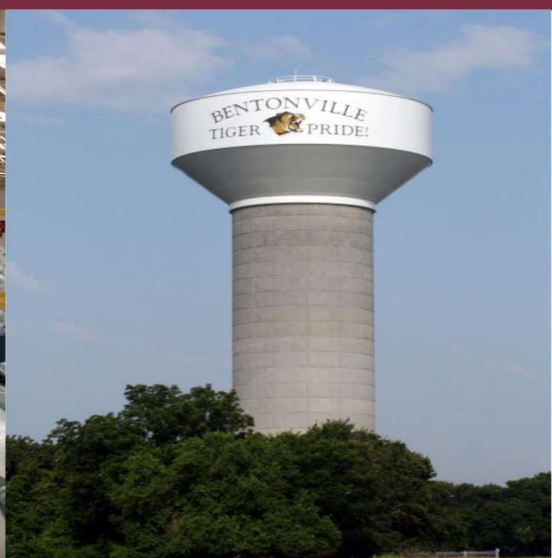
Water Master Plan Update

PREPARED FOR

Bentonville Water Utilities

April 2024

Bentonville Water Utilities
Water Master Plan Update

City of Bentonville
Bentonville, Arkansas

Prepared by:

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

April 2024

Garver Project No. 22W01291

Engineer's Certification

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

Christopher R. Buntin, PE
State of Arkansas PE License 12716

Digitally Signed 04/15/2024

Josef N. Dalaeli, PE
State of Arkansas PE License 20296

Digitally Signed 04/15/2024

This page intentionally left blank.

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
$	United States dollar
AACE	Association for the Advancement of Cost Engineering
ABS	acrylonitrile butadiene styrene
ADD	average daily demand
ADH	Arkansas Department of Health
AMI	advanced metering infrastructure
AR	Arkansas
ARDOT	Arkansas Department of Transportation
BCWD #1	Benton County Water District #1
BPS	booster pump station
BWD	Beaver Water District
BWRPWA	Benton/Washington Regional Public Water Authority
BWU	Bentonville Water Utilities
C	Hazen-Williams friction coefficient
CIP	capital improvement plan
City	City of Bentonville
D	diameter (in inches)
DBP	disinfection byproducts
D/DBP	disinfectants and disinfection byproducts
DGTC	David Glass Technology Center
DMA	district metered area
EPA	United States Environmental Protection Agency
EPS	extended-period simulation
EST	elevated storage tank
ft	feet
GIS	geographic information systems
GLUMRB	Great Lakes - Upper Mississippi River Board
gpcd	gallons per capita per day
gpm	gallons per minute
GST	ground storage tank
HAA	haloacetic acid
HDPE	high-density polyethylene
HGL	hydraulic grade line
hp	horsepower
hr	hour
HSPS	high service pump station
HWL	high-water level
HWY	highway
I-49	Interstate 49
IESWTR	interim enhanced surface water treatment rule
IFC	International Fire Code
in.	inches
IQR	interquartile range
LCR	Lead And Copper Rule
LCRI	Lead And Copper Rule Improvements
LCRR	Lead And Copper Rule Revisions
LF	linear feet

Acronym/Abbreviation	Definition
LRAA	locational running annual averages
LS	lump sum
LT1ESWTR	Long Term 1 Enhanced Surface Water Treatment Rule
LWL	low-water level
MCL	maximum contaminant level
M/DBP	microbial and disinfection byproducts
MDD	maximum daily demand
MG	million gallons
MGD	million gallons per day
mg/L	milligrams per liter
MTP	metropolitan transportation plan
N/A	not applicable
NDWAC	National Drinking Water Advisory Committee
No.	number
NOM	natural organic matter
NRW	non-revenue water
NWA	Northwest Arkansas
NWARPC	Northwest Arkansas Regional Planning Commission
OH&P	overhead and profit
OPCC	opinion of probable construction cost
PE	polyethylene
POA	property owners association
POR	preferred operating range
PS	pump station
psi	pound per square inch
PVC	polyvinyl chloride
PWS ID	public water system identification
RWU	Rogers Water Utilities
SCADA	supervisory control and data acquisition
SDWA	Safe Drinking Water Act
SID	suburban improvement district
SS	steady state
SWTR	surface water treatment rules
SWU	Springdale Water Utilities
TH	total head
TM	technical memorandum
TOC	total organic carbon
TTHM	total trihalomethanes
VFD	variable frequency drive
WCPS	Wester Corridor Pump Station
WHO	Walmart Home Office
WMP	water master plan
WSA	water service area
WTP	water treatment plant

1.0 Executive Summary

1.1 Introduction

Bentonville Water Utilities (BWU) staff has continued to show their commitment to their Vision Statement of "assuring the citizens, businesses, and guests we serve that quality plans are developed, proper water and wastewater infrastructure is installed and that the future of the water utilities has a solid foundation for generations to come" through the development of this Water Master Plan (WMP) update. BWU's commitment to their vision statement is demonstrated in this WMP update, and significant investments are required to accommodate growth.

The process of updating the WMP required a collaborative process with BWU staff. Many BWU staff members played an integral role in the development of the WMP by dedicating valuable time and effort through workshops, meetings, site visits, etc. Additionally, the Bentonville Planning Department, Beaver Water District (BWD), Northwest Arkansas Regional Planning Commission (NWARPC), and other stakeholders cooperated throughout the process and volunteered pertinent information.

BWU has experienced rapid growth in recent years and now serves a 2023 retail population of approximately 58,890. The system receives water from Beaver Lake, which is treated and pumped by BWD to BWU's transmission lines and ultimately residential, commercial, and wholesale customers. The system contains roughly 372 miles of connected water mains, enough to stretch from Bentonville to Des Moines, Iowa. The distribution system also has two active pump stations (PS), three elevated storage tanks (EST), and two ground storage tanks (GST).

The primary objectives of the WMP update include the following:

- Document staff knowledge
- Assess existing system
- Project demand over selected planning horizons
- Analyze water quality data and identify solutions to any issues
- Identify and mitigate risk within the system
- Identify improvements necessary to maintain desired level of service over the planning horizons
- Develop a living Capital Improvement Plan (CIP) to allow BWU to plan and budget projects

1.2 Growth Projections

Enclosed in Appendix A is the Growth Projection Technical Memorandum (TM1). This TM defines design and assessment criteria for the evaluation of the BWU distribution system. Additionally, population projections and per-capita water demands were evaluated and used to estimate water system demands for both BWU's distribution system and larger wholesale connections. Garver and BWU collaborated and decided to use a growth rate of 6.5% for BWU retail customers. The City of Bentonville is in the early stages of a future land use map update, so future land use designations were not available during the development of this WMP update. Garver, BWU staff, and stakeholders collaborated to determine six different growth areas to spatially allocate the projected demands for the 5-year, 10-year, and 20-year planning horizons. The existing and projected demands for both average day demand (ADD) and maximum day demand (MDD) conditions are illustrated in Table 1-1.

Table 1-1: ADD and MDD Demands for Planning Horizons

Year	Bentonville		Bella Vista POA		Cave Springs		Total	
	ADD (MGD)	MDD (MGD)	ADD (MGD)	MDD (MGD)	ADD (MGD)	MDD (MGD)	ADD (MGD)	MDD (MGD)
2023 (projected)[1]	13.3	19.4	2.3	4.0	0.7	1.5	16.3	24.9
2028	19.8	26.9	2.7	4.6	1.0	2.1	23.4	33.6
2033	26.0	35.8	3.1	5.4	1.4	2.9	30.5	44.0
2043	46.2	64.5	4.1	7.2	2.6	5.4	52.9	77.1

Notes:
1. Demands for 2023 were projected based on data available at the time of this analysis.

1.3 Existing System Assessment

Enclosed in Appendix B is the Existing System Assessment Technical Memorandum (TM2). TM2 contains information for existing infrastructure, historical operational data, and the hydraulic model calibration process. Garver evaluated the performance of the water distribution system using the calibrated hydraulic model under ADD and MDD conditions for the planning horizons discussed in Section 1.2. The performance of the system was assessed by evaluating water supply, storage, pumping, available fire flow, minimum and maximum pressures, pressure variations, pipe velocity, head loss gradient, source tracing, and water age.

The deficiencies within the system are documented within TM2. The significant findings include:

- The firm capacity of the existing BWD high service pump station (HSPS) has been exceeded by historical maximum day demands. BWD is in the process of upgrading their pumping capacity.
- The system storage capacity is in a deficit of approximately 0.4 million gallons (MG).
- The system experiences high pressures, some areas reaching approximately 200 psi, in various parts of the system.
- The 24-inch transmission main along I Street experiences a high head loss gradient which causes excessive head losses during tank filling operations and periods of peak demand.

1.4 Capital Improvement Plan

Due to the extreme volatility in population projections for the City of Bentonville, Garver and BWU focused on developing a detailed CIP for the next 10 years rather than detailing projects farther in the future that will ultimately be reassessed in the next WMP update. However, projects were still identified for future planning horizons with less detail for compatibility. The CIP projects were developed to improve the system performance using the design criteria outlined in TM1 and TM2. The findings are summarized in the Capital Improvement Plan Technical Memorandum (TM3), which is enclosed in Appendix C.

The proposed CIP projects are illustrated in Table 1-2. The projects are displayed in Figure 1-1. TM3 contains a project profile for each of these projects, which includes a project description, justification, unintended consequences, special considerations, potential alternatives, additional professional services, opinion of probable construction cost (OPCC), and schematic.

Table 1-2: Proposed Water System Improvements

Horizon	Project Type	Project Name	Proposed Size
2028	Transmission	Supply Transmission Main Extension (Existing 48-inch to I Street tank site)	48-inch
		Western Corridor Transmission Main	48-inch
		East Loop (Moberly Lane 24-inch to Highway 102 tank site)	24-inch
		Southwest Elevated Storage Tank Transmission Main	24-inch
	Storage	Northeast Elevated Storage Tank	2 MG
		Southwest Elevated Storage Tank	2 MG
		I Street Ground Storage Tank Replacement	6 MG
2033	Transmission	Southwest Ground Storage Tank Transmission Main	36-inch
		Northeast Loop Phase I (Tiger Elevated Storage Tank to J Street)	24-inch
		Central Transmission Mains (I Street tank site to Core transmission loops)	24-inch
		Northeast Loop Phase II (NE Tiger Boulevard to Southeast 8th Street)	24-inch
	Storage	Southwest Ground Storage Tank and Pump Station	6 MG

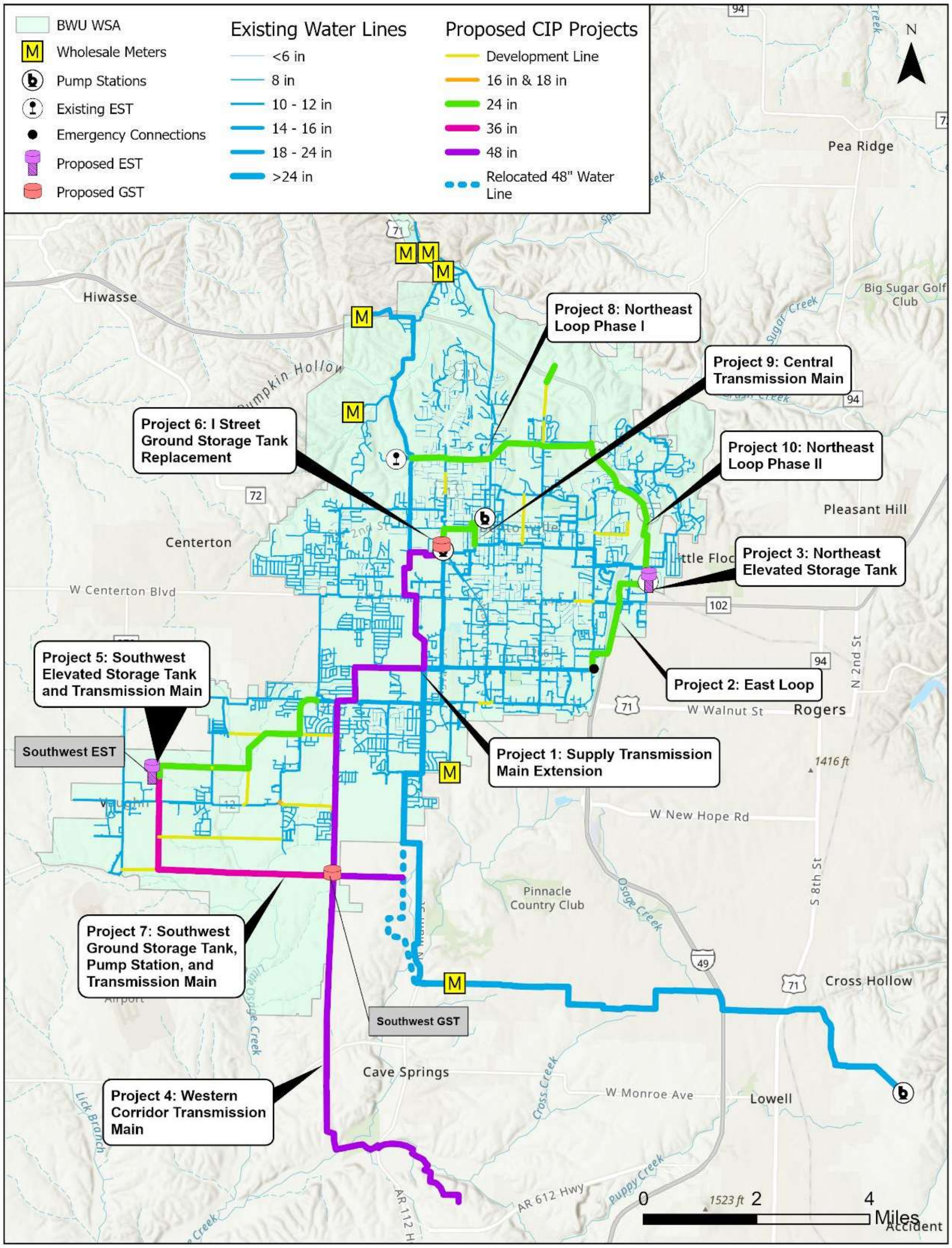


Figure 1-1: CIP Overview Map

1.5 Distribution System Water Quality Analysis

The next component of the BWU WMP update is the Distribution System Water Quality Analysis Technical Memorandum (TM4), which is enclosed in Appendix D. The purpose of this TM is to provide a summary of water quality data for BWU's water distribution system and identify current deficiencies and provide alternatives to improve water quality. Garver evaluated disinfectant residual, disinfection byproducts, and lead and copper within the system. BWU is proactively working on regulatory lead and copper rule revisions under a separate project with Garver. Additionally, Garver considered ongoing regulatory activity that may require BWU to take steps towards compliance.

Water quality within the distribution system is generally good; however, items such as tank mixing and water age can be improved. Garver determined that tank mixing improvements for the Highway 102 EST and new storage tanks could prevent dead zones, short-circuiting, and thermal stratification.

Water age is elevated in the northern and eastern portions of the system and could be improved by implementing better looping in the system with 12-inch and larger water lines. Additionally, separating supply transmission from the distribution system during normal operations with normally closed or controlled valves to establish flow-through patterns at storage tanks would help reduce maximum water age in the system.

1.6 Major Infrastructure Risk Assessment

TM1 through TM3 were developed with the assumption that the BWU distribution system is operating as designed. However, to protect the public from a catastrophic system failure leading to limited access to clean water, BWU staff emphasized risk mitigation. BWU and Garver previously worked together in 2021 to complete a water system risk and resilience assessment and emergency response plan. The Major Infrastructure Risk Assessment Technical Memorandum (TM5) further evaluated risk by identifying vital infrastructure and determining the impacts on the system if selected infrastructure failed. TM5 is enclosed in Appendix E. Garver identified nine potential modes of failure and summarized system impacts as well as CIP projects that could mitigate the associated risk. Figure 1-2 displays the nine scenarios that were evaluated.

One of the primary ways BWU could mitigate risk is adding and improving emergency connections with adjacent water utilities and wholesale water suppliers. In the event of major infrastructure failure, BWU could open the connections to draw water from neighboring suppliers to provide emergency supply to Bentonville residents. This would broaden the window of time allowed for BWU to implement a solution. The entities evaluated include Rogers Water Utilities (RWU), Benton/Washington Regional Public Water Authority (BWRPWA), and Springdale Water Utilities (SWU). The potential connections are displayed in Figure 1-3.

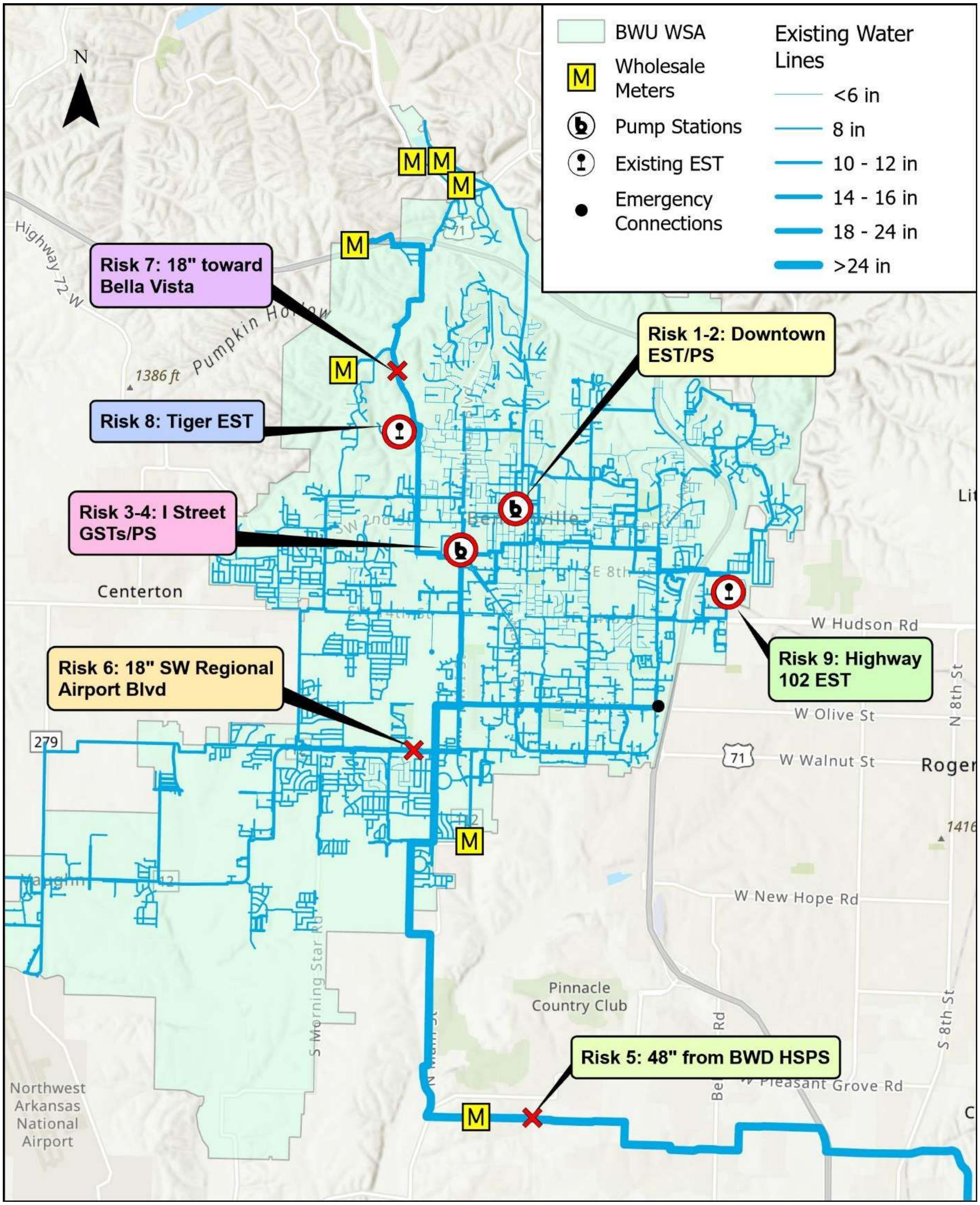


Figure 1-2: Major Infrastructure Risk Assessment Model Scenarios

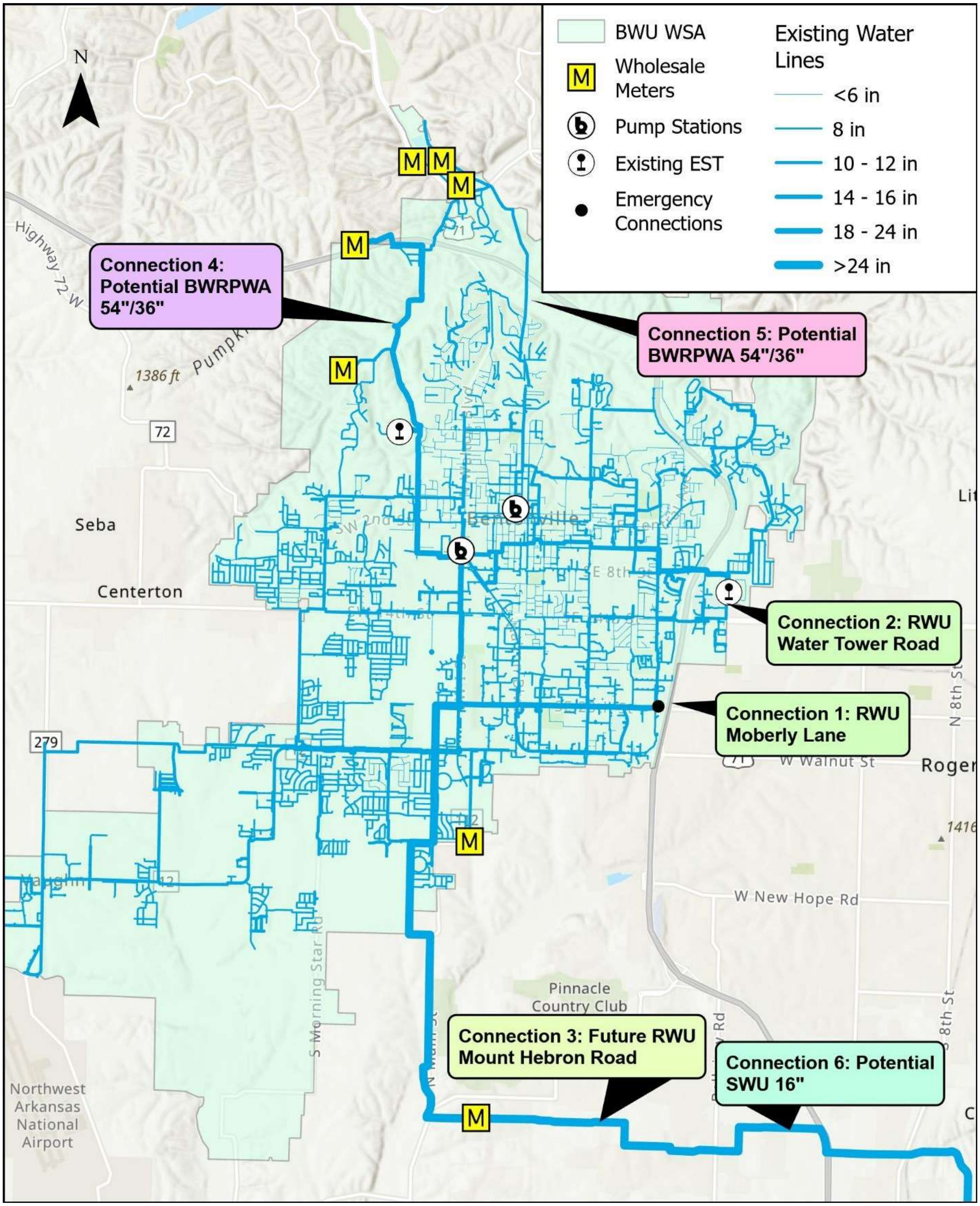


Figure 1-3: Emergency Connection Alternatives

1.7 Path Forward

BWU staff have already taken steps to advance the implementation of vital capital improvements outlined in the WMP update. Continued commitments are needed to advance forward with the rapid growth in the City of Bentonville. BWU staff will continue to engage stakeholders and periodically (about every 5-years) update the WMP as growth continues to evolve. It is recommended that BWU leadership continue to engage all support staff and provide additional training. A critical tool is having staff that can utilize the water distribution system hydraulic model to evaluate new development scenarios, troubleshoot any problems, and update the model as new capital improvements are implemented. BWU staff is also taking steps to update the water distribution system monitoring and control system hardware and software. This will enable staff to efficiently operate, optimize, and rapidly solve any problems in the water distribution system. Having local outside support resources (on an on-call basis) to aid BWU staff is recommended.

Garver greatly appreciates the opportunity to work with the dedicated staff at BWU and serve the City of Bentonville and its citizens, businesses, and guests.

APPENDIX A
Growth Projection Technical Memorandum No. 1

Bentonville Water Utilities
Water Master Plan Update

Technical Memorandum No. 1
Growth Projection

City of Bentonville
Bentonville, Arkansas

Prepared by:

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

April 2024

Garver Project No. 22W01291

Table of Contents

List of Figures

List of Tables

1.0 Introduction

1.1 Overview

In 2018, the City of Bentonville Water Utilities Department (BWU) completed a Water Master Plan (WMP) update that included a hydraulic model of the BWU water distribution system. The 2018 WMP evaluated historical trends, estimated future demands, and prioritized infrastructure improvements in the water distribution system to maintain an adequate level of service to BWU customers. This technical memorandum (TM) was prepared for BWU as the first part of the Bentonville Water Master Plan Update. The purpose of this TM is to present historical and projected population and water demands that will be used to assess the capacity of the BWU distribution system and identify capital improvements.

1.2 Ownership and Management

BWU owns and operates the water and wastewater systems that serve the City of Bentonville (City). The Arkansas Department of Health (ADH) public water system identification (PWS ID) number for BWU is 041. BWU has adopted the following mission and vision statements:

"The mission of Bentonville's Water Utilities dedicated staff is to serve as water and wastewater professionals, providing consistent, reliable and sustainable services for the citizens of Bentonville, AR."

"Bentonville's water utility staff remains steadfast in assuring the citizens, businesses, and guests we serve that quality plans are developed, proper water and wastewater infrastructure is installed, and that the future of the water utilities has a solid foundation for generations to come. We are committed to hold true to a high standard of conduct from our team, which will be reflected in the operation and maintenance of Bentonville's water utilities systems. We will pursue avenues and set standards that will ensure Bentonville's water and wastewater systems will function properly and provide quality service for today's population and projected growth. Bentonville's water utilities team is ready to assist you today, tomorrow and into the future."

1.3 System History and Background

BWU has experienced rapid growth over recent years and now serves a 2023 retail population of approximately 58,890. This rapid growth in the community has prompted planning of investments in water distribution infrastructure to deliver adequate quantities of potable water to its customers while also meeting regulatory requirements.

BWU distributes drinking water that is purchased from Beaver Water District (BWD). The purchased water is surface water from Beaver Lake that has been treated at the Joe M. Steele and Hardy W. Croxton Water Treatment Plants (Figure 1-1) located in Lowell, Arkansas east of the intersection of North Primrose Road and Nail Avenue.

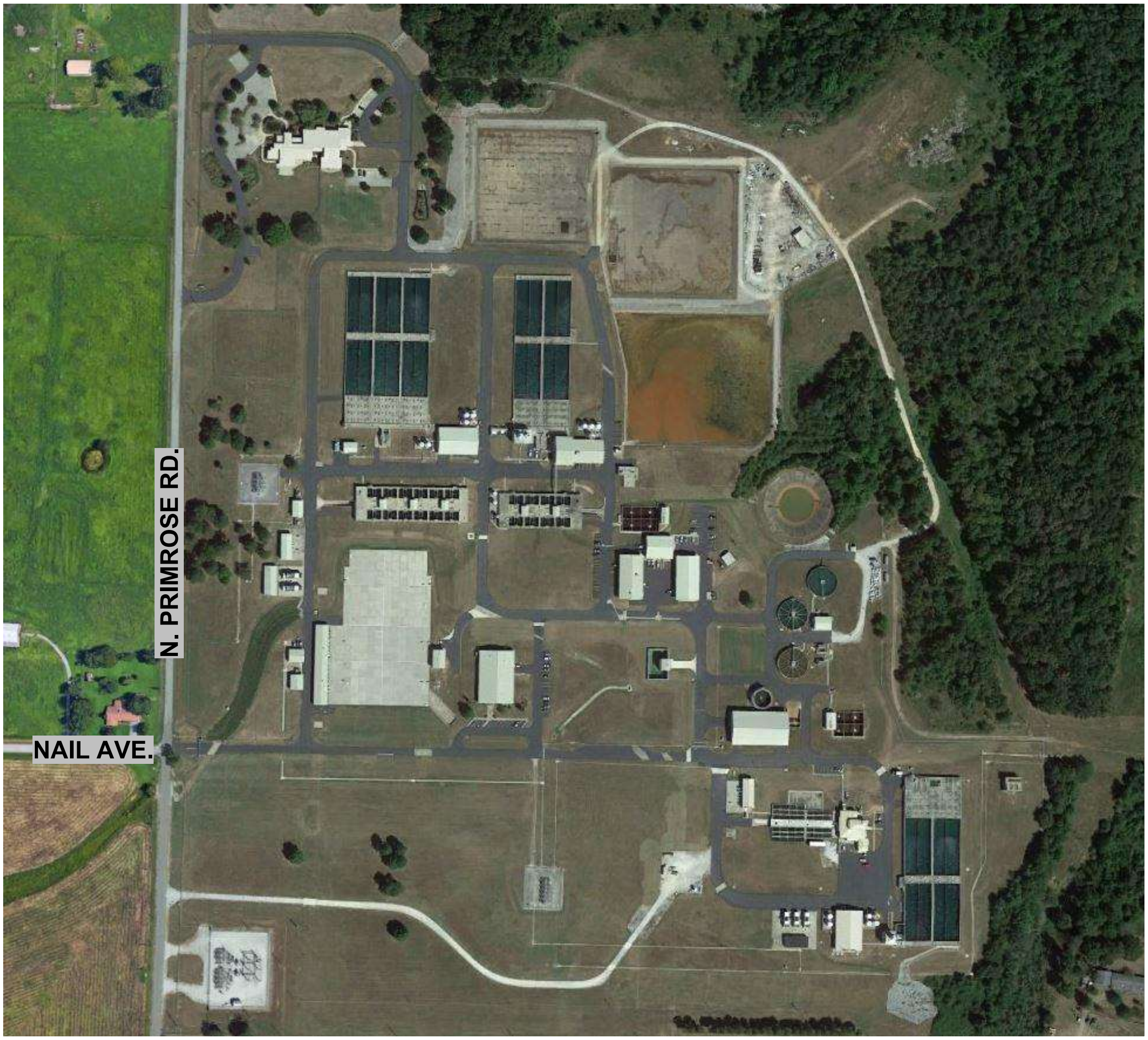


Figure 1-1: Joe M. Steele and Hardy W. Croxton Water Treatment Plants

1.3.1 Rogers Water Utilities

BWU and Rogers Water Utilities (RWU) previously shared supply infrastructure from BWD, which consisted of two intertie points between the RWU and BWU system. In 2006, Bentonville constructed a 48-inch transmission line from BWD which eliminated the need for routine use of the previously shared supply infrastructure. However, between April 21, 2021 and May 13, 2021, RWU and BWU used these two connection points to send water from RWU to BWU during a repair of the BWU transmission line. Over that period, RWU conveyed approximately 182 million gallons of water to BWU.

1.4 Related Documents

Table 1-1 summarizes the previous work by Garver and others used in this WMP Update. The reference names listed in the table are used throughout this report to refer to each document.

Table 1-1: Related Documents

Document	Author/Agency	Date	Reference Name
2018 Water Master Plan	Olsson	Feb. 2018	2018 WMP
Bentonville Community Plan	Houseal Lavigne	Oct. 2018	Bentonville Community Plan
Master Plan Demand and Transmission Capacity Update – Beaver Water District	Olsson	Feb. 2020	Beaver Water District Master Plan
Northwest Arkansas Regional Planning Commission (NWARPC) Metropolitan Transportation Plan	NWARPC	March 2021	NWARPC MTP
Walmart Water Modeling Study	Walter P Moore and Associates, Inc.	March 2021	Walmart Water Modeling Study

1.5 Design and Assessment Criteria

Design criteria and regulatory requirements from a variety of sources were assembled to develop the evaluation criteria for analysis of the distribution system. Specifically, documents from the following sources were reviewed:

- Arkansas Department of Health (ADH)
- Great Lakes – Upper Mississippi River Board (GLUMRB) – 10 States Standards
- City of Bentonville Municipal Code Chapter 98 – Utilities
- City of Bentonville 2021 Water Utilities Department Specifications
- American Water Works Association (AWWA) Manuals

Table 1-2 summarizes the evaluation criteria that were used for water system assessments.

Table 1-2: Water System Evaluation Criteria

Criteria	Limiting Source	Description
Supply	ADH	ADH requires the evaluation of source water adequacy, for both quality and quantity concerns, for the planning period. A minimum supply criteria of 1.2 times maximum day demand will be used to evaluate supply capacity.
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	Minimum storage capacity equal to average daily consumption (Unless sources have sufficient capacity with standby power to supplement peak demands)
	ADH	Sufficient useable storage shall be provided with consideration given to average day demand, peak hourly demand, power outages, and fire flows, if applicable.
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.
	10 States Standards (guideline)	The normal working pressures in the distribution should be approximately 60–80 psi and not less than 35 psi.
Fire Flow	IFC	The City enforces Arkansas Fire Prevention Codes – 2021 Edition (based on the International Fire Code, 2021 Edition). A system-wide minimum pressure criteria of 20 psi is used to determine available fire flow.
Maximum Flow Velocity	AWWA (guideline)	Water distribution lines should not experience a maximum flow velocity of 6 ft/s. (Note: Guideline is not a regulatory requirement and will be used to identify water lines for potential replacement)
Maximum Head Loss Gradient	AWWA (guideline)	The maximum head loss gradient for smaller pipes (diameter < 16 inches) should not exceed 7 ft/1,000 ft. The maximum head loss gradient for larger pipes (diameter ≥ 16 inches) should not exceed 3 ft/1,000 ft. (Note: Guideline is not a regulatory requirement and will be used to identify water lines for potential replacement)

1.6 Historical Data Collection

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

- Customer meter data (2019-2022)
- Hydrant flow data (2021-2022)
- BWD Water Quality Reports (2019-2021)
- GIS base files with water infrastructure information
- Monthly operation reports (2017-2022)
- BWU SCADA data for pump operations and tank levels (2021-2022)
- As-built drawings of multiple pipe segments in the distribution system
- As-built drawings of storage tanks and pump stations

2.0 Water Service Area

2.1 Water Service Area

The existing BWU water distribution system serves the City of Bentonville and surrounding unincorporated areas. The BWU water service area (WSA) is illustrated in Figure 2-1.

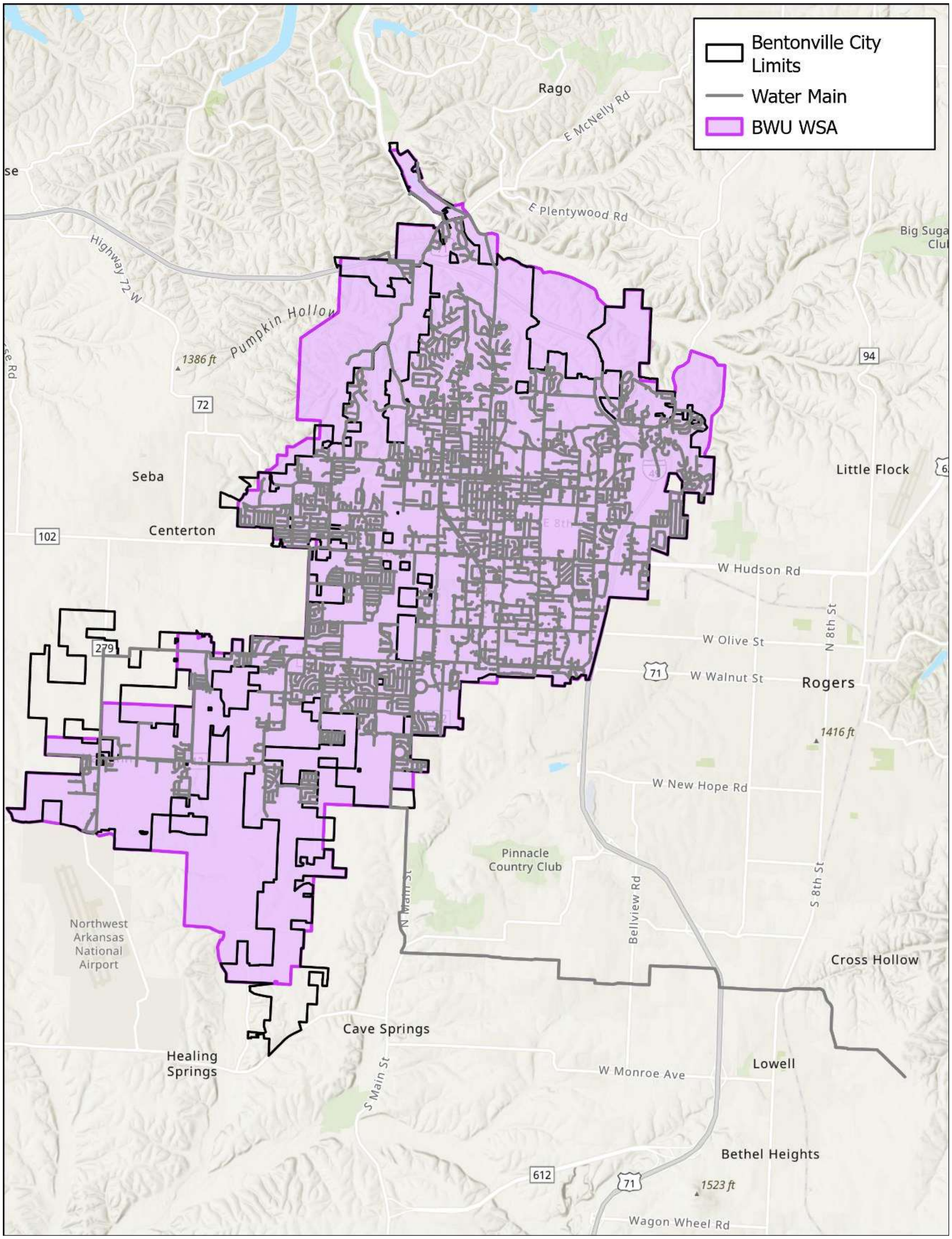


Figure 2-1: BWU Water Service Area

2.2 Adjacent Water Utilities

The water utilities adjacent to BWU's WSA are shown in Figure 2-2. Clockwise from the north, BWU's WSA is bounded by the following water utilities:

- Bella Vista Village Property Owners Association (Bella Vista POA)
- Old Bella Vista Property Owners Association (Old Bella Vista POA)
- Benton-Washington Regional PWA (BWRPWA)
- Benton County Water District #1 (BCWD #1)
- Rogers Water Utilities (RWU)
- Springdale Water Utilities (SWU)
- Cave Springs Waterworks (Cave Springs)
- Highfill Water Department (Highfill)
- Centerton Waterworks (Centerton)
- Oak Hills Suburban Improvement District (Oak Hills SID)

BWU has several secondary wholesale customers as shown in Table 2-1. The remaining adjacent utilities and their respective water suppliers and secondary wholesale customers are also shown.

Table 2-1: Water Suppliers for Adjacent Utilities

Water Supplier	Direct Wholesale Customer	Secondary Wholesale Customer
Beaver Water District	BWU	Bella Vista POA
		Old Bella Vista POA
		Oak Hills SID
		Cave Springs
	RWU	BCWD #1
	SWU	-
BWRPWA	Bella Vista POA	-
	Centerton	-
	Highfill	-
	BCWD #1	-

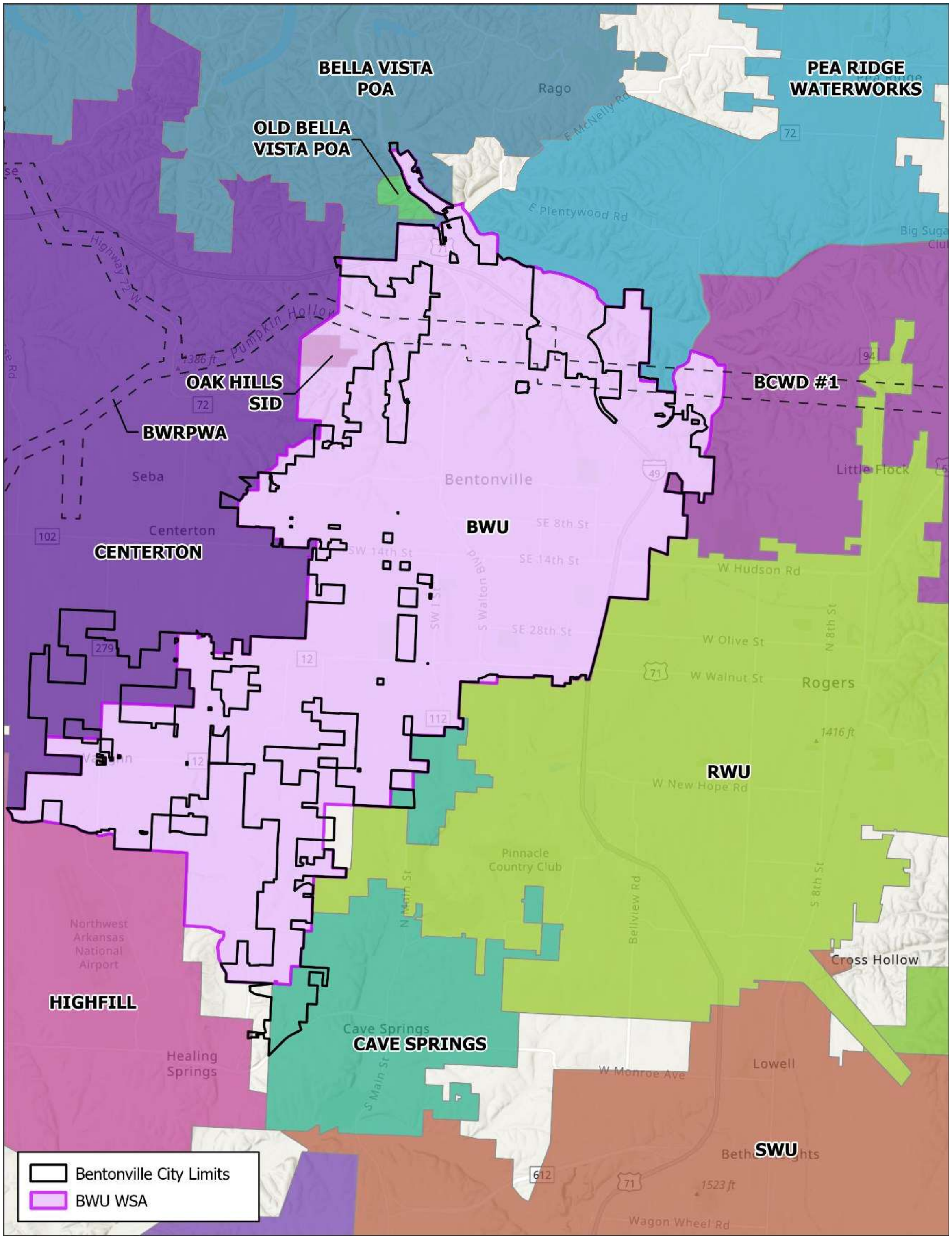


Figure 2-2: Water Suppliers for Adjacent Utilities

2.3 Wholesale Water Service Area

BWU sells wholesale water to the following utilities:

- Bella Vista POA
  - The Bella Vista POA purchases water from both BWU and BWRPWA. As of July 2023, the portion of the Bella Vista POA water system served by BWU includes 11,660 service connections (307 commercial and 11,353 residential). The Bella Vista POA estimates that the population served from the BWU supply is 24,750, which is approximately 75% of the total Bella Vista POA water service population of 33,000.
- Old Bella Vista POA
  - The Old Bella Vista POA purchases all of its water supply from BWU and serves a population of approximately 105.
- Cave Springs
  - Cave Springs purchases all of its water supply from BWU and serves a population of approximately 5,900.
- Oak Hills SID
  - The Oak Hills SID purchases all of its water supply from BWU and serves a population of approximately 140.

2.4 Beaver Water District

BWD sells potable water, sourced from Beaver Lake, to four customer cities as shown in Table 2-2. With a treatment capacity of 140 MGD and daily pumping capacity of 150 MGD, the existing BWD existing capacity is significantly more than the historical maximum day usage. The planned, ultimate build-out treatment capacity for BWD is 220 MGD. Table 2-2 includes the historic day peak demands of the customers currently served by BWD. Analysis of BWD water rights, water supply, and treatment capacity for buildout conditions is not included herein.

Table 2-2: BWD Customer Demand Summary (from BWD Website)

BWD Customer	Historic Peak Day Demand(1) (MGD)
Fayetteville	33.5
SWU	27.7
RWU	18.7
BWU	24.2
BWD Total	**102.5**

Notes:
1. The BWD total shown is for the overall system as of February 2023 and is not the sum of individual customers.

2.5 Land Use

The BWU service area encompasses a range of different land use types. The Existing Land Use from the Bentonville Community Plan is illustrated in Figure 2-3. The Future Land Use provided by BWU staff is illustrated in Figure 2-4. BWU staff anticipate that the density of future developments may be higher than the current future land use designations as the WSA continues to develop. Land use is a first-level indicator of water usage characteristics of an area.

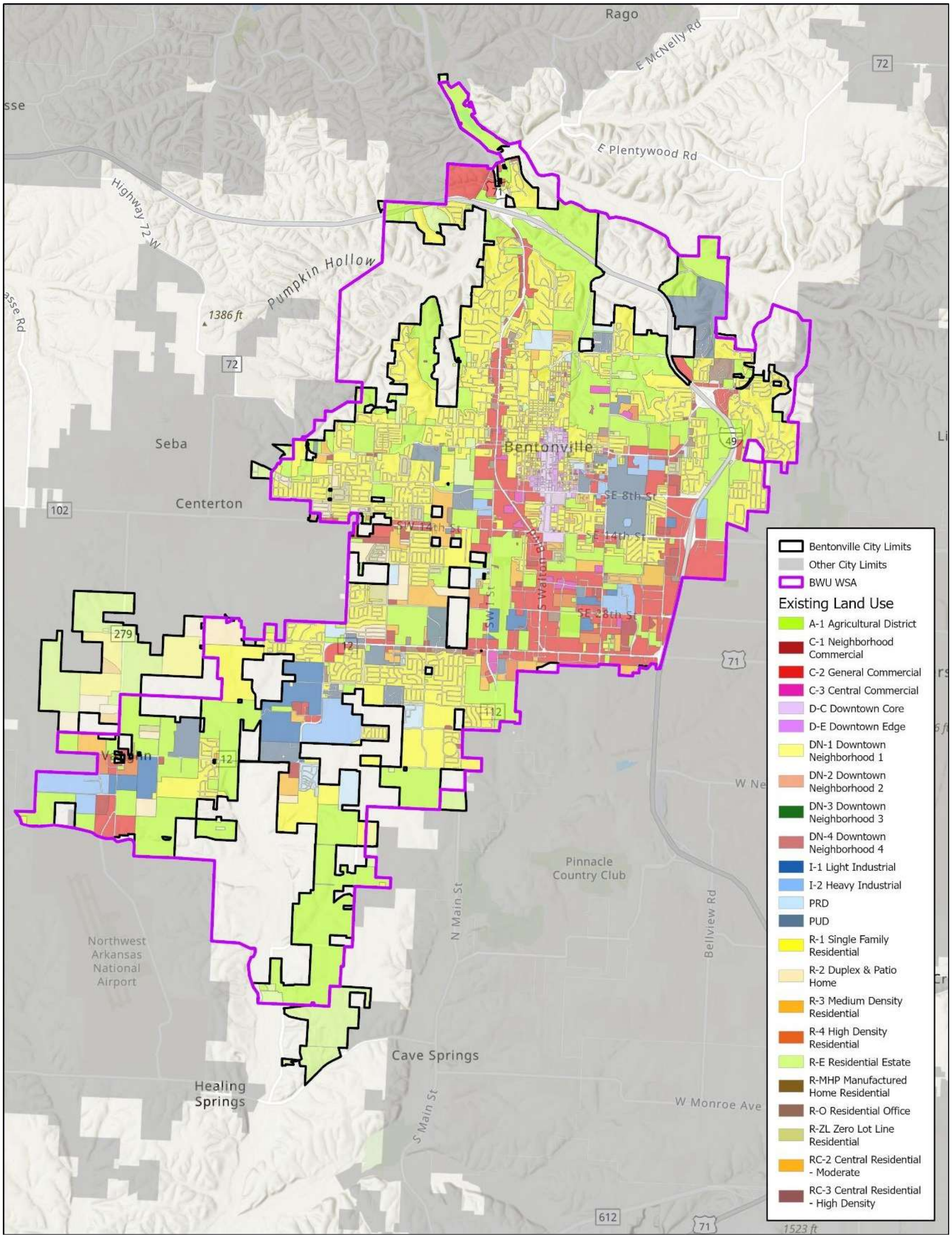


Figure 2-3: Existing Land Use

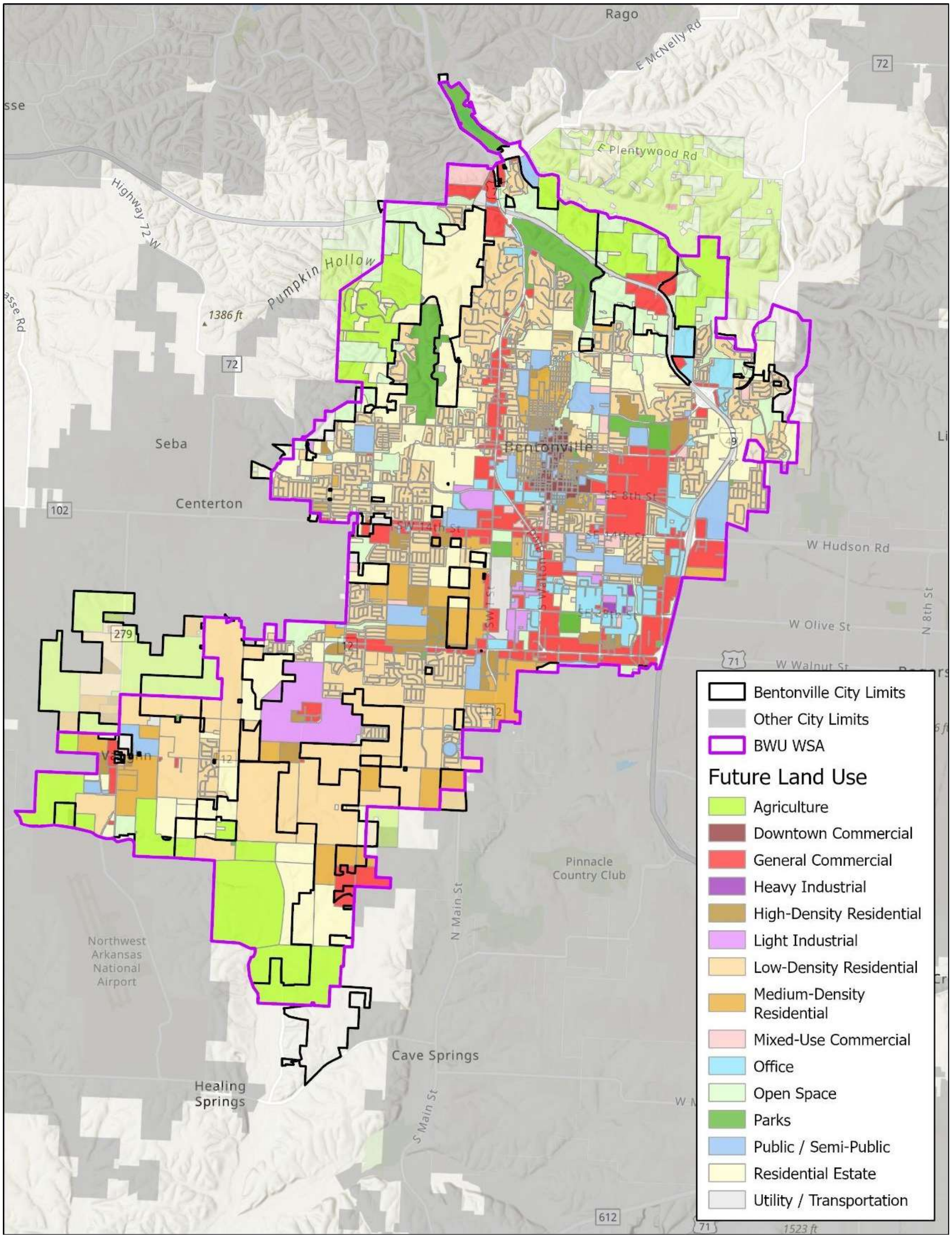


Figure 2-4: Future Land Use

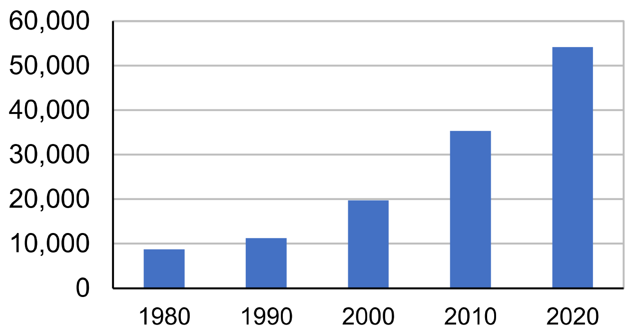
3.0 Historical Population and Water Demands

3.1 Historical Population Growth

The information obtained from the U.S. Census Bureau, shown in Table 3-1, contains population estimates for the years of 1980 through 2020 while the associated column chart illustrates the population estimates over time. BWU serves a retail population of approximately 58,890 as of 2023. BWU also supplies water to multiple wholesale customers as discussed in Section 2.3. Figure 3-1 summarizes the historical population growth in the retail and large wholesale water systems served by BWU.

Table 3-1: Bentonville U.S. Census Population Data

Year	Population
1980	8,756
1990	11,257
2000	19,730
2010	35,301
2020	54,120



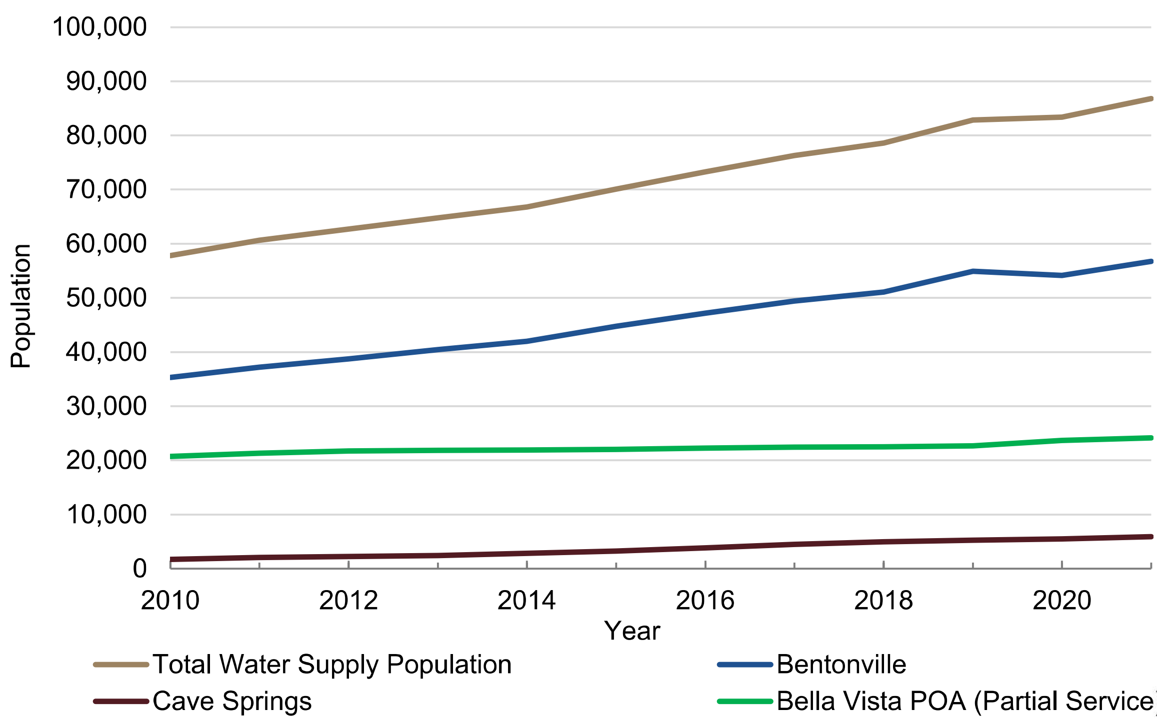


Figure 3-1: Historical Retail and Large Wholesale Customer BWU Service Population

3.2 Historical Water Demands

BWU provided Garver with historical water purchase data dating back to January of 2017. Additionally, the 2018 WMP included historical demands back to 1987. The historical average day and maximum day demands, as well as the population estimates, are illustrated in Figure 3-2. The figure indicates that the population growth over the last 20 years has generally been linear. However, the change in average and maximum day demands has been less consistent. The average day demand increased in the early 2000s, then reduced late in the decade only to increase more significantly from 2010 to 2020. The maximum day demands have fluctuated but have steadily increased for the last four years. From 2021 to 2022 there was just over a 5 MGD increase in maximum day demands. This increase may be explained by several contributing factors, including hot and dry weather conditions, commercial demands returning to pre-pandemic levels, and increases in non-revenue water (NRW).

