FINAL REPORT

# CITY OF GARDNER

## WATER MASTER PLAN UPDATE
## GARDNER, KANSAS

PEC PROJECT NO. 34-160422-000-7923

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# Table of Contents

# List of Tables



# List of Graphs

# List of Figures



# List of Appendices

# EXECUTIVE SUMMARY

The City of Gardner's current water supply and distribution system consists of raw water intake and pumps at Hillsdale Reservoir, Hillsdale Water Treatment Plant (WTP), high service pumps and storage reservoirs at the WTP, and storage facilities, low service/booster pump stations, and waterlines throughout the City's distribution system. Following a detailed analysis of each of the water system components, it was determined a large number of components in the system are either nearing capacity or are already under capacity to meet current maximum day (MD) demands. The system also lacks redundancy to maintain adequate operation under a large emergency event.

Table ES-1 outlines the water demands experienced from 2011 to 2015, the projected water demands through 2040, and the system's current water supply and treatment capacity. The City's existing raw water intake capacity (column 4) and existing Hillsdale WTP capacity (column 5) should be designed and upgraded to meet the maximum day demand (column 3). The subject columns and associated demands and capacities are in bold in Table ES-1.

**Table ES-1: Existing and Projected Water Demands vs. Existing Water System Capacities**

| Year | AD Demand (MGD) | Maximum Day Demand (MGD) | Existing Raw Water Intake Capacity (MGD) | Existing Hillsdale WTP Capacity (MGD) | Gardner Water Rights from Hillsdale Reservoir (MGD) |
|---|---|---|---|---|---|
| 2011-2015 | 2.36 | **4.72** | **4.32** | **4.00**[1] | 9.30 |
| 2020 | 2.60 | **5.00** | **4.32** | **4.00**[1] | 9.30 |
| 2025 | 2.95 | **5.65** | **4.32** | **4.00**[1] | 9.30 |
| 2030 | 3.34 | **6.38** | **4.32** | **4.00**[1] | 9.30 |
| 2035 | 3.78 | **7.21** | **4.32** | **4.00**[1] | 9.30 |
| 2040 | 4.28 | **8.15** | **4.32** | **4.00**[1] | 9.30 |

[1] Based on WTP operator knowledge, staff becomes uncomfortable and WTP operates inefficiently once water demands and treatment processes exceed 3.0 MGD. WTP Staff also indicated that 3.0 MGD is the maximum output they are confident in being able to produce over an extended period of time.

The City's water supply and treatment capabilities for the time period from 2011 and 2015, struggled to meet system demands and become inadequate as the City continues to see growth and increased water demands through the planning period. Additionally, the raw water transmission line from the intake structure to the WTP and the treated water transmission main from the WTP to the distribution system lack redundancy. Combined, these two transmission mains extend 7 miles and a significant emergency event to either one of the lines would cut off the City's sole source of potable water to the distribution system.

The City's distribution system is currently operated inefficiently by utilizing two low service pump stations and one booster pump station in addition to the high service pumps at the WTP. The City has adequate storage capacity in its elevated storage in the distribution system and clearwell storage at the WTP, eliminating the need for ground storage reservoirs in the system.

In order to meet current water demands, it is recommended the City immediately begin negotiations with WaterOne for a 1.0 MGD treated water supply connection with infrastructure in place to allow for supply of 2.0MGD in the future. This connection will extend the useful life of the existing WTP and provide the City with a redundant water supply source. It is anticipated the 1.0 MGD connection would be utilized to help with average day demands and the existing WTP would be used to meet peaking demands. It is also recommended the City begin planning for the construction of a new WTP to be completed within the next 10 years.

Table ES-2 outlines additional recommendations, implementation timelines, and estimated costs to improve the City's system operation, address system deficiencies, and provide long term water sustainability for the City of Gardner.

**Table E2: Recommended Improvements, Timeline and Estimated Costs**

| Item | Improvement | Approximate Recommended Implementation Date | MD System Demand When Improvements Are Needed | Estimated Project Costs |
|---|---|---|---|---|
| 1 | 1.0 MGD Connection to WaterOne | 2018 | Over 4.0 MGD (Current Conditions) | $5,400,000[1] |
| 2 | Control Valve on 183rd Street Tower | 2019 | NA | $200,000 |
| 3 | Take Kill Creek BPS Offline | 2019 | NA | NA |
| 4 | Switch SCADA Controls to Kill Creek Tower | 2019 (After completion of Item 2) | NA | NA |
| 5 | Take Above Ground and Underground Reservoirs and Associated Pump Stations Offline | After Completion of Item 1 | NA | NA |
| 6 | New 6.0 MGD WTP, HSPS, Clearwells | 2027 (With completion of Item 1) | 6.0 MGD | $42,000,000 to $50,000,000 [2] |
| 7 | Redundant 16-inch Treated Water Transmission Line | In time for new WTP Startup | 6.0 MGD | $7,150,000 |
| 8 | Redundant 8-inch (min.) Raw Waterline | In time for new WTP Startup | 6.0 MGD | $970,000 |
| 9 | Upgrade Raw Water Pump Station | In time for new WTP Startup | 6.0 MGD | $630,000 |
| 10 | Upgrade new WTP to 8.0 MGD | 2040 (With completion of Items 1 and 6) | 8.0 MGD | $7,500,000 |
| 11 | Upgrade WTP to 10.0 MGD | Beyond Planning Period/As Needed (With completion of items 1, 6, and 9) | 10.0 MGD | $7,500,000 |
| 12 | Acquire Additional Water Rights | Beyond Planning Period/As Needed | 9.3 MGD (AD) | Varies based on source and how the rights are obtained. |
| 13 | Cast Iron Pipe and AC Pipe Replacements | As Funds Allow | NA | Varies based on pipe size, locations, service connections, etc. Approx. $100 to $200 per LF. |
| 14 | Looped 12-inch Waterlines Throughout City | As Funds are Available and As Needed to Serve Future Development | NA | $550,000 per mile |

[1] Assumes 2.0 MGD SDC for 20 years and estimated costs for WaterOne infrastructure costs passed on to City.
[2] Range provided to account for potential alternative treatment processes and contingencies for a planning level cost estimate.

# 1.0 Introduction

The City of Gardner, Kansas, retained the services of Professional Engineering Consultants, P.A. (PEC) to perform a detailed analysis of the City's water supply, water treatment, and distribution system capacities and capabilities. This report includes the water use projections used to determine necessary supply and treatment capacities needed, information used to update the City's computer water model, the analysis of the model to determine system deficiencies, and the recommended supply, treatment, and distribution system improvements.

## A. Study Objective

The primary objective of this study is to determine the water supply, treatment, and distribution system improvements needed to address anticipated future conditions and projected future demands. The study will include analyzing population growth, potential system expansion, and the water system piping, pumping capabilities, and storage volumes and provide a summary of potential water system improvements that will address future conditions and any current concerns of low pressure, water age, and flows within the existing system.

The City's water system should be capable of delivering average day and peak hour demands to its customers, as well as provide adequate fire flows while meeting the maximum day demand conditions. Using these parameters, along with future needs, an analysis of the water system serving the City of Gardner will be performed to determine where problem areas may exist. Once deficiencies are determined, improvements to the system will be proposed to resolve the problem areas.

A computerized model of the City's distribution system was provided by the City and utilizes Bentley WaterGEMS software. The model will be updated as necessary, analyzed for adequate pressure, fire flow delivery, water storage, and conveyance of future flows. This study will include evaluation of any current problem areas and determine the potential effects of future demands on the existing system for the study period to 2040. This study will also include preparation of estimated costs for any recommended system improvements.

## B. Scope of Study

This study includes the following elements:

- Evaluate water use records and develop water demand projections through the year 2040.
- Evaluate existing water supply, treatment, and distribution facilities.
- Update of the City's existing computer water model to include all lines 6" and larger, and smaller lines as necessary. Update existing and projected demands.
- Determine areas not adequately served by the existing distribution system.
- Evaluate fire protection capabilities of the existing distribution system.
- Develop recommendations to address supply, treatment, flow, pressure, and fire flow deficiencies in the existing water system.
- Establish cost estimates for recommended system improvements.

## 2.0 Population Projections

To accurately analyze current system performance and improvements needed to provide for future growth, projected water usage, or demands, must be established. Completely accurate projections are difficult to achieve, but analysis of historical records and current conditions provide insight into anticipated future trends and provide reasonable estimates for system evaluation. The analysis period for this study is through the year 2040.

The City of Gardner performed a study that reviewed historical population data and included an analysis of several possible growth scenarios to establish a projected annual growth rate and project the City's population through the year 2040. The result of this study identified a projected baseline annual average growth rate of approximately 2.89% per year. Based on the annual average growth rate and the existing City population in 2015, Table 1 identifies the anticipated population projections through the year 2040.

**Table 1: Population Projections**

| Year | Population (Base Line Growth) | Population (High Line Growth) |
|---|---|---|
| 2015 | 20,868 | 20,868 |
| 2020 | 23,140 | 24,430 |
| 2025 | 25,790 | 29,000 |
| 2030 | 28,850 | 34,580 |
| 2035 | 32,440 | 41,690 |
| 2040 | 36,580 | 51,270 |

The population study also included projections of the City's growth exceeded the average growth rate experienced in the past. This higher growth rate and the corresponding population projections are also shown in Table 1.

# 3.0 Water Use Projections

Municipal water use projections are commonly determined by multiplying the projected population by the City's average daily usage per person (gallons per capita per day – GPCD). For this report, 95 GPCD will be used for water usage calculations. The background for this determination is explained in more detail later in this section. This calculation is only part of the requirements for a complete water system analysis. A water utility must also be able to supply water at varying flow rates. Yearly, monthly, daily, and hourly variations in water usage are expected. Water usage is typically higher in dry years and during summer months. Water usage also typically follows a diurnal pattern, being low at night and peaking in the early morning and late afternoon/evening. The water usage rates most important to the design and operation of a water system are the following:

- Average Day (AD)
- Maximum Day (MD)
- Peak Hour (PH)

Average Day (AD) demand is the total annual water use divided by the number of days in a year. The AD demand is used as a basis for estimating MD and PH demands. The AD demand is also typically used to estimate future supply requirements, revenues, and operating costs.

Maximum Day (MD) demand is typically the highest water usage day of the year, and typically occurs in the summer months when daily water usage is highest. The water supply facilities must be capable of supplying this quantity of water, and treatment facilities must be capable of processing this quantity of water. Additionally, the City's high service pumps must be capable of supplying this quantity of treated water to the distribution system.

Peak Hour (PH) demand is the maximum quantity of water used during any one hour of the year. Since distribution system pressures are typically the lowest during PH demands, the size and location of distribution facilities are generally determined on the basis of this condition. PH water requirements are partially met through the treated water supply system and partially met through the use of strategically located storage reservoirs. This minimizes the required capacity of transmission mains and supply pumps to allow a more uniform and economical operation of the water supply, treatment, and pumping facilities.

## A. Existing Water Rights

The City of Gardner is a founding member of the Hillsdale Area Water Cooperative (HAWC). HAWC has a contract with the State of Kansas Water Office with respect to available water supply storage in Hillsdale Lake. In addition to Gardner, the other members of HAWC are the City of Edgerton, City of Spring Hill, Franklin County RWD #1, Johnson County RWD #7, Miami County RWD #1, #2, and #4, and the City of Wellsville. Combined, the approved maximum amount of water available for purchasing under the contract is just over 5.3 billion gallons per year (BGY). This agreement is effective as of January 1, 2013 with a contract length of 40 years.

Of this 5.3 BGY, the City of Gardner is allocated 63.95% of the available water rights, as outlined in the HAWC Interlocal Cooperation Agreement. Therefore, the City of Gardner's available water rights from Hillsdale Lake are just over 3.38 BGY, or approximately 9.3 MGD. Additionally, in the event of an approved reallocation of water rights by the HAWC members, minimum exit quantities have been put in place as part of this agreement. Gardner's water rights allocation cannot be dropped below 82.43% of its current allocation, or cannot be dropped below 2.8 BGY. This calculates to approximately 7.65 MGD.

If any reduction in total water rights to the HAWC is required by any regulatory agency, per the agreement, any such regulatory actions shall be applied pro-rata for all members, meaning the percentage of total water rights available remain unchanged, even though the actual volume of available water may be decreased.

In addition to the water rights at Hillsdale Lake, and as indicated in the Gardner Water Supply & Treatment Plant Study completed in 2008, the City had water rights at Gardner Lake totaling approximately 1.7 MGD. This water was treated at the Gardner Water Treatment Plant (WTP), which was abandoned in 2005. However, following a review of the City's water rights in Gardner Lake it appears the City is only authorized for approximately 295 MILLION GALLONS PER year (MGY), or approximately 0.8 MGD of this 295 MGY, and as of January 2017, approximately 195 MGY have been pulled for the City for water right violation. This leaves 100 MGY, or 0.27 MGD, available for municipal use.

## B. Past Trends of Water Use

Historical water usage information is important in the analysis of a city's water system. Accurate historical data is needed to establish trends to reasonably predict future demands and system needs. The City provided water usage reports dating back to 2005. Years 2011 through 2015 were reviewed in detail to determine average annual water usage, allowing the AD demand to be calculated.

The total AD demand was determined by taking the total amount of raw water diverted/purchased from Hillsdale Lake, and dividing by 365 days. The City of Gardner has one large water user, the New Century AirCenter, that accounts for 10% to 20% of the total water used. The total AD demand and the AD demand for New Century are shown in Table 2.

The AD demand for New Century was subtracted from the total AD demand, and the resulting number was divided by the historical population in each year to determine the average daily usage per person. The total AD demand, New Century AD Demand, historical population, and average daily usage per person is shown in Table 2.

**Table 2: Historical Water Usage**

| Year | Raw Water Purchased/Diverted Million Gallons (MG) | Total AD Demand (MGD) | Total Water Purchased by New Centrury (MG) | New Century AD Demand (MGD) | Population | Average Daily Usage Per Person (GPCD)[1] |
|---|---|---|---|---|---|---|
| 2011 | 795.23 | 2.18 | 66.51 | 0.18 | 20,121 | 99 |
| 2012 | 836.14 | 2.29 | 74.62 | 0.20 | 20,318 | 102 |
| 2013 | 745.75 | 2.04 | 81.88 | 0.22 | 20,473 | 89 |
| 2014 | 753.23 | 2.06 | 93.26 | 0.26 | 20,667 | 87 |
| 2015 | 672.61 | 1.84 | 100.74 | 0.28 | 20,868 | 75 |
| **Average** | **760.59** | **2.08** | **N/A** | **N/A** | **N/A** | **91** |

[1] Does not include New Century Usage

Demands are typically higher in the summer months when compared to the remaining months of the year and water usage is also typically directly affected by the amount of precipitation received. As Table 2 shows, there were higher water demands during 2011 and 2012 which were years that experienced well below average precipitation. Years 2013 and 2014 were slightly below the average annual precipitation while 2015 experienced precipitation well above average. To be conservative and account for potentially drier years, an average daily usage per person of 95 GPCD will be used to determine future water projections.

In addition to the annual water use reports, the City provided daily meter readings from the Hillsdale WTP for the amount of water discharged from the plant and pumped to the distribution system. The daily pumping records were reviewed to calculate the average daily demand and determine the MD demand. The MD demand was divided by the AD demand to calculate a peaking factor. The calculated factor MD demand is 2.0 and will be utilized for the purpose of this study.

Peak hourly demands are experienced during daily high usage periods. Typically, these periods occur in the morning when residents are getting ready for work and in the evening when residents return home. The highest PH demand generally occurs in conjunction with a maximum usage summer day. Actual peak hourly usage data was not available. However, the typical peaking factor between PH and AD demands is 3.0 for cities similar in size to Gardner. For the purposes of this study, the factor of 3.0 will be used.

## C. Large Water Users

As discussed previously, the City of Gardner has one large water user that will be evaluated separately. The New Century AirCenter has an agreement with the City that requires the City to be able to deliver no less than 200,000 gallons per day at a rate of no less than 500 gallons per minute (GPM). The historical water demand for New Century is shown in Table 2.

Table 2 shows that the total and average usage by New Century is steadily increasing each year. For the purposes of this study, it is assumed that the usage by New Century will continue to increase approximately 0.02 MGD per year through the planning period. Additionally, when comparing the higher usage months to the average usage months, a peaking factor of 1.5 was calculated for MD demands. The MD demand will also be assumed for the PH demand at New Century, since the quantity and flow rate of water will not see large fluctuations due to utilization of an onsite water storage tank that receives the flow from the City.

## D. Water Loss

As with most municipal water systems, the City of Gardner experiences some amount of water loss. Water loss is the difference between the water entering the supply system from the raw water pumps at Hillsdale Lake and water sold. Inaccurate or old, deteriorating meters that do not register flows accurately sometimes account for significant water loss. All systems experience some water loss as an ordinary part of operation. Water loss is also called “unaccounted for water” to distinguish it from losses that occur for known reasons, such as for water treatment processes or hydrant flushing. Amounts of unaccounted water usage are typically expressed as a percentage of the total amount pumped and/or purchased. The American Water Works Association (AWWA) recommends that water loss be maintained at 10% or less. For the purpose of this report, water loss is defined as the difference between the quantity of water pumped and the quantity of water sold to customers.

The amount of water unaccounted for the years 2011 through 2015 was identified in the annual water use reports provided by the City. The amount of unaccounted for water and the percent of the total water pumped is shown in Table 3.

**Table 3: Unaccounted for Water**

| Year | Unaccounted for Water (MGY) | Percent of Total Water Pumped |
|---|---|---|
| 2011 | 138.76 | 17.45% |
| 2012 | 112.43 | 13.45% |
| 2013 | 70.11 | 9.40% |
| 2014 | 70.21 | 9.32% |
| 2015 | 28.49 | 4.24% |

As shown in Table 3, the City's unaccounted for water is on a steady decline from 2011 to 2015 and is currently at a very low rate. This unaccounted-for water percentage should be monitored regularly in order to keep the overall water loss at a minimum.

## E. Projected Water Demands

To determine the projected water demands for the design year, the average daily usage per person, or per capita, must be established. The total projected annual demands are then calculated based on the per capita usage (95 GPCD) and the projected future populations that were established previously. This calculated annual demand is added to the projected New Century AirCenter demand to determine the total AD water demand. The projected demands through 2040 are shown in Table 4.

**Table 4: Projected Water Demands (Base Line Population Projections)**

| Year | Projected Population | AD Demand (City Customers, MGD) | AD Demand (New Century, MGD) | Total AD Demand (MGD) |
|---|---|---|---|---|
| 2015[1] | 20,868 | 1.98 | 0.30 | 2.28 |
| 2020 | 23,140 | 2.20 | 0.40 | 2.60 |
| 2025 | 25,790 | 2.45 | 0.50 | 2.95 |
| 2030 | 28,850 | 2.74 | 0.60 | 3.34 |
| 2035 | 32,440 | 3.08 | 0.70 | 3.78 |
| 2040 | 36,580 | 3.48 | 0.80 | 4.28 |

[1] 2015 Data based on actual water usage.

As the City continues to grow, it will attract additional industrial and commercial users. Future commercial and industrial usage is difficult to forecast. Typically, the per capita usage that includes commercial and industrial users is used for water use projections. This method assumes that as the population increases, the commercial and industrial usage will increase at the same proportion.

## F. Projected Maximum Day and Peak Hour Demands

The AD demands projected in Table 4 are useful in evaluating the adequacy of the City's water supply quantity. As previously discussed, MD and PH demands are required to analyze the actual treatment capabilities and ability of the distribution system to convey the necessary demands. By applying the previously determined factors of 2.0 and 3.0 for MD and PH, respectively, to the AD projections, these demands can be calculated and evaluated to determine the water system's ability to provide adequate flow and pressure. Additionally, the New Century AirCenter demand factor of 1.5 was applied to its AD demand and included in the MD and PH demand calculations. Table 5 summarizes the City's projected water demands through the year 2040 using base line population projections. The demands in parenthesis are projected demands if the City experiences population growth based on the high end projections in Table 4.

**Table 5: Projected Maximum Day and Peak Hour Demands**

| Year | AD Demand (MGD) | Maximum Day Demand (MGD) | Peak Hour Demand (MGD) |
|---|---|---|---|
| 2015[1] | 2.28 | 4.41 | 6.40 |
| 2020 | 2.60 (2.72) | 5.00 (5.24) | 7.19 (7.56) |
| 2025 | 2.95 (3.26) | 5.65 (6.26) | 8.10 (9.02) |
| 2030 | 3.34 (3.89) | 6.38 (7.47) | 9.12 (10.76) |
| 2035 | 3.78 (4.66) | 7.21 (8.97) | 10.30 (12.93) |
| 2040 | 4.28 (5.67) | 8.15 (10.94) | 11.63 (15.81) |

[1] 2015 Data based on actual water usage. Peak hour demand calculated using demand factor.

## G. Fire Flow Demands

The most strenuous demands on a distribution system are the flows required for fire suppression. When analyzing the system for its ability to meet fire demands, fire flows are applied in conjunction with the maximum daily demands to simulate a worst case scenario. In order for the system to be considered capable of providing the required fire flow, the pressure at any point within the system cannot drop below 20 pounds per square inch (psi). This is the minimum residual pressure required by the Kansas Department of Health and Environment (KDHE) at any time in a distribution system.

The minimum requirement of 20 psi is intended to prevent a vacuum from being created within the distribution system. If a vacuum is created, meaning negative pressures occur in the system, pipes can collapse and water can be drawn into the distribution system from the soil around the pipes or other potential contamination sources. This situation results in main breaks and potential contamination of the water in the distribution system. This condition is most likely to occur under high flow conditions, particularly fire flows.

Currently the Insurance Services Offices of Kansas (ISO) is the review agency for developing guidelines for fire insurance ratings for the communities. The ISO will typically determine Fire Flow Demands for various sectors of a city as part of their evaluation of the City's fire protection capabilities.

Per standard ISO requirements, a single story 1,500 square foot home of wood frame construction has a required fire flow of 1,045 GPM, and the minimum allowable fire flow is 500. For purposes of this model, a fire flow requirement of 3,000 GPM will be assumed for industrial and heavy commercial areas, 2,000 GPM for light commercial areas, and 1,000 GPM for residential areas.

# 4.0 Existing Water Supply, Treatment, and Distribution System

## A. General

The City's existing water system consists of a raw water intake structure at Hillsdale Lake, raw water pumps, WTP, ground storage, elevated storage, and high service and low service pumps. The distribution system also includes over 125 miles of water mains and over 1,100 fire hydrants. Figure 1 shows the existing distribution system. The raw water intake and water treatment plant are located approximately 7 miles and 5 miles south, respectively, of the Gardner city limits along Moonlight Road.

## B. Water Supply

1. The City's raw water intake structure is approximately 45 feet deep and consists of three (3) intake pipes that extend out into Hillsdale Lake at three (3) different elevations. The intake structure also consists of three (3) submersible constant speed pumps designed to provide 1,500 GPM at 190 feet total dynamic head (TDH). The raw water pumps convey water approximately two (2) miles through a 16-inch water line to the existing WTP. The flow into the plant is controlled by an actuated valve near the treatment plant based on the amount of influent water needed to meet the current discharge demands.

2. Downstream of the raw water pumps sodium permanganate is injected into the raw water and chlorine dioxide is fed prior to entering the WTP. The sodium permanganate is an oxidant commonly used to treat iron and manganese and can also be used to control zebra mussels. Chlorine dioxide is commonly used to address taste and odor issues and also aides in the removal of iron and manganese.

