Water Distribution System Facility Plan

June 2017

ch2m

MEDFORD WATER COMMISSION

Water Distribution System Facility Plan

Prepared for

Medford Water Commission

June 2017

1100 NE Circle Boulevard
Corvallis, OR 97330

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Acronyms and Abbreviations

ADD	Average day demand
AMI	Automated meter infrastructure
AWWA	American Water Works Association
BBS	Big Butte Springs
cfs	cubic feet per second
CIP	Capital improvements plan
EPID	Eagle Point Irrigation District
gpcd	gallons per capita per day
gpm	gallons per minute
HSPS	Duff No. 1 WTP high service pump station
IWA	International Water Association
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MDD	Maximum day demand
MG	Million gallons
mgd	million gallons per day
MMD	maximum month demand
MWC	Medford Water Commission
OAR	Oregon Administrative Rules
ORS	Oregon Revised Statutes
OWRD	Oregon Water Resources Department
PHD	Peak hour demand
PS	Pump station
PSU	Portland State University
PRC	PSU Population Research Center
RTCR	Revised total coliform rule
SCADA	Supervisory control and data acquisition
SWTR	surface water treatment rule
TAP	Talent-Ashland-Phoenix (master meter)
UGB	urban growth boundary
URA	Urban Reserve Area
WTP	Water treatment plant

SECTION 1

Introduction

This Water Distribution System Facility Plan provides an update to Medford Water Commission's (MWC's) July 2007 plan. It describes the evaluation of the system and presents recommended improvements to address current and future needs. It includes discussion of specific projects and preparation of an updated, 20-year capital improvements plan (CIP). Although it presents specific projects and proposed dates for implementing these projects, it must be recognized that the plan is intended as a guide. MWC will regularly review the specific projects and their schedules, and will adjust ensure that the system is managed efficiently to meet customer needs.

1.1 Financial Plan

MWC plans to prepare an updated 10-year financial plan based on the CIP developed in this facility plan. The financial plan, which is a required master plan component per the state's rules for community water systems, is not included as part of this document.

1.2 Acknowledgements

Preparation of this plan was a joint effort between MWC and CH2M, involving the following individuals:

1.2.1 MWC Staff

- Eric Johnson, P.E., Interim MWC Manager and Principal Engineer (Project Manager)
- Rodney Grehn, P.E., MWC Engineer (Distribution System Modeling and Planning)
- Jim Stockton, CET, Water Treatment Director
- Ken Johnson, Operations Superintendent
- Andy Huffman, Construction Administrator
- Rosie Pindilli, Water Quality Director

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- Jason Anderson, Vice Chair
- Daniel Bunn
- Leigh Johnson
- Bob Strosser

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- Paul Berg, P.E., Project Manager
- Jennifer Henke, P.E., Modeling and System Evaluation
- Daniel Morse, P.E., Modeling and System Evaluation
- Sheryl Stuart, P.E., Project Engineer, System Demands and Projections

System Description

The MWC owns and operates a public water system that currently serves individual customers inside and outside the Medford city limits. MWC also provides water to two water districts and six nearby cities on a wholesale basis. The MWC system has been assigned the state and federal Public Water System Identification No. 4100513. This section describes the facilities that make up the system. The tables and figures referenced are attached at the end of the section.

2.1 System Configuration

The configuration of the system is illustrated in three attachments at the end of this section, **Figure 2-1**—a system map, **Figure 2-2**—a system schematic, and **Figure 2-3**—a system hydraulic schematic.

The major components of the system include the Big Butte Springs (BBS) and associated disinfection facility, the Robert A. Duff Water Treatment Plant (Duff No. 1 WTP), Control Stations (which provide both pressure reducing and pumping functions), pump stations serving high elevation zones, reservoirs, and transmission and distribution piping that interconnect the system. As illustrated in the hydraulic schematic, the system serves a range of topography, which necessitates the use of multiple pump stations and reservoirs to provide appropriate pressures and reliable service to all MWC customers.

The system operates in two distinct modes. 'Forward mode' describes the operation when BBS is the only water supply to the system. Water moves 'forward' through pressure reducing valves in the Control Stations from the Gravity Zone into the Reduced Pressure Zone. This occurs when the Duff No. 1 WTP is off-line, currently from October through April of each year. 'Reverse mode' describes the operation when the Duff No. 1 WTP is operating, and water supply is provided from both BBS and the plant. The Control Stations generally operate in the pumping mode during this time, moving water from the Reduced Pressure Zone into the Gravity Pressure Zone.

2.2 Water Supply

MWC's water supplies are described in detail in the *Big Butte Springs and Duff Water Treatment Plant Facility Plan* and the *Water Management and Conservation Plan*, both of which were prepared in 2016.

The principal year-round source of water is the BBS, located about 30 miles northeast of Medford and five miles east of the town of Butte Falls. The potential capacity from the springs varies from 25 to 35 mgd depending on rainfall, snow pack, and groundwater conditions. However, the transmission pipelines limit withdrawal to a maximum of 26.4 mgd. During drought conditions, withdrawal may be curtailed because of reduced flow or the needs of Eagle Point Irrigation District (EPID). During a drought in 1992, flow was limited to 20 mgd during the month of June and 25 mgd during the remainder of the year.

During the summer months of May through October, the Rogue River is used as a supplemental source of water. Water is withdrawn near the Duff No. 1 WTP, located approximately three miles north of Medford city limits near TouVelle State Park. Its current treatment capacity is 45 mgd, although expansion projects are underway or soon to be initiated that will bring its capacity to 65 mgd.

2.3 Pressure Zones

The MWC water system serves areas with elevations ranging from 1,250 to 2,250 feet. To maintain system pressures within an acceptable range at customer taps, the system has been divided into nine pressure zones shown in the hydraulic schematic and summarized in **Table 2-1**. This table describes the service levels, including the minimum and maximum pressures at customer connections. The minimum pressure provided at the customer connections is determined by subtracting the upper customer elevation value from the reservoir overflow elevation, and converting this value to pressure. The maximum pressure provided is determined by subtracting the lower customer elevation from the reservoir overflow elevation, and converting the value to pressure. As shown in Figure 2-1, MWC will add pressure zones 6 through 10, in the eastern area of the city, as development occurs.

The two largest pressure zones are the Gravity Zone which supplies most of the City of Medford and areas southwest of the city, and the Reduced Pressure Zone which supplies north Medford, Central Point, Eagle Point, and the White City area. The remaining pressure zones are fed by pump stations. Each has at least one reservoir that provides gravity storage to the customers within the zone.

2.4 Distribution Storage Reservoirs

MWC has sixteen reservoirs in service, including the Duff No. 1 WTP clearwell. The largest reservoir system is the Capital Reservoir with an overall capacity of 12 MG in three separate reservoirs. These reservoirs are fed from the BBS transmission lines and provide storage for the Gravity Zone and Reduced Pressure Zone. The total storage capacity, including the 4.8-MG Duff No. 1 WTP clearwell, is 36.2 MG. All distribution reservoirs are located on hills, and therefore provide gravity storage for the service level they feed. **Table 2-2** lists all reservoirs in service, including their service level, overflow elevation, material type, volume, and date of construction. Only three reservoirs, Southwest, Barneburg, and Highlands do not have backup storage capacity.

2.5 Distribution Pump Stations

MWC has nine operating pump stations that supply water to service levels at higher elevations than the Gravity Zone. **Table 2-3** provides a summary of the pump stations including service level, year built, associated reservoir, and total capacity. In addition, there are three Control Stations (Martin, Rossanley, and Conrad) that provide both pumping and pressure reducing functions. During forward flow mode, they transfer water from the Gravity Zone into the Reduced Pressure Zone. During reverse flow mode, they pump water from the Reduced Pressure Zone into the Gravity Zone.

2.6 Distribution Piping System

MWC has approximately 476 miles of pipeline in its water transmission and distribution system. The system is predominantly looped and located within public rights-of-way, giving the commission access for repairs and maintenance. The pipeline system has been upgraded and expanded annually to serve the city's growing demands. Approximately 40 percent of the existing system has been installed or replaced since 1990. **Figures 2-4 and 2-5** provide an inventory of the existing waterlines in the MWC system. A large percentage of the pipelines are made of either ductile iron (66 percent) or cast iron (28 percent). Most pipe installed prior to the mid-1960s was cast iron; ductile iron has been installed in most cases since then. About 68 percent of the pipe is 6 and 8 inches in diameter.

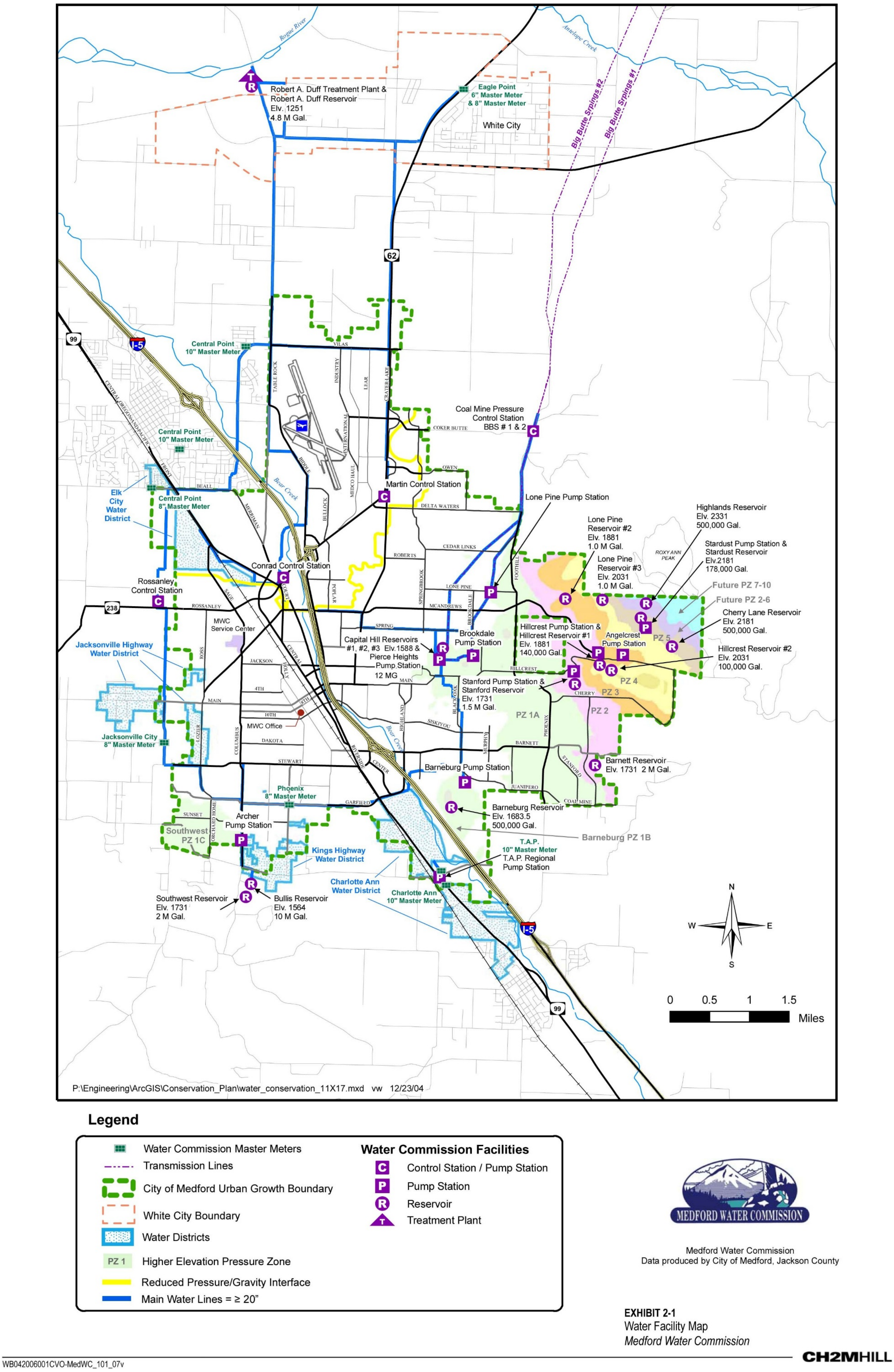


Figure 2-1. Water Facility Map

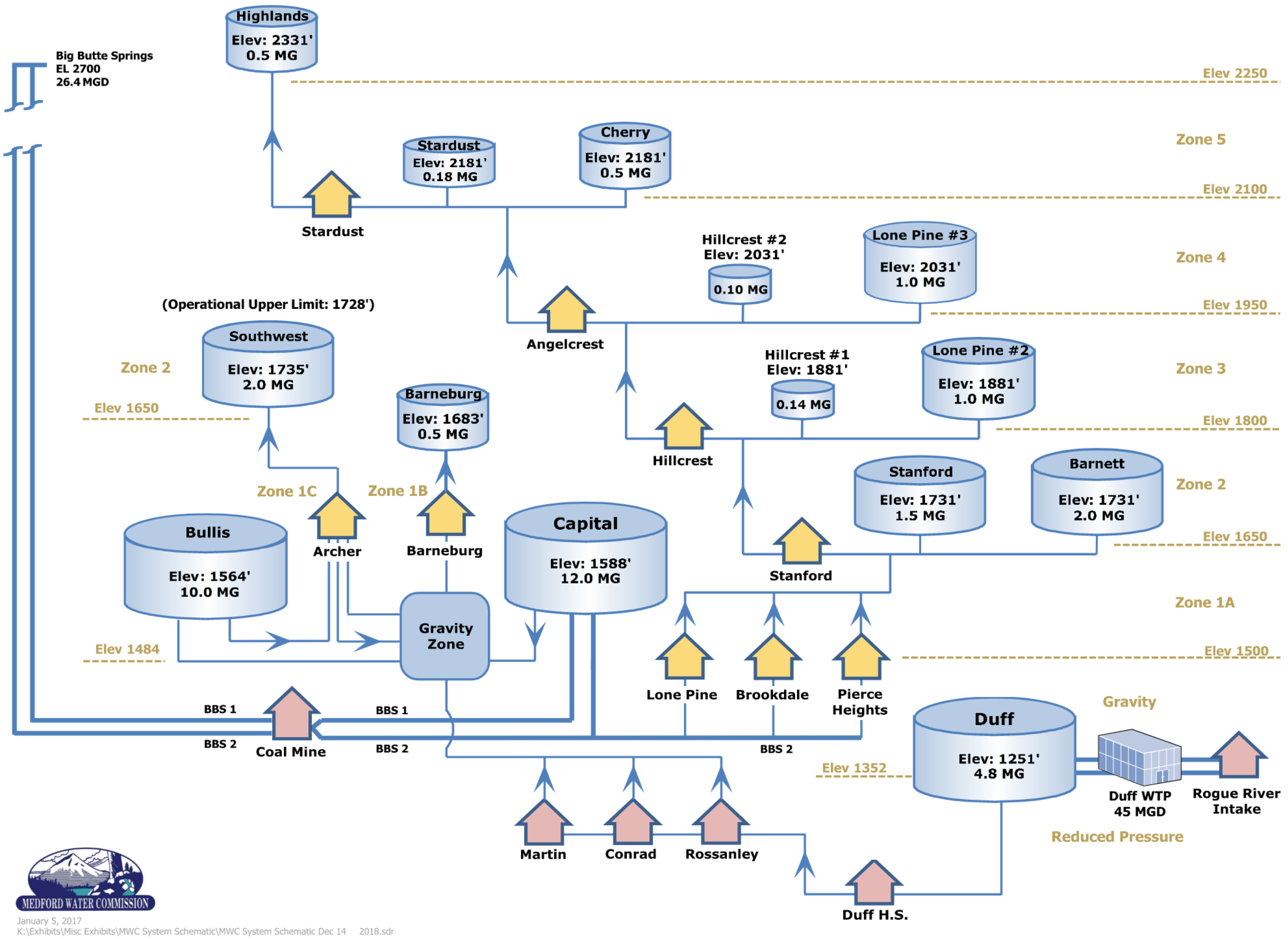
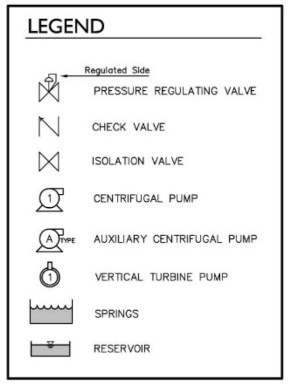


Figure 2-2. MWC System Schematic



PUMP STATION	PUMP	HP	FLOW (gpm)	YEAR INST
Rogue Intake	1	500	15,625	1968
	2	200	5,200	1968
	3	500	15,625	1982
	4	200	5,200	1995
	5	200	5,200	1968
Duff High Service	1	450	5,800	1968
	2	450	5,400	1968
	3	450	5,400	1968
	4	800	10,500	1981
	5	900	10,500	1995
Martin Control Station	1	100	1,750	1976
	2	100	1,750	1976
Conrad Control Station	1	125	2,000	1968
	2	125	2,000	1968
	3	125	2,000	1988
Rossanley Control Station	1	200	4,000	1994
	2	200	4,000	2000
Angelcrest Pump Station	1	30	600	1972
	2	30	600	1972
	3	30	600	1972
Archer Pump Station	1	60	4,200	1981
	2	60	4,200	1981
	4	50	900	1999
	5	30	550	1999
	6	10	100	1999
	Aux	70	700	1999

PUMP STATION	PUMP	HP	FLOW (gpm)	YEAR INST
Barneburg Pump Station	1	40	800	1979
	2	40	800	1979
	Aux	100	800	1997
Brookdale Pump Station	1	100	1,500	1969
	2	100	1,500	1969
	3	30	480	1971
	Aux	50	550	1971
Hillcrest Pump Station	1	25	490	1972
	2	60	1,000	1972
	3	60	1,000	1972
Lone Pine Pump Station	1	100	1,500	2005
	2	75	1,000	2005
	3	Future 100	Future 1,500	-
	Aux	-	1,500	2005
Pierce Heights Pump Station	1	100	1,300	2000
	2	75	700	2000
Stanford Pump Station	1	25	440	1972
	2	100	1,800	1972
	3	75	1,400	1996
Stardust Pump Station	1	25	350	1995
	2	50	800	1995
	Aux	70	600	1995

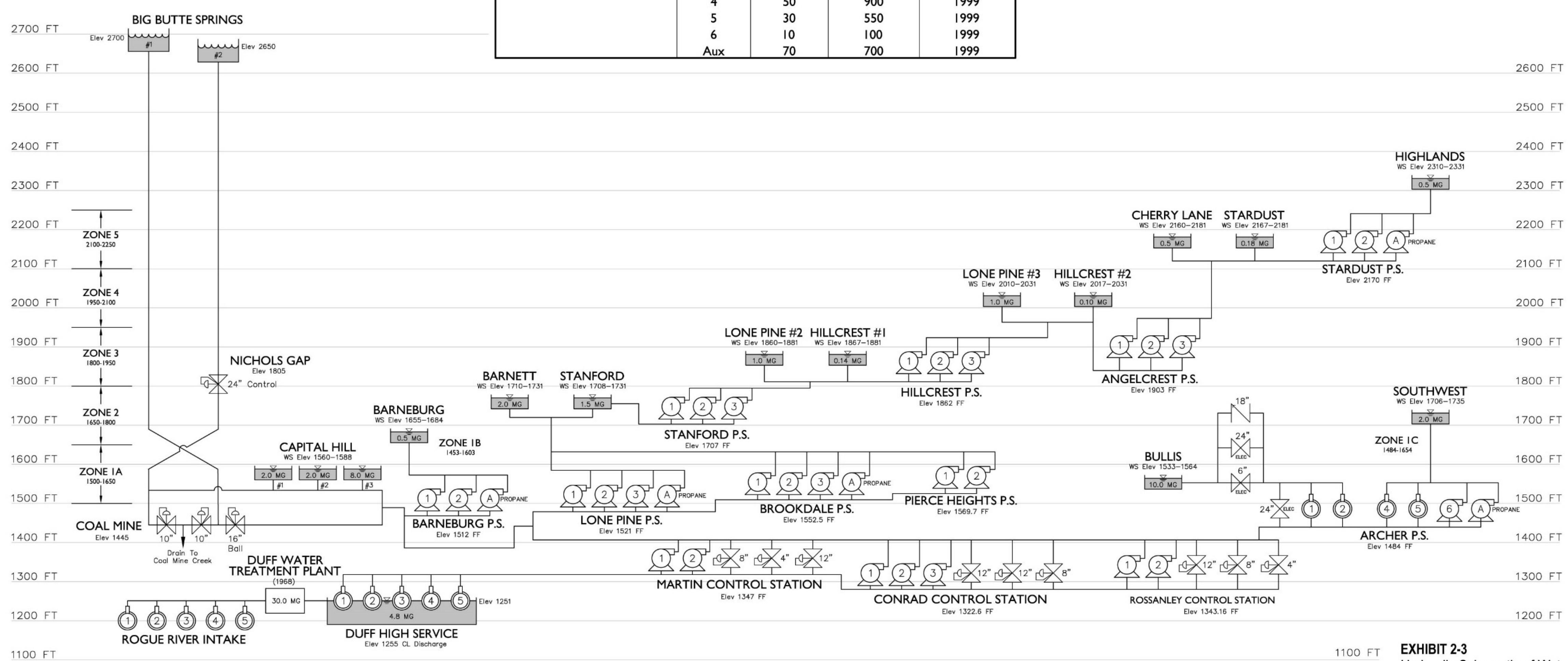


EXHIBIT 2-3
Hydraulic Schematic of Water Distribution System
Medford Water Commission

CH2MHILL

WB042006001CVO-MedWC_102_03

Figure 2-3. Hydraulic Schematic of Water Distribution System

Table 2-1. MWC Pressure Zones
Medford Water Commission Water Distribution System Facility Plan

Pressure Zone Name	Reservoirs	Reservoir Overflow Elevation (ft)	Lowest Customer Elevation (ft)	Maximum Static Pressure (ft)	Highest Customer Elevation (ft)	Minimum Customer Pressure (psi)
Reduced Pressure[a]	-		1250	-	1352	-
Gravity Zone	Capital	1,588	1352	102	1500	38
Zone 1A[b]	Stanford; Barnett	1,731	1500	100	1650	35
Zone 1B[c]	Barneburg	1,684	1,453	100	1,603	35
Zone 1C[d]	Southwest	1,735	1,484	109	1,654	35
Zone 2	Hillcrest #1; Lone Pine #2	1,881	1650	100	1800	35
Zone 3	Hillcrest #2; Lone Pine #3	2,031	1800	100	1950	35
Zone 4	Stardust; Cherry Lane #4	2,181	1950	100	2100	35
Zone 5	Highlands	2,331	2100	100	2250	35

[a] In winter the Reduced Pressure Zone is served from the Gravity Zone through pressure reducing valves at Conrad, Martin, and Rossanley Pressure Control Stations. In summer this zone is served by pumping from the Duff WTP.

[b] Zone 1A is also known as Zone 1.

[c] Zone 1B is also known as Barneburg Zone.

[d] Zone 1C is also known as Southwest Zone.

Table 2-2. MWC Reservoir Inventory
Medford Water Commission Water Distribution System Facility Plan

Name	Pressure Zone	Overflow Elevation (ft)	Volume (MG)	Material	Year Built
Capital #1	Gravity Zone	1,588	2.0	Concrete	1908
Capital #2	Gravity Zone	1,588	2.0	Concrete	1927
Capital #3	Gravity Zone	1,588	8.0	Concrete	1945
Bullis	Gravity Zone	1,564	10.0	Concrete	1965
Barnett	Zone 1A	1,731	2.0	Concrete	1983
Stanford	Zone 1A	1,731	1.5	Concrete	1971
Barneburg	Zone 1B	1,684	0.5	Concrete	1959
Southwest	Zone 1C	1,735	2.0	Concrete	2000
Hillcrest No. 1	Zone 2	1,881	0.14	Concrete	1972
Lone Pine No. 2	Zone 2	1,881	1.0	Concrete	2005
Hillcrest No. 2	Zone 3	2,031	0.10	Concrete	1972
Lone Pine No. 3	Zone 3	2,031	1.0	Concrete	2006
Stardust	Zone 4	2,181	0.18	Concrete	1972
Cherry Lane No. 4	Zone 4	2,181	0.5	Concrete	1996
Highlands	Zone 5	2,331	0.5	Concrete	1996
Duff WTP Clearwell	Reduced Pressure	1,251	4.8	Concrete	1968
		Total	36.2		

Table 2-3. MWC Pump Station Inventory
Medford Water Commission Water Distribution System Facility Plan

Pump Station Name	Pressure Zone	Year Built	Pumps From	Pumps to Reservoir (Overflow Elevation feet)	Total Capacity (gpm)
Archer	Gravity Zone	1981	Bullis	Capital (1,588)	8,400
Lone Pine	Zone 1A	2005	Gravity Zone	Stanford and Barnett (1,731)	2,500
Brookdale	Zone 1A	1969	Gravity Zone	Stanford and Barnett (1,731)	3,480
Pierce Heights	Zone 1A	2000	Gravity Zone	Stanford and Barnett (1,731)	2,000
Barneburg	Zone 1B	1979	Gravity Zone	Barneburg (1,684)	1,600
Archer	Zone 1C	1999	Gravity Zone	Southwest (1,735)	2,250
Stanford	Zone 2	1972	Zone 1 Reservoirs	Hillcrest #1 and Lone Pine No. 2 (1,881)	3,640
Hillcrest	Zone 3	1972	Zone 2 Reservoirs	Hillcrest #2 and Lone Pine No. 3 (2,031)	2,490
Angelcrest	Zone 4	1972	Zone 3 Reservoirs	Stardust and Cherry Lane No. 4 (2,181)	1,800
Stardust	Zone 5	1995	Zone 4 Reservoirs	Highlands (2,331)	1,150

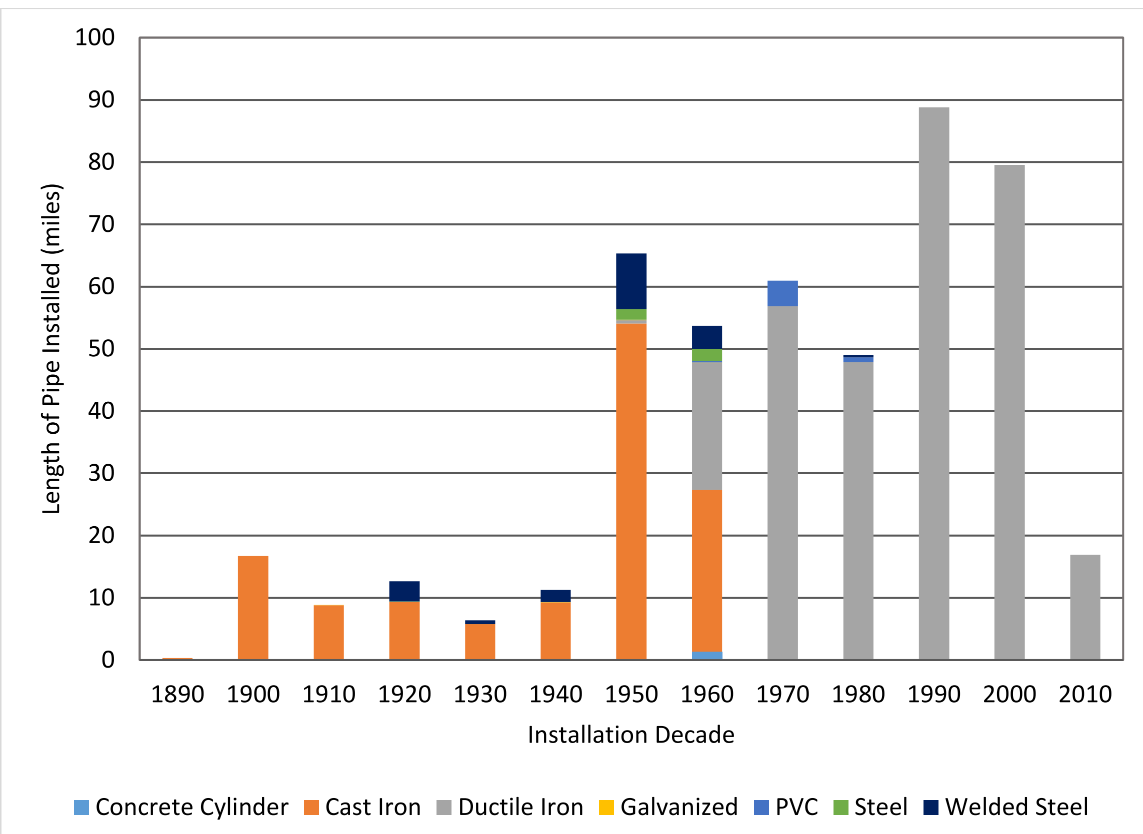


Figure 2-4. Inventory of Existing Water Lines by Installation Year and Length

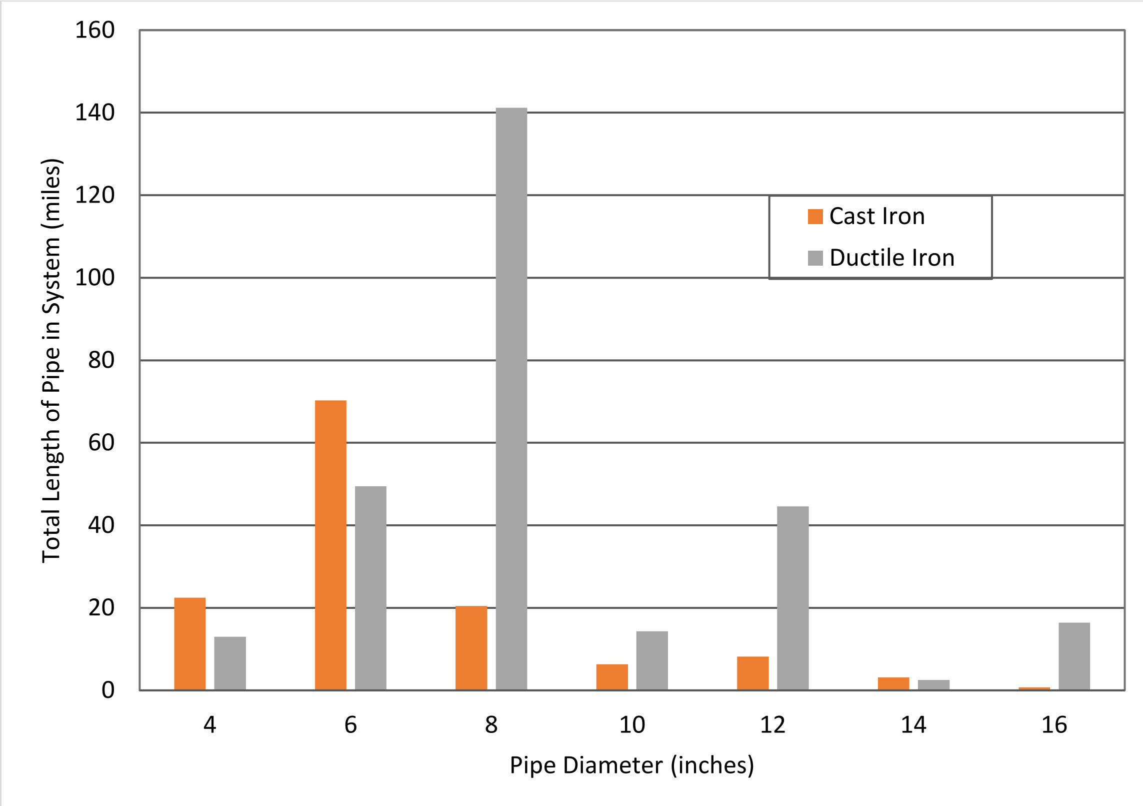


Figure 2-5. Inventory of Existing Cast and Ductile Iron Water Lines by Diameter

SECTION 3

Water Demand History

This section describes the recent history of water use in MWC's water system. The historical data include average and maximum demands, per capita demands, metered consumption, and values for nonrevenue water. This documentation of recent water use within MWC provides the basis for projecting future water use. Additional information regarding water use within Medford is provided in MWC's 2016 *Water Management and Conservation Plan*, also prepared by CH2M.

3.1 Terminology

Production refers to the quantity of water delivered to the distribution system. "Production" and "demand," as used within this report, are synonymous. For MWC, production is the total amount of water entering the distribution system from Big Butte Springs and the Duff WTP. Production may be divided into two broad categories: water that provides revenue to the utility, and water that does not provide revenue, also known as nonrevenue water. **Figure 3-1** illustrates this breakdown using the International Water Association/American Water Works Association (IWA/AWWA) water audit schematic.

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Nonmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Nonrevenue Water</td></tr>
<tr><td>Unbilled Nonmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections to Customers' Meters</td></tr>
</table>

Figure 3-1. International Water Association/American Water Works Association Water Audit Schematic

Revenue water consists of all billed, metered water consumption, and any billed unmetered consumption, such as water that is sold for construction but is not metered. Some nonrevenue water is to be expected, including authorized, unbilled metered or unmetered consumption such as use for firefighting, and hydrant flushing, unauthorized consumption, water loss because of meter inaccuracies, and real losses through leaks, reservoir overflows, and evaporation. MWC estimates and accounts for unbilled authorized water uses including hydrant use, firefighting, water quality sampling, and main flushing. Reservoir drainage for maintenance, and water flushed when the BBS pipelines are transitioned from full to partial flow mode also are recorded.

MWC has a sophisticated SCADA system that monitors and calculates many system parameters including production rates, reservoir storage volumes, and flow into and out of storage reservoirs. A SCADA calculation subtracts the unavoidable overflow at the Capital Reservoirs from daily demand calculations. The overflow primarily occurs during the winter months when BBS pipeline flows exceed demands since the system does not accommodate ongoing adjustments to match real-time demands. The overflow volume at Capital Reservoirs or other reservoirs is not currently automatically totalized, and must be estimated manually. MWC was implementing changes as this report was being prepared to automatically track and record overflows from the Capital Reservoirs.

Hourly water demands fluctuate in response to water use patterns by residential, commercial, and industrial customers. These short-term demands are met by a combination of production and withdrawals from the storage reservoirs.

Metered use or consumption refers to the portion of water use that is recorded by customer meters. Connection refers to a metered connection of a customer to MWC's system. Revenue water refers to billed consumption, and *nonrevenue water* refers to the difference between production and revenue water.

Specific demand terms include the following:

- Average day demand (ADD)*:* total annual production divided by 365 days
- Maximum day demand (MDD): the highest daily production during a calendar year
- 3-day Maximum day demand (3-d MDD): the average of the three highest consecutive daily demands
- Maximum monthly demand (MMD)*:* the average daily demand during the calendar month with the highest total demand
- Peak-hour demand (PHD): the highest hourly demand during a calendar year

MDD is an important value for water system planning. The supply facilities (Big Butte Springs and the Duff WTP) must be capable of meeting the MDD. If the MDD exceeds the combined supply capacity on any given day, finished water storage levels will be reduced. Consecutive days at or near the MDD will result in a water shortage. The 3-day MDD provides an indication of the duration of a peak use period.

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

3.2 System Demands

Table 3-1 and **Figure 3-2** summarize demand records for the overall MWC system from 2000 through 2015. The overall system represents both individual retail accounts, and sales to other cities and water districts. ADD, MMD, MDD, 3-d MDD, and peaking factors are presented.

ADD values have ranged from 25.8 mgd to 30.6 mgd. The growth in the ADD has been steady throughout this period, averaging approximately 0.21 mgd increase per year as illustrated by the linear regression line in Figure 3-2.

Table 3-1. Summary of MWC System Demands
Medford Water Commission Water Distribution System Facility Plan

Year	ADD (mgd)	MMD (mgd)	MDD (mgd)	3-d MDD (mgd)	Date of MDD	MMD to ADD Peaking Factor	MDD to ADD Peaking Factor
2000	25.8	43.8	51.8		1-Aug	1.7	2.0
2001	27.3	46.0	50.3		10-Aug	1.7	1.8
2002	27.0	45.0	52.6		11-Jul	1.7	1.9
2003	26.2	45.8	57.8		29-Jul	1.7	2.2
2004	28.9	49.8	54.5		8-Aug	1.7	1.9
2005	28.6	52.5	59.7		4-Aug	1.8	2.1

Table 3-1. Summary of MWC System Demands
Medford Water Commission Water Distribution System Facility Plan

Year	ADD (mgd)	MMD (mgd)	MDD (mgd)	3-d MDD (mgd)	Date of MDD	MMD to ADD Peaking Factor	MDD to ADD Peaking Factor
2006	29.3	51.5	55.9	55.0	20-Jul	1.8	1.9
2007	27.2	46.6	55.6	55.2	10-Jul	1.7	2.0
2008	26.7	47.8	57.6	57.1	30-Jul	1.8	2.2
2009	27.7	51.3	61.8	61.0	29-Jul	1.8	2.2
2010[a]			57.4	56.6	23-Jul		
2011	25.9	47.2	48.8	47.2	9-Aug	1.8	1.9
2012	29.5	47.7	52.1	51.3	18-Aug	1.6	1.8
2013	29.9	51.7	56.0	54.3	23-Jul	1.7	1.9
2014	30.6	50.5	53.0	52.6	16-Jul	1.7	1.7
2015	30.4	49.7	62.3	58.8	3-Jul	1.6	2.1
Average	**28.1**	**48.5**	**55.4**	**54.9**		**1.7**	**2.0**

[a] Annual production values were unavailable because of difficulties with master metering.

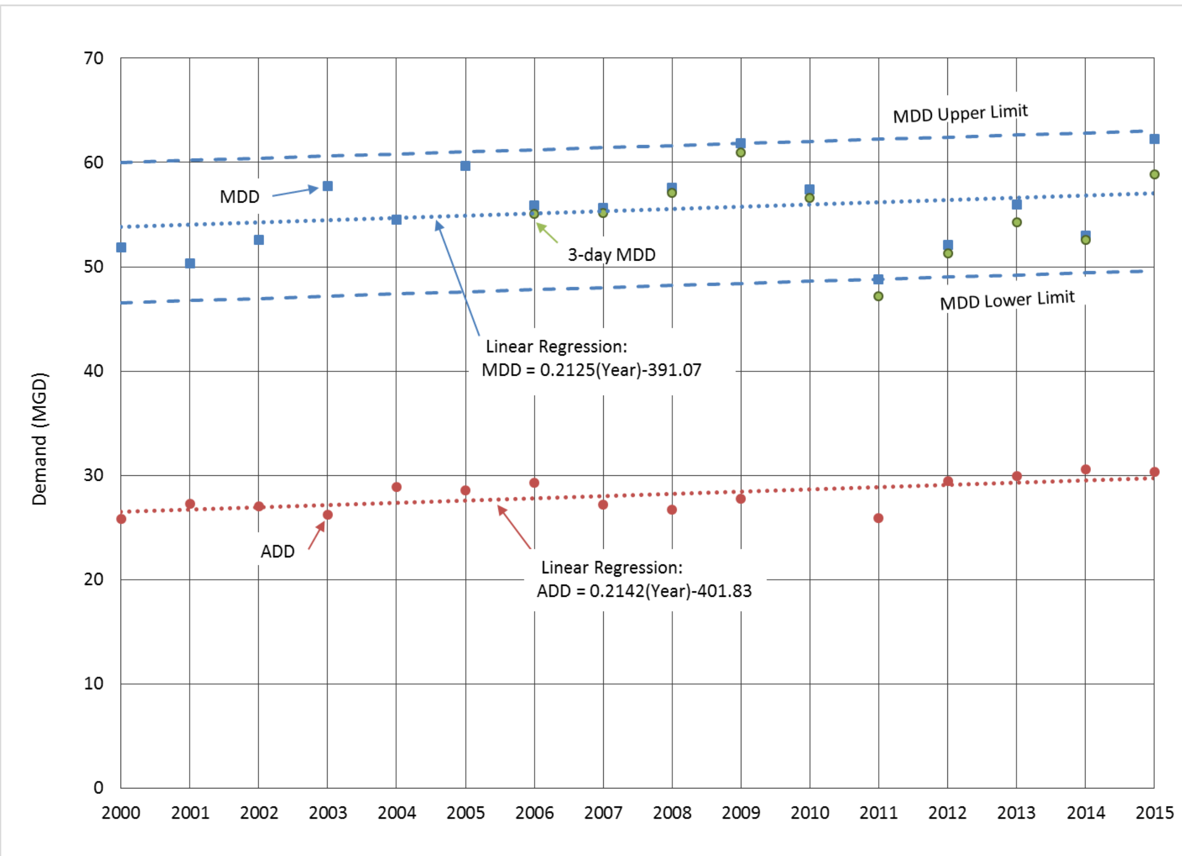


Figure 3-2. Average, Maximum Day, and 3-day Maximum Day Demand Records 2000-2015

Within the period 2000 to 2015, the MDD ranged from a low of 48.8 mgd to a high of 62.3 mgd, and fell within a band of minus 7 mgd to plus 6 mgd of the linear regression average MDD. The highest value of 62.3 mgd occurred on July 2, 2015. The MDD occurred in July for nine of the years shown, and in August for six of the years. The 3-day MDDs were only slightly lower than the MDD, indicating that rather than being a single day event, peak demand events can last for up to three days.

MDDs fluctuate from year to year because they are strongly influenced by weather patterns and the economy. Factors influencing MDD include the following:

- High temperatures
- Number of consecutive days at high temperatures
- When the high temperatures occur during the summer (for example, if high temperatures occur earlier in the summer, the demands are often higher than if they occur later in the summer; summer demands are highly influenced by landscape irrigation, and this trend could be explained by evapotranspiration rates [actual plant water needs] declining after mid-July or simply because customers may tire of maintaining green landscapes later in the summer)
- Overall rainfall levels during the summer
- Consecutive days without rainfall
- Number of new homes with new landscapes, since owners will generally take extra care to keep newly installed landscapes thoroughly watered
- Regional drought messaging, especially via news media
- Economic downturns affecting all customers concerned about water bills, whether industrial, commercial, or residential.

Figure 3-3 shows the contribution of the other cities' ADD to the MWC system ADD. Other cities' contribution grew considerably between 2000 and 2008, largely because of increasing demands in Central Point and Eagle Point. The remaining cities had relatively stable ADDs, averaging 6.6 mgd, between 2008 and 2015. Because MWC went through a transition in billing system software, 2013 data were not available. In late summer of 2014, MWC began serving the City of Ashland through the Talent-Ashland-Phoenix (TAP) master meter shown to the south in the MWC service area in Figure 2-1. Talent and Phoenix also receive most their water through this connection, with a portion also provided through Phoenix's Garfield Street meter. Water demands of the other cities grew from approximately 16 percent of MWC system demand in 2000 to 22 percent of MWC system demand in 2015.

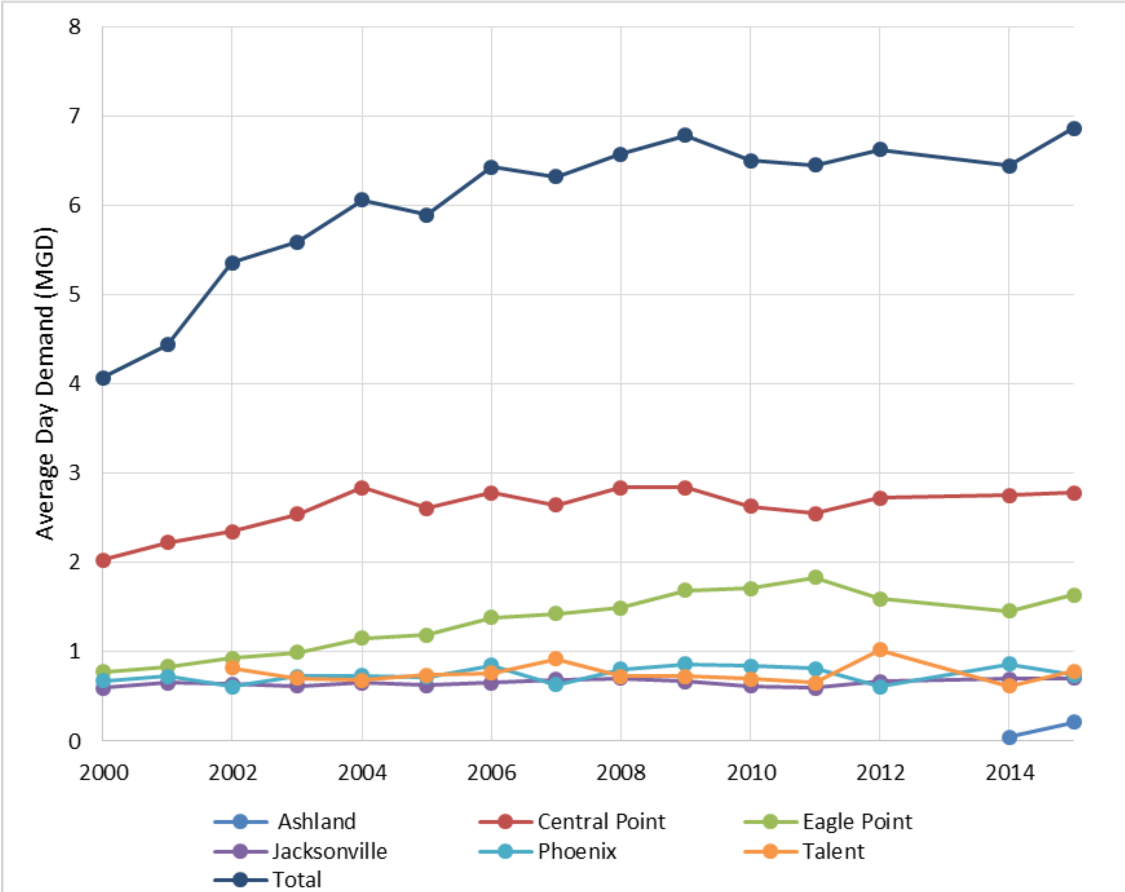


Figure 3-3. ADD for Other Cities 2000-2015

3.2.1 Peak Hour Demands

The peak hour demands (PHD) on the MWC system were assessed by an evaluation of the diurnal demand of the MWC system. As a whole, the ratio of the PHD to the MDD for the MWC system for recent demands is 1.56. This value is slightly higher than the peak hour factor of 1.5 applied in the 2007 plan. This PHD is used to assess the performance of the distribution system and to consider storage volume. The evaluation of the PHD was performed using extended period simulation that encompasses both PHD and minimum demands on a maximum day to assess water delivery, reservoir refill, and use of equalization storage in one analysis run.