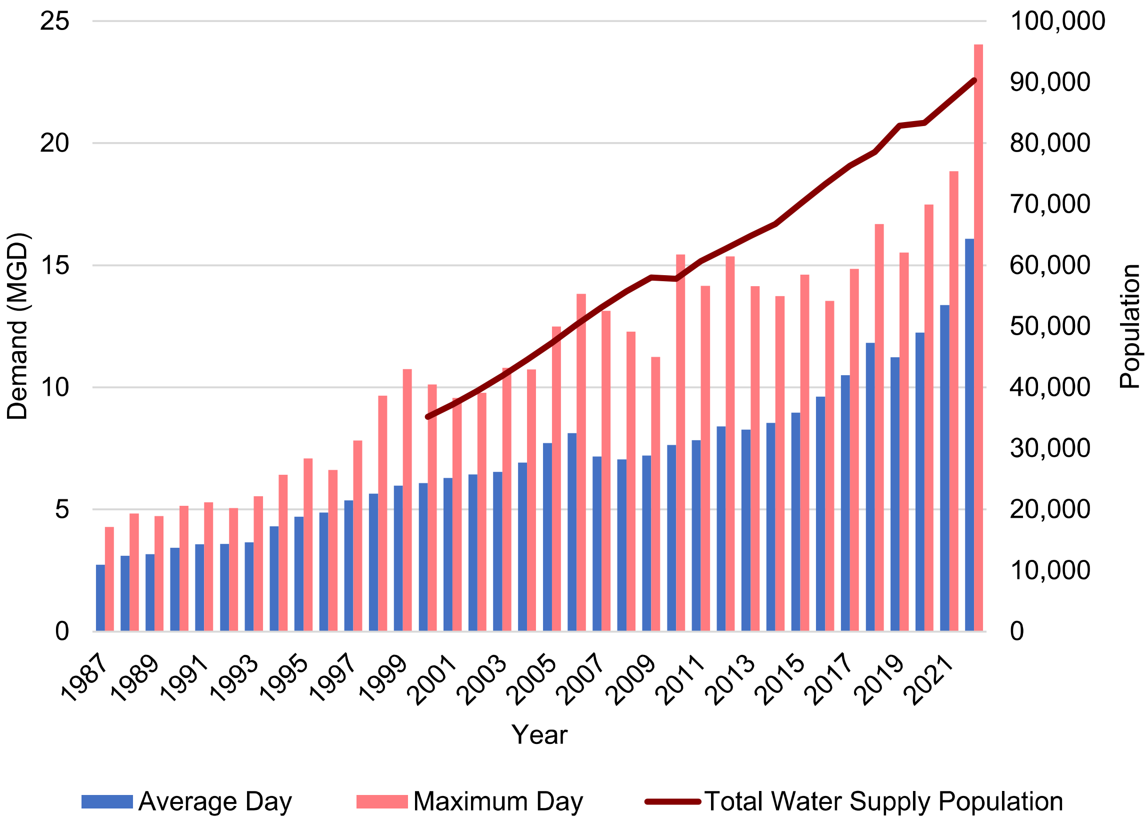


Figure 3-2: Historical Daily Water Purchased

Figure 3-3 illustrates how the purchase volume for each month has changed over recent years. The purchase volume in April to May of 2021 was impacted by an interruption in the wholesale supply to Bella Vista POA for approximately three weeks during a transmission line repair. BWU appears to have similar patterns in water production from year to year, as the maximum typically falls in July, August, or September while the minimums occur between January and April.

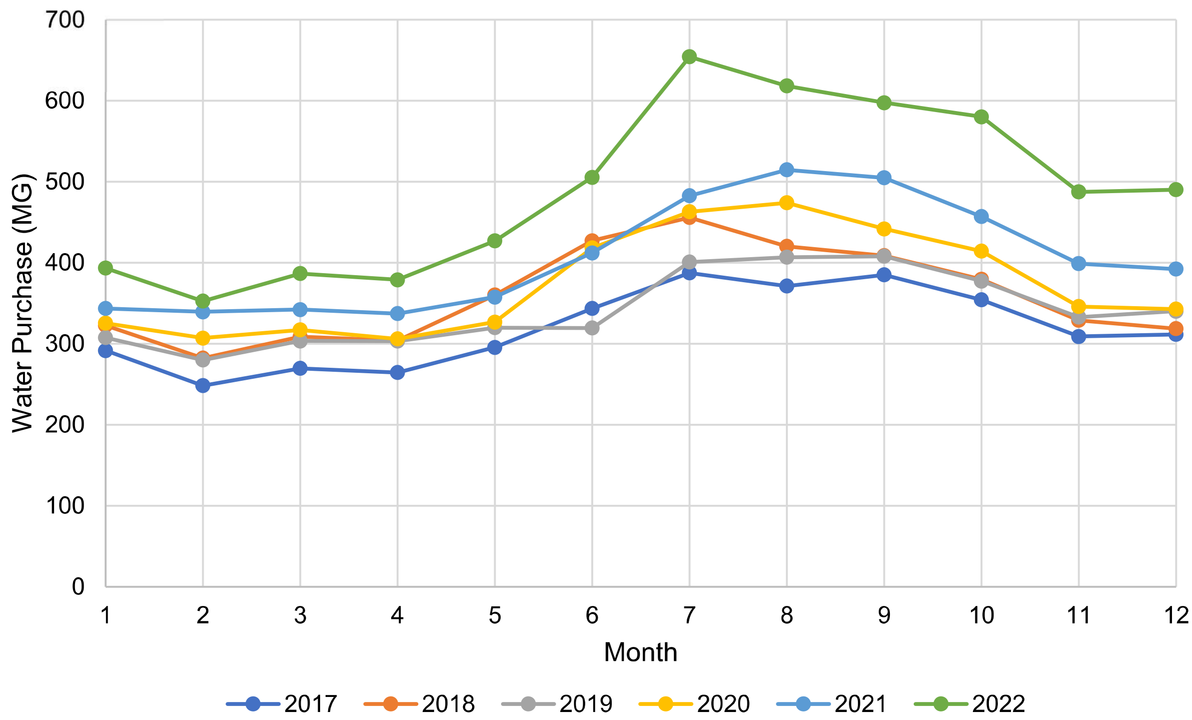


Figure 3-3: Water Purchase History by Month

3.3 Historical Customer Billing Data

BWU provided Garver with historical customer billing data for 2019 through 2022. Garver categorized demands into four separate user classes: Commercial, Wholesale, Residential, and NRW. Figure 3-4 illustrates the percent of total demand broken down into user classes. The NRW was calculated as the difference in total annual water purchase volume and total annual billed volume. The NRW was divided into real and apparent losses based on the ratio estimated for the 2021 water audit. Residential water use accounts for the highest portion of the billed volume at 24% of the annual water use. The wholesale and commercial customers account for approximately 21% and 15% of water use, respectively.

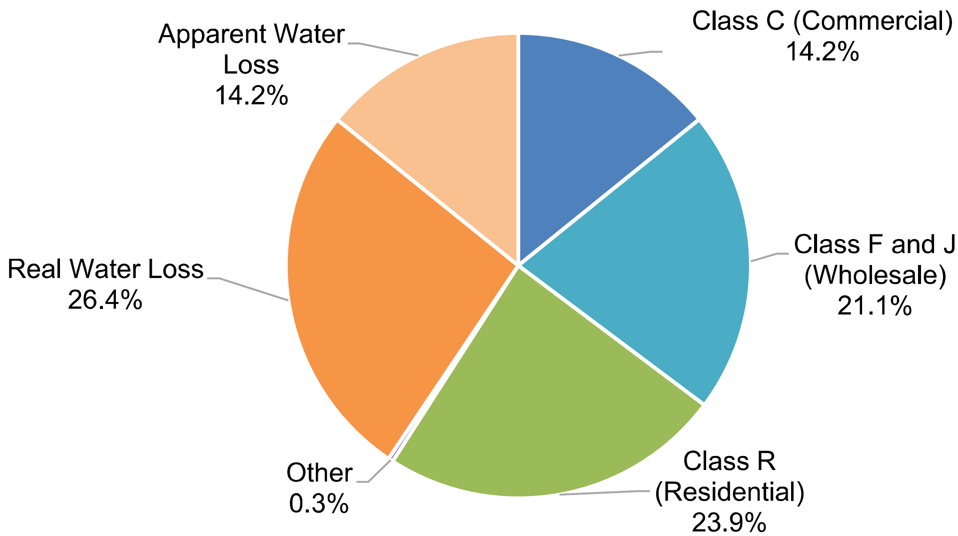


Figure 3-4: Percent Demand by User Class (2019-2022)

Figure 3-5 illustrates the trends over time for each user class as well as the total sales amongst all user classes while excluding NRW. The total NRW has steadily increased over the last four years, averaging out to approximately 1 MGD of additional NRW per year while the total sales of all other user classes has only increased by an average of approximately 0.5 MGD per year. Wholesale and residential customer demands have increased, however not nearly at the rate of NRW. Section 3.5 discusses NRW in more detail, including the potential impact of apparent losses caused by residential/irrigation customer meter inaccuracies. Commercial customers experienced a dip in total demand after 2019, likely as a result of the COVID pandemic, but had nearly a 0.4-MGD increase in volume from 2021 to 2022. This increase brought commercial sales beyond 2019 levels.

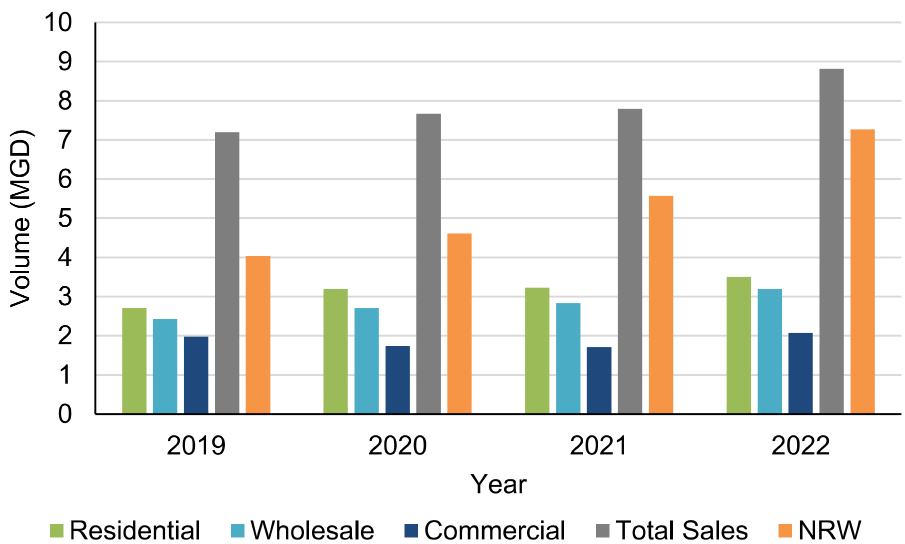


Figure 3-5: Demand by User Class

Figure 3-6 illustrates the monthly use by major user classes (residential, commercial, and the two large wholesale customers) based on customer billing data. Figure 3-7 shows irrigation use by class with customers split into residential and commercial classes. These charts indicate that there has been a steady increase in both residential and irrigation use since 2019. Commercial use was lower in 2020 and 2021 during the pandemic but increased back to pre-pandemic levels in 2022. Both Bella Vista POA and Cave Springs generally trend with residential uses in Bentonville and are generally trending higher year-over-year.

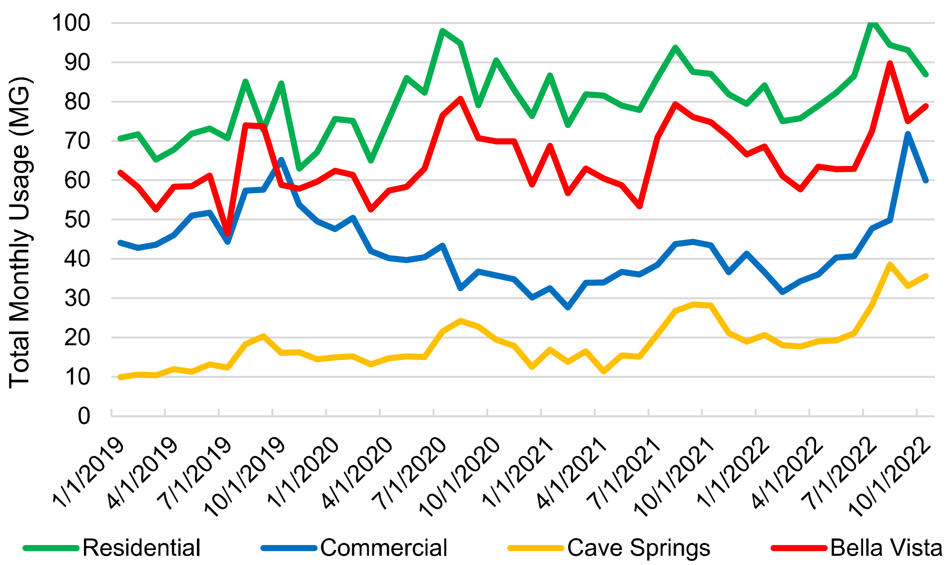


Figure 3-6: Monthly Use by User Class

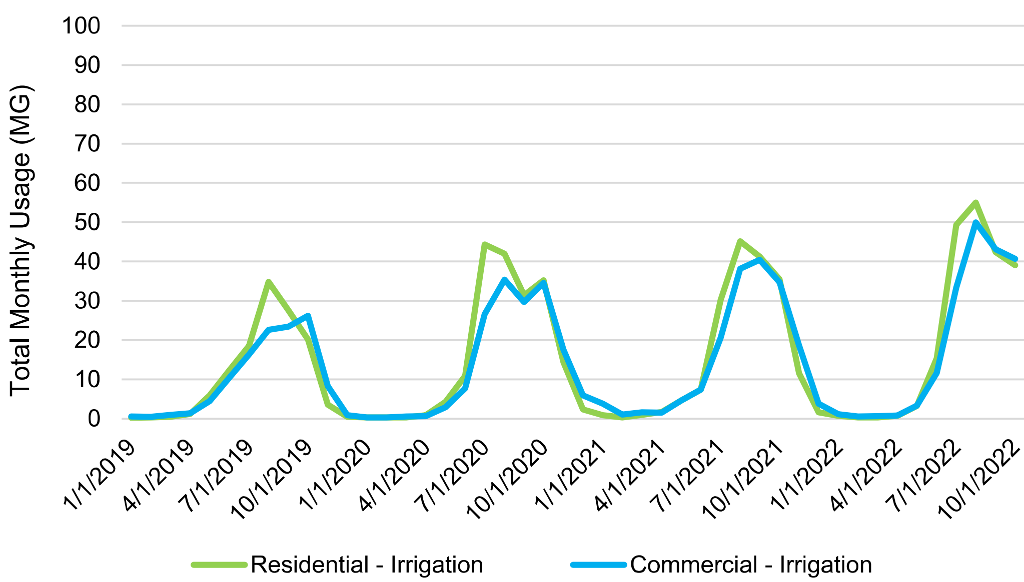


Figure 3-7: Monthly Irrigation Use by User Class

3.4 Per Capita Water Demands

Garver evaluated per capita demands using historical populations of the total population supplied by BWU (Bentonville, Oak Hills SID, Cave Springs, Old Bella Vista POA, and a portion of Bella Vista POA). As populations grow, per capita water usage values often tend to drop as denser developments with more efficient plumbing fixtures are installed. Figure 3-8 illustrates the per capita demand for average day and maximum day demand conditions over time. The per capita demands for BWU decreased significantly between 2000 and 2010; however, the per capita demands have been increasing again in recent years. Following discussions with BWU staff, this aligns with the sudden increase of NRW within the system following the installation of new meters for the implementation of advanced metering infrastructure (AMI) in 2012. Historical NRW data before 2019 was not available for identifying long term trends at the time of this analysis. More discussion of NRW is provided in Section 3.5. Additional factors that could influence the per capita demands are increased commercial usage and changes in residential development characteristics.

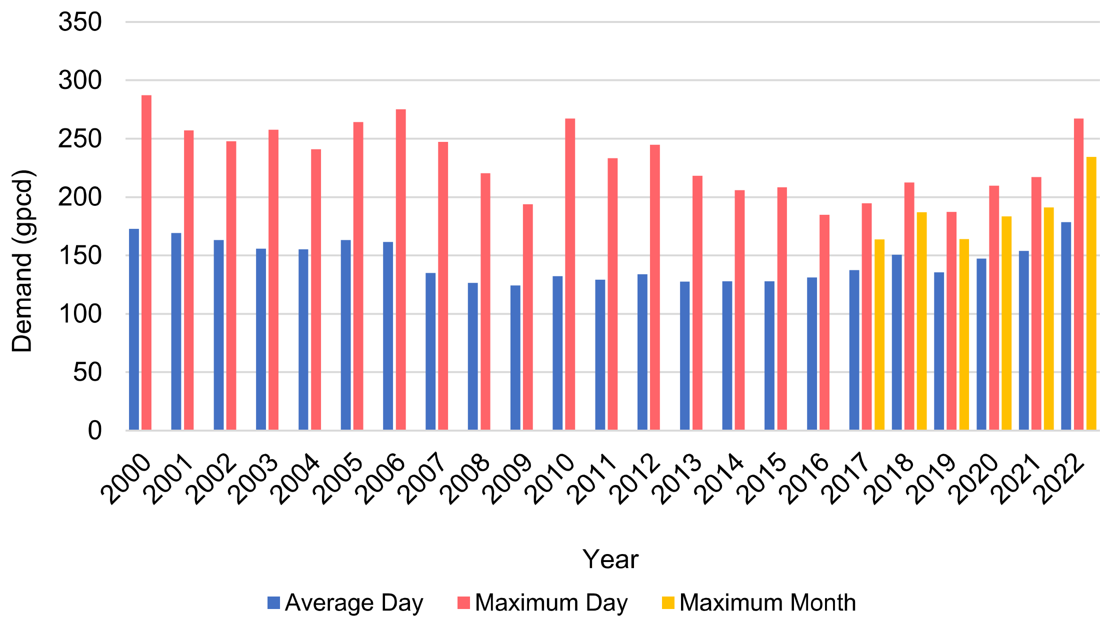


Figure 3-8: Historical Per Capita Water Supply

Table 3-2 provides a summary of average and maximum month per capita demands for BWU retail customers and the two large wholesale customers, Bella Vista POA and Cave Springs, from 2019 to 2022. Retail customers have the highest per capita demands, which reflects the significant commercial demands within the City of Bentonville. Prior to 2023, daily demands were not recorded for the Cave Springs and Bella Vista POA flow meters. Garver estimated the Bella Vista POA maximum day demand for 2022 was 160 gpcd based on instantaneous SCADA data. In 2023, BWU began recording daily flow data for Bella Vista POA and Cave Springs via the AMI system. The maximum day per capita demands for Bella Vista POA and Cave Springs prior to August 14, 2023, were 127 gpcd and 215 gpcd, respectively. Refer to Section 4.2 for further detail on how these per capita demand values were used to determine future demands.

Table 3-2: Historical Per Capita Retail and Large Wholesale Customer Water Demands

Year	Bentonville		Bella Vista POA		Cave Springs	
	Average Day (gpcd)	Maximum Month (gpcd)	Average Day (gpcd)	Maximum Month (gpcd)	Average Day (gpcd)	Maximum Month (gpcd)
2019	160	190	88	109	87	129
2020	176	218	92	113	103	147
2021	179	223	92	123	110	159
2022	220	285	92	121	134	206

3.5 Non-Revenue Water

Non-revenue water (NRW) can be defined as the difference between the water supplied to the system and that is not billed to customers. As mentioned in the previous subsection, NRW has continued to increase rapidly in the last few years. Table 3-3 includes data on the BWU distribution system. The data includes:

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

Table 3-3: Water Purchased and Billed Comparison

Year	Annual Purchase Volume (MG)	Annual Sales Volume (MG)	Non-Revenue Water (MG)
2019	4,099	2,626	1,473
2020	4,481	2,800	1,681
2021	4,881	2,845	2,036

With increasing concerns over NRW, BWU staff have taken steps to identify the root cause. BWU staff indicated that NRW significantly increased following installation of new residential and irrigation meters as part of the conversion to AMI meters in 2012. This led to speculation that the residential meters are not accurately reading water consumption. As a result, BWU began a study to investigate water losses. In addition to the meter inaccuracies, BWU staff suggested that there have been significant losses from service lines installed after 2006 due to improper installation. The study findings to date suggest the residential and irrigation meters may be significantly under-registering. The apparent losses in the BWU 2021 water audit accounted for approximately 35% of the total water losses.

4.0 Population and Water Demand Projections

4.1 Population Projections

Garver used population estimates reported by the U.S. Census Bureau from 1980 to 2021 to identify historical trends in population growth, as discussed in Section 3.1. In addition to U.S. Census estimates, Garver also compared projections from the 2018 WMP, 2018 Bentonville Community Plan, and NWARPC MTP. According to the 2018 Bentonville Community Plan, the area that was within a quarter mile of existing utilities in 2018 has the capacity to support a population of at least 110,000 people. Additional development is anticipated as access to utilities expands and redevelopment occurs in and around the core of the City, so there appears to be ample developable land to accommodate projected growth for the foreseeable future.

Figure 4-1 shows historical Bentonville population growth compared to recent projections. The blue line represents a linear growth projection from the 2020 population to the NWARPC 2045 population projection. Recent growth significantly exceeded the growth projected in the 2018 Community Plan and Water Master Plan.

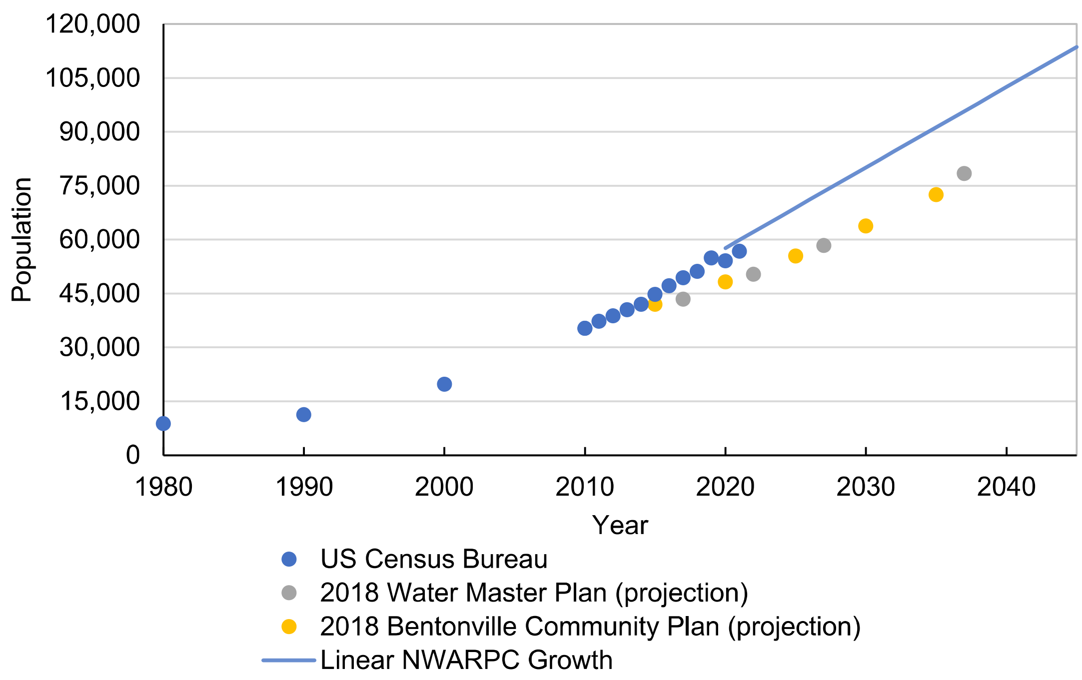


Figure 4-1: Previous Bentonville Population Projections

BWU staff provided a population growth rate range of 5% to 6.5% for the BWU retail and Cave Springs wholesale service areas through 2045. Figure 4-2 shows the projections for the retail, wholesale, and total water supply populations based on the 6.5% growth rate. The Bella Vista POA provided population and demand projections using a constant growth rate of 3%.

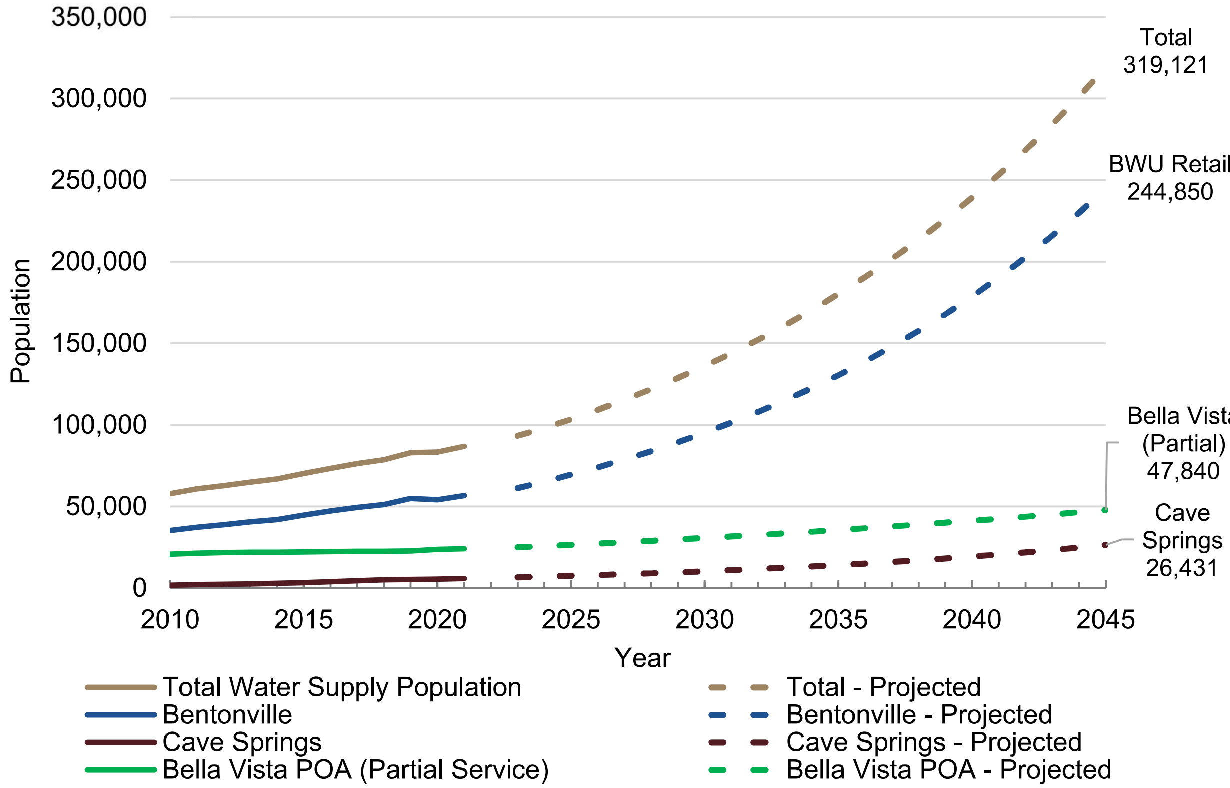


Figure 4-2: Projected Retail and Large Wholesale Customer BWU Service Population With 6.5% Growth Rate

4.2 Water Demand Projections

As discussed in Sections 3.1 and 3.4, Garver used the populations of the cities of Bentonville, Cave Springs, and Bella Vista POA served by BWU to determine historical average day and maximum day per capita demand values. Based on the best information available at the time of this analysis, Garver developed the projected water demands per capita summarized in Table 4-1. The Bella Vista POA provided average annual demand projections assuming 75.9% of their supply will be purchased from BWU. Garver multiplied the per capita demand values by the corresponding population to calculate the projected flows for each scenario.

Table 4-1: Projected Water Demands Per Capita

Bentonville		Bella Vista POA		Cave Springs	
Average Day (gpcd)	Maximum Day (gpcd)	Average Day (gpcd)	Maximum Day (gpcd)	Average Day (gpcd)	Maximum Day (gpcd)
200	285	92	160	110	230

Additionally, Garver used anticipated demands for the redevelopment of the Walmart Home Office (WHO) campus as outlined in the Walmart Water Modeling Study. The initial phases of the new WHO are anticipated to be completed in 2023, with buildout anticipated in 2025. To account for this additional demand, Garver assumed that the demand will start at 1 MGD in 2023 and increase to the projected total of 3 MGD by the completion of WHO in 2025. Garver projected future demands by adding the WHO demands to the population-based demand projections resulting from the per capita demand assumptions.

Figure 4-3 and Figure 4-4 illustrate the historical demands and the range of projected average and maximum day demands in relation to the population projections using the growth rate range of 5% to 6.5%. Figure 4-5 shows the demand and population projections for BWU retail customers using a growth rate of 6.5%.

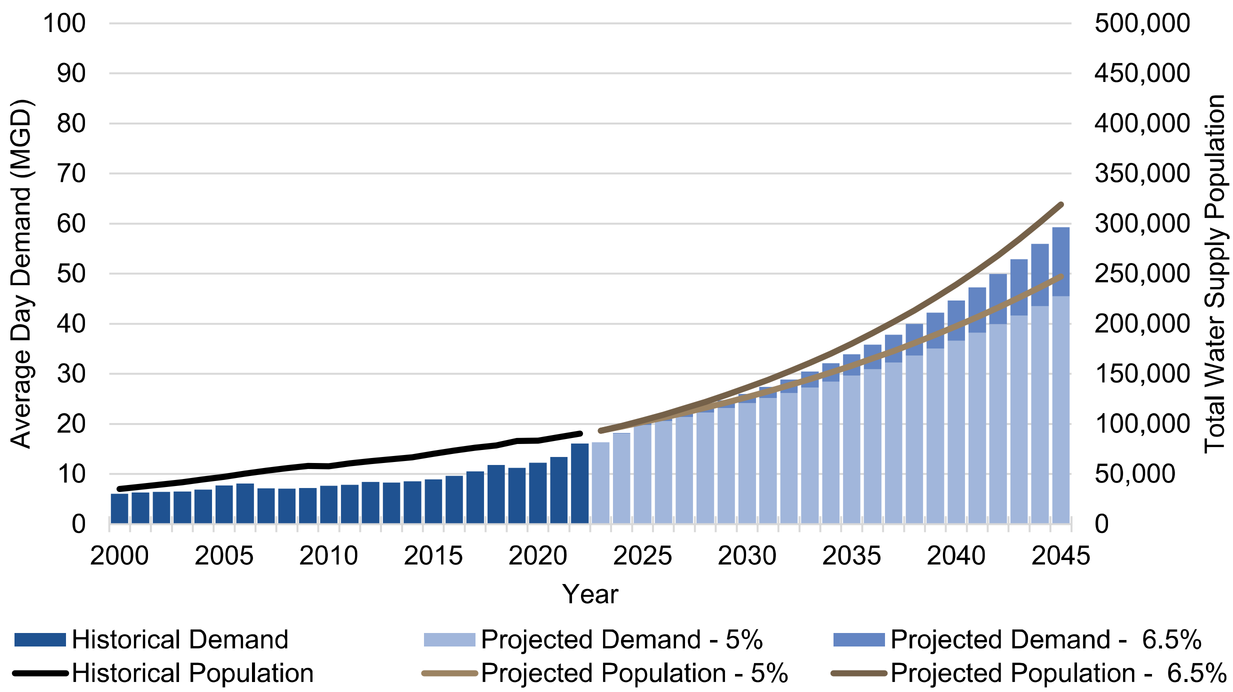


Figure 4-3: Historical and Projected Average Day Demands

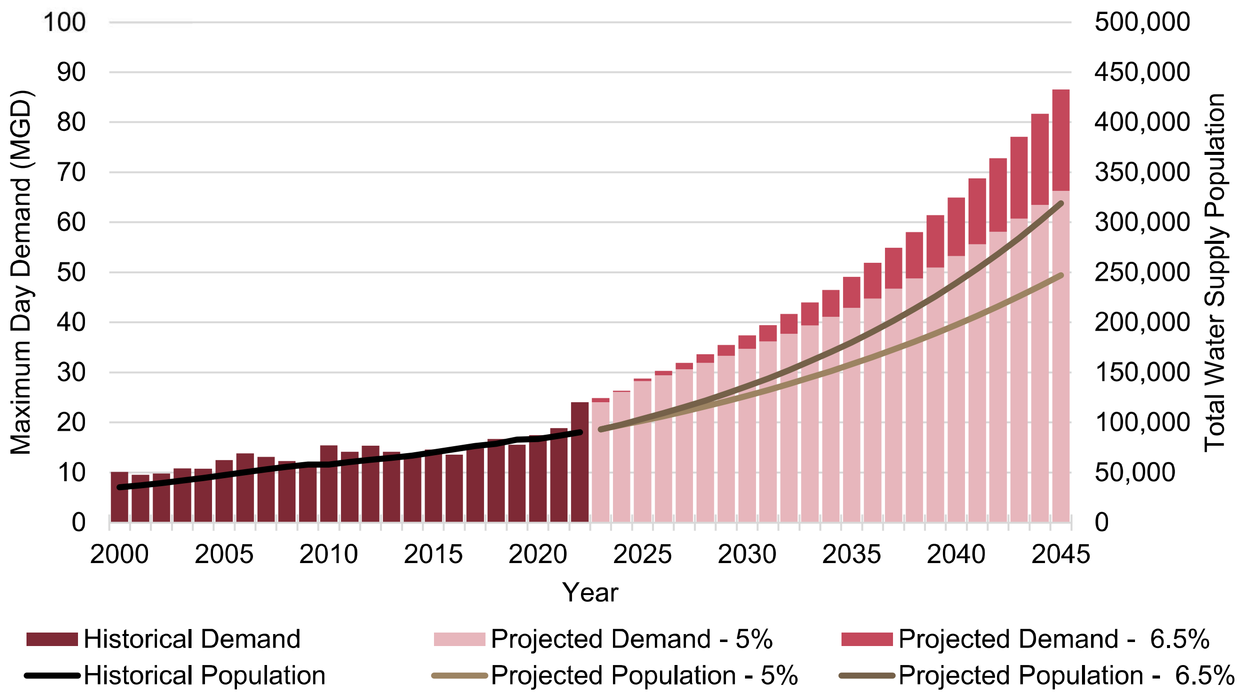


Figure 4-4: Historical and Projected Maximum Day Demands

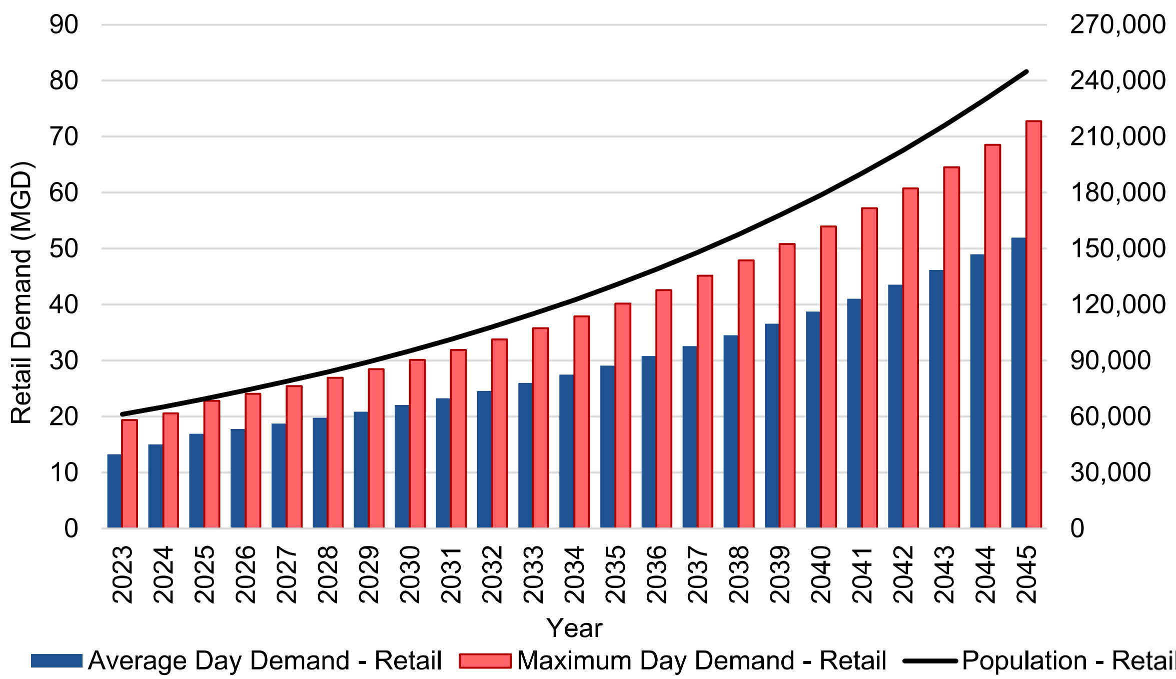


Figure 4-5: Projected Retail Population and Water Demands With 6.5% Growth Rate

4.3 Growth Areas

The 2018 WMP delineated five growth areas within the Bentonville planning area to allocate future demands. After discussions with BWU staff, Garver made the following modifications to the 2018 WMP areas:

- Expanded Downtown area into Core area that extends east to Interstate 49
- Transferred Northeast J Street Interchange from Northeast area to Infill area
- Created a new South area

Each area was assigned a percentage of the future demand, which was determined by collaborating with BWU staff. For example, if the selected planning horizon is projected to increase total demand by 10 million gallons per day (MGD) and the Core area was assigned 30% of the demand, an additional 3 MGD of demand would be allocated within the Core area. The growth areas and their corresponding total demand percentages are illustrated in Figure 4-6. The percent of total demands for each growth area is shown in Table 4-2.

Table 4-2: Percent of Total Projected Demand for BWU Growth Areas

Growth Area	10-year % Demand	20-year % Demand
Core	39%	30%
Infill	29%	22%
Southwest	32%	24%
West	-	10%
Northeast	-	7%
South	-	7%

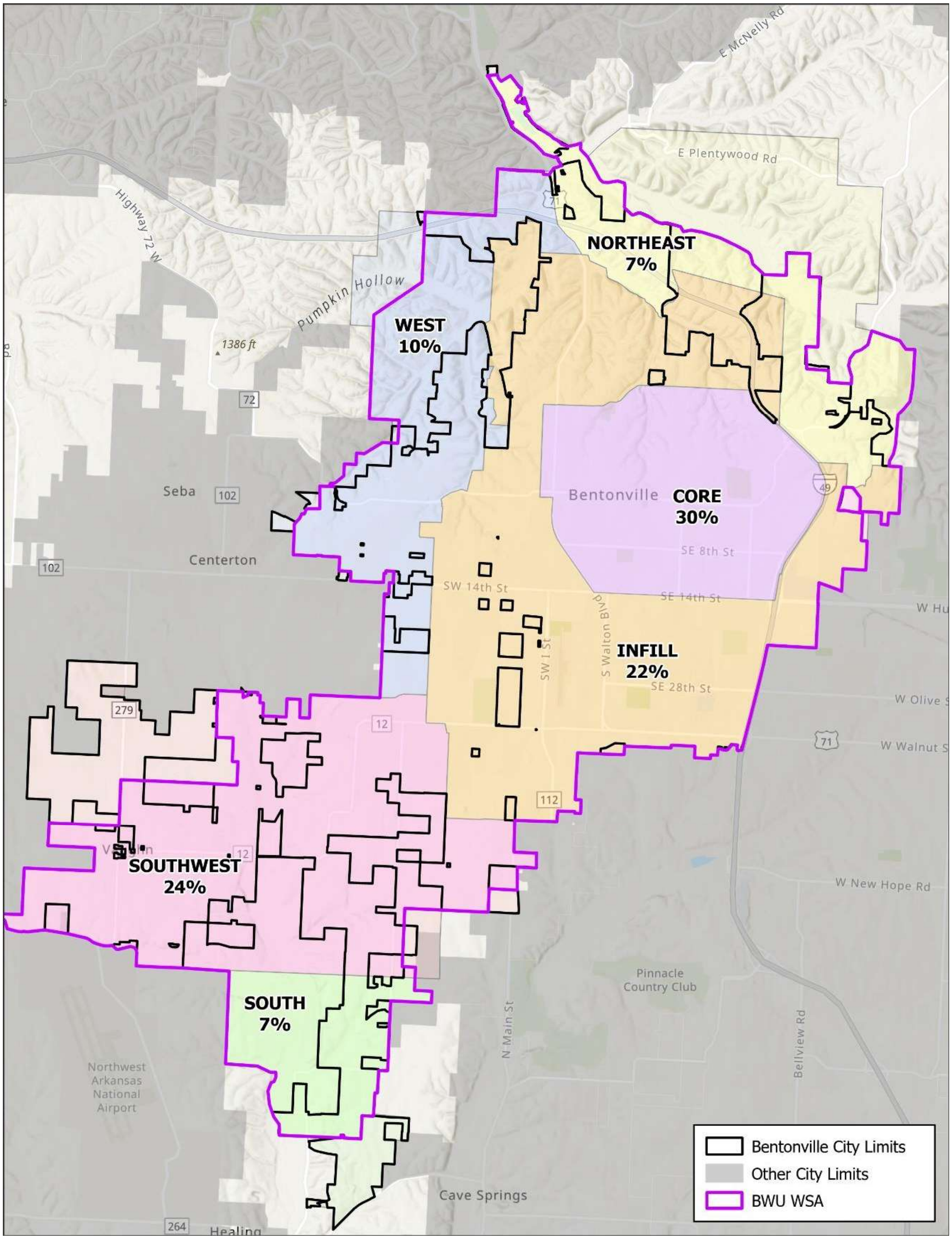


Figure 4-6: BWU Growth Areas and 20-year Percent of Projected Demands

4.4 Planning Horizons

Existing system (using 2023 projected demands), 5-year (2028), 10-year (2033), and 20-year (2043) planning horizons will be used to develop a 10-year CIP for BWU. The 20-year (2043) projections will be used to confirm the sizing of the proposed improvements and develop conceptual long-term improvements. The selected planning horizons and associated maximum day and average day demands are shown in Table 4-3.

Table 4-3: ADD and MDD Demands for Planning Horizons

Year	Bentonville		Bella Vista POA		Cave Springs		Total	
	ADD (MGD)	MDD (MGD)	ADD (MGD)	MDD (MGD)	ADD (MGD)	MDD (MGD)	ADD (MGD)	MDD (MGD)
2023 (projected)[1]	13.3	19.4	2.3	4.0	0.7	1.5	16.3	24.9
2028	19.8	26.9	2.7	4.6	1.0	2.1	23.4	33.6
2033	26.0	35.8	3.1	5.4	1.4	2.9	30.5	44.0
2043	46.2	64.5	4.1	7.2	2.6	5.4	52.9	77.1

Notes:
1. Demands for 2023 were projected based on data available at the time of this analysis.

APPENDIX B
Existing System Assessment Technical Memorandum No. 2

Bentonville Water Utilities
Water Master Plan Update

Technical Memorandum No. 2
Existing System Assessment

City of Bentonville
Bentonville, Arkansas

Prepared by:

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

April 2024

Garver Project No. 22W01291

Table of Contents

List of Figures

List of Tables

1.0 Introduction

This technical memorandum (TM) was prepared for Bentonville Water Utilities (BWU) as part of the Bentonville Water Master Plan Update. This is the second TM for the project, following the Growth Projection TM. The purpose of this TM is to:

- Provide a summary of the major components of BWU's water distribution system
- Document the steps taken to develop the distribution system hydraulic model
- Present results of the existing distribution system assessment

Data provided by BWU and Beaver Water District (BWD) on recent system improvements, water production, and water demands were used to develop the hydraulic model of the distribution system documented in this TM.

2.0 Existing Facilities

BWU owns, operates, and maintains the water distribution system that consists of pump stations, water storage tanks, and water mains. The entire system is operated on a single pressure plane. Figure 2-1 shows an overview of BWU's water distribution system, including locations of all pump and storage facilities, emergency connections with adjacent water distribution systems, and wholesale meters. Additional details on the existing facilities are provided in the following subsections. Figure 2-2 illustrates the BWU water distribution system schematic, which includes high-water level (HWL), low-water level (LWL), and base elevations of water storage tanks as well as design flow rates of the pumps within the system.

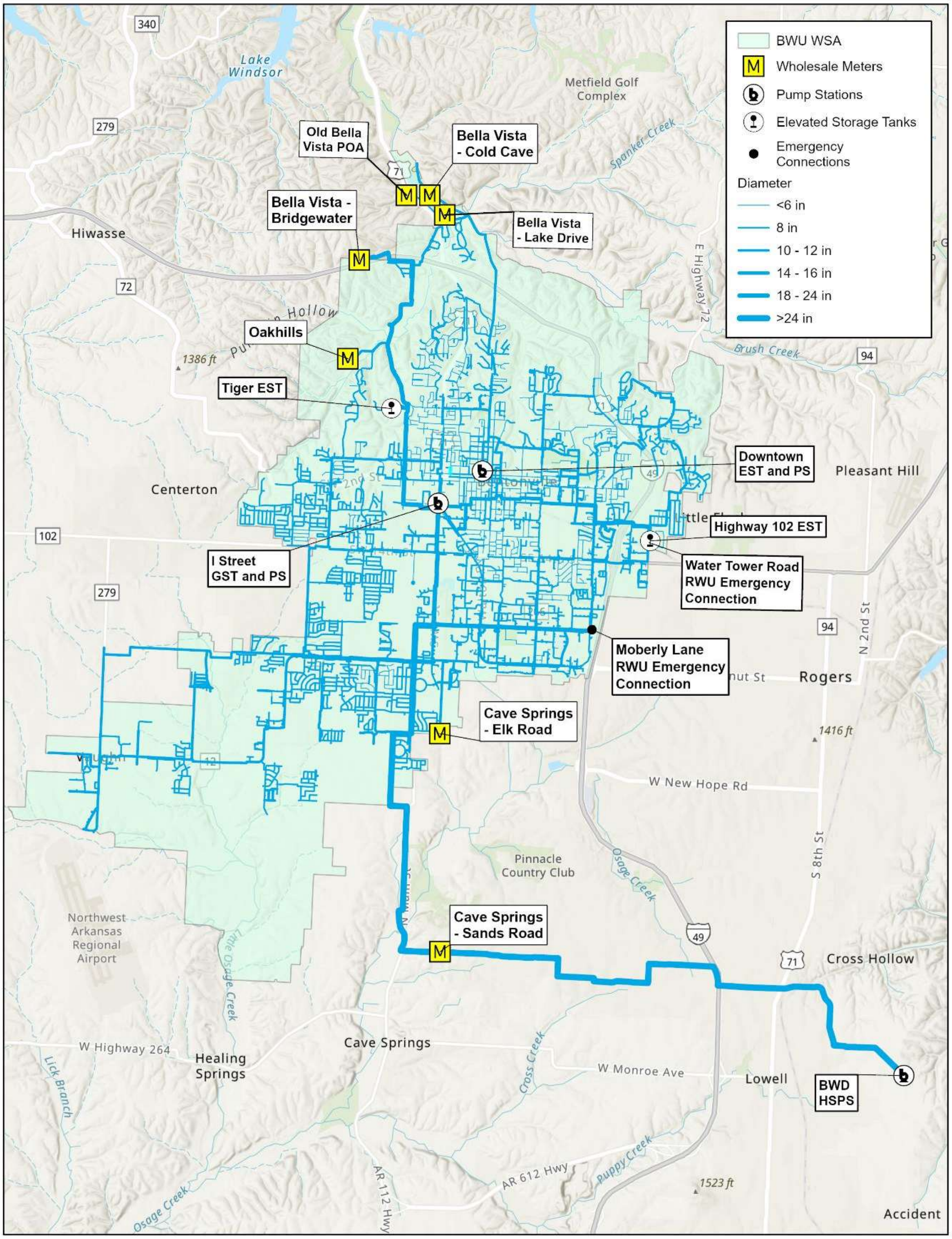


Figure 2-1: Existing Distribution System Overview

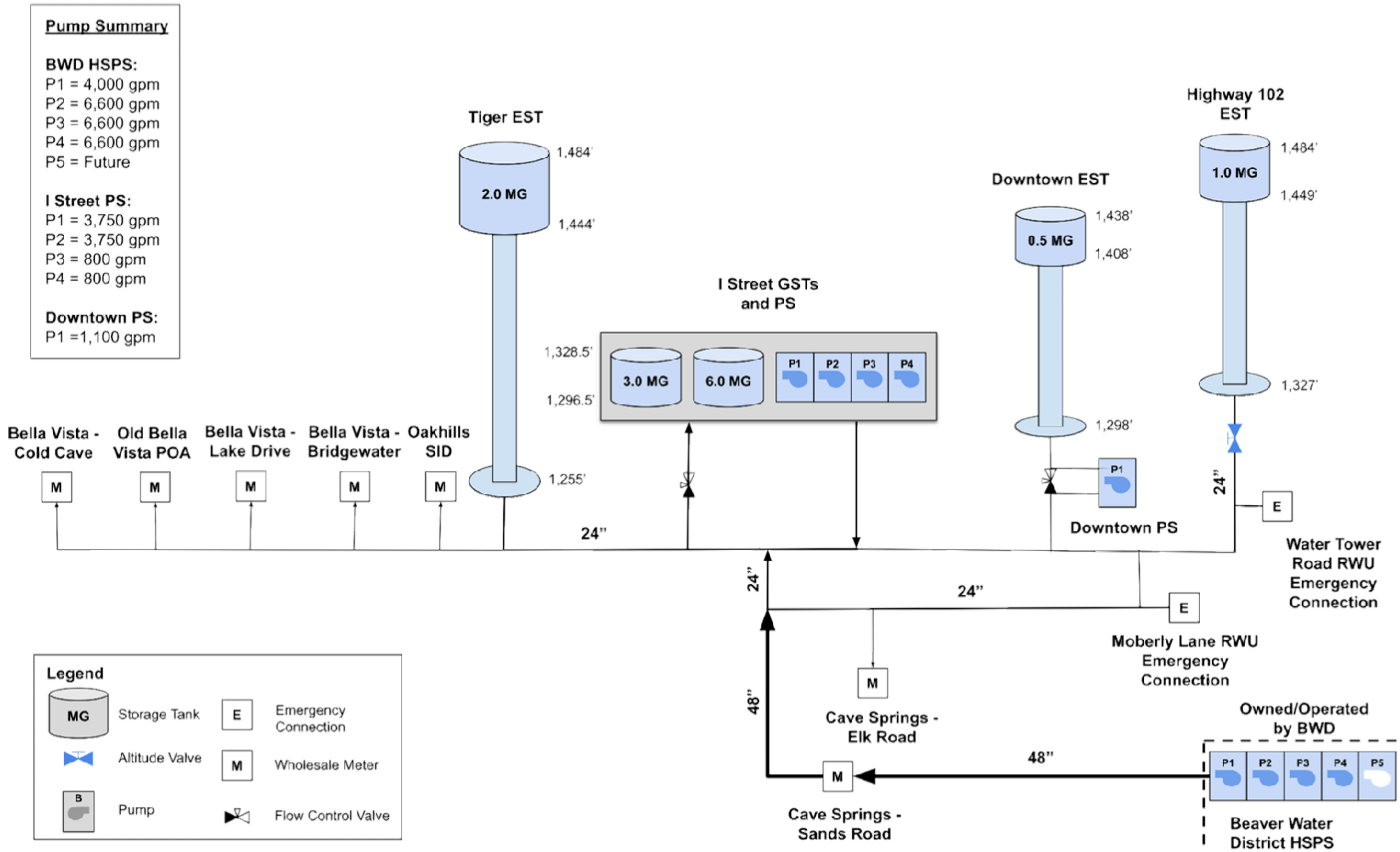


Figure 2-2: BWU System Schematic

2.1 Water Supply

BWU purchases wholesale water from BWD. BWD supplies treated water from Beaver Lake to BWU. There are no contractual limits for water supply to BWU; however, the supply that can be provided by BWD is limited by capacity of the BWD high-service pump station (HSPS).

2.1.1 BWD HSPS

Water is pumped from the HSPS adjacent to the BWD WTP to the BWU water distribution system via a 48-inch transmission main. The existing pumps and their associated design flow, design head, and rated horsepower as of October 2023 are shown in Table 2-1. BWU staff notified Garver that summer demands are nearing the capacity of the BWD HSPS. As a result, BWD has ordered an additional 6,600 gpm pump to add to the existing HSPS. Due to significant lead times, this pump is not anticipated to be installed until late 2023 or 2024.

Table 2-1: BWD HSPS Pumps

Pump Number	Design Flow (gpm)	Design Flow (MGD)	Design Head (ft)	Rated Horsepower (hp)
1	4,000	5.8	135	250
2	6,600	9.5	165	500
3	6,600	9.5	165	500
4	6,600	9.5	165	500
Firm Capacity[1]	**15,970**	**23**	-	-
Total Capacity	**18,400**	**26.5**	-	-
Notes: *1. Firm capacity presented in the BWD 2023 Water Master Plan.*				

2.2 Transmission Mains

BWU currently owns and operates approximately 13.8 miles of 48-inch transmission main that starts at the BWD HSPS and ties into the BWU water distribution system at the southwest corner of Southwest I Street and Southwest 28th Street. This transmission main was designed and constructed in 2007. The 48-inch transmission main connects to two 24-inch pipes, one continuing north toward the I Street Tank Site and the other branching east toward the Moberly Lane RWU Emergency Connection. Refer to Figure 2-1 for the transmission main alignment.

2.3 Distribution Pipes

BWU's water distribution system contains a variety of pipe sizes and materials. Approximately 372 miles of pipe are active throughout the water distribution system. Table 2-2 provides a summary of the lengths of pipe by diameter and material, while Figure 2-3 illustrates the data in a bar chart.

Table 2-2: BWU Water Distribution System Water Line Inventory by Material and Size

Line Size (in)	PVC (LF)	Asbestos Cement (LF)	Ductile Iron (LF)	Cast Iron (LF)	Other[1] (LF)	Unknown (LF)	Total (LF)
≤4	24,912	3,064	12	12,307	15,482	7,293	**63,070**
6	164,740	133,264	7,373	25,092	13,787	150	**344,406**
8	905,295	34,173	24,950	36,095	7,904	21,526	**1,029,943**
10	47	-	26	2	-	-	**75**
12	230,889	15,400	59,085	10,445	22,922	180	**338,921**
16	870	-	4,462	19	9,307	-	**14,658**
18	13,848	-	12,405	-	-	-	**26,253**
24	11,199	-	22,894	378	6,674	-	**41,145**
48	72,849	-	7	-	-	-	**72,856**
Total	**1,424,649**	**185,901**	**131,214**	**84,338**	**76,076**	**29,149**	**1,931,327**

Notes:
1. Includes HDPE, PE, ABS, and galvanized pipe materials.

