CITY OF
SIOUX FALLS

WATER DISTRIBUTION SYSTEM MASTER PLAN

AE2S

DECEMBER 2023

WATER DISTRIBUTION SYSTEM MASTER PLAN MASTER PLAN

For

CITY OF SIOUX FALLS

December 2023

Professional Certification

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of South Dakota.

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Table of Contents

List of Figures

List of Tables

CITY OF SIOUX FALLS

WATER DISTRIBUTION SYSTEM MASTER PLAN

EXECUTIVE SUMMARY

AE2S

DECEMBER 2023

INTRODUCTION

Proactively addressing system challenges is critical to ensure sustainable system operations. Water system challenges come in many forms including population growth, increasing water demands, aging infrastructure, increased regulatory requirements, emerging technological trends, and effective capital improvements planning. The 2023 Sioux Falls Distribution System Master Plan (DSMP) provides a guide for near-term (20-year) Capital Improvements Plan and long-term (100-year) planning to the City of Sioux Falls' (City) water distribution system. The recommended improvements included in the Capital Improvements Plan (CIP) will be the basis for future planning, financing, designing, constructing, and implementation of solutions to meet the City 's water distribution system needs. This document serves as an Executive Summary to the 2023 Sioux Falls DSMP report.

UNDERSTANDING OF THE EXISTING SYSTEM

The City's current water supply comes from both its own water purification plant (WPP) and purchased water from Lewis and Clark Regional Water System. Currently, the water distribution system is divided into four pressure zones. Water storage consists of four ground storage reservoirs and four water towers. Pumping facilities consist of high service pumping at the WPP and pump stations at each of the reservoirs.

SUBSTANTIAL AREA GROWTH

Steady growth requires diligent planning and sizing of facilities and transmission pipelines to provide adequate capacity for now and into the future.

WATER PURIFICATION PLANT UTILIZATION

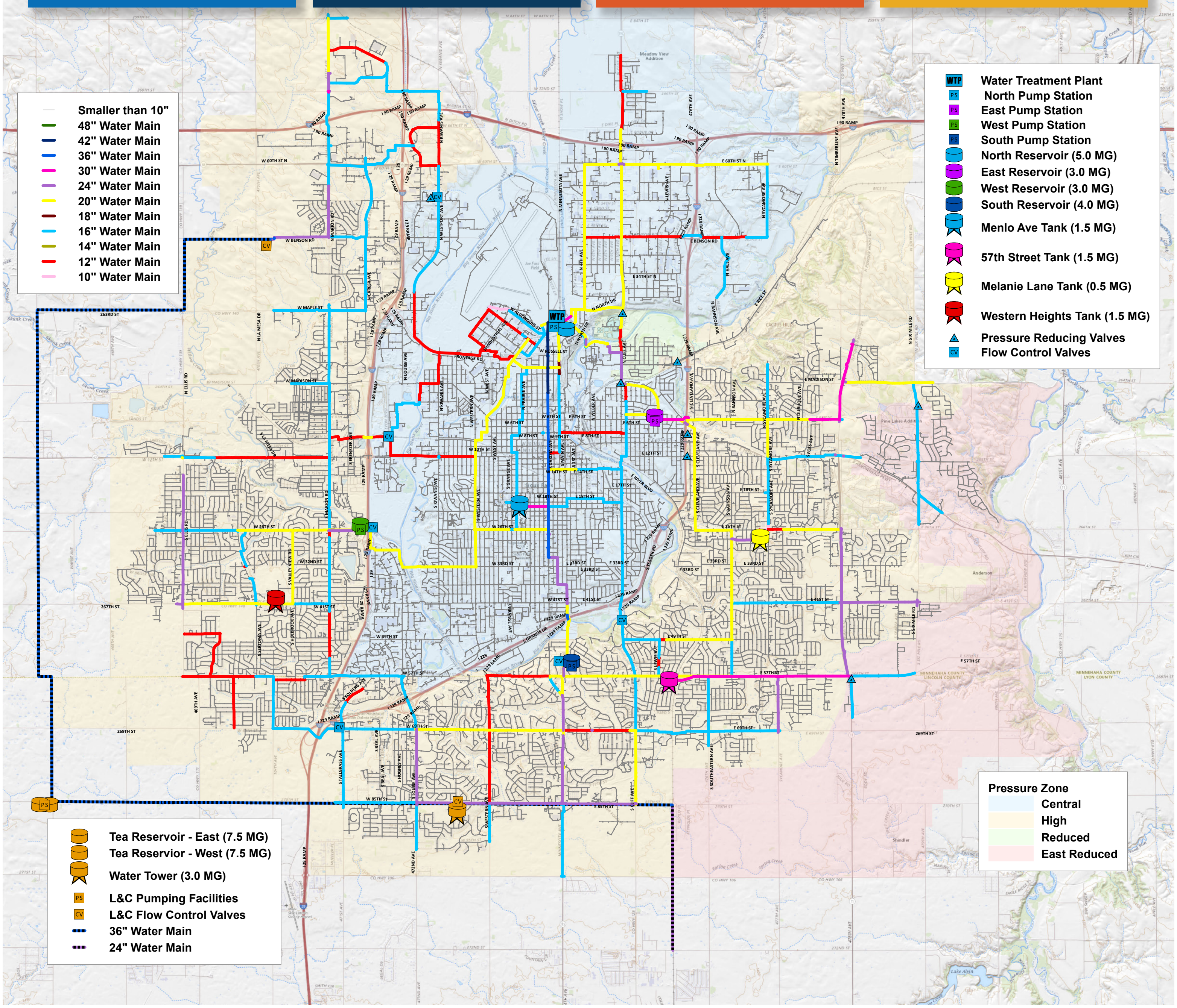
Determining infrastructure improvements to ensure full utilization of the defined capacity from the existing plant into the system.

LEWIS & CLARK RWS UTILIZATION

Determining capacity improvements to allow greater utilization of L&C RWS into the system.

FUTURE WATER SUPPLY CONSIDERATIONS

Developing a conceptual system plan for incorporating a future water supply connection considering a 100-year growth plan.



PROACTIVE PLANNING

Establishing Planning Periods

The establishment of planning periods is a critical component in the development of the WDMP. Planning periods were established for near-term (20 year) and long-term (100-year) for planning the future growth of the system. The extent of the overall growth area used in this planning effort is shown in the figure on the next page.

› NEAR-TERM GROWTH (20-Year Plan)

› LONG-TERM GROWTH (100-Year Plan)

UNDERSTANDING FUTURE GROWTH

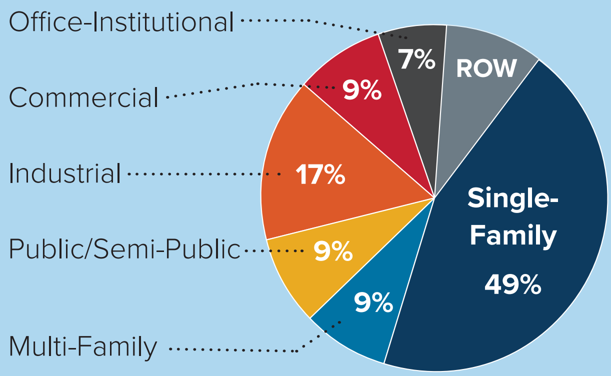
A collaborative approach involved input from City Planning including future land use plan and growth tiers, along with population and employment data from traffic analysis zones. The overall growth area was based on expanding latest land use areas to incorporate the most current wastewater planning boundary. These areas were then populated with estimated residential dwelling units (DU) and developable commercial and industrial acres.

LOOKING AT GROWTH AND DEMAND MULTIPLE WAYS

Population Horizon	Population	
	Residential	Employment
2022	202,600	155,300
2025	213,700	163,400
2030	237,200	178,200
2035	263,300	194,100
2040	292,300	211,600
2045	309,000	223,700
2066	339,900	247,300
2116	506,000	367,000

UNASSIGNED LAND USE AREAS

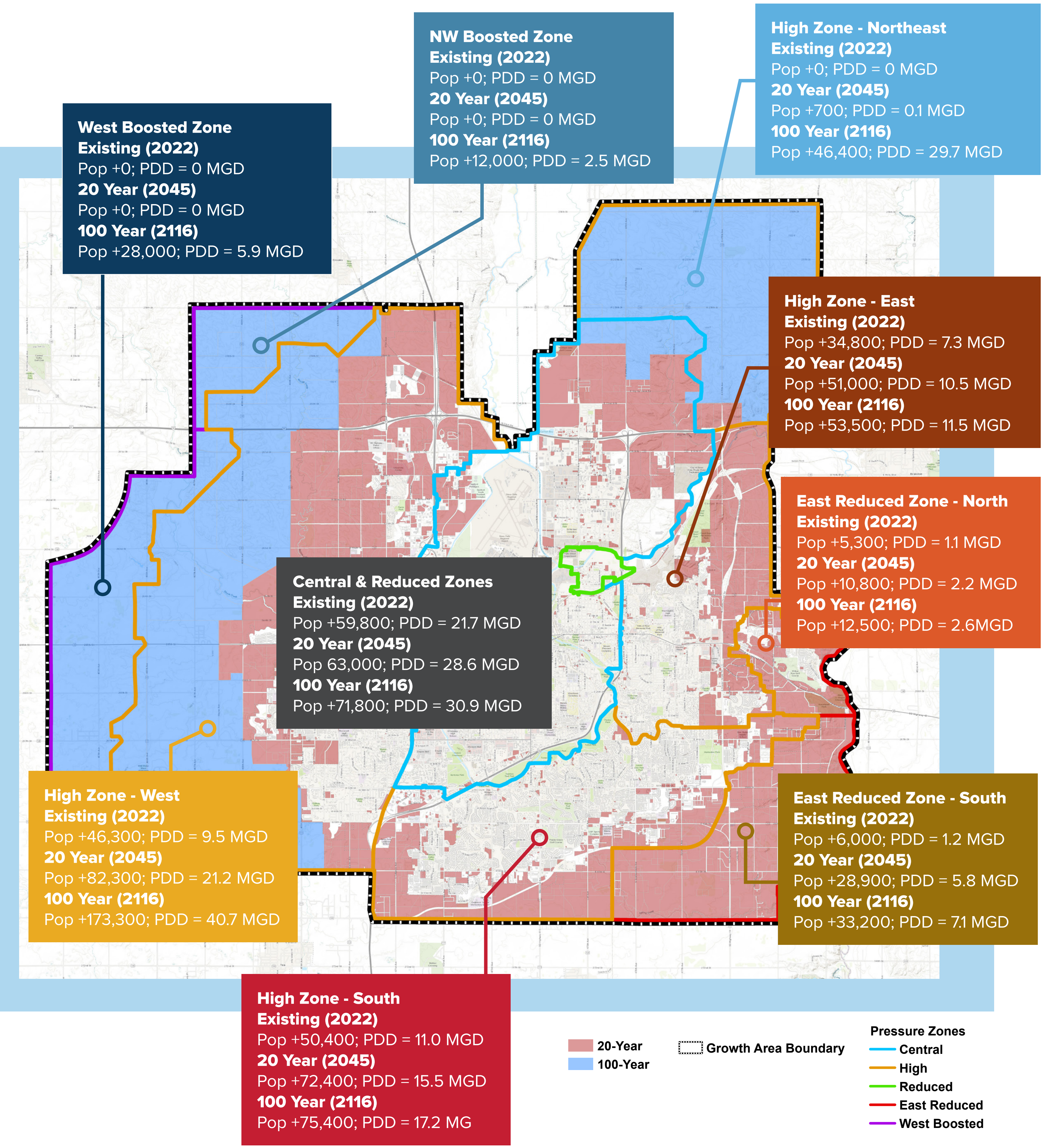
Areas within the growth boundary, but outside of the currently defined land use plan for undeveloped areas. Assumed developable area equaled 90% of a 640-acre Section. Information based on Shape 2040 Sioux Falls.



PLANNING DENSITIES

Residential Planning Densities	
Single family units/ac	2.74
Multi family units/ac	16.10
Avg household size	2.40
Employment Planning Densities	
Industrial employment / ac	9.93
Retail employment / ac	29.04
Office employment / ac	33.51
Institutional employment / ac	26.14

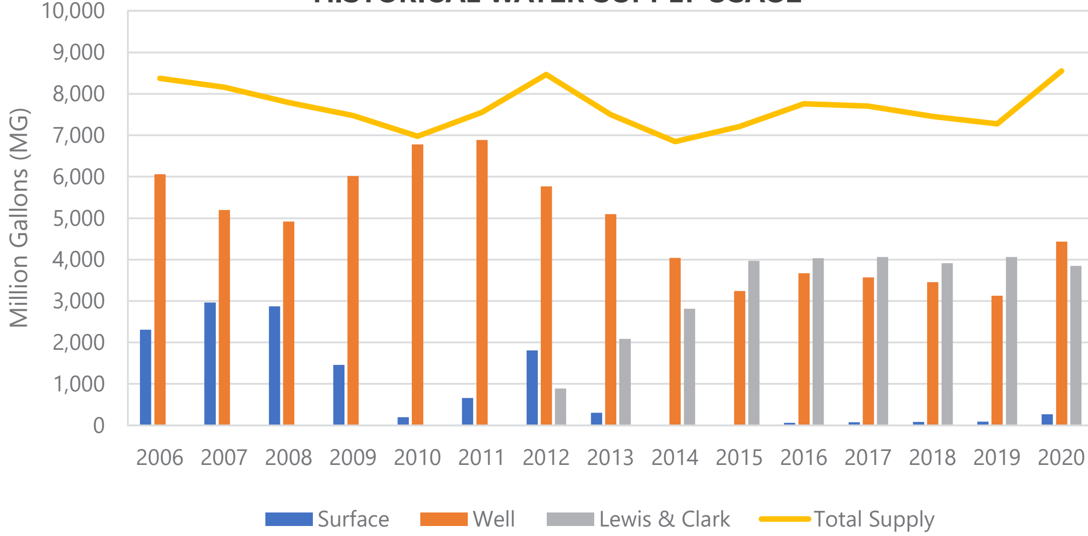
For this planning effort, a 2.0 to 2.2 percent annual growth rate is used to estimate future population projections through 2040 planning period, which is consistent with the rate currently utilized by the City's Planning Department. Projections beyond 2040, followed projections related to the 2018 Wastewater Master Plan including some adjustments to reflect recent changes to growth boundaries.


West Boosted Zone
Existing (2022)
Pop +0; PDD = 0 MGD
20 Year (2045)
Pop +0; PDD = 0 MGD
100 Year (2116)
Pop +28,000; PDD = 5.9 MGD
NW Boosted Zone
Existing (2022)
Pop +0; PDD = 0 MGD
20 Year (2045)
Pop +0; PDD = 0 MGD
100 Year (2116)
Pop +12,000; PDD = 2.5 MGD
High Zone - Northeast
Existing (2022)
Pop +0; PDD = 0 MGD
20 Year (2045)
Pop +700; PDD = 0.1 MGD
100 Year (2116)
Pop +46,400; PDD = 29.7 MGD
High Zone - East
Existing (2022)
Pop +34,800; PDD = 7.3 MGD
20 Year (2045)
Pop +51,000; PDD = 10.5 MGD
100 Year (2116)
Pop +53,500; PDD = 11.5 MGD
East Reduced Zone - North
Existing (2022)
Pop +5,300; PDD = 1.1 MGD
20 Year (2045)
Pop +10,800; PDD = 2.2 MGD
100 Year (2116)
Pop +12,500; PDD = 2.6MGD
Central & Reduced Zones
Existing (2022)
Pop +59,800; PDD = 21.7 MGD
20 Year (2045)
Pop 63,000; PDD = 28.6 MGD
100 Year (2116)
Pop +71,800; PDD = 30.9 MGD
High Zone - West
Existing (2022)
Pop +46,300; PDD = 9.5 MGD
20 Year (2045)
Pop +82,300; PDD = 21.2 MGD
100 Year (2116)
Pop +173,300; PDD = 40.7 MGD
East Reduced Zone - South
Existing (2022)
Pop +6,000; PDD = 1.2 MGD
20 Year (2045)
Pop +28,900; PDD = 5.8 MGD
100 Year (2116)
Pop +33,200; PDD = 7.1 MGD
High Zone - South
Existing (2022)
Pop +50,400; PDD = 11.0 MGD
20 Year (2045)
Pop +72,400; PDD = 15.5 MGD
100 Year (2116)
Pop +75,400; PDD = 17.2 MG
20-Year
100-Year
Growth Area Boundary
Pressure Zones
Central
High
Reduced
East Reduced
West Boosted

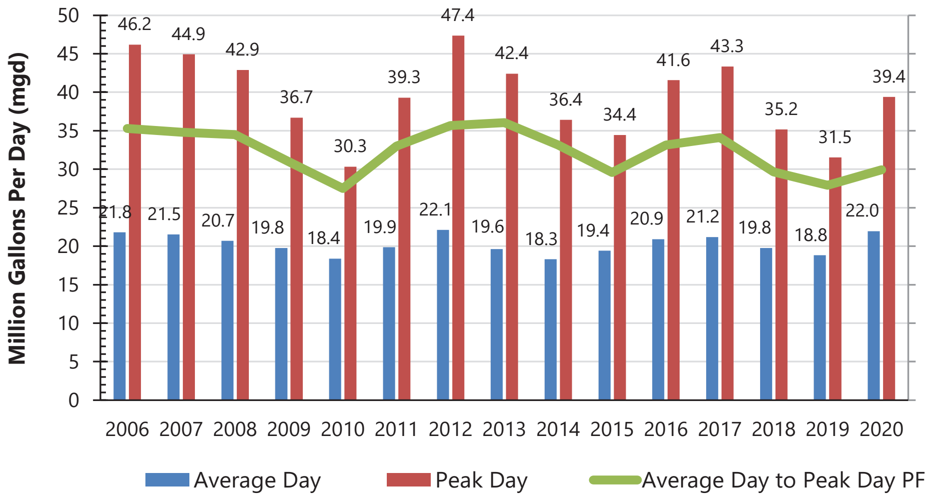
HOW MUCH WATER DO WE USE?

Water use characterization is critical when assessing the performance of the existing and future distribution system. Understanding how water is currently being used can help refine water conservation goals and establish strategies to better position the utility to meet future water needs.

HISTORICAL WATER SUPPLY USAGE



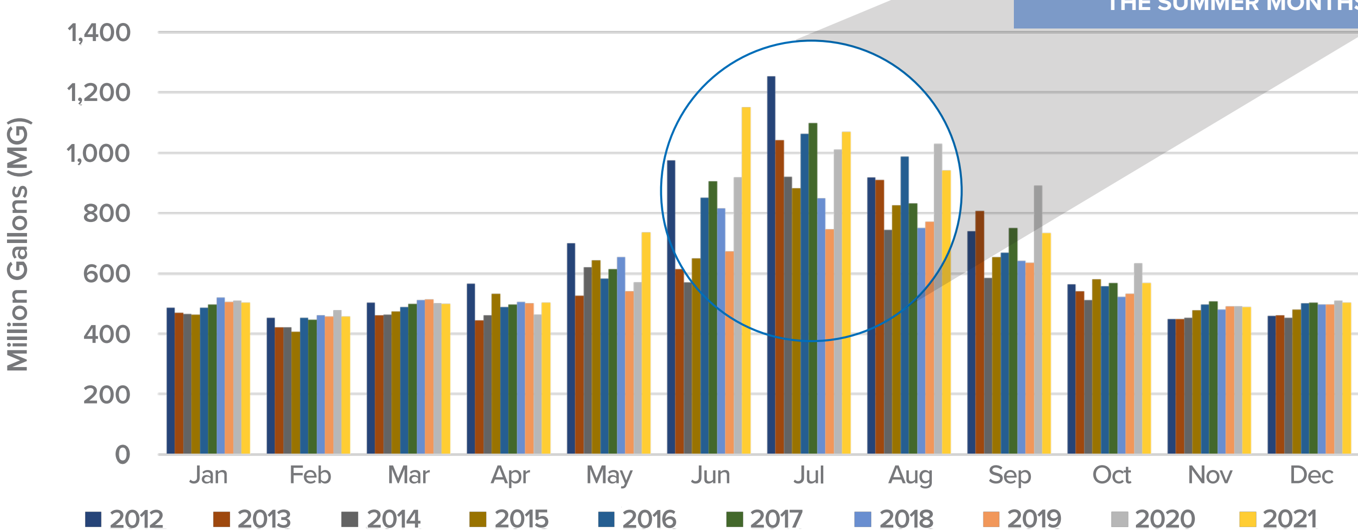
HISTORICAL WATER DEMANDS AND PEAKING FACTORS



Peaking factors are calculated by dividing Maximum Day Demand (MDD) by the Average Day Demand (ADD). Based on past trends, a peaking factor of 2.2 is recommended for system design.

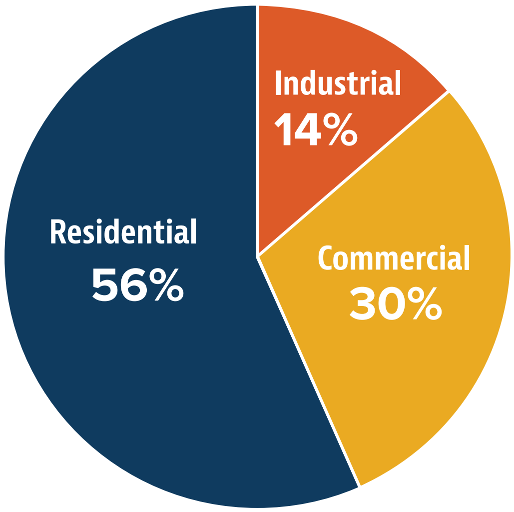
OVER THE PAST 10-YEARS THE MDD HAS ALWAYS OCCURRED DURING THE SUMMER MONTHS

SEASONAL VARIATIONS IN WATER USAGE



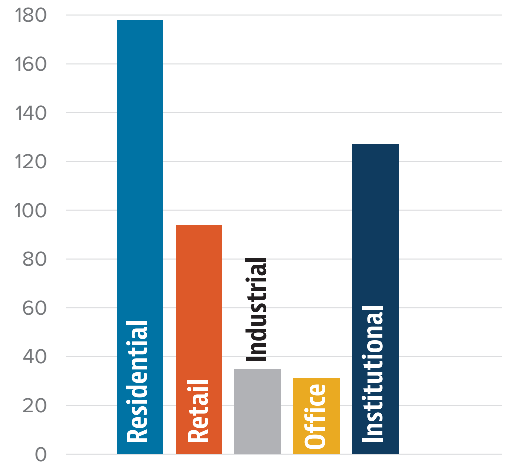
WHO ARE OUR CUSTOMERS
& HOW MUCH WATER ARE THEY USING?

Understanding where the City's water is delivered after treatment, and the quantity your customers need is important when estimating future water demands.



Consumption by User Type
(based on 2022 Water Meter Data)

Water Use Characterization
MAXIMUM DAY DEMAND (GPCD)



(for projecting future demands based on landuse types)

HOW MUCH WATER WILL WE NEED?

Based on planning information such as traffic analysis zones and land use planning, the number of households and number of employees were determined for each of the parcels in the growth areas. Land use planning densities were used for undesignated areas for single-family and multi-family residential, industrial, retail, office, and institutional properties to determine households and employees for each of these undeveloped and undesignated parcels. The number of people per household was determined based on an average household size of 2.40 persons per household. Water demands were calculated based on water demand factors for each of the following classifications.

Planning Horizon	Peak Water Demand				Additional Large Industry	Needed WTP Capacity	Lewis and Clark RWS Capacity
	Residential	Employment	Total	Per Capita			
	MGD	MGD	MGD	gpcd	MGD	MGD	MGD
2022	36.1	15.6	51.7	255	0.00	34.7	17.0
2025	38.1	19.4	57.5	269	3.24	40.5	17.0
2030	42.2	23.5	65.8	277	6.24	37.8	28.0
2035	46.9	24.7	71.6	272	6.24	43.6	28.0
2040	52.0	25.0	77.1	264	6.24	49.1	28.0
2045	55.0	28.8	83.8	271	9.24	49.8	34.0
2066	60.5	30.2	90.7	267	9.24	56.7	34.0
2116	90.1	38.0	128.1	253	9.24	94.1	34.0

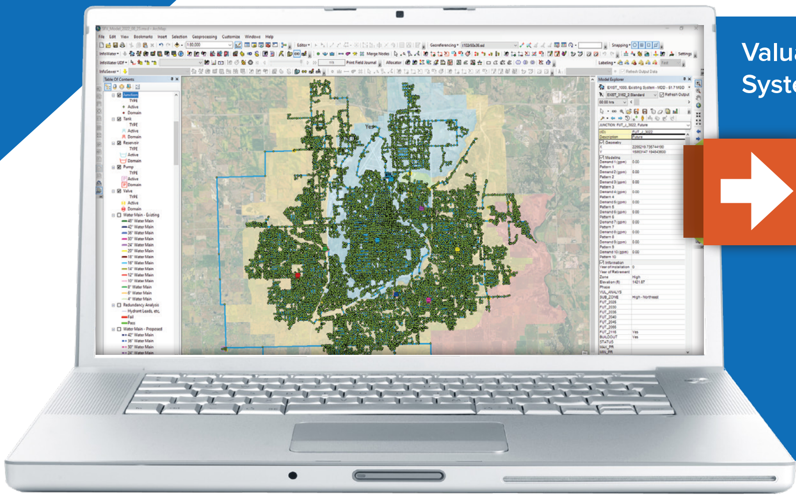
Note: Additional Large Industry demands are included in the Peak Water Demand.

The traffic analysis zone and land use GIS data were correlated and a water demand was determined for each land tract. This demand was then allocated within the existing and future water system network within the hydraulic model. The table above represents the total future water demand for the City for each planning period.

Overall per capita demand changes - each planning period is dependent on the addition of large water use industries planned each year and allocation of land use type within each planning year.

MODEL UPDATE & CALIBRATION

The development of an accurately calibrated model provides the City with the ability to analyze countless scenarios and answer the looming “What If” questions as the City grows and expands.



Valuable Tool to Quickly Diagnose System Challenges and Plan for Growth

- System Pressure
- Storage Requirements
- Storage Operation
- Transmission Capacity
- Fire Flow
- Water Source Management
- Criticality Assessment
- Emergency Water Management

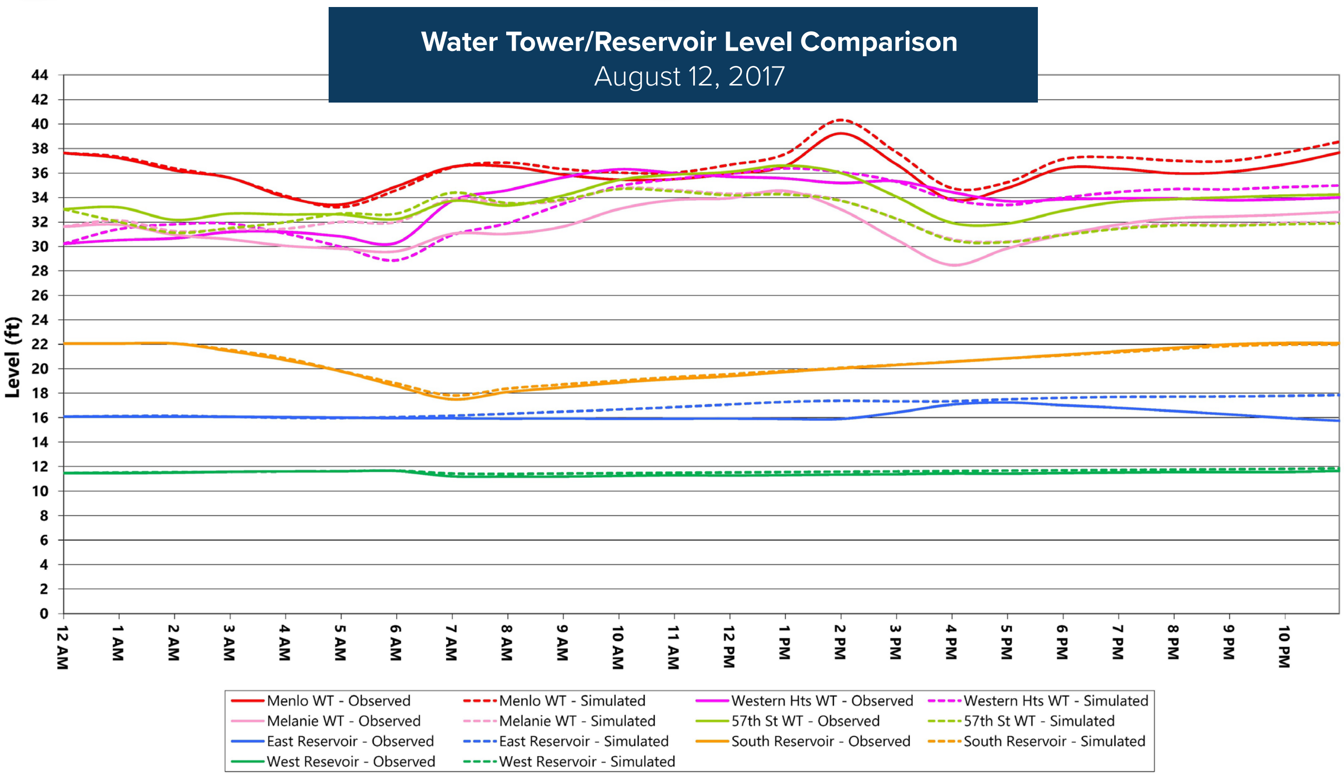
MODEL DEVELOPMENT AND CALIBRATION

Creating a model that accurately simulates a water distribution system is essential to ensure its usefulness of the model. Actual water usage was spatially allocated in the model to accurately simulate the demand on the system. Numerous flow tests were conducted throughout the City to ensure the model was calibrated correctly and accurately in order to simulate existing conditions.

97 HYDRANT FLOW TESTS **+** **12** EXTENDED PERIOD TESTS

“All Pipe” Model Provides Accurate Simulation

The new hydraulic model is an “all pipes” model, meaning that it maintains a one-to-one relationship between individual elements in the City’s GIS database and pipes in the model. An “all pipes” model results in a more accurate simulation, and enables continuous model updates and maintenance with changes in the City’s GIS database (that reflect changes in its infrastructure). **This is critical for a City growing as fast as Sioux Falls and to avoid the model becoming outdated. The City now has a valuable tool that can be utilized with a higher degree of confidence and accuracy.**



SYSTEM EVALUATION

The water distribution system was evaluated under existing and future demand conditions using the calibrated hydraulic model. The model was used to better understand the current limitations of the system and identify deficiencies. An understanding of the limitations of the existing water distribution system is critical to the development and expansion of the system for satisfactory system performance, longevity, and to accommodate future growth. The system evaluation included review of the following components:

PRESSURE – Identifies areas of high and low pressure, as well as investigates pressure fluctuations across the system.

STORAGE – Evaluates the adequacy of storage for the existing system and determines future distribution system storage requirements. Also, investigates current operational practices and provides recommendations to City staff to improve system efficiency.

PUMPING CAPACITY – Evaluates the City's ability to pump water under various conditions, in particular when the largest pump is taken out of service for maintenance. In addition, determines the City's ability to transfer water from the Lower Zone to the Upper Zone under emergency conditions.

TRANSMISSION CAPACITY – Identifies water mains that exceed recommended velocity and headloss criteria.

FIRE FLOW – Evaluates the ability of the distribution systems to effectively deliver fire flow during maximum day demand, as well as identify areas that currently do not meet the City's recommended fire flow goals.

PRESSURE

Challenges

- Reaching pressures greater than 80 psi in the southeast expansion areas of the City
- Future growth area on the west side of the City will eventually expand into areas of higher elevation requiring a new pressure zone.

Recommendations

- East Reduced Pressure Zone - Define the expansion of the reduced pressure zone on the east and southeast side of the City.
- Manage growth on the west side of the City in areas close to the boundaries of the western High Zone.

Overall pressures within a majority of the distribution system fall within the recommended pressure ranges.

Parameter	Recommended Goal
Minimum Pressure	40 psi
Desired Pressure Range	50 – 80 psi
Maximum Pressure	100 psi
Residual Pressure for Fire Flow	20 psi

Pressure Zone	Pressure Range				
	< 40 psi	40 psi to 50 psi	50 psi to 80 psi	80 psi to 100 psi	> 100 psi
Central	0%	0.5%	40%	55%	5%
East Reduced	0%	3%	63%	34%	0%
HIgh - East	0%	2%	67%	25%	6%
HIgh - South	0%	0%	43%	51%	6%
HIgh - West	0%	0%	58%	30%	13%
Reduced	0%	0%	48%	52%	0%
Overall System	0%	0.5%	48%	45%	7%

STORAGE

EXISTING STORAGE CAPACITY

20 MG Total Storage Volume

4 Ground Storage Reservoirs

4 Elevated Storage Tank

The existing distribution system storage was evaluated for adequacy with respect to operational storage, fire protection storage, and emergency storage. Total system storage should be the greater of the following:

1. The sum of operational storage (during MDD) plus fire storage, or
2. The sum of operational storage (during MDD) plus emergency storage.

STORAGE RECOMMENDATIONS (Future Capacity Increase by 6 MG)

60th St Water Tower (1.5 MG)

- **Provide redundant water tower within Central Pressure Zone to allow the existing Menlo Water Tower to be taken off line for maintenance**
- **Operational and fire Storage for the northern part of the Central Zone to developing industrial areas around I-229**

Powder House Rd Water Tower (1.5 MG)

- **Provide greater storage within the northeast area of the High Pressure Zone**
- **Operational and fire storage for growing areas within the Veterans Pkwy Corridor**

Benson Rd Water Tower (3.0 MG)

- **Provide water storage for growing areas in the NW area of the High Pressure Zone**
- **Operational and fire storage for commercial and industrial areas such as Foundation Park**
- **Directly filled by the Lewis and Clark Regional Water System with an overflow 20 feet higher than existing towers in the High Zone**
- **Operate as a key supply connection and storage for the High Pressure Zone with the ability for pump improvements to secure full capacity from Lewis and Clark Regional Water System**

PUMPING CAPACITY

Future Lewis and Clark RWS Connection

EXISTING PUMP CAPACITY

Supply Pumping

WPP High Service Pumps
- Big Blue/Transfer Pumps

Lewis and Clark Regional Water System
- Benson Rd Connection
- 85th St Connection

Reservoir and Pump Stations

East Reservoir
South Reservoir
West Reservoir

PUMPING RECOMMENDATIONS

WPP High Service Pumps/ Reservoir and Pump Stations

- **No capacity improvements required in next 20 years**
- **If planning pump replacement due to wear, consider pump capacity upgrades to meet long term future growth**
- **Consider variable speed pump upgrades to allow greater operational flexibility**

Lewis and Clark RWS

Benson Road Connection
- **Upgrade valving and metering to allow greater capacity**
- **Upgrade transmission pipelines from this connection to provide greater capacity into the High Pressure Zone**

Future 12th St Connection
- **Provide future connection to the High Zone**
  - **West for greater capacity**

TRANSMISSION CAPACITY

A transmission pipeline capacity assessment was conducted to identify water mains that exceeded the recommended velocity and headloss criteria. As water moves through the pipes in the distribution system, pressure is reduced due to friction between the moving water and the walls of the pipe. This pressure reduction is termed headloss and is dependent on flow rate, pipe length, pipe diameter, pipe material, bends, fittings, and valves in the system. Water mains were considered for up-sizing if the following velocity and headloss criteria were experienced during peak hourly demands.

- Velocities greater than 5 fps;
- Small diameter pipes (10-inch or less) have headlosses greater than 5 feet/1,000 feet; or
- Large diameter pipes (16-inch or greater) having headlosses greater than 2 feet/1,000

TRANSMISSION RECOMMENDATIONS

Transmission Capacity (WPP to Central Zone)

Meet growing demand and provide greater capacity to the Central Pressure Zone through upgrading the capacity of the Minnesota Avenue Transmission Pipeline that delivers water to the West, South, and East Reservoirs. Provide key transmission capacity from the Water Purification Plant.

Transmission Capacity to Foundation Park

Provide greater demand and fire flow capacity to support continued industrial growth.

Transmission Highway (Veterans Highway)

Ensure adequate transmission capacity to serve the north and south corridor within the High Zone between the East Reservoir and the 57th St Water Tower.

Transmission Highway (Benson Road South)

Provide greater capacity to the Lewis and Clark Regional Water System connection at Benson Road to deliver water to areas to the South along the North and South corridor of the High Zone on the West side of the system.

Transmission Capacity to the East Reservoir

Meet growing demands to the High Zone on the East side of the system, as this area is the furthest from the Lewis and Clark Regional Water System.

Transmission Highway (East Reduced Pressure Zone)

Extend transmission pipelines, as the system grows into the Southeast portion of the East Reduced Pressure Zone to meet system demands along with fire flow requirements.

FIRE FLOW

A fire flow analysis was performed on individual hydrants and distribution main junctions throughout the entire existing distribution system to analyze the transmission and distribution system piping capacity.

Excellent fire flow throughout majority of water system

Pressure Zone	Available Fire Flow (gpm) based on Residual Pressure of 20 psi					
	< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000
Central	0%	0%	1%	7%	11%	81%
Reduced	0%	2%	8%	33%	28%	30%
HIgh - East	0%	2%	2%	7%	9%	81%
HIgh - South	0%	0%	0%	3%	6%	90%
HIgh - West	0%	0%	1%	5%	8%	86%
East Reduced	0%	0%	13%	13%	21%	53%
Overall System	0%	0.4%	1%	6%	9%	83%

20-YEAR PLAN

Short-Term (0-5 Years)

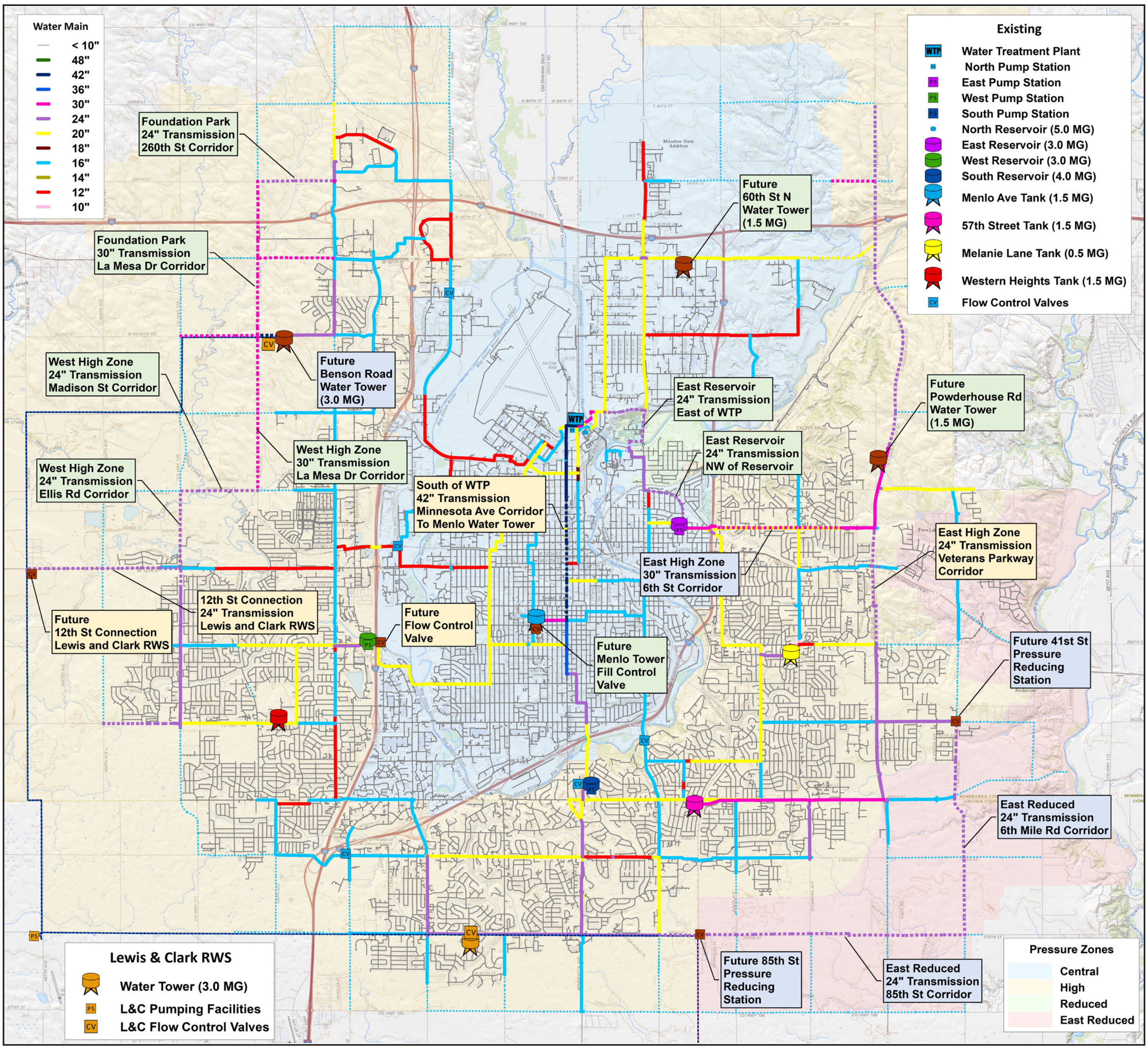
- Upsize/Replacement - Minnesota Ave Transmission Pipeline
- New Transmission Pipeline along Veterans Parkway
- Future 12th St. Lewis and Clark RWS Connection

Near-Term (5-15 Years)

- Continued Phases of Minnesota Ave Transmission Pipeline
- Upsize/Replacement of Transmission - WPP to East Reservoir
- Transmission south of Lewis & Clark Benson Road Connection
- Future 60th Street Water Tower within Central Pressure Zone
- Transmission to Foundation Park for Increased Capacity
- Future Powder House Rd Water Tower within High Zone -East

Long-Term (15+ Years)

- Final Phase - Minnesota Ave Transmission Pipeline
- Transmission Pipelines (East Reduced Pressure Zone)
- Pressure Reducing Stations for East Reduced Pressure Zone
- High Zone - East Transmission to Powder House Rd Tower
- Benson Road Water Tower within the High Zone - West



100-YEAR PLAN

Why a Long-Term Plan?

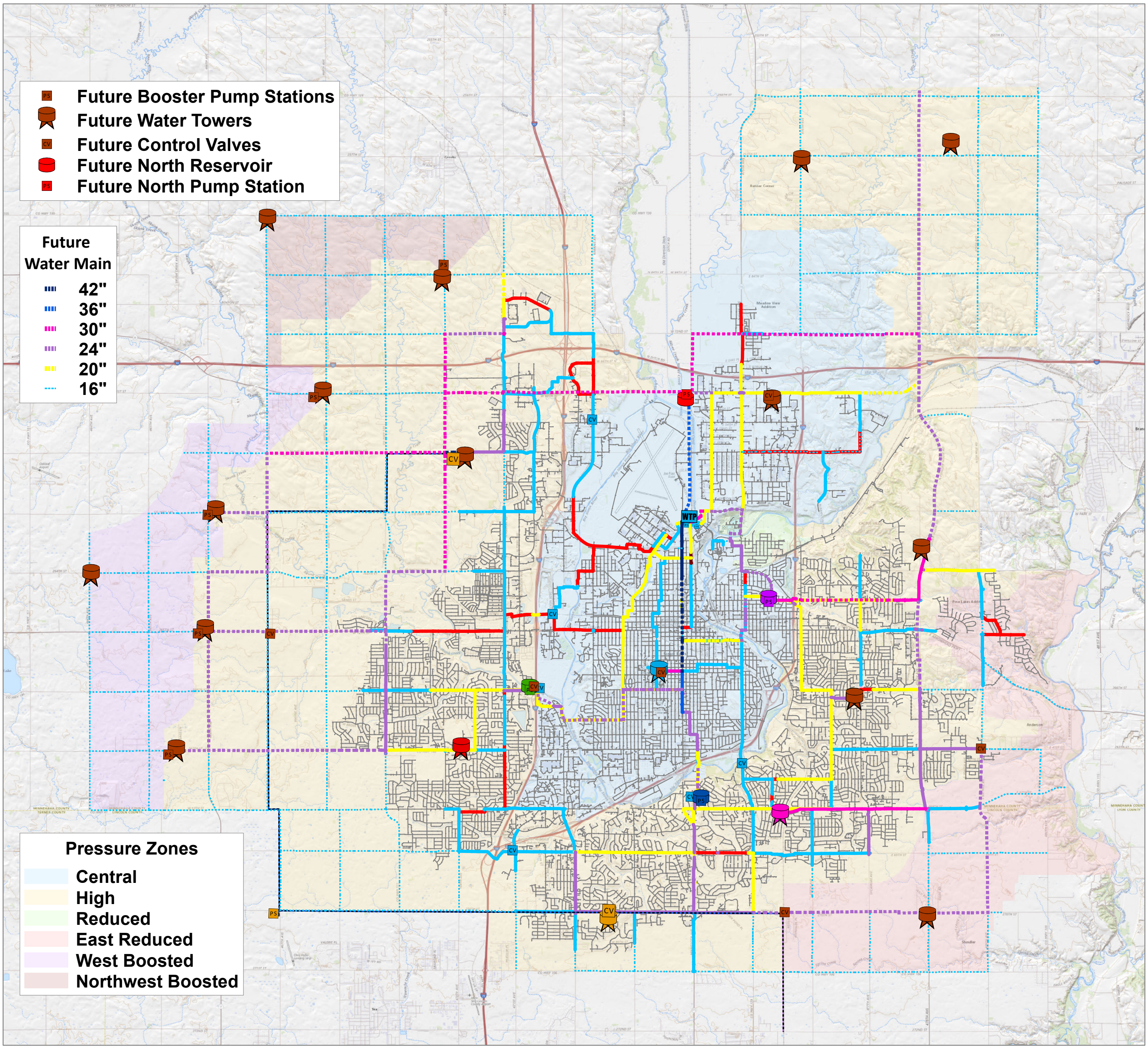
- Build capacity into the transmission pipelines as it is more difficult and more costly to upsize/parallel in the future
- Planning for future water storage and acquiring the land ahead of growth to ensure best location
- Defining boundaries of future pressure zones
- Incorporation of connections of a future water supply

Key Infrastructure

- Additional Water Towers (11)
- Two Additional Boosted Pressure Zones
- North Ground Storage Reservoir and Pump Station
- Additional WPP Clearwell Storage
- Expansion of Transmission Pipelines into Growth Areas

Looking Ahead While Building Today

- Investment in infrastructure in the next 20 years could impact the capacity of water distribution system in the future



CAPITAL IMPROVEMENTS PLANNING

Projects identified for the Capital Improvement Plan (CIP) were divided into eight categories briefly summarized below. The development of these categories provided the conceptual framework for CIP development, project prioritization and timeframe progressions, and correlated projects to the City's present fiscal resources (i.e. what type of project makes the best use of the available capital improvement budget).

CONDITION ASSESSMENT (CA)
Used to identify high-risk degradation of a pipeline before failure, or to verify that there is viable life remaining in a segment of pipeline so that financial resources are spent strategically on its replacement or rehabilitation.

GROWTH & DEVELOPMENT
Provide the necessary infrastructure to serve both existing and future customers. These projects primarily consist of "backbone" water transmission mains in the near-term.

OPTIMIZATION
Improve system water quality, promote network efficiency, help with pressure management, or eliminate facilities to reduce operating costs and improve overall network performance.

REHABILITATION & REPLACEMENT (R&R)
Rehabilitation and replacement projects are generally associated with pipe segments that experience high break rates, water quality issues, are undersized (cannot attain fire flow goal), or require frequent maintenance.

STORAGE
Increase the overall water storage capacity of the system, ensure adequate fire flow, and supplement water supply during periods of peak demand planned maintenance or emergencies.

STUDIES
Studies provide more detailed information so that the City can make informed decisions regarding the cost and timing of future projects.

SUPPLY
Increase the overall water supply available to the distribution system, which ensures the City maintains its current level of service and can adequately provide water to existing and future customers.

TRANSMISSION
Consists of large diameter transmission main (16-42 inches) that originate from sources of supply and convey large volumes of water throughout the entire distribution system.

CIP PRIORITIZATION

CIPs identified within this DSMP were developed for a 20-year planning timeframe. Specific project timing was determined using the hydraulic model, detailed demand trend charts for supply needs and storage tanks, and anticipated system growth maps developed by the City Planning Department. Project timing and ranking were further refined based on input from City staff.

Capital Improvement Project	Project Category	Anticipated CIP Year	Anticipated CIP Cost
System Improvements - Defined Projects			
Minnesota Ave Corridor - Phase 2: 2nd St to 8th St - Material	Rehabilitation & Repair	2024	$3,000,000
Minnesota Ave Corridor - Phase 2: 2nd St to 8th St	Rehabilitation & Repair	2025	$2,300,000
Veterans Parkway Transmission from E 26th St to E 6th St	Transmission	2025	$5,017,000
12th Street Connection to L&C RWS - Phase 1A - Transmission	Supply	2025	$1,798,000
Minnesota Ave Corridor - Phase 3: 8th St. to 14th St.	Rehabilitation & Repair	2026	$5,428,000
12th Street Connection to L&C RWS - Phase 2 - Meter Building	Supply	2026	$1,798,000
12th Street Connection to L&C RWS - Phase 1B - Transmission	Supply	2026	$4,180,000
West Reservoir Control Valve	Optimization	2026	$453,000
Minnesota Ave Corridor - Phase 4: 14th St to 18th St	Rehabilitation & Repair	2028	$3,902,000
Transmission to East Reservoir - East of WTP-Phase 1	Rehabilitation & Repair	2029	$2,195,000
East Reservoir Transmission Upgrades - Hidden Hills	Rehabilitation & Repair	2029	$2,290,000
West High Zone Transmission-La Mesa: Benson to Maple - Phase 1	Transmission	2029	$5,384,000
Transmission to East Reservoir - East of WTP - Phase 2	Rehabilitation & Repair	2030	$2,735,000
West High Zone Transmission-Ellis: Windmill to Madison - Phase 2	Transmission	2030	$4,951,000
Transmission to East Reservoir - East of WTP - Phase 3	Rehabilitation & Repair	2031	$3,011,000
West High Zone Transmission-Madison - Ellis to La Mesa - Phase 3	Transmission	2031	$4,268,000
60th Street Tower	Storage	2031	$10,175,000
Menlo Water Tower Fill Control Valve	Optimization	2031	$548,000
West High Zone Transmission-La Mesa: Madison to Maple-Phase 4	Transmission	2032	$6,066,000
Foundation Park - La Mesa Dr, Benson Rd to 54th St N	Transmission	2033	$5,897,000
Foundation Park - La Mesa Dr, 54th St N to 62nd St N	Transmission	2034	$5,233,000
Foundation Park - 260th St - La Mesa Dr to Marian Rd	Transmission	2035	$4,130,000
Foundation Park - N La Mesa Dr - 62nd St N to 260th St	Transmission	2036	$7,058,000
Powder House Road Tower	Storage	2037	$12,374,000
Minnesota Ave Corridor - Phase 5: 18th St to 21st St	Rehabilitation & Repair	2038	$5,175,000
East Reduced Zone Transmission - Six Mile Rd: E 26th to 41st	Transmission	2038	$2,989,000
East Reduced Zone Transmission - 85th St: Southeastern to Cliff	Transmission	2038	$4,750,000
41st St Pressure Reducing Station	Optimization	2038	$679,000
East High Zone Transmission E 6th St: I-229 to Bahnson Ave	Transmission	2039	$10,683,000
East Reduced Zone Transmission - Six Mile Rd: E 41st to E 57th	Transmission	2040	$4,277,000
East High Zone Transmission: Bahnson Ave to Sycamore Ave	Transmission	2040	$9,111,000
East High Zone Transmission: Sycamore Ave to N Foss Ave	Transmission	2041	$10,262,000
East Reduced Zone Transmission-85th St: Southeastern to Hwy 11	Trasnsmission	2042	$9,364,000
85th St Pressure Reducing Station	Optimization	2042	$761,000
East Reduced Zone Transmission - Six Mile Rd: E 57th to E 85th	Transmission	2043	$8,576,000
East Reduced Zone Transmission - 85th St: Hwy 11 to Six Mile Rd	Transmission	2044	$5,031,000
Benson Rd Water Tower	Storage	2045	$25,606,000
System Improvements - Defined Projects [1]			
Water Storage Rehabilitation	Rehabilitation & Repair	2023 - 2045	$16,312,000
City Wide Water Main Replacement Projects	Rehabilitation & Repair	2023 - 2045	$62,490,000
Water Pipe Trenchless Rehabilitation	Rehabilitation & Repair	2023 - 2045	$29,367,000
Transmission System Improvements - New Growth	Growth & Development	2023 - 2045	$1,250,000
Other Mains - Unforeseen Water Projects	Rehabilitation & Repair	2023 - 2045	$23,379,000
Neighborhood Reconstruction Program	Rehabilitation & Repair	2023 - 2045	$22,737,000
Major Street Reconstruction Program - Replacement	Rehabilitation & Repair	2023 - 2045	$20,181,000
Arterial Street Improvements - New Growth	Growth & Development	2023 - 2045	$46,418,000
Miscellaneous Water Main Project	Rehabilitation & Repair	2023 - 2045	$2,200,000

[1] Yearly undefined projects, anticipated CIP Cost is total from 2023 to 2045.

SUSTAINABLE WATER UTILITY

The 2023 Sioux Falls DSMP provides a guide for capital improvements that will be the basis for planning, financing, designing, constructing, and implementing of solutions to meet the City's foreseeable water system needs for years to come. As the City cycles through the planning process, some uncertainties and changes can be expected. However, the approach, methodology, and investment the City has made in this planning effort provides City staff with a proactive planning approach for responding to future challenges and maintaining a clear vision and consistent direction for the Utility!

Prepared By:

AE2S

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Chapter 1 Introduction

The City of Sioux Falls (City) is located in southeast South Dakota in Minnehaha and Lincoln Counties. The City is the largest in the state with a current estimated population of over 200,000. Sioux Falls is home to banking, financial, medical, manufacturing and food processing facilities. A state map identifying the location of Sioux Falls is provided in. Figure 1.1.

Figure 1.1 Sioux Falls Location Map

1.1 Water System Master Planning Process

Municipal water utilities must continuously plan to identify opportunities and to address system challenges. Water system opportunities and challenges come in many forms, such as population growth, increasing water demands, aging infrastructure, increased regulatory standards and requirements, emerging technological trends and technological advancements, and effective capital improvements planning.

Master planning provides policymakers and the public with a detailed report on infrastructure needs and the recommended actions to accommodate those needs. Master planning helps establish priorities for the construction and implementation of necessary improvements. Lastly, a master plan can be used as a tool to pursue and support requests for capital improvement funding. For these reasons and many others, the City has adopted the Master Planning process for its water system. The City recognizes that prudent management of annual operation and maintenance budgets, optimizing short-term capital improvement expenditures, and maximizing the benefits of long-term capital improvements require a consistent direction for the utility, which can be attained through a robust planning process.

As the City adopts and cycles through the planning process, some uncertainties and changes are expected. The impacts of these changes are best managed through a continued proactive planning approach. Responding to future challenges is most appropriately accomplished through a fluid planning process that enables the City to maintain a clear vision and consistent direction for the Sioux Falls water distribution system.

The 2023 Sioux Falls Water Distribution System Master Plan provides a guide for short-term, near-term, and long-term management of capital improvements for Sioux Fall's water system. The recommended improvements included in the Capital Improvements Plan (CIP) are the basis for planning, financing, designing, constructing, and implementation of solutions to meet Sioux Fall's water system needs for years to come.

1.2 Purpose and Scope

AE2S developed this Master Plan through a collaborative planning process with representatives of the City and the Project Team. The following list summarizes the objectives of this Master Plan:

1. Prepare an overview of the current system.
2. Review any previous study efforts and outline their potential impact on this master plan effort.
3. Prepare updated growth and land use projections for the periods of 10 years, 20 years, 50 years, and 100 years.
4. Prepare and update water demand projections for the planning period for each water service zone within the City.
5. Review the current state of water conservation in the City, identify how conservation affects water use patterns, and estimate what impacts conservation efforts will have on future water use.
6. Evaluate the water distribution system to accept full utilization of both water from the existing Water Purification Plant and the Lewis & Clark Regional Water System including storage and pumping facilities, transmission mains, and pressure zones.
7. Develop and prioritize future infrastructure needs to meet water demands in each planning period. Provide planning level opinions of cost for each improvement.

The following chapters present the findings and results of the work performed to satisfy each of the stated objectives of the Water Distribution System Master Plan. Supplemental information comprises the Appendices.

1.3 Previous Distribution System Studies

The last overall system planning effort for a water distribution system master plan was completed two decades ago. While several other reports and documents have been completed in more recent years for specific areas of the system. Table 1.1 summarizes the documents used in the development of the water system master plan.

Table 1.1 Previous Distribution System Studies

Title	Author	Date
Water Distribution System Master Plan Update	Ulteig Engineers	May 2003
Future Water Supply Evaluation	AE2S	January 2005
Acceptance of Sioux Falls Interim Period Water Lewis & Clark Regional Water System	AE2S	July 2010
Northwest Sioux Falls Hydraulic Analysis	APEX Engineering	January 2014
Hydraulic Analysis of the Northwest Area	AE2S	July 2016

1.3.1 Water Distribution System Master Plan Update

In May 2003, Ulteig Engineers, Inc. completed the Water Distribution System Master Plan Update for the City of Sioux Falls. The Water Distribution System Master Plan Update provided population and water demand projections through 2025. The report estimated that the 2025 population would be 206,752. The 2025 ADD was estimated to be 32.2 mgd (155.7 gpcd), and the PDD was estimated to be 89.5 mgd (432.9 gpcd).

Recommendations for short-term and long-term improvements were identified for system deficiencies as a result of the hydraulic modeling. Short-term improvements were prepared for the years 2003 through 2010. The year 2010 was chosen because of its timing associated with the proposed L&C RWS. The short-term improvements included additional storage facilities, expansion of pumping facilities, and distribution and transmission water main improvements throughout the City.

The Water Distribution System Master Plan Update provided recommendations for long-term improvements for the years 2011 through 2025 to the City of Sioux Falls' distribution and storage facilities based on receiving supplemental water from the L&C RWS, as well as recommendations if L&C RWS were not constructed. The report recommended that treated water from the L&C RWS, if constructed, be distributed to existing storage facilities in the South and West Reservoirs. If L&C RWS is constructed, it was also identified that two large diameter transmission mains may not be required. These two mains are a 36-inch transmission main from the intersection of Minnesota Avenue North and Russel Street to the West Reservoir and a 36-inch transmission main from the intersection of Minnesota Avenue South and 31st Street to the intersection of Phillips Avenue and Interstate 229. Water from L&C RWS would then be directly routed to the periphery of the distribution system on peak days. The remainder of the time, water from L&C RWS would be sent to the water plant for blending with treated water produced by the City to minimize water quality issues.

If the L&C RWS is not constructed and the Sioux Falls WPP requires expansion to treat additional water instead of receiving treated supplemental water, the report recommended that additional clearwell storage be constructed at the WPP site. The report also indicated that the two 36-inch transmission mains discussed above would be essential to the delivery of water throughout the City of Sioux Falls' water distribution system.

1.3.2 Future Water Supply Evaluation

In January 2005, Advanced Engineering and Environmental Services, LLC completed the Future Water Supply Evaluation for the City of Sioux Falls. The projected population growth and associated increase in water demands for the city were estimated to surpass the capacity of the existing water sources by the year 2012. The projected water supply shortage was primarily attributed to the susceptibility of the existing sources to dry climate conditions. As a strategy to obtain additional water supply capacity, the City of Sioux Falls is a member of the L&C RWS.

A planning period of 50 years beyond the implementation deadline of year 2012 was established due to the complexity, limited expandability, and significant costs associated with the construction of new water supply, transmission, and treatment system infrastructure. Water system concepts and implementation schedules for capital improvements were developed for three alternatives: (1) the L&C RWS Alternative; (2) the Missouri River Pipeline Alternative; and (3) the Missouri River Pipeline Alternative with Consecutive Users. Under the L&C RWS Alternative, the City of Sioux Falls would participate in the proposed L&C RWS project and receive its allocated capacity by the year 2012. The City could receive additional capacity from L&C RWS via expansion of the system by year 2017 if members agree to expand the system and assign their share of expanded capacity to the City, providing sufficient capacity through year

2037. The increased water demands beyond 2037 would be met via an independent project by the City of Sioux Falls that utilizes future use appropriations from the Missouri River at Gavin's Point Dam.

With regards to the City's participation in the L&C RWS project, the City commissioned this study effort to assess the impacts of reduced levels of Federal funding and capacity available through system expansion and provide a comparison to the concept of utilizing the City's future use permit on the Missouri River. The results of the Future Water Supply Evaluation indicated that the City of Sioux Falls should continue to participate in the L&C RWS project to meet the projected water demands through year 2037 based on the assumptions made as part of the study effort, the present worth of the alternatives considered, and additional alternative considerations.

1.3.3 Acceptance of Sioux Falls Interim Period Water Lewis & Clark RWS

In July 2010, Advanced Engineering and Environmental Services, LLC completed an update to the Future Water Supply Evaluation for the City of Sioux Falls. The project culminated in a memo titled Acceptance of Sioux Falls Interim Period Water Lewis & Clark Regional Water System. The technical memorandum was used to evaluate and recommend accepting or deferring Sioux Falls Additional Capacity from the Lewis & Clark Regional Water System (L&C RWS) during the Interim Period, termed Sioux Falls Interim Period Water in the Second Amendment to the Amended and Restated Commitment Agreement (ARCA) between Lewis & Clark and the City.

Following the recommendation to pursue Sioux Falls Additional Capacity from Lewis & Clark in the Future Water Supply Evaluation, the ARCA, dated October 1st, 2005, between the City and Lewis & Clark provided that the City receive Sioux Falls Additional Capacity of 17 MGD from Lewis & Clark. To provide the 28.007 MGD of capacity (11.007 MGD of Base System Capacity and 17 MGD of Sioux Falls Additional Capacity) to the City and the capacity to the other Members Lewis & Clark, Lewis & Clark planned to construct a 45 MGD Water Treatment Facilities.

The construction of the Water Treatment Facilities was broken into three phases. During the Phase II, the capacity of the Water Treatment Facilities was expanded and provides Sioux Falls as of 2023 with the available supply of water from L&C RWS of 17 mgd. Further phases of expansion of the Water Treatment Facilities anticipated in the future will provide Sioux Falls with expanded capacity to 28 mgd in 2026. With a future expansion of the Water Treatment Facilities to 60 mgd in 2030, the L&C RWS would expand its capacity to provide 34 mgd to the City of Sioux Falls.

1.3.4 Northwest Sioux Falls Hydraulic Analysis

In January 2014, APEX Engineering completed a hydraulic modeling analysis of the city's northwest corner at the request of the City. The hydraulic analysis looked at a proposed commercial/industrial development utilizing 20 MG per month. The City requested analysis of existing infrastructure and the construction of a new 16-inch watermain was sufficient to supply the area with water to meet pressure and fire flow requirements.

The project required field testing to calibrate the water model. After field testing, it was determined the model correlated well with field testing. The study looked at four alternatives to boost pressure in the area. 1) constructing a single 16-inch transmission main to the site; 2) constructing a 16-inch transmission main with booster pump; 3) constructing 16-inch and 12-inch transmission mains to the site; and 4) constructing an elevated storage tank near the McCrosson Boys Ranch. The only viable alternative was determined to be constructing a new 16-inch main with booster pump.

1.3.5 Hydraulic Analysis of the Northwest Area

In June 2016, Advanced Engineering and Environmental Services, LLC provided the City with a second hydraulic model analysis of the developing northwest area of the city. At the time, water was currently being fed to the area through a 16-inch watermain traveling north on Marion Rd that ended at the McCrosson Boys Ranch.

This technical memorandum summarized the approach and results of the requested analysis to 1) determine if hydraulic characteristics established by the current 1670 ft overflow elevation will meet current and future pressure and flow requirements of the northwest area. 2) if the hydraulic characteristics established by the 1670 ft overflow elevation are not satisfactory, describe the associated deficiencies, and 3) analyze how a future L&C RWS connection at 41st St would affect water delivery to the southwest area.

Based on discussions with city staff, minimum pressure and fire flow criteria were developed for the area. The analysis also defined the growth area and based on traffic analysis zones (TAZ) residential, commercial, and industrial populations were developed.

Based on the results from the hydraulic analysis using the water model and anticipated growth, it was determined that 1) if the city desired a pressure of greater than 50 psi in the area, then a new pressure zone would be required with a future water tower with an overflow elevation of 1705 ft and flow control valves to define the new pressure zone; 2) if the city can tolerate lower pressures in the higher elevations within the northwest pressure zone, then the existing high-pressure zone with a hydraulic grade line of 1670 would be sufficient in this area.

1.3.6 Previous Water Distribution System Planning and Analysis

After completion of the calibration of an updated hydraulic model of the water distribution system in 2018, a number of planning and analysis tasks were undertaken prior to the start of this master planning project. Table 1.2 provides a list of tasks completed for planning of the water distribution system.

Table 1.2 Previous Water Distribution System Planning

Planning & Analysis	Description	Year Completed
Transmission Pipeline Capacity to East Reservoir and Pump Station	Evaluate existing capacity to deliver water from Water Purification Plant to the East Reservoir. Review replacement of existing transmission pipelines and recommend future size and layout.	2018
Lewis & Clark RWS Connection and Capacity	Determine existing capacity to transfer water from the Lewis & Clark RWS into the water distribution system. Recommended improvements for increasing capacity south of the L&C RWS Benson Road Connection.	2019
Minnesota Transmission Pipeline Replacement	Based on reconstruction of Minnesota Avenue south of Russell Street, evaluate the existing and future system capacity related to the existing transmission pipeline and recommend upsizing.	2019
Future Water Tower Storage -Central Pressure Zone	Review existing system operations with Menlo Tower offline. Evaluate additional water tower storage within the Central Pressure Zone and provide recommendation on size and location.	2019
Reservoir and Pump Station Improvement Recommendations	Review existing operations and determine improvements to increase capacity to move water from High Zone to Central Zone at West, South, and East Reservoirs and Pump Stations.	2019
East Reduced Pressure Zone	Layout of the overall reduced pressure zone to define the boundary and location of future pressure reducing stations.	2020

Chapter 2 Existing System Overview

Sioux Falls currently receives its drinking water from both a city owned and operated water treatment plant (WTP), and purchases treated water from the Lewis & Clark Regional Water System (L&C RWS). The WTP is in northern Sioux Falls, near the Sioux Falls Regional Airport and pumps water into the distribution system at this location. Treated water is also received into the distribution system from the L&C RWS in both the northwest and south central side of the city. The water distribution system that delivers water from these water supplies consists of water storage and pumping facilities along with transmission pipelines and water main to ultimately take water to the meters of the customers. The following sections describe in more detail the Sioux Falls water system. A map of the existing water system is shown in Figure 2.1.

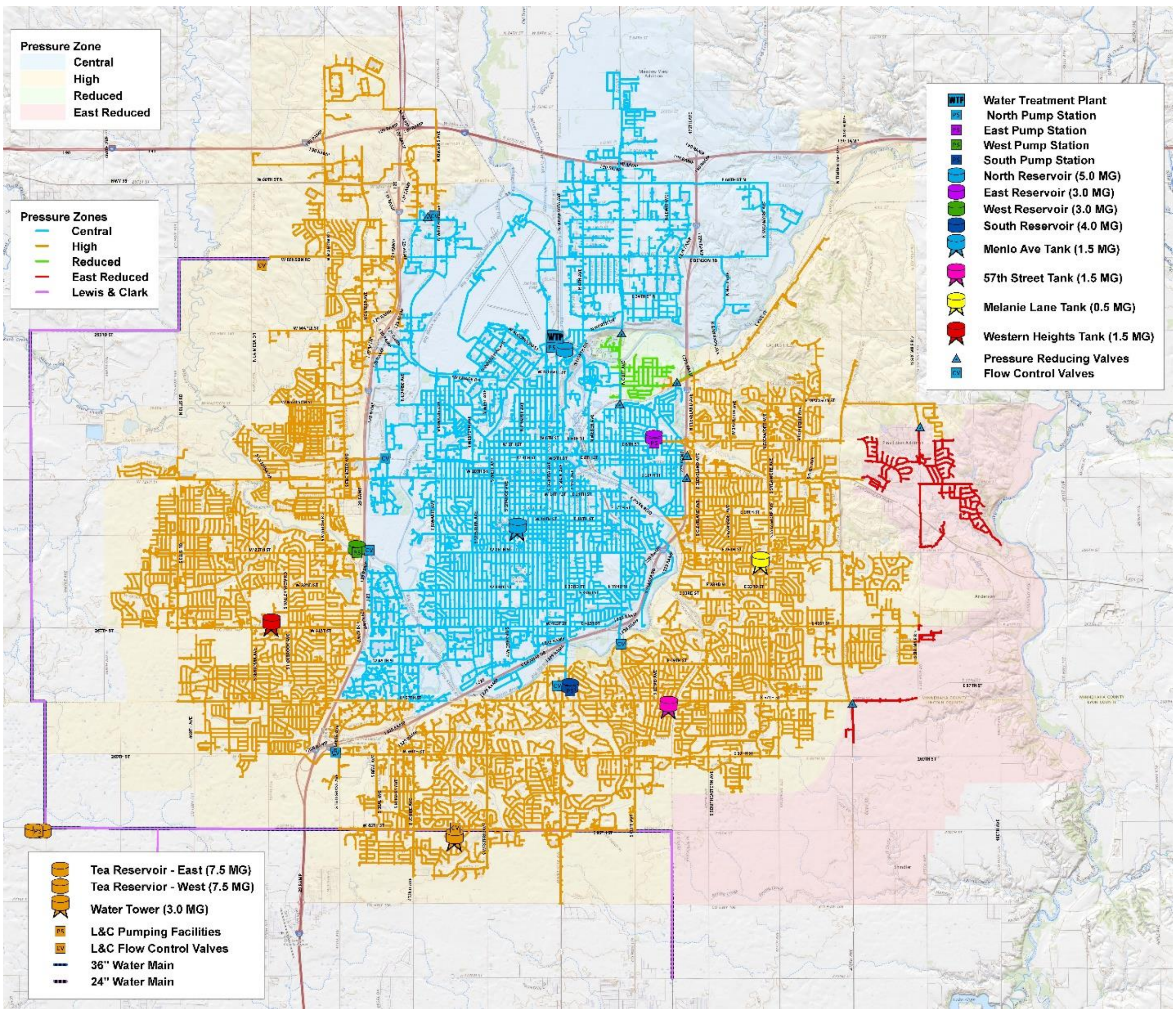


Figure 2.1 Map of Existing Water System

2.1 Water Supply and Treatment

The water supply and treatment system for the City of Sioux Falls consists of production wells and surface water supplied to a water treatment plant owned and operated by the City. Sioux Falls also receives treated water from a secondary source supplied by Lewis & Clark Regional Water System (L&C RWS). A map showing the locations of the water purification plant (WPP) and connections points to Lewis & Clark RWS in relation to the water distribution system is presented in Figure 2.2.

2.1.1 Raw Water Supply

The raw water supply to the WPP consists of groundwater from the Big Sioux Aquifer (BSA), the Middle Skunk Creek Aquifer (MSCA), and surface water from the Big Sioux River (BSR). The BSA

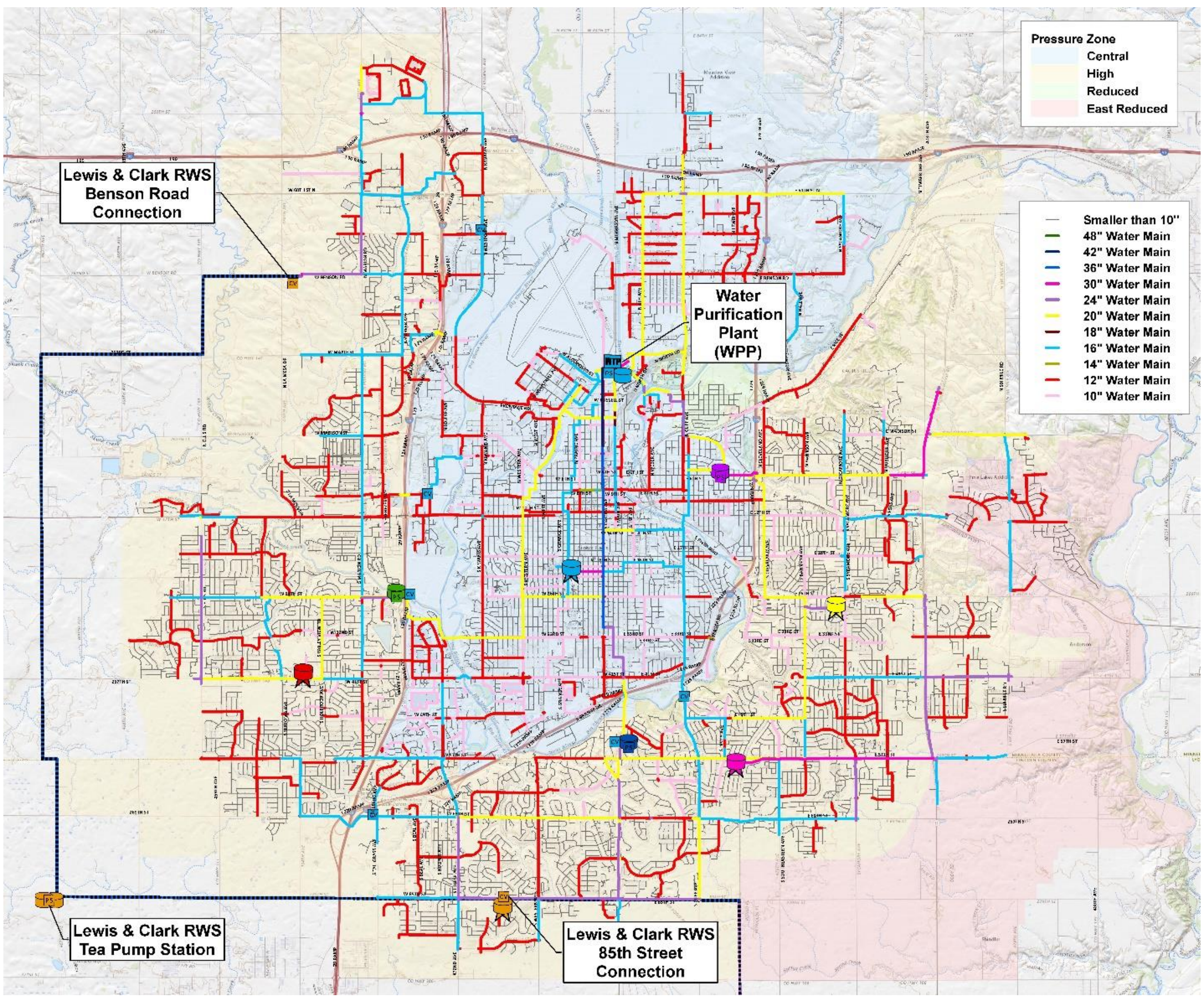


Figure 2.2 Existing Water Supply and Treatment Facilities

is a shallow unconfined aquifer which underlies the Big Sioux River Basin. The Big Sioux River Basin runs along the eastern edge of South Dakota. The City currently holds existing and future water rights from the BSA from just north of the City of Baltic to just south of the Sioux Falls Regional Airport. The annual diversion rate allowed by current and future water rights in the BSA exceeds 77,000 Acre-feet / year which equates to an average rate of 68.7 mgd.

The city has fifty-three wells located in the BSA: seventeen wells are Bragstad wells, sixteen wells are collector wells, one well is a Wolf well, and nineteen wells are small diameter gravel pack wells. The oldest well was constructed in 1911. The city is currently constructing a new collector well which will replace an existing Bragstad well and is scheduled to be completed in early 2024.

The MSCA is a shallow unconfined aquifer which underlies the Skunk Creek basin just west of the Big Sioux River Basin. Skunk Creek flows through the basin from northwest to southeast, discharging into the Big Sioux River in western Sioux Falls. The MSCA wells are located approximately 15 miles to the northwest of the WTP. Thirteen small diameter gravel pack wells exist in the Middle Skunk Creek Aquifer. The annual diversion rate allowed by current and future water rights exceeds 5,000 Acre-feet / year which equates to an average rate of 4.5 mgd.

Nearly 60 miles of raw water transmission mains ranging in size from 6 inches to 48 inches divert water to the WTP. Most of the pipe consists of ductile iron but small areas of PVC, concrete, and cast iron also exist. The large raw water transmission mains entering the water plant from the north are concrete.

The BSR drainage basin upstream of Sioux Falls covers nearly 5,000 square miles in eastern South Dakota and southwestern Minnesota. The river ultimately discharges into the Missouri River in the far southeastern corner of the state. Land use within the river basin is primarily agricultural with corn, soybeans, wheat, and alfalfa as the major crops. Livestock including beef cattle, dairy cattle, and hogs are raised in pastures or in confined animal feeding operations. Around the city, the river channel has been modified to reduce the effects of flooding by creating a diversion channel to the east which diverts flood waters around the city. A dam on the main channel, north of the airport allows water to flow down the main channel through the city or during times of high river flows to be diverted around the city. A low head dam on the diversion channel creates a pool of water from where the city pumps water for the WTP.

The BSR pump station is located just north of the airport, where the main channel and diversion channel split. The annual diversion rate allowed by current and future water rights equals 50,000-acre feet. The BSR Pump Station contains two – 15 million gallon per day pumps and one – 5 million gallon per day pump. The river water is pumped through a separate 48-inch transmission main which transitions to a 36-inch main as it travels to the water treatment plant. When BSR water is being treated, the raw surface water is pumped into the pretreatment basin (Actiflo) prior to flowing to the lime softening basins. Groundwater is usually pumped directly into the lime softening basins, bypassing the Actiflo treatment system.

2.1.2 Water Purification Plant

The WPP was constructed in 1954 as a single stage lime softening plant. The initial design flow rate was 26 million gallons per day (mgd). The WPP was designed as a groundwater plant to remove total hardness, iron, and manganese. In 1972, a mirror image of the treatment plant was constructed which increased the flow rate to 54 million gallons per day. In the early 1990's, the Big Sioux River pump station was completed, allowing the WTP to treat surface water. This was about the same time the federal drinking water regulations were changing for those drinking water systems treating surface water or groundwater under the influence.

Several modifications were made to the treatment process in response to the addition of surface water and increased drinking water regulations. Issues with disinfection byproducts, taste and odors, finished water turbidity, and chlorine decay in the distribution system were a few of the issues experienced when treating surface water. The modifications included:

- Rehabilitation of the gravity filters to include new filter underdrains, air scour, surface wash, backwash pump improvements, dual media including sand and granular activated carbon (GAC) caps, and new backwash return basin.
- Clearwell improvements to improve chlorine contact time (CT)
- Construction of a new chemical feed facility and adding new chemicals including powdered activated carbon, ferric chloride, and ammonia.
- Conversion to chloramines as the secondary disinfectant in the distribution system
- Addition of a pretreatment system for treating surface water (Actiflo)
- The addition of filter to waste on the gravity filters
- Construction of 5 new gravity filters to increase the filtration capacity to approximately 75 million gallons per day. (Not to be confused with treatment capacity).

Each of these improvements have allowed the City of Sioux Falls to surpass all drinking water regulatory requirements and produce some of the best tasting water in the state of South Dakota.

From the WPP water flows into a 4.0 million gallon (MG) Underground Clearwell. Water flows from the Clearwell into a wetwell, where water is pumped into the distribution system by high service pumps. Water can also be transferred from the Clearwell to a 5.0 MG above ground storage reservoir (North Reservoir) by transfer pumps, then allowed to flow by gravity back to the wetwell when needed to balance WTP operations with system demands.

2.1.3 Lewis & Clark Regional Water System

The L&C RWS is a wholesale provider of treated drinking water to 20 member cities and rural water systems that expands over a 5,000 square mile area. The L&C RWS treatment plant is located just north of Vermillion, South Dakota and delivers water into southeast South Dakota, northwest Iowa, and southwest Minnesota. Planning for the system began in 1990 and authorized for construction by congress in 2000. Construction on the system began in 2004. Sioux Falls began receiving water from LCWRS in August 2012 and is the largest purchaser of water from the system. Currently the city can contractually purchase just over 17 million gallons per day with an ultimate capacity up to 34.4 million gallons per day when the system is complete.

