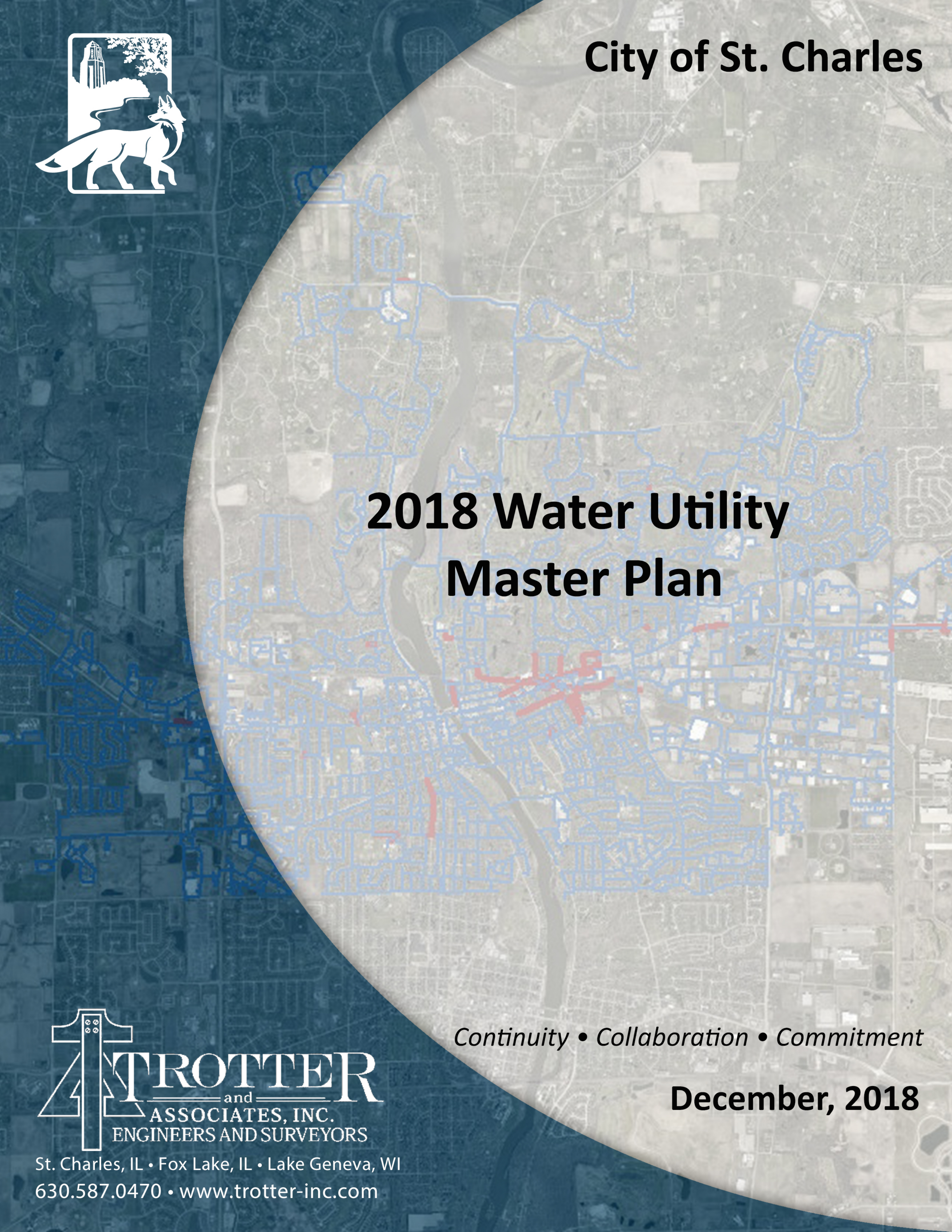

City of St. Charles

2018 Water Utility Master Plan

Continuity • Collaboration • Commitment

December, 2018

TROTTER and ASSOCIATES, INC.
ENGINEERS AND SURVEYORS
St. Charles, IL • Fox Lake, IL • Lake Geneva, WI
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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

GENERAL BACKGROUND

The City of St. Charles was incorporated in 1874 and is located in Kane County, Illinois. St. Charles straddles the Fox River between South Elgin and Geneva. The City developed its first potable water supply in 1907. Since then, the City has been dedicated to providing a continuous supply of safe, reliable, and economical potable water to its more than 19,000 accounts. The clients who receive water from the City of St. Charles constitute residential, commercial, industrial, and institutional users. In total, these clients consume approximately 3.34 million gallons of water per day. The existing water facilities maintained by the City include seven wells, four treatment facilities, three elevated towers, several ground storage reservoirs, and approximately 240 miles of water main.

The City of St. Charles has an estimated population of 33,408 based on the 2010 Census and interpolated growth projections. The City Council has recently approved several new developments throughout the City limits that will increase the overall demand on the system. As a result, the City has been actively pursuing a strategic plan to address water quality and quantity through a 20-year planning horizon. In order to better sequence and develop capital projects, it is in the City's best interest to maintain an updated Water System Master Plan. The plan was developed as a collaborative effort with input from Public Works, Engineering, Finance, and Community Development Departments. The Water System Master Plan provides a roadmap for the water distribution system, supply, treatment, and storage improvements required to meet the City's short and long-term goals.

MASTER PLANNING

A Water Master Plan Facility Plan is a management and planning document used to identify, evaluate, and plan required water distribution and other infrastructure improvements. It provides an assessment of the distribution, storage, and supply abilities to meet both current and future regulatory requirements and provides critical information for improvements to correct current or projected deficiencies.

Master plans are typically updated every five to ten years, or when significant changes in growth or regulatory requirements have occurred or are expected. The City of St. Charles most recent Water Master Plan was prepared in 2007 and is now more than ten years old. Since the 2007 update, the City has implemented a number of the recommendations including the installation of new and replaced water main, construction of the Red Gate water tower, and the construction of the Well #3/4 Treatment Facility among others. However, in an effort to be proactive the City is seeking to update the Master Plan to develop a single document which includes a Capital Improvements Plan to assist in budgeting for necessary improvements and to provide a guide for future improvements.

The ultimate goal of this plan is to establish the community's current and future water production and infrastructure needs and develop an implementation plan to meet those needs. This plan will provide the blueprint for future improvements, expansion phasing, and capital improvement projects.

COMMUNITY NEEDS

The City of St. Charles has grown from a community of 17,492 in 1980 to 27,910 people in 2000 to an estimated 33,403 people in 2018, as determined with an annual growth projection of 1.0% from the 2016 American Community Survey. Historically, the City has had adequate capacity to serve its planning area under all circumstances. During extremely high water usages, the City has been required to supplement well supply from the ground storage reservoirs, however at no point was the system in jeopardy of not meeting demands.

Water usage has generally decreased over the past decade as a result of higher efficiency water fixtures, watering restrictions, and a public effort to reduce unnecessary water consumption. While the City should not depend on a decrease in demand, this trend is seen in most communities and represents a national shift rather than a local anomaly. It is unlikely that demand will return to levels seen in the early 2000's unless significant droughts or growth are experienced.

Section 2 of this Plan identifies population growth projections for five-year, 2030, and 2040 planning horizons. In order to estimate the future water demand that the City must be able to provide, four growth categories were developed and analyzed. These include:

- 2018 'Current' – This represents the existing average and maximum day demands on the system
- 2023 'Planned' – This includes developments which are in construction, planning, or RFP stages
- 2030 'Programmed' – Includes areas identified in the Land Use Plan as potential developments
- 2040 'Future' – Represents the estimated population at the end of this study's planning horizon

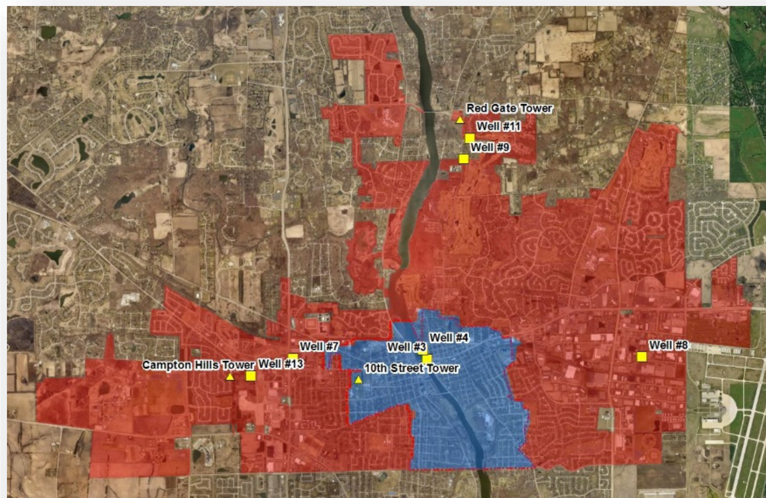
Table 2-1: Future Water Demands

	Current 2018	Planned 2023	Programmed 2030	Future 2040
Current P.E.	53,200	53,200	53,200	53,200
Growth P.E.	-	12,900	20,093	26,570
Total P.E.	53,200	66,100	73,594	80,000
Average Day Demand "ADD" (MGD)	4.00	5.00	5.50	6.00
Maximum Day Demand "MDD" (MGD)	9.74	12.10	13.50	14.60
Water Production Capacity Req'd (MGD)	**10.00**	**12.10**	**14.00**	**15.00**

As will be discussed in Section 2, the City has capacity to provide the average daily demand throughout the four planning horizons. However, the maximum day demand exceeds what is currently available due to the reduced capacity of the aging wells. Analysis of the existing wells and alternatives for additional water supply sources are reviewed in Section 5 and Section 6 of this report, respectively.

WATER DISTRIBUTION SYSTEM EVALUATION

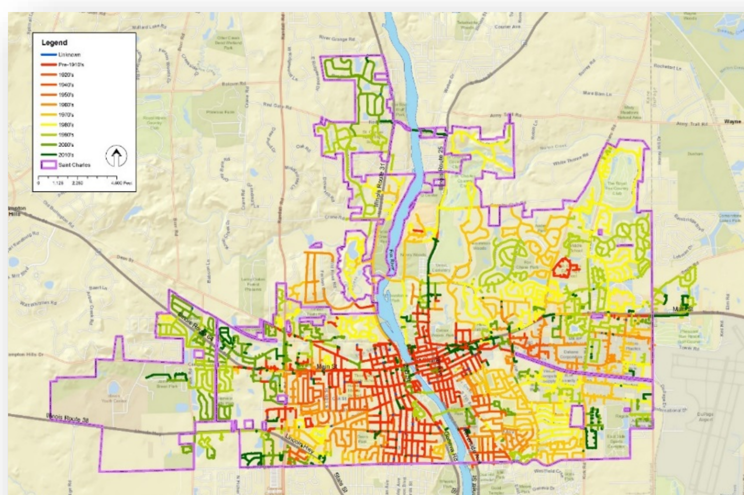
The City Water Department has adopted proactive water main maintenance, flushing, and rehabilitation programs to sustain the level of service provided to the community. The water main rehabilitation program is often coordinated with the City's Capital Improvement's Program for street rehabilitation and reconstruction to minimize costs. The City's water system has a large service area that is divided into two zones to maintain adequate water pressures across varying topographic regions, the Inner Service Area (shown in blue) and Outer Service Area (shown in red).



The City's water distribution system includes roughly 240 miles of water main, 2,900 fire hydrants, and 2,700 valves. For planning purposes the value of water main and other system components can be estimated to project a total system asset value. As calculated in Section 3, the existing City of St. Charles water distribution system value is estimated at approximately $190 million including system valves and hydrants, prior to depreciation. The total replacement cost for the water system, estimated at approximately $300 million, was calculated by adding 50% the unit asset value to account for surface restoration, contingencies, project management, design and administration. Based on straight-line depreciation and a seventy-five-year service life for this infrastructure, an average of $4.50 Million would need to be budgeted annually in order to replace all of the existing distribution system by the year 2093. This budgetary amount would need to be increased by the Construction Cost Index (CCI) each year, which has averaged 2.92% over the decade.

This annual reinvestment should be prioritized based on a number of criteria including main diameter, age, break frequency, soil conditions, and the presence of lead services, among others. These criteria are discussed in Section 3 of this report, with recommended alternatives for rehabilitation of the distribution system in Section 4.

City of St. Charles - Water Main Age



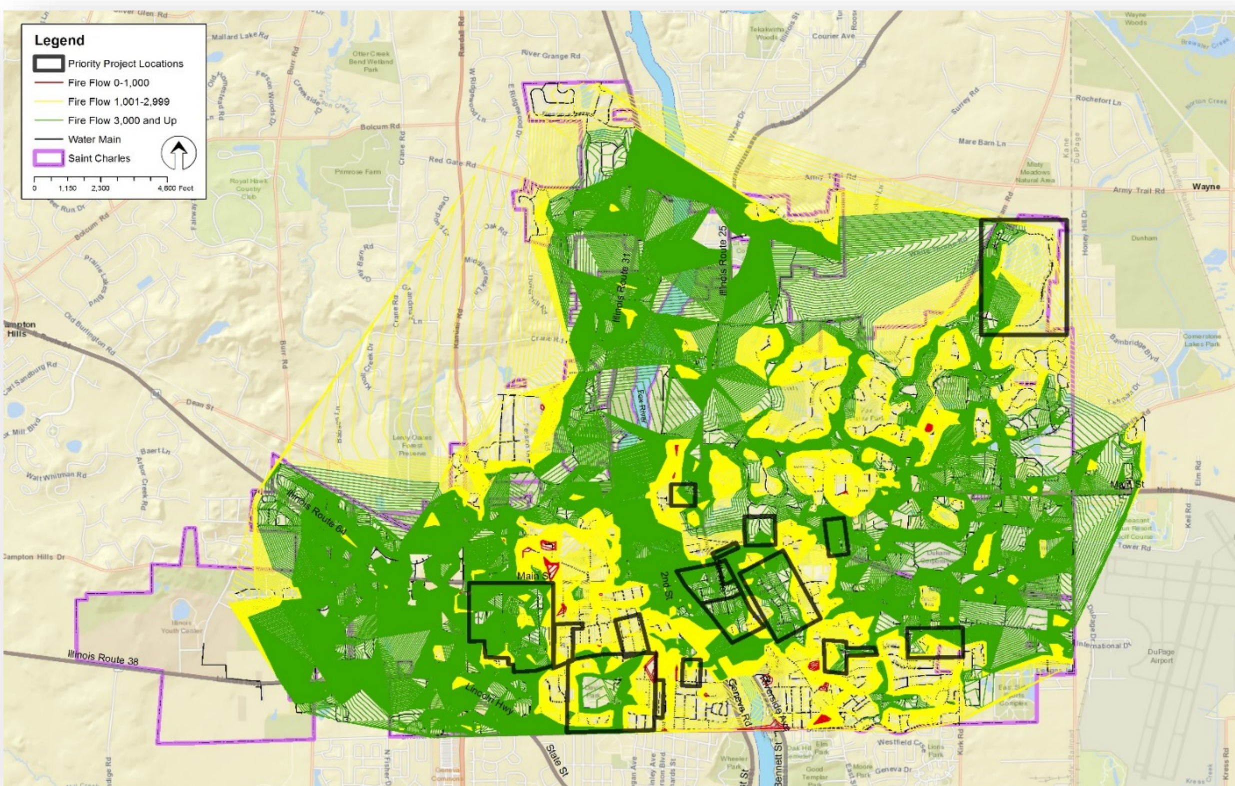
Distribution System Alternatives

Through work sessions with City staff, a number of capital improvement projects were identified to rehabilitated and upgrade the distribution system. As will be discussed in Section 3, the water system has been constructed throughout the last century. As a result of the age of the system, many of the components are at or beyond their anticipated service life and will require rehabilitation or replacement.

Through review of water main age, size, material, break history, and available fire flows detailed in Section 3, 17 priority rehabilitation areas within the distribution system were identified. These areas may exhibit low available fire flow (AFF), a high frequency of main breaks, or a combination of issues. Each of these areas are discussed in further detail in the following pages, with prioritization of the improvements reviewed at the end of this section. The projects are numbered by orientation and do not represent prioritization. Full line item cost estimates for each project can be found in Appendix A.

A. Davis Elementary School
B. Munhall Elementary School
C. Route 64 East
D. Lincoln Elementary School
E. 11th and 12th Street north of Prairie Street
F. Prairie Street – 5th to 8th
G. 3rd / 4th Street Alley
H. Horne & Ash Street
I. Route 25 and North Avenue
J. Route 64 and 9th Avenue
K. Monroe west of 7th Ave
L. South Second west of 7th Ave
M. Route 64 & Tyler Road
N. South Avenue
O. Fairview Neighborhood
P. Fox Ridge Elementary School
Q. Royal Fox Subdivision

Available Fire Flows - Projects Completed



WATER SUPPLY, TREATMENT & STORAGE FACILITIES

The City of St. Charles water supply and storage system consists of seven wells, three water treatment facilities, a 300,000-gallon spheroid water tower, a 1,500,000-gallon spheroid water tower, a 1,000,000-gallon Hydropillar® water tower, and several ground storage reservoirs with booster stations. As with most municipal water supplies, the existing infrastructure has been constructed over several decades and the components within the system vary in age. The City of St. Charles follows a rigorous maintenance program for the wells, towers and distribution system to ensure reliability of the infrastructure.

The City currently has an active booster station and ground storage reservoir capacity of 2.9 million gallons. These ground storage reservoirs are used in conjunction with the existing elevated water towers to meet the Maximum Hourly Demand and Fire Flow Demands placed on the system.

The City's Wells and Water Towers have been strategically placed throughout the City's service area, and source water is supplied by two distinct aquifers. Well #7, 9, 11 and 13 are supplied by a shallow sand and gravel aquifer commonly known as the St. Charles Aquifer. Wells #3, 4, and 8 are supplied by a deep aquifer known as the Galesville Aquifer. Presently, the City's wells operate at 52.9% of the capacity that they were designed to produce. This lowered production is especially prevalent at Wells 7 and 11, with Well 7 not being used to pump any water and Well 9 operating at approximately 50% of design capacity.

Well and Reservoir Design Capacities

	System Served	Design Capacity (GPM)	Design Capacity (MGD)	Firm Capacity (GPM)	Firm Capacity (MGD)	Reservoir Capacity (gallons)
3	Inner	1,000	1.44	1,000	1.44	250,000
4	Inner	1,000	1.44	-	-	250,000
Total	**Inner**	**2,000**	**2.88**	**1,000**	**1.44**	**500,000**
7	Outer	1,750	2.52	1,750	2.52	175,000
8	Outer	1,200	1.73	1,200	1.73	2,000,000
9	Outer	2,150	3.10	-	-	0
11	Outer	1,900	2.74	1,900	2.74	236,500
13	Outer	1,500	2.16	1,500	2.16	0
Total	**Outer**	**8,500**	**12.25**	**6,350**	**9.15**	**2,411,500**

Production is set at current levels at each well for a specific reason – chlorination capacities, elevated iron levels, pump curve limitations, and physical age of the well pumps themselves. It should be noted that these "current" rates are designed to *produce the highest quality of water possible* by maximizing use of wells that produce the highest quality water. While Well #7 specifically has been removed from routine service, it could be brought back online during peak periods if necessary. These current rates and required future capacities are discussed in further detail in Section 6.

WATER SUPPLY, TREATMENT & STORAGE ALTERNATIVES

While the City's well sources have a design capacity in excess of 15 MGD and a firm capacity of 12 MGD, this has been reduced due to the age of the wells and treatment facilities. Specifically, Well #7 is run as infrequently as possible due to the age of the filtration facility and high iron concentrations in the source water. To meet maximum day demands the City can utilize this well, however it is in need of significant upgrades or replacement. Alternatives for rehabilitation or replacement of this treatment facility are reviewed in Section 6, but it is recommended that the City plan and budget for interconnection of Well #7 and Well #13, with common iron-removal treatment occurring at the Oak Street Facility.

As detailed in Section 2 – Community Needs, the City of St. Charles anticipates significant growth over the next five years. For planning purposes, this growth is anticipated to result in increased maximum day water usage on a linear basis. As a result, the current maximum day demand of 9.74 MGD may increase to 12.1 MGD in 2023 by the end of the 5-year planning horizon. Therefore, the City should continue reviewing alternatives for additional water supply and treatment, and must maintain all current facilities. This includes the short-term rehabilitation/interconnection of Well #7 as a priority project.

The table below lists each of the alternative supply sources, their associated capital cost, the treatment facility capital cost, and total project cost. Due to the significantly higher cost associated with either connection to DuPage Water Commission or conversion to surface water supply (Fox River), these alternatives have been omitted from further consideration.

Table 6-4: Summary of Supply Alternative Costs

Alternative	Supply Capital Cost	Treatment Capital Cost	Total Alternative Capital Cost
Alternative 3 - Well 10	$3,640,000	$7,470,000	$11,110,000
Alternative 4 - Well 12	$3,620,000	$7,470,000	$11,090,000
Alternative 5 - Well 14	$3,950,000	$7,470,000	$11,420,000
Alternative 6 - Galesville Well @ 7/13	$3,110,000	-	$3,110,000
Alternative 7 - Galesville @ 9/11	$3,190,000	-	$3,190,000

Due to the relatively short-term requirement for additional supply, the City may elect to move forward with further investigation of groundwater alternatives. This would include investigating potential shallow well sites through boring of test holes and ultimately production evaluation with test wells. Once a potential site has been identified, it is recommended that two test holes be drilled to locate an adequate formation. Once located, a test well and several observation wells should be drilled to conduct a capacity evaluation. The test holes and test wells are anticipated to cost approximately $200,000 in total and should be budgeted over the next two years.

If deep wells are going to be considered, alternative means of radium removal should be investigated as an alternative to blending. One option for radium removal would be pelletizing treatment, further discussed in Section 7. A pilot with this technology is estimated to cost approximately $50,000 for a six month sidestream scale program. Similarly, it is recommended that this be budgeted for the short-term.

WATER SOFTENING

As discussed in Section 5, the majority of the City's existing water treatment facilities remain in good condition and should only require routine rehabilitation and maintenance over the planning period. In addition to maintaining excellent water quality, the City has identified implementing city-wide (utility-scale) water softening as a concept to be evaluated.

Hardness in water is the presence of dissolved magnesium and calcium ions. These ions combine most commonly with carbonate ions in water to create mineral deposits. Although water hardness is not regulated by the EPA in its Primary or Secondary Drinking Water Regulations, it constitutes a common challenge in providing quality drinking water. Hardness presents aesthetic concerns to consumers such as mineral deposits in piping, diminished soap effectiveness, and decreased lifespans of appliances.

Calcium and magnesium ions enter drinking water primarily through the dissolution of minerals in subterranean aquifers. As the City of St. Charles sources all of its drinking water from shallow and deep wells, high concentrations of hardness are to be expected. Tests have displayed that each of the seven wells currently used by the city provide water that is classified as either "Hard" or "Very Hard".

Table 6-2: Existing Water Supply Hardness

Water Source	mg/L as $CaCO_3$
Well 3	250
Well 4	240
Well 7	530
Well 8	260
Well 9	450
Well 11	530
Well 13	430
Hardness	**mg/L as $CaCO_3$**
Soft	0 to 75
Moderately Hard	75 to 150
Hard	150 to 300
Very Hard	300 and above

Water softening in St. Charles is currently achieved primarily through household water softening systems. These systems are paid for and operated by residents and require regular replacement of a softener salt media. Implementation of city-wide softening would reduce reliance on these devices, and the shift away from household softening could garner public support for the project. At present, the high hardness entering homes can scale pipes before reaching household softeners or the softeners may not be maintained well enough to work efficiently. As such, the City receives a number of complaints from consumers regarding the hardness of their water.

The City currently operates ion-exchange processes at the combined Well #3/4 facility, as well as the Ohio Avenue/Well #8 facility. This process is utilized to remove radium present in the deep well water, but as by-product also removes hardness. As a result, water quality varies across the distribution system with some residents receiving softer water, and others harder water.

Viable alternatives for municipal water softening have developed rapidly over recent years, resulting in several potential technologies with different removal efficiencies and characteristics. Four potential alternatives that could be employed by the City of St. Charles are ion-exchange, lime softening, membrane softening, and pelletizing. Each of these technologies provide distinct benefits and draw backs, which will be reviewed in detail within Section 7. Alternatives and combinations of alternatives for each have been compiled as well.

The City has reviewed a number of alternative technologies to provide Utility-scale water softening. There are significant challenges associated with each technology, specifically relating to ion-exchange treatment. During previous planning efforts ion-exchange was identified as the preferable water softening technology, however in light of recent developments on chloride limitations in wastewater effluent this option will likely no longer be a viable standalone alternative.

The table below illustrates the capital cost associated with implementing water softening at each regional facility, as well as the total utility-scale capital cost. If the City elects to continue the water softening discussion, staff may elect to pilot test any of the alternatives to determine the efficiency utilizing City water sources. Further evaluations would also be warranted to investigate the feasibility of siting a regional Well #9/11 softening facility along Route 25 at the previously described location, as well as the viability of constructing a regional Well #7/13 softening facility adjacent to the existing Oak Street Filtration Facility.

Utility Scale Softening Summary (20% Contingency)			
Softening Process	**Well #7/13 Capital Cost**	**Well #9/11 Capital Cost**	**Total Capital Cost**
Ion Exchange	$10,012,230	$11,910,039	**$21,922,269**
Nanofiltration	$29,727,210	$34,754,501	**$64,481,711**
Lime Softening	$33,249,600	$42,403,079	**$75,652,679**
Pellet Softening	$16,040,450	$30,362,830	**$46,403,280**
Pellet/IEX Softening	$20,429,057	$33,726,663	**$54,155,720**

Recommendations and Summary

The City is responsible for providing safe and reliable water service for the communities both within the corporate boundary and in the neighboring areas. The preceding sections have described the Planning Area, the current and future capacity needs, the existing supply, storage, treatment, and distribution system infrastructure, and future improvements that should be budgeted within the duration of this Master Plan.

A significant amount of the water system equipment and distribution system has reached or has exceeded its respective service life. Diligent maintenance and operation have provided the City with exceptional equipment longevity; however, several major systems will require replacement within the next 10 years. Recommendations have been separated into two groups: annual equipment replacement and Capital Improvement Projects. Incorporating a number of items requiring replacement into a single capital project provides cost efficiencies in the form of scales of economy and consolidating contractor's costs.

The implementation schedule for capital improvements is driven by the urgency of rehabilitation and the benefit of upgrades to the system. The prioritization of large-scale capital improvements is discussed in Section 6 and smaller scale rehabilitations follow the replacement timeframe based on service life and installation year of equipment. The projects identified throughout Sections 4 and 6 are outlined in the table below. The annual expenditure included is approximately $3.0-$4.0M which can be increased or decreased according to the City's available funding.

City of St. Charles - Water Master Plan
5 Year Capital Improvements Plan

		Fiscal Year Cash Flow ($ in Millions, 2018)					
	Project Description	**2020**	**2021**	**2022**	**2023**	**2024**	**Project Total**
S	AMI Meter Implementation	1.40	1.30	1.30			***4.00***
S	10th Street Tower Re-Coating & Repairs	0.50					***0.50***
S	Well #11 Chlorine Upgrades	0.50					***0.50***
S	Well #7/13 Interconnection - Phased	5.32					***5.32***
R	Well #8 & Ohio Avenue Rehabilitation	1.68					***1.68***
R	Well #9 Rehabilitation		0.75				***0.75***
R	Well #13 Rehabilitation			0.18			***0.18***
R	Well #3/4 Rehabilitation			0.89			***0.89***
S	Galesville Well at Oak Street				3.20		***3.20***
S	Galesville Well at Well #11					3.20	***3.20***
R	Well #11 Rehabilitation					0.60	***0.60***
							0.00
	Fiscal Year Total:	**9.40**	**2.05**	**2.37**	**3.20**	**3.80**	***20.82***

S Water Supply/Storage
R Rehabilitation

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SECTION 1

INTRODUCTION AND BACKGROUND

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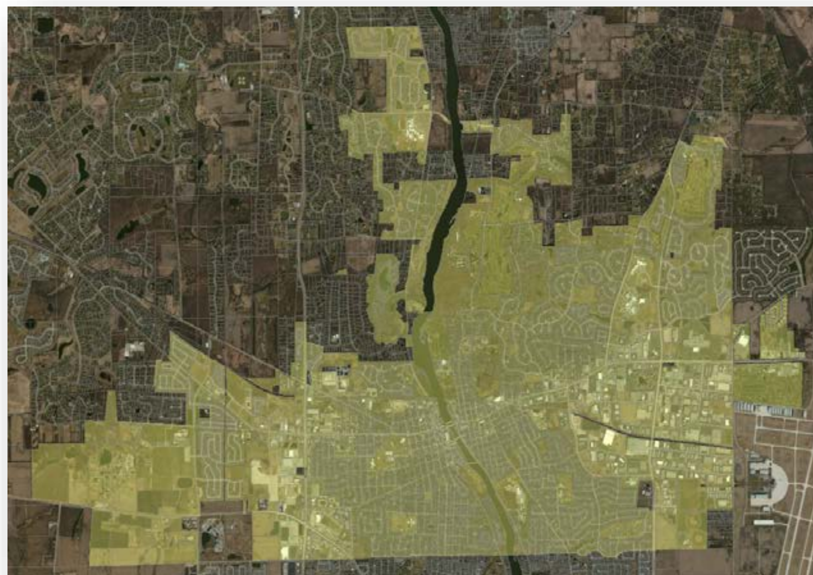
1. Introduction and Background

1.1. General Background

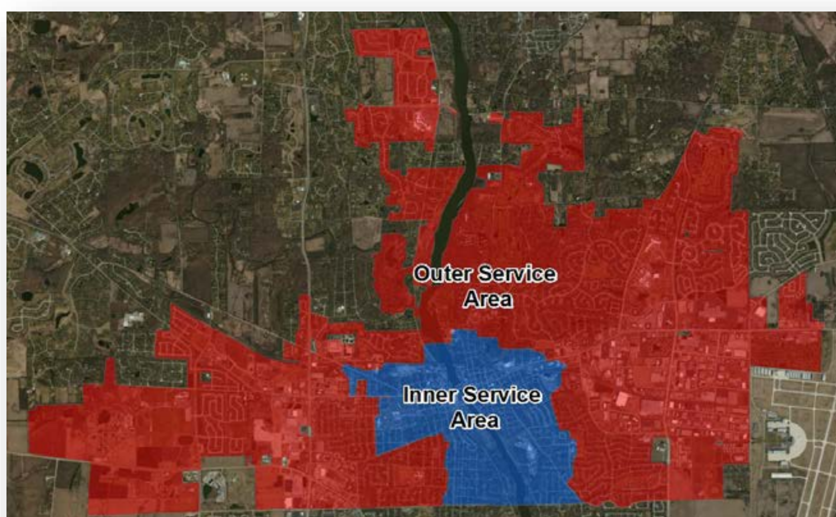
The City of St. Charles was incorporated in 1874 and is located in Kane County, Illinois, along the Fox River between Geneva and South Elgin. The City developed its first potable water supply in 1907. Presently, the City provides a continuous supply of safe, reliable and economical potable water to all of it residents and businesses, which includes approximately 19,419 accounts based on water billing data. The City actively manages a strategic plan to address water quality and quantity issues through annual inspection, replacement, and expansion programs.

The City of St. Charles has grown from a community of 17,492 residents in 1980 to 27,910 in 2001 and 33,403 people in 2018, as estimated using the American Community Survey. The residential water usage for the community in 2018 was 2,133,411 gallons per day, while the non-residential (commercial, industrial, and municipal) usage was approximately 1,208,134 gallons per day. This equates to an average daily usage of approximately 3.34 MGD across the service area.



City of St. Charles – Corporate Boundary

The City's water system has a large service area that is divided into two zones to maintain adequate water pressures across varying topographic regions. The Inner Service Area (shown in blue) generally serves the residents and businesses within the valley along the Fox River. The Outer Service Area (shown in red) supplies water to the remainder of the City and is generally at a higher elevation. The figure to the right provides a basic overview of the two service areas. The two service areas are connected via pressure sustaining valves which regulate the water pressure in the two zones. However, the two zones operate largely independently and the pressure sustaining valves are rarely opened.



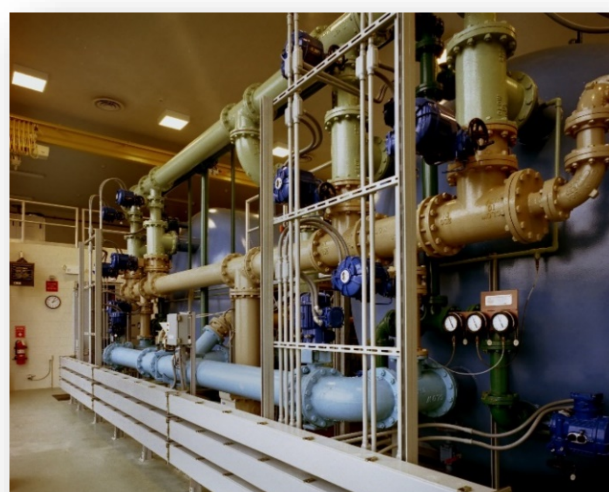
1.2. Existing Distribution System

The City of St. Charles maintains roughly 240 miles of water main and approximately 2,840 fire hydrants. As stated previously, the distribution system is divided into inner and outer zones. The City is able to transfer water between zones through the use of the seven pressure sustaining valves. These valves can be manually operated to provide water to the inner system from the outer system and are rarely opened.

The City Water Department has adopted proactive water main maintenance, flushing, and rehabilitation programs to sustain the level of service provided to the community. The water main rehabilitation program is often coordinated with the City's Capital Improvement's Program for street rehabilitation and reconstruction to minimize costs.

1.3. Existing Treatment and Storage Infrastructure

The City of St. Charles water supply and storage consists of seven wells, three water treatment facilities, a 300,000-gallon spheroid water tower, a 1,500,000-gallon spheroid water tower, a 1,000,000-gallon Hydropillar® water tower, and several ground storage reservoirs with booster stations. As with most municipal water supplies, the existing infrastructure has been constructed over several decades and the components within the system vary in age. The City of St. Charles follows a rigorous maintenance program for the wells, towers and distribution system to ensure reliability of the infrastructure

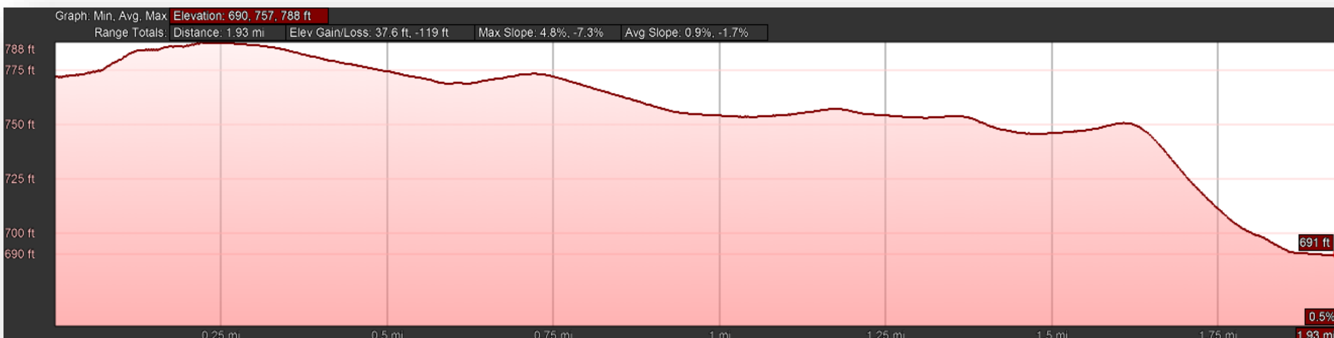


The City of St. Charles' source water is supplied by two distinct aquifers. Well #7, 9, 11 and 13 are supplied by a shallow sand and gravel aquifer commonly known as the St. Charles Aquifer. This shallow formation provides water with high concentrations of iron in some locations (west of the Fox River). At Well #7 and 13, water is currently filtered to remove iron. Well #3, 4, and 8 are supplied by a deep sandstone aquifer known as the Ironton-Galesville Aquifer. Water from this aquifer has concentrations above the USEPA Maximum Contaminant Level for radium and is treated to meet this regulation using a combination of Hydrous Manganese Oxide (HMO) filtration and Ion Exchange. The City currently has active booster station and ground storage reservoir capacity of 2.90 million gallons. These ground storage reservoirs are used in conjunction with the existing elevated water towers to meet the Peak Hourly and Fire Flow Demands placed on the system.

1.4. WATER SYSTEM TYPICAL OPERATION

The City's robust SCADA system works in conjunction with experienced operational staff to handle non-routine events as well as perform continual modifications to optimize water quality. In general, the water system operates based on the elevated storage tank levels. The levels of these three tanks dictates which wells/booster pumps run, and at what speeds, as shown in the tables below. All three elevated storage tanks are strategically located throughout the system to maintain consistent pressure in each of the two service zones. The hydraulic grade line (HGL) represents total pressure supplied relative to sea level.

The City maintains an HGL of approximately 910 feet in the outer service area. Therefore, if the elevation in the system is 780 feet above sea level, the water pressure at this location would equate to 56 psi (910 ft HGL – 780 ft Elevation = 130 ft ÷ 2.31 ft/psi). Similarly, the City maintains an HGL of approximately 855 feet in the inner service area. This portion of the community is much lower in elevation near the river, dropping to as low as 690 feet, which would equate to 72 psi. An elevation profile of Route 64 between the Campton Hills tower and the Fox River is shown below.



Campton Hills Tower	
Tower HGL	**Well #13**
909.75	1,000 GPM
908.75	1,100 GPM
901.75	1,200 GPM

Red Gate Tower			
Tower HGL	**Well #9**	**Well #11 Booster A**	**Well #11 Booster B**
911.54	900 GPM	-	-
911.44	1,000 GPM	700 GPM	-
906.34	1,100 GPM	700 GPM	700 GPM

10th Street Tower		
Tower HGL	**Well #3/4 Booster A**	**Well #3/4 Booster B**
859.50	750 GPM	-
855.00	675 GPM	675 GPM
854.50	750 GPM	750 GPM

1.5. Purpose and Scope

A Water Master Plan Facility Plan is a management and planning document used to identify, evaluate, and plan required water distribution and facility improvements. It provides an assessment of the distribution, storage, and supply abilities to meet both current and future loads, flows and regulatory requirements and provides critical information for improvements to correct current or projected deficiencies.

Master plans are typically updated every five to ten years, or when significant changes in growth or regulatory requirements have occurred or are expected. The City of St. Charles most recent Water Master Plan was prepared in 2007 and is now more than ten years old. Since the 2007 update, the City has implemented a number of the recommendations including the installation of new and replaced water main, construction of the Red Gate water tower, and the construction of the Well #3/4 Treatment Facility, among others. However, in an effort to be proactive the City is seeking to update the Master Plan to develop a single document which includes a Capital Improvements Plan to assist in budgeting for necessary improvements and to provide a guide for future improvements.

The ultimate goal of this plan is to establish the community's current and future water production and infrastructure needs and develop an implementation plan to meet those needs. This plan will provide the blueprint for future improvements, expansion phasing, and capital improvement projects. Throughout development of the Water System Master Plan, the City's staff and Trotter and Associates have worked together closely to determine the City's needs and evaluate alternative solutions. These meetings were essential to ensure the proposed implementation plan satisfies the City's expectations and regulatory requirements.

A significant portion of the planning effort is dedicated to the analysis of the existing distribution system. Therefore, the City's WaterCAD model has been updated to reflect the distribution system's current capabilities under Maximum Day Demand (MDD) and Fire Flow conditions. Water supply requirements were evaluated based on updated population projections, and limitations within the distribution system. Similarly, the City is investigating the potential for implementing water softening processes city-wide to produce a finished water of consistent quality throughout the service area. Section 6 of the report details the available technologies and associated costs of water softening.

1.6. Summary

The following sections will provide a detailed analysis of the City of St. Charles' long-term needs and a selection of alternatives, cost estimates and schedule for implementation of the recommended improvements to the distribution system and water supply, storage, and treatment infrastructure.

- Section 2 – Community Needs
- Section 3 – Existing Distribution System Evaluation
- Section 4 – Analysis for Distribution System Alternatives
- Section 5 – Evaluation of Existing Water Supply, Treatment & Storage Facilities
- Section 6 – Analysis of Water Supply, Treatment, and Storage Alternatives
- Section 7 – Recommendations and Summary

SECTION 2

COMMUNITY NEEDS

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2. COMMUNITY NEEDS

2.1 INTRODUCTION

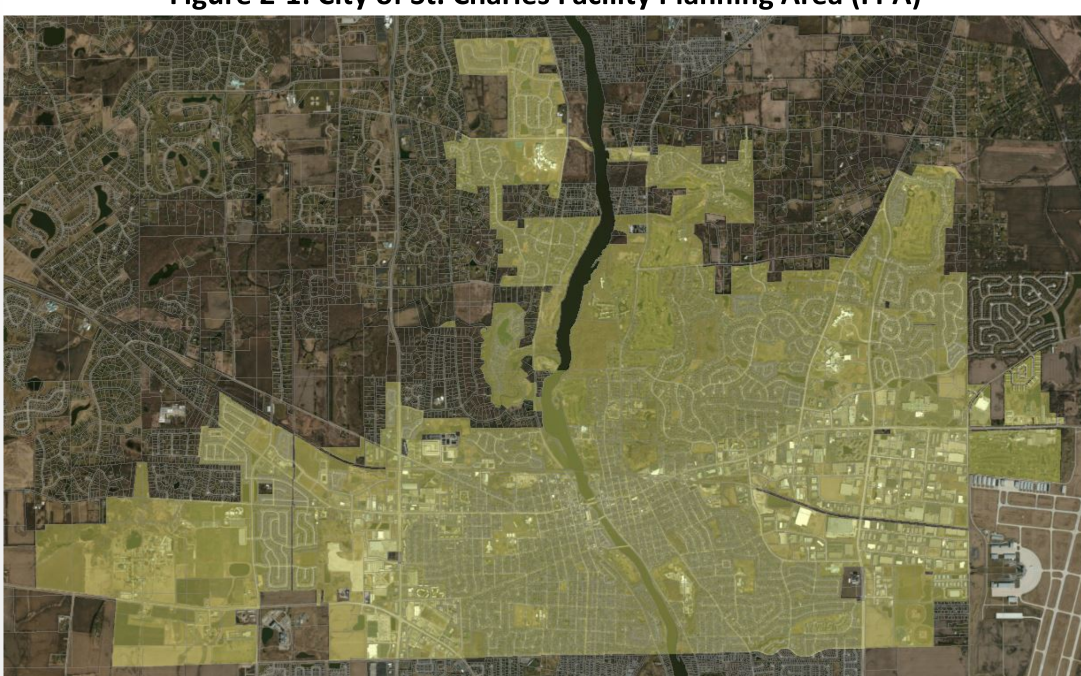
This section includes a discussion of City's water service planning area, current and future population equivalents, water usage, and regulatory considerations in order to provide a complete evaluation of the City's drinking water needs. The City has experienced significant growth since completion of the 2007 Water Master Plan, and as such projecting for future water demands will be critical to the City's long-term planning.

2.2 GENERAL BACKGROUND

The City of St. Charles is located in Kane County, 40 miles west of Chicago and is approximately 9,500 acres in size. The City of St. Charles is situated along the Fox River and its location has made it attractive to residential, industrial and commercial development. The City of St. Charles Facility Planning Area (FPA) is bounded on the south by Geneva, on the north by South Elgin, and West Chicago to the east. The City's boundary is shown below in yellow.

The City of St. Charles has grown from a community of 17,492 in 1980 to 27,910 people in 2000 to an estimated 33,403 people in 2018, as determined with an annual growth projection of 1.0% from the 2016 American Community Survey population estimate of 32,745. The City Council has recently approved several new developments throughout the City limits that have increased the overall demand on the system. The remaining undeveloped properties within the St. Charles service area have been assigned a land use and density.

Figure 2-1: City of St. Charles Facility Planning Area (FPA)



2.3 Existing Conditions

Most communities contain both residential and non-residential land uses. Analysis of current and future water usage is often done on the basis of "population equivalents", or P.E., which provide a common basis for residential and non-residential demands to be analyzed. One P.E. is equivalent to the water consumed by one resident, as determined by historic data. This can then be applied to non-residential water usage to obtain a total equivalent population for the City's service area.

2.3.1 Residential Population

The historical growth of the residential population within the service area has varied over the past 25 years. In 2017, the City had a total customer base (including residential and non-residential) of 12,428 accounts. However, this cannot necessarily be correlated with the total population served. In order to determine the total PE within the City's Service Area, the residential population is established as the first step. The City's population from the 2010 census can be found in Table 2-1. The table not only identifies the existing population with the City, but also the anticipated 2040 population based on the Chicago Metropolitan Agency for Planning (CMAP) population projection of 1.0% growth per year for Kane County.

This growth projection equates to a 2018 population estimate of 35,717 and a 2040 estimate of 44,493 total residents. This data has proven to overestimate growth for many area communities, as it is based primarily on data gathered during the housing boom of the 2000's. Therefore, the American Community Survey is utilized as a secondary reference to check CMAP estimates.

By utilizing the 2016 American Community Survey (ACS) in conjunction with the CMAP growth projection, a more accurate representation of the 2018 population could be achieved. The ACS is a yearly survey executed by the U.S. Census Bureau which contacts over 3.5 million households. This data is used to provide updated community estimates in the 10 years between nationwide censuses. Table 2-2 displays a projection of the ACS estimate to forecast the population in 2018. This Master Plan uses the ACS population value in conjunction with the CMAP growth projections to estimate the 2018 population of the City of St. Charles as 33,403. This value will be used moving forward for PE calculations.

Table 2-1: CMAP Population Projections to 2040 (2010 Census Basis)

Municipality Served	2010 Census Population	CMAP Projection	2018 Population Forecast	2040 Population Forecast
City of St. Charles	32,974	1.0%	35,717	44,493

Table 2-2: ACS Population Projections to 2040 (2016 Survey Basis)

Municipality Served	2016 ACS Population	CMAP Projection	2018 Population Forecast	2040 Population Forecast
City of St. Charles	32,745	1.0%	33,403	41,577

2.3.2 Total Population Equivalents

The table below illustrates the breakdown between residential and non-residential water billing throughout the City over the past five full fiscal years. The non-residential water billing includes commercial, industrial, non-profit, and any billed-municipal water usage.

Table 2-3: Total Water Billed (FY2014 – FY 2018)

Fiscal Year	Total (GPD)	Residential (GPD)	Non-Residential (GPD)
FY2014	3,389,936	2,136,367	1,253,569
FY2015	3,353,600	2,125,293	1,228,307
FY2016	3,336,239	2,063,707	1,272,532
FY2017	3,343,206	2,069,836	1,273,370
FY2018	3,341,545	2,133,411	1,208,134
5-Year Average:	3,352,905	2,105,723	1,247,182
	100%	62.8%	37.2%

The residential and non-residential water usage remained relatively consistent between FY2014-2018 with year-over variations of no more than 3.0%. As shown in the table, the residential water usage in the City accounts for nearly 63% of billings, though it represents more than 90% of total accounts. This annual water billed does not represent the total water metered, however, which is discussed on the following page as unaccounted-for water and non-revenue water.

The residential population equivalents were calculated by dividing the residential water sold by the total number of residents within the Service Area. The 2018 population estimate of 33,403 based on the ACS projection was utilized for this estimate as it follows the approximations used by the City. This per capita water usage equates to 63.0 gpd/capita, which was then used to determine the equivalent population of the non-residential water usage. This resulted in an additional 19,797 PE to be served by the City's water distribution system for a total of 53,200 PE.

Table 2-3: Current Total Population Equivalent

Description	Total
5-Year Average Residential Water Use (GPD)	2,105,723
Residential PE	33,403
Residential Per Capita Water Use (GPD)	63.0
Non-Residential Water Use (GPD)	1,247,182
Non-Residential PE (at 63.7 GPD/PE)	19,797
Total Current PE	**53,200**

2.3.3 Water Loss

While the City must meet the system water demand on a daily basis, not all of this water can be metered or billed. This difference in net production and authorized consumption is commonly referred to as water loss. This water loss consists of both real losses (main breaks, flushing, and leakage) and apparent losses (metering inaccuracies and unauthorized consumption). As tracked by the City, this would be referred to as Unaccounted-For Water (UFW). Additionally, a portion of the metered water usage is not billed. This may be due to the water being used by municipal accounts which will not be billed, or other known agreements which are in place. The difference between the net water produced and the total billed (and collected) is referred to as Non-Revenue Water, which includes water loss or UFW. The table below shows the approximate unaccounted-for water and non-revenue water over the past five calendar years.

Table 2-4: Water Loss Evaluation

Calendar Year	Pumped (MGD)	Metered (MGD)	Billed (MGD)	UFW (%)	NRW (%)
2013	4.09	3.50	-	14.43%	-
2014	3.97	3.64	3.39	8.31%	14.61%
2015	3.92	3.57	3.34	8.93%	14.80%
2016	3.91	3.61	3.37	7.67%	13.81%
2017	4.07	3.62	3.40	11.06%	16.46%
Average:	**3.99**	**3.59**	**3.38**	**10.12%**	**15.46%**

The average unaccounted-for water/water loss of systems in the United States is approximately 16%, according to the US EPA. The City of St. Charles is currently just over 10.0%, indicating a well-maintained system. The City's non-revenue water exceeds 15%, however, indicating possible metering issues or a large quantity of municipal or un-billed usage. This is further discussed in Section 4 relating to the City's meter replacement program. Additionally, while the gallons billed per capita was found to be 63 gpd/PE, the water usage is higher due to this water loss. The average water pumped of 4.0 MGD divided among the 53,200 PE equates to 75 gpd/PE pumped.

2.4 Future Population Projections

In order to estimate the future water demand that the City must be able to provide, four growth categories were developed and analyzed. These include:

- 2018 'Current' – This represents the existing average and maximum day demands on the system
- 2023 'Planned' – This includes developments which are in construction, planning, or RFP stages
- 2030 'Programmed' – Includes areas identified in the Land Use Plan as potential developments
- 2040 'Future' – Represents the estimated population at the end of this study's planning horizon

The current usage is discussed previously in this section, with a five-year average daily demand of just under 4.0 MGD. The approved and potential population equivalents were established by reviewing the City's Community Development records, wastewater treatment plant records, approved development plans, and the City's Comprehensive Land Use Plan. Analysis of the projected land use was the basis for developing future population projections.

2.4.1 2023 – Planned Population Projection

The table below lists all ongoing development projects in the City of St. Charles, the type of project, the PE factor associated with this category, and the total additional estimated PE. These projects include those currently in construction and planning approval stages of the development process. As shown, nearly 13,000 additional PE of planned population is anticipated in the five-year horizon.

Project Description	Project Type	PE Factor	Additional PE
AJR Filtration Expansion – Development of additional industrial space to the south of the existing facility, east of Kirk Rd. Expected to double facility size within five years. Estimated using current facility's water consumption.	Industrial	Present Facility: 103 PE	103
Anthem Heights – Single-family subdivision located north of Rt. 64 and west of Randall Road. 78 units currently under construction.	Residential	3.5	273
Charlestown Mall Redevelopment – Redevelopment of the existing lot will include 288 apartments, 210 townhomes, and 145,000 square feet of new commercial space.	Commercial/ Residential	.5 GPD/sqft (commercial) /3.5 (townhome)/2.5 (apartment)	2,600
Crystal Lofts – 14 single-family townhomes currently under construction at the corner of 13th and Indiana Avenues.	Residential	3.5	50
East Side Park Natatorium – 65,000 square foot aquatics center proposed for development east of Kirk Road. Olympic size pool has 660,000-gallon volume, and smaller 3-lane pool and aquatic playground is estimated to have 1/4th of the volume (165,000 gallons). The total evaporation rate of both pools was calculated to be 131 gpd.	Public	Volume replaced twice + evaporation rate.	73
First Street Project Phase 3 – Third phase of redevelopment includes three buildings between Rt. 64 and Illinois St. along the riverfront. Combined retail and office space of 84,000 square feet and approximately 50 residential units.	Retail/Office/ Residential	.5 GPD/sqft (retail/office)/2.5 per unit (residential)	785
First Street Project Phase 4 – Redevelopment project includes construction of three buildings between First St. and Rt. 31, with mixed retail, office, and residential spaces. Buildings include 22 residential units and 66,000 square feet of office and commercial space	Retail/Office/ Residential	.5 GPD/sqft (retail/office)/2.5 per unit (residential)	575
Gun Range – Construction of a covered facility at the police gun range adjacent to the West Side Wastewater Treatment Facility off of Rt. 38. Estimated to be equivalent to a 1-bedroom home.	Residential	3.5 PE	4

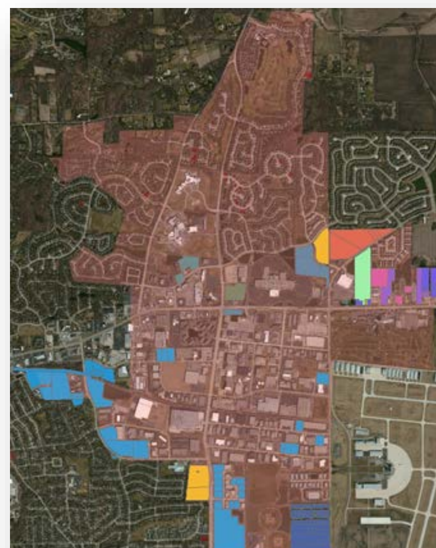
Project Description (continued)	Project Type	PE Factor	Additional PE
IYC Annexation – Illinois Youth Center would be connected to the existing distribution network. Facility has a capacity of 348 and averages 138 youth's. Located west of Peck Rd., between Campton Hills Rd. and Rt. 38.	Public	2015 Wastewater Facility Plan	1,026
Lexington Club – 142 single-family homes, townhouses, and rowhouses being constructed north of State and Dean Streets between 5th and 12th Streets.	Residential	3-3.5	440
Petkus Property – 27 acres of undeveloped property identified in the Comprehensive Land Use Plan for future development as apartments and townhomes. Current proposal includes 416 units.	Residential	2.5	1,040
Pheasant Run – Annexation and development of single family homes on the golf course of Pheasant Run Resort. Property consists of 104 acres at the intersection of Rt. 64 and Kautz Rd.	Residential	3.5 PE per quarter acre of property, with 25% open space	1,092
Police Facility – 60,000 square foot police station construction south of Rt. 64, between 14th and 17th St. TAI modeling of the facility estimated a water demand of 1,500 gallons per day.	Public	From 2018 TAI Facility Modeling Memo	25
Prairie Centre – Redevelopment of 27-acre property bounded by Rt. 38, Prairie St., and Randall Rd. Includes 609 multi-family residences and 116,000 square feet of retail space.	Commercial/ Residential	From Planned Urban Development Report	2,290
Prairie Winds – 250 multi-family units and a shared Club House located between Peck and Randall Roads, north of Bricher Road. Future possible expansion is outlined in 2015 Wastewater Facility Plan and accounts for remaining PE.	Residential	From 2015 Wastewater Facility Plan	2,026
Silverado Memory Care – Senior and assisted living facility under construction north of Rt. 64, across from Pheasant Run Resort. Designed to support 90 residents.	Residential	1.96 per bed-space (JCAR)	180
Unnamed Commercial Development – Located north of Rt. 64, east of Smith Rd. Behind Volkswagen dealership and Silverado Memory Care. The lot has an approximate area of 81,056 square feet and 50% of the lot can be expected to be built out for commercial usage.	Commercial	0.5 GPD/sqft	318
		Total Additional PE:	**12,900**

2.4.2 2030 – Programmed Population Projection

In 2015, a Facility Plan was drafted for the wastewater facilities of the City of St. Charles by Trotter and Associates. This Facility Plan included an analysis of future growth that could occur in the City by analyzing the PE that would be added if undeveloped regions of St. Charles were to be built out. This report utilized the 2010 Census population to calculate a 2015 estimated total population equivalent of approximately 56,000. After analyzing available regions for development based on meetings with the City's Community Development Department, the report concluded that 12,600 PE would be added if the facility planning area was built out, resulting in a total PE of 68,600.

