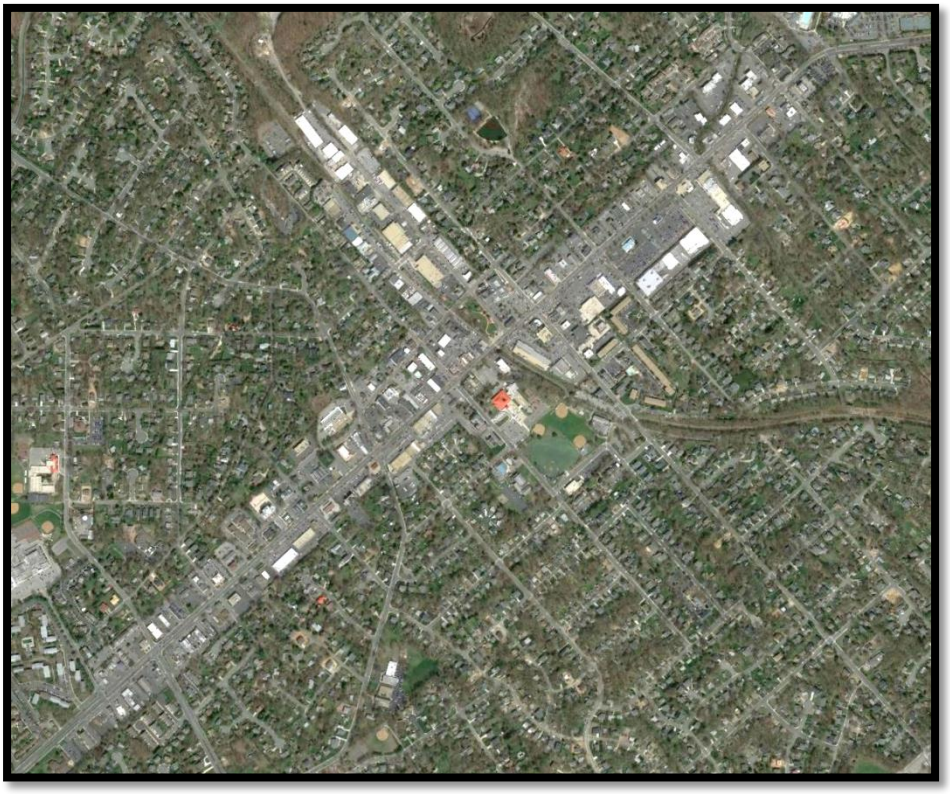
WATER SYSTEM STUDY: MAPLE AVENUE CORRIDOR

TOWN OF VIENNA, Virginia

FINAL REPORT



FINAL REPORT **NOVEMBER 2015**

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

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I. INTRODUCTION

Whitman, Requardt, and Associates (WRA) has conducted a water capacity study for the Town of Vienna to analyze the present and future water demands of the Maple Avenue (Route 123) commercial district. The intent of this study is to evaluate the Town's current water distribution system and the ability to supply adequate fire flow during peak demand using a 24 hour extended simulation analysis. Based on data obtained from the current Town of Vienna water model, in this study WRA has made recommendations for infrastructure improvements to meet the present and future demands of the Maple Avenue commercial district.

II. BACKGROUND:

For the analysis, the Town of Vienna and Fairfax Water provided the following information:

- WaterGEMS V8i Water Model
- GIS Shapefiles
- Town of Vienna Water System Maps
- Current Pressure Reducer Valve (PRV) Pressure Settings and Elevations
- Current Tank Elevations
- Town of Vienna Historic Water Wholesale Purchase Data
- Town of Vienna Billing Records
- Town of Vienna Water Consumption Records
- Fire Flow Testing Data
- Pressure Logger Data

The original water model was developed by WRA in 2006 and updated in 2009. The model included two elevated tanks, one ground storage tank and one pump station. This model was calibrated for steady state and extended period simulations (EPS). This model was also used to estimate the water age in the system.

Demand and Population Projection Assumptions:

WRA reviewed all pertinent information including individual billing records but found it difficult to allocate demands due to the large volume of meter records compared to the simplicity of the model. Additionally, no population forecasting data was available for analysis.

Due to limited data to simulate future demands for the Maple Avenue commercial district, WRA and the Town of Vienna agreed that it would be most efficient to place a 30% increase on all present demands within the Maple Avenue commercial district. It was concluded that the demands in the current water model were sufficient since the corridor has not experienced significant development since the model was created.

Fire Flow Analysis Assumptions:

After creating present and future water demand scenarios, WRA evaluated the system capacity by selecting five locations (See Appendix A) along the Maple Avenue corridor and placing a three hour fire flow demand of 2700 GPM to simulate a fire flow during peak usage. When modeling fire flow demands for commercial developments, a range of 2500-3000 GPM is typically used by convention. After each simulated test, WRA evaluated the lowest pressures in the distribution system and noted the locations of the low pressures (See Appendix B and C).

