City of Wilsonville

ADOPTED: September 06, 2012 Ord. 707

WATER SYSTEM MASTER PLAN

KELLER associates

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City of Wilsonville

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EXPIRATION DATE: 12-31-13

WATER SYSTEM MASTER PLAN

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Water System Master Plan

City of Wilsonville, Oregon

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ACRONYMS, ABBREVIATIONS, AND SELECTED DEFINITIONS

AC	asbestos cement
ADD	average day demand
Amp	electrical amperage rating
AWWA	American Water Works Association
blow-off	end-of-line valve and fittings used for manual flushing of pipelines
Conc	concrete
C	Celcius
CCTV	closed circuit television
CFD	computational fluid dynamic
CI	cast iron
CIP	Capital Improvement Plan
CT	concentration x T_{10}
CU	elemental designation for copper material
DI	ductile iron
DC	direct current electricity
EDU	equivalent dwelling unit
EPA	U.S. Environmental Protection Agency
ERU	equivalent residential unit
fps	feet per second
ft	feet (or) foot
hp	horsepower
GIS	geographic information system
gpcd	gallons per capita per day
gpm	gallons per minute
gpm/sf	gallons per minute per square foot
hrs	hours
HRT	hydraulic residence time
ID	identification
in	inch
Level A	The lowest pressure service area in Wilsonville (also referred to as “A Level”)
Level B	The middle pressure service area in Wilsonville (also referred to as “B Level”)
Level C	The higher pressure service area in Wilsonville (also referred to as “C Level”)
Level D	A future, highest pressure service area in Wilsonville (also referred to as “D Level”)
LIDAR	light detection and ranging
LMI	Liquid Metronic Incorporated (metering pump)
MCC	motor control center
MDD	maximum day demand
Metro	An elected, regional government for the Portland metropolitan area
MFDU	multi-family dwelling unit
MG	million gallons
mgd	million gallons per day
mg·min/L	milligram-minute per liter
mg/L	milligrams per liter

min	minutes
OAR	Oregon Administrative Rules
ODHS	Oregon Department of Human Services
ODWR	Oregon Department of Water Resources
O&M	operation and maintenance
PDD	peak day demand
pH	potential Hydrogen (measure of the acidity or basicity)
PHD	peak hour demand
PLC	programmable logic control unit
ppd	pound per day
ppm	parts per million
PRV	pressure reducing valve
psi	pounds per square inch
PSU	Portland State University
PVC	polyvinyl chloride plastic
RCP	reinforced concrete pipe
SCADA	supervisory control and data acquisition
sf	square feet
SFDU	single family dwelling unit
T_{10}	time required for 10% of the inlet chemical concentration to reach the outlet
T_{90}	time required for 90% of the inlet chemical concentration to reach the outlet
T_{10}/T_{90}	more conservative hydraulic efficiency factor obtained by dividing T_{10} by T_{90}
T_{10}/HRT	hydraulic efficiency factor
TAZ	traffic analysis zone
turnout	refers to a water delivery point or water enters the distribution system
TVF&R	Tualatin Valley Fire and Rescue
TVWD	Tualatin Valley Water District
UGB	urban growth boundary
UPS	uninterruptible power supply
URA	urban reserve area
USEPA	U.S. Environmental Protection Agency
US	United States
UV	ultraviolet radiation
VFD	variable frequency drive
WMP	water master plan
WMCP	water management and conservation plan
WRWTP	Willamette River Water Treatment Plant
WSMP	water system master plan
WTP	water treatment plant

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Water System Master Plan

Executive Summary

INTRODUCTION AND OVERVIEW

Keller Associates, Inc. was commissioned in 2011 to complete a Water System Master Plan that would update the 2002 plan. This water master plan is a 20-year planning document that focuses primarily on Wilsonville's water distribution system. This system includes the City's network of water pipelines, storage tanks, valves, and hydrants. An overview of the system is illustrated in Figure 1, found in Appendix A of this report.

The primary water supply for Wilsonville is from a state-of-the-art surface water treatment plant, commissioned in April 2002. This master plan includes an evaluation of the existing treatment plant capacity, and identifies minor improvements to accommodate an increase in the production rate from 12 to 15 million gallons per day. (A more comprehensive evaluation and master plan for the treatment plant is not part of this document, but the City intends to complete one at a later date.) The plan also evaluates the existing groundwater wells that now serve as an emergency backup supply to the City.

In general, Wilsonville's water system is in great condition, providing a safe and reliable water source to the residents and businesses serviced. Water rights are sufficient for projected needs, the treatment plant is only 10 years old, and the majority of the pipelines and other distribution facilities are less than 30 years old. The City has well-trained employees who perform regular maintenance of the facilities, and few deficiencies exist.

This planning document identifies upgrades to the water system to accommodate anticipated future demands. The plan also identifies potential vulnerabilities and localized areas where the fire protection could be improved. Recommended improvements for the 20-year planning horizon are discussed in more detail in the technical summary that follows, and generally include the following:

- An additional 3.0 million gallons (MG) of water storage tank
- Completion of the 48-inch transmission pipeline
- A new 16-inch waterline under the Willamette to Charbonneau District
- Minor water treatment plant upgrades
- Miscellaneous pipeline and facility upgrades intended to improve operations, water quality, and fire protection

In addition to these capital improvements, this plan identifies repair and replacement needs and recommends continued routine maintenance activities. These include:

- Ongoing pipeline, hydrant, and meter replacement programs
- Ongoing maintenance and upgrades to the well facilities to retain functionality as a reliable backup supply
- Efforts to reduce the amount of unaccounted for water (water loss) to less than 10%

TECHNICAL SUMMARY

This section provides a summary of the major findings of the master plan. It includes brief discussions of water demand assumptions, water system asset conditions, system deficiencies, and recommendations for improvements to the water storage and distribution system. A partial assessment of the water treatment capabilities is also provided consistent with this documents' focus on City of Wilsonville needs and requirements. Long range planning for the Willamette River Water Treatment Plan (WRWTP) involves multiple parties and is beyond the scope of this document.

ES.1 DESIGN CONDITIONS

ES.1.1 Demographics

The study area is illustrated in Figure 2, found in Appendix A. It includes the area within the existing Urban Growth Boundary, plus portions of Clackamas and Washington County Urban Reserve Areas expected to be incorporated into Wilsonville. The study area is intended to coincide with the ongoing Transportation System Plan update.

Based on an evaluation of population projections from various sources, an annual residential growth rate of 2.9% was assumed. Both single family and multi-family dwelling units were assumed to grow at this rate until build-out of their respective parts of the study area.

For nonresidential development, the number of employees in the study area was projected (per previous planning studies) to double over a 20-year period. This equates to an annual average nonresidential growth rate of 3.5%.

ES.1.2 Water Demand

Water production data from 2005 to 2009 was used to establish water demand patterns (due to current economic conditions, 2010 was not considered representative of normal usage). Table ES.1 shows the values used to estimate future demands.

TABLE ES.1 – Water Demands by User Type

	Single Family	Multi-Family	Commercial	Industrial
Average Daily Demand				
gallons/Household	247	162	-	-
gpm/Acre	-	-	1.93	0.56
Maximum Day Demand				
gallons/Household	606	283	-	-
gpm/Acre	-	-	3.3	0.84

gpm = gallons per minute

For build-out, industrial demands were increased by an additional 25 percent to reflect redevelopment, additional infill, and higher water users within existing structures. Three large future industries totaling 1.0 mgd in demand were also included in future water usage projections.

The existing treatment plant and Wilsonville transmission system will also provide supplemental potable water supply to the City of Sherwood. Sherwood is currently receiving up to 2.5 mgd, and by 2015 will be receiving 5.0 mgd.

Table ES.2 summarizes the future demands for residential and nonresidential users, future industry, and supplemental supply for the City of Sherwood. Supply to the City of Sherwood was assumed to increase to 10 mgd in 2030 and 20 mgd at final build-out. Build-out of the study area is projected to occur in the year 2036 for nonresidential areas, and in the year 2045 for residential areas.

TABLE ES.2 – Future Water System Demands

Scenario	2010	2015	2020	2025	2030	Build-out
Population	19,525	22,525	25,986	29,979	34,585	52,400
Households	7,873	9,083	10,478	12,088	13,946	21,129
Residential						
Average, mgd	1.70	1.96	2.26	2.60	3.00	4.21
Peak Day, mgd	3.62	4.17	4.82	5.56	6.41	8.74
Peak Hour, mgd	6.16	7.10	8.19	9.45	10.9	14.86
Nonresidential						
Average, mgd	1.50	1.79	2.12	2.52	2.99	3.09
Peak Day, mgd	3.08	3.66	4.35	5.16	6.13	6.35
Peak Hour, mgd	5.24	6.23	7.40	8.79	10.4	10.80
Other Miscellaneous						
3 Future Large Industries	0.00	0.50	0.75	1.00	1.00	1.00
Sherwood	0.00	5.00	5.00	10.0	10.0	20.0
Total System						
Average, mgd	3.20	9.24	10.1	16.1	17.0	28.3
Peak Day, mgd	6.70	13.3	14.9	21.7	22.5	36.1
Peak Hour, mgd	11.4	18.8	21.3	29.2	32.3	46.7

mgd = million gallons per day

ES.2 WATER SYSTEM EVALUATION

The City of Wilsonville's primary supply comes from the Willamette River. A state-of-the-art treatment plant produces high-quality finished water that is pumped into a transmission pipeline and conveyed to the City's distribution system through three delivery points ("turnouts") as shown on Figure 1. The system also includes four storage reservoirs, two booster stations, over 107 miles of distribution pipeline, three pressure zones, and eight wells.

Keller Associates updated the City's existing computer model of the City's distribution system. Every storage reservoir, booster station, and City pipeline 4-inches and larger were included in the model. The model was refined as field measurements were compared to model results in a process referred to as calibration. The City now has a highly accurate and dynamic hydraulic model of their water system. This tool can be used and updated to quickly investigate potential system impacts from new users.

ES.2.1 Storage

Storage in a water system is provided for operational flexibility, to meet peak demands, for fire flows, and for emergency conditions. The City's four existing storage reservoirs provide 7.6 million gallons (MG) of effective (or useable) storage. These reservoirs are located within the City's distribution system, providing needed operating, peaking, fire, and emergency storage. In addition to these four reservoirs, a minimum storage volume is maintained in the treatment plant clearwell for chlorine disinfection. During an emergency, it was assumed that this water would also be available to the City, providing an additional 1.08+ MG of emergency storage. Adding the clearwell emergency storage provides the City with approximately 8.7 MG of storage. Based on a worst case scenario (no backup wells to supplement storage), the total storage required is anticipated to increase from 9 MG to almost 18 MG by 2030.

The City has plans to construct an additional 3.0 MG storage reservoir near the intersection of Tooze and Baker Road. This reservoir, combined with existing storage, will provide sufficient long-term storage for the City's 20-year needs provided that the City continues to maintain the majority of the existing backup wells to offset storage needs. This storage volume would also allow the existing Charbonneau tank to be abandoned, provided a secondary supply line is constructed to the District.

ES.2.2 Pumping

The Charbonneau Booster Station and the B-to-C Booster Station are currently the only two pumping facilities in the distribution system. The Charbonneau Booster Station runs only periodically because the Charbonneau District can usually receive needed flows and pressures through the connection to the main distribution system (Zone B). The B-to-C Booster Station works together with the C Level Reservoir to meet the pressure and flow needs of the C Level pressure zone. No additional booster pumping is required for the current system, but several upgrades to the existing booster stations are recommended. As the City grows, a future D Level Booster Station will be required to service the northeast corner of the study area.

ES.2.3 Distribution System

The existing distribution system was evaluated for age, physical condition, water pressure, and capability to provide fire flows.

Age & Physical Condition

Most of the pipe materials are ductile iron or cast iron, which can have a life of 75-100 years in non-aggressive soil environments. However, recurring problems have been reported with some cast iron pipe – particularly those sections installed in the 1970s (approximately 32,800 feet of pipeline), much of which is located in the Charbonneau District. In addition, approximately 1,700 feet of small diameter steel pipe sections may need to be replaced, since these pipe materials are generally in poorer condition. These problematic pipeline sections are recommended for replacement within the next 20 years. Replacement of 34,500 feet of pipe over the next 20 years will involve replacing an average of 1,725 feet of pipe per year.

In addition to the pipeline sections that need to be replaced, the City has identified 40 fire hydrants that need replacing. Hydrant and pipeline replacement projects should be coordinated with each other and with planned street repairs wherever possible to minimize costs. Replacements should also be coordinated with the Tualatin Valley Fire and Rescue.

Keller Associates recommends that the City continue their meter testing and replacement program of large commercial meters on a 3-year cycle, and expand the residential meter testing program to include a representative sample (100±) each year.

Fire Flows

Based on water system modeling, fewer than 5 percent (55 of approximately 1200) locations modeled in the system cannot meet the target fire flow standard (1500 gpm residential, 3000 gpm commercial/industrial). Most of these are dead-end or short lengths of smaller diameter piping.

Pressure

Most modern appliances and plumbing fixtures operate best when water system pressures are between 50 psi and 80 psi. Water system modeling shows that much of Wilsonville's water system will experience water pressure greater than 80 psi. This is because the greater part of Wilsonville is served by the B Level pressure zone (refer to Figure 5 in Appendix A for pressure zone map). This arrangement is not uncommon for water systems, but does require that individual pressure regulators be installed to regulate pressures below 80 psi. For Wilsonville's system, Keller Associates recommends that individual pressure regulators be installed on all new connections. This will give the City the greatest flexibility in operations, while providing a level of protection to the user. Where future mainline pressures are anticipated to exceed 120 psi, special piping is recommended.

There are also some areas of low pressure in the northern portion of the system. While none of the areas are less than 40 psi, these may be areas the operations crew should monitor as the system continues to evolve. In order to provide water service with pressures greater than 40 psi to the northeast portion of the study area, a new pressure zone will be required. Existing and future pressure zones are illustrated in Figure 5 in Appendix A.

Water Loss

The City has active meter testing and leak detection programs. However, in recent years unaccounted for water (often referred to as water loss) amounted to between 15.7% and 17.6% of the total reported water produced at the water treatment plant. Efforts to locate this water, which were completed in conjunction with this study, suggest that the actual unaccounted for water is closer to 13% (refer to Section 2.3). Keller Associates recommends the following activities to reduce the unaccounted for water to less than 10%:

- Continued leak detection and large meter testing programs.
- Expand leak detection to include private unmetered fire lines.
- Implement residential meter testing and replacement programs.
- Account for water treatment plant utility water and onsite irrigation usage.
- Enhance tracking of water loss by trending water loss on a 12-month volumetric moving average basis.
- More aggressively investigate atypical low water uses. This process can be partially automated with the billing system, flagging accounts with no water usage or water usage substantially less than that reported for the same time the previous year.
- Look at partitioning of segments of the City (e.g. Charbonneau District) and compare metered delivery volumes for the region to the total of the individual meter readings.

These recommendations will be included in Wilsonville's forthcoming Water Management and Conservation Plan. The plan is currently being prepared in accordance with OAR 690.86.

Other Issues

Other system vulnerabilities and inefficiencies were found while evaluating the existing water system. Additional improvements were recommended to address these issues.

One of the vulnerabilities discovered in Wilsonville's system was single line connections to large parts of the system. In the event that the single pipeline were to rupture, the entire downstream area would be without water. Looping is recommended. Examples of these areas include the single line supplying Zone C north of Elligsen, and the Canyon Creek, Ash Meadow, and Sundial apartments.

Another vulnerability found in the system was hydrant coverage shortage in several of the more populated sections of the water system (based on a maximum service area radius of 300 feet from the hydrant). Hydrants, and in some cases new or upsized pipelines, are proposed to provide adequate coverage in the evaluated areas.

One inefficiency relates to the operations of the Charbonneau tank. Under the current operation, water enters the tank from the water system and then has to be pumped again into the water system to be used. The improvements identified in this plan will remove unnecessary pumping.

ES.2.4 Wells

The City owns and maintains eight potable groundwater wells that once supplied all of the City's drinking water. Since the completion of the water treatment facility in 2002, these wells are designated for emergency backup water supply only. Keller Associates reviewed the well conditions, water rights status, availability of standby power, water quality, and pump tests (conducted as part of the study) to prioritize which well facilities warrant upgrades and continued maintenance, and which ones should be considered for potential abandonment or conversion to nonpotable (e.g. irrigation) use.

Given the potential for the Charbonneau District to become isolated from the remainder of the system due to an earthquake, it was felt that the two Charbonneau wells should be maintained as a critical backup supply source for areas south of the Willamette River. The Wiedeman, Boeckman, Gesellshaft, and Elligsen wells all have deficiencies, but should be maintained as part of the City's backup water supply. Keller Associates recommends that the City consider abandoning the Canyon Creek and repurposing Nike well for local irrigation purposes. Before abandoning any well, the City should carefully review the long-term benefits of maintaining/transferring existing water rights.

ES.2.5 Treatment and Transmission Overview

The Willamette River Water Treatment Plant (WRWTP), completed in 2002, is jointly owned by the City of Wilsonville and the Tualatin Valley Water District (TVWD). Most of the existing treatment plant is currently rated for 12-15 mgd, with portions capable of handling 70+ mgd. Though a detailed treatment study was outside the scope of this master plan, hydraulics and process capacities were analyzed. With relatively minor upgrades or policy changes, the WRWTP will be able to treat the design production rate of 15 mgd. Based on projected system demands, a major plant expansion would be needed sometime after 2020. A separate water treatment plant master plan is needed to define what additional plant upgrades are needed to increase the capacity beyond 15 mgd.

Multiple evaluations have been performed on the WRWTP's production capacity each with different results. Applying the more conservative assumptions, the current plant capacity is 12 mgd. Under these assumptions, the limitation of the treatment plant is the clearwell storage volume. Under the current City policy of maintaining 1.25 million gallons of operational storage

(15 mgd for 2 hours), the remaining storage is insufficient to provide adequate disinfection contact time. However, modifying the policy to keep only 0.30 million gallons of operational storage (a conservative estimate of what is needed for on-site operations) would result in a treatment capacity in excess of 15 mgd. Alternatives to policy modification include capital improvements to the clearwell such as adding mixer pumps or baffles. In either case, a new tracer study on the clearwell is warranted because the previous tracer study results are only applicable for flows up to 9.5 mgd. Further details on this subject can be found in Chapter 4.

In addition to the potential clearwell limitations, there are also transmission limitations. When flows begin to exceed 12.5 mgd from the WRWTP, a sudden stop in flow (e.g. power failures) can lead to damaging surge conditions in the transmission and distribution lines. A 750 cubic foot hydropneumatic tank is recommended to mitigate this potential damage and allow the plant to safely operate at 15 mgd.

ES.2.6 Charbonneau District

Because of the age and isolated nature of the Charbonneau District, Keller Associates evaluated the water distribution system needs specific to the District service area. The single largest concern for the District area is the risk associated with an earthquake. An earthquake could easily disrupt the single pipeline service that feeds the District. Additionally, the Charbonneau tank that would service the District is at risk of settling during a major earthquake. Settling of the tank is not anticipated to result in a catastrophic failure and release of water, but it would result in loss of use of the reservoir. To address these risks, Keller Associates evaluated tank rehabilitation and replacement options and investigated the possibility of a secondary supply pipeline under the Willamette River (refer to Section 3.3). Constructing the secondary pipeline appears to be the lowest cost and lowest risk alternative. The pipeline alternative will also allow for the abandonment of the existing tank and booster station which are approximately 35 years old.

The Charbonneau District also has a disproportionate amount of older and undersized pipelines that will require replacement within the planning period. Additionally, stricter fire protection standards will require additional hydrants and associated pipelines if the system is going to be brought up to current standards. For a more complete evaluation of the District, refer to Appendix F.

ES.3 RECOMMENDATIONS

ES.3.1 Prioritized Improvement Plan

Recommended improvements resulting from the system evaluation are presented in this section in order of priority. These improvements are necessary to meet the available fire flow standards, provide hydrant coverage, address hydraulic restrictions, correct deficiencies in the physical condition of the existing system components, increase system storage capacity, and provide reliable backup well capability. Also included are development-driven and City-identified capital improvement projects.

Prioritization of the improvements was developed in consultation with City staff. Table ES.3 summarizes the recommended capital improvements.

Priority 1 improvements represent more urgent facility and pipeline improvements, and projects to increase fire flows that are currently less than 1,000 gpm. Priority 1A improvements are recommended within the next 5 years and (for capital projects) are intended to guide development of the water-related, 5-year Capital Improvement Plan (CIP). Priority 1B improvements are recommended by 2022. Priority 2 improvements are those that are needed within the next 20 years, and include lower priority facility upgrades and replacements, and projects to improve fire flows currently between 1,000 and 1,500 gpm. Hydrants needed for residential area coverage not tied to a Priority 1 improvement, are considered Priority 2 improvements.

Priority 3 improvements include facility replacements and pipeline improvements, to be implemented as development or redevelopment occurs. These may include improvements intended to correct marginal fire flow deficiencies, to address poor hydrant coverage in developed industrial/commercial areas, or to provide water to currently unserviced future growth areas.

Each improvement is assigned a numeric identifier that corresponds to the Priority Improvements and Replacements map (Figure 4, Appendix A). The primary purpose for the recommended improvements is also noted in the capital improvement tables, along with an opinion of probable cost.

The various improvements listed in the capital improvement plan may have all or a portion of the cost attributed to future growth because they are intended to benefit growth. Where this is the case, the incoming development or redevelopment is responsible for the growth portion of the cost through the application of system development charges. To assist in future system development charge evaluations, Keller Associates has estimated the portion of the improvement cost that could be attributed to growth. It should be noted that additional capital improvements to expand the treatment capacity of the Willamette River Water Treatment Plant are not included in Tables ES.3.

TABLE ES.3 – Priority Capital Improvements

ID#**	Item	Primary Purpose	Total Estimated Cost	Growth Apportionment %	Growth Apportionment Cost	Operating Fund	Additional Annual O&M
Priority 1A Improvements (by 2017)							
Water Supply							
106	Portable Flow Meter (for well tests)	Operations	$ 13,000	0%	$ -	$ 13,000	$ 1,360
Water Treatment and Transmission							
	Surge Tank	Operations	$ 170,000	100%	$ 170,000	$ -	$ 960
	Clearwell Improvements (assume policy change)	Operations	$ -	100%	$ -	$ -	
Water Storage							
121	C Level Reservoir Security and Sampling Improvements	Operations	$ 18,000	0%	$ -	$ 18,000	$ 640
123	Charbonneau Reservoir Chlorine Monitoring	Operations	$ 7,000	0%	$ -	$ 7,000	$ 960
124	Automated Valve at Tooze/Westfall (West Side Tank)	Operations	$ 58,000	100%	$ 58,000	$ -	$ 580
125	3.0 Million Gallon West Side Tank and 24-inch Transmission (in Pre-design)*	*Growth*	$ 5,840,000	100%	$ 5,840,000	$ -	$ 17,160
126	Elligsen West Tank - Add Altitude Valve	Operations	$ 31,000	100%	$ 31,000	$ -	$ 580
Booster Stations & Turnouts							
140	Charbonneau Booster PRV & SCADA	Operations	$ 22,000	20%	$ 4,400	$ 17,600	$ 920
Water Distribution Piping							
163	18-inch Loop on Barber St. (Montebello to Kinsman)	Growth	$ 371,000	100%	$ 371,000	$ -	$ 320
165	48-inch Transmission on Kinsman St. - Barber to Boeckman (in Design)*	*Growth*	$ 3,960,000	100%	$ 3,960,000	$ -	$ 3,000
	Total Priority 1A Improvements		**$ 10,490,000**		**$ 10,434,400**	**$ 55,600**	**$ 26,480**
Priority 1B Improvements (by 2022)							
Water Supply							
110	Nike Well Telemetry & Misc. Improvements	Operations	$ 35,000	32%	$ 11,300	$ 23,700	$ 420
111	Wiedeman Well Generator & Telemetry	Operations	$ 98,000	12%	$ 11,300	$ 86,700	$ 2,460
112	Boeckman Well Telemetry Upgrade	Operations	$ 26,000	43%	$ 11,300	$ 14,700	$ 420
113	Gesellschaft SCADA & Instrumentation	Operations	$ 32,500	35%	$ 11,300	$ 21,200	$ 420
114	Elligsen Well Instrumentation	Operations	$ 20,000	29%	$ 5,700	$ 14,300	$ 120
Booster Stations & Turnouts							
143	Charbonneau Booster Flow Meter Vault	Replacement/ Operations	$ 29,000	54%	$ 15,700	$ 13,300	$ 380
Water Distribution Piping							
160	8-inch Upgrade on Jackson St.	Fire Flow	$ 64,000	0%	$ -	$ 64,000	$ 100
161	8-inch Upgrade on Evergreen St.	Fire Flow	$ 83,000	0%	$ -	$ 83,000	$ 200
162	8-inch Loop N. of Seely St.	Fire Flow	$ 8,000	0%	$ -	$ 8,000	$ 100
164	10-inch Extension on Montebello St.	Growth (School)	$ 217,000	100%	$ 217,000	$ -	$ 400
166	8-inch Loop between Boberg St. & RR (north of Barber)	Fire Flow	$ 78,000	0%	$ -	$ 78,000	$ 200
167	8-inch Loop on Boones Ferry (north of Barber)	Operations	$ 19,000	0%	$ -	$ 19,000	$ 100
168	10-inch Loop (Appts E. of Canyon Creek/Burns)	Fire Flow	$ 41,000	0%	$ -	$ 41,000	$ 100
169	8-inch Loop between Vlahos & Canyon Creek	Fire Flow	$ 42,000	0%	$ -	$ 42,000	$ 100
170	8-inch Upgrade on Metolius cul-de-sac	Fire Flow	$ 54,000	0%	$ -	$ 54,000	$ 100
171	8-inch Loop on Metolius private drive	Operations	$ 20,000	0%	$ -	$ 20,000	$ 100
172	8-inch Upgrade on Middle Greens	Hydrant Coverage	$ 68,000	0%	$ -	$ 68,000	$ 200
173	Fairway Village Hydrant on French Prairie	Hydrant Coverage	$ 10,000	0%	$ -	$ 10,000	$ 100
175	16-inch Willamette River Crossing to Charbonneau District	Displace Charb. Tank	$ 1,532,000	0%	$ -	$ 1,532,000	$ 3,600
	Total Priority 1B Improvements		**$ 2,476,500**		**$ 283,600**	**$ 2,192,900**	**$ 9,620**

