Tontitown Water Distribution System Master Plan

A Little Town, A Lot of Tradition

Prepared For:

Tontitown Water Utilities

October 2021

GARVER

GarverUSA.com

Tontitown Water Distribution System Master Plan

Tontitown Water Utilities
Tontitown, Arkansas

Prepared by:

2049 E. Joyce Blvd., Suite 400
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October 2021

Garver Project No. 18048025

Engineer's Certification

I hereby certify that this Comprehensive Water Master Plan was prepared by Garver under my direct supervision for Tontitown Water Utilities.

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No. 12716

Digitally Signed 01/07/2022

GARVER LLC
No. 766

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1.0 Executive Summary

1.1 Introduction and Background

In 2020, the City of Tontitown's water distribution system underwent significant operational changes. Prior to these changes, the City received water from Springdale Water Utilities through three connections along the east side of the City. In 2020, the City constructed a new elevated storage tank, booster pump station, and 18-inch transmission line connecting to the Benton/Washington Regional Public Water Authority transmission lines to the West.

The previous water distribution master plan was completed in April of 2008. Garver was authorized by the City of Tontitown to complete an updated comprehensive water distribution master plan to reflect the recent distribution system changes and anticipated system growth. The updated master plan is intended to provide the City of Tontitown a planning document to aid in the prioritization of updates within the distribution system to assure that regulations and the City's desired level of service continue to be met as the City grows.

The master plan included assistance from several staff from the City of Tontitown. Throughout the process of developing the master plan, Garver coordinated with the Tontitown's Public Works Director and other City employees to ensure that the plan was tailored to meet the City's expectations.

1.2 Existing and Future System Assessment

Enclosed in Appendix A and Appendix B are the Hydraulic Model Calibration and Validation and the Future System Assessment and Capital Improvements technical memorandums, respectively. Appendix C includes the water loss audit on the City's water distribution system using data from 2019.

Population projections and per-capita water demands were evaluated and used to estimate total water system demands, shown in Table 1-1 below for average day and maximum day conditions for each of the planning horizons.

Table 1-1: Population and Demand Projections

Planning Horizon	Projection Type	Population	Average Day Demand (MGD)	Maximum Day Demand (MGD)
Existing	NA (Recorded)	4,358	0.428	0.872
2025	Linear Trend	6,699	0.670	1.340
	Exponential Trend	7,032	0.703	1.406
2040	Linear Trend	12,549	1.255	2.510
	Exponential Trend	22,522	2.522	4.505
Buildout	NA	64,361	6.436	12.872

The design criteria generally included pressure, velocity, fire flow, and effective water storage. Based upon the demand projections and validation of the hydraulic model, various design scenarios are outlined in Appendix B. Results for each of the planning horizons with respect to the design criteria are also shown in Appendix B.

Improvements included in the CIP are broken into two categories: 2025 Improvements and 2040 Improvements. Improvements listed in the 2025 category should be completed by the year 2025 and 2040 improvements should be completed by the year 2040. These improvements, along with the projected cost in 2020 dollars, are listed in Table 1-2 and Table 1-3 below. Maps of these improvements can be seen in Appendix B.

Table 1-2: 2025 Improvements

Project Number	Project Name	Dia. (in)	Length (LF)	Cost per LF	Estimated Cost (2020 Dollars)
1A	1-MG Southeast EST	NA	NA	NA	$5,000,000
1B	12-inch Waterline for SE EST	12”	7,821	$180	$1,410,000
1C	8-inch Waterline for SE EST	8”	469	$120	$60,000
2	Old HWY 68	12”	2,385	$180	$430,000
3	Wildcat Creek	8”	8,676	$120	$1,050,000
4	HWY 112 (1)	12”	3,179	$180	$580,000
5	HWY 112 (2)	12”	4,213	$180	$760,000
TOTAL					**$9,290,000**

Table 1-3: 2040 Improvements

Project Number	Project Name	Dia. (in)	Length (LF)	Cost per LF	Estimated Cost (2020 Dollars)
6	Harmon Road	8”	5,427	$120	$660,000
7	Klenc Road (1)	8”	2,685	$120	$330,000
8	Klenc Road (2)	8”	2,516	$120	$310,000
9	Klenc Road to Barrington Connection	8”	2,594	$120	$320,000
10	HWY 412 (1)	12”	9,390	$180	$1,700,000
11	1-MG Northwest EST	NA	NA	NA	$5,000,000
12	Waterline from SE EST to HWY 112	12”	2,515	$180	$460,000
13	Barrington Road	8”	5,402	$120	$650,000
14	Pianalto to Klenc Connection	8”	5,187	$120	$630,000
15	Harmon to Pianalto Connection	8”	5,223	$120	$630,000
16	HWY 412 to Harmon Connection	8”	4,106	$120	$500,000
17	Harmon Road Extension (North of HWY 412)	8”	2,569	$120	$310,000
18	Wc Road 852	8”	1,495	$120	$180,000
19	Morsani Road Extension to Pianalto Road	8”	1,299	$120	$160,000
20	Mantegani to Pianalto Connection	8”	2,465	$120	$300,000
21	Liberty to Ardemagni Connection	8”	1,387	$120	$170,000
22	Barrington to Maestri Connection (1)	8”	3,631	$120	$440,000
23	Barrington to Maestri Connection (2)	8”	3,020	$120	$370,000
24	Mantegani to Liberty Connection	8”	1,556	$120	$190,000
25	Javello to Liberty Connection	8”	3,123	$120	$380,000
26	Pianalto Road Extension to Javello Road	8”	1,583	$120	$190,000
27	Jones Road Extension to HWY 112	8”	3,100	$120	$380,000
28	Ardemagni to Sabatini Connection	8”	2,654	$120	$320,000

1.3 Conclusion

Cost totals for the 2025 and 2040 planning horizons are approximately $9,290,000 and $24,370,000, respectively. While some of the upgrades included in the 2040 planning horizon may be development driven, the City should begin planning to implement the upgrades included in the 2025 planning horizon. The new elevated storage tank will satisfy the storage requirement that the City is quickly approaching while the other projects will help ensure that development within the current city limits will not be limited by the City's ability to provide water.

Using this planning document, as well as the hydraulic model, will help support sustainable growth of Tontitown's water distribution system. While some of this master plan may be conceptual, development trends will allow for prioritization of some longer-term improvements over others. Garver proposes that updates to the water master plan be made every five years to keep up to date with the existing conditions of the system and anticipated growt

Project Number	Project Name	Dia. (in)	Length (LF)	Cost per LF	Estimated Cost (2020 Dollars)
29	Apple Blossom Lane	8”	10,158	$120	$1,220,000
30	Taldo Loop	8”	3,755	$120	$460,000
31	Wc Road 753	8”	3,083	$120	$370,000
32	Harmon Road (South of Wildcat Creek)	8”	2,983	$120	$360,000
33	Wc Road 857	8”	5,377	$120	$650,000
34	Morsani Avenue	8”	3,956	$120	$480,000
35	South Mantegani Road	8”	1,343	$120	$170,000
36	HWY 412 (2)	8”	6,559	$120	$790,000
37	Washington Avenue	8”	1,349	$120	$170,000
38	HWY 412 (3)	8”	3,162	$120	$380,000
39	Via De Tonti Lane	8”	1,864	$120	$230,000
40	Pozza Lane	8”	754	$120	$100,000
41	Maestri Road	8”	6,077	$120	$730,000
42	Belmont Way	8”	1,516	$120	$190,000
43	Malbec Road	8”	914	$120	$110,000
44	Sbanotto Avenue	8”	354	$120	$50,000
45	Sabatini Road	8”	1,227	$120	$150,000
46	Ardemagni Road	8”	2,296	$120	$280,000
47	Jevello Road	8”	1,051	$120	$130,000
48	HWY 412 to Pialto Connection	8”	482	$120	$60,000
49	HWY 412 Service Connection	8”	1,472	$120	$180,000
50	Brush Creek	8”	10,064	$120	$1,210,000
51	Lynch Ave	8”	2,287	$120	$280,000
52	Wc Road 2033	8”	2,184	$120	$270,000
53	Wc Road 3805	8”	3,769	$120	$460,000
54	White Oak Drive	8”	752	$120	$100,000
55	Oak Hills Drive	8”	719	$120	$90,000
56	Leelynjean Lane	8”	968	$120	$120,000
TOTAL					**$24,370,000**

APPENDIX A

Technical Memorandum – Hydraulic Model Calibration and Validation

Tontitown Water Distribution System Master Plan

Technical Memorandum
Hydraulic Model Calibration and Validation

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Appendix

1.0 Introduction

This technical memorandum (TM) was prepared for the City of Tontitown (City) as part of the Tontitown Water Master Plan project. The purpose of this TM is to document the steps taken to verify, calibrate, and validate the hydraulic model of Tontitown's water distribution system.

Data provided by the City was used to model the City's water distribution system. Information on the existing infrastructure, water production, and demand were integrated into the hydraulic assessment of Tontitown's distribution system documented in this TM.

2.0 Existing System Overview

2.1 Water Service Area

Figure 2-1 outlines the public water service areas surrounding the City of Tontitown. The two public water systems adjacent to Tontitown include Springdale Water Utilities (SWU) and Washington Water Authority (WWA). WWA serves an area within Tontitown's city limits south of Kelly Avenue.

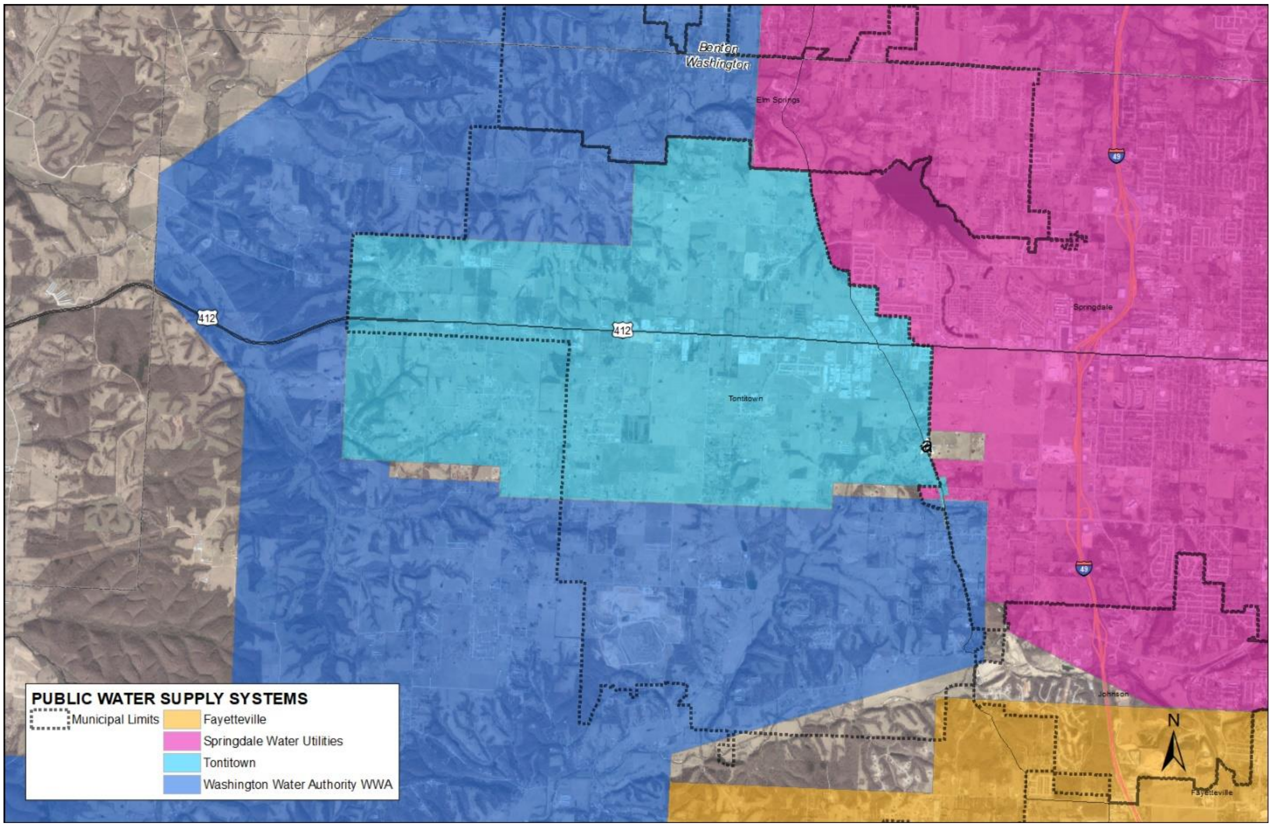


Figure 2-1: Public Water Service Areas

2.2 Existing System Infrastructure

Prior to April of 2020, the City of Tontitown purchased potable water from SWU for distribution to customers in the City's system. In April of 2020, the City began purchasing wholesale potable water from Benton Washington Regional Public Water Authority (BWRPWA) with a newly installed booster pump station, approximately 10-mile length of an 18-inch transmission main, and a 500,000-gallon elevated storage tank (EST). The SWU connections were maintained for emergency supply, which is discussed in further detail in Section 2.2.1. An overview of the entire distribution system can be seen in Figure 2-2. The following subsections describe the infrastructure within the City's water distribution system.

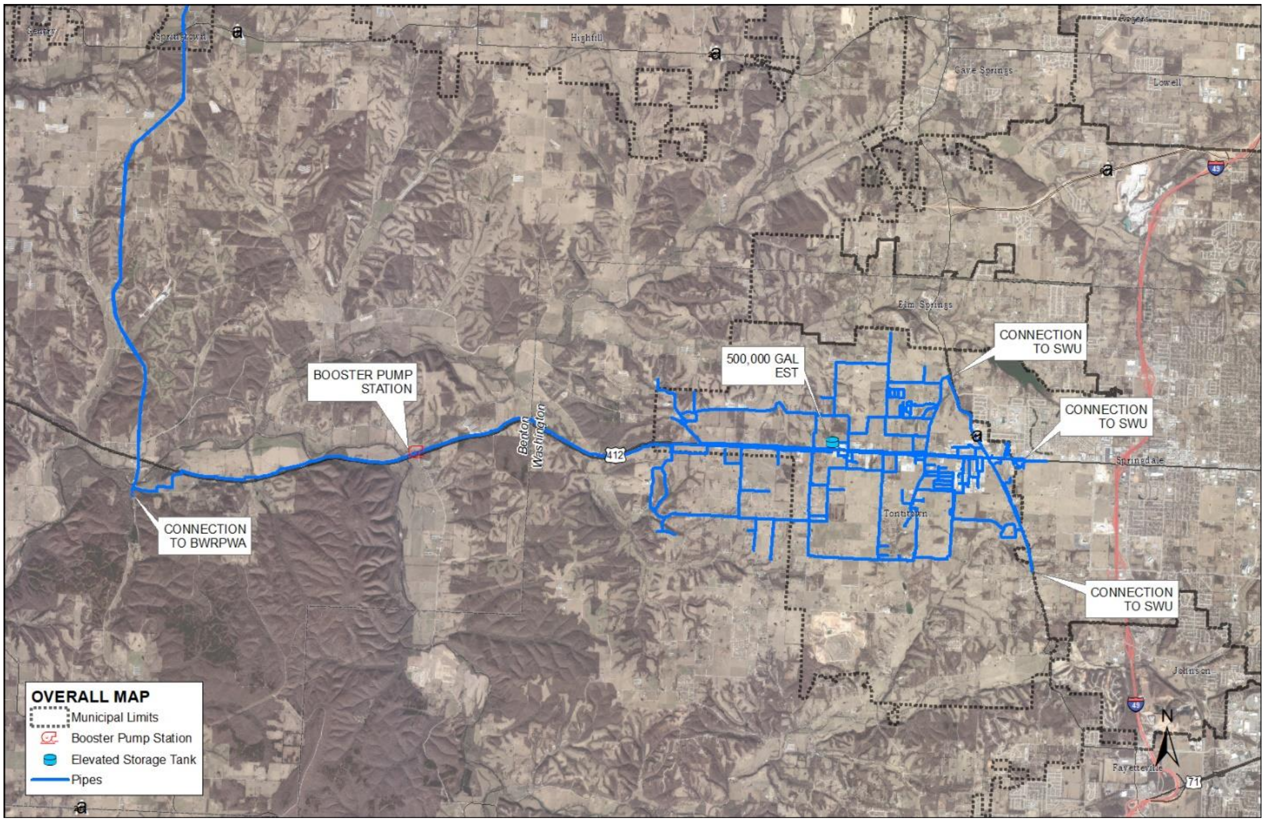


Figure 2-2: Overall Map

2.2.1 Sources of Supply

Prior to switching over to BWRPWA's supply, Tontitown purchased water from SWU at three master meters on the East side of the distribution system, which are shown in Figure 2-3. The Tontitown connections supply water from the main pressure zone of the SWU distribution system, which has a hydraulic grade line (HGL) set by the Fitzgerald Tank Farm. This HGL typically varies from 1,510-1,518 feet.

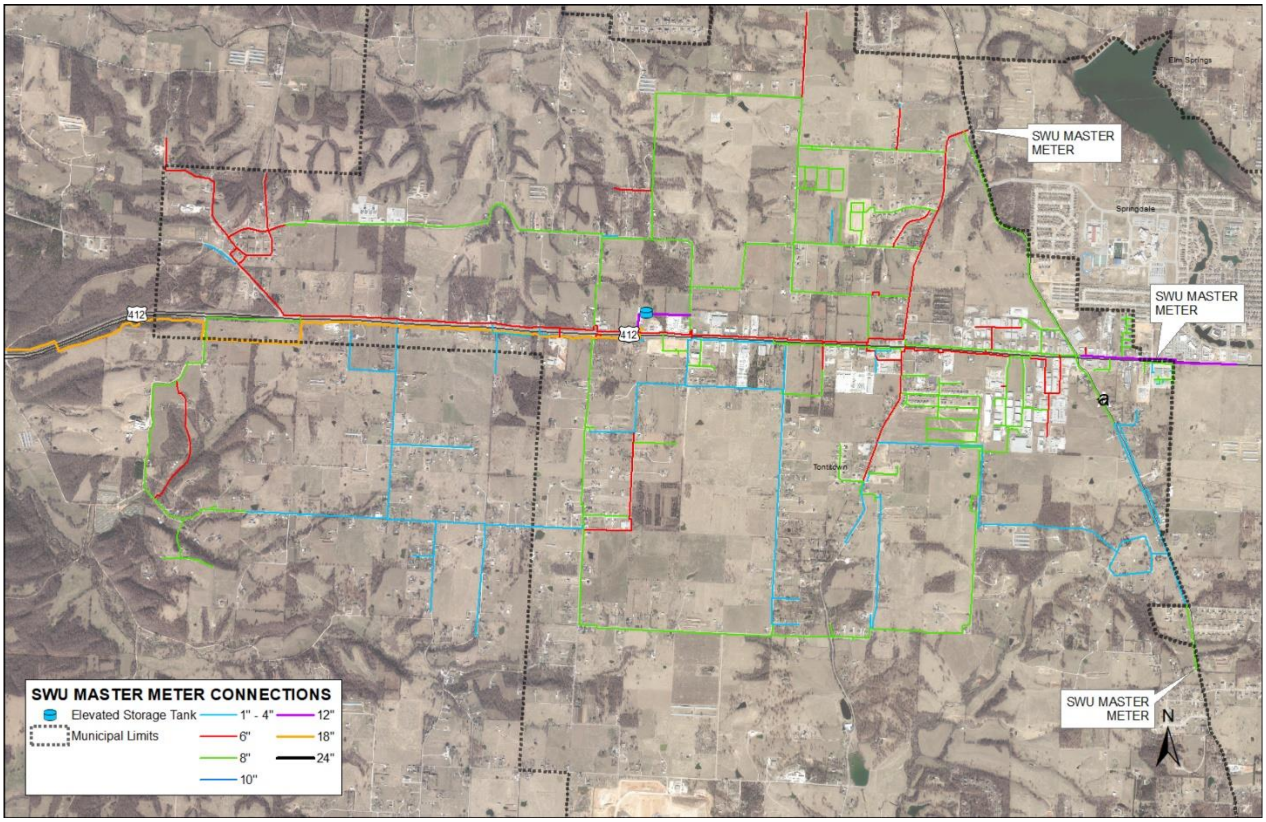


Figure 2-3: SWU Master Meter Connections

Since transitioning to BWRPWA water, the distribution system HGL is set by the elevated storage tank, which has a high-water level of 1,480 feet. Water levels in the EST typically range from approximately 1,468 feet to 1,472 feet. When the booster pump station is running, the HGL increases throughout the system with the western portion of the system experiencing the most drastic increase.

In case of a booster pump station failure or extreme demands in the City's water distribution system, flow control valves were installed near the SWU connections to allow SWU to provide Tontitown water in case of emergencies.

2.2.2 Pressure Zones

The City's water system is comprised of a single pressure zone that is regulated by the booster pump station and elevated storage tank.

2.2.3 Booster Pump Station and Transmission Line

Prior to 2020, the City of Tontitown purchased potable water from SWU for distribution to customers in the City's system. In 2020, approximately 10 miles of 18-inch transmission line and a booster pump station were put online to convey BWRPWA water from the Decatur Tanks to the City's distribution system, with the transmission line terminating near the City's elevated storage tank.

Table 2-1 summarizes the rated flows/design point and best efficiency point (BEP) for each pump at the pump station as well as the third pump that will be installed when future demands require an additional pump. BEPs were obtained from manufacturer pump curves. Typical flow indicates the approximate flow and head that the pumps operate at in the model. The BEPs of the pumps were used to evaluate their compatibility with system hydraulics.

Table 2-1: Pump Station Pump Summary

Pump Number	Typical Flow (gpm)	Typical Head (ft)	BEP Flow (gpm)	BEP Head (ft)
1	1,750	422	2,236	360
2	1,750	422	2,236	360
Future 3	1,750	422	2,236	360

2.2.4 Storage Tanks

In addition to the booster pump station and the transmission line from BWRPWA, a new 50-foot diameter, 500,000-gallon elevated storage tank was constructed and put online in 2020. This new storage tank is located north of Highway 412 and roughly 1,200 feet to the west of the South Mantegani Road and Highway 412 intersection. Information pertaining to the EST is outlined in Table 2-2.

Table 2-2: Elevated Storage Tank Summary Information

	Storage Capacity	Base Elevation (ft)	LWL (ft)	HWL (ft)
Elevated Storage Tank	500,000 gal	1303.50	1,443.00	1,480.00

3.0 Historical Data Analysis

3.1 Data Collection

The following data was provided by the City for use in the model verification, calibration, and validation:

- Map of the water distribution system with pipe size
- Customer meter data
- As-built drawings of multiple pipe segments in the distribution system
- As-built drawings of the elevated storage tank in the distribution system
- SCADA data for elevated storage tank water levels

3.2 Distribution System Pipes

The water distribution system contains a variety of pipe sizes and materials. Approximately 69 miles of pipe are active throughout the water distribution system. Table 3-1 provides a summary of the pipe lengths in the system organized by pipe diameter, whereas Table 3-2 provides a summary of pipe lengths by material. A map of the pipe material and size is provided in Figure 3-1.

Table 3-1: Tontitown Water Distribution Pipe Diameter

Pipe Diameter (in)	Total Length of Pipe (ft)
<4	67,516
4	13,556
6	66,133
8	154,648
10	23
12	6,331
18	57,635
Total	**365,842**

Table 3-2: Tontitown Water Distribution Pipe Material

Pipe Material	Total Length of Pipe (ft)
Ductile Iron	81,225
AC	3,289
PVC	281,328
Total	**365,842**

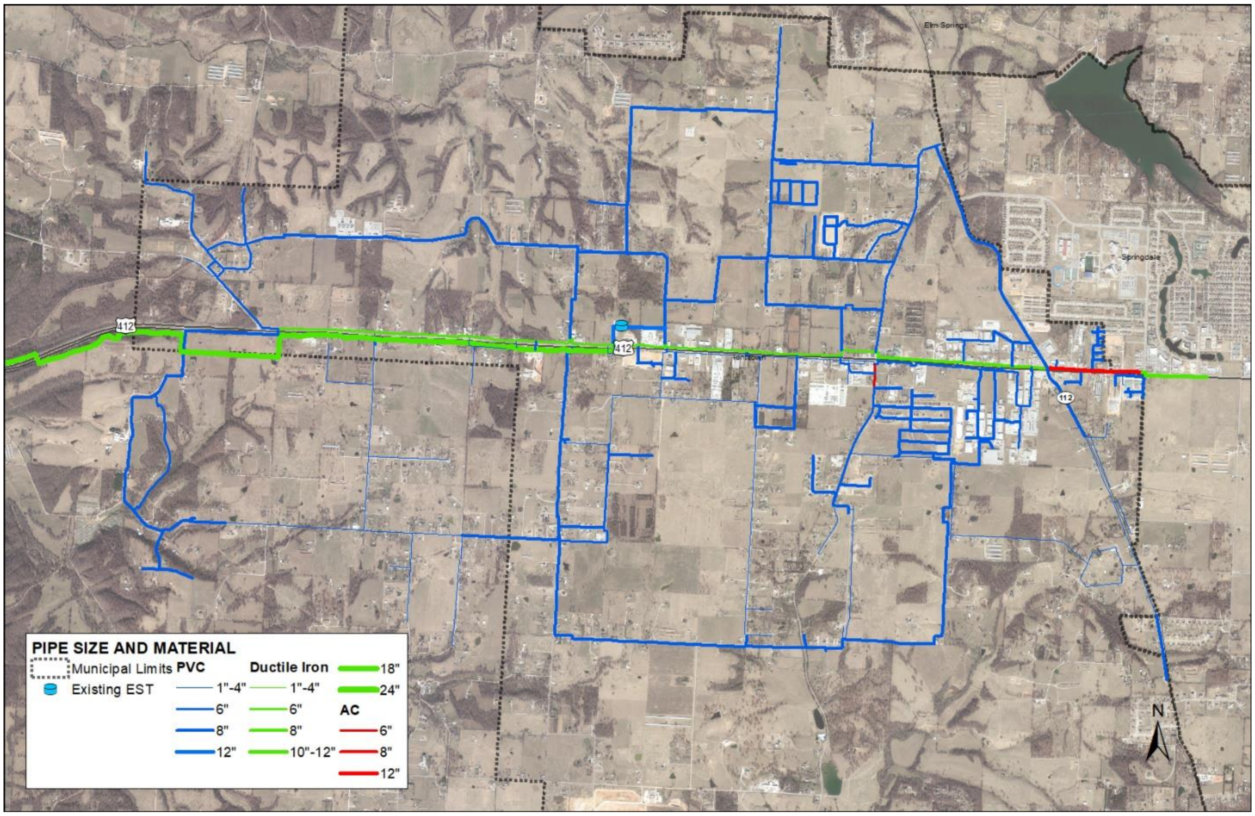


Figure 3-1: Pipe Size and Material

3.3 Historical Population

The information obtained from the U.S. Census Bureau shown in Table 3-3 contains population estimates for the years from 2000 to 2019. Garver used this information in developing the population projections in Section 4.1.

Table 3-3: Tontitown U.S. Census Population Data

Year	Population	Year	Population
2000 Census	2,082	2010 Census	2,460
2001	2,127	2011	2,479
2002	2,154	2012	2,526
2003	2,194	2013	2,596
2004	2,240	2014	2,683
2005	2,312	2015	2,799
2006	2,376	2016	3,498
2007	2,407	2017	3,719
2008	2,415	2018	4,008
2009	2,432	2019	4,358

3.4 Water System Demands

Historical water production rates were based on customer meter data provided by the City. Customer meter data from 2019 average day demand was assigned to nearby node elements. All simulations discussed in this report are based off this data with various demand multipliers to simulate different demands conditions.

Table 3-4 includes information about the City's distribution system prior to switching over to BWRPWA supply. This data was derived from the City's records. The data includes:

1. Annual Purchase Volume: Number of gallons of potable water purchased by the City of Tontitown from SWU
2. Annual Sales Volume: Number of gallons of potable water sold by the City of Tontitown to its customers
3. Non-Revenue Water: Difference between purchase volume and sales volume. Includes water losses and unbilled consumption (municipal uses).

Table 3-4: Water Purchased and Billed Comparison

Year	Annual Purchase Volume (MG)	Annual Sales Volume (MG)	Non-Revenue Water (MG)
2000	70.09	81.79	-11.70
2001	66.90	65.46	1.44
2002	66.93	64.00	2.93
2003	69.91	67.20	2.71
2004	68.83	69.97	-1.15
2005	83.28	79.67	3.61
2006	83.63	78.25	5.38
2007	82.77	87.65	-4.88
2008	88.58	72.62	15.96
2009	85.78	72.53	13.25
2010	95.89	83.37	12.52
2011	100.88	88.27	12.60
2012	106.16	91.60	14.56
2013	92.05	81.89	10.15
2014	89.34	78.44	10.90
2015	96.99	82.65	14.33
2016	100.36	88.07	12.29
2017	110.12	84.78	25.34
2018	144.86	91.34	53.52
2019	153.53	103.27	50.26

Table 3-5 outlines the amount of water purchased by user class. The data from 2009 to 2019 shows the percentage of demand for each class and is broken down as follows:

- Residential = 63.95%
- Commercial = 28.05%
- Irrigation = 5.79%
- Agricultural = 2.21%

Table 3-5: Total Water Consumption by User Class

Year	Total Residential Usage (MG)	Total Commercial Usage (MG)	Total Irrigation Usage (MG)	Total Agricultural Usage (MG)
2009	46.29	21.85	3.63	NA
2010	50.73	35.47	4.46	NA
2011	52.53	26.12	5.20	6.13
2012	57.30	25.57	5.97	2.58
2013	47.31	23.36	3.51	2.32
2014	49.86	21.34	5.36	1.42
2015	48.21	15.44	3.20	1.51
2016	52.62	22.84	4.98	2.07
2017	56.94	21.42	5.82	1.66
2018	67.07	22.50	6.65	1.29
2019	63.72	23.92	4.90	1.52

Figure 3-2 displays how the average day purchase volume for each month has changed over recent years. There is a noticeable jump in average purchase volume from the year 2017 to 2018 and 2019. In addition to this jump, the peak months appear to have shifted to months later in the year. Comparing Figure 3-2 to Table 3-4, there is a similar jump after the year 2017 in non-revenue water. The correlation between these two items could warrant investigation into potential water loss in the system.

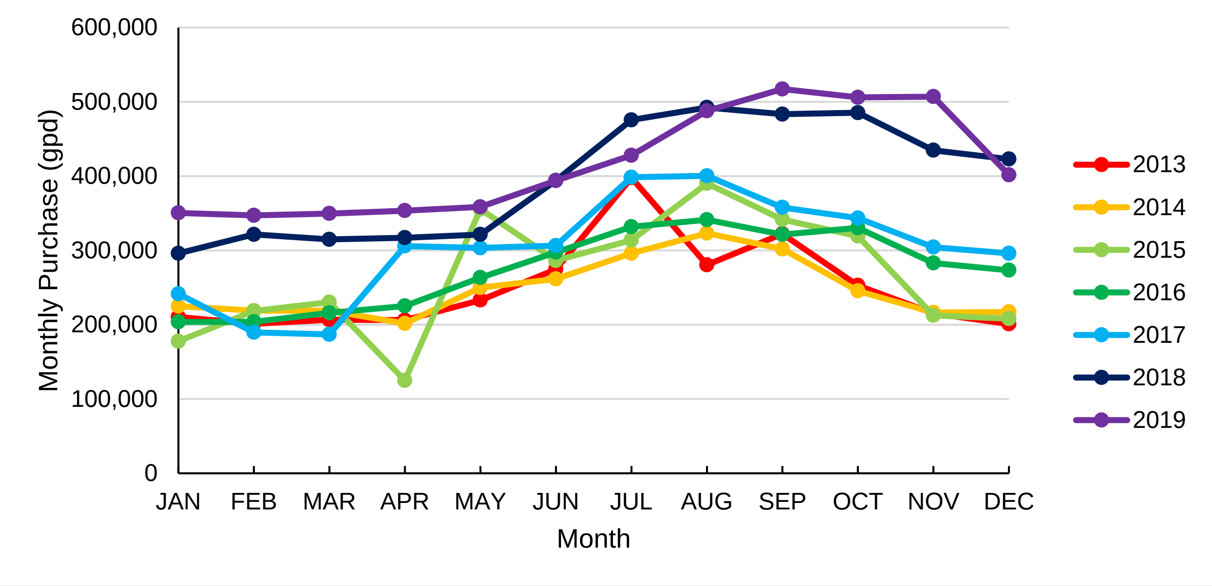


Figure 3-2: Tontitown Daily Water Purchase History by Month

Figure 3-3 illustrates the average daily water purchase volume in comparison to the average daily water sales volume. This figure provides a visual for the relationship between the jump in purchased water compared to the sudden increase in the non-revenue water. Also note that after 2017, the water purchased data appears to most closely correlate with the population data. This may indicate that the City's water meters need to be tested and/or replaced.

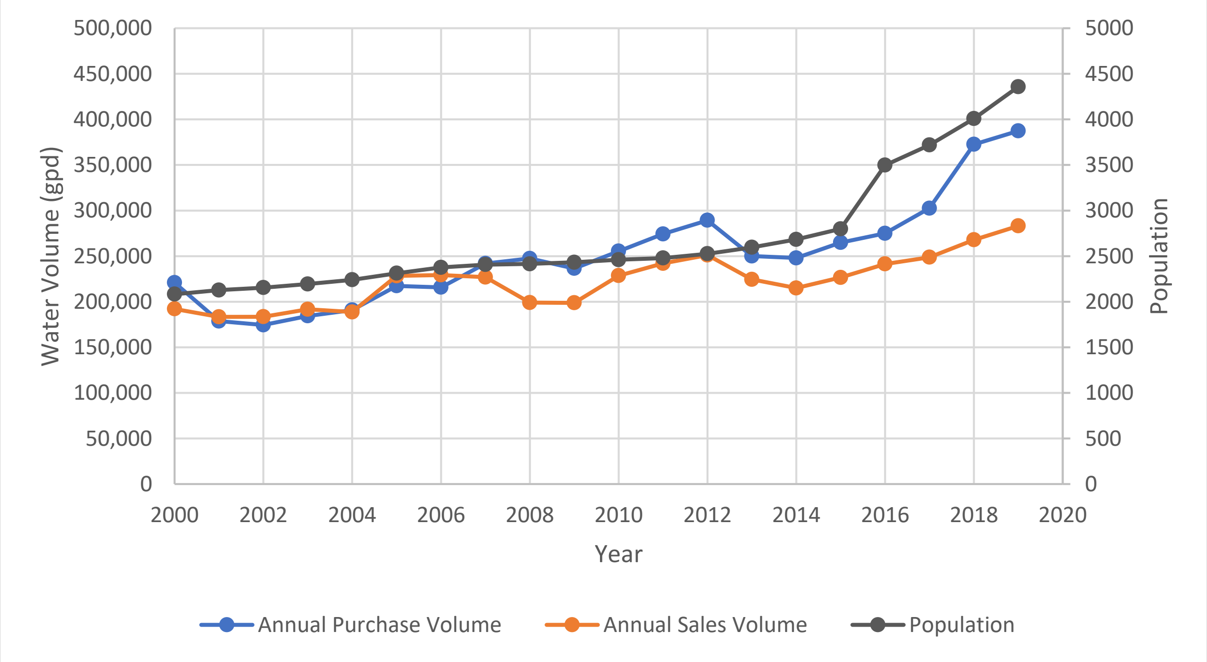


Figure 3-3: Tontitown Average Daily Water Purchase vs. Sales Volume

4.0 Population and Flow Projections

4.1 Population Projections

Garver utilized population numbers reported by the U.S. Census Bureau from 2000 to 2019 and projected growth based on exponential trends. Garver also projected populations based on linear trends since 2015. The projection based on the linear trend serves as the bottom of the population projection envelope, while the projection based on an exponential trend serves as the top of the envelope. The linear projection adds approximately 390 people per year, while the exponential growth is based on a growth rate of approximately 8% per year. The population projection envelope is shown in Figure 4-1 while the projected 2040 populations for each are summarized in Table 4-1.

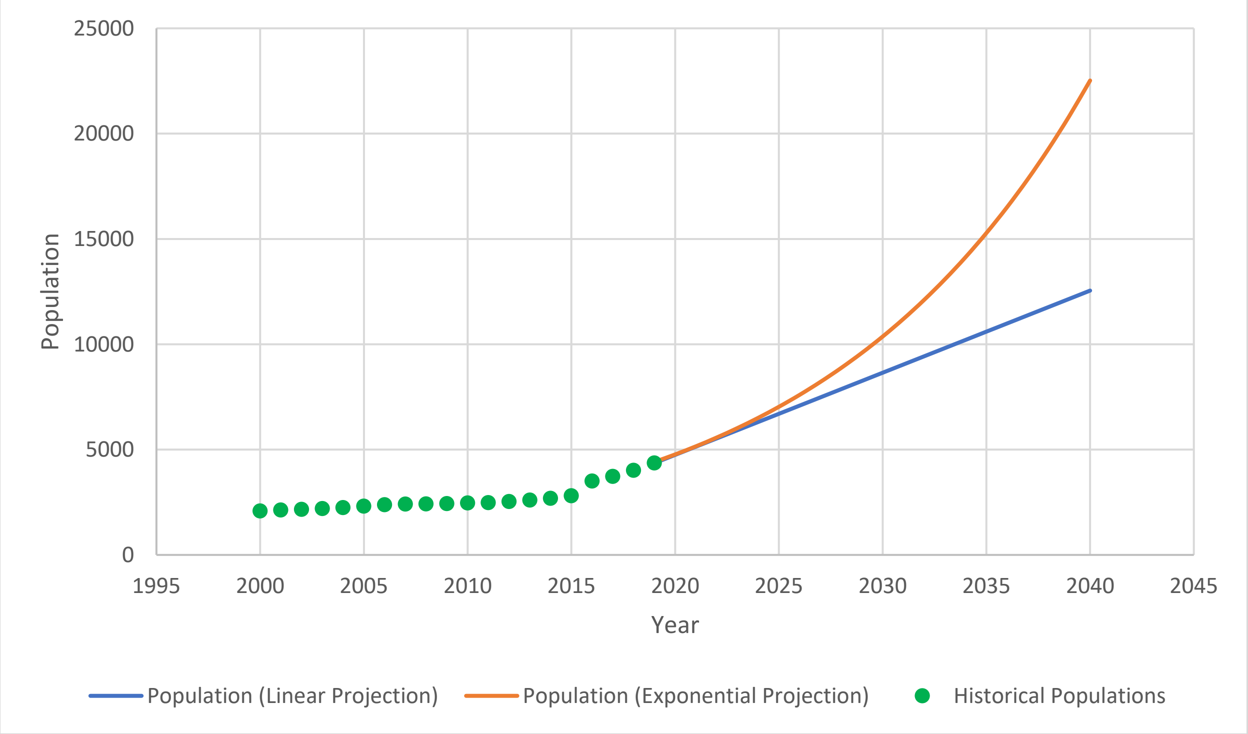


Figure 4-1: Population Projections Envelope for Existing City Limits

Table 4-1: Population Projections

Projection Type	Projected 2040 Population
Linear Trend	12,549
Exponential Trend	22,522

4.2 Water Demand Projections

Monthly water purchased data provided by the City for the period of January 2000 through June 2020 was combined with estimated population values based on U.S. Census information (with linear interpolation applied to estimate populations for 2001-2009 and 2011-2014). Additionally, a 1.2 factor was applied to average day during max month usage values to estimate maximum day values; this factor is based on experience with analysis of systems throughout Arkansas and Oklahoma. Furthermore, historical demand information for Rogers and Springdale was reviewed, as it is reasonable to assume that per capita usage values for Tontitown will trend towards regional averages as the City continues to expand. Based on all these factors, the values listed in Table 4-2 were assumed as per capita average and maximum day values.

Table 4-2: Estimated Per Capita Demands

Demand Condition	Per Capita Demand (gpcd)
Average Day	100
Maximum Day	200

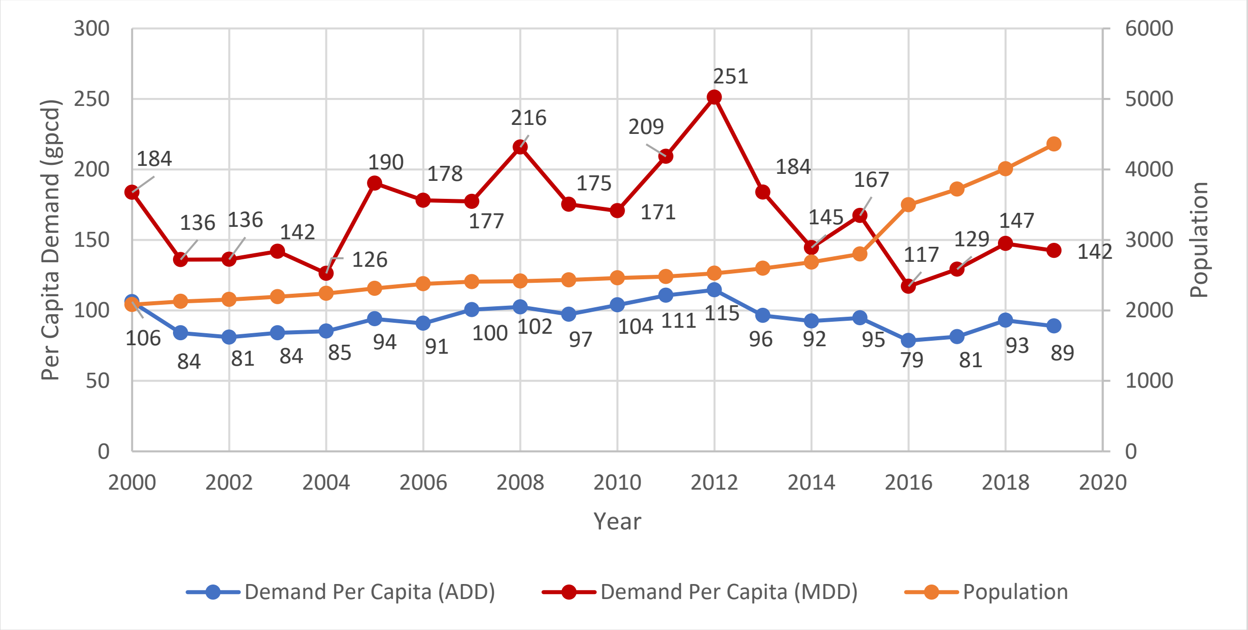


Figure 4-2: Per Capita Demands (Water Purchased)

Figure 4-2 illustrates the demand per capita results since 2000 based on water purchased data. This data provides Garver the ability to estimate the demand projections based on population projections. Note that the ADD and MDD per capita values are listed in Table 4-2, however these values do not reach the peaks of the historical per capita demands. The year of 2012 experienced an unusually high per capita demand which could be partially explained by annual rainfall data shown in Figure 4-3. Years with low amounts of rainfall could lead to higher demands. Garver decided to move forward with values lower than the peaks as per capita demands during MDD conditions only surpassed 200 gpcd three times over the last 20 years.

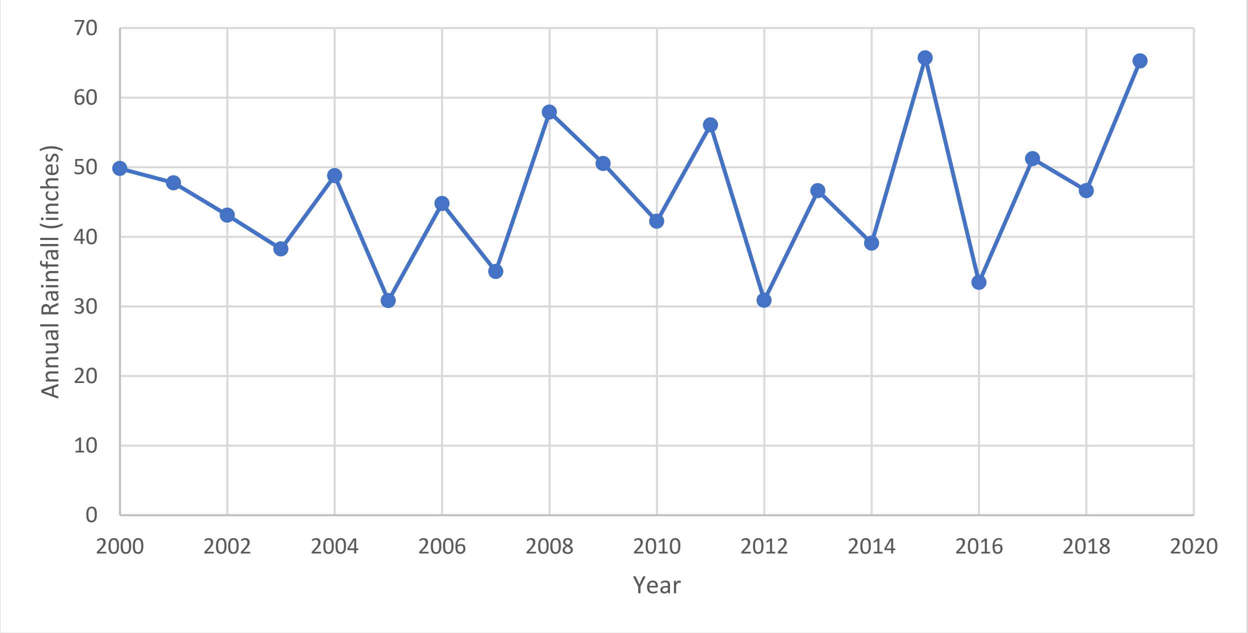


Figure 4-3: Annual Rainfall (Fayetteville)

The projected demands over the next 20 years for both linear and exponential projections are displayed in Figure 4-4 while projected 2040 demands are shown in Table 4-3.

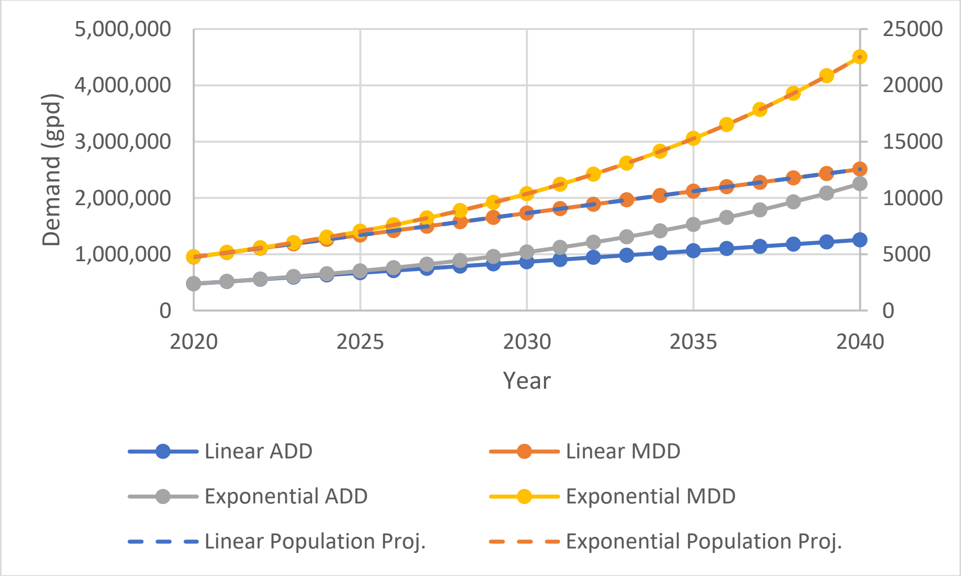


Figure 4-4: Demand Projections

Table 4-3: 2040 Demand Projection

Projection Type	Population	Average Day Demand (MGD)	Maximum Day Demand (MGD)
Linear Trend	12,549	1.255	2.510
Exponential Trend	22,522	2.522	4.505

4.3 Buildout Estimates

Buildout population estimates were completed based on land use and planning area shapefiles provided by the City. City land use and the Tontitown Planning Area are shown in Figure 4-5.

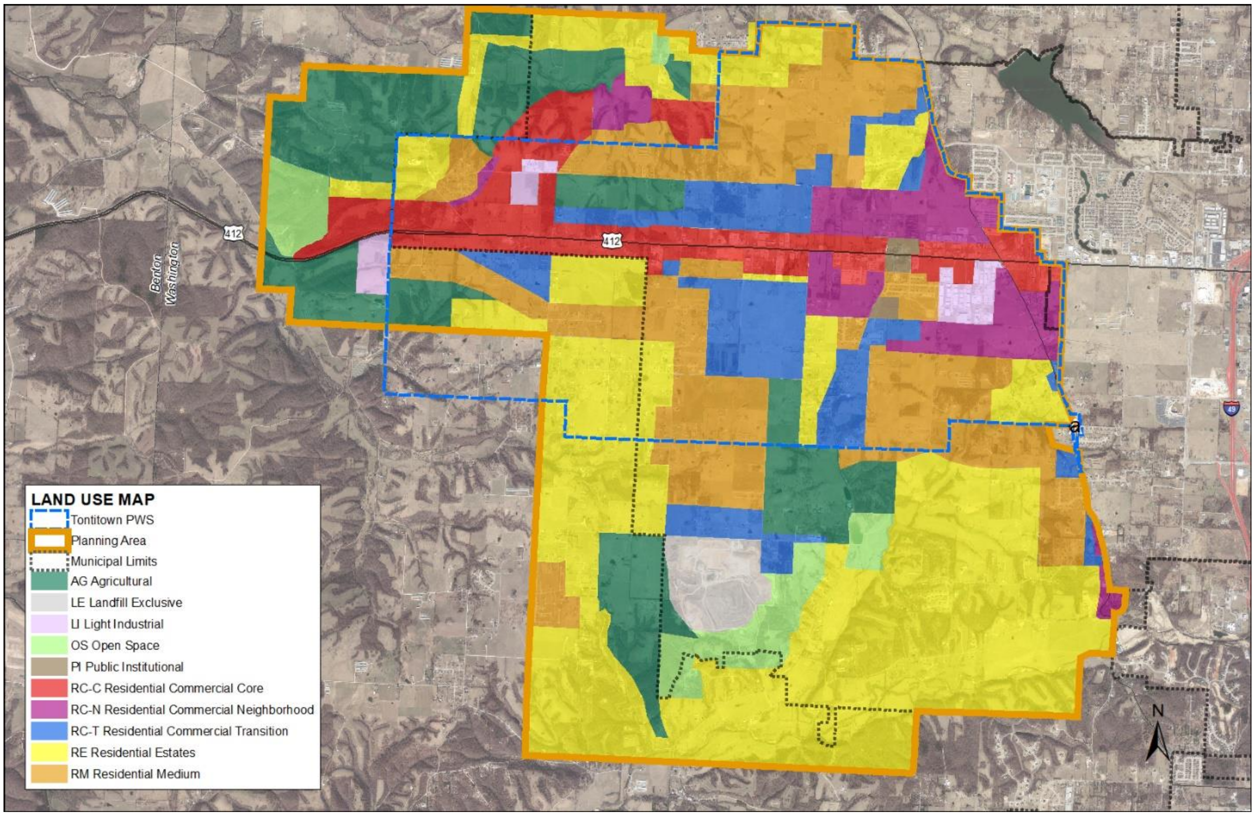


Figure 4-5: City Land Use Map

Populations were estimated assuming 2.57 people per dwelling unit and the following numbers of dwelling units per acre for different land use classifications:

- AG = 0.2 units/ac
- RE = 1 unit/ac
- RM = 4 units/ac
- RC-N = 12 units/ac
- RC-T = 9 units/ac
- RC-C = 14 units/ac

For areas outside of the provided land use shape file, Garver assumed a density of one unit per acre per Washington County zoning. Areas within flood plains, national forests, and developed land (besides land designated as agriculture land use) were excluded in these projections. To account for commercial development within mixed use areas, Garver assumed that lands designated as RC-N, RC-T and RC-C would be 80%, 50% and 20% residential development, respectively. To account for space required for streets, stormwater detention, green space, etc. in residential and agricultural areas (AG, RE, and RM) Garver assumed that 20% of residential area would not be used for housing.

Garver used these assumptions to determine four different buildout projections, which are shown in Figure 4-6. These different buildout projections can be described as follows:

1. **Buildout 1 – City Limits:** Assumes that the current Tontitown Public Water System service area expands to the current city limits.
2. **Buildout 2 – Planning Area:** Assumes that the current Tontitown Public Water System service area expands to the Tontitown Planning Area and also includes the area of the current service area that lies outside of the Tontitown Planning Area.
3. **Buildout 3 – Western Expansion:** Assumes that the current Tontitown Public Water System service area will expand west to the BWRPWA connection.
4. **Buildout 4 – Existing WSA:** Assumes that the current Tontitown Public Water System service area does not expand.

The City of Tontitown decided to move forward with the assumption that Buildout 3 would be the boundary of the City's ultimate buildout.

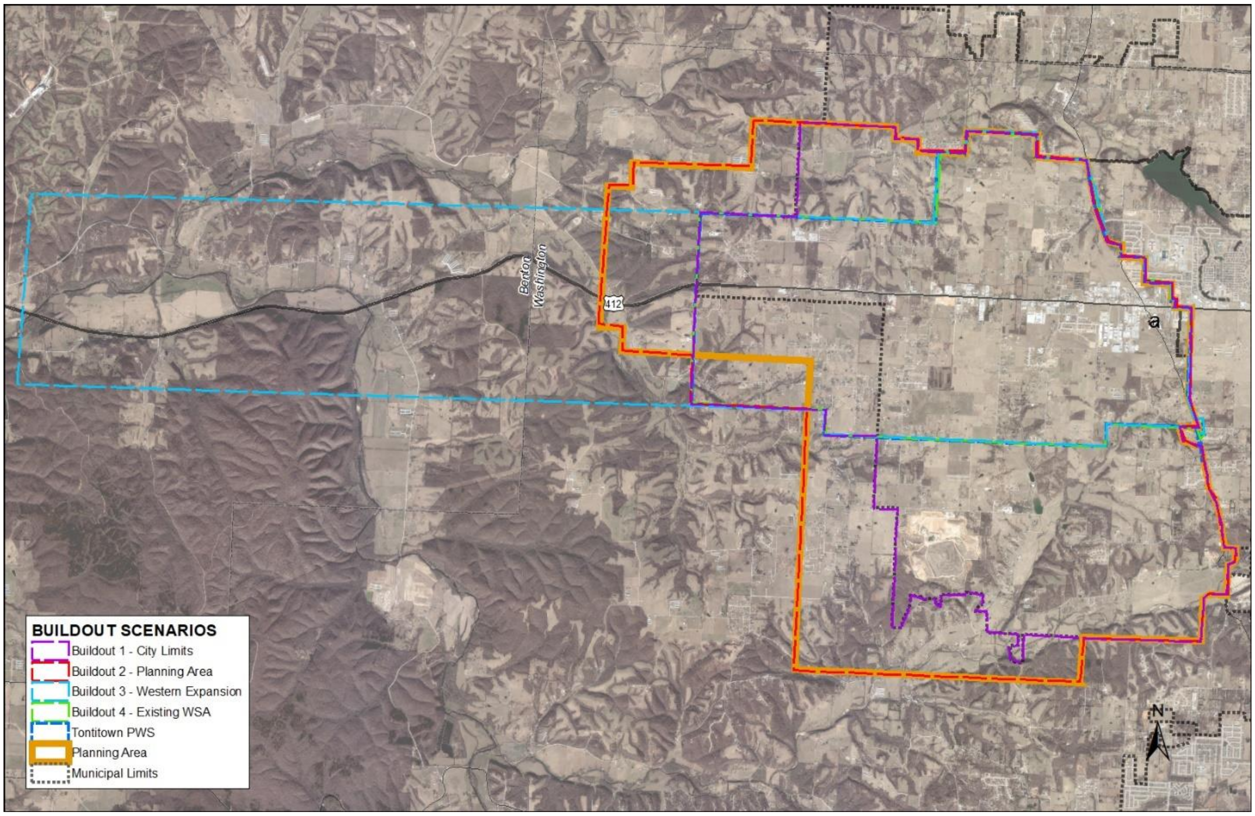


Figure 4-6: Buildout Scenarios Map

Table 4-4 outlines the results of these projections as well as the associated average day and max day demands. The per capita values used in the previous subsection were also used in these projections to determine demands. Note that buildout projections were cross-referenced with the linear and exponential trend population projections to ensure compatibility between the population numbers.

Table 4-4: Planning Area Buildout Projection

Service Area Alternative	Population	Average Day Demand (MGD)	Maximum Day Demand (MGD)
City Limits	62,275	6.228	12.455
Planning Area	72,032	7.203	14.406
Western Expansion	64,361	6.436	12.872
Existing WSA	52,509	5.251	10.502

5.0 Model Development

Garver recently created an AutoCAD file that included overall layout, pipe diameters, and pipe material within Tontitown's distribution system. Garver had previously modeled the transmission line to assist with design of the booster pump station that was put online in 2020. The model developed for the booster pump station was then updated to include the rest of the distribution system.

5.1 Model Water Demand

The City of Tontitown provided Garver with 2019 customer water meter data that was inserted into the WaterGEMS model. These average demands were assigned to a nearby pipe or node within Tontitown's distribution system.

Using data from the City's SCADA system that logs the water surface elevation within the elevated storage tank, a diurnal curve was developed to simulate the system's demands as they fluctuate during the average 24-hour period. This curve is discussed in Section 5.2.

5.2 Diurnal Curve Development

Historical data from the EST SCADA system was utilized to develop a diurnal demand multiplier curve. Changes in the water surface elevation within the elevated storage tank were logged throughout multiple days ranging from May 15, 2020 to May 29, 2020 were used to determine an average hourly demand. General knowledge on how the pumps are controlled allowed Garver to determine when pumps were active and idle so that data influenced by the pumps could be omitted. Calculations were performed to produce a composite average day demand. Maximum day conditions were simulated by multiplying the average day demands by a factor of 2.00 which was determined after looking at recent maximum day demands compared to average day demands. The demand curve is presented in Figure 5-1 and Table 5-1.

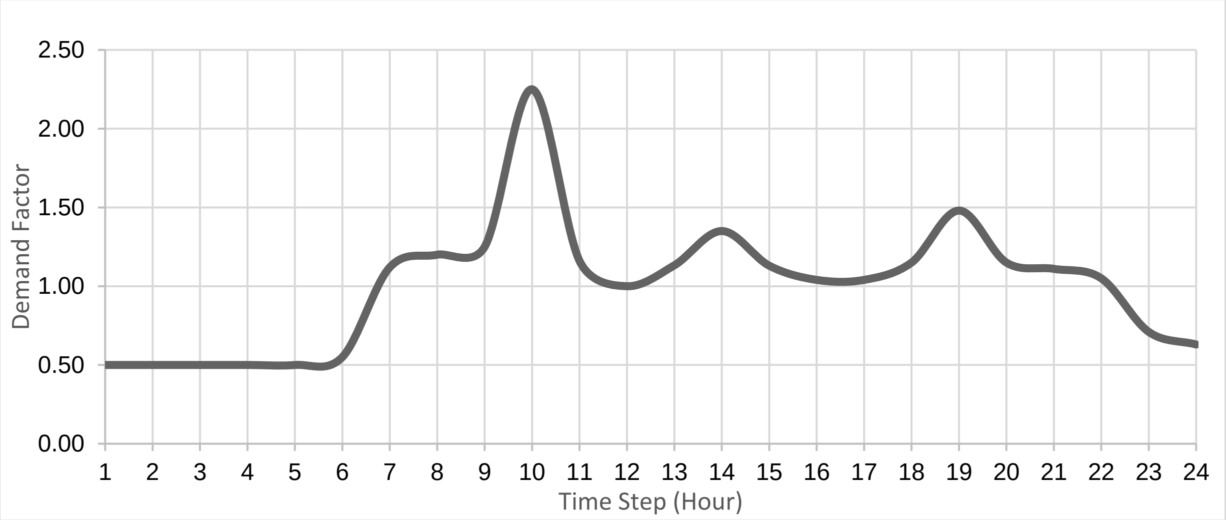


Figure 5-1: Diurnal Curve

Table 5-1: Diurnal Pattern

Time (hr)	Demand Multiplier
1	0.50
2	0.50
3	0.50
4	0.50
5	0.50
6	0.55
7	1.12
8	1.20
9	1.25
10	2.25
11	1.16
12	1.00
13	1.13
14	1.35
15	1.13
16	1.04
17	1.04
18	1.15
19	1.48
20	1.15
21	1.11
22	1.05
23	0.71
24	0.63

5.3 Model Pipe Geometry

The pipes in the model were developed using an AutoCAD file recently developed by Garver, and additional updates were provided by City staff. As such, the existing infrastructure within the model has been updated as accurately as possible.

5.4 Model Water Supply and Pumping

The City's water distribution system contains one pump station which is located on the northwest corner of US Highway 412 and Robinson Road. The pump station receives water from the Decatur Tanks on the northwest corner of Y City Road and Bredehoeft Road near Gentry, Arkansas. Since the booster pump station and transmission line was recently designed by Garver, all pump data was included in the existing model.

5.5 Model Storage

The City utilizes one elevated storage tank in their water distribution system that has a capacity of 500,000 gallons and overflow elevation of 1,480 feet. The EST is located on the north side of West Henri

De Tonti Boulevard approximately 1,100 feet west of the intersection of N. Mantegani Road and US Highway 412. The EST was put online in May of 2020 as part of the City’s transition from receiving flow from SWU to BWRPWA.

6.0 Hydraulic Field Data Collection

6.1 Continuous Pressure Monitoring

Garver installed pressure loggers at eight different locations throughout the distribution system to monitor pressures over the course of a few days during two separate time spans. The first round of pressure loggers collected data from March 27, 2020 to April 9, 2020. The second round of pressure loggers were installed from April 27. 2020 to May 5, 2020. Locations of these pressure loggers can be seen in Figure 6-1. Loggers are indicated with an 'L' followed by 'A' or 'B'. 'A' indicates the location of a logger during the first round and 'B' indicates the location of a logger during the second round. 'C' indicates the logger was moved to a new location during flow testing to record additional pressure drop data.

The intent for the two separate rounds of data collection was to compare the conditions from when the City received water from SWU (first round) to the conditions when the City received water from BWRPWA (second round) with the newly activated booster pump station and EST.

6.2 Flow Tests

In addition to the pressure loggers installed throughout the distribution system to monitor pressures, seven individual fire flow tests were conducted on May 5, 2020. For each flow test, one hydrant was opened (flow hydrant) and allowed to flow while the pressure was measured at another nearby hydrant (test hydrants). The pressures during the flow tests were also recorded by the pressure loggers. Static pressures were recorded before the flow hydrant was opened, and residual pressures were recorded while the flow hydrant was open.