3.2.2 Monthly Demands

MWC experiences considerably higher demands in the summer months, much of which is related to irrigation of landscapes. **Figure 3-4** illustrates this seasonal trend in water demand, and presents monthly production by source for 2012 through 2015. BBS production is measured with magnetic flow meters located at the Coal Mine Pressure Control Station shown in Figure 2-1 on the transmission lines at the northeast edge of the distribution system. Because some customers are served upstream of these meters, the total flow is determined as the sum of flow at the Coal Mine meters plus the sum of metered customer flow upstream of Coal Mine. The BBS production pattern results from the two different modes of operation: half-pipe mode through the winter and spring months, and full-pipe mode in the summer months. Duff No. 1 WTP generally operates approximately 6 months of the year. Duff No. 1 WTP was brought online in April in 2013, 2014, and 2015, and in May in 2012, and operation continued through September in 2013 and 2014, and through part of October in 2012 and 2015.

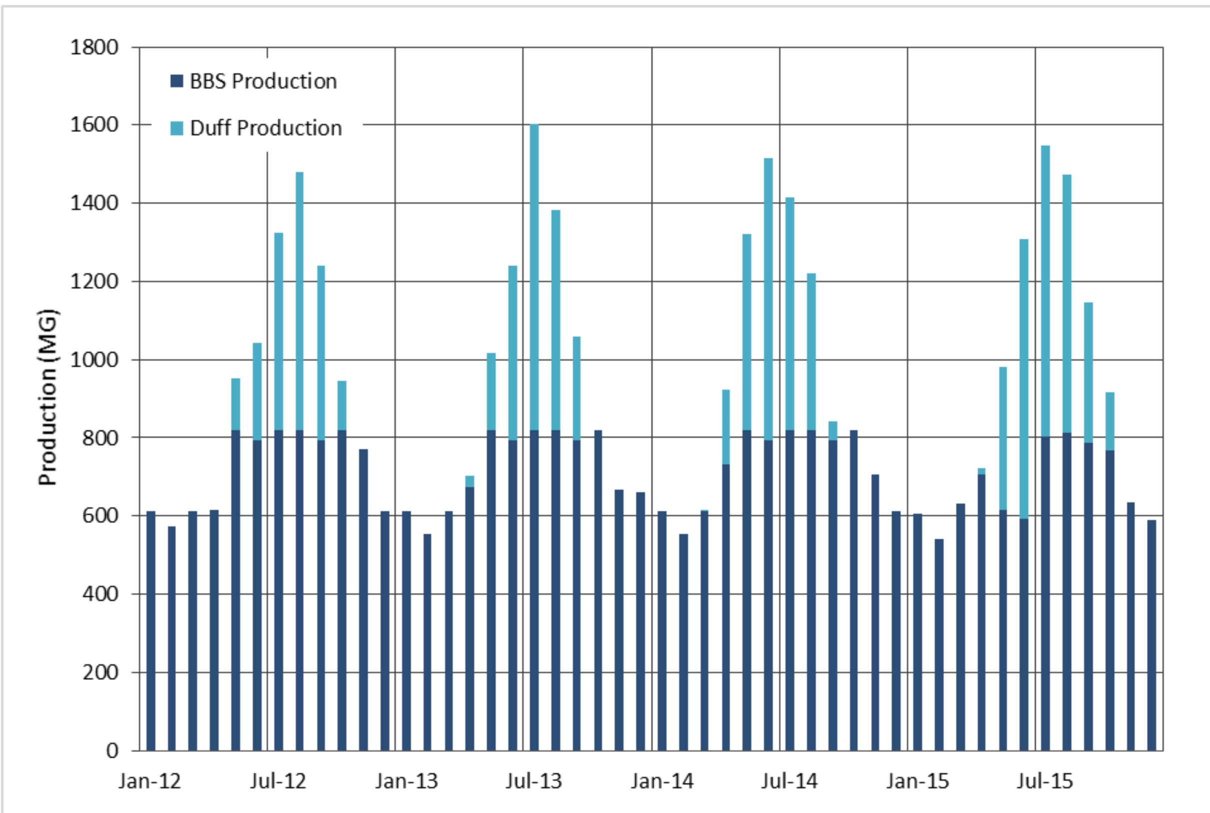


Figure 3-4. Monthly Production by Source 2013-2015

Figure 3-5 presents the percentage of monthly production from the Duff No. 1 WTP for each month for 2012 through 2015, and the average value for the 4-year period. Duff No. 1 WTP contributed from 38 percent to 49 percent of the water delivered into the system, and averaged 44 percent of July production for the period. Duff contributed an unusual percentage of June production in 2015, accounting for 55 percent of the monthly production. This was a result of using the BBS source at half-pipe level in June of 2015, rather than at full pipe as normally occurs during June. This mode of operation enabled the Eagle Point Irrigation District (EPID) to more fully use the shared Big Butte Springs source in June, delaying their use of Willow Lake water to meet demands. This action was taken due to unusually low snowfall levels in winter 2014-15, and coordinated efforts to avoid excessive draining of the lake. This is not the protocol during most years, but has been done during a few other drought years, and can be expected to occur from time to time in the future.

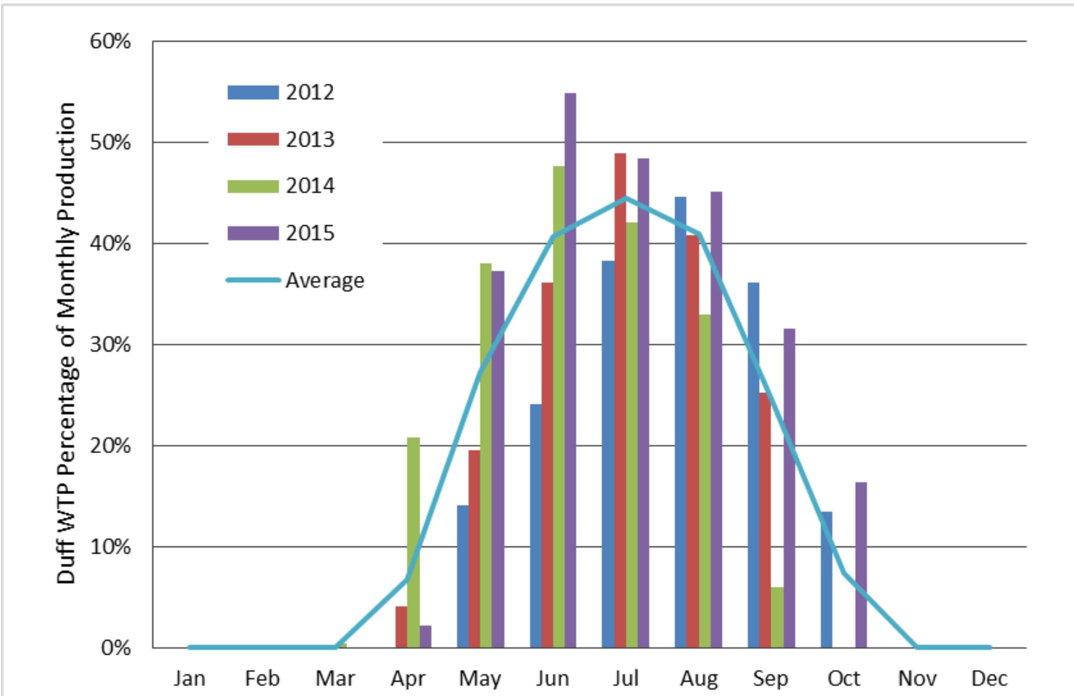


Figure 3-5. Percentage of Monthly Production Contributed from Duff WTP, 2013-2015

Figure 3-6 presents monthly production for 2015. In this presentation, the portion of BBS production that serves customers upstream of the flow meters at Coal Mine Pressure Control Station is indicated. Also shown is the portion of BBS flow that exceeds system demand and is therefore overflowed at Capital Reservoir during the winter months. The total flow from BBS is the sum of the sales above Coal Mine, the estimated overflow at the Capital Reservoirs, and the portion entering the city's distribution system (the bar shown as the remainder of the BBS production).

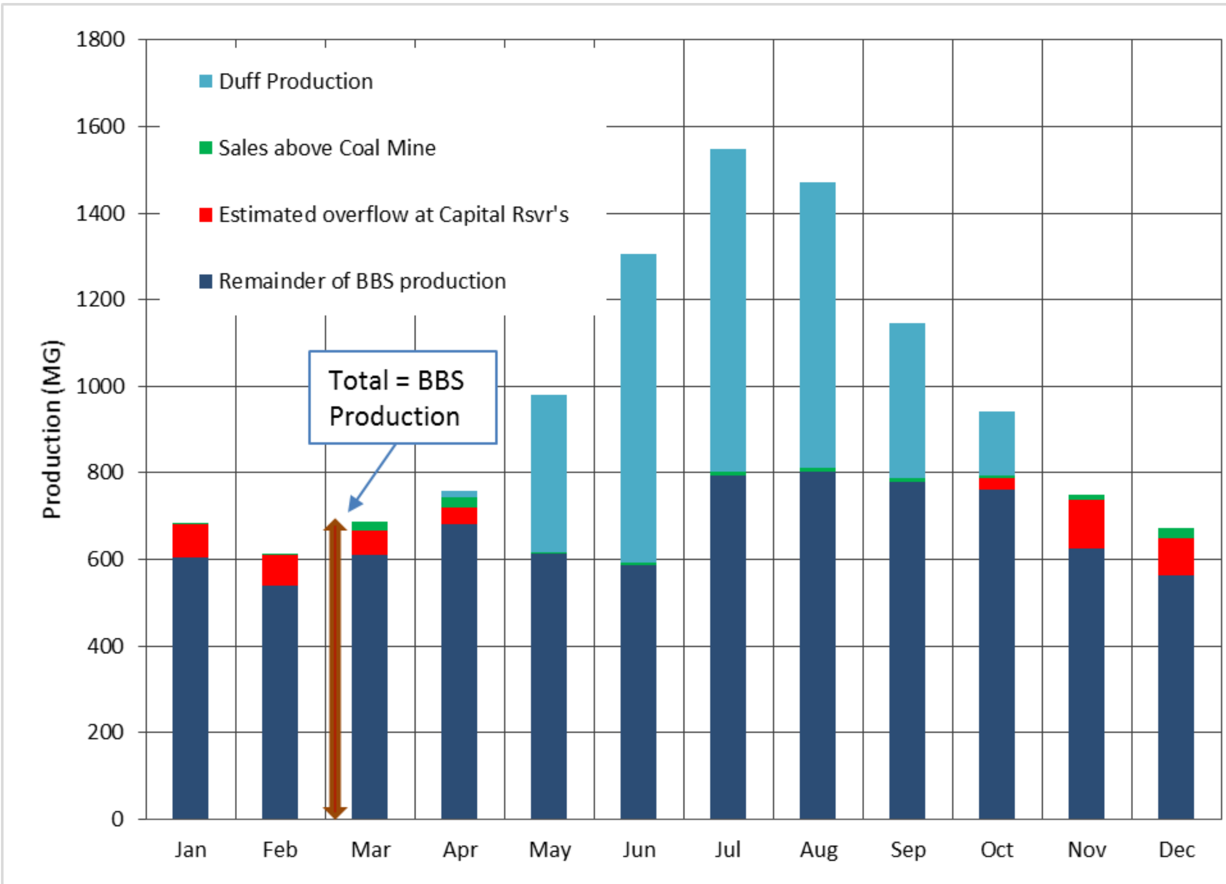


Figure 3-6. Monthly Production with BBS Flow Components Identified, 2015

Figure 3-7 shows the system wide monthly demands as a percentage of annual demand for 2015. July averaged over 14 percent of annual demand, and demand during the four-month period from June through September averaged 49 percent of total annual demand.

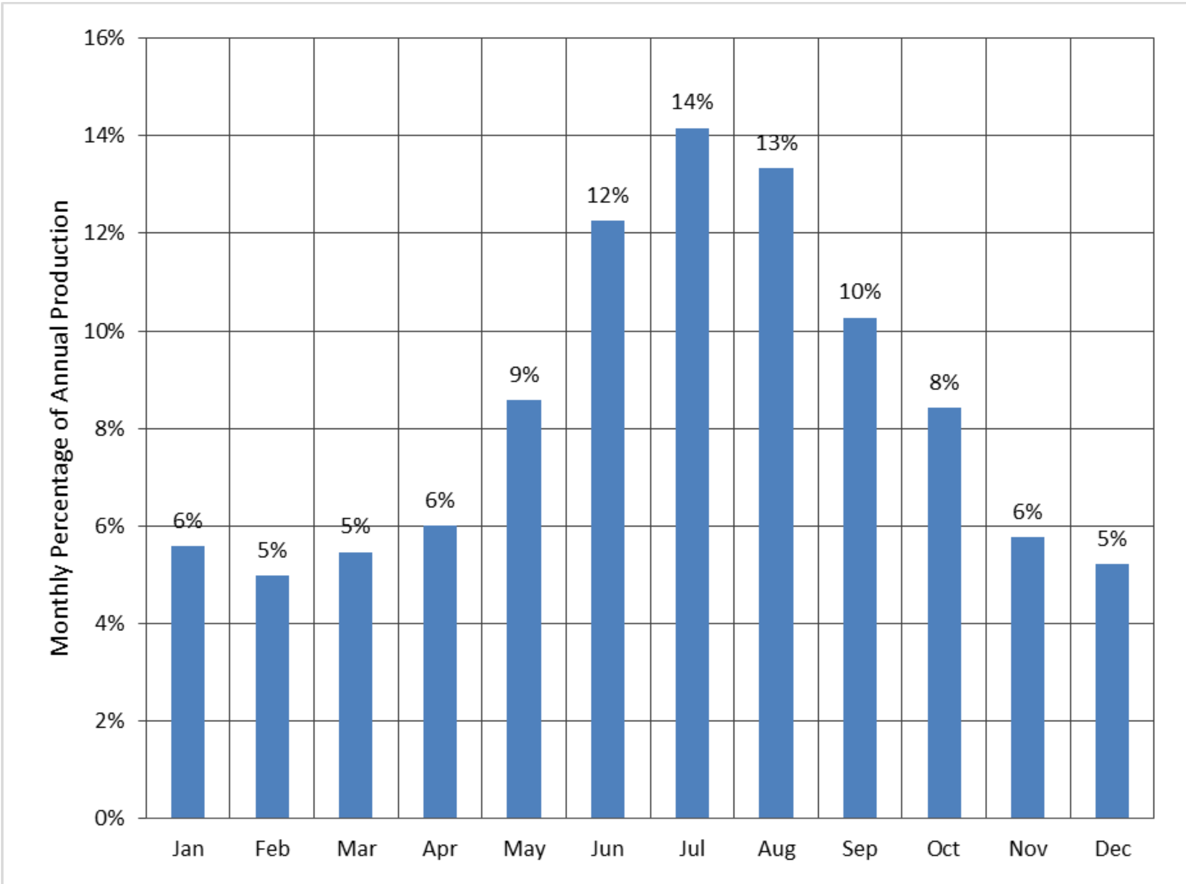


Figure 3-7. Monthly Production as a Percentage of Annual Production, 2015

The monthly demands of other cities are presented in **Figures 3-8** and **3-9.** Figure 3-8 presents monthly demand in terms of volume and Figure 3-9 presents monthly demand in terms of a daily rate for the six other cities served by MWC for the period 2012 to 2015. Because MWC went through a transition in billing system software, 2013 data were not available. The overall peak monthly demand for the other cities occurred in July and August of the 3 years shown. The highest maximum monthly demand (MMD) for the other cities totaled nearly 14 mgd in July of 2015. MWC serves five of the other cities year-round, but only serves Ashland during the summer months.

Collectively, the wholesale cities purchased 26 percent of water sold by MWC in 2015, varying from approximately 23 percent in winter months to approximately 28 percent during the summer.

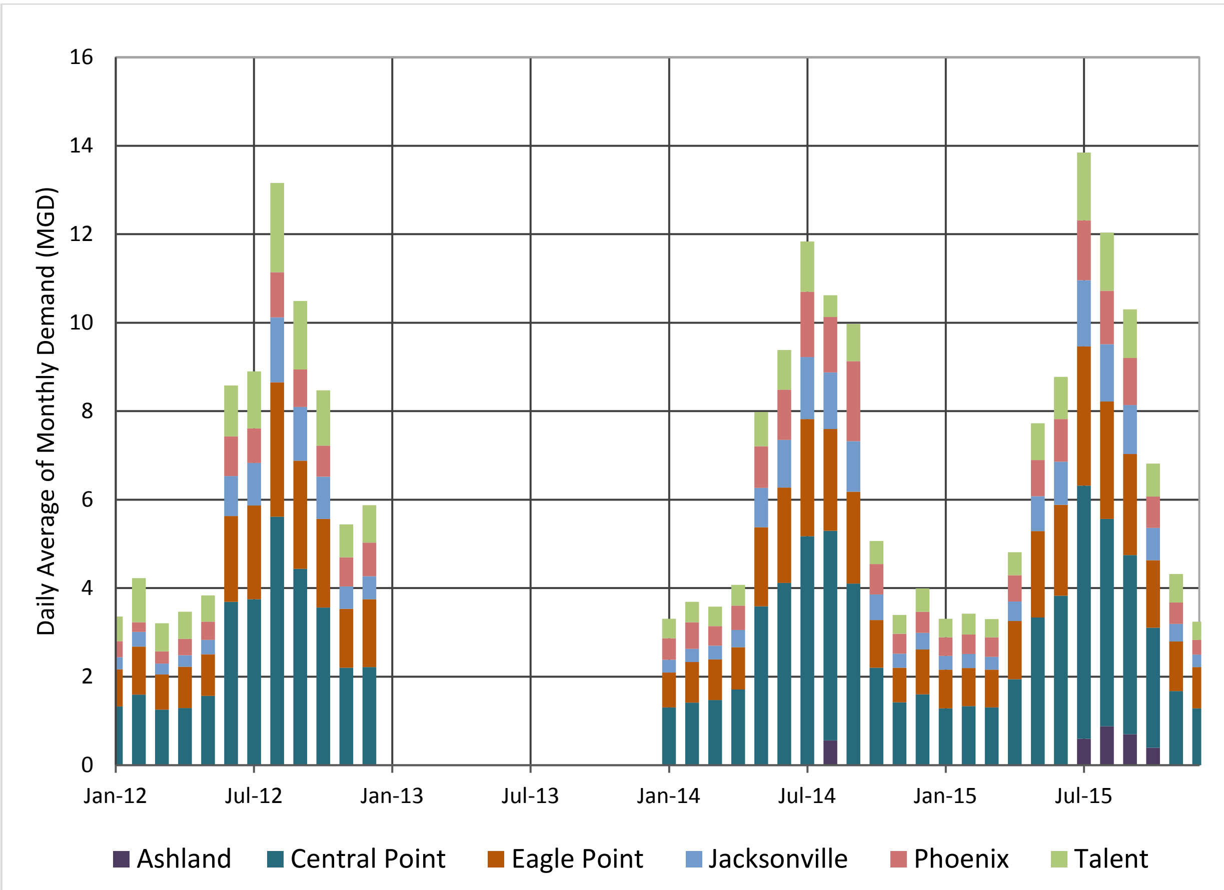


Figure 3-8. Monthly Demand of Other Cities, 2013-2015

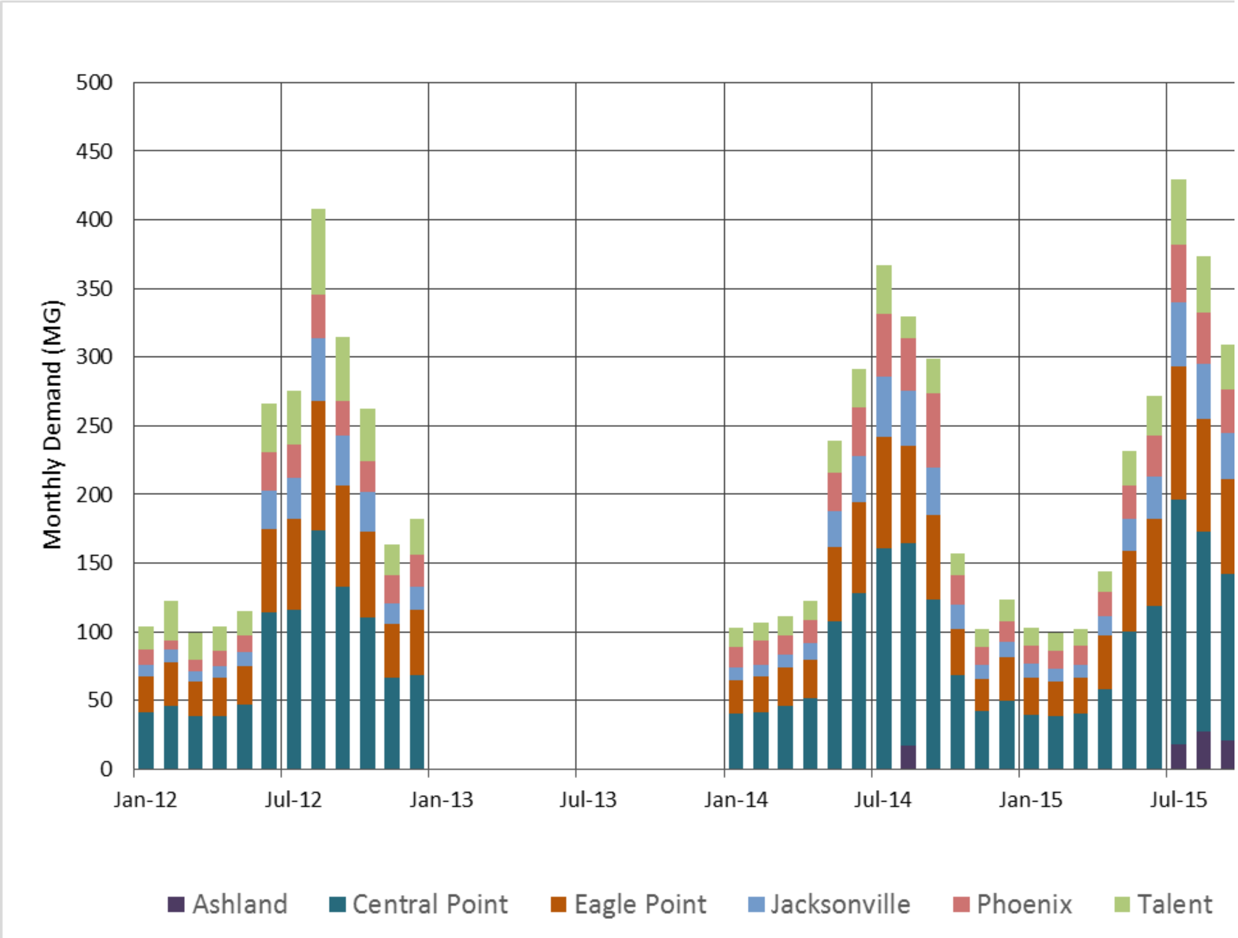


Figure 3-9. Monthly Demand of Other Cities, 2013-2015

Figure 3-10 shows the historical MMDs for the other cities from 2007 through 2015. Also shown is a hypothetical total MMD for other cities that would occur if all cities experienced a maximum month in the same month. Demands associated with the other cities remained relatively constant for the period. Central Point had the highest MMD, averaging 5.7 mgd for the period. Eagle Point was next, averaging 3.1 mgd, while Jacksonville, Phoenix, and Talent all had MMDs averaging 1.5 mgd for the period. The variability of use for Phoenix and Talent is believed to be related to metering issues with the Talent meter that determines the division of TAP line use between these two cities.

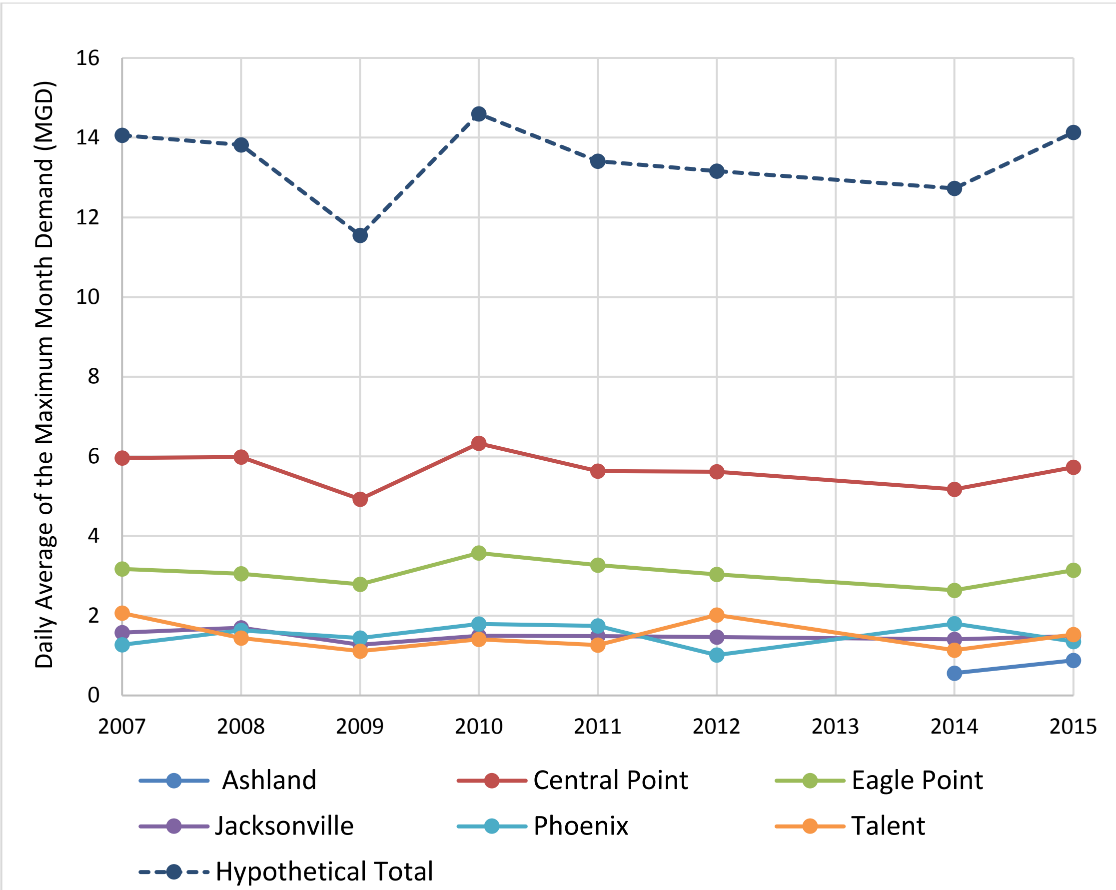


Figure 3-10. Historical Maximum Month Demand for Other Cities, 2007-2015

3.2.3 Peaking Factor

Peaking factors help describe the water system's peak summer use as compared with other usage parameters. **Figure 3-11** illustrates the history of MWC's peaking factors. The overall system MDD to ADD peaking factor has ranged from 1.8 to 2.2 and averaged 2.0 over the period 2000-2015. The system wide MDD to MMD peaking factor averaged 1.14, and the MMD to ADD peaking factor averaged 1.7 over the period.

MDD data disaggregated for each customer group were not available because meters are read monthly, rather than daily. MWC is in the process of installing automated meter infrastructure (AMI) throughout the water system, but completion is still several years away.

AMI-capable registers have also been installed on all the wholesale city master meters except the TAP meter, with work currently ongoing to access similar real-time use data for the TAP meter. The TAP meter is equipped with a data logger and values are downloaded monthly. When completed, these master meters will provide granular usage data for the wholesale cities group, and their actual peak usage can be accurately determined.

Without these tools available for this study, however, MDD values for customers were estimated by multiplying the MMD values of the customer group by the overall system MDD to MMD peaking factor.

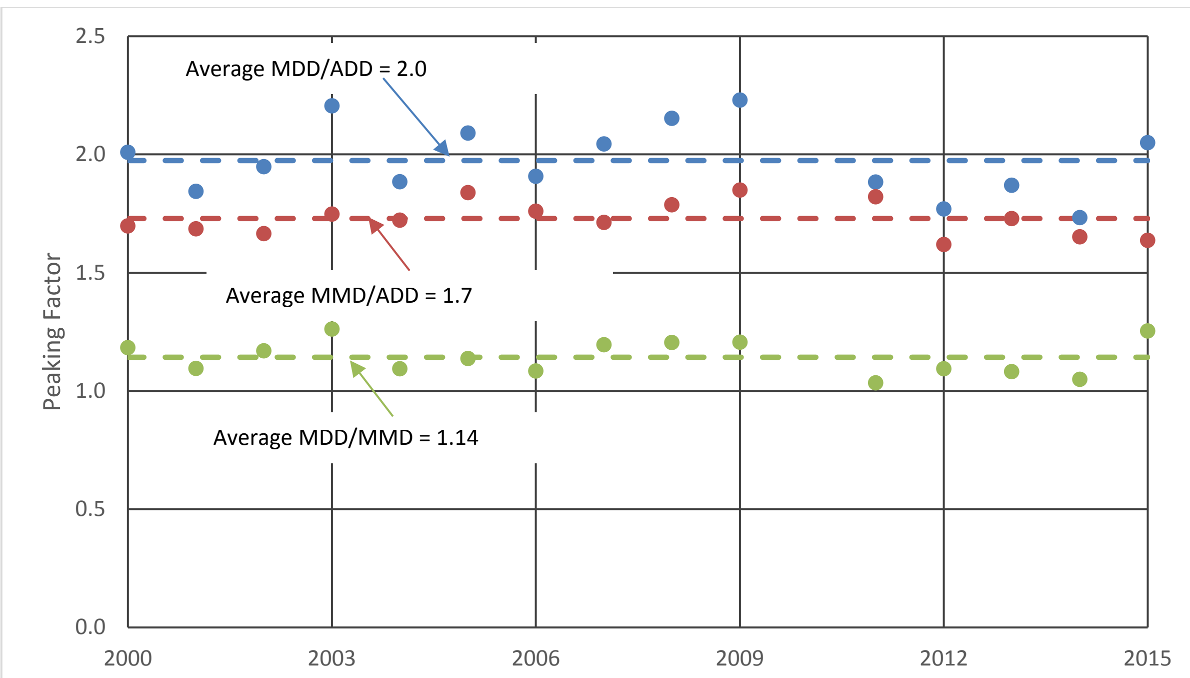


Figure 3-11. Historical System Wide Peaking Factors, 2000-2015

3.2.4 Per Capita Demands

Per capita demands are calculated as daily demand divided by service population. Since demand includes use by commercial, industrial, and municipal customers as well as residential customers, the per capita value exceeds the amounts of water used by a typical individual. The region's hot and dry summers result in peak demands significantly higher than average demands.

The per capita demand values are important because they are used for projecting future water use.

Table 3-2 shows the estimated service area populations for cities, water districts, and customers inside and outside of Medford city limits for 2015. Populations served within White City, the water districts, and individual accounts outside city limits were estimated by MWC staff based on U.S. Census data

(U.S. Census Bureau, 2010), account data, and field investigation. Service area populations for the cities were estimated by adjusting the certified population estimates for 2015 from Portland State University's Population Research Center to account for households not receiving water but within city boundaries, or receiving water but outside of boundaries. The service area population for White City was similarly reduced from U.S. Census Bureau data to account for households within the community boundary that do not receive water service. The total 2015 service area population was estimated at 136,100.

Table 3-2**.** Determination of MWC Service Area Population, 2015
Medford Water Commission Water Distribution System Facility Plan

		Adjustments to Population					
	Population[a]	**Housing Units Served Outside Limits**	**Housing Units Not Served Inside Limits**	**Net Housing Units Served**	**Average House-hold Size**	**Population Adjustment**	**MWC Service Area Populations[b]**
Ashland[c]	20,405					-15,300	5,105
Central Point	17,485	34	3	31	2.61	80	17,565
Eagle Point	8,695	21	2	19	2.62	50	8,745
Jacksonville	2,880	74	5	69	2.02	140	3,020
Medford	77,655	0	130	-130	2.44	-320	77,335
Phoenix	4,585	0	0	0	2.26	0	4,585
Talent	6,270	35	0	35	2.29	80	6,350
White City	8,530	0	16	-16	3.08	-50	8,480
Other outside customers	1080	0	0	0	-	-	1,080
Water Districts	3,835	0	0	0	-	-	3,835
Total							**136,100**

[a] Population values for cities and the White City Unincorporated Community area were obtained from the Portland State University Population Research Center. Populations for water districts, and other outside customers were estimated by MWC staff from census data, account records, and field surveys.

[b] Service area population accounts for only those households receiving water service. Therefore, households outside of a given boundary that receive water service are added, and households within the boundary that do not receive water service are subtracted.

[c] Service population for the City of Ashland was estimated at 25 percent of the city population based on MWC providing approximately 25 percent of Ashland's peak day water usage.

Per capita demand values are presented in **Table 3-3**. Per capita demands range considerably between the entities identified in Table 3-3, because of different mixes of residential, commercial, and industrial components. Most the region's industrial customers are in White City and the remainder of the outside customer group, and these entities have the highest per capita demands. Water Districts and the City of Medford also have larger commercial and industrial sectors than the wholesale cities. In addition, the City of Medford houses most the region's institutional customers, including two hospitals, and most federal, state, and county government offices. This diversity of water users is reflected in the varied per capita demand values of individual entities.

For the City of Medford and outside customers, ADD was estimated as metered consumption plus a proportionate amount of the total nonrevenue water to represent total demand. Adding nonrevenue water to the metered consumption of retail customers resulted in the data from all customers being consistent, because wholesale customers' per capita demand includes nonrevenue water that occurs downstream of the wholesale customer master meters.

Table 3-3. Estimated 2015 Per Capita Demands of MWC Customers
Medford Water Commission Water Distribution System Facility Plan

	MWC Service Area Population[a]	Estimated Per Capita ADD (gpcd)	Estimated Per Capita MMD (gpcd)[b]	Estimated Per Capita MDD (gpcd)[c]
Ashland[d]	5,105	--	173	197
Central Point	17,565	158	326	372
Eagle Point	8,745	188	360	410
Jacksonville	3,020	235	494	564
Medford[e]	77,335	218	401	457
Phoenix	4,585	161	296	337
Talent	6,350	123	241	275
White City	8,480	443	650	741
Other outside customers	1,080	443	650	741
Water Districts	3,835	263	585	667
System wide Values[e]	**136,100**	**218**	**365**	**458**

[a] Service area population accounts for only those households receiving water service. Therefore, households outside of a given boundary that receive water service are added, and households within the boundary that do not receive water service are subtracted. Service area population from Figure 3-11.

[b] Per capita MMD = Per capita ADD x MMD/ADD peaking factor specific to customer.

[c] Per capita MDD = Per capita MMD x overall system MDD/MMD peaking factor. The overall system MDD/MMD = 1.1.

[d] Values for Ashland are not representative of the whole community but are strictly based on demand satisfied by MWC.

[e] Demand attributed to authorized overflow was not included in the per capita demand calculation, because this portion of demand will decrease over time as winter-time demands begin to match production from BBS.

Note:

gpcd = gallons per capita per day

3.2.5 Demand Factors Inside City of Medford

Per capita demand factors presented thus far include all metered water use for all categories of demand (residential, commercial, industrial) plus nonrevenue water. Demand attributed to authorized overflow was not included in the per capita demand calculation, because this portion of demand will decrease in coming years as wintertime demands begin to match production from BBS. In 2015, the City of Medford's metered consumption accounted for 76 percent of water sales. Therefore, 76 percent of the nonrevenue water (not including overflow) was added to the inside Medford metered consumption to estimate demand. The remaining 24 percent of nonrevenue water was apportioned between outside customers and water districts.

3.2.5.1 Residential Per Capita Demand Factors

The overall per capita ADD for the City of Medford in 2015 was estimated at 218 gpcd. This represents a reduction from the estimated per capita demand of 246 gpcd in 2005, as used in the last facility plan. Further discussion of the per capita demand and its trend in the MWC system is provided in the 2016 *Water Management and Conservation Plan*. From billing data, single-family residential use represented 55 percent and multi-family use represented 16 percent of the total consumption within city limits. Per the *Medford Comprehensive Plan, Housing Element,* 2010, in 2009, single-family residences accounted for 64 percent of dwelling units and multi-family residences accounted for approximately 36 percent of dwelling units. Therefore, the single- and multi-family residential per capita demands were estimated as follows:

- Single-family average daily per capita demand = 0.55(218 gpcd)/0.64 = 187 gpcd
- Multi-family average daily per capita demand = 0.16(218 gpcd)/0.36 = 97 gpcd

A peaking factor of 2.0 was used to adjust ADD per capita to MDD per capita for specific residential categories.

3.2.5.2 Commercial and Industrial Demand Factors

Both commercial and industrial water demand within the City of Medford averaged 1.5 gpm per acre (2,160 gpd per acre). This was computed by dividing water demand by existing commercial and industrial enterprises by the occupied land area in each customer class to obtain average day demand factors, in gallons per minute per acre. This factor is comparable to commercial and industrial demand factors from other Oregon communities.

3.3 Consumption and Nonrevenue Water

As discussed previously in this section, all systems have unavoidable losses, and some portion of the water treated by a water utility is not expected to be sold. This “nonrevenue water” can include both legitimate “authorized” unbilled uses and “unauthorized” uses. MWC attempts to track and make estimates to quantify authorized uses, including water used by fire departments for fire suppression and training, usage by local public works agencies, and MWC’s own water system operational tasks such as hydrant flushing, main flushing, water quality sampling stations, and estimated losses from repaired main breaks. Also tracked are overflows at the Capital Reservoirs, which largely occur during winter months, and are unavoidable because flows from BBS cannot be adjusted to match real-time demands. All of these authorized unmetered water uses contribute to nonrevenue water.

Nonrevenue water also includes losses that cannot be tied to specific legitimate activities, and are referred to as unauthorized or unaccounted-for usage. Falling within this category are apparent losses associated with metering or data handling errors, water theft, and real losses from leakage.

In determining a system’s nonrevenue water rate, the IWA/AWWA water audit method excludes wholesale water sales. For the MWC system, this means that the other cities’ demands are removed from the calculation. This is because the other cities determine their own nonrevenue water rates, with the MWC master meter values equaling their production. In situations such as MWC’s where the water sold to wholesale customers is wheeled through the supplier’s distribution system to reach wholesale meters, the IWA/AWWA methodology does not recognize that losses tend to be proportional to flows and pipe sizing. By eliminating wholesale sales from the computation, the nonrevenue water is compared to a lower “net” production, in turn resulting in higher percentages of overall nonrevenue water for MWC and of the unauthorized/unaccounted-for portion of that nonrevenue water.

Figure 3-12 provides a breakdown of total water production by category for 2015. This graph shows that of the 17 percent nonrevenue water associated with MWC's retail customers in 2015, 6 percent (519 MG) was authorized, and 10.5 percent (900 MG) was attributable to unauthorized causes such as water theft, leakage, or apparent losses associated with meter error and data handling errors.

As per the IWA/AWWA water audit methodology, the 10.5 percent unauthorized loss results from comparing unauthorized losses to water only used by City of Medford customers (8,585 MG), rather than a comparison to total production (11,090 MG). The percentage is approximately 8 percent, if unauthorized losses were compared to City of Medford customers plus water use by other city customers. With a total of 10.5 percent unauthorized or unaccounted for nonrevenue water, MWC's leakage rate is likely below the 10 percent target of OWRD for municipal systems. MWC is committed to refining SCADA calculations to continue to document nonrevenue water and to evaluate areas for reducing this metric. A more complete discussion of nonrevenue water is provided in the 2016 *Water Management and Conservation Plan*.

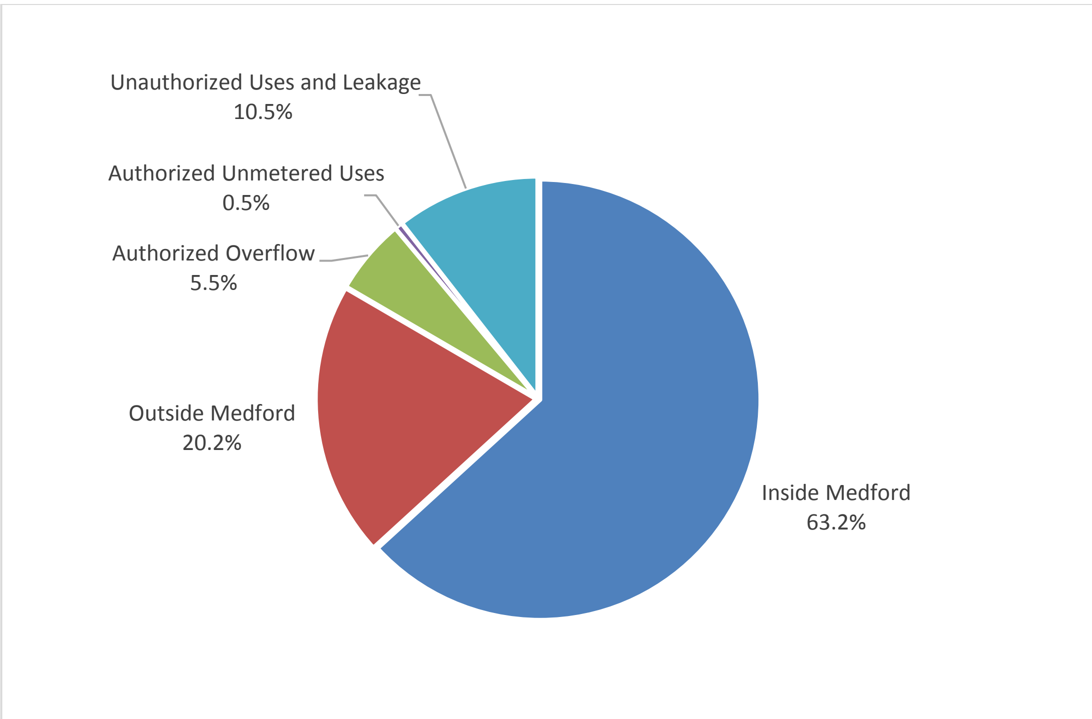


Figure 3-12. Water Use by Category Excluding Other Cities, 2015

3.3.1 Inside Medford, Outside, and District Customers

A summary of annual consumption by billing system classification for MWC's system is shown in **Table 3-4**.

Table 3-4. MWC Metered Consumption by Customer Category
Medford Water Commission Water Management and Conservation Plan

	Single-family		Multi-family		Commercial		Industrial		
Year	**Inside**	**Outside and Districts**	**Inside**	**Outside and Districts**	**Inside**	**Outside and Districts**	**Inside**	**Outside and Districts**	**Total**
2014	2,917	382	855	266	1,303	212	208	904	7,047
2015	3,009	382	857	261	1,350	219	183	862	7,122
Average	**2,963**	**382**	**856**	**263**	**1,326**	**216**	**196**	**883**	**7,085**
Percent	**42%**	**5%**	**12%**	**4%**	**19%**	**3%**	**3%**	**12%**	**100%**

Figure 3-13 illustrates the distribution of customer use between inside and outside City of Medford boundaries. The types of water use inside city limits are primarily residential (both single and multi-family) and commercial. Most the industrial water use is located outside Medford city limits in White City. Therefore, the per capita use values for White City and other outside customers is considerably higher than the per capita use for more densely populated areas with less industry within Medford city limits.

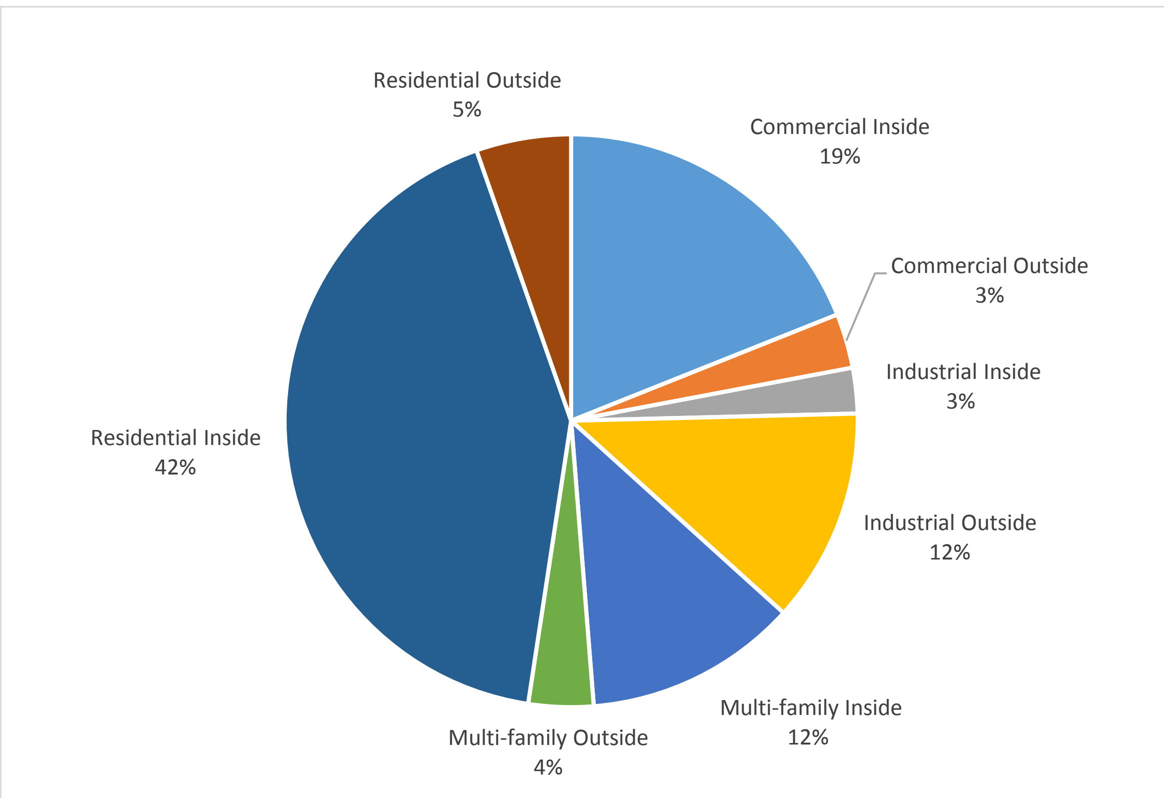


Figure 3-13. Water Use by Billing Category Inside, Outside, and District Customers, 2015

3.3.2 Customers inside Medford

Table 3-5 summarizes annual metered consumption by category for customers within the City of Medford for 2010 through 2015.

Table 3-5. City of Medford Annual Metered Consumption, 2010-2015
Medford Water Commission Water Distribution System Facility Plan

Year[a]	Single-family (MG)	Multiple-family (MG)	Commercial (MG)	Industrial (MG)	Total (MG)
2010	2,653	822	1,190	232	4,897
2011	2,498	803	1,145	203	4,650
2012	2,672	820	1,208	212	4,911
2014	2,917	855	1,303	208	5,282
2015	3,009	857	1,350	183	5,399
Average	**2,750**	**831**	**1,239**	**208**	**5,028**
Percent	**55%**	**17%**	**25%**	**4%**	**100%**

[a] Because of the billing system transition, annual data for 2013 were not available.