Water is drawn from the Elk Point aquifer next to the Missouri river just southwest of Vermillion. The system has water rights reserved up to 45,165 acre feet of water. Nine small diameter angle wells are used to pump the water from the aquifer. A horizontal collector well was recently completed which has significantly increased the amount of groundwater available to the treatment plant. Construction is scheduled to be completed in 2023.

The WTP uses the lime softening process to remove total hardness, iron, and manganese. Treated water quality and thus the treatment process was selected to mirror the water quality produced from the WTP in Sioux Falls. A single 52-inch diameter cement lined welded steel pipe brings water up to the Tea, SD reservoir near Sioux Falls. The Tea reservoir consists of 2 – 7.5-million-gallon reservoirs and a pump station. The Tea pump station boosts water pressure in the main transmission lines going north and east of Sioux Falls. A 3-million-gallon water tower is located in southwest Sioux Falls and provides water to the City of Sioux Falls, North Lincoln County Rural Water, and water systems connected to the east.

Water from the L&C RWS enters the Sioux Falls distribution system at the West Benson Road Meter Station in northwest Sioux Falls and at the 85th St Water Tower in southwest Sioux Falls. Each entry point to the Sioux Falls distribution system from the L&C RWS has a flow meter, control valve, blocking valves, and pressure monitoring. The flow control valves are controlled by the Sioux Falls Water Plant operators through the SCADA system and are manipulated depending on the water demands in the distribution system.

Sioux Falls is currently working with L&C RWS to begin design of the water treatment plant addition which will increase the available water supply to the city up to 34.4 mgd.

2.2 Pressure Zones

The water distribution system is typically separated into two key pressure zones and two sub-zones, which are described in Table 2.1. The boundary of a pressure zone is typically based on the topography of the area, and is identified by the elevation contour that corresponds to the boundary between pressure zones. Figure 2.3 provides a map with the layout of the pressure zones. Figure 2.4 provides a general understating of pressures within each of the pressure zones defined by the hydraulic grade line based on the defined overflow elevation.

The transfer of water from the water supplies to pressure zones is described in Table 2.2. This table provides information on options for transferring water between pressure zones via pressure reducing valves, pump stations, and/or flow control valves.

Table 2.1 Summary of Existing Pressure Zone Information

Pressure Zone Designation	Water Tower	Water Tower Elevations (ft)		Elevations Served (ft)		Static Pressure (psi)	
		Low Level	Overflow	High	Low	High	Low
Central	Menlo	1593	1636	1543	1405	100	40
High	Melanie	1632	1670	1570	1440	100	43
	57th Ave	1632	1670				
	Western Heights	1630	1670				
Reduced	None	pressure reduced	HGL 1535	1378	1308	98	68
East Reduced	None	pressure reduced	HGL 1580	1465	1350	100	50

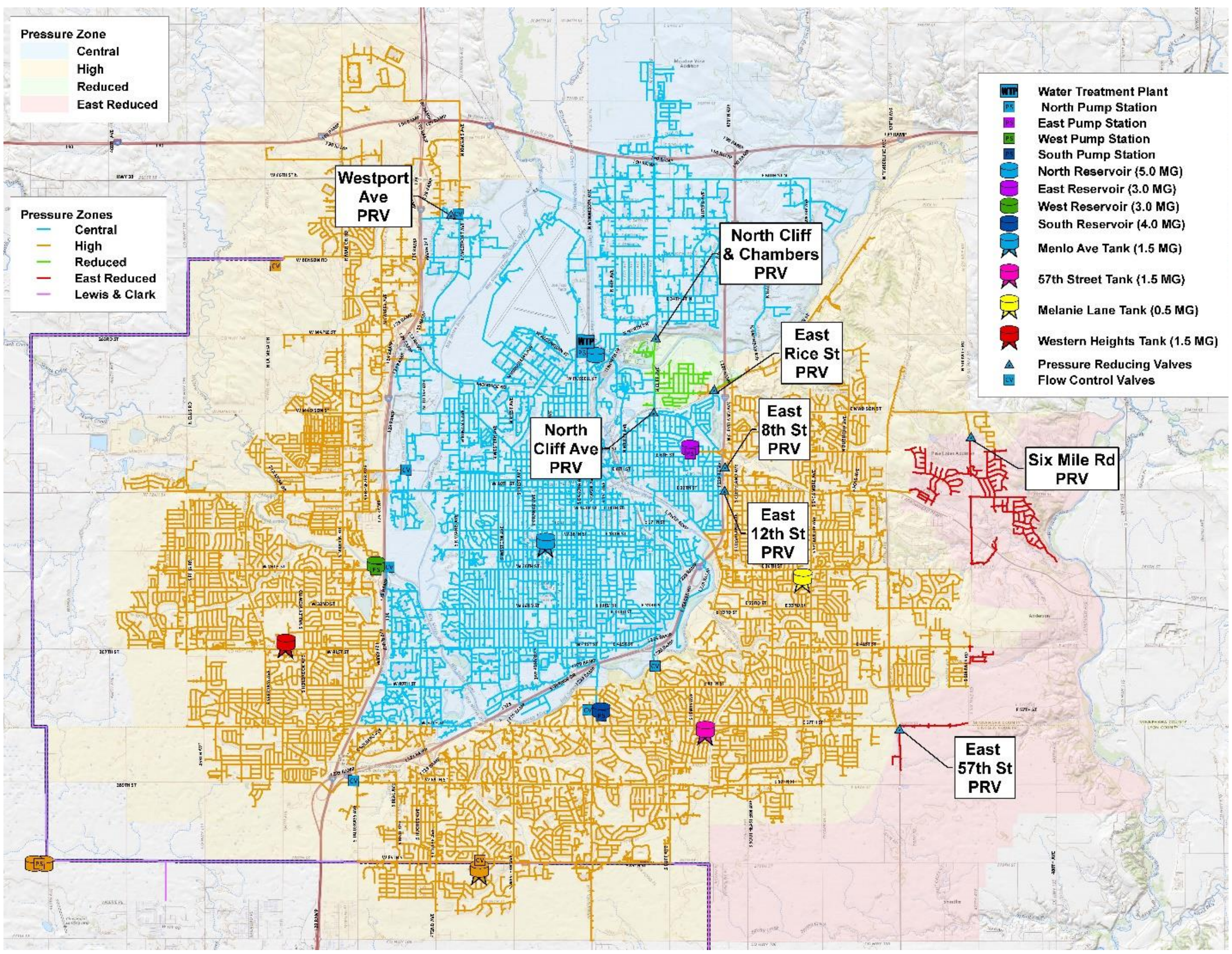


Figure 2.3 Existing Pressure Zone Boundaries and PRVs

Central Zone

	Elev. (ft)
Overflow =	1635
Static Pressure	
10 psi	1612
15 psi	1600
20 psi	1589
25 psi	1577
30 psi	1566
35 psi	1554
40 psi	1543
45 psi	**1531**
50 psi	**1520**
55 psi	**1508**
60 psi	**1496**
65 psi	**1485**
70 psi	**1473**
75 psi	**1462**
80 psi	**1450**
85 psi	1439
90 psi	1427
95 psi	1416
100 psi	1404

East Reduced Pressure Zone

	Elev. (ft)
Overflow =	1580
Static Pressure	
10 psi	1557
15 psi	1545
20 psi	1534
25 psi	1522
30 psi	1511
35 psi	1499
40 psi	1488
45 psi	**1476**
50 psi	**1465**
55 psi	**1453**
60 psi	**1441**
65 psi	**1430**
70 psi	**1418**
75 psi	**1407**
80 psi	**1395**
85 psi	1384
90 psi	1372
95 psi	1361
100 psi	1349

Reduced Zone

	Elev. (ft)
Overflow =	1535
Static Pressure	
10 psi	1512
15 psi	1500
20 psi	1489
25 psi	1477
30 psi	1466
35 psi	1454
40 psi	1443
45 psi	**1431**
50 psi	**1420**
55 psi	**1408**
60 psi	**1396**
65 psi	**1385**
70 psi	**1373**
75 psi	**1362**
80 psi	**1350**
85 psi	1339
90 psi	1327
95 psi	1316
100 psi	1304

Figure 2.4 Pressure Zones – Defining Areas

Table 2.2 Pressure Zone Information Related to Water Supply/Transfer Options

Pressure Zone Designation	Water Supply/Transfer Options	
Central	Water Purification Plant	
	Transfer From High Zone Through Flow Control Valves	
High	Lewis & Clark RWS Through	85^{th} St Connection
		Benson Rd Connection
	Pumped from Central Zone Through	East Reservoir & Pump Station
		West Reservoir & Pump Station
		South Reservoir & Pump Station
Reduced	Central Zone Through PRVs	
East Reduced	High Zone Through PRVs	

2.2.1 Pressure Reducing Valves

Pressure reducing valves (PRV)s throttle automatically to prevent the downstream hydraulic grade line from exceeding a set value. PRVs are used to prevent high downstream pressures which could cause damage. In a closed pressure zone with no water storage, PRVs regulate the pressure by controlling the downstream pressure at a set hydraulic grade line based on a pressure setting for the downstream side of the PRV. In a system with water storage, a PRV is used to allow water flow from a high pressure zone to a lower pressure zone when the pressure gets below a certain setpoint which can occur during periods of high demand such as a fire flow demand.

Typically in a closed pressure zone with no water storage, PRV vaults contain a small and large PRV. The smaller PRV is set to handle domestic flows while the larger PRV is set to open on large demands such as fire flow. For pressure zones with water storage, PRV vaults typically contain only a large PRV for the main purpose of providing flow during a fire demand or period of large water demand during the day. Table 2.3 lists the PRV vaults along with the PRV size, operational type, elevation, source zone and discharge zone. Operational types are either domestic or fire.

Table 2.3 Pressure Reducing Valve Information

Name	Size (inches)	Operational Type	Elevation (feet)	From	To
Six Mile Rd	16	Fire	1463	High PZ	East Reduced PZ
	8	Domestic			
East 57th St	16	Fire	1423	High PZ	East Reduced PZ
	8	Domestic			
North Cliff Ave and Chambers	10	Fire	1371	Central PZ	Reduced PZ
	4	Domestic			
North Cliff Ave	10	Fire	1365	Central PZ	Reduced PZ
	4	Domestic			
East Rice St	8	Fire	1341	Central PZ	Reduced PZ
	4	Domestic			
East 12th St	6	Fire	1508	High PZ	Central PZ
East 8th St	6	Fire	1485	High PZ	Central PZ
Westport Ave	10	Fire	1486	High PZ	Central PZ

2.2.2 Flow Control Valves

Flow controls are located throughout the system and provide operators with the flexibility to control the ability to move water from one area of the distribution system to another. These valves include a SCADA control valve actuator and a flow meter. A list of existing flow control valves is provided in Table 2.4 and locations show in Figure 2.5. The following are some of the control options.

- Moving water from the High Pressure Zone to the Central Pressure Zone
- Moving water between the High Zone from east to west or vice-versa.

Table 2.4 Flow Control Valve Information

Flow Control Valves	From	To	Control Type
Lyons Blvd	High PZ	Central PZ	SCADA
Cliff Ave	High PZ	Central PZ	SCADA
Westport Ave	High PZ	Central PZ	SCADA
South Reservoir	High PZ	Central PZ	SCADA
West Reservoir	High PZ	Central PZ	SCADA
69th St near I-229	High PZ	High PZ	SCADA

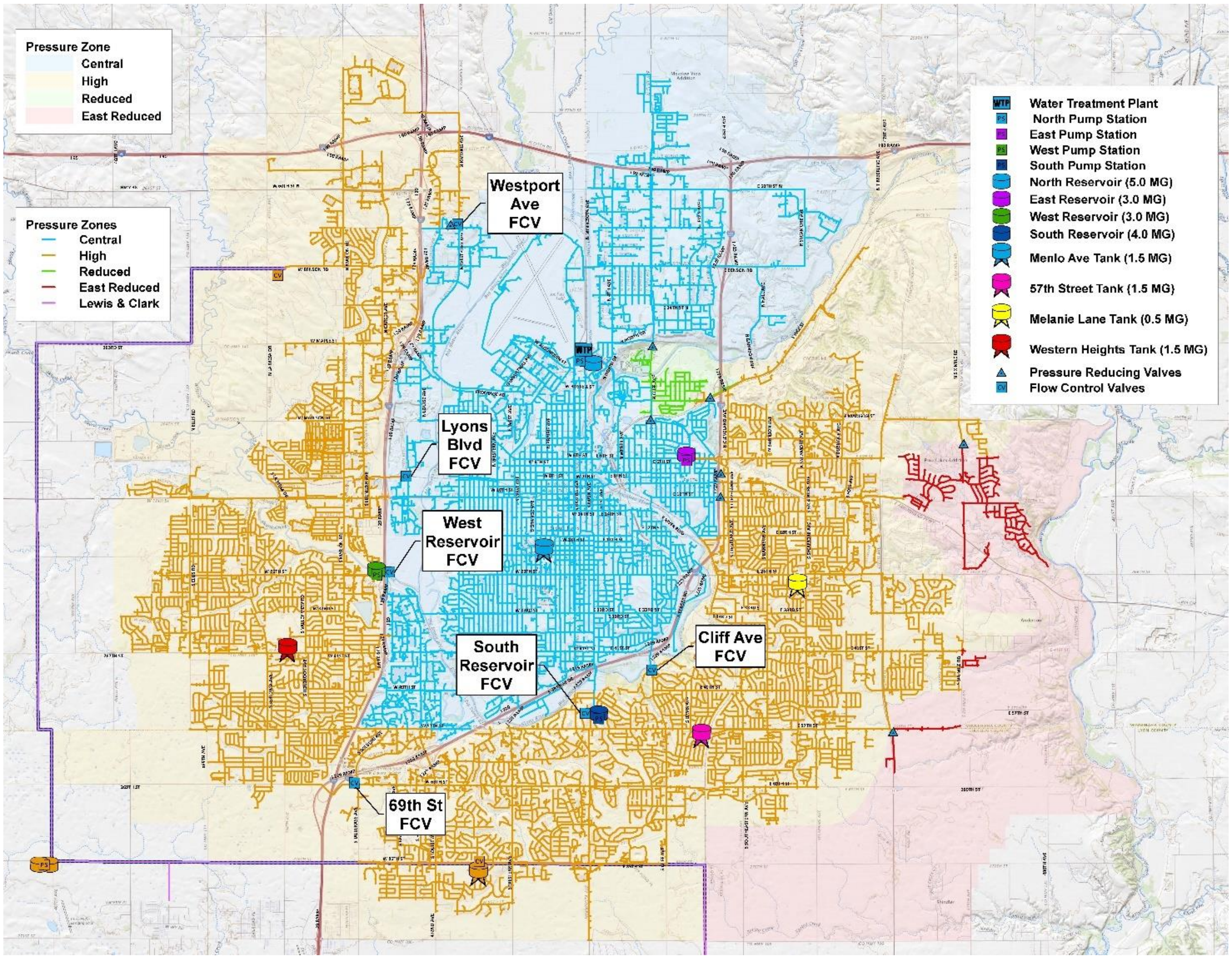


Figure 2.5 Existing Flow Control Valves

The control valves that allow water to move from the High Zone to the Central Zone provide the ability to move water from Lewis & Clark RWS that enters the High Zone to transfer to the Central Zone. These control valves can provide the ability to maximize the utilization of the capacity from the Lewis & Clark RWS at both the 85th St Connection and the Benson Rd Connection.

The control valve located at 69th St near I-229 allow the operators to understand typically how much flow is moving from east to the west that is mostly coming from the L&C RWS 85th St. Connection. This operation will be effective when two other manual gate valves are closed at 85th St and 57th St where the water main crosses I-29. This control can prevent the overfilling or allow the ability to fluctuate the Western Heights Water Tower.

2.3 Water Storage and Pumping Facilities

The Sioux Falls water distribution system has a total finished water storage volume of 24.0 million gallons (MG) in several storage facilities. These storage facilities provide operational storage to meet system demands, provide emergency storage, provide fire flow storage, and help maintain a uniform pressure in the distribution system during peak hourly demands. Water storage facilities include 9.0 MG located at the WTP with the Clearwell and North Reservoir (Big Blue). Three ground storage reservoirs are located along the boundary of the two pressure zones that provide storage for pumping to the High Pressure Zone. The East, West, and South Reservoirs have a combined storage of 10.0 MG. There are four water towers that have a combined capacity of 5.0 MG. The Menlo Water Tower serves the Central Pressure Zone while the Melanie, 57th Street, and Western Heights Water Towers serve the High Pressure Zone.

2.3.1 Ground Storage Facilities

Information for each of the ground storage facilities including tank style, size, head range and elevations for base of the reservoir and overflow are provided in Table 2.5. The Clearwell, East Reservoir, West Reservoir, and South Reservoir are buried underground concrete tanks. The North Reservoir (Big Blue) located at the Water Purification Plant is an above ground steel tank. These reservoirs range in size from 3 million gallons to 5 million gallons.

Table 2.5 Existing Storage Information – Ground Storage

Water Storage Facility Name	Tank Style	Size (MG)	Head Range (ft)	Base Elevation (ft)	Overflow Elevation (ft)
Clearwell	Rectangular Tank	4.0	11.0	1410.0	1421.5
North Reservoir	Cylindrical Tank	5.0	39.0	1425.5	1464.5
East Reservoir	Rectangular Tank	3.0	20.0	1445.0	1465.0
South Reservoir	Rectangular Tank	4.0	23.0	1433.0	1456.0
West Reservoir	Cylindrical Tank	3.0	12.8	1416.0	1428.8

2.3.2 Ground Storage and Pumping

Ground storage and pumping within the distribution system consist of following five facilities. The WPP Clearwell and North Reservoir provide storage and pumping into the Central Pressure Zone. The East, South, and West Reservoirs provide the ability to store water from the Central Zone and ability to pump water from these reservoirs to the High Pressure Zone. Table 2.6 provides a list of ground storage facilities including type of storage and how they interact with the system. Table 2.7 provides a list of pumping facilities that pump from these ground storage facilities and their interaction with the distribution system. Figure 2.6 shows a map showing the locations of the ground storage and pumping facilities.

- WPP Clearwell and High Service Pumps
- North Reservoir (Big Blue) and Transfer Station
- East Reservoir and Pump Station
- South Reservoir and Pump Station
- West Reservoir and Pump Station

Table 2.6 Existing Ground Storage Facilities

Storage	Storage Type	Filled From	Zone Served
Clearwell	Pumped	WTP	Central PZ
North Reservoir	Pumped/ Gravity	Clearwell	HSP Wetwell
East Reservoir	Pumped	Central PZ	High PZ
South Reservoir	Pumped	Central PZ	High PZ
West Reservoir	Pumped	Central PZ	High PZ
		High PZ	High PZ

Table 2.7 Existing Pumping Facilities

Pump Stations	From	To	To Storage
WPP High Service Pumps	North Reservoir/ Clearwell	Central Zone	Menlo Water Tower
WPP Transfer Pumps	Clearwell	NA	North Reservoir
East Reservoir Pump Station	East Reservoir	High PZ	High Zone Water Towers
South Reservoir Pump Station	South Reservoir	High PZ	High Zone Water Towers
West Reservoir Pump Station	West Reservoir	High PZ	High Zone Water Towers

2.3.3 WPP Clearwell and High Service Pumps

The High Service Pumps are used to convey water to the Central Pressure Zone and pump from the WPP Clearwell. The WPP Clearwell has a capacity of 4.0 million gallons. A summary of the pump capacities is provided in Table 2.8. Information is provided on horsepower (hp), rated flow in gallons per minute (gpm) and million gallons per day (MGD), and rated total dynamic head (TDH). Variable frequency drives (VFD) are installed on high service pumps 3 and 4.

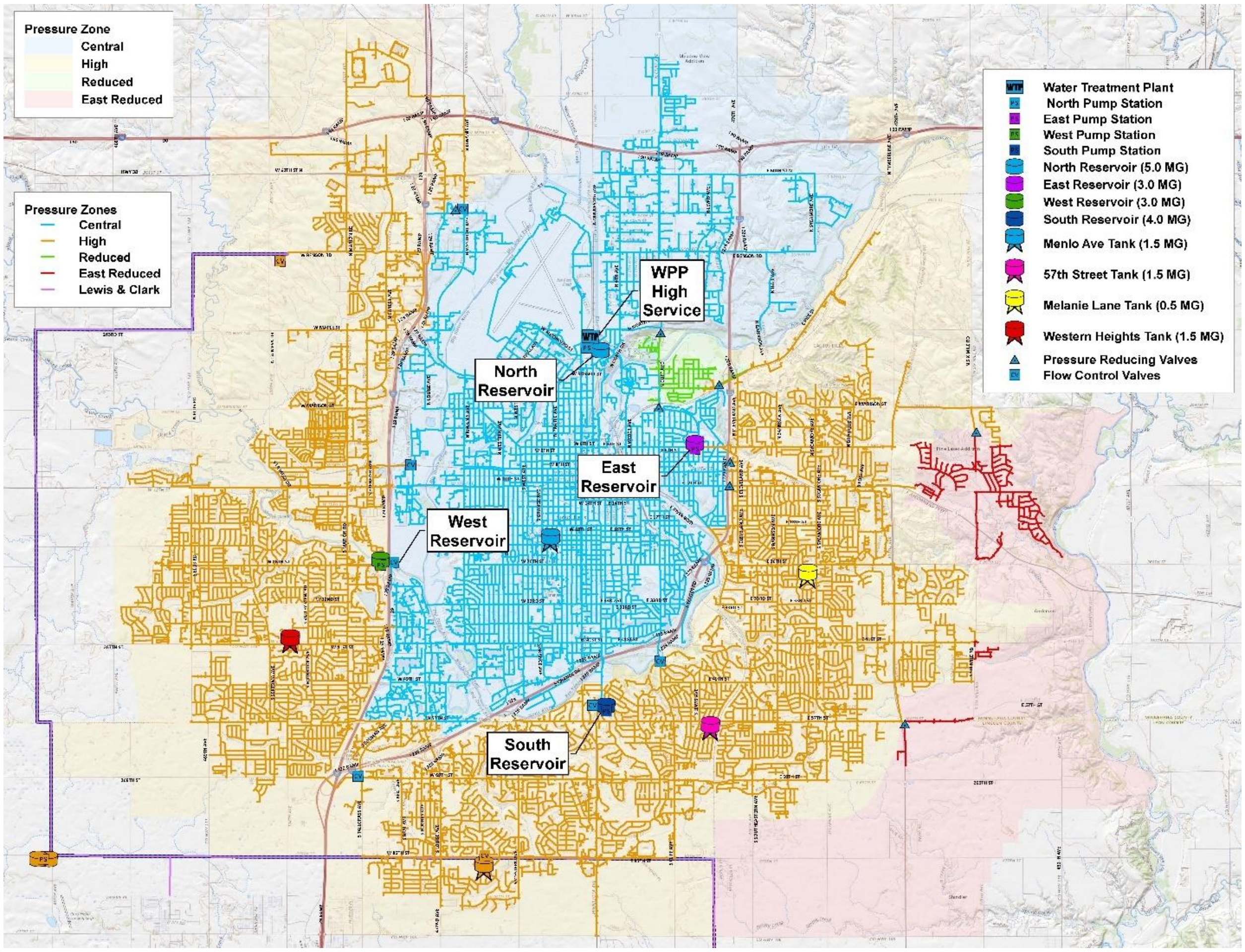


Figure 2.6 Existing Ground Storage Reservoir and Pump Station Facilities

Table 2.8 WPP High Service Pumps

Pump Name	Size (hp)	Rated Flow (gpm [MGD])	Rated TDH (feet)
Pump No. 1	600	7,000 [10.1]	240
Pump No. 2	600	7,000 [10.1]	240
Pump No. 3 (VFD)	900	10,500 [15.1]	240
Pump No. 4 (VFD)	600	7,000 [10.1]	240
Pump No. 5	900	10,500 [15.1]	240
Pump No. 6	900	10,500 [15.1]	240
Pump No. 7	600	6,950 [10.0]	240
Pump No. 8	600	6,950 [10.0]	240
Pump No. 9	600	6,950 [10.0]	240

2.3.4 North Reservoir (Big Blue) and Transfer Pump Station

The North Reservoir (Big Blue) has a capacity of 5 million gallons and provides above ground storage at the Water Purification Plant. A transfer pump station pumps water from the WPP Clearwell to the North Reservoir when there is excess capacity based on when the Clearwell reaches a set level. When there is greater pumping from the WPP high service pumps, a transfer valve opens that allows water to flow back from the North Reservoir to the WPP Clearwell. The transfer pump station consists of three pumps and information on these pumps is provided in Table 2.9. This reservoir provides expanded clearwell storage to provide the ability to operate the water purification plant at a constant flow rate throughout the day and use this storage to meet changes in hourly demand throughout the day.

Table 2.9 North Reservoir Transfer Pump Station

Pump Name	Size (hp)	Rated Flow (gpm [MGD])	Rated TDH (feet)
Pump No. 1	150	6,000 [8.6]	50
Pump No. 2	150	6,000 [8.6]	50
Pump No. 3	150	6,000 [8.6]	50

2.3.5 East Reservoir and Pump Station

The East Reservoir Pumps are used to convey water from the East Reservoir to the High Pressure Zone. The East Reservoir has a storage capacity of 3.0 million gallons. A summary of the pump capacities is provided in Table 2.10. The operation of the pumps at the East Reservoir Pump Station are based on the tank levels of the Melanie Water Tower.

Table 2.10 East Reservoir Pump Station

Pump Name	Size (hp)	Rated Flow (gpm [MGD])	Rated TDH (feet)
Pump No. 1	300	3,100 [4.5]	240
Pump No. 2	300	3,100 [4.5]	240
Pump No. 3	300	3,600 [5.2]	240
Pump No. 4	300	3,600 [5.2]	240
Pump No. 5	300	3,100 [4.5]	240

2.3.6 South Reservoir and Pump Station

The South Reservoir Pumps are used to convey water from the South Reservoir to the High Pressure Zone. The South Reservoir has a storage capacity of 4.0 million gallons. A summary of the pump capacities is provided in Table 2.11. The operation of the pumps at the South Reservoir Pump Station are based on the tank levels of the 57th Street Water Tower.

Table 2.11 South Reservoir Pump Station

Pump Name	Size (hp)	Rated Flow (gpm [MGD])	Rated TDH (feet)
Pump No. 1	150	2,100 [3.0]	220
Pump No. 2	150	2,100 [3.0]	220
Pump No. 3	150	2,100 [3.0]	220
Pump No. 4	400	5,000 [7.2]	248
Pump No. 5	400	5,000 [7.2]	248

2.3.7 West Reservoir and Pump Station

The West Reservoir Pumps are used to convey water from the West Reservoir to the High Pressure Zone. The storage capacity of the West Reservoir is 3.0 million gallons. A summary of the pump capacities is provided in Table 2.12. The operation of the pumps at the West Reservoir Pump Station are based on the tank levels of the Western Heights Water Tower.

Table 2.12 West Reservoir Pump Station

Pump Name	Size (hp)	Rated Flow (gpm [MGD])	Rated TDH (feet)
Pump No. 1	250	2,750 [4.0]	250
Pump No. 2	250	2,750 [4.0]	250
Pump No. 3	250	2,750 [4.0]	250
Pump No. 4	250	2,750 [4.0]	250
Pump No. 5	250	2,750 [4.0]	250
Pump No. 6	250	2,750 [4.0]	250

2.3.8 Water Tower Storage

Water tower storage within the water distribution system is located in the two main pressure zones to provide floating storage. These water towers provide storage for hourly demand fluctuations and for emergencies related to fire demands or water main breaks/pump shutdowns. A list of the existing water towers is provided in Table 2.13 and shares which pressure zone they serve along with how they interact with pump stations and water supply connections. A map of the locations of each of the existing water towers is shown in Figure 2.7.

Water tower storage within the Central Pressure Zone consists of one water tower with a volume of 1.5 MG. There are three water towers located within the High Pressure Zone with a combined storage of 3.5 MG. Information on these water towers is provided in Table 2.14.

Table 2.13 Existing Water Towers

Storage	Storage Type	Filled From	Zone Served
Menlo Water Tower	Floating	WPP	Central PZ
Melanie Water Tower	Floating	L&C RWS/ Pump Stations	High PZ
57^{th} St Water Tower	Floating	L&C RWS/ Pump Stations	High PZ
Western Heights Water Tower	Floating	L&C RWS/ Pump Stations	High PZ

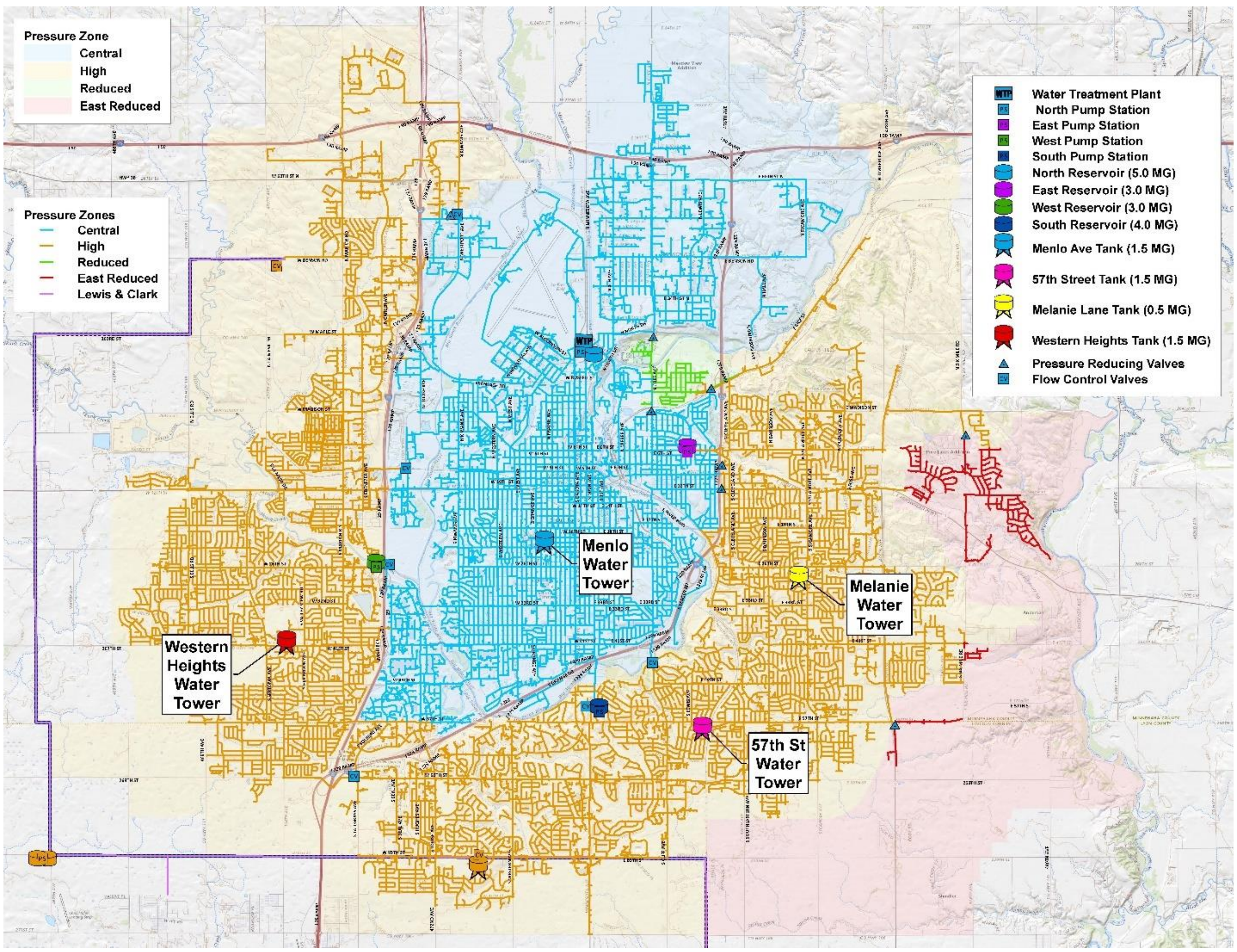


Figure 2.7 Existing Water Towers

Table 2.14 Distribution Storage Information – Water Towers

Water Storage Facility Name	Tank Style	Size (MG)	Head Range (ft)	Base Elevation (ft)	Low Water Elevation (ft)	Overflow Elevation (ft)
Menlo Water Tower	Metal Spheroid	1.5	46	1491.0	1589.0	1635.0
Melanie Water Tower	Metal Spheroid	0.5	38	1545.0	1632.0	1670.0
57th Ave Water Tower	Composite	1.5	40	1520.0	1630.0	1670.0
Western Heights Water Tower	Composite	1.5	40	1530.0	1630.0	1670.0

2.4 Water Distribution System Network

The City's distribution system consists of a network of components that transfer water from the treatment and supply to storage and pumping facilities to meet customer demands. These components consist of transmission and distribution system piping, isolation valves, and fire hydrants.

2.4.1 Transmission Pipelines

The transmission pipeline system within the Sioux Falls water distribution system generally consists of 16-inch pipelines up to 42-inch pipelines. There are about 115 miles of transmission pipelines which make up about 12 percent of the overall distribution system. The majority of these transmission pipelines consists of about 61 miles of 16-inch and about 41 miles of 20-inch. While a small portion of the overall system, these pipelines provide the backbone capacity of transferring water into the overall water main network. A map highlighting the transmission pipeline system is shown in Figure 2.8. The following is a description highlighting some of the key transmission pipelines within the distribution system.

Table 2.15 Key Transmission Pipelines

Transmission Pipeline	Size	Description
Minnesota Ave	36"	From the WPP to Central Zone to the network to the each of the ground storage reservoirs and Menlo Tower
Western Ave	20"	From WPP to the West Reservoir
East of WPP	20", 24"	From WPP to the East Reservoir
South of Menlo WT	24", 20"	From Menlo Tower south to South Reservoir
High Pressure Zone	16", 20", 24"	Developing a 24" backbone along with 16" and 20"

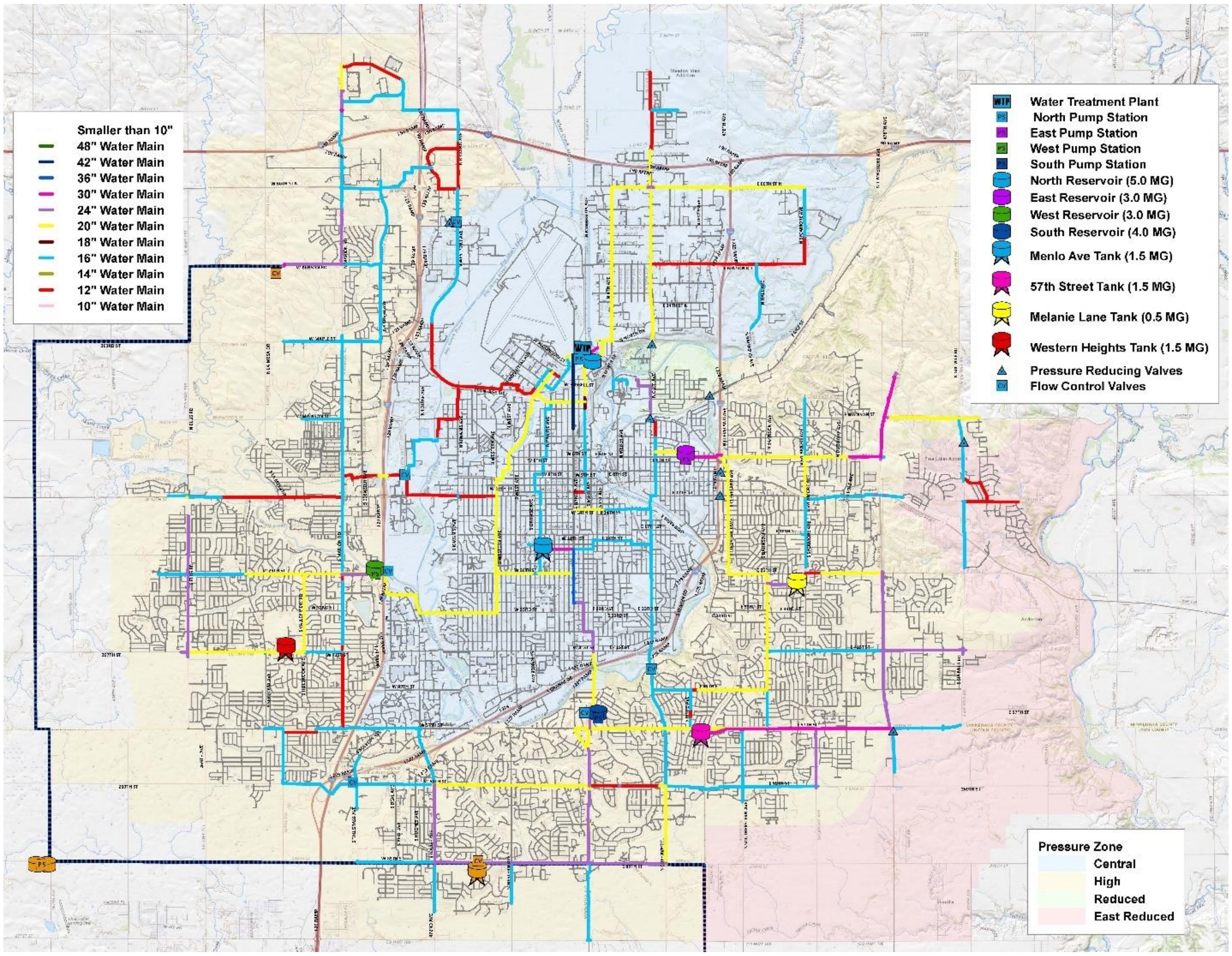


Figure 2.8 Existing Transmission Pipelines

2.4.2 Water Main

The water distribution system network consists of approximately 941 miles of water main owned and maintained by the city, varying in size from four-inches up to 48-inches in diameter. Water main within the system consists of sizes from 4-inch through 14-inch. Transmission pipelines are considered pipelines that are 16-inch and greater. Approximately sixty-eight percent (68%) of the total pipe length ranges in size from 6 to 8-inches.

Eighty percent (80%) of the water main consists of polyvinyl chloride (PVC) pipe or ductile iron pipe (DIP). PVC pipe constitutes most of the water main (392 miles) while DIP pipe constitutes the remaining significant portion (368 miles). Cast iron (CIP) pipe consists of about 176 miles of which 114 miles have been relined with a cement mortar lining. Water main information, including size and material, is included in Table 2.16.

Table 2.16 City Owned and Maintained Water Main Information

Pipe Size (inches)	Length of Pipe by Material (feet)				Total Pipe Length (feet)	Total Pipe Length (miles)	% by Size
	CIP	DIP	PVC	CON			
4	16,466	10,320	8,757		35,543	6.7	0.7%
6	599,308	256,377	132,476		988,161	187.2	19.9%
8	117,438	818,928	1,446,506		2,382,872	451.3	47.9%
10	84,102	164,374	1,743		250,219	47.4	5.0%
12	48,053	284,300	369,967		702,320	133.0	14.1%
14	1,377	5	282		1,664	0.3	0.0%
16	40,947	211,299	71,056		323,302	61.2	6.5%
18	936	3	2		941	0.2	0.0%
20	21,726	163,565	16,992	13,090	215,373	40.8	4.3%
24	241		21,790	135	22,166	4.2	0.4%
30		27,433			27,433	5.2	0.6%
36	93	380		11,976	12,449	2.4	0.3%
42		3,514		3,144	6,658	1.3	0.1%
48		420			420	0.1	0.0%
Total Length (feet)	930,687	1,940,918	2,069,571	28,345	4,969,521		
Total Length (miles)	176.3	367.6	392.0	5.4		941.2	
% by Material	18.7%	39.1%	41.6%	0.6%			

2.4.3 Hydrants and Valves

The most common valve type in the distribution system is an isolation valve. Isolation valves can be closed to block the flow of water from one pipe to another pipe. The isolation valves allow the ability to isolate a small portion of the water distribution system, so that repairs and maintenance impact only a limited number of customers. Isolation valves in the Sioux Falls water distribution system are predominantly gate valves with some butterfly valves located on large diameter water main. The system also includes about 23,000 city owned isolation valves along with 4,900 privately owned isolation valves.

There are nearly 8,200 city owned fire hydrants and 1,450 privately owned fire hydrants used for fire protection in the Sioux Falls water distribution system. The fire hydrants are located in key locations to provide access for firefighting around Sioux Falls. The number of fire hydrants presented in this report may not include all private hydrants and is representative of infrastructure included as information provided by Sioux Falls

2.4.4 Billing and Metering

The City of Sioux Falls currently conducts residential, commercial, and industrial utility billing on a monthly basis with each customer account receiving a bill. Each utility bill includes billing for water, wastewater usage. Several hundred accounts in the city also receive city electrical services and are billed accordingly. Water bills include both a water basic charge and a water volume charge. The water basic charge is based on the meter size on the account and whether the account is residential or commercial and if the meter is inside or outside the city. Table 2.17 lists the Water Basic Charge for the city.

The water volume charge is based on an increasing block rate. Rates are also based on whether the meter is inside or outside the city limits. Each of these categories is broken down further into residential single-family, residential multi-family, and commercial. Water meters are read in units of 100 cubic feet (748 gallons). Water rates for residential single family are shown in Table 2.18. Water rates for Residential Multi-Family are shown in Table 2.19. Commercial rates are shown in Table 2.20.

Table 2.17 Sioux Falls Water Division Monthly Water Basic Charge

Meter Size	Residential (inside city)	Residential (outside city)	Commercial (inside city)	Commercial (outside city)
5/8"	$3.29	$7.03	$12.92	$31.67
3/4"	$4.40	$9.76	$14.07	$34.57
1"	$8.09	$16.43	$15.56	$38.27
11/2"	$17.06	$37.31	$20.10	$49.60
2"	$23.63	$53.76	$24.92	$61.64
3"	$52.59	$126.09	$55.43	$137.93
4"	$85.46	$208.22	$90.08	$224.58
6"	$167.66	$413.68	$176.70	$441.16
Water/Sewer Service Rates and Fees as of 1/1/2023				

Table 2.18 Residential Single-Family Water Volume Charge

Usage	Inside City (per 100 CCF)	Outside City (per 100 CCF)
1 to 7 CCF	$3.75 / CCF	$9.04 / CCF
8 to 50 CCF	$4.01 / CCF	$9.67 / CCF
51 to 150 CCF	$7.48 / CCF	$18.06 / CCF
Over 150 CCF	$11.22 / CCF	$27.10 / CCF
Water/Sewer Service Rates and Fees as of 1/1/2023		

Table 2.19 Residential Multi-Family Water Volume Charge

Charge Type	Inside City	Outside City
Less than 2.5 times most-current 12-month average	$3.75	$9.04
2.5 or more times most-current 12-month average	$7.48	$9.67
Water/Sewer Service Rates and Fees as of 1/1/2023		

Table 2.20 Commercial Water Volume Charge

Charge Type	Inside City	Outside City
Less than 2.5 times most-current 12-month average	$3.21	$7.75
2.5 or more times most-current 12-month average	$6.42	$15.48
Water/Sewer Service Rates and Fees as of 1/1/2023		

2.5 Water System Operation

This section will provide insight into the operation of the water system. The water system consists of moving water from the water supply sources to the main two pressure zones followed by serving the two remaining pressure zones from these two main pressure zones.

The two main pressure zones within the system are the Central Pressure Zone and the High Pressure Zone. These two pressure zones have elevated water storage which float on the system to maintain a hydraulic grade line which defines pressures throughout these pressure zones. The Central Pressure Zone receives water from the Water Purification Plant through pumping from the Clearwell and high service pumps. The High Pressure Zone receives water from two connections from the Lewis & Clark RWS at the Benson Road Connection and the 85th Street Connection. Water can be transferred from the High Pressure Zone to the Central Pressure Zone through SCADA controlled flow control valves located at five locations within the system. Water can be transferred from the Central Pressure Zone to the High Pressure Zone by pumping at pump station located at the East Reservoir, South Reservoir, and West Reservoir.

The two remaining pressures zones are closed zones where pressure reducing valves set the hydraulic grade line which defines the pressures for these zones. The Reduced Pressure Zone receives water from both the Central Pressure Zone and the High Pressure Zone. The East Reduced Pressure Zone receives water from the High Pressure Zone.

2.5.1 Water Supply Operations

Water supply operations consist of supply from the Water Purification Plant and the Lewis & Clark RWS connections. Table 2.21 provides an overview of each facility and a summary of how each facility is used in system operations.

The Water Purification Plant pumps water from the Clearwell using the high service pumps which maintain an desired level within the Menlo Water Tower. The North Reservoir (Big Blue) at the WPP allow for additional storage to be used during peak water demands allowing the WPP plant to be operated at a constant flow rate during the day. During low water demands, water is moved into the North Reservoir by using the North Reservoir Transfer Pumps. Then during high demands, water is allowed to flow back to the Clearwell from the North Reservoir through a flow control valve. This operation allows the ability to maintain a consistent level within the Clearwell when there are fluctuations in high service pumping flows that are either greater or less than the WPP production.

The Lewis & Clark RWS 85th Street Connection allows water to flow into the High Pressure Zone by a SCADA controlled flow control valve located at the Lewis & Clark 85th Street Water Tower. Operators at the WPP set a flow rate for the flow control valve and adjust based on desired flow into the system to maintain desired water levels within the 57th Street Water Tower and the Western Heights Water Tower.

The Lewis & Clark RWS Benson Road Connection allows water into the High Pressure Zone by a SCADA controlled valve that can be used in either a pressure sustaining mode or a flow control mode. Currently, the valve is operated in a pressure sustaining mode to provide a variable flow into the system based on maintaining a consistent hydraulic grade line to provide consistent pressures to this area. The hydraulic grade line setting is slightly higher than the overflow of the Western Heights Water Tower.

Table 2.21 Water Supply Operations

Supply	System Operation
Water Purification Plant High Service Pumps	High service pumps are operated based on maintaining adequate level within the Menlo Water Tower within the Central PZ.
L&C RWS Benson Road Control Valve	Operates based on a set pressure to provide a hydraulic grade line (HGL) of 1670 to 1680 into the High PZ from the L&C RWS. The HGL will be adjusted depending on demands and time of year.
L&C RWS 85th St Control Valve	Operated through SCADA for a set flow rate into the High PZ. Operators monitor water tower levels within the High PZ to adjust flow rate from L&C RWS.
Pump Stations/Control Valves	**System Operation**
North Reservoir Transfer Pumps	Pumps water from the WTP Clearwell to the North Reservoir.
North Reservoir Transfer Control Valve	Allows water to flow from the North Reservoir to the WTP high service pump wetwell based on flow control.
Storage	**System Operation**
Clearwell	Provides storage for plant operations, balancing plant production, and emergency storage. High service pumps deliver water to Central PZ.
North Reservoir	Provides storage for balancing plant production and emergency storage. Transfer pumps move water from the Clearwell to the North Reservoir and a control valve allows water to move back to the Clearwell.
Menlo Water Tower	Provides floating storage for the Central PZ.

The operations of the supply of the Lewis & Clark connections are dependent on the ability of the system to take the full allocation of capacity set for the City of Sioux Falls. The ability to deliver this capacity into the High Pressure Zone is dependent on demand within the High Pressure Zone. If demand is not adequate within the High Pressure Zone to use up the available capacity, then flow control valves located between the High Pressure Zone and the Central Pressure Zone are opened to allow flow to move into the Central Pressure Zone.

2.5.2 Ground Storage Reservoir Operations

The transfer of water between the Central Pressure Zone and the High Pressure Zone consists of the ability to move water into and out of ground storage reservoirs through pumps and control valves. Control valves are also located at key locations within the system to allow water to move from the High Pressure Zone to the Central Pressure Zone. Table 2.22 provides a list of these facilities including a summary of how each of these facilities is used in system operations.

Table 2.22 Ground Storage Reservoir Operations

Pump Stations	System Operation
East Pump Station	Pumps water from the East Reservoir to the High PZ. Pumps are operated based levels within the Melanie Water Tower.
South Pump Station	Pumps water from the South Reservoir to the High PZ. Pumps are operated based levels within the 57th Ave Water Tower.
West Pump Station	Pumps water from the West Reservoir to the High PZ. Pumps are operated based levels within the Western Heights Water Tower.
Storage	**System Operation**
East Reservoir	Provides storage for pumping to the High Pressure Zone via the East Pump Station. Reservoir is filled from the Central PZ through a control valve.
South Reservoir	Provides storage for pumping to the High Pressure Zone via the South Pump Station. Reservoir is filled from the Central PZ through a control valve.
West Reservoir	Provides storage for pumping to the High Pressure Zone via the West Pump Station. Reservoir is filled from the High PZ or Central PZ through a control valve.
Melanie Water Tower	Provides floating storage for the High PZ.
57th Ave Water Tower	
Western Heights Water Tower	
Flow Control Valves	**System Operation**
Lyons Blvd	Provides the ability to move water from the High PZ to the Central PZ. SCADA is used to control a set flow rate that is adjusted by WTP operators.
Cliff Ave	
West Reservoir	
South Reservoir	
54th St N and Westport Ave	

The East Reservoir and Pump Station receives water from the Central Pressure Zone by a fill control valve that allows a set flow rate into the reservoir. Water can be pumped from the reservoir and flow based on levels within the Melanie Water Tower. The East Reservoir and Pump Station provides the main source of water for the east portion of the High Pressure Zone. This is in part due to it being the furthest from a supply connection to the Lewis & Clark RWS.

The South Reservoir and Pump Station receives water from the Central Pressure Zone by a fill control valve that allows a set flow rate into the reservoir. The pump station is able to pump water from the reservoir to the High Pressure Zone and the pump operation is based on maintaining adequate levels within the 57th Street Water Tower. This pump station is key in working with the East Reservoir Pump Station and the Lewis & Clark 85th Street Connection to supply water withing the south portion of the High Pressure Zone.

With the overall interconnection between the south and east portions of the High Pressure Zone, operations of the South Reservoir Pump Station and the L&C RWS 85th Street Connection can have a direct influence on the operational capacity of the East Pump Station. If South Reservoir Pump Station and L&C RWS 85th Street Connections are under-utilized during high demand periods, the East Reservoir Pump Station can see a greater demand for pumping capacity.

The West Reservoir and Pump Station receives water from the Central Pressure Zone by a fill control valve that allows a set flow rate into the reservoir. The pump station is able to pump water from the reservoir to the High Pressure Zone and the pump operation is based on maintaining adequate levels within the Western Heights Water Tower. This pump station works in tandem with supply from the two Lewis & Clark RWS connections at 85th Street and Benson Road to supply water in the south and west portions of the High Pressure Zone. The following are two modes that are used to operate the West Reservoir during different demand periods based on the time of year.

- The first mode is during low demand times as in the fall, winter, and spring where excess water taken from L&C RWS during low demand times is dumped into West Reservoir to be pumped out during high demand times.
- The second mode will occur when water demand is high as in the summer and will operate similar to the other two ground storage reservoir and pump stations which receive water from the Central Pressure Zone and pump to the High Pressure Zone.

This ground storage reservoir and pump station is operated in the first mode to maximize the amount of water used from the L&C RWS. When water demands in the High Pressure Zone exceed the amount of water supplied by L&C RWS, the reservoir and pump station is transferred to the second operational mode.

2.5.3 Pressure Reducing Valve Station Operations

A summary of the operations of each of the pressure reducing valve stations within the distribution system are provided in Table 2.23. Three pressure reducing valve stations operate to reduce the pressure into the Reduced Pressure Zone from either the Central Pressure Zone or the High Pressure Zone. Two pressure reducing valve stations reduce the pressure into the East Reduced Pressure Zone from the High Pressure Zone. Two pressure reducing valve stations provide transfer of water from the High Pressure Zone to the Central Pressure Zone during periods of high demands such as a fire flow demand.

Table 2.23 Pressure Reducing Valve Station Operations

Pressure Reducing Valves	System Operation
East Rice St	Provides flow to the Reduced PZ based on a set pressure.
North Cliff Ave	
North Cliff Ave and Chambers	
East 8th St	Provides the ability for water to move from the High PZ to the Central PZ under conditions where pressure drops within the Central Zone due to high demands such as a fire demand.
East 12th St	
Six Mile Rd	Provides flow to the East Reduced PZ based on a set pressure.
East 57th St	

Chapter 3 Planning Horizons and Water Demands

The goals of this chapter of the Water Distribution System Master Plan are to:

1. Document and analyze the current historical population and water demands.
2. Project population and water demand for the City of Sioux Falls using updated growth and land use projections for the selected planning horizon.
3. Identify increases in water consumption corresponding to growth of land use categories.
4. Establish water volume demand estimates for each planning period for each water service zone.

Sources of information used in this report include:

- The City of Sioux Falls GIS Utility Database
- Shape Sioux Falls 2040 Comprehensive Plan with minor amendment
  - Future Land Use
  - Growth Tier Map
- Historical water meter reading data
- 2045 Sioux Falls MPO Long-Range Transportation Plan
- 2018 Wastewater Treatment and Collection System Master Plan
- Sioux Falls Long Range Traffic Model
- Sioux Falls Planning Division historical population data

3.1 Planning Horizon

The Master Plan will look at the following planning horizon as shown in Table 3.1. The 5-year, 10-year and 20-year planning horizons will be used to ensure future water supply and treatment concepts have sufficient capacity for the 20-year timeframe and sufficient water infrastructure is planned to move the water throughout the distribution system. The 50-year and 100-year planning horizon is adopted to ensure critical long-term water supply and infrastructure needs are planned and met and consideration is given to an extrapolated population that promotes planning effort with legacy implications.

Table 3.1 Planning Horizon Summary

Planning Horizon	Type of Planning	Timeframe (years)	Years
Short-Term	CIP	0-5	2023 - 2027
Near-Term	CIP	5-15	2028 - 2037
Long-Term	CIP	15+	2038 - 2045
50-year Plan	Legacy	50	2066
100-Year Plan	Legacy	100	2116

3.2 Planning Boundaries

For systems experiencing significant growth, such as the City of Sioux Falls defining the study service area is necessary to provide a framework to: 1) define system capacity milestones, 2) develop appropriate phasing of capital improvements, and 3) strategically integrate improvements with existing infrastructure. The ultimate goal of this approach is to maximize the economic benefit of the improvements.

The study area was developed by reviewing current planning documentation, considering previously completed facility plans, evaluating geographical boundaries, and having discussions with City staff. Ultimately, this resulted in using boundaries already established from the recent planning efforts performed for the City, which include the following:

1. 2018 Wastewater Treatment and Collection System Master Plan
2. Go Sioux Falls 2045 Long-Range Transportation Plan
3. Shape Sioux Falls 2040 – Comprehensive Plan

The 2018 Wastewater Treatment and Collection System Master Plan projected population growth and wastewater service areas in the Sioux Falls region. To coordinate population estimates and future growth areas between the Wastewater Treatment and Collection System Master Plan and the Water Distribution System Master Plan, both plans utilized Long-Range Transportation Plan traffic analysis zones (TAZs). These TAZ's were developed for the Sioux Falls Region in cooperation with the Sioux Falls Metropolitan Planning Organization. The Water Reclamation Master Plan utilized the 2040 Long Range Transportation Plan. Since then, the Long-Range Transportation Plan has been updated to 2045 which was used in this planning effort.

The project boundaries for the Water Distribution System Master Plan followed the general boundaries created under the 2018 Wastewater Treatment and Collections Master Plan which provided consistency between both planning efforts. The project boundaries were adjusted based on updated information and planning based on the following information.

- Proposed Updates to the Future 2040 Land Use Map
- Changes to the Water Service Area Map
- Changes to the Sewer Service Area Map

The major change was near the southern boundary between Sioux Falls and the cities of Harrisburg and Tea as shown in the Water Service Area Map presented in Figure 3.1. The Water Distribution System Master Plan projected growth using the updated Shape Sioux Falls 2040

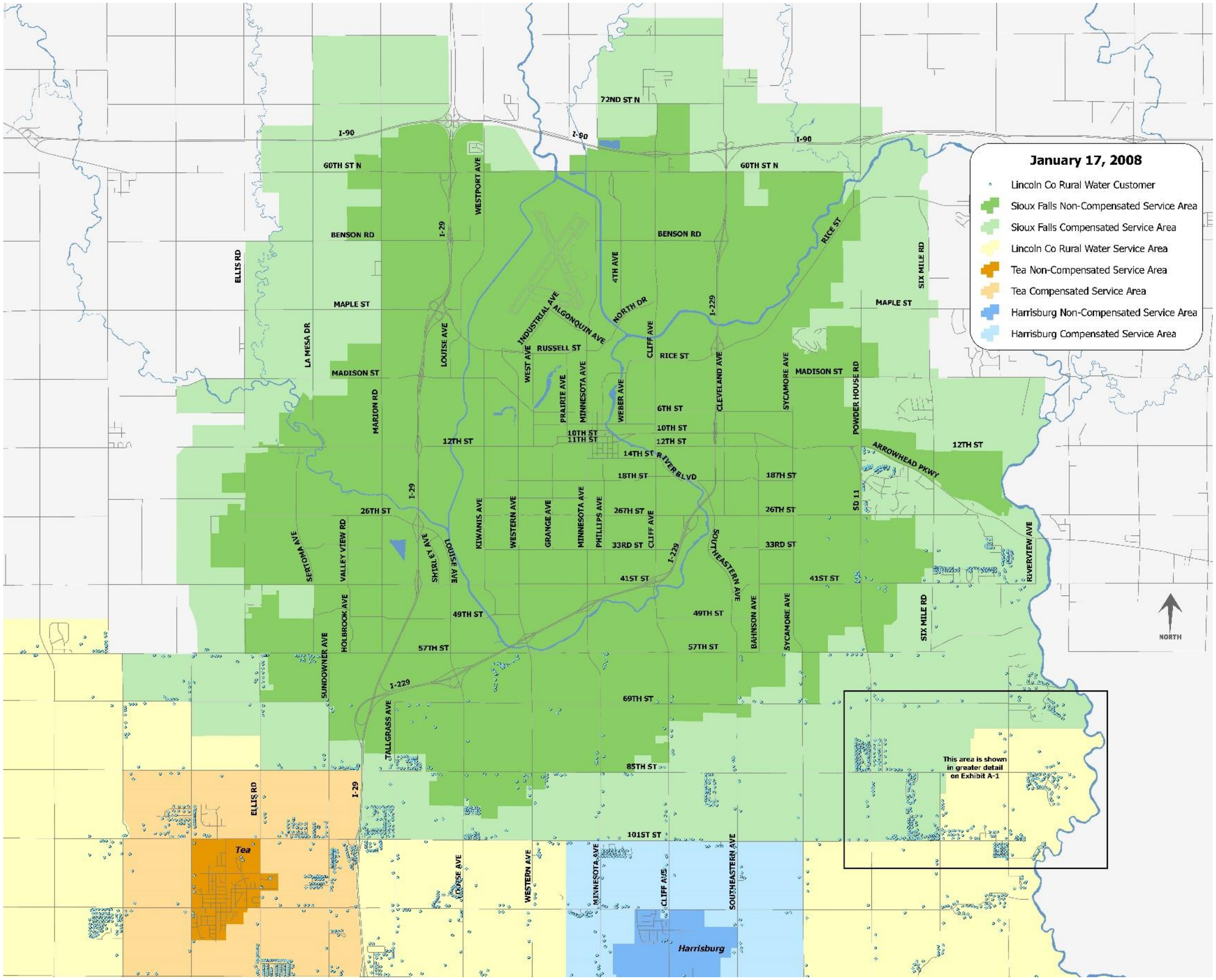


Figure 3.1 Water Service Area Map

plan along with additional growth areas as designated by the Sioux Falls Planning Department. Future modifications may need to be made as the area continues to develop and grow to accommodate a better understanding of water service areas served by the City of Sioux Falls and other water providers depending on the capacity of each entity to provide an adequate level of service.

These boundaries establish the future growth areas and provide consistency between recent planning efforts. The study service area boundary used for the Water Distribution System Master Plan is presented in Figure 3.2 Areas of future growth within the City have been identified for each planning horizon.

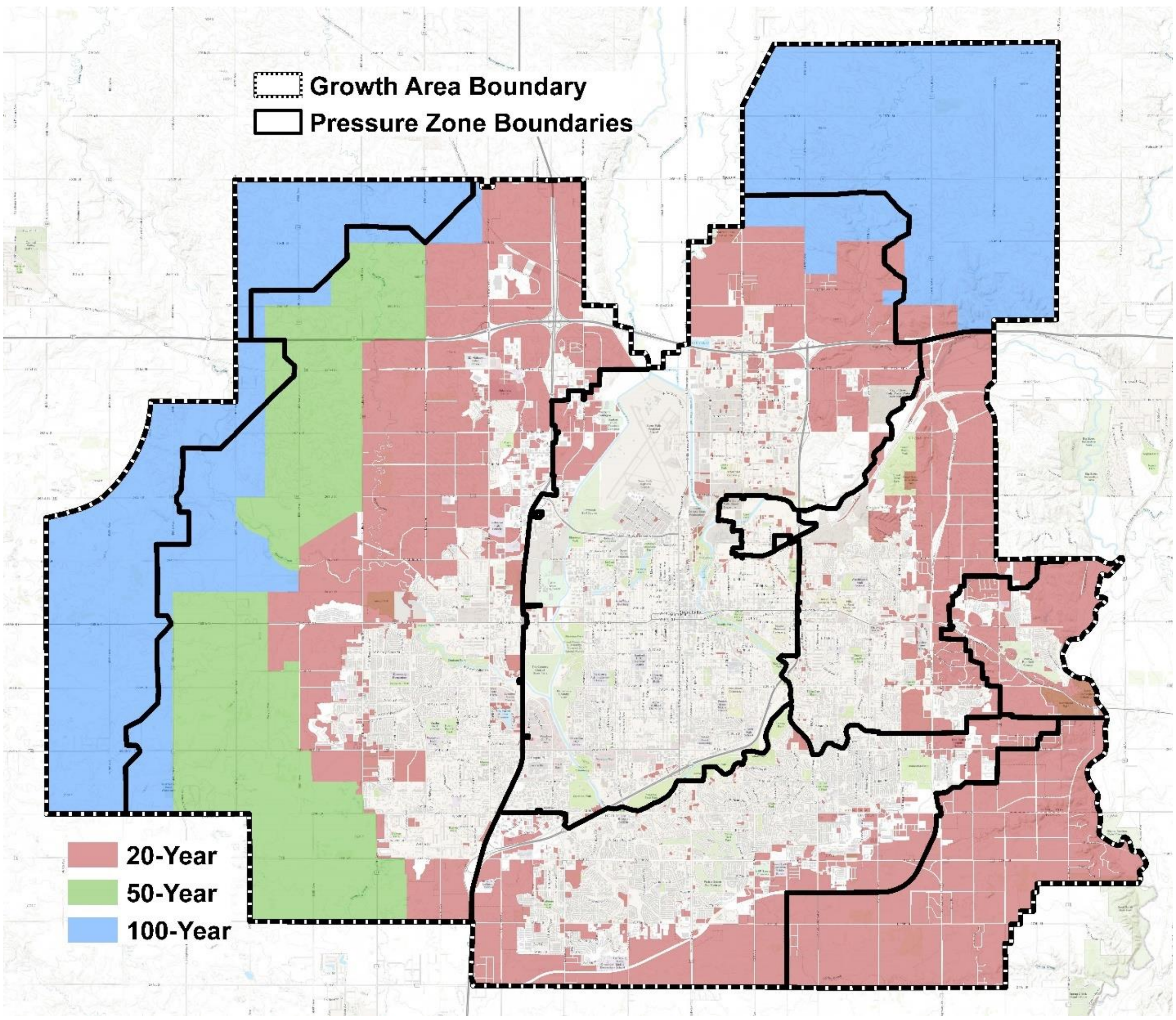


Figure 3.2 Water Distribution System Study Area Boundary

3.2.1 Pressure Zone Expansion

As the city grows and the boundaries expand to the east and west, changes in elevation will necessitate the addition of two new pressure zones. As the elevation increases to the west and northwest, it creates areas with static pressure less than 50 psi. Figure 3.3 highlights the planned expansion of the city over the next 100 years and the anticipated static pressures in those areas.

To serve these areas in the west and northwest, new pressure zones will need be developed and served by initially booster pump station and followed by future water tower storage. These new boosted pressures zones are not anticipated to be required until after 2045. Figure 3.4 shows the anticipated boundaries for the proposed new pressure zones.

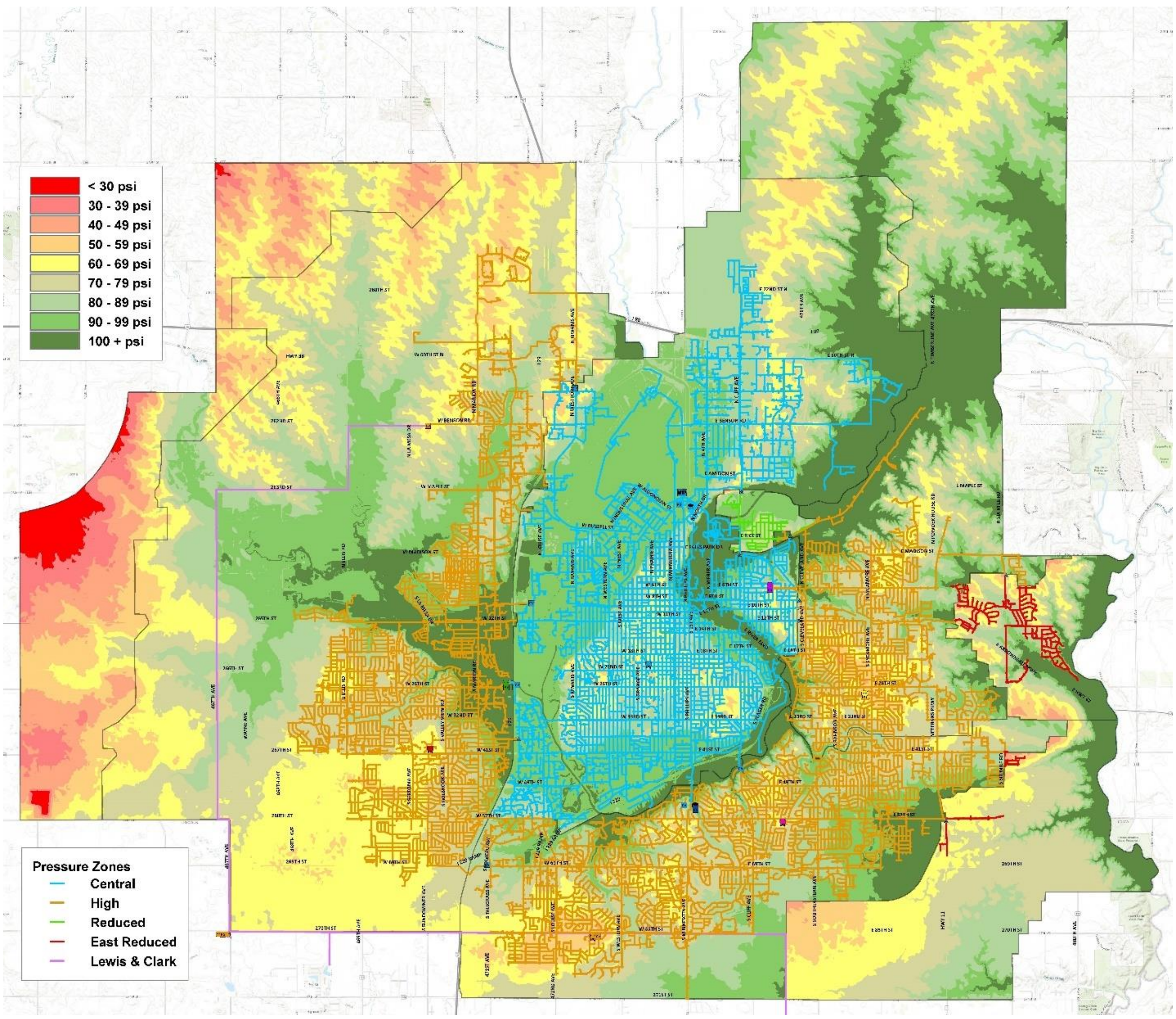


Figure 3.3 Future growth areas with anticipated static water pressure

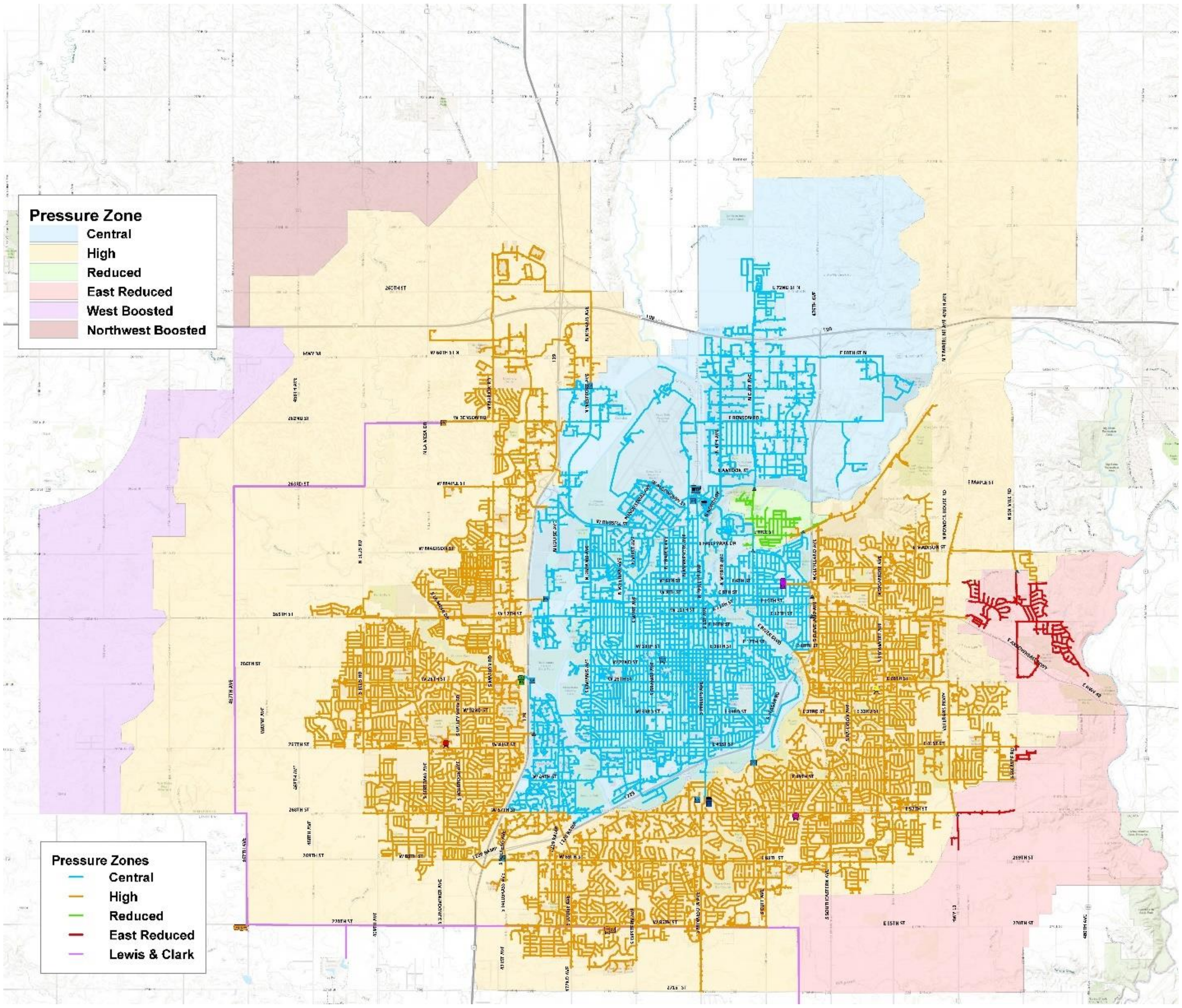


Figure 3.4 Future Distribution System Pressure Zone Expansion

3.3 Population Projections

Population growth can have a significant impact on water use in a community. Sioux Falls' population has steadily increased over the past decade. An estimated annual population growth rate was evaluated based on historic U.S. Census Bureau population trends, recent growth patterns and trends, and Sioux Falls Planning Department estimates. Increases have ranged from 0.9 percent in 2009 to 3.3 percent in 2021 with an average of 2.2 percent over the past 25 years. The current population for 2022 is estimated to be 202,600. Figure 3.5 shows the historical population growth for the city in the past 25 years.

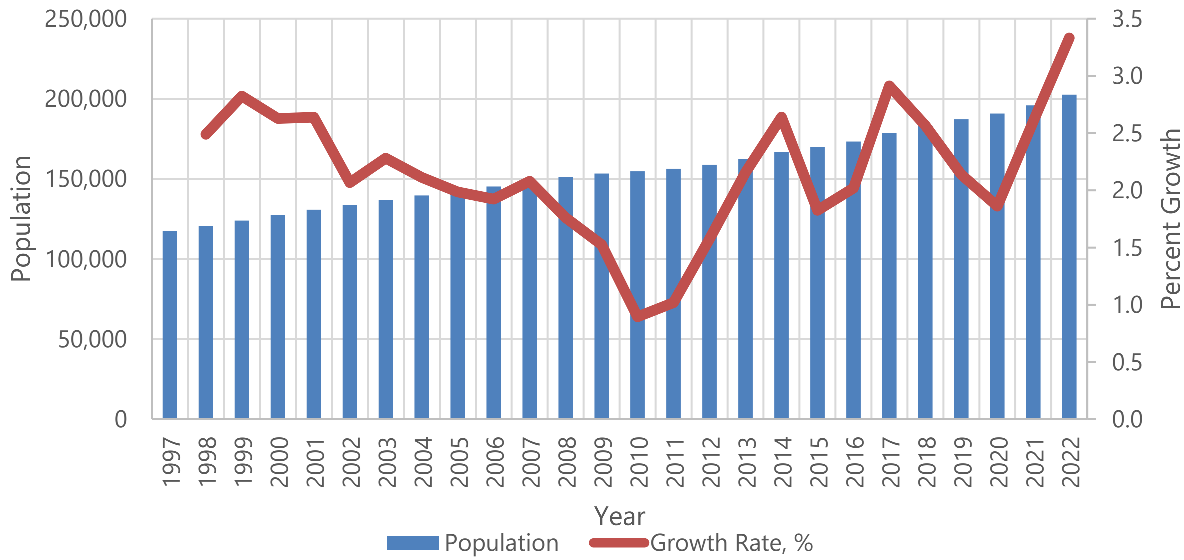


Figure 3.5 Sioux Falls Historical Population

For this report, a 2.0 to 2.2 percent annual growth rate was used to estimate future population projections through the 2040 planning period, which is consistent with the current rate utilized by the City's Planning Department. For projections beyond 2040, the report followed the 2018 Wastewater Treatment and Collection System Master Plan with a few adjustments to reflect recent changes to the projected growth boundaries. Table 3.2 shows the projected populations used for this study.

The population estimates generated from this analysis were compared with the estimates in the 2018 Wastewater Treatment and Collection System Master Plan and Shape Sioux Falls 2040 Comprehensive Plan. Due to updates in the planning boundaries as well as updated direction

Table 3.2 Population Projections

Planning Horizon	Timeframe (years)	Population	
		Residential	Employment
2022	Current	202,600	155,300
2025	5	213,700	163,400
2030	10	237,200	178,200
2035	15	263,300	194,100
2040	20	292,300	211,600
2045	25	309,000	223,700
2066	50	339,900	247,300
2116	100	506,000	367,000

Sioux Falls Planning Staff recommended 2.2% growth through 2040 – data as of February 2022

Population estimates after 2040 followed the 2018 Wastewater Master Plan on population growth rates to 2.2 percent through 2040 by the City Planning Department, the populations presented in the Water Distribution System Master Plan are greater than the population used in the 2018 Wastewater Treatment and Collection System Master Plan. This reflects the consistent strong growth in the last five years which is planned to continue into the next 20 years.

3.4 Land Use Plan and Growth Projections

For each planning horizon, the City identified areas of Sioux Falls expected to experience growth within current City limits, or expected to be annexed into the City based on development trends. The land use associated with each growth area assigns land use designations to guide the type of development that will occur on a parcel of land. A current land use map is shown in Figure 3.6 and associated land use designations used by the City are as follows:

- Single Family Residential
- Multi-Family Residential
- Office
- Institution and Education
- Commercial/Retail
- Industrial, Mining, and Airport
- Parks and Trails
- Green Space
- Public and Private Right-of-Way

Along with this land use information, information from the 2045 Long-Range Transportation Plan (LRTP) was used in understanding planned growth through 2045. The traffic analysis model used in the development of the LRTP provides an understanding of growth using traffic analysis zones (TAZ) which included information related to residential, retail, office, commercial, and industrial land uses. The residential data included the number of households and average size of household to calculate the residential population. The employment data included the number of employees broken out by institutional, office, retail, and industrial land use types. This data was available in georeferenced polygons for each of the individual TAZ areas.

A map shown in Figure 3.7 represents the layout of the system for the next 25 years and is correlated to the planning related to the 2045 traffic analysis. Based on the growth tier represented in this map, residential and employment populations could be determined spatially and related to the planning horizons.