These flow tests provided additional information that could not be acquired from continuous pressure monitoring under normal conditions. Combining the data from the SCADA system on the EST levels and the fire flow tests, Garver could determine boundary conditions such as whether the pumps were on at the time of the flow test and the tank water surface elevation.

The fire flow tests are especially useful when it comes to determining a Hazen-Williams C factor for pipes throughout the system. Performing these tests creates high flows in the area that the test is being conducted, which leads to a pressure drop resulting from the friction losses in the pipes. Using the pressure drops obtained from the flow tests Garver was able to adjust C values in the water model to best simulate the City's distribution system.

The locations of these Flow Hydrants (F) and Test (Pressure Gauge) Hydrants (G) are shown in Table 6-1 and Figure 6-1. The flow test results are shown in Table 6-2.

Table 6-1: Flow Test Locations

Test #	Location
1	South Maestri Road and Freedom Place
2	South Maestri Road and US Hwy 412
3	3,800 feet south of East Fletcher Avenue and Piazza Road intersection
4	West Baker Avenue and Sabatini Road
5	South Pianalto Road and Kelly Avenue
7	Liberty Avenue and Wc Road 903
8	1,500 feet east of Rocky Lane and Wildcat Creek Boulevard

Table 6-2: Flow Test Results (May 5, 2020)

Test #	Time of Flow	Hydrant Flow (gpm)	Static Test Gauge Pressure (psi)	Residual Test Gauge Pressure (psi)	Drop Test Gauge (psi)
1	9:35 AM	287	92	2	90
2	9:50 AM	1,132	84	56	28
3	11:10 AM	1,266	98	60	38
4	10:24 AM	1,208	88	62	26
5	12:00 PM	1,168	92	62	30
7	12:30 PM	684	82	38	44
8	1:10 PM	1,353	NA	NA	NA

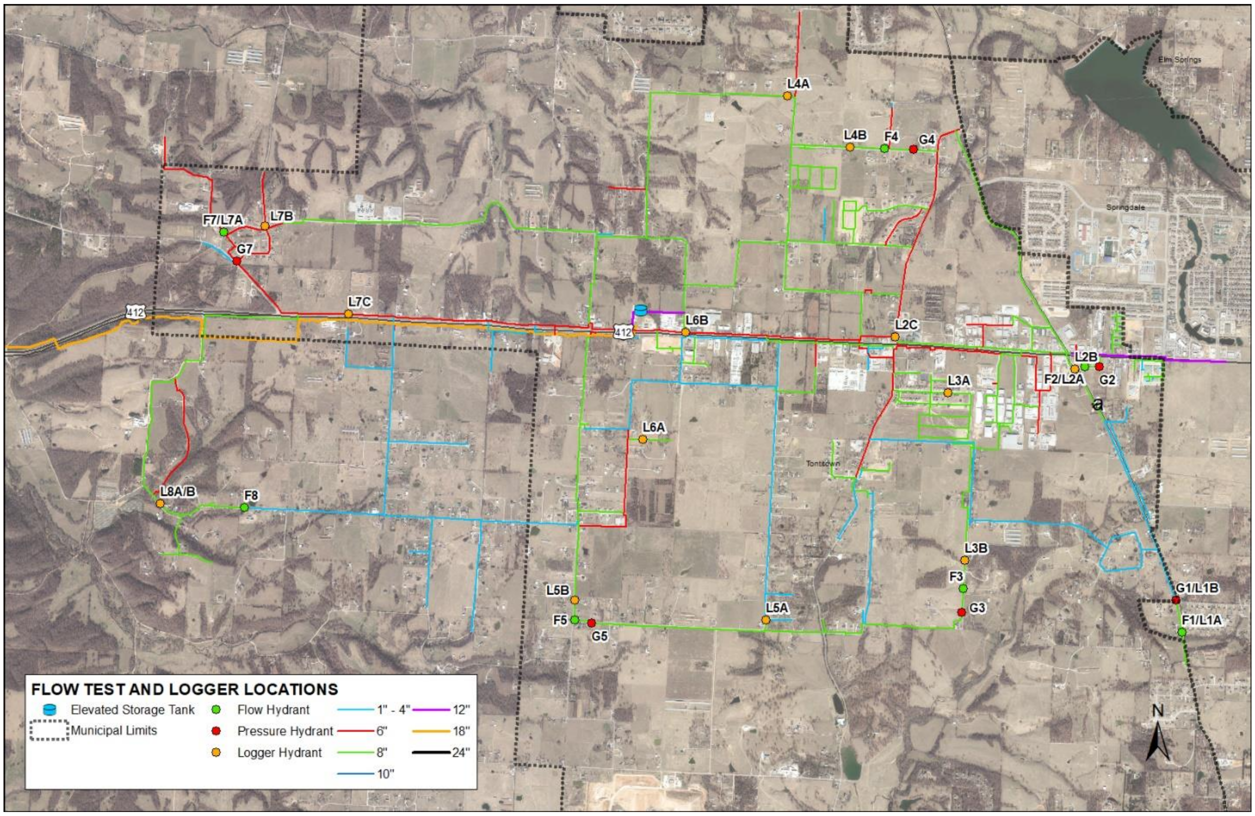


Figure 6-1: Flow Test and Logger Location Map

7.0 Hydraulic Model Calibration and Validation

The hydraulic model was calibrated and validated based on the results from the model verification and field data described in Section 6.0. The model calibration included adjustment to friction factors and additional pipe diameter and configuration updates.

7.1 Flow Test Calibration

The pressure logger data and pressure gauge measurements taken during the flow test on May 5 were compared to model results under the same conditions. A base scenario was created that modeled pressures throughout the day on May 5, 2020, which was used to assess the static pressures measured in conjunction with the flow testing. For each hydrant test, a scenario was created that included the hydrant flow as a point demand in the model. Model pressures were obtained at the model location corresponding to the hydrants used for pressure measurements (test hydrants).

Figure 7-1 and Figure 7-2 show the calibration results for static pressures and pressure drops, respectively. In both figures, results measured in the field are plotted along the horizontal axis for each location, while the results calculated in the model are plotted along the vertical axis. On Figure 7-1, static pressures when the booster station is operating are shown in green, and static pressures with the pumps off are shown in blue.

On Figure 7-2, the results before calibration are shown as blue dots and the results with the calibration adjustments are shown as red dots. The data point labels include the test number followed by the pressure gauge (G) or logger (L) number. Based on the pressure logger data recorded in the field, the pumps began operating during each flow test. To most accurately calibrate the model to mimic field conditions, it is necessary to determine the effects of the pumps on the loggers. The static pressures with the pumps operating were compared to the residual pressures during the flow tests to determine the pressure drops in Figure 7-2.

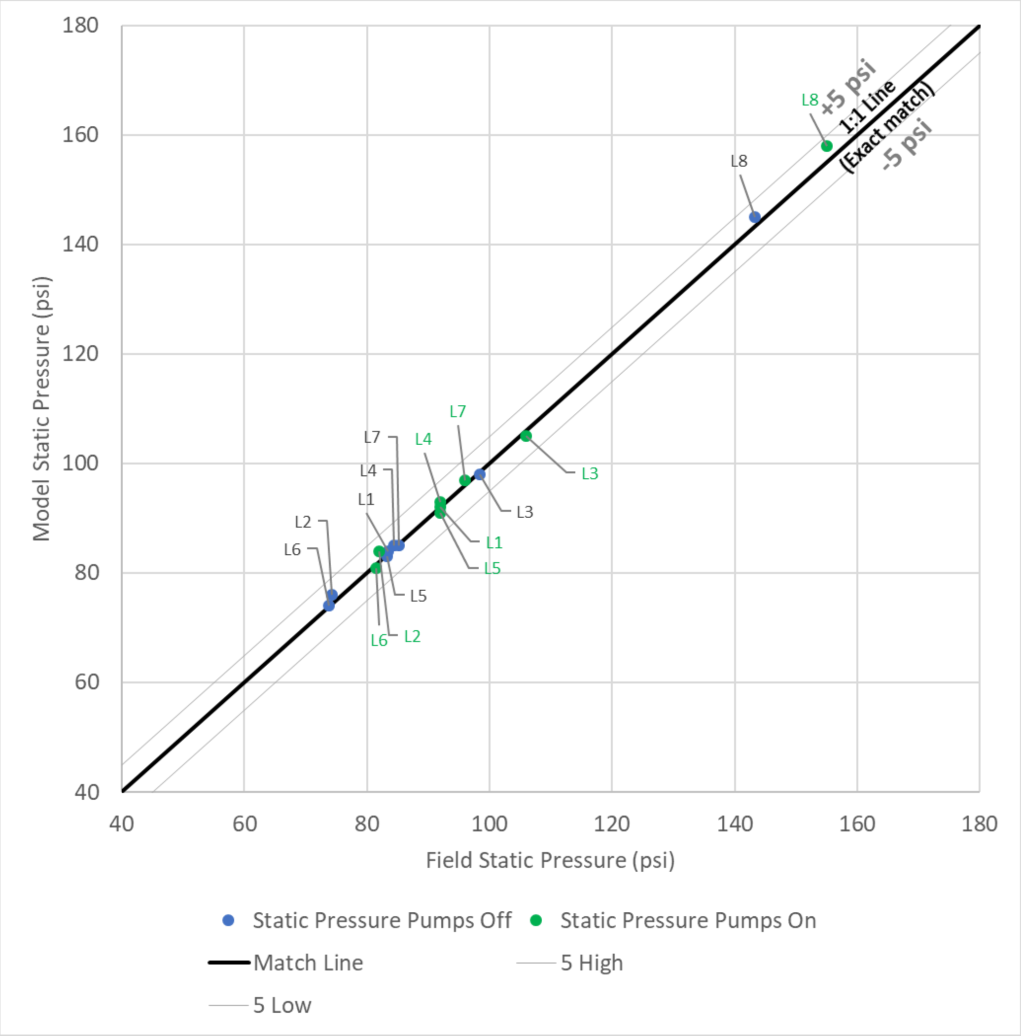


Figure 7-1: Static Pressure - Field vs. Model

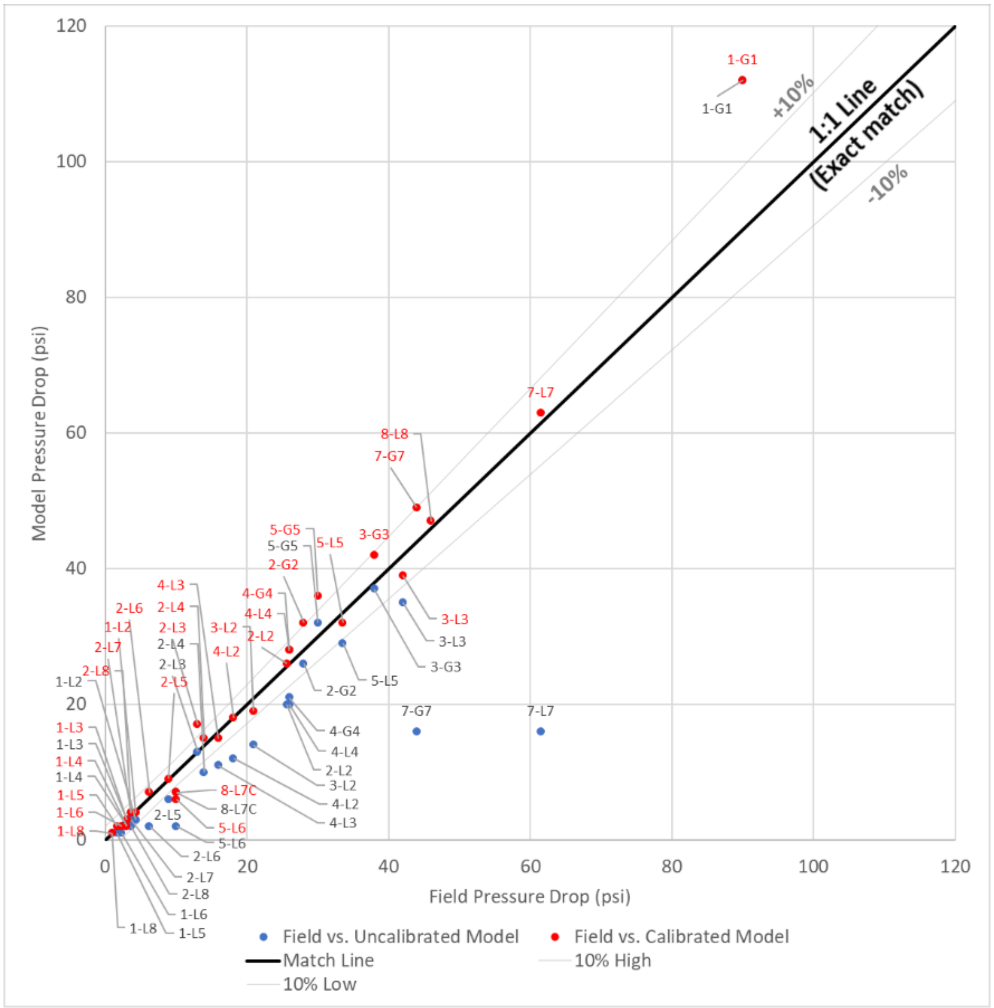


Figure 7-2: Pressure Drop - Field vs. Model

Perfect agreement between the field measurements and model results is represented by points that fall directly on top of the 1:1 line in the figures. A range of ± 5 psi is shown to account for the anticipated level of precision for static pressures, which depends on agreement between the elevation data (used in the model) and pressure gauge measurement (for field values). Additionally, a range of the greater of ± 2 psi or ± 10% of the measured pressure drop is shown to account for the anticipated level of precision for pressure drops.

Some pressure gauge (‘G’) data points in Figure 7-2 appear to fall farther from perfect agreement with the model for pressure drops. This may have been caused due to variability in when the pressure gauge measurements were taken when the pump operating status changed during each flow test. The pressure logger (‘L’) data points appear to show acceptable agreement with the model, with the exception of flow test location 1 at the end of a long dead-end and small-diameter water line.

In order to reach the level of accuracy demonstrated in the aforementioned figures, adjustments to the infrastructure in the model were necessary. Figure 7-3 displays the changes that were made to the model throughout the calibration process. Pipes shown in red indicate pipes where the roughness coefficients were changed (either increased or decreased) to match residual pressures.

Noteworthy changes to the characteristics of the infrastructure in the distribution system include:

1. The transmission line ‘C’ value was raised to decrease the amount of head loss from the booster pump station to the tank.
2. The ‘C’ values in the 6-inch pipes in the northwest corner of the system were decreased to create a more significant pressure loss when experiencing higher flows.
3. The ‘C’ values in the 8-inch pipes in the southwest corner of the system were increased to create less of a pressure drop when experiencing higher flows.
4. After analyzing the results of both Garver’s fire flow tests and fire flow tests conducted by the City, it is likely that there is a valve closed in the 8-inch loop (notated in Figure 7-3). Throughout the calibration process Garver assumed that this valve was closed.

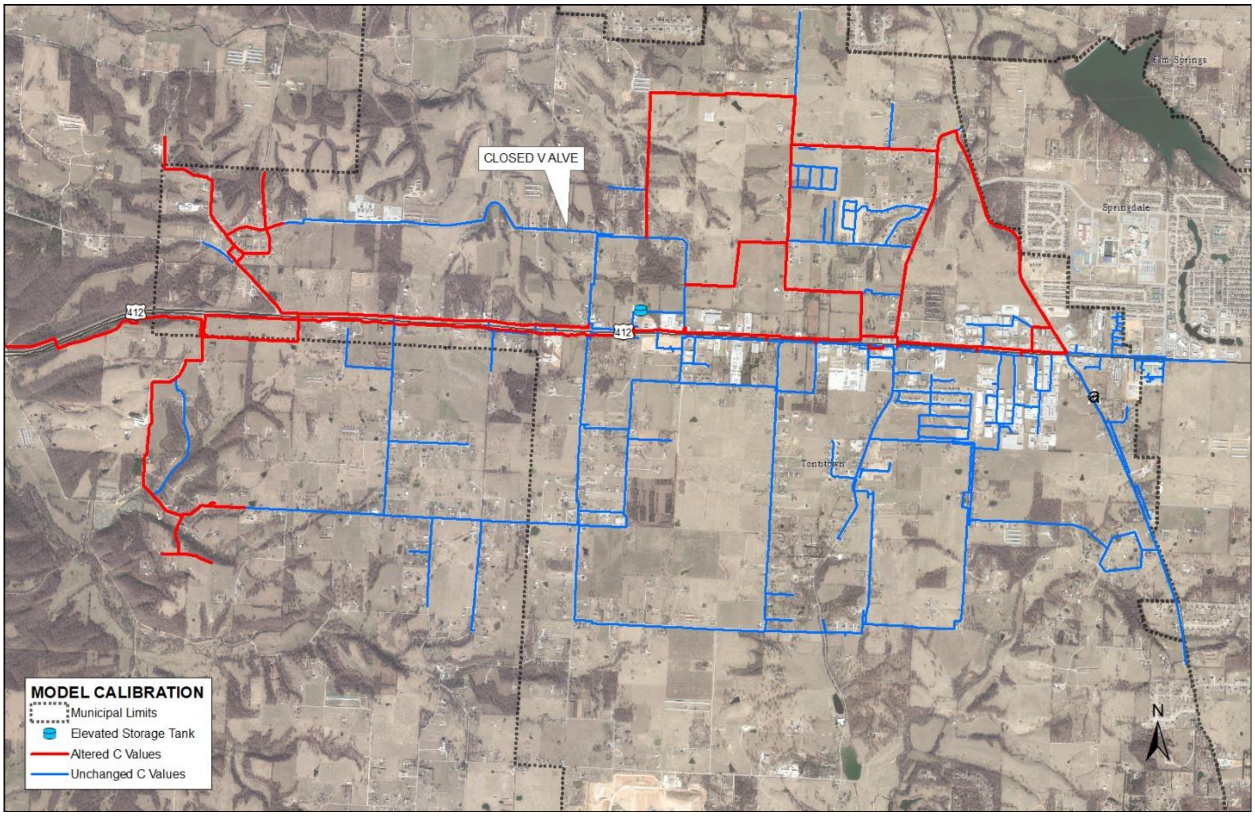


Figure 7-3: Model Calibration

7.2 Hydraulic Model Validation

7.2.1 Historical SCADA Data Validation

Garver received multiple sets of SCADA data for tank levels for the days following the switch from SWU water to BWRPWA water with the newly activated booster pump station. Figure 7-4 contains SCADA tank level data from May 27, 2020 and compares it to the results from the model extended period simulation (EPS). Demands were adjusted to closely resemble an average day in May as opposed to running a typical average day demand.

The tank levels in the model range from 164.5 feet to 168.5 feet, while the field data indicates that the EST operates within the range of 175 feet to 179 feet. Although this appears to be a large discrepancy, the HGLs were compared between the model and field data from the pressure loggers appear to be similar. Therefore, it appears that the SCADA water level measurements may have a different reference elevation than the ground level at the base of the tank. The patterns shown in the two sets of data generally match, with the tank level fluctuating between the pump on and pump off setpoints at the booster pump station.

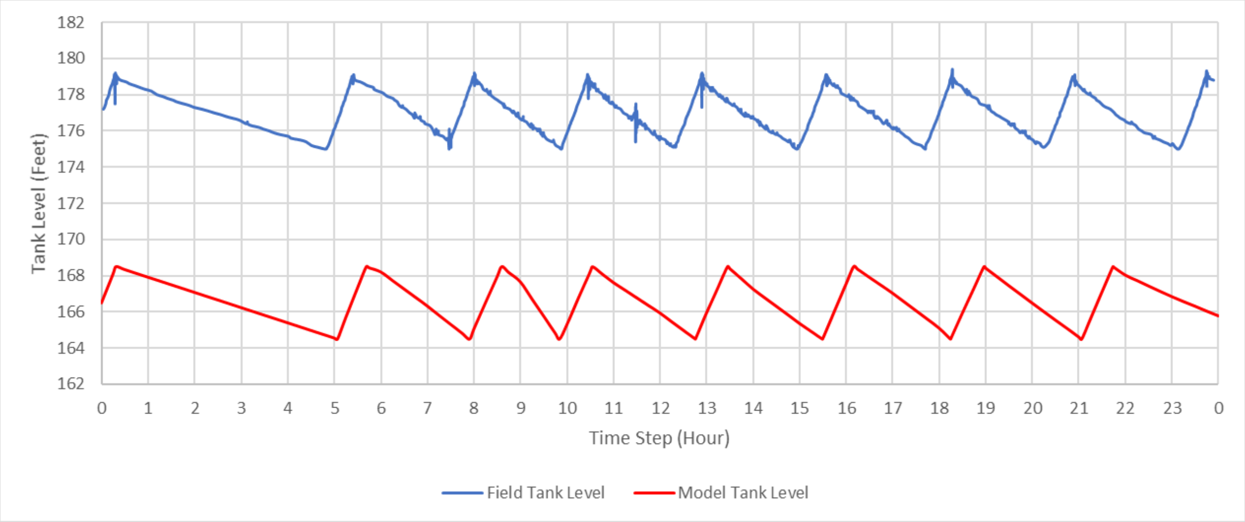


Figure 7-4: Tank Level - Field vs. Model

Figure 7-5 shows the fluctuations in the HGL throughout the day on May 4, 2020. Given that pressure logger #6 is close in proximity to the EST, the HGL's should closely align with the tank levels and is primarily how Garver decided that the EST was not operating between 175 and 179 feet, but rather between 168 and 172 feet.

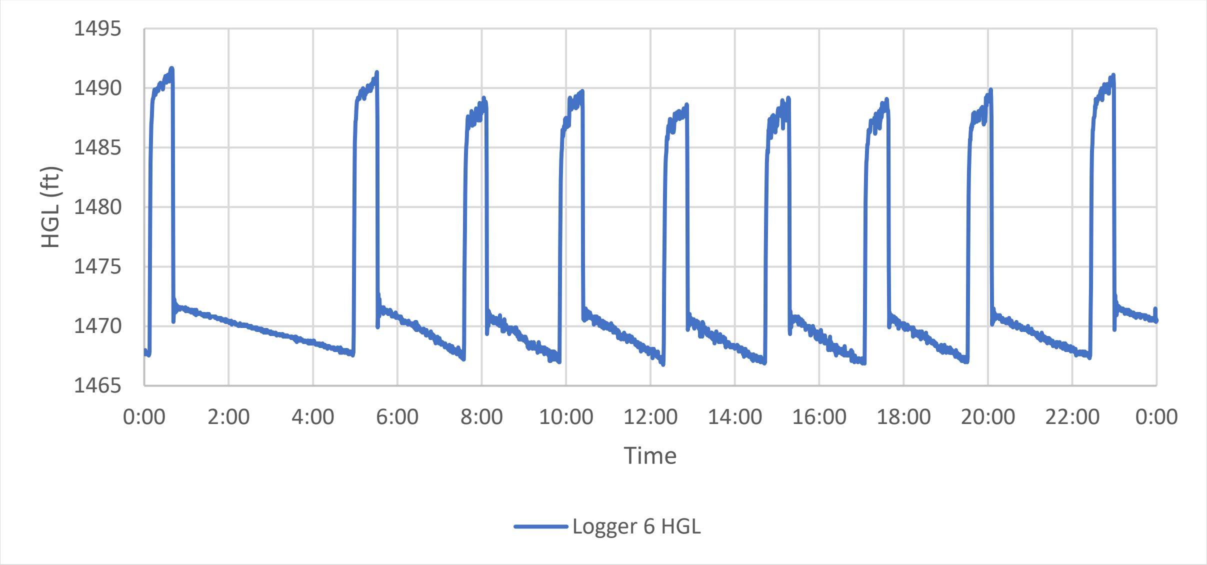


Figure 7-5: Logger 6 HGL Data (5/4/20)

7.2.2 Pressure Monitoring Validation

The pressure logger data for May 1 was compared to the results of the extended period simulation with the calibrated model, as shown in Figure 7-6. The model results show good agreement with the recorded pressures.

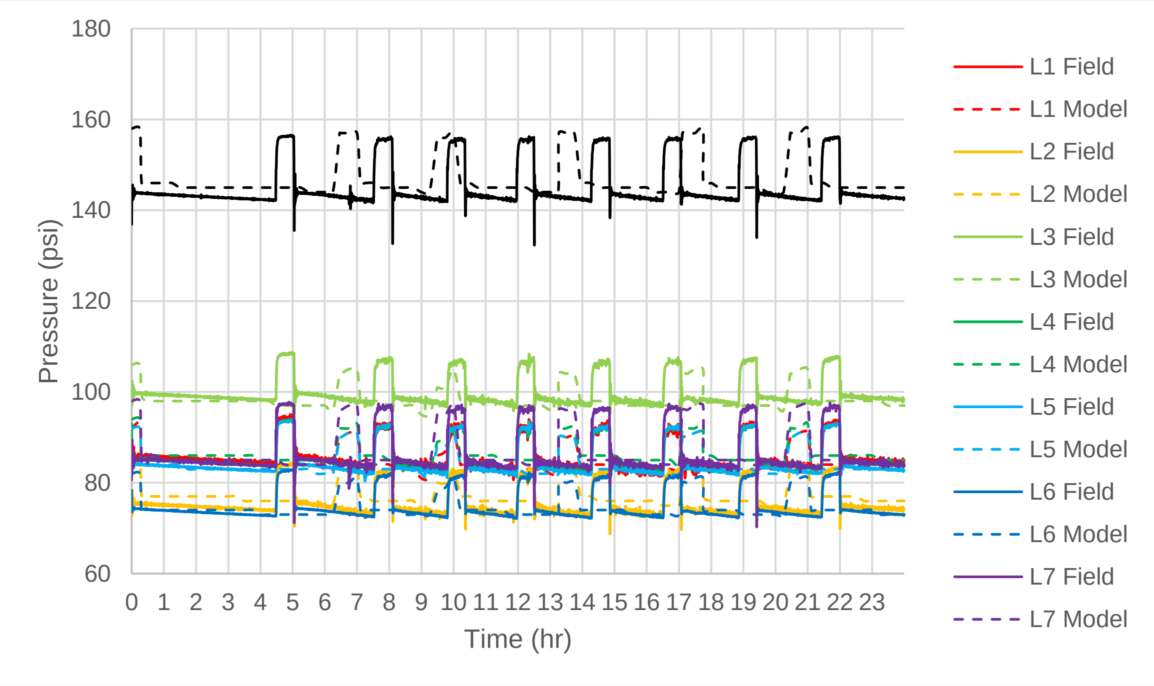


Figure 7-6: Pressure Loggers - Field vs. Model

Table 7-1: Pumps On vs. Pumps Off Pressures

	Pumps On		Pumps Off	
Logger Number	**Field (psi)**	**Model (psi)**	**Field (psi)**	**Model (psi)**
1	92	92	83.5	84
2	82	84	74.5	76
3	106	105	98.5	98
4	92	93	84.5	85
5	92	91	83.5	83
6	81.5	81	73.5	74
7	96	97	85	85
8	155	158	143	145

Table 7-1 compares the average pressures of the loggers when the pumps are on versus when they are off in the field and in the model. This data was used to ensure that the pumps were providing an accurate pressure increase throughout the system when the pumps at the booster pump station turn on.

8.0 Design Criteria

Table 8-1 summarizes the system criteria that were used for system assessments. These criteria will also be used for future system assessments.

Table 8-1: Summary of System Requirements

Criteria	Limiting Source	Description
Supply	BWRPWA – City of Tontitown Water Purchase Contract	The maximum purchase amount of this contract is 64.5 MG per month. Increases in the maximum purchase amount may be completed by amendment and with the approval of a majority of the Seller's Board of Directors.
Pumping	10 States Standards	Each booster pumping station shall contain not less than two pumps with capacities such that peak demand can be satisfied with the largest pump out of service.
		To ensure continuous service when the primary power has been interrupted, a power supply shall be provided from a standby or auxiliary source.
Storage	10 States Standards	Storage structures should be designed to ensure water age does not exceed five days
	ADH	Sufficient useable storage shall be provided with consideration given to average daily demand, peak hourly demand, power outages, and fire flows, if applicable.
	BWRPWA	Requires storage equal to average daily demand
Minimum Pressure	ADH	A minimum pressure of 20 pounds per square inch shall be maintained, except under emergency conditions such as a fire flow or main break.
Fire Flow	IFC	The City of Tontitown enforces the International Fire Code (Volume 3). A system-wide minimum pressure criteria of 20 psi will be used to determine available fire flow.
Maximum Flow Velocity	AWWA (guideline)	Water distribution lines should not experience a maximum flow velocity of 5 ft/s. (Note: AWWA guidelines suggest keeping velocities under 4 – 6 ft/s, however Garver will use 5 ft/s as the threshold moving forward)

9.0 Existing System Assessment

9.1 Supply

The City of Tontitown currently purchases potable water from BWRPWA. In the BWRPWA – City of Tontitown Water Purchase Contract, Tontitown is allowed to purchase 64.5 million gallons of water per month which equates to approximately 2.08 million gallons per day. Since the year 2000, Tontitown's maximum month demand according to water purchased data was 528,653 gallons, leaving an excess supply of over 1.5 million gallons per day during that month.

Using the per capita demands in Table 4-2 and an approximate max month to average day ratio of 1.7, it was determined that to exceed this purchase limit the population would need to reach approximately 12,235. Referring back to population projections, this number would not be surpassed until 2033 with an exponential population increase and 2040 with a linear population increase. Max month demand projections are shown in relation to the contractual monthly purchase allowance in Figure 9-1.

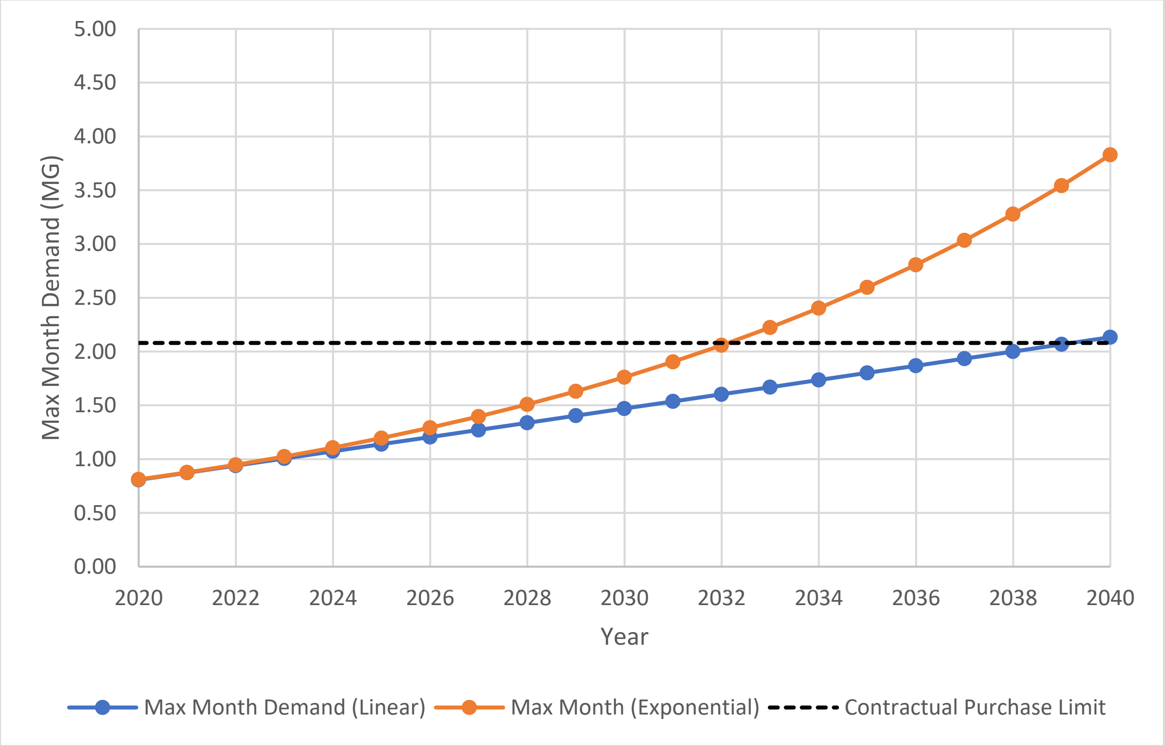


Figure 9-1: Max Month Demand Projections

9.2 Storage

According to the Water Master Plan (WMP) produced by others in 2008, the general criterion used for storage capacity is that the tank should be sized so that there is enough storage to equal one average day water demand. In 2020 the City activated the 500,000-gallon EST. Tontitown purchased an average of roughly 390,000 gallons of water per day from SWU in 2019.

The demand projections indicate that the average day demand will exceed 500,000 gallons when the population is 5,556. Referring back to population projections, this would occur between the years of 2022 and 2023 depending on whether the City experiences linear or exponential growth.

9.3 Pump Stations

The 10 States Standard requires that each booster pump station shall be designed so that if the largest pump were to be taken out of service, the remaining pumps will be able to provide peak demand. The current pumps in the booster pump station operate around 2,000 gpm each. The booster pump station could therefore supply approximately 2.88 MGD with one pump out of service.

The demand projections indicate that the maximum day demand will exceed 2.88 MGD in 2035 under the assumption that the town experiences exponential growth or in 2045 assuming linear growth.

9.4 Fire Flow

The available fire flow results for ADD and MDD are shown in Appendix A, Exhibits 1 and 2. The available fire flow throughout most of the distribution system is greater than 1,500 gpm. In general, fire flow deficiencies throughout the City’s distribution system are primarily the result of undersized lines.

9.5 Minimum Pressure

The minimum pressure results for the ADD and MDD scenarios are shown in Appendix A, Exhibits 3 and 4. As shown in the figure, minimum pressures are not currently an issue within the City. With the booster pump station tied directly into the distribution system, pressures should not drop below acceptable levels even if the tank level temporarily dropped outside of its normal operating range. Arkansas Department of Health requires a minimum pressure of 20 psi. For peak hour demand conditions, the hydraulic model results indicate the minimum distribution system pressure is 57 psi.

9.6 Maximum Pressure

Excessive pressure within a water distribution system can lead to problems such as leaks or damage to infrastructure. After running EPS simulations for both ADD and MDD scenarios it was determined that pressures within the system may be verging on exceeding acceptable limits. The highest pressure in the system was recorded near pressure logger #8 at 160 psi. The results of the two simulations are shown in Exhibits 5 and 6 in Appendix A. If maximum pressure is deemed a problem, there are relatively simple solutions that could alleviate the issue. One way that could prevent excessive pressures would be to install pressure reducing valves in high pressure areas to limit pressures to a certain value or lower. If minor pressure reduction would suffice, the valves connecting to the transmission line could be closed to eliminate pressure increases when pumps kick on.

9.7 Pipe Velocity

AWWA guidelines recommend that no pipe should experience a maximum velocity of greater than 5 feet per second during peak flow. Exhibits 7 and 8 in Appendix A display the results regarding maximum velocity for each segment of pipe within the distribution system during average day and maximum day conditions. All modeled pipe velocities are below the AWWA maximum velocity guideline.

9.8 Water Age

All water age simulations were run assuming a water age of zero at the connection to the BWRPWA transmission line. Water age at that point would need to be added to the modeled water ages in this TM to obtain the total water age from the point of chlorination.

Garver completed two simulations to analyze water age in the water distribution system. Both simulations were performed using average day demand conditions. The first of the two used the assumption that the valves on the connections to the transmission line were closed, meaning that the booster pump station feeds the elevated storage tank without being tied into the distribution system. The second assumed these valves were open, meaning that the booster pump station not only feeds the elevated storage tank but also pumps water throughout the system.

Exhibits 9 and 10 in Appendix A display the results of both these simulations. The results indicate that water age moderately improves with the connections to the transmission main closed. When looking at the water age in the tank, the maximum water age with connections open is roughly 4.25 days while the maximum water age with the connections closed is roughly 3 days.

If it is determined that water age is a problem with the distribution system, there are a few different actions that can be taken. These potential solutions are as follows:

1. Close valves at connections to transmission line – Forcing the water from the booster pump station directly to the elevated storage tank would be anticipated to decrease water age by approximately 1.25 days. The connections allow water to bypass the EST and go directly from the booster pump station to the distribution system, which increases the time water spends in the EST.
2. Increase Drawdown Cycle – Increasing the drawdown cycle by broadening the set points of the pump could improve water age. This would allow more water to leave the elevated storage tank before the pumps turn on thus increasing turnover in the tank. This would also increase the mixing time in the tank since pumps would be operating for a longer period of time helping to ensure adequate mixing before water enters the distribution system.

The City can monitor chlorine residual and disinfection by-product (DBP) concentrations with the new source of supply to determine if water age becomes a problem.

APPENDIX A

Exhibits

Exhibit 1: Available Fire Flow (ADD)

Exhibit 2: Available Fire Flow (MDD)

Exhibit 3: Minimum Pressure (ADD)

Exhibit 4: Minimum Pressure (MDD)

Exhibit 5: Maximum Pressure (ADD)

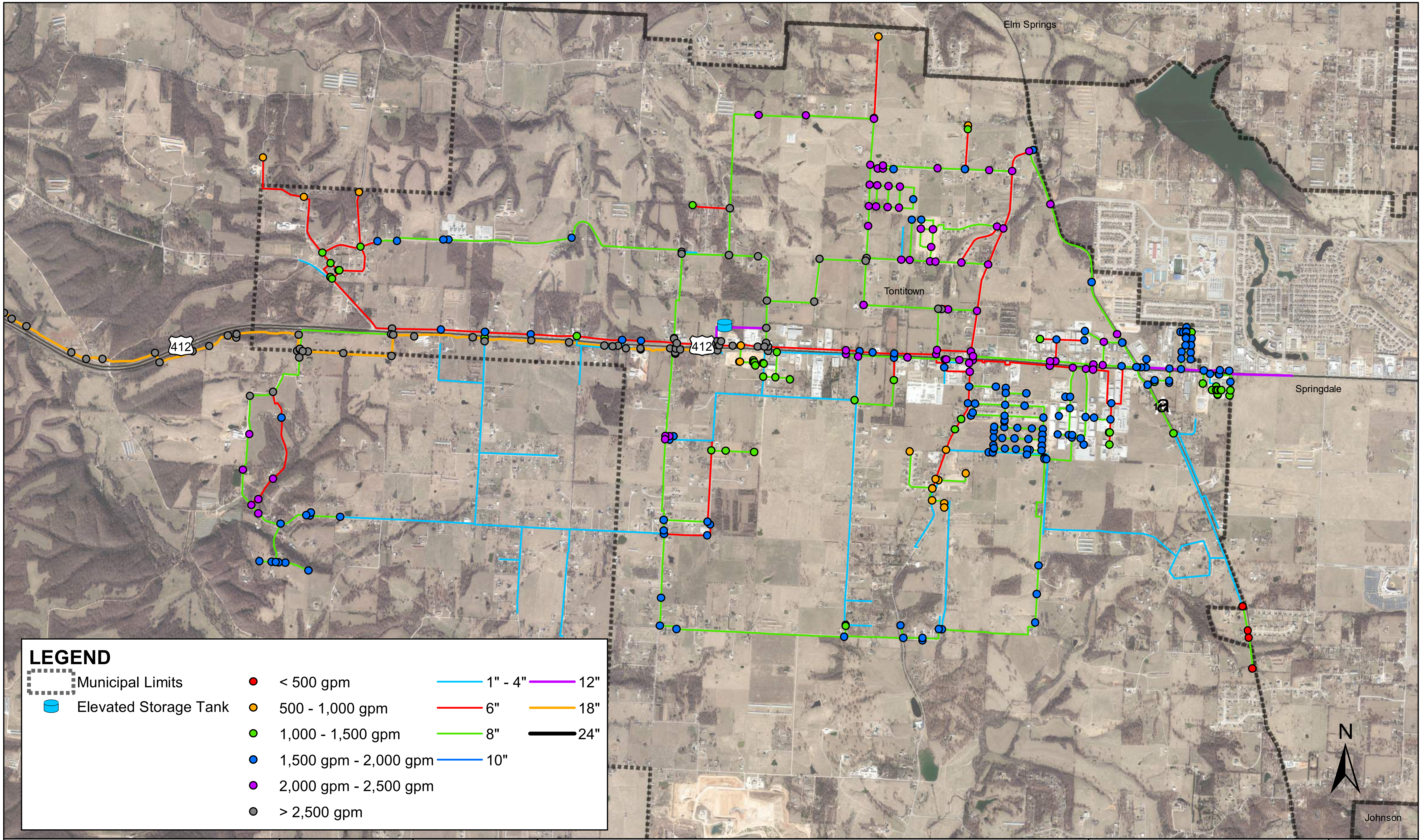
Exhibit 6: Maximum Pressure (MDD)

Exhibit 7: Maximum Velocity (ADD)

Exhibit 8: Maximum Velocity (MDD)

Exhibit 9: Maximum Water Age (Connections Closed)

Exhibit 10: Maximum Water Age (Connections Open)



AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1**

BAR IS ONE INCH ON
ORIGINAL DRAWING

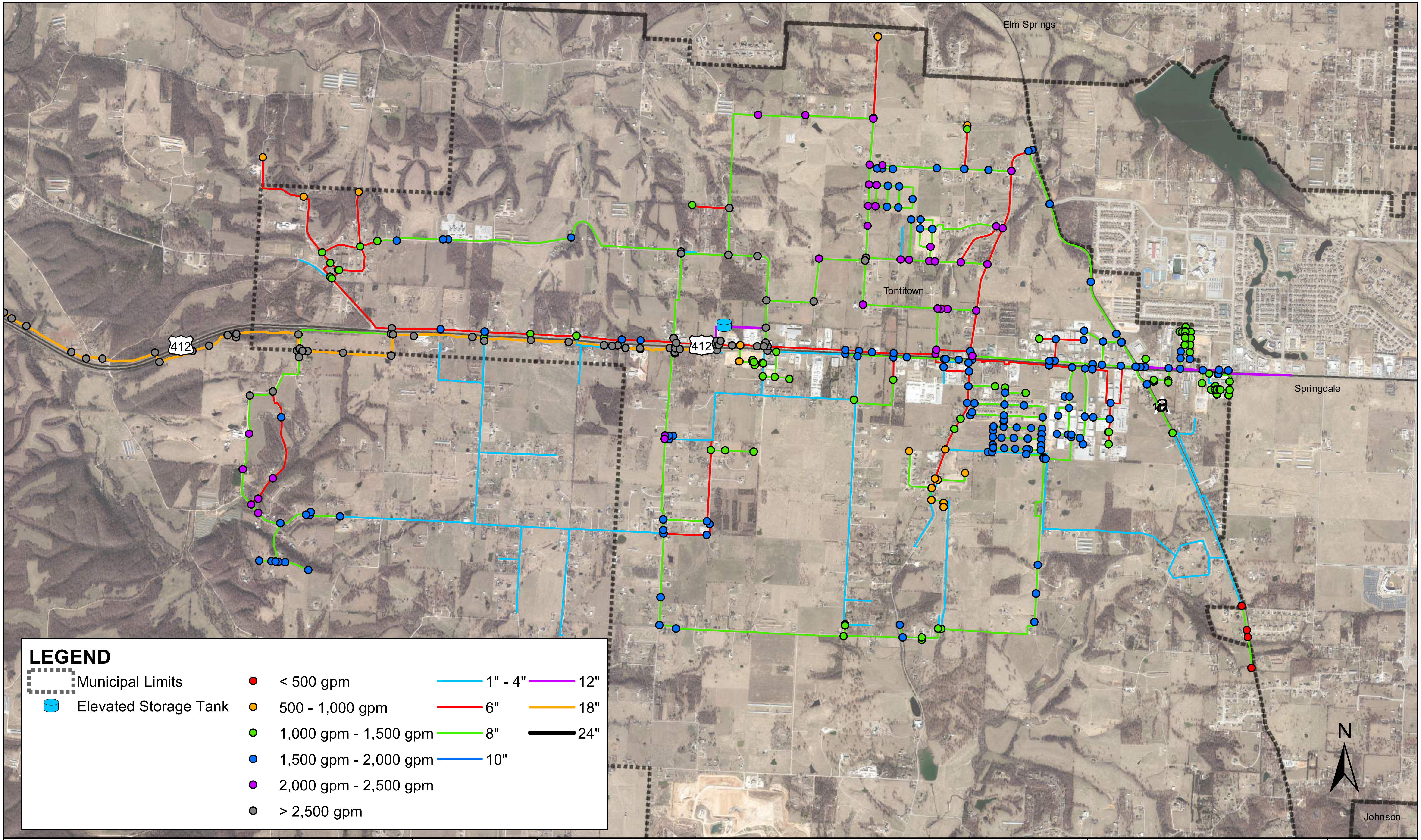
1"

IF NOT ONE INCH ON
THIS SHEET, ADJUST

JOB NO.: 18048025
DATE: AUGUST 2020

TONTITOWN WATER UTILITIES
TONTITOWN, AR
TONTITOWN WATER MASTER PLAN

2049 East Joyce Blvd.
Suite 400
Fayetteville, AR 72703
(479) 527-9100



AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2**

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TONTITOWN WATER MASTER PLAN

CITY OF
TONTITOWN

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Suite 400
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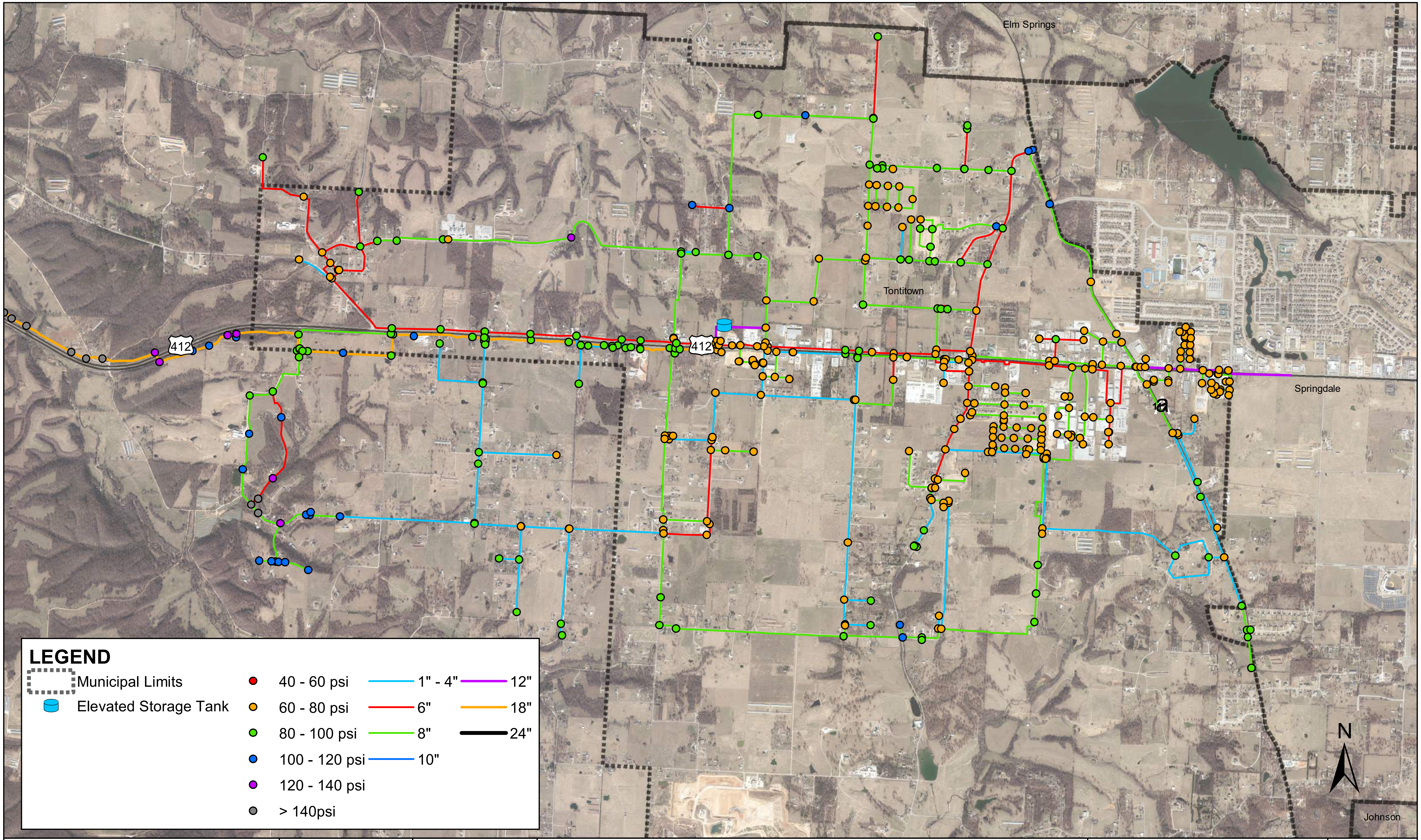

MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3**

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Fayetteville, AR 72703
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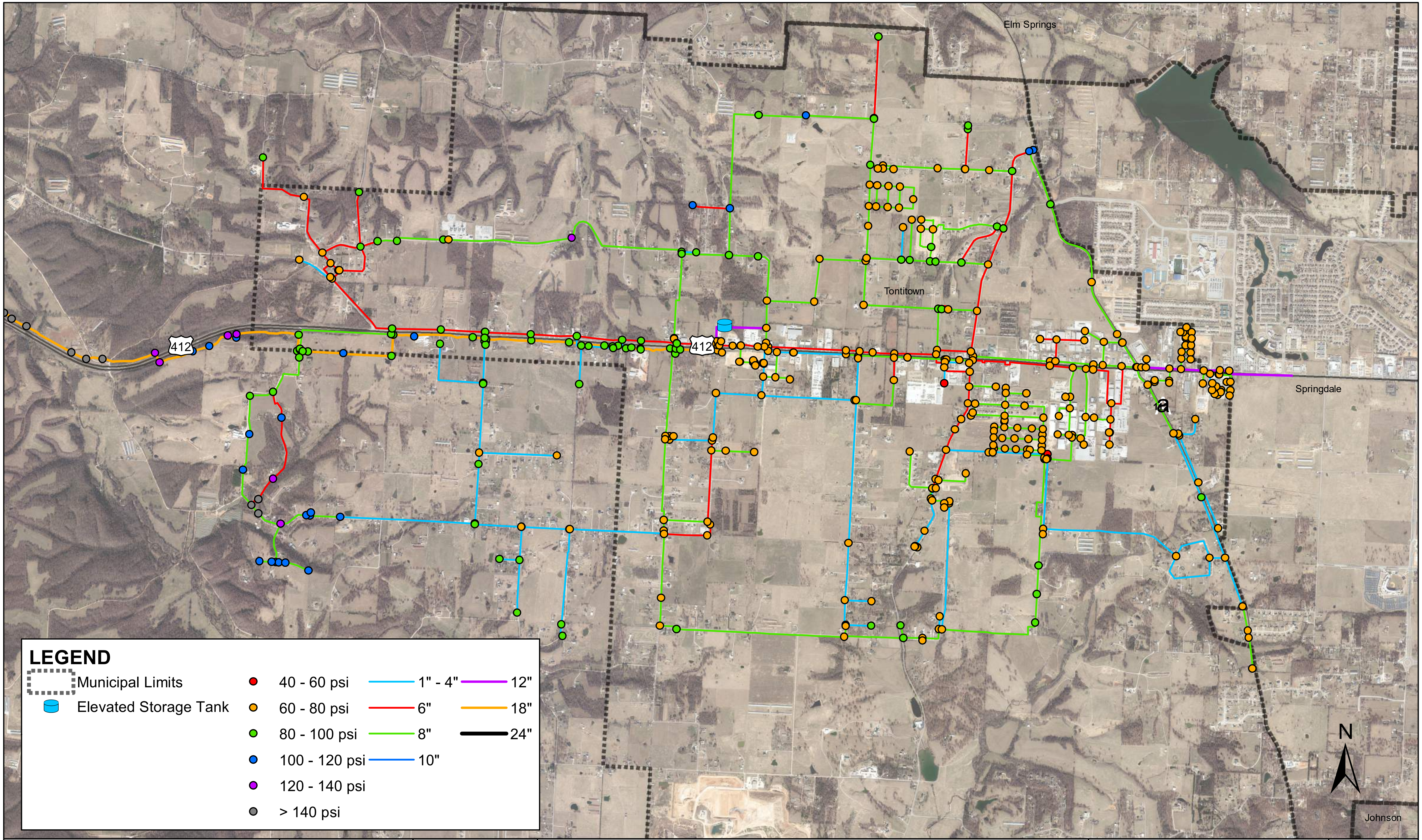

MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4**

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TONTITOWN

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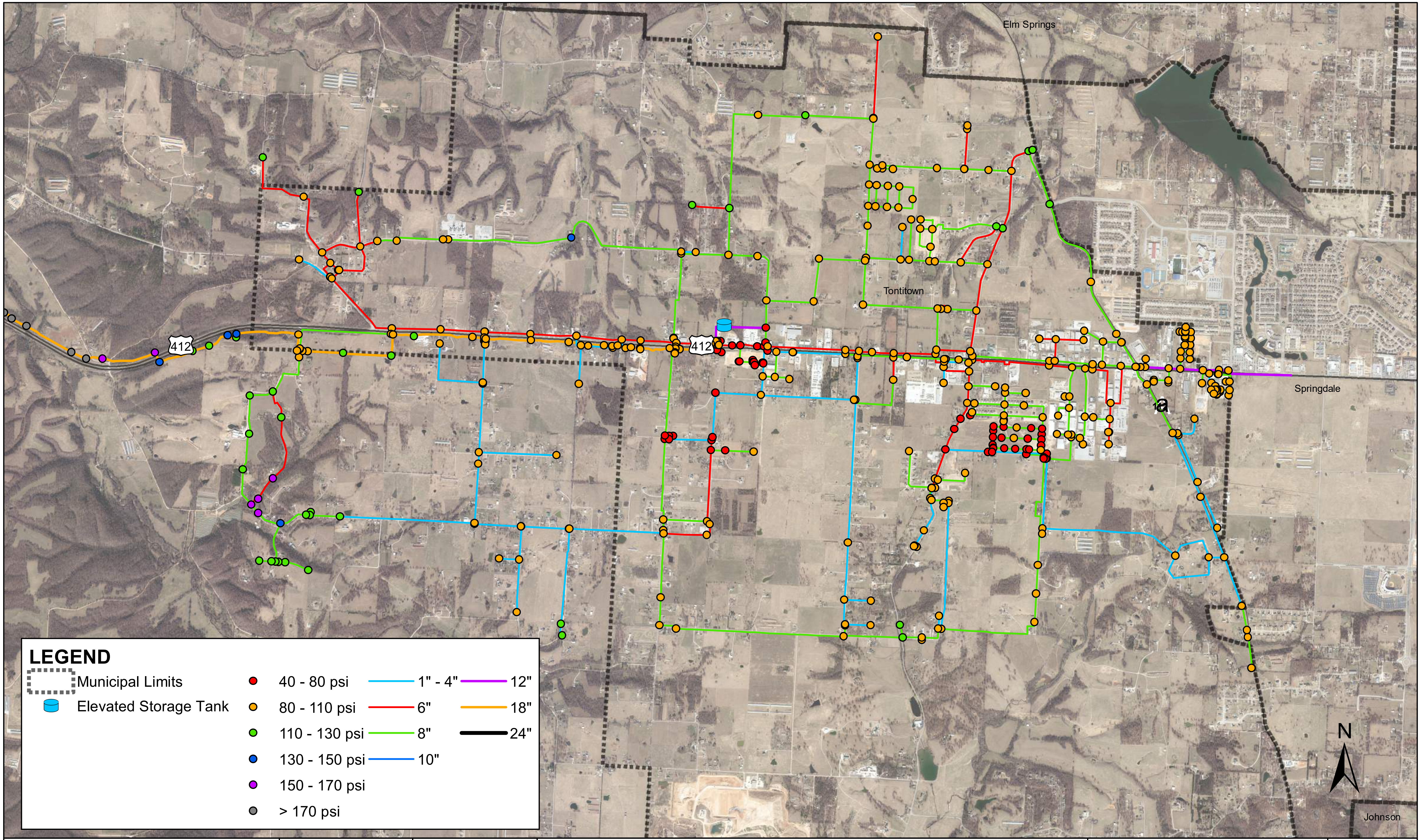

MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5**

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TONTITOWN

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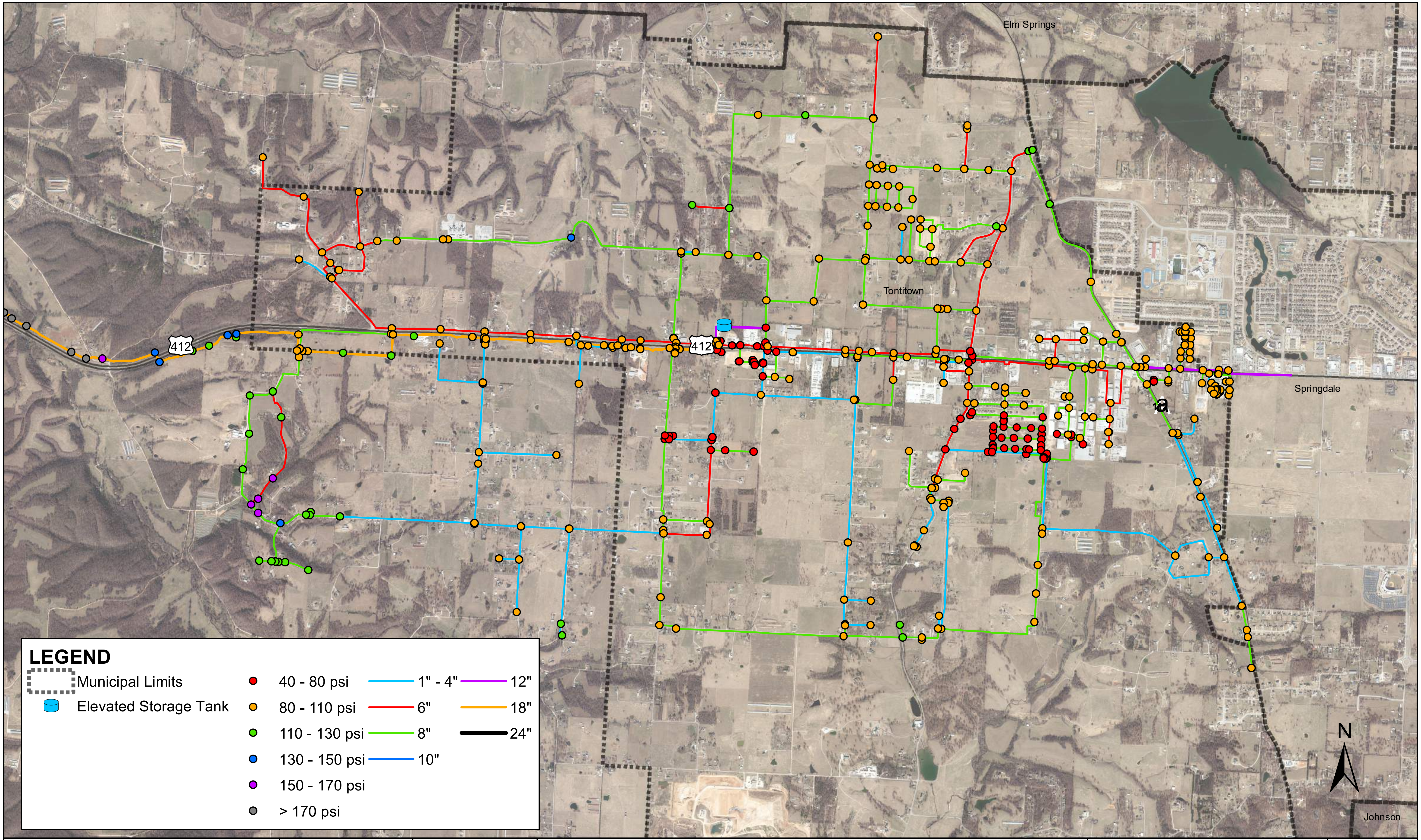

MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6**

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IF NOT ONE INCH ON
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DATE: AUGUST 2020

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TONTITOWN WATER MASTER PLAN

CITY OF
TONTITOWN

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Fayetteville, AR 72703
(479) 527-9100

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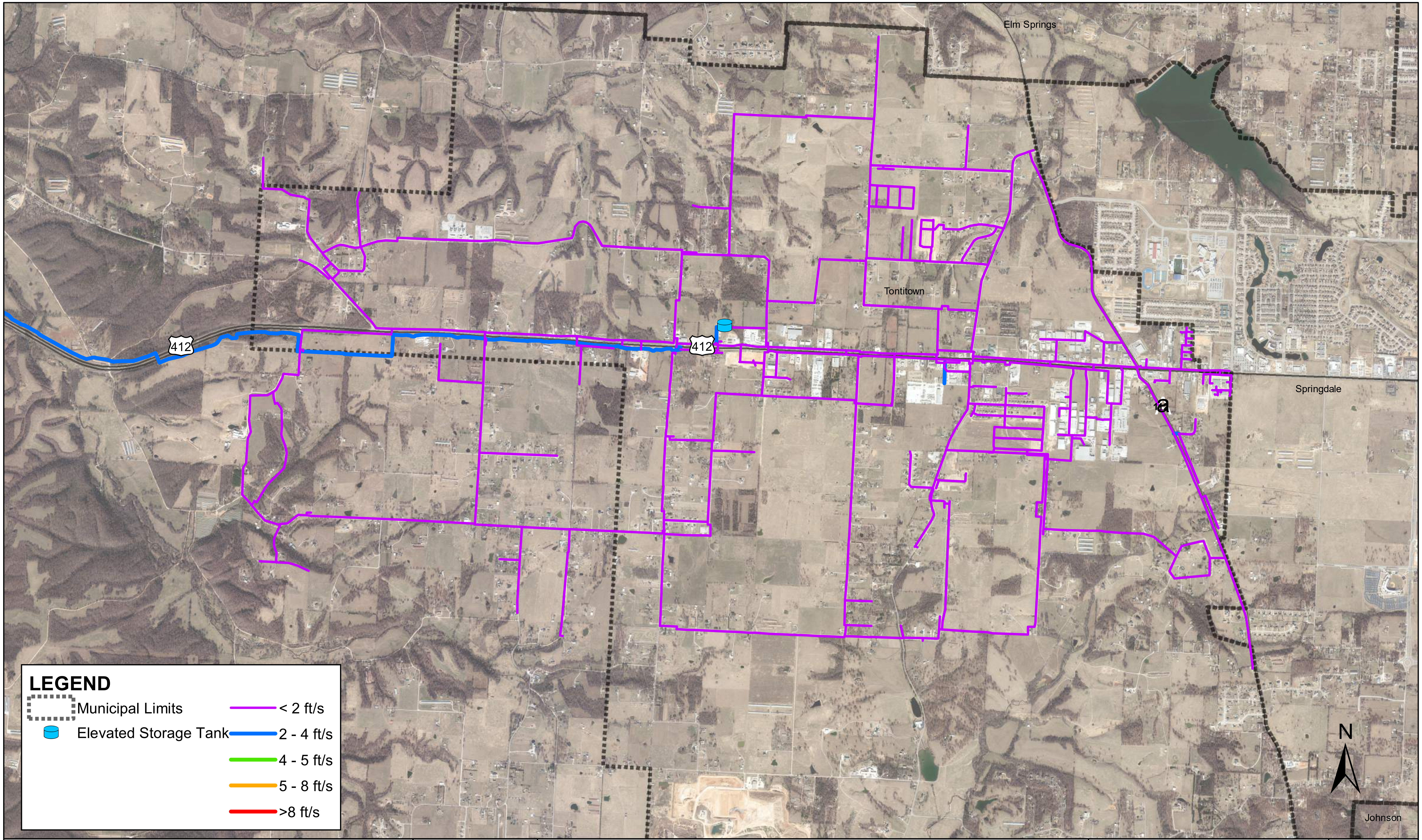