Figure 3-14 shows the monthly metered consumption by customer category for the City of Medford from 2010 to 2015.

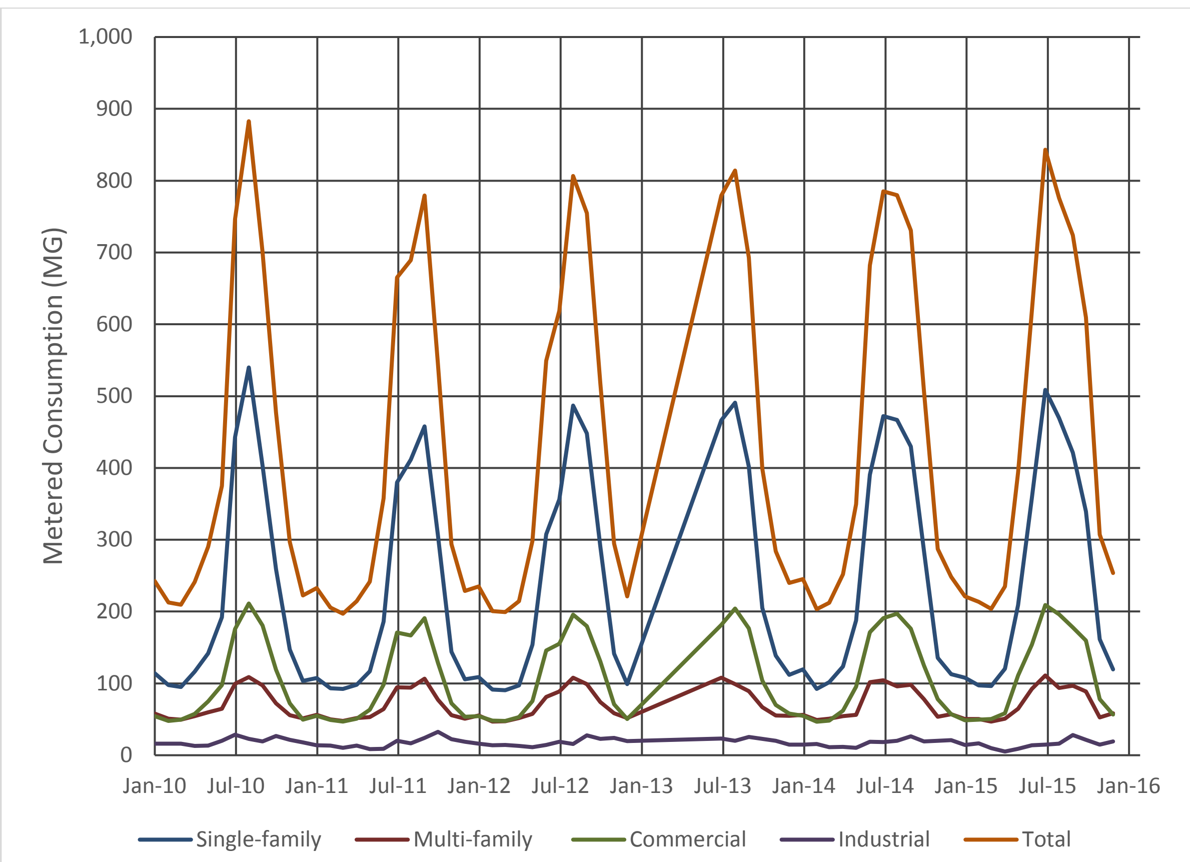


Figure 3-14. Monthly Metered Consumption by Category for Customers within the City of Medford, 2010-2015

SECTION 4

Water Demand Projections

This section describes projected water demands in MWC's water system. Historical per capita water demand, and service area population projections were used to project future water demand. A further discussion of demand projections is available in MWC's 2016 *Water Management and Conservation Plan*.

4.1 Methodology

A constant per capita approach was used to project future water demands. Per capita values represent the system demand divided by service population. Therefore, they include residential, commercial, industrial, and municipal demands as well as nonrevenue water. As noted in Section 3, MWC serves a variety of customers: retail customers include individual customers inside and outside the City of Medford's city limits including residents of unincorporated White City, and wholesale customers include four water districts surrounding Medford and six nearby cities. Baseline 2015 per capita demands were estimated from service area population estimates and water demands for each of these customer types and were presented in Section 3, Tables 3-2 and 3-3. Future water demands are projected by multiplying a constant per capita demand value by the projected population.

In general, the constant per capita approach provides a reasonable estimate of future demand. However, this approach assumes that the proportion of residential to other types of demand remains relatively constant with time. If significant changes occur, for example the loss or addition of a high-demand industry such as food processing or wood products, per capita values will need to be adjusted. Conservation activities are likely to impact per capita use levels somewhat during the planning period. However, since neither the focus nor magnitude of such reductions is currently known, impacts of conservation have not been incorporated into projections.

4.2 Population Forecast

The previous facility plan relied on population projections based on preliminary projections developed for Jackson County as part of a coordinated population forecast to be included in an update of the county's Comprehensive Plan in accordance with ORS 195.036. In 2013, through legislative action, responsibility for regional population projections was transferred from counties to the Portland State University (PSU) Population Research Center (PRC). The PRC finalized its Coordinated Population Forecast for Jackson County, its Urban Growth boundaries (UGB) and Area Outside UGBs 2015-2065 in June 2015. These UGB population projections were used to determine projected average annual growth rates for populations within Medford, the other cities, White City, and outside customers. PRC-certified 2015 population estimates for the cities were adjusted to service populations as described in Section 3.

Table 4-1 presents the criteria used to project service area populations for the retail and wholesale customers of MWC. Because White City is more urban than rural, an average of city growth rates was used to project future population within the White City area, rather than the lower non-city growth rates.

Table 4-1. Population Growth Rates and Demand Factors for MWC
Medford Water Commission Water Distribution System Facility Plan

Criteria	Ashland	Central Point	Eagle Point	Jacksonville	Medford	Phoenix	Talent	White City[c]	Outside Customers[d]	Water Districts[d]
2015 Service Area Population[a] =	5,105	17,565	8,745	3,020	77,335	4,585	6,350	8,480	1080	3,835
AA Growth Rate 2015-2025[b] =	0.6%	1.1%	2.6%	2.3%	1.2%	1.8%	1.5%	1.7%	2.5%	-1.2%
AA Growth Rate 2025-2040 [b] =	0.3%	1.0%	1.6%	1.5%	1.0%	1.5%	1.8%	1.4%	2.4%	-1.1%
AA Growth Rate 2040-2065 [b] =	0.1%	0.6%	0.7%	1.5%	0.7%	1.1%	1.6%	1.0%	1.0%	1.0%
Per Capita ADD (gpcd) =	42	158	188	235	218	161	123	443	443	299
Per Capita MMD (gpcd) =	173	326	360	494	401	296	241	650	650	666
Per Capita MDD (gpcd) =	197	372	411	565	458	338	276	742	742	761

[a] Service Area Population reflects an adjustment to the cities' population to add households outside of city limits who receive water service and/or subtract city residents who do not receive water service from the city. See Table 2-15 for detailed analysis.

[b] Average annual growth rates for each period were obtained from the *Coordinated Population Forecast for Jackson County, its Urban Growth boundaries (UGB) and Area Outside UGBs 2015-2065.*

[c] Because of its urban nature, White City growth rates were taken as an average of Medford and other wholesale city growth rates.

[d] Growth rates estimated by MWC staff to reflect dissolution of water districts, many of whom will become outside customers.

As discussed in Section 3, service area populations are determined from within-boundary populations by adjusting for households located within boundaries but not receiving water, or receiving water but located outside of boundaries. Estimated average annual growth rates for each period were applied to baseline 2015 service area populations to project future service area populations:

$$P_t = P_{t_0}(1+R)^{(t-t_0)} \tag{1}$$

Where

P_t = service area population at any time t
P_{t0} = service area population at time zero
R = average annual growth rate.

MWC policies limit the extension of water service beyond the boundaries of incorporated cities and the White City Unincorporated Community Boundary. Service area population growth is therefore expected to occur within these urban entities, rather than as individual outside customers or within water districts. As city boundaries grow, individuals and water districts are likely to be annexed. MWC staff provided service population estimates for water districts and outside customers. **Table 4-2** presents projected service area populations, and Figure 4-1 shows the urban reserve areas where growth in demand was forecast for MWC.

Table 4-2. Projected MWC Service Area Populations
Medford Water Commission Water Distribution System Facility Plan

Community	2016	2026	2036
Ashland[a]	5,231	6,469	7,184
Central Point	17,761	19,823	21,850
Eagle Point	8,968	11,433	13,418
Jacksonville	3,088	3,832	4,454
Medford	78,242	87,776	97,088
Phoenix	4,667	5,557	6,429
Talent	6,444	7,491	8,958
White City	8,627	10,207	11,728
Outside customer	1,086	1,416	1,796
Water Districts	3,856	3,361	3,009
Total	137,970	157,364	175,914

[a] Ashland's initial service population set equal to ¼ of the city population. Service area population increases were set equal to the overall city population increase.

4.3 Projected Water Demands

Table 4-3 summarizes future ADD, MMD, and MDD values for 2016, 2026, and 2036. **Figure 4-2** shows the projected system-wide and City of Medford MDDs through 2056.

Table 4-3. Summary of Projected Demands (mgd)
Medford Water Commission Water Distribution System Facility Plan

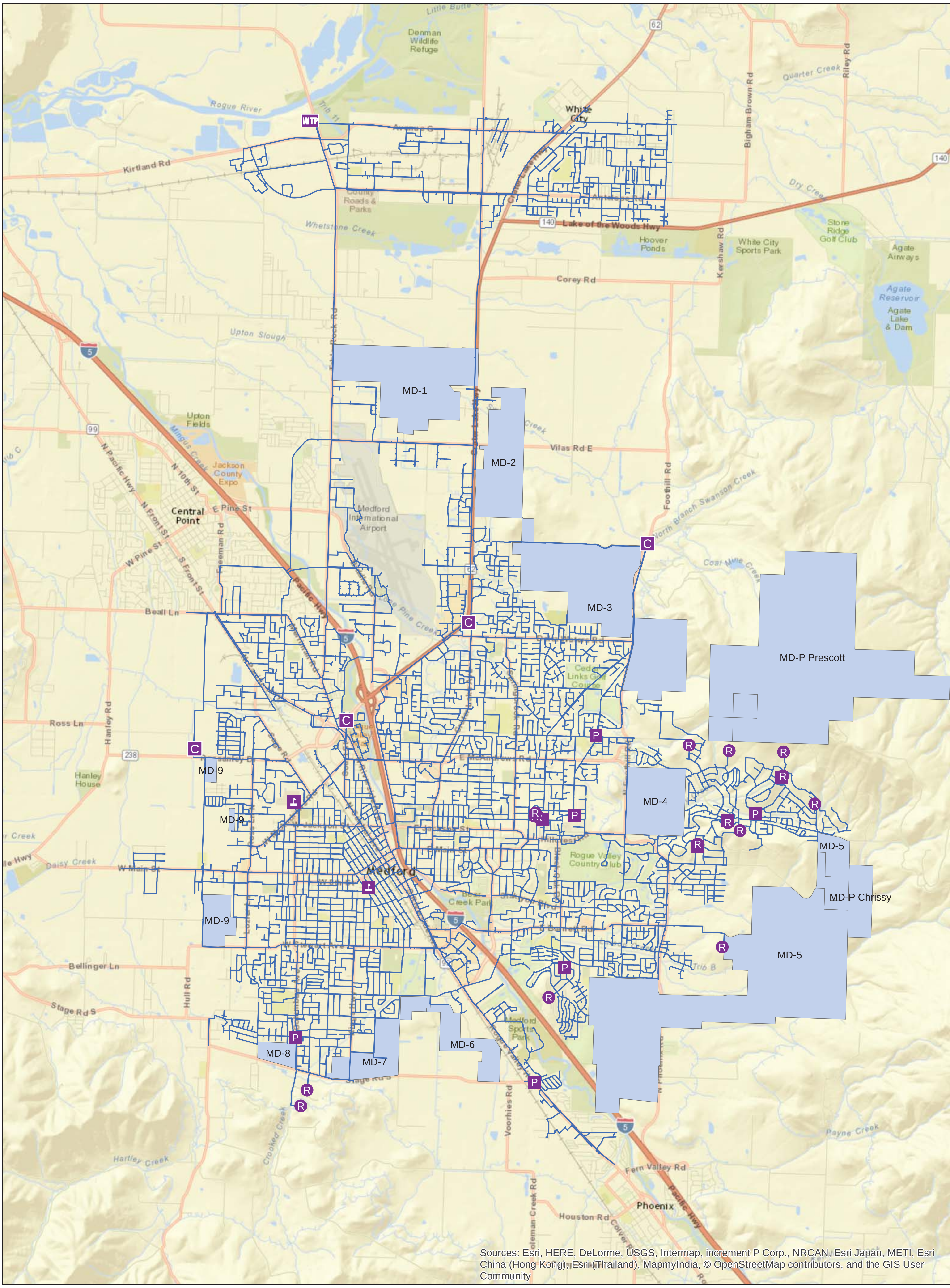
	2016			2026			2036		
City	**ADD**	**MMD**	**MDD**	**ADD**	**MMD**	**MDD**	**ADD**	**MMD**	**MDD**
Ashland	0.2	0.9	1.0	0.3	1.1	1.3	0.3	1.2	1.4
Central Point	2.8	5.8	6.6	3.1	6.5	7.4	3.5	7.1	8.1
Eagle Point	1.7	3.2	3.7	2.1	4.1	4.7	2.5	4.8	5.5
Jacksonville	0.7	1.5	1.7	0.9	1.9	2.2	1.0	2.2	2.5
Medford	17.0	31.3	35.8	19.1	35.2	40.2	21.2	38.9	44.4
Phoenix	0.8	1.4	1.6	0.9	1.6	1.9	1.0	1.9	2.2
Talent	0.8	1.6	1.8	0.9	1.8	2.1	1.1	2.2	2.5
White City, Outside, and Water Districts[a]	5.5	8.9	10.1	6.2	10.1	11.5	6.9	11.1	12.7
Total	**29.5**	**54.6**	**62.4**	**33.6**	**62.3**	**71.1**	**37.5**	**69.5**	**79.3**

[a] The demands for White City, other outside customers, and water district are combined because of similarity in demand characteristics, and because the population from water districts has tended to transition into the outside customer group over time.

The overall system ADD is projected to be 33.6 mgd (52 cfs) by 2026 and 37.5 mgd (58 cfs) by 2036. The overall system MDD is projected to approach 71.1 mgd (110 cfs) by 2026 and 79.3 mgd (123 cfs) by 2036. Other cities' MDDs represent an increasing percentage of overall system MDD from approximately 23 percent in 2016 to 26 percent by 2036.

4.3.1 Impact on Duff WTP

As overall system demand increases, Duff WTP will be required to produce larger quantities of water for longer periods to make up the deficit between demand and the 26.4 mgd maximum production capacity of the Big Butte Springs. **Figure 4-3** shows that by 2022, Duff WTP may be required to operate year round. The projected wintertime demands for year 2022 are still below the 26.4 mgd capacity of BBS, however, as wintertime demands approach this value, the Duff No. 1 WTP will need to be actively used throughout the year, because it cannot be idled and then immediately brought online.



LEGEND

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

Urban Reserves

N

0 2,500 5,000 Feet

FIGURE 4-1
Urban Reserves Areas
MWC Facility Plan

ch2m.

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Figure 4-2 shows the projected system-wide and City of Medford MDDs through 2065.

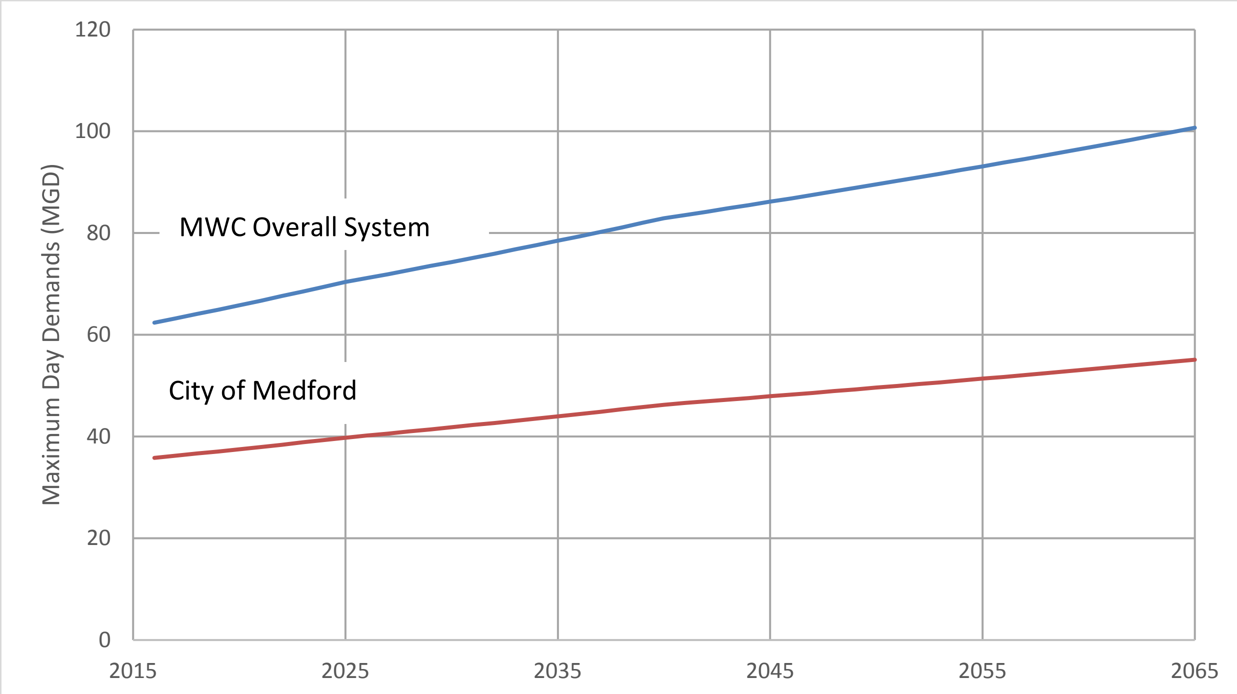


Figure 4-2. Projected Overall System and City of Medford MDDs

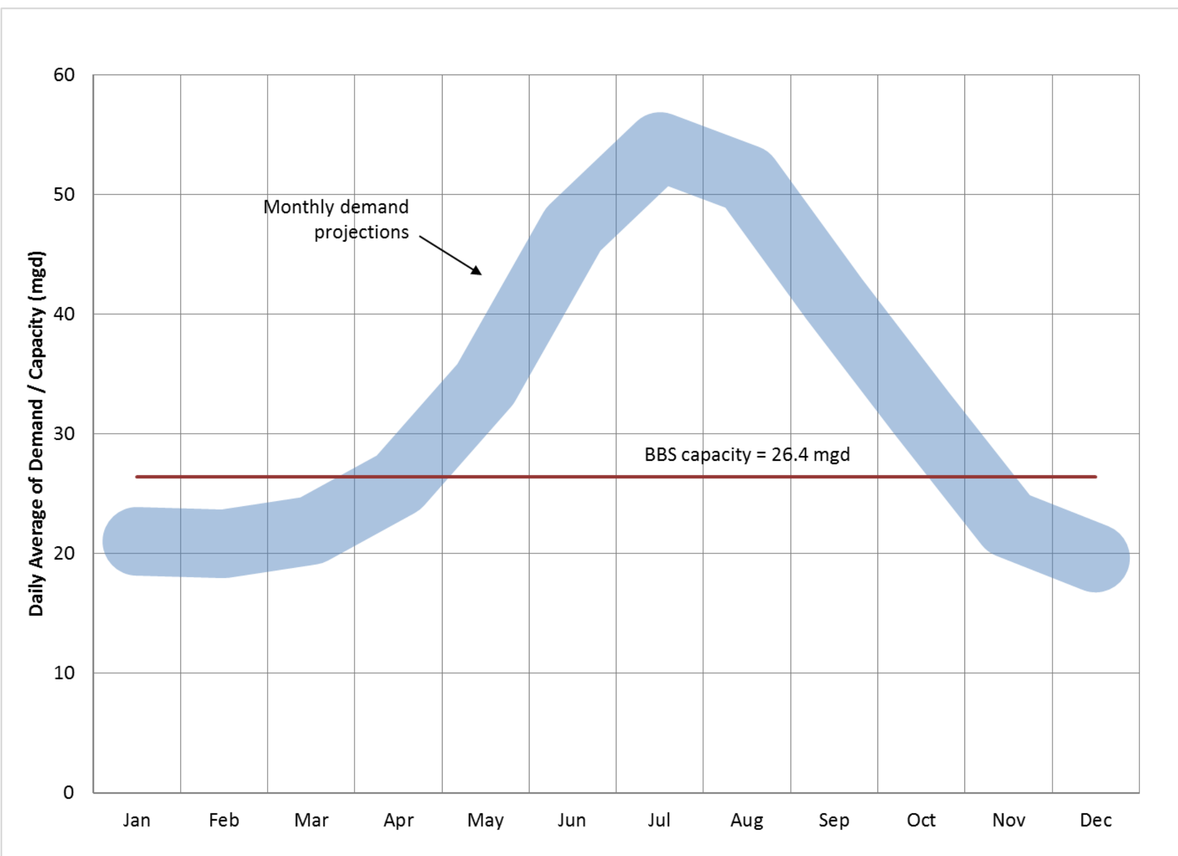


Figure 4-3. Monthly demand projections for 2022

Figure 4-4 summarizes anticipated water supply expansions necessary to keep pace with projected demands. Because the timeline for these improvements and the capacities required are estimates, the plans for capacity expansions need to be re-evaluated at regular intervals.

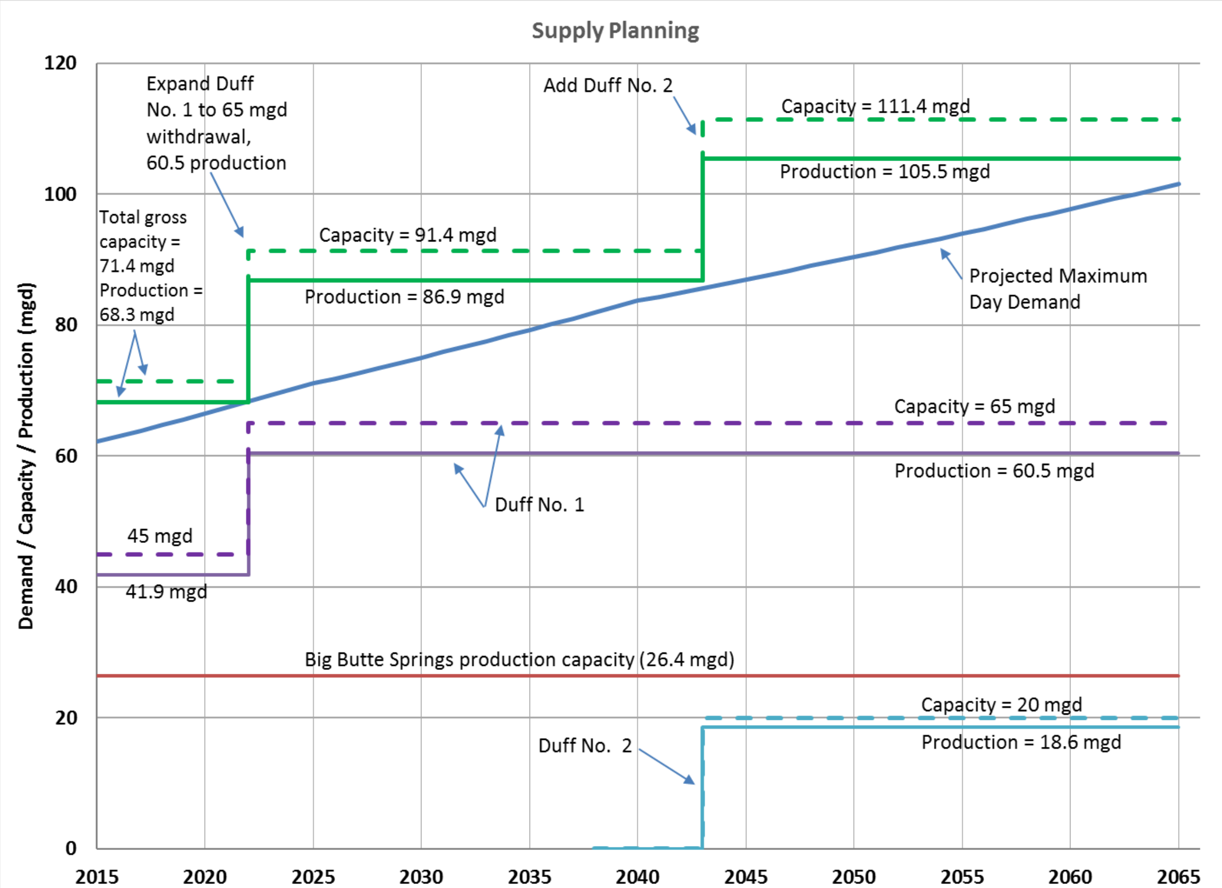


Figure 4-4. Water supply planning chart

4.3.2 Buildout Demands for Upper Pressure Zones

The work on the 2007 plan included developing buildout population and demand estimates for the upper pressure zones. These were reviewed and adjusted to account for changes since 2007, which were relatively minor. To account for future city expansion, the area defined as the expansion areas were assessed, and the proposed future land use was used to develop a water demand for each area that was then aligned and prorated to align with the population growth projections.

4.3.2.1 Residential Demand

Residential demand was determined from estimates of developable land area, projected dwelling unit densities (dwelling units per acre) based on zoning, population per dwelling unit (people per dwelling unit), and the average single- and multi- family residential per capita demand (gallons for residential use per person-day).

As determined in Section 3, Table 3-3, the overall average day per capita demand for the City of Medford in 2015 was estimated at 218 gpcd. Based on the proportion of single- and multi-family residential water use to overall water use, single-family residential demand was estimated at 187 gpcd, and multi-family residential demand was estimated at 97 gpcd. (See page 3-6.) Maximum day residential per capita demands were estimated by multiplying ADD per capita values by Medford's MDD/ADD peaking factor of 2.0. MDD per capita for single family residences was estimated at 374 gpcd (187 gpcd x

2.0= 374 gpcd), and MDD per capita for multi-family residences was estimated at 194 gpcd (97 gpcd x 2.0 = 288 gpcd).

4.3.2.2 Commercial and Industrial Demand

As described in Section 3, an analysis of commercial and industrial water demand within the City of Medford yielded average day demand factors of 1.5 gpm per acre (2,160 gpd per acre) for each category. These factors were applied to the available land zoned for commercial, industrial, and mixed use development to estimate buildout demands by pressure zone within the urban reserve area for Medford.

4.3.2.3 Summary

There are approximately 360 acres zoned commercial and industrial and 6,000 acres zoned residential in the upper pressure zones. At buildout, approximately 74,000 people will live in these areas. At buildout, the upper pressure zones will require a maximum demand of approximately 24 mgd. If growth to buildout in the upper pressure zones occurs within fifty years, the demand from these areas will represent approximately 28 percent of the City of Medford demand, and 17 percent of total system demand by 2056.

Distribution System Regulatory Review

Community water systems are governed by rules developed by the U.S. Environmental Protection Agency (EPA) for implementation of the Safe Drinking Water Act Amendments. Oregon, as a primacy state, is required to implement water quality regulations at least as stringent as EPA's rules. For the most part, Oregon has adopted identical regulations to those at the federal level. Additional Oregon rules are highlighted in this section. Additional information on regulations and water quality within MWC's system may be found in the *Big Butte Springs and Duff Water Treatment Plant Facility Plan* that was prepared in parallel to this plan, also by CH2M.

5.1 State Requirements

Oregon's drinking water regulations have requirements that indirectly relate to distribution water quality, including backflow prevention program rules, operator certification rules, and product acceptability criteria. In general, the state's rules govern the quality of water and not the way it is distributed. However, the rules do contain a limited number of standards with storage and piping criteria:

- Distribution piping shall be designed and installed so that the pressure measured at the property line of any user shall not be reduced below 20 psi (OAR 333-061-0050(9)(e)).
- Wherever possible, dead ends shall be minimized by looping. Where dead ends are installed, blow-offs of adequate size shall be provided for flushing (OAR 333-061-0050(9)(h)).
- Wherever possible, distribution pipelines shall be located on public property. Where pipelines are required to pass through private property, easements shall be obtained from the property owner and shall be recorded with the county clerk (OAR 333-061-0050(9)(a)).
- Wherever possible, booster pumps shall take suction from reservoirs to avoid the potential for negative pressures on the suction line, which could result when the pump suction is directly connected to a distribution main. Pumps that take suction from distribution mains shall be provided with a low-pressure cutoff switch on the suction side set at no less than 20 psi (OAR 333-061-0050(8)(a, b)).

The state's rules also include construction standards that must be met when new projects are designed and constructed. Construction standards are found in OAR 333-061-0050.

5.2 Federal Regulations

The following federal regulations, which have been adopted by Oregon, also have implications for the distribution system:

- Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
- Revised Total Coliform Rule (RTCR)
- Lead and Copper Rule
- Stage 2 Disinfection By-Products Rule

Secondary disinfection requirements are the one aspect of the LT2ESWTR that relate to distribution water quality. This rule requires that the residual disinfectant concentration in the water entering the distribution system is equal to or greater than 0.2 mg/L and that the residual disinfectant concentration in the distribution system cannot be undetectable in more than 5 percent of the samples each month for two consecutive months. Water in the distribution system with a heterotrophic bacteria concentration less than or equal to 500 cfu/mL is deemed to have a detectable disinfectant residual.

MWC has complied with the requirements of the SWTR. MWC currently disinfects so that water in the distribution system has a chlorine residual of approximately 0.5 mg/L.

The EPA published the Revised Total Coliform Rule (RTCR) in February 2013. The RTCR is the revision to the 1989 Total Coliform Rule. MWC was required to comply with the RTCR beginning April 1, 2016. Total coliforms are a group of related bacteria that are (with few exceptions) not harmful to humans. EPA considers total coliforms a useful indicator of pathogens for drinking water. Total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system.

Key provisions of the RTCR include:

- Setting a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) for *E. coli* for protection against potential fecal contamination. In general, the water industry is moving away from monitoring for total coliform bacteria to *E. coli* because *E. coli* are better indicators of pathogens.
- Setting a total coliform treatment technique requirement.
- Requirements for monitoring total coliforms and *E. coli* per a sample siting plan and schedule specific to the PWS.
- Requirements for assessments and corrective action when monitoring results show that a system may be vulnerable to contamination.
- Public notification requirements for violations.
- Specific language for systems to use in their Consumer Confidence Reports when they must conduct an assessment or if they incur an *E. coli* MCL violation.

MWC has consistently complied with the previous Total Coliform Rule and has complied with the RTCR.

The Lead and Copper Rule, though not new, warrants specific mention because of the heightened concerns about high lead levels in drinking water in U.S. water utilities that occurred in 2016. A detailed discussion of this rule and MWC's compliance history is included in the 2016 *Big Butte Springs and Duff Water Treatment Facility Plan*. MWC plans to conduct a detailed corrosion evaluation of its system, with possible outcomes including treatment adjustments, and more intensive management of water age and flushing within the distribution system.

Model Development and System Analysis

6.1 Introduction

This section presents a description of the hydraulic model used to evaluate MWC's water distribution system and the results for the analyses for existing and projected future conditions. It is divided into four subsections. The first subsection defines the criteria used to evaluate the various system components; the second subsection explains how the computer model was developed and used in the analysis; the third subsection contains a description of the analyses, results, and evaluations; and the fourth includes recommendations for improvements of the water distribution system to address existing conditions. The updated hydraulic model files were provided to MWC as a project deliverable.

6.2 Analysis and Design Criteria

This subsection describes the evaluation criteria used in the modeling analyses. These criteria were developed based on MWC's historical practices and experience, recommendations developed from other water utilities, and the regulatory requirements of the Oregon Drinking Water Services program of the Oregon Health Authority. Appendix A provides a summary of the design criteria for MWC's system and that were used for the evaluations presented in this water facilities plan.

6.2.1 Source and Pumping

The supply systems from BBS and the Duff WTP need to meet the system-wide MDD, with peak hour demands met by a combination of supply pumping and withdrawals from distribution reservoirs. Similarly, the pump stations supplying each service zone are sized to deliver maximum day demands into that zone, plus supplying the maximum day demands for higher zones fed from that zone. Peak demands that exceed MDD are met by a combination of flow out of distribution reservoirs and the pumps supplying that zone. In practice, the variability of pumping rates, reservoir levels, and demands yield results that do not exactly follow this description but nevertheless, it forms a reasonable basis for sizing facilities.

A further criterion is that the supply pumps delivering water into a zone are to meet the MDD with the largest single unit out of service. This is referred to as firm capacity; it enables the pump systems to meet MDD even in the event of a mechanical failure or shut down for maintenance of the largest pump.

6.2.2 Fire Flow

Fire flow criteria have been established by Medford Fire-Rescue, based on guidelines established by the National Fire Protection Association. They range from a minimum of 1,000 gpm for a 2-hour duration for low density, single family residential areas to 4,000 gpm for 4 hours in areas with schools and hospitals.

6.2.3 Storage

Distribution storage is provided to meet three needs, as follows and as further described in Section 9, Reservoir Improvements:

- Equalization Storage—this is the storage provided to meet short-term peak demands. For MWC's system, the equalization storage need is estimated to equal 15 percent of the MDD.
- Emergency Storage—this is storage provided to supply customers during emergency supply disruptions. The inherent reliability in having two supplies, BBS and the Duff WTP system, reduces the risk in MWC's system. The emergency storage criterion has been set at 33 percent of MDD.

- Fire Flow Storage—fire flow storage is provided to supply the very high hydrant flows that are needed for relatively short durations of time. This volume is more cost-effectively provided in storage reservoirs than from the production sources. The determination of fire flow storage volumes for a specific service zone is a discrete calculation equal to the required hydrant flow rate multiplied by the required hydrant flow duration. The required flow and duration are dependent on customer types within a zone and independent of maximum day or peak hour demands. Because fire flow storage requirements are not dependent on demands, they do no increase proportionally as demands grow.

6.2.4 Pipelines

Pipelines should be looped as much as possible to prevent pipe dead-ends, to maintain high water quality, and to increase the reliability of the system. The sizing of pipelines should be for the maximum potential flows in the zoning or planning area. The fire flow requirements commonly dictate pipeline sizes. Two separate classifications of pipelines were considered in the modeling and analysis of the system, with the following specific evaluation criteria considered for each.

Distribution mains (14-inch diameter and smaller):

- They must have the carrying capacity to provide the peak hour demands while maintaining pressures above 35 psi, and should have flow velocities below 10 feet per second (fps) and head loss below 10 feet for every 1,000 feet of pipe length under peak hour demands.
- They must have the carrying capacity to maintain pressures below 100 psi for off-peak demands (during reservoir refill periods that occur during nighttime hours).
- They must provide the required flows of a combination fire and MDD with a minimum residual pressure of 20 psi through the distribution system as established by the Oregon Drinking Water Services program in OAR 333-61-025. MWC has established a criterion that residual pressures shall not drop below 35 psi at the customer meter.

Transmission pipelines (larger than 14-inch diameter):

- They should have the carrying capacity to maintain pipeline flow velocities below 7 fps during maximum day demands and to limit headloss per 1,000 feet of pipe length to acceptable levels. There is often a need to limit head loss to 2 to 5 feet per 1000 feet of pipe length, although the acceptable level will vary depending on the combined carrying capacity of the transmission system and the available head.
- They must have the carrying capacity to maintain pressures below 100 psi for off-peak demands (during reservoir refill periods that occur during nighttime hours).

6.3 Hydraulic Distribution System Model

6.3.1 Description of the Model

The hydraulic model consists of a 'data' model representing the distribution system and the computer software capable of performing a hydraulic analysis. The computer software interprets the data model using mathematical equations.

The data model is a representation of the existing installed facilities and hydraulic characteristics, including all pump stations, tanks, pipelines, and valves that are required. The required valves are those that are normally closed, altitude valves, and pressure reducing or sustaining valves. The data model incorporates the following details:

- **Reservoirs**—water surface elevation, overflow elevation, top and floor elevations, tank volume, tank diameter, and location

- **Pumps**—centerline elevation, flow and head characteristic that represent the pump curve, location
- **Pipes**—nominal diameter, length, pipe roughness coefficient as a function of the age of and material of the pipe, elevations where pipes connect to one another, and location
- **Control Valves**—pressure reducing and sustaining valves, altitude valves, normally closed valves, and other control valves, if any
- **Water Use (Demands)**—average water demand value for average day and maximum day, diurnal demand curves to simulate each hour of the demand condition, including minimum hour and peak hour, and location of each demand
- **Hydrants**—hydrant lateral locations are designated with a node classification

This project uses customized geographic information system (GIS) applications for water distribution system analysis that share information with various databases and pipe network analysis software. GIS software is used to manage, display, report, and analyze the hydraulic data described above.

The pipe network analysis software performs the computations of flow rates in pipes and pressures at junctions. The modeling calculation program used in this project is EPANET, a public-domain program developed by the EPA. This software determines the distribution of flow in a pipe network and calculates the resulting pressures. The model calculates head losses in pipes with the Hazen-Williams energy loss equation. The software package that was used was InfoWater by Innovyze. The InfoWater software provides the user interface with the calculation program and gives the operator tools that are used for analyzing and displaying results.

6.3.2 Development of the Hydraulic Model

The MWC hydraulic model included both the physical features of the hydraulic model and the control features and logic for all facilities to make the hydraulic model a full extended period simulation (EPS) model.

6.3.2.1 Network Development

The MWC hydraulic model was developed from MWC's GIS database. The primary elements of the data model were taken from the GIS database using the GIS Gateway within the InfoWater software. Once each of the model components (pipes, valves, reservoirs, junctions, and pumps) were input into the hydraulic model, automated GIS routines were performed to enhance the connectivity and elevation information that existed in the MWC system. Additional information that was not included in the database, such as details on elevations and diameters of reservoirs, pump flow and head characteristics, and control information, was then input manually. Initial Hazen-Williams C-factors were applied based on material type and age, with adjustments considered during model calibration.

Using the InfoWater Demand Allocator, demands were allocated to the MWC hydraulic model by spatially linking the individual customer meters to model junctions that were identified as demand nodes. The customer meter data was a shapefile of the customer meters that was previously joined through database actions with the consumption data from the MWC billing system so that the billing information was directly joined to the model.

Once the average water usage was allocated to the model, the demands were scaled to match the water production information as measured by the MWC SCADA system. This approach distributes nonrevenue water into the allocated demands.

6.3.2.2 Controls Development

The control of many of the facilities in the MWC system is automated, with control of the operation of the pump stations to the MWC upper pressure zones governed by the tank level in each pressure zone that the pump stations are supplying. However, the control of the Duff WTP HSPS, the Control Stations, and the operation of the Bullis Reservoir are often performed manually. Operations staff have established guidelines and targets for maintaining levels in the Capital Reservoirs, and the operation of the Control Stations and Duff WTP HSPS are operated to maintain those levels. Operations staff also have targets and operation schemes that have been performed for the operation of the Bullis Reservoir in conjunction with the Archer PS, but the controls for these three facilities are not typically automated.

The current control methodology for the pump stations supplying the upper zones was input into the model. Automated control methodologies were developed for the operation of the Duff WTP high service pumps and the Control Stations that simulated the manual operator control. Control strategies for the Bullis Reservoir and Archer Pump Station were also developed and incorporated into the system assessment scenarios.

6.3.2.3 Facility Management

Managing the facilities that are active in any given model scenario is important so that model results are easily reproducible. To manage the facilities that are active for the existing model as compared to the future scenario models, additional fields were added to the model database to support tracking and management of active facilities. These active facilities are managed through database queries.

6.3.3 Calibration Methods and Results

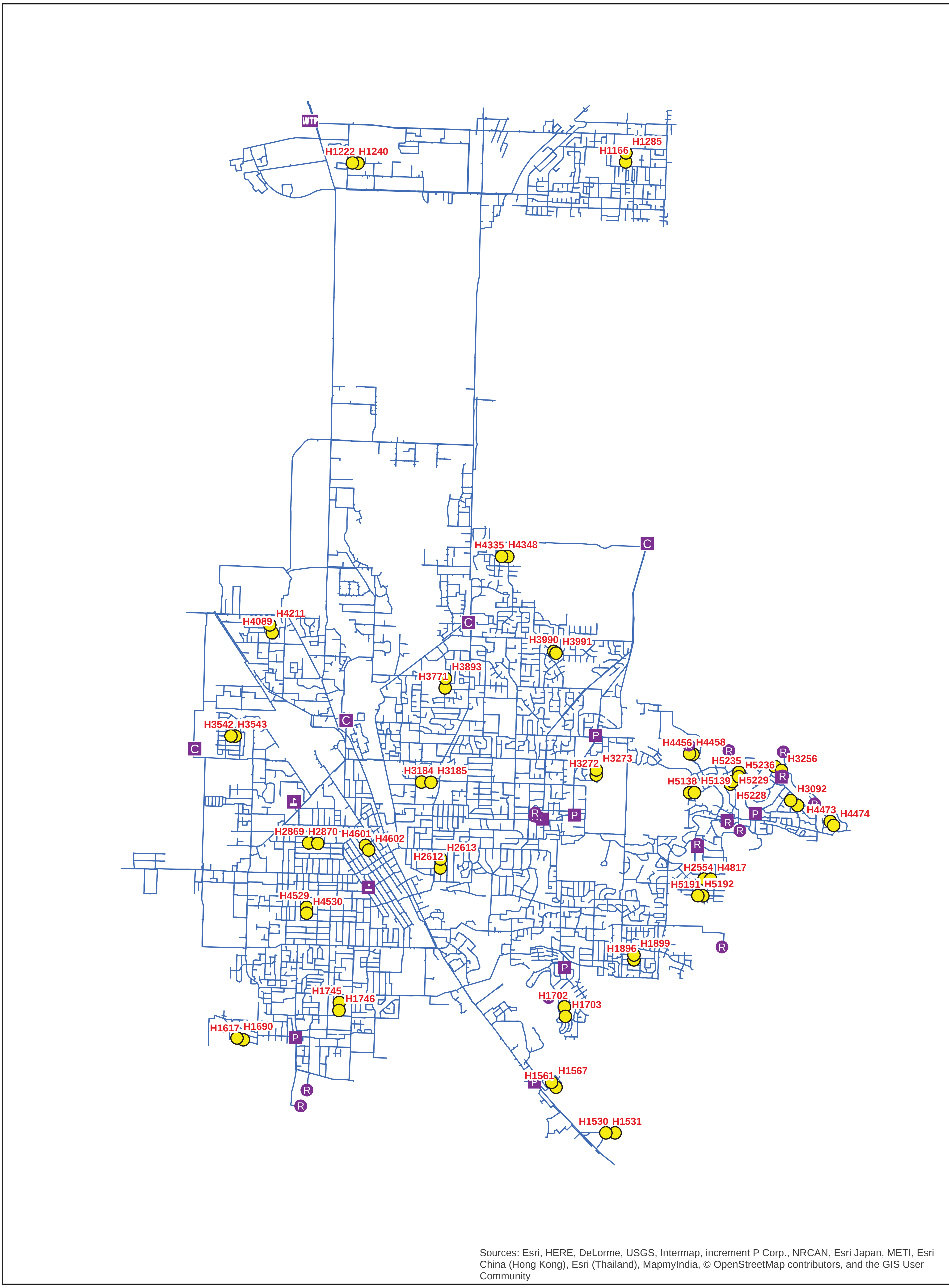
This model was calibrated to field-collected and SCADA reported data. For the steady state calibration using hydrant flow tests, the calibration consisted of comparing pressures measured in the field before and during a hydrant flow test to those predicted by the computer model for the flow conditions created in the field. The EPS calibration compared SCADA reported tank levels, pressures, flow rates, and hydraulic grade lines (HGLs) with those computed by the hydraulic model. For both the steady state and EPS calibration, if adjustments were needed in the model, the model data was adjusted and the calibration scenario rerun to compare results again until a reasonable range of agreement was achieved. The criterion established by the MWC for the calibration was to match the field data within 10 percent.

The field testing and measurement procedures to support model calibration for steady state and EPS conditions and details on the calibration results are further described in the following sections.

6.3.3.1 Steady State Field Measurements

Field-measured data provide a better understand the existing conditions in the water distribution system and were used to supplement the system operating data that is available from SCADA. Hydrant pressure and flow tests were performed by MWC staff on a series of days from November 17 to November 20, 2015. Field crews from the MWC installed pressure monitors and conducted hydrant flow tests at 28 points throughout the system. Once the hydrant flow tests were complete, SCADA data was compiled for the times during the flow tests to set boundary conditions in the hydraulic model to simulate the hydrant flow tests. The locations of the hydrant flow tests are shown in **Figure 6-1**.

For each of the hydrant flow tests, the MWC staff installed a Dickson PR-300 pressure recorder at a residual monitor hydrant and then flowed an adjacent hydrant that was also equipped with a pressure recorded on its flow apparatus. The testing was structured so that several pressure recorders were deployed at once and MWC staff rotated through each location, performing the hydrant flow tests prior to moving the equipment to the next set of locations. The time series of pressures recorded by the pressure recorders was analyzed to determine the static pressure before the hydrant was flowed and the residual pressure when the hydrant was flowing. A summary of the data collected in the field during the hydrant flow tests is summarized in **Table 6-1**.



LEGEND

Hydrant Test Locations

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-1
Hydrant Test Locations
MWC Facility Plan

ch2m.

Table 6-1. Hydrant Flow Test Data
Medford Water Commission Water Distribution Facility Plan

Test	Field Flow (gpm)	Static Pressure (psi)	Residual Pressure (psi)
1	1,292	92	45
2	1,469	65	62
3	1,390	51	48
4	1,572	34	23
5	1,409	61	60
6	1,563	72	67
7	1,563	91	66
8	1,155	48	45
9	1,719	86	78
10	1,131	39	37
11	1,774	33	30
12	1,283	60	56
13	1,369	65	57
14	1,390	103	57
15	1,155	53	44
16	1,615	91	78
17	1,303	26	19
18	1,143	87	68
19	1,648	88	80
20	711	93	55
21	1,800	104	100
22	961	106	99
23	1,634	NA	NA
24	1,333	67	56
25	1,521	33	29
26	1,611	96	81
27	1,779	104	102
28	1,390	67	61

6.3.3.2 Steady State Calibration Results

For each of the hydrant flow tests that was conducted, both the field measured and model predicted static pressures and the relative pressure drop were compared. Pressures were compared for all locations that had data loggers installed during any test. This approach to the calibration provided several data points for each hydrant flow event to calibrate against. The calibration goal for the static calibration was to have at least 90 percent of the results within 10 percent of the field data values. For the residual calibration runs, the goal was to have the model predicted pressure drop within at least 5 to 10 psi of the field pressure drop.

