FINAL REPORT

Water System Master Plan

Prepared for

City of Cornelius, Oregon

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Acronyms and Abbreviations

ADD	average day demand
ASR	aquifer storage and recovery
AWWA	American Water Works Association
DBP	disinfection by-product
EPA	U.S. Environmental Protection Agency
gal	gallon
gpcd	gallons per capita per day
gpm	gallons per minutes
ISO	Insurance Services Office
JWC	Joint Water Commission
LCR	Lead and Copper Rule
MCL	maximum contaminant level
MDD	maximum day demand
MG	million gallons
mgd	million gallons per day
PHD	peak hour demand
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinyl chloride
SCADA	supervisory control and data acquisition
UGB	urban growth boundary

SECTION 1

Plan Summary

1.1 Scope of Master Plan

This master plan was developed to guide the city's investments in its public drinking water system. The plan updates the city's February 2004 *Water Master Plan*. It includes an evaluation of the system and preparation of a 20-year capital improvements plan. The plan was developed to fulfill the state's requirements for water system master plans found in OAR 333-061-0060 (5), except for the description of financing options, which will be conducted by the city following adoption of the plan.

1.2 Background

As the first phase of this plan was being prepared, the City of Cornelius was designing and drilling an aquifer storage and recovery (ASR) test well, located near the city's existing reservoir and pump station in Water Park. The master plan completion was put on hold until the success of this test well was known. The findings indicated that ASR is a feasible option for the city. The planned use of this ASR well has been incorporated into this final master plan document.

The water demand projections included in the plan were based on published population growth estimates developed by a local planning agency. However, as the plan was being finalized in the late fall of 2016, private property developers were in discussions with city staff about possible near-term, large residential developments to be located in the city. Barring an economic turndown, the developments have the potential to add 4,000 people to the city's water service area. If such growth develops, this will accelerate the need for projects that are demand-driven, such as water supply and storage projects, and will accelerate the need for installing water mains in currently unserved areas.

The water supply sections of this plan describe the city's wholesale purchases from the City of Hillsboro and integration of the planned ASR well with this supply. A possible change to this scenario was also noted by the city as the plan was being finalized. As of December 2016, city staff reported that discussions were being held between Cornelius and Forest Grove about the idea of having Cornelius become a wholesale purchaser of treated drinking water from Forest Grove. Presumably, this would replace some but not all of the purchase from Hillsboro. The evaluation of the system presented in this master plan did not account for this possible water supply change.

1.3 Description of Existing System

Cornelius owns and operates a regulated public community potable water system to serve its citizens (state and federal Public Water System Identification No. 00218). The system currently serves approximately 12,000 people with approximately 3,060 customer accounts.

The city purchases treated water from the City of Hillsboro as its sole source, but this supply will be supplemented with production from the ASR well in the future. The use of the ASR well will not decrease the city's purchase of water from Hillsboro on an annual basis because an ASR system is not an independent source.

Cornelius has three master meter connections to the 72-inch Joint Water Commission (JWC) finished water transmission pipeline that passes through the city and these connections provide the city's water supply. Even with the ASR well in operation, the supply from the JWC transmission pipeline will remain as the original source of the city's water, with the difference being that more will be purchased in the winter months for storage in the groundwater aquifer using the ASR well. Less water will be purchased in the summer when water is recovered and pumped into the system from the well.

In addition to the ASR well being developed, the city's system includes approximately 32 miles of buried pipelines, a 1.5-million-gallon concrete storage tank, and a booster pump station. The city can use the water stored in the tank to help meet peak demands, although this is not the typical use for this system. Generally, the stored water is reserved for meeting emergencies. Water is periodically pumped from the tank to cycle the contents to avoid water quality problems from excessive storage age. The ASR well has been drilled next to the tank and pump station. Water from the ASR well will be pumped into the tank, where it can be mixed with surface water from the city's existing supply and then pumped into the distribution system.

1.4 Regulatory Compliance

Cornelius' system has operated in compliance with all applicable state and federal drinking water regulations. As a purchasing system, the city's responsibilities relate to meeting the regulations for distribution water quality. These distribution standards address microbiological contaminants, corrosion by-products (lead and copper), and disinfection by-products.

Corrosion by-products are regulated by the Lead and Copper Rule (LCR). Though not new, the LCR warrants specific mention because of the heightened concerns about high lead levels in drinking water in U.S. water utilities that occurred in 2016. Lead is almost never present in measurable levels in source waters. Rather, it is introduced into public water supplies through internal pipe corrosion. Small amounts of lead may be used in plumbing fixtures or in older solder compounds for copper pipe. As internal pipe corrosion occurs, small amounts of lead may be dissolved into the water.

All of Cornelius' routine, required monitoring results for lead and copper have complied with current standards. The system is currently required to conduct detailed sampling at what are classified as the highest risk locations every three years. The last monitoring was conducted in July 2014. The results, from 31 sample locations, showed a 90th percentile lead level that was below the detection limits (reported as 0.0000 mg/L). Lead was not detectable in at least 90 percent or 28 of the 31 samples. The 90th percentile copper level was found to be 0.09 mg/L, below the copper action level of 1.35 mg/L. The sampling results from 2008 and 2011 were similar to the values for 2014. However, although the city's routine monitoring has fully complied with the LCR, the city conducted extra sampling in the late summer, early fall of 2016 and found elevated lead levels in some city facilities including public drinking fountains.

At the time this report was being prepared, concerns about lead exposure from drinking water had been heightened by the experience in Flint, Michigan, where a change in water sources resulted in higher corrosion rates, leading to higher lead levels. This problem was compounded by a failure to take action by city, state, and federal employees and regulators. Primarily as a result of this highly publicized incident, the EPA implemented short-term changes to the LCR and proposed additional changes. As occurred in Cornelius, other Oregon systems found elevated lead levels in schools and public drinking fountains even though they were in compliance with the LCR. This was the case for Portland, Medford, and Corvallis. These results suggest that the current LCR is inadequate for protecting the public from elevated lead in drinking water.

As a minimum, new regulations will increase the monitoring requirements for lead in drinking water. Depending on the findings from additional monitoring, the city, working with Hillsboro and the JWC, may need to implement further protective measures. For Cornelius, an additional factor is the introduction of the ASR system. Although most of the water introduced into the system from the ASR well will be recovered surface water that has been injected, the system will produce a blend of injected and native groundwater, particularly toward the end of a seasonal recovery period. The water quality changes from introducing the native groundwater into the distribution system need to be carefully monitored. No regulatory compliance issues are expected from the use of ASR but additional monitoring steps have been recommended in this master plan.

1.5 Service Goals

The city's water quality and service goals provide planning, design, and operational guidelines for the water system. They address a variety of topics including fire flows, main sizing, operating pressures, and backflow protection. The goals are summarized in Chapter 4.

1.6 Water Use

In recent years, the city has purchased an average of 400 million gallons per year or approximately 1.1 million gallons per day (mgd) from Hillsboro. The rate of use is less than 1.1 mgd during the winter months and is equal to approximately twice that rate during a high use summer day. On a per capita basis, the average annual water use has declined by about 25 percent over the past 15 years.

A high nonrevenue water rate has been a challenge for the city. Revenue is not derived from water use that is not accounted for through customer meters. The previously used term *unaccounted water* is being replaced in the water industry with *nonrevenue water*. Based on a comparison of purchased flows through the master meters to recorded totals from the customer meters, the city did not receive revenue for one gallon out of every five that it purchased in fiscal year 2014-2015. The rate in the previous four years was one gallon out of every four. The difference between purchased and sold volumes results from leakage, meter inaccuracies, accounting processes, and unmetered uses. Reducing nonrevenue water is a high priority for the city because the cost for this lost water has averaged about $200,000 per year in recent years.

Water use is expected to increase by 50 percent by the end of the 20-year planning period, based on applying available population projections to recent per capita water use values. The actual water use growth will depend on many factors including general economic conditions, the timing and extent for the urban growth boundary expansion, and shifts within the make-up of the customer base, specifically, the types and extent of residential, commercial, and industrial developments. As noted previously in this chapter, one possible scenario is for the city to experience rapid population growth beginning in 2017. Property developers have suggested that they may add sufficient houses to accommodate 4,000 new city residents by 2022. The addition of 4,000 people to the city's water service area would represent nearly the entirety of the projected growth for the 20-year plan using published growth projections by a local planning agency. Such rapid growth would accelerate the need for capital projects described in this plan.

1.7 Distribution System Analysis

A distribution system hydraulic model was prepared and used in the master planning process. The network model provides an electronic record of the city's piping system and a tool to evaluate the performance of the system under a number of 'what if' scenarios. Modeling runs were performed for the existing system with and without the ASR supply.

In general, the modeling indicated that water can be delivered at acceptable pressures throughout the city during peak use periods, and that ASR injection and recovery modes will function acceptably. The significant weakness for the existing customer base is that the system is not capable of delivering the 1,000 gpm minimum residential fire flow to all areas of the city. The backbone pipe network is sufficient for delivering fire flows, but there are locations with small, dead-end pipelines limiting flows near their ends.

To enable the ASR system to function as intended, the existing booster pump station located at Water Park will need to be expanded and upgraded. The existing two domestic pumps need to be replaced with larger pumps, and rather than being constant speed, they should be replaced with variable speed pumps. Additionally, the existing fire pump can be replaced with a larger constant speed fire pump to improve system reliability. These changes will require significant mechanical and electrical upgrades. With the proposed 500 gpm ASR well and the expanded booster pump station, the system will be capable of supplying peak demands and fire flows for short durations even if the supply from the JWC transmission pipeline is down.

The central area of the city's pipe network includes about 7,000 feet of small diameter steel pipelines. These lines are prone to leakage and may be contributing to the city's relatively high nonrevenue water percentage. The distribution system analysis accounted for the city's ongoing replacement of these lines with larger lines. Once completed, the city's distribution pipe network will generally be capable of meeting peak hour and fire flow criteria throughout the system. Only a few isolated areas with hydrant fire flows slightly below the desired level will remain.

The report also provides a possible configuration of added pipes to serve an expanded urban growth boundary. These pipe additions will be needed as the city grows. An initial grid of pipelines was preliminarily sized for the southeast area of the city, where a significant amount of the growth is projected to occur. A second reservoir tank will be needed to serve this area. A ground-level storage tank with a booster pump station, similar to the one in use at Reservoir Park, was included in the future model, and the model results indicate that this approach will function acceptably with the remainder of the system.

1.8 Capital Improvements Plan

The following list presents system deficiencies and needed improvements:

1. The existing master meters at the three Hillsboro connections do not read within specification at very low flows; however, the volume of water below specification flow rates is very small. The master meters are being upgraded by the City of Hillsboro and this will help address this issue. In addition to Hillsboro's upgrades, the city's capital improvements plan includes the installation of compound meters downstream of Hillsboro's meters to confirm the record of flows into the system.
2. Customer meters also must provide accurate readings for a proper accounting of water use. Based on the average age and range of ages for customer meters, the capital improvements plan includes replacement of all customer meters over a three-year period beginning in fiscal year 2017-2018. The new meters will include remote read capabilities to improve operational efficiency in the system.
3. The city is part-way into a five-year program of replacing small diameter, steel pipelines. The completion of this program will increase the available fire flows and reduce system leakage. The remaining projects in this pipe replacement program are listed in the capital improvements plan.
4. An expansion of the existing Water Park booster pump station will be needed to enable the ASR system to operate at its full capacity. The full use of the proposed 500 gallon per minute (gpm) ASR well will not be achievable until the modifications to the pump station are completed.
5. The modeling found that while the existing pipe network is capable of supplying peak demands, there are a few locations where the system cannot supply the minimum residential fire flow of 1,000 gpm. These hydrants are generally located at the end of cul-de-sacs where it may not be feasible to add a pipe to complete a looped system. A number of pipeline improvements are included in the CIP to address areas with low fire flows.

6. The capital improvements plan includes a seven-year replacement program for all asbestos-cement pipe remaining in the system, at an annual cost of $500,000. The replacement program is scheduled to begin in fiscal year 2021-2022.
7. The city will need to add a second storage tank. Depending on the demand growth within the city, the second tank will be needed in the not too distant future. The city should purchase property for this tank as soon as possible. The property selection should accommodate the possible addition of a second ASR well.
8. The seismic condition of the existing storage tank should be considered to determine if it warrants rehabilitation. The pump station may also be in need of a seismic upgrade.
9. A project is included for removal and disposal of paint containing lead on the exterior of the storage tank. This is not an issue affecting water system performance, but is an environmental concern.
10. A grid of large diameter (12-inch) water mains has been developed for currently unserved areas that are expected to be brought into the city's urban growth boundary. These are intended to be representative locations, with the understanding that the final layout will depend on the nature of the property development. Furthermore, only the 12-inch mains are shown. It is understood that these mains will be interconnected and looped using a grid of 8-inch mains.

System Description

2.1 Service Area

The City of Cornelius is situated in Washington County about 20 miles west of Portland. It is bounded by Council Creek on the north, Hillsboro on the east, the Tualatin River on the south, and Forest Grove on the west. This is illustrated in the system map shown in Chapter 7.

Cornelius' Public Water System (Public Water System ID No. 00218) served approximately 12,161 people as of December 2016. Approximately 98 percent of these people live within the city limits or urban growth boundary (UGB). Those services outside the UGB have been in place since before the UGB was established or have been added by agreement with the City of Hillsboro. The city is mostly residential with some commercial and light industrial developments. Much of the remaining vacant land within the UGB is zoned commercial although expansion of the UGB to accommodate residential growth is anticipated.

2.2 Source of Supply

The city currently obtains all of its water as a wholesale customer of the City of Hillsboro. Hillsboro supplies Cornelius from three Hillsboro-owned master meters. All three master meters are connected to the JWC North Transmission Pipeline, which is a 72-inch pipeline that passes through Cornelius in a west to east direction. **Table 2-1** describes the locations, sizes, and pressures at the master meter connections. There is also a fourth master meter connection located farther to the east, at approximately the intersection of Baseline Road and East Lane, that can be used as the city grows in that direction.

The city's test results for the recently drilled ASR well were favorable and the city is moving ahead with developing this as a second supply. The planned production rate, also called recovery rate, is 500 gallons per minute (gpm). The city will continue to purchase all of its water from Hillsboro but will increase purchases in the winter, with the excess being stored underground through the ASR well at a rate of about 400,000 gallons per day. This same water will be pumped from the ASR well during the peak demand period in the summer. The use of ASR will reduce peak withdrawals from Hillsboro, will address a significant portion of the city's storage needs, and will provide an emergency backup supply.

Table 2-1. Master Meter Connections

Location/Name	Meter Size (inch)	Pressure Reducing Valves: Large (inch)	Pressure Reducing Valves: Small (inch)	Maximum Recorded Flow (gpm) (Note 2)	Hydraulic Values: Maximum Upstream Pressure (psi)	Typical Upstream Pressure (psi)	Pressure Downstream of PRV (psi)	Pipe Centerline Elevation (feet)	Hydraulic Grade Line (feet)
10th & Heather	10	6	3	1,800	155	147	67	162	317
12th & Baseline	6	6	3	1,080	150	148	61	173.3	314
Basco (also called Sonic; east of 17th off Baseline St)	6	6	3	2,125	149	146	59	176.5	313

Notes:

1. Maximum upstream pressure based on static pressure from Fern Hill Reservoirs at 520 feet elevation and pipe centerline 5 feet below ground surface
2. Maximum recorded flow values are uncertain; data from SCADA system were inconsistent.

2.3 Water Rights

The city obtains water by means of Hillsboro's water rights on the Tualatin River and storage rights in upper Tualatin and Trask River basins. The run of river rights are limited to the wet months, from mid-September through mid-May. Water is withdrawn from Barney Reservoir and Scoggins Reservoir to meet summertime demands. Cornelius holds groundwater rights for four wells but their capacities are small and their use is limited to irrigation for city parks. The city is currently exploring obtaining groundwater rights that would allow the ASR well to not only recover stored water but also to extract native groundwater.

2.4 System Components

The city's system includes, in addition to the newly constructed ASR well, approximately 36 miles of buried pipelines, a 1.5-million-gallon concrete storage tank, and a booster pump station.

2.4.1 Pipelines

The city's 36 miles of pipelines are primarily comprised of polyvinyl chloride (PVC) and ductile iron, both of which are considered durable materials for most ground conditions. The system includes about one and a half-miles of steel pipe, dating from the 1950s and 1960s, which has been found to be prone to leaks, so the city has made replacement of these lines a priority. There is a small amount of small diameter galvanized pipe, which is in need of replacement because of its size and because this material is also subject to corrosion and leakage. The system has about four miles of asbestos cement pipe. This is not a health concern because asbestos fibers become a problem when inhaled, not ingested. But asbestos cement pipe does deteriorate over time and also is targeted for replacement. **Figure 2-1** displays the composition of pipe materials in the city's system.

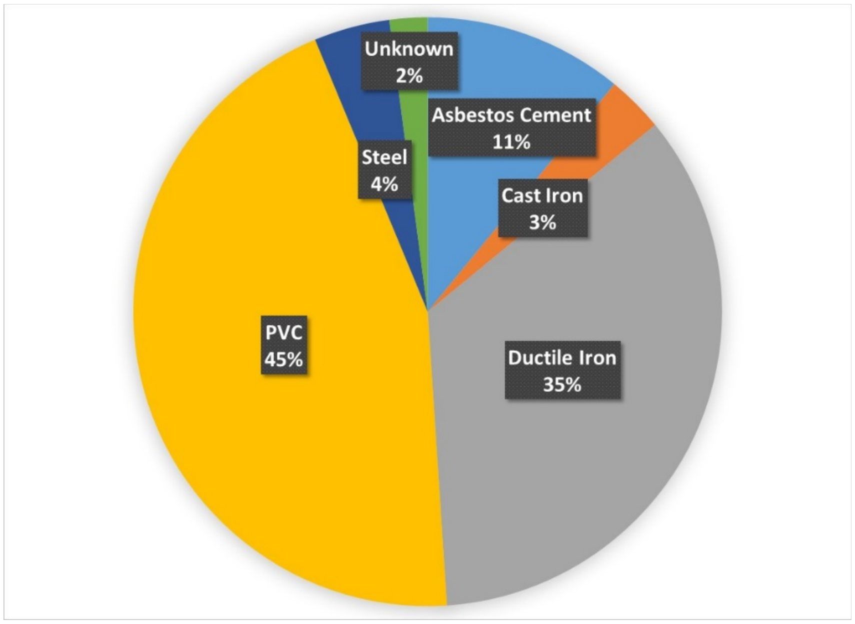

Figure 2-1. Pipe Inventory for Cornelius

2.4.2 Storage Tank and Booster Pump Station

The city has a 1.5 million gallon prestressed concrete ground-level storage tank and booster pump station located at Water Park.

The tank is approximately 100 feet in diameter and 30 feet tall, and was constructed in 1969. An altitude valve reduces pressures as water enters the tank, to keep it from overflowing, and the pump station is needed to return water into the system at distribution pressures. The seismic design criteria in use in 1969 were considerably less stringent than today's standards; current standards take into account the potential for a Cascadia Subduction Zone earthquake. Therefore, it is likely that this tank would not withstand a severe earthquake and remain undamaged.

The tank was painted on the exterior when constructed and the paint is flaking off, as illustrated in **Figure 2-2**. This does not affect its performance nor the quality of water stored inside, but is visually unappealing and further, is an apparent environmental concern because city staff report that the paint contains lead.

