua Street and Atkinson Street	60	60	20	21	630	830	1.32	840
28	Steamboat Lane	61	64	20	27	630	870	1.38	960
29	95 Piscataqua Street	63	65	20	30	610	890	1.46	1,020
30	Piscataqua Street and Cranfield Street	60	61	21	25	610	870	1.43	930

*New Hydrants installed along the new transmission main

Notes

1. 2016 and 2020 Available Fireflows were calculated based on the static and residual pressures of the flow hydrant.
2. Hydrant 15 was not flowed in 2020 due to site restraints. Available fire flows were calculated based on its residual pressures flowing a separate hydrant. It is recommended that these flows be confirmed during spring flushing.
3. Hydrant 6 on Oliver Lane had a lower than expected available fire flow considering the flows at Hydrants 7 and 8. This could be due to the valve not fully open during testing, an obstruction in the hydrant service, it being an older hydrant, or a misreading during testing. Like Hydrant 15 this hydrant should be tested again during the Town's flushing program.
4. Hydrant Color codes have been provided based on National Fire Protection Association (NFPA) and American Water Works Association (AWWA).

NFPA CODE

Greater than 1,500
1,000-1,499 gpm
500-999 gpm
Less than 500 gpm

Table 1 shows available fire flows within the New Castle System improved as a result of construction of the new water transmission main. The hydrants connected directly to the new main were replaced as part of the project (See Table 1). These locations showed significant improvement in available fire flow. Also as shown on Table 1, hydrants not directly connected to the new water main project also saw an increase in available fire flows.

Figure 1 (attached) identifies the Town's 31 hydrants with their associated available fire flow color code.

The 2016 Water System Evaluation predicted available fire flows for multiple alternatives to the Town and City's distribution system including replacing the transmission main between the Shapleigh Island meter pit and the meter pit at the intersection of Main Street and Wentworth Road (Alt 1A), which is similar to the work completed in 2020. The evaluation's recommended alternative was Alt. 1D which included improvements to the water main from Marcy Street in Portsmouth, across Peirce Island, and through New Castle up the Wentworth Hotel. Table 2 compares the data of those alternatives to the calculated available fire flows after the work completed to date in 2020.

Table 2: Predicted Available Fire Flows (@ 20 psi) Comparison¹

Hydrants Evaluated in 2016 ²	Location	2016 Alt 1D Predicted Available Fire Flows after all Recommended Improvements are Completed (gpm)	2016 Alt 1A Predicted Available Fire Flows After Replacing the Transmission Main Between the 2 Meters (gpm)	2020 Calculated Available Fire Flows from Flow Testing (gpm)
#7	Oliver St. and Cape Road	1,080	760	920
#17	Cranfield Street and Colonial Lane	1,751	800	1,000
#20	Main Street and Atkinson Street.	1,875	840	960

1. 2016 available fire flows (UE, 2016) were predicted using the City's hydraulic water model under conservative parameters (i.e. max day demands). The 2020 transmission main also included sections of main (HDPE and PVC) with lower friction values that were not modeled in 2016.
2. 2016 evaluation points located within the City's system used to develop recommended improvements (with the exception of Morgans Way, not evaluated in 2020) are located in Table 4.

At the locations identified above, the 2020 calculated available fire flows exceed the flows modeled in 2016 within the New Castle System. For example, the 2016 Water System Evaluation predicted an available fire flow of 760 GPM at Hydrant 7 (Oliver Street and Cape Road) upon completion of the transmission main improvements between the two meter pits. The calculated available fire flow, based on the 2020 hydrant flow testing program, is 920 GPM. Improvements also were noted at the other locations listed. While the 2020 improvements increased the available

fire flows throughout the Town, it is noted that other improvements need to be completed before the recommended Alt 1D available fire flows can be achieved.

Flow Routing Evaluation

Part of the 2020 improvement program included removal of the check valves at the two (2) meter pit locations (See Figure 1). Removal of check valves allowed water to flow freely in both directions thereby improving the system's ability to meet fire demands. Importantly, the following elements remain in place:

- At Shapleigh Island, an 8" meter and the original 8" waterline under the Sawtelle Bridge.
- At the Main St./Wentworth Rd. pit, a 6" meter interposed between the new 12" main on Main St. and the 8" main on Wentworth Rd. The 8" bypass previously only manually opened in the event of fire flow necessity, is now permanently opened coincident with the removal of the check valve at this location.