Table 6-2 shows the comparison of the field data to the model-predicted data. Five of the 28 tests were not used in the statistical analysis of the results because of a bad data logger. The average percent difference for the static results is 3 percent, and each individual test was within 10 percent of the field data. For the results of the residual calibration runs, the results for eighteen of the locations showed that the model-predicted pressure drop was within 5 psi of the field predicted pressure drop, and all but two of the remaining locations showed that the model-predicted drop was within 10 psi of the field pressure drop. The locations that the model-predicted residual pressure was greater than 10 psi different than the field data (after friction factors were adjusted) were in the Charlotte Anne area, and the model was over predicting the pressure drop. This difference was considered as the system analysis was being conducted and for system improvements that were recommended in this area.

Table 6-2. Comparison of Field Data to Model Predicted Data
Medford Water Commission Water Distribution Facility Plan

	Field		Model						
Test	Static Pressure (psi)	Residual Pressure (psi)	Static Pressure (psi)	Residual Pressure (psi)	Static Difference (psi)	Percent Difference	Field Pressure Drop (psi)	Model Pressure Drop (psi)	Delta in Drop (psi)
1	92	45	90	35	2	2%	47	55	-8
2	65	62	63	60	2	3%	3	3	0
3	51	48	48	45	3	6%	3	3	0
4[a]	34	23	93	59	-59	-176%	10	33	
5	61	60	57	56	4	6%	2	1	0
6	72	67	70	65	2	3%	5	5	-1
7	91	66	89	63	2	2%	26	27	-1
8	48	45	51	47	-3	-7%	3	4	-1
9	86	78	85	75	1	1%	8	10	-2
10	39	37	37	35	2	5%	2	2	0
11[a]	33	30	90	80	-56	-171%	3	9	
12	60	56	60	51	0	0%	4	9	-5
13[b]	65	57	62	50	3	4%	8	12	-4
14[b]	103	57	98	36	5	5%	46	61	-15
15[c]	53	44	53	25	0	1%	9	28	-19
16	91	78	88	75	3	4%	13	13	0
17[a]	26	19	70	56	-44	-170%	6	13	
18	87	68	84	72	2	3%	18	12	6
19	88	80	87	77	2	2%	9	10	-1
20	93	55	92	61	1	1%	38	31	7
21	104	100	102	102	1	1%	4	0	4
22	106	99	104	99	2	2%	7	5	2
23	NA	NA	92	64	NA	NA	NA	NA	NA
24	67	56	65	53	2	3%	11	13	-1
25[a]	33	29	98	86	-65	-199%	4	11	
26	96	81	104	87	-7	-8%	15	16	-2
27	104	102	103	97	1	1%	3	6	-3
28	67	61	64	57	3	5%	7	7	0

[a] These tests used the same logger that was identified as giving bad data during the testing.
[b] Charlotte Anne service area.
[c] High headloss low pressures in older 4-inch parallel to existing 24-inch.

6.3.3.3 EPS Calibration

The EPS calibration was conducted by developing diurnal demand curves for the allocated demand and then running a model simulation for a selected period based upon a review of the SCADA data. Automated controls were used to the maximum extent possible and were only varied when the data reported via SCADA demonstrated that there was variance from the standard operating procedure. A comparison was made of the model predicted and the SCADA reported level variation for the reservoirs within the system and of the model predicted pump station flow rates to those reported in SCADA. The goal for the EPS calibration was to have the model predict the level variation without 3 -5 feet of the SCADA reported values.

The calibrated model was used to perform the system analyses described in the following sections of this section.

6.4 Areas of Concern

MWC staff have noted several areas of concern in operating the distribution system. The goal in this master plan was to evaluation options to address these concerns, as well as considering future needs. The following subsections discuss the major concerns.

6.4.1 Peak Operation Delivery from Duff No. 1 WTP

A significant system limitation relates to high rates of pumping from the Duff No. 1 WTP. The plant currently has a maximum treatment capacity of 45 mgd (31,300 gpm) and will be expanded to 65 mgd (45,100 gpm) by approximately 2022. Its highest production to date was approximately 28,500 gpm for several hours but not for an entire day. Because the Duff No. 1 WTP clearwell reservoir is primarily dedicated to providing chlorine contact time and supply for filter backwashes, it has only a limited capacity for buffering differences between plant production and the high service pumping rate. Therefore, a plant production rate of 45 mgd requires an average high service pumping rate of 31,300 gpm for 24 hours a day.[1] The expansion to 65 mgd will require high service pumping that averages 45,100 gpm over 24 hours, with only minor variations below and above that rate because of the limited storage at the plant.

A sustained rated of 31,300 gpm is not currently possible for the Duff No. 1 WTP. The transmission pipelines and distribution storage are inadequate to deliver and store 31,300 gpm for 24 hours a day. The distribution system can receive a 31,300 gpm rate during peak demand periods, such as between 7:00 am and 10:00 am or between about 5:00 pm and 8:00 pm. However, when customer demands are lower, it is not possible to pump 31,300 gpm from the plant into the system. The discharge pressure at the plant's high service pump station (HSPS) rises to 110-115 psi and higher during these low demand periods. The high pressure causes the pumps to operate inefficiently as pressures exceed about 105 psi and eventually, as pressures continue to rise, the pumping capacity declines. The high pressures are also a concern for the hydraulic integrity of the system.[2]

Customer demand patterns will always fluctuate during a day, with morning and evening peaks. The goal is to have sufficient storage and transmission capacity so that the plant can operate 24 hours a day at its maximum rate, with the delivered water either meeting peak customer demands directly or refilling reservoirs when demands are lower. The limitations in both the available storage and the transmission piping restrict production from the Duff No. 1 WTP. There is insufficient reservoir volume to receive water during off-peak times and insufficient transmission capacity to deliver water from the plant to reservoirs in the system.

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[1] Water treatment plant capacities are generally described in terms of million gallons per day (mgd). However, for pumping systems, the units of gallons per minute (gpm) are more meaningful. A further point related to this discussion is the difference between the Duff No. 1 WTP production rate and its finished water delivery rate into the system. The finished water delivery rate equals the production rate minus water used for backwashing filters, which averages approximately 7 percent for the Duff No. 1 WTP. For clarity in discussion, this difference is not included in the text. More detail on this topic is included in the Big Butte Springs and Robert Duff No. 1 Water Treatment Plant Facility Plan.

[2] A sudden shutdown of the high service pumps during when the delivery pressure is high would further exacerbate surge conditions. The need for surge protection improvements is addressed in the *Big Butte Springs and Duff Water Treatment Plant Facility Plan*.

Further exacerbating this problem is that MWC's wholesale customers do not withdraw water from MWC's system at a steady rate over the course of a day. A review of wholesale customer master meter records indicates that even though MWC's wholesale customers maintain their own storage within their systems, there is still a pronounced peak from the MWC supply. It would help the steady-state operation of the Duff No. 1 WTP if the wholesale customers withdrew water from MWC at a constant rate.

Bullis Reservoir is located at the far southwest corner of the distribution system, requiring additional head to fill the tank compared to the Capital Reservoir tanks. The design of Bullis Reservoir accounted for this by placing Bullis Reservoir at a lower elevation. It has an overflow elevation of 1564 feet compared to the overflow elevation of 1588 feet for the Capital Reservoirs. This allows Bullis Reservoir to be filled directly by the Gravity Zone (by the head delivered from BBS or by a combination of BBS and the Control Stations pumps during reverse flow). However, the fill rate of Bullis Reservoir must be controlled to avoid creating low pressures in other parts of the system. In addition, low lift pumping is required to deliver water from Bullis Reservoir back into the Gravity Zone under most conditions. The low lift pumps (No. 1 and 2) in the Archer Pump Station must be used to increase slightly the head of water from Bullis Reservoir to match the hydraulic grade line in the Gravity Zone. This represents an operational system that must be controlled and involves some energy cost, but it also presents an opportunity since the system operators can select a delivery rate rather than relying on gravity flow out of the tank. An operational strategy for managing Bullis Reservoir was developed and included in the hydraulic model delivered for this master plan. It sets a target fill rate during nighttime hours of up to 1,500 gpm and pumping from Bullis Reservoir during the morning peak demand until early afternoon. This operational strategy will help in enabling the Duff No. 1 WTP and its high service pump station to operate at a steady rate throughout the day.

Transmission alternatives and storage alternatives were evaluated using the hydraulic model to address these limitations, thereby allowing steady production from the Duff No. 1 WTP of up to 65 mgd. The transmission recommendations, which are generally more straightforward, are discussed in Section 7, Pipeline Improvements. The more involved analysis related to determining the best solution for adding storage. The options included ground-level or elevated tanks, located in either the Reduced Pressure or Gravity Zone. These storage options are presented and examined in a later section of this chapter.

6.4.2 Water Age

Managing water age in the MWC system is a concern for operations staff, because of the desire to maintain a chlorine residual and to prevent bacteriological regrowth. These concerns typically occur during the period when Duff No. 1 WTP is online, even though the water demand in the system is higher during these periods. The difference in source water quality, the change from solely BBS water to a combination of Duff WTP and BBS water, tends to decrease the chlorine residual more quickly in the distribution system. The Bullis Reservoir is the primary concern related to water age, while the east side reservoirs are also routinely monitored. The Bullis Reservoir is at the far end of the system, and the east side reservoirs go through a series of storage and pumping systems, so water reaching the tanks has already spent a relatively long time in the system. If the contents of the tanks are not actively managed, the age for water stored in them can become excessive. MWC currently operates the east side reservoirs in a regular fill and draw operation to promote turnover, and the operational strategy presented within this master plan for Bullis Reservoir will help with reducing its water age.

6.4.3 Main Replacements

As noted in Section 2, System Description, 28 percent of the water mains are cast iron lines installed prior to the mid-1960s. More than 50 percent of these are 6-inches in diameter. Approximately 18 percent are 4-inches in diameter and 16 percent are 8-inches in diameter.

MWC staff has identified that while many of these mains appear to be in good condition, there is a concern that based upon their age, deferring main replacements may create a backlog of replacement needs in the future. A programmatic approach to upgrading and replacing aging infrastructure can be considered to spread costs and avoid a concentrated period of failures. A proposed pipe replacement program is described in Section 7. MWC may wish to employ internal pipe videography to gather more information about the need for pipe replacements.

6.4.4 Operational Automation

Improving the automated operational features of the system, such as filling of the Capital Reservoirs, is also a goal for MWC so that balancing the Duff No. 1 WTP high service pumping, the operation of the Control Stations, and the operation of the other pump stations in the system can be done in a manner that is reliable and efficient. Operational automation may contribute to lower energy costs. Approaches for operational automation have been developed as part of the system analysis for operation of the Control Stations and the Duff No. 1 WTP high service pumping based upon the levels in the Capital Reservoirs and were applied in the analysis runs for each of the system alternatives assessed. These strategies are included in the hydraulic model provided to MWC as a project deliverable and are described in Chapter 8.

6.4.5 Reservoir Replacement and Rehabilitation

The Capital Reservoirs in the MWC system are key to the operation of the system because they provide the largest volume in the Gravity and Reduced Pressure Zones, they are close to the entry point for water entering the system from BBS, and because of their proximity to the Control Stations. The reservoirs provide flow balancing for water from both BBS and the Duff No. 1 WTP. Furthermore, because they store the largest volume at any one location (12 MG), they are an important supply for emergencies and fire needs.

Therefore, it represents a significant system liability that the three Capital Reservoirs are old and were not designed and constructed in accordance with seismic standards in use today. MWC believes that all three tanks warrant replacement. Absent a detailed evaluation, it is uncertain if they should be replaced with two or three tanks and if the final replacement volume can be increased over the current 12 MG total volume of the three reservoirs. It is unlikely that the three tanks can be replaced by a single new tank because it would be very difficult to operate the system with no storage at this location during the approximately two-year construction time. The capital improvements plan developed in this facility plan includes an evaluation of options and staging for replacement of the Capital Reservoirs.

There are also smaller reservoirs (Hillcrest Reservoirs #1 and #2 serving Zones 2 and 3, and Stardust Reservoir, serving Zone 4) in the upper zones that need replacement. Replacement and rehabilitation of existing reservoirs is a concern for MWC because of the amount of time that a reservoir will need to be out of service for these activities and the lack of redundancy in the system during construction. To maintain redundancy of operations, the recommended reservoir improvements presented in this plan incorporate phasing requirements so that the level of redundancy that MWC desires is maintained.

6.4.6 Pump Station and Rehabilitation

Six of the pump stations were constructed in the mid-1970s or before, and may warrant rehabilitation. More detailed condition assessments will be necessary to determine when rehabilitation of these stations should occur.

6.5 Existing (2016) System Analysis

The analysis of the MWC water distribution system was conducted for the existing system and demands, and for projected future demands. It included evaluations of improvement alternatives to meet demand requirements and alleviate the identified concerns. A summary of the existing system analysis is presented within this subsection, followed by a description of the approach and various alternatives developed to address the deficiencies identified with the growth projected for the future system.

The calibrated hydraulic model was used to simulate system performance under existing demands to determine the system's ability to meet design criteria. The system was evaluated through an extended period simulation (EPS) analysis for two different demand and supply conditions. One condition represented an average day demand (ADD) scenario when supply is only provided by BBS (forward flow mode). The second condition was for a maximum day demand (MDD) condition with both the BBS and the Duff No. 1 WTP in operation (reverse flow mode). In addition to the EPS analysis for each condition, a fire flow analysis was also performed for each demand and supply condition.

Annual consumption data that were provided by MWC were used to distribute demands throughout the system. The diurnal demand curves developed from review of the SCADA data were applied to the model for both ADD and MDD for the EPS evaluations. A comparison of the diurnal data for ADD and MDD is shown in **Figure 6-2**. EPS scenarios were used to assess the range of demand conditions, including peak hour demand and the capability of the MWC system to refill reservoirs. By using an EPS analysis approach, the MWC system was assessed dynamically and results are presented for an entire run and not just a steady state evaluation. Controls for the EPS analyses followed the controls provided by MWC. The EPS included automation of facilities that are not currently automated such as the pumping rates at the Control Stations and at the Duff No. 1 WTP high service pump station.

The maximum capacity of the BBS transmission is 26.4 mgd. This flowrate value was used as the supply from the springs for all the analyses. For the MDD evaluation, the balance of the supply was provided by the Duff No. 1 WTP. Pump stations were operated up to their firm capacity in all analyses, including fire flow analyses. Firm capacity is the capacity of a pump station, or a group of pump stations if they serve the same zone, with the largest single pump out of service. This is a standard industry practice that ensures that a reasonable level of redundancy is provided.

Table 6-3 provides a summary of the total demand and supply used for the 2016 existing system analyses. The evaluation of the existing system investigated the available storage and pumping capacity as well as the capacity of the piping system to meet the specified design criteria under each of the various flow conditions. The fire flow analysis was conducted system-wide at locations that were identified as where a hydrant connects to the system with its hydrant lateral. The land use designation of the area in which the model node is located determines the required fire flow.

Table 6-3. 2016 Demand and Supply
Medford Water Commission Water Distribution Facility Plan

Demand Condition	Demand (mgd)
Average Day Demand	29.5
Maximum Day Demand	62.4

6.5.1 Average Day Demand: Big Butte Springs Supply Only

The minimum system-wide pressures for the 2016 ADD condition (approximately 29 mgd) and in forward mode operation with only the BBS in service are shown in **Figure 6-3**. The distribution of model nodes within incremental pressure ranges are shown in **Figure 6-4**. There were some model nodes that are under 35 psi but these are near storage reservoirs or on the suction side of pumps, and therefore, not a concern.

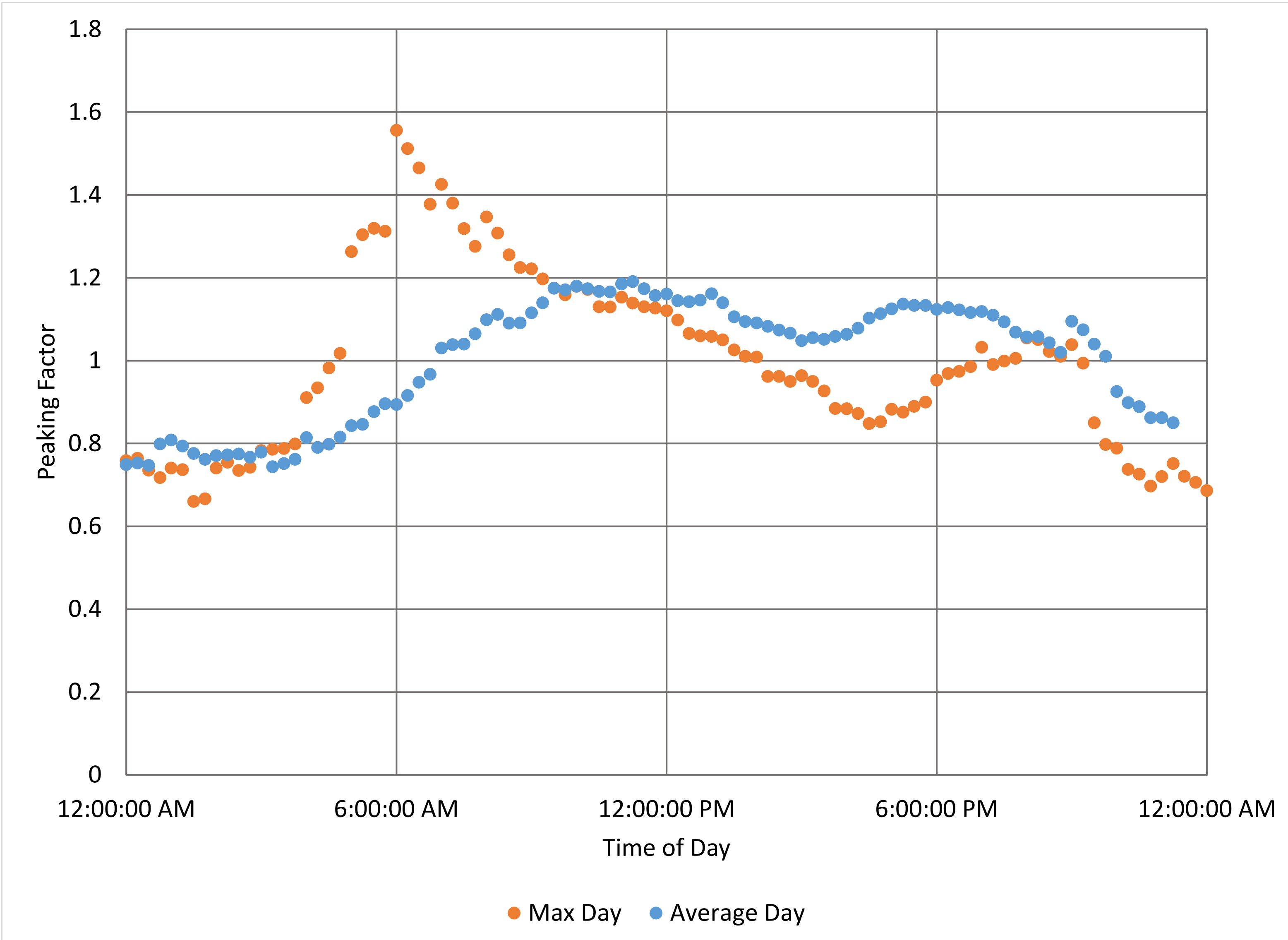


Figure 6-2. Comparison of the Diurnal Data for Average and Maximum Day Demands

6.5.2 Maximum Day Demand: Big Butte Springs and Duff WTP

The 2016 MDD (approximately 63 mgd) analysis runs were performed with reverse mode operation with both the BBS and the Duff No. 1 WTP in operation. The minimum system-wide pressures for the MDD condition are shown in **Figure 6-5**. The percentage of nodes within incremental pressure ranges are shown in **Figure 6-6**.

When system-wide pressure predictions that are shown in Figure 6-3 (forward mode) are compared to those shown in Figure 6-5 (reverse mode), the area around the Control Stations shows the variable water pressures that are experienced seasonally by customers in those areas. These pressure variations may be 20 psi or higher.

The average pressure that customers experience in the non-summer months north of the Control Stations is controlled by pressure reducing valves (PRVs) in the Control Stations. During the summer, water pressures north of the Control Stations drop significantly because this zone is fed by the Duff No. 1 WTP high service pump station and this area is at the farthest distance from the pump station.

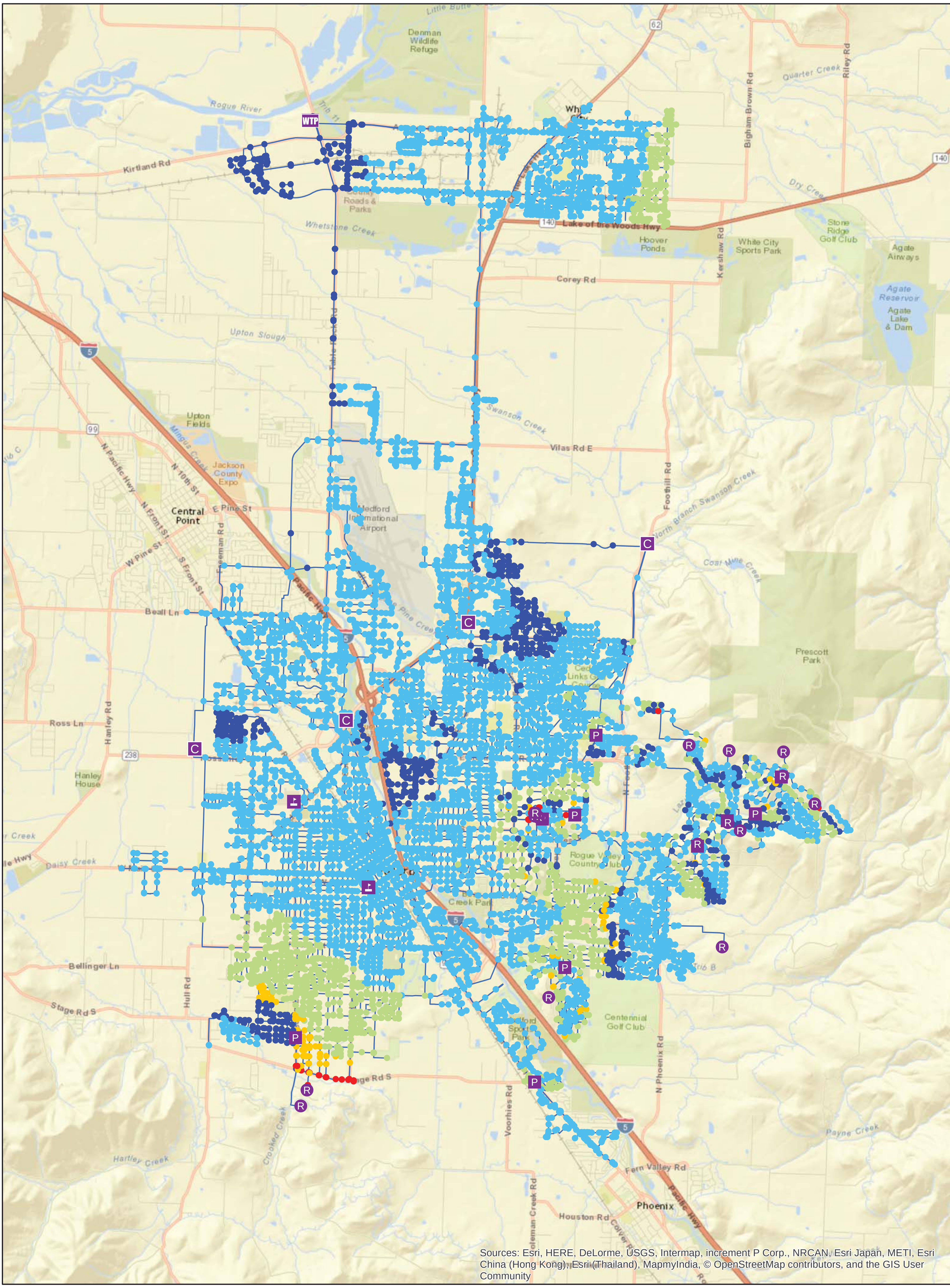
MWC has identified this as a challenge in operating their system. One mitigating measure that has been considered, both in the previous master plan and in preparation of this plan, was the installation of booster pumps mid-way between the Duff No. 1 WTP and the Control Stations. The use of intermediate booster stations would allow for lower discharge pressures at the Duff No. 1 WTP high service pump discharge as well as lessening the summer-to-winter pressure differences north of the Control Stations. However, this approach was rejected. The addition of intermediate booster pump stations would impose significant capital and operating costs, and would complicate operations to the extent that pressure surges may be unavoidable. The balancing of the Duff No. 1 WTP production, the Duff No. 1 WTP high service pumping rates, and the pumping at the Control Stations is difficult to achieve; the addition of intermediate booster pump stations might impose hydraulic limitations that cannot be addressed in day-to-day operations.

6.5.3 Reservoir Refill Analysis

For both the ADD and MDD analysis runs, each of the reservoirs within the system could be refilled by the pump station(s) supplying the pressure zones within a 24-hour period. The Hillcrest 1 and Hillcrest 2 reservoirs are small reservoirs and both of those reservoirs exhibit excessive cycling because of their size and proximity to pump stations. These reservoirs provide a supply buffer to existing pump stations, and as new reservoirs are constructed in the MWC upper pressures zones, these tanks may be able to be removed from service.

6.5.4 Fire Flow Analysis

A system-wide fire flow analysis was conducted for both forward mode and reverse mode operation. The available fire flows at model demand nodes for both conditions are shown in **Figures 6-7 and 6-8**. The available fire flow shows the system capacity and overall trends in delivering fire flow and where the fire flow may be limited and should not be considered to show individual hydrant flow availability. Using the specified land use information, each node was also assigned a fire flow category to evaluate if the available fire flow met the fire flow standards as outlined by MWC. **Figures 6-9 and 6-10** show the results of this analysis for forward mode and reverse mode, respectively. In these exhibits, the nodes are identified that do not meet the fire flow requirements based on the required fire flow at each location as defined by the land use. It should be noted that the results shown in Figures 6-9 and 6-10 are shown for individual locations, and in some cases, the required fire flow could be provided by adjacent hydrants. The results from the future system analysis were considered before developing improvements specific to improving fire flows.



LEGEND

Minimum Pressure (psi)

- < 20
- 20 - 30
- 30 - 50
- 50 - 90
- > 90

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-3
Existing Average Day Demand, Minimum Pressure
MWC Facility Plan

ch2m

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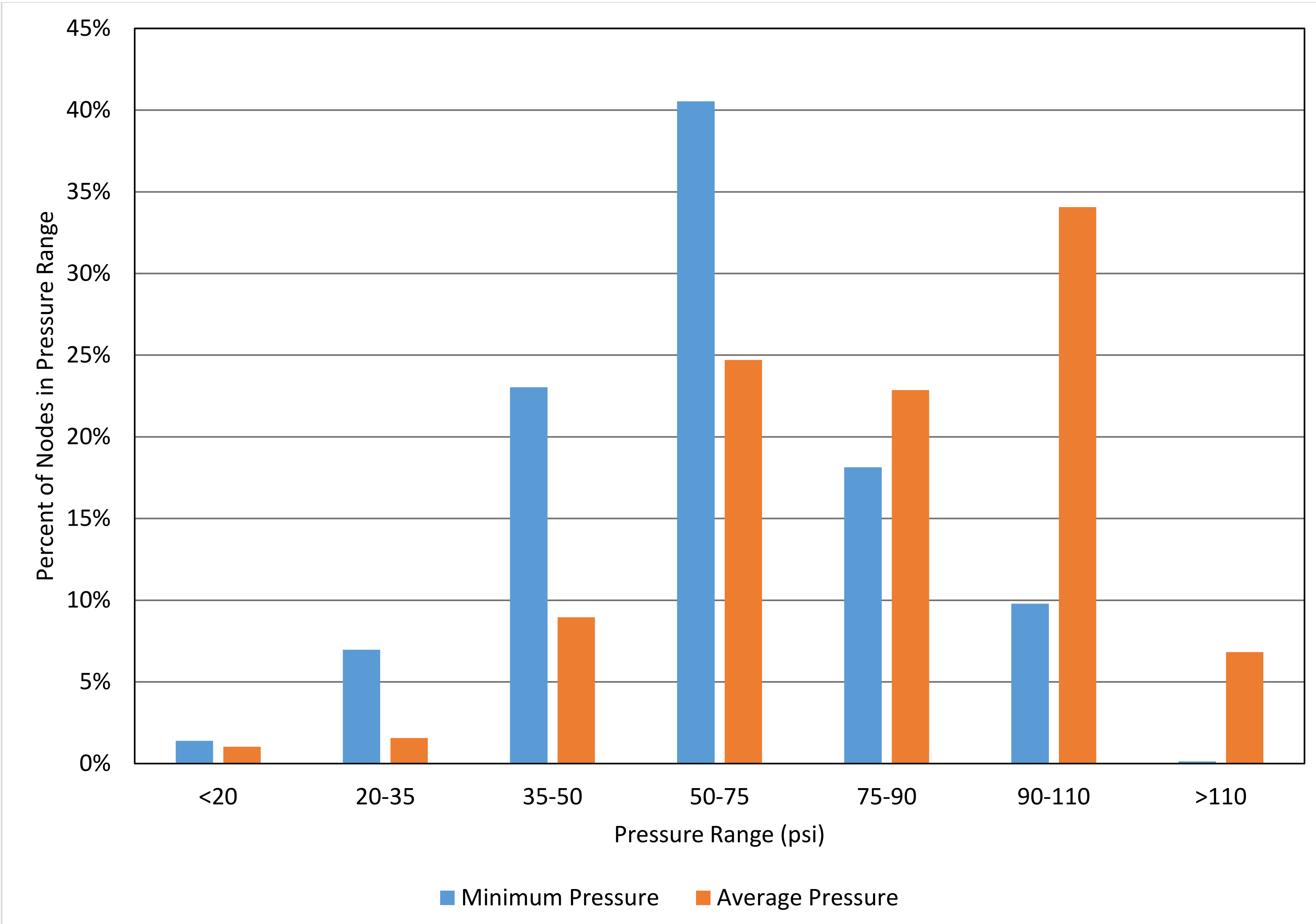
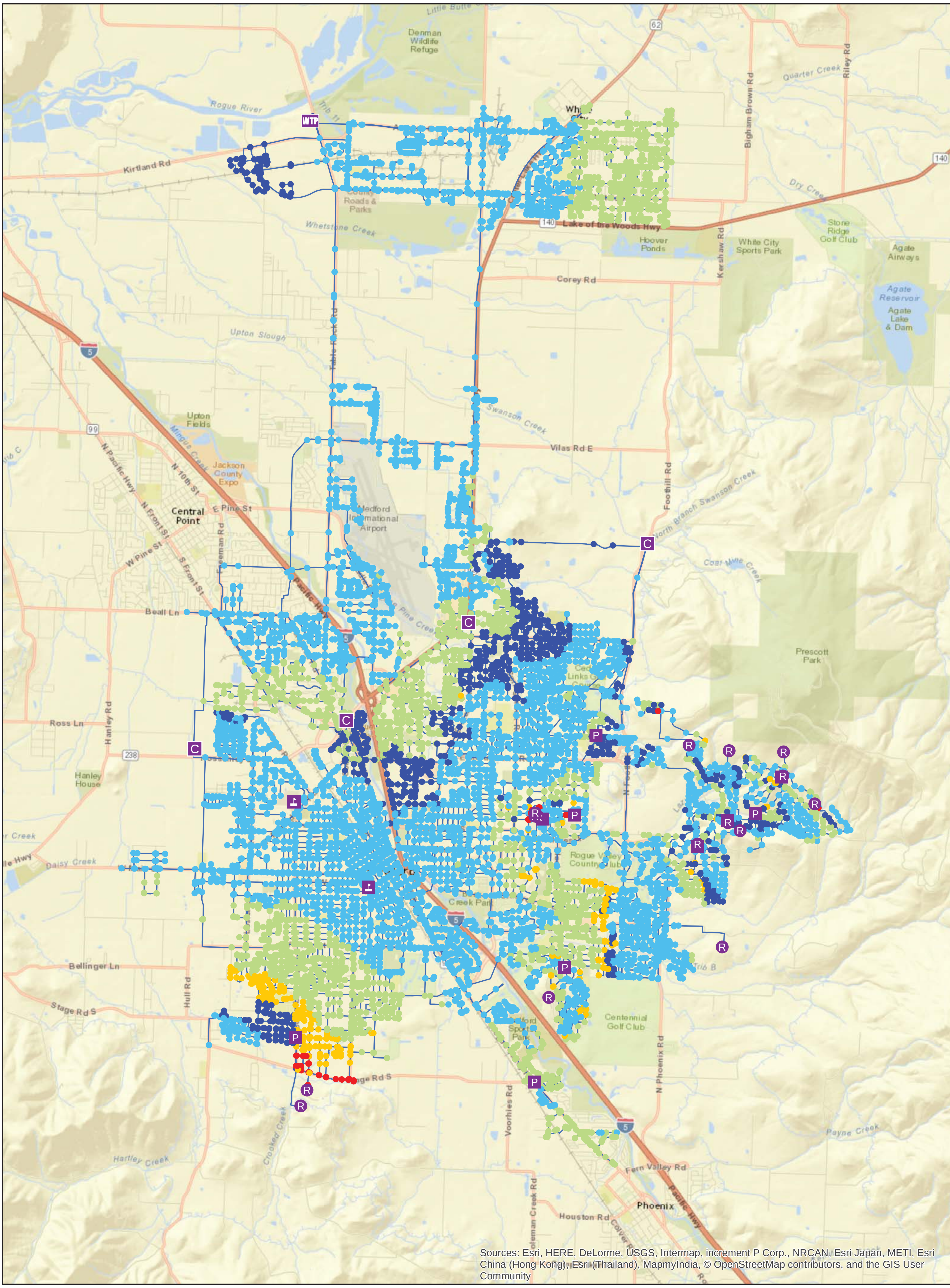


Figure 6-4. Pressures for 2016 Average Day Demand—Distribution of Nodes within Pressure Ranges



LEGEND

Minimum Pressure (psi)

- < 20
- 20 - 30
- 30 - 50
- 50 - 90
- > 90

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-5
Existing Maximum Day Demand, Minimum Pressure
MWC Facility Plan

ch2m

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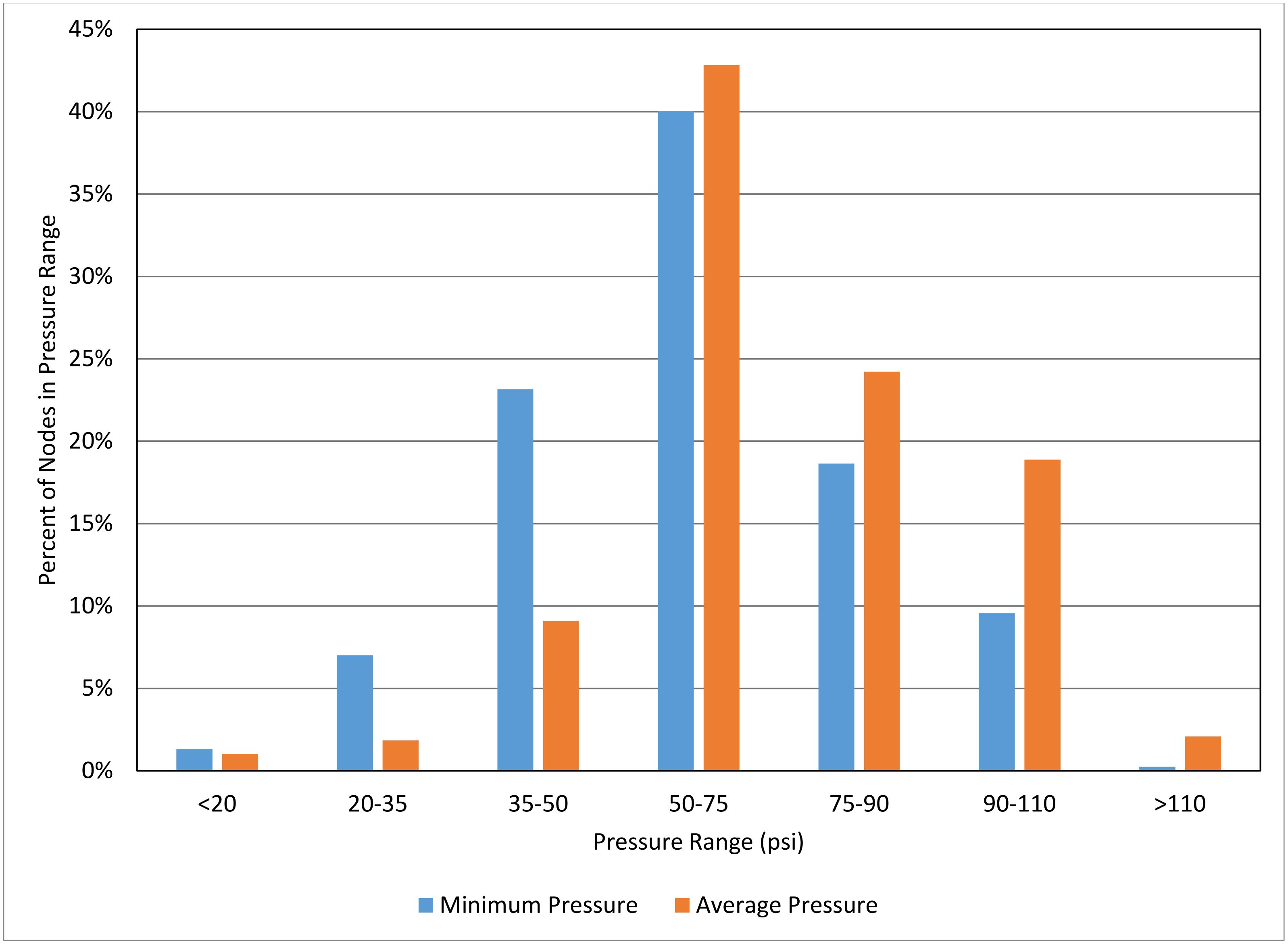
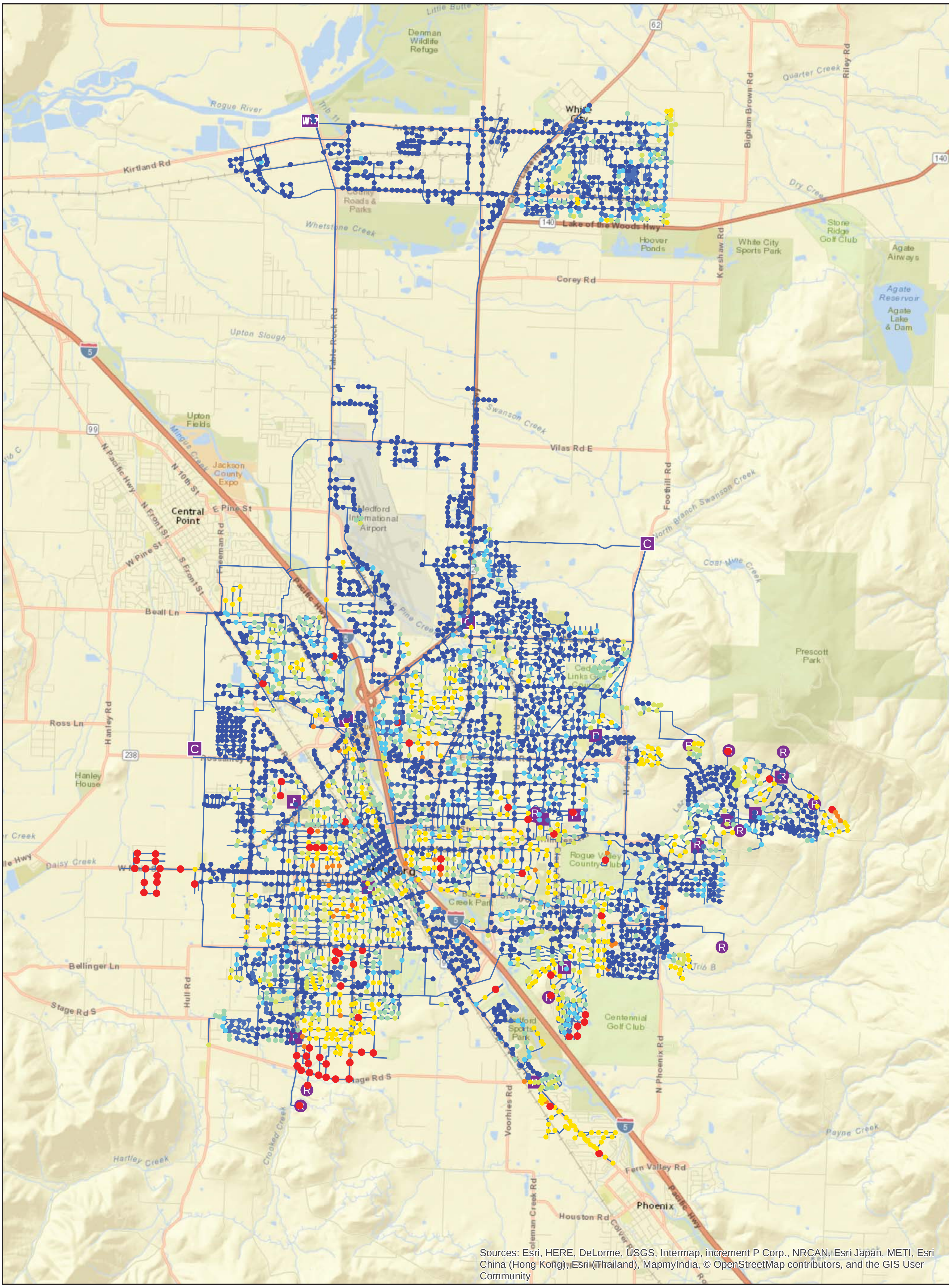


Figure 6-6. Pressures for 2016 Maximum Day Demand—Distribution of Nodes within Pressure Ranges



LEGEND

Available Flow (gpm)

- < 850
- 850 - 1,000
- 1,000 - 2,000
- 2,000 - 2,500
- 2,500 - 3,000
- 3,000 - 3,500
- 3,500 - 4,000
- > 4,000

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-7
Available Fire Flow,
Forward Flow
MWC Facility Plan

ch2m

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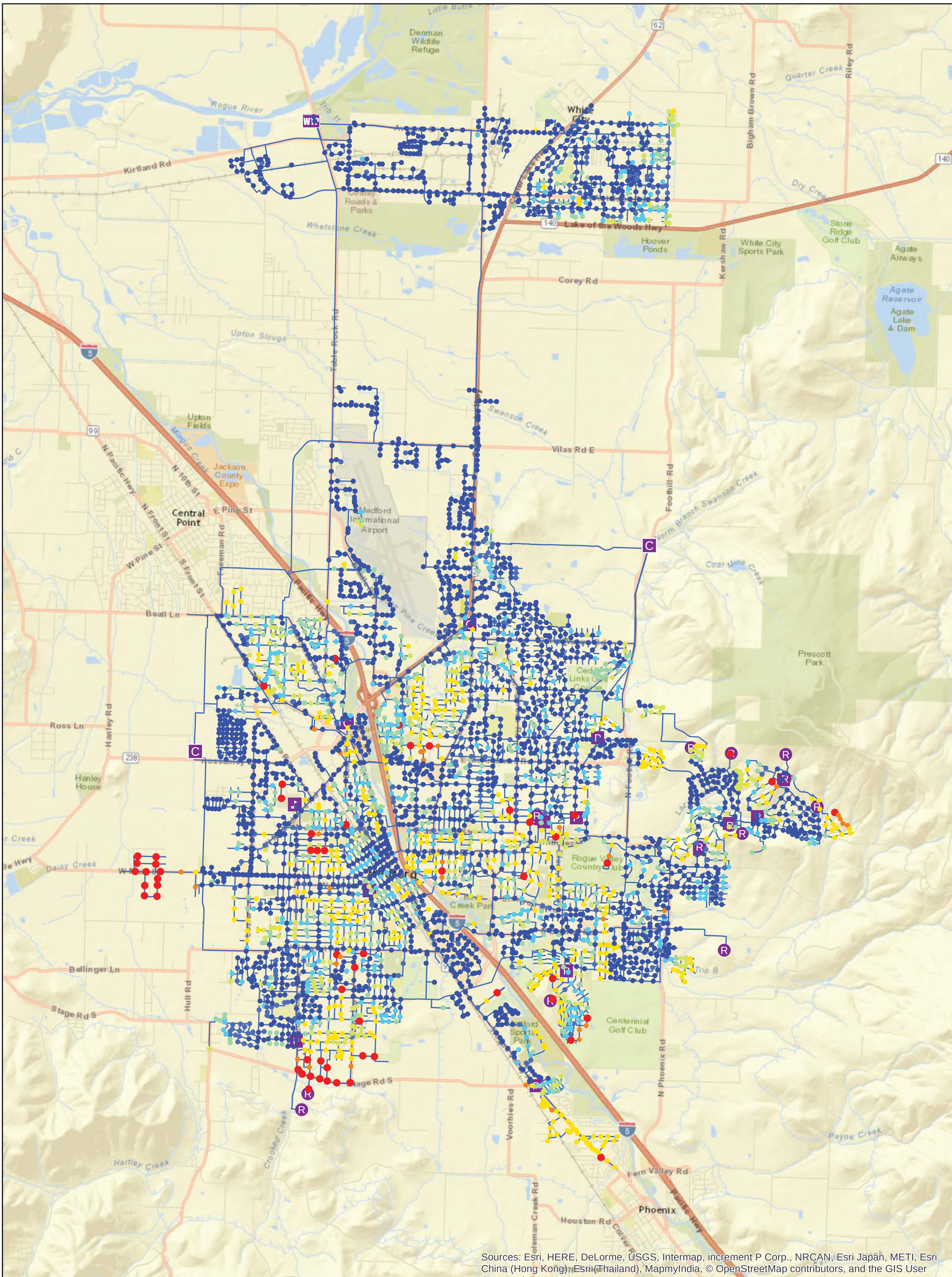

LEGEND

Available Flow (gpm)

- < 850
- 850 - 1,000
- 1,000 - 2,000
- 2,000 - 2,500
- 2,500 - 3,000
- 3,000 - 3,500
- 3,500 - 4,000
- > 4,000

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-8
Available Fire Flow,
Reverse Flow
MWC Facility Plan