III. MODELING & ANALYSIS:

To initialize the model, all of the pressure reducing valves were updated to the current settings supplied by The Town of Vienna; Table 1 shows the pressure settings:

Table 1: Town of Vienna PRV Settings

PRV Name	Status	Size	Pressure
Earl	OFF	6"	N/A
Maple Avenue	ON	12"	68 PSI[1]
Old Courthouse Road	ON	12"	60 PSI[1]
Montmorency	ON	6"	54 PSI[2]
Vale	ON	6"	55 PSI
Electric Avenue	ON	10"	45 PSI
Park	ON	8"	52 PSI

Notes:
1. Pressure settings for the Maple Avenue and Old Courthouse Road PRVs could not be verified and are from the 2009 update of the model.
2. Montmorency pressure setting is assumed to be 10 PSI below normal operating pressure.

Validation of the Model:

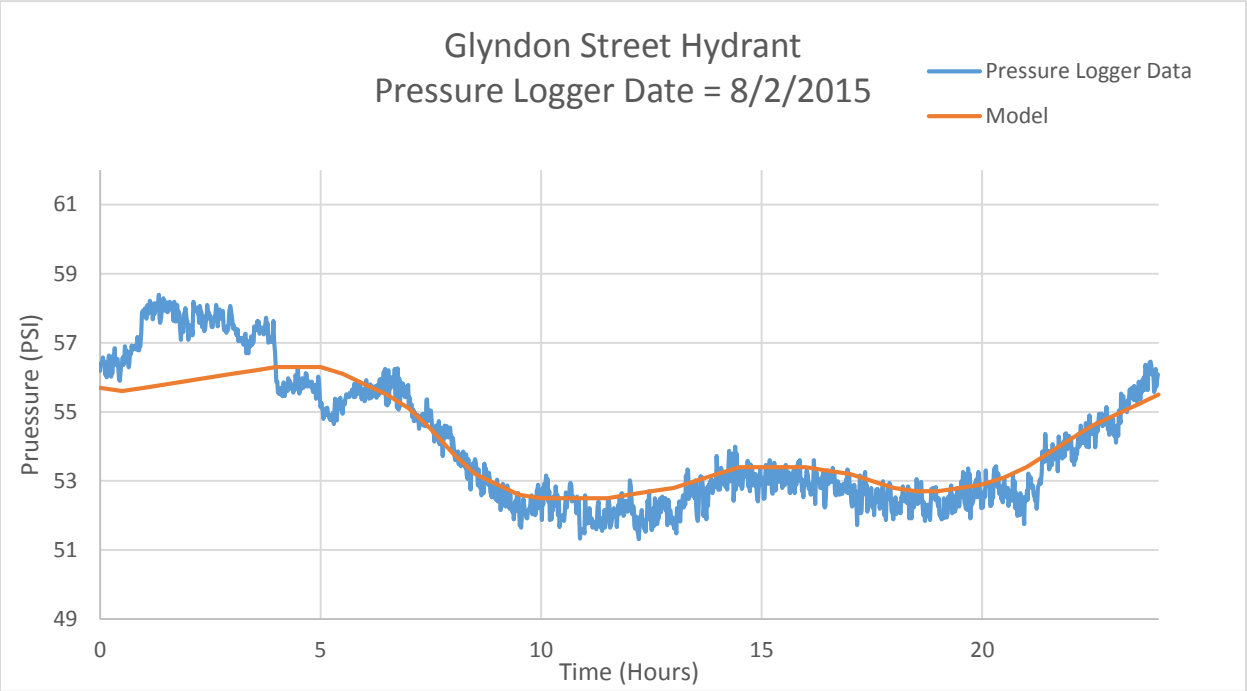
The accuracy of the updated base model (max day) was validated by using field fire flow tests and fire hydrant pressure logger data supplied by the Town of Vienna. WRA selected three fire flow tests which used at least two hydrants: a flow hydrant and residual hydrant for an accurate comparison.

The results of the fire flow tests when compared to 24 hour simulation in the model are as follows:

Fire Flow Test A: West St. NW (5/11/2015)	**Flow Hydrant ID = 38-3-20A**		**Residual Hydrant = 38-3-20**			
	Static PSI	**Flow (GPM)**	**Static PSI**	**Residual PSI**		
Field	N/A	1061	51	41		
Model	52	1061	50	47		
Fire Flow Test B: Emmanual Church (2/12/2015)	**Flow Hydrant ID = 38-3-54**		**Residual Hydrant ID = 38-3-98**			
	Static PSI	**Flow (GPM)**	**Static PSI**	**Residual PSI**		
Field	63	1007	63	45		
Model	57	1007	57	42		
Fire Flow Test C: Moseby's Landing (1/5/2015)	**Flow Hydrant ID = 38-3-43**		**Flow Hydrant ID = 38-3-51**		**Residual Hydrant ID = 38-3-50**	
	Static PSI	**Flow (GPM)**	**Static PSI**	**Flow (GPM)**	**Static PSI**	**Residual PSI**
Field	N/A	775	N/A	746	46	33
Model	41	775	41	746	41	29

Based on the results of the fire flow tests on existing fire hydrants, WRA observed that the pressures of residual hydrants in the field and model were within an acceptable range of 5-6 PSI.