3. In addition to the raw water supply, the City currently has an emergency water supply agreement in place with Johnson County RWD #7. The agreement is outdated by its reference to Gardner Lake and Gardner Lake WTP and does not stipulate the volume, quantity, flow rate, or pressures required or available from either side in an emergency event. Based on City Staff knowledge, this connection does not have the pressure of flow capabilities necessary to act as an emergency source of water. Johnson County RWD #7 will not be considered a viable option for an alternative source of water. Additionally, it is recommended the City reevaluate and renegotiate the agreement to depict current conditions.

## C. Water Treatment Plant

1. The City of Gardner currently operates one (1) water treatment plant to provide its sole source of water to the City's water customers, the Hillsdale WTP. The treatment plant is located approximately 5 miles south of the Gardner city limits along Moonlight Road and is a single stage water softening treatment plant with a design peaking capacity of 4.0 MGD. A schematic diagram of the WTP process is included in the technical memorandum in Appendix A. The schematic was included with the WTP operation and maintenance manual provided by the Larkin Group following design and construction of the plant. While the design peaking capacity is 4.0 MGD, based on operator knowledge, the WTP can't produce more than 3.8 MGD and the operators are uncomfortable with the plant operation was the treatment capacity exceeds 3.0 MGD.

2. A summary of the WTP components from the raw water intake to the High Service Pumps are outlined below:

    i. Raw Water Intake and Pump Station
    ii. Sodium Permanganate Chemical Feed
    iii. Chlorine Dioxide Chemical Feed
    iv. Powdered Activated Carbon
    v. Carbon Contact Basin
    vi. Flash Mix Transfer Well
    vii. Primary Flash Mix
    viii. Flow Splitter
    ix. Pulsating Clarifier
    x. Filters
    xi. Clearwell Transfer Well
    xii. Chlorine Contact Basin
    xiii. 1.0 Million Gallon (MG) Clearwell
    xiv. High Service Pumps

3. A technical memorandum is included in Appendix A that provides further detail into the WTP treatment capabilities and deficiencies. The technical memorandum is based on review of the original design of the WTP, site visits to the WTP, and discussions with City staff with knowledge of the day-to-day WTP operation.

## D. Distribution System

### 1. Water Mains

The City's water distribution system consists of over 125 miles of waterlines. The original waterlines serving the City were constructed as early as the 1940s with steady growth through the 1980s. Since 1990, the City has seen significant growth and expansion of the distribution system. Figure 2 illustrates the expansion of the distribution system by indicating the ages of the existing system piping.

As the system has expanded, pipe materials used were consistent with the development of more advanced piping products. Piping installed in the system during the 1940s until the 1970s was primarily cast iron, with some asbestos cement. Older cast iron pipes were not uniform in size, were not cement lined, and often did not have good hydraulic characteristics. Newer piping materials include ductile iron and polyvinyl chloride (PVC) pipe installed since the 1970s provide a longer life span while maintaining good flow characteristics. Figure 3 illustrates the existing distribution system by pipe material. Due to the age and hydraulic characteristics it is recommended the City pursue a replacement program for existing cast iron, transite, and asbestos cement pipes.

The hydraulics of the distribution system are based on both the waterline materials that are present and their age. As pipes age, buildup occurs which reduces the effective diameter and creates poorer hydraulic flow characteristics. Roughness coefficients are assigned to pipes in the model to represent the hydraulic conditions in the pipe. Older, cast iron pipes will have a lower coefficient value to represent a reduced hydraulic capacity, while newer PVC pipes will have a higher roughness coefficient since they are able to convey more water with less resistance.

The City's distribution system consists primarily of PVC pipe which accounts for over 80% of the total length of pipe in the system. The majority of the distribution system is relatively new with over 70% of the waterlines installed after the year 1990. Finally, the system also includes a significant number of larger diameter pipes, with over 25% of the distribution system consisting of 12-inch or large diameter pipes. The combination of these three (3) attributes allow for the overall system to have very good flow characteristics.

### 2. Fire Hydrant Coverage

The City of Gardner's distribution system includes over 1,000 fire hydrants. Typically, fire hydrants are located at every block and at a spacing of 500 feet or less. Fire hydrant coverage based on a 400-foot fire hydrant radius is shown in Figure 4. In general, the City has adequate fire hydrant coverage.

## E. Distribution System Storage, Pumps, and Controls

### 1. Storage

The pressure in the City's distribution system is maintained through pumping from ground water storage reservoirs and from two (2) elevated water storage towers. In addition to maintaining pressure in the system, the water storage also provides a volume of water for flow equalization, fire flows, and emergency use.

The existing distribution system includes three ground storage reservoirs and two (2) elevated storage towers as shown in Figure 1. All of the pumps at each reservoir have back-up power generators that are intended to keep the pumps operating in the event of a power outage. The locations and physical properties of the system storage reservoirs and tanks are listed in Table 6.

**Table 6: Existing System Storage**

| Name | Volume (MG) | Type |
|---|---|---|
| WTP Clearwell | 1.00 | Ground Storage |
| Downtown Underground Storage | 0.50 | Ground Storage |
| Downtown Ground Storage | 0.50 | Ground Storage |
| 183rd Elevated Spheroid Tower | 0.50 | Elevated Storage |
| Kill Creek Elevated Tower | 1.00 | Elevated Storage |
| **TOTAL VOLUME** | **3.50** | |

### 2. High Service Pumps

The City is supplied water utilizing high service pumps at the Hillsdale WTP. The existing pumps at the WTP convey water from the 1.0 MG clearwell through an 18-inch water main to the Gardner city limits. There are a total of three (3) constant speed pumps, two (2) of which have 150 horsepower (HP) motors and are rated for 2,000 GPM at 233 ft. of head. The third pump has a 200 HP motor and is rated for 2,350 GPM at 256 ft. of head. The pump system is designed to have a maximum of two (2) pumps operating in parallel to deliver water to the distribution system with one (1) pump in standby. For design purposes, the firm pump capacity is considered the maximum available pumping rate with the largest pump out of service.

At the individual design flow rates of the pumps, the two (2) smaller pumps can deliver approximately 2.88 MGD and the larger pump can deliver approximately 3.38 MGD. When operating in parallel, the two (2) smaller pumps can deliver approximately 2,600 GPM, or 3.74 MGD. This is considered the firm pumping capacity. With one (1) small pump and the larger pump operating in parallel, the available flow is approximately 2,950 GPM, or 4.25 MGD.

### 3. Booster and Low Service Pump Stations

In addition to the high service pumps at the WTP, the City also has six (6) additional pumps located within the distribution system. Two (2) pumps located at the Kill Creek Tower act as booster pumps to fill the tower and were installed to try and improve the tower cycling. The four (4) pumps located near downtown act as low service pumps to allow the ground storage to be made available to the distribution system. The booster and low service pump stations are summarized in Table 7 below.

**Table 7: Booster and Low Service Pumps**

| Location | Number of Pumps | Design Capacity (GPM) | Design Head (ft) |
|---|---|---|---|
| Kill Creek Tower Booster Pumps | 2 | 425 | 70 |
| Downtown Underground Storage | 2 | 500 | 166 |
| Downtown Ground Storage | 2 | 425 | 100 |

### 4. Control System

The City utilizes a Supervisory Control and Data Acquisition (SCADA) system to monitor and control the water supply, treatment, and distribution. A simplified explanation of the SCADA system controls and operations are outlined below:

- The existing WTP onsite clearwell level calls for the plant to operate when it reaches a low level set point.
- When the plant begins operating, it calls for the raw water pumps at the intake structure to operate.
- The raw water flow into the WTP is control by an actuated valve upstream of the WTP.
- The 183rd Street elevated tower level calls for the high service pumps to operate based on low/high level set points, providing water to the distribution system.
- Low/high level set points at the downtown ground storage reservoirs call for automated valves to open/close to fill the reservoirs.
- The 183rd Street elevated tower level also calls for the low service pumps to operate at the ground storage reservoirs.
- The Kill Creek Booster Pumps operate based on the high/low levels in the Kill Creek Tower. When the booster pumps are operating, this tower is isolated from the system.

# 5.0 Distribution System Model

A computer model of the City of Gardner's existing distribution system was provided by the City. The water model utilized the software program WaterGEMS, which is available from Bentley Systems, Incorporated. The WaterGEMS program is a network model that allows the user to construct a graphical pressure system and analyze the hydraulics with the program's algorithms. The program calculates theoretical system pressures at pipe junctions (nodes) for specific water demands and also has the ability to estimate how a system operates over an extended period of time. The user is able to manipulate demands and other input parameters to help model different usage conditions or improvements that are planned for the system.

The computer model is used only as a tool to assist in determining the adequacy of a distribution system in meeting the chosen design conditions. The results of the model are reviewed, but final recommendations for improvements are based on a balance of the computer results, experience, and information received from the City of Gardner.

## A. Information Required

The WaterGEMS model operates based on characteristics of each pipe, pump, and storage units that are entered into the computer program. Parameters that are required for each pipe section include the diameter, length, and roughness coefficient or "C" value which is a measure of the relative roughness of the pipe. The rougher the interior of the pipe, the more pressure loss will occur as water travels through the pipe. Roughness is attributed to deposits, corrosion, etc. Lower "C" values associated with very smooth or new pipe. The values are initially estimated during model development based on the type and age of the pipe, and are modified during the calibration stage of modeling.

Storage units can include below or at grade reservoirs or elevated tanks. Each is included in the model as tank of a known diameter (or cross-sectional area) with a maximum water surface elevation, a minimum water surface elevation, and an assumed starting water surface elevation for model analysis.

WaterGEMS also has the capability to model pumps within the distribution system. Modeling pumps is accomplished by inputting head and flow conditions for each particular pump based on the manufacturer's pump curve.

Additional system elements that can be analyzed by WaterGEMS include: system isolation, pressure-reducing or flow control valves, fire hydrants. and system operational controls.

## B. Water Model Updating

The computer model provided by the City already included the majority of the City's distribution system, which included pumps and storage. The model was compared to the updated GIS map also provided by the City, and any waterlines that were not included were added to the model. The model provided by the City did not include existing fire hydrants, so these were also added to the model. Additionally, all characteristics of the existing water model were reviewed in detail to verify all elements of the model were up to date and accurate. This included verifying storage volumes, pump curves, pipe sizes, pipe materials, and system controls.

## C. Model Calibration

The water model provided by the City was previously calibrated as part of water modeling updates performed in 2011. This included field fire hydrant flow testing in order to calculate the anticipated "C" values for different pipe materials. These findings were outlined in a task memo presented to the City dated September 7, 2011. Based on the calibration data, the model was assumed to be calibrated based on the "C" values determined. New waterlines that were installed since 2011 were either PVC or ductile iron pipe and were updated in the water model with a "C" value of 140. The "C" values used in the existing model are outlined below:

- Cast Iron = 120
- Ductile Iron = 140
- PVC = 140
- Asbestos Cement = 140

Once the model was determined to be updated and calibrated based on all of the information provided by the City, it was compared to graphs from the existing system's SCADA to see how the model compared to real system operation. Based on this review, the modeling of the existing towers, reservoirs, and pumps operations were determined to be very similar to actual system operations. However, some modifications were made to modeled demands and tank/valve operation at New Century AirCenter to better simulate the existing SCADA operation as provided by the City.

## D. Demand Distribution

Demands are modeled by applying an outlet flow load to junction nodes (nodes) in the system. The total demands established for the current system and projected future growth must be distributed among the model nodes to reasonably represent the actual allocation of demand in the City's system.

As part of the 2011 water model update, demands were distributed throughout the system to account for large users, commercial users, and residential users. During the evaluation for this study, it was assumed that the overall distribution of demands remained relatively unchanged. In order to evaluate the model to account for the decrease in water use since 2011, an overall demand factor was applied to the model to depict the demands experienced in 2015 for AD, MD, and PH. Similarly, when evaluating the model for future demands, demand multipliers were used to increase the anticipated flows at the existing nodes.

# 6.0 Model Analysis

The distribution system model was analyzed under MD, PH, and fire flow demand conditions to assess the performance of the existing system under current demands, and under future demands to determine improvements needed to address flow and pressure problems. Typically, the most strenuous condition on a water distribution system is the occurrence of a fire flow during a MD demand. If a system is capable of delivering adequate fire flows under MD demands, then it is also capable of providing adequate pressures during AD, MD, and PH demands.

In addition to the steady state evaluations, the model was analyzed under an extended period simulation for 48 hours to evaluate the operation of the system as demands fluctuate during the day. The model was also analyzed for water age over a two-week simulated period during AD demands.

## A. Existing Distribution System Pressures with Current Demands (Steady State Analysis)

The model was evaluated under the existing system conditions to determine existing deficiencies and problem areas with respect to anticipated pressures. This evaluation was performed using AD, MD, and PH demands in a steady state scenario in the water model. For the demand scenarios, the initial water elevation for both towers was assumed to be approximately 7.5 feet below the overflow elevations and no pumps running. The tower elevations correspond to the pump on level set point or the lowest level the tower will reach during normal system operation, in the 183rd Street tower. Additionally, the steady state model assumes that neither downtown ground storage tank is taking water and that NewCentury is taking water at 500 GPM.

System flows and pressures will vary depending on several factors including treatment plant production, actual demand, pump operation, and tower levels. As such, the model pressures obtained will not be exactly the same as what may be measured in the field or experienced in the actual system. The model information is used as a tool to help determine potential system problems and improvements.

The system was analyzed under current AD, MD, and PH demands. Table 8 summarizes the model pressures calculated under present conditions.

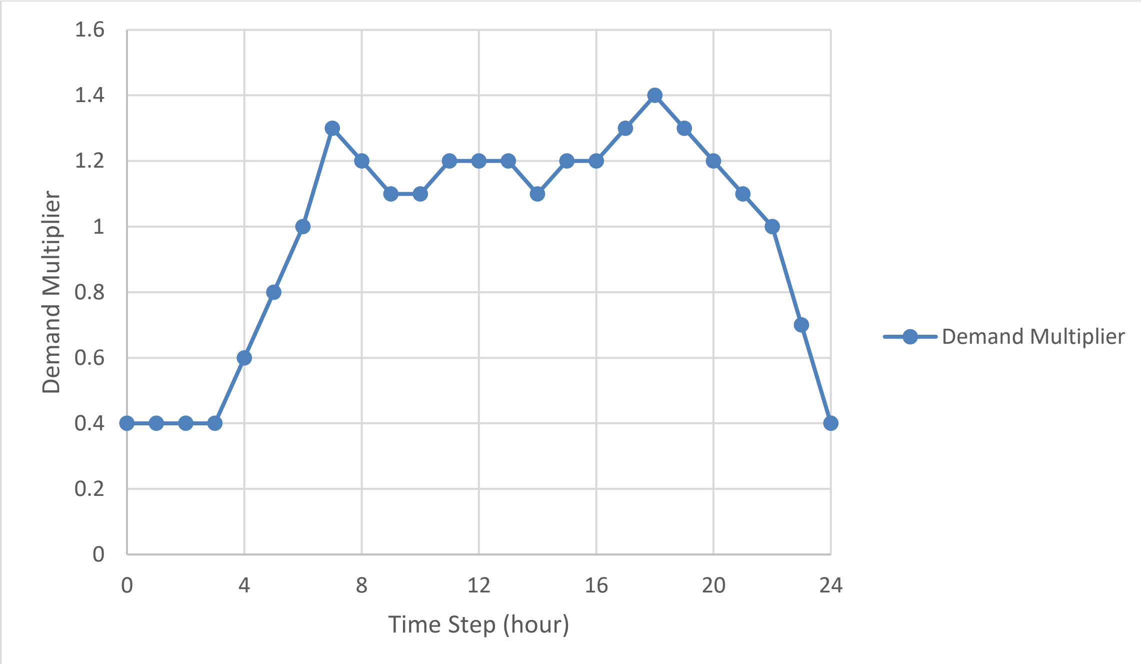
**Table 8: Modeled System Pressures Under Present Conditions**

| Location | System Demand (MGD) | Low Pressure (psi) | High Pressure (psi) |
|---|---|---|---|
| Average Day Demand | 2.28 | 46.8 | 88.3 |
| Maximum Day Demand | 4.41 | 45.8 | 87.5 |
| Peak Hour Demand | 6.40 | 44.4 | 86.3 |

Figures 5 and 6 illustrate the model pressures in the City under current MD and PH conditions, respectively. The model indicates pressures in the existing distribution system range from approximately 44 to 86 psi during PH demands, meeting KDHE's requirement of 20 psi minimum system pressure. The areas with the lowest pressures are typically due to topography, where higher ground elevations result in lower static pressures.

## B. Existing Distribution System Pressures with Current Demands (Extended Period Simulation)

In addition to running steady state analyses to evaluate system pressures, extended period simulations (EPS) were performed to evaluate water tower and reservoir cycling, and pumping patterns. The EPS were evaluated under MD demand conditions over a 48-hour period. During a normal day of water usage, demands overnight are typically much lower than the demands during the day. Additionally, there is typically a spike in water usage in the morning and evenings to account for people waking up and getting home from work. Due to these patterns throughout the day, a diurnal curve was established for residential demands based on recommendations from the AWWA. This diurnal curve is shown graphically in Graph 1 below.




**Graph 1: Diurnal Curve**

In addition to the diurnal curve used for residential usage, schools and commercial facilities also follow specific patterns throughout a day. For these two (2) demand patterns, a time span of 12 hours was utilized with a demand factor of 2.0 during the 12 hours, with no demand indicated during the remaining 12 hours. For schools, this demand was modeled from 6:00 a.m. to 6:00 p.m. and for commercial the demand was modeled from 8:00 a.m. to 8:00 p.m.

Once the demand patterns are determined and applied to the model, the EPS is finalized by setting up controls to mimic the City's SCADA system. The tower set points for calling on pumps and the reservoir set points for operating control valves were inserted into the model based on information provided by the City for the existing controls. The tower, reservoir, and pumping cycles can then be reviewed and analyzed.

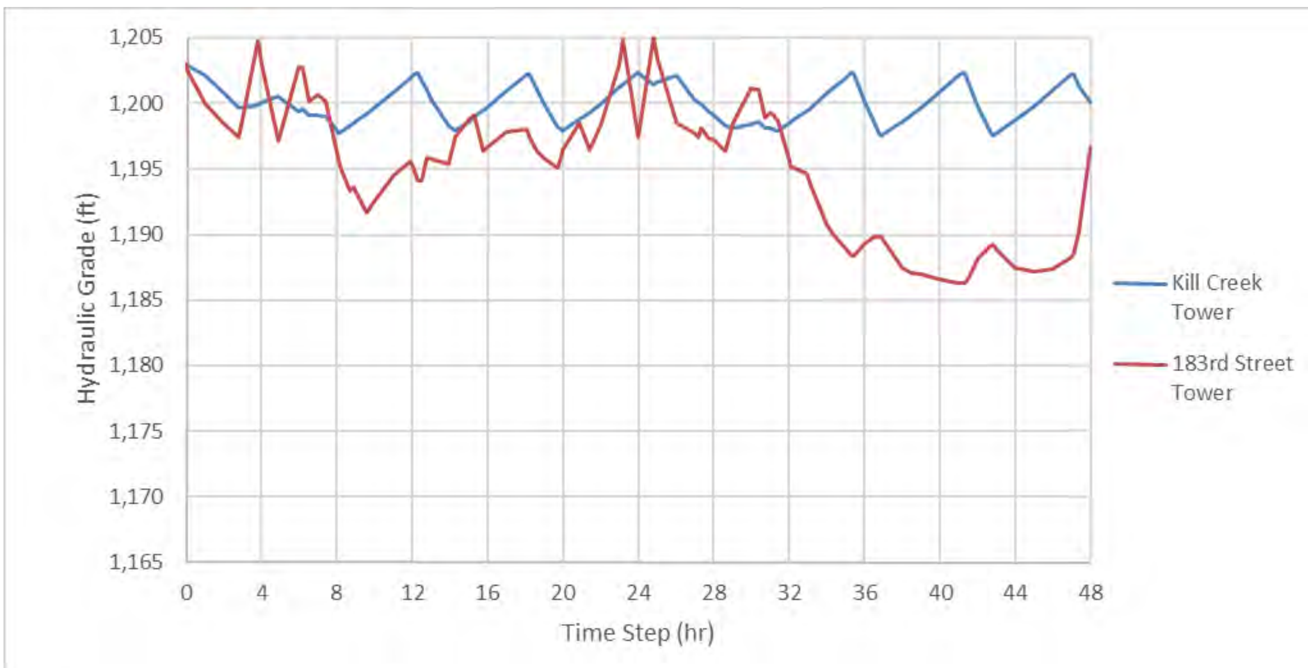
The following outlines the potential issues and deficiencies of the current system based on the EPS analysis.

- The 183rd Street Water Tower controls the high and low service pumps in the system. Due to this operational set up and the fact that the Kill Creek Water Tower has twice the capacity and located over four (4) miles further away from the high service pumps, the 183rd Street Towers drains and fills much faster than the Kill Creek tower. This leads to short cycling of the Kill Creek tower and potential chlorine/waterage issues.

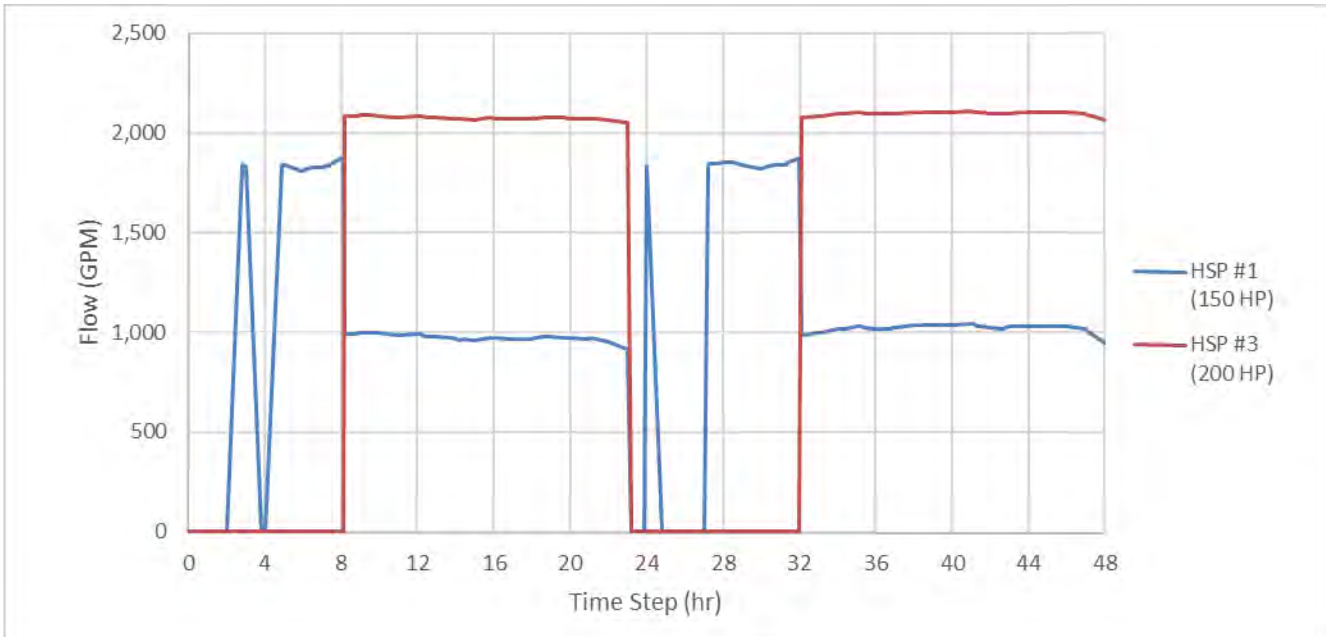
- The Kill Creek Booster Pump Station was installed to help limit the short cycling of the Kill Creek tower. While the booster pump station (BPS) has helped with the tower cycles, during the pumping cycles the tower is isolated from the distribution system. Meaning the 1.0 MG of storage is not available for emergencies during a pumping cycle. Additionally, the BPS had added operation, maintenance, and electricity costs that could potentially be eliminated if the tower floated on the system.