The pump station is located in a ground-level building with a basement, located next to the tank. The station includes two domestic service pumps and one fire pump. All are constant speed, vertical turbine, can-type pumps. The pumps and their capacities are summarized in **Table 2-2**. There is no backup power provided for the pumps.

Figure 2-2. Photo of Existing Reservoir Tank Showing Failing Coating

Table 2-2. Booster Pumps

Pump No.	HP	Manufacturer	Model	Stages	Capacity	
					Flow (gpm)	Head (feet)
1	15	Johnston	8AC	5	180	175
2	15	Johnston	8AC	5	180	175
3 (fire)	40	Johnston	10DC	5	800	175

SECTION 3

Regulatory Compliance and Water Quality

3.1 Existing and Future Regulatory Requirements

As a purchasing public water system, Cornelius must comply with drinking water quality regulations that relate to the distribution system. These regulations consist of the following federal U.S. Environmental Protection Agency (EPA) rules, all of which have been adopted by Oregon:

- Total Coliform Rule
- Lead and Copper Rule
- Stage 2 Disinfection By-Products Rule

The city has been in compliance with each of these regulations. This is based upon a review of the online data provided through the Oregon Health Authority website. The only negative items noted for the city were monitoring and reporting violations, when the city reported results after the due date.

In addition to the water quality rules, the city has been in compliance with the following operational requirements:

1. Cross connection control program
2. Consumer confidence reporting
3. Management of records
4. Operator certification

3.1.1 Revised Total Coliform Rule

From January 2002 through the end of December 2016, the city collected 1,759 coliform samples from the distribution system for compliance monitoring. Of this total, 13 had positive results, indicating the presence of total coliform bacteria. The most recent positive coliform result occurred in September 2013. Total coliform bacteria are the most generic of the surrogate parameters and alert the operators to possible contamination. All of the follow up samples to these positive results, of which three are required each time, were negative for the presence of total coliform. The city did not have a positive fecal coliform sample during this period. Fecal coliform and *E. coli* are more specific indicators of contamination than total coliform bacteria. The city’s clean record for fecal coliform indicates that the system provides a reliable supply of safe drinking water with respect to microbial contaminants.

3.1.2 Lead and Copper Rule

Corrosion by-products are regulated by the LCR. The LCR warrants specific mention because of the heightened concerns about high lead levels in drinking water in U.S. water utilities that occurred in 2016. Lead and copper are almost never present in measurable levels in source waters. Rather, they are introduced into public water supplies through internal pipe corrosion. Small amounts of lead may be used in plumbing fixtures or in older solder compounds for copper pipe. As internal pipe corrosion occurs, small amounts of lead may be dissolved into the water.

All of Cornelius’ routine, required monitoring results for lead and copper have complied with current standards. The system is currently required to conduct detailed sampling at what are classified as the highest risk locations every three years. The last monitoring was conducted in July 2014. The results, from 31 sample locations, showed a 90th percentile lead level of 0.0000 mg/L, meaning that lead was not detectable in at least 90 percent or 28 of the 31 samples. The 90th percentile copper level was found to be 0.09 mg/L, below the copper action level of 1.35 mg/L. The sampling results from 2008 and 2011 were very similar to the values for 2014. However, although the city’s routine monitoring has fully complied with the LCR, the city conducted extra sampling in the late summer, early fall of 2016 and found elevated lead levels in some city facilities including public drinking fountains.

At the time this report was being prepared, concerns about lead exposure from drinking water had been heightened by the experience in Flint, Michigan, where a change in water sources resulted in higher corrosion rates, leading to higher lead levels. This problem was compounded by a failure to take action by city, state, and federal employees and regulators. As occurred in Cornelius, other Oregon systems found elevated lead levels in schools and public drinking fountains even though they were in compliance with the LCR. This was the case for Portland, Medford, and Corvallis. These results suggest that the current LCR is inadequate for protecting the public from elevated lead in drinking water. Primarily as a result of the highly publicized Flint incident, the EPA implemented short-term changes to the Lead and Copper Rule (LCR) and proposed additional long-term changes. The short-term changes were the following:

- Required utilities to notify the state regulator whenever there is a change in treatment processes and/or a change in source water.
- Required state regulators to identify whether a corrosion control study is warranted based on the reported change in treatment or source water, and further to determine if they will require only a desktop study or also a demonstration study.

Cornelius' planned use of ASR falls under the first bullet item. The city will need to notify the state when the ASR system becomes operational. Although most of the water introduced into the system from the ASR well will be recovered surface water that has been injected, the system will produce a blend of injected and native groundwater, particularly toward the end of a seasonal recovery period. The water quality changes from introducing some native groundwater into the distribution system need to be carefully monitored. No regulatory compliance issues are expected from the use of ASR but additional monitoring steps have been recommended later in this chapter. A further discussion of the blending of the ASR recovery water with the city's existing supply is also presented later in this chapter.

EPA's proposed long-term changes to the LCR included the following:

- Separation of lead and copper sampling from one another, meaning they may have different location and frequency requirements.
- For those systems with water quality that is susceptible to copper corrosion, they may need to monitor at newly constructed houses or conduct pipe loop tests.
- Broaden the extent of lead monitoring sites. The current LCR provides a good overview of corrosion rates and lead levels, but there is concern that it may overlook some locations with high levels.
- Depending on monitoring results, a system may need to develop an optimal corrosion control plan and receive approval for it from the state. This plan may require review and approval every few years.

It remains to be seen if EPA's proposed long-term changes will be adopted, as the Flint problems have prompted public and political discussions and several proposals. In late April 2016, U.S. Congressman Kildee introduced a House Bill that would reduce the lead action level from the current level of 15 micrograms per liter (µg/L) to an eventual level of 5 µg/L, being phased in over the course of a decade. While it appears that Cornelius would comply with this proposed rule change, the issue has alerted water utilities to the need for a thorough examination of their systems to ensure that high lead levels are not being overlooked and, even if the system complies with the LCR, to determine if there are critical locations such as schools where elevated lead levels are occurring.

3.1.3 Disinfection By-Products

Figures 3-1 and 3-2 provide monitoring results for disinfection by-products from the city's system over an eleven-year period. There are two groups of regulated disinfection by-products, total trihalomethanes and haloacetic acids. The monitoring results for the city have been below the standards for both groups. In accordance with the Stage 2 Disinfection By-Product Rule, the city selected two worst-case sampling locations for on-going compliance monitoring. These have been the only locations used in recent months and will be used in the future. The two locations are 500 SW 345th Avenue and at the Water Park Reservoir.

Although all results have been below the regulatory standards, it is noted that the total trihalomethanes value was unusually high and approaching the 0.080 mg/L standard for both sample location in November 2016. The values on this date were 0.0735 mg/L at 500 SW 345th Avenue and 0.0646 mg/L at the Water Park Reservoir sample site. The haloacetic acid values were also unusually high at both sampling sites for the May 2016 sampling. The values on this date were 0.0506 mg/L at 500 SW 345th Avenue and 0.0462 mg/L at the Water Park Reservoir sample site. The reason for these relatively high values is unknown.

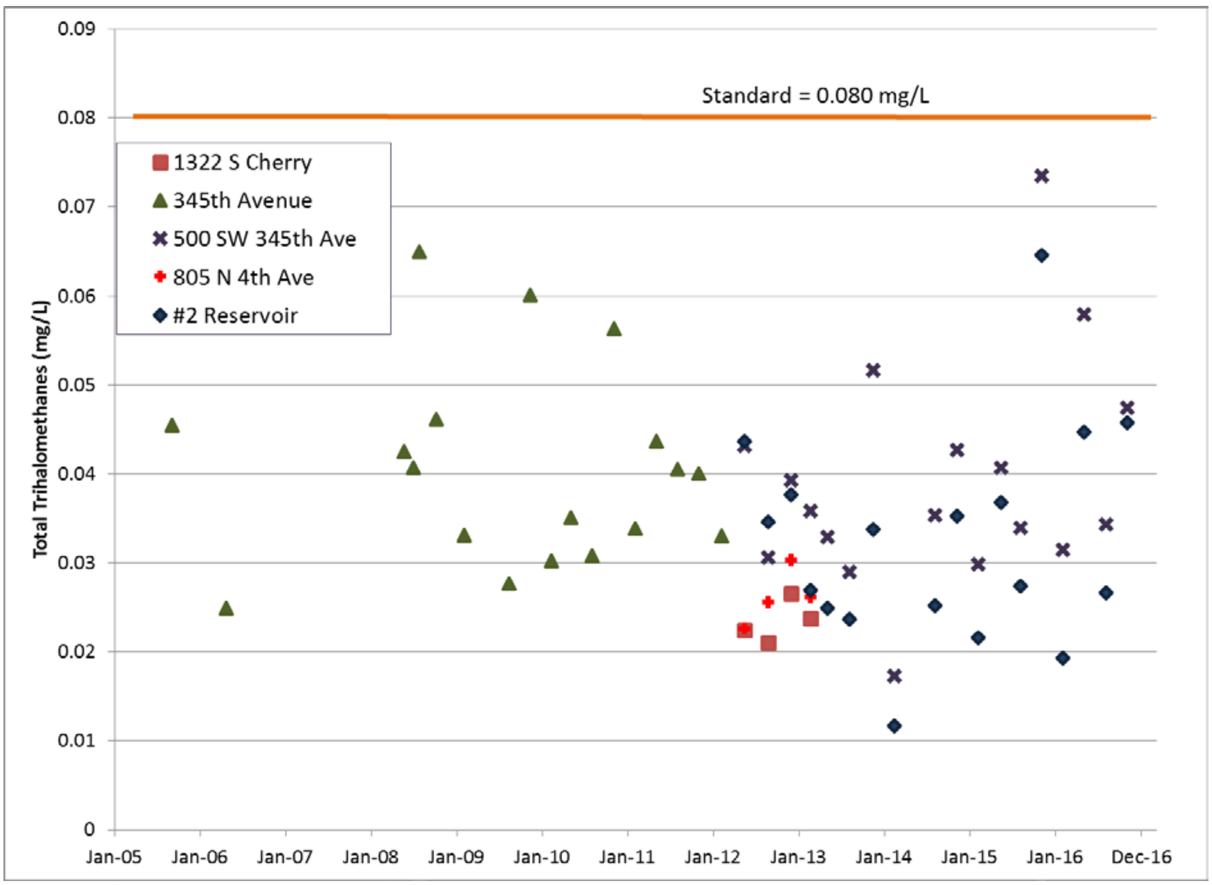

Figure 3-1. Total Trihalomethanes Distribution System Compliance Sampling Results

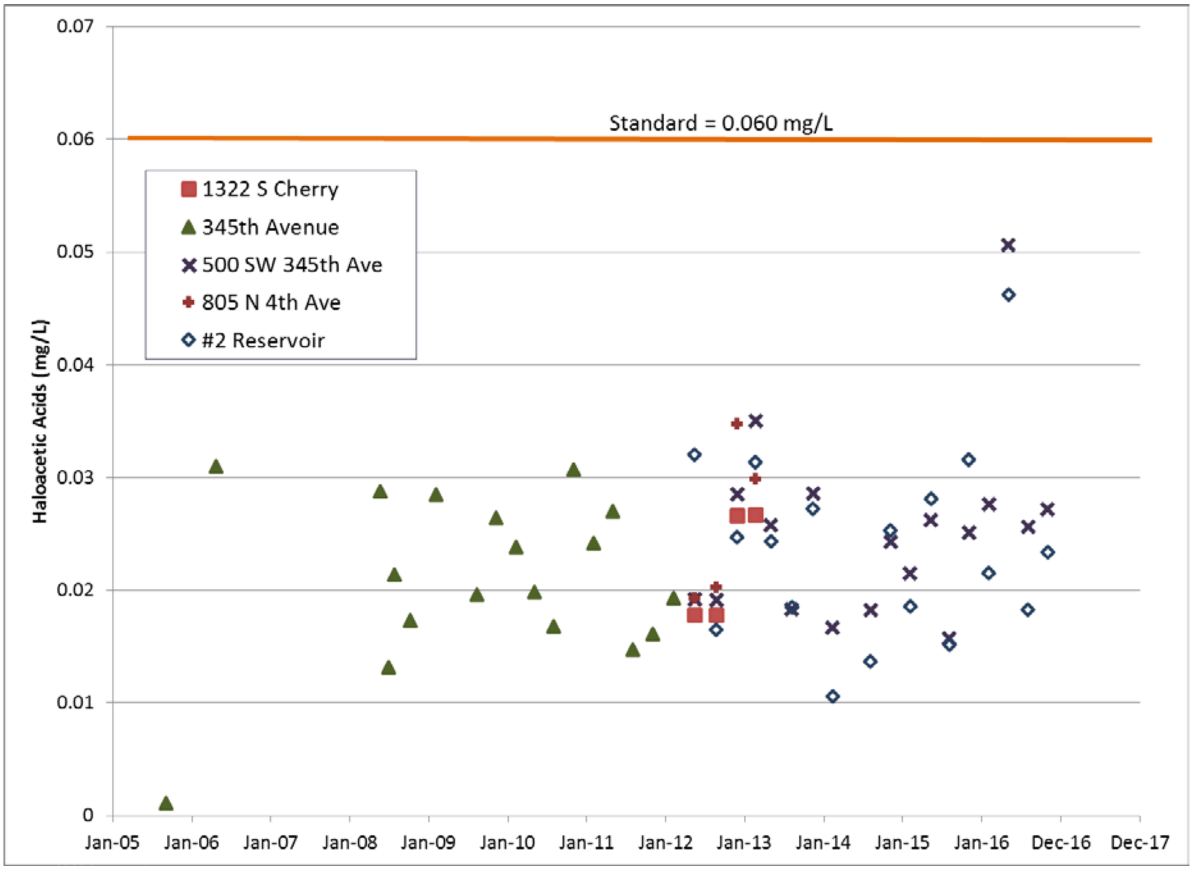

Figure 3-2. Haloacetic Acid Distribution System Compliance Sampling Results

3.2 Nonregulatory Water Quality Needs

Nonregulatory water quality issues primarily consist of taste and odor problems or complaints associated with elevated levels of iron and manganese, which are not health concerns but do cause discolored water. The city receives relatively few water quality complaints each year. There do not appear to be any significant nonregulatory water quality needs with the city's current supply. The city's system provides a high quality water that is safe for domestic use and also suitable for a wide range of commercial and industrial uses.

3.3 Potential Water Quality and Regulatory Concerns for the Planned ASR Supply

The city's planned use of an ASR water supply, even though the original source will remain the JWC transmission pipeline, may introduce water quality and regulatory concerns because of the introduction of some native groundwater. In general, the water pumped (recovered) from the well will be surface water from the city's existing master meter connections to the JWC transmission line that has been injected into the well during the preceding storage cycle. However, as the recovery cycle continues in any one season, it is expected that water pumped from the well will become a blend of stored surface water and native groundwater. The stored water in the ASR well displaces native groundwater away from the well and this same water is recovered. The stored water moves slowly within the aquifer and, combined with dispersion around the perimeter, the result is that a mix of stored water and native groundwater may be pumped late in the recovery season.

The report on the ASR test well recommended that the recovery during the first year of operation should be limited to 40 percent of the injected volume to establish a water quality buffer in the well.[1] Nevertheless, as the groundwater storage bubble slowly moves, it is conceivable that the recovered water will represent a blend of stored surface water and native groundwater, and that the percentage of groundwater will be greater at the end of the recovery cycle. A blend of 50 percent surface water and 50 percent native groundwater was used in this master plan evaluation for analyzing potential water quality impacts in the city's system. This ratio is not based on specific aquifer and pumping conditions. It is thought to be conservative and the actual portion of native groundwater may always remain less than 50 percent, even at the end of a recovery cycle. The actual blend may differ considerably and should be tracked using water quality parameters as suggested in the test well report.

The recovered water that is pumped from the well will be further blended with surface water in the city's distribution system because the recovered water pumping capacity of the ASR well will be less than the city's water demands. The city will not be able to use only the ASR well to meet all customer demands, except for an emergency, when water use is curtailed. Instead, the city will normally supplement the supply from the ASR well with water from the JWC transmission line. When the ASR well is operating, customers living close to and north of the ASR well will receive primarily recovered ASR water and those living close to or south of the transmission line will receive primarily water from the JWC transmission pipeline. Those customers located in intermediate areas will receive a mixture of ASR water and water from the JWC transmission pipeline.

The city's water system operators will need to develop acceptable standard operating procedures for balancing use of the ASR well with withdrawals through the JWC master meters. In particular, the goal will be to operate the ASR as close to full-time as possible during the recovery season to maximize its benefits to the city. A discussion of the impacts of storing water in the ASR well during winter months and recovering water during summer months is provided in the water supply discussion included in this master plan. If possible, especially toward the end of the recovery season when the percentage of native groundwater rises, it may be ideal to partially fill the tank each day from the JWC supply so the recovered water can be further blended before pumping it into the system. However, hydraulically, it may not be possible to partially fill the tank with JWC-supplied water if the ASR well is pumping continuously. Thus, it may be advantageous to operate the well only part-time during the last weeks of the recovery period. The operators can make this determination based on the water quality monitoring suggested in this section.

3.3.1 Summary of Potential ASR System Impacts on Water Quality and Regulatory Compliance

The following potential water quality impacts from operating the ASR well were examined. The water quality impacts will be accentuated as the percentage of native groundwater increases in the recovered water. A summary of impacts follows, with additional detail provided in subsequent sub-sections.

1. Exceedances of any primary maximum contaminant levels (MCLs). No MCL exceedances are anticipated, although careful monitoring is warranted because the blend of recovery and native groundwater may change the corrosion characteristics of the water. One possible result is higher lead levels in the distribution system
2. Fluoride. JWC does not add fluoride to its water whereas the native groundwater sample had a fluoride level of 1.2 mg/L. This is not necessarily problematic but should be monitored. The city should advise its customers if water supplied from the ASR well has fluoride levels approaching EPA's target level for drinking water of 0.7 mg/L.

[1] *Summary of Test Well Drilling at the Water Park for the City of Cornelius* (GSI Water Solutions, Inc., May 2015)

3. Aesthetic impacts (nonhealth water quality parameters such as taste, odor, and color). The water pumped from the ASR well will have higher levels of chlorides, total dissolved solids, iron and manganese, particularly as the percentage of native groundwater increases late in the recovery season. Higher levels of these parameters may be noticed by the city's customers and may be found objectionable.

The water quality data used for the two sources were obtained from the *Summary of Test Well Drilling at the Water Park for the City of Cornelius* (GSI Water Solutions, May 11, 2015) and from reports provided by Hillsboro for year 2015 for the Joint Water Commission finished water supply. The test results for the native groundwater are from a single test; subsequent tests may show variability.

3.3.2 Potential for MCL Exceedances and Elevated Fluoride Levels

The federal and Oregon drinking water regulations establish maximum contaminant level (MCL) standards for 95 contaminants, including 9 in the microbial category, 8 disinfection by-products (DBPs) and residuals, 18 inorganics (including lead and copper), 53 organics, and 7 radiologic contaminants.

The water supplied by JWC complied with all MCLs according to data reported on the state's website through 2015. Since three drinking water regulations, the Stage 2 Disinfection By-Products Rule, the Total Coliform Rule, and the LCR, are not measured at the treatment plant outlet but instead are measured within each wholesale customer distribution system or at customer taps, these data were not included among the data provided by JWC. The sampling for these last three rules performed by the city has complied with each rule.