WRA additionally used pressure logger data from a recently installed hydrant located on Glyndon Street between Locust Street and Cabin Road and compared the results to a 24 hour maximum day model simulation. The results of the comparison are in the graph below:



The graph demonstrates that the pressures recorded in the field closely match the pressures observed in the model. Given the data observed when comparing the fire flow tests and the pressure logger data to the results of the model, WRA is confident that the model will predict system pressures and capacity within acceptable limits.

Fire Flow Simulations:

After the model was updated and validated, five independent simulations were performed at five intersections along the Maple Avenue corridor; for each 24 hour simulation, a 3 hour 2700 GPM fire flow demand was placed at each intersection with the fire flow starting at 8 AM. The lowest pressure in the system was recorded for each 24 hour simulation as shown in Table 2.

After simulating the fire flow at present max daily demand, all demands within the Maple Avenue commercial district were increased by 30%. Five additional fire flows were then simulated with the same 3 hour 2700 GPM fire flow demands at the same five intersections along Maple Avenue (See Table 3).

IV. RESULTS:

Table 2: Present Max Daily Demand at Maple Avenue				
Fire Flow Simulation No.	**3 HR Fire Flow @ Peak Demand (8 AM)**	**Location of Demand**	**Min. Pressure in System (PSI)**	**Critical?** [1]
1	2700 GPM	Maple Ave/Nutley St.	27.1	No
2	2700 GPM	Maple Ave/Pleasant St.	27.0	No
3	2700 GPM	Maple Ave/ Center St.	26.7	No
4	2700 GPM	Maple Ave/ Glyndon St.	26.3	No
5	2700 GPM	Maple Ave/E St.	15.5	YES

Table 3: 130% Max Daily Demand at Maple Avenue				
Fire Flow Simulation No.	**3 HR Fire Flow @ Peak Demand (8 AM)**	**Location of Demand**	**Min. Pressure in System (PSI)**	**Critical?** [1]
1	2700 GPM	Maple Ave/ Nutley St.	27.0	No
2	2700 GPM	Maple Ave/Pleasant St.	26.9	No
3	2700 GPM	Maple Ave/ Center St.	26.6	No
4	2700 GPM	Maple Ave/ Glyndon St.	26.2	No
5	2700 GPM	Maple Ave/E St.	15.2	YES
5A[2]	2700 GPM	Maple Ave/E St.	25.4	No

Notes:

1. Critical pressure is considered below 20 PSI.
2. Model Simulation 5A is an alternative scenario where Hines Street/Follin Avenue 8-inch and 12-inch water mains were connected to improve system capacity.

Analysis of Results:

In Table 2, the minimum system pressures Fire Flow Simulations 1 through 4 ranged from 26.3 to 27.1 PSI which were all above the critical pressure of 20 PSI. Fire Flow Simulation 5 had a below critical pressure of 15.5 PSI. Referring to Appendix B, the area where the critical pressures occurred is east of Maple Avenue around Wolftrap Road and Kramer Drive.

In Table 3, when demands were increased by 30% within the Maple Avenue commercial district, the minimum pressure for Fire Flow Simulations 1 through 4 had a range of 26.2 to 27.0 PSI. As in the first scenario, all pressures were above critical pressure. Fire Flow Simulation 5 had a below critical pressure of 15.2 PSI. Referring to Appendix C, the area where the critical pressures occurred is in the same area, east of Maple Avenue around Wolftrap Road and Kramer Drive.

The most likely cause of the critical pressures in Fire Flow Simulation 5 for both max day scenarios is that the area east of Maple Avenue is at higher elevation; when demand is increased to 2700 GPM during a 3 hour fire flow the pressure cannot be sustained above 20 PSI due to limits of the system capacity.

Other Observations:

- When the model was run for all fire flow simulations, it was observed that domestic demand had little effect on the results.