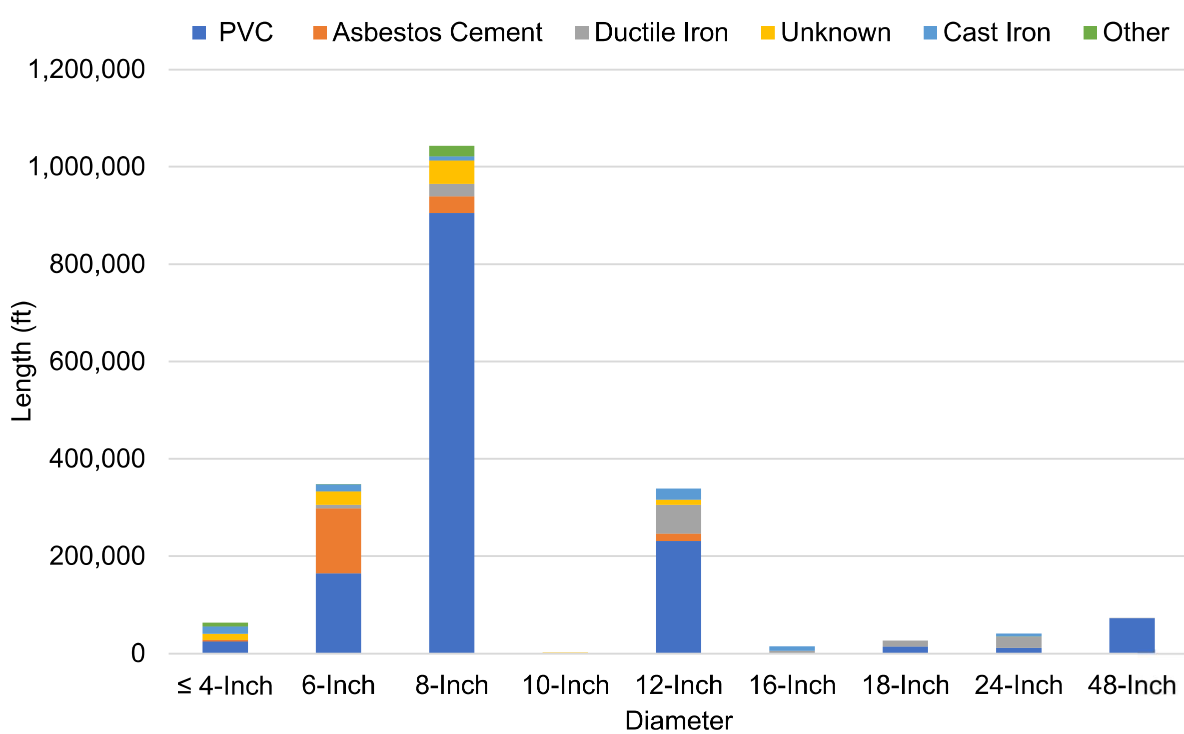


Figure 2-3: BWU Water Distribution System Water Line Inventory by Material and Size

2.4 Wholesale Connections

BWU currently has metered connections to Bella Vista Village Property Owners Association (POA), Old Bella Vista POA, Oakhills Suburban Improvement District (SID), and Cave Springs Waterworks. The locations of these connections are illustrated in Figure 2-1. There are currently no contractual limits to water supply to any of the BWU wholesale customers.

2.5 Emergency Connections

Existing emergency connections are shown in Figure 2-1. The existing and future emergency connections will be discussed further in the Major Infrastructure Risk Assessment TM.

2.5.1 Moberly Lane

The Moberly Lane Emergency Connection is located at the intersection of 28th Street and Moberly Lane. Built in 1986, the station contains isolation valves, a pressure transducer, and a meter to record flow between the cities, if necessary. The meter station is situated on a 24-inch water line. BWU staff indicated that the Moberly Lane station is the best indicator of system pressure and that they typically monitor this pressure while adjusting pumping rates at the I Street Pump Station (PS) facility. The meter within the meter station is shown in Figure 2-4.

Figure 2-4: Moberly Lane Emergency Connection Meter

2.5.2 Water Tower Road

The Water Tower Road Emergency Connection is connected to a 24-inch water line adjacent to the Highway 102 Elevated Storage Tank (EST), which is located north of the Southeast 14th Street and Southeast Water Tower Road intersection. BWU staff indicated that there are plans to replace the existing building in the near future.

2.6 Pumping and Storage Facilities

Table 2-3 and Table 2-4 contain information about the ESTs, ground storage tanks (GSTs), and pump station facilities that BWU owns and operates. Additional information about each facility is provided in the subsequent subsections, with the Highway 102 EST presented first, followed by the Tiger EST, the I Street facilities, and the Downtown facilities.

Table 2-3: Storage Types and Volumes

Description	Type	Volume (MG)
Highway 102	EST	1.0
Tiger	EST	2.0
Downtown	EST	0.5
I Street	GST	6.0
I Street	GST	3.0
Total Capacity	-	**12.5**

Table 2-4: Pump Station Capacities

Description	No. of Pumps	Firm Capacity (gpm)
I Street	4	7,000
Downtown	1	N/A*
******The Downtown Pump Station does not contain any redundant pumps, thus resulting in a firm capacity of 0 gpm*		

2.6.1 Highway 102 EST

The Highway 102 EST is located approximately one third of a mile north of the intersection of Highway 102 and North Water Tower Road. The site consists of a single 1-MG EST which is one of the two ESTs that set the single pressure plane HGL of 1,484 feet. Table 2-5 contains details about the Highway 102 EST.

Due to the proximity of the Highway 102 EST to the Water Tower Road RWU Emergency Connection, the Highway 102 EST Site includes an altitude valve (Figure 2-6) to prevent the tank from overflowing; however, it is likely that it no longer closes during normal operations as the RWU connection is used solely as an emergency connection.

Table 2-5: Highway 102 EST Features

Description	EST
Capacity	1 MG
Year	1969
Diameter (ft)	70
Base Elevation (ft)	1,327
LWL (ft)	1,449
HWL (ft)	1,484
Overflow Diameter (in)	12

Figure 2-5: Highway 102 EST

Figure 2-6: Highway 102 Altitude Valve

2.6.2 Tiger EST

The Tiger EST is located on the western side of the City, southwest of the intersection of Punkin Hollow Road and Northwest 12th Street. The Tiger EST has a HWL of 1,484 feet and was constructed at the same time the 48-inch transmission main came online in 2007. The tank contains a single inlet/outlet pipe with a passive mixing system. The Tiger EST does not have an altitude valve. Table 2-6 contains data on the features of the Tiger EST while Figure 2-7 displays a photo of the EST.

Table 2-6: Tiger EST Features

Description	EST
Capacity	2 MG
Year	2007
Diameter (ft)	97
Base Elevation (ft)	1,255
LWL (ft)	1,444
HWL (ft)	1,484
Overflow Diameter (in)	18

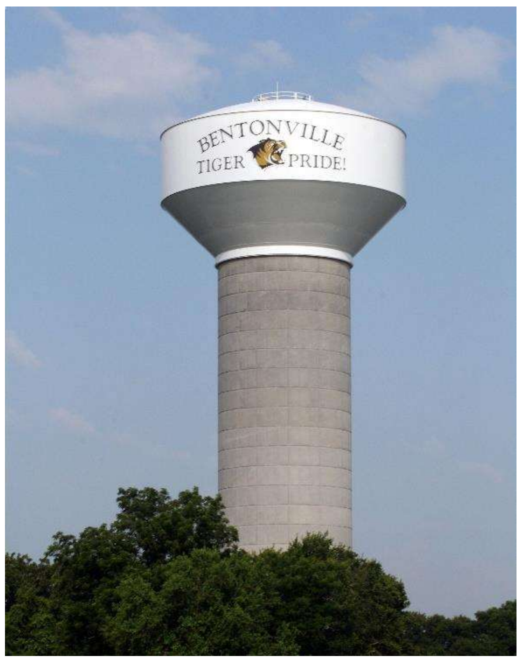


Figure 2-7. Tiger EST

2.6.3 I Street Tanks and Pump Station

The I Street Tank and Pump Station Site is located near the intersection of Southwest I Street and Walton Boulevard. The Site contains two GSTs, one with a capacity of 3 MG and the other 6 MG, as well as a pump station containing four pumps. Table 2-7 contains information on the two GSTs. Figure 2-8 and Figure 2-9 are photos of the 6-MG and 3-MG GSTs, respectively.

Table 2-7: I Street Tanks Features

Description	GST	GST
Capacity	3 MG	6 MG
Year	1982	1995
Diameter (ft)	126	180
Base Elevation (ft)	1,296.5	1,296.5
LWL (ft)	1,296.5	1,296.5
HWL (ft)	1,328.5	1,328.5
Overflow Diameter (in)	20	20

Figure 2-8: 6-MG I Street GST

Figure 2-9: 3-MG I Street GST

The I Street Pump Station was constructed the same year (1982) as the 3-MG GST and initially contained two pumps. In 1998, the Pump Station was expanded to add two additional pumps. The two 3,750-gpm pumps operate on variable frequency drives (VFDs) while the two 800-gpm pumps are constant speed pumps equipped with soft starters. The pumps are configured to withdraw water from the two GSTs and convey water to the rest of the water distribution system. During a site visit to the site, BWU staff indicated that the Moberly Lane RWU Emergency Connection is the best indicator of system pressure and operators monitor and adjust pumping operations from GSTs if needed. Table 2-8 contains the design flow, design head and rated horsepower for the four existing pumps. Section 4.3 presents a more detailed pumping analysis for the I Street Pump Station. Figure 2-10 is a photo of the I Street Pump Station pipe gallery.

Table 2-8: I Street Pump Features

Pump Number	Year of Install	Typical Operating Flow (gpm)	Design Flow[1] (gpm)	Design Head[1] (ft)	Rated Horsepower (hp)
1	1982	-	800	210	75
2	1982	-	800	210	75
3	1998	-	3,750	210	250
4	1998	-	3,750	210	250
Firm Capacity	-	**7,000**	-	-	-
Total Capacity	-	**9,500**	**9,100**	-	-

Notes:
1. Based on pump nameplate information.

Figure 2-10: I Street Pipe Gallery

2.6.4 Downtown EST and Pump Station

The Downtown Site is located northwest of the intersection of the Northwest 2nd Street and Northwest A Street, and it consists of a single 0.5-MG EST and a pump station with a single pump. While the tank is an EST, the HWL is below the operating range of the Tiger EST and the Highway 102 EST. The tank is typically filled using a solenoid control valve, and water is pumped back out of the tank into the distribution system. During a site visit, Garver noted that there does not appear to be a drainage system in place in case of an overflow event. Table 2-9 contains data on the features of the Downtown EST and Figure 2-11 shows a photo of the EST.

Table 2-9: Downtown EST Features

Description	EST
Capacity	0.5 MG
Year	1953
Diameter (ft)	55
Base Elevation (ft)	1,298
LWL (ft)	1,408
HWL (ft)	1,438

Figure 2-11: Downtown EST

The Downtown Pump Station consists of a single pump that pumps water from the EST to the distribution system. There is only one pump in the facility, so there is currently no pump redundancy. Table 2-10 contains the pump data from the Downtown Pump Station, and Figure 2-12 shows a photo of the interior of the Pump Station.

Table 2-10: Downtown Pump Features

Pump Number	Typical Operating Flow (gpm)	Design Flow[1] (gpm)	Design Head[1] (ft)	Rated Horsepower (hp)
1	800	1,100	50	25
Firm Capacity	**0**	**0**	-	-
Total Capacity	**800**	-	-	-
Notes: *1. Based on pump nameplate information.*				

Figure 2-12: Downtown Pump Station

2.7 Normal Operations

BWU staff provided Garver with historic SCADA data to help determine the following typical operating procedures:

- The BWD HSPS operators monitor the Highway 102 EST, Tiger EST, and I Street GSTs when controlling pumps. During peak demand months, the pumps are operating at full capacity for most of the day.
- The BWD HSPS operators typically turn off all but one large pump when I Street pumps turn on.

- The I Street pumps typically turn on around 7 a.m. at around 8,700 gpm, bringing the I Street GSTs to their minimum level by around noon.
- The I Street GST fill control valve opens around 7 p.m. at an approximate fille rate of 4,000 gpm until the I Street pumps turn on around 7 am. The tank levels typically range from 15 to 25 feet.
- The Tiger EST floats on the system. The tank level typically varies based on I Street and BWD pump operations. Tank levels are typically between 30 and 35 feet but drop to around 25 feet during peak demands.
- The Highway 102 EST floats on the system. The tank level typically varies based on I Street and BWD pump operations. Tank levels are typically between 25 and 30 feet.
- The Downtown EST has tank levels typically ranging from 15 to 28 feet. The pump typically turns on around 7 a.m. and off around noon. The tank is usually filled from 1 to 3 a.m.

3.0 Model Development

Garver evaluated the water distribution system using Bentley's WaterGEMS hydraulic modeling software. Garver created a new hydraulic model based on GIS shapefiles for pipes and facilities provided by BWU. Information from previous modeling efforts completed by others during the 2018 WMP was also used during the model development process. Elevations throughout the model were assigned using the 1/3 arc-second digital elevation models published by the United States Geological Survey. The following sections describe the development of the hydraulic model.

3.1 Model Pipes

Pipe diameter and material were imported to the model pipes based on the pipe GIS shapefile. Pipe lengths were calculated by the modeling software. A Hazen-Williams C factor (C) of C=120 was initially assigned to all pipes, which is consistent with the calibrated C values for nearly all pipes in the 2018 WMP hydraulic model.

3.2 Model Supply and Pumping

The hydraulic model includes the BWD HSPS, I Street, and Downtown Pump Stations. Manufacturer pump curves provided by BWU were digitized and assigned to the corresponding pumps in the model. The BWD HSPS pumps are typically controlled manually by the BWD operators based on a combination of I Street Pump Station operations, EST levels, and system demands throughout the day. The BWD HSPS controls were included in the model as time-based controls that adjust flow hourly as needed to meet system demands and maintain an adequate water level in ESTs in the system. For average day demands, the BWD HSPS flow rates were reduced during I Street Pump Station operations to match general trends observed in historical SCADA data. The controls for the I Street and Downtown Pump Stations were based on time-based setpoints provided by BWU and general trends observed in historical SCADA data.

3.3 Model Storage

The hydraulic model includes the distribution system storage tanks. The base elevation, overflow elevation, and diameter of each tank were assigned to each tank based on record drawings provided by

BWU. The BWD clearwell was modeled as a reservoir with a constant HGL matching the HGL from the 2018 WMP.

3.4 Model Demands

Historical and projected water demands were presented in the Growth Projection TM. The distribution system was evaluated using 2023 projected demands for this existing system assessment. These demands represent potential average and maximum day demands for the system based on recent population growth. The demands also include increasing demands from the new Walmart Home Office as described in the Growth Projection TM.

3.4.1 Spatial Distribution of Demand

The spatial distribution of demand was completed by dividing BWU system demands into three major components as listed below. The list below also provides information on how demands for each category were developed. All meter locations were based on GIS information provided by BWU.

- Non-revenue water: It was assumed that the non-revenue water in the system accounted for 40% of the system's total production, excluding Walmart Home Office and David Glass Technology Center (DGTC) demands. This is consistent with non-revenue water trends observed in the Growth Projection TM. NRW was assigned spatially by uniformly distributing demands across customer billing locations from GIS that had monthly billing consumption in 2022.
- Large customer and wholesale demands: This category includes demands for meters associated with Bella Vista, Cave Springs, Walmart Home Office, and Walmart DGTC. Bella Vista and Cave Springs demands were assumed to be 16% and 4% of overall system demands excluding Walmart Home Office and DGTC demands, respectively. Both Walmart meter demands were set to the same value for average and maximum day demands based on a combination of planned and billed consumption data.
- Residential/commercial customer demands: This category was assigned demands using billed consumption for each meter and accounted for 40% of the overall system demands, excluding the Walmart Home Office and DGTC demands. Average billed consumption over the last year of billing data provided was used to adjust this category to match projected 2023 average demands for this category, while maximum month consumption from the last year of billing data provided was used to adjust this category to match projected 2023 maximum day demands for this category.

3.4.2 Diurnal Curve Development

Hourly consumption data for approximately 100 customer meters was used to develop diurnal patterns for the BWU system. The Bella Vista and Walmart DGTC meters were assigned pumping patterns to match the typical timing and observed maximum pumping rate associated with the meters. The Bella Vista demand was split between the Bridgewater and Cold Cave meters proportionally based on average usage across the meters. Pumping rates of 1,900 gpm were assigned to the Bridgewater meter and 1,600 gpm to the Cold Cave meter. A pumping rate of 180 gpm was assigned to the Walmart DGTC meter. All other meters were assigned general residential or commercial diurnal patterns developed from aggregation of individual residential and commercial meter consumption. The Cave Springs wholesale meters was assigned the general residential diurnal pattern since no hourly consumption data was provided for its meters. The diurnal and pumping patterns used for the 2023 average day demands are documented in Figure 3-1 and Table 3-1. The overall system diurnal curve is also presented and was observed to be consistent with overall system mass balance from historical SCADA data. The overall system diurnal pattern is generally flatter than any one component of the diurnal curve components because individual peaks are averaged out and real water loss was assumed to be constant.

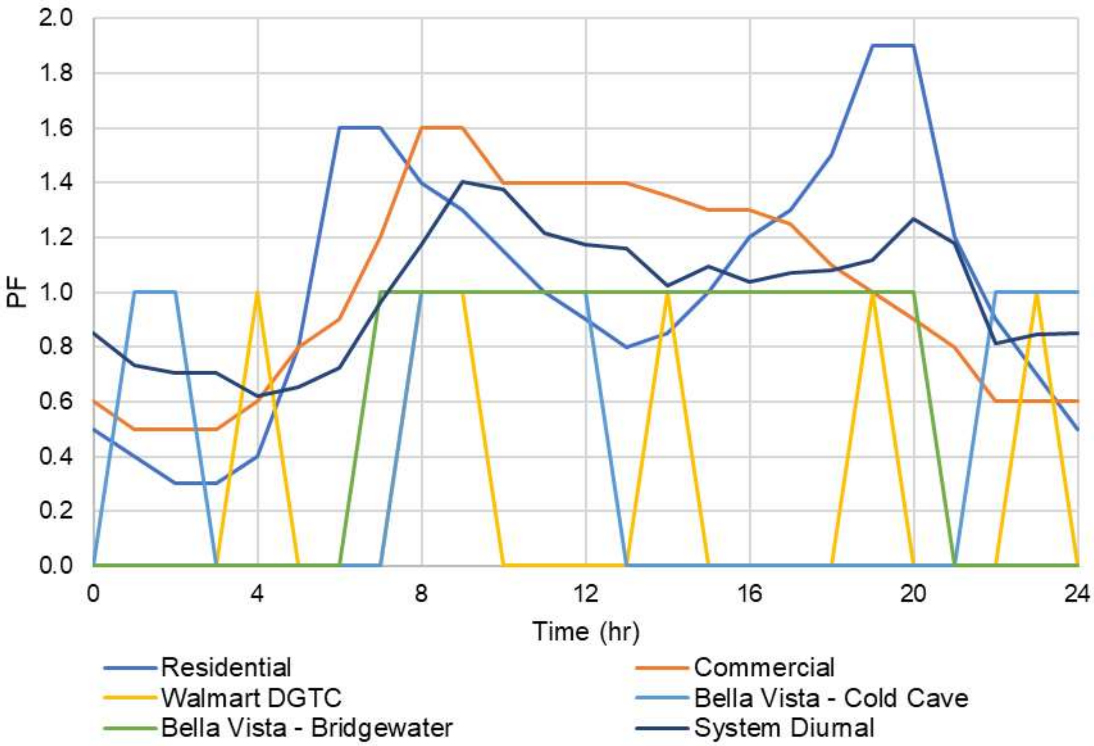


Figure 3-1: 2023 ADD Diurnal Patterns

Table 3-1: 2023 ADD Diurnal Patterns

Time (hr)	Res	Comm	WHO	Walmart DGTC	Bella Vista - Cold Cave	Bella Vista - Bridgewater	System (Model Generated)
0	0.50	0.60	0.40	0.00	0.00	0.00	0.74
1	0.40	0.50	0.60	0.00	1.00	0.00	0.71
2	0.30	0.50	1.00	0.00	1.00	0.00	0.71
3	0.30	0.50	1.90	0.00	0.00	0.00	0.62
4	0.40	0.60	0.80	1.00	0.00	0.00	0.61
5	0.80	0.80	0.80	0.00	0.00	0.00	0.73
6	1.60	0.90	0.90	0.00	0.00	0.00	0.98
7	1.60	1.20	1.10	0.00	0.00	1.00	1.19
8	1.40	1.60	1.70	1.00	1.00	1.00	1.37
9	1.30	1.60	1.70	1.00	1.00	1.00	1.34
10	1.15	1.40	1.20	0.00	1.00	1.00	1.23
11	1.00	1.40	1.20	0.00	1.00	1.00	1.19
12	0.90	1.40	1.40	0.00	1.00	1.00	1.17
13	0.80	1.40	1.90	0.00	0.00	1.00	1.04
14	0.85	1.35	1.90	1.00	0.00	1.00	1.06
15	1.00	1.30	1.40	0.00	0.00	1.00	1.05
16	1.20	1.30	1.00	0.00	0.00	1.00	1.08
17	1.30	1.25	0.80	0.00	0.00	1.00	1.10
18	1.50	1.10	0.80	0.00	0.00	1.00	1.13
19	1.90	1.00	0.60	1.00	0.00	1.00	1.24
20	1.90	0.90	0.40	0.00	0.00	1.00	1.20
21	1.20	0.80	0.40	0.00	0.00	0.00	0.83
22	0.90	0.60	0.40	0.00	1.00	0.00	0.85
23	0.70	0.60	0.40	1.00	1.00	0.00	0.81
24	0.50	0.60	0.40	0.00	0.00	0.00	0.74

3.5 Scenarios

Garver evaluated the existing BWU water distribution system using the scenarios summarized in Table 3-2.

Table 3-2: System Assessment Scenario Summary

Scenario	EPS/SS[1]	Demands	Pump Stations Active	Results Analyzed
Average Day Demand	EPS	Average Day Demands	All	Maximum Pressure, Maximum Water Age, Maximum Source Trace
Maximum Day Demand	EPS	Maximum Day Demands	All	Minimum Pressure, Maximum Pipe Velocity, Maximum Head Loss Gradient
Fire Flow	SS	Maximum Day Demands	Firm Capacity at BWD HSPS (Tank levels set to lowest level from MDD EPS, which is half full)	Available Fire Flow
Notes: 1. EPS = Extended Period Simulation. SS = Steady State				

3.6 Hydraulic Field Data Collection

3.6.1 Continuous Pressure Monitoring

Garver used a total of eight (8) pressure loggers to monitor pressures throughout the distribution system as a tool to aid in model calibration. Garver conducted two rounds of continuous pressure monitoring, the first of which was used to collect pressure data within the distribution system from September 1, 2022 to September 8, 2022. For the second round, the pressure monitors were installed along the 48-inch transmission main to obtain data on head loss and capture any transient activity from September 20, 2022 to September 30, 2022. The data collected was used to identify typical operating pressures and to calibrate the model. The locations of these pressure loggers are shown in Figure 3-2.

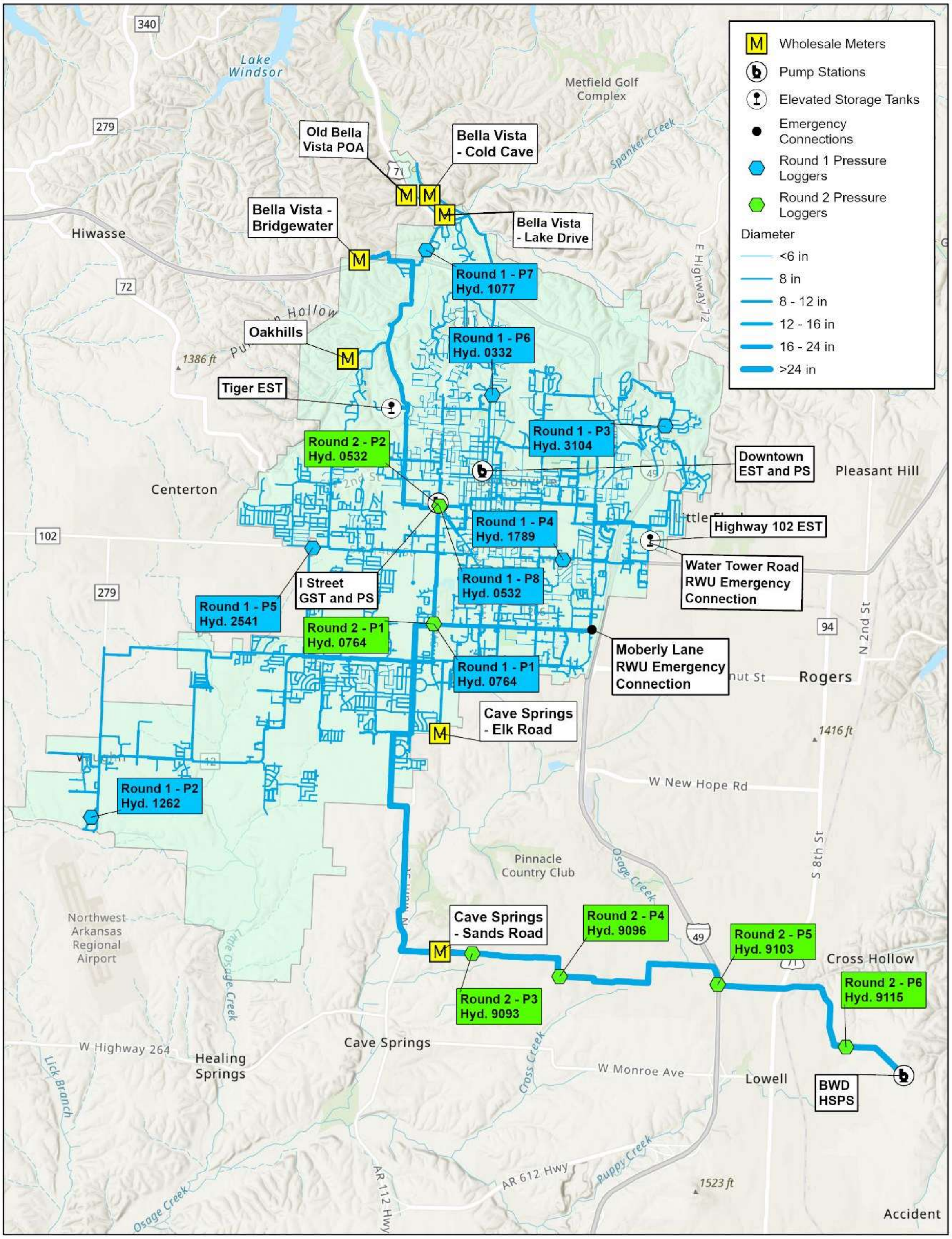


Figure 3-2. Continuous Pressure Loggers Locations

3.6.2 Flow Tests

In addition to continuous pressure logging, Garver also conducted a series of 11 flow tests to record how the system pressures respond to high flows. These tests were conducted in September of 2022 to capture responses during higher demands in the system. For each flow test, one hydrant was opened (flow hydrant) and allowed to flow while the pressure was measured at a nearby hydrant (residual test hydrant). The pressures during the flow tests were also recorded by the pressure loggers described in Section 3.6.1. These tests measured localized distribution system responses to various demands, which were used to help determine the Hazen-Williams pipe roughness coefficient as described in Section 3.8. Figure 3-3 illustrates the locations of the 11 flow tests performed. Table 3-3 contains the data collected during the flow tests.

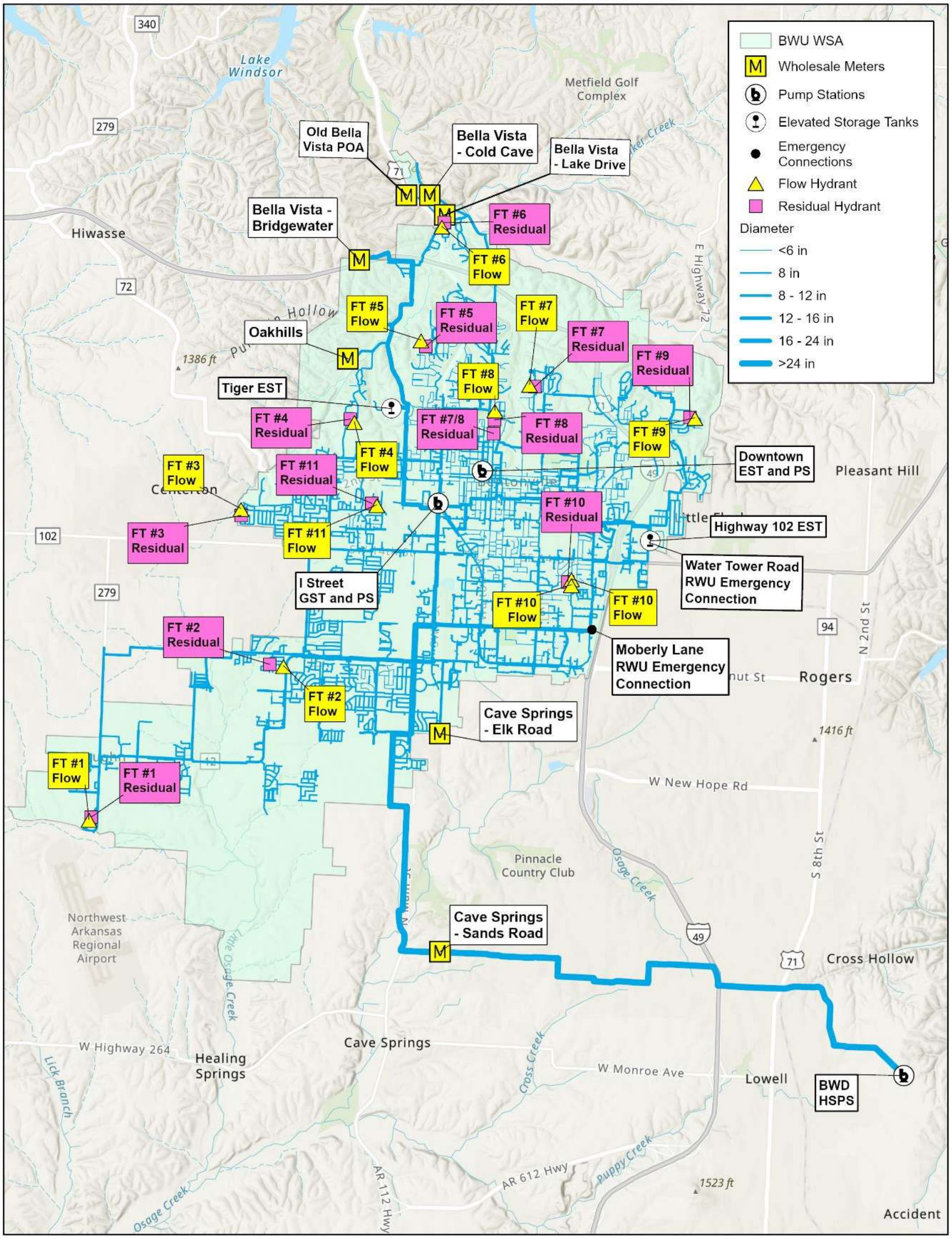


Figure 3-3. Flow Testing Locations

Table 3-3: Flow Test Locations

	Flow Hydrant				Residual Hydrant			
Flow Test	**Description**	**Flow Hydrant ID**	**Elevation (ft)**	**Flow (gpm)**	**Residual Hydrant ID**	**Elevation (ft)**	**Static (psi)**	**Residual (psi)**
1A	Half flow	H-1257	1,266	602	H-1262	1,273	84	75
1B	Full flow			1,226				67
2	-	H-2941	1,240	1,347	H-1662	1,220	107	93
3	-	H-1923	1,233	1,452	H-1922	1,243	98	83
4	-	H-2623	1,253	1,395	H-2624	1,246	97	83
5	-	H-1153	1,240	1,212	H-430	1,260	84	56
6	-	H-2027	1,040	1,999	H-2548	1,033	178	161
7-R1	Residual 1	H-1370	1,253	1,260	H-1369	1,253	91	76
7-R2	Residual 2				H-9320	1,260	85	82
8-R1	Residual 1	H-328	1,250	1,223	H-109	1,273	81	74
8-R2	Residual 2				H-9320	1,260	86	82
9	-	H-1568	1,260	1,385	H-1569	1,253	96	86
10A	H-2723: open; H-958: closed	H-2723, H-958	1,292 (H-2723 and H-958)	1,323 (H-2723)	H-1785	1,289	75	70
10B	H-2723: open; H-958: open			1,240 (H-2723) and 1,163 (H-958)				62
10C	H-2723: closed; H-958: open			1,278 (H-958)				69
11	-	H-1142	1,250	1,426	H-1144	1,243	99	87

3.7 Pressure Monitoring Validation

The first step of the field testing included conducting two rounds of continuous pressure logging throughout the distribution system. Garver used this data to determine how pressures typically varied throughout the day and to assist in determining static pressures in the hydraulic model. Garver used eight pressure loggers and deployed them throughout the distribution system from September 1, 2022 to September 8, 2022. The locations of the pressure loggers are illustrated in Figure 3-2.

After completing the first round of pressure logging, Garver conducted a second round of pressure logging using six pressure loggers installed along the length of the 48-inch transmission main with the intent of determining head loss along the main while also detecting any transient activity. These loggers were deployed from September 20, 2022 to September 30, 2022. The locations of these loggers can be seen in Figure 3-2.

Figure 3-5 and Figure 3-6 summarize the range of field data readings collected during both rounds of pressure logging. Pressure data from pressure loggers and ground elevations at the pressure logger locations were used to create the hydraulic grade line (HGL) values presented. HGLs provide a metric to track the overall system hydraulics. Field readings are presented in a box and whisker diagram format to provide a graphical representation of descriptive statistics such as the minimum, maximum, mean, median, interquartile range, and outliers of a data set. Figure 3-4 shows an example box and whisker plot.

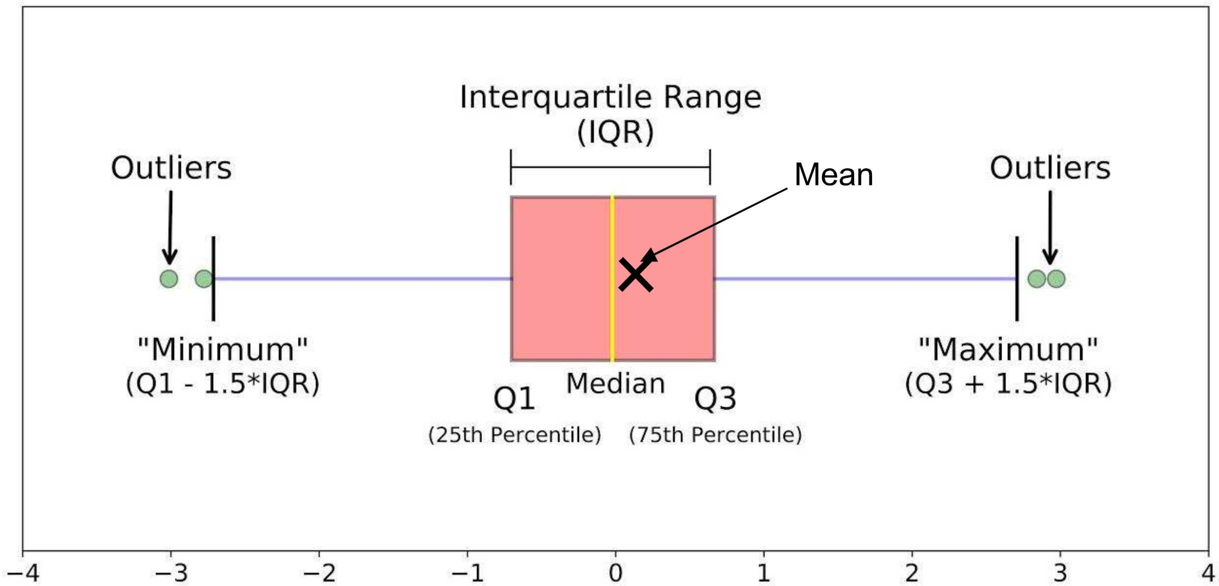
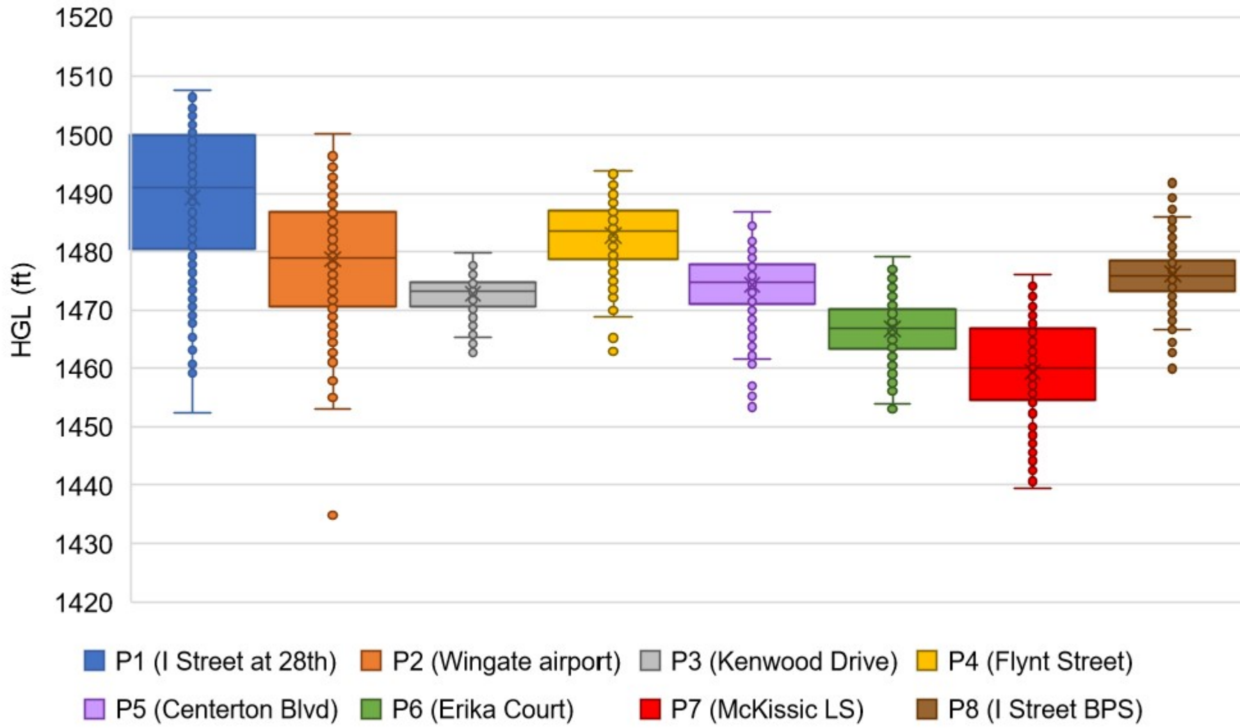


Figure 3-4: Example Box and Whisker Plot



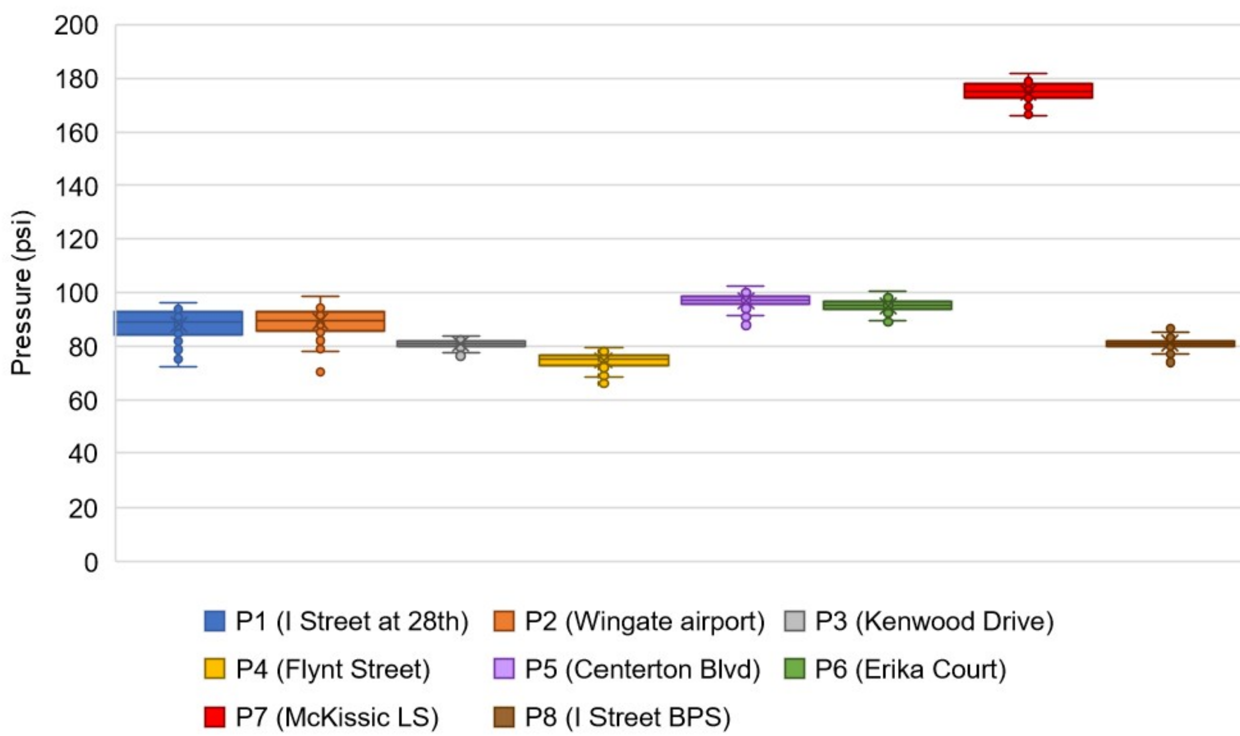


Figure 3-5: Pressure Logger Round 1 HGL (top) and Pressure (bottom) Field Data

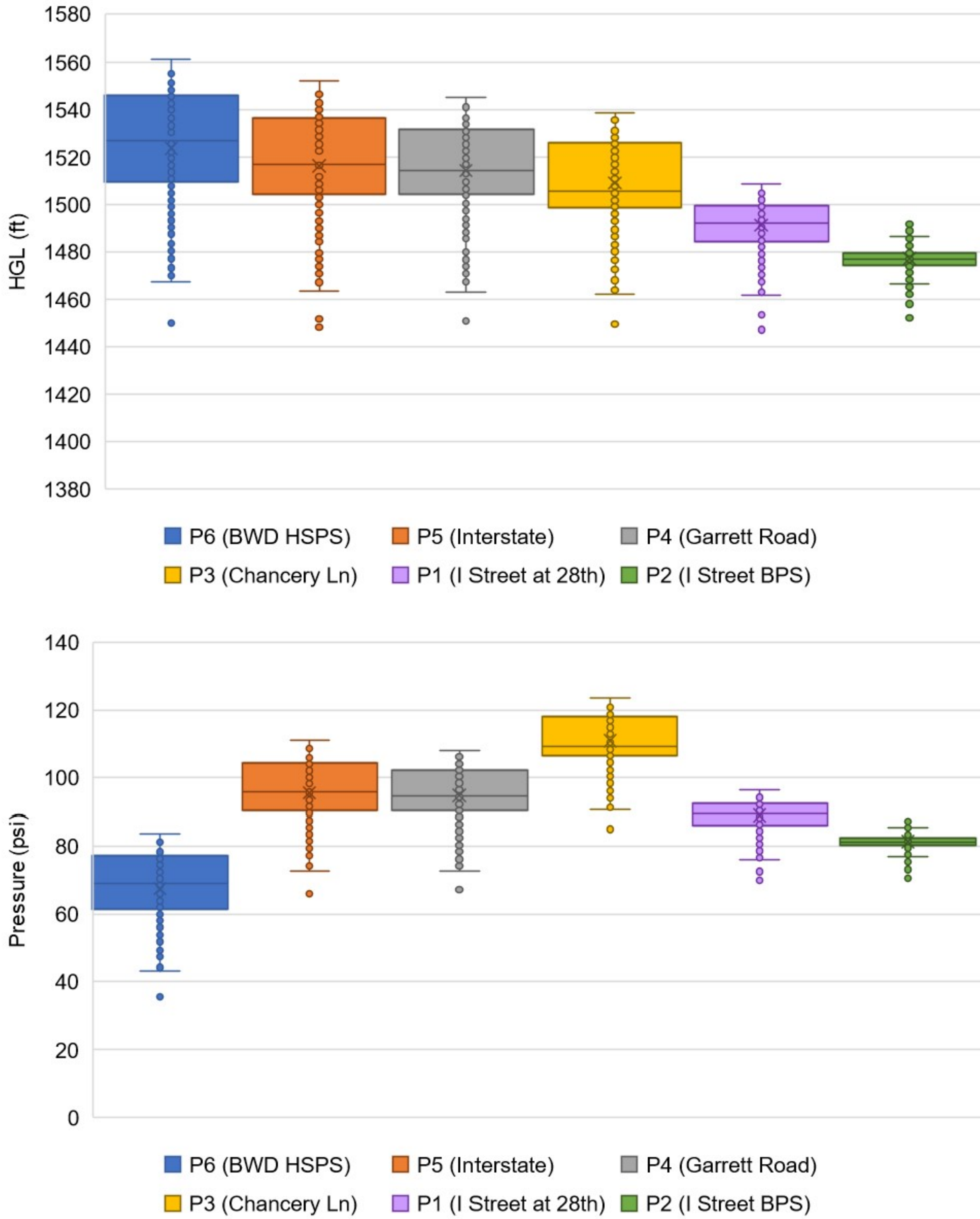


Figure 3-6: Pressure Logger Round 2 HGL (top) and Pressure (bottom) Field Data

3.8 Flow Test Validation and Calibration

Garver compared the pressure logger data from the continuous monitoring period and SCADA readings to model results at the locations to validate the model under typical operating conditions. Figure 3-7 through Figure 3-9 show the comparison of field data recorded during both rounds of pressure logging to model results. As shown in the figures, the model is experiencing the same general overall range of HGLs measured in the field during the two rounds of pressure logging conducted. Where there are significant differences between the model HGL and the range of HGLs recorded in the field, these differences are typically in areas that are the most impacted by BWD pump operations. The model controls are set to replicate typical daily pumping operations based on clock time and represent the full range of actual manual operations.

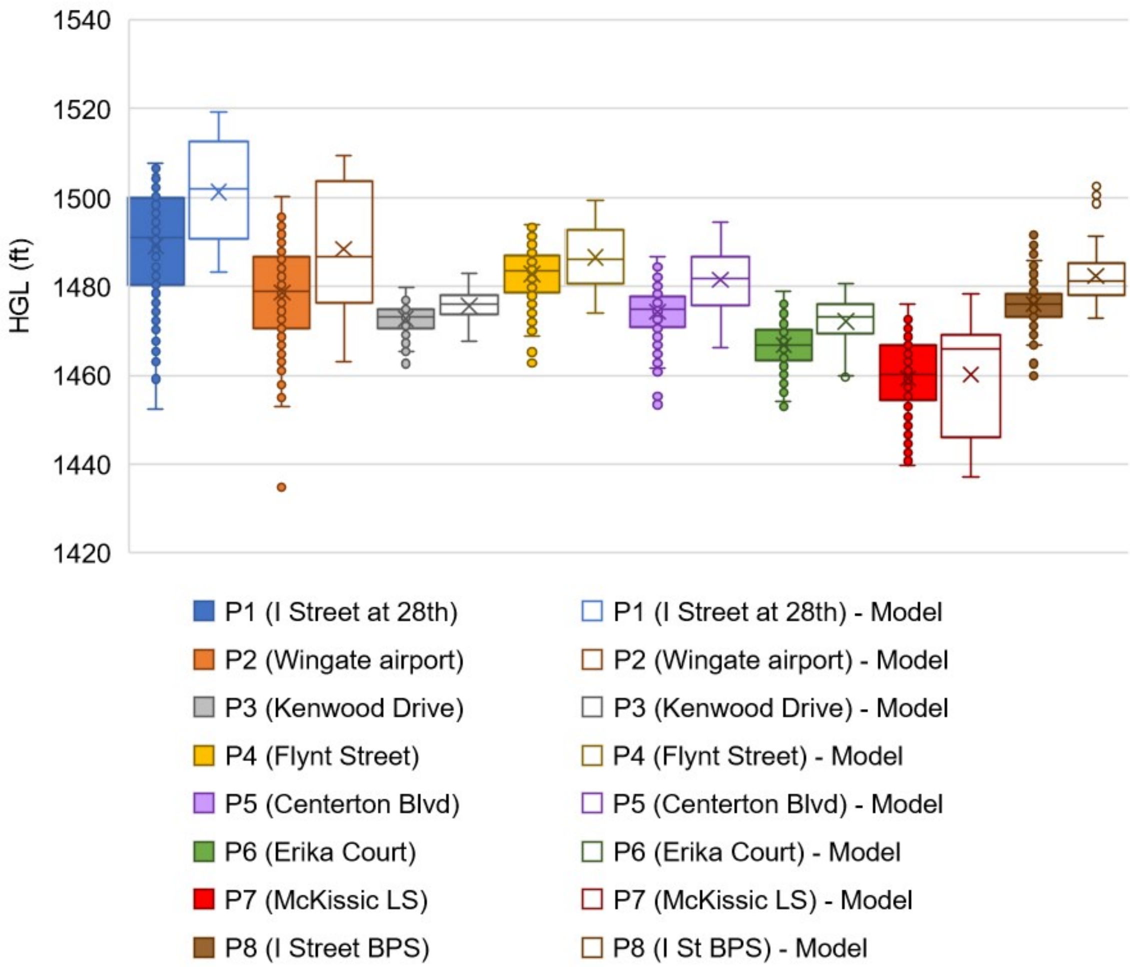


Figure 3-7: Pressure Logger Round 1 Comparison to Model Results

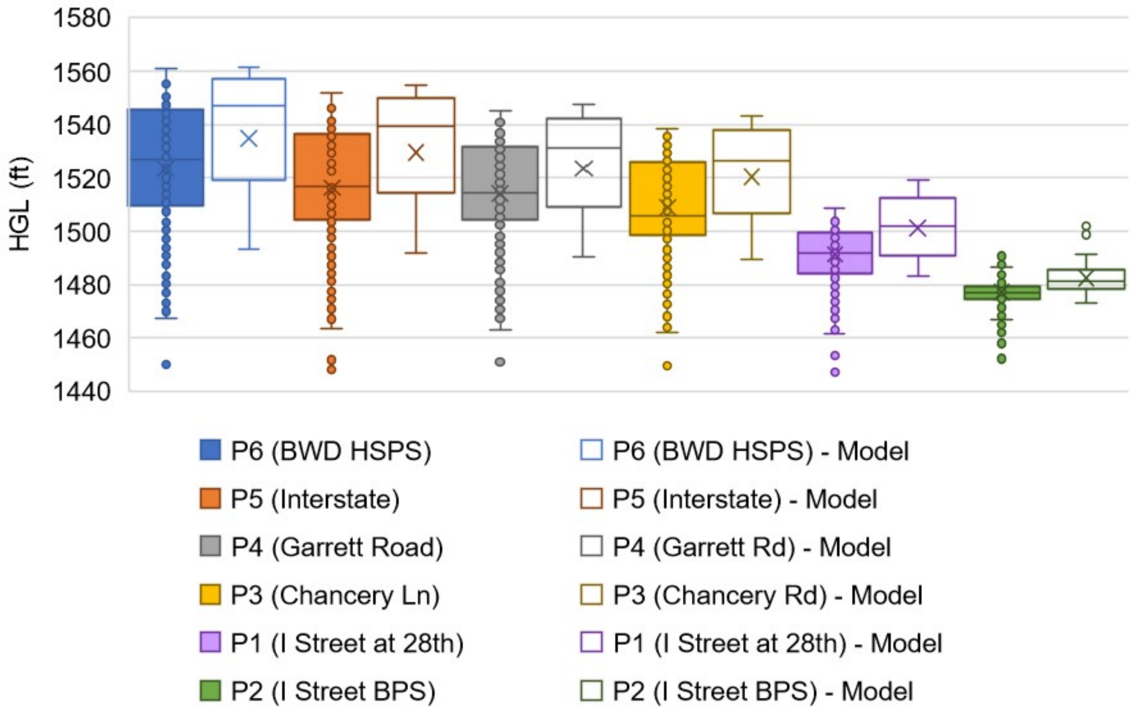


Figure 3-8: Pressure Logger Round 2 Comparison to Model Results

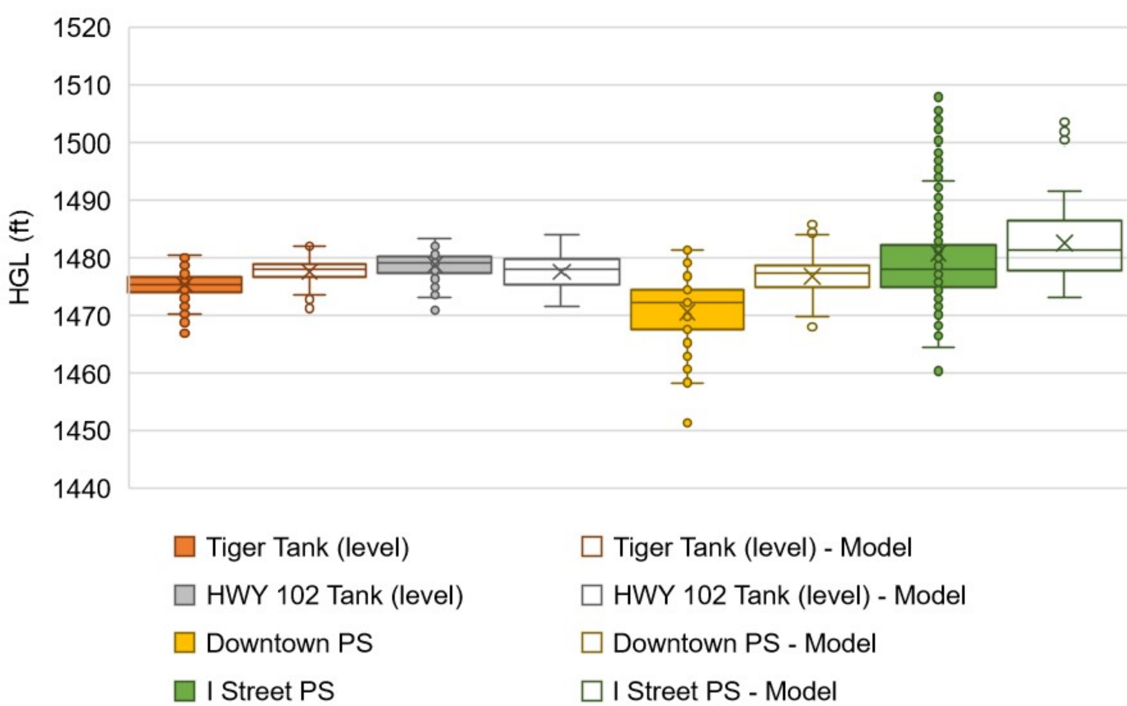


Figure 3-9: Pressure Logging Rounds 1 & 2 BWU SCADA Reading Comparison to Model Results

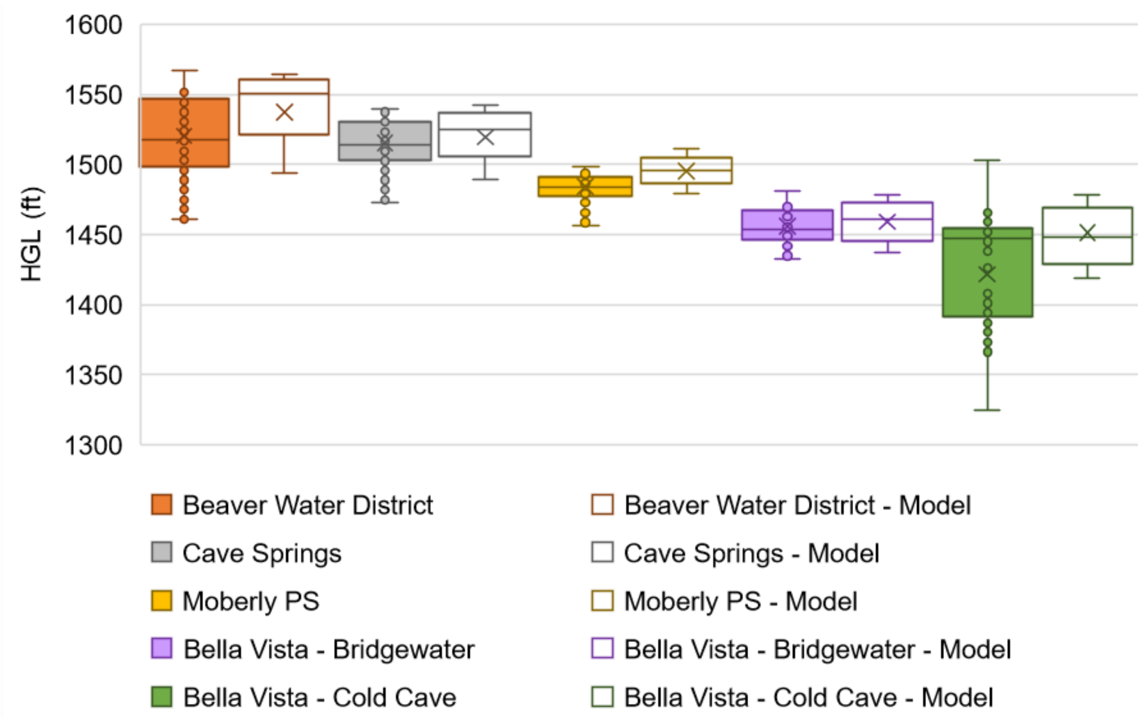


Figure 3-10: Pressure Logging Rounds 1 & 2 BWD/Wholesale SCADA Reading Comparison to Model Results

Garver also compared the pressure logger data and pressure gauge measurements taken during the flow tests to model results under the same conditions. A static (no hydrant flow) pressure scenario was created for each flow test to model the conditions prior to each test. A flow test scenario was also created for each test to include the hydrant flow as a point demand in the model. Model pressures were obtained for each static pressure and flow test scenario at the model junctions corresponding to the hydrants used for pressure measurements (test hydrants).