* Needed projects previously identified in 2002 Water Master Plan, but not yet completed

** Colored/Bold ID #s are mapped on Figure 4 in Appendix A for reference

NOTE: Costs are in 2012 dollars

TABLE ES.3 – Priority Capital Improvements (Continued)

ID#**	Item	Primary Purpose	Total Estimated Cost	Growth Apportionment		Operating Fund	Additional Annual O&M
				%	Cost		
Priority 2 Improvements (by 2030)							
Water Supply							
203	Gesellschaft Well Generator	Operations	$ 78,000	0%	$ -	$ 78,000	$ 2,160
205	Charbonneau Well Mechanical Building	Operations	$ 81,000	0%	$ -	$ 81,000	$ 1,800
	Video Surveillance (various wells)	Operations	$ 22,000	0%	$ -	$ 22,000	$ 3,000
Booster Stations & Turnouts							
241	Meter Valve at Wilsonville Rd turnout	Operations	$ 118,000	0%	$ -	$ 118,000	$ 980
Water Distribution Piping							
260	10-inch Extension on 4th St. (E. of Fir)	Fire Flow	$ 69,000	7%	$ 4,900	$ 64,100	$ 200
261	8-inch Loop - Magnolia to Tauchman	Fire Flow	$ 59,000	0%	$ -	$ 59,000	$ 100
262	8-inch Upsize on Olympic cul-de-sac	Fire Flow	$ 44,000	0%	$ -	$ 44,000	$ 100
263	8-inch Loop near Kinsman/Wilsonville	Fire Flow	$ 36,000	0%	$ -	$ 36,000	$ 100
264	10-inch Loop near Kinsman/Gaylord	Fire Flow	$ 82,000	6%	$ 5,200	$ 76,800	$ 200
265	8-inch Upsize on Lancelot	Fire Flow	$ 100,000	0%	$ -	$ 100,000	$ 200
266	Fire Hydrants (main City)	Fire Flow	$ 119,000	0%	$ -	$ 119,000	$ 200
267	Fire Hydrants (Charbonneau)	Fire Flow	$ 46,000	0%	$ -	$ 46,000	$ 100
268	8-inch Loop near Kinsman (between Barber & Boeckman)	Fire Flow	$ 126,000	0%	$ -	$ 126,000	$ 200
269	8-inch Upsize near St. Helens	Fire Flow	$ 26,000	0%	$ -	$ 26,000	$ 100
270	8-inch Loop near Parkway Center/Burns	Fire Flow	$ 66,000	0%	$ -	$ 66,000	$ 100
271	8-inch Loop near Burns/Canyon Creek	Fire Flow	$ 110,000	0%	$ -	$ 110,000	$ 200
272	10 & 8-inch Loop near Parkway/Boeckman	Fire Flow	$ 315,000	4%	$ 12,600	$ 302,400	$ 500
273	12-inch Loop crossing Boeckman	Water Quality	$ 16,000	0%	$ -	$ 16,000	$ 100
274	8-inch Loop at Holly/Parkway	Water Quality	$ 56,000	0%	$ -	$ 56,000	$ 100
275	8-inch Upsize on Wallowa	Fire Flow	$ 62,000	0%	$ -	$ 62,000	$ 100
276	8-inch Upsize on Miami	Fire Flow	$ 68,000	0%	$ -	$ 68,000	$ 200
277	8-inch Extension for hydrant coverage on Lake Bluff	Hydrant Coverage	$ 63,000	0%	$ -	$ 63,000	$ 100
278	8-inch Upsize on Arbor Glen	Hydrant Coverage	$ 92,000	0%	$ -	$ 92,000	$ 200
279	8-inch Loop at Fairway Village	Fire Flow	$ 42,000	0%	$ -	$ 42,000	$ 100
280	8-inch Extension for fire flow - private drive/Boones Bend	Fire Flow	$ 18,000	0%	$ -	$ 18,000	$ 100
281	8-inch Upsize on East Lake	Fire Flow/Hydrant	$ 187,000	0%	$ -	$ 187,000	$ 300
282	8-inch Extension for fire flow on Armitage Pl	Fire Flow	$ 55,000	0%	$ -	$ 55,000	$ 100
283	8-inch Upsize on Lake Point Ct	Hydrant Coverage	$ 56,000	0%	$ -	$ 56,000	$ 100
284	8-inch Loop - Franklin St to Carriage Estates	Water Quality	$ 94,000	0%	$ -	$ 94,000	$ 200
285	8-inch Upgrade on Boones Ferry Rd (south of 2nd St)	Replace/Upsize	$ 44,000	0%	$ -	$ 44,000	$ 100
286	Valves at Commerce Circle & Ridder Rd/Boones Ferry I-5 Crossing	Operations	$ 44,000	0%	$ -	$ 44,000	$ 100
	Total Priority 2 Improvements		**$ 2,394,000**		**$ 22,700**	**$ 2,371,300**	**$ 12,140**
Priority 3 Development Dependent Improvements (by Build-out)							
Water Distribution Piping							
361	Zone D Booster Station at C Level Tank	Growth	$ 609,000	100%	$ 609,000	$ -	$ 11,000
362	Upsize costs (greater than 8 inches) for future distribution piping	Growth	$ 9,659,000	100%	$ 9,659,000	$ -	$ 39,120
	Total Priority 3 Improvements		**$ 10,268,000**		**$ 10,268,000**	**$ -**	**$ 50,120**
TOTAL CAPITAL IMPROVEMENTS (Priority 1-3)			**$ 25,628,500**		**$21,008,700**	**$ 4,619,800**	**$ 98,360**

* Needed projects previously identified in 2002 Water Master Plan, but not yet completed.

** Colored/Bold ID #s are mapped on Figure 4 in Appendix A for reference

NOTE: Costs are in 2012 dollars

ES.3.2 Comprehensive Plan Goals, Policies, and Implementation Measures

The City's Comprehensive Plan provides the context within which the water master plan has been developed. Efforts have been made to solicit citizen input and coordinate with other agencies and organizations consistent with Comprehensive Plan Goal 1.2. The primary goal of the water master plan is derived from Wilsonville's Comprehensive Plan Goal 3.1 providing for infrastructure in general and is as follows:

> To assure that good quality public facilities and services are available with adequate capacity to meet community needs, while also assuring that growth does not exceed the community's commitment to provide adequate facilities and services.

(Note: On adoption, City Council modified Goal 3.1 as follows: To assure that good quality public facilities and services are available with adequate but not excessive capacity to meet community needs, while also assuring that growth does not exceed the community's commitment to provide adequate facilities and services.)

The majority of the water related policies are highlighted in Comprehensive Plan Policy 3.1.5 which states:

> The City shall continue to develop, operate and maintain a water system, including wells, pumps, reservoirs, transmission mains and a surface water treatment plant capable of serving all urban development within the incorporated City limits, in conformance with federal, state, and regional water quality standards. The City shall also continue to maintain the lines of the distribution system once they have been installed and accepted by the City.

Keller Associates recommends the existing Implementation Measure 3.1.5.b be revised as follows (additions underlined):

> All major lines shall be extended in conformance to the line sizes indicated on the Master Plan and, at a minimum, provisions for future system looping shall be made. If the type, scale, and/or location of a proposed development negatively impacts operating pressures or available fire flows to other properties as determined by the City Engineer, the Development Review Board may require completion of looped water lines, off-site facilities, pipelines, and/or facility/pipelines to achieve or maintain minimum pressures or fire flows as a condition of development approval. (Adopted)

Keller Associates also recommends the following additional policies for consideration. Refer to Chapter 7 for recommended implementation measures associated with these policies.

Proposed Policy 3.1.6: The City of Wilsonville shall continue a comprehensive water conservation program to make effective use of the water infrastructure, source water supply and treatment processes. (Adopted)

Proposed Policy 3.1.7: The City of Wilsonville shall maintain an accurate user demand profile to account for actual and anticipated demand conditions in order to assure an adequately sized water system. (Adopted)

Proposed Policy 3.1.8: The City of Wilsonville shall coordinate distribution system improvements with other CIP projects, such as roads, wastewater, and storm water, to save construction costs and minimize public impacts during construction. (Adopted)

ES.3.3 Operations and Maintenance Recommendations

In addition to the capital improvement projects identified in the preceding tables, Keller Associate identified several major repairs and replacements which are summarized in Table ES.4 (see also Figure 4, Appendix A). Additionally, there are several larger routine maintenance activities, recurring system management related projects, and ongoing replacement/rehabilitation activities that are recommended on an annual or recurring basis. These activities are summarized in Table ES.5.

When it comes to maintenance, repair, and replacement activities, the key recommendation is to establish an adequate budget consistent with the selected replacement life span of the facilities. Keller Associates recommends that future user rate evaluations consider needed capital improvements as well as the budget increases needed to fund a 20-year maintenance and replacement program.

TABLE ES.4 – Major Repairs and Replacements

ID#*	Item	Primary Purpose	Total Estimated Cost
Priority 1A (by 2017)			
Water Supply			
100	Nike Well Rehab & Misc. Maintenance	Maintenance	$ 30,000
101	Canyon Creek Well (assumes potential abandonment)	Maintenance	$ 26,000
102	Wiedeman Well Misc. Maintenance	Maintenance	$ 24,000
103	Boeckman Well Rehab Pump	Maintenance	$ 20,000
104	Gesellschaft Building Maintenance	Maintenance	$ 4,500
105	Elligsen Well Compressor & Controls	Maintenance	$ 8,000
Water Storage			
120	Elligsen Res. - Replace Ladder Fall Protection System	Replacement	$ 12,000
123	Charbonneau Reservoir Reseal between Roof and Wall	Maintenance	$ 4,000
Booster Stations & Turnouts			
141	B to C Booster Replacements	Replacement	$ 21,000
142	Painting & Safety Nets at Turnouts	Maintenance	$ 22,000
Priority 1B (by 2022)			
Water Storage			
127	Replace Sealant at Base of C Level Reservoir	Maintenance	$ 7,000
Booster Stations & Turnouts			
144	Replace Cover on Burns PRV	Replacement	$ 9,000
Priority 2 (by 2030)			
Water Supply			
200	Nike Well New Roof and Trim, Paint	Maintenance	$ 13,000
201	Wiedeman Well Replace Metal Siding	Maintenance	$ 20,000
202	Boeckman Well Pump Motor & Replace Roof and Trim	Replacement/ Maintenance	$ 21,000
203	Gesellschaft Well Roof Maintenance	Maintenance	$ 4,000
204	Elligsen Well MCC Replacement & Building Maintenance	Replacement/ Maintenance	$ 22,000
Water Distribution Piping			
287	Replace service lines - Parkway Ave	Replacement	$ 77,000
288	Replace service lines - Wilson cul-de-sacs	Replacement	$ 227,000
289	Replace service lines - Mariners Drive	Replacement	$ 22,000
290	Replace service lines - Old Town	Replacement	$ 15,000
Water Storage			
220	Paint Elligsen Reservoirs (interior)	Maintenance	$ 460,000
221	Paint C Level Reservoir (interior)	Maintenance	$ 180,000
Booster Stations & Turnouts			
240	Relocate Parkway PRV out of Elligsen Rd intersection	Replacement	$ 75,000
Future (beyond 2030)			
Water Supply			
300	Nike Well - Replace MCC	Replacement	$ 15,000
301	Wiedeman Well MCC & Building Maintenance	Maintenance	$ 18,000
302	Gesellschaft Well Building Maintenance	Maintenance	$ 5,000
Water Storage			
320	Paint Elligsen Reservoirs (exterior)	Maintenance	$ 310,000
321	Paint C Level Reservoir (exterior)	Maintenance	$ 115,000
	TOTAL MAJOR REPAIRS AND REPLACEMENTS		**$ 1,786,500**

* Colored/Bold ID #s are mapped on Figure 4 in Appendix A for reference

NOTE: Costs are in 2012 dollars

TABLE ES.5 – Recurring Maintenance Costs

Activity	Budget	Frequency
Wash exterior of above-ground tanks	$5,000/each	Every 5 years
Clean and inspect interior of tanks	$5,000/each	Every 10 years
Pipeline and valve replacement (coordinate with planned street improvements, 1725 feet/year)	$ 173,000	Annual recommended budget for 20-year planning period
Meter replacement (250 meters/year)	$ 50,000	Annual recommended budget (assumes 20-year life)
Hydrant replacement (10 hydrants/year)	$ 30,000	Annual recommended budget
Well hole and facility upgrades/maintenance	$95,000-$105,000	Annual budget (includes 6 wells)
GIS and water model updates	$ 6,000	Recommended annual budget for 3rd party support
Water Master Plan update	$ 150,000	Every 5 years
Water Management and Conservation Plan (WMCP)	$ 20,000	Every 10 years, beginning 2022
WMCP progress reports	$ 5,000	Every 10 years, beginning 2017

ES.3.4 User Rates and System Development Charges

The scope of this study did not include an evaluation of user rates and system development charges (SDC). The City intends to complete a separate rate study at a later date to address the impacts of the Water Master Plan on the utility rates. The rate study should also incorporate findings from the upcoming water treatment plant master plan. It is anticipated that the Capital Improvement Plan, the identified Major Repairs and Replacements, and the recommended operational and maintenance activities will be used in establishing these fees. Additionally, the estimated percent of each improvement attributed to growth will be useful in developing the growth component of the SDC.

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1.0 EXISTING SYSTEM DESCRIPTION

This chapter provides an introduction to the water system master planning effort and describes Wilsonville's existing water system infrastructure.

1.1 INTRODUCTION

The City of Wilsonville authorized Keller Associates, Inc. to complete a Water System Master Plan in February 2011. The previous master plan was completed in 2002 by Montgomery Watson Harza. Over the course of the last decade, many changes have occurred to the water system, including the completion of a state-of-the-art surface water treatment plant that has displaced the City's groundwater wells as the primary water supply. The primary purposes of this planning effort include the following:

- Update water system demands and demand projections for an expanded study area, including water sales to the City of Sherwood.
- Update the planning criteria used to evaluate system performance and prioritize improvements.
- Update the existing water distribution system hydraulic computer model.
- Evaluate the current condition of the City's water system assets.
- Identify existing and anticipated future deficiencies.
- Update the City's capital improvement plan as it pertains to the water distribution system (pipelines, wells, booster stations, and tanks).
- Provide a review of existing water treatment facilities and identify potential bottlenecks that would need to be addressed to reach a 15 mgd treatment capacity.

Complementing this master plan and performed as a separate task is a Water Management and Conservation Plan that will replace the previous plan completed in 2004.

1.2 EXISTING SYSTEM OVERVIEW

The City of Wilsonville's primary supply comes from the Willamette River. The Willamette River Water Treatment Plant (WRWTP) is a state-of-the-art treatment plant. It produces high-quality finished water that is pumped into 63-inch and 48-inch transmission pipelines. From the transmission pipeline, water is conveyed to the City's distribution through three delivery points, referred to as "turnouts." The transmission pipeline also extends to a delivery point near Tooze Road and Westfall to provide transmission to the City of Sherwood.

Figure 1 (Appendix A) illustrates the existing water distribution system. The City's service area is made up of three pressure service areas or pressure zones. From the turnouts, water flows to pressure zone B, the main pressure zone that services most of the City. The Elligsen reservoirs directly serve this zone. Water is pumped from pressure zone B to zone C (and the C Level reservoir) via the B to C Booster Station. Water to the Charbonneau District (pressure zone A) is delivered across the river in pipeline attached to I-5 Bridge and through pressure reducing valves located inside the Charbonneau booster station. Backup wells, the Charbonneau tank, and the Charbonneau booster station provide system redundancy and emergency water supply to the Charbonneau District.

1.2.1 Water Treatment Plant

The Willamette River Water Treatment Plant (WRWTP) was commissioned to provide a reliable long-term water supply to Wilsonville and the surrounding area. The new treatment facility has allowed the City to continue to grow and has eliminated concerns of declining aquifer levels that resulted from excessive pumping of the City's groundwater wells. The facility was completed in 2002 and has been providing high quality water to the City since it was completed.

Ownership of the water treatment plant is shared with the Tualatin Valley Water District (TVWD). Unit treatment process and facilities initially constructed at the existing treatment plant are generally rated for 15 mgd, with portions of the site such as the buildings and intake structure capable of handling 70+ mgd. The July 2000 Agreement between Wilsonville and TVWD (Wilsonville Resolution No. 1661) specifies that of the first phase plant capacity of 15 mgd, Wilsonville owns 10 mgd and TVWD 5 mgd.

A preliminary evaluation of the treatment plant process capacities is provided in Chapter 4 of this report. The City of Wilsonville, in partnership with the TVWD, will need to complete a more comprehensive treatment facility master plan update within the next few years.

1.2.2 Transmission Pipelines

Wilsonville conveys water from the WRWTP to the distribution system through a 4,000-foot long, 63-inch steel transmission. At Wilsonville Road, the 63-inch transmission line wyes to two 48-inch transmission lines. Each of the 48-inch steel lines has a design capacity of 40 mgd (5 fps design velocity). Currently only one of these 48-inch transmission lines is installed. The final connecting section of this transmission line is currently under design. When completed, this line will carry supply northwest to Sherwood and other turn-outs to the Wilsonville distribution system.

1.2.3 Water Distribution System Piping, Valves, Hydrants, and Meters

The City has approximately 107 miles of waterlines ranging from 2 inches to 63 inches in diameter. According to GIS records, the City also has over 3341 valves, 1005 hydrants, over 5000 meters, and 262 blow-offs. Table 1.1 summarizes the variations in pipe materials and sizes for the distribution system.

Most of the pipe materials are ductile iron or cast iron. Because of the large amount of new growth that has occurred since 1980, the majority of the City's infrastructure is also relatively new. An evaluation of the existing distribution system conditions along with recommended replacement budgets can be found in Technical Memorandum No. 1 located in Appendix B. Chapter 3 summarizes existing pipeline capacity and fire hydrant coverage deficiencies.

TABLE 1.1 – Wilsonville Pipe Material Summary

Pipe Diameter (in)	Pipe Material Lengths Per GIS(ft)							Total by Diameter (ft)	% of Total
	Steel	CU	Ductile Iron	CI	Conc	PVC	Unknown		
Unknown	0	0	3,680	191	0	0	5,332	9,203	1.54%
2"	328	135	415	1,095	0	0	211	2,184	0.37%
2.5"	0	0	546	0	0	0	0	546	0.09%
3"	0	0	5	0	0	0	0	5	0.00%
4"	38	0	16,312	5,233	10	72	74	21,739	3.65%
6"	0	25	67,930	8,213	0	901	5,721	82,790	13.89%
8"	0	0	209,556	8,584	0	1,326	12,999	232,465	38.99%
10"	0	0	27,219	11,848	0	0	808	39,875	6.69%
12"	0	0	93,041	6,620	234	0	828	100,723	16.89%
14"	1,039	0	23,008	2,032	0	0	0	26,079	4.37%
16"	0	0	5,112	0	0	0	0	5,112	0.86%
18"	0	0	32,466	25	0	0	218	32,709	5.49%
24"	0	0	619	0	0	0	1,555	2,174	0.36%
48"	7,053	0	0	0	0	0	0	7,053	1.18%
63"	4,338	0	0	0	0	0	0	4,338	0.73%
Total by Material (ft)	*12,796*	*160*	*479,909*	*43,842*	*244*	*2,299*	*27,746*	*566,995*	*100.0%*
% of Total	*2.15%*	*0.03%*	*80.50%*	*7.35%*	*0.04%*	*0.39%*	*4.65%*	*107.4*	*MILES*

1.2.4 Water Storage

There are four existing storage reservoirs located in the distribution system. These include the two above-ground welded steel Elligsen Reservoirs (constructed in 1970 and 1992) that service the main pressure zone (Zone B), the buried concrete Charbonneau Reservoir (constructed in 1978) that services Zone A, and the above-ground welded steel C Level Reservoir (constructed in 1999) that services the upper pressure zone. Combined, these reservoirs provide approximately 7.6 million gallons of effective storage. A detailed evaluation of the existing reservoir conditions and storage capacities along with recommended improvements can be found in Technical Memorandum No. 1 and Technical Memorandum No. 3 located in Appendix B. A summary of these evaluations and recommendations can be found in Chapter 3.

1.2.5 Backup Wells

The City currently maintains eight groundwater wells. These wells were once the primary potable supply, but since the completion of the WRWTP these wells serve as an emergency backup water supply. These wells include Nike, Canyon Creek, Wiedeman, Boeckman, Geshellschaft, Elligsen, and two additional wells located within the Charbonneau District (Charbonneau wells #2 and #3). Technical Memorandum No. 5, Attachment 1 in Appendix B shows the location of all the well facilities. A detailed evaluation of these wells can be found in Technical Memorandum No. 5 located in Appendix B, and a summary of the findings is presented in Chapter 3 of this report.

1.3 SUMMARY OF PREVIOUS PLANNING EFFORTS

In preparing this master plan update, Keller Associates has built upon previous planning efforts completed by others. A list of documents evaluated as part of this study includes the following:

- City of Wilsonville Well Site Review Report (GSI, 2004)
- Transportation System Plan (Entranco, 2009)
- Transit Master Plan (SMART Transit, 2008)
- Water System Master Plan (MWH, 2002)
- Water Management and Conservation Plan (Wilsonville, 1998 and 2004)
- Waterline Leak Detection Reports (Utility Services Associates, 2000-2010)
- Comprehensive Plan (Wilsonville, 2010 and 2011)
- 20-Year Look (Wilsonville, 2008)
- Water System Surveys (ODHS, 2008 and 2012)
- Planning documents for various developments, including Basalt Creek, Coffee Creek, Brenchley Estates, Graham Oaks, West Side, and Villebois
- Technical Memorandum, Hydraulic Analysis (MWH, Feb 22, 2011)
- Technical Memorandum, Hydraulic Transient (MWH, April 6, 2011)
- Technical Memorandum, Willamette River WTP Disinfection (CT) Analysis (WMH, April 7, 2011)
- Willamette River Water Treatment Plant Master Plan (MWH, 2006)
- Willamette River Water Supply System, Preliminary Engineering Report (MSA, 1998)
- Operations and Maintenance Manuals and record drawings for the water treatment plant and distribution system facilities
- Elligsen, Charbonneau, and C Level Reservoir Inspection Reports (LiquiVision, 2009)
- Elligsen Seismic Evaluation (KPFF, 1998)
- Parks Master Plan (MIG, 2007)

- Development Code (Wilsonville, 2010 and 2011)
- Sherwood Water System Master Plan (MSA, 2005)
- Bicycle and Pedestrian Master Plan (Atla, 2006)
- Economic Opportunity Analsyis Report (Cogen Owens Cogan, Otak, FCS Group, 2008)
- Infrared Electrical Inspection (PMT, 2011)
- Charbonneau Tank Seismic Study (Keller Associates, 2012)

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2.0 DEMAND FORECASTS

This chapter evaluates the existing and future water system demands for residential and nonresidential uses. Water loss and irrigation demands are also summarized.

2.1 METHODOLOGY

Demand forecasts were developed using a combination of current water demands for existing residential and nonresidential users, population and household data, employment and commercial/industrial acreage, anticipated residential and nonresidential growth rates within the defined study area, and estimated per capita demand rates for different user groups.

A review of different methodologies and available data was conducted to determine the best approach to estimate existing and future demands. The data revealed that the 2002 Water Master Plan overestimated a peak day demand for 2010 at more than twice the actual (measured) peak day demand. These previous estimates were made prior to the completion of the water treatment plant and without the benefit of several years of operational data. Keller Associates worked closely with City staff to review actual operational data and develop future demand estimates that reflect historical demand growth but still provide a modest amount of conservatism. In determining existing and future demands, the following methodology was used:

1. Historical system demands for 2005-2009 were used to define the existing average day and peak day water usage for the system.
2. Recent SCADA data was reviewed to develop a 24-hour demand pattern for summer and winter periods. This information was used to estimate the peak hour demand.
3. Where possible, the water meter data were spatially allocated to the distribution system using the City's billing data and geographic information system (GIS). Approximately 85% of current demand could be linked to specific locations. The remaining 15% was distributed to developed parcels based on existing land use and acreage.
4. Existing demands per household and estimated residential units per gross acre were used to project future residential demands.
5. Existing per acre demands for commercial/industrial areas were used to project future nonresidential demands.

2.2 EXISTING DATA REVIEW AND ANALYSIS

Study area acreage, land use (zoning), population, and water usage data were analyzed to determine existing conditions and establish the methodology for generating demand forecasts. This section summarizes the data, analysis, and background associated with the water demand forecast methodology.

2.2.1 Study Area and Land Use

The study area was developed with input from City planning staff, and is illustrated in Figure 2 (Appendix A). The study area is consistent with the WV Comprehensive Plan and includes the area within the existing Urban Growth Boundary (UGB) and those portions of Clackamas County and Washington County Urban Reserve Areas (URAs) that are anticipated to be incorporated into Wilsonville. These urban reserve areas include Area 6 and Area 7 identified in the 20-Year Look prepared in 2008. The study area is also intended to coincide with the ongoing Transportation System Plan update.