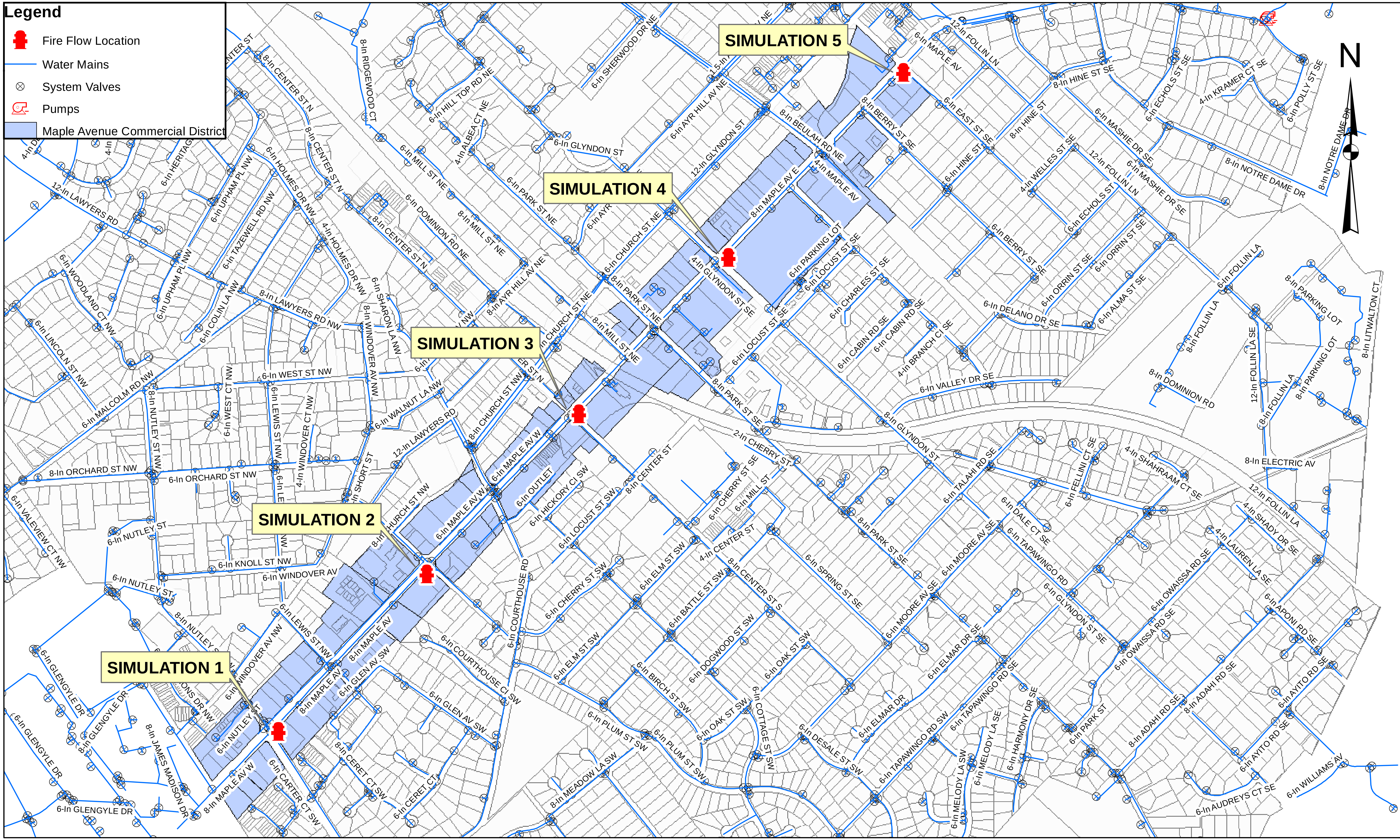
V. RECOMMENDATIONS:

To alleviate critical pressures observed during Fire Flow Simulation 5 for both max day scenarios, WRA recommends connecting the 8-inch water main in Hines Street to the 12-inch water main in Follin Lane. According to water system maps, these water mains are currently not connected.

Referring to Table 3, Fire Flow Simulation 5A, when the two pipes were connected in the model, the lowest pressure in the system was raised from 15.2 PSI to 25.4 PSI. By connecting the two pipes, the 12-inch pipe would provide the extra capacity required when the uppermost part of the Maple Avenue is under fire flow demand.

APPENDIX A

MAPLE AVENUE HYDRANT SIMULATION LOCATIONS



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FIRE FLOW LOCATIONS IN MODEL

APPENDIX B

PRESENT MAX DAILY DEMAND PRESSURE CONTOURS

HYDRANT SIMULATIONS 1-5

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- System Valve
- Pumps
- Maple Avenue Commercial District