Figure 3-11 and Figure 3-12 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. The data point labels include the flow test number followed by lettering (A, B, etc.) for different flow rates at the location and a dash with residual numbering (R1, R2, etc.) for flow test locations with multiple residual locations. Perfect agreement between the field measurements and model results is represented by points that fall directly on top of the thick black 1:1 line in the figures. A range of ± 5 psi is shown within the gray dashed lines on Figure 3-11 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% (whichever is greater) of the measured pressure drop is shown within the gray dashed lines on Figure 3-12 to account for the anticipated level of precision for pressure drops.

The results presented in Figure 3-11 and Figure 3-12 are following corrections of GIS pipe connectivity issues and adjustments of C factors from the default value of C=120 to C=130 for all pipes. Even though the model performed best with C factors of C=130, system assessments using the hydraulic model were conducted using C factors of C=120 to be more conservative and consistent with 2018 WMP modeling efforts.

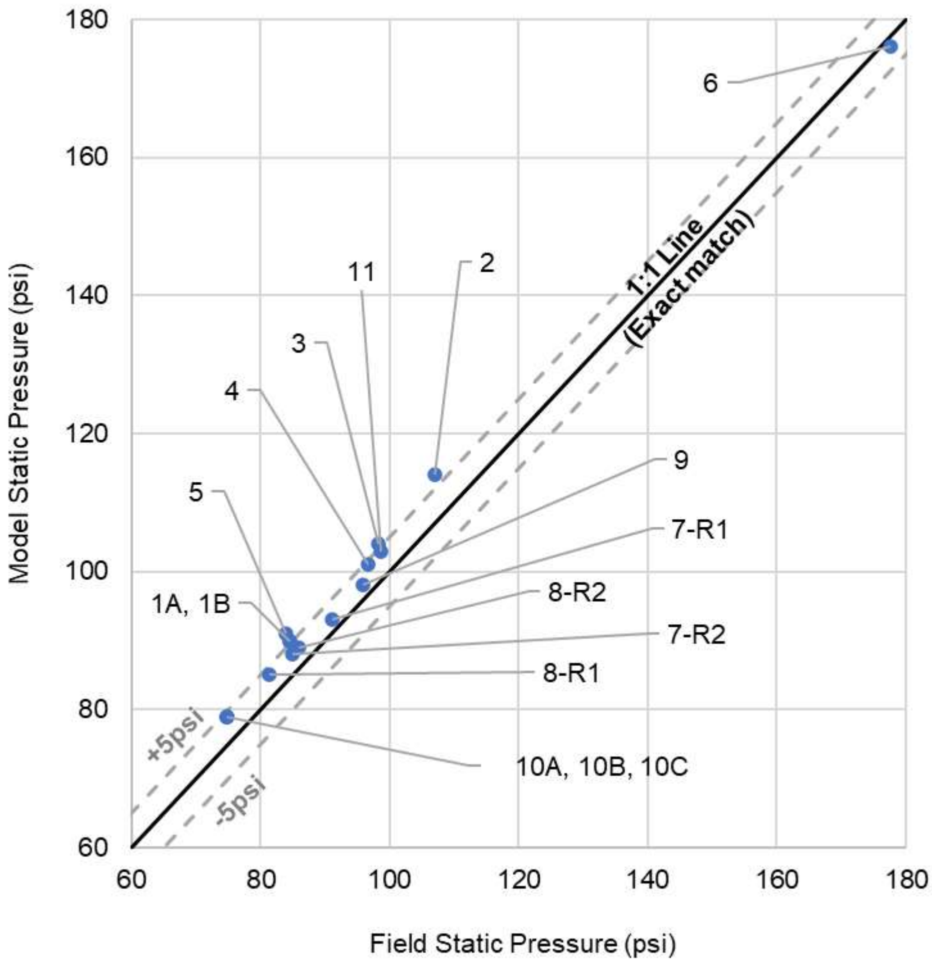


Figure 3-11: Flow Test Static Pressure Comparison with Model Results

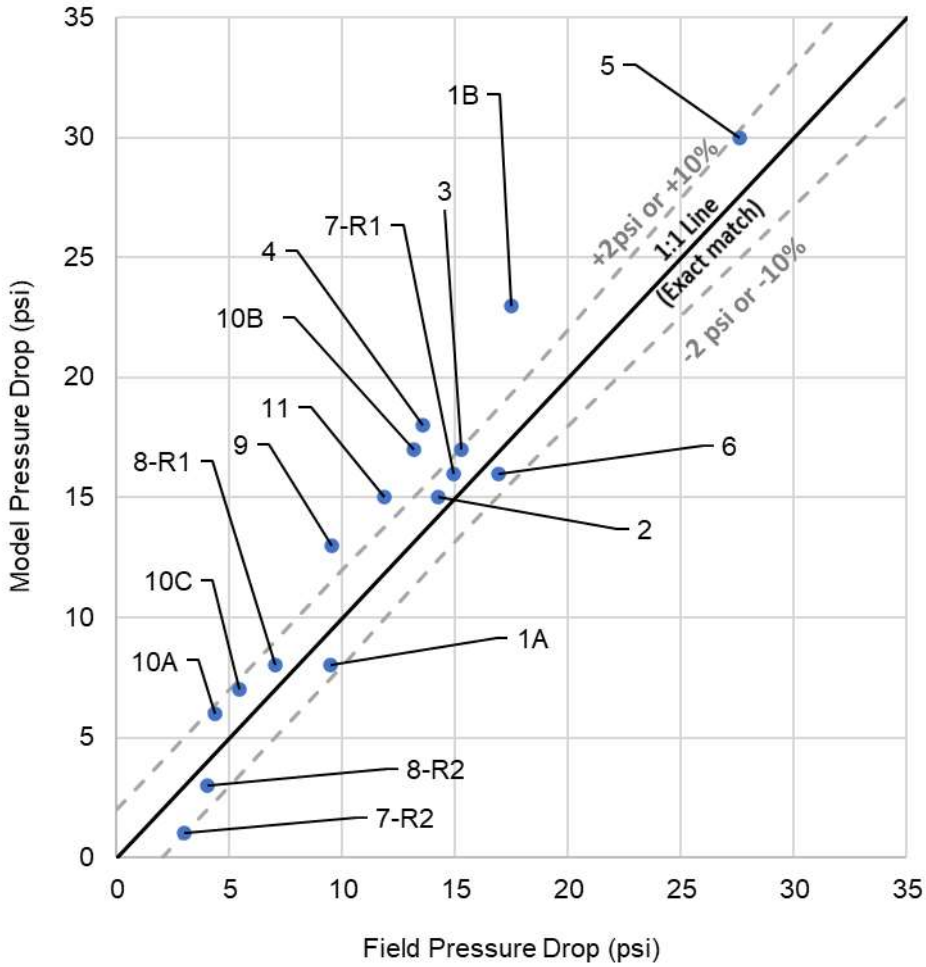


Figure 3-12: Flow Test Pressure Drop Comparison with Model Results

4.0 Existing System Assessment

The evaluation criteria for the existing system assessment were presented in the Growth Projections TM. The following sections describe the assessments for each component of the BWU distribution system.

4.1 Supply

BWD supplies water to BWU via an HSPS owned and operated by BWD. BWD completed a Water Master Plan in October 2023 in which the existing and planned supply capacity to BWU was documented. In this plan, BWD presented an existing firm capacity of 23 MGD as of 2023, which is consistent with current hydraulic model results. Based on hydraulic model results, the total BWD HSPS existing capacity is approximately 26.5 MGD. The highest historical maximum day demand to date was approximately 24 MGD, which exceed the existing firm capacity of the HSPS. However, BWD has ordered an additional 6,600 gpm pump to add to the existing HSPS. This pump is anticipated to be installed before summer in 2024. Table 4-1 summarizes the comparison of BWU firm capacity anticipated for 2024 to total maximum day demands from the Growth Projection TM.

Table 4-1: Existing Supply Assessment

Year	Maximum Day Demand (MGD)	BWD HSPS Firm Capacity[1] (MGD)	Firm Capacity Surplus/Deficit (MGD)
2023	25	27	+2
Notes: *1. Expanded firm capacity for 2024 presented in the BWD 2023 Water Master Plan.*			

4.2 Storage

The Arkansas Department of Health (ADH) requires sufficient useable storage with consideration given to average day demand, peak hourly demand, power outages, and fire flows, if applicable. Garver compared the BWU water storage capacity to the evaluation criteria of a volume equal to 1 day at average day retail demands, which is adequate for most similar systems and consistent with 10 States Standards. The total storage volume of the system (12.5 MG) was used for this analysis. Table 4-2 summarizes the comparison of BWU system storage to projected average day retail demands from the Growth Projection TM. Comparing average day demand projections to existing total storage, the BWU system has a current deficit of approximately 0.4 MG. This deficit may increase significantly when the new Walmart Home Office is completed as described in the Growth Projection TM.

Table 4-2: Existing Storage Assessment

Year	Average Day Retail Demand (MGD)	Storage Capacity (MG)	Storage Surplus/Deficit (MG)
2022	12.9	12.5	-0.4

4.3 Pumping

Figure 4-1 illustrates the pumping analysis conducted for the I Street Pump Station. The pump curves for the small (14.31-inch impeller diameter Fairbanks pumps) and large (17.2-inch impeller diameter ITT A-C pumps) pumps were compared to the historical SCADA data received for the pump station and the existing system model results from the calibrated hydraulic model. The approximate total head (TH) was calculated based on the SCADA data available (GST level and discharge pressure), neglecting minor losses. The following conclusions can be drawn from this analysis:

- Historical SCADA data indicates that the I Street Pump Station generally operates with a TH ranging from 150 ft to 200 ft, neglecting minor losses.
- The historical SCADA and model results are generally within the preferred operating region (POR) of the larger pumps, but the lower TH values observed are near the high end of the POR of the smaller pumps.
- The shutoff head for the smaller pumps is lower than the shutoff head for the larger pumps, which could lead to operational issues if system TH values were higher. However, historical SCADA and

model results indicates that TH ranges for the system allow for the operation of both pumps during most conditions.

- The TH range of the POR for the larger pumps is wider (150-260 ft) than the smaller pumps (160-220 ft), which could lead to periods where the smaller pumps operate outside the POR when operated with the larger pumps.
- The model results (including minor losses) show a similar range of predicted flow rates compared to historical SCADA data. The higher flow rates predicted by the model can be attributed to higher demand assumptions compared to the historical data.

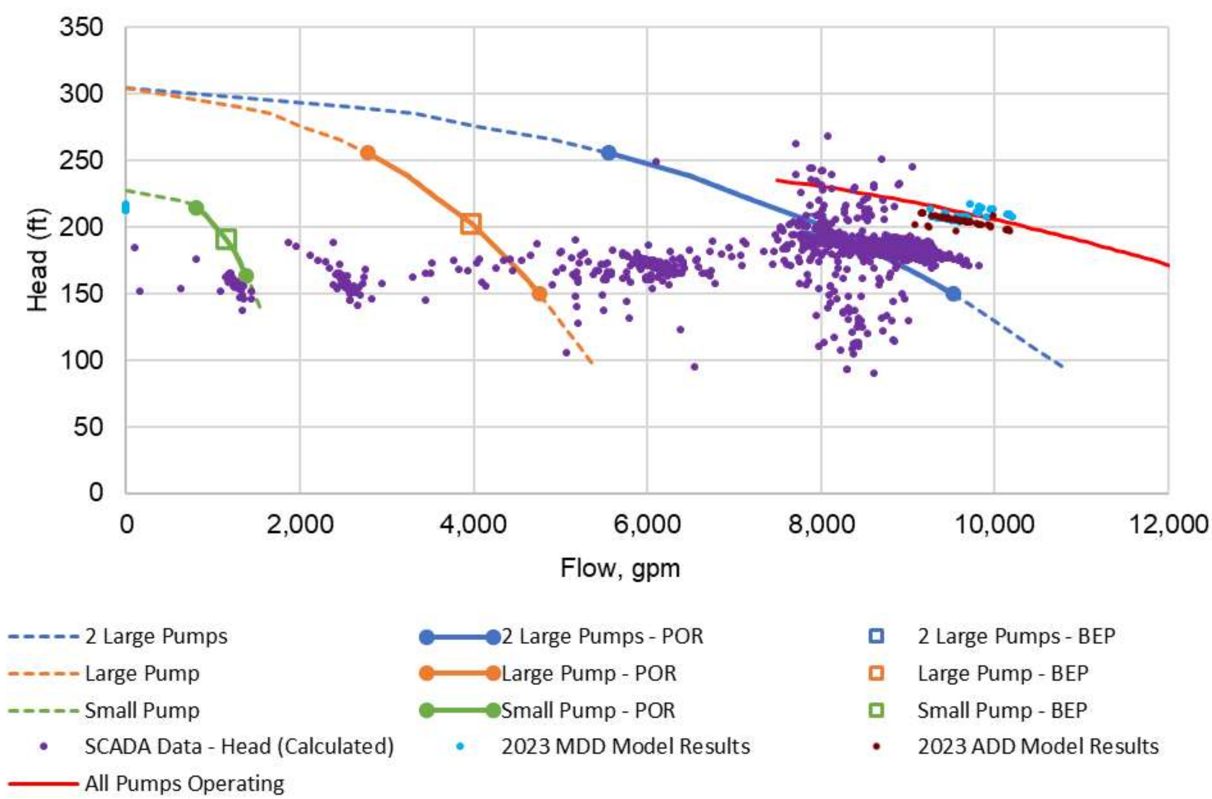


Figure 4-1: I Street Pump Analysis

4.4 Fire Flow

The available fire flow results for the 2023 fire flow scenario are shown in Figure 4-2. The model results show available fire flow throughout most of the distribution system is greater than 1,500 gpm. The following areas experience available fire flow values below 1,500 gpm:

- Neighborhoods west of Walton Boulevard north of Northwest 12th Street.
- Recent development near the intersection of Morning Star Road and Scoggins Road.

The typical fire flow requirement for a system is 1,000 gpm for residential areas per the 2021 IFC while commercial fire flow requirements are site-specific but are typically 1,500 gpm or greater.

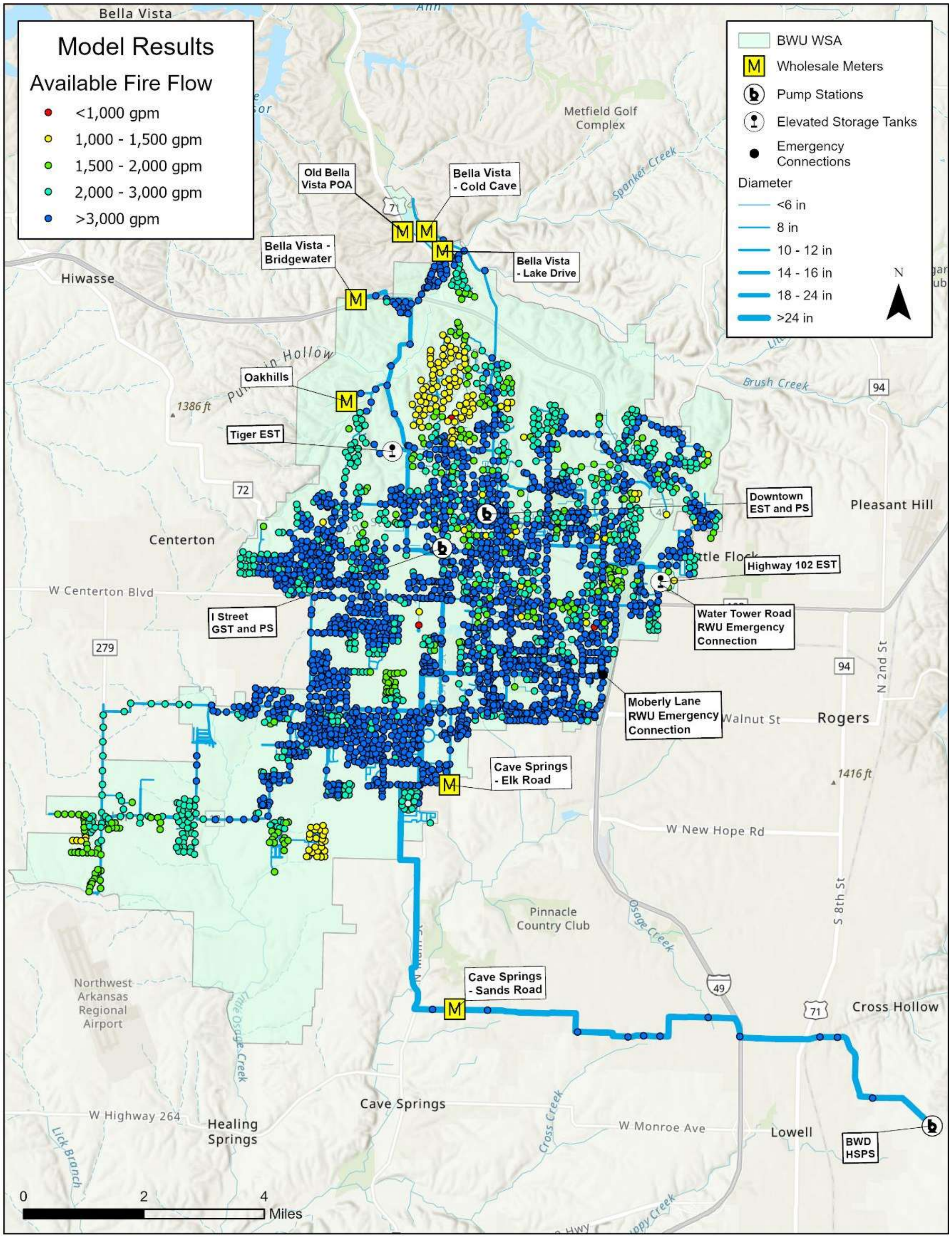


Figure 4-2: 2023 Available Fire Flow Results

4.5 Minimum Pressure

The minimum pressure results for the 2023 MDD scenario are shown in Figure 4-3. The BWU system generally does not experience minimum pressures below 60 psi. However, there are several areas that experience minimum pressures above 120 psi. More discussion of these high-pressure areas is provided in Section 4.6.

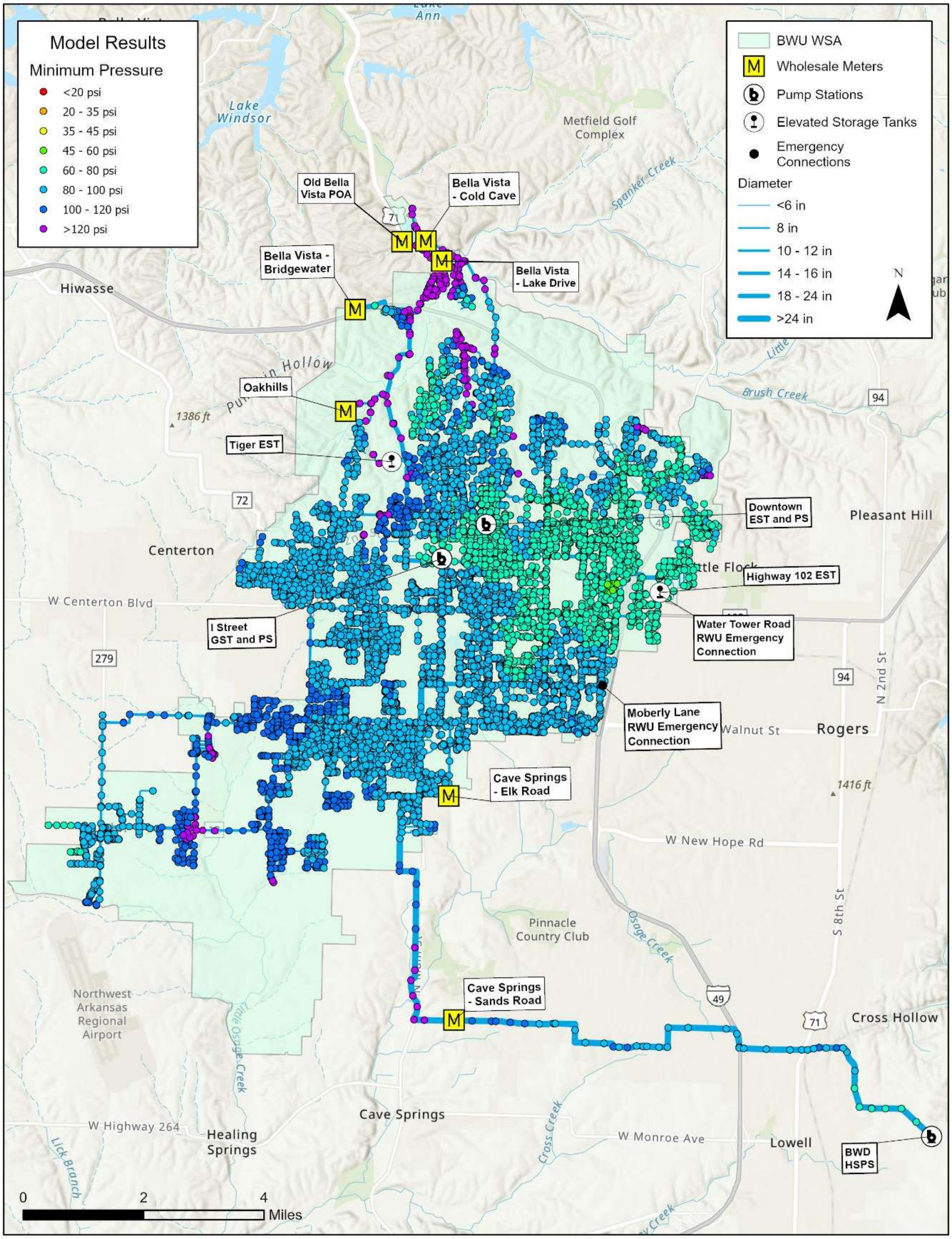


Figure 4-3: 2023 Minimum Pressure Results

4.6 Maximum Pressure

The maximum pressure results for the 2023 ADD scenario are shown in Figure 4-4. A majority of the BWU system experiences maximum pressures ranging from 60 to 100 psi. The following areas experience maximum pressure greater than 120 psi:

- Areas surrounding and just to the north of Interstate 49 near Bella Vista. The model results in this area included maximum pressures up to approximately 198 psi.
- The 48-inch transmission at the Osage Creek crossing. The model results in this area included pressures up to approximately 160 psi.
- Low-elevation areas in the southwest region of the BWU system. The model results in this area included maximum pressures up to approximately 142 psi.

The Osage Creek crossing and southwest area maximum pressures are sensitive to the operations of the BWD HSPS and could be higher than the values presented during higher flow operations at the BWD HSPS.

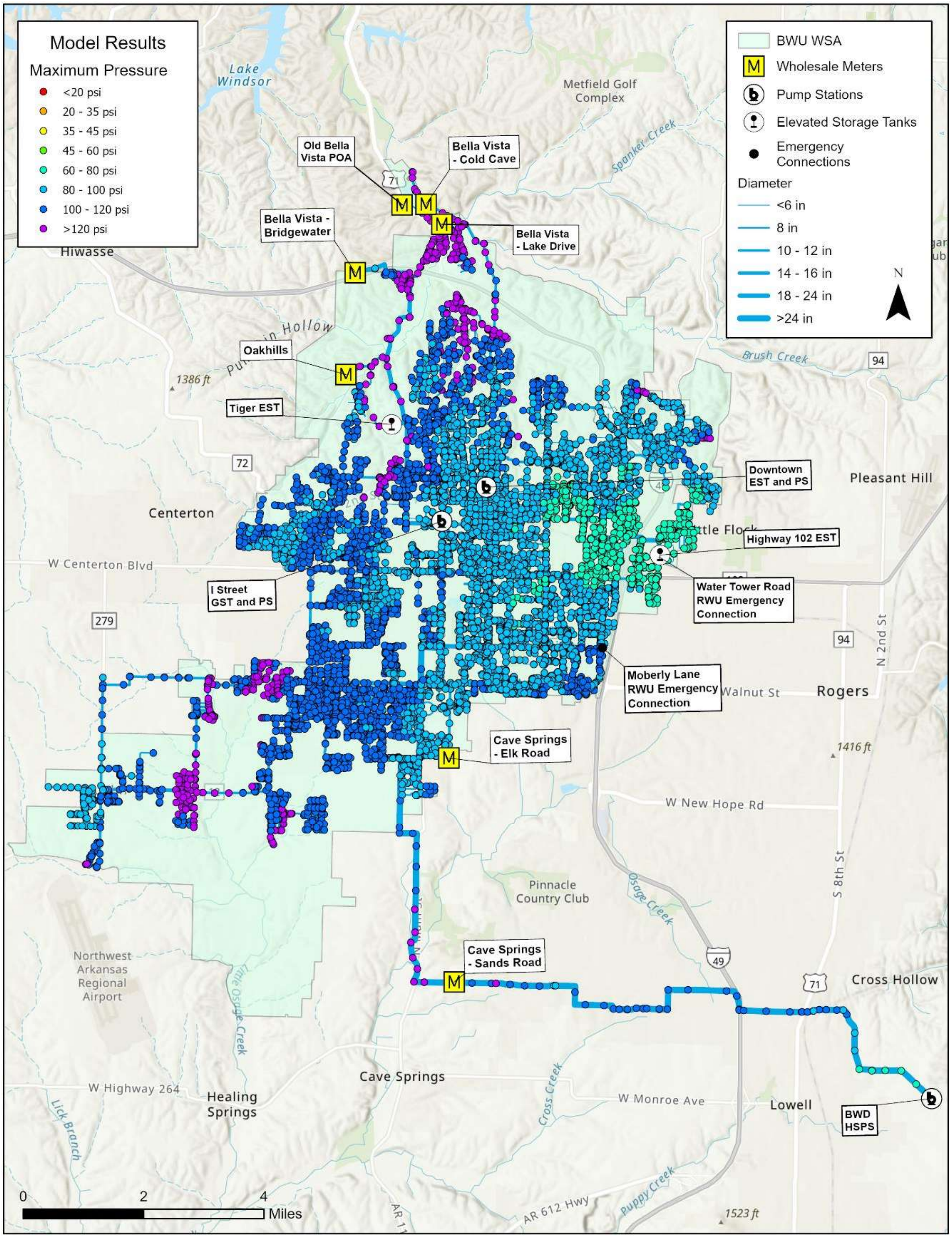


Figure 4-4: 2023 Maximum Pressure Results

4.7 Pressure Variation

The pressure variation results for the 2023 MDD scenario are shown in Figure 4-5. These results show the difference between the maximum and minimum pressure at each location over the course of the day. While pressure variation is not regulated by ADH, excessive changes in pressure can impact water loss and customer satisfaction. The following areas experience the highest pressure variations:

- Areas surrounding and just to the north of Interstate 49 near Bella Vista. The model results in this area show pressure variations of over 20 psi.
- The southwest region of the BWU system. The model results in this area show pressure variations of 15–20 psi.

Pressure variations increase with distance from elevated storage tanks and are caused by head losses between the elevated storage tanks and both pump stations and high-demand areas. Undersized transmission mains increase the magnitude of the head losses and pressure variations resulting from the changes in flow.

The northern area near Bella Vista is impacted by significant wholesale demands. During peak demand periods, the head losses between the elevated storage tanks and the wholesale connections lead to lower pressures at the northern end of the distribution system.

The southwestern area is impacted by BWD HSPS operations. There is no elevated storage tank in this area to stabilize system pressures, so pressures increase during peak pumping periods due to head losses between the BWD HSPS and the BWU tanks.

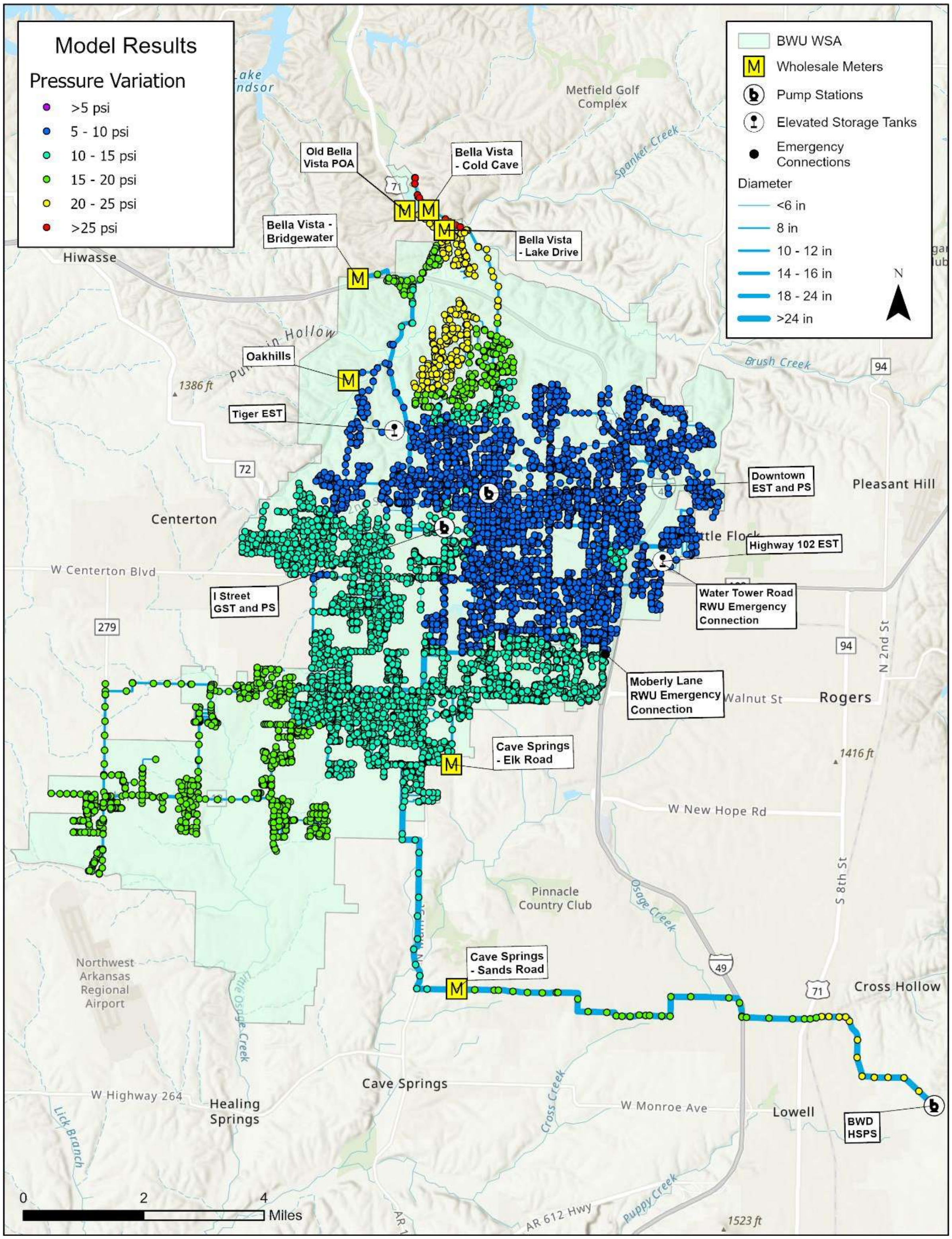


Figure 4-5: 2023 Pressure Variation Results

4.8 Pipe Velocity

The maximum flow velocity results for the 2023 MDD scenario are shown in Figure 4-6. Model results show maximum flow velocities exceed 6 ft/s in the following areas:

- The 24-inch meter vault at the Cave Springs wholesale meter connection at Sands Road.
- The 24-inch transmission main along I Street between 14th Street and the end of the 48-inch transmission line from the BWD HSPS. Model results show this 24-inch transmission main experiences maximum velocities higher than 6 ft/s during I Street PS tank filling operations and generally experiences maximum flow velocities between 3.75 ft/s and 5.50 ft/s during other periods of the 2023 MDD scenario.

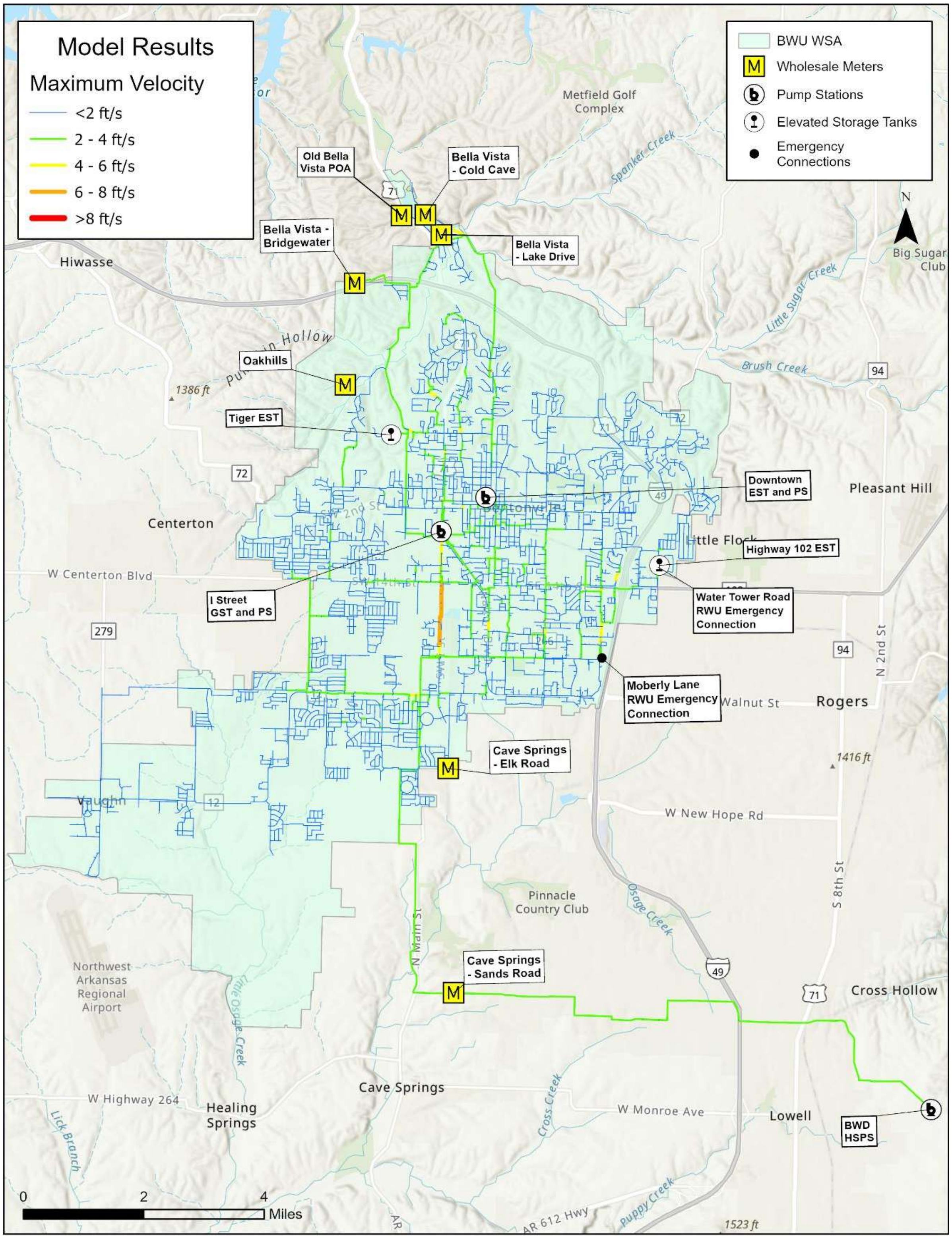


Figure 4-6: 2023 Maximum Velocity Results

4.9 Head Loss Gradient

The maximum head loss gradient results for the 2023 MDD scenario are shown in Figure 4-7. These results can be used to identify pipe segments where additional looping or larger pipe diameters would reduce head losses. Given the generally high pressures in the distribution system, these head losses are generally not impairing system performance overall. Maximum head loss gradients for smaller pipes (diameter < 16 inches) exceed 7 ft/1,000 ft in the following areas:

- Existing 6-inch water line along Northwest Bella Vista Road north of Tiger Boulevard.
- Existing 6-inch water line along Northwest 12th Street west of Northwest K Street.
- Existing 6-inch water line along Ridgefield Street and existing 8-inch water line along Northwest J Street that supply water to neighborhoods west of Walton Boulevard north of Northwest 12th Street.
- Various areas in downtown Bentonville that are just downstream of larger transmission mains.

Maximum head loss gradients for larger pipes (diameter ≥ 16 inches) exceed 3 ft/1,000 ft in the following areas:

- The 24-inch meter vault at the Cave Springs wholesale meter connection at Sands Road.
- The 18-inch transmission line north of Tiger EST that acts as the main supply to the two Bella Vista wholesale meter connections.
- The 24-inch transmission main along I Street between I Street Pump Station and the end of the 48-inch transmission line from the BWD HSPS. This 24-inch transmission main experiences maximum head loss gradients larger than 3 ft/1,000 ft during I Street PS tank filling operations based on model results.
- The 16-inch transmission main west of Main Street to the I Street Pump Station. This 16-inch transmission main experiences maximum head loss gradients larger than 3 ft/1,000 ft during periods when both large pumps at the I Street Pump Station are operating at full speed based on model results.

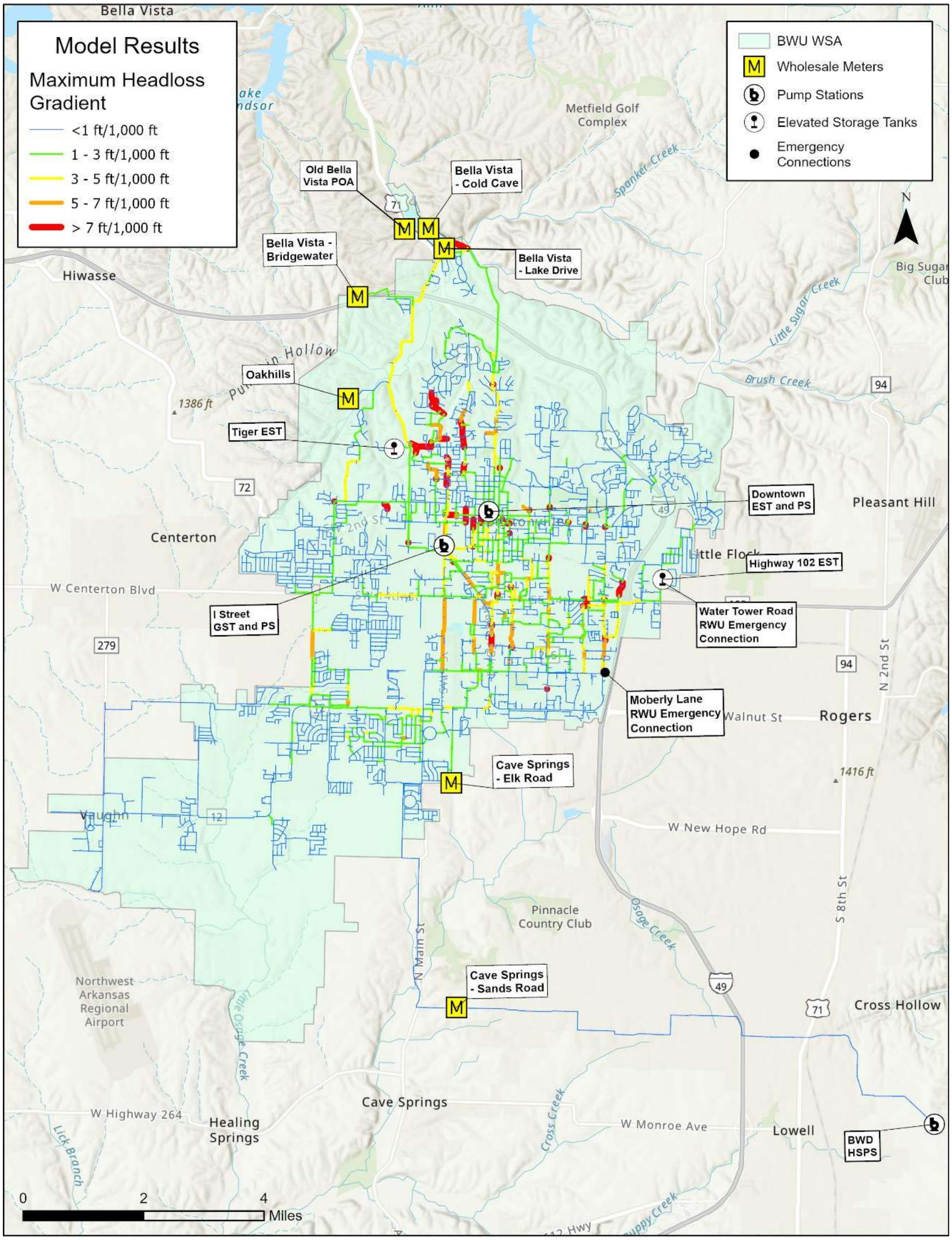


Figure 4-7: 2023 Maximum Head Loss Gradient Results

4.10 Source Trace

Figure 4-8 through Figure 4-11 show the model results for source tracing of each of the storage tanks. The model results show that the southern portion of the system typically receives water directly from the BWD HSPS, with flows from the tanks generally supplying areas to the north during periods of peak demand and/or pump operations of the I Street and Downtown Pump Stations. More specifically, during I Street Pump Station operations, the I Street GSTs supply most of the water for nearly half of the system, including the Tiger and Downtown ESTs. Model results show the other tanks have a smaller zone of influence generally to the north of the tank along large-diameter lines.

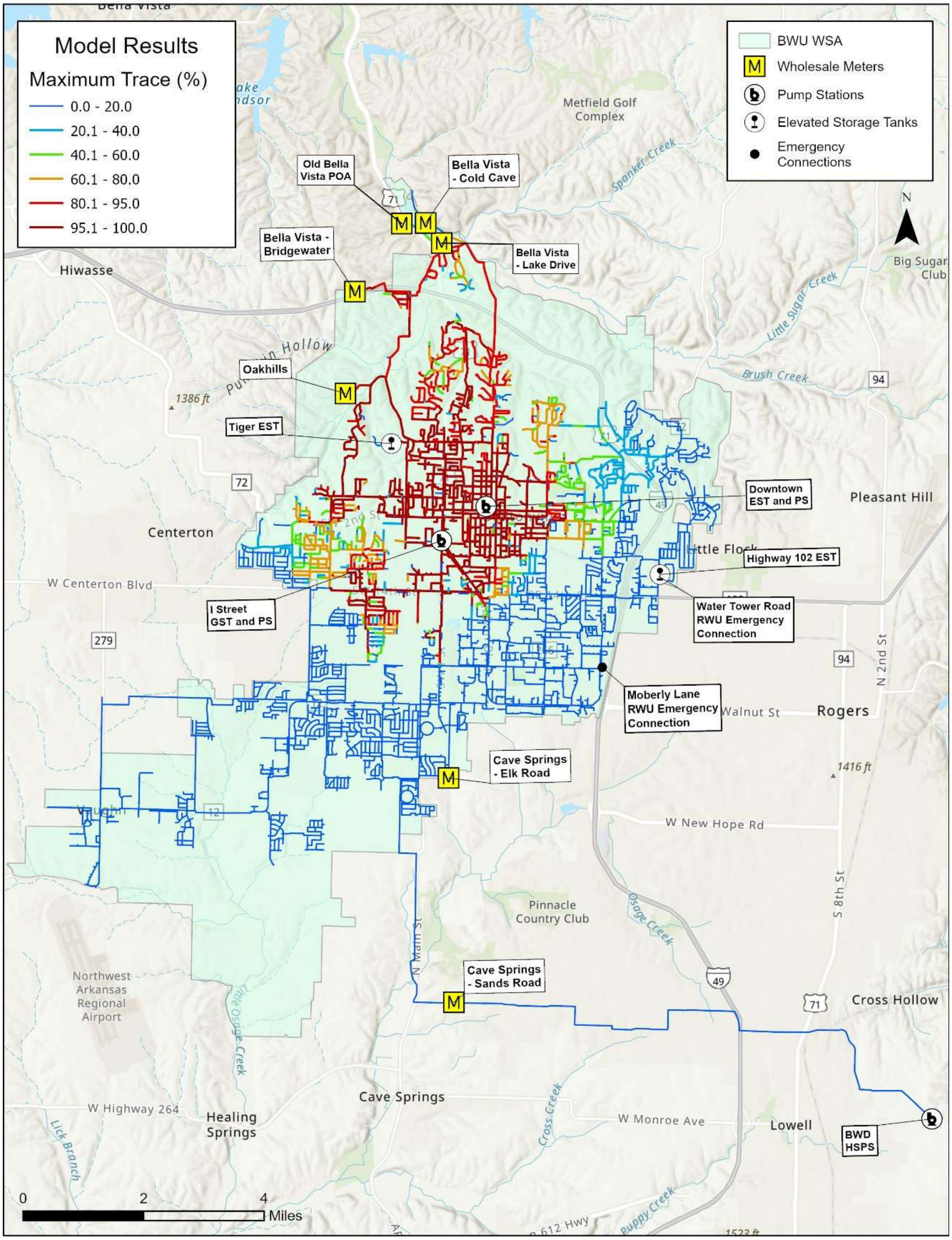


Figure 4-8: 2023 Maximum Source Trace Results for I Street GSTs and PS

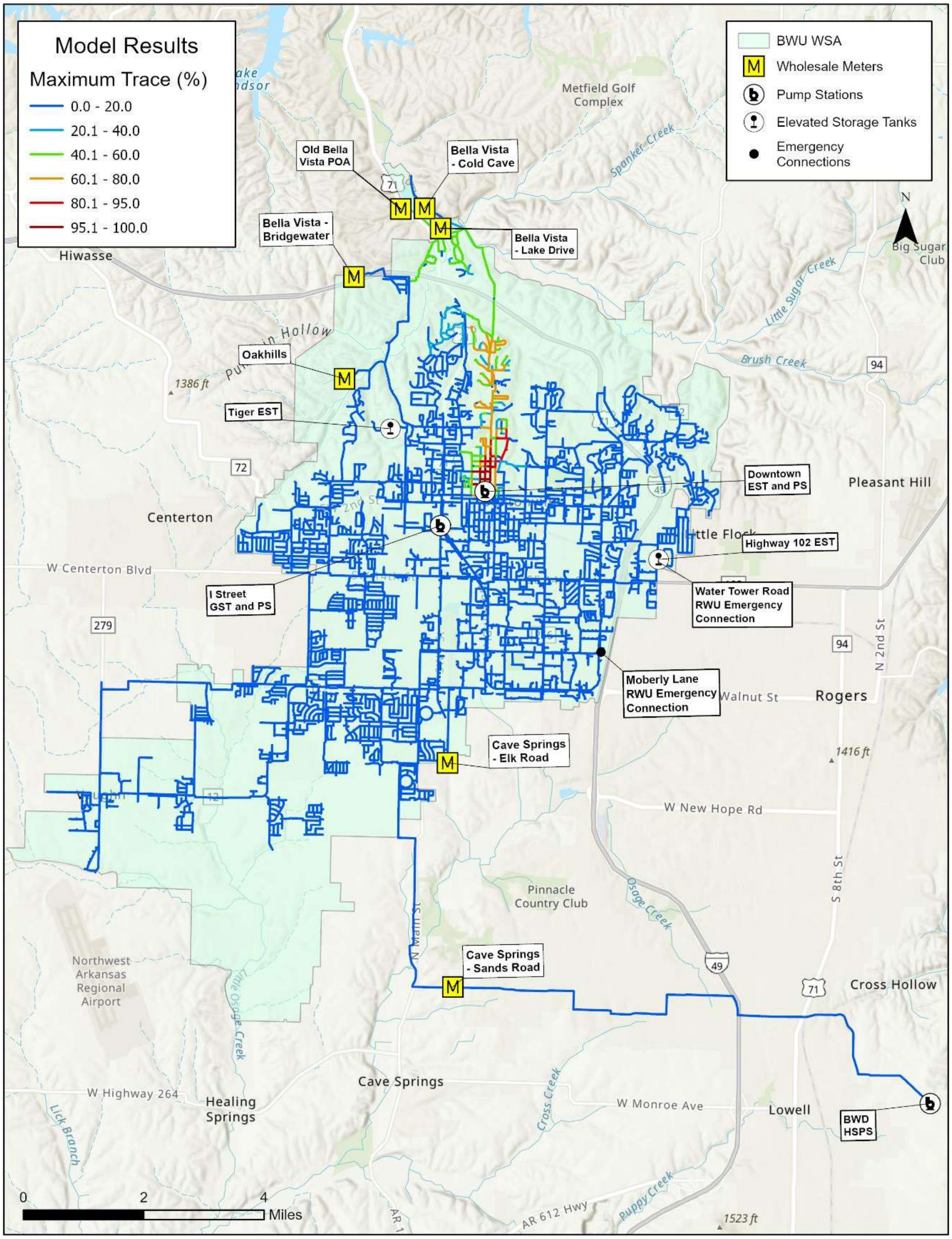


Figure 4-9: 2023 Maximum Source Trace Results for Downtown EST and PS

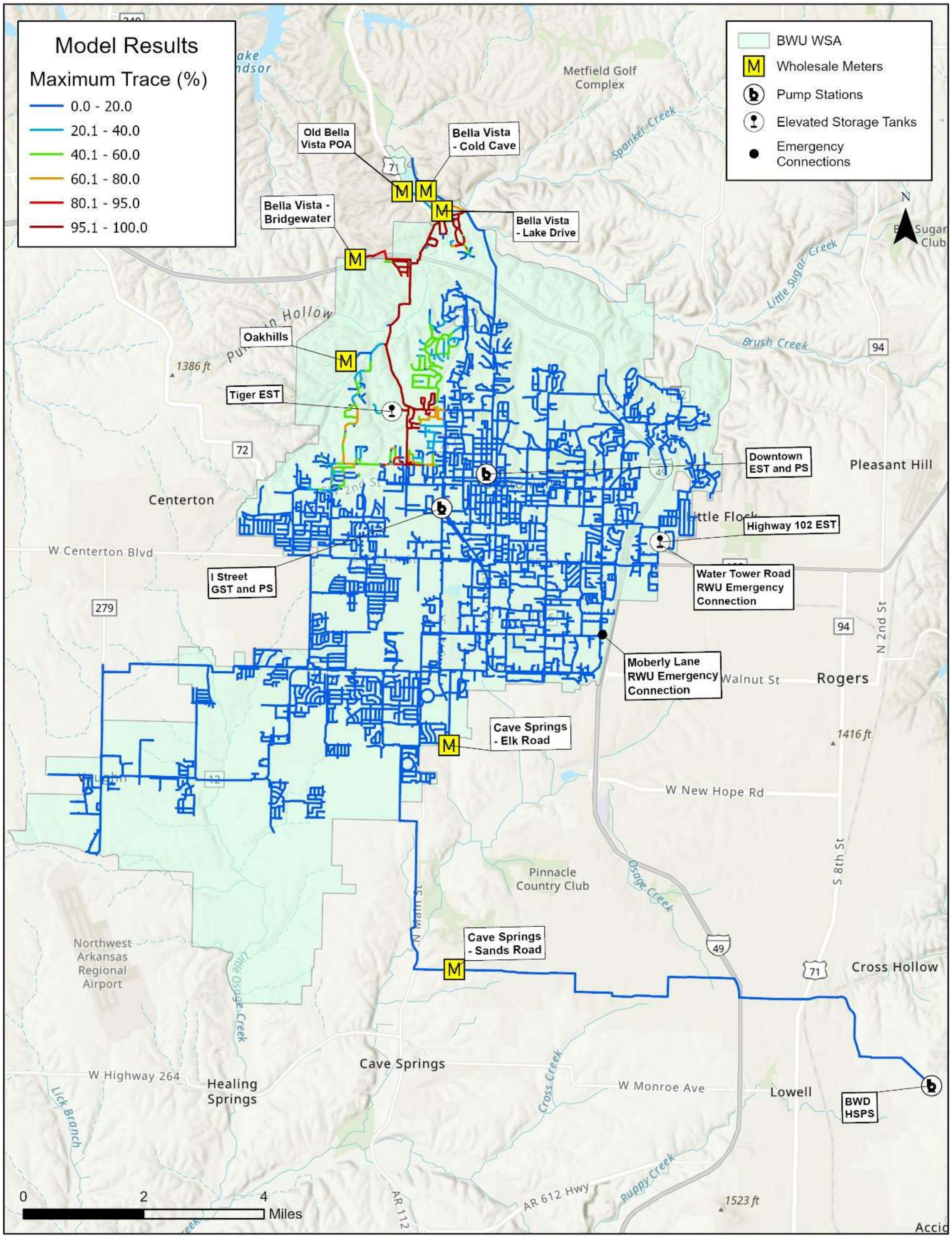


Figure 4-10: 2023 Maximum Source Trace Results for Tiger EST

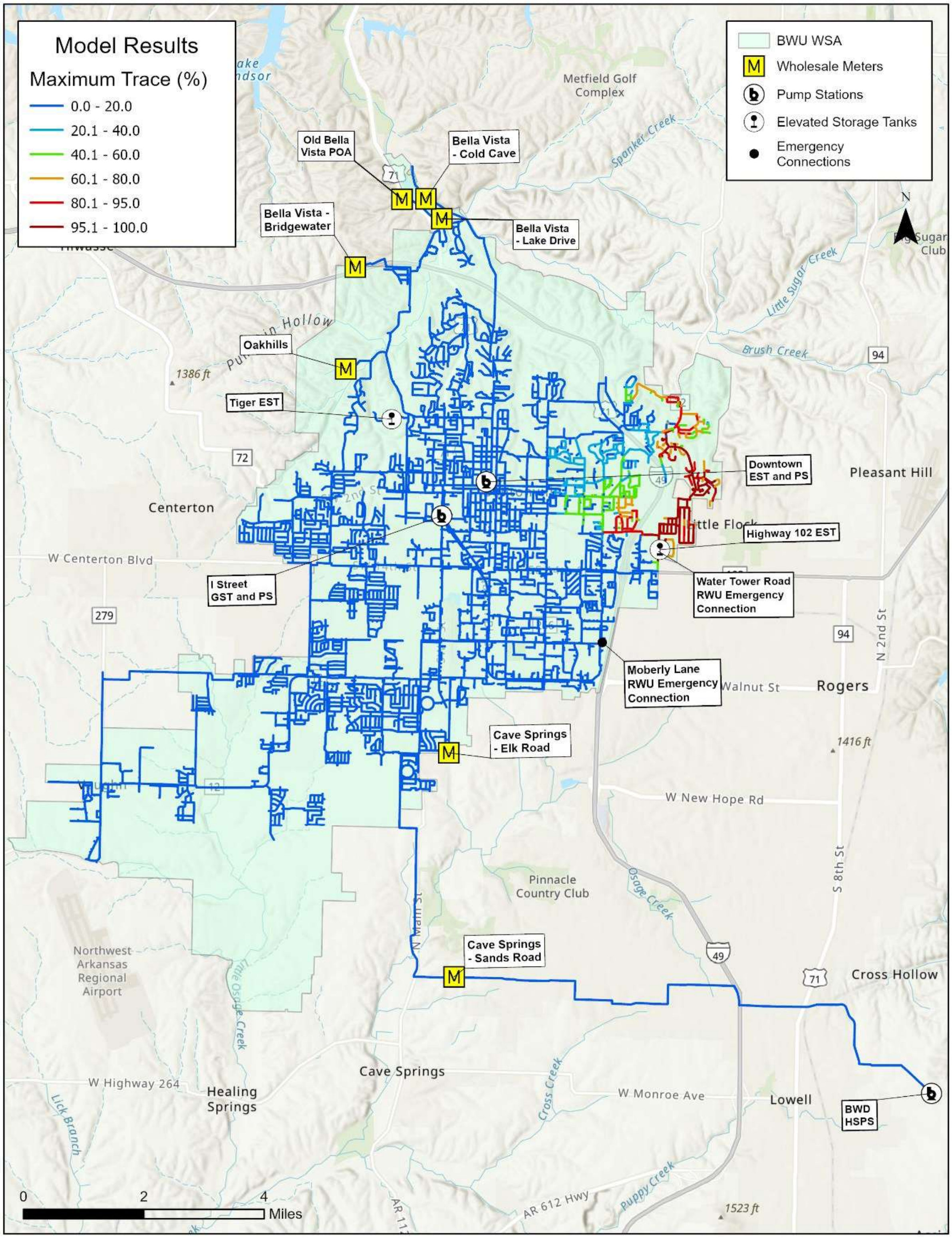


Figure 4-11: 2023 Maximum Source Trace Results for Highway 102 EST

4.11 Water Age

An analysis of water age within the system was completed to identify points within the current distribution system with high water age. Water age is often an indicator of overall water quality, with a lower water age often correlating to a better water quality. Excessive age can also contribute to disinfectant decay, the formation of DBPs, and bacterial growth within the system. Figure 4-12 shows the maximum water age during the ADD scenario for areas with non-zero demands. The highest water age is present within the northern portion of the system in the areas influenced by the storage tanks as discussed in the previous section. The southwestern corner of the system is not typically influenced by the storage tanks but has additional water age that can be attributed to low demands relative to the upstream pipe volume. The water age in this area would be anticipated to decrease with increasing water demand. The model results indicate the water age throughout the system is generally low, with maximum values generally less than five days.