- During the peaking hours of the simulations, the tower levels continue to fall even though the high service and low service pumps are operating. This indicates that there is likely not adequate pumping capacity available from the high service pumps. While the system can currently recover during low demand times, this could potentially become an issue as demands increase in the future.

Graphs 2 and 3 show the elevated storage cycles and the high service pumping cycles over the 48 hour EPS.




**Graph 2: Elevated Storage Cycles (Existing Demands)**




**Graph 3: Existing High Service Pump Cycles**

## C. Existing Fire Flow Analysis

As noted previously, fire flow conditions are the most strenuous on a distribution system, as a large quantity of water is required to be provided in a short period of time. The model determines the fire flow available at hydrants in the system by applying an increasing demand on each hydrant individually under MD conditions until a residual pressure of 20 psi is reached somewhere in the system. Once a system pressure falls to 20 psi, the model stops the simulation and the flow applied to the hydrant at that time is its maximum available fire flow. Figure 7 illustrates the model fire flows available in the system under current MD demands.

For the purposes of this model analysis, the minimum fire flow required is 500 GPM which represents a residential or light commercial fire. Heavy commercial and industrial areas require a higher fire flow of 2,000 to 3,000 GPM. Additionally, similar to the pressure evaluation performed above, the tower elevations are assumed to be 7.5 feet below overflow with no pumps running.

The model indicates that approximately 99.6% of the system modeled hydrants can provide at least 1,000 GPM under current MD demands, and approximately 66.4% can provide at least 3,000 GPM. Only four (4) of the system model hydrants provide less than 1,000 GPM of fire flow. Three (3) of these hydrants are located on either a 6-inch or 8-inch dead-end water line and one is located on the discharge line from the underground reservoir pump station. The fire flow analysis does not incorporate pumps into the available fire flows, so when these pumps are operating, there would be additional flow available from the hydrant on the dis charge line. Table 9 shows the percentage of fire hydrants in the identified available flow ranges.

**Table 9: Available Fire Flows**

| Available Fire Flows (GPM) | Number of Hydrants | Percentage of Total |
|---|---|---|
| Less than 1,000 | 4 | 0.4 |
| 1,000 to 1,500 | 24 | 2.3 |
| 1,500 to 2,000 | 91 | 8.6 |
| 2,000 to 3,000 | 237 | 22.3 |
| More than 3,000 | 705 | 66.4 |
| **TOTAL** | **1,061** | **N/A** |

## D. Existing Distribution System with 2040 Demands (Steady State)

The model was also evaluated to determine if the existing distribution system could provide adequate flow and pressure under the projected 2040 demands without any improvements. The modeled conditions for tanks and pumps remain the same. Table 10 summarizes the model pressures calculated under 2040 demand conditions.

**Table 10: Modeled System Pressures Under 2040 Demand Conditions**

| Location | System Demand (MGD) | Low Pressure (psi) | High Pressure (psi) |
|---|---|---|---|
| Average Day Demand | 4.28 | 46.1 | 87.7 |
| Maximum Day Demand | 8.15 | 43.6 | 85.7 |
| Peak Hour Demand | 11.63 | 40.1 | 82.6 |

Figures 8 and 9 shown the resulting pressures under MD and PH demands, respectively. Under 2040 PH conditions, system pressures range from a low of approximately 40 psi to a high of approximately 83 psi. Similar to the results for current demand conditions, all pressure nodes are well above the 20 psi KDHE requirement.

The existing system was also evaluated to determine available fire flows under the projected 2040 MD demands. The number of fire hydrants with available fire flows under 1,000 GPM remained unchanged, however, there was a large number of fire hydrants that fall into the 2,000 to 3,000 GPM range and can no longer provide 3,000 GPM. Table 11 shows the percentage of fire hydrants in the identified available flow ranges and the locations are depicted in Figure 10.

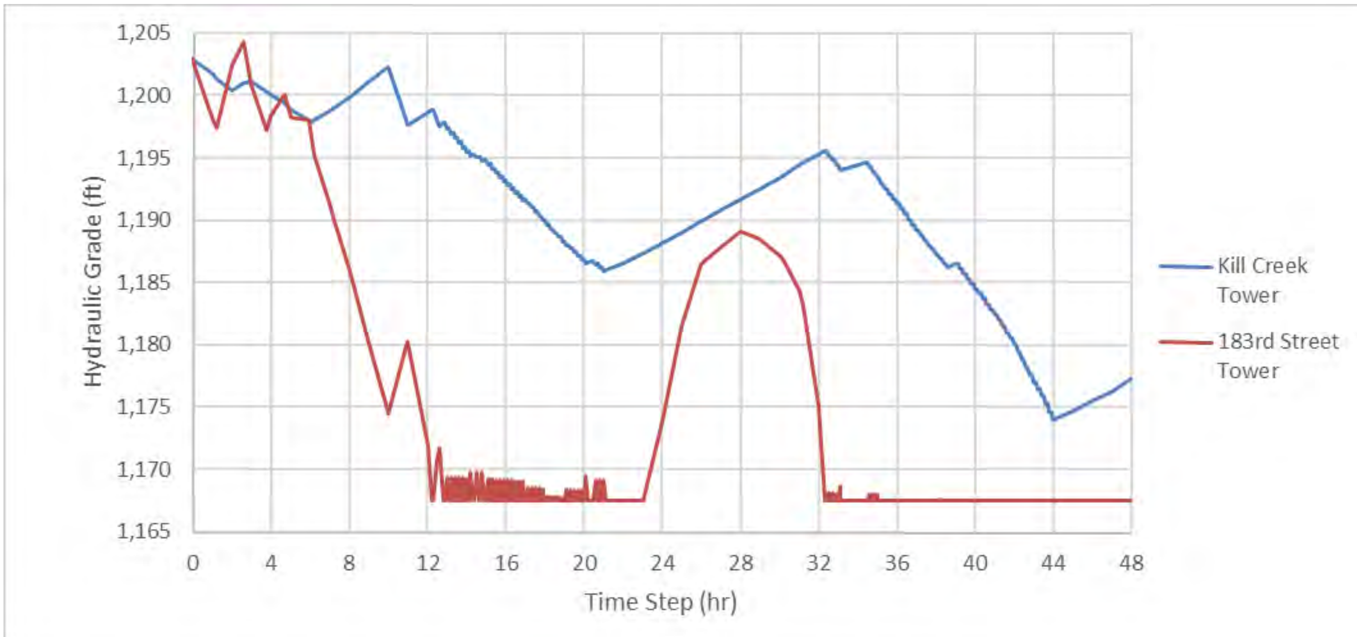
**Table 11: Available Fire Flows Under 2040 Demands**

| Available Fire Flows (GPM) | Number of Hydrants | Percentage of Total |
|---|---|---|
| Less than 1,000 | 4 | 0.4 |
| 1,000 to 1,500 | 33 | 3.1 |
| 1,500 to 2,000 | 122 | 11.5 |
| 2,000 to 3,000 | 713 | 67.2 |
| More than 3,000 | 189 | 17.8 |
| **TOTAL** | **1,061** | **N/A** |

## E. Existing Distribution System Pressures with 2040 Demands (Extended Period Simulation)

The existing system was also evaluated under an EPS for the anticipated MD demands for 2040. The demand patterns and controls maintained the same as the original EPS analysis performed under current demands.

Based on this analysis, the system currently does not have adequate pumping capabilities to serve the anticipated MD demand conditions in 2040. As shown in Graph 4 below, the towers drain within the first 24 hours of this scenario. In order to address this issue, changes will likely need to be made to the system with respect to both controls/operation and upgrades to existing equipment.




**Graph 4: Elevated Storage Cycles (2040 Demands)**

## F. Pumping System Analysis

System high service pumps should have available capacity to deliver the MD demand to the distribution system. The existing high service pumps, at the Hillsdale WTP, have a total firm capacity of 2,600 GPM or approximately 3.74 MGD. Firm capacity assumes that the largest pump at the WTP is out of service, which is consistent with KDHE requirements for distribution system design. The total projected MD demand for the year 2040 is 8.02 MGD. The existing high service pumps do not appear to be able to adequately supply the projected 2040 demands. Additionally, and more importantly, these pumps do not appear to have adequate capacity to provide MD demands for current system requirements.

## G. Water Storage Analysis

Water storage tanks benefit a municipal distribution system by providing large volumes of water for peak or emergency demands. They also provide more consistent pressures at points distant from the system's high service pumps. Water towers are generally preferred over ground storage and pump stations because of their reliability during a power failure. Water towers also reduce pumping and transmission main capacity requirements, while allowing for more consistent and economical operation of supply facilities.

Water storage tanks are an important part of a distribution system for three reasons. They provide for 1) equalization storage, 2) fire protection, and 3) emergency demands. According to KDHE design criteria, "the system shall be capable of replenishing the storage each night during low demand periods." The following discussion estimates the storage requirements for each demand situation and calculates a total required storage.

### 1. Equalization Storage

The first goal of distribution storage is to minimize the effects of peak hourly demand fluctuations on the source of supply. The quantity should be sufficient to supply all usage in excess of the City's MD demand in order to meet the PH demand. Thus, the storage is the difference between the pumping rate and the PH demand.

Since the storage volume required for equalization of a distribution system depends on the hourly demand patterns of the system, peak hourly demands must be determined. Hourly demand information was not available for the distribution system. Information from other municipalities has allowed for the development of a typical ratio of equalization volume with respect to MD demand. A commonly accepted value is 15% of MD demand. The resulting equalization volume is 0.59 MG for current conditions and 1.04 MG for 2040 projected conditions.

### 2. Fire Protection Storage

Fire protection storage provides water for fire protection at any location in the City without being required to rely on the system source. The desired fire flow that will be evaluated in this study is 3,000 GPM for an industrial fire. Per the ISO, the required duration for a 3,000 GPM fire is three (3) hours. The resulting storage volume required for fire protection is 0.54 MG for both current and projected conditions.

### 3. System Emergencies

Conservative engineering practice suggests that a volume of water be maintained to provide service during a temporary interruption to the supply. Such an interruption may be the result of a power failure at the water treatment plant, loss of supply, large water main breaks, or a natural disaster. As far as quantifying this volume, KDHE only recommends that some storage be available for "minor contingencies", and does not specify a particular volume or percentage. The actual storage requirement depends on the reliability of the water system and varies for each City.

The WTP and high service pump station are located five (5) miles south of the city limits, with this currently being the only source of water for the distribution system. In the event the water treatment plant or high service pump station would require a complete shutdown, or if there would be a major waterline break on the transmission main to the city, it is assumed that the downtime period will not exceed 8 hours during AD demand. In Section 3, it was determined that the City's current AD usage is 2.28 MGD for current conditions and 3.48 MGD for 2040 projected conditions. For an 8-hour emergency, the resulting storage volume is 0.66 MG for current conditions and 1.16 MG for 2040 projected conditions.

### 4. Total Storage Required

Two (2) methods are commonly used to calculate the total elevated water storage volume recommended for the system. The first method is to use the worst case scenario by adding the flow equalization, emergency storage, and fire protection volumes together for the total elevated volume. This method provides a very conservative estimate, but increases water age in the system since a much higher volume of usage is needed for turnover. The second method is to add the emergency storage volume to the flow equalization volume and the fire protection volume to the flow equalization volume and use the higher volume. This method is still conservative, but reduces the amount of storage volume required while still providing a safe volume in case of emergency. The second method is the method selected in this study to determine the recommended storage for the distribution system. The recommended storage volumes for current and projected 2040 conditions are as shown in Table 12.

**Table 12: Total Recommended Water Storage Volume**

| Year | Average Day Demand (MGD) | Maximum Day Demand (MGD) | Equalization Volume[1] (MG) | Emergency Volume[2] (MG) | Fire Protection Volume[3] (MG) | Total Volume Needed[4] (MG) |
|---|---|---|---|---|---|---|
| 2015 | 1.98 | 3.96 | 0.59 | 0.66 | 0.54 | 1.26 |
| 2040 | 3.48 | 6.95 | 1.04 | 1.16 | 0.54 | 2.20 |

[1] Equalization Volume = 15% of Maximum Day Demand
[2] Emergency Volume = 8 hours x Average Day Demand
[3] Fire Protection Volume = 3,000 GPM x 3 Hours
[4] Total Volume Needed = Equalization Volume + Emergency Volume or Fire Protection Volume (Greater of the Two)

As identified previously, the City's existing storage capacity is 3.50 MG, meaning the City has adequate storage availability.

## H. Water Age

According to the Stage 2 Disinfectants and Disinfection Byproducts Rule by the Environmental Protection Agency (EPA), published January 4, 2006, all water systems must conduct an initial distribution system evaluation to identify compliance monitoring locations for high disinfection byproducts. The oldest water in the distribution system may contain the highest levels of disinfection byproducts. These areas should be considered for monitoring locations.

To evaluate water age for the distribution system, an EPS was modeled using AD demands. According to the model results, the water age in the system is typically three (3) days or less and the results are shown on Figure 11. Water age in a few isolated areas in the more densely populated and developed portions of town are shown to have water age up to approximately six (6) days. The locations appear to be on dead-end waterlines with very few water users.

There are also areas that the model indicates the water age is over 10 days. Almost all of these locations are large dead-end lines with little or no demand, most of which appear to be installed for future expansion.

In general, the quality of water and disinfection residual should remain at acceptable levels if the age of the water is less than 7 days. Model results indicate that water age within the distribution system could potentially be the cause if low chlorine residual or high disinfection byproduct readings are experienced.

# 7.0 Summary

Overall, the existing water system appears to be mostly adequate to meet current water demands with respect to supply, treatment, pumping, storage, and pressures. However, there appear to be inefficient operational inefficiencies and system capacity deficiencies that will reveal themselves as the City's anticipated water demands increase. A summary of the existing conditions and any potential issues are outlined below.

## A. Water Rights and Raw Water Supply

The City of Gardner's water rights from Hillsdale Lake are adequate to supply water to its customers through the planning period. The projected MD water demand in 2040 is approximately 8.15 MGD, with current water rights for approximately 9.3 MGD. However, the pumps at the current raw water intake structure are each rated for approximately 2.16 MGD, or approximately 4.32 MGD with two (2) pumps in operation. These pumps do not appear to provide adequate capacity to meet current MD demands of 4.41 MGD, or 2040 demands of 8.15 MGD. It should be noted that during the planning period the City should consider additional feed sources or additional rights for beyond 2040, or if a large user is considering locating to the City.

Another potential issue or deficiency in the water supply system is that the entire City's raw water supply is fed through one waterline approximately two miles to the treatment plant. If this waterline experienced a major break or leak, then there would be no supply of raw water to the WTP during the down time for repairs.

Finally, and as indicated previously, the City currently has water rights available from the Gardner City Lake. However, these water right totaled approximately 295 MGY before 2017, and as of January 2017 have been reduced to 100 MGY. Even with the full complement of water rights totaling 295 MGY if the municipal water rights were reinstated, this source of water would only allow for approximately 0.8 MGD to be treated and supplied to the City.

## B. Water Treatment

The technical memorandum in Appendix A explains deficiencies and issues with respect to treatment and operation of the WTP in detail. With respect to capacity, the existing WTP is rated for a peaking capacity of 4.0 MGD, can currently only operate at 3.8 MGD max, and becomes very inefficient after exceeding 3.0 MGD. Additionally, WTP Staff indicated 3.0 MGD is the maximum output they are confident in being able to produce over an extended period of time. Similar to the raw water intake pumps, this treatment capacity is not adequate for current MD demands, or 2040 MD demands.

## C. High Service Pumps

The City's existing high service pumps have the ability to pump a maximum of 2,950 GPM, or 4.25 GPM, with one (1) large pump and one (1) small pump running. This capacity appears to be adequate for current MD demands, but does not appear to be sufficient through the planning period. Additionally, KDHE considers the firm pumping capacity as the amount of flow that can be provided with the largest pump out service. Based on firm pumping capacity, the two (2) small pumps can deliver a flow rate of approximately 2,600 GPM, or 3.74 MGD, which is not adequate capacity for current or future demand needs.

Based on information from City Staff, the two smaller pumps (Pump #1 and #2) were operating inefficiently and not meeting design flow rates. Due to this, Pump # 2 was over hauled in March 2015 and Pump #2 will be overhauled in Fall 2017. City Staff believes this work will allow the pumps to operate as originally designed.

Similar to the potential issue at the raw water intake structure, the entire treated water supply is fed through one waterline from the WTP to the city limits and subsequent distribution system. If this waterline experienced a major break or leak, then there would be no treated water supply to the distribution system during the down time for repairs.

## D. Distribution System

The majority of the City's distribution system, over 80% of the total length of pipe, was constructed after the year 1990. Similarly, the waterline pipe materials reflect the relatively young age of the distribution system with over 90% of the total length of waterline consisting of Ductile Iron or PVC materials. This large amount of newer pipe materials provides the system with very good flow characteristics. While there are small amount of cast iron, asbestos, cement and transite pipe in the system, these pipe materials have poor flow characteristic and are subject to breaks and leaks at a higher rate. It is recommended the City replace these lines as funds become available.

The distribution system maintains pressure well above the KDHE minimum of 20 psi even under high projected demand conditions and also appears to have adequate available fires flows throughout this system. This is due, in part, to the large diameter waterlines throughout the system and the looping of these lines. Over 25% of the total length of pipe in the system is over 12-inches in diameter and allows large volumes of water to be available throughout the system.

## E. Storage

The City's distribution system currently has 3.5 MG of available storage in various locations throughout the system. This includes 1.5 MG of elevated storage and 2.0 MG of ground/underground storage that is pumped to the system. This 3.5 MG is larger than the amount of recommended storage by nearly 0.9 MG. While this additional storage is currently aiding the system in overcoming its supply and treatment capacities under MD demands, the large amount of excess storage could potentially lead to water quality or chlorine residual issues in the system due to water age.

Additionally, the current layout of the storage in the distribution system leads to operational issues in the existing elevated towers. Due to the size and distance from the water treatment plant of the 1.0 MG Kill Creek Water Tower, this tower does not cycle adequately under AD and MD demands. This is due to the 183rd Street Water Tower cycling much quicker with half the storage capacity and also its proximity to the treated water supply line from the WTP.

A short term solution to this situation was to install a BPS at the base of the tower that fills the tower when called upon, but during these filling cycles the tower is isolated from the distribution system. This potentially leaves the distribution system without 1.0 MG of stored water in the event of large demand event such as a fire. Operating these booster pumps also results in the use of additional electricity and added operation and maintenance costs that may not be necessary.

# 8.0 Recommendations

The City of Gardner has adequate water rights to serve the community through the planning period of 2040. However, the raw water pumping capacity, water treatment capacity, and treated water supply pumping capacity are not adequate to provide projected demands through 2040. These capacities are also not adequate to support current peaking water demands. It is recommended the City begin planning for significant system wide capacity upgrades to maintain the ability to serve the projected water demands and maintaining its ability to serve these demands by means of the City's own water rights, treatment, and supply capabilities. The following are recommended improvements to the City's water system through the planning period.

## A. Water Supply Improvements

- As an immediate solution to the capacity issues, it is recommended the City pursue a connection and consider an agreement with WaterOne to provide 1.0 MGD of water supply, with infrastructure in place to allow for supply of 2.0 MGD in the future for a minimum agreement length of 20 years. By obtaining 1.0 MGD of additional treated water supply, the City can extend the useful life of the existing raw water pumps, WTP, and high service pumps while a plan is put in place for necessary upgrades. It is also recommended that a BPS be installed at the WaterOne connection point since there may be times the WaterOne pressure is not adequate to feed the City's system. This will also allow the flowrate and pressure of water into the system can be adequately controlled. Water quality from both sources of supply will need to be evaluated for compatibility. Additional infrastructure may be required to make water compatible. Costs for this infrastructure was not included in the cost estimates.

- As water demands increase and the City's infrastrure and treatment capacities are upgraded, it is recommended the existing raw water pumps be upgraded. VFDs are recommended on the new pumps to allow operation to meet demands. It is recommended that the new pumps be rated for 2,800 GPM to replace the existing 1,500 GPM pumps. When running by themselves, the new pumps would provide over 4.0 MGD, and with two (2) pumps running would provide over 8.0 MGD, meeting the projected 2040 demands.

- It is recommended a minimum 8-inch raw waterline be installed to run parallel to the existing 16-inch raw waterline from the raw water pumps to the WTP. This waterline will provide additional capacity when operating the new pumps at 8.0 MGD and will also provide redundancy to the WTP. If the City desires full redundancy capabilities, this line can be increased to a new 15-inch raw waterline.
- As the planning period of 2040 approaches, the City should continue to monitor and analyze its water usage rates to compare the actual water demand growth or increases to the projected demands as outlined in this report. It appears unlikely, but if the projections appear to be increasing at a much more rapid rate and the AD demand nears 8.0 MGD, it is recommended the City begin pursuing options to obtain additional water rights. While the City's existing water rights are adequate through the planning period of this report, any large unanticipated growth or large increase in projected water demands could potentially exceed the current water rights in Hillsdale Lake.

## B. Water Treatment Improvements

The Hillsdale WTP was designed for a treatment capacity of 4.0 MGD. Although based on operator knowledge and as outlined in Appendix A, the WTP likely only achieves a capacity of approximately 3.8 MGD. WTP Staff also indicated 3.0 MGD is the maximum output they are confident in being able to produce over an extended period of time. Appendix A includes recommendations and estimated costs to allow the WTP to operate more efficiently and achieve the peaking capacity of 4.0 MGD.

However, based on the current and projected MD demands, 4.0 MGD is not an adequate peaking capacity to meet demand requirements. The existing plant also has many deficiencies and issues that would need to be addressed before considering the possibility of further expansion. It is recommended the City pursue construction of a new 6.0 MGD conventional WTP to meet projected demands through nearly year 2030. It is also recommended this new WTP be constructed to allow for further expansion to meet projected demands of 2040, as well as the ability to expand further to meet potential demands beyond the planning period. By sizing the plant to allow for expansion, the City's actual growth and water demand can be monitored to verify the plant is neither oversized or undersized for the actual demand conditions.

Three different scenarios were evaluated to reach this recommendation. Scenario A included construction of a new 2.0 MGD water treatment facility near the existing WTP, and keep the existing plant in operation. Scenario B was the evaluation that included the new 6.0 MGD plant with the capability to expand to 8.0 and 10.0 MGD in the future. Scenario C was the possibility of constructing a new water treatment facility near Gardner City Lake and utilizing existing water rights in the lake.

For Scenario A, the new 2.0 MGD water treatment facility evaluated is a standard conventional water treatment facility. The capital cost of this type of facility does not include any advanced processes. Upgrading the existing 4.0 MGD water treatment plant does not include providing any advanced processes. Advanced processes or additional needed treatment requirements could add 30% in additional capital costs for this facility. Capital costs include the ability to expand the new water treatment plant to 4.0 MGD and then to 6.0 MGD firm capacities. The current water treatment facility layout is not favorable for expansion. When the facility was recently upgraded, expansion was not considered for hydraulics, chemical storage, clarification nor filtration. It is possible to expand the current facility but process relocation, facility modifications, capital costs, excavation and sequencing of construction would make it unfeasible.