N

40 PSI

50 PSI

30 PSI

40 PSI

50 PSI

30 PSI

50 PSI

30 PSI

40 PSI

50 PSI

50 PSI

50 PSI

50 PSI

50 PSI

6-In CENTER ST

8-In CENTER ST N

8-In RIDGEWOOD CT

12-In BEULAH RD NE

6-In HILL TOP RD NE

4-In ALBEACT NE

6-In GLYNDON ST

6-In MAPLE AV

6-In EAST ST SE

8-In BERRY ST SE

8-In HINE ST SE

6-In ECHOLS ST SE

4-In KRAMER CT SE

6-In POLLY ST

8-In NOTRE DAME DR

6-In MASHIE DR SE

4-In WELLES ST SE

12-In FOLLIN LN

6-In HINE ST

8-In HINE ST

8-In BEULAH RD NE

12-In GLYNDON ST

6-In MILL ST NE

6-In PARK ST NE

6-In AYR HILL AV NE

6-In CHURCH ST NE

8-In MAPLE AV E

4-In MAPLE AV

6-In PARKING LOT

6-In LOCUST ST SE

6-In CHARLES ST SE

6-In CABIN RD SE

4-In BRANCH CI SE

6-In DELANO DR SE

6-In ORRIN ST SE

6-In ALMA ST SE

6-In FOLLIN LA

8-In FOLLIN LA

8-In PARKING LOT

8-In LITWALTON CT

12-In FOLLIN LA SE

6-In VALLEY DR SE

8-In DOMINION RD

6-In GLYNDON ST

8-In PARK ST SE

2-In CHERRY ST

6-In TALAHI RD SE

4-In SHAHRAAM CT SE

8-In ELECTRIC AV

4-In SHADY DR SE

4-In LAUREN LA SE

6-In APONI RD SE

6-In AYITO RD SE

8-In ADAHI RD SE

6-In OWAISSA RD SE

6-In TAPAWINGO RD

6-In MOORE AV SE

6-In DALE CT SE

6-In FELLINI CT SE

6-In WILLIAMS AV

6-In AUDREYS CT SE

6-In MCHENRY ST SE

6-In HOLMES DR NW

6-In UPHAM PL NW

6-In TAZEWELL RD NW

4-In HOLMES DR NW

6-In DOMINION RD NE

8-In MILL ST NE

8-In AYR HILL AV NW

6-In SHARON LA NW

8-In WINDOVER AV NW

6-In COLIN LA NW

6-In BLAIR RD

6-In UPHAM

6-In WEST ST NW

6-In WALNUT LA NW

6-In LAWYERS RD

6-In HIGHLAND ST NW

6-In MALCOLM RD NW

8-In NUTLEY ST NW

6-In WEST CT NW

6-In LEWIS ST NW

6-In SHORT ST

6-In ORCHARD ST NW

6-In VALEVIEW CT NW

6-In OAK VALE CT NW

6-In NUTLEY ST

6-In KNOLL ST NW

6-In WINDOVER AV

8-In CHURCH ST NW

8-In CENTER ST N

8-In CHURCH ST

8-In CENTER ST S

6-In MAPLE AV W

6-In OUTLET

6-In HICKORY CI SW

6-In LOCUST ST SW

6-In CHERRY ST SW

6-In ELM ST SW

6-In PLEASANT ST SW

6-In COURTHOUSE RD

6-In COURTHOUSE CI SW

6-In GLEN AV SW

8-In MAPLE AV

6-In COMMONS DR NW

6-In GLENGYLE DR

8-In GLENGYLE DR

8-In JAMES MADISON DR

6-In RAMBLING RD

6-In GLENGYLE DR

8-In CERET CT SW

6-In CERET CT

8-In NUTLEY ST

8-In MAPLE AV W

6-In PLUM ST SW

8-In MEADOW LA SW

8-In HILLCREST DR SW

6-In BIRCH ST SW

6-In OAK ST SW

6-In COTTAGE ST SW

6-In DOGWOOD ST SW

6-In BATTLE ST SW

4-In CENTER ST

6-In SPRING ST SE

6-In ELMAR DR

6-In ELMAR DR SE

6-In DESALE ST SW

6-In TAPAWINGO RD SW

6-In MELODY LA SW

6-In MELODY LA SE

6-In HARMONY DR SE

6-In PARK ST

8-In ADAHI RD SE

1,400 700 0 Feet

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SIMULATION 1: 3 HR FIRE FLOW @ 2700 GPM
PRESENT MAX DAILY DEMAND AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- LGIM_WaterSystemValves
- Pumps
- Maple Avenue Commercial District