MAX VELOCITY (ADD)

Figure Number: **EXHIBIT 7**

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DATE: AUGUST 2020

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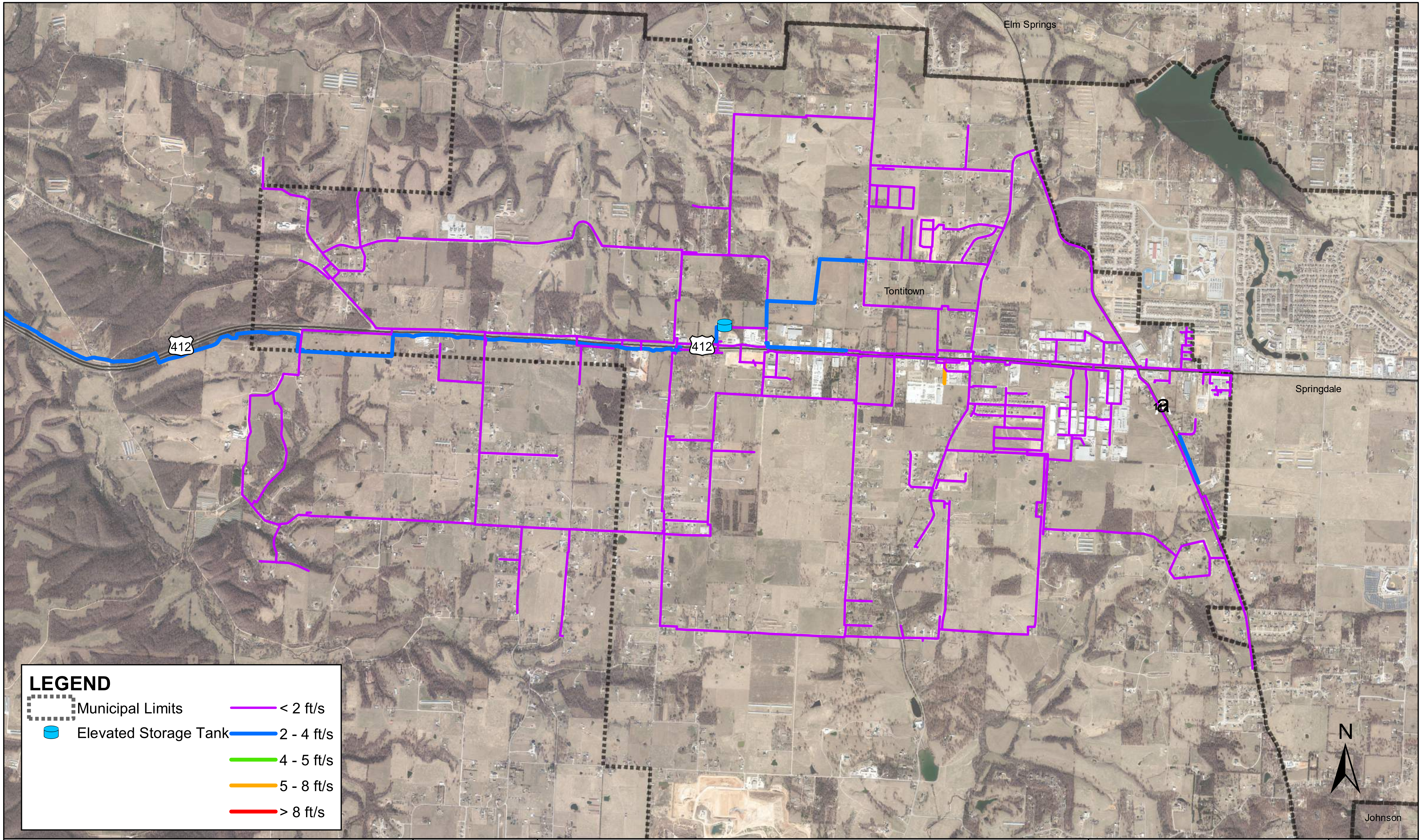
TONTITOWN, AR
TONTITOWN WATER MASTER PLAN

CITY OF
TONTITOWN

2049 East Joyce Blvd.
Suite 400
Fayetteville, AR 72703
(479) 527-9100

GARVER



MAX VELOCITY (MDD)

Figure Number: **EXHIBIT 8**

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ORIGINAL DRAWING

1"

IF NOT ONE INCH ON
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DATE: AUGUST 2020

TONTITOWN WATER UTILITIES
TONTITOWN, AR
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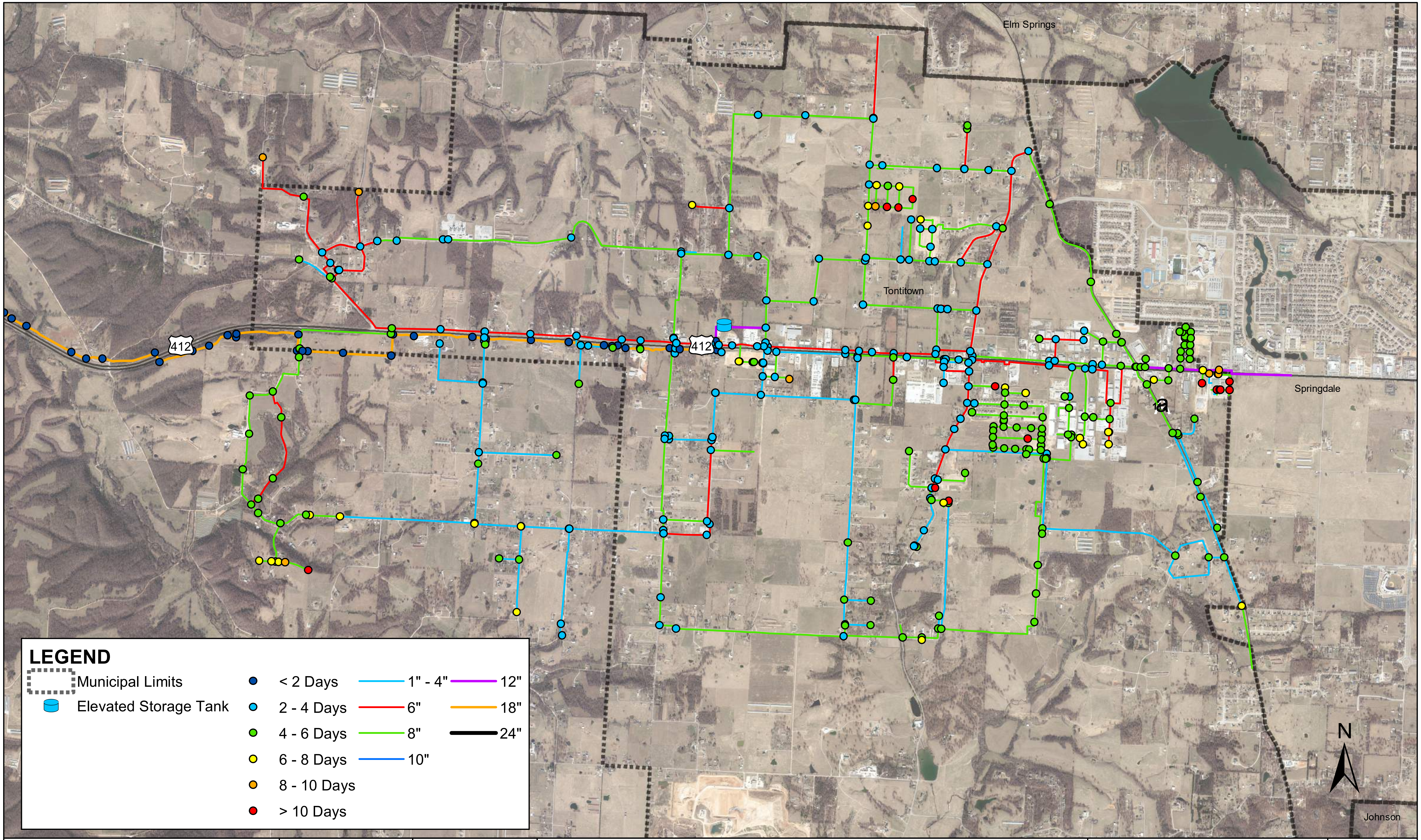

MAX WATER AGE (CONNECTIONS CLOSED)

Figure Number: **EXHIBIT 9**

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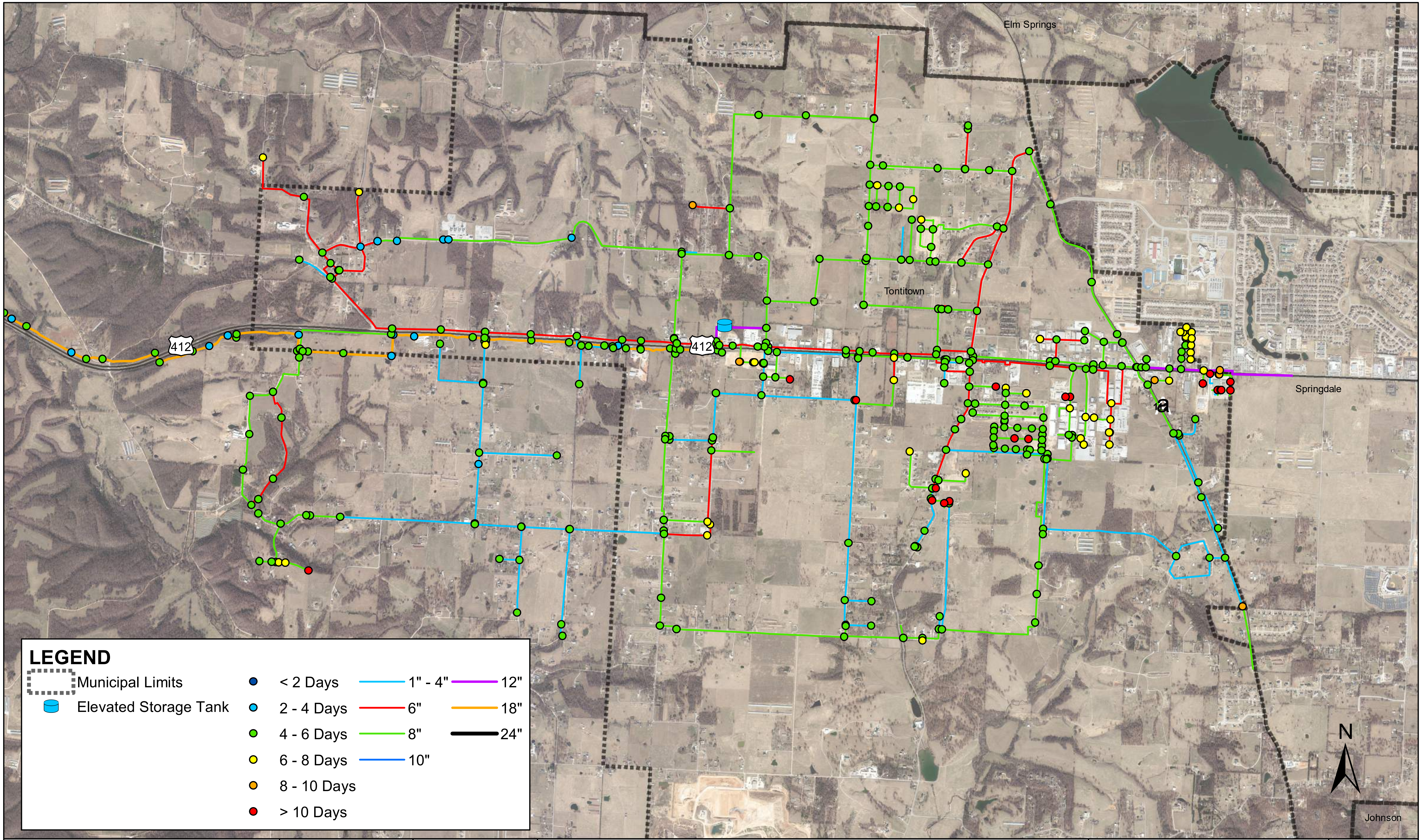

MAX WATER AGE (CONNECTIONS OPEN)

Figure Number: **EXHIBIT 10**

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TONTITOWN WATER UTILITIES
TONTITOWN, AR
TONTITOWN WATER MASTER PLAN

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APPENDIX B

Technical Memorandum –
Future System Assessment and Capital Improvements

Tontitown Water Distribution System Master Plan

Technical Memorandum
Future System Assessment and Capital Improvements

Tontitown Water Utilities
Tontitown, Arkansas

Prepared by:

2049 E. Joyce Blvd., Suite 400
Fayetteville, AR 72703

October 2021

Garver Project No. 18048025

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Appendix

1.0 Introduction

This is the second technical memorandum (TM) prepared for the City of Tontitown (City) as part of the Tontitown Water Master Plan project. The first TM was the Existing System Assessment TM.

After meeting with the City, Garver made slight modifications to demand and population projections and refined the the potential buildout service area. In addition to addressing the changes made since the first workshop, this TM discusses how future water distribution system scenarios were developed and recommends capital improvements to keep the system operating efficiently with the growing demands.

2.0 Water Model Buildout Demands Update

Garver documented population and demand projections in the first TM. During the first workshop, Garver and the City discussed these population and demand projections. Initially, Garver considered four scenarios when developing projections. Coordination with the City ultimately led to identification of a single buildout boundary that encompasses the existing water service area, as well as a westward expansion which terminates near the connection with the BWRPWA transmission line, as shown in Figure 2-1.

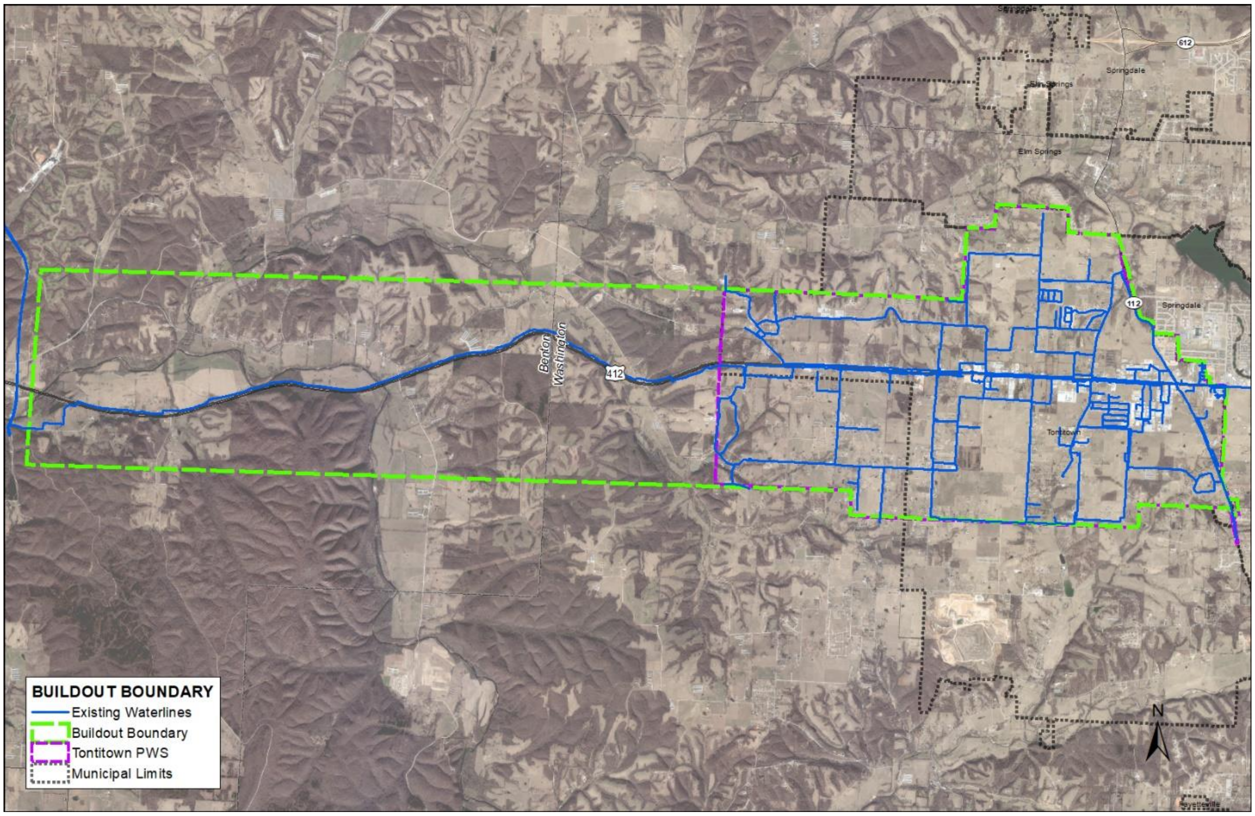


Figure 2-1: Buildout Boundary

Garver adjusted the demand projection based on discussions with the City. Then, Garver developed a method to spatially allocate these demands to junctions in the hydraulic water model. Changes to the original projections and development of spatial demand assignment are discussed in the following sections.

2.1 Demand Projection Methodology

Two assumptions have changed since the first workshop that impact the demand projections:

1. Land use zoned as "RM" changed from a density of 5 units per acre to 4 units per acre.
2. Occupants per household originally had been assumed to be 3 (a conservative value) but was altered to align with the Washington County average of 2.57.

Table 2-1 illustrates the buildout population and demand for the original projection and for the updated projection, after the new assumptions were applied.

Table 2-1: Buildout Projection Comparison

	Original	Updated
Buildout Population	78,819	64,361
Average Day Demand (MGD)	7.882	6.436
Maximum Day Demand (MGD)	15.764	12.872

2.2 Demand Allocation Methodology

While the focus of the demand projection was intended to determine expected future demands in the system, demand allocation spatially distributes those future demands in the hydraulic water model. The process of allocating demand started similarly to the original demand projection – assigning parcels within the buildout area with the underlying City's land use designation. All fully-developed land was excluded, along with land lying within National Park grounds and floodplains. All land use designations were assigned a unit density, which mirrors the same densities of the adjusted demand projections with the addition of commercial areas. Since the original demand projections simply utilized a demand per capita assumption, it was not necessary to separate demands into different user classes. Instead, the per capita values encompassed all possible demands under a blanket value. Spatially allocating demands warranted a more detailed approach to determine where agricultural, industrial, residential, and commercial demands would be located. The details of the assumptions for land use are displayed in Table 2-2.

Table 2-2: Demand Allocation Assumptions

Land Use Designation	Units Per Acre	Percent Residential	Percent Commercial
Agricultural (AG)	0.2	NA	NA
RE	1	100%	NA
RM	4	100%	NA
RC-N	12	80%	20%
RC-T	9	50%	50%
RC-C	14	20%	80%
LI	0.2	NA	NA
Washington County Zoning (WC)	1	100%	NA

The "Units Per Acre" column in Table 2-2 only applies to the residential portion of the mixed use areas designated as RC-N, RC-T, and RC-C. Garver determined the commercial density to be approximately 0.5 units per acre which was used to calculate the number of commercial units in the mixed-use areas. Garver also utilized the same open space percentage of 20% for all land use designations to account for right of way, green space, etc.

After determining the number of units in the buildout area by user class, Garver analyzed recent system summary billing reports provided by the City. Both average day and maximum day scenarios were evaluated, and relatively conservative values were chosen to be assigned to each unit in the model. The breakdown of daily demands per unit in a customer class is shown in Table 2-3.

Table 2-3: Demand Per Unit by Customer Class

Customer Class	Average Day Demand (gpd)	Maximum Day Demand (gpd)
Residential	268	536
Commercial	490	980
Agricultural	1,008	2,016
Industrial	576	1,152

3.0 Future Scenario Demand Adjustment

For each future scenario, demands were scaled down from buildout demand to align as closely as possible to the projected demands from the first TM. For each scenario, the City's distribution system was divided into different regions to account for certain regions developing faster than others.

The regions for each of the future scenarios include:

1. Southeastern Region
2. Eastern Region
3. Midwestern Region
4. Hickory Meadows and South Pointe Subdivisions (HMSP) Region
5. Western Expansion Region

Table 3-1 contains the demands for the existing condition in the water model to provide a baseline for demand growth in the five regions. While each of the scenarios in the following sections contain the Western Expansion Region, the only scenarios that contain any additional future demands in that region are the two buildout scenarios. All other scenarios contain junctions that were assigned to the Western Expansion Region; however, no additional demands were added.

Table 3-1: Existing Demands by Region

Region	Existing Demand (gpd)	Demand at Buildout (gpd)	Percent of Buildout
Southeastern	31,219	184,781	16.9%
Eastern	323,539	3,504,211	9.2%
Midwestern	72,634	1,137,370	6.4%
HMSP	0	342,461	0.0%
Western Expansion	0	1,254,413	0.0%

3.1 2025 Horizon

The regions and their associated junctions within the model are displayed in Figure 3-1. In both ADD and MDD scenarios, most of the demand increase is associated with the HMSP Region, Midwest Region, and East Region. The HMSP region was scaled down from the total buildout demand to a total demand that would account for the anticipated subdivision developments.

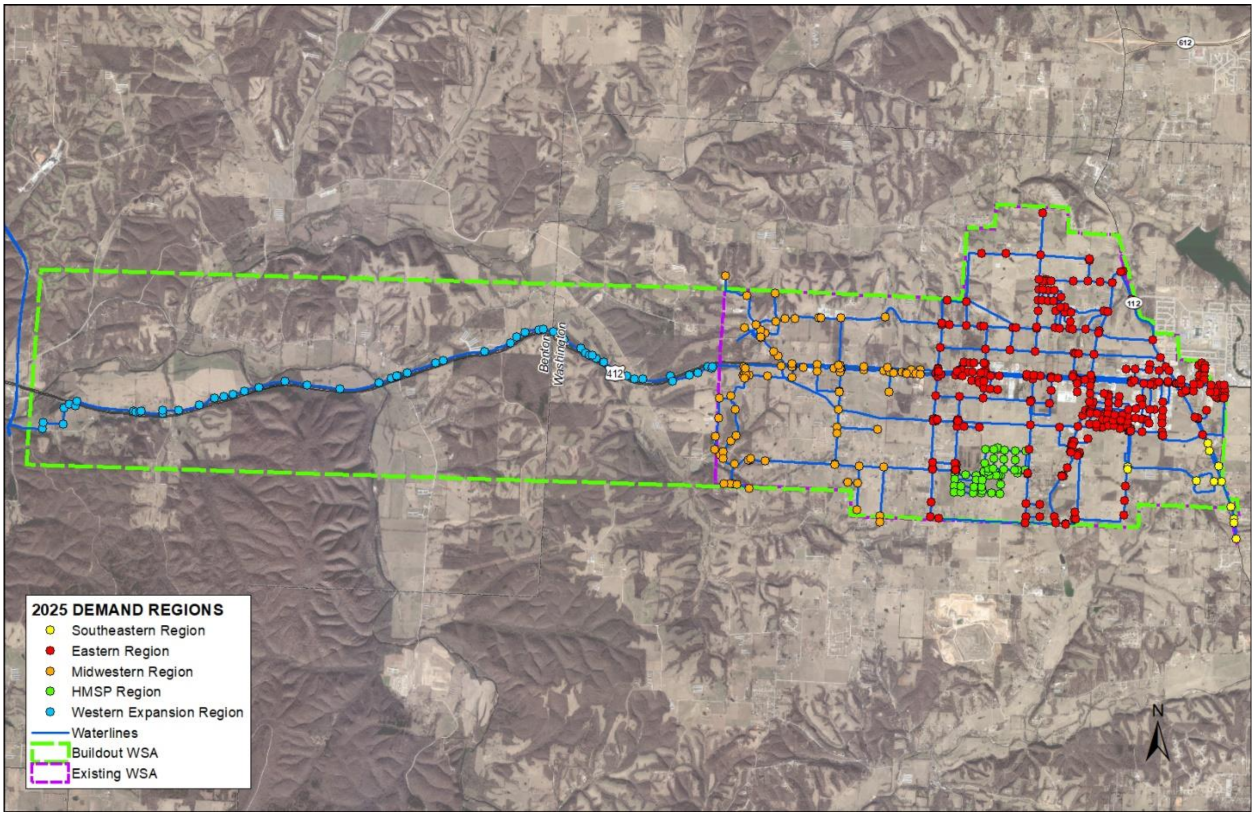


Figure 3-1: 2025 Demand Regions

3.1.1 2025 ADD

Table 3-2 contains the demand total in each region in comparison to the final buildout demand in the same region. Demands were added in each region to represent anticipated demands in the 5-year horizon.

Table 3-2: 2025 ADD Progress Toward Buildout by Region

Region	Demand at 2025 (gpd)	Demand at Buildout (gpd)	Percent of Buildout
Southeastern	31,219	184,781	16.9%
Eastern	413,280	3,504,211	11.8%
Midwestern	98,640	1,137,370	8.7%
HMSP	161,827	342,461	47.3%
Western Expansion	0	1,254,413	0.0%

3.1.2 2025 MDD

The original demand projections from the first TM used a 2:1 MDD to ADD ratio, so to develop maximum day demands for the scenarios in this TM the average day demands were doubled. Irrigation demands were added on top of this.

3.2 2040 Horizon

The regions for the 2040 Scenario are shown in Figure 3-2. The boundaries of the regions are identical. The only difference between the regions is the addition of new junctions in the 2040 Scenario resulting from anticipated pipes to be constructed between 2025 and 2040.

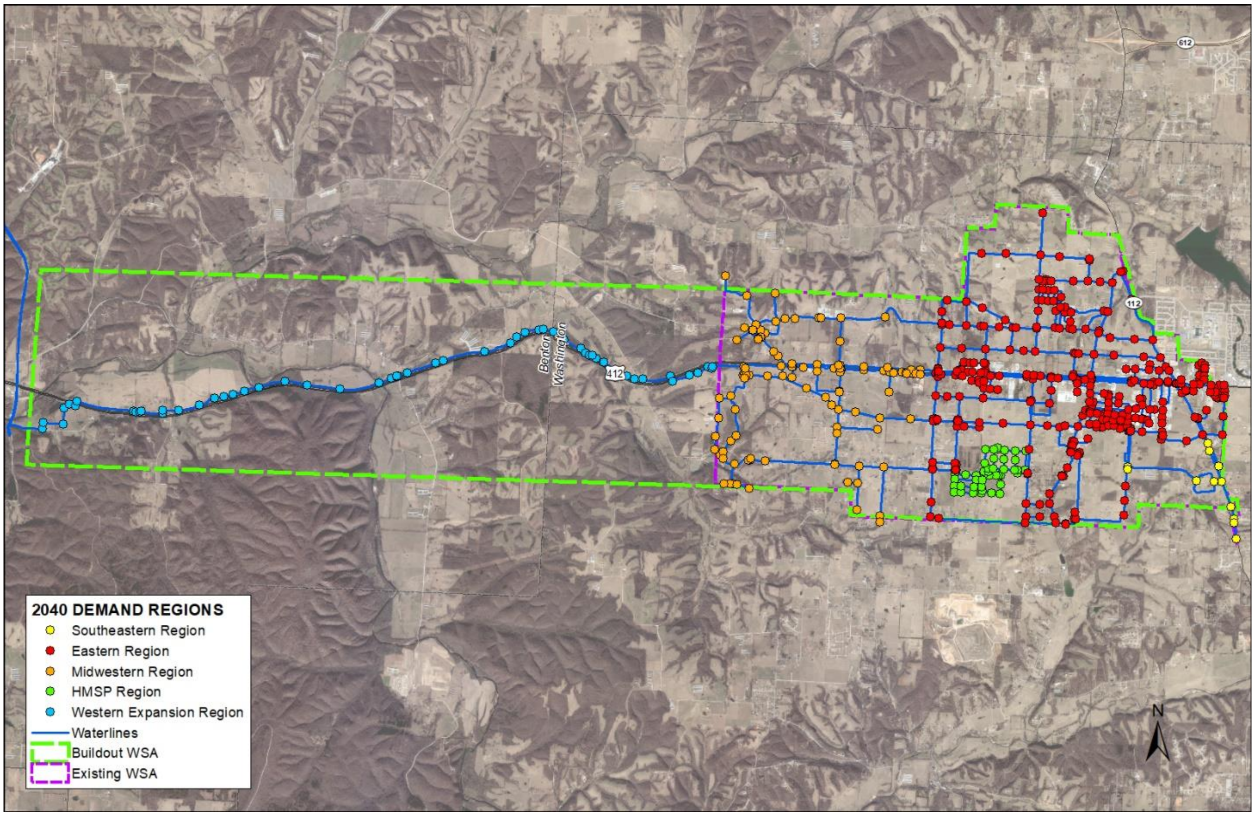


Figure 3-2: 2040 Demand Regions

3.2.1 2040 ADD

Table 3-3 shows the percent of the buildout demand that each region contains.

Table 3-3: 2040 ADD Progress Toward Buildout by Region

Region	Demand at 2040 (gpd)	Demand at Buildout (gpd)	Percent of Buildout
Southeastern	38,909	184,781	21.1%
Eastern	1,690,618	3,504,211	48.2%
Midwestern	266,400	1,137,370	23.4%
HMSP	253,555	342,461	74.0%
Western Expansion	0	1,254,413	0.0%

3.2.2 2040 MDD

Similar to the 2025 MDD Scenario, the demands for the 2040 MDD Scenario were developed by applying a peaking factor of two to the average day demands and included additional irrigation demands.

3.3 Buildout Demands

The total buildout demands by region are broken down in Table 3-4. This information may be helpful for future planning and provides the City with anticipated demands if the decision is made to expand west.

Table 3-4: Buildout Demands by Region

Existing/Future WSA	Region	Average Day Demand (gpd)	Percent of Total Demand
Existing	Southeastern	184,781	2.9%
Existing	Midwestern	1,137,370	17.7%
Existing	Eastern	3,504,211	54.6%
Existing	HMSP	342,461	5.3%
Future	Western Expansion	1,254,413	19.5%
Existing WSA Subtotal		**5,168,823**	**80.5%**
Future WSA Subtotal		**1,254,413**	**19.5%**

Garver utilized a diurnal curve that more closely aligns to expected demands based on data collected in Northwest Arkansas from larger municipalities. The diurnal curve used in the buildout scenarios can be seen in Figure 3-3 and Table 3-5.

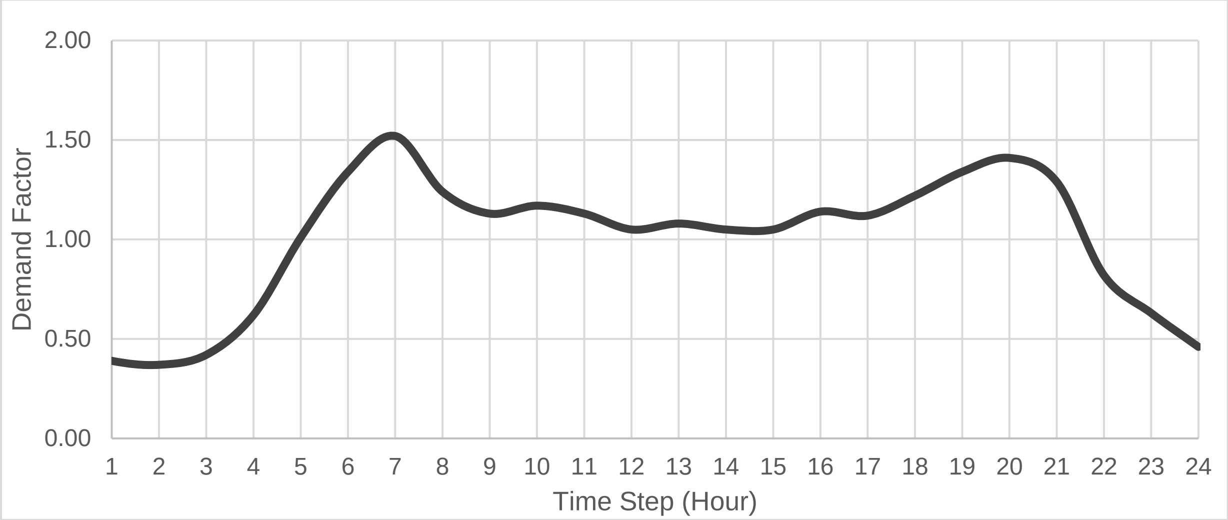


Figure 3-3: Diurnal Curve

Table 3-5: Diurnal Pattern

Time (hr)	Demand Multiplier
1	0.46
2	0.39
3	0.37
4	0.42
5	0.62
6	1.01
7	1.34
8	1.52
9	1.24
10	1.13
11	1.17
12	1.13
13	1.05
14	1.08
15	1.05
16	1.05
17	1.14
18	1.12
19	1.22
20	1.34
21	1.41
22	1.29
23	0.82
24	0.63

4.0 Improvements by Scenario

4.1 2025 Improvements

Improvements in the 5-year planning scenario are included in the following sections. The City has multiple projects in the design phase that are anticipated to be constructed within the next few years, as discussed in Section 4.1.1.

4.1.1 Projects in Progress

The 2025 Scenario includes three projects that have already been proposed and are currently in progress. All three are set to be completed by 2025 and are described below:

1. Wildcat Creek Waterline – This includes approximately 1,357 LF of 8-inch waterline along Wildcat Creek Boulevard that will replace the existing 3-inch waterline.
2. Highway 412 Waterline – This project includes approximately 12,075 LF of 18-inch waterline that will be installed along the north side of Highway 412 from the EST to Highway 112.
3. Hickory Meadows and South Pointe Development – This project includes the two subdivisions being developed south of Highway 412 and between Klenc Road and Pianalto Road. It also includes approximately 2,400 LF of 8-inch waterline along Klenc Road extending north from Kelly Avenue.

These three projects are included in the 2025 Scenario but are not included in cost estimates.

4.1.2 New Southeast Elevated Storage Tank

BWRPWA requires that the City provide storage equal to the average day demand at a minimum. With the City's average day demands quickly approaching the current storage capacity of 500,000 gallons, a new elevated storage tank will be required in the near future. In the first workshop with the City, multiple sites were discussed for the next tank location. From that discussion, it was determined that the preferred tank site would be a piece of property south of Industrial Road that the City currently owns. The existing grade of this property is similar to the grade at the existing EST site, which would allow a similar tank height to be utilized.

This new tank requires additional upgrades to operate efficiently. These upgrades include the following:

1. Approximately 7,821 LF of 12-inch waterline replacing the waterline along Barrington Road from Highway 412 to East Fletcher Avenue and then east along Fletcher Avenue to the proposed EST.
2. Approximately 469 LF of 8-inch waterline from the 6-inch waterline along Industrial Road to the proposed 12-inch waterline connecting the proposed EST.

The proposed 12-inch waterline will increase transmission capacity to the proposed EST and will also increase available fire flow at the site proposed for a new school on the northeast corner of Barrington and Fletcher. Increased residential development is anticipated around the school following its construction.

The proposed EST will have a capacity of one million gallons as opposed to the existing EST, which has a capacity of 500,000 gallons. Garver proposes an altitude valve be installed to prevent the tank from overflowing in the case that the future Eastern Supply Source has a higher HGL than the existing water distribution system. Utilizing the demand projections from the previous TM, this additional storage should be adequate until 2035 with the assumption that the City experiences exponential growth.

4.1.3 Old Highway 68 Improvement

The final proposed upgrade within the 5-year planning horizon includes approximately 2,385 LF of waterline to be upsized from a 6-inch to 12-inch pipe along Old Highway 68 and Highway 412. This upgrade improves fire flow in the northwest corner of the distribution system, increases minimum pressures during peak demand periods, and helps prepare for the third elevated storage tank that is proposed in the 20-year planning horizon.

With the large industrial users in the northwestern region, along with much of the area zoned as mixed use, this segment of pipe is seen as an upgrade that would greatly benefit the City within the next few years. Eventually, Garver advises that this 12-inch upgrade be continued all the way along Highway 412 to the central EST to allow for connections to a large-diameter local distribution main rather than the existing 18-inch transmission line.

4.1.4 Wildcat Creek Improvement

Following discussions with the City of Tontitown, it was determined that upsizing the 3-inch waterline along Wildcat Creek would be prioritized in the 2025 Horizon. Upsizing to an 8-inch waterline will increase fire flows throughout the southwest region of the distribution system, improve looping, and better prepare the City for development in the region.

4.1.5 Highway 112 Improvements

With the Highway 112 widening project being planned in the near future, Garver recommends that the City begin coordinating with the Arkansas Highway Commission for potential aid in financing the waterline improvements.

The waterline improvements along the highway will be broken into two parts. The first segment includes roughly 3,000 linear feet of pipe running from Highway 412 south along Highway 112 which will be upsized to 12 inches. This will nearly complete the 12-inch loop feeding the proposed Southeast Elevated Storage Tank.

4.1.6 2025 Improvements Summary

The projects and associated costs included in the 2025 Planning Scenario are summarized in Table 4-1. The estimated costs include professional services, contingency, and construction. Totals are rounded up to the nearest $10,000.

Table 4-1: 2025 Proposed Improvement Summary

Project Number	Project Name	Dia. (in)	Length (LF)	Cost per LF	Estimated Cost (2020 Dollars)
1A	1-MG Southeast EST	NA	NA	NA	$5,000,000
1B	12-inch Waterline for SE EST	12”	7,821	$180	$1,410,000
1C	8-inch Waterline for SE EST	8”	469	$120	$60,000
2	Old HWY 68	12”	2,385	$180	$430,000
3	Wildcat Creek	8”	8,676	$120	$1,050,000
4	HWY 112 (1)	12”	3,179	$180	$580,000
5	HWY 112 (2)	12”	4,213	$180	$760,000
TOTAL					**$9,290,000**

4.2 2040 Improvements

Improvements that are recommended within the 20-year horizon are listed in Table 4-2 and can be seen on a map in Appendix A, Exhibit 3.

4.2.1 2040 Improvements Summary

Table 4-2: 2040 Proposed Improvement Summary

Project Number	Project Name	Dia. (in)	Length (LF)	Cost per LF	Estimated Cost (2020 Dollars)
6	Harmon Road	8”	5,427	$120	$660,000
7	Klenc Road (1)	8”	2,685	$120	$330,000
8	Klenc Road (2)	8”	2,516	$120	$310,000
9	Klenc Road to Barrington Connection	8”	2,594	$120	$320,000
10	HWY 412 (1)	12”	9,390	$180	$1,700,000
11	1-MG Northwest EST	NA	NA	NA	$5,000,000
12	Waterline from SE EST to HWY 112	12”	2,515	$180	$460,000
13	Barrington Road	8”	5,402	$120	$650,000
14	Pianalto to Klenc Connection	8”	5,187	$120	$630,000
15	Harmon to Pianalto Connection	8”	5,223	$120	$630,000
16	HWY 412 to Harmon Connection	8”	4,106	$120	$500,000
17	Harmon Road Extension (North of HWY 412)	8”	2,569	$120	$310,000
18	Wc Road 852	8”	1,495	$120	$180,000
19	Morsani Road Extension to Pianalto Road	8”	1,299	$120	$160,000
20	Mantegani to Pianalto Connection	8”	2,465	$120	$300,000
21	Liberty to Ardemagni Connection	8”	1,387	$120	$170,000
22	Barrington to Maestri Connection (1)	8”	3,631	$120	$440,000
23	Barrington to Maestri Connection (2)	8”	3,020	$120	$370,000
24	Mantegani to Liberty Connection	8”	1,556	$120	$190,000
25	Javello to Liberty Connection	8”	3,123	$120	$380,000
26	Pianalto Road Extension to Javello Road	8”	1,583	$120	$190,000
27	Jones Road Extension to HWY 112	8”	3,100	$120	$380,000

28	Ardemagni to Sabatini Connection	8”	2,654	$120	$320,000
29	Apple Blossom Lane	8”	10,158	$120	$1,220,000
30	Taldo Loop	8”	3,755	$120	$460,000
31	Wc Road 753	8”	3,083	$120	$370,000
32	Harmon Road (South of Wildcat Creek)	8”	2,983	$120	$360,000
33	Wc Road 857	8”	5,377	$120	$650,000
34	Morsani Avenue	8”	3,956	$120	$480,000
35	South Mantegani Road	8”	1,343	$120	$170,000
36	HWY 412 (2)	8”	6,559	$120	$790,000
37	Washington Avenue	8”	1,349	$120	$170,000
38	HWY 412 (3)	8”	3,162	$120	$380,000
39	Via De Tonti Lane	8”	1,864	$120	$230,000
40	Pozza Lane	8”	754	$120	$100,000
41	Maestri Road	8”	6,077	$120	$730,000
42	Belmont Way	8”	1,516	$120	$190,000
43	Malbec Road	8”	914	$120	$110,000
44	Sbanotto Avenue	8”	354	$120	$50,000
45	Sabatini Road	8”	1,227	$120	$150,000
46	Ardemagni Road	8”	2,296	$120	$280,000
47	Jevello Road	8”	1,051	$120	$130,000
48	HWY 412 to Pialto Connection	8”	482	$120	$60,000
49	HWY 412 Service Connection Upsize	8”	1,472	$120	$180,000
50	Brush Creek	8”	10,064	$120	$1,210,000
51	Lynch Ave	8”	2,287	$120	$280,000
52	Wc Road 2033	8”	2,184	$120	$270,000
53	Wc Road 3805	8”	3,769	$120	$460,000
54	White Oak Drive	8”	752	$120	$100,000
55	Oak Hills Drive	8”	719	$120	$90,000
56	Leelynjean Lane	8”	968	$120	$120,000
TOTAL					**$24,370,000**

4.3 Buildout Improvements

Two buildout scenarios were created due to the uncertainty of where the City would purchase water once demands exceed the existing source's capacity. One of these scenarios includes an Eastern Supply to compliment the BWRPWA transmission main connection. The second scenario utilized the BWRPWA connection as the sole water supply, assuming improvements would be made to increase its capacity.

Both scenarios contain a westward expansion of the distribution system which terminates near the BWRPWA transmission line connection. As part of the westward expansion, an additional 1.25 million gallon EST would be constructed. Both scenarios also upsize all water mains to a minimum of 8 inches and proposes an 18-inch waterline to connect the Southeastern EST to Highway 412. Maps of the buildout scenarios can be seen in Appendix A, Exhibits 4 through 7.

4.3.1 East and West Supply

Major improvements unique to the East and West Supply Scenario include an eastern supply source to accommodate demands exceeding the current capacity of the BWRPWA booster station and transmission line, and upsizing the existing 12-inch line along the eastern portion of Highway 412 to an 18-inch line. Also included in the proposed improvements is a 2.25 million gallon ground storage tank (GST) near the proposed Southeast EST and additional 500,000 gallon EST next to the existing Central EST. The additional storage is intended to satisfy the requirement that the City contains storage equivalent to the average day demand. Utilizing a GST rather than constructing more EST's will save capital in construction costs. Although the current placement of this GST is near the proposed Southeast EST, other locations may be considered.

Along with the GST, a flow control valve and pump station will need to be constructed to control flow in and out of the GST. With the majority of the flow in maximum day conditions provided from the eastern supply, the proposed booster pump station will help provide the flow and head needed to cycle the Central and Northwestern EST's.

4.3.2 BWRPWA Supply

To increase the BWRPWA supply capacity to meet Buildout MDD, an additional parallel 24-inch transmission main would be required originating at the BWRPWA transmission line connection. In addition to the transmission line, the existing booster pump station would need upgrades to ensure that the pumps could provide sufficient flow and head.

Similar to the East and West Supply Buildout Scenario, a GST is proposed to satisfy requirements for total storage within the City's distribution system. The proposed GST is a 2.75 million gallon tank with a flow control valve and booster pump station that will help regulate flow in and out of the GST. In this scenario, the GST is located in close proximity to the existing Central EST, but other locations may be considered.

5.0 Scenario Results

A series of simulations were performed for each scenario to ensure that the proposed improvements are adequate to keep the distribution system functioning efficiently. The simulations include available fire flow, minimum pressure, maximum pressure, and maximum pipe velocity.

Refer to Table 8-1 in Section 8.0 of TM1 for the design criteria that Garver used to determine acceptable results.

5.1 2025 Horizon

The hydraulic model results from the 2025 Scenario can be seen in Appendix B.

5.1.1 Fire Flow

There is a noticeable increase in available fire flow throughout the system after the 2025 proposed improvements in comparison to the existing system fire flow in TM1. With the addition of the Southeast Elevated Storage Tank, the eastern portion of the system experiences drastically improved available fire flow on lines 6-inch and greater.

The replacement of the 6-inch waterline along Old Highway 68 with the 12-inch waterline significantly improves available fire flows. Without this improvement, the minimum fire flow on the looped 6-inch lines in the northwest corner would be approximately 1,115 gpm under maximum day demand conditions. With the new 12-inch waterline, available fire flow would increase to available flows exceeding 1,500 gpm on junctions that are not on dead-end lines. The dead-end lines in this area, however, are still not able to provide adequate fire flow.

The Wildcat Creek waterline upsizing allows for fire protection in the area and further improves system looping. Not only does it allow fire protection along Wildcat Creek Road, it also increases available fire flow to the East and West parts of the system. The improvements along Highway 112 increase fire flows to acceptable ranges and will allow development along the Highway.

5.1.2 Minimum Pressure

Although the results indicate that there are a few junctions that fall within the 40 – 60 psi range under maximum day demand conditions, the minimum pressure of the system within the existing water service boundary is 57 psi which is not a cause for concern.

5.1.3 Maximum Pressure

The maximum pressure concerns in the southwest corner of the distribution system remain a concern. However, replacing the undersized waterline along Wildcat Creek Road may diminish the chances of infrastructure failure due to these high pressures.

Aside from the southwest corner of the distribution system, there are not any other significant improvements in the maximum pressures needed throughout the rest of the system.

5.1.4 Maximum Velocity

There are no concerns with maximum velocity in the existing water distribution system. The 2025 Scenario showed results similar to existing velocities.

5.2 2040 Horizon

The hydraulic model results from the 2040 Scenario can be seen in Appendix C.

5.2.1 Fire Flow

Results from the 2040 fire flow simulations indicate that there are no significant deficiencies in the City's ability to provide fire flow. Aside from a few undersized dead-end lines, all other areas within the distribution system are capable of providing a minimum of 1,500 gpm.

5.2.2 Minimum Pressure

While the exhibits showing the results of the minimum pressures within the system indicate that there are junctions with pressures falling within the 40 – 60 psi range, the minimum system pressure only reaches 55 psi. This is not a pressure that should be cause for concern.

5.2.3 Maximum Pressure

Maximum pressures in the southwest corner of the distribution system remain an issue in the 2040 planning horizon.

5.2.4 Maximum Velocity

There are no concerns with maximum velocity throughout the distribution system in the 2040 Scenario.

5.3 Buildout – East and West Water Source

The first of the two buildout scenarios assumes that the City will purchase water from BWRPWA as well as a future source to the east, whether that be SWU, BWD or another water provider. This scenario is preferred and more likely compared to the alternate buildout scenario.

Results for the simulations described in the following sections can be found in Appendix D.

5.3.1 Fire Flow

Aside from dead-end lines, there are no significant deficiencies within the existing water distribution area. As a result of the improvements with looping throughout town and upsizing undersized lines, the City can provide sufficient fire flow to customers throughout the existing service area. The Western Expansion Area, contrarily, does not always have the ability to provide sufficient fire flow to all types of development.

The 8-inch loop to the west of the booster pump station contains multiple junctions where fire flows lie within the 1,000 – 1,500 gpm range. If the area remains zoned for residential development, fire flow should be sufficient. However, if the area is rezoned for commercial or industrial development these fire flows may be inadequate. Another option would be to terminate the westward expansion at the booster pump station.

5.3.2 Minimum Pressure

With the rolling terrain in the Western Expansion Area, minimum pressures reach levels that are less than adequate. The lowest value reached by a junction in the Western Expansion Area is 52 psi. Although there are a few junctions that fall within the 40 to 60 psi range within the existing water service boundary, the lowest service pressure falls to 56 psi. This is not necessarily a regulatory problem as much as it is a level of service goal. Issues with minimum pressures can be mitigated by either avoiding development in certain areas where pressures would be a problem or implementing infrastructure such as pressure sustaining valves to maintain adequate pressures.

5.3.3 Maximum Pressure

Similar to the issues with minimum pressure, maximum pressure issues arise in the Western Expansion Area as a result of the rolling terrain. The maximum pressure within the Western Expansion Area reaches 175 psi in the area nearest to the BWRPWA transmission lines. Issues with maximum pressures can be mitigated or avoided altogether by preventing development in those problem areas or utilizing PRV’s in areas with excessive pressures.

5.3.4 Maximum Velocity

Compared to the previous scenarios, the results in these exhibits contain a substantial number of pipes that lie within the 4 – 5 ft/s and 5 – 8 ft/s range. A few segments of pipe have velocities exceeding 8 ft/s. Pipe velocities in these areas may need to be re-evaluated as development progresses throughout the water system.

5.4 Buildout – BWRPWA Supply

In this buildout scenario, Garver uses the assumption that all water will be provided from the west. Much of the infrastructure between the two buildout scenarios is the same, however, the single source scenario requires an additional 24-inch transmission line originating at the BWRPWA transmission line connection and booster pump station upgrades.

All results described in the following sections can be found in Appendix E.

5.4.1 Fire Flow

The results of the fire flow simulation resulted in a nearly identical outcome to the fire flow simulation for the East and West Source Scenario. The City may determine that some areas in the Western Expansion Area should be avoided, or that adequate fire flow will not be provided for every development in the area.

5.4.2 Minimum Pressure

The minimum pressures in the Western Expansion Area again appear to be nearly identical to the East and West Supply Scenario. One minor difference in minimum pressures between the two scenarios, however, is lower minimum pressures around the eastern portion of Highway 412 due to the lack of an eastern water supply source. Refer to Section 5.3.2 for ways to combat the issues with minimum pressures.

5.4.3 Maximum Pressure

Results for maximum pressure are nearly identical to the East and West Supply Scenario. Refer to Section 5.3.3 for ways to mitigate maximum pressure issues.

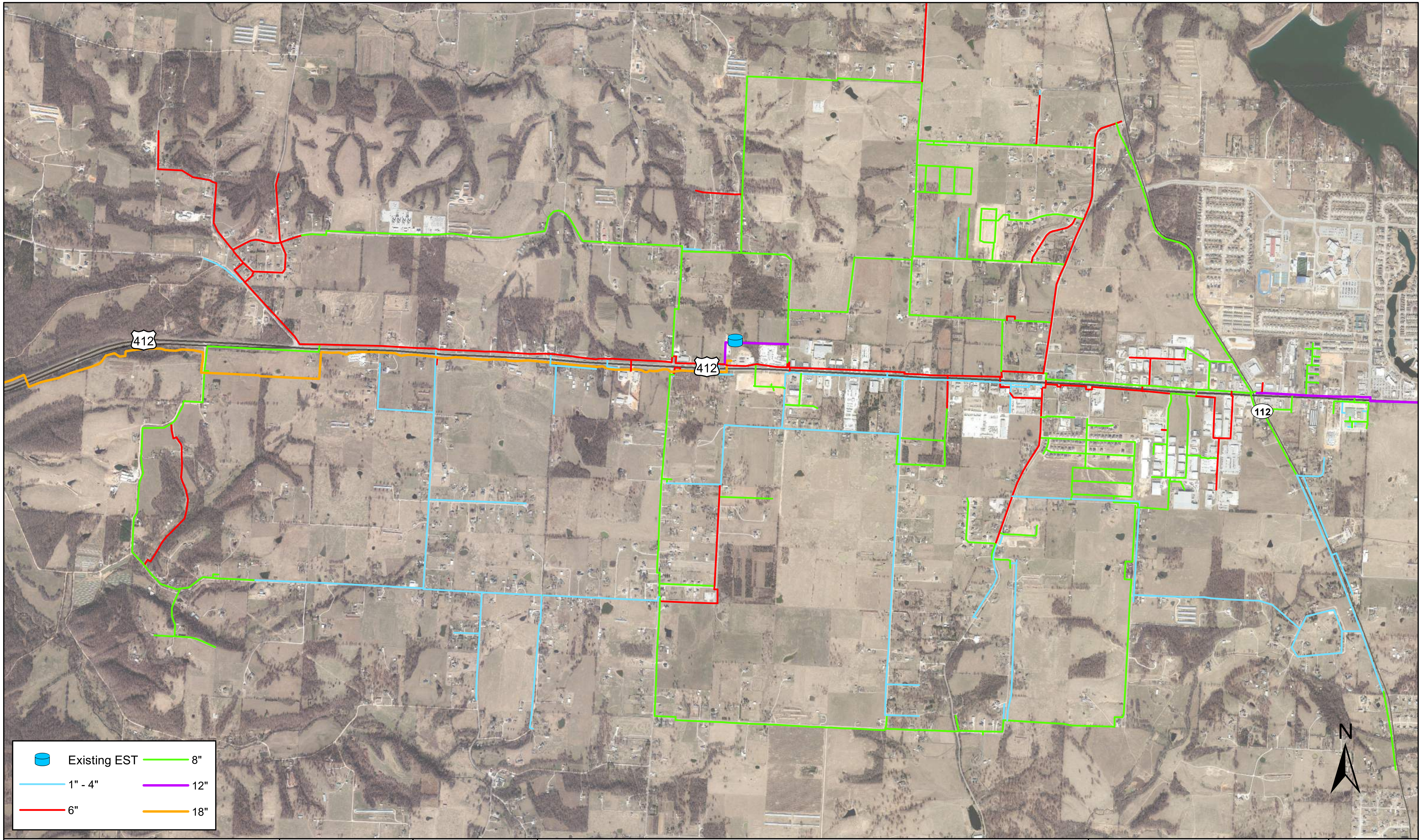
5.4.4 Maximum Velocity

The results for the maximum velocities within the distribution system indicate that there are a few segments of pipe that lie within the 4 – 5 ft/s and 5 – 8 ft/s range. Pipe velocities in these areas may need to be re-evaluated as development progresses throughout the water system. There are also pipes around the proposed GST that reach velocities exceeding 8 ft/s. These pipes may need to be upsized depending on the layout of the facilities.

