Big Butte Springs and Robert A. Duff Water Treatment Plant Facility Plan

December 2016

ch2m

MEDFORD WATER COMMISSION

FINAL REPORT

Big Butte Springs and Robert A. Duff Water Treatment Plant Facility Plan

Prepared for:

Medford Water Commission

December 2016

ch2m

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Executive Summary

Introduction

The *Big Butte Springs and Duff Water Treatment Facility Plan* describes current and projected needs, and lists recommended capital improvements for Medford Water Commission's two drinking water supply systems, the Big Butte Springs (BBS) and the Rogue River/Duff Water Treatment Plant (WTP). The plan was prepared in parallel to the 2016 *Distribution System Facility Plan* and the 2016 *Water Management and Conservation Plan*. This plan builds on and updates the 2008 *Robert A. Duff Water Treatment Plant Facility Plan*.

MWC's Big Butte Springs (BBS) supplies up to 26.4 million gallons per day (mgd) of drinking water. The water from the springs, collected in sub-surface spring boxes, is of high quality and requires only chlorination treatment. The cost-effectiveness of the supply is further enhanced by its gravity flow to the city; energy is often a major cost component for water utilities and the BBS supply has low energy requirements.

MWC's second supply is from the Rogue River. Water is withdrawn from the river near Table Rock Road and pumped to the Duff WTP where it is treated through a number of process steps and then pumped to the city. The existing plant is labeled as Duff No. 1; a second plant will eventually be added next to it, and is labeled Duff No. 2 in this report. Currently, the Duff No. 1 WTP operates only during the high demand season, approximately May through September. Its current treatment capacity is 45 mgd.

Description of Big Butte Springs

MWC's principal year-round source of water is the Big Butte Springs (BBS), located about thirty miles northeast of Medford. The capacity from the springs, as estimated by MWC staff, varies from approximately 25 to 35 mgd depending on seasonal rainfall, snow pack, and groundwater conditions. However, the two 24-inch diameter transmission pipelines from the BBS treatment facility to the city limit withdrawal to a maximum of 26.4 mgd (or 40.8 cubic feet per second). In 2015, BBS supplied over eight billion gallons to the MWC system, representing about 73 percent of the system's total water use.

From the spring through the fall, when system demands exceed approximately 20 mgd, the BBS transmission lines are operated at a 'full pipe' flow of 26.4 mgd, and any demands in excess of 26.4 mgd are provided by the Duff No. 1 WTP. The exception to this is when Eagle Point Irrigation District needs to draw water from Big Butte Creek prior to July 1st. When demands are between 20 and 26.4 mgd and the BBS transmission pipelines are operating in full pipe mode, the excess water is dechlorinated and overflowed at the Capital Reservoirs. As water demands decline in the fall, the Duff WTP is taken offline and then, when demands decline to approximately 20 mgd, one of the two transmission pipelines is changed to 'half pipe' operation. A valve at the upstream end of the transmission line is partially closed, reducing the flow in one of the lines to about one-half its maximum capacity. This action decreases the delivery of water from BBS to approximately 19.8 mgd.

The only treatment provided for water from BBS is chlorination, as the supply is currently classified as groundwater. However, MWC is monitoring microbiological water quality from individual springs upstream of the chlorine addition during 2016 to determine if reclassification of one or more springs is necessary. Reclassification would mean that the spring source is surface water influenced, and would trigger required actions to eliminate direct surface water influence or possibly, to increase the level of treatment.

Description of Duff WTP No. 1

MWC withdraws water from the Rogue River and treats it in the Duff No. 1 WTP to supplement the supply from BBS and as a redundant supply should there be a failure of the BBS supply system. Typically, the Duff No. 1 WTP is operated from May through September or October, with the start-up and shut-down dates depending on system demands compared to the BBS supply. In 2015, the Duff No. 1 WTP supplied over three billion gallons to the system, representing approximately 27 percent of total supply.

The Duff No. 1 WTP was initially put into service in 1968. Its original summer treatment capacity was 15 mgd. It was subsequently expanded to 30 mgd in 1983 and then to its present 45-mgd treatment capacity through a series of projects beginning in 1998. MWC has begun most of the further expansion projects described in the 2008 plan, including expansion of the intake, installation of rapid mix and flocculation-sedimentation basins (under construction in 2016), solids handling improvements, and the addition of a second backwash pump. These projects not only position the plant for its final expansion to 65 mgd for summertime production, but also will enable it to operate reliably year-round. As system demands approach and then exceed the BBS's capacity of 26.4 mgd, the Duff No. 1 WTP will shift from seasonal to year-round operation.

The remaining projects to achieve a 65 mgd treatment capacity include adding filters and expanding the high service pump system. A pilot project is anticipated to precede the addition of filters, to provide guidance for their design criteria. The piloting will also be used to examine possible changes in the ozone system and the possible addition of a corrosion control chemical.

A significant component of the previous master plan was examining expansion options for MWC's Rogue River supply. The decision was made to expand the existing Duff WTP to a buildout treatment capacity of 65 mgd, and to provide production beyond 65 mgd through a separate plant situated next to the existing plant.

Water Quality and Regulatory Evaluation

MWC has consistently complied with all state and federal water quality regulations. MWC received the 'Outstanding Performer' status from Oregon Drinking Water Services following the state's last two system surveys conducted in September 2009 and June 2014. A water system survey is an on-site review of a system's sources, treatment, storage facilities, distribution system, operation and maintenance procedures, monitoring, and management, for the purpose of evaluating the system's capability of providing safe drinking water to the public.

Despite achieving compliance with current drinking water standards, MWC was taking further steps as this report was being prepared to examine levels of metals, primarily lead and copper, leaching within the distribution system. Lead, copper, and other metals are not present in MWC's water sources or occur at very low levels, but internal pipe and fixture corrosion introduces low levels of metals into the water, with the greatest concern being lead. The Lead and Copper Rule requires water utilities to specifically test high-risk, single family residences for lead and copper. MWC's water has been in full compliance with this regulation. However, metals leaching was found in MWC's distribution system in 2016 through extra sampling. Based on these findings, MWC began an investigation of all connection lines ('pigtails') from the mains to customer meters older than 1946 to find and replace undocumented lead pigtails. Additionally, MWC intends to conduct a corrosion study starting in 2017. One possible outcome of the study is an adjustment to the treatment process at BBS or Duff No. 1 WTP, or both.

Big Butte Springs

BBS is currently classified as groundwater by the State of Oregon, and therefore, requires only chlorine addition to achieve a residual for blending with treated surface water from the Rogue River. However, the springs are currently being evaluated to determine if they are groundwater under the direct influence of surface water (GWUDI). MWC began a one-year sampling program for *E. coli* for each individual spring in January 2016, as required by the state drinking water program. The next step will be to conduct Microscopic Particulate Analyses (MPAs) to confirm the preliminary findings and determine if additional treatment is needed. If one or more springs are found to be GWUDI, then MWC would have the options of a) discontinuing the use of the spring or springs showing surface water influence, b) rebuilding the spring collection boxes for affected springs, and c) applying additional treatment, probably consisting of disinfection by ultraviolet (UV) light, if a system-wide upgrade was found to be warranted.

The monitoring indicates that Rancheria Springs has the highest probability to be GWUDI. This spring is only used during dry years, approximately every third or fourth year on average, when the aquifer levels drop too low to obtain 26.4 mgd from the other springs. If Rancheria Spring was found to be GWUDI, MWC anticipates its first course of action would be to rebuild the Rancheria Spring collection box.

Duff Water Treatment Plant

The Duff No. 1 WTP has produced water that complies with all state and federal standards, both for those contaminants monitored in water leaving the plant and for distribution system contaminants, which include microbiological contaminants, disinfection by-products, and corrosion by-products (lead and copper). In recent years, the Rogue River supply has had higher algae levels and algal toxins. The plant processes include ozonation, which is considered a best available technology for algal toxins.