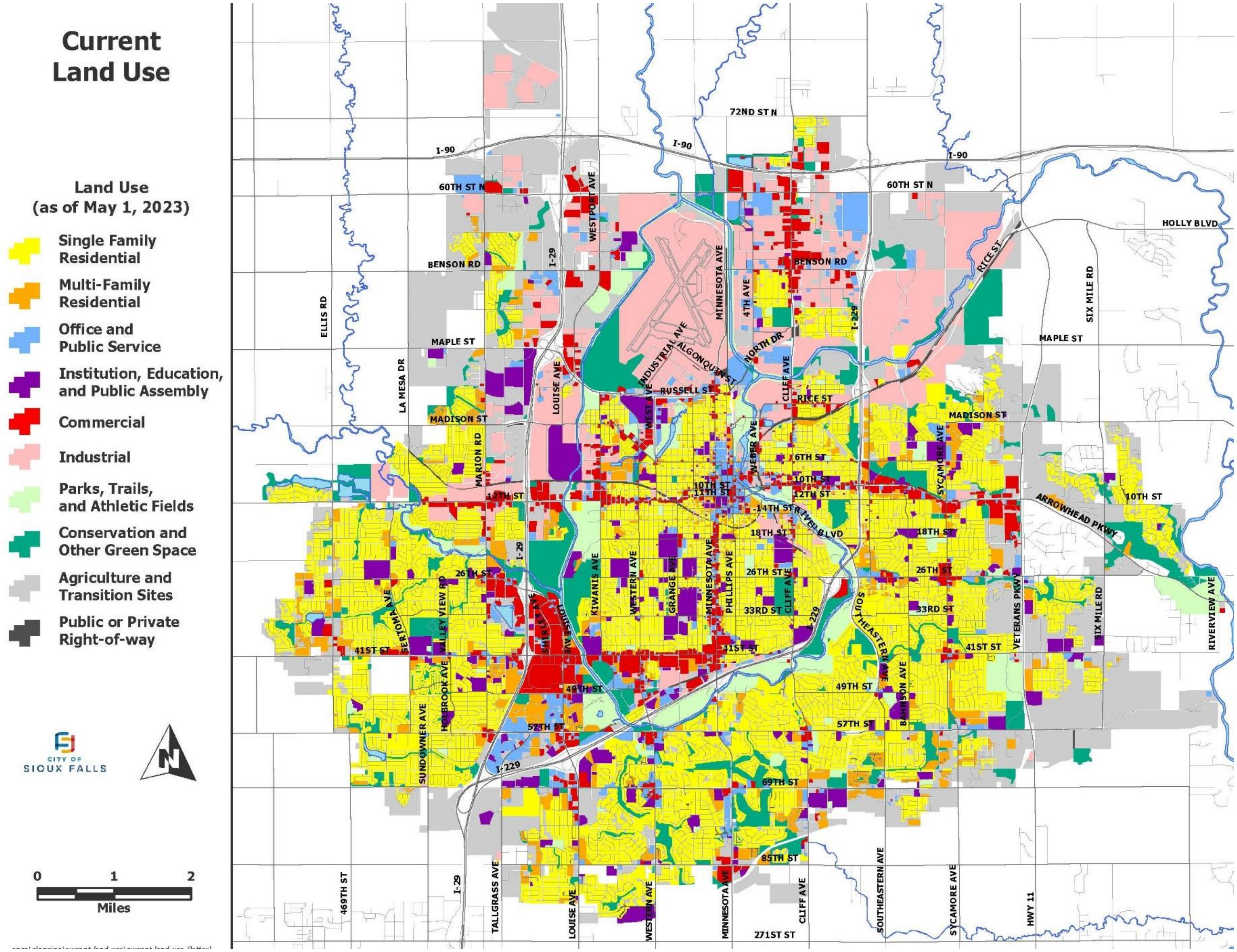


Figure 3.6 Land Use Map

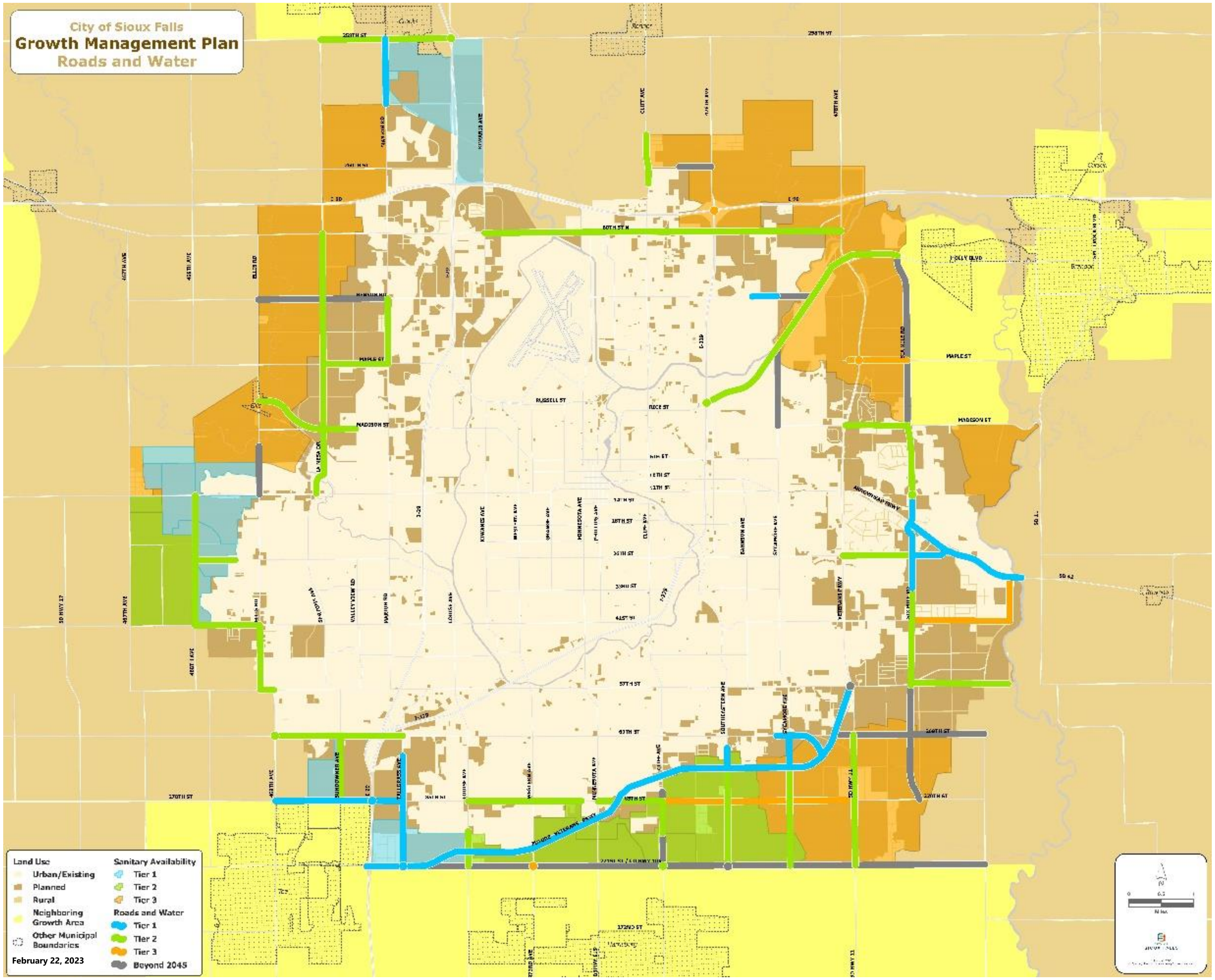


Figure 3.7 Growth Tier Map – Roads and Water

3.4.1 Land Use Planning for 50-Year and 100-Year Planning Horizons

The overall growth area boundary for the Water Distribution System Master Plan represented in Figure 3.2 encompasses areas beyond the 2040 Land Use Planning and the 2045 Long-Range Transportation Planning. In order to understand the 50-year and 100-year planning, areas that do not have a land use designation will need to follow general platting guidelines. The 50-year and 100- year residential and employment densities will be determined based duty factors and planning densities applied for each usage class shown in Table 3.3.

Table 3.3 Planning Densities Used for Projecting Future Growth

Category	Duty / Scale Factor
Platting	
Developed Land / 640-ac Section	90%
Single Family	49%
Multi Family	9%
Public / Semi Public	9%
Industrial	17%
Commercial	9%
Office / Institutional	7%
Residential Planning Densities	
Single Family Units / Acre	2.74
Multi-Family Units / Acre	16.10
Median Household Size (Persons / Unit)	2.40
Employment Planning Densities	
Industrial Employment	9.93
Retail Employment	29.04
Office Employment	33.51
Institutional Employment / Acre	26.14

3.4.2 Growth Projections

A full buildout population for residential and employment was determined utilizing the duty factors and planning densities provide in Table 3.3 for undesignated land use areas along with determining populations for undeveloped areas with designated land use categories. Population information extracted from the 2045 TAZ data was correlated with these buildout populations to determine percent infill for areas which were then extrapolated for each of the planning horizons. The populations for each of the planning horizons were then used to populate each of the land use polygon areas based on land use designation and growth tier area. This analysis allowed the ability to spatially apply the residential and employment populations throughout the system planning boundary. This spatial layout of populations provided the foundation for the next step of applying the water duty factors developed in the water use characterization to be used in the allocation of water demands within the hydraulic model for each of the planning horizons.

3.4.3 Growth Tiers

The City of Sioux Falls Planning using future urbanized areas (tiers) to guide city growth outside of the city limits and allow planning of when urban services will be available when programmed into the capital improvements program. These tiers provide direction of when annexation will take place and when development is planned to occur. Growth tiers were presented earlier in Figure 3.7 that encompasses the growth through the next 25 years. The growth tiers were expanded to Tier 4 and Tier 5 to provide for understanding growth out to 100- planning as a part of the 2018 Wastewater Treatment and Collection System Master Plan.

The growth tiers and associated planning horizons are shown in Table 3.4. These growth tiers were used along with the population information provided in the TAZ information and planning densities related to land use designations to develop population and demand projections for planning horizons. The growth tiers also provided guidance of the infrastructure needs for the next 25-years in development of CIP projects and associated timelines.

Table 3.4 Growth Tiers

Future Urbanized Areas (Tiers)	Planning Horizons (Years)
Tier 1	0 to 5
Tier 2	6 to 15
Tier 3	15 to 25
Tier 4*	25 to 50
Tier 5*	50 to 100

*Tiers 4 & 5 are not shown on current planning maps, however; are a part of long-term planning characterized by the 2018 Wastewater Master Plan.

3.5 Water Use Characterization

Water use characterization involves analysis of existing water demands to better understand Sioux Fall's water use. Water use characterization is necessary to assess the capabilities of the City's existing facilities to adequately serve current water demands and to ensure the design and functionality of proposed water system components can sufficiently accommodate future water demands. This section provides an overview of Sioux Fall's historical water use trends and defines recent water production and demand trends.

3.5.1 Water Demand Definitions

For this Master Plan, water demand is described in the following terms:

- Average Annual Demand (AAD) – The total volume of water delivered to the system in a full year expressed in million gallons.

- Average Daily Demand (ADD) – The total volume of water delivered to the system over a year divided by 365 days. The average use in a single day expressed in million gallons per day.
    - Averaged Daily Winter Demand (Winter Demand) – The million gallons per day average during the months of December, January, and February when system demands are low.
    - Average Daily Summer Demand (Summer Demand) – The million gallons per day average during the months of June, July, and August when system demands are high.
- Maximum Month Demand (MMD) – The million gallons per day average during the month with the highest water demand. The highest monthly usage typically occurs during a summer month.
- Peak Day Demand (PDD) – The largest volume of water delivered to the system in a single day expressed in million gallons per day.
- Peaking Factor – The ratio of PDD to ADD.

3.5.2 Water Supply Usage

Historical water usage for the City of Sioux Falls created using water supply data from 2006 to 2020 provided by the Water Purification Plant staff. A graph representing the water supplied by well production and surface water to the WTP and purchased from the Lewis & Clark Rural Water System is shown in Figure 3.8 which the following are observations from review of this information.

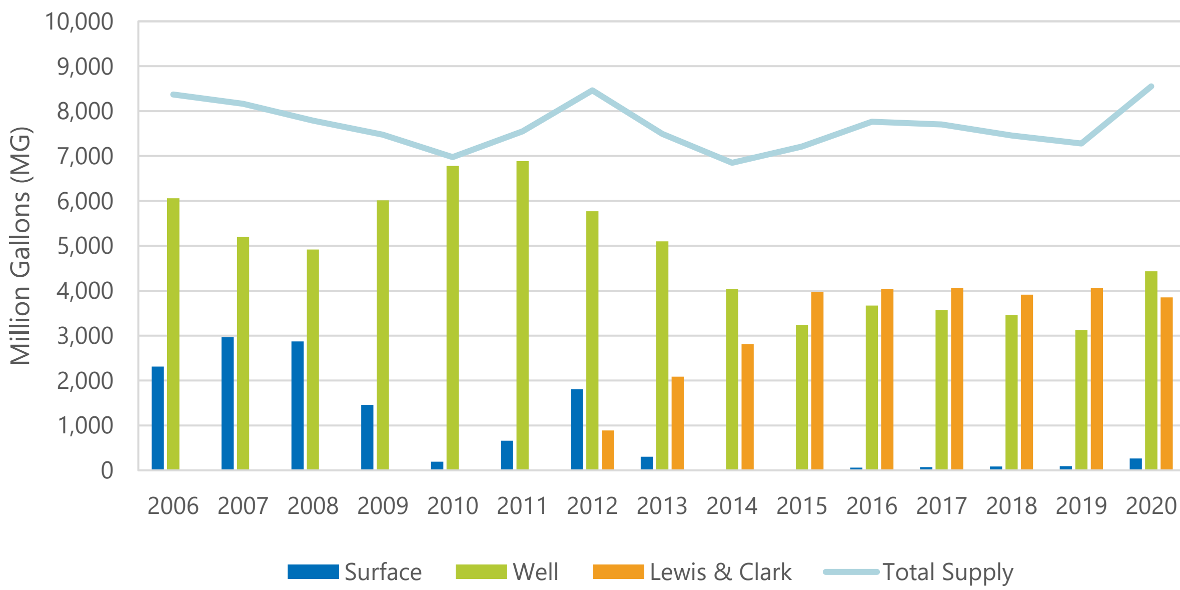


Figure 3.8 Historical Water Supply Usage

- Increased use of surface water during dry years prior to receiving supply water from Lewis & Clark RWS.
- Consistent use of supply water from Lewis & Clark RWS since 2015.
- Limited use of surface water since the start of receiving supply water from Lewis & Clark RWS.

3.5.3 Historical Water Demands

The average day demand, peak day demand, and respective peaking factor from 2006 to 2020 are shown in Figure 3.9. In reviewing this information, here are some key observations.

- Historical peak day water demand was 47.4 mgd in 2012.
- Typical average day demand is about 20 mgd.
- During wet years when the peak day water demand is lower the peaking factor is lower and during dry years when the peak day water demand is higher, the peaking factor is higher.
- The average peaking factor over the past 15 years is 2.0. Based on historical water use data and knowledge of other systems the size of Sioux Falls, a peaking factor of 2.2 is recommended for determining overall future water demands.

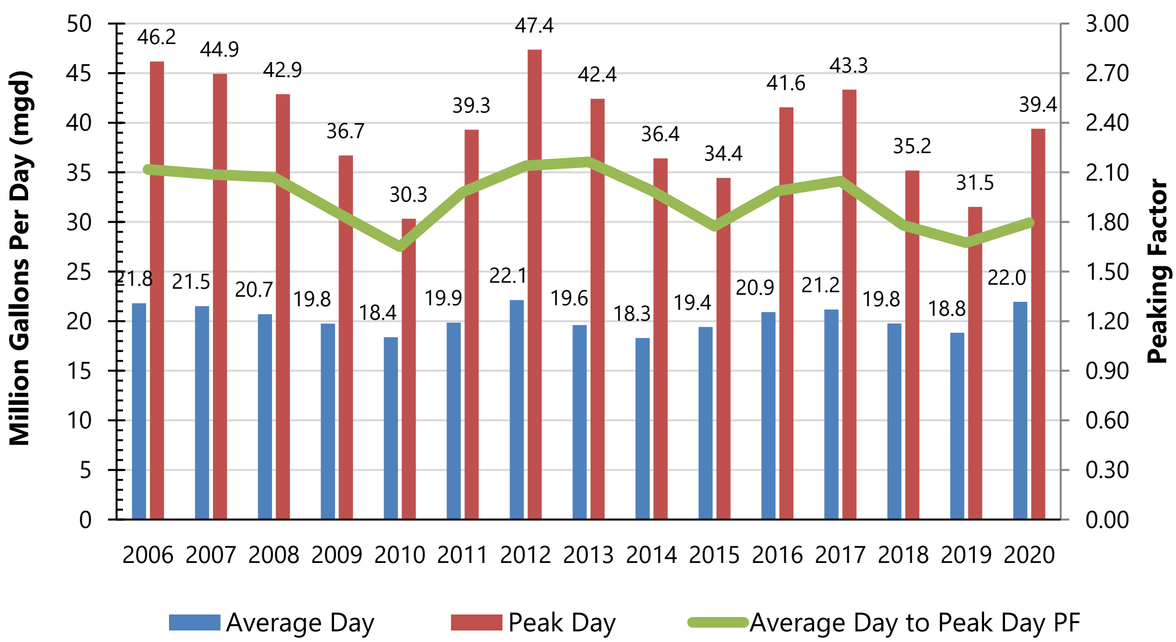


Figure 3.9 Historical Water Demands and Peaking Factors

3.5.4 Seasonal Variations

Water production and usage varies depending on the season. The average daily water usage per month was evaluated to determine which months had the highest water demand. Figure 3.10 shows the maximum monthly demands from 2012 to 2021 which the following are observations from review of this information.

- July is typically the peak month for water demands followed by either June or August.
- Winter months between November and April have had very consistent demands over the last 10 years.

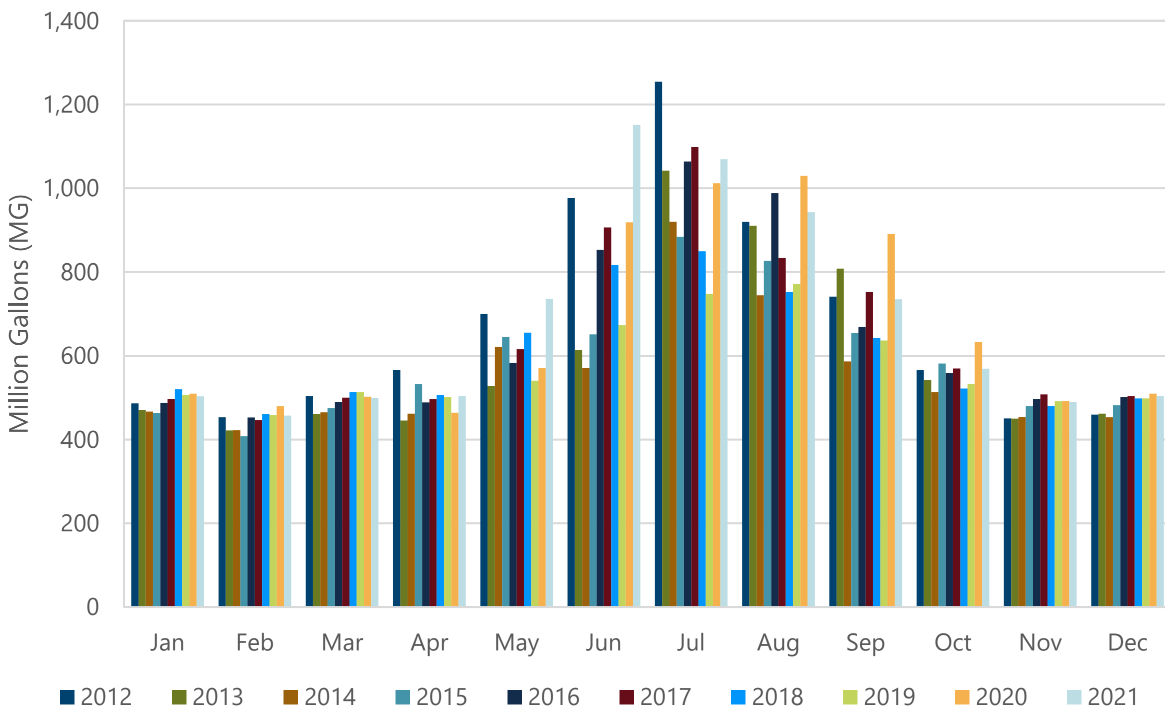


Figure 3.10 Seasonal Variations in Water Usage

3.5.5 Per Capita Demand Water Demand

The total per capita water use for the City between 2006 and 2020 for water produced is shown in Figure 3.11. The per capita use rate is not the amount the average person uses; instead it takes into account all water uses including residential, commercial, industrial, etc., and includes water used by those who commute to the City from the surrounding area for work and visit for commerce and tourism. Per capita water demands are calculated by dividing total water produced divided by population. Per capita water demands are expressed in gallons per capita per day (gpcd).

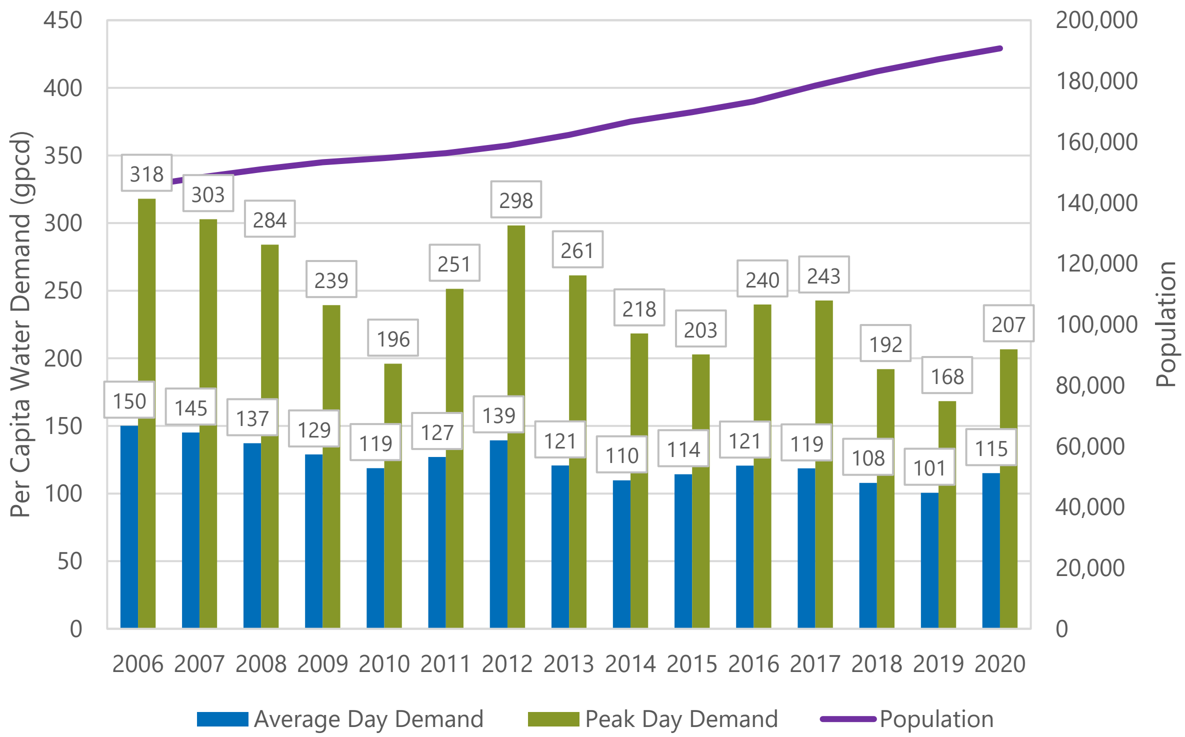


Figure 3.11 Historical Per Capita Water Demands

Despite steady population growth since 2006, the per capita demand trends are decreasing, which is notable, given Sioux Falls' recent growth rate. The demand patterns could be attributable to infrastructure improvements, higher-efficiency plumbing fixtures, and conservation efforts. For projecting a reasonable current system water demand, the following will be used for per-capita water demand by population which includes anticipated non-revenue water (NRW) as shown in Table 3.5. As will be described in later sections, this plan utilizes water demand by land use classification to estimate future water demands.

Table 3.5 Current System Per Capita Demand

Demand	Per Capita
Average Day	115 gpcd
Peak Day	255 gpcd

3.5.6 Metered Water Consumption

The City measures water consumption through customer water meters. Historical water meter records from 2006 through 2020 were evaluated to determine overall customer water consumption and be water demand by user class. Figure 3.12shows water usage over the years based on user type. Figure 3.13 provides a perspective of the overall average percentage of usage for each user class. Key observations from reviewing this data are the following:

- Residential water use is very dependent on the weather and lawn water usage each year.
- Commercial water use has shown decline in 2013 and consistent demand after that time.
- Industrial water use has been consistent over the years. This usage could increase with the recruitment of additional industry with large water requirements.
- Residential water demand encompasses the majority of the water usage followed by commercial usage and then industrial usage.

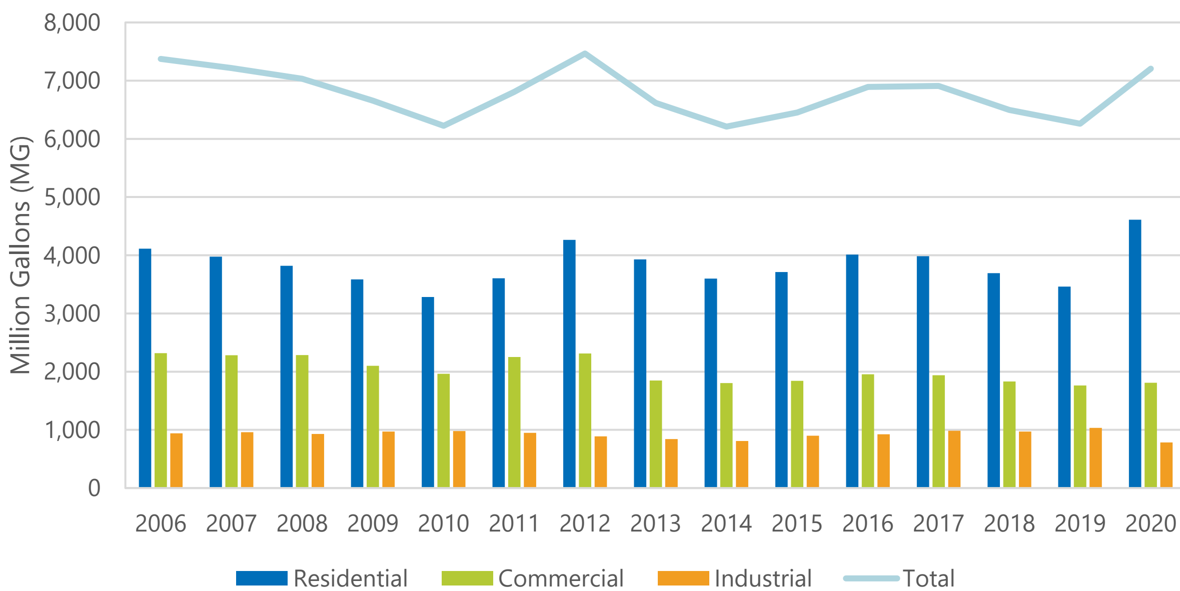


Figure 3.12 Metered Water Consumption by Year

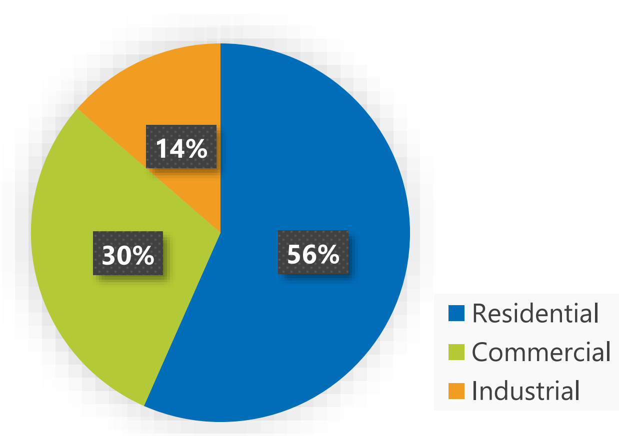


Figure 3.13 Consumption by User Type

3.5.7 Non-Revenue Water (NRW) and Water Loss

Non-revenue water (NRW) is specifically defined to include the sum of specific types of water loss and any authorized, unbilled consumption that occurs within the water distribution system. This definition is provided in the IWA/AWWA Water Balance shown as shown in Figure 3.14. Water utilities routinely produce more water than the volume of metered water. While the difference can occur in a variety of ways, water loss is generally attributed to water lost through aging infrastructure and meter reading inaccuracies. Other common sources of water loss include firefighting, hydrant use for flushing and overflow of storage tanks.

<table>
<tr><th colspan="7">The IWA/AWWA Water Balance</th></tr>
<tr><td rowspan="9">Volume From Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported (corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td>Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Unauthorized Consumption</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td rowspan="2">Water Imported (corrected for known errors)</td><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to the Point of Customer Metering</td></tr>
<tr><td colspan="7">NOTE: All data in volume for the period of reference, typically one year.</td></tr>
</table>

***Figure 3.14 IWA/AWWA Water Balance*[1]**

Figure 3.15 show the water production, metered demand, calculated NRW and water loss percentages. Over the last ten years, the NRW (or unmetered water) ranged from 6 percent (2011) to 11 percent (2017), with an average of 9 percent over the 10-year timespan. Currently, there is no national standard for NRW, but the guidance given by the U.S. EPA for maximum NRW is typically between 10 and 15 percent. There does appear to be a slight increasing trend in NRW for Sioux Falls. A NRW rate of 9 percent is recommended for future planning purposes.

[1] AWWA (American Water Works Association). 2016. Manual M36, *Water Audits and Loss Control Programs*. 4th ed. Denver, CO: AWWA.

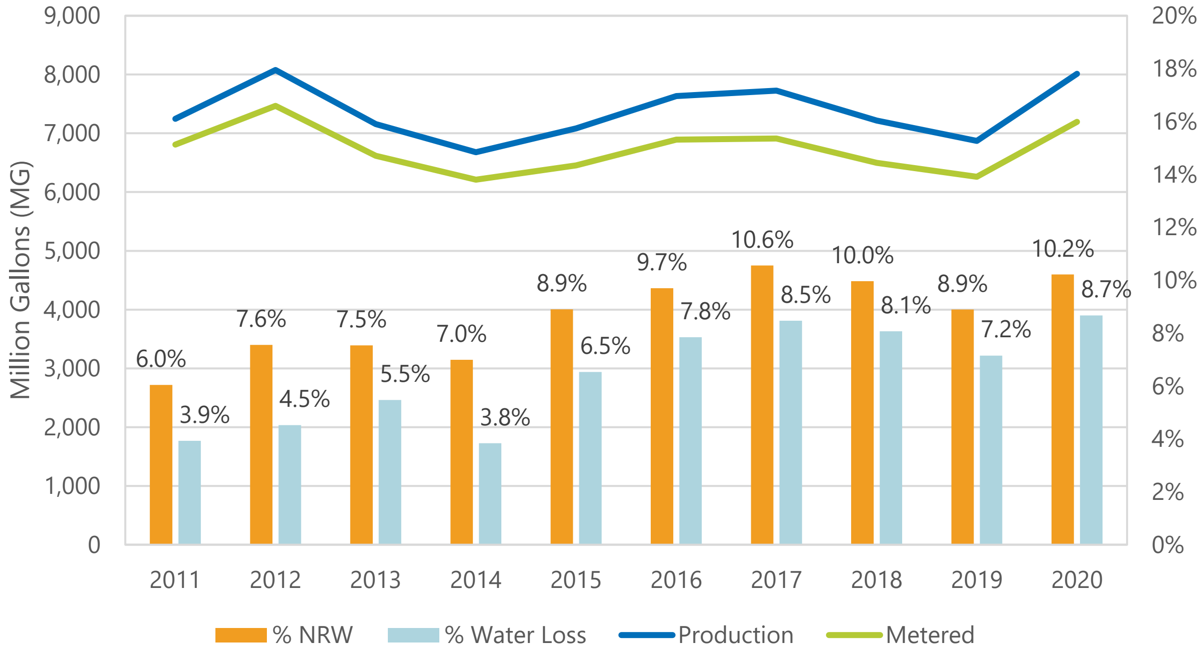


Figure 3.15 Non-Revenue Water (NRW) and Water Loss

The City should strive to reduce the amount of NRW, which can be achieved through a variety of methods. Conducting a meter accuracy analysis to ensure meter readings are correct, as well as conducting a condition assessment on the existing distribution system in an attempt to identify leaking pipes are recommended to minimize NRW for Sioux Falls. The installation of meters at strategic locations in the system may offer significant value in identifying specific areas contributing to system leakage.

3.6 Water Demand Projections

Historical water use data is frequently used to project future usage demands. Water demand projections are crucial when sizing future infrastructure and developing capital improvement plans. This section presents the City's projected future water demand over the following time increments in Table 3.6.

Table 3.6 Planning Increments

Planning Year	Planning Horizon
2025	5-Year
2030	10-Year
2035	15-Year
2040	20-Year
2045	25-Year
2066	50-Year
2116	100-Year

Future water demands were determined using the population projections and then correlating these populations with the TAZ information from the 2045 Long-Range Transportation Plan along with planning density information tied to the land use plan data. To utilize this data effectively, the projections were broken into a near term population and water demand projection through 2045 and then a long-term projection through 2116.

3.6.1 Future Per Capita Demand Projections by Usage Classification

Projecting future water demands first involves analyzing historical peak day and peak month water demands during high use periods. The highest water demands typically occur in summer months during drought years. Historical peak day water demands were analyzed, and the following months were selected for review in Table 3.7.

Individual customer water meter data was obtained from the City Utility Billing office for each of these months. This data was provided in a geo-referenced (mapped) format within the city's geographical information system (GIS) which was then linked to polygon layers related to TAZ information and parcel data containing zoning categories as listed in Table 3.8. Using the GIS linked data, maximum month water use per capita, or employee was developed for each major zoning category based on the information provided by the linked 2018 TAZ data. The maximum month per capita water use was then adjusted to correlate to the known total peak day demands by using a peaking factor.

In review of the industrial data, it was determined that the large industrial/institutional water users had a huge impact on the per capita water demand for the industrial category. In order to

Table 3.7 Historical Peak Day

Month/Year	Peak Day Water Demand (MGD)
July 2012	47.4
July 2017	43.3
July 2020	39.4
June 2021	44.4

Table 3.8 TAZ and Zoning Data

TAZ Information	Zoning Category
Households People per Household	Residential
Retail Employees	Retail
Industrial Employees	Industrial
Office Employees	Office
Institutional Employees	Institutional

prevent overestimating water demands for industrial users across the city, the two largest industrial/institutional users (Smithfield Foods and the South Dakota State Penitentiary) were removed from this analysis and the industrial per capita demand was recalculated. Demands for these large water users are shown in Table 3.9.

Once the preliminary peak day water demands were calculated, the water use data from the 2 largest industrial users was added back in to calculate the total peak day water demand. Table 3.10 shows the adjusted per capita per day water demands based on usage classification.

Table 3.9 Large Water Users

Large Water User	Demand (gpd)
Smithfield Foods	3,600,000
South Dakota State Penitentiary	268,000

Table 3.10 Per Capita/Employee Demand

Usage Classification	Average Day Demand (gpcd)	Peak Day Demand (gpcd)
Residential (per capita)	67	178
Retail (per employee)	35	94
Industrial (per employee)	32	35
Office (per employee)	16	31
Institutional (per employee)	64	127

These per capita per day water demand factors were then applied to the 2018 TAZ data and then added to these demands for a total water demand. These demands were then compared to estimated 2018 average day and peak day demands based on per capita day water demands of 115 gpcd and 250 gpd, respectively. This analysis was done to check that the data was going to correlate with each other.

3.6.2 Future Large Industrial Users

With the development of large industrial park areas, the Sioux Fall Development Foundation is leading efforts to bring industry to the City of Sioux Falls to support overall growth and development. Some of the industries that are interested in developing within the city require a large amount of water for their processes. Over the last several years, there have been large water user requests for two areas within the City of Sioux Falls. The following are two key areas that are sought for development of industries desiring large water demand capacity.

- Foundation Park located northwest of in the intersection of Interstates 29 and 90
- Near Benson Road east of Interstate 229

Anticipated water demands for these areas are based on requests that have been received in the last five years. These projected water demands are presented in Table 3.11 including the location and planning year used to incorporate into system planning. These large water demands were placed in these specific locations to in order to not overestimate other land use areas that are designated for industrial growth and are conducive to light industry with low water demand requirements

Table 3.11 Future Large Industrial Water Users

Planning Year	Location	Water Demand (MGD)
2025	Foundation Park	3.24
2030	Benson Rd east of I-229	3.00
2045	Benson Rd east of I-229	3.00

3.6.3 Future Water Demands (Near-Term)

The near-term water demand projections would encompass the planning years from 2025 to 2045. These future water demands used the updated 2045 TAZ data correlated to the city's future development Tier 3 growth area from Shape Sioux Falls 2040. When the population projections were updated in mid-2022 with a new growth rate of 2.2 percent per year, the 2045 TAZ data was more representative of the planning year 2035. The 2045 TAZ data originally developed with a population growth rate of 2.0 percent per year through 2045. Planning years 2040 and 2045 would be developed from a buildout population for the overall master planning boundary.

Planning Years 2025, 2030, and 2035

The average and peak day per capita water usage was applied to the 2045 TAZ data for each land use category using populations for residential and employment data through the GIS for determining the peak day water demand. The large industrial and institutional demands from Smithfield Foods and the South Dakota State Penitentiary were then added to these demands. In addition, the future large industrial users were added for the locations within Foundation Park and Benson Road East of I-229. This data then provided a water demand projection for the planning year 2035. To get the future water demands for planning years 2025 and 2030, a percent infill was applied to each of the growth tiers represented in by the 2045 TAZ data representing planning year 2035.

Planning Years 2040 and 2045

For planning years 2040 and 2045, the population data within the 2045 TAZ data did not extend past 2035, therefore the population and water demand data was developed based on a buildout analysis incorporating the overall master plan boundaries. The buildout analysis incorporated the population densities for residential and employment land use type found in Table 3.3.

Based on these densities, the overall buildout population was determined for all of the undeveloped area including the undesignated land use areas. Once these populations were developed, infill percentages were incorporated for each of the growth tiers and then correlated to the overall population projections for the planning years 2040 and 2045.

Using the average and peak day per capita day water usage applied to the populations for residential and employment. Since these growth areas did not include the existing populations that were represented in the 2045 TAZ data, the existing populations and water demands were incorporated into this analysis. The large industrial and institutional demands from Smithfield Foods and the South Dakota State Penitentiary were then added to these demands. In addition, the future large industrial users were added for the locations within Foundation Park and Benson Road East of I-229. This data then provided a water demand projection for the planning year 2045. Through this analysis, the future water demands were determined for the planning years 2040 and 2045.

Summary of Near-Term Future Water Demands

Based on this analysis, Table 3.12 and Table 3.13 provides a summary of projected water demands for average day and peak day demands for the planning years 2025 through 2045.

Table 3.12 Average Day Water Demand – Planning Years 2025 to 2045

Planning Horizon	Population	Average Day Water Demand			Per Capita	Future Large Industrial User*
		Residential MGD	Employment MGD	Total MGD	gpcd	MGD
2025	213,700	14.4	13.2	27.5	129	3.24
2030	237,200	15.9	16.7	32.7	138	6.24
2035	263,300	17.7	17.3	35.0	133	6.24
2040	292,300	19.6	17.4	37.0	127	6.24
2045	309,000	20.8	20.7	41.5	134	9.24

*Future Large Industrial Water User is included in the total water demand.

Table 3.13 Peak Day Water Demand – Planning Years 2025 to 2045

Planning Horizon	Population	Peak Day Water Demand			Per Capita	Future Large Industrial User*
		Residential MGD	Employment MGD	Total MGD	gpcd	MGD
2025	213,700	38.1	19.4	57.5	269	3.24
2030	237,200	42.2	23.5	65.8	277	6.24
2035	263,300	46.9	24.7	71.6	272	6.24
2040	292,300	52.0	25.0	77.1	264	6.24
2045	309,000	55.0	28.8	83.8	271	9.24

*Future Large Industrial Water User is included in the total water demand.

3.6.4 Future Water Demands (Long-Term)

This section covers the development of demands for the long-term water demands for planning years 2066 and 2116 which corresponds with the 50-year and 100-year planning horizons. The population and water demand data was developed based on a buildout analysis incorporating the overall master plan boundaries.

The buildout analysis incorporated the population densities for residential and employment land use type found in Table 3.3. Based on these densities, the overall buildout population was determined for all of the undeveloped area including the undesignated land use areas. For non-designated land use areas beyond the current 2045 land use plan, it was necessary to follow general platting guidelines to allocate water use to unassigned land use areas. Table 3.3 lists the platting guidelines followed per section of land for this analysis. With the help of the City Planning Department, two additional growth tiers were developed in the Wastewater Treatment and Collection System Master Plan for the future years of 2066 and 2116 to evenly allocate the future growth within the city as shown in Figure 3.2.

Once these populations were developed and the expansion of the growth tiers to five tiers, infill percentages were incorporated for each of the growth tiers and then correlated to the overall population projections for the planning years 2066 and 2116. Using the average and peak day per capita day water usage applied to the populations for residential and employment. The existing populations and water demands were incorporated into this analysis to provide overall populations and water demands. The large industrial and institutional demands from Smithfield Foods and the South Dakota State Penitentiary were then added to these demands. In addition, the future large industrial users were added for the locations within Foundation Park and Benson Road East of I-229. Through this analysis, the future water demands were determined for the planning years 2066 and 2116.

<u>Summary of Long-Term Future Water Demands</u>

Based on this analysis, Table 3.14 and Table 3.15 provides a summary of projected water demands for average day and peak day demands for the planning years 2066 through 2116.

Table 3.14 Average Day Water Demand – Planning Years 2066 and 2116

Planning Horizon	Population	Average Day Water Demand			Per Capita	Future Large Industrial User*
		Residential	Employment	Total		
		MGD	MGD	MGD	gpcd	MGD
2066	339,900	22.8	21.4	44.2	130	9.24
2116	506,000	34.0	25.3	59.3	117	9.24

*Future Large Industrial Water User is included in the total water demand.

Table 3.15 Peak Day Water Demand – Planning Years 2066 and 2116

Planning Horizon	Population	Peak Day Water Demand			Per Capita	Future Large Industrial User*
		Residential	Employment	Total		
		MGD	MGD	MGD	gpcd	MGD
2066	339,900	60.5	30.2	90.7	267	9.24
2116	506,000	90.1	38.0	128.1	253	9.24

*Future Large Industrial Water User is included in the total water demand.

3.6.5 Future Water Demands Summary

A summary of the projected water demands is provided in Table 3.16 Water demands were also broken down for service areas based on pressure zone boundaries and are shown in Table 3.17. Figure 3.16 shows a map with the projected water demands based on each of the service areas.

Table 3.16 Water Demand Projection Summary

Planning Horizon	Population	Average Day Water Demand	Peak Day Water Demand	Future Large Industrial User*
		MGD	MGD	MGD
2025	213,700	27.5	57.5	3.24
2030	237,200	32.7	65.8	6.24
2035	263,300	35.0	71.6	6.24
2040	292,300	37.0	77.1	6.24
2045	309,000	41.5	83.8	9.24
2066	339,900	44.2	90.7	9.24
2116	506,000	59.3	128.1	9.24

*Future Large Industrial Water User is included in the total water demand.

Table 3.17 Water Demand Projection – Pressure Zones/Service Areas

Pressure Zone		Peak Day Water Demand							
		Existing 2022	2025	2030	2035	2040	2045	2066	2116
		MGD	MGD	MGD	MGD	MGD	MGD	MGD	MGD
Central		21.4	21.4	24.4	24.6	25.1	28.3	28.6	30.6
High	East	7.3	7.4	7.9	8.6	9.9	10.5	10.9	11.5
	South	11.0	11.3	12.5	14.3	14.7	15.5	16.2	17.2
	West	9.5	14.5	17.2	19.5	20.2	21.2	25.8	40.7
	Northeast	0	0	0	0.1	0.1	0.1	0.2	9.7
Reduced		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
East Reduced	North	1.1	1.2	1.5	1.7	2.0	2.2	2.3	2.6
	South	1.2	1.4	2.0	2.5	4.8	5.8	6.4	7.1
NW Boosted		0	0	0	0	0	0	0	2.5
West Boosted		0	0	0	0	0	0	0	5.9
Total Demand		51.7	57.5	65.8	71.6	77.1	83.8	90.7	128.1

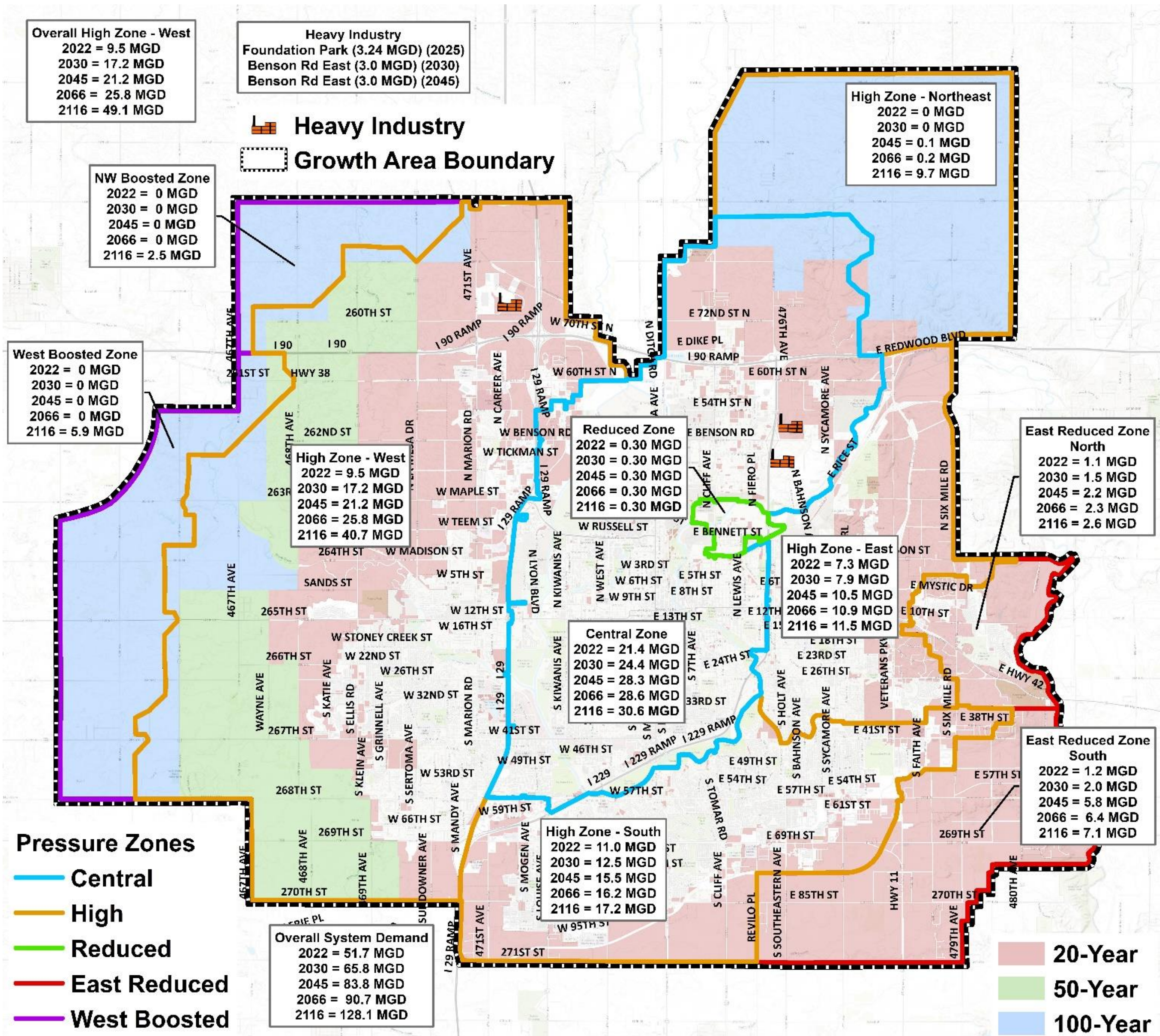


Figure 3.16 Water Demand Projection Map

Chapter 4 Hydraulic Model

A water distribution system model provides a greater understanding of the utility's water system and establishes a foundation for future distribution system improvements. The hydraulic model can be used for identifying system deficiencies and guiding the design of proposed improvements for growth of the water distribution system. The hydraulic model can assist in daily operations, emergency response planning, troubleshooting, and determination of the system's ability to deliver fire flows, evaluation of operating strategies for pumping and storage, and completion of water quality investigations.

The hydraulic model is a dynamic tool for planning the direction of Sioux Falls's water distribution system and can be used to provide policymakers with information to support multi-million-dollar decisions to address infrastructure needs. As such, the hydraulic model will need to be continuously updated in response to the changes made within the distribution system network as well as with changes in system demands.

4.1 Overview

With current and future growth of the water system, the City of Sioux Falls retained Advanced Engineering and Environmental Services, Inc. (AE2S) to update and calibrate the water distribution model to ensure that the system is performing and functioning correctly to effectively evaluate their water distribution system. The development and calibration of the hydraulic model consisted of the following key tasks.

1. Hydraulic Model Development
2. Water Demands and Allocation
3. Distribution System Field Testing
4. Hydraulic Model Calibration

4.1.1 Hydraulic Model Development

The development of the hydraulic model included updating and enhancing the current hydraulic model to match the current GIS of the water system. The modeling software used to develop the model was Innovyze Infowater as shown in Figure 4.1 Information from the existing hydraulic model was verified and incorporated into the new enhanced GIS-based hydraulic model and hydraulic features and elements missing in the current model were added. The model was developed into an "all pipes model" that includes every pipe within the GIS to help improve the connectivity between the model and GIS along with providing efficiencies with updating the model in the future. The model development process included the review and

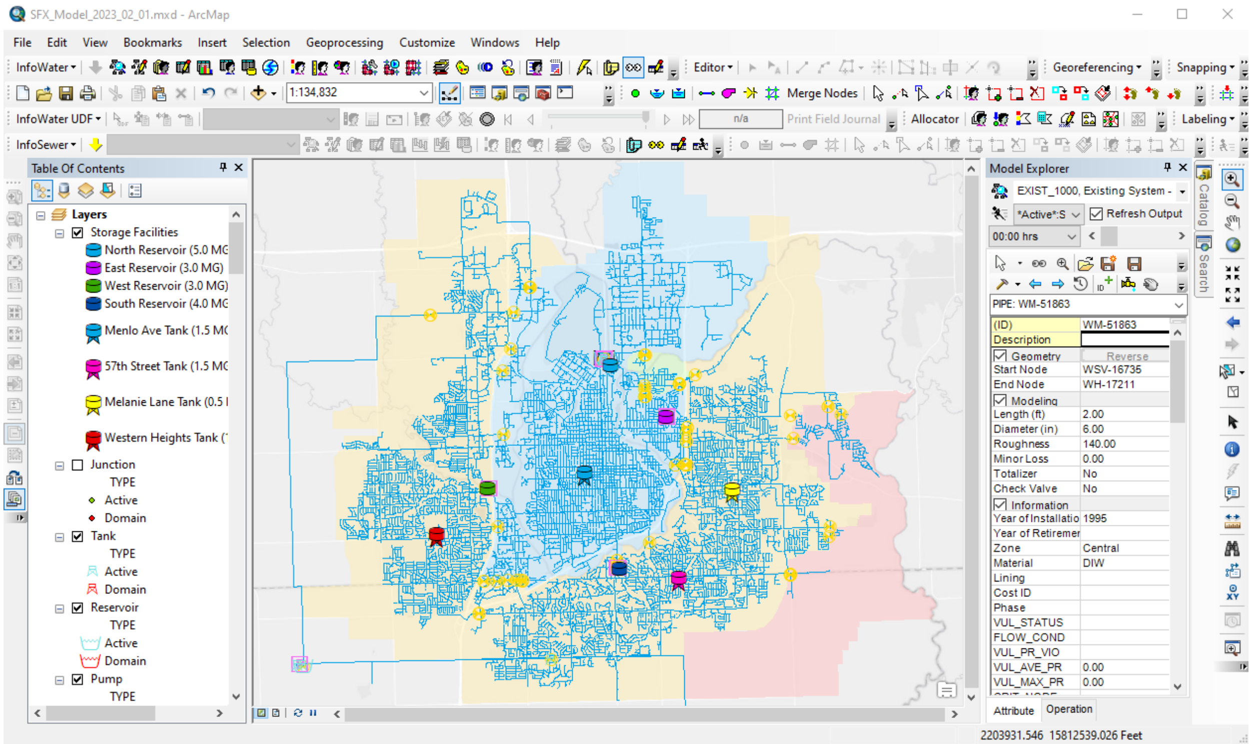


Figure 4.1 Screenshot of the InfoWater Model

verification of the existing model to gain a better understanding of the existing water distribution system and ensure accuracy of the data obtained from the improved water distribution model. The following tasks were completed during the development of the current hydraulic model.

1. Reviewed current hydraulic model and provided recommendations.
2. Performed site visits to all storage, pumping, and active valve facilities.
3. Obtained latest GIS information of the watermain, valves, and hydrants.
4. Developed protocol for GIS transfer to the hydraulic model based on City staff's input.
5. Met with City staff on GIS integration with the hydraulic model.
6. Generated all-pipes hydraulic model from GIS data including hydrants and fixed connectivity.
7. Verified watermain information (size, material, year installed).
8. Updated elevation data for fire hydrants and system nodes.
9. Obtained as-built information for pump station and storage facilities.
10. Redrew and entered information on pump station information (used actual drawing/asbuilt layouts, pump curves).
11. Redrew and entered information on water storage information (used actual drawing/asbuilt layouts, volume curves).

12. Redrew and entered information on active valves features (PRVs, check valves, actuated valves).
13. Conducted staff interviews to ask questions on system operation.
14. Setup operational controls to match how the system is operated by the operators.

4.1.2 Water Demands and Allocation

An important step in setup of the hydraulic model is the allocation of demands within the model. A crucial element of water distribution modeling is determining accurate, representative water demands and the spatial distribution of these demands throughout the water distribution system because water demand is the driving force behind the hydraulic dynamics of a water distribution system. Water demand allocation is the process of accurately distributing these water demands to the correct points of consumption within the model. Demands were allocated based on geocoded customer meter data with an example shown in Figure 4.2. Hourly demand patterns were created based on SCADA data then incorporated into the hydraulic model. The following tasks were completed under this task.

1. Obtained and reviewed historical water supply flows from water supply flow data.
2. Obtained water customer billing record information.
3. Met with City staff to discuss customer water meter integration with demand allocation.
4. Developed a plan for allocating water billing data within the model.
5. Determined unaccounted for water loss within the system.

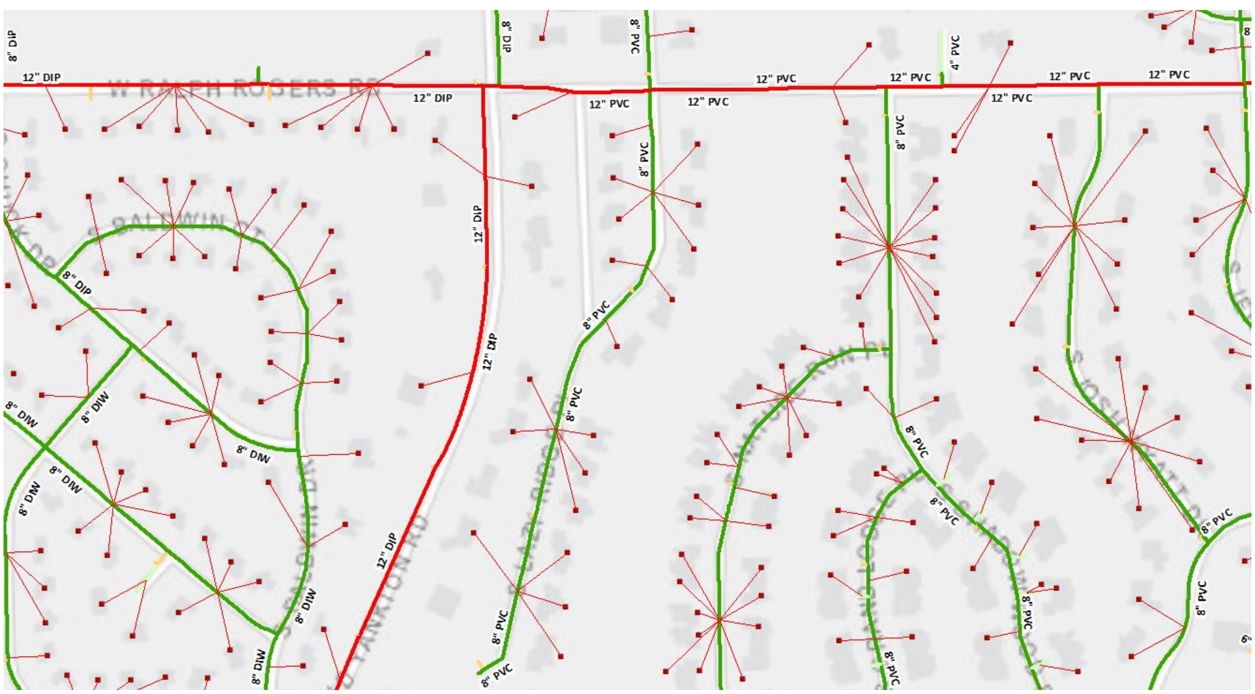


Figure 4.2 Hydraulic Model – Customer Meter Demand Allocation

6. Determined average day, maximum day, winter day, summer day, and maximum hour demands for existing system.
7. Determined individual projections for large water users.
8. Developed demand spreadsheet based on SCADA data to create hourly demand patterns for each zone and overall service area.
9. Created hourly demand graphs and reviewed demand patterns with operators.
10. Collected information on hourly demand patterns for large water users.
11. Allocated demands within the hydraulic model based on geocoded water consumption records.

4.1.3 Distribution System Field Testing

Water distribution system field testing consists of collecting field data for the calibration of the water distribution system model including water storage levels, pump flow monitoring, flow metering at supply connection, fire hydrant flow tests, and extended pressure tests. Field testing was completed in summer of 2017 with assistance from City staff.

During performance of field testing, background data was collected on water storage levels, pumping flow rates, and flow metering from the supply connection. In September 2017, fire hydrant flow tests were conducted at 97 locations throughout the distribution system. A map showing the locations of the fire flow tests is shown in Figure 4.3. The water reservoir levels and other SCADA data were recorded during the same timeframe and used in the calibration process.

Extended pressure testing was performed at 12 strategic locations within the distribution system to assist in estimating distribution system pipe roughness coefficients (C-factors) for large diameter transmission pipelines. Locations were chosen along transmission pipelines between pumping facilities and storage facilities to compare the hydraulic grade line results within the hydraulic model and results from the field testing. Hydrant flow testing occurred in August 2017 which is during a summer demand period for verification of the updated model during a relatively high demand period within the system. The following are the steps taken to complete the field testing.

1. Developed a calibration plan including fire flow testing, extended period testing, and flow monitoring.
2. Reviewed plan with City staff and planned coordination during the testing.
3. Coordinated with staff on collecting SCADA data on key facilities such as pumping and storage.
4. Coordinated installation of pressure recorders to verify water storage level calibration with SCADA system.

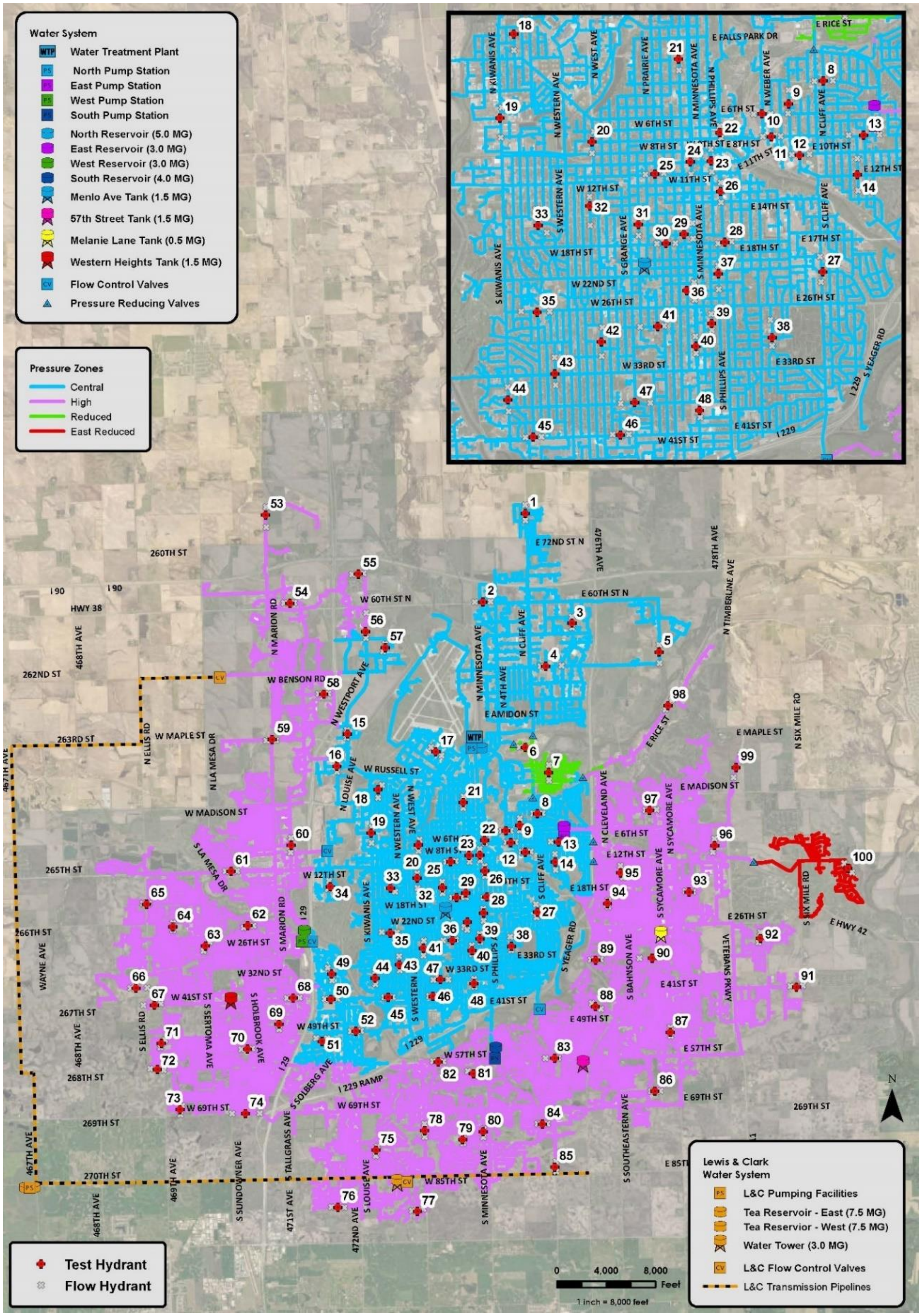


Figure 4.3 Fire Flow Testing Locations

5. Performed pumping performance and setup with existing conditions by coordination with operators and collection of SCADA data.
6. Collected background SCADA data on storage and pumping facilities.
7. Provided a fire hydrant flow test manual and maps showing testing locations.
8. Completed 97 fire hydrant flow tests.
9. Performed extended pressure testing at 12 locations by installing 12 hydrant pressure recorders for a period of 2 weeks during the calibration project.
10. Analyzed and created a summary of fire flow test data and extended pressure testing data.

4.1.4 Hydraulic Model Calibration

This task included the completion of the model calibration for simulations that would represent "real world" conditions within the water distribution including storage and pumping facilities. The model calibration compared the field data with the model predicted data. Adjustments were made to the model until it matched the field data over a wide range of operating scenarios. The following is the process used to complete the calibration of the hydraulic model.

1. Completed static calibration based on fire hydrant flow test data.
   a. Compiled and reviewed data from fire flow testing.
   b. Ran hydraulic model and calibrated pressures for static conditions.
   c. Ran hydraulic model and calibrated pressures for flow testing conditions.
   d. Prepared documentation for calibration.
2. Completed extended period simulation (EPS) calibration based on SCADA data to match water storage levels and pumping flowrates over a 24 hr period and one week. Comparison of water storage levels from actual SCADA data with model results is shown in Figure 4.4.
   a. Compiled and reviewed data from extended pressure testing.
   b. Setup hydraulic model to match pump flows and demands.
   c. Ran and calibrated hydraulic model to match water tower levels and pressures.
   d. Prepared documentation on calibration.

4.2 Model Updates

The need to maintain an updated hydraulic model critical for Sioux Falls. Not only does the model provide a tool for the evaluation of the existing system, but it also provides a tool for evaluation of future changes to the distribution system. The hydraulic model is updated on a yearly basis to ensure that it accurately reflects existing water system conditions. Updates typically include the following tasks.

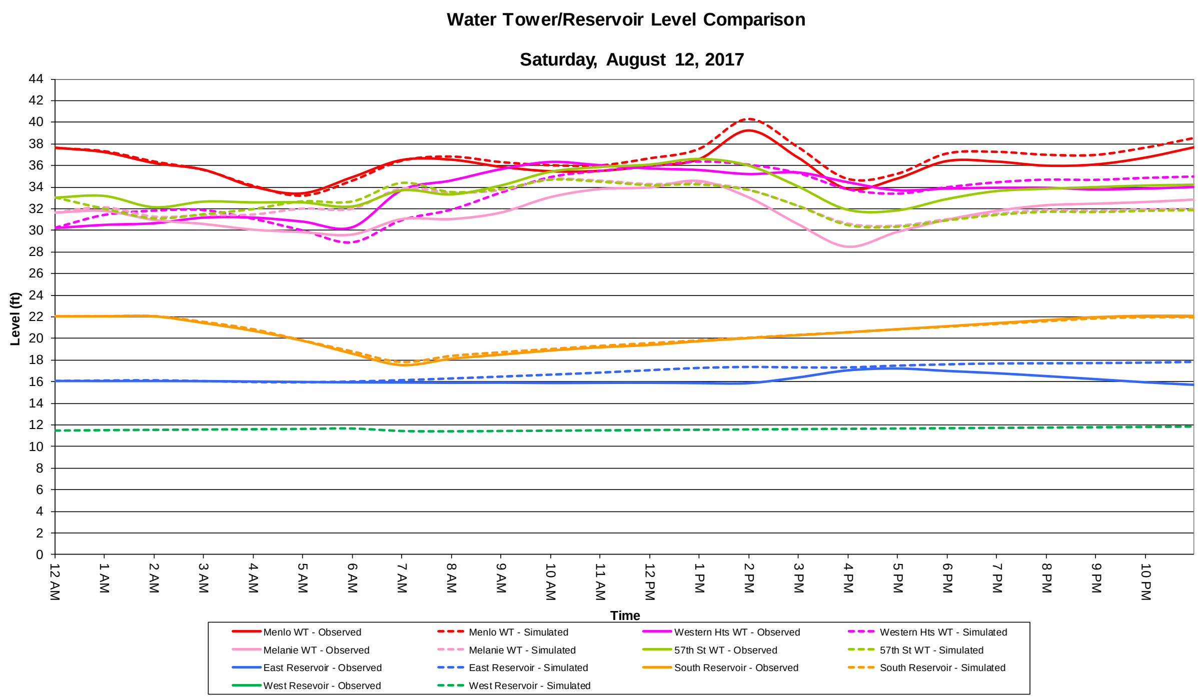


Figure 4.4 Extended Pressure Simulation Calibration – Storage Levels

- Incorporation of the latest GIS database information.
- Update of demands using customer meter data.
- Validation of the hydraulic model using ongoing fire flow test data and latest SCADA data using pump flow rates, storage levels, and pressure information.

4.3 Ongoing Modeling Support

Ongoing modeling services include analysis for planning system expansion, changes to existing system operations, and evaluation of impacts associated with infrastructure improvements. The following are some types of efforts related to provide hydraulic modeling support.

- Providing pressure and available fire flow information for each fire hydrant within the system
- Creation of pressure contour maps
- Analysis of operational changes to the distribution system
  - Impacts of a water tower or reservoir offline
  - Impacts of a transmission pipeline offline
  - Changes to supply of water from WPP and/or Lewis & Clark RWS
- Troubleshoot pressure and flow issues based on potentially closed valves
- Determine available capacity for potential large industrial users

- Determine sizing for new transmission or water main
- Layout and evaluation of pressure zone boundaries and location of future pressure reducing stations
- Providing valve, transmission pipeline, and water main criticality analysis
- Analyzing and recommending sites for future water storage facilities
- Evaluation of improvements to reservoir and pump stations
  - Analysis of available storage and pumping capacity
  - Review of pump curves for pump replacement/upgrades
  - Analysis of flow control valves
- Determine impacts related to potential abandoning of existing infrastructure.
- Performing water age analysis

Chapter 5 Water Conservation

By doing an internet search, you will find many definitions of water conservation. Many of these definitions have subtle variations, but all lead to the same conclusion, preserving water through careful planning, control, development, and management of water. Although the American Water Works Association does not specifically define water conservation, it does summarize most definitions of water conservation as: The implementation of lasting long-term improvements in water use efficiency while maintaining quality of life standards. In essence, it is doing more with less, not doing without.

5.1 Why Have a Water Conservation Program

Currently the Federal Government does not mandate water utilities practice water conservation. However with the passage of the National Energy Policy Act of 1992 and the development of the USEPA Watersense program in 2016 to make water fixtures more water efficient, manufacturers have been pushed to develop fixtures which use less water. Through these manufacturer based modifications, consumers have seen the effects of reduced water usage as they change out fixtures either by design or necessity. Depending on the region of the country you live in, some states may require water utilities to have some sort of water conservation plan as in the arid southwest. Even though not federally mandated, water conservation has gained acceptance among water utilities across the country. In 2016 The American Water Works Association conducted a survey which showed over 74% of utilities in the United States have a formal conservation program. Utilities develop water conservation programs to:

(1) Reduce water and wastewater demand and capacity utilization and operating costs

(2) Meet long term water supply planning needs

(3) Lower customer costs

(4) Reduce energy use

(5) Address short-term water emergencies.

The effort a utility puts into a conservation program generally depends on the climate and sustainability of their drinking water source. In addition, the utility must evaluate which goals they want to meet and how quickly they want to meet them. Active water conservation programs demonstrating water use reductions can have a positive impact on economic growth within a community by increasing the economy on the saved resource, and customer savings on their utility bills.

5.2 City of Sioux Falls Water Conservation Program

The City of Sioux Falls has had an active conservation program since the 1990's when daytime watering restrictions were developed. Since then, the city has added several other features to the program that have demonstratively reduced water demands and are summarized further in this section.

Communities with active water conservation programs need to continually evaluate their programs to determine their effectiveness. This evaluation will allow the city to continually update and plan for future water demands and determine the effectiveness of the conservation program elements. Water conservation is an evolving science with communities trying different approaches to help customers reduce water use. Many communities find education is the key to the most effective program and requires continual updating. The following chapters will lay out how Sioux Falls has developed and modified its conservation program and the benefits of that program. Further enhancements to the program are also suggested to continue to reduce water consumption across the community.

5.3 Historical Water Conservation Practices

Historically, Sioux Falls' overall strategy to reduce water use includes but is not limited to the following conservation and water rate actions:

- City Council passed an ordinance to prohibit lawn watering from noon to 5 pm daily extending from June 1st to August 31st (1991)
- City developed a tiered water rate structure (1999)
- The city hired an Environmental Analyst to develop the City's conservation plan. (2002)
- The first conservation plan included rebates for low flow toilets; high efficiency washing machines and the availability of conservation kits to city water customers (Late 2002)
- Educational programs developed to make water customers aware of the rebate program and how to reduce water usage. This includes bill stuffers, radio commercials, press releases, information placed on the city website, and the addition of a watering complaint hotline. (2003)
- City expands increasing block water rate structure to 3 tiers (2003)
- Rebates for rain sensors for existing irrigation systems were added to the water conservation plan. (2005)
- The city develops a 4-tier increasing block water rate structure to account for high water users. (2006)

- The city moves to odd / even watering restrictions to compliment the current noon to 5 pm watering restrictions between June 1st and August 31st. (2007)
- City extends the odd / evening and noon to 5 pm watering restrictions to year-round and develops additional restrictions based on flow in the Big Sioux River. (2008)
- The city adds rebates for irrigation controllers to the water conservation plan. In addition, rain sensors are required for all new irrigation system installations (2008)
- The city begins a rain barrel program providing customers the opportunity to learn how to construct a rain barrel. To advertise the program, the city partnered with the Lawn and Garden show to give away rain barrels at the annual show. The ultimate prize giveaway being a rain barrel personally painted by a city staff person. (2009)
- A Sustainability Master Plan is developed through the Environmental Division by SAIC which included a section on water conservation. Tactics were listed to reduce demand for potable water to meet urban irrigation needs. Strategies include developing city codes to allow use of greywater and promote the use of city wastewater effluent for urban irrigation. (2012).
- Water Program Coordinator position is developed in the Water Division, and a team member hired to help with water conservation projects. This position is responsible for 3 other programs within the city as well. (2014)
- City develops educational brochures on the benefits of replacing high flow toilets with low flow toilets focusing on multi-family units (2015)
- City surveys industrial and commercial customers to determine knowledge of rebate programs. Many of those customers are unaware of available rebates. (2014 / 2015)
- City develops program to focus on larger complexes with multiple toilets (2015)
- The rebate program for high efficiency washing machines is discontinued due to lower washer cost and higher repeat applicants. (2015)

Funding for the conservation program is provided in the yearly city budget through the Water Division. Funds are available for the rebate program plus an educational component. The educational component is shared with the Environmental Division which will use the funds to provide educational materials to the public.

5.4 Effectiveness of the Water Conservation Program

The conservation program in Sioux Falls has been very successful at reducing both indoor and outdoor water demands. The program has consisted of:

- Providing customer rebates for the purchase of low flow toilets, high efficiency washing machines, rain sensors, and irrigation timers.
- Odd / Even lawn watering restriction
- Daytime lawn watering prohibitions
- Tiered increasing block water rate structure
- Public education

Because each of these programs were started at about the same time, it is difficult to determine how effective each program was at reducing water usage in the city. As a whole, since the inception of the program in 2003, water usage in the City has decreased substantially.

The success of the conservation program can be shown by comparing the average day and peak day water usage from the late 1990's to the early 2020's. Table 5.1 shows the historical population and water usage for the city. For the period, the year 2002 was a drought year which saw the peak day water use of 49 mgd and a peak day gpcpd usage of 374. This high usage is what steered the city to develop the conservation program. Even though the population of Sioux Falls increased by over 73,000 people from 1998 to 2020, the average day usage decreased from 173 gpcpd in 1998 to 115 gpcpd in 2020, a 33% decrease. The peak day usage saw a 30% decrease from 320 gpcpd in 1998 to 225 gpcpd in 2021.

One way to measure the progress of the conservation program is to compare water use in the city against water use across the region. Water use data in gallons per capita per day (GPCD) from several communities from the states of North Dakota, Minnesota, and Nebraska was obtained to compare GPCD use in Sioux Falls. Data from Lincoln, NE; Fargo, ND; Bismarck, ND; Maple Grove, MN; Woodbury, MN and Edina, MN were compared to Sioux Falls GPCD usage for average day and maximum day. Table 5.2 compares the Sioux Falls GPCD to these cities. The data shows Sioux Falls water use based on GPCD is very comparable to other communities in the region. Average day use is slightly higher than the average day use in the communities in North Dakota and Minnesota but less than the average use in Lincoln NE. The peak day usage is less than all communities except Lincoln, NE. This data shows the city of Sioux Falls is on the right track for water usage as compared to other communities in the region.

Table 5.1 Historical Water Usage in Sioux Falls, SD

Year	Population	Average Day MGD	Peak Day MGD	Average Day gpcpd	Peak Day gpcpd
1998	117,500	20.3	37.6	173	320
1999	120,500	20.7	37.9	172	315
2000	124,000	21.5	44	173	355
2001	127,350	21.1	38	165	298
2002	130,800	22	49	168	374
2003	133,550	22.3	41.2	166	309
2004	139,600	20.9	39.8	152	285
2005	142,450	20.9	43.5	148	305
2006	145,250	21.8	44.6	146	307
2007	148,300	21.5	43.2	145	291
2008	151,000	20.7	41.7	137	276
2009	153,300	19.8	34.8	128	227
2010	154,700	18.4	29.8	118	192
2011	156,300	19.9	36.2	125	232
2012	158,800	22.1	44.5	138	280
2013	162,300	19.6	40.8	121	251
2014	166,700	18.3	36.3	110	218
2015	169,800	19.4	36.4	114	215
2016	173,300	20.9	39.3	120	227
2017	178,500	21.2	43.3	119	243
2018	183,200	19.8	35.2	108	192
2019	187,200	18.8	29.8	100	159
2020	190,750	22	39.4	115	207
2021	195,850		44.0		225

Table 5.2 Water usage in GPCD from Different Cities Across the Region

City	Population	Average Day gpcd	Peak Day gpcd
Lincoln, NE	291,000	122	320
Fargo, ND	166,000	109	170
Woodbury, MN	75,100	100	240
Bismarck, ND	74,600	130	285
Maple Grove, MN	70,250	112	242
Edina, MN	52,900	112	240
Sioux Falls, SD	208,900	115	225

5.4.1 Realized Water Reduction Trends

To further show realized water use reductions through the conservation program, water use was analyzed through the city based on winter, summer, maximum month, and peak day. Data from the Water Division Future Water Supply Needs Tech Memo (Updated June 2020) was updated to include 2020 and 2021 flows as supplied by the City. Figure 5.1 shows water reduction trends in gallons per capita per day (gpcpd) realized by the city since the inception of the conservation program for all customer water classes including residential, commercial, and industrial. Through this program, winter or base line indoor water usage has decreased from 130 gpcpd in the winter of 2001/2002 to under 90 gpcpd in the winter of 2020/2021. This is a reduction of just over 30 percent for indoor water usage. This reduction can be attributed to not only the rebates provided by the city for low flow toilets and high efficiency washing machines but federal requirements for the installation of water efficient appliances in new construction.

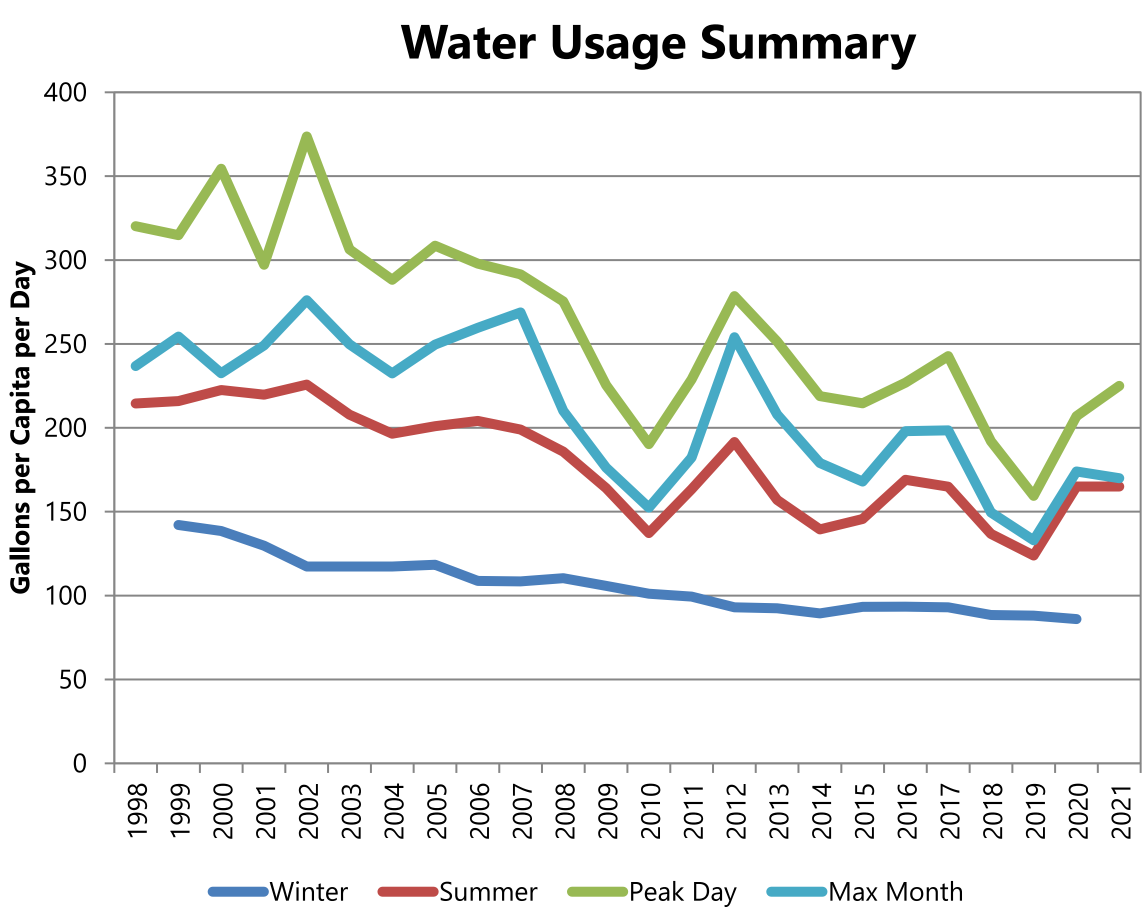


Figure 5.1 Yearly Water Usage in GPCPD for Residential and Commercial Water Customers

Reductions in peak day, maximum month, and summer water demands have also been realized during this same time period and are shown in Figure 5.1. These demands are most affected by weather patterns but a downward trend in water use is apparent. Large water demand fluctuations during the summer are seen from year to year and are based on temperature and precipitation departures from normal. Figure 5.2 shows the effect of these departures from normal on peak day, maximum month, and summer time water usage from 1998 to 2021. During years of above normal precipitation, water demands decrease. For years with below normal precipitation water demands increase. From 2010 through 2021, most summers were above normal precipitation, which reduced peak day and peak month summer demands. Only 2012, 2013, 2017, and 2020 had below normal precipitation during the summer. For the year 2012, precipitation was nearly 9 inches below normal, the last major drought year for the region. Late 2020 and early 2021 also had reduced summer precipitation. Summer 2020 was over 5 inches below normal for precipitation. The year 2021 started out below normal for precipitation, but late summer rains pushed the area to above normal precipitation for the summer.