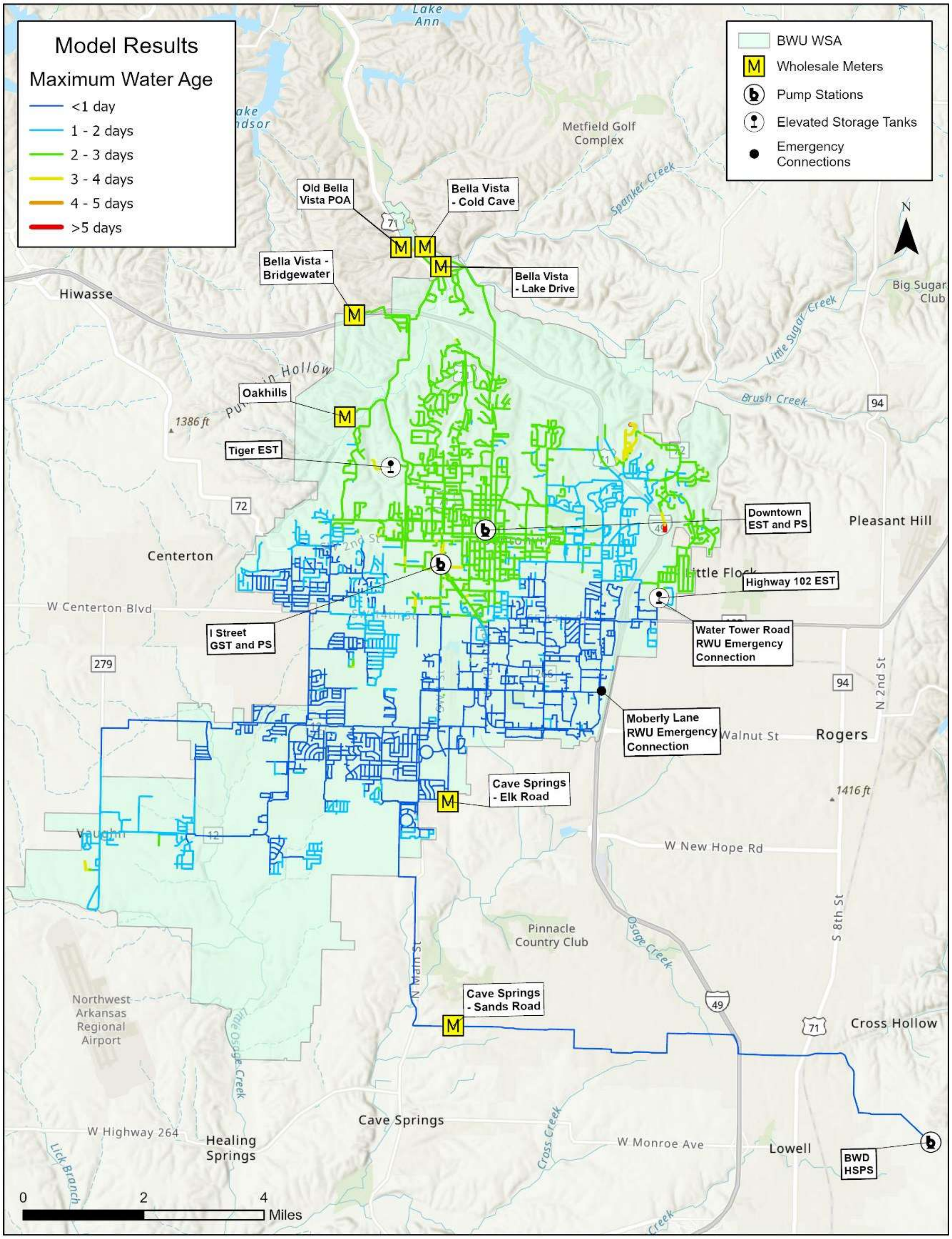


Figure 4-12: 2023 Maximum Water Age Results

APPENDIX C
Capital Improvement Plan Technical Memorandum No. 3

Bentonville Water Utilities

Water Master Plan Update

Technical Memorandum No. 3
Capital Improvement Plan

City of Bentonville
Bentonville, Arkansas

Prepared by:

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

April 2024

Garver Project No. 22W01291

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Introduction

This technical memorandum I was prepared for Bentonville Water Utilities (BWU) as part of the Bentonville Water Master Plan Update. This is the third TM for the project, following the Growth Projection TM and the Existing System Assessment TM. The purpose of this TM is to:

- Evaluate system performance for future planning horizons
- Present an overview of the capital improvements required to accommodate future growth
- Present detailed project descriptions for improvements anticipated to be needed by 2033

2.0 Future System Assessment at Planning Horizons

This section summarizes the future system assessments completed to identify water system projects for the 10-year CIP. The hydraulic model developed for this WMP Update and desktop analyses were used for the evaluation over the future planning horizons (2028, 2033, and 2043). The Growth Projection TM details the planning horizons and water system evaluation criteria used for this WMP Update.

2.1 Supply Assessment

Beaver Water District (BWD) supplies water to BWU via a high-service pump station (HSPS) owned and operated by BWD. BWD completed a Water Master Plan in October 2023 in which the planned supply capacity to BWU was documented. In this plan, BWD planned to complete minor improvements to the existing BWD HSPS and install new infrastructure including a new pipeline and pump station (Western Corridor Pump Station (WCPS)). Figure 2-1 summarizes the planned BWD supply capacity compared to the projected maximum day demands for the BWU system. This figure also shows an accelerated BWD supply with updated information for timings of improvements to the existing BWD HSPS and expected completion of the WCPS. The accelerated BWD supply also implements the addition of a pump at WCPS to meet BWU projections over the 20-year planning period. The following conclusions can be drawn from this supply analysis:

- Maximum day demand projections presented in the Growth Projection TM are higher than those anticipated in previous BWD master plans. The increased maximum day demand projections result in supply deficits by the end of the 20-year planning horizon.
- After the installation of the additional pump in the existing BWD HSPS, the BWD supply capacity will be adequate for 2024 projected maximum day demands.
- Transmission improvements discussed in Section 2.4 will decrease head losses and reduce discharge pressures at the BWD HSPS with all of the pumps running, which will increase the maximum supply capacity.
- Until the completion of the WCPS, the BWD supply firm capacity may not be adequate to supply maximum day demands during hot and dry summer conditions.
- BWD may need to accelerate the installation of the fourth pump at the WCPS to meet maximum demands for BWU over the entire 20-year planning horizon.
- Additional BWD improvements beyond those presented in their 2023 Water Master Plan will be required when maximum day demands reach 40 MGD.

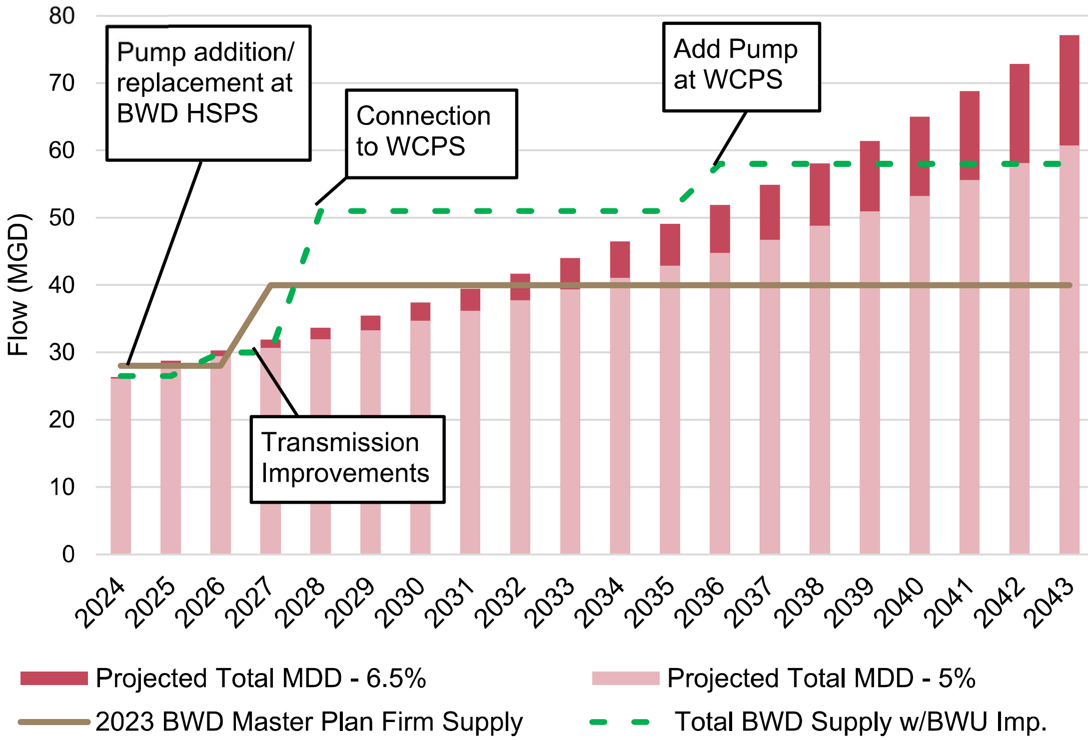


Figure 2-1: Future Supply Capacity Assessment

2.2 Storage Capacity Assessment

Garver compared the BWU storage capacity to the evaluation criteria of a volume equal to one day at projected retail average day demands, as shown in Figure 2-2. Several new storage tanks will be required to serve the future growth anticipated in the BWU retail service area. Addressing storage deficiencies is a multi-year process to plan, design, and construct each new facility, and new storage should be sized to cover storage requirements into the future for a reasonable horizon. However, excessive storage capacity can increase water age and degrade water quality; therefore, storage tank capacity should be added incrementally as needed in response to increasing demands. The proposed storage tank improvements have been divided into multiple phases to increase flexibility and manage costs.

Table 2-1 presents advantages and disadvantages of elevated and ground storage tanks (GSTs). Elevated storage tanks (ESTs) are likely to be most beneficial distributed throughout the BWU distribution system where they would tend to stabilize system pressures and would be less impacted by supply pump operations. GSTs are likely to be most beneficial along major BWD supply transmission mains. Multiple GSTs can also be constructed over time at a single site to provide options for phasing over time without causing excessive water age. Section 2.4 presents tank improvements that Garver included in the hydraulic modeling of the future planning horizons. The tank locations and volumes can be modified as additional sites are identified, which may also require modification of the associated transmission main sizing and alignments.

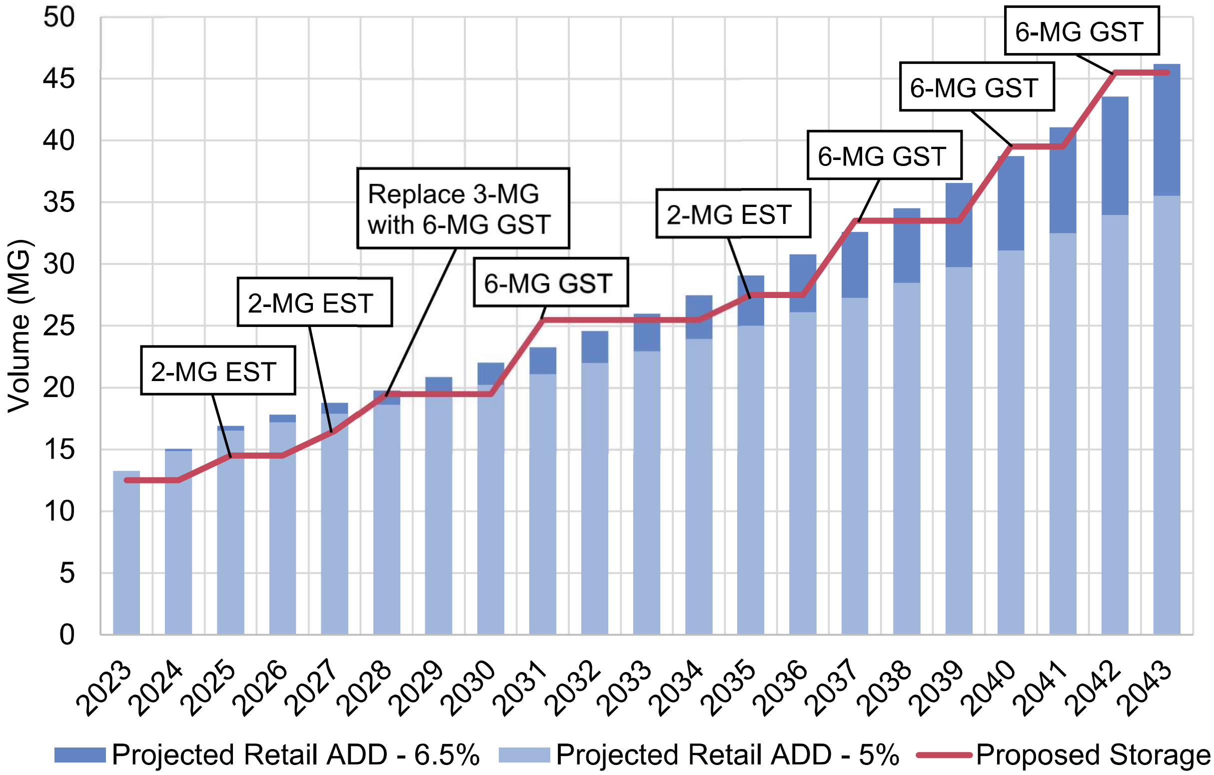


Figure 2-2: Future Storage Capacity Assessment

Table 2-1: Storage Type Considerations

Storage Types	Advantages	Disadvantages
Elevated	• Stable system pressures • No pumping required ○ Simpler operation ○ More reliable ○ No energy costs	• High construction cost per gallon • No local control over tank level ○ Prone to low/high turnover • Generally less cost-effective above 2 MG • High visual impact
Ground Storage with Booster Pumping	• Lower construction cost per gallon (for tank) • Larger volumes available/ more cost-effective • Easier to phase in additional storage (tank farm) • Large volumes/pump stations can be used to supplement supply/transmission • Less visual impact	• Pumping required • Additional controls • Reliability depends on pumping/power • Additional energy costs

2.3 Hydraulic Model Results

All deficiencies identified in the Existing System Assessment TM were non-regulatory. However, the transmission capacity limitations currently cause excessive head losses and impact the supply capacity of the BWD HSPS. Additional storage capacity will also be needed to provide emergency storage as system demands increase. Garver used the hydraulic model to identify the improvements needed to address existing deficiencies and support future growth. Appendix A presents exhibits of the model results at the 2028, 2033, and 2043 horizons. The 2043 horizon was primarily used to verify the sizing of the 2033 improvements would be adequate for future demands and provide a long-term road map for the transmission network. The future horizon model results highlight that the improvements will result in lower maximum flow velocities and less variability in both service pressures and tank levels as demands increase.

2.4 Future System Improvements

Garver used the hydraulic model to identify water distribution system improvements to address existing transmission capacity limitations (see Existing System Assessment TM) and to provide additional capacity to serve future growth. Proposed improvements identified for the water distribution system are listed in Table 2-2 and illustrated in Figure 2-3 through Figure 2-5. More details about these improvements are presented in Sections 4.0 and 6.0.

The 2028 improvements Include an extension of the existing 48-inch supply transmission main to the I Street tank site, which will significantly increase transmission capacity from the BWD HSPS to the Core growth area. The improvements also include connection to the BWD WCPS once it is complete. The WCPS connection will provide redundancy and the capacity needed to meet projected peak demands during hot and dry summers. Finally, storage and transmission improvements will provide more stable pressures in the Core and Southwest growth areas.

The 2033 improvements will primarily continue to increase transmission capacity to the Core and Southwest growth areas as well as to the Bella Vista POA wholesale meters. A new GST and pump station site near the Western Corridor Transmission Main is also anticipated to provide emergency storage and additional pumping capacity to meet peak hour demands.

Table 2-2: Proposed Water System Improvements

Horizon	Project Type	Project Name	Proposed Size
2028	Transmission	Supply Transmission Main Extension (Existing 48-inch to I Street tank site)	48-inch
		Western Corridor Transmission Main	48-inch
		East Loop (Moberly Lane 24-inch to Highway 102 tank site)	24-inch
		Southwest Elevated Storage Tank Transmission Main	24-inch
	Storage	Northeast Elevated Storage Tank	2 MG
		Southwest Elevated Storage Tank	2 MG
		I Street Ground Storage Tank Replacement	6 MG
2033	Transmission	Southwest Ground Storage Tank Transmission Main	36-inch
		Northeast Loop Phase I (Tiger Elevated Storage Tank to J Street)	24-inch
		Central Transmission Mains (I Street tank site to Core transmission loops)	24-inch
		Northeast Loop Phase II (NE Tiger Boulevard to Southeast 8th Street)	24-inch
	Storage	Southwest Ground Storage Tank and Pump Station	6 MG

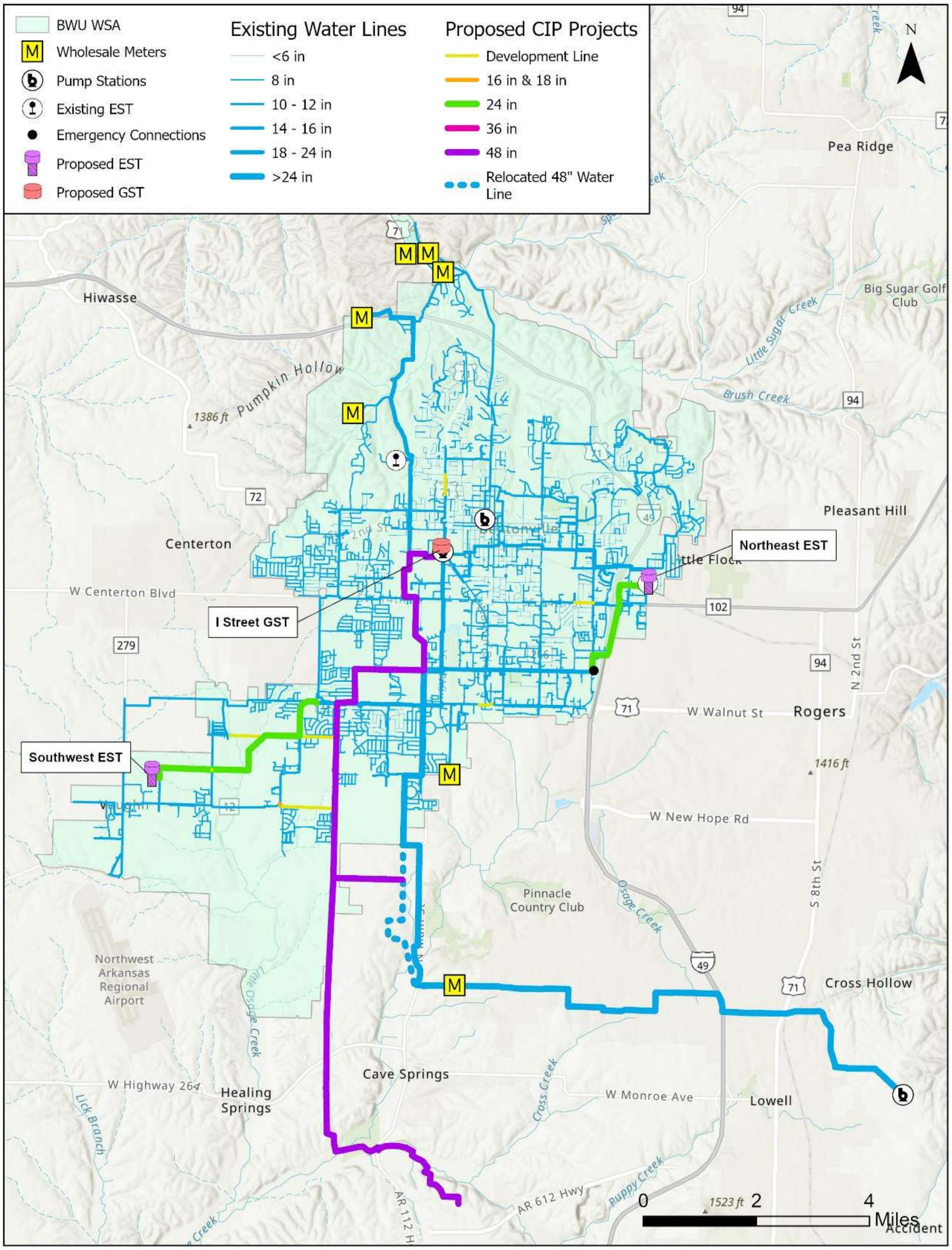


Figure 2-3: 2028 Horizon Improvements

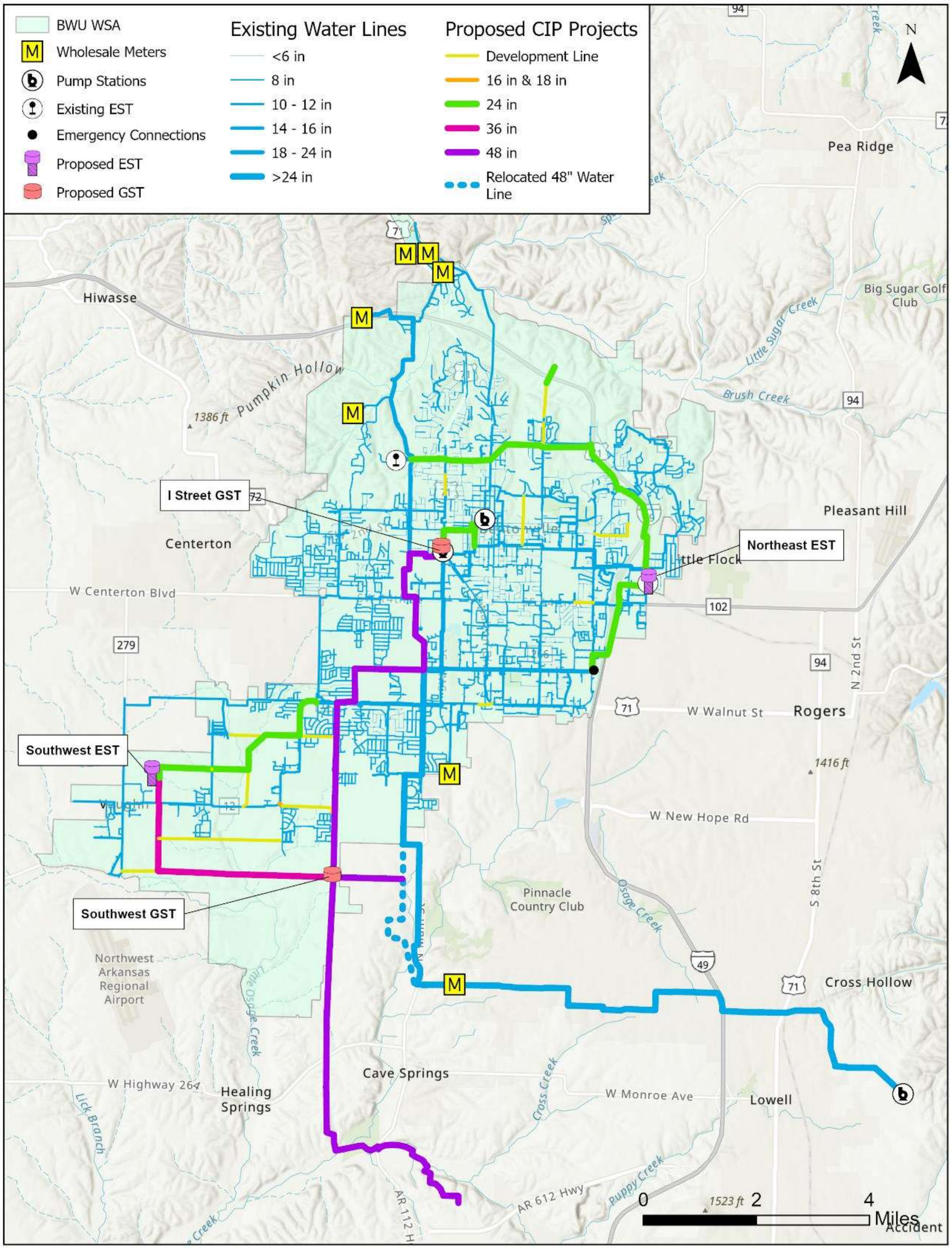


Figure 2-4: 2033 Horizon Improvements

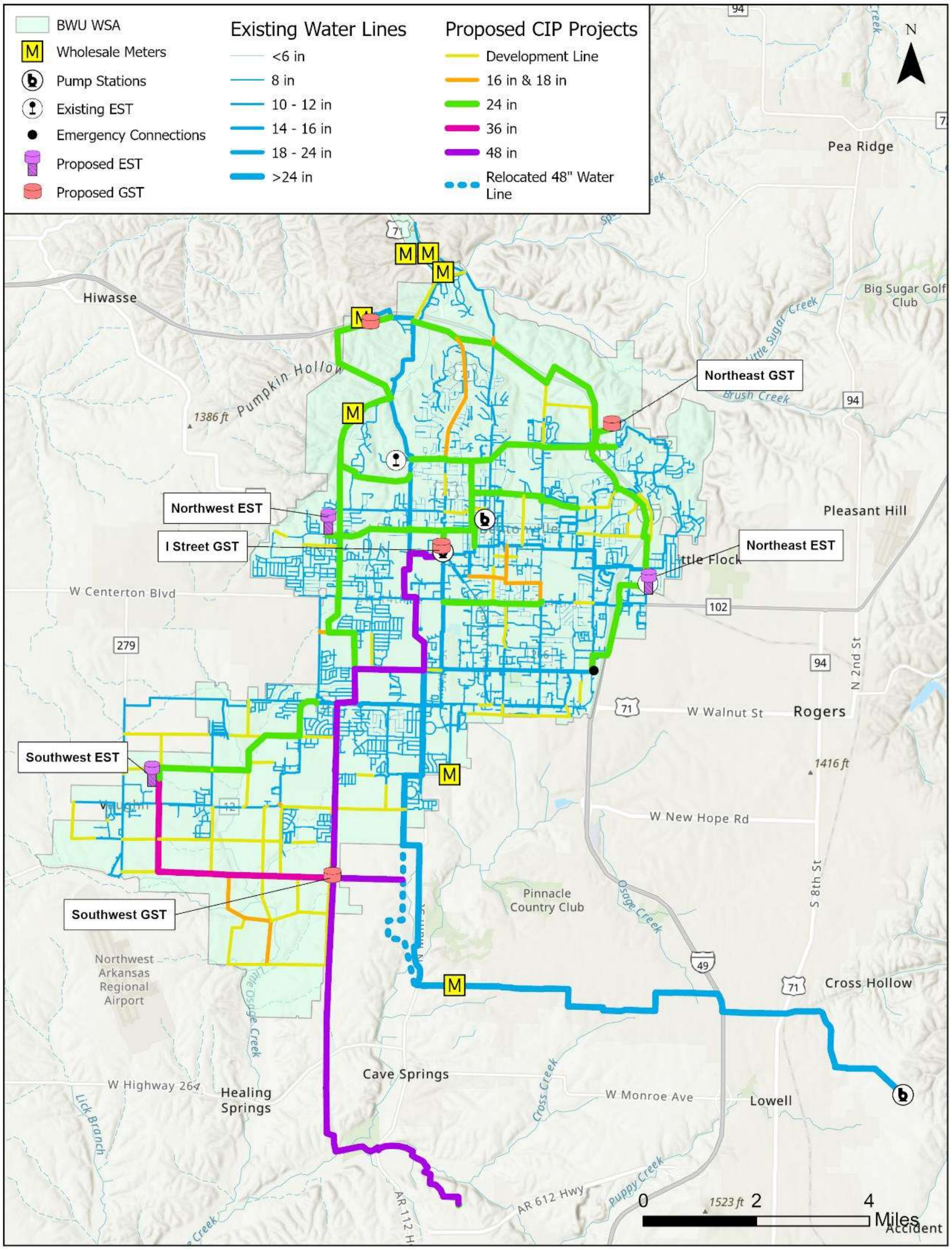


Figure 2-5: 2043 Horizon Improvements

3.0 Long-Term Improvement Considerations

While this WMP Update is focused on improvements for the next 5–10 years, Garver identified additional long-term improvement considerations that may be useful in guiding design efforts to provide future flexibility and to respond to development proposals that differ from projected demands in scale or location.

3.1 Core Growth Area Loop

The proposed improvements will create a large-diameter transmission main loop around the northern and eastern edges of the Core growth area, from the end of the 24-inch transmission main at Moberly Lane to the Tiger EST. This loop will reduce pressure variations on the northeastern side of the Core/Infill areas and will improve operations by reducing the difference in tank levels in the Tiger and Highway 102 ESTs during summer months.

The Northeast Loop may incorporate the existing 24-inch segment on Southeast 8th Street. Extensions north and west from Southeast 8th Street could then eventually be connected to the proposed 24-inch transmission main running east from the Tiger EST to Northeast J Street. Diameters larger than 24 inches could be considered for segments of this loop if an additional GST site is identified on the northeastern side of the Core area outside of the loop. Otherwise, a 24-inch loop would provide sufficient capacity until demands increase significantly and/or additional storage capacity is installed. Additional 12-inch connections between the large-diameter loops in the Core growth area will also improve transmission capacity from the BWD supply to the ESTs and developments with high demands.

3.2 District Metered Areas and/or Pressure Zones

The BWU distribution system is currently operated as a single pressure zone. As improvements are made to the system, there may be opportunities to divide the distribution system into multiple pressure zones and/or district metered areas (DMAs). Pressure management, particularly for areas with typical pressures well above 100 psi, has the potential to significantly reduce background leakage. Additionally, providing flow meters at supply points and connection points between pressure zones would allow the zones to function as DMAs that could be used to track water losses in each area and support leak detection and water efficiency programs.

The distribution system has three main regions that could be candidates for developing pressure zones and/or DMAs:

- **Southwest** – The area west of the 48-inch supply transmission main and south of 28th Street is the area of the system that is most influenced by BWD HSPS pumping operations and is generally at slightly lower elevations than the central area. This area includes most of the Southwest and South growth areas, which are currently less developed but have significant growth potential. This area is also less looped with the remainder of the distribution system because of the shape of the service area and could therefore be isolated from the system. The new Southwest EST could be designed to provide a lower HGL to a new pressure zone if desired.

However, it may be advantageous to keep the operating range similar to the existing ESTs to have flexibility during emergency operations.

- **Central** – The central portion of the service area includes the Core growth area and portions of the surrounding areas that are at the highest elevations in the distribution system. This area already contains multiple ESTs and does not have excessively high service pressures, so pressure management is not required. However, incorporating flow meters at supply connections and connections to other zones would allow this area to function as a DMA.

- **North** – The northern portion of the service area is at considerably lower elevations than the central area and contains areas with pressures near 200 psi, so pressure management would likely be beneficial in this area. The area is currently served by two transmission mains that cross the steep slopes down from the central area, so it could easily be isolated to form a new pressure zone. The supply pressure requirements for the wholesale connections in this area may limit how much the pressure can be decreased. Potential ways to address these limitations include changing the pressure limits during wholesale contract renewal negotiations and/or installing separate wholesale supply transmission mains parallel to distribution lines in this area.

3.3 Western Corridor Transmission Main and Related Improvements

BWU demands during hot and dry summers have nearly reached the supply capacity of the existing BWD HSPS, as discussed in Section 2.1. The WCPS that is being constructed by BWD will provide a second point of supply. BWU will be responsible for a transmission main connecting the WCPS to the BWU distribution system. The new source of supply will increase both total supply capacity and redundancy for the existing BWD HSPS and 48-inch transmission main.

Garver evaluated potential alignments for the Western Corridor Transmission Main. The 2018 Water Master Plan presented a potential alignment that would have connected to the existing 48-inch transmission main in Cave Springs. However, the projected demands have increased significantly from those presented in the 2018 Water Master Plan, and connecting both supplies to a single 48-inch transmission main would not provide adequate supply transmission capacity to meet the updated projected demands. A separate transmission main also eliminates the point of failure for BWD supply along the existing transmission main.

Based on BWU staff's input, Garver evaluated a transmission alignment that would connect the Western Corridor Pump Station to the end of the existing 48-inch supply transmission main, providing a fully redundant supply transmission main. The existing 48-inch transmission main already runs through the Rogers Water Utilities service area south of Southwest Regional Airport Boulevard, so alignments farther east of the existing transmission main would cross heavily developed areas in the Rogers Water Utilities service area. Farther west, conflicts with the Northwest Arkansas Regional Airport and the Highfill Water Department service area are likely. Additionally, the Little Osage Creek valley is at significantly lower elevations where the transmission main would have excessively high pressures.

Based on the limitations farther east and west and the anticipated locations of future growth and infrastructure, Garver modeled a preliminary alignment for the Western Corridor Transmission Main that crosses Spring and Osage Creeks and runs north primarily along Morningstar Road. This corridor would provide proximity to both the existing 48-inch transmission main for an additional southern connection and to the Southwest growth area, which has the capacity for significant long-term growth.

A route study for the Western Corridor Transmission Main could be beneficial to refine the alignment and potential initial and future connection points for supply infrastructure. Installing pressure and/or flow control valves at intermediate connection points could minimize pressure and tank level variability in the distribution system. Installing flow meters at all supply connections would allow BWU to track water loss in the transmission main and any future DMAs.

4.0 Capital Improvement Plan Summary

This section summarizes the methodology used to develop a 10-year CIP to prioritize and estimate costs for proposed improvements identified in Section 2.4. More detailed information about each project is provided in Section 5.0. An overview map of the CIP projects is shown in Figure 4-1. Figure 4-2 and Figure 4-3 summarize the proposed project schedule and proposed spending schedule with 30% construction cost contingency to complete the CIP projects. Table 4-1 and Table 4-2 summarize the project details described in Section 5.0 and presented in Section 6.0 for each project.

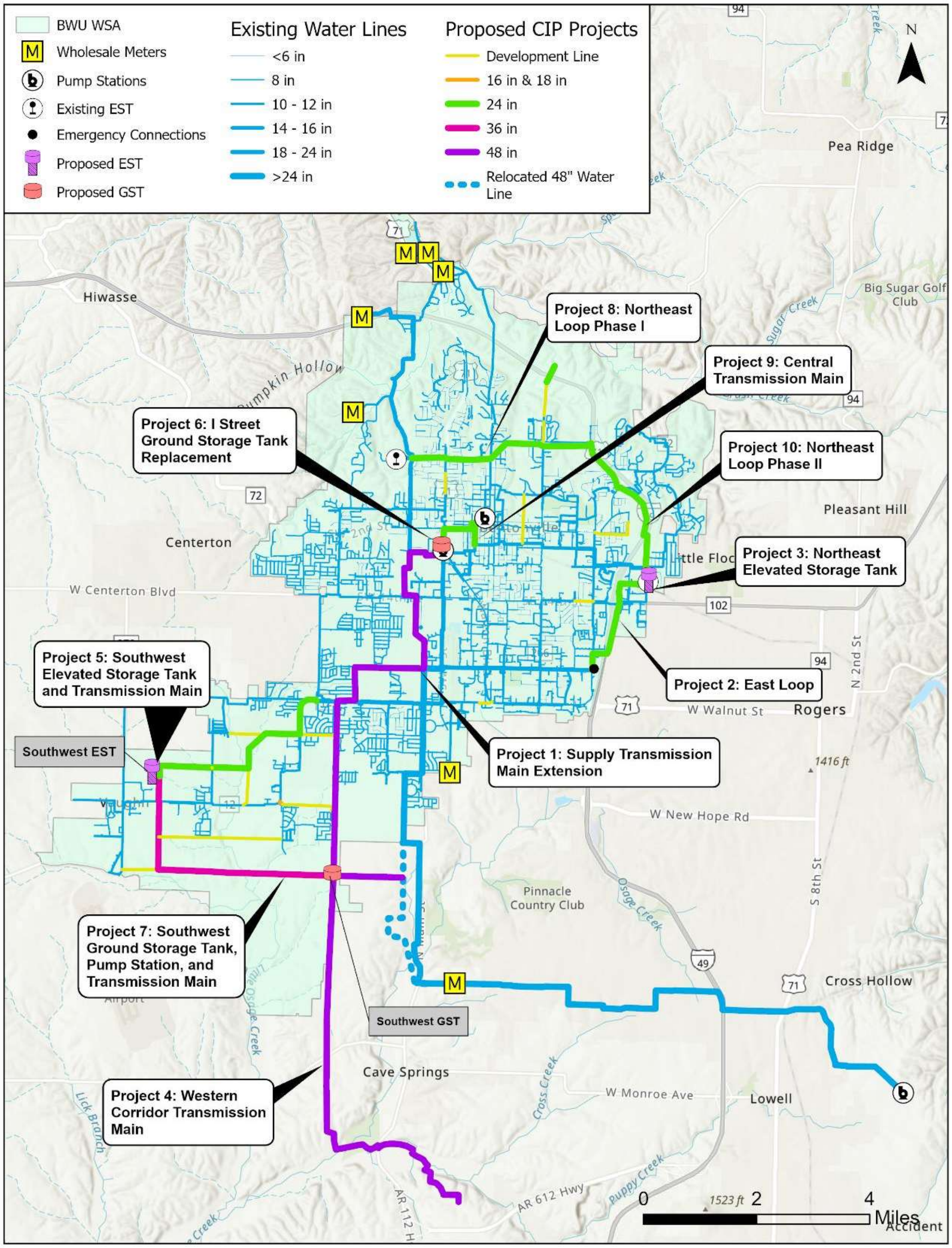


Figure 4-1: CIP Overview Map

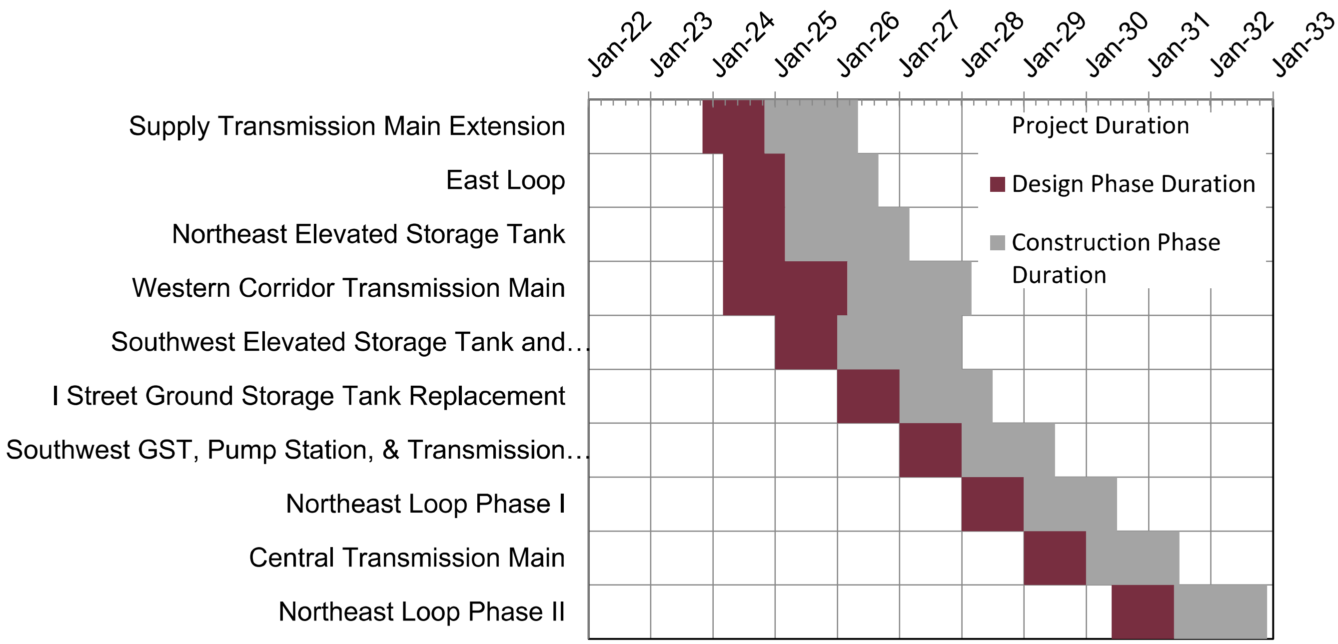


Figure 4-2: Proposed CIP Schedule

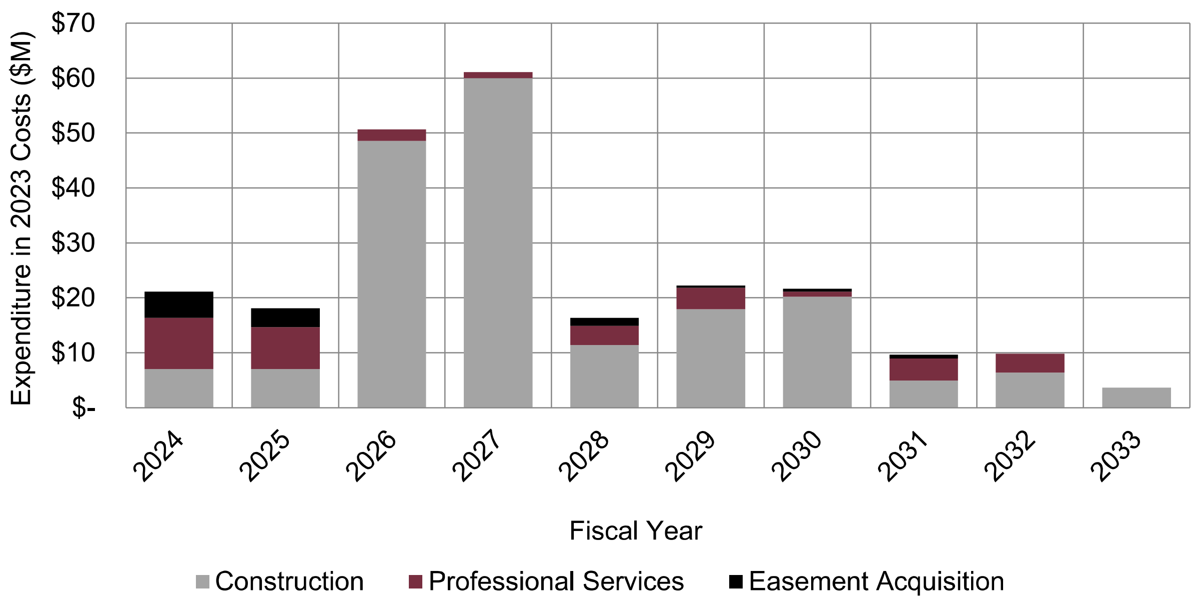


Figure 4-3: Proposed Capital Outlay Schedule

Table 4-1: Water CIP Project Details

Project Identification							Schedule				
Project	**Description**	**Size**	**Location**	**Flexibility**	**Primary Trigger**	**Secondary Trigger**	**Capacity Threshold**	**Threshold Year**	**Start Date**	**Project Complete**	**Total Project Duration**
1	Supply Transmission Main Extension	48-inch	Existing 48-inch to I Street Tank Site	Low	Capacity	Growth	MDD = 26.5 MGD	2024-2026	11/1/2023	2025	30
2	East Loop	24-inch	Moberly Lane 24-inch to Highway 102 Tank Site	Low	Operational	Capacity	N/A	2023-2024	3/1/2024	2026	30
3	Northeast Elevated Storage Tank	2 MG	N Water Tower Road	Medium	Capacity	Operational/Growth	Retail ADD = 12.5 MGD	2023-2024	3/1/2024	2027	36
4	Western Corridor Transmission Main	48-inch	Western Corridor Pump Station to Supply Transmission Main	Low	Capacity	Operational/Growth	MDD = 30 MGD	2027-2030	3/1/2024	2028	48
5	Southwest Elevated Storage Tank and Transmission Main	2 MG 24-inch	SW Barron Road to SW Rainbow Farm Road	Medium	Capacity	Operational/Growth	Retail ADD = 14.5 MGD	2024-2028	1/1/2025	2028	36
6	I Street Ground Storage Tank Replacement	6 MG	I Street and Walton Boulevard	Medium	Capacity	Operational/Growth	Retail ADD = 16.5 MGD	2026-2032	1/1/2026	2028	30
7	Southwest GST, Pump Station, & Transmission Main	6 MG 36-inch	Morning Star Road to SW Opal Road	Medium	Capacity	Operational/Growth	Retail ADD = 19.5 MGD	2027-2033	1/1/2027	2029	30
8	Northeast Loop Phase I	24-inch	Tiger EST to J Street	Medium	Operational	Capacity	N/A	2027-2033	1/1/2028	2030	30
9	Central Transmission Main	24-inch	I Street Tank Site to Core Transmission Loops	High	Operational	Capacity	N/A	2028-2033	1/1/2029	2031	30
10	Northeast Loop Phase II	24-inch	NE Tiger Boulevard to Southeast 8th Street	High	Capacity	Operational/Growth	N/A	2031-2033	6/1/2030	2032	30

Table 4-2: Water CIP Project Costs

	2023 Costs				Forecasted Cost[1]			
Project	**Professional Services – Design, Bidding, and Construction Services**	**Easement Acquisition**	**Total Construction Cost**	**Total Project Cost**	**Professional Services – Design, Bidding, and Construction Services**	**Easement Acquisition**	**Total Construction Cost**	**Total Project Cost**
1	$2,708,000	$1,354,000	$13,537,000	$17,599,000	N/A	N/A	N/A	N/A
2	$1,345,000	$673,000	$6,723,000	$8,741,000	N/A	N/A	N/A	N/A
3	$1,383,000	$169,000	$13,826,000	$15,378,000	N/A	N/A	N/A	N/A
4	$10,477,000	$5,239,000	$52,384,000	$68,100,000	N/A	N/A	N/A	N/A
5	$2,070,000	$848,000	$20,696,000	$23,614,000	$2,262,000	$927,000	$23,294,000	$26,483,000
6	$2,205,000	N/A	$22,048,000	$24,253,000	$2,482,000	N/A	$25,560,000	$28,042,000
7	$6,917,000	$1,479,000	$34,582,000	$42,978,000	$8,019,000	$1,715,000	$41,293,000	$51,027,000
8	$866,000	$433,000	$4,327,000	$5,626,000	$1,035,000	$518,000	$5,322,000	$6,875,000
9	$1,046,000	$523,000	$5,230,000	$6,799,000	$1,287,000	$644,000	$6,626,000	$8,557,000
10	$1,414,000	$707,000	$7,070,000	$9,191,000	$1,792,000	$896,000	$9,225,000	$11,913,000

[1]Project No. 1-4 cost estimates are based on 2023 Costs due to the projected start date. 2023 Costs are based on the current bidding environment and are not scaled for future market costs.

5.0 CIP Project Development

5.1 Project Triggers

Each project was prioritized based on project triggers or project justifications. Project triggers are described in Table 5-1 and listed in order of priority, from highest priority to lowest priority. Hydraulic modeling results were used to identify project triggers and when these triggers occurred over the planning horizons. The combination of the identified project triggers and occurrence of project triggers over the planning horizon were used to prioritize and phase the identified projects. In addition, flexibility was assigned to projects based on their prioritization and phasing with highly-flexible projects being able to potentially be moved to later dates. For example, a project with a regulatory trigger phased to address an existing issue will have a low flexibility.

Table 5-1: Project Triggers

Project Trigger	Description
Regulatory	This trigger is activated if regulatory requirements (e.g., minimum residual pressure, available fire flow, etc.) would not be met.
Capacity	This trigger is activated if additional source, storage, or transmission capacity is needed to meet future system-wide peak demands.
Growth	This trigger is activated as a primary trigger if a line is an extension or loop required to serve new developments. This trigger is activated as a secondary trigger if a capacity improvement is required to serve additional demands.
Fire Flow	This trigger is activated if a portion of the system does not have available fire flows that meet or exceed minimum required fire flow rates.
Condition	This trigger is activated based on deteriorating conditions of existing infrastructure, as identified during field investigations. Field investigations were limited to above-grade infrastructure. As such, the condition trigger was not applied to any buried linear infrastructure.
BWU Directed	This trigger is activated when BWU staff have indicated that items will be replaced, are required as part of upcoming policy changes, or are needed to manage growth.
Operational	This trigger is activated when an improvement will provide an operational benefit. An example would be looping and dead-end requirements that would improve water quality and minimize flushing.

5.2 Project Timelines

Project priorities were assigned based on the identified triggers to establish the recommended project order for an overall timeline to meet 5-year and 10-year planning horizons. Each project has also been assigned a flexibility rating of low, medium, or high. Projects with higher flexibility can be deferred until later in the planning horizon, depending on the City's available funding or changing system conditions which may impact the need for the project (such as unexpected delays in development that delay the need for capacity improvements).

The threshold date is the year the existing capacity of the system would be exceeded without the proposed project. Start dates were selected based on the anticipated project duration to achieve completion before the threshold date. The start date is then used to capture anticipated costs for the life of the project, by escalating the total estimated 2023 costs at a rate of 3% to the start date for the engineering and construction items.

5.3 Cost Development

Costs estimates were prepared for each individual project based on industry standards and the 2023 bidding environment. These costs are an estimate and should be re-evaluated as each project nears its start date. Each project has the following costs associated with the Total Project Cost Estimate:

- Construction Cost Estimate/Bid Items
- Engineering Design/Professional Services Estimate
- Easement Acquisition

The cost estimates included in this CIP are Class 4 estimates as defined by the Association for the Advancement of Cost Engineering (AACE), which is consistent with cost estimates developed for studies. The expected accuracy range for the estimates is -30% to +50% of the estimated values. Additional details will need to be developed for each project to develop Class 3 estimates for budget authorization or control. Based on the current market volatility in 2023, factors such as material and labor shortages may impact project costs. Labor shortages typically reduce the number of bidders for infrastructure projects, and the bids received are generally higher to account for the uncertainty in labor costs. Material selection based on current conditions and direct procurement may be beneficial to control costs and reduce uncertainty in project schedules.

Generally based on guidance from AACE, Figure 5-1 shows that each project phase milestone will result in further delineation of the project elements, resulting in tighter ranges of accuracy as the project progresses. Figure 5-1 is an example of how the project estimate's accuracy range will decrease as the project develops.

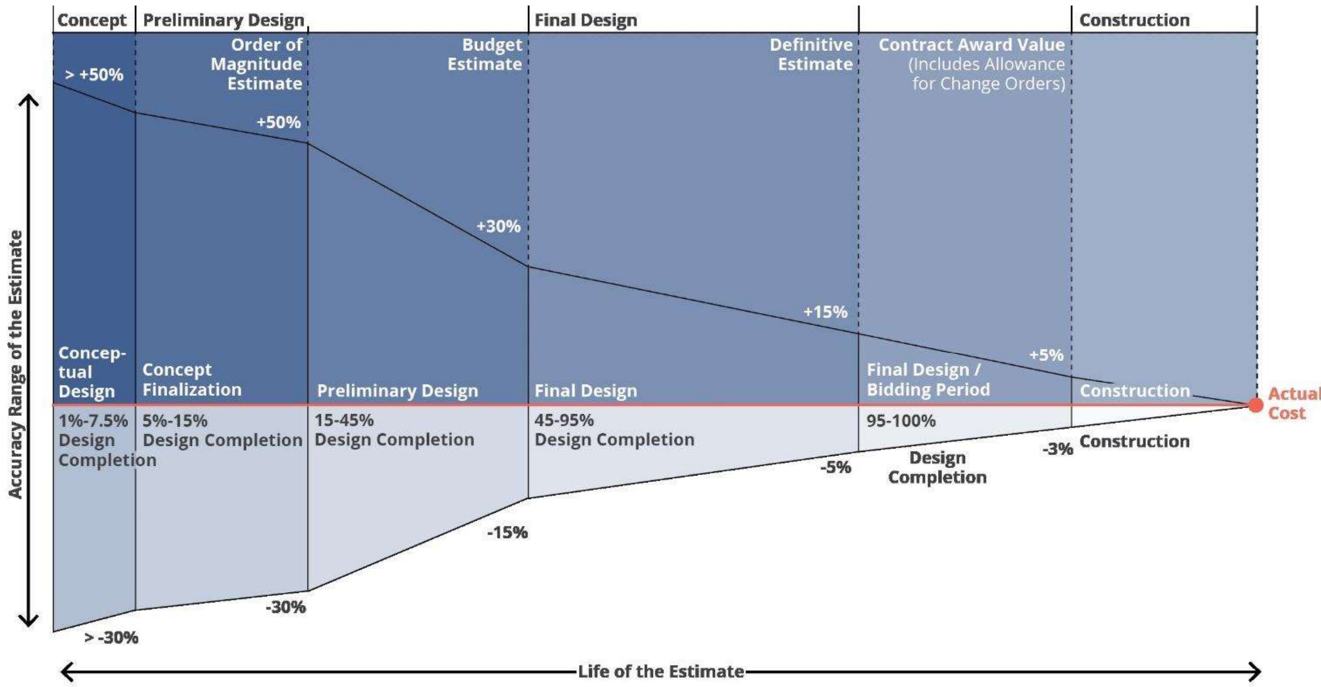


Figure 5-1: Project Cost Funnel

5.3.1 Construction Costs

Construction cost is the estimated cost once the project has been designed and is ready for the bid phase to begin. Based upon discussions with BWU staff, the construction costs are comprised of bid items and includes a construction cost contingency of 30%.

Costs for water lines, tanks, and pumping facilities were developed as described in the following sections. Individual bid items are described as follows:

- *General Improvements*: Anticipated sitework, backfill, erosion control, rehabilitation of existing structures, and testing.
- *Water Line Installation:* Material, labor, contractor's overhead costs associated with pipe installation on a linear footage basis depending on the water line size.
- *Unforeseen Construction Costs:* Cost for anticipated service connections and connections to existing pipes, including isolation valves. This cost is assumed to be approximately 5% of the construction subtotal.
- *Electrical:* Anticipated material costs for electrical equipment associated with new pumps, wiring, conduit, rehab of existing buildings, new electrical associated with new buildings, and SCADA integration.

Water line costs have been estimated based on per linear foot unit costs, presented in Figure 5-2. Costs are based upon similar facilities completed by Garver. Cost estimates related to stream crossings have been estimated by doubling the water line unit costs. Cost estimates related to bored road crossings are based upon bids from recent projects reviewed by Garver. The actual project costs will vary based on a variety of factors, including the amount of asphalt and concrete repair; number, length, and type of crossings (creeks, roads, railroads, etc.); pipe material and pressure class; and soil characteristics in the project area.

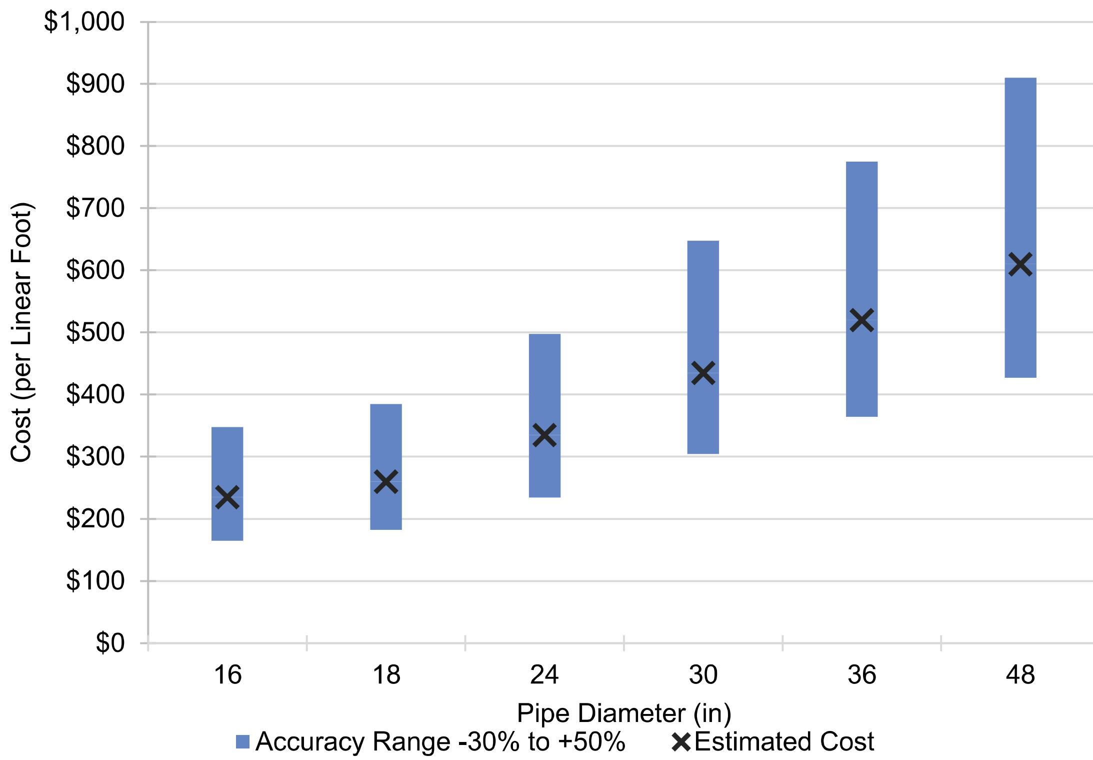


Figure 5-2: Construction Cost Estimation for Water Lines

Storage tank costs have been estimated based on proposed storage type (ground/elevated), tank volume, and historical experience with similar projects. Storage tank cost estimates include tank mixing system. Actual project costs will vary based on a variety of factors, including piping requirements, site grading, foundation requirements, baffling or mixing desired, and architectural treatment for the tank exterior.