Since this report in 2015, a number of new areas for development as well as larger parcels of land for major development were identified or re-designed. Therefore, some of the regions from the pending development list on the previous pages were not included in the 2015 Facility Plan. The 2015 report divided the City among drainage basins and identified regions of potential future growth within these basins. The following subsections include the drainage basins identified in the 2015 report that contained growth regions which differed from or did not include areas that are currently being developed. The drainage basins are outlined transparently, while regions for development are overlaid with opaque polygons representing the development type (residential, commercial, etc.)

2.4.2.1 Eastern Drainage Basin



The figure to the right indicates the regions for development identified in the 2015 Wastewater facility plan. Regions currently being developed in this basin are the Petkus Property (northeast orange trapezoid), the unnamed commercial property (green property below Petkus), Silverado Memory Care, (pink property adjacent to commercial property), and the AJR filtration expansion (light blue rectangle on southern border). The Charlestown Mall redevelopment, Pheasant Run residential projects, and East Side Park pool are located in this basin but were not outlined in the 2015 report.

2.4.2.2 SC-02 Basin

This basin is located on the west side of the city. The most notable development in this region is the Prairie Center development. This is the large green rectangle toward the north of the basin. The 2015 plan predicted total build-out PE growth of 116, whereas the current 2018 plan would add 2,975 PE. As such, the 2015 plan is discounted for this region.

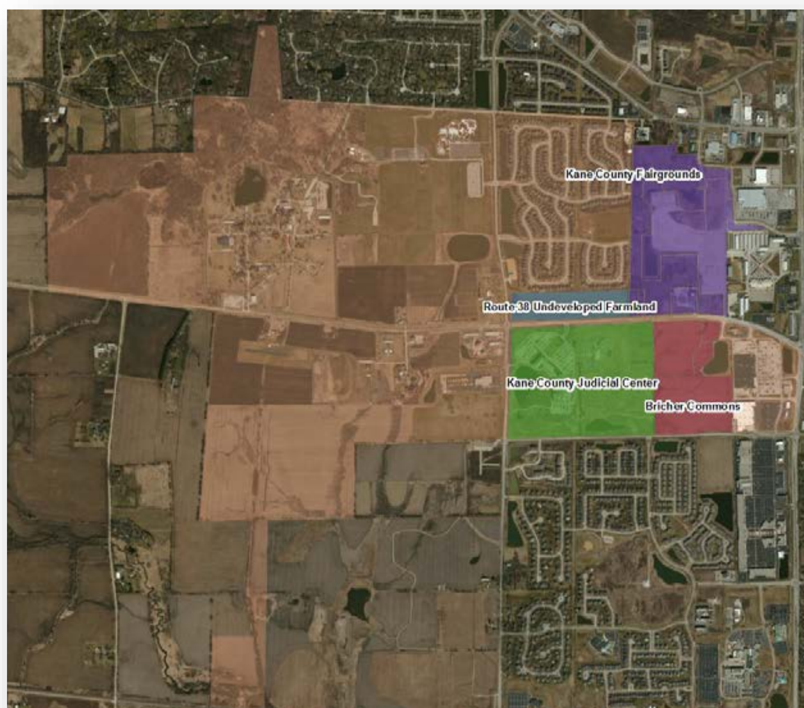
2.4.2.3 SC-05 Basin

The SC-05 Basin contains the Lexington Club development highlighted in blue. This ongoing development was already accounted for in 2015, and will not be counted again from the list of new developments.

2.4.2.4 Reneaux Manor Basin

The 2015 Facility Plan identified regions of the Reneaux Manor Plan for residential and commercial development. The largest green region along the north end of the figure at right has been built into the Anthem Heights residential development. This was included in the build-out PE from the 2015 result, so this development is not included from the list in section 2.4.1.

2.4.2.5 Southwest Gravity Basin



The portion of the basin to the right outlined as “Bricher Commons” is currently undergoing development into the Prairie Winds subdivision. The first phase of this project has been completed, while a second phase is likely to take place in the northern half of this project region. On the western-most side of this basin is the Illinois Youth Corrections facility. The 2015 Facility Plan included a value of the PE associated with the IYC as it currently receives wastewater service from the City of St. Charles. Future annexation would also provide potable water service, and as such this PE was used for the programmed estimate.

The table below displays the ongoing projects that were included in the 2015 Wastewater Facility Plan as well as the new developments that have been designed since this report. The table also displays the remaining programmed PE from the 2015 report, as calculated by subtracting the ongoing projects that were included in the report from the total programmed PE that the 2015 report calculated.

Table 2-5: Remaining PE/PE Comparison 2015 WW Master Plan

Included in 2015 Facility Plan		Not Included in 2015 Facility Plan	
Development	**PE**	**Development**	**PE**
AJR	103	Charlestown Redevelopment	2600
Anthem Heights	273	Crystal Lofts	50
IYC Annexation	1026	East Side Park Pool	73
Lexington Club	440	First Street Phase 3	785
Petkus Property	1040	First Street Phase 4	575
Prairie Winds	2026	Gun Range	4
Silverado Mem Care	180	Pheasant Run	1092
Unnamed Commercial	318	Police Facility	25
-	-	Prairie Centre	2290
Total:	**5,406**	**Total:**	**7,494**

By combining the current 2018 population equivalents as found using the ACS estimate, the ongoing development projects, and the remaining land-use based programmed development from the 2015 report, the necessary distribution capacity for the City of St. Charles can be calculated. This equates to the 53,200 current PE, plus the additional 12,900 PE currently planned, plus the 7,494 programmed growth results in a total 2030 Programmed PE of 73,594.

2.4.3 2040 – Future Population Projection

The growth from the current 2018 population estimate to the 2030 programmed estimate equates to an approximate 2.8% annual growth rate. It is anticipated that future development past the 2030 estimate will become vertically driven, as the vast majority of land designated for development would have been occupied. Therefore, annual growth of 1.0% or less, which is consistent with more densely populated communities to the east, is projected through the 2040 planning horizon. Based on this growth rate, the 'Future' population project is estimated at approximately 80,000 PE. This would represent a total growth of over 50% in the 22-year period. While this seems high based on historical trends, the amount of planned development the City is currently experiencing is significant. Therefore, future water demands should be based on this conservative estimate.

2.4.4 Future Population Projection Summary

The approved/permitted, and potential population equivalents were established by reviewing the City's detailed water and sewer billing records, wastewater treatment plant flow monitoring records, approved development plans, and the City's Comprehensive Land Use Plan. Analysis of the projected land use was the basis for developing future population projections. This data was compiled to detail the City's future population projects in four categories; Current, Planned, Programmed, and Future. These growth estimates are summarized in the table below.

Table 2-6: Future Population Projects Summary

	Current 2018	Planned 2023	Programmed 2030	Future 2040
Current P.E.	53,200	53,200	53,200	53,430
Growth P.E.	-	12,900	20,093	26,570
Total P.E.	53,200	66,100	73,594	80,000

2.5 Capacity Requirements

As discussed in Section 1, the average daily demand and maximum day demand are defined using historic information based on the City's billing and pumpage data throughout each year. The average daily usage and maximum day usage are the criteria used by the Illinois EPA to evaluate the water systems production needs. In accordance with Title 35, Subtitle F, Part 654.202, the Illinois EPA requires the public water supply to have sufficient capacity to meet the average daily usage with the largest producing well out service and meet the maximum day usage with all of the wells in production. These criteria are the minimum requirements.

Systems with multiple wells are typically designed to meet the maximum daily demand with the largest well out of production. This design allows the municipality to meet the needs of the residents and businesses while performing routine maintenance on the supply wells. Without this redundancy, the work must be performed in off-peak periods, which restricts and increases the cost of the maintenance activities.

2.5.1 Historic Water System Demands

In order to determine the adequacy of the existing supply and distribution system, historical peak day and month consumption data was reviewed. The table on the following page illustrates the peak day demand of each month over the past 13 years. The numbers reflect the total amount of water supplied by the City, not the water billed to customers. The variation between water supplied and water sold is attributed to the various forms of water loss. The 10-year average water usage was calculated to be 4.07 MGD.

While five-year and 10-year historical demands are typically utilized for planning purposes, the City experienced significant demands in 2005, 2006 and 2007. Therefore, these years will also be used as they are indicative of actual water consumption during periods of low precipitation and high population growth.

Table 2-7: Historic Water System Demands

	Inner Zone Max Consumption		Outer Zone Max Consumption		System Max Consumption
Year	1st Largest	2nd Largest	1st Largest	2nd Largest	
2005	1.70 MG	1.57 MG	8.04 MG	7.82 MG	9.74 MG
2006	1.32 MG	1.19 MG	7.61 MG	6.65 MG	8.93 MG
2007	1.43 MG	1.38 MG	7.19 MG	5.94 MG	8.48 MG
2008	1.72 MG	1.54 MG	6.76 MG	6.40 MG	8.04 MG
2009	1.40 MG	1.27 MG	6.06 MG	5.76 MG	6.97 MG
2010	1.24 MG	1.20 MG	5.50 MG	5.32 MG	6.70 MG
2011	1.25 MG	1.14 MG	6.59 MG	5.04 MG	7.72 MG
2012	1.66 MG	1.65 MG	7.48 MG	6.80 MG	8.96 MG
2013	1.42 MG	1.30 MG	5.36 MG	5.04 MG	6.78 MG
2014	1.32 MG	1.26 MG	4.89 MG	4.79 MG	5.85 MG
2015	1.37 MG	1.30 MG	4.83 MG	4.63 MG	5.84 MG
2016	1.63 MG	1.44 MG	5.07 MG	4.65 MG	6.51 MG
2017	1.40 MG	1.37 MG	6.53 MG	4.89 MG	7.94 MG

The maximum day demand over the previous 10-year period was 9.74 MGD in July of 2005. This maximum appears representative as the second and third maximum day demands were 8.96 MGD and 8.93 MGD in 2012 and 2006, respectively. To further analyze the historical water usage, maximum day peaking factors were calculated. These factors are the ratio of the maximum day each year, to the average daily usage of that same year.

Average	MGD
1-Year	4.07
5-Year	3.98
10-Year	4.07

The ultimate peaking factor is calculated as the ratio of the maximum day to either the 5-year or 10-year daily average usage. This provides a more conservative approach to planning and is used in hydraulic modeling. The 5-year average daily usage was 3.98 MGD, and the 10-year average daily usage 4.07 MGD. These corresponded to peaking factors of 2.45 and 2.39, respectively. A peaking factor of 2.0 or under is considered typical, and as such the peaks observed by the City appear high but within reason. Therefore the 2.45 peaking factor will be utilized for planning and hydraulic modeling.

Peaking Factor (Based on 9.74 MGD MDD)	
5-Year	2.45
10-Year	2.39

2.5.2 Overall System Capacity

Historically, the City has had adequate capacity to serve its planning area under all circumstances. During extremely high water usages, the City has been required to supplement well supply from the ground storage reservoirs, however at no point was the system in jeopardy of not meeting demands.

Future Water Demands

Water usage has generally decreased over the past decade as a result of higher efficiency water fixtures, watering restrictions, and a public effort to reduce unnecessary water consumption. While the City should not depend on a decrease in demand, this trend is seen in most communities and represents a national shift rather than a local anomaly. It is unlikely that demand will return to levels seen in the early 2000's unless significant droughts are experienced.

Section 2.4 of this Plan identified population growth projections for five-year, 2030, and 2040 planning horizons. Associated increases in water demand for each of these phases was developed by extrapolating current water usage per PE. For example, at the calculated 75 gallons per PE/day of water pumped, the 2023 population estimate of 66,329 equates to a total average daily demand of approximately 5.0 MGD. The table below includes the extrapolated demands based on population projects.

Table 2-8: Future Water Demands

	Current 2018	Planned 2023	Programmed 2030	Future 2040
Current P.E.	53,200	53,200	53,200	53,200
Growth P.E.	-	12,900	20,093	26,570
Total P.E.	53,200	66,100	73,594	80,000
ADD (MGD)	4.00	5.00	5.50	6.00
MDD (MGD)	9.74	12.10	13.50	14.60
Firm Capacity Required	**10.00**	**12.10**	**14.00**	**15.00**

The firm capacity that is recommended is the minimum amount of well production available with the largest well out of service. With a current maximum day demand of 9.74 (based on historical data) the recommended firm capacity is 10.0 MGD. The tables above illustrate the maximum day demand increasing proportionally to the average demand based on population growth. While the maximum day demand may not follow a linear relationship, this provides a conservative estimate for water supply planning.

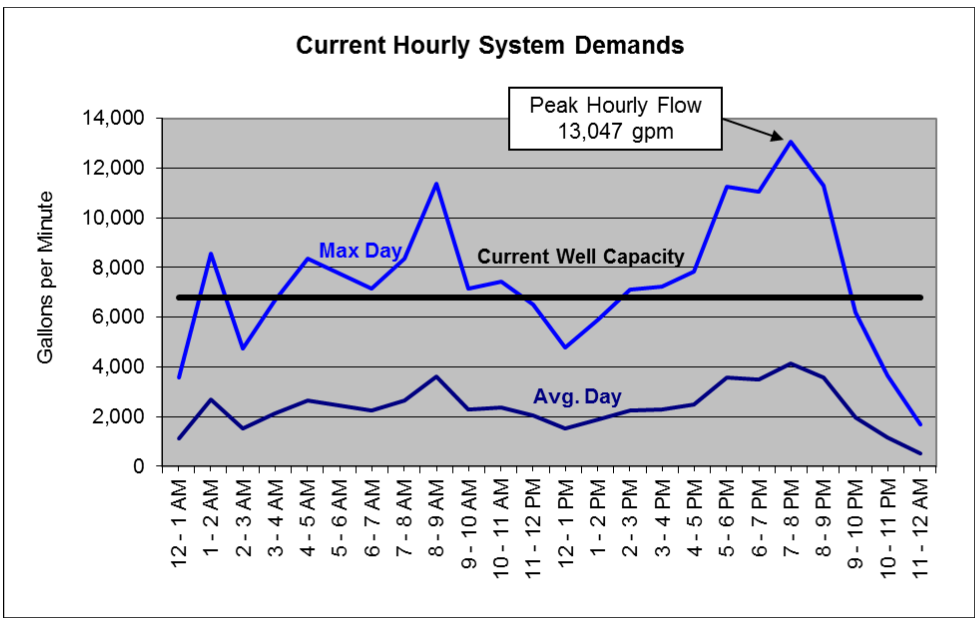
The city has a total well design capacity of 15.13 MGD and a firm capacity of 12.03 MGD. However, due to the age and condition of the wells, the production capacity is currently limited to approximately 11.59 MGD with a firm capacity of 9.43 MGD. As shown in the table, the City has capacity to provide the average daily demand throughout the four planning horizons. However, the maximum day demand exceeds what is currently available due to the lowered production capacity of wells at all phases. Analysis of the existing wells and alternatives for additional supply sources are reviewed in Section 5 and Section 6 of this report. These sections also delineate production capacity of the inner and outer zones and growth within each.

Ability to Meet Peak Hourly Demands

The maximum day usage was identified as 9.74 MGD in 2005. To determine the system's ability to meet the maximum day demand, the diurnal peak of the maximum day is reviewed. The diurnal curve represents the water usage across a typical 24-hour day. For example, water usage at 2:00 am is minimal, and is represented with a 0.5 multiplier of the day's total usage. Similarly, a community such as St. Charles with a significant commercial base may see a maximum hour usage at 9:00 am when both residential and commercial operations are using water, and a multiplier of 1.5 – 2.0 may be observed.

The Peak Hourly Flow is defined as the maximum hourly flow, often occurring on the maximum day. To evaluate the system's ability to meet this flow, trending of the actual diurnal flows seen by the City was performed. These diurnal factors were then applied to the average daily demand and maximum day demand to create the chart below. The peak hourly flow would be anticipated to occur at 7:00 PM on the maximum day with an hourly flow rate of just over 13,000 gpm.

Figure 2-2: Hourly System Demands



The 'current well capacity' line in the graph above represents the 9.80 MGD (7,300 gpm) well production firm capacity that would be available if Well #7 was brought online and all well outputs maximized to practical levels. The hourly flow exceeds this production capacity several times throughout the day, which would require boosting flow into the system from ground storage. The total supplemental volume required on this maximum day is approximately 1.2 MG. While the City has this storage capacity available, the system would be unable to adequately refill the reservoirs during off-peak hours in the event of multiple consecutive high-demand days.

Therefore, in order to meet any potential maximum day demand events, as well as future growth demands, the City should consider pursuing additional water sources. As previously stated, this issue and potential solutions are evaluated in Section 5 and Section 6 of this report.

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SECTION 3

EXISTING DISTRIBUTION SYSTEM EVALUATION

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3. EXISTING DISTRIBUTION SYSTEM EVALUATION

This section describes the current conditions, deficiencies, and maintenance issues related to the City's water distribution system. A hydraulic analysis of the City's distribution system was performed in order to identify restrictions within the existing distribution system and develop recommendations for future improvement projects. Current water supply, storage, and treatment will be reviewed in Section 5.

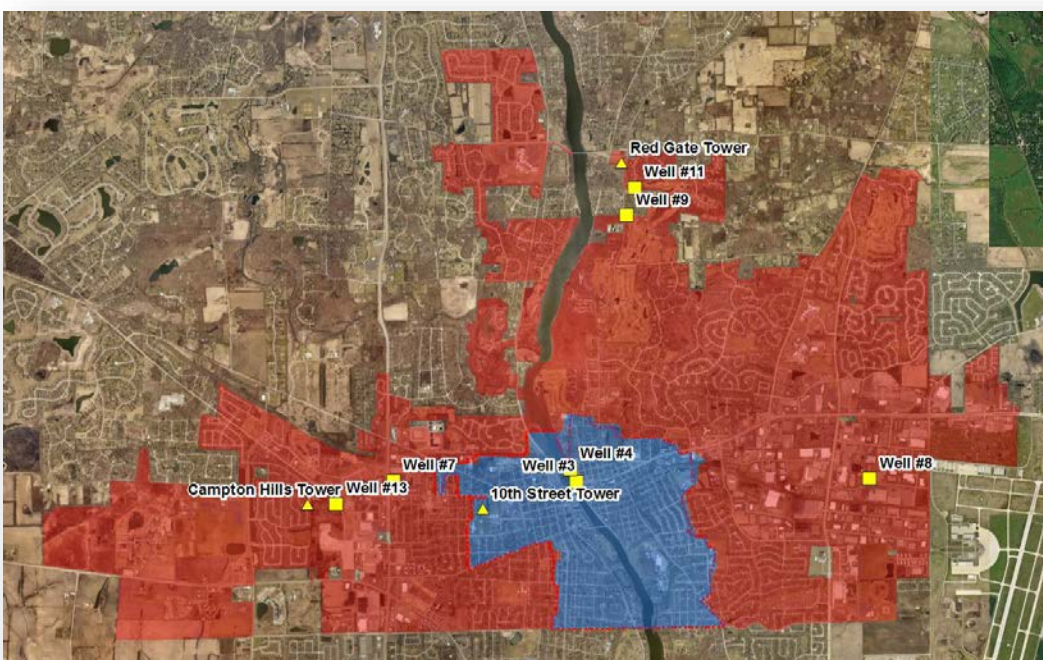
3.1 GENERAL BACKGROUND

The City of St. Charles has grown from a community of 17,492 residents in 1980 to 27,910 in 2001 and 33,403 in 2018. The residential water billed for the community in Fiscal Year 2018 was 2,133,000 gallons per day, while the non-residential (commercial, industrial, and municipal) usage was approximately 1,208,000 gallons per day. The total pumpage was approximately 4.0 MGD, which includes unbilled or unmetered water pumpage.

The City of St. Charles maintains roughly 240 miles of water main, approximately 2,900 fire hydrants, 2,700 valves, and two distinct service areas within the distribution system. Historically, the City has been able to transfer water from the outer service area to the inner through the use of manually operated pressure sustaining valves. However, under typical operation these valves remain closed.

The City Water Department has adopted proactive water main maintenance, flushing, and rehabilitation programs to sustain the level of service provided to the community. The water main rehabilitation program is often coordinated with the City's Capital Improvement's Program for street rehabilitation and reconstruction to minimize costs. As stated previously, the City's water system has a large service area that is divided into two zones to maintain adequate water pressures across varying topographic regions, the Inner Service Area (shown in blue) and Outer Service Area (shown in red)

Figure 3-1: Water System Zone and Structure Map



3.1.1 Inner Service Area

The Inner Service Area generally serves the residents and businesses within the valley along the Fox River, and for the most part, the downtown area. In general, this is the older portion of town, and has approximately 46 miles of water main, 400 valves, and 500 hydrants. In 2017 this zone had an approximate residential demand of 600,000 gpd and commercial demand of 350,000 gpd. The Inner Service Area is supplied by two wells, Wells #3 and 4, which are located in the heart of downtown on Riverside Avenue. In addition, this service zone also has an elevated storage tank located on 10th street.

The majority of water main, especially in the downtown area, is smaller than eight-inches in diameter, with an appreciable amount of 4-inch main. Smaller main sizes were a common practice when these mains were installed, but current design standards dictate that new water mains should be no smaller than eight inches. These design standards were implemented to address the long-term efficiency loss due to corrosion and present-day fire flow demands.

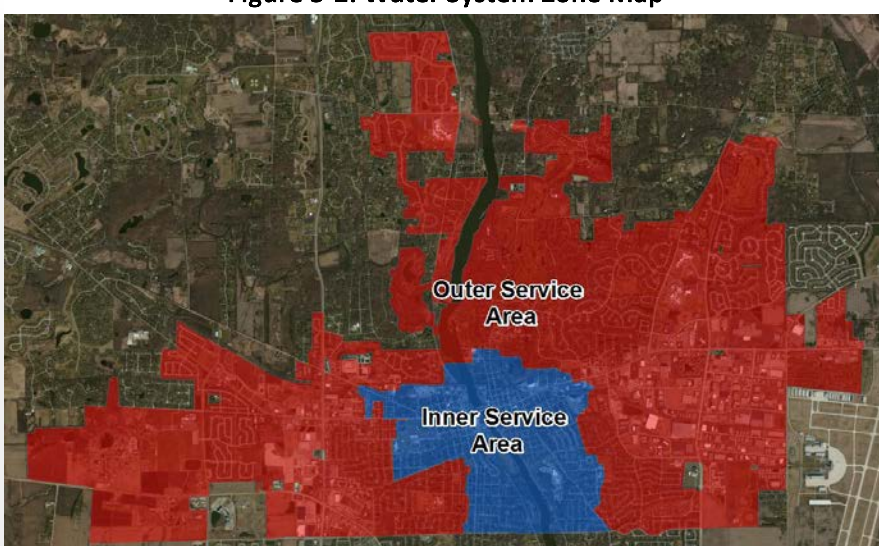
3.1.2 Outer Service Area

The Outer Service Area supplies water to the remainder of the City and is generally at a higher elevation, with the largest demands. The Outer Service Area has approximately 194 Miles of water main, 2,300 valves, and 2,400 hydrants. In 2017 this zone had an approximate residential demand of 1.96 MGD and commercial demand of 1.16 MGD.

The Outer Service Area is supplied by multiple wells, including Wells #7, 8, 9, 11, and 13. However, the operation of each of these wells is dependent on system conditions, and if other system components are down for maintenance. Two elevated storage tanks are located within the outer service area, one tower is located on the western side of town (Campton Hills Tower) and the other one the northeastern side of town (Red Gate Tower). The two service areas are connected via pressure reducing valves which are capable of supplying water to the Inner Service Area from the Outer Service Area if Wells 3 and 4 are out of service. These manually operated PRVs are rarely utilized and some may be non-operational.

The Outer Service Area in general consists of newer water main that is eight-inches in diameter or larger. This is a result of new construction following the new design standards that were implemented, which typically allows for greater capacity, and minimal efficiency loss.

Figure 3-2: Water System Zone Map



3.2 WATER QUALITY

The City of St. Charles is committed to supplying a safe, reliable and economical potable water supply to all residents and businesses within the City's service area. The City operates three water treatment facilities and provides chlorination and fluoridation to ensure that they are providing a safe water supply. As a result, the City meets all IEPA and USEPA requirements for primary and secondary water quality standards.

While the existing water supply is safe, it also contains high levels of the minerals calcium and magnesium, commonly referred to as hardness. Hard water is common in water systems that use groundwater as their source. As groundwater travels through the aquifer it dissolves minerals such as calcium and magnesium. The City of St. Charles has a water hardness range of 19 – 30 grains per gallon, which is generally defined as very hard, as seen in the following AWWA Hardness Classification Scale table. As a result, many of St. Charles' customers treat their water with privately owned water softeners.

Table 3-1: AWWA Hardness Classification Scale

Hardness Classification	Grains per Gallon (gpg)	Parts per Million or mg/l
Soft	0 to 4.3	0 to 75
Moderately Hard	4.3 to 8.8	75 to 150
Hard	8.8 to 17.1	150 to 300
Very Hard	17.1 and above	300 and above

The Environmental Protection Agency does not have a Primary or Secondary drinking water standard regarding water hardness as it does not present any health concerns. The concerns associated with hardness levels are related to aesthetics, such as mineral deposits, soap consumption and service life of appliances.

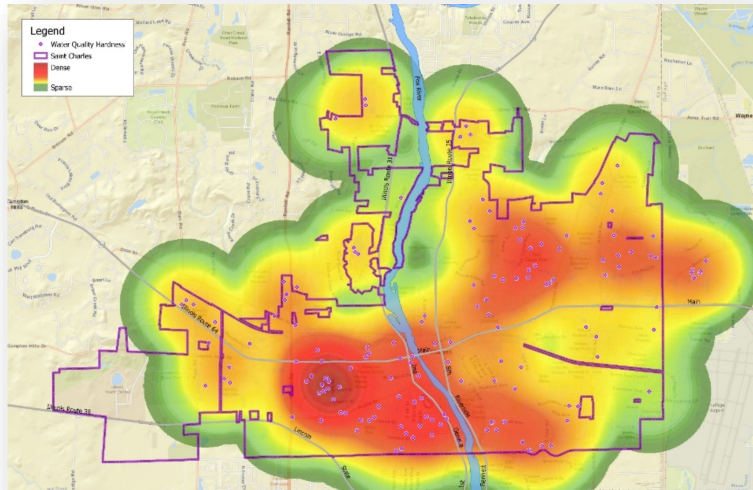
The City completed the Ohio Avenue Water Treatment Facility in 2006. This facility uses a combined Hydrous Manganese Oxide (HMO) and Ion Exchange filtration process to achieve the primary objective of radium removal. As a byproduct of the use of these technologies, the Ohio Avenue Facility also achieves significant removal of carbonate hardness associated with calcium and magnesium ion concentrations. The City has since constructed a treatment facility for Wells 3 and 4 which uses the same treatment processes to remove radium from deep well sources.

Recently, there has been increased interest within the City to investigate softened water throughout the community. As a result, alternatives for expansion of water softening for the City will be further investigated in Section 6.

3.2.1 Hardness

Water hardness is one of the leading reasons for water quality complaints in the City of St. Charles. The City tracks hardness complaints by address, allowing for the creation of the heat map to the right. The gray dots indicate an address that has registered a water hardness complaint, and concentrated areas of complaints are highlighted by shades of orange or red. Expanded municipal water softening would serve to decrease the frequency of these complaints greatly and alternatives to achieve this goal are discussed in Section 6.

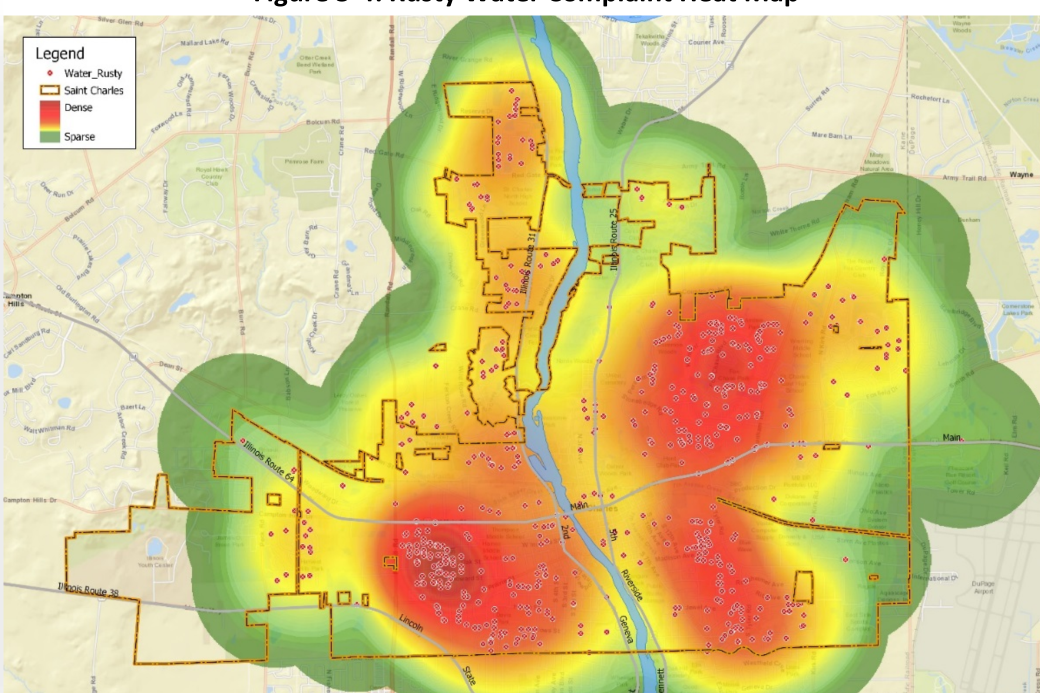
Figure 3-3: Water Hardness Complaint Heat Map



3.2.2 Rusty Water

Complaints of rusty water are highlighted in the heat map shown below. Gray dots indicate an address where a complaint has been registered, and orange and red regions display locations with higher densities of complaints. Rusty water is discolored and contains iron, but typically results no health concerns. Customer calls regarding rusty water are often during periods of hydrant flushing, when higher velocities of water are carried through the system. This is considered normal and should not be read as a cause for concern.

Figure 3-4: Rusty Water Complaint Heat Map



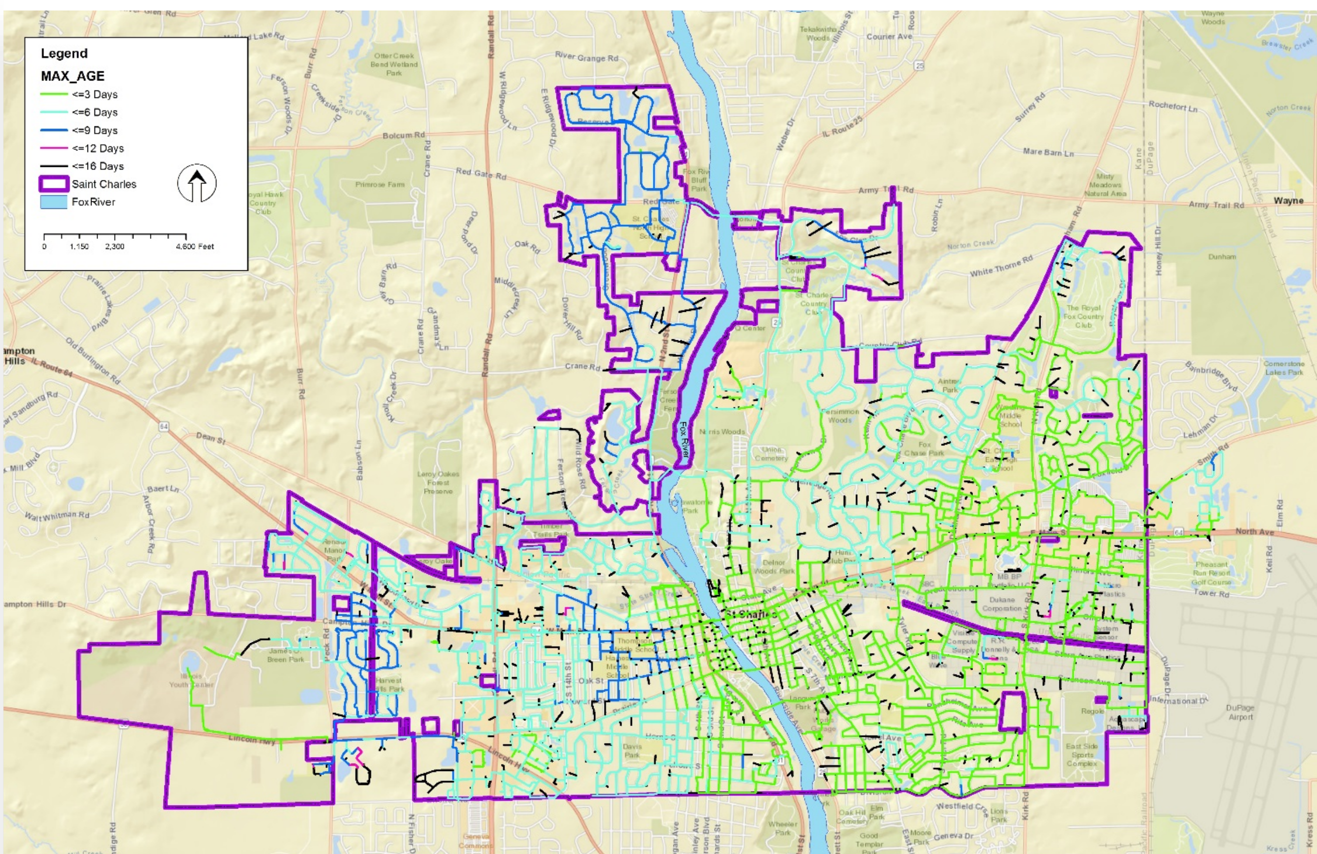
3.2.3 Water Age

Over the last few years, water age has become more of a concern, and many are working on ways to minimize the water age throughout the water distribution system. Water age can be affected by several different factors, which include water system demands, well run time, reservoir capacity, elevated storage capacity, water main layout, water main size, etc.

Typically, water age is defined at the amount of time (days) of which water resides in the system prior to entering the customer's home. The longer it takes for water to leave the water treatment plant and enter a home for consumption can result in loss of chlorine residual, odors, and potentially color changes. In general, anything less than three days age is considered 'very good'.

The City's water system was modeled to identify the water age throughout the system based on usage. The figure below shows the water age within each pipe on average. Light Green identifies areas of water age of less than three days, light blue represents areas with less than six days, dark blue represents less than nine days. On average the City's system has a water age of three to six days. The area of longer-duration ages is typically found in the northwest portion of the system and is likely related to the 1.5 MG elevated storage tank in this region. This tower is needed as it provides storage and improves water pressure throughout the City, providing net benefits. The City does not experience issues with a loss of chlorine residual, odors, or color change associated with water age.

Figure 3-5: System Wide Water Age



3.3 Distribution System Evaluation

The City's water distribution system includes roughly 240 miles of water main, 2,900 fire hydrants, and 2,700 valves. For planning purposes the value of water main and other system components can be estimated to project a total system asset value. As shown in the table below, the existing City of St. Charles water distribution system value is estimated at approximately $190 million including system valves and hydrants, prior to depreciation. The total replacement cost for the water system, estimated at approximately $300 million, was calculated by adding 50% the unit asset value to account for surface restoration, contingencies, project management, design and administration.

Table 3-2: Distribution System Asset Value & Replacement Cost

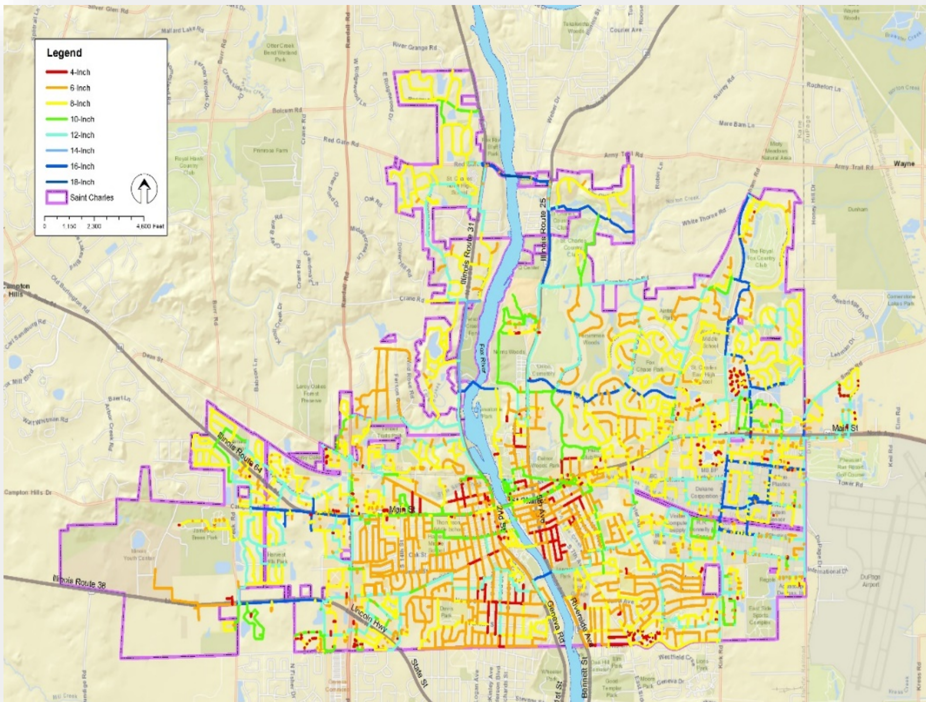
System Asset	Quantity	Unit Cost	Total Asset Value ($ Million)	Total Replacement Cost ($ Million)
<4-Inch Main	16,400	$120	$1.97	$2.95
4-Inch Main	44,900	$120	$5.39	$8.08
6-Inch Main	316,900	$120	$38.03	$57.04
8-Inch Main	436,300	$120	$52.36	$78.53
10-Inch Main	106,800	$130	$13.88	$20.83
12-Inch Main	216,900	$140	$30.37	$45.55
14-Inch Main	4,200	$150	$0.63	$0.95
16-Inch Main	60,900	$175	$10.66	$15.99
18-Inch Main	1,500	$185	$0.28	$0.42
Unknown Main	55,700	$150	$8.36	$12.53
System Valves	2,700	$4,500	$12.15	$24.30
Hydrants	2,900	$5,500	$15.95	$31.90
Total:	-	-	**$190.01**	**$299.07**

Based on straight-line depreciation and a seventy-five-year service life for this infrastructure, an average of $4.00 Million would need to be budgeted annually in order to replace all of the existing distribution system by the year 2093. This budgetary amount would need to be increased by the Construction Cost Index (CCI) each year, which has averaged 2.92% over the past decade. This annual reinvestment should be prioritized based on a number of criteria including main diameter, age, break frequency, soil conditions, and the presence of lead services, among others. These criteria will be discussed within this section, with recommended alternatives for rehabilitation and upgrade of the distribution system in Section 4.

3.3.1 Water Main Size

Shown below is the water main layout for the City of St. Charles. Water main in red represents 4-inch, pink 6-inch, yellow 8-inch, green 10-inch, teal 12-inch, light blue 14-inch, blue 16-inch and dark blue 18-inch. The table below identifies the breakdown of the water main sizing within the City. As shown in the table, the majority of the water main in the community is six and eight inch, with downtown areas generally smaller diameter.

Figure 3-6: Water Main Size



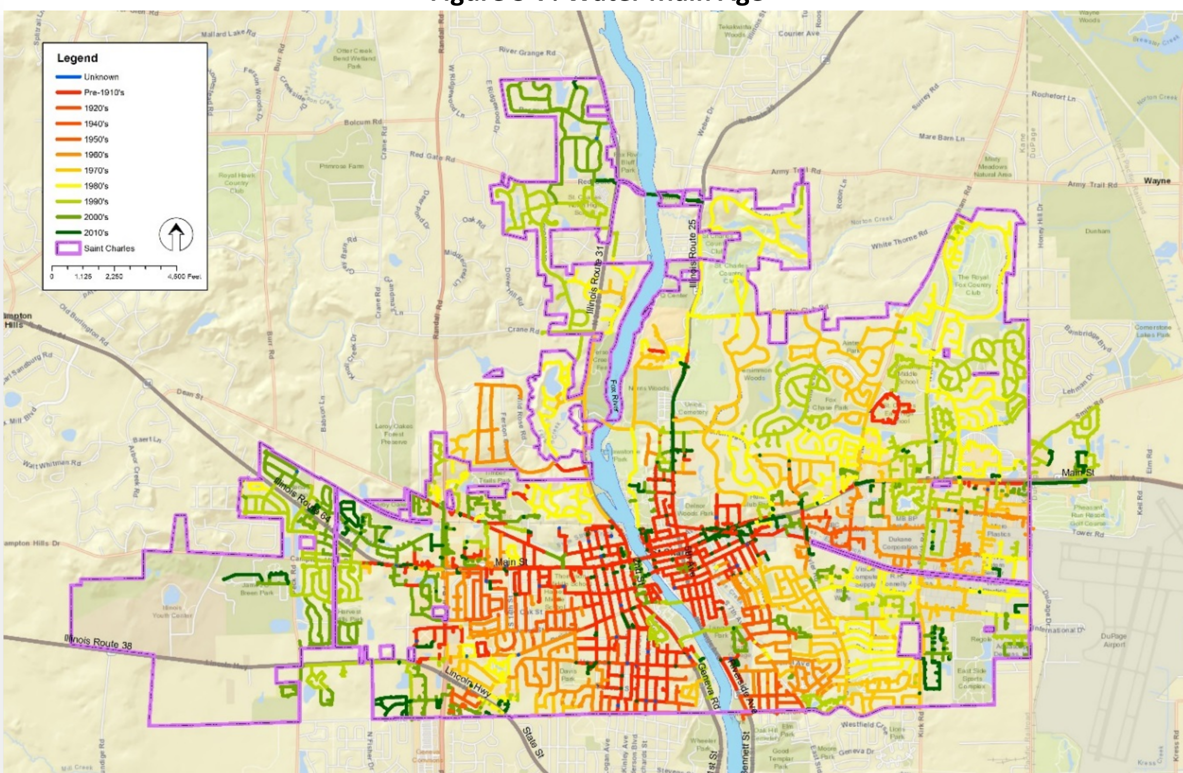
	Feet	Miles	%
≤4-Inch	61,299	11.6	4.9%
6-Inch	316,945	60.0	25.1%
8-Inch	436,283	82.6	34.6%
10-Inch	106,841	20.2	8.5%
12-Inch	216,941	41.1	17.2%
14-Inch	4,238	0.8	0.3%
16-Inch	60,865	11.5	4.8%
18-Inch	1,541	0.3	0.1%
Unknown	55,739	10.6	4.4%
Total	1,260,691	238.8	100.0%

Current accepted practice is installation only of 8-inch and larger diameter water main. This includes residential as well as commercial applications. Historically, water main as small as 4-inch was installed for residential areas. As fire flow requirements and water quality concerns have grown, the need for larger main has as well. The City of St. Charles has minimal 4-inch diameter main, comprising less than 4% of the total system and isolated primarily to the inner service area. Industry standard for many years was to utilize 6-inch for residential areas, and as such makes up more than 25% of the City's system. While this provides adequate fire protection in some areas, it may be insufficient in neighborhoods with large homes requiring commercial-grade fire protection.

3.3.2 Water Main Age

Shown below is the water main installation date for the City of St. Charles. Water main in red represents pipe installed in the 1950's or earlier, orange the 1960's and 1970's, yellow 1980's, green 1990's and 2000's, and dark green is 2010's. The table below identifies the breakdown of the water main installation dates within the City. As shown in the table, the majority of the water main (65%) was installed in the between 1970 and 2010 with a median installation year in the early 1980's.

Figure 3-7: Water Main Age



According to the AWWA's "Buried No Longer" study performed in 2012, the lifespan of water main depends primarily on material and installation region. For the Midwest region, PVC water main can be expected to last approximately 55 years, ductile iron between 50-100 years, and cast iron 85-120 years (in the absence of pressure and other operational issues). From a capital replacement standpoint, water main is anticipated to last up to 75 years if properly installed. Roughly 30% of the City's distribution system is 50 years or older. Therefore, during capital planning, the City should include age as a metric for replacement prioritization.

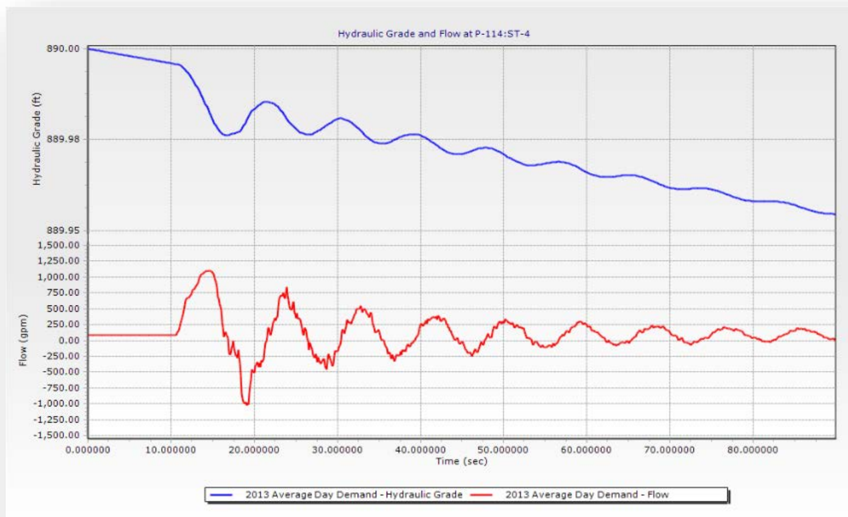
	Feet	Miles	%
<1930	216,817	41	17.20%
1940	3,975	0.8	0.30%
1950	63,426	12	5.00%
1960	120,742	22.9	9.60%
1970	186,983	35.4	14.80%
1980	215,824	40.9	17.10%
1990	229,505	43.5	18.20%
2000	149,687	28.3	11.90%
2010	66,901	12.7	5.30%
Unknown	6,781	1.3	0.50%
Total	1,260,691	238.8	100.00%

3.3.3 Water Hammer

Water hammer can be a nuisance to customers, as well as cause serious damage to the water distribution system such as water main breaks or pump damage. Water hammer results during transient conditions in the piping system. The longitudinal transient wave that moves throughout the system causes pressures to oscillate repeatedly between alternating peaks and valleys while the transient conditions persists and then gradually subsides. The duration and magnitude of the transient condition are dependent on the dynamics, geometry, and operation of the system.

Severe transient conditions, such as that than can be created when a pump is taken off line rapidly following a loss of power, can pull a vacuum during the drop-in pressure that occurs as the transient pressure wave moves away from the pump, only to be followed by a rapid climb to pressures far in excess of normal operating pressures. The arrival of the return longitudinal wave is marked by the water hammer sound as the wave rebounds and reverses.

In many communities, transients have caused unwanted discharge of RPZ backflow preventers, and there are few operational adjustments that can be made to control the water hammer that is experienced. The transients result from the configuration of the distribution system and usually a result of areas remote from the nearest open-air water surface (water tower). This is often the case with communities that have undersized or distant elevated storage tanks.



The City of St. Charles does not currently experience routine water hammer issues. Historically, areas in the northwest region of the community observed significant pressure variations. This primarily occurred at and north of the St. Charles North High School. As a result, the 2007 Water Master Plan recommended installation of an elevated storage tank capable of providing consistent pressures and fire flow capacity to this area of the City. The installation of the Red Gate tower at Route 25 and Red Gate Road provides the necessary buffer to avoid significant pressure fluctuations and transients. In order to further mitigate water hammer and reduce main breaks, the City should install soft starts or VFDs on booster pumps.

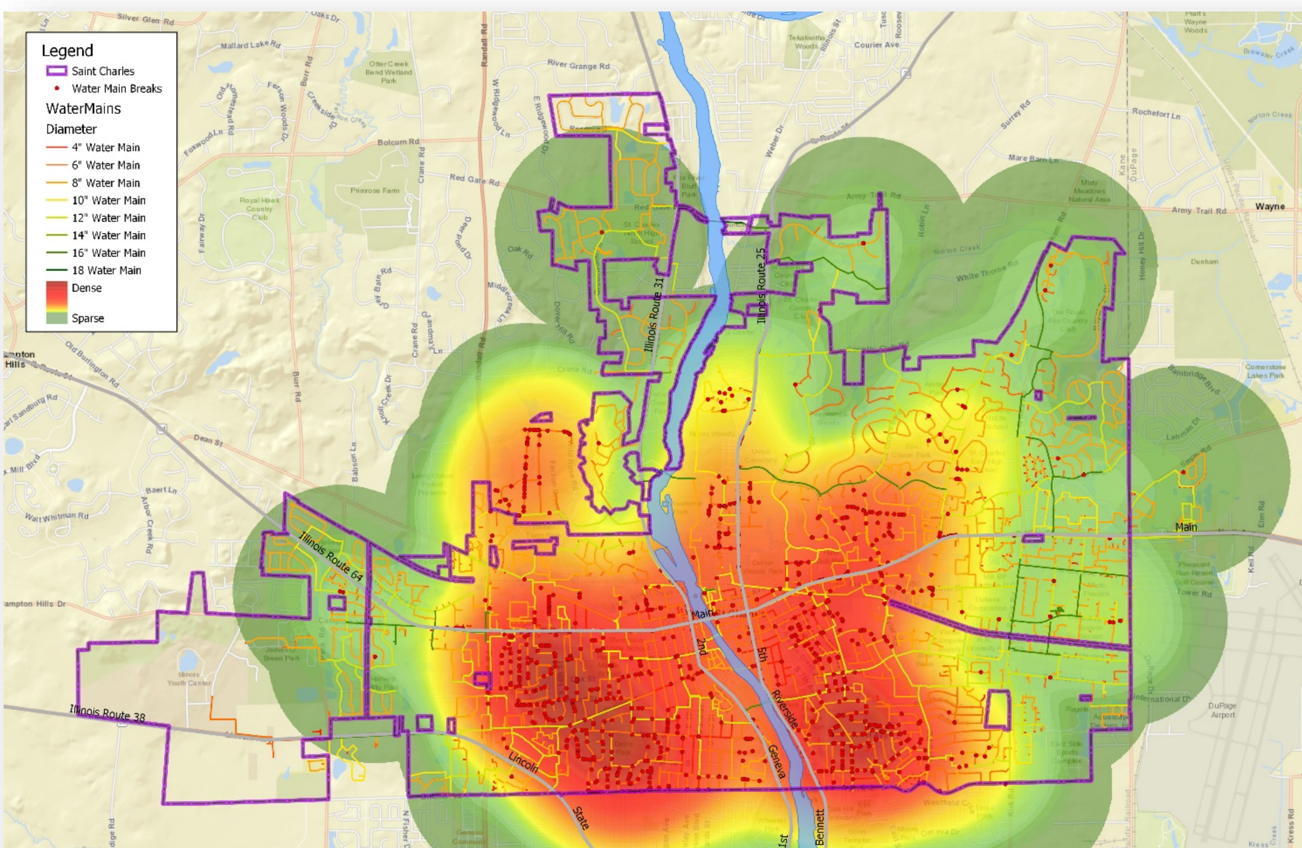
3.3.4 Water Main Breaks

The City of St. Charles water distribution system has been in operation since the early 1900's, and the rate of deterioration of water mains exceeds the rate of replacement. The majority of rehabilitation work performed within the system has been a direct result of leakage or water main breaks.

The system has been identified as relatively fragile because of the age of the water main piping and the materials that much of it was constructed using (e.g. cast-iron). The City should work to replace the older and deteriorated sections of water main pipe with piping manufactured of non-corrosive materials such as PVC, HDPE, or wrapped ductile iron as the majority of the City contains corrosive soils.

The following map identifies the City's water distribution system, with a heat map overlay identifying potential problem areas within the City limits. Areas in green have very few water main breaks, yellow and orange have progressively more main breaks, and shades of red depict areas with the highest concentrations of main breaks. These failures could be a result of a combination of several factors including insufficient construction materials or techniques, "hot" soils which can be the cause of increased pipe deteriorating, etc. These specific locations should be kept in mind when water main is being repaired and replaced. Further investigations may be needed to identify if different construction techniques or materials are warranted.