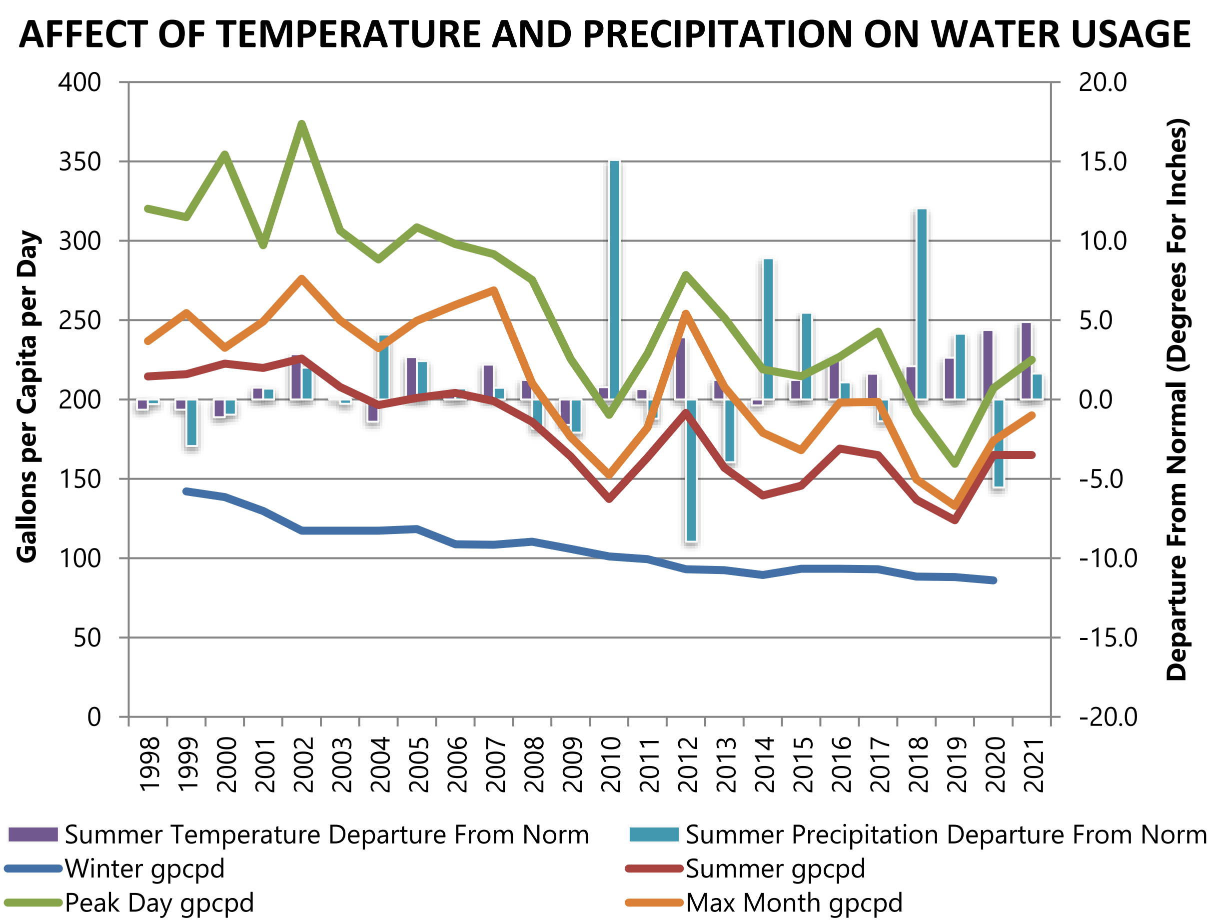


Figure 5.2 Water Use Reduction in GPCPD from 1998 to 2021

The peak day demand has been reduced from 370 gpcpd in 2002 to 280 gpcpd in 2012, the last significant drought in Sioux Falls. This is nearly a 25 percent reduction in peak day water demands. If you consider the drought in late 2020 into early summer 2021, the peak day demand was reduced even further to 225 gpcpd, a 39 percent reduction. In 2021 the peak day was reached in June, before late summer rains reduced water demands. Due to the pandemic, water demands should be used with caution in 2020 and 2021.

Maximum month demands decreased from 276 gpcpd in 2002 to 254 gpcpd in 2012 (8 percent reduction) and to 190 gpcpd in early 2021 (31 percent reduction). Summer months demands decreased from 226 gpcpd in 2002 to 192 gpcpd in 2012 (15 percent reduction) and to 163 gpcpd in 2021 (28 percent reduction). Late summer rains tempered the summer demands in 2021, so this reduction should be used with caution.

The realized water use reductions can also be attributed to increased water rates and how water rates are structured. The city has a 4-tier increasing block water rate for residential customers. This equates to the more you use, the more you pay. Increasing water rates will also reduce water usage as households try to reduce their water bill. Figure 5.3 relates how increasing water rates has affected water usage through the conservation program for the city.

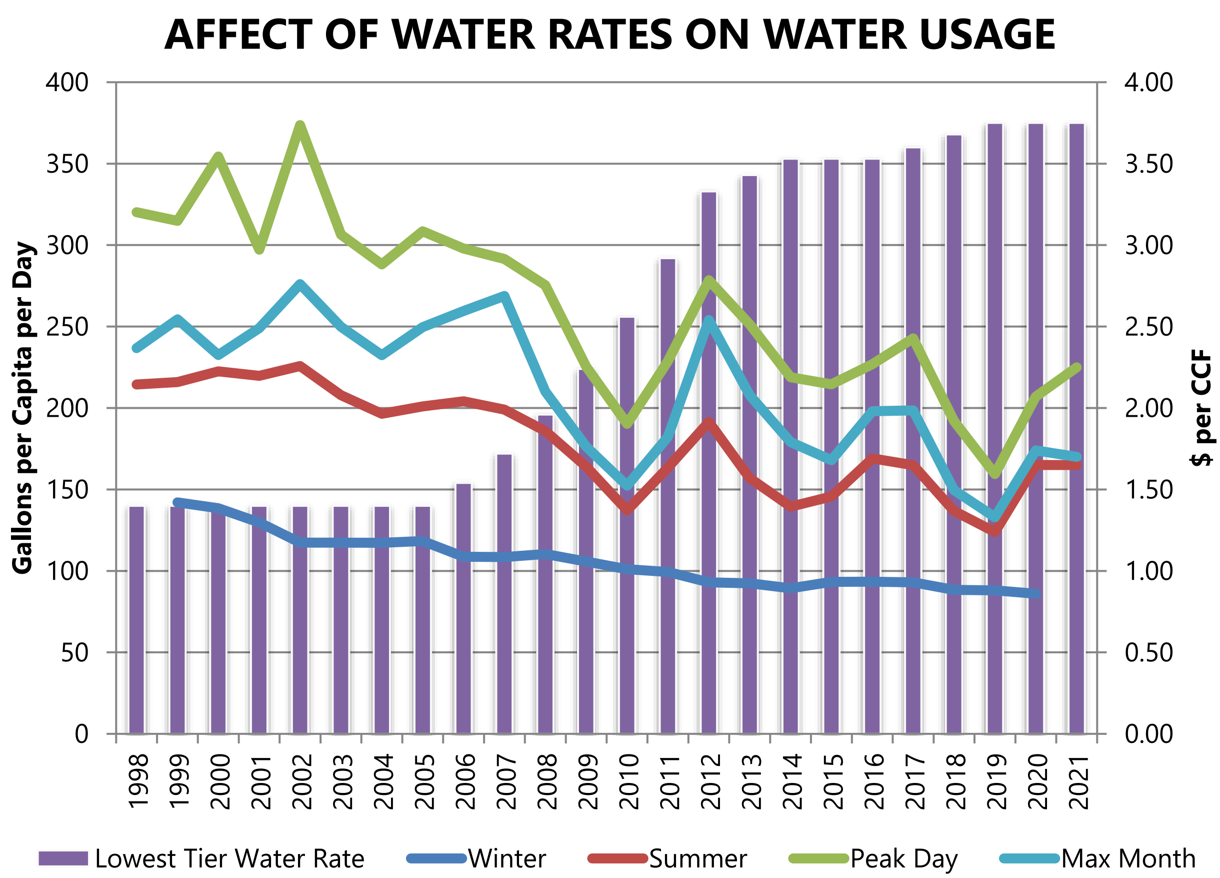


Figure 5.3 Effect of Water Rates on Water Usage

The greatest water use reductions occurred between 2006 and 2012 when water rate increases were near or above 14 percent per year. As rate increases have leveled off, so have the water use reductions.

Figure 5.4 shows the yearly water use in gpcpd for both residential and commercial users. For this analysis, only yearly residential and commercial water usage was available and could not be broken down into summer, peak month, and peak day usage.

From 2006 to 2021, both residential and commercial water usage has decreased. Variations in water usage are more apparent for residential customers than for commercial customers. During the drought year of 2012, both residential and commercial customer water usage increased with residential usage showing a greater increase. In 2020, residential usage saw an increase while commercial usage remained flat. This most likely is due to the pandemic with more residential customers working from home causing increasing water usage while commercial water usage stagnated due to empty buildings. The city should continue to evaluate yearly water usage from each customer class to determine if residential water usage

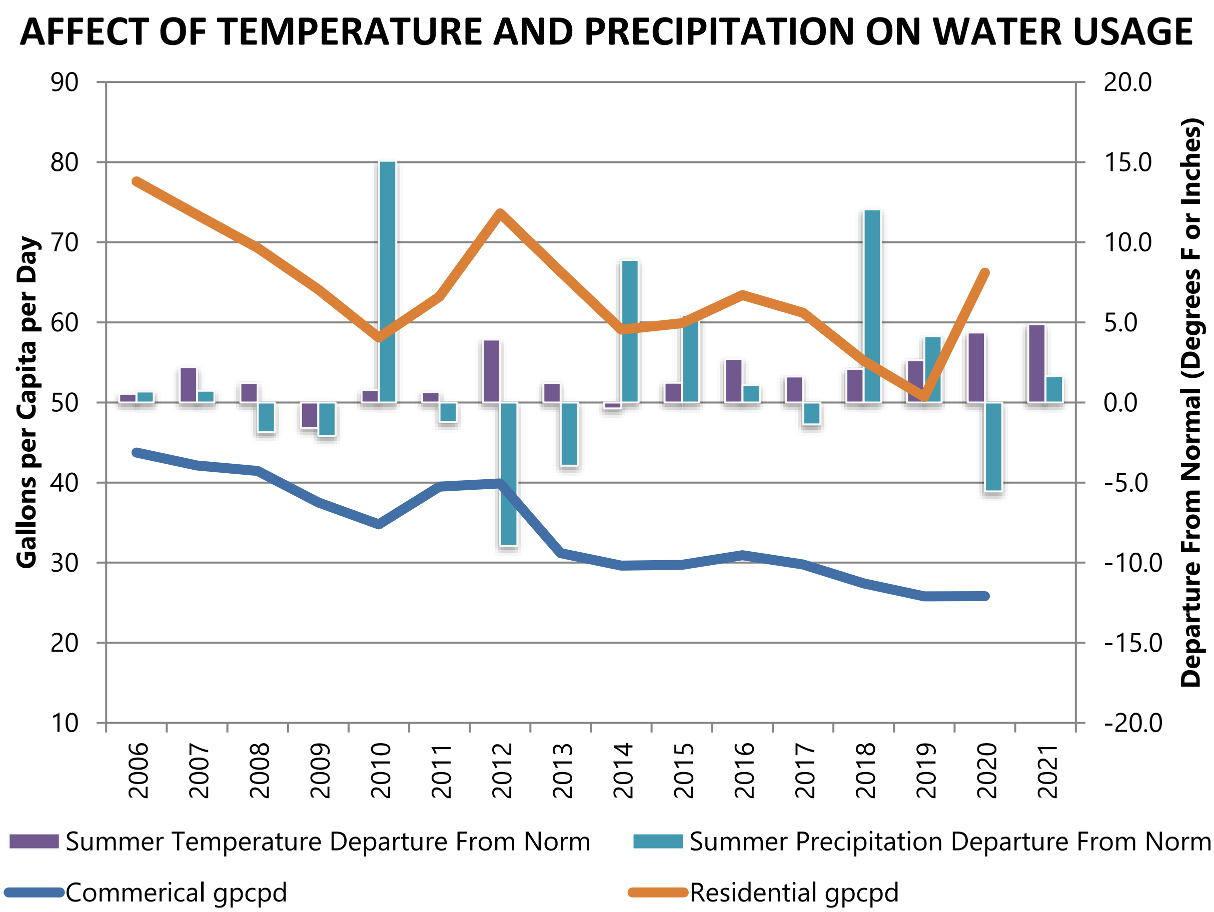


Figure 5.4 Effect of Temperature and Precipitation on Water Usage

decreases while commercial water usage increases or if this will be a new pattern of water usage. Many water utilities across the country are reporting similar changes in water use patterns due to the pandemic.

5.4.2 Avoided Infrastructure

Most water infrastructure is designed to meet peak demands in some future year. The timing of constructing facilities is dependent on the growth of water demand. Water reductions from conservation programs, especially peak day water demand reductions can have a significant effect on the timing of construction of these facilities.

To show the impact the conservation program had on the overall water use in the city and the need for water infrastructure, the amount of water which would have been required if the conservation program were not implemented was determined. This estimated peak day water use was based on current population growth and water use prior to the start of the conservation programs. For Sioux Falls, 2002 was used as the peak day demand year (374 gpcpd). This estimated peak day demand was used to create the baseline peak day flow which was then compared to actual peak day water use.

Figure 5.5 shows the baseline peak day flow which would have driven water infrastructure construction had the conservation program not been implemented. In 2021, without a conservation program, the city would have required infrastructure to meet a peak day flow of just over 73 mgd. Comparing the baseline peak day flow to the actual measured peak day flow of just over 44 mgd, the conservation program has decreased peak day flow by just over 29 mgd. This reduction has delayed, downsized, and or eliminated many infrastructure improvement projects.

To put the water use reductions into perspective, based on the source water, treatment, and distribution system improvements recommended in this report, several of the Water Division driven projects would already have been constructed to meet the peak day water demand required without conservation measures. The City would have replaced the equipment in basins 2 and 3 and repaired basin 1 within the treatment plant ($9.7 million). The City would have requested Lewis & Clark Regional Water System to increase capacity to allow the city to take the maximum 34 mgd, the city's maximum allotment ($76 million).

Distribution system improvements would have included enhancements to take the full 34 MGD allotment from Lewis & Clark into the Northwest, West, and Southwest portions of the city. The projects would include the 12th St connection and additions to the west Watermain transmission highway ($27 million).

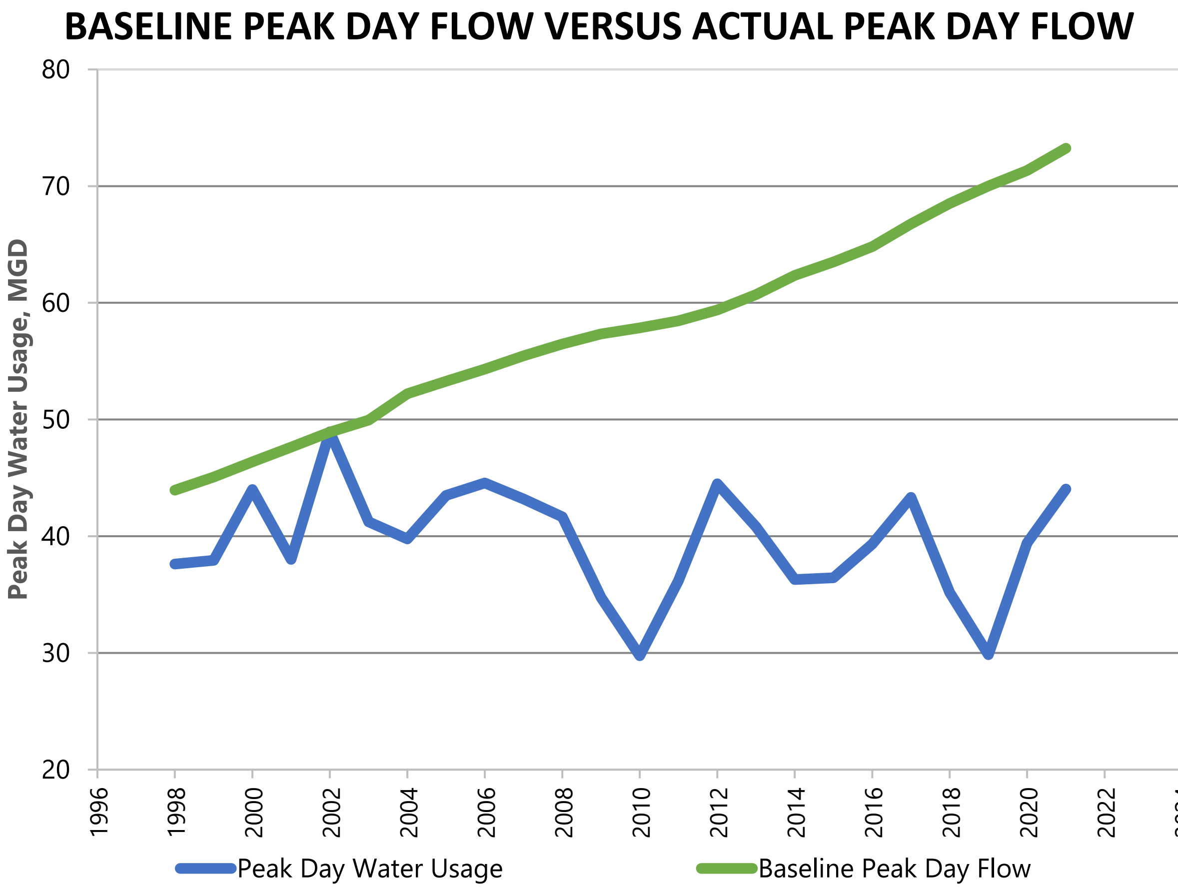


Figure 5.5 Baseline Peak Day Flow Versus Actual Peak Day Flow

Because of increased wear and tear on the equipment including pumps and motors, the operation and maintenance costs would increase substantially along with chemical and power costs. The added wear and tear would also require additional water plant staff to maintain the equipment. It should also be noted that the city would be finalizing plans for additional water supplies to meet the rapidly increasing demands.

Based on current construction costs it is estimated that the conservation program has delayed or avoided the cost of projects for source water, treatment, and distribution with a total construction cost as shown in Table 5.3.

Table 5.3 Conservation Program Averted Costs

Source Water Projects	Current CIP Cost
Treatment Improvements (Basins 1, 2, and 3)	$9,700,000
Distribution System Upgrades (12th St Conn & West WM Hwy)	$27,000,000
Lewis & Clark RWS Improvements (34 MGD max)	$76,000,000
Total Delayed Project Costs	$112,700,000

5.5 The Future of Water Conservation

Over the past decade, the city has realized significant water use reductions. Based on existing water use data, further reductions in peak day and peak month usage can still be realized with further enhancements to the conservation program. It is not anticipated that baseline or winter gpcpd usage will decline appreciably over the coming years, even with further conservation efforts. This does not mean the city should abandon programs to reduce indoor water use for older homes and businesses such as rebates for low flow toilets. Extra effort will be required to locate and educate customers about the benefit of low flow toilets and reduced water usage.

Technologies and strategies that are available for consideration for a community with the climate, size, and structure such as Sioux Falls are listed below. The recommended strategies have been put in categories to help city leaders evaluate each recommendation. The categories include Management; Technology; Landscape, Education, and Rebates and Grants.

5.5.1 Management

- As a first step, the Water Division should develop a Water Management Plan which provides guidance on the efficient use of available water resources and the implementation of watering restrictions. This plan will spell out at a minimum the water system capacity, water conservation policies and future goals, causes for watering restrictions, expected actions by the utility customers, enforcement of the restrictions, education, and how to measure the effectiveness of each program. This plan will help set the path forward for future water conservation actions and methods to change the plan. (The spreadsheet used to create the charts and graphs in this report will be provided to the city so they can continue to update the information for future evaluations.)
- Develop an interdepartmental team approach to water conservation across the City. Include staff from the Water Division, Property Maintenance, Parks & Recreation Division, Environmental Division, Code Enforcement, Innovation & Technology, and Planning. Consider some or all members on this team to help the Water Division develop the Water Management Plan.
- Review city standards and codes to encourage the use of water saving devices and landscapes in city construction projects. Special attention should be given to City transportation plans that include vegetated medians. Medians and boulevards should be designed for the lowest water use possible. If vegetated landscapes are designed, drip irrigation is encouraged over the use of sprinkler heads.
- Review enforcement policies for lawn watering complaints. Develop strategies for monitoring water use and how to address excessive use. Austin, Texas has modified their administrative code to instead of processing watering violations as a criminal matter through municipal courts, they classify violations as an administrative matter and assess

fines through the customer utility bill. This ensures the fine will stay within the water budget instead of the city general fund.

- Research current state law and local ordinances which will allow for the reuse of greywater from larger commercial and industrial customers to be reused as toilet flush water. Across the country several larger building complexes such as apartments, schools, and businesses will collect greywater from sinks, showers, and or rainwater to reuse as toilet flush water. These types of systems will filter and then disinfect the water prior to reuse. Some larger buildings or complexes will collect all their wastewater, treat the wastewater and then reuse as toilet flush water or irrigation water. Building designers have found it cheaper for building owners to treat the entire wastewater flow and reuse it than to separate out the greywater from the black water for treatment and reuse.
- Currently South Dakota Department of Agriculture and Natural Resources (DANR) allows treated municipal wastewater for reuse as landscape irrigation water for golf courses, cemeteries, parks, playgrounds, lawns, and other areas with public access. South Dakota DANR would modify the existing discharge permit for the wastewater facility to include a reuse outfall. Because this effluent would have the potential for human contact, the effluent would have a lower bacteria standard plus DANR would require additional nutrient monitoring.
  - The SDDANR Drinking Water Program does not support any effort to reuse wastewater (direct potable reuse) as a drinking water source currently.
  - Several water quality parameters are important to consider when determining the feasibility of reuse water for irrigation uses. Salinity is considered to be the most important parameter when determining reuse water for irrigation. High salinity can lead to slow growth of grass and plants, discoloration, wilting, and damage to the root system. If the commercial or industrial customer uses ion exchange softening in their process, the salinity of their graywater may be elevated. In order to reduce the salinity, processes such as reverse osmosis would most likely be required to reduce the salinity concentration below that which can affect plants.
- Partner with the Sioux Falls Development Foundation to market companies which can utilize treated wastewater effluent within their manufacturing processes such as boiler water, cooling tower water, and production water. The City of Fargo, ND in association with Cass Rural Water District have developed an Effluent Reuse Facility (ERF) to produce a high-quality reliable water supply source from the effluent of Fargo's Water Reclamation Facility to be used by a Soybean Crushing Facility. This Soybean Crushing Facility is located 8 miles west of Fargo and will be delivered through a 12-inch supply line. Cooling Tower blowdown generated by the facility will be pumped back to the Fargo Water Reclamation Facility for treatment. The ERF treatment facility located at the Fargo Water Reclamation

Facility consists of Ultra Filtration / Reverse Osmosis membranes which produce a high quality wastewater effluent.

5.5.2 Technology

- Acquire software or cell phone applications that allow the water utility customer to view their water usage. The City is currently integrating software called MyMeter to allow customers to view their water usage in near real time. Provide education to customers on how to use the new application as they are then more apt to understand their water usage trends and adjust them accordingly to their budget.
- Utilize AWWA Version 6.0 of the Water Audit Software to audit the water supplies and implement controls to minimize system losses. This software has been around for over 15 years and helps utilities control water loss through reducing apparent losses, controlling system leakage, managing pressures, and documenting their progress through key performance indicators and benchmarks. After inputting the utility data, the software will create a dashboard where the city can compare their results against other validated utility data across the United States. The software is free from AWWA. Free Water Audit Software | American Water Works Association (awwa.org)

5.5.3 Landscape

- The city should work with the South Dakota State University Extension Service and Minnehaha Master Gardeners to develop a plan for addressing landscape options for low water use. Items to address include:
  - A list of trees, shrubs, and plants that are drought tolerant and are appropriate for the great plains region. The list should be made available on the city webpage and local nurseries should have stock available for purchase. The South Dakota Natural Resources Conservation Service (NRCS) has a publication specific to South Dakota called Living Landscapes in South Dakota which can be used as a starting point. The City Environmental Division is working with the Minnehaha Conservation District to develop a Prairie and Pollinator Garden Pilot Program to help homeowners create these types of landscapes with seeds and guidelines for planting.
  - To compliment the list of trees, shrubs, and plants, the city should consider a rebate program for utility customers that purchase drought tolerant plants.
  - Several low water use demonstration landscapes should be developed in parks across the city. These landscapes would provide visual and educational benefits on how to develop a low water use landscape for utility customers. Educational seminars including city parks specialists and guest speakers could be held at these landscapes.
- Replace turf grasses with native grasses on select city properties to reduce irrigation requirements. This will also reduce mowing and maintenance requirements.

5.5.4 Education

- Educational programs that complement the rebate programs should be developed and continually marketed to the utility customers. These educational programs should target the appropriate audience for which the rebate is created.
- Encourage businesses that have existing or planned expansive green areas which will be irrigated to use low water use turfs and develop larger areas with zero or low water use landscaping and plants.
- Target multi-family apartment complexes and hotels for education on reductions in water use such as low flow toilets and lawn irrigation. Develop educational pieces that utilize real world examples of reduced water usage in Sioux Falls. The city has already completed several low flow toilet replacement projects which have significantly reduced water usage within buildings. Figure 5.6 below is a 42-unit apartment complex which replaced their pre-1992 toilets with high efficiency toilets in 2020 showing the amount of water saved by replacing the current high flow toilets. Payback for this retrofit was less than two years.

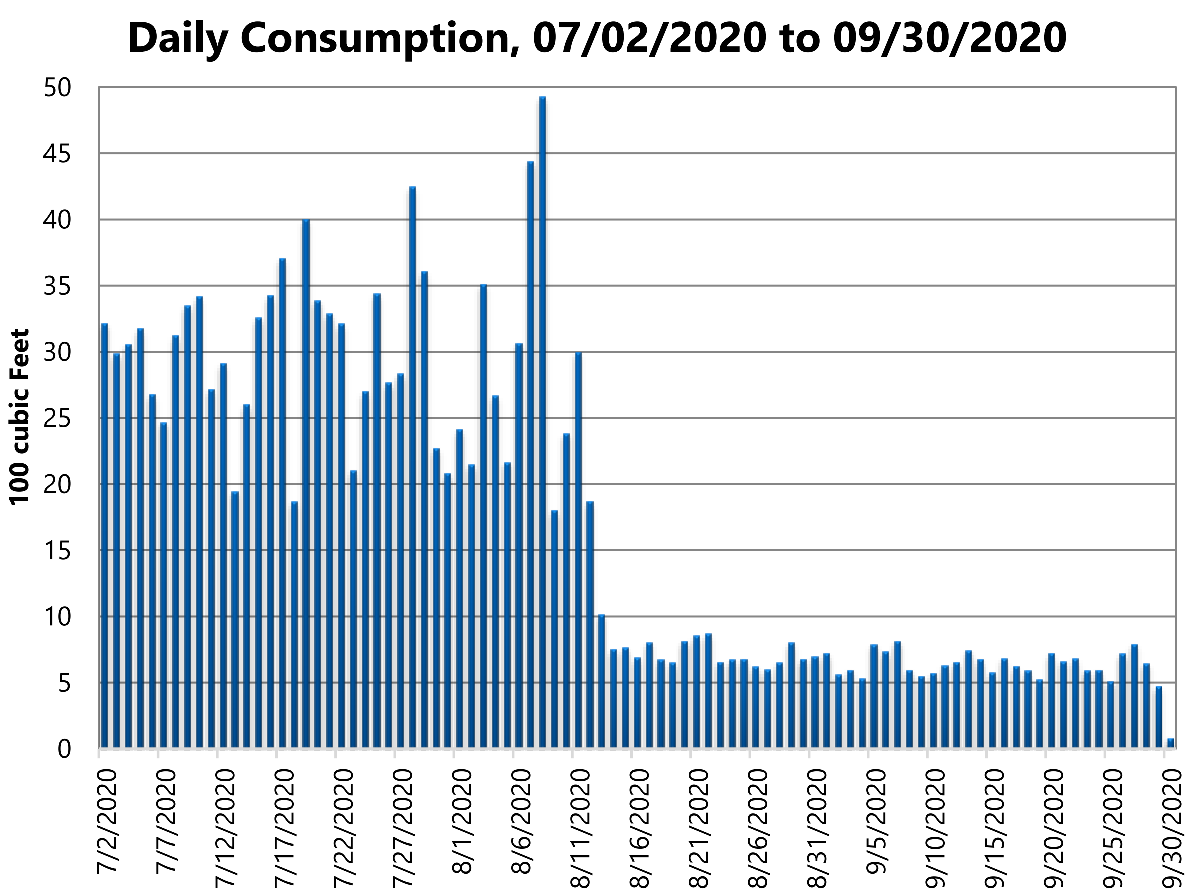


Figure 5.6 Effect of Replacing Pre-1992 Toilets with High Efficiency Toilets at a Forty-Two Unit Apartment Complex

- Provide water use surveys especially for commercial, industrial, and institutional construction. These surveys can be completed by the customer with assistance from city personnel if required. A report can be generated for the customer to show how much water they use and potential areas to reduce water usage..

5.5.5 Rebates and Grants

Consider developing a rebate program for low water use devices in commercial / industrial properties. Many commercial / industrial customers have very unique processes that use water and developing a one size fits all rebate program can miss some potential water savings. Some water systems are focusing first on learning about how their commercial / industrial customers use water and what would motivate them to implement water saving measures. Some one size fits all rebate programs include:

- High efficiency dishwashers.
- High efficiency spray nozzles.
- Low flow toilets / dual flush toilets
- Low flow urinals
- Commercial laundry facilities
- Outdoor irrigation systems

Developing a program to survey water use in commercial / industrial customers should be considered to capture some of those missed water saving opportunities.

- Consider developing a Water Saving Incentive Program for commercial / industrial customers which can provide rebates or grants to those consumers who upgrade their equipment to reduce water usage. This program would cover equipment which is not covered under a normal rebate program which are discovered by the survey recommended above. Water reduction goals would need to be achieved to receive the grant.
- Be prepared to address corporate inquiries on being "Water Positive". Large corporations such as Microsoft are moving to put more water back into the environment than they use. The city should consider developing guidance on how companies can reduce their water footprint with systems such as storm water collection and infiltration systems and low impact developments.

5.6 Summary

The City of Sioux Falls has successfully reduced water demands through its conservation program and water rates. Further enhancements are possible within the current city structure. The greatest reductions are still possible in outdoor water usage. It is recommended the city continue the program with several modifications over the next 5 to 10 years. Some of the more important recommendations include:

- Developing a Water Management Plan for the Water Division
- Utilize free AWWA Water Audit Software
- Work with the current billing software MyMeter to allow water users to view their water usage nearly real time.
- Develop a list of drought tolerant plant and grass species for eastern South Dakota and publish that list.
- Develop low water use demonstration gardens across the city
- Work with City planners and engineers to reduce or eliminate water usage in roadway medians
- Work with developers of large-scale housing developments to plant low water use landscapes.
- Develop, institute, and maintain an educational program to consumers on the importance of and how to conserve water.

Even though the water conservation program has reduced water demands, the city will continue to grow and must push the water further out into the distribution system. This movement of water will still require significant infrastructure investment. The city should continue to update water demands and the water model every few years to continue to realize the benefits of the conservation program.

Chapter 6 Design Parameters and Evaluation Criteria

Design parameters identify the features and performance requirements of distribution system infrastructure and provide the standard against which system performance is assessed. The design parameters and criteria presented within this section were used to evaluate the performance of the existing Sioux Falls water distribution system (Chapter 7 Existing System Evaluation), and to conceptualize system improvements (water mains, storage, and pumping facilities) necessary to maintain system reliability and accommodate future growth and development of the system (Chapter 8 Future System Evaluation).

Design parameters and evaluation criteria are established herein for water system pressures, distribution system storage, pumping facilities, transmission and distribution piping, and fire protection. The criteria were established based on industry standards, South Dakota Department of Agriculture & Natural Resources (DANR) regulations and their endorsed 10 States Standards[1], existing city codes, and engineering judgment.

6.1 System Pressure

When evaluating the adequacy of a water distribution system, it is paramount to ensure that adequate pressure is supplied throughout the system. Generally, there are five design parameters used to evaluate and layout the distribution system. These parameters are listed in Table 6.1 along with their definition and how they are used to evaluate the distribution system.

Table 6.1 Definition of Design Parameters Related to System Pressure

Parameter	Definition
Minimum Pressure during Peak Hour Demand[1]	Pressure to be maintained during peak hour demand to help ensure customers experience adequate pressure during normal system operation.
Desired Pressure Range	Desired pressure range provides guidance in the development of pressure zone boundaries and gives the most customers the ideal level of pressure for everyday uses.
Maximum Pressure during Minimum Demand	Pressure greater than the maximum pressure are to be avoided as these pressures can be problematic, resulting in a number of issues such as increased wear on system components, more frequent leaks and breaks, and extreme pressure variations.
Residual Pressure for Fire Flow	Pressure recommended to ensure an adequate supply of water to the pumper trucks, while overcoming any friction losses within the pipeline branch, hydrant, and fire hoses.
Maximum Pressure Fluctuation	Large fluctuations in pressures can be an indication of capacity issues within the distributions system pipelines related to excessive headloss. This is based on the range of pressure fluctuation at a single point experienced over a 24-hour period.

[1] Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers, Recommended Standards For Water Works, 2022 Edition.

Maintaining desired pressures within the distribution system is critical to maintaining successful operational performance. To develop recommended goals for the Sioux Falls system, the following references were used to define these recommendations.

- Ten States Standards for Water Works
- AWWA M32 – Computer Modeling for Water Distribution Systems[2]
- International Fire Code[3]

Based on these guidelines presented above and discussions with City Staff, the following pressure goals are recommended for the Sioux Falls system and are summarized in Table 6.2. Additional information from each of these guidelines is summarized in the following sections to provide more background information for the development of these recommended goals.

Table 6.2 Design Parameters Pressure Recommendation

Parameter	Ten States Standards Recommended by SD DANR	AWWA M32	Recommended Goal
Minimum Pressure during Peak Hour Demand[1]	35 psi	35 psi	40 psi
Desired Pressure Range	60 – 80 psi	60 – 90 psi	50 – 80 psi
Maximum Pressure during Minimum Demand[2]	100 psi	110 psi	100 psi
Residual Pressure for Fire Flow	20 psi	20 psi	20 psi
Maximum Pressure Fluctuation	Not addressed	20 – 30 psi	20 psi

1 Areas near storage and/or on the edges of pressure zones, a minimum of 35 psi during peak hour operations is acceptable.
2 Maximum pressure above 100 psi is considered acceptable on the edge of pressure zones and where new zones are not warranted.

6.1.1 Ten State Standards for Water Works

Following the Ten States Standards, the desired distribution system working pressure is between 60 to 80 psi (implying a recommended pressure fluctuation range of around 20 psi). The minimum working pressure in the distribution system should be more than 35 psi and the maximum static pressures should be less than 100 psi or pressure reducing devices shall be provided on mains or as part of the meter setting on individual service lines in the distribution system.

[2] American Water Works Association, Manual M32: Computer Modeling of Water Distribution Systems – Fourth Edition, 2017.

[3] International Code Council, Inc., 2018 International Fire Code (IFC), 2018.

6.1.2 AWWA M32 – Computer Modeling of Water Distribution Systems

The Computer Modeling of Water Distribution Systems, AWWA Manual M32 – Fourth Edition provides guidance and recommendations for design pressure parameters within the distribution system. The manual suggests there are three design pressures that are defined for each distribution system: maximum pressure, minimum pressure during peak hour, and minimum pressure during fire flow. The range of pressure fluctuations at a single point experienced over a 24-hour period may also be analyzed; pressure is typically kept to less than 20 or 30 psi. The manual provides the following as typical pressure design criteria.

- 90–110 psi during minimum demands
- 35–50 psi during maximum hour
- 60–90 psi during average demands
- 20 psi minimum during maximum day plus fire flow

6.1.3 International Fire Code

The minimum pressure during fire flows, as recommended by the 2018 International Fire Code and the National Fire Protection Association, is 20 psi at any point in the distribution system. The value of 20 psi is used to ensure an adequate supply of water to the pumper fire trucks, while overcoming any friction losses within the pipeline branch, hydrant, and fire hoses.

6.2 Distribution System Storage

Water distribution system storage is provided to ensure reliability of supply, maintain pressure, equalize pumping and treatment rates, reduce the size of transmission mains, and improve operational flexibility and efficiency. Storage facilities should be sized to provide for the following:

1. Equalization Storage – Provide storage to meet peak hour demands and pressure equalization;
2. Fire Protection Storage – supply storage for fire flow demands; and
3. Emergency Storage – to provide water reserves for contingencies such as system failures, power outages, emergencies, and operational flexibility/reliability (e.g., flooding, earthquake, ability to remove reservoir for maintenance without adverse consequence to customers, etc.).

Figure 6.1 depicts storage requirements, inclusive of situations where sufficient capacity exists for winter (low-use) adjustment. During the summer, the system fully utilizes

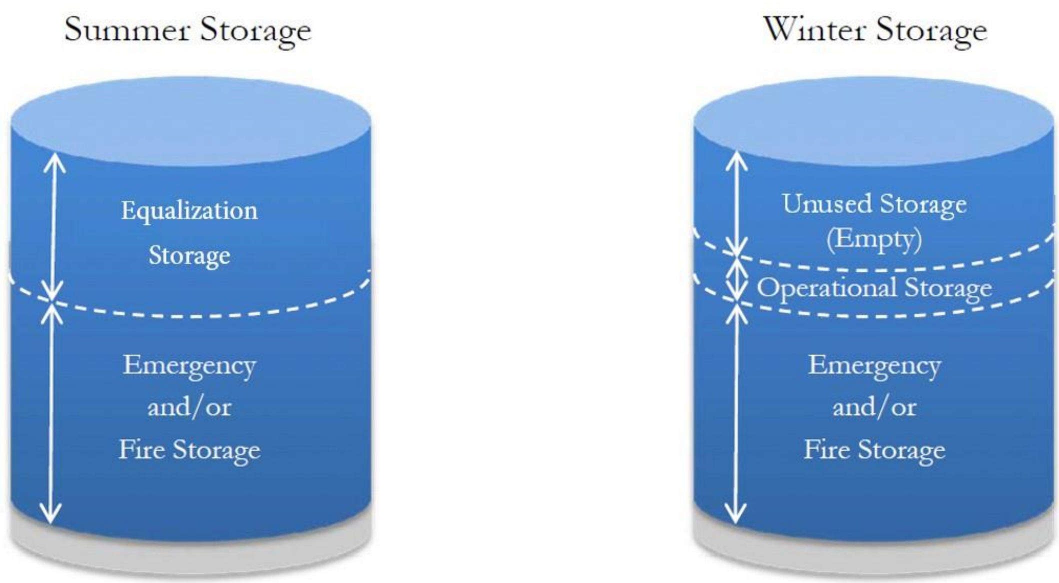


Figure 6.1 System Storage Example Diagram

equalization storage to provide for hourly demand fluctuations. During the winter months, the operators may lower the operational levels to promote more daily fluctuations with in the storage to promote turnover of water within the reservoir or tank.

6.2.1 Equalization Storage

A primary function of storage facilities within the distribution system is equalization. Water demand in most utilities varies significantly throughout the course of the day, and water treatment facilities tend to operate most efficiently at a constant rate. In order to meet these variations in demand, the water utility can vary the source, vary the pumping rate, or provide equalization through the process of filling and draining storage reservoirs and storage tanks within the distribution system. Equalization storage enables the water treatment facilities to operate at a predetermined rate, depending on the utility's preference.

The amount of operational storage required is a function of the available water supply and booster pumping capacity, distribution piping capacity, and system demand characteristics. The fraction of water production that must be stored during a maximum day as operational storage depends on the individual utility, system configuration, and operational procedures. The hourly demand curve for peak day demand was evaluated against the available source supply which included water supplies and transfer between pressure zones. Figure 6.2 shows the overall and each major pressure zone demand requirements versus available water supply. Available water supply was based on providing the average hourly demand over the peak day demand. When demand exceeds the available water supply, operational storage volume is required to maintain system functionality as well as fire/emergency volume.

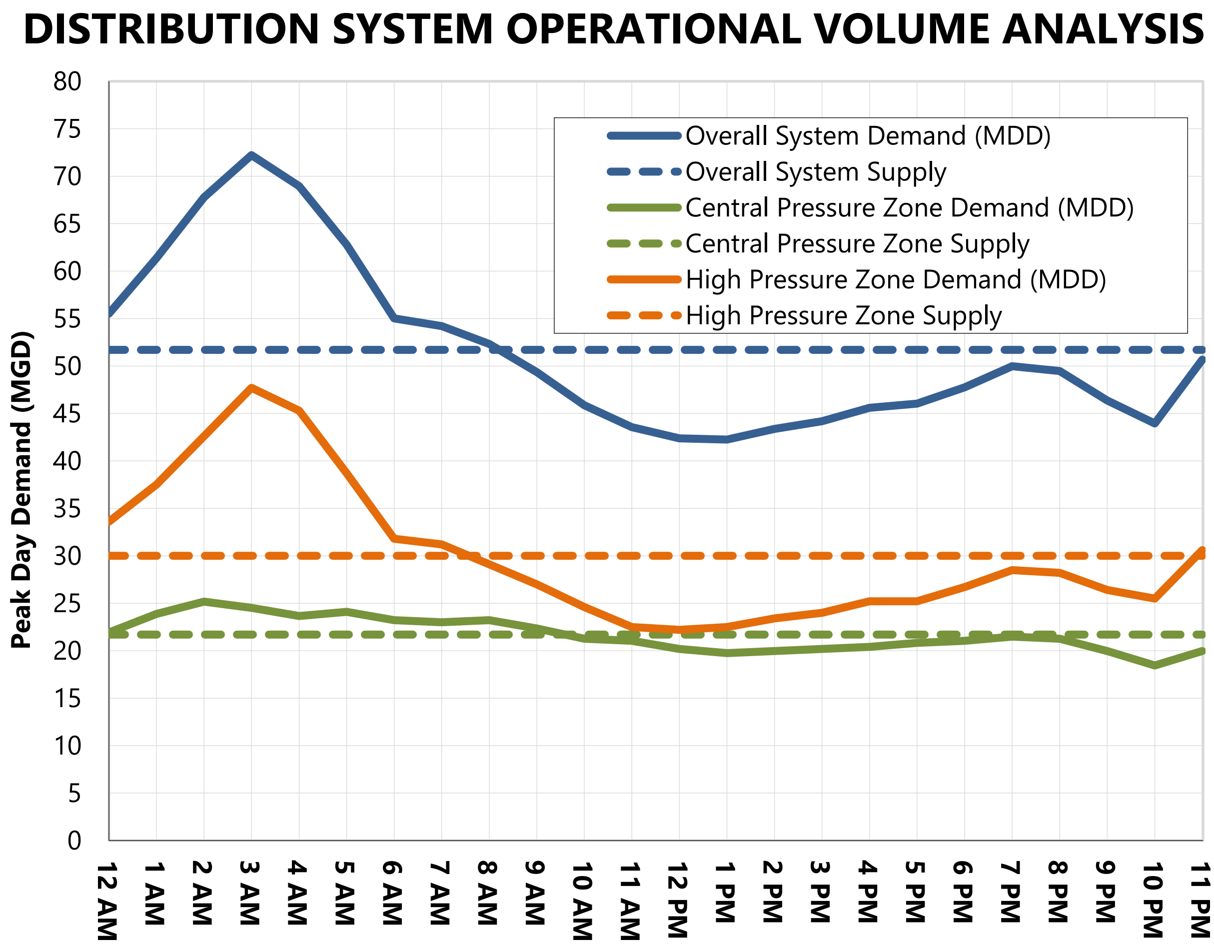


Figure 6.2 Operational Volume Analysis

The fraction of water production that must be stored during a maximum day as equalization storage depends on the individual utility, and the utility's operational pumping practices. Options for operational pumping modes include the following:

- Operate at a constant rate to simplify operation and reduce demand charges.
- Adjust flow to roughly match demand and minimize use of storage
- Pump during off-peak hours to take advantage of reduced energy costs
- Operate with a reasonable number of starts per unit time.

Typical volumes as a fraction of the maximum daily demand for the various operational pumping modes are provided in Table 6.3. The values range from a low of zero for variable speed pumping, to a high of 0.50 for off-peak pumping. The upper range of values are typical for those systems with higher peak demands, while the lower values are typical for those systems with a flatter daily demand curve.

Table 6.3 Typical Equalization Volume Fractions for Operation Pumping Modes[4]

Pumping Operation Type	Equalization Volume as Fraction of Daily Demand
Constant Pumping	0.10 – 0.25
Match Daily Demand (Constant)	0.05 – 0.15
Off-Peak Pumping	0.25 – 0.50
Variable Speed Pumping	0

Based on evaluation of hourly demand curves, equalization storage volume was calculated to be about 10 percent for summer conditions for the Sioux Falls water distribution system. Therefore, the recommended equalization storage for Sioux Falls distribution system is 10 percent of the peak day demand. Additionally, equalization storage should be provided within the top 50 percent of the storage tanks/reservoirs to enable operators to have an operating range that maintains adequate system pressures and maintain emergency storage.

6.2.2 Fire Flow Storage

A second component in providing adequate fire protection is retaining sufficient fire storage volume within the distribution system. The fire storage volume required for a system is determined by multiplying the fire demand by the required flow duration of the fire. Fire flow requirements for the City of Sioux Falls are found in greater detail in Section 6.5

In order to ensure that the City has adequate fire storage for all types and size of structures, the design parameter used to evaluate the adequacy of fire storage within the City of Sioux Falls' distribution system is an 8,000 gpm fire demand over a four hour period or two simultaneous 4,000 gpm fire demands over a four hour period, complying with the most stringent requirements of the 2018 IFC. As a result, the recommended total fire storage is 2.0 MG. This fire storage should be provided within its area of influence or service area of the distribution system. As the distribution system continues to expand, this fire storage should be provided within multiple service areas of the distribution system.

AWWA Manual M31[5] suggests that properly sized elevated water tanks should normally hold between 30 and 75 percent of their volume in reserve as dedicated fire storage. This reserve capacity can then automatically feed into the distribution system when the fire flow demands and domestic use exceeds the capacity of the high service pumps.

[4] Walski, T.M. 2000. Water Distribution Systems Handbook, Chapter 10: "Hydraulic Design of Water. Distribution Storage Tanks," McGraw-Hill, New York, NY.

[5] American Water Works Association, Distribution system requirements for fire protection (Manual M31) (2008). Denver, CO.

For evaluation of water storage, the following criteria are recommended in evaluating each of the main pressure zone areas within the system.

- Fire storage within each of these storage facilities was reserved in the bottom 50% of each facility.
- Water tower storage capacity was evaluated based on providing a minimum storage capacity to meet the requirements of a 3,000 gpm fire demand over a period of 3 hours.
- To provide for the maximum threshold of fire demand within the system based on the International Fire Code, ground storage requirements were evaluated based on a fire demand of 8,000 gpm over a 4-hour period.
- Ground storage and pumping capacity required to fight a 8,000 gpm fire or two 4,000 gpm fires over a 4-hour period was based on first subtracting available water tower storage to determine remaining storage capacity required from ground storage.

6.2.3 Emergency Storage

Emergency storage provides water for domestic consumption during events such as transmission or distribution main failures, raw water contamination events, extended power outages, failure of raw water transmission facilities, failure of treatment facilities, or a natural disaster.

No industry-standard formula exists for determining the amount of emergency storage required by a utility. Emergency storage requirements are typically policy decisions that are based on an assessment of the perceived vulnerability of the utility's water supply, risk of failures, and the desired degree of system reliability.

If a utility has redundant sources and treatment facilities with auxiliary power, or power supplied from multiple sources, the need for emergency storage may be relatively small. However, enough emergency storage should be available to handle a catastrophic pipe break that cannot be isolated easily. If a utility has a single source without auxiliary power and a relatively unreliable distribution system, a significant volume of emergency storage may be prudent.

The Sioux Falls water distribution system receives water from its Water Purification Facility and from Lewis & Clark Regional Water System (L&C RWS). The Water Purification Facility receives source water from wells and from surface water sources. The treatment facility also has multiple transmission pipelines leaving the plant in four different pipeline headers which creates redundancy in transmission capabilities leaving the treatment facility. L&C RWS has two connections to the High Pressure Zone and the distribution system has the ability to move water from the High Pressure Zone to the Central Pressure Zone. The City has a robust maintenance team and equipment to handle challenges related to transmission breaks in a timely manner.

The transmission pipelines within the network have been developed over time to create redundancy within the system.

Based on a review of the reliability of the water supply, treatment, distribution system, and past system failures, the following storage criterion is recommended for the City of Sioux Falls.

- Emergency storage within each of these storage facilities was reserved in the bottom 50% of each facility.
- Assume only one of the two water supplies within the system are offline or compromised at a time. Determine the impacts of having the Water Purification Plant or Lewis & Clark RWS offline to meet system demands.
- Goal of providing adequate emergency storage to operate the system for a ½ day (12 hours) during average day demands in an emergency.
- Determine response times related to average day demand and peak day demand conditions.

For emergency situations, City Sioux Falls should implement water use restrictions and rationing, reducing the system per capita demand rate to 115 gpcd which provides enough water to allow industries that require process water to remain in production in the case of a major disruption in the ability to deliver water to the overall system.

6.2.4 Total Storage

The City's recommended total water storage capacity should be the greater of the following:

1. The sum of operational storage plus fire flow storage; or
2. The sum of operational storage plus emergency storage.

The amount of total system storage and system facility capacity required to meet these criteria will change over time as the City continues to grow and water usage increases. Storage parameters should be met in each of the large pressure zones. The large pressure zones should include capacity for smaller pressure reducing and boosted pressure zones served from the large pressure zone. Table 6.4 presents the water distribution system storage criteria used for master planning purposes. These are the guidelines that will be used to evaluate storage requirements and available capacity with the existing system evaluation (7.4 Water Storage Capacity) and future system evaluation (8.3.2 Water Storage Improvements).

Table 6.4 Hydraulic Criteria Storage Recommendations

Storage Capacity	Criteria
Operational Storage	10 percent of PDD
Fire Storage	Fire storage to be provided is based on a single 8,000 gpm fire over a 4 hour period or two 4,000 gpm fires happening concurrently during a 4 hour period. (per large zone) Water tower storage to provide adequate storage for a 3,000 gpm fire for 3 hours. Ground storage and pumping will provide remaining capacity for a large 8,000 gpm fire demand for 4 housrs
Emergency Storage	Emergency storage equal to 0.5 days ADD with only one of the water supply sources offline during an emergency.
Total Water Storage Capacity	Total storage should be the greater of: 1. The sum of operational storage plus fire flow; or 2. The sum of operational storage plus emergency storage

6.3 Pumping Facility Capacity

Appropriate pumping facility capacity should be provided to meet the following conditions within the water system:

1. In pressure zones with storage – The system must have at a minimum adequate firm capacity to supply peak day demand (PDD) for the zone service area.
2. In pressure zones without storage – Pump stations supplying constant pressure service must have firm pumping capacity adequate to meet peak hour demand (PHD) for the zone service area while simultaneously supplying the largest fire flow demand in the zone.
3. Ground storage and pumping – The system should provide adequate pumping capacity greater than average flow during peak day demand to meet equalization storage requirements greater than available within the top 50 percent of water tower storage set aside for equalization storage in the zone service area.
4. Fire pumping capacity is required to provide the ability to pump water from the ground storage reservoirs to meet large fire demands. Analysis for determining required fire flow pumping capacity was based on a 8,000 gpm fire for a duration of 4 hours based on the International Fire Code. Required pumping capacity from ground storage was based on first subtracting available water tower storage.

5. Emergency pumping capacity is required to provide the ability to pump water from the ground storage reservoirs to meet system demand during emergencies related to water supply being offline for a certain period of time. It was assumed that only one of the two water sources would be offline at a time. Emergency pumping capacity required was based on the providing initial capacity of peak day demand conditions.

Pump station capacity guidelines are based on firm capacity, which is defined as the capacity of the system with the largest pump out of service. Pumping facilities identified as critical (provides service to pressure zone(s) without sufficient fire or emergency storage) should be equipped with an on-site, backup power generator. Less critical facilities should be equipped with a receptacle to allow for a connection to a portable generator.

6.4 Transmission and Distribution Mains

Guidelines for the design of transmission and distribution piping vary from state to state and from utility to utility. Ten States Standards provides design guidance on the minimum and maximum working pressures in a distribution system. The American Water Works Association (AWWA) also provides some guidelines on design parameters such as pipe velocity, head loss, and fire flows. Other guidelines for design parameters such as minimum and maximum pressures, head loss, and fire flows are established within design handbooks specifically written for water distribution system analyses. Ultimately, most of the design criteria used in evaluating transmission and distribution piping remains at the discretion of the utility.

Pipelines are sized to meet maximum flow conditions, which generally occur during maximum day plus fire flow or peak hour demand conditions. Pipelines are expected to carry water from sources, including water towers, reservoirs, and pump stations, to the customer without excessive pressure loss.

Transmission pipelines are large pipes that carry water longer distances and branch off to feed the distribution pipelines. Distribution pipelines are generally referred to as pipelines in the street to which fire hydrants and customer service leads are connected. Evaluation parameters for pipelines vary by size and generally be grouped into two categories:

1. Transmission pipelines (12-inch and larger)
2. Distribution pipelines (10-inch and smaller)

Establishing a maximum permissible velocity in a pipe must consider headloss, as velocity is only indirectly the limiting factor in evaluating pipe sizes for a distribution system. Essentially, headloss caused by velocity controls pipe sizing requirements. Pipeline velocities also have a direct effect on hydraulic surges and water hammer created in pipelines. As a result, criteria for both maximum permissible velocity and headloss were established for evaluating the performance of the Sioux Falls distribution system.

6.4.1 Velocity Criteria

Insight into performance guidelines with respect to pipeline velocities was obtained from *Advanced Water Distribution Modeling and Management*[6]. Because transmission pipelines carry water over longer distances than the distribution pipelines, the headlosses should be minimized to avoid large pressure fluctuations. The authors acknowledge that in larger pressure zones (several miles across), velocities as low as three fps may cause excessive headloss within the distribution system. The authors also identify that at velocities of 10 fps, pressures within the distribution system decline quickly and problems associated with water hammer become more pronounced.

AWWA Manual M32 states that a distribution system is considered to have deficient pipe looping or sizing when velocities greater than four to six fps occur under normal operating conditions.

Hydraulic surge, or transient pressure, is used to determine required pipe thickness under some pipe manufacturer guidelines. Calculations to determine required pipe thickness are based on internal pressure that includes a 100 psi allowance for surge pressure and a 2:1 safety factor. The surge pressure allowance is based on a 50 psi pressure rise for each foot per second of extinguished velocity, and the fact that most domestic water systems operate at approximately two fps. As stated previously, AWWA recommends that maximum velocities for pipelines be five fps or less, and one of the reasons for this limit listed is to minimize hydraulic surge pressures.

For small diameter pipe at the maximum recommended velocity of five fps, a pipeline would need to be designed to accommodate a 250 psi pressure surge (five fps x 50 psi/fps), which significantly encroaches on the safety factor for the typical municipal distribution system pipe.

High velocities can also scour pipe lining materials of various pipes. For DI pipe with cement-mortar lining, the Ductile Iron Pipe Research Association (DIPRA) recommends a maximum flow velocity of 14 fps to minimize disbonding of the cement-mortar lining from the inside of the pipe.

Based on the preceding information, the following design guidelines for acceptable pipeline velocities were established for this evaluation under PHD conditions:

- Transmission pipelines (12-inch and larger) = less than three fps
- Distribution pipelines (10-inch and smaller) = less than five fps

Velocity guidelines will be used in subsequent sections for the analysis of the distribution system for PHD under ADD and PDD conditions. Velocity guidelines assist in the indication of potential

[6] Walski, Thomas M.; Chase, Donald V.; Savic, Dragan A.; Grayman, Walter; Beckwith, Stephen; and Koelle, Edmundo, "Advanced Water Distribution Modeling and Management" (2003). Civil and Environmental Engineering and Engineering Mechanics Faculty Publications. Paper 18

problems associated with hydraulic surge pressures. Existing pipelines exceeding these criteria will not necessarily be identified for replacement unless there are known existing problems within the distribution system. However, if new pipelines are planned to replace old deteriorated pipelines, then the new pipelines should be sized appropriately to meet these guidelines.

Dedicated transmission pipelines (i.e., pipelines not interconnected with the distribution system), can be designed for higher velocities than 3 fps without impacting distribution system performance. Velocity guidelines for these pipelines should be evaluated on a case-by-case basis.

6.4.2 Headloss Criteria

Headloss is a more important concern than velocity for determining pipe sizing requirements; therefore, it is desirable to set a limit on the amount of headloss in a pipe. Headloss provides a better indication of the capacity of pipelines because the roughness coefficient of the pipeline, also known as the C-factor, and the associated velocities within the pipeline are accounted for.

Headloss is most commonly referred to in terms of feet of headloss per 1,000 feet of pipe length (feet/1,000 feet). AWWA recommends headloss not exceed 6 feet/1,000 feet for pipes less than 16 inches in diameter or 3 feet/1,000 feet for pipes greater than or equal to 16 inches in diameter during normal operation conditions. However, because higher headloss often contributes to inadequate distribution system pressures, performance standards used to evaluate larger diameter transmission pipelines and distribution pipelines are generally substantially lower than the AWWA guideline.

According to *Modeling, Analysis, and Design of Water Distribution Systems*[7], the author recommends transmission pipelines be sized to handle the maximum hour flow. In order to maintain a reasonable headloss within transmission pipelines during maximum hour flow, headloss should be limited to between 1 and 2 feet/1,000 feet. AWWA recommends transmission pipelines should be sized to handle the largest of the following flows:

1. Peak hour flow,
2. Maximum day flow plus fire flow, or
3. Replenishment flow rate.

Based on this consideration, the allowable headloss recommended for the system should be limited to between 2 and 5 feet/1,000 feet. Based on the preceding information, the following design guidelines for acceptable pipeline headloss were established for this evaluation under PHD conditions:

[7] Cesario, L. (1995). Modeling, analysis, and design of water distribution systems. Denver, CO: American Water Works Association.

- Transmission pipelines (12-inch and larger) = less than 2 feet/1,000 feet
- Distribution pipelines (10-inch and smaller) = less than 5 feet/1,000 feet

Headloss guidelines will be used in subsequent sections for the analysis of the distribution system PHD under ADD and PDD conditions. Headloss guidelines assist in the indication of potential problems associated with the hydraulic capacity of water mains to move water from the pumping facilities to water storage.

Existing pipelines exceeding these criteria will not necessarily be identified for replacement unless they are contributing to known problems within the distribution system. However, if new pipelines are planned to replace old deteriorated pipelines, then the new pipelines should be sized appropriately to meet these guidelines. As with the velocity guidelines for dedicated transmission pipelines, the rate of headloss experienced within dedicated transmission pipelines may exceed the guidelines presented herein, but should be evaluated on a case-by-case basis.

6.5 Fire Protection

There are no legal requirements that specify a water system must be sized adequately to provide water for fire protection. Fire protection is considered a secondary purpose for a public water system, and is an issue typically addressed at the policy level within each community. The decision to provide water for fire protection requires careful consideration of fire flow requirements when sizing pipelines, pumps, and storage reservoirs because it results in higher capital and O&M costs. However, provisions for fire flows provide a valuable public service by reducing the potential loss of human life and property, and improving fire insurance ratings within the community, which can reduce insurance costs.

The City of Sioux Falls Fire Department has adopted the 2018 International Fire Code (IFC) for rules and regulations for the prevention and control of fires and fire hazards. The IFC is a model code regulating minimum fire safety requirements for new and existing buildings, facilities, and storage process.

As stated in the IFC, the minimum fire flow required for one- and two-family dwellings that do not exceed 3,600 square feet and do not have an automatic sprinkler system is 1,000 gpm. For one- and two-family dwellings exceeding 3,600 square feet, and for all buildings other than one- and two-family dwellings, the minimum fire flow, and flow durations, are presented in Table 6.5. The minimum fire flow for these types of structures ranges from 1,500 gpm to 8,000 gpm, over durations from two to four hours. The IFC does provide criteria that allows the needed fire flow to be reduced by up to 75% if fire sprinklers are installed in the building.

Table 6.5 2018 IFC Minimum Required Fire Flow and Flow Duration for Buildings

Fire-Flow Calculation Area (square feet)					Fire Flow (gpm)[2,3]	Flow Duration (hours)[3]
Type IA and IB[1]	Type IIA and IIA[1]	Type IV and V-A[1]	Type IIB and IIIB[1]	Type V – B[1]		
0 – 22,700	0 – 12,700	0 – 8,200	0 – 5,900	0 – 3,600	1500	2
22,701 – 30,200	12,701 – 17,000	8,201 – 10,900	5,901 – 7,900	3,306 – 4,800	1750	
30,201 – 38,700	17,001 – 21,800	10,901 – 12,900	7,901 – 9,800	4,801 – 6,200	2000	
38,701 – 48,300	21,801 – 24,200	12,901 – 17,400	9,801 – 12,600	6,201 – 7,700	2250	
48,301 – 59,000	24,201 – 33,200	17,401 – 21,300	12,601 – 15,400	7,701 – 9,400	2500	
59,001 – 70,900	33,201 – 39,700	21,301 – 25,500	15,401 – 18,400	9,401 – 11,300	2750	
70,901 – 83,700	39,701 – 47,100	25,501 – 30,100	18,401 – 25,900	11,301 – 13,400	3000	3
83,701 – 97,700	47,101 – 54,900	30,101 – 40,600	21,801 – 25,900	13,401 – 15,600	3250	
97,701 – 112,700	54,901 – 63,400	35,201 – 40,600	25,901 – 29,300	15,601 – 18,000	3500	
112,701 – 128,700	63,401 – 72,400	40,601 – 46,400	29,301 – 33,500	18,001 – 20,600	3750	
128,701 – 145,900	72,401 – 82,100	46,401 – 52,500	33,501 – 37,900	20,601 – 23,300	4000	4
145,901 – 164,200	82,101 – 92,400	52,501 – 59,100	37,901 – 42,700	23,301 – 26,000	4250	
164,201 – 183,400	92,401 – 103,100	59,101 – 66,000	42,701 – 53,000	26,301 – 29,300	4500	
183,401 – 203,700	103,101 – 114,600	66,001 – 73,300	47,701 – 53,000	29,301 – 32,600	4750	
203,701 – 225,200	114,601 – 126,700	73,301 – 81,100	53,001 – 58,600	32,601 – 36,000	5000	
225,201 – 247,700	126,701 – 139,400	81,101 – 89,200	58,601 – 65,400	36,001 – 39,600	5250	
247,701 – 271,200	139,401 – 152,600	89,201 – 97,700	65,401 – 70,600	39,601 – 43,400	5500	
271,201 – 295,900	152,601 – 166,500	97,701 – 106,500	70,601 – 77,000	43,401 – 47,400	5750	
295,901 – Greater	166,501 – Greater	106,501 – 115,800	77,001 – 83,700	47,401 – 51,500	6000	
		115,801 – 125,500	83,701 – 90,600	51,501 – 55,700	6250	
		125,501 – 135,500	90,601 – 97,900	55,701 – 60,200	6500	
		135,501 – 145,800	97,901 – 106,800	60,201 – 64,800	6750	
		145,801 – 156,700	106,801 – 113,200	64,801 – 69,600	7000	
		156,701 – 167,900	113,201 – 121,300	69,601 – 74,600	7250	
		167,901 – 179,400	121,301 – 129,600	74,601 – 79,800	7500	
		179,401 – 191,400	129,601 – 138,300	79,801 – 85,100	7750	
		191,401 – Greater	138,301 – Greater	85,101 – Greater	8000	

1 Types of construction are based upon the International Building Code.

2 Measured at 20 psi.

3 Obtained from 2018 IFC.

Recommended goals for fire protection for specific building and land use types are shown in Table 6.6 for general guidelines for fire protection within the community. These guidelines will be used in evaluating the fire protection capacity of the existing and future systems. These guidelines, which include both fire flows and storage volume requirements are based upon simplified recommendations from the *2018 International Fire Code*.

The preceding fire protection goals were established for this evaluation at the individual hydrants and distribution main junctions within the hydraulic model under peak day conditions. The fire flow analysis within this Water Distribution System Master Plan are intended only for general planning purposes and may not reflect actual fire flow required by the size and construction type of a specific development or structure and will not identify specific non-conforming developments or structures. Actual fire flow requirements for building permit acquisition with the city shall be in accordance with the 2018 International Fire Code.

Table 6.6 Fire Flow Availability Goals

Building / Land Use Type	Fire Flow (gpm)[1]	Duration (hours)	Volume (gal)
Low-Density Residential	1,000	2	180,000
Apartment Residential	2,000	2	240,000
Institutional	1,500	2	180,000
Commercial*	2,000	2	240,000
Industrial*	3,000	3	540,000

1. Fire flow is the flow rate supplied at a specific node within the system at a residual pressure of 20 psi which still allows enough pressure to operate a neighboring second story faucet.
2. Industrial fire flow volume calculated at 3,000 gpm for 3 hours.

6.6 Design Parameters and Evaluation Criteria Summary

Table 6.7 summarizes the water system design parameters and evaluation criteria presented in the previous subsections. This includes recommendations for the following parameters:

- Minimum and maximum system pressures
- Storage capacity
- Distribution main sizing related to the following
  - Maximum pipeline velocity
  - Maximum headloss
- Fire flow/duration requirements

Table 6.7 Summary of Design and Evaluation Criteria

<table>
<tr><th>Component</th><th colspan="2">Criteria</th></tr>
<tr><th>Distribution System Pressures</th><th colspan="2">Pressure (psi)</th></tr>
<tr><td>Maximum Pressure [a]</td><td colspan="2">100</td></tr>
<tr><td>Minimum Pressure during Peak Hour demand</td><td colspan="2">40</td></tr>
<tr><td>Minimum Pressure during a Fire Flow</td><td colspan="2">20</td></tr>
<tr><td>Desired Pressure Range</td><td colspan="2">50 - 80</td></tr>
<tr><td>Maximum Pressure Fluctuation</td><td colspan="2">20</td></tr>
<tr><th colspan="3">Water Demand for Distribution Sizing</th></tr>
<tr><td>Gallons Per Capita Per Day (gpcd) for Average Day Demand (ADD)</td><td colspan="2">115</td></tr>
<tr><td>Gallons Per Capita Per Day (gpcd) for Peak Day Demand (PDD)</td><td colspan="2">250</td></tr>
<tr><td>Peak Hour Demand (PHD) Peaking Factor</td><td colspan="2">1.6</td></tr>
<tr><th colspan="3">Storage Capacity [b]</th></tr>
<tr><td>Operational Storage per Zone</td><td colspan="2">10 percent of the peak day demand</td></tr>
<tr><td>Fire Storage</td><td colspan="2">Fire storage to be provided is based on a single fire occurring within a 24-hr period</td></tr>
<tr><td>Emergency Storage</td><td colspan="2">Emergency storage equal to 0.5 days average day demand</td></tr>
<tr><td>Total System Storage</td><td colspan="2">Total storage should be the greater of:</td></tr>
<tr><td></td><td colspan="2">1. The sum of operational storage plus fire flow; or</td></tr>
<tr><td></td><td colspan="2">2. The sum of operational storage plus emergency storage</td></tr>
<tr><td colspan="3">Major pressure zones should be evaluated to provide adequate equalization storage and emergency storage within the overall pressure zone. Major pressure zones should be reviewed by service areas to provide adequate fire protection within these areas. Reduced pressure zones and boosted pressure zones from a major pressure zone should be included in the evaluation of the major pressure zone.</td></tr>
<tr><th>Water Transmission and Distribution Pipelines</th><th>Velocity (fps)</th><th>Headloss (feet/1000 feet)</th></tr>
<tr><td>Transmission pipelines (12-inch and larger)</td><td>Less than 3</td><td>Less than 2</td></tr>
<tr><td>Distribution pipelines (10-inch and smaller)</td><td>Less than 5</td><td>Less than 5</td></tr>
<tr><th>Fire Flow Requirements [c]</th><th>Flow Rate (gpm)</th><th>Duration (hrs)</th></tr>
<tr><td>Single Family Residential</td><td>1,000</td><td>2</td></tr>
<tr><td>Multi-family/Apartment Residential</td><td>2,000</td><td>2</td></tr>
<tr><td>Educational Building</td><td>1,500</td><td>2</td></tr>
<tr><td>Commercial</td><td>2,000</td><td>2</td></tr>
<tr><td>Industrial</td><td>3,000</td><td>3</td></tr>
<tr><td colspan="3">The City Fire Department follows the International Fire Code to determine Needed Fire Flow. These are general requirements for master planning purposes and may not be indicative of the requirements for specific developments or buildings. Each development should be evaluated on a case-by-case basis.</td></tr>
</table>

Chapter 7 Existing System Evaluation

This chapter evaluates the existing water distribution system and its ability to meet recommended water system service and performance criteria under various water demand conditions. The chapter includes evaluations for both system capacity and hydraulic performance. Key sections include the following:

- Water System Pressure Analysis
- Water Storage Capacity
- Pumping Capacity
- Transmission and Water Main Capacity
- Fire Flow Analysis

Evaluations, findings, and recommendations for addressing deficiencies identified in the City's existing water distribution system are summarized and included in this chapter. These recommendations are used in the development of the CIP. The recommended CIP is described in further detail in Chapter 9.

7.1 Existing System Demands

Different demands scenarios were developed for use within the hydraulic model for the evaluation of the existing system. The distribution system is the most stressed during periods of maximum demand. This section summarizes the system's ability to provide adequate water pressure and fire flow under the worst-case conditions. If the system can meet the worst-case scenario, it follows that it will perform as well or better during times of lower demands. Demand development is described in Chapter 3, and the demand allocation process is described in Section 4.1.2

7.1.1 Average Day Demand

The ADD modeling scenario provides a representative evaluation of the typical day-to-day operation of the water distribution system. The ADD of 23.3 mgd was determined using a current population of 202,600 and a per capita water usage of 115 gpcd based on the water usage characterization.

7.1.2 Peak Day Demand

The PDD modeling scenario provides a representative evaluation of the operation of the water distribution system during a peak day demand of 51.7 mgd. The PDD was determined based on a current population of 202,600 and using a per capita water usage of 255 gpcd per the water usage characterization. While the existing water system has only experienced a peak day demand of 47.4 MGD in 2012 with a population of 158,800, the system could experience another dry summer along with an increased population could create a higher demand.

7.1.3 Peak Hour Demand

A hourly demand pattern analysis was completed for both the Central and High pressure zones based on existing SCADA system data to reflect actual system conditions. Figure 7.1 shows the hourly demand pattern used in all extended period simulation evaluations.

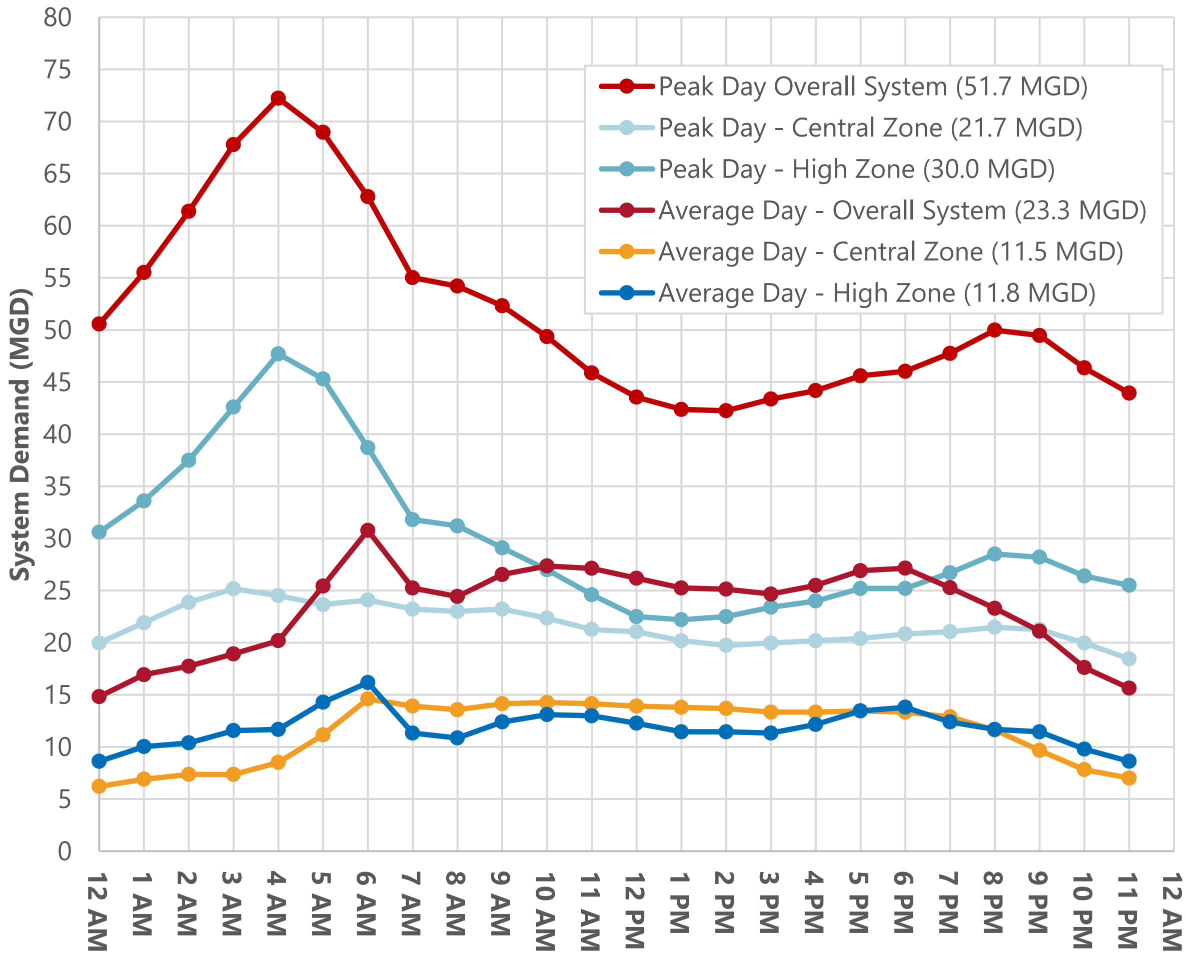


Figure 7.1 Existing Hourly Demand Curves

7.1.4 System Demand Overview

The demands used within the hydraulic model for the existing system are presented in Table 7.1. These demands can be used to evaluate the existing system because they are representative of usage patterns experienced historically.

Table 7.1 Water Demands – Pressure Zones/Service Areas

Main Zone	Zones Served	Average Day Demand		Peak Day Demand	
		(MGD)	(MGD)	(MGD)	(MGD)
Central	Central	11.4	11.5	21.4	21.7
	Reduced	0.1		0.3	
High - East	High	2.8	3.2	7.3	8.4
	Reduced	0.4		1.1	
High - South	High	4.3	4.8	10.9	12.1
	Reduced	0.5		1.2	
High - West	High	3.8	3.8	9.5	9.5
Total		23.3	23.3	51.7	51.7

7.2 System Modeling Scenarios

Demands presented in the previous section were used in three modeling scenarios to evaluate the existing system against the performance criteria documented in Chapter 6. Table 7.2 lists the different modeling scenarios developed for use in the hydraulic analysis and evaluation of the existing system.

Table 7.2 Existing System Modeling Scenarios

Model Scenario	Scenario Demand Condition	Simulation Type	Description
Existing	Average Day Demand (ADD)	Extended Period Simulation	This scenario evaluates the City's supply facilities and transmission/distribution system capabilities during existing ADD and day-to-day operations.
Existing	Peak Day Demand (PDD)	Extended Period Simulation	This scenario evaluates the City's supply facilities and transmission/distribution system capabilities during the peak demands of the existing PDD.
Existing	Available fire flow during PDD	Steady State	This scenario calculates the available fire flow at a residual pressure of 20 psi during PDD conditions.

7.3 Water System Pressure Analysis

When determining the adequacy of a distribution system, a primary parameter to check is the predicted pressure. The following pressure criteria established previously in Chapter 6 are shown in Table 7.3.

Table 7.3 Water System Pressure Criteria

Parameter	Recommended Goal
Minimum Pressure during Peak Hour Demand[1]	40 psi
Desired Pressure Range	50 – 80 psi
Maximum Pressure during Minimum Demand[2]	100 psi
Residual Pressure for Fire Flow	20 psi
Maximum Pressure Fluctuation	20 psi

1 Areas near storage and/or on the edges of pressure zones, a minimum of 35 psi during peak hour operations is acceptable.

2 Maximum pressure above 100 psi is considered acceptable on the edge of pressure zones and where new zones are not warranted.

7.3.1 Minimum Pressure – Peak Day Demand (PDD)

Minimum pressures represent the pressure during peak hour demand during peak day demand conditions. An extended period simulation was performed, and the minimum pressure served in the system are represented in Table 7.4 and Figure 7.2.

- No locations with pressures less than the goal of a minimum pressure of 40 psi.
- Majority of pressures ranged from 50 psi to 100 psi with 94% within this range.
- Overall, 54% of locations were within the desired pressure range is from 50 psi and 80 psi.
- Within Central and Reduced Pressure zones, a larger percentage were within the 80 to 100 psi and these areas represent commercial and industrial areas with a desire for greater pressure.
- Overall, pressures greater than 100 psi were about 5 percent of the system.
- The map of pressures shown in Figure 7.2 provides a picture of pressures across each pressure zone.
- Pressures ranging from 40 psi to 50 psi generally are located in areas of higher elevation and along the boundaries of the pressure zones.

Table 7.4 Minimum Pressure during PDD

Pressure Zone	Pressure Range					Goal
	< 40 psi	40 psi to 50 psi	50 psi to 80 psi	80 psi to 100 psi	> 100 psi	> 40 psi
Central	0%	1%	44%	51%	4%	100%
Reduced	0%	0%	48%	52%	0%	100%
High - East	0%	2%	70%	22%	6%	100%
High - South	0%	0%	56%	40%	4%	100%
High - West	0%	0%	64%	30%	7%	100%
East Reduced	0%	4%	65%	31%	0%	100%
Overall System	0%	1%	54%	40%	5%	100%

7.3.2 Average Pressure – Peak Day Demand (PDD)

Average pressures represent the typical pressure over a typical 24-hour period during peak day demand conditions. An extended period simulation was performed, and the average pressure within the system are represented in Table 7.5 and Figure 7.3.

- Typical pressures ranged from 50 psi to 100 psi.
- Over 99% of the system has pressures greater than desired pressure of 50 psi.