Table 5-2: Construction Cost Estimation for Storage Tanks

Type	Volume	Construction Cost
Ground Storage Tank	6 MG	$9,500,000
Elevated Storage Tank	2 MG	$9,000,000

5.3.2 Professional Services

The engineering estimate includes all professional services needed to bid each project, including survey, deed research (as needed), preliminary design, final design of all improvements, and construction phase services. This cost is approximately 20% for water line projects and 10% for storage tank projects of the total estimated construction costs, including contingency.

5.3.3 Easement Acquisition

The engineering estimate includes easement acquisitions needed to bid each project, including coordination of land acquisition and land value. This cost is typically 10% of the subtotal, including additional easements for tank sites.

6.0 CIP Project Profiles

A project profile has been developed for each of the individual CIP projects. These project profiles are included in the following pages. Table 6-1 provides a summary of the information contained in each project profile.

Table 6-1: Project Profile Summary

Section	Description
Description	General description of the project.
Justification	Need for the project.
Unintended Consequences	Consequences that should be considered prior to implementing the project, e.g., increased water age due to additional storage volumes.
Special Considerations	Considerations for related projects, existing conditions, or potential schedule drivers.
Potential Alternatives	Alternative projects and/or conditions that would delay or eliminate the need for the project.
Additional Professional Services	Professional services in addition to typical design that may be required for each project.
Total Project Cost Estimate	Cost estimate for each project. Potential alternatives and additional professional services are not included in the OPCC.
Schematic	Map of project location (outlined in black).

Project 1: Supply Transmission Main Extension

Project Identification	
Number:	1
Location:	Existing 48-inch to I Street Tank Site
Flexibility:	Low
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Growth
Capacity Threshold:	MDD = 26.5 MGD
Threshold Year:	2024-2026
Start Date:	11/1/2023
Project Complete:	2025
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 17.60**

Project Description
This project includes installation of a new 48-inch transmission main along I Street from Southwest 28th Street to Southwest 8th Street, where it will connect to the existing 24-inch line just south of the I Street Tank Site.

Justification
Head losses in the existing 24-inch transmission main along I Street currently create a steep system curve for the BWD HSPS and limit the maximum supply capacity. This project will resolve the existing system transmission main capacity deficiency and provide the transmission capacity required to meet the projected system demands.

Unintended Consequences
The transmission main extension will reduce head losses significantly, which will impact BWD HSPS operations and typical tank levels in the Tiger and Highway 102 ESTs. The project will also allow for higher GST filling rates (approximately double the existing filling rate) while sustaining higher system pressures and EST levels. Reducing high velocities in the 24-inch transmission main along I Street will also reduce the potential for transient events in the distribution system. It will likely be necessary to install an altitude valve in the location provided as part of the original design to reduce the risk of overflowing the Tiger EST.

Special Considerations
The connection south of the I Street site could be configured to allow a future connection directly to the GST fill line. The Little Osage Creek crossing and street crossings may need to be revised during detailed design to determine the preferred alignment.

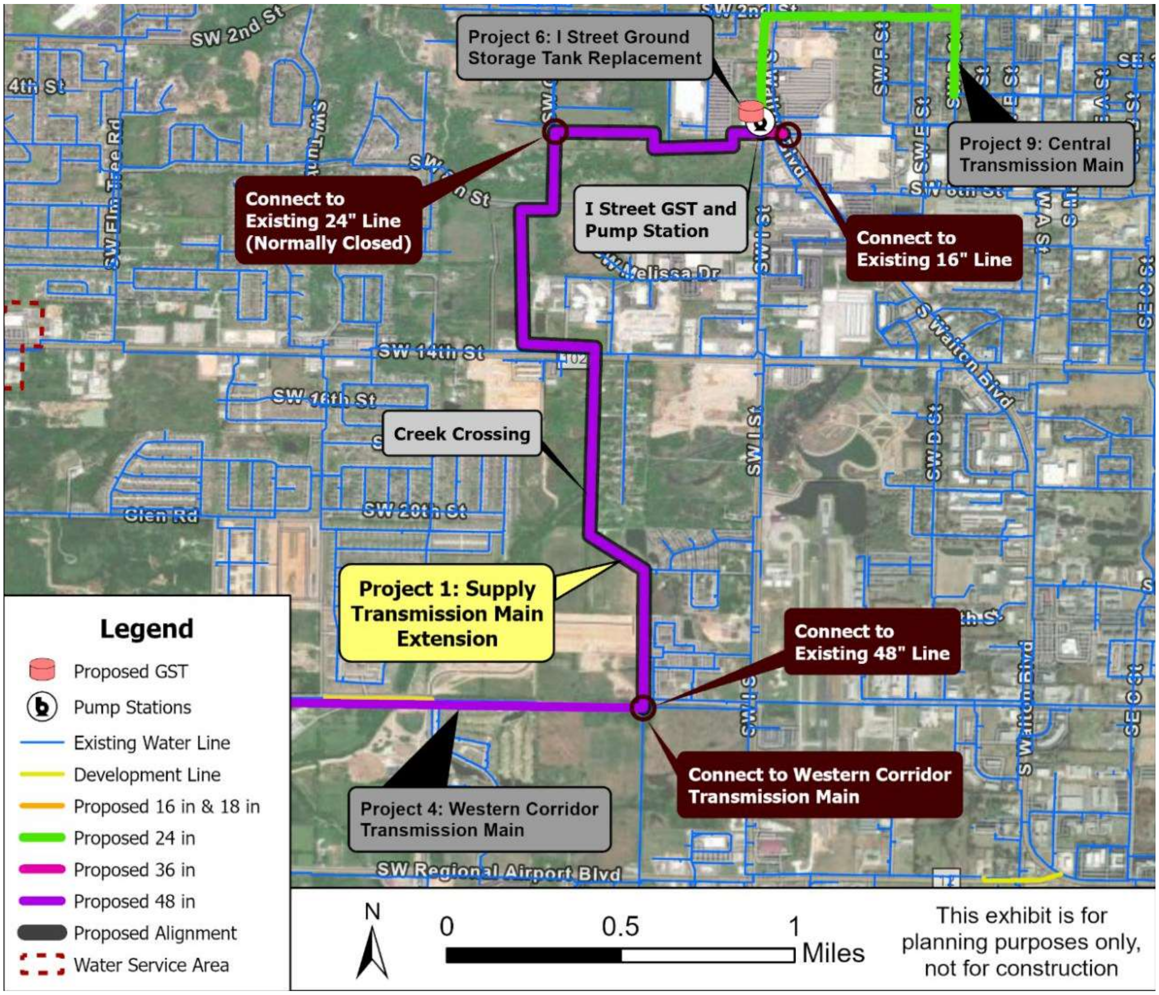
Potential Alternatives
The proposed diameter of 48 inches is anticipated to provide sufficient supply transmission capacity through at least 2033. A second transmission loop was included in the 2043 improvements to increase capacity if demands continue to increase significantly in the northern half of the service area (including Bella Vista POA wholesale demands). The second transmission loop would provide redundancy, but the initial phase could also be upsized to delay the need for additional parallel capacity.

Additional Professional Services
A routing study to determine the preferred alignment for this project is anticipated to be completed as part of the design phase.

Project 1: Supply Transmission Main Extension				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
48	Pipe Installation	$ 610	13,755	$ 8,391,000
48	Creek Crossing #1	$ 1,220	100	$ 122,000
36	Walton Boulevard Bore	$ 2,400	250	$ 600,000
48	SW 14th Street Bore	$ 3,200	250	$ 800,000
-	Unforeseen Construction Costs	-	-	$ 500,000
Construction Subtotal				$ 10,413,000
30% Contingency (Construction Subtotal)				$ 3,124,000
Professional Services - Design, Bidding, and Construction Services				$ 2,708,000
Easement Acquisition				$ 1,354,000
Total Project Cost with 30% Construction Cost Contingency				$ 17,599,000

[1]All cost values have been rounded up the nearest $1,000.

Project 1: Supply Transmission Main Extension



Project 2: East Loop

Project Identification	
Number:	2
Location:	Moberly Lane 24-inch to Highway 102 Tank Site
Flexibility:	Low
Schedule	
Primary Trigger:	Operational
Secondary Trigger:	Capacity
Capacity Threshold:	N/A
Threshold Year:	2023-2024
Start Date:	3/1/2024
Project Complete:	2026
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 8.74**

Project Description
This project includes installation of a new 24-inch line parallel to Interstate-49 from the existing 24-inch line at Moberly Lane to North Water Tower Road, where it will connect to the existing 24-inch line near the Highway 102 Tank Site.

Justification
Insufficient transmission capacity across central Bentonville causes high velocities and excessive head losses during periods of peak demands, which makes it challenging to maintain adequate tank levels in the Highway 102 EST. This project will resolve the existing transmission capacity deficiency and provide capacity to meet the projected demands in the Core growth area.

Unintended Consequences
None identified.

Special Considerations
Arkansas Department of Transportation (ARDOT) coordination and right-of-way/easement acquisition will likely be necessary for this water line. Portions of the alignment along Interstate-49 from Southeast 28th Street to the Arkansas Missouri Trail may need to be revised during detailed design based on the right-of-way and roadway alignments.

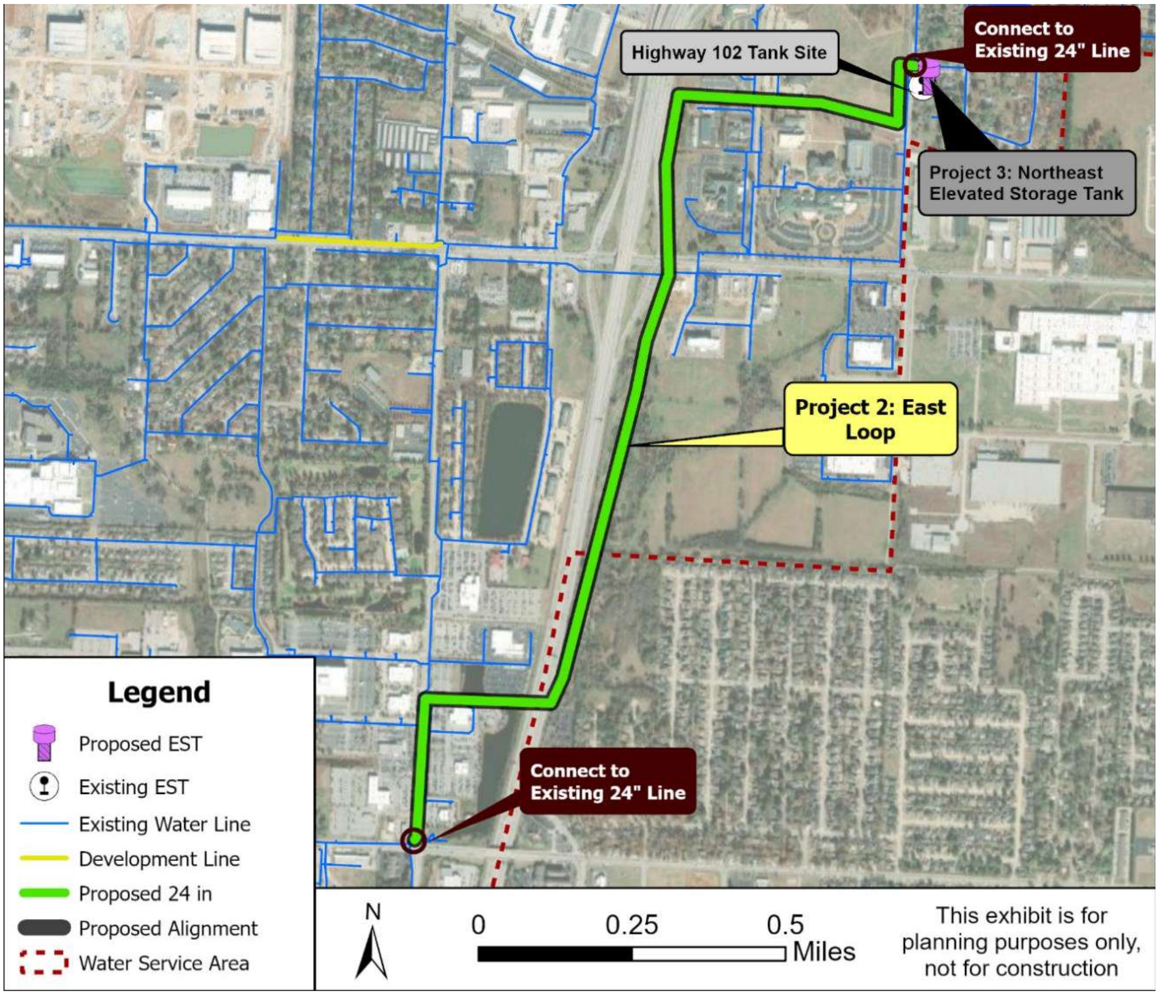
Potential Alternatives
None identified.

Additional Professional Services
A routing study is anticipated to determine the preferred alignment for this project.

Project 2: East Loop				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	Pipe Installation	$ 350	10,060	$ 3,521,000
24	Interstate 49 Bore	$ 2,000	500	$ 1,000,000
24	SE 14th Street Bore	$ 1,600	250	$ 400,000
-	Unforeseen Construction Costs	-	-	$ 250,000
Construction Subtotal				$ 5,171,000
30% Contingency (Construction Subtotal)				$ 1,552,000
Professional Services - Design, Bidding, and Construction Services				$ 1,345,000
Easement Acquisition				$ 673,000
Total Project Cost with 30% Construction Cost Contingency				$ 8,741,000

[1]All cost values have been rounded up the nearest $1,000.

Project 2: East Loop



Project 3: Northeast Elevated Storage Tank

Project Identification	
Number:	3
Location:	N Water Tower Road
Flexibility:	Medium
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Operational / Growth
Capacity Threshold:	Retail ADD = 12.5 MGD
Threshold Year:	2023-2024
Start Date:	3/1/2024
Project Complete:	2027
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	24
Total Project Duration:	36
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 15.38**

Project Description
This project includes installation of a new 2-MG elevated storage tank (EST) at the Highway 102 Tank Site on North Water Tower Road.

Justification
Additional storage capacity on the eastern side of the service area will help stabilize pressures and compensate for transmission capacity limitations during periods of peak demands. The additional storage volume will also contribute to emergency storage needed to keep pace with increasing average retail demands.

Unintended Consequences
Increased system storage has the potential to impact water age and exacerbate issues with loss of residual disinfection and/or generation of disinfection byproducts in the system.

Special Considerations
Storage additions should be coordinated with the East Loop project. Additionally, any new storage tanks should be installed with separate inlet and outlet water lines. It is prudent to install a tank mixing system to facilitate mixing and minimize potential short-circuiting and development of stagnation zones within the tank.

Land acquisition is anticipated for the proposed site location.

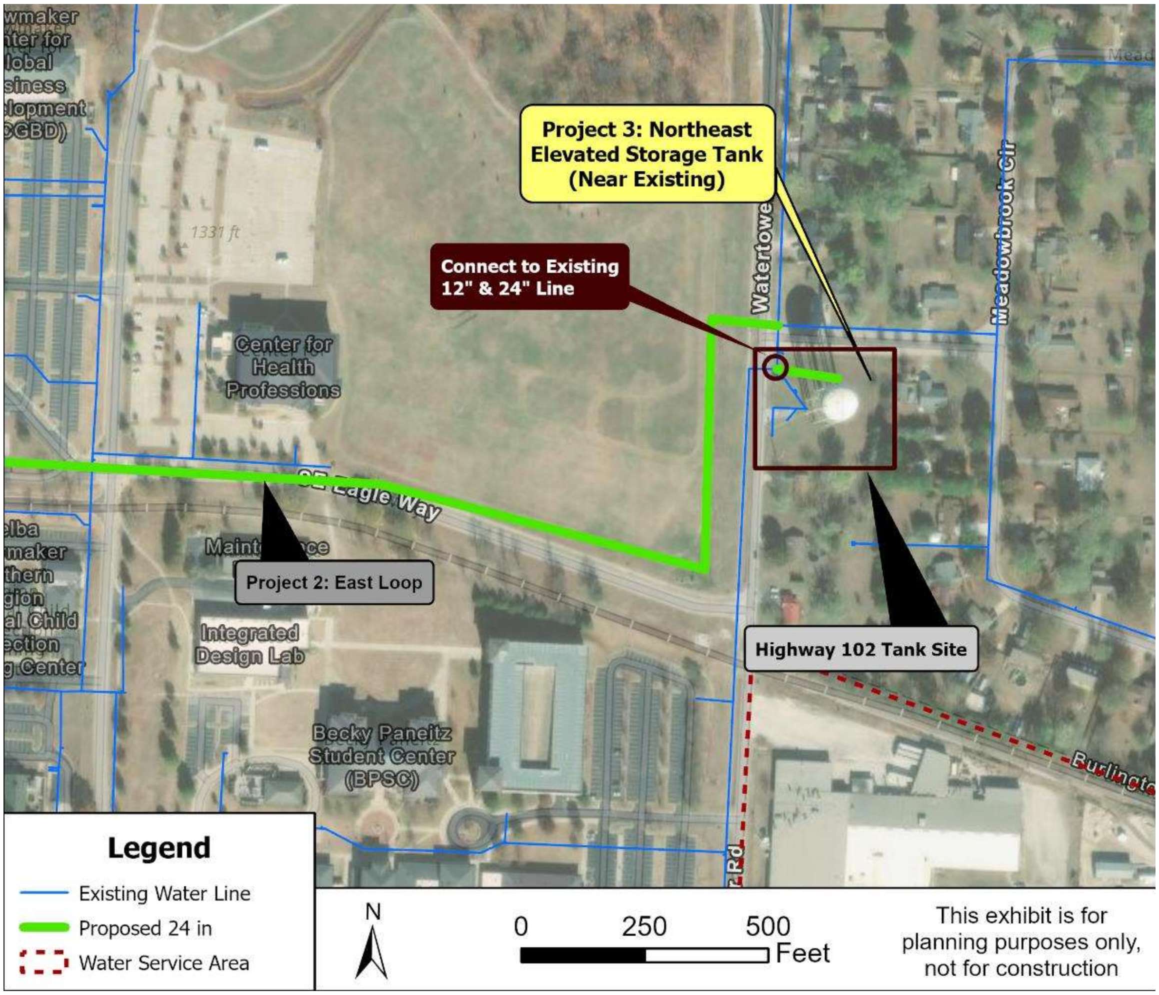
Potential Alternatives
A tank site north of the existing Highway 102 EST site along the Northeast Loop could provide the same benefits. A large-diameter transmission main would need to be extended to the preferred tank site.

Additional Professional Services
A tank siting study could be beneficial to determine the preferred location of the storage tank if land cannot be acquired within a quarter of a mile of the Highway 102 EST.

Project 3: Northeast Elevated Storage Tank			
Description	**Unit**	**Quantity**	**Cost**
2-MG EST	LS	1	$ 9,000,000
Electrical	LS	1	$ 50,000
Site Improvements	LS	1	$ 200,000
Unforeseen Construction Costs	LS	1	$ 510,000
Diameter (in)	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	$ 350	2500	$ 875,000
		Construction Subtotal	$ 10,635,000
		30% Contingency (Construction Subtotal)	$ 3,191,000
		Professional Services - Design, Bidding, and Construction Services	$ 1,383,000
		Easement Acquisition	$ 169,000
		Total Project Cost with 30% Construction Cost Contingency	$ 15,378,000

[1]All cost values have been rounded up the nearest $1,000.

Project 3: Northeast Elevated Storage Tank



Project 4: Western Corridor Transmission Main

Project Identification	
Number:	4
Location:	Western Corridor Pump Station to Supply Transmission Line
Flexibility:	Low
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Operational / Growth
Capacity Threshold:	MDD = 30 MGD
Threshold Year:	2027-2030
Start Date:	3/1/2024
Project Complete:	2028
Project Implementation (Months)	
Predesign:	-
Engineering/Design:	24
Bid/Construction:	24
Total Project Duration:	48
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 68.10**

Project Description

This project includes installation of a new 48-inch transmission main along Morning Star Road from the Western Corridor Pump Station to Southwest 28th Street, where it will connect to the pipe improvements completed as part of Project 1.

Justification

BWU demands are nearing the supply capacity of the existing BWD HSPS. The Western Corridor Pump Station will provide a second point of supply, which will increase both total supply capacity and redundancy for the existing BWD HSPS and 48-inch transmission main.

Unintended Consequences

None identified.

Special Considerations

Provisions should be made as part of the design for future projects connecting to the Western Corridor Transmission Main, including the Southwest Supply Transmission Main and the Southwest GST. The Southwest GST is anticipated to be near the Western Corridor Transmission Main or along the Southwest Supply Transmission Main to allow for a flow-through configuration. A metered and flow-controlled low-flow bypass for the GST could be installed before the GST is constructed. Including flow meters at all supply connections to the Western Corridor Transmission Main would allow BWU to track water loss in the transmission main and future DMAs.

If the alignment of a future parallel large-diameter supply extension to the Core Growth area is identified, a future connection point could be incorporated into the Western Corridor Transmission Main.

Potential Alternatives

None identified.

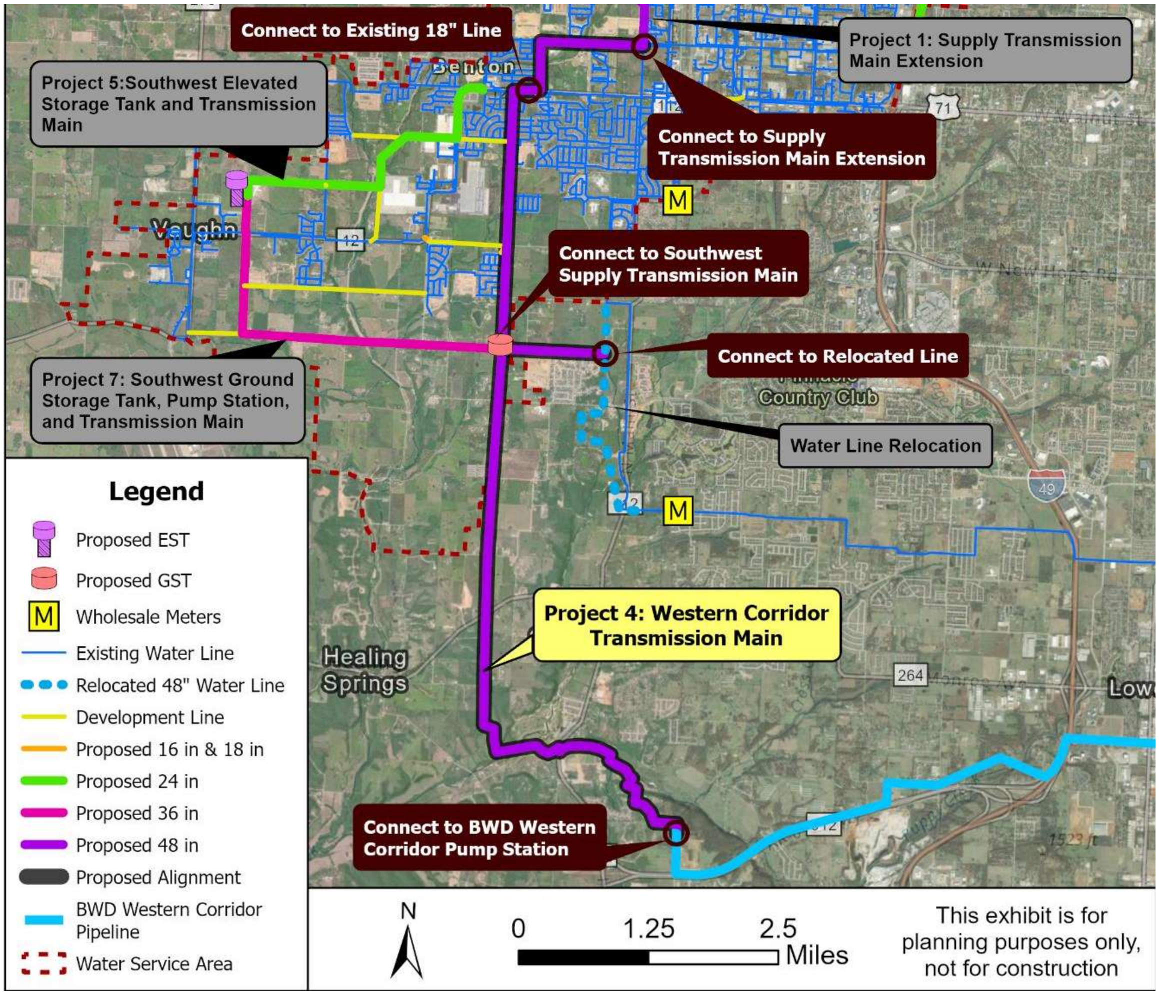
Additional Professional Services

A routing study is anticipated to determine the preferred alignment for this project.

Project 4: Western Corridor Transmission Main				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
48	Pipe Installation	$610	61,346	$ 37,422,000
48	Spring Creek Crossing	$1,220	125	$ 153,000
48	HWY 264 Bore	$3,200	250	$ 800,000
-	Unforeseen Construction Costs	-	-	$ 1,920,000
Construction Subtotal				$ 40,295,000
30% Contingency (Construction Subtotal)				$ 12,089,000
Professional Services - Design, Bidding, and Construction Services				$ 10,477,000
Easement Acquisition				$ 5,239,000
Total Project Cost with 30% Construction Cost Contingency				$ 68,100,000

[1]All cost values have been rounded up the nearest $1,000.

Project 4: Western Corridor Transmission Main



Project 5: Southwest Elevated Storage Tank and Transmission Main

Project Description
This project includes installation of a new 2-MG elevated storage tank (EST) on a City-owned site near Southwest Barron Road and installation of a 24-inch transmission main along Opal Road from the storage tank site to Southwest Regional Airport Boulevard, where it will connect to an existing 18-inch line.

Justification
Additional storage capacity on the southwestern side of the service area will help stabilize pressures and compensate for transmission capacity limitations during periods of peak demands, especially as demands increase in the Southwest growth area. The additional storage volume will also contribute to emergency storage needed to keep pace with increasing average retail demands. The proposed transmission main will resolve the existing transmission capacity limitations at the tank site and provide capacity to meet the projected demands in the area.

Unintended Consequences
Increased system storage has the potential to impact water age and exacerbate issues with loss of residual disinfection and/or generation of disinfection byproducts in the system.

Project Identification	
Number:	5
Location:	SW Barron Road to SW Rainbow Farm Road
Flexibility:	Medium
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Operational / Growth
Capacity Threshold:	Retail ADD = 14.5 MGD
Threshold Year:	2024-2028
Start Date:	1/1/2025
Project Complete:	2028
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	24
Total Project Duration:	36
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 23.61**
Forecasted Costs ($ Millions)	**$ 26.48**

Special Considerations
The tank water level range should be evaluated based on existing operations and future plans for DMAs or pressure zones. If the system continues to operate as a single pressure zone, it may be necessary to increase the high water level in this EST compared to the existing ESTs due to its proximity to the supply transmission mains. Pressure monitoring prior to design may be beneficial as part of the pre-design evaluation for the project.

The Southwest GST, Pump Station, and Supply Transmission Main is anticipated to be operated in a flow-through configuration to pump to the Southwest EST and Southwest growth area, so a large-diameter connection to the Southwest Transmission Main should be included for a future extension.

Any new storage tanks should be installed with separate inlet and outlet water lines. It is prudent to install a tank mixing system to facilitate mixing and minimize potential short-circuiting and development of stagnation zones within the tank.

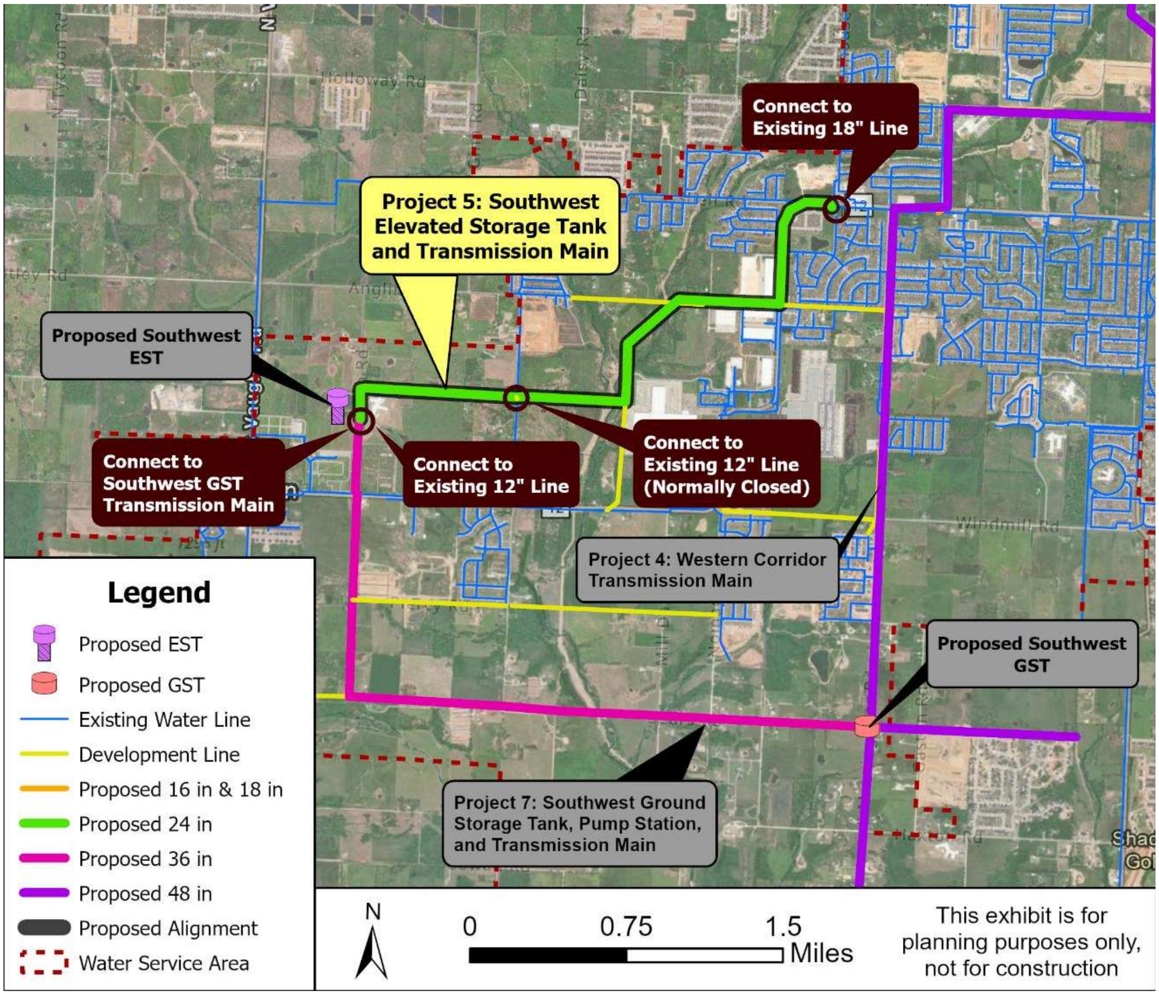
Potential Alternatives
None identified.

Additional Professional Services
A pre-design study is anticipated for this project to confirm transmission main sizing/alignment, the operating HGL for the tank, and potential controls changes for BWD operations once the initial CIP projects are completed.

Project 5: Southwest Elevated Storage Tank and Transmission Main			
Description	**Unit**	**Quantity**	**Cost**
2-MG EST	LS	1	$ 9,000,000
Electrical	LS	1	$ 50,000
Site Improvements	LS	1	$ 200,000
Unforeseen Construction Costs	LS	1	$ 760,000
Diameter (in)	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	$ 350	16885	$ 5,910,000
		Construction Subtotal	$ 15,920,000
		30% Contingency (Construction Subtotal)	$ 4,776,000
		Professional Services - Design, Bidding, and Construction Services	$ 2,070,000
		Easement Acquisition	$ 848,000
		Total Project Cost with 30% Construction Cost Contingency	$ 23,614,000

[1]All cost values have been rounded up the nearest $1,000.

Project 5: Southwest Elevated Storage Tank and Transmission Main



Project 6: I Street Ground Storage Tank Replacement

Project Identification	
Number:	6
Location:	I Street and Walton Boulevard
Flexibility:	Medium
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Operational / Growth
Capacity Threshold:	Retail ADD = 16.5 MGD
Threshold Year:	2026-2032
Start Date:	1/1/2026
Project Complete:	2028
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 24.25**
Forecasted Costs ($ Millions)	**$ 28.04**

Project Description

This project includes installation of a new 6-MG ground storage tank (GST) at the existing I Street Tank Site, where it will replace the existing 3-MG GST. It is anticipated that yard piping improvements and a pump station with an operation center upgrade will also be completed as part of this project.

Justification

The proposed storage tank will provide an additional 3 MG of emergency storage to keep pace with projected retail demands. Yard piping improvements will be required to accommodate the new tank, and pump station improvements will address limitations of the existing configuration and allow more operational flexibility for filling and pumping operations. Pump station improvements will include a new pump station facility because there is not room for additional equipment in the existing building. The pump station improvements also include the addition of a new SCADA operations center.

Unintended Consequences

Increased system storage has the potential to impact water age and exacerbate issues with loss of residual disinfection and/or generation of disinfection byproducts in the system. I Street tank filling and pumping operations may need to be modified after installation of the larger GST to prevent excessive water age.

Special Considerations

None identified.

Potential Alternatives

None identified.

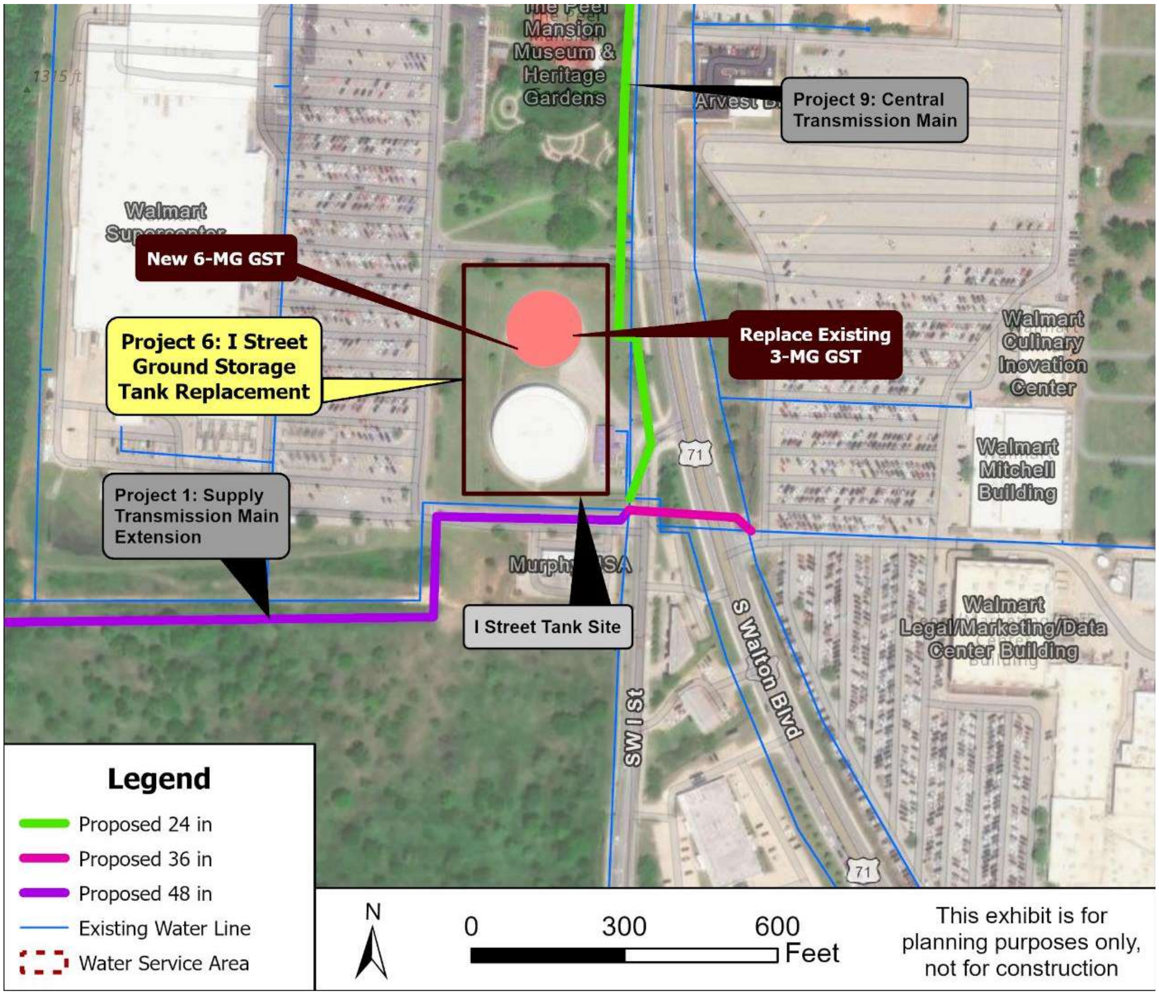
Additional Professional Services

A condition assessment of the existing pump station and building may be beneficial to identify the full scope of needed improvements.

Project 6: I Street Ground Storage Tank Replacement			
Description	**Unit**	**Quantity**	**Cost**
6-MG GST	LS	1	$ 9,500,000
Electrical	LS	1	$ 50,000
Site Improvements	LS	1	$ 200,000
Demolition	LS	1	$ 150,000
Pump Station and Operation Center Upgrades	LS	1	$ 6,000,000
Site Piping Improvements	LS	1	$ 250,000
Unforeseen Construction Costs	LS	1	$ 810,000
Construction Subtotal			$ 16,960,000
30% Contingency (Construction Subtotal)			$ 5,088,000
Professional Services - Design, Bidding, and Construction Services			$ 2,205,000
Total Project Cost with 30% Construction Cost Contingency			$ 24,253,000

[1]All cost values have been rounded up the nearest $1,000.

Project 6: I Street Ground Storage Tank Replacement



Project 7: Southwest Ground Storage Tank, Pump Station, & Transmission Main

Project Identification	
Number:	7
Location:	Morning Star Road to SW Opal Road
Flexibility:	Medium
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Operational / Growth
Capacity Threshold:	Retail ADD = 19.5 MGD
Threshold Year:	2027-2033
Start Date:	1/1/2027
Project Complete:	2029
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 42.98**
Forecasted Costs ($ Millions)	**$ 51.02**

Project Description
This project includes installation of a new 6-MG ground storage tank (GST), a 10-MGD pump station, and a 36-inch transmission main that will connect the Western Corridor Transmission Main and the Southwest elevated storage tank (EST) site.

Justification
The system's emergency storage needs are anticipated to exceed the storage capacity of I Street GSTs and the proposed ESTs. New GSTs will likely be the most cost-effective way to continue to increase emergency storage. A new GST near the Western Corridor Transmission Main can be filled directly from the BWD supply and pumped into the distribution system without adding excessive water age. Additionally, a new pump station at this location will provide additional operational flexibility during both normal and emergency operations.

Unintended Consequences
None identified.

Special Considerations
Land acquisition is anticipated for the proposed tank site and easements may be required for the preferred transmission main alignment.

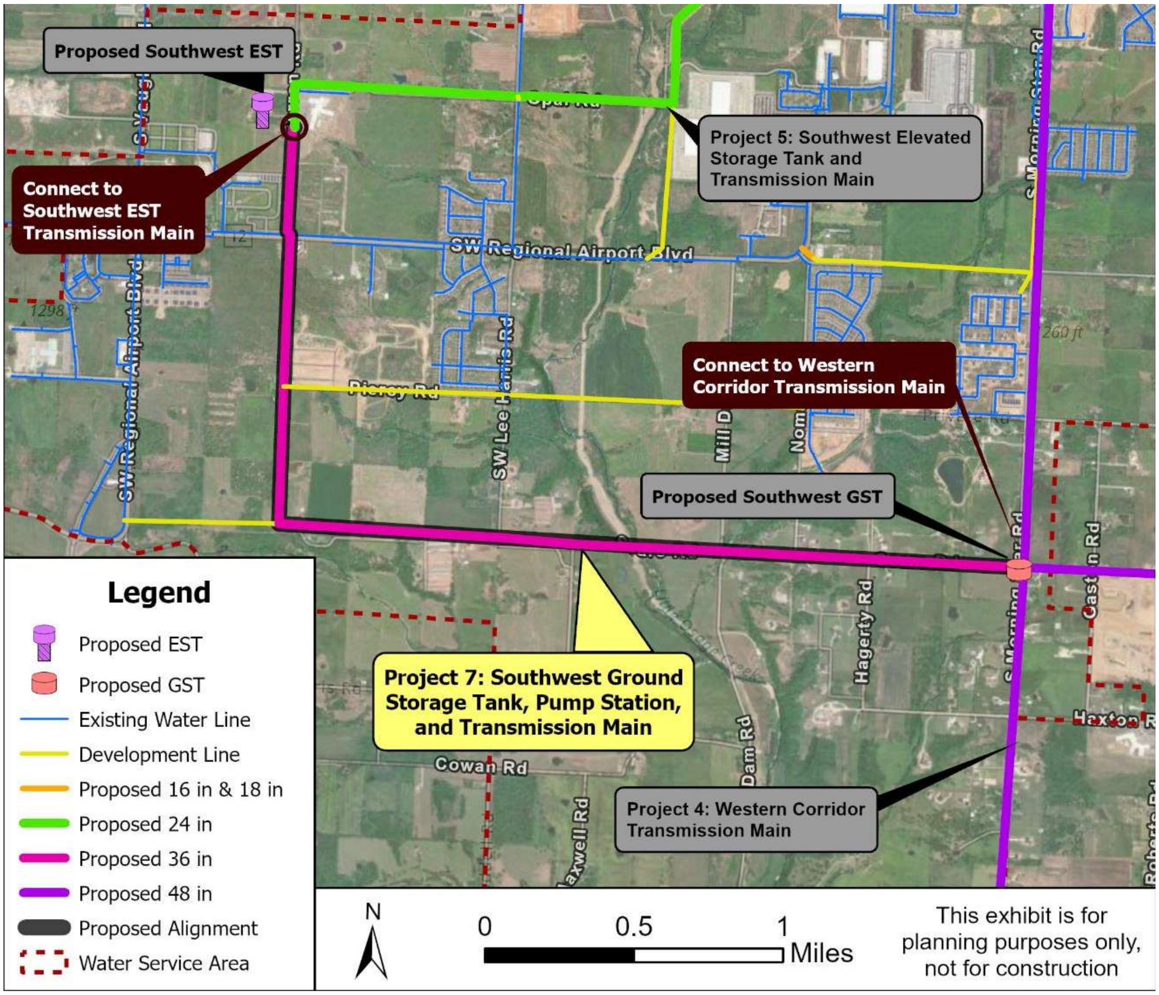
Potential Alternatives
None identified.

Additional Professional Services
A pre-design study is anticipated to determine the preferred alignment for this project and the preferred location of the GST and pump station on the proposed site. The study could also include an updated hydraulic analysis based on field conditions after installation of earlier CIP projects.

Project 7: Southwest GST, Pump Station, & Transmission Main				
Description		**Unit**	**Quantity**	**Cost**
6 MG Ground Storage Tank		LS	1	$ 9,500,000
Electrical		LS	1	$ 50,000
Site Improvements		LS	1	$ 200,000
10 MGD Booster Station		LS	1	$ 5,000,000
Unforeseen Construction Costs		LS	1	$ 1,270,000
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
36	Pipe Installation	$520	20,147	$ 10,477,000
36	Little Osage Creek Crossing	$1,040	100	$ 104,000
			Construction Subtotal	$ 26,601,000
			30% Contingency (Construction Subtotal)	$ 7,981,000
			Professional Services - Design, Bidding, and Construction Services	$ 6,917,000
			Easement Acquisition	$ 1,479,000
			Total Project Cost with 30% Construction Cost Contingency	$ 42,978,000

[1]All cost values have been rounded up the nearest $1,000.

Project 7: Southwest Ground Storage Tank, Pump Station, and Transmission Main



Project 8: Northeast Loop Phase I

Project Identification	
Number:	8
Location:	Tiger EST to J Street
Flexibility:	Medium
Schedule	
Primary Trigger:	Operational
Secondary Trigger:	Capacity
Capacity Threshold:	N/A
Threshold Year:	2027-2033
Start Date:	1/1/2028
Project Complete:	2030
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 5.63**
Forecasted Costs ($ Millions)	**$ 6.87**

Project Description
This project includes installation of a new 24-inch line along Tiger Boulevard from the Tiger elevated storage tank (EST) to J Street, where it will connect to the existing 12-inch line. This line is anticipated to be extended in the future to loop to other larger water mains in the Core growth area.

Justification
Increasing demands in the northern part of the service area will cause excessive head losses and fluctuations in system pressures and EST levels. This project will provide capacity to meet the projected system demands in the area. See Section 3.1 for additional information.

Unintended Consequences
None identified.

Special Considerations
None identified.

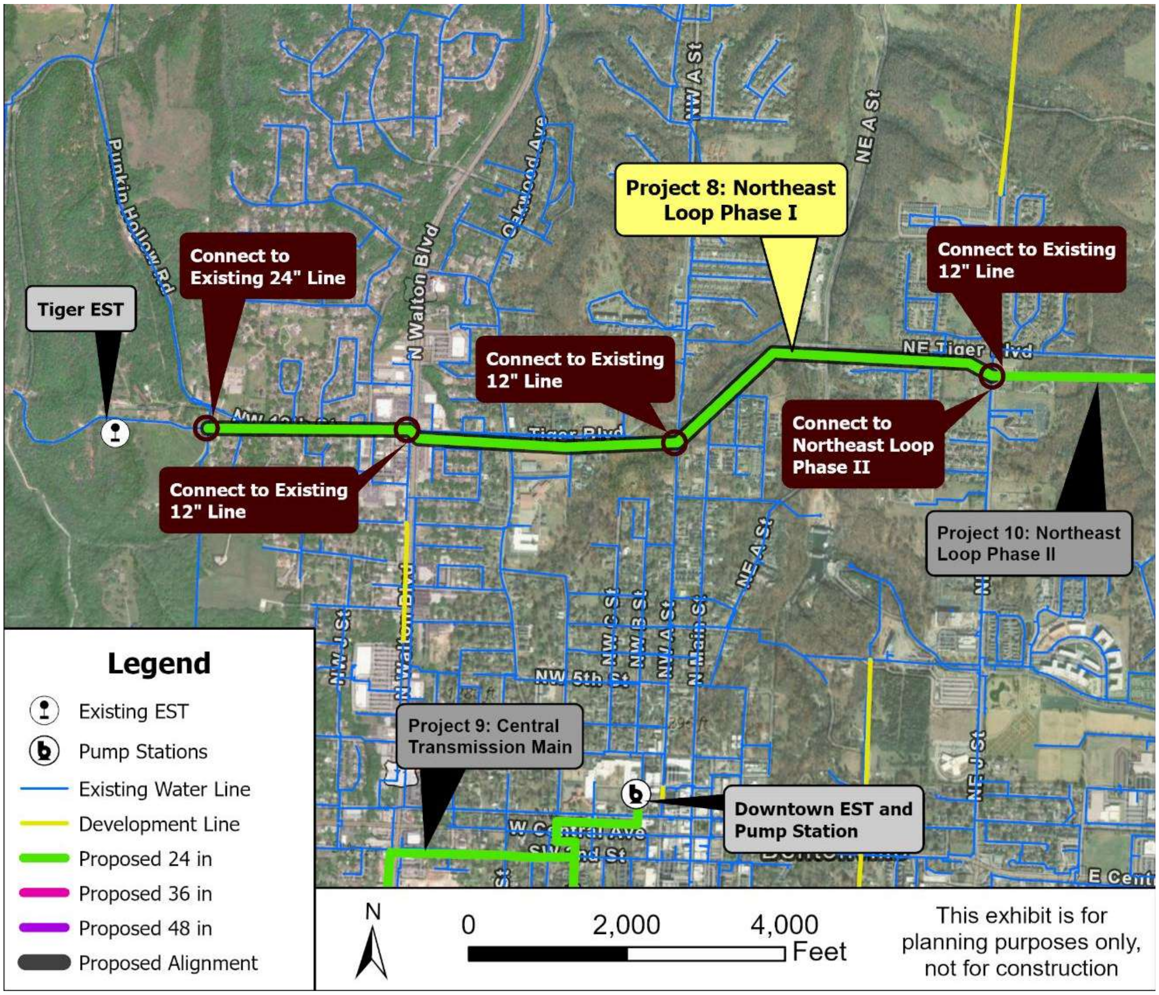
Potential Alternatives
Multiple smaller loops could be installed over time to provide equivalent capacity around the northeast side of the Core growth area.

Additional Professional Services
A routing study may be beneficial to determine the preferred alignment for this project.

Project 8: Northeast Loop Phase I				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	Pipe Installation	$350	7,907	$ 2,768,000
24	Walton Boulevard Bore	$1,600	250	$ 400,000
-	Unforeseen Construction Costs	-	-	$ 160,000
Construction Subtotal				$ 3,328,000
30% Contingency (Construction Subtotal)				$ 999,000
Professional Services - Design, Bidding, and Construction Services				$ 866,000
Easement Acquisition				$ 433,000
Total Project Cost with 30% Construction Cost Contingency				$ 5,626,000

[1]All cost values have been rounded up the nearest $1,000.

Project 8: Northeast Loop Phase I



Project 9: Central Transmission Main

Project Identification	
Number:	9
Location:	I Street Tank Site to Core Transmission Loops
Flexibility:	High
Schedule	
Primary Trigger:	Operational
Secondary Trigger:	Capacity
Capacity Threshold:	N/A
Threshold Year:	2028-2033
Start Date:	1/1/2029
Project Complete:	2031
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 6.80**
Forecasted Costs ($ Millions)	**$ 8.56**

Project Description

This project includes installation of new 24-inch lines from the I Street Tank Site along Walton Boulevard, where the lines will connect to the Core Transmission Loops.

Justification

Increasing demands in the northern and eastern parts of the service area will cause excessive head losses and fluctuations in system pressures and EST levels. This project will include a connection to the large diameter transmission main from the I Street tank site to the 16-inch transmission main and the 12-inch loop at the Downtown EST. This transmission main could be extended in the future to a ground storage tank (GST) in the northeast part of the system. The location of this future GST has not been determined.

Unintended Consequences

None identified.

Special Considerations

The Walton Boulevard crossing should be evaluated to determine the optimal location.

Potential Alternatives

The existing 16-inch transmission main east of I Street could be replaced with a larger transmission main to provide a portion of the transmission capacity required.

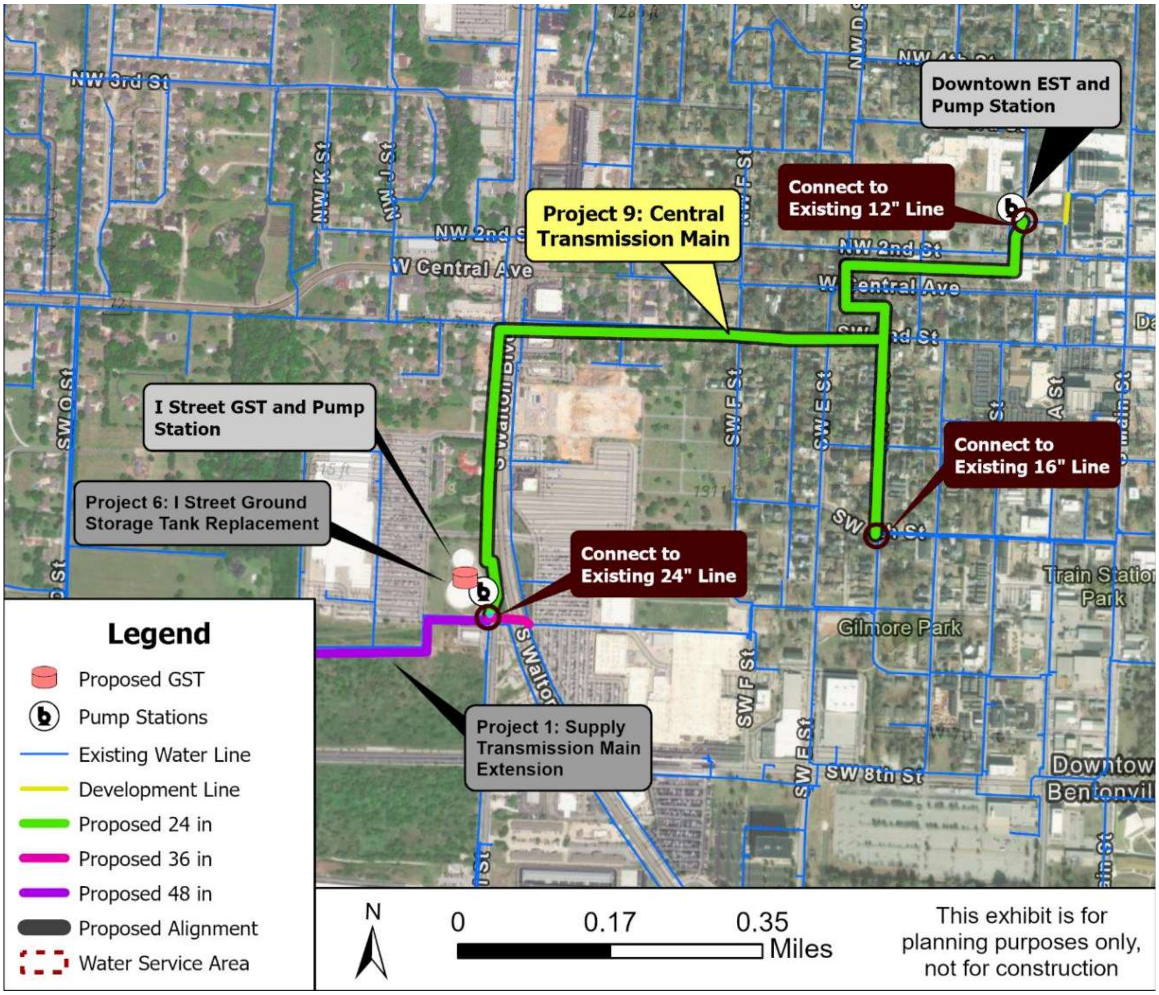
Additional Professional Services

A routing study may be beneficial to determine the preferred transmission main configuration and alignment for this project.

Project 9: Central Transmission Main				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	Pipe Installation	$350	9,780	$ 3,423,000
24	Boring Across Walton	$1,600	250	$ 400,000
-	Unforeseen Construction Costs	-	-	$ 200,000
			Construction Subtotal	$ 4,023,000
			30% Contingency (Construction Subtotal)	$ 1,207,000
			Professional Services - Design, Bidding, and Construction Services	$ 1,046,000
			Easement Acquisition	$ 523,000
			Total Project Cost with 30% Construction Cost Contingency	$ 6,799,000

[1]All cost values have been rounded up the nearest $1,000.

Project 9: Central Transmission Main



Project 10: Northeast Loop Phase II

Project Identification	
Number:	10
Location:	NE Tiger Boulevard to Southeast 8th Street
Flexibility:	High
Schedule	
Primary Trigger:	Capacity
Secondary Trigger:	Operational/Growth
Capacity Threshold:	N/A
Threshold Year:	2031-2033
Start Date:	6/1/2030
Project Complete:	2032
Project Implementation (Months)	
Predesign:	3
Engineering/Design:	9
Bid/Construction:	18
Total Project Duration:	30
Total Project Cost (30% construction cost contingency)	
2023 Costs ($ Millions)	**$ 9.19**
Forecasted Costs ($ Millions)	**$ 11.92**

Project Description
This project includes completion of the 24-inch loop started with the Northeast Loop Phase I project. This project will extend from NE Tiger Boulevard and run south parallel to Interstate-49 down to Southeast 8^{th} Street, where it will connect to the existing 24-inch line.