Figure 3-8: Water Main Break History



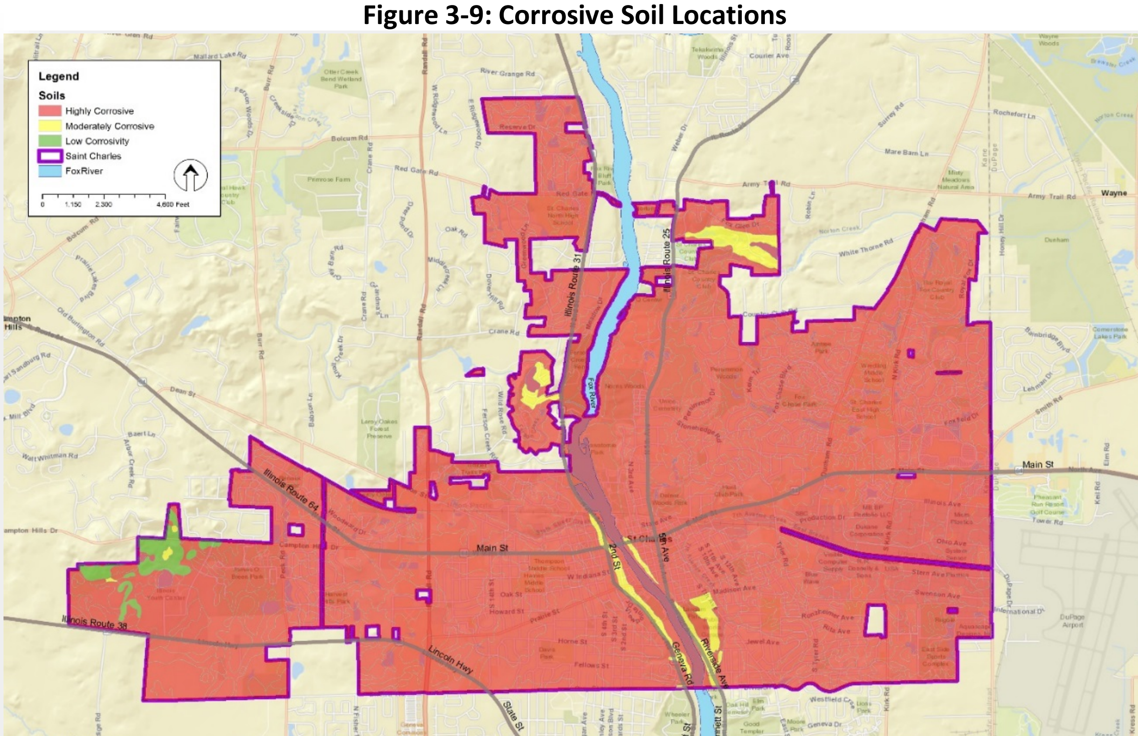
3.3.5 Corrosive Soils

The City of St. Charles has experienced a significant number of water main breaks throughout the distribution system. One of the affecting factors of water main breaks has been identified and attributed to corrosive soils. Over time, as water main is exposed to corrosive soils, the pipe and fittings begin to deteriorate both internally and externally. As a result of this decay the service life of the water main is significantly reduced, much of this is due to the reduced wall thickness of the water main itself. The images to the right were taken by City staff in 2018 and illustrate the effect of corrosion on water main.

The graphic below illustrates the various corrosivity levels of soils within the City, as mapped by the US Department of Agriculture (USDA). Green represents low soil corrosivity, yellow moderate, and red high. Unfortunately, approximately 97% of the City of St. Charles' service area falls within the 'high' corrosivity soil areas.

The City should work to replace the older and deteriorated sections of water main pipe with piping manufactured of non-corrosive materials such as PVC or HDPE. If ductile-iron pipe is going to be utilized, it should be double-wrapped in polyethylene given the damage that the aggressive soils in the area have caused to the existing iron-based piping.

Figure 3-9: Corrosive Soil Locations



3.3.6 Lead Service Survey

Lead and Copper Rule Background

In response to the 1986 amendment to the Safe Drinking Water Act, the Environmental Protection Agency (EPA) adopted the Lead and Copper Rule (LCR) in 1991. The LCR requires water suppliers to deliver water that is minimally corrosive, thereby reducing the likelihood that lead and copper will be introduced into the drinking water from the corrosion of customer lead and copper plumbing materials. Prior to the LCR inception, the previous standard was to measure lead at the entry point to the distribution system and report issue when levels exceeded 50 parts per billions (ppb). While the old system was easier to test and enforce, most of the lead and copper reaching the taps of customers was (and still is) already within the system in the form of lead solder and the lining of old piping. In accordance to the new rule, testing must be done at the tap of customers on a six (6) month, year, or triennial schedule (smaller districts with a history of low results may only need to test every 9 years).

Over the years, the LCR has seen a few adaptations. Namely, in January of 2000, municipalities were required to install the “best available corrosion control mechanisms” and to continue to observe water levels even after the implementation of corrosion control. In 2004 and 2006, revisions and minor additions to the rule were implemented, in 2007 the EPA enhanced implementation in the areas of monitoring, treatment, customer awareness, and service line replacement. And in 2016 the EPA published additional options that may further revise the rule in the future.

In its current state, the LCR still requires testing at the customer’s tap. If 10% of the tested taps exceed a concentration of 15 ppb for lead, or copper concentrations exceed 1300 ppb further action is required to minimize corrosion. Please note, municipalities are only in violation if they report concentrations greater than those noted and do nothing to fix the issue within a predetermined period of time. These fixes may include replacement of piping, fixtures and fittings within the system, or it may be more cost effective to change the corrosivity of the water within the system to prevent pickup of the unwanted chemicals.

City of St. Charles Lead Service Survey

In 2018, the City surveyed customers to gather information about the type of water services installed. There were 2,195 responses to the survey out of 19,419 total water billing accounts (11.3% response).

Table 3-3: Service Material Survey

Service Type	Number of Respondents	Percent
Copper	1,571	71.6%
Plastic	134	6.1%
Lead	168	7.7%
Galvanized	298	13.6%
Ductile	23	1.0%
Unknown	1	0.0%
Total	2,195	100%
No Response	17,224	---

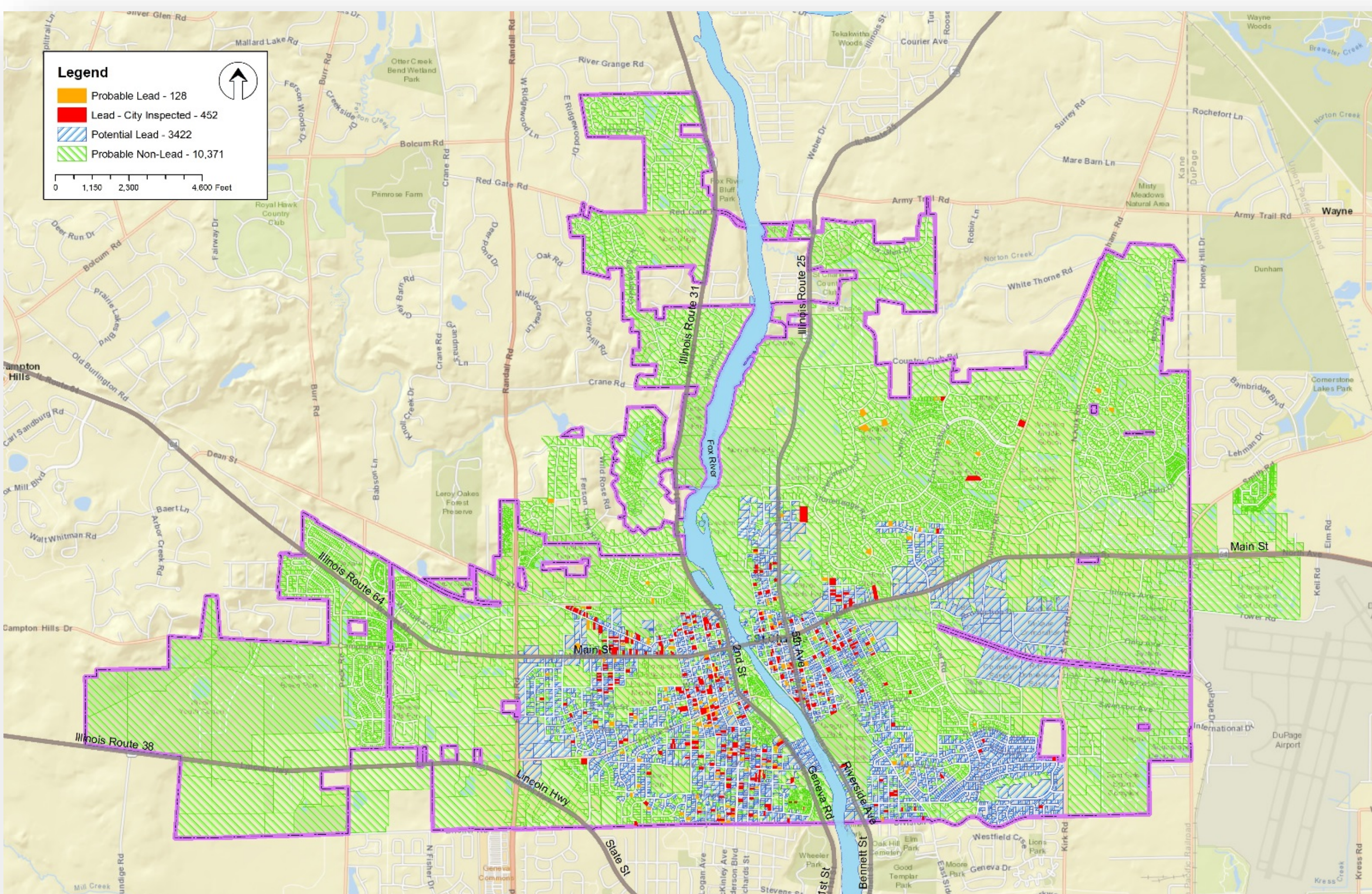
There were 168 lead-type service responses from the customer survey. Of those 168 services, 16 have been confirmed lead by City inspection while 24 have been confirmed copper by City inspection. The City has inspected 3,234 services throughout the system. Of those inspected, 452 (14.0%) have been confirmed as lead services.

To quantify the lead service inventory throughout the system, four groups were identified. The groups and description of each are listed below:

1. Lead: Services the City has confirmed lead type from home inspections.
2. Probable Lead: Services identified by survey as lead, less City-inspected non-lead.
3. Potential Lead: Services where lead is a potential based on water main age.
4. Probable Non-Lead: Services were lead is not probable based on water main age.

The figure below illustrates the locations of each group throughout the City and quantities identified.

Figure 3-10: Water Service Material



Currently, the State is only requiring replacement of lead services if they are on a water main which is also being replaced. The permitting process is being utilized for enforcement at this point, however it is anticipated that lead service replacement requirements will continue to develop over the next 12-18 months. For planning purposes, replacement of lead services was evaluated to determine the potential financial impact to the City. The service replacement has been broken into the following two alternatives:

1. Water Main to B-Box: Services would be replaced from City's water main to a new b-box. This work would be completed on City owned water system and within right-of way.

2. Water Main to House Meter: Services would be replaced from City's water main to a new b-box located within the right-of-way and then continue to the existing water meter located within the house. This work would be completed on both City owned water system (within right-of-way) and on private water service (within private property). Access to the house is also required to penetrate the building's foundation and make the final connection.

Cost for replacement would vary greatly depending on length of service, location of City's water main, and restoration (pavement, driveway, sidewalk, etc.). The table below provides an associated cost for each group and type of replacement. Of the Potential Lead group, it is estimated that 30% of these would be lead service requiring replacement. This percentage is based on the overall City inspected confirmed lead services, relative to the number of City inspected services within the 'probably lead' areas. No replacement cost is figured for the Probable Non-lead group, since these are not anticipated to contain lead.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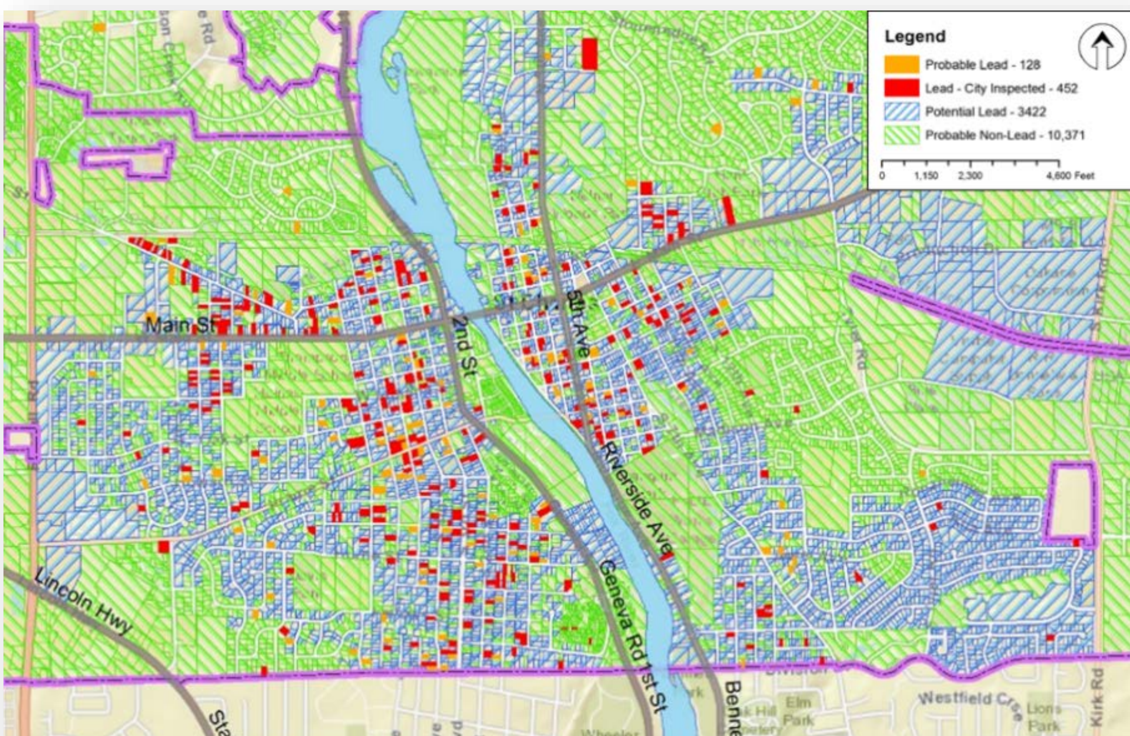
	Number of Parcels	Lead Service Replacement Cost	
		Main to B-Box ($3,500 each)	Main to Meter ($9,000 each)
Lead – City Inspected	452	$1,582,000	$4,068,000
Probable Lead – City Survey	128	$448,000	$1,152,000
Potential Lead (30%)	3,422	$3,593,100	$9,239,400
Probable Non-Lead	10,371	$0	$0
Total:	14,373	**$5,620,000**	**$14,460,000**

Lead Service Summary

An estimated replacement cost for lead services has been developed for the City of St. Charles. If the City elects to move forward with the replacement of lead services, it is recommended that the City budget for the replacement of 100% of both "Lead – City Inspected" and "Probable Lead – City Survey" categories. In addition, it is also recommended that the City budget to replace approximately 30% of the services identified as "Potential Lead". The anticipated costs for the program would vary depending on if the lead service are replaced from the main to the B-Box or from the main to the meter. The range between the two alternatives is estimated to be \$5.6 – 14.5M.

If the City elects to move forward with the replacement of the lead services, it would be recommended that the City continue to perform service inspections either as a dedicated study, or continued as part of the meter department inspections. Continuing these inspections would provide a more accurate total quantity of the services to be replaced and could potentially save the City from budgeting funds that are not used from year to year during a replacement project. A continued and expanded inspection lead study is the first priority in determining future steps toward lead service abatement.

The lead service regulations are still being developed and are changing continually. It is anticipated that over the next year, the pending regulations will be better defined and outlined. As a result, it is recommended that the City continue to monitor these regulations to better identify the future requirements in regards to lead services.



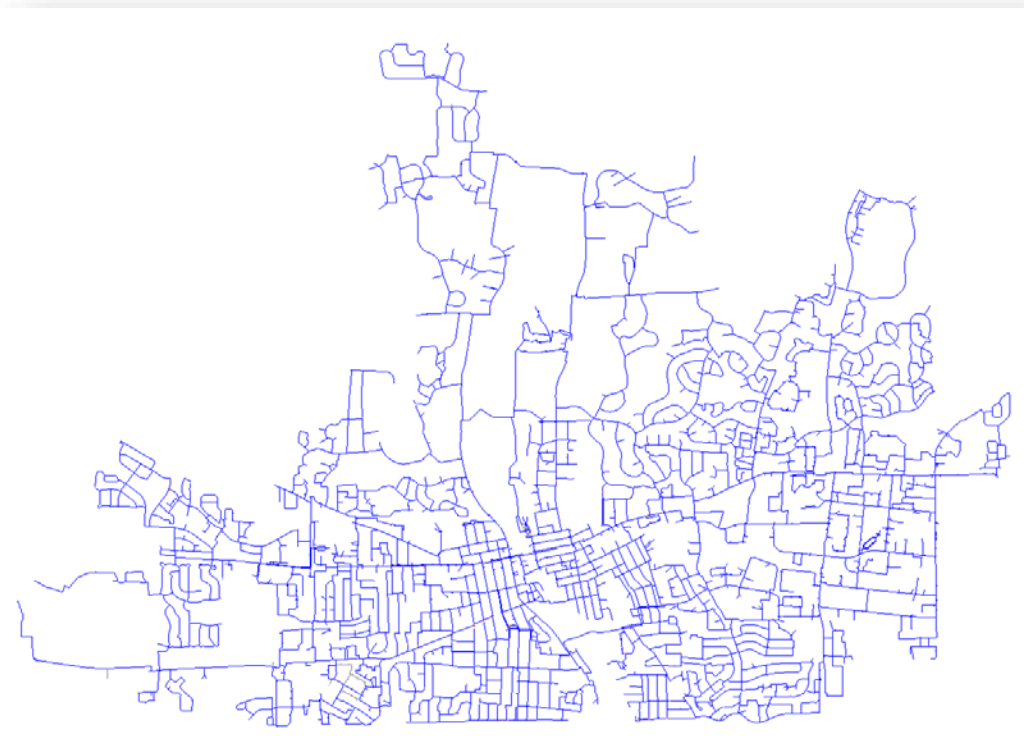
3.4 WATER DISTRIBUTION SYSTEM MODELING

The City maintains a Bentley WaterCAD® V8i distribution system model, hosted by Trotter and Associates, Inc. The model is a valuable tool for evaluating the impact of potential development, as well as to measure the benefits received from capital improvement and rehabilitation projects. In 2007, the WaterCAD® model was updated from its 2001 version to reflect the distribution system's capabilities under Maximum Day Demand (MDD) and Fire Flow conditions.

In 2013 the City elected to rebuild the model from the existing GIS data which incorporate all of the improvements that occurred since 2007. The updated water model had also been modified to include data for all hydrants throughout the service area. Since 2013, multiple water main improvement projects have occurred, as well as the development of new properties. The 2013 model was updated based on new GIS data to reflect those changes. Upon incorporation of the new updates, and minor calibration of the hydraulic model, multiple scenarios and analysis were performed on the existing system. The results of this analysis are as follows.

The features in the model include wells, storage facilities, and distribution system. Each feature's characteristics are simulated within the model, including pipe sizes and lengths, storage reservoir characteristics, pump performance curves and ground elevations. The purpose of the model was to analyze the existing distribution system, to identify capacity issues and to evaluate the impacts of proposed improvements. The accuracy of the current model is sufficient to evaluate existing conditions and to make future recommendations for upgrade of the City's distribution system based on future projected demands. The figure below shows the existing system as modeled in WaterCAD V8i. However, as the City performs improvements, it is recommended that the water model be updated regularly.

Figure 3-11: WaterCAD Water System Map



3.4.1 Water Model Assumptions and Limitations

The following assumptions were utilized to most accurately analyze the water system for the Master Plan. The model used a water velocity constraint of 15 feet per second, which ensures system stability during flushing and fire flow events. The available fire flows and pressures reported represent instantaneously available capacities at the water main and fire hydrants listed throughout.

Assumptions were made in regard to future water usage/daily demands for the City, as necessary. Per the Joint Committee on Administrative Rules – Tile 35, Appendix B: Commonly Used Quantities of sewage flows from Miscellaneous Type Facilities was also used when existing data was not available.

3.4.2 Water Model Calibration

Once the model was updated to include modifications since the 2013 update, it was necessary to verify that the conditions of the model accurately represent the actual operations of the distribution system. To do this, the City performed multiple hydrant tests throughout the two service areas and the entire distribution system. Hydrant testing is critical for distribution modeling and requires a specific operating procedure. The City of St. Charles utilized a pitot nozzle during all hydrant testing. The pitot allowed the Public Works Department to obtain accurate and consistent results for all tests.

The City provided a specific data sheet outlining all data collected during the hydrant tests. For example, the data sheet identified the test and flow hydrants, time of day, flow received, and both residual and static pressures. The Public Works Department also provided information in regard to all boundary conditions during testing, identifying the booster pumps and wells that were running, along with the water tower hydraulic elevations, as well as pressures and flows throughout the system.

The results were used to calibrate the distribution model to reflect the field observations. Creation and calibration of the hydraulic model was performed in accordance with the recommendations of the American Water Works Association's "Computer Modeling of Water Distribution Systems" Manual (AWWA M-32). Each flow test was input individually by setting the time of day, booster pump flows, supply pressure and flows, and water tower elevations. During the initial evaluation, the static pressures were verified and minor adjustments made to obtain a minimal margin of error. The observed fire flow in the field was simulated in the model as a point demand, and the model was run to verify that the residual pressure recorded in the field closely match those projected by the model.

Calibration is an iterative task, and requires that most of the points be revisited two to three times to ensure that the modifications that were made didn't affect other tests. Calibration began with hydrants near connection points to water supplies (wells), and moved outward, away from supply sources. For accurate results it was necessary to have the hydraulic model correctly depict pipe diameters, lengths, pumps, controls, etc., the model relies largely on the Hazen-Williams roughness coefficients or C-Factors. The fire flow testing results were found to track closely with those supplied during the 2013 rebuild of the water model, indicating that the hydraulics were properly calibrated.

3.4.3 Fire Flow Requirements

Per the adopted 2015 International Fire Code, the fire-flow duration for commercial properties is two hours for Needed Fire Flows (NFFi) up to 3,000 gpm and three hours for needed Fire Flows up to 4,000 gpm. Properties requiring greater than 4,000 gpm fire flows require a flow duration of four hours.

The needed fire-flow duration for 1-and 2-family dwellings with an effective area of 3,600 square feet or less is one hour, and dwellings larger than 3,600 square feet is two hours. Buildings other than one and two-family dwellings require fire flows per table B105.1 (minimum required fire-flow and flow durations for buildings) within Appendix B of the International Fire Code. These requirements are also reviewed on a case-by-case basis by the City Fire Department during development review.

Figure 3-12: 2015 IFC Fire Flow Requirements – Appendix B

TABLE B105.1(2)
REFERENCE TABLE FOR TABLES B105.1(1) AND B105.2

FIRE-FLOW CALCULATION AREA (square feet)					FIRE-FLOW (gallons per minute)[b]	FLOW DURATION (hours)
Type IA and IB[a]	Type IIA and IIIA[a]	Type IV and V-A[a]	Type IIB and IIIB[a]	Type V-B[a]		
0-22,700	0-12,700	0-8,200	0-5,900	0-3,600	1,500	
22,701-30,200	12,701-17,000	8,201-10,900	5,901-7,900	3,601-4,800	1,750	
30,201-38,700	17,001-21,800	10,901-12,900	7,901-9,800	4,801-6,200	2,000	
38,701-48,300	21,801-24,200	12,901-17,400	9,801-12,600	6,201-7,700	2,250	2
48,301-59,000	24,201-33,200	17,401-21,300	12,601-15,400	7,701-9,400	2,500	
59,001-70,900	33,201-39,700	21,301-25,500	15,401-18,400	9,401-11,300	2,750	
70,901-83,700	39,701-47,100	25,501-30,100	18,401-21,800	11,301-13,400	3,000	
83,701-97,700	47,101-54,900	30,101-35,200	21,801-25,900	13,401-15,600	3,250	3
97,701-112,700	54,901-63,400	35,201-40,600	25,901-29,300	15,601-18,000	3,500	
112,701-128,700	63,401-72,400	40,601-46,400	29,301-33,500	18,001-20,600	3,750	
128,701-145,900	72,401-82,100	46,401-52,500	33,501-37,900	20,601-23,300	4,000	
145,901-164,200	82,101-92,400	52,501-59,100	37,901-42,700	23,301-26,300	4,250	
164,201-183,400	92,401-103,100	59,101-66,000	42,701-47,700	26,301-29,300	4,500	
183,401-203,700	103,101-114,600	66,001-73,300	47,701-53,000	29,301-32,600	4,750	
203,701-225,200	114,601-126,700	73,301-81,100	53,001-58,600	32,601-36,000	5,000	
225,201-247,700	126,701-139,400	81,101-89,200	58,601-65,400	36,001-39,600	5,250	
247,701-271,200	139,401-152,600	89,201-97,700	65,401-70,600	39,601-43,400	5,500	
271,201-295,900	152,601-166,500	97,701-106,500	70,601-77,000	43,401-47,400	5,750	
295,901-Greater	166,501-Greater	106,501-115,800	77,001-83,700	47,401-51,500	6,000	4
—	—	115,801-125,500	83,701-90,600	51,501-55,700	6,250	
—	—	125,501-135,500	90,601-97,900	55,701-60,200	6,500	
—	—	135,501-145,800	97,901-106,800	60,201-64,800	6,750	
—	—	145,801-156,700	106,801-113,200	64,801-69,600	7,000	
—	—	156,701-167,900	113,201-121,300	69,601-74,600	7,250	
—	—	167,901-179,400	121,301-129,600	74,601-79,800	7,500	
—	—	179,401-191,400	129,601-138,300	79,801-85,100	7,750	
—	—	191,401-Greater	138,301-Greater	85,101-Greater	8,000	

For SI: 1 square foot = 0.0929 m^2, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa.
a. Types of construction are based on the *International Building Code*.
b. Measured at 20 psi residual pressure.

3.4.4 WaterCAD Model Hydraulic Analysis & Results

The City's distribution system was analyzed to see the flows available through the service areas for both the Inner and Outer Service Areas Systems. During this analysis, the model was run under maximum daily demand (MDD) conditions to provide a conservative analysis of the system. A peaking factor of 2.25 was used to establish the demand for the maximum day conditions, which was substantiated by historical flow data provided by the City.

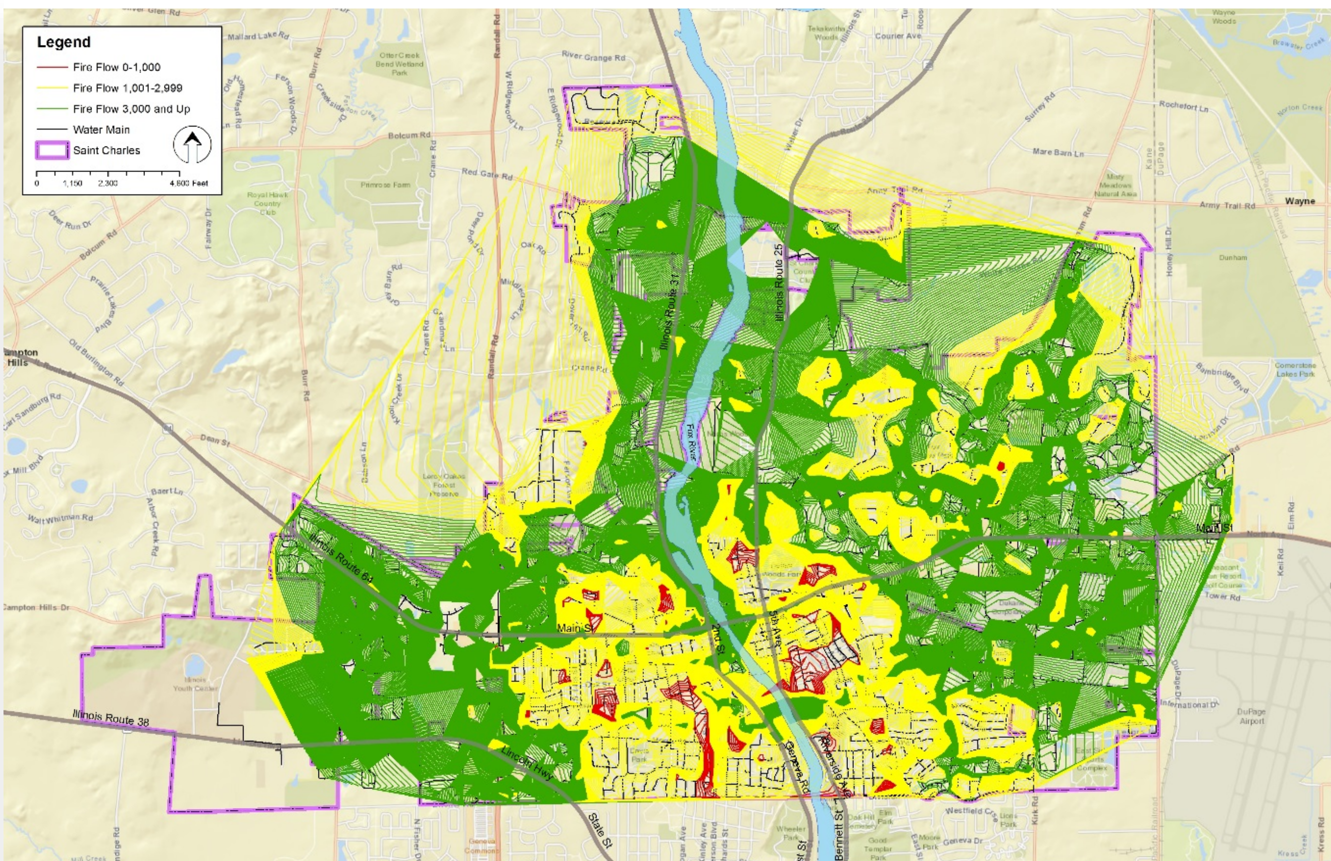
The following sections provide an analysis of the water distribution system based on both available fire flows, and pressure. Specific areas for improvements have been identified within each scenario, and include an engineer's estimate for probable project cost.

Present Day Available Fire Flows

The WaterCAD computer modelling software was used to identify the available fire flow capacity throughout the City of St. Charles water distribution system, defined as the maximum deliverable flow from a single hydrant, while maintaining residual pressures no less than 20 psi. An extended period analysis provided a comprehensive overview of the system's status over a 24-hour period including peak demand conditions.

The results from the simulation were then used to generate an available fire flow contour map. The fire flow contour map below has identified the available fire flows throughout the City, and each contour is defined as less than or equal to the value presented. The fire flow contour map below identifies areas of insufficient fire flow, flow less than 1,000 gpm, in red, potentially insufficient areas of fire flow between 1,000 and 3,000 gpm in yellow and areas of sufficient fire flow greater than 3,000 gpm in green. Each of the areas of concern was analyzed, the cause determined, and recommended improvements developed to alleviate the situation.

Figure 3-13: City of St. Charles - Available Fire Flows

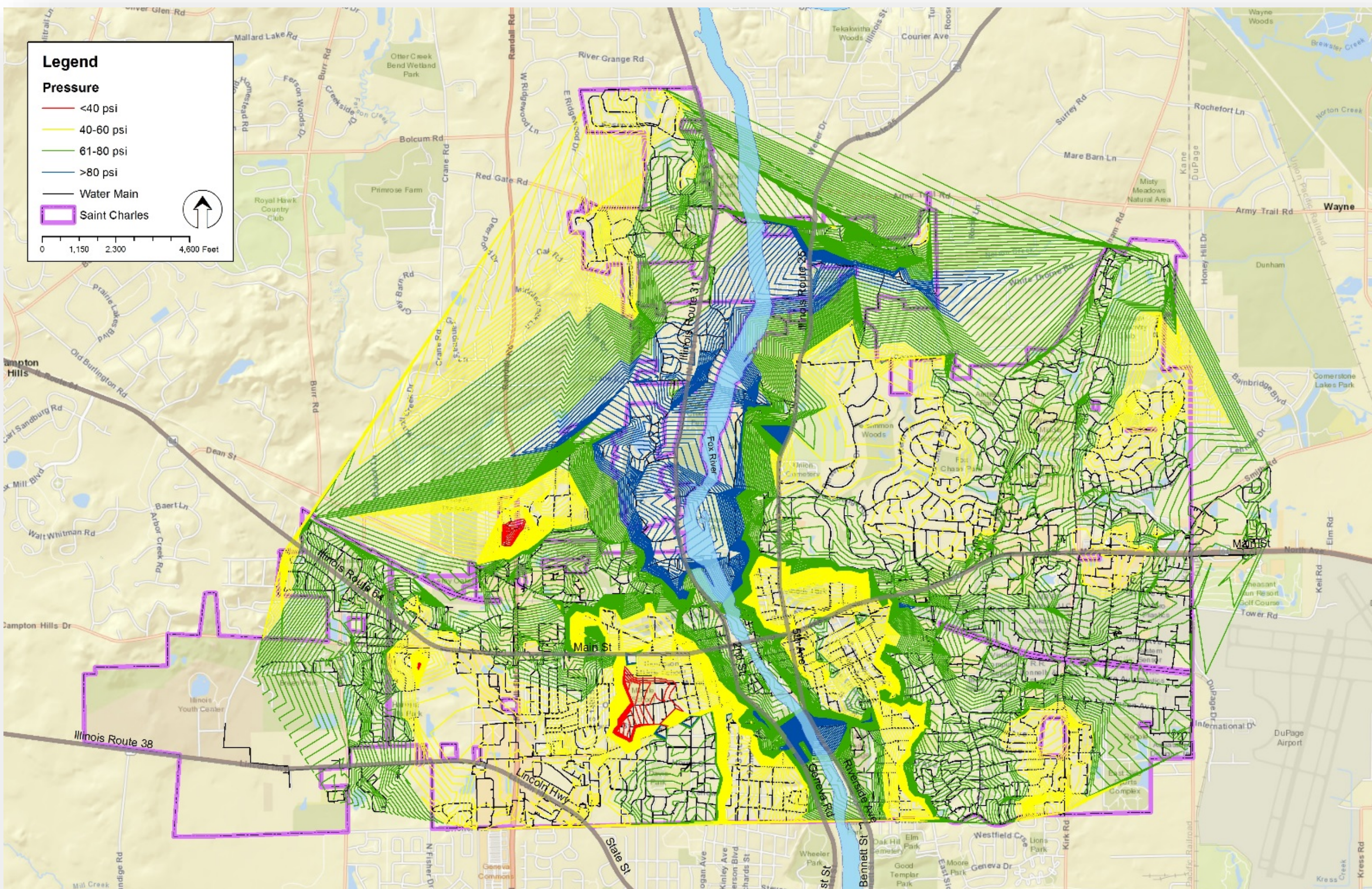


Present Day Pressure Contour Map

In addition to fire flow, the WaterCAD computer modelling software was used to identify the available pressures throughout the City of St. Charles water distribution system. An extended period analysis provided a comprehensive overview of the system's status over a 24-hour period including peak demand conditions.

The pressure contour map below has identified areas of low pressure, defined as less than or equal to 40 psi, in red and areas 40-60 psi are in yellow, 60-80 psi are in green, and greater than 80 psi are in dark blue. The areas of low pressure identified during the analysis were due to high ground elevation in comparison with the hydraulic grade-line of the distribution system. Overall the City has wall distributed contour map the majority of areas around 60-80 psi.

Figure 3-14: City of St. Charles Pressure Contour Map



3.5 Distribution System Summary

The City of St. Charles water distribution system is over 240 miles of water main piping, valves, fire hydrants, and service connections. The total asset value of the distribution system is approximately $300M as identified in the table below. Based on a 75-year service life for the buried water infrastructure, the City would need to be investing approximately $4.0 Million annually into replacement of the system.

System Asset	Quantity	Unit Value	Total Asset Value ($ Million)	Total Replacement Cost ($ Million)
<4-Inch Main	16,400	$120	$1.97	$2.95
4-Inch Main	44,900	$120	$5.39	$8.08
6-Inch Main	316,900	$120	$38.03	$57.04
8-Inch Main	436,300	$120	$52.36	$78.53
10-Inch Main	106,800	$130	$13.88	$20.83
12-Inch Main	216,900	$140	$30.37	$45.55
14-Inch Main	4,200	$150	$0.63	$0.95
16-Inch Main	60,900	$175	$10.66	$15.99
18-Inch Main	1,500	$185	$0.28	$0.42
Unknown Main	55,700	$150	$8.36	$12.53
System Valves	2,700	$4,500	$12.15	$24.30
Hydrants	2,900	$5,500	$15.95	$31.90
Total:	-	-	**$190.01**	**$299.07**

It is recommended that the City not only budget for the annual replacement program, but also prioritize specific projects through the service area. Section 4 outlines 17 specific projects that address available fire flows throughout the City and consist of both rehabilitation and upgrade of the distribution system as well. The prioritization of these projects will be discussed in Section 4. Each project is rated based on criteria such as main diameter, age, available fire flows, break frequency, lead services, water quality, and several others. This prioritization was utilized for the development of the Capital Improvements Program and Implementation Schedule within Section 8.

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SECTION 4

ANALYSIS FOR DISTRIBUTION SYSTEM ALTERNATIVES

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4. Analysis for Distribution System Alternatives

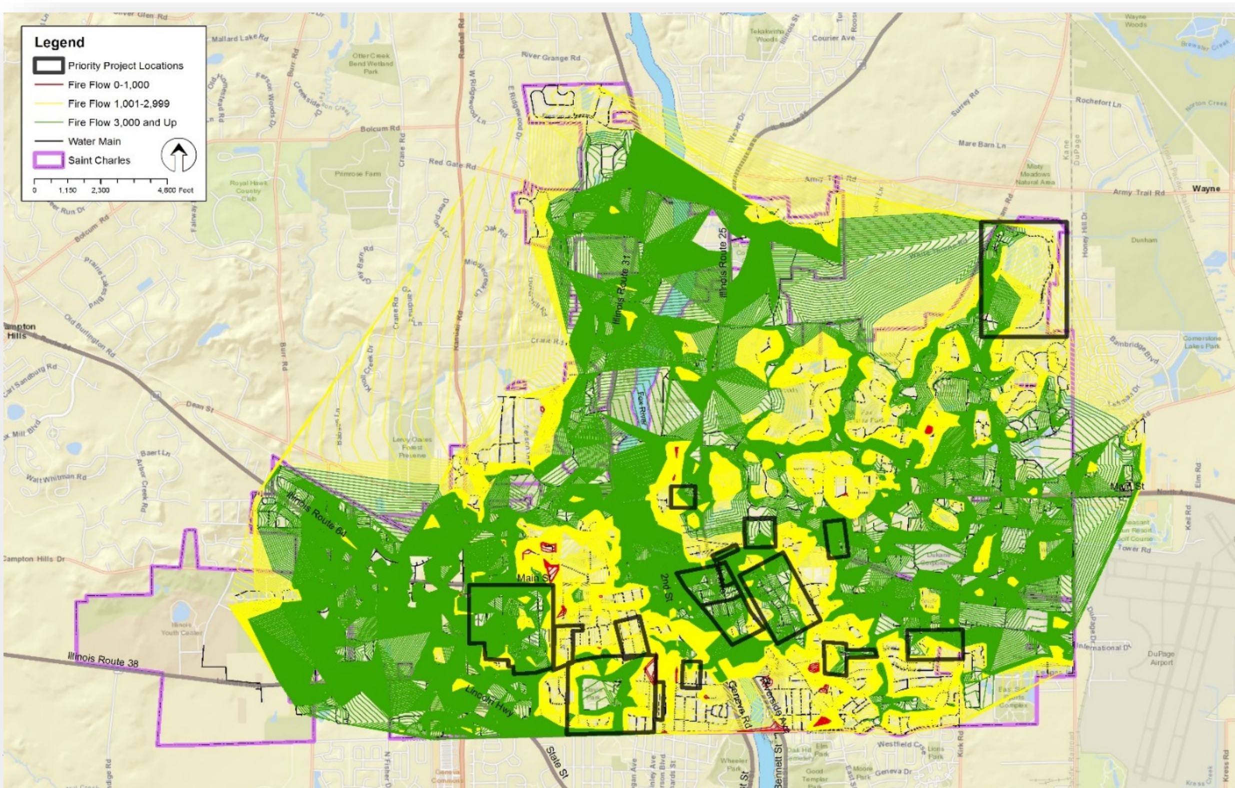
4.1. Recommended Distribution System Capital Improvement Projects

Through work sessions with City staff, a number of capital improvement projects were identified to rehabilitated and upgrade the distribution system. As discussed in Section 3, the water system has been constructed throughout the last century. As a result of the age of the system, many of the components are at or beyond their anticipated service life and will require rehabilitation or replacement.

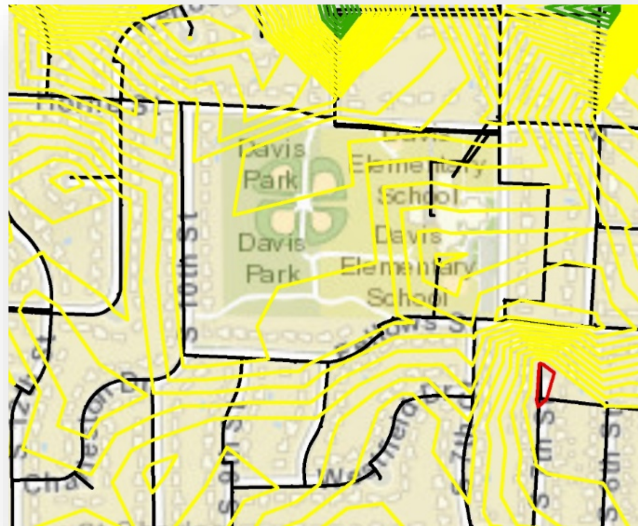
Through review of water main age, size, material, break history, and available fire flows detailed in Section 3, 17 priority rehabilitation areas within the distribution system were identified. These areas may exhibit low available fire flow (AFF), a high frequency of main breaks, or a combination of issues. Each of these areas are discussed in further detail in the following pages, with prioritization of the improvements reviewed at the end of this section. The projects are numbered by orientation and do not represent prioritization. Full line item cost estimates for each project can be found in Appendix A.

A. Davis Elementary School
B. Munhall Elementary School
C. Route 64 East
D. Lincoln Elementary School
E. 11th and 12th Street north of Prairie Street
F. Prairie Street – 5th to 8th
G. 3rd / 4th Street Alley
H. Horne & Ash Street
I. Route 25 and North Avenue
J. Route 64 and 9th Avenue
K. Monroe west of 7th Ave
L. South Second west of 7th Ave
M. Route 64 & Tyler Road
N. South Avenue
O. Fairview Neighborhood
P. Fox Ridge Elementary School
Q. Royal Fox Subdivision

Figure 4-1: Available Fire Flows - Projects Completed



4.1.1. Davis Elementary School – 12" water main

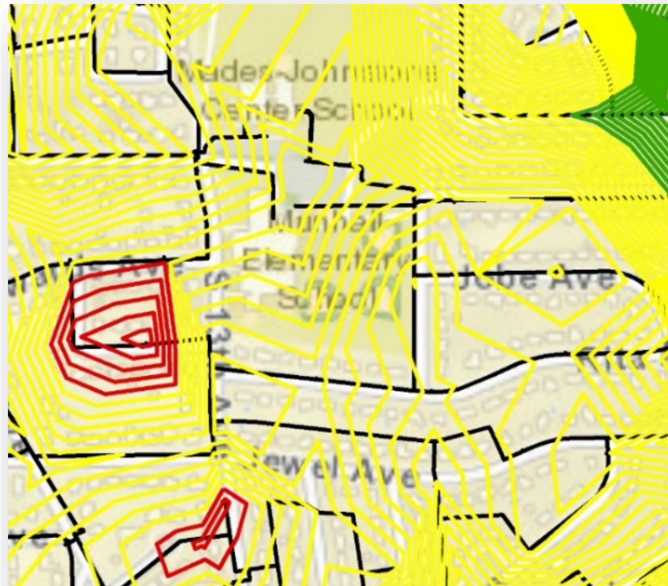


Davis Elementary School is served by 6-inch mains to the north, east and west and an 8-inch main to the south. These mains are capable of providing an estimated range of 1,800 to 2,200 gpm of available fire flow. It is desired to have the ability to attain 3,000 gpm of fire flow for schools and commercial areas.

The 6-inch mains on 7th, 7th Ct., and Gray Street should be replaced with 12-inch mains, as well as along fellows and 10th. Additionally, these 12-inch mains should be directly connected to the 12-inch main on 14th Street to provide the additional flow, and all 6-inch main from 4th Street to 12th should be upsized to 8-inch. These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential.

Davis Elementary School Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$8,197,813
			SUBTOTAL CONSTRUCTION	**$8,197,813**
			CONTINGENCY @ 20%	$1,639,563
			ENGINEERING @ 15%	$1,229,672
			CONSTRUCTION TOTAL	**$11,067,047**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Davis Elementary School Area Improvements				
Abandonment of Existing Water Main - 6"	29,287	FT	$15	$439,305
Ductile Iron Water Main, Class 52, 8"	19,087	L.F.	$100	$1,908,700
Gate Valve in Vault, 8"	64	Each	$4,500	$288,000
Ductile Iron Water Main, Class 52, 12"	10,200	L.F.	$150	$1,530,000
Gate Valve in Vault, 12"	34	Each	$6,500	$221,000
Fire Hydrant, Complete	98	EA	$5,500	$539,000
Water Service Connection, Short	256	EA	$2,500	$640,000
Water Service Connection, Long	256	EA	$3,500	$896,000
Trench Backfill	8,682	C.Y.	$65	$564,328
Pavement Removal and Replacement	9,762	S.Y.	$100	$976,233
Landscape Restoration	13,016	S.Y.	$15	$195,247
PROJECT TOTAL				$8,197,813

4.1.2. Munhall Elementary School

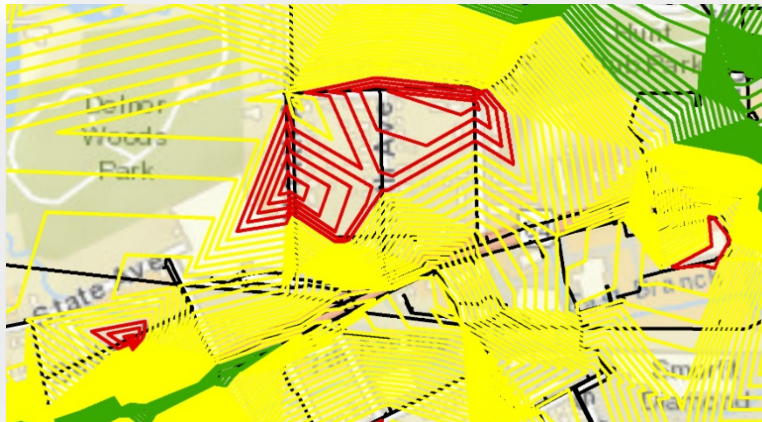


The area surrounding Munhall Elementary School is served by 6-inch mains in the Outer Service Area to the east and south and both 6 and 8-inch mains to the west. These mains are capable of providing an estimated range of 1,100 to 2,000 gpm of available fire flow. It is desired to have the ability to attain 3,000 gpm of fire flow for schools and commercial areas.

The 6-inch mains in the Outer Service Area on Mildred, Rita and Ronzheimer Avenues should be increased to 12-inch and reconnected to the 12-inch main on Tyler Road. These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential.

Munhall Elementary School Area Improvements				
Description				Total Probable Cost
		SUMMARY		
SITEWORK				$1,612,403
			SUBTOTAL CONSTRUCTION	**$1,612,403**
			CONTINGENCY @ 20%	$322,481
			ENGINEERING @ 15%	$241,860
			CONSTRUCTION TOTAL	**$2,176,744**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Munhall Elementary School				
Abandonment of Existing Water Main - 12"	4,124	FT	$17	$70,108
Ductile Iron Water Main, Class 52, 12"	4,124	L.F.	$150	$618,600
Gate Valve in Vault, 12"	14	EA	$4,500	$63,000
Pressure Reducing Valve and Vault	1	Each	$20,000	$20,000
Fire Hydrant, Complete	15	Each	$5,500	$82,500
Water Service Connection, Short	29	EA	$2,500	$72,500
Water Service Connection, Long	29	EA	$3,500	$101,500
Trench Backfill	4,124	C.Y.	$65	$268,060
Pavement Removal and Replacement	2,749	S.Y.	$100	$274,900
Landscape Restoration	2,749	S.Y.	$15	$41,235
PROJECT TOTAL				$1,612,403

4.1.3. Route 64 east



The water main running along Route 64 on the east side of town from 9th Avenue to Hunt Club Drive is 6 inches in diameter and capable of providing an estimated range of 700 to 2,500 gpm of fire flow. This is commercially zoned area and the distribution system should be capable of 3,000 gpm of fire flow. Additionally, the 6-inch main along Wing Avenue in the Inner Service Area connects with the 10-inch main of the Outer Service Area at the intersection of Wing and 13th Avenue. Adding valves at Route 64, at both 13th, and 11th, would push the Outer Zone to the South. These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential.

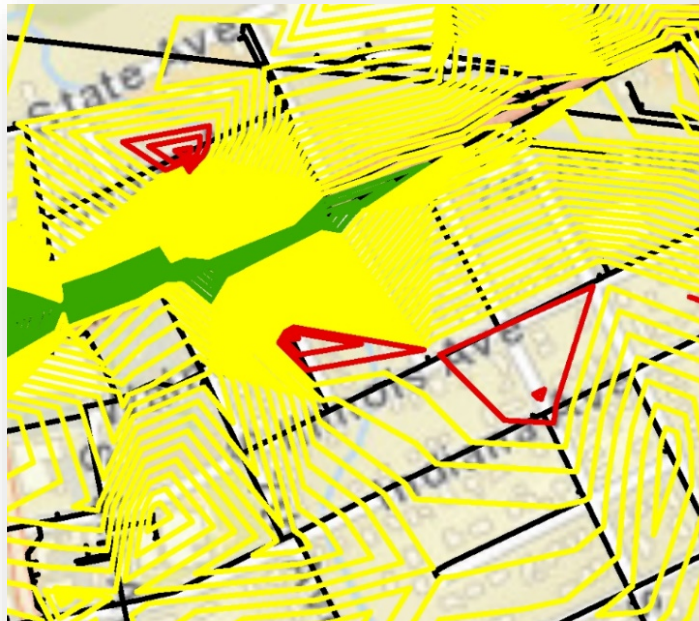
These entire runs should be replaced with 10-inch diameter water mains. These improvements would increase the available fire flow in excess of the required amounts. The associated cost estimate for these improvements is give below.

Route 64 from 6th Avenue to Hunt Club Drive Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$1,294,650
			SUBTOTAL CONSTRUCTION	**$1,294,650**
			CONTINGENCY @ 20%	$258,930
			ENGINEERING @ 15%	$194,198
			CONSTRUCTION TOTAL	**$1,747,778**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Route 64 from 6th Avenue to Hunt Club Drive				
Abandonment of Existing Water Main - 10"	3,450	FT	$17	$58,650
Ductile Iron Water Main, Class 52, 10"	3,450	L.F.	$120	$414,000
Gate Valve in Vault, 10"	12	Each	$5,500	$66,000
Fire Hydrant, Complete	12	Each	$5,500	$66,000
Water Service Connection, Short	35	EA	$2,500	$87,500
Water Service Connection, Long	36	EA	$3,500	$126,000
Trench Backfill	3,350	C.Y.	$65	$217,750
Pavement Removal and Replacement	2,250	S.Y.	$100	$225,000
Landscape Restoration	2,250	S.Y.	$15	$33,750
PROJECT TOTAL				$1,294,650

4.1.4. Lincoln Elementary School

The area surrounding Lincoln Elementary School is served by 6-inch mains in the Inner Service Area. These mains are capable of providing an estimated range of 1,300 to 2,200 gpm of available fire flow. It is desired to have the ability to attain 3,000 gpm of fire flow for schools and commercial areas.

The 6-inch main on 7th, and 6th Ave from Route 64 to Indiana Avenue should be increased to a 10-inch main. These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential.



Lincoln Elementary School Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$483,411
			SUBTOTAL CONSTRUCTION	**$483,411**
			CONTINGENCY @ 20%	$96,682
			ENGINEERING @ 15%	$72,512
			CONSTRUCTION TOTAL	**$652,605**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Lincoln Elementary School				
Abandonment of Existing Water Main - 10"	1,900	FT	$17	$32,300
Ductile Iron Water Main, Class 52, 10"	1,900	L.F.	$120	$228,000
Gate Valve in Vault, 10"	7	Each	$5,500	$38,500
Fire Hydrant, Complete	7	Each	$5,500	$38,500
Water Service Connection, Short	5	EA	$2,500	$12,500
Water Service Connection, Long	6	EA	$3,500	$21,000
Trench Backfill	563	C.Y.	$65	$36,611
Pavement Removal and Replacement	633	S.Y.	$100	$63,333
Landscape Restoration	844	S.Y.	$15	$12,667
PROJECT TOTAL				$483,411

4.1.5. 11th Street and 12th Street north of Prairie Street

The 6-inch water mains running south on 11th Street and 12th Street in the Inner Service Area connect with the Outer Service Area at Prairie Street. This connection is usually kept closed to isolate the two service zones, essentially creating dead-end mains on 11th and 12th Streets for an available fire flow of 400 gpm to 1,700 gpm at the lowest point at the 12th St. dead end.

By increasing the size of the water main from Oak St. to 12th Avenue from the 6-inch main in place to a 10-inch diameter pipe, as well as upsizing the water main along 10th Street to 11th Street to 8-inch would allow for more flow through this area. Additionally, interconnecting the mains on Howard will allow for increased water capacity in this area therefore increasing the available fire flow. The result of these improvements would increase the available fire flow in excess of 1,500 gpm requirement for Residential areas. The associated cost estimate for these improvements is provided below.

11th Street & 12th Street North of Prairie Street Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$743,160
			SUBTOTAL CONSTRUCTION	**$743,160**
			CONTINGENCY @ 20%	$148,632
			ENGINEERING @ 15%	$111,474
			CONSTRUCTION TOTAL	**$1,003,267**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
11th Street & 12th Street North of Prairie Street				
Abandonment of Existing Water Main - 8"	3,200	FT	$15	$48,000
Ductile Iron Water Main, Class 52, 8"	3,200	L.F.	$100	$320,000
Gate Valve in Vault, 8"	11	Each	$4,500	$49,500
Fire Hydrant, Complete	11	Each	$5,500	$60,500
Water Service Connection, Short	12	EA	$2,500	$30,000
Water Service Connection, Long	13	EA	$3,500	$45,500
Trench Backfill	949	C.Y.	$65	$61,660
Pavement Removal and Replacement	1,067	S.Y.	$100	$106,667
Landscape Restoration	1,422	S.Y.	$15	$21,333
PROJECT TOTAL				$743,160

4.1.6. Prairie Street from 5th Street to 8th Street

The 4-inch water main running along Prairie Street from 5th Street to 8th Street contains four interconnections between the Inner and Outer Service areas normally kept closed to isolate the two service areas. These closed connections then create dead-ends to the mains in both service zones resulting in available fire flows of 700 gpm in the Outer Service Area and 500 gpm in the Inner Service Area.

By increasing the water main along 7th, 6th, and 5th Street, as well as along Cutler and Prairie to an 8-inch would increase the capacity of both areas for the Inner and Outer service areas. These improvements would increase the available fire flow in excess of 1,500 gpm requirement for Residential areas. The associated cost estimate for these improvements is provided below.