The native groundwater quality from testing of the newly drilled ASR well indicated that the water met all MCLs. However, the native groundwater exceeded the *proposed* MCL for radon of 300 picocuries per liter (pCi/L) with a value of 460 pCi/L. The proposed MCL for radon was established in 2003 and the EPA has no schedule for finalizing the regulation. The proposed MCL of 300 pCi/L is for systems without a Multi-Media Mitigation Program, a program addressing other potential sources of radon since the contribution from drinking water, even for water exceeding 300 pCi/L, is relatively small compared to other radon exposure sources. According to the proposed regulation, if the system employs a Multi-Media Mitigation Program, the MCL is 4,000 pCi/L.

Although the native groundwater complies with all MCLs, another consideration is whether it would have an impact on the corrosion characteristics of water within the distribution system, resulting in higher rates of lead found through sampling at customer taps for the LCR. It is possible that the blending of the highly oxidized surface water with the reduced native groundwater could destabilize pipe protective pipe scale and increase levels of lead.

The JWC water has a fluoride level of <0.2 mg/L whereas the fluoride level in the single sample of native groundwater was 1.2 mg/L. A 50/50 blend is expected to have a fluoride level of 0.6-0.7 mg/L. A fluoride level of 0.6-0.7 mg/L is below the MCL for fluoride of 4.0 mg/L and below the secondary standard of 2.0 mg/L. The EPA recommends that utilities that add fluoride for dental health protection target a level of 0.7 mg/L.

Commonly, dentists will recommend fluoride supplements for children in areas with low fluoride levels in drinking water, which would be the case in Cornelius. If the recovered water from the ASR well delivers water into the system with a fluoride level approaching or equal to 0.7 mg/L for extended periods, the city should advise dentists and the public that fluoride supplements are not necessary during those times.

3.3.3 Potential for Aesthetic Water Quality Impacts

Table 3-1 shows the potential water quality parameters that could impact aesthetics, with values included for JWC water and the native groundwater.

Table 3-1. Water Quality Parameters of Concern for Aesthetic Impacts

Parameter	Secondary Standard	Possible Impacts	JWC 2015 Average	Native Groundwater
Aluminum	0.05–0.2 mg/L	Colored water	<0.004 mg/L	<0.02 mg/L
Chloride	250 mg/L	Salty taste	5.28 mg/L	380 mg/L
Color	15 color units	Visible tint	<5 color units	10 color units
Copper	1.0 mg/L	Metallic taste; blue-green staining	<0.005 mg/L	0.002 mg/L
Fluoride	2.0 mg/L	Tooth discoloration	<0.2 mg/L	1.2 mg/L
Iron	0.3 mg/L	Rusty color; sediment; metallic taste; reddish or orange staining	<0.05 mg/L	0.15 mg/L
Manganese	0.05 mg/L	Black to brown color; black staining; bitter metallic taste	<0.001 mg/L	0.14 mg/L
pH	6.5–8.5	Low pH: bitter metallic taste; high pH: slippery feel; soda taste	7.2 pH units	7.5 pH units
Sulfate	250 mg/L	Salty taste	112 mg/L	<0.5 mg/L
Total dissolved solids	500 mg/L	Deposits; colored water; staining; salty taste	84 mg/L	870 mg/L
Zinc	5 mg/L	Metallic taste	<0.005 mg/L	<0.02 mg/L
Silica	None	Potential spotting	18 mg/L	66 mg/L
Hardness	None	Hardness deposits; more difficulty in rinsing soap	24 mg/L as $CaCO_3$	120 mg/L as $CaCO_3$
Temperature	None	Warmer water can contribute negatively to taste and odor complaints	9.4 C	19.6 C
Sodium	None[a]	Taste	10.4 mg/L	220 mg/L

[a] Sodium less than 20 mg/L is recommended for people on a sodium restricted diet.

The potential aesthetic impacts include the following:

- The chloride level in a 50/50 blended water will approach the secondary standard of 250 mg/L and the salty taste chloride imparts may be noticed by some customers
- The iron level in a 50/50 blended water will slightly exceed the secondary standard of 0.3 mg/L, which could result in some orange staining and a metallic taste
- The manganese level in a 50/50 blended water will exceed the secondary standard of 0.05 mg/L, resulting in black staining and possibly a metallic taste
- The total dissolved solids level in a 50/50 blended water will approach and may exceed the secondary standard of 500 mg/L, resulting in possible deposits, staining, and a salty taste
- The sodium level in a 50/50 blended water may cause a salty taste

All of these aesthetic impacts are more likely to be noticed by customers living on the boundary between the ASR water delivery and the delivery from the JWC transmission line if the water quality changes from one day or time to the next. Customers become accustomed to the quality of the drinking water they receive and may find the water fully acceptable even when secondary standards are exceeded if the quality is consistent. However, when the quality varies, customers become more sensitive and may notice and complain about the quality even if the levels remain below the secondary standards. In addition, the temperature of the native groundwater may exceed the temperature of the JWC water, further exacerbating the negative aesthetic impacts.

3.3.4 Potential for Increased Pipe Corrosion

The change in water quality from the present surface water supply to the potential 50/50 blended water supply may destabilize pipe scale that has accumulated over time, resulting in higher rates of pipe corrosion. This is a concern for two reasons. One is that a more corrosive water can increase levels of lead, because lead in drinking water primarily occurs from the corrosion of customer pipes and customer fixtures. The second concern is economic, as increased rates of corrosion reduce the service life of the city's mains and of customer plumbing systems.

The city's last round of regulatory monitoring for lead, monitoring which is conducted at customer taps per state and federal requirements, indicated that the 90th percentile value was 0.0 mg/L (undetected) compared to the lead action level standard of 0.015 mg/L. Copper, though not the health concern of lead, is measured at the same time to provide a more complete picture of the water's corrosion rates. The 90th percentile copper level was reported as 0.090 mg/L, more than ten times below the copper action level standard of 1.35 mg/L. The results indicate that the city's current water supply from the JWC transmission line has a low corrosion rate.

The pipe scale that develops in water pipe can be destabilized by changing the oxidation condition of the distribution system or by changing the pH of the water in the distribution system. Lead in premise piping fixtures can also be affected by changes in oxidation reduction potential and pH. The introduction of a blend of native groundwater and recovered surface water could cause these changes.

The solubility of lead in water depends on the pH and the oxidation-reduction potential, with the latter being a measurement of the water's potential to corrode pipe materials as if they were anodes. The introduction of native groundwater may change the pH and oxidation-reduction potential balance, moving the water from a less corrosive to more corrosive condition. The oxidation-reduction potential can be measured with a relatively inexpensive instrument, using calibration standards, much as pH is measured. The city may wish to measure these parameters along with increasing lead and copper monitoring both before and during ASR operation to carefully track the impact of using ASR on the system.

3.3.5 Recommendations for the ASR System Design and Operations

The following recommendations were developed based on the blending analysis conducted as part of this master plan:

1. Pump from the ASR well into the Water Park Reservoir, rather than directly from the ASR well into the distribution system, for two reasons. One is that ASR water can be introduced into the tank through a spray nozzle, above the water surface, to provide aeration, which will reduce radon levels and add dissolved oxygen. The added dissolved oxygen will help to mitigate differences between the native groundwater and the city's present JWC supply. Secondly, pumping into the tank and then from the tank into the distribution system allows for another opportunity to blend the water, if a portion of the water in the tank is from the current JWC supply. It may not always be possible to introduce much or any JWC water into the tank while operating the ASR well as full recovery. A discussion of water balance within the system once ASR is operational is presented elsewhere in this report.

2. Provide increased water quality monitoring, including the following:
    - Use general water quality parameters to track and estimate the blend of native groundwater and recovered surface water in the water pumped from the ASR well. These parameters can include hardness, pH, total dissolved solids and others.
    - Monitor the oxidation-reduction potential of water in the distribution system at several representative locations during recovery and nonrecovery periods, to track impacts from using the ASR well.
    - Measure iron and manganese levels of water from the ASR well discharge periodically during recovery cycles.
    - Increase lead and copper monitoring during recovery cycles, particularly for those customers receiving a greater proportion of ASR water.

SECTION 4

Level of Service Goals

The city's level of service goals are summarized in **Table 4-1**. The criteria presented in this table provided a basis for evaluating the performance of the distribution system as discussed later in this report.

Table 4-1. Level of Service Goals

No.	Item	Value	Discussion
1	Fire flows for single-family residential areas	1,000 gpm for 2 hours	Based on criteria set forth in February 2004 master plan for city. Insurance Services Office (ISO) uses 1000 gpm for 2 hours
2	Fire flows for schools, commercial, industrial, and multi-family buildings	3,000 gpm for 3 hours	ISO provides full credit for 3,500 gpm for 3 hours
3	Minimum pressure during fire flows	20 psi	Oregon's rules require a minimum of 20 psi at all times in the distribution system
4	Hydrant spacing	250 feet between hydrants	City's criterion more stringent than ISO
5	Hydrant type	Provide at least one large pumper outlet (typically a 4-inch port)	ISO downgrades fire hydrants that do not have at least one large pumper outlet.
6	Residential piping: sizes and looping	12" diameter outer loops (for <= 1 square mile) 8" diameter internal grid 6" diameter in cul-de-sacs (for <250 feet length).	Follows February 2004 master plan. Oregon's rules state that dead end lines should be minimized. (Washington and Ten States Standards require a minimum of 6-inch diameter for mains)
7	Transmission mains: sizing	Limit velocities to 5.0 fps for peak day demands, but consider higher as discussed	This represents criterion from February 2004 master plan. (It may be more strict than necessary. Other systems evaluate on a case-by-case basis, based on allowable head loss, and allow velocities up to 8-10 fps.)
8	Operating pressures	58-60 psi is typical within the city for peak hour demands	Current system pressures are within an acceptable range--high enough to meet customer needs but low enough to reduce leakage and to minimize pumping costs. City can control pressures by adjusting pressure reducing valves at master meter connections.
9	System storage volume	Hillsboro requires 3 times average day demand; however, the use of ASR can replace this storage requirement (provided pump can be supplied with backup power)	Hillsboro requires 3 times average day demand

Table 4-1. Level of Service Goals

No.	Item	Value	Discussion
10	Valve exercising	Exercise all valves at least once every 4 years. Consider more frequent exercising for older valves and large diameter valves (>= 12")	
11	Chlorine residual	Report to Hillsboro if chlorine residual from JWC master meters is below 0.3 mg/L for more than 4 hours. Residual shall be detectable in all parts of the distribution system at all times.	Oregon (and federal rules) require: A residual of not less than 0.2 mg/L for more than 4 hours for water entering the distribution system; and A residual cannot be undetectable in more than 5 percent of distribution samples each month
12	Distribution water quality	Heterotrophic bacteria (HPC) levels shall be less than 500 cfu/mL	Oregon (and federal rules) allow for measuring heterotrophic bacteria (HPC) if no chlorine residual is measured; indicates that 500 cfu/mL is standard
13	Backflow prevention standards	Maintain backflow protection program	Fulfill Oregon's rules
14	Water use record keeping	Track average and maximum day demands, and nonrevenue water. Track and report annual water use to OWRD. Maintain water quality monitoring and other operational records according to Oregon rules.	Oregon's rules have some requirements for record keeping
15	Main Flushing	Flush dead end and problem area mains once every 6 months; the goal for entire system is once every 4 years	No specific rules
16	Reservoir inspection / cleaning	Inspection every 5 years using divers; cleaned only as inspection shows need	No specific rules
17	Reservoir turnover	City will be evaluating reservoir turnover in more detail after bringing the ASR well online, and will establish a target for turnover time.	AWWA recommends complete turnover every 3-5 days. Depends on water quality. Many systems do not experience problems even though the water age is longer than AWWA recommendations
18	Isolation valving	Maximum of 4 valves to close in order to isolate segment	Typical water system practice
19	Number of services on an isolation segment	Not more than 30 homes maximum	Typical water system practice
20	Flushing dead ends	All dead ends shall have blow-offs for flushing	Typical water system practice
21	Reservoir design: inlet / outlet piping	Provide separate inlet/outlet piping for all new reservoirs; consider inlet riser pipe to improve mixing. Existing tank will have separate inlet for ASR production.	Oregon rules: "When a single inlet/outlet pipe is installed and the reservoir floats on the system, provisions shall be made to insure an adequate exchange of water to prevent degradation of the water quality…" (OAR 333-061-0050 (7))

Table 4-1. Level of Service Goals

No.	Item	Value	Discussion
22	Master plan: update schedule	Annual minor updates; more significant review every 5 years; comprehensive review every 10 years	Oregon rules require a "current" master plan
23	Capital improvements plans	Proposed: Annual updates; ensure that 5-year plans follow general guidelines of the master plan.	No specific rules

SECTION 5

Water Use

This section describes the water use history for Cornelius' water system, and presents projected future water needs based on recent water use trends. Average and maximum demands, per capita demands, and nonrevenue water are documented.

5.1 Definition of Terms

Demand refers to total water use, the sum of metered consumption (residential, commercial, governmental and industrial), unmetered uses (for example, firefighting or hydrant flushing), and water lost to leakage but not accounted for by customer meters. The terms *demand* and *purchased supply* are used synonymously in this report, since Cornelius purchases all of its water from Hillsboro.

Instantaneous water demands fluctuate in response to water use patterns by residential, commercial, and industrial customers. For example, instantaneous demands may exceed the purchased supply rate during morning and afternoon/early evening peaks. The city's booster pump station delivers water into the system from the reservoir to make up the supply difference. A peak hour demand was estimated and used for the distribution system modeling analyses.

Nonrevenue water refers to the difference between demand (purchased water) and metered consumption. Nonrevenue water results from several factors including authorized, unmetered water used for system flushing or fire-fighting, and from meter inaccuracies, billing errors, and leakage. A specific discussion of nonrevenue water and other water audit terms is presented later in this chapter.

Specific demand terms include the following:

- Average day demand (ADD) equals the total annual production divided by 365 days.
- Maximum day demand (MDD) equals the highest system demand that occurs on any single day during a calendar year.
- Peak hour demand (PHD) equals the highest hourly demand

The most common units for expressing demands are million gallons per day (mgd). One mgd is equivalent to 695 gallons per minute (gpm) or 1.55 cubic feet per second (cfs).

5.2 Average, Maximum Day, and Peak Hour Demands

The city's purchased supply history was developed from electronic records provided by the city or those provided by Hillsboro for the master meters. These records were used to determine both average and maximum day demands.

Figure 5-1 summarizes average day demands (ADDs) from 2001 through 2015.[2] The ADD is the total water purchased over a 12-month period, divided by 356 to obtain a daily average. The ADD has slightly declined over this period, ranging from a low of 1.02 mgd in 2015 to a high of 1.25 mgd experienced in 2004. The downward trend has occurred despite a service population increase of 22 percent from 2004 to 2015, from 9,735 to 11,900.

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[2] Cornelius records water purchases from Hillsboro from the JWC transmission pipeline and records consumer water sales on a fiscal year basis, from July 1 through June 30. Values indicated in this report are assigned to the second calendar year in the fiscal year. Thus, a value listed as being for 2015 means that is represents July 1, 2014, through June 30, 2015.

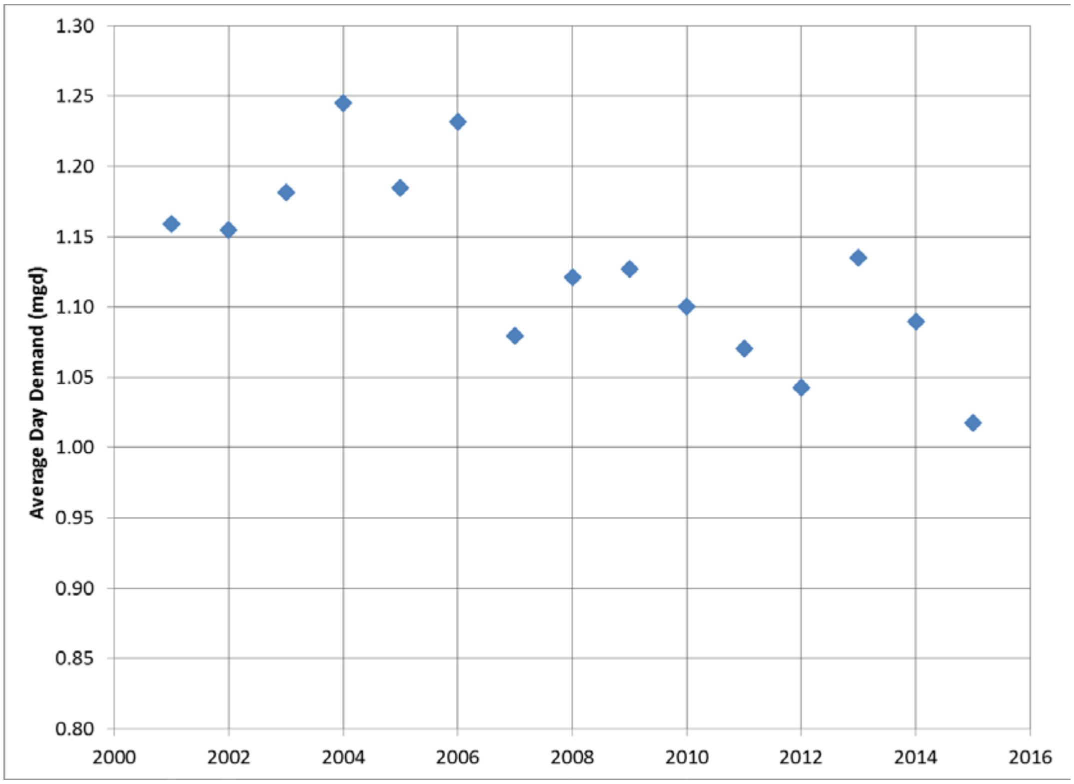

Figure 5-1. Average Day Demand History

The decline in ADD during a time when the service population has grown is reflected in a significant drop in per capita use, as shown in **Figure 5-2**. The ADD per capita demand averaged 119 gallons per capita per day (gpcd) over the years 2001-2004 but dropped to 92 gpcd for years 2010-2015. This represents a decline of 23 percent or an average decline of slightly more than 2 percent per year from 2004 to 2015. There may be a variety of factors involved in this decrease, including code requirements for water-efficient plumbing fixtures, general economic conditions, greater emphasis on conservation, higher costs for water, and fewer new homes which require larger amounts of water for establishing new landscapes. This decline is consistent with declining per capita use across the United States. Since 1998, nationwide per capita use has declined by an average of 2.1 percent per year for the period 1998 through 2014.[3]

The per capita values are based on dividing all water use by the population so the value accounts for commercial and industrial water use. If the service population is growing but the quantity of water used by commercial and industrial customers declines, this will also contribute to lower per capita demands. The per capita value of 92 gpcd was used to project future ADDs.

[3] Crea, Joseph F., and Beckley, Thomas A., *Money Matters*, Journal American Water Works Association. March 2016.