Existing land use is illustrated in Figure 2-2. For those areas not yet developed, anticipated future land use was provided by City planning staff and is illustrated in Figure 2-3. (All figures referenced in this report can be found in Appendix A.)

2.2.2 Population and Household Data

Three sources of historical population data were reviewed as part of this study. These include US Census Bureau data, Portland State University (PSU) certified population estimates, and estimates developed from City of Wilsonville building permit information. The census data is believed to be the most accurate source of population data, but is only available for 10-year increments. PSU provides certified population estimates annually. However, the original PSU estimate for 2010 was 7.5% lower than the year 2010 census estimate. In 2011, after publication of the 2010 census data, PSU revised their 2010 population estimate to be in line with the 2010 census. The discrepancy between the original and revised estimates could be explained in part by the number of people per household assumed in the population estimates and the inclusion or exclusion of unoccupied units. According to census data, the number of people per household actually increased from 2.35 people per *occupied* household in 2000 to 2.48 people per *occupied* household in 2010, contrary to general planning assumptions which predict declining numbers of people per household.

Table 2.1 summarizes historical growth rates and the corresponding compounded 10-year average annual growth rates for 1980 - 2010. Even with the recession conditions that started in 2008, the City of Wilsonville averaged an approximate 3.4% annual population growth rate from 2000 to 2010.

Table 2.2 summarizes the growth data in terms of households for both Federal census data and for Wilsonville Planning Department data.

TABLE 2.1 – Historical Population Summary

Year	Census		PSU Certified Estimates[1]		Wilsonville Planning Department[2]	
	Population	Growth Rate[3]	Population	Growth Rate	Population	Growth Rate
1980	2,950					
1990	7,106	9.2%	7,225		9,030	
2000	13,991	7.0%	14,365	7.1%	14,772	5.0%
2010	19,509	3.4%	19,525[4]	3.1%	18,020	2.0%

1. PSU certified estimates reflect estimated July populations, whereas census data reflects April population.
2. Estimates from building data and an estimated population of 2.15 people per household.
3. Growth rates are calculated average annual growth rates.
4. Adjusted by PSU in 2011. Original estimate (before census) was 18,095.

TABLE 2.2 – Historical Household Summary

Year	Census[1]	Wilsonville Planning Department[3]		
		SFDU[2]	Multi-Family	Total
1990	3,327	2,172	2,028	4,200
2000	6,407	3,316	3,555	6,871
2010	8,487	3,745	4,846	8,591
2000-2010 Annual Growth	2.9%	1.2%	3.7%	2.3%

1. Total housing units includes occupied and vacant housing units.
2. SFDU = single family dwelling unit.
3. Multi-family includes apartments, condominiums, and duplexes. Mobile home units are included in SFDU.

In projecting future residential growth and associated water demand, historical populations were reviewed along with population projections developed as part of the 2002 Water Master Plan, 2004 Water Management and Conservation Plan, the 2006 Transit Master Plan, the 2007 Parks Master Plan, the 2008 20-Year Look, and the 2009 Transportation Plan. These previous estimates assumed annual residential growth rates between 2.42% and 3.15%. Four of the documents use approximately 2.9% as the annual growth rate.

According to the census data, the number of households increased from 6,407 to 8,487 between 2000 and 2010. This corresponds to an average annual growth rate of approximately 2.9% for households. This lower growth rate in households reflects the change in household density (2.34 and 2.48 people per household reported in 2000 and 2010, respectively). Both the 2000 and 2010 household densities based on census data were higher than the 2.15 people per household used by Wilsonville Planning Department. It should also be noted that the estimated vacancy rate from the census data remained relatively consistent at 7.3% and 7.4% reported in 2000 and 2010, respectively.

Since the demands per household are based on actual meter readings, they are felt to be a better basis for future demands than the demand per capita (i.e. person). Assumed household densities were therefore not considered to influence future demand projections. For planning purposes for this study, City staff indicated that **a 2.9% annual residential growth rate should be used for both population and the number of households, corresponding to a 2.9% annual growth rate in residential water demand**. This assumption implies that the household density will continue to be approximately 2.48 people per household.

The build-out population for the study area was calculated to be about 52,400 (21,129 households) using anticipated land use, estimated dwelling units per gross acre, and estimated people per household. Based on these assumptions and the projected growth rate, build-out of the residential areas could occur by the year 2045.

In distributing the new growth in households, Keller Associates used planned dwelling units for those developments that have already completed preliminary or final planning efforts. These include Villebois (approximately 1630 undeveloped units as of December 2009), Frog Pond (estimated 1000 dwelling units from 20-Year Look), and Brenchley Estates (estimated 763 dwelling units). For those future residential areas that currently do not have dwelling unit estimates, the following assumptions were made:

- Undeveloped property zoned for single family dwelling units will average 7 units per gross acre.
- Undeveloped property zoned for multi-family dwelling units will average 20 units per gross acre.
- Where land use does not differentiate between single family and multi-family, it is assumed that 50% of the area will be multi-family and 50% will be single family residential. This produces a composite average of 13.5 units per gross acre.

These assumptions are consistent with historical data and the expectations of City planning staff.

2.2.3 Nonresidential Growth

In the 2002 Water Master Plan, nonresidential use was assumed to have an annual growth rate that varied from 15% for the first 5 years, followed by 7.5% for the next 10 years, then 1% for the final 5 years. However, the actual growth rate from 2000 to 2010 (in terms of the number of water accounts) has been approximately 1.8%, which is lower than the residential growth rate. Additionally, the total nonresidential water usage in Wilsonville has steadily declined over the last five years, despite an increasing number of accounts. While there are significant differences in the number of existing employees reported, the Comprehensive Plan (2010), the previous Transportation System Plan (2009), the Economic Opportunity Analysis (2008), and the 20-Year Look (2008) all show the number of employees essentially doubling over a 20-year period. A doubling in employees equates to an average annual employment growth rate of about 3.5%, which is slightly higher than the anticipated residential population growth rates assumed in the respective planning documents.

Previous water demand planning efforts looked at water usage per employee and utilized the traffic analysis zone (TAZ) and employment growth concepts developed by Metro in transportation planning efforts as the basis for predicting and distributing existing and future nonresidential water demands. By linking individual meter demands to parcels, Keller Associates was able to utilize land use data and quantify current nonresidential demands per developed acre. This allowed us to quantify per acre demands for Wilsonville land uses – something that the City has not been able to do in the past. Furthermore, these per acre demands include irrigation usage, which is often independent of the number of employees. For these reasons, the calculated per acre demands were felt to be more representative of actual baseline conditions than a corresponding demand per employee. Metro estimates of employee growth were therefore not used, and a per acre demand basis was assumed for future nonresidential development.

For this planning study, an annual **average annual growth rate of 3.5%** will be applied to nonresidential development. Based on the anticipated growth rate, build-out of the nonresidential areas could occur by year 2036. This growth in demand could occur from development of land or from existing developed land. Because of the preponderance of warehouse-type facilities, existing demands per acre are comparatively low to typical published values for industrial areas. In evaluating build-out demands for industrial properties, Keller Associates assumed that existing per acre demands would increase by 25 percent for build-out conditions in all industrially-zoned areas. This was done to allow for increased (e.g. higher density) use and/or redevelopment of existing commercial/industrial parcels, and to better account for a potential reversal of some of the recessionary declines in water usage experienced since 2006. The estimated demands per industrial and commercial acre are presented in section 2.4.2 of this report.

Supplementing assumed nonresidential demand, the City also identified a few site-specific water demand forecasts. Specifically, an increase in the Coffee Creek Correction Facility prison population of 650 inmates was assumed (from the current count 1,500 inmates to a future count 2,150 inmates), as were three future large water users (two 0.25 mgd users and one 0.5 mgd user), plus three future public schools.

2.2.4 Water Production Data and Existing Demand Summary

Daily production data was reviewed for the period from 2005 to 2010 to establish annual average, seasonal, and maximum day demand patterns. This data is summarized in Table 2.3. The annual average flow remained relatively constant from 2006-2009 despite an increasing number of water users. Maximum day water demands also peaked in 2008 at 6.6 mgd. All demands (average, peak, etc.) in 2010 were below the previous 5 years, primarily due to current economic conditions. Therefore, 2010 was not considered to be representative of normal usage conditions, and the 2005-2009 average was used to represent current (2010) baseline conditions.

TABLE 2.3 – Finished Water Production Summary

	2005	2006	2007	2008	2009	2010	5-Year Avg. (2005-2009)
Yearly Average, mgd	2.81	3.10	3.16	3.13	3.07	2.82	3.05
Minimum Month, mgd	1.85	1.92	2.24	2.12	2.10	2.06	2.05
Maximum Month, mgd	5.22	5.38	5.29	5.48	5.27	5.18	5.33
Maximum Day, mgd	6.08	6.34	6.51	6.60	6.45	5.87	6.40
Peak Hour, mgd	10.34	10.78	11.07	11.22	10.96	9.97	10.87

For comparison purposes, Table 2.4 shows the water production data on a per capita basis. Existing baseline system demands are summarized in Table 2.5 and were calculated by multiplying the 2010 population by the 2005-2009 average per capita demand.

TABLE 2.4 – Finished Water Production Summary (gpcd)*

	2005	2006	2007	2008	2009	2010	5-Year Avg. (2005-2009)
Population**	17,753	18,156	18,715	19,290	19,376	19,525	18,658
Yearly Average	158	171	169	162	158	145	164
Minimum Month	104	106	120	110	108	106	110
Maximum Month	294	297	282	284	272	266	286
Maximum Day	343	349	348	342	333	300	343
Peak Hour	582	594	591	582	566	511	583

* gallons per capita per day.

** Certified PSU population for 2005-2009 were adjusted upward approximately 7.5% to reflect the difference between the original 2010 PSU certified estimate (previous to adjusting to reflect 2010 Census data) and the 2010 Census data.

TABLE 2.5 – 2010 Baseline System Demands

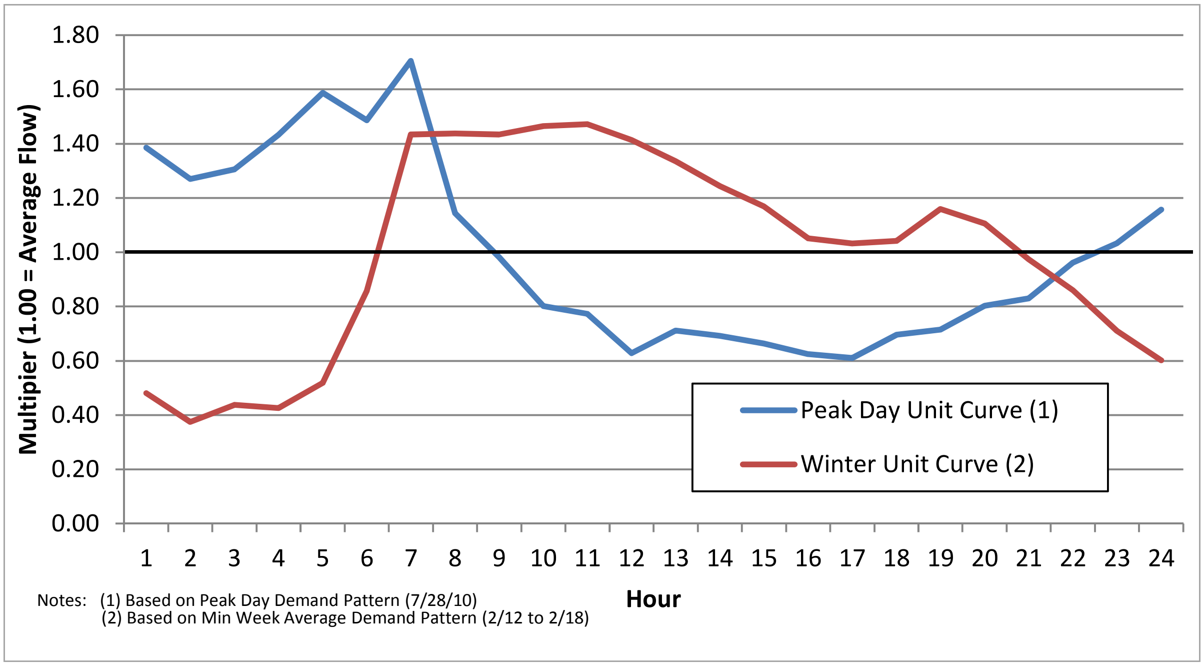
	Per Capita Demand* (gpcd)	System Demand (mgd)
Yearly Average	164	3.20
Minimum Month	110	2.15
Maximum Month	286	5.58
Maximum Day	343	6.70
Peak Hour	583	11.4

*Per capita demands are shown for reference and include nonresidential uses.

2.2.5 SCADA Data and Existing Peak Hour Demands

Peak hour demands were estimated based on demand patterns developed from 24-hour supervisory control and data acquisition (SCADA) data provided by the City. Chart 2.1 illustrates the water usage patterns for the system during the winter and summer periods. For the summer period, the high water usage during the night-time and early morning hours reflect irrigation usage within the city. A peak hour demand equivalent to approximately 1.7 times the corresponding average daily flow is anticipated around 7:00 a.m. during the summer months.

CHART 2.1 – Water Usage Pattern



2.2.6 Water Meter Data and Water Usage per User Category

Water consumption data for various categories of residential and nonresidential users were reviewed, summarized, and evaluated. This data is required reporting data for municipal water management and conservation plans submitted to the Oregon Department of Water Resources, and is used internally to look at major water use trends. Chart 2.2 shows the annual water usage for each user category. The decline in total water system consumption can largely be attributed to significant declines in commercial and industrial water usage, which peaked in 2006 and has declined by 30% since then. The total residential demand has held relatively steady between 2005 and 2010, despite the increasing number of residential users. This is believed to be a result of a combination of factors, including individual water conservation measures, higher water rates, low water use fixtures (low flush toilets, high efficient washers, etc.), and enhanced water awareness.

CHART 2.2 – Annual Water Usage by User Category

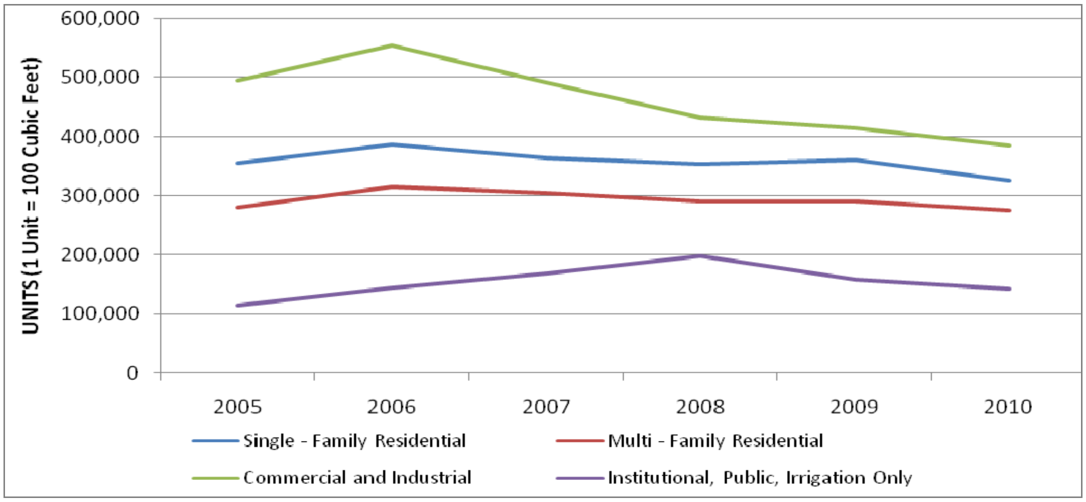
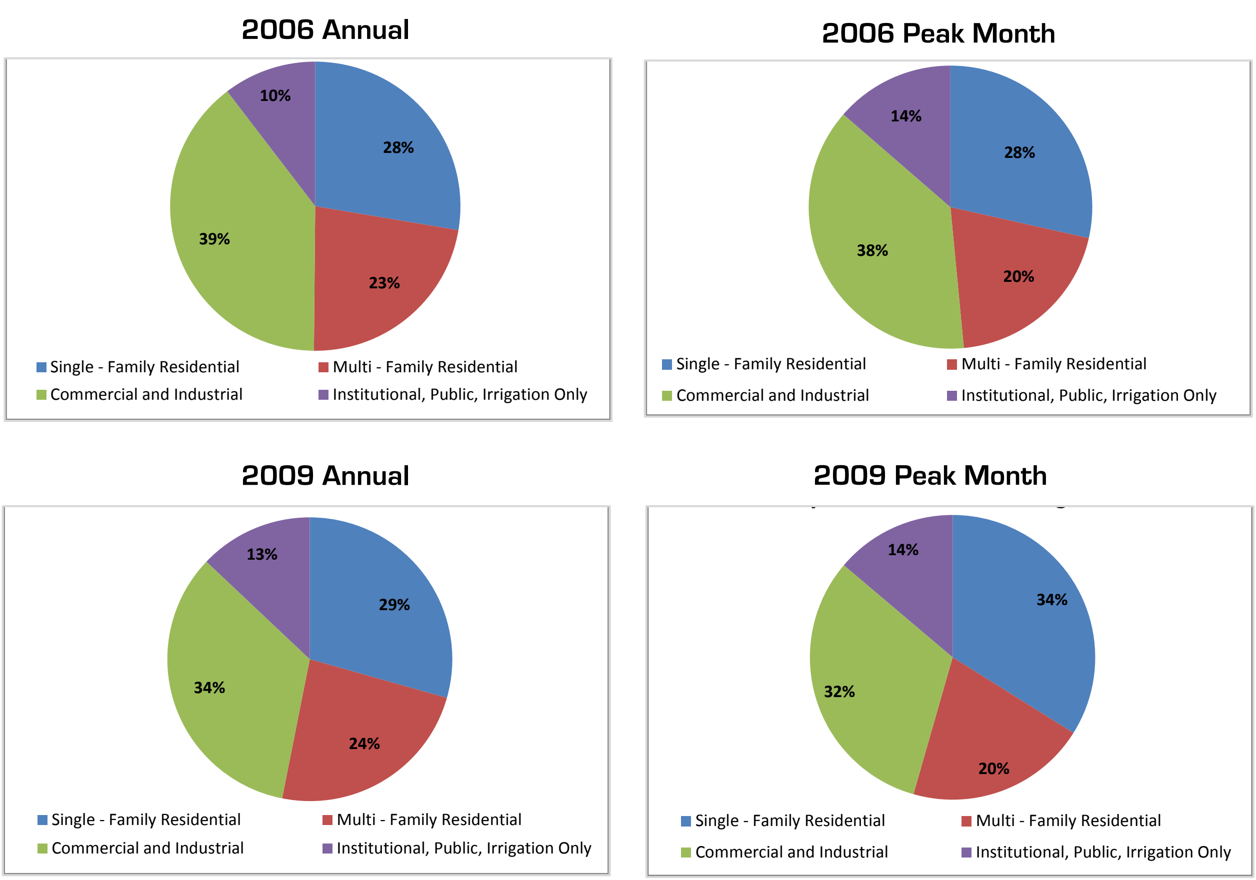


Chart 2.3 illustrates the water usage by user category on an annual and peak month basis. In 2009, water usage for single family dwelling units (blue) makes up 34% of the peak month water usage, as opposed to 29% of the annual water usage. This illustrates that single family dwelling units likely use more irrigation water than other types of water users as a percentage of total water usage.

CHART 2.3 – Annual & Peak Month Water Usage by Category (2006 & 2009)



2.2.7 Water Meter Data and Irrigation Demands

The City of Wilsonville requires separate meters and charges different rates for major irrigation users; however, determining an accurate estimate of total irrigation demand in the city remains difficult. While the City billing system has approximately 380 "irrigation" accounts, these irrigation accounts do not represent all of the total irrigation demand, and in some cases, irrigation accounts reported in the billing software include potable water uses that are fully consumptive (e.g. water bottling plant). This is because water metered through a regular meter is used as the flow basis for sewer billings, while water metered through an irrigation meter is not. Additionally, many accounts, particularly single-family residential properties, are provided both irrigation and potable water through a single meter. This creates calculation difficulties in estimating total irrigation demand.

In reviewing the irrigation account and total demand data from Wilsonville billing database, Keller Associates believes irrigation demands for Wilsonville are best estimated by comparing total water system demand during the winter months to those during the irrigation season. The 2005-2009 average winter-time (January, February, and December months) water system demands are approximately 2.076 mgd. Table 2.6 compares the winter average demands to average monthly system demands for March through November. Based on these comparisons, irrigation is estimated to account for approximately one-third of the total annual water usage and 60% of the demand during the months of July and August (though the percentages are highly variable from month to month).

TABLE 2.6 – Irrigation Water Usage

Period	2005-2009 Average (mgd)	Estimated Irrigation Usage (mgd)	% Irrigation Usage	"Irrigation Only" Accounts (mgd)
January	2.084	0	0%	0.007
February	2.060	0	0%	0.018
March	2.132	0.056	3%	0.027
April	2.187	0.111	5%	0.066
May	2.988	0.913	31%	0.274
June	3.912	1.836	47%	1.140
July	5.157	3.081	60%	1.738
August	5.226	3.151	60%	1.723
September	4.064	1.988	49%	1.362
October	2.520	0.444	18%	0.520
November	2.108	0.033	2%	0.057
December	2.084	0	0%	0.025
Winter*	2.076	0	0%	0.017
Average	**3.044**	**0.968**	**32%**	**0.580**

*Includes January, February, and December

Keller Associates recommends that the City continue efforts to track and quantify irrigation usage within the system. Future water conservation measures may have an impact on irrigation usage, which in turn could affect utility revenues. User rate structures can also be used to influence water usage patterns. For future demand forecasts, irrigation usage has been built into the demand estimates. The irrigation usage per residential unit was assumed to remain constant over time.

2.3 UNACCOUNTED FOR WATER

All water systems experience some water loss. Unaccounted for water is defined as the difference between water produced and water delivered to the customer, corrected for any unmetered uses such as hydrant flushing, fire fighting, street cleaning, etc. If water loss exceeds 10%, then Oregon Administrative Rules (OAR Division 86) require that the water supplier implement a leak detection program. These rules require that the program be regularly scheduled and systematic, address distribution and transmission facilities, and utilize methods and technologies appropriate to the supplier's size and capabilities. Tracking water loss and developing a leak detection and repair program is required by, and is addressed in more detail in a Water Management and Conservation Plan (WMCP). Wilsonville has, and maintains a leak detection and repair program consistent with their WMCP. This has involved performing leak detection evaluations of 25% of their system annually, regular meter testing and upgrades of the City's larger meters, and repairing leaks as they are encountered. The City also tracks unaccounted-for-water on an ongoing monthly basis.

Unaccounted for water (water loss) for Wilsonville is summarized in Table 2.7. The data indicates unaccounted for water increased substantially beginning in 2007, and presently accounts for approximately 180 MG (17.5%) of the total water produced. This is substantially higher than the 10% standard set forth in OAR Division 86.

TABLE 2.7 – Water Production vs. Loss (MG)

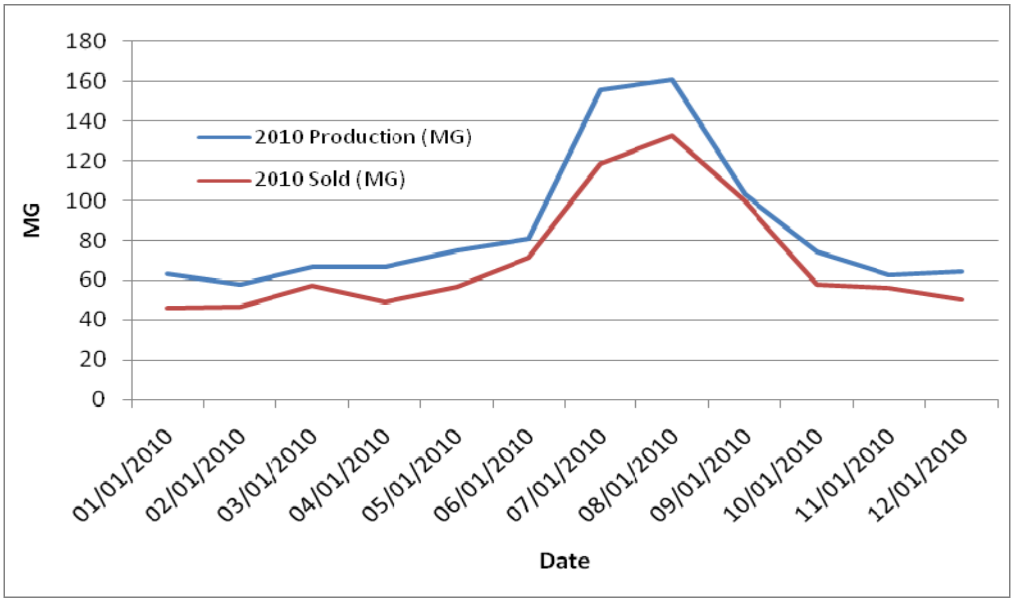
	2005	2006	2007	2008	2009	2010
Produced	1,016	1,130	1,153	1,143	1,120	1,030
Sold*	938	1,060	1,000	961	919	846
Other Uses**	3.5	3.5	3.5	3.5	4.1	3.4
Unaccounted	74	67	150	179	197	181
% Unaccounted	7.3%	5.9%	13.0%	15.7%	17.6%	17.5%

* Includes bulk water sales

** Includes estimated water usage for flushing, sampling, chlorine injection pump operation, street sweeper, and combination line cleaner

Chart 2.4 compares the water sold to that produced and delivered to the water system on a month-by-month basis in 2010. Similar figures were developed for 2006-2009. A significant amount of unaccounted for water appears to occur throughout the year indicating that unaccounted for water is not tied to unmetered irrigation use. During periods of low demand, water loss may make up a larger percentage (although not a large volume) of the total water produced. Keller Associates recommends that the City track volumetric losses. Trending 12-month moving averages will provide the City a better indicator of whether water loss reduction efforts are improving conditions; however, some conclusions can be drawn from the current data.