Prairie Street from 5th to 8th Street Area Improvements	
Description	Total Probable Cost
SUMMARY	
SITEWORK	$1,553,675
SUBTOTAL CONSTRUCTION	**$1,553,675**
CONTINGENCY @ 20%	$310,735
ENGINEERING @ 15%	$233,051
CONSTRUCTION TOTAL	**$2,097,461**

Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Prairie Street from 5th to 8th Street				
Abandonment of Existing Water Main - 8"	6,600	FT	$15	$99,000
Ductile Iron Water Main, Class 52, 8"	6,600	L.F.	$100	$660,000
Gate Valve in Vault, 8"	22	Each	$4,500	$99,000
Fire Hydrant, Complete	22	EA	$5,500	$121,000
Water Service Connection, Short	30	EA	$2,500	$75,000
Water Service Connection, Long	31	EA	$3,500	$108,500
Trench Backfill	1,957	C.Y.	$65	$127,175
Pavement Removal and Replacement	2,200	S.Y.	$100	$220,000
Landscape Restoration	2,933	S.Y.	$15	$44,000
PROJECT TOTAL				$1,553,675

4.1.7. 3rd Street/ 4th Street Alley

The 4-inch water main running along Horne Street in the Inner Service Area connects with the Outer Service Area just west of 4th Street. This connection is usually kept closed to isolate the inner and outer systems which then creates a dead-end main resulting in an available fire flow of 400 gpm. Additionally, the 4-inch main running south from Horne to Gray Street in the alley between 3rd Street and 4th Street also has insufficient fire flow.

Parallel to the 3rd St. alley water main is a 12-inch water main that runs along 3rd Street. By increasing the 4-inch water main in the alley and on Horne Street between 3rd and 4th to an 8-inch diameter main and connecting the new main to the 12-inch main on 3rd Street at Horne and also at Fellows would allow for an adequate fire flow to reach this area. These improvements would increase the fire flow capacity for approximately 60 residences. These improvements would increase the available fire flow in excess of the 1,500 gpm requirement for Residential areas.

The associated cost estimate for these improvements is provided below.

3rd Street/4th Street Alley Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$1,122,930
			SUBTOTAL CONSTRUCTION	**$1,122,930**
			CONTINGENCY @ 20%	$224,586
			ENGINEERING @ 15%	$168,440
			CONSTRUCTION TOTAL	**$1,515,956**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
3rd Street/4th Street Alley				
Abandonment of Existing Water Main - 8"	2,350	FT	$15	$35,250
Ductile Iron Water Main, Class 52, 8"	2,350	L.F.	$100	$235,000
Gate Valve in Vault, 8"	8	Each	$4,500	$36,000
Fire Hydrant, Complete	8	EA	$5,500	$44,000
Water Service Connection, Short	34	EA	$2,500	$85,000
Water Service Connection, Long	34	EA	$3,500	$119,000
Trench Backfill	4,302	C.Y.	$65	$279,630
Pavement Removal and Replacement	2,868	S.Y.	$100	$286,800
Landscape Restoration	150	S.Y.	$15	$2,250
PROJECT TOTAL				$1,122,930

4.1.8. Horne Street and Ash Street

The area spanning from Mosedale to McKinley and from 2nd Street to Ash Street has been identified as an area of insufficient fire flow. This area within the Inner Service Area contains mostly 4-inch water main. These smaller diameter pipe sizes combined with dead-end mains can result in low available fire flows in this area estimated to range from 140 gpm to 970 gpm.

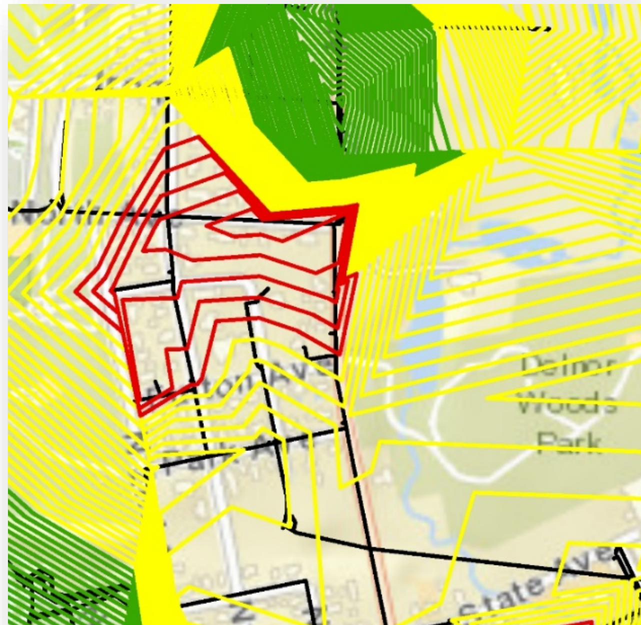
By increasing the 4-inch water main on Elm and Ash Streets, as well as on Horne Street from Elm to Pine to 8-inch diameter main would allow for additional flow in this area. However, these improvements still leave isolated areas of potential low fire flow at the McKinley Street dead-end and at the intersection of Mosedale and 2nd Street.

By increasing the 6-inch main on McKinley to 8-inch and by installing an 8-inch diameter main connecting the 2nd Street main to the proposed 8-inch Elm Street main would provide the additional fire flow to these remaining areas. These improvements would increase the available fire flow in excess of the 1,500 gpm requirement for Residential areas.

The associated cost estimate for these improvements is provided below.

Horne Street & Ash Street Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$1,155,868
			SUBTOTAL CONSTRUCTION	**$1,155,868**
			CONTINGENCY @ 20%	$231,174
			ENGINEERING @ 15%	$173,380
			CONSTRUCTION TOTAL	**$1,560,422**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Horne Street & Ash Street				
Abandonment of Existing Water Main - 8"	3,550	FT	$15	$53,250
Ductile Iron Water Main, Class 52, 8"	3,550	L.F.	$100	$355,000
Gate Valve in Vault, 8"	12	Each	$4,500	$54,000
Fire Hydrant, Complete	12	EA	$5,500	$66,000
Water Service Connection, Short	31	EA	$2,500	$77,500
Water Service Connection, Long	31	EA	$3,500	$108,500
Trench Backfill	3,271	C.Y.	$65	$212,615
Pavement Removal and Replacement	2,181	S.Y.	$100	$218,100
Landscape Restoration	2,181	S.Y.	$15	$10,903
PROJECT TOTAL				$1,155,868

4.1.9. Route 25 and North Avenue



The area around the intersection of North Avenue and Route 25 contains mostly 4-inch and 6-inch water main. This area is the boundary between the Inner and Outer Service Areas with the interconnections between the two service areas being normally closed. Therefore, these closed connections have created dead-end mains that result in low fire flows of approximately 900 gpm.

The installation of 10-inch water main along Route 25 connecting at North Street and running south/west to 2nd Ave along park, as well as upsizing the water main to 8-inch would increase the fire flows within the area. In addition to installing larger water main, closing system valves at Park Ave and opening closed valves along North Ave. to move the outer zone south would also increase pressures and fire flows.

These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. The associated cost estimate is provided below.

Route 25 and North Avenue Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$1,339,972
SUBTOTAL CONSTRUCTION				**$1,339,972**
CONTINGENCY @ 20%				$267,994
ENGINEERING @ 15%				$200,996
CONSTRUCTION TOTAL				**$1,808,962**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Route 25 and North Avenue				
Abandonment of Existing Water Main - 8"	3,650	FT	$15	$54,750
Ductile Iron Water Main, Class 52, 8"	3,650	L.F.	$100	$365,000
Gate Valve in Vault, 8"	13	Each	$4,500	$58,500
10" DIP Directional Drill	250	L.F.	$1,000	$250,000
Ductile Iron Water Main, Class 52, 10"	1,800	L.F.	$120	$216,000
Gate Valve in Vault, 10"	6	Each	$5,500	$33,000
Fire Hydrant, Complete	13	EA	$5,500	$71,500
Trench Backfill	1,126	C.Y.	$65	$73,222
Pavement Removal and Replacement	1,817	S.Y.	$100	$181,667
Landscape Restoration	2,422	S.Y.	$15	$36,333
PROJECT TOTAL				$1,339,972

4.1.10. Route 64 and 9th Avenue

Just north of the intersection of Route 64 and 9th Avenue a 6-inch water main runs along Cedar Avenue. This water main in conjunction to the water main running North/South along 6th Ave should be increased in and tied into the 10-inch water main along Route 64.

By connecting the Cedar Avenue 6-inch main to the 10-inch main at Route 64 would eliminate this low fire flow area. These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential.

The associated cost estimate for these improvements is provided below.

Route 64 and 9th Avenue Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$231,696
			SUBTOTAL CONSTRUCTION	**$231,696**
			CONTINGENCY @ 20%	$46,339
			ENGINEERING @ 15%	$34,754
			CONSTRUCTION TOTAL	**$312,789**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Route 64 and 9th Avenue				
Abandonment of Existing Water Main - 8"	1,100	FT	$15	$16,500
Ductile Iron Water Main, Class 52, 8"	1,100	L.F.	$100	$110,000
Gate Valve in Vault, 8"	4	Each	$4,500	$18,000
Fire Hydrant, Complete	4	EA	$5,500	$22,000
Trench Backfill	326	C.Y.	$65	$21,196
Pavement Removal and Replacement	367	S.Y.	$100	$36,667
Landscape Restoration	489	S.Y.	$15	$7,333
PROJECT TOTAL				$231,696

4.1.11. Monroe Avenue West of 7th Avenue

The area east of 4th Avenue and west of 7th Avenue from South Avenue to the north to Spring Avenue to the south consists primarily of 4-inch diameter water main with multiple dead-end locations. These small diameter mains and dead-ends have created a low fire flow area ranging from 500 gpm to 1,100 gpm.

By increasing the water main size in this entire area bound by South Ave to the North, 7th Ave to the east, Spring Ave to the South, and Riverside Ave to the West to 8-inch diameter will significantly increase the water main. The water main in this area is not only small in size, but also has reached the end of its service life.

These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. The associated cost estimate for these improvements is provided below.

Monroe Avenue West of 7th Avenue Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$2,337,566
			SUBTOTAL CONSTRUCTION	**$2,337,566**
			CONTINGENCY @ 20%	$467,513
			ENGINEERING @ 15%	$350,635
			CONSTRUCTION TOTAL	**$3,155,714**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Monroe Avenue West of 7th Avenue				
Abandonment of Existing Water Main - 8"	8,800	FT	$15	$132,000
Ductile Iron Water Main, Class 52, 8"	8,800	L.F.	$100	$880,000
Gate Valve in Vault, 8"	30	Each	$4,500	$135,000
Fire Hydrant, Complete	30	EA	$5,500	$165,000
Water Service Connection, Short	84	EA	$2,500	$210,000
Water Service Connection, Long	84	EA	$3,500	$294,000
Trench Backfill	2,609	C.Y.	$65	$169,566
Pavement Removal and Replacement	2,933	S.Y.	$100	$293,333
Landscape Restoration	3,911	S.Y.	$15	$58,667
PROJECT TOTAL				$2,337,566

4.1.12. South Second Avenue West of 7th Avenue

The area east of South 2nd Avenue and west of 7th Avenue from Route 64 to the north to South Avenue to the south consists primarily of 4-inch diameter water main with multiple dead-end locations. These small diameter mains and dead-ends have created a low fire flow area ranging from 1,400 gpm to 3,000 gpm.

By increasing the water main size to an 8-inch in this entire area will significantly increase the water main. The water main in this area is not only small in size, but also has reached the end of its service life.

These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. The associated cost estimate for these improvements is provided below.

South Second Ave. Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$2,252,505
			SUBTOTAL CONSTRUCTION	**$2,252,505**
			CONTINGENCY @ 20%	$450,501
			ENGINEERING @ 15%	$337,876
			CONSTRUCTION TOTAL	**$3,040,882**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
South Second Ave. Area Improvements				
Abandonment of Existing Water Main - 8"	8,200	FT	$15	$123,000
Ductile Iron Water Main, Class 52, 8"	8,200	L.F.	$100	$820,000
Gate Valve in Vault, 8"	28	Each	$4,500	$126,000
Fire Hydrant, Complete	28	EA	$5,500	$154,000
Water Service Connection, Short	90	EA	$2,500	$225,000
Water Service Connection, Long	91	EA	$3,500	$318,500
Trench Backfill	2,431	C.Y.	$65	$158,005
Pavement Removal and Replacement	2,733	S.Y.	$100	$273,333
Landscape Restoration	3,644	S.Y.	$15	$54,667
PROJECT TOTAL				$2,252,505

4.1.13. Route 64 & Tyler Road

The water main along Tyler Road, near Production Dr. is an 8-inch water main. In order to increase fire flows in the area, the existing connection to Route 64 should be repaired. The existing connection to Route 64 from Tyler road has been closed due to a water main break that could not be addressed due to location and depth. By reconnecting these two water mains, as well as upsizing a portion of the water main to a 12-inch, the flows will increase within this area.

These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas, and remove the bottleneck. The associated cost estimate for these improvements is provided below.

Tyler Road Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$512,684
			SUBTOTAL CONSTRUCTION	**$512,684**
			CONTINGENCY @ 20%	$102,537
			ENGINEERING @ 15%	$76,903
			CONSTRUCTION TOTAL	**$692,123**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Tyler Road Area Improvements				
Ductile Iron Water Main, Class 52, 10"	1,800	L.F.	$120	$216,000
Gate Valve in Vault, 10"	6	Each	$5,500	$33,000
Jack and Bore	200	FT	$500	$100,000
Fire Hydrant, Complete	6	EA	$5,500	$33,000
Water Service Connection, Short	4	EA	$2,500	$10,000
Water Service Connection, Long	4	EA	$3,500	$14,000
Trench Backfill	534	C.Y.	$65	$34,684
Pavement Removal and Replacement	600	S.Y.	$100	$60,000
Landscape Restoration	800	S.Y.	$15	$12,000
PROJECT TOTAL				$512,684

4.1.14. South Avenue

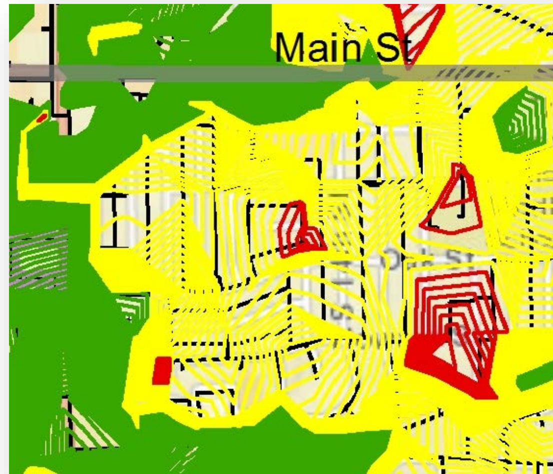
The area east of 7th Avenue and west of 14th Avenue from Indiana to the north to Fern Avenue to the south consists primarily of 4-inch and 6-inch diameter water mains, and minimal amounts of 8-inch. These small diameter mains have created a low fire flow area ranging from 700 gpm to 1,900 gpm.

By increasing the water main size in this entire area will significantly increase the water main. The water main in this area is not only small in size, but also has reached the end of its service life. In addition, continuing the water main along Indiana to the west as a 10-inch from the Lincoln Elementary Project to the 10-inch running along 14th Street would significantly increase the available capacity as well.

These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. The associated cost estimate for these improvements is provided below.

South Street Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$2,659,608
			SUBTOTAL CONSTRUCTION	**$2,659,608**
			CONTINGENCY @ 20%	$531,922
			ENGINEERING @ 15%	$398,941
			CONSTRUCTION TOTAL	**$3,590,470**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
South Street Area Improvements				
Abandonment of Existing Water Main - 8"	15,500	FT	$15	$232,500
Ductile Iron Water Main, Class 52, 8"	15,500	L.F.	$100	$1,550,000
Gate Valve in Vault, 8"	52	Each	$4,500	$234,000
Ductile Iron Water Main, Class 52, 10"	1,450	L.F.	$120	$174,000
Gate Valve in Vault, 10"	5	Each	$5,500	$27,500
Fire Hydrant, Complete	57	EA	$5,500	$313,500
Water Service Connection, Short	190	EA	$2,500	$475,000
Water Service Connection, Long	190	EA	$3,500	$665,000
Trench Backfill	5,025	C.Y.	$65	$326,608
Pavement Removal and Replacement	5,650	S.Y.	$100	$565,000
Landscape Restoration	7,533	S.Y.	$15	$113,000
PROJECT TOTAL				$2,659,608

4.1.15. Fairview Apartments



The area east of Randall Road and west of 12th Street from Route 64 to the north to Prairie Street to the south consists primarily of 4-inch and 6-inch diameter water mains, backyard water main, and minimal amounts of 8-inch. These small diameter mains have created a low fire flow area ranging from 800 gpm to 2,900 gpm.

The water main in this area is not only small in size, but also has reached the end of its service life. By increasing the water main size in this entire area will significantly increase the available flows and operational disruptions due to breaks. In addition, upsizing the water main in the area to 8-inch, running a new 10-inch water main along Oak Street, and connecting to the existing 10-inch water main near 10th street, as well as the proposed 10-inch water main for the new police station would significantly increase the available capacity as well.

These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. The associated cost estimate for these improvements is provided below.

Fairview Dr. Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$4,982,324
			SUBTOTAL CONSTRUCTION	**$4,982,324**
			CONTINGENCY @ 20%	$996,465
			ENGINEERING @ 15%	$747,349
			CONSTRUCTION TOTAL	**$6,726,137**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Fairview Dr. Area Improvements				
Abandonment of Existing Water Main - 8"	26,500	FT	$15	$397,500
Ductile Iron Water Main, Class 52, 8"	26,500	L.F.	$100	$2,650,000
Gate Valve in Vault, 8"	89	Each	$4,500	$400,500
Ductile Iron Water Main, Class 52, 10"	5,200	L.F.	$120	$624,000
Gate Valve in Vault, 10"	18	Each	$5,500	$99,000
Fire Hydrant, Complete	106	EA	$5,500	$583,000
Water Service Connection, Short	299	EA	$2,500	$747,500
Water Service Connection, Long	300	EA	$3,500	$1,050,000
Trench Backfill	9,397	C.Y.	$65	$610,824
Pavement Removal and Replacement	10,567	S.Y.	$100	$1,056,667
Landscape Restoration	14,089	S.Y.	$15	$211,333
PROJECT TOTAL				$4,982,324

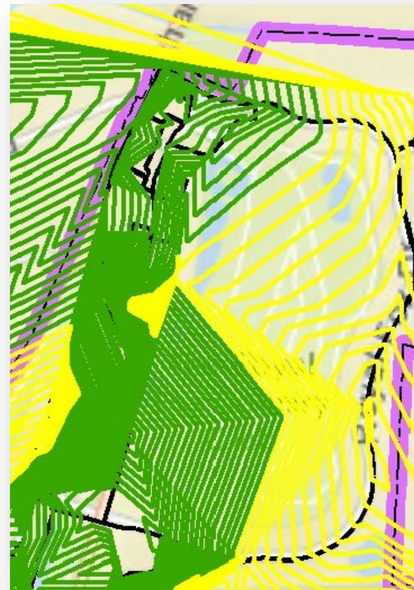
4.1.16. Fox Ridge Elementary School

The area surrounding Fox Ridge Elementary School is served by 6-inch mains in the Outer Service Area. These mains are capable of providing an estimated range of 1,900 to 2,500 gpm of available fire flow. It is desired to have the ability to attain 3,000 gpm of fire flow for schools and commercial areas.

The 6-inch main on Midway Avenue and Ronzheimer Ave should be increased to a 10-inch main. These improvements would increase the available fire flow in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. However, the remaining areas within the subdivision should also be planned on being upsized to 8-inch as part of the annual replacement program.

Fox Ridge Elementary School Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$518,921
			SUBTOTAL CONSTRUCTION	**$518,921**
			CONTINGENCY @ 20%	$103,784
			ENGINEERING @ 15%	$77,838
			CONSTRUCTION TOTAL	**$700,543**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Fox Ridge Elementary School Area Improvements				
Abandonment of Existing Water Main - 6"	2,600	FT	$12	$31,200
Ductile Iron Water Main, Class 52, 10"	17,50	L.F.	$120	$210,000
Gate Valve in Vault, 10"	6	Each	$5,500	$33,000
Fire Hydrant, Complete	6	EA	$5,500	$33,000
Water Service Connection, Short	18	EA	$2,500	$45,000
Water Service Connection, Long	18	EA	$3,500	$63,000
Trench Backfill	519	C.Y.	$65	$33,721
Pavement Removal and Replacement	583	S.Y.	$100	$58,333
Landscape Restoration	778	S.Y.	$15	$11,667
PROJECT TOTAL				$518,921

4.1.17. Royal Fox



The Royal Fox neighborhood has had several water main breaks, and water quality reports over the last several years. As a result, it is recommended that the water main within the subdivision be replaced with newer technologies such as PVC. The water main should be replaced in kind as an 8-inch.

These improvements would continue to provide the area with available fire flows in excess of the 3,000 gpm requirement for Commercial areas and 1,500 gpm for Residential. These improvements should mitigate the water quality complains and remove the continual repair work due to breaks. The associated cost estimate for these improvements is provided below.

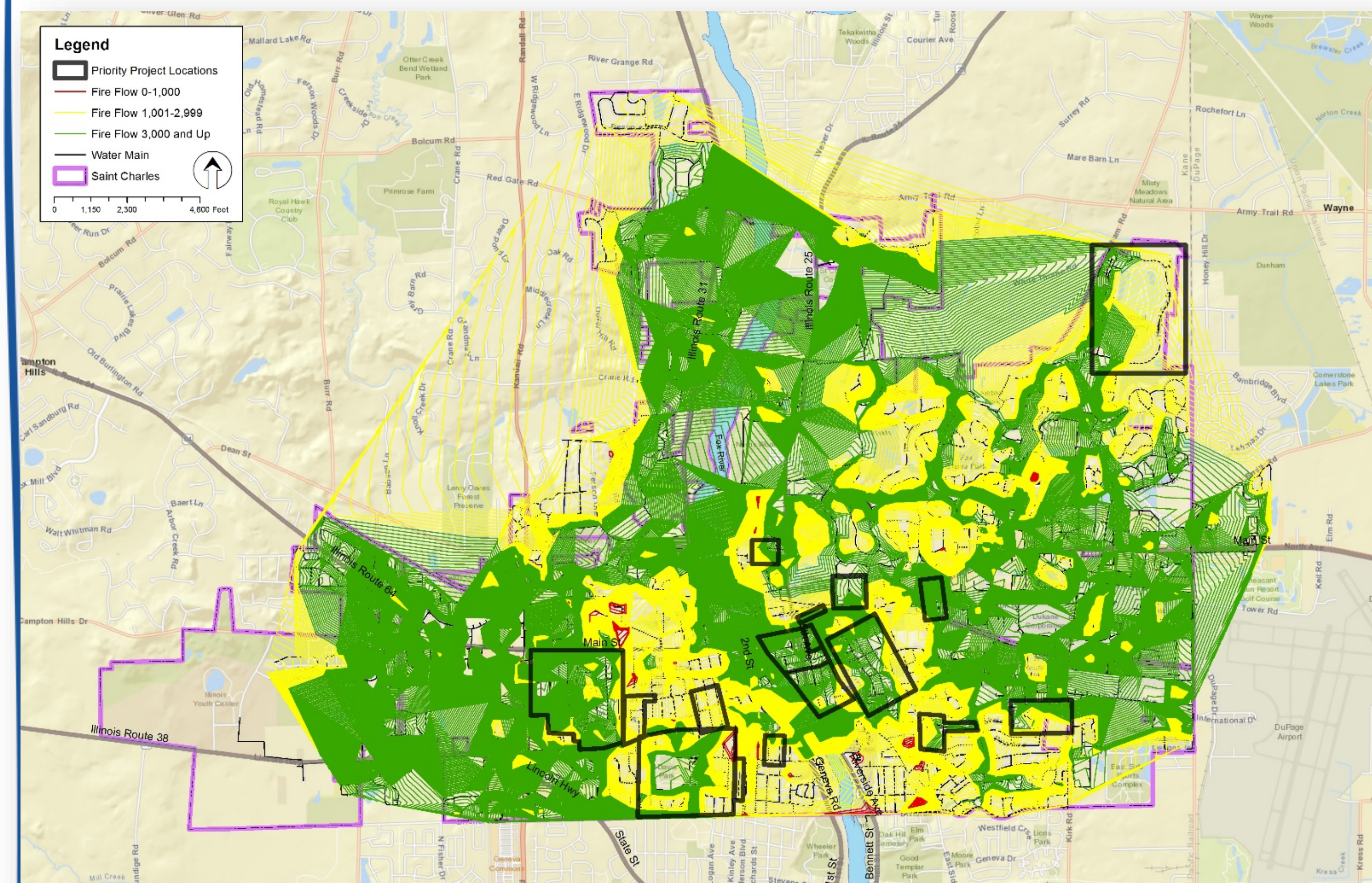
Royal Fox Area Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$3,102,794
			SUBTOTAL CONSTRUCTION	**$3,102,794**
			CONTINGENCY @ 20%	$620,559
			ENGINEERING @ 15%	$465,419
			CONSTRUCTION TOTAL	**$4,188,772**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Royal Fox Area Improvements				
Abandonment of Existing Water Main - 8"	12,250	FT	$15	$183,750
Ductile Iron Water Main, Class 52, 8"	12,250	L.F.	$100	$1,225,000
Gate Valve in Vault, 8"	41	Each	$4,500	$184,500
Fire Hydrant, Complete	41	EA	$5,500	$225,500
Water Service Connection, Short	93	EA	$2,500	$232,500
Water Service Connection, Long	93	EA	$3,500	$325,500
Trench Backfill	3,631	C.Y.	$65	$236,044
Pavement Removal and Replacement	4,083	S.Y.	$100	$408,333
Landscape Restoration	5,444	S.Y.	$15	$81,667
PROJECT TOTAL				$3,102,794

Summary of Water Main Fire Flow Improvements

If the above identified improvements were completed, the resulting fire flow map would be as shown below. The areas in black are the outlined project locations.

As indicated the majority of the areas with less than 1,000 gpm (red) of available fire flow have been eliminated with only the wells and other negligible areas remaining. Additionally, most of the downtown and outlying commercial areas have been increased to over 3,000 gpm of available fire flow.

Figure 4-2: Available Fire Flows - Projects Completed



Impacts of Upsizing Water Mains Throughout the System

The City has adopted minimum fire flow requirements of 1,000 gpm in residential neighborhoods and 3,000 gpm in commercial/industrial/institutional areas. Figure 4-2 indicates that the existing distribution system lacks capacity to deliver the minimum fire flow (3,000 gpm) throughout a portion of the downtown area, where a large portion of commercial/industrial/and institutional areas reside. The majority of the residential areas in the heart of the downtown area have sufficient fire flow protection in excess of 1,500 gpm.

The water mains in these older residential areas were constructed with 4-inch and 6-inch diameter pipe. The distribution system includes roughly 12 miles of 4-inch diameter and 60 miles of 6-inch diameter water main. Not only are these mains of inadequate size, but for the most part also have reached the end of their useful service life; their replacement should be planned.

Figure 4-5 illustrates the impact on fire flows throughout the City's water distribution system of replacing all 4-inch and 6-inch water mains with larger 8-inch piping. Upon completion, the water system would have capacity to provide all residential areas with fire flows in excess of 1,500 gpm, and most all commercial locations with over 3,000 gpm.

Prioritization of the capital improvements projects should be based upon the City's knowledge and understanding of the age and condition of the undersized pipe segments. The WaterCAD model in indicates that within areas of undersized water main, available flows are restively uniform but deficient to convey necessary fire flows. No one particular area seems to contain a particularly restrictive hydraulic condition. For this reason, additional criterion such as corrosive soils, high-capacity users, and potential need for emergency services should be used to prioritize projects.

There exists approximately 380,000 lineal feet of 4-inch and 6-inch water main in the system. A long-term 25-year plan to replace these pipes would include the replacement of 15,200 l.f. of pipe per year.

The replacement cost for the 4-inch and 6-inch water main is listed in total to be $90 million. The replacement cost for fire hydrants and water valves in these areas is estimated at $17 million for a total program cost of $107 million.

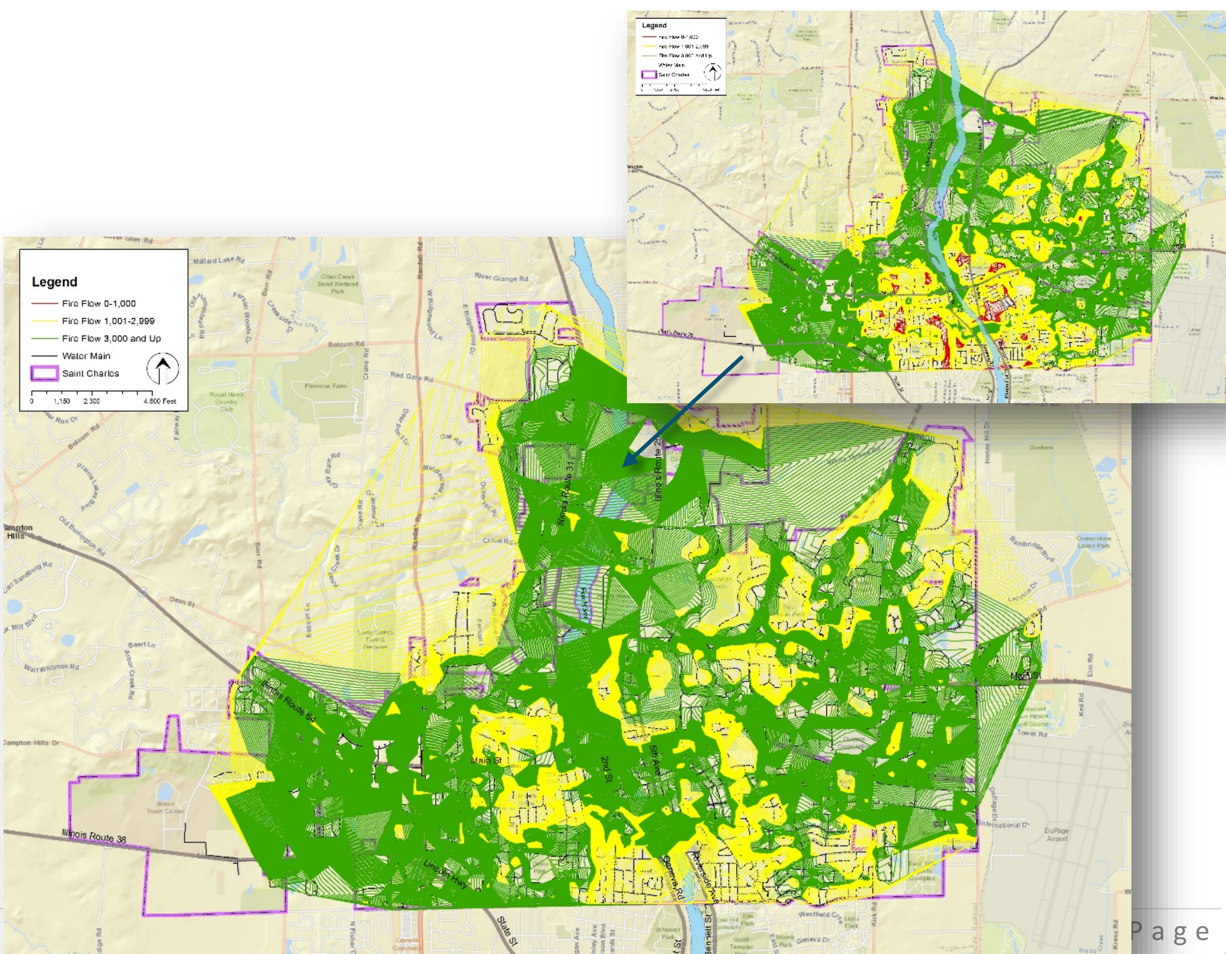
Straight-line spending and ignoring inflation requires an annual capital expenditure of approximately $4.3 million in order to have completed the replacement of all 4-inch and 6-inch water main by the year 2043 or 25 years.

Probable capital costs for an example annual water main replacement project are presented in Table 4-1.

Table 4-1: City Wide 4 & 6-Inch Water Main Replacement

Upsize 4 & 6-inch Water Main Improvements				
Description				Total Probable Cost
SUMMARY				
SITEWORK				$78,526,162
			SUBTOTAL CONSTRUCTION	**$78,526,162**
			CONTINGENCY @ 20%	$15,705,232
			ENGINEERING @ 15%	$11,778,924
			CONSTRUCTION TOTAL	**$106,010,318**
Description	Quantity	Unit	Unit Price	Total Probable Cost
SITEWORK				
Davis Elementary School Area Improvements				
Abandonment of Existing Water Main - 6"	378,244	FT	$15	$5,673,660
Ductile Iron Water Main, Class 52, 8"	378,244	L.F.	$100	$37,824,400
Gate Valve in Vault, 8"	1,261	Each	$4,500	$5,674,500
Fire Hydrant, Complete	1,261	EA	$5,500	$6,935,500
Trench Backfill	112,128	C.Y.	$65	$7,288,342
Pavement Removal and Replacement	126,081	S.Y.	$100	$12,608,133
Landscape Restoration	168,108	S.Y.	$15	$2,521,627
PROJECT TOTAL				$78,526,162

Figure 4-3: Upsizing Water Main (Before/After)



4.2. Prioritization of Distribution System Improvement Projects

In order to objectively rank the identified distribution system capital improvement projects, the below prioritization matrix was created. Through work sessions with City staff, the following eight criteria were identified as most important when selecting a project:

1. Lead Service – The relative amount of lead services removed as part of the project.

2. Water Quality – Replacement of main associated with water quality complaints.

3. Impact Value – Large Improvements throughout the project area for the associated costs, including coordination with sewer, storm, and roadway capital improvement projects.

4. Water Main Age – With main installed in the 1960's approaching the end of its service life.

5. Main Break Frequency – Replacement of main breaking often reduces staff labor and expense.

6. Public Safety/Available Fire Flow – High density locations near Public Facilities such as Schools, or Municipal Buildings.

Each of these criteria were then weighted with a 1-6 factor (as indicated in the list above), with the higher number indicating the greater weight. The 17 projects were then given a score from 1-5 for each of the criteria, which were then multiplied by the weight factor and added together to arrive at a total score or "Criticality Index."

As illustrated in Table 4-3 on the following page, the projects ranged in criticality from 23 to 89, with the three highest projects being the Davis Primary School, Fairview Subdivision, and 11th and 12th Streets. The estimated project costs for these three projects are \$6.78 Million, \$7.20 Million, and \$0.75 Million, respectively.

Due to the scope of the of the Davis Primary School and the Fairview Subdivision improvements, it is recommended that this project be broken into phases to a more manageable project cost. The City should look to budget for each of the 17 projects to be implemented as part of a total capital improvement plan. The larger projects could be broken into multiple phases in order to make them financially manageable.

The prioritization table listed on the next table represents the 17 projects identified for implementation but can also be used as a guideline for identifying future projects. The listed criteria can be applied for other areas of concern in the future to assist with further project scheduling.

Table 4-2: Capital Project Prioritization Table

	Project Description	Capital Cost	Project Selection Criteria						Total Score	Ranking
			Public Safety/AFF	Lead Service	Water Quality	Water Main Age	Main Break Frequency	Impact Value		
			6	1	2	4	5	3		
1	Fairview Subdivision	$7,200,000	3	3	5	3	5	3	77	2
2	11th & 12th Street	$750,000	5	3	2	3	4	2	75	3
3	Davis Primary School	$6,780,000	4	3	5	3	5	5	89	1
4	Prairie St. (5th - 8th)	$1,460,000	5	5	4	4	2	2	75	4
5	3rd St. & 4th St. Alley	$1,490,000	5	4	1	4	1	2	63	11
6	Horne St. & Ash St.	$1,530,000	4	4	2	4	2	1	61	14
7	Rt. 25 & North Ave.	$340,000	4	3	2	5	3	2	72	8
8	South Second Ave.	$3,970,000	2	4	2	5	2	3	59	15
9	Lincoln Elementary School	$650,000	4	2	1	5	2	5	73	6
10	Monroe Avenue	$3,160,000	4	4	3	5	2	3	73	7
11	Rt. 64 & 9th Ave.	$170,000	3	2	3	5	2	2	62	12
12	South Ave east of 14th	$4,090,000	3	3	3	3	4	2	65	10
13	Rt. 64 north to Wing	$1,730,000	4	4	1	5	3	3	74	5
14	Munhall Elementary School	$1,890,000	3	1	3	3	2	5	62	13
15	Tyler Road & Route 64	$690,000	4	1	1	3	3	4	66	9
16	Fox Ridge Elementary School	$950,000	3	1	1	2	1	5	49	16
17	Royal Fox Subdivision	$4,700,000	1	1	2	1	1	1	23	17
		$41,550,000								

4.3. WATER METER REPLACEMENT PROGRAM

The City contracted with Power System Engineering, Inc. in 2017/18 to complete a business case analysis of beginning a Water Meter Replacement Program. This study focused on a benefit analysis of Advanced Metering Infrastructure (AMI) versus traditional Automated Meter Reading (AMR) systems for the replacement program.

AMI systems are advantageous as they allow for more frequent transmission of data regarding a customer’s water consumption. AMR systems also necessitate manual utility billing, whereas AMI will institute automated billing processes. AMR requires drive-by meter reading and features one-way communication, where the meter provides information only to the utility. AMI, however, allows for two-way communication where the utility can slow usage at a location through telecommunications with the meter. Meter information will also be transmitted to the utility for billing, reducing the man hours needed in tracking meter data throughout the City.

There are many variations of AMI systems presently available, but the majority of these systems were not found to be compatible with the City of St. Charles due to prohibitively high costs, extensive equipment requirements, frequency specifications, interference susceptibility, and a lack of focus on water meters. For these reasons, the report by Power System Engineering suggested that the City of St. Charles install a wireless AMI system that will support the variety of meters present in the City while also reliably and resiliently reporting meter data to the utility.

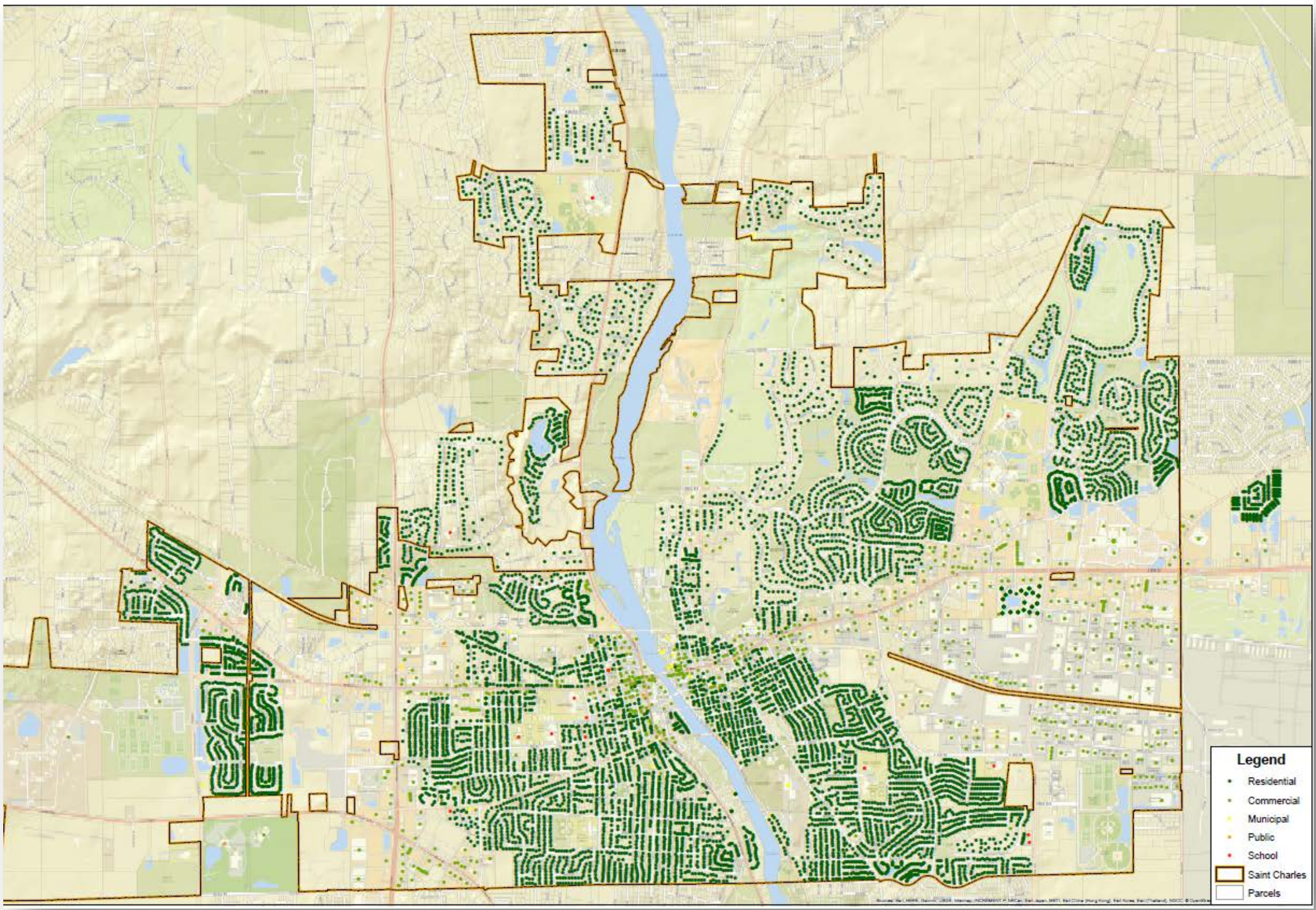
Category	Cellular	Power Line Carrier	Wireless: Mesh	Wireless: Tower Based
Percentage of meters read	Best	OK	Best	Best
Outage Detection	Better	Poor or not available	Better	Best
Electric, water, wastewater, and natural gas	Poor or not available	Poor or not available	Best	Best
Detects phase	Poor or not available	Best	OK	OK
Backhaul communications	Best	Better	OK	OK
Home Area Network support	Best	Poor or not available	Better	Better
Communications/Network speed	Best	Poor or not available	Better	OK
Typical Cost (Upfront and Recurring)	Poor or not available	OK	Better	Better

Best Better OK Poor or not available

4.3.1. St. Charles Water Meter Inventory

The City of St. Charles currently reads approximately 12,500 water meters monthly. These meters are categorized as commercial, residential, school, municipal, and public by their functions. The figure below displays the distribution of these categories throughout the community, as well as a summary of the quantities of these different roles.

Figure 4-4: City of St. Charles Water Meter Location Map



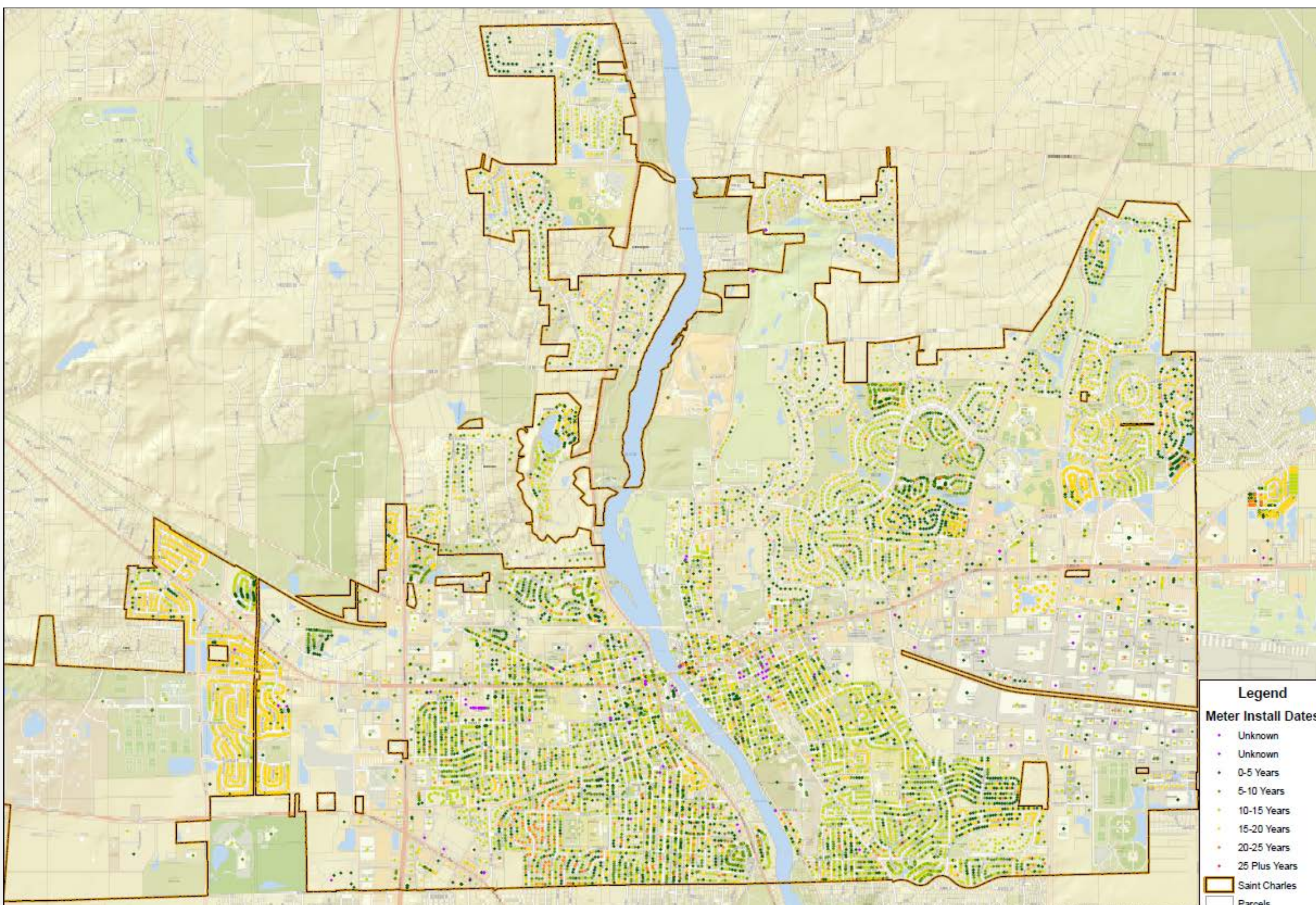
Category	Quantity
Commercial	1,052
Municipal	28
Public	17
Residential	10,996
School	29
Total	**12,122**

Future replacement of meters will be prioritized based upon the age and size of existing meters. Shown below are the meter sizes used throughout the City of St. Charles as well as the division of ages of meters.

Size (inch)	Quantity
0.5	19
0.63	22
0.75	7,333
1	4,514
1.25	1
1.5	157
2	53
3	13
4	6
Total	**12,118**

Age	Quantity
0-5 Years	2,001
5-10 Years	2,433
10-15 Years	4,079
15-20 Years	3,667
20-25 Years	496
25+ Years	6
Total	**12,682**

Figure 4-5: City of St. Charles Water Meter Installation Date Map



4.3.2. Water Meter Replacement Program Recommendations

The study conducted by Power System Engineering estimates a cost range for complete implementation of AMI throughout the City of St. Charles of $4.0M to $6.25M. The components included in this estimation are listed in the figure below, and the estimated cost is based upon previous implementations in similarly sized utilities.

Table 4-3: Water Meter Replacement Program Cost Estimate

#	Category	AMI
1	AMI Infrastructure	$200,000
2	AMI Software and Servers	$100,000
3	Meters and Modules	$3,300,000
4	AMI Project Management	$95,000
5	Backhaul Costs	$30,000
6	AMI Deployment Meter Installation	$650,000
7	Demand Response, CVR, and Other Implementation	$200,000
	Estimated Cost	**$4,575,000**
8	Annual Software License Fees and Support – Year 1	$50,000
	Estimated Project Costs	**$4,625,000**
9	Estimated Operations, Maintenance, and Recurring Fees (Over 15 Years – less year 1)	$925,000
	Estimated Total Cost of Ownership	**$5,550,000**

The City of St. Charles's 2018-2019 Capital Improvement Plan budgets a total of $3,935,001 between the years of 2019 and 2022 for the implementation of Advanced Metering Infrastructure. Additional funding may need to be allotted to this program depending on vendor costs and final technology choices. Based upon these cost estimates, the PSE survey estimates a breakeven on investment between 10 and 15 years after project completion.

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SECTION 5

EVALUATION OF EXISTING WATER SUPPLY, TREATMENT & STORAGE FACILITIES

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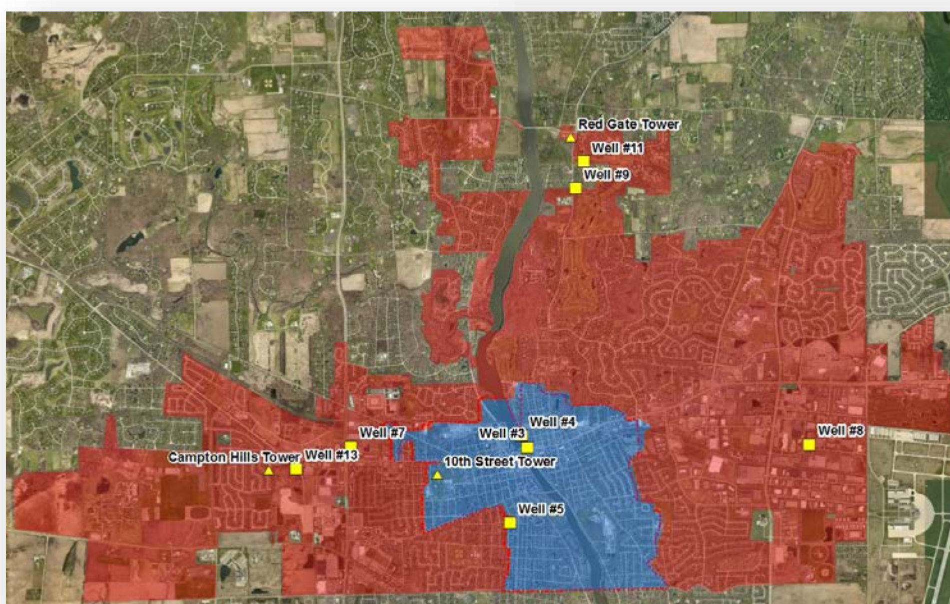
5. Evaluation of Existing Water Supply, Treatment & Storage Facilities

5.1. General Water System Information

The City of St. Charles water supply and storage system consists of seven wells, three water treatment facilities, a 300,000-gallon spheroid water tower, a 1,500,000-gallon spheroid water tower, a 1,000,000-gallon Hydropillar® water tower, and several ground storage reservoirs with booster stations. As with most municipal water supplies, the existing infrastructure has been constructed over several decades and the components within the system vary in age. The City of St. Charles follows a rigorous maintenance program for the wells, towers and distribution system to ensure reliability of the infrastructure.

The City currently has an active booster station and ground storage reservoir capacity of 2.9 million gallons. These ground storage reservoirs are used in conjunction with the existing elevated water towers to meet the Maximum Hourly Demand and Fire Flow Demands placed on the system.

The City's Wells and Water Towers have been strategically placed throughout the City's service area, and source water is supplied by two distinct aquifers. Well #7, 9, 11 and 13 are supplied by a shallow sand and gravel aquifer commonly known as the St. Charles Aquifer. Wells #3, 4, and 8 are supplied by a deep aquifer known as the Galesville Aquifer. The exhibit at right shows the different sites of the both the wells and elevated storage sites.



5.2. WATER SYSTEM CAPACITIES

The Ten States Standards for Water Works recommends that a community be capable of supplying enough water to meet the maximum day demand with the largest well not operating (firm capacity). The following table provides an overview of the supply wells at design and firm capacities, as well as reservoir capacities.

Table 5-1: Well and Reservoir Design Capacities

	System Served	Design Capacity (GPM)	Design Capacity (MGD)	Firm Capacity (GPM)	Firm Capacity (MGD)	Reservoir Capacity (gallons)
3	Inner	1,000	1.44	1,000	1.44	250,000
4	Inner	1,000	1.44	-	-	250,000
Total	**Inner**	**2,000**	**2.88**	**1,000**	**1.44**	**500,000**
7	Outer	1,750	2.52	1,750	2.52	175,000
8	Outer	1,200	1.73	1,200	1.73	2,000,000
9	Outer	2,150	3.10	-	-	0
11	Outer	1,900	2.74	1,900	2.74	236,500
13	Outer	1,500	2.16	1,500	2.16	0
Total	**Outer**	**8,500**	**12.25**	**6,350**	**9.15**	**2,411,500**

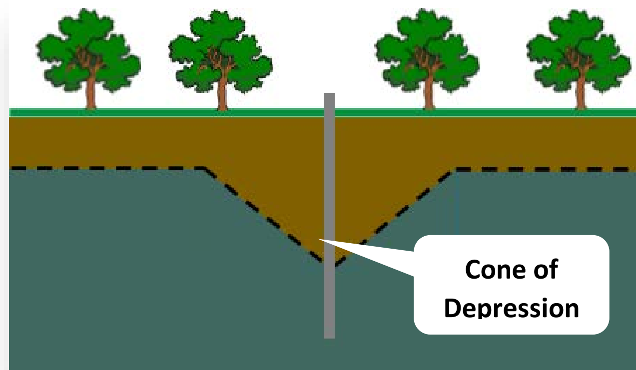
The City's system firm capacity is 1.44 MGD for the inner, and 9.15 MGD for the outer service area (with the largest wells out of service in each zone). This equates to a total system firm capacity of 10.6 MGD. The City of St. Charles has identified that the highest consumption rate over the past three years was 6.51 MGD in July 2016. However, looking further into historical pumping records shows a maximum of 9.74 MGD in 2005 and 8.96 MGD in 2012, which should be considered during long-term planning.