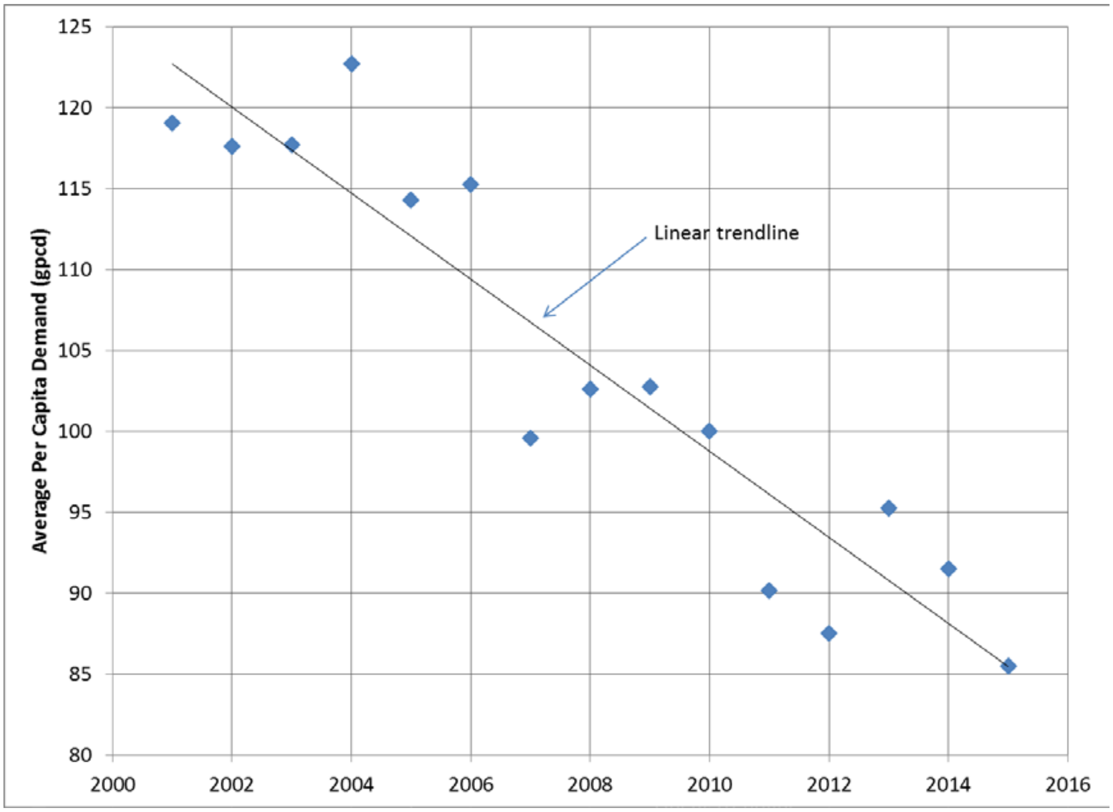

Figure 5-2. Per Capita Average Day Demand History

MDDs were determined from continuously-recorded supervisory control and data acquisition (SCADA) records for the master meters for the past four years. The range from 2010-2015 was 1.83 to 2.61 mgd, with an average of 2.07 mgd. These values are illustrated in **Figure 5-3**. The MDD values have been relatively constant except for one higher value in 2012. The average per capita MDD for 2010-2015 was 176 gpcd, as illustrated in **Figure 5-4**. This is lower than for many western Oregon water utilities. The relatively low commercial and industrial water use compared to the city's population is at least partly responsible. In contrast, communities having industrial customers that use large quantities of water may have per capital MDD values of 400 gpcd or higher. The per capita value of 176 gpcd was used to project future MDDs.

While the SCADA data for the master meters provide flow values throughout the day, data were not available to determine concurrent reservoir filling or emptying rates. Without this information, it was not possible to determine peak hour demands for the system. Similar Oregon water utilities have peak hour demands that are about two-times the MDD and this multiplier was used for Cornelius. This provided a reasonable estimate to use in the distribution system modeling analyses.

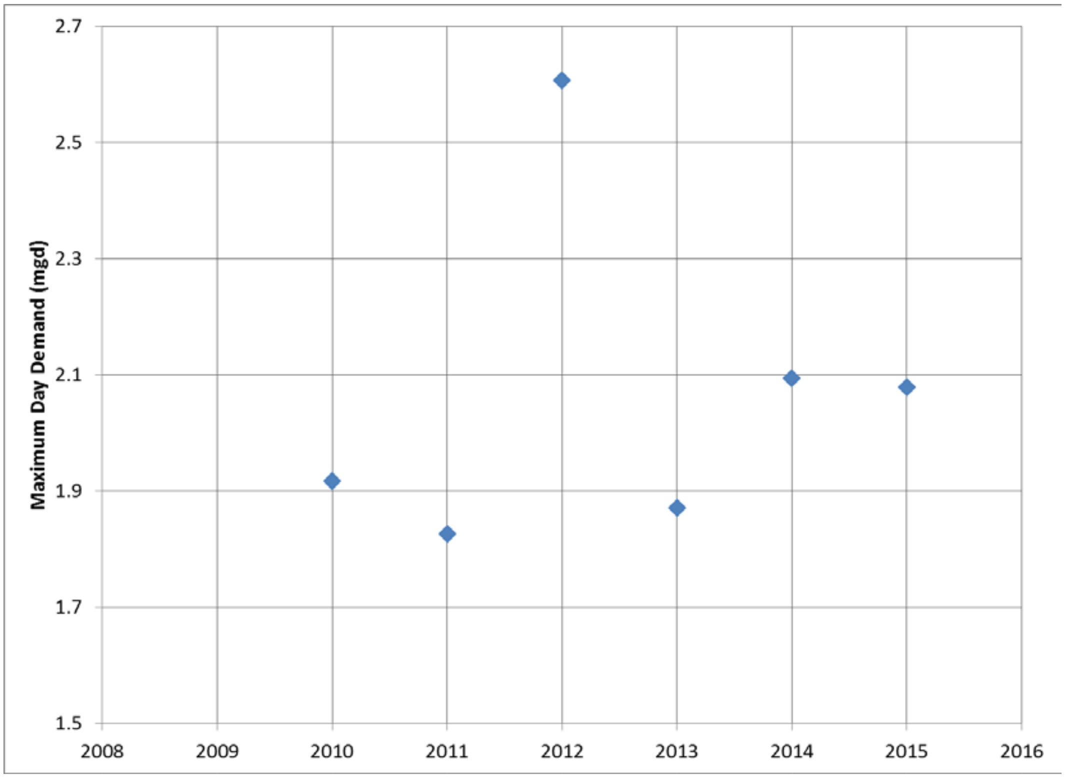

Figure 5-3. Maximum Day Demand History

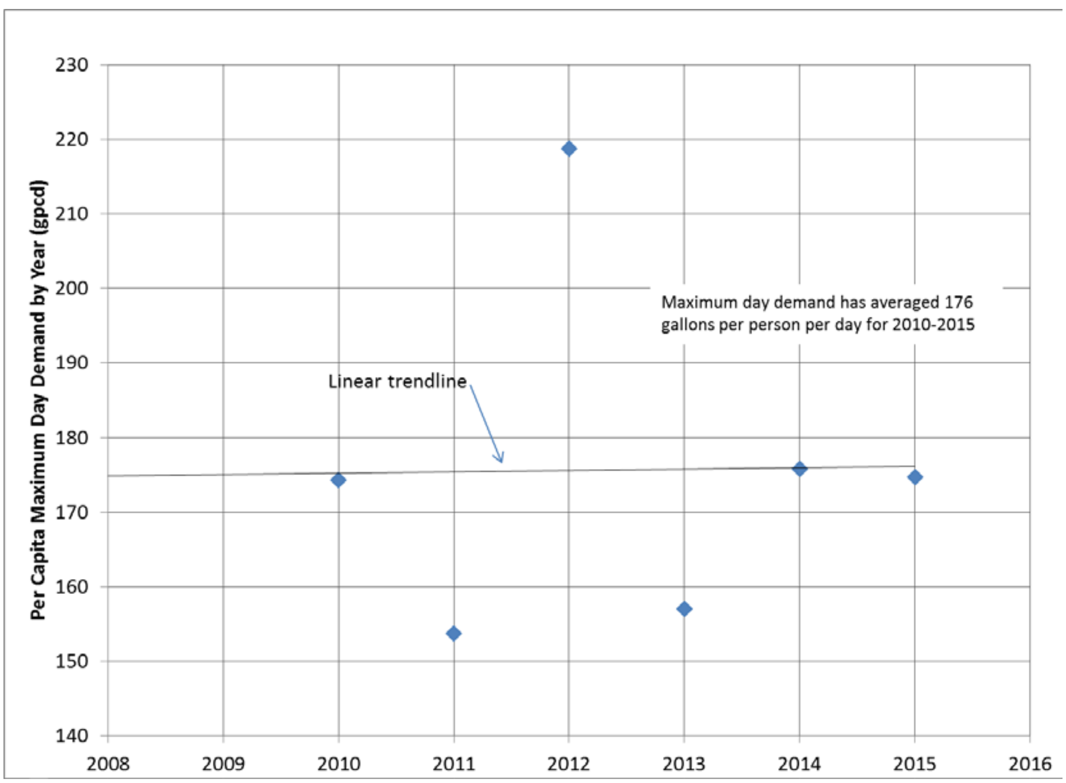

Figure 5-4. Per Capita Maximum Day Demand History

Historic service population and demand data are tabulated in **Table 5-1**. The values for the service population were obtained from the Portland State University Population Research Center. The city's population has remained nearly unchanged since fiscal year 2011-2012.

Table 5-1. Summary of Service Population and Demand Data for Fiscal Years 2000-2001 through 2012-2013

Fiscal Year[a]	Service Population	Total Purchased Supply (MG)	ADD (mgd)	MDD (mgd)	ADD Per Capita (gpcd)	MDD Per Capita (gpcd)
00-01	9,735	423	1.16	ND[b]	119	ND
01-02	9,820	421	1.15	ND	118	ND
02-03	10,040	431	1.18	ND	118	ND
03-04	10,150	455	1.25	ND	123	ND
04-05	10,368	433	1.18	ND	114	ND
05-06	10,685	450	1.23	ND	115	ND
06-07	10,840	394	1.08	ND	100	ND
07-08	10,925	409	1.12	ND	103	ND
08-09	10,970	411	1.13	ND	103	ND
09-10	11,003	402	1.10	1.92	100	174
10-11	11,869	391	1.07	1.83	90	154
11-12	11,915	381	1.04	2.61	87	219
12-13	11,915	414	1.13	1.87	95	157
13-14	11,910	398	1.09	2.09	91	176
14-15	11,900	371	1.02	2.08	86	175

[a] Fiscal year data are from July 1st of the first year through June 30th of the second.
[b] ND = No data available

5.3 Water Consumption Records

Water use in Cornelius is dominated by residential customers. As shown for years 2009-2014 in **Figure 5-5**, single-family and multi-family residential customers use approximately 85 percent of water in the city, with the remainder used by the city (for municipal buildings and park irrigation), commercial customers, and light industrial customers. Of the residential portion, the single-family component has ranged from 63-64 percent and the multi-family component has ranged from 20-24 percent.

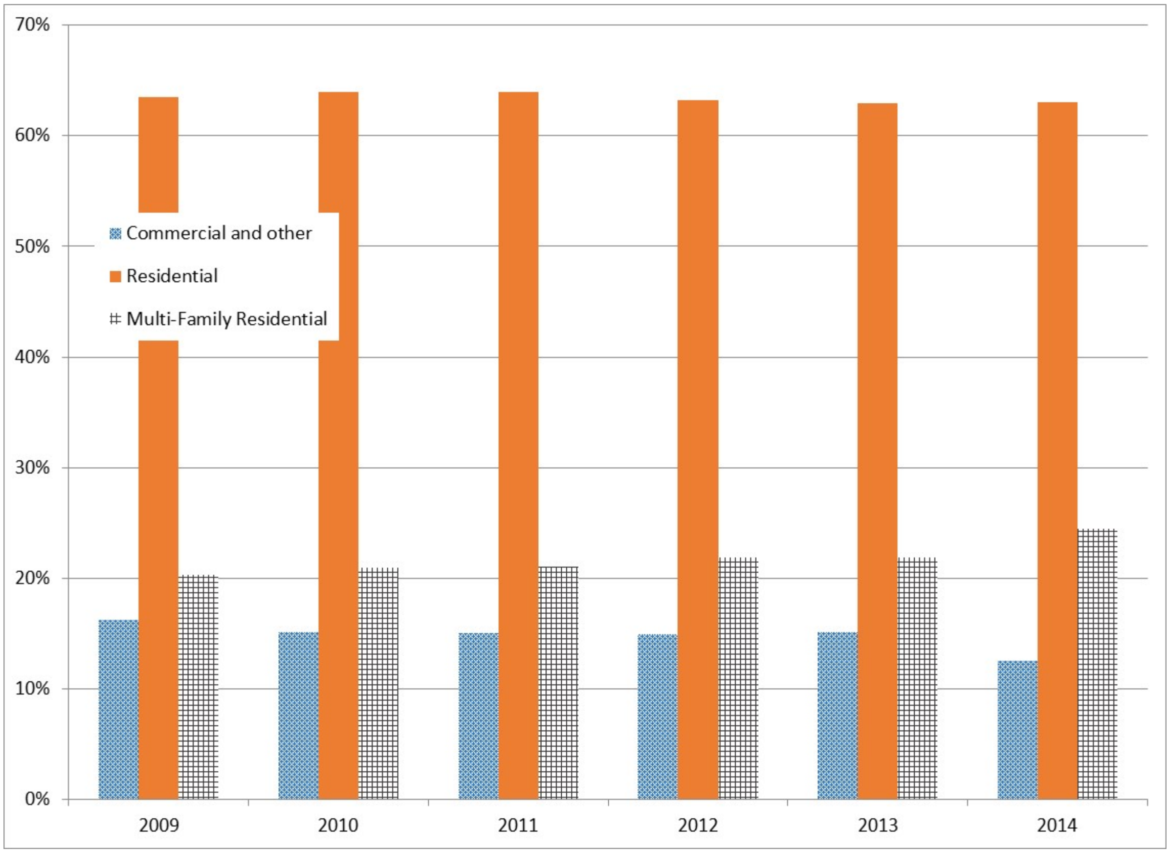

Figure 5-5. Metered Use by Customer Category

5.4 Nonrevenue Water

5.4.1 Historical Trends

A comparison of the purchased water data with the metered consumption data provides a value for nonrevenue water.[4] The percentage of nonrevenue water equals the system input volume (purchased water as measured at the master meters) minus the billed metered consumption, divided by the system input volume. There are a number of sources of nonrevenue water, as illustrated in the water balance chart from the International Water Association and American Water Works Association (AWWA) shown in **Figure 5-6**. It includes metered use that is not billed, unauthorized consumption, metering inaccuracies, leakage, and other components. A detailed water audit is needed to determine the major contributions to nonrevenue water for a particular utility.

[4] Nonrevenue water was formerly termed unaccounted for water. Nonrevenue water has become the industry standard terminology because it is a more inclusive term. For example, a utility may account for water use from an activity such as a hydrant flow test but not derive revenue from this water. Nonrevenue water, with its defined sub-components, captures this type of occurrence with more clarity.

A	B	C	D	E
System Input Volume = System Demand (For Cornelius, the flow entering the system as measured at the master meters)	Authorized Consumption	Billed Authorized Consumption	Billed metered consumption Billed unmetered consumption	Revenue Water
		Unbilled Authorized Consumption	Unbilled metered consumption Unbilled, unmetered consumption	Nonrevenue Water
	Water Losses	Apparent Losses	Unauthorized consumption Metering inaccuracies Systematic data handling errors	
		Real Losses	Leaks in distribution pipes Leaks and overflow from storage tank Leaks in service connections up to point of customer meters	

Figure 5-6. Components of the IWA/AWWA Water Balance[5]

Figure 5-7 summarizes the annual nonrevenue water percentage for 2001 through 2015. The rate ranged from 13-40 percent and averaged 25 percent over the period. Overall, the nonrevenue percentage has been lower in the past nine years as compared to the rates experience in 2002-2006. The rate averaged less than 20 percent for 2007-2010. However, the rate climbed slightly in 2011-2015 and has averaged 25 percent for the past five years. All water systems have unavoidable water losses. However, a nonrevenue water rate of 25 percent is relatively high compared to other Oregon water utilities.

[5] Adopted from AWWA Manual of Water Supply Practices M36. *Water Audits and Loss Control Programs, Third Edition,* 2003.

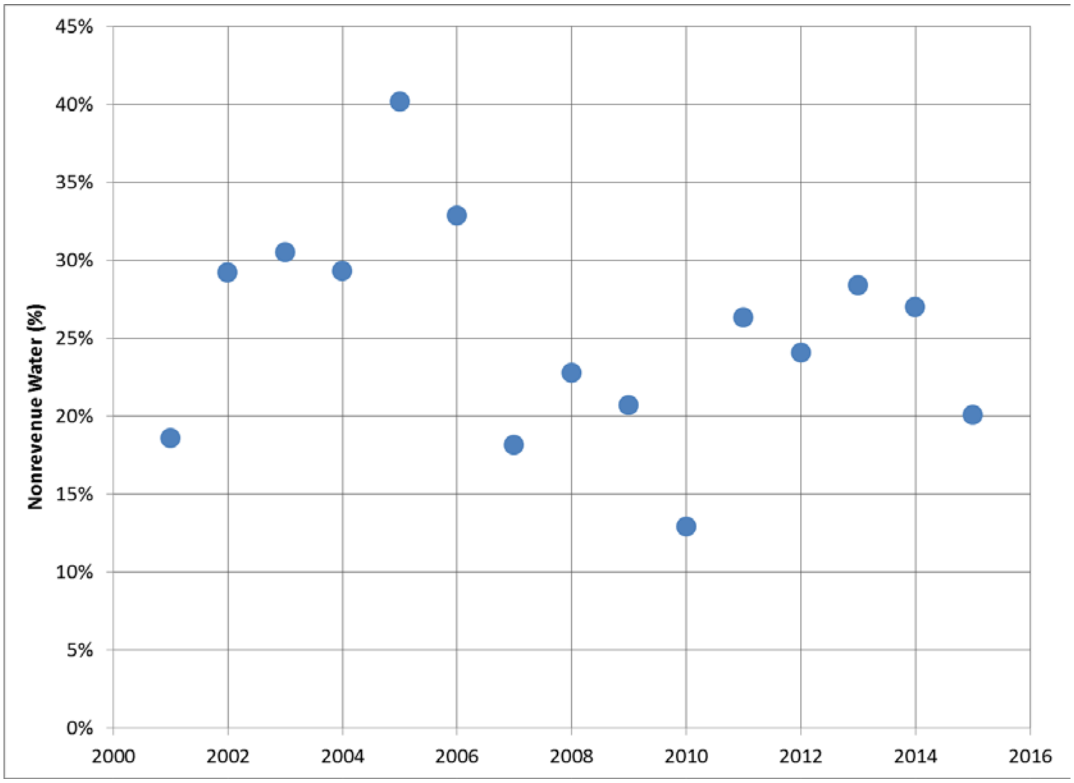

Figure 5-7. Nonrevenue Water by Percentage

In terms of the unbilled volume, the nonrevenue water ranged from 52 to 174 million gallons per year for 2001 through 2015. It averaged 106 million gallons per year over this time. The average unbilled volume for the past five years has been 99 MG per year. Based on the unit cost charged by Hillsboro, the average cost of the nonrevenue water over the past five years has been $190,000 per year. The nonrevenue volume and cost figures are shown in **Figures 5-8 and 5-9** and are tabulated in **Table 5-2**. The city may wish to conduct a detailed water audit, following the guidance provided by the International Water Association and the American Water Works Association, to determine the factors contributing to the relatively high nonrevenue water values.