Capital Improvement Recommendations

The recommended projects presented in the capital improvements plan of this report are the following:

Big Butte Springs

BBS1. Rebuild Rancheria Spring collection system to protect water quality (2017-2018)

BBS2. Upon completion of corrosion study, possible addition of a corrosion control chemical system for treatment of BBS water

BBS3. Replace meters on the two BBS transmission mains, near the springs, to improve accuracy of measurements (2018-2019)

BBS4. Bury electrical supply and communication lines from Fish Lake Highway to the main chlorination and controls building, to improve reliability of operations (2019-2020)

BBS5. Replace portions of BBS #1 transmission main, as coatings and joints begin to fail (future)

Duff No. 1 WTP

D1. Complete construction of flocculation-sedimentation basin improvements to improve treatment and prepare plant for year-round operation (2016-2018)

D2. Improve storage system for bulk hypochlorite to reduce degradation (2017-2018)

D3. Upon completion of corrosion study, possible addition of corrosion control chemical system to reduce potential for lead dissolution

D4. Replace finished water meters with magnetic meters to improve accuracy of flow measurements (2018-2019)

D5. Add maintenance building (2018-2019)

D6. Conduct pilot testing to guide filter expansion and use of ozone system (2018-2019)

D7. Evaluate opportunity and costs for using ozone to achieve primary disinfection for 65 mgd capacity versus adding reservoir storage; include evaluation of baffling options to improve plant reservoir efficiency and evaluation of reservoir expansion options; consider possible finished water pH adjustment for corrosion control and the impact on required contact time; refer to *Water Distribution Facility Plan* for discussion on storage needs within the Reduced Pressure and Gravity Zones (2018-2019)

D8. Rehabilitate Filters 5-8 by replacing media, support gravel, and underdrains (2019-2021)

D9. Add containment area and drain system for outside chemical truck unloading (2019-2020)

D10. Add filters to obtain 65 mgd plant capacity (2019-2021)

D11. Replace raw water Pump No. 5 with 22.5 mgd pump with a variable speed drive and 500 hp motor to obtain 65 mgd capacity (2020-2021)

D12. Replace ozone generators and associated equipment, to address aging equipment and its possible need for primary disinfection (2020-2022)

D13. Add new high service pump building, pumps, and surge protection to obtain 65 mgd capacity (2020-2022)

D14. Add two solids handling basins to obtain 65 mgd capacity (2020-2022)

D15. Add filter-to-waste tank and recycle pumping system to return this water to plant inlet, to improve water use efficiency and decrease loading on the solids handling system (future)

D16. Install 2000kW backup power generator, transfer switch, and control modifications to enable 15 mgd capacity under standby power conditions (future)

Development Plans for Duff No. 2

The previous master plan described plans for a second plant, located on the same property as the existing Duff No. 1 WTP, to increase withdrawals from the Rogue River to 125 mgd. It described the early planning conclusions for this facility, including the selection of a membrane filtration and ozonation process, and integration of the No. 1 and 2 plants. The intent is that the process selection will be reviewed and refined during a preliminary design, because the understanding of the source water quality, treatment options, regulations, and treatment equipment will continue to evolve in the interim. No further evaluations of the Duff No. 2 intake or treatment plant were included in the present plan.

According to the updated demand projections presented in this report, the initial 20 mgd treatment capacity of Duff No. 2 WTP will be needed by year 2043. To meet this date, the design will need to commence in 2038. MWC has already obtained the environmental permit for the plant site and is currently working with permitting agencies to secure the intake permit. MWC plans to conduct the design and construction of the No. 2 intake facility prior to the 10-year limit of the river permit, which will be in 2024-2026.

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Acronyms and Abbreviations

ADD	average day demand
BBS	Big Butte Springs
cfs	cubic feet per second
CIP	capital improvements plan
CPC	contaminant of potential concern
CT	product of chlorine residual and contact time (used for monitoring primary disinfection)
E. coli	Escherichia coli (bacteria)
EPA	United State Environmental Protection Agency
EPID	Eagle Point Irrigation District
FTW	filter-to-waste
gpm	gallons per minute
GWUDI	groundwater under the direct influence of surface water
HSPS	high service pump station
LRAA	location running annual average (as applied to DBP monitoring)
MCL	maximum contaminant level
MDD	maximum day demand
mgd	million gallons per day
MPA	microscopic particulate analysis
MWC	Medford Water Commission
SCADA	supervisory control and data acquisition
TOC	total organic carbon
TTHM	total trihalomethanes
UV	ultraviolet
WHO	World Health Organization
WTP	water treatment plant

Introduction and Planning Goals

1.1 Introduction

The *Big Butte Springs and Duff Water Treatment Plant Facility Plan* provides a capital improvements plan (CIP) for improvements and expansion of the Medford Water Commission's two water supplies. It is a companion plan to the *Water Distribution System Facility Plan* and the *Water Management and Conservation Plan*, both of which were prepared during the same time. It builds on the August 2008 *Robert A. Duff Water Treatment Plant Facility Plan*. Many of the projects described in the 2008 plan have been implemented by MWC in the years since that plan was completed.

The MWC relies on two water supplies, the Big Butte Springs (BBS) and the Rogue River. BBS provides up to 26.4 million gallons per day year-round. The Rogue River supply is treated in the Robert A. Duff Water Treatment Plant (Duff No. 1 WTP), which has a current summertime treatment capacity of 45 mgd.

The current unit cost for water obtained from BBS is considerably less than the unit cost for water obtained from the Duff No. 1 WTP because the treatment requirements and power costs for BBS spring water are low compared to those for the river supply. The BBS requires disinfection, only, and flows by gravity to the system, whereas the Rogue River supply requires extensive treatment and must be pumped to deliver it to customers. Eventually, portions of both BBS transmission lines will require replacement and these projects could require major investments.

Based on data provided by MWC for recent years, the unit cost for BBS water is approximately $0.066 per 1000 gallons. This cost covers the operation of the chlorination system, transmission line maintenance, watershed management, and similar expenditures. The cost for Duff No. 1 WTP water is about ten times higher at approximately $0.50 per 1000 gallons. Labor and power are large components of the ongoing costs for Duff No. 1 WTP.

1.2 Planning Goals and Expansion of Duff No. 1 WTP

This facility plan was prepared to determine a CIP that addresses current water supply needs and investments needed to address projected demand growth.

The term water supply is used to describe all system components needed to deliver water to the distribution system. These components include the BBS collection and treatment facilities, the BBS transmission pipelines, and the Rogue River intake, treatment, and pumping facilities. It is common practice for water utilities to size water supply facilities to be equal to or greater than the anticipated maximum day demand (MDD), which is the highest single day demand that is anticipated during the year. Storage within the distribution system is provided to meet the peak demand periods during that day, as well as to provide supply for fighting fires or short-term emergencies. If the MDD exceeds the water supply capacity for a longer than anticipated duration, the distribution storage will decline putting the system at risk of a shortage. The occurrence of successive days of demands exceeding supply will bring about the need for curtailment.

MWC's 2016 MDD was approximately 62 mgd. Based on population projections for the MWC service area, the demand is expected to grow by about 1.24 percent per year for the coming 20 years, resulting in a MDD of 79.3 mgd in 2036.