APPENDIX A

Existing System Map and Scenario Improvements

Exhibits



EXISTING DISTRIBUTION SYSTEM

Figure Number: **EXHIBIT 1**

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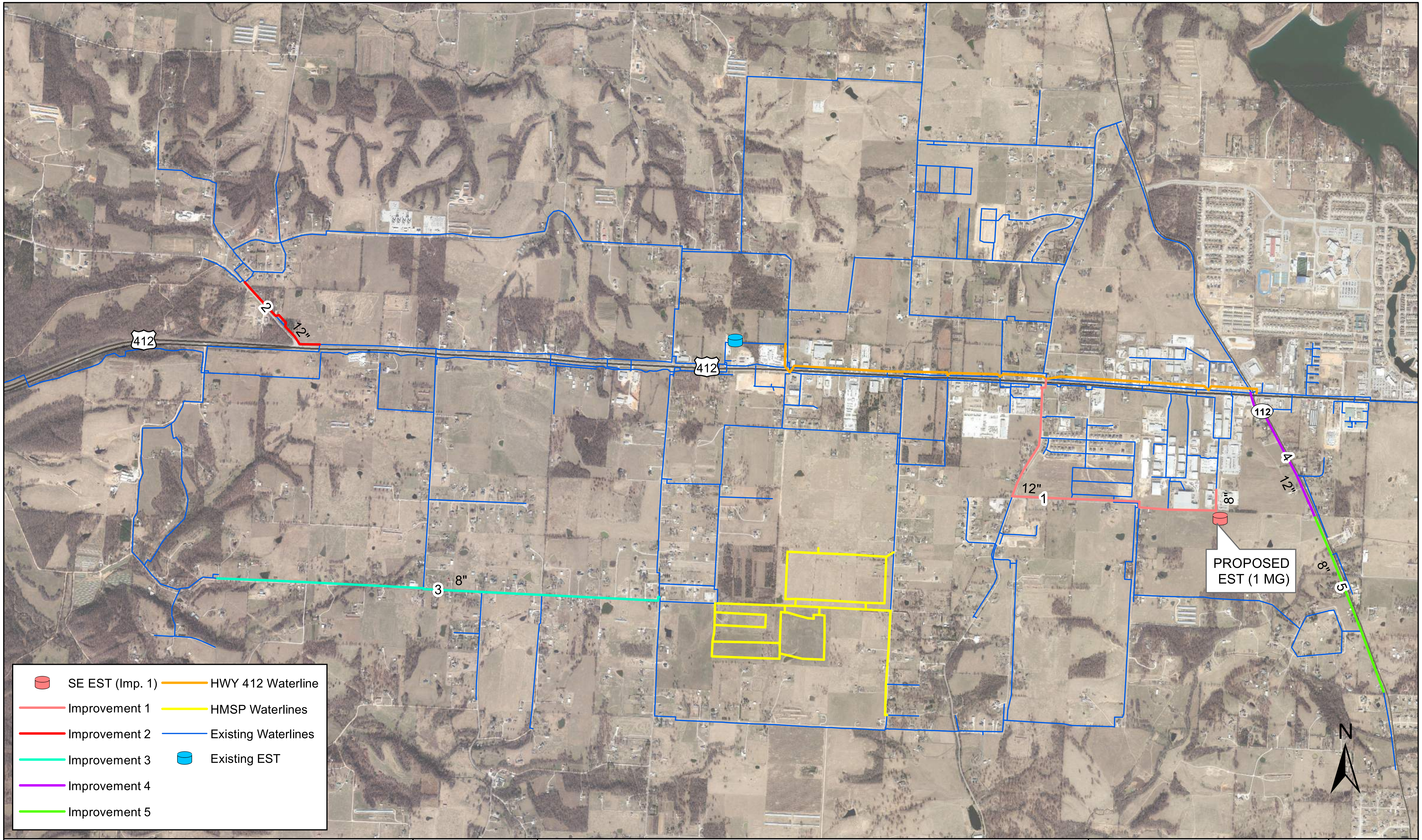

2025 IMPROVEMENTS MAP

Figure Number: **EXHIBIT 2**

BAR IS ONE INCH ON ORIGINAL DRAWING

1"

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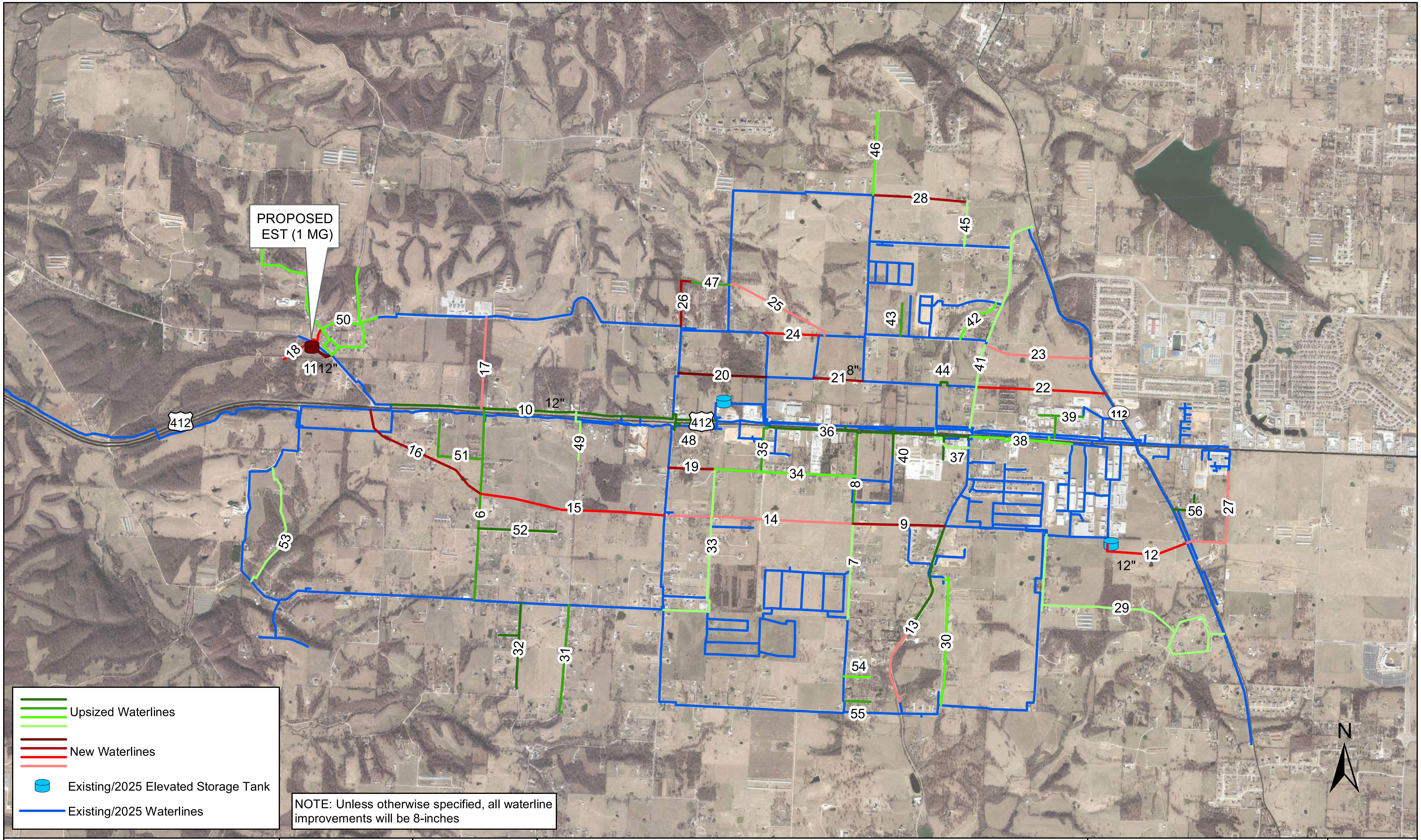

NOTE: Unless otherwise specified, all waterline improvements will be 8-inches

2040 IMPROVEMENTS MAP

Figure Number: **EXHIBIT 3**

BAR IS ONE INCH ON ORIGINAL DRAWING

1"

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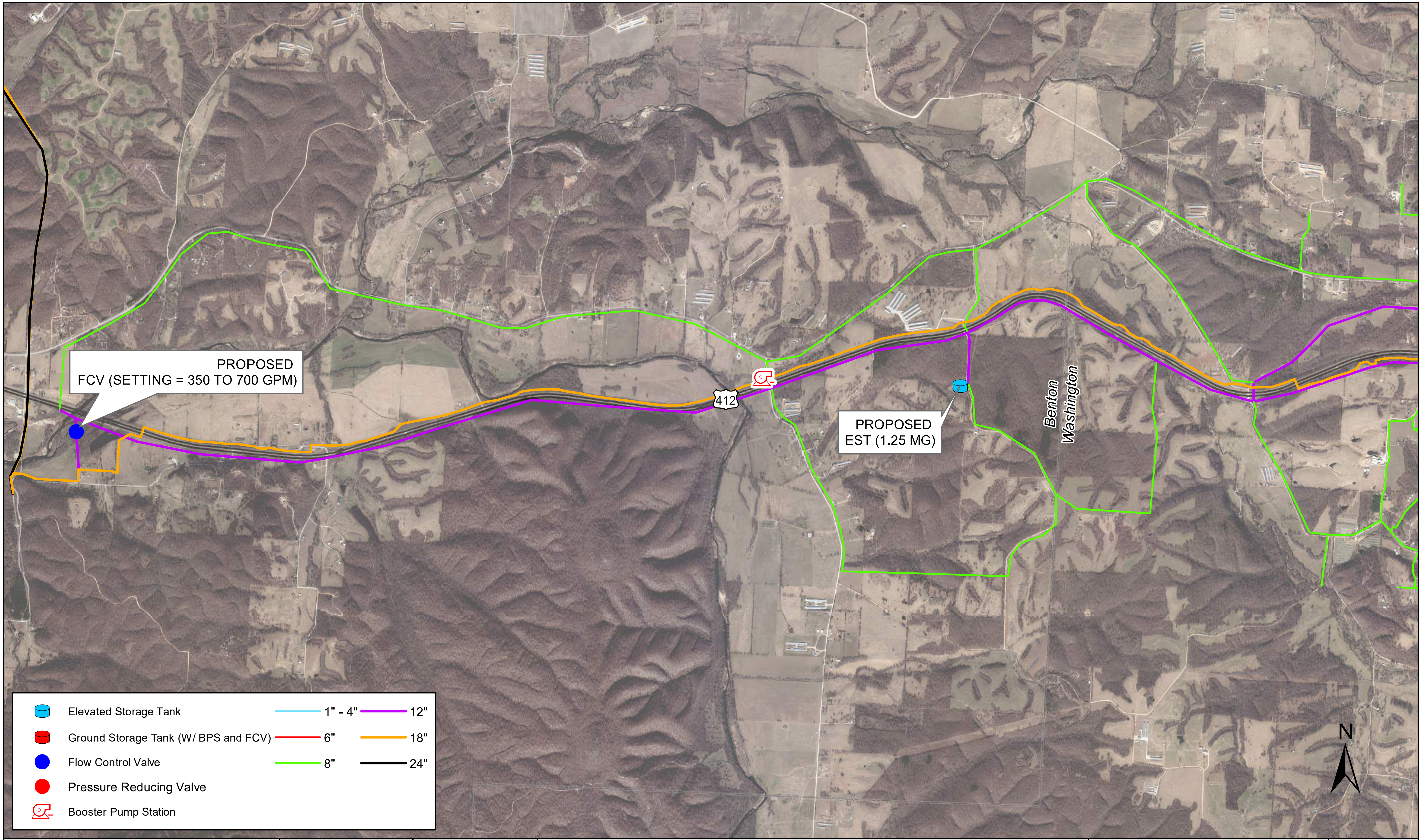

EAST/WEST SUPPLY BUILDOUT MAP (1 OF 2)

Figure Number: **EXHIBIT 4**

BAR IS ONE INCH ON ORIGINAL DRAWING

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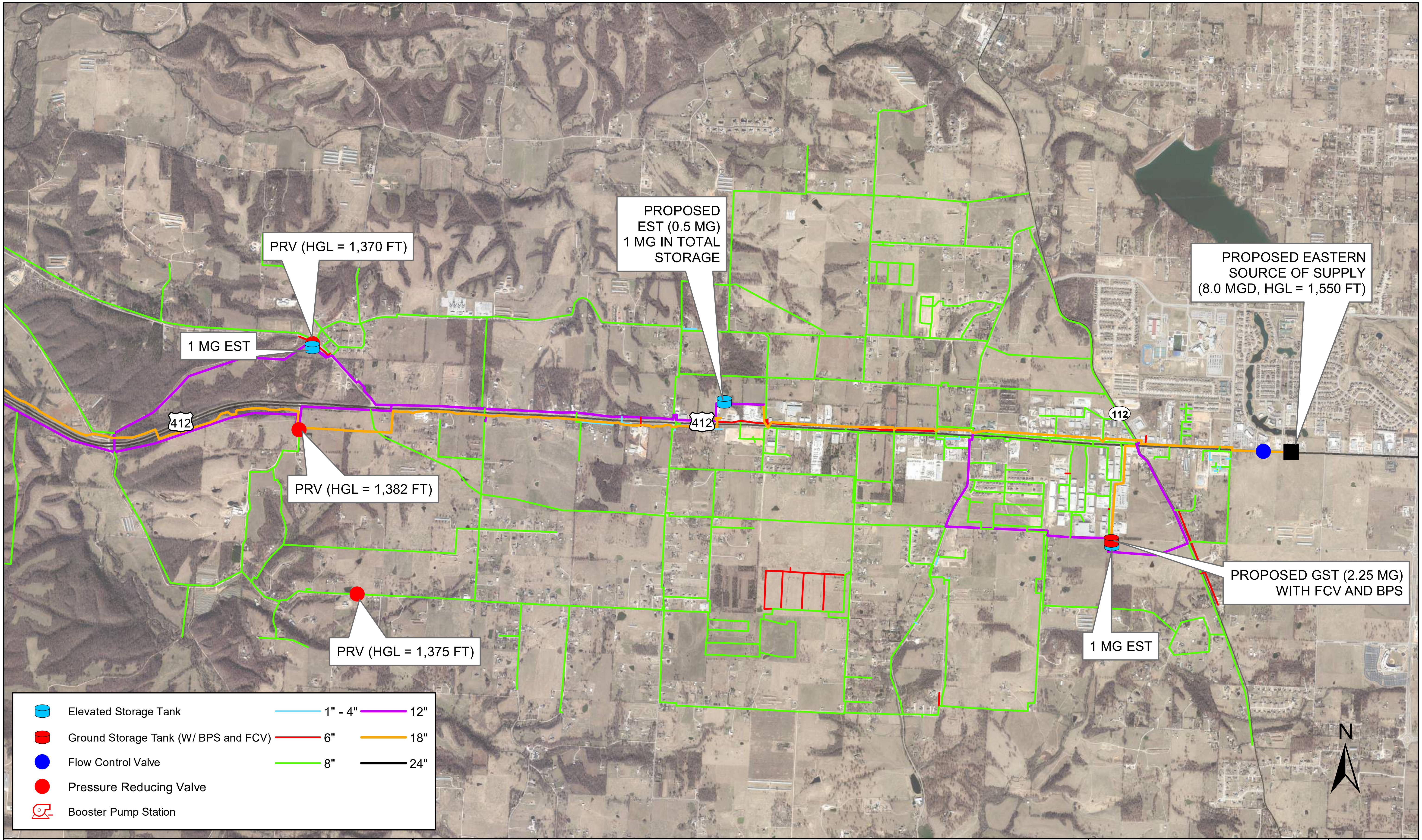

EAST/WEST SUPPLY BUILDOUT MAP (2 OF 2)

Figure Number: **EXHIBIT 5**

BAR IS ONE INCH ON ORIGINAL DRAWING

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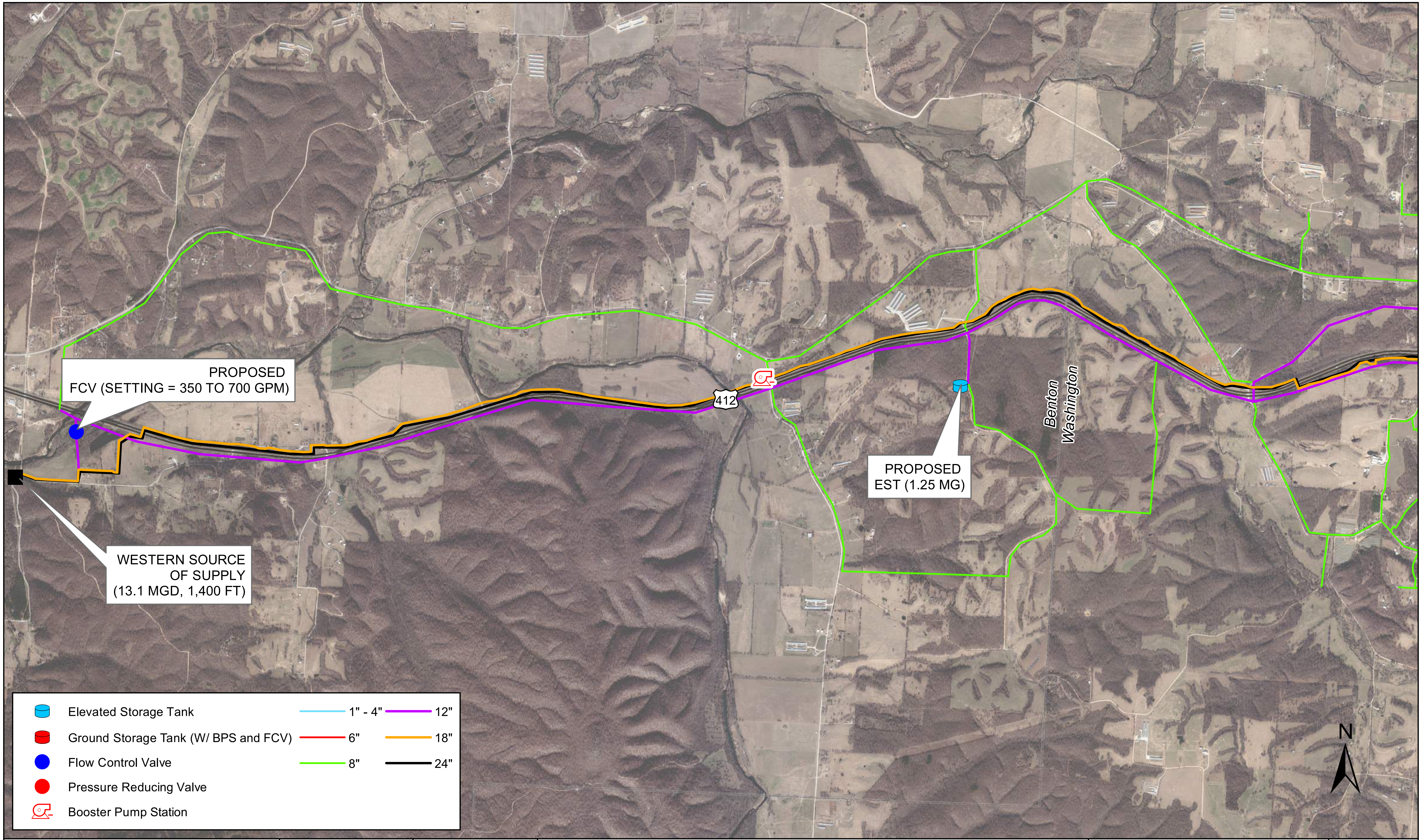

BWRPWA SUPPLY BUILDOUT MAP
(1 OF 2)

Figure Number: **EXHIBIT 6**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

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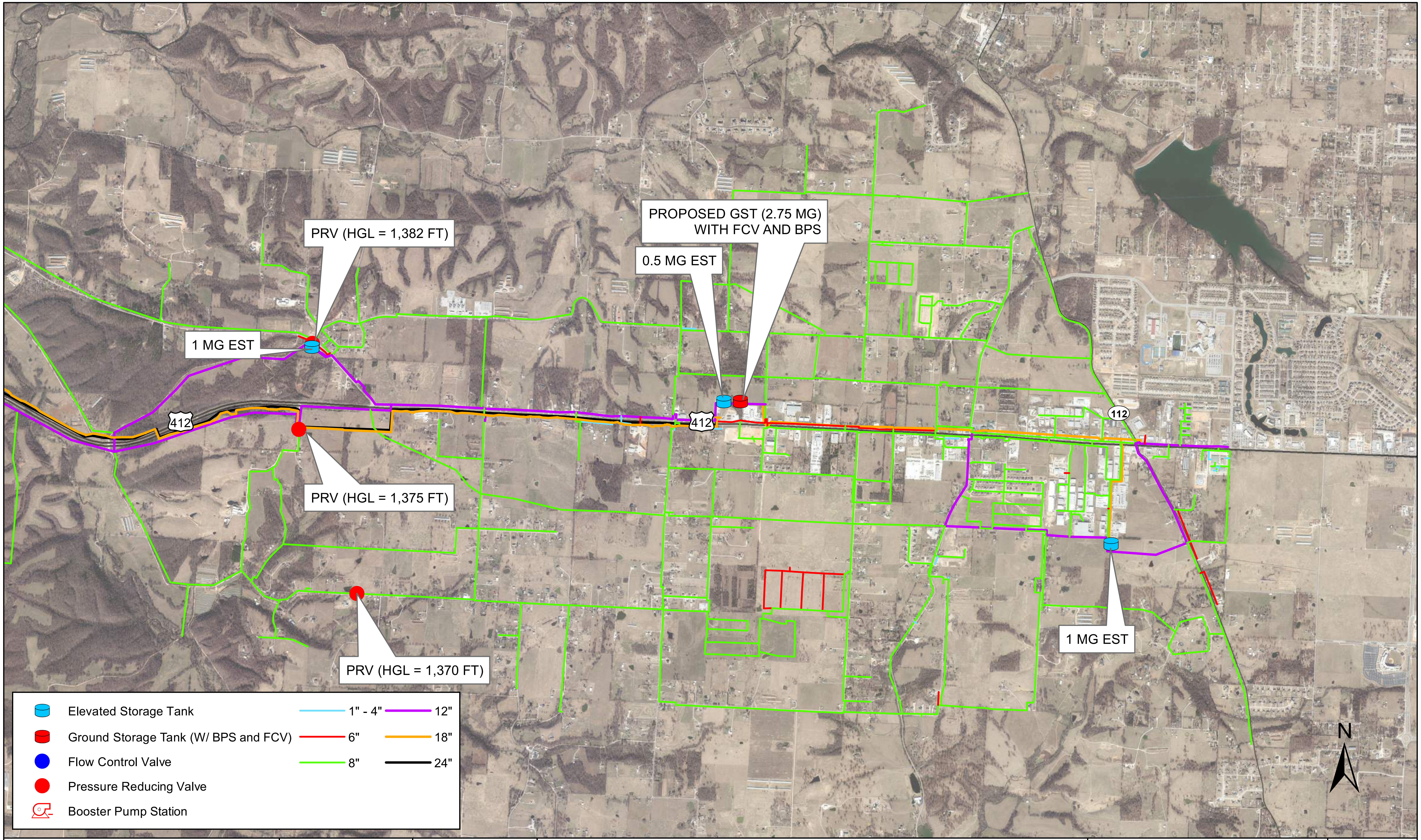

BWRPWA SUPPLY BUILDOUT MAP (2 OF 2)

Figure Number: **EXHIBIT 7**

BAR IS ONE INCH ON
ORIGINAL DRAWING

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APPENDIX B
2025 Scenario Results

Exhibits

Exhibit 1: Available Fire Flow (ADD)

Exhibit 2: Available Fire Flow (MDD)

Exhibit 3: Minimum Pressure (ADD)

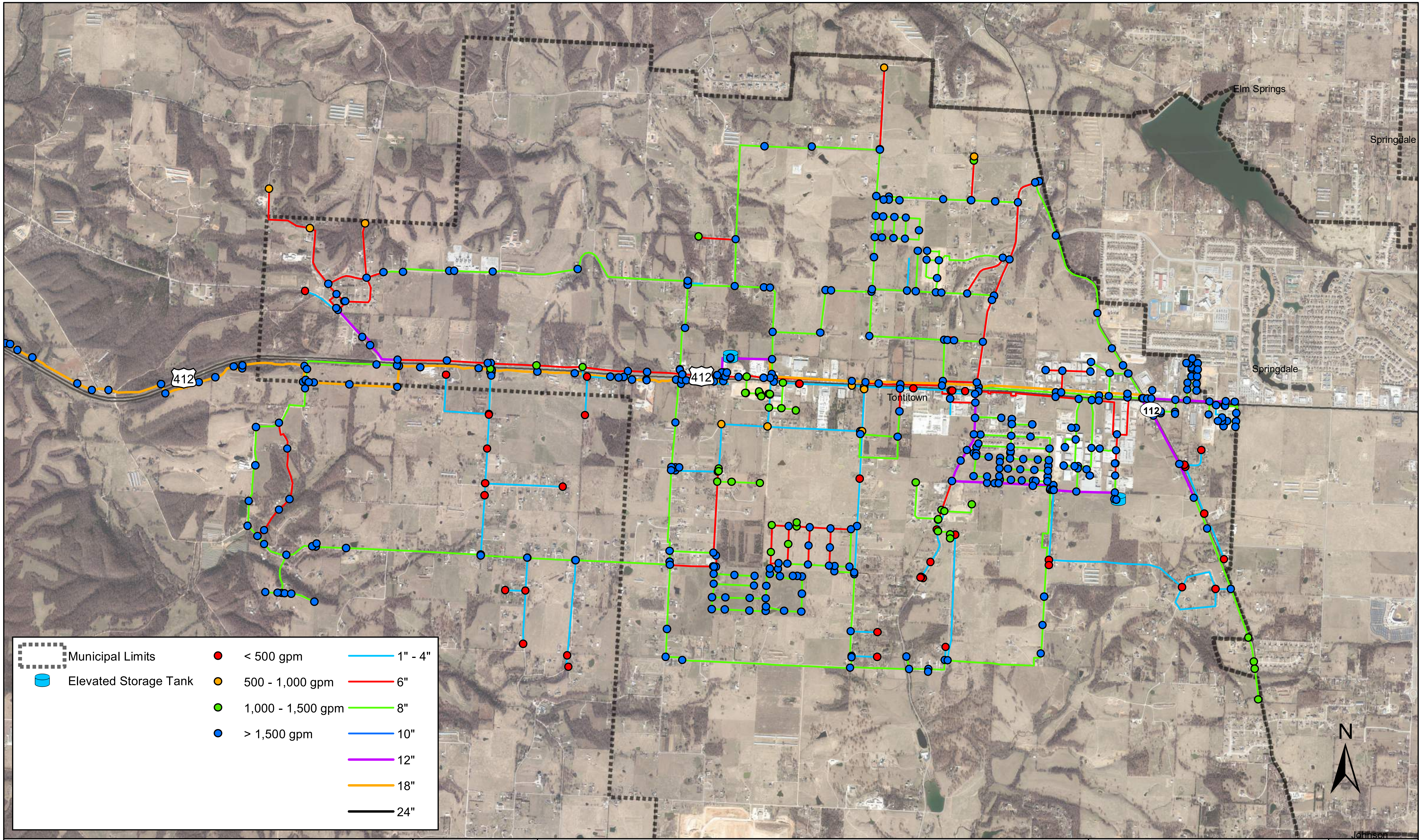
Exhibit 4: Minimum Pressure (MDD)

Exhibit 5: Maximum Pressure (ADD)

Exhibit 6: Maximum Pressure (MDD)

Exhibit 7: Maximum Velocity (ADD)

Exhibit 8: Maximum Velocity (MDD)



2025 AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1**

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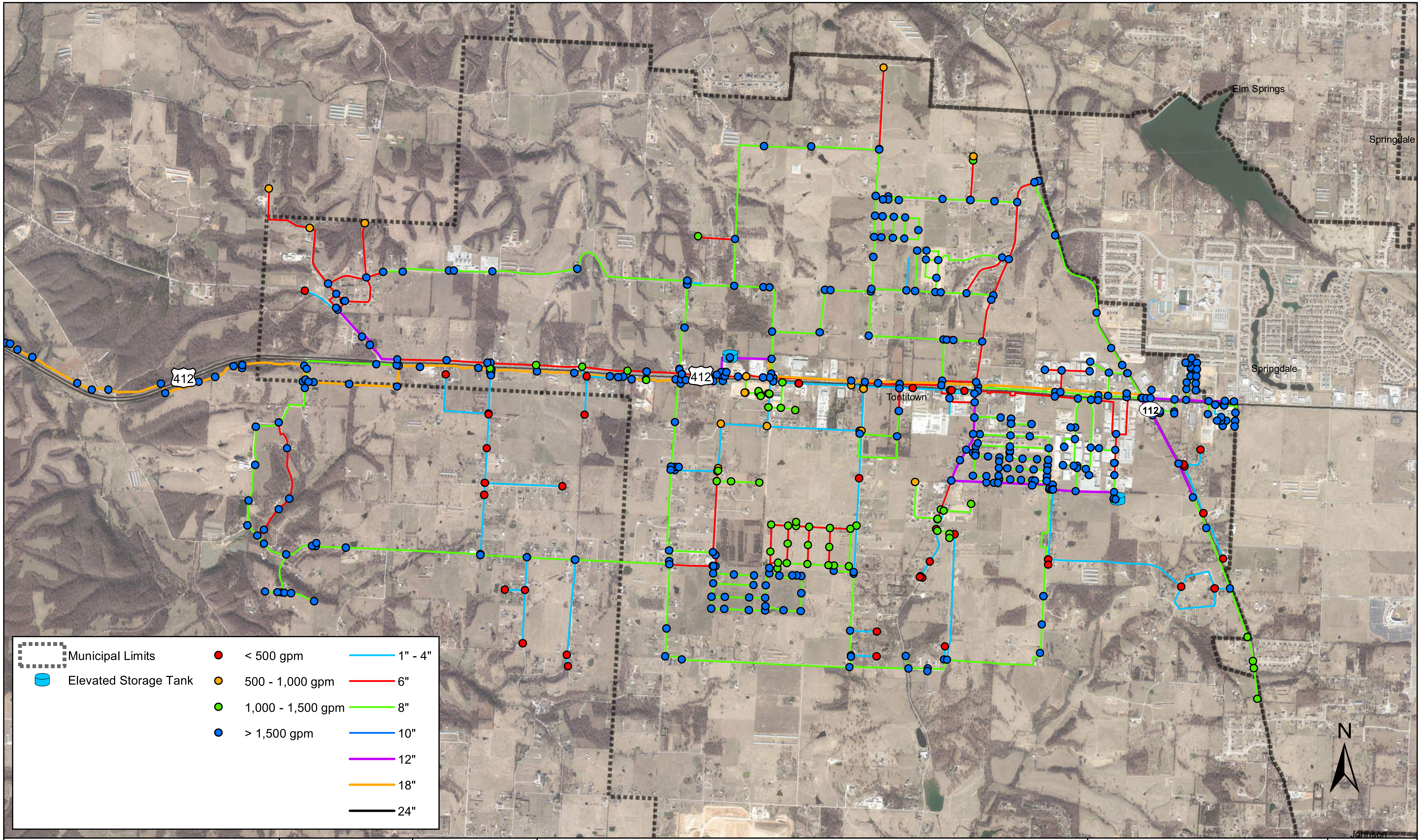

2025 AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2**

BAR IS ONE INCH ON
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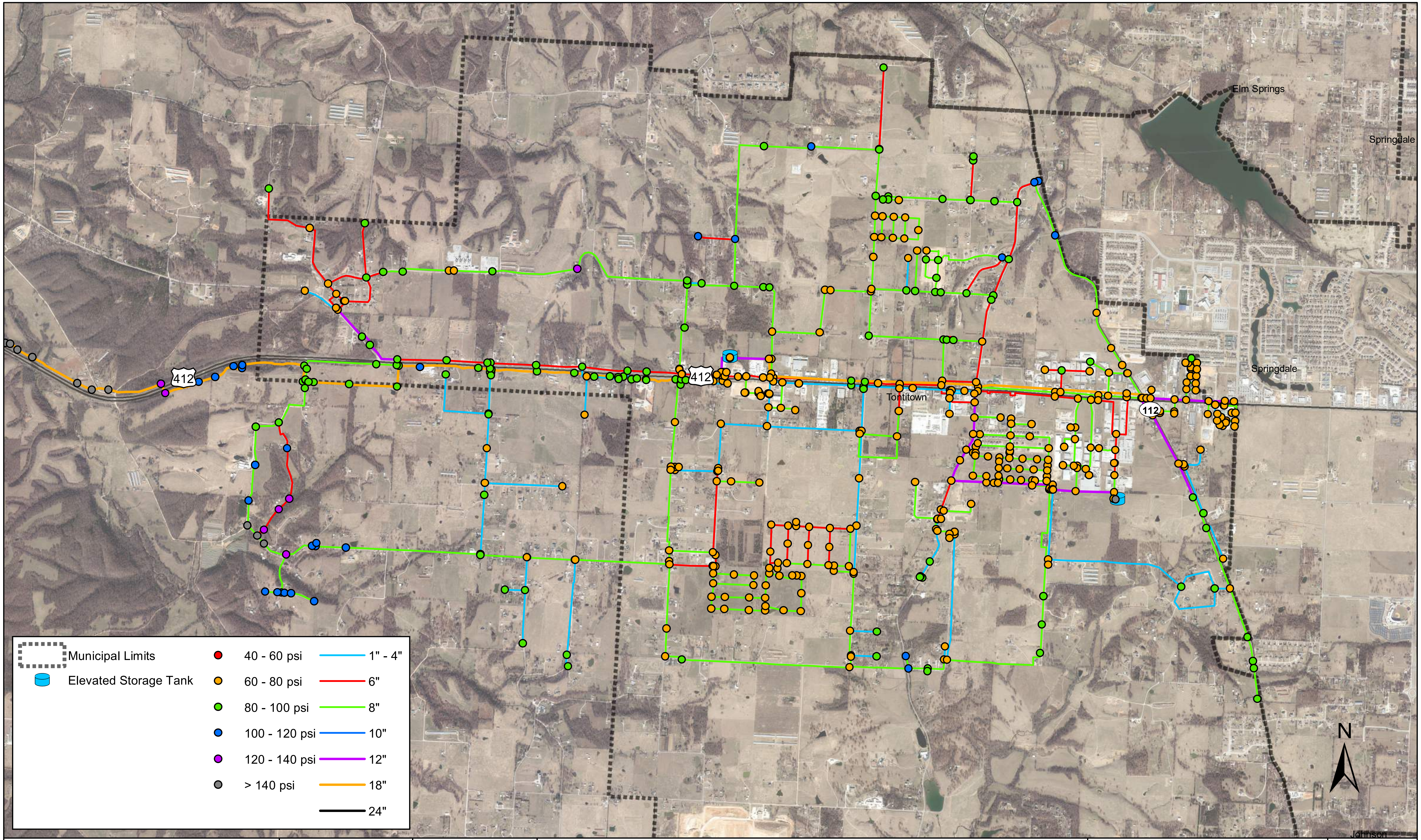

2025 MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3**

BAR IS ONE INCH ON ORIGINAL DRAWING

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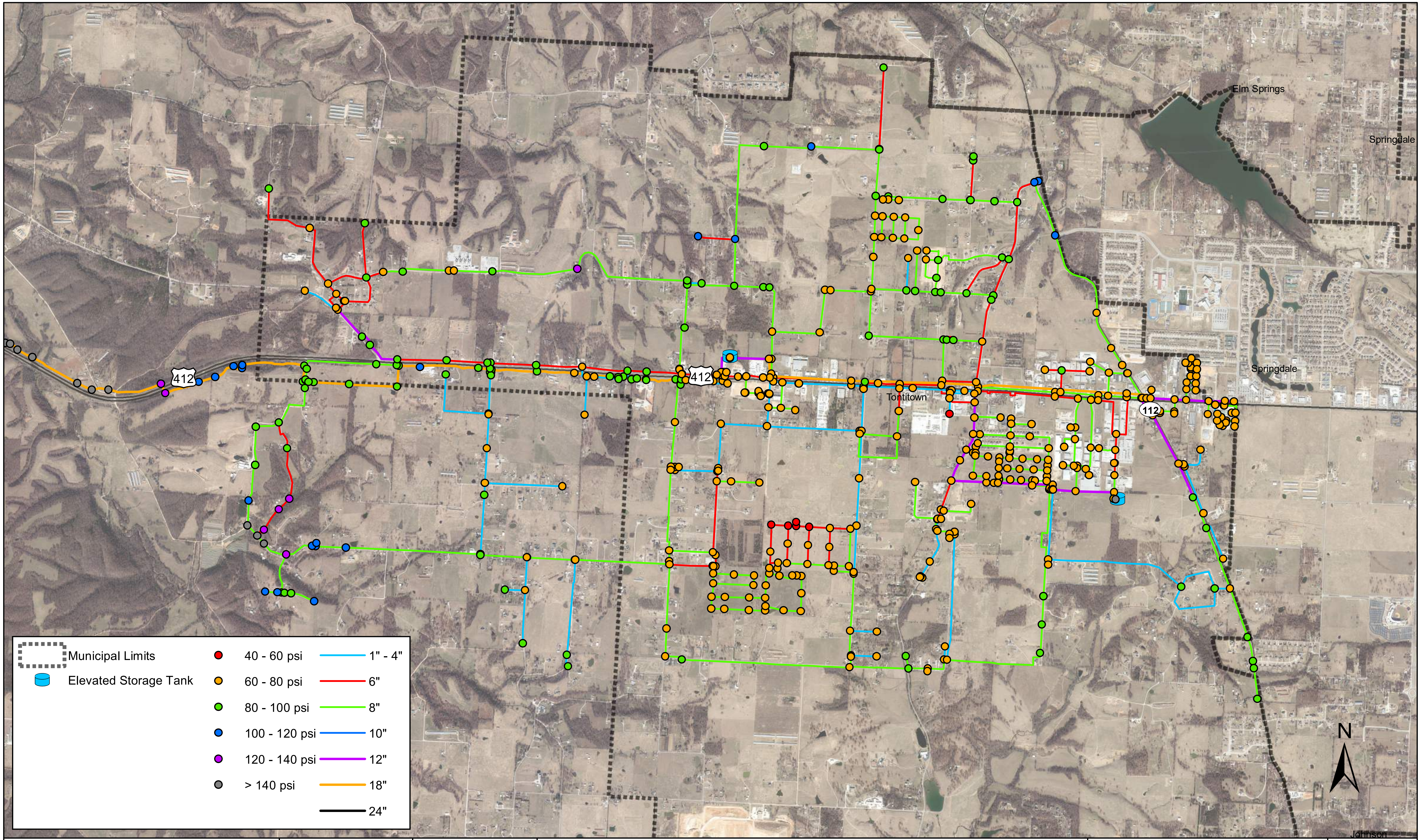

2025 MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4**

BAR IS ONE INCH ON
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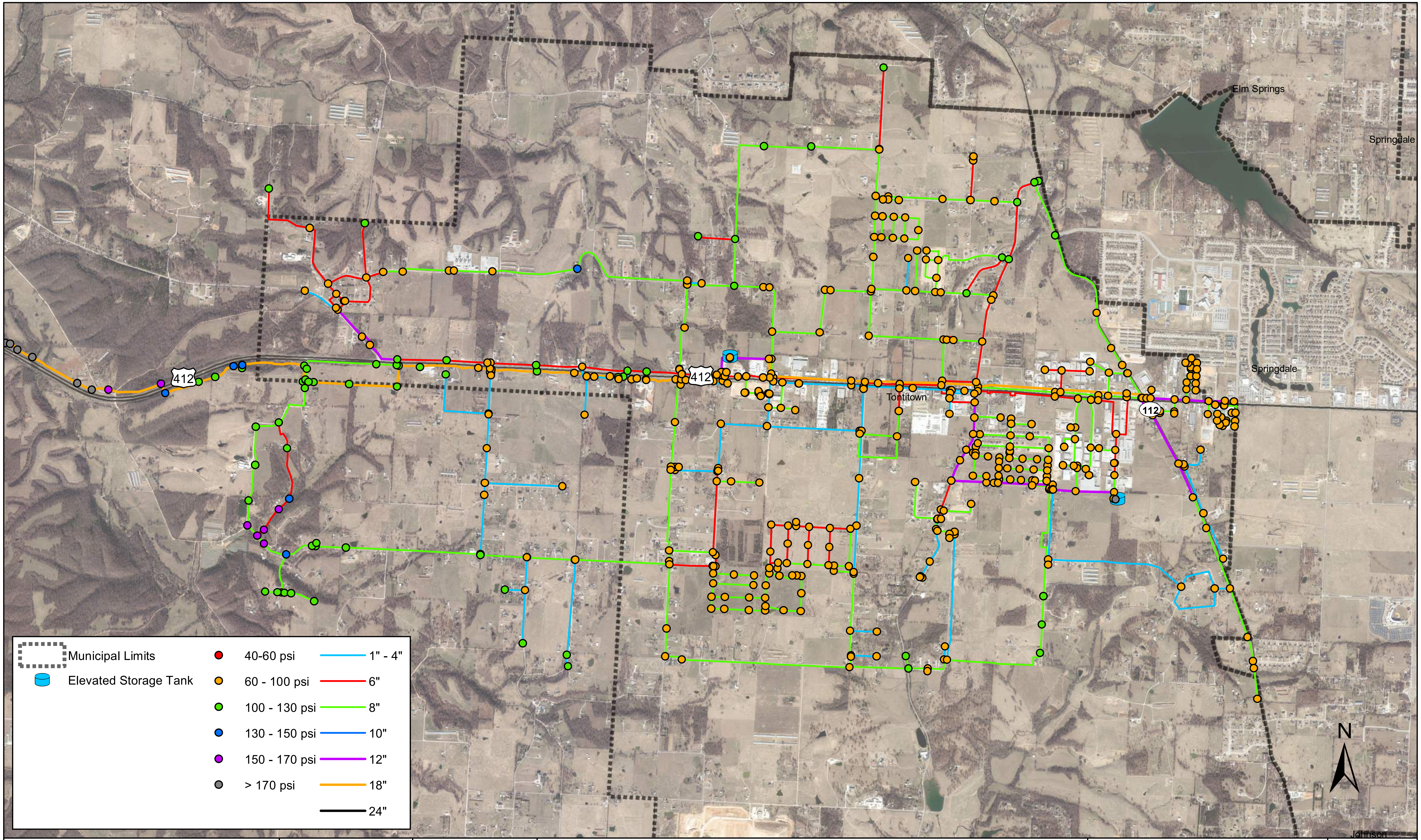

2025 MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5**

BAR IS ONE INCH ON
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1"

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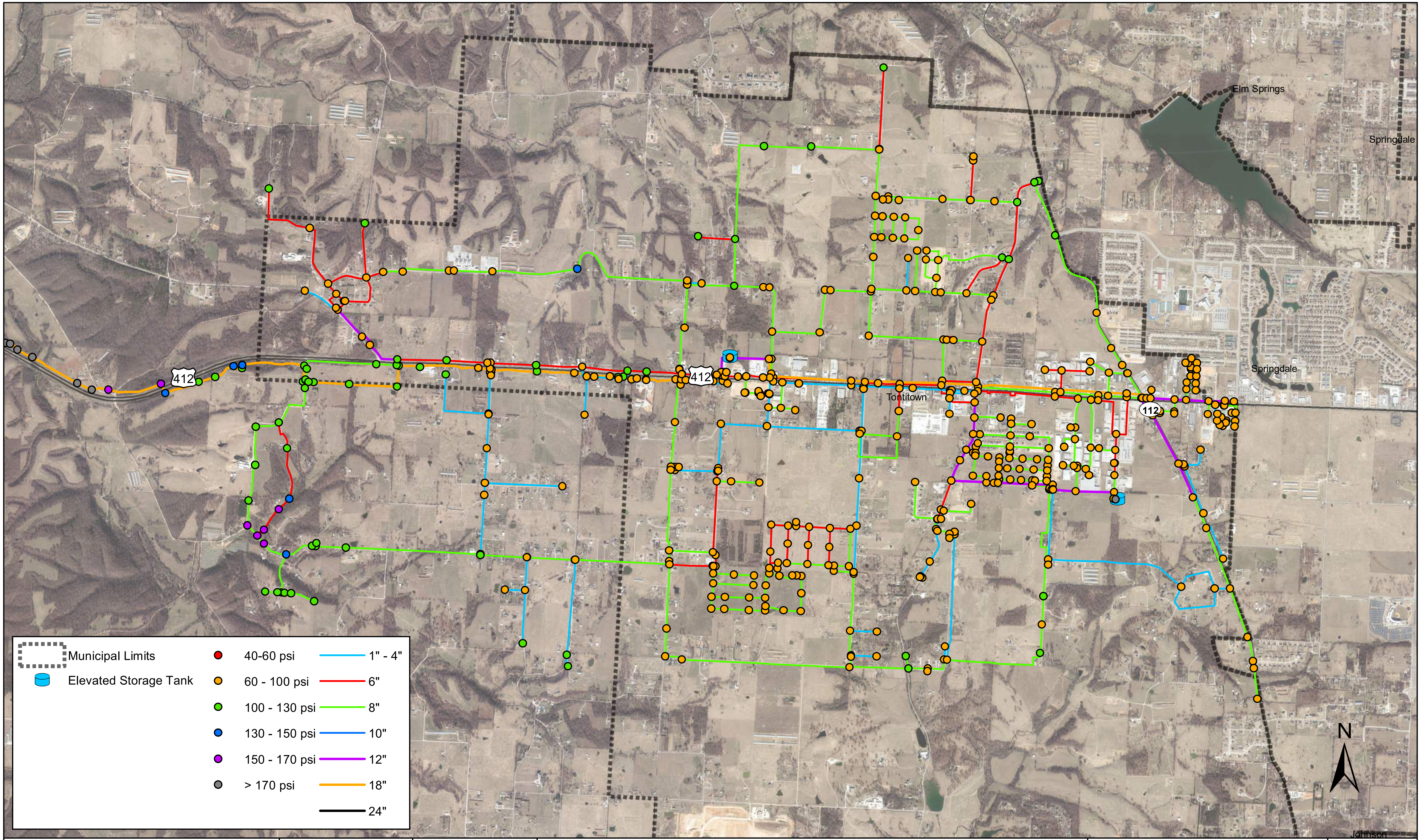

2025 MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6**

BAR IS ONE INCH ON
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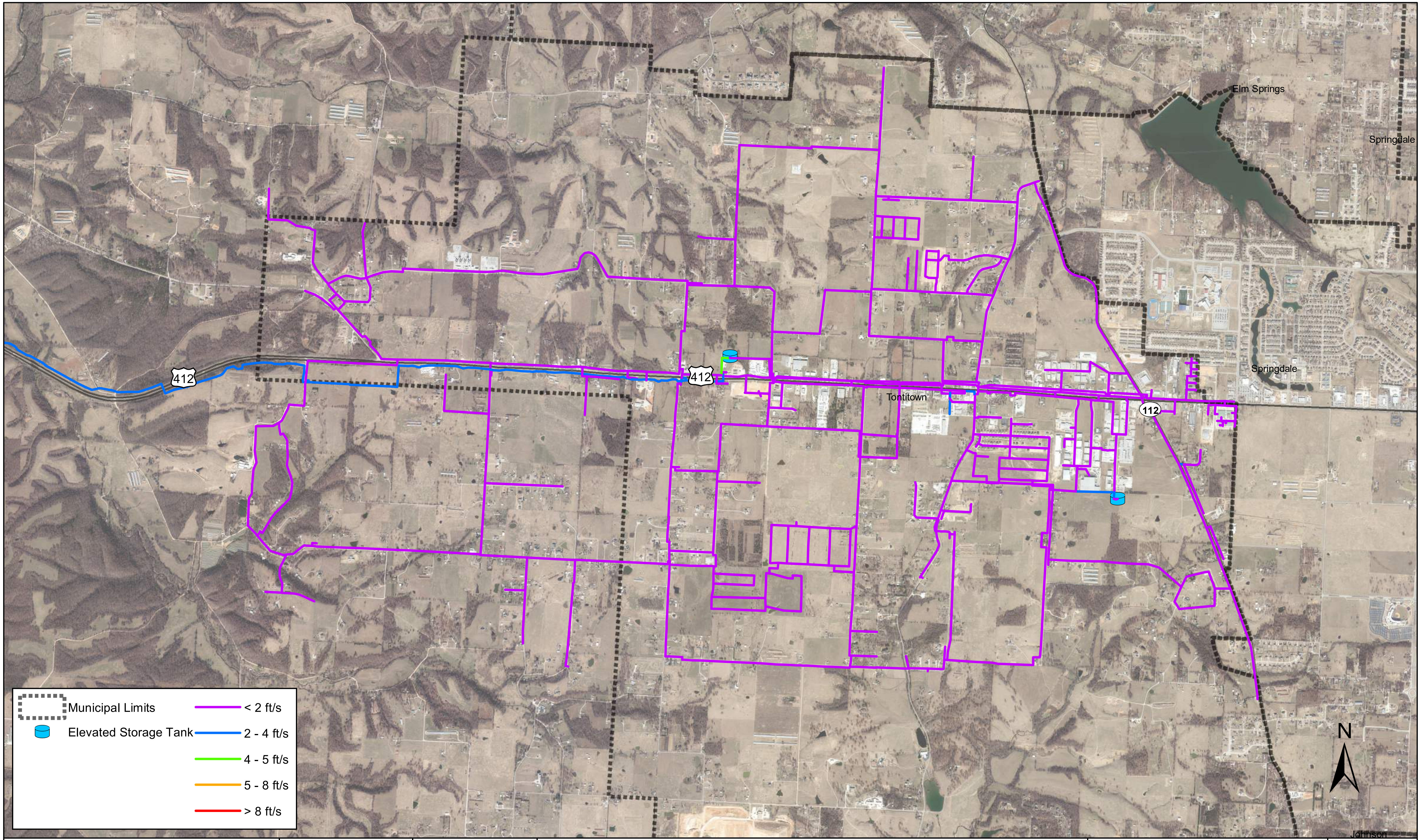

2025 MAXIMUM VELOCITY (ADD)

Figure Number: **EXHIBIT 7**

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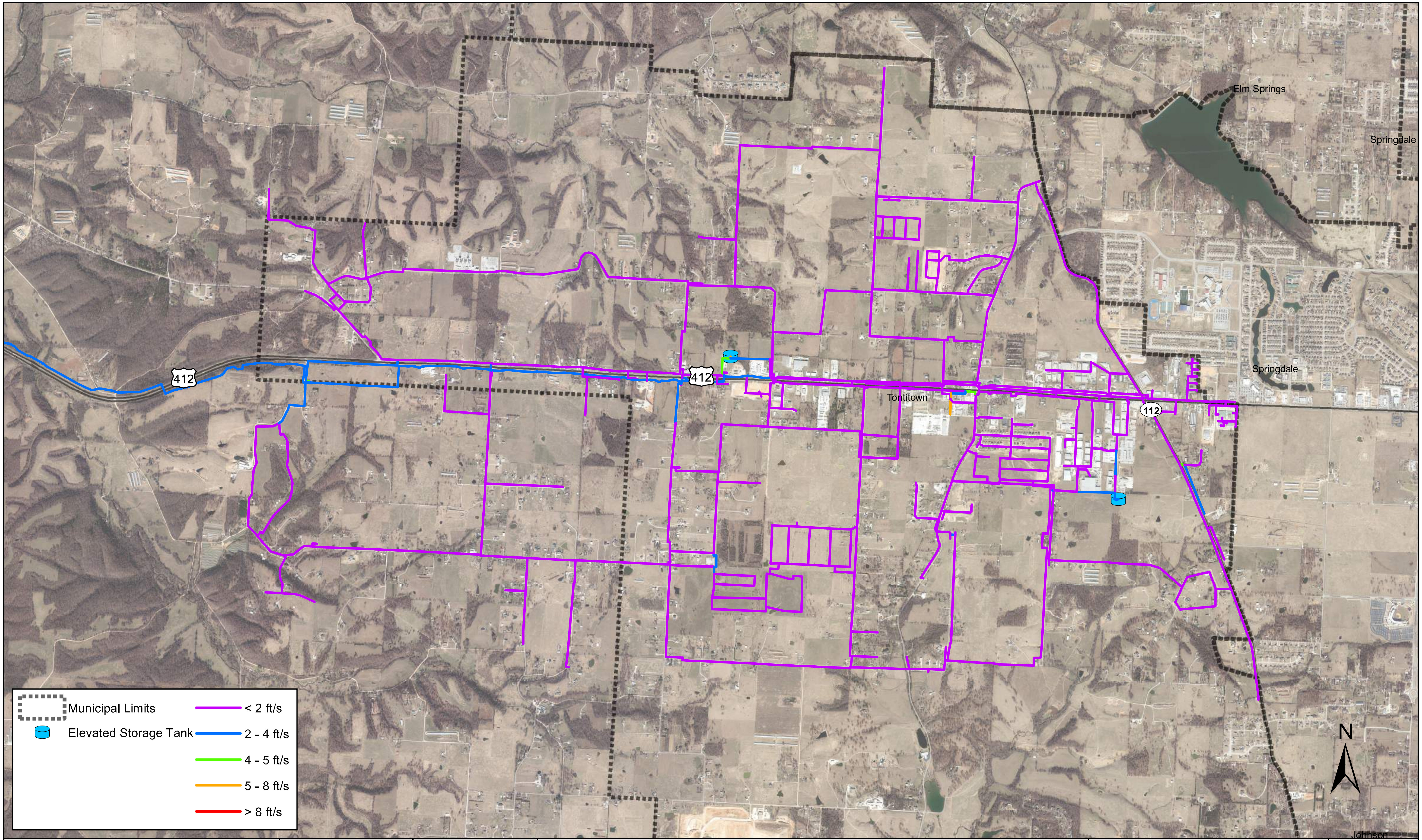

2025 MAXIMUM VELOCITY (MDD)

Figure Number: **EXHIBIT 8**

BAR IS ONE INCH ON
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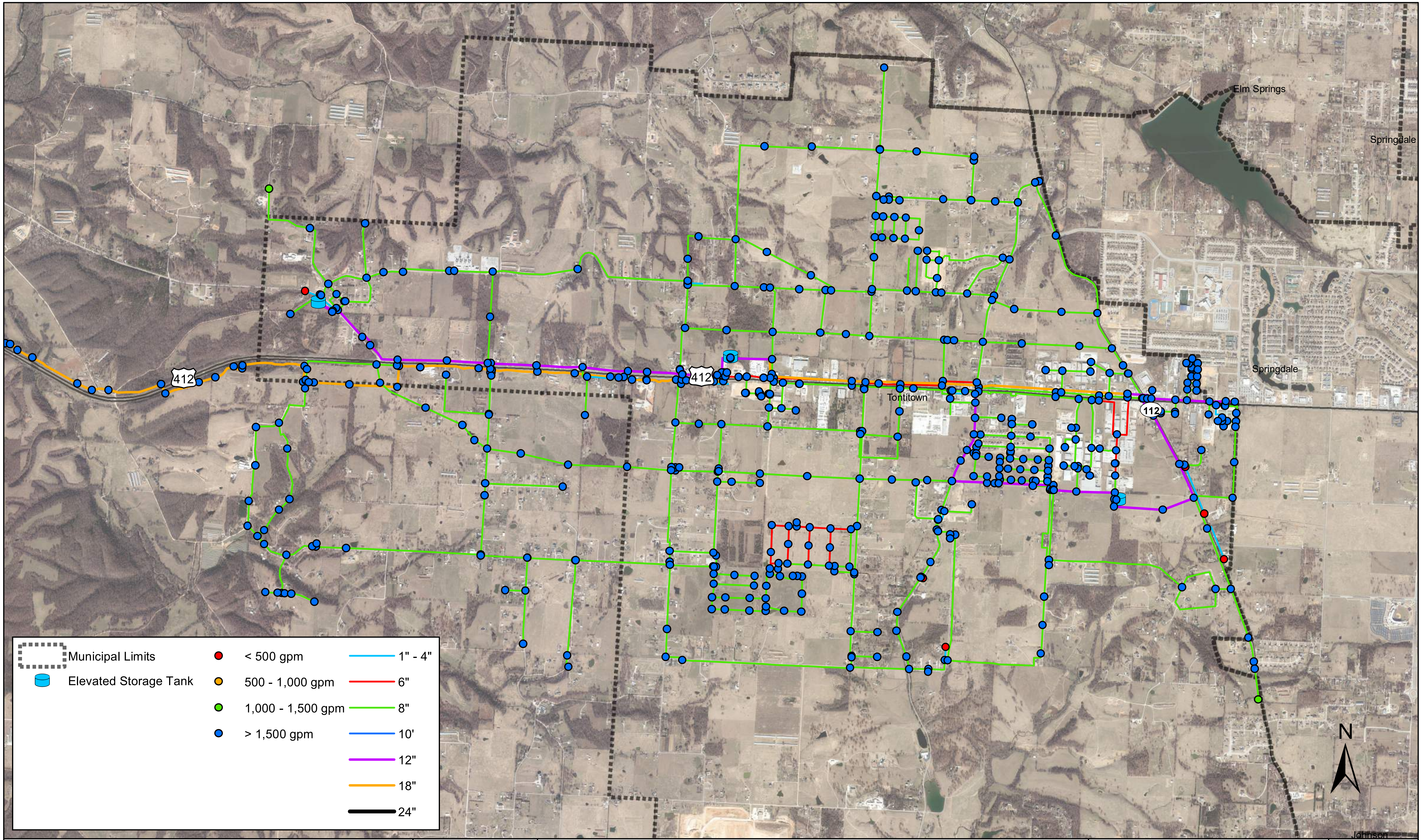
APPENDIX C

2040 Scenario Results

Exhibits



2040 AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

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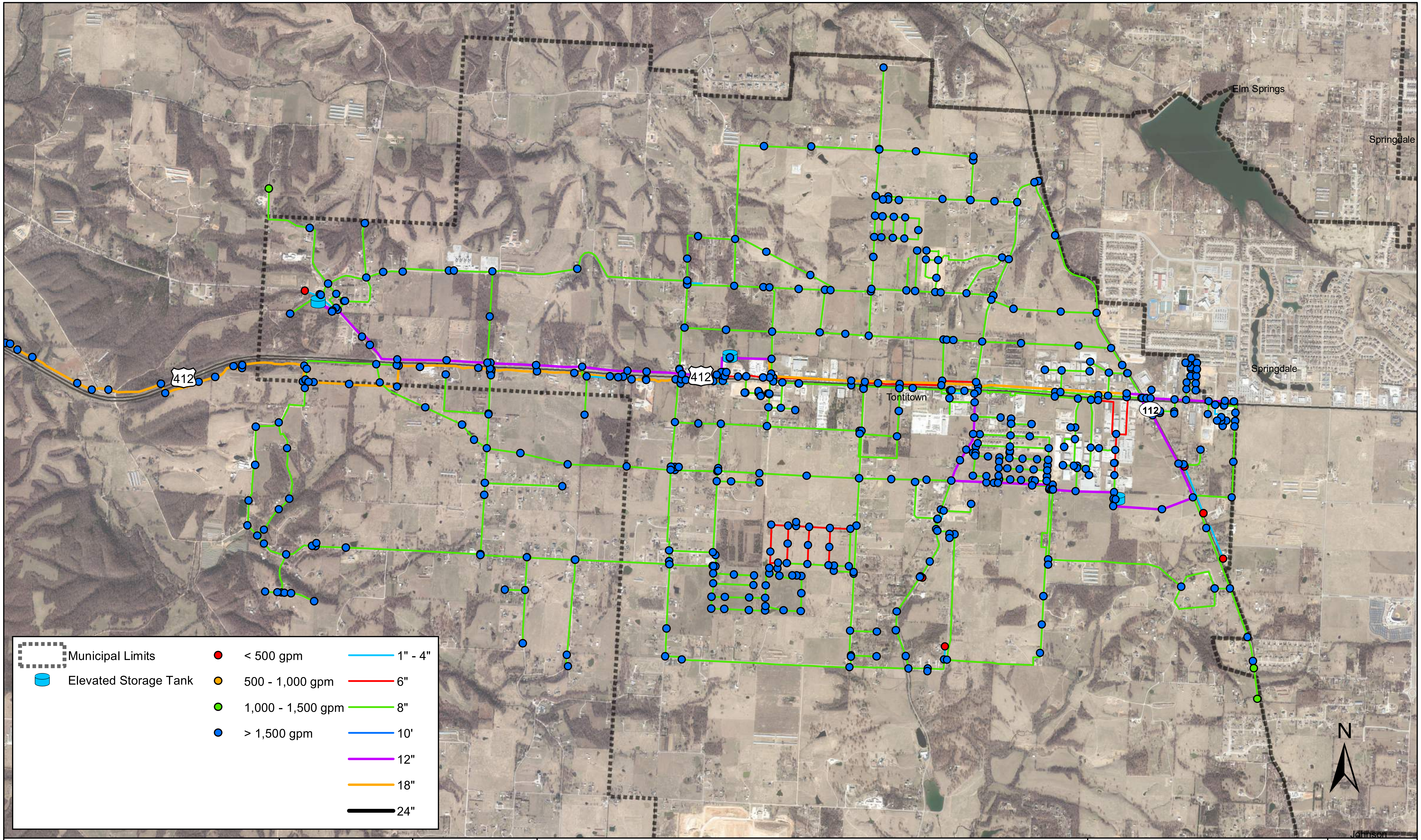

2040 AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

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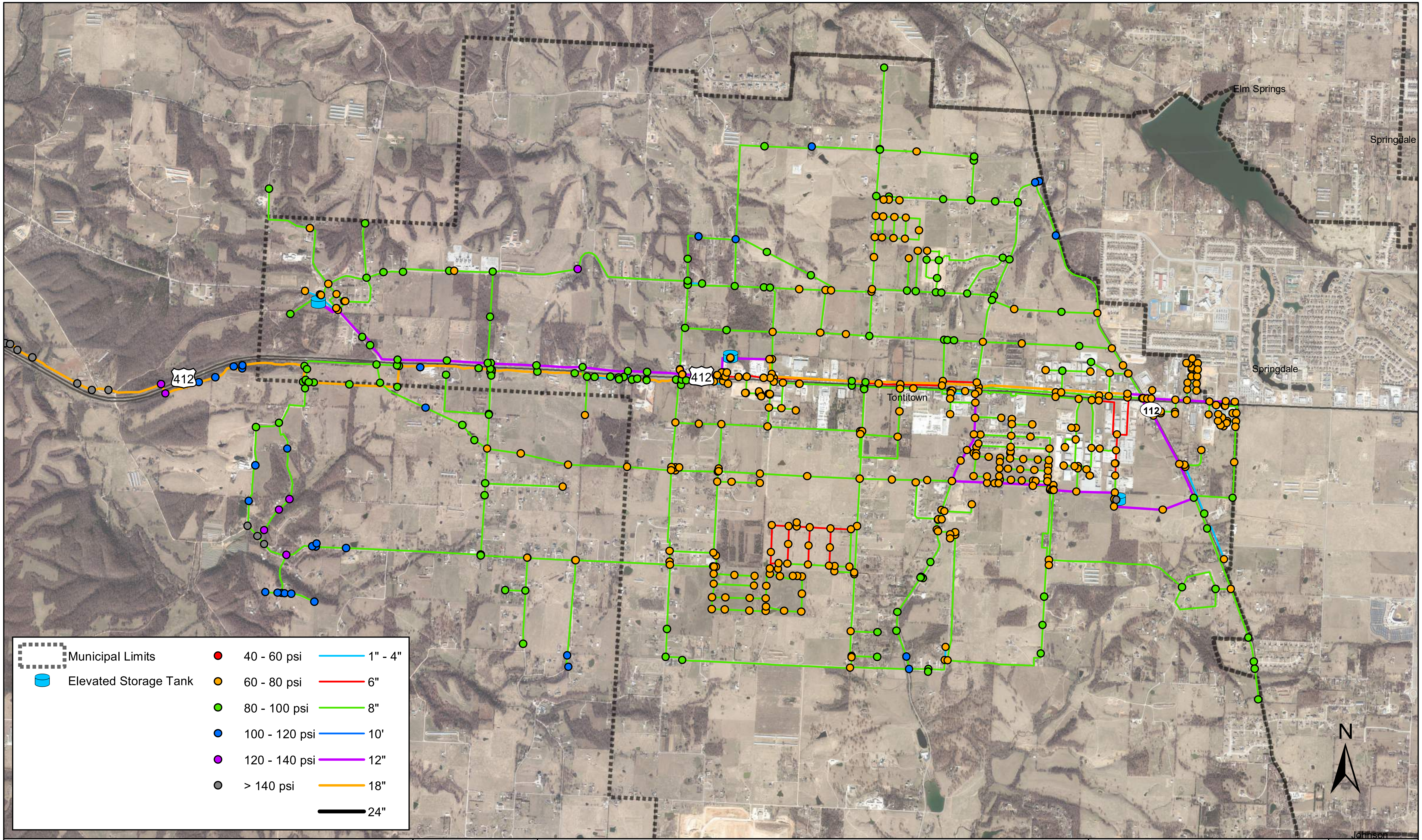

2040 MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3**

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ORIGINAL DRAWING

1"

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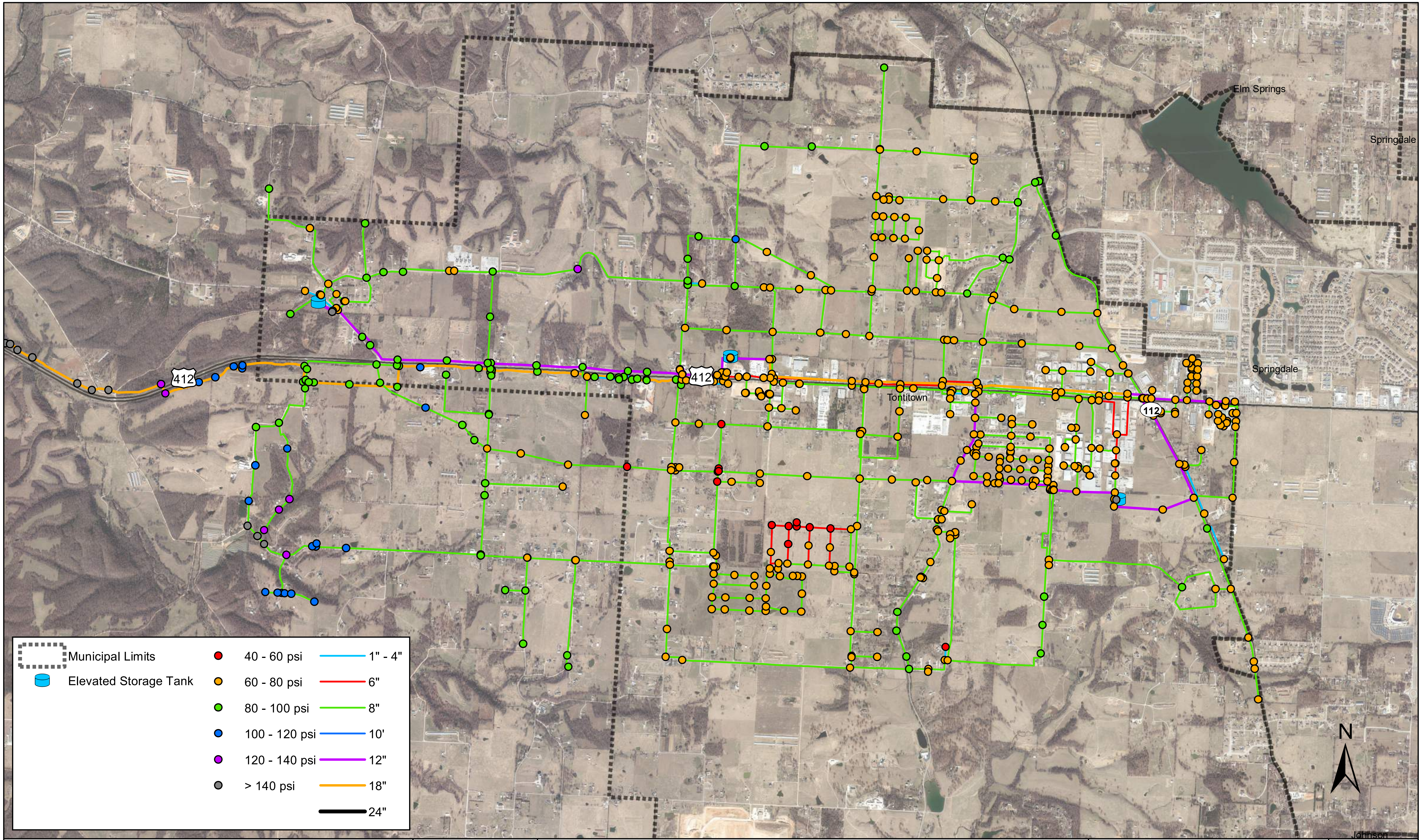