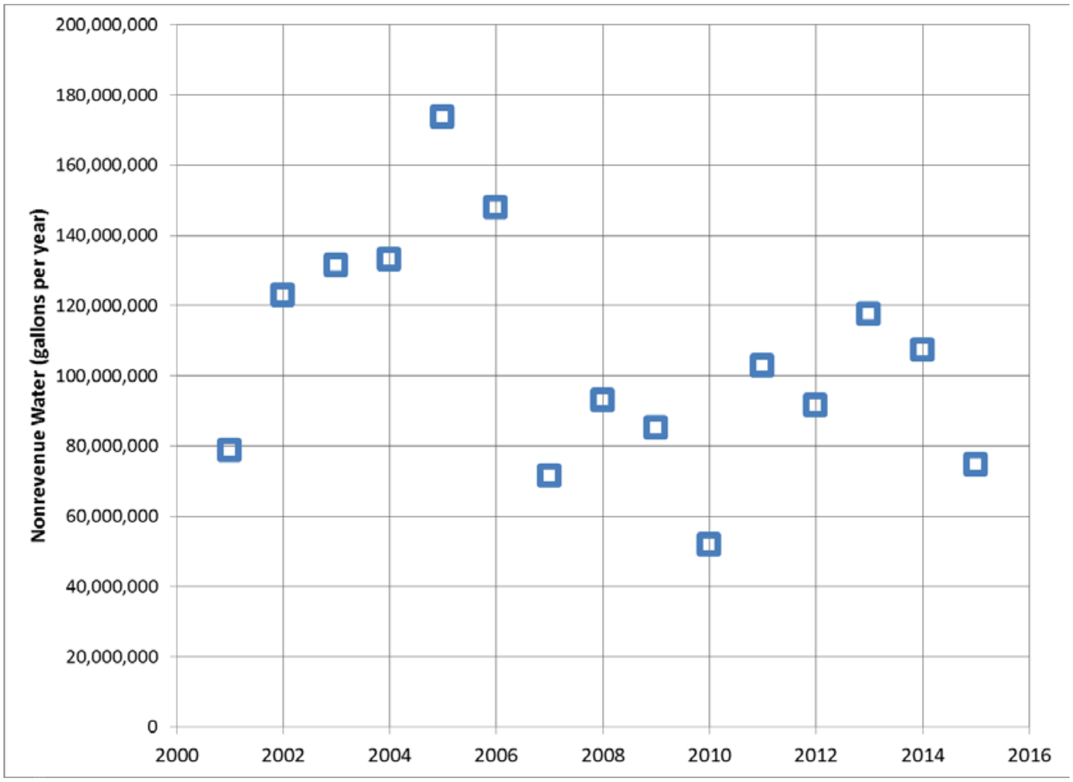

Figure 5-8. Nonrevenue Water by Volume

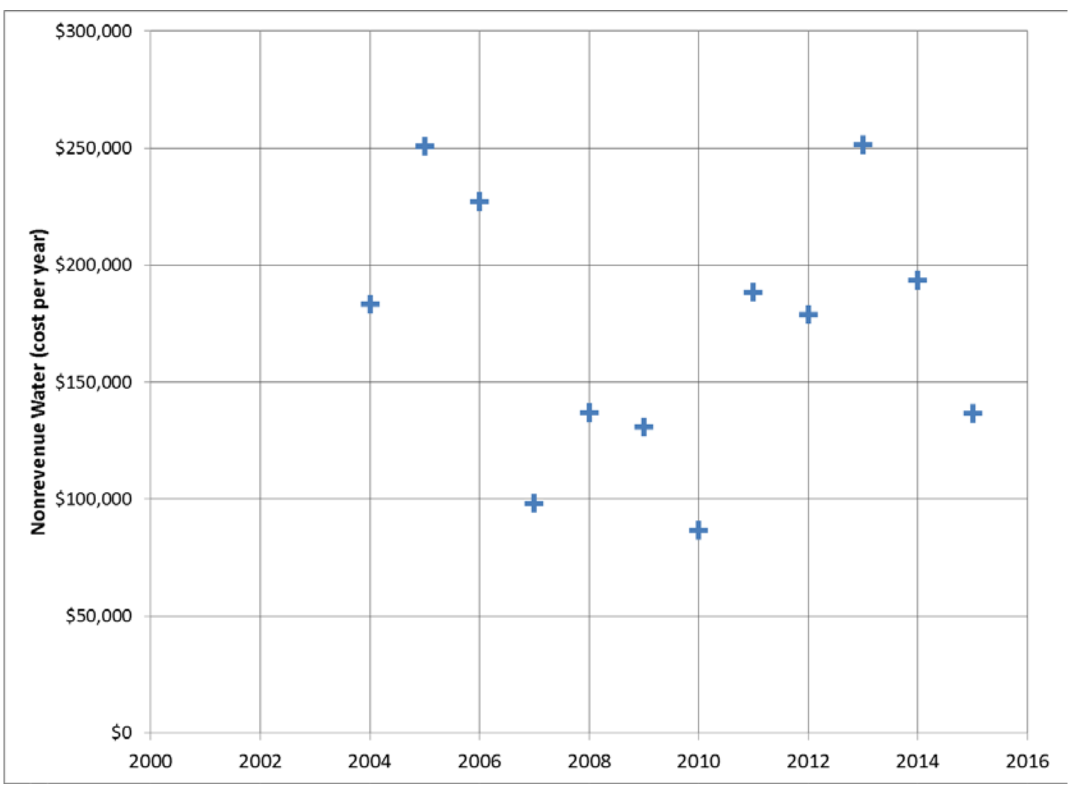

Figure 5-9. Nonrevenue Water Cost

Table 5-2. Summary of Consumption, Demand, and Nonrevenue Water Data for Fiscal Years 2000-2001 through 2014-2015

Fiscal Year	Total Consumption (gal)	Total Purchased Supply (gal)	Nonrevenue Water (gal)	Nonrevenue Water (percent)	Hillsboro Water Rate ($/cf)	Nonrevenue Water Cost
00-01	344,489,100	423,099,468	78,610,368	19 percent		
01-02	298,503,800	421,455,364	122,951,564	29 percent		
02-03	299,773,022	431,251,172	131,478,150	30 percent		
03-04	321,381,266	454,530,428	133,149,162	29 percent	$1.03	$183,300
04-05	258,863,813	432,507,064	173,643,251	40 percent	$1.08	$250,700
05-06	301,837,830	449,575,676	147,737,846	33 percent	$1.15	$227,100
06-07	322,581,930	393,979,828	71,397,898	18 percent	$1.03	$98,300
07-08	316,143,496	409,173,204	93,029,708	23 percent	$1.10	$136,800
08-09	326,243,854	411,409,724	85,165,870	21 percent	$1.15	$130,900
09-10	349,806,351	401,604,940	51,798,589	13 percent	$1.25	$86,600
10-11	287,886,865	390,741,918	102,855,053	26 percent	$1.37	$188,400
11-12	288,966,391	380,507,072	91,540,681	24 percent	$1.46	$178,700
12-13	296,666,828	414,256,929	117,590,101	28 percent	$1.60	$251,500
13-14	290,425,300	397,752,927	107,327,627	27 percent	$1.35	$193,700
14-15	296,850,100	371,380,504	74,530,404	20 percent	$1.37	$136,500

5.4.2 Leak Survey History

The city’s February 2004 water master plan described leak detection surveys that had been conducted in the city. The city hired an outside specialty firm to conduct five separate leak detection surveys from 1995 to 2003. The surveys detected from 5 to 11 leaks per survey, with estimated water losses ranging from 13 to 72 gallons per minute (gpm) per survey. On an annual basis, the combined total of the leaks that were found represented losses of 104,000 million gallons per year. The city subsequently repaired the identified leaks.

The city focused the leak detection surveys on areas of the system that were suspected to have the most problems with leakage. While many of the most serious leaks may have been found and repaired, the results suggest that leaks were and may continue to be a source of nonrevenue water. The city’s system has a significant amount of steel and galvanized pipe, which has been identified by the city as a source for many of the leaks. In addition, the city’s system has a significant amount of asbestos cement (AC) pipe. AC pipe is relatively fragile and has been a source of leaks in some utilities particularly as it reaches 50 years of installed service. The city has been aggressively replacing steel pipelines with PVC lines, as described in the distribution chapter of this report.

5.5 Demand Projections

Water demands are generally projected by using recent per capita use trends and multiplying them by population projections. For Cornelius, the following values were used to estimate future demands:

- Per capita average day demand = 92 gpcd (average for fiscal years 2009-2010 through 2014-2015)
- Per capita maximum day demand = 176 gpcd (average for fiscal years 2009-2010 through 2014-2015)
- Year 2035 population = 18,102 (as published in the "2035 Reviewed TAZ Forecast Distribution" by MetroScope GAMMA HH Forecast, published 2013)

The per capita demands were held constant for the planning period because the averages for the last six full years of data already represent a significant decline in per capita use from ten years ago. The per capita use declines may reflect the increasing cost for water, general economic conditions for the community, and an increasing focus on water conservation; they may have also resulted from declining commercial and industrial use as a percentage of overall system use. It is possible the per capita use rates will further decline or it may be that the per capita use rate will stabilize. A change in the mix between single family residential, multi-family residential, commercial, and industrial customers can alter the per capita values, since the per capita values are based on the total water use within the city divided by the population. For example, the addition of an industry that uses large volumes of water would cause an increase in the per capita rates.

Table 5-3 presents a tabulation of population and demand projections through year 2035, using the per capita projection criteria and the published population projections. The same information is presented graphically in **Figure 5-10**. The growth in population from 11,900 in 2015 to 18,102 in 2035 yields an average annual growth rate of approximately 2.1 percent. If this growth occurs and the per capita rates remain constant, the average and maximum day demands will increase by 50 percent over today's values. The ADD will be approximately 1.7 mgd in 2035, and the MDD will be 3.2 mgd.

Just prior to publication of this report, the city learned that private developers expected to proceed with significant residential development in the city in the coming years. According to these developers, the number of new houses planned may accommodate 4,000 additional people in the next five years. This growth would be much higher than the rate of 2.1 percent per year. If this growth does indeed occur, adjustments to the timing of capital projects will be needed.

Table 5-3. Population and Demand Projections

Year	Service Population	ADD (mgd)	MDD (mgd)
2016	12,152	1.12	2.14
2017	12,410	1.14	2.18
2018	12,673	1.17	2.23
2019	12,942	1.19	2.28
2020	13,216	1.22	2.33
2021	13,496	1.24	2.38
2022	13,782	1.27	2.43
2023	14,074	1.29	2.48
2024	14,372	1.32	2.53

Table 5-3. Population and Demand Projections

Year	Service Population	ADD (mgd)	MDD (mgd)
2025	14,677	1.35	2.58
2026	14,988	1.38	2.64
2027	15,306	1.41	2.69
2028	15,630	1.44	2.75
2029	15,961	1.47	2.81
2030	16,299	1.50	2.87
2031	16,645	1.53	2.93
2032	16,998	1.56	2.99
2033	17,358	1.60	3.06
2034	17,726	1.63	3.12
2035	18,102	1.67	3.19

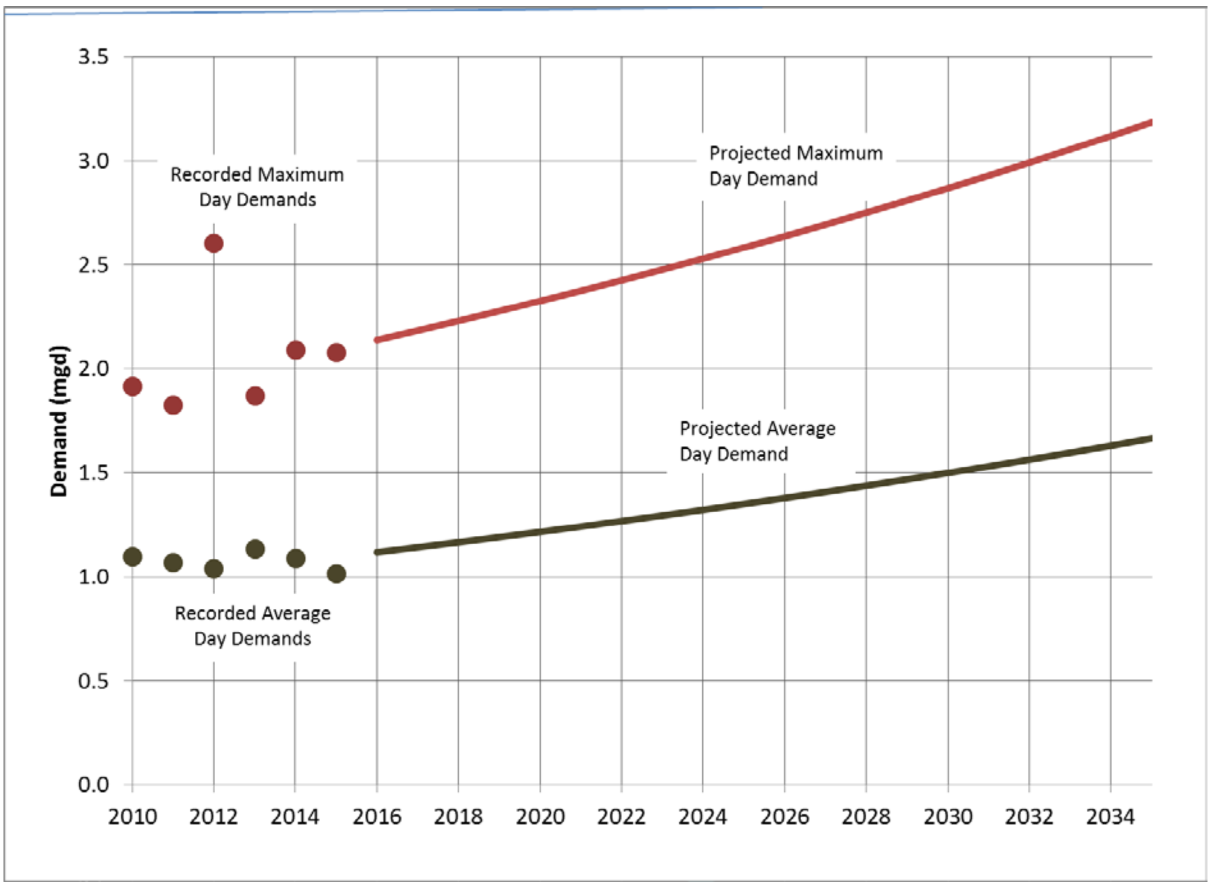

Figure 5-10. Projected Demand Growth

Water Supply

6.1 Integration of ASR System

As of 2016, Cornelius' only water supply was purchased water from Hillsboro, delivered through the JWC transmission pipeline connections. As described in this report, the city is currently developing an ASR supply. It will not be a truly independent supply, as the concept for the ASR system is that the city will purchase excess water during the winter months, store this water underground, and then recover this water during the high demand summer months. It increases the reliability of the city's system, making it less vulnerable during droughts and emergencies.

The goal for the ASR system, according to the test report, is to store approximately 50 million gallons (MG) per year over a wintertime period of 180 days. The actual storage volume shall slightly exceed 50 MG so that, at 95 percent recovery, the summertime withdrawal can total 50 MG.[6]

The typical injection rate will be 200 gpm over approximately 180 days to store slightly in excess of 50 MG. The normal recovery cycle will consist of pumping 500 gpm from the well continuously for a period of about 70 days to recover the full 50 MG. The recovery period may be lengthened if the ASR well pump is operated at less than 24 hours per day, which might be necessary depending on reservoir levels and system demands. As an example, if the ASR well is operated 20 hours per day, the recovery period for 50 MG would be lengthened to 83 days.

As discussed in the water quality section of this report, the plan is to pump from the ASR well into the existing storage tank at Water Park, and then to pump from the tank into the distribution system. The city's existing pump station at this location has two domestic pumps, each sized to deliver 180 gpm into the system. The station also includes one 800 gpm fire pump. It will be necessary to replace the domestic pumps will be necessary to achieve the desired operation of the ASR system. Each of the two domestic pumps should be replaced with a variable frequency drive pump to allow for a pumping range of 200 gpm to 800 gpm at about 175 feet of discharge head. The variable pumping rate feature is necessary to balance a constant ASR pumping rate of 500 gpm into the tank with variable distribution demands. The variable speed booster pumps will have adjustable output to match customer demands.

The fire pump can be replaced with a larger constant speed pump if the city believes it is important to meet residential fire flows using the ASR supply and booster pump station without service from the JWC transmission pipeline. It is recommended, if the fire pump is replaced, that the new pump be capable of producing approximately 1500 gpm at 175 feet of head. The larger fire pump will enable the city's water system to supply residential fire flows even without supply from the JWC system, thus improving system reliability.

Associated improvements are needed in the instrumentation and SCADA system to provide manual and automatic systems for managing the system, as well as appropriate alarms. For this to be considered a reliable emergency system, backup power should be provided for both the ASR well pump and the pump station.

[6] As described in the test report (GSI, 2015), the initial cycle will involve storing approximately 100 MG to create an initial buffer zone. Additionally, on a periodic basis, the suggested approach is for the city to store 70 MG while limiting recovery to the typical 50 MG to re-establish the buffer.

6.2 Annual Water Balance Using ASR Well

The ASR system will not change the annual total for purchases from Hillsboro, but will change the timing of the purchases. This is illustrated for projected 2016 demands in **Figure 6-1**. The ASR well will not be operational in 2016 but this chart provides a visualization of how using the ASR well will change the pattern of purchasing water from Hillsboro. Additional water will be purchased through the winter months for storage in the aquifer through the ASR well. The city will reduce purchases from Hillsboro during the summer months because the ASR well will withdraw stored water for delivery into the system. In addition to reducing summertime purchases, the ASR system will provide an emergency supply leaving the city less vulnerable to emergencies and making up for a significant storage deficit.

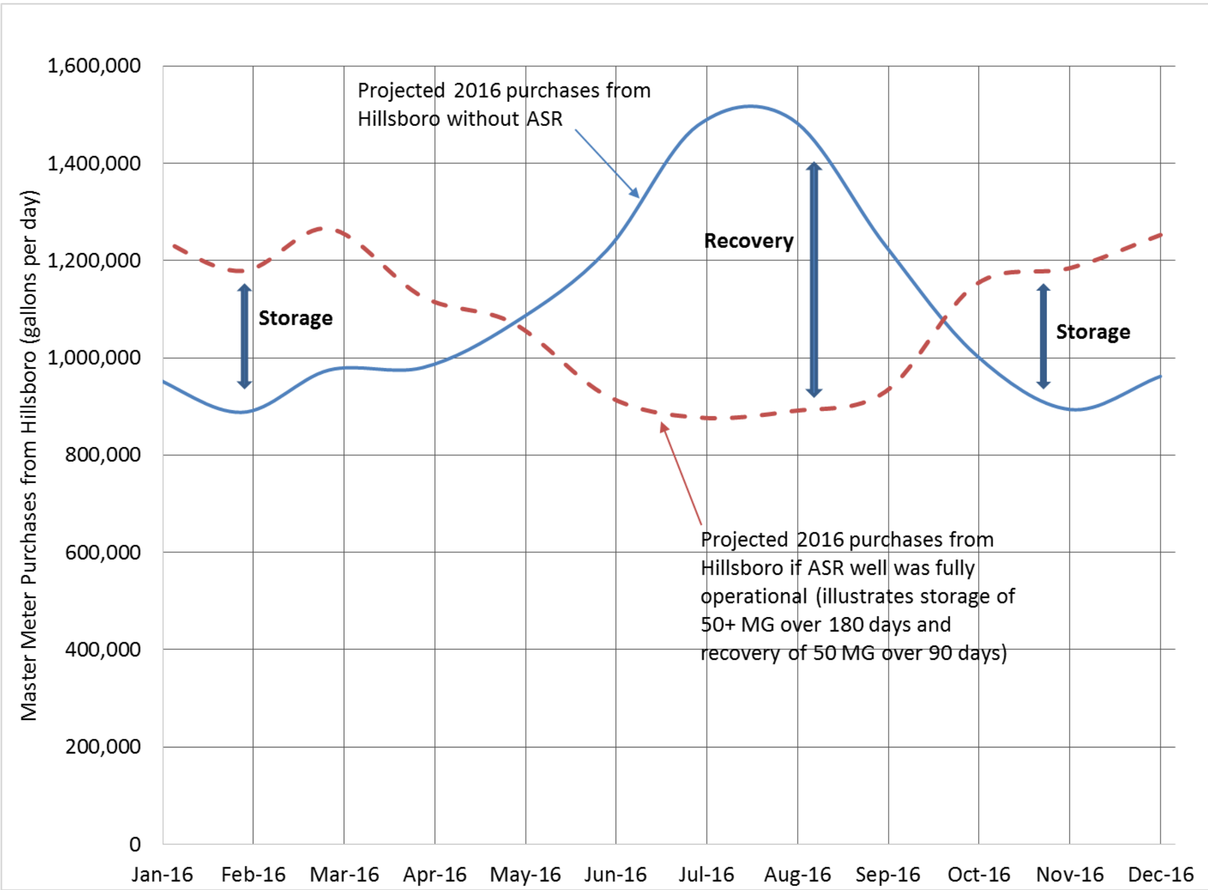

Figure 6-1. Illustration of ASR Operation Impacts Using 2016 Projected Demands

6.3 Daily Water Balance Using ASR Well

Variable rate pumping is recommended for the pump station because customer demands vary throughout the day and may drop to less than the ASR pumping rate of 500 gpm during the nighttime. The SCADA records from the master meters were used to determine minimum system demands during recent summer periods, the normal ASR recovery period. The following minimums occurred:

- 2011: 447 gpm
- 2012: 312 gpm
- 2013: 441 gpm

The system demands may have even been less than these values, because a portion of the water entering the system may have been for filling the tank. Variable rate pumping is needed to allow the pumped supply from the tank, which is fed by the ASR well, to adjust to changing demands. The pump station cannot deliver 500 gpm into the system when demands are less than 500 gpm. Since the delivery into the system will be less than 500 gpm during the night, it must exceed 500 gpm during the day to allow the ASR well pump to continuously recover 500 gpm, which is the goal during the recovery season.