The BBS provides up to 26.4 mgd. The Duff No. 1 WTP has a treatment capacity of 45 mgd, allowing it to deliver approximately 41.9 mgd to the system when the water used for backwashing filters is taken into account. Therefore, the current delivery capacity into the system is 68.3 mgd.[1]

The proposed next increment of expansion for Duff No. 1 WTP will bring the treatment capacity to 65 mgd and the delivery capacity to 60.5 mgd. Together with the supply of 26.4 mgd from BBS, this will increase the system production capacity to 86.9 mgd. As MWC demands approach this value, a further capacity increase will be accomplished by adding the Duff No. 2 WTP, which also will withdraw water from the Rogue River. The initial increment of the Duff No. 2 WTP is planned for a treatment capacity of 20 mgd and a delivery capacity to the system of 18.6 mgd. The first phase of Duff No. 2 WTP will need to be online by 2043, according to the demand projections presented in this plan.

Figure 1-1 summarizes the expansion plans for MWC's water supply. The expansion of Duff No. 1 to a treatment capacity of 65 mgd is scheduled to be completed by year 2022. The specific expansion plans include the following increments:

- Complete construction of flocculation-sedimentation basin improvements to improve treatment and prepare plant for year-round operation (2016-2018)
- Conduct pilot testing to guide filter expansion and use of ozone system (2018-2019)
- Rehabilitate Filters 5-8 by replacing media, support gravel, and possibly underdrains (2019-2021)
- Add four filters to obtain 65 mgd plant capacity (2019-2021)
- Replace raw water Pump No. 5 with a 22.5 mgd pump with a variable speed drive and 500 hp motor to obtain 65 mgd capacity (2020-2021)
- Add new high service pump building, pumps, and expand surge protection to obtain 65 mgd capacity (2020-2022)
- Add two solids handling basins to support the 65 mgd treatment capacity (2020-2022)
- Evaluate opportunity and costs for using ozone to achieve primary disinfection for 65 mgd capacity versus adding reservoir storage, with determination of possible locations for reservoir addition (2018-2019).

1.3 Wintertime Operation of Duff No. 1 WTP

Currently, Duff No. 1 WTP operates only during the summertime peak water use period because the current late fall through early spring demands are less than the 26.4 mgd capacity of BBS. Recent annual day demands (ADDs) have been approximately 30 mgd for the MWC system; however, the ADD is an annual average that accounts for summer peaks. The recent non-summer demands have ranged from 19-23 mgd, which is below the 26.4 mgd production capacity of BBS.

[1] In this report, the terms withdrawal, treatment capacity, gross production, and raw water flow are equivalent, and refer to the flow rate of water being delivered to the treatment plant. The terms production, finished water production, net production, finished water flow, and delivery capacity are equivalent and refer to the flow rate of water that can be delivered to the customers. The two values are identical for the BBS because no water is used in the treatment process; its withdrawal rate is equal to the production rate delivered to customers. However, for the Duff No. 1 WTP, the finished water production is equal to about 93% of the withdrawal rate. About 7% of the treated water is used for backwashing filters or other in-plant uses. For example, when Duff No. 1 WTP is fully expanded to a treatment capacity of 65 mgd, it will be capable of delivering approximately 60.5 mgd to customers in the system (65 - (7% x 65) = 60.5).

System growth will cause the demands in the late fall through early spring period to approach the capacity of BBS in the coming years. In 2015, the Duff No. 1 WTP operated from May through October. This period of operation may further lengthen to April through October and at some point, a shift will be made to year-round operation.

MWC's current thinking is that the operation of Duff No. 1 WTP should change to year-round when the winter demands reach approximately 24 mgd, which is within 2-3 mgd of the BBS capacity of 26.4 mgd. This 2-3 mgd margin is necessary because it can take up to 4 weeks to perform long-term shutdown of the plant and about the same time to return it to full service. Therefore, if only BBS is supplying the system and demands are close to 26.4 mgd, a small increase in demands so they exceed 26.4 mgd would put the system at a shortfall. The period when the plant is maintained active year-round but needs only to produce a small amount of water to supplement BBS will complicate operations. The operators will need to find the right balance between keeping the plant active and yet maximizing the percentage of water supplied by BBS, since the BBS supply has a lower unit cost than the Duff supply.

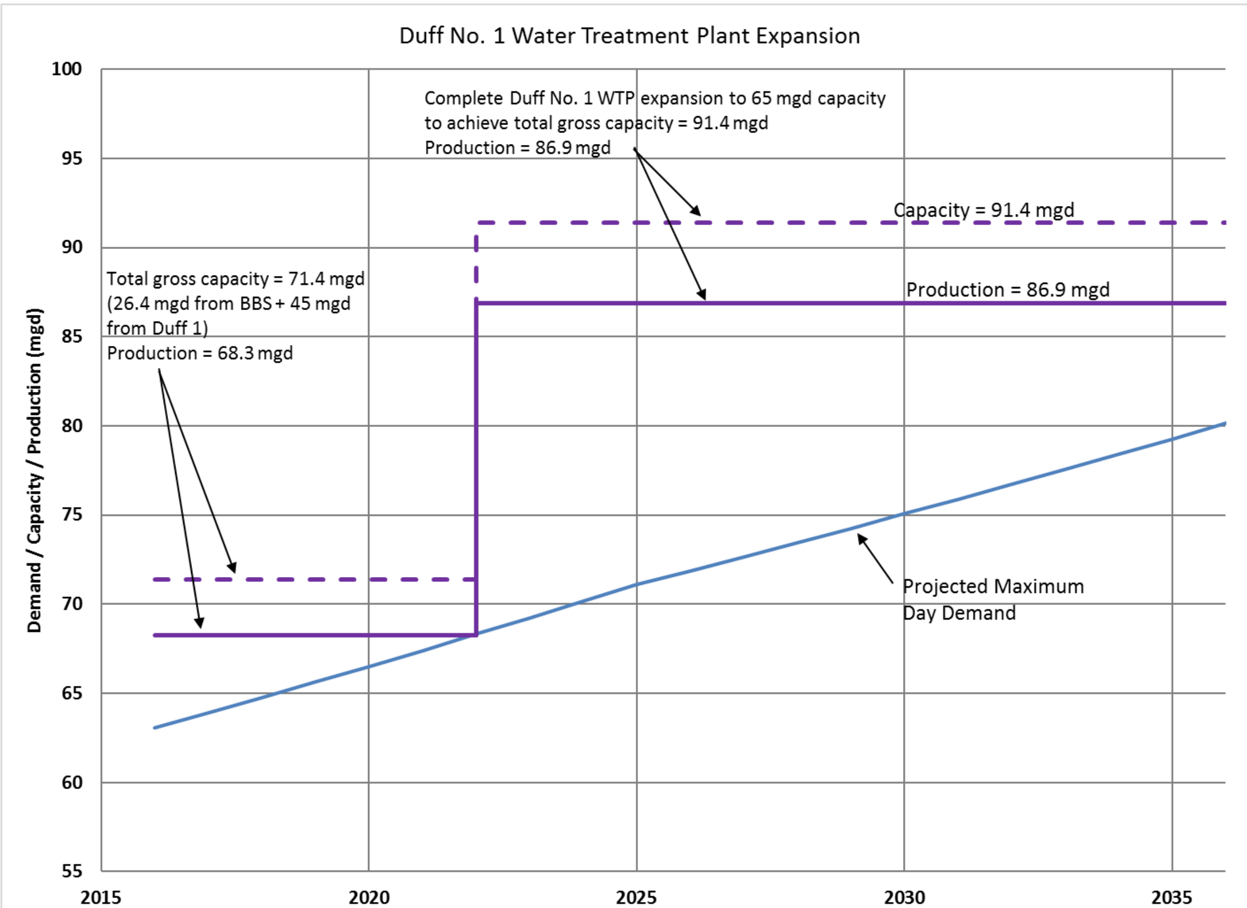

Figure 1-1. Expansion Plans for Duff No. 1 Water Supply

Figure 1-2 illustrates seasonal demands as projected for 2022. The broad line reflects the normal variations in demands plus the uncertainty of demand projections. Because of these factors and because starting and stopping Duff No. 1 WTP requires several days, the plant will need to begin year-round operation as wintertime demands approach the BBS capacity of 26.4 mgd. This may occur as early as 2022.