2040 MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4**

BAR IS ONE INCH ON
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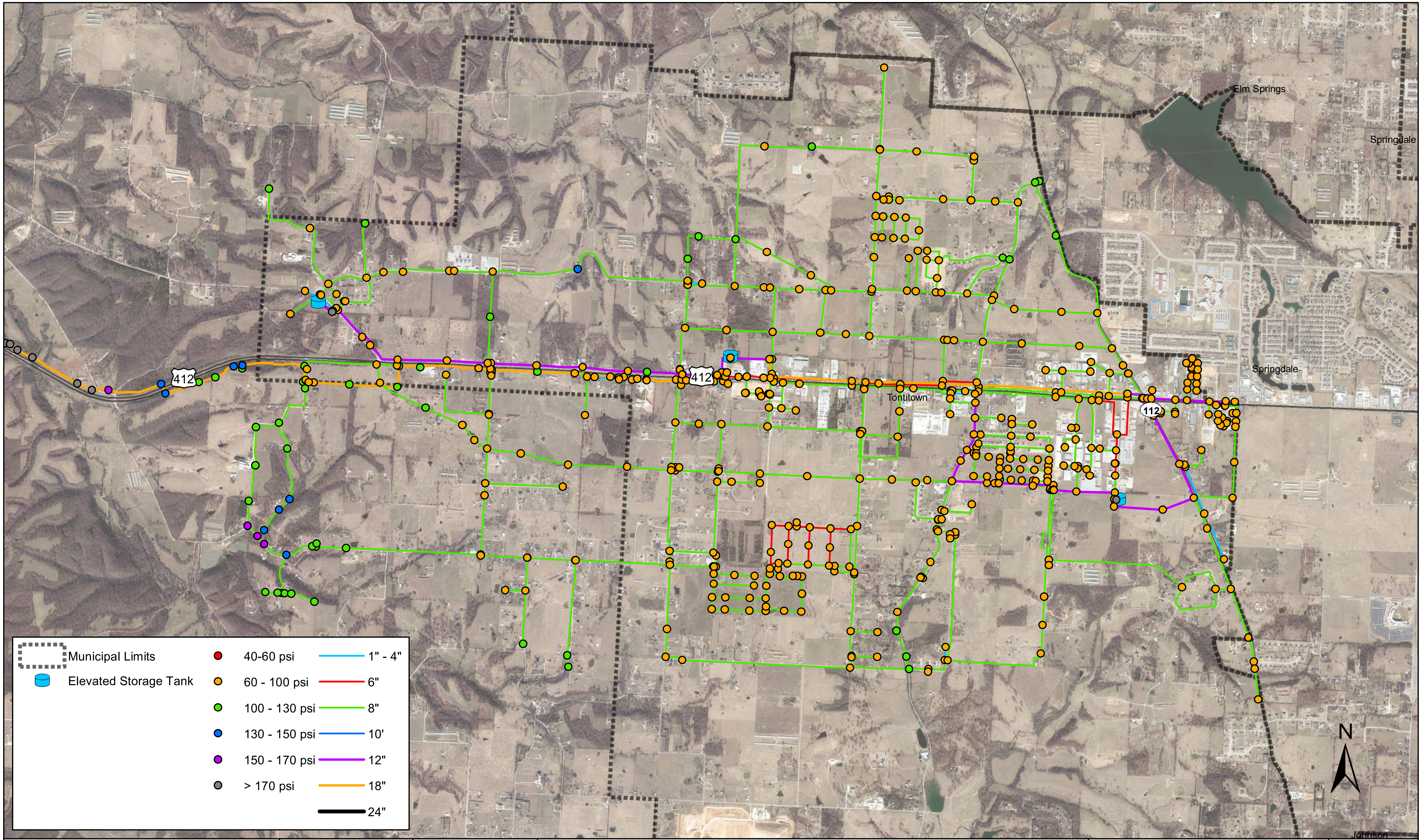

2040 MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5**

BAR IS ONE INCH ON
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1"

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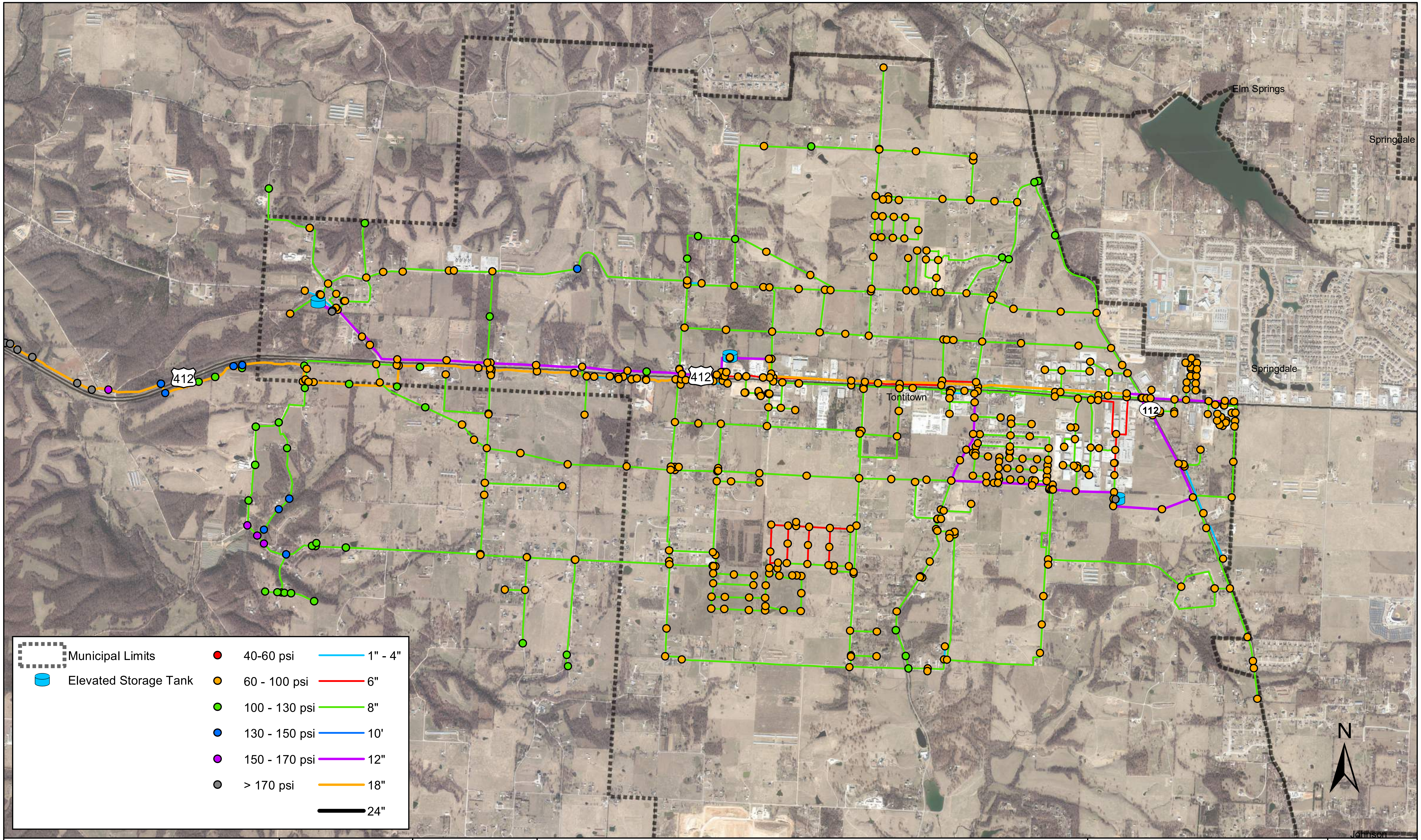

2040 MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

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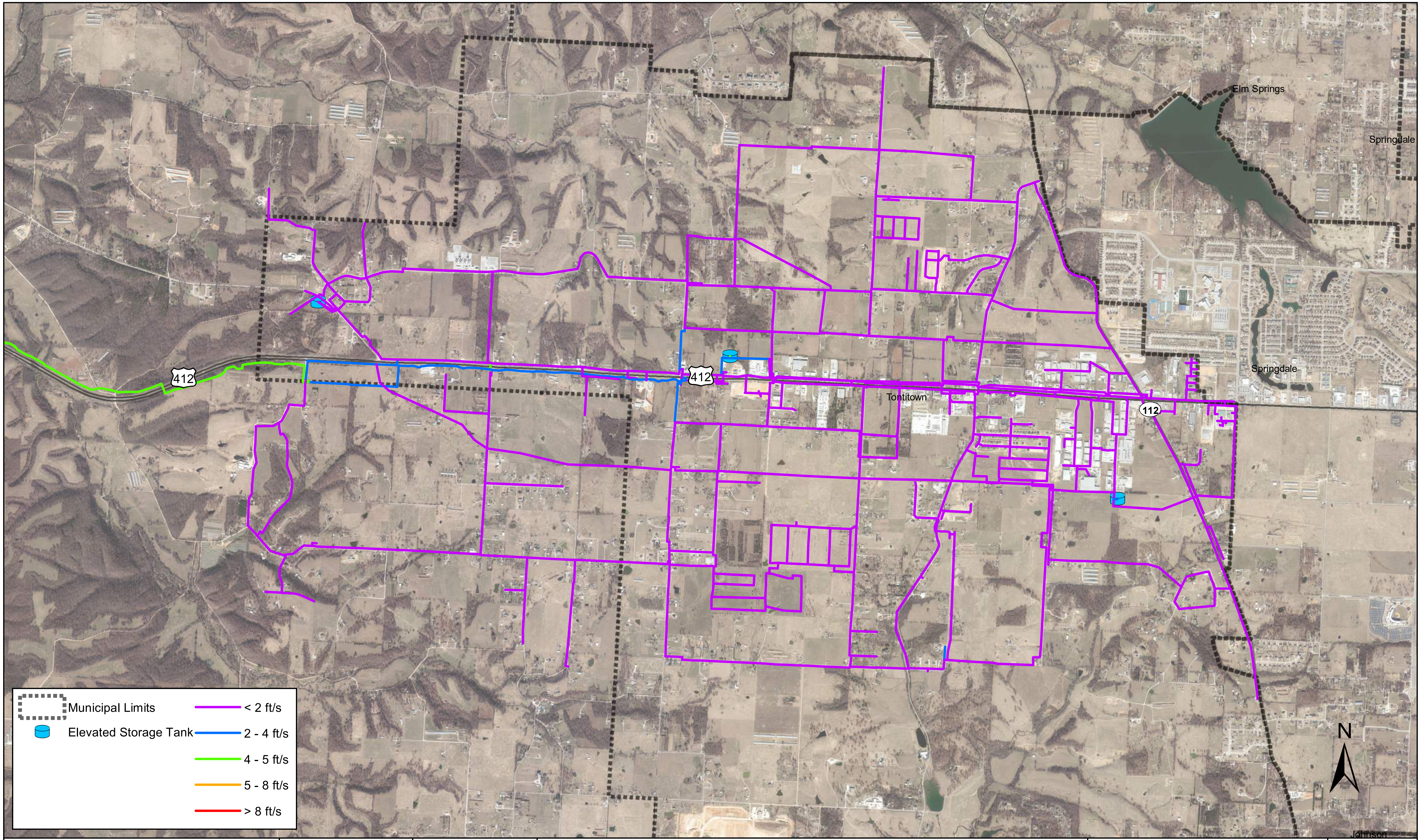

2040 MAXIMUM VELOCITY (ADD)

Figure Number: **EXHIBIT 7**

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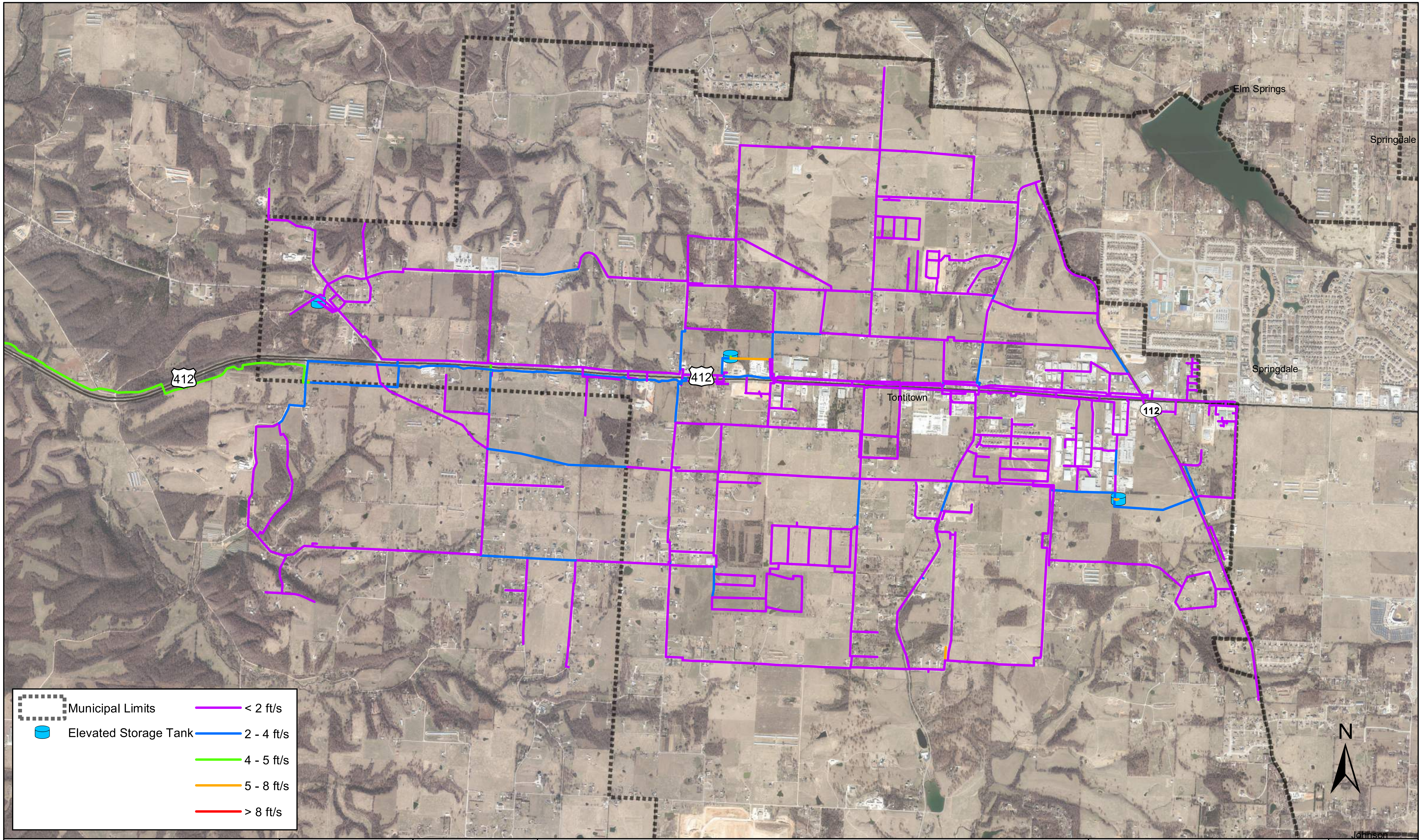

2040 MAXIMUM VELOCITY (MDD)

Figure Number: **EXHIBIT 8**

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ORIGINAL DRAWING

1"

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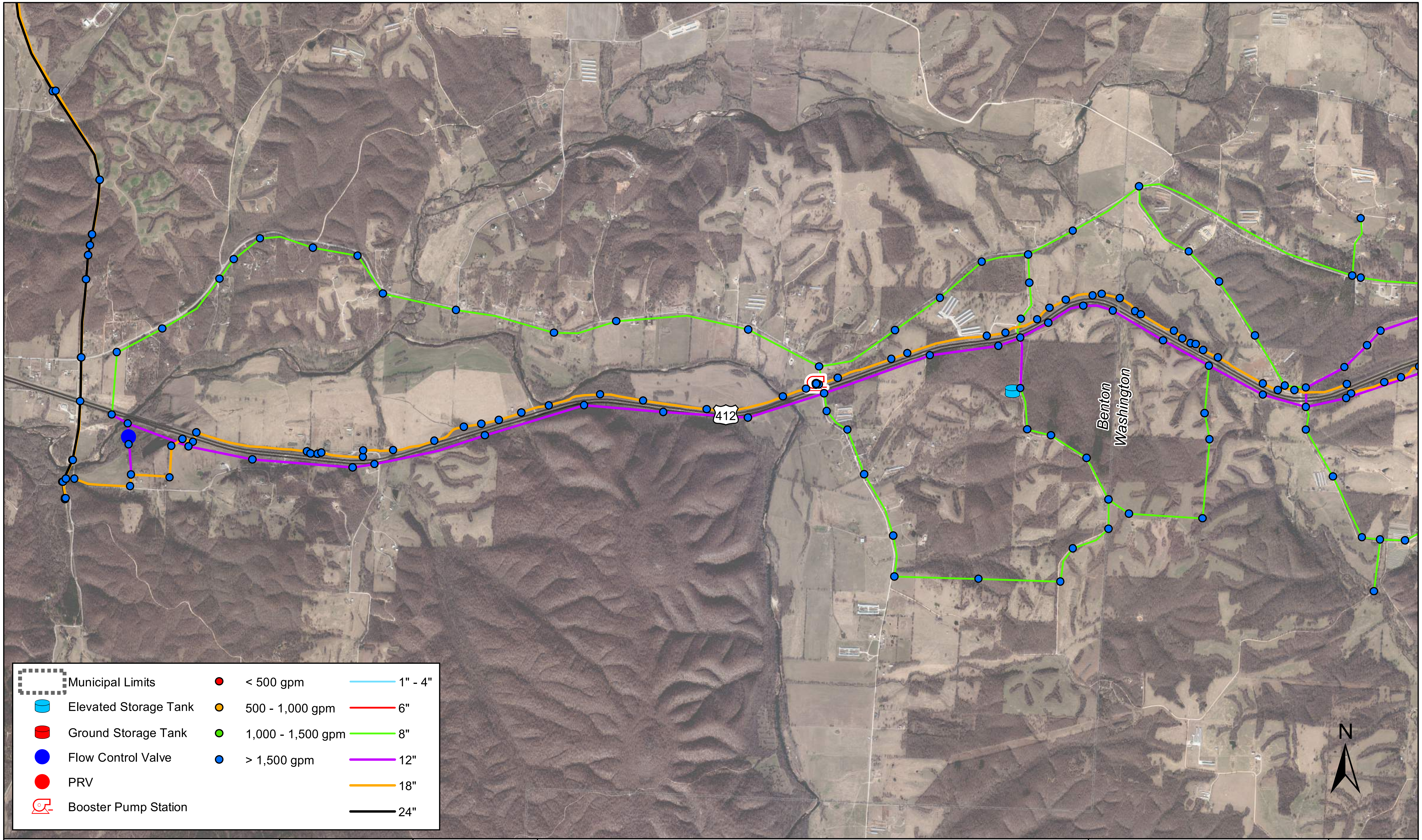
APPENDIX D
East and West Supply Buildout Results

Exhibits



EAST/WEST SUPPLY BUILDOUT AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1A**

BAR IS ONE INCH ON ORIGINAL DRAWING

1"

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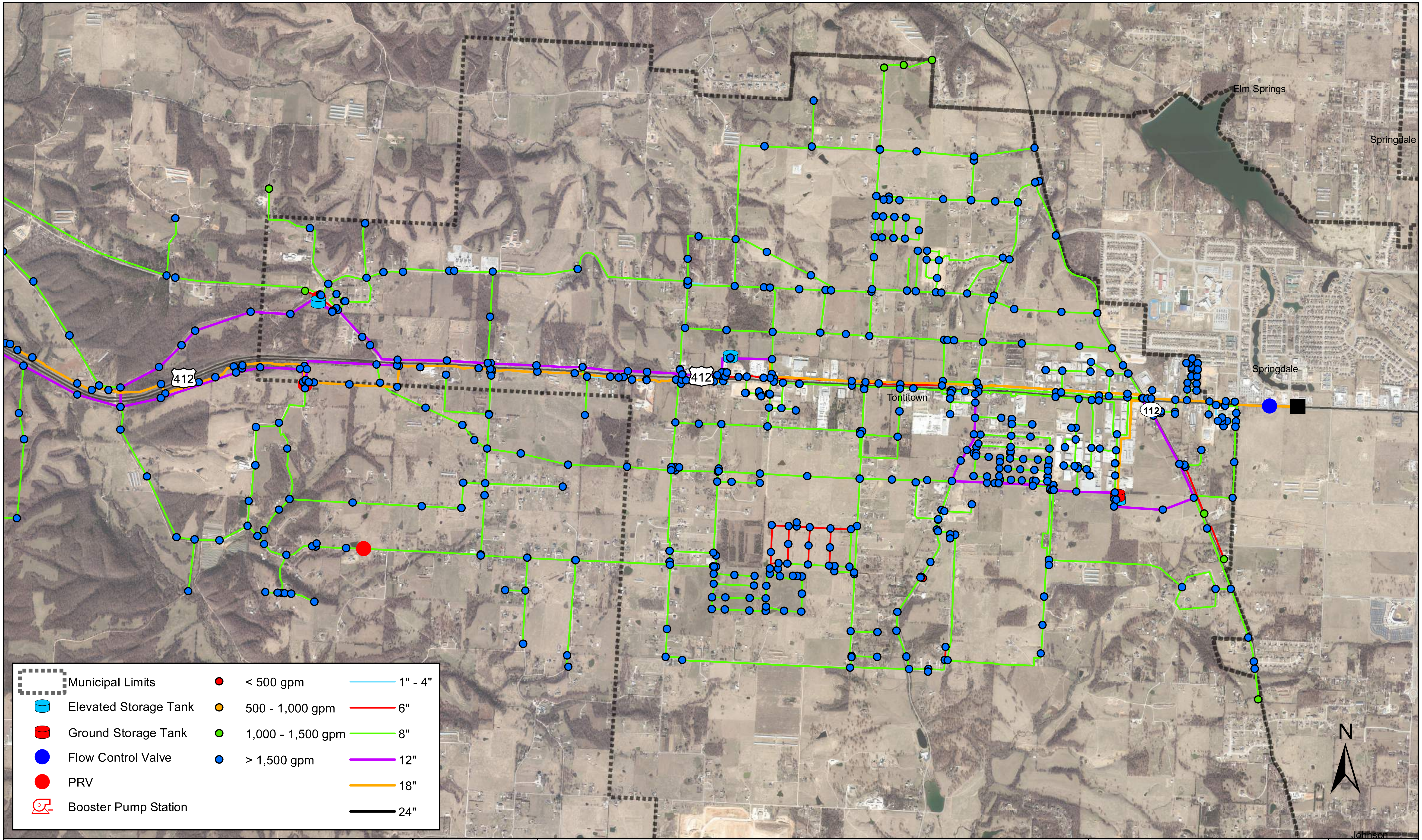

EAST/WEST SUPPLY BUILDOUT
AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1B**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

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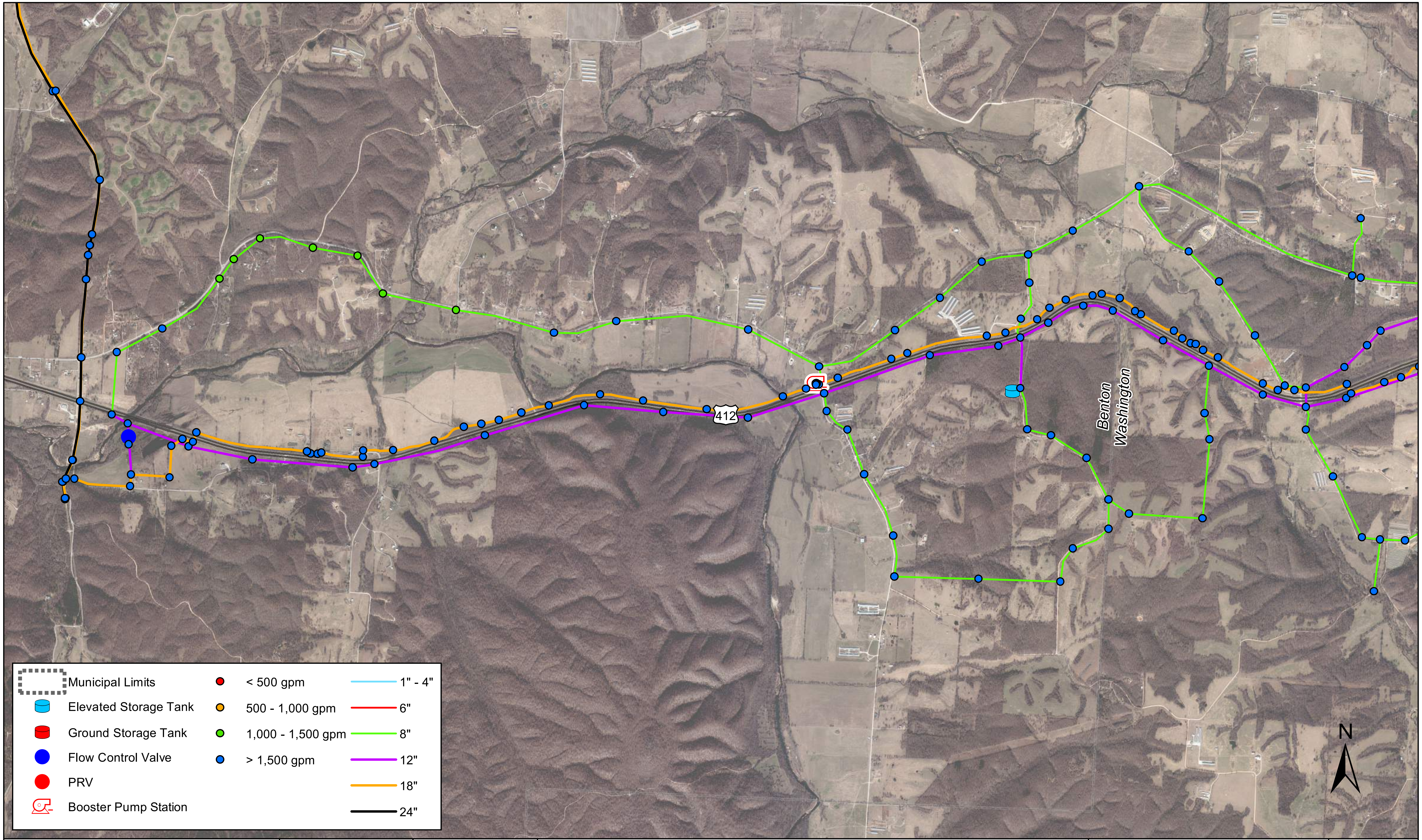

EAST/WEST SUPPLY BUILDOUT AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2A**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

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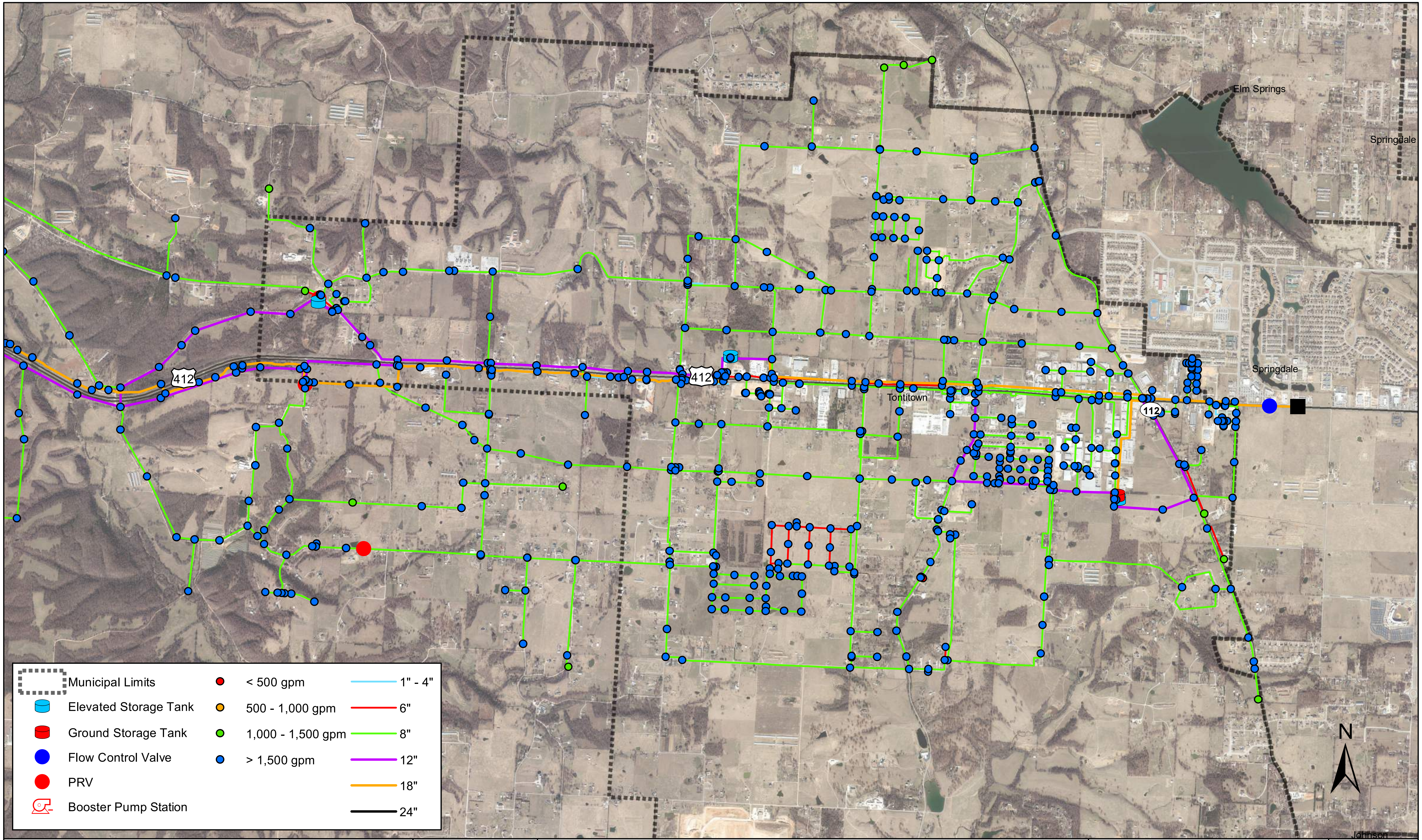

EAST/WEST SUPPLY BUILDOUT
AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2B**

BAR IS ONE INCH ON
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1"

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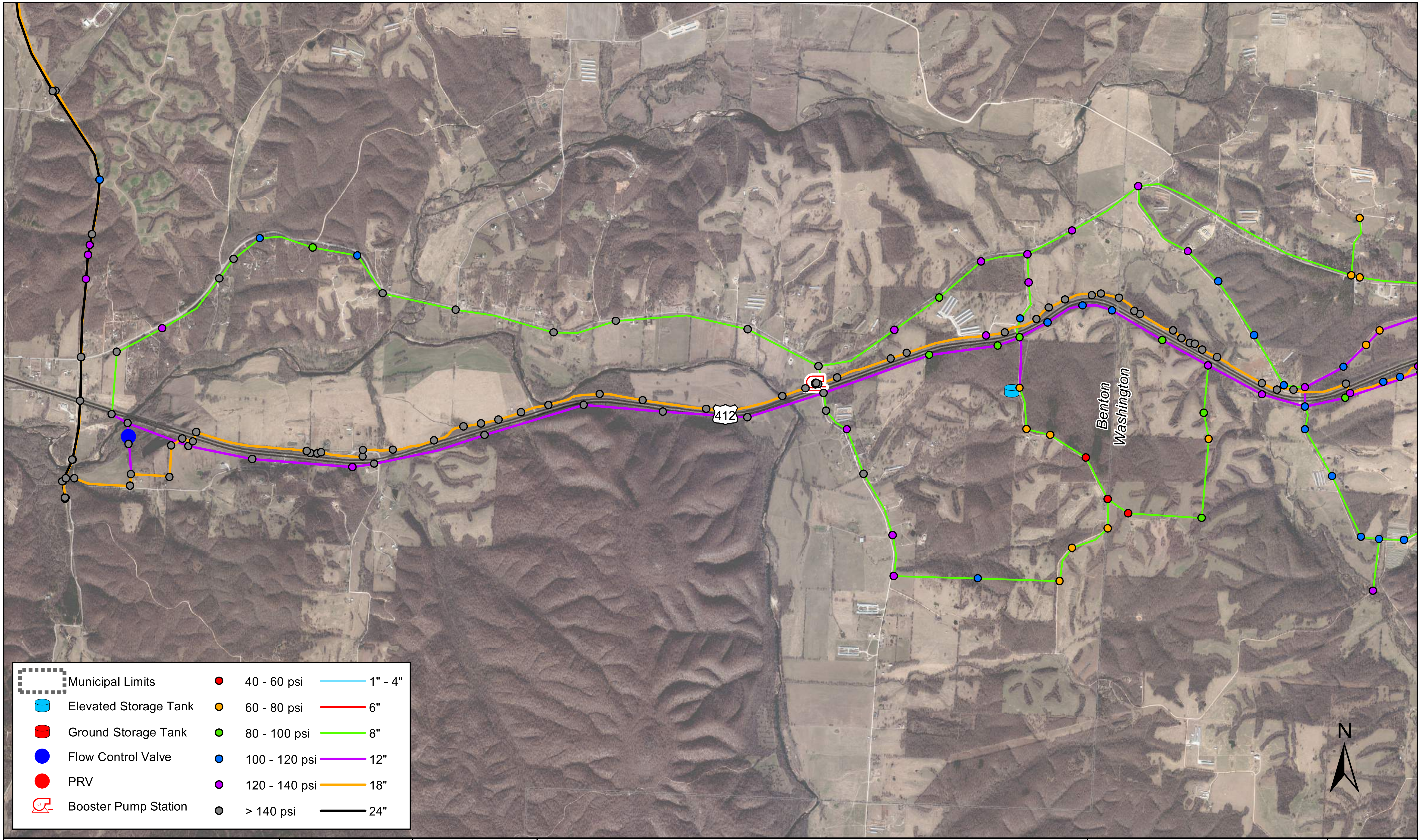

EAST/WEST SUPPLY BUILDOUT
MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3A**

BAR IS ONE INCH ON
ORIGINAL DRAWING

1"

IF NOT ONE INCH ON
THIS SHEET, ADJUST

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DATE: NOVEMBER 2020

TONTITOWN WATER UTILITIES
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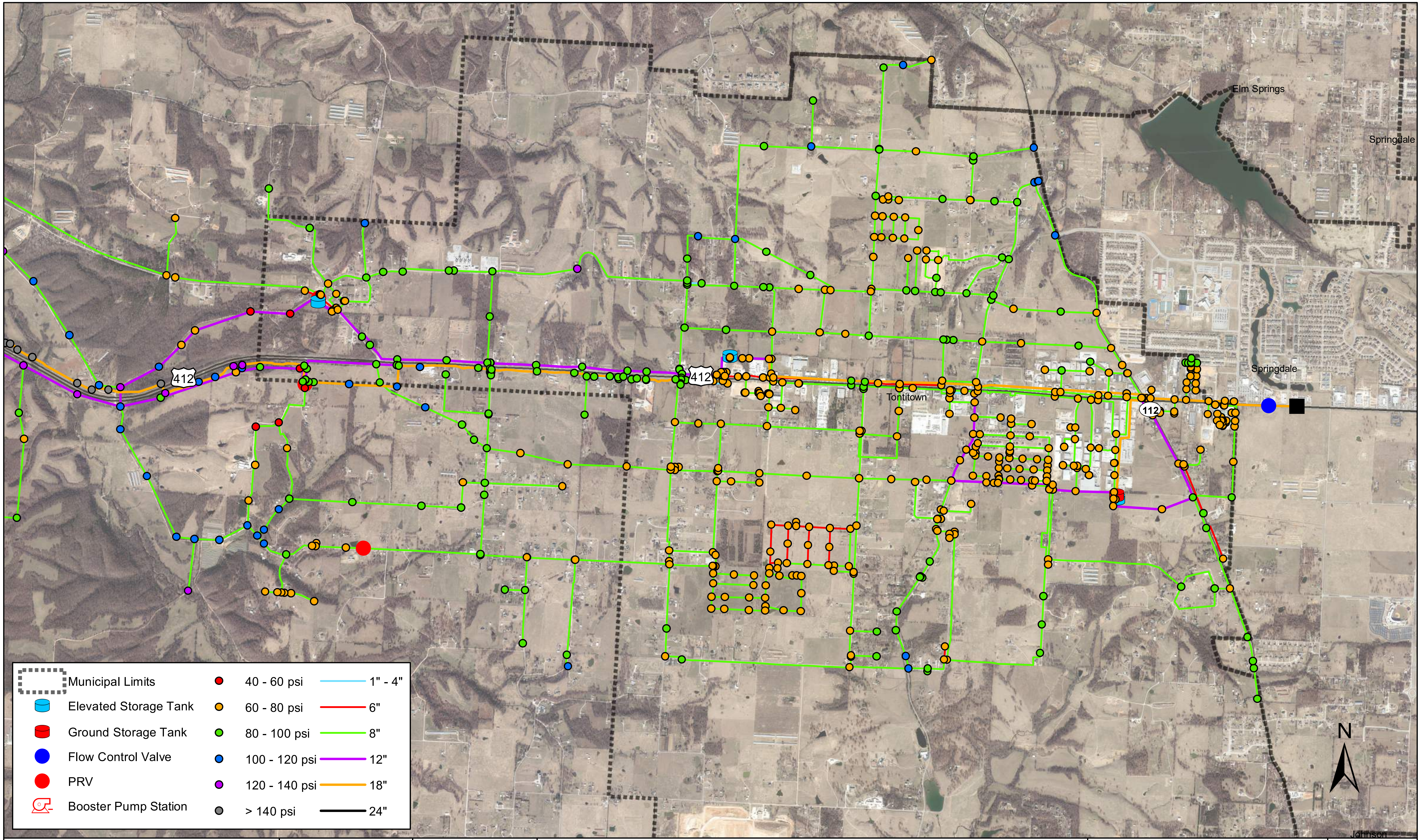

EAST/WEST SUPPLY BUILDOUT MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3B**

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ORIGINAL DRAWING

1"

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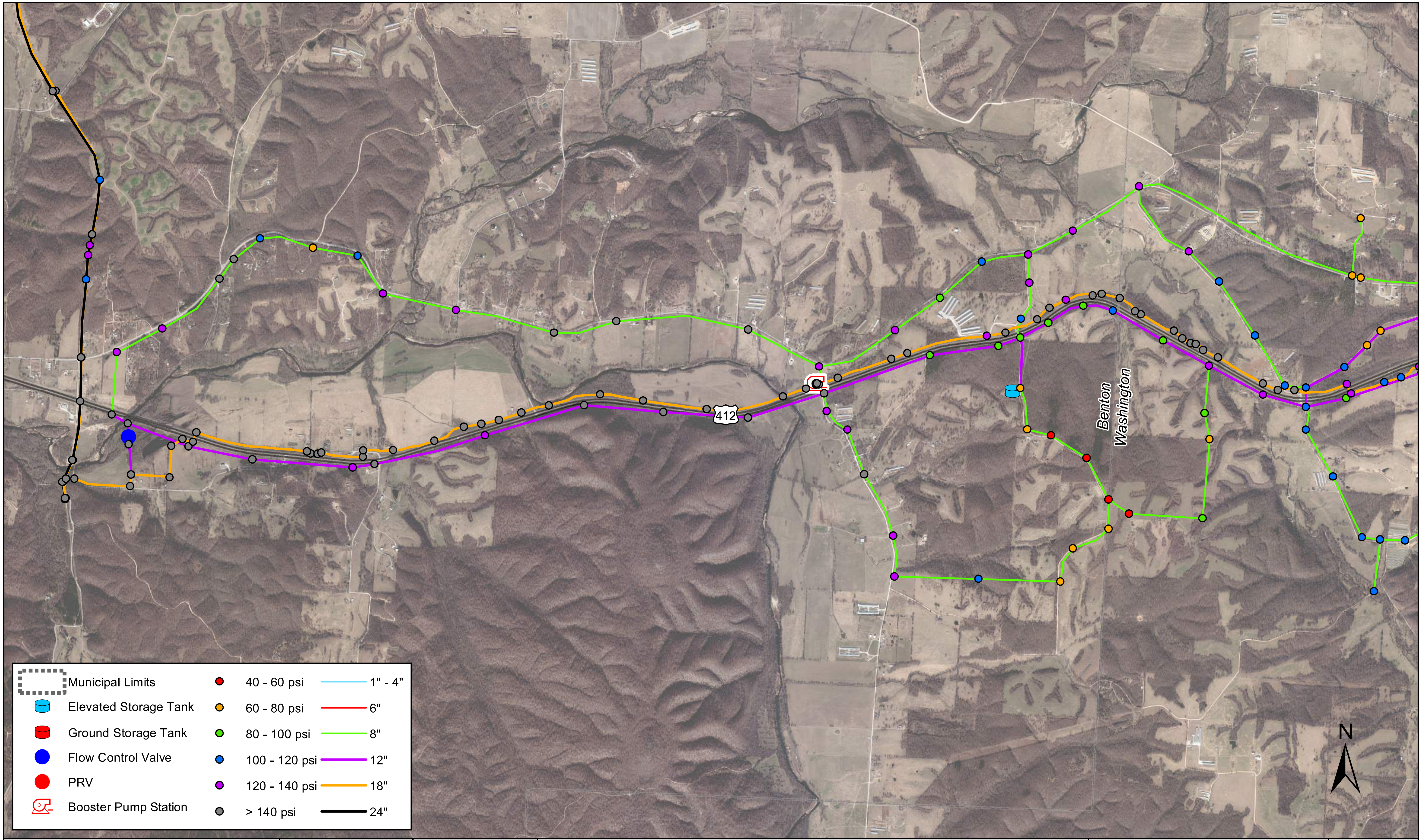

EAST/WEST SUPPLY BUILDOUT MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4A**

BAR IS ONE INCH ON ORIGINAL DRAWING

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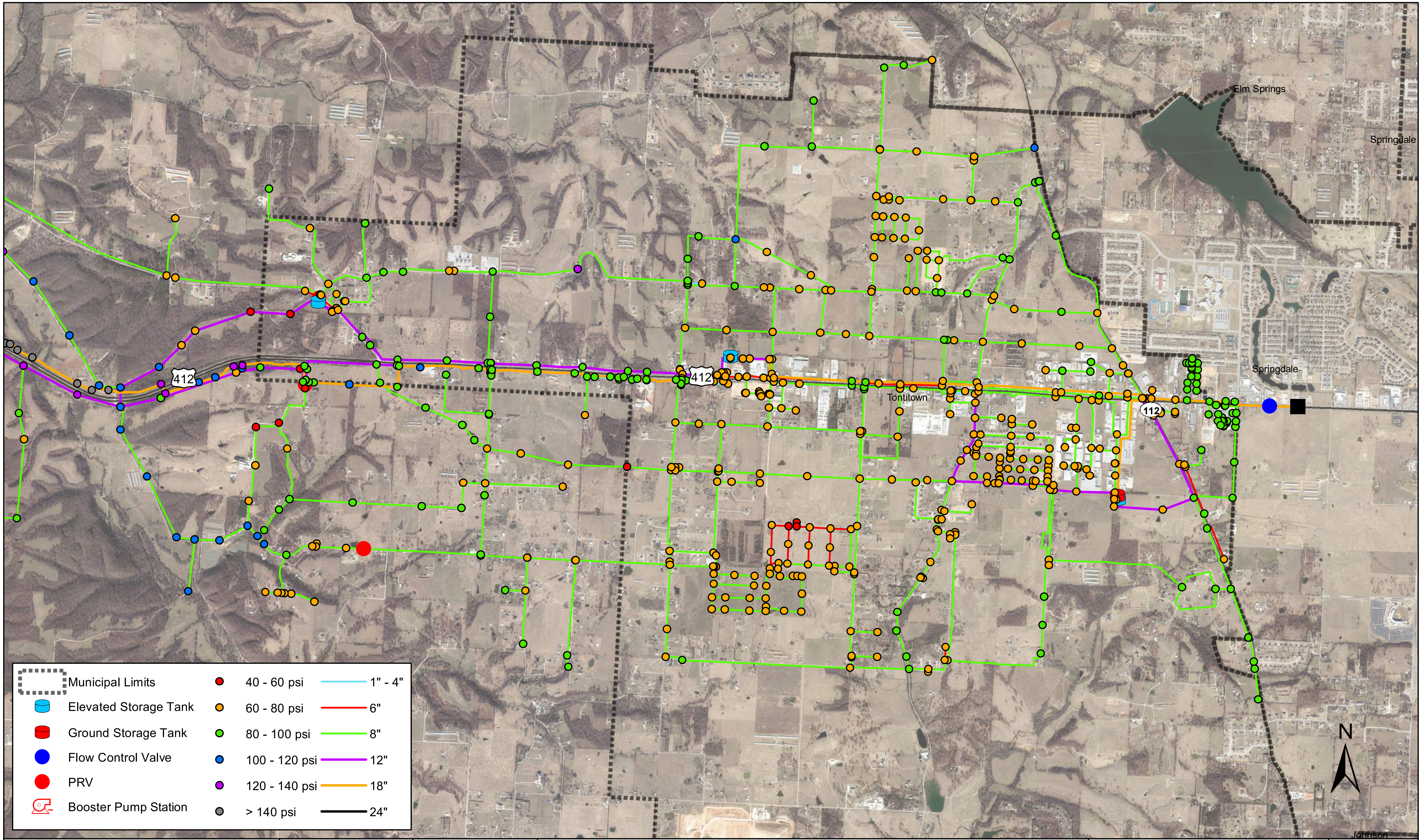

EAST/WEST SUPPLY BUILDOUT MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4B**

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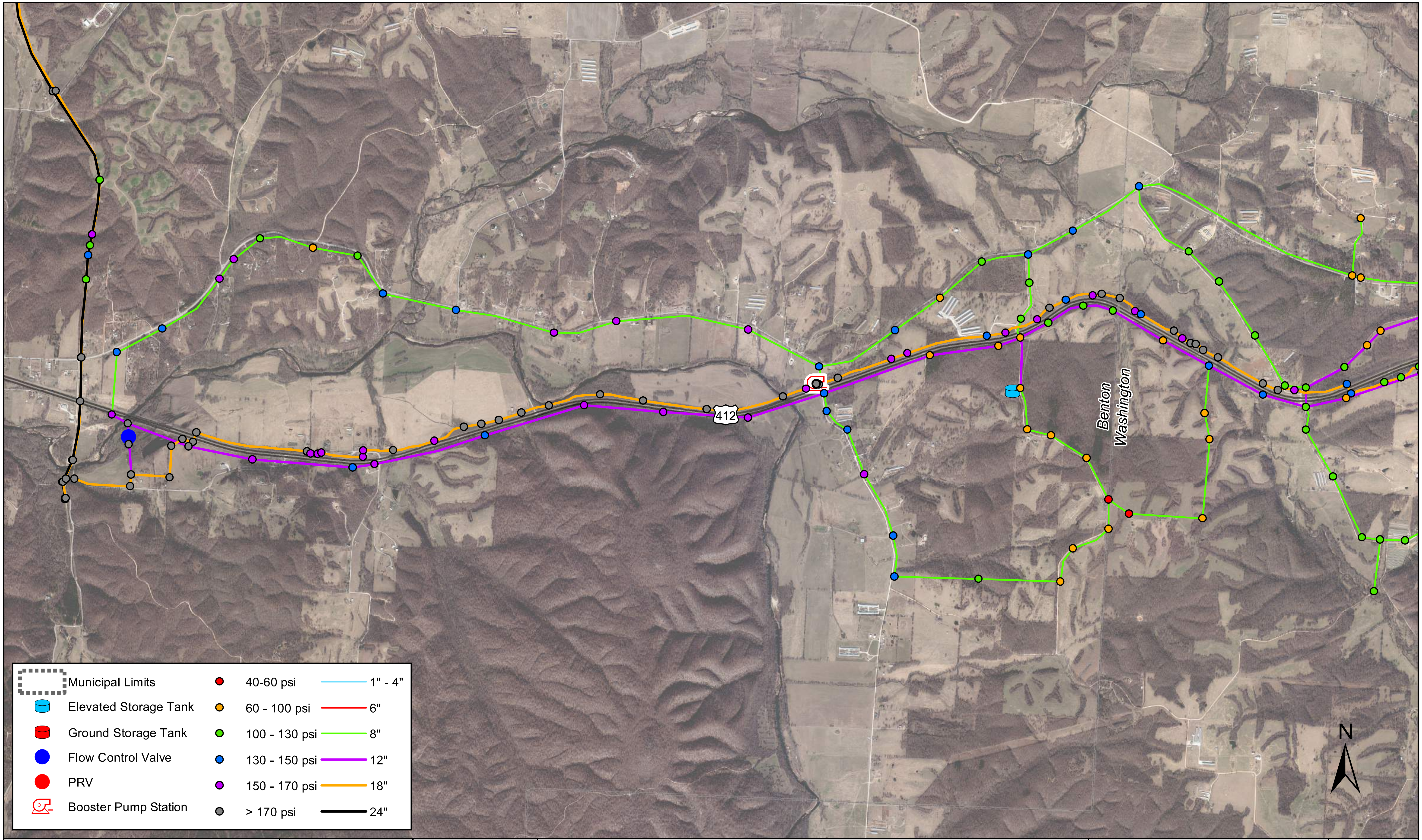

EAST/WEST SUPPLY BUILDOUT MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5A**

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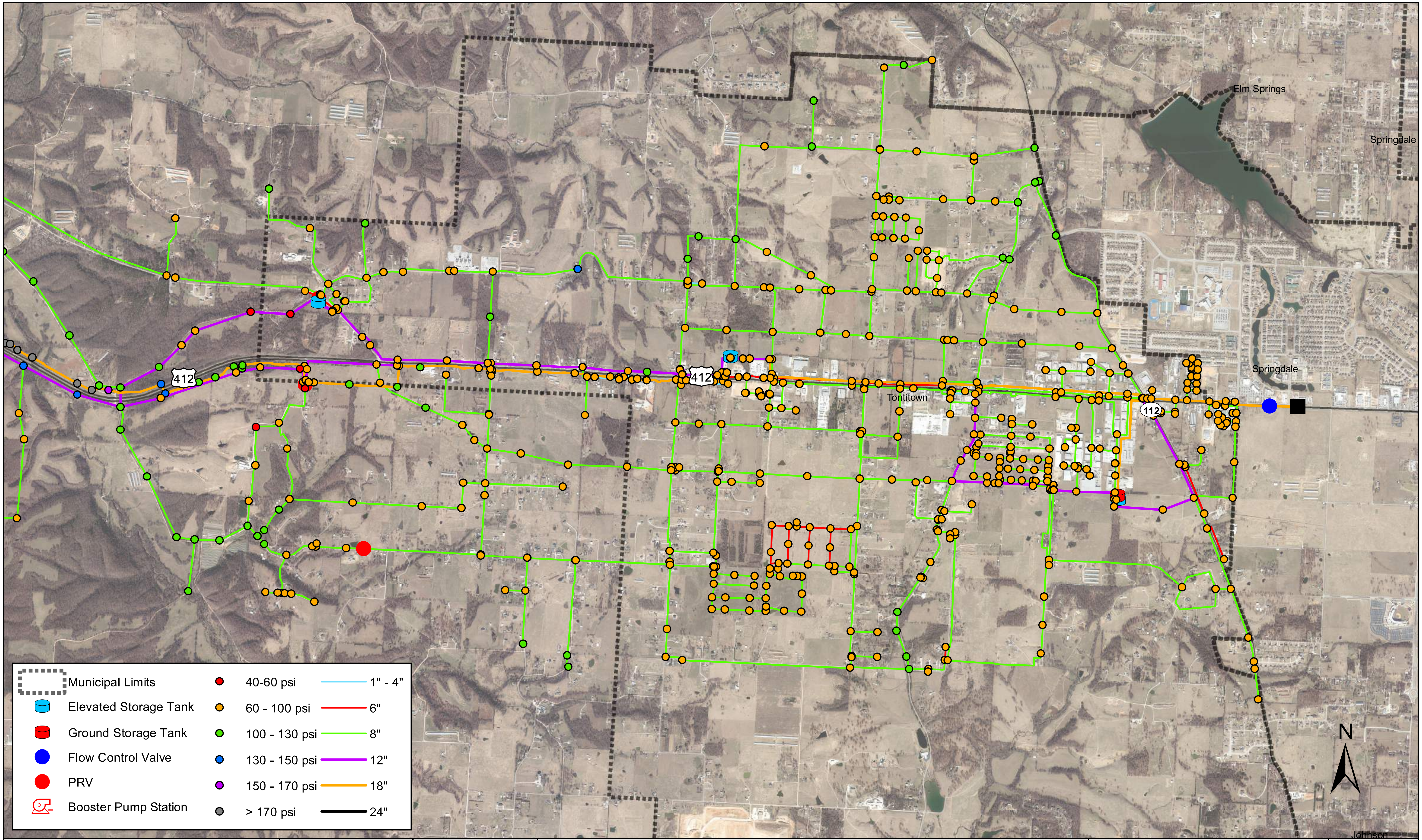

EAST/WEST SUPPLY BUILDOUT MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5B**

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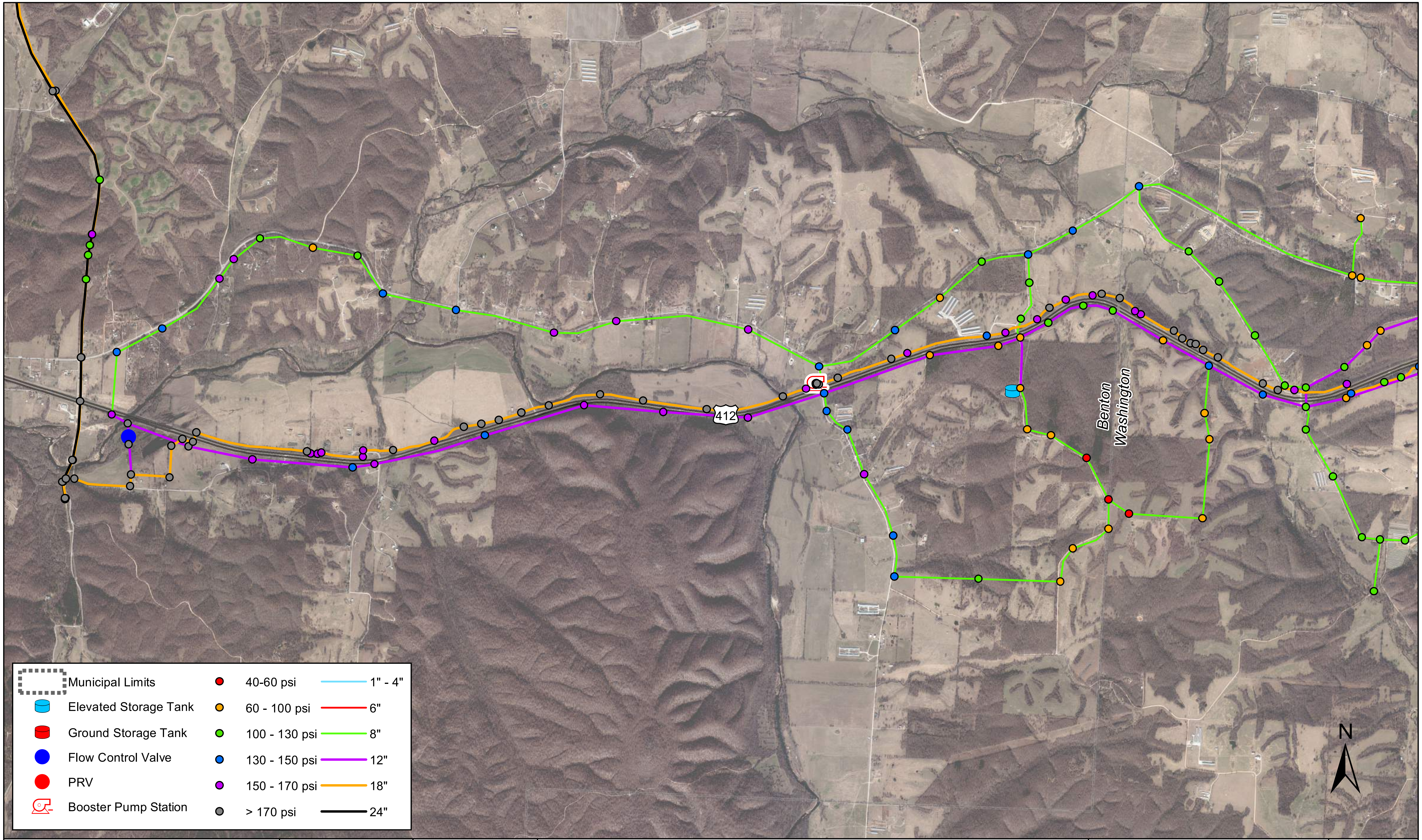

EAST/WEST SUPPLY BUILDOUT
MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6A**

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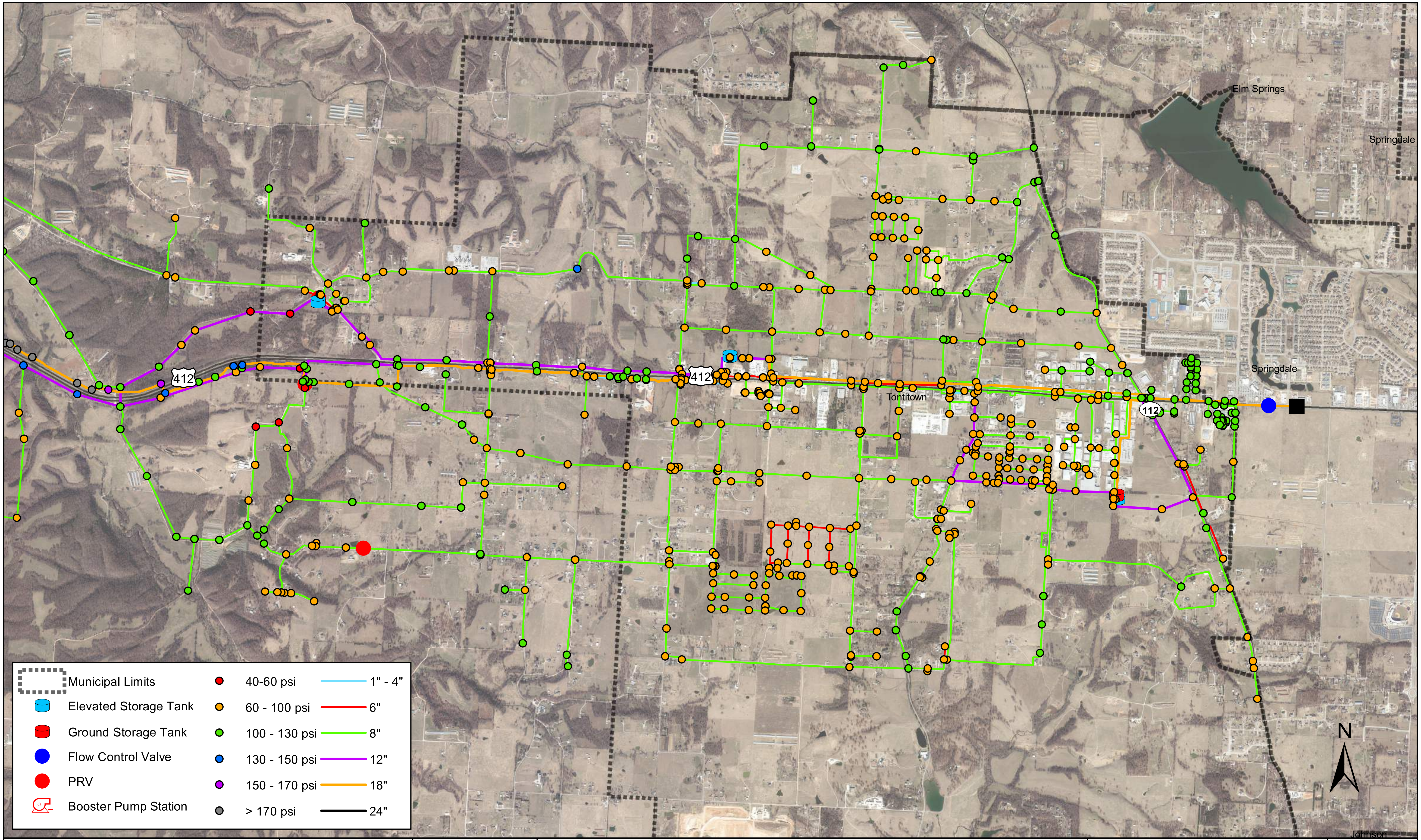

EAST/WEST SUPPLY BUILDOUT
MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6B**

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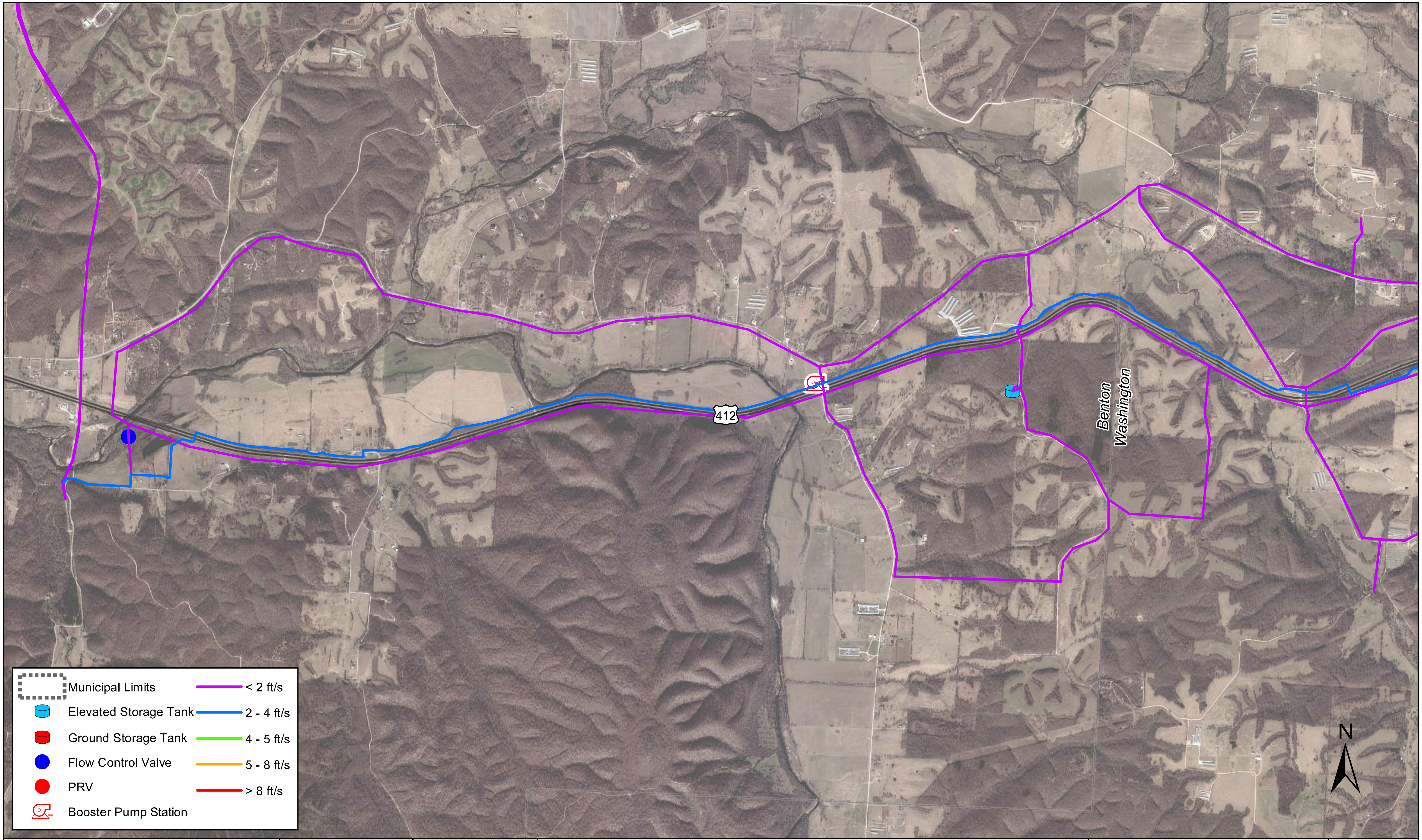