Table 7.5 Average Pressure during PDD

Pressure Zone	Pressure Range				
	< 40 psi	40 psi to 50 psi	50 psi to 80 psi	80 psi to 100 psi	> 100 psi
Central	0%	0.5%	40%	55%	5%
East Reduced	0%	3%	63%	34%	0%
High - East	0%	2%	67%	25%	6%
High - South	0%	0%	43%	51%	6%
High - West	0%	0%	58%	30%	13%
Reduced	0%	0%	48%	52%	0%
Overall System	0%	0.5%	48%	45%	7%

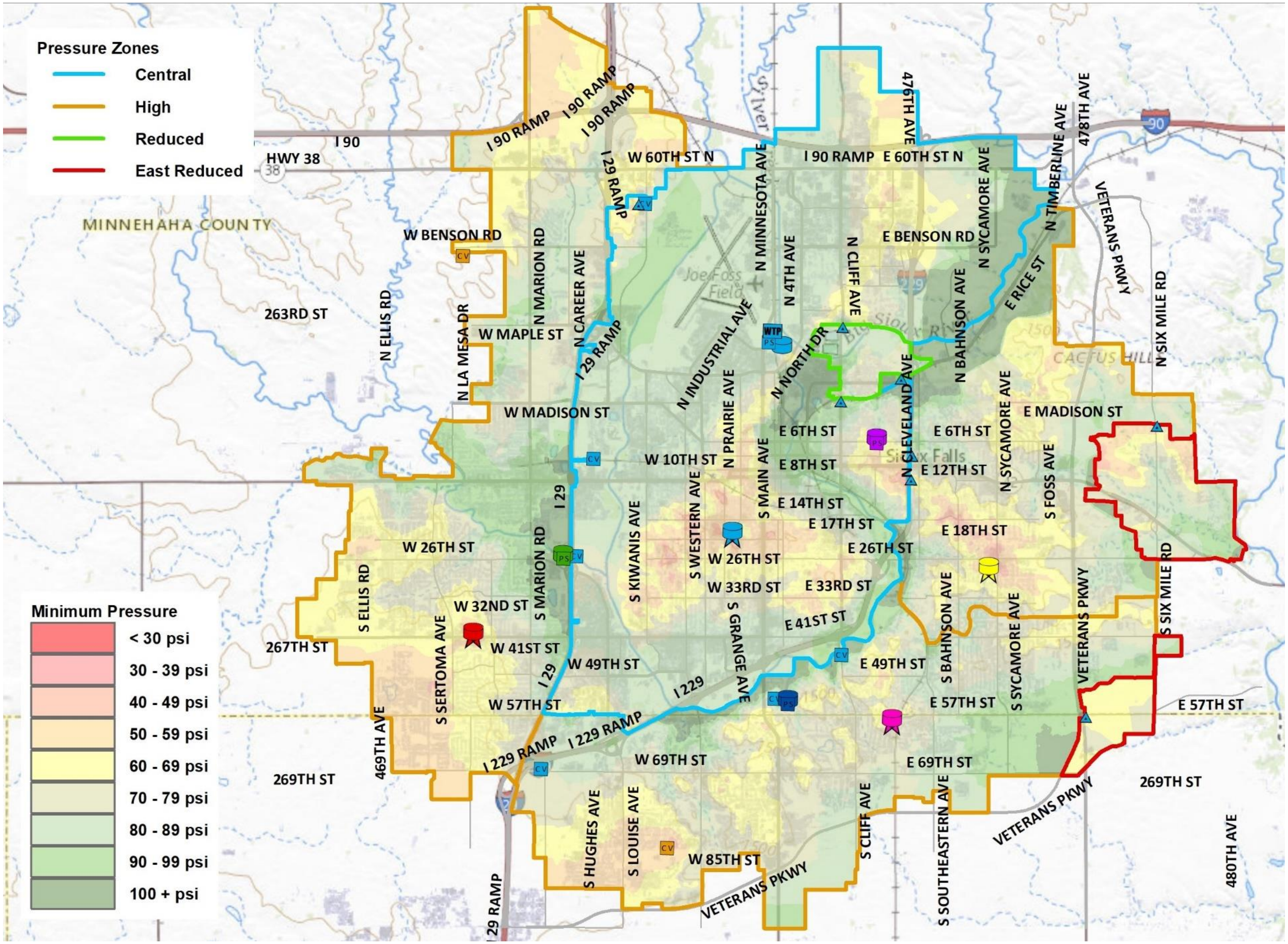


Figure 7.2 Minimum Pressure - PDD

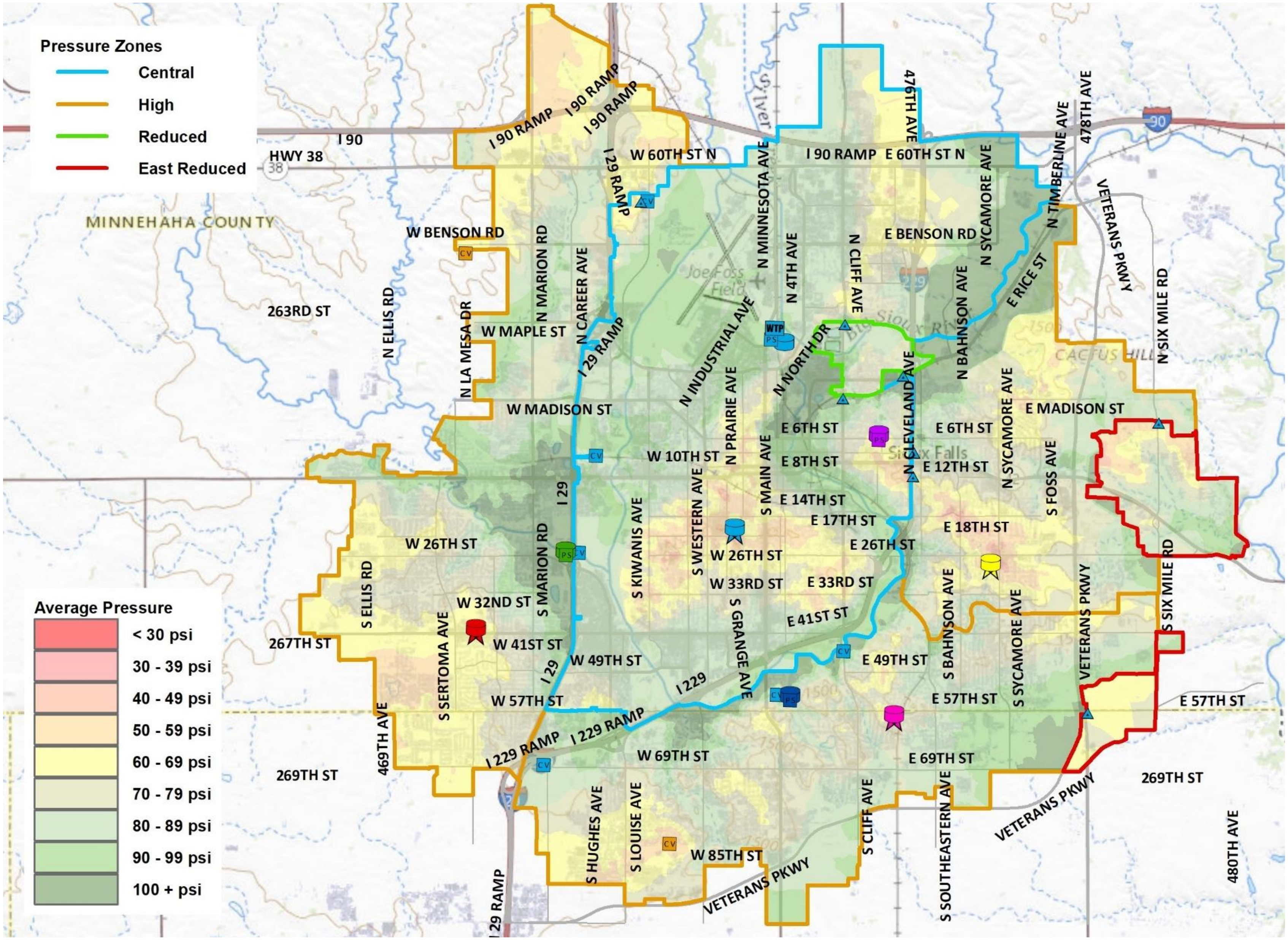


Figure 7.3 Average Pressure - PDD

7.3.3 Maximum Pressure – Peak Day Demand (PDD)

Maximum pressures represent the highest pressures found within the system and can occur during low demand periods or discharge pressure during peak pumping conditions. Maximum pressures can also be located in areas of low elevation and near boundaries of pressure zones. An extended period simulation was performed, and the maximum pressure served in the system are represented in Table 7.6 and Figure 7.4.

- Less than 10% of the system has pressures greater than the goal of being under 100 psi.
- Areas of high pressure are located generally in the following areas:
  - West of I-29 in vicinity of the West Reservoir Pump Station and is indicative of the area near the pump station and adjacent to the pressure zone boundary.
  - Along the Big Sioux River along the north boundary of the High Zone – South near the South Reservoir Pump Station which is a low elevation area on this boundary.
  - Along East Rice Street which borders the Big Sioux River located in a low elevation area within both the High Zone – East and the Central Zone.
  - Area south of S. 57th Street and east of Sycamore Ave which is along the boundary of the High Zone – South and the East Reduced Zone. The East Reduced Zone has been further refined in recent years to provide better pressure transition between these zones.

Table 7.6 Maximum Pressure during PDD

Pressure Zone	Pressure Range					Goal
	< 40 psi	40 psi to 50 psi	50 psi to 80 psi	80 psi to 100 psi	> 100 psi	< 100 psi
Central	0%	0%	36%	57%	7%	93%
Reduced	0%	0%	48%	52%	0%	100%
High - East	0%	1%	63%	29%	7%	93%
High - South	0%	0%	34%	58%	7%	93%
High - West	0%	0%	52%	33%	15%	85%
East Reduced	0%	3%	62%	35%	0%	100%
Overall System	0%	0%	43%	49%	9%	91%

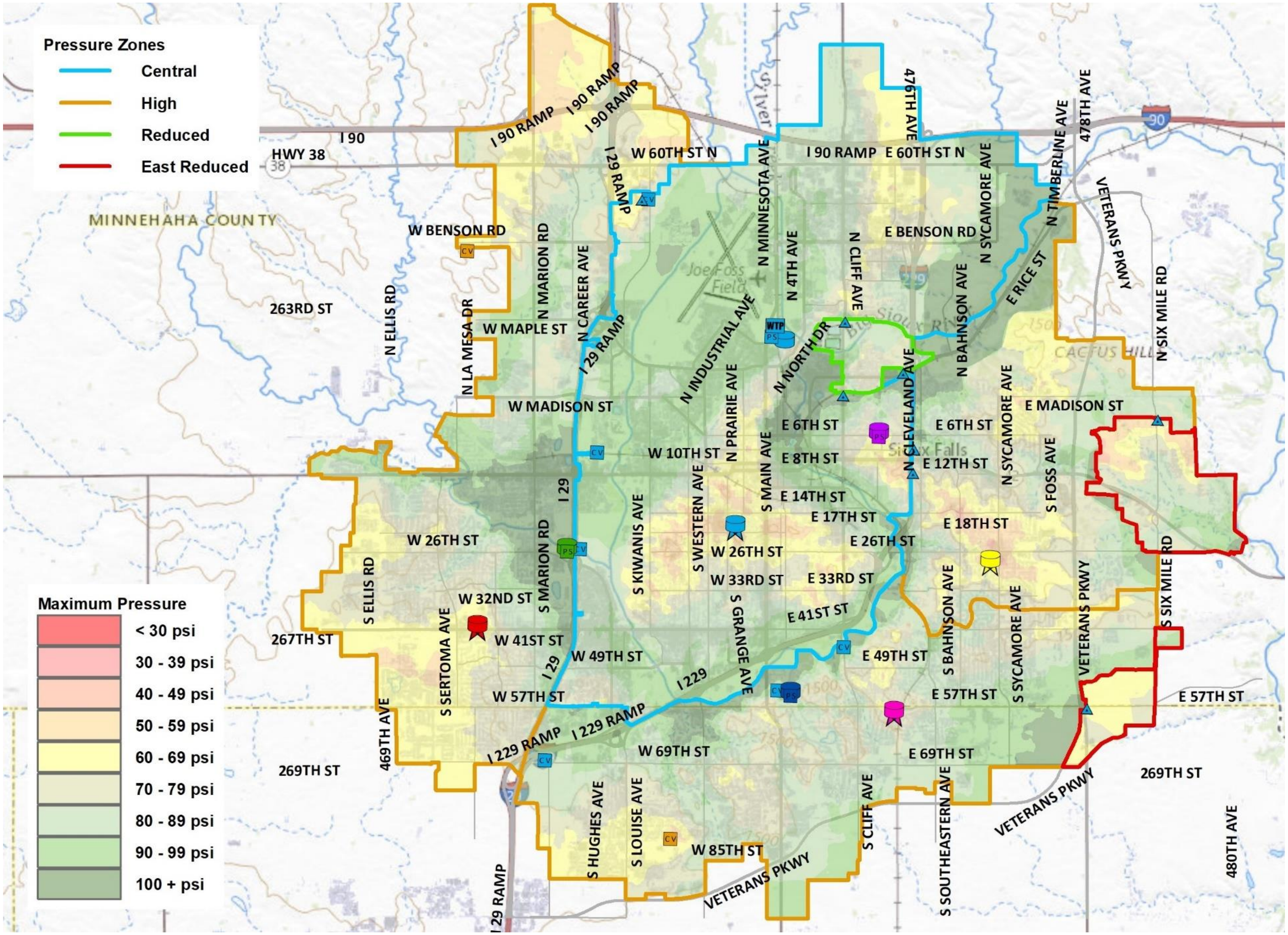


Figure 7.4 Maximum Pressure - PDD

7.3.4 Pressure Fluctuation – Peak Day Demand (PDD)

While the minimum and maximum pressures in the system have clearly defined criteria, evaluation of the difference in simulated maximum and minimum pressures provide another metric to measure system performance. The operation of large pumps in the system, such as drinking water facility distribution pumps, can cause pressures to increase significantly. Alternatively, a pump station withdrawing a large flow rate of water from a pressure zone can drop pressures, especially when the pump station is located far away from the tank or production source.

Pressure fluctuation is the difference between the maximum and minimum pressure experienced at any one location in the distribution system over a 24-hour period. An extended period simulation was performed, and the pressure fluctuation within the system are represented in Table 7.7 and Figure 7.5.

- Overall, the pressure fluctuation within the system was less than 10 psi with 61% less than 5 psi.
- A majority of the pressure fluctuation between 5 psi and 10 psi occurs in the south and west portions of the High Pressure Zone due to operation of the West Reservoir. As the system expands its transmission capabilities, this area will see less potential for fluctuation. However, it is well below the desired level of fluctuation of 20 psi.

Table 7.7 Pressure Fluctuation during PDD

Pressure Zone	Pressure Range					Goal
	0 psi to 5 psi	5 psi to 10 psi	10 psi to 15 psi	15 psi to 20 psi	> 20 psi	< 20 psi
Central	77%	23%	0%	0%	0%	100%
Reduced	100%	0%	0%	0%	0%	100%
High - East	98%	2%	0%	0%	0%	100%
High - South	40%	60%	0%	0%	0%	100%
High - West	30%	70%	0%	0%	0%	100%
East Reduced	100%	0%	0%	0%	0%	100%
Overall System	61%	39%	0%	0%	0%	100%

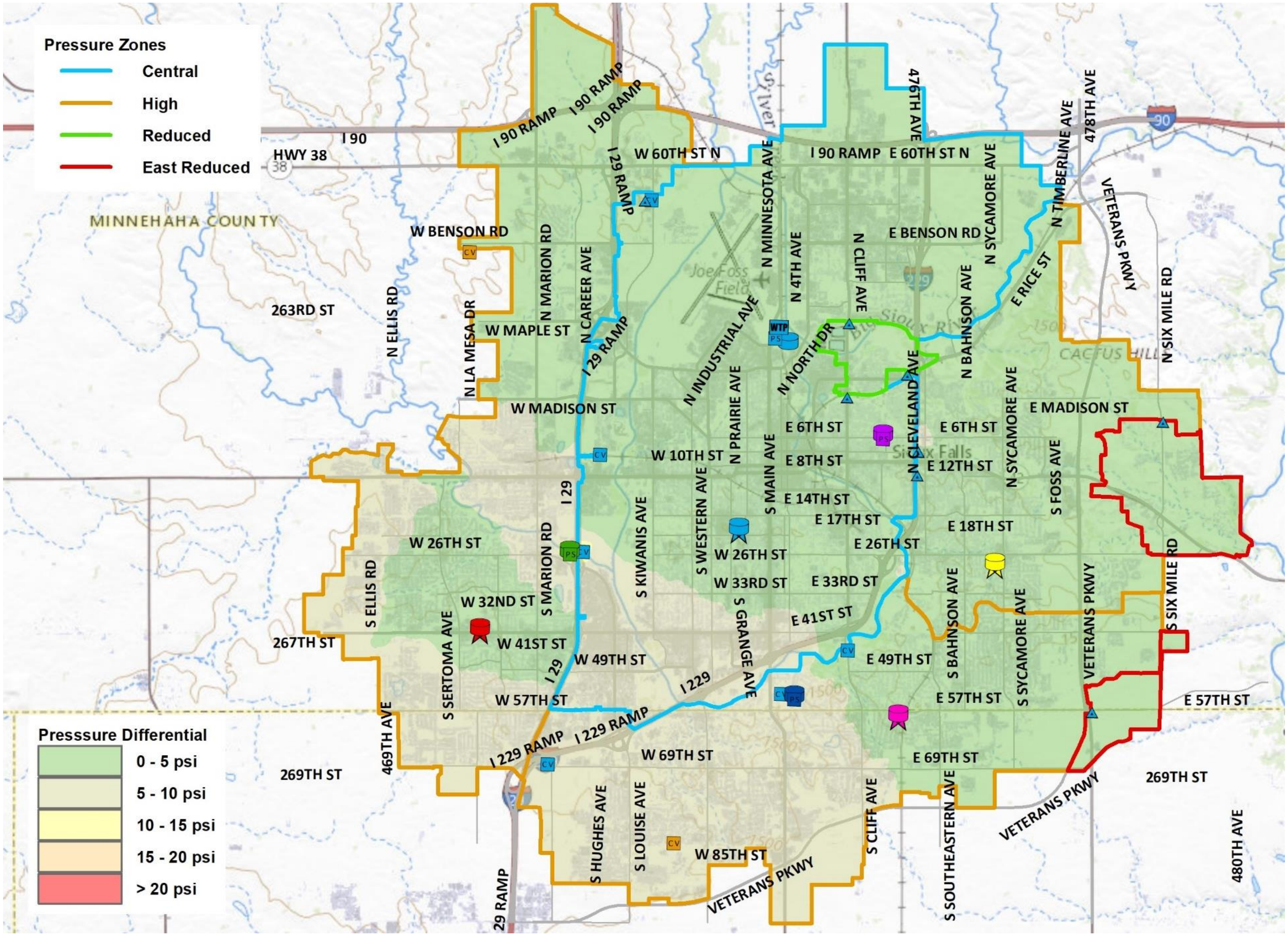


Figure 7.5 Pressure Fluctuation - PDD

7.3.5 Average Pressure – Average Day Demand (ADD)

Average pressures represent the typical pressure over a typical 24-hour period during average day demand conditions. Pressures on average day demands reflect typical pressures that occur most of the time within system. An extended period simulation was performed, and the average pressure within the system are represented in Table 7.8 and Figure 7.6.

- Typical pressures ranged from 50 psi to 100 psi.
- Over 99% of the system has pressures greater than desired pressure of 50 psi.
- Overall, only a small percentage of the system experiences pressures greater than 100 psi.
- Generally, lower pressures occur at high elevations within the system and higher pressures at lower elevations within the system. Pressure zone boundaries can also impact pressures on either side of the zone boundary.

Table 7.8 Average Pressure during ADD

Pressure Zone	Pressure Range				
	< 40 psi	40 psi to 50 psi	50 psi to 80 psi	80 psi to 100 psi	> 100 psi
Central	0%	0.1%	39%	56%	5%
East Reduced	0%	2.6%	62%	36%	0%
High - East	0%	1.7%	66%	26%	6%
High - South	0%	0.1%	55%	41%	4%
High - West	0%	0%	56%	31%	13%
Reduced	0%	0%	48%	52%	0%
Overall System	0%	0.3%	50%	44%	7%

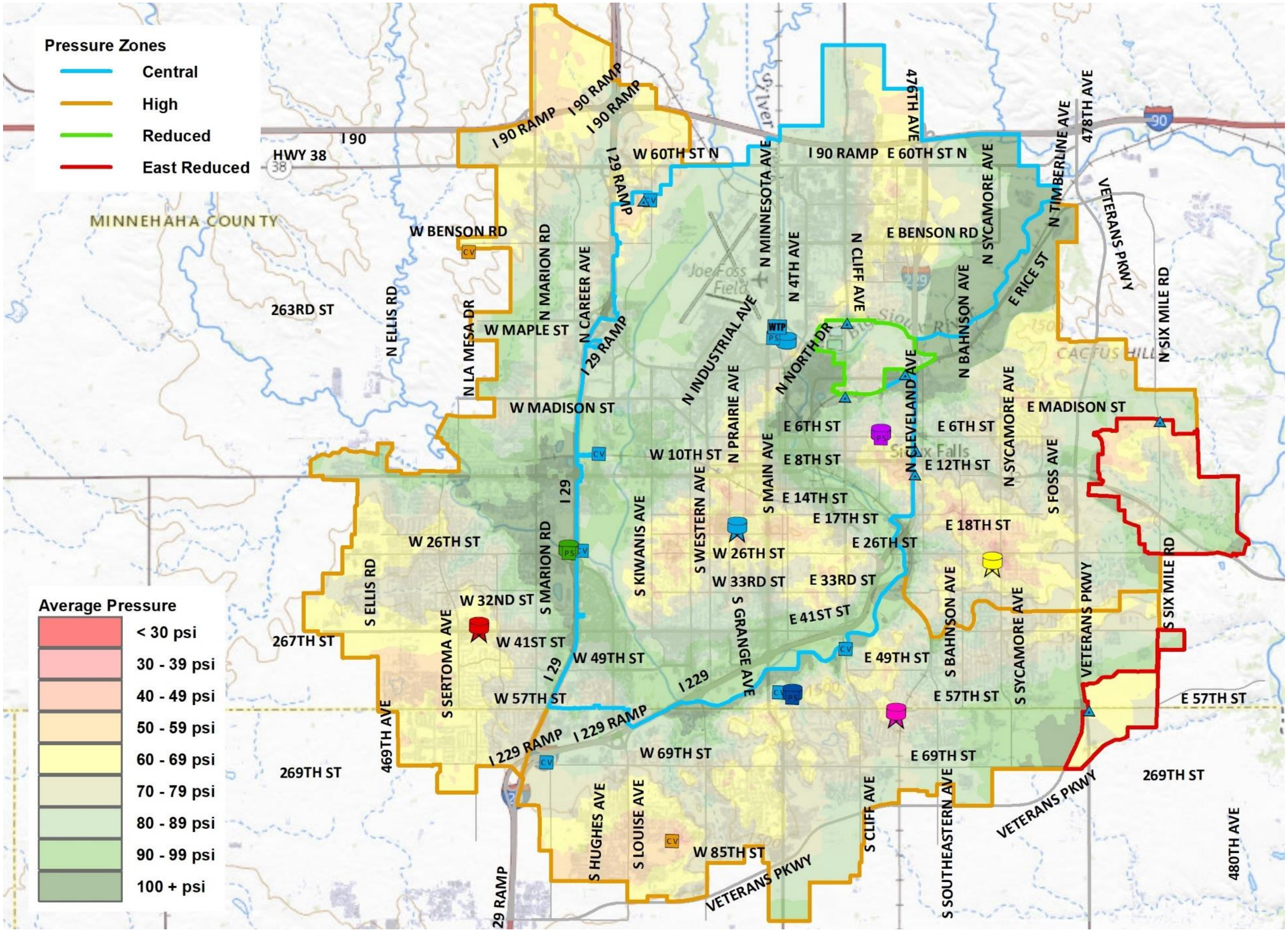


Figure 7.6 Average Pressure - ADD

7.3.6 Pressure Fluctuation – Average Day Demand (ADD)

While the minimum and maximum pressures in the system have clearly defined criteria, evaluation of the difference in simulated maximum and minimum pressures provide another metric to measure system performance. The operation of large pumps in the system, such as drinking water facility distribution pumps, can cause pressures to increase significantly. Alternatively, a pump station withdrawing a large flow rate of water from a pressure zone can drop pressures, especially when the pump station is located far away from the tank or production source.

Pressure fluctuation is the difference between the maximum and minimum pressure experienced at any one location in the distribution system over a 24-hour period. An extended period simulation was performed, and the pressure fluctuation within the system are represented in Table 7.9 and Figure 7.7.

- Overall, the pressure fluctuation within the system was less than 5 psi with 99% less than 5 psi.
- These results are well within the goal of less than 20 psi.

Table 7.9 Pressure Fluctuation during ADD

Pressure Zone	Pressure Range					Goal
	0 psi to 5 psi	5 psi to 10 psi	10 psi to 15 psi	15 psi to 20 psi	> 20 psi	< 20 psi
Central	100%	0%	0%	0%	0%	100%
Reduced	100%	0%	0%	0%	0%	100%
High - East	100%	0%	0%	0%	0%	100%
High - South	99%	1%	0%	0%	0%	100%
High - West	100%	0%	0%	0%	0%	100%
East Reduced	100%	0%	0%	0%	0%	100%
Overall System	100%	0%	0%	0%	0%	100%

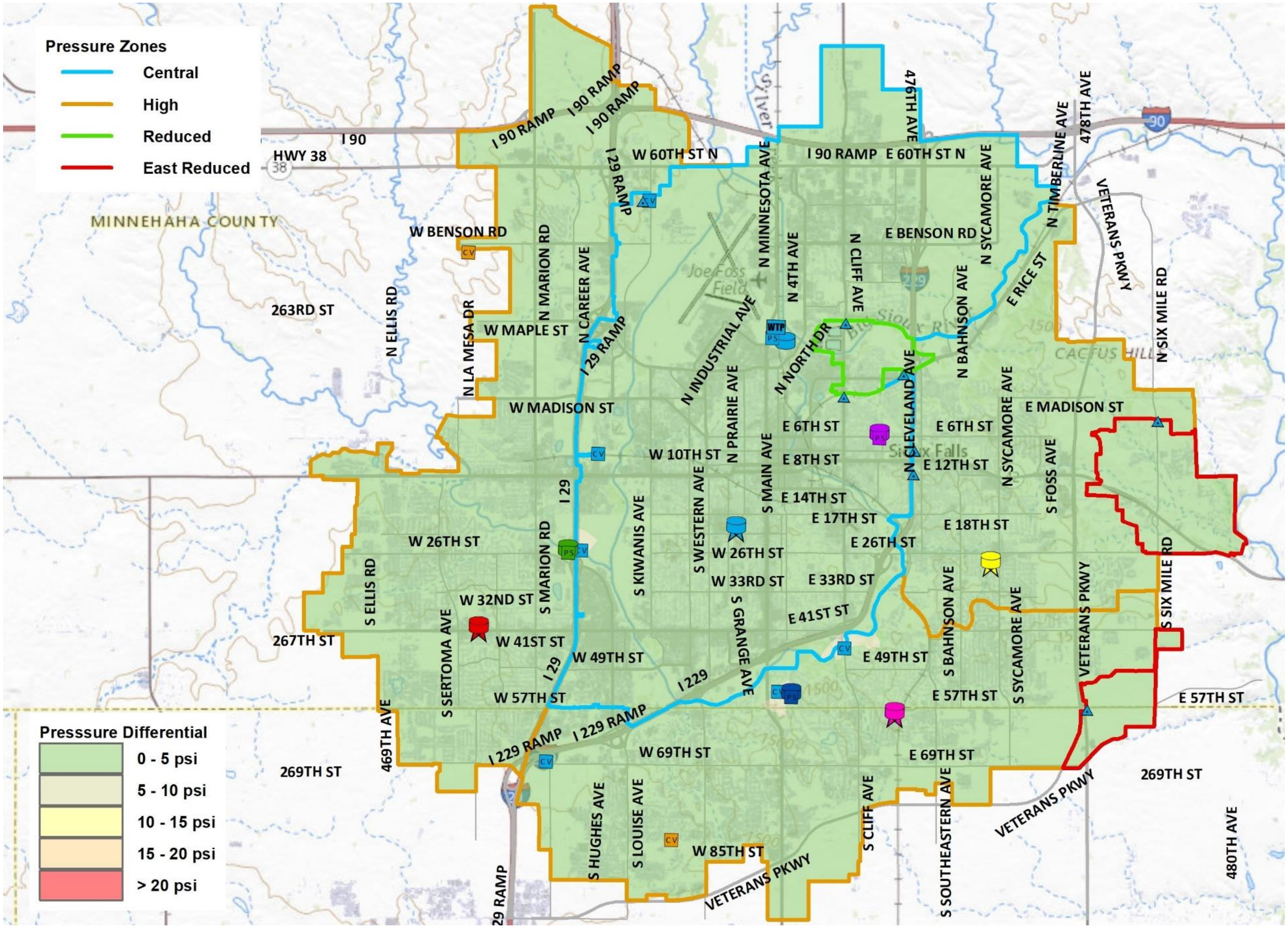


Figure 7.7 Pressure Fluctuation - ADD

7.3.7 System Pressure Overview

System pressures were evaluated for both peak day demands and average day demands. Results were presented for minimum, average, and maximum pressures along with fluctuations in pressure from minimum and maximum pressure.

- No locations with pressures less than the goal of a minimum pressure of 40 psi.
- Majority of pressures ranged from 50 psi to 100 psi with 94% within this range.
- Over 99% of the system has pressures greater than desired pressure of 50 psi.
- Less than 10% of the system has pressures greater than the goal of being under 100 psi.
- Overall, the pressure fluctuation within the system was less than 10 psi with 61% less than 5 psi.
- Overall, the system provides a great level of service in relation to pressures within system while minimizing areas with high pressures.

7.4 Water Storage Capacity

The existing distribution system storage was evaluated under current conditions with respect to storage adequacy for each of the following objectives:

- Equalization storage
- Fire protection storage
- Emergency storage

The amount of storage required was determined based on evaluation of equalization storage plus fire storage, or emergency storage, whichever is larger. The logic behind this basis of analysis is that a fire is not likely to occur at the same time as a critical pipe break, pump failure, or power outage.

7.4.1 System Operational Characteristics

Understanding of the operational characteristics within the system is important to understand the need for water storage within the overall system. This section will provide an overview of the water distribution system, while more detailed information is presented in Chapter 2. A map showing location of existing storage facilities is shown in Figure 7.8.

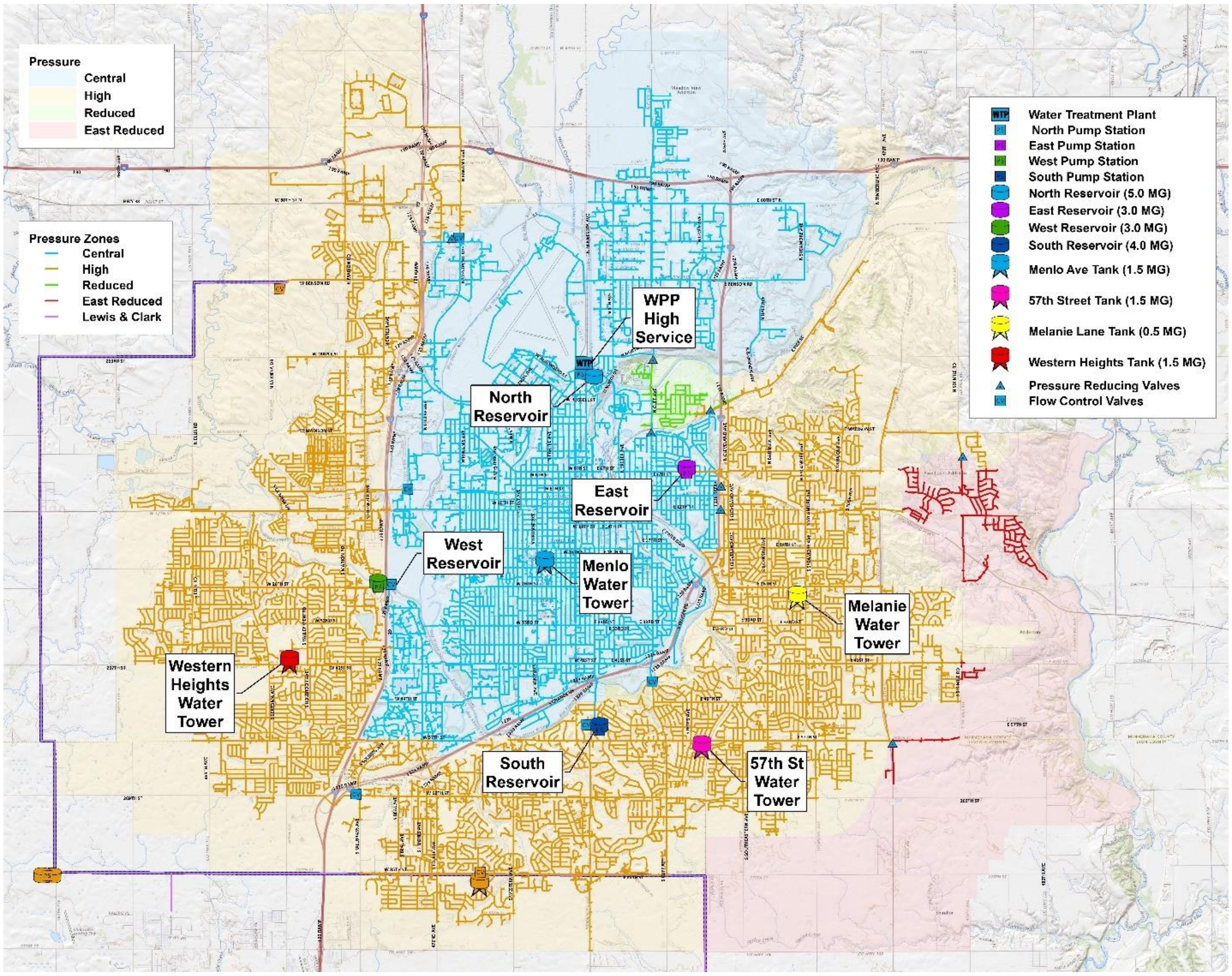


Figure 7.8 Existing Storage and Pumping Facilities

- Water Supply from Water Purification Plant and Lewis & Clark RWS
  - WPP delivers water into the Central Zone
  - L&C RWS delivers water into the High Zone – South through the 85th St Connection and High Zone – West through the Benson Road Connection
- Water Storage Reservoirs receive water from the Central Zone and pumps water to the High Zone
  - East Reservoir pumps to the High Zone – East
  - South Reservoir pumps to the High Zone – South
  - West Reservoir pumps to the High Zone -West

- Water can be transferred from the High Zone to the Central Zone
    - Westport Control Valve – from High Zone – West
    - Lyons Control Valve – from High Zone – West
    - West Reservoir Control Valve – from High Zone – West
    - South Reservoir Control Valve – from High Zone – South
    - Cliff Control Valve – from High Zone – South
- Water Tower Storage
    - Menlo Water Tower serves the Central Zone
    - Melanie Water Tower serves the High Zone – East
    - 57th St Water Tower serves the High Zone – South
    - Western Heights Water Tower serves the High Zone - West

The system has been developed to provide operational flexibility to deliver water throughout the system along with system redundancy. Water operations staff utilize these water system facilities to manage pumping and storage throughout the system to ensure an adequate level of service throughout the system.

7.4.2 Equalization Storage

Equalization storage provides storage to meet demands in excess of the production and delivery capabilities. Equalization storage required was determined to be ten percent of peak day demand based on analysis of hourly demand patterns of the system as defined in Section 6.2 .

The amount of required equalization storage for each major pressure zone is provided in Table 7.10. Analysis of available equalization storage for water tower storage and ground storage reservoirs is shown in Table 7.11 with a summary of remaining available capacity and additional storage needed is shown in Table 7.12.

- Available equalization storage was based on 50% of the capacity within each of the storage facilities.
- Assumed that available equalization storage within the water towers would be used first, then remaining would be pumped from the ground storage reservoirs.
- Pumping capacity at ground storage reservoirs would provide the ability to deliver storage to meet peak hour demands not provided within water tower storage.
- Ability to move water into and out of the ground storage reservoirs provides operational flexibility in managing water tower levels within each of the pressure zones.

Table 7.10 Equalization Storage Required

Main Zone	Zones Served	Peak Day Demand		Equalization Storage Required
		(MGD)	(MGD)	(MG)
Central	Central	21.4	21.7	2.17
	Reduced	0.3		
High - East	High	7.3	8.3	0.83
	Reduced	1.1		
High - South	High	10.9	12.1	1.21
	Reduced	1.2		
High - West	High	9.5	9.5	0.95
Total		51.7	51.7	5.17

Table 7.11 Equalization Storage Analysis

Main Zone	Storage Required	Water Tower Storage			Ground Storage & Pumping		
		Facility	Available (MG)	Used (MG)	Facility	Available (MG)	Used (MG)
Central	2.17	Menlo	0.75	0.75	North (Big Blue)	2.50	1.42
High - East	0.83	Melanie	0.25	0.25	East Reservoir	1.50	0.58
High - South	1.21	57th Ave	0.75	0.75	South Reservoir	2.00	0.46
High - West	0.95	Western Heights	0.75	0.75	West Reservoir	1.50	0.20
Total	5.2		2.50	2.50		7.50	2.66

Refer to Table 7.12 for summary of analysis including remaining capacity and additional storage needed.

Understanding the capacity of the equalization storage within the system consists of assessing the required amount of equalization storage with the available storage that is shown in Table 7.12. This analysis shows the remaining equalization storage capacity within the existing system.

- Overall, the existing system has adequate capacity to meet the existing equalization storage requirements.
- Remaining equalization storage capacity within the Central Zone is about 33%. The Menlo Water Tower provides the only elevated storage within the Central Zone. Planning for a future Central Zone water tower would increase the equalization storage capacity along with providing redundancy if one of the water towers is taken offline.
- Each of the High Zone areas have remaining storage capacity greater than 50% which will provide capacity for future growth.

Table 7.12 Equalization Storage Capacity

Main Zone	Storage Required	Total Storage		Remaining Storage Capacity		Additional Storage Needed
		Available	Used			
		(MG)	(MG)	(MG)	%	(MG)
Central	2.17	3.25	2.17	1.08	33%	0.00
High - East	0.83	1.75	0.83	0.92	52%	0.00
High - South	1.21	2.75	1.21	1.54	56%	0.00
High - West	0.95	2.25	0.95	1.30	58%	0.00
Total	5.2	10.00	5.16	4.84	48%	0.00

7.4.3 Fire Storage

Fire protection storage provides the amount of water to meet fire protection requirements. Fire storage volume was determined by multiplying the required maximum fire flow rate by the required duration of time. Fire storage was analyzed based on the water tower storage and ground reservoir and pumping storage. Fire storage within each of these storage facilities was reserved in the bottom 50% of each facility.

Water tower storage was evaluated based on providing a minimum storage capacity to meet the requirements of a 3,000 gpm fire demand over a period of 3 hours. Results of this analysis are provided in Table 7.13 provide the following conclusions.

- Water tower storage was able to provide the desire capacity of 3,000 gpm for a 3 hour duration with the exception of the Melanie Water Tower in the High Zone - East.
- Future water tower storage in the High Zone – East would be beneficial to providing greater level of service. In the near-term, existing ground storage and pumping at the East Reservoir will provide the additional desired capacity.

Table 7.13 Fire Flow Storage Capacity within Water Towers

Main Zone	Water Tower Storage					Additional Capacity needed to provide for 3,000 gpm for 3 hrs
	Facility	Available	Fire Flow Capacity (gpm) based on Fire Duration			
		(MG)	2 hrs	3 hrs	4 hrs	
Central	Menlo	0.75	6,250	4,167	3,125	0
High - East	Melanie	0.25	2,083	1,389	1,042	1,611
High - South	57th Ave	0.75	6,250	4,167	3,125	0
High - West	Western Heights	0.75	6,250	4,167	3,125	0
Total		2.50				

To provide for the maximum threshold of fire demand within the system based on the International Fire Code, ground storage requirements were evaluated based on a fire demand of 8,000 gpm over a 4-hour period. Results of this analysis are provided in Table 7.14 provide the following conclusions.

- Review of available ground storage and pumping capacity and required capacity from ground storage based on first subtracting available water tower storage shows that there is adequate capacity within overall storage to fight a 8,000 gpm fire or two 4,000 gpm fires over a 4-hour period.

Table 7.14 Fire Flow Storage Capacity within Ground Storage Reservoirs

Main Zone	Ground Storage & Pumping Storage			Capacity for 8,000 gpm Fire Demand for a 4 hr Duration	
	Facility	Available	Available Fire Flow Capacity based on Fire Duration of 4 hrs	Available from Water Tower	Required from Ground Storage & Pumping
		(MG)	(gpm)	(gpm)	(gpm)
Central	North (Big Blue)	2.50	10,417	3,125	4,875
High - East	East Reservoir	1.50	6,250	1,042	6,958
High - South	South Reservoir	2.00	8,333	3,125	4,875
High - West	West Reservoir	1.50	6,250	3,125	4,875
Total		7.50			

7.4.4 Emergency Storage

Emergency storage is the amount of water necessary to operate the distribution system during events such as pipeline failures, equipment failures, power outages, water treatment plant failures, raw water contamination events, and natural disasters. The evaluation of emergency storage based on the following conditions.

- Determine response times related to average day demand and peak day demand conditions.
- Assuming only one of the two water supplies within the system are offline or compromised at a time. Table 7.15 provides an understanding of the impacts of having the Water Purification Plant or Lewis & Clark RWS offline to meet system demands.
- Emergency storage within each of these storage facilities was reserved in the bottom 50% of each facility. Table 7.16 provides an overview of available emergency storage.
- Goal of providing adequate emergency storage to operate the system for a ½ day (12 hours) during average day demands in an emergency.

Table 7.15 Emergency Demands based on Supply Conditions

Water Supply		Average Day Demand	Peak Day Demand	Demand Minus Available Supply	
Water Purification Plant	Lewis & Clark RWS			Average Day Demand	Peak Day Demand
(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)
32.0	0.0	23.2	51.6	0.0	19.6
0.0	17.0	23.2	51.6	6.2	34.6

Table 7.16 Available Emergency Storage

Main Zone	Water Tower Storage		Ground Storage & Pumping		Overall Storage Available
	Facility	Available (MG)	Facility	Available (MG)	(MG)
Central	Menlo	0.75	North (Big Blue)	2.50	5.25
			WPP Clearwell	2.00	
High - East	Melanie	0.25	East Reservoir	1.50	1.75
High - South	57th Ave	0.75	South Reservoir	2.00	2.75
High - West	Western Heights	0.75	West Reservoir	1.50	2.25
Total		2.50		9.50	12.00

Analysis of available emergency storage to evaluate the ability remaining water supply to provide for average and peak day demands and then determine the amount of response time would be available to meet demands before using all of the available storage. A summary of the analysis is provided in Table 7.17 including estimated response times for average and peak day demand conditions.

- Lewis & Clark RWS offline and supply from the Water Purification Plant
  - Average day demand conditions, the system would be able to meet the supply needs.
  - Maximum demand conditions, the emergency storage would be able to provide almost 15 hours of response time.
- Water Purification Plant offline and supply from Lewis & Clark RWS
  - Average day demand conditions, the emergency storage would be able to provide about 46 hours of response time.
  - Maximum demand conditions, the emergency storage would be able to provide almost 8 hours of response time.
- Under emergency conditions, capacity from the L&C RWS 85th St Connection would be required to exceed the allocation of 11 mgd under existing conditions due to transmission pipeline capacity limitation south of L&C RWS Benson Road Connection.

Table 7.17 Response Time to Emergency based on Available Storage Capacity

Water Supply		Available Emergency Storage	Response Time to Emergency		Additional storage required to provide 12 hour response time with one water supply offline during average day demands
Water Purification Plant	Lewis & Clark RWS		Average Day Demand	Peak Day Demand	
(MGD)	(MGD)	(MG)	(hrs)	(hrs)	MG
32.0	0.0	12.0	Supply meets demand	14.7	0.0
0.0	17.0	12.0	46.5	8.3	0.0

7.5 Pumping Capacity

Water distribution pumping plays key roles in the ability to deliver water from the Water Purification Plant to the Central Zone as well as pumping water from each of the storage reservoirs to the High Zone. Pumping capacity within the system was evaluated for the following system conditions. A map showing location of existing pumping facilities is shown in Figure 7.8.

- Equalization
- Fire Pumping
- Emergency Pumping

7.5.1 Equalization Pumping Capacity

Equalization pumping capacity is required to provide for peak hour demands. Additional pumped storage may be necessary to make up remaining required equalization storage that is greater than what is available in water tower storage. Using extended period simulation of the peak day demands provided the ability to determine the required pump capacity for delivering equalization storage from ground storage reservoirs. Results of available pumping capacity along with required capacity is shown in Table 7.18.

Table 7.18 Pumping Capacity Analysis to meet Peak Hour Demands

Main Zone	Pumping Facility	Available Pumping Capacity		Capacity Required for Pumping Equalization Storage		Remaining Capacity	Additional Pumping Capacity Requirements	
		(MGD)	(gpm)	(MGD)	(gpm)		(MGD)	(gpm)
Central	WPP High Service	72.4	50,278	40.8	28,333	44%	0.0	0
High - East	East Reservoir	26.0	18,056	8.1	5,625	69%	0.0	0
High - South	South Reservoir	23.2	16,111	5.8	4,028	75%	0.0	0
High - West	West Reservoir	22.6	15,694	3.2	2,222	86%	0.0	0

- Overall, each of the existing pumping facilities has adequate capacity to meet current demand conditions.
- Water Purification Plant High Service Pumping has about 44 percent remaining capacity. However, a future planned water tower within the Central Zone to provide redundancy will also provide additional equalization storage and will increase the remaining capacity with this future water tower project.
- As growth continues to occur in the High Zone – East, the remaining pumping capacity of the pumps at the East Reservoir will reduce over time until additional equalization storage is provided within the High Zone – East with the addition of a future water tower.
- The remaining pumping capacity of the West Reservoir will increase as more water becomes available from a future connection to L&C RWS and further extension of transmission pipelines south from the L&C RWS Benson Road Connection.
- Remaining capacity at the South Reservoir will continue to decrease over time based on continued growth within the High Zone – South and the East Reduced Zone.

7.5.2 Fire Pumping Capacity

Fire pumping capacity is required to provide the ability to pump water from the ground storage reservoirs to meet large fire demands. Storage is available within existing water towers to provide generally for a fire demand of 3,000 gpm for 3 hours. For very large fires with demands greater than 4,000 gpm for at least 4 hours require the ability to pump available storage from the ground storage reservoirs.

Analysis for determining required fire flow pumping capacity was based on a 8,000 gpm fire for a duration of 4 hours based on the International Fire Code. The current largest fire demand within the system is known to be 7,500 gpm. Based on this information, the fire flow pumping capacity requirements are provided in Table 7.19. Results of available pumping capacity along with required fire pumping capacity is shown in Table 7.20

- Overall, each of the existing pumping facilities has adequate capacity to meet current fire demand conditions based on a large fire within the system.
- With future water tower storage planned for the Central Zone, the remaining fire pumping capacity for the Water Purification Plant High Service pumps will increase from the current remaining capacity of 34%.
- With plans for additional storage within the High Zone – East, the remaining fire pumping capacity for the East Reservoir pumps will increase from the current remaining capacity of 30%.
- The South Reservoir and West Reservoir pump stations have remaining fire pumping capacity of 45% and 55% which will serve these areas within the system for several years.

Table 7.19 Fire Flow Capacity Requirements

Main Zone	Pumping Facility	Capacity for Peak Hour Demands to Meet Equalization Storage Requirements		Pumping Capacity Needed for 8,000 gpm Fire Demand for a 4 hr Duration		Total Required Pumping Capacity	
		(MGD)	(gpm)	(MGD)	(gpm)	(MGD)	(gpm)
Central	WPP High Service	40.8	28,333	7.0	4,875	47.8	33,208
High - East	East Reservoir	8.1	5,625	10.0	6,958	18.1	12,583
High - South	South Reservoir	5.8	4,028	7.0	4,875	12.8	8,903
High - West	West Reservoir	3.2	2,222	7.0	4,875	10.2	7,097

Table 7.20 Pumping Capacity Analysis to meet Fire Flow Demands

Main Zone	Pumping Facility	Available Pumping Capacity		Total Required Pumping Capacity		Remaining Capacity	Additional Pumping Capacity Requirements	
		(MGD)	(gpm)	(MGD)	(gpm)		(MGD)	(gpm)
Central	WPP High Service	72.4	50,278	47.8	33,208	34%	0.0	0
High - East	East Reservoir	26.0	18,056	18.1	12,583	30%	0.0	0
High - South	South Reservoir	23.2	16,111	12.8	8,903	45%	0.0	0
High - West	West Reservoir	22.6	15,694	10.2	7,097	55%	0.0	0

7.5.3 Emergency Pumping Capacity

Emergency pumping capacity is required to provide the ability to pump water from the ground storage reservoirs to meet system demand during emergencies related to water supply being offline for a certain period of time. It was assumed that only one of the two water sources would be offline at a time. Available water supply capacity with one of the water sources offline is shown in Table 7.21.

Table 7.21 Available Supply Capacity with One Water Supply Offline

Water Supply		Average Day Demand	Peak Day Demand	Demand Minus Available Supply	
Water Purification Plant	Lewis & Clark RWS			Average Day Demand	Peak Day Demand
(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)
32.0	0.0	23.2	51.6	0.0	19.6
0.0	17.0	23.2	51.6	6.2	34.6

Emergency pumping capacity required was based on the providing initial capacity of peak day demand conditions. Note that as the emergency evolves, water conservation measures maybe implemented to reduce the water demands closer to average day demand conditions. As demands decrease, remaining pumping capacity will increase over time.

Analysis of required emergency pumping capacity based on peak day demand conditions as compared to available pumping capacity is shown in Table 7.22. Note that required emergency pumping capacity includes the ability to meet peak hour demands utilizing equalization storage capacity within the ground storage reservoirs.

- Overall, each of the existing pumping facilities has adequate capacity to meet current emergency pumping capacity requirements within the system.
- Under emergency situation of the Water Purification Plant offline, supply from L&C RWS at 85th St Connection would have to exceed the allowable allocation of 11 MGD during this emergency to provide the full allocation of 17 MGD to the system due to transmission pipeline capacity limitations from the L&C RWS Benson Road Connection.

Table 7.22 Pumping Capacity Analysis during Emergency Situations

Main Zone	Pumping Facility	Available Pumping Capacity		Capacity Required for Pumping Emergency Storage		Remaining Capacity	Additional Pumping Capacity Requirements	
		(MGD)	(gpm)	(MGD)	(gpm)		(MGD)	(gpm)
Central	WPP High Service	72.4	50,278	64.7	44,926	11%	0.0	0
High - East	East Reservoir	26.0	18,056	13.3	9,241	49%	0.0	0
High - South	South Reservoir	23.2	16,111	19.4	13,456	16%	0.0	0
High - West	West Reservoir	22.6	15,694	15.2	10,544	33%	0.0	0

7.6 Transmission and Water Main Capacity

As established in Chapter 6, a distribution system is considered to have deficient water main looping or sizing if the following conditions are experienced during peak hour demand.

- Velocities greater than 5 fps;
- Water Main (10-inch or less) have headlosses greater than 5 feet/1,000 feet; or
- Transmission Pipelines (12-inch or greater) having headlosses greater than 2 feet/1,000 feet.

Although none of these thresholds are definitive, they pose a concern as they can indicate a potentially diminished capacity to convey water or excess wear and tear on pipes. Existing pipelines not meeting these performance criteria are not recommended for replacement unless there are known problems within the water distribution system. However, if these pipes are replaced due to street rehabilitation or other projects, the new pipelines should be sized to meet the maximum velocity and headloss guidelines.

Figure 7.9 illustrates the results of headloss analysis (feet/1,000 feet) for existing peak day demand conditions for transmission pipelines and Figure 7.10 for water main as defined above. Pipes identified exceeding the velocity threshold typically aligned with results from the headloss analysis.

Peak Day Demand Conditions

General observations of headloss exceeding the established criteria for peak day demand conditions included the following areas of transmission capacity.

- East of the Water Purification Plant to the East Reservoir
  - Indication of future capacity challenges delivering water to the High Zone – East via the East Reservoir as this area continues to growth.
  - Consider upsizing future transmission improvements.
- Along N Westport Ave
  - Higher headloss due to transfer of flows from High Zone – West to Central Zone
  - Consider additional transfer locations such as at the West Reservoir where pipelines between the two zones have greater capacity.
- To West Reservoir through the Central Zone
  - Indication of future capacity challenges to deliver water to West Reservoir
  - Consider future upsizing if replacing transmission pipelines.
- From East Reservoir to the High Zone -East.
  - Consider completion of transmission pipeline along Veterans Parkway from 6th St to 26th St. to improve north/south transmission within the High Zone.
- To South Reservoir from the Central Zone
  - Indication of future capacity challenges delivering water to High Zone – South
  - Consider upsizing in any future replacement projects.
- From South Reservoir to the east into the High Zone – South.
  - As growth continues to occur, consider continued extension of pipelines along 85th St. S.
- Along 69th St S west of I-29 to the High Zone – West
  - Consider future transmission pipelines south from L&C RWS Benson Road Connection to provide greater capacity to south areas within the High Zone – West.

Reviewing results of capacity of water main within the system showed no major indications for future capacity challenges under peak day demand conditions.

<u>Average Day Demand Conditions</u>

Figure 7.11 illustrates the results of headloss analysis (feet/1,000 feet) for existing average day demand conditions for transmission pipelines and Figure 7.12 for water main as defined above. General observations of headloss exceeding the established criteria for average day demand conditions included the following areas of transmission capacity.

- Along Cliff Ave between High Zone – South and Central Zone
  - Capacity in this transmission is dependent on transfer of flows from the upper zone to the lower zone. This will change over time as the system grows and will not be a concern based on implementation of additional transfer capacity at the South Reservoir.
- Overall, there are no major concerns with headloss during average day demands within the transmission pipelines and water main.

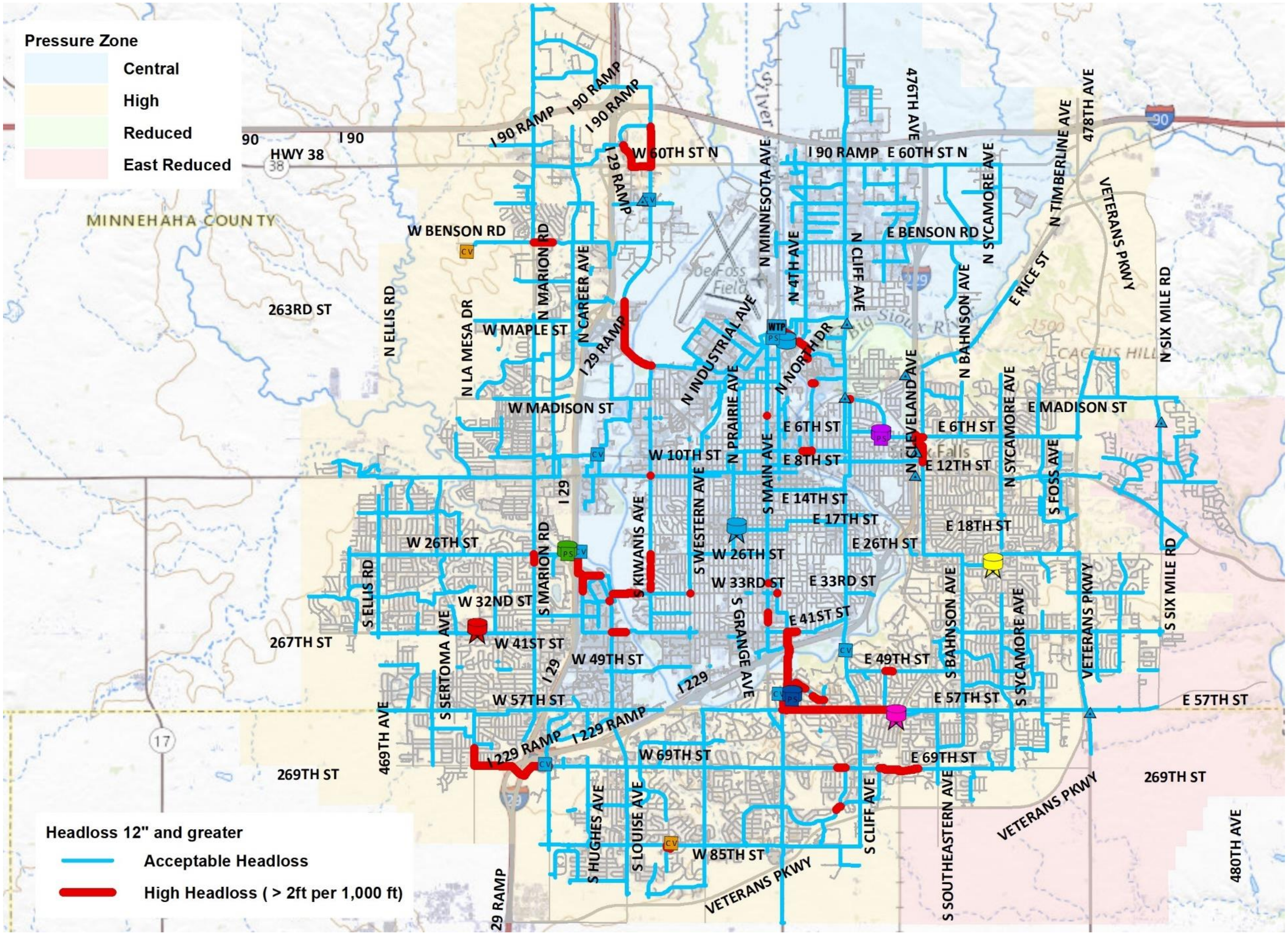


Figure 7.9 Transmission Pipeline Capacity - PDD

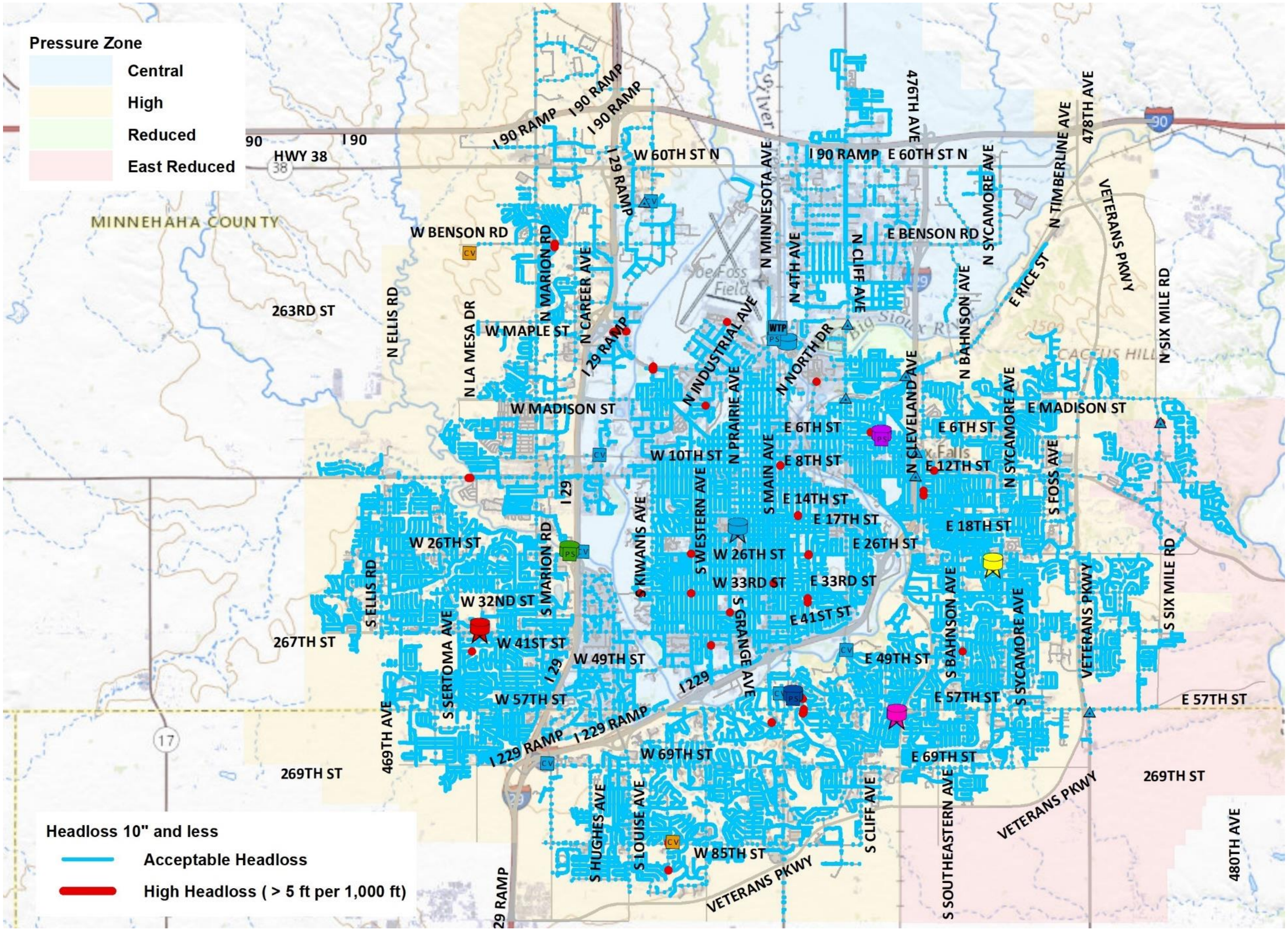


Figure 7.10 Water Main Capacity - PDD

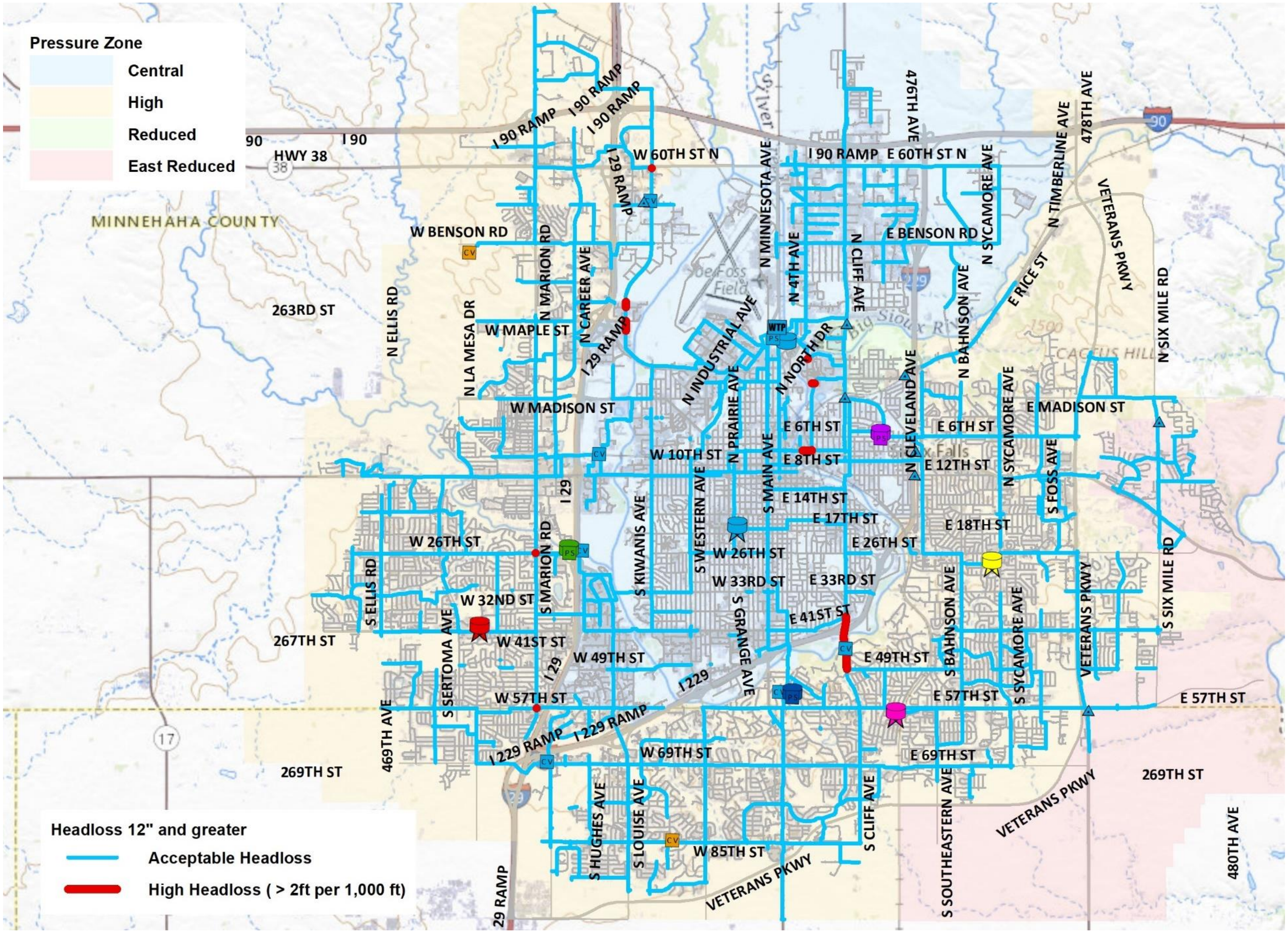


Figure 7.11 Transmission Pipeline Capacity - ADD

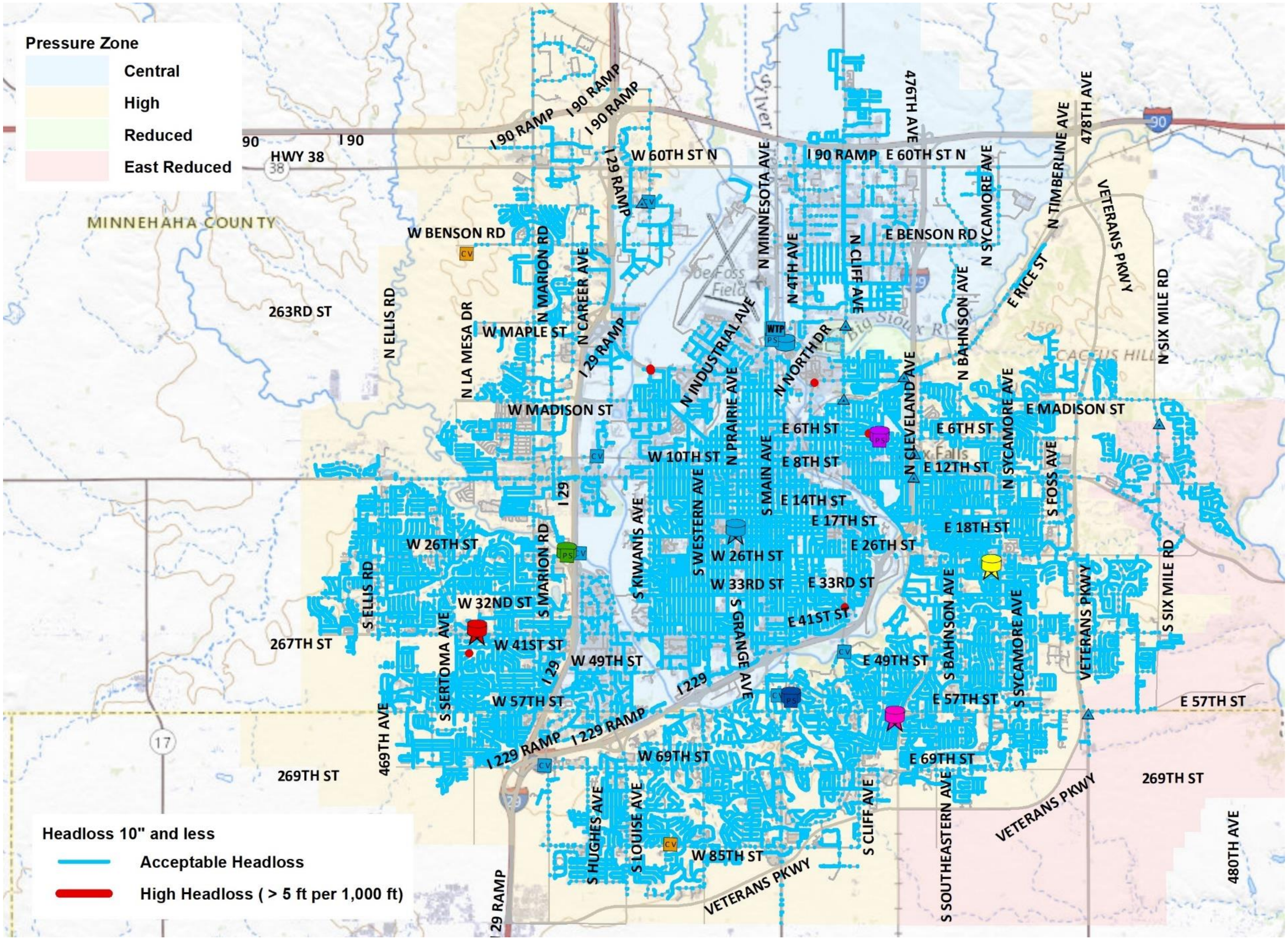


Figure 7.12 Water Main Capacity - ADD

7.7 Fire Flow Analysis

A fire flow analysis was performed on individual hydrants and distribution main junctions throughout the entire existing distribution system to analyze the transmission and distribution system piping capacity. The results were calculated using a steady state scenario based on the following system conditions:

- Fire Flow availability based on one hydrant or distribution main junction flowing at a time. (Hydrant capacity can be significantly different from main capacity depending on the hydrant lead.)
- Minimum residual pressure of 20 psi.
- Peak day demand conditions.
- Pump operation based on system controls and operations during peak day demand.
- Reservoir and tank levels set at 50 percent full (top 50 percent reserved for operational storage).

The results of available fire flow capacity are shown in Table 7.23 for each of the pressure zones and overall system. Figure 7.13 shows a map of available fire flows within the system.

Table 7.23 Available Fire Flow Capacity

Pressure Zone	Available Fire Flow (gpm) based on Residual Pressure of 20 psi					
	< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000
Central	0%	0%	1%	7%	11%	81%
Reduced	0%	2%	8%	33%	28%	30%
High - East	0%	2%	2%	7%	9%	81%
High - South	0%	0%	0%	3%	6%	90%
High - West	0%	0%	1%	5%	8%	86%
East Reduced	0%	0%	13%	13%	21%	53%
Overall System	0%	0.4%	1%	6%	9%	83%

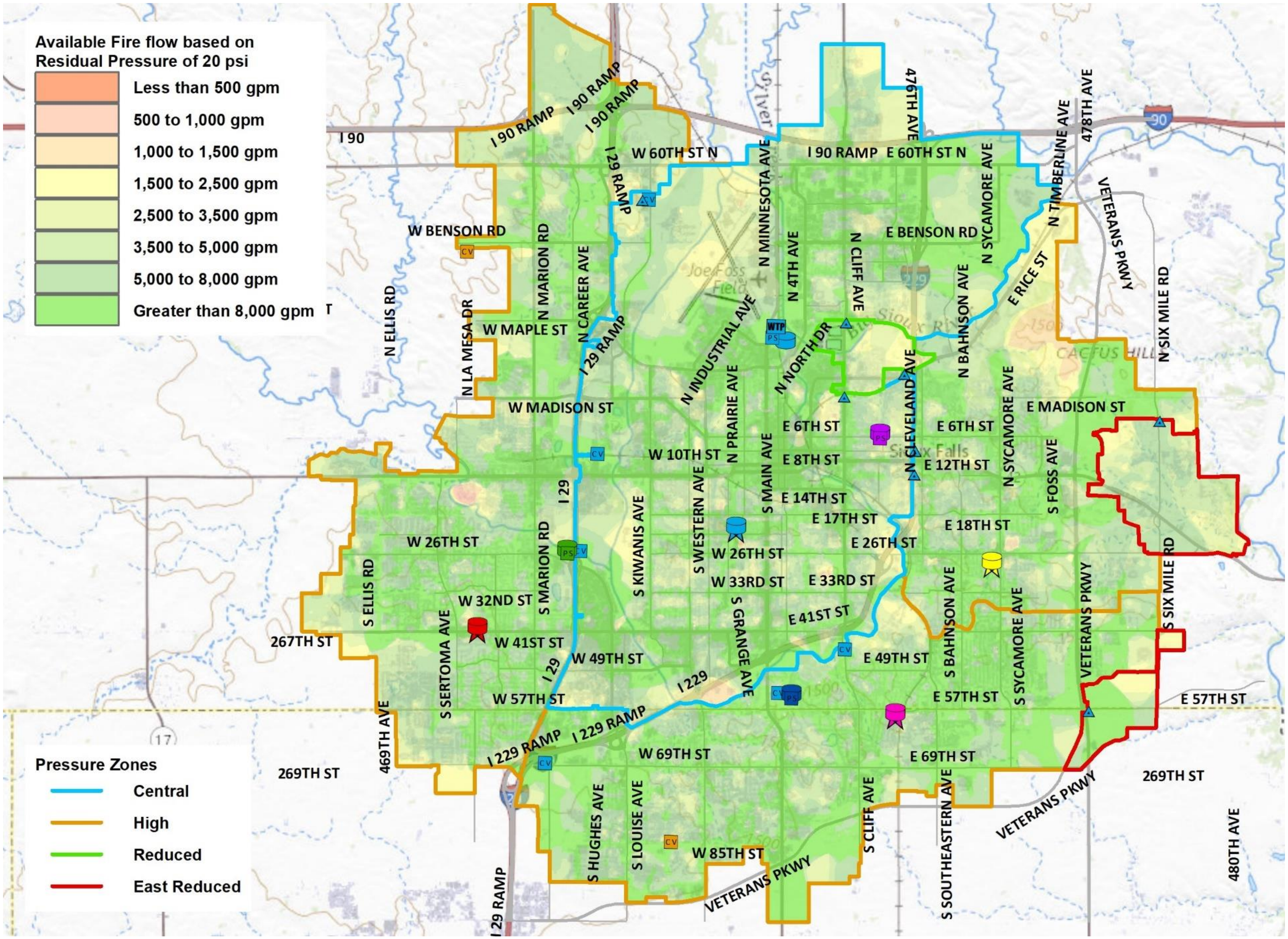


Figure 7.13 Available Fire Flow - PDD

- There are no areas within the system that have less than 1,000 gpm available fire flow on the city-owned system.
- Overall, 99% of the system is capable of available fire flow greater than 1,500 gpm.
- Over 83% of the system is capable of providing available fire flow greater than 4,000 gpm.

7.7.1 Available Fire Flow Based on Land Use Categories

Further analysis was provided for available fire flow capability based on the following land use categories. A summary of the capability of system to provide available fire flow goals for land use categories are found in Table 7.24.

For more specific information on system capabilities refer to the tables listed in the below summary.

Table 7.24 Available Fire Flow Capacity – Summary based on Land Use

Land Use	Refer to Table	Available Fire Flow Goal	Percent of system that is capable of providing desired goal
Low-Density Residential	Table 7.25	1,000	100%
Apartments	Table 7.26	2,000	98%
Commercial	Table 7.27	2,000	99%
Institutional	Table 7.28	1,500	98%
Industrial	Table 7.29	3,000	94%

Table 7.25 Available Fire Flow Capacity – Low-density Residential

Landuse Area		Available Fire Flow (gpm) based on Residual Pressure of 20 psi						Goal
		< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000	> 1,000
RS	Single-Family Residential - Suburban	0%	1%	1%	7%	11%	81%	100%
RD-1	Residential - Single and Twin	0%	0%	2%	7%	12%	79%	100%
RD-2	Residential - Suburban Townhome	0%	0%	2%	10%	9%	79%	100%
RT-1	Single-Family Residential - Traditional	0%	0%	2%	8%	9%	81%	100%
RT-2	Residential - Traditional Townhome	0%	0%	0%	0%	3%	97%	100%
RCD	Residential Cluster Development (PUD)	0%	0%	0%	0%	0%	100%	100%
RR	Rural Residential	0%	0%	0%	8%	4%	88%	100%
MH	MH Manufactured Housing	0%	0%	0%	4%	26%	70%	100%
Overall System		0%	0%	1%	7%	11%	80%	100%

Table 7.26 Available Fire Flow Capacity – Apartments

Landuse Area		Available Fire Flow (gpm) based on Residual Pressure of 20 psi						Goal
		< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000	> 2,000
RA-1	Apartments Low Density	0%	1%	1%	5%	6%	87%	98%
RA-2	Apartments Moderate Density	0%	0%	1%	3%	9%	87%	99%
RA-3	Apartments High Density	0%	0%	1%	9%	13%	78%	99%
POPUD	Pedestrian-Oriented PUD (mixed-use)	0%	0%	0%	0%	9%	91%	100%
LW	Live/Work	0%	0%	3%	2%	13%	82%	97%
Overall System		0%	0%	2%	4%	9%	85%	98%

Table 7.27 Available Fire Flow Capacity – Commercial

Landuse Area		Available Fire Flow (gpm) based on Residual Pressure of 20 psi						Goal
		< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000	> 2,000
C-1	Pedestrian-Oriented Commercial	0%	0%	0%	0%	13%	88%	100%
C-2	Neighborhood Commercial	0%	0%	1%	3%	5%	91%	99%
C-3	Community Commercial	0%	0%	1%	2%	4%	93%	99%
C-4	Regional Commercial	0%	0%	0%	3%	4%	93%	100%
DTPUD	Downtown PUD (mixed-use)	0%	0%	1%	3%	1%	95%	99%
O	Office	0%	0%	1%	3%	6%	91%	99%
Overall System		0%	0%	1%	3%	4%	92%	99%

Table 7.28 Available Fire Flow Capacity – Institutional

Landuse Area		Available Fire Flow (gpm) based on Residual Pressure of 20 psi						Goal
		< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000	> 1,500
S-1	General Institutional	0%	0%	3%	3%	7%	87%	100%
S-2	Campus Insititutional (PUD)	0%	3%	1%	8%	3%	84%	97%
Overall System		0%	2%	2%	7%	4%	85%	98%

Table 7.29 Available Fire Flow Capacity – Industrial

Landuse Area		Available Fire Flow (gpm) based on Residual Pressure of 20 psi						Goal
		< 1,000	1,000 to 1,500	1,500 to 2,000	2,000 to 3,000	3,000 to 4,000	> 4,000	> 3,000
I-1	Light Industrial	0%	0%	1%	4%	7%	87%	94%
I-2	Heavy Industrial	0%	0%	0%	8%	5%	87%	92%
AP	Airport	0%	0%	0%	0%	0%	100%	100%
Overall System		0%	0%	1%	5%	7%	87%	94%

7.7.2 Review of ISO Needed Fire Flow

This section examines the ability to achieve required fire flow rates at hydrants throughout the system based on information received from ISO on needed fire flow for specific building locations. The modeled available fire flow (AFF) at each hydrant in the system was compared to any nearby building which the needed fire flow (NFF) was provided in the ISO data. The results of this analysis is provided in Table 7.30.

- Needed fire flows within the system range from 500 gpm up to 7,500 gpm.
- The system is capable of meeting 94% to 100% of these needed fire flow requirements.
- Of eleven locations that were not capable of meeting the needed fire flow requirements, two were within 1,000 gpm and the remaining nine were within 500 gpm of the available fire flow needed.
- Overall, this analysis shows that the water distribution system is very capable of meeting needed fire flow requirements.

Table 7.30 ISO Needed Fire Flow Sites and Available Fire Flow Capacity

Needed Fire Flow	Locations		Needed Fire Flow	Locations	
	# of Sites	Percent capable of providing Needed Fire Flow		# of Sites	Percent capable of providing Needed Fire Flow
500	196	100%	3,500	93	98%
750	359	100%	4,000	18	100%
1,000	295	100%	4,500	16	94%
1,250	325	100%	5,000	11	100%
1,500	314	100%	5,500	1	100%
1,750	234	100%	6,000	4	100%
2,000	216	100%	6,500	1	100%
2,250	210	100%	7,000	0	Not Applicable
2,500	112	98%	7,500	1	100%
3,000	121	95%	8,000	0	Not Applicable

7.8 Summary of Existing System Evaluation

An understanding of the limitations of the existing water distribution system is critical to the development and expansion of the system for satisfactory system performance, longevity and to accommodate future growth. The following represents a categorized summary of the key findings identified based on the analysis of the existing system.

7.8.1 Pressure Analysis

Overall, the system provides a great level of service in relation to pressures within system while minimizing the total area with high pressures.

- No locations with pressures less than the goal of a minimum pressure of 40 psi.
- Majority of pressures ranged from 50 psi to 100 psi with 94% within this range.
- Over 99% of the system has pressures greater than desired pressure of 50 psi.
- Less than 10% of the system has pressures greater than the goal of being under 100 psi.

- Overall, the pressure fluctuation within the system was less than 10 psi with 61% less than 5 psi.
- As the system continues to grow, it is recommended to review development in relation to the boundaries of the pressure zones to prevent areas of pressure less than 40 psi and minimize pressures greater than 80 psi where feasible.

7.8.2 Storage Capacity

Overall, storage capacity within the existing system has adequate to meet the existing storage requirements for equalization, fire, and emergency storage conditions.

- Recommend considering future water tower storage within the Central Pressure Zone to provide additional equalization storage capacity along with providing redundancy to the Menlo Water Tower when that is required to be taken offline for maintenance.
- Recommend future water tower storage in the High Zone – East for the benefit of providing greater level of service for fire storage and future equalization storage as this system continues to grow. Additional equalization storage will increase the available pumping capacity of the East Reservoir as it will not need to pump a greater amount for peak hour demands.

7.8.3 Pumping Capacity

Overall, each of the existing pumping facilities has adequate capacity to meet current demand conditions. Pump facilities also have the ability to meet pumping conditions for delivering water from ground storage reservoirs for equalization, fire, and emergency demand conditions.

- There are no recommendations for changes to increase pumping capacity at any of the existing pumping facilities.
- If any of the existing pumps are to be replaced based on condition, it is recommended to review overall pumping capacity in relation to future system growth.

7.8.4 Transmission Pipeline and Water Main Capacity

A review of headloss related to transmission pipeline capacity provides an indication of actual or potential future challenges of delivering water from supply to storage. Excessive headloss can also lead to large pressure fluctuations as well as low pressure conditions. Recommended to review these transmission corridors when considering pipeline replacement.

- East of the Water Purification Plant to the East Reservoir
  - Indication of future capacity challenges delivering water to the High Zone – East via the East Reservoir as the area within the High Pressure Zone – East continues to experience additional growth and development.
  - Consider upsizing future transmission improvements.
- Along N Westport Ave
  - Higher headloss due to transfer of flows from High Zone – West to Central Zone
  - Consider additional transfer locations such as at the West Reservoir where pipelines between the two zones have greater capacity.
- To West Reservoir through the Central Zone
  - Indication of future capacity challenges to deliver water to West Reservoir
  - Consider future upsizing if replacing transmission pipelines.
- From East Reservoir to the High Zone -East.
  - Consider completion of transmission pipeline along Veterans Parkway from 6^{th} St to 26^{th} St. to improve north/south transmission within the High Zone.
- To South Reservoir from the Central Zone
  - Indication of future capacity challenges delivering water to High Zone – South
  - Consider upsizing in any future replacement projects.