Table 5-2: City of St. Charles Historical Water Consumption

	Inner Zone Max Consumption		Outer Zone Max Consumption		Combined Max Consumption
Year	1st Largest	2nd Largest	1st Largest	2nd Largest	
2005	1.70 MG	1.57 MG	8.04 MG	7.82 MG	9.74 MG
2006	1.32 MG	1.19 MG	7.61 MG	6.65 MG	8.93 MG
2007	1.43 MG	1.38 MG	7.19 MG	5.94 MG	8.48 MG
2008	1.72 MG	1.54 MG	6.76 MG	6.40 MG	8.04 MG
2009	1.40 MG	1.27 MG	6.06 MG	5.76 MG	6.97 MG
2010	1.24 MG	1.20 MG	5.50 MG	5.32 MG	6.70 MG
2011	1.25 MG	1.14 MG	6.59 MG	5.04 MG	7.72 MG
2012	1.66 MG	1.65 MG	7.48 MG	6.80 MG	8.96 MG
2013	1.42 MG	1.30 MG	5.36 MG	5.04 MG	6.78 MG
2014	1.32 MG	1.26 MG	4.89 MG	4.79 MG	5.85 MG
2015	1.37 MG	1.30 MG	4.83 MG	4.63 MG	5.84 MG
2016	1.63 MG	1.44 MG	5.07 MG	4.65 MG	6.51 MG
2017	1.40 MG	1.37 MG	6.53 MG	4.89 MG	7.94 MG

5.2.1. 18-Hour Run Time Capacity

Figure 5-1: Cone of Depression



Traditionally, a community's firm system capacity is a function of the capacity remaining with the largest well out of service and is based on a 24-hour run time for each well. During this period the community must be capable of meeting the maximum day demand. Peak hour demands are met by drawing from elevated storage or booster pumping water from ground level storage.

When running a well for a long duration (days), the aquifer can be stressed and start to create a **cone of depression** (see figure to the right). A cone of depression occurs when the aquifer water surface elevation begins to drop near the well due to the inability to recharge adequately. When a system experiences a depressed aquifer, it can result in lower pumping capacities. Therefore, this evaluation will also consider well capacity on an 18-hour run time basis in addition to the traditional 24-hour cycle. While the City of St. Charles has not experienced significant capacity reductions during periods of extended pumping, it should still be taken into account.

The table below illustrates the well capacities updated to reflect a maximum 18-hour run time. Additionally, the far-right column lists the inner and outer pressure zone production capacities with the largest well out of service (firm capacity).

Table 5-3: Well and Reservoir 18-Hour Run Time Capacity

Well and Reservoir Capacity - Modified Run Time					
	System Served	Capacity (GPM)	Capacity (MGD)	18 Hour Run Capacity	18 Hour Run Firm Capacity
3	Inner	1,000	1.44	1.08	-
4	Inner	1,000	1.44	1.08	1.08
Total	**Inner**	**2,000**	**2.88**	**2.16**	**1.08**
7	Outer	1,750	2.52	1.89	1.89
8	Outer	1,200	1.73	1.30	1.30
9	Outer	2,150	3.10	2.33	-
11	Outer	1,900	2.74	2.06	2.06
13	Outer	1,500	2.16	1.62	1.62
Total	**Outer**	**8,500**	**12.25**	**9.20**	**6.87**

With the City's well pump time reduced to 18-hours per day, the firm capacity is reduced to 1.08 MGD for the inner system, and 6.87 MGD for the outer. These numbers can be used for evaluating the system's ability to meet average day demands, however they are not intended to be used for maximum demand scenarios when wells will be pumping as much as necessary to meet demand.

5.2.2. Current Well Capacities

Each of the wells in the City of St. Charles is operated at a lower production rate than originally designed, for a variety of reasons. As such, the actual capacity of City's water distribution network is significantly lower than the design specifications indicate. The current well capacities in the table below indicate the actual operating production rates under existing conditions.

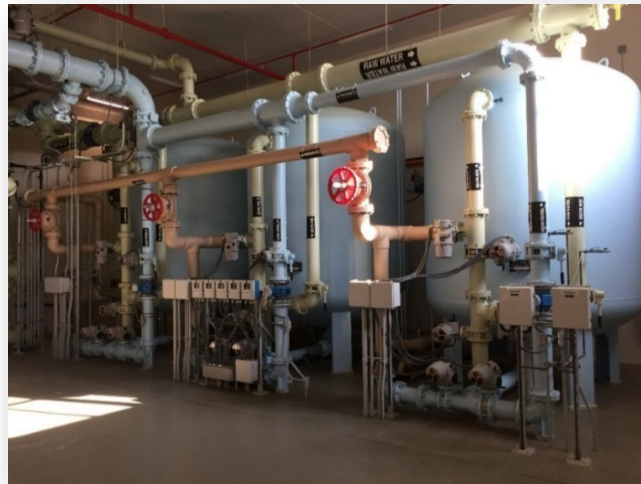
Presently, the City's wells operate at 52.9% of the capacity that they were designed to produce. This lowered production is especially prevalent at Wells 7 and 11, with Well 7 not being used to pump any water and Well 9 operating at approximately 50% of design capacity. Production is set at current levels at each well for a specific reason – chlorination capacities, elevated iron levels, and pump curve limitations. It should be noted that these "current" rates are designed to *produce the highest quality of water possible* by maximizing use of wells that produce the highest quality water. While Well #7 specifically has been removed from routine service, it could be brought back online during peak periods if necessary. These current rates and required future capacities are discussed in further detail in Section 6.

Table 5-4: Current Well Capacity

Well	System Served	Design Capacity (GPM)	Design Capacity (MGD)	Current Capacity (GPM)	Current Capacity (MGD)
3	Inner	1,000	1.44	850	1.22
4	Inner	1,000	1.44	750	1.08
Total	**Inner**	**2,000**	**2.88**	**1,600**	**2.30**
7	Outer	1,750	2.52	0	0
8	Outer	1,200	1.73	950	1.38
9	Outer	1,900	3.10	1,500	2.16
11	Outer	1,900	2.74	1,000	1.44
13	Outer	1,500	2.16	1,500	2.16
Total	**Outer**	**8,250**	**12.25**	**4,950**	**7.14**

5.3. Water Supply and Treatment Evaluation

5.3.1. Well #3 & 4



Wells #3 and #4 are located within the municipal complex along First Avenue. Well #3 is located in the courtyard north of City Hall at 2 E. Main Street. The well was originally drilled into the Mt. Simon Aquifer in 1919. The well construction included a casing down to bedrock but was left open to multiple aquifers including the dolomite, St. Peter, Galesville and Mt. Simon. During the 1970's it was found that the Mt. Simon formation contained high chloride concentrations. To mitigate the problem, the City of St. Charles sealed the well to formations up to the Galesville Aquifer, which is still used today. The existing well is 1,192 feet deep with a pump setting of 804 feet below grade. The static water level in the well is 416 feet below grade or 388 feet above the pump.

Well #4 is located adjacent to the City of St. Charles Police Department. Similar to Well #3, the well was originally open to several aquifers, including the Mt. Simon and Galesville Aquifers. Around 1970, the City modified the well by sealing the lower portion, the Mt. Simon Aquifer, to eliminate contamination by chlorides. Well #4 is 1,645 feet deep with a pump setting of 821 feet below grade. The static water level in the well is 370 feet below grade or 451 feet above the pump.

Although Wells #3 and #4 are only approximately 540 feet from each other, the City charts approximately a 45-foot difference in static water elevation between the two wells. This difference could be attributed to several causes. One explanation is that since the City does not run Wells #3 and #4 simultaneously, one well will inevitably have a lower static water elevation as a result of more recent use, and lengthy recharge times. A second explanation is that the upper formation may be sealed off in Well #3 and not in Well #4 contributing to Well #4's higher water level. A third explanation is that Well #4 is still seeing some static pressure from the Mt. Simon aquifer.
In 2012, the City constructed a new water treatment plant at Well #3 & 4, to treat the raw influent for Radium, as well as to provide softened water to the Inner Service Area.

Finished water from Wells 3 and 4 is a composite of water that has taken three paths through the filtration plant. The flows in the table at right describe how water is divided when each of the wells is in operation and when both wells are being run simultaneously. Dividing the flow and blending with raw water allows the City to efficiently treat water while still achieving the necessary contaminant removal levels.

(GPM)	Well 3	Well 4	Well3/4
HMO Filtration	385	381	783
Ion Exchange	500	504	987
Bypass Flow	115	115	230
Total Flow	1000	1000	2000

An ion exchange system was installed at the water treatment plant and functions in the same way as many household water softening systems. Raw water is fed into the ion exchange unit where it comes in contact with a cation charged resin bed. The resin exchanges positively charged ions such as magnesium and calcium, the primary contributors to water hardness, for innocuous sodium ions. Over time, even with repeated backwashing, the capacity of the resin to replenish its concentration of sodium ions will be reduced. It is suggested that the City test a core sample of the ion exchange resin at Well 3/4, as the relatively recent construction of this facility will provide a strong baseline reading.

Well 3 Radium (pCi/L)	10.92
Well 4 Radium (pCi/L)	10.44
Softener Radium (pCi/L)	2.03
HMO Radium (pCi/L)	2.01

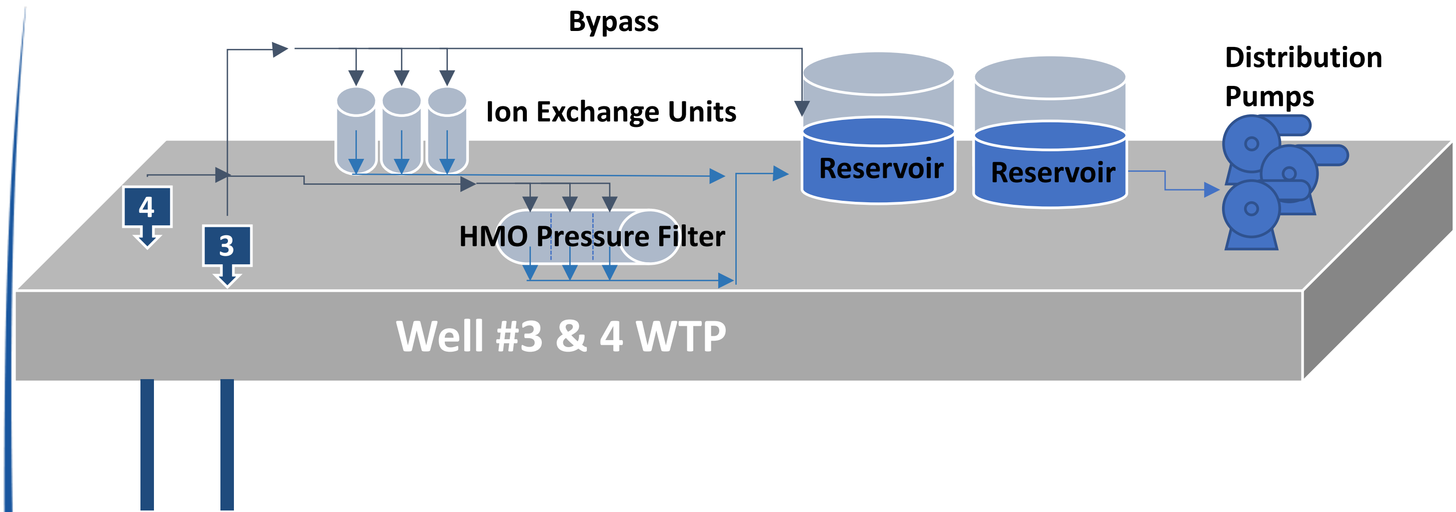
The ion exchange process has a very high removal rate for not only calcium and magnesium ions, but also Radium 226 and 228. Since the implementation of this technology, the City has seen radium removal rates in excess of 80%. Removal is likely higher but finished radium levels fall below concentrations that can be accurately measured. The MCL for combined radium 226 and 228 is 5 pCi/L. Presently, radium removal through ion exchange and HMO filtration achieves finished radium concentrations of 2.03 and 2.01 pCi/L, respectively, allowing for blending to occur with raw water and remain below the regulated concentration.

	Actual	Design
Filter Radius (ft)	4.5	4.5
Rate (gal/minute/sqft)	7	7.76
Filters online	2	2
Pi	3.14	3.14
Flow Rate (gal/min)	890.64	987

Calculations determined that the system should be limited to a forward flow rate below the system's initial design rate. 10 State Standards indicate that a forward flow rate should not exceed 7 gallons per minute per square foot of bed area. As shown to the right, the design flow rate of 987 gallons per minute would lead to a flux of 7.75 gallons per minute per square foot. As such, the system should only run at 890 gallons per minute.

GPM	Well 3	Well 4	Well3/4
HMO Filtration	385	381	783
Ion Exchange	500	504	987
Bypass Flow	115	115	230
Total Flow	1000	1000	2000

The Ion Exchange system was combined with a HMO (Hydrous Manganese Oxide) filtration system. The treatment process includes the creation of a HMO slurry, which is a mixture of manganese sulfate, potassium permanganate, and water. This HMO slurry is injected into the raw water prior to filtration. The HMO particles absorb radium from the raw water and are filtered out in the anthracite filter media. Routine backwash cycles clear HMO particles from the filter media. Backwash flow is diverted to the City's sanitary sewers. By combining the HMO process with ion exchange the City is able to meet both the radium removal requirement and the hardness removal goal for the inner system. Shown at right is the blending rate through the two treatment processes and bypass when each well is online as well as when both wells are simultaneously in operation.



Treated water mixed with bypass water is pumped to two, 250,000-gallon reservoirs. Water is pumped from storage to meet demand through three booster pumps housed within the treatment plant. These pumps are capable of pushing water to the outer zone during times of high demand.

Shown below are the well and pump history logs for Wells #3 and 4. These records indicate that the pump at Well 3 has not been replaced since 1984 and has been serviced every 7 years, on average, since installation. The pump at Well 4 was installed in 1970 and has been serviced every 6 years, on average.

Well #3 Layne Maintenance and Rehabilitation History									
Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
1919	NEW WELL	14	555	104+					
1946			600	200+					
3/9/1947	MAINT	127	560	174	47				11.9
1952		148							
5/3/1955	MAINT	177	1125	320	143				7.9
5/18/1971	MAINT	323	550	601	278		601		2
10/26/1971	PRE REHAB	451	650	626	175	35	707		3.7
10/26/1971	POST REHAB	376	852	604	228	15	639		3.7
3/30/1977	MAINT	417	692	666	249	13	696	230/230/230	2.8
9/24/1982	PRE REHAB	399	671	734	335	0	734	245/245/245	2
9/29/2982	POST REHAB	419	807	700	281	0	700	260/260/255	2.9
8/20/1984		439	767	709	270	4	718	230/230/230	2.8
3/2/1992	MAINT	391	852	640	249	6	654	250/252/250	3.4
7/11/1994	MAINT	416	909	658	242	12	686	240/240/245	3.8
4/13/2001	MAINT	418	969	628	210	10	651	248/249/250	4.6
6/10/2008	MAINT	445	909	650	205	11	675	249/245/248	4.4
6/16/2014	MAINT	473	852	681	208	14	713	240/240/242	4.1

Well #4 Layne Maintenance and Rehabilitation History									
Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
1936	NEW	90	1000	235	145				6.9
1952	REPAIR	145	1146	240	95				12.1
12/3/1970	NEW BJ SUB								
6/7/1971	WELL MOD	370							
8/6/1972	REPAIR	332	632	520	188	25	578	195	3.4
4/3/1977	COL EXT	370	554	545	175	8	563		3.2
10/13/1982	REPAIR	350	681	729	379	30	798	235/255/225	1.8
10/20/1982	ACID	363	963	661	298	5	673	220/220/240	3.2
9/19/1984	REPAIR	442	916	663	221	10	686	245/250/252	4.1
3/24/1992	MAINT	386	888	675	289	0	675	264/266/269	3.1
5/6/1998	REPAIR	370	881	667	297	30	736	254/258/268	3
5/19/2005	MAINT	390	807	739	349	15	774	242/242/252	2.3
7/15/2011	REPAIR	457	751	699	242	30	768	231/241/236	3.1
10/14/2011	REPAIR	457	783	663	206	30	732	235/241/241	3.8

5.3.2. Well #5

Well #5 was located at the intersection of 3rd Street and Bowman Street. This well was designed to provide water for the Inner Service Area and has a capacity of 1.44 MGD. However, Well #5 drew water from the Galesville Aquifer and therefore the raw water contained radium levels above the EPA established maximum containment level. As a result, Well #5 has been taken out of service. The well has been sealed and demolished at the recommendation of the Illinois EPA since the last Water Utility Master Plan.

5.3.3. Well #7

Located on Randall Road just north of the intersection with Illinois Route 64, Well #7 provides water to the outer service area with a capacity of 2.52 MGD. Constructed in 1965, Well #7 is supplied by a shallow sand and gravel aquifer commonly known as the St. Charles Aquifer. The well depth is 175 feet with a pump setting at 110 feet below grade.

As shown in the water quality table below, Well #7 has concentrations of metals such as iron and manganese at or above the Minimum Concentration Level set by the US EPA. This facility is designed to reduce these concentrations below the MCL through aeration and filtration. The well also displays very high hardness levels in its influent water of around 530 mg/L as calcium carbonate.

In 1968 a tray aeration unit was installed to remove the naturally occurring iron in the raw water, replacing the original polyphosphate feed system. The 1968 upgrade also involved the installation of a new 175,000-gallon below-grade concrete storage reservoir and booster station in addition to piping modifications to allow for the bypass of raw water directly to the distribution system.

Well 7	Influent	MCL
Hardness (mg/L)	530	n/a
Iron (mg/L)	2.7	0.3
Manganese (mg/L)	0.05	0.05

In 1970, four Walker Process dual-media deep bed gravity filters, each with two filter cells, were installed within a new filter building over the existing below-grade storage reservoir. These filters were designed to remove the oxidized iron particles from the raw water following the tray aeration unit. The new filter building was also equipped with an air/water filter backwash system connected to a concrete sump with a dual submersible-pump lift station to collect the filter backwash water for conveyance to the City's sanitary sewer system. Also installed in 1970 was a vacuum blower to increase the aeration capacity of the tray aerator.

Since 1970 several modifications at Well #7 have been made. In 1978 the tray aeration unit was replaced with a General Filter pressure aeration system or Atomerator™. However, high iron concentrations were still detected in the finished water. In 1996 the original filter media was replaced and the filter underdrain was cleaned in an attempt to improve finished water quality. Following these improvements, the filters continued to deteriorate resulting in an increase from weekly to daily filter backwashes and no substantial change to water quality. The following year the anthracite portion of the media was replaced with sand and automated filter backwash controls were installed improving the filter performance but high concentrations of iron were still present and frequent backwashing still occurred.

In 2001 Well #7 only produced 2.16 MGD and was indicating iron removal efficiency problems and shortened filter run times. In 2002 improvements were completed consisting of new piping, installation of a potassium permanganate chemical feed system to chemically oxidize the iron in the raw water and replacement of filter media with manganese greensand. The runtime between filter backwashes and finished water quality dramatically improved following these improvements. The City Water Department had operated Well #7 at 1600 GPM as opposed to the full capacity of 1900 GPM, equating to 2.52 MGD. This was done in order to decrease the number of times per day that the well was starting and shutting down due to the small capacity of the on-site reservoir.

Following the 2002 improvements, the City commissioned Hungerford & Terry, Inc. to perform an evaluation of the manganese greensand media to identify the remaining service life and determine whether a media replacement was necessary. Four cores were sent to a testing facility and analyzed, and included the North Tank East and West Cells, as well as the South Tank East and West Cells. The samples were collected by using a small pipe to remove the media from a single cross-sectional area, a total of one quart of material was removed from each cell. Overall, the media itself was in good condition regarding size, uniformity, hardness, and coating. In addition, the material for the most part was free of foreign debris and didn't exhibit appreciable backwashing issues. It was determined that the material was in good condition physically.

In regards to manganese removal, each sample was tested individually. Typically, it is recommended that the media should be able to remove about 300 gr/ft^3 or more of manganese to be considered effective. Tests of the City's Well #7 media in 2016 showed that the media was exhausted, having a removal rate of approximately 60 gr/ft^3. This information has been included in the table below.

Table 5-5: 2016 Well #7 Cell Core Test Results

Unit	As Received (gr/ft^3)	1st Regen (gr/ft^3)	2nd Regen (gr/ft^3)
Far West Cell	58	88	58
Center West Cell	67	34	34
Far East Cell	62	93	62
Center East Cell	62	31	62

In the 15 years since the last rehabilitation, Well #7 has again experienced a decline in finished water quality. Due to the deteriorating condition of the filter equipment and media, Well #7 has seen significantly increased iron levels in the finished water. For this reason, this well is utilized as little as possible. The treatment facility is run routinely to maintain residuals and exercise equipment; however, finished water is pumped to distribution only during periods of high demand.

Well #7 and the associated treatment facility are beyond their respective service lives and will require significant rehabilitation in the near future. This includes equipment and piping, as well as the structures themselves. Section 6 will present alternatives for rehabilitation or replacement.

Shown below is the Well and Pump History Log for Well #7. The pump at this facility was replaced in 1995, and since then has been serviced twice, averaging 11 years between repairs.

Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
??	NEW WELL	60	1960	69	9				217.8
11/1/1972	REPAIR				0		0		
3/5/1974	REPAIR	53	1893	58	5	22	109	95-95-97	378.6
8/10/1977	REPAIR	68	1266	89	21	40	181	92/93/90	60.3
2/18/1980	REPAIR	53	1893	63	10	30	132	100/101/102	189.3
4/18/1980	REPAIR	52	1486	62	10	30	131	88/88/86	148.6
9/3/1980	REPAIR	52	550	61	9	10	84	58/56/56	61.1
2/4/1983	REPAIR	62	1313	63	1	30	132	81/81/81	1313
6/20/1983		57	1321	61	4	30	130	86/85/84	330.3
12/5/1983	REPAIR	60		65					
10/24/1990		62	1808	68	6	10	91	82/85/86	301.3
12/12/1991	REPAIR	62	1820	67	5	10	90	84/86/84	364
9/20/1993	REPAIR	56	4594	63	7	12	91	75/75/75	227.7
10/27/1995	REPAIR	64	1364	69	5	15	104	64/64/64	272.8
10/31/1995		64	1507	71	7	15	106	71/73/73	215.3
4/21/2003	MAINT	62	1953	71	9	15	106	80	271
5/10/2010	MAINT	65	1381	71	6	30	140	79/77/77	230.2

5.3.4. Well #8 – Ohio Avenue Water Treatment Facility

Well #8 is located at the intersection of Ohio Avenue and 37th Avenue. Well #8 and a booster station were constructed in the 1960's to serve the expanding eastern industrial park and surrounding business district in the Outer Service Area. The original facilities included a 1,200 GPM well, two 1,000,000-gallon steel ground storage reservoirs, and a booster station. Well #8 was originally installed to a depth of 1,368 feet with a pump setting of 811 feet below grade.

Similar to Wells #3 and 4, Well #8 draws from the Galesville Aquifer and therefore the raw water contains naturally occurring Radium. The combined radium 226 and 228 level in the raw water is 11.99 pCi/L, well above the MCL of 5 pCi/L. As a result, in order to maintain compliance with Radium standards, raw water from Well #8 was blended with water from the distribution system in the ground storage reservoirs. Due to blending requirements, Well #8 was limited in production to approximately 10% of its 1.73 MGD capacity. The 2001 Water Supply Report recommended a radium removal facility be constructed on the Well #8 site. The construction of this facility has allowed for production from Well 8 to reach 1.38 MGD. A secondary benefit of the radium removal technology utilized at the Ohio Avenue treatment facility is softened water. Raw water from Well #8 contains a hardness level of 298 mg/L, but treatment through HMO filtration and ion exchange achieves a finished hardness concentration of between 140 mg/L and 180 mg/L.

The Ohio Avenue Water Treatment Facility is located adjacent to the existing booster station and was designed by Trotter and Associates. At the treatment facility, raw water is split between three Ion Exchange Units and one, four-cell HMO Horizontal Pressure Filter which together can treat up to 2 million gallons per day. These processes are used in parallel to remove radium and soften the water to the desired levels of the City. This facility is the first to ever employ this blending strategy, and as such has received recognition for its groundbreaking design and efficiency from the American Water Works Association (AWWA). The Ohio Avenue Water Treatment Facility has been used as a template for the Well 3/4 facility as well as other treatment plants around the nation.
Since construction of the facility in 2006, degradation of the ion exchange media is likely to have occurred. The ion exchange units maintain a high removal efficiency during present operation of at least 85%. However, it is suggested that the resin be test and replaced if necessary during this Plan's effective period.

Well 8	
Hardness (mg/L)	260
Iron (mg/L)	0.028
Radium (pCi/L)	11.99
Radium - Softener (pCi/L)	1.71
Radium - HMO (pCi/L)	1.79

During development of the filtration facility, it was calculated the City would need to treat 66-80% of water in order to meet the combined radium MCL. Treatment of 66-80% of water would result in water hardness lower than the targeted 140 mg/L. Therefore, the ion exchange process was combined with HMO Filtration to maintain ideal water conditions.

The HMO (Hydrous Manganese Oxide) Process is a fairly recent radium removal treatment process developed by Dr. Richard Valentine at the University of Iowa. In this treatment HMO slurry is created by mixing manganese sulfate with potassium permanganate and made into a slurry by blending with water. This HMO slurry is then injected into the raw water prior to filtration. The HMO particles absorb radium from the raw water and are filtered out in the anthracite filter media. The HMO particles are removed from the filter during routine backwash operations and transported to the sanitary sewer. The City commissioned water quality analysis of samples by PDC Laboratories in early 2018. This study returned the radium concentrations displayed in the water quality table shown here.

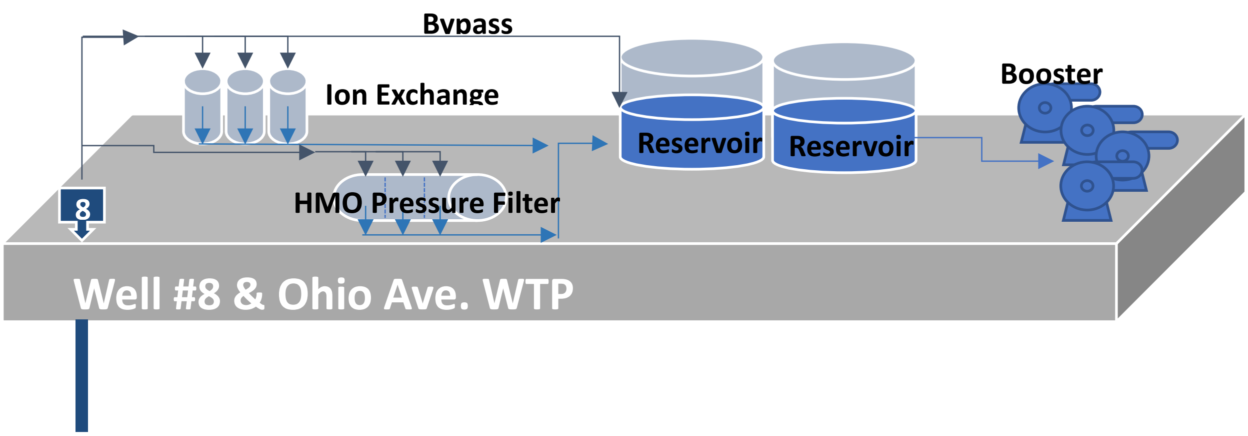
By combining the HMO Process with Ion Exchange, the City is now able to meet both the radium removal requirement and the hardness removal goal. As a result, the productivity of Well #8 has increased from 0.173 MGD to 1.3 MGD since the construction of the filtration facility.

Several upgrades to this facility have been identified to further improve its production of high quality water. A conversion from gaseous chlorine disinfection to sodium hypochlorite has been designed for this well but has yet to be implemented. The well head was converted to a pitless adaptor, improving ease of maintenance and reducing the risk of freezing. Variable Frequency Drives were also installed at this facility to reduce wear on motors.

Well #8 is the only facility in the City to operate on 2300V electricity. This is a result of the size of the well pump, and the depth of the pumping level. A traditional 480V motor would require a significantly larger cable to carry the requisite current, and the largest Byron-Jackson motor available for this voltage is 300 HP. The previous well pump motor was 400 HP, and the existing is currently 350 HP which resulted in a slight decrease in capacity. The current well pump in service is designed for 1200 gpm at 760 ft TDH, which does not exceed 300 HP on its curve. Therefore, conversion to 480V may be possible, but due to the age of the pump it would be recommended that the City replace the pump and motor in combination. The cost of this conversion and replacement is estimate at $750,000 for the new pump and motor including pulling and setting. An additional $250,000 is estimated for an appropriately sized drive with sine wave filter, breaker, metering switchboard, utility transformer and replaced service secondaries including installation. It is recommended that the City budget $1.0M for this conversion.

The ion exchange units and HMO pressure filters at Ohio Avenue are capable of treating more water than Well #8 is capable of producing. This additional treatment capacity could be used to treat the production capacity of another well. In the future, another Galesville aquifer well could be drilled and treated at the Ohio Avenue Facility. An additional well would increase the region that receives water from Ohio Avenue, as the water currently only meets the demands of the industrial park that it is located within. Increasing the area served by the Ohio Avenue Facility would increase residential access to softened water and could decrease water quality complaints in the surrounding neighborhoods. The additional well would not be able to be drilled at the existing Ohio Avenue location, as this close proximity to Well #8 would decrease the static water elevation below acceptable levels. Standard practice typically dictates wells in the same aquifer be located at least 1000 ft away from each other.

Water produced at the Ohio Avenue facility has historically been distributed based upon local pressure. A transducer onsite detects when the region around the Ohio Avenue WTP demands additional water and pushes water through the booster pump. This operation is unique to the rest of the City, where water production is dictated by water tower levels. In the future, the Ohio Avenue WTP will also operate based upon water tower levels, matching the operation of the rest of the City's distribution system.



Shown below is the maintenance log for Well #8 and the pump that services it. The pump was last replaced in 1979 and has been serviced once every 10 years since installation, on average.

Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
4/17/1978	NEW	363	1526	590	227				6.7
5/23/1979	NEW BJ	396	1236	592	196	15	627	69.5	6.3
5/5/1988	EXTEND	387	1158	731	344	16	768	73/73/74	3.4
9/21/1988	WELL REHAB	390	1305	674	284	16	711	74/74/74	4.6
3/20/1995	MAINT	397	1231	706	309	20	752	74/72/72	4
2/15/2000	REPAIR	405	1205	723	318	20	769	74/71/74	3.8
12/19/2005	EXTEND	423	1073	734	311	20	780	76/73/76	3.5
4/21/2011	REPAIR	400	1096	740	340	20	786	71/70/72	3.2
12/13/2013	REPAIR	429	1147	766	337	20	812	71/73/73	3.4

5.3.5. Well #9

Well #9 is located on north Illinois Route 25, near the intersection with Sunset Drive. This well draws from the shallow sand and gravel St. Charles Aquifer. Well #9 was originally constructed with capacity to deliver in excess of 1,900 GPM or 2.74 MGD. Current output from the well is set to 1,500 GPM in order to balance water production throughout the City's distribution system.

Well #9 is the City's most economical water source, because it pumps directly from the aquifer to the distribution system without reservoirs, booster stations, or treatment. The only requirements for water quality adjustment include fluoridation and chlorination prior to entering the distribution system, although Well #9 has very high hardness of 450 mg/L. As a result, the City's water system relies heavily on Well #9 as its primary source for meeting the community's demands. The performance of this well has been optimized through the implementation of a VFD, which has improved pump startup and overall efficiency greatly.

Well 9	Influent	MCL
Hardness (mg/L)	450	n/a
Iron (mg/L)	<0.010	0.3
Manganese (mg/L)	0.016	0.05

In 2018, an inspection of the Well's electrical service and grounding revealed many inadequacies that should be addressed. Presently, the system disconnect from the grid is located at the MCC inside of the building. A generator installed outside of the building is connected to the ATS, which switches power from the transformer and the generator to the structure. In order to meet NEC regulations, the existing current transformer should be replaced with a current transformer/main that could operate as the first point of disconnect for the system. This new CT/main also must be grounded to meet regulations. The existing 277/480 three-phase service is not grounded at the service first point of disconnect, due to the installation of the ATS. The generator is also scheduled for replacement, and the existing ATS should be evaluated to determine if it will be used with the new generator. The generator must be grounded independently of the CT, with its own ground triad and neutral bonded to ground. Improper or insufficient grounding will lead to stray and circulating currents that can damage equipment and cause electrolysis within the structure.

Well #9 has undergone several improvements since its initial construction. This has included an upgrade of the original 150 horsepower pump motor to a 200-horsepower motor, as well as the installation of a reduced voltage starter, both in 2002. More recently, in 2007, the pump depth was increased 10 feet in response to decreased static water elevations.

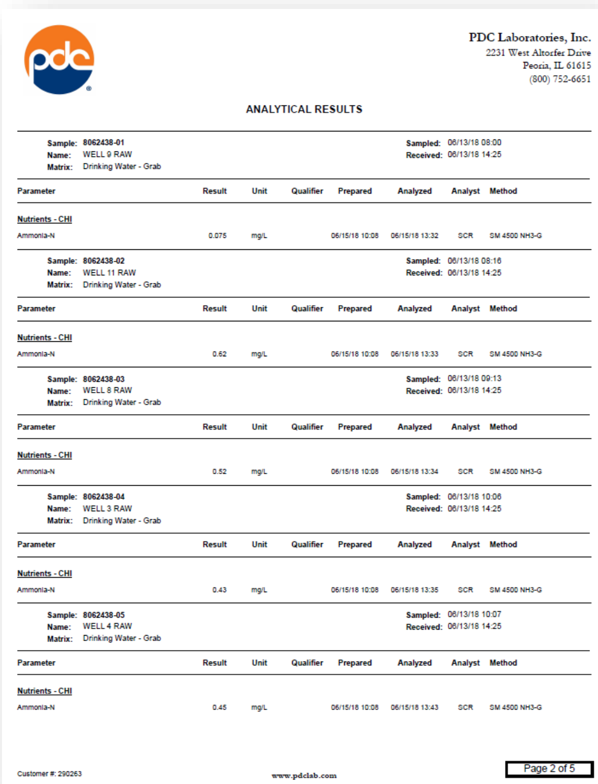
Shown below is the history and maintenance log for the well and pump at Well #9. This log indicates that the pump was last replaced in 1981 and has been serviced 9 times since then, an average of every 4 years.

Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
12/7/1979	NEW	23	1585	32	9				176
3/12/1981	NEW PUMP	25	1750	33	8	100	264	180/150/170	219
12/19/1988	REPAIR	29	1468	34	5	100	265	170/170/175	294
11/6/1989	REPAIR	26	1570	33	7	100	264	155/155/155	224
2/6/1992	REPAIR	28	1976	34	6	100	265	159/160/160	329
10/7/1997	REPAIR	28	1964	34	6	100	265	195/187/195	327
1/8/1999	REPAIR	29	1964	34	5	100	265	195/187/195	393
4/12/2004	MAINT	28	1953	36	8	100	267	180/185/190	244
5/25/2007	REPAIR	18	1964	26	8	100	257	187/193/189	246
3/27/2014	MAINT	32	2055	40	8	100	271	160/210/200	257
7/13/2016	REPAIR	26	1953	35	9	100	266	151/191/180	217

5.3.6. Well #11

Well #11 is located on north Route 25 near the intersection with Fox Glen Drive. The infrastructure at this site includes; a shallow well, a 236,500-gallon reservoir, three booster pumps, chlorination and fluoridation systems. This well was designed to have a production capacity of 1,900 GPM, or 2.74 MGD.

Since its original construction, Well #11 has not required any major improvements. A future concern that should be addressed is the status of the booster pumps at Well #11. Although the facility houses three boosters, only one booster pump (Booster A) is run currently. This is because the boosters are capable of outrunning the well, which would lead to the reservoir being drained. Increasing the current production capacity of the well would address this concern and allow the City to use the facility more efficiently.



PDC Laboratories, Inc.
2231 West Altorfer Drive
Peoria, IL 61615
(800) 752-6651

ANALYTICAL RESULTS

Sample: 8062438-01 **Sampled:** 06/13/18 08:00
Name: WELL 9 RAW **Received:** 06/13/18 14:25
Matrix: Drinking Water - Grab

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Nutrients - CHI							
Ammonia-N	0.075	mg/L		06/15/18 10:08	06/15/18 13:32	SCR	SM 4500 NH3-G

Sample: 8062438-02 **Sampled:** 06/13/18 08:16
Name: WELL 11 RAW **Received:** 06/13/18 14:25
Matrix: Drinking Water - Grab

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Nutrients - CHI							
Ammonia-N	0.62	mg/L		06/15/18 10:08	06/15/18 13:33	SCR	SM 4500 NH3-G

Sample: 8062438-03 **Sampled:** 06/13/18 09:13
Name: WELL 8 RAW **Received:** 06/13/18 14:25
Matrix: Drinking Water - Grab

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Nutrients - CHI							
Ammonia-N	0.52	mg/L		06/15/18 10:08	06/15/18 13:34	SCR	SM 4500 NH3-G

Sample: 8062438-04 **Sampled:** 06/13/18 10:06
Name: WELL 3 RAW **Received:** 06/13/18 14:25
Matrix: Drinking Water - Grab

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Nutrients - CHI							
Ammonia-N	0.43	mg/L		06/15/18 10:08	06/15/18 13:35	SCR	SM 4500 NH3-G

Sample: 8062438-05 **Sampled:** 06/13/18 10:07
Name: WELL 4 RAW **Received:** 06/13/18 14:25
Matrix: Drinking Water - Grab

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Nutrients - CHI							
Ammonia-N	0.45	mg/L		06/15/18 10:08	06/15/18 13:43	SCR	SM 4500 NH3-G

Customer #: 290263 www.pdclab.com Page 2 of 5

Well 11	Influent	MCL
Hardness (mg/L)	530	n/a
Iron (mg/L)	0.19	0.3
Manganese (mg/L)	0.082	0.05

The well is presently operated at 1,000 GPM as this is the maximum amount that can be effectively chlorinated. Water from the well appears to be unable to maintain a chlorine residual, possibly due to ammonia converting chlorine ions to chloramines. The ammonia present in Well #11 raw water is 0.62 mg/L, which is the highest of any of the production wells. Additionally, the ammonia concentration in Well #9 is an order of magnitude lower at 0.075 mg/L. It is recommended that the City continue ammonia and chloramine testing at this facility, and if it is determined that elevated ammonia levels are limiting the chlorine residual the City should consider improvements to the chlorination system to regain the maximum capacity of this well. These improvements will be further discussed in the implementation plan within Section 7.

Water quality analysis commissioned by the City of St. Charles was executed in 2018 by PDC Laboratories. This study found that the concentration of manganese in water from Well #11 exceeded the MCL set by the US EPA in its Secondary Drinking Water Standards. As such, further testing should be executed at this facility to determine the extent of this problem and if treatment is required. Further testing is encouraged as the water from Well #9, which is located under a half mile away and draws from the same aquifer, provides water with a manganese concentration of 0.016 mg/L, far below the MCL. Other than this concern, raw water from Well #11 does not exceed any MCLs for primary or secondary standards. As such, no additional treatment beyond chlorination and fluoridation is required.

The table below displays the well and pump historical log for Well #11. This data displays that the pump was replaced in 1990 and has been serviced, on average, every 9 years.

Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
11/3/1988	NEW	23	1725	27.5	4.5				383
11/15/1988	DEVELOP	24	1522	28	4				381
11/28/1988	AQ TEST	24	1609	28	4				402
3/5/1990	NEW PUMP	20	1900	24	4	10	47	34/34/34	475
9/25/1997	MAINT	30	1507	34	4	12	62	34/34/34	377
3/16/2004	MAINT	24	1850	28	4	7	44	31/32/32	463
1/26/2010	PWM	23	1673	31	8	8	49	35/36/36	209
2/1/2011	MAINT	24	1507	31	7	10	54	32/33/33	215

5.3.7. Well #13

Well #13 is located on the west side of the community on Oak Street just south of Illinois Route 64. The well site was identified in the 1980's as a potential water supply site for the City and was annexed in the early 1990's as part of the West Gateway annexation. Based on test drilling and analysis performed on the well site, it was anticipated that the water quality at Well #13 would be very similar to the water quality at Well #7 and would therefore require iron removal. The City elected to construct a new well and iron removal facility on the site to provide additional capacity to the Outer Zone.

In 2003 the Oak Street Water Filtration Facility was completed providing the City the ability to produce 2.16 MGD of treated water for domestic, commercial and fire suppression use. Well #13 draws water from the St. Charles Aquifer with a well depth of 156 feet and a pump setting at 120 feet below grade. The well pumps raw water to the filtration facility where it is combined with chlorine and potassium permanganate solutions to oxidize the iron in the raw water. Flow is then split between two, two-cell horizontal pressurize filters, which completes the removal of iron by filtering out the oxidized iron through greensand filter media. Once the water has been filtered, fluoride and chlorine are injected.

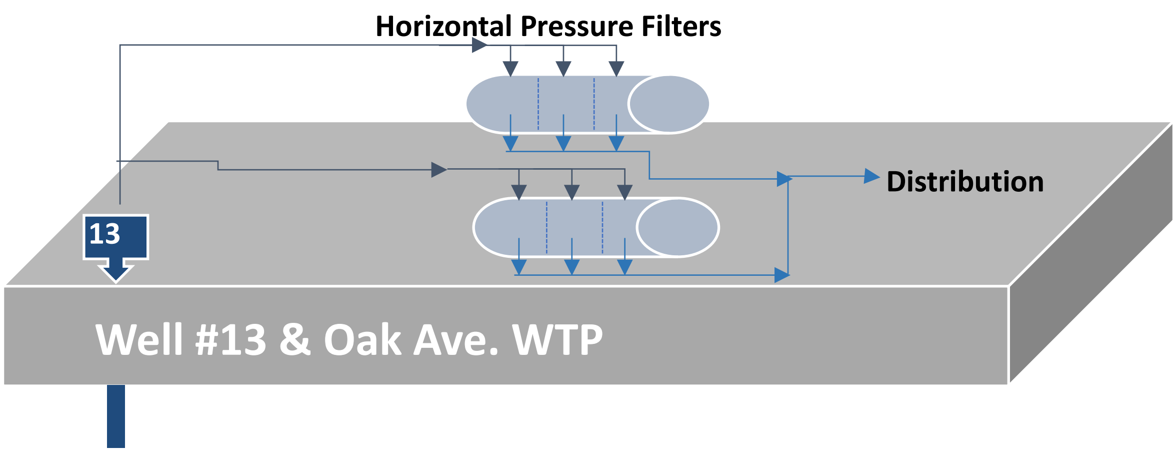
Greensand is a manganese oxide media originally developed in the 1930's and has been proven effective for oxidation and removal of iron, manganese and hydrogen sulfide. In the 1960's, Hungerford and Terry, Inc. patented a manufacturing process of "greensand," which provides a longer, more reliable service life. Oak Street Filtration Facility is capable of removing in excess of 90% of the iron from Well #13's raw water. The Oak Street Water Filtration Facility was designed and constructed to include a new well and water treatment facility. Well 13 draws from the St. Charles Aquifer with a well depth of 156 feet and a pump setting 120 feet below grade. The total treatment capacity of Well #13 is 2.16 MGD or about 1,500 GPM. Well #13 was constructed in 2003, shortly after the replacement of the media in Well #7. During the design of Well #13, TAI evaluated the long-term needs of the City, and several accommodations were made in regard to future expansion at this facility.

The water treatment facility was designed not only to treat the capacity of the new well on-site, but also allow for future expansion. The building was designed to accommodate water softening equipment in the existing work room/garage. Furthermore, the site is designed such that a duplicate of the Oak Street Treatment Facility could be constructed directly west of the existing facility. The intent of these provisions was to allow Well #7 to pump direct to the Oak Street site for treatment and/or softening in the future.

As shown in the water quality table on the following page, water drawn from Well 13 has high concentrations of hardness and metals such as iron and manganese. The Oak Street Filtration Facility is designed to reduce these concentrations below the Maximum Concentration Levels set by the EPA. Treatment at the Oak Street Facility begins with the addition of chlorine and potassium permanganate to the raw water to oxidize iron and manganese ions. Flow is then split between two, two-celled horizontal pressure filters. These filters remove oxidized metals through filtration using greensand, a manganese oxide media. The Oak Street Facility is capable in removing in excess of 90% of Well 13's raw water iron concentration.

Well 13	Influent	MCL
Hardness (mg/L)	430	n/a
Iron (mg/L)	1.4	0.3
Manganese (mg/L)	0.05	0.05

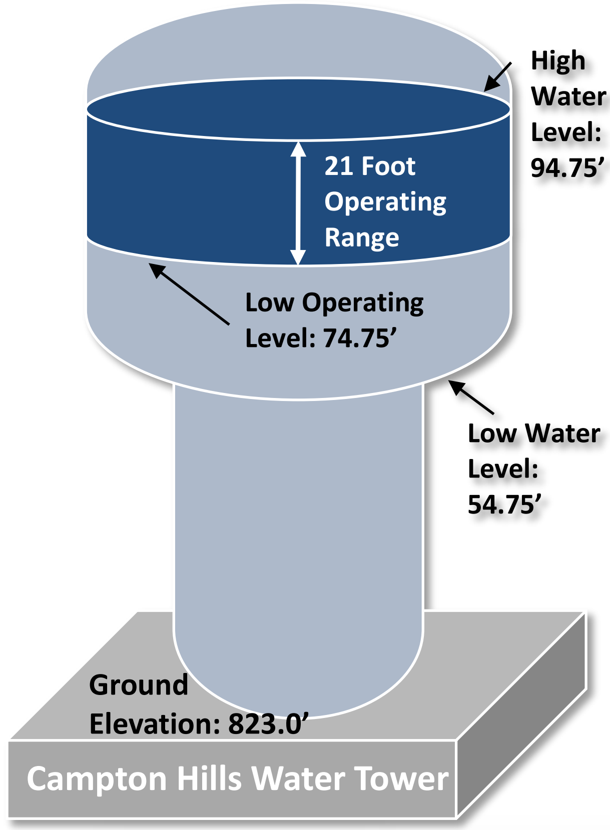
Since the construction of the Oak Street Water Filtration Facility, Trotter and Associates has coordinated with the City of St. Charles to update the facility with the installation of a Variable Frequency Drive and a conversion of the disinfection process from gaseous chlorine to sodium hypochlorite at Well 13.



The following table displays the well history at the Oak Street Filtration Facility. The pump at Well 13 is the newest well in the City's distribution network, as it was replaced as recently as 2002. The new pump has been serviced twice, an average of 8 years between services.

Date	Action	Static Level (ft)	Capacity (GPM)	Pump Level (ft)	Draw Down (ft)	Lbs	Total Dynamic Head	AMPS/127 (draw on motor/full load)	SPQ (specific capacity)
7/10/2001	NEW	79	1551	87	8				194
7/11/2002	NEW BJ	82	1594	90	8	8	108	170/168/170	199
4/5/2007	REPAIR	83	1609	89	6	50	2056	169/170/169	268
11/27/2013	MAINT	84	1522	90	6	50	206	172/172/173	254

5.4. Elevated Storage



The City owns and maintains three elevated storage tanks (water towers) and a number of ground storage reservoirs throughout the service area. Through analysis of the City’s existing water storage and expected growth, Trotter and Associates (TAI) does not recommend constructing any additional water storage during the 10-year planning horizon of the 2018 Water Master Plan. TAI estimates that the City will have an average daily water demand of 5.5 million gallons and a maximum daily water demand of 13.5 million gallons in 2030. This maximum daily demand is used to calculate the recommended water storage, which was determined to be approximately 5.79 million gallons (MG). The City currently has a storage capacity of 5.7 MG. This deficit of 90,000 gallons is considered acceptable within the planning period of this report, but the City’s storage needs should be reevaluated during the next Water Master Plan.

5.4.1. Red Gate Tower

The Red Gate Water tower is located on the southwest corner of Red Gate Road, and Route 25. During the 2007 Master Plan, it was identified that an additional water tower was necessary to address the need for addition elevated water storage, as well as to address fire flow and pressure concerns. The Reserves of Saint Charles, located north of Saint Charles North High School, exhibited lower and less consistent pressures and fire flows than areas further south in the system. These issues were attributed to the fact that The Reserves is an area that is at a higher elevation than the majority of the system. As a result, this area was the first to be effected during any abnormal situation such as fire flows or supply infrastructure being removed for servicing.

The 2007 report recommended the construction of an additional water tower, and outlined potential sites throughout the City. In 2011 the City selected the Red Gate Road and Route 25 location. The 1,500,000-gallon spheroid was constructed and placed online in late 2016, and serves the northern portion of the system. As part of the project, a new 16-inch water main installed, crossing the Fox River and made direct improvements to The Reserves in terms of available fire flows and pressures. The spheroid tower relays and receives information through the citywide SCADA system. Red Gate Tower is run off of Wells 9 and 11 to meet fire flow demands and daily usage in the Outer Service Area.

5.4.2. Campton Hills Tower

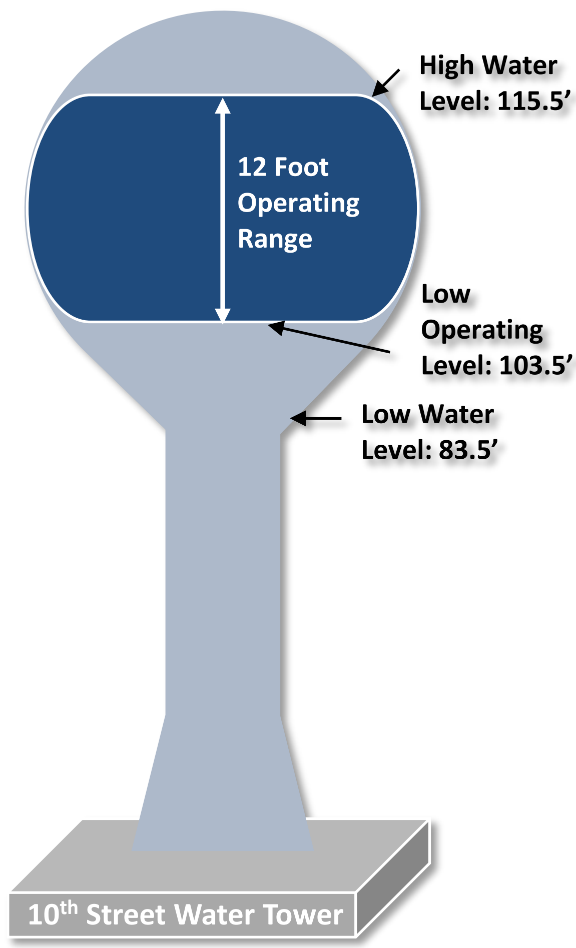
The Campton Hills Water Tower is located at 36W565 Campton Hills Road. This hydropillar type tower was constructed in 1986 and serves the Outer Service Area with a capacity of 1,000,000 gallons.

The hydropillar is monitored via the citywide SCADA system and has an overflow level of 94.75 feet above grade. The Tower is used in conjunction with Wells #7, 9, 11, and 13 to meet the usage and fire flow demands within the Outer Service Area. In conjunction, Well #8 and its associated infrastructure supplies the Outer Service Area based on local pressure within the industrial park instead of water elevations in the Campton Hills Tower.

At the time of this report, the Campton Hills Water Tower is currently undergoing a re-coating of the interior and exterior. It is not anticipated that any further major rehabilitation will be required at this site within the planning horizon of this report.

5.4.3. 10th Street Tower

The 10th Street Water Tower was constructed in 1956, is located at 103 South 10th Street just North of Haines Middle School. This water spheroid tower has a capacity of 300,000 gallons, and serves the Inner Service Area.



Working in conjunction with the booster station 3/4, the 10th Street Water Tower helps provide consistent pressures and provide adequate fire flows for the inner system. The Tower is monitored via the citywide SCADA system and has an overflow level of 115.5 feet above grade. The City of St. Charles has elected to use the top twelve feet of this tower for bounce prior to calling for water from booster station 3/4.

The 10th Street tower is in significant need of re-coating and minor structural repairs to the steel tank. Due to the proximity of this tower to the middle school and neighborhood, it is anticipated that a full enclosure shroud with negative pressure system may be required for re-coating. At the time of this report the City was scheduling meetings with tower coating companies to provide an analysis of the structural repairs necessary and enclosure requirements. It is recommended that the City plan and budget for this re-coating and repairs in the 2020 Fiscal Year.