EAST/WEST SUPPLY BUILDOUT MAXIMUM VELOCITY (ADD)

Figure Number: **EXHIBIT 7A**

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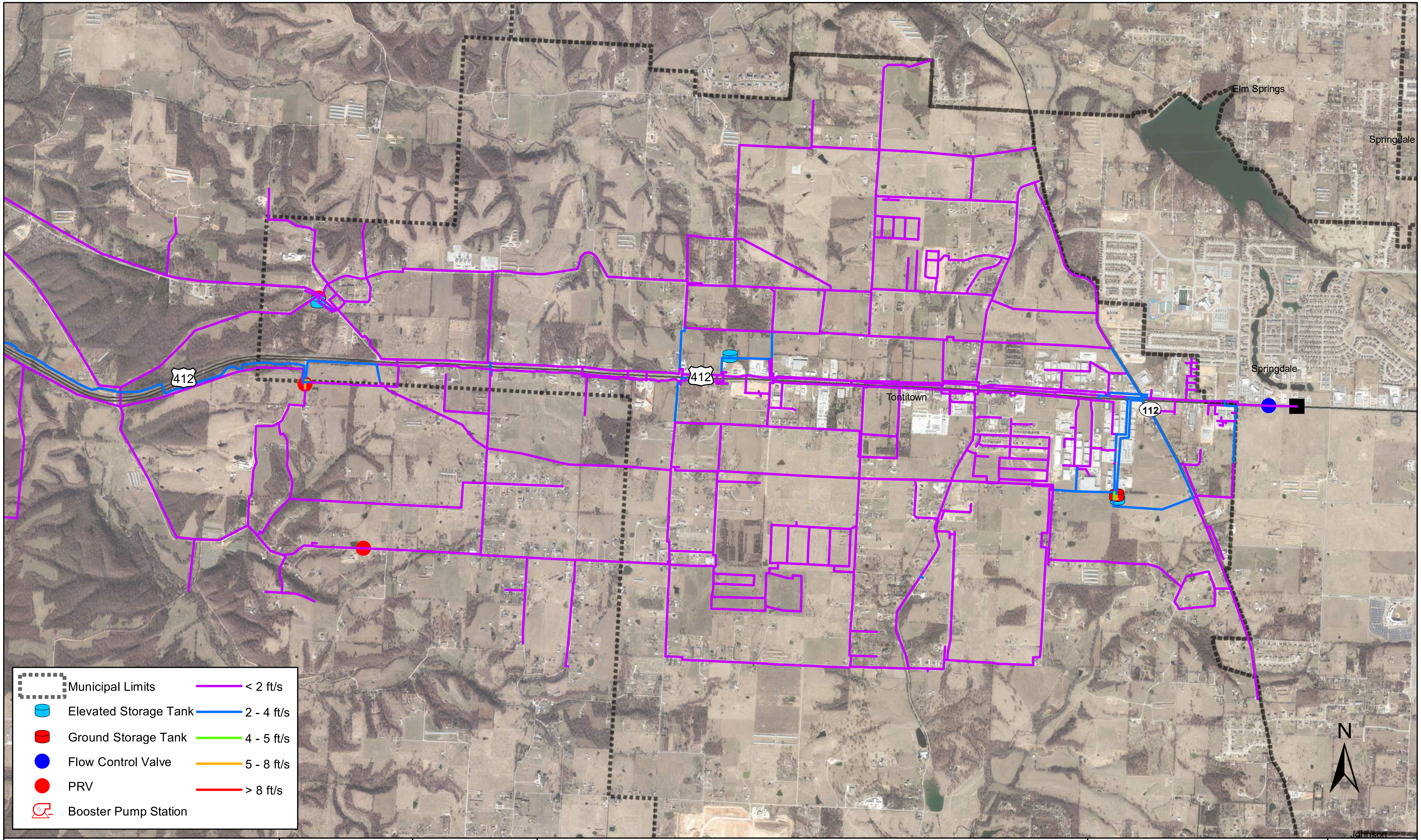

EAST/WEST SUPPLY BUILDOUT
MAXIMUM VELOCITY (ADD)

Figure Number: **EXHIBIT 7B**

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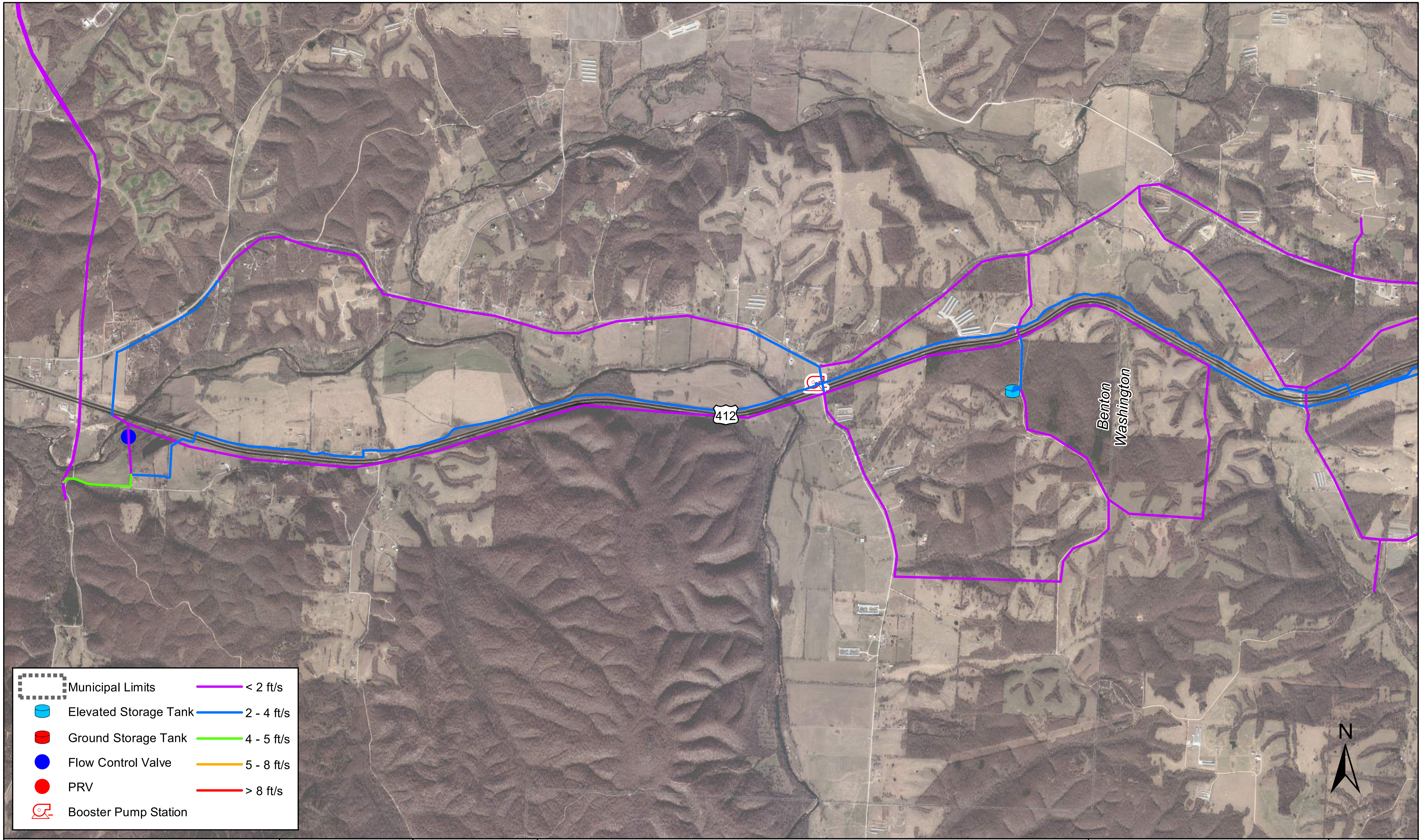

EAST/WEST SUPPLY BUILDOUT
MAXIMUM VELOCITY (MDD)

Figure Number: **EXHIBIT 8A**

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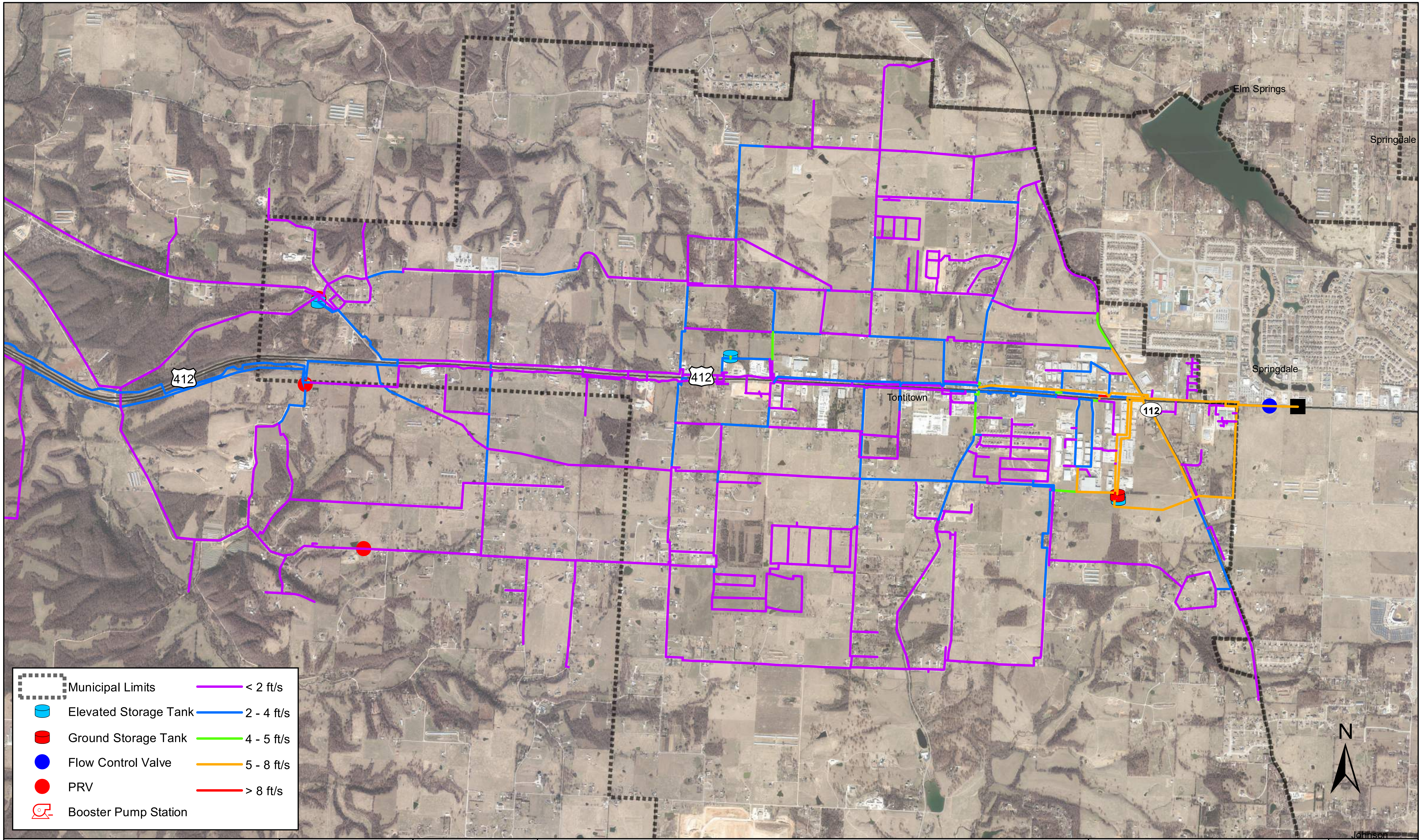

EAST/WEST SUPPLY BUILDOUT MAXIMUM VELOCITY (MDD)

Figure Number: **EXHIBIT 8B**

BAR IS ONE INCH ON ORIGINAL DRAWING

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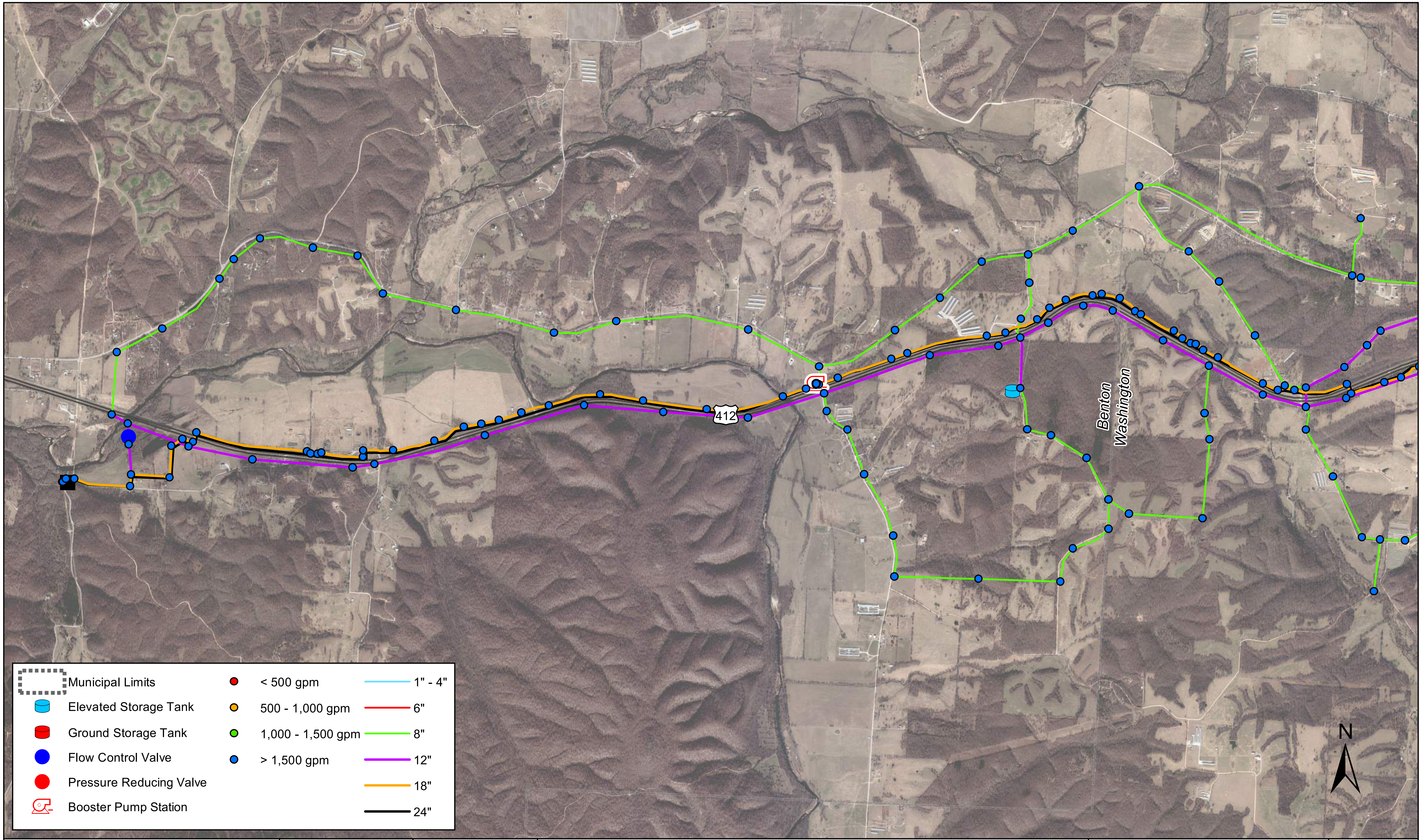
APPENDIX E
BWRPWA Supply Buildout Results

Exhibits



BWRPWA SUPPLY BUILDOUT AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1A**

BAR IS ONE INCH ON ORIGINAL DRAWING

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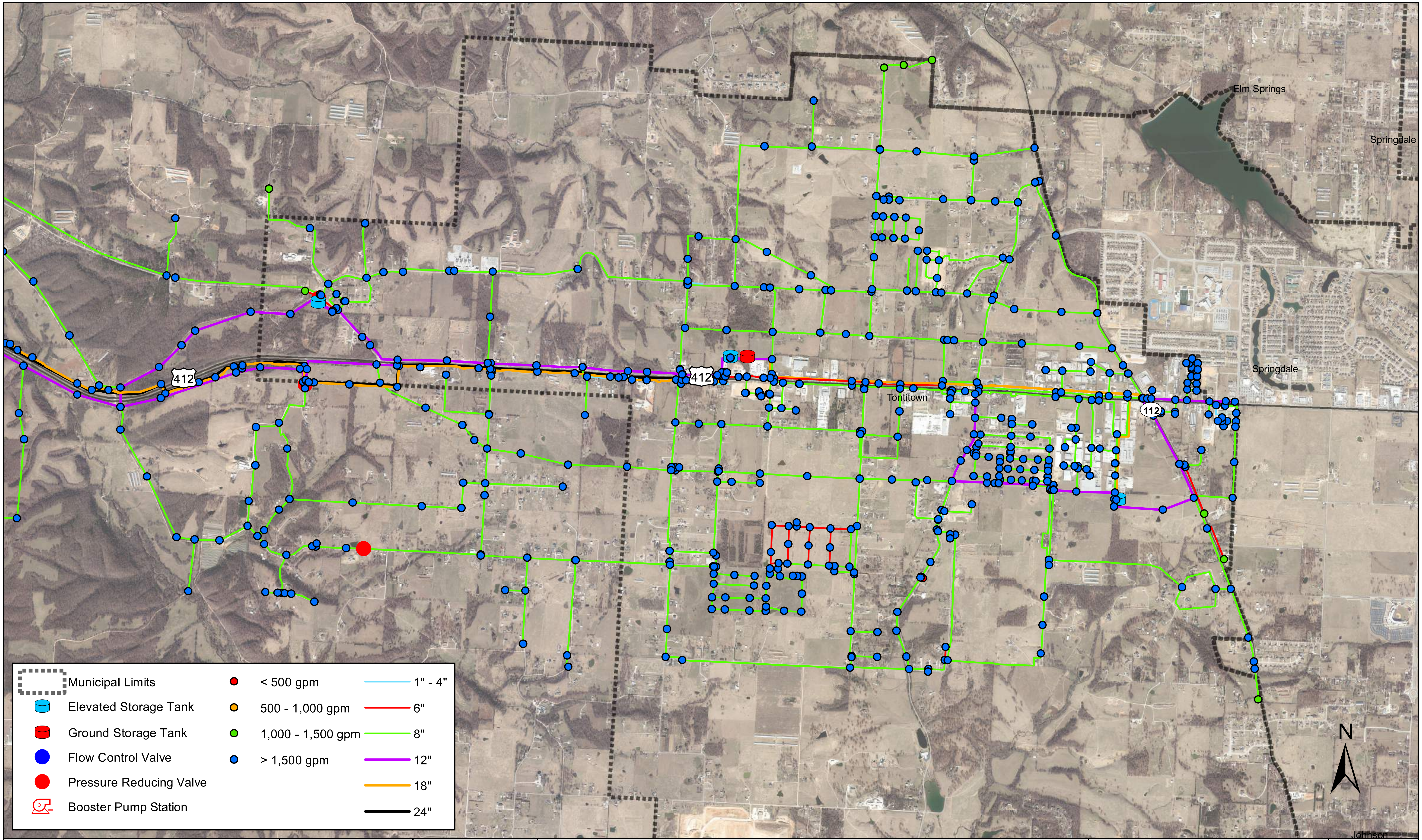

BWRPWA SUPPLY BUILDOUT AVAILABLE FIRE FLOW (ADD)

Figure Number: **EXHIBIT 1B**

BAR IS ONE INCH ON
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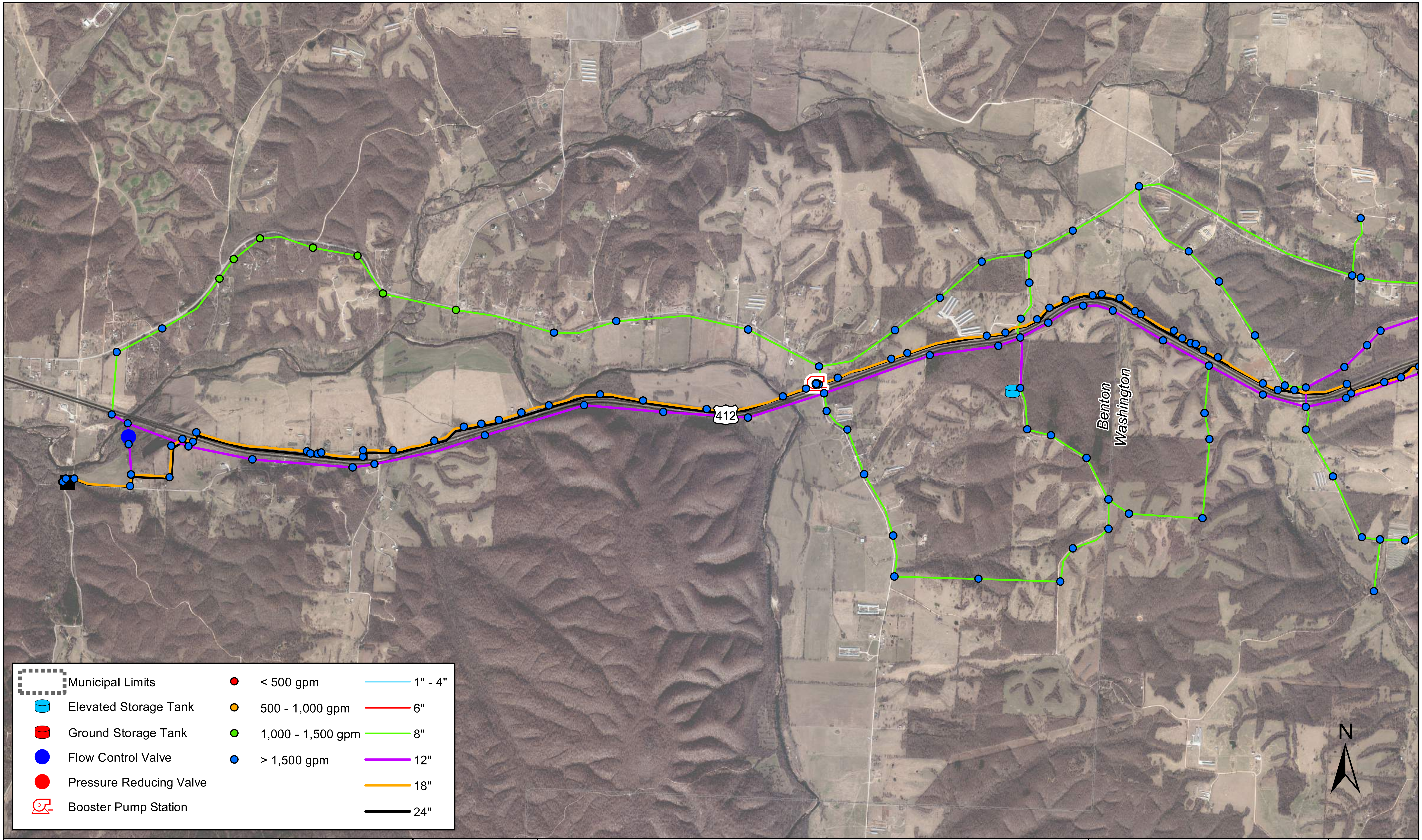

BWRPWA SUPPLY BUILDOUT AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2A**

BAR IS ONE INCH ON ORIGINAL DRAWING

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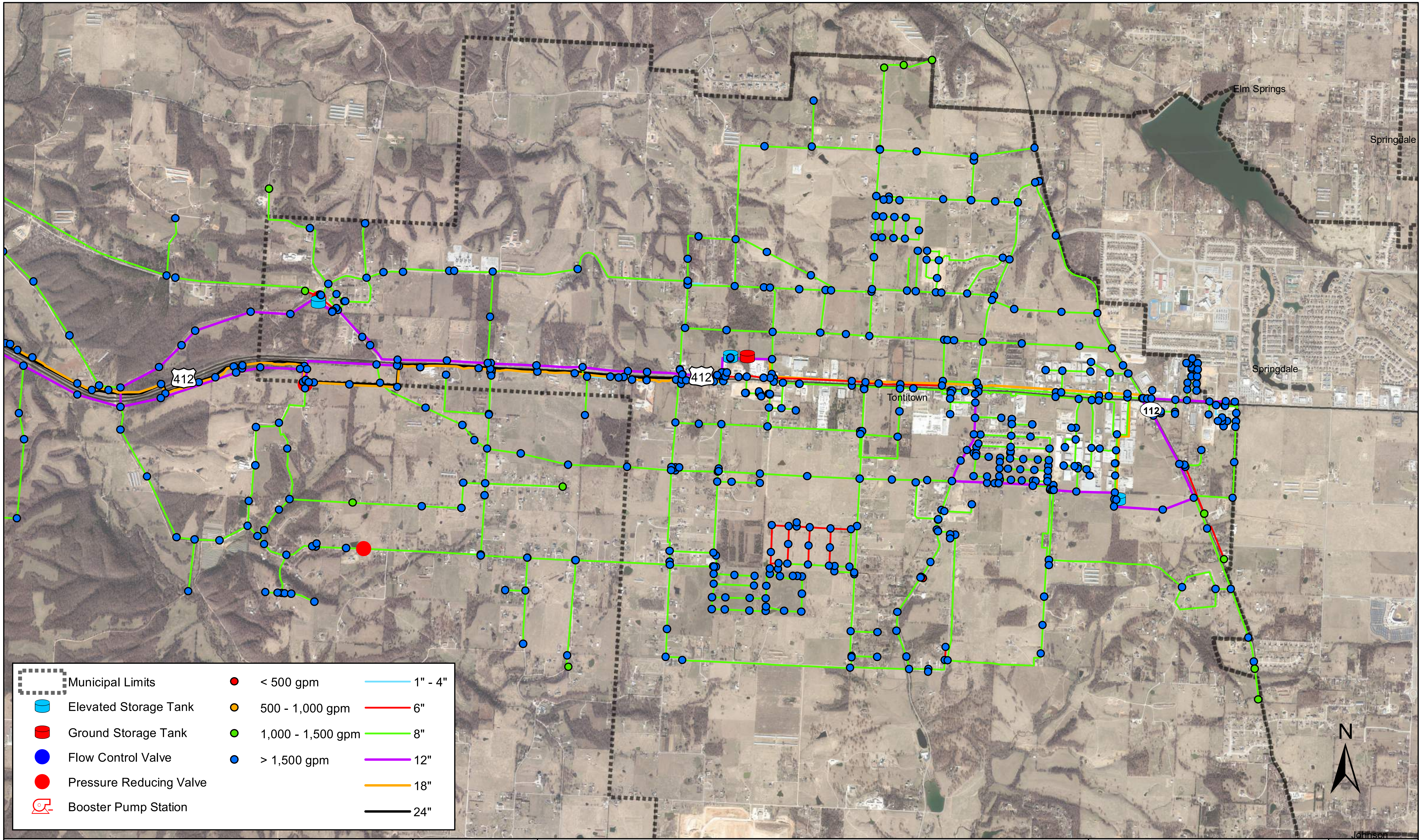

BWRPWA SUPPLY BUILDOUT
AVAILABLE FIRE FLOW (MDD)

Figure Number: **EXHIBIT 2B**

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ORIGINAL DRAWING

1"

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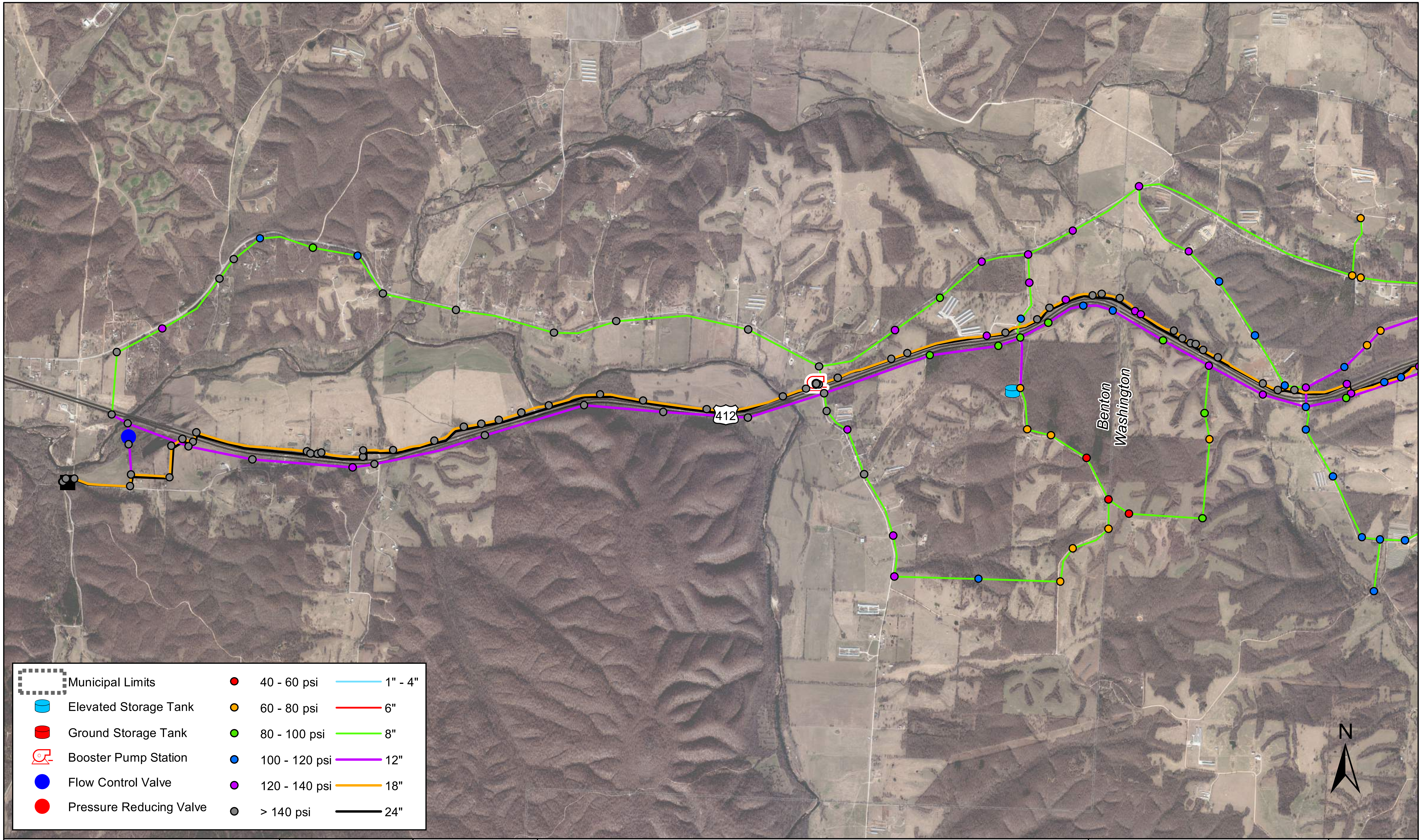

BWRPWA SUPPLY BUILDOUT
MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3A**

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ORIGINAL DRAWING

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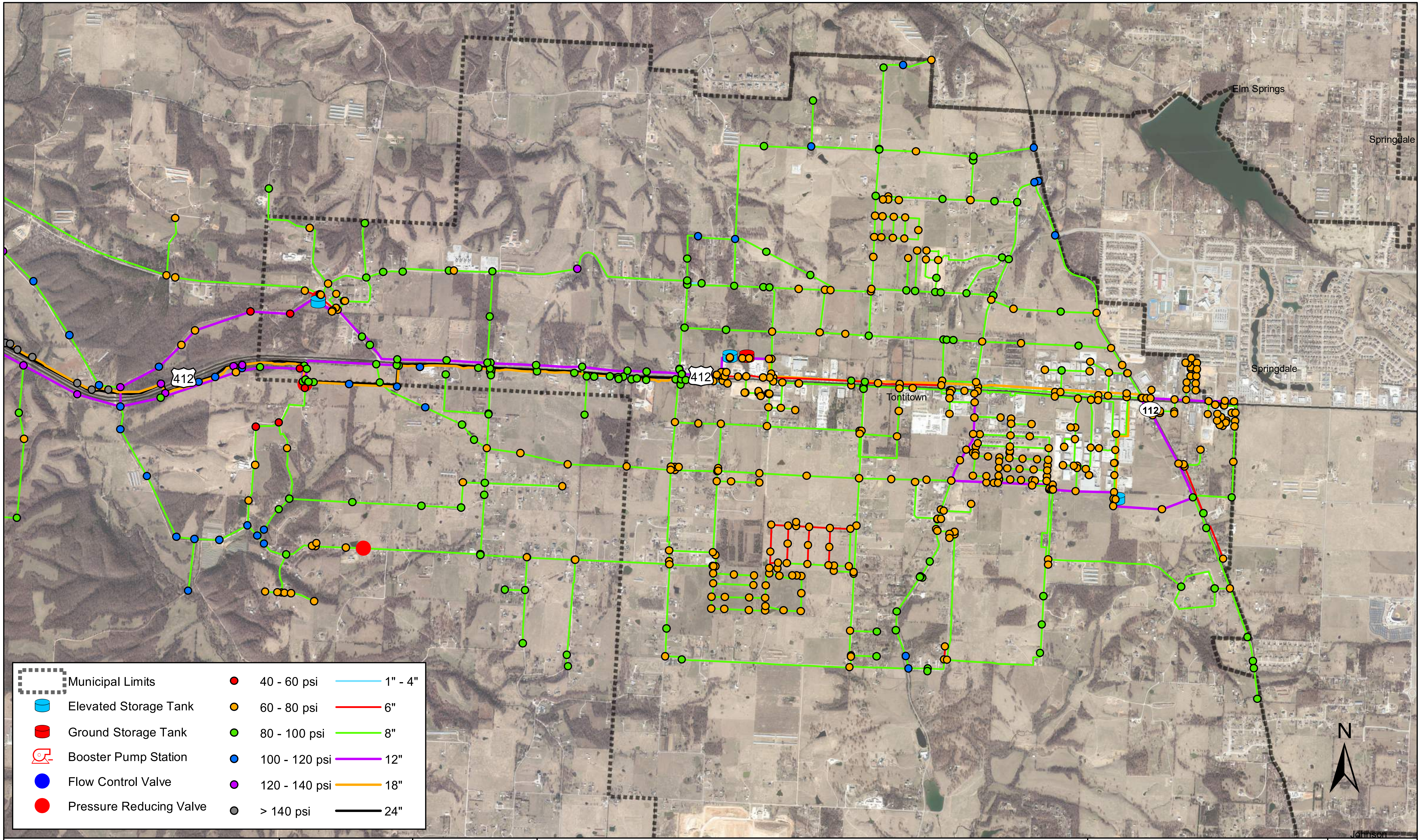

BWRPWA SUPPLY BUILDOUT MINIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 3B**

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1"

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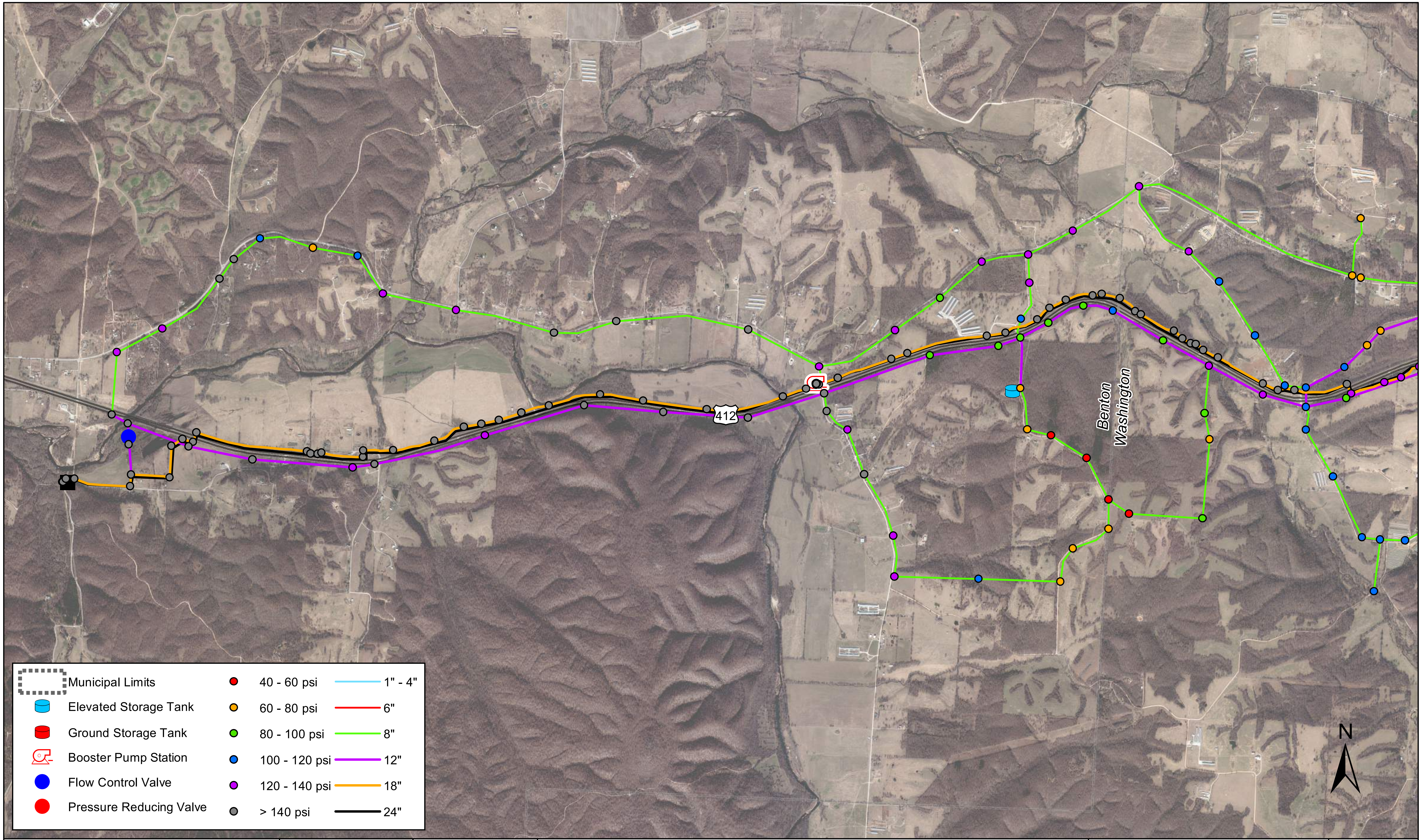

BWRPWA SUPPLY BUILDOUT
MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4A**

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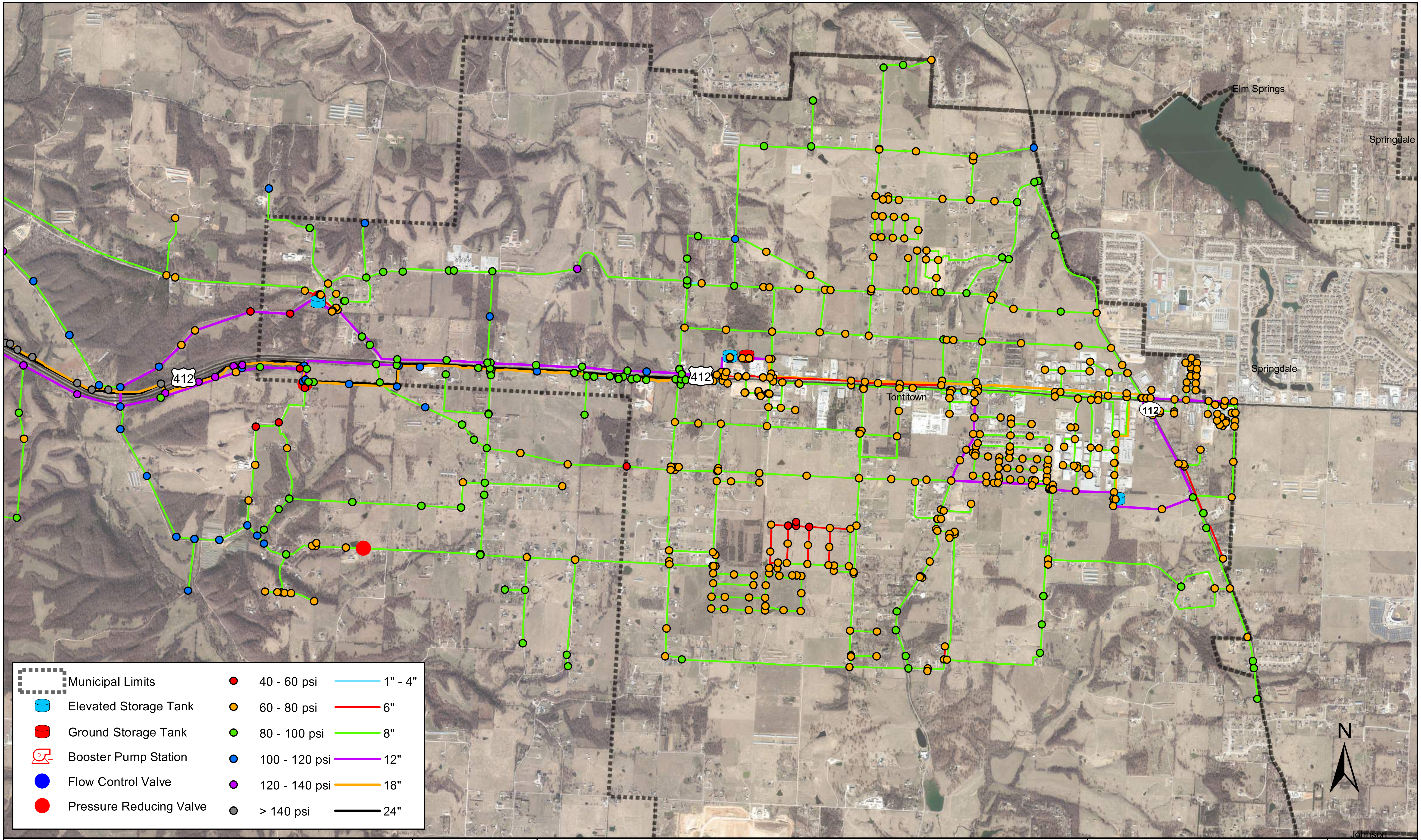

BWRPWA SUPPLY BUILDOUT
MINIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 4B**

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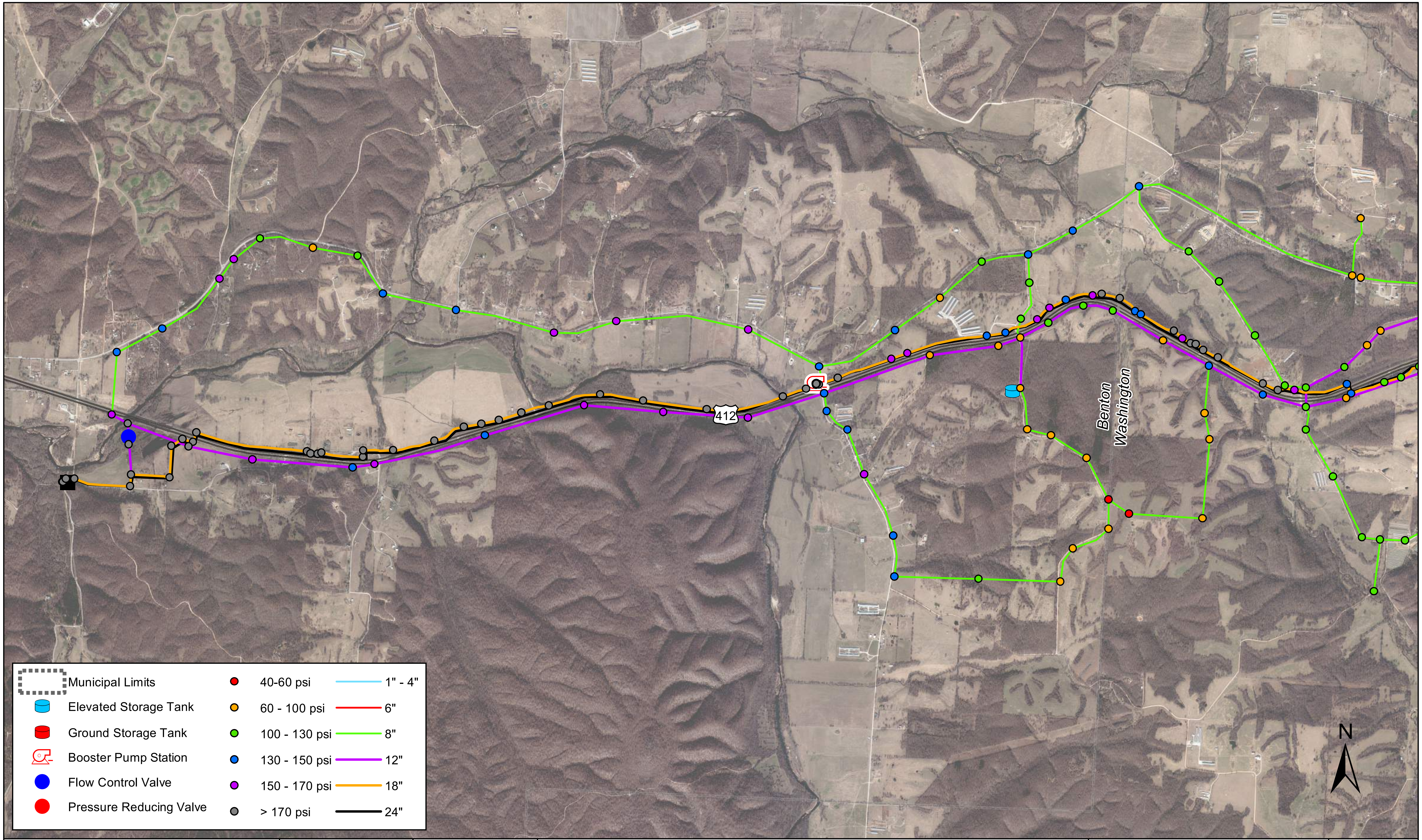

BWRPWA SUPPLY BUILDOUT
MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5A**

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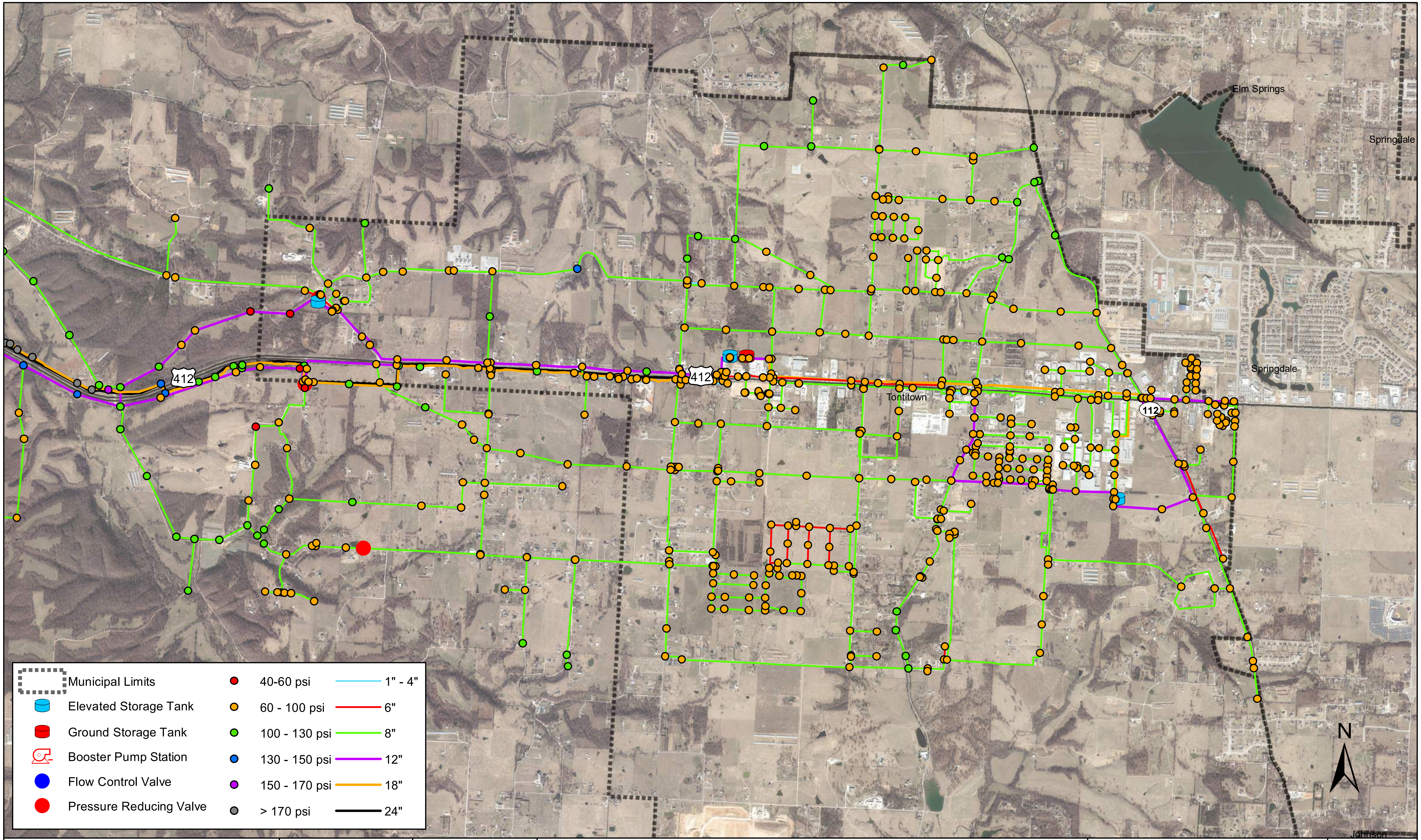

BWRPWA SUPPLY BUILDOUT
MAXIMUM PRESSURE (ADD)

Figure Number: **EXHIBIT 5B**

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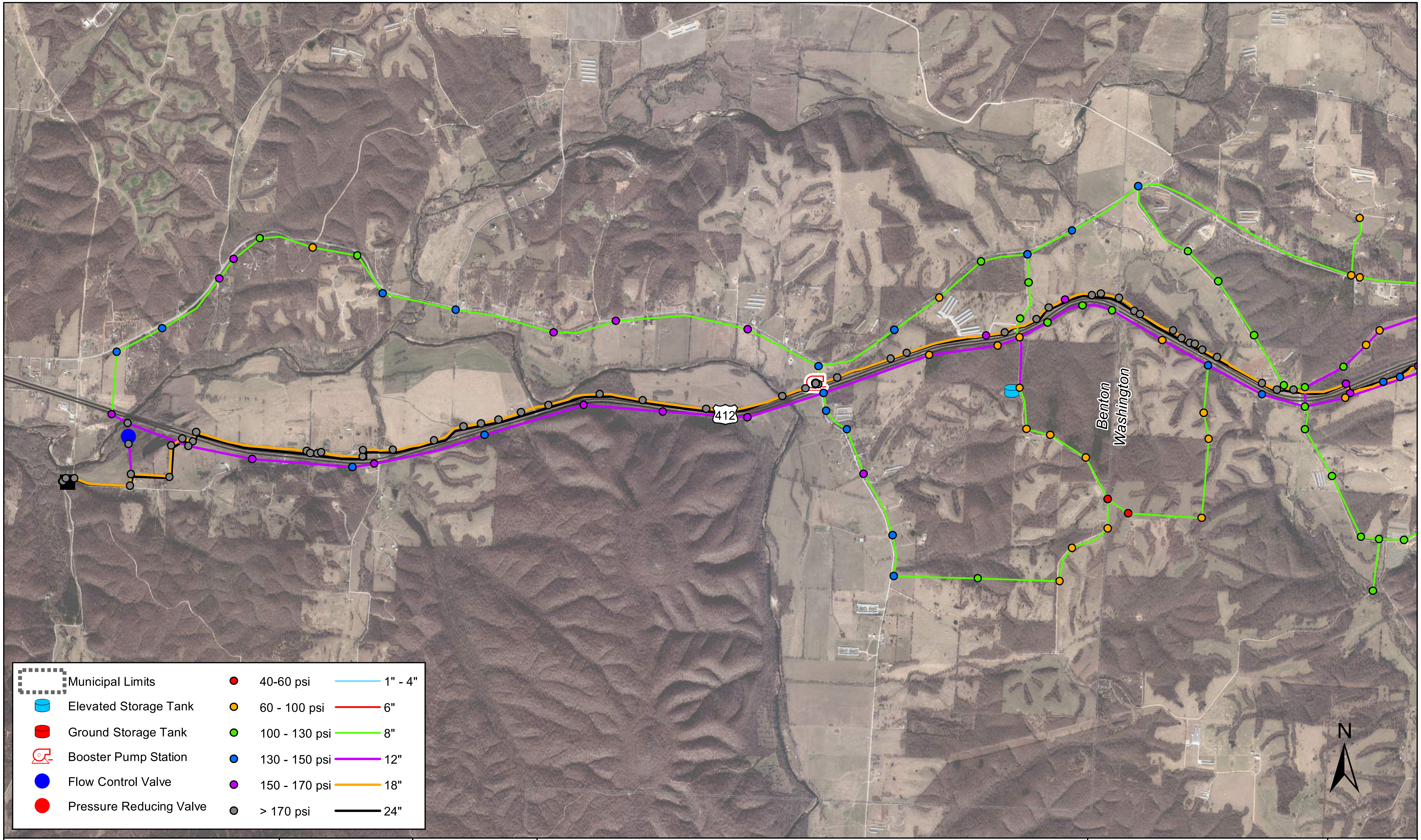

BWRPWA SUPPLY BUILDOUT
MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6A**

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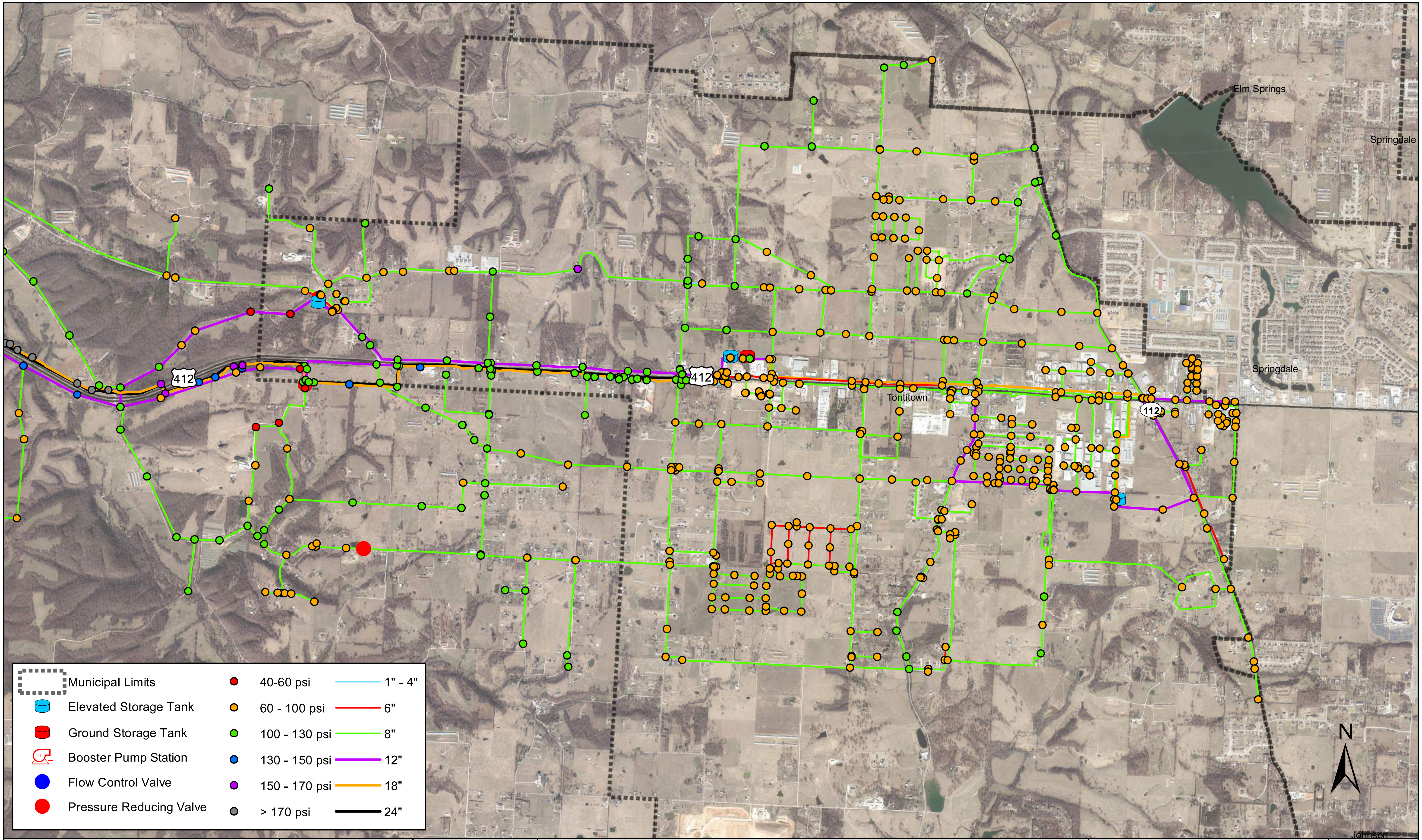

BWRPWA SUPPLY BUILDOUT
MAXIMUM PRESSURE (MDD)

Figure Number: **EXHIBIT 6B**

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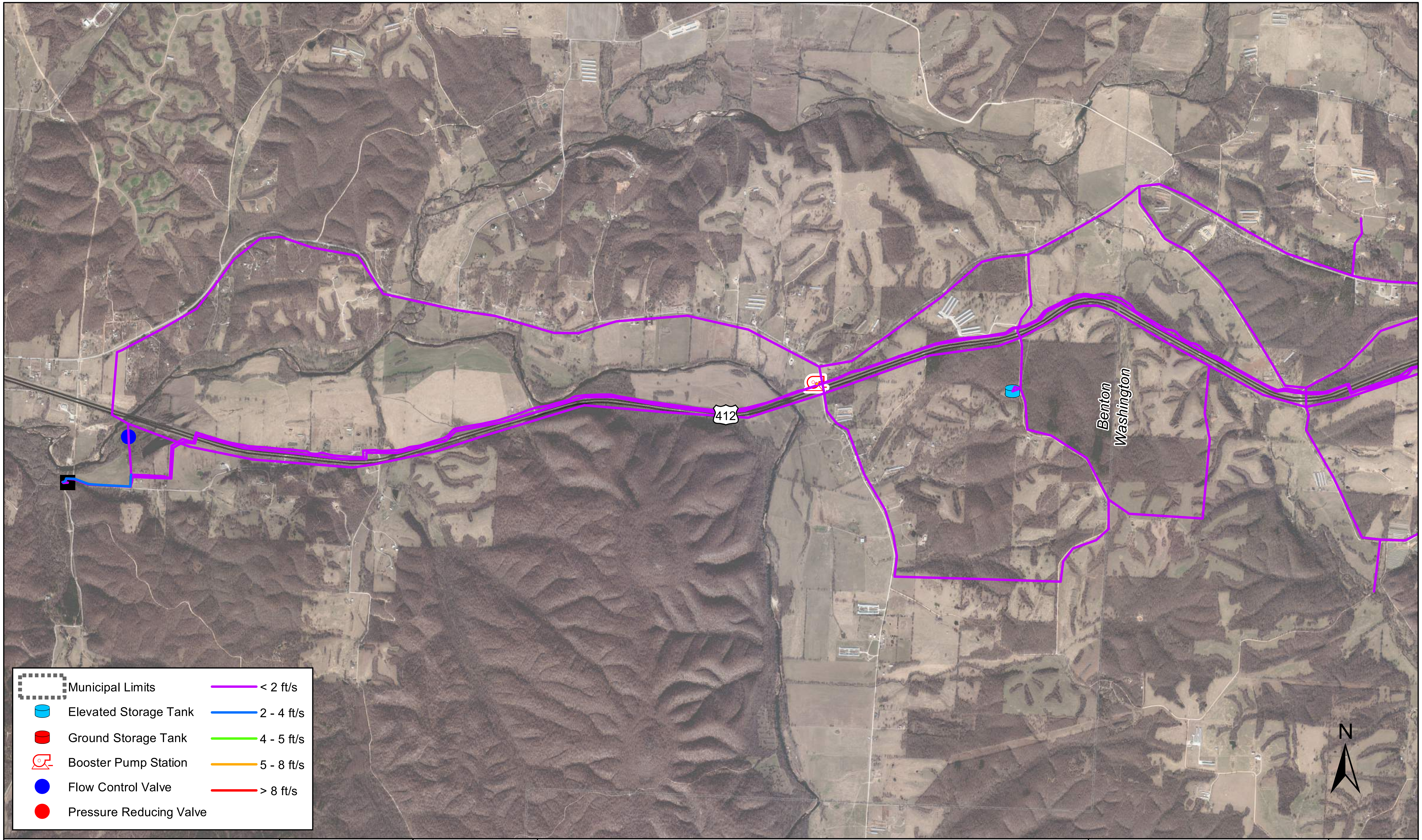

BWRPWA SUPPLY BUILDOUT MAXIMUM VELOCITY (ADD)