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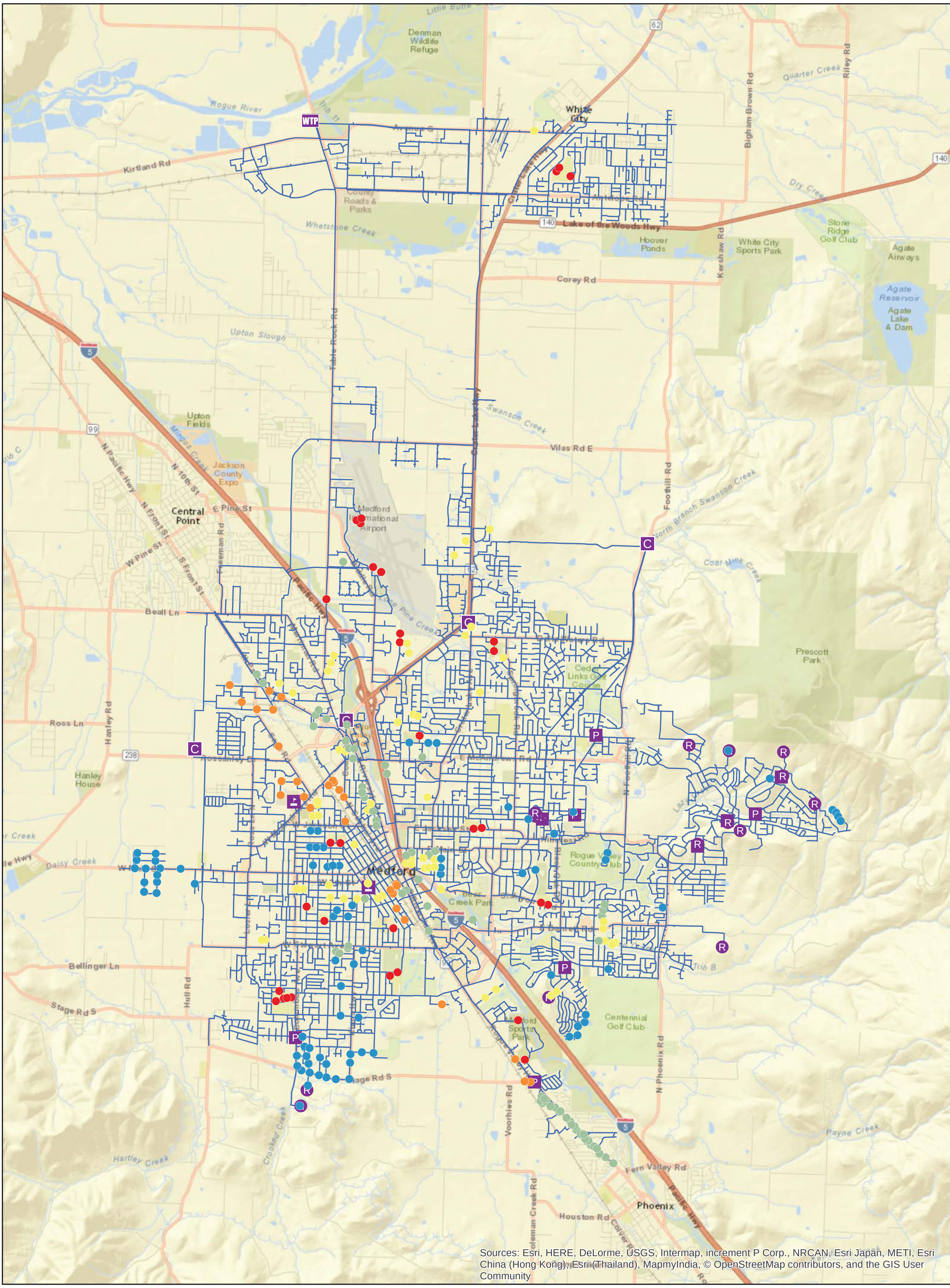
ch2m



LEGEND

Required Fire Flow (gpm)

- 1,000
- 2,000
- 2,500
- 3,000
- 3,500

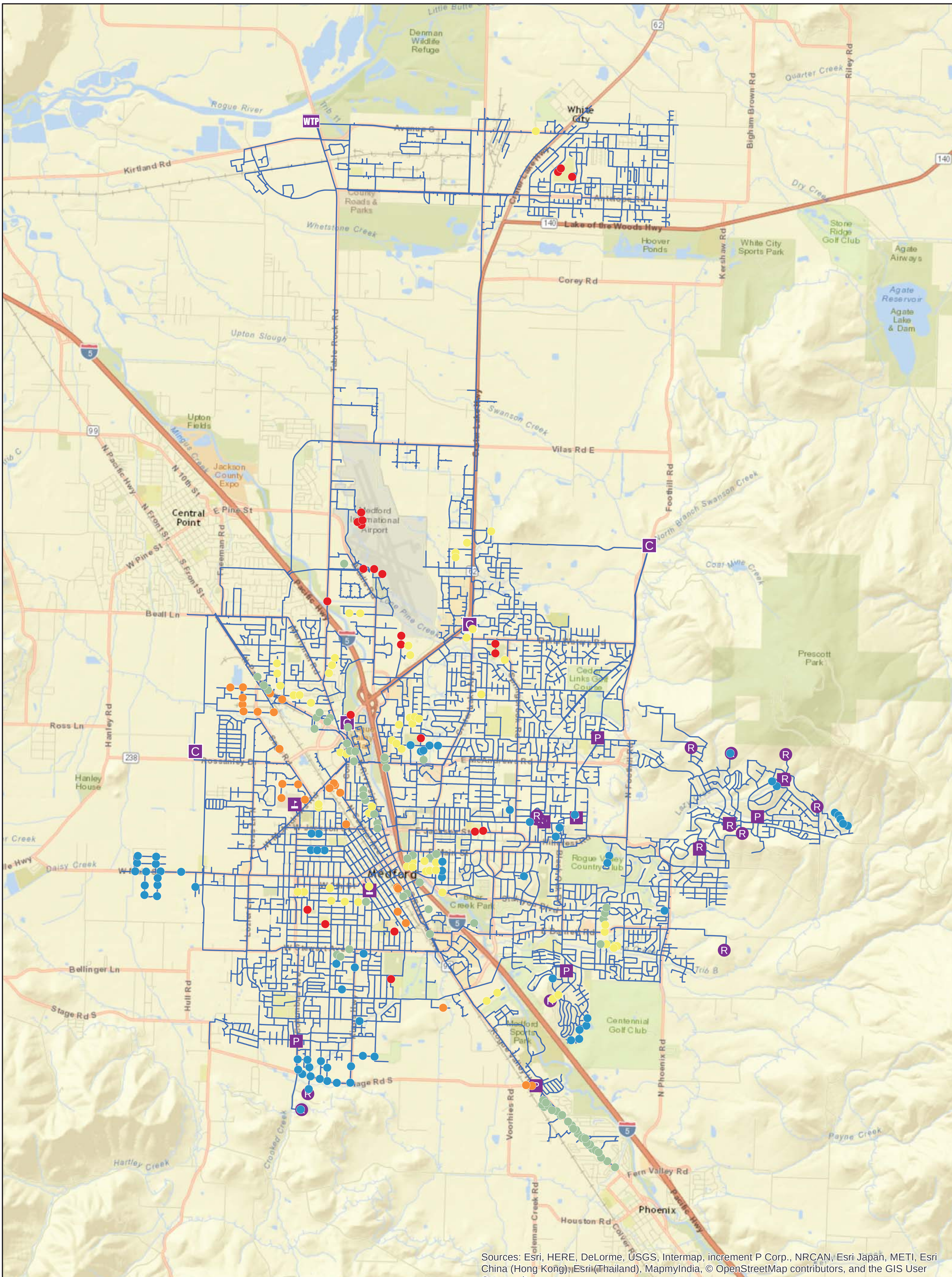
MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-9
Fire Flow Deficiency Areas, Forward Flow
MWC Facility Plan



LEGEND

Required Fire Flow (gpm)
- 1,000
- 2,000
- 2,500
- 3,000
- 3,500

MWC Facilities
- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-10
Fire Flow Deficiency Areas, Reverse Flow
MWC Facility Plan

ch2m

MWC_MDD_FF_NotMeet 2/12/2017 1:08:42 PM

6.5.5 Recommended Improvements for the Existing System

Based on the analysis of the existing system presented in this section, there are no recommended improvements identified for immediate construction to increase capacity except as related to the discussion of providing additional storage in the Gravity and Reduced Pressure Zones. However, there are some hydrants that currently provide fire flows that are less than MWC's criteria. Recommended improvements have been included in the capital improvements plan to address the fire flow deficiencies. These recommendations were developed after reviewing findings from the future system analysis to ensure that they were sized to meet long-term needs.

6.6 Future System Analysis

The model was used to simulate system performance under future (2036) demands to determine the system's ability to meet design criteria. By 2036, the system will only operate under reverse mode conditions; that is, the Duff No. 1 WTP will operate year-round. The projected ADD and MDD conditions were evaluated for reverse mode operation, and a summary of the demands for these periods is shown in **Table 6-4**.

Table 6-4. 2036 Demand and Supply
Medford Water Commission Water Distribution Facility Plan

Demand Condition	Demand (mgd)
Average Day Demand	37.5
Maximum Day Demand	79.3

The maximum capacity of the BBS transmission is 26.4 mgd. This was used as the supply from the springs for all the future analyses. Like the existing system analysis, up to firm capacity was used for all pump stations. With the growth of the MWC service area into the upper zones in the southeastern and southwestern portions of Medford, improvements including new pump stations, reservoirs, transmission piping, and distribution piping will be required. The recommended upgrades to transmission piping, distribution piping, pump stations, and reservoirs are summarized in subsequent sections.

6.6.1 Future System Alternatives

The improvements required to meet the future system design criteria and to meet MWC's goals for operational consistency center around providing additional storage for equalization as well as additional conveyance facilities (pipelines and pump stations) for delivering future demands. To address the future needs, there was not a single obvious answer to changing or improving the system to allow a steady production rate from the Duff No. 1 WTP. Therefore, several alternatives were identified that could meet the future needs. Each of these alternatives brings benefits for supporting different aspects of system operation.

The hydraulic model, particularly with the extended period simulation capability, was used to examine these alternatives that included transmission line additions, storage improvements, and possible Control Station upgrades to enable the system to receive a 42,000 gpm (60.5 mgd) flow from Duff No. 1 WTP continuously over a 24-hour day. The companion facility plan for the Duff No. 1 WTP describes high service pump and surge protection improvements that will also be needed for buildout of the plant.

The primary difference in each of the alternatives is the location of new storage. There is currently no distribution storage provided in the Reduced Pressure Zone. The Duff No. 1 WTP does include a clearwell reservoir, but the volume provided in this tank is dedicated to meeting disinfection contact time and other in-plant storage needs. It is not available for providing equalization storage for the distribution system. The Gravity Zone has large reservoirs: the Capital Reservoirs and Bullis Reservoir, with a combined volume of 22 MG. However, they are located a considerable distance from the Duff No. 1 WTP, and all are downstream of the Control Station pumping facilities. Bullis Reservoir is located at the far southwest end of the distribution system.

The following improvement alternatives were developed as model scenarios and were examined during this master plan analysis:

- Add storage at the Duff No. 1 WTP, to provide a buffer between plant production and high service pumping, allowing pumping to vary over a day while the plant production remains constant
- Add a ground-level storage reservoir to serve the Reduced Pressure Zone located on Coker Butte; in this case, the plant production and high service pumping rates would need to match one another, but the reservoir would provide a place to receive water during low demand times, with the goal being to limit pressure increases at the Duff No. 1 WTP HSPS discharge
- If possible, increase the total storage volume at the Capital Reservoirs site; being downstream of the Control Stations (during reverse flow conditions), this option would allow for more constant rate pumping from the Control Stations, which limits pressure build-up at the high service pump discharge at the Duff No. 1 WTP
- Add new Gravity Zone storage located northeast of the intersection of Foothills Road and Delta Waters Road; this option provides similar benefits as increasing the storage volume at the Capital Reservoirs site
- Add new Reduced Pressure Zone storage at Hanley Hill; this option provides similar benefits as the Coker Butte option although the Hanley Hill site is farther away from the Control Stations and most of the distribution system, so it may not function as effectively
- Add a ground level storage tank and pump station in the Reduced Pressure Zone; water entering the tank will lose its hydraulic head and then will need to be pumped to return it to the system, but a ground-level tank has a lower cost than an elevated tank while providing flexibility on location
- Add an elevated tank in either the Reduced Pressure Zone; an elevated storage tank has a greater cost per gallon than a ground-level tank, but it can be a cost-effective solution because its location, which is flexible, may reduce the need for new connecting pipelines; in addition to high cost, the Federal Aviation Administration limits tall structures near airports and neighboring landowners may object to an elevated tank

Adding storage at the Duff No. 1 WTP would effectively address the storage shortfall and enable steady-state operation of the plant, but it is an uncertain solution because of hydraulics and available land. The existing reservoir is set into the ground to receive gravity flow from the filters. Additional storage would need to have the same maximum water surface elevation to function in a like manner. Adding clearwell storage with a higher maximum water surface would limit the available head in the filters. The land area for adding another Duff No. 1 WTP clearwell is limited because much of the land surrounding the plant is part of the Vernal Pool Reserve, an environmentally sensitive land that supports the rare fairy shrimp. The capital improvements plan presented in the companion 2016 *Big Butte Springs and Duff Water Treatment Plant Facility Plan* includes an engineering project to evaluate clearwell expansion possibilities.

The option of installing a Reduced Pressure Zone tank on Coker Butte would accomplish the goal of allowing a steady rate of production from the Duff plant, but this could be an expensive project. MWC would need to purchase property at the correct elevation, and such land would likely come at a premium cost. In the modeling analyses, to evaluate the performance of this option, a reservoir was situated with a bottom elevation of 1455 feet and an overflow elevation of 1487 feet. It filled and emptied effectively, while limiting the Duff No. 1 WTP HSPS discharge head to a maximum of 110 psi. This option would require significant new pipes to connect it to the system.

The option of a new Gravity Zone tank located northeast of Foothills Road and Delta Waters Road is like the Coker Butte option in that it would involve property acquisition and require new pipes. This site has an additional complicating factor in that its elevation should be higher than the Capital Reservoirs to account for the changing HGL across the system, but this may impact the performance of the Capital Reservoirs. Details for this option were not examined in this facility plan.

The Hanley Hill option has a relatively long common fill and empty line to the tank, which will reduce the turnover rate of water stored in the tank. Managing a tank in this location would introduce the same challenge that MWC currently experiences with cycling water in Bullis Reservoir. A Hanley Hill Reservoir would be sited to serve the Reduced Pressure zone. For the master plan evaluation, the tank was situated with a bottom elevation of 1430 feet and an overflow elevation of 1462 feet. If actively operated, a tank at this location could also contribute to limiting discharge pressures from the Duff No. 1 WTP HSPS. But the relatively long single pipeline for filling and emptying is a concern that warrants careful evaluation.

A ground level tank option in the Reduced Pressure Zone, sited next to customers and not on a hill, would provide the required equalization storage to limit discharge pressures from the Duff No. 1 WTP and allow steady-state operation of the plant. However, any water that is delivered into a ground level storage tank would need to be pumped into the distribution system. This introduces operation and maintenance costs that will not be experienced with other storage options. A ground level storage tank and pump station option would complicate the pumping conditions in the Reduced Pressure Zone by adding a pump station that would be feeding customers and pumps at the Control Stations. This may be acceptable but warrants further evaluation. An advantage of a ground-level tank set in the lower evaluation areas of the Reduced Pressure Zone is that it would allow for flexibility in selecting a property. The tank could be located near one of the primary transmission mains to ensure a high rate of turnover and to shorten the length of a connecting pipeline.

An elevated tank could potentially be placed in either in Reduced Pressure or Gravity Zone, depending on property availability and the acceptability of an elevated tank. There are advantages to adding storage to the Reduced Pressure Zone, to more effectively buffer production from the Duff No. 1 WTP, so it was assumed that if an elevated tank was selected, it would be in the Reduced Pressure Zone. An elevated tank preserves the hydraulic head and avoids the need for re-pumping but the tank itself is more expensive than a ground-level tank. For the master planning evaluation, the elevated tank was placed in the White City area, with a bottom elevation of 1465 feet and a depth of 45 feet. Based on discussions with CBI Inc., a leading national constructor of elevated tanks, the cost for an elevated tank in the Medford area is about two to two-and-one-half times the cost for a ground level tank. The higher the ground elevation, the lower the height of the tank and the lower its cost will be.

Adding volume at the Capital Reservoirs site is attractive because it would minimize the need for new pipe and because it is known that this location functions acceptably in the system. However, storage in this location, downstream of the Control Stations, is not as effective in preventing high discharge pressures at the Duff No. 1 WTP HSPS as are the options of adding storage in the Reduce Pressure Zone. Furthermore, as noted previously, the feasibility of increasing the storage volume at this location is uncertain. It will require demolishing one or more existing tanks before a new tank can be constructed and even in this case, the available land area may not allow for much if any increase in storage volume. MWC has noted that the Capital Reservoirs are due for replacement. A new storage option should be implemented soon so that these replacement projects can proceed.

Based upon the evaluation of each of the storage options, there are benefits to the Duff No. 1 WTP HSPS operation if storage is provided in the Reduced Pressure Zone. It is easier to manage the discharge pressure at the HSPS with storage in the Reduced Pressure Zone. The provision of storage in the Reduced Pressure Zone will also help to limit customer pressure fluctuations that are currently observed in the Reduced Pressure Zone when the Control Stations are operating in pumping mode. Adding storage in the Reduced Pressure Zone by using an elevated tank, by using a ground-level tank with a pump station, or by installing a ground-level tank on Coker Butte are more favorable than installing a ground-level tank on Hanley Hill. The Hanley Hill option would result in limited turnover of the water because of the long connecting pipeline. But all may be acceptable options.

The option of adding storage at the Delta Waters site, close to the supply from Big Butte Springs provides additional storage in the Gravity Zone but the hydraulic grade line (HGL) of storage at this site would need to be higher than the Capital Reservoirs since it is closer to the supply point, where the HGL is higher than the existing Capital Reservoirs. The option of replacing the aging Capital Reservoirs with additional storage at the Capital Reservoir site makes use of existing infrastructure and of existing property. However, it may be necessary to add storage at another Reduced Pressure or Gravity Zone location prior to demolition and reconstruction of the Capital Reservoirs to enable the system to function acceptably during the construction period.

Table 6-5 provides a planning-level, cost comparison of the options, based on adding 5 million gallons of storage. The comparison is not to imply that adding 5 million gallons is the right volume; further consideration of the volume is needed. By comparative costs, it means that the costs presented in the table indicate variations among alternatives and do not necessarily capture costs common to each alternative. The options are listed per a preliminary ranking of desirability by MWC, from most favorable (#1) to least favorable (#7). The most favorable option is adding to the Duff No. 1 WTP clearwell volume. The unknown for this option is whether there is available nearby land that makes it a feasible option.

The least cost option is adding storage volume at the Capital Reservoirs site, but as noted, it is uncertain if it will be possible to increase the storage volume at this location. The two next lowest cost options are using the Hanley Hill site or installing a ground level tank with a pump station. Both options have disadvantages as discussed. The next two lowest cost options are adding to the clearwell storage at Duff No. 1 WTP or installing a Reduced Pressure Zone tank on Coker Butte. Either of these two options would be a favorable solution if they are found to be feasible.

A further factor warranting consideration is the restrictions on height of structures in the Reduced Pressure Zone and the northern area of the Gravity Zone because of the airport. Per Part 77 of the Federal Aviation Administration (FAA) regulations, there exist maximum height limits for structures depending on proximity to the airport. These limits are further restricted for consideration of the flight path based on the specific orientation of the runways. Based on the location of the Rogue Valley International Medford Airport, it is anticipated that most elevated reservoir sites or reservoirs placed at an elevation higher than the airport will require filing with the FAA. The Hanley Hill site, approximately 18,000 ft from the airport runway may not require filing due to its distance from the airport. Ground level tanks along Crater Lake Avenue north of Vilas Road may also not require filing. An assessment would be required for any planned reservoir based on the specific structure height and location.

6.6.2 2036 Maximum Day Demand: Big Butte Springs and Duff WTP

The 2036 MDD (approximately 79 mgd) analyses were performed for reverse mode operation. New piping is proposed to serve developing areas in the southeastern portions of Medford, and additional piping improvements and zone realignment from the Gravity Zone to the Southwest Zone (1C) with service by the Archer PS are proposed to alleviate low pressures in the southwestern portions of Medford. By incorporating these piping improvements and the zone realignment, the system pressures were increased to more desirable levels. However, there are some pressures at the higher elevation areas of the Gravity Zone, close to the Zone 1A boundary, that are periodically below the 35-psi level. If these areas were brought into Pressure Zone 1A, the pressures would be above the maximum pressure criterion. MWC may consider bringing these areas into Pressure Zone 1 and serving them through a pressure reducing valve.

Table 6-5. Comparison of Reduced Pressure and Gravity Zone Storage Options for a 5 MG Tank

Medford Water Commission Water Distribution Facility Plan

							Connecting Pipe Needs						
No.	Option	Positives	Negatives	Relative Tank Cost	Relative Pump Station Cost	Relative Land Cost	Diameter (in)	Length (ft)	Unit Cost	Pipeline Cost	Other Relative Costs (if any)	Total Construction	Discussion
1	Increase clearwell storage volume at Duff	Not dependent on transmission lines to balance flows	Unsure if land availability will allow this	$9,750,000	$0	$200,000	42	1,000	$462	$462,000		$10,800,000	Requires engineering analysis to determine feasibility (analysis project included in the BBS/Duff WTP plan)
							36	1,000	$396	$396,000			
2	Add tank at Capital site	Existing site; proven effective through current operations; replacements warranted anyway because of condition	Unsure if 5 MG can be added; neighborhood issues, at least during construction	$7,800,000	$0	$0	$0	0	$0	$0	$200,000	$8,000,000	Existing tanks require replacement, so this provides an opportunity to expand storage volume at the same time. However, it is uncertain whether the site provides sufficient space for a larger total volume. Other relative cost is for cell tower relocation.
3	Reduced Pressure Zone ground level tank with pump station	Allows for flexibility in locating tank	O&M required for another large pump station; higher energy costs	$6,500,000	$2,000,000	$200,000	36	1,000	$396	$396,000		$9,100,000	Operation of new pump station complicates Reduced Pressure Zone operation, with another pump station pumping into the closed zone
4	Ground level on Coker Butte	Adding storage in RP zone is most effective	May be using prime land for a tank; neighborhood acceptability may be an issue	$6,500,000	$0	$600,000	36	6,000	$396	$2,376,000		$10,300,000	Land availability is questionable
							36	2,000	$396	$792,000			
5	Ground level Foothills/Delta Waters Rd (Gravity Zone)	Would act much like Capital Reservoirs; opportunities for direct feed from BBS	May be using prime land for a tank; neighborhood acceptability may be an issue	$6,500,000	$0	$300,000	36	15,000	$396	$5,940,000		$12,700,000	Land availability is questionable; maximum water surface needs to be higher than existing Capital Reservoirs due to proximity to the BBS supply (higher HGL)
6	Hanley Hill (Reduced Pressure Zone)	MWC owns property	The distance from distribution system & main transmission lines makes it less effective and introduces stagnant water concerns	$6,500,000	$0	$0	30	6,500	$330	$2,145,000		$8,600,000	MWC owns property; consider whether operational procedures can address possible stagnant water concerns
7	Elevated tank in Reduced Pressure	Allows for flexibility in locating tank (although need to consider FAA restrictions); preserves head	Not a facility type that MWC currently has (more complicated maintenance); neighboring property owners may not like elevated tank	$16,250,000	$0	$200,000	36	1,000	$396	$396,000		$16,800,000	Tank height (cost) depends on location within Reduced Pressure Zone

The system-wide minimum pressures for the MDD condition under reverse mode operation are shown in **Figure 6-11**, and the percentage of nodes within the defined pressure ranges are shown in **Figure 6-12**. The system-wide maximum pressures for the MDD condition for the future system analysis are shown in **Figure 6-13**.

6.6.3 2036 Average Day Demand: Big Butte Springs and Duff WTP

The 2036 ADD (approximately 38 mgd) analyses were performed for reverse mode operation using the improvements identified to meet the MDD needs. By this date, it is anticipated that the Duff No. 1 WTP will operate year-round, and therefore the system will function in reverse mode year-round. The system-wide minimum pressures for the ADD condition under reverse mode operation are shown in **Figure 6-14**, and the percentage of nodes within the defined pressure ranges are shown in **Figure 6-15**. The system-wide maximum pressures for the ADD condition for the future system analysis are shown in **Figure 6-16**. New pump stations and reservoirs are also able to operate effectively under ADD conditions.

6.6.4 Reservoir Refill Analysis

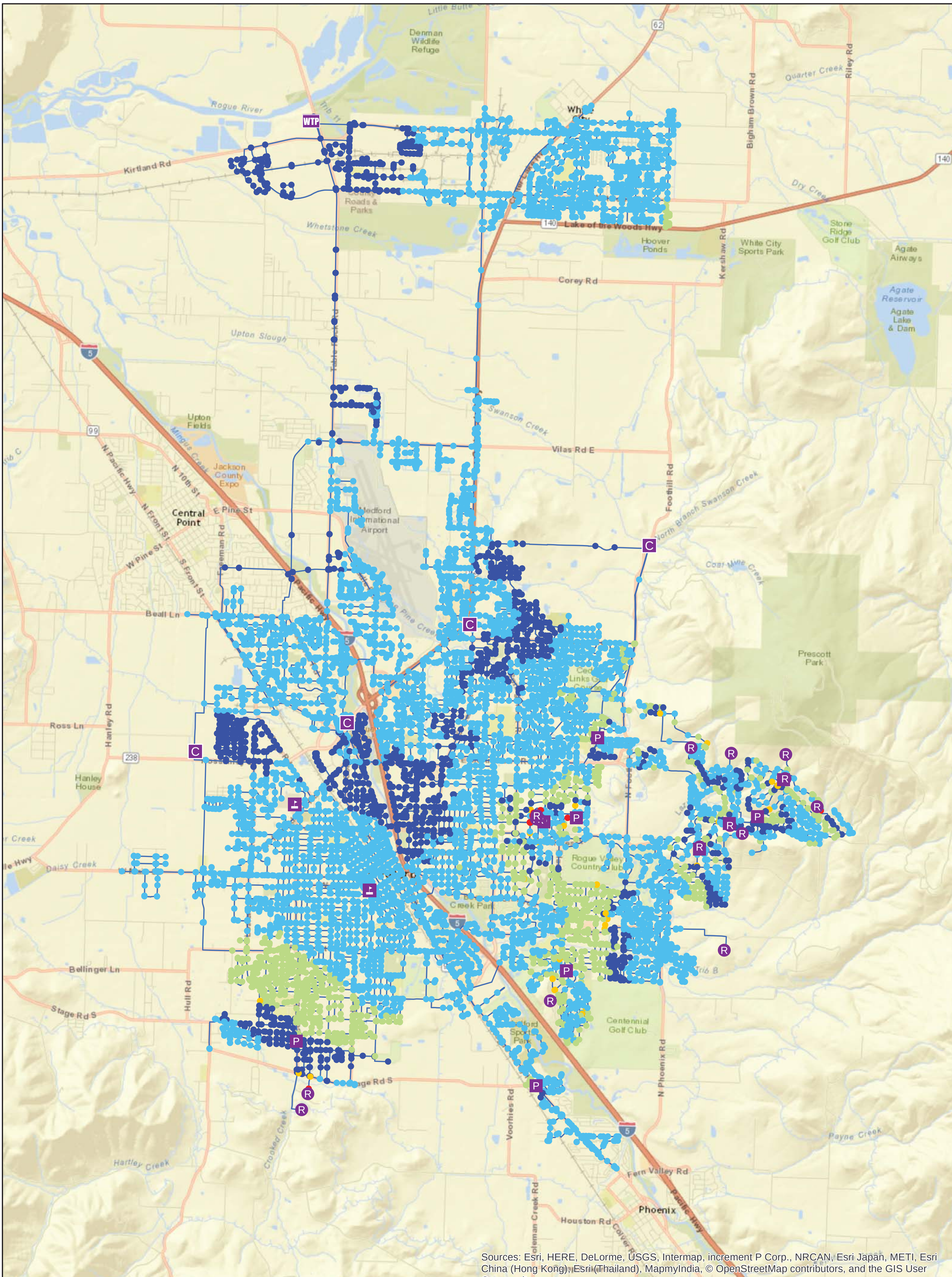
For both the ADD and MDD analysis runs, each of the reservoirs within the system could be refilled by the pump station(s) supplying the pressure zones within a 24-hour period. Proposed reservoirs and pump stations were incorporated into the system with automated controls that aligned with existing control philosophy and smaller reservoirs like the Hillcrest #1 and #2 and Stardust were removed from service.

6.6.5 2036 Fire Flow Analysis

A system-wide fire flow analysis was conducted with future demands for reverse mode operation. The available fire flows at model demand nodes is shown in **Figure 6-17** and shows similar limitations as shown for the 2015 fire flow analysis.

6.7 Recommended Improvements for the Future System

Subsequent sections present recommended improvements for the pipe system, pump stations, and reservoirs within the system. The pipeline needs, with a focus on transmission pipelines, are presented in Chapter 7. Chapter 8 addresses pump station needs and Chapter 9 addresses storage needs.



LEGEND

Minimum Pressure (psi)

- < 20
- 20 - 30
- 30 - 50
- 50 - 90
- > 90

MWC Facilities

- C — CONTROL STATION, EXISTING
- P — PUMP STATION, EXISTING
- R — RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP — WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-11
Future Average Day Demand, Minimum Pressure
MWC Facility Plan

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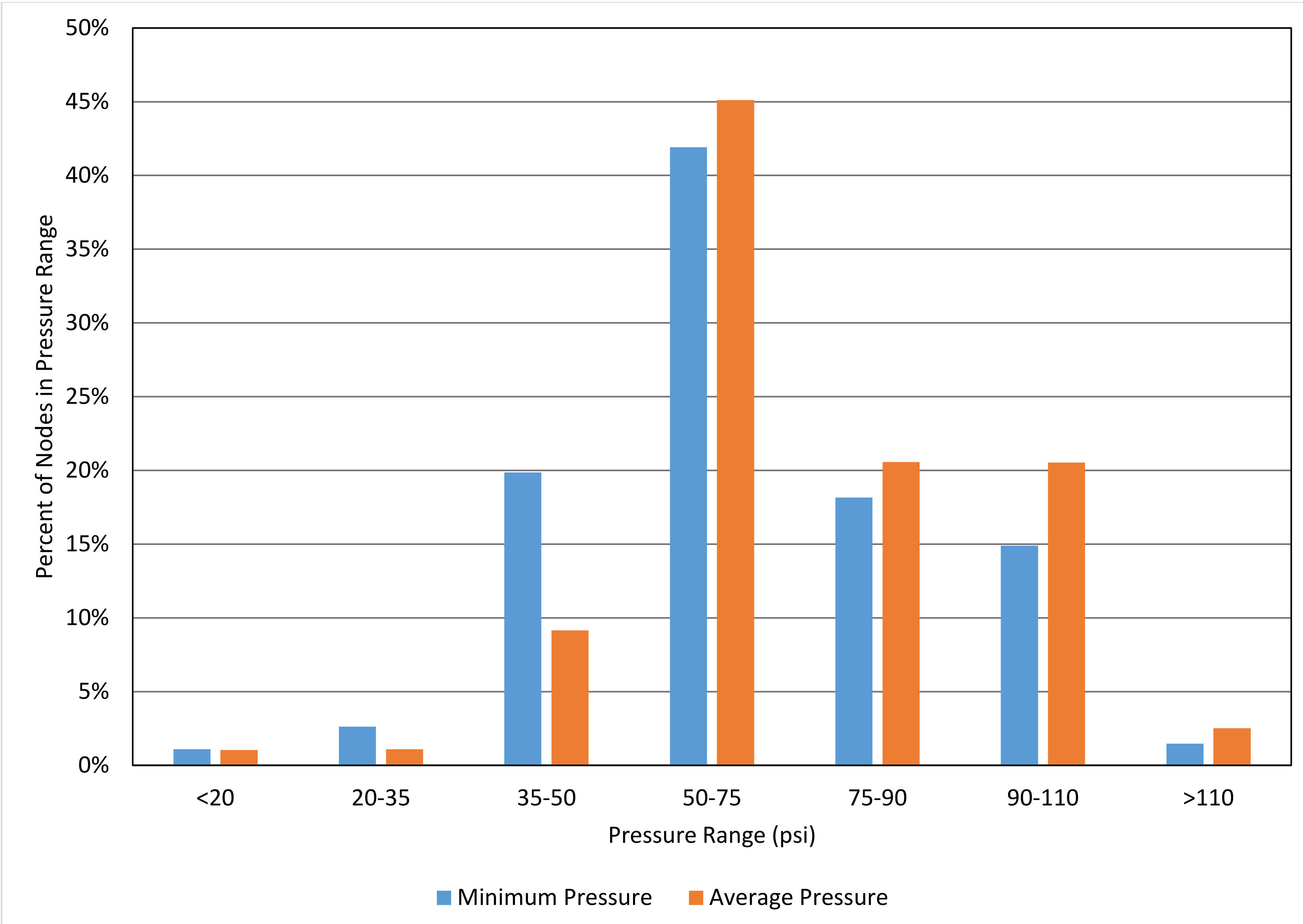
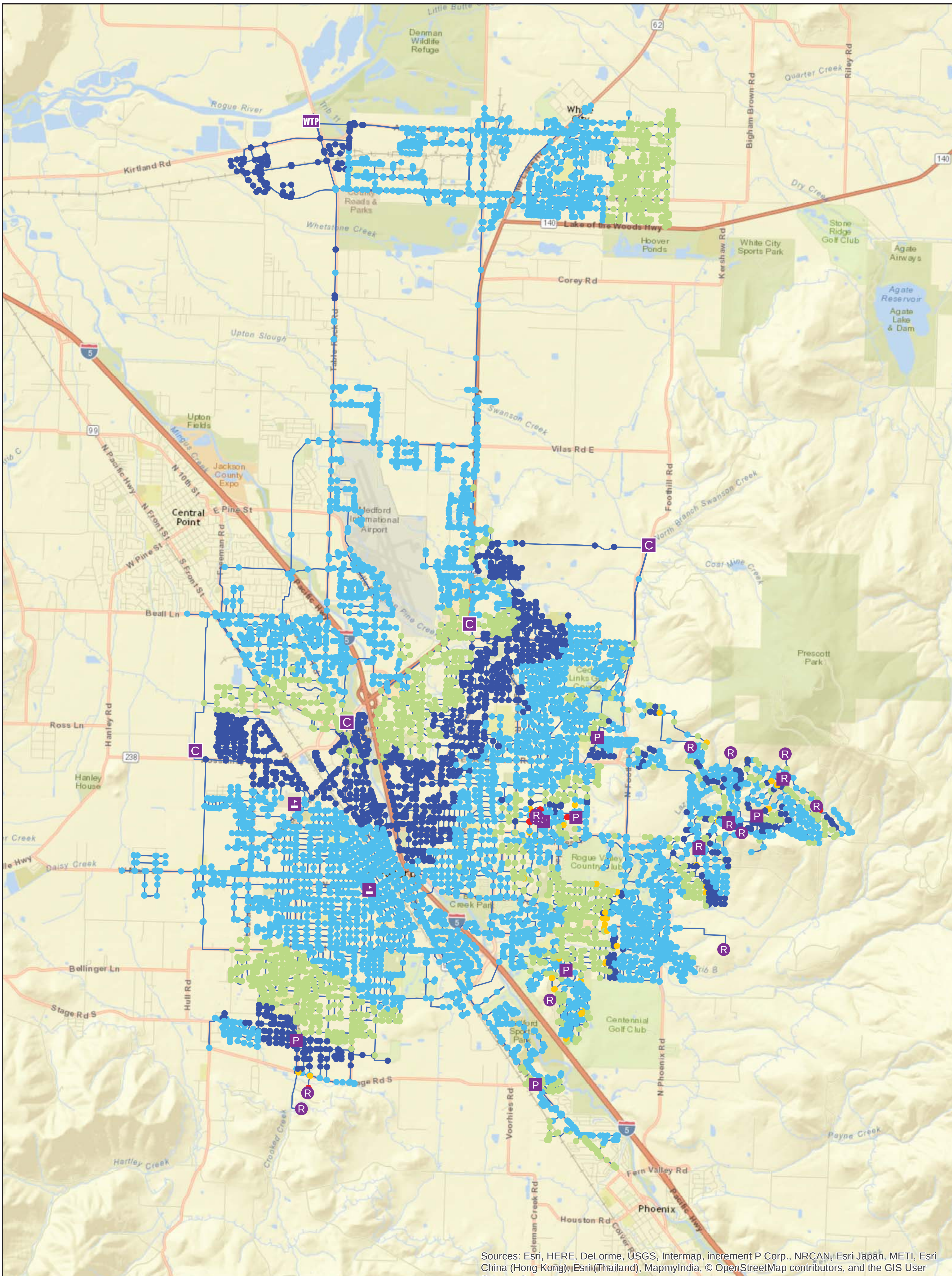


Figure 6-12. 2036 Maximum Day Demand—Distribution of Nodes within Pressure Ranges



LEGEND

Minimum Pressure (psi)

- < 20
- 20 - 30
- 30 - 50
- 50 - 90
- > 90

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-13
Future Maximum Day Demand, Minimum Pressure
MWC Facility Plan

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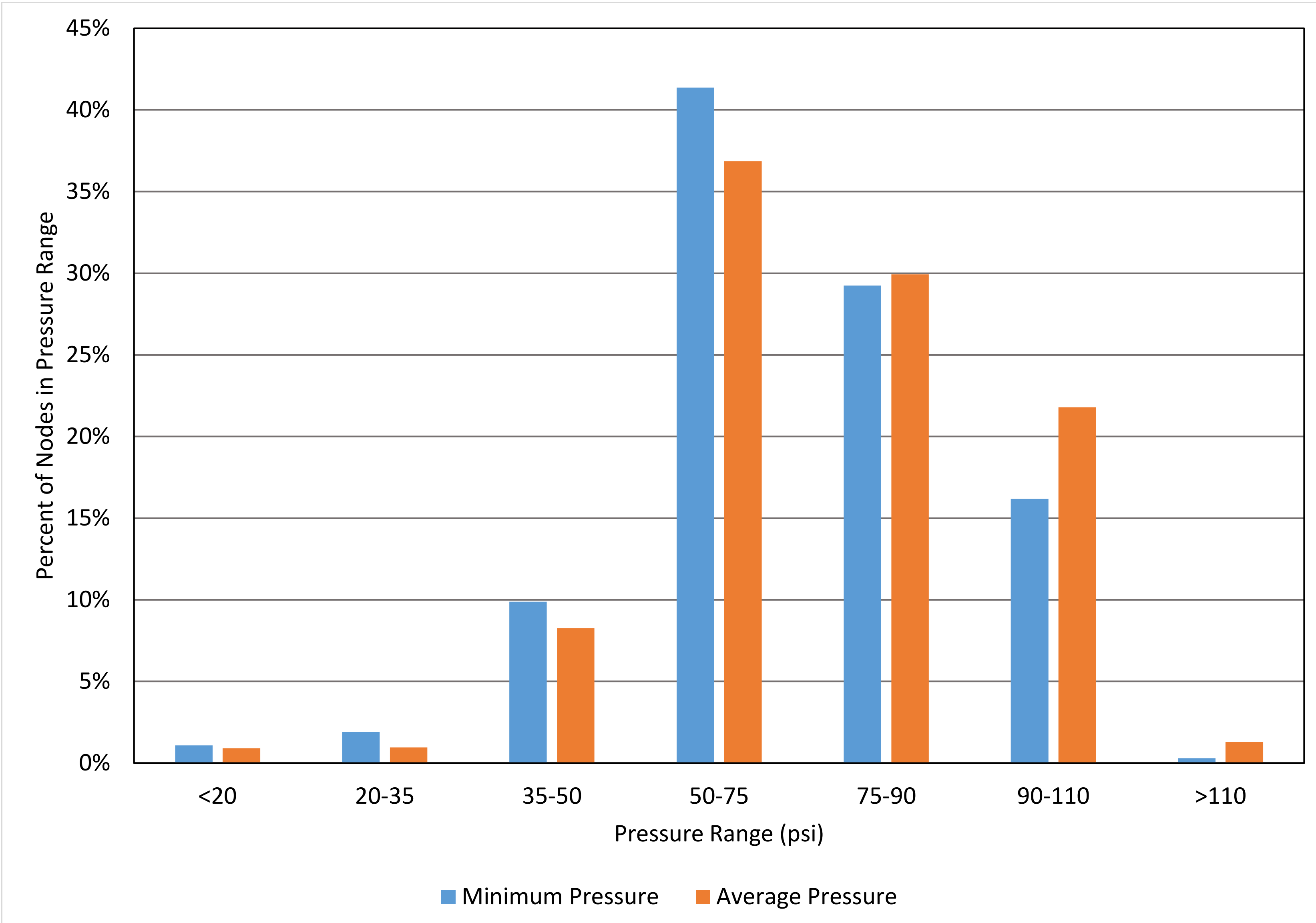
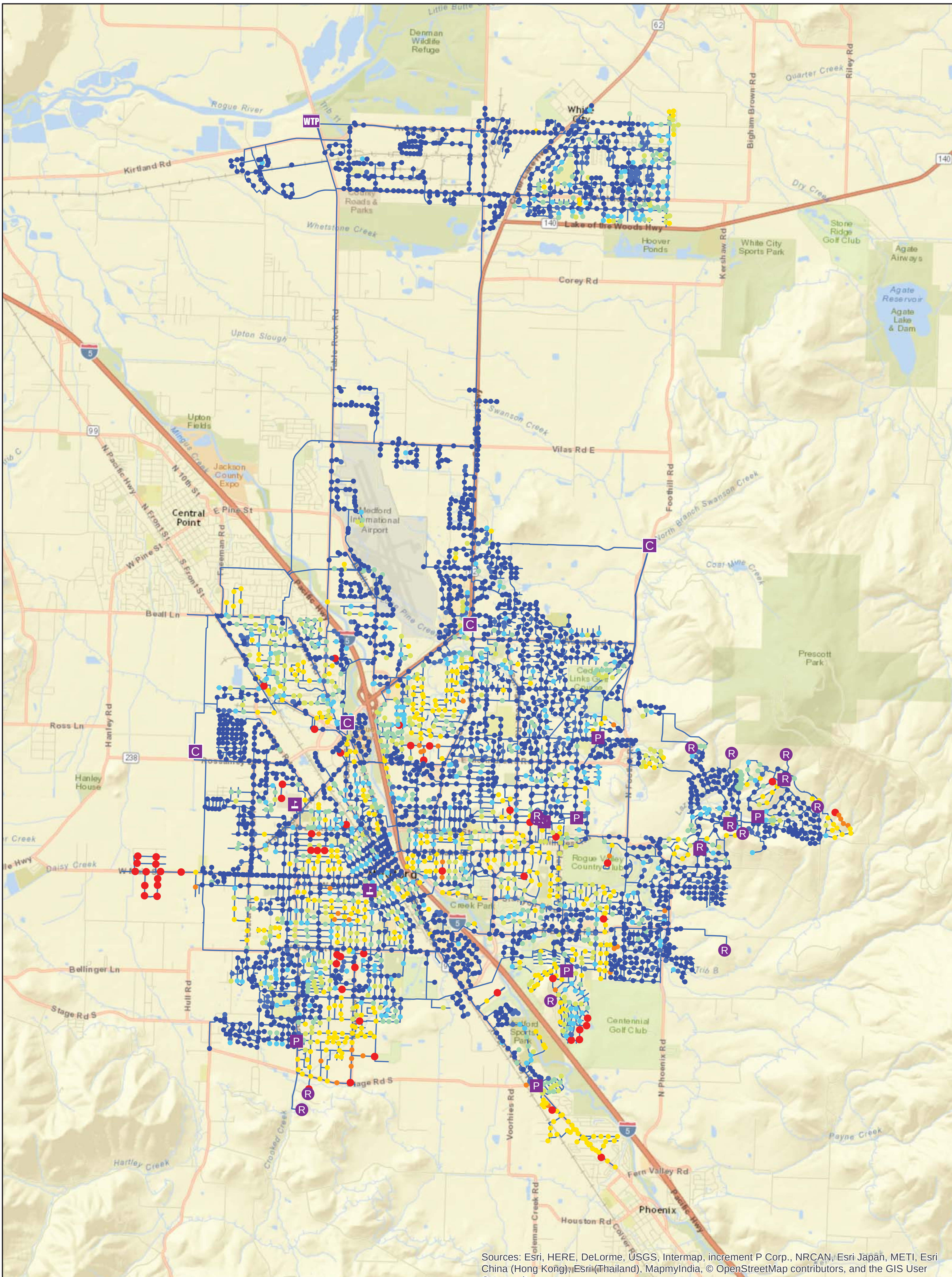


Figure 6-14. 2036 Average Day Demand—Distribution of Nodes within Pressure Ranges



LEGEND

Available Flow (gpm)

- < 850
- 850 - 1,000
- 1,000 - 2,000
- 2,000 - 2,500
- 2,500 - 3,000
- 3,000 - 3,500
- 3,500 - 4,000
- > 4,000

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 6-15
Future Available Fire Flow
MWC Facility Plan

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SECTION 7

Pipeline Improvements

7.1 Introduction

This section describes pipeline additions to increase conveyance of water, which will allow MWC to meet current and projected demands at acceptable pressures throughout the system. The discussion is divided into two sections, transmission improvements and distribution improvements. Transmission pipelines refer to the larger diameter pipelines (16-inches in diameter and larger) that feed large segments of the distribution system, such as the pipelines that deliver water from the Duff No. 1 WTP to Medford. The distribution pipelines (14-inches in diameter and smaller) provide service within a single pressure zone. A final section addresses replacement of aging cast iron pipe.

7.2 Transmission Pipeline Improvements

The transmission pipeline improvements that are recommended in the next 20 years for the MWC system are shown in **Figure 7-1.** The improvements are grouped by project and are described below.

Reduced Pressure Zone transmission pipeline, from Duff No. 1 WTP to Vilas Road (PL-1). This project consists of a 36-inch pipeline from the Duff No. 1 WTP, south along Table Rock Road to Vilas Road. This route selection is preliminary; the specific alignment will be selected during a preliminary design. The primary questions on selecting a route are constructability and cost. It will take on-the-ground assessments to determine whether sufficient right-of-way is available with a minimum of interferences with existing buried utilities. The pipeline is needed to improve conveyance through the Reduced Pressure Zone as the Duff No. 1 WTP is expanded to its full buildout capacity.