7.8.5 Fire Flow Analysis

Overall system was very capable of providing adequate available fire flow for goals related to different land use categories. A majority of the system could provide available fire flow greater than 4,000 gpm. Review of existing ISO location for needed available fire flow showed that fire flow needs at these locations were met 99% of the locations.

- Recommend to continue to provide a robust network, including water main looping, that is capable to provide adequate available fire flows.

Chapter 8 Future System Evaluation

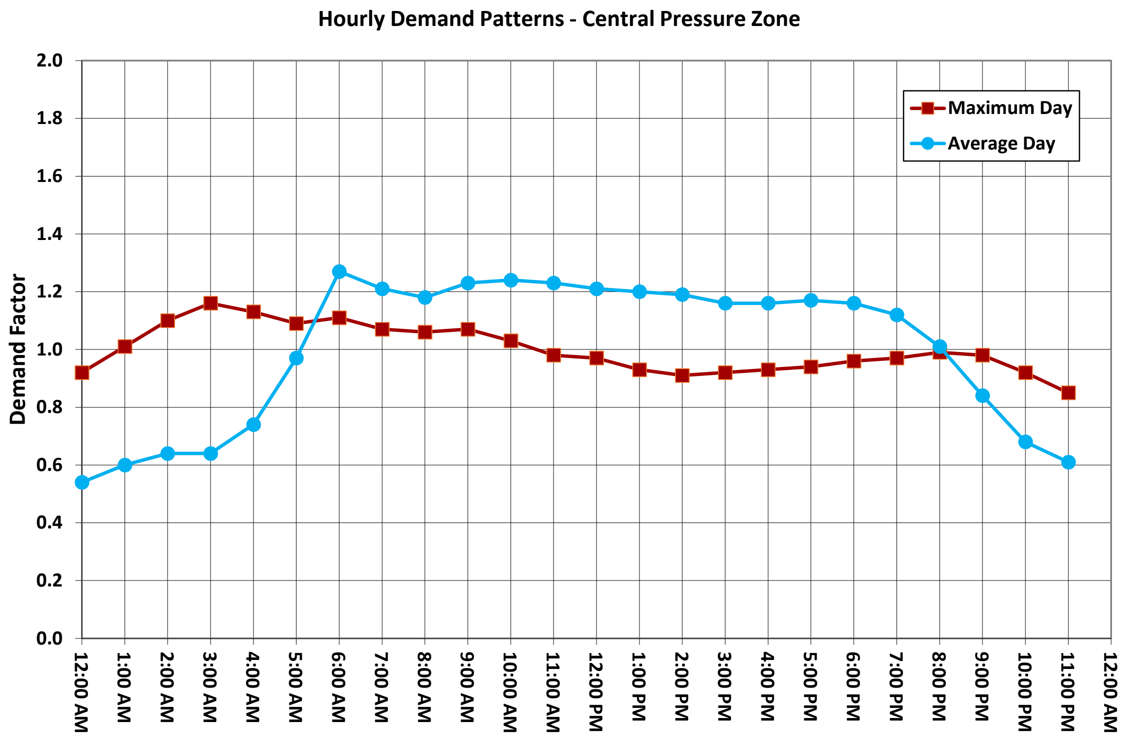
This chapter presents the plan for the City's future water distribution system and the expansions and improvements necessary to meet recommended water system service performance criteria under future water demand conditions. The hydraulic model was used to evaluate and identify future distribution system infrastructure needs and address deficiencies identified in the existing system evaluation discussed in Chapter 7 – Existing System Evaluation. The development of the CIP, scheduling, and prioritization of improvements is presented in Chapter 9 – Capital Improvement Plan.

8.1 Future System Demands

Demand data sets were developed within the hydraulic model for use in evaluation of the future system using the methodology described in Section 3.6 – Water Demand Projections. A summary of the future system demands used within the hydraulic model are presented in Table 8.1. The current diurnal demand curves (Average Day and Maximum Day) were applied to the future demand data to develop the future diurnal demand curves to conduct extended period simulation model runs. Figure 8.1 shows the overall system diurnal demand curves for average day and peak day demand.

Table 8.1 Future System Demands

Planning Horizon	Planning Year	Average Demand		Peak Demand		Additional Large Industry
		MGD	Per Capita gpcd	MGD	Per Capita gpcd	MGD
2018	Historical	36.0	196	45.8	250	0.00
2022	Today	40.8	201	51.7	255	0.00
2025	5 yr	46.0	215	57.5	269	3.24
2030	10 yr	53.1	224	65.8	277	6.24
2035	15 yr	57.6	219	71.6	272	6.24
2040	20 yr	61.8	211	77.1	264	6.24
2045	25 yr	67.7	219	83.8	271	9.24
2066	≈50 yr	73.0	215	90.7	267	9.24
2116	≈100 yr	102.0	202	128.1	253	9.24



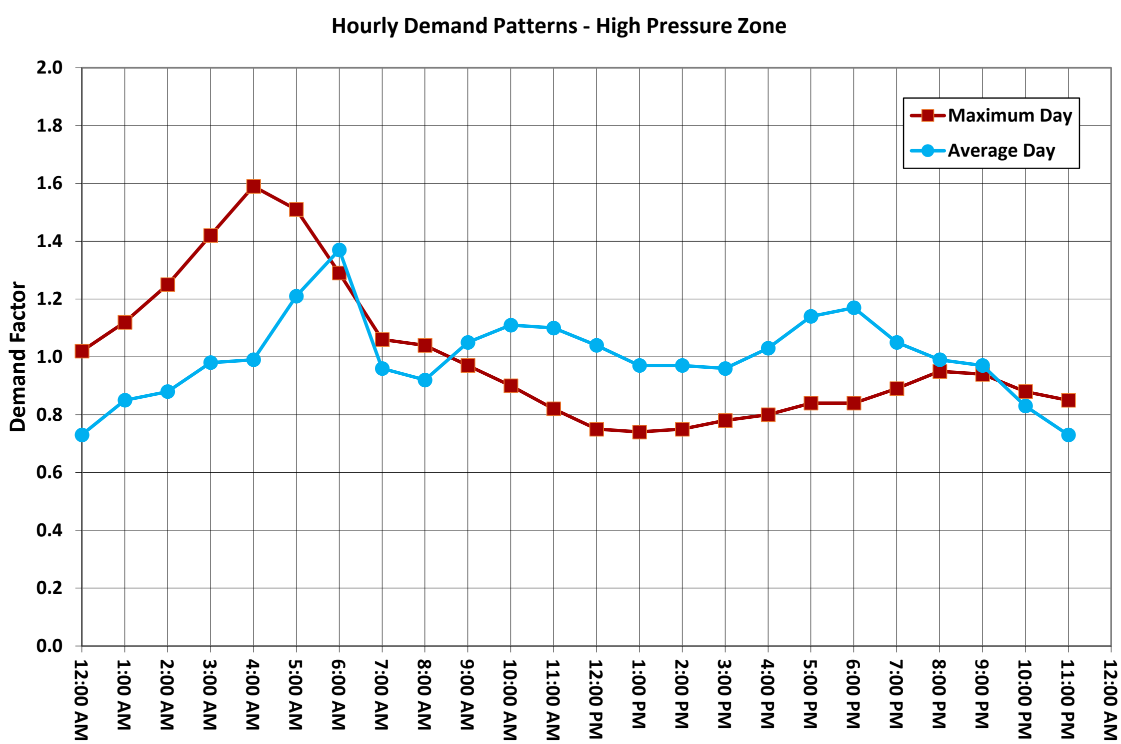


Figure 8.1 Hourly Demand Patterns

8.2 Future System Modeling Scenarios

Future modeling scenarios were setup to analyze the system for future growth of the water system. Layouts of the system were created for several growth scenarios including a near-term (20 year) and long-term (100-year) planning horizons as generally outlined in Table 8.2.

Table 8.2 Future System Modeling Scenarios

Modeling Scenario	Scenario Demand Condition	Simulation Type	Description
Future	Average Day Demand (ADD)	Extended Period Simulation	This scenario evaluates the City's supply facilities and transmission/distribution system capabilities during future day-to-day operations for the future ADD at near-term (20-yr) and long-term planning (100-yr).
Future	Peak Day Demand (PDD)	Extended Period Simulation	This scenario evaluates the City's supply facilities and transmission/distribution system capabilities during the peak demands of the future PDD at near-term (20-yr) and long-term planning (100-yr).
Future	Available flow during PDD	Steady State	This scenario calculates the available fire flow at a residual pressure of 20 psi during PDD conditions at at near-term (20-yr) and long-term planning (100-yr)..

8.3 Water System Improvements (Near-term) (20-year Plan)

This section will outline distribution system improvements recommended within the next 20 year period to allow for system growth and expansion along with reinvestment into the existing infrastructure through replacement and rehabilitation. A map of proposed infrastructure is shown in Figure 8.2. Recommended improvements will focus on the following areas:

1. Infrastructure required to access the planned increased capacity from Lewis & Clark Regional Water System of 34 million gallons per day by 2031 which includes a another connection to the Lewis & Clark RWS transmission pipeline along with transmission improvements.
2. Replacement and upgrades of the transmission capacity from the Water Purification Plant to the East Reservoir and Pump Station.
3. Transmission pipelines south of the Lewis & Clark RWS Benson Road Connection for increased capacity for growth and providing increased redundancy within the system.
4. Replacement and upgrade to transmission pipelines that coincide with the major street reconstruction of Minnesota Ave which provides greater capacity to from the Water Purification Plant to the south into the Central Pressure Zone which provides water to each of the three reservoirs and the Menlo Water Tower.

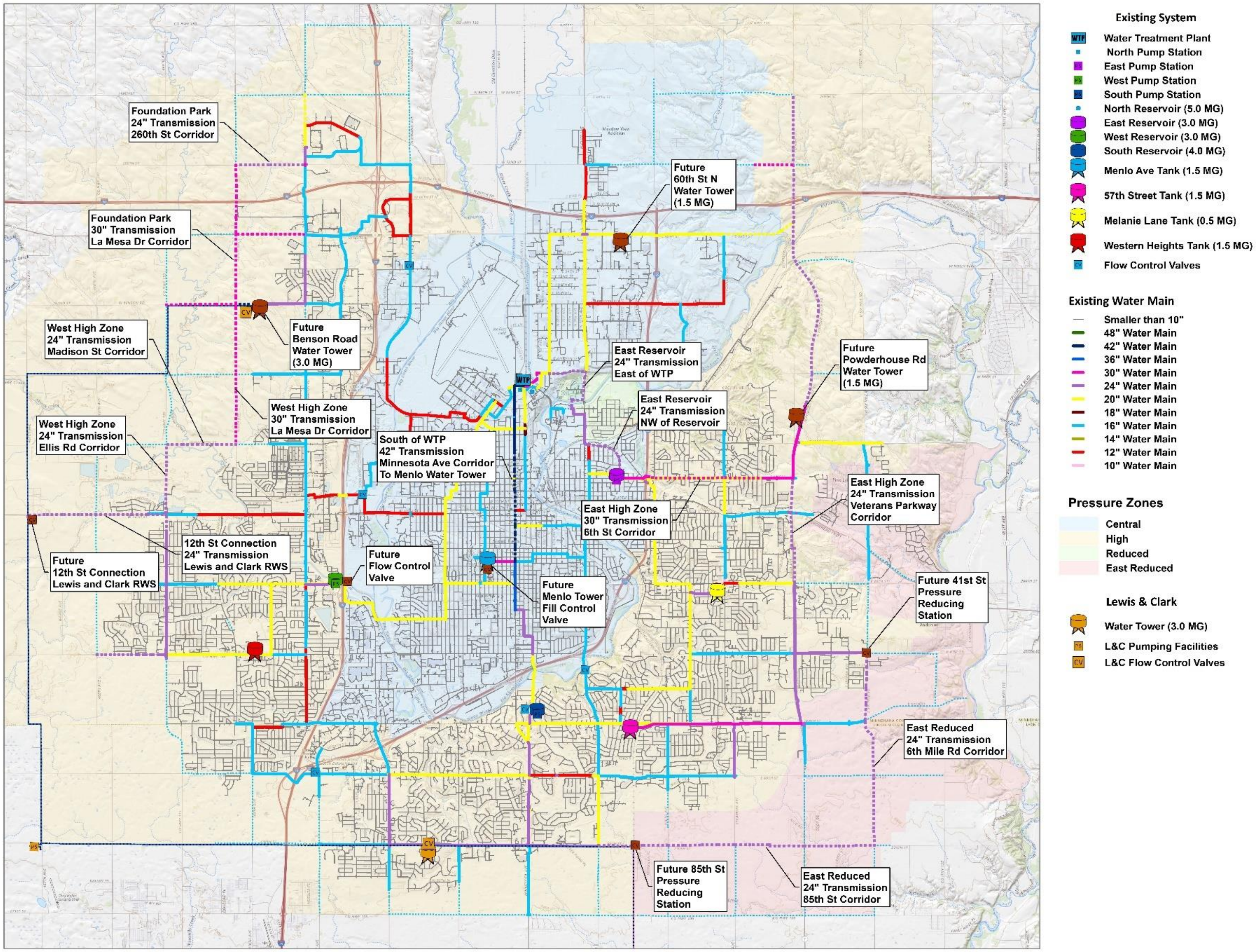


Figure 8.2 Future System Map – 20 Year Plan

5. Transmission pipelines to Foundation Park which are dependent on ongoing requests for water related to industrial development and growth.
6. Transmission pipeline improvements within the High Pressure Zone on the east side of the system related to Veterans Parkway and east of the East Reservoir to support continued growth.
7. As the City continues to expand to the south and east, additional transmission pipelines are planned to be extended into the East Reduced Pressure Zone to support this growth.
8. Future water tower storage is planned throughout the system. A water tower is planned to provide redundancy to the Menlo Water Tower and provide storage for the north east area of Central Pressure Zone. Another water tower is planned for the High Pressure Zone on the east side of the system within new growth area. To provide storage and redundancy, a water tower is planned near Lewis & Clark RWS Benson Road connection within the High Pressure Zone to serve continued growth on the west side of the system.

8.3.1 Lewis & Clark Regional Water System Connection Capacity

The Lewis & Clark Regional Water System (L&C RWS) supplies water to the High Pressure Zone through currently two connections. Table 8.3 provides the current and future capacities based on the existing Lewis & Clark RWS and future system expansion. The original reserve capacity for Sioux Falls was 11 MGD, but an additional 17 MGD was requested after the raw water pipeline was under construction. Sioux Falls will have access to all 28 MGD of treated water after the Phase 3 Water Treatment Plant Upgrade which is anticipated to be completed in the summer of 2026. When the Lewis & Clark system is expanded to 60 MGD, Sioux Falls will have access to an additional 6 MGD.

Lewis & Clark RWS supply connections to the distribution system are located at the Lewis & Clark RWS 85th Street Water Tower and Lewis & Clark RWS Benson Road Meter Connection. Figure 8.3 shows as map of the locations of these connections. Current allocation at these existing connections based on guaranteed available capacity. Guaranteed available capacity is based on the planned capacity for each of the L&C RWS transmission pipelines from the L&C RWS Tea Pump Station to each of the connections to the City of Sioux Falls.

Table 8.3 Available Capacity from L&C RWS

Time	Reserve Capacity
Original	11 MGD
Current	17 MGD
Available in 2026	28 MGD
Available in 2031	34 MGD

1. 85th St Connection = 11.0 MGD
2. Benson Road Connection = 9.0 MGD
3. Maximum overall allocation between connections = 17 MGD

8.3.1.1 85th Street Connection

This connection is located at the base of the Lewis & Clark RWS 85th Street Water Tower. The water tower receives water from the Lewis & Clark Tea Pump Station through a 36-inch transmission pipeline. System analysis shows that the 85th Street Connection can provide up to 20 MGD into the City's distribution system based on maintaining adequate operational level within the 85th Street Connection. Lewis & Clark RWS policy states that the guaranteed allocation for this connection is 11 MGD. Lewis & Clark RWS will allow greater flow into the City's distribution system, but will not provide a guarantee allocation greater than 11 MGD at this location. Remaining guaranteed capacity has been allocated to the Lewis & Clark RWS Benson Road Connection.

8.3.1.2 Benson Road Connection

This connection is located along Benson Road about one mile west of Marion Road. This connection receives water from the Tea Pump Station through a 36-inch transmission pipeline. System analysis shows that the Benson Road connection can provide up to 4 MGD of capacity based on the current system demands and the transmission pipeline capacity within the west High Pressure Zone.

8.3.1.3 System Improvements to Access Lewis & Clark RWS Capacity

With the guaranteed capacity capped at 11 MGD at the 85th Street Connection, the remaining current and future capacity would need to be accessed from the Benson Road Connection and/or another connection to the Lewis & Clark RWS 36-inch transmission pipeline between the Tea Pump Station and the Benson Road Connection. In order to access greater capacity from the Lewis & Clark RWS, the following changes to the system improve the available capacity at the Benson Road Connection.

- Water demands increased based on continued growth in the West High Pressure Zone
- Transfer flow capacity increased between the West High Zone and the Central Zone
- Transmission pipeline capacity increased between the Benson Road Connection and the Western Heights Water Tower
- Additional connection to the Lewis & Clark RWS Transmission Pipeline between the Tea Pump Station and the Benson Road Connection

Based on the 20-year plan, the system would provide the ability to access the full capacity of 34 MGD from Lewis & Clark RWS under peak day demands based on the these improvements and forecasting of demands related to growth within the High Pressure Zone. Lewis & Clark RWS plans to provide an available capacity of 28 MGD by 2026 and a capacity of 34 MGD by 2031.

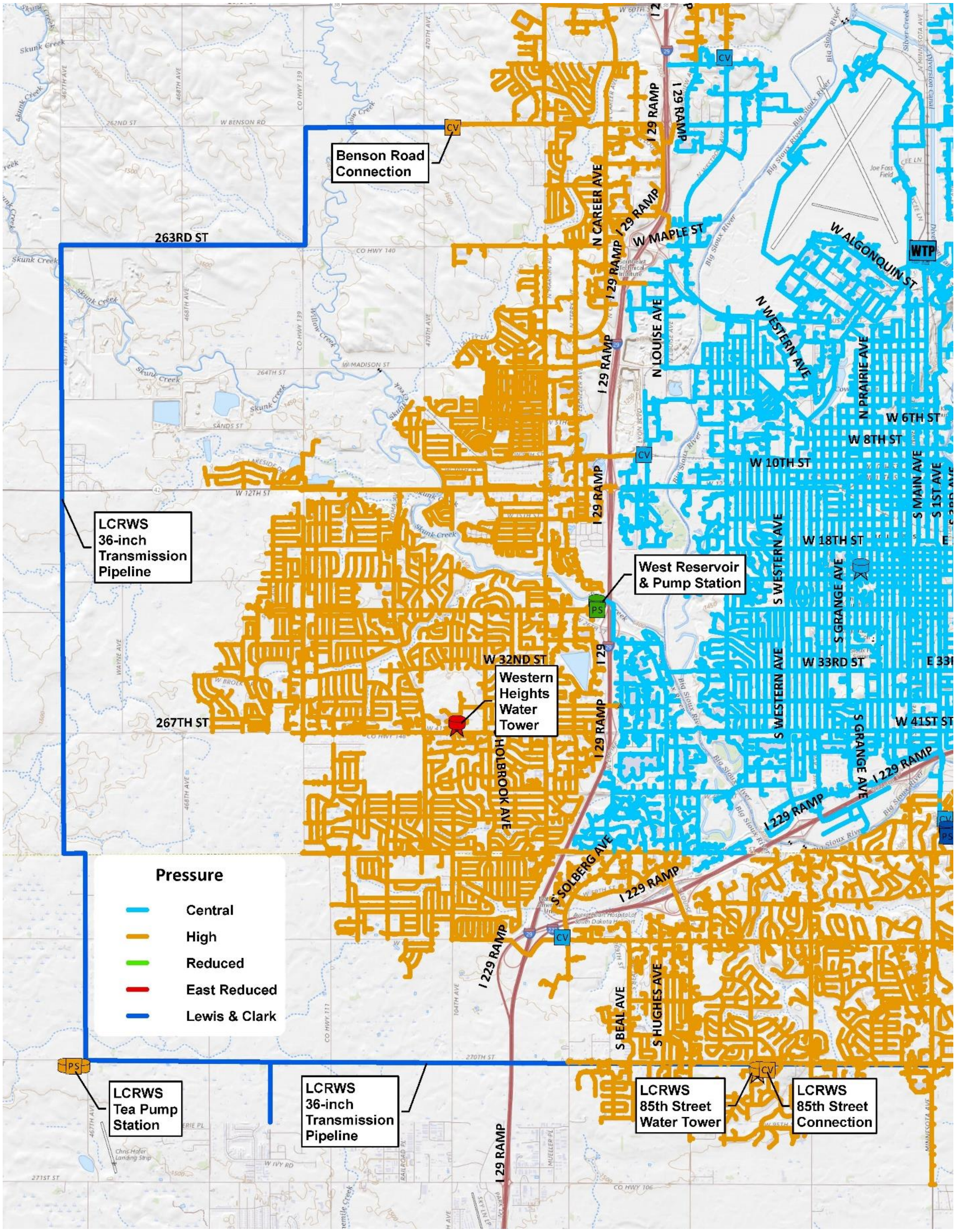


Figure 8.3 Existing Connections to the Lewis & Clark Regional Water System

Based on this information, analysis was analyzed to determine which infrastructure improvements could provide these capacities with the most benefits to the system and cost effectiveness. The master plan hydraulic model incorporates system demands anticipated in 2025 and 2030 to account for the impacts of demands on accessing available capacity. Scenarios analyzed were the following and results are outlined in Table 8.4.

1. Current system without the completion of the transmission pipeline south of Benson Road or the 12th Street Connection.
2. Completion of the transmission pipeline south of Benson Road, but no 12th Street Connection.
3. Completion of the transmission pipeline and the 12th St Connection
4. Lewis & Clark RWS connection at 12th St without completion of the transmission pipeline south of Benson Road.
5. Control valve at West Reservoir and Pump Station would be required for each of these scenarios to allow flow to be transferred from the High Pressure Zone to the Central Pressure Zone.

Table 8.4 Results of Scenario Analysis Related to Access L&C RWS Capacity

Growth Year	Capacity Alternatives		Lewis & Clark RWS Connections			
	Transmission south of Benson Road Completed	12th St Connection Online	Benson Road Connection (MGD)	85th St Connection (MGD)	12th St Connection (MGD)	Total Capacity (MGD)
2025	No	No	10.1	11.0	0.0	21.1
	Yes	No	15.7	11.0	0.0	26.7
	Yes	Yes	11.7	11.0	10.8	33.5
	No	Yes	10.3	11.0	11.6	32.9
2030	No	No	Not Feasible Option			
	Yes	No	16.9	11.0	0.0	27.9
	Yes	Yes	12.1	11.0	11.1	34.3
	No	Yes	12.2	11.0	11.1	34.3

Review of Analysis Results:

1. Completion of the transmission pipeline south of the Benson Road Connection would provide 26.7 MGD in 2025 and 27.9 MGD in 2030.
2. The 12th St Connection would provide a connection to the 24-inch along Ellis Road and provide capacity to demands in the southwest portion of the High Zone and allow ability to access 32.9 MGD in 2025 and the full 34 MGD in 2030. The 12th Street connection provides direct access to the capacity of the existing 24-inch transmission pipeline that extends south to transfer flow to West Reservoir and Western Heights Water Tower.

3. Completion of the transmission pipeline and the connection at 12th St would provide 33.5 MGD in 2025 and full capacity of 34 MGD in 2030.
4. Results show that it is necessary to complete at least one of these projects by 2030 in order to have adequate capacity to meet system demands related to projected growth and development.

Review of Project Costs:

Based on 2022 construction costs estimates without engineering or contingencies, the following are the costs to complete these projects:

1. Transmission Pipeline south of Benson Road Connection = $ 9.9 million (4.25 miles of 30" and 24")
2. Transmission Pipeline along 12th St and Meter Building = $ 4.8 million (2.0 miles of 24" and meter building)
3. West Reservoir and Pump Station Control Valve = $ 404,000 (provide ability to deliver flow from High Pressure Zone to Central Pressure Zone)

Conclusions and Recommendations:

A description and benefit of each project is provided below and a layout of proposed projects is shown in Figure 8.4. Table 8.5 provides information on project cost and timeline.

Table 8.5 Project Cost and Timeline Related to Access L&C RWS Capacity

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
12th Street Connection to Lewis & Clark RWS Phase 1A - Transmission Pipeline	2025	$ 1,798,000
12th Street Connection to Lewis & Clark RWS Phase 2 - Meter Building	2026	$ 1,798,000
12th Street Connection to Lewis & Clark RWS Phase 1B - Transmission Pipeline	2026	$ 4,180,000
West Reservoir Control Valve	2026	$ 453,000
West High Zone Transmission – Phase 1 La Mesa Dr: Benson Rd to W Maple St	2029	$ 5,384,000
West High Zone Transmission – Phase 2 N Ellis Rd: Windmill Ridge St to Madison St	2030	$ 4,951,000
West High Zone Transmission – Phase 3 Madison St - Ellis Rd to La Mesa Dr	2031	$ 4,268,000
West High Zone Transmission – Phase 4 La Mesa Dr: Madison St to Maple St	2032	$ 6,066,000

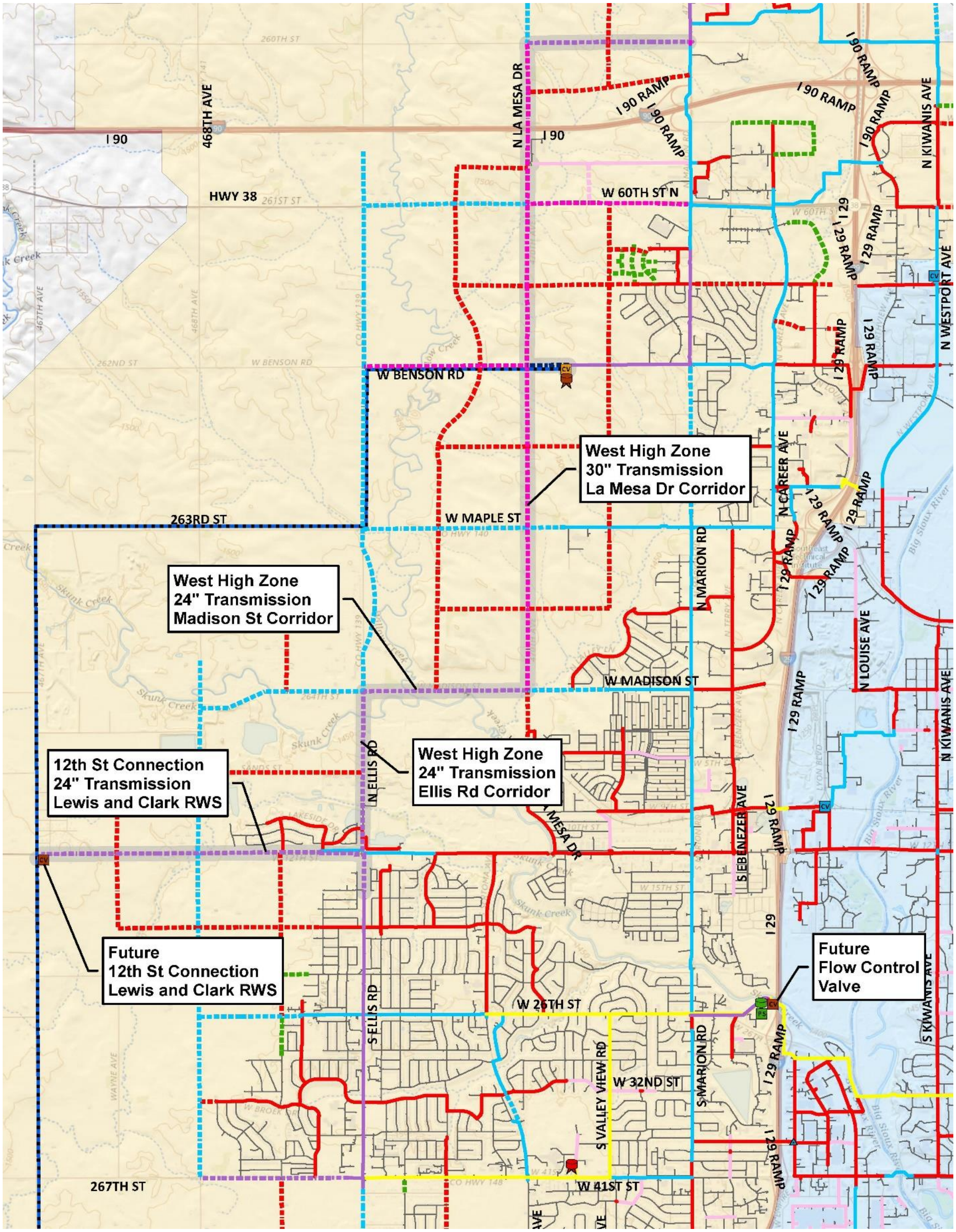


Figure 8.4 Layout of Projects Related to Access L&C RWS Capacity

Lewis & Clark RWS Connection at 12th St

Lewis & Clark RWS Connection at 12th St would provide the needed capacity and would be the most cost-effective solution to meet the near-term capacity to the growth areas south of Benson Road. The Lewis & Clark RWS 12th Street connection would also provide greater flexibility for operations of the system for WTP operators and provide greater redundancy when the Western Heights Water Tower is offline.

Transmission Pipelines

Transmission pipelines overall are necessary for building the backbone of the transmission network to supply growth. While the 12th Street connection would provide further redundancy to areas within the northeast part of the West High Pressure Zone, the ability to serve areas north of the connection would be limited until completion of the transmission pipelines between the Benson Road Connection and the 12th Street Connection. Upon completion of the transmission pipeline north to the Benson Road, both of the connections would provide redundancy and more capacity for growth within the High Pressure Zone.

West Reservoir Control Valve

The control valve at West Reservoir to automate the ability to deliver flow from the High Zone to the Central Zone is necessary to access all the capacity of the Lewis & Clark RWS with either the transmission pipeline project south of Benson Road or the Lewis & Clark RWS 12th Street Connection.

8.3.2 Water Storage Improvements

With continued growth area development and system expansion, additional water tower storage will be required within the water distribution system. Water storage is necessary for providing equalization storage during peak hour demands to balance the requirements for pumping and transmission pipeline capacity. Water storage also provides for emergency demands related to fire flow along with potential shutdowns of pump stations and transmission pipelines.

8.3.2.1 60th Street Water Tower

The 60th Street Water Tower is currently planned at a site along 60th Street N east of N Lewis Ave. Location of the water tower is shown in Figure 8.5.

Design Parameters:

- Size = 1.5 Million Gallons
- Head Range = 40 feet
- Overflow Elevation = 1635 feet

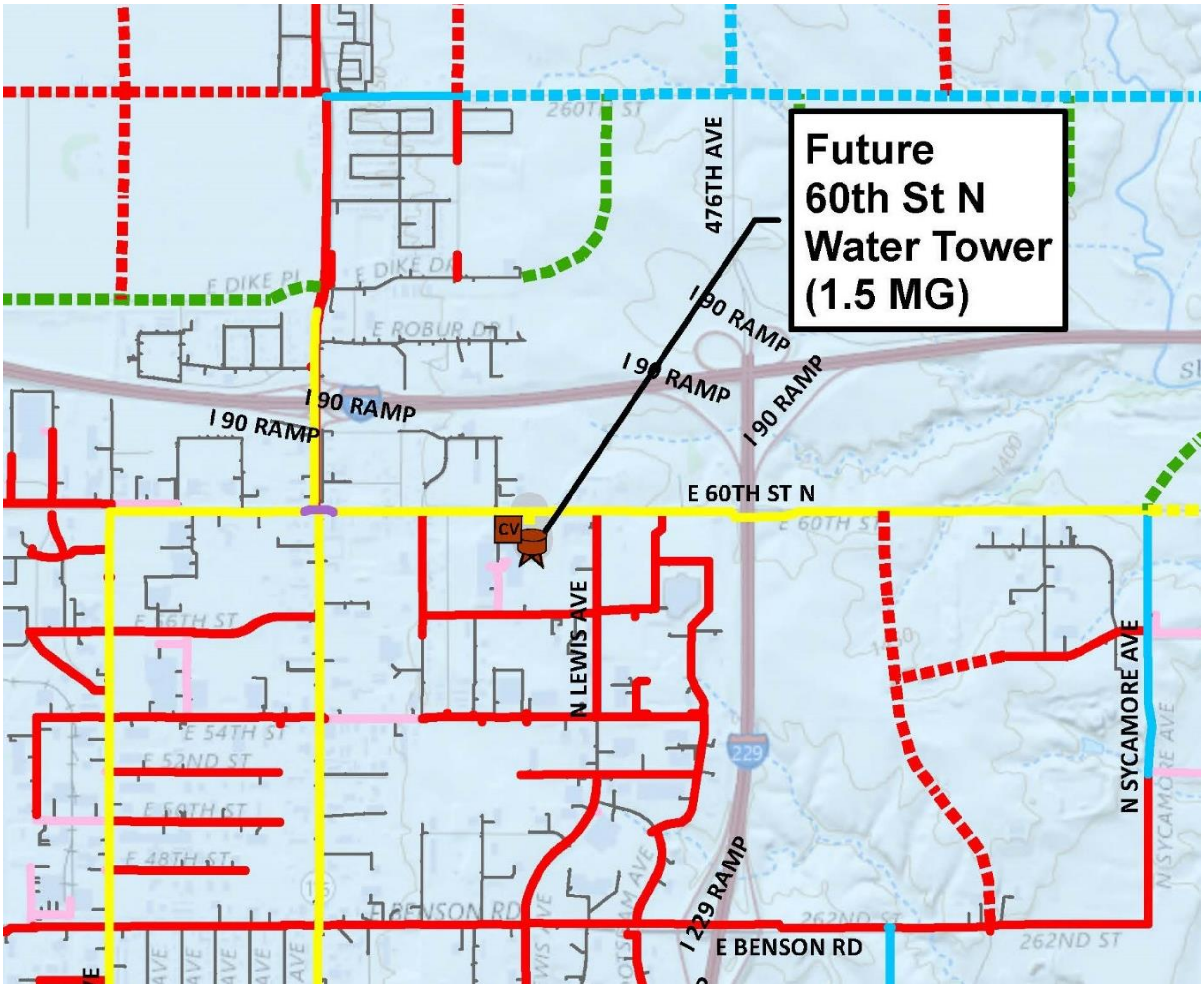


Figure 8.5 60th Street Water Tower Location

<u>Project Benefits:</u>

- Provide redundant water tower within the Central Pressure Zone.
- Allow the existing Menlo Water Tower to be taken offline for maintenance.
- Operational and fire storage for developing areas around I-229.

8.3.2.2 Powder House Road Water Tower

The Powder House Road Water Tower is currently planned at a site along North Powder House Road north of Madison Street and east of Veterans Parkway. Location of the water tower is shown in Figure 8.6.

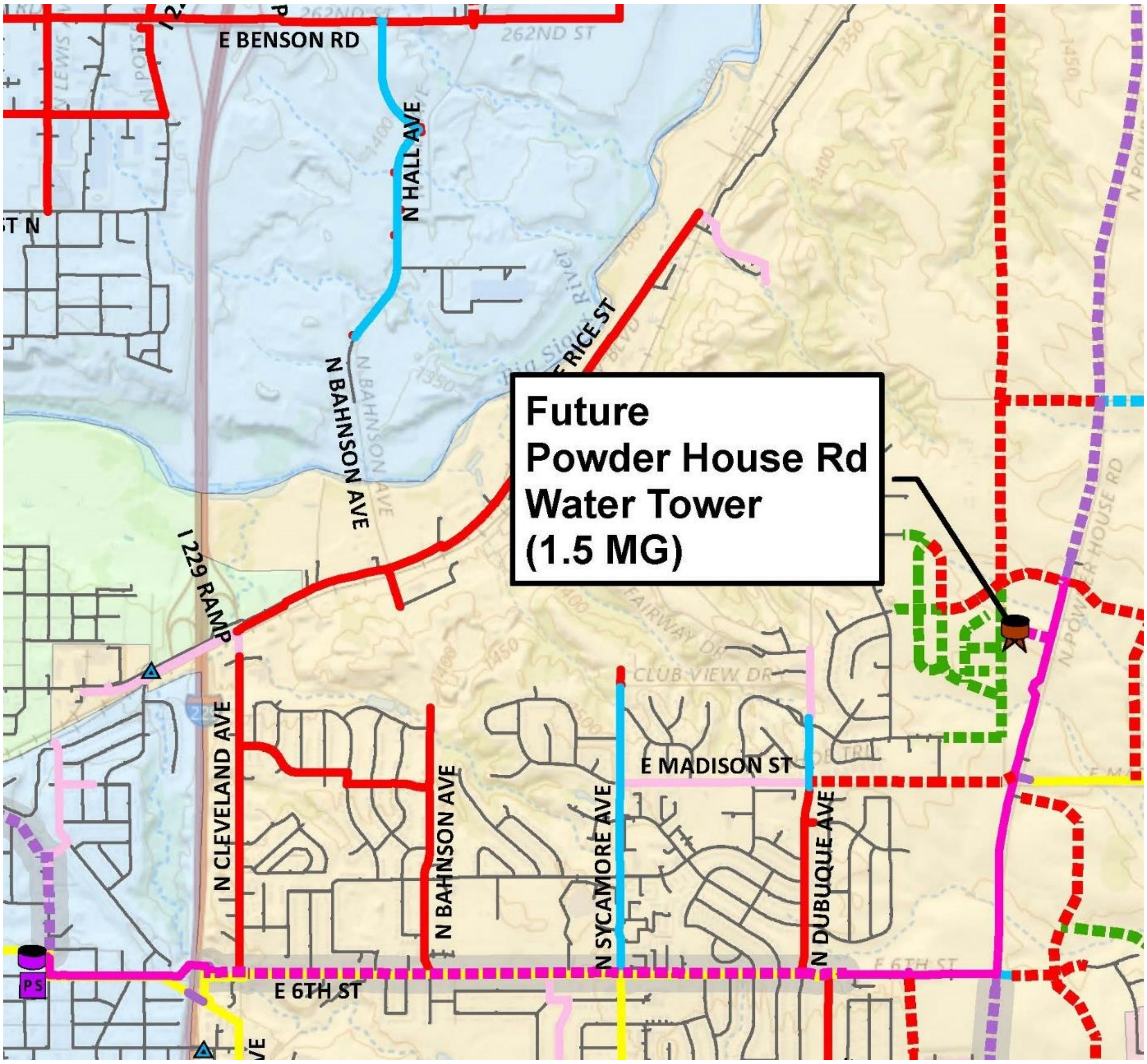


Figure 8.6 Powder House Road Water Tower Location

Design Parameters:

- Size = 1.5 Million Gallons
- Head Range = 40 feet
- Overflow Elevation = 1670 feet

Project Benefits:

- Provide increased storage capacity within the northeast area of the High Pressure Zone.
- Operational and fire storage for developing areas within the Veteran Parkway corridor.

8.3.2.3 Benson Road Water Tower

The Benson Road Water Tower is currently planned at a site near the Lewis & Clark Regional Water System Benson Road Connection to the water distribution system. Location of the water tower is shown in Figure 8.7.

Design Parameters:

- Size = 3.0 Million Gallons
- Head Range = 60 feet
- Overflow Elevation = 1690 feet

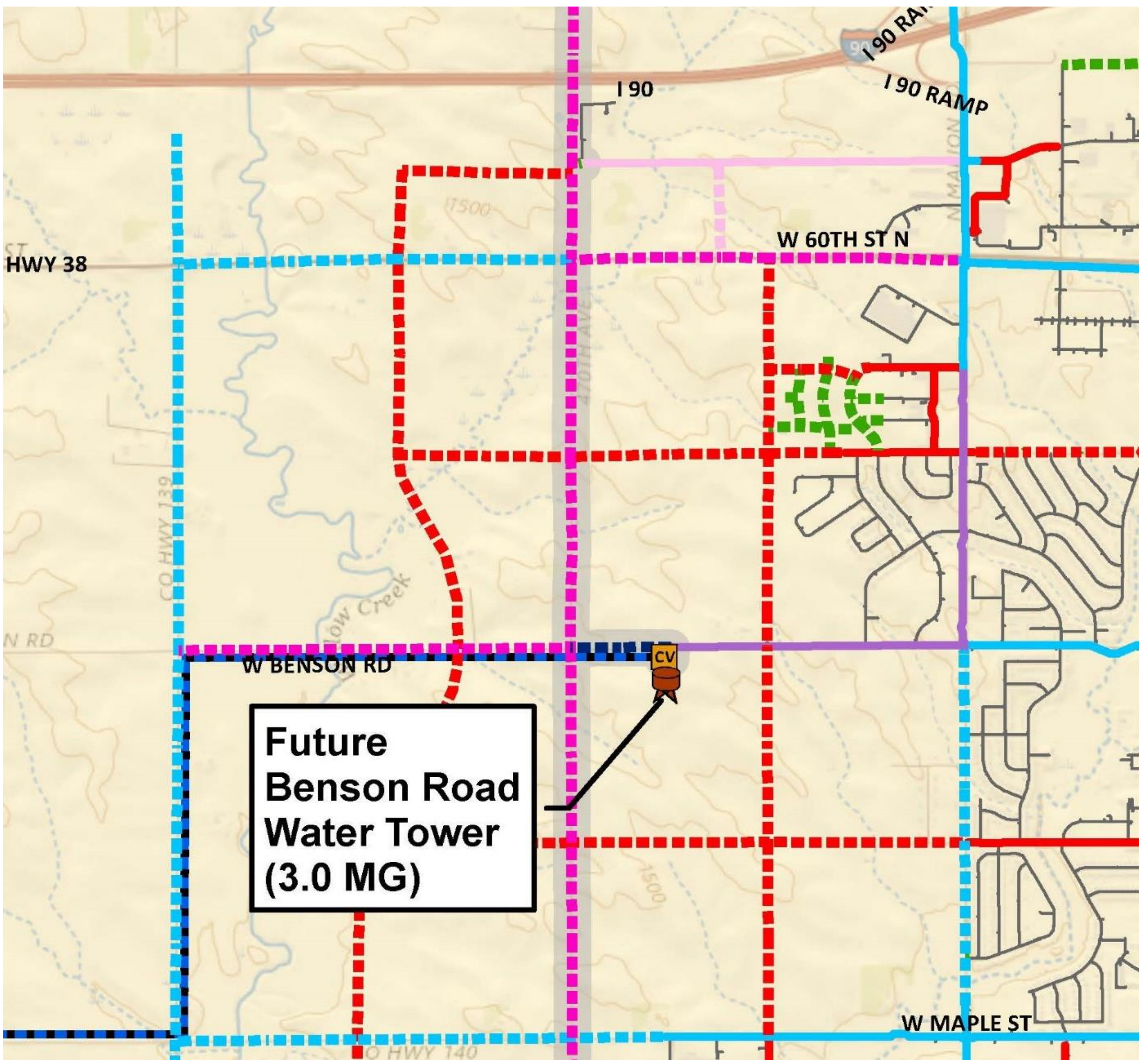


Figure 8.7 Benson Road Water Tower Location

Project Benefits:

- Designed with a hydraulic grade line to facilitate the movement of water from this connection point to existing and future storage within the High Pressure Zone.
- Operational and fire storage for developing areas for the northwest area of the High Pressure Zone.

Other Considerations:

- Coordination with Lewis & Clark RWS would provide an understanding of the ability of the Lewis & Clark Tea Pump Station to fill this proposed water tower to an hydraulic grade line of 1690 feet. Provisions should be made in the design to allow for the ability to provide booster pumps in the base of the water tower to be able to maximize the capacity of the Lewis & Clark RWS supply in the case of not having adequate hydraulic grade line from the Tea Pump Station.
- Site layout along with transmission pipeline layout to the tower site should incorporate a potential connection for an additional future water supply. Transmission pipelines from this site have been sized to provide additional capacity beyond the currently planned Lewis & Clark RWS capacity to the Benson Road Connection.

8.3.2.4 Summary of Water Storage Cost and Implementation Timeline

A list of future water storage projects is provided in Table 8.6. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.6 Project Cost and Timeline Related to Water Storage Improvements

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
60th Street Tower	2031	$ 10,175,000
Powder House Road Tower	2037	$ 12,374,000
Benson Road Tower	2045	$ 25,606,000

8.3.3 Transmission Pipeline Improvements

Transmission pipeline improvements planned for the water distribution consist of replacement and upsizing of existing transmission pipelines and extension of transmission pipelines into new growth areas. These improvements provide for the ability of the system to transfer water from the water supply to water storage facilities along with customers that are served in these areas.

8.3.3.1 Minnesota Ave Transmission Corridor

This project consists of replacing and upsizing an existing 36-inch concrete transmission pipeline with a 42-inch pipeline shown in Figure 8.8. This proposed transmission pipeline will provide increased capacity to deliver water south of the water purification plant to the overall pipe network that transfers water to the East Reservoir, West Reservoir and South Reservoir as shown in Figure 8.9.

This transmission pipeline project is currently driven in association with the major street reconstruction of Minnesota Ave from Russell Street to 18th Street. The street project is currently divided into the following four phases. It is recommended completing a final fifth phase to upsize the remaining transmission pipeline to the connection of the existing 30-inch on 21st St which connects the Menlo Water Tower.

- Phase 1: W. Russell St. to W. 2nd St. (Completed)
- Phase 2: W. 2nd St. to W. 8th St.
- Phase 3: W. 8th St. to W. 14th St.
- Phase 4: W. 14th St to W. 18th St.
- Phase 5: W. 18th St. to W. 21st St.

Project Benefits:

- Provides greater capacity to deliver water within the Central Pressure Zone from the Water Purification Plant south to the Menlo Water Tower and further distributed through the system to the South Reservoir, East Reservoir, and West Reservoir. From each of these Reservoirs and Pump Stations water is transferred to the High Pressure Zone.
- Provides key capacity to the East Reservoir and South Reservoir which serve new growth areas in the east and south High Pressure Zone along with the East Reduce Zone. These areas have limited ability to receive water from the Lewis & Clark Regional Water System and will rely on capacity from this transmission pipeline that receives water from the Water Purification Plant.

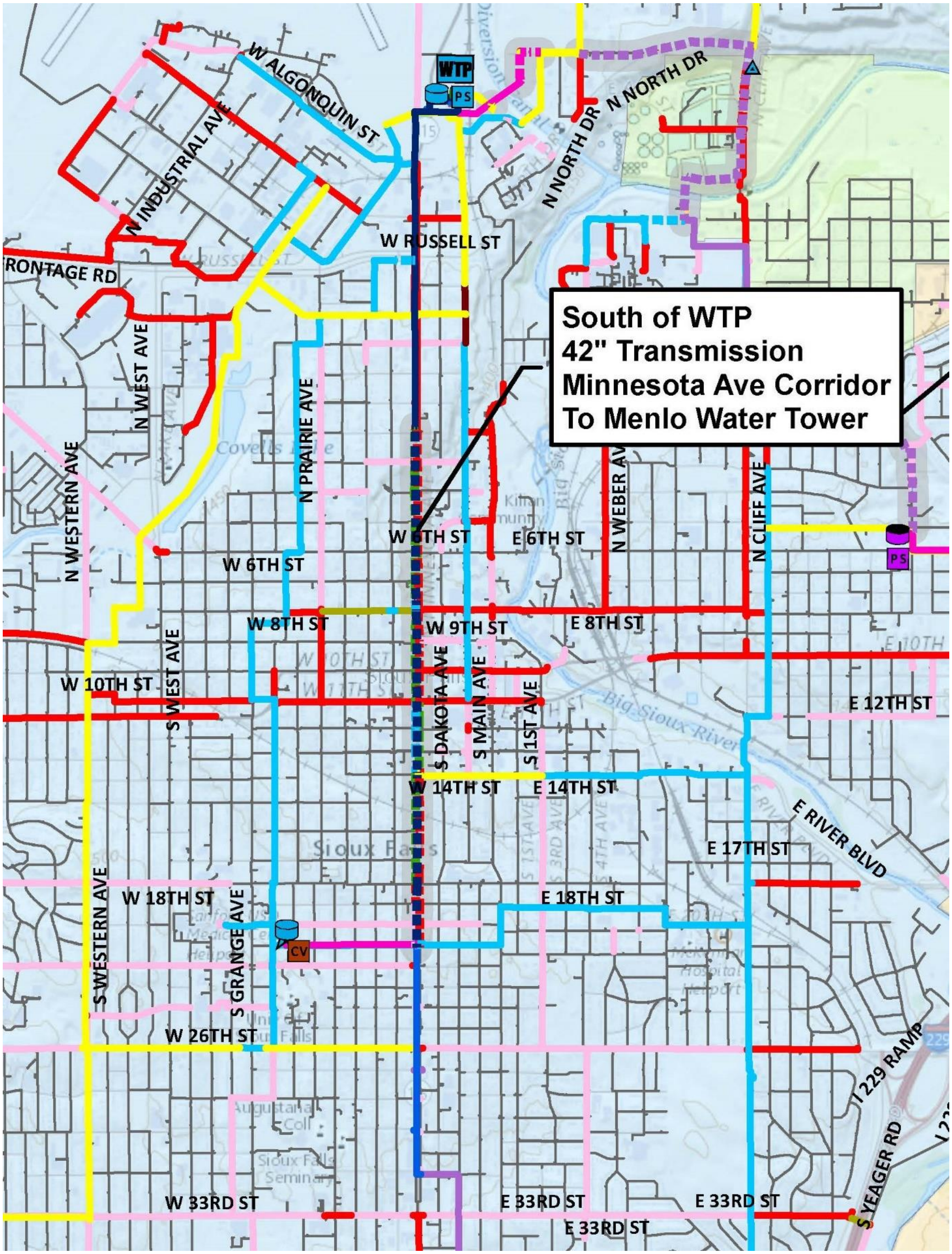


Figure 8.8 Minnesota Ave Transmission Pipeline Corridor

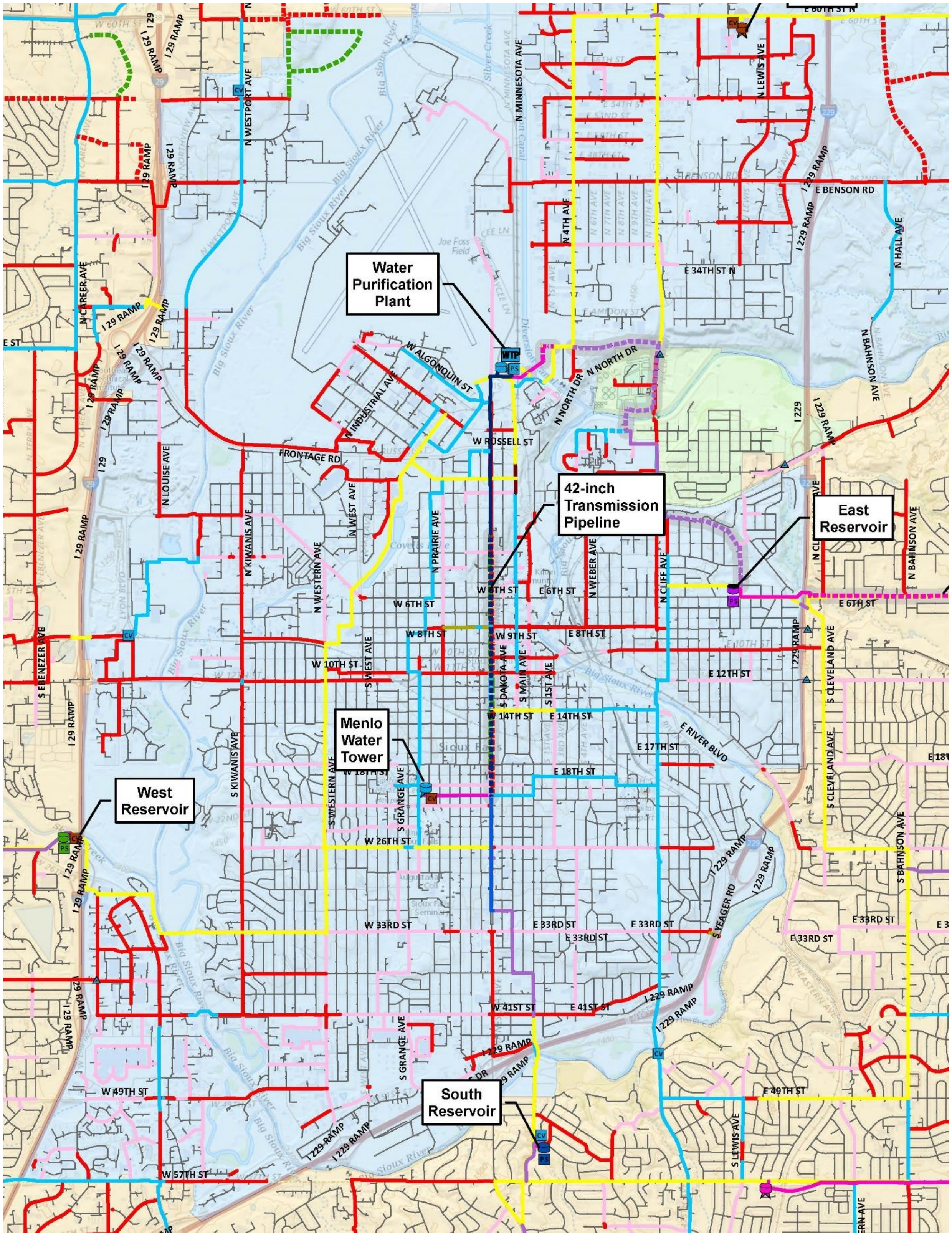


Figure 8.9 Minnesota Ave Transmission Pipeline Overview

Project Cost and Implementation Timeline

A list of phased Minnesota Avenue transmission projects is provided in Table 8.7 The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.7 Project Cost and Timeline - Minnesota Ave Transmission Pipeline

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
Phase 1: W Russell St. to W 2nd St.	2022	$ 6,908,000
Phase 2: 2nd St. to 8th St. - Material Acquisition	2024	$ 3,000,000
Phase 2: 2nd St. to 8th St.	2025	$ 2,300,000
Phase 3: 8th St. to 14th St.	2026	$ 5,428,000
Phase 4: 14th St. to 18th St.	2028	$ 3,902,000
Phase 5: 18th St. to 21st St.	2038	$ 5,175,000

8.3.3.2 Transmission to East Reservoir

Transmission capacity from the Water Purification Plant to East Reservoir and Pump Station is recognized as key to provide for future growth to the east and south High Pressure Zone. These transmission projects will replace existing pipelines that have experienced failures and are reaching the end of their useful life while providing the opportunity to upsize these pipelines to provide greater capacity for future growth and development within east and south areas of the High Pressure Zone and East Reduced Pressure Zone. Figure 8.10 provides an overview of the proposed project segments. The project will be broken into the following two key projects.

- East of Water Purification Plant
- Northwest of East Reservoir

Transmission Pipelines East of Water Purification Plant

Along with providing greater transmission pipeline capacity, a key aspect of this project is to replace two existing transmission pipelines that parallel each other. This transmission pipeline follows a corridor that runs near the Big Sioux River Diversion Channel, then crosses the Big Sioux River and connects near a large industrial user. One of the transmission pipelines continues along the diversion channel corridor.

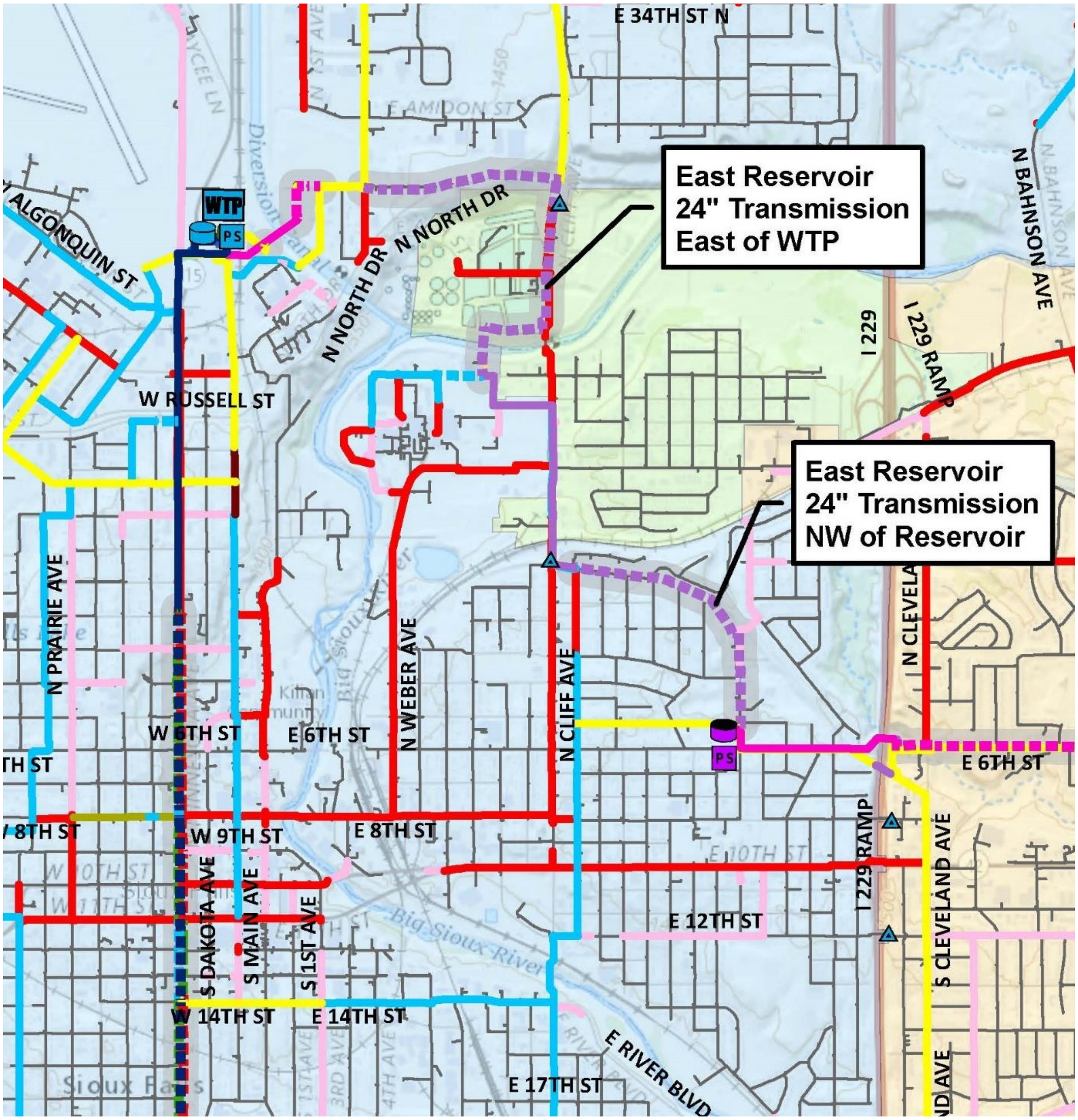


Figure 8.10 East Reservoir Transmission Pipeline Overview

and then connects with a new transmission pipeline. Each of these pipelines have reached their useful life with significant main breaks that have cause issues with the integrity of the dikes serving the diversion channel. This project reroutes the transmission pipeline in a route that moves the pipeline away from the diversion channel.

This project consists of installation of 30-inch and 24-inch transmission pipelines as shown in Figure 8.11. The project will also include a dual transmission pipeline across the Big Sioux River to provide redundancy in case one of the pipelines fails under the river.

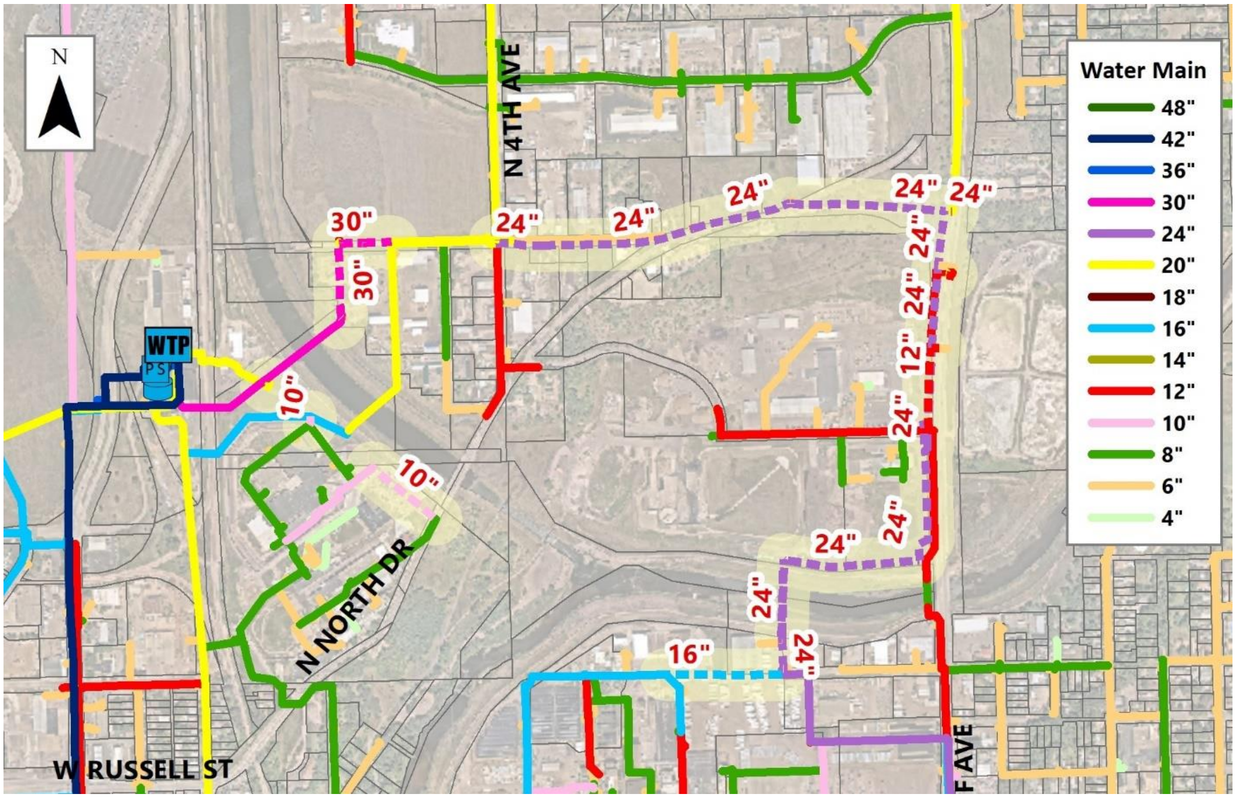


Figure 8.11 Transmission East of the Water Purification Plant to East Reservoir

Transmission Improvements Northwest of East Reservoir

The transmission pipeline is being planned to be replaced due to its age and acceptability to water main failure. With the recent development in the Hidden Hills area, the current pipeline alignment is within the backyards. The replacement of the transmission pipeline will allow the opportunity to increase the size and capacity of this transmission pipeline that delivers water to the East Reservoir.

The project will consist of replacing the existing 20-inch concrete pipeline with a new 24-inch from the existing 24-inch at Sherman Avenue to the East Reservoir. Pipeline would be relocated to existing abandoned railroad right-of-way with some additional easements. A layout of the proposed project is shown in Figure 8.12.

Project Benefits:

- Replaces existing transmission pipelines that are currently in poor condition and have reached the end of their useful life.
- Provides increased capacity to deliver water from the water purification plant to the East Reservoir.

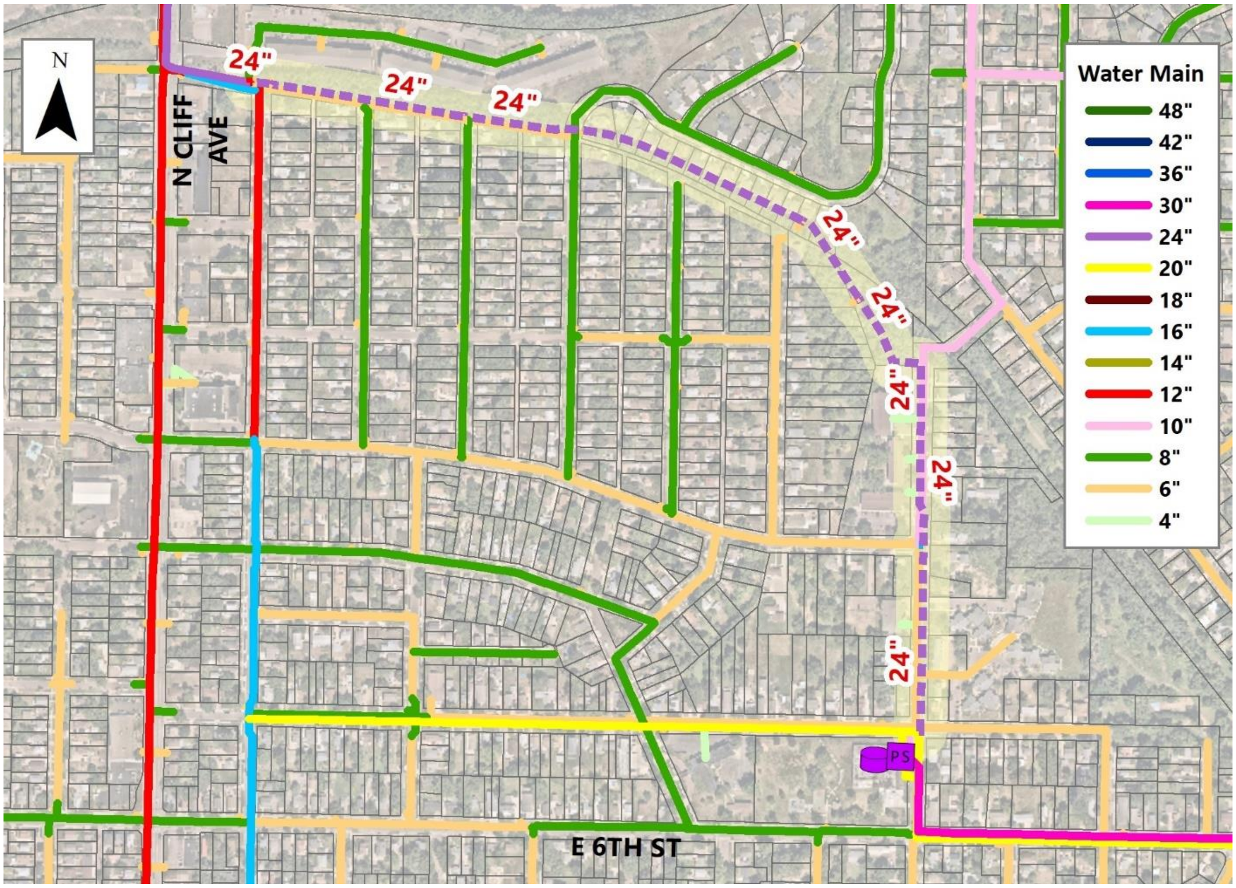


Figure 8.12 Transmission Pipeline NW of East Reservoir (Hidden Hills)

Project Cost and Implementation Timeline

A list of phased transmission projects east of the Water Purification Plant to the East Reservoir are provided in Table 8.8 The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.8 Project Cost and Timeline – Transmission Pipeline to East Reservoir

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
Transmission to East Reservoir - East of WTP-Phase 1	2029	$ 2,195,000
East Reservoir Transmission Upgrades Hidden Hills (NW of Reservoir)	2029	$ 2,290,000
Transmission to East Reservoir - East of WTP-Phase 2	2030	$ 2,735,000
Transmission to East Reservoir - East of WTP-Phase 3	2031	$ 3,011,000

8.3.3.3 East High Zone Transmission Improvements

Transmission capacity from the East Reservoir and Pump Station is key to provide for future growth to the east and south High Pressure Zone. These transmission projects are new transmission pipelines that will provide greater capacity for future growth and development within east and south areas of the High Pressure Zone and East Reduced Pressure Zone. Figure 8.13 provides an overview of the proposed project segments. The two key transmission pipeline projects are the following.

- Transmission Pipeline along Veteran's Parkway
- Transmission Pipeline along East 6th Street

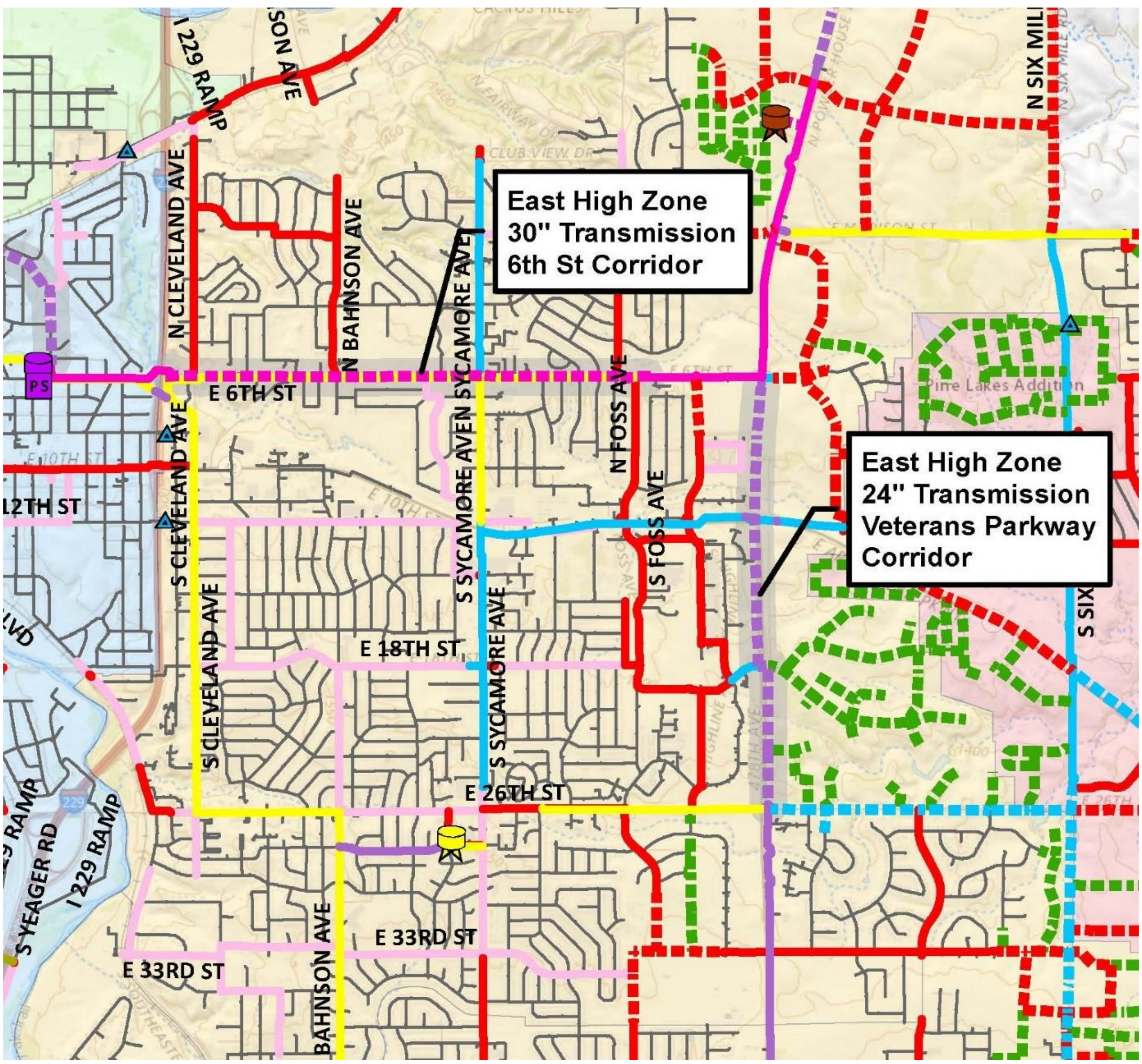


Figure 8.13 East High Zone Transmission Pipeline Improvements

Transmission Pipeline along Veteran's Parkway

This transmission provides transmission capacity to serve the north and south corridor within the High Pressure Zone between the East Reservoir and Pump Station to the 57th Street Water Tower. This project consists of installation of 24-inch transmission pipelines from East 6th Street to East 26th Street along Veteran's Parkway as shown in Figure 8.14. The proposed pipeline will connect to existing 24-inch transmission pipeline at East 6th Street and at East 26th Street.

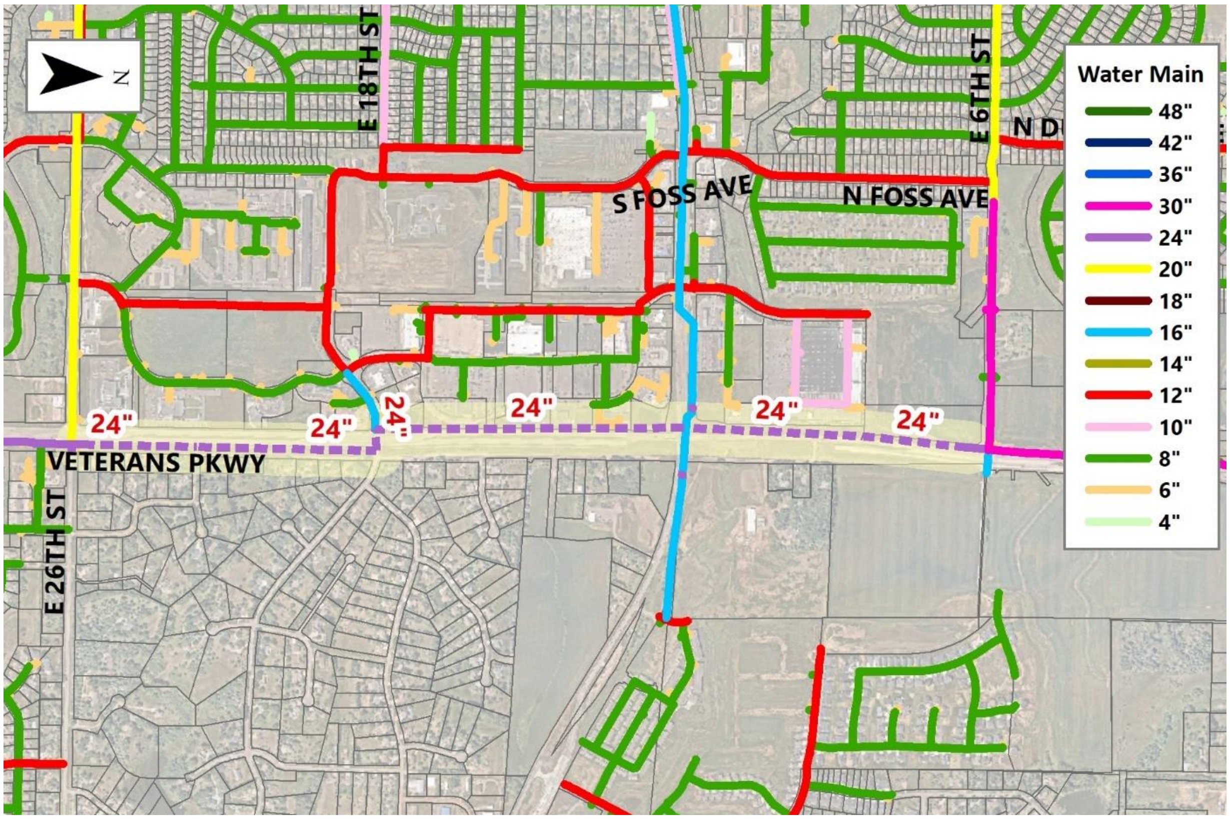


Figure 8.14 East High Zone Transmission Pipeline (Veteran's Parkway)

Transmission Pipeline along East 6th Street

This transmission provides increased transmission capacity by upsizing the existing 20-inch transmission pipeline to provide greater capacity for pumping water from the East Reservoir to the east High Pressure Zone. This project consists of installation of 30-inch transmission pipeline from and existing 30-inch transmission pipeline near I-229 and extend to an existing 30-inch near Foss Avenue as shown in Figure 8.15. This proposed 30-inch transmission pipeline would connect to the 30-inch transmission pipeline that continues north to the proposed Powder House Road Water Tower site and also provide connection to the future 24-inch pipeline which allows water to flow south to the 57th Street Water Tower.

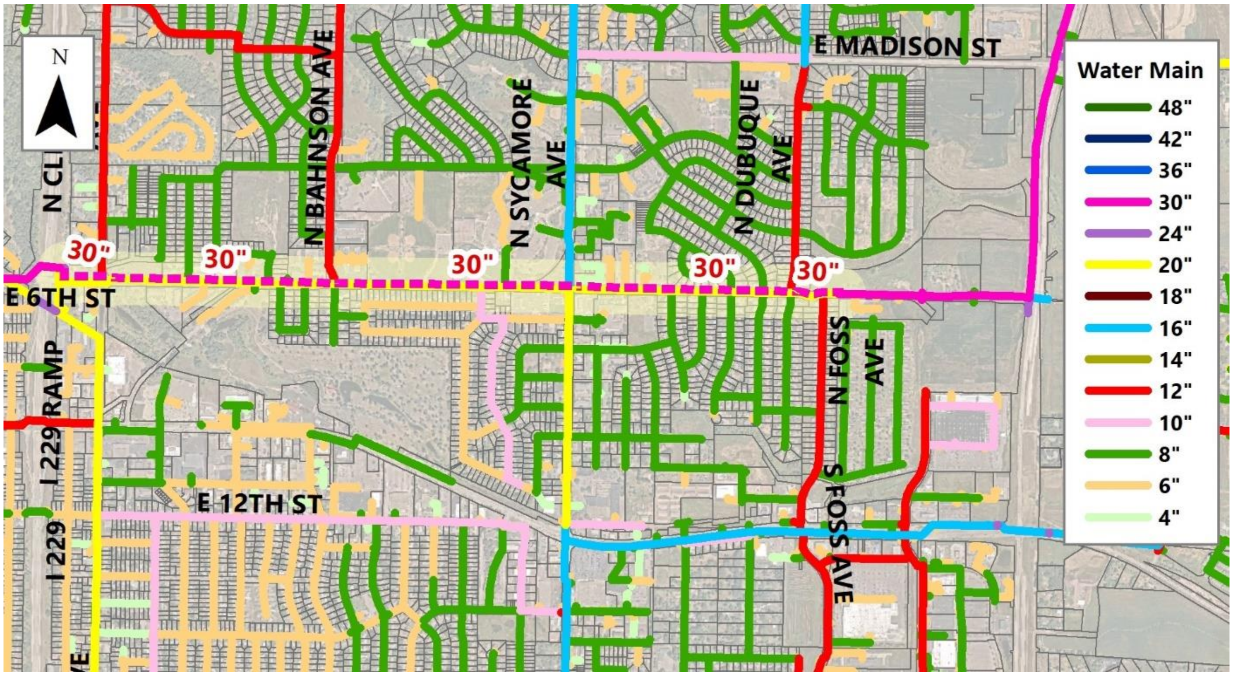


Figure 8.15 East High Zone Transmission Pipeline (East 6th Street)

Project Benefits:

- Provides greater capacity for future growth and development within east and south areas of the High Pressure Zone and East Reduced Pressure Zone.
- Improves capacity to and from future Powder House Road Water Tower.

Project Cost and Implementation Timeline

A list of transmission projects from within the East High Zone are provided in Table 8.9 The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.9 Project Cost and Timeline – East High Zone Transmission Pipeline

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
Veterans Parkway Transmission from E 26th St to E 6th St	2025	$ 5,017,000
East High Zone - East Reservoir Transmission E 6th St I-229 to Bahnson Ave	2039	$ 10,683,000
East High Zone - East Reservoir Transmission: Bahnson Ave to Sycamore Ave	2040	$ 9,111,000
East High Zone - East Reservoir Transmission: Sycamore Ave to N Foss Ave	2041	$ 10,262,000

8.3.3.4 West High Zone Transmission Improvements

As growth continues to expand on the west side of city, transmission pipeline capacity will provide key role in the ability to serve this growth. This portion of the High Pressure Zone receives water from the West Reservoir Pump Station and the Lewis & Clark RWS Benson Road connection. Water storage within this portion of the pressure zone is served by the Western Heights Water Tower. Transmission pipeline improvements near the Lewis & Clark RWS Benson Road Connection are necessary to support growth in this areas by expanding capacity to Foundation Park north of Benson Road as well as capacity to the south to deliver water to the Western Heights Water Tower near 41st Street. A layout of the system and proposed transmission pipeline projects is shown in Figure 8.16. The two key transmission pipeline projects are the following.