CHART 2.4 – Water Loss by Month for 2010



The City regularly tracks their water usage and takes active efforts to identify and minimize unaccounted for water. City staff recognize the complexities and challenges of this task and is currently focusing their efforts on understanding and reducing the unaccounted for water. Potential sources of unaccounted for water in the Wilsonville system and their potential for occurrence include the following:

Source	Potential
• Unmetered water users	Low
• Water theft	Low
• Leaky pipes, valves, hydrants, services	Moderate
• Older individual water meters	Moderate
• Meter inaccuracies	High

Unmetered Water Users

The City has gone to great lengths to meter all users, including City-owned facilities. City staff were not aware of any unmetered services within the City when the planning effort began. However, through the process of troubleshooting discrepancies in finished water meter production data, City staff discovered that utility water and onsite irrigation at the water treatment plant was not being accounted for. In March of 2012, water plant staff took physical readings over a week period to approximate utility water usage and potable water usage (excluding irrigation). According to their calculations, the water plant operators could account for approximately 7 million gallons of unaccounted for water annually. A portion of the landscape irrigation would be in addition to this and has not yet been quantified. Keller Associates recommends that all routine water usage be metered and accounted for each month.

Another unmetered source of water usage could results from unmetered private fire lines. According to City staff, most of the older large campuses like Nike, Joes, Xerox, Ore-Pac, etc. have private fire loops that are not metered. Flushing of their lines is not metered. While it may not be cost-effective to meter these lines, the City should consider requiring these lines to be leak tested every four years similar to other City pipelines.

Water Theft

Water theft could result from contractors or other water users illegally taking water from the City's system. This could occur at fire hydrants or from illicit connections to the City's mainlines. Water theft from hydrants would likely be observed by City staff if it amounted to significant amounts of water. The probability that water theft accounts for a significant portion of the water loss is believed to be low.

Leaky Pipes, Valves, Hydrants, Services

Water loss is often attributed to older, leaky pipes. The City of Wilsonville has taken a proactive approach to detecting and eliminating water system leaks. Leak detection studies are completed annually, and identified leaks are typically fixed soon thereafter.

In investigating unaccounted for water, the City should also be aware that there is a realistic lower limit of water loss that is generally not cost-effective to go below. Keller Associates used the AWWA water audit method for calculating unavoidable annual real losses at approximately 50 million gallons per year, which represents about 5% water loss for 2010. The City of Wilsonville should consider this as a reference value representing the attainable technical low limit of leakage.

Meter Inaccuracies

Meter accuracy, particularly for large meters, is often responsible for the largest percentage of unaccounted for water. The City has taken a proactive approach to improve meter accuracy. According to City staff, all individual flow meters 3-inches in size and larger have been tested, calibrated, and repaired within the past few years.

However, further data review brought into question the accuracy of the finish water meter at the water treatment plant, the large meters at the three distribution system turnouts, and the accuracy of previous water loss calculations. Some history on the finish water meter is summarized as follows:

- According to plant records, the finish water meter was reading 8% low prior to September 2006 and some meter adjustments were made. This may explain why the water loss appears to have jumped in 2007.
- Sometime after the adjustments were made in 2006, operations staff observed that the raw water flow values measured slightly less than the finished water flow. After several efforts to understand this difference, no further adjustments were made to either flow meter.
- Keller Associates compared plant finish water meter readings to the totalized flow entering the Wilsonville distribution system as recorded by the flow meters at the two active delivery points (Wilsonville and Kinsman turnouts)

during this period. The 2010 peak week and minimum weekly flows were compared. The finish flow meter recorded values that were higher than the total recorded at the two delivery points by 6% and 4% for the low flow and high flow periods, respectively. A subsequent analysis of December 2011 data (post additional meter calibration completed in the fall of 2011) shows that the finish water meter was still about 6% higher than flow recorded at the turnouts. Onsite utility water usage is believed to account for less than 1%, and the unmetered portion of the irrigation usage has not yet been quantified.

- Keller Associates initially reviewed one week of SCADA data in an effort to compare the metered flow to the calculated flow based on a change in volume. This analysis suggested that the meter readings were actually about 2.5% low. However, it was also recognized that this value varied from 1% low to 3.8% low for different days, suggesting that there may be sources of error that are not accounted for. A subsequent analysis of December 2011 data shows that the finish water meter was reading between 2.4% and 3.0% higher than measured volumes calculated using clear well depths.
- Based on the data available, it appears that the finish water meter is likely reading about 3% higher than it should. Keller Associates recommends that the City continue to scrutinize water meter data as part of ongoing water balance / water loss calculations.

In September 2011, City staff discovered that one of the meters for a large school had failed sometime in 2008. A review of the monthly meter readings for this account suggests that meter readings for most of 2008 were not accurate. A value of zero was recorded for every month since September 2008. Based on water consumed from this single account in 2007, it is estimated that close to 8.6 million gallons of water were not accounted for in 2009 and 2010. *Adjusting Table 2.6 to reflect this water usage, account for 7 MG utility water usage at the water plant, and to reflect a 3% error in the finish water meter readings would result in an estimated <u>% unaccounted for water of about 13%</u> for 2009-2010.* This illustrates the importance of tracking changes in water usage for large users and regularly testing large water meters.

In summary, Keller Associates believes that the actual water losses are likely less than calculated (primarily as a result of meter accuracies), but may still exceed the 10 percent standard. The City has been proactive in their water loss reduction program, and Keller Associates recommends that the City continue to take measures to identify and remove sources of water loss. Annual leak detection studies, water meter testing and replacements, and ongoing water loss audits should continue.

If these efforts do not produce the desired results, Keller Associates recommends that the City partition off portions of the City and compare metered water usage to that delivered for various regions within the City. For many regions, this may be accomplished with little capital investment. For example, a new water meter is recommended to measure the water going into the Charbonneau District. Comparing monthly water meter readings from this master meter to the total water usage from all the individual meters within the District would allow the City to quantify the water loss for this area and compare the water loss for this area to the system as a whole. Similarly, by closing valves at strategic locations, the City could use existing turnouts to supply certain regions of the City. Care should be made to notify the fire authority so that valves could be opened in the event of a fire.

For future demand forecasts, Keller Associates has assumed that the water loss reduction programs will continue, and water loss will only grow in proportion to the increase in water system demands.

2.4 WATER DEMAND FORECAST

Consistent with the methodology presented earlier, separate water demand forecasts were prepared for residential and nonresidential users, and for supplemental supply to the City of Sherwood. These are detailed in the subsections below.

2.4.1 Residential Demand Forecast

The average annual residential demand (including single family and multi-family users) for 2005-2010 has consistently made up 50-53% of the total system demand. Table 2.8 summarizes the estimated demands for single family and multi-family residential dwelling units. The number of single family dwelling units was estimated from 2010 meter account data. Because many multi-family users, such as large apartment complexes, are metered as single accounts, the total multi-family units was estimated by subtracting the number of single family accounts from the 2010 Census data showing 8487 households. The estimated number of multi-family households is consistent with estimates prepared by the Wilsonville staff during the first quarter of 2010.

For reference, Table 2.8 also lists current residential demands per unit compared to the previous planning document (2002 Water Master Plan). Daily average demands have not changed much from previous estimates. However, water usage data shows that the estimated maximum day water usage for this study is considerably lower than previous assumptions.

TABLE 2.8 – Residential Demands per Dwelling Unit (gallons/day)

	Single Family	Multi-Family
Number of Units	**3756**	**4731**
Average Daily Demand		
Current Planning Document	**247**	**162**
Compare to 2002 WMP	251	161
Maximum Day Demand		
Current Planning Document	**606**	**283**
Compare to 2002 WMP	866	375

In estimating future demands, single family and multi-family dwelling units were both assumed to grow at a rate of 2.9% until build-out of their respective parts of the study area.

2.4.2 Nonresidential Growth Forecast

Water system demands were summarized by land use for commercial and industrial areas after linking the water system demands (including all irrigation accounts) to parcels in Wilsonville. Table 2.9 summarizes the results. Maximum day demands were approximated based on system peaking factors (Maximum Day is approximately 120% of the Maximum Month demand). Demands also reflect the 2005-2009 average industrial/commercial usage.

TABLE 2.9 – Commercial / Industrial Demands per Acre

Parameter	Commercial	Industrial
Developed Area (acres)	**300**	**830**
January Demand (gpm/acre)	0.59	0.28
Maximum Month Demand (gpm/acre)	2.3	0.46
Maximum Day Demand (gpm/acre)	3.3	0.84

It should be noted that the industrial values are relatively low compared to other communities, which generally have industrial demands exceeding commercial demands on a per acre basis. The relatively low industrial demand per acre likely reflects the preponderance of distribution warehouse type uses encountered in Wilsonville. For build-out, industrial demands were increased by an additional 25 percent to reflect redevelopment, additional infill, and higher water users within existing structures.

Additionally, at the direction of City Engineering staff, three large future industries were also included in future water usage projections. These include a 0.5 mgd industrial user in the first five years, a 0.25 mgd industrial user by year 10, and another 0.25 mgd industrial user by year 15.

2.4.3 Sherwood Water Demands

In addition to supplying the existing water demands for the City of Wilsonville, the existing treatment plant and Wilsonville transmission and system will provide a guaranteed potable water supply to the City of Sherwood. This demand is anticipated to grow from a contractually specified peak of 2.5 mgd in 2011-2012 to a peak of 5.0 mgd by 2015. Sherwood demand is expected to vary by month and season; however, for modeling purposes, the daily demand was assumed to be constant, so no peak hour or peak day adjustment factors are applied to Sherwood demands. The 5.0 mgd demand is also assumed to eventually increase to 20.0 mgd at build-out.

2.4.4 Summary of Demand Forecast

Table 2.10 summarizes the future demands for residential and nonresidential users, future industry, and the City of Sherwood.

TABLE 2.10 – Future Water System Demands

Scenario	2010	2015	2020	2025	2030	Build-out*
Population	19,525	22,525	25,986	29,979	34,585	52,400
Households	7,873	9,083	10,478	12,088	13,946	21,129
Residential (increase of 2.9% per year)						
Average, mgd	1.70	1.96	2.26	2.60	3.00	4.21
Minimum Month, mgd	1.14	1.31	1.52	1.75	2.02	2.83
Maximum Month, mgd	3.01	3.48	4.01	4.63	5.34	7.48
Peak Day, mgd	3.62	4.17	4.82	5.56	6.41	8.74
Peak Hour, mgd	6.16	7.10	8.19	9.45	10.9	14.86
Nonresidential (increase of 3.5% per year)						
Average, mgd	1.50	1.79	2.12	2.52	2.99	3.09
Minimum Month, mgd	1.01	1.20	1.43	1.69	2.01	2.08
Maximum Month, mgd	2.57	3.05	3.62	4.30	5.11	5.27
Peak Day, mgd	3.08	3.66	4.35	5.16	6.13	6.35
Peak Hour, mgd	5.24	6.23	7.40	8.79	10.4	10.80
Other Miscellaneous						
3 Future Large Industries	0.00	0.50	0.75	1.00	1.00	1.00
Sherwood	0.00	5.00	5.00	10.0	10.0	20.0
Total System						
Average, mgd	3.20	9.24	10.1	16.1	17.0	28.3
Minimum Month, mgd	2.15	8.01	8.69	14.4	15.0	25.9
Maximum Month, mgd	5.58	12.0	13.4	19.9	21.4	33.8
Peak Day, mgd	6.70	13.3	14.9	21.7	22.5	36.1
Peak Hour, mgd	11.4	18.8	21.3	29.2	32.3	46.7

* Residential demands reflect larger proportion of multi-family households at build-out, with historically lower usage than single family households

3.0 SYSTEM ANALYSIS

This chapter documents the planning criteria used to evaluate the existing distribution system, summarizes existing deficiencies, and presents recommended improvements.

3.1 PLANNING CRITERIA

Planning criteria include water system demands (established in Chapter 2), planning period, the study area, and the criteria by which the existing distribution system is evaluated.

Planning Period

Planning efforts focused primarily on two planning periods – existing and buildout. Existing conditions are based on 2010 conditions. Buildout was estimated to occur in 2038. Demands were calculated for intermediate planning periods to assist in phasing of improvements such as water supply and storage needs.

Study Area, Land Use, and Population

The service area, land use, and population assumptions for this report are outlined in Chapter 2.

Evaluation Criteria

The evaluation criteria were developed with input from City staff. A comparison of the evaluation criteria used for this study to that assumed in the previous master plan is illustrated in Table 3.1 on the following page.

Minimum pressure criteria are intended to protect human health during emergencies and avoid low pressure complaints from customers. Higher pressure criteria are intended to protect plumbing fixtures and existing mainlines.

Desired fire flows were developed with input from the local fire authority. Providing mechanical redundancy (or firm capacity) ensures that the City is able to deliver water during high demand periods even when any one of the pumps servicing the area is off-line.

Backup source and storage evaluations are evaluated together, recognizing that the existing backup wells can offset emergency storage requirements during an extended plant shutdown.

Equalization storage, or peaking storage, refers to the storage required to meet peak hour demands in excess of the supply pumping capacity. For planning purposes, the supply pumping capacity is assumed to be equal to the average peak daily demand. Operational storage is the volume of water drained from the reservoirs during normal operation before the water sources begin pumping to refill the reservoirs.

TABLE 3.1 – Planning Criteria

Planning Criteria	Keller Assoc. (2012)	Previous WMP (2002)
Pressures		
Min pressure while delivering MDD + Fire, psi	20	20
Min pressure while delivering PHD, psi	40	40 (typ. demands)
Max pressure without pressure regulator, psi	80	Not Specified
Max pressure in mainlines (w/o special pipe), psi	120	100 (typ. demands)
Velocities		
Max for pipes < 12" under PDD+fire, or PHD, fps	10+	10*
Fire Flows		
Minimum for new residential areas, gpm	1500	1500
Target for commercial/industrial areas, gpm	3000	Not specified
Power Outage		
System delivery of ADD + fire?	Yes	Yes
Mechanical Redundancy		
Deliver PHD with largest pump out of service?	Yes	No (only MDD)
Deliver MDD+Fire with largest pump out of service?	Yes	Not specified
Backup Source		
Deliver ADD to Charboneau District with pipe failure?	Yes. 2+ days	Not specified
Deliver ADD demands with WTP out of service?	Yes. 2+ days	Yes
Storage		
Equalization storage for demands in excess of MDD	Yes (14.6% calculate from SCADA)	Yes (assumed at 25% of MDD)
Operation storage	10% of each reservoir	None included outside of WTP clearwell
Fire storage**	3000 gpm for 4 hours	3000 gpm for 4 hours
Emergency storage***	2 times ADD	2 times ADD
Can tank be taken offline for maintenance?	Yes	Yes (zone C supply from Tualatin intertie)

*Previous report assumed all pipes less than 8" in diameter were inadequate for fire protection; Keller allows 10+ fps for fire

**Per local fire authority

***Emergency storage needs can be reduced using wells equipped with standby power.

Abbreviations:

WMP = Water Master Plan
MDD = Maximum Day average Demand
PHD = Peak Hour Demand
ADD = Average Day Demand
WTP = Water Treatment Plant
psi = pounds per square inch
fps = feet per second
gpm = gallons per minute

3.2 HYDRAULIC MODEL DEVELOPMENT

3.2.1 Physical Modeling Inputs

The City of Wilsonville previously constructed and maintained an H20Net water model. This modeling platform is an Innovyze product which operates in AutoCAD. In 2008, the City elected to update and migrate the existing model to a GIS platform product, also by Innovyze, called InfoWater v. 8.1.

In 2011 Keller Associates reviewed the existing model against the best available mapping and information on the city water system. This review uncovered a number of inconsistencies and gaps in the water model. With field investigations and guidance from City staff, the main lines and other major components of the water system were corrected in the water model to reflect a more accurate picture of the system's current arrangement. Numerous "dummy" pipes used in certain modeling methods were removed from the model for clarity.

Pipe materials and their associated roughness values were also reviewed and corrected based on input from City staff. A Hazen-Williams roughness coefficient of 100 was assigned where pipe materials could not be reasonably determined. This value is generally considered an appropriately conservative value given the possible age and material of the water lines in Wilsonville's system.

Many of the existing model elevations were found to be inconsistent with the City's 2-foot LIDAR ground elevation contours. The physical elevations of the modeled junctions affect many aspects of the modeling, including calibration, reported pressures, and fire flow evaluations. In light of the potential impacts, the junction elevations were corrected to the LIDAR data.

Other system components such as pumps, pressure reducing valves, and storage reservoirs were compared to the available record drawings, curves, and operation manuals. These elements were also updated and corrected in the model to reflect the best available data.

3.2.2 System Demand Allocation

Keller Associates linked water consumption data from the City's billing database to the GIS parcel dataset. Although challenging, this accurately allocated demand quantities and locations in the water model. Approximately 85% of the water demands could be linked to specific locations, and the remaining 15% was distributed to developed parcels based on existing land use, acreage, and billing account type (i.e. industrial, commercial, etc.)

To facilitate a more seamless update of demand allocation in the future, it is recommended that the City create a meter dataset. Each meter in the GIS meter dataset and the billing database should be assigned a unique numeric meter ID. This common meter ID between the two sources of information will allow for 100% correlation with relatively little effort. It is recommended that the City continue their efforts to identify each account type as industrial, commercial, multi-family, single family, irrigation and so forth.

3.2.3 Model Calibration

To ensure the computer model results are consistent with observed field conditions, the model is calibrated to field observed test data.

A series of 11 field tests was performed through a coordinated effort with City staff and Keller Associates. The purpose of the testing is to observe the system reaction to higher than usual water demands. The demands were created by opening multiple fire hydrants at strategic points throughout the water system. Pressure changes at observation hydrants were observed and recorded, along with boundary conditions at turn-outs (pressure reducing valves delivering flow from the Water Treatment Plant to the distribution system), tanks, and booster pumps. These demands and boundary conditions for each test were then simulated in the model to see if the model reacted like the system. The calibration results shown in Appendix D indicate that the current model matches within 2-3 psi of field observations.

The calibrated water model was employed in all existing and future scenario evaluations related to this study. The scenarios explored and their results are detailed in section 3.5 *Distribution System Evaluation*.

Although primarily developed for this study, the water model can serve as a powerful planning and system management tool for the City of Wilsonville. It is recommended that the City consider regularly updating, running, and calibrating the water model. To do so, the City will need to purchase the Info Water Software.

3.3 STORAGE EVALUATION

In evaluating the existing storage reservoirs, Keller Associates calculated the existing effective storage, and required storage volumes, and documented the condition of the existing storage reservoirs.

Physical Conditions

In general, three of four existing storage reservoirs are in good shape, and will remain serviceable throughout the 20-year planning horizon. An evaluation of the conditions and recommended upgrades to the existing storage facilities can be found in Technical Memorandum No. 1 (Appendix B). A seismic evaluation of the Charbonneau Tank (Appendix H) shows that this facility is at risk during a major earthquake. Because of the large expense associated with rehabilitating the tank, Keller Associates recommends that the tank eventually be abandoned. Additional discussion about the Charbonneau tank is contained in this section and in Appendices F and H.

Existing and Future Storage Needs

Table 3.2 summarizes the effective available storage for each of the City's existing reservoirs. The effective storage was calculated using available record drawings and reflects the useable volume of water in the storage reservoir. Dead storage (the volume of water below the pipe outlet) was excluded from the available storage supply. Additionally, a one foot freeboard was assumed between the maximum water surface elevation and the overflow elevation. This freeboard prevents the City from inadvertently overflowing the tank and wasting water.

TABLE 3.2 – Existing Effective Storage

Storage Reservoir	Volume[1] (MG)
Elligsen B-1 West	1.98
Elligsen B-2 East	2.97
C Level	1.96
Charbonneau	0.70
WTP Clearwell[2]	1.08
Total without Clearwell	*7.60*
Total with Clearwell	*8.67*

1. Assumes 1 foot freeboard to overflow. Excludes dead storage volume.
2. Assumes 92.9% of the minimum clearwell volume for summertime worst-case conditions when plant is operating at capacity of 15 mgd.

A portion of the clearwell volume at the water treatment plant was also considered in calculating existing available water storage. Under emergency conditions when the treatment plant may be cut off from the river supply, it is assumed that the clearwell volume containing the treated water at the water treatment plant would still be available. While the clearwell volume provides 2.5 MG of storage, this storage volume can fluctuate substantially depending on plant operations. However, a minimum clearwell volume is always maintained to ensure adequate chlorine contact time prior to delivering treated water to the distribution system. In estimating the available water for the City of Wilsonville during an emergency, Keller Associates assumed the worst-case condition which corresponds to the minimum clearwell volume necessary for treatment during a summer maximum day period (1.16 MG per original CT analysis, see Table 4.1. Note that this value could vary depending on future tracer study results). According to City staff, the City of Wilsonville is entitled to 92.9% of the available volume based on the portion of the clearwell construction costs that were funded by the City (Resolution 1661).

Table 3.3 summarizes the storage needs for 2010 and 2030. The total storage required is anticipated to increase from 9 MG to almost 18 MG by 2030. Total storage volumes do not account for the existing backup wells which can replace needed storage water during a two-day emergency event, as described in the next section.

TABLE 3.3 – Storage Needs (No Wells)

Storage Component	Year 2010	Year 2030
Operating Storage[1] (MG)	0.87	1.17
Peaking Storage[2] (MG)	0.98	1.75
Fire Storage[3] (MG)	0.72	0.72
Emergency Storage[4] (MG)	6.40	14.00
Total Storage Required (MG)	*8.97*	*17.64*
Less Storage Available (MG)	*-8.67*	*-8.67*
Storage Need (MG)	**0.30**	**8.97**

1. Operating storage recommendation is 10% of effective volume. For year 2030, it includes an additional 10% storage for the currently proposed 3 MG new tank.
2. Based on Wilsonville demand pattern, assumes supply equals max day demand.
3. Assumes 3000 gpm for 4 hours.
4. Assumes City desires to provide 2 times the average day demand

Although the above analysis indicates a current deficiency of 0.30 MG, the conservative nature of the analysis assumptions would not indicate that a current storage problem exists.

Potential Impacts of Backup Well Supply on Storage Needs

During an emergency event, the City's eight backup wells can supplement water demands. With the exception of the Charbonneau District wells, these wells all pump into the Level B pressure zone. Technical Memorandum No. 3 (Appendix B) documents several scenarios that were considered along with their potential impact on the storage need. With the preferred scenario (includes removing Nike and Canyon Creek wells from the potable system), the 2030 projected storage needs is reduced from 8.97 MG to 2.05 MG.

For the 20-year planning period, the cost to maintain these six wells as a backup supply is between a third and one half the cost of constructing the equivalent amount of storage. Additionally, it should be noted that another benefit of maintaining the backup wells is that in the event of an extended interruption of the water treatment supply, the wells would be able to provide a critical level of service indefinitely as long as fuel could be obtained to run the generators.

Charbonneau Tank

Concurrent to this study, a separate seismic evaluation of the Charbonneau Tank and was completed (see Appendix H). The geotechnical investigation completed as part of this evaluation showed that the tank is at risk during a major earthquake. Mitigating these risks would be almost as expensive as construction a new tank. Given the age of the existing tank (constructed in 1978), rehabilitating the existing tank was not felt to be a cost-effective solution.

As an alternative to replacing the existing tank, Keller Associates also investigated displacing the tank. By providing a secondary 16-inch transmission pipeline to the Charbonneau District via a directional bore under the Willamette River, the City could more effectively use available storage in the B Level pressure zone to service the District. This pipeline could provide the needed fire flows and system redundancy currently provided by the Charbonneau tank and booster facilities. Displacing the tank would also eliminate energy inefficiencies associated with cycling water through the existing tank (currently requires water that enters the tank to be pumped again into the system). Additionally, operation and maintenance costs associated with the tank and booster facility could be reduced or eliminated. A life-cycle cost comparison shows that the secondary pipeline option will be a better long-term solution for the District (see Appendix E for life cycle costs and Appendices F and G for additional discussion). A summary comparison of the alternatives is shown in Table 3.4. The 16-inch pipeline alternative is a lower-cost alternative when looking at a 20+ year planning period.

TABLE 3.4 – Charbonneau Storage Alternatives

Option	Description	Capital Cost	Annual O&M Cost
1A	Rehabilitate Existing Tank	$ 1,829,000	
	Booster Station & Misc. Upgrades	120,000	
		$ 1,949,000	$ 24,100
1B	Replace Existing Tank	$ 2,284,000	
	Booster Station & Misc. Upgrades	120,000	
		$ 2,404,000	$ 24,100
2	New 16-inch Pipeline Across River	$ 1,532,000	
	Additional Storage in Zone B	700,000	
		$ 2,232,000	$ 3,600

Displacing the Charbonneau Tank will increase the future storage needs by an additional 0.7 MG. This results in a storage need of 9.69 MG if the wells are not accounted for, and 2.77 MG if the preferred wells are accounted for.

Storage Recommendations

Keller Associates understands that the City has already identified a tank site located near the intersection of Tooze and Baker Road, west of the City. The proposed site is capable of holding two reservoirs. The City has already begun pre-engineering to move forward with an initial 3.0 MG storage reservoir, with a second reservoir to follow in the future. This storage reservoir will be located in pressure zone B and will also float on the water system (same overflow elevation as the Elligsen tanks). By maintaining all but the Nike and Canyon Creek wells as backup potable water suppliers, the proposed 3.0 MG storage should be adequate for the City's projected 20-year need, even with the future abandonment of the Charbonneau tank.