**Table 13: Scenario A – Total Planning Capital Costs**

| Item | Total Capital Costs[1,2] |
|---|---|
| New 2 MGD Water Treatment Plant[3] | $22,920,721.00 to $29,796,937.00 |
| Upgraded Existing 4 MGD Water Treatment Plant | $8,023,490.00 to $10,430,537.00 |
| Total Planning Estimate Capital Cost | $30,944,211.00 to $40,227,474.00 |

[1]All Costs should be considered preliminary in nature and used for budgeting purposed only. [2]Engineering News Record Construction Cost Index (CCI) for March 2017 is 10277.
[3]The capital cost include intake, raw water conveyance, treatment, 1.0 MG finished water storage and high service pumping. Transmission costs are not included in the capital costs.

The new 2.0 MGD WTP would provide additional capacity to the existing water production capabilities for the City of Gardner. It is anticipated that this new water treatment facility would be operated at full firm capacity of 2.0 MGD with the current (newly upgraded) water treatment facility would operate at 1.0 MGD. The current water treatment facility would have a firm capacity of 4.0 MGD that could be used for peaking purposes during the planning period. This operational approach would maximize the use of the new water treatment facility thus fully benefiting from much of the capital investments. With this approach, the new water treatment facility would operate 24 hours per day and the current facility would operate 6 hours per day to produce an average total daily amount of 3.0 MGD.

The present worth scenarios evaluation includes estimated operational and maintenance costs over the planning period.

## Table 14: Scenario A – Total Planning Present Worth Costs

| Item | Total Present Worth | Percentage of Total |
|---|---|---|
| Total Present Worth Capital Cost[1] | $38,768,640.00 | 33% |
| Electricity Operational Costs[2] | $4,391,804.00 | 4% |
| Consumables - Chemicals[2] | $19,950,866.00 | 17% |
| Annuitized Preventative Maintenance Costs[2] | $26,861,350.00 | 23% |
| Annuitized Maintenance Sinking Fund - Equipment / Reserve[2] | $2,470,800.00 | 2% |
| Operational Costs - Labor[2] | $25,123,801.00 | 21% |
| **TOTAL** | **$117,567,261.00** | **100%** |

[1]Present worth (20 year) analysis includes additional operational costs required to operate and maintain improvements described within the alternative. Analysis include total project cost financed at an interest rate of 2.25%.
[2]Consumer Price Index (CPI) for electricity, commodities, transportation and utilities from the U.S. Department of Labor.

For Scenario B, the new 6.0 MGD water treatment facility was also evaluated as a standard conventional water treatment facility and does not include advanced processes. Advanced processes or additional needed treatment requirements could add 20% in additional capital costs for this facility. Capital costs include the ability to expand the new water treatment plant to 8.0 MGD and then to 10.0 MGD firm capacities.

## Table 15: Scenario B – Total Planning Capital Costs

| Item | Total Capital Costs[1,2] |
|---|---|
| New 6 MGD Water Treatment Plant Planning Estimate Capital Cost[3] | $41,842,527.00 to $50,211,032.00 |

[1]All Costs should be considered preliminary in nature and used for budgeting purposed only. [2]Engineering News Record Construction Cost Index (CCI) for March 2017 is 10277.
[3]The capital cost include intake, raw water conveyance, treatment, 2.25 MG finished water storage and high service pumping. Transmission costs are not included in the capital costs.

A new 6.0 MGD water treatment facility will meet the water production needs over the planning period. It is anticipated that this new water treatment facility on average would be operated at the firm capacity of 6.0 MGD for a period of 12 hours per day, thus producing a total of 3.0 MGD.

### Table 16: Scenario B – Total Planning Present Worth Costs

| Item | Total Present Worth | Percentage of Total |
|---|---|---|
| Total Present Worth Capital Cost[1] | $52,422,240.00 | 50% |
| Electricity Operational Costs[2] | $3,795,159.00 | 4% |
| Consumables - Chemicals[2] | $15,421,627.00 | 15% |
| Annuitized Preventative Maintenance Costs[2] | $20,110,865.00 | 19% |
| Annuitized Maintenance Sinking Fund - Equipment / Reserve[2] | $1,299,000.00 | 1% |
| Operational Costs - Labor[2] | $12,763,428.00 | 12% |
| **TOTAL** | **$105,812,319.00** | **100%** |

[1]Present worth (20 year) analysis includes additional operational costs required to operate and maintain improvements described within the alternative. Analysis include total project cost financed at an interest rate of 2.25%.
[2]Consumer Price Index (CPI) for electricity, commodities, transportation and utilities from the U.S. Department of Labor.

Scenario C was reviewed for the possibility of constructing a new WTP near the Gardner City Lake to utilize existing water rights. However, the amount of water rights available are not enough to make this a viable option. Additionally, if water rights were available or additional water rights were obtained to allow for a new 2.0 MGD water treatment facility, the proposed costs would be similar to Scenario A, but would likely be higher because separate onsite storage and high service pumping would need to be included in the WTP construction.

The option to build a new WTP at the Gardner City Lake was also compared to the recommendation of obtaining a secondary source of water from WaterOne. While there are many different options associated with the WaterOne connection and the Gardner Lake WTP, a straight 2.0 MGD comparison for initial capital costs were evaluated. A 2.0 MGD connection to WaterOne for a period of 20 years is estimated to cost approximately $5,400,000 and a new 2.0 MGD WTP is estimated to cost over $20,000,000. Additionally, the new supply connection will not require the City to hire additional staff to maintain and operate the equipment, will consume much less electricity, and cost much less to operate and maintain overall. One positive to constructing a new plant would be that the City could potentially reacquire their water rights and utilize the rights to meet system demands. However, this positive does not appear to outweigh the much larger initial capital costs required to construct a new WTP. Based on these obstacles, Scenario C was not evaluated in further detail and is not recommended.

Scenario B has a lower present worth value of $11,754,924 or approximately $587,747.10 per year over the planning period than Scenario A. The most significant difference between the two (2) scenarios is the operational labor costs. It is estimated that 16 employees would be needed for Scenario A whereas 8 employees would be needed for Scenario B. There are intangible operational benefits for water treatment facility staff in operating a single facility from a monitoring and process control. It is recommended that the City of Gardner pursue Scenario B.

## C. High Service Pump Improvements

- It is recommended the City install either soft starts, slow opening check valves, or VFDs on the existing pumps to reduce/eliminate surging and water hammer issues. These issues should be evaluated in more detail to determine the proper or most effective solution to the surging issues.
- Based on the City's decision regarding an alternative treated water supply source and new WTP construction, new larger high service pumps may be required as demands increase. It is recommended any new pumps be installed to replace one of the smaller existing pumps and rated for a minimum of 2,800 GPM.
- A new high service pump station is recommended as part of the WTP upgrades.

## D. Storage and Low Service/Booster Pump Improvements

- It is recommended an electronic control valve be installed on the existing 183rd Street Water Tower to shut off flow to the tower when the water elevation is 1-foot below the overflow elevation. It is also recommended that the SCADA controls for the high service pumps be switched from the 183rd Street Water Tower to the Kill Creek Water Tower.
- It is recommended the Kill Creek BPS be taken out of service to allow the water tower to operate and cycle based on the high service pumps at the WTP. This will eliminate unnecessary operation and maintenance (O&M) and electrical costs associated with the booster pumps and will no longer isolate the tower from the system during a filling cycle.

- Following completion of the water supply connection to WaterOne, it is recommended the existing above ground and underground storage tanks and their associated pumps stations be taken out of service. The City has adequate system storage in their existing elevated towers and WTP clearwell without the need for this 1.0 MG. There does not appear to be a benefit to having this storage during normal system operation, as the high service pumps will be trying to replenish the additional volume that the low service pumps are supplying to the system. This will eliminate O&M and electrical costs to the City.

- Additional clearwell storage of potentially up to 3.0 MG with emergency backup power is recommended as part of the WTP upgrades.

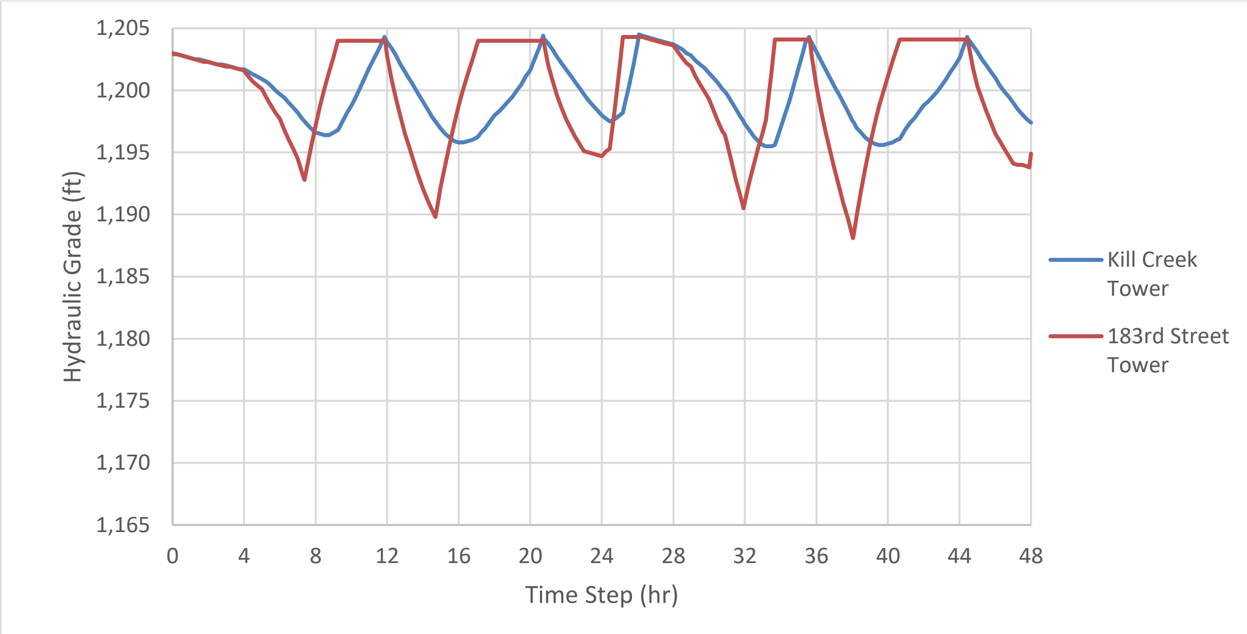
## E. Distribution System

- As part of either the high service pump upgrades or the new WTP construction, it is recommended a new 16-inch redundant waterline be installed from the WTP to the Gardner City limits. The new waterline will allow for a constant feed of water to the City during a waterline emergency and will also provide adequate capacity for the projected 2040 demand conditions.

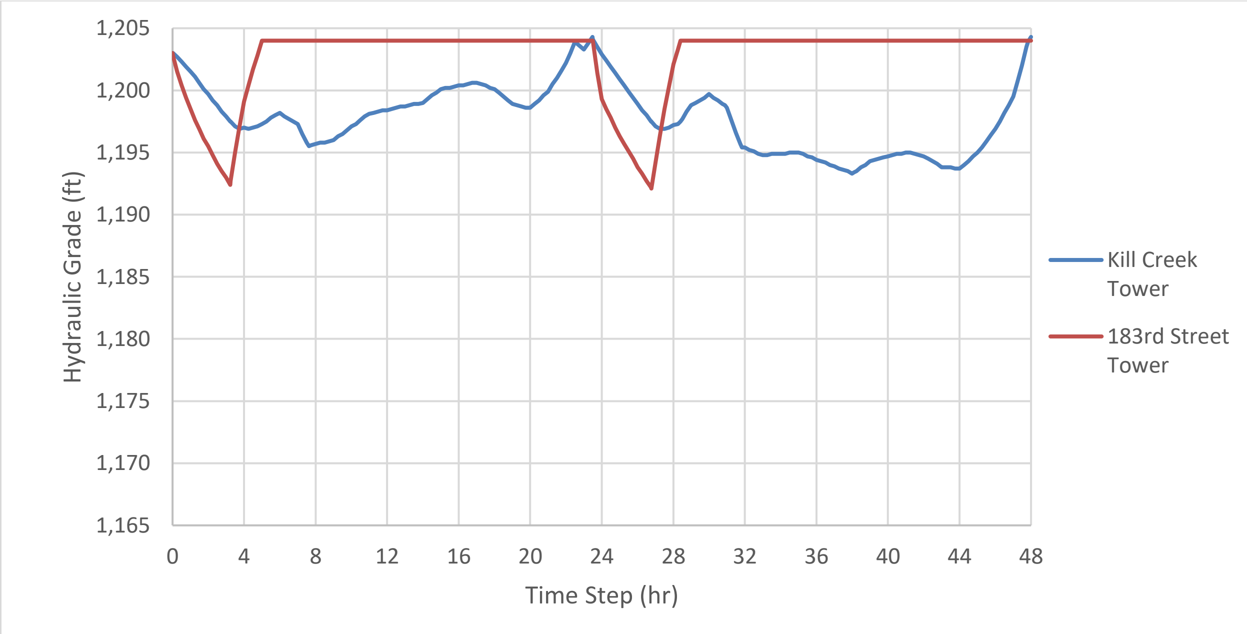
- Overall, the City's distribution system within the City limits has good hydraulic characteristics, pressures, and flows. There are no major improvements recommended to the system. However, old cast iron, asbestos cement and transite pipes are known for their poor flow characteristics and reliability as they age. It is recommended the City have a contingency plan in place to replace these old waterlines in the future. While it is not a high priority, it is recommended the City complete the looping of the 12-inch water mains throughout the City to connect areas where gaps exist.

- The estimated cost for replacing existing 4 through 8-inch aging waterlines is approximately $100 to $200 per lineal foot. Meaning replacement of ½ mile of waterlines care range from approximately $250,000 to $500,000. It is recommended the City allocate approximately $1 million dollars available per year to address the waterline replacement. This would allow for a minimum of 1 mile of replacements per year.

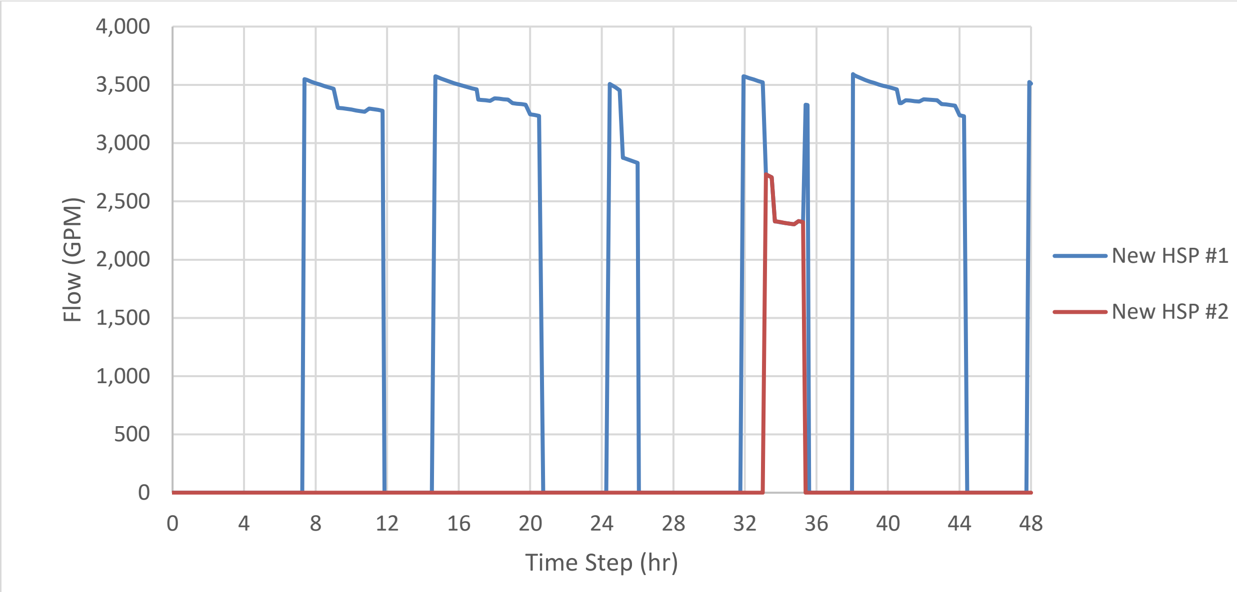
Figure 12 shows all of the recommended improvements to the distribution system. Since the existing elevated water towers remain unchanged, the resulting steady state analyses with respect to pressures and available fire flows throughout the distribution system will remain similar to the original model analysis. However, the EPS analysis will change greatly. Graphs 5, 6, 7 and 8 below show the resulting cycles of the elevated storage tanks and high service pumps with recommended improvements completed.



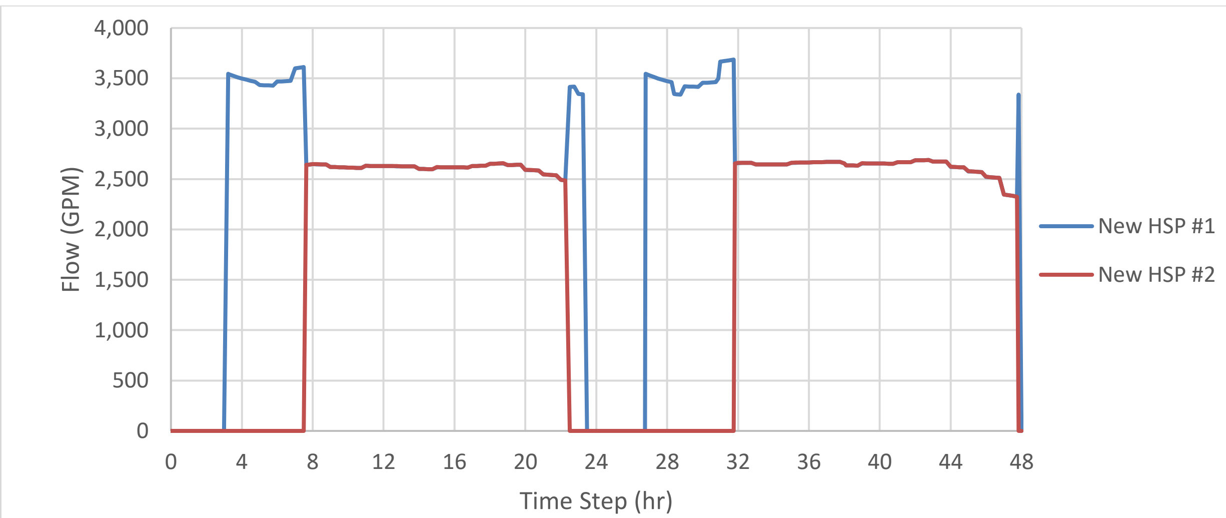

**Graph 5: Elevated Storage Cycles with Recommended Improvements (Existing Demands)**




**Graph 6: Elevated Storage Cycles with Recommended Improvements (2040 Demands)**

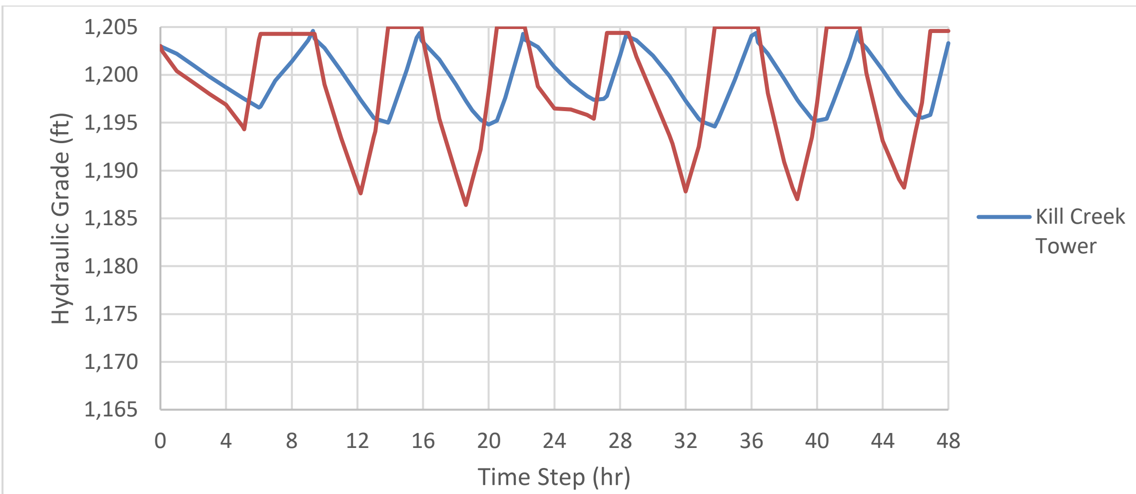



**Graph 7: Proposed High Service Pump Cycles (Existing Demands, 1.0 MGD WaterOne Supply)**




**Graph 8: Proposed High Service Pump Cycles (2040 Demands, No WaterOne Supply)**

As shown on the graphs above, the removal of the booster and low service pumps, installation of the larger high service pumps with the new WTP, the redundant treated water transmission line, and controlling the high service pumps with the Kill Creek Tower improves the tower and pumping cycles from the current operation and allows the system to maintain operation through 2040 without draining the tanks. However, as shown in Graph 6, during 2040 MD demands there are long periods of time throughout the day that the 183rd Street tower control valve will be closed to the system while the high service pumps keep up with necessary demands. This is not ideal, but as the model shows, this tower is able to cycle at least once each day due to the lower demands overnight. Under 2040 AD demands, the system is able to operate with much more desirable cycles. The 2040 AD demand tower cycles are shown in Graph 9.