Figure 6-2 illustrates a possible summer day water balance for the city's system when the ASR well is in recovery mode. This illustration uses 2016 demands; the balance will change as demands vary. The city's hourly demand through the day is approximated by the dark green, dashed line. The ASR well is operated at a steady rate of 500 gallons per minute (gpm) throughout the day, which is the goal so as to withdraw the full stored amount during the summer. The flow needed from the booster pump station, shown as the red dotted line, ranges from zero during the night to 750 gpm during the day.[7] The shortfall between the supply into the system from the booster pump station and the hourly customer demands is met by withdrawals from the JWC transmission pipeline. The top solid blue line on the chart displays how the reservoir volume fluctuates during the day. The value for this line is indicated on the right-hand vertical axis. The ASR system adds complexity. It will be necessary for the operations staff to develop standard operating procedures to guide day-to-day decisions.

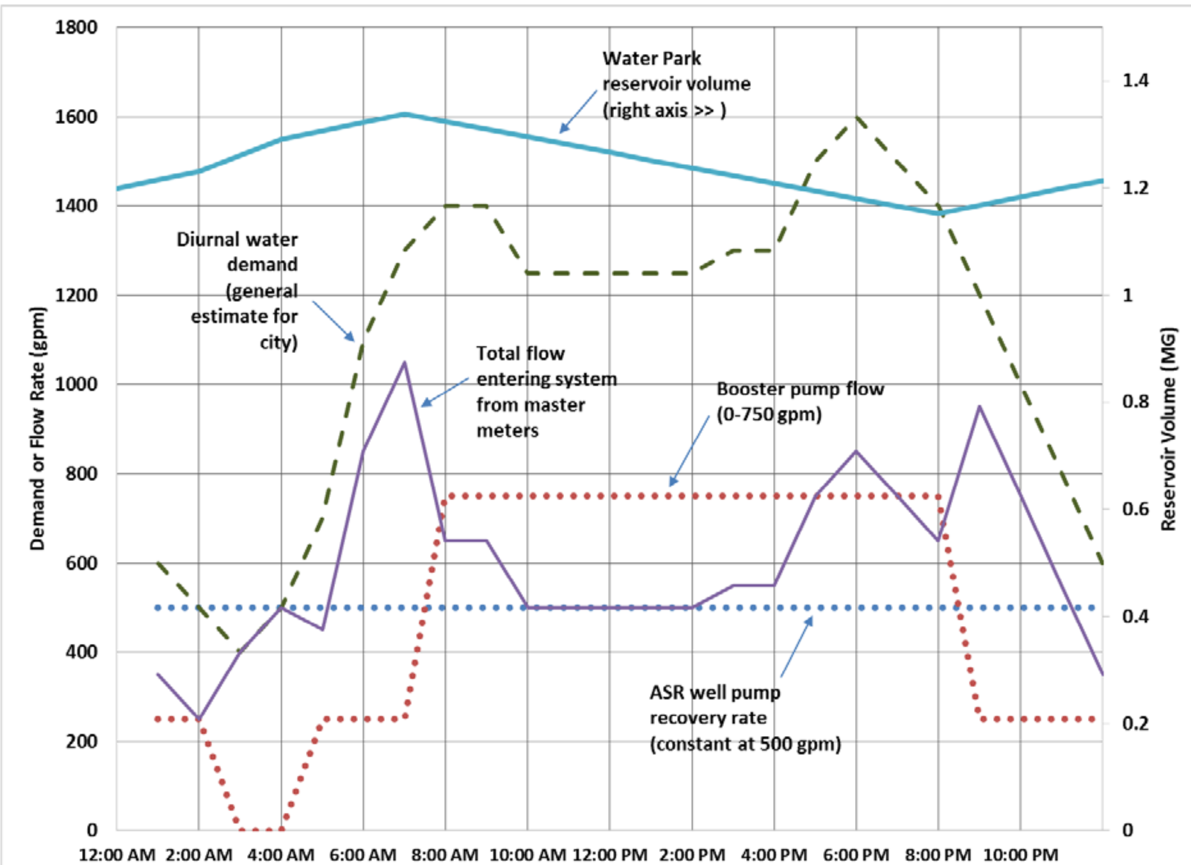

Figure 6-2. Cornelius Water Balance for a Summer Demand Day with ASR Operational

6.4 Water Rights

As a wholesale customer of Hillsboro, the City of Cornelius does not own and does not need to own water rights. The water delivered to the city is obtained through water rights owned by the JWC and

[7] The booster pumping rate illustrated in this figure assumes that the booster pump station is modified as described in the capital improvements plan presented in this master plan, to increase the maximum pumping rate and to use variable rate pumps.

their partner agencies. Since the concept of an ASR system is to recover stored water, the city will continue in the same manner without a need for water rights. The city does not need a water right for use of the ASR system if it is only recovering the allowed volume of water authorized by the ASR limited license. The City's ASR limited license application was being prepared as this master plan was being written. Once in place, the limited license will allow recovery of 95 percent of water stored via ASR on an annual basis.

Consideration was being given as this master plan was being prepared for submitting an application for a groundwater water right for the city, to allow the ASR well to withdraw in excess of the 95 percent value of stored water. This option would provide flexibility for the city's operations. However, as discussed in the water quality section of this report, there are some concerns with using a 50/50 blend of stored and native groundwater, and these concerns would become greater should the proportion of groundwater be further increased. The viability of using native groundwater will depend not only on water rights, but also evaluating the water quality impacts of using a greater proportion of native groundwater.

6.5 Emergency Supply Connections

Cornelius' distribution system abuts Forest Grove's system on the west and Hillsboro's on the east, both conditions providing an opportunity for adding emergency interties to improve system reliability. Although the supply from the JWC transmission pipeline has been reliable, it was shut down for a few weeks during one event in recent years when a leak was discovered. The city's proposed ASR system will generally be available as a water supply should this occur in the future, but it is also possible that an outage occurs when the ASR storage has been exhausted at the end of the pumping cycle. It is recommended that the city install emergency interties to both Forest Grove and Hillsboro, particularly because the required investment for either one is relatively minor. These projects have been included in the capital improvements plan.

6.6 Future Water Supply Option

Shortly before this report was finalized, the city had initiated discussions with Forest Grove about purchasing a portion of the city's water from Forest Grove, in lieu of only purchasing water from Hillsboro. The option was too uncertain to warrant evaluation in this plan. If Forest Grove is amenable to this plan and the cost is favorable for Cornelius, a further needed step is to determine if a connection to Forest Grove will function acceptably within the current distribution system. The hydraulic model developed and used for this master plan can be applied to examine the functionality of this option.

6.7 Future ASR Well

The capital improvements plan included in this master plan includes the addition of Reservoir No. 2, located on the eastern side of the city. It is recommended that the property purchased for this facility be sufficiently sized to accommodate the future installation of ASR Well No. 2.

The feasibility of installing an ASR well on the eastern side of the city is uncertain. It appears that a productive basalt layer underlies this area, similar to the one for the ASR well at Water Park. However, the depth to the basalt layer may be deeper for the eastern site compared to the Water Park site. The southeastern location is more favorable than a northeastern location, to minimize the depth to the basalt layer. The preliminary assumption is that the second ASR well would have a similar storage capacity (50 MG) and a similar recovery rate (500 gpm) to the first ASR well.

The city's experience with the initial ASR well will be valuable for deciding if a second ASR well is a cost-effective and reliable supply alternative. Unfortunately, the city may need to move ahead with property acquisition for both Reservoir No. 2 and the second ASR well in the near future, prior to gaining much experience with the first ASR well. If possible, a reservoir site should be selected that could accommodate a well with at least 100 feet of city property ownership on all sides, and in a location that minimizes potential interference with existing wells.

SECTION 7

Distribution System Evaluation

7.1 Storage

The city's water supply contract with Hillsboro requires the city to provide storage equal to three times the average day demand (ADD).[8] For 2016, the projected ADD equals 1.12 mgd, resulting in a storage requirement of 3.4 MG. Since the existing reservoir has a volume of 1.5 MG, this leaves a current deficit of 1.9 MG.

The ASR system that is being developed addresses this storage deficit. The use of ASR will not alter the city's average day demand withdrawals from the JWC transmission system because it is a storage and recovery system. However, in an emergency, it functions as a storage reservoir. If operated at 500 gpm over three days, the ASR system would produce 2.2 MG, so it is suggested that the ASR system should offset Hillsboro's storage requirement by this amount. At the time this master plan was prepared, the agreement with Hillsboro had not yet been modified to reflect the city's use of ASR. Although this contractual change had not been made, the city directed CH2M to base the storage planning on this approach.

Table 7-1 is a table illustrating the city's demand projections and resulting storage requirements with and without factoring in the ASR supply. Once the ASR system is fully operational, projected for 2018, the combination of the city's existing tank and the ASR system will provide an equivalent storage volume of 3.7 MG compared to a need of 3.5 MG, providing a surplus of 0.2 MG. The storage requirement of three times ADD increases proportionately as demands increase. According to the demand projections presented in this plan, the city would again face a deficit after 2020. The storage deficit is projected to reach 1.3 MG at the end of the 20-year planning period. Figure 7-1 illustrates the city's storage needs graphically, with and without ASR.

[8] The city staff asked for the master plan to include an evaluation of the Hillsboro's requirement for storing three times the ADD, based on general industry practices. It is common for wholesale suppliers to provide water up to the MDD rate of the purchasing system, and to require wholesale purchasing systems to provide sufficient storage so that they do not draw peak hour demands from the supplier's system. In addition, it is common to require the purchaser to supply its own needs for emergency and fire suppression storage. To examine how meeting these needs compares with the three times ADD requirement, the storage requirement can be evaluated using the following typical water system criteria: 1) Equalization storage = 25 percent of MDD, or approximately 0.5 MG for current Cornelius demands; 2) Fire storage = 3,000 gpm for 3 hours or 0.54 MG, based on the design and operating criteria presented in this plan; 3) Emergency storage = one ADD or 1.1 MG for current demands; recognizing that the fire storage component may also be available to lengthen the time the system can operate using emergency storage. Using these three factors, the current storage need for Cornelius equals 2.1 to 2.2 MG, or about two times the current ADD of 1.1 mgd. This analysis suggests that the three times ADD requirement for storage may be high.

Table 7-1. Storage Needs Calculations for Cornelius

					No ASR	With ASR			
Year	ADD (mgd)	MDD (mgd)	Needed Storage (MG)	Reservoir Volume (MG)	+ Surplus or - Deficit (MG)	ASR Production (gpm)	ASR Production (mgd)	ASR production over 3 days (MG)	+ Surplus or - Deficit (MG)
2013	1.13	1.87	3.4	1.5	-1.9				
2014	1.09	2.09	3.3	1.5	-1.8				
2015	1.02	2.08	3.1	1.5	-1.6				
2016	1.12	2.14	3.4	1.5	-1.9	0	0.0	0.00	-1.9
2017	1.14	2.18	3.4	1.5	-1.9	250	0.4	1.08	-0.8
2018	1.17	2.23	3.5	1.5	-2.0	500	0.7	2.16	0.2
2019	1.19	2.28	3.6	1.5	-2.1	500	0.7	2.16	0.1
2020	1.22	2.33	3.6	1.5	-2.1	500	0.7	2.16	0.0
2021	1.24	2.38	3.7	1.5	-2.2	500	0.7	2.16	-0.1
2022	1.27	2.43	3.8	1.5	-2.3	500	0.7	2.16	-0.1
2023	1.29	2.48	3.9	1.5	-2.4	500	0.7	2.16	-0.2
2024	1.32	2.53	4.0	1.5	-2.5	500	0.7	2.16	-0.3
2025	1.35	2.58	4.1	1.5	-2.6	500	0.7	2.16	-0.4
2026	1.38	2.64	4.1	1.5	-2.6	500	0.7	2.16	-0.5
2027	1.41	2.69	4.2	1.5	-2.7	500	0.7	2.16	-0.6
2028	1.44	2.75	4.3	1.5	-2.8	500	0.7	2.16	-0.7
2029	1.47	2.81	4.4	1.5	-2.9	500	0.7	2.16	-0.7
2030	1.50	2.87	4.5	1.5	-3.0	500	0.7	2.16	-0.8
2031	1.53	2.93	4.6	1.5	-3.1	500	0.7	2.16	-0.9
2032	1.56	2.99	4.7	1.5	-3.2	500	0.7	2.16	-1.0
2033	1.60	3.06	4.8	1.5	-3.3	500	0.7	2.16	-1.1
2034	1.63	3.12	4.9	1.5	-3.4	500	0.7	2.16	-1.2
2035	1.67	3.19	5.0	1.5	-3.5	500	0.7	2.16	-1.3

Note: According to the city's agreement with Hillsboro, the city must provide storage = 3x ADD. The ASR well could run over these 3 days, reducing storage need according to its production rate.

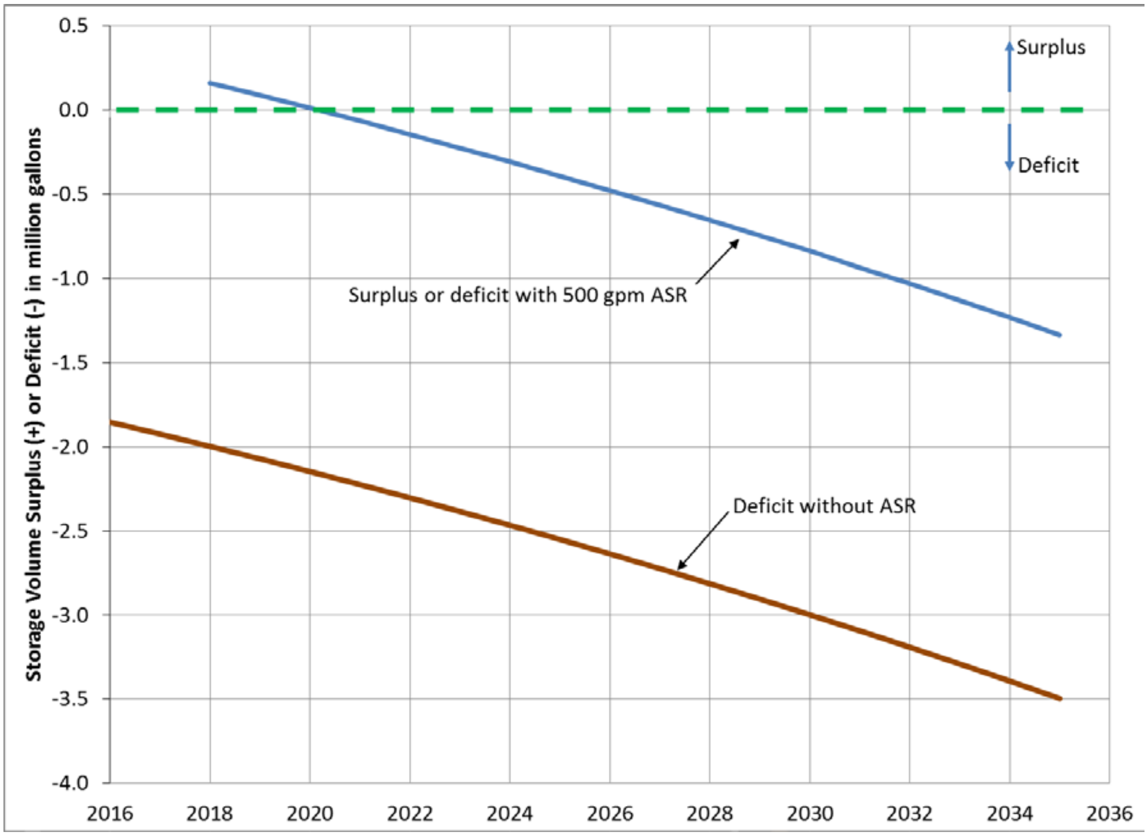

Figure 7-1. Storage Needs, With and Without ASR

The construction cost for a reservoir tank has a significant economy of scale, so it is cost effective to add a single reservoir with large enough volume to meet storage needs for many years. The addition of a second reservoir with a volume of 1.5 million gallons has been used in this master plan for the capital improvements planning. It is advisable for the city to purchase property as soon as possible to secure property for a second tank. As discussed in the water supply chapter of this report, it is desirable to obtain sufficient property for siting a second ASR well adjacent to the tank.

The ideal location would be on a hill to allow the water surface within the tank to match the distribution hydraulic grade line but no such hills are located within the city. This leaves the city with two options. One is to build a ground-level tank with a pump station. This is the arrangement currently used with the Water Park tank. As water enters the tank, much of its head pressure is lost and it is necessary to pump from the tank into the system. The other option is to build an elevated tank so the water surface matches the system hydraulic grade line. In this case, the tank would deliver water into the system by gravity flow. An elevated tank is more reliable in emergencies because of the gravity flow, although the installation of a backup generator for a pump station can make that option nearly as reliable as gravity storage. The other advantage for an elevated tank is that the energy imparted into the water (in the form of pressure) is not lost when water enters the tank, whereas for a ground level tank, this energy is lost and must be replaced through pumping.

Although these factors make elevated tanks desirable, elevated tanks can be undesirable from an aesthetic standpoint and even if acceptable in a neighborhood, their cost generally exceeds that of a ground level tank plus pump station, especially in an area with high seismic design criteria such as Cornelius. Based on a discussion of these factors, the city’s direction was for the capital improvements plan to assume the use of a ground level tank with a pump station.