To assess this benefit, UE was tasked with evaluating the impact to the Town's water system of a water main break on either the Wentworth Road, or Peirce Island side of the New Castle distribution system. UE and Town staff performed the following three flow test scenarios at Hydrant #21 located on the Main Street in the vicinity of the Town Offices:

- **Scenario 1:** Water coming from Peirce Island is shut-off at the Sawtelle Bridge. Flow to the Village is only available from Wentworth Road.
- **Scenario 2:** Water from Wentworth Road is shut-off at Main Street and Wentworth Road. Flow to the New Castle is only available from Peirce Island (through the new 12- inch diameter transmission main).
- **Scenario 3:** Normal operating conditions. Flow can enter the New Castle distribution system from both Wentworth Road and Peirce Island.

Table 3 below summarizes the results of the three flow test scenarios:

Table 3: Routing Impacts to Available Fire Flows at Hydrant 21 @ 20 psi Residual Pressure.

Hydrant	Location	Available Fire Flow With Shapleigh Island Valved Shut (gpm)	Available Fire Flow with Wentworth Road Valved Shut (gpm)	Available Fire Flow under Normal Conditions (gpm)
21	Downtown Village	420	900	970

This exercise shows available fire flow within the New Castle Distribution System is significantly impacted by the routing of water entering the system. The higher friction factor and smaller pipe on Wentworth Road reduces the amount of available fire flow to the system. Previous hydraulic model evaluations predicted that replacing the City of Portsmouth water main (with a new 12-inch

diameter main) on Wentworth Road would allow approximately 20% more water to reach the village area of New Castle and increase available fire flows. Using the predicted increase from the 2016 model, this translates to a potential of approximately 1,160 gpm at Hydrant #21 after replacing the water main on Wentworth Road.

Flow Testing within the City of Portsmouth System

UE, along with Town and City Staff, flow tested 5 hydrants within the City's distribution system located in New Castle (Figure 1). These hydrants were located along Wentworth Road and were used to determine the impacts of the transmission main improvements to that portion of the Town. Table 4 below shows the results of those flow tests:

Table 4: City of Portsmouth Available Fire Flows @ 20 psi Residual

Hydrant Location ¹	2016 Existing Available Fire Flows Predicted by the Model (gpm)	2016 Calculated Available Fire Flows from Field Tests (gpm) ^{2,3}	2020 Calculated Available Fire Flows from Field Tests (gpm) ³	Available Flow Improvement Multiplier
A: Pit Lane and Wentworth Road	N/A	330	800	2.42
B: Shaw Circle near Wentworth Road	753	N/A	710	N/A
C: Hydrant near the Great Island Common	669	330	590	1.79
D: Wild Rose Lane and Wentworth Road	N/A	270	330	1.22
E: Near Spring Hill Road and Wentworth Road	N/A	280	610	2.18

1. Locations B and C were used as evaluation points in the 2016 Report to develop the recommended improvements. The model predicted the existing available fire flows higher than what was later calculated during the Town's flushing program. The model then predicted that the available fire flows for Alt 1A would be 809 gpm and 753 gpm for locations B and C respectively. The 2020 improvements show that even though the available fire flows were less than what the model predicted, the amount of increased available fire flow was greater than what was predicted.

2. 2016 Flows were measured during the Town's Hydrant Flushing Program. At the time the check valve was in place and the bypass was closed. 2020 improvements have removed the check valve on Wentworth Road and flow freely moves between the two systems.