Figure Number: **EXHIBIT 7A**

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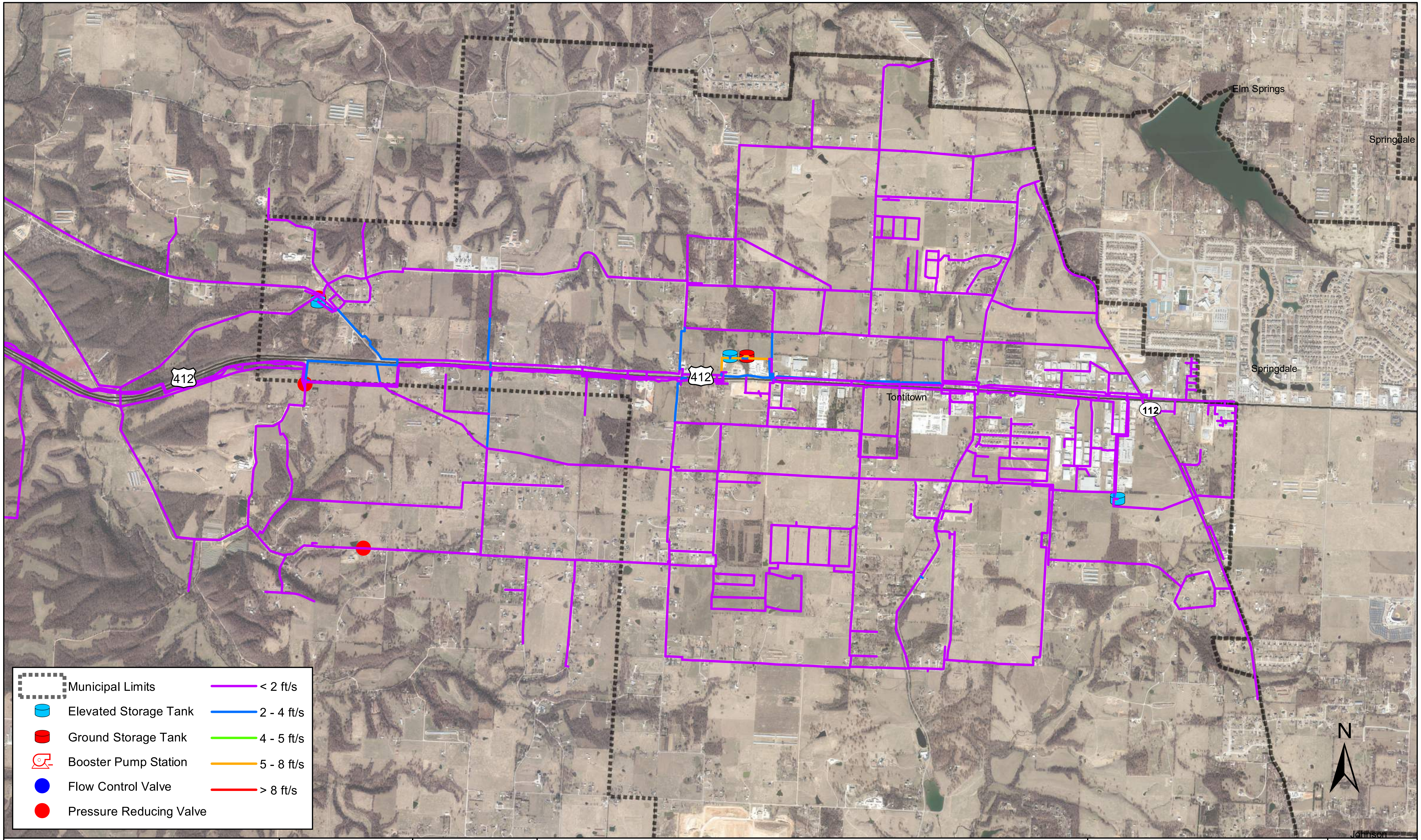

BWRPWA SUPPLY BUILDOUT
MAXIMUM VELOCITY (ADD)

Figure Number: **EXHIBIT 7B**

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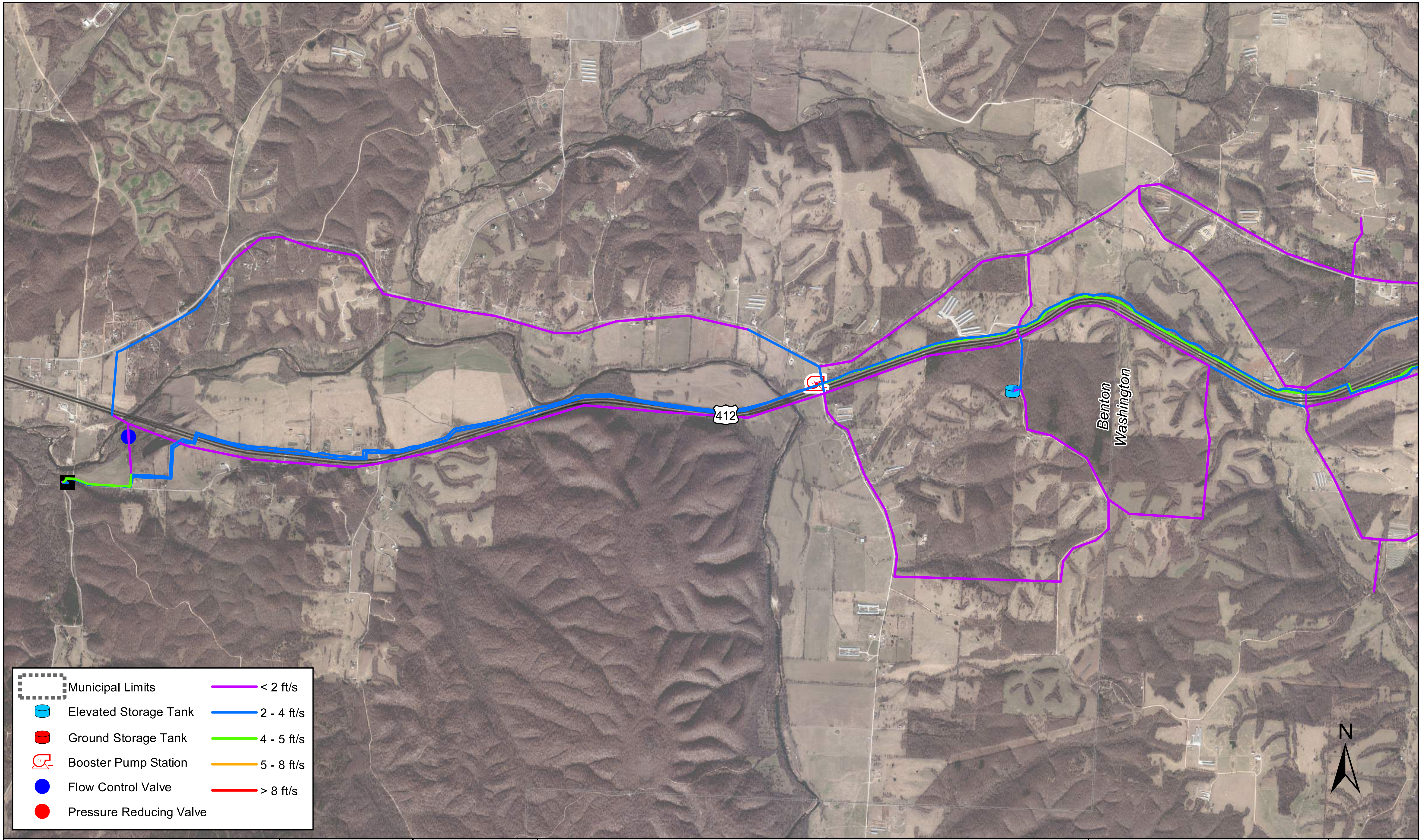

BWRPWA SUPPLY BUILDOUT MAXIMUM VELOCITY (MDD)

Figure Number: **EXHIBIT 8A**

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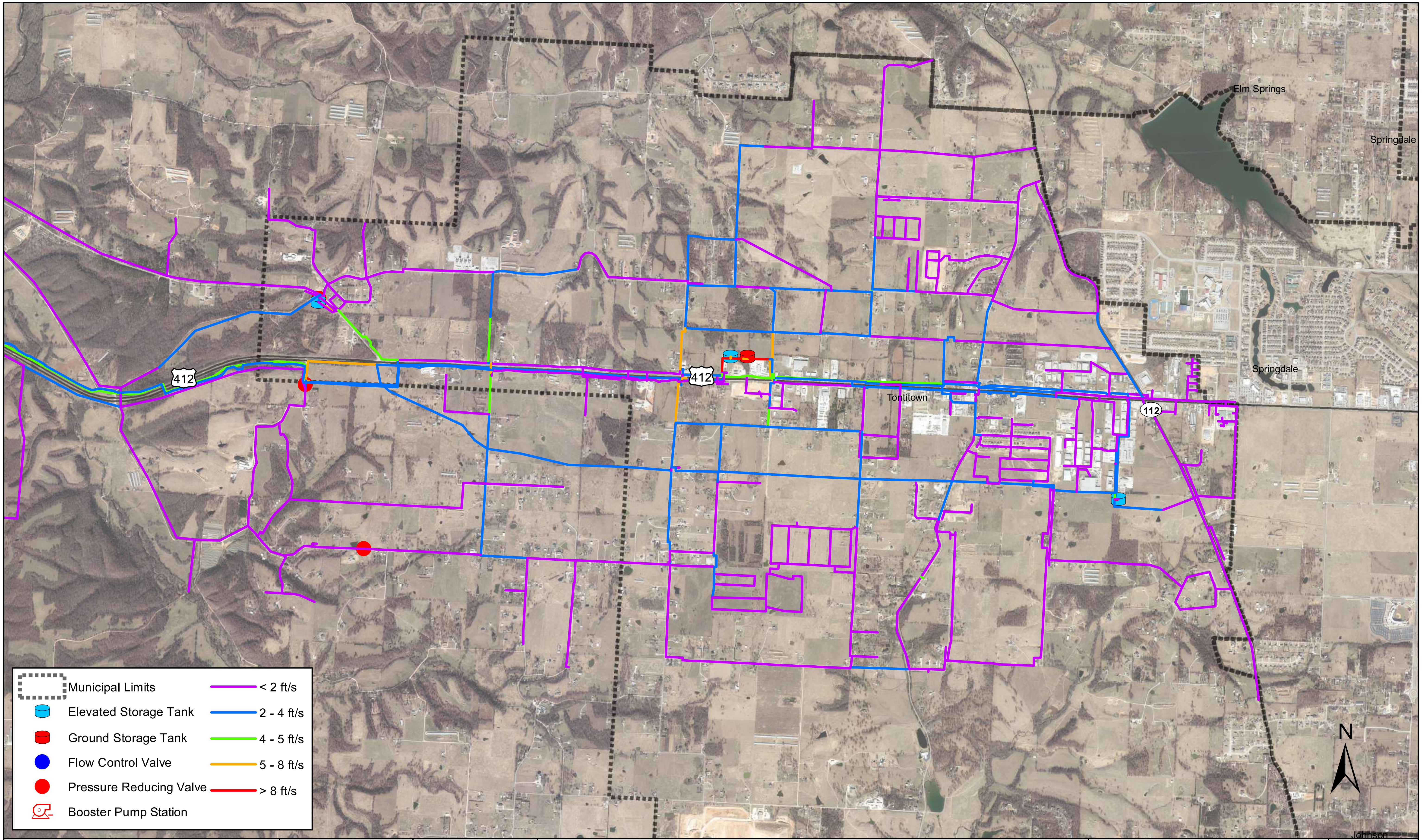

BWRPWA SUPPLY BUILDOUT
MAXIMUM VELOCITY (MDD)

Figure Number: **EXHIBIT 8B**

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APPENDIX C
2019 Water Loss Audit

1.0 Water Loss Audit

Garver performed a water loss audit on the City's water distribution system using data from 2019 following the guidance in the American Water Works (AWWA) Manual M36: Water Audits and Loss Control Programs. The audit was completed using the AWWA Free Water Audit Software, which is available at *https://www.awwa.org/Resources-Tools/Resource-Topics/Water-Loss-Control*. This audit includes data analyses to estimate the extent and evaluate the characteristics of the City's water losses. This evaluation will assist the City in pursuing further investigations and ultimately propose solutions to reduce water losses. Reducing water losses will enable the City to maximize the ability to meet customer demands with existing City water resources, potentially delaying the need to develop additional sources and/or purchase water from other suppliers.

The American Water Works Association (AWWA) defines water losses as the difference between the water supplied to the system and authorized consumption, which is any use authorized by the water supplier. Authorized consumption includes not only metered and billed water used by retail customers, but also unbilled consumption by other authorized users.

Data provided by the City indicated that Tontitown experienced 48 MG of water loss in 2019. Of that 48 MG, 18 MG was determined to be "unavoidable" Annual Real losses (UARL) which is determined by a formula using the miles of pipe, operating pressure, and number of connections in the distribution system. The infrastructure leakage index (ILI) is defined as the ratio of actual to unavoidable losses, and AWWA recommends using this for water loss planning rather than percentage of production, which is highly sensitive to customer consumption. In 2019, Tontitown's ILI was 2.65. The water audit report provided in the following pages contains a breakdown of different ranges of ILI values and what they mean for the systems performance in terms of water loss. According to these target ILI guidelines, the target ILI should be less than 3 if costs to develop or operate sources is not "low". Overall, Tontitown is within an acceptable range for water loss. However, there is room for improvement as decreasing the ILI to a value closer to 2 is ideal.

The City should continue to monitor water loss with the new water source and elevated storage tank in place to see if there are changes. The switch from Springdale pressure may reduce water loss slightly, but there is additional potential for water loss from the new supply transmission main.

AWWA Free Water Audit Software v5.0

This spreadsheet-based water audit tool is designed to help quantify and track water losses associated with water distribution systems and identify areas for improved efficiency and cost recovery. It provides a "top-down" summary water audit format, and is not meant to take the place of a full-scale, comprehensive water audit format.

Auditors are strongly encouraged to refer to the most current edition of AWWA M36 Manual for Water Audits for detailed guidance on the water auditing process and targetting loss reduction levels

The spreadsheet contains several separate worksheets. Sheets can be accessed using the tabs towards the bottom of the screen, or by clicking the buttons below.

Please begin by providing the following information

Name of Contact Person: James Clark
Email Address: pwdirector@tontitownar.gov
Telephone | Ext.: 479-361-2700
Name of City / Utility: City of Tontitown
City/Town/Municipality: Tontitown
State / Province: Arkansas (AR)
Country: USA
Year: 2019 Calendar Year

Audit Preparation Date: 12/8/2020
Volume Reporting Units: Million gallons (US)
PWSID / Other ID: AR0000566

The following guidance will help you complete the Audit

All audit data are entered on the ***Reporting Worksheet***

☐	Value can be entered by user
🟨	Value calculated based on input data
🟪	These cells contain recommended default values

Use of Option (Radio) Buttons: Pcnt: 0.25% ● ○ Value:

Select the default percentage by choosing the option button on the left

To enter a value, choose this button and enter a value in the cell to the right

The following worksheets are available by clicking the buttons below or selecting the tabs along the bottom of the page

Instructions
The current sheet. Enter contact information and basic audit details (year, units etc)

Reporting Worksheet
Enter the required data on this worksheet to calculate the water balance and data grading

Comments
Enter comments to explain how values were calculated or to document data sources

Performance Indicators
Review the performance indicators to evaluate the results of the audit

Water Balance
The values entered in the Reporting Worksheet are used to populate the Water Balance

Dashboard
A graphical summary of the water balance and Non-Revenue Water components

Grading Matrix
Presents the possible grading options for each input component of the audit

Service Connection Diagram
Diagrams depicting possible customer service connection line configurations

Definitions
Use this sheet to understand the terms used in the audit process

Loss Control Planning
Use this sheet to interpret the results of the audit validity score and performance indicators

Example Audits
Reporting Worksheet and Performance Indicators examples are shown for two validated audits

Acknowledgements
Acknowledgements for the AWWA Free Water Audit Software v5.0

If you have questions or comments regarding the software please contact us via email at: wlc@awwa.org

AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5.0

? Click to access definition
\+ Click to add a comment

Water Audit Report for: City of Tontitown (AR0000566)
Reporting Year: 2019 | 1/2019 - 12/2019

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

Master Meter and Supply Error Adjustments

WATER SUPPLIED

<----------- Enter grading in column 'E' and 'J' ---------->

								Pcnt:		Value:	
Volume from own sources:	+	?	n/a	0.000	MG/Yr	+	?		● ○		MG/Yr
Water imported:	+	?	7	153.530	MG/Yr	+	?		● ○		MG/Yr
Water exported:	+	?	n/a	0.000	MG/Yr	+	?		● ○		MG/Yr

Enter negative % or value for under-registration
Enter positive % or value for over-registration

WATER SUPPLIED: 153.530 MG/Yr

AUTHORIZED CONSUMPTION

Click here: ?
for help using option buttons below

						Pcnt:		Value:	
Billed metered:	+	?	6	103.270	MG/Yr				
Billed unmetered:	+	?	n/a	0.000	MG/Yr				
Unbilled metered:	+	?	n/a	0.000	MG/Yr				
Unbilled unmetered:	+	?		1.919	MG/Yr	1.25%	● ○		MG/Yr

Default option selected for Unbilled unmetered - a grading of 5 is applied but not displayed

Use buttons to select percentage of water supplied
OR
value

AUTHORIZED CONSUMPTION: ? 105.189 MG/Yr

WATER LOSSES (Water Supplied - Authorized Consumption) 48.341 MG/Yr

Apparent Losses

						Pcnt:		Value:	
Unauthorized consumption:	+	?		0.384	MG/Yr	0.25%	● ○		MG/Yr

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

Customer metering inaccuracies:	+	?	2	1.043	MG/Yr	1.00%	● ○		MG/Yr
Systematic data handling errors:	+	?		0.258	MG/Yr	0.25%	● ○		MG/Yr

Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed

Apparent Losses: ? 1.685 MG/Yr

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: ? 46.656 MG/Yr

WATER LOSSES: 48.341 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: ? 50.260 MG/Yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains:	+	?	7	58.3	miles
Number of active AND inactive service connections:	+	?	7	1,467	
Service connection density:		?		25	conn./mile main

Are customer meters typically located at the curbstop or property line? Yes

Average length of customer service line: + ?   (length of service line, beyond the property boundary, that is the responsibility of the utility)

Average length of customer service line has been set to zero and a data grading score of 10 has been applied

Average operating pressure:	+	?	5	90.0	psi

COST DATA

Total annual cost of operating water system:	+	?	8	$0	$/Year
Customer retail unit cost (applied to Apparent Losses):	+	?	9	$0.00	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	+	?	5	$0.00	$/Million gallons

☐ Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 63 out of 100 *****

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Water imported
2: Customer metering inaccuracies
3: Billed metered

AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0

Water Audit Report for: City of Tontitown (AR0000566)
Reporting Year: 2019 | 1/2019 - 12/2019

***** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 63 out of 100 *****

System Attributes:

Apparent Losses:	1.685	MG/Yr
+ Real Losses:	46.656	MG/Yr
= **Water Losses:**	**48.341**	MG/Yr
? Unavoidable Annual Real Losses (UARL):	17.60	MG/Yr
Annual cost of Apparent Losses:	$2	
Annual cost of Real Losses:	$0	Valued at **Variable Production Cost**

Return to Reporting Worksheet to change this assumpiton

Performance Indicators:

Financial:	Non-revenue water as percent by volume of Water Supplied:	32.7%	
	Non-revenue water as percent by cost of operating system:	17337.1%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	3.15	gallons/connection/day
	Real Losses per service connection per day:	N/A	gallons/connection/day
	Real Losses per length of main per day*:	2,191.27	gallons/mile/day
	Real Losses per service connection per day per psi pressure:	N/A	gallons/connection/day/psi
	From Above, Real Losses = Current Annual Real Losses (CARL):	46.66	million gallons/year
	? Infrastructure Leakage Index (ILI) [CARL/UARL]:	2.65	

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

AWWA Free Water Audit Software:
User Comments

Use this worksheet to add comments or notes to explain how an input value was calculated, or to document the sources of the information used.

General Comment:	

Audit Item	Comment
Volume from own sources:	WTP Raw Meter
Vol. from own sources: Master meter error adjustment:	N/A
Water imported:	Water Purchases from OKC
Water imported: master meter error adjustment:	N/A
Water exported:	Bethany sells water at retail rates to 3 small mobile home parks located throughout the distribution system. Given the consumption and location of these suppliers, their consumption is included in metered billed rather than water exported.
Water exported: master meter error adjustment:	N/A
Billed metered:	Based on consumption records extracted from City's billing system. Excludes consumption associated with connections served by Bethany's sewer system only and a different water supplier.
Billed unmetered:	No known billed unmetered connections except during temporary meter outages.
Unbilled metered:	City Hall has a meter that is unbilled. City Hall consumption was provided by the City for 2017.

Audit Item	Comment
Unbilled unmetered:	All municipal facilities other than City Hall are unmetered. Includes City pool, fire station, police and court complex, public works complex, parks and recreation office, City parks, and WTP.
Unauthorized consumption:	Estimated to be low. Known causes are unauthorized hydrant uses and contractor use of OKC hydrant meters at Bethany hydrants.
Customer metering inaccuracies:	No meter testing program is in place. Meters tested in response to customer complaints are typically accurate.
Systematic data handling errors:	Default value used.
Length of mains:	Based on City maps.
Number of active AND inactive service connections:	Based on consumption records extracted from City's billing system. Excludes connections served by Bethany's sewer system only and a different water supplier.
Average length of customer service line:	Meters located at curb stop.
Average operating pressure:	One pressure zone. Fluctuations during high demands are not measured.
Total annual cost of operating water system:	Based on Water Utility line item in City's Balances Report.
Customer retail unit cost (applied to Apparent Losses):	Based on City water rates for usage up to 10,000 gallons per month.
Variable production cost (applied to Real Losses):	Based on sum of chemicals, maintenance, maintenance supplies, and utilities line items in balance report.

AWWA Free Water Audit Software: Water Balance

WAS v5.0

Water Audit Report for:	City of Tontitown (AR0000566)	
Reporting Year:	2019	1/2019 - 12/2019
Data Validity Score:	63	

		Water Exported *0.000*	**Billed Water Exported**			**Revenue Water** 0.000
Own Sources **(Adjusted for known errors)** *0.000*	**System Input** *153.530*	**Water Supplied** *153.530*	**Authorized Consumption** *105.189*	**Billed Authorized Consumption** *103.270*	**Billed Metered Consumption (water exported is removed)** *103.270*	**Revenue Water** 103.270
					Billed Unmetered Consumption *0.000*	
				Unbilled Authorized Consumption *1.919*	**Unbilled Metered Consumption** *0.000*	**Non-Revenue Water (NRW)** 50.260
					Unbilled Unmetered Consumption *1.919*	
			Water Losses *48.341*	**Apparent Losses** *1.685*	**Unauthorized Consumption** *0.384*	
					Customer Metering Inaccuracies *1.043*	
					Systematic Data Handling Errors *0.258*	
Water Imported *153.530*				**Real Losses** *46.656*	**Leakage on Transmission and/or Distribution Mains** *Not broken down*	
					Leakage and Overflows at Utility's Storage Tanks *Not broken down*	
					Leakage on Service Connections *Not broken down*	

WAS v5.0

AWWA Free Water Audit Software:
Dashboard

The graphic below is a visual representation of the Water Balance with bar heights propotional to the volume of the audit components

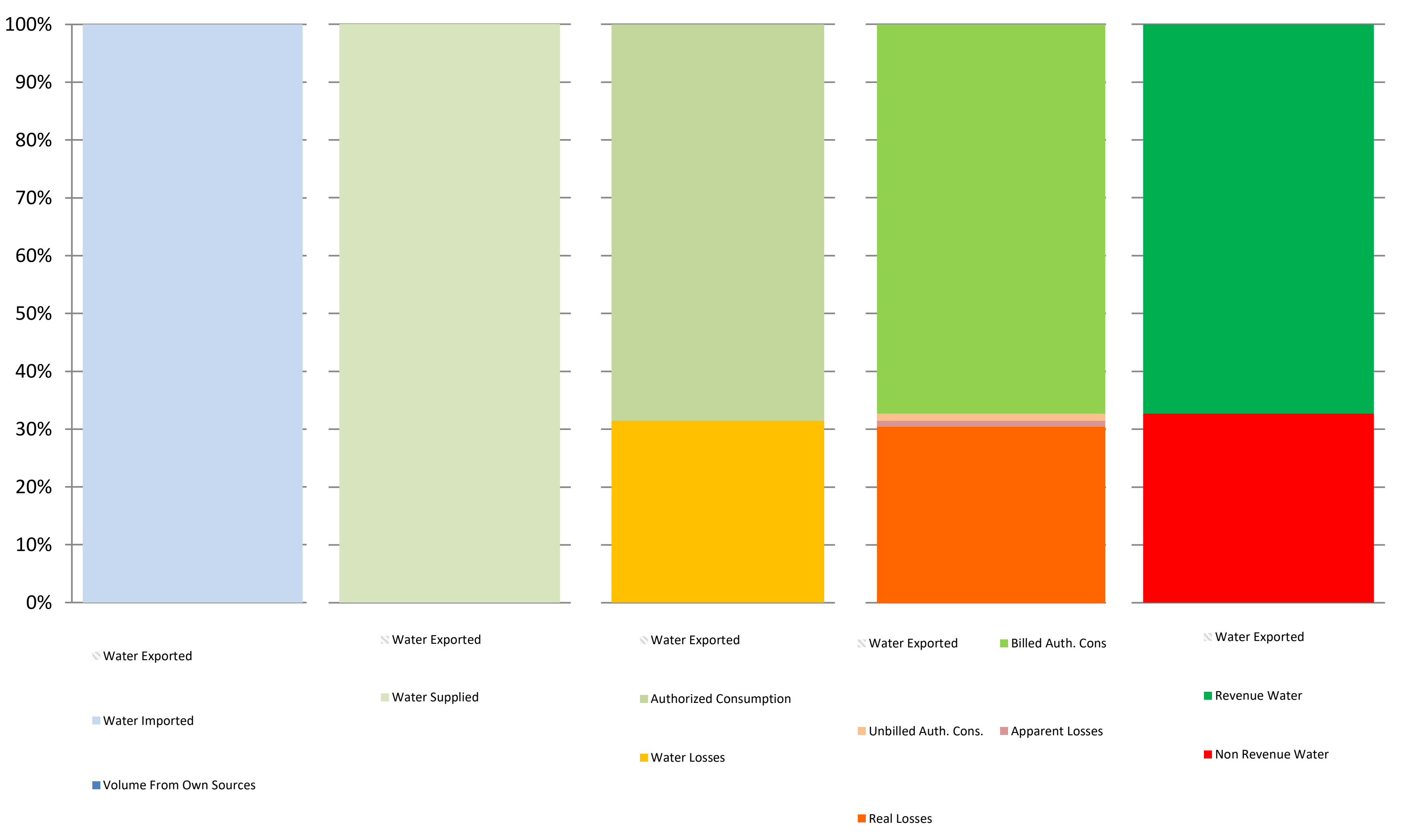
Water Audit Report for: City of Tontitown (AR0000566)

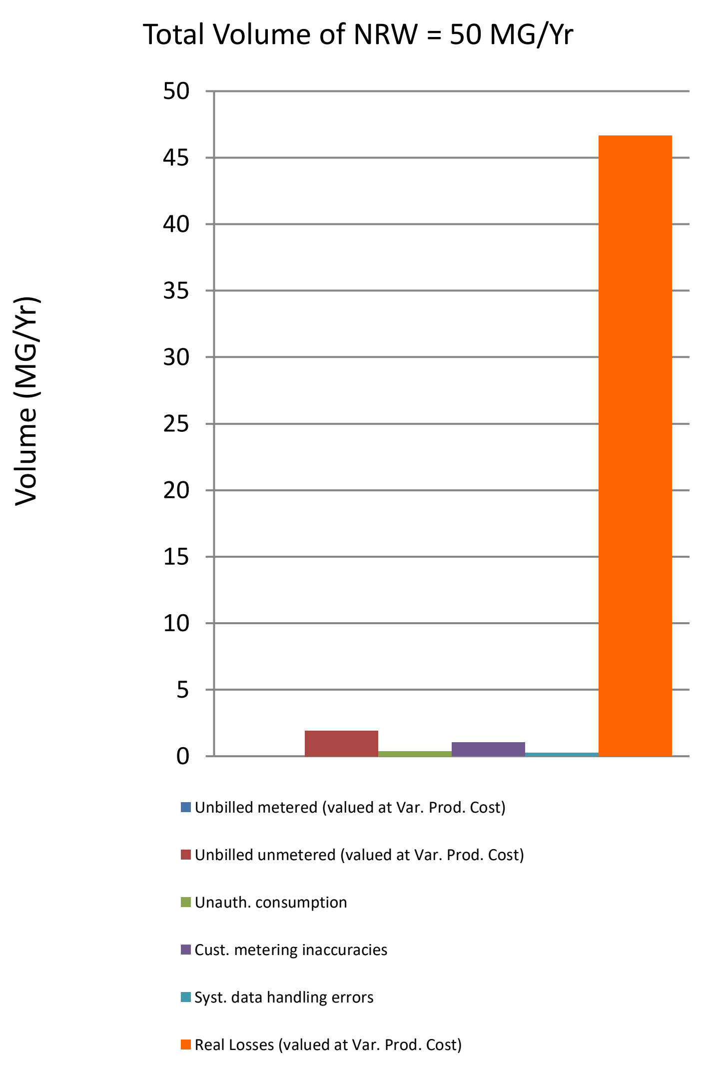
Reporting Year: 2019 1/2019 - 12/2019

Data Validity Score: 63

● Show me the VOLUME of Non-Revenue Water

○ Show me the COST of Non-Revenue Water





AWWA Free Water Audit Software: Grading Matrix

WAS 5.0

The grading assigned to each audit component and the corresponding recommended improvements and actions are highlighted in yellow. Audit accuracy is likely to be improved by prioritizing those items shown in red

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
WATER SUPPLIED											
Volume from own sources:	Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)	Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted.	25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted.	Conditions between 2 and 4	50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing or electronic calibration conducted.	Conditions between 4 and 6	At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually, with less than 10% found outside of +/- 3% accuracy. Procedures are reviewed by a third party knowledgeable in the M36 methodology.
Improvements to attain higher data grading for "Volume from own Sources" component:		to qualify for 2: Organize and launch efforts to collect data for determining volume from own sources	to qualify for 4: Locate all water production sources on maps and in the field, launch meter accuracy testing for existing meters, begin to install meters on unmetered water production sources and replace any obsolete/defective meters.		to qualify for 6: Formalize annual meter accuracy testing for all source meters; specify the frequency of testing. Complete installation of meters on unmetered water production sources and complete replacement of all obsolete/defective meters.		to qualify for 8: Conduct annual meter accuracy testing and calibration of related instrumentation on all meter installations on a regular basis. Complete project to install new, or replace defective existing, meters so that entire production meter population is metered. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing and calibration of related instrumentation for all meter installations. Repair or replace meters outside of +/- 3% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to further improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
Volume from own sources master meter and supply error adjustment:	Select n/a only if the water utility fails to have meters on its sources of supply	Inventory information on meters and paper records of measured volumes exist but are incomplete and/or in a very crude condition; data error cannot be determined	No automatic datalogging of production volumes; daily readings are scribed on paper records without any accountability controls. Flows are not balanced across the water distribution system: tank/storage elevation changes are not employed in calculating the "Volume from own sources" component and archived flow data is adjusted only when grossly evident data error occurs.	Conditions between 2 and 4	Production meter data is logged automatically in electronic format and reviewed at least on a monthly basis with necessary corrections implemented. "Volume from own sources" tabulations include estimate of daily changes in tanks/storage facilities. Meter data is adjusted when gross data errors occur, or occasional meter testing deems this necessary.	Conditions between 4 and 6	Hourly production meter data logged automatically & reviewed on at least a weekly basis. Data is adjusted to correct gross error when meter/instrumentation equipment malfunction is detected; and/or error is confirmed by meter accuracy testing. Tank/storage facility elevation changes are automatically used in calculating a balanced "Volume from own sources" component, and data gaps in the archived data are corrected on at least a weekly basis.	Conditions between 6 and 8	Continuous production meter data is logged automatically & reviewed each business day. Data is adjusted to correct gross error from detected meter/instrumentation equipment malfunction and/or results of meter accuracy testing. Tank/storage facility elevation changes are automatically used in "Volume from own sources" tabulations and data gaps in the archived data are corrected on a daily basis.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically balances flows from all sources and storages; results are reviewed each business day. Tight accountability controls ensure that all data gaps that occur in the archived flow data are quickly detected and corrected. Regular calibrations between SCADA and sources meters ensures minimal data transfer error.
Improvements to attain higher data grading for "Master meter and supply error adjustment" component:		to qualify for 2: Develop a plan to restructure recordkeeping system to capture all flow data; set a procedure to review flow data on a daily basis to detect input errors. Obtain more reliable information about existing meters by conducting field inspections of meters and related instrumentation, and obtaining manufacturer literature.	to qualify for 4: Install automatic datalogging equipment on production meters. Complete installation of level instrumentation at all tanks/storage facilities and include tank level data in automatic calculation routine in a computerized system. Construct a computerized listing or spreadsheet to archive input volumes, tank/storage volume changes and import/export flows in order to determine the composite "Water Supplied" volume for the distribution system. Set a procedure to review this data on a monthly basis to detect gross anomalies and data gaps.		to qualify for 6: Refine computerized data collection and archive to include hourly production meter data that is reviewed at least on a weekly basis to detect specific data anomalies and gaps. Use daily net storage change to balance flows in calculating "Water Supplied" volume. Necessary corrections to data errors are implemented on a weekly basis.		to qualify for 8: Ensure that all flow data is collected and archived on at least an hourly basis. All data is reviewed and detected errors corrected each business day. Tank/storage levels variations are employed in calculating balanced "Water Supplied" component. Adjust production meter data for gross error and inaccuracy confirmed by testing.		to qualify for 10: Link all production and tank/storage facility elevation change data to a Supervisory Control & Data Acquisition (SCADA) System, or similar computerized monitoring/control system, and establish automatic flow balancing algorithm and regularly calibrate between SCADA and source meters. Data is reviewed and corrected each business day.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters. Continue to replace or repair meters as they perform outside of desired accuracy limits. Stay abreast of new and more accurate water level instruments to better record tank/storage levels and archive the variations in storage volume. Keep current with SCADA and data management systems to ensure that archived data is well-managed and error free.
Water Imported:	Select n/a if the water utility's supply is exclusively from its own water resources (no bulk purchased/ imported water)	Less than 25% of imported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of imported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of imported water sources are metered, other sources estimated. Occasional meter accuracy testing conducted.	Conditions between 4 and 6	At least 75% of imported water sources are metered, meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually for all meter installations. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of imported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of imported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually for all meter installations, with less than 10% of accuracy tests found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Imported Volume" component: *(Note: usually the water supplier selling the water - "the Exporter" - to the utility being audited is responsible to maintain the metering installation measuring the imported volume. The utility should coordinate carefully with the Exporter to ensure that adequate meter upkeep takes place and an accurate measure of the Water Imported volume is quantified.)*		to qualify for 2: Review bulk water purchase agreements with partner suppliers; confirm requirements for use and maintenance of accurate metering. Identify needs for new or replacement meters with goal to meter all imported water sources.	To qualify for 4: Locate all imported water sources on maps and in the field, launch meter accuracy testing for existing meters, begin to install meters on unmetered imported water interconnections and replace obsolete/defective meters.		to qualify for 6: Formalize annual meter accuracy testing for all imported water meters, planning for both regular meter accuracy testing and calibration of the related instrumentation. Continue installation of meters on unmetered imported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all imported water interconnections. Maintain annual meter accuracy testing for all imported water meters and conduct calibration of related instrumentation at least annually. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Conduct meter accuracy testing for all meters on a semi-annual basis, along with calibration of all related instrumentation. Repair or replace meters outside of +/- 3% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Continue to conduct calibration of related instrumentation on a semi-annual basis. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Water imported master meter and supply error adjustment:	Select n/a if the Imported water supply is unmetered, with Imported water quantities estimated on the billing invoices sent by the Exporter to the purchasing Utility.	Inventory information on imported meters and paper records of measured volumes exist but are incomplete and/or in a very crude condition; data error cannot be determined Written agreement(s) with water Exporter(s) are missing or written in vague language concerning meter management and testing.	No automatic datalogging of imported supply volumes; daily readings are scribed on paper records without any accountability controls to confirm data accuracy and the absence of errors and data gaps in recorded volumes. Written agreement requires meter accuracy testing but is vague on the details of how and who conducts the testing.	Conditions between 2 and 4	Imported supply metered flow data is logged automatically in electronic format and reviewed at least on a monthly basis by the Exporter with necessary corrections implemented. Meter data is adjusted by the Exporter when gross data errors are detected. A coherent data trail exists for this process to protect both the selling and the purchasing Utility. Written agreement exists and clearly states requirements and roles for meter accuracy testing and data management.	Conditions between 4 and 6	Hourly Imported supply metered data is logged automatically & reviewed on at least a weekly basis by the Exporter. Data is adjusted to correct gross error when meter/instrumentation equipment malfunction is detected; and to correct for error confirmed by meter accuracy testing. Any data gaps in the archived data are detected and corrected during the weekly review. A coherent data trail exists for this process to protect both the selling and the purchasing Utility.	Conditions between 6 and 8	Continuous Imported supply metered flow data is logged automatically & reviewed each business day by the Exporter. Data is adjusted to correct gross error from detected meter/instrumentation equipment malfunction and/or results of meter accuracy testing. Any data errors/gaps are detected and corrected on a daily basis. A data trail exists for the process to protect both the selling and the purchasing Utility.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically records data which is reviewed each business day by the Exporter. Tight accountability controls ensure that all error/data gaps that occur in the archived flow data are quickly detected and corrected. A reliable data trail exists and contract provisions for meter testing and data management are reviewed by the selling and purchasing Utility at least once every five years.
Improvements to attain higher data grading for "Water imported master meter and supply error adjustment" component:		to qualify for 2: Develop a plan to restructure recordkeeping system to capture all flow data; set a procedure to review flow data on a daily basis to detect input errors. Obtain more reliable information about existing meters by conducting field inspections of meters and related instrumentation, and obtaining manufacturer literature. Review the written agreement between the selling and purchasing Utility.	to qualify for 4: Install automatic datalogging equipment on Imported supply meters. Set a procedure to review this data on a monthly basis to detect gross anomalies and data gaps. Launch discussions with the Exporters to jointly review terms of the written agreements regarding meter accuracy testing and data management; revise the terms as necessary.		to qualify for 6: Refine computerized data collection and archive to include hourly Imported supply metered flow data that is reviewed at least on a weekly basis to detect specific data anomalies and gaps. Make necessary corrections to errors/data errors on a weekly basis.		to qualify for 8: Ensure that all Imported supply metered flow data is collected and archived on at least an hourly basis. All data is reviewed and errors/data gaps are corrected each business day.		to qualify for 10: Conduct accountability checks to confirm that all Imported supply metered data is reviewed and corrected each business day by the Exporter. Results of all meter accuracy tests and data corrections should be available for sharing between the Exporter and the purchasing Utility. Establish a schedule for a regular review and updating of the contractual language in the written agreement between the selling and the purchasing Utility; at least every five years.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters; work with the Exporter to help identify meter replacement needs. Keep communication lines with Exporters open and maintain productive relations. Keep the written agreement current with clear and explicit language that meets the ongoing needs of all parties.
Water Exported:	Select n/a if the water utility sells no bulk water to neighboring water utilities (no exported water sales)	Less than 25% of exported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of exported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of exported water sources are metered, other sources estimated. Occasional meter accuracy testing conducted.	Conditions between 4 and 6	At least 75% of exported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of exported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of exported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually for all meter installations, with less than 10% of accuracy tests found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Exported Volume" component: (*Note: usually, if the water utility being audited sells (Exports) water to a neighboring purchasing Utility, it is the responsibility of the utility exporting the water to maintain the metering installation measuring the Exported volume. The utility exporting the water should ensure that adequate meter upkeep takes place and an accurate measure of the Water Exported volume is quantified.*)		to qualify for 2: Review bulk water sales agreements with purchasing utilities; confirm requirements for use & upkeep of accurate metering. Identify needs to install new, or replace defective meters as needed.	To qualify for 4: Locate all exported water sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered exported water interconnections and replace obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all exported water meters. Continue installation of meters on unmetered exported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all exported water interconnections. Maintain annual meter accuracy testing for all exported water meters. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 3% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
Water exported master meter and supply error adjustment:	Select n/a only if the water utility fails to have meters on its exported supply interconnections.	Inventory information on exported meters and paper records of measured volumes exist but are incomplete and/or in a very crude condition; data error cannot be determined Written agreement(s) with the utility purchasing the water are missing or written in vague language concerning meter management and testing.	No automatic datalogging of exported supply volumes; daily readings are scribed on paper records without any accountability controls to confirm data accuracy and the absence of errors and data gaps in recorded volumes. Written agreement requires meter accuracy testing but is vague on the details of how and who conducts the testing.	Conditions between 2 and 4	Exported metered flow data is logged automatically in electronic format and reviewed at least on a monthly basis, with necessary corrections implemented. Meter data is adjusted by the utility selling (exporting) the water when gross data errors are detected. A coherent data trail exists for this process to protect both the utility exporting the water and the purchasing Utility. Written agreement exists and clearly states requirements and roles for meter accuracy testing and data management.	Conditions between 4 and 6	Hourly exported supply metered data is logged automatically & reviewed on at least a weekly basis by the utility selling the water. Data is adjusted to correct gross error when meter/instrumentation equipment malfunction is detected; and to correct for error found by meter accuracy testing. Any data gaps in the archived data are detected and corrected during the weekly review. A coherent data trail exists for this process to protect both the selling (exporting) utility and the purchasing Utility.	Conditions between 6 and 8	Continuous exported supply metered flow data is logged automatically & reviewed each business day by the utility selling (exporting) the water. Data is adjusted to correct gross error from detected meter/instrumentation equipment malfunction and any error confirmed by meter accuracy testing. Any data errors/gaps are detected and corrected on a daily basis. A data trail exists for the process to protect both the selling (exporting) Utility and the purchasing Utility.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically records data which is reviewed each business day by the utility selling (exporting) the water. Tight accountability controls ensure that all error/data gaps that occur in the archived flow data are quickly detected and corrected. A reliable data trail exists and contract provisions for meter testing and data management are reviewed by the selling Utility and purchasing Utility at least once every five years.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Water exported master meter and supply error adjustment" component:	▨	to qualify for 2: Develop a plan to restructure recordkeeping system to capture all flow data; set a procedure to review flow data on a daily basis to detect input errors. Obtain more reliable information about existing meters by conducting field inspections of meters and related instrumentation, and obtaining manufacturer literature. Review the written agreement between the utility selling (exporting) the water and the purchasing Utility.	to qualify for 4: Install automatic datalogging equipment on exported supply meters. Set a procedure to review this data on a monthly basis to detect gross anomalies and data gaps. Launch discussions with the purchasing utilities to jointly review terms of the written agreements regarding meter accuracy testing and data management; revise the terms as necessary.		to qualify for 6: Refine computerized data collection and archive to include hourly exported supply metered flow data that is reviewed at least on a weekly basis to detect specific data anomalies and gaps. Make necessary corrections to errors/data errors on a weekly basis.		to qualify for 8: Ensure that all exported metered flow data is collected and archived on at least an hourly basis. All data is reviewed and errors/data gaps are corrected each business day.		to qualify for 10: Conduct accountability checks to confirm that all exported metered flow data is reviewed and corrected each business day by the utility selling the water. Results of all meter accuracy tests and data corrections should be available for sharing between the utility and the purchasing Utility. Establish a schedule for a regular review and updating of the contractual language in the written agreements with the purchasing utilities; at least every five years.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters; work with the purchasing utilities to help identify meter replacement needs. Keep communication lines with the purchasing utilities open and maintain productive relations. Keep the written agreement current with clear and explicit language that meets the ongoing needs of all parties.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
AUTHORIZED CONSUMPTION											
Billed metered:	n/a (not applicable). Select n/a only if the entire customer population is not metered and is billed for water service on a flat or fixed rate basis. In such a case the volume entered must be zero.	Less than 50% of customers with volume-based billings from meter readings; flat or fixed rate billing exists for the majority of the customer population	At least 50% of customers with volume-based billing from meter reads; flat rate billing for others. Manual meter reading is conducted, with less than 50% meter read success rate, remainding accounts' consumption is estimated. Limited meter records, no regular meter testing or replacement. Billing data maintained on paper records, with no auditing.	Conditions between 2 and 4	At least 75% of customers with volume-based, billing from meter reads; flat or fixed rate billing for remaining accounts. Manual meter reading is conducted with at least 50% meter read success rate; consumption for accounts with failed reads is estimated. Purchase records verify age of customer meters; only very limited meter accuracy testing is conducted. Customer meters are replaced only upon complete failure. Computerized billing records exist, but only sporadic internal auditing conducted.	Conditions between 4 and 6	At least 90% of customers with volume-based billing from meter reads; consumption for remaining accounts is estimated. Manual customer meter reading gives at least 80% customer meter reading success rate; consumption for accounts with failed reads is estimated. Good customer meter records eixst, but only limited meter accuracy testing is conducted. Regular replacement is conducted for the oldest meters. Computerized billing records exist with annual auditing of summary statistics conducting by utility personnel.	Conditions between 6 and 8	At least 97% of customers exist with volume-based billing from meter reads. At least 90% customer meter reading success rate; or at least 80% read success rate with planning and budgeting for trials of Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) in one or more pilot areas. Good customer meter records. Regular meter accuracy testing guides replacement of statistically significant number of meters each year. Routine auditing of computerized billing records for global and detailed statistics occurs annually by utility personnel, and is verified by third party at least once every five years.	Conditions between 8 and 10	At least 99% of customers exist with volume-based billing from meter reads. At least 95% customer meter reading success rate; or minimum 80% meter reading success rate, with Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) trials underway. Statistically significant customer meter testing and replacement program in place on a continuous basis. Computerized billing with routine, detailed auditing, including field investigation of representative sample of accounts undertaken annually by utility personnel. Audit is conducted by third party auditors at least once every three years.
Improvements to attain higher data grading for "Billed Metered Consumption" component:	If n/a is selected because the customer meter population is unmetered, consider establishing a new policy to meter the customer population and employ water rates based upon metered volumes.	to qualify for 2: Conduct investigations or trials of customer meters to select appropriate meter models. Budget funding for meter installations. Investigate volume based water rate structures.	to qualify for 4: Purchase and install meters on unmetered accounts. Implement policies to improve meter reading success. Catalog meter information during meter read visits to identify age/model of existing meters. Test a minimal number of meters for accuracy. Install computerized billing system.		to qualify for 6: Purchase and install meters on unmetered accounts. Eliminate flat fee billing and establish appropriate water rate structure based upon measured consumption. Continue to achieve verifiable success in removing manual meter reading barriers. Expand meter accuracy testing. Launch regular meter replacement program. Launch a program of annual auditing of global billing statistics by utility personnel.		to qualify for 8: Purchase and install meters on unmetered accounts. If customer meter reading success rate is less than 97%, assess cost-effectiveness of Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) system for portion or entire system; or otherwise achieve ongoing improvements in manual meter reading success rate to 97% or higher. Refine meter accuracy testing program. Set meter replacement goals based upon accuracy test results. Implement annual auditing of detailed billing records by utility personnel and implement third party auditing at least once every five years.		to qualify for 10: Purchase and install meters on unmetered accounts. Launch Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) system trials if manual meter reading success rate of at least 99% is not achieved within a five-year program. Continue meter accuracy testing program. Conduct planning and budgeting for large scale meter replacement based upon meter life cycle analysis using cumulative flow target. Continue annual detailed billing data auditing by utility personnel and conduct third party auditing at least once every three years.		to maintain 10: Continue annual internal billing data auditing, and third party auditing at least every three years. Continue customer meter accuracy testing to ensure that accurate customer meter readings are obtained and entered as the basis for volume based billing. Stay abreast of improvements in Automatic Meter Reading (AMR) and Advanced Metering Infrastructure (AMI) and information management. Plan and budget for justified upgrades in metering, meter reading and billing data management to maintain very high accuracy in customer metering and billing.
Billed unmetered:	Select n/a if it is the policy of the water utility to meter all customer connections and it has been confirmed by detailed auditing that all customers do indeed have a water meter; i.e. no intentionally unmetered accounts exist	Water utility policy does not require customer metering; flat or fixed fee billing is employed. No data is collected on customer consumption. The only estimates of customer population consumption available are derived from data estimation methods using average fixture count multiplied by number of connections, or similar approach.	Water utility policy does not require customer metering; flat or fixed fee billing is employed. Some metered accounts exist in parts of the system (pilot areas or District Metered Areas) with consumption read periodically or recorded on portable dataloggers over one, three, or seven day periods. Data from these sample meters are used to infer consumption for the total customer population. Site specific estimation methods are used for unusual buildings/water uses.	Conditions between 2 and 4	Water utility policy does require metering and volume based billing in general. However, a liberal amount of exemptions and a lack of clearly written and communicated procedures result in up to 20% of billed accounts believed to be unmetered by exemption; or the water utility is in transition to becoming fully metered, and a large number of customers remain unmetered. A rough estimate of the annual consumption for all unmetered accounts is included in the annual water audit, with no inspection of individual unmetered accounts.	Conditions between 4 and 6	Water utility policy does require metering and volume based billing but established exemptions exist for a portion of accounts such as municipal buildings. As many as 15% of billed accounts are unmetered due to this exemption or meter installation difficulties. Only a group estimate of annual consumption for all unmetered accounts is included in the annual water audit, with no inspection of individual unmetered accounts.	Conditions between 6 and 8	Water utility policy does require metering and volume based billing for all customer accounts. However, less than 5% of billed accounts remain unmetered because meter installation is hindered by unusual circumstances. The goal is to minimize the number of unmetered accounts. Reliable estimates of consumption are obtained for these unmetered accounts via site specific estimation methods.	Conditions between 8 and 10	Water utility policy does require metering and volume based billing for all customer accounts. Less than 2% of billed accounts are unmetered and exist because meter installation is hindered by unusual circumstances. The goal exists to minimize the number of unmetered accounts to the extent that is economical. Reliable estimates of consumption are obtained at these accounts via site specific estimation methods.
Improvements to attain higher data grading for "Billed Unmetered Consumption" component:		to qualify for 2: Conduct research and evaluate cost/benefit of a new water utility policy to require metering of the customer population; thereby greatly reducing or eliminating unmetered accounts. Conduct pilot metering project by installing water meters in small sample of customer accounts and periodically reading the meters or datalogging the water consumption over one, three, or seven day periods.	to qualify for 4: Implement a new water utility policy requiring customer metering. Launch or expand pilot metering study to include several different meter types, which will provide data for economic assessment of full scale metering options. Assess sites with access difficulties to devise means to obtain water consumption volumes. Begin customer meter installation.		to qualify for 6: Refine policy and procedures to improve customer metering participation for all but solidly exempt accounts. Assign staff resources to review billing records to identify errant unmetered properties. Specify metering needs and funding requirements to install sufficient meters to significant reduce the number of unmetered accounts		to qualify for 8: Push to install customer meters on a full scale basis. Refine metering policy and procedures to ensure that all accounts, including municipal properties, are designated for meters. Plan special efforts to address "hard-to-access" accounts. Implement procedures to obtain a reliable consumption estimate for the remaining few unmetered accounts awaiting meter installation.		to qualify for 10: Continue customer meter installation throughout the service area, with a goal to minimize unmetered accounts. Sustain the effort to investigate accounts with access difficulties, and devise means to install water meters or otherwise measure water consumption.		to maintain 10: Continue to refine estimation methods for unmetered consumption and explore means to establish metering, for as many billed remaining unmetered accounts as is economically feasible.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Unbilled metered:	select n/a if all billing-exempt consumption is unmetered.	Billing practices exempt certain accounts, such as municipal buildings, but written policies do not exist; and a reliable count of unbilled metered accounts is unavailable. Meter upkeep and meter reading on these accounts is rare and not considered a priority. Due to poor recordkeeping and lack of auditing, water consumption for all such accounts is purely guesstimated.	Billing practices exempt certain accounts, such as municipal buildings, but only scattered, dated written directives exist to justify this practice. A reliable count of unbilled metered accounts is unavailable. Sporadic meter replacement and meter reading occurs on an as-needed basis. The total annual water consumption for all unbilled, metered accounts is estimated based upon approximating the number of accounts and assigning consumption from actively billed accounts of same meter size.	Conditions between 2 and 4	Dated written procedures permit billing exemption for specific accounts, such as municipal properties, but are unclear regarding certain other types of accounts. Meter reading is given low priority and is sporadic. Consumption is quantified from meter readings where available. The total number of unbilled, unmetered accounts must be estimated along with consumption volumes.	Conditions between 4 and 6	Written policies regarding billing exemptions exist but adherence in practice is questionable. Metering and meter reading for municipal buildings is reliable but sporadic for other unbilled metered accounts. Periodic auditing of such accounts is conducted. Water consumption is quantified directly from meter readings where available, but the majority of the consumption is estimated.	Conditions between 6 and 8	Written policy identifies the types of accounts granted a billing exemption. Customer meter management and meter reading are considered secondary priorities, but meter reading is conducted at least annually to obtain consumption volumes for the annual water audit. High level auditing of billing records ensures that a reliable census of such accounts exists.	Conditions between 8 and 10	Clearly written policy identifies the types of accounts given a billing exemption, with emphasis on keeping such accounts to a minimum. Customer meter management and meter reading for these accounts is given proper priority and is reliably conducted. Regular auditing confirms this. Total water consumption for these accounts is taken from reliable readings from accurate meters.
Improvements to attain higher data grading for "Unbilled Metered Consumption" component:		to qualify for 2: Reassess the water utility's policy allowing certain accounts to be granted a billing exemption. Draft an outline of a new written policy for billing exemptions, with clear justification as to why any accounts should be exempt from billing, and with the intention to keep the number of such accounts to a minimum.	to qualify for 4: Review historic written directives and policy documents allowing certain accounts to be billing-exempt. Draft an outline of a written policy for billing exemptions, identify criteria that grants an exemption, with a goal of keeping this number of accounts to a minimum. Consider increasing the priority of reading meters on unbilled accounts at least annually.		to qualify for 6: Draft a new written policy regarding billing exemptions based upon consensus criteria allowing this occurrence. Assign resources to audit meter records and billing records to obtain census of unbilled metered accounts. Gradually include a greater number of these metered accounts to the routes for regular meter reading.		to qualify for 8: Communicate billing exemption policy throughout the organization and implement procedures that ensure proper account management. Conduct inspections of accounts confirmed in unbilled metered status and verify that accurate meters exist and are scheduled for routine meter readings. Gradually increase the number of unbilled metered accounts that are included in regular meter reading routes.		to qualify for 10: Ensure that meter management (meter accuracy testing, meter replacement) and meter reading activities for unbilled accounts are accorded the same priority as billed accounts. Establish ongoing annual auditing process to ensure that water consumption is reliably collected and provided to the annual water audit process.		to maintain 10: Reassess the utility's philosophy in allowing any water uses to go "unbilled". It is possible to meter and bill all accounts, even if the fee charged for water consumption is discounted or waived. Metering and billing all accounts ensures that water consumption is tracked and water waste from plumbing leaks is detected and minimized.
Unbilled unmetered:		Extent of unbilled, unmetered consumption is unknown due to unclear policies and poor recordkeeping. Total consumption is quantified based upon a purely subjective estimate.	Clear extent of unbilled, unmetered consumption is unknown, but a number of events are randomly documented each year, confirming existence of such consumption, but without sufficient documentation to quantify an accurate estimate of the annual volume consumed.	Conditions between 2 and 4	Extent of unbilled, unmetered consumption is partially known, and procedures exist to document certain events such as miscellaneous fire hydrant uses. Formulae is used to quantify the consumption from such events (time running multiplied by typical flowrate, multiplied by number of events).	Default value of 1.25% of system input volume is employed	Coherent policies exist for some forms of unbilled, unmetered consumption but others await closer evaluation. Reasonable recordkeeping for the managed uses exists and allows for annual volumes to be quantified by inference, but unsupervised uses are guesstimated.	Conditions between 6 and 8	Clear policies and good recordkeeping exist for some uses (ex: water used in periodic testing of unmetered fire connections), but other uses (ex: miscellaneous uses of fire hydrants) have limited oversight. Total consumption is a mix of well quantified use such as from formulae (time running multiplied by typical flow, multiplied by number of events) or temporary meters, and relatively subjective estimates of less regulated use.	Conditions between 8 and 10	Clear policies exist to identify permitted use of water in unbilled, unmetered fashion, with the intention of minimizing this type of consumption. Good records document each occurrence and consumption is quantified via formulae (time running multiplied by typical flow, multiplied by number of events) or use of temporary meters.
Improvements to attain higher data grading for "Unbilled Unmetered Consumption" component:		to qualify for 5: Utilize the accepted default value of 1.25% of the volume of water supplied as an expedient means to gain a reasonable quantification of this use. to qualify for 2: Establish a policy regarding what water uses should be allowed to remain as unbilled and unmetered. Consider tracking a small sample of one such use (ex: fire hydrant flushings).	to qualify for 5: Utilize accepted default value of 1.25% of the volume of water supplied as an expedient means to gain a reasonable quantification of this use. to qualify for 4: Evaluate the documentation of events that have been observed. Meet with user groups (ex: for fire hydrants - fire departments, contractors to ascertain their need and/or volume requirements for water from fire hydrants).		to qualify for 5: Utilize accepted default value of 1.25% of the volume of water supplied as an expedient means to gain a reasonable quantification of all such use. This is particularly appropriate for water utilities who are in the early stages of the water auditing process, and should focus on other components since the volume of unbilled, umetered consumption is usually a relatively small quatity component, and other larger-quantity components should take priority.	to qualify for 6 or greater: Finalize policy and begin to conduct field checks to better establish and quantify such usage. Proceed if top-down audit exists and/or a great volume of such use is suspected.	to qualify for 8: Assess water utility policy and procedures for various unmetered usages. For example, ensure that a policy exists and permits are issued for use of fire hydrants by persons outside of the utility. Create written procedures for use and documentation of fire hydrants by water utility personnel. Use same approach for other types of unbilled, unmetered water usage.		to qualify for 10: Refine written procedures to ensure that all uses of unbilled, unmetered water are overseen by a structured permitting process managed by water utility personnel. Reassess policy to determine if some of these uses have value in being converted to billed and/or metered status.		to maintain 10: Continue to refine policy and procedures with intention of reducing the number of allowable uses of water in unbilled and unmetered fashion. Any uses that can feasibly become billed and metered should be converted eventually.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
APPARENT LOSSES											
Unauthorized consumption:	▨	Extent of unauthorized consumption is unknown due to unclear policies and poor recordkeeping. Total unauthorized consumption is guesstimated.	Unauthorized consumption is a known occurrence, but its extent is a mystery. There are no requirements to document observed events, but periodic field reports capture some of these occurrences. Total unauthorized consumption is approximated from this limited data.	conditions between 2 and 4	Procedures exist to document some unauthorized consumption such as observed unauthorized fire hydrant openings. Use formulae to quantify this consumption (time running multiplied typical flowrate, multiplied by number of events).	Default value of 0.25% of volume of water supplied is employed	Coherent policies exist for some forms of unauthorized consumption (more than simply fire hydrant misuse) but others await closer evaluation. Reasonable surveillance and recordkeeping exist for occurrences that fall under the policy. Volumes quantified by inference from these records.	Conditions between 6 and 8	Clear policies and good auditable recordkeeping exist for certain events (ex: tampering with water meters, illegal bypasses of customer meters); but other occurrences have limited oversight. Total consumption is a combination of volumes from formulae (time x typical flow) and subjective estimates of unconfirmed consumption.	Conditions between 8 and 10	Clear policies exist to identify all known unauthorized uses of water. Staff and procedures exist to provide enforcement of policies and detect violations. Each occurrence is recorded and quantified via formulae (estimated time running multiplied by typical flow) or similar methods. All records and calculations should exist in a form that can be audited by a third party.
Improvements to attain higher data grading for "Unauthorized Consumption" component:	▨	to qualify for 5: Use accepted default of 0.25% of volume of water supplied. to qualify for 2: Review utility policy regarding what water uses are considered unauthorized, and consider tracking a small sample of one such occurrence (ex: unauthorized fire hydrant openings)	to qualify for 5: Use accepted default of 0.25% of system input volume to qualify for 4: Review utility policy regarding what water uses are considered unauthorized, and consider tracking a small sample of one such occurrence (ex: unauthorized fire hydrant openings)		to qualify for 5: Utilize accepted default value of 0.25% of volume of water supplied as an expedient means to gain a reasonable quantification of all such use. This is particularly appropriate for water utilities who are in the early stages of the water auditing process.	to qualify for 6 or greater: Finalize policy updates to clearly identify the types of water consumption that are authorized from those usages that fall outside of this policy and are, therefore, unauthorized. Begin to conduct regular field checks. Proceed if the top-down audit already exists and/or a great volume of such use is suspected.	to quality for 8: Assess water utility policies to ensure that all known occurrences of unauthorized consumption are outlawed, and that appropriate penalties are prescribed. Create written procedures for detection and documentation of various occurrences of unauthorized consumption as they are uncovered.		to qualify for 10: Refine written procedures and assign staff to seek out likely occurrences of unauthorized consumption. Explore new locking devices, monitors and other technologies designed to detect and thwart unauthorized consumption.		to maintain 10: Continue to refine policy and procedures to eliminate any loopholes that allow or tacitly encourage unauthorized consumption. Continue to be vigilant in detection, documentation and enforcement efforts.
Customer metering inaccuracies:	select n/a only if the entire customer population is unmetered. In such a case the volume entered must be zero.	Customer meters exist, but with unorganized paper records on meters; no meter accuracy testing or meter replacement program for any size of retail meter. Metering workflow is driven chaotically with no proactive management. Loss volume due to aggregate meter inaccuracy is guesstimated.	Poor recordkeeping and meter oversight is recognized by water utility management who has allotted staff and funding resources to organize improved recordkeeping and start meter accuracy testing. Existing paper records gathered and organized to provide cursory disposition of meter population. Customer meters are tested for accuracy only upon customer request.	Conditions between 2 and 4	Reliable recordkeeping exists; meter information is improving as meters are replaced. Meter accuracy testing is conducted annually for a small number of meters (more than just customer requests, but less than 1% of inventory). A limited number of the oldest meters are replaced each year. Inaccuracy volume is largely an estimate, but refined based upon limited testing data.	Conditions between 4 and 6	A reliable electronic recordkeeping system for meters exists. The meter population includes a mix of new high performing meters and dated meters with suspect accuracy. Routine, but limited, meter accuracy testing and meter replacement occur. Inaccuracy volume is quantified using a mix of reliable and less certain data.	Conditions between 6 and 8	Ongoing meter replacement and accuracy testing result in highly accurate customer meter population. Testing is conducted on samples of meters of varying age and accumulated volume of throughput to determine optimum replacement time for various types of meters.	Ongoing meter replacement and accuracy testing result in highly accurate customer meter population. Statistically significant number of meters are tested in audit year. This testing is conducted on samples of meters of varying age and accumulated volume of throughput to determine optimum replacement time for these meters.	Good records of all active customer meters exist and include as a minimum: meter number, account number/location, type, size and manufacturer. Ongoing meter replacement occurs according to a targeted and justified basis. Regular meter accuracy testing gives a reliable measure of composite inaccuracy volume for the customer meter population. New metering technology is embraced to keep overall accuracy improving. Procedures are reviewed by a third party knowledgeable in the M36 methodology.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Customer meter inaccuracy volume" component:	If n/a is selected because the customer meter population is unmetered, consider establishing a new policy to meter the customer population and employ water rates based upon metered volumes.	to qualify for 2: Gather available meter purchase records. Conduct testing on a small number of meters believed to be the most inaccurate. Review staffing needs of the metering group and budget for necessary resources to better organize meter management.	to qualify for 4: Implement a reliable record keeping system for customer meter histories, preferably using electronic methods typically linked to, or part of, the Customer Billing System or Customer Information System. Expand meter accuracy testing to a larger group of meters.		to qualify for 6: Standardize the procedures for meter recordkeeping within an electronic information system. Accelerate meter accuracy testing and meter replacements guided by testing results.		to qualify for 8: Expand annual meter accuracy testing to evaluate a statistically significant number of meter makes/models. Expand meter replacement program to replace statistically significant number of poor performing meters each year.		to qualify for 9: Continue efforts to manage meter population with reliable recordkeeping. Test a statistically significant number of meters each year and analyze test results in an ongoing manner to serve as a basis for a target meter replacement strategy based upon accumulated volume throughput.	to qualify for 10: Continue efforts to manage meter population with reliable recordkeeping, meter testing and replacement. Evaluate new meter types and install one or more types in 5-10 customer accounts each year in order to pilot improving metering technology.	to maintain 10: Increase the number of meters tested and replaced as justified by meter accuracy test data. Continually monitor development of new metering technology and Advanced Metering Infrastructure (AMI) to grasp opportunities for greater accuracy in metering of water flow and management of customer consumption data.
Systematic Data Handling Errors:	Note: all water utilities incur some amount of this error. Even in water utilities with unmetered customer populations and fixed rate billing, errors occur in annual billing tabulations. Enter a positive value for the volume and select a grading.	Policies and procedures for activation of new customer water billing accounts are vague and lack accountability. Billing data is maintained on paper records which are not well organized. No auditing is conducted to confirm billing data handling efficiency. An unknown number of customers escape routine billing due to lack of billing process oversight.	Policy and procedures for activation of new customer accounts and oversight of billing records exist but need refinement. Billing data is maintained on paper records or insufficiently capable electronic database. Only periodic unstructured auditing work is conducted to confirm billing data handling efficiency. The volume of unbilled water due to billing lapses is a guess.	Conditions between 2 and 4	Policy and procedures for new account activation and oversight of billing operations exist but needs refinement. Computerized billing system exists, but is dated or lacks needed functionality. Periodic, limited internal audits conducted and confirm with approximate accuracy the consumption volumes lost to billing lapses.	Conditions between 4 and 6	Policy and procedures for new account activation and oversight of billing operations is adequate and reviewed periodically. Computerized billing system is in use with basic reporting available. Any effect of billing adjustments on measured consumption volumes is well understood. Internal checks of billing data error conducted annually. Reasonably accurate quantification of consumption volume lost to billing lapses is obtained.	Conditions between 6 and 8	New account activation and billing operations policy and procedures are reviewed at least biannually. Computerized billing system includes an array of reports to confirm billing data and system functionality. Checks are conducted routinely to flag and explain zero consumption accounts. Annual internal checks conducted with third party audit conducted at least once every five years. Accountability checks flag billing lapses. Consumption lost to billing lapses is well quantified and reducing year-by-year.	Conditions between 8 and 10	Sound written policy and procedures exist for new account activation and oversight of customer billing operations. Robust computerized billing system gives high functionality and reporting capabilities which are utilized, analyzed and the results reported each billing cycle. Assessment of policy and data handling errors are conducted internally and audited by third party at least once every three years, ensuring consumption lost to billing lapses is minimized and detected as it occurs.
Improvements to attain higher data grading for "Systematic Data Handling Error volume" component:		to qualify for 2: Draft written policy and procedures for activating new water billing accounts and oversight of billing operations. Investigate and budget for computerized customer billing system. Conduct initial audit of billing records by flow-charting the basic business processes of the customer account/billing function.	to qualify for 4: Finalize written policy and procedures for activation of new billing acocunts and overall billing operations management. Implement a computerized customer billing system. Conduct initial audit of billing records as part of this process.		to qualify for 6: Refine new account activation and billing operations procedures and ensure consistency with the utility policy regarding billing, and minimize opportunity for missed billings. Upgrade or replace customer billing system for needed functionality - ensure that billing adjustments don't corrupt the value of consumption volumes. Procedurize internal annual audit process.		to qualify for 8: Formalize regular review of new account activation process and general billing practices. Enhance reporting capability of computerized billing system. Formalize regular auditing process to reveal scope of data handling error. Plan for periodic third party audit to occur at least once every five years.		to qualify for 10: Close policy/procedure loopholes that allow some customer accounts to go unbilled, or data handling errors to exist. Ensure that billing system reports are utilized, analyzed and reported every billing cycle. Ensure that internal and third party audits are conducted at least once every three years.		to maintain 10: Stay abreast of customer information management developments and innovations. Monitor developments of Advanced Metering Infrastructure (AMI) and integrate technology to ensure that customer endpoint information is well-monitored and errors/lapses are at an economic minimum.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
SYSTEM DATA											
Length of mains:		Poorly assembled and maintained paper as-built records of existing water main installations makes accurate determination of system pipe length impossible. Length of mains is guesstimated.	Paper records in poor or uncertain condition (no annual tracking of installations & abandonments). Poor procedures to ensure that new water mains installed by developers are accurately documented.	Conditions between 2 and 4	Sound written policy and procedures exist for documenting new water main installations, but gaps in management result in a uncertain degree of error in tabulation of mains length.	Conditions between 4 and 6	Sound written policy and procedures exist for permitting and commissioning new water mains. Highly accurate paper records with regular field validation; or electronic records and asset management system in good condition. Includes system backup.	Conditions between 6 and 8	Sound written policy and procedures exist for permitting and commissioning new water mains. Electronic recordkeeping such as a Geographical Information System (GIS) and asset management system are used to store and manage data.	Conditions between 8 and 10	Sound written policy exists for managing water mains extensions and replacements. Geographic Information System (GIS) data and asset management database agree and random field validation proves truth of databases. Records of annual field validation should be available for review.
Improvements to attain higher data grading for "Length of Water Mains" component:		to qualify for 2: Assign personnel to inventory current as-built records and compare with customer billing system records and highway plans in order to verify poorly documented pipelines. Assemble policy documents regarding permitting and documentation of water main installations by the utility and building developers; identify gaps in procedures that result in poor documentation of new water main installations.	to qualify for 4: Complete inventory of paper records of water main installations for several years prior to audit year. Review policy and procedures for commissioning and documenting new water main installation.		to qualify for 6: Finalize updates/improvements to written policy and procedures for permitting/commissioning new main installations. Confirm inventory of records for five years prior to audit year; correct any errors or omissions.		to qualify for 8: Launch random field checks of limited number of locations. Convert to electronic database such as a Geographic Information System (GIS) with backup as justified. Develop written policy and procedures.		to qualify for 10: Link Geographic Information System (GIS) and asset management databases, conduct field verification of data. Record field verification information at least annually.		to maintain 10: Continue with standardization and random field validation to improve the completeness and accuracy of the system.
Number of active AND inactive service connections:		Vague permitting (of new service connections) policy and poor paper recordkeeping of customer connections/billings result in suspect determination of the number of service connections, which may be 10-15% in error from actual count.	General permitting policy exists but paper records, procedural gaps, and weak oversight result in questionable total for number of connections, which may vary 5-10% of actual count.	Conditions between 2 and 4	Written account activation policy and procedures exist, but with some gaps in performance and oversight. Computerized information management system is being brought online to replace dated paper recordkeeping system. Reasonably accurate tracking of service connection installations & abandonments; but count can be up to 5% in error from actual total.	Conditions between 4 and 6	Written new account activation and overall billing policies and procedures are adequate and reviewed periodically. Computerized information management system is in use with annual installations & abandonments totaled. Very limited field verifications and audits. Error in count of number of service connections is believed to be no more than 3%.	Conditions between 6 and 8	Policies and procedures for new account activation and overall billing operations are written, well-structured and reviewed at least biannually. Well-managed computerized information management system exists and routine, periodic field checks and internal system audits are conducted. Counts of connections are no more than 2% in error.	Conditions between 8 and 10	Sound written policy and well managed and audited procedures ensure reliable management of service connection population. Computerized information management system, Customer Billing System, and Geographic Information System (GIS) information agree; field validation proves truth of databases. Count of connections recorded as being in error is less than 1% of the entire population.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Number of Active and Inactive Service Connections" component:	**Note: The number of Service Connections does not include fire hydrant leads/lines connecting the hydrant to the water main**	to qualify for 2: Draft new policy and procedures for new account activation and overall billing operations. Research and collect paper records of installations & abandonments for several years prior to audit year.	to qualify for 4: Refine policy and procedures for new account activation and overall billing operations. Research computerized recordkeeping system (Customer Information System or Customer Billing System) to improve documentation format for service connections.		to qualify for 6: Refine procedures to ensure consistency with new account activation and overall billing policy to establish new service connections or decommission existing connections. Improve process to include all totals for at least five years prior to audit year.		to qualify for 8: Formalize regular review of new account activation and overall billing operations policies and procedures. Launch random field checks of limited number of locations. Develop reports and auditing mechanisms for computerized information management system.		to qualify for 10: Close any procedural loopholes that allow installations to go undocumented. Link computerized information management system with Geographic Information System (GIS) and formalize field inspection and information system auditing processes. Documentation of new or decommissioned service connections encounters several levels of checks and balances.		to maintain 10: Continue with standardization and random field validation to improve knowledge of system.
Average length of customer service line:	Note: if customer water meters are located outside of the customer building next to the curb stop or boundary separating utility/customer responsibility, then the auditor should answer "Yes" to the question on the Reporting Worksheet asking about this. If the answer is Yes, the grading description listed under the Grading of 10(a) will be followed, with a value of zero automatically entered at a Grading of 10. See the Service Connection Diagram worksheet for a visual presentation of this distance.	Gradings 1-9 apply if customer properties are unmetered, if customer meters exist and are located inside the customer building premises, or if the water utility owns and is responsible for the entire service connection piping from the water main to the customer building. In any of these cases the average distance between the curb stop or boundary separating utility/customer responsibility for service connection piping, and the typical first point of use (ex: faucet) or the customer meter must be quantified. Gradings of 1-9 are used to grade the validity of the means to quantify this value. (See the "Service Connection Diagram" worksheet)									Either of two conditions can be met for a grading of 10: a) Customer water meters exist outside of customer buildings next to the curb stop or boundary separating utility/customer responsibility for service connection piping. If so, answer "Yes" to the question on the Reporting Working asking about this condition. A value of zero and a Grading of 10 are automatically entered in the Reporting Worksheet . b). Meters exist inside customer buildings, or properties are unmetered. In either case, answer "No" to the Reporting Worksheet question on meter location, and enter a distance determined by the auditor. For a Grading of 10 this value must be a very reliable number from a Geographic Information System (GIS) and confirmed by a statistically valid number of field checks.
		Vague policy exists to define the delineation of water utility ownership and customer ownership of the service connection piping. Curb stops are perceived as the breakpoint but these have not been well-maintained or documented. Most are buried or obscured. Their location varies widely from site-to-site, and estimating this distance is arbitrary due to the unknown location of many curb stops.	Policy requires that the curb stop serves as the delineation point between water utility ownership and customer ownership of the service connection piping. The piping from the water main to the curb stop is the property of the water utility; and the piping from the curb stop to the customer building is owned by the customer. Curb stop locations are not well documented and the average distance is based upon a limited number of locations measured in the field.	Conditions between 2 and 4	Good policy requires that the curb stop serves as the delineation point between water utility ownership and customer ownership of the service connection piping. Curb stops are generally installed as needed and are reasonably documented. Their location varies widely from site-to-site, and an estimate of this distance is hindered by the availability of paper records of limited accuracy.	Conditions between 4 and 6	Clear written policy exists to define utility/customer responsibility for service connection piping. Accurate, well-maintained paper or basic electronic recordkeeping system exists. Periodic field checks confirm piping lengths for a sample of customer properties.	Conditions between 6 and 8	Clearly worded policy standardizes the location of curb stops and meters, which are inspected upon installation. Accurate and well maintained electronic records exist with periodic field checks to confirm locations of service lines, curb stops and customer meter pits. An accurate number of customer properties from the customer billing system allows for reliable averaging of this length.	Conditions between 8 and 10	
Improvements to attain higher data grading for "Average Length of Customer Service Line" component:	▨	to qualify for 2: Research and collect paper records of service line installations. Inspect several sites in the field using pipe locators to locate curb stops. Obtain the length of this small sample of connections in this manner.	to qualify for 4: Formalize and communicate policy delineating utility/customer responsibilities for service connection piping. Assess accuracy of paper records by field inspection of a small sample of service connections using pipe locators as needed. Research the potential migration to a computerized information management system to store service connection data.		to qualify for 6: Establish coherent procedures to ensure that policy for curb stop, meter installation and documentation is followed. Gain consensus within the water utility for the establishment of a computerized information management system.		to qualify for 8: Implement an electronic means of recordkeeping, typically via a customer information system, customer billing system, or Geographic Information System (GIS). Standardize the process to conduct field checks of a limited number of locations.		to qualify for 10: Link customer information management system and Geographic Information System (GIS), standardize process for field verification of data.		to maintain 10: Continue with standardization and random field validation to improve knowledge of service connection configurations and customer meter locations.
Average operating pressure:	▨	Available records are poorly assembled and maintained paper records of supply pump characteristics and water distribution system operating conditions. Average pressure is guesstimated based upon this information and ground elevations from crude topographical maps. Widely varying distribution system pressures due to undulating terrain, high system head loss and weak/erratic pressure controls further compromise the validity of the average pressure calculation.	Limited telemetry monitoring of scattered pumping station and water storage tank sites provides some static pressure data, which is recorded in handwritten logbooks. Pressure data is gathered at individual sites only when low pressure complaints arise. Average pressure is determined by averaging relatively crude data, and is affected by significant variation in ground elevations, system head loss and gaps in pressure controls in the distribution system.	Conditions between 2 and 4	Effective pressure controls separate different pressure zones; moderate pressure variation across the system, occasional open boundary valves are discovered that breech pressure zones. Basic telemetry monitoring of the distribution system logs pressure data electronically. Pressure data gathered by gauges or dataloggers at fire hydrants or buildings when low pressure complaints arise, and during fire flow tests and system flushing. Reliable topographical data exists. Average pressure is calculated using this mix of data.	Conditions between 4 and 6	Reliable pressure controls separate distinct pressure zones; only very occasional open boundary valves are encountered that breech pressure zones. Well-covered telemetry monitoring of the distribution system (not just pumping at source treatment plants or wells) logs extensive pressure data electronically. Pressure gathered by gauges/dataloggers at fire hydrants and buildings when low pressure complaints arise, and during fire flow tests and system flushing. Average pressure is determined by using this mix of reliable data.	Conditions between 6 and 8	Well-managed, discrete pressure zones exist with generally predictable pressure fluctuations. A current full-scale SCADA System or similar realtime monitoring system exists to monitor the water distribution system and collect data, including real time pressure readings at representative sites across the system. The average system pressure is determined from reliable monitoring system data.	Conditions between 8 and 10	Well-managed pressure districts/zones, SCADA System and hydraulic model exist to give very precise pressure data across the water distribution system. Average system pressure is reliably calculated from extensive, reliable, and cross-checked data. Calculations are reported on an annual basis as a minimum.
Improvements to attain higher data grading for "Average Operating Pressure" component:	▨	to qualify for 2: Employ pressure gauging and/or datalogging equipment to obtain pressure measurements from fire hydrants. Locate accurate topographical maps of service area in order to confirm ground elevations. Research pump data sheets to find pump pressure/flow characteristics	to qualify for 4: Formalize a procedure to use pressure gauging/datalogging equipment to gather pressure data during various system events such as low pressure complaints, or operational testing. Gather pump pressure and flow data at different flow regimes. Identify faulty pressure controls (pressure reducing valves, altitude valves, partially open boundary valves) and plan to properly configure pressure zones. Make all pressure data from these efforts available to generate system-wide average pressure.		to qualify for 6: Expand the use of pressure gauging/datalogging equipment to gather scattered pressure data at a representative set of sites, based upon pressure zones or areas. Utilize pump pressure and flow data to determine supply head entering each pressure zone or district. Correct any faulty pressure controls (pressure reducing valves, altitude valves, partially open boundary valves) to ensure properly configured pressure zones. Use expanded pressure dataset from these activities to generate system-wide average pressure.		to qualify for 8: Install a Supervisory Control and Data Acquisition (SCADA) System, or similar realtime monitoring system, to monitor system parameters and control operations. Set regular calibration schedule for instrumentation to insure data accuracy. Obtain accurate topographical data and utilize pressure data gathered from field surveys to provide extensive, reliable data for pressure averaging.		to qualify for 10: Annually, obtain a system-wide average pressure value from the hydraulic model of the distribution system that has been calibrated via field measurements in the water distribution system and confirmed in comparisons with SCADA System data.		to maintain 10: Continue to refine the hydraulic model of the distribution system and consider linking it with SCADA System for real-time pressure data calibration, and averaging.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
COST DATA											
Total annual cost of operating water system:	▨	Incomplete paper records and lack of financial accounting documentation on many operating functions makes calculation of water system operating costs a pure guesstimate	Reasonably maintained, but incomplete, paper or electronic accounting provides data to estimate the major portion of water system operating costs.	Conditions between 2 and 4	Electronic, industry-standard cost accounting system in place. However, gaps in data are known to exist, periodic internal reviews are conducted but not a structured financial audit.	Conditions between 4 and 6	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited periodically by utility personnel, but not a Certified Public Accountant (CPA).	Conditions between 6 and 8	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited at least annually by utility personnel, and at least once every three years by third-party CPA.	Conditions between 8 and 10	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited annually by utility personnel and annually also by third-party CPA.
Improvements to attain higher data grading for "Total Annual Cost of Operating the Water System" component:	▨	to qualify for 2: Gather available records, institute new financial accounting procedures to regularly collect and audit basic cost data of most important operations functions.	to qualify for 4: Implement an electronic cost accounting system, structured according to accounting standards for water utilities		to qualify for 6: Establish process for periodic internal audit of water system operating costs; identify cost data gaps and institute procedures for tracking these outstanding costs.		to qualify for 8: Standardize the process to conduct routine financial audit on an annual basis. Arrange for CPA audit of financial records at least once every three years.		to qualify for 10: Standardize the process to conduct a third-party financial audit by a CPA on an annual basis.		to maintain 10: Maintain program, stay abreast of expenses subject to erratic cost changes and long-term cost trend, and budget/track costs proactively
Customer retail unit cost (applied to Apparent Losses):	Customer population unmetered, and/or only a fixed fee is charged for consumption.	Antiquated, cumbersome water rate structure is used, with periodic historic amendments that were poorly documented and implemented; resulting in classes of customers being billed inconsistent charges. The actual composite billing rate likely differs significantly from the published water rate structure, but a lack of auditing leaves the degree of error indeterminate.	Dated, cumbersome water rate structure, not always employed consistently in actual billing operations. The actual composite billing rate is known to differ from the published water rate structure, and a reasonably accurate estimate of the degree of error is determined, allowing a composite billing rate to be quantified.	Conditions between 2 and 4	Straight-forward water rate structure in use, but not updated in several years. Billing operations reliably employ the rate structure. The composite billing rate is derived from a single customer class such as residential customer accounts, neglecting the effect of different rates from varying customer classes.	Conditions between 4 and 6	Clearly written, up-to-date water rate structure is in force and is applied reliably in billing operations. Composite customer rate is determined using a weighted average residential rate using volumes of water in each rate block.	Conditions between 6 and 8	Effective water rate structure is in force and is applied reliably in billing operations. Composite customer rate is determined using a weighted average composite consumption rate, which includes residential, commercial, industrial, institutional (CII), and any other distinct customer classes within the water rate structure.	Conditions between 8 and 10	Current, effective water rate structure is in force and applied reliably in billing operations. The rate structure and calculations of composite rate - which includes residential, commercial, industrial, institutional (CII), and other distinct customer classes - are reviewed by a third party knowledgeable in the M36 methodology at least once every five years.
Improvements to attain higher data grading for "Customer Retail Unit Cost" component:	▨	to qualify for 2: Formalize the process to implement water rates, including a secure documentation procedure. Create a current, formal water rate document and gain approval from all stakeholders.	to qualify for 4: Review the water rate structure and update/formalize as needed. Assess billing operations to ensure that actual billing operations incorporate the established water rate structure.		to qualify for 6: Evaluate volume of water used in each usage block by residential users. Multiply volumes by full rate structure.	Launch effort to fully meter the customer population and charge rates based upon water volumes	to qualify for 8: Evaluate volume of water used in each usage block by all classifications of users. Multiply volumes by full rate structure.		to qualify for 10: Conduct a periodic third-party audit of water used in each usage block by all classifications of users. Multiply volumes by full rate structure.		to maintain 10: Keep water rate structure current in addressing the water utility's revenue needs. Update the calculation of the customer unit rate as new rate components, customer classes, or other components are modified.
Variable production cost (applied to Real Losses):	Note: if the water utility purchases/imports its entire water supply, then enter the unit purchase cost of the bulk water supply in the Reporting Worksheet with a grading of 10	Incomplete paper records and lack of documentation on primary operating functions (electric power and treatment costs most importantly) makes calculation of variable production costs a pure guesstimate	Reasonably maintained, but incomplete, paper or electronic accounting provides data to roughly estimate the basic operations costs (pumping power costs and treatment costs) and calculate a unit variable production cost.	Conditions between 2 and 4	Electronic, industry-standard cost accounting system in place. Electric power and treatment costs are reliably tracked and allow accurate weighted calculation of unit variable production costs based on these two inputs and water imported purchase costs (if applicable). All costs are audited internally on a periodic basis.	Conditions between 4 and 6	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Pertinent additional costs beyond power, treatment and water imported purchase costs (if applicable) such as liability, residuals management, wear and tear on equipment, impending expansion of supply, are included in the unit variable production cost, as applicable. The data is audited at least annually by utility personnel.	Conditions between 6 and 8	Reliable electronic, industry-standard cost accounting system in place, with all pertinent primary and secondary variable production and water imported purchase (if applicable) costs tracked. The data is audited at least annually by utility personnel, and at least once every three years by a third-party knowledgeable in the M36 methodology.	Conditions between 8 and 10	Either of two conditions can be met to obtain a grading of 10: 1) Third party CPA audit of all pertinent primary and secondary variable production and water imported purchase (if applicable) costs on an annual basis. or: 2) Water supply is entirely purchased as bulk water imported, and the unit purchase cost - including all applicable marginal supply costs - serves as the variable production cost. If all applicable marginal supply costs are not included in this figure, a grade of 10 should not be selected.
Improvements to attain higher data grading for "Variable Production Cost" component:	▨	to qualify for 2: Gather available records, institute new procedures to regularly collect and audit basic cost data and most important operations functions.	to qualify for 4: Implement an electronic cost accounting system, structured according to accounting standards for water utilities		to qualify for 6: Formalize process for regular internal audits of production costs. Assess whether additional costs (liability, residuals management, equipment wear, impending infrastructure expansion) should be included to calculate a more representative variable production cost.		to qualify for 8: Formalize the accounting process to include direct cost components (power, treatment) as well as indirect cost components (liability, residuals management, etc.) Arrange to conduct audits by a knowledgable third-party at least once every three years.		to qualify for 10: Standardize the process to conduct a third-party financial audit by a CPA on an annual basis.		to maintain 10: Maintain program, stay abreast of expenses subject to erratic cost changes and budget/track costs proactively