Keller Associates further recommends that the City look closely at operation controls in planning and designing the new tank. During portions of the year, the City may want to increase the volume between pump on and off set points. This will ensure a higher tank turnover, which will reduce the potential for water stagnation. Because of differences in locations, size and transmission piping, it is likely that the new water tank will not fill at the same rate as the Elligsen tanks. Altitude valves may be needed at the new tank site and potentially at the existing Elligsen tanks.

3.4 PUMPING FACILITIES

In evaluating the existing booster stations, Keller Associates documented the condition of the existing storage reservoirs and compared firm pumping capacity to existing and project peak demands. Firm capacity refers to the pumping capacity with the largest pump offline.

Physical Conditions

In general, the booster pump stations are in good condition and well maintained, with some components of the Charbonneau Booster Station reaching the end of their useful life. An evaluation of the conditions and recommended upgrades to the existing pumping facilities can be found in Technical Memorandum No. 1.

Capacity

The Charbonneau Booster Station and the B- to- C Booster Station are currently the only two pumping facilities in the distribution system.
The Charbonneau Booster Station runs only periodically because the Charbonneau District can usually receive needed flows and pressures through the PRV connection from Zone B. The Charbonneau tank can be used to augment supply from Zone B. The pumps can be manually turned on (process not currently automated) if the flows and pressures from zone B cannot keep up with the demand in Zone A. The booster station consists of one 40-hp pump and two 75-hp pumps. These pumps pull water from the Charbonneau tank and pump into the Charbonneau system upstream of the PRV. The 40-hp pump can deliver roughly 300 gpm, and the 75-hp pumps can deliver roughly 750 gpm each at the target head of about 300 feet. According to City staff, only one 75-hp and the 40-hp pump have ever been exercised at one time.

The B-to-C Booster Station works together with the C Level Reservoir to meet the pressure and flow needs of the C Level pressure zone. The booster station consists of one 7.5-hp pump, two 25-hp pumps, and one 50-hp pump. These pumps each deliver 50 gpm, 400 gpm, and 800 gpm respectively.

Both booster facilities have a firm capacity greater than what is anticipated to be needed in the 20-year planning period.

Future Booster Station(s)

As development continues to the northeast portion of the study area, another booster station (C-to-D Booster Station) will be required to deliver the necessary pressures. Keller Associates proposes that this booster facility be located near the C Level tank.

An additional temporary booster station may be required to service a portion of land located in the northern reach of the study area and west of the interstate. This area ultimately can be served by the C Level pressure zone, but will require a pipeline crossing of the interstate. A small temporary booster station could allow for development in this area prior to construction of the necessary pipelines connecting the region to the C Level pressure zone.

3.5 DISTRIBUTION SYSTEM EVALUATION

3.5.1 Existing System Evaluation and Deficiencies

The physical condition of the existing distribution system was evaluated in connection with this study. The results of this evaluation can be found in Technical Memorandum 1. In general, the distribution system is in good condition. This section summarizes the hydraulic condition of the system.

Available Fire Flow Analysis

The calibrated water model was employed in evaluating the water system's capability to provide for high water demands in emergency scenarios such as structural fires. The flow rate required at various points in the system was previously determined as described in section 3.1 *Planning Criteria*.

Points on dead-end water lines that are less than 300-feet long and without hydrants were excluded from the evaluation. In consulting with City staff, it was determined that these points do not need to provide fire flow because the flow could be obtained from the main line to which these smaller dead-end lines are connected.

For over 95% of the system, there is more than adequate fire protection. Chart 3.1 highlights points in the system that cannot presently meet the established fire flow standard. Many of these localized deficiencies provide fire flows that are close to the desired standard and can be corrected with minor improvements. For example, a site may be deemed industrial and therefore require a 3,000 gpm demand but can currently provide only 90% of that flow (or falls 10% short). As system improvements are prioritized, minor deficiencies such as these will only be corrected as development or redevelopment occurs. On the other end of spectrum, there may be a residential area needing 1,500 gpm but it can only provide 30% of that flow (or falls 70% short). These deficiencies are higher priority and trigger a capital improvement based solely on the fire flow deficiency. Chart 3.1 breaks the deficiencies down into general categories based on the shortfall percentages.

Each of the failing points highlighted in Chart 3.1 was evaluated with City staff, and local improvements were developed to correct the problems. Other factors than just the local fire flow failure were considered in prioritizing fire flow improvements, such as, proximity to a point in the system providing the full fire flow requirement. For example, a failing hydrant may be less than 100 feet away from a passing hydrant, thereby decreasing the urgency for a system improvement in that area. These improvements are discussed generally in Section 3.5.4 *Recommended Improvements*, identified graphically in Figure 4 in Appendix A, and listed individually in the cost estimates found in Appendix E.

CHART 3.1 – Wilsonville Localized Fire Flow Deficiencies

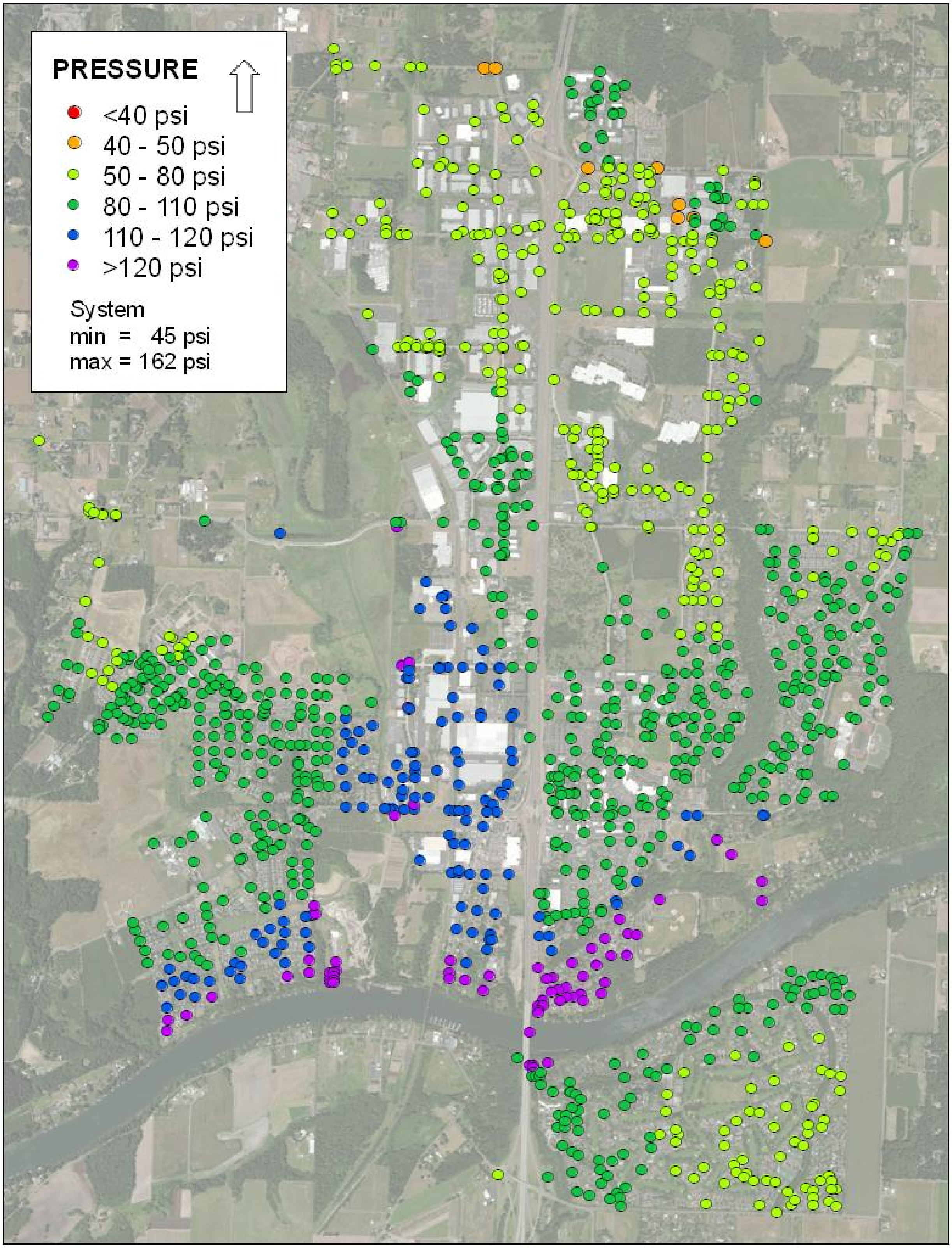
System Pressures

Most modern appliances and plumbing fixtures operate best when water system pressures are between 50 psi and 80 psi. The calibrated water model was employed in evaluating typical water system pressures. Chart 3.2 illustrates the model results for typical water system pressures under an annual average day demand scenario.

Much of Wilsonville's water system will experience water pressure greater than 80 psi. This is because the greater part of Wilsonville is served by the B Level pressure zone. This arrangement is not uncommon for water systems, but does require that individual pressure regulators be installed to regulate customer pressures to below 80 psi. For Wilsonville's system, Keller Associates recommends that individual pressure regulators be installed on all new connections. This will give the City the greatest flexibility in operations, while providing a level of protection to the user. Where future mainline pressures are anticipated to exceed 120 psi, special piping is recommended.

There are also some areas of low pressure in the northern portion of the system. While none of the areas are less than 40 psi, these may be areas the operations crew should monitor as the system continues to evolve. In order to provide water service with pressures greater than 40 psi to the northeast portion of the study area, a new pressure zone will be required (Level D pressure zone).

CHART 3.2 – Wilsonville Typical System Pressures



As shown in Chart 3.2, most of the water system will typically experience water pressure greater than 80 psi. In these areas, individual pressure regulators are recommended for all connections. Where mainline pressures will be more than 120 psi, special piping is recommended. The City typically requires ductile iron pipe, and standard pressure class ductile iron pipe for sizes that would be used in the distribution system is typically rated for 250-350 psi working pressure. There are some 120+ psi locations in the system where unknown pipe materials or materials other than ductile iron pipe are installed. As yet, these installations have not been problematic and are not recommended for replacement. However, if site specific problems should arise, it is recommended that they be replaced with a suitable pressure class pipe. A comparison of Chart 3.2 *Typical System Pressures* and the pipe material figure found in Appendix A reveals portions of the system that may fall into this category.

There are also some areas of low pressure in the northern portion of the system. While none of the areas are less than 40 psi, these may be areas the operations crew should monitor as the system continues to evolve.

Another system pressure standard is that service lines pressures cannot drop below 40 psi under a peak hour demand scenario. The model shows that the City's water system is robust enough to absorb peak hour demands with negligible pressure changes from an annual average day demand scenario.

Other System Deficiencies

Other system deficiencies found while evaluating the existing water system are classified as vulnerabilities or inefficiencies.

A common vulnerability discovered in Wilsonville's system was single line (e.g. non-looped) connections to large parts of the system. In the event that the single line were to rupture, the entire downstream area would be without water. Examples of these areas include the single line supplying Zone C north of Elligsen, the Charbonneau District, and the Canyon Creek, Ash Meadow, and Sundial apartments. Each of these locations was reviewed with City staff, and necessary local improvements were developed to address these vulnerabilities.

Other vulnerabilities found in the system were hydrant coverage shortages. For planning purposes, the City has set a maximum service area radius of 300 feet from the hydrant consistent with the Tualatin Valley Fire and Rescue (TVF&R) maximum spacing of 600 feet. The more populated sections of the water system were evaluated for coverage, and several gaps were identified (see Chart 3.3). New hydrants, and in some cases new or upsized pipelines, are recommended to provide more coverage in the evaluated areas. An additional 20 hydrants are recommended to provide coverage to structures or areas further than 400 feet from an existing hydrant. Another 15 hydrants are recommended to service areas further than 300 feet from an existing hydrant.

CHART 3.3 – Hydrant Coverage Deficiency Areas

Another potential system deficiency is a small section of high velocity flows in a 4-inch diameter pipe segment within the Charbonneau District. Velocities higher than 6 feet per second (fps) can result in unnecessary energy loss and cause excessive wear on the affected piping and equipment. Higher system velocities also increase the potential for damage from transient surges in the water system. In general, velocities are below 6 fps in the City's water system. In a model evaluation of the Charbonneau system, velocities of 12 fps were identified in a 4-inch supply pipeline segment under a peak hour demand scenario.

In evaluating a potential correction for the high velocities in the 4-inch line, it was determined that no improvement is necessary at this time. The system has operated in this fashion for years without problems. Serving a lower pressure zone inherently requires burning energy through a PRV, as is the case with the Charbonneau District. This section of pipe (located in the Charbonneau Booster Pump Building) should be monitored for early wear. If this section proves to be problematic, upsizing the 4-inch line or providing an additional supply point to Charbonneau would decrease velocity through the existing 4-inch connection.

The largest inefficiency found in the water system is the independent well, tank, booster facility in the Charbonneau District. These facilities allow the Charbonneau system to operate independently under emergency conditions, but are rarely used because the system typically operates off the single line feed across the I-5 Bridge crossing the Willamette River. The cost of maintaining the Charbonneau facilities could be eliminated by installing a second connection to the Charbonneau District. This connection could be made using a directional bore to install a 16-inch water line connection under the Willamette River from Rose Lane to French Prairie Road. Additional discussion regarding this improvement and the Charbonneau District's water system can be found in Appendix F.

The improvements identified to address these and other deficiencies are discussed generally in Section 3.5.4 *Recommended Improvements*, identified graphically in Figure 4 in Appendix A, and listed individually in the cost estimates found in Appendix E.

3.5.2 Future System Evaluation

Future System Construction

Starting with the calibrated water model, future water infrastructure was added to the model using existing planning information for areas such as Villebois, Coffee Creek, Brenchley Estates, and Frog Pond. Input from the City served as the basis for such facilities as the future Zone B (West side) storage reservoir location, the Sherwood connection at the intersection of Tooze Road and Westfall Road, and the completion of Segment 3B of the 48-inch transmission main in Kinsman Road.

The planned land use for the study area shown in Figure 2 (Appendix A) provided direction for line sizing and arrangement. Water system demands were allocated to the future areas using available demand estimates for master planned areas and land use acreage based estimates provided in Chapter 2 *Demand Forecasts.*

The City's 2-foot elevation contour dataset was used to identify the pressure zone best suited to serve future areas. Because the ground elevations in future growth areas in the northeast section of the study area are too high to be serviced by any of the existing pressure zones, Pressure Zone D was created. The target hydraulic grade for Zone D is approximately 590 feet. For evaluation purposes, a Zone D booster station has been modeled at the C Level Reservoir.

Future System Fire Flow and Pressures

The future system infrastructure was developed to ensure adequate fire flow and operating pressures to the intended service areas. The model was used to ensure proper line sizing and pressure zone connection. Figure 4 (Appendix A) illustrates the future system layout with recommended line diameters, and Figure 5 identifies the existing and future pressure zones in the water system.

3.5.3 Recommended Improvements

The recommended improvements resulting from the system evaluation are presented in this section by priority. These improvements are necessary to meet the available fire flow standards and provide hydrant coverage. Also included are the development-driven and City-identified capital improvement projects. Prioritization of the improvements was developed in consultation with City staff.

Priority 1A improvements are those that will likely happen within the next five years, while Priority 1B will occur within the next ten years. These may include projects that improve fire flows that are currently less than 1,000 gpm, or projects that are related to current developments and city-led improvements.

Priority 2 improvements are those that will likely happen within the next twenty years. These may include projects that improve fire flows that are currently greater than 1,000 gpm but less than 1,500 gpm. They may also be development-driven or City-led projects that are considered near-term. Hydrants needed for residential area coverage not tied to a Priority 1 improvement are considered Priority 2.

Priority 3 improvements are those that will happen as development or redevelopment occurs. These are implemented as needed or beyond the 20-year planning horizon and may include improvements intended to correct marginal fire flow deficiencies or poor hydrant coverage in developed industrial and commercial areas. Other future improvements are intended to provide water to currently unserviced areas.

Figure 4 (Appendix A) illustrates the priority improvements. The improvement identifiers on the figure correspond to capital improvement cost information provided in Chapter 5 and Appendix E.

3.6 BACKUP WELL SUPPLY

The City owns and maintains eight potable groundwater wells. These wells once supplied all of the City's drinking water. Since the completion of the water treatment facility, these wells serve only as an emergency backup water supply. These wells include Nike, Canyon Creek, Wiedeman, Boeckman, Geshellschaft, Elligsen, and two additional wells located within the Charbonneau District (Charbonneau wells #2 and #3). A detailed evaluation of these well facilities was documented in Technical Memorandum No. 5 (see Appendix B). The location of these well facilities is illustrated in Attachment 1 of the technical memorandum.
Keller Associates reviewed the well conditions, water rights status, availability of standby power, and water quality with City staff to prioritize which well facilities warrant upgrades and continued maintenance, and which ones should be considered for abandonment or conversion to nonpotable wells that could potentially provide local irrigation needs.

Given the potential for the Charbonneau District to become isolated from the remainder of the system during an earthquake, it was felt that the Charbonneau wells should be maintained as a critical backup supply source. Wiedemann and Geshellshaft wells have historically been good producers and should be maintained. Wiedemann should be equipped with standby power in order to be a more reliable source during an emergency event. The City should continue to take steps to certificate the water right at Geshellshaft (currently the largest producing well in the system). Keller Associates recommends that Elligsen be retained because the water right is certificated and because of its proximity to the storage tanks and Zone C. While there have been some concerns about the poor production capacity of Boeckman, recent pump tests show that it has maintained its historic production rate. Given the relatively new facilities at Boeckman and the presence of standby power, Keller Associates recommends that this facility be retained for the 20-year planning period.

Because of the significant expense to upgrade the Canyon Creek well and its questionable capacity, it may be more cost effective to just abandon this well. However, it may be worthwhile to investigate potential local irrigation uses which would not require standby power upgrades nor the same level of service that is required for potable wells.

The Nike well has historically been a large producer and is the City's only flowing artesian well. The well has poor water quality and in recent years has experienced significant declines in production capacity, believed to be from biofouling of the well screens. Keller Associates recommends that the Nike well be preserved for local irrigation purposes.

The backup wells provide more than just a reliable long-term secondary source of drinking water. Groundwater wells that are equipped with emergency generators can serve to offset emergency storage needs. Impacts on emergency storage requirements are summarized in Section 3.3.

The annual costs to upgrade and maintain all but the Nike and Canyon Creek wells are estimated to be about $95,000 to $105,000 per year.

3.7 CHARBONNEAU DISTRICT SUMMARY

The Charbonneau District is located south of the Willamette River and has several unique issues that justified special consideration within this Master Plan. Water supply to the District comes primarily via a single transmission pipeline across the interstate bridge. Backup wells, a buried concrete storage tank, and a booster facility are maintained to provide a backup supply to the system and to supplement fire demands.

The Charbonneau District represents a significant portion of the City's "older" water system assets, and many of these assets have been targeted in this study for replacement within the 20-year planning period. In addition, many of the pipelines were completed when 4-inch and 6-inch pipeline sizes were used to provide residential fire protection. New fire protection standards generally require minimum pipe diameters of 8 inches. Fire hydrant spacing in many areas also does not meet current City standards.

Because of the potential for the District to become isolated from the rest of the City's water system, Keller Associates considered such an isolation event when evaluating emergency water supply and storage needs. The District's backup wells are capable of sustaining average day demands (but not peak summer demands) during an extended isolation event. Additionally, the existing storage reservoir is capable of providing volume equivalent to approximately 2,500 gpm of fire protection for a duration of 2 hours. However, if the reservoir is unavailable or damaged, the wells cannot provide adequate fire flow on their own.

Recommendations to address these deficiencies are summarized in the Capital Improvement Plan. For a more complete evaluation of the Charbonneau District system, including facility replacement needs and recommended improvements, please refer to earlier parts of this Chapter 3, Chapter 5, and Appendix F.

4.0 WILLAMETTE RIVER WATER TREATMENT PLANT AND TRANSMISSION PIPELINE

4.1 OVERVIEW

The purpose of this section is to provide a general overview of improvements necessary to attain a 15 mgd treatment capacity at the Willamette River Water Treatment Plant (WRWTP). It is currently anticipated that the total 15 mgd capacity will be divided between the City of Sherwood (5 mgd) and the City of Wilsonville (10 mgd). Under current planning assumptions, a 15 mgd plant production rate is projected to be necessary by 2020. To achieve finish water flows greater than 15 mgd, a more detailed study specific to the WRWTP is needed. In addition to the current plant capacity, the current transmission capacity evaluation results are presented in this chapter.

4.2 WATER TREATMENT PLANT CONSIDERATIONS

The WRWTP was evaluated for both hydraulic and treatment capacity. The following sections summarize the existing capacities and what improvements are necessary to attain a 15 mgd production rate.

4.2.1 Hydraulic Capacity Evaluation

The plant is designed to treat 15 mgd now and up to 70 mgd in the future at the current plant site. Near the existing plant site is a future "upper plant site" which has room to accommodate a 50-mgd plant. Because of these initial design considerations, much of the plant is hydraulically capable of carrying at least 15 mgd and in many cases 70+ mgd. Hydraulic calculations were performed to confirm the original plant hydraulic design as shown on the hydraulic profile. No significant discrepancies were found. The greatest difference was an isolated 1.64 foot difference at the raw water pump station. This comes from the head loss in a check valve on the pump discharge that may have been excluded from the original hydraulic profile. This has only a minor impact with a slight increase in the pumping head condition for the raw water pumps.

The following subsections summarize the hydraulic capacity of the major plant components with respect to the targeted 15 mgd production rate.

Raw Water Intake and Caisson

The caisson is a 48-foot interior diameter containment located directly beneath the raw water pump station. The caisson is approximately 80-feet deep and is fed by a 72-inch diameter river intake line. The intake line extends approximately 350 feet out into the Willamette River and is equipped with two 66-inch diameter intake screens. The rated capacity for the intake screens as presently installed is 70 mgd.

It should be noted that there is some discrepancy on the intake line size. Most of the record drawings indicated the diameter to be 72-inch. However, a 76-inch diameter is reported in the Operations and Maintenance Manual Section 2, as well as on Sheet 2M-1 of the record drawings.

Raw Water Pump Station

The raw water pump station pulls water from the caisson and delivers pressurized water to the plant for treatment. There are presently 4 pumps installed, with pads and piping for an additional 6 pumps in the future. There are three 7.5-mgd pumps and one 4-mgd pump. One of the 7.5-mgd pumps is a constant speed, and the remaining pumps are equipped with variable speed drives. With the largest pump off-line, the raw water pump station can deliver 19 mgd.

Piping

The internal plant piping that conveys water through the treatment process is not a limiting factor in achieving the targeted 15-mgd rate. A typical hydraulic design constraint for piping is to maintain velocities below 8 fps. The pipeline conveying supply from the raw water booster station through most of the plant is a 54-inch diameter line. At flow rate of 15 mgd, the velocity in this line is 1.5 fps. At a flow rate of 70 mgd, the velocity in the line is 6.8 fps. Near the end of the WTP treatment chain, the main pipe diameter increases to 60 inches. This larger size accommodates flows up to 100 mgd before reaching the 8 fps design constraint. The piping is also large enough to eliminate any concern with excessive friction headloss at the design flow rate.

Influent Meter

The influent flow meter is an ABB MagMaster magnetic flow meter. The meter is located immediately downstream of the raw water pump station along the 54-inch in-plant line. As flow approaches the meter, the pipeline is narrowed down to a 24-inch diameter line to increase the velocity and thereby improve the meter’s accuracy. Following the meter, the line is expanded back up to a 54-inch diameter. According to the meter manufacturer’s specifications, the velocity through the meter should be greater than 1.64 ft/second (or 3.3 mgd) for optimal accuracy. At 15 mgd, the velocity in the 24-inch line segment is over 7 ft/second. The maximum flow rate for the meter is specified by the manufacturer at 64 mgd. Manufacturer documentation can be found in Appendix G.

Coagulation / Ozone Contact Basins

Because the ozone contact basins and coagulation units are for treatment only, the hydraulic capacity is not the limiting factor for flows of 15+ mgd. The flow capacity limitations are dependent on the treatment constraints of these units.

Dual Media Filters

There are four filter beds, each with six feet of granular activated carbon atop one foot of sand. The underdrain is an engineered system made of plastic blocks with an integrated media support cap. The filters are operated with a constant head which is controlled by an upstream overflow and a downstream weir. The control design for the filter system is defined as constant rate – level controlled.

Because filters function as treatment, their capacity is limited by treatment considerations rather than hydraulics. High flow rates could be pushed through the filters from a hydraulic perspective, but the process water may not receive the full benefit of the filters. The associated piping and channeling are all designed to carry at least 15 mgd, which is the filtration system's rated treatment capacity.

Clearwell

Hydraulically, the clearwell provides a buffer between variations in the plant's production rate and the City's demand rate. Allowing for 1 foot of freeboard, the usable clearwell volume has been calculated at 2.49 MG using AutoCAD and the original record drawings. There are various volumes reported throughout the available documentation on the clearwell, so some effort was made to calculate the volume more precisely by accounting for the volume of the interior support columns and pipe trough intrusions in the clearwell. This calculated volume also accounts for the design minimum water surface elevation of 103 feet in the clearwell.

At this volume, the pumps can deliver the design rate of 15 mgd for 4.6 hours without inflows from the treatment plant. According to the April 7, 2011 Technical Memo on the Clearwell CT Analysis, the City of Wilsonville's current operational goal is to provide at least 2 hours of emergency storage in the event that plant production ceased.

There are also other storage reservoirs throughout the distribution system that can provide the system's storage need without requiring storage from the clearwell. Refer to the storage evaluation found in Chapter 3 of this report for an in-depth storage analysis for the system.