Tanks can be constructed of prestressed concrete, as is the case for the city's existing tank, or can be made of welded steel. A concrete tank does not need to be coated on either the inside or outside. A welded steel tank requires painting on both the inside and outside, and both surfaces will require recoating every 20 to 25 years. Both concrete and steel can be designed to withstand earthquakes. Welded steel tanks have a lower construction cost than prestressed concrete for tanks with volumes of two million gallons and smaller, but when life-cycle costs are considered, the costs may be similar

One option is for the entire tank to be buried, with the ground above being available for athletic fields. A buried tank limits the material selection to concrete and increases the cost because of specialized design features. The decision as to whether to build a ground level or buried tank depends on neighborhood issues and the value of the land. If the value of the land for a park or athletic fields is high, a buried tank can be a good answer. Some of the key considerations for completely burying a tank include the following:

- Cost of the structure will increase (thicker walls, larger columns, thicker roof slab)
- Handling the overflow from a buried tank can become a challenge
- Vents from the tank (a necessary feature to allow water to enter and exit) require additional protective measures since the property will be a public area
- Access points (hatches) require additional features to provide safe access while also ensuring security
- A roof membrane coating system is usually included to protect against groundwater entry through the roof

Because of these factors and concerns, the capital plan presented in this master plan assumes a 1.5-million-gallon ground-level tank rather than a buried tank. The options of burying the tank or building an elevated tank can be further explored during the preliminary design for the project.

7.2 Distribution Pipe Network Analysis

A distribution system network model was developed and used to analyze the capability of the system to provide adequate flows and pressures, both for the existing system under current water demands and for projected future demands. The modeling was performed using InfoWater software, which is a GIS-integrated water distribution modeling application using the EPANET computation engine. **Figure 7-2** is a map showing the existing distribution system.

7.2.1 Existing System Analysis

The existing system was evaluated for a maximum day demand of 2.1 mgd and a peak hour of twice that value. The ability of the system to supply fire flows during a maximum day demand was checked, while maintaining a minimum pressure of 20 psi in all parts of the system. The 20 psi minimum pressure is per Oregon's drinking water rules.

The existing system performed acceptably for providing peak hour flows with adequate pressures. For the most part, the system also provided fire flows that met the city's level of service goals. The majority of the exceptions for fire flows were isolated locations where a hydrant is served by a single dead-end pipeline. There are a few locations where deficient available fire flows are the result of small diameter loops. **Figure 7-3** displays the fire flow modeling results for the existing system.

The city is entering the third year of a five-year program of replacing old and undersized steel. The program also includes completion of pipe loops in a few locations. These projects are concentrated in the central areas of the system.

The recommended improvement pipelines are listed in **Table 7-2**, which summarizes the recommended projects to upgrade the existing system. Nearly all of these projects are already included in the city's five-year replacement program. The only additions are noted. The city's standard material for new lines is PVC C900. With these improvements included in the system, the capability of the system to meet the fire flow criteria was substantially improved.

Table 7-2. Proposed Pipe Improvements to Meet Current System Needs

Label	Location	Length(feet)	Diameter (inches)
Projects in City's 5-Year Pipe Replacement Program			
P83	S Fawn St, between S 10th Ave to S 11th Ave	405	8
P99	S 12th Ave, between S Beech St to S Cherry St	315	12
P101	S 12th Ave, between S Alpine St to S Beech St	270	12
P453	S Fawn St, between S 11th Ave to S 12th Ave	320	8
P477	S 16th Ave, between S Beech St to S Cherry St	310	8
P481	S 16th Ave, between Alpine/Beech alley to S Beech St	60	8
P487, P103, P483	S 12th Ave, between E Baseline St to S Alpine St	360	12
P485	S Alpine St, between S 8th Ave to S 10th Ave	580	8
P1057	S Alpine St, between S 10th Ave to S 12th Ave	710	8
P1077	S Elder Ct., between S 15th Ave to cul-de-sac	250	8
P1387	S 16th Ave, between S Alpine St to Alpine/Beech alley	255	8
P365, P393	S 10th Ave, between S Fawn St to S Heather St	360	8
P367	S Ginger St, between S 8th Ave to S 10th Ave	555	8
P455	S 11th Ave, between S Elder St to S Fawn St	245	8
P457	S 11th St, between S Dogwood St to S Elder St	265	8
P567	N 13th Ave, between N Fremont St to N Fremont Ln	190	8
P575	N 13th Ave, between N Fremont Ln to N Davis St	375	8
P583	N 15th Ave, between N Fremont St to N Davis St	380	8
P625	N Gray St, between N 14th Ave to N 15th Ave	280	8
P1263	N 15th Ave, south from N Davis St	280	8
P1349	N 15th Ave, between N Gray St to N Fremont St	190	8
Projects Not Included in City's 5-Year Pipe Replacement Program			
P651	Connection to 12" near Water Park	50	8
P1389	Between S 16th Ave and S Alpine St existing piping,running east/west; completing loop	235	8

In addition to evaluating the performance of the existing system for supplying peak hour demands and fire flows, the model was also used to evaluate the capability of the system to deliver the 200 gpm injection flow to the ASR well, and to deliver water into the system during the ASR recovery cycle. The existing pipe network, with the improvements described in Table 7-2 incorporated, was found to be capable of delivering the 200 gpm injection flow to the ASR well.

As described in the preceding chapter of this report, the planned recovery pumping rate from the ASR well is 500 gpm. This flow will be pumped to the reservoir, and then will be delivered into the system from the reservoir using the booster pump station. A continuous pumping rate of 500 gpm from the ASR well into the reservoir requires that the booster pumping station be capable of pumping greater than 500 gpm during high demand periods because the booster pump rate will need to be less than 500 gpm during the nighttime low demand period.

The proposed booster pump station improvements were incorporated in the hydraulic model to determine if expansion of the station capacity would function acceptably in the system. It was found that the distribution piping network is acceptable for delivering flows of up to approximately 800 gpm from the booster pump station into the system. The booster pumps were modified to each having a capacity of 750 gpm at 175 feet of head for the analyses.

The capability of the booster pump station to meet fire flows within the system without any supply from the JWC transmission pipeline was also evaluated. For this analysis, the fire pump was replaced with a larger pump, sized at 1500 gpm at 175 feet of head. With this pump in place and with no supply coming through the master meters, the system can generally meet single family residential fire flow requirements throughout the system.

7.2.2 Future System

Demands for modeling the future system were set to 3.2 mgd for the MDD and approximately 4,400 gpm (6.3 mgd) to approximate the peak hour demands. The replacement pipes listed in Table 7-2 were included in the model. The future modeling also assumed an expansion of the urban growth boundary to the southeast and northeast and a backbone piping network was added to provide service to these areas. **Figures 7-4 and 7-5** illustrate these changes and the modeling results. **Table 7-3** summarizes the new pipes that were added to provide service to an expanded urban growth boundary. These 12-inch pipelines provide the overall framework for the expanded system. A grid of 8-inch pipelines will also be needed to provide service to all new customers.

Table 7-3. Pipelines Proposed for Meeting Growth Needs

Map No.	Length (feet)	Diameter (inches)
Pipelines Proposed for Growth in East Cornelius		
P1209	1,515	12
P1211, P1393	2,590	12
P1213	1,365	12
P1215	820	12
P1217	1,310	12
P1219	785	12
P1221	1,140	12
P1395	1,570	12
P795	460	12
P797	150	12
Pipelines Proposed for Growth in Southeast Cornelius		
P1223	240	12
P1225, P1295	1,000	12
P1319	230	12
P1301	240	12
P1321	530	12
P1227	420	12
P1233, P1297	520	12
P1251, P1253, P1337	1,520	12
P1341	425	12
P1339	505	12
P1249	540	12
P1255	740	12
P1397	225	12
P1399	130	12

Table 7-3. Pipelines Proposed for Meeting Growth Needs

Map No.	Length (feet)	Diameter (inches)
P1401	1,345	12
P1403	1,550	12
P1405	215	12
P1407	225	12
P1409	795	12

The expansion shown for the urban growth boundary is approximate and therefore, the location and lengths of the new pipes to serve these areas are approximate. Furthermore, their locations will need to be adjusted depending on property ownership, availability of easements, street and right of way locations, and other factors.

The new pipes shown in Table 7-3 are all listed as 12 inches in diameter. The actual needed sizes depend on fire flow requirements for these areas; peak hour demands are typically not the drivers. Smaller pipes can be used if it is only necessary to provide residential fire flows (1,000 gpm) as opposed to meeting the higher fire flows needed for schools, commercial, industrial, and multi-family use (3,000 gpm).

In the southeast expansion area, the use of 12-inch pipes would enable the system to supply 3,000 gpm fire flows to the far edges of the expanded system. If 8-inch pipes were used instead, the system could supply 3,000 gpm only in the expansion areas close to the existing system. The use of 8-inch pipelines is acceptable for this expanded service if the land use is entirely single-family residential. A future school has been included in the planning for fire flows; the needed 3,000 gpm fire flow for a school is available based on the 12-inch piping backbone of the network. Depending on the school's location within the southeast expansion area, only some of the piping may be required to be 12 inches.

Similarly, for the northeast expansion area, a grid of 8- and 12-inch pipelines would enable supply of 1,000-1,500 gpm fire flows throughout the expansion area. This is acceptable if the entire expansion is single-family residential. If the expansion is to include schools, multi-family residential, commercial, or industrial lands, then the area should be served with 12-inch lines, as shown in Figure 7-4.

The northeast expansion area is also considered to be a more likely location for the new storage tank since the average elevation is slightly higher than the southeast expansion area and since the undeveloped nature of this area provides an opportunity for locating a tank. It was also assumed that the fourth master meter, located approximately at 29th and Baseline and which is currently not in use, will be activated to supply the future expanded areas and to enable filling of a new tank in this area. As described in the storage discussion earlier in this chapter, additional storage will be needed to fulfill the city's purchase obligations with Hillsboro as demands within the system grow. A tank location on the east end of the system was found to perform acceptably. The city should move toward securing property for this second tank.

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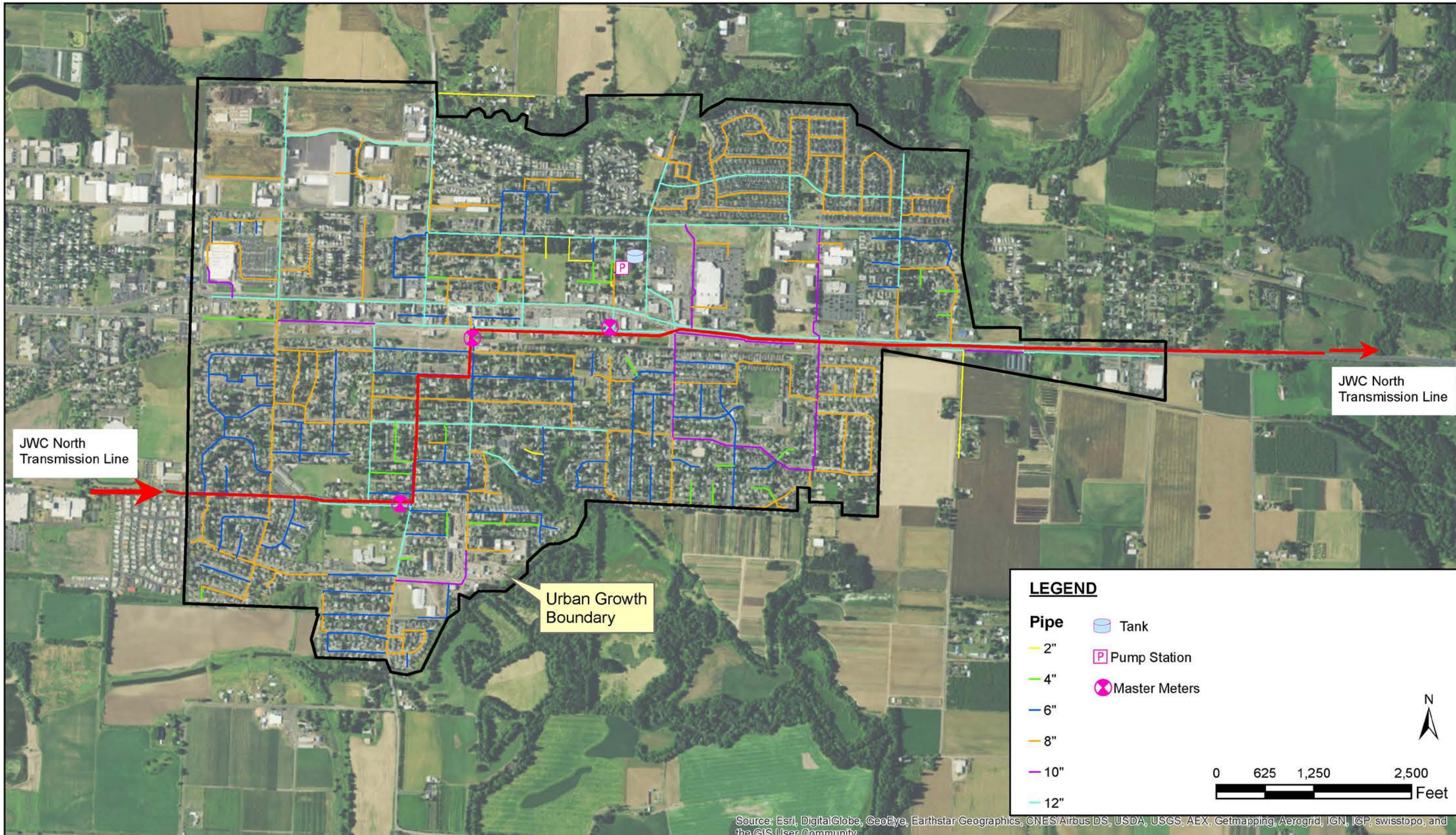

Figure 7-2. Existing Distribution System

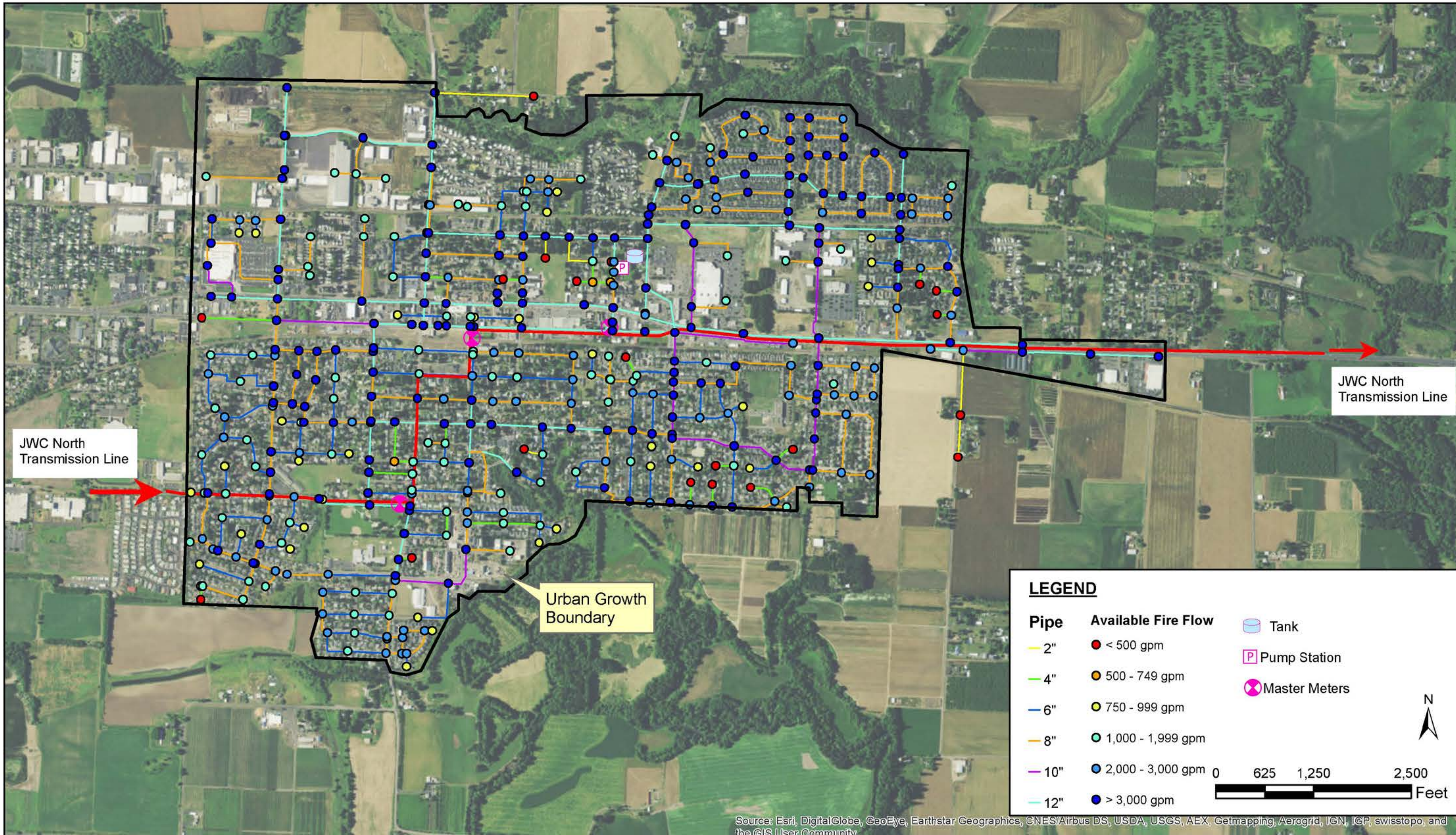

Figure 7-3. Existing System: Available Fire Flows

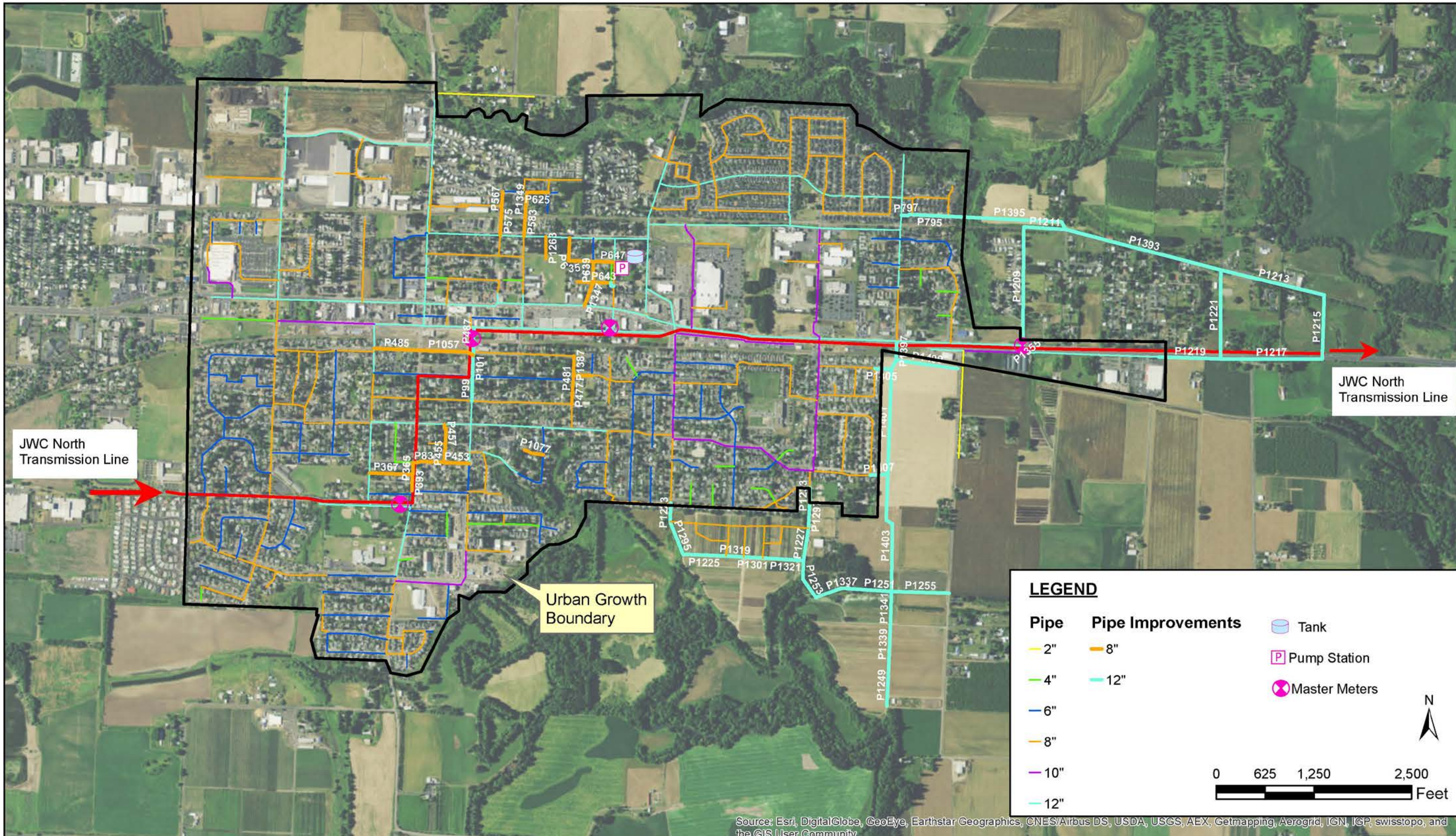

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Figure 7-4. 2035 System: Piping Improvements