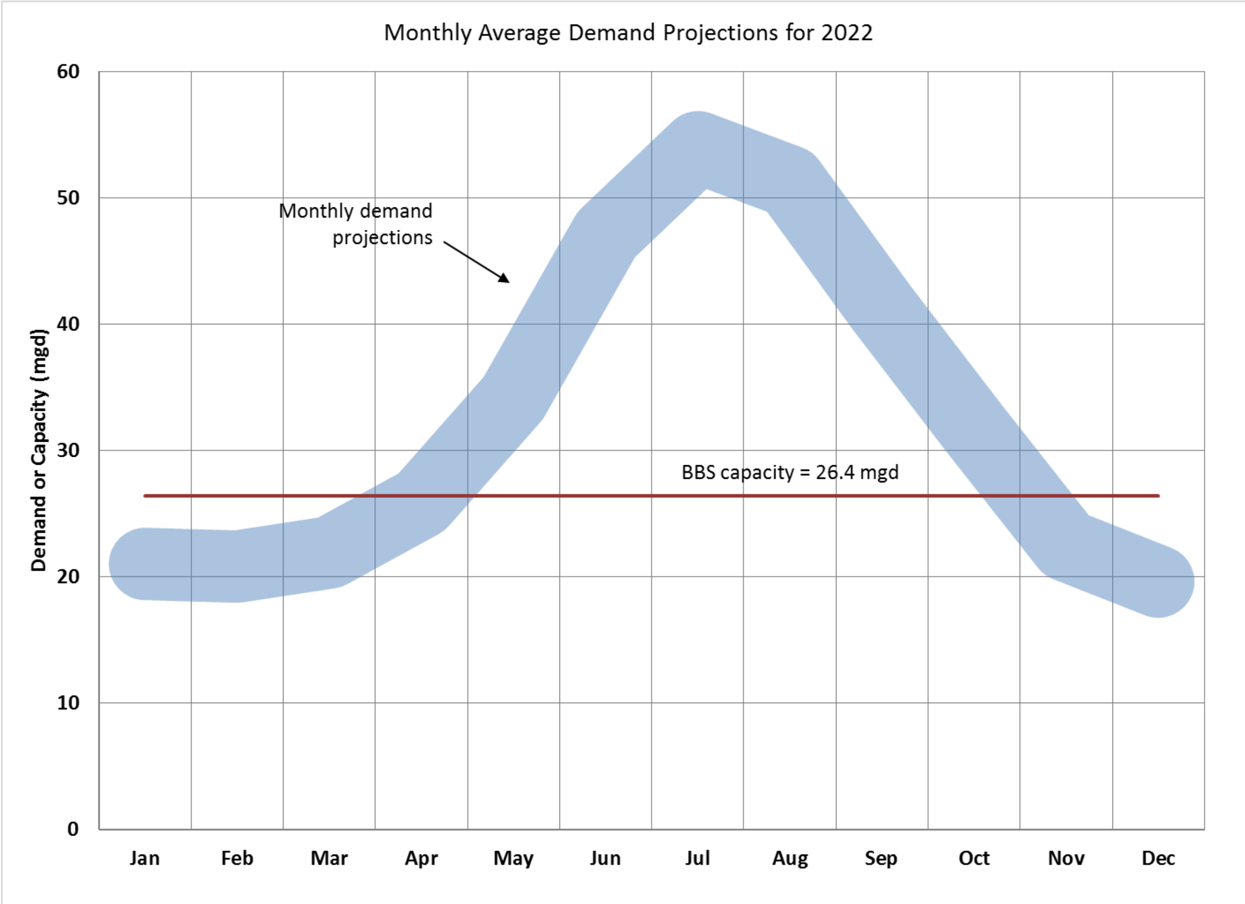

Figure 1-2. MWC Seasonal Demands and Impact on Year-Round Operation of Duff No. 1 WTP

1.4 Addition of Duff No. 2 WTP

A significant effort during the 2008 plan development was evaluating options for the Duff No. 2 WTP. It was decided that the plant would be constructed next to Duff No. 1 WTP and would draw from the Rogue River with an intake in the vicinity of the existing Rogue River intake. In the years since, MWC has moved forward on purchasing additional property along the river to provide space for the second intake, and has begun permitting activities to reserve the land needed for the plant. Figure 1-3 illustrates the timing for adding the first phase of Duff No. 2 WTP based on the current demand projections. According to this timeline, the design effort would begin in 2038 with a construction completion and startup date of 2043. The plan is to construct Duff Intake No. 2 in 2024-2026, prior to expiration of the environmental permit. The second intake will provide redundancy to the existing intake during the years before Duff No. 2 WTP is constructed.

Since the Duff No. 2 water supply represents such a large investment, MWC will continue to carefully track system demand growth and will adjust the timing for this project accordingly. Furthermore, the preliminary process selection made during the 2008 planning should be reevaluated in light of treatment technology advancements and regulatory changes that will certainly occur in the intervening years.

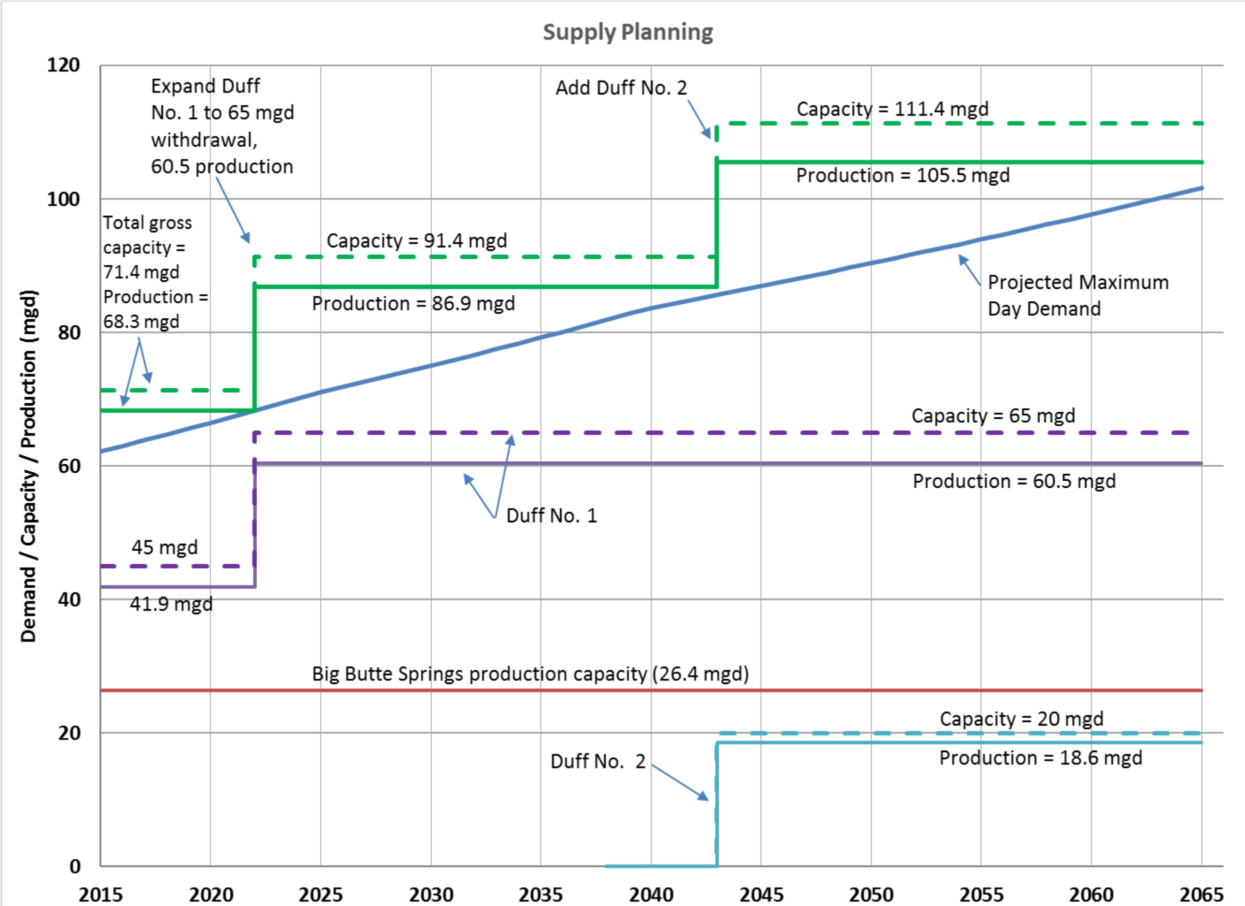

Figure 1-3. MWC Water Supply Plan

1.5 Project Team

The following individuals served on the MWC Board of Commissioners, or were involved in the preparation of this plan representing MWC or CH2M:

<u>MWC Commissioners</u>

Leigh Johnson, Chair
Lee Fortier, Vice Chair
John Dailey
Jason Anderson
Bob Strosser

<u>MWC Staff</u>

Larry Rains, Manager
Eric Johnson, Principal Engineer and Project Manager
Jim Stockton, Water Treatment Director
Rosie Pindilli, Water Quality Director
Bob Jones, Geologist
Ken Johnson, Operations Superintendent

<u>CH2M</u>

Paul Berg, Project Manager
Jennifer Henke, Senior Engineer
Sheryl Stuart, Project Engineer
Kim Ervin, Senior Engineer

Big Butte Springs

2.1 Description

MWC's primary source of water is from the BBS. This source supplied 73 percent of the system's total annual demands in 2015. MWC staff have estimated that the springs' capacity ranges from 25 to 35 mgd depending on seasonal rainfall, snow pack, and groundwater conditions, but the transmission piping limits delivery to a maximum of approximately 26.4 mgd.

2.1.1 Water Rights

BBS diversions are allowed under Certificate 53323 (30 cfs), Certificate 86994 (10.8 cfs) which is a partial perfection of Permit S-6703, and Permit S-6884 of which 3.1 cfs has been developed from Rancheria Spring. When the natural flow from the headwaters and BBS are insufficient to meet the full water rights of MWC and Eagle Point Irrigation District (EPID), stored water is released from Willow Lake under Certificates 87017 and 86995.

MWC holds water rights for Big Butte Creek, as does EPID. In 1952, MWC constructed the Willow Creek Dam, to form the 350 acre Willow Lake with a usable surface water storage capacity of 8,000 acre-feet or 2.6 billion gallons. MWC releases water from Willow Lake to increase flow in Big Butte Creek for use by EPID, and thereby allows a greater portion of high quality spring water to be used by MWC while satisfying EPID. Depending on drought conditions and the needs and rights of EPID, there may be times when MWC cannot obtain the full 26.4 mgd capacity of BBS. Additional details on water rights for BBS are provided in the 2016 *Water Management and Conservation Plan*.

2.1.2 Facilities

BBS is comprised of seven individual spring collection systems, which are interconnected to feed the two transmission pipelines. The springs are located about 22 miles northeast of Medford, within the Rogue River watershed boundary. MWC owns approximately 3300 acres of property surrounding the springs. In addition to the individual spring collection boxes and piping, the BBS facility includes a central chlorination and controls building, two smaller buildings near the central building where chlorine is injected into each transmission pipeline, and a caretaker's house. A MWC employee serves as the caretaker and operator of the springs, and lives on the property to provide security and 24/7 operational service.

The central building is relatively new and in good condition. It houses a sodium hypochlorite chemical system and instrumentation and controls. Three 2500-gallon tanks are used to store 12.5 percent hypochlorite solution. On-line instruments in the building include chlorine, turbidity, and pH analyzers for each transmission pipeline. Water samples for the online instruments are withdrawn from the transmission pipelines a short distance downstream of the chemical injection points, and piped back to the central building.

The BBS system delivers water by gravity flow to Medford except for low lift pumping. The Rancheria Spring is located on the BBS property but is at a little lower elevation than the other springs. Water from this spring is pumped into one of the transmission pipelines downstream of the chlorine feed point. The operators account for this downstream introduction of water by adjusting the chlorine dose appropriately. Springs 1-3 are also pumped up to the 1927 intake during the summer season.

The Rancheria Spring is only used in the late summer/early fall, if the production from the other springs is less than the transmission capacity of 26.4 mgd. This decision has been made both because this water requires pumping and because it may be the one spring that is surface water influenced, as described later in this section. The regulatory term for surface water influence is groundwater under the direct influence of surface water (GWUDI).

Backup propane generators are installed onsite for both the central building, to power controls and the hypochlorite system, and at the Rancheria Spring pump building. Overhead lines deliver power and communications to the BBS facilities from Fish Lake Highway. The lines are occasionally damaged by storms and blowing branches.

The two transmission pipelines are both 24-inch nominal diameter steel. Pipeline No. 1, a welded steel line with a coal tar lining on the inside and coal tar coating on the outside, was installed in 1927. Pipeline No. 2 is a mechanically coupled steel line. It has a coal tar lining on the inside and a coal tar coating on the outside, and was installed in the early 1950s. Both lines are thought to be in good condition. MWC staff recently completed a rebuild of all existing cathodic protection sites and added sites. As of August 2016, both pipelines have full cathodic protection from the BBS site to the Capital Hill Reservoir Site. This cathodic protection system will extend the lives of the pipelines.

2.1.3 Treatment

All seven springs are currently classified as groundwater sources by the state with the only required treatment consisting of chlorination. According to the Oregon Public Health Drinking Water Data Online webpage, the required minimum chlorine level for BBS at the entry point to the distribution system, the first customer location on the transmission pipelines, is 0.25 mg/L.

Although the springs are currently classified as groundwater, the state has required MWC to sample each spring individually, upstream of chlorination, for total coliform and *E. coli* bacteria once per month during the calendar year 2016 to provide data for the state to assess each spring's classification. One possible outcome is that the state would consider one or more of the individual springs as a GWUDI. This finding would necessitate rebuilding one or more spring collection box and/or upgrading the level of treatment that is provided.

Table 2-1 summarizes sample results per spring through August 2016. Total coliforms have been detected in five of the springs with the greatest number of positive results from Rancheria Spring. All *E. coli* samples have been negative except for two samples from Rancheria Spring. *E. coli* measurements are considered to be the best indicators of significant contamination from human or animal sources but total coliform are also important as an indicator of surface contamination because they are not normally found in groundwater.

Table 2-1. Big Butte Springs Monitoring Results

Name	Total Coliform Positive	*E. coli* Positive
1927 Intake	1	0
East Intake	1	0
Rancheria	12	2
Spring #1	1	0
Spring #2	0	0
Spring #3	1	0
Spring #4	0	0

Based on the positive occurrence for *E. coli*, the state will require MWC to conduct microscopic particulate analyses (MPAs) for at least the Rancheria Spring. Partially buried concrete spring boxes have been installed to collect water from the other six springs. However, for the Rancheria Spring, water is collected using buried perforated pipe installed in rounded river rock. It does not appear that this collection method offers the same protection from surface water above the spring infiltrating into the collection system. MWC has recognized that improvements to the collection system for this spring may be warranted and will await the findings from the MPA testing to determine how to address this concern. Another option is to discontinue the use of Rancheria Spring.