Treatment constraints which prevent using the full clearwell volume as backup storage are addressed in sub-section 4.2.2 of this report.

High Service Pumps

The high service pump station pulls water from the clearwell and delivers it to the City through a 63-inch diameter transmission line. The pump station consists of four pumps. There is one 4-mgd pump, and three 7.5-mgd pumps. One 7.5-mgd pump is a constant speed pump, and the other pumps are equipped with variable frequency drives. With the largest pump offline, the booster station can still deliver 19 mgd. The high service pump station has plumbing and pads for two future pumps.

In the event of a utility power failure, only one pump (the 4.0-mgd variable speed pump) will be operational. The other pumps are not connected to the plant's emergency power system.

A power failure can also lead to surge conditions if the pumps were to suddenly stop while delivering flows between 12.5 to 15 mgd. More information regarding this surge potential can be found in the City of Wilsonville Hydraulic Transient Analysis technical memorandum dated April 6, 2011. A 750-cubic-foot hydropneumatic tank is recommended for protection against transient surge damage for flows greater than 12.5 mgd.

4.2.2 Treatment Capacity Evaluation

The treatment train in the water treatment plan begins with flash mixing and ends with the clearwell. This section presents the results of a treatment capacity evaluation of the WRWTP. The evaluation is limited to the major plant components and therefore excludes auxiliary systems such as backwash and chemical feed.

Flash Mixing Treatment Capacity

Typical design standards for flash mixing address flow rate, nozzle velocity, and mixing energy to ensure adequate flash mixing performance. The current flash mixing process is adequate and within typical design standards, with the exception of the nozzle velocity.

The recommended nozzle velocity is 20-25 fps. The current maximum nozzle velocity is approximately 11 fps (based on a 1,000-gpm flash-mixing pump rate and a 6.25-inch orifice diameter Distribojet spray nozzle).

If the coagulation and clarification process is working well, no changes are recommended. If some improvement in the coagulation and clarification process is desired, reducing the flash mixing nozzle size may improve the mixing and coagulation conditions.

Coagulation and Clarification Treatment Capacity

This is a proprietary process (Actiflo by Kruger), but is rated by the manufacturer to safely accommodate 15 mgd. The two trains can easily treat 7.5 MG each. According to the manufacturer, one train alone can treat 15 mgd temporarily while the other is out of service. No modifications are anticipated in order to be able reach 15 mgd.

Ozone Treatment Capacity

The treatment plant has two ozone generators, each capable of producing 300 pounds per day (which translates to 2.76 mg/L at a flow rate of 15 mgd). A minimum 95% transfer efficiency is standard design criteria. The transfer efficiency rate is the portion of the ozone produced that actually transfers to the water as a residual concentration. A 95% transfer rate on 2.76 mg/L results in more than enough production to reach the targeted residual of 2.0

mg/L. The generators have a 10:1 turn down ratio, so as little as 30 ppd could be produced to accommodate lower plant flow rates.

The intermediate ozone system is intended to provide additional inactivation of Giardia, viruses, and cryptosporidium beyond what is required by state and federal regulations. Ozone can also help minimize aesthetic pollutants that cause taste and odor.

The current operational goal at the plant is to provide a 1-log inactivation of Cryptosporidium with the ozone. In order to achieve inactivation through disinfection, a specific contact time or CT value is needed (where C=residual disinfectant concentration, and T=contact time). The CT is the disinfectant concentration multiplied by effective contact time. By EPA's current standards, the effective contact time in the CT calculation is the time at which 10% of the inlet concentration is observed at the outlet, or commonly referred to as the T_{10}.

According to the EPA CT tables, a 1-log inactivation can be achieved during the summer (15°C design temp) with a CT of 6.2 and during the winter (4.1°C design temp) with a CT of 17.5. With a target concentration of 2.0 mg/L, the T_{10} summer would need to be 3.1 minutes. The T_{10} winter would need to be 8.75 minutes.

The design hydraulic residence time (HRT) in each of the two contact basin trains is 14.5 minutes at 7.5 mgd per train (for a total of 15 mgd). This means the hydraulic efficiency factor (calculated as T_{10}/HRT) for the basins would need to be at least 0.6 in order to achieve the desired CT.

The hydraulic efficiency factor has not yet been determined for the basins. However, the arrangement of the baffles and the geometry of the basins are such that 0.6 is likely achievable. Regardless, this value should be verified with a tracer study and computer modeling.

In summary, the ozone treatment capacity appears to be sufficient to treat up 15 mgd; however, the T_{10}/HRT factor for each contact basin has yet to be verified. The EPA guidance manual recommends that the highest tracer study test flow rate used to determine hydraulic efficiently be at least 91% of the maximum flow rate anticipated in the clearwell. With this standard in mind, the basins will need to have a tracer study performed at a flow rate of at least 6.8 mgd.

Dual Media Filters Treatment Capacity

There are two bays of two filter beds each for a total of four filter beds. The empty bed contact time is 7.5 minutes at the design flow rate of 6 gallons per minute per square foot (gpm/sf). The filter rate can safely increase up to 8 gpm/sf to accommodate one filter out of service. In pilot testing, the filters reliably treated water to plant operation goals up to 12 gpm/sf. Each filter has a treatment capacity of 4 mgd based on 6 gpm/sf, for a total of 16 mgd for four filters.

Clearwell Treatment Capacity

The clearwell functions both as an operational water storage facility and as a finishing disinfection contact chamber. From the total available storage volume, the clearwell provides operational volume and CT volume. Operational storage is used for backwashing the plant filters, other miscellaneous potable uses at the plant, and distribution system demands beyond the plant's production capacity or to provide water during a plant outage. Under current operations, the storage volume is also used to provide for system demands during the night when the plant is off-line. The current operating policy established by the City requires a reserve volume equal to a minimum of two hours at the design maximum flow rate.

Because the storage volume component fluctuates throughout the day, it cannot be counted on to provide the necessary volume for achieving contact time. Therefore, a minimum CT volume must be maintained at all times in order to achieve the required disinfection.

It is important to recognize that the clearwell is the second disinfection process in the WRWTP. The first disinfection process occurs in the ozone contact chambers discussed in this chapter. By EPA standards, only one of these disinfection processes is necessary. However, Oregon regulations do not recognize disinfection before filtration (OAR 333-061-0050). Therefore, the disinfection provided by the ozone contact chambers located upstream of the filters is not formally acknowledged by Oregon regulations despite the fact that the actual benefit of the disinfection is provided.

Just as it is with the ozone contact chambers, the clearwell's disinfection capacity is measured by CT. The CT in the clearwell was recently evaluated and the results were reported in the *CT Analysis Technical Memorandum* (CT Memo) prepared by MWH dated April 7, 2011.

The analysis in the CT Memo is based on assumptions of total contact volume, operating storage requirements, residual chlorine concentration, finish water pH, and hydraulic efficiency. Each of these factors ultimately determines the treatment capacity of the clearwell, and therefore the production capacity of the plant.

Based on the assumptions stated in the CT Memo (pg. 5), the current clearwell capacity is 15 mgd in the summer and 10 mgd in the winter. These parameters are summarized in Table 4.1.

TABLE 4.1 – CT Analysis 1: Summer and Winter

Parameter	Summer/Winter Value	Units	Comments
Total Available Storage Volume	2.9	MG	Accounts for 1-foot freeboard
CT Required	18/39	mg·min/L	Provides 0.5 log Giardia inactivation at given temp (15°C/4°C) and pH (8.0)
C Value	1.0	mg/L	Free chlorine concentration in clear well
Minimum T_{10} Required	18/39	min	Contact time needed to achieve CT
Ratio of T_{10} to HRT	0.16	-	Factor accounts for higher flow rates and conservative assumptions
Minimum HRT Required	111/242	min	Hydraulic residence time needed to achieve CT
Minimum Clearwell Volume	1.16/1.7	MG	Volume in clearwell needed to achieve CT at maximum production rate while meeting operational storage requirement of 2 hours.
Operational Storage Available	1.6/1.1	MG	Volume available to meet the required 2-hour operational storage (Total available volume-Minimum CT volume)
Operational Storage Time at Maximum Flow Rate	2.5/2.6	hrs	Hours of maximum flow rate available from operational storage
Maximum Flow Rate	15/10	mgd	This is the production capacity of the WRWTP and the treatment capacity of the clearwell.

Another analysis presented in the CT Memo (pg. 5) changed the contact time volume to include the volume of the 63-inch transmission line leading from the clearwell to the distribution system turnout at Brockway Drive. Under this analysis, the clearwell capacity is 24.1 mgd in the summer and 15.4 mgd in the winter. As stated in the memo, this would require the installation of a chlorine residual analyzer at Brockway, and temperature and pH probes along the transmission line route. In addition to these items, this option would require the installation of an 8-inch diameter, 1,200-foot return line from the Brockway turnout back to the WRWTP for on-site culinary use.

Yet another analysis presented in the CT Memo (pg. 6) looked at adjusting the finish water pH from the current 8.0 down to 7.5. This would result in a clearwell capacity of 18.6 mgd in the summer and 12.3 mgd in the winter.

Other options presented in the CT Memo for increasing the current clearwell capacity included adding baffling to the clearwell interior to improve the hydraulic efficiency, incorporating UV disinfection after filtration, and pursuing a change to Oregon's post-filtration disinfection regulation which is more stringent than the United States Safe Drinking Water Act.

For the purposes of this master plan, the clearwell assumptions were revisited and analyses were performed using different design assumptions. One of the factors revisited was the total available volume in the current clearwell. After reviewing the original plant record drawings and applying a 1-foot freeboard, it is calculated that the available clearwell volume is approximately 2.5 MG as opposed to the previously assumed 2.9 MG (*Willamette River WTP Operations and Maintenance Manual*, Section 6, pg 6-1).

Another design assumption is the hydraulic efficiency factor or the T_{10}/HRT. A tracer study was completed on the WRWTP clearwell in 2003 to discover how quickly water can pass from the clearwell inlet to the outlet, and therefore how much time the disinfectant in the clearwell has to act on the water. T_{10} represents the time for 10% of the tracer to pass through, while T_{90} is the time at which 90% of the inlet concentration is observed at the outlet. The T_{10} is commonly used as the T in the CT calculation.

The 2003 tracer study resulted in a ratio of the T_{10} over the theoretical residence time (also referred to as the hydraulic residence time or HRT) of 0.16. Previously, this ratio has been used to calculate the required CT volume for flow rates up to 35 mgd, and thereby determine the treatment capacity of the clearwell. However, there are some potential problems with using this ratio in such a manner.

The EPA *Guidance Manual on Disinfection Profiling and Benchmarking* states that the relationship between detention time and flow is proportional but not generally a linear function (USEPA, May 2003, Appendix E.2). In simple terms, this means that the T_{10} ratio will be different for different flow rates. In fact, data from the WRWTP tracer study reveals a T_{10} to HRT ratio of 0.16 at 6,000 gpm, and a T_{10} to HRT ratio of 0.22 at 3,000 gpm. The highest flow rate used to develop the 0.16 factor was 8.6 mgd. Therefore, according to the EPA criteria for tracer study flow rates, the factor of 0.16 T_{10} to HRT should not be applied to flows higher than 9.5 mgd. In order to obtain an acceptable T_{10} to HRT ratio for a design flow of 15 mgd, the tests would need to be performed for flows of at least 9,500 gpm.

Moreover, recent research suggests that using the T_{10} to HRT factor will overestimate the contact time (*Evaluation of Hydraulic Efficiency of Disinfection Systems Based on Residence Time Distribution Curves*, Wilson and Venayagamoorthy, 2010). According to this research, Computational Fluid Dynamic (CFD) modeling will provide the best accuracy in determining the hydraulic efficiency of a clearwell. Alternatively, using at least a T_{10}/ T_{90} ratio will more closely approximate the contact time than the current standard practice. As an example, the original tracer study data on the WRWTP clearwell suggests that the T_{10}/ T_{90} ratio is 0.07, as opposed to 0.16 for the T_{10} to HRT ratio. In short, using the T_{10}/ T_{90} ratio as the hydraulic efficiency factor is more conservative than the current EPA and industry standard of using the T_{10}/ HRT ratio.

Without the benefits of a tracer study at higher flow rates or CFD modeling, it is impossible to determine the actual hydraulic efficiency factor of the clearwell. Analyses were performed using more conservative hydraulic efficiency factors to evaluate the potential impact on the clearwell's capacity, and consequently the WRWTP's capacity.

EPA's minimum hydraulic efficiency factor of 0.10 is defined as typical for unbaffled clearwell conditions such as the clearwell in the WRWTP (EPA *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, Appendix C, Table C-5).

After accounting for the change in the total available volume and hydraulic efficiency factor, the resulting capacity of the clearwell is 12 mgd for the summer (as opposed to the previously assumed 15 mgd) and 7 mgd for the winter (as opposed to the previously assumed 10 mgd) with a chlorine dose of 1 mg/L and a pH of 8.0. Table 4.2 summarizes the values discussed in this section.

TABLE 4.2 – CT Analysis 2: Summer and Winter

Parameter	Summer/Winter Value	Units	Comments
Total Available Storage Volume	2.5	MG	Accounts for 1-foot freeboard
CT Required	18/39	mg·min/L	Provides 0.5 log Giardia inactivation at given temp (15°C/4°C) and pH (8.0)
C Value	1.0	mg/L	Free chlorine concentration in clear well
Minimum T_{10} Required	18/39	min	Contact time needed to achieve CT
Ratio of T_{10} to HRT	0.1	-	Factor accounts for higher flow rates and conservative assumptions
Minimum HRT Required	180/390	min	Hydraulic residence time needed to achieve CT
Minimum Clearwell Volume	1.50/1.91	MG	Volume in clearwell needed to achieve CT at maximum production rate while meeting operational storage requirement of 2 hours.
Operational Storage Available	1.0/0.59	MG	Volume available to meet the required 2-hour operational storage (Total available volume-Minimum CT volume)
Operational Storage Time at Maximum Flow Rate	2	hrs	Hours of maximum flow rate available from operational storage
Maximum Flow Rate	12/7	mgd	This is the production capacity of the WRTP based on the limiting factors on the clearwell.

An alternative analysis performed in connection with this study evaluated the effect of reducing the operating storage requirement from 2 hours at maximum production rate to a reasonable minimum of what is needed for plant operations only. This allows the gravity controlled reservoirs in the distribution system to provide for system demands during plant outages or peak demands. Relying on distribution system storage for distribution system demands is more efficient and streamlined than pumping storage from the treatment plant's clearwell. All pressure zones in the distribution system currently have the capability to be supplied by a gravity reservoir. The reservoir storage volumes will likely need to be expanded as demands grow, but this will be part of the distribution system improvements and not the water treatment plant improvements.

The largest use for treated operational volume at the treatment plant is filter backwash. Because the clearwell is the source for filter backwash water, the operational storage volume maintained in the clearwell at the plant could be based on the maximum filter backwash rate and duration.

One filter can be backwashed at a time without sacrificing the combined 16 mgd filtration rate, because the flow rate to the active filters can be increased from 4 mgd to 5.33 mgd for short periods of time. At a plant production rate of 15 mgd, only one filter at a time would require a backwashing. An operations-based storage volume could be as outlined in Table 4.3.

TABLE 4.3 – Plant Operational Volume in Clearwell

Parameter	Value
Backwash Rate 1 (gpm/sf)	6
Backwash Rate 2 (gpm/sf)	18
Backwash Duration for Rate 1 (min)	5
Backwash Duration for Rate 2 (min)	8
Single Filter Area (sf)	463
Backwash Volume for One Filter (MG)	0.08
% Additional Volume for Other Plant Needs (assumed as % of backwash volume)	25
Safety Factor	3
Total Operational Volume in Clearwell (MG)	**0.30**

Under this analysis, the operational storage component is reduced to 0.30 MG from the previously assumed 1.25 MG. Table 4.4 summarizes the impact on the clearwell treatment capacity.

TABLE 4.4 – CT Analysis 3: Summer and Winter

Parameter	Summer/Winter Value	Units	Comments
Total Available Storage Volume	2.5	MG	Accounts for 1-foot freeboard
CT Required	18/39	mg·min/L	Provides 0.5 log Giardia inactivation at given temp (15°C/4°C) and pH (8.0)
C Value	1.0	mg/L	Free chlorine concentration in clear well
Minimum T_{10} Required	18/39	min	Contact time needed to achieve CT
Ratio of T_{10} to HRT	0.1	-	Factor accounts for higher flow rates and conservative assumptions
Minimum HRT Required	180/390	min	Hydraulic residence time needed to achieve CT
Minimum Clearwell Volume	2.5/2.5	MG	Volume in clearwell needed to achieve CT at maximum production rate while meeting operational storage requirement of 0.3 MG.
Operational Storage Available	0.3/0.3	MG	Volume available to meet the required 2-hour operational storage (Total available volume-Minimum CT volume)
Maximum Flow Rate	17.5/8.1	mgd	This is the treatment capacity of the clearwell. The plant may have other limiting factors.

As seen in this analysis, modification of the operational storage requirement frees up storage volume in the clearwell to meet the CT storage requirements despite the more conservative design assumptions of a reduced volume and a lower hydraulic efficiency. With these design assumptions in place, the targeted 15 mgd plant production rate could be supported with volume to spare in the clearwell.

Other design assumptions that could also affect the clearwell disinfection capacity would include a more conservative hydraulic efficiency factor (T_{10}/T_{90}), an increased chlorine residual concentration (>0.1 mg/L), and the effects of an internal clearwell mixing machine.

An analysis using the more conservative T_{10}/T_{90} ratio as the hydraulic efficiency factor for the clearwell was not performed due to the tracer study flows being too low to apply to the targeted 15 mgd plant production rate. This may be a possibility after a new tracer study is completed.

Although not commonly used, an internal clearwell mixing machine may be a means of improving the CT. An analysis of an internal clearwell mixing machine would be specific to the device and would be best performed by the manufacturer through modeling or other means. This analysis is similar to the baffling option presented in the CT Memo in that it would improve the T_{10} in the clearwell and effectively raise the hydraulic efficiency factor.

An analysis of increased chlorine was not performed due to the probable aesthetic water quality impacts.

4.3 TRANSMISSION PIPELINE CONSIDERATIONS

The purpose of the transmission line is to convey water to the system with minimal head loss (to avoid excess pumping costs) and moderate velocity (to avoid system surges and undue stress). Typically, velocities should be less than 8 fps and head loss should be as low as possible, but certainly no more than 10 psi from the treatment plant to the distribution system.

The nearly 4,000-foot, 63-inch steel transmission line from the plant to the distribution system can carry 15 mgd with negligible head loss and 1 fps velocity. At 70 mgd (build-out of the lower site), the transmission would lose less than 2 psi and the velocity would be about 5 fps. At 120 mgd (build-out of the upper and lower site), the transmission would lose less than 5 psi and the velocity would be just under 9 fps.

At Wilsonville Road, the 63-inch transmission line from the WRWTP wyes to two 48-inch transmission lines. Each of the 48-inch steel lines has a design capacity of 40 mgd (5-fps velocity). Currently only one of these 48-inch transmission lines is installed. The final connecting section of this transmission line is currently under design. When completed, this line will carry supply northwest to Sherwood and other turnouts to the Wilsonville distribution system.

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5.0 CAPITAL IMPROVEMENT PLAN

5.1 OVERVIEW

The capital improvement plan is presented in this section. Each improvement is recommended as a means for addressing existing or future needs in the water system. The necessary improvements were identified by evaluating the various system components against the evaluation criteria established in Chapter 3 of this report, as well as local, state, and federal standards.

Priority 1A improvements are those that will likely happen within the next five years, while Priority 1B will occur within the next ten years. These may include projects that improve fire flows that are currently less than 1,000 gpm, or projects that are related to current developments and city-identified priority improvements.

Priority 2 improvements are those that will likely happen within the next twenty years. These include projects that improve fire flows that are currently greater than 1,000 gpm but less than 1,500 gpm. They also be development driven or City-led projects that are considered near-term. Hydrants needed for residential area coverage not tied to a Priority 1 improvement, are considered Priority 2.

Priority 3 improvements are those that will happen as development or redevelopment occurs. These may or may not occur within the 20- year planning horizon. These also include improvements intended to correct marginal fire flow failures or poor hydrant coverage in developed industrial and commercial areas. Other Priority 3 improvements are intended to provide water to currently unserviced areas.

Table 5.2 contains the recommended improvements for the system components of supply, storage, and distribution for the respective priorities. The numeric identifier assigned to the improvements corresponds to the capital improvement plan map found in Appendix A, Figure 4. The primary purpose for the recommended improvements is also noted in the capital improvement tables. The following legend (Table 5.1) summarizes the primary purposes.

TABLE 5.1 – Improvement Primary Purpose Legend

Primary Purpose	Explanation Legend
Compliance	An improvement needed to correct an existing condition that is out of compliance with a federal, state, or local regulations
Operations	An improvement that addresses a component's interaction with other components in the system.
Maintenance	An improvement addressing a recurring or chronic maintenance problem. May also be a standard maintenance task.
Replacement	Replacement of a component that is beyond its useful life, undersized, etc.
Growth	Improvements that are necessary due primarily to growth.
Fire Flow	Improvements necessary to provide the targeted fire flow.
Water Quality	Improve the water quality.
Hydrant Coverage	Improve accessibility of fire hydrants to water service area.

The various improvements listed in the capital improvement plan may have a portion of the cost attributed to future growth because they are, at least in part, intended to benefit growth. Where this is the case, the incoming development or redevelopment is responsible for the growth portion of the cost. To assist in future system development charge evaluations, Keller Associates has estimated the portion of the improvement cost that could be attributed to growth.

Each improvement is accompanied by an opinion of probable cost. This is a planning level estimate, based on unit pricing and project budgeting numbers provided by the City. More accurate cost estimates should be obtained at the time of preliminary design for the specific project. Additional details of the cost breakdown for each of the improvements can be found in Appendix E.

Based on the demand projections in this study, water treatment plant expansions may be needed around 2020. However, it should be noted that the capital improvement plan presented in this section contains only those treatment plant improvements necessary to achieve a 15 mgd production rate. For higher rates, a separate master plan is needed, and must be completed before the City's long-range capital improvement plan and associated Rate Study can be determined. These tasks (Treatment Plant Master Plan, and Rate Study) are planned to occur in the next two years.

Additional capital expenses associated with major repairs and replacements of existing water facilities are summarized in Chapter 6.