Lone Pine Pump Station extension to south and east (PL-3a and 3b). To support growth in the upper zones and to deliver water to the reservoirs and pump stations planned for the upper zones, a 16-inch pipe from Lone Pine Pump Station is recommended to parallel the existing 12-inch pipe from the Lone Pine Pump Station to Hillcrest, on Foothill Road (3a). (If the 12-inch pipeline is abandoned, the new pipe should be upsized to 24 inches.) In addition to this pipeline, a 16-inch pipe is recommended to the east along Lone Pine Road to deliver water to the Lone Pine Reservoir 1 (3b).

Pressure Zone 1 connection to Zone 1 loop (PL-4). This project is important for delivering water from the north to the south in Pressure Zone 1. The proposed 16-inch pipeline will connect to the Lone Pine extension at Hillcrest and Foothills Road and will continue to the south and then to east of North Phoenix Road on Calle Vista Drive where it will connect to the Zone 1 loop.

Pressure Zone 1 southern loop (PL-6). This proposed loop of 16-inch and 12-inch pipe will be in the southern area of Pressure Zone 1. The 16-inch pipe will connect to Pressure Zone 1 near Stanford and Wingate and continue south to Barnett Road, where the transition from 16-inch to 12-inch occurs. The pipeline will continue south to Coal Mine Road and then loop back to the west at North Phoenix Road. This project will be driven by development in an Urban Reserve Area (URA).

Crater Lake Avenue transmission pipeline, from Martin Control Station to McAndrews Road (PL-7). As the pumping capacity at Martin Control Station is increased, additional conveyance capacity is needed to move the water away from the Control Station. To accomplish this, a 16-inch diameter pipe is recommended to parallel the existing 14-inch and 16-inch diameter pipes along Crater Lake Avenue from the Martin Control Station to McAndrews Road.

Barnett feeder transmission pipeline, from Barnett Pump Station to Shamrock Drive (PL-8). As the upper zones of the MWC service area develop and when the Barnett Pump Station is constructed at the

Barnett Reservoir site, a 16-inch diameter pipeline is recommended as the size of the discharge pipeline from the pump station up to Shamrock Road where it will connect to two existing 12-inch pipelines. One of the 12-inch pipelines continues to the west along Shamrock Road while the other 12-inch pipeline continues north and connects to piping in Cherry Lane. It appears that the need for this pipeline will occur outside of the 20-year planning window.

Conrad supply transmission pipeline from Beall Lane to Conrad Control Station (PL-9). To support the additional conveyance in the Reduced Pressure Zone, additional supply capacity has been identified for the suction side of the Conrad Control Station. The pipeline is recommended to be an 18-inch pipeline, from Beall Lane to the Conrad Control Station, along Merriman Road. This is a preliminary route for this pipeline and it is possible that the pipeline may follow an alternative route.

Reduced Pressure Zone northern east-west conveyance toward Eagle Point (PL-10). This proposed 30-inch pipeline will convey water to the east in White City to support the future delivery of water to Eagle Point and to eastern areas of White City. This pipeline extends the recently constructed 48-inch pipeline along Avenue G to near the Eagle Point delivery point.

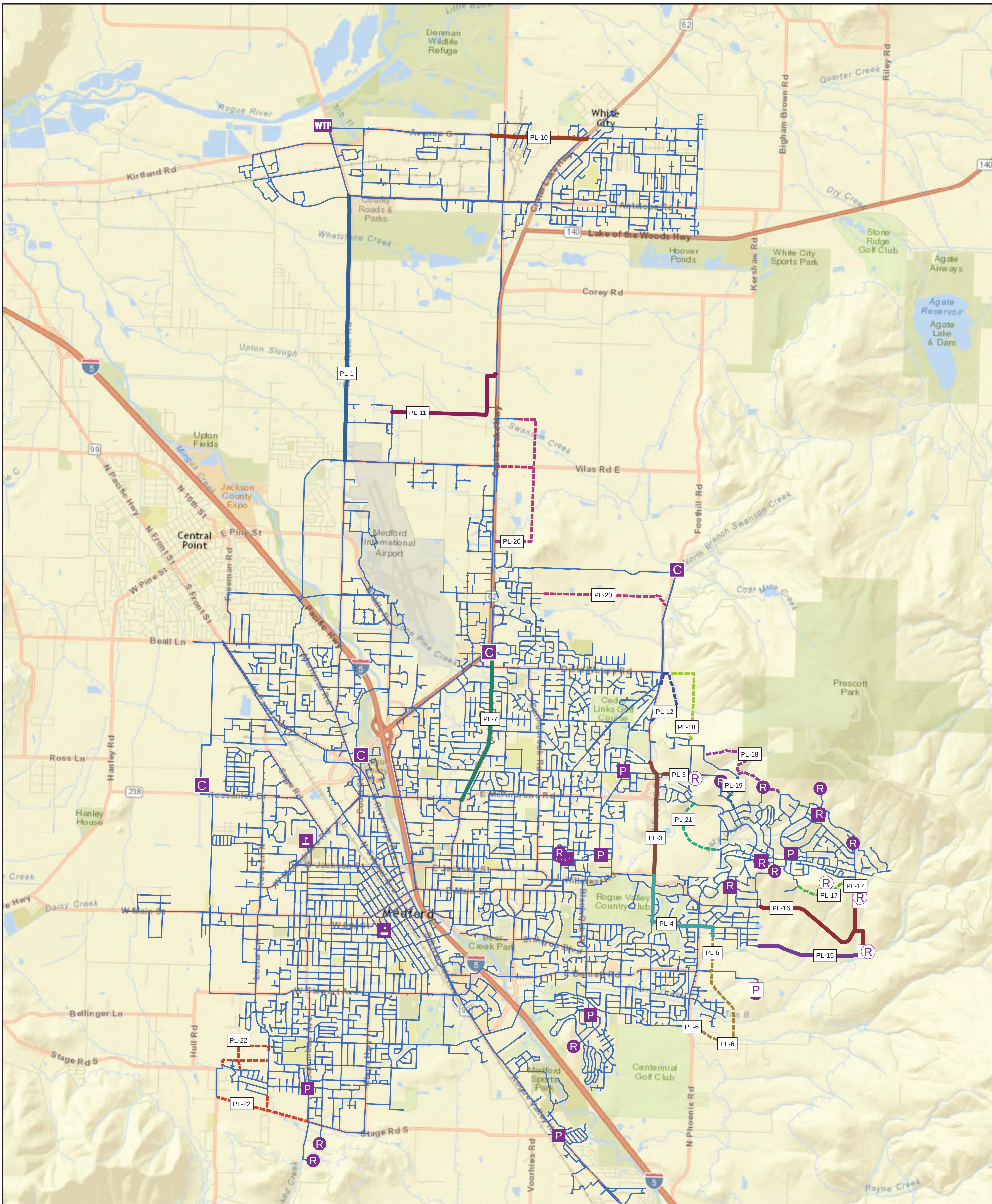
Reduced Pressure Zone central east-west conveyance for development (PL-11). As development occurs in the areas identified for growth within the Reduced Pressure Zone, this 16-inch pipeline will support east-west conveyance between the pipelines on Table Rock Road and Crater Lake Avenue. The alignment is uncertain and will depend on development in this area.

7.3 Distribution Pipeline Improvements

Distribution improvements are recommended in the upper pressure zones and in the southwestern portion of the MWC service area to complete piping loops. Pressure zone reconfiguration is also recommended for the Southwest (Zone 1C) pressure zone to alleviate the low pressures at the higher elevation areas in the Gravity Zone. The distribution piping improvements are indicated by project number and diameter in **Figure 7-2.** Each of the piping improvements recommended in the upper pressure zones are recommended to be 12-inch diameter pipelines, except for a pipeline for new development in Pressure Zone 2. The piping improvements in the southwest portion of the MWC service area are a combination of 12-inch diameter and 8-inch diameter pipes. No new pipes are required for the pressure zone reconfiguration.

The recommended projects are the following:

1. Pressure Zone 1: 12-inch piping in North Terrace area (PL-12). This piping will alleviate piping restrictions that currently exist for delivering water to Lone Pine Pump Station and Capital Reservoir.
2. Pressure Zone 1: 12-inch loop in the southern area of this pressure zone, to feed Cherry Lane Reservoir and pressure Zone 2 Pump Station (PL-14).
3. Pressure Zone 2: 12-inch loop in southern area on East Barnett Road, to provide flow to pump stations for upper zones (PL-15).
4. Pressure Zone 3: 12-inch loop from Cherry Lane Reservoir to pump station that will supply Zone 4; located on Cherry Lane Road (PL-16).
5. Pressure Zone 4: 12-inch loop in southern area of zone (PL-17); timing depends on development in URA.
6. Pressure Zone 3: 12-inch pipe to provide for North Terrace extension from pressure Zone 3 to 4 (PL-18); timing depends on development in URA.
7. Pressure Zone 3: 12-inch pipe to connect northern end of pressure Zone 3 (PL-19); timing depends on development in URA.



LEGEND

Project

PL-1: North-South Conveyance	PL-10: Reduced Pressure-East/West	PL-6: Z1 South Loop	PL-21: Zone 2 FF
PL-3: Lone Pine Extension	PL-11: East-West Connector, Growth	PL-12: Zone 1 North Terrace	PL-22: Southwest Loop
PL-4: Zone 1 Connection	PL-15: Zone 2 South Loop	PL-17: Zone 4 Loop	PL-18: North Upper 2_Future
PL-7: Martin Supply	PL-16: Zone 3 Loop	PL-19: Zone 3 Conveyance Connection	PL-18: North Zone 3, Zone 4 Extension
	PL-9: Conrad Feeder	PL-20: Piping to Meet Growth	

LEGEND

MWC Facilities

C CONTROL STATION, EXISTING	OFFICE, EXISTING
P PUMP STATION, EXISTING	WTP WATER TREATMENT PLANT, EXISTING
R RESERVOIR, EXISTING	P PUMP STATION, FUTURE
	R RESERVOIR, FUTURE

FIGURE 7-1
Pipe Improvements by Project
MWC Water Distribution Facility Plan

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0 2,500 5,000 Feet

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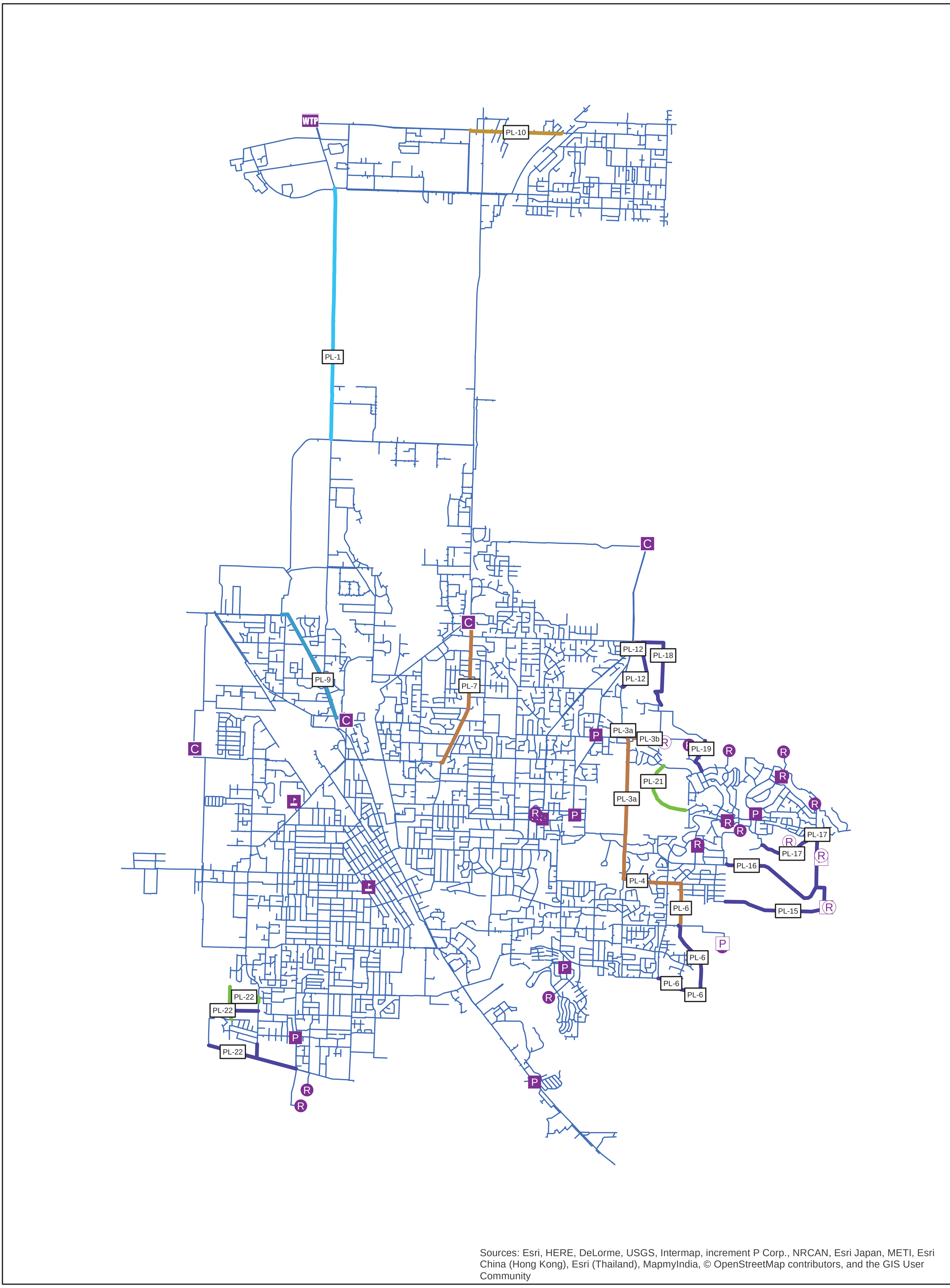


LEGEND

Diameter (in)
- 8
- 12
- 16
- 18
- 30
- 36

MWC Facilities
- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING
- P PUMP STATION, FUTURE
- R RESERVOIR, FUTURE

N

0 2,500 5,000 Feet

FIGURE 7-2
Pipeline Improvements by Diameter
MWC Water Distribution Facility Plan

ch2m

8. Reduced Pressure Zone and Gravity Zone: 12-inch pipe to provide service to development areas (PL-20); timing depends on development in URA.
9. Pressure Zone 2: 8-inch pipe to provide service to development areas (PL-21); timing depends on development in URA.
10. Gravity Pressure Zone: 8-inch and 12-inch piping to continue looping and serve development areas in the southwest areas of Medford (PL-22); timing depends on development in URA.

7.4 Cast Iron Pipeline Replacement

MWC's distribution system has 131.8 miles of cast iron pipe installed between the years 1890 and 1960. For additional information, see Figures 2-7 and 2-8 in Section 2, System Description. It is anticipated that these pipes will need to be replaced in the coming decades. Most of these pipelines have a diameter of 8 inches or less.

For purposes of planning, an average useful life of 150 years was assigned to this pipe stock. This is based on observations provided by MWC of the condition of existing cast iron pipe in the system. The actual useful life will vary for pipes within the MWC system based on many factors, including the soil conditions, typical flow velocities, quality of the original pipe material, and installation conditions.

Using the 150-year useful life value and assuming an average replacement diameter of 8 inches, the needed investment per year for replacing cast iron pipe is shown in **Figure 7-3**. The bars show the investment per year when averaged by decade. The line shows the annual investment required if the replacements were equalized over the entire period. The costs shown in Figure 7-3 are in 2016 dollars using a unit replacement cost of $160 per foot for an average pipeline diameter of 8 inches. The average length of pipe replaced per year is 1.3 miles. Given that the pipe replacement needs will not only vary by age but also depend on the quality of the original pipe, the quality of the installation, soil types, external loadings, and other factors, the age triggering cost-effective replacement will vary considerably. The smoothed investment line provides an indication of the annual cost if the entire stock of cast iron pipe was replaced at a set cost per year.

In addition to generating the annual replacement costs, an analysis of older cast-iron pipelines that contribute to low fire flows was conducted to guide prioritization for replacements. This additional look at prioritization allows MWC to adjust the replacement schedule and focus on those pipelines that may be triggered to be replaced earlier than their age due to capacity concerns. **Figure 7-4** shows the prioritized grouping of pipelines based upon fire flow availability and age that align with the forecasted pipe replacement costs.

7.5 Operational Enhancements

Based upon the concern of chlorine residual loss when the Duff No. 1 WTP is online, MWC may wish to consider emphasizing proactive pipe cleaning activities to improve water quality. A review of options available such as unidirectional flushing or other physical pipe cleaning approaches should be conducted in parallel with assessing the water quality and drivers for the cleaning. This will allow for the selection of the optimal approach for improving distribution system water quality.

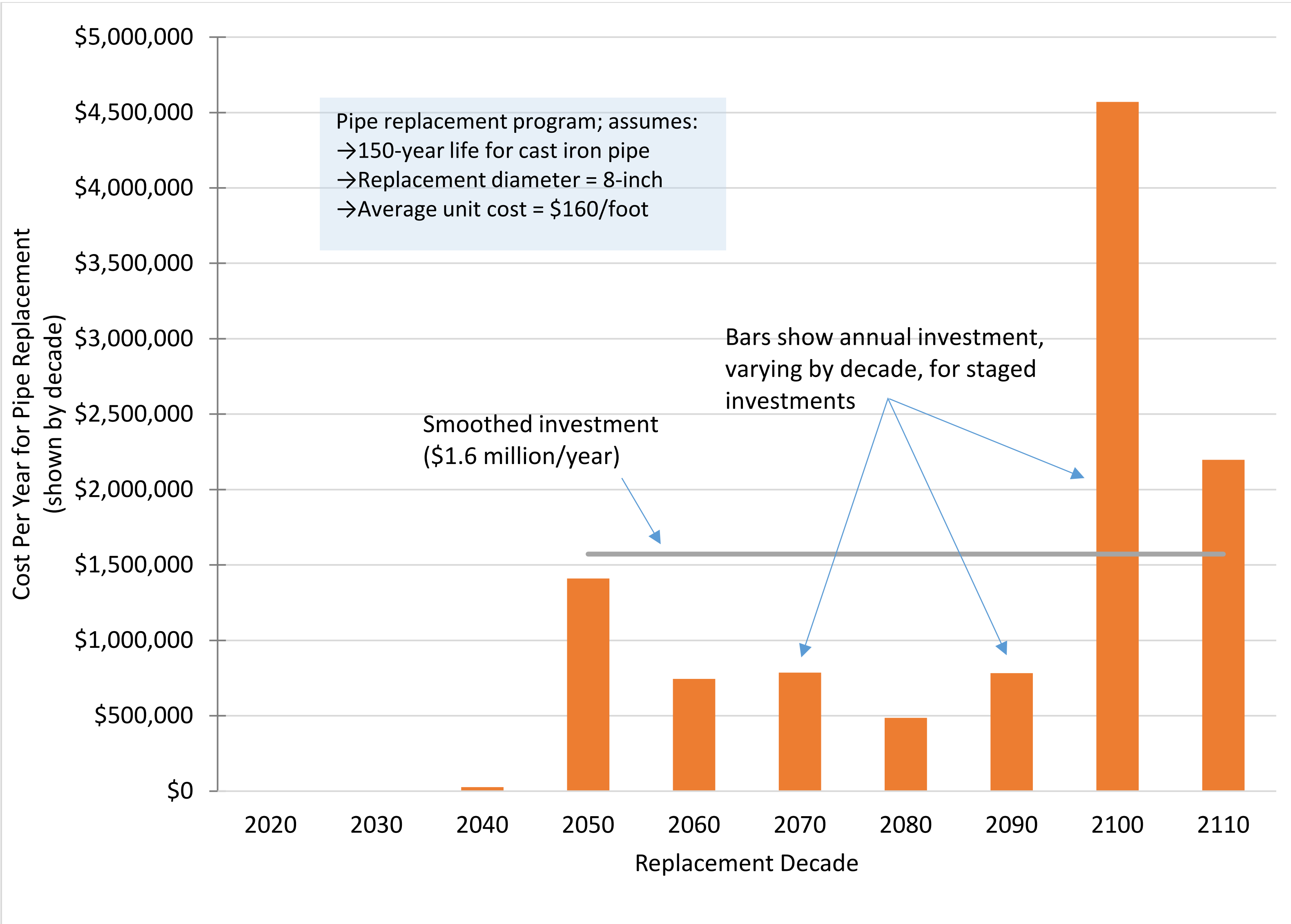
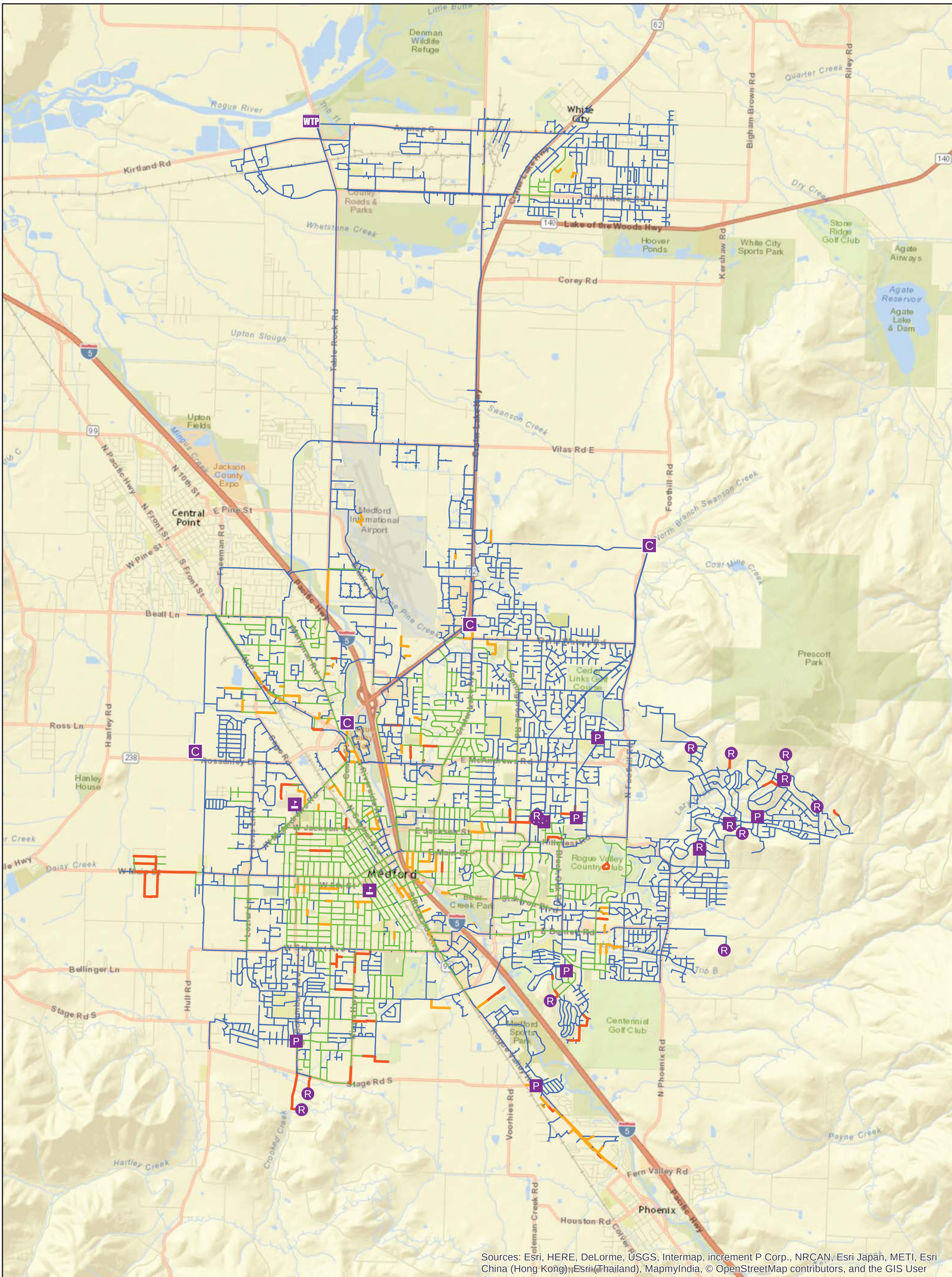


Figure 7-3. Cost per year for cast iron pipe replacement



LEGEND

Water Main Summary

- Non-Cast Iron
- Cast Iron
- Priority Main Replacement 1
- Priority Main Replacement 2

MWC Facilities

- C CONTROL STATION, EXISTING
- P PUMP STATION, EXISTING
- R RESERVOIR, EXISTING
- OFFICE, EXISTING
- WTP WATER TREATMENT PLANT, EXISTING

N

0 2,500 5,000 Feet

FIGURE 7-4
Priority Cast Iron Main Replacement for Fire Flow
MWC Facility Plan

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Pump Station and Control Station Evaluation

8.1 Introduction

The MWC water distribution system is comprised of nine pressure zones. The pressure zones consist of Reduced Pressure, Gravity, three sections of Zone 1, and upper zones 2 through 5. In the future, as the service area expands within the Medford Urban Reserve Area, higher elevation zones will be added. This section describes the control and pump station improvements needed to convey water through the MWC system and serve these individual zones.

The Duff No. 1 WTP high service pump station (HSPS) delivers water under pressure into the Reduced Pressure Zone. During reverse flow operating mode, water from the Reduced Pressure Zone is pumped into the Gravity Zone through the three Control Stations, which are Martin, Rossanley, and Conrad. All the upper zones are fed by pump stations. Water is pumped from the Gravity Zone to supply Zone 1; water from Zone 1 is pumped to supply Zone 2; and so forth. Therefore, the pumps feeding Zone 1 must have the capacity to meet the demands within Zone 1, Zones 2-5, and future zones located above Zone 5.

The pumping capacities are sized to deliver at least the MDD into each pressure zone, under firm capacity. Firm capacity is defined as operation with the largest pump feeding the zone out of service. If the zone is fed from multiple pump stations, the firm capacity is with the largest single pump from all stations out of service, not one pump in each station.

The pumping capacity analysis was performed by comparing the maximum day demand (MDD) for a zone with the rated capacity of the pump stations serving the zone. For Zones 1A, 1B, 1C, 2, Gravity, and Reduced Pressure Zones, the needs were evaluated by considering MDDs that were projected for 2036. These zones are large enough that it is appropriate to implement incremental expansions, with further expansions needed to meet demand growth beyond those values projected to occur by 2036. For Zones 2-5, the buildout demand was used to evaluate pumping capacity requirements. The additional demands between 2016 demand levels and buildout levels can be met by the addition of a single new pump station or in some cases, by the addition or replacement of pumps within an existing station.

8.2 Pump Station Improvements

Table 8-1 presents an analysis of the control and pump station needs, using the demand projections presented in Section 4. This table and all other exhibits referenced in this section are attached following the text.

No immediate improvements for pump stations are required to meet current demands. However, improvements will soon be required to meet the growth in the upper pressure zones and to convey additional water from the Duff No. 1 WTP. The expansion of the high service pump station (HSPS) at the Duff No. 1 WTP is discussed in the companion *Big Butte Springs and Duff Water Treatment Plant Facility Plan* (2016).

Proposed locations of new and expanded pump stations are shown in Section 10, Capital Improvements Plan. Discussions of the individual pump stations are presented in the paragraphs that follow. **Figures 8-1 to 8-6** present timing charts for pump station improvements, charts that relate the expansion needs to demands. These figures are included at the end of this section.

8.2.1 Zone 1A Pumping

Pierce Heights, Brookdale, and the Lone Pine 1 Pump Stations serve Zone 1A. As shown in Table 8-1 and Figure 8-1, the combined firm capacity of these pump stations is 6,480 gpm (9.3 mgd).

The proposed expansion for the pumping into Zone 1A is based on incrementally meeting needs in Zone 1A and Zone 2, with accommodation for buildout demands in the smaller zones above Zone 2. The specific proposed plan is to add 1,500 gpm of capacity at Lone Pine PS No. 1 (PS-3). The next incremental capacity expansion can be accomplished by replacing one or more pumps at the Brookdale Pump Station to increase its capacity by 1,500 gpm, although this expansion does not appear to be needed within the 20-year planning horizon.

Farther into the future, it appears that a new pump station serving the north end of Zone 1A may be needed. Two or three pumps should be installed initially for a capacity of 3,050 gpm, with expansion slots provided so that the pump station could be expanded by approximately 3,050 gpm to meet long-term needs.

8.2.2 Zone 1B Pumping

The current 800 gpm capacity of the Barneburg Pump Station appears to be sufficient to meet long-term needs in Zone 1B. No expansions are planned for pumping into this service area. This is illustrated in **Figure 8-2**.

8.2.3 Zone 1C Pumping

The current 650 gpm capacity of the Archer Pump Station appears to be sufficient to meet the long-term needs in Zone 1C. No expansions are planned for pumping into this service area. This is illustrated in **Figure 8-3**.

8.2.4 Zone 2 Pumping

Zone 2 is currently served by the Stanford Pump Station, as shown in **Figure 8-4**. The firm capacity of this station is 1,840 gpm (2.6 mgd). This capacity is just sufficient for 2016 demands and if growth occurs as projected, the need for the zone will exceed the capacity of the Stanford Pump Station in the next few years. Zone 2 is a large enough service area to warrant incremental expansion, particularly when the upper zones fed from Zone 2 are considered. The first proposed expansion is to increase the capacity of the Stanford Pump Station (PS-5) and then build the Lone Pine Pump Station 2 (PS-7) at the new Lone Pine No. 1 Reservoir site with a capacity of 3,500 gpm.

Previous plans showed adding the Barnett Pump Station (PS-1), located at the Barnett Reservoir site, but the slower growth in this portion of the system has pushed this project outside of the 20-year planning period. When constructed, the Barnett Pump Station will draw suction from the Barnett Reservoir and deliver water into Zone 2. The proposed capacity of the Barnett Pump Station is 2,000 gpm. Additional pumping capacity beyond 2036 will be needed if growth continues as projected. The proposed plan for addressing this need is to add a third Zone 2 pump station located in the northern area of Zone 2.

Table 8-1. Pump and Control Station Evaluation

							2016		2036 / Buildout		
	To Zone	**Facility Type**	**Facility Name**	**No. Pumps or PRVs**	**Existing Total Pump or PRV Capacity (gpm)**	**Existing Firm Capacity (gpm)**	**MDD (gpm)**	**Surplus or (Deficit) in gpm**	**MDD[1] (gpm)**	**Surplus or (Deficit) in gpm**	**Recommendations / Comments**
2036 Evaluation	Gravity	Metering/ Control valve	Coal Mine	NA	18,300			0		0	Coal Mine is current capable of delivering entire capacity of Big Butte Springs system, which equals 18,300 gpm or 26.4 mgd.
	Reduced Pressure	High service pump station	Duff WTP	5	37,600	27,100	25,300	1,800	37,100	(10,000)	Expansion of the Duff high service pump station is enable plant to operate at planned capacity of 60 mgd.
	To Gravity Zone during Reverse Flow Condition (pumping mode)	Pump station	Conrad	3	6,000	6,000	8,530	4,970	15,800	(2,300)	A third pump can be added at both Martin (1750 gpm). Pumping capacity at Conrad can also be increased.
		Pump station	Martin	2	3,500	3,500					
		Pump station	Rossanley	2	8,000	4,000					
	Gravity (Bullis Rsvr)	Pump station	Archer	2	8,400	4,200	3,470	730	3,500	700	The Archer PS feeds Bullis Reservoir, a 10-MG tank. The recommended pump capacity is 5 mgd to achieve a theoretical turnover of 2 days.
	1A	Pump station	Lone Pine	2	2,500	1,000	4,230	2,250	10,200	(3,720)	To meet needs through 2036: Add one 1500 gpm pump at Lone Pine PS. Beyond 2036: Add one 1500 gpm pump at Brookdale PS. Meet further growth needs by installing a new pump station at the north end of Zone 1A. Buildout can be met by expanding this new PS or adding another new station to the south.
		Pump station	Brookdale	3	3,480	3,480					
		Pump station	Pierce Heights	2	2,000	2,000					
Buildout Evaluation	1B	Pump station	Barneburg	2	1,600	800	365	435	585	220	No improvement necessary
	1C	Pump station	Archer	3	1,550	650	277	373	441	210	No improvement necessary
	2	Pump station	Stanford	3	3,640	1,840	1,575	265	5,900	(4,060)	Install a new PS at the Barnett Rsvr to serve the SE area of Zone 2. Add 3rd PS on the north end at Lone Pine Rsvr No. 1, since growth is projected for this area. This 3rd PS could be sized to meet buildout needs; alternatively a 4th PS could be added farther north to serve the RPS area.
	3	Pump station	Hillcrest	3	2,490	1,490	1,006	484	4,825	(3,330)	Add Cherry Lane PS 1, located at Cherry Lane Rsvr No. 2.
	4	Pump station	Angelcrest	3	1,800	1,200	685	515	1,698	(500)	Add Cherry Lane PS 2, located at Cherry Lane Rsvr No. 3.
	5	Pump station	Stardust	2	1,150	350	146	204	760	(410)	Replace pumps with larger pumps at Stardust to meet buildout needs.
	6	Pump station	(None currently)				0		391	(390)	Install a closed end PS to serve this area until there are enough customers to warrant a reservoir (approx. 25 houses). Closed end PS shall have a small, continuously running (jockey) pump, 2 pumps each sized at MDD, and a 1000 gpm fire pump.

Notes: 1. For small, upper zones, storage improvements should be sized to meet buildout demands.
2. Firm capacity = pump station or PRV capacity with largest single unit out of service.