If the eventual determination is that one or more springs are GWUDI and a rebuild of the collection system(s) was unsuccessful in eliminating surface influence, the following additional actions will be required according to Oregon Administrative Rules (OARs) Chapter 333, Section 061-0032:

- Conduct regular raw water bacteriological monitoring, including for *Cryptosporidium*
- Ensure that fecal coliform and turbidity levels remain within standards
- Conduct a prescribed watershed control program (an action already implemented by MWC, though some activities and reports may need adjustments to fully comply)
- Be subject to annual state onsite inspections of the watershed control program and the disinfection treatment process
- Apply a second disinfectant (in addition to chlorine) such as chlorine dioxide, ozone, or UV light to achieve at least 2-log inactivation of *Cryptosporidium*

The major change and major cost impact to MWC would be the addition of a second disinfectant system. UV disinfection is almost certainly the disinfectant of choice based on cost and complexity considerations, as compared to using chlorine dioxide or ozone. MWC has already collected UV absorbance data for BBS water in case it becomes necessary to use UV disinfection. The data show that UV transmittance values are very high (ranging from 97.2 to 99.5 percent, with an average of 98.5 percent) for two and one-half years' of data. The high transmittance will minimize the expense of a UV system, although it would still represent a major capital as well as operating investment for MWC. A UV treatment system would require installation of treatment equipment, additions and modifications to the building and controls to accommodate this equipment, and electrical supply and backup power improvements.

2.1.4 Hydropower Generation

Currently, the BBS transmission pipelines deliver water to the Coalmine station with excess head. Pressure reducing valves are used at the Coalmine station and the upstream Nichols Gap station to reduce pressures prior to water entering the MWC distribution system. An option that MWC has considered, and was preliminarily evaluated during the course of the present project, was using this excess head to generate electricity using in-pipe turbines.

Hydropower generation is allowed in Oregon under an expedited water rights process when withdrawals are limited to the amounts used for drinking water production. The expedited process allows MWC to obtain a hydroelectric certificate for water being used for municipal purposes under an existing water right. This would be a relatively straightforward process with little risk or cost. The expedited process would not allow MWC to withdraw more water from BBS than will be used for municipal supply.

The excess pressure available for hydropower generation at Coalmine station is approximately 15 psi, based on discussions with MWC staff. Further analysis of the available head would be warranted before proceeding with a project. Using the 15 psi value and considering the recent withdrawal rates for BBS, the estimated power production and gross revenue from the power can be estimated as shown in Table 2-2. The estimated value of the energy is $32,000 per year. While this represents an opportunity for MWC, it introduces some risk that the hydraulic changes in the transmission piping system would have unintended consequences to the system. A pressure surge that could possibly damage the pipelines is a major concern to MWC because of the system's reliance upon BBS and the low cost water it provides. Primarily because of this concern, MWC decided against pursuing hydropower generation.

Table 2-2. Hydropower Generation and Revenue Estimates

Month	Flow (mgd)	Flow (cfs)	Head (ft)	Potential Power (kW, assumes 55% overall efficiency)	Annual Power Production (kWh, assuming 80% operation)
Jan	19.8	30.6	35	50	30,000
Feb	19.8	30.6	35	50	36,000
Mar	19.8	30.6	35	50	30,000
Apr	19.8	30.6	35	50	29,000
May	19.8	30.6	35	50	30,000
Jun	26.4	40.8	35	66	38,000
Jul	26.4	40.8	35	66	39,000
Aug	26.4	40.8	35	66	39,000
Sep	26.4	40.8	35	66	38,000
Oct	19.8	30.6	35	50	30,000
Nov	19.8	30.6	35	50	29,000
Dec	19.8	30.6	35	50	30,000
TOTAL kWh					**398,000**
Gross annual revenue generation at $0.08 per kWh					**$32,000**

2.1.5 Capital Upgrades

The near-term improvements to be considered for BBS consist of the following:

- BBS1. Rebuild Rancheria Spring to improve water quality.
- BBS2. Depending on the outcome of MWC's corrosion study, possibly add a corrosion control chemical system. If a new chemical system is added, MWC may also wish to review staffing levels for operation and maintenance of BBS.
- BBS3. Replace the insertion meters located at the upstream end of the transmission pipelines, at the BBS complex, with magnetic meters on both transmission pipelines to provide better accuracy in flow readings. MWC staff have noted that the existing meters at BBS provide data of uncertain quality although the meters downstream at Coalmine Station are considered to provide accurate data. A preliminary construction estimate for replacing the meters is $50,000. The lack of accurate meters at this location does not allow MWC to monitor and record water flows in the transmission pipelines above Coalmine station with the desired level of certainty.
- BBS4. Install power and communication lines in underground conduit from Fish Lake Highway to the central chlorination and controls building to improve power supply reliability. MWC staff have performed preliminary analyses for installing these underground utilities and believe the construction cost may be approximately $300,000.

If, following the rebuild of Rancheria Spring, surface water influence is observed, or if other springs show surface water influence, MWC will need to implement changes to comply with the treatment requirements for GWUDI. This would involve the installation of a UV disinfection system along with ancillary components such as the extension of three-phase power to the site, additional backup power, a new building or buildings, and control and instrumentation upgrades.

MWC has also considered whether upgrades to the chlorine feed lines are warranted. Alternatives proposed include installing duplicate feed lines with containment or installing backup feed systems at each chemical injection facility. No conclusions have been reached at this time, so neither of these improvements have been included in the capital plans.

A significant long-term project, the timing for which is unknown, is replacement of portions of and eventually the entire BBS transmission pipelines. The two existing pipelines each have a length of approximately 26 miles. Based on MWC's inspections and conclusion that both pipelines are in good condition, MWC decided not to include a rehabilitation or replacement project for portions or all of the lines in the current CIP. The need for a rehabilitation or replacement project should be examined carefully in future updates because this will be a substantial project for MWC. For example, if replacement was found to be necessary and if a single 36-diameter pipeline was sufficient to replace the carrying capacity of both pipelines, the cost for the new pipeline might approach $60 million dollars. It is unlikely that full replacement of both lines will occur at one time. More likely, MWC will begin a series of projects to replace sections of the lines as they begin to fail.

Rogue River Supply

In addition to BBS, MWC obtains water from the Rogue River. MWC operates an intake on the river at River Mile 131.3, just downstream of the Table Rock Road Bridge and about 3 miles north of the Medford city limits. Water is pumped from this intake to the Duff WTP, generally called the Duff No. 1 WTP in this report to distinguish it from a proposed Duff No. 2 WTP planned for the same location.

Duff No. 1 WTP was initially put into service in 1968 with a treatment capacity of 15 mgd.[2] The treatment capacity was subsequently expanded to 30 mgd in 1983 and to its present, 45-mgd treatment capacity through a series of projects beginning in 1998. The rapid mix and flocculation improvements made at that time led to the state's classification of the plant as conventional filtration, with a filtration credit of 2.5 log removal for *Giardia* cysts for the 45 mgd summer capacity. However, the flocculation and sedimentation loading rates are high. The improvements to the flocculation/sedimentation pretreatment processes, currently under construction, will enable the plant to perform as a conventional filtration plant up to the planned capacity of 65 mgd, once other needed expansions have been completed. The plant is expected to operate effectively year round but to date, has only been used during the summer period.

Figure 3-1 provides a process schematic for Duff No. 1 WTP and Table 3-1 provides a tabular summary of the major processes and their capacities.

3.1 Water Rights

MWC holds a 1954 municipal water use permit (Permit S-23210) for withdrawing 65 mgd (100 cubic feet per second, or cfs) with a point of diversion located at MWC's existing intake. Of this right, 60.85 cfs (39.3 mgd) was certificated (Certificate 86832) for use by Medford. Permit S-23210 for 39.15 cfs has been extended to 2050 with fish persistence conditions. The planned expansion to 65 mgd (100 cfs) will enable full use of Permit S-23210. However, since this facility also treats water associated with water rights held by other cities served, Duff No. 2 WTP will be needed to fully exercise municipal Rogue River water rights. Additional information about water rights was provided in the 2016 *Water Management and Conservation Plan* that was prepared in parallel with this facility plan.