- Transmission Pipeline towards Western Heights Water Tower
- Transmission Pipeline to Foundation Park

While these projects will increase the ability of the Lewis & Clark RWS Benson Road Connection to deliver additional capacity from the Lewis & Clark System, an additional connection will need to be made near 12th Street with a transmission pipeline extended from the Lewis & Clark RWS 36-inch transmission pipeline to the existing 24-inch transmission pipeline near the intersection of 12th Street and South Ellis Road. This project is further discussed in the section related to Lewis & Clark Regional Water System Connection Capacity.

<u>Transmission Pipeline towards Western Heights Water Tower</u>

This transmission provides increased transmission capacity from the Lewis & Clark RWS Benson Road Connection to the south within the West High Pressure Zone. The pipeline will connect this water supply point with an existing 24-inch transmission pipeline located along Ellis Road near 12st Street. The proposed transmission pipeline projects would consist of the following pipeline segments. A layout of this transmission pipeline is show in Figure 8.17.

- 42-inch along Benson Road east from the L&C RWS connection to La Mesa Drive
- 30-inch along La Mesa Drive from Benson Road to Madison Street
- 30-inch along Madison Street from La Mesa Drive to Ellis Road
- 24-inch along Ellis Road from Madison Street to 12th Street

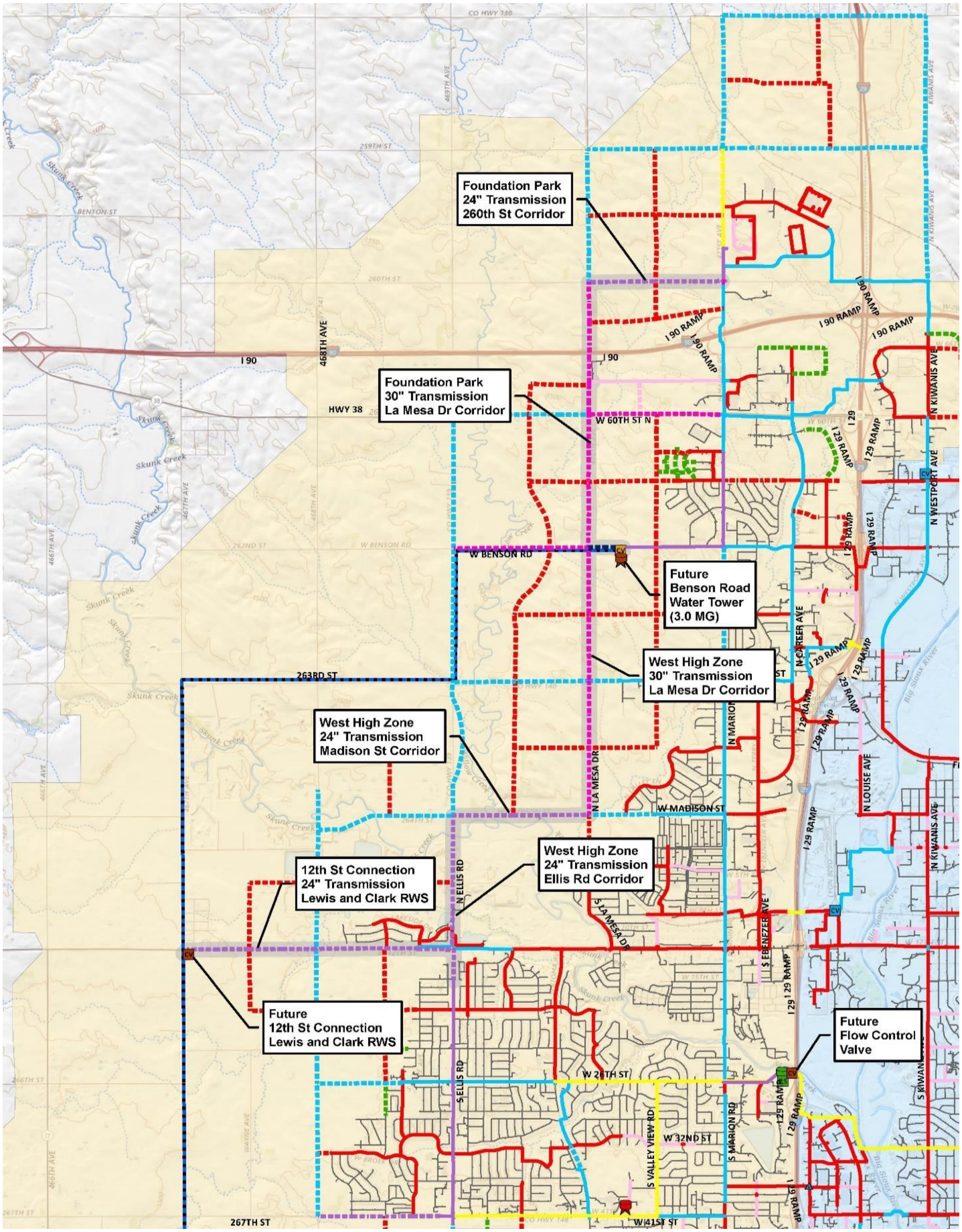


Figure 8.16 West High Zone Transmission Pipeline Layout

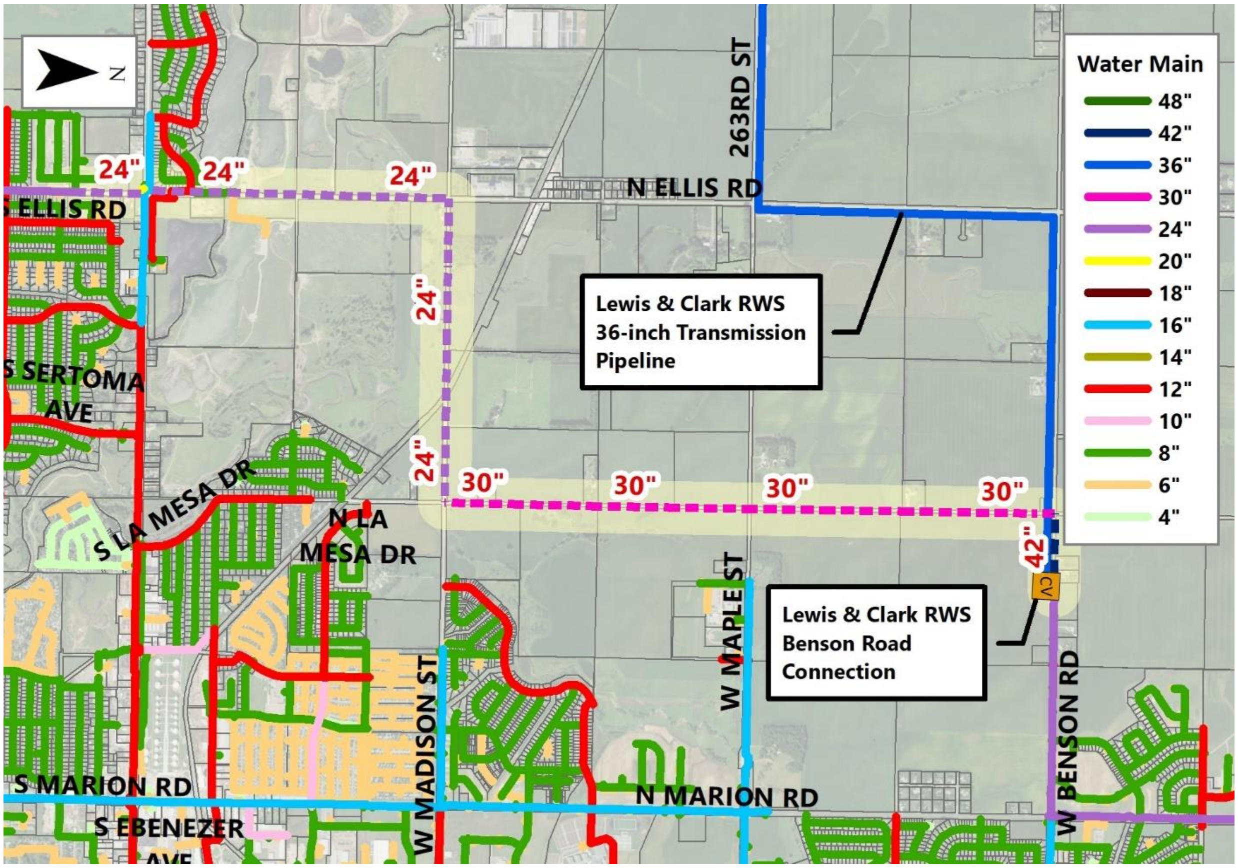


Figure 8.17 West High Zone Transmission towards Western Heights Water Tower

Project Benefits:

- Interconnects the existing Lewis & Clark RWS Benson Road Connection with a future 12th Street Connection to the Lewis & Clark RWS creating greater access to the available capacity of the Lewis & Clark RWS.
- Delivers greater transmission capacity to transfer water to the southwest area of the West High Pressure Zone towards Western Heights Water Tower.
- Improves the ability to access greater capacity of Benson Road Connection of Lewis & Clark RWS.
- Provides redundancy to Foundation Park if Lewis & Clark RWS is offline at the Benson Road Connection.

Project Cost and Implementation Timeline

A list of transmission projects related to the West High Zone towards the Western Heights Water Tower are provided in Table 8.10. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.10 Project Cost and Timeline – High Zone Transmission To Western Heights Tower

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
West High Zone Transmission – Phase 1 La Mesa Dr: Benson Rd to W Maple St	2029	$ 5,384,000
West High Zone Transmission – Phase 2 N Ellis Rd: Windmill Ridge St to Madison St	2030	$ 4,951,000
West High Zone Transmission – Phase 3 Madison St - Ellis Rd to La Mesa Dr	2031	$ 4,268,000
West High Zone Transmission – Phase 4 La Mesa Dr: Madison St to Maple St	2032	$ 6,066,000

Transmission Pipeline to Foundation Park

With continued growth and requests for industrial water within the Foundation Park development north of I-90 and east of I-29, there will be a need to expand transmission pipeline capacity to this area. The existing system serving the Foundation Park area currently has a capacity of 3.31 MGD with currently about 0.9 MGD to 1.9 MGD committed to current development of C.J. Foods, Phases 1 & 2 leaving about 1.4 MGD to 2.4 MGD remaining for future industrial demand. The area currently can provide an available fire flow ranging from 3,000 gpm to 4,000 gpm.

With the ability of the wastewater collection system to be expanded from 2.4 MGD up to 6.6 MGD. The available water capacity of 3.3 MGD could be exceeded in the future based on recruitment by developers of high water demand users. Based on the potential need to expand the current water transmission capacity from 3.3 MGD to at least 6.6 MGD, a transmission pipeline project would be required to meet the increased industrial water demands. This project would increase the overall transmission capacity to 7.6 MGD. The proposed transmission pipeline projects would consist of the following pipeline segments. A layout of this transmission pipeline is show in Figure 8.18.

- 30-inch along La Mesa Drive from Benson Road to 260th Street
- 24-inch along 260th Street from La Mesa Drive to Marion Road

Project Benefits:

- Increases overall capacity to greater than the future planned wastewater capacity of 6.6 MGD.
- Expands the ability to use the capacity available from Lewis & Clark RWS at the Benson Road Connection.

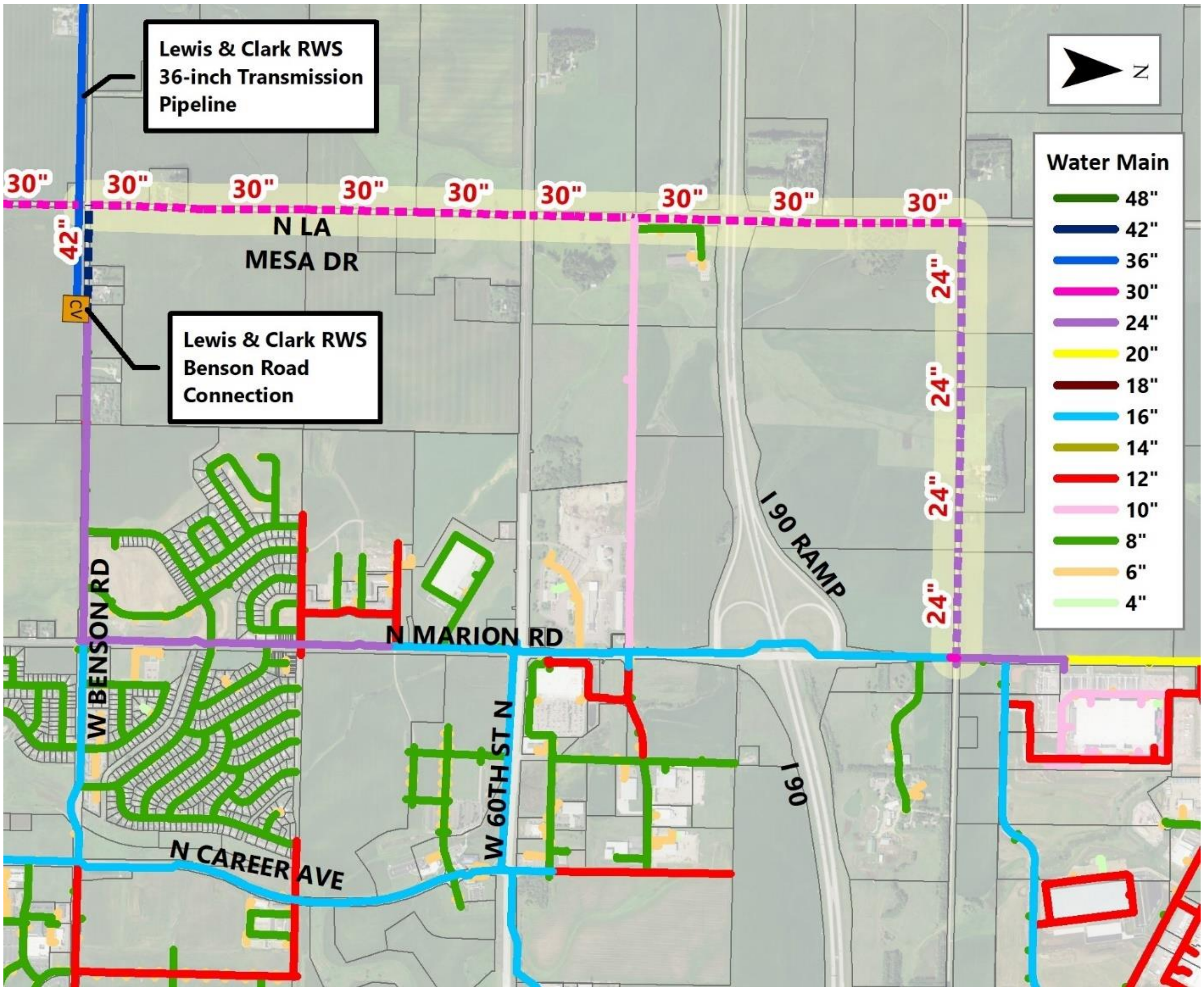


Figure 8.18 West High Zone Transmission Pipeline to Foundation Park

- Investment in transmission pipeline will ensure adequate capacity for future growth and for an interim period of time provide greater available fire flow for this area until significant demands require the need for water storage in this area to the north and west.
- Provide greater transmission pipeline capacity for areas north of I-90
- Provide capacity for further growth east of the current Foundation Park Development.

Project Cost and Implementation Timeline

A list of transmission projects related to the West High Zone transmission pipelines to Foundation Park are provided in Table 8.11. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.11 Project Cost and Timeline – West High Zone Transmission to Foundation Park

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
Foundation Park Transmission Pipeline La Mesa Dr, Benson Rd to 54th St N	2033	$ 5,897,000
Foundation Park Transmission Pipeline La Mesa Dr, 54th St N to 62nd St N	2034	$ 5,233,000
Foundation Park - 260th St Transmission Pipeline La Mesa Dr to Marion Rd	2035	$ 4,130,000
Foundation Park Transmission Pipeline N La Mesa Dr - 62nd St N to 260th St	2036	$ 7,058,000

8.3.3.5 East Reduced Pressure Zone Transmission Improvements

The East Reduced Pressure Zone serves the east and southeast areas of the city and is served from the High Pressure Zone via two pressure reducing valve stations. This area served by the East Reduced Pressure Zone is relatively undeveloped with a majority of the current development in the north part of the pressure zone. Over the next several years, this pressure zone will see significant growth with the southern expansion of Veterans Parkway which will require expansion of transmission pipelines to serve this area. Figure 8.19 provides an overview of the proposed layout of future transmission pipelines. The following are key transmission pipelines within this pressure zone along with two future pressure reducing valve stations.

- 24-inch Transmission Pipeline along 85th Street from Cliff Avenue to Six Mile Road
- 24-inch Transmission Pipeline along Six Mile Road from 85th Street to 41st Street
- 85th Street Pressure Reducing Valve Station
- 41st Street Pressure Reducing Valve Station

<u>Benefits:</u>

- Expanded transmission pipeline capacity to serve the southeast portion of the East Reduced Pressure Zone.
- Provide capacity to meet system demands along with fire flow requirements.
- Transmission pipeline network will connect two existing and two future pressure reducing stations that will serve the interconnected pressure zone.

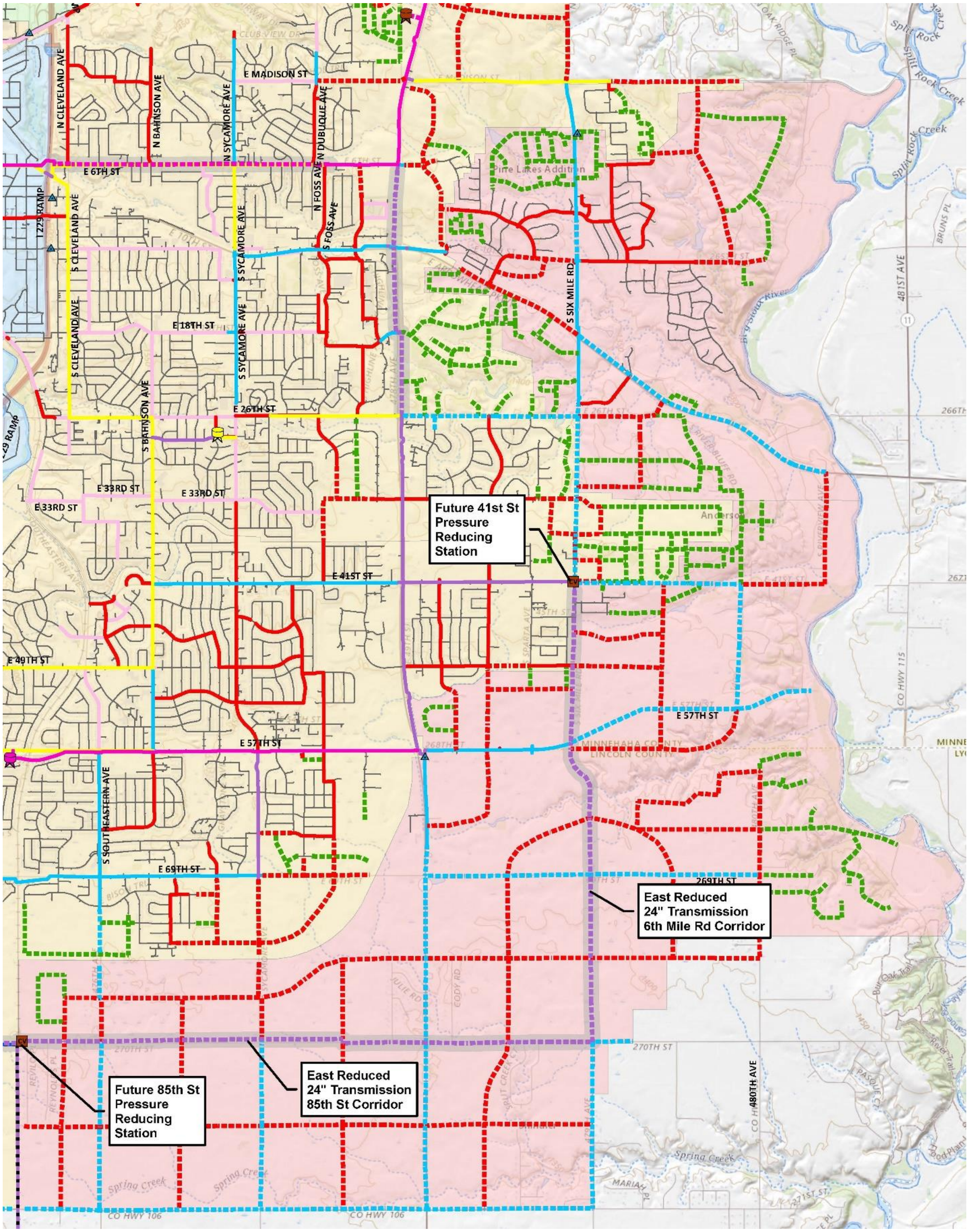


Figure 8.19 East Reduced Zone Transmission Pipeline

Project Cost and Implementation Timeline

A list of transmission projects related to transmission pipelines within the East Reduced Pressure Zone are provided in Table 8.12. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.12 Project Cost and Timeline – East Reduced Zone Transmission Pipelines

Capital Improvement Project	Anticipated Implementation Year	Probable Opinion of Project Cost
East Reduced Zone Transmission - Six Mile Rd Corridor E 26th St to 41st St	2038	$ 2,989,000
East Reduced Zone Transmission - 85th St Corridor: Southeastern Ave to Cliff Ave	2038	$ 4,750,000
East Reduced Zone Transmission - Six Mile Rd Corridor: E 41st St to E 57th St	2040	$ 4,277,000
East Reduced Zone Transmission - 85th St Corridor: Southeastern Ave to Highway 11	2042	$ 9,364,000
East Reduced Zone Transmission - Six Mile Rd Corridor: E 57th St to E 85th St	2043	$ 8,576,000
East Reduced Zone Transmission - 85th St Corridor Highway 11 to Six Mile Rd	2044	$ 5,031,000

8.3.3.6 Transmission Pipeline Extensions into New Growth Areas

Over the last five years, the City has been extending about three (3) miles of new transmission pipelines into growth areas. These transmission pipelines vary in size from 12-inch to 42-inch depending on the need for transmission capacity planned for the system through the 100-year planning period.

System extension improvements were identified as those improvements that provide for future service area development within the planning period areas. A majority of these improvements represent an extension of the distribution system that will be constructed as the system continues to grow. The water main sizes shown on these figures can be used to serve as a guide for the distribution system planning when growth and development materialize in these areas.

In order to provide standardization of water main layout, continuation of the "grid" of 16-inch water main on section lines and 12-inch water main on quarter-section lines was recommended. In areas near ground storage reservoir/pump stations and water towers, the water main sizes may be increased to handle the larger flows and minimize headloss within the distribution system framework. This layout also provides a system with the capacity to handle high fire flow demands along major street corridors.

Planning Considerations:

- Transmission pipeline projects greater than 16-inch were identified as specific projects in the previous sections related to areas served by these proposed transmission pipelines.
- In the CIP planning, it was assumed that the City would continue to extend about three (3) miles of transmission pipelines per year. In years where designated transmission pipelines would be planned to be constructed that are greater than 16-inch, this quantity would be subtracted from the three (3) miles and the remaining length of transmission pipeline would be added to the CIP as length of 16-inch transmission pipeline.
- Transmission pipelines of 12-inch are considered to be a part of the development and costs would be covered by the developer.

8.3.4 Control Valve Improvements

Control valve improvements planned within the distribution system provide the following capabilities:

- Ability to move water from a higher pressure zone to a lower pressure zone.
- Provide operational flexibility by allowing the ability to control fill rates into water storage facilities.

8.3.4.1 West Reservoir Control Valve

A future flow control valve is planned for installation within the West Reservoir and Pump Station as shown in Figure 8.20. The flow control valve would allow water to flow from the High Pressure Zone to the Central Pressure Zone. The water from the High Pressure Zone could also be used to fill the West Reservoir. While the system has had the ability to allow flow between the two pressure zones in the past, it required manually opening and closing of valves at the site and also provided operational limitations when configured in this operational mode. This project would include a new SCADA controlled valve with the ability to monitor and set the flow rate for delivering from the High Pressure Zone to the Central Pressure Zone.

Benefits:

- Provides the ability to access a greater amount water from the Lewis & Clark RWS via the Benson Road Connection and the future 12th Street Connection. Currently, existing Lyon Boulevard Flow Control Valve and Westport Avenue Flow Control Valve have limited capacity due to existing transmission pipeline capacity within the vicinity of these connections.
- Greater operational flexibility with the ability to control the transferring of flow from the Water Purification Plant using the SCADA system.

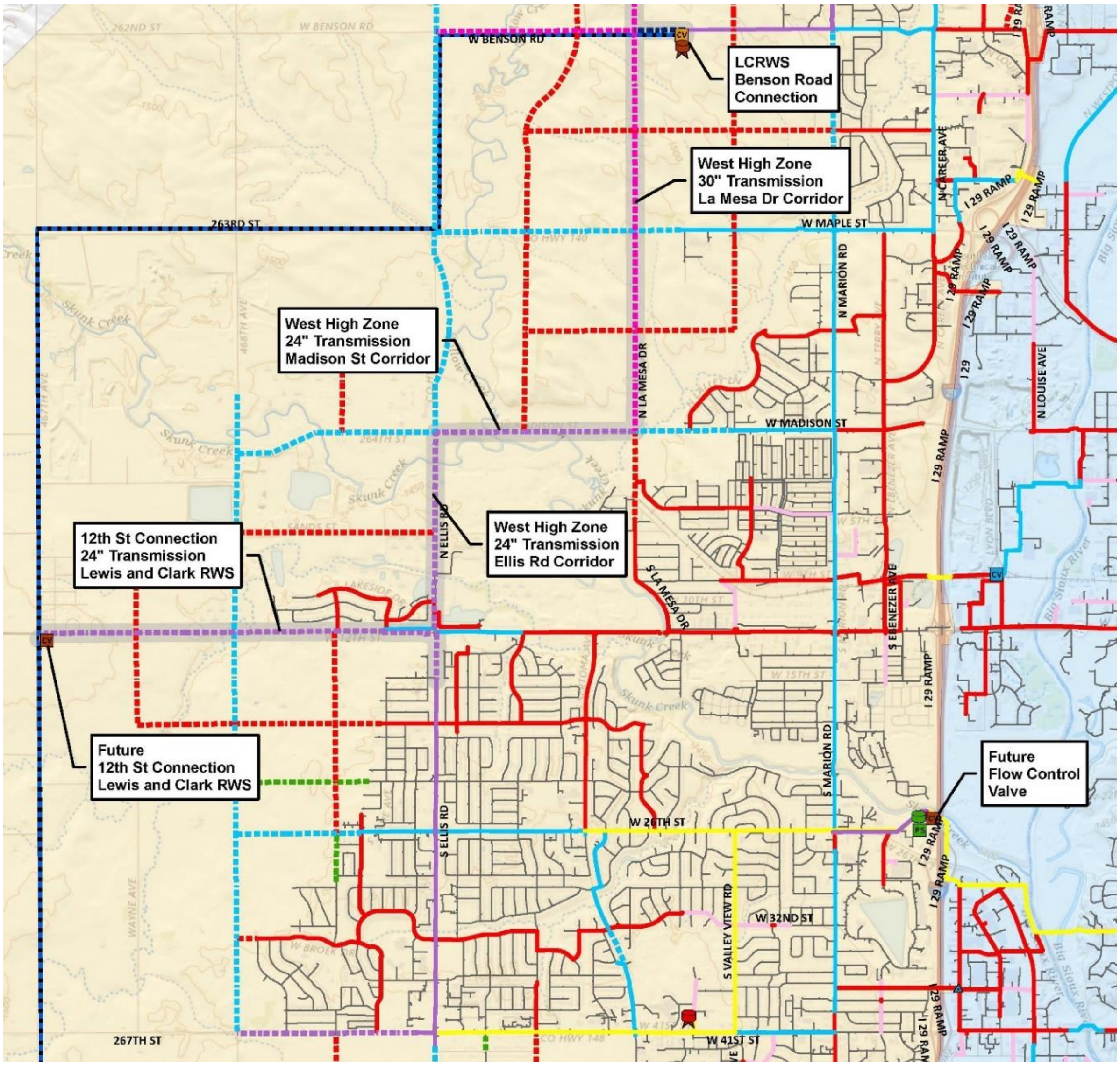


Figure 8.20 West Reservoir Control Valve

Project Cost and Implementation Timeline

A list of transmission projects related to installation of the West Reservoir Control Valve are provided in Table 8.13. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.13 Project Cost and Timeline – West Reservoir Control Valve

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
West Reservoir Control Valve	2026	$ 453,000

8.3.4.2 Menlo Water Tower Fill Control Valve

Tower fill control at the Menlo Water Tower will be necessary upon completion of the future 60th Street Water Tower. Figure 8.21 provides general layout of the facilities to provide a better understanding of the following narrative. The ability to control the fill rate of the water tower would help maximize the storage within the water towers and minimize the impacts from demand fluctuations within each water tower's service area. The fill control valve could be set through the SCADA system to limit the flow into one water tower and push water to the other water tower within the same pressure zone. The fill control valve would consist of a electric actuated butterfly valve to control the fill rate into the water tower and a check valve that would allow water to leave the water tower in the case of an emergency and is not dependent on the position of the fill control valve.

Benefits:

- Provides greater operational flexibility to allow the ability to force water to areas of high demand and maintain adequate levels within each of the water towers within the same pressure zone. It would also prevent a tower from reaching overflow level while another water tower is at a lower water level would receive greater flow to fill it from the distribution system.
- Allows the ability to overcome hydraulic limitations within the distribution system that do not allow the water storage to float closer to the same levels under peak demand conditions.
- Helps control the flow into and out of the water tower, which helps turn over the water and minimizes the potential of water age issues.

Project Cost and Implementation Timeline

A list of transmission projects related to installation of the Menlo Water Tower Fill Control Valve are provided in Table 8.14. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.14 Project Cost and Timeline – Menlo Water Tower Fill Control Valve

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
Menlo Water Tower Fill Control Valve	2031	$ 548,000

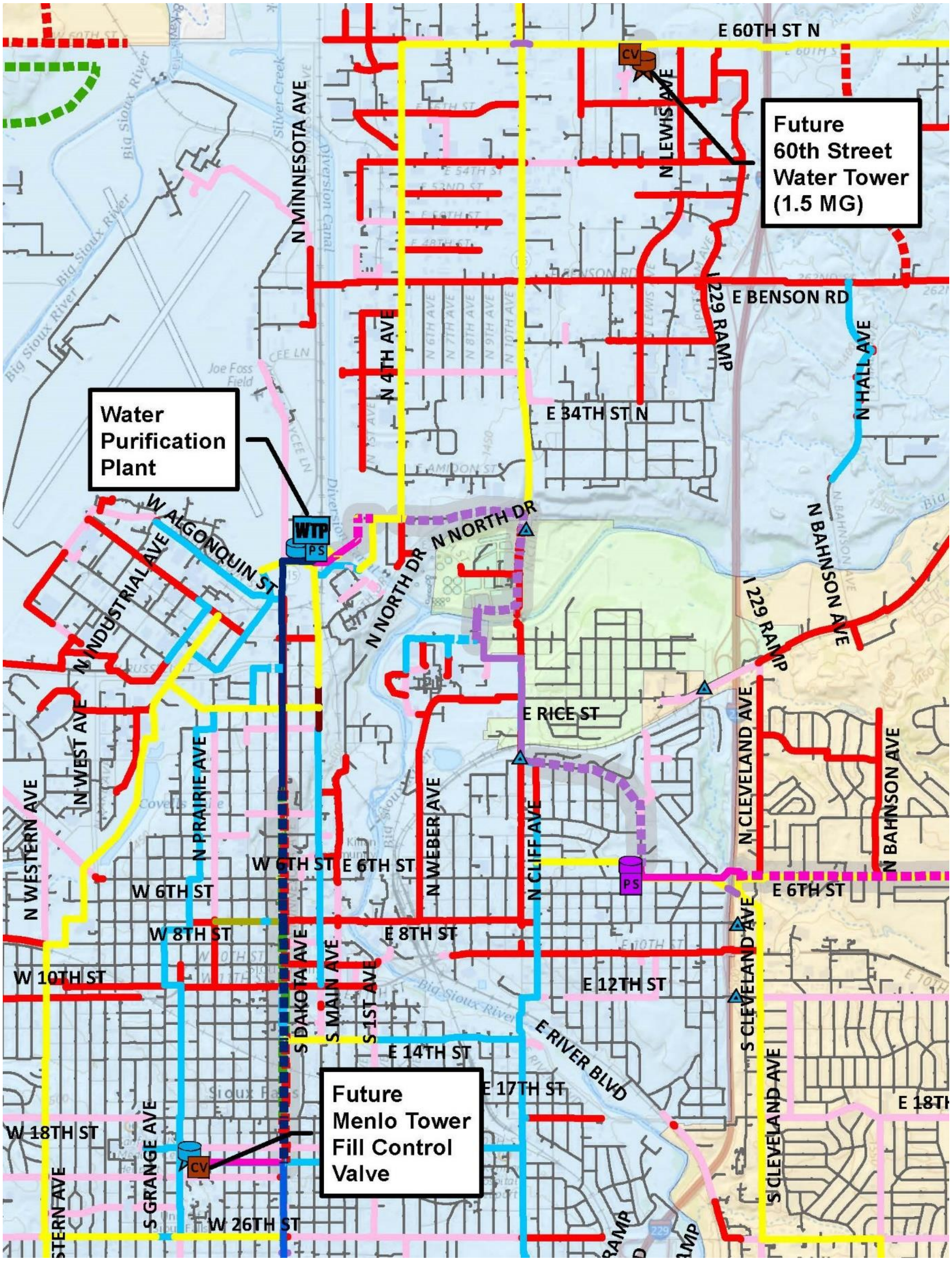


Figure 8.21 Menlo Water Tower Fill Control Valve

8.3.4.3 East Reduced Pressure Zone Valve Stations

The East Reduced Pressure Zone serves the east and south areas of the water distribution system. There is currently a defined boundary that creates a split between the High Pressure Zone and the East Reduced Pressure Zone. The East Reduced Pressure Zone generally serves those areas where pressures would exceed 80 psi if served by the High Pressure Zone. The hydraulic grade line served by the pressure reducing valves is 1,580 feet for this pressure zone as outlined in Section 2.2 Pressure Zones. The boundary of the East Pressure Zone was determined to minimize the impacts to existing areas that were already served by the distribution system and concentrated on new development areas. The boundary of the East Pressure Zone allows the ability to develop the area with consideration to minimize the creation of dead-end water main associated with isolation of the two pressure zones.

The proposed boundary will allow the ability to plan for the split between the High Pressure Zone and the proposed East Pressure Zone. It was determined to be difficult to go into existing areas and develop a new pressure zone without creating deadend watermain due to isolation of these areas. A map of the East Reduced Pressure Zone is shown in Figure 8.22.

The boundary of the East Reduced Pressure Zone along with the general layout of the distribution system within the pressure zone allowed the ability to determine how the system would be served by pressure reducing valve stations. Currently the pressure zone is served by the following two pressure reducing valve stations. The following are the existing and future PRV stations serve planned to serve all of the development within this pressure zone.

- Six Mile Road PRV Station (existing)
- 57th Street PRV Station (existing)
- 41st Street PRV Station (future)
- 85th Street PRV Station (future)

The pressure reducing valve stations consist of two pressure reducing valves. One valve provides flow for daily domestic demand within the area being served. The other valve is a larger valve with the capacity to serve fire demands. The PRV stations include water meters and upstream/downstream pressure transducers that are able to send data back to the SCADA system to allow water purification plant operators to monitor pressures and flow.

Benefits:

- Manage pressures to minimize areas with pressures greater than 80 psi.
- Monitor pressures and flows at the PRV stations to notify staff of valve failure or water main leaks within the pressure zone.
- Calculation of water loss within the pressure zone using PRV station meters and comparing with automated meter reading data of customers within the pressure zone.

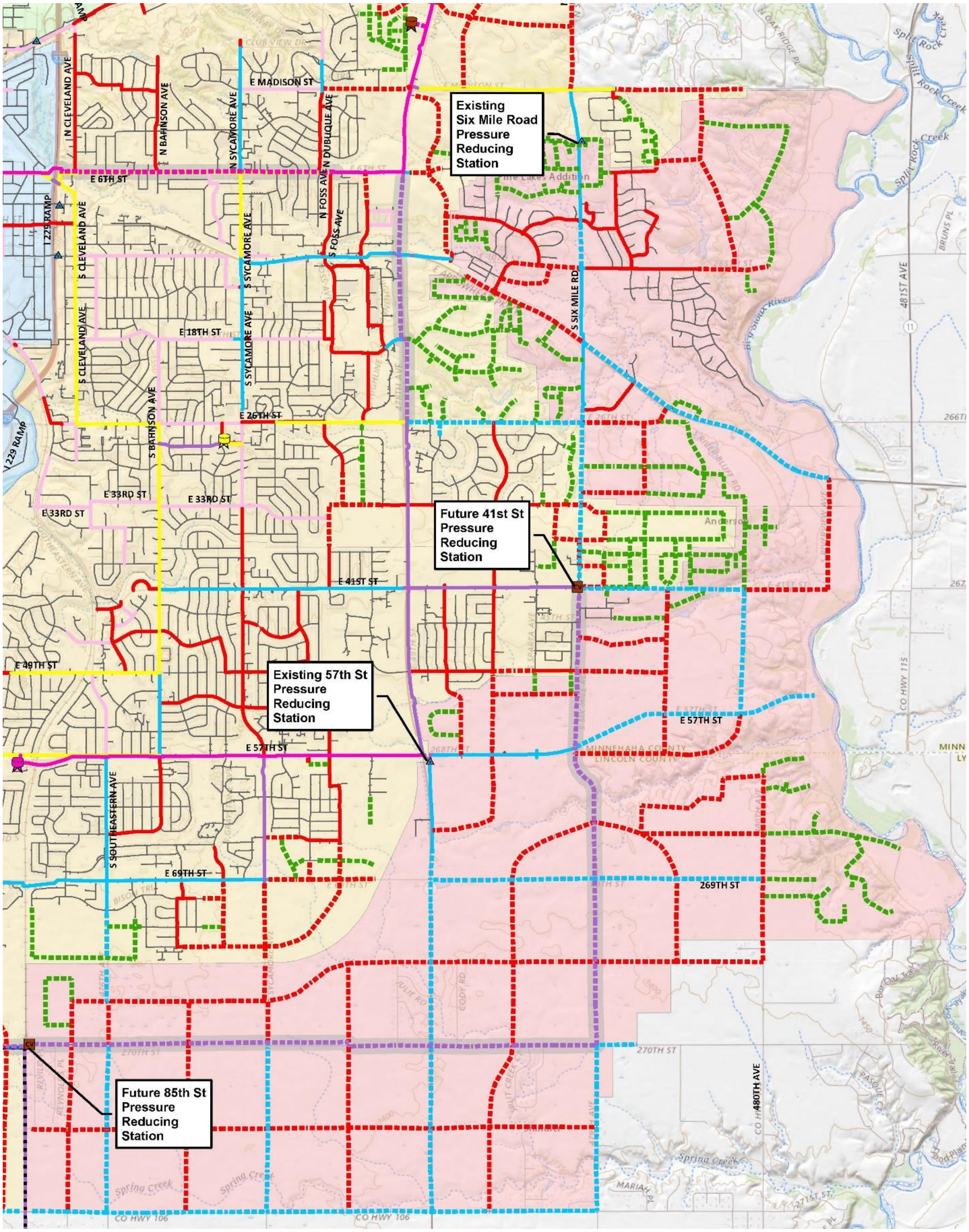


Figure 8.22 East Reduced Pressure Zone Pressure Reducing Stations

Project Cost and Implementation Timeline

A list of transmission projects related to installation of the Menlo Water Tower Fill Control Valve are provided in Table 8.15. The table provides the anticipated year of implementation along with an indexed cost which includes inflation costs.

Table 8.15 Project Cost and Timeline – East Reduced Zone Valve Stations

Capital Improvement Project	Anticipated Implementation Year`	Probable Opinion of Project Cost
41st St Pressure Reducing Station	2038	$ 679,000
85th St Pressure Reducing Station	2042	$ 761,000

8.3.5 Pump Station Improvements

This section provides an understanding of the system pumping capacity at the Water Purification Plant and at each of the East, South, and West Reservoirs. The goal of this section to review the existing pumping capacity against future PDD demands and identify capacity deficiencies. A map showing each of the existing pump stations is shown in Figure 8.23.

8.3.5.1 High Service Pump Station

The high service pumping at Water Purification Plant consists of nine pumps with different pumping capacities. These pumps deliver water from the storage capacity at the treatment plant which includes the Clearwell and the North Reservoir (Big Blue) to the distribution system and transfers water to the Menlo Water Tower and future 60th Street Water Tower along with providing water to fill the East, South, and West Reservoirs. Under the 20-year peak day demand scenario for the year 2045, following provides an overview of operations and flows delivered to the distribution system.

Average Discharge Flow = 49.8 MGD

Range of Discharge Flow = 35.5 MGD – 72.4 MGD

High Service Pumps Operated = HSP #1, HSP #3, HSP #4, HSP #5, HSP #6

High service pumps #3 and #4 were operated so that the pumps ramped up and down using variable speed drives to meet system demand based on the Menlo Water Tower level. Pumps #1 and #6 were operated during peak hour demands to ensure adequate level within the Melno Water Tower. Pump #5 was operated continuously to provide a base flow to the system. Pumps #2, #7, #8, #9 were not required to operate to meet the overall flow requirements needed for the peak day demands.

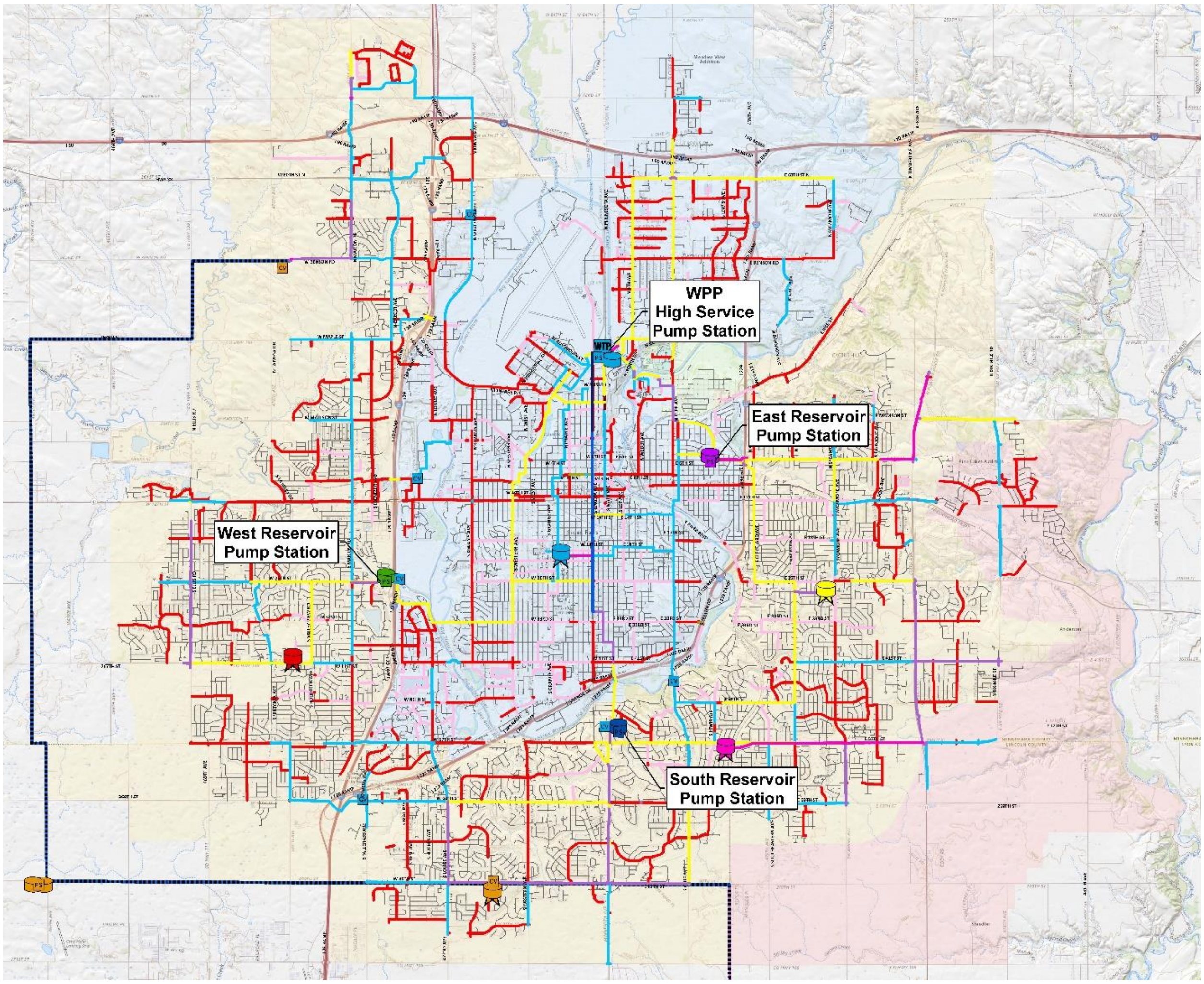


Figure 8.23 Existing Pump Stations

Conclusion and Recommendations:

- The existing high service pumps have adequate capacity to meet the system demands for the 20 year growth period.
- While there are no recommendations to upgrade the current pumping capacity, it is recommended that any pump modifications or replacements consider the pumping requirements beyond the 20-year planning period.
- To provide greater operational capabilities and flexibility of pump combinations, additional variable speed drives should be considered as this pumping system is upgraded in the future.

8.3.5.2 East Reservoir Pump Station

The pumping system at East Reservoir consists of five pumps with different pumping capacities. All five pumps typically operate around a capacity of 5 MGD for each pump. These pumps deliver water from the East Reservoir into the East High Pressure Zone to the Melanie Water Tower, 57th Street Water Tower and a future Powder House Road Water Tower.

Under the 20-year peak day demand scenario for the year 2045, following provides an overview of operations and flows delivered to the distribution system. The East Reservoir pumps work in tandem with the South Reservoir Pump Station to provide flow into the High Pressure Zone. Operation of the East Reservoir pumps and South Reservoir pumps requires balancing of the pump combinations and capacities. If the South Reservoir Pump Station does not pump enough water into the system, the system will require the East Reservoir Pump Station to deliver a greater flow into the system and require more pumping and longer pumping times for the pumps meeting peak hour demands or to run continuously to keep up with demands.

Average Discharge Flow =	20.5 MGD
Range of Discharge Flow =	16.7 MGD – 26.0 MGD
Pump #1 and #2 Flow Capacity =	4.7 MGD each
Pump #3 and #4 Flow Capacity =	5.7 MGD each
Pump #5 Flow Capacity =	5.0 MGD each
Reservoir Pumps Operated =	#1, #2, #3, #4, #5

Conclusion and Recommendations:

- The East Reservoir pumps have adequate capacity to meet the system demands for the 20-year growth period.
- While there are no recommendations to upgrade the current pumping capacity, it is recommended that any pump modifications or replacements consider the pumping requirements beyond the 20-year planning period. Growth beyond 20 years shows the need to upgrade pumps #1 and #2 to similar capacity of pumps #3 and #4.

8.3.5.3 South Reservoir Pump Station

The pumping system at South Reservoir consists of five pumps with different pumping capacities. The pump station consists of three smaller capacity pumps and 2 larger capacity pumps with a range from 2.6 MGD to 7.5 MGD. These pumps deliver water from the South Reservoir into the East and South High Pressure Zone areas to the 57th Street Water Tower and the Melanie Water Tower. Under the 20-year peak day demand scenario for the year 2045, following provides an overview of operations and flows delivered to the distribution system.

The South Reservoir pumps work in tandem with the East Reservoir Pump Station to provide flow into the High Pressure Zone. Operation of the South Reservoir pumps and East Reservoir pumps requires balancing of the pump combinations and capacities. If the South Reservoir Pump Station does not pump enough water into the system, the system will require the East Reservoir Pump Station to deliver a greater flow into the system and require more pumping and longer pumping times for the pumps meeting peak hour demands or to run continuously to keep up with demands.

Another factor that affects the operations of the South Reservoir Pump Station is the flow received from the Lewis & Clark RWS 85th Street Connection. The Lewis & Clark RWS 85th Street Connection provides up to 11 MGD of guaranteed supply capacity and up to 19 MGD of capacity if available. The Lewis & Clark RWS supply and offset the amount of pumping capacity needed from the Central Zone which receives its supply from the Water Purification Plant.

Note that this pump station has the capability of allowing flow from the High Pressure Zone to the Central Pressure Zone with the operation of a valve within the pump station. This control valve is automated and the flow and operation can be performed through the WPP SCADA system.

Average Discharge Flow =	14.1 MGD
Range of Discharge Flow =	6.0 MGD – 23.2 MGD
Pump #1, #2, #3 Flow Capacity =	2.6 MGD each
Pump #4, #5 Flow Capacity =	7.5 MGD each
Reservoir Pumps Operated =	#1, #2, #3, #4, #5

Conclusion and Recommendations:

- The South Reservoir pumps have adequate capacity to meet the system demands for the 20-year growth period.
- While there are no recommendations to upgrade the current pumping capacity, it is recommended that any pump modifications or replacements consider the pumping requirements beyond the 20-year planning period. Growth beyond 20 years shows the need to upgrade pumps #1, #2, and #3 to similar capacity of pumps #4 and #5.

8.3.5.4 West Reservoir Pump Station

The pumping system at West Reservoir consists of six pumps with all the same pumping capacity of about 3.8 MGD each. These pumps deliver water from the West Reservoir into the West High Pressure Zone to the Western Heights Water Tower and a future Benson Road Water Tower. Under the 20-year peak day demand scenario for the year 2045, following provides an overview of operations and flows delivered to the distribution system.

The West Reservoir pumps provide capacity to meet peak hour demands within the West High Zone. Water supplied from the West Reservoir comes from the Water Purification Plant through the Central Pressure Zone. The Lewis & Clark RWS Benson Road Connection and future 12th Street Connection provides a capacity of up to 23 MGD. The pumps at West Reservoir provide flow during peak hour demands along with the ability to turn over water within the West Reservoir each day. The West Reservoir pumps also provide capacity into the West Pressure Zone if there is an emergency related to a fire or if the Lewis & Clark Connections are offline.

Average Discharge Flow =	9.4 MGD (two pumps running during peak hour)
Range of Discharge Flow =	3.8 MGD – 22.6 MGD
Pumps #1 - #6 Flow Capacity =	3.8 MGD each
Reservoir Pumps Operated =	#1, #2 (to meet peak hour and turnover West Reservoir)

Note that this pump station has the capability of allowing flow from the High Pressure Zone to the Central Pressure Zone with the operation of valves within the pump station. A future project includes providing the ability to automation to the control valve to for improved operation.

Conclusion and Recommendations:

- The West Reservoir pumps have adequate capacity to meet the system demands for the 20-year growth period.
- There are no recommendations to upgrade the current pumping capacity. With the availability of supply capacity from the Lewis & Clark RWS, there is no expectation for the need to upgrade these pumps in the future.
- Recommend providing automation to control valves to allow greater operational control for delivering water from the High Pressure Zone to the Central Pressure Zone.

8.3.6 Water Storage Rehabilitation

The distribution system currently consists of four water towers and one above-ground storage reservoir. In order to maintain the original investment, regularly planned maintenance is carried out on these facilities. Figure 8.24 shows a map of existing storage facilities.

Reconditioning water towers and tanks typically includes structural repairs, interior and exterior blast, and repainting the interior and exterior surfaces of the water towers. The City is working on developing a plan for regular scheduled maintenance of the existing water towers and tanks based on a yearly plan using a contractor specializing in this field.

The regular scheduled water tower maintenance typically involves draining down the water towers and tanks, removing the sediment from the water towers and tanks, and touch up repairs and painting. As part of the regular maintenance, a photo journal report is also prepared for each water tower. Based on a review of the photo journal reports and general recommendations for reconditioning water towers and tanks with contractors specializing in this field, it was assumed that a water tower reconditioning schedule of 15 to 20 years would be appropriate for inclusion in regular maintenance budget planning.

Table 8.16 provides rehabilitation timelines for the current facilities. The current budgeting process considers full rehabilitation every 20 years. After a full rehabilitation, an inspections occur at the facility every five years. At the 5 year inspection, the City pays for the inspection and the company that performed the full rehabilitation performs any needed repairs as a part of the warranty services related to the full rehabilitation. At the 10 year and 15 year inspections, the City incurs any costs related to the inspection and associated repairs identified in the inspection of the facility.

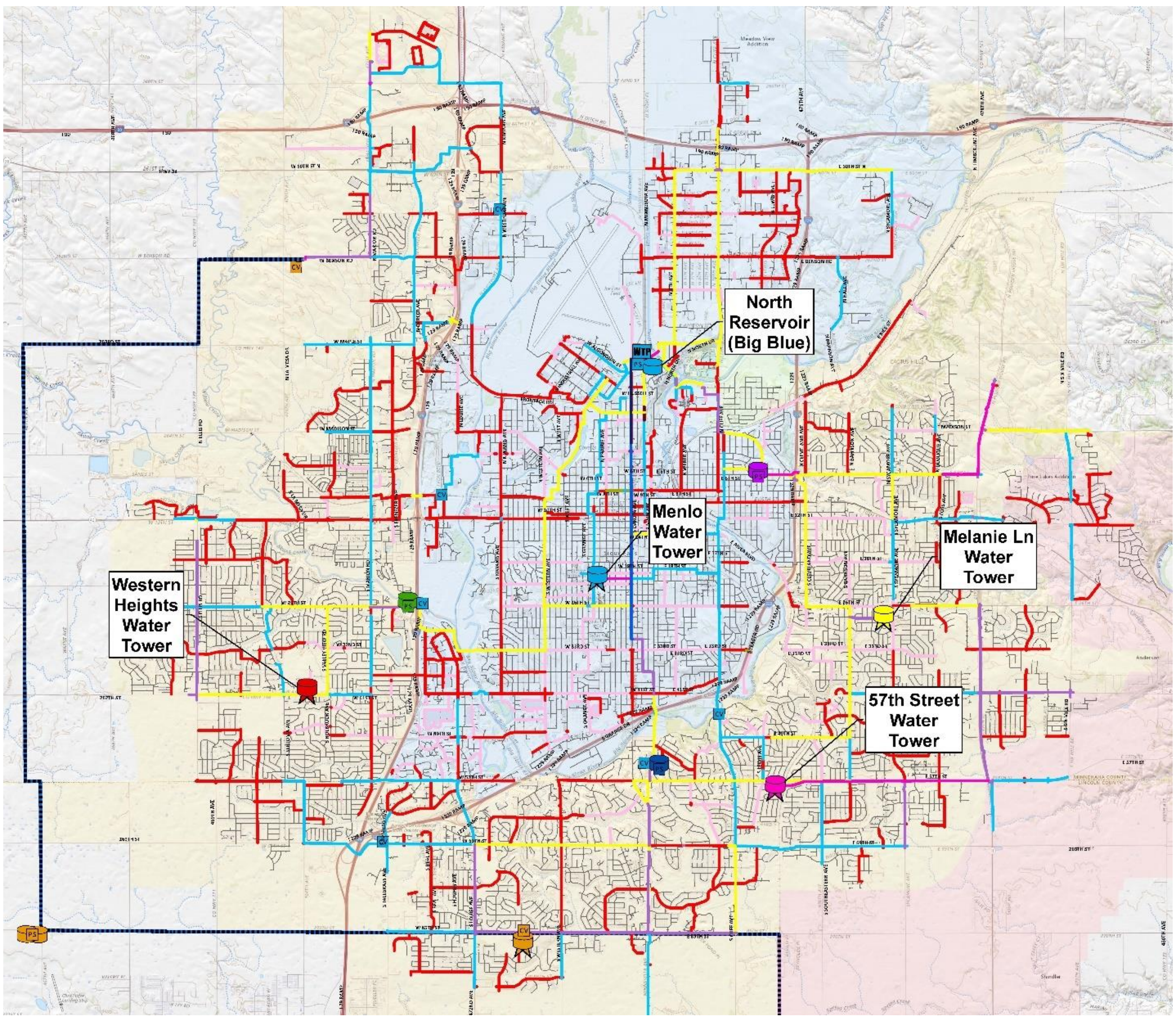


Figure 8.24 Existing Storage Facilities

Table 8.16 Storage Facility Full Rehabilitation Timeline

Facility	Full Rehabilitation Year
Menlo Water Tower	2015
Western Heights Tower	2018
Melanie Water Tower	2020
North Reservoir (Big Blue)	2024
57th St Water Tower	2025

8.3.7 Water Distribution and Transmission Replacement/Rehabilitation

One of the major key components of the water system is the buried assets which is broken into water mains within the distribution system and transmission pipelines within the transmission system. The water industry has under-invested in these buried assets as presented in the Dawn of the Replacement Era – Reinvesting in the Drinking Water Industry and Buried No Longer – Confronting America's Water Infrastructure Challenge, published by American Water Works Association (AWWA). In ongoing planning, it will be important to understand what the amount of investment needed to maintain an acceptable level of service to customers. The following provides a summary of these buried transmission and water main assets within the system.

Water Distribution System

- Water distribution system consists of water main ranging from 4-inch to 14-inch.
- This water main accounts for 87 percent (825 miles) of the water system.
- Approximately 54 percent of the water distribution system mains are 8-inch in diameter and approximately 23 percent of the water distribution mains are 6-inch in diameter.
- Cast iron (CI) material makes up about 20 percent (165 miles) of the water main of which 33 percent (55 miles) will be over 100 years old in the next 20 years.
- Ductile iron (DI) material accounts for 35 percent (293 miles) of which 69 percent (201 miles) is non poly-wrapped.
- Remaining 44 percent (367 miles) consists of polyvinyl chloride (PVC) material.

Water Transmission System

- Water transmission pipeline size range from 16-inch to 48-inch.
- The transmission pipelines accounts for 13 percent (127 miles) of the system.
- Majority of the water transmission pipelines consist of 16-inch in diameter (48 percent), 20-inch (32 percent) and 24-inch (13 percent).
- Ductile iron (DI) material accounts for 71 percent (90 miles) of which 51 percent (46 miles) is non poly-wrapped.

- Cast iron (CI) material makes up about 10 percent (13 miles) of the transmission pipeline of which 36 percent (5 miles) will be over 100 years old in the next 20 years.
- Concrete (CON) material consists of about 4 percent (5 miles) with majority in sizes from 20-inch to 42-inch.
- Remaining 15 percent (19 miles) consists of polyvinyl chloride (PVC) material.

Condition of Water Distribution Main and Water Transmission Pipelines

An important factor in determining the condition of the water distribution system and transmission system is reviewing water main break data. Water main and transmission pipeline breaks impact level of service to system customers related to disruption in water service and available system capacity.

Table 8.17 shows the number of breaks per year along with a breakdown on a monthly basis. Review of this table shows a major portion of breaks occur in the winter months and summer months when temperatures are either at their coldest or warmest. Table 8.18 shows water main breaks based on pipe material.

Table 8.17 Water Main Break Information

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Total
2008	12	10	8	8	4	4	5	5	10	7	4	6	**83**
2009	9	2	2	1	3	3	5	1	2	4	0	6	**38**
2010	4	5	11	5	3	4	3	2	4	0	10	4	**55**
2011	8	9	6	7	4	3	7	4	4	3	10	2	**67**
2012	8	2	11	0	6	2	10	10	1	4	6	8	**68**
2013	15	11	6	4	0	5	1	2	4	2	3	2	**55**
2014	6	10	4	2	4	3	2	2	3	1	5	5	**47**
2015	6	1	0	6	2	2	3	1	2	0	4	4	**31**
2016	4	2	4	5	5	6	4	5	1	3	3	6	**48**
2017	6	2	0	1	2	2	8	2	3	1	2	2	**31**
2018	9	10	8	8	6	3	3	6	2	2	1	7	**65**
2019	11	8	6	5	3	6	8	4	5	3	3	2	**64**
2020	8	9	2	0	2	2	10	8	5	6	2	2	**56**
2021	8	14	7	3	2	4	6	10	2	1	5	7	**69**
Monthly Break Total	114	95	75	55	46	49	75	62	48	37	58	63	**777**
	14.7%	12.2%	9.7%	7.1%	5.9%	6.3%	9.7%	8.0%	6.2%	4.8%	7.5%	8.1%	
Average Monthly Breaks	11.4	9.5	7.5	5.5	4.6	4.9	7.5	6.2	4.8	3.7	5.8	6.3	

Table 8.18 Water Main Breaks Based on Material

Year	CIP	CIP Relined	DIP	DIP / Wrap	PVC	Other/ Unknown	Yearly Total
2008	18	22	33	3	2	5	**83**
2009	11	8	12	2	2	3	**38**
2010	7	17	17	8	4	2	**55**
2011	11	13	31	8	3	1	**67**
2012	21	15	13	6	0	13	**68**
2013	11	17	17	7	1	1	**54**
2014	6	16	14	2	2	7	**47**
2015	8	6	9	4	1	3	**31**
2016	7	14	12	4	0	7	**44**
2017	9	4	10	6	0	2	**31**
2018	31	0	11	20	1	2	**65**
2019	6	25	19	8	2	0	**60**
2020	13	11	11	17	0	4	**56**
2021	12	24	22	8	0	3	**69**
Totals	171	192	231	103	18	53	**768**
	22.3%	25.0%	30.1%	13.4%	2.3%	6.9%	
	363		334		18	53	
	47.3%		43.5%		2.3%	6.9%	

Some key observations based on review of data are the following:

- Almost 91 percent of the water main breaks were in cast iron (CI) and ductile iron (DI) pipe material.
- Each of these pipe materials were almost an even amount with cast iron have 52 percent and ductile iron having 48 percent.
- While cast iron pipe (1910 to 1975) has been serving the water system much longer than ductile iron pipe (1965 to present), there have been almost as many water main breaks with the ductile iron pipe in recent years.
- Water main breaks within cast iron pipe occur within the 1940s and 1950s.,
- In ductile iron pipe, a majority of the break pipe installed in the 1980s with majority in non poly-wrapped pipe.

Distribution and Transmission Replacement

Due to aging water distribution systems, it is important for utilities to set aside funds for replacement and/or rehabilitation of water main and transmission pipeline infrastructure. The typical industry guideline for annual water main replacement is 1 percent of the total length of water main. This results in full water system replacement every 100 years. In many communities, replacement rates have been lower than 1 percent, therefore current needed replacement rate is often higher than 1 percent. A review of the last five years of projects related to water main and transmission pipeline projects provides the following perspective on replacement.

- Transmission pipeline replacement has been about 0.8 miles per year which is about 0.6 percent of the current 127 miles of transmission pipelines.
- Water main replacement has been about 2.4 miles per year which is about 0.3 percent of the current 825 miles of water main.
- To replace all of the cast iron water main that will be 100 years old in the next 20 years would require an investment of 2.4 miles per year. However this increases to 3.1 miles per year the next 10 years, and onward up to 4 miles per year due to growth of the City over the years to replace all of the cast iron water main.
- Not all pipe lasts 100 year as seen in some of the ductile iron pipe that is currently 30-40 years old and in need of replacement due to corrosive soils.
- The amount of replacement can vary over time dependent on factors related to the growth of the community along with the age, material, joints, and environmental conditions.

The City currently uses the following programs for replacement and rehabilitation. Each year these funds are allocated to key problem areas for water main breaks and areas being considered for overall street rehabilitation.

- City Wide Water Main Replacement Projects
  - Projects driven by the Water Division
  - Replacement of 12-inch and smaller water main typically within residential areas
  - Replacement based on areas of high number of documented water main breaks
- Neighborhood Reconstruction Program
  - Projects driven by the Engineering Division
  - Replacement of 12-inch and smaller water main within areas of residential street redevelopment
  - Evaluated based on known condition of water main and type of street reconstruction.

- Water Pipe Trenchless Rehabilitation
  - Projects driven by the Water Division
  - Pipe bursting
  - Lining existing 16-inch and larger transmission pipelines rather than replacement
  - Ductile iron pipe cathodic protection retrofit for water main and transmission pipelines to extend the life of older pipelines within areas of street overlays.
- Transmission System Improvements
  - Projects driven by the Water Division
  - Transmission pipeline replacement for 16-inch and larger pipelines
  - Replacement based on areas of high number of documented water main breaks.
  - Considerations for upsizing pipelines for increased capacity related to future growth.
- Major Street Reconstruction Program
  - Projects driven by the Engineering Division
  - Transmission pipeline replacement for 16-inch and larger pipelines
  - Evaluated based on known condition of water main and type of street reconstruction
  - Considerations for upsizing pipelines for increased capacity related to future growth.

The following are key questions relating to how much funds are needed each year for re-investment in the buried assets of the water system.

- Development of annual water main replacement rates.
- Recommendations for risk-based prioritization of water main replacement/rehabilitation.
- Benchmarking of the Sioux Falls water distribution system characteristics against other municipalities.

Recommendations

1. Continue to re-invest in replacing water main and transmission pipelines to ensure adequate level of service to customers.
2. Complete a "Water Main and Transmission Pipeline Capital Planning Study" for the following purposes:
   a. Determine level of service and key performance indicators
   b. Benchmarking of the City's system at a national level and to comparable cities.
   c. Determination of the level of reinvestment through replacement and/or rehabilitation of the system over the next 20 years.
   d. Prioritize funds to focus on assets of the greater need.

8.4 Water System Improvements (Long-term) (100-year Plan)

It is difficult to look ahead and understand what is going to happen with future growth, so why create a long-term plan of the water distribution system for the next 100 years? The answer to this question is that investment in infrastructure in the next 20 years could impact the capacity of water distribution system in the future. A roadmap of the system based on the best available planning information is provided in Figure 8.25. The layout of the future water system provides the following benefits.

- Incorporation of connections of a future water supply
- Building capacity into the transmission pipeline network
- Location of future storage
- Defining boundaries of future pressure zones

8.4.1 Future Water Supply

The present water distribution system receives water from the existing Water Purification Plant and two connections to the Lewis & Clark Regional Water System. In planning for a 100 years of growth, the peak day demand for the system would be about 128 MGD. The following table provides a breakdown of capacities planned for water supply facilities within the system. The water supply capacity of the Water Purification Plant and the Lewis & Clark RWS is ultimately planned for 109 MGD. The remaining water supply need would come from a future water supply with a capacity of 19 MGD.

In development of the future water distribution system, the system was laid out and sized to deliver a peak day demand of 128 MGD from each of these water supplies. The distribution transmission pipeline system was also sized to meet peak hour demands in sizing pumping, storage, and transmission pipelines. The assumptions for water supply in the water future water distribution system were based are shown in Table 8.19. Figure 8.26 shows the location and capacity of each of the proposed water supply points.

In review of planning for growth from the 20-year plan to the 100-year plan, a majority of the growth will occur on the west side of the system along with some growth areas to the northeast. The growth in the west side of the system will eventually exceed the 23 MGD of capacity provided by the Lewis & Clark RWS.

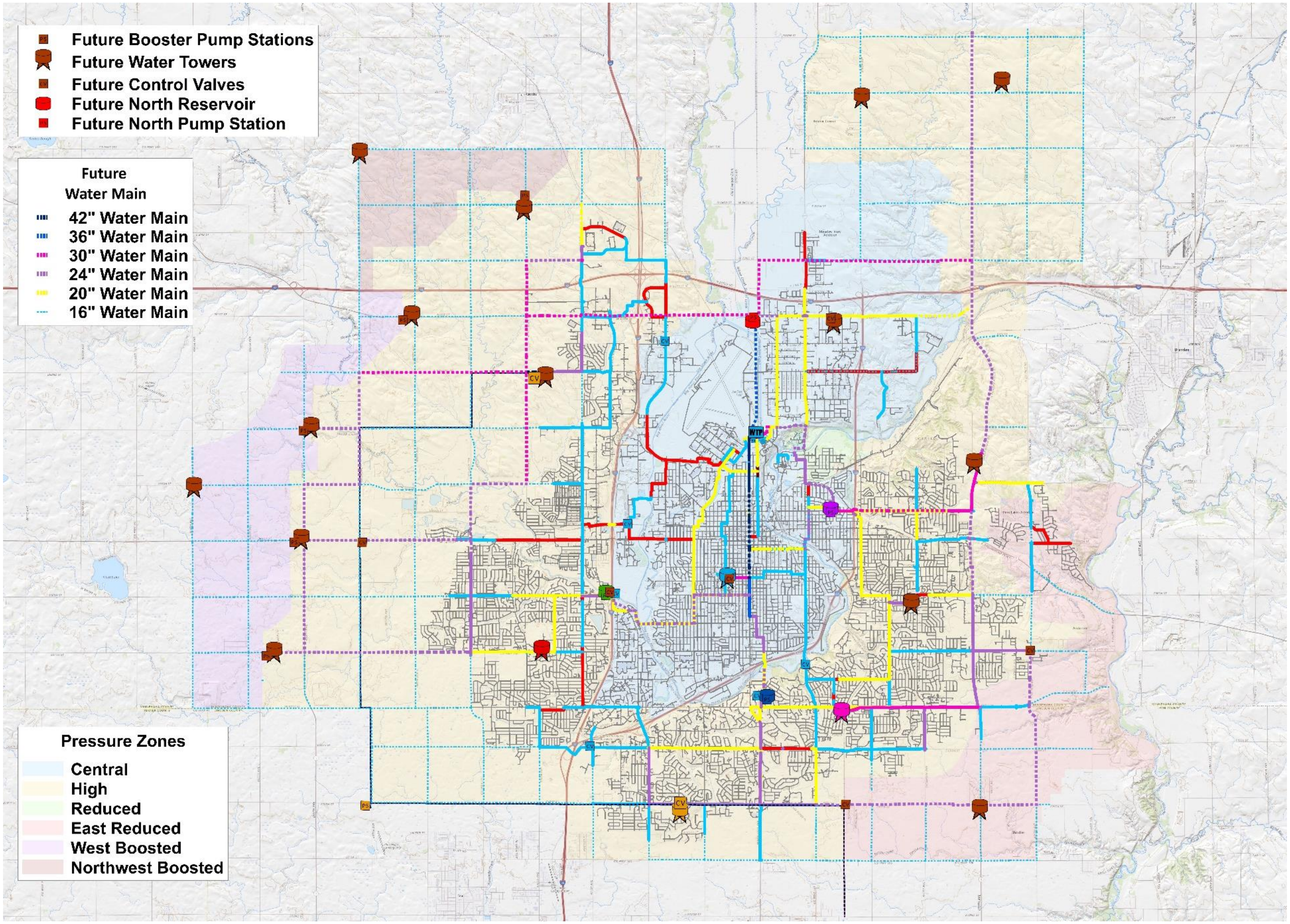


Figure 8.25 Future System Map – 100 Year Plan

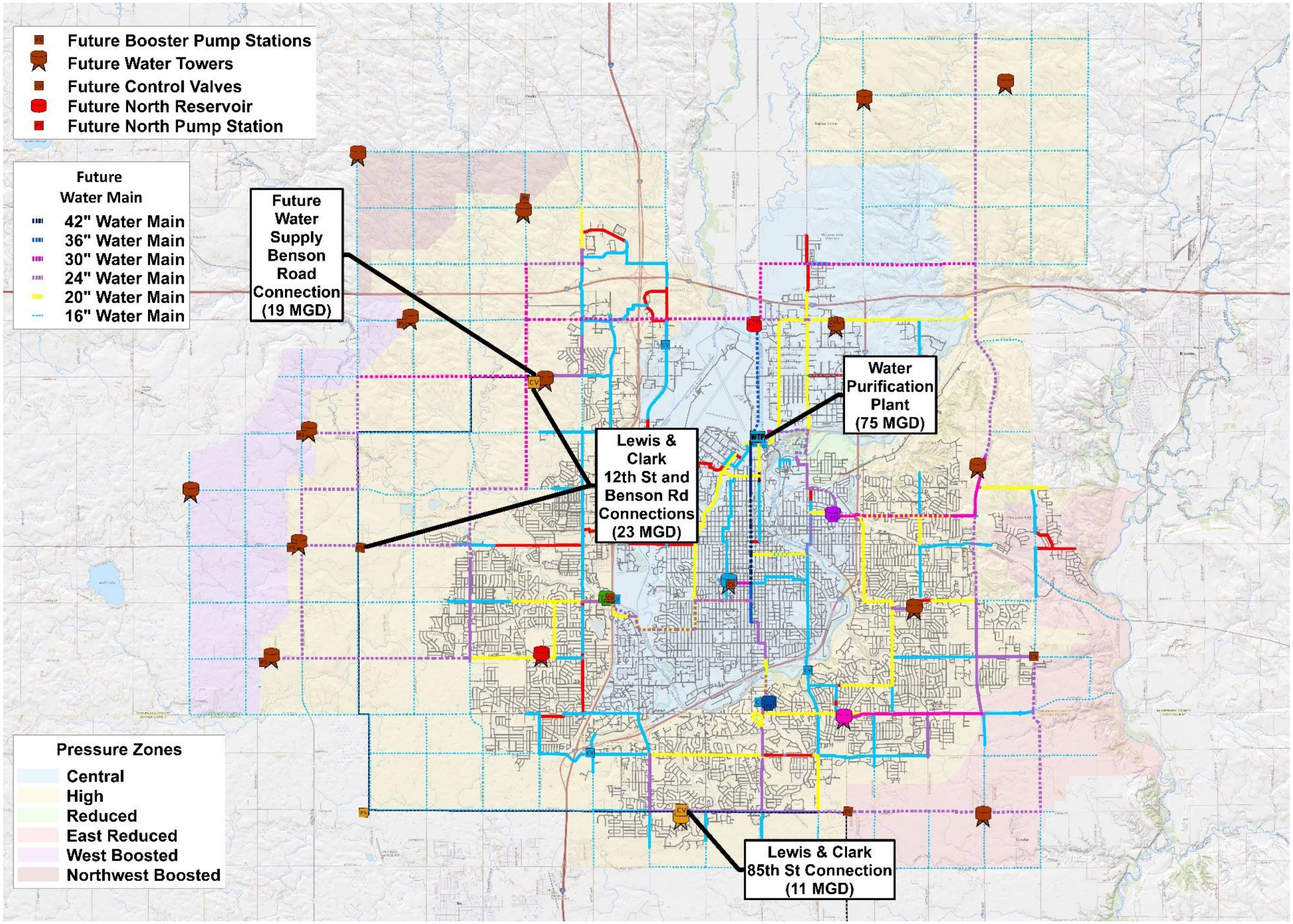


Figure 8.26 Future Water Supply – 100-Year Plan

Table 8.19 Water Supply Capacity Planning

Water Supply	Capacity
Water Purification Plant	75 MGD
Lewis & Clark RWS	34 MGD
Future Water Supply	19 MGD
Total Supply Capacity	128 MGD

- Water Purification Plant 75 MGD
- Lewis & Clark RWS
  - Benson Road and 12th St Connections 23 MGD
  - 85th Street Connection 11 MGD
- Future Water Supply
  - *Benson Road Connection 19 MGD*

For the purposes of this study, a future water supply connection would be planned at the Benson Road Connection which would be able to serve the future growth areas on the west side of the system. This future water supply would be able to fill the future Benson Road Water Tower that is planned to have a capacity of 3 million gallons. This Benson Road Water Tower is also planned to have a hydraulic grade line of about 20 feet higher than the other water towers located in the pressure zone that this connection serves.

8.4.2 Future Pressure Zones

An overview of the water distribution system and various pressure zones is presented in Figure 8.27. The future water distribution system will expand from four existing pressure zones to six pressure zones. Two new pressure zones will be formed on the west side of the system in areas of higher elevation. A list of the existing and new pressure zones is provided in Table 8.20. The boundary of a pressure zone is based on the topography of the area, and is identified by the elevation contour that corresponds to the boundary between pressure zones. Elevations and pressures served by each of the pressure zones and assists in defining the pressure zones is shown in Figure 8.28.

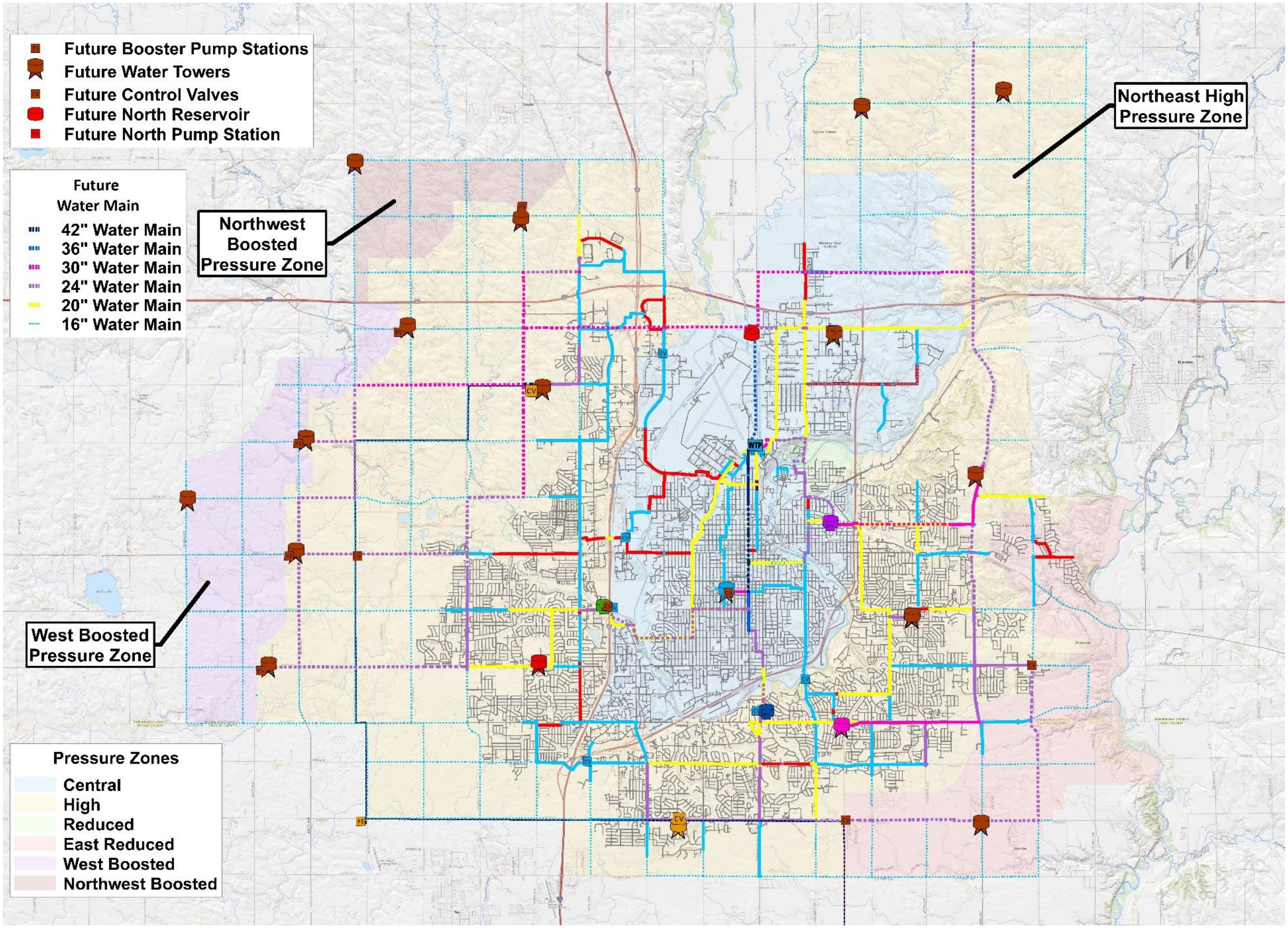


Figure 8.27 Future Pressure Zones – 100-Year Plan

Table 8.20 Summary of Pressure Zone Information

Pressure Zone	Water Tower	Water Tower Elevation		Elevations Served		Static Pressure	
		Low Level (ft)	Overflow (ft)	High (ft)	Low (ft)	High (psi)	Low (psi)
Central	Menlo	1589	1635	1543	1405	100	40
	60th St (future)	1589	1635				
High	Melanie	1630	1670	1570	1440	100	40
	57th Ave	1630	1670				
	Western Heights	1630	1670				
	Powder House (future)	1630	1670				
	Benson Road (future)	1630	1690				
	Future Tanks	1630	1670				
Reduced	None	pressure reduced	HGL 1535	1378	1308	98	68
East Reduced	None	pressure reduced	HGL 1580	1488	1349	100	40
	85th St (future)	1540	1580				
West Boosted	Future Tanks	1740	1700	1616	1509	100	54
Northwest Boosted	Future Tanks	1740	1700	1607	1509	100	58

Reduced Zone

Static Pressure	Elev. (ft)
Overflow =	1535
10 psi	1512
15 psi	1500
20 psi	1489
25 psi	1477
30 psi	1466
35 psi	1454
40 psi	1443
45 psi	**1431**
50 psi	**1420**
55 psi	**1408**
60 psi	**1396**
65 psi	**1385**
70 psi	**1373**
75 psi	**1362**
80 psi	**1350**
85 psi	1339
90 psi	1327
95 psi	1316
100 psi	1304

East Reduced Pressure Zone

Static Pressure	Elev. (ft)
Overflow =	1580
10 psi	1557
15 psi	1545
20 psi	1534
25 psi	1522
30 psi	1511
35 psi	1499
40 psi	1488
45 psi	**1476**
50 psi	**1465**
55 psi	**1453**
60 psi	**1441**
65 psi	**1430**
70 psi	**1418**
75 psi	**1407**
80 psi	**1395**
85 psi	1384
90 psi	1372
95 psi	1361
100 psi	1349

Central Zone

Static Pressure	Elev. (ft)
Overflow =	1635
10 psi	1612
15 psi	1600
20 psi	1589
25 psi	1577
30 psi	1566
35 psi	1554
40 psi	1543
45 psi	**1531**
50 psi	**1520**
55 psi	**1508**
60 psi	**1496**
65 psi	**1485**
70 psi	**1473**
75 psi	**1462**
80 psi	**1450**
85 psi	1439
90 psi	1427
95 psi	1416
100 psi	1404

High Zone

Static Pressure	Elev. (ft)
Overflow =	1670
10 psi	1647
15 psi	1635
20 psi	1624
25 psi	1612
30 psi	1601
35 psi	1589
40 psi	1578
45 psi	**1566**
50 psi	**1555**
55 psi	**1543**
60 psi	**1531**
65 psi	**1520**
70 psi	**1508**
75 psi	**1497**
80 psi	**1485**
85 psi	1474
90 psi	1462
95 psi	1451
100 psi	1439

West and Northwest Boosted Pressure Zone

Static Pressure	Elev. (ft)
Overflow =	1740
10 psi	1717
15 psi	1705
20 psi	1694
25 psi	1682
30 psi	1671
35 psi	1659
40 psi	1648
45 psi	**1636**
50 psi	**1625**
55 psi	**1613**
60 psi	**1601**
65 psi	**1590**
70 psi	**1578**
75 psi	**1567**
80 psi	**1555**
85 psi	1544
90 psi	1532
95 psi	1521
100 psi	1509

Figure 8.28 Pressure Zones – Defining Areas

The preliminary layout of future pressure zones was achieved by reviewing contour maps that show the topography of the future growth areas. Normally, the difference between steps in pressure zones should be between 80 and 120 feet. Larger step sizes will either over-pressurize the lower elevation customers in a zone, or under-pressurize those in higher elevations (or both). Smaller step sizes require an excessive number of zones, and consequently, an excessive number of pumps, tanks, and PRVs.