5.5. CONDITION ASSESSMENT TABLE

Equipment	Manufacturer	Condition	Installation Year	Service Life	Replacement Year
Well 3/4					
Airwash Blower	Kaeser	Fair Condition	2009	25	2034
Brine Pump	Peri-flo	Fair Condition	2009	5	2014
Chemical Feed Transfer Pump (x 2)	March	Fair Condition	2009	10	2019
HMO Chemical Mixer (x 2)	Lightnin	Fair Condition	2009	10	2019
HMO Feed Pump	Periflo	Fair Condition	2009	10	2019
HMO Solution Storage Tank (x 2)	Poly Pro	Fair Condition	2009	25	2034
HMO Supply - BBU	Watts	Fair Condition	2009	10	2019
Horizontal Pressure Filter	Tonka	Good Condition	2009	25	2034
Ion Exchange Vessel (x 3)	Tonka	Good Condition	2009	25	2034
Manganese Sulfate Storage Tank	Poly Pro	Good Condition	2009	20	2029
Sodium Permanganate Storage Tank	Poly Pro	Good Condition	2009	20	2029
Well 3 Pump & Motor	Byron Jackson	Fair Condition	1984	40	2024
Well 4 Pump & Motor	Byron Jackson	Poor Condition	1970	40	2010
Motor Control Center	Square D	Good Condition	2009	30	2039
Centrifugal Pump 1	Aurora	Good Condition	2009	25	2034
Centrifugal Pump 2	Aurora	Good Condition	2009	25	2034
Centrifugal Pump 3	Aurora	Good Condition	2009	25	2034
125 HP Motor 1		Good Condition	2009	25	2034
75 HP Motor 2		Good Condition	2009	25	2034
75 HP Motor 3		Good Condition	2009	25	2034
VFD 1		Good Condition	2009	10	2019
VFD 2		Good Condition	2009	10	2019
VFD 3		Good Condition	2009	10	2019
Magnetic Flow Meter - 8"	Endress & Hauser	Good Condition	2009	20	2029
Magnetic Flow Meter - 8"	Endress & Hauser	Good Condition	2009	20	2029
Magnetic Flow Meter - 10"	Endress & Hauser	Good Condition	2009	20	2029
Magnetic Flow Meter - 10"	Endress & Hauser	Good Condition	2009	20	2029
Magnetic Flow Meter - 10"	Endress & Hauser	Good Condition	2009	20	2029
Magnetic Flow Meter - 10"	Endress & Hauser	Good Condition	2009	20	2029
Magnetic Flow Meter - 12"	Endress & Hauser	Good Condition	2009	20	2029
Well 7					
Generator	EM	Needs Replacement - End of Service Life	1970	30	2000
Dual-Media Deep Bed Gravity Filter (x 4)	Walker	Needs Replacement - End of Service Life	1970	25	1995
Pressure Aeration System	General Filter	Needs Replacement - End of Service Life	1976	25	2001
Well 7 Pump & Motor	Byron Jackson	Fair Condition	1995	40	2035
Motor Control Center	Allen-Bradley	Needs Replacement - End of Service Life	1970	30	2000
Mag Meter	Badger	Good Condition	1990	30	2020
Mag Meter	Badger	Good Condition	1990	30	2020
Centrifugal Pump 1	Pentair/Aurora	Fair Condition	1990	25	2015
Centrifugal Pump 2	Pentair/Aurora	Fair Condition	1990	25	2015
Centrifugal Pump 3	Pentair/Aurora	Fair Condition	1990	25	2015
75 HP Motor 1	Marathon Electric	Good Condition	1990	25	2015
50 HP Motor 1	General Electric	Good Condition	1990	25	2015
50 HP Motor 1	General Electric	Good Condition	1990	25	2015

Equipment	Manufacturer	Condition	Installation Year	Service Life	Replacement Year
Well 8					
Chlorine Scrubber	RJ Environmental Products	Good Condition	2006	15	2021
Gas Chlorinator	Wallace and Tiernan	Good Condition	2006	15	2021
Gas Detector	Wallace and Tiernan	Good Condition	2006	10	2016
HMO Day Tank	Chem-Trainer	Good Condition	2006	15	2021
HMO Day Tank Mixer	Lightnin EV	Good Condition	2006	15	2021
HMO Feed Pump (x 2)	Watson Marlow	Good Condition	2006	15	2021
HMO Mixing Tank	Chem-Tainer	Good Condition	2006	15	2021
HMO Mixing Tank Mixer	Lightnin EV	Good Condition	2006	15	2021
HMO Pressure Filter	USFilter	Good Condition	2006	25	2031
HMO Transfer Pump	Fybroc	Good Condition	2006	10	2016
Ion Exchange Unit (x 3)	USFilter	Good Condition	2006	25	2031
Magnetic Flow Meter	Endress & Hauser	Good Condition	2006	20	2026
Manganese Sulfate Solution Tank	Chem-Tainer	Good Condition	2006	15	2021
Manganese Sulfate Tank Mixer	Lightnin EV	Good Condition	2006	15	2021
Manganese Sulfate Transfer Pump	Fybroc	Good Condition	2006	15	2021
Well 8 Pump & Motor	Byron Jackson	Fair Condition	1979	40	2019
Well/Booster Motor Control Center	Square D	Fair Condition	1979	30	2009
Centrifugal Pump 1	Aurora	Good Condition	1985	25	2010
Centrifugal Pump 2	Aurora	Good Condition	1985	25	2010
Centrifugal Pump 3	Aurora	Good Condition	1985	25	2010
Centrifugal Pump 4	Aurora	Good Condition	1985	25	2010
100 HP Motor 1		Good Condition	1985	25	2010
100 HP Motor 1		Good Condition	1985	25	2010
150 HP Motor 3		Good Condition	1985	25	2010
150 HP Motor 3		Good Condition	1985	25	2010
VFD 1	Eaton	Good Condition	2016	10	2026
VFD 2	Eaton	Good Condition	2016	10	2026
VFD 3	Eaton	Good Condition	2016	10	2026
VFD 4	Eaton	Good Condition	2016	10	2026
Generator - 900 kW	Kohler	Good Condition	2006	30	2036
Well 9					
Chlorinator	Marathon Electric	Good Condition	2010	15	2025
Fluoride Feed Pump	Marathon Electric	Good Condition	2010	10	2020
Generator	Caterpillar	Fair Condition	1981	30	2011
Mag Meter	Badger	Good Condition	1981	30	2011
Well 9 Pump & Motor	Byron Jackson	Fair Condition	1981	40	2021
Motor Control Center	Square D/Eaton	Needs Replacement - End of Service Life	1981	30	2011
Well 11					
Chlorinator			2010	15	2025
Ejector Pump			2010	10	2020
Fluoride Feed Pump			2010	10	2020
Generator	Cummins	Fair Condition	1990	30	2020
Well 11 Pump & Motor	Byron Jackson	Fair Condition	1990	40	2030
Motor Control Center	Square D	Fair Condition	1990	30	2020
Magnetic Flow Meter	Badger	Good Condition	1990	30	2020
Centrifugal Pump 1	Aurora	Fair Condition	1990	25	2015
Centrifugal Pump 2	Aurora	Fair Condition	1990	25	2015
Centrifugal Pump 3	Aurora	Fair Condition	1990	25	2015
75 HP Motor 1		Good Condition	1990	25	2015
50 HP Motor 1		Good Condition	1990	25	2015
50 HP Motor 1		Good Condition	1990	25	2015

Equipment	Manufacturer	Condition	Installation Year	Service Life	Replacement Year
Well 13					
Chlorine Scrubber	RJ Environmental Products	Good Condition	2002	15	2017
Chlorine Booster Pump	Webtrol EZ	Good Condition	2002	10	2012
Chlorine Booster Pump	Webtrol EZ	Good Condition	2002	10	2012
Fluoride Metering Pump	LMI Milton Roy	Good Condition	2002	10	2012
Hypochlorite System	Wallace and Tiernan	Good Condition	2002	10	2012
Potassium Permanganate Metering Pump	LMI Milton Roy	Good Condition	2002	10	2012
Well 13 Pump & Motor	Byron Jackson	Good Condition	2002	40	2042
Motor Control Center	Allen-Bradley	Good Condition	2002	30	2032
Horizonal Pressure Filters	US Filter	Good Condition	2002	25	2027
Generator	Generac	Good Condition	2002	30	2032

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SECTION 6

ANALYSIS OF WATER STORAGE, SUPPLY AND TREATMENT ALTERNATIVES

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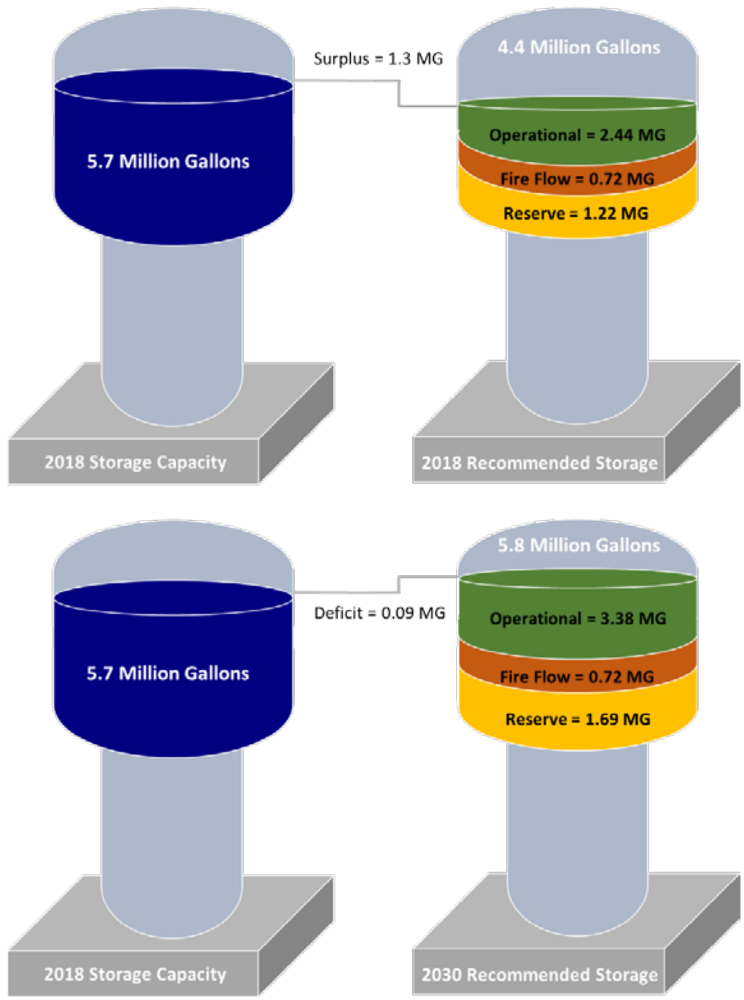
6. Analysis of Water Storage, Supply and Treatment Alternatives

Section 5 of this study reviewed the current condition and capacity of the City's water storage infrastructure, supply sources, and treatment facilities. Options for additional water supply and associated treatment will be reviewed in this section, with a review of water softening alternatives in Section 7.

6.1. Water Storage Alternatives

Recommended water storage consists of three components; fire flow, operational, and reserve storage. Fire flow requires 3,000 gallons per minute for four hours, or 720,000 gallons of storage. Operational storage is equivalent to 25% of the maximum day demand (13.50 million gallons), or 3.38 million gallons. Lastly, the City should maintain 12.5% of the maximum day demand, 1.69 million gallons in reserve storage. Combining these components gives a recommended 2018 Storage of approximately 4.4 MG and a 2030 storage capacity of 5.79 MG.



The exhibits to the right display the current storage capacity for the City of St. Charles, as well as the 2018 and 2030 storage recommendations for the three components detailed above. As shown in the exhibit, the City currently has a storage surplus of 1.3 MG, but may see a deficit of approximately 90,000 gallons by 2030.

As previously discussed, this deficit is minimal and within the acceptable boundaries for the planning horizon. It should also be noted that while the City has a 'surplus' based on recommended standards, the storage serves a number of additional purposes such as reduction in water hammer and increased fire flows in areas of water towers.

While it is not recommended that the City construct additional water storage over the next 10 years, the existing storage facilities will need to be maintained and rehabilitated. The City budgets for tank inspections annually on a rotating basis to cover all storage infrastructure. Most of the City's water storage infrastructure remains in very good condition, but the Campton Hills Water Tower and 10th Street Water Tower will require rehabilitation in the near-term. As of September 2018, the Campton Hills Tower is undergoing a re-coating which will keep the tank in good operating condition through the planning horizon. The 10th Street Tower will however require minor structural repairs as well as a full recoating. Ground storage reservoirs at Ohio Avenue will also require minor repair work, which is currently budgeted for the FY2020 period.

6.2. Water System Supply Alternatives

As detailed in Section 2 Community Needs, the City is experiencing significant current, planned, and programmed growth. This growth has exceeded the Chicago Metropolitan Agency for Planning's (CMAP) projections, and will require optimizing the existing production wells, and planning for additional sources as well. The table below illustrates the current capacity of the wells. It should be noted that the wells utilized on a daily basis are based on which can *produce the highest quality of water possible* by maximizing use of wells that produce the highest quality water. During a Maximum Day Demand scenario all available wells would be utilized, which is represented in the Current (2018) columns on the right.

		Design		Current (2018)	
Well	**System Served**	**Design Capacity (GPM)**	**Design Capacity (MGD)**	**Current Capacity (GPM)**	**Current Capacity (MGD)**
3	Inner	1,000	1.44	850	1.22
4	Inner	1,000	1.44	750	1.08
Total	**Inner**	**2,000**	**2.88**	**1,600**	**2.3**
7	Outer	1,750	2.52	1,500	2.16
8	Outer	1,200	1.73	950	1.37
9	Outer	2,150	3.10	1,500	2.16
11	Outer	1,900	2.74	1,000	1.44
13	Outer	1,500	2.16	1,500	2.16
Total	**Outer**	**8,500**	**12.25**	**6,450**	**9.29**
		Total System Capacity:	15.13		11.59
		Total Firm Capacity:	12.03		9.43

While the City's well sources have a design capacity in excess of 15 MGD and a firm capacity of 12 MGD, this has been reduced due to the age of the wells and treatment facilities. Specifically, Well #7 is run as infrequently as possible due to the age of the filtration facility and high iron concentrations in the source water. To meet maximum day demands the City can utilize this well, however it is in need of significant upgrades or replacement. Alternatives for rehabilitation or replacement of this treatment facility are reviewed in the following pages.

Section 2 identified the required water production capacities at each step in the community's future development. If additional sources are not identified and installed, the City may be required to curtail development or institute more stringent water use restrictions. In order to maintain adequate capacity, several alternatives for additional water supply are reviewed in the following sections. This additional demand and supply deficiency is outlined in the table on the following page.

	Future Demands and Supply Capacities				
Year	Max Demand (MGD)	Total Supply (MGD)	Total Deficiency (MGD)	Firm Supply (MGD)	Firm Deficiency (MGD)
2018	9.74	11.59	0.00	9.43	0.31
2023	12.10	11.59	0.51	9.43	2.67
2030	13.50	11.59	1.91	9.43	4.07
2040	14.60	11.59	3.01	9.43	5.17

6.2.1. Well No. 7 Rehabilitation Alternatives

In order to maintain the current system capacity, the City will need to rehabilitate Well #7 in the short-term. Loss of this source would further restrict the total capacity of the water supply system. The 2017 Well #7 & 13 Interconnection Evaluation reviewed a number of alternatives for long-term production and treatment at Well No. 7. These alternatives included rehabilitation of Well No. 7 at the existing site, construction of a new treatment facility at the existing site or pumping to the Oak Street Treatment Facility. The following section will detail the alternatives for long-term treatment.

1. *Alternative #1 – Well No. 7 Partial Rehabilitation ($5.0M)*

   This alternative includes the replacement of the well pump and booster pumps, piping reconfiguration, replacement of the filter equipment, filter media, and rehabilitation of electrical and controls systems. The existing building and structure is maintained, and no exterior improvements would be made. Additionally, the exterior façade is in poor condition and delaminating. This component would require a removal and replacement with a new exterior system.

2. *Alternative #2 - Well No. 7 Full Reconstruction ($6.5M)*

   This alternative includes the replacement of the well pump and booster pumps, complete reconstruction of the existing water treatment facility, piping reconfiguration, replacement of the filter equipment, filter media, and rehabilitation of electrical and controls systems. The existing reservoir is maintained, but all concrete above grade is removed and replaced, including filter cell basins.

3. *Alternative #3 - Interconnection with Additional Treatment Capacity in Oak Street ($5.3M)*

   This alternative includes piping reconfiguration at both Well No. 7 and 13 to allow for the interconnection of these two wells. Additional filtration capacity would be constructed at the Well #13/Oak Street site within the existing work room/garage, the replacement of the well pump at Well No. 7 with an increased head condition, as well as updating of the electrical and controls systems. This alternative also includes the demolition of the Well No. 7 treatment facility.

4. *Alternative #4 - Interconnection with Additional Treatment Capacity in New Building ($9.5M)*

   This alternative includes the replacement of the well pump with an increased head condition, a new Water Treatment Facility directly west of Well No. 13 that is similar to the existing Oak Street Facility, piping reconfiguration at both Well No. 7 and 13 to allow for the interconnection, and updating of the electric and controls systems. This alternative also includes the demolition of the Well No. 7 treatment facility.

Alternative #1 - Well No. 7 Partial Rehabilitation

Well No. 7 and the associated water treatment facility are approximately 50 years old. This Well is capable of producing 1,900 GPM, but is utilized only during peak demands due to high iron levels in the finished water. The existing system includes a well, gravity filtration, reservoir, and booster station. In 2002, the City reinvested in the treatment facility and replaced media and mechanical components, which were reaching the end of their service life. The remaining components of the pumping and treatment systems are nearing the end of their useful service life and the facility as a whole will require major rehabilitation in the short term.

While the treatment technology utilized at Well No. 7 is nearing 50 years old, it could be replaced in kind. Replacing the pumping equipment, piping, filter equipment and media may provide approximately 10 years of acceptable service life. It is anticipated that after this period the treatment facility structure would require replacement, and as such this alternative should be considered short-term.

For Alternative #1, the existing above grade structures would remain. However, the interior components would be removed and replaced. This includes the filter cell media, filter cell equipment, well pump, booster pumps, piping, as well as a new generator and electrical equipment. Although this alternative does extend the service life of Well No. 7, the existing building is reaching the end of its useful service life and is only expected to last an additional 10 years approximately. As stated previously, the existing structure has some delamination of the exterior façade which would also require replacement.

The estimated construction cost for the partial rehabilitation of Well No. 7 is approximately $4.3M and the recommended project budget is $5.0M, which includes engineering and contingencies.

Alternative #1 – Well No. 7 Partial Rehabilitation	
Description	Total Probable Cost
SUMMARY	
GENERAL CONDITIONS	$581,426
SITE WORK	$95,550
WELL #7	$2,890,140
Construction Sub-Total	$3,567,116
Contingency @ 20%	$713,423
Engineering @ 15%	$642,081
PROBABLE PROJECT COST:	**$4,922,620**

Alternative #2 - Well No. 7 Full Reconstruction

In 2007, Trotter and Associates completed a Water System Master Plan for the City. During that reviewed, Well No. 7 was evaluated to identify the costs associated with a full rehabilitation, both with and without water softening to be included. The two evaluations included the purchase of a piece of property in close proximity to the existing facility and construction of a new well and water treatment facility off the Randall Road frontage.

However, over ten years later, it is no longer feasible or recommended to purchase additional land and expand the Well No. 7 Water Treatment Facility in this location. The Randall Road corridor has expanded since the original construction and it is not in the City's long-term strategy to increase the presence of the facility in this area.

A new engineer's estimate was developed to identify the cost to completely rehabilitate the existing water treatment plant in kind, within the same footprint. The underground concrete, including reservoir and vaults would be maintained, but virtually all other components would be replaced. This includes a new brick and block structure and new concrete poured for the filter cells. The estimated project cost range is between $5.5M and $6.5M including design and construction engineering.

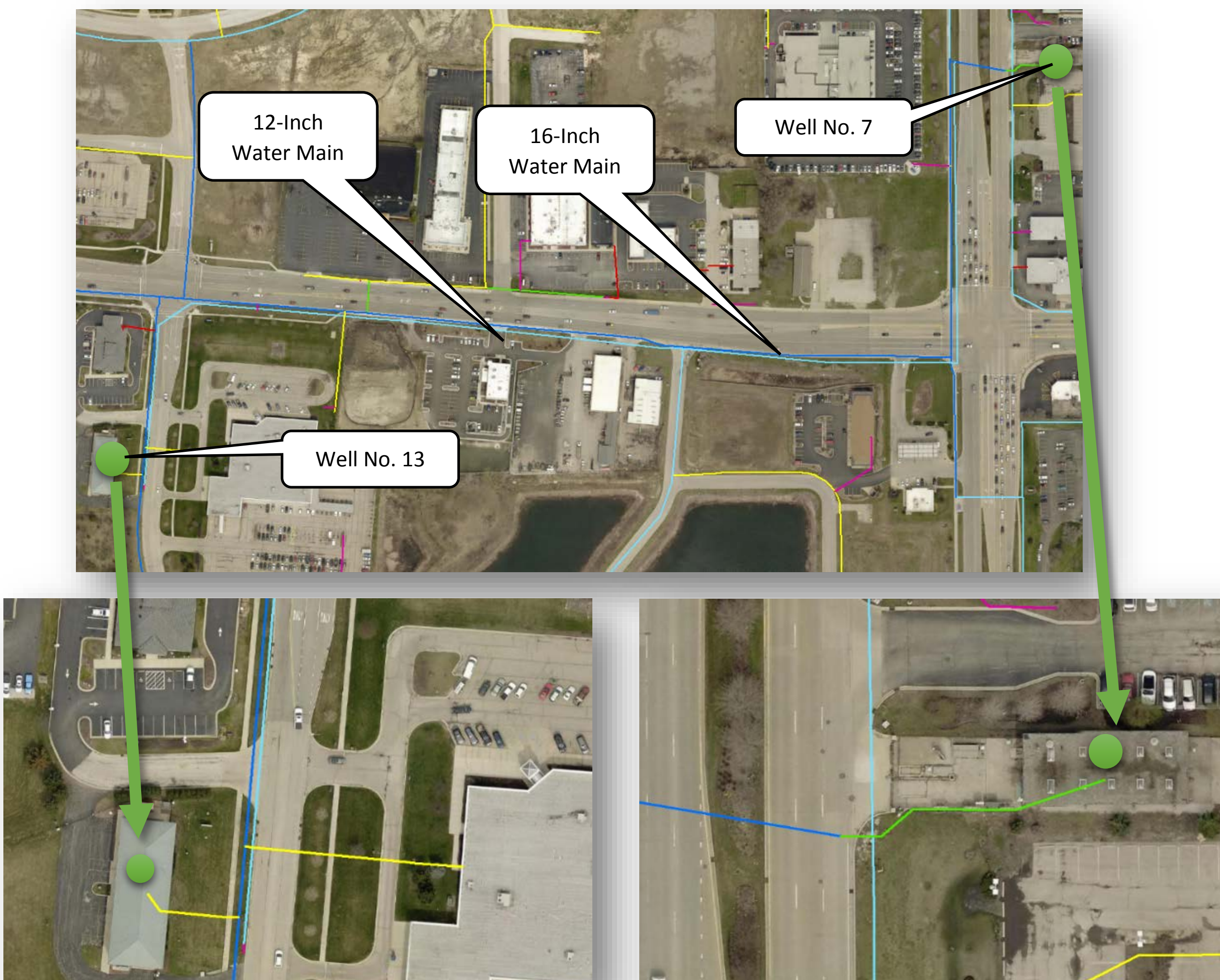
Alternative #2 – Well No. 7 Full Rehabilitation	
Description	Total Probable Cost
SUMMARY	
GENERAL CONDITIONS	$784,826
SITE WORK	$152,925
WELL #7	$3,736,400
Construction Sub-Total	$4,674,151
Contingency @ 20%	$934,830
Engineering @ 15%	$841,347
PROBABLE PROJECT COST:	**$6,450,328**

Alternative #3 - Interconnect with Additional Capacity in Oak Street Building

During the expansion of the City's water distribution system to the west, interconnecting Well No. 7 and 13 was discussed and reviewed. At the time, there was no need to complete the interconnection. However, several years later during Route 64 roadway improvements the decision was made to run a parallel main between the two wells for future use. Currently, only one of the water mains is in service and is providing potable water to the distribution system, the second water main does not provide service and is flushed regularly.

One water main is 16-inches in diameter (shown in blue, below), and the other is 12-inches in diameter (shown in teal). Both of the water mains are directly connected to Well No. 7. However, only the 16-inch water main is connected to Well No. 13. The existing 12-inch water main parallel's the 16-inch the entire route from Well No. 7 to Well No. 13, and dead ends near along Oak Street between Well No. 13 and the St. Charles Post Office.

Using the parallel piping along Route 64, Well No. 7 could be reconfigured to send raw water to Well No. 13 for treatment. This reconfiguration would allow for the City to decommission the existing water treatment facility at Well No. 7. The following alternative provides an interconnection of Well No. 7 and 13, as well as the addition of capacity for both water treatment plants.



Following site improvements at both Well #7 and Well #13 for the interconnection, and replacement of the Well #7 pump with increased head condition, additional filtration capacity would be added to the Oak Street site within the existing building. The current facility will be retrofitted with two additional filters. The new filters will be a four-cell design similar to the Ohio Ave. facility. The new filters will be installed in the garage of Well No. 13, and will provide the necessary capacity to operate both Well No. 7 and 13 concurrently.

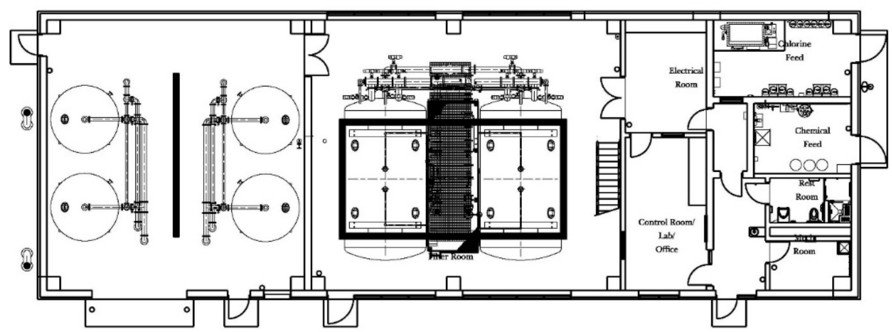
A cost estimate summary for this interconnection and capacity expansion described is included below. The estimated cost of the interconnection is between $850,000 and $1.0M including design and construction engineering. The estimated cost of adding treatment capacity at Oak St. is $3.7M and $4.3M including design and construction engineering. Combined, the total cost of this alternative is approximately $5.3M.

Alternative #3 – Interconnection with Additional Capacity in Existing Building	
Description	Total Probable Cost
SUMMARY	
GENERAL CONDITIONS	$460,037
SITE WORK	$245,300
WELL #7	$986,900
WELL #13 / OAK STREET FACILITY	$2,149,950
Construction Sub-Total	$3,842,187
Contingency @ 20%	$768,437
Engineering @ 15%	$691,594
PROBABLE PROJECT COST:	**$5,302,217**

Alternative #4 - Interconnect with Additional Capacity in New Building

Well No. 13 was designed with additional open space to the west of the existing building. Phase 1 of this alternative includes the costs associated with the incorporation of a new treatment facility directly to the west of Well No. 13. This new treatment facility would provide water treatment for Well No. 7.

With the construction of a new facility to the west, the Oak Street site could then provide treatment both Well No. 7 and No. 13. With this alternative, Well No. 7 would be rehabilitated with a new well pump, and would ultimately send raw water to the new Water Treatment Facility at Well No. 13. The new facility would include pressure filters for iron removal. This configuration would allow the well to pump through the treatment process and directly to the distribution system.



The advantage of this alternative is the potential for redevelopment of the Randall Road frontage and removal of aging infrastructure. In addition, the City would have two nearly identical water treatment facilities on one site, which would make it convenient for operations and maintenance.

After completion of the new treatment facility, the Well No. 7 treatment plant, reservoir, and booster pumps could be removed from service and the building demolished. A new, small, well house would need to be constructed to enclose electrical switchgear and controls systems.

The estimated project cost range is between $7.7M and $9.0M including design and construction engineering, with the range representing 20% contingency.

Alternative #4 – Interconnection with Additional Capacity in New Building	
Description	Total Probable Cost
SUMMARY	
GENERAL CONDITIONS	$880,307
SITE WORK	$1,076,215
WELL #7	$986,900
WELL #13 / ADDITIONAL TREATMENT FACILITY	$3,639,679
Construction Sub-Total	$6,583,101
Contingency @ 20%	$1,316,620
Engineering @ 15%	$1,184,958
PROBABLE PROJECT COST:	**$9,084,680**

6.2.2. Alternate Available Sources

In 2007 the Kane County Water Resources Division conducted a workshop on the implementation of sustainable water supplies in Kane County. This workshop identified four potential water sources for the developing communities of Kane County to meet future water demands; Lake Michigan, the Fox River, Shallow Aquifers and Deep Aquifers. These remain the four most cost-effective and reliable methods of water production.

Alternative #1 - Lake Michigan

The City of St. Charles was contacted by the DuPage Water Commission (DWC) in September 2017 regarding the extension of service of treated Lake Michigan Water to serve the City. The DuPage Water Commission is a separate government entity formed under the State of Illinois Water Act of 1985. The DuPage Water Commission is managed by a 13-member board, six board members are from member communities, six members are from DuPage County, and the Chair is appointed by the County Board Chair. The DuPage Water Commission currently serves 23 communities. The Commission is currently working with the Village of Bartlett to extend water service and discussing service extension with the Villages of Oswego and Montgomery as well.

The Water Commission's 48-inch transmission main is located near the intersection of Illinois Route 64 and Prince Crossing Road in unincorporated West Chicago. During this study, contact was made with the Executive Director of the DuPage Water Commission to discuss the potential for the extension of service. The Water Commission's allocation has reserve capacity to meet the City of St. Charles' future average day demand of 5.0 MGD as defined in Section 2.

The transmission main would likely be extended to a common facility near the intersection of Route 64 and Smith Road. The distance from the existing transmission main at Prince Crossing to Smith Road is approximately four miles. Based on rough hydraulics and a maximum day demand of 13.6 MGD, a 36-inch water transmission main would be required with a velocity of 3 ft/s. It is assumed that the transmission main could be constructed within the right-of-way for Route 64. Along the route, the transmission main would need to cross Illinois Route 59, as well as the Powis Road railroad crossing. However, this is a relatively straightforward construction project. The estimated cost of extending a 36-inch transmission main is approximately $11M.

Water from DWC would be stored in a reservoir and the water would need to be boosted to match the City's hydraulic grade line. The Commission requires the City to maintain the equivalent of two days' allotment in storage, which would equate to 10 million gallons. The City's current storage equates to roughly 5.6 million gallons; therefore, the City would likely need to construct additional storage. The cost of the booster station and reservoir is estimated to be $10.5M

Many communities served by the DWC are supplied water through multiple connections. Due to the distance from the nearest Commission supply point, the City of St. Charles would have only one transmission main. The City's distribution system has not been constructed to convey flow from a single point on the east side of the system across the entire service area. In order to accommodate a single source of supply, some major distribution system improvements would be required. Through use of the hydraulic model, a simplified alternative was developed to assist in estimating the cost for the distribution improvements. The most straightforward solution would include construction of a second 24-inch transmission main extending from the DWC supply point at Route 64 and Smith Road to the Campton Hills tower location. This main would likely extend south along Kautz Road from the supply point to Division Street, run west under the river and along Gray Street, and north along Peck Road. This would allow the distribution system pressures to remain similar to those currently experienced. The estimated cost of this secondary transmission main is approximately $15.0M.

The DuPage Water Commission requires all member communities to purchase their allocation, which is estimated to cost $14 to 16 million. The Commission would require that the City of St. Charles extend the transmission main from its current location to a metering structure in close proximity to the City. The new transmission main and metering structure would ultimately be owned and maintained by DWC. In addition, the City will likely need to construct ground storage reservoirs, a booster station, and distribution improvements to accommodate a single location of supply.

The City of St. Charles current base rate is $3.60 per thousand gallons, which covers the cost of production, treatment, distribution, operations, and debt service. The Commission's current rate for bulk water supply is $4.94 per thousand gallons. The City's current water loss equates to approximately 15%. Therefore, the City should estimate the cost of water supply to be $4.94 times 1.15 or $5.68 per thousand gallons sold, plus the cost for distribution, operations, and debt service. Therefore, the City's rate would need to increase to cover the cost of purchased water and also include any capital improvements required to implement the connection to DWC. A conceptual cost estimate for the capital improvements required is included below.

Table 6-1: DWC Estimated Supply Conversion Cost

Conversion to DuPage Water Commission/Lake Michigan		
Description		Total Probable Cost
SUMMARY		
CONNECTION FEE		$14,000,000
LAND ACQUISITION		$400,000
GENERAL CONDITIONS		$1,562,480
TRANSMISSION MAINS		$26,140,000
SITEWORK		$1,674,000
DWC METERING STRUCTURE		$449,705
CLEAR WELL		$1,720,000
BOOSTER STATION		$2,224,295
RESERVOIRS		$6,600,000
	SUBTOTAL CONSTRUCTION	**$54,770,480**
	CONTINGENCY @ 20%	$10,954,096
	CONSTRUCTION TOTAL	**$65,724,576**

Alternative #2 - Fox River

The Fox River is an available source for drinking water and is currently used by the City of Aurora and the City of Elgin. Withdrawal from the Fox River is limited during low flow periods and regulated by the Illinois Department of Natural Resources. The limiting factor is the seven-day low flow in a ten-year period, commonly referred to as the 7Q10. The 7Q10 for the Fox River in St. Charles is 152 cfs. While the Fox River may be a viable alternative, one of the sources for the river is the shallow aquifer currently used by the City. The static and pumping water levels for Well 7, 9, 11 and 13 are all above the NWL of the Fox River. It is widely recognized that these shallow aquifers contribute to the flow of the River and are essentially a source for the river. Under these circumstances, it is much more economical for the community to draw its water directly from the aquifers rather than downstream (i.e. the river). Furthermore, treatment of the shallow well water is much more economical than treatment of surface water. Surface water contains significantly greater contaminants such as silt, nutrients, fecal and others, generally requiring a higher treatment level. It is not recommended that the City pursue Fox River water.

Groundwater Well Sources

The shallow sand and gravel aquifer is a significant natural resource for the community. The limits of the aquifer have been established and recharge is provided through local precipitation. Static levels within the aquifer vary seasonally as well as from year to year. Since the source water is local precipitation, the water level is affected by drought conditions. The Illinois State Water Survey has begun to develop a model in conjunction with Kane County. While previous models have been prepared for this aquifer, the ISWS model should provide a more accurate estimation of this aquifer's sustainability. Based on current field observations for static water levels, it is unlikely that this aquifer is being overused under current conditions.

Three deep aquifers are available; St. Peters Sandstone, Ironton Galesville, and the Mt. Simon Aquifer. The St. Peter Sandstone Aquifer, sometimes referred to as the Ancell Unit, is currently not used by the City of St. Charles because of its limited production capacity. Local wells in this formation produce 200 to 400 gpm. The water within the St. Peters Sandstone commonly requires treatment for radium reduction.

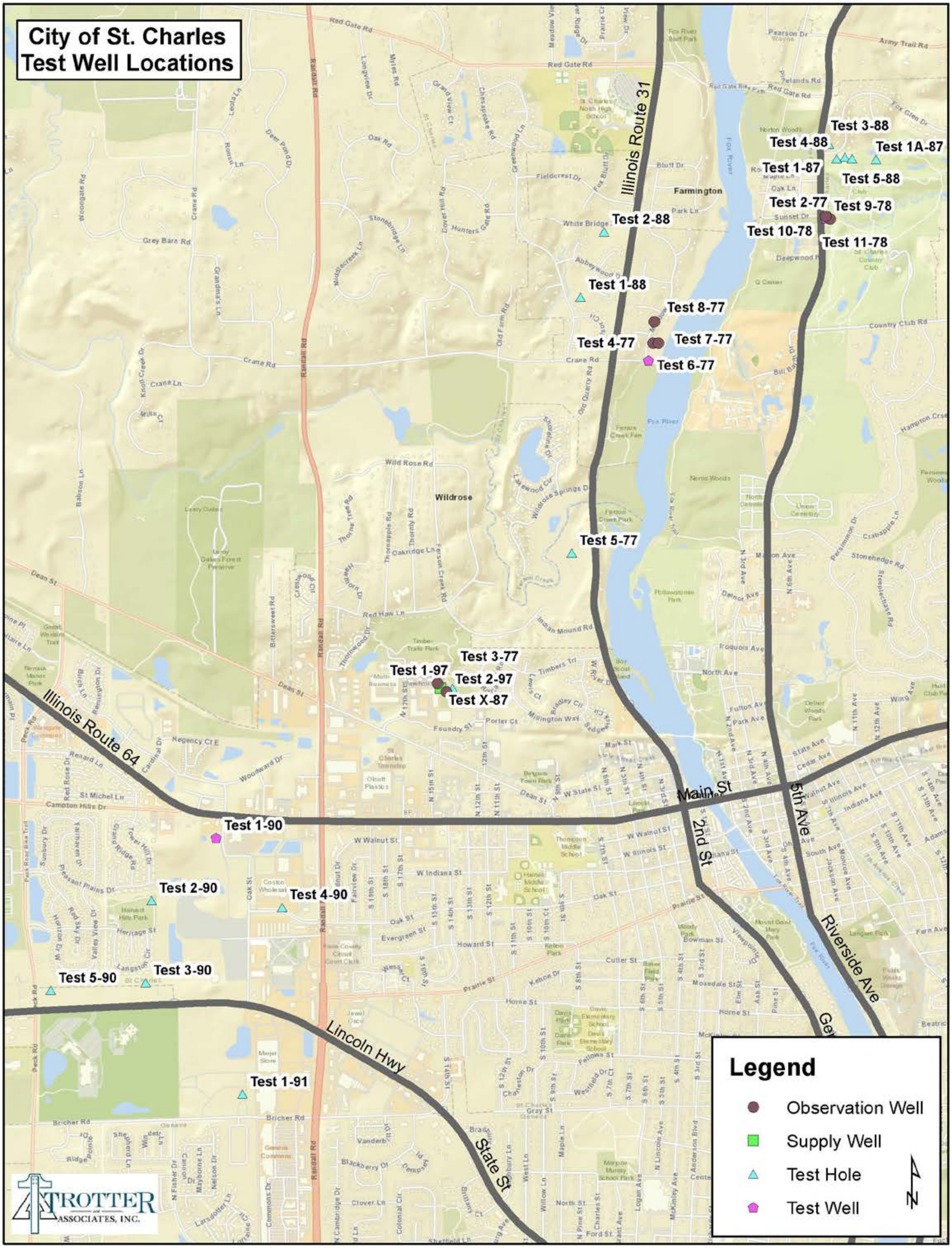
The City has three active production wells within the Ironton Galesville Aquifer. Wells #3, 4 and 8 produce between 750 and 1200 gpm each. The raw water from the wells contains radium and requires blending or treatment to meet Drinking Water Standards. This aquifer is utilized by many of the communities throughout the Fox Valley Area. At one time, most of the communities in the Chicago Metropolitan Area were drawing water from this aquifer. In the early to mid-1990's, many communities east of the Fox Valley switched to Lake Michigan Water. Since that time the aquifer's static level has begun to recover. However, as the far west suburbs continue to develop, more water is being drawn from this source. The Illinois State Water Survey (ISWS) has developed an extensive model of this aquifer as well as documented its decline, recovery and sustainable capacity.

The Mt. Simon Aquifer is much deeper source. Wells #3 and 4 were at one time open to both the Galesville and Mt. Simon Aquifers. While the Mt. Simon is a significant source, the City sealed the wells from the lower formation in the 1970's. This was done to mitigate concerns regarding high chloride concentrations.

At the 2007 Kane County Sustainable Water Supply Workshop, representatives of the ISWS provided an overview of the challenges in managing withdrawal from the available sources. The area-wide analysis demonstrates that while adequate water is available, conservation of these resources is prudent to protect the long-term viability of water supply systems. The Illinois State Water Survey encouraged use of surface and shallow aquifer water for base demands and relying on the deep aquifers during drought and peak demand periods.

A number of test holes, test wells, and observation wells were contracted by the City between 1977 and 1997 to locate suitable high-capacity production wells. A table listing each of these testing locations is included below, and a map depicting each is shown on the following page.

Name	Function	Driller's Log	Notes
1-77	Test Hole	X	For Well 8/1-77
2-77	Test Hole	X	Becomes Well 9
3-77	Test Hole	X	Moline
4-77	Observation Well	X	For Well 10/6-77
5-77	Test Hole	X	Indian Mound/Ferson Creek
6-77	Test Well		Potential Well 10
7-77	Observation Well		For Well 10/6-77
8-77	Observation Well		For Well 10/6-77
9-78	Test Well		
10-78	Observation Well		For Well 9/9-78
11-78	Observation Well		For Well 9/9-78
1-80	Test Hole		Closest to Well 11 Location
1-87	Test Hole		Becomes Well 11
1-87A	Test Hole		
X-87	Supply Well		Foundry Supply, Used as Test Well in '97 by City
1-88	Test Hole	X	Well 12 Candidate
2-88	Test Hole	X	Well 12 Candidate
3-88	Test Hole	X	For Well 11
4-88	Test Hole	X	For Well 11
5-88	Test Hole	X	For Well 11
1-90	Test Well	X	Becomes Well 13
2-90	Test Hole	X	
3-90	Test Hole	X	
4-90	Test Hole	X	
5-90	Test Hole	X	
1-91	Test Hole	X	Bricher Road
1-97	Observation Well		For Foundry/X-87
2-97	Observation Well		For Foundry/X-87


City of St. Charles
Test Well Locations
Test 3-88
Test 4-88
Test 1A-87
Test 1-87
Test 5-88
Test 2-77
Test 9-78
Test 2-88
Test 10-78
Test 11-78
Test 1-88
Test 8-77
Test 4-77
Test 7-77
Test 6-77
Test 5-77
Test 3-77
Test 1-97
Test 2-97
Test X-87
Test 1-90
Test 2-90
Test 4-90
Test 5-90
Test 3-90
Test 1-91
Illinois Route 31
Illinois Route 64
Main St
2nd St
5th Ave
Riverside Ave
Lincoln Hwy
State St
Legend
Observation Well
Supply Well
Test Hole
Test Well
TROTTER AND ASSOCIATES, INC.

Alternative #3 – Well #10 (Crane Road Shallow Well))

Well #10 was identified as a potential site for a shallow sand and gravel well. A 1500-minute pumping test was performed in 1978, with three observation wells being utilized along with Test Well 6-77 (Well #10). The Well #10 site is located east of the intersection of Illinois Route 31 and Crane Roads. The pumping test indicated that Well #10 would be capable of providing 1,000 GPM. A radius of influence of 1,050 feet was determined, while the nearest existing well (Well #9) is over 4,000 feet away. However, this test indicated that the pumping rate during the test may have been higher than the aquifer can recharge locally. The risk of plugging the well with excessive fine sands or sediments can be reduced by increasing the bore hole diameter, the screen diameter, and the screen length. The static water level at this site was found to be about 14 feet above the level of the Fox River, indicating that the aquifer is surcharged by local precipitation.

One issue identified within the test well log is that due to the increased recharge rate it is likely that the aquifer confinement layer is not sufficient to isolate from surface (Fox River) recharge. This would be classified as groundwater under the influence and may require additional treatment steps.

Alternative #3 - Well #10 (Crane Road Shallow Well)				
Description				Total Probable Cost
SUMMARY				
16" TRANSMISSION MAIN	4500	Lin. Ft	$220	$990,000
DRILLING SHALLOW WELL	1	Lump Sum	$500,000	$500,000
SHALLOW WELL PUMP	1	Each	$350,000	$350,000
PRE-ENGINEERED WELL HOUSE	1	Lump Sum	$500,000	$500,000
SITE ELECTRICAL	1	Lump Sum	$100,000	$100,000
LAND ACQUISITION	2	Acre	$100,000	$200,000
			SUBTOTAL CONSTRUCTION:	**$2,640,000**
			CONTINGENCY @ 20%:	$528,000
			ENGINEERING & ADMIN @ 15%:	$475,200
			PROJECT TOTAL:	**$3,643,200**

Alternative #4 – Well #12 (Abbeywood Drive Shallow Well)

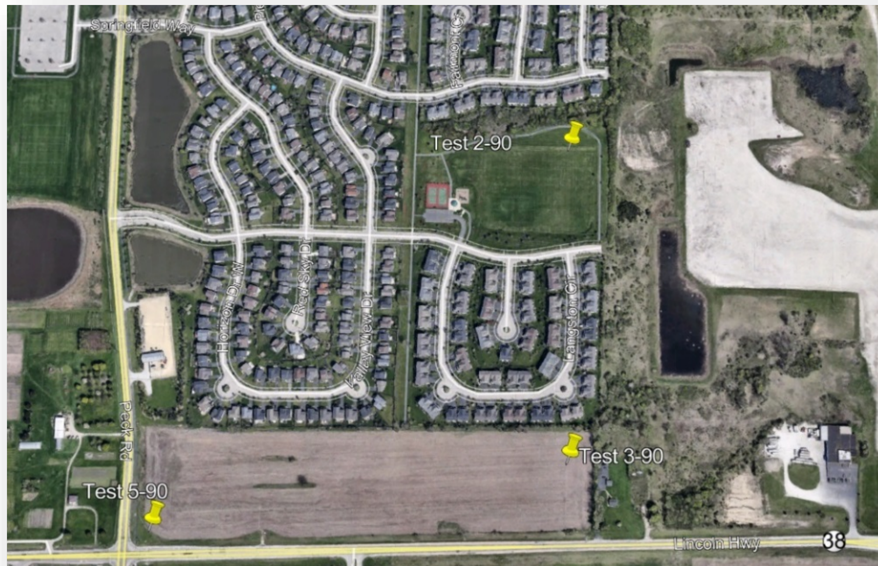
Well #12 was identified as a potential site for shallow sand and gravel well in the late 1980's but has not been developed. Two sites for Well #12 were identified, test wells 1-88 and 2-88. These test wells are located north-west of the intersection of Crane Road and Route 31 near Abbeywood Drive. Further testing would be needed at Well #12 to determine the productivity for a well at this site. The water distribution and sanitary sewer infrastructure in this area may require minor improvements for implementation of this alternative.

While not noted in the driller's log, due to this well site's proximity to Well #10 it is possible Well #12 would also be considered groundwater under the influent from the State's perspective. Further testing at this location would be necessary to determine whether additional treatment (beyond iron filtration) would be required.

Alternative #4 - Well #12 (Abbeywood Drive Shallow Well)				
Description				Total Probable Cost
SUMMARY				
16" TRANSMISSION MAIN	4200	Lin. Ft	$220	$924,000
DRILLING SHALLOW WELL	1	Lump Sum	$500,000	$500,000
SHALLOW WELL PUMP	1	Each	$350,000	$350,000
PRE-ENGINEERED WELL HOUSE	1	Lump Sum	$500,000	$500,000
SITE ELECTRICAL	1	Lump Sum	$100,000	$100,000
LAND ACQUISITION	2.5	Acre	$100,000	$250,000
			SUBTOTAL CONSTRUCTION:	**$2,624,000**
			CONTINGENCY @ 20%:	$524,800
			ENGINEERING & ADMIN @ 15%:	$472,320
			PROJECT TOTAL:	**$3,621,120**

Alternative #5 – Well #14 (St. Charles/Shallow Aquifer)

Well #14, or the Peck Road well, has not been extensively reviewed. There has been some evidence that the St. Charles aquifer lies under the fields east of Peck Road. Based on the aquifer model developed by the Illinois State Water Survey, it appears that the recharge water for the aquifer in this area is from open lands further west. The Peck Road property was first considered as a location for a new shallow well in 1990. Two wells were drilled on this property (Test Well 3-90 and 5-90), with another test well (Test Well 2-90) further north at Harvest Hills Park. Further testing at these wells could determine their productivity and recharge capability. All three test wells are located sufficiently far away from the nearest existing well (Well #13) to not encounter mutual interference.



Test wells 3-90 and 5-90 returned no known confined aquifer of sufficient depth to indicate a high production well at the sites immediately north of Route 38. The USGS and ISGS does not have current information on the shallow aquifer at this location. Further testing would require to determine the suitability of this well site.

Alternative #5 - Well #14 (Peck Road Shallow Well)				
Description				Total Probable Cost
SUMMARY				
16" TRANSMISSION MAIN	4600	Lin. Ft	$220	$1,012,000
DRILLING SHALLOW WELL	1	Lump Sum	$500,000	$500,000
SHALLOW WELL PUMP	1	Each	$350,000	$350,000
PRE-ENGINEERED WELL HOUSE	1	Lump Sum	$500,000	$500,000
SITE ELECTRICAL	1	Lump Sum	$100,000	$100,000
LAND ACQUISITION	4	Acre	$100,000	$400,000
SUBTOTAL CONSTRUCTION:				**$2,862,000**
CONTINGENCY @ 20%:				$572,400
ENGINEERING & ADMIN @ 15%:				$515,160
PROJECT TOTAL:				**$3,949,560**

Alternative #6 – Galesville Well with Conveyance to Well 7/13 Common Treatment Plant

Another option includes constructing a deep (Galesville) well near to the proposed softening facility for Wells #7 and 13 that will be discussed later in this report. The well would be drilled on-site at the combined treatment facility, as this would minimize the cost of water main to bring the water to treatment. The deep well would only be used sparingly during normal operation but provide back-up supply during maintenance or drought periods.

This alternative would eliminate the need for construction of additional treatment sites or off-site utilities and would be limited to the cost of the well and raw water main. Addition of a Galesville well at this location would allow all three wells to operate simultaneously in a high-flow event and provide an additional 1,000 GPM capacity to the system. Limiting the existing deep well to 1,000 gpm will produce finish water below the threshold of 5 pCi/L when blending with the two shallow wells. The estimated cost for the well is $3.1M and could be constructed in conjunction with a softening facility or at a later date.

Alternative #6 - Galesville Well at Wells #7/13				
Description				Total Probable Cost
SUMMARY				
16" TRANSMISSION MAIN	250	Lin. Ft	$220	$55,000
DRILLING DEEP WELL (1,000 GPM)	1	Lump Sum	$1,250,000	$1,250,000
DEEP WELL PUMP	1	Each	$750,000	$750,000
CHEMICAL SYSTEM UPGRADES	1	Lump Sum	$100,000	$100,000
ELECTRICAL UPGRADES	1	Lump Sum	$100,000	$100,000
			SUBTOTAL CONSTRUCTION:	**$2,255,000**
			CONTINGENCY @ 20%:	$451,000
			ENGINEERING & ADMIN @ 15%:	$405,900
			PROJECT TOTAL:	**$3,111,900**

Alternative #7 – Galesville Well with Conveyance to Well 9/11 Common Treatment Plant

This alternative is identical to Alternative #6 with the exception that the Galesville well would be constructed near Well 11. This deep well would be limited to 500 gpm to maintain a finish water below 5 pCi/L when blended with Well 11.

Alternative #7 - Galesville Well at Wells #9/11				
Description				Total Probable Cost
SUMMARY				
16" TRANSMISSION MAIN	500	Lin. Ft	$220	$110,000
DRILLING DEEP WELL (500 GPM)	1	Lump Sum	$1,250,000	$1,250,000
DEEP WELL PUMP	1	Each	$750,000	$750,000
CHEMICAL SYSTEM UPGRADES	1	Lump Sum	$100,000	$100,000
ELECTRICAL UPGRADES	1	Lump Sum	$100,000	$100,000
			SUBTOTAL CONSTRUCTION:	**$2,310,000**
			CONTINGENCY @ 20%:	$462,000
			ENGINEERING & ADMIN @ 15%:	$415,800
			PROJECT TOTAL:	**$3,187,800**

Cost Summary of Alternative Supplies

Displayed in the table below are the costs associated with each of the seven alternatives for additional water supply discussed. This table includes project cost, increased well production capacity, and cost per gallon of increased capacity. The table provides a direct comparison of alternatives on a cost per gallon basis. No cost information is given for the Fox River alternative, as the capital costs to the entirety of the City's water infrastructure to surface water treatment would be prohibitively high. Additional capacity from connection to the DuPage Water Commission was calculated as the difference between the Build-Out required Maximum Capacity and the present day Maximum Capacity.

Table 6-2: Summary of Supply Alternative Capital Costs

Alternative	Project Cost	Capacity Increase (MGD)	Cost per gallon of increased production
Alternative 1 - DuPage Water Commission	$65,750,000	4.86	$13.53
Alternative 2 - Fox River	N/A	N/A	N/A
Alternative 3 - Shallow Well 10 (Crane & Rt. 31)	$3,640,000	2.16	$1.69
Alternative 4 - Shallow Well 12 (Crane & Rt. 31)	$3,620,000	2.16	$1.68
Alternative 5 - Shallow Well 14 (Peck & Rt. 38)	$3,950,000	2.16	$1.83
Alternative 6 - Galesville Well @ 7/13	$3,110,000	1.44	$2.16
Alternative 7 - Galesville @ 9/11	$3,190,000	1.44	$2.22

6.3. Treatment of Additional Water Supplies

Depending on the groundwater source, additional treatment may be necessary prior to distribution. At a minimum, chlorination and fluoridation of sources would be required. If this was the only treatment necessary, a standalone well house with chemical addition would likely be sufficient. However, if new shallow wells are constructed, iron filtration may be necessary, and if deep wells are constructed this may require radium removal treatment.

If a shallow well was constructed on the west side of the river, it is likely iron would be present in concentrations over the MCL set by the Illinois EPA. This is the case for Well's #7 and #13 and can be estimated to be similar in size and scale to any of Wells #10, 12 or 14. A conceptual cost estimate for the iron filtration facility required for any of these three shallow wells is included below. It should be noted that this does not include a lift station or sanitary sewer improvements. While sanitary sewer capacity may be available for the Well #14 site, the sites along Route 31 would require further investigation of sewer routing and likely installation of larger diameter sewer main.

Shallow Well Iron Filtration Facility	
Description	Total Probable Cost
SUMMARY	
GENERAL CONDITIONS	$695,748
SITE WORK	$1,076,215
TREATMENT FACILITY	$3,639,679
Construction Sub-Total	$5,411,642
Contingency @ 20%	$1,082,328
Engineering @ 15%	$974,096
PROBABLE PROJECT COST:	**$7,468,066**

At the conceptual level, it is estimated that construction of a deep well at either Well #13 or Well #11 would not require radium removal due to its intended use. The additional water supplies are intended only to provide adequate flow for the maximum day demand, in which instance all available wells would be utilized. The radium concentrations at these deep wells would be estimated to be similar to existing Wells #3, 4 & 8 at approximately 12 pCi/L. If blended with 2,500 gpm at the Oak Street facility from Wells #7 and 13 the estimated final radium concentration would be below 3.5 pCi/L at 1,000 gpm deep well capacity. The viability of blending should be reviewed with the EPA during the future well study discussed on the following page.

Similarly, at Well #11 the effluent radium concentration would be approximately 4.8 pCi/L at a 1,000 gpm deep well design. To provide a level of conservatism, a deep well at Well #11 would likely be limited to 500-750 gpm. Therefore, additional treatment capacity beyond chlorination and fluoride addition may not be necessary. Additionally, an evaluation of the impacts of the additional influent radium at the WWTP's, as this could impact the solids disposal, and potentially require additional treatment or disposal methods. If blending is not an option, it is recommended that the City perform a pilot study to identify the viability of the radium removal with the pellet technology at each specific well site location.

6.4. Summary

As detailed in Section 2 – Community Needs, the City of St. Charles anticipates significant growth over the next five years. For planning purposes, this growth is anticipated to result in increased maximum day water usage on a linear basis. As a result, the current maximum day demand of 9.74 MGD may increase to 12.1 MGD in 2023 by the end of the 5-year planning horizon. Therefore, the City should continue reviewing alternatives for additional water supply and treatment, and must maintain all current facilities. This includes the short-term rehabilitation/interconnection of Well #7 as a priority project.

The table below lists each of the alternative supply sources, their associated capital cost, the treatment facility capital cost, and total project cost. Due to the significantly higher cost associated with either connection to DuPage Water Commission or conversion to surface water supply (Fox River), these alternatives have been omitted from further consideration.

Table 6-4: Summary of Supply Alternative Costs

Alternative	Supply Capital Cost	Treatment Capital Cost	Total Alternative Capital Cost
Alternative 3 - Well 10	$3,640,000	$7,470,000	$11,110,000
Alternative 4 - Well 12	$3,620,000	$7,470,000	$11,090,000
Alternative 5 - Well 14	$3,950,000	$7,470,000	$11,420,000
Alternative 6 - Galesville Well @ 7/13	$3,110,000	-	$3,110,000
Alternative 7 - Galesville @ 9/11	$3,190,000	-	$3,190,000

While the construction of new shallow wells represent a higher capital cost, they can be utilized any time and can be alternated with other production wells to minimize equipment runtime. Installation of a deep well and operating under a blending scenario requires that the associated shallow well be run simultaneously with the deep well to achieve sufficient radium levels. The result of this would likely be that the deep wells would be run very infrequently, and only run to waste for sampling, and the associated shallow well would be utilized on a near-constant basis.