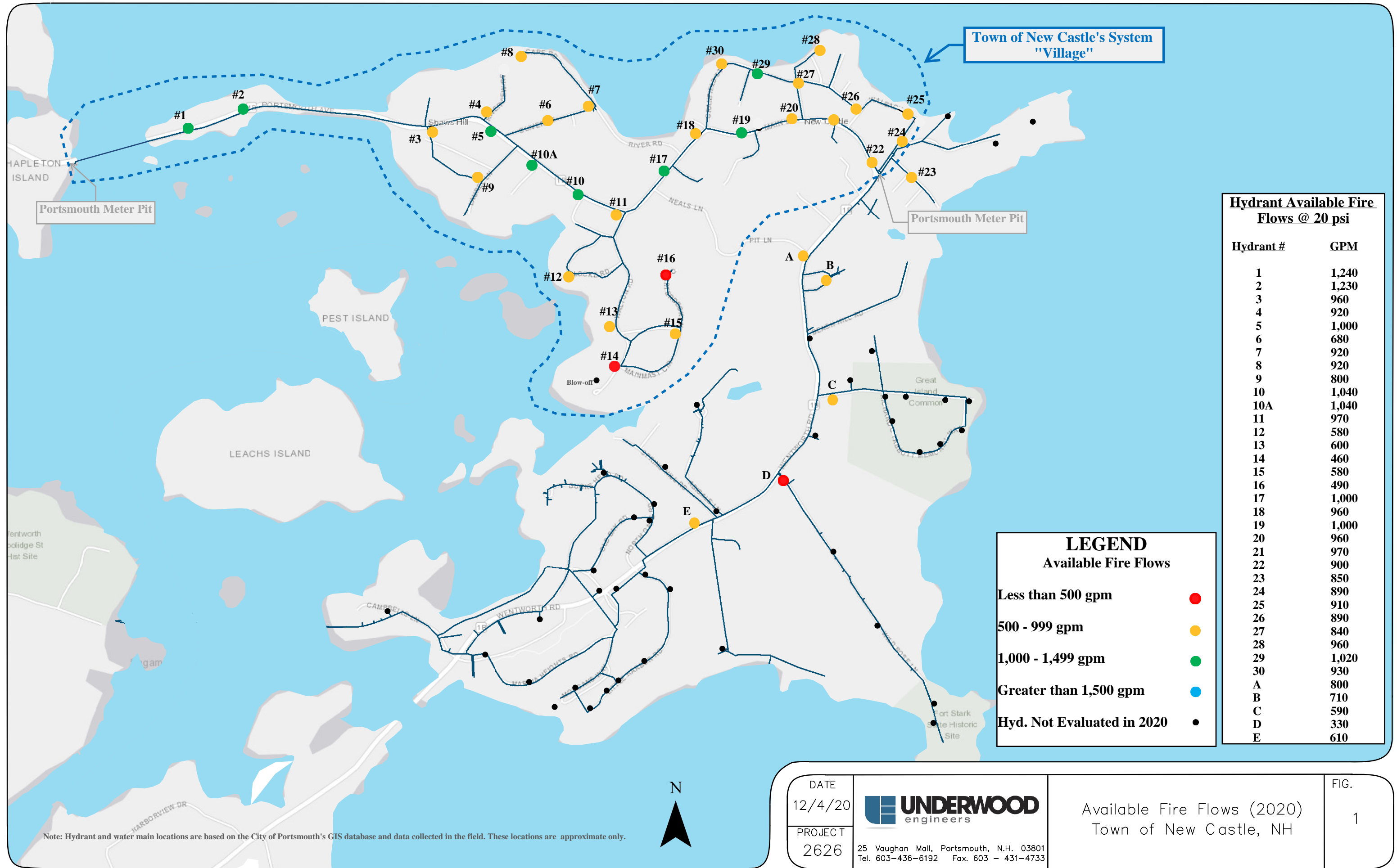
3. Available fire flows for the Portsmouth Hydrants were calculated using the measured data of the flow hydrant for both 2016 and 2020. These values should be confirmed during the Town and City's next flushing cycle.

The flow test results in Table 4 show there were improvements to the available fire flows along Wentworth Road as well. This is due to the increase in flow located at the end of the new transmission main on Wentworth Road and the removal of the check valve that was in place during the 2016 evaluation.

Conclusions

Underwood Engineers offers the following conclusions:

- The first phase of the recommended transmission main improvements project increased the available fire flows within the New Castle distribution system.
- Available fire flows routed from Wentworth Road are negatively impacted by the smaller water main with the higher friction along that road.
- Portions of the City's distribution system near the improvement project saw an increase in available fire flows due to its proximity to the newer main and the removal of the check valves at either end of New Castles system.
- The 2016 goals for available fire flows have partially been met. Additional improvements are needed to obtain the target flows identified in the 2016 engineering report.
- Hydrant flows should be confirmed on a regular basis.



Hydrant Available Fire Flows @ 20 psi	
Hydrant #	GPM
1	1,240
2	1,230
3	960
4	920
5	1,000
6	680
7	920
8	920
9	800
10	1,040
10A	1,040
11	970
12	580
13	600
14	460
15	580
16	490
17	1,000
18	960
19	1,000
20	960
21	970
22	900
23	850
24	890
25	910
26	890
27	840
28	960
29	1,020
30	930
A	800
B	710
C	590
D	330
E	610

LEGEND

Available Fire Flows

Less than 500 gpm

500 - 999 gpm

1,000 - 1,499 gpm

Greater than 1,500 gpm

Hyd. Not Evaluated in 2020

Note: Hydrant and water main locations are based on the City of Portsmouth's GIS database and data collected in the field. These locations are approximate only.