50 PSI
30 PSI
40 PSI
50 PSI

8-In RIDGEWOOD CT
6-In RIDGEWOOD CT NE
6-In GLYNDON ST NE
6-In SHERWOOD DR NE
12-In BEULAH RD NE
6-In AYR HILL AV NE
6-In COUNCIL CT
12-In MAPLE AV
6-In EAST ST
12-In FOLLIN LN
8-In HINE ST SE
6-In KRAMER DR SE
4-In KRAMER CT SE
6-In POLLY ST SE
8-In NIBLICK DR SE
8-In NOTRE DAME DR
6-In MASHIE DR SE
12-In FOLLIN LA SE
8-In CENTER ST N
6-In HOLMES DR NW
6-In TAZEWELL RD NW
4-In HOLMES DR NW
6-In BLAIR RD NW
LAWYERS RD NW
8-In LAWYERS RD NW
6-In LINCOLN ST NW
8-In MALCOLM RD NW
6-In LEWIS ST NW
6-In WEST ST NW
8-In NUTLEY ST NW
6-In WEST CT NW
6-In WALNUT LA NW
6-In JADE CT NW
6-In VALEVIEW CT NW
8-In ORCHARD ST NW
6-In ORCHARD ST NW
6-In WINDOVER AV NW
8-In GLENGYLE DR
6-In JAMES MADISON DR
6-In COMMONS DR NW
6-In RAMBLING RD
8-In CHAIN BRIDGE RD
8-In MENDON LA
6-In CARTER CT SW
8-In CERET CT SW
8-In WADE HAMPTON DR SW
6-In GLEN AV SW
6-In NUTLEY ST
6-In MILL ST NE
6-In ALBEA CT NE
4-In JEAN PL NE
6-In PARK ST NE
8-In MILL ST NE
6-In DOMINION RD NE
6-In AYR HILL AV NE
6-In CHURCH ST NE
8-In CHURCH ST NE
12-In CHURCH ST NE
12-In CHURCH ST NW
12-In LAWYERS RD
8-In CENTER ST S
6-In MAPLE AV W
8-In MAPLE AV W
12-In MAPLE AV W
6-In PLEASANT ST SW
6-In COURTHOUSE CI SW
6-In COURTHOUSE RD SW
6-In OUTLET
6-In LOCUST ST SW
6-In CHERRY ST SW
6-In ELM ST SW
6-In BATTLE ST SW
6-In COTTAGE ST SW
6-In BIRCH ST SW
6-In PLUM ST SW
8-In MEADOW LA SW
8-In MOORE AV SW
6-In DESALE ST SW
8-In COTTAGE ST SW
8-In MAPLE AV E
6-In PARK ST
4-In GLYNDON ST SE
8-In PARK ST SE
6-In PARKING LOT
8-In MAPLE AV E
6-In LOCUST ST SE
6-In CHARLES ST SE
6-In CABIN RD SE
4-In BRANCH CI SE
6-In GLYNDON ST
6-In DELANO DR SE
6-In VALLEY DR SE
6-In DOMINION RD SE
2-In CHERRY ST
6-In MILL ST
8-In CENTER ST
4-In CENTER ST
6-In SPRING ST SE
8-In CENTER ST S
6-In MOORE AV SE
6-In ELMAR DR SE
6-In TAPAWINGO RD SE
6-In LULLABY LA SE
8-In TALAHI RD SE
6-In GLYNDON ST SE
6-In DALE CT SE
6-In MOORE AV SE
6-In TAPAWINGO RD SE
8-In PARK ST SE
6-In OWAISSA CT SE
6-In OWAISSA RD SE
6-In PARK ST
8-In ADAHI RD SE
6-In AYITO RD SE
6-In AUDREYS CT SE
6-In WILLIAMS AV
6-In REDWOOD DR
6-In ONONDIO CI SE
4-In SHADY DR SE
4-In LAUREN LA SE
12-In NINOVAN RD
6-In NINOVAN RD SE
4-In SHAHRAAM CT SE
8-In TALAHI RD SE
6-In ALMA ST SE
6-In ECHOLS ST
6-In BERRY ST SE
8-In BERRY ST SE
8-In MAPLE AV
6-In HINE ST
6-In EAST ST SE
8-In HINE ST SE
8-In HINE ST
8-In DOMINION RD
8-In FOLLIN LA
6-In FOLLIN LA
12-In FOLLIN LA
8-In PARKING LOT

1,400 700 0 Feet

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SIMULATION 2: 3 HR FIRE FLOW @ 2700 GPM
PRESENT MAX DAILY DEMAND AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- System Valve
- Pumps
- Maple Avenue Commercial District

50 PSI
30 PSI
40 PSI

1,400 700 0 Feet

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SIMULATION 3: 3 HR FIRE FLOW @ 2700 GPM
MAX PRESENT DAILY DEMAND AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- System Valves
- Pumps
- Maple Avenue Commercial District

N

1,400 700 0 Feet

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SIMULATION 4: 3 HR FIRE FLOW @ 2700 GPM
PRESENT MAX DAILY DEMAND AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- Water Mains
- System Valves
- Pumps
- Maple Avenue Commercial District

N

1,000 500 0 Feet

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SIMULATION 5: 3 HR FIRE FLOW @ 2700 GPM
PRESENT MAX DAILY DEMAND AT MAPLE AVENUE

APPENDIX C

130% MAX DAILY DEMAND INCREASE PRESSURE CONTOURS

HYDRANT SIMULATIONS 1-5 & ALTERNATE SIMULATION 5A

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- System Valves
- Pumps
- Maple Avenue Commercial District