Due to the relatively short-term requirement for additional supply, the City may elect to move forward with further investigation of groundwater alternatives. This would include investigating potential shallow well sites through boring of test holes and ultimately production evaluation with test wells. Once a potential site has been identified, it is recommended that two test holes be drilled to locate an adequate formation. Once located, a test well and several observation wells should be drilled to conduct a capacity evaluation. **The test holes and test wells are anticipated to cost approximately $200,000 in total and should be budgeted over the next two years.**

If deep wells are going to be considered, alternative means of radium removal should be investigated as an alternative to blending. One option for radium removal would be pelletizing treatment, further discussed in Section 7. **A pilot with this technology is estimated to cost approximately $50,000 for a six-month sidestream scale program. Similarly, it is recommended that this be budgeted for the short-term.**

SECTION 7

WATER SOFTENING

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7. Water Softening

The majority of the City's existing water treatment facilities remain in good condition and should only require routine rehabilitation and maintenance over the planning period. In addition to maintaining excellent water quality, the City has identified implementing city-wide (utility-scale) water softening as a concept to be evaluated. The water softening level being evaluated consists of a finished water hardness of approximately 130 mg/L hardness, this is similar to water quality provided from Lake Michigan.

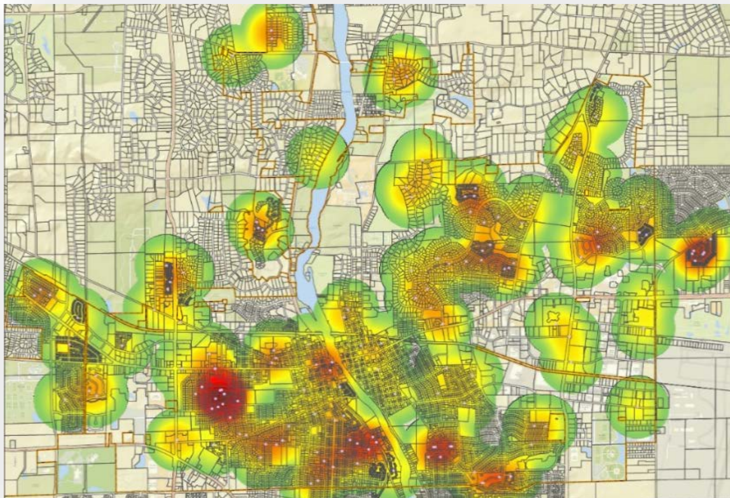
Hardness in water is the presence of dissolved magnesium and calcium ions. These ions combine most commonly with carbonate ions in water to create mineral deposits. Although water hardness is not regulated by the EPA in its Primary or Secondary Drinking Water Regulations, it constitutes a common challenge in providing quality drinking water. Hardness presents aesthetic concerns to consumers such as mineral deposits in piping, diminished soap effectiveness, and decreased lifespans of appliances.

Calcium and magnesium ions enter drinking water primarily through the dissolution of minerals in subterranean aquifers. As the City of St. Charles sources all of its drinking water from shallow and deep wells, high concentrations of hardness are to be expected. Tests have displayed that each of the wells used by the city provide water that is classified as either "Hard" or "Very Hard". Even Lake Michigan water which is commonly referred to as "soft" is actually categorized as "Moderately Hard" at 130 mg/L.

Table 6-1: Existing Water Supply Hardness

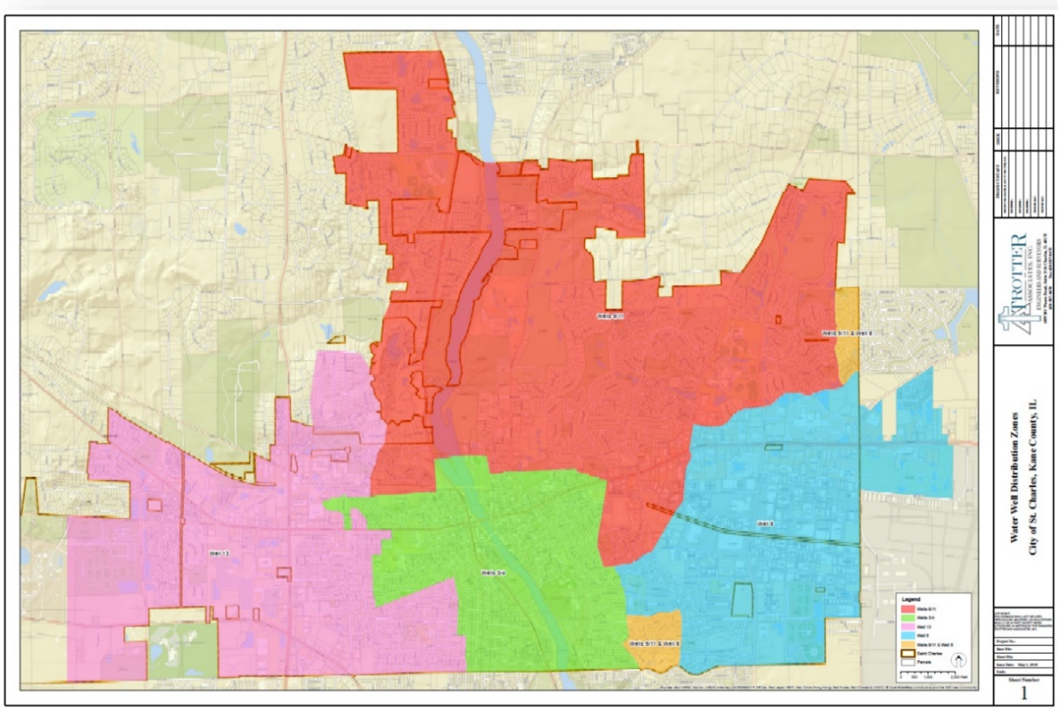
Water Source	mg/L as $CaCO_3$
Well 3	250
Well 4	240
Well 7	530
Well 8	260
Well 9	450
Well 11	530
Well 13	430
Hardness	**mg/L as $CaCO_3$**
Soft	0 to 75
Moderately Hard	75 to 150
Hard	150 to 300
Very Hard	300 and above

Water softening in St. Charles is currently achieved primarily through household water softening systems. These systems are paid for and operated by residents and require regular replacement of a softener salt media. Implementation of city-wide softening would reduce reliance on these devices and could potentially reduce the use of household softening. At present, the high hardness entering homes can scale pipes before reaching household softeners or the softeners may not be maintained well enough to work efficiently. As such, the City receives a number of complaints from consumers regarding the hardness of their water. The figure on the following page illustrates the occurrence of water quality complaints for hardness around the City. These complaints were recorded over the past five years and plotted over in ArcGIS. The heat map was constructed with higher densities of complaints indicated in red.



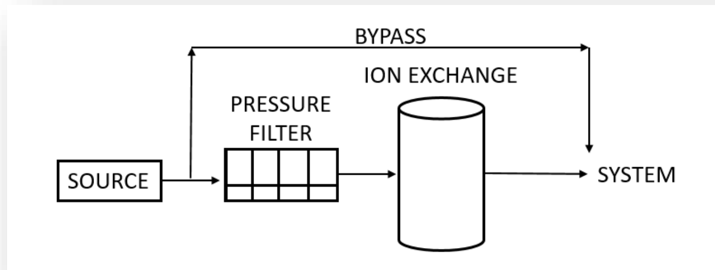
The City currently operates ion-exchange processes at the combined Well #3/4 facility, as well as the Ohio Avenue/Well #8 facility. This process is utilized to remove radium present in the deep well water, but as by-product also removes hardness. As a result, water quality varies across the distribution system with some residents receiving harder water than others. However, the level of hardness is still within the “Hard” to “Very Hard” range. The exhibit to the right illustrates the zone of influent for each well and treatment facility.

Viable alternatives for municipal water softening have developed rapidly over recent years, resulting in several potential technologies with different removal efficiencies and characteristics. Four potential alternatives that could be employed by the City of St. Charles are ion-exchange, lime softening, membrane softening, and pelletizing. Each of these technologies provide distinct benefits and draw backs, which will be reviewed in the following sections. Alternatives and combinations of alternatives for each have been compiled as well.

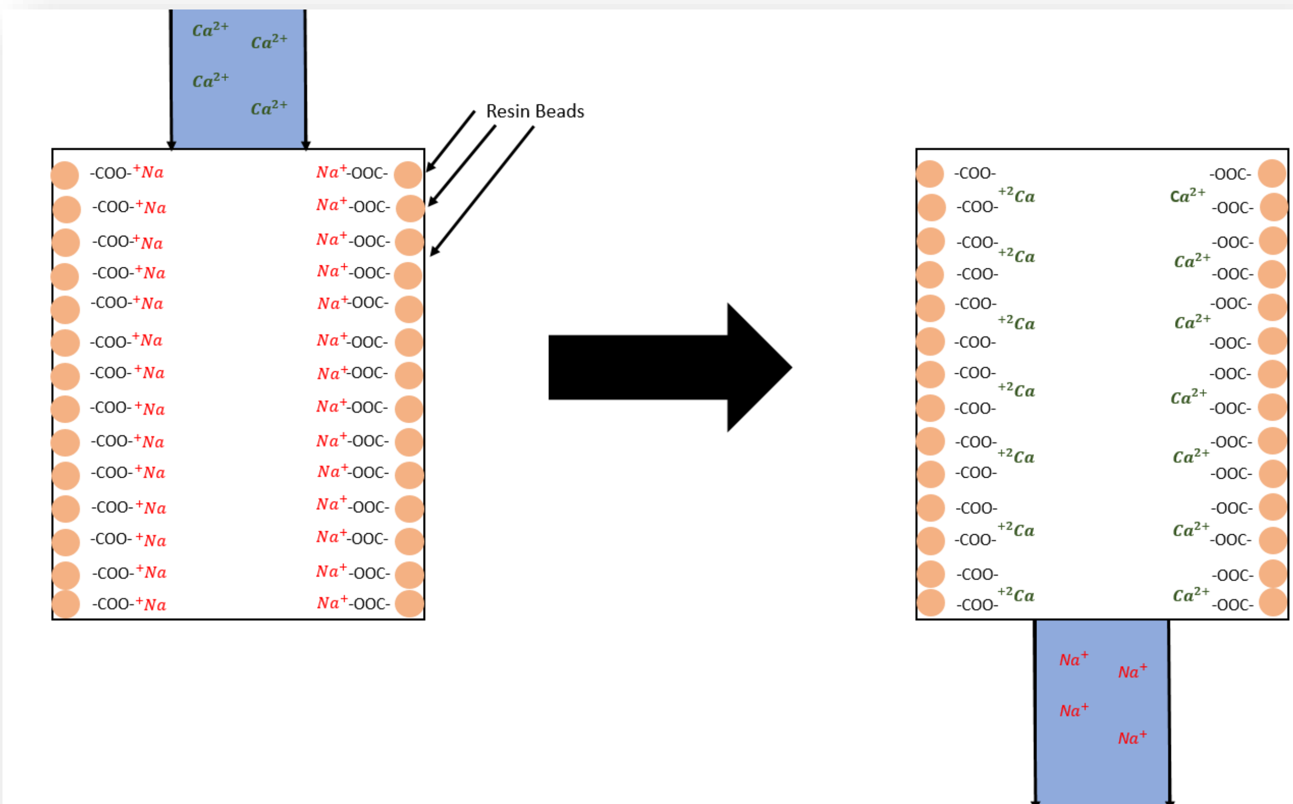


7.1. Overview of Water Softening Technologies

7.1.1. Ion-Exchange Softening



Municipal ion-exchange technology uses similar mechanisms to the household water softeners that are currently employed by many residents of St. Charles. An ion-exchange resin featuring positively charged sodium ions bound to negative anion groups is used to attract positively charged calcium and magnesium ions in the influent water. This resin consists of plastic beads with a diameter of around 0.6 mm, with each bead bonded to a mobile sodium ion. Calcium and magnesium ions, possess a greater affinity for the resin than sodium ions, so the resin will “exchange” the sodium cation for the calcium or magnesium cation, removing it from the source water. Sodium ions will not contribute to pipe scaling or mineral formation as they are significantly more soluble than calcium or magnesium. Shown at right is the system diagram. The system diagram displays that this alternative requires fewer additional pre- and post-treatment processes when compared to other alternatives discussed in this report.



Continuous cycles through the resin will degrade the concentration of available sodium ions for ion-exchange. In order to replenish or recharge the resin, a brine solution is used to backwash the media. Water with a high concentration of sodium chloride is used for backwashing, though this water has the capacity to raise chloride concentrations in effluent water. As backwashing is completed, the wastewater will have very high concentrations of calcium and magnesium ions that it has removed from the ion-exchange media as well as chlorides, and will need to be treated. In the City of St. Charles, this wastewater from backwashing presents the most significant challenge associated with the implementation of city-wide ion exchange.

Chlorides leaving the ion exchange unit must be carefully monitored, as the wastewater facilities of the City of St. Charles already have high chloride concentrations in their influent waters. The Main Wastewater Treatment Facility has a chloride concentration of 505 mg/L and the West Side Treatment Plant has concentration of 475 mg/L. Additionally, the Main and West Side Treatment Plants have effluent chloride concentrations of 476 and 486 mg/L, respectively. Wastewater treatment facilities have minimal removal efficiency for chlorides as they are not design for this purpose. As such, additional influent chlorides from ion exchange processes would not be removed in effluent wastewater.

These high concentrations of chlorides raise concern regarding the concentrations of chlorides that would be added by future implementation of ion exchange systems. Each combined treatment facility for Wells 7/13 and Wells 9/11 would be designed to treat a maximum flow of 3,000 GPM. The influent water has a total hardness of approximately 500 mg/L. Treatment would target a finished hardness of 130 mg/L. Flow would be divided through eight treatment vessels, each with a diameter of 10 feet. During average daily operation, the two systems would treat a total of 2,157,840 gallons, as 26% of flow would bypass the softeners. The eight treatment vessels would use a total of 18,864 pounds of salt each day. Therefore, the systems require 9,616 lbs of salt to treat 1,000,000 gallons of water. Sodium chloride is 61% chloride by weight, and using the current daily influent flow of 5 MGD to the Main Treatment Plant and 0.5 MGD to the West Side Treatment Plant, it was found that ion exchange at Wells 9/11 and 7/13 would lead to influent chloride concentrations of 715 mg/L at the Main WWTP and 2573 mg/L at the West WWTP.

Over the last 10 years, chlorides have become a regulatory discussion, with wastewater facilities tributary to impaired waterways receiving NPDES permit limits for chlorides. Future regulations regarding chlorides are likely to set a Maximum Contamination Level of 500 mg/L in wastewater effluent. Furthermore, wastewater from the City of St. Charles discharges directly into the Fox River which is currently listed by the Illinois EPA in its 303 (d) list of impaired waterways, with a “medium” priority level for chloride pollution.

In order to examine the plausibility of softening using ion exchange, the scenario where no residential softeners were used in the City. The load for chlorides coming from existing ion exchange technologies at Wells 3/4 and 8, along with a 50 mg/L base concentration for chlorides from wells, would be 255 mg/L to the Main WWTP. If a 500 mg/L MCL were to be mandated in the future along with a 100 mg/L security factor, the City would be able to add around 150 mg/L of chlorides. Any future implementation of expanded ion exchange technology would likely exceed this limitation. Therefore, in order to utilize additional ion exchange softening, residential softeners would need to be removed from service.

7.1.2. Lime-Soda Ash Softening

Where ion-exchange works to chemically remove hardness in an aqueous solution, lime softening chemically removes carbonate hardness by inducing solid precipitation. The chemicals added in this process are lime/calcium hydroxide ($Ca(OH)_2$) and soda ash/sodium carbonate (Na_2CO_3). Addition of lime serves to raise the pH, which is crucial in encouraging precipitation of calcium and magnesium ions. Soda ash is added to provide an ample source of carbonate ions for calcium hardness to react and precipitate with. Upon addition of these chemicals, magnesium is precipitated as magnesium hydroxide ($Mg(OH)_2$) while calcium is precipitated as calcium carbonate ($CaCO_3$) as shown below.

$$H_2CO_3 + Ca(OH)_2 \quad \rightarrow \quad CaCO_3 + 2H_2O$$

At the influent pH of 6.5-8.5, the dominant carbonate species is carbonic acid. As lime is added to the raw water, it will first react with carbonic acid due to the high reactivity of this acid. This reaction does not change hardness levels. In order to improve the effectiveness of lime addition, aeration can be used as a pre-treatment step. Aeration will increase the pH of the water, converting carbonic acid molecules to bicarbonate and carbonate ions that will be used to reduce calcium hardness. The concentration of carbonic acid in the source water will need to be determined for the City of St. Charles's wells, which can be determined by testing the carbon dioxide concentration.

$$Ca^{2+} + 2HCO_3^- + Ca(OH)_2 \rightarrow 2CaCO_3(s) + 2H_2O$$

This is the precipitation reaction for the removal of calcium ions. Bicarbonate ions formed as the pH of the water is raised will react with the free calcium ions that constitute calcium hardness. The equation also indicates that the ratio between calcium in the water and lime added is 1:1, meaning that for each mg/L of calcium hardness, 1 mg/L of lime will need to be added.

$$Mg^{2+} + 2HCO_3^- + 2Ca(OH)_2 \quad \rightarrow \quad 2CaCO_3 + Mg(OH)_2(s) + 2H_2O$$

This is the precipitation reaction for the removal of magnesium ions. Magnesium precipitates at a higher pH than calcium (over 11 as opposed to 10), so additional lime must be added to raise the availability of hydroxide ions. The equation displays this, as each mg/L of magnesium will need two mg/L of lime to precipitate one mg/L of magnesium hydroxide. This process is referred to as Excess Lime Treatment.

Water pulled from some wells in St. Charles also contains significant non-carbonate hardness, as well as carbonate hardness. These differences are shown below. Wells 3/4 and 8 pull from the Ironton-Galesville aquifer, while wells 9/11 and 13 pull from the St. Charles aquifer. When alkalinity exceeds total hardness, it is indicative of a lack of non-carbonate hardness, whereas the positive difference between total hardness and alkalinity represents the presence of non-carbonate hardness.

Source	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	Difference/Non-Carbonate Hardness (mg/L as $CaCO_3$)
Wells 3/4	163	299	-136
Well 8	162	285	-123
Wells 9/11	482	346	136
Well 13	435	303	132

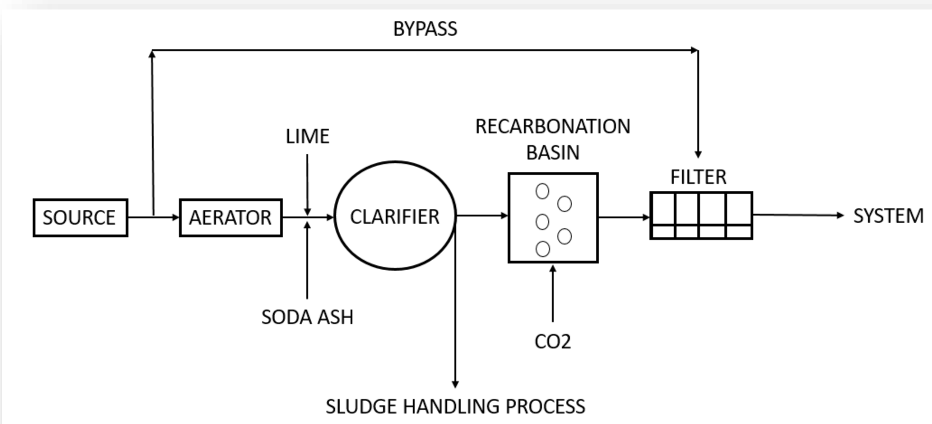
To remove non-carbonate hardness, soda ash will need to be added to the water as well as lime. The equations for the removal of non-carbonate hardness are shown below, with sulfate used as an example of a non-carbonate anion.

$$Mg^{2+} + SO_4^{2-} + Ca(OH)_2 \rightarrow Mg(OH)_2(s) + Ca^{+} + SO_4^{2-}$$

This is the first step in the removal of dissolved non-carbonate hardness. Magnesium associated to the non-carbonate anion is dissociated during the high-pH addition of lime, resulting in the precipitation of magnesium hydroxide just as discussed in the lime addition steps. However, sulfate ions begin to associate with free calcium ions introduced by the addition of lime. This results in further non-carbonate hardness that will need to be removed with soda ash.

$$Ca^{2+} + SO_4^{2-} + Na_2CO_3 \rightarrow CaCO_3\,(s) + 2Na^{+} + SO_4^{2-}$$

Finally, calcium hardness is removed by precipitation as calcium carbonate. Sodium ions in the water will not contribute to hardness and are added to the water in place of the removed calcium ions, just as they are in ion-exchange. The solids precipitated through lime and soda ash addition be removed via coagulation/flocculation followed by sedimentation. After the particles have been removed in sedimentation, water is re-carbonated by the injection of carbon dioxide. This will serve to raise the water's pH to acceptable drinking water standards before it is provided to the customer. Finally, water is filtered through a dual-media sand and anthracite filter and stored or distributed. In order to maintain the desired concentration of hardness as opposed to softening all water, source water may be blended with treated water in a ratio of about 1:4. This blending will also mediate the pH of the finished water, reducing the level of reaeration required. The overall suggested system diagram is displayed below.



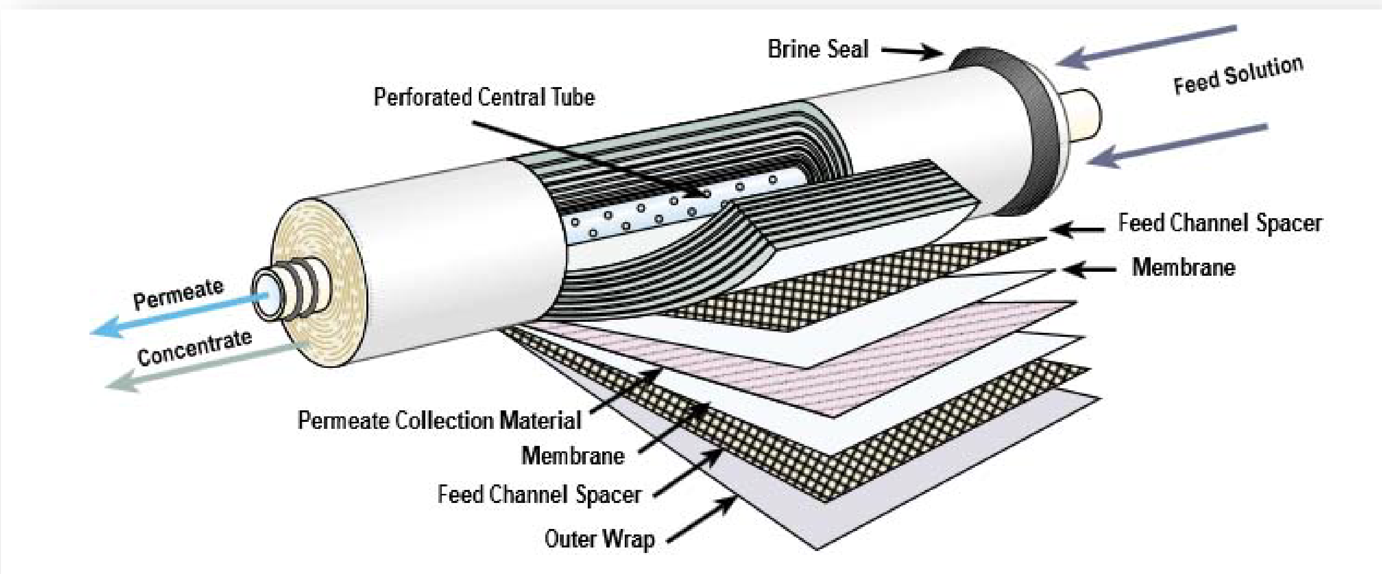
Lime softening will require a larger footprint when compared to other alternatives discussed, as mixing and sedimentation basins would need to be constructed as well as the final filter. This softening method will also require careful dosing, as excess final concentrations of lime could lead to corrosive water. Finally, solid lime softening waste would need to be transported and dewatered to be properly disposed. This process can produce 1,000 to 8,000 pounds of solid waste per million gallons of water treated. The City of St. Charles would need to develop a means to dispose of this waste. Lime softening does not require backwashing.

7.1.3. Nanofiltration (Membrane) Softening

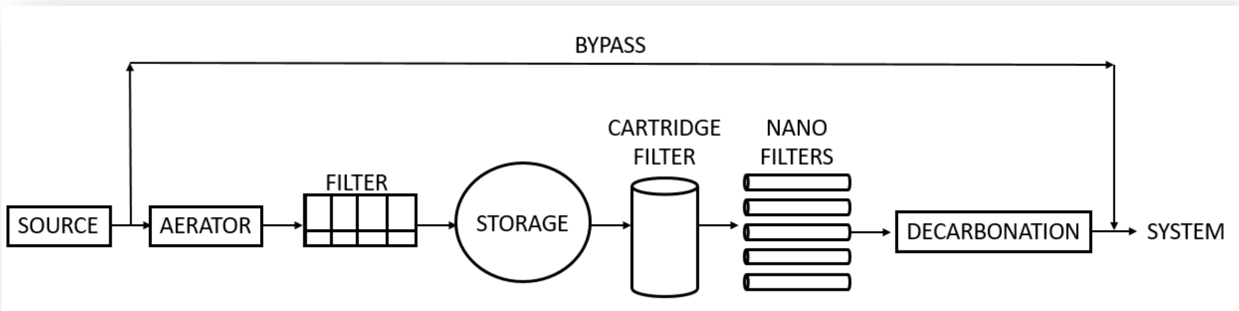
Membrane softening works using physical mechanisms, whereas technologies such as ion-exchange or lime softening use chemical processes. In membrane softening, influent water is forced through a semi-permeable membrane at very high pressures. For nanofiltration, a pore size of 0.001 nanometers is used. Reverse osmosis uses smaller pores, with a size of 0.0001 – 0.001 nm. In order to prevent fouling or blocking of these pores, water treated using membrane softening should first pass through a more porous cartridge filter to reduce the concentration of larger particles.

Reverse osmosis uses very high pressure to reverse the natural process of balancing concentrations known as osmosis. Water would tend to flow across a semi-permeable membrane from a region with more dissolved solids to a region with fewer dissolved solids in order to balance the concentrations of contaminants between the two regions. In reverse osmosis, a pump is used to force water through a membrane from the more contaminated raw region to the pure effluent region. In natural osmosis, a molecular gradient is the impetus for movement of water whereas reverse osmosis uses an induced pressure gradient to encourage water movement.

Membranes are commonly wound in a spiral around a central collection tube, as shown in the figure below. Water is then fed laterally through the spiral, and pressure will force water through the membrane where it will be brought the collection tube through an inner channel space. As the influent runs parallel to the membrane surface, water will carry away magnesium and calcium ions from the membrane surface, preventing fouling. The magnesium and calcium ions will exit the filter in concentrated form where they can be collected for wastewater treatment.



Membrane softening technologies can be advantageous due to their small footprints and high removal efficiencies. Desired effluent hardness levels can be easily maintained by updating the blending ratio of untreated water, as treated water from nanofiltration has lower quality variability than in the case of other technology alternatives. Another advantage of membrane filtration is that it requires fewer chemical inputs than other softening processes. Lastly, the modular nature of membrane technologies mean that it is easy to add capacity to these systems. If the population of the community expands beyond current projections, the city would be able to add additional racks of membrane spirals as opposed to constructing larger facilities as would be necessitated by other alternatives. The process diagram below shows the technologies used in membrane filtration softening.



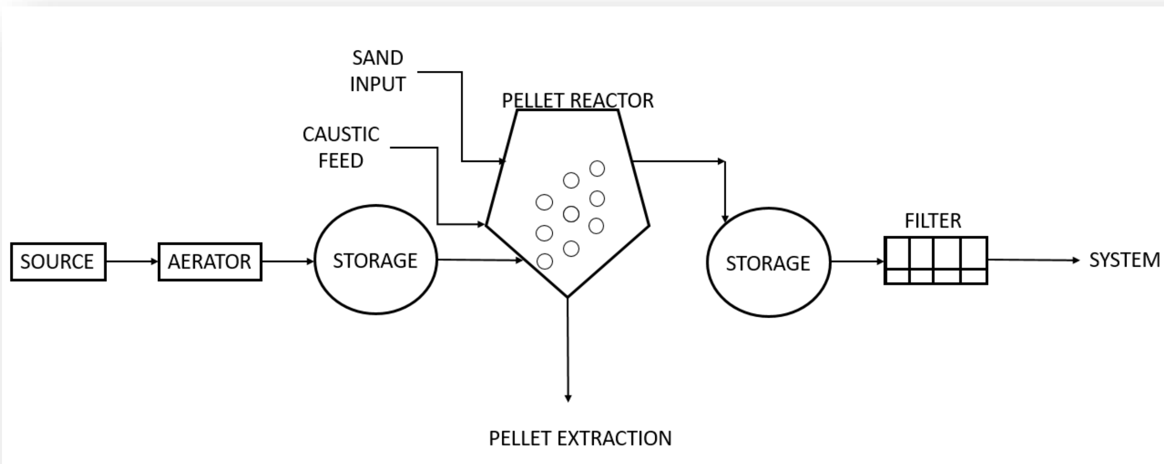
A significant challenge associated with membrane softening is the high level of reject water produced. Contemporary reverse osmosis systems reject approximately 20% of water that enters the system. This is a challenge particularly for the Wells #7 and 13 for the City of St. Charles, where the reject water would be treated at the West Side Wastewater Treatment Plant which currently lacks the capacity to handle the reject water that would be produced by reverse osmosis at these wells. Therefore, reject from a Well #7/13 nanofiltration facility may need to be pumped to one of the Main WWTP tributary basins.

Recently the City has discussed potentially expanding the existing West Side Wastewater Treatment Plant. If an expansion project is on the horizon for the West Side Facility, the City could increase the proposed capacity to include the reject water from the membrane softening process. This determination would need to be made prior to entering into the design of the West Side WRF.

Conversely, membrane filtration is an attractive alternative for the City of St. Charles as the process removes chlorides from influent water. Chloride waste from softening is one of the primary concerns for the City, so an alternative utilizing membrane softening could effectively address this concern.

7.1.4. Pellet Softening

The name pellet softening is derived from the waste product that is created through the usage of this method. Whereas waste products from all other alternatives are liquids that will be treated at the wastewater treatment facility, palletization produces a small ball coated in calcium carbonate. Pelletization reactors consist of a bottom-fed tank filled with fine-grain sand. Raw water is injected into the base of the tank along with sodium hydroxide or lime to raise the pH and encourage reaction with charged sand particles. As the water level rises and calcium ions aggregate on sand particles, the heaviest particles settle toward the bottom of the tank while little particles rise and fluidize to react with more ions of hardness. Large, dense pellets are removed from the base of the tank and fresh sand is added to the reactor to maintain a consistent bed volume. Pellets have a residence time of around 100 days. After the pellet reactor, water is filtered to reduce the likelihood of pellet moving past the system. The figure below displays the system process for pellet softening.



Pellet softening uses a small footprint and reduces the load on wastewater facilities when compared to other alternatives. The pellet waste product is largely innocuous, as it is primarily sand particles coated with limestone. This process also reduces chloride concentrations in influent water. This is ideal as other alternatives contribute to higher chloride concentrations in effluent water sent to wastewater facilities. The City of St. Charles should prioritize a process that will minimize chloride emissions, as the present chloride levels at their wastewater facilities are already nearing or surpassing chloride standards that are likely to come into effect during the lifespan of this Master Plan. Similar to lime softening, pellet softening will also require a reaeration step to lower the pH to within potable levels. A major concern associated with pellet softening is that it does not remove magnesium hardness. Magnesium hardness exceeds the recommended level of 40 mg/L in St. Charles Wells 7, 9, 11, and 13. At these wells, failure to reduce the magnesium hardness would provide a finished hardness concentration of approximately 280 mg/L, well above the target concentration of 130 mg/L.

7.2. Alternatives for Softening Well #7 & 13

Due to the high capital cost and operational oversight required, constructing common treatment facilities typically provides the most cost-effective solution for water softening. Therefore, softening of the City's four shallow sand and gravel aquifer wells have been grouped into two common plants – Well #7 & 13 and Well #9 & 11. Constructing a single softening plant fed by the four shallow wells is not practical. This would require conveying water across the river at least twice, once for treatment and again for distribution. Five alternatives for each combined softening facility were developed, including ion-exchange, nanofiltration, lime softening, pelletizing, and finally a combination of pelletizing and ion-exchange. The overall goal for each process is to soften the City's water supply to approximately 130 mg/L, which is consistent with Lake Michigan supplied water, and is within the "Moderately Hard" range. The following analysis and costs are predicated on the fact that the interconnect between Well #7 and 13 has been completed. If the City elects not to complete that project prior to the softening being implemented, those additional costs need to be included into the budget.

7.2.1. Alternative #1A – Well #7/13 Ion-Exchange Softening

A combined softening facility for Well #7 & 13 would be constructed at the Oak Street Treatment Facility, as was laid out during the original design of the facility in the early 2000's. This would require replacement of the Well #7 pump to be able to convey flow to the Oak Street Treatment Facility. This facility would be upgraded with two additional pressure filters in the north garage bay area to treat the elevated levels of iron and manganese in the raw water. A new combined softening facility with six 10-ft diameter vessels would be installed, as well as brine systems. It is anticipated that this facility could be constructed on the existing site and acquisition of additional land would be unnecessary. A conceptual cost estimate for construction of this facility is included below, as well as a conceptual layout of the potential improvements on the following page.

Alternative #1A - Ion Exchange Softening at Well #7/13 Common Plant		
Description		Total Probable Cost
SUMMARY		
GENERAL CONDITIONS		$922,408
SITEWORK		$1,082,215
WELL #13 / ION EXCHANGE FACILITY		$5,003,316
EFFLUENT LIFT STATION		$247,300
	Construction Sub-Total	**$7,255,239**
	Contingency @ 20%	$1,451,048
	Engineering & Administration @ 15%	$1,305,943
	PROBABLE PROJECT COST:	**$10,012,230**

While the simplest solution, ion-exchange softening alone at a combined treatment facility for Wells 7 and 13 is likely not a viable alternative as the effluent chloride waste concentrations would be too high for the existing Westside Wastewater Treatment Plant to handle. The Westside Plant currently receives chloride concentrations of 475 mg/L. as previously discussed, wastewater facilities do not remove appreciable amounts of chlorides without membrane filtration, and as such the addition of regenerate waste chlorides would result in concentrations through the WWTP over 500 mg/L. Even with conveyance of waste to the Main WWTP, chloride concentrations would be in excess of 700 mg/L.

The operational costs of ion-exchange process are well known to the City, with the vast majority of the cost coming from the use of salt brine. It is anticipated that approximately 10,000 lbs per day would be utilized by the common facility to provide an average daily flow of 1.5 MGD. There is no additional power requirement associated with this alternative. Operational oversight would be limited to personnel checking on the facility during rounds and some minor lab work and maintenance, anticipated at an additional 10 hours per week. The waste stream generated would require treatment, which is quantified by applying the City's sewer rate for treatment of $3.74/1,000 gallons. This results in an increase in annual O&M of approximately $300,000, or $0.54 per 1,000 gallons produced.

Alternative #1A - Well #7/13 Ion Exchange Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	10,000	lbs	$ 0.05	$ 182,500.00
Carbon Dioxide	0	gallons	$ 0.85	$ -
Calcium Hydroxide	0	lbs	$ 0.15	$ -
Sodium Hydroxide (50%)	0	lbs	$ 0.31	$ -
Sulfuric Acid (93%)	0.00	gallons	$ 2.50	$ -
Antiscalant	0.00	gallons	$ 0.25	$ -
Sand Media	0	lbs	$ -	$ -
			Total Annual Chemical Cost:	$ 182,500.00
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
-				
			Total Annual Power Cost:	$ -
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	10	Hours	$ 100.00	$ 52,000.00
			Total Annual Labor Cost:	$ 52,000.00
Waste Stream	**Daily Production**		**Cost/1,000 Gal**	**Annual Cost**
3% of Forward Flow	45,000	Gallons	$ 3.74	$ 61,429.50
			Total Annual Waste Stream Cost:	$ 61,429.50
			Total Annual O&M Cost:	**$ 295,929.50**
			Cost per Thousand Gallons:	**$ 0.54**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 4,909,400		20	$ 245,470.00
Structures	$ 2,115,447		50	$ 42,308.94
			Total Annual Depreciation:	$ 287,778.94


1
2
3
Legend
1. Ion Exchange
2. Pressure filters
3. System
1A
Well No. 7 & 13 Ion Exchange Softening
City of St. Charles, Kane, IL
TROTTER
ASSOCIATES, INC.
ENGINEERS AND SURVEYORS
PROJECT STAFF
ISSUE
REVISIONS
DATE

7.2.2. Alternative #1B – Well #7/13 Nanofiltration

As discussed in Section 6.3, nanofiltration contributes no additional chlorides to the waste stream as it does not require resin regeneration. Within a nanofiltration softening facility source water would be pumped from the wells through an induced draft aerator and into a 500,000 gallon raw water holding reservoir. It would then be boosted through pressure filtration to remove the significant amount of iron and manganese present to levels below 0.05 mg/L. While this is fairly conservative, membrane filtration facilities in the area have struggled greatly with excessive iron levels damaging the membranes if not filtered adequately. Similar to the first alternative, this option includes two additional pressure filters in the Oak Street facility, and mirror image of that facility with four additional pressure filters.

Following pressure filtration, the water is treated through 5-micron cartridge filters and subsequently the nanofiltration system. It is anticipated that four nanofiltration treatment skids would be required, each with an array of 18:10 elements for a total of 180 membranes per skid. Finished water is de-carbonated and flows into a 500,000 gallon reservoir, which is then booster to distribution.

Additional land would need to be purchased due to the footprint of the nanofiltration facility. Land is estimated at $100,000/ acre and may be available directly south of Oak Street at the County Fairgrounds.

Alternative #1B - Nanofiltration at Well #7/13 Common Plant		
Description		Total Probable Cost
SUMMARY		
LAND ACQUISITION		$400,000
GENERAL CONDITIONS		$2,247,352
SITEWORK		$2,123,925
INDUCED DRAFT AERATOR		$210,000
RAW WATER RESERVOIR		$1,880,000
PRESSURE FILTRATION FOR WELL #7		$5,593,460
MEMBRANE SYSTEM		$7,206,720
FINISHED WATER RESERVOIR		$1,880,000
	SUBTOTAL CONSTRUCTION	**$21,541,457**
	CONTINGENCY @ 20%	$4,308,291
	ENGINEERING & ADMINISTRATION @ 15%	$3,877,462
	PROBABLE PROJECT COST:	**$29,727,210**

Nanofiltration requires little in the way of chemical treatment as previously discussed. An antiscalant would be required to keep the membranes clean, estimated at approximately five gallons per day, with sulfuric acid addition for pH control. High pressure boosting into the pressure filtration is required as well as final boosting to the distribution system which represents an increase in power consumption of $126,000 annually. Similar to ion-exchange processes, nanofiltration does not require extensive oversight which is estimated at 10 hours additional each week. The most significant operations cost associated with nanofiltration is the reject stream at 20% of forward flow. Due to the volume of this waste stream at design conditions (900,000 GPD), this waste stream will have to be pumped to the Main WWTP tributary basin nearly one mile away. This lift station and forcemain cost has been incorporated into the capital cost estimate. At $3.74/1,000 gallons for treatment, this equates to over $400,000 each year for treatment of the waste stream. Therefore, the total annual additional O&M cost for nanofiltration is estimated at $615,000 or $1.12 per 1,000 gallons produced. Recently the City has discussed potentially expanding the existing West Side Wastewater Treatment Plant. If an expansion project is on the horizon for the West Side Facility, the City could increase the proposed capacity to include the reject water from the membrane softening process. This determination would need to be made prior to entering into the design of the West Side WRF.

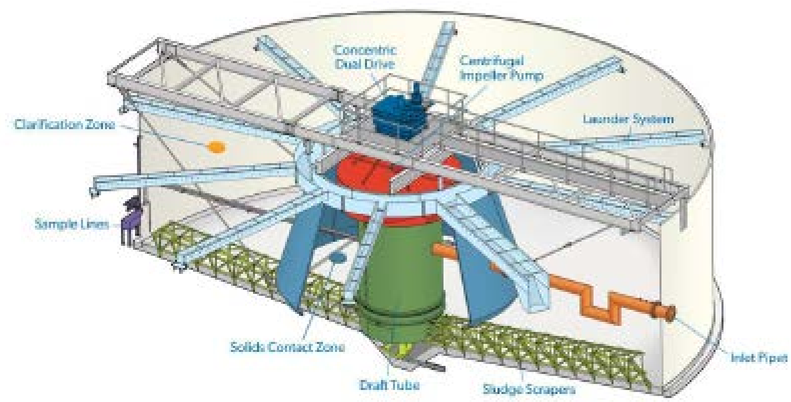
Alternative #1B - Well #7/13 Nanofiltration Facilitiy O&M Costs						
Chemical	**Daily Usage**		**Cost/Unit**		**Annual Cost**	
Salt Brine	0	lbs	$	0.05	$	-
Carbon Dioxide	28	gallons	$	0.85	$	8,687.00
Calcium Hydroxide	0	lbs	$	0.15	$	-
Sodium Hydroxide (50%)	0	lbs	$	0.31	$	-
Sulfuric Acid (93%)	0.92	gallons	$	2.50	$	834.97
Antiscalant	5.55	gallons	$	9.00	$	18,231.75
Sand Media	0	lbs	$	-	$	-
			Total Annual Chemical Cost:		$	27,753.72
Power	**Daily Usage**		**Cost/Unit**		**Annual Cost**	
Filter Booster Pumps	1,440	kW	$	0.08	$	42,048.00
System Booster Pumps	2,880	kW	$	0.08	$	84,096.00
			Total Annual Power Cost:		$	126,144.00
Labor	**Hours per Week**		**Cost/Hour**		**Annual Cost**	
Operations	10	Hours	$	100.00	$	52,000.00
			Total Annual Power Cost:		$	52,000.00
Waste Stream	**Daily Production**		**Cost/1,000 Gal**		**Annual Cost**	
20% of Forward Flow	300,000	Gallons	$	3.74	$	409,530.00
			Total Annual Waste Stream Cost:		$	409,530.00
			Total Annual O&M Cost:		**$**	**615,427.72**
			Cost per Thousand Gallons:		**$**	**1.12**
Depreciation	**Value**		**Service Life**		**Annual Cost**	
Membrane Replacement	$	1,440,000	5		$	288,000.00
Equipment	$	9,757,200	20		$	487,860.00
Structures	$	20,039,863	50		$	400,797.27
			Total Annual Depreciation:			$1,176,657.27


Legend
1. Draft Aerators
2. Clear well
3. Booster Station
4. Pressure filters
5. Cartridge filters
6. Membranes
7. De-carbonation
8. Reservoir
9. Booster station
10. System
Well No. 7 & 13 Nano Filtration
City of St. Charles, Kane, IL
TROTTER
ASSOCIATES, INC.
ENGINEERS AND SURVEYORS
1B

7.2.3. Alternative #1C – Well #7/13 Lime Softening

Lime softening is utilized by a number of surrounding communities including West Chicago, Aurora, and Elgin. While an effective form of treatment, there are a number of drawbacks. The footprint associated with these processes is typically the largest due to the required circular contact clarifiers. Unlike ion-exchange and nanofiltration facilities, lime softening plants cannot startup and shutdown as needed. The sludge generated and maintained in the clarifiers would require constant circulation to avoid solidification which does not allow for the same “on-demand” nature of ion-exchange and nanofiltration.

As a result of needing to maintain constant flows through the process, the lime softening alternative incorporates 1.0 MG reservoirs at the head of the process, as well as another 1.0 MG reservoir for finished water holding. Water would be pulled from the clear well and aerated prior to entering the two 55-foot diameter solids contact clarifiers where hardness is precipitated out and wasted as a sludge. Treated water flows through re-carbonation and into cluster gravity filters prior to disinfection and storage.

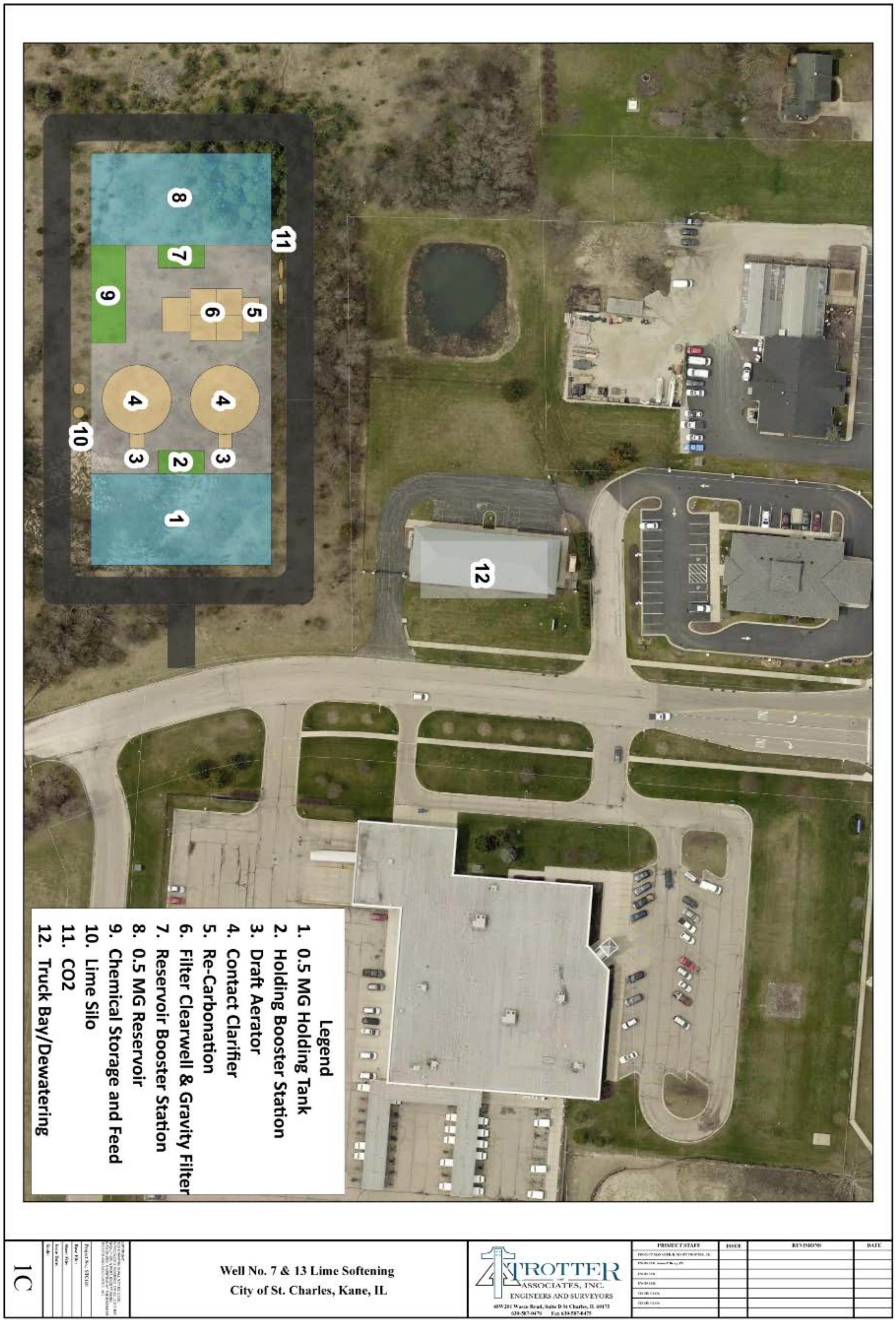


Due to the footprint of the lime softening process, it is anticipated that eight acres would need to be purchased to build the facilities. For handling of the lime sludge the City could construct dewatering facilities within the existing Oak Street plant, or utilize three drying beds, each 135’ x 20’.

Alternative #1C - Lime Softening at Well #7/13 Common Plant	
Description	Total Probable Cost
SUMMARY	
LAND ACQUISITION	$800,000
GENERAL CONDITIONS	$2,460,658
SITEWORK	$1,392,425
INDUCED DRAFT AERATOR	$210,000
SOLIDS CONTACT CLARIFIERS	$2,650,000
RE-CARBONATION	$320,000
GRAVITY FILTERS	$1,985,000
DISINFECTION	$250,000
FINISHED WATER RESERVOIR	$3,058,000
TREATMENT BUILDING	$7,838,830
DRYING BEDS (3 @ 135' x 20')	$3,129,000
SUBTOTAL CONSTRUCTION	**$24,093,913**
CONTINGENCY @ 20%	$4,818,783
ENGINEERING & ADMINISTRATION @15%	$4,336,904
PROBABLE PROJECT COST:	**$33,249,600**

Lime softening has the highest operational cost associated with it due to the chemicals required, the operational oversight, and waste sludge produced. Nearly 4,000 lbs of calcium hydroxide (lime) would be required to treat an average daily flow of 1.5 MGD at the combined Well #7 & 13 plant. Additionally, carbon dioxide would be utilized for re-carbonation prior to filtration. The only additional power costs are the two sets of booster pumps, however it is anticipated that the facility would need to be staffed 24/7 at an annual cost of approximately $875,000. Dewatering of lime sludge (if performed mechanically) would cost $200,000 annually and disposal of the dewatered sludge an additional $145,000. This results in a total annual O&M cost in excess of $1.5M, or $2.80 per 1,000 gallons produced.

Alternative #1C - Well #7/13 Lime Softening Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	0	lbs	$ 0.05	$ -
Carbon Dioxide	28	gallons	$ 0.85	$ 8,687.00
Calcium Hydroxide	4,000	lbs	$ 0.15	$ 219,000.00
Sodium Hydroxide (50%)	0	lbs	$ 0.31	$ -
Sulfuric Acid (93%)	1.00	gallons	$ 2.50	$ 912.50
Antiscalant	0.00	gallons	$ 2.50	$ -
Sand Media	0	lbs	$ -	$ -
			Total Annual Chemical Cost:	$ 228,599.50
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 84,096.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	168	Hours	$ 100.00	$ 873,600.00
			Total Annual Power Cost:	$ 873,600.00
Waste Stream	**Daily Production**		**Cost/Unit**	**Annual Cost**
Dewatering	4	Dry Tons	$ 140.00	$ 204,400.00
Disposal	20	Cu. Yds.	$ 20.00	$ 144,467.51
			Total Annual Waste Stream Cost:	$ 348,867.51
			Total Annual O&M Cost:	**$1,535,163.01**
			Cost per Thousand Gallons:	**$ 2.80**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 6,275,500		20	$ 313,775.00
Structures	$ 23,951,746		50	$ 479,034.93
			Total Annual Depreciation:	$ 792,809.93


Legend
1. 0.5 MG Holding Tank
2. Holding Booster Station
3. Draft Aerator
4. Contact Clarifier
5. Re-Carbonation
6. Filter Clearwell & Gravity Filter
7. Reservoir Booster Station
8. 0.5 MG Reservoir
9. Chemical Storage and Feed
10. Lime Silo
11. CO2
12. Truck Bay/Dewatering
Well No. 7 & 13 Lime Softening
City of St. Charles, Kane, IL
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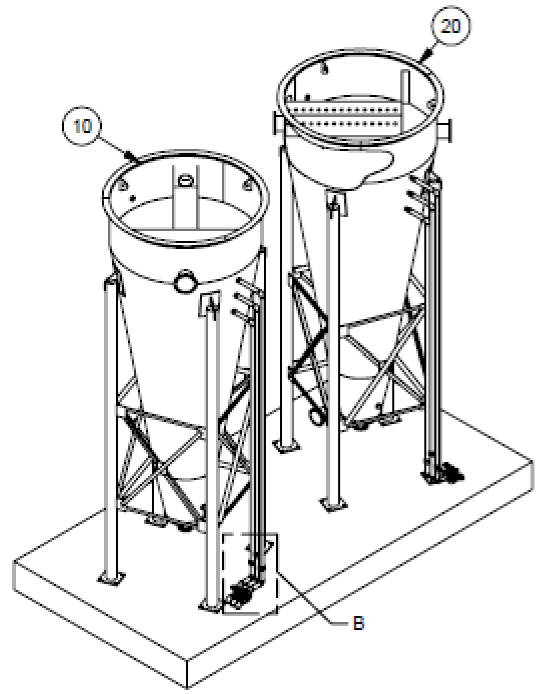
7.2.4. Alternative #1D – Well #7/13 Pelletizing

A common pelletizing facility would have a relatively small footprint compared to either lime softening or nanofiltration. The reactors are vertical which requires the structures to be tall, but each unit would likely be only 10 feet in diameter. Water would be pumped from each of the wells through draft aerators and into a 250,000 gallon clearwell. This would then be boosted into the pelletizing reactors where caustic soda is fed to increase the pH and allow for fluidized contact with the sand media bed. Hardness is precipitated on the media, and treated water flows over the weir trough at the top of the unit and into a second 250,000 gallon holding tank. Water is then boosted through pressure filters and discharged into the distribution system.

The most significant drawback to the softening treatment process is the limited ability to remove magnesium-based hardness. The City's wells are comprised of a 40/60 split between magnesium based hardness and calcium based hardness. While the pellet reactors can remove calcium hardness very effectively, typically only 20-25% of magnesium hardness can be removed. Adding more caustic to raise the pH to 11 or greater, and slowing down the process, may achieve higher magnesium removal efficiencies, but it is not anticipated that a final effluent of 130 mg/L hardness could be achieved with pelletizing alone. The estimated hardness would be in the range of 200-250 mg/L.