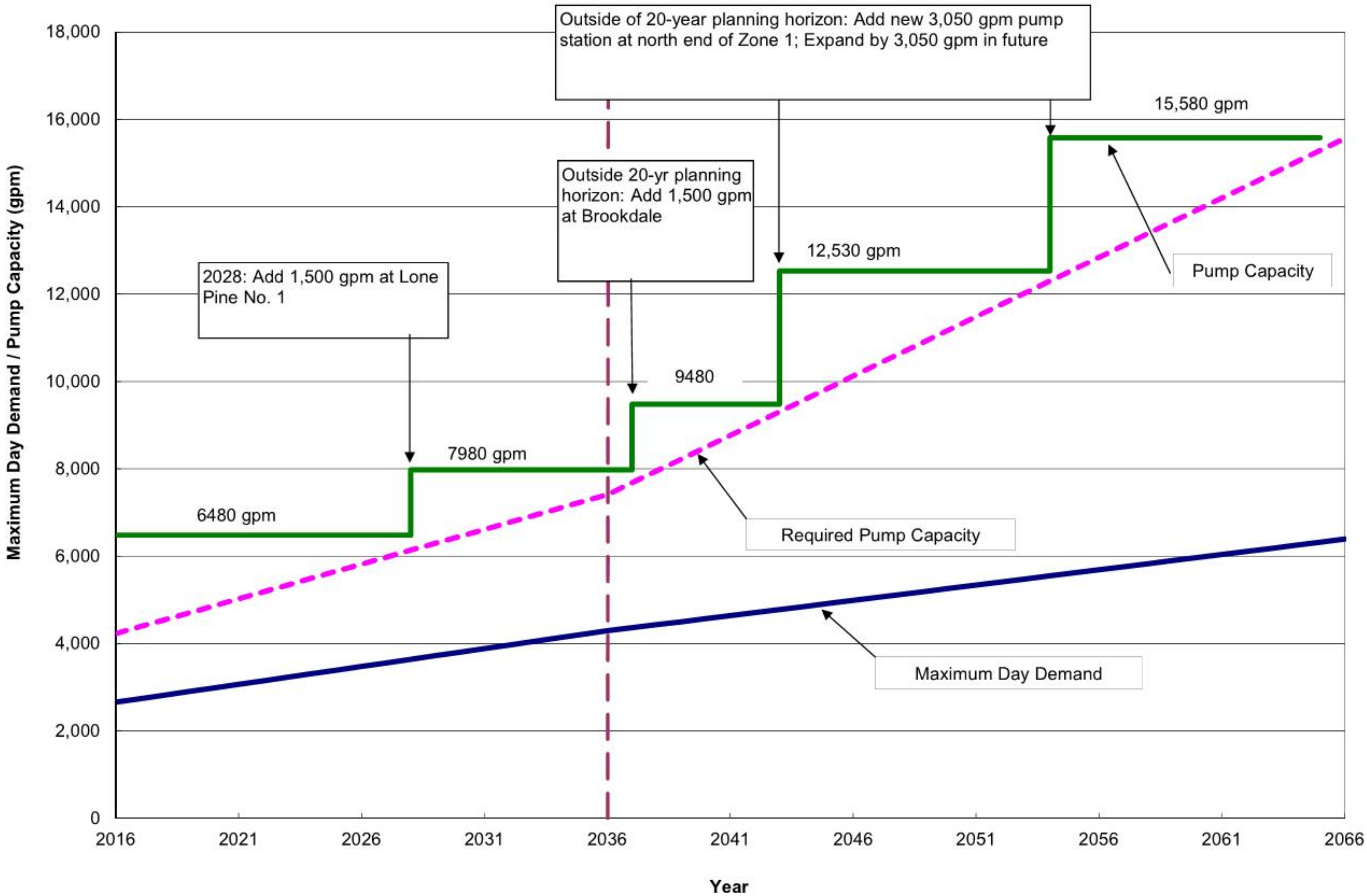


Figure 8-1. Zone 1A Pump Station Planning

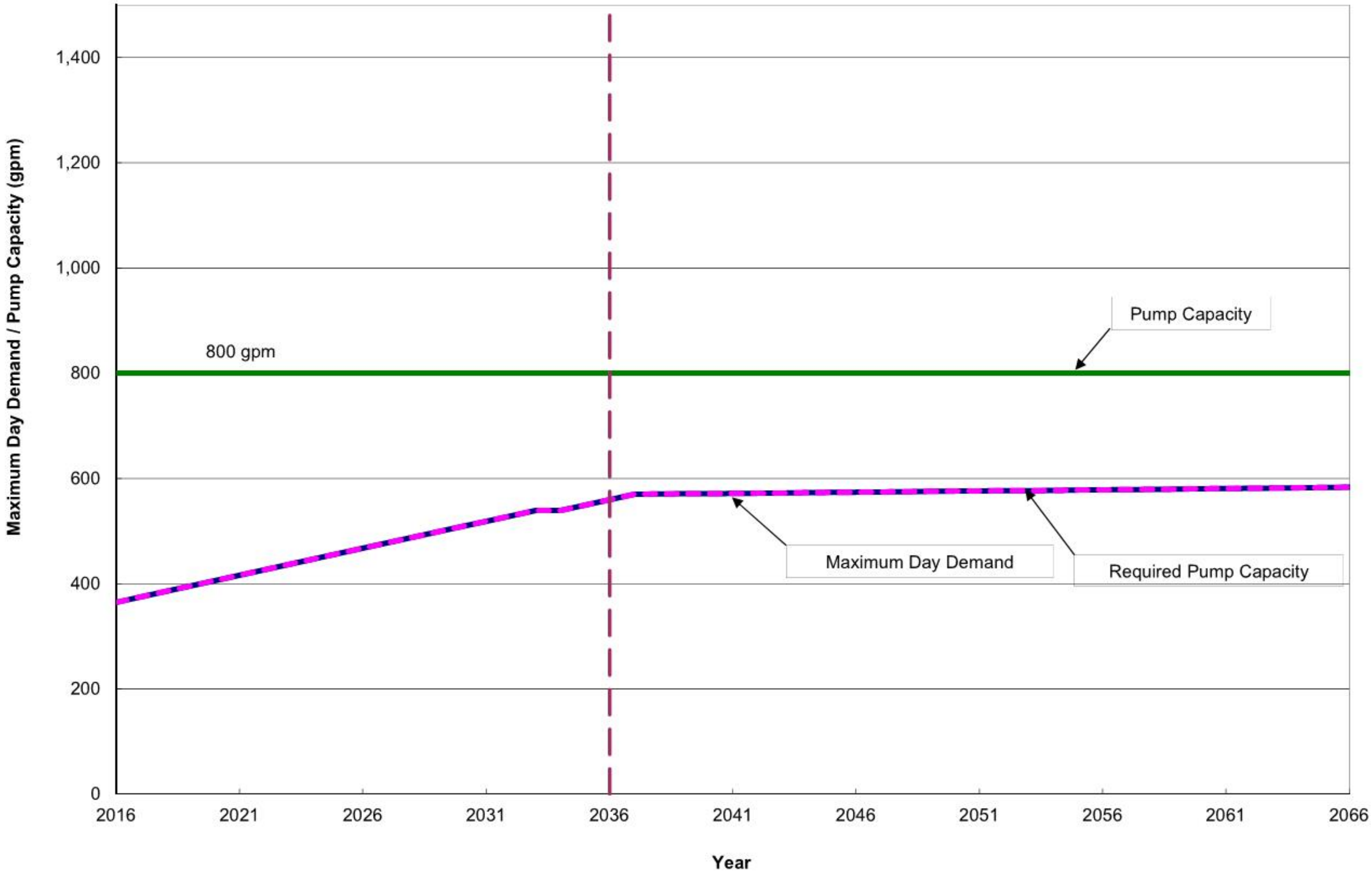


Figure 8-2. Zone 1B Pump Station Planning

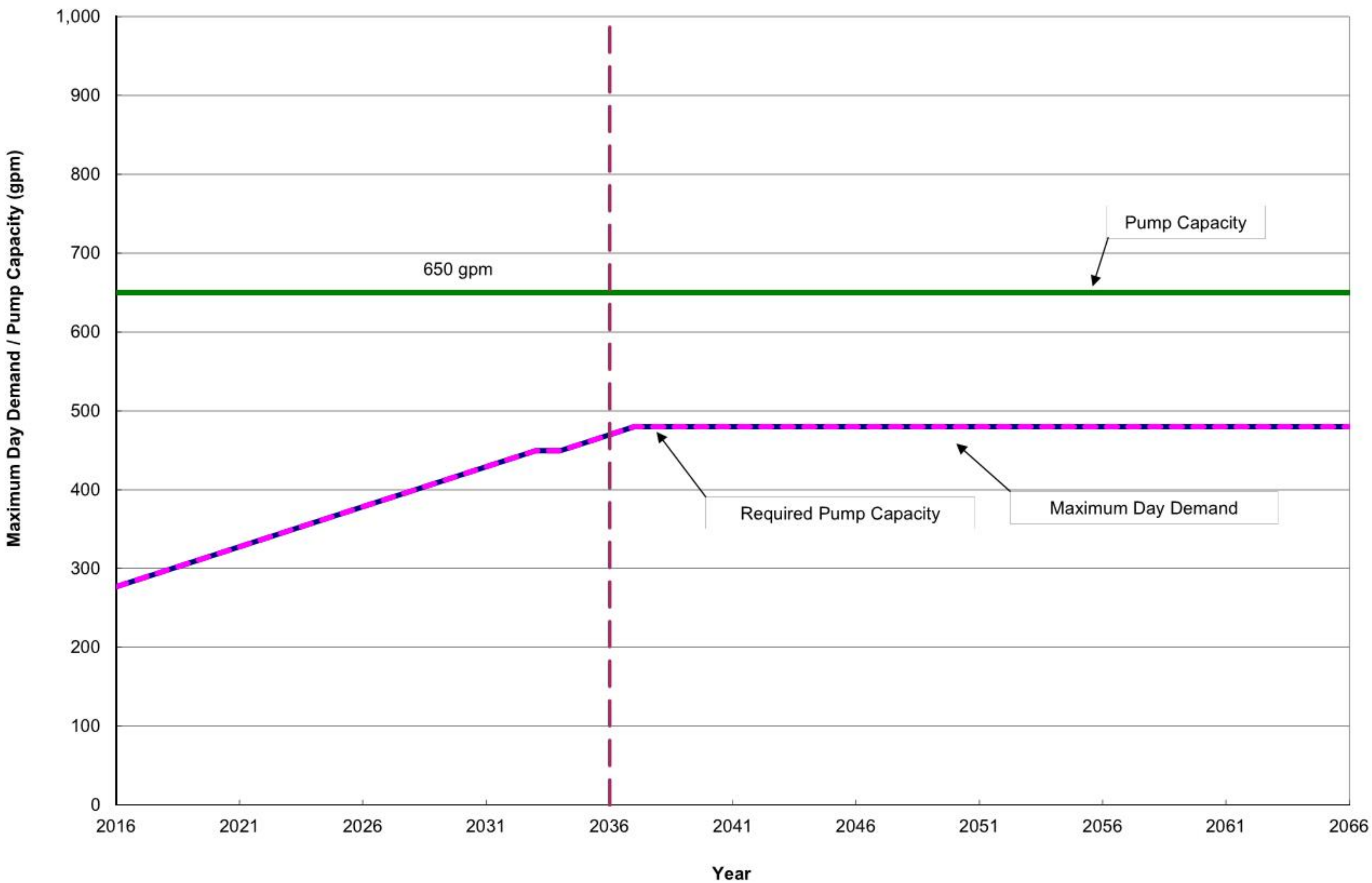


Figure 8-3. Zone 1C Pump Station Planning

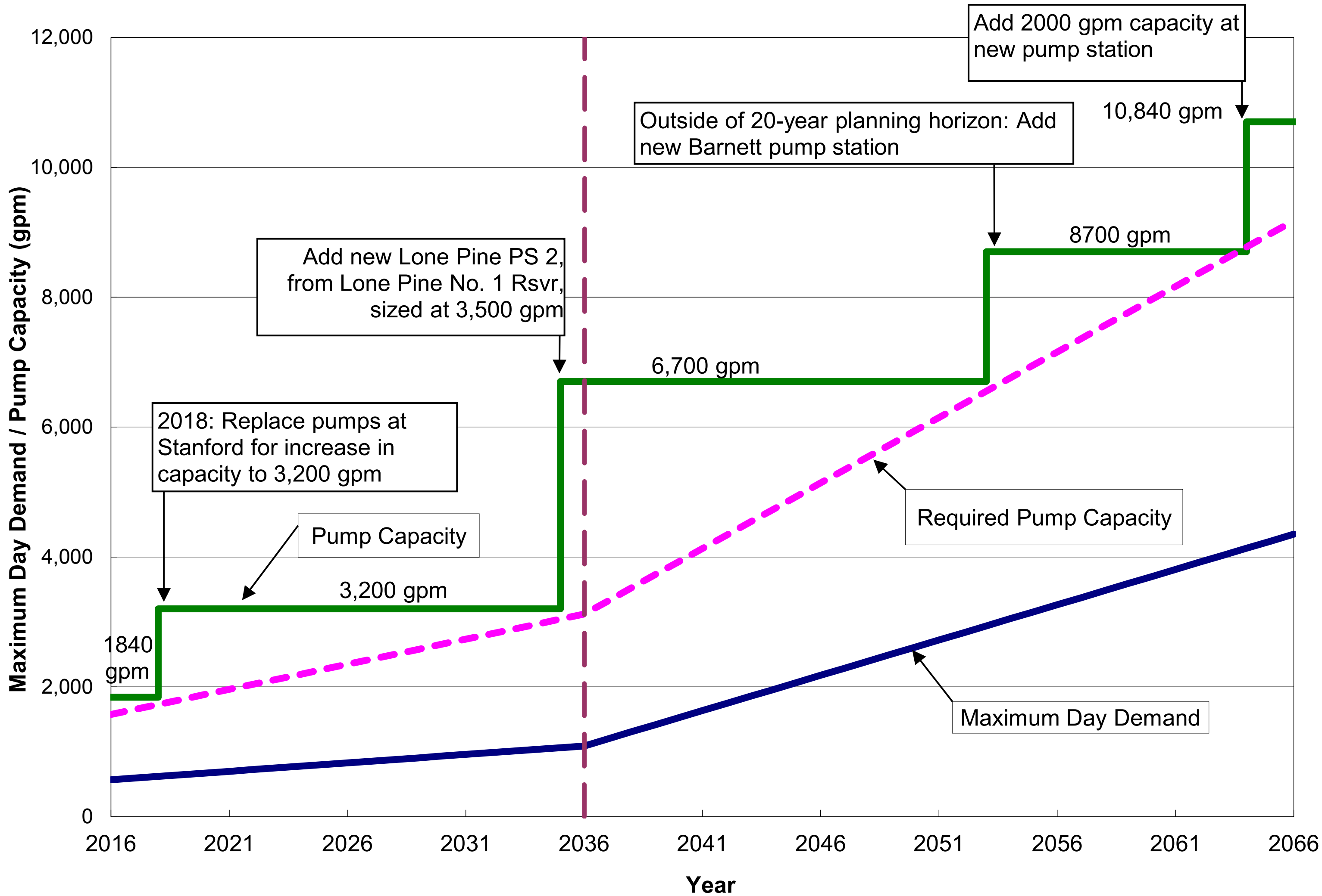


Figure 8-4. Zone 2 Pump Station Planning

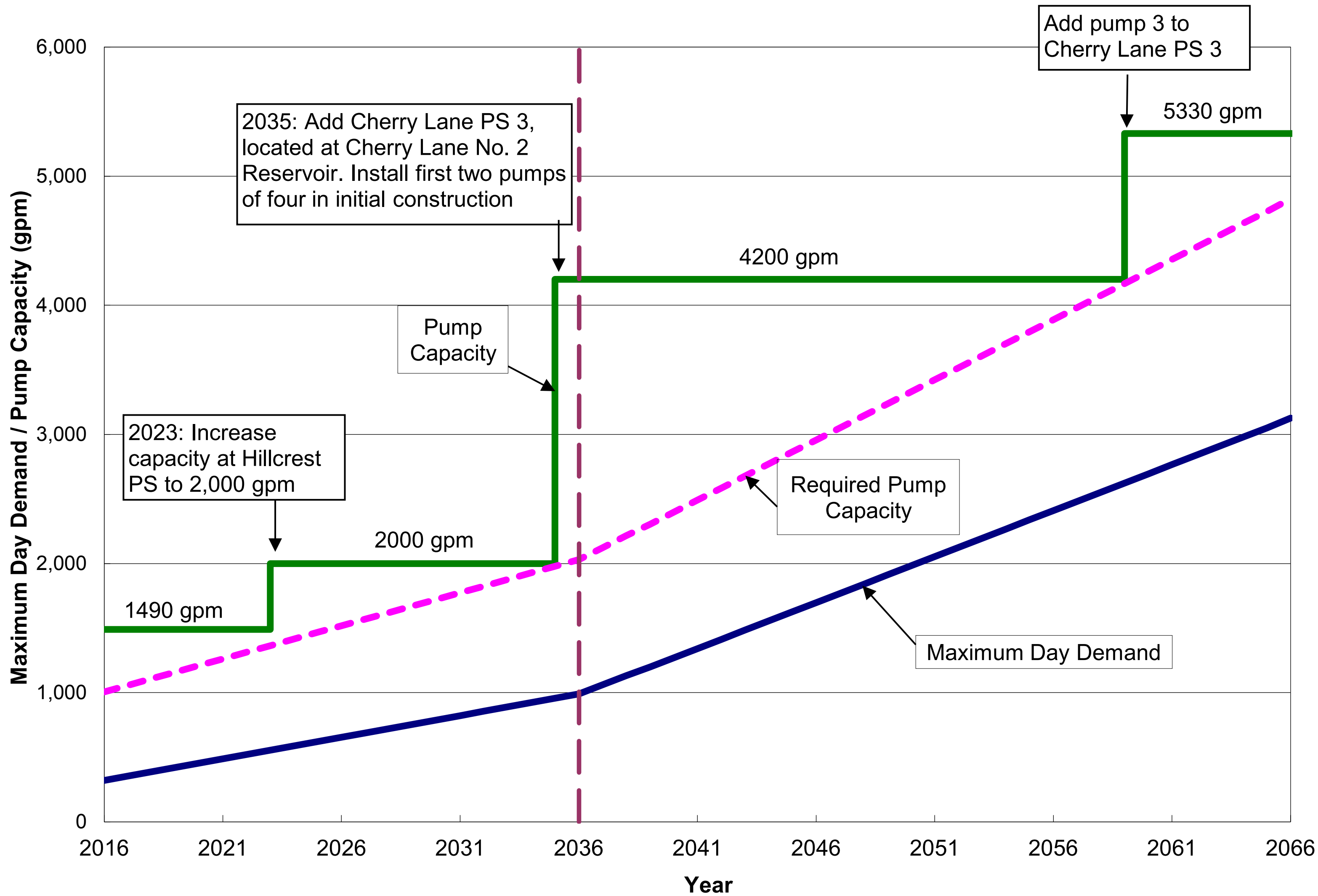


Figure 8-5. Zone 3 Pump Station Planning

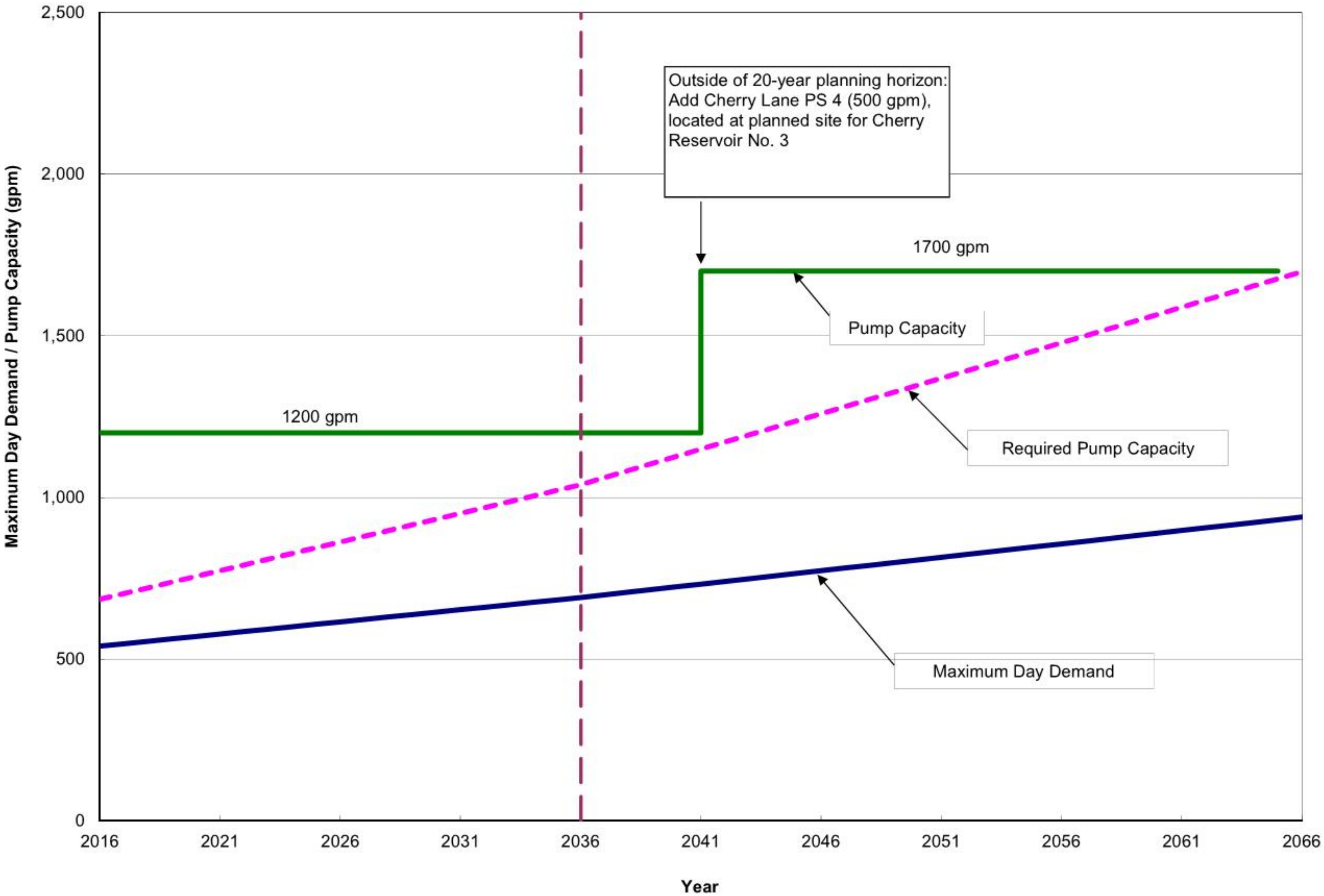


Figure 8-6. Zone 4 Pump Station Planning

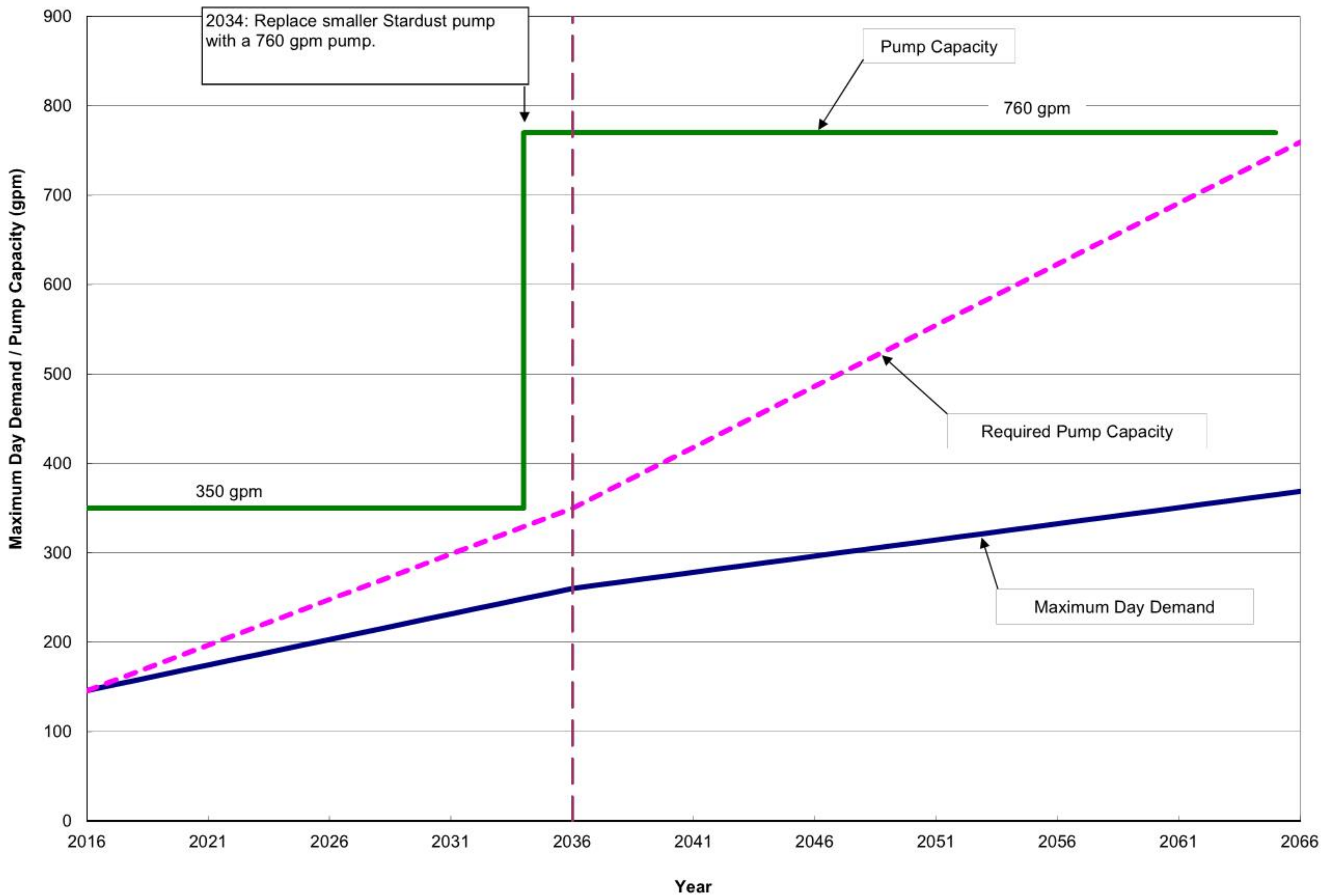


Figure 8-7. Zone 5 Pump Station Planning

8.2.5 Zone 3 Pumping

Pumping into Zone 3 is provided by the Hillcrest Pump Station, located at the Hillcrest Reservoir. The firm capacity of the Hillcrest Pump Station is 1,490 gpm (2.1 mgd), as shown in **Figure 8-5**. This capacity exceeds the existing need of approximately 1,000 gpm. Projected system growth is such that additional capacity for pumping into Zone 3 will be needed by about 2023. The proposed plan for meeting the projected deficit is to first increase the capacity of the Hillcrest Pump Station (PS-6) and then install a new pump station, the Cherry Lane Pump Station 3, located at the site of the future Cherry Lane Reservoir 2 (PS-2). The recommended approach is for the Hillcrest Pump Station to be increased to 2,000 gpm, and this new pump station to be sized to accommodate a buildout capacity of 2,200 gpm. This might be accomplished by using four pumps.

8.2.6 Zone 4 Pumping

Zone 4 is served by the Angelcrest Pump Station. It has a capacity of 1,200 gpm (1.7 mgd), as shown in **Figure 8-6**. An additional 500 gpm (0.7 mgd) is required to meet the buildout demands. To meet the buildout demands, Cherry Lane Pump Station 4 is recommended at the site of the future Cherry Lane Reservoir 3. However, this is not anticipated to be needed within the 20-year planning horizon.

8.2.7 Zone 5 Pumping

Zone 5 is served by the Stardust Pump Station that has a firm capacity of 350 gpm (0.5 mgd) as shown in **Figure 8-7**. At buildout, the demand to be served through Pressure Zone 5 is 760 gpm (1.1 mgd). The Stardust Pump Station should be upgraded with larger pumps to meet the buildout demand (PS-4). Per the demand projections presented in this plan, the expansion of the Stardust Pump Station will be needed in 2034.

8.2.8 Zones 6-10 Pumping

Currently, there is no development in Zones 6-10. As development begins, a closed end pump station can serve these areas until there are enough customers to warrant a reservoir (approximately 25 houses). Each closed end pump station should have two pumps that are each sized to meet the MDD (one provided for redundancy), one smaller jockey pump that can operate continuously, and a 1,000 gpm fire pump.

8.3 Control Station Evaluation and Improvements

There are currently three Control Stations (Martin, Conrad, and Rossanley), which provide the dual functions of reducing pressure during forward mode periods and pumping during reverse mode periods. Forward mode is defined as the operating scenario when water in the Reduced Pressure Zone is being supplied from Big Butte Springs. During such times, the pressure must be decreased as water flows from the Gravity Zone into the Reduced Pressure Zone to maintain pressures within acceptable levels. Reverse mode is defined as the operating scenario when the Duff No. 1 WTP is operating and water must be pumped from the Reduced Pressure Zone to feed the Gravity Zone. This subsection provides an evaluation of the pressure reducing and pumping capacities of the Control Stations for future demands.

8.3.1 Control Stations: Pressure Reducing Capacity Analysis

Currently, the Control Stations provide the pressure reducing function, in forward operating mode, for five to six months per year. As the system demand grows, this period will shorten and then will be eliminated altogether except as an emergency function. As winter demands approach the capacity of the Big Butte Springs, MWC will begin to operate the Duff No. 1 WTP year around. Per the demand projections presented in this study, year around operation will occur by about 2022. Until then, the pressure reducing capacity of the Control Stations must be able to meet the non-summer demand in the Reduced Pressure Zone, including potentially emergency and fire demands, as well as the demands from White City, Central Point, and Eagle Point.

As of 2016, the total pressure reducing capacity of the Control Stations was approximately 10,000 gpm and the firm capacity was approximately 8,200 gpm. These values are not exact, as a drop in pressure on the downstream side could allow for even greater flows. The pressure reducing valves (PRVs) are normally delivering up to the ADD for the Reduced Pressure Zone, or about 4,800 gpm for 2016 demands. If a major fire was to occur in the Reduced Pressure Zone, the PRVs could conceivably be called upon to deliver an additional 4,000 gpm into the zone, for a total of 8,800 gpm. Their firm capacity of 8,200 gpm would likely be sufficient to meet this need, as it is not an absolute value. Furthermore, it is less likely that a PRV will fail than a pump, so PRV firm capacity does not warrant the same importance as firm capacity in a pump station. Their total capacity of 10,000 gpm is more than sufficient to convey ADD plus a 4,000 gpm fire flow.

Once the Duff No. 1 WTP is being operated year-round, the capacity need through the PRVs will drop. They may need to supplement production from the plant when it is operated at low rates, or possibly contribute water to the Reduced Pressure Zone in the event of a major fire or an emergency. But since the Duff No. 1 WTP HSPS will normally contribute at least some of the flow into the zone, the demand on the PRVs will be less than it is today.

In summary, it appears that the combined capacity of the PRVs is sufficient for 2016 demands and for projected demands until the Duff No. 1 WTP is operated year-round. No expansion of their capacity is proposed.

8.3.2 Control Stations: Pumping Capacity Analysis

The pumping capacity of the Control Stations must be able to meet the maximum day demand (MDD) for the Gravity and upper zones that is not provided by the BBS (26.4 mgd) during the time that the Duff No. 1 WTP is in operation and the system is operated in reverse mode configuration.

To evaluate the required capacity, the total MDD for the Gravity Zone, all upper pressure zones, and customer cities that are served through the Gravity Zone was calculated. The 26.4 mgd flow from the BBS was included as a supply, and the remaining amount must be the capacity from the three Control Stations. In 2016, the firm pumping capacity of pumping from the Control Stations was 13,500 gpm. The required pumping capacity was 8,500 gpm. This indicates that they had a surplus capacity of 5,000 gpm.

By 2036, the demand projections suggest that a pumping capacity of 15,800 gpm will be needed. This would result in a pumping deficit of 2,300 gpm compared to the firm capacity of 13,500 gpm. This deficit could be addressed by adding a pump at Martin Control Station or expanding the capacity of one or more pumps at the Conrad Control Station. However, this projected deficit of 2,300 gpm is relatively small compared to the overall pumping capacity of the Control Stations. Furthermore, a significant amount of storage is provided in the Gravity Zone, making it less important to provide firm capacity for the pumps supply this zone. With consideration of these factors, no capital project has been included for expanding the pumping capacity of the Control Stations. This need can be further considered in the next facility plan update.

8.3.3 New Intermediate Booster Pump Stations Evaluation

The 2007 plan discussed the possible future addition of intermediate booster pump stations to be in the Reduced Pressure Zone. The purpose of such stations would be to allow the Duff No. 1 WTP HSPS to deliver water at lower pressures, with the booster pump stations adding head to deliver water at sufficient pressures to the Control Stations and in the southern area of the Reduced Pressure Zone.

The two proposed intermediate booster pump stations, potentially located on properties owned by MWC at Four Corners and at Midway, would divide the Reduced Pressure Zone into two halves. The lower elevation, northern half, would continue to be fed through PRVs in the existing Control Stations during forward mode. During reverse mode, this area would continue to be fed directly from the Duff No. 1 WTP HSPS. Booster pumps in the two new stations would lift water into the upper (southern) half of the Reduced Pressure Zone during this operating mode.

The benefit to be achieved by adding the two intermediate booster pump stations would be to increase pressures for customers living in the southern area of the Reduced Pressure Zone during reverse mode conditions. Presently, customers in this area use approximately 5 mgd (during a MDD period) and receive this water at a pressure range of approximately 35-45 psi, as described in Section 6. Although these pressures meet MWC's target minimum of 35 psi, they are relatively low compared the pressures provided throughout the remainder of the system. The installation of the new pump stations would increase pressures to 55-65 psi, about a 20-psi increase.

Based on further review of the option of adding intermediate booster pump stations, it is not a recommended solution. The addition of these booster pump stations would complicate the delivery of water from the Duff No. 1 WTP, making the system less reliable. It would require carefully balancing pumping rates from the Duff No. 1 WTP HSPS, the intermediate booster pump stations, and the Control Stations. The necessary balance would continually change as demands and production from the Duff WTPs vary. Theoretically, it would be possible for the SCADA system to be programmed to accomplish this flow balance, but from a practical standpoint, it does not seem advisable. Relatively minor changes in demands or pump performance could result in pressure swings or surge conditions. This is the primary concern; another disadvantage would be both the capital cost for installing these stations and the ongoing operation and maintenance costs. The preferred solution, instead, is adding storage as discussed in Chapter 6 in the Reduced Pressure or Gravity Zone, together with adding north-to-south transmission capacity.

8.4 Operational Improvements

The new and upgraded pump stations outlined in this section are intended to work in concert with the reservoir improvements outlined in Section 9. The operation of both existing and future pump stations was simulated with an automated approach, using the hydraulic model. The model was used to examine strategies for pumping rates and times, with a goal being to ensure that storage allocated for equalization purposes is used.

It is recommended that the operational approaches embedded in the hydraulic model be reviewed MWC's operators and incorporated into day-to-day system operations to help baseline production from the Duff No. 1 WTP during peak demand periods. The operational approaches coordinate use of the Control Stations with the Duff No. 1 WTP HSPS, as well as operation of the Archer Pump Station and the use of Bullis Reservoir. The approaches generally incorporate the following guidelines:

- Baseline flow from the Control Stations and the Duff No. 1 WTP HSPS with a defined number of pumps on at each station
- Additional pumps turned on at the Control Stations and Duff No. 1 WTP HSPS when the Capital Reservoirs level drops to 24.5 feet; and turned off when the level climbs to 30.0 feet
- If not already on, turn on a pump at Rossanley Control Station when the Southwest Reservoir is being filled by the Archer Pump Station

These approaches are like, but more specific, than current operational practices.

In addition to developing automated approaches for the Control Stations, operational strategies were examined for Bullis Reservoir to make better use of its 10 MG storage volume. MWC already incorporates standard operating procedures for using Bullis Reservoir; the hydraulic modeling allowed for an examination of what-if scenarios and the opportunity to fine-tune the procedures. Specific inputs to manage the following procedures were incorporated in the model:

- Turn on one pump during peak demand to offset pumping of demand through the Control Stations
- Fill Bullis Reservoir during lower demand periods but manage the fill rate to mitigate pressure impacts from filling Bullis Reservoir
- Maintain a separation of time between pumping and filling so that water pumped from Bullis Reservoir is consumed and not directly returned to the reservoir

In the upper east pressure zones, new pump stations outlined in this section and reservoirs outlined in Section 9 are planned to meet future growth. Operation of these new facilities was also defined in the future operating scenarios portion of the model. The fill and draw operation followed similar procedures as outlined for the existing facilities where pumps were controlled by level in the reservoir in the pressure zone that the pump stations are pumping to. In general, the reservoirs were drawn down approximately 25 percent before a pump was activated to turn on and refill the reservoir.

SECTION 9

Reservoir Improvements

This section describes the storage needs evaluation and the recommended reservoir improvements to meet current and future needs in each pressure zone.

9.1 Storage Criteria

The common approach used for reservoir sizing, the one used in previous MWC plans and used again in this plan, is to size distribution storage to meet the following needs:

- Equalization Storage—storage provided to meet peak hour demands. The equalization storage component provides a buffer between the production rate and the hour-to-hour use rate by customers. Production facilities are sized to provide MDDs. Equalization storage supplies customers during the periods during a day when instantaneous demands exceed the MDD rate. The equalization need for MWC's system, based on review of peak hour demand records, is 15 percent of the MDD. This represents an average for the entire system. The equalization need varies by zone and may be higher than 15 percent in smaller, predominately residential zones.
- Emergency Storage—storage provided for supply interruptions. This component is provided so that water can continue to be supplied to customers for some period if the supply sources are unexpectedly shut off. Example causes for supply disruptions include natural disasters, extended power failures, transmission pipeline breaks, and mechanical failures. Since MWC has two independent supplies, BBS and the Duff No. 1 WTP, the chances of both systems being unexpectedly shut off is low. Emergency storage has been sized at 33 percent of MDD, which for 2016 demands, is approximately 56 percent of the ADD.
- Fire Flow Storage—storage provided to provide water to hydrants for fighting fires. Reservoirs have dedicated storage that is provided to meet the high flow but short duration requirements of fighting fires. The volume is dictated by the needed flow and duration criteria, which vary per land use within a zone. MWC's criteria for single family residential areas is 1,000 gpm for 2 hours, resulting in a total volume of 120,000 gallons. MWC's goal for areas with either a school or hospital is to provide at least 4,000 gpm for 4 hours, for a total of 960,000 gallons.

These criteria for establishing storage needs are summarized in Appendix A, Design and Operating Criteria. The storage requirements shall be met in each pressure zone.

Historically, equalization storage has only been provided for MWC demands and not wholesale customers. However, based upon a review of the wholesale customer master meters, MWC's wholesale customers are currently obtaining flows exceeding MDDs from MWC. Another way of saying this is that wholesale customers are peaking from MWC's system. To account for that in the storage analysis, 15 percent of the wholesale customer demand has been incorporated into the required equalization storage. Wholesale customers do provide their own emergency and fire flow storage.

9.2 Storage Analysis

Table 9-1 summarizes the storage analyses for each zone. The equalization and emergency needs are directly linked to demands within each zone; as demands grow, the volume needed for these components of storage will increase. The fire storage needs are based on land use within the zone and are dictated by the land use requiring the greatest storage volume. This table compares the existing storage volumes to the needs for 2016 and 2036 based on the demand projections developed as part of this study. Charts that illustrate the timing of the needed storage improvements are provided in **Figures 9-1 through 9-6.** Table 9-1 and the figures are attached at the end of the section.

9.2.1 Reduced Pressure and Gravity Zones

The Reduced Pressure Zone is served though PRVs from the Gravity Zone for approximately eight months of the year and directly from the Duff No. 1 WTP during the summer months. There is currently no distribution storage provided in the Reduced Pressure Zone. Its equalization, emergency, and fire flow needs are met either by storage provided in the Gravity Zone, with flow through the PRVs, or possibly by ramping up pumping from the Duff No. 1 WTP HSPS if it is not already operating at MDD rates.

The storage needs for the Reduced Pressure Zone are directly related to the discussion provided in Section 6 regarding the additional storage needed to operate the Duff No. 1 WTP and its HSPS at a constant rate throughout a day. As shown in the table row that combines Reduced Pressure and Gravity Zones, the two zones combined have only a small current deficit of 0.3 MG. By 2036, this deficit is projected to grow to 4.2 MG. However, this evaluation does not consider the needs related to allowing the Duff No. 1 WTP to operate at a constant rate throughout the day, with concurrent constant rate operation of the Duff No. 1 WTP HSPS. The distance from the plant HSPS to the Capital Reservoirs and, especially to Bullis Reservoir, limit the usefulness of the storage in the Gravity Zone to meet equalization needs. As discussed in Section 6, this shortcoming can be addressed by adding storage at the plant, or by adding storage in either the Reduced Pressure or Gravity Zone. Several specific options were evaluated, with findings presented in Section 6. A placeholder project for adding storage in the Reduced Pressure Zone has been included as Project R-4.

Per MWC operations staff, it is reasonable to allocate 25 percent of the Capital Reservoirs volume and 20 percent of the Bullis Reservoir volume to equalization needs. The 20 percent equalization use of Bullis Reservoir exceeds typical use of this storage volume, and can only be accomplished through operational changes. Using these limits, the 2036 storage deficit for the Gravity and Reduced Pressure Zones increases to 5.2 MG. Although this full deficit will not be reached until projected 2036 demands occur, the current challenges of operating the Duff No. 1 WTP HSPS at a constant rate over 24 hours suggests that this additional storage is needed in the near-term.

A further consideration is the replacement need for all three Capital Reservoirs. Based on their age and condition, MWC believes it will be necessary to replace rather than rehabilitate these tanks. The two older tanks, constructed in 1908 and 1927, each hold 2.0 MG. The third Capital Reservoir, holding 8.0 MG, was constructed in 1945.

MWC staff have preliminarily examined constraints at the Capital Reservoirs site and believe that it will not be possible to add storage at this site without demolishing one or more of the existing tanks. It is unclear if the total storage volume can be increased when the tanks are replaced. This will be examined as part of the Reduced Pressure/Gravity Zone analysis, which is needed to allow for increased high service pumping from the Duff No. 1 WTP (R-3). Projects to replace these tanks have been included in the capital improvements plan, but the opportunity to increase the total storage volume at the site is unknown so the replacement projects are for the same size tanks (R-5, R-6, and R-7).

9.2.2 Pressure Zone 1

Pressure Zone 1 is divided into 3 areas (1A, 1B, 1C). Each section of Zone 1 serves the same elevation range, but the three areas are isolated from one another and therefore, need to be evaluated individually for storage needs.

Zone 1A is served by the Barnett and Stanford Reservoirs. It serves a major regional hospital. Through the analysis of the combined size of these reservoirs (3.5 MG) and the comparison with the required storage volume needed to serve Zone 1A, the current capacity of the reservoirs is sufficient to meet

2036 demands. However, a storage deficit occurs shortly after 2036, so the Lone Pine No. 1 reservoir (R-2) is planned in 2034 to be online when the storage deficit occurs. This is shown in Figure 9-1.

Zone 1B serves a large elder care facility and other critical customers. It is served by the Barneburg (0.5 MG) Reservoir. A storage deficit of 0.1 MG was estimated for buildout demands, as shown in Figure 9-2. Although the buildout storage requirements were projected to be slightly higher than the existing storage for this zone, no additional storage was recommended for the Zone 1B area because the projected deficit was too small to warrant the installation of another reservoir. However, the lack of redundancy for the zone is a concern, especially because of the critical customers, and warrants further evaluation outside of the scope of this master plan.

Zone 1C is served by the Southwest Reservoir, and the existing storage of 2.0 MG is sufficient to meet the buildout storage requirements of the zone, even with the expansion of the zone to serve additional high elevation areas. Figure 9-3 illustrates the evaluation for Zone 1C.

9.2.3 Pressure Zone 2

Pressure Zone 2 is expected to experience significant growth soon as the southeastern area of Medford develops. The existing storage that is available in Zone 2 is provided from the Hillcrest No. 1 and the Lone Pine No. 2 Reservoirs. These two reservoirs provide a total of 1.14 MG. The future buildout required volume of storage for this zone is 3.2 MG, as shown in Figure 9-4. It is recommended that this storage deficit be provided by the Cherry Lane No. 2 Reservoir and that the reservoir be sized at 2.0 MG. This project falls near the end of the 20-year planning horizon (R-8). Because the Hillcrest No. 1 Reservoir provides only 140,000 gallons, MWC could abandon this reservoir without changing the recommendation for the new Cherry Lane No. 2 Reservoir.

9.2.4 Pressure Zone 3

In Pressure Zone 3, the current volume of storage is 1.1 MG provided by the Hillcrest No. 2 (100,000 gallons) and the Lone Pine No. 3 (1.0 MG) Reservoirs. The total volume of storage needed at buildout for this pressure zone is 2.3 MG, as shown in Figure 9-5. A new 1.5 MG reservoir, Cherry Lane No. 3 (R-1), is recommended to meet the future storage needs. Because the Hillcrest No. 2 Reservoir provides only 100,000 gallons, MWC could abandon this reservoir without changing the recommendation for the new Cherry Lane No. 3 Reservoir. However, this need is projected to occur outside of the 20-year planning horizon.

9.2.5 Pressure Zone 4

Pressure Zone 4 currently has a storage volume of 0.68 MG, provided by Stardust (built 1972, 180,000 gallons) and Cherry Lane No. 4 (500,000 gallons) Reservoirs. The required storage volume for this zone at buildout is 0.8 MG, as shown in Figure 9-6. Based on the small volume of additional storage that is needed for this zone, no storage improvements are recommended for this zone to meet the buildout demands.

9.2.6 Pressure Zone 5

The storage for Pressure Zone 5 is currently provided by the Highlands Reservoir (0.5 MG). The volume of the Highlands Reservoir is 0.5 MG which is greater than the required storage volume for Pressure Zone 5, as shown in Figure 9-7. Therefore, no additional storage improvements are recommended for Pressure Zone 5.

9.2.7 Pressure Zones 6-10 (Future)

There are currently no pressure zones above Zone 5. As the city grows, the areas higher in elevation than served in Zone 5 may eventually develop. If pressure Zones 6 and above develop, they can be operated as closed-end pump systems until approximately 25 to 40 houses are built in a given zone. A closed-end system means that the pump stations serving these zones will not pump to an open surface in a reservoir, but will have at least one pump that operates 24-7 to keep the system pressurized. Once the number of customer connections grows to 25 and above, a tank can be added so the zone operates as other zones within MWC's system. The tanks can be sized at that time based on an estimate of the buildout needs of the zone.

Table 9-1. Reservoir Evaluation

								Evaluation Based on 2016 Demands (MG)							Evaluation Based on 2036 or Buldout Demands (MG)[1]					
	Service Zone	Reservoir Name	Overflow Elev (ft)	Individual Volume (MG)	Total Zone Volume (MG)	2016 MDD for Zone (mgd)	Wholesale Demand	Equalization (=0.15 x MDD)	Emergency (= 0.33 x MDD)	Fire[2]	Total Need	Surplus / (Deficit)	Future MDD (mgd)[1]	Wholesale Demand	Equalization (=0.15 x MDD)	Emergency (= 0.33 x MDD)	Fire[2]	Total Need	Surplus / Deficit	Equal-ization Need
2036 Evaluation	Reduced Pressure**	Duff WTP Clearwell	(Pumped)	0.0	0.0	13.7	10.4	3.62	4.51	0.00	8.1	(8.1)	17.0	13.7	4.60	5.61	0.96	11.2	(11.2)	
	Reduced Pressure** and Gravity	Capital	1588	12.0	22.0	39.3	16.5	8.37	12.97	0.96	22.3	(0.3)	45.6	22.1	10.15	15.05	0.96	26.2	(4.2)	(5.2)
		Bullis	1564	10.0																
	1A	Barnett	1731	2.0	3.5	3.8		0.57	1.26	0.54	2.4	1.1	6.2		0.93	2.04	0.54	3.5	(0.0)	
		Stanford	1731	1.5																
Buildout Evaluation	1B	Barneburg	1684	0.5	0.5	0.5		0.08	0.17	0.18	0.4	0.1	0.8		0.13	0.28	0.18	0.6	(0.1)	
	1C	Southwest	1735	2.0	2.0	0.4		0.06	0.13	0.18	0.4	1.6	0.6		0.10	0.21	0.18	0.5	1.5	
	2	Hillcrest No. 1	1881	0.14	1.14	0.8		0.12	0.27	0.18	0.6	0.6	6.3		0.94	2.07	0.18	3.2	(2.0)	
		Lone Pine No. 2	1881	1.0																
	3	Hillcrest No. 2	2031	0.10	1.10	0.5		0.07	0.15	0.18	0.4	0.7	4.5		0.68	1.49	0.18	2.3	(1.2)	
		Lone Pine No. 3	2031	1.0																
	4	Stardust	2181	0.18	0.68	0.8		0.12	0.26	0.12	0.5	0.2	1.4		0.20	0.45	0.12	0.8	(0.1)	
		Cherry Lane No. 4	2181	0.5																
	5	Highlands	2331	0.5	0.5	0.2		0.03	0.07	0.12	0.2	0.3	0.5		0.08	0.18	0.12	0.4	0.1	
	6	(None currently)		0.0	0.0	0.0		NA	NA	NA	NA	NA	0.6		0.08	0.19	0.12	0.4	(0.4)	

Notes:

1. For small, upper zones, storage improvements should be sized to meet buildout demands.
2. Refer to Design and Operating Criteria in appendix for fire storage needs.
3. Storage needs are not additive; the needs shown for 2036 and buidlout account for the 2016 needs
4. The 2036 deficit for Reduced Pressure / Gravity is shown as 4.2 MG. However, because of limitations in drawing down both Bullis and Capital, the needed addition to meet equalization is at least 5.2 MG.