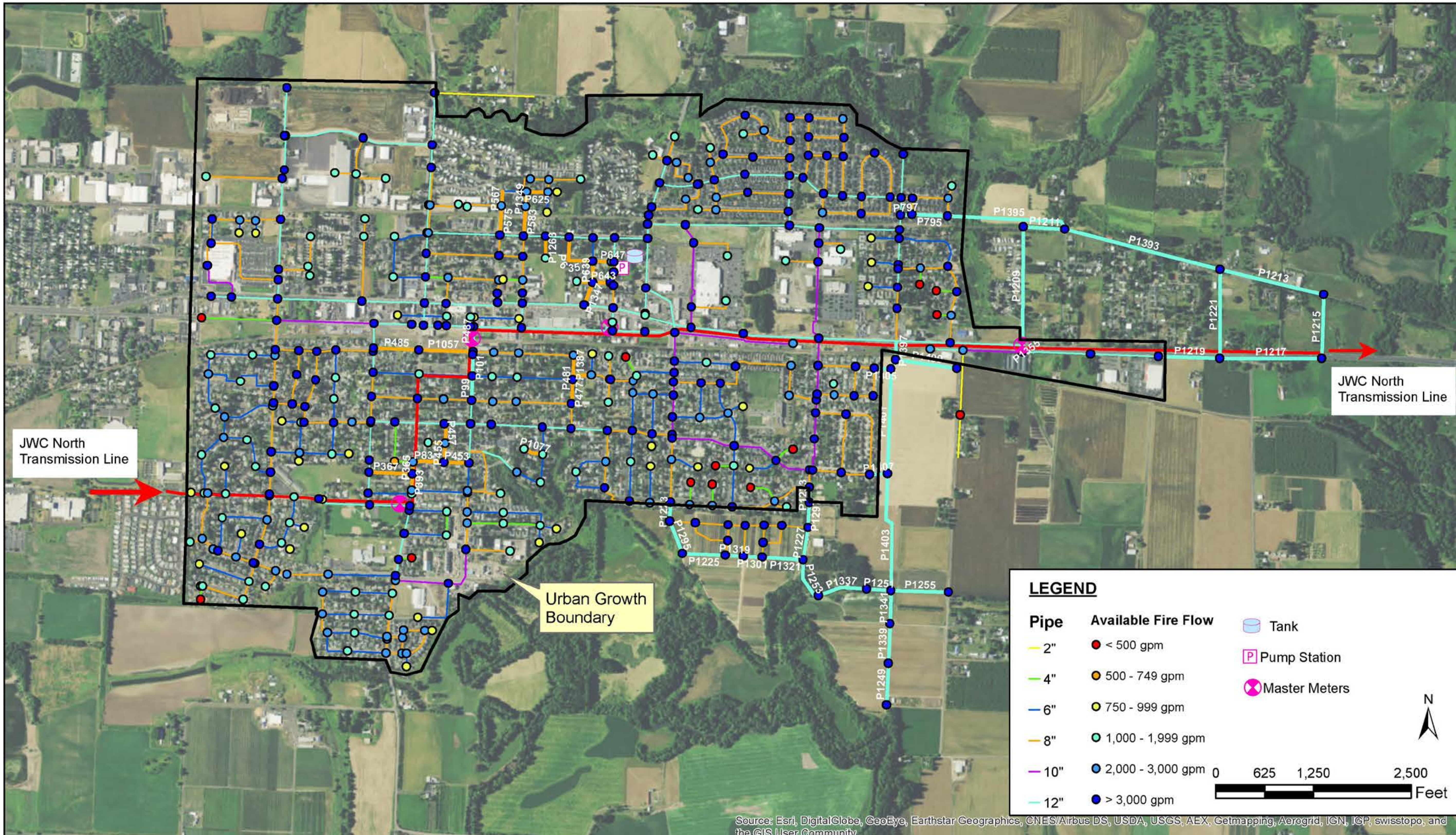

Figure 7-5. 2035 System: Available Fire Flows

SECTION 8

Capital Improvements Plan

This section summarizes the capital project recommendations developed for Cornelius' water system. The proposed projects are listed in Table 8-1. The table indicates whether the project is primarily to address existing system needs or is to address projected growth. The timing for the growth-related projects depend on the rate of the city's population growth.

Project cost estimates are provided to guide the city's budgeting. The costs are conceptual-level, only, and should be further examined and refined as the project implementation nears. An allowance for engineering design has been added to the construction estimate to arrive at a total project cost. Cost estimates are provided using mid-2016 rates, at an approximate *Engineering News Record* Seattle-area Construction Cost Index value of 10,550. They should be escalated to the date of implementation as annual budgets are established.

The uncompleted portion of the city's ongoing steel pipe replacement program has been included in the capital improvements plan. In addition to this work, other significant projects include expansion and improvements to the existing booster pump station to enable full operation of the ASR system, and removal and disposal of the exterior lead-containing paint on the existing tank. Although it is for a future, growth-driven need, it is recommended that the city proceed in the near future with purchasing property to hold in reserve for a second storage tank and pump station.

Table 8-1. Capital Improvements Plan

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						For Pipeline Improvements		Planning Estimate	
Pipe No.	Proposed Year for Near-Term Projects	Project Name	Project Description (and Water Demand Trigger, Where Applicable)	Project Purpose	System Develop-ment Charge Eligible?	Diameter (inches)	Length (feet)	Construction	Total Project (includes design allowance)
	2017-2018	Rate study	Evaluate current water rates and system development charges	Stay current with financing needs	Yes			$0	$12,000
	2017-2018 to 2020-2021	Customer meter replacement	Replace customer water meters with radio read/automated meters; cost estimated by city staff	Rehabilitation (improve tracking of use; increase operations efficiency)	No			$600,000	$600,000
	2017-2018	Removal and disposal of existing paint on tank	Exterior paint on existing tank contains lead. As it is beginning to break off, it should be appropriately removed and disposed to prevent contamination	Environmental remediation	No			$190,000	$228,000
	2017-2018	Emergency intertie with Forest Grove	Interconnect existing 12" line on Adair St to existing 10" line on Adair St. in Forest Grove (assumes that Forest Grove pays for line inside their city limits)	System reliability	No	12	180	$39,000	$47,000
P83	2017-2019	S Fawn St, between S 10th Ave to S 11th Ave	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	405	$59,000	$71,000
P99	2017-2019	S 12th Ave, between S Beech St to S Cherry St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	12	315	$69,000	$83,000
P101	2017-2019	S 12th Ave, between S Alpine St to S Beech St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	12	270	$59,000	$71,000
P453	2017-2019	S Fawn St, between S 11th Ave to S 12th Ave	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	320	$47,000	$57,000
P477	2017-2019	S 16th Ave, between S Beech St to S Cherry St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	310	$45,000	$54,000
P481	2017-2019	S 16th Ave, between Alpine/Beech alley to S Beech St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	60	$9,000	$11,000
P487, P103, P483	2017-2019	S 12th Ave, between E Baseline St to S Alpine St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	12	360	$78,000	$94,000
P485	2017-2019	S Alpine St, between S 8th Ave to S 10th Ave	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	580	$84,000	$101,000
P1057	2017-2019	S Alpine St, between S 10th Ave to S 12th Ave	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	710	$103,000	$124,000
P1077	2017-2019	S Elder Ct., between S 15th Ave to cul-de-sac	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	250	$36,000	$44,000
P1387	2017-2019	S 16th Ave, between S Alpine St to Alpine/Beech alley	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	255	$37,000	$45,000
P365, P393	2017-2019	S 10th Ave, between S Fawn St to S Heather St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	360	$52,000	$63,000
P367	2017-2019	S Ginger St, between S 8th Ave to S 10th Ave	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	555	$80,000	$96,000
P455	2017-2019	S 11th Ave, between S Elder St to S Fawn St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	245	$36,000	$44,000
P457	2017-2019	S 11th St, between S Dogwood St to S Elder St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	265	$39,000	$47,000
P567	2017-2019	N 13th Ave, between N Fremont St to N Fremont Ln	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	190	$28,000	$34,000
P575	2017-2019	N 13th Ave, between N Fremont Ln to N Davis St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	375	$54,000	$65,000

Table 8-1. Capital Improvements Plan

Pipe No.	Proposed Year for Near-Term Projects	Project Name	Project Description (and Water Demand Trigger, Where Applicable)	Project Purpose	System Develop-ment Charge Eligible?	Improvements: Diameter (inches)	Improvements: Length (feet)	Planning Estimate: Construction	Planning Estimate: Total Project (includes design allowance)
P583	2017-2019	N 15th Ave, between N Fremont St to N Davis St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	380	$55,000	$66,000
P625	2017-2019	N Gray St, between N 14th Ave to N 15th Ave	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	280	$41,000	$50,000
P1263	2017-2019	N 15th Ave, south from N Davis St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	280	$41,000	$50,000
P1349	2017-2019	N 15th Ave, between N Gray St to N Fremont St	Remaining in city's 5-year pipe replacement program	Reduce leakage and improve fire flows	No	8	190	$28,000	$34,000
	2018-2019	Booster pump station expansion	Reevaluate following full-scale ASR operations. Preliminary concept is to replace existing pumps with two domestic 800 gpm variable speed pumps and one 1500 gpm constant speed fire pump. May require replacement of piping, pump cans, and electrical panels; modification of controls. Assumes existing building does not require significant remodeling, although changes to lights and HVAC may be needed.	To enable proper functioning of ASR system--allows full capacity of ASR well to be delivered into system	Yes			$800,000	$920,000
	2018-2019	Purchase property for second tank	Secure property for eventual addition of second storage tank	Growth	Yes				$500,000
	2018-2019	Evaluate seismic condition of existing tank	Structural analysis to determine if seismic upgrades are warranted	System reliability	No				$25,000
	2018-2019	Emergency intertie with Hillsboro	Interconnect existing 12" lines on Baseline Road at East Lane (east of 341st), one belonging to Cornelius and one to Hillsboro	System reliability	No	12	100	$22,000	$27,000
	2019-2021	Master meters	Install compound meters downstream of Hillsboro meters at the 3 existing connections (10th & Heather, 12th & Baseline, Basco). Install in new vaults. Select locations to limit depth of burial and to minimize surface impacts (to pavement, etc). Use magnetic meters with proximity readers so operators do not need to enter vaults to read meters. Provide facilities to accommodate future SCADA connection. Cost is a general allowance, since the project is not clearly defined yet.	Verify flows into system; improve tracking of water use	No			$100,000	$120,000
P1389	2019-2020	16th Street to Alpine Street Connector	Add pipeline between 16th Street and South Alpine Street to create loop and improve fire flows	Improve fire flows and system reliability	No	8	235	$34,000	$41,000
P651	2019-2020	Connection to 12" near Water Park	Complete connections to loop system	Improve fire flows and system reliability	No	8	50	$8,000	$10,000
	2021-2022 to 2027-2028	Replacement of asbestos cement (AC) pipe	Annual allowance for 7 years of $500,000 to replace about 11 blocks of main per year; upsize 4" and 6" mains to 8" in most locations	Improve system reliability and improve fire flows	Partially				$3,500,000
						TOTAL OF PLANNED PROJECTS			**$7,334,000**
Possible Future Projects; Timing and Need for Projects Depend on Water Demand Growth									
		Install Reservoir No. 2 and pump station	1.5 million gallon ground-level steel tank and 1,000 gpm booster pump station; plan site to accommodate possible second ASR well	Growth	Yes			$4,700,000	$5,400,000
P1209		East Lane pipeline	For east UGB expansion: East Lane, between SW Baseline St (tie into existing 8") and North Railroad	Growth	Yes	12	1,515	$328,000	$394,000
P1211/ P1393		North Railroad pipeline #1	For east UGB expansion: North Railroad, between East Lane and NW 334th Ave	Growth	Yes	12	2,590	$560,000	$672,000
P1213		North Railroad pipeline #2	For east UGB expansion: North Railroad, between NW 334th Ave and NW 331st Ave	Growth	Yes	12	1,365	$295,000	$354,000

Table 8-1. Capital Improvements Plan

Pipe No.	Proposed Year for Near-Term Projects	Project Name	Project Description (and Water Demand Trigger, Where Applicable)	Project Purpose	System Development Charge Eligible?	Improvements: Diameter (inches)	Improvements: Length (feet)	Planning Estimate: Construction	Planning Estimate: Total Project (includes design allowance)
P1215		NW 331st pipeline	For east UGB expansion: NW 331st Ave, N/S between SW Baseline St and North Railroad	Growth	Yes	12	820	$178,000	$214,000
P1217		SW Baseline pipeline	For east UGB expansion: SW Baseline St, E/W between NW 334th Ave and NW 331st Ave	Growth	Yes	12	1,310	$283,000	$340,000
P1219		North Railroad pipeline #3	For east UGB expansion: North Railroad, E/W from NW 334th Ave to existing 8"	Growth	Yes	12	785	$170,000	$204,000
P1221		NW 334th pipeline	For east UGB expansion: NW 334th Ave, N/S between SW Baseline St and North Railroad	Growth	Yes	12	1,140	$247,000	$297,000
P1395		North Railroad pipeline #4	For east UGB expansion: Parallel to North Railroad, E/W from intersection of North Railroad and NW 341st Ave. and SE corner of W Holladay Way loop	Growth	Yes	12	1,570	$340,000	$408,000
P795		W Holladay Way pipeline	For east UGB expansion: Replacement of existing 8" with 12", from SE corner of Holladay Way Loop to SW corner	Growth	No	12	460	$100,000	$120,000
P797		Easement pipeline near W Holladay Way	For east UGB expansion: Replacement of existing 8" with 12", easement section	Growth	No	12	150	$33,000	$40,000
P1223		S. Jasper Dr. pipeline #1	For southeast UGB expansion: S Jasper Dr., from S Ginger St to S Heather St.	Growth	Yes	12	240	$52,000	$63,000
P1225/ P1295		S. Jasper Dr. pipeline #2	For southeast UGB expansion: S Jasper Dr., from S Heather St. to 22nd Ave.	Growth	Yes	12	1,000	$216,000	$260,000
P1319		S. Jasper Dr. pipeline #3	For southeast UGB expansion: S Jasper Dr., from S 22nd Ave. to 24th Ave.	Growth	Yes	12	230	$50,000	$60,000
P1301		S. Jasper Dr. pipeline #4	For southeast UGB expansion: S Jasper Dr., from S 24th Ave. to 25th Ave.	Growth	Yes	12	240	$52,000	$63,000
P1321		S. Jasper Dr. pipeline #5	For southeast UGB expansion: S Jasper Dr., from S 25th Ave. to 26th Ave.	Growth	Yes	12	530	$115,000	$138,000
P1233/ P1297		S. 26th Ave. pipeline #1	For southeast UGB expansion: S 26th Ave., from S Ginger St. to S. Heather St.	Growth	Yes	12	520	$113,000	$136,000
P1227		S. 26th Ave. pipeline #2	For southeast UGB expansion: S 26th Ave. from S Heather St. to S Jasper Dr.	Growth	Yes	12	420	$91,000	$110,000
P1251/ P1253/ P1337		S. Kodiak St. pipeline #1	For southeast UGB expansion: S Kodiak St, from S 29th Blvd. to corner of S Jasper Dr. and S 26th Ave.	Growth	Yes	12	1,520	$329,000	$395,000
P1341		S. 29th Blvd. pipeline #1	For southeast UGB expansion: S 29th Blvd., from S Kodiak St. to S Magnolia Dr.	Growth	Yes	12	425	$92,000	$111,000
P1339		S. 29th Blvd. pipeline #2	For southeast UGB expansion: S 29th Blvd., from S Magnolia Dr. to S Oleander Dr.	Growth	Yes	12	505	$110,000	$132,000
P1249		S. 29th Blvd. pipeline #3	For southeast UGB expansion: S 29th Blvd, from S Oleander Dr. to S Quartz Dr.	Growth	Yes	12	540	$117,000	$141,000
P1255		S. Kodiak St. pipeline #2	For southeast UGB expansion: S Kodiak St., from S 354th Ave. to S 29th Blvd.	Growth	Yes	12	740	$160,000	$192,000
P1397		S. 29th Blvd. pipeline #4	For southeast UGB expansion: S 29th Blvd, from SW Baseline St. to south of railroad tracks	Growth	Yes	12	225	$49,000	$59,000
P1399		S. 29th Blvd. pipeline #5	For southeast UGB expansion: S 29th Blvd, from south of railroad tracks to S Alpine St.	Growth	Yes	12	130	$29,000	$35,000
P1401		S. 29th Blvd. pipeline #6	For southeast UGB expansion: S 29th Blvd., from S Alpine St. to S Dogwood St.	Growth	Yes	12	1,345	$291,000	$350,000
P1403		S. 29th Blvd. pipeline #7	For southeast UGB expansion: S 29th Blvd., from S Dogwood St. to S Kodiak St.	Growth	Yes	12	1,550	$335,000	$402,000
P1405		S. Alpine St. pipeline	For southeast UGB expansion: S Alpine St., from S 29th Blvd to S 28th St.	Growth	Yes	12	215	$47,000	$57,000
P1407		S. Dogwood St. pipeline	For southeast UGB expansion: S Dogwood St., from S 29th Blvd to S 28th St.	Growth	Yes	12	225	$49,000	$59,000
P1409		S. 29th Blvd. pipeline #8	For southeast UGB expansion: Parallel to railroad tracks, W/E from S 29th Blvd. to SW 345th Ave.	Growth	Yes	12	795	$172,000	$207,000
TOTAL FOR POSSIBLE FUTURE PROJECTS									**$11,413,000**

Note: A "Yes" under System Development Charge Eligible means project is 100% related to growth; projects with a "No" address existing needs