TABLE 5.2 – Priority Capital Improvements

ID#**	Item	Primary Purpose	Total Estimated Cost	Growth Apportionment		Operating Fund	Additional Annual O&M
				%	Cost		
Priority 1A Improvements (by 2017)							
Water Supply							
106	Portable Flow Meter (for well tests)	Operations	$ 13,000	0%	$ -	$ 13,000	$ 1,360
Water Treatment and Transmission							
	Surge Tank	Operations	$ 170,000	100%	$ 170,000	$ -	$ 960
	Clearwell Improvements (assume policy change)	Operations	$ -	100%	$ -	$ -	
Water Storage							
121	C Level Reservoir Security and Sampling Improvements	Operations	$ 18,000	0%	$ -	$ 18,000	$ 640
123	Charbonneau Reservoir Chlorine Monitoring	Operations	$ 7,000	0%	$ -	$ 7,000	$ 960
124	Automated Valve at Tooze/Westfall (West Side Tank)	Operations	$ 58,000	100%	$ 58,000	$ -	$ 580
125	3.0 Million Gallon West Side Tank and 24-inch Transmission (in Pre-design)*	*Growth*	$ 5,840,000	100%	$ 5,840,000	$ -	$ 17,160
126	Elligsen West Tank - Add Altitude Valve	Operations	$ 31,000	100%	$ 31,000	$ -	$ 580
Booster Stations & Turnouts							
140	Charbonneau Booster PRV & SCADA	Operations	$ 22,000	20%	$ 4,400	$ 17,600	$ 920
Water Distribution Piping							
163	18-inch Loop on Barber St. (Montebello to Kinsman)	Growth	$ 371,000	100%	$ 371,000	$ -	$ 320
165	48-inch Transmission on Kinsman St. - Barber to Boeckman (in Design)*	*Growth*	$ 3,960,000	100%	$ 3,960,000	$ -	$ 3,000
	Total Priority 1A Improvements		**$ 10,490,000**		**$ 10,434,400**	**$ 55,600**	**$ 26,480**
Priority 1B Improvements (by 2022)							
Water Supply							
110	Nike Well Telemetry & Misc. Improvements	Operations	$ 35,000	32%	$ 11,300	$ 23,700	$ 420
111	Wiedeman Well Generator & Telemetry	Operations	$ 98,000	12%	$ 11,300	$ 86,700	$ 2,460
112	Boeckman Well Telemetry Upgrade	Operations	$ 26,000	43%	$ 11,300	$ 14,700	$ 420
113	Gesellschaft SCADA & Instrumentation	Operations	$ 32,500	35%	$ 11,300	$ 21,200	$ 420
114	Elligsen Well Instrumentation	Operations	$ 20,000	29%	$ 5,700	$ 14,300	$ 120
Booster Stations & Turnouts							
143	Charbonneau Booster Flow Meter Vault	Replacement/ Operations	$ 29,000	54%	$ 15,700	$ 13,300	$ 380
Water Distribution Piping							
160	8-inch Upgrade on Jackson St.	Fire Flow	$ 64,000	0%	$ -	$ 64,000	$ 100
161	8-inch Upgrade on Evergreen St.	Fire Flow	$ 83,000	0%	$ -	$ 83,000	$ 200
162	8-inch Loop N. of Seely St.	Fire Flow	$ 8,000	0%	$ -	$ 8,000	$ 100
164	10-inch Extension on Montebello St.	Growth (School)	$ 217,000	100%	$ 217,000	$ -	$ 400
166	8-inch Loop between Boberg St. & RR (north of Barber)	Fire Flow	$ 78,000	0%	$ -	$ 78,000	$ 200
167	8-inch Loop on Boones Ferry (north of Barber)	Operations	$ 19,000	0%	$ -	$ 19,000	$ 100
168	10-inch Loop (Appts E. of Canyon Creek/Burns)	Fire Flow	$ 41,000	0%	$ -	$ 41,000	$ 100
169	8-inch Loop between Vlahos & Canyon Creek	Fire Flow	$ 42,000	0%	$ -	$ 42,000	$ 100
170	8-inch Upgrade on Metolius cul-de-sac	Fire Flow	$ 54,000	0%	$ -	$ 54,000	$ 100
171	8-inch Loop on Metolius private drive	Operations	$ 20,000	0%	$ -	$ 20,000	$ 100
172	8-inch Upgrade on Middle Greens	Hydrant Coverage	$ 68,000	0%	$ -	$ 68,000	$ 200
173	Fairway Village Hydrant on French Prairie	Hydrant Coverage	$ 10,000	0%	$ -	$ 10,000	$ 100
175	16-inch Willamette River Crossing to Charbonneau District	Displace Charb. Tank	$ 1,532,000	0%	$ -	$ 1,532,000	$ 3,600
	Total Priority 1B Improvements		**$ 2,476,500**		**$ 283,600**	**$ 2,192,900**	**$ 9,620**

* Needed projects previously identified in 2002 Water Master Plan, but not yet completed

** Colored/Bold ID #s are mapped on Figure 4 in Appendix A for reference

NOTE: Costs are in 2012 dollars

TABLE 5.2 – Priority Capital Improvements (Continued)

ID#**	Item	Primary Purpose	Total Estimated Cost	Growth Apportionment		Operating Fund	Additional Annual O&M
				%	Cost		
Priority 2 Improvements (by 2030)							
Water Supply							
203	Gesellschaft Well Generator	Operations	$ 78,000	0%	$ -	$ 78,000	$ 2,160
205	Charbonneau Well Mechanical Building	Operations	$ 81,000	0%	$ -	$ 81,000	$ 1,800
	Video Surveillance (various wells)	Operations	$ 22,000	0%	$ -	$ 22,000	$ 3,000
Booster Stations & Turnouts							
241	Meter Valve at Wilsonville Rd turnout	Operations	$ 118,000	0%	$ -	$ 118,000	$ 980
Water Distribution Piping							
260	10-inch Extension on 4th St. (E. of Fir)	Fire Flow	$ 69,000	7%	$ 4,900	$ 64,100	$ 200
261	8-inch Loop - Magnolia to Tauchman	Fire Flow	$ 59,000	0%	$ -	$ 59,000	$ 100
262	8-inch Upsize on Olympic cul-de-sac	Fire Flow	$ 44,000	0%	$ -	$ 44,000	$ 100
263	8-inch Loop near Kinsman/Wilsonville	Fire Flow	$ 36,000	0%	$ -	$ 36,000	$ 100
264	10-inch Loop near Kinsman/Gaylord	Fire Flow	$ 82,000	6%	$ 5,200	$ 76,800	$ 200
265	8-inch Upsize on Lancelot	Fire Flow	$ 100,000	0%	$ -	$ 100,000	$ 200
266	Fire Hydrants (main City)	Fire Flow	$ 119,000	0%	$ -	$ 119,000	$ 200
267	Fire Hydrants (Charbonneau)	Fire Flow	$ 46,000	0%	$ -	$ 46,000	$ 100
268	8-inch Loop near Kinsman (between Barber & Boeckman)	Fire Flow	$ 126,000	0%	$ -	$ 126,000	$ 200
269	8-inch Upsize near St. Helens	Fire Flow	$ 26,000	0%	$ -	$ 26,000	$ 100
270	8-inch Loop near Parkway Center/Burns	Fire Flow	$ 66,000	0%	$ -	$ 66,000	$ 100
271	8-inch Loop near Burns/Canyon Creek	Fire Flow	$ 110,000	0%	$ -	$ 110,000	$ 200
272	10 & 8-inch Loop near Parkway/Boeckman	Fire Flow	$ 315,000	4%	$ 12,600	$ 302,400	$ 500
273	12-inch Loop crossing Boeckman	Water Quality	$ 16,000	0%	$ -	$ 16,000	$ 100
274	8-inch Loop at Holly/Parkway	Water Quality	$ 56,000	0%	$ -	$ 56,000	$ 100
275	8-inch Upsize on Wallowa	Fire Flow	$ 62,000	0%	$ -	$ 62,000	$ 100
276	8-inch Upsize on Miami	Fire Flow	$ 68,000	0%	$ -	$ 68,000	$ 200
277	8-inch Extension for hydrant coverage on Lake Bluff	Hydrant Coverage	$ 63,000	0%	$ -	$ 63,000	$ 100
278	8-inch Upsize on Arbor Glen	Hydrant Coverage	$ 92,000	0%	$ -	$ 92,000	$ 200
279	8-inch Loop at Fairway Village	Fire Flow	$ 42,000	0%	$ -	$ 42,000	$ 100
280	8-inch Extension for fire flow - private drive/Boones Bend	Fire Flow	$ 18,000	0%	$ -	$ 18,000	$ 100
281	8-inch Upsize on East Lake	Fire Flow/Hydrant	$ 187,000	0%	$ -	$ 187,000	$ 300
282	8-inch Extension for fire flow on Armitage Pl	Fire Flow	$ 55,000	0%	$ -	$ 55,000	$ 100
283	8-inch Upsize on Lake Point Ct	Hydrant Coverage	$ 56,000	0%	$ -	$ 56,000	$ 100
284	8-inch Loop - Franklin St to Carriage Estates	Water Quality	$ 94,000	0%	$ -	$ 94,000	$ 200
285	8-inch Upgrade on Boones Ferry Rd (south of 2nd St)	Replace/Upsize	$ 44,000	0%	$ -	$ 44,000	$ 100
286	Valves at Commerce Circle & Ridder Rd/Boones Ferry I-5 Crossing	Operations	$ 44,000	0%	$ -	$ 44,000	$ 100
	Total Priority 2 Improvements		**$ 2,394,000**		**$ 22,700**	**$ 2,371,300**	**$ 12,140**
Priority 3 Development Dependent Improvements (by Build-out)							
Water Distribution Piping							
361	Zone D Booster Station at C Level Tank	Growth	$ 609,000	100%	$ 609,000	$ -	$ 11,000
362	Upsize costs (greater than 8 inches) for future distribution piping	Growth	$ 9,659,000	100%	$ 9,659,000	$ -	$ 39,120
	Total Priority 3 Improvements		**$ 10,268,000**		**$ 10,268,000**	**$ -**	**$ 50,120**
TOTAL CAPITAL IMPROVEMENTS (Priority 1-3)			**$ 25,628,500**		**$21,008,700**	**$ 4,619,800**	**$ 98,360**

* Needed projects previously identified in 2002 Water Master Plan, but not yet completed.

** Colored/Bold ID #s are mapped on Figure 4 in Appendix A for reference

NOTE: Costs are in 2012 dollars

6.0 OPERATIONS, MAINTENANCE, AND REPLACEMENT RECOMMENDATIONS

6.1 OVERVIEW

The City of Wilsonville was recently designated by the Oregon Health Authority, Drinking Water Program as an Outstanding Performer. Keller Associates also acknowledges the efforts of City staff to maintain a quality system.

This section highlights operational and maintenance related recommendations intended to improve or maintain the level of services as it pertains to the City's water distribution system, including booster pumping facilities, PRV stations, storage facilities, pipelines, valves, hydrants, well facilities, and controls. This section also summarizes major repairs and replacements anticipated within the 20-year planning period and provides recommended budgets for annual/recurring maintenance related activities. Operation and maintenance recommendations for the treatment plant are not included in this evaluation.

6.2 MAJOR REPAIRS AND REPLACEMENTS

In addition to the capital improvement projects identified in Chapter 5, Keller Associate identified several major repairs and replacements which are summarized in Table 6.1 (see also Figure 4, Appendix A). These have been organized by priority based on when the improvements are needed.

6.3 ONGOING AND ANNUAL MAINTENANCE COSTS

There are several larger routine maintenance activities, recurring system management related projects, and ongoing replacement/rehabilitation activities that are recommended on an annual or recurring basis. These activities are summarized in Table 6.2. Additional discussion about operational and maintenance activities is presented in the following sections.

TABLE 6.1 – Major Repairs and Replacements

ID#*	Item	Primary Purpose	Total Estimated Cost
Priority 1A (by 2017)			
Water Supply			
100	Nike Well Rehab & Misc. Maintenance	Maintenance	$ 30,000
101	Canyon Creek Well (assumes potential abandonment)	Maintenance	$ 26,000
102	Wiedeman Well Misc. Maintenance	Maintenance	$ 24,000
103	Boeckman Well Rehab Pump	Maintenance	$ 20,000
104	Gesellschaft Building Maintenance	Maintenance	$ 4,500
105	Elligsen Well Compressor & Controls	Maintenance	$ 8,000
Water Storage			
120	Elligsen Res. - Replace Ladder Fall Protection System	Replacement	$ 12,000
123	Charbonneau Reservoir Reseal between Roof and Wall	Maintenance	$ 4,000
Booster Stations & Turnouts			
141	B to C Booster Replacements	Replacement	$ 21,000
142	Painting & Safety Nets at Turnouts	Maintenance	$ 22,000
Priority 1B (by 2022)			
Water Storage			
127	Replace Sealant at Base of C Level Reservoir	Maintenance	$ 7,000
Booster Stations & Turnouts			
144	Replace Cover on Burns PRV	Replacement	$ 9,000
Priority 2 (by 2030)			
Water Supply			
200	Nike Well New Roof and Trim, Paint	Maintenance	$ 13,000
201	Wiedeman Well Replace Metal Siding	Maintenance	$ 20,000
202	Boeckman Well Pump Motor & Replace Roof and Trim	Replacement/ Maintenance	$ 21,000
203	Gesellschaft Well Roof Maintenance	Maintenance	$ 4,000
204	Elligsen Well MCC Replacement & Building Maintenance	Replacement/ Maintenance	$ 22,000
Water Distribution Piping			
287	Replace service lines - Parkway Ave	Replacement	$ 77,000
288	Replace service lines - Wilson cul-de-sacs	Replacement	$ 227,000
289	Replace service lines - Mariners Drive	Replacement	$ 22,000
290	Replace service lines - Old Town	Replacement	$ 15,000
Water Storage			
220	Paint Elligsen Reservoirs (interior)	Maintenance	$ 460,000
221	Paint C Level Reservoir (interior)	Maintenance	$ 180,000
Booster Stations & Turnouts			
240	Relocate Parkway PRV out of Elligsen Rd intersection	Replacement	$ 75,000
Future (beyond 2030)			
Water Supply			
300	Nike Well - Replace MCC	Replacement	$ 15,000
301	Wiedeman Well MCC & Building Maintenance	Maintenance	$ 18,000
302	Gesellschaft Well Building Maintenance	Maintenance	$ 5,000
Water Storage			
320	Paint Elligsen Reservoirs (exterior)	Maintenance	$ 310,000
321	Paint C Level Reservoir (exterior)	Maintenance	$ 115,000
	TOTAL MAJOR REPAIRS AND REPLACEMENTS		**$ 1,786,500**

* Colored/Bold ID #s are mapped on Figure 4 in Appendix A for reference

NOTE: Costs are in 2012 dollars

TABLE 6.2 – Recurring Maintenance Costs

Activity	Budget	Frequency
Wash exterior of aboveground tanks	$5,000/each	Every 5 years
Clean and inspect interior of tanks	$5,000/each	Every 10 years
Pipeline and valve replacement (coordinate with planned street improvements, 1725 feet/year)	$ 173,000	Annual recommended budget for 20-year planning period
Meter replacement (250 meters/year)	$ 50,000	Annual recommended budget (assumes 20-year life)
Hydrant replacement (10 hydrants/year)	$ 30,000	Annual recommended budget
Well hole and facility upgrades/maintenance	$95,000-$105,000	Annual budget (includes 6 wells)
GIS and water model updates	$ 6,000	Recommended annual budget for 3rd party support
Water Master Plan update	$ 150,000	Every 5 years
Water Management and Conservation Plan (WMCP)	$ 20,000	Every 10 years, beginning 2022
WMCP progress reports	$ 5,000	Every 10 years, beginning 2017

6.4 BOOSTER PUMP STATIONS

The B to C Level Booster Pump Station is relatively new (constructed in 1999) and appears to be well maintained. Operation and maintenance related improvements include replacing the exhaust system for the generator and eventually upgrading the chlorine injection pump system to current model (refer to Technical Memorandum No. 1, Appendix B for additional details). Keller Associates recommends that the operations and maintenance manual be periodically updated and that the manufacturer's recommendations be followed for all equipment. Additionally, the City should ensure that each pump is exercised at least monthly and that pump performance is monitored.

The Charbonneau Booster Pump Station is much older than the B to C Level Booster Pump Station. The SCADA system does not currently turn on the booster pumps in the event of a low-pressure event (such as a fire). Automating this process would ensure that water would be provided in the event that the supply pipeline from the distribution system is out of service or not adequate to supply peak fire demands. Keller Associates recommends that the SCADA controls be upgraded to allow this flexibility and that this "alternate" control scenario be periodically tested. This improvement should be coordinated with the recommendation to provide a pressure relief to the pressure zone. The proposed new flow meter and system pressure readings should be integrated into the City's SCADA system. The meter readings should periodically be compared to the total of the individual water meters to quantify unaccounted for water within the District service area.

6.5 TANK FACILITIES

Maintenance recommendations for the tank facilities were also identified in Technical Memorandum No. 1. The exterior of each of the three aboveground reservoirs should be cleaned about every 5 years. Interior cleaning and inspection of each of the four reservoirs should occur every 10 years. Capital improvements recommended in the Technical Memorandum No. 1 will also ensure that the City's assets are maintained.

Keller Associates further recommends that the City look closely at controls in planning and designing the new West Side tank. During portions of the year, the City may want to increase the volume between pump on and off set points. This will ensure a higher tank turnover which will reduce the potential for water stagnation. Because of differences in locations, size and transmission piping, it is likely that the new water tank will not fill at the same rate as the Elligsen tanks. Altitude valves may be needed at the new tank site and potentially at the existing Elligsen tanks. Special care should be taken so that any added control valves would be installed in such a way as to mitigate the potential of creating system pressure surges.

6.6 DISTRIBUTION SYSTEM

Flushing

The City currently has an active flushing program. The program could be enhanced by developing a directional flushing program, which is a systematic approach to exercising valves and hydrants in a way that encourages water to be flushed from one side of the system to the other.

Valve Exercise

All valves should be exercised at least annually.

Pressure Reducing Valves

Pressure reducing valve settings should be checked every 6 to 12 months. The valves should also be refurbished every 2 to 5 years as needed.

Leak Detection

The City currently has an active leak detection and elimination program which should continue as long as unaccounted for water loss exceeds 10 percent of the City's total finish water production.

Meter Testing Program

The City should continue their program of regularly testing and replacing (as required) large diameter flow meters on a 3-year cycle. The City should also begin testing residential meters beginning with 100± meters per year. Records should be kept reporting meter ID, age, and accuracy. The frequency and number of residential meters to be tested should be adjusted based on meter testing results.

Pipeline, Valve, Hydrant and Meter Replacement Programs

The City has been proactive in their replacement programs. Replacement budgets for pipelines, valves, hydrants, and meters were developed in Technical Memorandum No. 1. Replacing older infrastructure will result in less unaccounted for water and continued high levels of service. Emphasis should be given to replacing pipelines in areas with lower levels of fire protection, and where older, more problematic cast iron pipelines exist as reflected on the Priority Improvements Map (Figure 4, Appendix A). Wherever possible, replacements should be coordinated with planned street improvements to minimize construction costs.

Remaining infrastructure life and replacement budgets should be reevaluated every five years.

Unaccounted for Water

Keller Associates recommends that the City continue to track and investigate unaccounted for water. A special, stand-alone study may be needed to fully resolve lingering issues with meter accuracy and unmetered uses. Emphasis should be given to the volume of water, rather than just the percent. Unaccounted for water should be tracked monthly to allow development of winter/summer and 12-month moving averages. Efforts to isolate portions of the City to investigate water loss for geographic regions could be spearheaded by City staff and will take coordination between engineering, water, and billing departments.

6.7 WELL FACILITIES

The well facilities are intended to serve as a backup supply, but have not been used with regularity since the new water treatment plant came on line several years ago. The wells are exercised on a weekly basis for a short period of time, but the operational time is inadequate to ensure the wells can operate in production mode, if needed. To ensure that these facilities are in proper working order for emergency supply, several capital improvements were identified in Technical Memorandum No. 5 (Appendix B). The technical memorandum also identified several operational improvements which include:

- Regular well pump exercise, for longer periods of time, including exercising the pump against back pressures similar to what they would experience if they were to pump into the distribution system.
- Training of operations staff and periodic simulations of emergencies (every 6-12 months). Ideally, these wells could actually be pumped into the system, even if the system is temporarily valved off and the flow is discharged via a nearby hydrant. This will ensure that the facilities are ready when they are needed.
- Upgrades to the SCADA system.
- Annual monitoring of flow capacities, and periodic well casing cleaning/refurbishing to preserve pump delivery capacities.
- Continued servicing of generators.

6.8 MISCELLANEOUS

The City's GIS database and AutoCAD (engineering) database contained different, conflicting and missing data (pipe age, pipe material, meter IDs, etc.). Keller Associates compared and updated the mapping to include a GIS-based map that captured the most updated and accurate data. This file should serve as the starting point for future mapping updates and provide the basis for a single database to be used by engineering and GIS staff. Keller Associates further recommends that the unique water meter ID for every water meter be used both in the billing system and within the GIS. This will allow the City to accurately allocate demands spatially within a system, which can be helpful in identifying areas where higher water loss may occur and can facilitate future upgrades to the City's water model.

The City's SCADA system should be continually updated to include reporting, trending, alarm features, etc. as needed.

Keller Associates recommends that the City's water model be updated annually and that this water master plan be updated every 3 to 5 years, depending on growth. Additionally, the City's Water Management and Conservation Plan (WMCP), is required by the Oregon Administrative Rules to be updated every ten years, with progress reports completed five years after each WMCP. The current (2004) WMPC is being updated, with completion scheduled for summer/fall 2012. Completing these planning documents in a timely manner will be important in ensuring that future water rights are protected and infrastructure is planned and scheduled to provide for the City's future needs.

6.9 STAFFING AND BUDGET IMPLICATIONS

The scope of this study did not include a rate study or an evaluation of existing and future staffing needs. However, the City should be aware that many of the recommendations may require additional staff time and materials or reallocation of resources. Specific activities anticipated to affect staffing requirements include: additional tracking of unaccounted for water usage, GIS mapping, residential meter testing, developing a directional flushing program, servicing pressure reducing valves, and rehabilitation and replacement of the distribution systems.

In completing any future rate analysis, the City should account for the items identified in the Capital Improvement Plan (Table 5.2), the list of Major Repairs and Replacements (Table 6.1), and the Recurring Maintenance Costs (Table 6.2). Increased staffing and operations and maintenance requirements will also occur as a result of normal growth, and this document assumes the City intends to provide a slightly increased level of service going forward. However, policy decisions made during the annual budget process or during the development of the rate study, or both, will ultimately determine acceptable staffing and budget levels, and the associated timing of certain improvements.

7.0 POLICIES AND IMPLEMENTATION MEASURES

7.1 OVERVIEW

The City's Comprehensive Plan provides the context within which the water master plan has been developed. Efforts have been made to solicit citizen input and coordinate with other agencies and organizations consistent with Comprehensive Plan Goal 1.2. Planning for the area within the Urban Growth Boundary has been completed consistent with Comprehensive Plan Goal 2.1. This section summarizes existing comprehensive plan goals, policies and implementation measures relative to the water system and proposes a few changes and add it policy.

The primary goal of the water master plan is derived from Wilsonville's Comprehensive Plan Goal 3.1 providing for infrastructure in general and is as follows:

> **To assure that good quality public facilities and services are available with adequate capacity to meet community needs, while also assuring that growth does not exceed the community's commitment to provide adequate facilities and services.**

Comprehensive Plan Goals, Policies, and Implementation Measures

The City's Comprehensive Plan provides the context within which the water master plan has been developed. Efforts have been made to solicit citizen input and coordinate with other agencies and organizations consistent with Comprehensive Plan Goal 1.2. The primary goal of the water master plan is derived from Wilsonville's Comprehensive Plan Goal 3.1 providing for infrastructure in general and is as follows:

> To assure that good quality public facilities and services are available with adequate capacity to meet community needs, while also assuring that growth does not exceed the community's commitment to provide adequate facilities and services.

(Note: On adoption, City Council modified Goal 3.1 as follows: To assure that good quality public facilities and services are available with adequate but not excessive capacity to meet community needs, while also assuring that growth does not exceed the community's commitment to provide adequate facilities and services.)

The majority of the water related policies are highlighted in Comprehensive Plan Policy 3.1.5 which states:

> The City shall continue to develop, operate and maintain a water system, including wells, pumps, reservoirs, transmission mains and a

surface water treatment plant capable of serving all urban development within the incorporated City limits, in conformance with federal, state, and regional water quality standards. The City shall also continue to maintain the lines of the distribution system once they have been installed and accepted by the City.

Keller Associates recommends the existing Implementation Measure 3.1.5.b be revised as follows (additions underlined):

All major lines shall be extended in conformance to the line sizes indicated on the Master Plan and, at a minimum, provisions for future system looping shall be made. If the type, scale, and/or location of a proposed development negatively impacts operating pressures or available fire flows to other properties as determined by the City Engineer, the Development Review Board may require completion of looped water lines, off-site facilities, pipelines, and/or facility/pipelines to achieve or maintain minimum pressures or fire flows as a condition of development approval. (Adopted)

Keller Associates also recommends the following additional policies for consideration. Refer to Chapter 7 for recommended implementation measures associated with these policies.

Proposed Policy 3.1.6: The City of Wilsonville shall continue a comprehensive water conservation program to make effective use of the water infrastructure, source water supply and treatment processes. (Adopted)

Proposed Policy 3.1.7: The City of Wilsonville shall maintain an accurate user demand profile to account for actual and anticipated demand conditions in order to assure an adequately sized water system. (Adopted)

Proposed Policy 3.1.8: The City of Wilsonville shall coordinate distribution system improvements with other CIP projects, such as roads, wastewater, and storm water, to save construction costs and minimize public impacts during construction. (Adopted)

The Comprehensive Plan also provides the following policies that were used to guide this master plan update:

Comprehensive Plan Policy 3.1.1. The City of Wilsonville shall provide public facilities to enhance the health, safety, educational, and recreational aspects of urban living.

Comprehensive Plan Policy 3.1.2. The City of Wilsonville shall provide, or coordinate the provision of, facilities and services concurrent with need (created by new development, redevelopment, or upgrades of aging infrastructure).

Comprehensive Plan Policy 3.1.3. The City of Wilsonville shall take steps to assure that the parties causing a need for expanded facilities and services, or those benefiting from such facilities and services, pay for them.

Comprehensive Plan Policy 3.1.5. The City shall continue to develop, operate and maintain a water system, including wells, pumps, reservoirs, transmission mains and a surface water treatment plant capable of serving all urban development within the incorporated City limits, in conformance with federal, state, and regional water quality standards. The City shall also continue to maintain the lines of the distribution system once they have been installed and accepted by the City.

Policy 3.1.5 provides the most specific direction relative to the water system and includes the following implementation measures:

Implementation Measure 3.1.5.a The City shall review and, where necessary, update the Water System Master Plan to conform to the planned land uses shown in the Comprehensive Plan and any subsequent amendments to the Plan.

Implementation Measure 3.1.5.b All major lines shall be extended in conformance to the line sizes indicated on the Master Plan and, at a minimum, provisions for future system looping shall be made. If the type, scale and/or location of a proposed development negatively impacts other existing properties or warrants minimum fire flows above that currently available to the development, the Development Review Board may require completion of looped water lines, off-site piping, and/or pipeline replacement in conjunction with the development.

Implementation Measure 3.1.5.c Extensions shall be made at the cost of the developer or landowner of the property being served. When a major line is extended that is sized to provide service to lands other than those requiring the initial extension, the City may:

1. Authorize and administer formation of a Local Improvement District to allocate the cost of the line improvements to all properties benefiting from the extension; or
2. Continue to utilize a pay-back system whereby the initial developer may recover an equitable share of the cost of the extension from benefiting property owners/developers as the properties are developed.

Implementation Measure 3.1.5.d All water lines shall be installed in accordance with the City's urban growth policies and Public Works Standards.

Implementation Measure 3.1.5.e The City shall continue to use its Capital Improvements Program to plan and schedule major water system improvements needed to serve continued development (e.g., additional water treatment plant expansions, transmission mains, wells, pumps and reservoirs).

Keller Associates recommends modifying Implementation Measure 3.1.5.b as follows:

Implementation Measure 3.1.5.b All major lines shall be extended in conformance to the line sizes indicated on the Master Plan and, at a minimum, provisions for future system looping shall be made. If the type, scale, and/or location of a proposed development negatively impacts operating pressures or available fire flows to other properties as determined by the City Engineer, the Development Review Board may require completion of looped water lines, off-site facilities, pipelines, and/or facility/pipelines to achieve or maintain minimum pressures or fire flows as a condition of development approval.

Additional recommended policies and implementation measures are presented below. These policies were developed previously as part of the 2002 Water Master Plan, but are not incorporated into the current (January 2011) Comprehensive Plan Update.

Proposed Policy 3.1.6 The City of Wilsonville shall continue a comprehensive water conservation program to make effective use of the water infrastructure, source water supply and treatment processes.