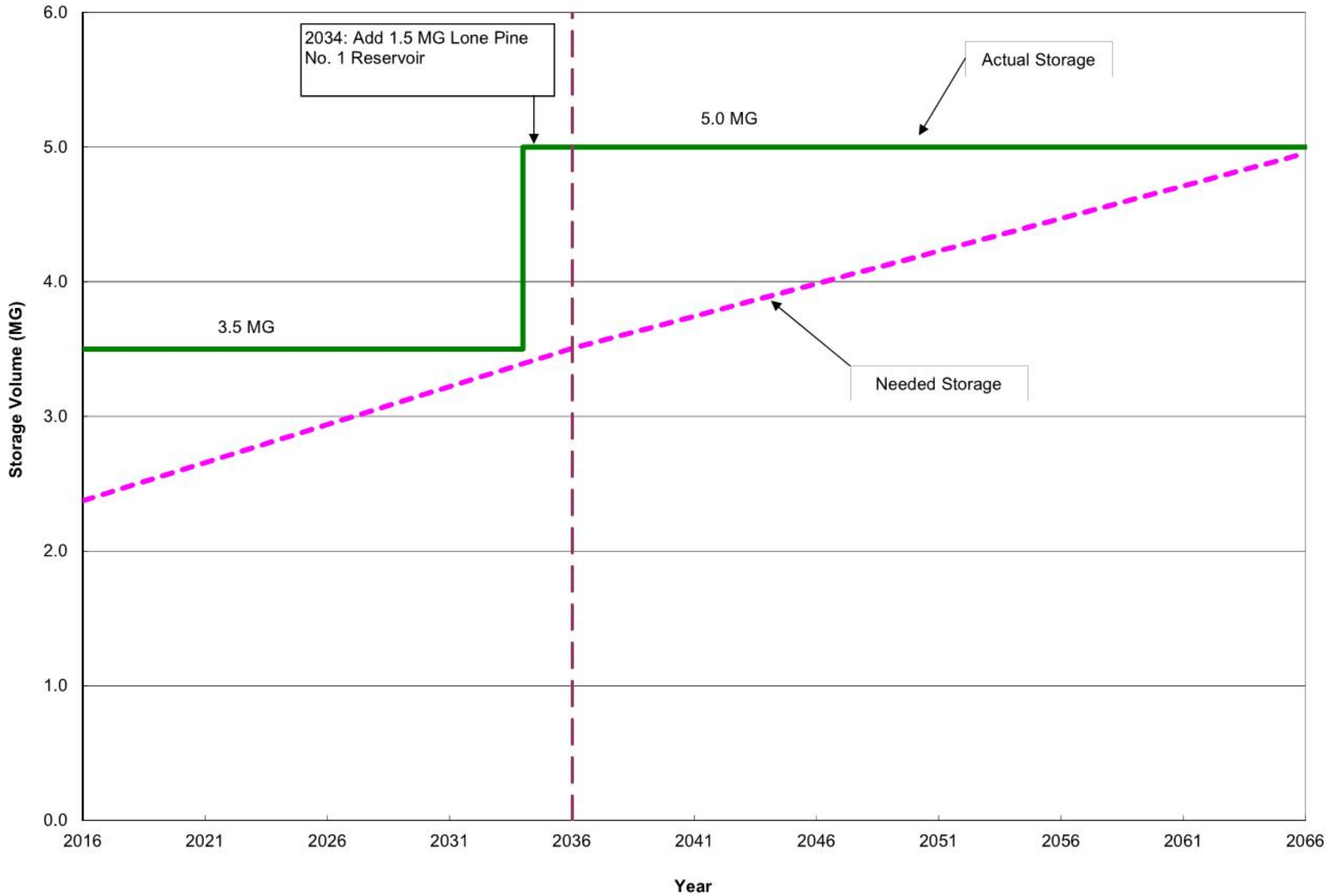


Figure 9-1. Zone 1A Reservoir Planning

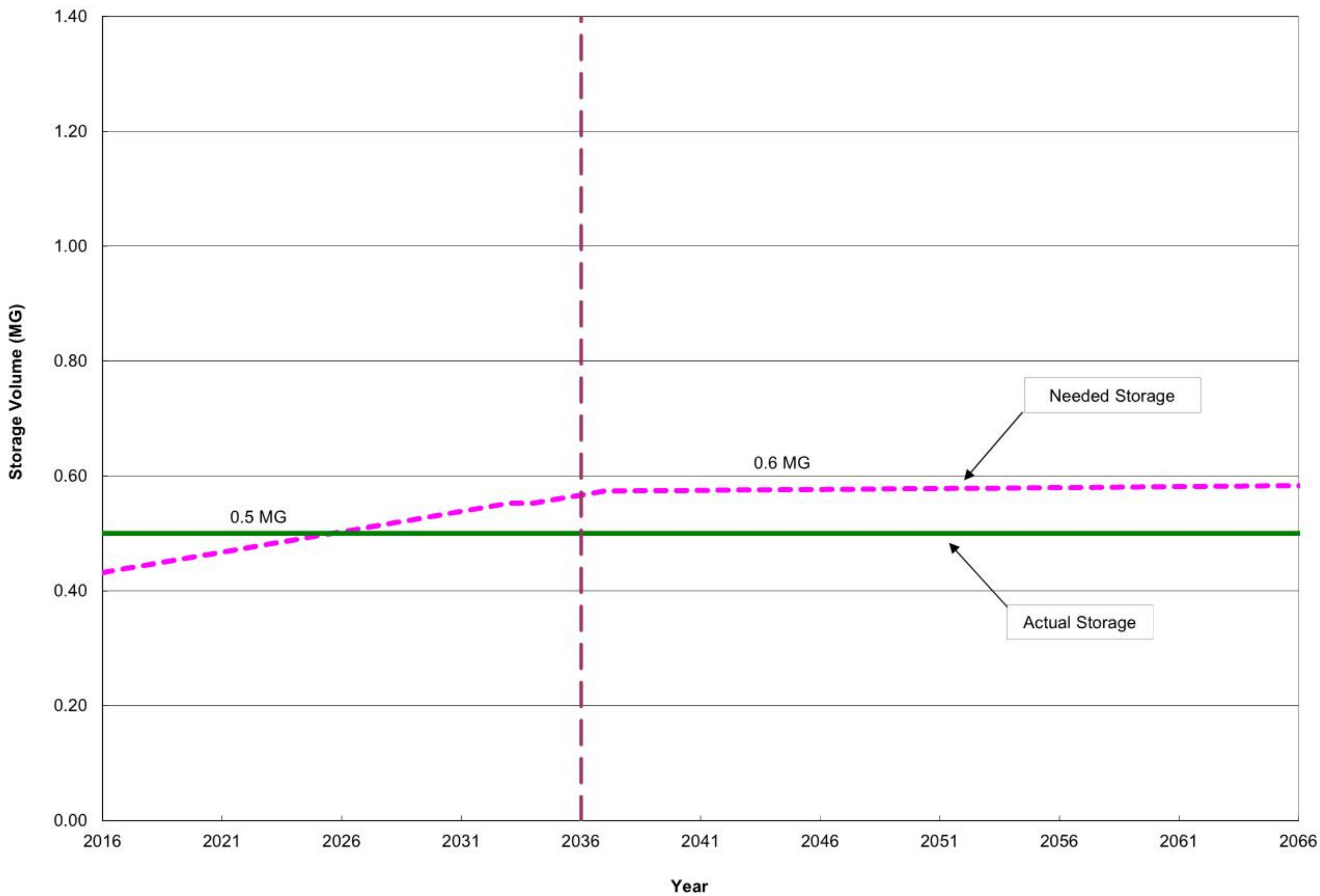


Figure 9-2. **Zone 1B Reservoir Planning**

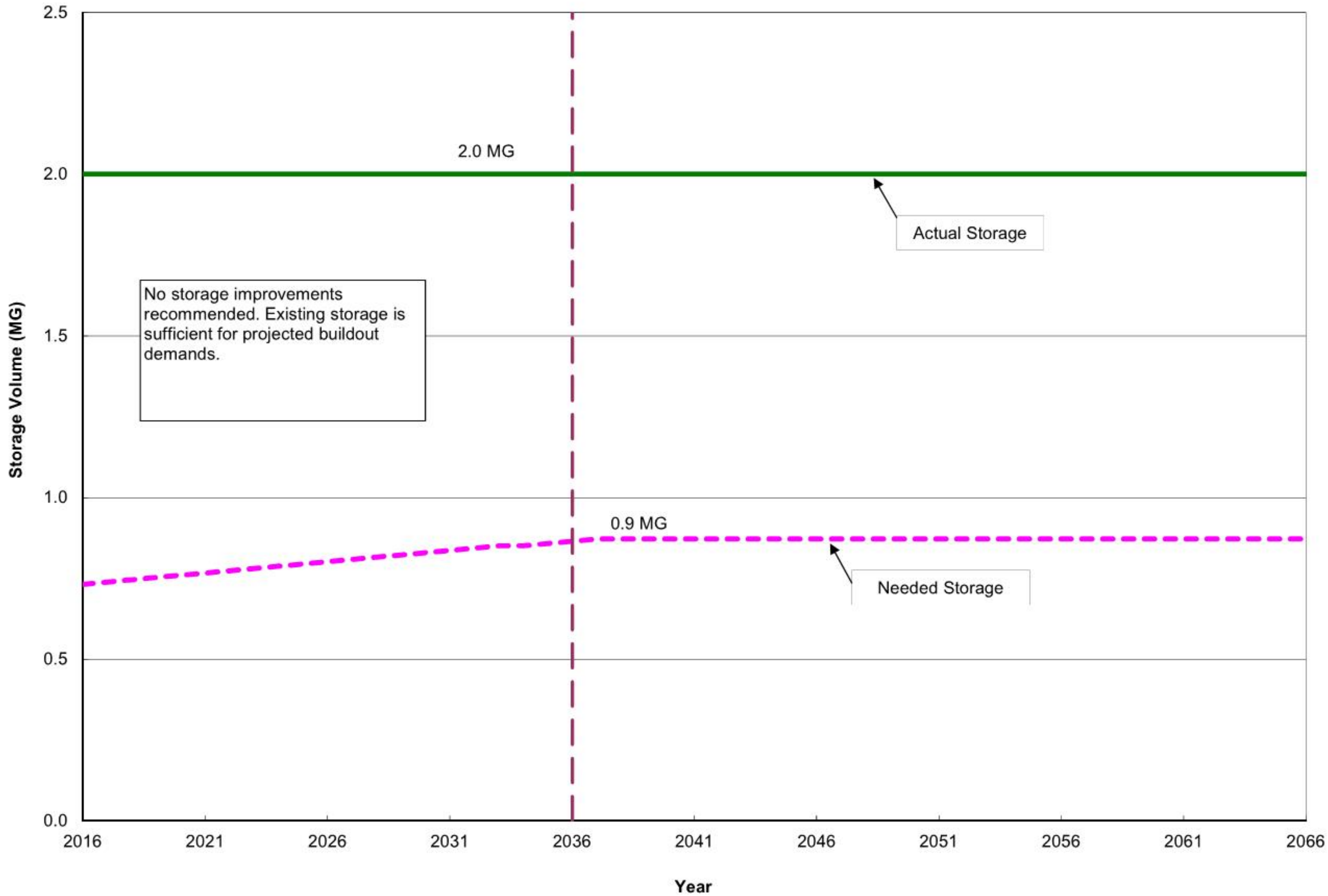


Figure 9-3. Zone 1C Reservoir Planning

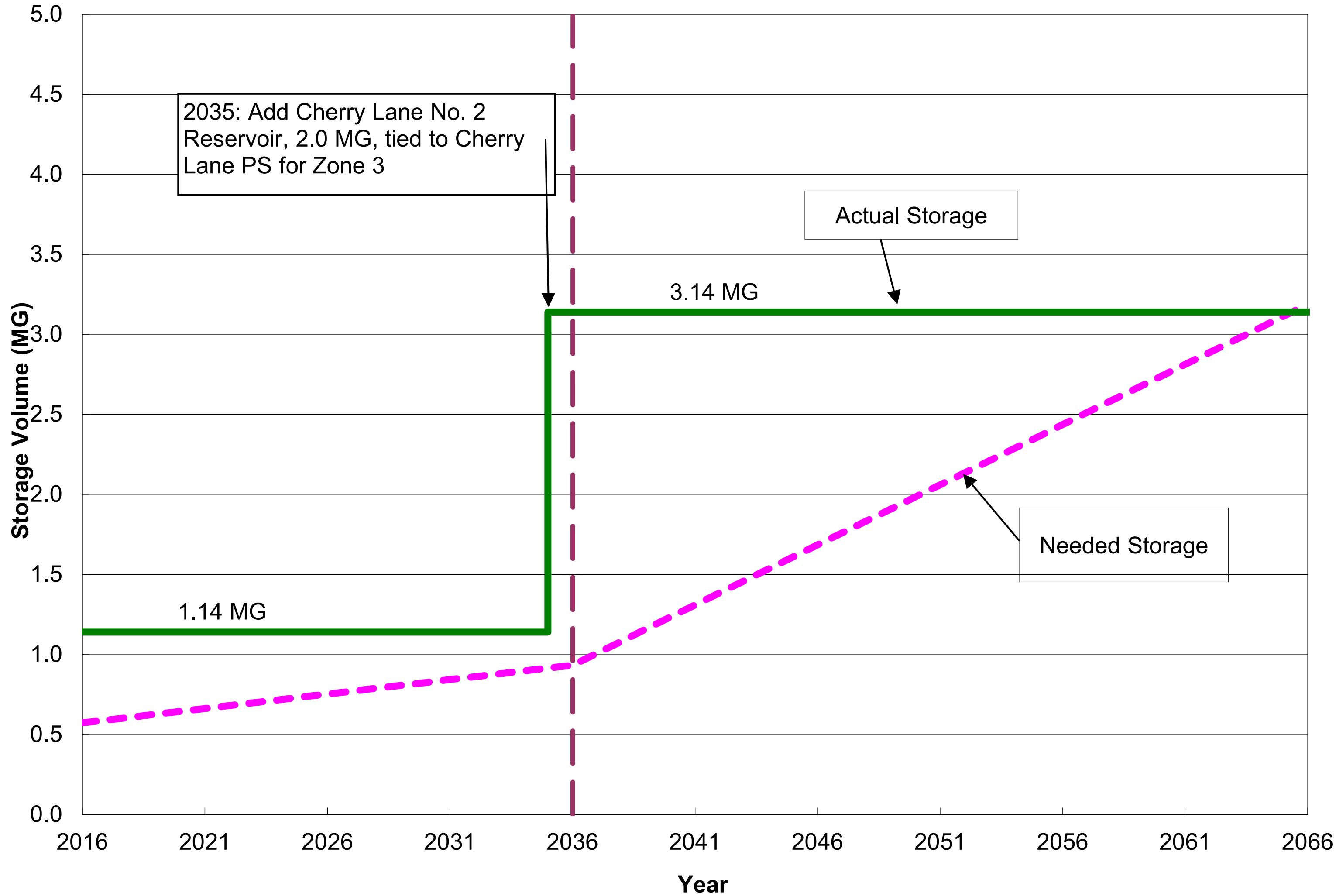


Figure 9-4. Zone 2 Reservoir Planning

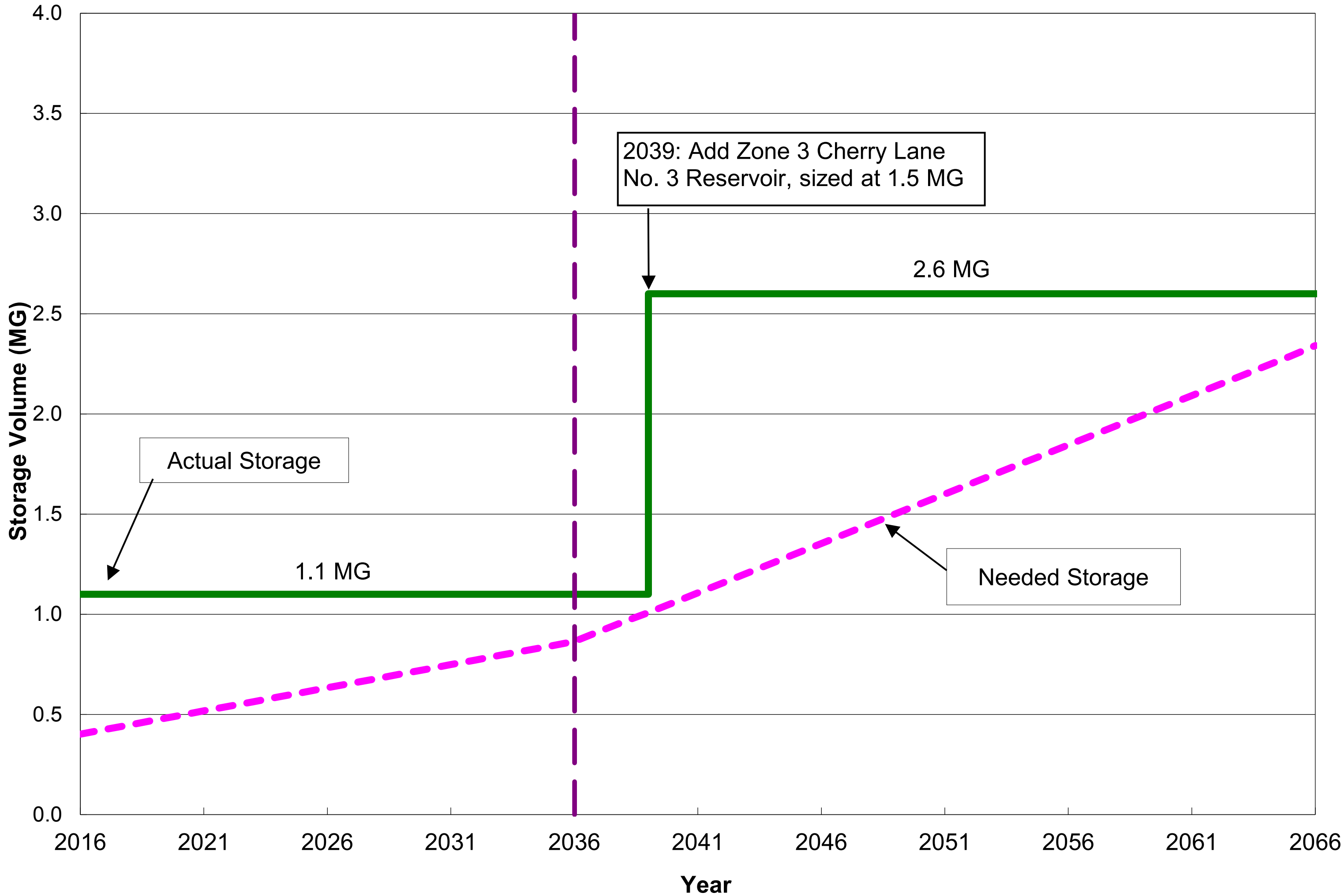


Figure 9-5. Zone 3 Reservoir Planning

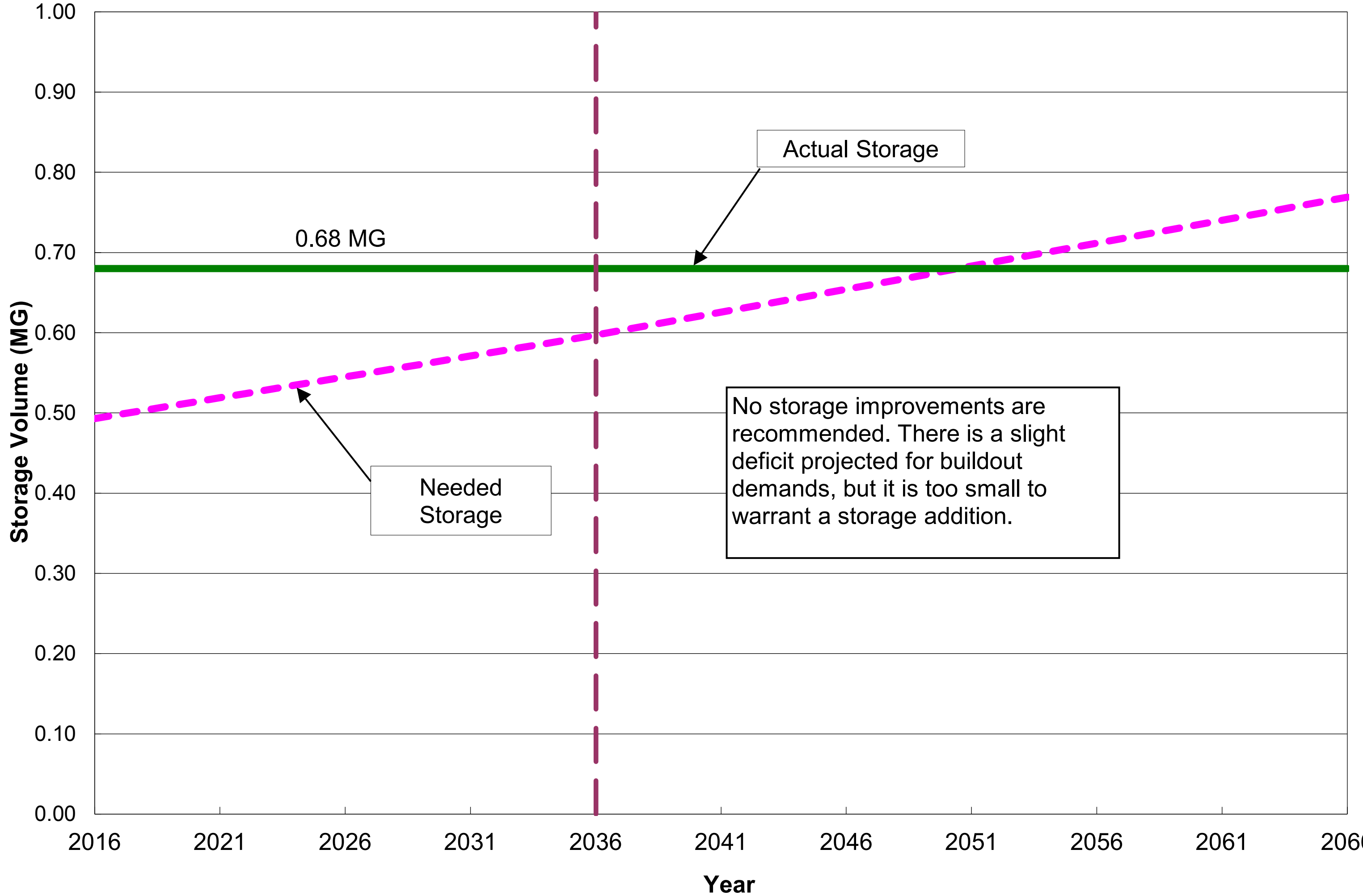


Figure 9-6. Zone 4 Reservoir Planning

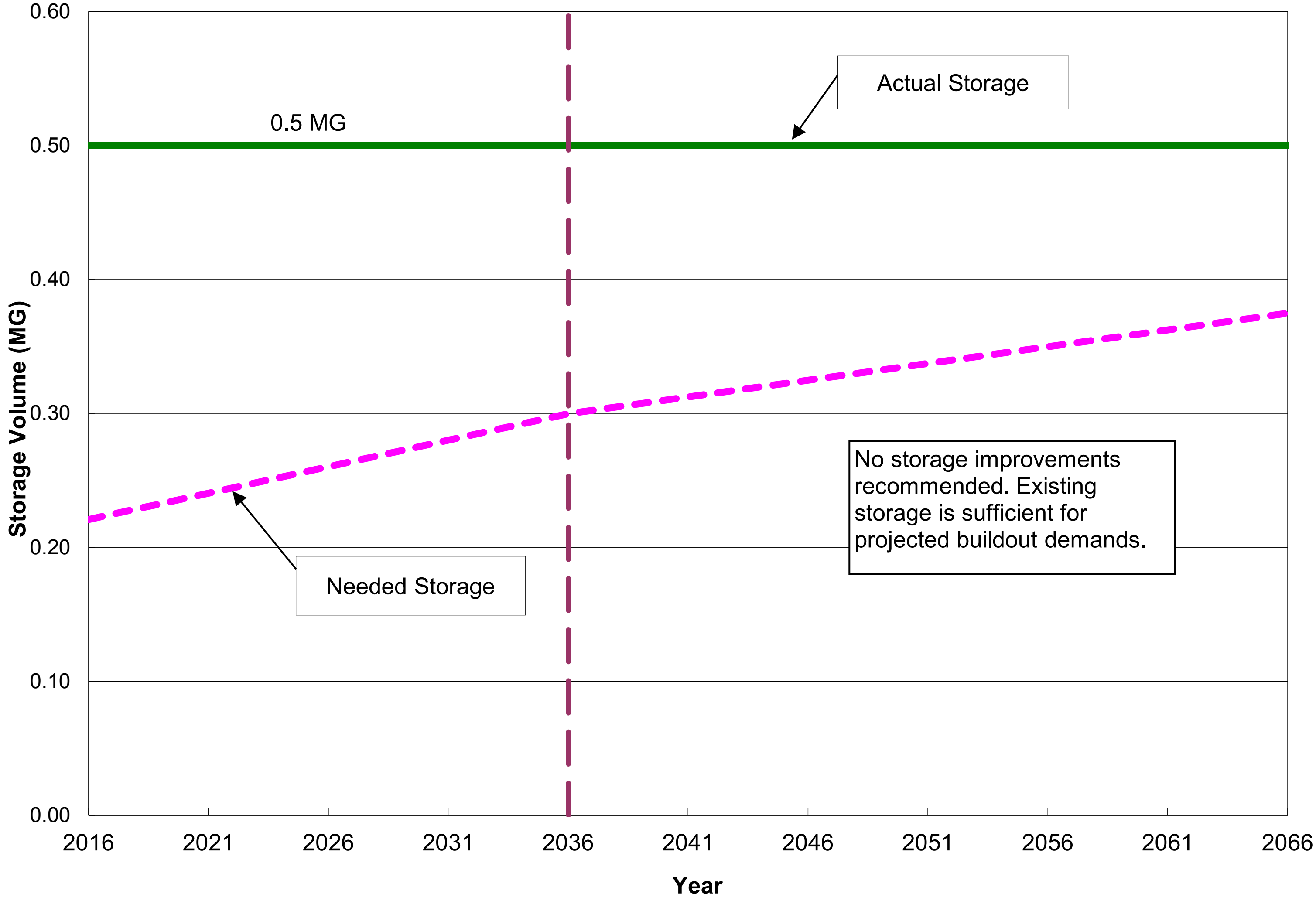


Figure 9-7. Zone 5 Reservoir Planning

Capital Improvements Plan

This section summarizes the improvements described and recommended in this report in a capital improvements plan (CIP) table. This plan addresses paragraph H in Oregon's rules for community water systems, within OAR 333-061-0060 (5) (b).

Paragraph G within this same section of the rules indicates that a water utility's plan shall provide a description of alternatives proposed for financing the CIP. MWC's intent is to finance the projects using a combination of customer rate payments and system development charges. This is consistent with its historical financing approach.

10.1 Capital Improvements Plan

The CIP is summarized in Table 10-1 and illustrated in Figure 10-1. Projected cash flow needs, based on the CIP table presented in this chapter, are provided in Figures 10-2, 10-3, and 10-4. Table 10-2 lists potential pipeline needs for the urban reserve areas, should they develop. No date has been assigned to these projects, since it is uncertain when and if they will be needed.

10.2 Project Timing

In most cases, the timing for recommended CIP projects is related to water demand growth. This may be overall MWC demand growth, as in the case of planning for the expansion of the Control Stations, or it may be demand growth within a specific service zone, as in the case of planning for a pump station or reservoir in an upper service zone. For some projects where a reservoir and pump station are located together and the timing for the construction of the reservoir is later than the pump station, the timing for those projects was adjusted so that implementation results in a complete working system.

Detailed planning charts were prepared for the demand-related improvements and these have been included in the respective sections for pipelines, Control Stations, pump stations, and reservoirs. The demand curves for the overall system, for MWC's outside customers, and for the Gravity and Reduced Pressure Zones reflect the projections presented earlier in this report. These projections are based on historical per capita water use within these areas and population projections prepared by local planning agencies.

In the case of the upper elevation service zones, there was no specific planning information available to project the rate of demand growth. However, by using the current zoning information and by applying historical water use by zone type, buildout demands were estimated for these upper zones. The demand curves for these zones that are presented in the timing charts reflect a straight-line increase from 2016 so that buildout demands are reached in approximately 2060.

Actual demand growth will vary from the projections based on many factors and therefore, MWC will track actual demand growth and adjust project timing in accordance with the actual values. This represents considerable effort and can be accomplished by reviewing pumping records for each service zone after a peak season to assess pump performance and operating times against pump station capacity; it will be necessary to track demand within each service zone as well as overall demands.

10.3 Project Cost Background

The project cost estimates are given in October 2016 dollars at an approximate *Engineering News-Record* Construction Cost Index for Seattle Area value of 10,596.

Prior to finalizing the funding for a project, it may be necessary to update the cost estimate to current costs and to develop a preliminary design to further define the project. Table 10-1 includes an approximate escalated cost based on an inflation rate of 2 percent per year, which has been the approximate average annual increase in utility construction costs over the past 25 years. The escalated values provide recognition of inflation and its impact on project costs when developing and revising annual budgets. Costs were escalated to the first calendar year of the planned fiscal year for implementing the improvement, or to a mid-point calendar year for multi-year projects. Additionally, MWC should consider if the 12 percent allowance for engineering, administration, and permitting is appropriate for any given project. This allowance was added for but may not be sufficient depending on the nature of the project.

Unit costs for estimating pipelines were based on a review of recent projects constructed for MWC. Table 10-3 provides a summary of these pipeline unit cost values. The values assume the use of ductile iron pipe.

Table 10-1. Distribution System Capital Improvements Plan

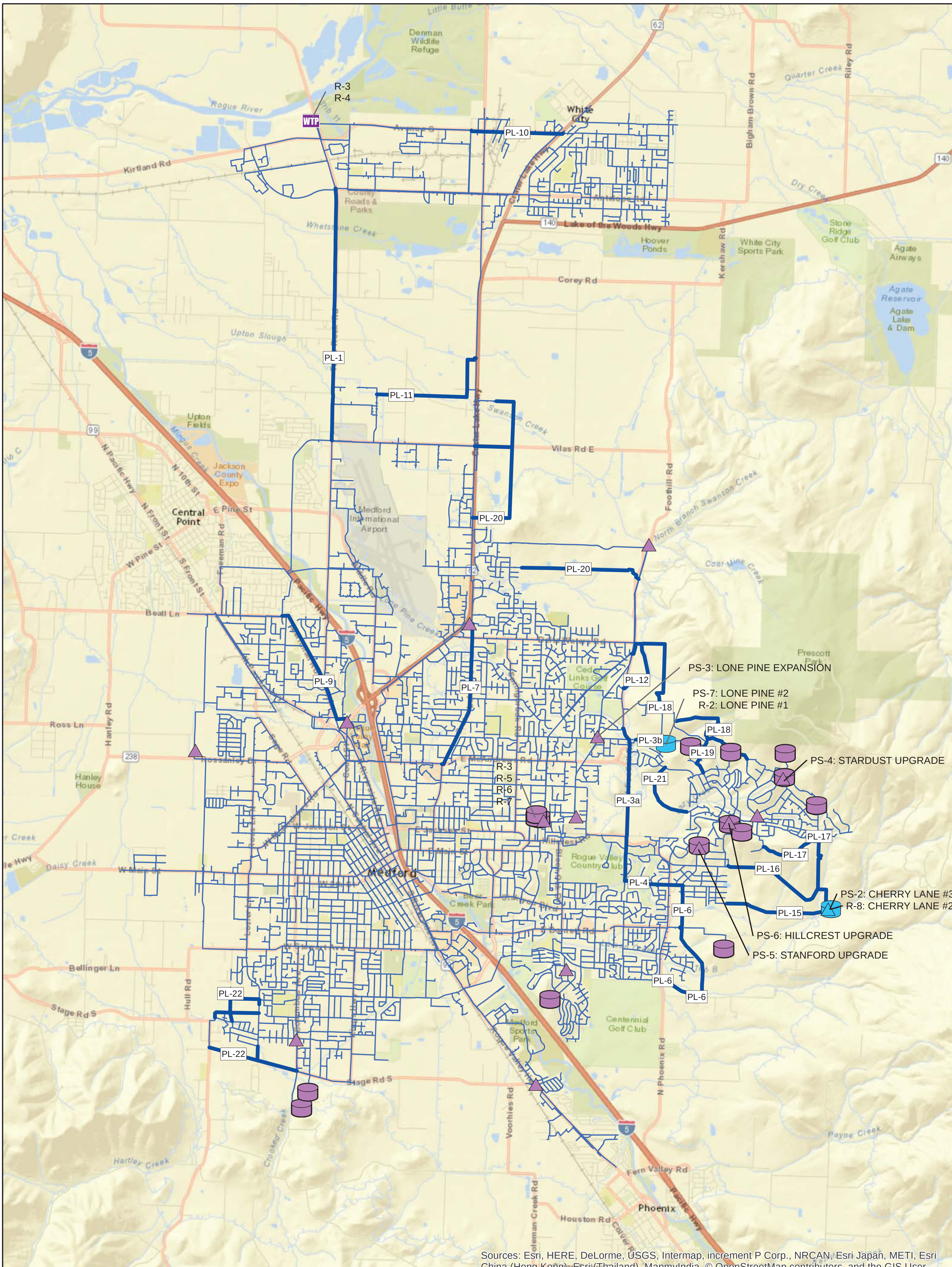
Project ID	Planned Date of Imple-mentation	Project Name	For Pipelines: Diameter (in)	For Pipelines: Length (ft)	Description	Basis of Need	2016 Construction Cost Estimate	2016 Project Cost with 12% for Engineering	2016 Project Total Cost	Project Cost Escalated to Date of Planned Implementation
Fiscal Years 2017-2018 to 2021-2022 (First 5 Years of 20-Year Plan)										
PS-5	2018-2019	Stanford PS upgrade			Expand firm pumping capacity at Stanford PS to 3,200 gpm by replacing Pump No. 1 with approx. 1800 gpm pump, similar to No. 2 (100 hp motor). Allowance included for piping and electrical modifications.	Growth	$150,000	$20,000	$170,000	$180,000
R-3	2019-2020	Engineering evaluation - storage options in Reduced Press/Gravity Zone; Capital Reservoirs evaluation			Conduct detailed evaluation of storage options for Reduced Pressure/Gravity Zones, to enable increased pumping from Duff No. 1 WTP; coordinate with primary disinfection evaluation project included in BBS/Duff Facility Plan; evaluate replacement options (timing for replacements, number of replacement tanks and their volumes, constructability issues) for Capital Reservoirs	Growth		$200,000	$200,000	$220,000
PL-3a	2019-2020	Lone Pine extension to Zone 1	16	6,100	Increase capacity to south of Zone 1 for balancing. Located on Foothill Rd. (Pipeline size assumes that existing 12-inch remains in service. If abandoned, replace proposed 16-inch with 24-inch.)	Growth	$1,270,000	$150,000	$1,420,000	$1,510,000
PL-4	2021-2022	Zone 1 connection	12	6,400	Extend capacity to Zone 1 south loop; located on Calle Vista Drive	Growth	$1,230,000	$150,000	$1,380,000	$1,530,000
R-4a	2020-2022	Construct new 5 MG storage in Reduced Pressure Zone			Cost based on adding clearwell storage at Duff No. 1 WTP. The implementation of this option depends on outcome of clearwell/disinfection evaluation project (D7) included in the BBS/Duff WTP Facility Plan. Construction will continue into 2022-2023. Construction cost for R-4a = one-half x (cost for 5 MG buried tank + cost for connecting transmission pipelines)	Growth	$5,400,000	$650,000	$6,050,000	$6,680,000
						Total, Years 1-5				**$10,120,000**
Fiscal Years 2022-2023 to 2026-2027 (Second 5 Years of 20-Year Plan)										
R-4b	2022-2023	Construct new 5 MG storage in Reduced Pressure Zone			Year 2 of 2 for construction of new 5 MG storage; based on adding buried clearwell storage at Duff No. 1 WTP. Construction cost for R-4b = one-half x (cost for 5 MG buried tank + cost for connecting transmission pipelines)	Growth	$5,400,000	$650,000	$6,050,000	$6,820,000
PL-7	2023-2024	Crater Lake Avenue transmission pipeline	16	8,300	Delivers water from Martin Control Station to McAndrews Road, on Crater Lake Avenue	Growth	$1,730,000	$210,000	$1,940,000	$2,230,000
PS-6	2023-2024	Hillcrest PS upgrade			Increase firm capacity at Hillcrest PS to 2,000 gpm by replacing Pump No. 1 with 1,000 gpm pump (60 hp motor). Allowance included for piping and electrical modifications.	Growth	$100,000	$10,000	$110,000	$130,000
R-5	2023-2025	Replace 1908 2.0 MG Capital tank			It appears that rehabilitation is not feasible and replacement is warranted. Project R-3 will help to identify best option. For budget planning, the budget assumes replacement of this tank with a new tank of the same volume.	Replacement	$3,400,000	$410,000	$3,810,000	$4,470,000
R-6	2025-2027	Replace 1927 2.0 MG Capital tank			It appears that rehabilitation is not feasible and replacement is warranted. Project R-3 will help to identify best option. For budget planning, the budget assumes replacement of this tank with a new tank of the same volume.	Replacement	$3,400,000	$410,000	$3,810,000	$4,650,000
						Total, Years 6-10				**$18,300,000**

Note: Costs were escalated to proposed date of implementation using 2% per year inflation.

Table 10-1. Distribution System Capital Improvements Plan

Project ID	Planned Date of Imple-mentation	Project Name	For Pipelines: Diameter (in)	For Pipelines: Length (ft)	Description	Basis of Need	2016 Construction Cost Estimate	2016 Project Cost with 12% for Engineering	2016 Project Total Cost	Project Cost Escalated to Date of Planned Implementation
Fiscal Years 2027-2028 to 2036-2037 (Last 10 Years of 20-Year Plan)										
PL-10	2027-2028	Reduced Pressure Zone, northern west to east connector	30	5,100	Increase capacity to eastern portion of White City/Eagle Point supply point; located on Avenue G in White City	Growth	$1,680,000	$200,000	$1,880,000	$2,340,000
R-7	2027-2029	Replace 1945 8.0 MG Capital Tank			It appears that rehabilitation is not feasible and replacement is warranted. Project R-3 will help to identify best option. For budget planning, the budget assumes replacement of this tank with a new tank of the same volume.	Replacement	$10,400,000	$1,250,000	$11,650,000	$14,780,000
PL-1	2027-2029	Reduced Pressure Zone north-south conveyance	36	14,000	Provide capacity to meet future growth and support management of Duff No. 1 WTP HSPS discharge pressures. This project eliminates the need for the booster pump stations. Located on Table Rock Road.	Growth	$5,540,000	$660,000	$6,200,000	$7,870,000
PS-3	2029-2030	Zone 1A Lone Pine Pump Station expansion			Expand pumping capacity to meet growth in upper zones by adding 1500 gpm (75-100 hp) Pump No. 3.	Growth	$130,000	$20,000	$150,000	$200,000
PL-9	2029-2031	Conrad Control Station feeder	18	7,100	From Beall Lane to Conrad Control Station, on Merriman Road. Reduces headloss to Control Station and adjacent areas in Reduced Pressure Zone.	Growth	$1,630,000	$200,000	$1,830,000	$2,420,000
PS-4	2034-2035	Replace small pump in Zone 5 Stardust Pump Station (760 gpm)			Pumping capacity expansion to meet growth in Zone 5	Growth	$30,000	$10,000	$40,000	$60,000
PL-3b	2034-2035	Lone Pine extension to reservoir	16	2,000	Provide connection from Lone Pine PS to new Lone Pine Reservoir, on Lone Pine Road	Growth	$420,000	$50,000	$470,000	$680,000
R-2	2034-2035	Add new Zone 1A 1.5 MG Lone Pine Reservoir			Storage expansion in Zone 1A to meet future requirements and provide storage to the northern end of the zone	Growth	$3,000,000	$360,000	$3,360,000	$4,800,000
PL-15	2035-2036	Zone 2 South loop	12	5,800	Extend service through Zone 2 to create a southern loop on East Barnett Road, to deliver water to upper zone pump stations	Growth	$1,110,000	$130,000	$1,240,000	$1,810,000
R-8	2035-2036	New Cherry Lane 2 Reservoir			New 2.0 MG reservoir	Growth	$3,400,000	$410,000	$3,810,000	$5,560,000
PS-7	2035-2036	New Lone Pine No. 2 Pump Station (3,500 gpm)			Provide supply to Zone 2 from new Lone Pine No. 1 Reservoir	Growth	$2,300,000	$280,000	$2,580,000	$3,760,000
PS-2	2035-2036	New Zone 3 Cherry Lane Pump Station (2,200 gpm)			Increase capacity to Zone 3	Growth	$1,900,000	$230,000	$2,130,000	$3,110,000
PL-16	2035-2036	Zone 3 loop	12	9,170	Extend service from the Cherry Lane PS to the future Zone 3 Reservoir and to other areas of Zone 3; located on Cherry Lane Road	Growth	$1,770,000	$210,000	$1,980,000	$2,890,000
PL-11	2036-2037	Reduced Pressure southern east to west connector (growth)	16	7,600	Extend service into development areas and provide connection between Crater Lake and Table Rock conveyance lines, north of Vilas Road	Growth	$1,580,000	$190,000	$1,770,000	$2,640,000
						Total, Years 11-20				**$52,920,000**

Note: Costs were escalated to proposed date of implementation using 2% per year inflation.



LEGEND

- WTP WATER TREATMENT PLANT, EXISTING; Water Treatment Plant, EXISTING
- Pipeline Improvements
- Existing Pump Station
- Existing Reservoir
- Future Pump Station
- Future Reservoir

N

0 2,500 5,000 Feet

FIGURE 10-1
Recommended Distribution System Improvements
MWC Water Distribution Facility Plan

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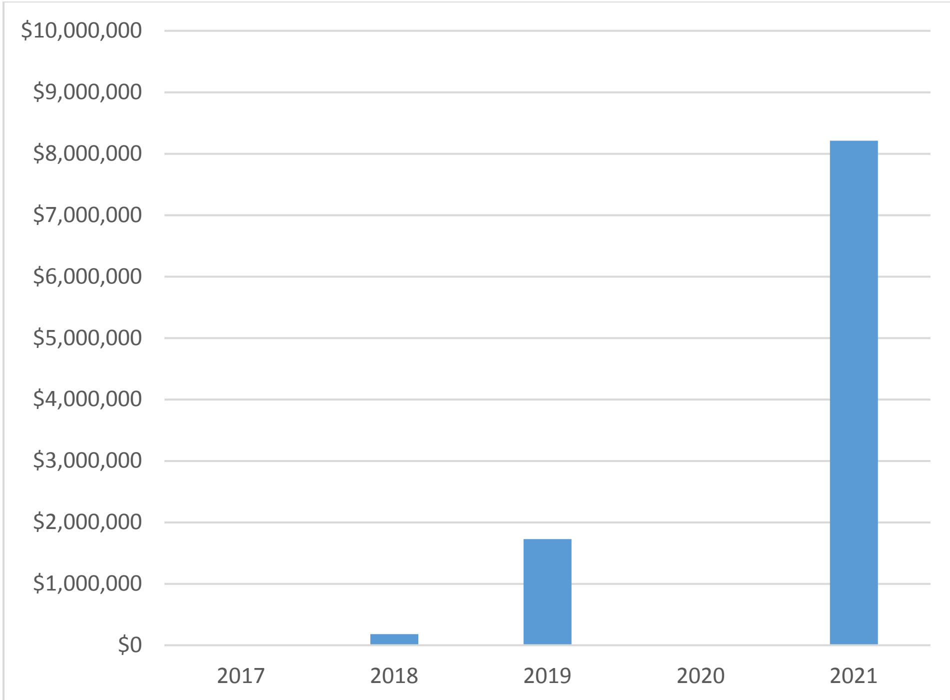

Figure 10-2. Cash Flow to Implement Distribution System Improvements for 2017-2018 through 2021-2022

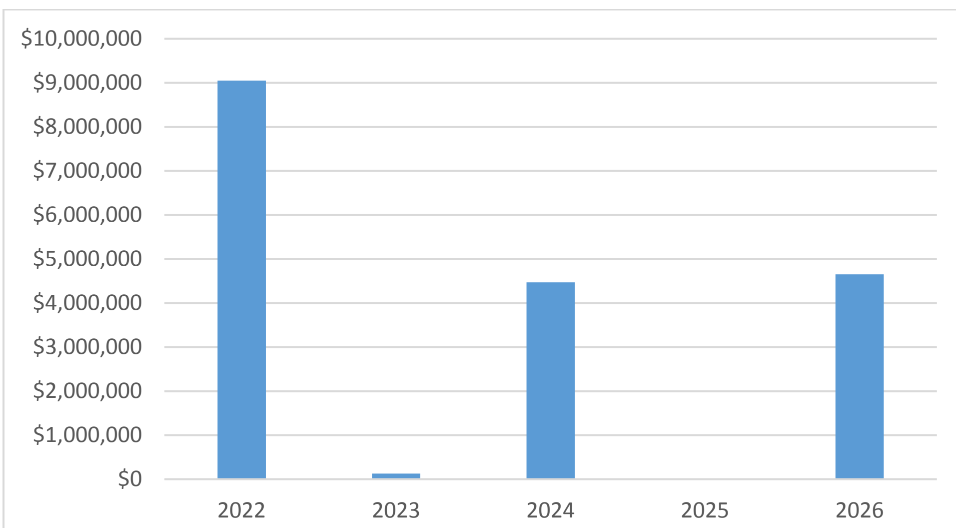

Figure 10-3. Cash Flow to Implement Distribution System Improvements for 2022-2023 through 2026-2027

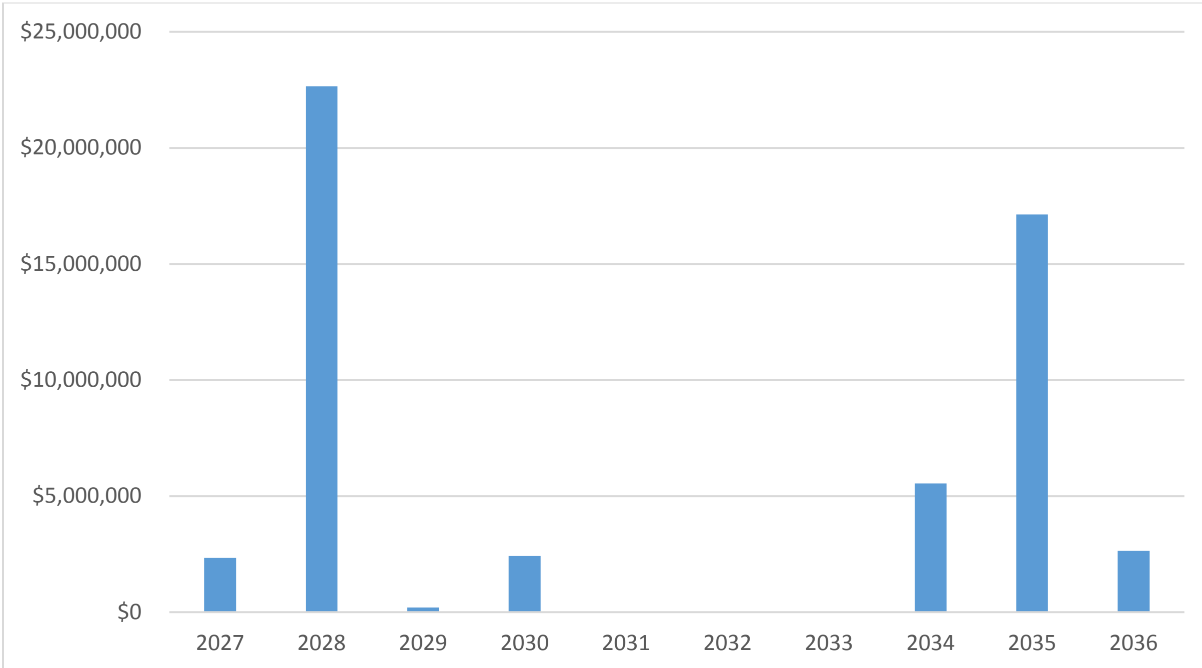

Figure 10-4. Cash Flow to Implement Distribution System Improvements for 2027-2028 through 2036-2037

Table 10-2. Potential Urban Reserve Capital Projects

Project ID	Project Name	Diameter (in)	Length (ft)	Description	2016 Construction Cost Estimate	2016 Project Cost with 12% for Engineering
Urban Reserve - Developer Driven Projects						
PL-6	Zone 1 South loop	12,16	8,300	Extend capacity to southern portion of Zone 1 for future growth. From Stanford and Wingate, south to Barnett Rd, south to Coal Mine Rd, west to North Phoenix Rd.	$1,640,000	$200,000
PL-12	Zone 1 North Terrace pipeline	12	3,800	Extend service into the planned area of Zone 1 in the northern area of the upper pressure zones, east of Foothill Rd	$730,000	$90,000
PL-17	Zone 4 Loop	12	3,800	Extend service in Zone 4 for development, on Aerial Heights Drive	$730,000	$90,000
PL-19	Zone 3 Connection to North	12	2,000	Connection to existing portions of Zone 3 to overcome headloss when additional growth occurs, on Bordeaux Ave and Park Ridge Drive	$380,000	$50,000
PL-20	Growth Areas	12	18,300	Pipelines to support growth in areas of potential growth in the gravity and reduced pressure zones, south of Coker Butter Rd	$3,510,000	$420,000
PL-21	Zone 2 Orchard Development	8	3,800	Pipeline to create a loop in Zone 2 if development occurs in the future in the Orchard area (in undeveloped area, west of E McAndrews Road)	$610,000	$70,000
PL-22	Southwest Loop	8,12	12,100	Piping to support future growth planned in the Southwest zone (Sunset Drive, S Stage Road)	$2,200,000	$260,000
PL-18	North Zone 2, 3, 4 Expansion/Growth	12	11,700	Provide conveyance in the norther portions of the upper zones as growth occurs (south of Delta Waters Rd, and east of Foothill Road)	$2,250,000	$270,000

Table 10-3. Unit Costs for Estimating Pipeline Construction
Medford Water Commission Water Distribution System Facility Plan

Diameter (in)	Construction Cost per Foot ($)
6	144
8	160
10	180
12	192
16	208
24	264
30	330
36	396
42	462
48	528

Appendix A
Design and Operating Criteria

No.	Item	MWC Criteria	Regulations or Published Criteria	Discussion
1	Fire flows for low density (single-family and duplex) residential areas	1,000 gpm for 2 hours (storage of 120,000 gallons)	ISO: 1000 gpm for 2 hours National Fire Protection Agency has sliding scale for single family residential: 0-3600 sf: 1000 gpm/2 hours 3601-4800 sf: 1750 gpm/2 hours 4801-6200 sf: 2000 gpm/2 hours 6001-7700 sf: 2250 gpm/2 hours	*Recommended Standards for Water Works* ('Ten States Standards') indicates that fire flows shall meet ISO standards. California Administrative Code requires 750 gpm minimum for residential one story, single family dwellings on average sized lots, and 2,000 gpm for more densely built areas, apartments, and light commercial. Oregon has no flow requirements, but does require 20 psi at all times. ISO standards also call for residual pressure of 20 psi.
2	Fire flows for medium and high-density multi-family residential areas	Minimum: 1,500 gpm for 2 hrs (180,000 gallons) Maximum: 2,750 gpm for 2 hrs (330,000 gallons)		See discussion for low-density residential fire flows. No specific Oregon requirements.
3	Fire flows for special high-density multi-family (three stories and higher residential areas)	Minimum: 3,000 gpm for 3 hrs (540,000 gallons) Maximum: 3,750 gpm for 3 hrs (675,000 gallons)		No Oregon requirements. ISO downgrades a community's insurance rating unless at least 3,500 gpm is available for 3 hours for habitational buildings such as schools. This category also includes care centers and light commercial.
4	Fire flows for schools and colleges	Minimum: 4,000 gpm for 4 hrs (960,000 gallons) Maximum: 6,000 gpm for 4 hrs (1.44 MG)	ISO: 3500 gpm for 3 hours (630,000 gallons)	No Oregon requirements. ISO downgrades a community's insurance rating unless at least 3,500 gpm is available for 3 hours for habitational buildings such as schools. This category also includes care centers and light commercial.
5	Fire flow for Institutions and Hospitals	Minimum: 4,000 gpm for 4 hrs (960,000 gallons) Maximum: 8,000 gpm for 4 hrs (1.92 MG)	ISO: 3500 gpm for 3 hours (630,000 gallons)	No Oregon requirements. ISO downgrades a community's insurance rating unless at least 3,500 gpm is available for 3 hours for habitational buildings such as schools. This category also includes care centers and light commercial.
6	Fire flows for commercial and industrial areas	Minimum: 2,000 gpm for 4 hrs (480,000 gallons) Maximum: 5,000 gpm for 4 hrs (1.2 MG)		No guidance from other states or Ten States Standards for commercial/industrial areas. ISO sets commercial and industrial fire flow requirements based on building material type and other variable factors, and may require up to 12,000 gpm for full insurance credit.
7	Hydrant spacing	Per Oregon Fire Code as amended by the City of Medford	ISO: 1000 feet maximum spacing	ISO credits hydrants for up to 1,000 gpm if located within 300 feet of structure, for 670 gpm if located 301 to 600 feet from structure, and for 250 gpm if located from 601 to 1000 feet from structure. A spacing of 1,000 feet maximum would ensure at least 1,000 gpm is available to each house.
8	Distribution piping: sizes and looping	Line flow velocity < 10.0 fps or head loss below 10.0 ft/1000ft of pipeline under maximum hour demand	Oregon: wherever possible, dead ends shall be minimized by looping. Where dead ends are installed, blow-offs of adequate size shall be provided for flushing.	MWC criteria follows WA Admin Code; meets OARs (minimize dead ends) and Ten States Standards (min of 6-inch mains). Several states require a minimum of 6-inch mains, and indicate that dead end lines shall be minimized. Proliferation of cul-de-sacs means that the criterion of allowing 6-inch diameter dead end mains up to 250 feet in length may result in a system that is not well-looped.
9	Transmission mains (≥ 16-in): sizing	Maintain flow velocity < 7.0 fps under MDD		No guidance from other states or Ten States Standards. Peak hour demands are uncommon, and sizing a transmission main for velocities of 8-10 fps will result in lower velocities a large percentage of the time.
10	Operating pressures	35 psi to 100 psi under maximum hour and off-peak demand Minimum 20 psi during fire flow event on a MDD	Oregon: minimum is 20 psi at the property line	Oregon's drinking water rules require 20 psi minimum and Oregon's plumbing code states that pressure reducing valves are needed for pressures above 80 psi. Ten States Standards indicates that normal working pressures should be 60-80 psi, and not less than 35 psi.
11	Equalization storage volumes: residential only	15% of pumping rate		Only general guidance is provided by states, indicating that equalization storage should consider city-specific daily use patterns.
12	Emergency storage volumes	0.33 x MDD		Washington regulations indicate that emergency storage may be reduced when there is a second independent supply, such as BBS and Rogue River in MWC's case.
13	Total storage	Sum of fire, equalization, and emergency storage volumes.		Washington codes allow a system to provide the total of the equalization storage plus the larger of the emergency or fire volumes. This approach assumes that a fire will not occur concurrently with an emergency failure. Need to balance distribution storage between meeting storage needs and water quality considerations.
14	Pump stations	Firm capacity = largest pump out of service	Oregon: wherever possible, booster pumps shall take suction from reservoirs to avoid the potential for negative pressures on the suction line. Pumps that take suction from distribution mains shall be provided with a low-pressure cutoff switch.	MWC's pump stations are supplied by reservoirs, except for the Control Stations

Abbreviations:

gpm = gallons per minutes	MDD = maximum day demand	psi = pounds per square inch
ISO = Insurance Services Offic	MG = million gallons	sf = square feet