3.2 Recent Upgrades to Duff No. 1 WTP

Since the 2008 master plan, MWC has or is completing the following major improvements and expansions for Duff No. 1 WTP:

- Replaced the traveling screens at Intake No. 1 with tee screens in 2009
- Replaced one high service pump to achieve a total capacity of 60 mgd and a firm capacity of 45 mgd in 2010
- Modified the interconnections and hydraulics of the finished water reservoirs in 2012
- Added a second filter backwash pump, for redundancy, in the existing high service pump room in 2013

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[2] See previous footnote on page 1-2 regarding treatment capacity. The delivery to the customers from the plant is approximately 93% of the raw water flow entering the plant. Raw water flow is equivalent to the treatment capacity. The delivery capacity to the customers is approximately 7 percent less than the treatment capacity because treated water is used for backwashing filters.

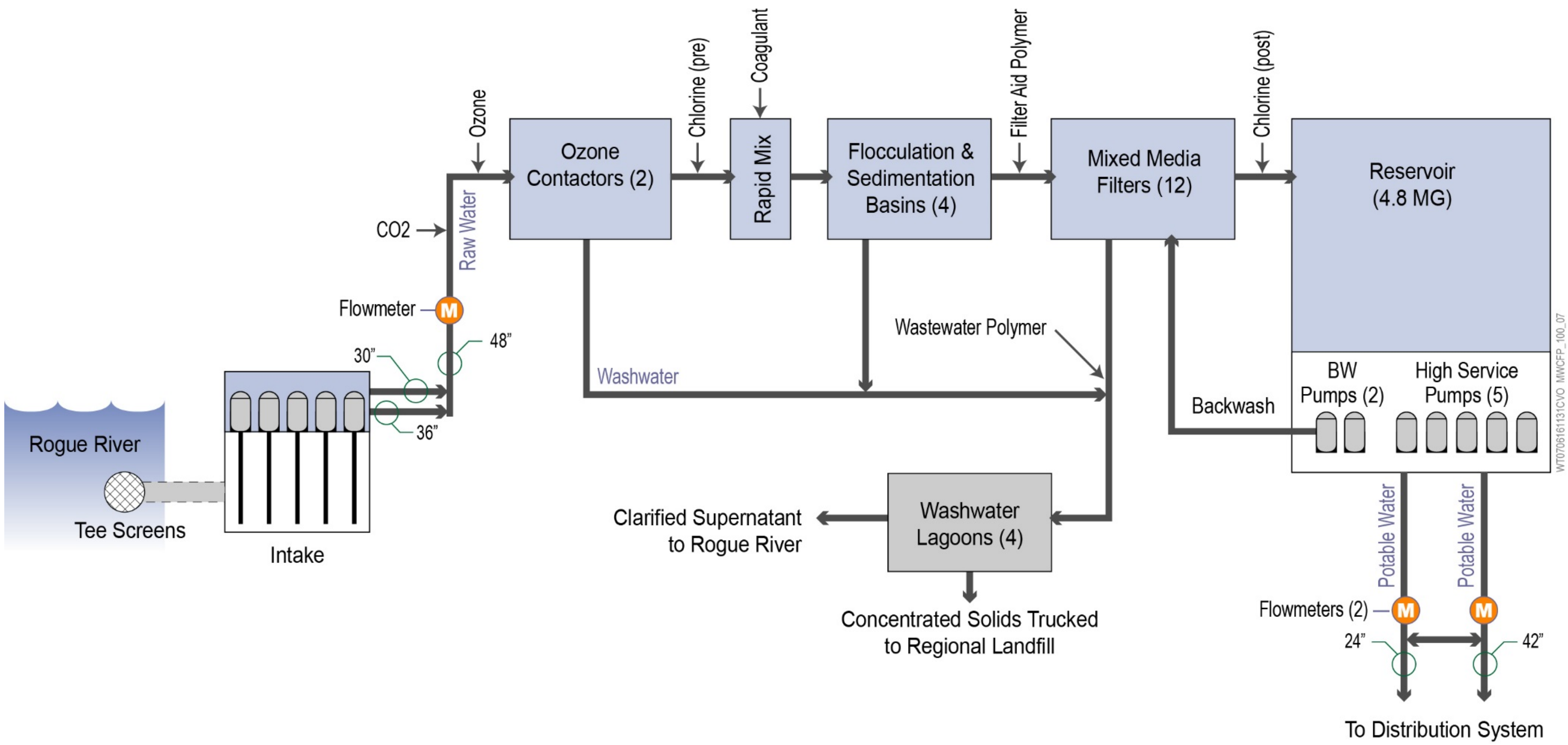

Figure 3-1. Duff No. 1 Process Schematic

- Upgraded the raw water pumps at the Intake No. 1 facility in 2015 to achieve a total capacity of 75 mgd and a firm capacity of 52 mgd
- Replaced the rapid mix, flocculation, and sedimentation with improved facilities, including the use of plate settlers (work ongoing, with completion planned by summer 2018)

Table 3-1. Duff No. 1 WTP Design Data Summary

Process	Existing Size or Capacity	Units	Notes
Plant Capacity			
Design Capacity Summer	45	mgd	
Nominal Capacity Wintertime	23	mgd	
Design Capacity Summer	31,000	gpm	
Nominal Capacity Wintertime	16,000	gpm	
Buildout Summertime Capacity	65	mgd	
Buildout Summertime Capacity	45,100	gpm	
Intake			
Type	Tee screens		
Capacity	65	mgd	
Raw Water Pumping			
Type	Vertical turbine		
Number of Pumps	5		
Capacity, pump No. 1	5,200	gpm	Constant speed; 200 hp; relocated in 2015
Capacity, pump No. 2	10,500	gpm	Variable speed; 400 hp; installed in 2015
Capacity, pump No. 3	15,625	gpm	Constant speed; 500 hp; installed 1982
Capacity, pump No. 4	15,625	gpm	Constant speed; 500 hp; installed 1995
Capacity, pump No. 5	5,200	gpm	Variable speed; 200 hp; installed 2007
Combined approximate capacity	75	mgd	All pumps running; does not allow for redundancy
Combined approximate capacity	52,000	gpm	All pumps running; does not allow for redundancy
Approximate firm capacity	52	mgd	One large pump out of service
Approximate firm capacity	36,000	gpm	One large pump out of service
Discharge head at 60 mgd	108	psi	Approximate
Raw Water Transmission Pipelines			
Diameter	30, 36, and 48"	inches	Parallel 30" and 36", followed by single 48"
Length	1,000	feet	
Capacity	65	mgd	
Ozone Contactors			
Number	2		
Type	baffled		
Volume, each	281,500	gallons	
Theoretical Detention time	12.5	minutes	At 65 mgd
Efficiency	70%		T10/T = 70%
T10 Detention time	8.8	minutes	At 65 mgd