N

1,400 700 0 Feet

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SIMULATION 1: 3 HR FIRE FLOW @ 2700 GPM
130% MAX DAILY DEMAND INCREASE AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- System Valves
- Pumps
- Maple Avenue Commercial District

N

1,400 700 0 Feet

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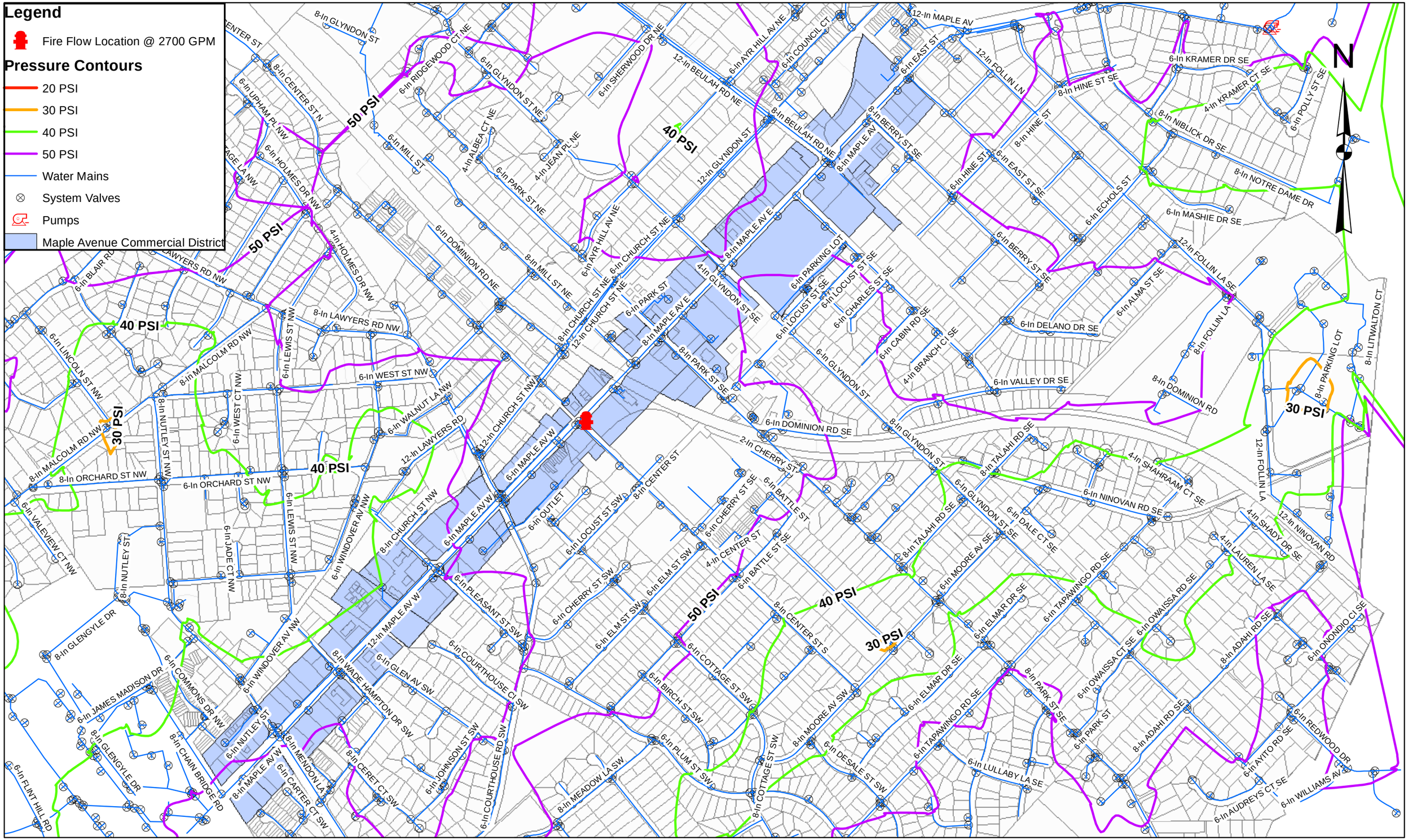
SIMULATION 2: 3 HR FIRE FLOW @ 2700 GPM
130% MAX DAILY DEMAND INCREASE AT MAPLE AVENUE