Proposed zone boundaries are not ironclad limits, but rather provide an initial, workable draft of a functional system layout. The pressure zone boundaries shown in Figure 8.27 also consider the layout of existing and future roads and other land features and generally follow the contours of the land. Smaller zones served by PRVs from the higher zone may by the best solution in areas with low elevation areas that are within a higher pressure zone.

8.4.3 Future Transmission Pipelines

A roadmap of transmission improvements for the water distribution system are presented within this section. Figure 8.29 highlights key transmission pipeline areas within the long-term plan. Transmission improvements are recommended to meet at least one of the following objectives:

- Capacity – build capacity into the transmission pipelines as it is more difficult and more costly to up-size/parallel in the future;
- System Extension –plan and layout of transmission pipelines for future service area growth and development; and
- Fire Flow – provide adequate fire flows for future commercial and industrial areas.

Key areas of transmission within the 100-year plan are the following:

- Transmission pipelines within West High Zone
- Transmission pipeline from the Water Purification Plant north to a future North Reservoir and Pump Station
- Transmission pipeline from the future North Reservoir and Pump Station west to the West High Zone
- Transmission Pipeline from the future North Reservoir and Pump Station east to the East High Zone and the Northeast High Zone
- Transmission Pipeline between the East High Zone and the Northeast High Zone

<u>Transmission with West High Zone</u>

Transmission pipelines will be key in delivering water further west within the West High Zone. The following are the purpose and benefits of these pipelines.

- Provide transmission of water to future water towers located along the west boundary of the pressure zone. As the system continues to expand to the west, another north/south transmission pipeline corridor will be needed to provide capacity for the expanded growth.
- Delivery of water to the future West Boosted Zone and Northwest Boosted Zone. These transmission pipelines will provide capacity to these future areas that will require new pressure zones boosted from pumps located at water towers serving the West High Zone.

The following is a list of key transmission pipeline projects:

- 30-inch extended west along Benson Road
- 24-inch west along 12th Street corridor
- 24-inch west along 41st Street corridor
- 24-inch extended north and south along the western edge of the West High Zone from Benson Road to 41st Street

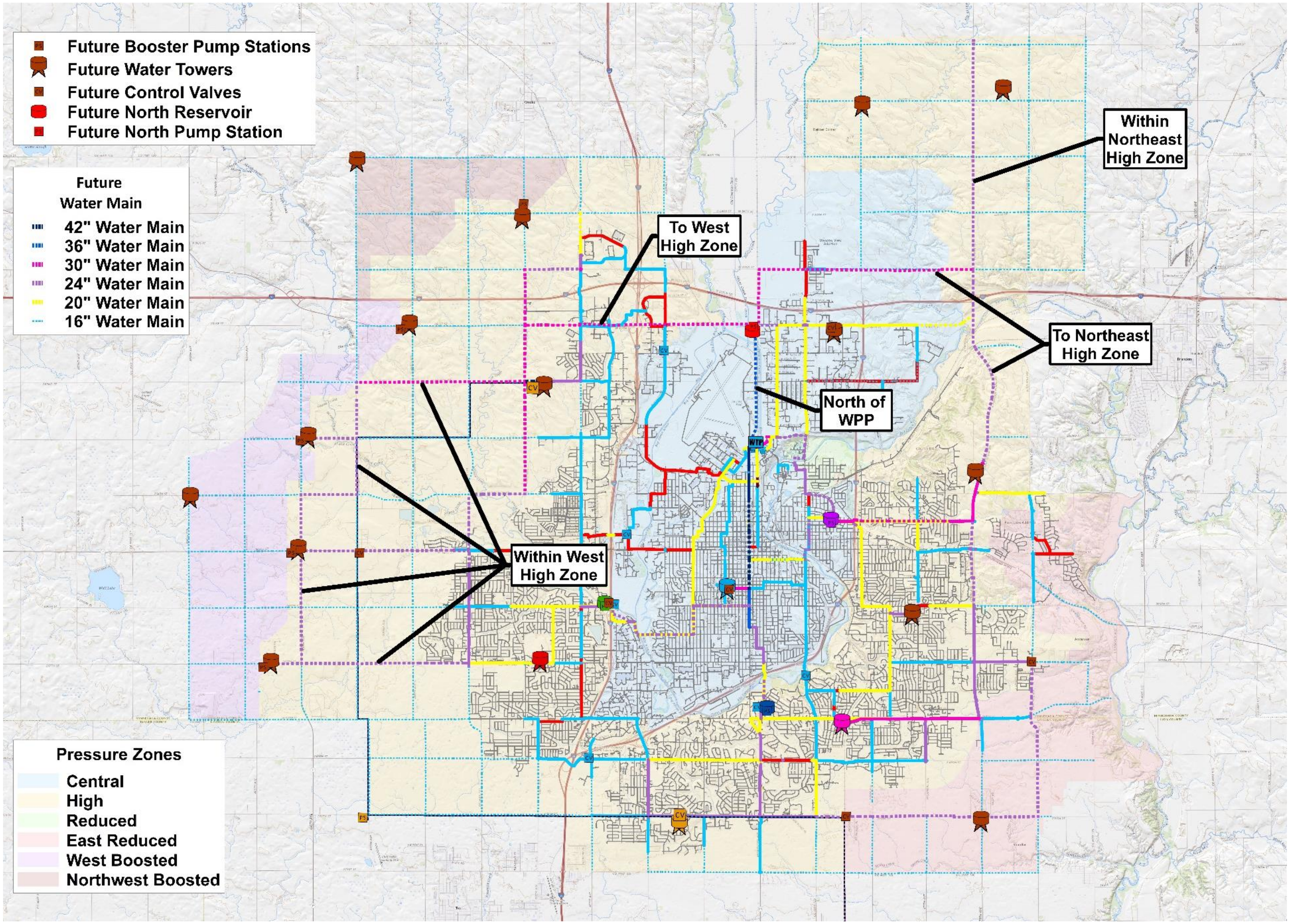


Figure 8.29 Future System Layout – Key Transmission Pipeline Corridors

Transmission from Water Purification Plant north to Future North Reservoir and Pump Station

This transmission pipeline will be critical to providing the ability to deliver expanded capacity from the Water Purification Plant to the West High Zone and the Northeast High Zone via the future North Reservoir and Pump Station. The project will consist of the following:

- 36-inch extended north along Minnesota Avenue from the Water Purification Plant to the future North Reservoir and Pump Station located near 60th Street North.

Transmission from future North Reservoir and Pump Station to West High Zone

This transmission pipeline would provide the ability to move water between the West High Zone and the Central Zone. The following are the purpose and benefits of these pipelines.

- Delivery of water to the West High Zone from the Water Purification Plant within the Central Zone via the ability to pump from the future North Reservoir and Pump Station.
- Ability to move water from the West High Zone to the Central Zone via a control valve at the future North Reservoir and Pump Station. This would allow the ability to access water from Lewis & Clark RWS and/or a future water supply connection at Benson Road.

The project will consist of the following:

- 30-inch pipeline along 60th Street North from the future North Reservoir and Pump Station at Minnesota Avenue to west to a future north/south 30-inch pipeline along La Mesa Drive that would either deliver water north to Foundation Park or south to the system network at Benson Road.

Transmission from future North Reservoir and Pump Station to Northeast High Zone

This transmission pipeline would provide the ability to deliver water from the Central Zone to the Northeast High Zone. The future North Reservoir and Pump Station would be able to pump water to the Northeast High Zone. The route of the pipeline would extend through the Central Zone to the boundary of the Northeast High Zone and would not serve any of the system within the Central Zone.

Note that the North Reservoir and Pump Station would receive water from the expanded capacity of the Water Purification Plant via transmission within the Central Zone. Water could also be transferred from the Northeast High Zone south to the East High Zone. The project will consist of the following:

- 30-inch pipeline along Minnesota Ave to 72nd Street North, then east along 72nd St N to a connection point north of the intersection of Interstate 90 and Veterans Parkway to connect with a future north/south 24-inch pipeline serving the Northeast High Zone to the north or transferring water to East High Zone to the south.

Transmission East High Zone and Northeast High Zone

This transmission pipeline would interconnect the East High Zone and the Northeast High Zone and allow water to flow back and forth between each of these pressure zones. This interconnect would provide capacity between the two pressure zones along with provide redundancy based the ability to receive water from either the East Reservoir and Pump Station or the future North Reservoir and Pump Station. The project will consist of the following:

- 24-inch pipeline along Veteran's Parkway from the future Powder House Water Tower north to 72nd Street North.

8.4.4 Future Water Storage Facilities

A key aspect of developing a 100-year plan is to determine potential need and location of future storage facilities. The future distribution system storage was evaluated to determine the location of future water storage facilities that would provide operational storage, fire protection storage, and emergency storage. A general layout of future storage within the distribution system is shown in Figure 8.30.

The following are key areas for future storage in planning for long-term growth.

- North Reservoir and Pump Station
- West High Zone Water Towers and Booster Pump Stations
- Northwest Boosted Zone Tower
- West Boosted Zone Tower
- Northeast High Zone Towers
- East Reduced Zone Tower

North Reservoir and Pump Station

This future reservoir and pump station would be able to pump water from the Central Zone to the either the West High Zone or the Northeast High Zone. Water storage would provide capacity for meeting peak hour demands through provided pump capacity. Water storage would also provide for emergency storage in the case of a transmission pipeline outage or disruption in water supply capacity. This project would consist of the following:

- Reservoir with a capacity of 5 million gallons
- Pump Station with overall capacity of 40 MGD using 5 pumps
- Flow Control Valve to allow water to move from the West High Zone to the Central Zone

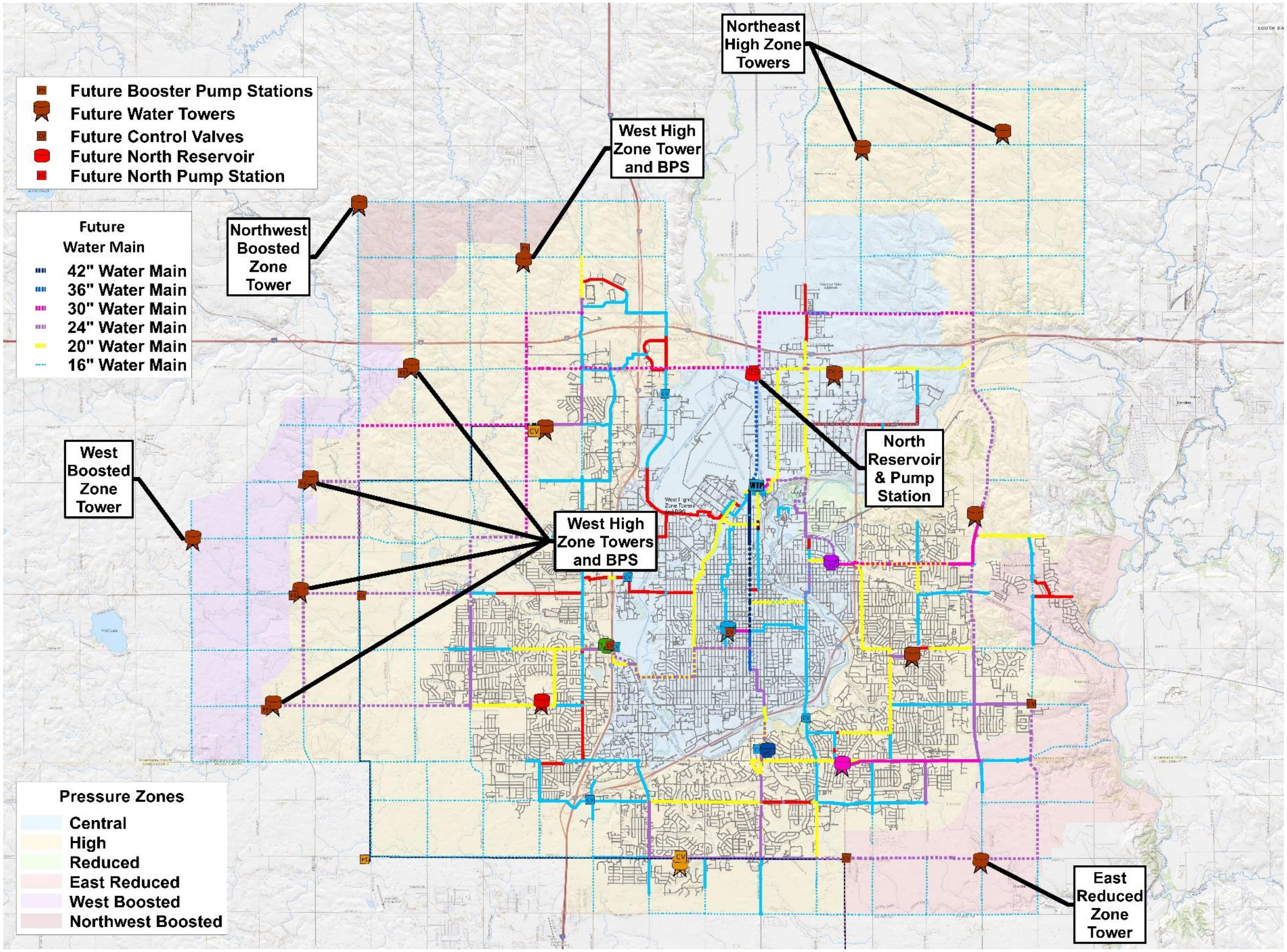


Figure 8.30 Future System Layout – Water Storage Facilities

West High Zone Water Towers and Booster Pump Stations

These future water towers provide expanded water storage within the West High Zone. These water towers would be located along the western edge of the pressure zone and would have booster pumps located in the base of the water tower to pump water to future Northwest Boosted Zone and the West Boosted Zone. Each of these future pressure zones would serve areas of high elevation that could not provide adequate pressure based on the hydraulic grade line of the West High Zone. Each water tower would consist of the following:

- 1.5 Million Gallon Water Tower
  - Overflow elevation = 1670 feet
  - Head Range = 40 feet
- Booster Pump Station in the base of the water tower
  - Two pumps with the ability to expand to four pumps
  - Initial setup to boost into a closed system maintaining a discharge pressure
  - Final setup to boost to a future water tower within the future pressure zone

Based on the current future layout of the West High Zone, it is anticipated that there would be five (5) future water towers based on each having a size of 1.5 million gallons. As the system grows and there is a better understanding of overall growth, consideration could be taken into account for building fewer water towers by upsizing the capacity of the remaining water towers in order to accommodate the storage requirements within this service area.

Northwest Boosted Zone Tower

Water storage will be necessary within the Northwest Boosted Zone as the area becomes developed with more system demand and fire flow requirements. Based on the current growth planned, one water tower would be required to meet system demands. The proposed tower would be based on the following:

- 1.5 Million Gallon Water Tower
  - Overflow elevation = 1740 feet
  - Head Range = 40 feet

West Boosted Zone Tower

Water storage will be necessary within the West Boosted Zone as the area becomes developed with more system demand and fire flow requirements. Based on the current growth planned, one water tower would be required to meet system demands. The proposed tower would be based on the following:

- 1.5 Million Gallon Water Tower
  - Overflow elevation = 1740 feet
  - Head Range = 40 feet

Northeast High Zone Towers

These future water towers provide expanded water storage within the Northeast High Zone. These water towers would be located on either side of the north/south transmission pipeline serving this growth area. Each water tower would consist of the following:

- 1.5 Million Gallon Water Tower
  - Overflow elevation = 1670 feet
  - Head Range = 40 feet

Based on the current future layout of the West High Zone, it is anticipated that there would be two (2) future water towers based on each having a size of 1.5 million gallons.

East Reduced Zone Tower

The East Reduced Zone receives its water from four (4) pressure reducing stations that deliver water from the East High Zone and South High Zone. These pressure reducing stations are able to meet the peak hour demands within this reduced pressure zone. With this pressure zone being very large and with considerable demand requirements, the East Reduced Zone will eventually affect the equalization storage to meet peak hour demands within the High Zone which may require additional water tower storage.

A future water tower could be constructed in either the High Zone or the East Reduced Zone. A water tower constructed within the East Reduced Zone would provide floating storage within this pressure zone. A proposed water tower would then be filled using a flow control strategy at each of the pressure reducing stations to fill the tower based on tower level. A water tower within the pressure zone would allow greater redundancy within the system for available fire flow storage and less likelihood of pressure fluctuations related to failures within the pressure reducing stations. Note that currently the pressure reducing stations are monitored for pressures upstream and downstream along with flow into the pressure zone. The proposed tower would be based on the following:

- 1.5 Million Gallon Water Tower
  - Overflow elevation = 1580 feet
  - Head Range = 40 feet

Chapter 9 Capital Improvement Plan

This chapter presents recommended CIP projects identified in the course of assessing the current water system and evaluating near-term and long-term needs. The recommended water system improvement projects represent the results of:

1) The existing and future system evaluations;
2) Multiple meetings with City staff.

An all-inclusive list of identified improvement projects was compiled for a comprehensive CIP evaluation. Cost estimates were generated for each project and the projects were prioritized utilizing a ranking process developed to facilitate spending capital dollars in the most cost-effective manner possible.

This chapter includes descriptions of the CIP project categories, cost estimate methodology, implementation considerations, and a summary of recommended improvements.

9.1 CIP Project Categories

Projects identified within the CIP were divided into the following eight categories:

- Supply
- Transmission
- Storage
- Growth and Development
- Rehabilitation and Repair
- Optimization
- Studies
- Condition Assessment

The development of these categories provided the conceptual framework for CIP development, project prioritization and timeframe progressions, and correlated projects to the City's present fiscal resources (i.e., what type of project makes the best use of the available capital improvement budget). Each category is described in the following subsections.

9.1.1 Supply

The intent of these projects is to increase the overall water supply available to the distribution system, which ensures the City maintains its current level of service, satisfies regulatory requirements, and adequately provides water to future customers.

9.1.2 Transmission

Projects identified for the transmission category were determined through the hydraulic modeling analysis. The identified projects consist of large diameter transmission mains (16-inch to 42-inch) that convey large volumes of water throughout the entire distribution system. The proposed transmission mains are critical to maintain both the existing and future levels of service.

9.1.3 Storage

Projects identified for the storage category were based on the evaluation the existing and future system analysis. These projects increase the overall water storage capacity of the system, ensure adequate fire flow, and supplement water supply during periods of planned maintenance or emergencies.

9.1.4 Growth and Development

Projects identified for the growth and development category provide the necessary infrastructure to serve both existing and future customers. Growth and development projects meet three needs:

1) Service for future development.
2) Demand for water supply in already developed areas.
3) Infill and redevelopment.

The timing of the need for growth and development projects can be difficult to predict. For this reason, the prioritization of improvements is evaluated as growth occurs.

9.1.5 Rehabilitation and Repair

Rehabilitation and repair projects are generally associated with pipe segments experiencing high break rates, water quality issues, are undersized (cannot attain fire flow goal), or require maintenance. The City is in the process of developing a risk assessment process utilizing these factors in a structured and systematic process was used as a means of identifying pipe segments with highest risk, measured through a consequence and likelihood of failure assessment, and then generating projects to mitigate the risk.

9.1.6 Optimization

Projects identified for the optimization category improve system water quality, promote network water efficiency and movement, help with pressure management, or eliminate facilities to reduce operating cost and improve overall network performance. These projects include transmission pipeline improvements, booster station improvements, and flow control upgrades.

9.1.7 Studies

The objective of study projects is to perform additional analysis and develop better information so the City can make informed decisions regarding future projects.

9.1.8 Condition Assessment

Condition assessment is a process used to identify degradation of a pipeline before failure, or to identify viable life remaining in a segment of pipeline to avoid spending money on unnecessary replacement or rehabilitation. There is a wide range of utility investment in condition assessment. The potential advantage of a robust condition assessment program is more efficient use of capital by prioritizing replacement projects and determining long-term funding needs.

9.2 Opinion of Probable Project Cost for CIP Development

This section describes the methodology used to develop the Opinion of Probable Project Cost (OPPC) for the various types of projects outlined in the WDSMP and contains the following information:

- Opinion of Probable Project Cost Basis
- Estimate Classification
- Estimating Exclusions
- Total Estimated Project Cost
- Total Opinion of Probable Project Cost

9.2.1 Opinion of Probable Project Costs Basis

The OPPC values were based on the total capital investment necessary to complete a project from engineering design through construction. All estimates are based on engineering experience and judgment, recent bid tabulations for projects of similar scope, and input from area contractors and material suppliers. All costs are presented in 2022 dollars and inflated for each CIP project based on the estimated year it will be bid or constructed.

Total estimated project costs were divided into five main components, as follows:

- Hard Costs – The actual physical construction of the project (i.e., excavation, materials, labor, restoration).
- Soft Costs – Fees that are not directly related to labor and building materials (i.e., architecture and engineering fees, permitting/environmental, contract administration, legal).
- Property Acquisition Costs – The cost to obtain property, right-of-way, and easements.
- Contingency – Amount added to the estimated cost to cover both identified and unidentified risk events that occur on the project.
- Inflation – The application of the average annual inflation rate anticipated between the time an estimate is prepared and when the project is bid or projected for construction.

The sum of these five components is the total OPPC. The OPPC values are based on the preliminary concepts and layouts of the water system components developed as a result of the hydraulic modeling of the system and corresponding recommendations. The estimate is to be an indication of fair market value and is not necessarily a reflection of the lowest bid. Fair market value is assumed to be mid-range tender considering four or more competitive bids.

9.2.2 Estimate Classification

The American Association of Cost Engineers (AACE) provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The purpose for following a classification process is to align the level of estimating with the use of the information. The estimates provided in the WDSMP are classified in accordance with the criteria established by the AACE cost estimating classification system referred to as Standard Practice 18R-97.

In accordance with AACE criteria, the OPPC values are representative of Class 4 estimates. A Class 4 estimate is defined as a study or feasibility estimate. Typically, the engineering effort is from 1 to 15 percent complete. Class 4 estimates are used to prepare planning-level effort cost scopes or complete an evaluation of alternative schemes, technical feasibility, and preliminary budget approval or approval to proceed to the next stage of implementation.

Expected accuracy for Class 4 estimates typically range from -30 to +50 percent, depending on the technical complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.

9.2.3 Estimating Exclusions

Unless specifically identified, the following was excluded in the development of the cost estimates:

- Environmental mitigation of hazardous materials and/or disposal.
- O&M costs for the project components.

9.2.4 Total Estimated Project Cost

The following sections provide a breakdown of each of the different items included in each cost component associated with developing the total OPPC for each project.

9.2.4.2 Hard Costs

Hard costs, sometimes referred to as contractor construction costs, represent the actual physical construction of a project. This section was divided into component unit costs and hard cost markups. The following sources of information were used to compile the hard cost estimates:

- Review of 2022 construction bid tabs for similar projects
- Review of current city estimates of construction costs
- Review of recently bid projects for city replacement projects
- Review of historical bid prices for the City
- Vendor, supplier, and contractor estimates for specific equipment and materials

9.2.4.3 Hard Cost Markups

Hard cost markups are applied to the hard costs and construction costs to calculate total construction costs. The hard cost markups are reflected in the individual capital improvement project cost estimates. Markups vary depending on the size and type of the project.

1. Mobilization/demobilization/insurance/permits/bonds – 0-8 percent
   Mobilization costs include the administrative costs and expenses to mobilize materials, equipment, and labor to the jobsite and demobilize upon project completion. Costs associated with contractor insurance, permits, and bonding are also included.
2. Traffic Control – 0-5 percent
   Traffic control was assigned to projects that occur in the public right-of-way, primarily transmission projects.
3. Erosion Control – 0-1 percent
   Erosion control will likely be required for all construction projects to ensure compliance with Storm Water Pollution Prevention Plans.
4. Testing and Construction Surveying – 0-3 percent
   Costs associated with materials testing during construction in addition to construction surveying and staking.

9.2.4.4 Soft Costs

To adequately complete the planning, design, and construction of projects listed in this WDSMP, there are significant soft costs to consider. Soft costs are non-construction labor costs consisting of architecture and engineering fees, permitting and environmental compliance, contract administration, legal fees, etc. Soft costs are applied to the hard costs plus the hard cost markups. A breakdown and summary of the soft costs included in the cost estimates are provided below.

1. Engineering Design – 0-20 percent
   Costs include preliminary engineering through final design, which involves the development of final project plans and specifications that will be stamped by a professional consulting engineer. Engineering costs include disciplines such as process, civil, electrical, mechanical, architectural, and structural. Costs also include surveying, testing, investigations, and inspections during the design phase.
2. Construction Administration and Management – 0-10 percent
   Costs include services to provide quality control, quality assurance, and construction management during the construction phase and services associated with the initial operation including training of operational, maintenance, and supervisory staff.
3. Legal and Administrative – 0-5 percent
   Costs associated with the local and State project approval process, and any legal costs, are included in this category. Responsible tasks may include road crossing permits, construction permits, county building permits, expenses incurred by the City, etc.
4. Other Soft Costs – Varies
   Several specialized projects required unique soft costs that vary from project to project, such as programming and startup for control system updates, hydraulic modeling and operational evaluations for flow control and booster station upgrades.

9.2.4.5 Property Acquisition Costs

Property acquisition costs are associated with purchasing property and acquiring right-of-way or easements for the project. These costs were generated based on average 2022 real estate values of land in Sioux Falls. This was appropriate for most of the identified CIP projects anticipated to be built outside of right-of-way.

9.2.4.6 Contingency

A contingency is an amount added to the base cost to cover both identified and unidentified risk events that occur on the project. Depending on the project type, the contingency values ranged from 10 to 30 percent. The contingency values were added to the overall project base cost (i.e., hard and soft costs) in anticipation of uncertainties inherent to the planning-level analysis completed for the WDSMP.

9.2.4.7 Inflation

Projects intended for construction several years in the future include a factor for inflationary impacts to address the general trend of cost indices, which accounts for future labor, material, and equipment cost increases beyond values at the time the estimate is prepared. For this planning-level analysis, the 2022 project costs were inflated to the construction year anticipated for each CIP project. An annual average inflation rate was generated based on historic inflation data to estimate inflation trends into the future.

9.2.4.8 Summary of Estimate Markups

Table 9.1 provides a summary of the suggested hard costs markups, soft costs, and contingency rate percentages.

Table 9.1 Total Estimate Project Markup Summary

Item	Rate Range (%)
Hard Cost Markups	
Mobilization/Demobilization/Insurance/Permits/Bonds	0-8
Traffic Control	0-5
Erosion Control	0-1
Testing and Construction Surveying	0-3
Soft Costs	
Engineering Design	0-20
Construction Administration and Management	0-10
Legal and Administrative	0-5
Other	
Property Acquisition	Unit Price
Contingency	10-30
Estimated Annual Inflation	2.9

9.3 CIP Timing, Prioritization, and Implementation

Following the basis of planning detailed in Chapter 3, CIPs identified within this WDSMP were divided into near-term (20 year) and long-term (100-year timeframes). Specific project timing was determined using the hydraulic model, detailed demand trend charts for supply wells and storage tanks, and anticipated system growth maps developed by City planning.

The project team then developed a prioritization process for near-term 20-year CIP, using a methodology with nine prioritization factors applicable to the types of projects identified in this WDSMP. Table 9.2 lists the nine prioritization factors used to help prioritize projects.

The prioritization resulted in a ranking for near-term projects. Projects consist of existing City CIPs, growth and development, or previously identified near-term projects rotated into the near-term planning period by City staff which is based on overlap with other utilities (i.e., road rehabilitation).

Table 9.2 Prioritization Factors

Prioritization Factors	
1	Are there other affected projects? Coordination, prerequisite, opportunistic, etc.
2	How is capacity affected by this project?
3	Describe the criticality (i.e., importance) of this project to the operation.
4	How is connectivity affected by this project? (Reliability/Redundancy)
5	What safety issues are mitigated with this project?
6	What regulations or standards are attained with this project?
7	How is efficiency improved by this project?
8	What is the impact of this project?

9.4 Recommended Capital Improvements

This section will provide an overview of the 20-year capital improvement budgeting for the water distribution system. The 20-year plan was based on an end year of 2045 to coordinate with the Go Sioux Falls 2045 planning efforts which gives an actual time frame of 22 years based on a current year of 2023. Future population and demand projections were based on the following years, 2025, 2030, 2035, 2040 and 2045.

Planning was considered for 50-year (2066) and 100-year (2116) periods to provide greater long-term understanding of the impacts of growth on infrastructure related to sizing of transmission pipelines that will be constructed in the next 20 years. Projects outside of the year 2045 were noted but not included in the 20-year capital improvement planning.

For the purpose of this section, capital improvement projects recommended for consideration were divided into the following time frames:

- Short-Term (0-5 year) (2023 to 2027)
- Near-Term (5-15 year) (2028 to 2037)
- Long-Term (15+ years) (2038 to 2045)

A map showing proposed improvements is shown in Figure 9.1. A cost summary for recommended improvements is shown in Figure 9.2 which shows a breakdown of costs for water driven and engineering driven projects. Figure 9.3 provides a understanding of costs related to project categories. Each of these figures show the costs in 5-year increments from 2023 to 2045.

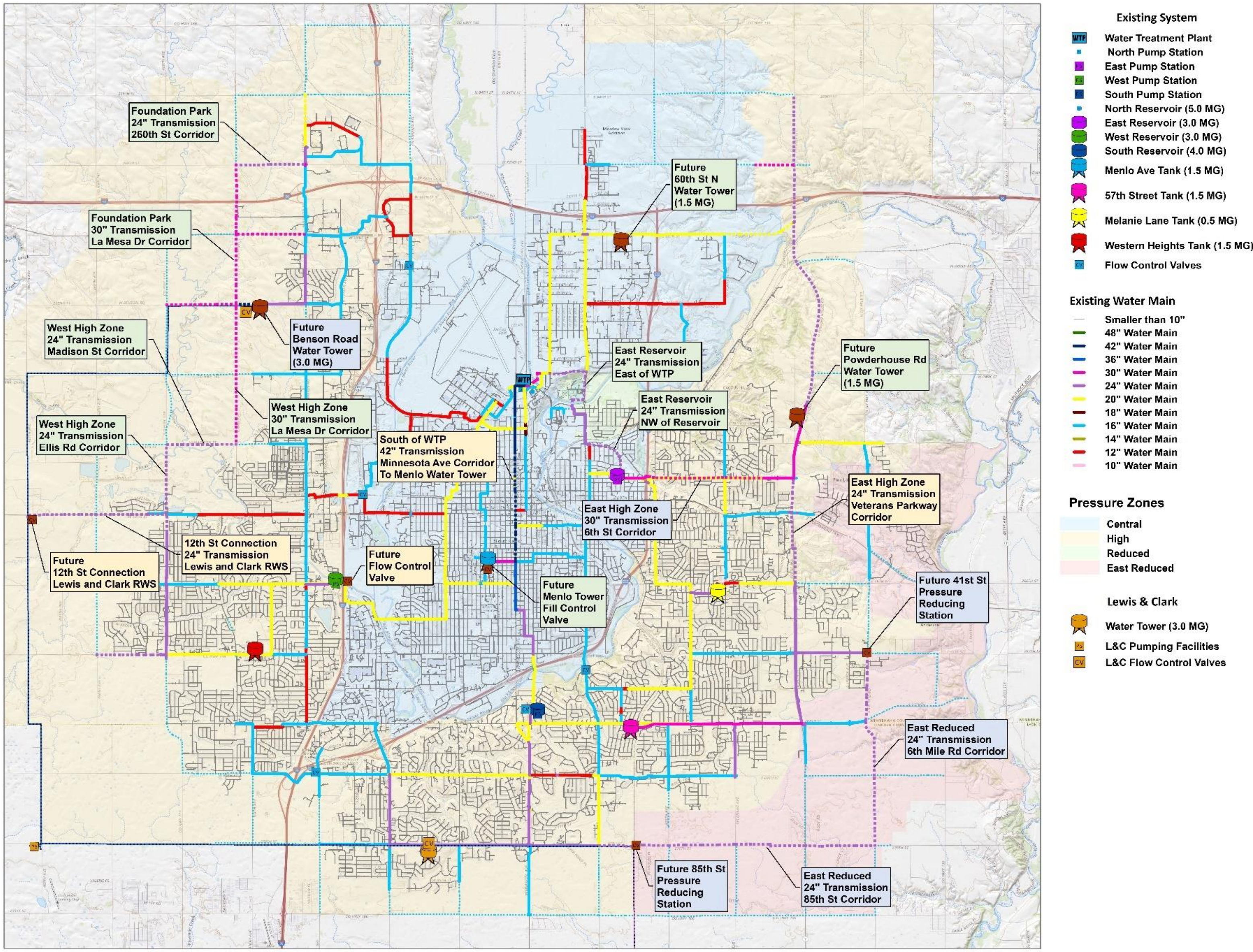


Figure 9.1 Proposed System Improvements – 20-Year Plan

Figure 9.2 CIP Costs based on 5-year increments – 20-Year Plan

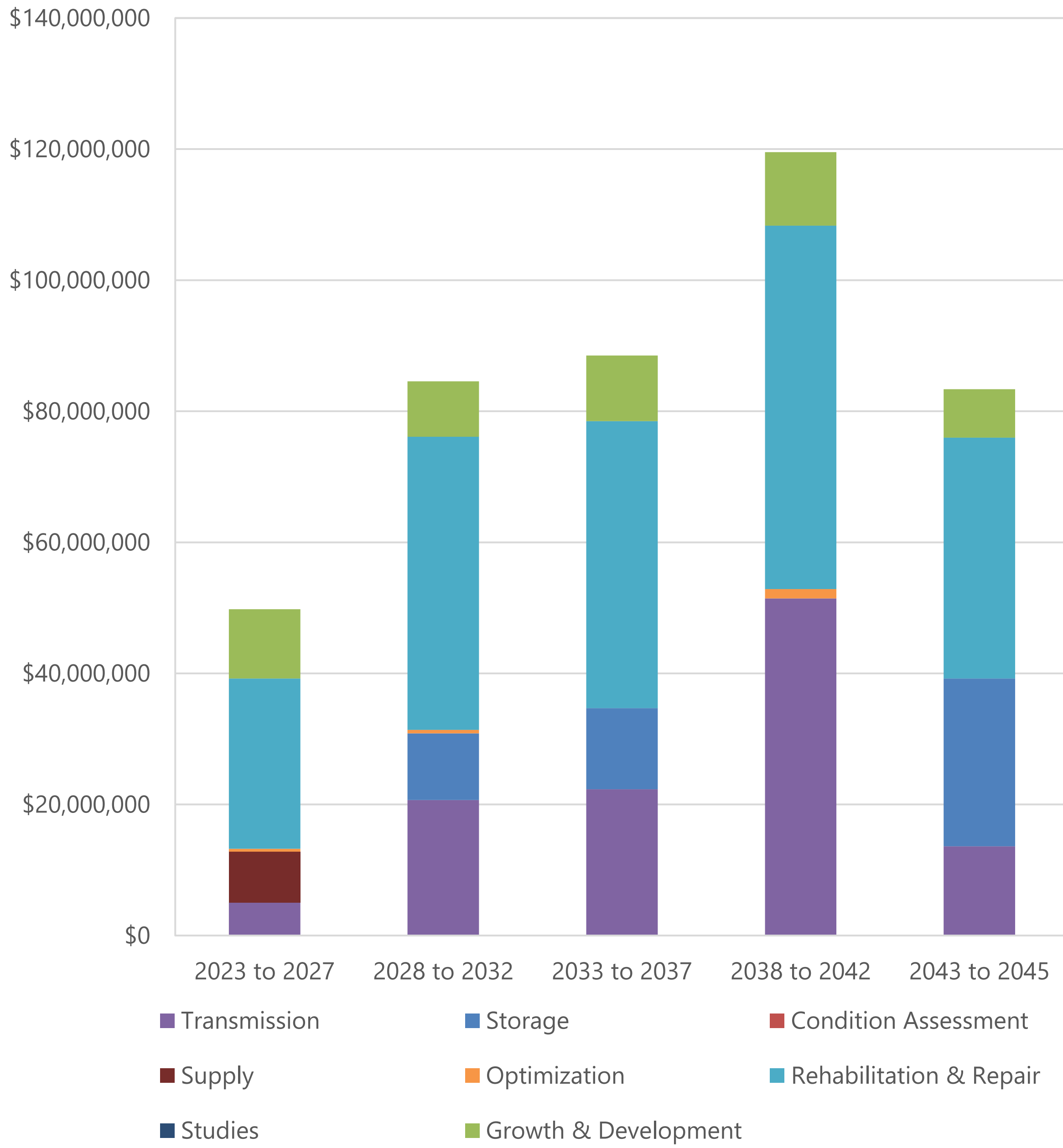


Figure 9.3 Project Categories and OPPC – 20-Year Plan

9.4.1 Short-Term (0-5 Years) CIP Projects

The following are key projects identified to be completed in the next 5 years from 2023 to 2027.

- Upgrade and Replacement of Transmission Pipeline along Minnesota Ave Corridor
- New Transmission Pipeline along Veterans Parkway
- New L&C RWS Connection and Transmission Pipeline at 12th Street

Figure 9.4 provides a map of proposed projects while a list of these project is included in Table 9.3. Figure 9.5 and Figure 9.6 provide an understanding of project costs related to funding and project categories.

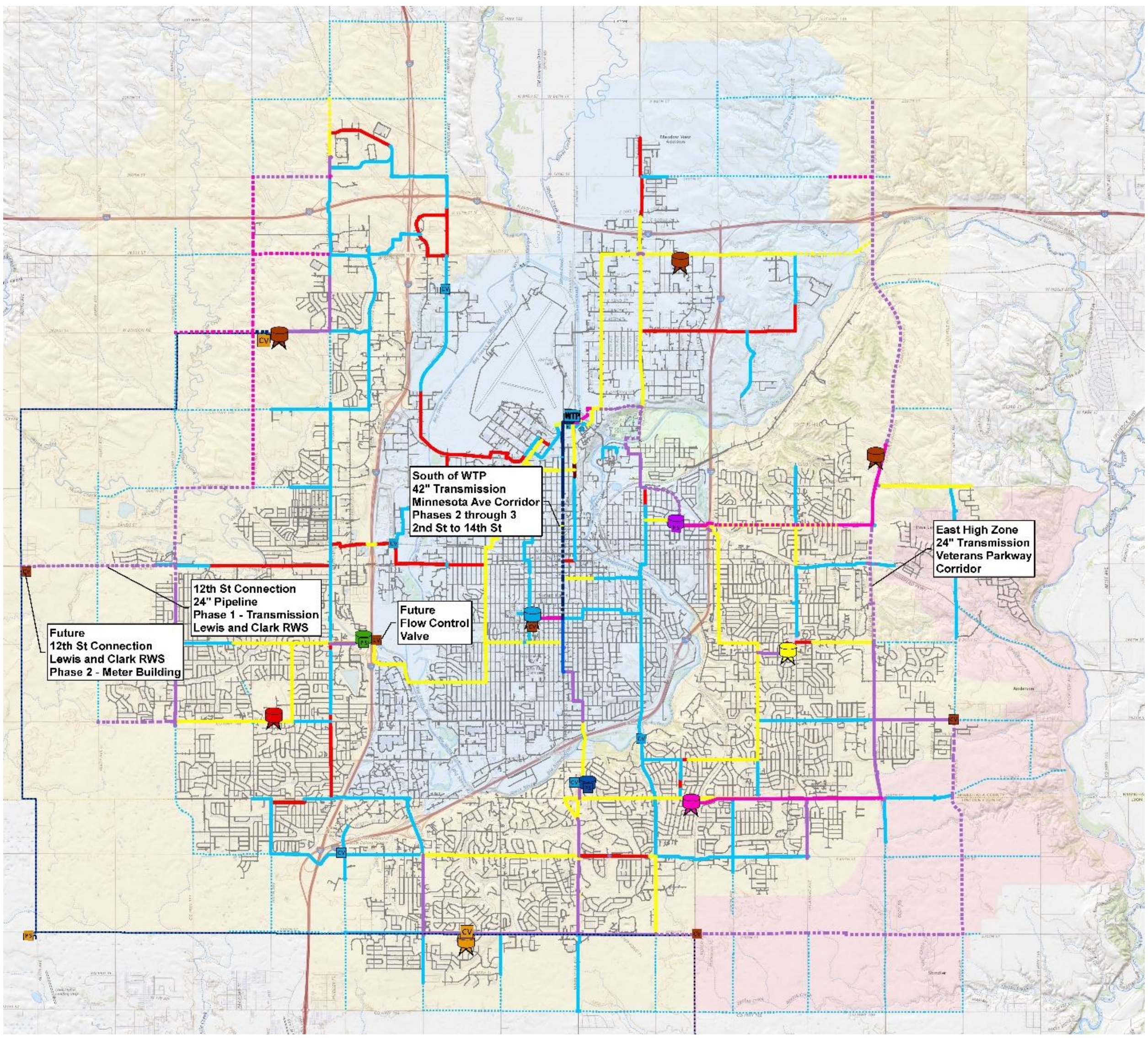


Figure 9.4 Proposed System Improvements – 0 to 5 Years

Table 9.3 Short-Term (0-5 Years) Capital Improvement Recommendations

Capital Improvement Project[1]	Funding Designation	Project Category	Project Year	OPPC	
System Improvements - Defined Projects					
Minnesota Ave Corridor - Phase 2: 2nd St to 8th St - Material	Engineering Driven	Rehabilitation & Repair	**2024**	$	3,000,000
Minnesota Ave Corridor - Phase 2: 2nd St to 8th St	Engineering Driven	Rehabilitation & Repair	**2025**	$	2,300,000
Veterans Parkway Transmission from E 26th St to E 6th St	Engineering Driven	Transmission	**2025**	$	5,017,000
12th Street Connection to L&C RWS - Phase 1A - Transmission	Water Driven	Supply	**2025**	$	1,798,000
Minnesota Ave Corridor - Phase 3: 8th St. to 14th St.	Engineering Driven	Rehabilitation & Repair	**2026**	$	5,428,000
12th Street Connection to L&C RWS - Phase 2 - Meter Building	Water Driven	Supply	**2026**	$	1,798,000
12th Street Connection to L&C RWS - Phase 1B - Transmission	Water Driven	Supply	**2026**	$	4,180,000
West Reservoir Control Valve	Water Driven	Optimization	**2026**	$	453,000
System Improvements - Undefined Projects[1]					
Water Storage Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$	3,300,000
City Wide Water Main Replacement Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$	1,950,000
Water Pipe Trenchless Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$	1,300,000
Transmission System Improvements - New Growth	Water Driven	Growth & Development	**Yearly**	$	1,250,000
Other Mains - Unforeseen Water Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$	1,700,000
Neighborhood Reconstruction Program	Engineering Driven	Rehabilitation & Repair	**Yearly**	$	4,675,000
Major Street Reconstruction Program - Replacement	Engineering Driven	Rehabilitation & Repair	**Yearly**	$	1,385,000
Arterial Street Improvements - New Growth	Engineering Driven	Growth & Development	**Yearly**	$	9,325,000
Miscellaneous Water Main Project	Engineering Driven	Rehabilitation & Repair	**Yearly**	$	940,000
		Total Opinion of Probable Cost		**$**	**49,799,000**

[1] Yearly undefined projects, OPPC is total over the five year period.
[2] 2023 through 2027 Planning Years

Figure 9.5 Yearly CIP Costs – 0 to 5 Years

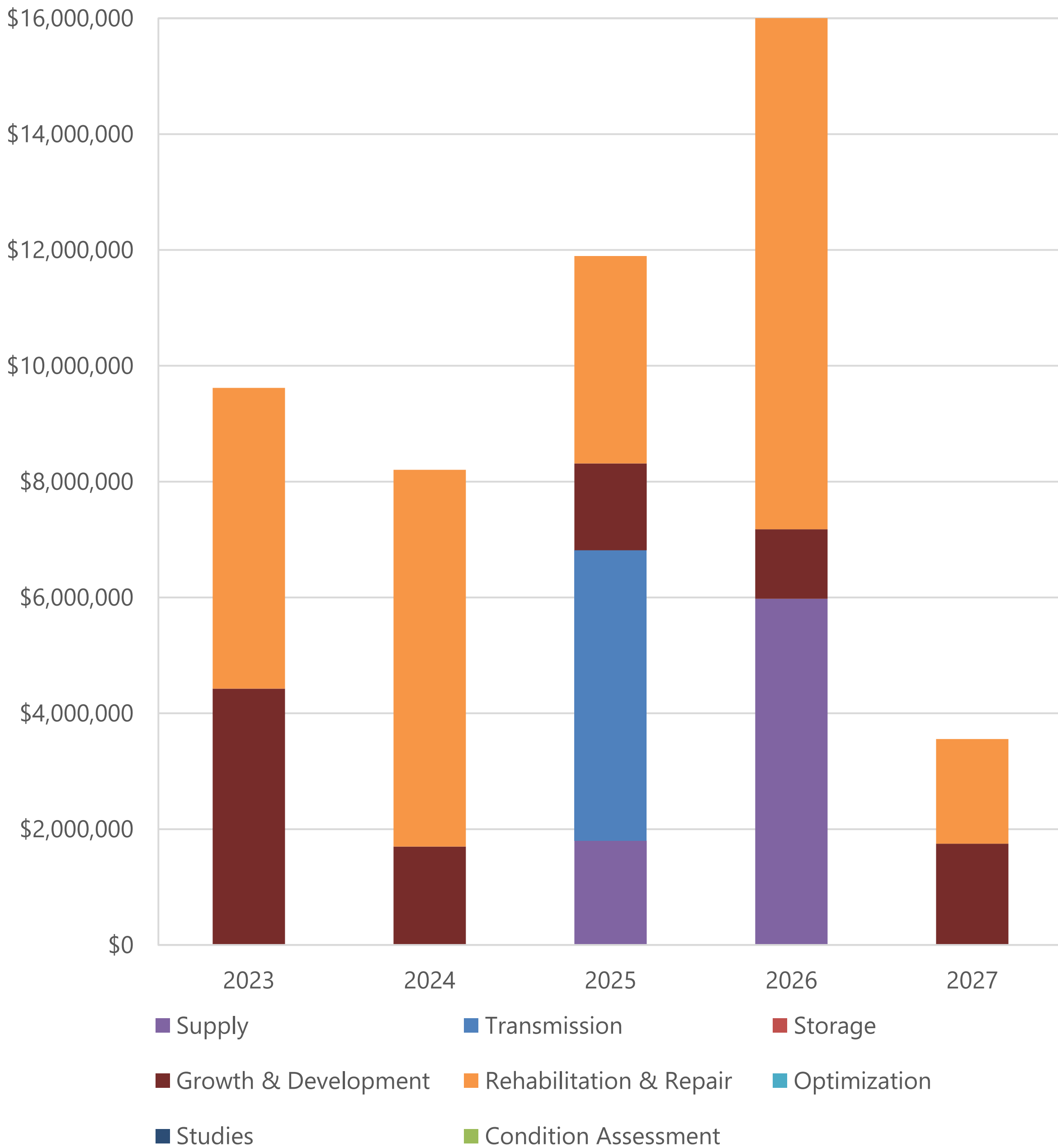


Figure 9.6 Project Categories and OPPC – 0 to 5 Years

9.4.2 Near-Term (5-15 Years) CIP Projects

The following are key projects identified to be completed in a ten year period from 2028 to 2037.

- Continued Phases of Replacement of Transmission Pipeline along Minnesota Ave Corridor
- Upgrade and Replacement of Transmission Pipelines from WPP to East Reservoir
- West High Zone Transmission Pipelines south of Lewis & Clark Benson Road Connection
- 60th Street Water Tower for Additional Storage within Central Pressure Zone
- Transmission Pipelines to Foundation Park for Increased Capacity
- Powder House Road Water Tower for Additional Storage in East High Zone

Figure 9.7 provides a map of proposed projects while a list of these project is included in Table 9.4. Figure 9.8 and Figure 9.9 show project costs related to funding and project categories.

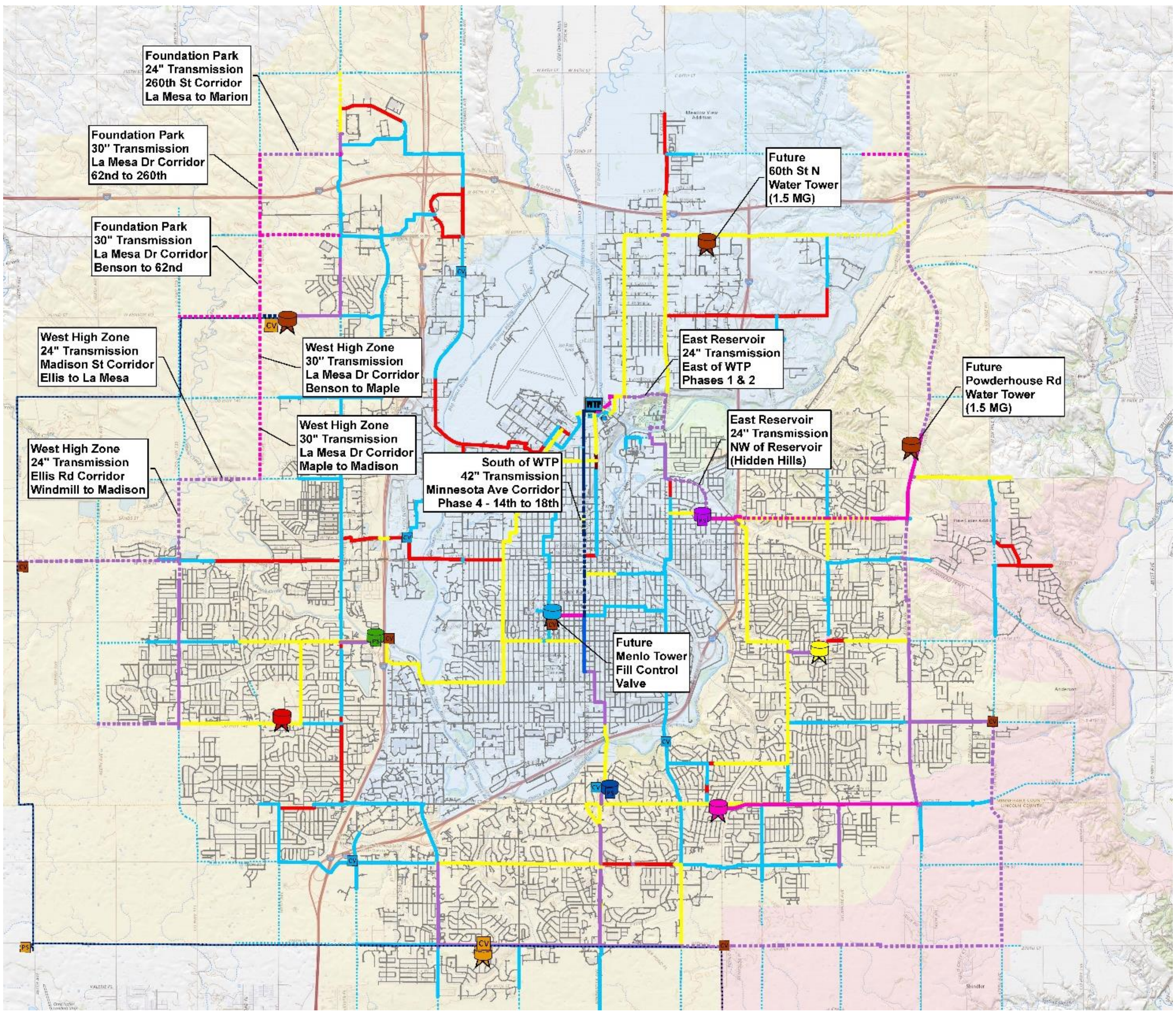


Figure 9.7 Proposed System Improvements – 5 to 15 Years

Table 9.4 Near-Term (5-15 Years) Capital Improvement Recommendations

Capital Improvement Project[1]	Funding Designation	Project Category	Project Year	OPPC
System Improvements - Defined Projects				
Minnesota Ave Corridor - Phase 4: 14th St to 18th St	Engineering Driven	Rehabilitation & Repair	**2028**	$ 3,902,000
Transmission to East Reservoir - East of WTP-Phase 1	Water Driven	Rehabilitation & Repair	**2029**	$ 2,195,000
East Reservoir Transmission Upgrades - Hidden Hills	Water Driven	Rehabilitation & Repair	**2029**	$ 2,290,000
West High Zone Transmission-La Mesa: Benson to Maple - Phase 1	Water Driven	Transmission	**2029**	$ 5,384,000
Transmission to East Reservoir - East of WTP - Phase 2	Water Driven	Rehabilitation & Repair	**2030**	$ 2,735,000
West High Zone Transmission-Ellis: Windmill to Madison - Phase 2	Water Driven	Transmission	**2030**	$ 4,951,000
Transmission to East Reservoir - East of WTP - Phase 3	Water Driven	Rehabilitation & Repair	**2031**	$ 3,011,000
West High Zone Transmission-Madison - Ellis to La Mesa - Phase 3	Water Driven	Transmission	**2031**	$ 4,268,000
60th Street Water Tower	Water Driven	Storage	**2031**	$ 10,175,000
Menlo Water Tower Fill Control Valve	Water Driven	Optimization	**2031**	$ 548,000
West High Zone Transmission-La Mesa: Madison to Maple-Phase 4	Water Driven	Transmission	**2032**	$ 6,066,000
Foundation Park - La Mesa Dr, Benson Rd to 54th St N	Water Driven	Transmission	**2033**	$ 5,897,000
Foundation Park - La Mesa Dr, 54th St N to 62nd St N	Water Driven	Transmission	**2034**	$ 5,233,000
Foundation Park - 260th St - La Mesa Dr to Marian Rd	Water Driven	Transmission	**2035**	$ 4,130,000
Foundation Park - N La Mesa Dr - 62nd St N to 260th St	Water Driven	Transmission	**2036**	$ 7,058,000
Powder House Road Water Tower	Water Driven	Storage	**2037**	$ 12,374,000
System Improvements - Undefined Projects[1]				
Water Storage Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$ 3,615,000
City Wide Water Main Replacement Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$ 28,494,000
Water Pipe Trenchless Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$ 13,169,000
Other Mains - Unforeseen Water Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$ 10,219,000
Neighborhood Reconstruction Program	Engineering Driven	Rehabilitation & Repair	**Yearly**	$ 9,382,000
Major Street Reconstruction Program - Replacement	Engineering Driven	Rehabilitation & Repair	**Yearly**	$ 8,813,000
Arterial Street Improvements - New Growth	Engineering Driven	Growth & Development	**Yearly**	$ 18,471,000
Miscellaneous Water Main Project	Engineering Driven	Rehabilitation & Repair	**Yearly**	$ 700,000
			Total Opinion of Probable Cost	**$ 173,080,000**

[1] Yearly undefined projects, OPPC is total over the planning period.
[2] 2028 through 2037 Planning Years

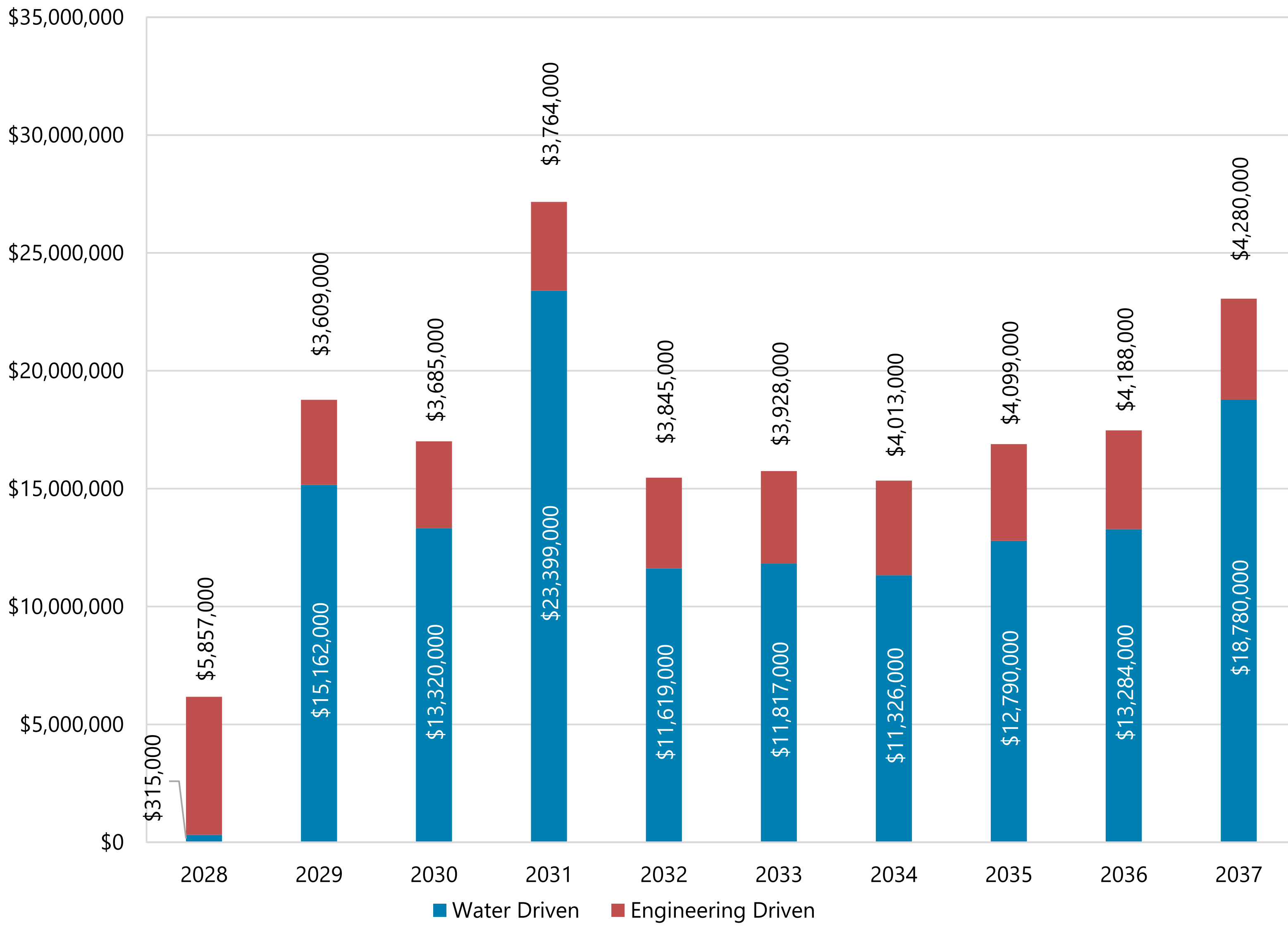


Figure 9.8 Yearly CIP Costs – 5 to 15 Years

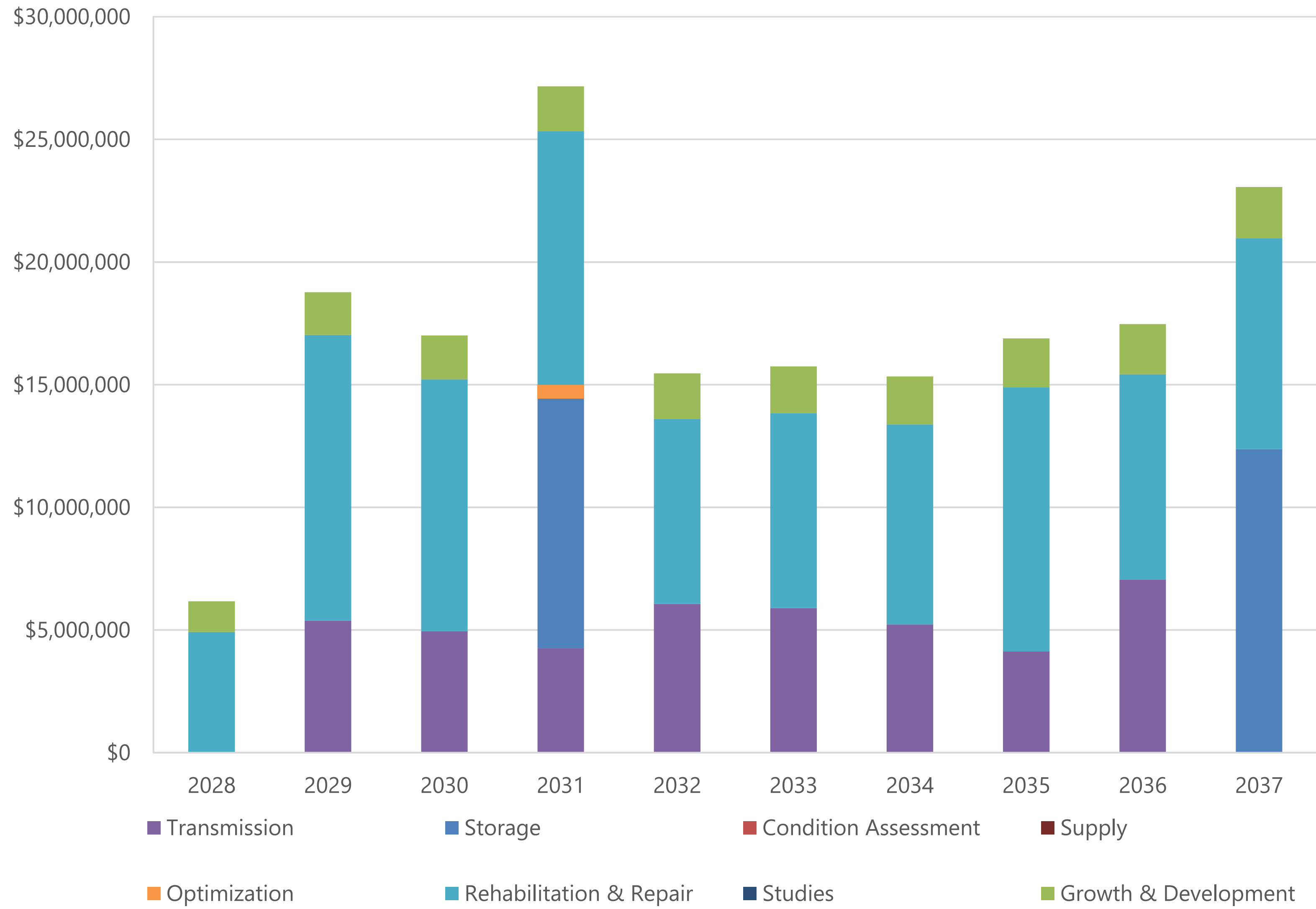


Figure 9.9 Project Categories and OPPC – 5 to 15 Years

9.4.3 Long-Term (15+ Years) CIP Projects

The following are key projects identified to be completed in the timeframe beyond the next 15 years planned from 2038 to 2045.

- Final Phase of Minnesota Ave Transmission Pipeline to the vicinity of Menlo Water Tower
- Transmission Pipelines within the East Reduced Pressure Zone
- Pressure Reducing Stations at 41st Street and 85th Street into East Reduced Pressure Zone
- Transmission Pipelines from East Reservoir into East High Zone to Powder House Road Tower
- Benson Road Water Tower for Additional Storage within the West High Pressure Zone

Figure 9.10 provides a map of proposed projects while a list of these project is included in Table 9.5. Figure 9.11 and Figure 9.12 show project costs related to funding and project categories.

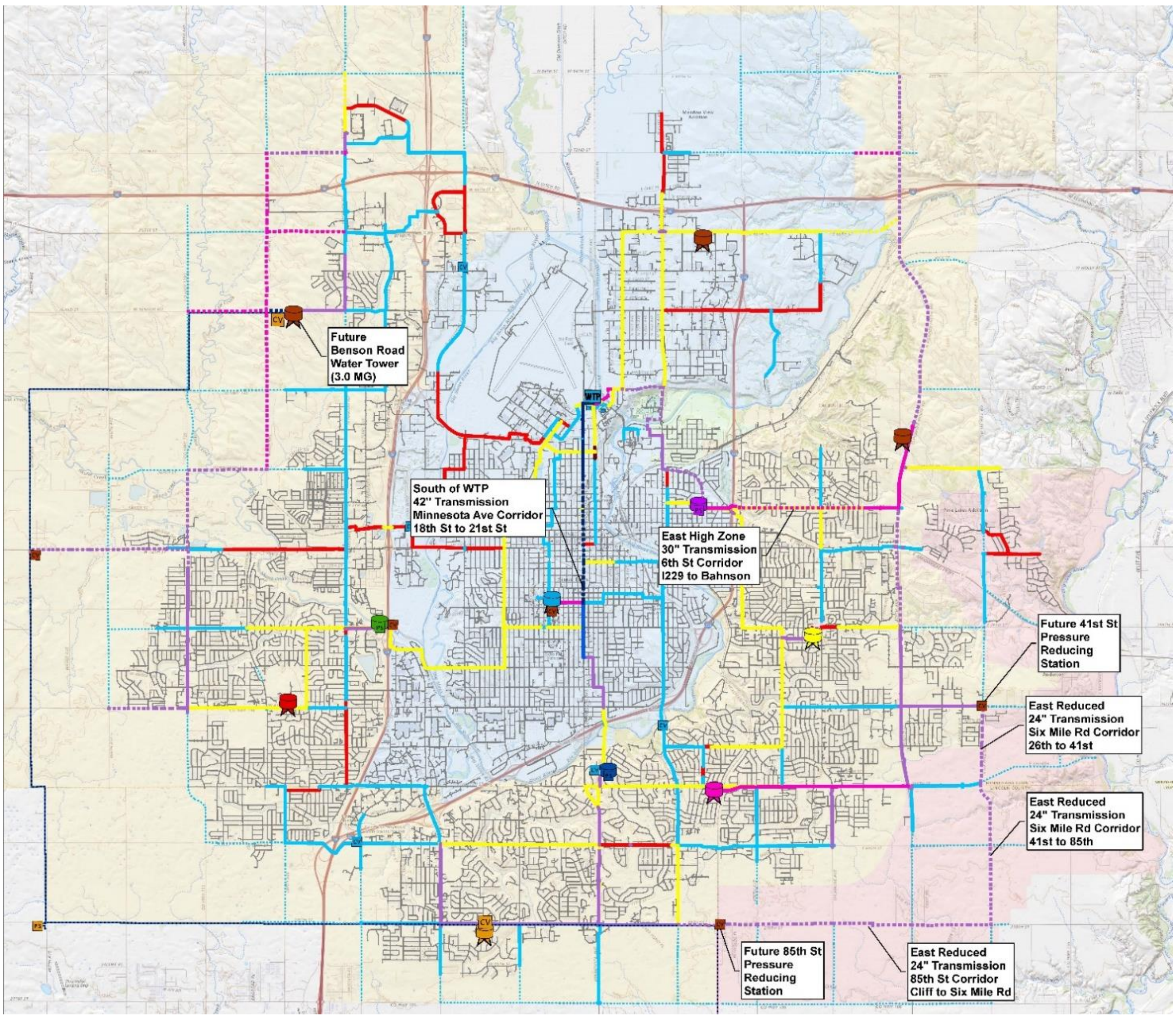


Figure 9.10 Proposed System Improvements – 15+ Years

Table 9.5 Long-Term (15+ Years) Capital Improvement Recommendations

Capital Improvement Project[1]	Funding Designation	Project Category	Project Year	OPPC
System Improvements - Defined Projects				
Minnesota Ave Corridor - Phase 5: 18th St to 21st St	Engineering Driven	Rehabilitation & Repair	**2038**	$ 5,175,000
East Reduced Zone Transmission - Six Mile Rd: E 26th to 41st	Water Driven	Transmission	**2038**	$ 2,989,000
East Reduced Zone Transmission - 85th St: Southeastern to Cliff	Water Driven	Transmission	**2038**	$ 4,750,000
41st St Pressure Reducing Station	Water Driven	Optimization	**2038**	$ 679,000
East High Zone Transmission E 6th St: I-229 to Bahnson Ave	Water Driven	Transmission	**2039**	$ 10,683,000
East Reduced Zone Transmission - Six Mile Rd: E 41st to E 57th	Water Driven	Transmission	**2040**	$ 4,277,000
East High Zone Transmission: Bahnson Ave to Sycamore Ave	Water Driven	Transmission	**2040**	$ 9,111,000
East High Zone Transmission: Sycamore Ave to N Foss Ave	Water Driven	Transmission	**2041**	$ 10,262,000
East Reduced Zone Transmission-85th St: Southeastern to Hwy 11	Water Driven	Transmission	**2042**	$ 9,364,000
85th St Pressure Reducing Station	Water Driven	Optimization	**2042**	$ 761,000
East Reduced Zone Transmission - Six Mile Rd: E 57th to E 85th	Water Driven	Transmission	**2043**	$ 8,576,000
East Reduced Zone Transmission - 85th St: Hwy 11 to Six Mile Rd	Water Driven	Transmission	**2044**	$ 5,031,000
Benson Rd Water Tower	Water Driven	Storage	**2045**	$ 25,606,000
System Improvements - Undefined Projects[1]				
Water Storage Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$ 9,397,000
City Wide Water Main Replacement Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$ 32,046,000
Water Pipe Trenchless Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$ 14,898,000
Other Mains - Unforeseen Water Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$ 11,460,000
Neighborhood Reconstruction Program	Engineering Driven	Rehabilitation & Repair	**Yearly**	$ 8,680,000
Major Street Reconstruction Program - Replacement	Engineering Driven	Rehabilitation & Repair	**Yearly**	$ 9,983,000
Arterial Street Improvements - New Growth	Engineering Driven	Growth & Development	**Yearly**	$ 29,835,000
Miscellaneous Water Main Project	Engineering Driven	Rehabilitation & Repair	**Yearly**	$ 560,000
		Total Opinion of Probable Cost		**$ 202,910,000**

[1] Yearly undefined projects, OPPC is total over the planning period.
[2] 2038 through 2045 Planning Years

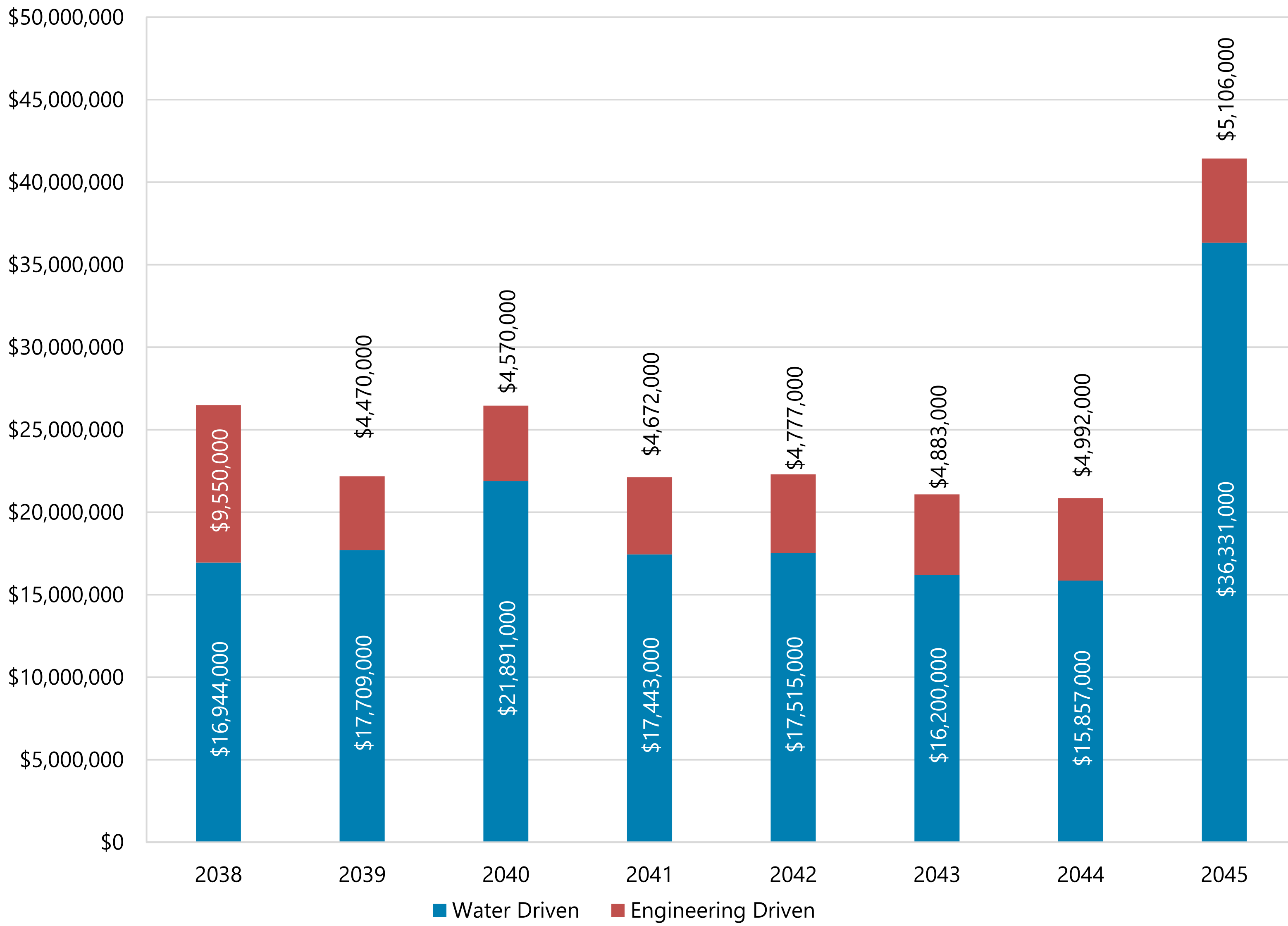


Figure 9.11 Yearly CIP Costs – 15+ Years

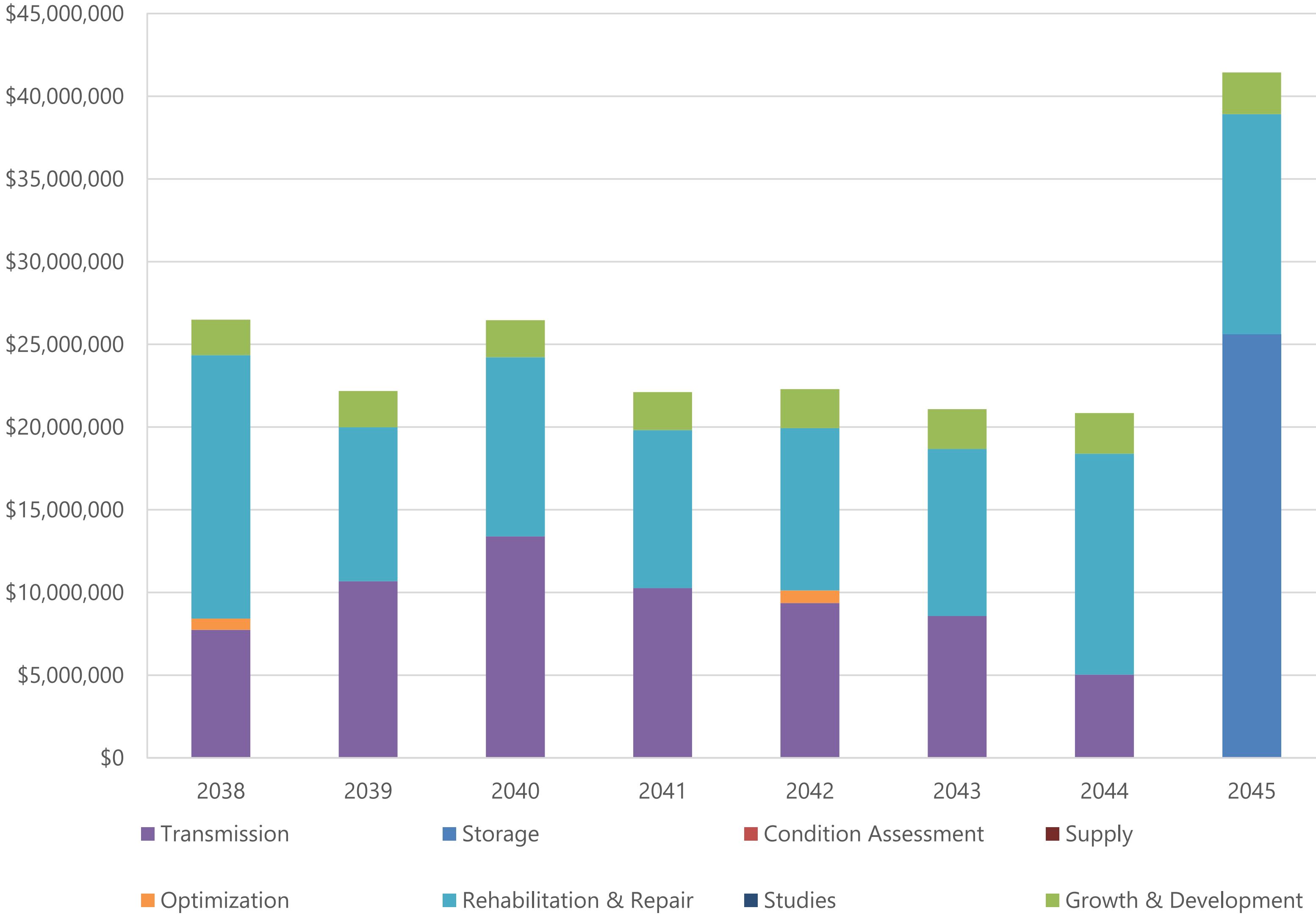


Figure 9.12 Project Categories and OPPC – 15+ Year