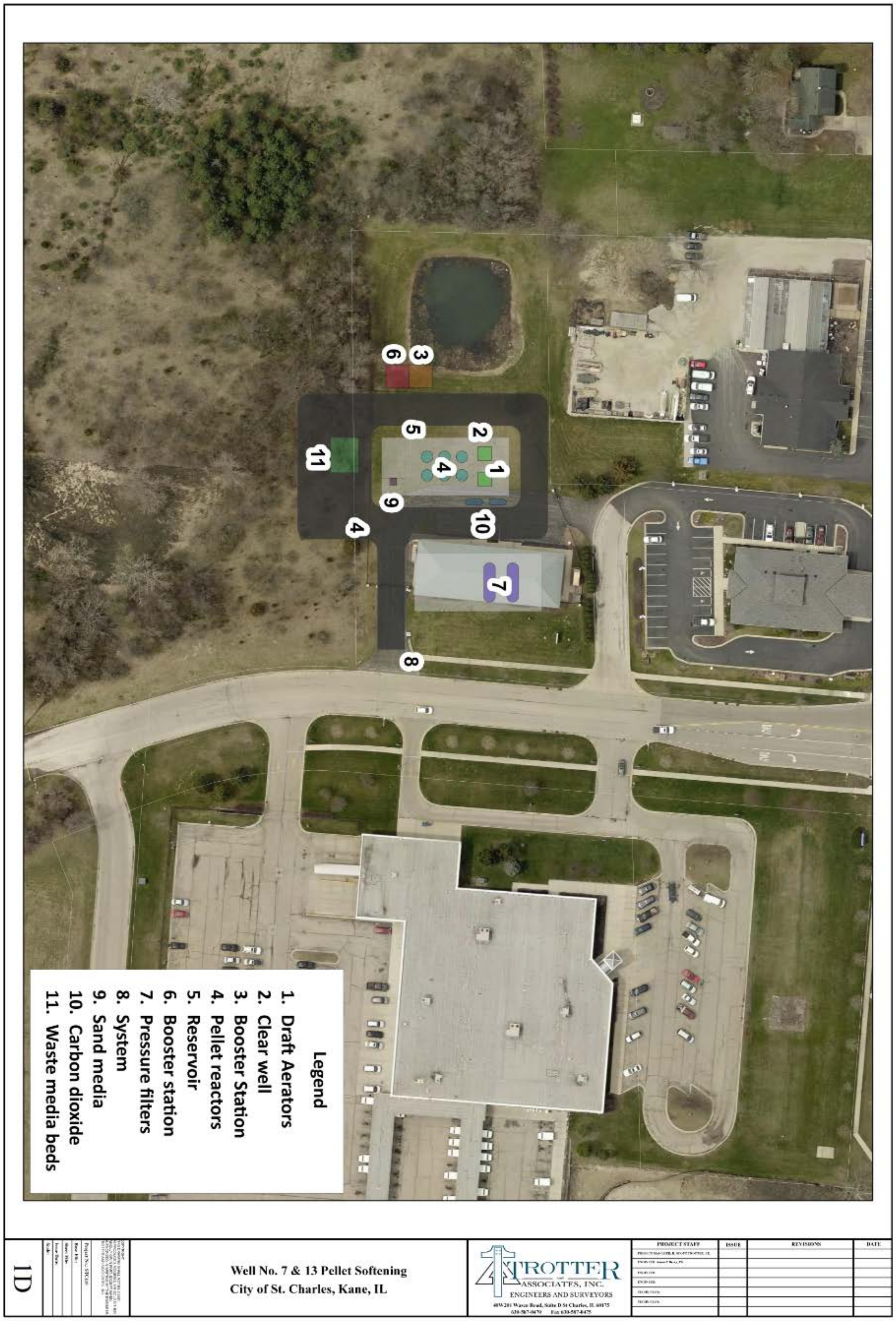


Similar to the nanofiltration facility, roughly four acres of land would need to be acquired to build the pelletizing facility to serve both Wells #7 & 13. The existing Oak Street facility would be expanded and used as final pressure filtration.

Alternative #1D - Pellet Softening at Well #7/13 Common Plant	
Description	Total Probable Cost
SUMMARY	
LAND ACQUISITION	$400,000
GENERAL CONDITIONS	$1,179,869
SITEWORK	$853,925
INDUCED DRAFT AERATOR	$210,000
CLEAR WELLS	$2,230,000
PELLET SOFTENING PLANT	$6,749,720
SUBTOTAL CONSTRUCTION	**$11,623,514**
CONTINGENCY @ 20%	$2,324,703
ENGINEERING & ADMINISTRATION @ 15%	$2,092,233
PROBABLE PROJECT COST:	**$16,040,450**

The operation and maintenance costs associated with the pelletizing process are relatively minimal. The greatest expense is the caustic soda utilized to increase the pH prior to entering the reactors, with nearly 1,000 lbs a day being added. Carbon dioxide is injected downstream of the reactors to bring the pH back within acceptable levels prior to filtration. The facility would likely need to be staffed approximately 20 hours per week, and similar power consumption with two sets of boosting pumps is expected. The waste media generated in this process is significantly less voluminous than lime softening with only two tons per day discharged. This waste media is blown down to exterior drying beds where it is hauled and used as a nutrient. The total annual O&M cost of the pelletizing plant is estimated at $350,000 or $0.64 per 1,000 gallons produced.

Alternative #1D - Well #7/13 Pelletizing Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	0	lbs	$ 0.05	$ -
Carbon Dioxide	0.30	tons	$ 128.00	$ 14,016.00
Calcium Hydroxide	0	lbs	$ 0.15	$ -
Sodium Hydroxide (50%)	1,001	lbs	$ 0.31	$ 113,263.15
Sulfuric Acid (93%)	0.00	gallons	$ 2.50	$ -
Antiscalant	0.00	gallons	$ 2.50	$ -
Sand Media	46	lbs	$ 0.10	$ 1,696.46
			Total Annual Chemical Cost:	$ 128,975.61
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 84,096.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	20	Hour	$ 100.00	$ 104,000.00
			Total Annual Power Cost:	$ 104,000.00
Waste Stream	**Daily Production**		**Cost/ton**	**Annual Cost**
Media Blowdown	2	tons	$ 40.00	$ 33,580.00
			Total Annual Waste Stream Cost:	$ 33,580.00
			Total Annual O&M Cost:	**$ 350,651.61**
			Cost per Thousand Gallons:	**$ 0.64**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 5,998,200		20	$ 299,910.00
Structures	$ 11,897,332		50	$ 237,946.65
			Total Annual Depreciation:	$ 537,856.65


Legend
1. Draft Aerators
2. Clear well
3. Booster Station
4. Pellet reactors
5. Reservoir
6. Booster station
7. Pressure filters
8. System
9. Sand media
10. Carbon dioxide
11. Waste media beds
Well No. 7 & 13 Pellet Softening
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7.2.5. Alternative #1E – Well #7/13 Pelletizing/Ion-Exchange

A final softening alternative was developed while evaluating the limitations of the pelletizing and ion-exchange processes. While ion-exchange is the simplest and most proven technology, it cannot be implemented on the full forward flow due to the chlorides generated in the regeneration waste. Pelletizing is also advantageous from a capital and operational cost perspective, but cannot remove large quantities of magnesium hardness. Therefore, a combination of these two alternatives was developed.

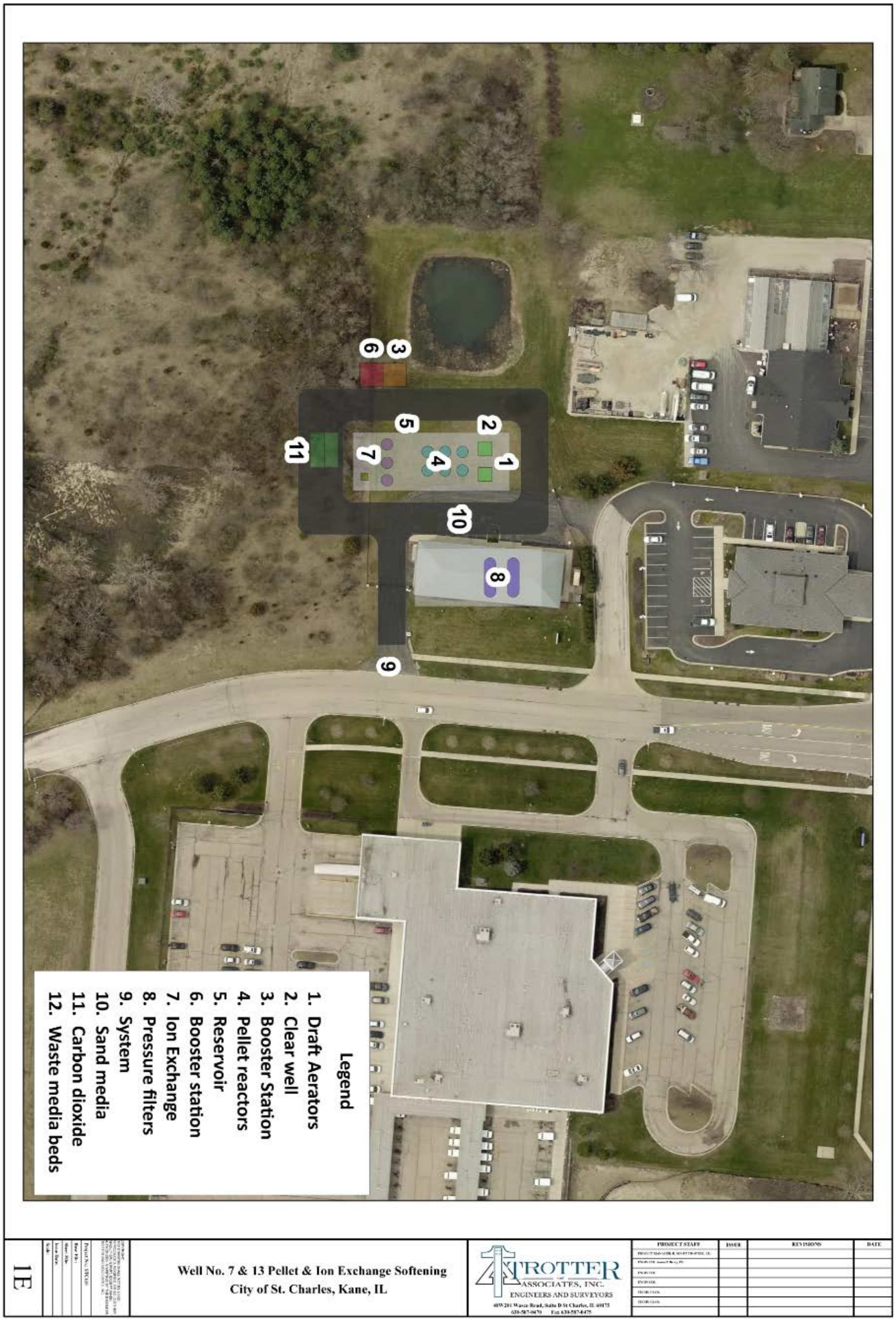
The process would work similar to Alternative #1D through the pelletizing plant, but following the pellet reactors a portion of the treated water would be sent to an ion-exchange process. The water flowing out of the pelletizing portion will likely have hardness concentrations from 200-250 mg/L. The majority of this will be the magnesium hardness, but ion-exchange is capable of removing either calcium or magnesium hardness. Therefore, the ion-exchange process would only need to treat approximately 40% of the flow to remove an additional 70-120 mg/L of hardness to the desired final effluent hardness of 130 mg/L.

In treating only an average daily flow of less than 600,000 gallons through ion-exchange, and treating a flow with concentration of 230 mg/L hardness on average, significantly less chlorides would be generated during regeneration of the resin. If City-wide softening was implemented with this combination facility at both 7/13 and 9/11 it is estimated that the chlorides tributary to the WWTP's would be approximately 260 mg/L or less if all residential water softeners were removed from service. If residential softeners were not removed from service, the additional ion-exchange chlorides load would increase the concentration in the WWTP effluent to nearly 600 mg/L. Therefore, if this option is selected a concerted effort would be needed to remove residential water softeners from service.

Alternative #1E - Pellet/Ion Combination at Well #7/13 Common Plant		
Description		Total Probable Cost
SUMMARY		
LAND ACQUISITION		$400,000
GENERAL CONDITIONS		$1,495,019
SITEWORK		$853,925
INDUCED DRAFT AERATOR		$210,000
CLEAR WELLS		$2,970,000
PELLET SOFTENING PLANT		$8,874,720
	SUBTOTAL CONSTRUCTION	**$14,803,664**
	CONTINGENCY @ 20%	$2,960,733
	ENGINEERING & ADMINISTRATION @ 15%	$2,664,660
	PROBABLE PROJECT COST:	**$20,429,057**

The operational costs associated with a combined pelletizing and ion-exchange softening plant would be very similar to that of a strictly pelletizing plant, with the addition of salt brine for the 40% forward flow ion-exchange as well as the regeneration waste from the ion-exchange process. Roughly 25% of the salt brine is required as the direct ion exchange Alternative #1A as less than half of the flow is being treated, and the flow treated has a reduced hardness in the 200-250 mg/L range as it was already partially softened by the pelletizing process. The total estimated annual O&M cost for this combined process is $420,000 or $0.77 per 1,000 gallons treated.

Alternative #1E - Well #7/13 Pelletizing/Ion Exchange Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	2,400	lbs	$ 0.05	$ 43,800.00
Carbon Dioxide	0.30	tons	$ 128.00	$ 14,016.00
Calcium Hydroxide	0	lbs	$ 0.15	$ -
Sodium Hydroxide (50%)	1,001	lbs	$ 0.31	$ 113,263.15
Sulfuric Acid (93%)	0.00	gallons	$ 2.50	$ -
Antiscalant	0.00	gallons	$ 2.50	$ -
Sand Media	46	lbs	$ 0.10	$ 1,696.46
			Total Annual Chemical Cost:	$ 172,775.61
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 84,096.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	20	Hour	$ 100.00	$ 104,000.00
			Total Annual Power Cost:	$ 104,000.00
Waste Stream	**Daily Production**		**Cost/ton**	**Annual Cost**
Media Blowdown	2	tons	$ 40.00	$ 33,580.00
3% of Forward Flow	18,000	Gallons	$ 3.74	$ 24,571.80
			Total Annual Waste Stream Cost:	$ 58,151.80
			Total Annual O&M Cost:	**$ 419,023.41**
			Cost per Thousand Gallons:	**$ 0.77**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 7,198,200		20	$ 359,910.00
Structures	$ 14,513,512		50	$ 290,270.25
			Total Annual Depreciation:	$ 650,180.25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Legend
1. Draft Aerators
2. Clear well
3. Booster Station
4. Pellet reactors
5. Reservoir
6. Booster station
7. Ion Exchange
8. Pressure filters
9. System
10. Sand media
11. Carbon dioxide
12. Waste media beds
Well No. 7 & 13 Pellet & Ion Exchange Softening
City of St. Charles, Kane, IL
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7.2.6. Life Cycle Costs of Selected Alternatives

In order to evaluate the life cycle costs of each of the alternatives, the following tables were constructed. The two tables represent the alternatives for Well #7 & 13 with and without the 20% conceptual contingency to create the anticipated range of construction costs. It should be noted that these estimated costs include engineering and legal/administrative, which is estimated at 15% of the construction total. The annual operating and maintenance costs for each facility are totalized over the 20 years cycle, with depreciation removed. The estimated life-cycle cost ranges are as follows:

- Alternative #1A Ion-Exchange - $18.5 – 20.6M
- Alternative #1B Nanofiltration - $41.6 – 46.6M
- Alternative #1C Lime Softening - $60.4 – 65.5M
- Alternative #1D Pellet Softening - $24.6 – 27.6M
- Alternative #1E Pellet/IEX Softening - $28.7 – 33.4M

Well #7/13 Combined Softening Facility (W/O Contingency)			
Softening Process	**Capital Cost**	**Annual O&M**	**Life Cycle Cost**
Ion Exchange	**$8,561,182**	$295,929.50	$14,479,772
Nanofiltration	**$25,418,919**	$615,427.72	$37,727,473
Lime Softening	**$28,430,817**	$1,535,163.01	$59,134,078
Pellet Softening	**$13,715,747**	$350,651.61	$20,728,779
Pellet/IEX Softening	**$17,468,324**	$419,023.41	$25,848,792

Well #7/13 Combined Softening Facility (W/ 20% Contingency)			
Softening Process	**Capital Cost**	**Annual O&M**	**Life Cycle Cost**
Ion Exchange	**$10,012,230**	$295,929.50	$15,930,820
Nanofiltration	**$29,727,210**	$615,427.72	$42,035,764
Lime Softening	**$33,249,600**	$1,535,163.01	$63,952,860
Pellet Softening	**$16,040,450**	$350,651.61	$23,053,482
Pellet/IEX Softening	**$20,429,057**	$419,023.41	$28,809,525

7.3. Alternatives for Softening Well #9 & 11

The same five softening process and combination of processes were reviewed for a common softening plant for Wells #9 & 11. These two wells are located on Illinois Route 25, approximately 1,000 feet from each other. The land surrounding Well #9 would not be suitable for a common softening plant as it is located within the 100 year regulated floodplain. The Well #11 site may have a small portion of land available directly east of the existing reservoir and booster station, however it is anticipated that this space would only be able to accommodate the softening process with the smallest footprint, ion-exchange. As a result the remainder of the alternatives have been conceptually site on an 18-acre plot directly north of the Q Center, west of Route 25. This land is owned by the Kane County Forest Preserve.

Utilizing this land would require pumping both wells to the common facility, with a 3,800 linear foot transmission main installed along Route 25 to the site. Each of the alternatives would be able to fit on the site outlined, and would likely only require use of the cleared land near the southeast corner of the property. While other properties may be available in the immediate area, an evaluation would be required to investigate protected areas, wetlands, and floodplains common along the Fox River and tributary waterways.

7.3.1. Alternative #2A – Well #9/11 Ion-Exchange Softening

As previously discussed, the ion-exchange facility would likely fit on the plot of land directly east of the existing Well #11 reservoir/booster station. The only structure required would be approximately 70 ft north/south and 150 ft east/west. Part of this land is currently owned by the City, and the remaining +/- 1.0 acre would need to be acquired from the adjacent St. Charles Country Club. The process flow would be identical to the Well 7 & 13 common IEX facility, however additional pressure filters would not be required as the iron and magnesium concentrations at Wells #9 & 11 are significantly lower.

Alternative #2A - Ion Exchange Softening at Well #9/11 Common Plant		
Description		Total Probable Cost
	SUMMARY	
LAND ACQUISITION		$100,000
GENERAL CONDITIONS		$1,073,289
SITE WORK		$1,116,325
WELL #9 & 11 TO WATER PLANT		$737,000
ION EXCHANGE PLANT		$5,603,849
	Construction Sub-Total	**$8,630,463**
	Contingency @ 20%	$1,726,093
	Engineering & Administration @ 15%	$1,553,483
	PROBABLE PROJECT COST:	**$11,910,039**

The operational costs would be similar to the Well #7 & 13 annual maintenance cost, with some additional depreciation due to the larger facility footprint (Oak Street Building reused and therefore no capital/depreciation associated with it). The total estimated annual O&M cost is $300,000 or $0.54 per 1,000 gallons of water produced.

Alternative #2A - Well #9/11 Ion Exchange Facilitiy O&M Costs						
Chemical	**Daily Usage**		**Cost/Unit**		**Annual Cost**	
Salt Brine	10,000	lbs	$	0.05	$	182,500.00
Carbon Dioxide	0	gallons	$	0.85	$	-
Calcium Hydroxide	0	lbs	$	0.15	$	-
Sodium Hydroxide (50%)	0	lbs	$	0.31	$	-
Sulfuric Acid (93%)	0.00	gallons	$	2.50	$	-
Antiscalant	0.00	gallons	$	9.00	$	-
Sand Media	0	lbs	$	0.10	$	-
				Total Annual Chemical Cost:	$	182,500.00
Power	**Daily Usage**		**Cost/Unit**		**Annual Cost**	
-						
				Total Annual Power Cost:	$	-
Labor	**Hours per Week**		**Cost/Hour**		**Annual Cost**	
Operations	10	Hours	$	100.00	$	52,000.00
				Total Annual Labor Cost:	$	52,000.00
Waste Stream	**Daily Production**		**Cost/1,000 Gal**		**Annual Cost**	
3% of Forward Flow	45,000	Gallons	$	3.74	$	61,429.50
				Total Annual Waste Stream Cost:	$	61,429.50
				Total Annual O&M Cost:	**$**	**295,929.50**
				Cost per Thousand Gallons:	**$**	**0.54**
Depreciation	**Value**		**Service Life**		**Annual Cost**	
Equipment	$	3,185,000	20		$	159,250.00
Structures	$	7,171,556	50		$	143,431.12
				Total Annual Depreciation:	$	302,681.12


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Legend
1. Reservoir
2. Ion Exchange
3. System
2A
Well No. 11 Ion Exchange
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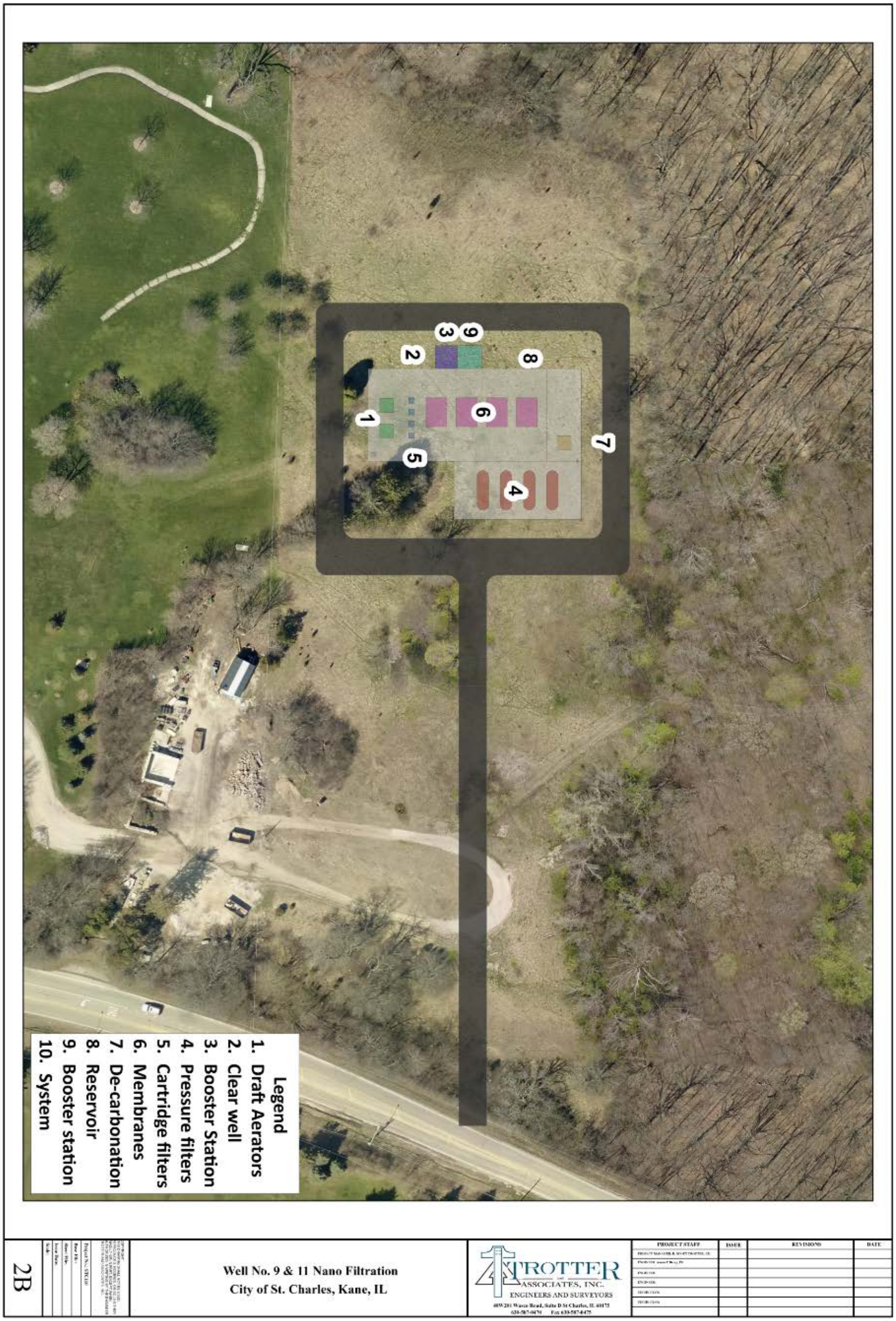
7.3.2. Alternative #2B – Well #9/11 Nanofiltration Softening

The nanofiltration process would proceed the same as the Well #7 & 13 membrane treatment facility, but would likely only require four pressure filters. This is a result of the reduced iron and manganese concentrations of the shallow source wells. It is anticipated that four pressure filters operating at a higher loading rate would be able to achieve removal levels consistent with the eight pressure filters required at Well #7 & 13. The operational costs would be nearly identical with an estimated O&M of $615,000 or $1.12 per 1,000 gallons produced.

Alternative #2B - Nanofiltration at Well #9/11 Common Plant	
Description	Total Probable Cost
SUMMARY	
LAND ACQUISITION	$400,000
GENERAL CONDITIONS	$2,608,366
SITEWORK	$3,123,675
WELL #9 & 11 TO WATER PLANT	$2,574,200
INDUCED DRAFT AERATOR	$210,000
RAW WATER RESERVOIR	$1,880,000
PRESSURE FILTRATION	$5,447,460
MEMBRANE SYSTEM	$7,060,720
FINISHED WATER RESERVOIR	$1,880,000
SUBTOTAL CONSTRUCTION	**$25,184,421**
CONTINGENCY @ 20%	**$5,036,884**
ENGINEERING & ADMINISTRATION @ 15%	**$4,533,196**
PROBABLE PROJECT COST:	**$34,754,501**

Alternative #2B - Well #9/11 Nanofiltration Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	0	lbs	$ 0.05	$ -
Carbon Dioxide	28	gallons	$ 0.85	$ 8,687.00
Calcium Hydroxide	0	lbs	$ 0.15	$ -
Sodium Hydroxide (50%)	0	lbs	$ 0.31	$ -
Sulfuric Acid (93%)	0.92	gallons	$ 2.50	$ 834.97
Antiscalant	5.55	gallons	$ 9.00	$ 18,231.75
Sand Media	0	lbs	$ 0.10	$ -
			Total Annual Chemical Cost:	$ 27,753.72
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Filter Booster Pumps	1,440	kW	$ 0.08	$ 42,048.00
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 126,144.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	10	Hours	$ 100.00	$ 52,000.00
			Total Annual Power Cost:	$ 52,000.00
Waste Stream	**Daily Production**		**Cost/1,000 Gal**	**Annual Cost**
20% of Forward Flow	300,000	Gallons	$ 3.74	$ 409,530.00
			Total Annual Waste Stream Cost:	$ 409,530.00
			Total Annual O&M Cost:	**$ 615,427.72**
			Cost per Thousand Gallons:	**$ 1.12**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Membrane Replacement	$ 1,440,000		5	$ 288,000.00
Equipment	$ 8,336,900		20	$ 416,845.00
Structures	$ 21,884,405		50	$ 437,688.11
			Total Annual Depreciation:	$1,142,533.11


Legend
1. Draft Aerators
2. Clear well
3. Booster Station
4. Pressure filters
5. Cartridge filters
6. Membranes
7. De-carbonation
8. Reservoir
9. Booster station
10. System
Well No. 9 & 11 Nano Filtration
City of St. Charles, Kane, IL
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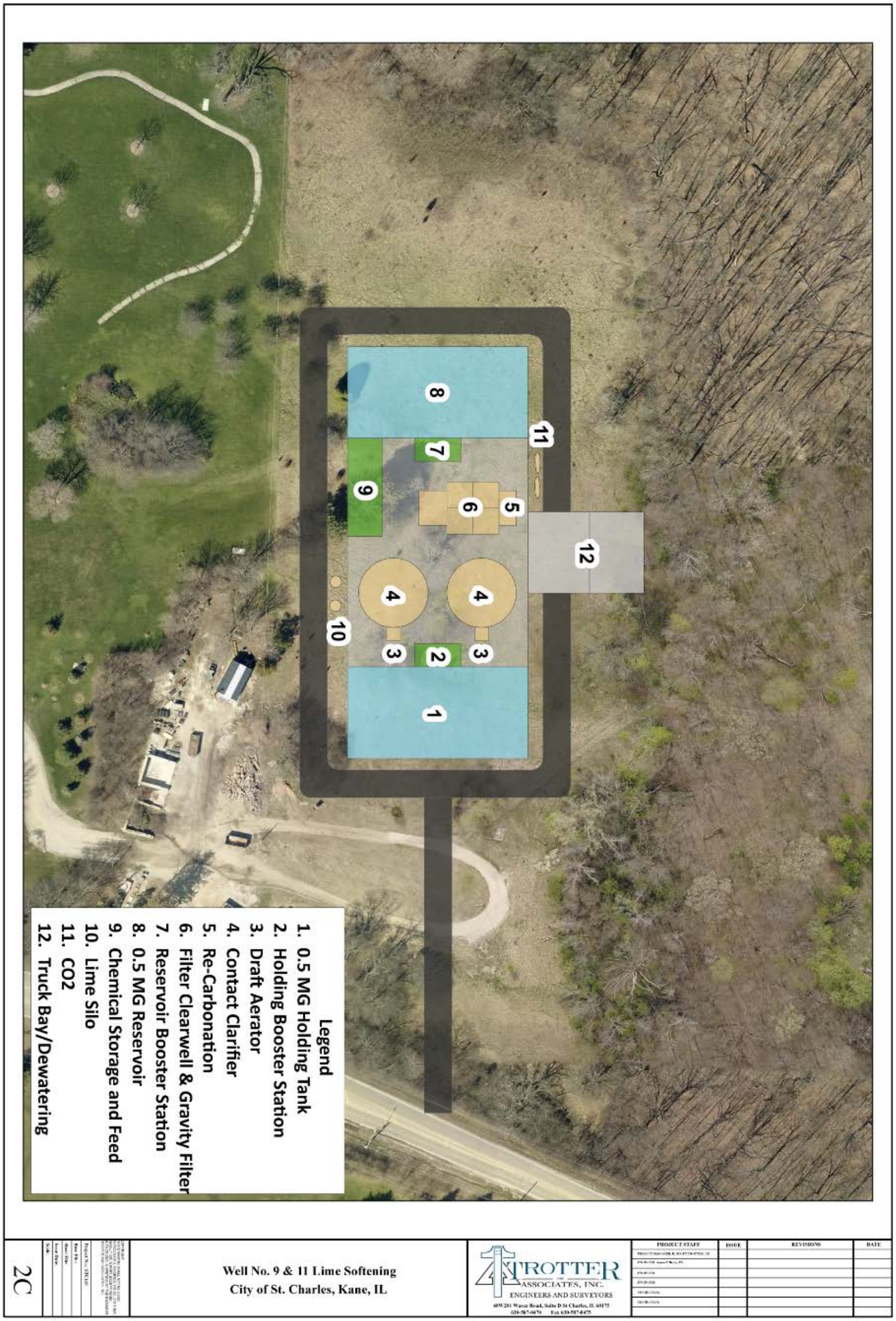
7.3.3. Alternative #2C – Well #9/11 Lime Softening

The lime softening facility has the largest footprint and would require a minimal land acquisition of 10-12 acres to allow for construction and ultimately ring roads around the facility. Again, the process flow would be identical to the Well #7 & 13 layout with the only major difference being the required construction of dewatering facilities onsite. In the Well #7 & 13 Alternative #1C the dewatering equipment and truck bays were constructed within the existing Oak Street building with new gravity filtration in the softening plant. At the Well #9/13 site either a dewatering building or drying beds would be required as there are no existing facilities on site. The estimated annual O&M costs are approximately $940,000 or $2.80 per 1,000 gallons produced. This is largely driven by the required 24/7 staffing and sludge handling/disposal costs.

Alternative #2C - Lime Softening at Well #9/11 Common Plant	
Description	Total Probable Cost
SUMMARY	
LAND ACQUISITION	$1,100,000
GENERAL CONDITIONS	$3,088,248
SITEWORK	$1,392,425
WELL #9 & 11 TO WATER PLANT	$3,185,200
INDUCED DRAFT AERATOR	$210,000
SOLIDS CONTACT CLARIFIERS	$2,650,000
RE-CARBONATION	$320,000
GRAVITY FILTERS	$1,985,000
DISINFECTION	$250,000
FINISHED WATER RESERVOIR	$3,058,000
TREATMENT BUILDING	$7,838,830
DEWATERING BUILDING (100' x 70')	$5,649,165
SUBTOTAL CONSTRUCTION	**$30,726,869**
CONTINGENCY @ 20%	$6,145,374
ENGINEERING & ADMINSTRATION @ 15%	$5,530,836
PROBABLE PROJECT COST:	**$42,403,079**

Alternative #2C - Well #9/11 Lime Softening Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	0	lbs	$ 0.05	$ -
Carbon Dioxide	28	gallons	$ 0.85	$ 8,687.00
Calcium Hydroxide	4,000	lbs	$ 0.15	$ 219,000.00
Sodium Hydroxide (50%)	0	lbs	$ 0.31	$ -
Sulfuric Acid (93%)	1.00	gallons	$ 2.50	$ 912.50
Antiscalant	0.00	gallons	$ 2.50	$ -
Sand Media	0	lbs	$ -	$ -
			Total Annual Chemical Cost:	$ 228,599.50
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 84,096.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	168	Hours	$ 100.00	$ 873,600.00
			Total Annual Power Cost:	$ 873,600.00
Waste Stream	**Daily Production**		**Cost/Unit**	**Annual Cost**
Dewatering	4	Dry Tons	$ 140.00	$ 204,400.00
Disposal	20	Cu. Yds.	$ 20.00	$ 144,467.51
			Total Annual Waste Stream Cost:	$ 348,867.51
			Total Annual O&M Cost:	**$1,535,163.01**
			Cost per Thousand Gallons:	**$ 2.80**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 6,659,800		20	$ 332,990.00
Structures	$ 30,212,442		50	$ 604,248.84
			Total Annual Depreciation:	$ 937,238.84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Legend
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3. Draft Aerator
4. Contact Clarifier
5. Re-Carbonation
6. Filter Clearwell & Gravity Filter
7. Reservoir Booster Station
8. 0.5 MG Reservoir
9. Chemical Storage and Feed
10. Lime Silo
11. CO2
12. Truck Bay/Dewatering
Well No. 9 & 11 Lime Softening
City of St. Charles, Kane, IL
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7.3.4. Alternative #2D – Well #9/11 Pellet Softening

The Pellet softening facility at Well #9 & 11 combined plant would require the construction of an additional building similar to Oak Street to house the four pressure filters. Otherwise, this alternative is nearly identical to the Well #7 & 13 pellet softening facility. While it has a lower capital cost and one of the lowest operations cost, it would likely not remove hardness down to the 130 mg/L range desired. While nearly all of the calcium hardness could be removed through the pellet reactors, little of the magnesium hardness would be precipitated out.

Alternative #2D - Pellet Softening at Well #9/11 Common Plant		
Description		Total Probable Cost
	SUMMARY	
LAND ACQUISITION		$400,000
GENERAL CONDITIONS		$2,292,996
SITEWORK		$2,273,675
WELL #9 & 11 TO WATER PLANT		$2,544,200
INDUCED DRAFT AERATOR		$210,000
CLEAR WELLS		$2,230,000
PELLET SOFTENING PLANT		$6,603,720
PRESSURE FILTRATION		$5,447,460
	SUBTOTAL CONSTRUCTION	**$22,002,051**
	CONTINGENCY @ 20%	$4,400,410
	ENGINEERING & ADMINISTRATION @ 15%	$3,960,369
	PROBABLE PROJECT COST:	**$30,362,830**

Alternative #2D - Well #9/11 Pelletizing Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	0	lbs	$ 0.05	$ -
Carbon Dioxide	0.30	tons	$ 128.00	$ 14,016.00
Calcium Hydroxide	0	lbs	$ 0.15	$ -
Sodium Hydroxide (50%)	1,001	lbs	$ 0.31	$ 113,263.15
Sulfuric Acid (93%)	0.00	gallons	$ 2.50	$ -
Antiscalant	0.00	gallons	$ 2.50	$ -
Sand Media	46	lbs	$ 0.10	$ 1,696.46
			Total Annual Chemical Cost:	$ 128,975.61
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 84,096.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	20	Hour	$ 100.00	$ 104,000.00
			Total Annual Power Cost:	$ 104,000.00
Waste Stream	**Daily Production**		**Cost/ton**	**Annual Cost**
Media Blowdown	2	tons	$ 40.00	$ 33,580.00
			Total Annual Waste Stream Cost:	$ 33,580.00
			Total Annual O&M Cost:	**$ 350,651.61**
			Cost per Thousand Gallons:	**$ 0.64**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 7,245,700		20	$ 362,285.00
Structures	$ 19,156,761		50	$ 383,135.23
			Total Annual Depreciation:	$ 745,420.23

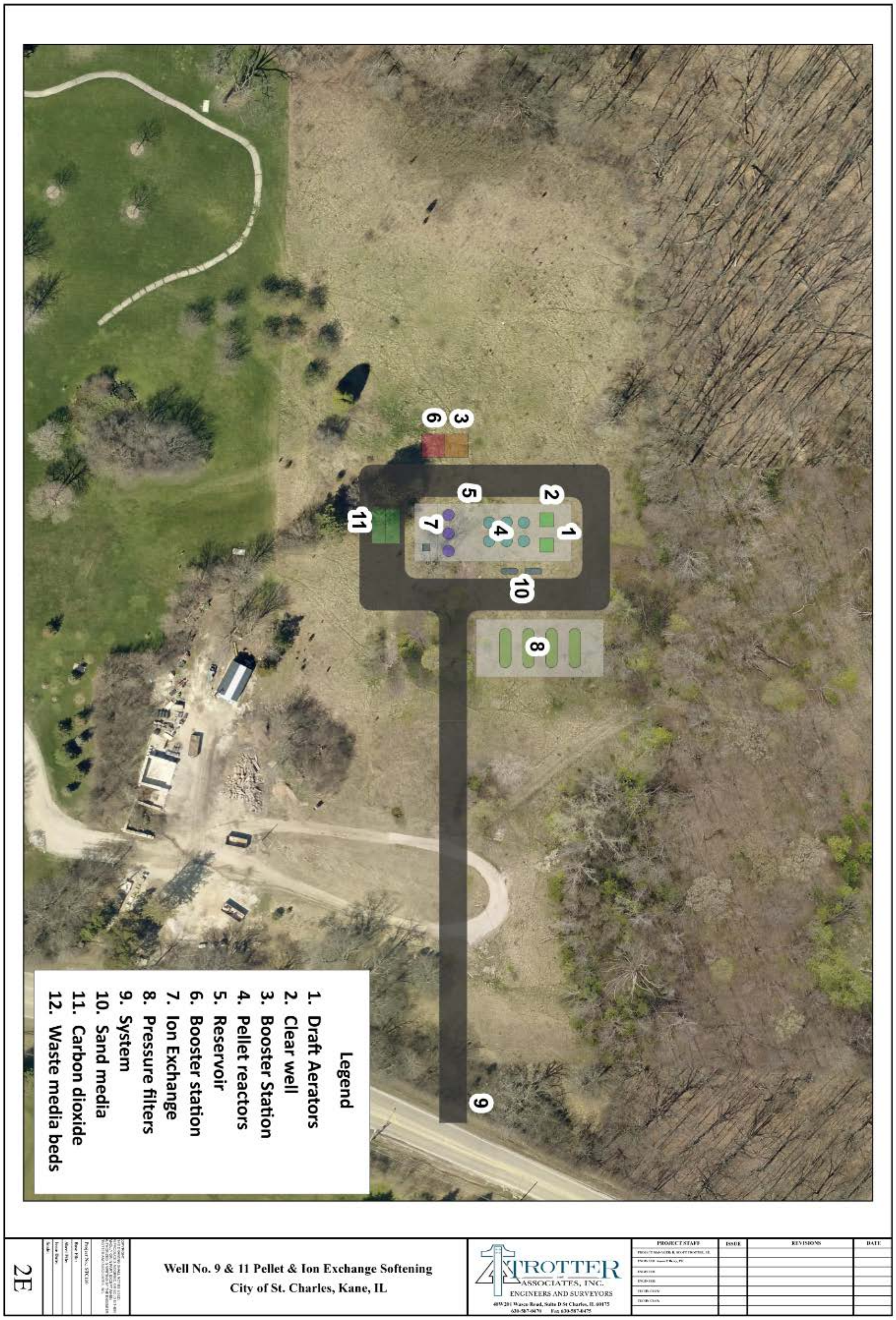

Legend
1. Draft Aerators
2. Clear well
3. Booster Station
4. Pellet reactors
5. Reservoir
6. Booster station
7. Pressure filters
8. System
9. Sand media
10. Carbon dioxide
11. Waste media beds
Well No. 9 & 11 Pellet Softening
City of St. Charles, Kane, IL
TROTTER ASSOCIATES, INC.
ENGINEERS AND SURVEYORS
2D

7.3.5. Alternative #2E – Well #9/11 Pellet/Ion-Exchange Softening

The combined pellet and ion exchange plant at Well #9 & 13 common facility would operate in the same manner as the west well's treatment plant. The full flow would be treated through the pellet reactors, with approximately 40% of the flow then entering the ion-exchange process, with the other 60% bypassed. It is anticipated that this would produce the desired 130 mg/L total hardness while minimizing the amount of chlorides generated and wasted to the WWTP's. If this facility and a common pellet/IEX facility at Well #7 & 13 was brought online, the estimated chlorides concentration at the Main WWTP would exceed 600 mg/L if no residential softeners were removed from service. Therefore, to remain below the 500 mg/L anticipated chlorides limit, a concerted effort to turn off residential water softeners would be required. The estimated annual operating cost of this facility would be $420,000 or $0.77 per 1,000 gallons.

Alternative #2E - Pellet/Ion Combination at Well #9/11 Common Plant	
Description	Total Probable Cost
SUMMARY	
LAND ACQUISITION	$400,000
GENERAL CONDITIONS	$2,534,556
SITEWORK	$2,273,675
WELL #9 & 11 TO WATER PLANT	$2,544,200
INDUCED DRAFT AERATOR	$210,000
CLEAR WELLS	$2,230,000
PELLET SOFTENING PLANT	$8,799,720
PRESSURE FILTRATION	$5,447,460
SUBTOTAL CONSTRUCTION	**$24,439,611**
CONTINGENCY @ 20%	$4,887,922
ENGINEERING & ADMINISTRATION	$4,399,130
PROBABLE PROJECT COST:	**$33,726,663**

Alternative #2E - Well #9/11 Pelletizing/Ion Exchange Facilitiy O&M Costs				
Chemical	**Daily Usage**		**Cost/Unit**	**Annual Cost**
Salt Brine	2,400	lbs	$ 0.05	$ 43,800.00
Carbon Dioxide	0.30	tons	$ 128.00	$ 14,016.00
Calcium Hydroxide	0	lbs	$ 0.15	$ -
Sodium Hydroxide (50%)	1,001	lbs	$ 0.31	$ 113,263.15
Sulfuric Acid (93%)	0.00	gallons	$ 2.50	$ -
Antiscalant	0.00	gallons	$ 2.50	$ -
Sand Media	46	lbs	$ 0.10	$ 1,696.46
			Total Annual Chemical Cost:	$ 172,775.61
Power	**Daily Usage**		**Cost/Unit**	**Annual Cost**
System Booster Pumps	2,880	kW	$ 0.08	$ 84,096.00
			Total Annual Power Cost:	$ 84,096.00
Labor	**Hours per Week**		**Cost/Hour**	**Annual Cost**
Operations	20	Hour	$ 100.00	$ 104,000.00
			Total Annual Power Cost:	$ 104,000.00
Waste Stream	**Daily Production**		**Cost/ton**	**Annual Cost**
Media Blowdown	2	tons	$ 40.00	$ 33,580.00
3% of Forward Flow	18,000	Gallons	$ 3.74	$ 24,571.80
			Total Annual Waste Stream Cost:	$ 58,151.80
			Total Annual O&M Cost:	**$ 419,023.41**
			Cost per Thousand Gallons:	**$ 0.77**
Depreciation	**Value**		**Service Life**	**Annual Cost**
Equipment	$ 8,370,700		20	$ 418,535.00
Structures	$ 20,956,833		50	$ 419,136.67
			Total Annual Depreciation:	$ 837,671.67


Legend
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City of St. Charles, Kane, IL
TROTTER
ASSOCIATES, INC.
ENGINEERS AND SURVEYORS
2E

7.3.6. Life Cycle Costs of Selected Alternatives

In order to evaluate the life cycle costs of each of the alternatives, the following tables were constructed. The two tables represent the alternatives for Well #9 & 11 with and without the 20% conceptual contingency to create the anticipated range of construction costs. It should be noted that these estimated costs include engineering and legal/administrative, which is estimated at 15% of the construction total. The annual operating and maintenance costs for each facility are totalized over the 20 years cycle, with depreciation removed. The estimated life-cycle cost ranges are as follows:

- Alternative #1A Ion-Exchange - $16.1 – 17.8M
- Alternative #1B Nanofiltration - $42.0 – 47.1M
- Alternative #1C Lime Softening - $67.0 – 73.1M
- Alternative #1D Pellet Softening - $33.0 – 37.4M
- Alternative #1E Pellet/IEX Softening - $37.2 – 42.1M

Well #9/11 Combined Softening Facility (W/O Contingency)			
Softening Process	**Capital Cost**	**Annual O&M**	**Life Cycle Cost**
Ion Exchange	**$10,183,947**	$295,929.50	$16,102,537
Nanofiltration	**$29,717,617**	$615,427.72	$42,026,171
Lime Softening	**$36,257,705**	$1,535,163.01	$66,960,965
Pellet Softening	**$25,962,420**	$350,651.61	$32,975,452
Pellet/IEX Softening	**$28,838,741**	$419,023.41	$37,219,209

Well #9/11 Combined Softening Facility (W/ 20% Contingency)			
Softening Process	**Capital Cost**	**Annual O&M**	**Life Cycle Cost**
Ion Exchange	**$11,910,039**	$295,929.50	$17,828,629
Nanofiltration	**$34,754,501**	$615,427.72	$47,063,055
Lime Softening	**$42,403,079**	$1,535,163.01	$73,106,339
Pellet Softening	**$30,362,830**	$350,651.61	$37,375,863
Pellet/IEX Softening	**$33,726,663**	$419,023.41	$42,107,131

7.4. SUMMARY

The City has reviewed a number of alternative technologies to provide Utility-scale water softening. There are significant challenges associated with each technology, specifically relating to ion-exchange treatment. During previous planning efforts ion-exchange was identified as the preferable water softening technology, however in light of recent developments on chloride limitations in wastewater effluent this option will likely no longer be a viable standalone alternative.

The table below illustrates the capital cost associated with implementing water softening at each regional facility, as well as the total utility-scale capital cost. If the City elects to continue the water softening discussion, staff may elect to pilot test any of the alternatives to determine the efficiency utilizing City water sources. Further evaluations would also be warranted to investigate the feasibility of siting a regional Well #9/11 softening facility along Route 25 at the previously described location, as well as the viability of constructing a regional Well #7/13 softening facility adjacent to the existing Oak Street Filtration Facility.

Utility Scale Softening Summary (20% Contingency)			
Softening Process	Well #7/13 Capital Cost	Well #9/11 Capital Cost	Total Capital Cost
Ion Exchange	$10,012,230	$11,910,039	**$21,922,269**
Nanofiltration	$29,727,210	$34,754,501	**$64,481,711**
Lime Softening	$33,249,600	$42,403,079	**$75,652,679**
Pellet Softening	$16,040,450	$30,362,830	**$46,403,280**
Pellet/IEX Softening	$20,429,057	$33,726,663	**$54,155,720**

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SECTION 8

RECOMMENDATIONS AND SUMMARY

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8. Recommendations and Summary

8.1. Implementation Plan

The City is responsible for providing safe and reliable water service for the communities both within the corporate boundary and in the neighboring areas. The preceding sections have described the Planning Area, the current and future capacity needs, the existing supply, storage, treatment, and distribution system infrastructure, and future improvements that should be budgeted within the duration of this Master Plan.

A significant amount of the water system equipment and distribution system has reached or has exceeded its respective service life. Diligent maintenance and operation have provided the City with exceptional equipment longevity; however, several major systems will require replacement within the next 10 years. Recommendations have been separated into two groups: annual equipment replacement and Capital Improvement Projects. Incorporating a number of items requiring replacement into a single capital project provides cost efficiencies in the form of scales of economy and consolidating contractor's costs.

The implementation schedule for capital improvements is driven by the urgency of rehabilitation and the benefit of upgrades to the system. The prioritization of large-scale capital improvements is discussed in Section 6 and smaller scale rehabilitations follow the replacement timeframe based on service life and installation year of equipment. The projects identified throughout Sections 4 and 6 are outlined in the table below. The annual expenditure included is approximately $3.0-$4.0M which can be increased or decreased according to the City's available funding.

City of St. Charles - Water Master Plan
5 Year Capital Improvements Plan

		Fiscal Year Cash Flow ($ in Millions, 2018)					
	Project Description	**2020**	**2021**	**2022**	**2023**	**2024**	**Project Total**
S	AMI Meter Implementation	1.40	1.30	1.30			***4.00***
S	10th Street Tower Re-Coating & Repairs	0.50					***0.50***
S	Well #11 Chlorine Upgrades	0.50					***0.50***
S	Well #7/13 Interconnection - Phased	5.32					***5.32***
R	Well #8 & Ohio Avenue Rehabilitation	1.68					***1.68***
R	Well #9 Rehabilitation		0.75				***0.75***
R	Well #13 Rehabilitation			0.18			***0.18***
R	Well #3/4 Rehabilitation			0.89			***0.89***
S	Galesville Well at Oak Street				3.20		***3.20***
S	Galesville Well at Well #11					3.20	***3.20***
R	Well #11 Rehabilitation					0.60	***0.60***
							0.00
	Fiscal Year Total:	**9.40**	**2.05**	**2.37**	**3.20**	**3.80**	***20.82***

S Water Supply/Storage
R Rehabilitation

8.2. Capital Funding and Alternative Funding Sources

The City of St. Charles has several different funding options available in order to successfully fund the outlined projects. Some of the different funding options include the Illinois EPA Low-Interest Loan State Revolving Fund (SRF), Bonds, and Grants.

8.2.1. Illinois EPA Low-Interest Loan State Revolving Fund (SRF)

The IEPA State Revolving Fund is a program that has been developed as a part of the Illinois Clean Water Initiative (CWI). It is this initiative that maintains the Public Water Supply Loan Program (PWSLP) which funds water distribution, supply, and storage projects, and has been doing so since the late 1980's. Each year, this program receives Federal Capital Funding which is matched with State Funds, interest earning, repayment money, and the sale of bonds. It is these funding mechanisms that are utilized by the State to form a continuous source of financing for the wastewater and stormwater projects.

The Illinois EPA Low-Interest Loan program was developed to provide financial assistance to both the public and private applications for design and construction of projects that protect or improve the quality of Illinois' water resources. In the past few years, the State has funded around $100-300 Million dollars of clean water projects at interest rates ranging from 1.75-2.21%.

A specific application process has been developed to obtain SRF funding, and requires a project nomination form, as well as planning approval of a project plan or facility plan for the community pursuing funding. The project planning report can be submitted anytime throughout the year, however an annual renewal of funding nomination forms should be sent into the State by January 31st of each year. Once a community has an approved proejct plan, additional documentation including a loan application will be completed with a financial checklist. At the point where the project has been bid, and is moved into contruction, a final loan agreement will be executed.

Each year the loan rate is established on July 1st, and a typical loan is written around a 20-year term. However, the state has recently developed additional programs to provide reduced interest rates for "small communities", and "hardship rates". Reduction of rates can also come from specific design considerations that reduce impacts on the environment and reduce the overall energy footprint. This reduction can equate to a reduction of 0.2% off the base interest rate.

8.2.2. Grants

The City may be eligible to receive grant funding from several different sources, including the Department of Commerce and Economic Opportunity (DCEO), as well as the USEPA. Each program is appropriated funds from U.S. Congress in January, and funds begin to be administered by each state in early spring. Each state receives a different allocation of funds depending on several factors that evaluate the total need. Therefore, a state in greater need of funds will be appropriated a larger quantity of funding.

Each of the different grant funding sources have numerous grants available. Typically, in both cases the grants that are obtained are tied to economic need, as well as an attempt to bring jobs and/or resources to the community. A grant that is provided to a community is typically less than $500,000, and is also matched by the community. Therefore, for a project that receives a $200,000 grant, the City would fund $200,000 as well, equating to a total project cost of $400,000.

Due to the income of neighborhoods within the service area, it is unlikely that the City would qualify for the need-based grant programs. The most applicable grant for communities such as St. Charles are energy grants, currently administered by Commonwealth Edison.

8.2.3. Bonds

Bonds can be broken into several different categories including General Obligation Bonds, Revenue bonds, and Tax Increment Financing District Funding.

General Obligation Bonds (GO)

A general obligation bond (GO) is secured through taxable property within a community and is a municipal bond that is backed by the credit and taxing power of the issuing jurisdiction. A GO bond is not issued against the revenue from a project or development. Therefore, the value of the bond is held completely against the asset value and not the amount of the utility consumed. Typically, a general obligation bond has lower interest rates as there is less risk of default and are generally used to fund projects that will serve the community, such as roads, parks, equipment, and bridges.

Revenue Bonds

A revenue bond is supported and funded by the revenue of a specific project, and/or user charge revenues. Typically, holders of revenue bonds can only rely on the specific project's income, has higher risk and pays a higher interest rate. Revenue bonds are issued in blocks of time that typically fully mature within 20 to 30 years. One disadvantage of the revenue bond is that there is inherent concern that the bond ordinance requires the establishment of reserve funds to cover the risk of revenues falling short of the retirement requirement, and this burden falls onto the users of the utility or product being purchased.

Tax Increment Financing District Funding (TIF)

A TIF district is formed within a specific boundary within the facility planning area or municipal boundary within the community. This TIF district is used to create and dedicate a source of revenue that can be used to fund and retire debt within a specific area. Typically, this type of bonding is done within an area that doesn't have infrastructure or services.

A TIF district is created prior to the development of a property and the value of the bond is set prior to the start of work. However, there is the option to add additional projects to a TIF district if it is proven that the district can withstand the added debt, the required revenues to payback the deficit, as well as sufficient time to pay it back.

The Tax Increment Allocation Redevelopment Act (TIF Act) in 1977, changed the TIF requirements and provided the ability of municipalities the power and authority to address the adverse conditions and conservation of areas within their planning areas. Municipalities are able to take redevelopment projects that were essential to the economic well-being of the community.

8.2.4. Recommended Funding for Capital Projects

A number of capital improvement projects have been identified as necessary for the continued operation and maintenance of the City's water system which range significantly in scale. The City has historically funded smaller capital improvements projects locally, utilizing available capital request funding. If the City elects to proceed with local funding of smaller scaling capital improvements, it is recommended that this include all projects under $3.0M.

The remaining capital projects in excess of $3.0-4.0M include implementation of city-wide softening and some water supply alternatives. It is recommended that the City consider funding these projects through the Illinois EPA's SRF low-interest loan program. The current interest rate is 1.84%, lower than typical bonding interest rates. Additionally, the debt service for the SRF loans could be accommodated through user rate increases, rather than property tax increases often used for funding General Obligation Bonds.

At the time of this report the City is currently under contract with Burns and McDonnell to complete an updated sewer and water rate study. It is anticipated that this will be completed in 2018, and should incorporate the recommendations of this Water Master Plan.

City of St. Charles

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