Justification
Increasing demands in the Core growth area will cause excessive head losses and fluctuations in system pressures and EST levels. This project will provide capacity to meet the projected system demands in the area and will improve EST level equalization. See Section 3.1 for additional information.

Unintended Consequences
None identified.

Special Considerations
None identified.

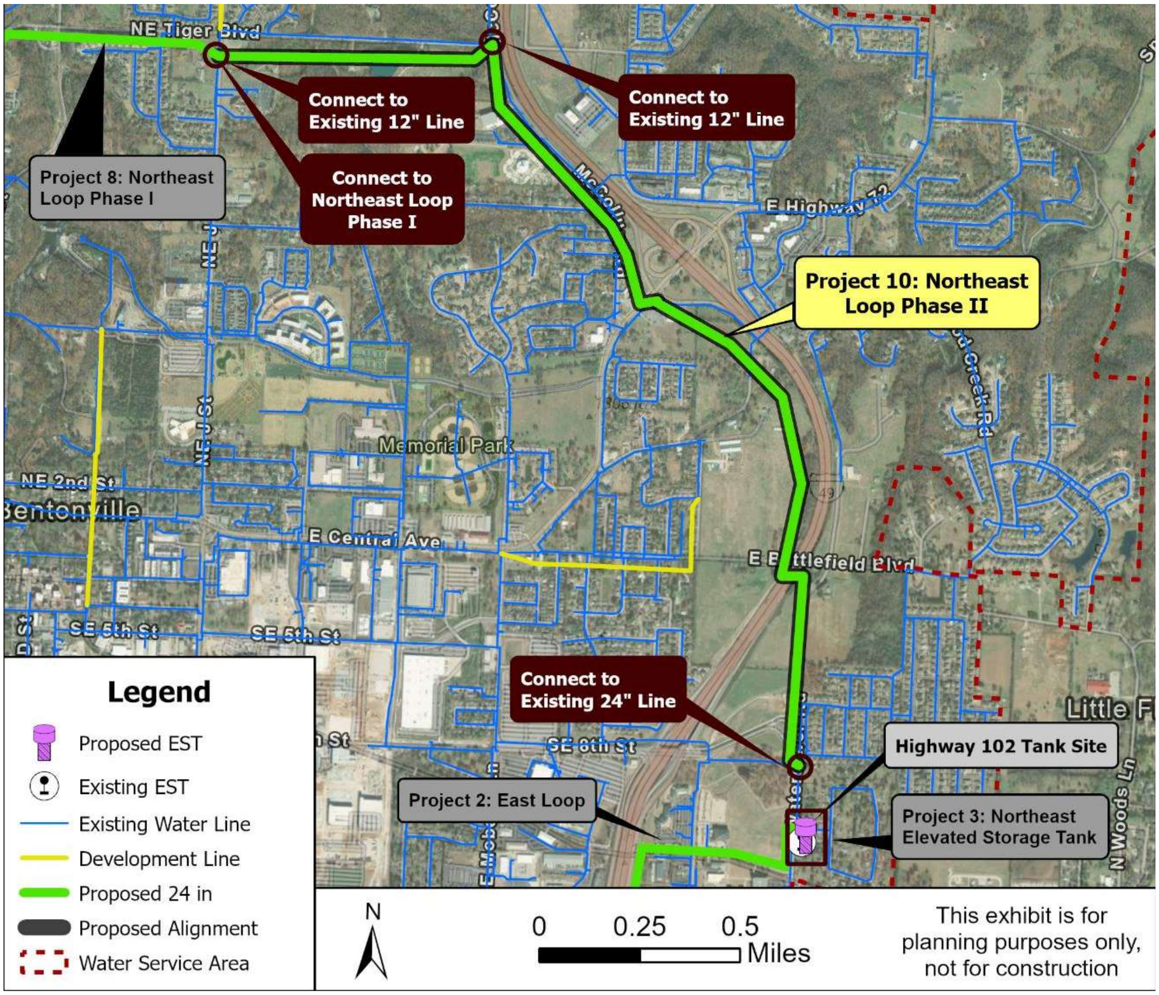
Potential Alternatives
Multiple smaller loops could be installed over time to provide equivalent capacity around the northeast side of the Core growth area.

Additional Professional Services
A routing study may be beneficial to determine the preferred alignment for this project.

Project 10: Northeast Loop Phase II				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	Pipe Installation	$350	11,021	$ 3,858,000
24	Interstate 49 Bore	$2,000	500	$ 1,000,000
24	HWY 72 Bore	$1,600	200	$ 320,000
-	Unforeseen Construction Costs	-	-	$ 260,000
Construction Subtotal				$ 5,438,000
30% Contingency (Construction Subtotal)				$ 1,632,000
Professional Services - Design, Bidding, and Construction Services				$ 1,414,000
Easement Acquisition				$ 707,000
Total Project Cost with 30% Construction Cost Contingency				$ 9,191,000

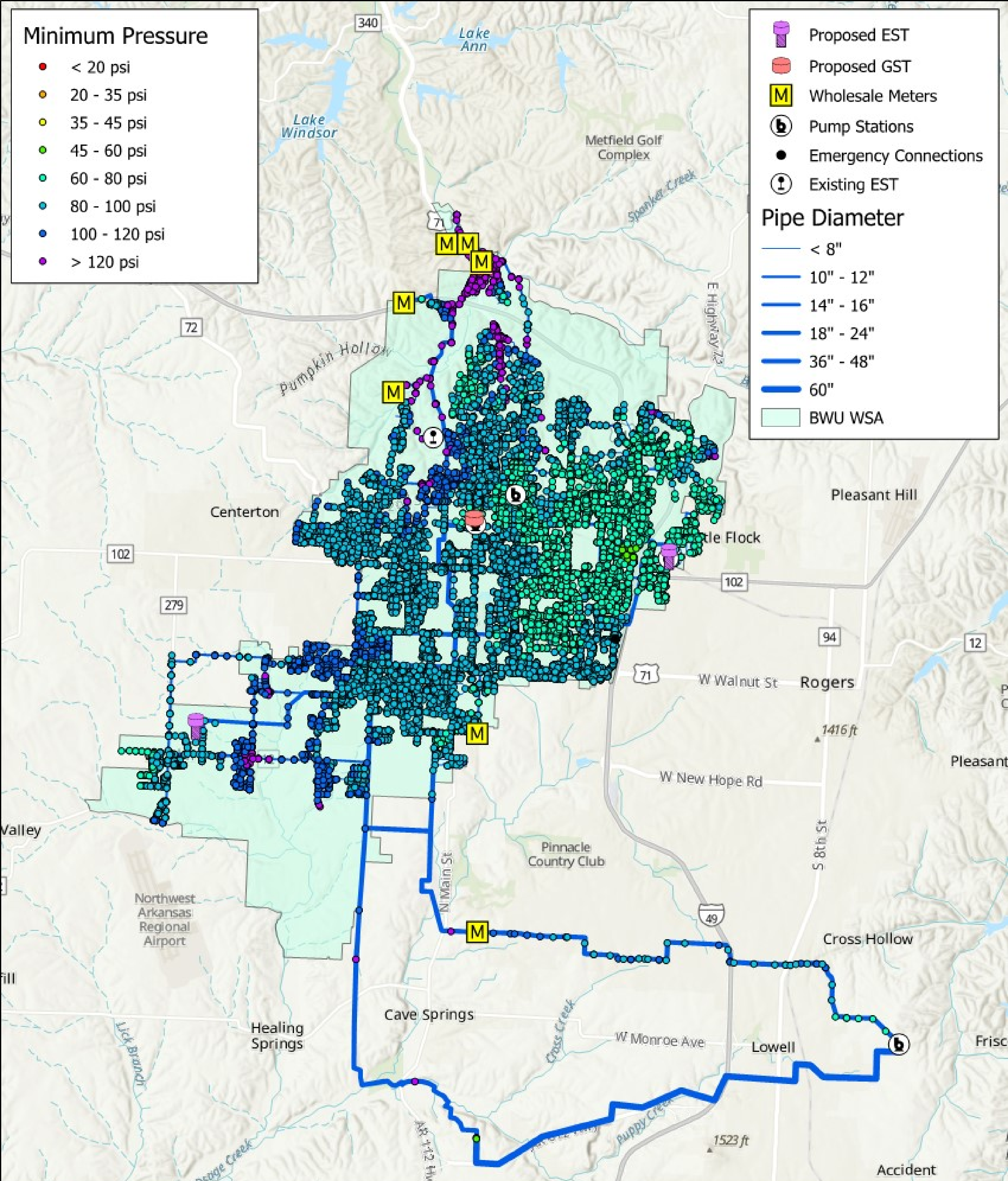
[1]All cost values have been rounded up the nearest $1,000.

Project 10: Northeast Loop Phase II



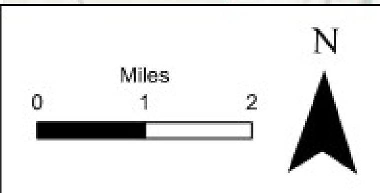
Appendix A

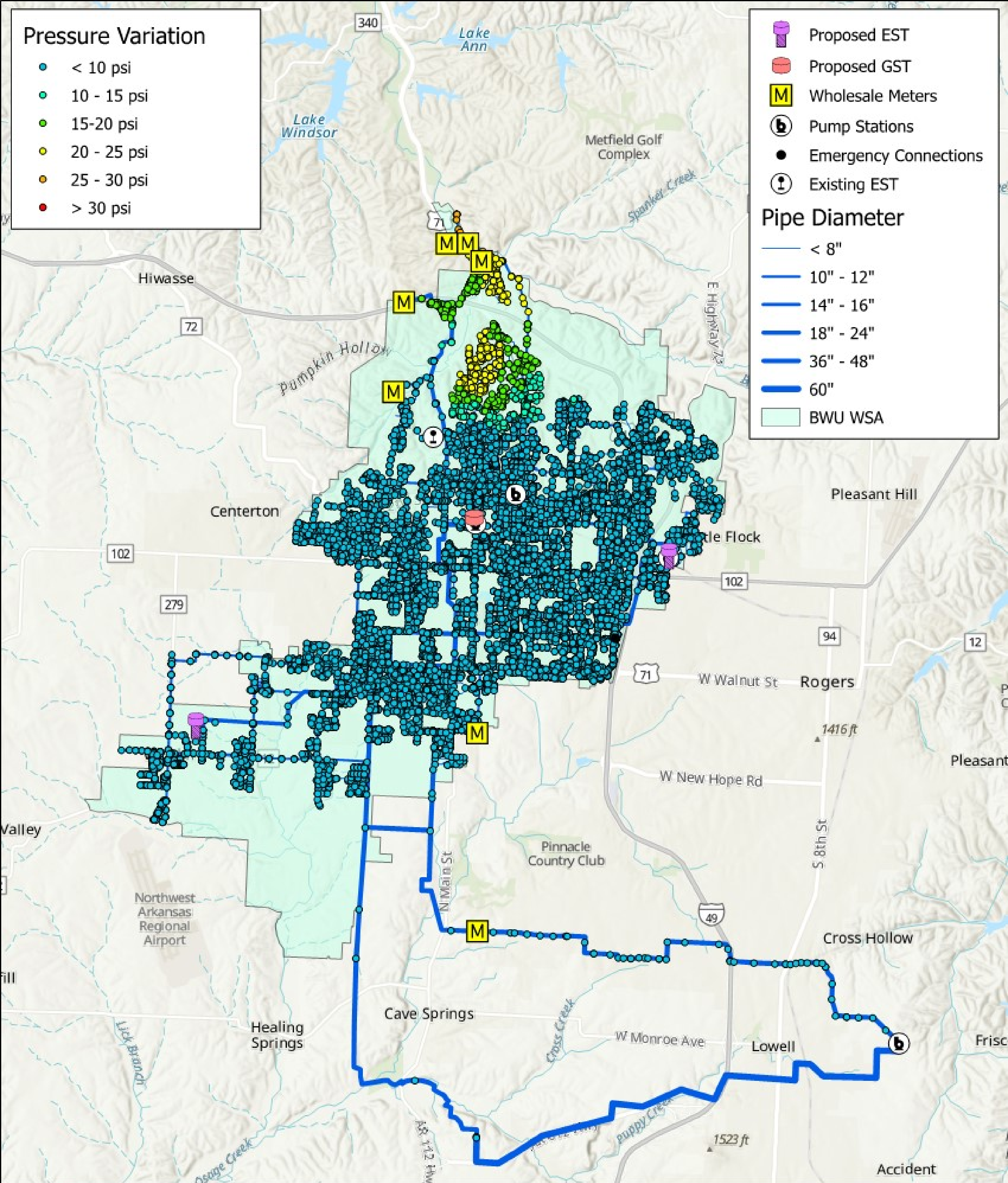
Hydraulic Model Results for Future Horizons



Proposed Water System – 2028 Horizon
Minimum Pressure – Maximum Day Demands

Exhibit 1





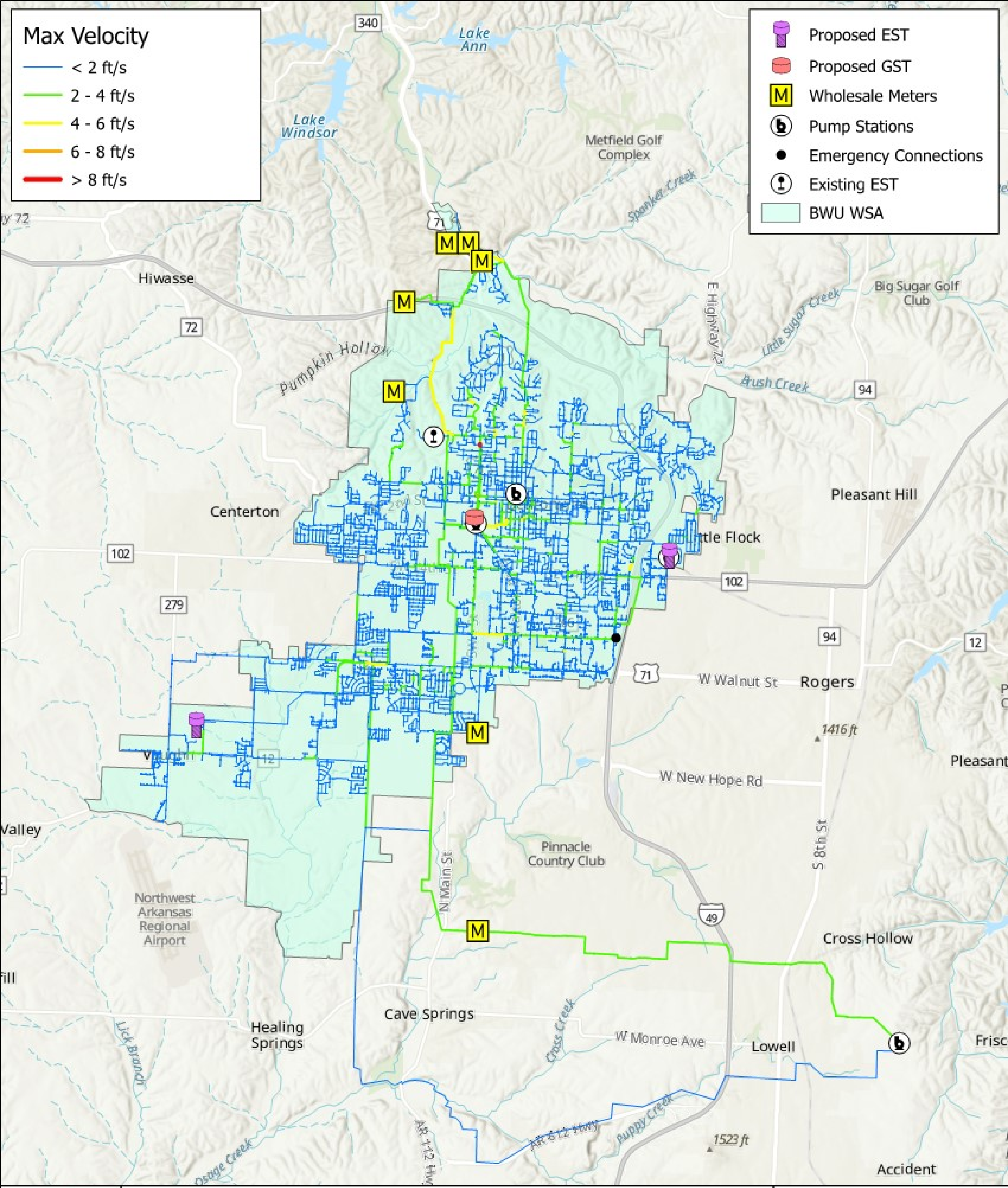
GARVER

Proposed Water System – 2028 Horizon
Pressure Variation – Maximum Day Demands

Exhibit 2

Miles
0 1 2

N



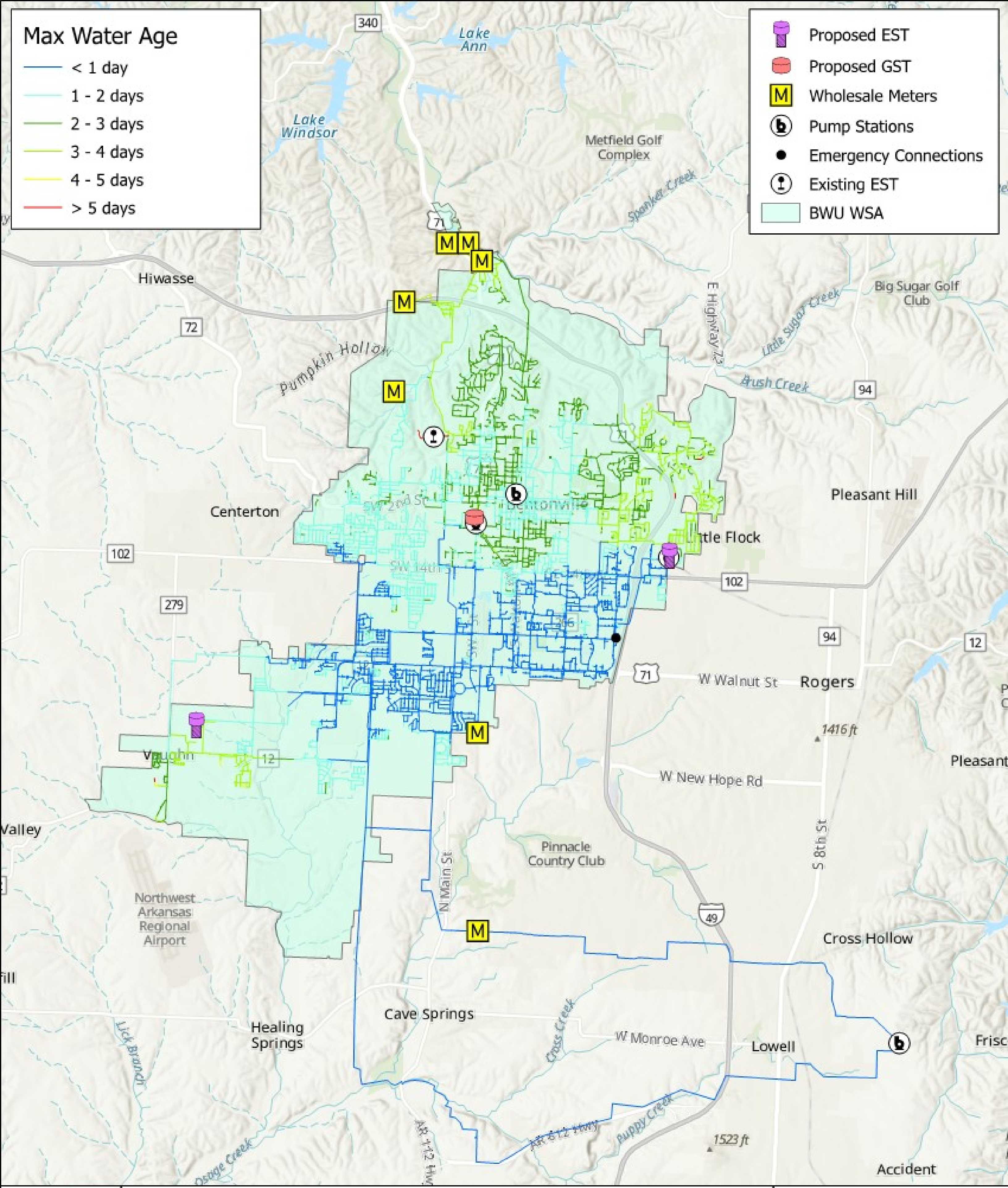
Proposed Water System – 2028 Horizon
Maximum Velocity – Maximum Day Demands

Exhibit 3

GARVER

Miles
0 1 2

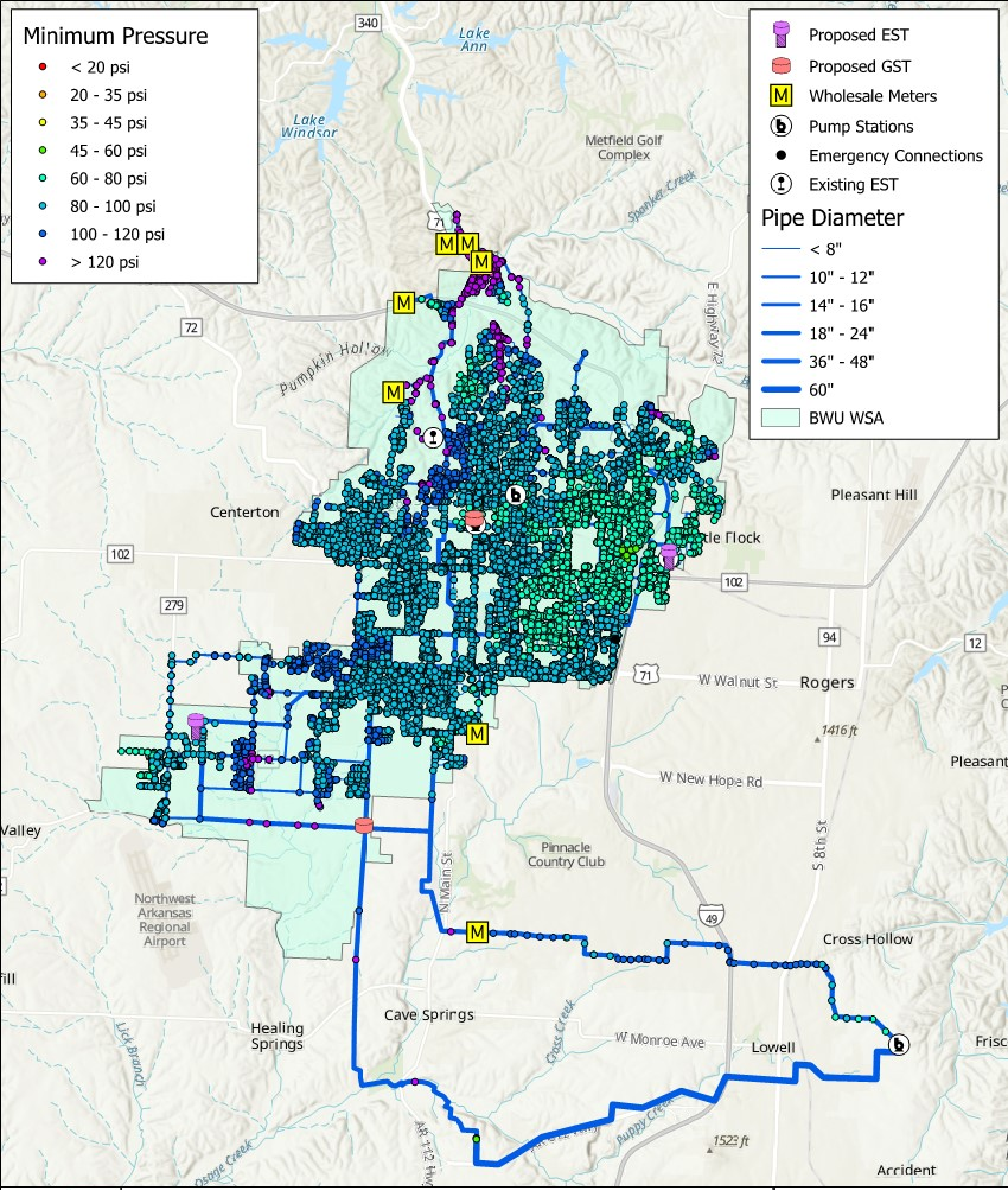
N



Proposed Water System – 2028 Horizon
Maximum Water Age – Maximum Month Demands

Exhibit 4

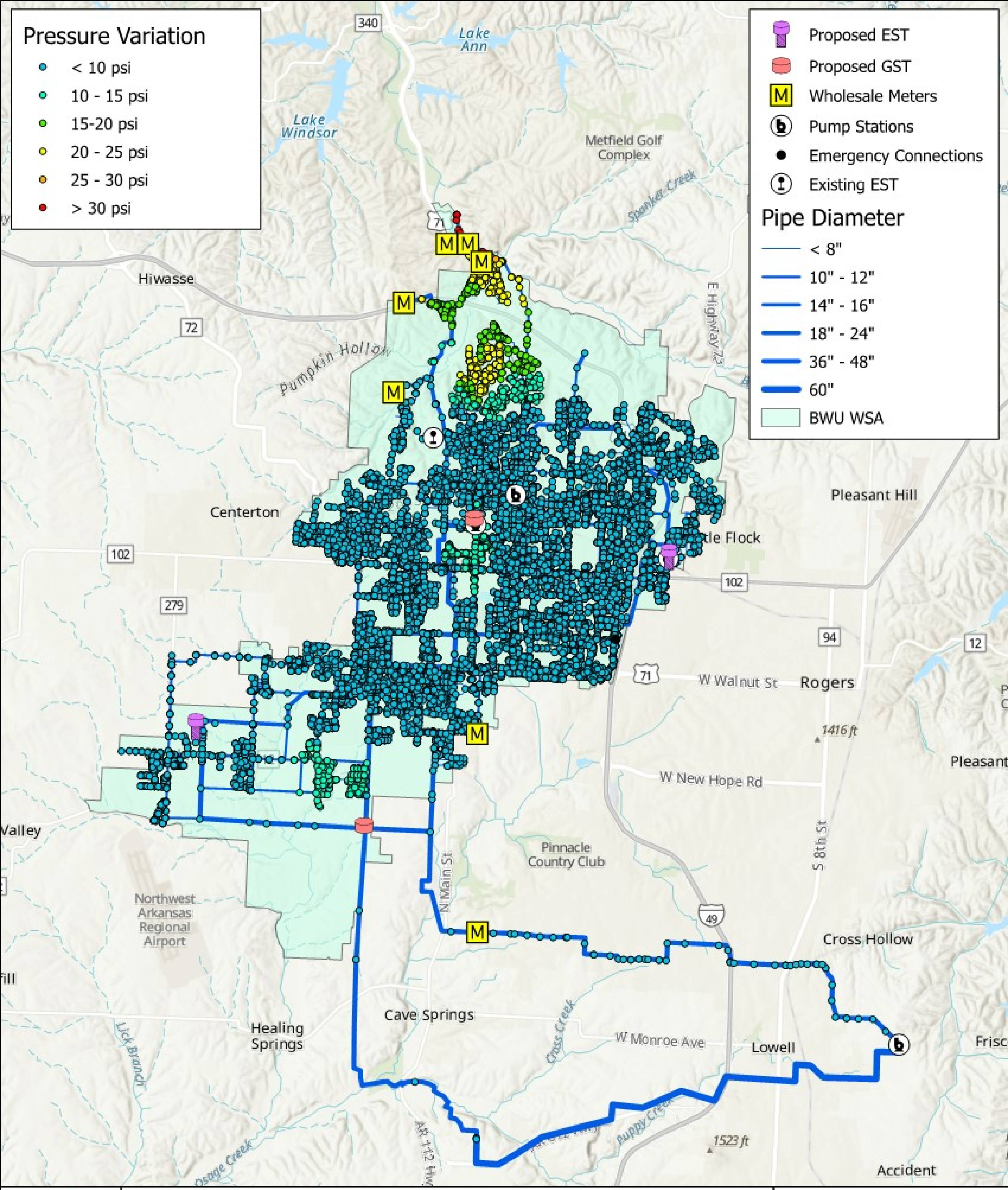
GARVER



GARVER

Proposed Water System – 2033 Horizon
Minimum Pressure – Maximum Day Demands

Exhibit 5



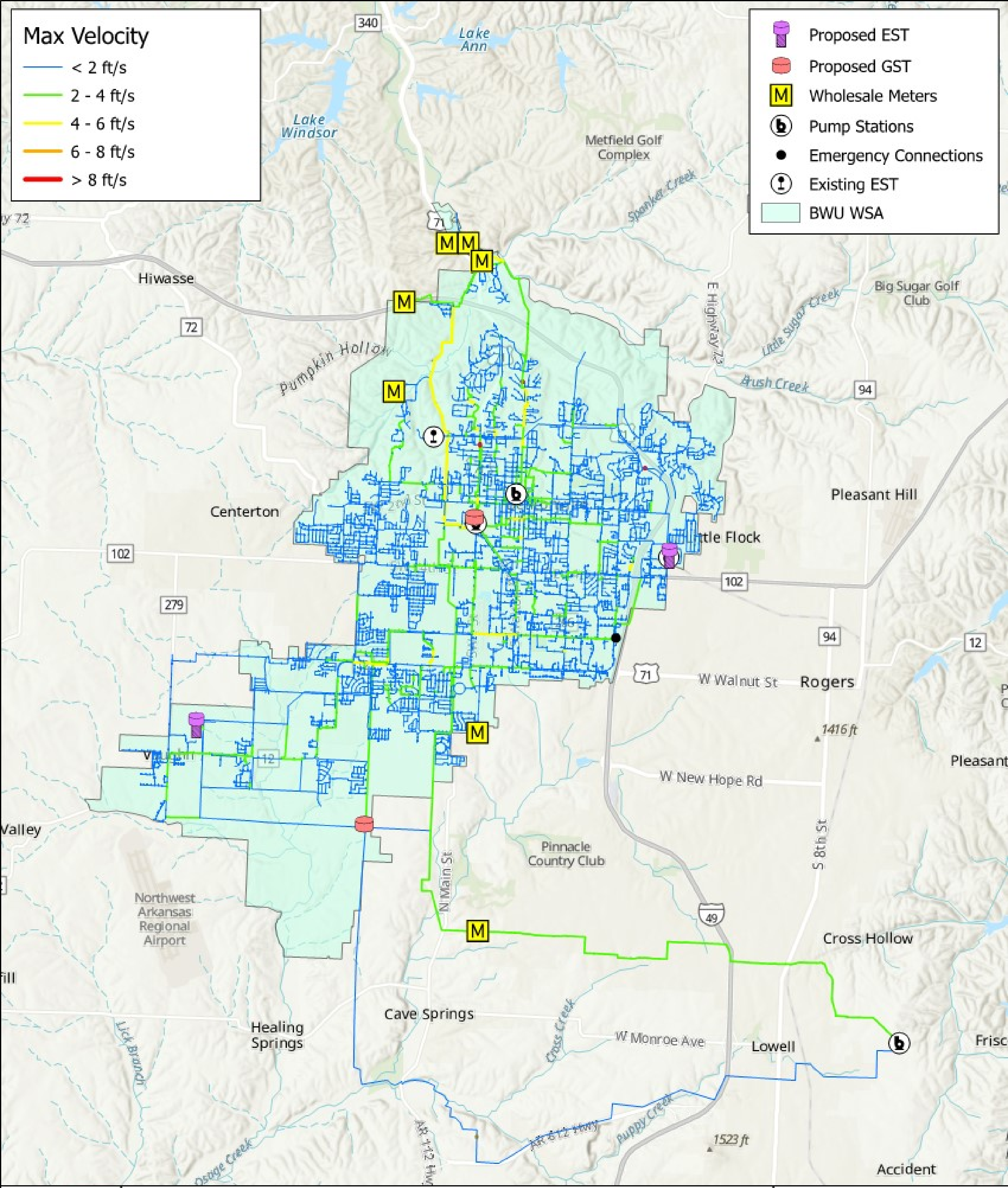
Proposed Water System – 2033 Horizon
Pressure Variation – Maximum Day Demands

Exhibit 6

GARVER

Miles
0 1 2

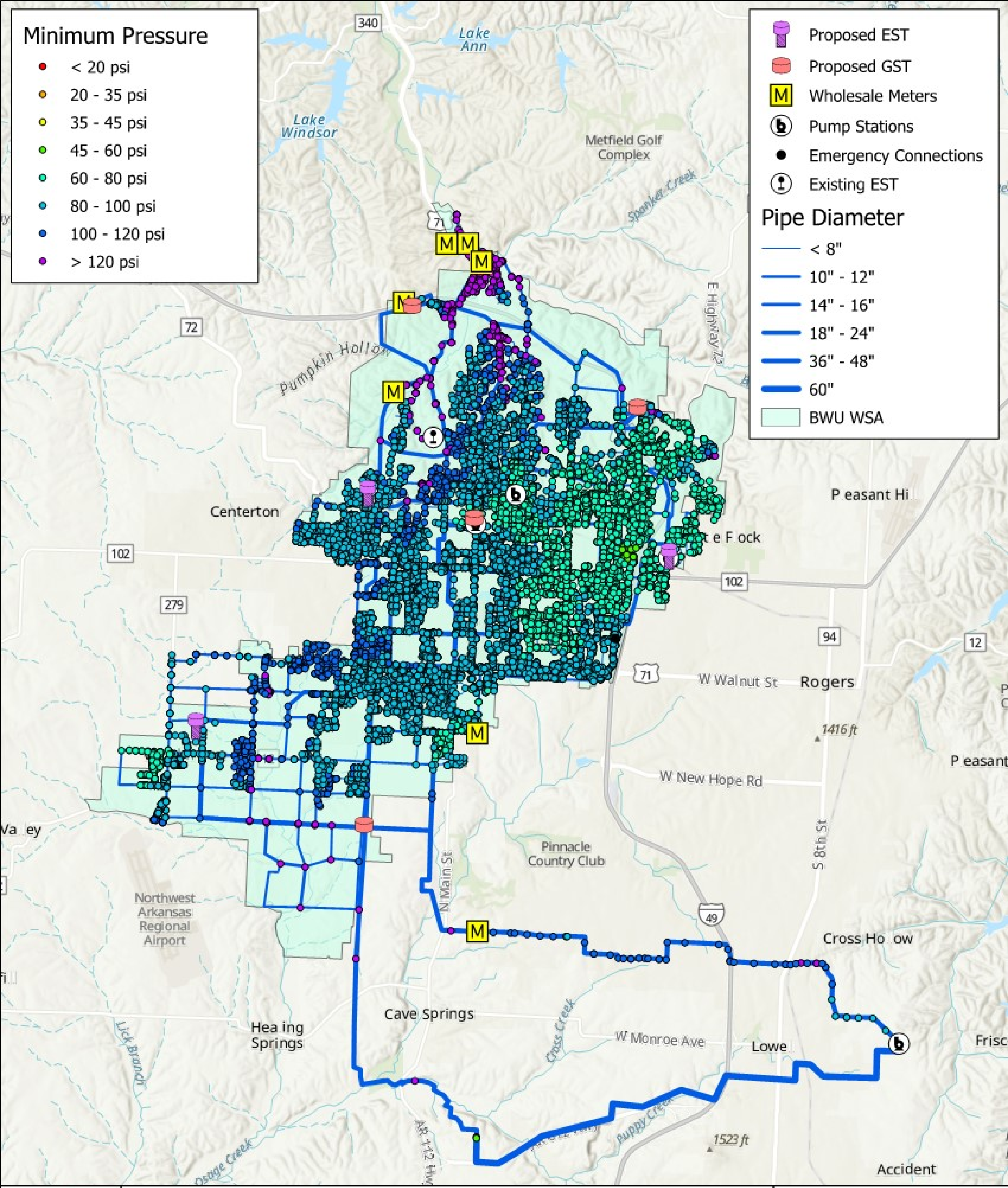
N



Proposed Water System – 2033 Horizon
Maximum Velocity – Maximum Day Demands

Exhibit 7

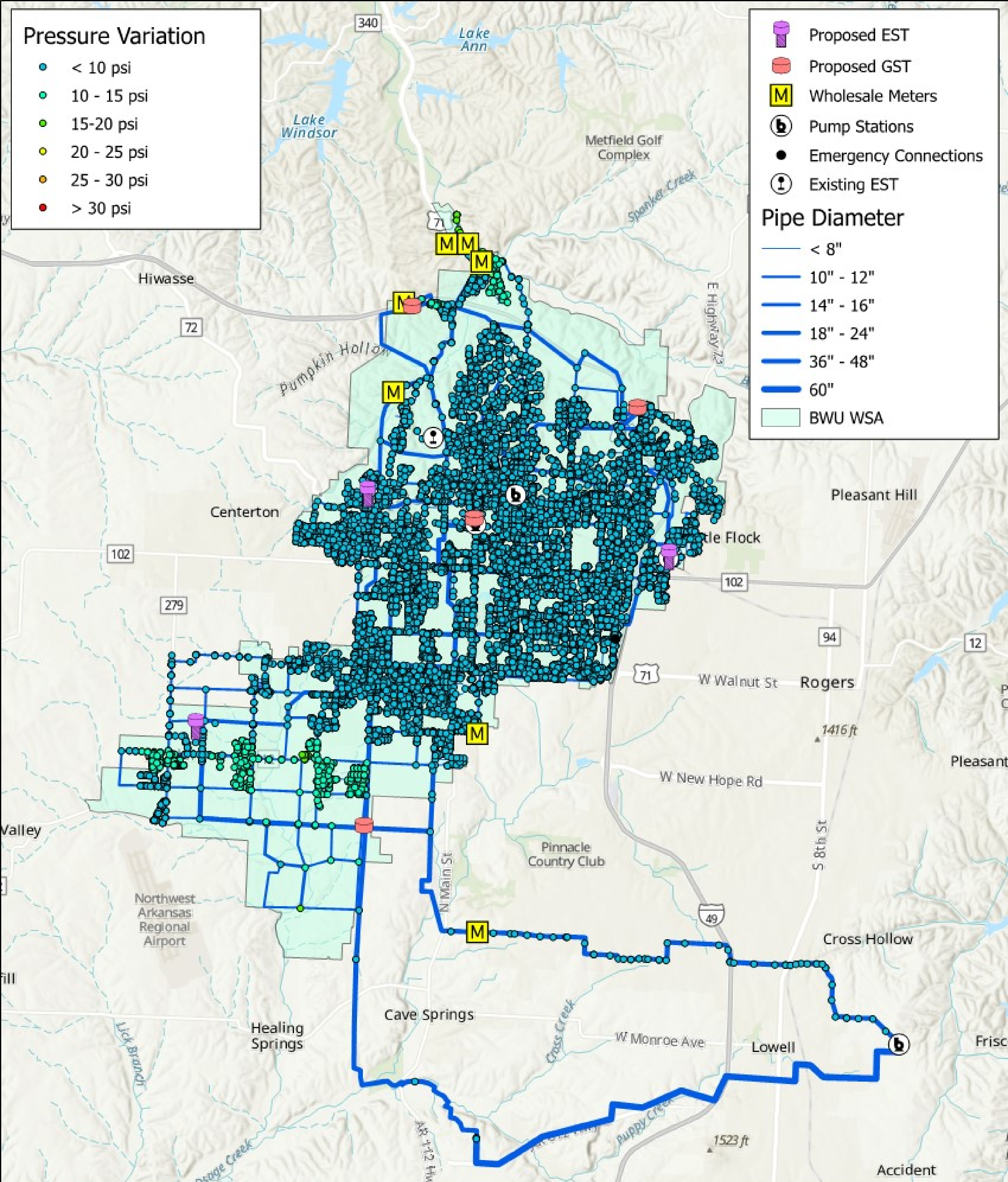
GARVER



Proposed Water System – 2043 Horizon
Minimum Pressure – Maximum Day Demands

Exhibit 8

GARVER



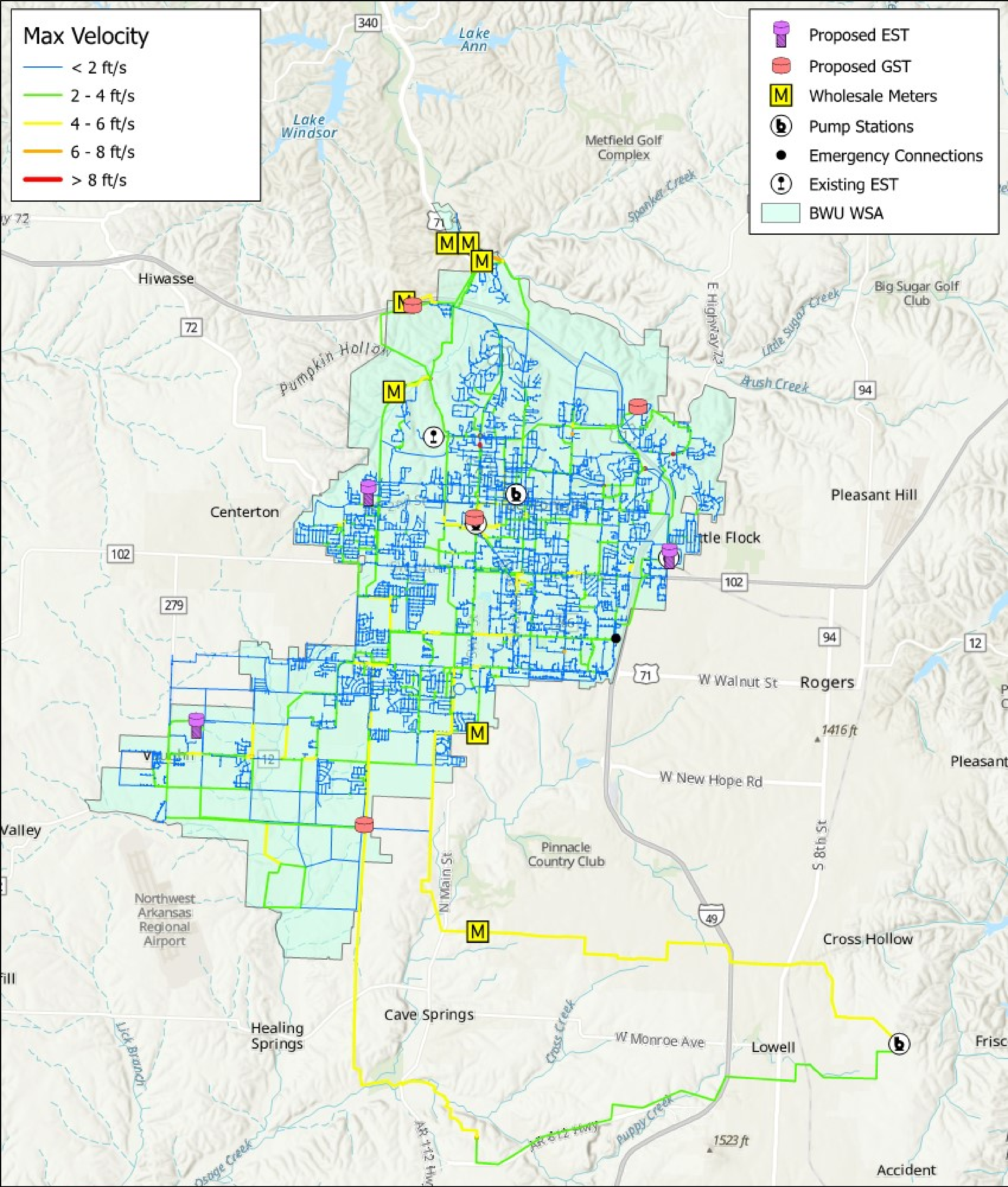
Proposed Water System – 2043 Horizon
Pressure Variation – Maximum Day Demands

Exhibit 9

GARVER

Miles
0 1 2

N



GARVER

Proposed Water System – 2043 Horizon
Maximum Velocity – Maximum Day Demands

Exhibit 10

Miles
0 1 2
N

APPENDIX D
Distribution System Water Quality Analysis Technical Memorandum No. 4

Bentonville Water Utilities
Water Master Plan Update

Technical Memorandum No. 4
Distribution System Water Quality Analysis

City of Bentonville
Bentonville, Arkansas

Prepared by:

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

April 2024

Garver Project No. 22W01291

Table of Contents

List of Figures

List of Tables

1.0 Introduction

This technical memorandum (TM) was prepared for Bentonville Water Utilities (BWU) as part of the Bentonville Water Master Plan Update. This is the fourth TM for the project, following the Capital Improvement Plan (CIP) TM. The purpose of this TM is to:

- Provide a summary of water quality data for BWU's water distribution system
- Identify current system deficiencies and provide alternatives to improve water quality

BWU purchases treated surface water from Beaver Water District (BWD). At the entry point, the water meets all Safe Drinking Water Act (SDWA) regulations and has a free chlorine residual for secondary disinfection. BWU does not perform additional treatment but is responsible for maintaining water quality in the distribution system. Regulatory compliance includes maintaining a detectable free chlorine residual, limiting free chlorine and disinfection byproduct (DBP) concentrations within specified limits, and preventing release of lead and copper from distribution system and premise plumbing materials.

Historical water quality data provided by BWU was used to gain a better understanding of the current system and aid in identification of current system challenges. The following water quality parameters, which are collected as part of regulatory compliance monitoring, were reviewed:

- Disinfectant Residual
- Disinfection Byproducts (DBPs)
- Lead and Copper

2.0 Disinfectant Residual

Disinfectant residuals serve as a surrogate for the potential for or presence of microbial activity and are typically lowest in areas with high water age or with sediment, corrosion products, biofilm, or other sources of chlorine demand.

Figure 2-1 summarizes disinfectant residual data provided by BWU from regulatory compliance sampling from January 2021 to July 2023. Samples are collected at 60 monitoring locations each month. The box-and-whisker plots show the 25^{th}–50^{th} percentile (lower box), 50^{th}–75^{th} percentile (upper box), and the minimum/maximum residuals (lower/upper whiskers). The outliers are denoted by "o" symbols. Average free chlorine residuals for the entire system, denoted by "x" symbols, generally ranged from 0.9 to 1.3 milligrams per liter (mg/L). Free chlorine residuals have generally been more variable during summer months.

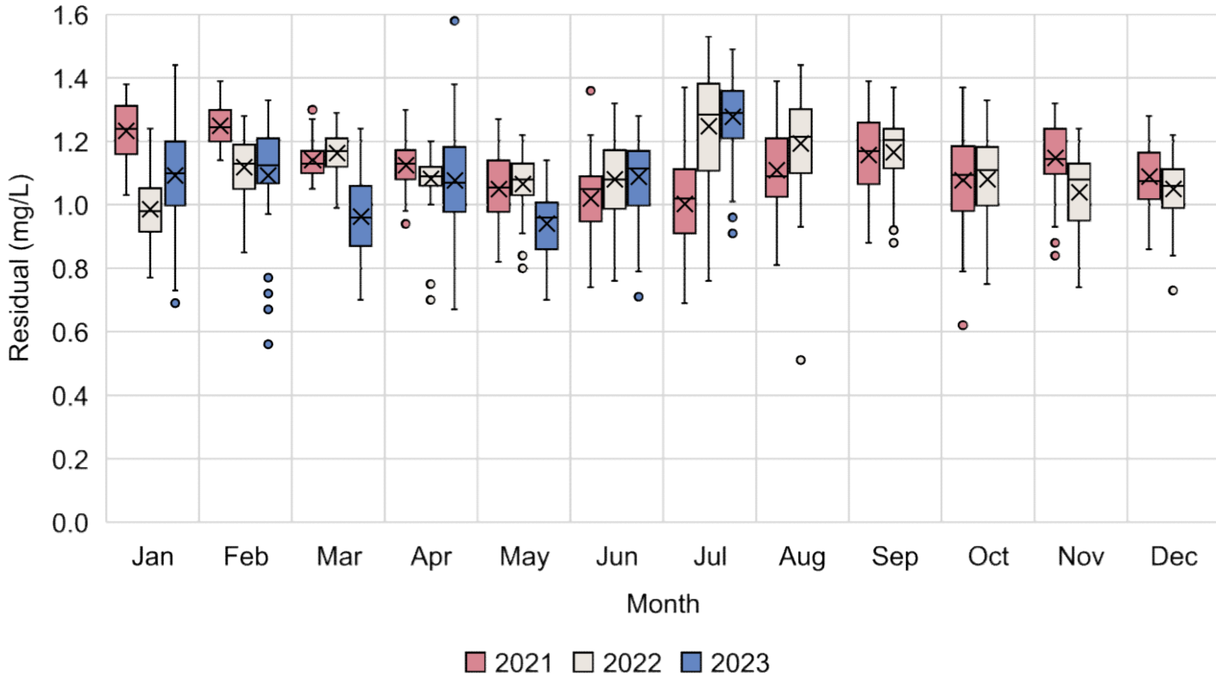


Figure 2-1: Free Chlorine Residual Box Plots by Month for January 2021 to July 2023

Figure 2-2 shows the minimum, average, and maximum residuals at each sample site for January 2021 through July 2023. The figure also shows 2023 maximum month water age results from the hydraulic model. Hydraulic modeling of the existing system is discussed in more detail in the Existing System Assessment TM. Free chlorine residuals generally averaged around 1.0 mg/L throughout most of the system, with lower residuals seen in the northern and eastern portions of the system. These lower free chlorine residuals are consistent with hydraulic model results showing higher water age in these portions of the system.

The hydraulic model results presented in the Existing System Assessment TM show that the southern portion of the system typically receives water directly from the BWD high-service pump station, with flows from the tanks generally supplying areas to the north during periods of peak demand and/or pump operations of the I Street and Downtown Pump Stations. The I Street ground storage tanks (GSTs) are filled from the distribution system overnight with a control valve, and the pumps operate during the day to pump water from the tanks back into the distribution system, so the turnover rate and hold times are managed by the system controls. The elevated storage tanks (ESTs) float on the distribution system, so water enters and leaves the tanks based on fluctuations in customer demands and the pumping operations at the BWD high-service pump station and the I Street pump station. Tank mixing and water age challenges and potential improvements are discussed in more detail in Section 6.0.

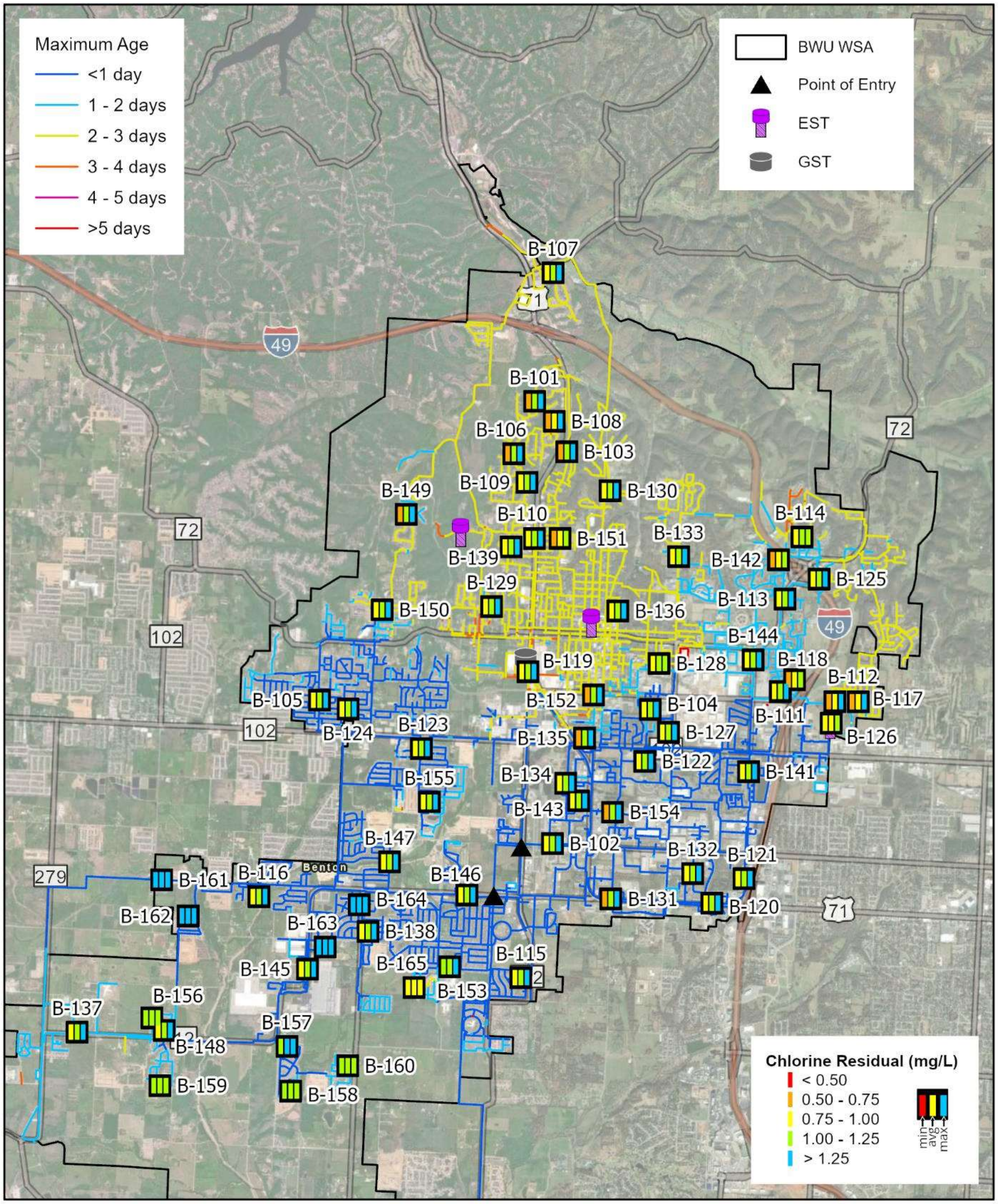


Figure 2-2: Existing System Chlorine Residuals and Water Age Model Results

Figure 2-3 shows box-and-whisker plots for sample sites where the minimum free chlorine residual, including outliers, was less than or equal to 0.85 mg/L between January 2021 to July 2023. The average free chlorine residuals for these sample sites were above 0.9 mg/L, but the free chlorine residuals were generally more variable overall compared to the other sample sites. Several of the sample sites with the lowest and most variable chlorine residuals are located north/northeast of downtown.

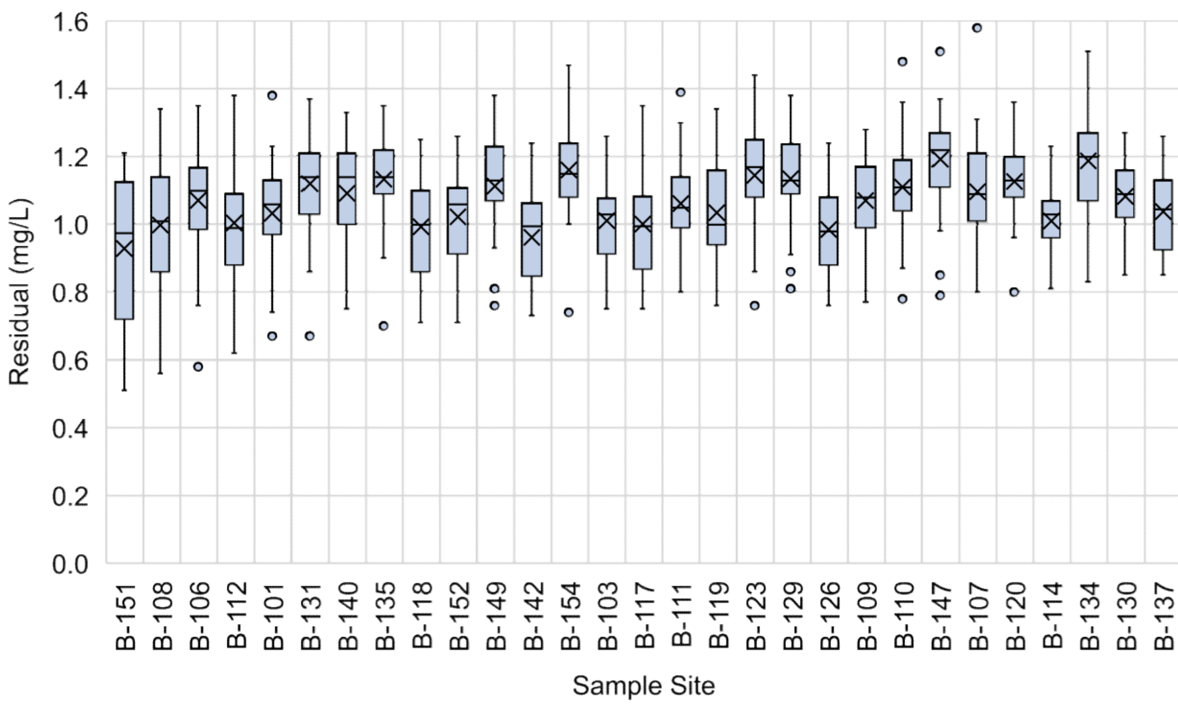


Figure 2-3: Free Chlorine Residual Box Plots for Selected Sample Sites for January 2021 to July 2023

3.0 Disinfection Byproducts

DBPs form when a disinfectant reacts with natural organic matter (NOM). Some DBPs are associated with negative impacts on human health and have maximum contaminant levels (MCLs) based on locational running annual averages (LRAAs) under the Stage 2 Disinfectants/DBP Rule. There are two groups of regulated DBPs that are measured in the BWU distribution system:

- Total trihalomethanes (TTHM), with an MCL of 80 micrograms per liter (µg/L)
- Haloacetic acid (HAA5), with an MCL of 60 µg/L

Figure 3-1 shows the July 2021 DBP concentrations for the four BWU DBP sampling locations. Figure 3-2 and Figure 3-3 show the HAA5 and TTHM LRAAs and individual sample results for each sampling location. Both HAA5 and TTHM LRAAs have consistently been below their MCLs, although some individual TTHM samples exceeded 80 µg/L. All quarterly results for HAA5 were below 60 µg/L. TTHMs and HAAs were highest at Site 041YD011, which has the highest modeled water age.