**Graph 9: Elevated Storage Cycles with Recommended Improvements (2040 AD Demands)**

# 9.0 Proposed Improvement Schedule

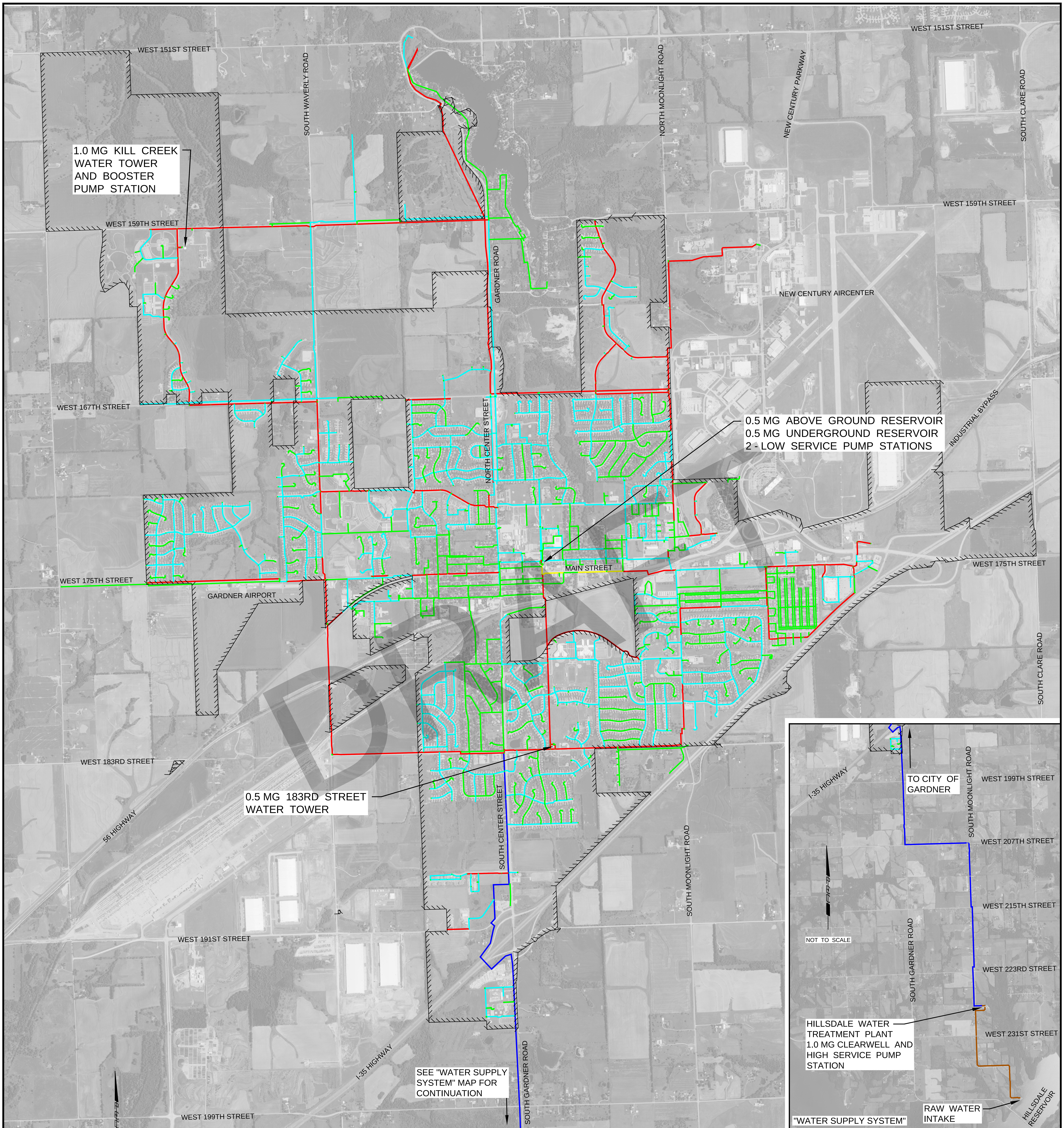
The following table outlines the recommended improvements and the recommended implementation dates in order to provide adequate water supply to the City of Gardner to meet projected demands. The table also includes the estimated project costs for each improvement. Breakdowns of the estimated project costs are included in Appendix B.

## Table 17: Recommended Improvements Timeline and Estimated Costs

| Item | Improvement | Approximate Recommended Implementation Date | MD System Demand When Improvements Are Needed | Estimated Project Costs |
|---|---|---|---|---|
| 1 | 1.0 MGD Connection to WaterOne | 2018 | Over 4.0 MGD (Current Conditions) | $5,400,000[1] |
| 2 | Control Valve on 183rd Street Tower | 2019 | NA | $200,000 |
| 3 | Take Kill Creek BPS Offline | 2019 | NA | NA |
| 4 | Switch SCADA Controls to Kill Creek Tower | 2019 (After completion of Item 2) | NA | NA |
| 5 | Take Above Ground and Underground Reservoirs and Associated Pump Stations Offline | After Completion of Item 1 | NA | NA |
| 6 | New 6.0 MGD WTP, HSPS, Clearwells | 2027 (With completion of Item 1) | 6.0 MGD | $34,000,000 to $55,000,000 [2] |
| 7 | Redundant 16-inch Treated Water Transmission Line | In time for new WTP Startup | 6.0 MGD | $7,150,000 |
| 8 | Redundant 8-inch (min.) Raw Waterline | In time for new WTP Startup | 6.0 MGD | $970,000 |
| 9 | Upgrade Raw Water Pump Station | In time for new WTP Startup | 6.0 MGD | $630,000 |
| 10 | Upgrade new WTP to 8.0 MGD | 2040 (With completion of Items 1 and 6) | 8.0 MGD | $7,500,000 |
| 11 | Upgrade WTP to 10.0 MGD | Beyond Planning Period/As Needed (With completion of items 1, 6, and 9) | 10.0 MGD | $7,500,000 |
| 12 | Acquire Additional Water Rights | Beyond Planning Period/As Needed | 9.3 MGD (AD) | Varies based on source and how the rights are obtained. |
| 13 | Cast Iron Pipe and AC Pipe Replacements | As Funds Allow | NA | Varies based on pipe size, locations, service connections, etc. Approx. $100 to $200 per LF. |
| 14 | Looped 12-inch Waterlines Throughout City | As Funds are Available and As Needed to Serve Future Development | NA | $550,000 per mile |

[1] Assumes 2.0 MGD SDC for 20 years and estimated costs for WaterOne infrastructure costs passed on to City.
[2] Range provided to account for potential alternative treatment processes and contingencies for a planning level cost estimate.

# Figures




SCALE: 1" = 1500'

0 500' 1000' 1500'

LEGEND

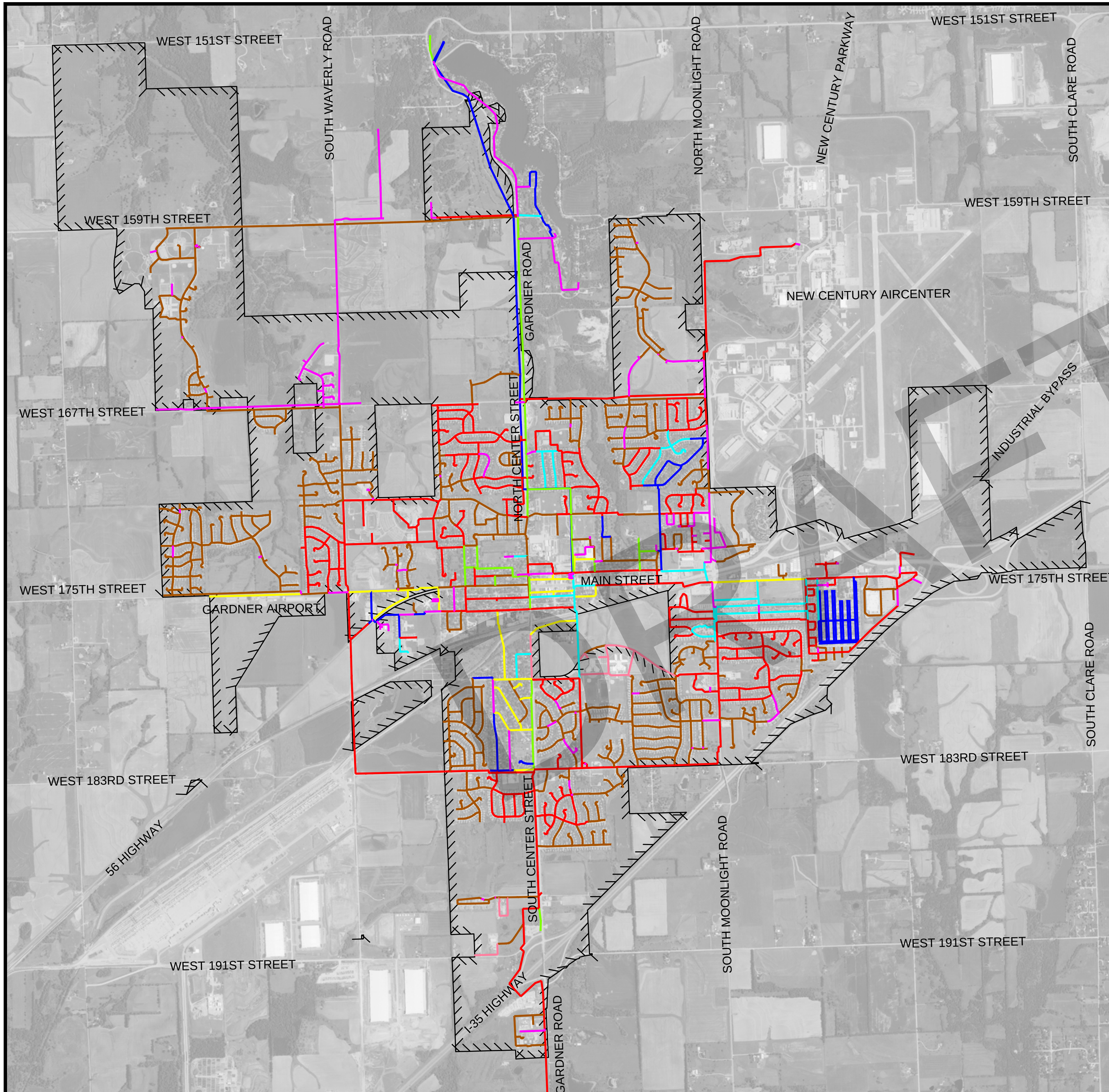
- 6 INCH DIAMETER PIPE AND SMALLER
- 8 INCH DIAMETER PIPE
- 10 INCH DIAMETER PIPE
- 12 INCH DIAMETER PIPE
- 16 INCH DIAMETER PIPE
- 18 INCH DIAMETER PIPE
- CITY LIMITS

CITY OF GARDNER, KANSAS

# FIGURE 1
# EXISTING WATER DISTRIBUTION SYSTEM

MAY 2017 PEC PROJECT NO. 34-160422

PEC PROFESSIONAL ENGINEERING CONSULTANTS, P.A. 303 SOUTH TOPEKA WICHITA, KS 67202 316-262-2691 www.pec1.com




LEGEND

PIPE INSTALLED

- BEFORE 1959
- 1960's
- 1970's
- 1980's
- 1990's
- 2000's
- AFTER 2010
- UNKNOWN

CITY OF GARDNER, KANSAS

# FIGURE 2
# WATER DISTRIBUTION SYSTEM PIPE AGE

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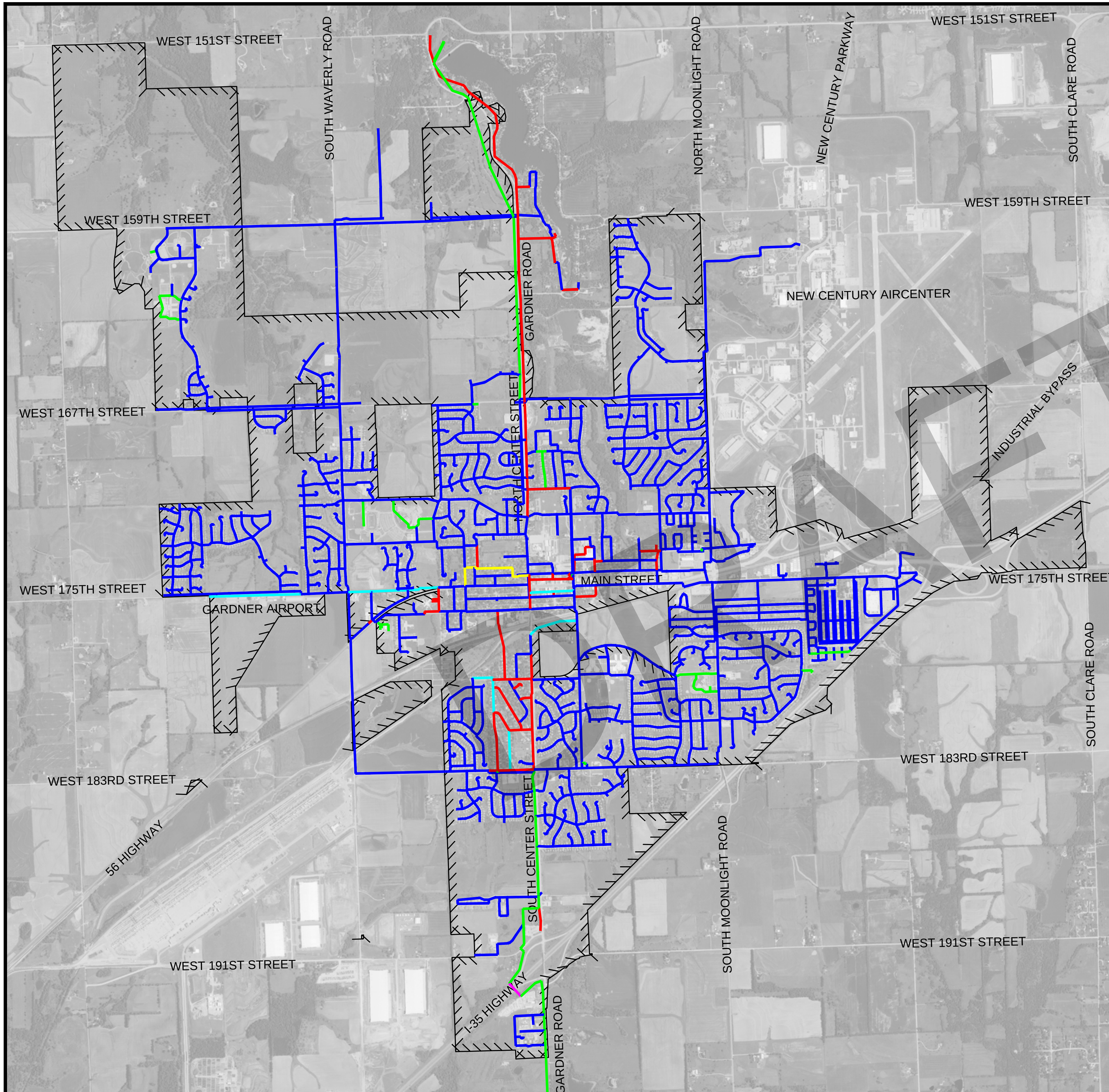


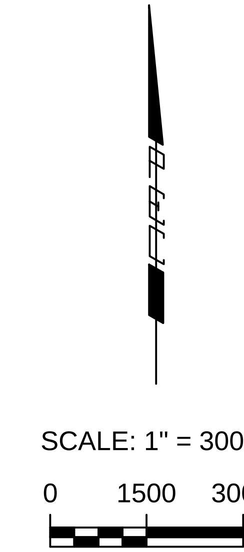


LEGEND

PIPE MATERIAL

- PVC
- DUCTILE IRON
- CAST IRON
- TRANSITE
- HDPE
- ASBESTOS CEMENT

CITY OF GARDNER, KANSAS

# FIGURE 3
# WATER DISTRIBUTION SYSTEM PIPE MATERIAL

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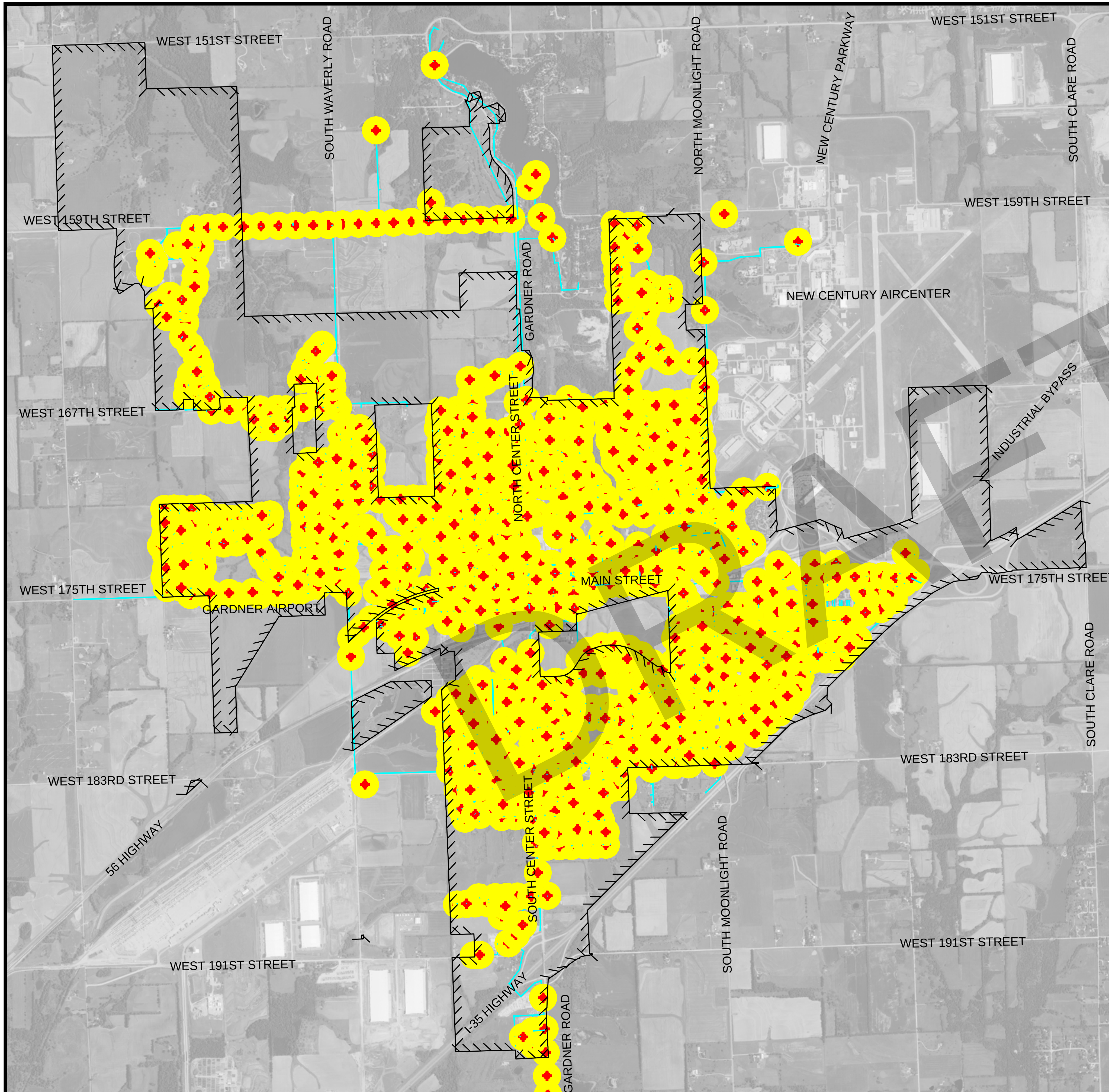




SCALE: 1" = 3000'

0 1500 3000

LEGEND

EXISTING WATERLINE

400' (RADIUS) FIRE HYDRANT COVERAGE

FIRE HYDRANT

CITY OF GARDNER, KANSAS

# FIGURE 4
# FIRE HYDRANT COVERAGE AREA

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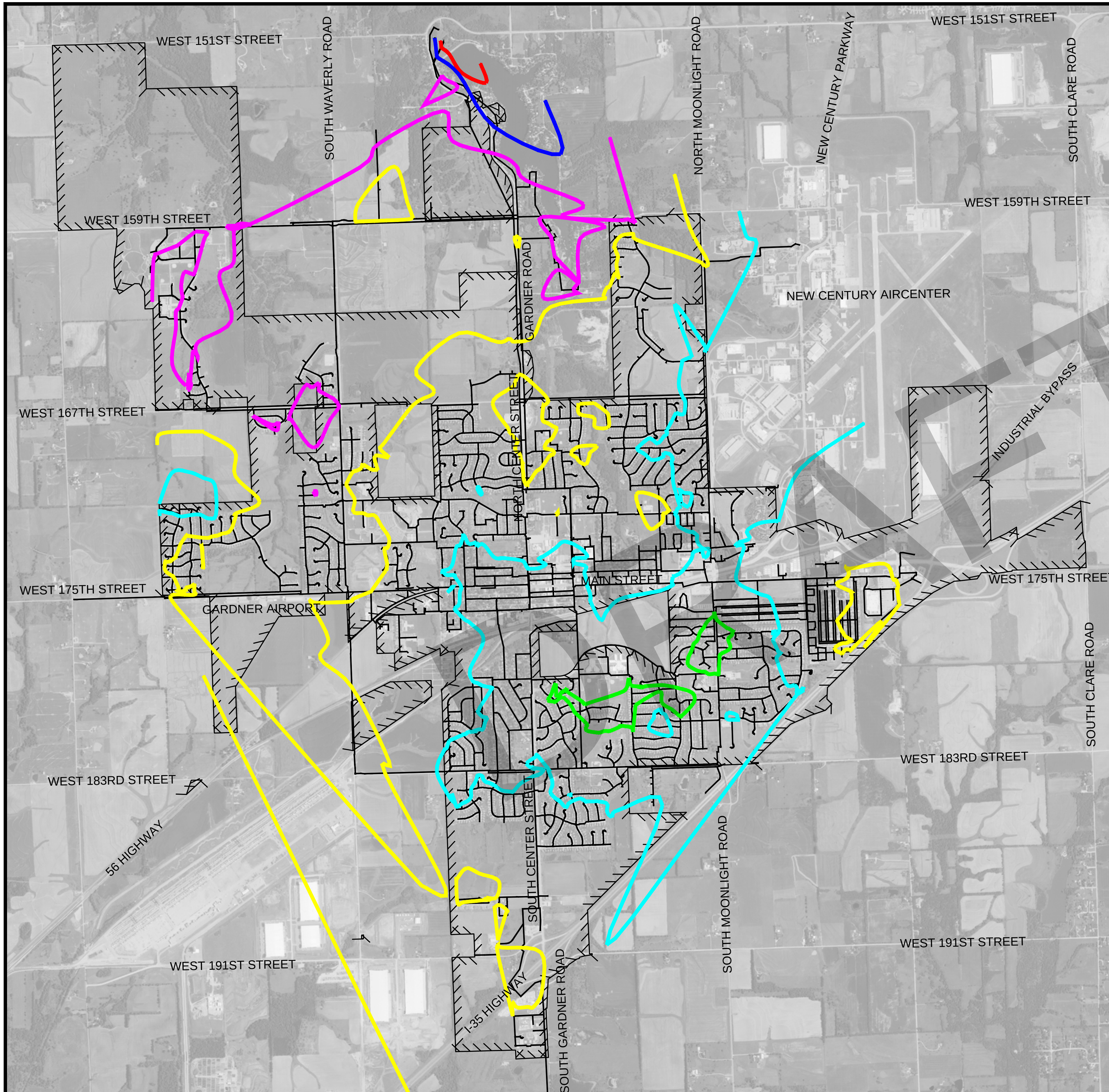




SCALE: 1" = 3000'