Proposed Implementation Measure 3.1.6.a The City will track system water usage through production metering and service billing records and take appropriate actions to maintain a target annual average unaccounted for water volume of less than 10% of total production.

Proposed Implementation Measure 3.1.6.b The City will maintain other programs and activities as necessary to maintain effective conservation throughout the water system.

Proposed Policy 3.1.7 The City of Wilsonville shall maintain an accurate user demand profile to account for actual and anticipated demand conditions in order to assure an adequately sized water system.

Proposed Implementation Measure 3.1.7.a The City will track system water usage through production metering and service billing records and take appropriate actions to maintain a target annual average unaccounted for water volume of less than 10% of total production.

Proposed Implementation Measure 3.1.7.b The City will maintain other programs and activities as necessary to maintain effective conservation throughout the water system.

Proposed Policy 3.1.8 The City of Wilsonville shall coordinate distribution system improvements with other CIP projects, such as roads, wastewater, and storm water, to save construction costs and minimize public impacts during construction.

7.1 ADOPTING ORDINANCE 707 (September 06, 2012)

See next page.

ORDINANCE NO. 707

AN ORDINANCE OF THE CITY OF WILSONVILLE ADOPTING AN UPDATED WATER SYSTEM MASTER PLAN AS A SUB-ELEMENT OF THE CITY'S COMPREHENSIVE PLAN; ADOPTING A CAPITAL IMPROVEMENT PROJECT LIST FOR WATER SUPPLY, STORAGE AND DISTRIBUTION; AND REPLACING ALL PRIOR WATER SYSTEM MASTER PLANS

WHEREAS, the City currently has a Water System Master Plan that was adopted by City Council (Ordinance No. 531) on January 7, 2002; and

WHEREAS, ORS 197.175 requires cities to prepare, adopt, and implement Comprehensive Plans consistent with statewide planning goals adopted by the Land Conservation and Development Commission; and

WHEREAS, ORS 197.712 (2)(e) requires cities to develop and adopt a public facilities plan for areas within the Urban Growth Boundary containing a population greater than 2,500 persons, including rough cost estimates for projects needed to provide sewer, water and transportation uses contemplated in the Comprehensive Plan and Land Use Regulations; and

WHEREAS, an updated Water System Master Plan is needed to account for growth and plan for future development; and

WHERAS, the update to the Water System Master Plan documents current water demand, evaluates current system deficiencies, estimates future water demands over a 20-year growth horizon, and estimates the capital and operation costs needed to meet these future demands; and

WHEREAS, in developing the new Water System Master Plan, the City has sought to carry out federal, state and regional mandates, provide for alternative improvement solutions to minimize public and private expense, avoid the creation of nuisances and maintain the public's health, safety, welfare and interests; and

WHEREAS, proposed amendments to the Water System Master Plan identifies changes to Comprehensive Plan Goal 3.1; and

WHEREAS, Keller Associates, the project consultant, and City staff conducted work sessions with the Planning Commission and City Council and held a public open house on the Water System Master Plan to solicit citizen input addressing Statewide Planning Goal #1 – Citizen Involvement; and

WHEREAS, following the timely mailing and publication of the required Ballot Measure 56 notice, the Wilsonville Planning Commission conducted a public hearing on July 11, 2012 and adopted Resolution Number LP12-0002 recommending the City Council adopt the Water System Master Plan; and

WHEREAS, after providing due public notice, as required by City Code and State Law, a public hearing was held before the City Council on August 20, 2012, at which time the City Council considered the recommendation of the Planning Commission, gathered additional evidence and afforded all interested parties an opportunity to present oral and written testimony concerning the Water System Master Plan; and

WHEREAS, the City Council has carefully considered the public record, including all recommendations and testimony, and being fully advised.

NOW, THEREFORE, THE CITY OF WILSONVILLE ORDAINS AS FOLLOWS:

1. FINDINGS.

   The above-recited findings are adopted and incorporated by reference herein, including the findings and conclusions of Resolution No. LP12-0002, which includes the staff report. The City Council further finds and concludes that the adoption of the updated Water System Master Plan is necessary to help protect the public health, safety and welfare of the municipality by planning that will help to ensure there will continue to be adequate capacity and quality of water within the City's municipal system.

2. DETERMINATION.

   Based upon such findings, the City Council hereby adopts the Water System Master Plan, attached hereto and marked as Exhibit A, and incorporated by reference as if fully se forth herein, which shall replace and supersede all prior Water System Master Plans adopted by Ordinance, resolution or motion.

3. EFFECTIVE DATE OF ORDINANCE.

   This Ordinance shall be declared to be in full force and effect thirty (30) days from the date of final passage and approval.

SUBMITTED to the Wilsonville City Council and read the first time at a regular meeting thereof on the 20th day of August, 2012, and scheduled for second reading at a regular meeting thereof on the 6th day of September, 2012, commencing at the hour of 7.P.M. at Wilsonville City Hall.

____
Sandra C. King, MMC, City Recorder

ENACTED by the City Council on the ____ day of September 2012, by the following votes:

YEAS:______ NAYS:______

____
Sandra C. King, MMC, City Recorder

DATED and signed by the Mayor this ___ day of _________ 2012.

____
Tim Knapp, Mayor

SUMMARY OF VOTES:

Mayor Knapp

Council President Nunez

Councilor Goddard

Councilor Starr

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City of Wilsonville

Figure 1: Existing City Distribution System

Figure 2: Study Area & Land Use

Figure 3: Existing System: Pipe Materials

Figure 4: Priority Improvements & Replacements

Figure 5: Existing & Future Pressure Zones

KELLER associates

APPENDIX A – FIGURES

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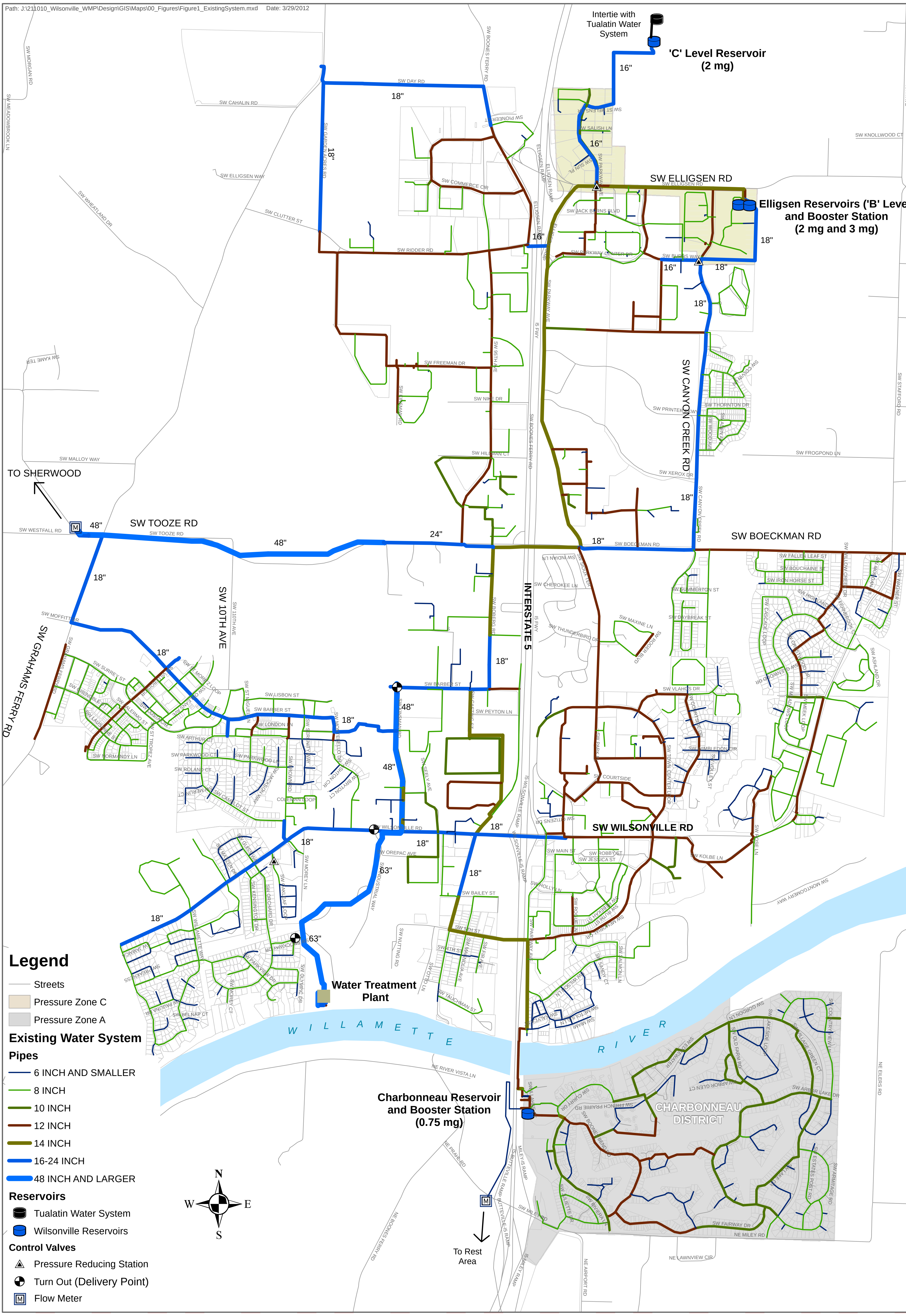

Figure:	Title:		Prepared for:	
1	Existing City Distribution System	WATER MASTER PLAN	CITY OF WILSONVILLE, OR	KELLER associates

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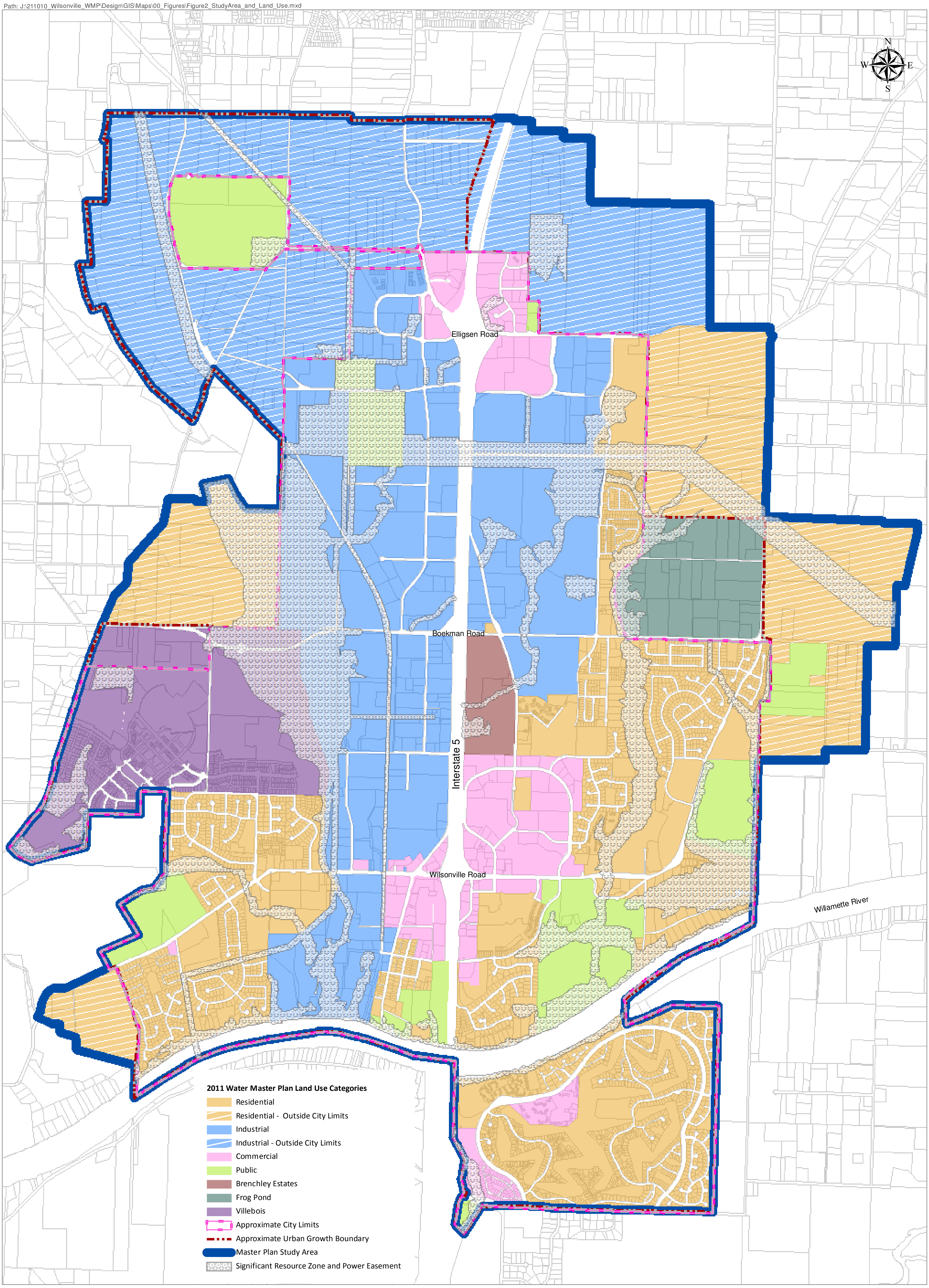

Figure:	Title:		Prepared for:	
2	Study Area & Land Use	WATER FACILITIES MASTER PLAN	CITY OF WILSONVILLE, OREGON	KELLER associates

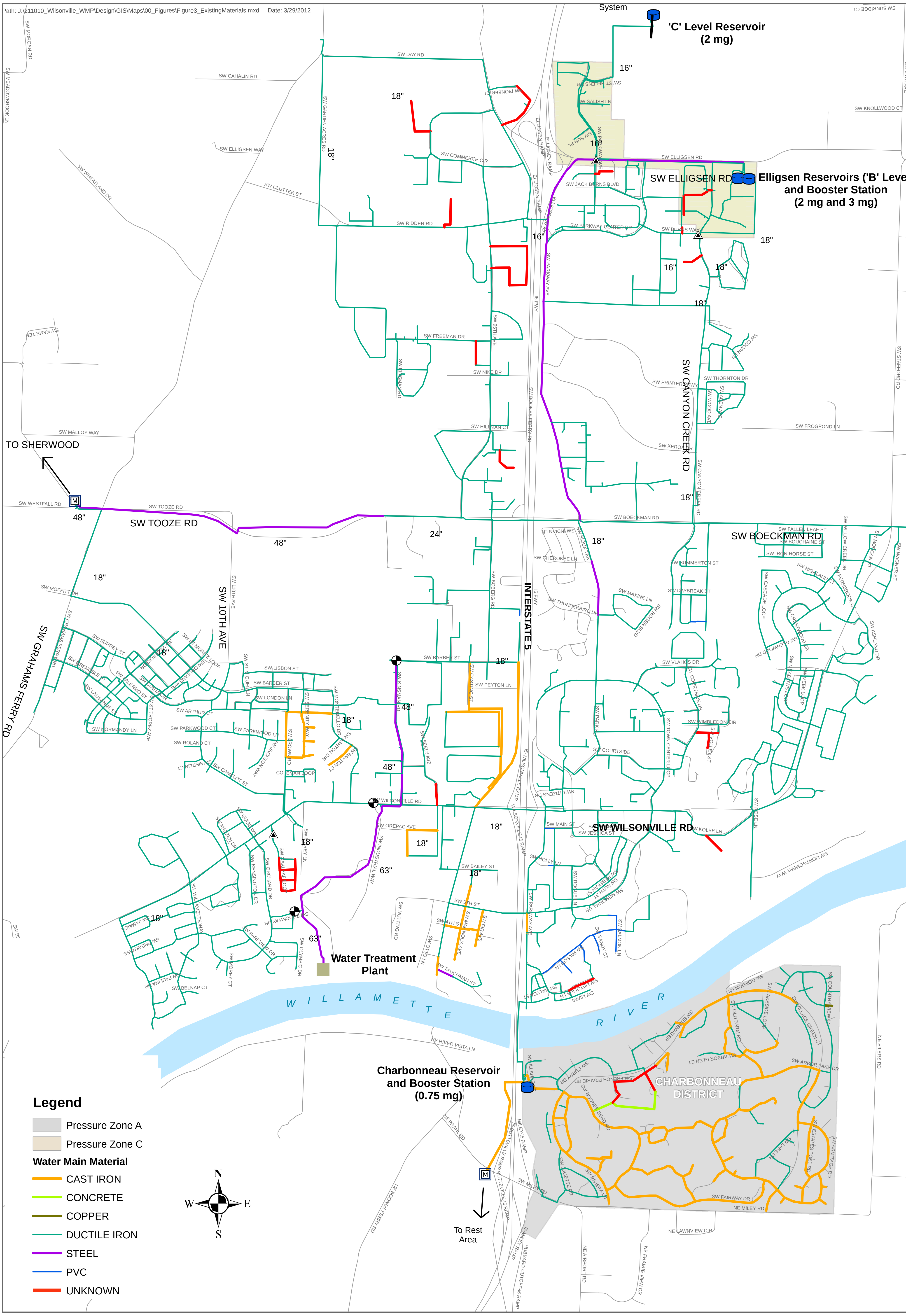

Figure:	Title:		Prepared for:	
3	Existing System: Pipe Materials	WATER MASTER PLAN	CITY OF WILSONVILLE, OR	KELLER associates

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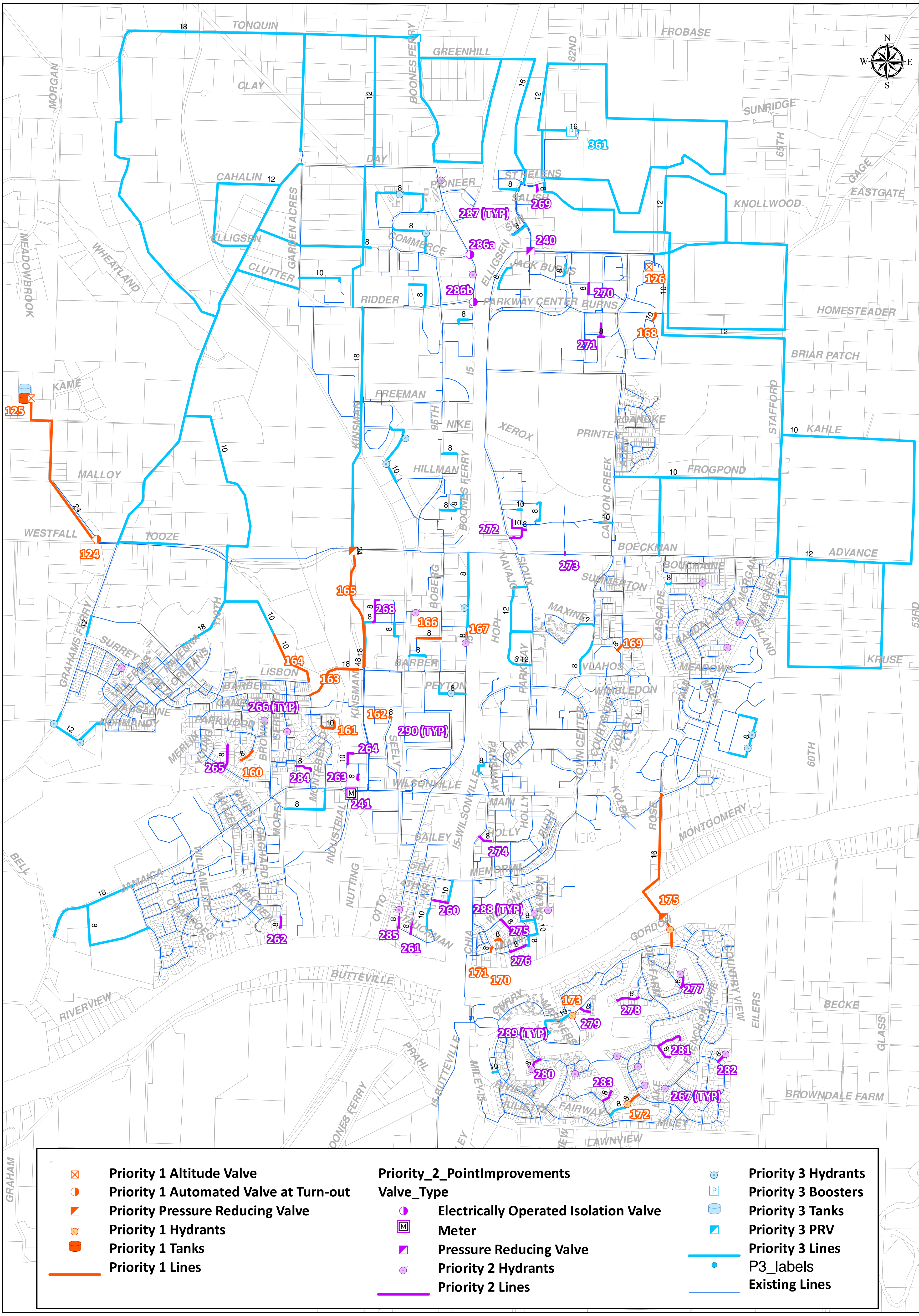

Figure:	Title:		Prepared for:	
4	Priority Improvements and Replacements	WATER FACILITIES MASTER PLAN	CITY OF WILSONVILLE, OREGON	KELLER associates

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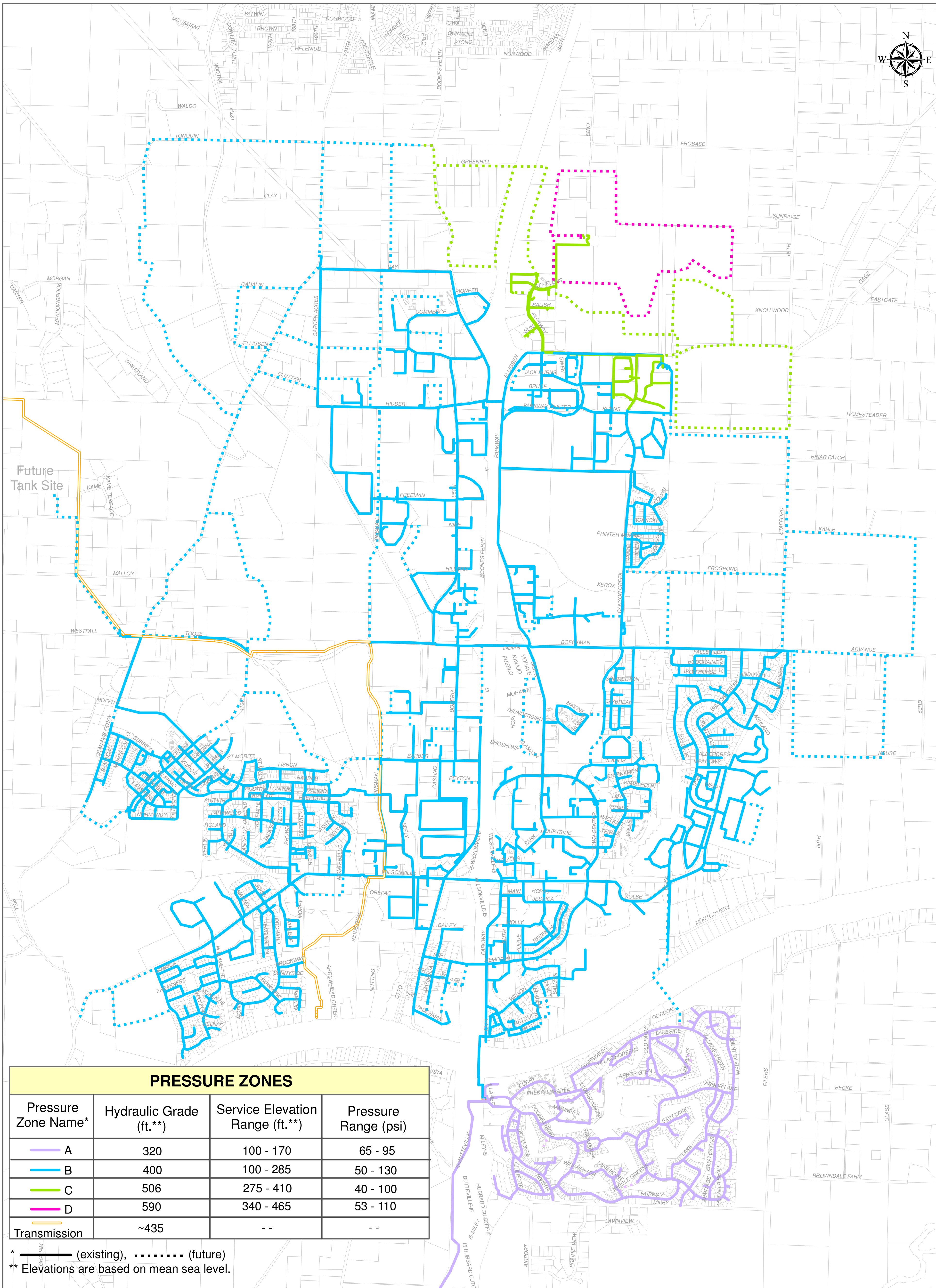

PRESSURE ZONES

Pressure Zone Name*	Hydraulic Grade (ft.**)	Service Elevation Range (ft.**)	Pressure Range (psi)
A	320	100 - 170	65 - 95
B	400	100 - 285	50 - 130
C	506	275 - 410	40 - 100
D	590	340 - 465	53 - 110
Transmission	~435	- -	- -

* (existing), (future)

** Elevations are based on mean sea level.

Figure:	Title:		Prepared for:	
5	Existing and Future Pressure Zones	WATER FACILITIES MASTER PLAN	CITY OF WILSONVILLE, OREGON	KELLER associates