AWWA Free Water Audit Software: Customer Service Line Diagrams

WAS v5.0

Average Length of Customer Service Line

The three figures shown on this worksheet display the assignment of the Average Length of Customer Service Line, Lp, for the three most common piping configurations.

Figure 1 shows the configuration of the water meter outside of the customer building next to the curb stop valve. In this configuration Lp = 0 since the distance between the curb stop and the customer metering point is essentially zero.

Figure 2 shows the configuration of the customer water meter located inside the customer building, where Lp is the distance from the curb stop to the water meter.

Figure 3 shows the configuration of an unmetered customer building , where Lp is the distance from the curb stop to the first point of customer water consumption, or, more simply, the building line.

In any water system the Lp will vary notably in a community of different structures, therefore the average Lp value is used and this should be approximated or calculated if a sample of service line measurements has been gathered.

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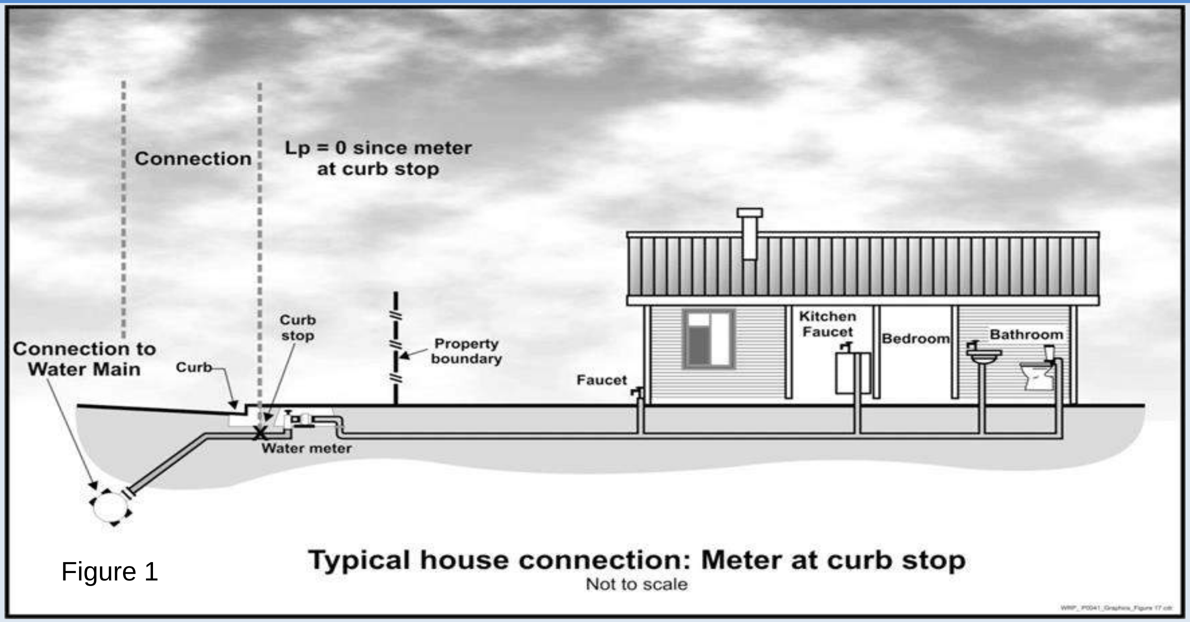


Figure 1

Typical house connection: Meter at curb stop

Not to scale

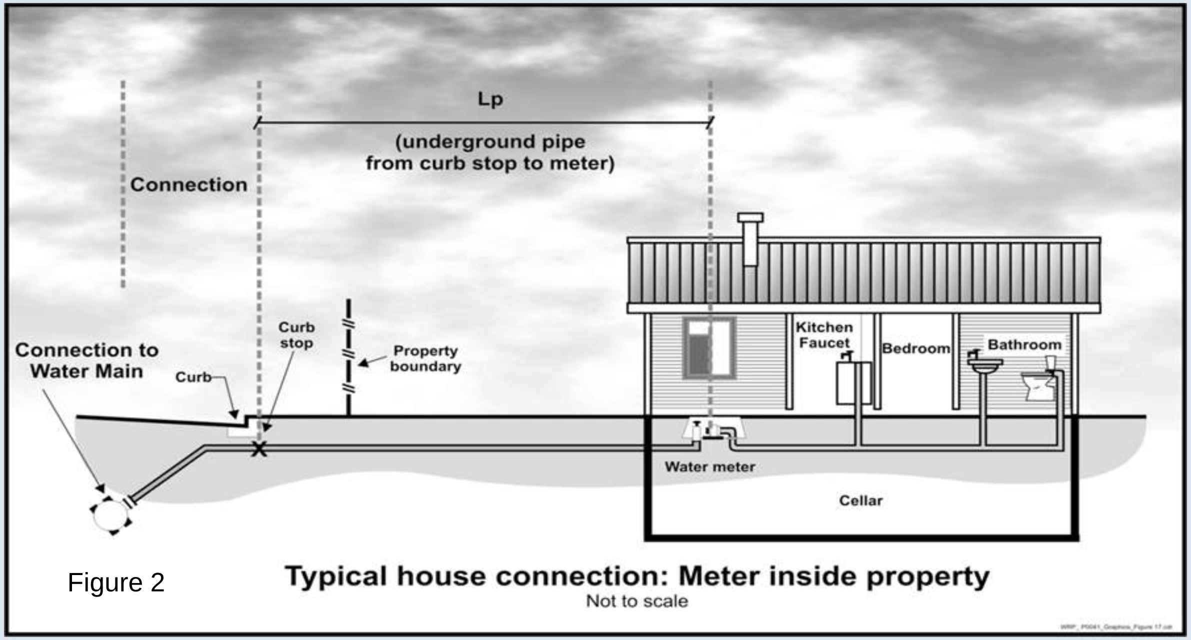


Figure 2

Typical house connection: Meter inside property

Not to scale

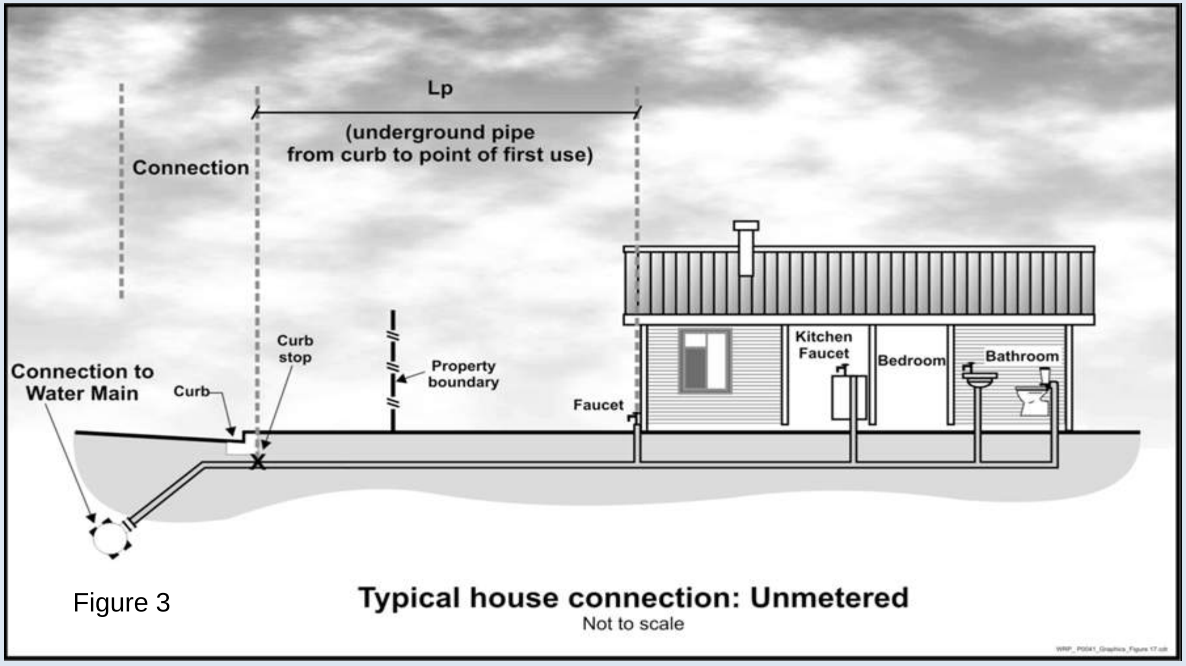


Figure 3

Typical house connection: Unmetered

Not to scale

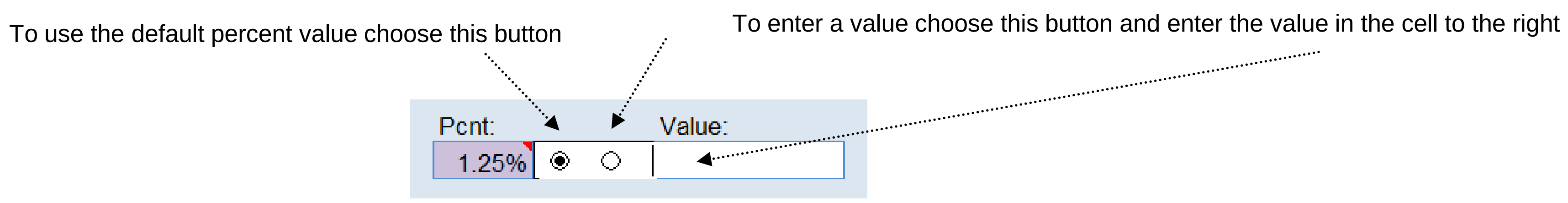
AWWA Free Water Audit Software:
Definitions

WAS v5.0

Item Name	Description
Apparent Losses Find	= unauthorized consumption + customer metering inaccuracies + systematic data handling errors Apparent Losses include all types of inaccuracies associated with customer metering (worn meters as well as improperly sized meters or wrong type of meter for the water usage profile) as well as systematic data handling errors (meter reading, billing, archiving and reporting), plus unauthorized consumption (theft or illegal use). NOTE: Over-estimation of Apparent Losses results in under-estimation of Real Losses. Under-estimation of Apparent Losses results in over-estimation of Real Losses.
AUTHORIZED CONSUMPTION Find	= billed water exported + billed metered + billed unmetered + unbilled metered + unbilled unmetered consumption The volume of metered and/or unmetered water taken by registered customers, the water utility's own uses, and uses of others who are implicitly or explicitly authorized to do so by the water utility; for residential, commercial, industrial and public-minded purposes. Typical retail customers' consumption is tabulated usually from established customer accounts as billed metered consumption, or - for unmetered customers - billed unmetered consumption. These types of consumption, along with billed water exported, provide revenue potential for the water utility. **Be certain to tabulate the water exported volume as a separate component and do not "double-count" it by including in the billed metered consumption component as well as the water exported component.** Unbilled authorized consumption occurs typically in non-account uses, including water for fire fighting and training, flushing of water mains and sewers, street cleaning, watering of municipal gardens, public fountains, or similar public-minded uses. Occasionally these uses may be metered and billed (or charged a flat fee), but usually they are unmetered and unbilled. In the latter case, the water auditor may use a default value to estimate this quantity, or implement procedures for the reliable quantification of these uses. This starts with documenting usage events as they occur and estimating the amount of water used in each event. (See Unbilled unmetered consumption)
View Service Connection Diagram **Average length of customer service line** Find	This is the average length of customer service line, Lp, that is owned and maintained by the customer; from the point of ownership transfer to the customer water meter, or building line (if unmetered). The quantity is one of the data inputs for the calculation of Unavoidable Annual Real Losses (UARL), which serves as the denominator of the performance indicator: Infrastructure Leakage Index (ILI). The value of Lp is multiplied by the number of customer service connections to obtain a total length of customer owned piping in the system. The purpose of this parameter is to account for the unmetered service line infrastructure that is the responsibility of the customer for arranging repairs of leaks that occur on their lines. In many cases leak repairs arranged by customers take longer to be executed than leak repairs arranged by the water utility on utility-maintained piping. Leaks run longer - and lose more water - on customer-owned service piping, than utility owned piping. If the customer water meter exists near the ownership transfer point (usually the curb stop located between the water main and the customer premises) this distance is zero because the meter and transfer point are the same. This is the often encountered configuration of customer water meters located in an underground meter box or "pit" outside of the customer's building. The Free Water Audit Software asks a "Yes/No" question about the meter at this location. If the auditor selects "Yes" then this distance is set to zero and the data grading score for this component is set to 10. If water meters are typically located inside the customer premise/building, or properties are unmetered, it is up to the water auditor to estimate a system-wide average Lp length based upon the various customer land parcel sizes and building locations in the service area. Lp will be a shorter length in areas of high density housing, and a longer length in areas of low density housing and varied commercial and industrial buildings. General parcel demographics should be employed to obtain a composite average Lp length for the entire system. Refer to the "Service Connection Diagram" worksheet for a depiction of the service line/metering configurations that typically exist in water utilities. This worksheet gives guidance on the determination of the Average Length, Lp, for each configuration.
Average operating pressure Find	This is the average pressure in the distribution system that is the subject of the water audit. Many water utilities have a calibrated hydraulic model of their water distribution system. For these utilities, the hydraulic model can be utilized to obtain a very accurate quantity of average pressure. In the absence of a hydraulic model, the average pressure may be approximated by obtaining readings of static water pressure from a representative sample of fire hydrants or other system access points evenly located across the system. A weighted average of the pressure can be assembled; but be sure to take into account the elevation of the fire hydrants, which typically exist several feet higher than the level of buried water pipelines. If the water utility is compiling the water audit for the first time, the average pressure can be approximated, but with a low data grading. In subsequent years of auditing, effort should be made to improve the accuracy of the average pressure quantity. This will then qualify the value for a higher data grading.
Billed Authorized Consumption	All consumption that is billed and authorized by the utility. This may include both metered and unmetered consumption. See "Authorized Consumption" for more information.
Billed metered consumption Find	All metered consumption which is billed to retail customers, including all groups of customers such as domestic, commercial, industrial or institutional. **It does NOT include water supplied to neighboring utilities (water exported) which is metered and billed. Be sure to subtract any consumption for exported water sales that may be included in these billing roles. Water supplied as exports to neighboring water utilities should be included only in the Water Exported component.** The metered consumption data can be taken directly from billing records for the water audit period. The accuracy of yearly metered consumption data can be refined by including an adjustment to account for customer meter reading lag time since not all customer meters are read on the same day of the meter reading period. However additional analysis is necessary to determine the lag time adjustment value, which may or may not be significant.
Billed unmetered consumption Find	All billed consumption which is calculated based on estimates or norms from water usage sites that have been determined by utility policy to be left unmetered. This is typically a very small component in systems that maintain a policy to meter their customer population. However, this quantity can be the key consumption component in utilities that have not adopted a universal metering policy. **This component should NOT include any water that is supplied to neighboring utilities (water exported) which is unmetered but billed. Water supplied as exports to neighboring water utilities should be included only in the Water Exported component.**

Item Name	Description
Customer metering inaccuracies Find	Apparent water losses caused by the collective under-registration of customer water meters. Many customer water meters gradually wear as large cumulative volumes of water are passed through them over time. This causes the meters to under-register the flow of water. This occurrence is common with smaller residential meters of sizes 5/8-inch and 3/4 inch after they have registered very large cumulative volumes of water, which generally occurs only after periods of years. For meters sized 1-inch and larger - typical of multi-unit residential, commercial and industrial accounts - meter under-registration can occur from wear or from the improper application of the meter; i.e. installing the wrong type of meter or the wrong size of meter, for the flow pattern (profile) of the consumer. For instance, many larger meters have reduced accuracy at low flows. If an oversized meter is installed, most of the time the routine flow will occur in the low flow range of the meter, and a significant portion of it may not be registered. It is important to properly select and install all meters, but particularly large customer meters, size 1-inch and larger. The auditor has two options for entering data for this component of the audit. The auditor can enter a percentage under-registration (typically an estimated value), this will apply the selected percentage to the two categories of metered consumption to determine the volume of water not recorded due to customer meter inaccuracy. Note that this percentage is a composite average inaccuracy for all customer meters in the entire meter population. The percentage will be multiplied by the sum of the volumes in the Billed Metered and Unbilled Metered components. Alternatively, if the auditor has substantial data from meter testing activities, he or she can calculate their own loss volumes, and this volume may be entered directly. Note that a value of zero will be accepted but an alert will appear asking if the customer population is unmetered. Since all metered systems have some degree of inaccuracy, a positive value should be entered. A value of zero in this component is valid only if the water utility does not meter its customer population.
Customer retail unit cost Find	The Customer Retail Unit Cost represents the charge that customers pay for water service. This unit cost is applied routinely to the components of Apparent Loss, since these losses represent water reaching customers but not (fully) paid for. Since most water utilities have a rate structure that includes a variety of different costs based upon class of customer, a weighted average of individual costs and number of customer accounts in each class can be calculated to determine a single composite cost that should be entered into this cell. Finally, the weighted average cost should also include additional charges for sewer, storm water or biosolids processing, but only if these charges are based upon the volume of potable water consumed. For water utilities in regions with limited water resources and a questionable ability to meet the drinking water demands in the future, the Customer Retail Unit Cost might also be applied to value the Real Losses; instead of applying the Variable Production Cost to Real Losses. In this way, it is assumed that every unit volume of leakage reduced by leakage management activities will be sold to a customer. Note: the Free Water Audit Software allows the user to select the units that are charged to customers (either $/1,000 gallons, $/hundred cubic feet, or $/1,000 litres) and automatically converts these units to the units that appear in the "WATER SUPPLIED" box. The monetary units are United States dollars, $.
Infrastructure Leakage Index (ILI) Find	The ratio of the Current Annual Real Losses (Real Losses) to the Unavoidable Annual Real Losses (UARL). The ILI is a highly effective performance indicator for comparing (benchmarking) the performance of utilities in operational management of real losses.
Length of mains Find	Length of all pipelines (except service connections) in the system starting from the point of system input metering (for example at the outlet of the treatment plant). It is also recommended to include in this measure the total length of fire hydrant lead pipe. Hydrant lead pipe is the pipe branching from the water main to the fire hydrant. Fire hydrant leads are typically of a sufficiently large size that is more representative of a pipeline than a service connection. The average length of hydrant leads across the entire system can be assumed if not known, and multiplied by the number of fire hydrants in the system, which can also be assumed if not known. This value can then be added to the total pipeline length. Total length of mains can therefore be calculated as: Length of Mains, miles = (total pipeline length, miles) + [{(average fire hydrant lead length, ft) x (number of fire hydrants)} / 5,280 ft/mile] or Length of Mains, kilometres = (total pipeline length, kilometres) + [{(average fire hydrant lead length, metres) x (number of fire hydrants)} / 1,000 metres/kilometre]
NON-REVENUE WATER Find	= Apparent Losses + Real Losses + Unbilled Metered Consumption + Unbilled Unmetered Consumption. This is water which does not provide revenue potential to the utility.
Number of active AND inactive service connections Find	Number of customer service connections, extending from the water main to supply water to a customer. Please note that this includes the actual number of distinct piping connections, including fire connections, whether active or inactive. This may differ substantially from the number of customers (or number of accounts). **Note: this number does not include the pipeline leads to fire hydrants - the total length of piping supplying fire hyrants should be included in the "Length of mains" parameter.**
Real Losses Find	Physical water losses from the pressurized system (water mains and customer service connections) and the utility's storage tanks, up to the point of customer consumption. In metered systems this is the customer meter, in unmetered situations this is the first point of consumption (stop tap/tap) within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows.
Revenue Water	Those components of System Input Volume that are billed and have the potential to produce revenue.
Service Connection Density Find	=number of customer service connections / length of mains

Item Name	Description
Systematic data handling errors Find	Apparent losses caused by accounting omissions, errant computer programming, gaps in policy, procedure, and permitting/activation of new accounts; and any type of data lapse that results in under-stated customer water consumption in summary billing reports. **Systematic Data Handling Errors result in a direct loss of revenue potential. Water utilities can find "lost" revenue by keying on this component.** Utilities typically measure water consumption registered by water meters at customer premises. The meter should be read routinely (ex: monthly) and the data transferred to the Customer Billing System, which generates and sends a bill to the customer. <u>Data Transfer Errors</u> result in the consumption value being less than the actual consumption, creating an apparent loss. Such error might occur from illegible and mis-recorded hand-written readings compiled by meter readers, inputting an incorrect meter register unit conversion factor in the automatic meter reading equipment, or a variety of similar errors. Apparent losses also occur from <u>Data Analysis Errors</u> in the archival and data reporting processes of the Customer Billing System. Inaccurate estimates used for accounts that fail to produce a meter reading are a common source of error. Billing adjustments may award customers a rightful monetary credit, but do so by creating a negative value of consumption, thus under-stating the actual consumption. Account activation lapses may allow new buildings to use water for months without meter readings and billing. Poor permitting and construction inspection practices can result in a new building lacking a billing account, a water meter and meter reading; i.e., the customer is unknown to the utility's billing system. Close auditing of the permitting, metering, meter reading, billing and reporting processes of the water consumption data trail can uncover data management gaps that create volumes of systematic data handling error. Utilities should routinely analyze customer billing records to detect data anomalies and quantify these losses. For example, a billing account that registers zero consumption for two or more billing cycles should be checked to explain why usage has seemingly halted. Given the revenue loss impacts of these losses, water utilities are well-justified in providing continuous oversight and timely correction of data transfer errors & data handling errors. If the water auditor has not yet gathered detailed data or assessment of systematic data handling error, it is recommended that the auditor apply the default value of 0.25% of the the Billed Authorized Consumption volume. However, if the auditor <u>has</u> investigated the billing system and its controls, and <u>has</u> well validated data that indicates the volume from systematic data handling error is substantially higher or lower than that generated by the default value, then the auditor should enter a quantity that was derived from the utility investigations and select an appropriate grading. <u>Note:</u> negative values are not allowed for this audit component. If the auditor enters zero for this component then a grading of 1 will be automatically assigned.
Total annual cost of operating the water system Find	These costs include those for operations, maintenance and any annually incurred costs for long-term upkeep of the drinking water supply and distribution system. It should include the costs of day-to-day upkeep and long-term financing such as repayment of capital bonds for infrastructure expansion or improvement. Typical costs include employee salaries and benefits, materials, equipment, insurance, fees, administrative costs and all other costs that exist to sustain the drinking water supply. Depending upon water utility accounting procedures or regulatory agency requirements, it may be appropriate to include depreciation in the total of this cost. This cost should not include any costs to operate wastewater, biosolids or other systems outside of drinking water.
Unauthorized consumption Find	Includes water illegally withdrawn from fire hydrants, illegal connections, bypasses to customer consumption meters, or tampering with metering or meter reading equipment; as well as any other ways to receive water while thwarting the water utility's ability to collect revenue for the water. Unauthorized consumption results in uncaptured revenue and creates an error that understates customer consumption. In most water utilities this volume is low and, if the water auditor has not yet gathered detailed data for these loss occurrences, it is recommended that the auditor apply a default value of 0.25% of the volume of water supplied. However, if the auditor has investigated unauthorized occurrences, and has well validated data that indicates the volume from unauthorized consumption is substantially higher or lower than that generated by the default value, then the auditor should enter a quantity that was derived from the utility investigations. Note that a value of zero will not be accepted since all water utilities have some volume of unauthorized consumption occurring in their system. Note: if the auditor selects the default value for unauthorized consumption, a data grading of 5 is automatically assigned, but not displayed on the Reporting Worksheet.
Unavoidable Annual Real Losses (UARL) Find	UARL (gallons)=(5.41Lm + 0.15Nc + 7.5Lc) xP, or UARL (litres)=(18.0Lm + 0.8Nc + 25.0Lc) xP where: Lm = length of mains (miles or kilometres) Nc = number of customer service connections Lp = the average distance of customer service connection piping (feet or metres) (see the Worksheet "Service Connection Diagram" for guidance on deterring the value of Lp) Lc = total length of customer service connection piping (miles or km) Lc = Nc X Lp (miles or kilometres) P = Pressure (psi or metres) The UARL is a theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. It is a key variable in the calculation of the Infrastructure Leakage Index (ILI). Striving to reduce system leakage to a level close to the UARL is usually not needed unless the water supply is unusually expensive, scarce or both. NOTE: The UARL calculation has not yet been proven as fully valid for very small, or low pressure water distribution systems. If, <u>in gallons:</u> (Lm x 32) + Nc < 3000 or P <35psi <u>in litres:</u> (Lm x 20) + Nc < 3000 or P < 25m then the calculated UARL value may not be valid. The software does not display a value of UARL or ILI if either of these conditions is true.

Item Name	Description
Unbilled Authorized Consumption	All consumption that is unbilled, but still authorized by the utility. This includes Unbilled Metered Consumption + Unbilled Unmetered Consumption. See "Authorized Consumption" for more information. For Unbilled Unmetered Consumption, the Free Water Audit Software provides the auditor the option to select a default value if they have not audited unmetered activities in detail. The default calculates a volume that is 1.25% of the Water Supplied volume. If the auditor has carefully audited the various unbilled, unmetered, authorized uses of water, and has established reliable estimates of this collective volume, then he or she may enter the volume directly for this component, and not use the default value.
Unbilled metered consumption Find	Metered consumption which is authorized by the water utility, but, for any reason, is <u>deemed by utility policy</u> to be unbilled. This might for example include metered water consumed by the utility itself in treatment or distribution operations, or metered water provided to civic institutions free of charge. **It does <u>not</u> include water supplied to neighboring utilities (water exported) which may be metered but not billed.**
Unbilled unmetered consumption Find	Any kind of Authorized Consumption which is neither billed or metered. This component typically includes water used in activities such as fire fighting, flushing of water mains and sewers, street cleaning, fire flow tests conducted by the water utility, etc. In most water utilities it is a small component which is very often substantially overestimated. **It does NOT include water supplied to neighboring utilities (water exported) which is unmetered and unbilled – an unlikely case.** This component has many sub-components of water use which are often tedious to identify and quantify. Because of this, and the fact that it is usually a small portion of the water supplied, it is recommended that the auditor apply the default value, which is 1.25% of the Water Supplied volume. Select the default percentage to enter this value. If the water utility <u>has</u> carefully audited the unbilled, unmetered activities occurring in the system, and has well validated data that gives a value substantially higher or lower than the default volume, then the auditor should enter their own volume. However the default approach is recommended for most water utilities. Note that a value of zero is not permitted, since all water utilities have some volume of water in this component occurring in their system.
Units and Conversions	The user may develop an audit based on one of three unit selections: 1) Million Gallons (US) 2) Megalitres (Thousand Cubic Metres) 3) Acre-feet Once this selection has been made in the instructions sheet, all calculations are made on the basis of the chosen units. Should the user wish to make additional conversions, a unit converter is provided below (use drop down menus to select units from the yellow unit boxes): Enter Units: 1 — Convert From… **Million Gallons (US)** = **Converts to…..** **3.06888329** **Acre-feet** (conversion factor = 3.06888328973723)
Use of Option Buttons	 **NOTE:** For Unbilled Unmetered Consumption, Unauthorized Consumption and Systematic Data Handling Errors, a recommended default value can be applied by selecting the Percent option. The default values are based on fixed percentages of Water Supplied or Billed Authorized Consumption and are recommended for use in this audit unless the auditor has well validated data for their system. Default values are shown by purple cells, as shown in the example above. If a default value is selected, the user does not need to grade the item; a grading value of 5 is automatically applied (however, this grade will not be displayed).
Variable production cost (applied to Real Losses) Find	The cost to produce and supply the next unit of water (e.g., $/million gallons). This cost is determined by calculating the summed unit costs for ground and surface water treatment and all power used for pumping from the source to the customer. It may also include other miscellaneous unit costs that apply to the production of drinking water. It should also include the unit cost of bulk water purchased as an import if applicable. It is common to apply this unit cost to the volume of Real Losses. However, if water resources are strained and the ability to meet future drinking water demands is in question, then the water auditor can be justified in applying the Customer Retail Rate to the Real Loss volume, rather than applying the Variable Production Cost. The Free Water Audit Software applies the Variable Production costs to Real Losses by default. However, the auditor has the option on the Reporting Worksheet to select the Customer Retail Cost as the basis for the Real Loss cost evaluation if the auditor determines that this is warranted.
Volume from own sources Find	The volume of water withdrawn (abstracted) from water resources (rivers, lakes, streams, wells, etc) controlled by the water utility, and then treated for potable water distribution. Most water audits are compiled for utility retail water distribution systems, so this volume should reflect the amount of <u>treated</u> drinking water that entered the distribution system. Often the volume of water measured at the effluent of the treatment works is slightly less than the volume measured at the raw water source, since some of the water is used in the treatment process. Thus, it is useful if flows are metered at the effluent of the treatment works. If metering exists only at the raw water source, an adjustment for water used in the treatment process should be included to account for water consumed in treatment operations such as filter backwashing, basin flushing and cleaning, etc. If the audit is conducted for a wholesale water agency that sells untreated water, then this quantity reflects the measure of the raw water, typically metered at the source.

Item Name	Description
Volume from own sources: Master meter and supply error adjustment Find	An estimate or measure of the degree of inaccuracy that exists in the master (production) meters measuring the annual Volume from own Sources, and any error in the data trail that exists to collect, store and report the summary production data. This adjustment is a weighted average number that represents the collective error for all master meters for all days of the audit year and any errors identified in the data trail. Meter error can occur in different ways. A meter or meters may be inaccurate by under-registering flow (did not capture all the flow), or by over-registering flow (overstated the actual flow). Data error can occur due to data gaps caused by temporary outages of the meter or related instrumentation. All water utilities encounter some degree of inaccuracy in master meters and data errors in archival systems are common; thus a value of zero should not be entered. Enter a negative percentage or value for metered data under-registration; or, enter a positive percentage or value for metered data over-registration.
Water exported Find	The Water Exported volume is the bulk water conveyed and sold by the water utility to neighboring water systems that exists outside of their service area. Typically this water is metered at the custody transfer point of interconnection between the two water utilities. Usually the meter(s) are owned by the water utility that is selling the water: i.e. the exporter. If the water utility who is compiling the annual water audit sells bulk water in this manner, they are an exporter of water. Note: The Water Exported volume is sold to wholesale customers who are typically charged a wholesale rate that is different than retail rates charged to the retail customers existing within the service area. Many state regulatory agencies require that the Water Exported volume be reported to them as a quantity separate and distinct from the retail customer billed consumption. For these reasons - and others - the Water Exported volume is always quantified separately from Billed Authorized Consumption in the standard water audit. **Be certain not to "double-count" this quantity by including it in both the Water Exported box and the Billed Metered Consumption box of the water audit Reporting Worksheet. This volume should be included only in the Water Exported box.**
Water exported: Master meter and supply error adjustment Find	An estimate or measure of the volume in which the Water Exported volume is incorrect. This adjustment is a weighted average that represents the collective error for all of the metered and archived exported flow for all days of the audit year. Meter error can occur in different ways. A meter may be inaccurate by under-registering flow (did not capture all the flow), or by over-registering flow (overstated the actual flow). Error in the metered, archived data can also occur due to data gaps caused by temporary outages of the meter or related instrumentation. All water utilities encounter some degree of error in their metered data, particularly if meters are aged and infrequently tested. Occasional errors also occur in the archived data. Thus, a value of zero should not be entered. Enter a negative percentage or value for metered data under-registration; or enter a positive percentage or value for metered data over-registration. If regular meter accuracy testing is conducted on the meter(s) - which is usually conducted by the water utility selling the water - then the results of this testing can be used to help quantify the meter error adjustment. Corrections to data gaps or other errors found in the archived data should also be included as a portion of this meter error adjustment.
Water imported Find	The Water Imported volume is the bulk water purchased to become part of the Water Supplied volume. Typically this is water purchased from a neighboring water utility or regional water authority, and is metered at the custody transfer point of interconnection between the two water utilities. Usually the meter(s) are owned by the water supplier selling the water to the utility conducting the water audit. The water supplier selling the bulk water usually charges the receiving utility based upon a wholesale water rate.
Water imported: Master meter and supply error adjustment Find	An estimate or measure of the volume in which the Water Imported volume is incorrect. This adjustment is a weighted average that represents the collective error for all of the metered and archived imported flow for all days of the audit year. Meter error can occur in different ways. A meter may be inaccurate by under-registering flow (did not capture all the flow), or by over-registering flow (overstated the actual flow). Error in the metered, archived data can also occur due to data gaps caused by temporary outages of the meter or related instrumentation. All water utilities encounter some level of meter inaccuracy, particularly if meters are aged and infrequently tested. Occasional errors also occur in the archived metered data. Thus, a value of zero should not be entered. Enter a negative percentage or value for metered data under-registration; or, enter a positive percentage or value for metered data over-registration. If regular meter accuracy testing is conducted on the meter(s) - which is usually conducted by the water utility selling the water - then the results of this testing can be used to help quantify the meter error adjustment.
WATER LOSSES Find	= apparent losses + real losses Water Losses are the difference between Water Supplied and Authorized Consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission systems, pressure zones or district metered areas (DMA); if one of these configurations are the basis of the water audit.

AWWA Free Water Audit Software:
Determining Water Loss Standing

WAS v5.0

Water Audit Report for: City of Tontitown (AR0000566)
Reporting Year: 2019 | 1/2019 - 12/2019
Data Validity Score: 63

Water Loss Control Planning Guide

	Water Audit Data Validity Level / Score				
Functional Focus Area	**Level I** (0-25)	**Level II** (26-50)	**Level III** (51-70)	**Level IV** (71-90)	**Level V** (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

Once data have been entered into the Reporting Worksheet, the performance indicators are automatically calculated. How does a water utility operator know how well his or her system is performing? The AWWA Water Loss Control Committee provided the following table to assist water utilities is gauging an approximate Infrastructure Leakage Index (ILI) that is appropriate for their water system and local conditions. The lower the amount of leakage and real losses that exist in the system, then the lower the ILI value will be.

Note: this table offers an approximate guideline for leakage reduction target-setting. The best means of setting such targets include performing an economic assessment of various loss control methods. However, this table is useful if such an assessment is not possible.

General Guidelines for Setting a Target ILI
(without doing a full economic analysis of leakage control options)

Target ILI Range	Financial Considerations	Operational Considerations	Water Resources Considerations
1.0 - 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low ratepayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0 -5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management, water conservation) are included in the long-term planning
>5.0 - 8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
Greater than 8.0	Although operational and financial considerations may allow a long-term ILI greater than 8.0, such a level of leakage is not an effective utilization of water as a resource. Setting a target level greater than 8.0 - other than as an incremental goal to a smaller long-term target - is discouraged.		
Less than 1.0	If the calculated Infrastructure Leakage Index (ILI) value for your system is 1.0 or less, two possibilities exist. a) you are maintaining your leakage at low levels in a class with the top worldwide performers in leakage control. b) A portion of your data may be flawed, causing your losses to be greatly understated. This is likely if you calculate a low ILI value but do not employ extensive leakage control practices in your operations. In such cases it is beneficial to validate the data by performing field measurements to confirm the accuracy of production and customer meters, or to identify any other potential sources of error in the data.		

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AWWA Free Water Audit Software: Acknowledgements

WAS v5.0

AWWA Water Audit Software Version 5.0 Developed by the Water Loss Control Committee of the American Water Works Association August, 2014

This software is intended to serve as a basic tool to compile a preliminary, or “top-down”, water audit. It is recommended that users also refer to the current edition of the AWWA M36 Publication, Water Audits and Loss Control Programs, for detailed guidance on compiling a comprehensive, or “bottom-up”, water audit using the same water audit methodology.

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- AWWA Water Audits and Loss Control Programs, M36 Publication, 3rd Edition, 2009
- Service Connection Diagrams courtesy of Ronnie McKenzie, WRP Pty Ltd.

VERSION HISTORY:

Version:	Release Date:	Number of Worksheets:	Key Features and Developments
v1	2005/ 2006	5	The AWWA Water Audit Software was piloted in 2005 (v1.0 beta). The early versions (1.x) of the software restricted data entry to units of Million Gallons per year. For each entry into the audit, users identified whether the input was measured or estimated.
v2	2006	5	The most significant enhancement in v2 of the software was to allow the user to choose the volumetric units to be used in the audit, Million Gallons or Thousand Cubic Metres (megalitres) per year. Two financial performance indicators were added to provide feedback to the user on the cost of Real and Apparent losses.
v3	2007	7	In v3, the option to report volumetric units in acre-feet was added. Another new feature in v3 was the inclusion of default values for two water audit components (unbilled unmetered and unauthorized consumption). v3 also included two examples of completed audits in units of million gallons and Megalitres. Several checks were added into v3 to provide instant feedback to the user on common data entry problems, in order to help the user complete an accurate water audit.
v4 - v4.2	2010	10	v4 (and versions 4.x) of the software included a new approach to data grading. The simple "estimated" or "measured" approach was replaced with a more granular scale (typically 1-10) that reflected descriptions of utility practices and served to describe the confidence and accuracy of the input data. Each input value had a corresponding scale fully described in the Grading Matrix tab. The Grading Matrix also showed the actions required to move to a higher grading score. Grading descriptions were available on the Reporting Worksheet via a pop-up box next to each water audit input. A water audit data validity score is generated (max = 100) and priority areas for attention (to improve audit accuracy) are identified, once a user completes the requied data grading. A service connection diagram was also added to help users understand the impact of customer service line configurations on water losses and how this information should be entered into the water audit software. An acknoweldgements section was also added. Minor bug fixes resulted in the release of versions 4.1 and 4.2. A French language version was also made available for v4.2.
v5	2014	12	In v5, changes were made to the way Water Supplied information is entered into software, with each major component having a corresponding Master Meter Error Adjustment entry (and data grading requirement). This required changes to the data validity score calculation; v5 of the software uses a weighting system that is, in part, proportional to the volume of input components. The Grading Matrix was updated to reflect the new audit inputs and also to include clarifications and additions to the scale descriptions. The appearance of the software was updated in v5 to make the software more user-friendly and several new features were added to provide more feedback to the user. Notably, a dashboard tab has been added to provide more visual feedback on the water audit results and associated costs of Non-Revenue Water. A comments sheet was added to allow the user to track notes, comments and to cite sources used.


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