0 1500 3000

LEGEND

- EXISTING WATERLINE
- < = 50 PSI
- 51 – 60 PSI
- 61 – 70 PSI
- 71 – 80 PSI
- 81 – 90 PSI
- > 90 PSI

CITY OF GARDNER, KANSAS

# FIGURE 5

## PRESSURE UNDER CURRENT MAXIMUM DAY DEMANDS

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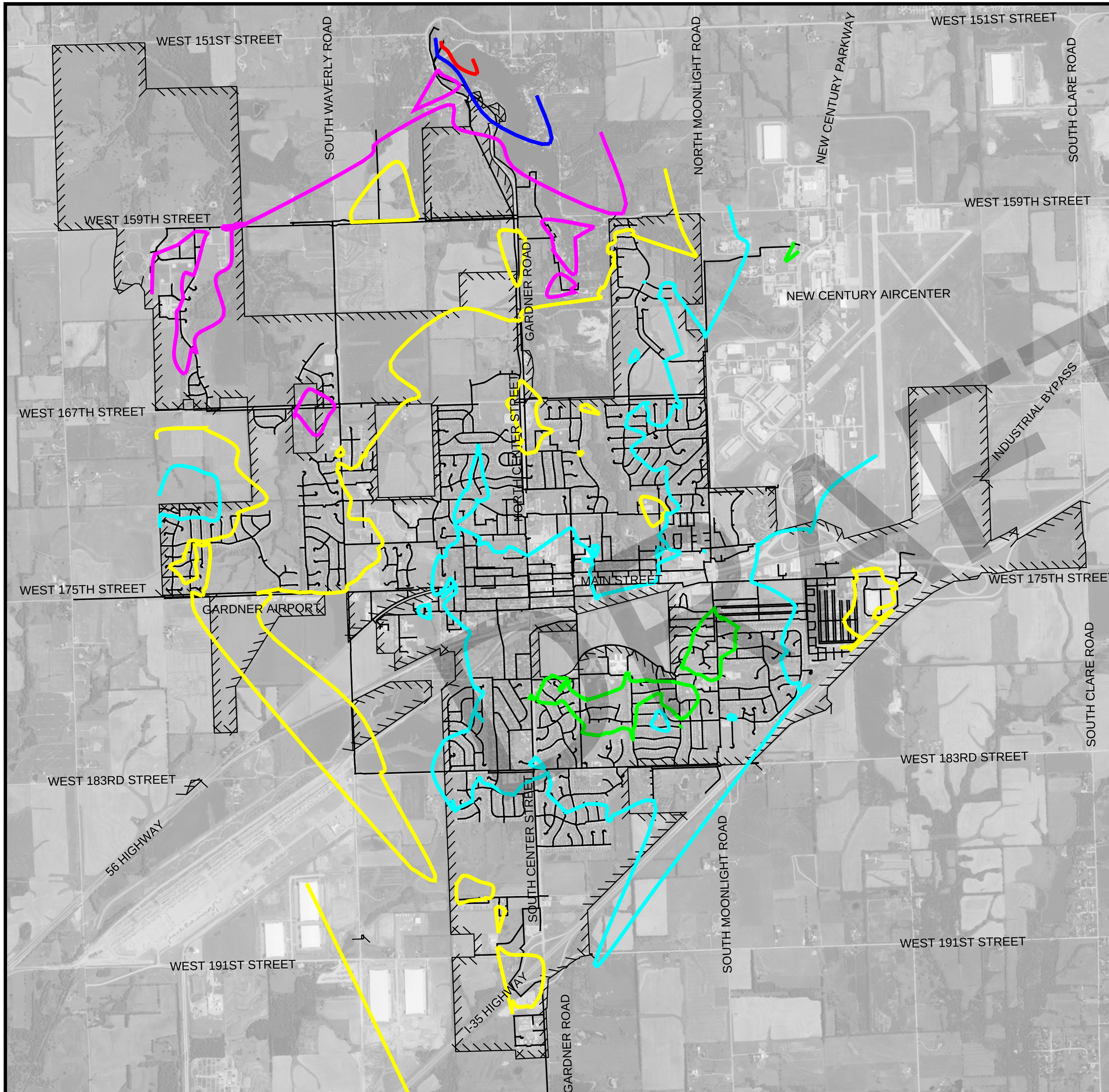


SCALE: 1" = 3000'

0 1500 3000

LEGEND

| | |
|---|---|
| — | EXISTING WATERLINE |
| — (green) | < = 50 PSI |
| — (cyan) | 51 – 60 PSI |
| — (yellow) | 61 – 70 PSI |
| — (magenta) | 71 – 80 PSI |
| — (blue) | 81 – 90 PSI |
| — (red) | > 90 PSI |

CITY OF GARDNER, KANSAS

# FIGURE 6

## PRESSURE UNDER CURRENT PEAK HOUR DEMANDS

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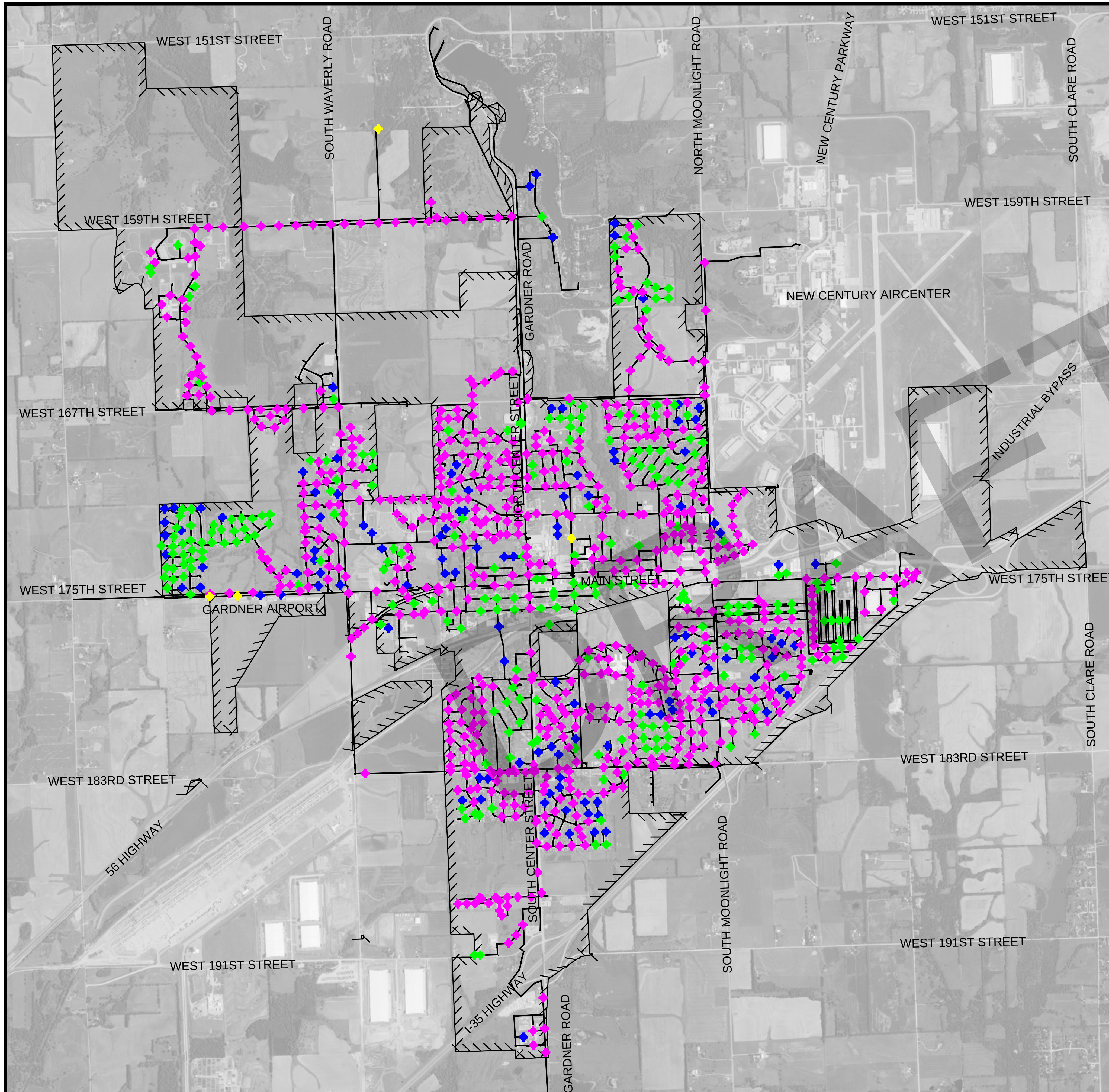


SCALE: 1" = 3000'

0 1500 3000

LEGEND

EXISTING WATERLINE

< = 1,000 GPM

< = 2,000 GPM

< = 3,000 GPM

> 3,000 GPM

CITY OF GARDNER, KANSAS

# FIGURE 7

## AVAILABLE FIRE FLOW UNDER CURRENT MAXIMUM DAY DEMANDS

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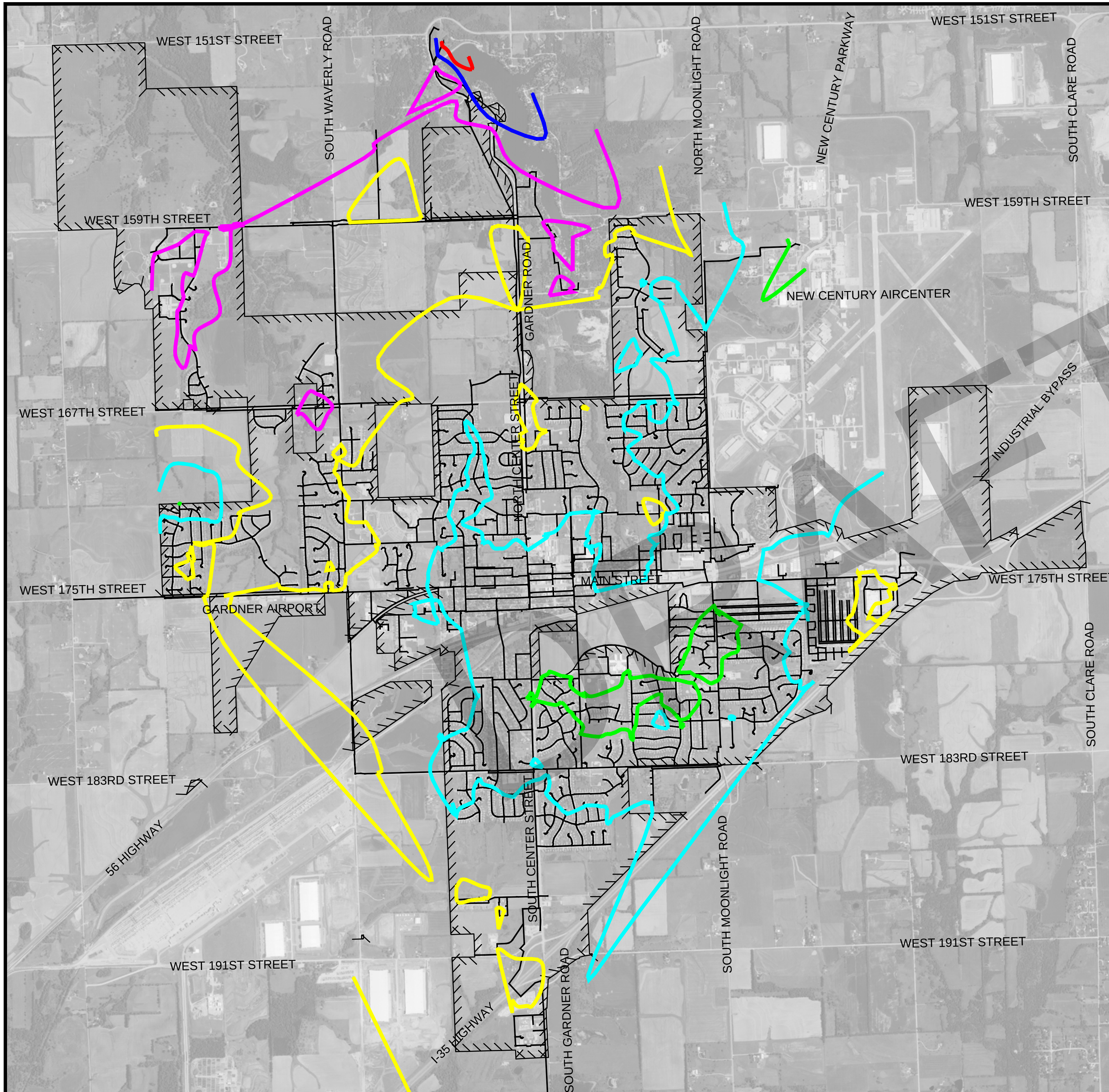


SCALE: 1" = 3000'

0 1500 3000

LEGEND

- EXISTING WATERLINE
- < = 50 PSI
- 51 – 60 PSI
- 61 – 70 PSI
- 71 – 80 PSI
- 81 – 90 PSI
- > 90 PSI

CITY OF GARDNER, KANSAS

# FIGURE 8
# PRESSURE UNDER 2040 MAXIMUM DAY DEMANDS

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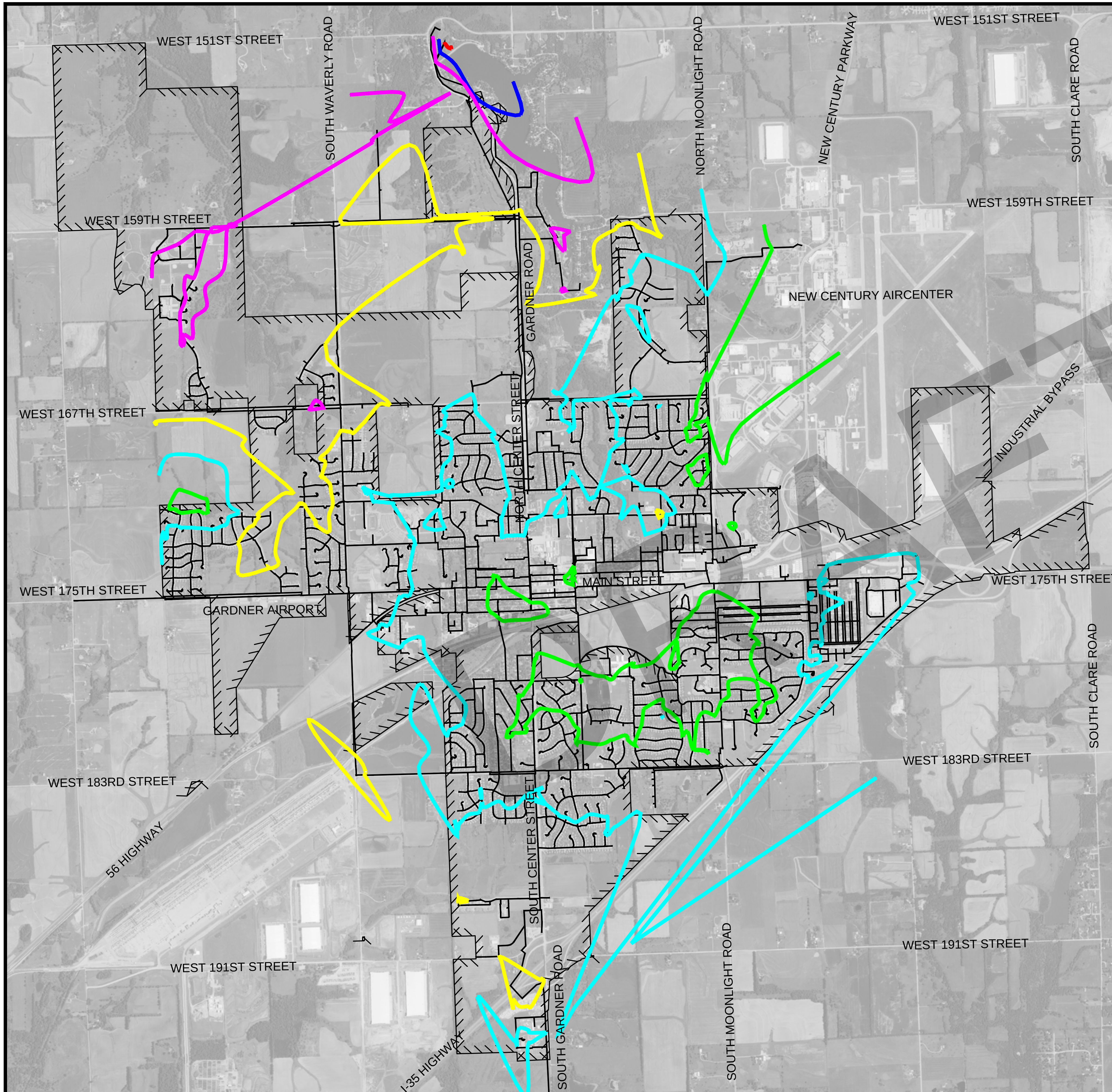




SCALE: 1" = 3000'

0 1500 3000

LEGEND

EXISTING WATERLINE
< = 50 PSI
51 – 60 PSI
61 – 70 PSI
71 – 80 PSI
81 – 90 PSI
> 90 PSI

CITY OF GARDNER, KANSAS

# FIGURE 9
# PRESSURE UNDER 2040 PEAK HOUR DEMANDS

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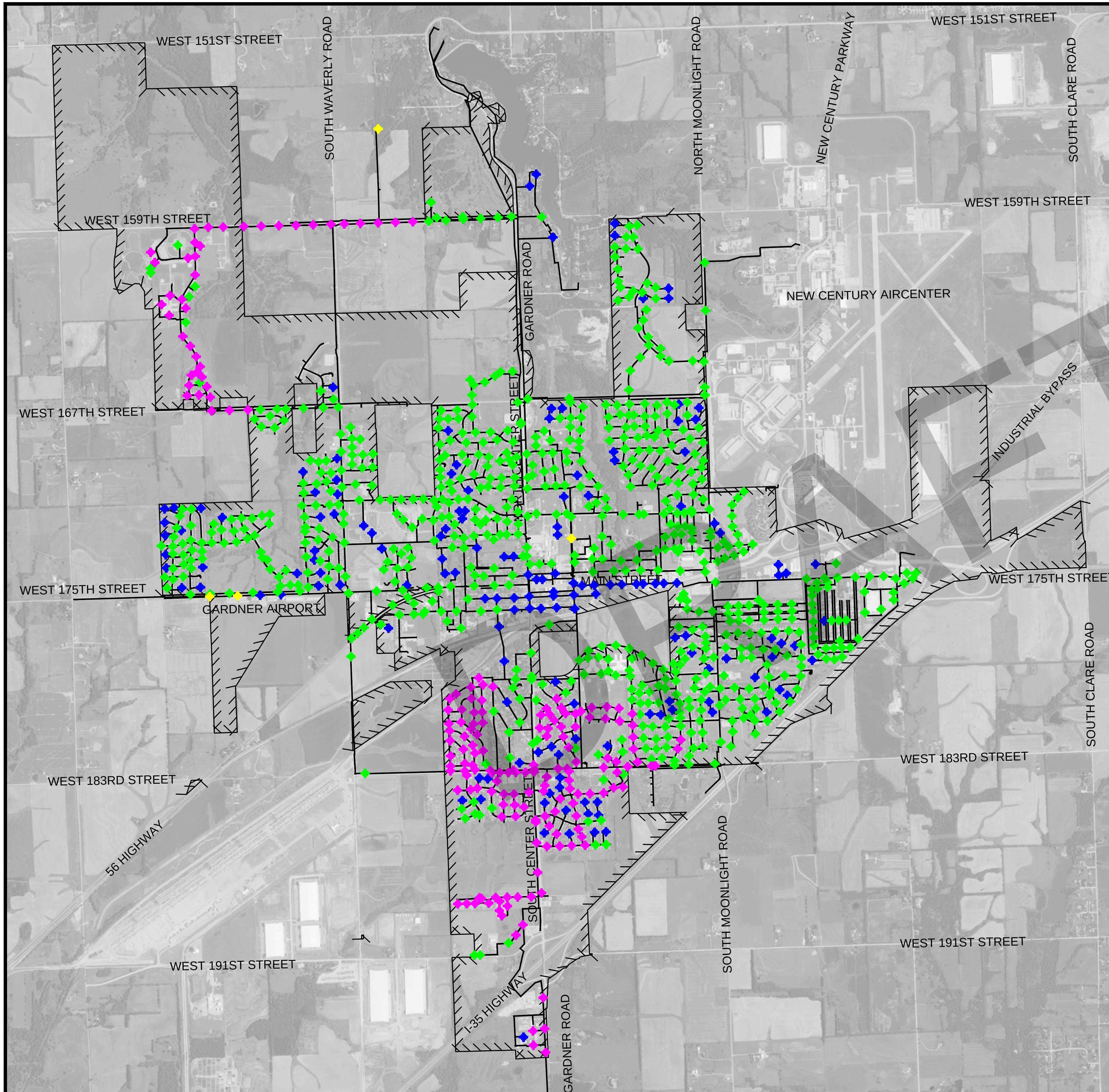


SCALE: 1" = 3000'

0 1500 3000

LEGEND

EXISTING WATERLINE

< = 1,000 GPM

< = 2,000 GPM

< = 3,000 GPM

> 3,000 GPM

CITY OF GARDNER, KANSAS

# FIGURE 10
# AVAILABLE FIRE FLOW UNDER 2040 MAXIMUM DAY DEMANDS

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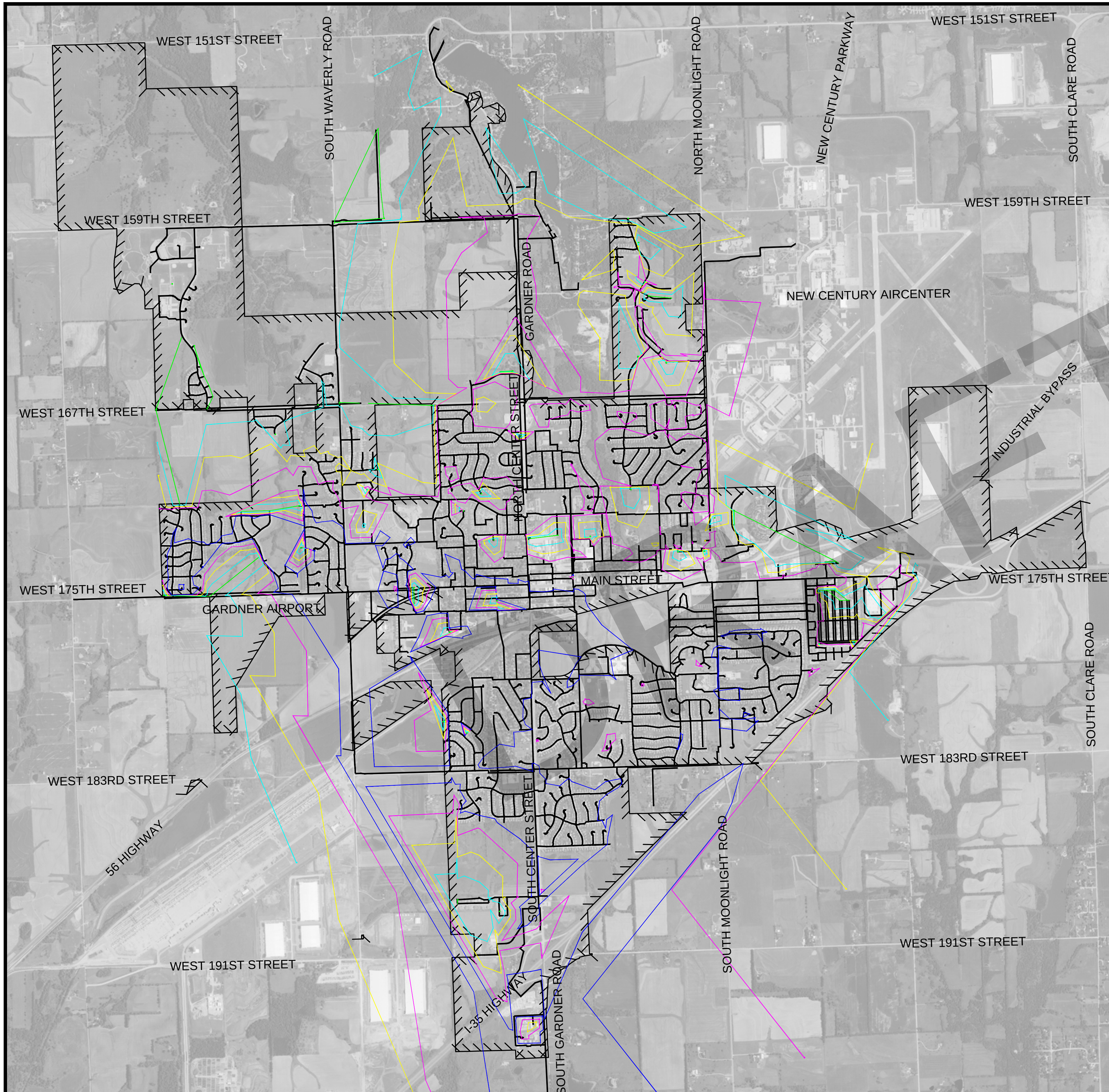