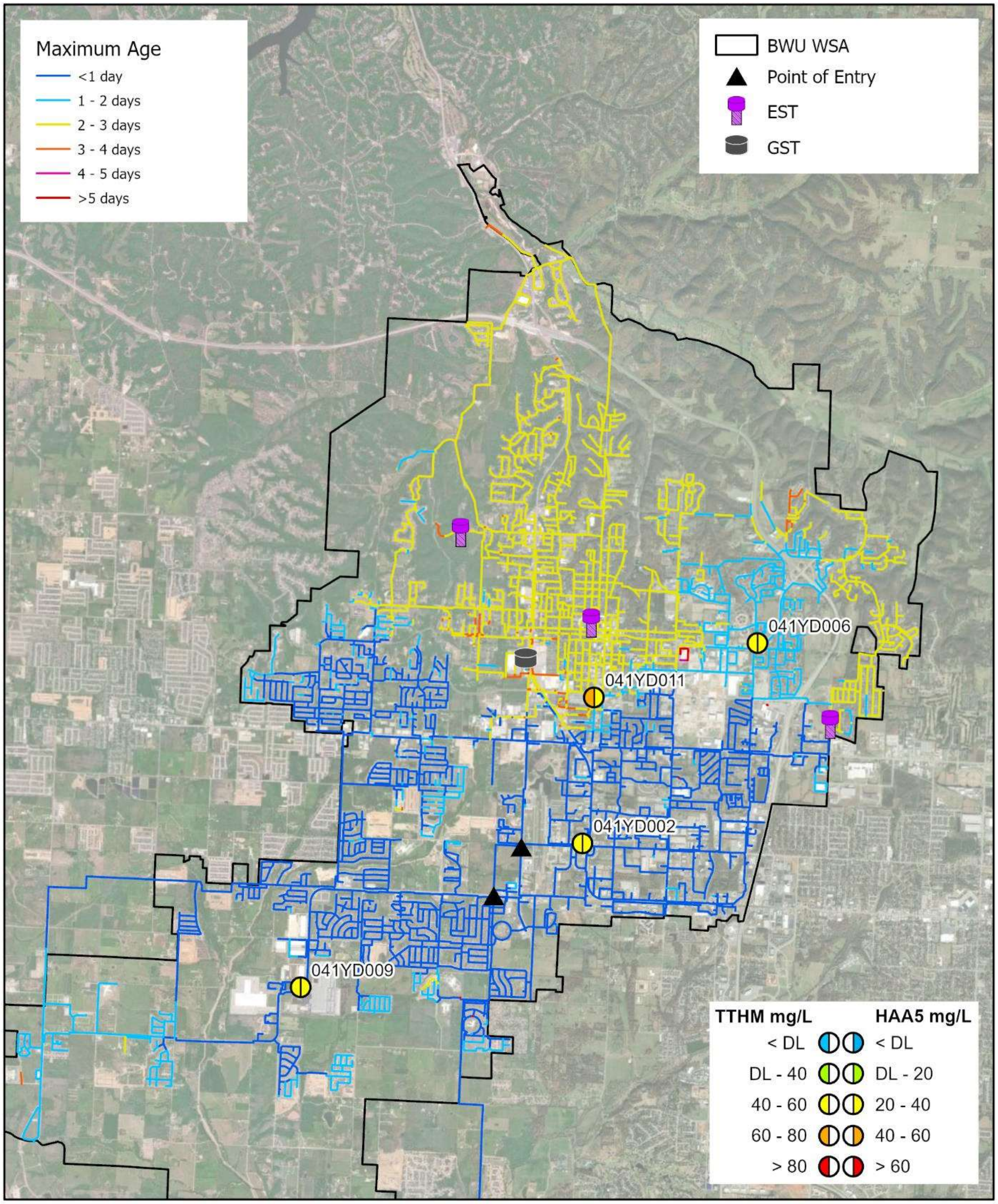


Figure 3-1: DBP Concentrations by Sample Location for July 2021

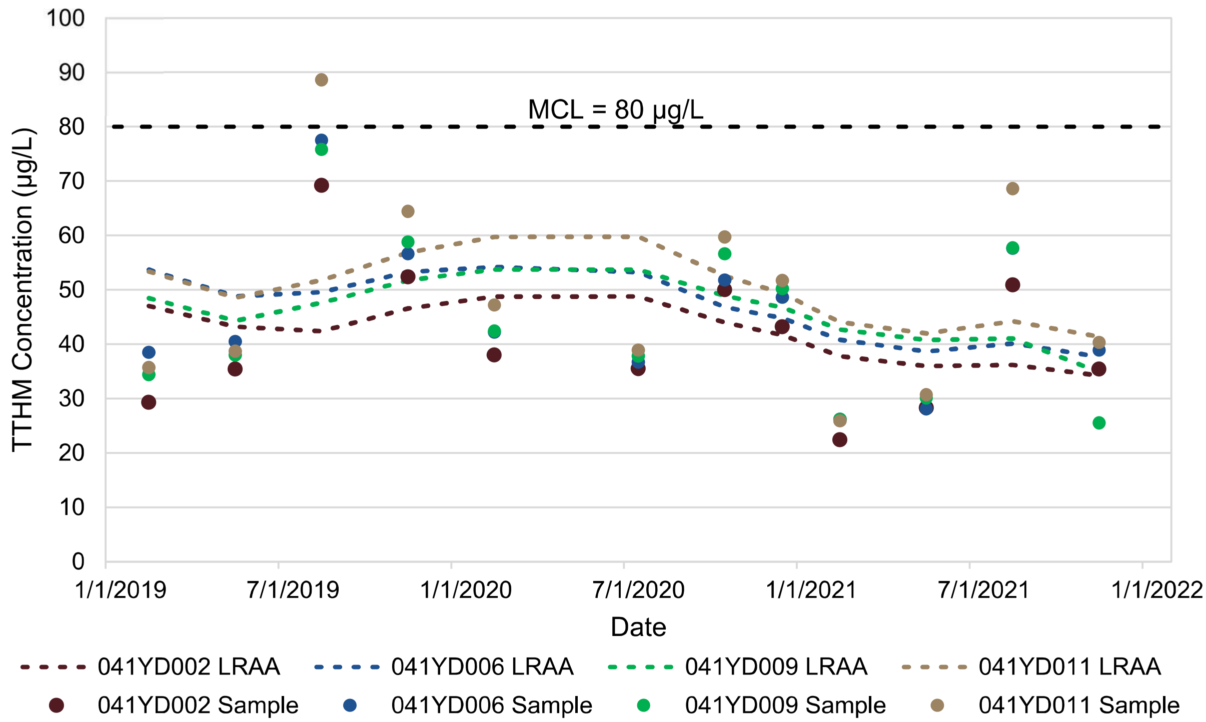


Figure 3-2: TTHM LRAAs and Individual Samples for 2019–2021

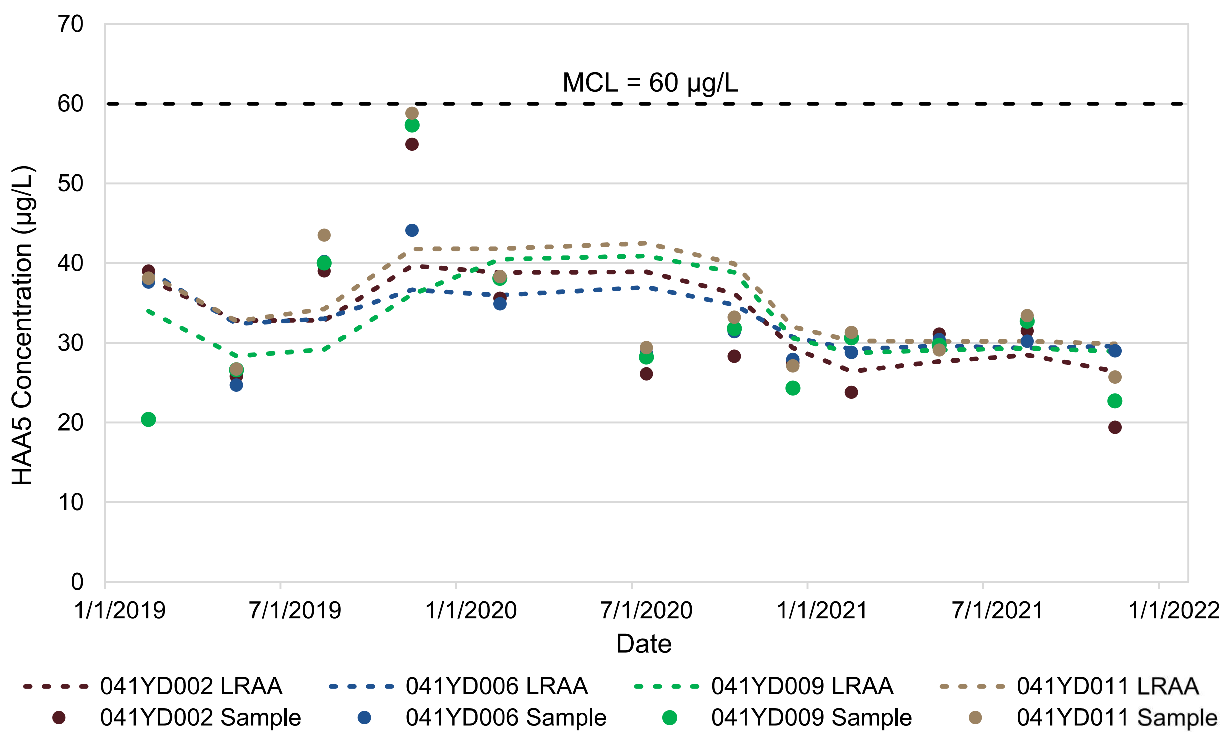


Figure 3-3: HAA5 LRAAs and Individual Samples for 2019–2021

4.0 Lead and Copper

Lead and copper typically enter drinking water via release from service line and premise plumbing materials. Lead and copper can both cause aesthetic complaints, and lead is associated with negative human health outcomes even at low levels.

The Lead and Copper Rule (LCR) sets action levels for copper and lead at 1.3 mg/L and 0.015 mg/L, respectively, based on the 90th percentile tap sample collected during each monitoring period. If the 90th percentile sample exceeds an action level, the water system must take steps to reduce lead or copper release, such as service line replacement or optimization of corrosion control treatment.

Lead and copper sample results from tap sampling conducted in the BWU distribution system from 2019 to 2021 are summarized in Table 4-1. The 90th percentile samples for both copper and lead remained below their action level except for one lead sample that was detected above its action level. Figure 4-1 shows the individual copper and lead sample results from July 2020.

Individual samples showed a lead concentration above 0.015 mg/L at one sample location and a copper concentration above 1.3 mg/L at a nearby sample location in July 2020 as shown in Figure 4-1. The United States Environmental Protection Agency (EPA)'s Lead and Copper Rule Revisions (LCRR), which has a compliance date of October 16, 2024, would require water systems to undertake steps to identify and if possible, address, the causes of individual samples that exceed the lead action level. However, the EPA recently released the proposed Lead and Copper Rule Improvements (LCRI), which is expected to be finalized prior to the LCRR compliance date and would replace many LCRR provisions with more stringent requirements. The proposed LCRI lowers the lead action level to 0.010 mg/L, which increases the likelihood that individual tap samples could require follow-up water quality testing and other actions. Both the LCRR and LCRI could alter the sampling locations to sites that are more prone to higher tap water lead concentrations.

Table 4-1: 90th Percentile Lead and Copper Concentrations for 2019–2021

MP Begin Date	Copper		Lead	
	90th Percentile Concentration (mg/L)	Number of Samples Exceeding Action Levels	90th Percentile Concentration (mg/L)	Number of Samples Exceeding Action Levels
01/01/2019-12/31/2021	0.035	0	0.001	1

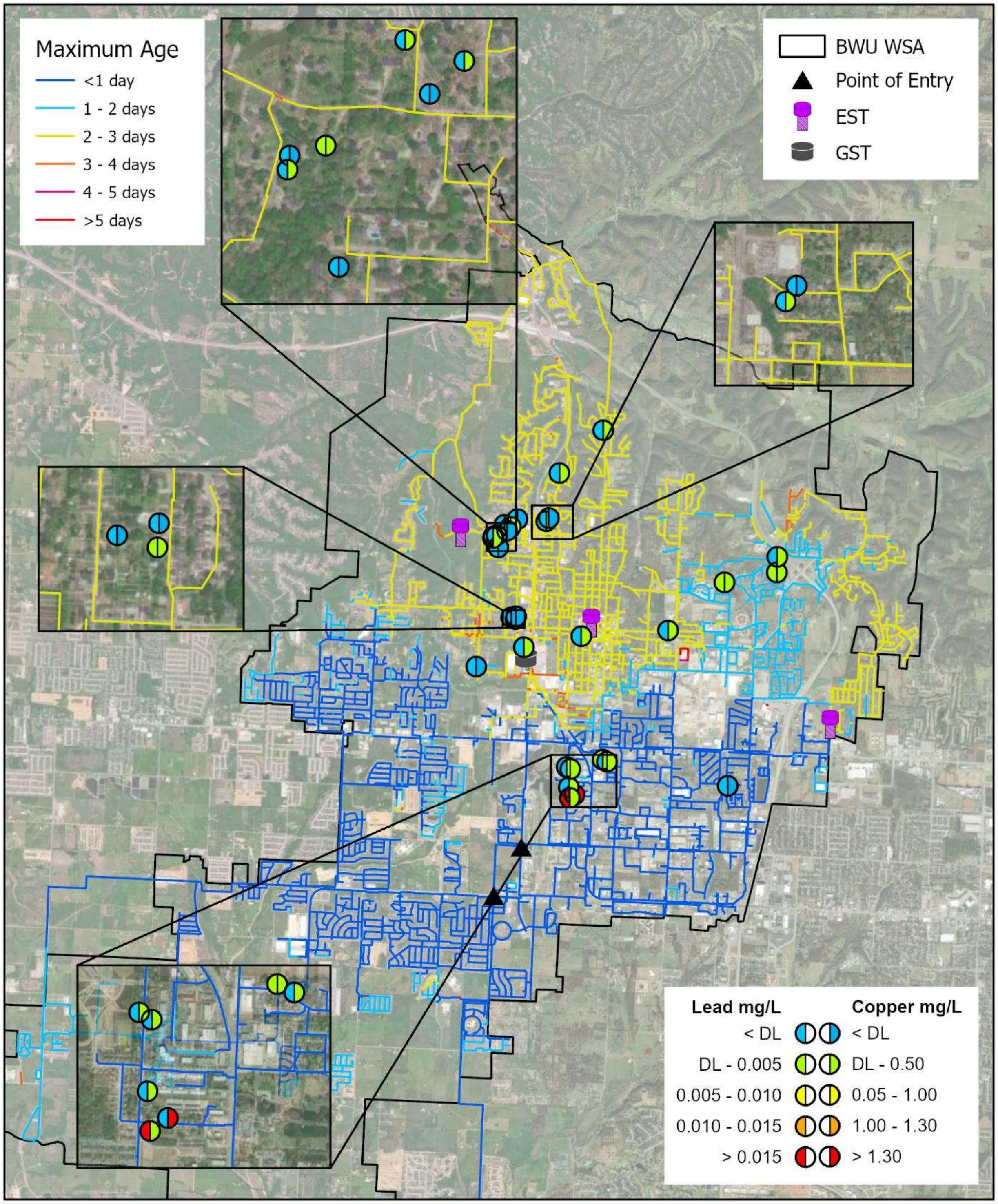


Figure 4-1: Maximum Lead and Copper Concentrations by Sample Location for July 2020

5.0 Ongoing Regulatory Activity

The EPA announced the proposed Lead and Copper Rule Improvements (LCRI) in November 2023 to make additional changes to the LCR and LCRR. In addition, the EPA is working on revisions to the microbial and disinfection byproducts (M/DBP) rules, including the Surface Water Treatment Rules (SWTR), Interim Enhanced Surface Water Treatment Rule (IESWTR), Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), and the Disinfectants and Disinfection Byproducts (D/DBP) Rules. Final regulations are expected within the next five years.

5.1 Lead and Copper Rule Improvements

The LCRI is intended to further strengthen health protection from lead in drinking water. The proposed rule was released in November 2023 and the final rule is anticipated to be published by October 2024. The key provisions of the proposed rule include:

- Achieving full replacement of lead and galvanized requiring replacement service lines within 10 years.
- Requiring water systems to regularly update their lead service line inventories, create a publicly available service line replacement plan, and identify the materials of service lines of unknown materials.
- Improving tap sampling protocols to include lead measurements in the first- and fifth-liter samples in sites with lead service lines to identify areas of the distribution system with high lead levels.
- Lowering the lead action level from 15 µg/L to 10 µg/L, still on a 90th percentile tap sample basis. This could result in water systems that have previously been able to meet LCR requirements needing to take action to reduce lead levels through lead service line replacement and/or corrosion control treatment. Individual samples above the action level would trigger distribution system and site assessments.
- Strengthening protections to reduce exposure by requiring water systems with multiple action level exceedances to conduct customer outreach and make filters available to customers.
- Direct resources to historically underserved households and communities, such as directing funds to these communities to provide financial assistance for replacement of lead service lines.

The proposed LCRI maintains the compliance date for the LCRR and the LCRR provision that all systems must prepare and submit a service line inventory to the State. However, the proposed LCRI would significantly change other LCRR requirements and shift the compliance dates for submitting sampling protocols and lead service line replacement plans.

5.2 Microbial and Disinfection Byproduct Rules

The EPA has begun the regulatory process for reviewing and potentially revising the M/DBP Rules. The EPA held webinars and solicited public comment on the existing rules in 2020 and 2021 to identify the need for and inform the content of revisions. The National Drinking Water Advisory Committee (NDWAC) formed a working group to identify rule revision options. The potential rule revision recommendations from the working group focus on:

- Disinfectant residual levels in drinking water distribution systems, such as by implementing numerical requirements for minimum residuals rather than the “detectable” residuals currently allowed in many states, including Arkansas, under the SWTR.
- Control of opportunistic pathogens such as *Legionella.*
- Control of bromide-containing DBPs, such as by regulating of the sum of nine haloacetic acids (HAA9) rather than HAA5, as currently regulated under the Stage 2 D/DBP Rule.
- TOC removal requirements and addition of new raw water bromide monitoring and control requirements.
- Water quality management in finished water storage tanks, such as through increased inspections and cleaning frequency through a find-and-fix or treatment-technique approach.
- Facilitating closer, collaborative relationships between wholesale and consecutive systems to improve operator training and water quality.

Historical data suggest that BWU is able to maintain a sufficient disinfectant residual throughout the drinking water distribution system. HAA5 has been below the MCL, and HAA9 is not expected to be a significant issue because BWU’s source water, Beaver Lake, has low bromide levels.

6.0 Water Quality Challenges and Improvements

6.1 Tank Mixing

Storage tanks serve multiple functions in water systems beyond simply storing water, including improving system pressures and pump operations. However, each storage tank also presents a potential site for water quality issues to emerge. One critical component in preventing water quality issues in storage tanks is mixing. Adequate mixing mitigates issues with dead zones, short-circuiting, and thermal stratification that may be caused by inlet/outlet configurations and low turnover.

The turnover in the I Street ground storage tanks (GSTs) and the Downtown elevated storage tank (EST) is controlled by filling and pumping operations and can therefore be adjusted as needed. The Tiger EST is equipped with a Tideflex Mixing System, which is an engineered mixing system that provides passive mixing with variable orifice nozzles. Detailed drawings of the Highway 102 EST were not available at the time of this analysis. However, given the age of this EST, its inlet/outlet configuration may not provide adequate mixing.

Garver would recommend considering mixing improvements for the Highway 102 EST the next time it is repainted or rehabilitated, or earlier if water quality issues arise. Garver also recommends including mixing systems for all new storage tanks. Tank mixers generally comprise a low-complexity and low-cost component (typically 1–3% of the cost of tank construction), and they mitigate potential water quality issues that can cause costs that may exceed the cost of adequate mixing.

6.2 Distribution System Water Age

The hydraulic model results presented in the Existing System Assessment TM show higher water age in the northern and eastern portions of the system, which are influenced by the storage tanks. The area north/northeast of downtown is not well-looped with large-diameter transmission mains with the rest of the system, which contributes to high water ages in these areas. Completing 12-inch and larger loops throughout this area, including the Core Growth Area loop discussed in the CIP TM, will improve circulation and reduce water age.

Another strategy that would lead to a more even distribution of water age across the distribution system is hydraulically separating supply transmission from the distribution system during normal operations with normally closed or controlled valves. Supplying water at strategic locations, e.g., directly to storage tanks and major transmission main intersections, would reduce the gradient of increasing water age with distance from the 48-inch supply transmission mains. Establishing a flow-through pattern at storage tanks also significantly increases turnover and reduces storage residence times. For example, the hydraulic model results for the 2028 horizon presented in the CIP TM show that the Southwest EST has the potential to significantly increase water age with projected demands. The increase in water age could be reduced by isolating the transmission main to the proposed Southwest EST from the parallel 12-inch distribution lines with normally closed or pressure-controlled valves.

6.3 Chlorine Boosting

Low chlorine residuals are currently not a significant issue for the BWU system. However, regulatory requirements and conditions like source water quality may change over time. For new storage facilities, BWU could consider acquiring adequate space to allow for chlorine boosting systems to be installed in the future should it ever become necessary.

APPENDIX E
Major Infrastructure Risk Assessment
Technical Memorandum No. 5

Bentonville Water Utilities
Water Master Plan Update

Technical Memorandum No. 5
Major Infrastructure Risk Analysis

City of Bentonville
Bentonville, Arkansas

Prepared by:

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

April 2024

Garver Project No. 22W01291

Table of Contents

List of Figures

List of Tables

1.0 Introduction

This technical memorandum (TM) was prepared for Bentonville Water Utilities (BWU) as part of the Bentonville Water Master Plan Update. This is the fifth TM for the project, following the Distribution System Water Quality Analysis TM. The purpose of this TM is to:

- Determine how to mitigate risks to critical water distribution system infrastructure
- Evaluate emergency connection alternatives with the following wholesale water suppliers and adjacent utilities:
    - Benton/Washington Regional Public Water Authority (BWRPWA)
    - Rogers Water Utilities (RWU)
    - Springdale Water Utilities (SWU)

2.0 Major Infrastructure Risk Assessment

2.1 Risk Model Scenario Summary

Garver used the BWU hydraulic model to determine the potential impacts of infrastructure failure on the BWU distribution system. Table 2-1 summarizes the risk scenarios evaluated for this analysis. The columns in the table provide the following information for each scenario:

- Facility – Facilities that were deactivated in the hydraulic model
- Improvements – CIP improvements that were included (or existing system if no improvements were included)
- Demand – Average day demand (ADD) or maximum day demand (MDD) conditions and planning horizon
- Impact – Primary impact of the facility failure on system performance (system pressures, velocities, tank levels, etc.)
- Cause – Primary system deficiency or lack of redundancy causing the impact
- Related CIP Projects – CIP projects that would provide the most mitigation for the impacts of facility failures

Figure 2-1 shows the locations of the following facilities that were evaluated:

- Downtown Elevated Storage Tank (EST) and Pump Station (PS)
- I Street Ground Storage Tanks (GSTs) and PS
- Existing 48-inch transmission main from the Beaver Water District (BWD) high-service pump station (HSPS) to the BWU distribution system
- 18-inch transmission main on SW Regional Airport Boulevard west of the connection with the 48-inch from the BWD HSPS
- 18-inch transmission main north of the Tiger EST running toward Bella Vista
- Tiger EST
- Highway 102 EST

Table 2-1: Major Infrastructure Risk Assessment Model Scenario Summary

No.	Facility	Improvements	Demands	Impact	Cause	Related CIP Projects
1	Downtown EST/PS	Existing	2023 MDD	Minimal	–	Central Transmission Main
2	Downtown EST/PS	2028 CIP without Southwest EST and Transmission Main	2028 MDD	Minimal	–	
3	I Street GSTs/PS	Existing	2023 MDD	Low EST Levels (Limited BWD Capacity)	Limited BWD Supply Capacity and BWU Transmission Capacity	Western Corridor Transmission Main
4	I Street GSTs/PS	2028 CIP without Southwest EST & Transmission Main	2028 MDD	Minimal with Modified BWD Pump Operation	–	
5	Existing 48-inch transmission main from BWD HSPS	2028 CIP	2028 MDD	>48 hours to empty ESTs	Limited BWD Western Corridor Pump Station Capacity	Western Corridor Transmission Main
6	18-inch transmission main on SW Regional Airport Blvd	Existing	2023 MDD	Higher Pressure Variations/ Velocities	No EST in SW, Limited Transmission Redundancy	Southwest EST and Transmission Main
7	18-inch transmission main toward Bella Vista	Existing	2023 MDD	Low Pressures	Limited Transmission Redundancy/ Looping	Northeast Transmission Main Loop
8	Tiger EST	Existing	2023 ADD	Higher Pressure Variations	Limited EST Capacity	Northeast EST, Southwest EST
9	Highway 102 EST	Existing	2023 ADD	Higher Pressure Variations	Limited EST Capacity	Northeast EST, Southwest EST

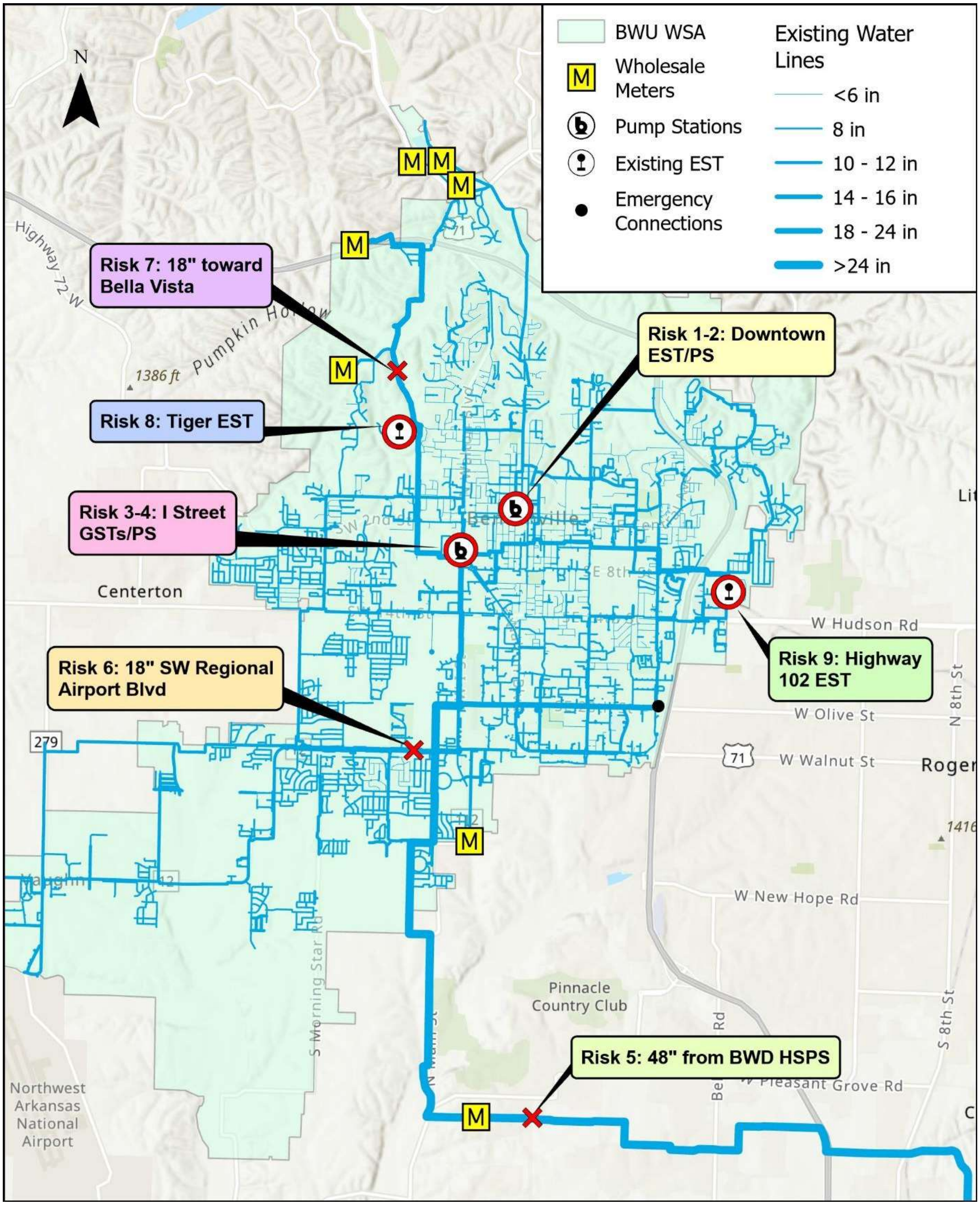


Figure 2-1: Major Infrastructure Risk Assessment Model Scenarios

2.2 Downtown Elevated Storage Tank and Pump Station (Risk Scenarios 1 and 2)

The Downtown EST and Pump Station provides operational and equalizing storage for the BWU distribution system. The water level range of the Downtown EST is below the operating range of the Highway 102 and Tiger ESTs, so the Downtown EST does not float on the distribution system. The Downtown EST is filled using a solenoid control valve during periods of lower demand, and water is pumped back out of the tank into the distribution system during periods of higher demand. The filling and pumping cycles are set manually by a timer that is adjusted throughout the year to accommodate seasonal changes in demand.

During normal operations, the Downtown EST filling cycle tends to delay filling in the other two ESTs overnight, and the pumping operations reduce the draining rate of the other two ESTs during peak morning demands. With the Downtown EST inactive, the range of minimum and maximum Highway 102 and Tiger EST levels in the hydraulic model was within two feet of the typical tank levels. Local pressures are slightly higher (<5 psi) with the Downtown EST pump operating, but the overall pressure range throughout the day of 75–80 psi in the surrounding area was the same with the Downtown EST inactive.

The Central Transmission Main project will extend a 24-inch transmission main from the I Street GSTs and Pump Station to the Downtown EST site. This transmission main will increase conveyance capacity to the area served by the 12-inch loops extending north and east from the Downtown EST. Once this transmission main is installed and additional ESTs are constructed, it may be possible to abandon the Downtown EST in the future rather than rehabilitate it to keep it in service.

2.3 I Street Ground Storage Tanks and Pump Station (Risk Scenarios 3 and 4)

The I Street GSTs provide significant operational and equalizing storage for the BWU distribution system. The GSTs are filled using a flow control valve overnight, and water is pumped back out of the tanks into the distribution system during peak demand periods. BWU maximum day demands are currently near the BWD HSPS capacity, so the I Street GSTs are critical to maintaining the desired water levels in the ESTs during peak hour demands.

With the I Street GSTs and Pump Station inactive, the ESTs would fill quickly during periods of low demands and drain quickly during periods of peak demands. The EST levels could drop below half full during peak demand periods without flow from the I Street GSTs, but the hydraulic model indicates the tanks would not fully empty and adequate minimum pressures would be maintained throughout the distribution system. During abnormal BWD HSPS operations with the I Street GSTs and Pump Station inactive, pressure fluctuations of over 20 psi could occur in the northern and southwestern portion of the distribution system, which are the farthest away from the ESTs.

The Western Corridor Transmission Main will provide additional capacity to increase supply during periods of peak demands, which would increase the minimum tank levels in the ESTs. The Southwest EST would maintain more stable pressures in the southwest portion of the distribution system during periods of abnormal BWD HSPS operations.

2.4 Existing 48-inch Transmission Main from BWD HSPS (Risk Scenario 5)

The existing 48-inch transmission main from the BWD HSPS is currently the only direct supply connection to the BWU distribution system. Without this transmission main, BWU has to rely on emergency supplies from the RWU emergency connections; this scenario has happened previously when the 48-inch transmission main was out of service. Once the Western Corridor Transmission Main is completed, there will be a second source of supply to the BWU distribution system. Garver modeled the BWU system with the 48-inch transmission main inactive after completion of the 2028 CIP projects under maximum day demand conditions. Garver assumed that wholesale supply from the BWU system to Cave Springs and the Bella Vista POA would be suspended during an outage of the 48-inch transmission main.

The BWD Western Corridor Pump Station (WCPS) is anticipated to have three pumps installed initially with a firm capacity of 14 MGD. With all three pumps operating and no flow from the existing 48-inch transmission main, the model indicated the BWD WCPS could supply up to 23 MGD, which is below the projected 2028 BWU retail MDD of 27 MGD. The hydraulic model predicts that the I Street GSTs would be depleted within approximately 36 hours, and the ESTs would empty within 60–72 hours. Being able to maintain system pressures for over 24 hours with the 48-inch transmission main offline will give BWU additional flexibility for maintenance and leak testing on the 48-inch transmission main.

2.5 18-inch Transmission Main on SW Regional Airport Boulevard (Risk Scenario 6)

The 18-inch transmission main on SW Regional Airport Boulevard is connected to the existing 48-inch transmission main from the BWD HSPS and conveys most of the flow to the Southwest growth area. When this 18-inch transmission main is offline west of the 48-inch connection, the hydraulic model indicates that the flow through the 8-inch loops south of SW Regional Airport Boulevard will increase significantly (see Figure 2-2), leading to high velocities and significant head losses. The additional head losses would result in pressure drops of over 20 psi in the Southwest growth area during peak demand periods.

Additional 12-inch looping west of the 48-inch transmission main and south of SW 14th Street would provide redundant transmission capacity to the southwest portion of the distribution system. The Southwest EST would also maintain more stable pressures in the southwest portion of the distribution system during periods of abnormal operations. In the future, a second supply connection to the Western Corridor Transmission Main is anticipated, and this connection could be used to mitigate a failure of the 18-inch transmission main on SW Regional Airport Boulevard.

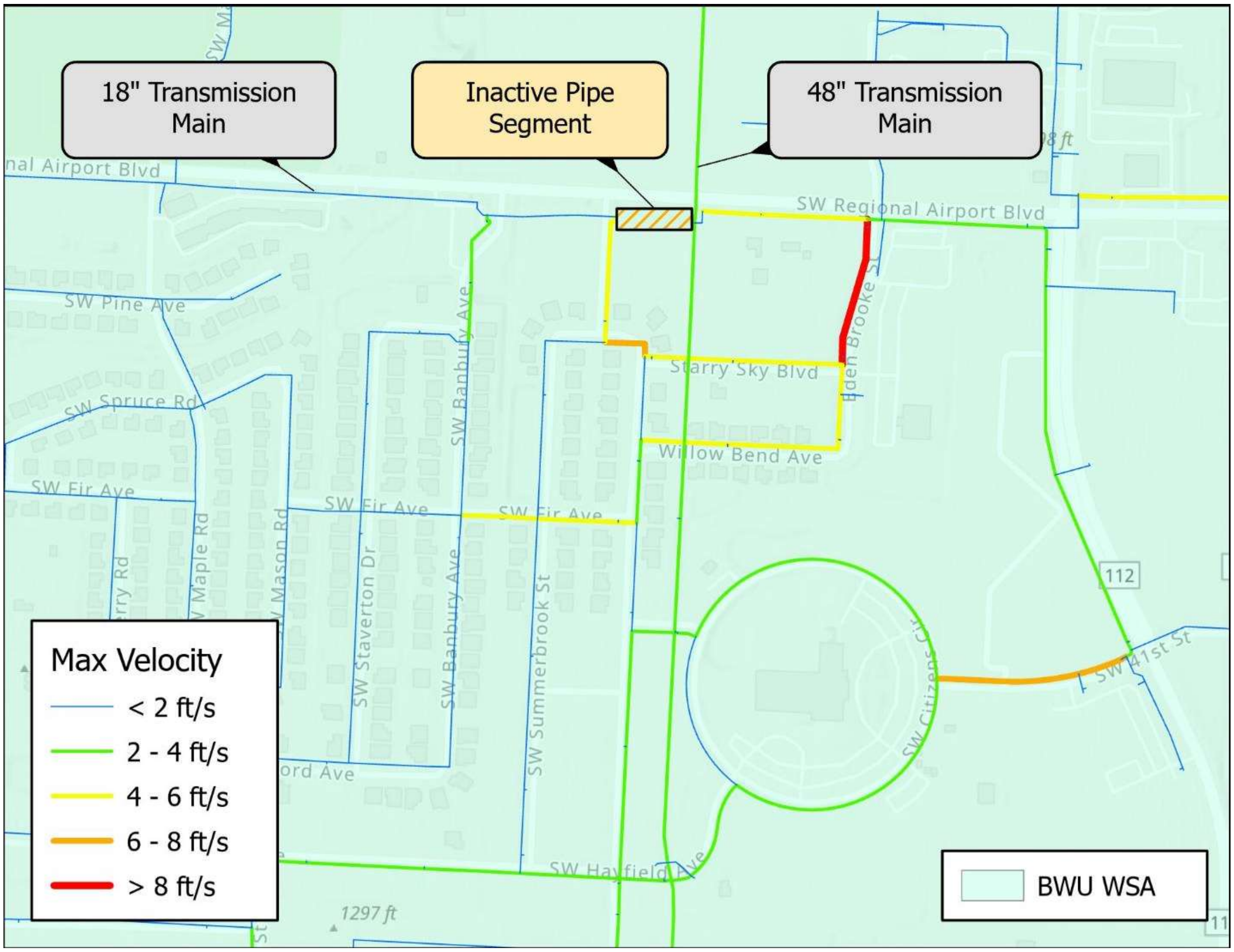


Figure 2-2: Maximum Velocity Model Results for Risk Scenario 6

2.6 18-inch Transmission Main toward Bella Vista (Risk Scenario 7)

The 18-inch transmission main running north along Punkin Hollow Road and Peach Orchard Road conveys most of the wholesale supply for the Bella Vista POA wholesale connections and also provides a loop for the Tiger EST to supply water to areas north of downtown Bentonville. The only other large-diameter loop to the northernmost portion of the service area is the 12-inch line running north from NW A Street.

Failure of the 18-inch transmission main would lead to high velocities and significant head losses (see Figure 2-3), which would cause low pressures downstream (north) of the failure. Pressures could reach as low as 20 psi unless the wholesale supply to the Bella Vista POA is significantly reduced or suspended. The Highway 102 EST would also tend to drain faster than the Tiger EST during the failure because there are currently no other large-diameter transmission mains running north or east from the Tiger EST.

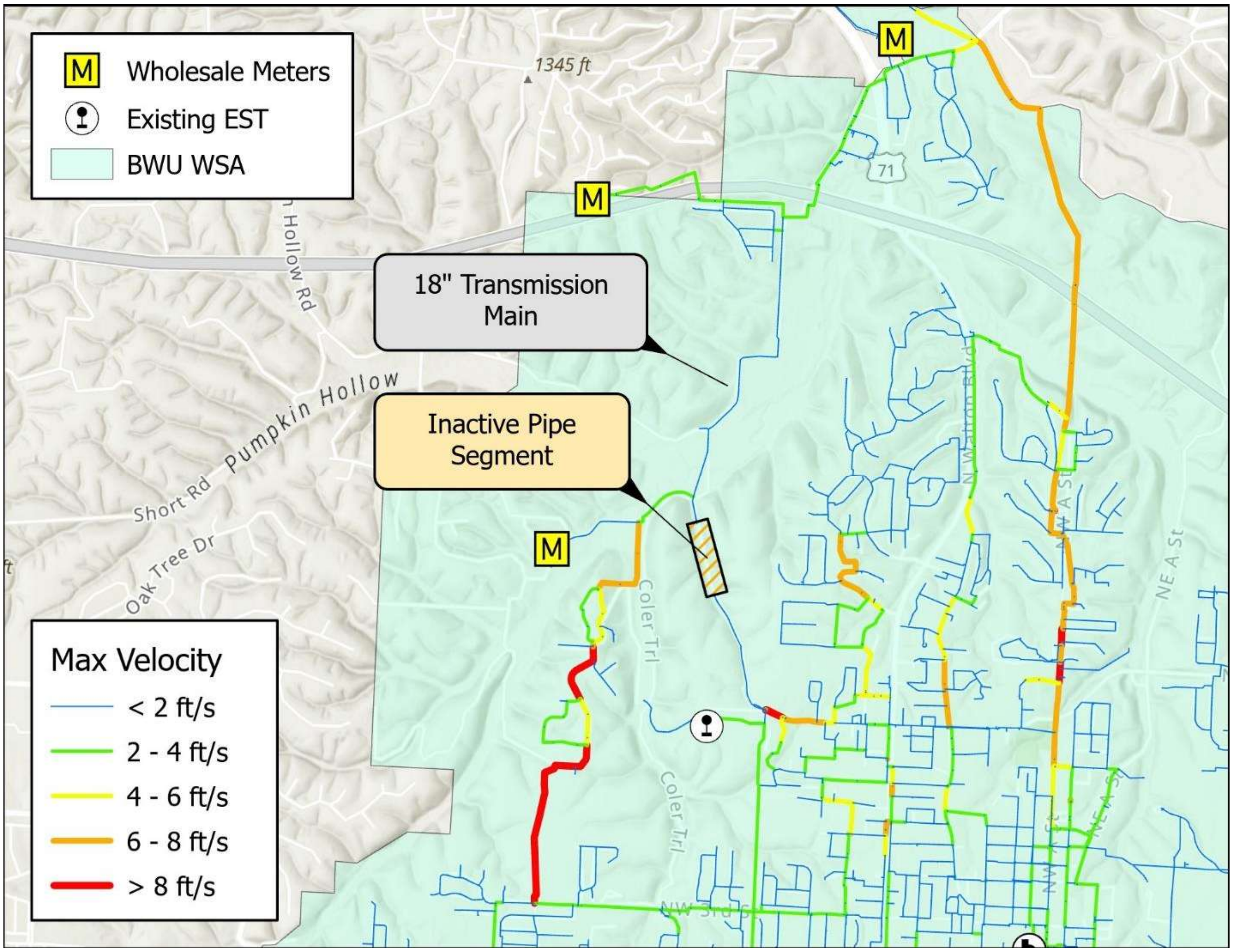


Figure 2-3: Maximum Velocity Model Results for Risk Scenario 7

With the wholesale supply to the Bella Vista POA significantly reduced or suspended, pressures at the north end of the distribution system could be maintained within their normal range, which is generally above 100 psi. Highway 102 EST tank levels would still fluctuate significantly but would be within the normal range for maximum day demand conditions.

The 24-inch Northeast Transmission Main Loop will help equalize levels in the Tiger and Highway 102 ESTs, but this project would not reduce head losses in the 12-inch line north of NW A Street. Reducing or suspending wholesale supply to the Bella Vista POA will be the best way to mitigate a failure of the 18-inch transmission main until additional large-diameter loops are constructed in the northern portion of the distribution system.

2.7 Tiger Elevated Storage Tank (Risk Scenario 8)

With the Tiger EST out of service, the EST volume floating on the system would be reduced from 3 MG to 1 MG. Therefore, the tank level in the Highway 102 EST would respond quickly to changes in demands and BWD HSPS operations. The BWD HSPS pumps would need to cycle more frequently to keep Highway 102 EST water levels within the normal operating range. Under average day demand conditions, the Highway 102 EST could likely be maintained within its typical water level range with modified BWD HSPS and I Street pumping operations. However, customer services pressures would fluctuate significantly (>35 psi) in the western half of the distribution system. Static pressures are high enough that the minimum pressures would still be well above 20 psi.

The proposed Northeast EST and Southwest EST would both provide additional operational storage that would reduce cycling of the BWD HSPS pumps with the Tiger EST offline. The Southwest EST would also maintain more stable pressures in the western portion of the distribution system.

2.8 Highway 102 Elevated Storage Tank (Risk Scenario 9)

The impacts of the Highway 102 EST failure would be similar to those of the Tiger EST failure; however, the larger volume of the Tiger EST would reduce the frequency of cycling for the BWD HSPS pumps. The increase in pressure fluctuations would also be similar but would impact the southwest and east ends of the distribution system. The proposed Northeast EST and Southwest EST would both provide additional operational storage that would reduce cycling of the BWD HSPS pumps with the Highway 102 EST offline. Both ESTs would also maintain more stable pressures throughout the distribution system.

3.0 Emergency Connection Alternatives

Garver evaluated emergency connection alternatives with the following wholesale water suppliers and adjacent utilities:

- Rogers Water Utilities (RWU)
- Benton/Washington Regional Public Water Authority (BWRPWA)
- Springdale Water Utilities (SWU)

The existing and potential future emergency connections are shown in Figure 3-1. Table 3-1 summarizes the pipe sizes and maximum potential capacity of each connection. The following sections provide additional details about operations using each connection based on simulations using the BWU hydraulic model.

Table 3-1: Emergency Connection Alternatives Summary

No.	Supplier/Utility	Status	BWU Pipe Size (in)	Other System Pipe Size (in)	Location	Maximum Potential Capacity
1	Rogers Water Utilities	Existing	24	24	Moberly Lane	9 MGD
2		Existing	24	24	Water Tower Road	9 MGD
3		Potential Future	48	24	Mount Hebron Road	10 MGD
4	Benton Washington Regional Public Water Authority	Potential Future	18	36/54 (Parallel)	Peach Orchard Road	9 MGD
5		Potential Future	12	36/54 (Parallel)	North of NW A Street	4 MGD
6	Springdale Water Utilities	Potential Future	48	16	Goad Springs Road	2 MGD

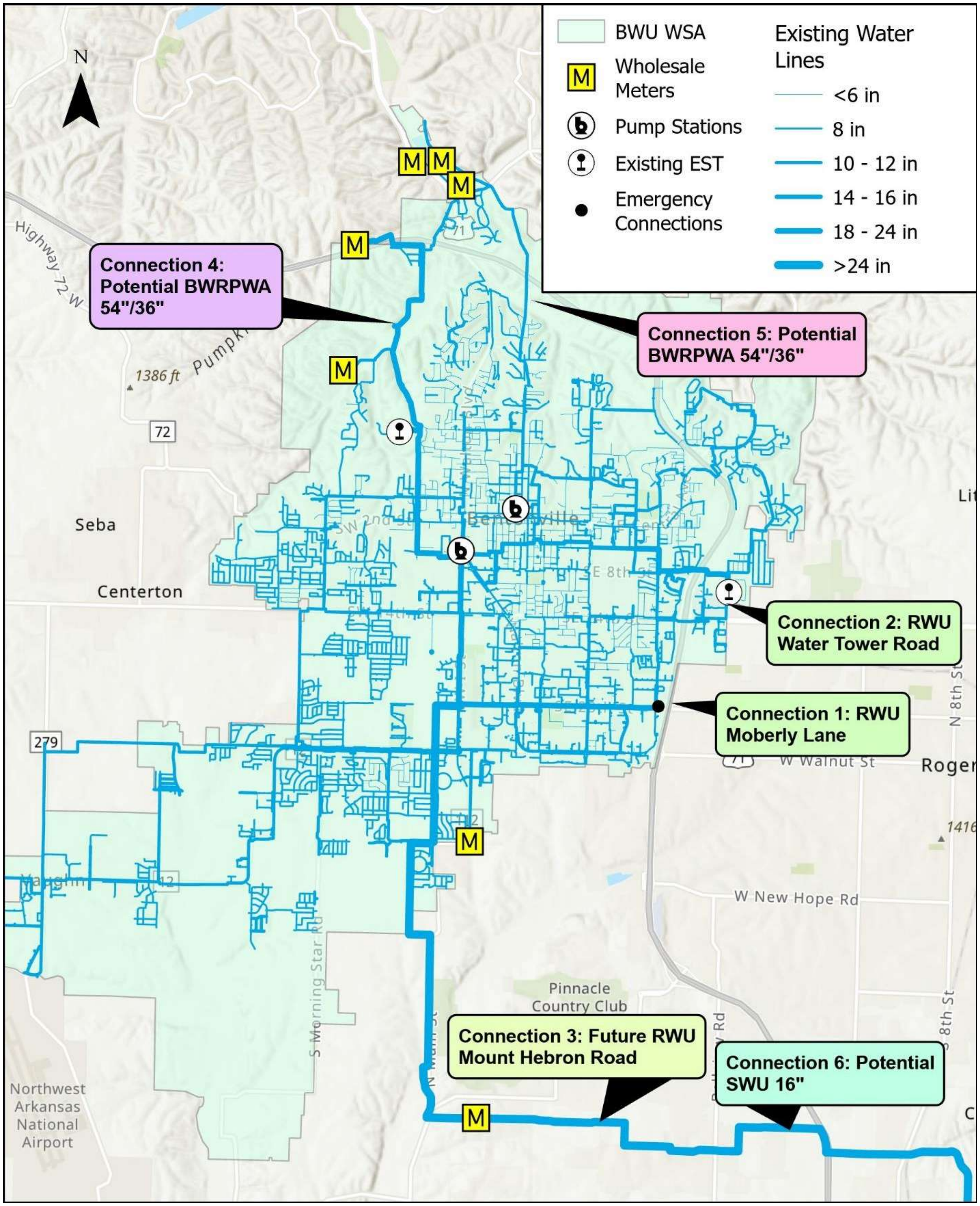


Figure 3-1: Emergency Connection Alternatives

3.1 Rogers Water Utilities

There are two existing emergency connections between the RWU and BWU distribution systems, which are located at Moberly Lane and Water Tower Road, respectively, on the eastern edge of the BWU distribution system. The RWU ESTs have a water level range of 1,475 feet to 1,509 feet, so BWU generally operates at a lower hydraulic grade line (HGL) than RWU. There are no pumping facilities at either location, so the existing connections can typically only be used to supply water from RWU to BWU. The existing emergency connections were used between April 21, 2021 and May 13, 2021, to supply water from RWU and BWU during a repair of the BWU 48-inch transmission line.

A 24-inch tee for a potential future RWU connection was installed at Mount Hebron Road during construction of the BWU 48-inch transmission main. RWU plans to install a connection at this location in the future that would include a GST and pump station, which would allow RWU to supply water from the BWU 48-inch transmission main to the RWU system.

3.1.1 Existing Emergency Connection Supply from RWU

The 24-inch transmission mains downstream of both existing emergency connections provide adequate capacity for flows up to existing average day demands up to approximately 17 MGD. When the Water Tower Road connection is active, the Highway 102 EST will tend to remain full with the altitude valve closed, and the system would float on the Tiger EST. A roughly equal flow split between the two connections maintains the highest Tiger EST levels of 30–70% full under average day demand conditions. The I Street filling/pumping operations would need to be modified or run manually to avoid high/low tank levels in the Tiger EST.

3.1.2 Existing Emergency Connection Supply from RWU with Future Improvements

The proposed improvements discussed in the Capital Improvement Plan (CIP) TM through 2033, especially the proposed 24-inch loop from the Highway 102 EST to the Tiger EST, will reduce head losses between the existing emergency connections and the Tiger EST. With these improvements, the Tiger EST levels can be maintained within their normal range with modified I Street filling/pumping operations. The levels in the proposed Southwest EST could also be maintained at about half full, which would keep customer service pressures within approximately 10 psi of typical pressures.

3.1.3 Future Emergency Connection to RWU at Mount Hebron Road

RWU anticipates installing a GST and pump station at the Mount Hebron site that will typically fill from the distribution system but could also fill from a future emergency connection with BWU. Based on this configuration, Garver assumed for the purposes of this analysis that the emergency connection flow rate would be controlled using a flow control valve. The hydraulic model confirms that a continuous flow of 8 MGD could be provided to RWU from the existing 48-inch supply line under average day demand conditions with minimal impacts to BWU operations. Two large BWD HSPS pumps would operate continuously when the emergency connection is active, and the capacity that could be supplied to RWU would be limited by the total BWD HSPS pumping capacity. Once the Western Corridor Transmission Main is completed, the supply to RWU could be increased to 10 MGD.

The new Mount Hebron Road emergency connection could also be used to supply from RWU to BWU during an emergency. Using the Mount Hebron Road connection in place of or at a higher flow rate than the Water Tower Road connection would reduce head losses in the BWU system and keep tank levels closer to their typical range.

3.2 Benton Washington Regional Public Water Authority

The existing 36-inch BWRPWA transmission main from the water treatment plant to the Centerton and Decatur Tanks passes through the northern part of the BWU distribution system. BWRPWA is also planning to construct a parallel 54-inch parallel transmission main north of the existing 36-inch transmission main. Both the 36-inch and 54-inch transmission main alignments cross the BWU 18-inch transmission main that runs from the Tiger EST north toward Bella Vista and the 12-inch water main that runs north from NW A Street toward Bella Vista.

Based on the 2021 BWRPWA Master Plan and Capital Improvement Plan, the HGL in the BWRPWA supply transmission mains will range from 1,495 feet to 1,600 feet depending on system operations. The HGL will typically be significantly higher than the HGLs within the BWU system at the point of connection. Therefore, pumping is not anticipated to supply water from a potential connection to the BWU distribution system. Rather, the supply capacity will be limited by the maximum velocity in the pipes downstream of the connection.

It is important to note that BWRPWA supplies water from a different water treatment plant than BWD, so the water supplied from an emergency connection with BWRPWA would have different water quality characteristics. In comparing BWRPWA and BWD water quality, Garver observed mostly similar water quality traits except that BWRPWA typically produces water with a lower pH than BWD. This could destabilize scales and increase the potential for metals (iron, lead, copper) release from distribution system materials during emergency use and would need to be monitored by BWU. Other water systems, including the City of Tontitown and the Bella Vista POA, have permanently or intermittently switched sources between BWD and BWRPWA and have reported minimal water quality issues.

3.2.1 Existing System

The supply capacity for connections to the existing 18-inch and/or 12-inch pipe would be limited by the maximum velocity. Although these pipes are connected near the north end of the distribution system, the hydraulic model indicates that the primary flow pathway from these connections would be to the south towards the elevated tanks and the majority of the demands. To limit velocities to approximately 8 feet per second under emergency conditions, the corresponding flow limits would be approximately 9 MGD for the 18-inch pipe connection and 4 MGD for the 12-inch pipe connection. With both connections active, the supply from BWRPWA would be just under the projected 2023 retail demands of 13 MGD. At this flow rate, the pressures in the distribution system near and north of the emergency connections would increase by approximately 30 psi, which could result in maximum pressures near 225 psi.

With the connection to the 18-inch transmission main active, the Tiger EST would quickly fill and remain full while the connection is active. An altitude valve would need to be installed at the Tiger EST to prevent overflows. With the altitude valve at the Tiger EST closed, the system would float on the Highway 102 EST. The Highway 102 EST would be less than half full but water levels would be high enough to keep customer service pressures within approximately 10 psi of typical pressures. The I Street filling/pumping operations would need to be modified or run manually to avoid high/low tank levels in the Highway 102 EST.

3.2.2 Future Improvements

The proposed improvements discussed in the CIP TM through 2033 would not significantly increase the capacity of the potential BWRPWA connections. Future large-diameter loops around the northern end of the distribution system would decrease the maximum velocities and maximum pressures in the BWU distribution system, but the impacts on elevated tank levels, with preferential filling of the Tiger EST, would be similar.

3.3 Springdale Water Utilities

SWU and BWU water service areas do not border each other, but the existing 48-inch transmission main from the BWD HSPS to the BWU distribution system passes near the northern edge of the SWU water service area near I-49. The only large-diameter water line in this portion of the SWU water distribution system is a dead-end 16-inch line running north on Goad Springs Road. This pipe is approximately half a mile from the BWU 48-inch transmission main, and the capacity of a connection at this location would be limited to a maximum of 2 MGD due to high velocities in the SWU system.