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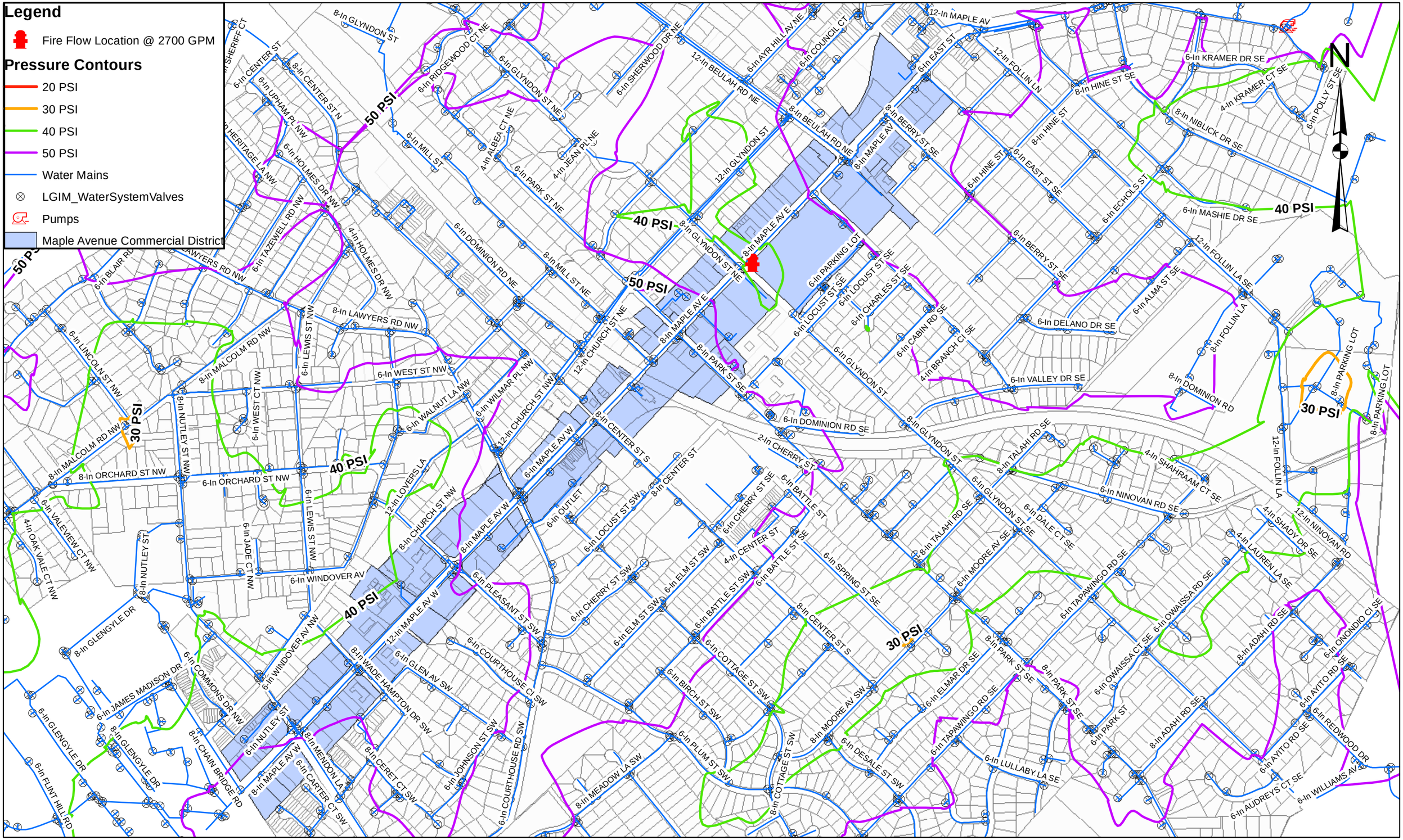
SIMULATION 3: 3 HR FIRE FLOW @ 2700 GPM
130% MAX DAILY DEMAND INCREASE AT MAPLE AVENUE



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SIMULATION 4: 3 HR FIRE FLOW @ 2700 GPM
130% MAX DAILY DEMAND INCREASE AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- Water Mains
- System Valves
- Pumps
- Maple Avenue Commercial District

N

50 PSI
40 PSI
20 PSI
30 PSI

1,000 500 0 Feet

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SIMULATION 5: 3 HR FIRE FLOW @ 2700 GPM
130% MAX DAILY DEMAND INCREASE AT MAPLE AVENUE

Legend

- Fire Flow Location @ 2700 GPM

Pressure Contours

- 20 PSI
- 30 PSI
- 40 PSI
- 50 PSI
- Water Mains
- System Valves
- Pumps
- Maple Avenue Commercial District

Proposed Improvement:
Connect 8-inch and 12-inch water mains at the intersection of Hine Street and Follin Lane.

N

1,000 500 0 Feet

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PROPOSED FOLIN LANE/ECHOLS STREET CONNECTION
SIMULATION 5A: 3 HR FIRE FLOW @ 2700 GPM
130% MAX DAILY DEMAND INCREASE AT MAPLE AVENUE

3701 Pender Dr., Suite 450, Fairfax, VA 22030