SCALE: 1" = 3000'

0 1500 3000

LEGEND

- EXISTING WATERLINE
- 48 HOURS
- 96 HOURS
- 192 HOURS
- 144 HOURS
- 240 HOURS

CITY OF GARDNER, KANSAS

# FIGURE 11

## EXISTING WATER DISTRIBUTION SYSTEM WATER AGE

MAY 2017 PEC PROJECT NO. 34-160422

PEC

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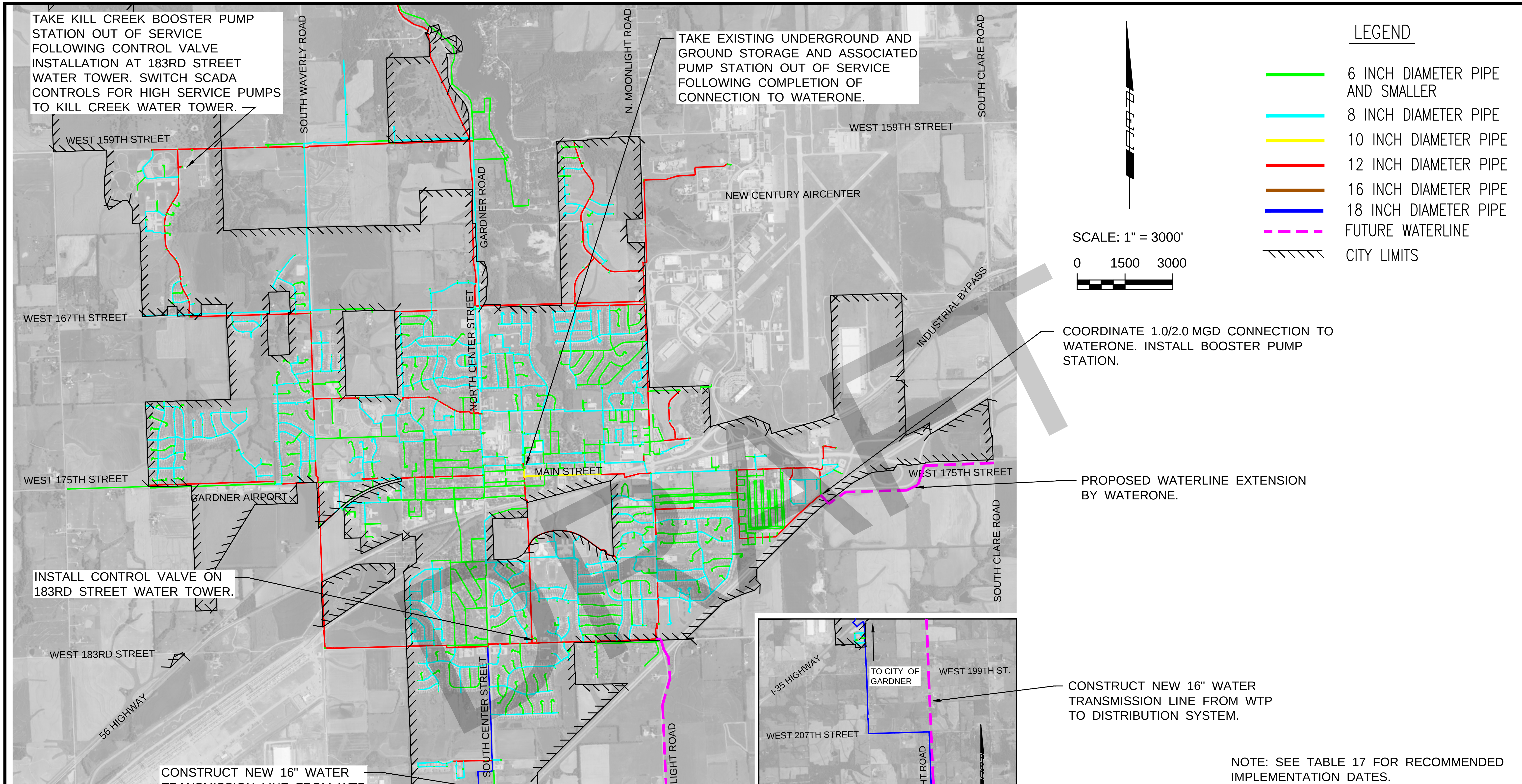


CITY OF GARDNER, KANSAS

# FIGURE 12

# WATER DISTRIBUTION SYSTEM RECOMMENDED IMPROVEMENTS

MAY 2017 PEC PROJECT NO. 34-160422

PEC PROFESSIONAL ENGINEERING CONSULTANTS, P.A. 303 SOUTH TOPEKA WICHITA, KS 67202 316-262-2691 www.pec1.com

# Appendix A

**TECHNICAL MEMORANDUM NO. 1**

**for**

**Evaluation of the Hillsdale Water Treatment Facility**

**Water Treatment Plant Evaluation**

**City of Gardner, Kansas**

**January 12, 2017**

**PEC Project No. 434-160422-000**

# TECHNICAL MEMORANDUM NO. 1

**For**

# Evaluation of the Hillsdale Water Treatment Facility

City of Gardner, Kansas

January 2017

Prepared By

Professional Engineering Consultants, P.A.

303 S. Topeka

Wichita, KS 67202

(316) 262-2691

**Contents**

## List of Figures



## List of Tables

## 1. Background

The Hillsdale Water Treatment Plant of the City of Gardner, Kansas, was evaluated as part of the Water Master Plan Update. The scope of this work included: identifying water treatment facility improvements for the projected future population; developing criteria to determine the feasibility of alternatives (including capital cost, operation and maintenance cost, ability to meet water quality, process reliability and flexibility, consistency with regulations and expressed policies of KDHE); identifying alternative sources for water supply in a supplemental or emergency capacity; and providing planning level construction cost estimates for alternatives.

## 2. Existing Conditions and Recommended Improvements

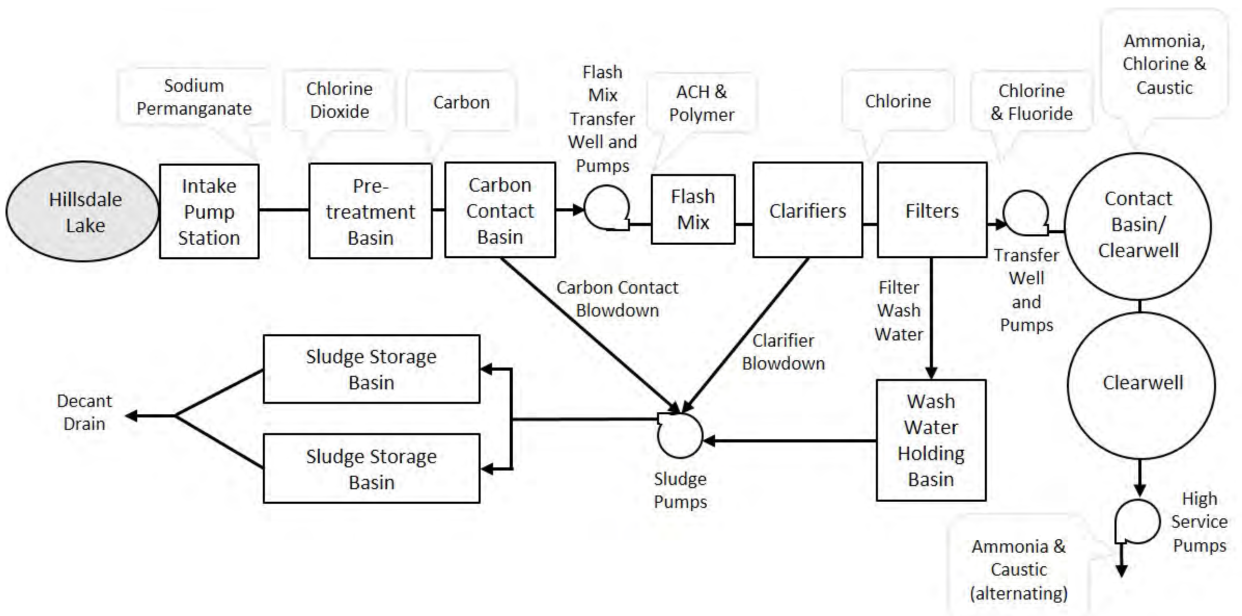


Figure A1: Hillsdale Water Treatment Plant Process Schematic

Currently, the Hillsdale Plant operates with the raw water intake at Hillsdale Lake, south of Gardner, Kansas (See Figure A1). At the intake, a 20% solution of sodium permanganate is fed at a rate of 300 gallons per week. After the intake pump station, the flow enters 10,250 linear feet (LF) of 16-inch waterline to the pretreatment basin. Prior to the pretreatment basin, chlorine dioxide is fed. The flow leaves the pretreatment basin and powdered activated carbon (PAC) is fed at 100 pounds per day to create a 6 – 9 mg/L PAC residual. After the pretreatment basin, the flow enters the carbon contact basin. Here, PAC works to absorb manganese and suspended solids that contribute to taste and odor issues. After the carbon contact basin, the flow is designed to enter the flash mix, but this is not currently in use. Thus, the flow is pumped directly from the carbon contact basin to the pulsating clarifier, bypassing the flash mix. Prior to the clarifiers, coagulants are added, including aluminum chlorohydrate and polymer. In the pulsating clarifiers, floc form around coagulants, settle out, and are removed from the flow. After the clarifiers, the flow enters one of seven (7) filter cells. The filters are periodically backwashed when they reach their treatment capacity (i.e., become fouled). After the filters, treated water is fed with fluoride and chlorine.  This flow is pumped to the chlorine contact basin (or, first clearwell), where it is dosed with ammonia, chlorine, and caustic.  Flow leaves the first clearwell and enters the second clearwell.  Treated water leaves the second clearwell to the high service pumps that lead to the distribution system.

On the solids handling side, blowdown waste is created by the carbon contact basin, clarifiers, and filter backwash.  The blowdown waste is collected at the basement level and sent to sludge pumps, which are downgrade of the facility.  The sludge pumps send the waste to the sludge storage basins, which are upgrade of the facility.  Decant drains to the surface from the sludge storage basins to the drains downgrade of the facility.

In 2005, the Hillsdale Plant was improved to double capacity from 2 MGD to 4 MGD.  However, the plant is currently facing challenges with achieving the designed capacity of 4 MGD.  The WTP operator indicated that the maximum capacity the plant can achieve is 3.8 MGD during peak flows.

The Water Treatment Plant of the City of Gardner, Kansas, was evaluated to identify issues with existing equipment, processes, operation and design.  On October 7, 2016, PEC walked through the facility with the WTP Operator and discussed the operational issues and shortcomings of the 2005 upgrades.  The following sections summarize the site visit observations and discussions.

## 2.1. Raw Water Intake

The Gardner WTP draws surface water from Hillsdale Lake. Currently, the raw water intake pumps lack variable-frequency drives (VFDs). Without VFDs, the pumps are unable to pump at lower rates to match flow rates at the WTP. The recommended improvement is to install VFDs on the existing raw water pumps, allowing turn down to match flow rates. This recommendation will increase the pump station efficiency by reducing the wasted energy used by the pumps.

According to the WTP operator, surrounding water supplies have encountered zebra mussels in their surface water intakes. Zebra mussels are an invasive species that propagate in waters with fast moving flow. This makes water intake screens and pipes the ideal place for zebra mussels to attach themselves. However, once the fast moving flow stops, the zebra mussels detach themselves from the pipes in order to again seek fast moving flow. To keep zebra mussels from completely blocking intake screens and pipes, the following improvements are recommended before the zebra mussels can become an issue: replacing the screens with a copper/zinc alloy; modifying the operational strategy by rotating the use of different intakes in the lake to avoid zebra mussels (e.g., switching to a different intake when the current intake is overrun with zebra mussels, then switching back to that intake when the zebra mussels have detached themselves); and installing oxidant chemical addition (e.g., chlorine dioxide), to discourage zebra mussel growth in the intake piping.

## 2.2. Pre-treatment Basin

Figure A1: Pre-treatment Basin (Facing NW), 10/07/2016

The pre-treatment basin is located on the south side of the treatment building. Currently, the pre-treatment basin operation indicates that the basin is undersized for peak flows. At peak flows, the WTP operator indicated that the water surface level reaches 0.5-inches below the basin hatch. The recommended improvements include: raising the elevation of the pre-treatment basin by approximately one (1) foot by building up the existing concrete structure, and putting in an overflow pipe. This recommendation will allow the plant to operate at peak flows without risk of overtopping the basin hatch.

## 2.3. Clarification

Figure A2: Pulsating Clarifier and Launders, 10/07/2016

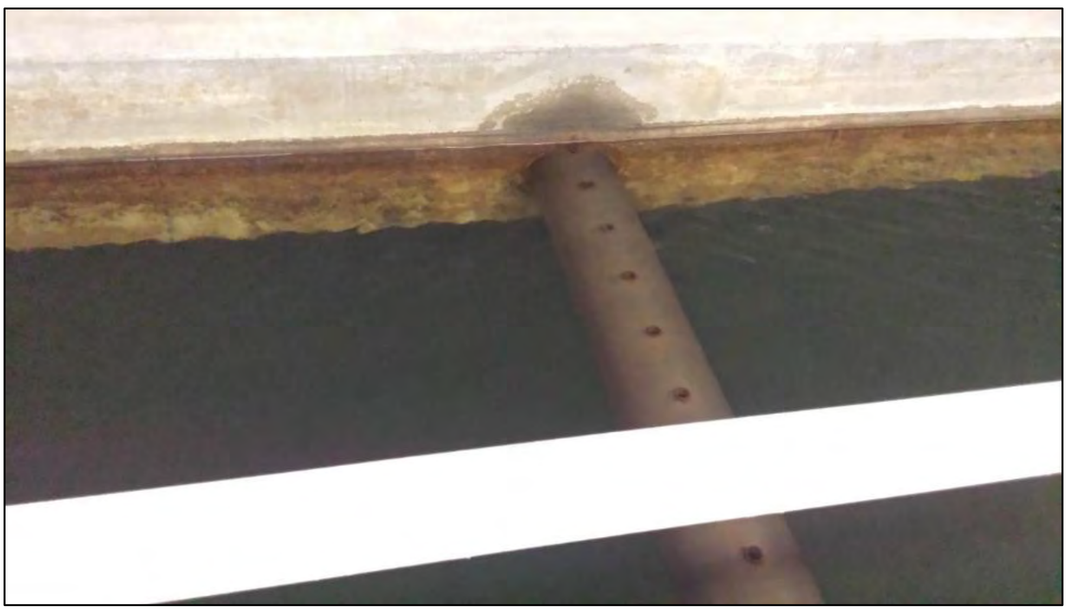

Figure A3: Pulsating Clarifier and Launders, 10/07/2016

Clarification during the 2005 upgrades was not increased. The existing pulsating clarifiers were sized to treat the original design flow of 2 MGD, and not the increased demand of 4.0 MGD. Additionally, the clarifier launders are uneven, not level, and in poor condition. The recommended improvements include: constructing a new structure for the installation of two (2) new clarifiers to double the clarification capacity, and removing and replacing existing launders with launders that are balanced.

### 2.4. Disinfection

After filtration, flow is dosed with chlorine and fluoride. According to the WTP operator, the chlorine ejector is experiencing vacuum issues with too much back pressure during free chlorine disinfection. The recommended improvement is to install a pump at the chlorine ejector. This improvement includes supplying and installing a supplemental booster pump to help with the excess back pressure faced by the chlorine ejector.

### 2.5. Filtration

Figure A4: Filter Cells and Splitter Weirs, 10/07/2016

Figure A5: Filter Cells and Splitter Weirs, 10/07/2016

Figure A6:  Unused Filter Cell, 10/07/2016

Figure A7:  Unused Filter Cell, 10/07/2016

Flow leaves the clarifiers and enters the filter cells via splitter weirs (Fig. A5, A6).  Current filter operation is inefficient because fouling occurs more often than designed.  As shown above, the flow entering is too turbulent, breaking up any floc that formed during mixing.  The large flocs break up and become smaller sub-micron floc that more quickly clogs the filters.  This creates shorter run times between backwashing than intended in the original design.  According to discussions with the plant personnel, the filters are backwashed daily, when they are designed to be backwashed every 96-120 hours.  Additionally, flow enters the filter bay from one end, which causes the filters closest to the influent to foul more quickly.  Uneven fouling along the filters creates unused filter capacity.  Additionally, the supplemental backwash water valve does not work.  As part of 2005 upgrades, the number of filters was increased from 5 to 7, instead of doubled to 10. The current number of filters is unable to handle flows efficiently, contributing to the shorter run times between backwashes. An additional filter cell is unusable because of a common wall with untreated water. The KDHE document *Policies, General Considerations, and Design Requirements for Public Water Supply Systems in Kansas* requires the "prevention of cross-connections and common walls between filtered and unfiltered water, including on-site sources of groundwater, and between potable and non-potable water. A dry well to separate filters from prior treatment steps will be required when there would otherwise be only a common wall between them" (see Chapter V.J.2.e.13). This recommended improvements to the filters include: removing splitter weir boxes; installing simul-wash troughs to increase efficiency; reconfiguring the piping for a hydraulically balanced filtration process (increasing the hydraulic head on the filters; installing rate of flow controllers, level transmitters, and a new pump); adding two (2) new filters to the two (2) unused filter cells in the west building; hard-piping installation; and replacing the supplemental backwater water valve. The cell sharing a common wall would be usable if the flow was hard-piped directly to the filter cells, bypassing the flash mix.

## 2.6. Contact Basin/ Clearwells

Figure A8: Contact Basin/ First Clearwell (Left) and Second Clearwell (Right) (Facing N), 10/07/2016

Figure A9: Contact Basin/ First Clearwell (Facing N), 10/07/2016

After filtration, flow enters the chlorine contact basin (or, first clearwell), followed by the second clearwell. According to the WTP operator, the contact basin and clearwell walls have been repaired many times, but still show signs of leaking. The recommended improvement is to: reevaluate the disinfection scheme and either: 1) replace the basins with two (2) new clearwells reconfigured to allow for operation in series; or 2) investigate the alternative of using ultraviolet (UV) disinfection for giardia inactivation.

## 2.7. Sludge Handling

Figure A10: Clarifier Blowdown (Basement Floor), 10/07/2016

Figure A11: Clarifier Blowdown (Basement Floor), 10/07/2016

Visual observation of the basement floor clarifier blowdown shows that the effluent is relatively thin (i.e., low percent solids). This suggest poor handling of solids. The recommended improvement is to reevaluate the solids handling process to produce higher percent solids with the new clarifiers proposed in these improvements.

Figure A12: Sludge Pump (South Region of Property), 10/07/2016

Figure A13: Sludge Pump (South Region of Property), 10/07/2016

The sludge pumps are located on the south and downgrade area of the property. The carbon contact blowdown and clarifier blowdown flow to the sludge pump, and are pumped upgrade to the north end of the property, expending much energy to lift the waste upgrade to the sludge storage basins.

Figure A14: Sludge Storage Basins at North End of Property (Facing N) 10/07/2016

Figure A15: Sludge Storage Basins at North End of Property (Facing NE), 10/07/2016

The sludge storage basins hold sludge and release flow downgrade to the discharge point at the south and downgrade edge of the property. The sludge pumps are at the south end of the property, downgrade of the storage basins.

Figure A16: Decant Drain to Surface (South Edge of Property) (Facing S), 10/07/2016

Figure A17: Decant Drain to Surface (South Edge of Property) (Facing S), 10/07/2016

Decant from the sludge storage basins is discharged at the south end of the property, downgrade. The location of the sludge storage basins is upgrade from the facility, pump, and discharge point, which is hydraulically ineffective and wastes energy (Fig. A13 – A18). In the current configuration, sludge is sent downgrade from the facility to the pump, then pumped back upgrade to the sludge basins, then sent downgrade to the discharge drain. The recommended improvements include: abandoning existing storage sludge basins on north edge of property; reconstituting the existing backwash holding basin in some capacity, e.g., using basin as a drying bed; and constructing two (2) new decant basins downgrade of plant, which would contain decant water from blowdown and backwash. The new basins would be designed to run in parallel and in series, with the ability of chemical addition if needed.

### 2.8. Backwash Holding Basin

The backwash holding basin is located downgrade of the treatment facility in the southeast corner of the property. Currently, the holding basin is used to contain waste from backwashing the filters. The waste in the holding basin is sent to the sludge pumps, which send the waste to the sludge storage basins at the north end of the property, upgrade of the facility. The location of this basin is not hydraulically efficient because the sludge pumps have to send the waste upgrade to the sludge storage basins. This adds to the high head pumping of solids. To eliminate this issue, the recommended improvement is to keep the existing holding basin structure and reconstitute it to function as a drying bed.

### 2.9. Chemical Storage

Figure A18: Chemical Storage, 10/07/2016

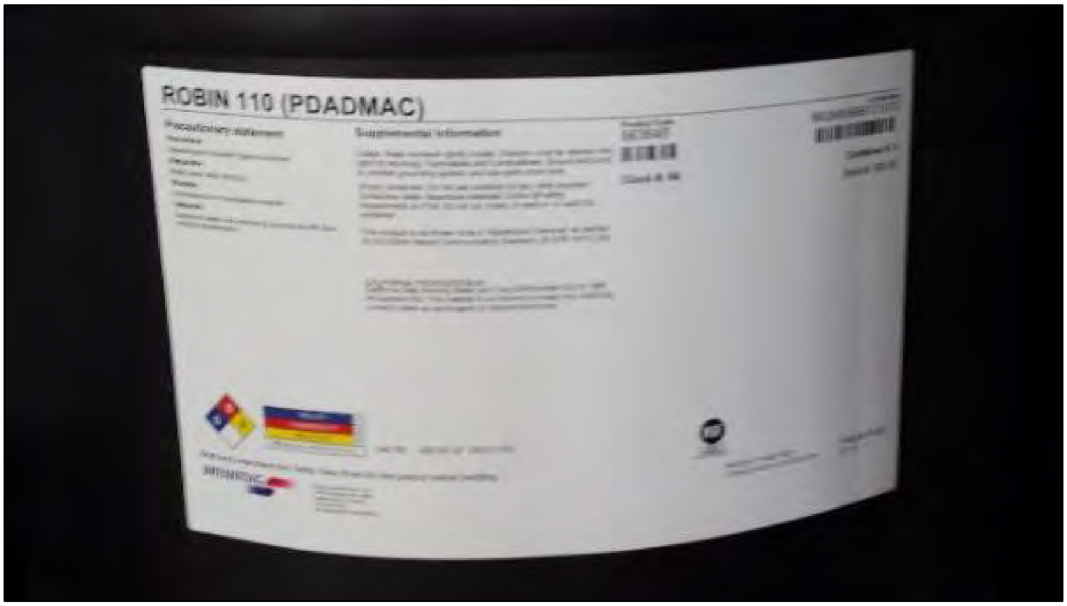


Figure A19: Chemicals in Use, 10/07/2016


Figure A20: Chemicals in Use, 10/07/2016


Figure A21: Chemicals in Use, 10/07/2016

Figure A22: Polymer Storage and Feed System, 10/07/2016

Figure A23: Polymer Storage and Feed System, 10/07/2016

Chemicals and chemical feed equipment are stored on the floor above the carbon contact basins, lacking proper containment (Fig. A19 – A24). The chemicals include: barrels of Robin 110 Poly Diallyldimethylammonium Chloride (pDADMAC); barrels of Hydrofluorosilicic Acid 24%; and bags of Ammonium Sulfate. In the case of a spill, the containment appears to be insufficient because of the volume of chemicals stored inside the spill containment curb wall. If a failure of the existing containment were to occur, the untreated water in the pre-treatment basin below would be vulnerable to chemical contamination with overtopping of the curb wall containment. The recommended improvements include: moving the location of the chemical storage, constructing a new building to house chemicals, and implementing proper containment of chemicals.

## 2.10. Electrical

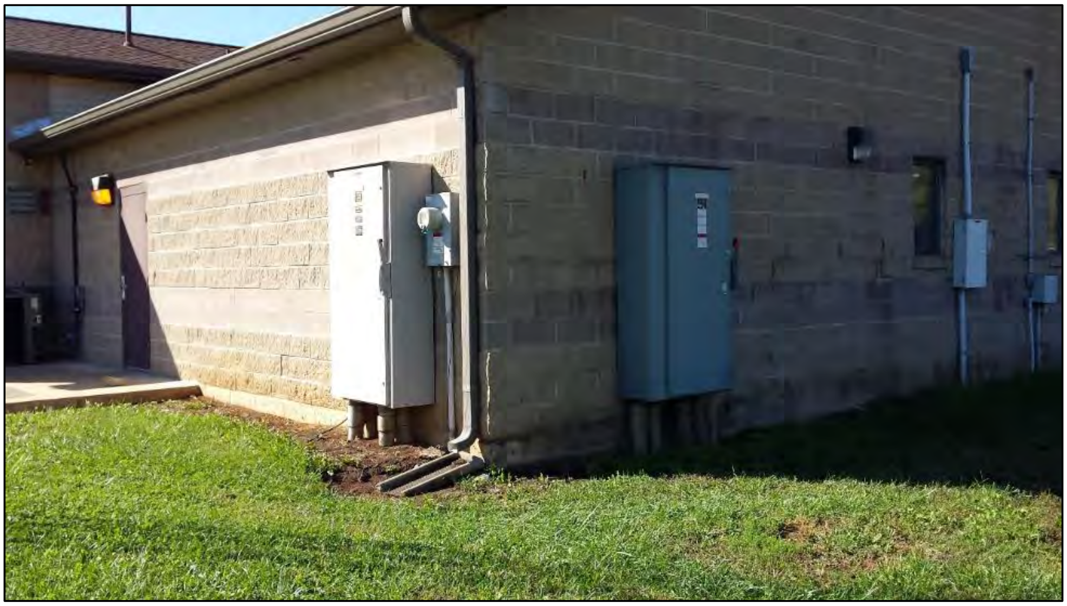

Figure A24: Electrical Boxes on Northeast Corner of Building, 10/07/2016

According to the WTP operator, there is no local grounding on equipment throughout facility. Currently, the only grounding is at one box on the northeast corner of the building. Additionally, the WTP operator indicated that there is no lightning protection. The recommended improvements include: adding additional electrical grounding to equipment within the facility, and improving lightning protection (evaluating the current lightning risk and installing measures necessary for proper lightning protection).

Figure A25: Generator to East of Building (Facing NE), 10/07/2016

Figure A26: Generator to Northeast of Buildings (Facing S), 10/07/2016


Figure A27: Generator to Northeast of Buildings (Facing S), 10/07/2016

According to the WTP operator, the generators are undersized for the facility (Fig. A26 – A28). The recommended improvement is to reevaluate the existing generators and install a new generator if the existing unit is insufficient.

## 3. Summary of Recommendations and Planning Level Cost Estimates

The following Table A1 is a summary of the recommendations, their associated priority, planning level capital cost estimate, and annual operation and maintenance cost estimate.

### 3.1. Hillsdale WTP Evaluation Summary

Table A1: Hillsdale WTP Evaluation Summary

| **Location** | **Items** | **Comments** | **Recommendation** | **Priority** | **Planning Level Cost Estimate** | **Estimated Annual Operation & Maintenance** |
|---|---|---|---|---|---|---|
| Raw Water Intake | | | | | | |
| | Intake | No VFDs on pumps. Pumps run at full speed regardless of flow. | Install VFDs on pumps. | Medium | $ 50,000 | $ 3,750 |
| | Zebra Mussels | May clog intake and pipes | Replace screens with Zn/Cu alloys. | Medium | $ 65,000 | $ 0 |
| | Zebra Mussels | May clog intake and pipes | Add additional oxidant to intake. | Low | $ 75,000 | $ 1,500 |
| | Zebra Mussels | May clog intake and pipes | Operationally change to rotating intake pipes, if possible. | Low | $ 0 | $ 0 |
| Pre-treatment Basin | | | | | | |
| | Basin | Water height too high during peak flow, 0.5-inches from top of hatch | Increase elevation of basin by building basin concrete walls; installing overflow pipe. | Medium | $ 35,000 | $ 0 |
| Clarifier | | | | | | |
| | Size | Not increased during 2005 updates, same size clarifier for 2MGD and 4 MGD. | Install two (2) new clarifiers in new structure. | High | $2,650,000 | $ 198,750 |
| | Launders | Launders not level, uneven. | Remove and replace launders. | Medium | $ 125,000 | $ 0 |
| Chlorine Feed point | | | | | | |
| | Free Chlorine Disinfection | Vacuum issue, too much back pressure. | Install supplemental booster pump. | High | $ 25,000 | $ 500 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Filtration | | | | | | |
| | 7 Filters | Too few filters for doubled load. Originally 5, but increased to 7 for doubled flowrate capacity. | Install 2 new filters in 2 spare filter cells (1 cell requires hard-piping, see: Spare Filter Cell). | High | $ 455,000 | $ 0 |
| | Equalizer/ Director Boxes/ Splitter Weirs | Incoming water too turbulent, breaks up floc and clogs filter more quickly/deeply. | Remove boxes and reconfigure piping to filters for hydraulically balanced filtration: including installing simul-wash troughs, rate of flow controllers, level transmitters, and a new pump. | High | $ 965,000 | $ 72,375 |
| | Spare Filter Cell | Spare cell is adjacent to flash mix, shares a common wall and cannot be currently used as filter. | Add hard-piping installation for flow directly to the spare filter cell, bypassing the flash mix. This allows an additional filter to be added. | High | $ 12,500 | $ 0 |
| | Backwash | Supplemental backwash water valve doesn't work. | Replace supplemental backwash water valve. | High | $ 8,500 | $ 0 |
| Clearwells | | | | | | |
| | Outer Wall | Leaks and has been attempted to be repaired. | Reevaluate disinfection scheme. Replace with new basins and reconfigure to allow for operation in series. An alternative is to investigate use of UV disinfection. | Medium | $1,250,000 | $ 23,750 |
| Sludge Handling | | | | | | |
| | Clarifier Blowdown | Sludge percent solids is too low. | Reevluate solids handling process with new clarifiers. | Low | $ 10,000 | $ 0 |
| | Sludge Storage Basins | Location is upgrade from facility, pump, and discharge point. | Abandon existing two (2) basins, construct two (2) new decant basins in downgrade location, designed to run in parallel and in series with the option of chemical feed if needed. | High | $ 750,000 | $ 56,250 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Backwash Holding Basin | | | | | | |
| | Backwash Holding Basin | Eliminate high head pumping of solids. | Reconstitute basin to function as a drying bed. | Medium | $ 250,000 | $ 10,000 |
| Chemical Storage | | | | | | |
| | Chemical Storage | Lacks proper containment, and is located above carbon contact basin. | Move chemical storage to new structure to remove possibility of chemical spill contamination of untreated water. Implement proper chemical containment. | High | $ 350,000 | $ 10,000 |
| General | | | | | | |
| | Grounding | No local grounding on equipment throughout facility. | Put grounding on all equipment within facility. | Medium | $ 85,000 | $ 6,375 |
| | Generator | Generator may be insufficient. | Resize generator, remove and install properly sized generator if required. | Low | $ 125,000 | $ 9,375 |
| | Lightning Protection | Protection may be insufficient. | Assess current lightning risk, install measures to improve lightning protection. | Medium | $ 75,000 | $ 5,625 |

The total planning level estimate cost for the recommendations included in the summary is $8,023,490. This includes $7,361,000 for construction and $662,490 for engineering.  The anticipated annual operation and maintenance cost is estimated to be $398,250 for costs associated with these upgrades.

### 3.2. Recommendations by Priority

The following Tables A2, A3, and A4 summarize the recommendations by priority level, with total cost estimates included at the end of each table for construction, engineering, and annual operation and maintenance.

Table A2: High Priority Recommendations

| Location | Items | Comments | Recommendation | Priority | Planning Level Cost Estimate | Estimated Annual Operation & Maintenance |
|---|---|---|---|---|---|---|
| Clarifier | | | | | | |
| | Size | Not increased during 2005 updates, same size clarifier for 2MGD and 4 MGD. | Install two (2) new clarifiers in new structure. | High | $2,650,000 | $ 198,750 |
| Chlorine Feed point | | | | | | |
| | Free Chlorine Disinfection | Vacuum issue, too much back pressure. | Install supplemental booster pump. | High | $ 25,000 | $ 500 |
| Filtration | | | | | | |
| | 7 Filters | Too few filters for doubled load. Originally 5, but increased to 7 for doubled flowrate capacity. | Install 2 new filters in 2 spare filter cells (1 cell requires hard-piping, see: Spare Filter Cell). | High | $ 455,000 | $ 0 |
| | Equalizer/ Director Boxes/ Splitter Weirs | Incoming water too turbulent, breaks up floc and clogs filter more quickly/deeply. | Remove boxes and reconfigure piping to filters for hydraulically balanced filtration: including installing simul-wash troughs, rate of flow controllers, level transmitters, and a new pump. | High | $ 965,000 | $ 72,375 |
| | Spare Filter Cell | Spare cell is adjacent to flash mix, shares a common wall and cannot be currently used as filter. | Add hard-piping installation for flow directly to the spare filter cell, bypassing the flash mix. This allows an additional filter to be added. | High | $ 12,500 | $ 0 |
| | Backwash | Supplemental backwash water valve doesn't work. | Replace supplemental | High | $ 8,500 | $ 0 |

| Location | Items | Comments | Recommendation | Priority | Planning Level Cost Estimate | Estimated Annual Operation & Maintenance |
|---|---|---|---|---|---|---|
| | | | backwash water valve. | | | |
| Sludge Handling | | | | | | |
| | Sludge Storage Basins | Location is upgrade from facility, pump, and discharge point. | Abandon existing two (2) basins, construct two (2) new decant basins in downgrade location, designed to run in parallel and in series with the option of chemical feed if needed. | High | $ 750,000 | $ 56,250 |
| Chemical Storage | | | | | | |
| | Chemical Storage | Lacks proper containment, and is located above carbon contact basin. | Move chemical storage to new structure to remove possibility of chemical spill contamination of untreated water. Implement proper chemical containment. | High | $ 350,000 | $ 10,000 |

The total planning level estimate cost for the recommendations identified as high priority is $5,685,440. This includes $5,216,000 for construction and $469,440 for engineering. The anticipated annual operation and maintenance cost is estimated to be $337,875 for costs associated with these upgrades.

Table A3: Medium Priority Recommendations

| Location | Items | Comments | Recommendation | Priority | Planning Level Cost Estimate | Estimated Annual Operation & Maintenance |
|---|---|---|---|---|---|---|
| Raw Water Intake | | | | | | |
| | Intake | No VFDs on pumps. Pumps run at full speed regardless of flow. | Install VFDs on pumps. | Medium | $ 50,000 | $ 3,750 |
| | Zebra Mussels | May clog intake and pipes | Replace screens with Zn/Cu alloys. | Medium | $ 65,000 | $ 0 |
| Pre-treatment Basin | | | | | | |
| | Basin | Water height too high during peak flow, 0.5-inches from top of hatch | Increase elevation of basin by building basin concrete walls; installing overflow pipe. | Medium | $ 35,000 | $ 0 |
| Clarifier | | | | | | |
| | Launders | Launders not level, uneven. | Remove and replace launders. | Medium | $ 125,000 | $ 0 |
| Clearwells | | | | | | |
| | Outer Wall | Leaks and has been attempted to be repaired. | Reevaluate disinfection scheme. Replace with new basins and reconfigure to allow for operation in series. An alternative is to investigate use of UV disinfection. | Medium | $1,250,000 | $ 23,750 |
| Backwash Holding Basin | | | | | | |
| | Backwash Holding Basin | Eliminate high head pumping of solids. | Reconstitute basin to function as a drying bed. | Medium | $ 250,000 | $ 10,000 |
| General | | | | | | |
| | Grounding | No local grounding on equipment throughout facility. | Put grounding on all equipment within facility. | Medium | $ 85,000 | $ 6,375 |
| | Lightning Protection | Protection may be insufficient. | Assess current lightning risk, install measures to improve lightning protection. | Medium | $ 75,000 | $ 5,625 |

The total planning level estimate cost for the medium priority recommendations identified is $2,109,150. This includes $1,935,000 for construction and $174,150 for engineering. The anticipated annual operation and maintenance cost is estimated to be $49,500 for costs associated with these upgrades.

Table A4: Low Priority Recommendations

| Location | Items | Comments | Recommendation | Priority | Planning Level Cost Estimate | Estimated Annual Operation & Maintenance |
|---|---|---|---|---|---|---|
| Raw Water Intake | | | | | | |
| | Zebra Mussels | May clog intake and pipes | Add additional oxidant to intake. | Low | $ 75,000 | $ 1,500 |
| | Zebra Mussels | May clog intake and pipes | Operationally change to rotating intake pipes, if possible. | Low | $ 0 | $ 0 |
| Sludge Handling | | | | | | |
| | Clarifier Blowdown | Sludge percent solids is too low. | Reevaluate solids handling process with new clarifiers. | Low | $ 10,000 | $ 0 |
| General | | | | | | |
| | Generator | Generator may be insufficient. | Resize generator, remove and install properly sized generator if required. | Low | $ 125,000 | $ 9,375 |

The total planning level estimate cost for the recommendations identified as low priority is $228,900. This includes $210,000 for construction and $18,900 for engineering. The anticipated annual operation and maintenance cost is estimated to be $10,875 for costs associated with these upgrades.

# Appendix B

**Cost Estimates**

| *Professional Engineering Consultants, P.A.*<br>303 S. Topeka<br>Wichita, Kansas 67202<br>Phone (316) 262-2691 | **City of Gardner, Kansas**<br>**Planning Level Cost Estimates**<br>**PEC Project Number 34-160422-000-7923**<br><br>**May 2017** |
|---|---|

## ENGINEER'S ESTIMATE - 1.0 MGD Connection to WaterOne
**(2.0 MGD Infrastructure)**

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE UNIT PRICE | ENGINEER'S ESTIMATE COST |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 1 | WaterOne System Development Charge (SDC)[1] | 1 | LS | 2,370,803.00 | $2,370,803.00 |
| 2 | WaterOne Water Distribution System Extension Cost[2] | 1 | LS | 1,500,000.00 | $1,500,000.00 |
| 3 | 12" Pipe | 250 | LF | 50.00 | $12,500.00 |
| 4 | 12" Valve Assemblies | 4 | EA | 3,500.00 | $14,000.00 |
| 5 | 1,400 GPM Booster Pump Station/Control Valve/Meter | 1 | EA | 1,000,000.00 | $1,000,000.00 |
| 6 | Erosion Control | 1 | LS | 5,000.00 | $5,000.00 |
| 7 | Site Clearing and Restoration | 1 | LS | 7,500.00 | $7,500.00 |
| | PROBABLE CONSTRUCTION COSTS | | | | $4,909,803.00 |
| | ITEM 3-7 CONSTRUCTION CONTINGENCIES @ 20% | | | | $207,800.00 |
| | ITEM 3-7 PROJECT COSTS @ 25% | | | | $259,750.00 |
| | TOTAL ESTIMATED PROJECT COSTS | | | | **$5,377,353.00** |

[1] Estimate includes SDC for 2.0 MGD over 20 years. While 1.0 MGD connection is the initial scenario, it is anticipated 2.0 MGD will be needed within 5 years.
[2] Estimated costs as outlined by WaterOne.

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Phone (316) 262-2691

**City of Gardner, Kansas**
**Planning Level Cost Estimates**
**PEC Project Number 34-160422-000-7923**

**May 2017**

## ENGINEER'S ESTIMATE - 183rd St. Tower Control Valve and Vault

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Control Valve and Vault | 1 | LS | 75,000.00 | $75,000.00 |
| 2 | 16" Pipe | 100 | LF | 200.00 | $20,000.00 |
| 3 | 16" Valve Assemblies | 3 | EA | 4,000.00 | $12,000.00 |
| 4 | Connect to Existing | 2 | EA | 10,000.00 | $20,000.00 |
| 5 | SCADA Controls/Integration | 1 | LS | 7,500.00 | $7,500.00 |
| 6 | Erosion Control | 1 | LS | 1,500.00 | $1,500.00 |
| 7 | Site Clearing and Restoration | 1 | LS | 3,500.00 | $3,500.00 |
| | PROBABLE CONSTRUCTION COSTS | | | | $139,500.00 |
| | CONTINGENCIES @ 20% | | | | $27,900.00 |
| | PROJECT COSTS @ 25% | | | | $34,875.00 |
| | TOTAL ESTIMATED PROJECT COSTS | | | | **$202,275.00** |

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|---|---|

## ENGINEER'S ESTIMATE - New 6.0 MGD Water Treatment Plant

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE | |
|---|---|---|---|---|---|
| | | | | UNIT PRICE | COST |
| | | | | | |
| | | | | | |
| 1 | 6.0 MGD Water Treatment Plant | 1 | LS | 25,500,000.00 | $25,500,000.00 |
| 2 | High Service Pumps and Storage | 1 | LS | 3,500,000.00 | $3,500,000.00 |
| 3 | Land Acquisition | 10 | ACRE | 50,000.00 | $500,000.00 |
| | | | PROBABLE CONSTRUCTION COSTS | | $29,500,000.00 |
| | | | CONTINGENCIES @ 20% | | $5,900,000.00 |
| | | | PROJECT COSTS @ 25% | | $7,375,000.00 |
| | | | TOTAL ESTIMATED PROJECT COSTS | | **$42,775,000.00** |

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**Planning Level Cost Estimates**
**PEC Project Number 34-160422-000-7923**

**May 2017**

## ENGINEER'S ESTIMATE - Redundant 16-inch Treated Water Transmission Line

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE | |
|---|---|---|---|---|---|
| | | | | UNIT PRICE | COST |
| | | | | | |
| | | | | | |
| 1 | 16" Pipe | 30,000 | LF | 150.00 | $4,500,000.00 |
| 2 | 16" Valve Assembly | 12 | EA | 4,000.00 | $48,000.00 |
| 3 | Fire Hydrant Assembly | 6 | EA | 4,500.00 | $27,000.00 |
| 4 | Air Release Assembly | 6 | EA | 5,500.00 | $33,000.00 |
| 5 | 30" Steel Encasement | 500 | LF | 450.00 | $225,000.00 |
| 6 | Connect to Existing | 2 | EA | 7,500.00 | $15,000.00 |
| 7 | Remove and Replace Pavement | 600 | LF | 75.00 | $45,000.00 |
| 8 | Erosion Control | 1 | LS | 12,500.00 | $12,500.00 |
| 9 | Site Clearing and Restoration | 1 | LS | 25,000.00 | $25,000.00 |
| | PROBABLE CONSTRUCTION COSTS | | | | $4,930,500.00 |
| | CONTINGENCIES @ 20% | | | | $986,100.00 |
| | PROJECT COSTS @ 25% | | | | $1,232,625.00 |
| | TOTAL ESTIMATED PROJECT COSTS | | | | **$7,149,225.00** |

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## ENGINEER'S ESTIMATE - Redundant 8-inch Raw Waterline

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 1 | 8-inch waterline | 12,000 | LF | 50.00 | $600,000.00 |
| 2 | 8" Valve Assembly | 5 | EA | 1,750.00 | $8,750.00 |
| 3 | Connect to Existing | 2 | EA | 5,000.00 | $10,000.00 |
| 4 | Air Release Assembly | 6 | EA | 5,500.00 | $33,000.00 |
| 5 | Erosion Control | 1 | LS | 4,500.00 | $4,500.00 |
| 6 | Site Clearing and Restoration | 1 | LS | 7,500.00 | $7,500.00 |
| | PROBABLE CONSTRUCTION COSTS | | | | $663,750.00 |
| | CONTINGENCIES @ 20% | | | | $132,750.00 |
| | PROJECT COSTS @ 25% | | | | $165,937.50 |
| | TOTAL ESTIMATED PROJECT COSTS | | | | **$962,437.50** |

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**May 2017**

## ENGINEER'S ESTIMATE - Upgrade Existing Raw Water Pump Station

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE UNIT PRICE | ENGINEER'S ESTIMATE COST |
|---|---|---|---|---|---|
| 1 | Submersible Pumps & Rails | 3 | EA | 100,000.00 | $300,000.00 |
| 2 | Pump Station Control Upgrades | 1 | LS | 50,000.00 | $50,000.00 |
| 3 | Electrical Upgrades | 1 | LS | 25,000.00 | $25,000.00 |
| 4 | Existing Structure Modifications | 1 | LS | 50,000.00 | $50,000.00 |
| 5 | Erosion Control | 1 | LS | 3,000.00 | $3,000.00 |
| 6 | Site Clearing and Restoration | 1 | LS | 5,000.00 | $5,000.00 |
| PROBABLE CONSTRUCTION COSTS | | | | | $433,000.00 |
| CONTINGENCIES @ 20% | | | | | $86,600.00 |
| PROJECT COSTS @ 25% | | | | | $108,250.00 |
| TOTAL ESTIMATED PROJECT COSTS | | | | | **$627,850.00** |

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## ENGINEER'S ESTIMATE - 12-inch Waterlines per Mile

| ITEM NO. | DESCRIPTION | QUANTITY | UNIT | ENGINEER'S ESTIMATE UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 1 | 12" Pipe | 5,280 | LF | 50.00 | $264,000.00 |
| 2 | 12" Valve Assemblies | 3 | EA | 3,500.00 | $10,500.00 |
| 3 | 12" Air Release Assemblies | 2 | EA | 3,000.00 | $6,000.00 |
| 4 | 20" Steel Encasemet | 100 | LF | 375.00 | $37,500.00 |
| 5 | Service Reconnections | 20 | EA | 1,200.00 | $24,000.00 |
| 6 | Waterline Abandonment | 1 | LS | 5,000.00 | $5,000.00 |
| 7 | Erosion Control | 1 | LS | 7,500.00 | $7,500.00 |
| 8 | Site Clearing and Restoration | 1 | LS | 20,000.00 | $20,000.00 |
| | PROBABLE CONSTRUCTION COSTS | | | | $374,500.00 |
| | ITEM 3-7 CONSTRUCTION CONTINGENCIES @ 20% | | | | $74,900.00 |
| | ITEM 3-7 PROJECT COSTS @ 25% | | | | $93,625.00 |
| | TOTAL ESTIMATED PROJECT COSTS | | | | **$543,025.00** |