Table 3-1. Duff No. 1 WTP Design Data Summary

Process	Existing Size or Capacity	Units	Notes
Rapid Mix			
Type	Side stream injection, 65 mgd		Side stream injection, sized for 65 mgd, will be placed into operation in 2018
Drive Type	Variable speed		
Flocculators			
Type	Vertical turbine, 3-stage, variable speed		Scheduled for completion in 2018
Number of Trains	4		
Detention Time	35	minutes	At 65 mgd
Sedimentation Basins			
Type	Inclined plate		Scheduled for completion in 2018
Number	4		
Hydraulic detention time	34	minutes	At 65 mgd
Sludge collection system	Chain and flight		
Filters			
Number	12		
Type	Gravity		
Area, each	528	square feet	
Total Area	6336	square feet	
Design Filter Rate	4.9	gpm/sf	For 45 mgd production; all filters in service
Design Filter Rate (one in BW)	5.4	gpm/sf	For 45 mgd production
Bed Design	mixed media		
Depth Anthracite	18	inches	
Depth Silica Sand	9	inches	
Depth Garnet	3	inches	
Total Fine Media Depth	30	inches	
Filter Underdrain Type			
No. 1-4	Wheeler		
No. 5-8	BIF Hydrocones		
No. 9-12	Leopold blocks		
Filter Backwash			
Number Pumps	2		
Type	Vertical Turbine		
Pump Capacity	11,000	gpm	Approximately 42.4 ft head
Pump Motor Size	150	hp	
Maximum Backwash Rate	19.9	gpm/sf	
Typical Duration, minutes	12.5	minutes	
Wastewater volume per backwash	76,000	gallons	Based on average metered volume

Table 3-1. Duff No. 1 WTP Design Data Summary

Process	Existing Size or Capacity	Units	Notes
Filter to Waste			
Typical Duration	20	minutes	
Wastewater FTW volume	26,600	gallons	Calculated, using 1330 gpm for 20 minutes
Combined Backwash and Filter to Waste			
Combined volume (BW + FTW)	102,600	gallons	Typical per filter backwash and restart
Ozone System			
Generation capacity	1,200	ppd	Two 600 ppd generators
Maximum applied dose	2.2	mg/L	At 65 mgd
Finished Water Storage: Reservoir and Clearwell			
Volume, gals	4,800,000	gallons	
Summer Nominal Detention Time	106	minutes	Entire volume divided by 65 mgd
Reservoir Efficiency (T10/T)	29%		Based on field tests conducted in 2013
Capacity for depth of 10 feet:			
Summer capacity	39	mgd	0.5 log, 14°C, 7.5 pH, 0.6 mg/L
Fall capacity	37	mgd	0.5-log, 10°C, 7.5 pH, 0.6 mg/L
Winter capacity	27	mgd	0.5-log, 5°C, 7.5 pH, 0.6 mg/L
Spring capacity	29	mgd	0.5-log, 8°C, 7.5 pH, 0.6 mg/L
Capacity for depth of 12 feet:			
Summer capacity	47	mgd	0.5 log, 14°C, 7.5 pH, 0.6 mg/L
Fall capacity	45	mgd	0.5-log, 10°C, 7.5 pH, 0.6 mg/L
Winter capacity	33	mgd	0.5-log, 5°C, 7.5 pH, 0.6 mg/L
Spring capacity	35	mgd	0.5-log, 8°C, 7.5 pH, 0.6 mg/L
High Service Pumps			
Type	Vertical turbine		
Number of Pumps	5		
Capacity, pump No. 1	5,800	gpm	450 hp, installed in 1968
Capacity, pump No. 2	5,400	gpm	450 hp, installed in 1968
Capacity, pump No. 3	10,500	gpm	900 hp, installed in 2010
Capacity, pump No. 4	10,500	gpm	800 hp, installed in 1981
Capacity, pump No. 5	10,500	gpm	900 hp, installed in 1995
Combined approximate capacity	60	mgd	
Combined approximate capacity	42,000	gpm	
Approximate firm capacity	45	mgd	With one large pump out of service
Approximate firm capacity	31,000	gpm	With one large pump out of service
Discharge head at 60 mgd	260	ft	

As part of the Long-Term 2 Enhanced Surface Water Treatment Rule, MWC is conducting a second round of *Cryptosporidium* monitoring on the source water for the plant from October 2015 through September 2017. The October 2015 sample results found zero *Cryptosporidium* oocysts. The monthly sampling resumed when the plant began operating in May 2016. The results for May, June, July, and August were all zero *Cryptosporidium* oocysts. It is not expected that the sampling will detect high enough levels of *Cryptosporidium* oocysts such that additional treatment processes will be required.

3.3 Duff No. 2 WTP

A detailed analysis of expansion options for the time when system demands exceed the combined capacity of BBS and Duff No. 1 WTP was conducted during the 2008 facility plan work. The decision was made to address future needs by the addition of what has been termed the Duff No. 2 WTP, which will also draw water from the Rogue River near the Table Rock Road Bridge and will be treated in a plant located next to Duff No. 1 WTP.

MWC has been working since the 2008 plan to secure its water rights for the Duff No. 2 intake on the Rogue River. This work has included purchase of a second property along the river, just downstream and adjoining the existing intake property. MWC is in the process of preparing the Joint 404 permit application to secure this future withdrawal and allow for construction of the river intake. Permits have been obtained from the Division of State Lands and the U.S. Army Corps of Engineers for the plant construction on the property north of the Duff No. 1 WTP. These permits require the management and maintenance of a Vernal Pool Preserve in perpetuity according to a plan approved by these two agencies and the U.S. Fish and Wildlife Service.

3.4 Production History for Duff No. 1 WTP

The existing Duff No. 1 plant is currently rated for a summertime treatment capacity of 45 mgd and a wintertime treatment capacity of approximately 23 mgd. The finished water production, the water that can be delivered to customers, equals the treatment capacity minus the water used for backwashing filters and other in-plant uses. The production efficiency equals the finished water production divided by the rate of river withdrawal.

To date, the highest hourly finished water production rate achieved through the plant was approximately 30,400 gallons per minute (gpm). This would be equivalent to 44 mgd if the production rate had been sustained over a full 24 hours (and not taking into account water used for backwashing filters), but the plant was only operated at this rate for about one hour. During this same day, July 1, 2015, the finished water production rate averaged 28,700 gpm from 5:00 am until 11:00 am.

The highest recent production for a single day occurred on the following day, July 2, 2015, when the net production for the day was 35.9 mgd. The daily finished production for June 30 through July 2, 2015, averaged 35.8 mgd.

It is thought that these values for finished water production are accurate, but the plant was undergoing control and instrumentation changes and therefore, did not accurately record values for the effluent (high service) water pumping. Therefore, there is uncertainty regarding the pumping and the production efficiency values during these days.

Recognizing that questions exist on the metering accuracy, the recorded production efficiency (delivered water divided by the river withdrawal) ranged from 88 to 94 percent for the peak summer months of 2014 and 2015. It has been lower during April, May, and October because of the part-time operation during these lower demand months. The filters are regularly backwashed even when the production is low, resulting in lower efficiencies during these months. The average efficiency during the high production months of 2014 and 2015 was approximately 93 percent, which is a typical level for a plant of this type. The use of the improved flocculation-sedimentation basins, scheduled for 2018, may improve the production efficiency.

System constraints, including limitations of the finished water transmission piping and system storage, have generally prevented the operators from producing a constant flow from the plant over a 24-hour period. Instead, production is ramped up steeply in the early morning to help maintain system reservoir storage during the peak demand periods. The production rate is reduced during the night or even completely shut off depending on system demands. In general, media filtration is most efficient for steady rates of production during the day. It is also less desirable from a treated water quality standpoint for the production rate to be frequently changed. The operators are careful to avoid abrupt and frequent rate changes but the limitations in the finished water transmission piping, storage, and pumping present a challenge to steady-state operation.

Since wintertime demands have remained less than the 26.4 mgd capacity of BBS, MWC has not needed to operate the plant during the winter months. Duff No. 1 could be brought on line should the BBS supply fail for any reason, but this has not happened. Because systems at the plant are shut down during the winter months, a few days are required for the plant to be brought online during an emergency and up to a few weeks for it to be brought online for continuous service.

Figure 3-2 displays Duff WTP finished water deliveries into the system for 2012-2015. Seasonal production has generally commenced in April and continued through September or into October. The peak monthly delivery over this period was 786 million gallons in July 2013, which is equivalent to an average of 25 mgd.

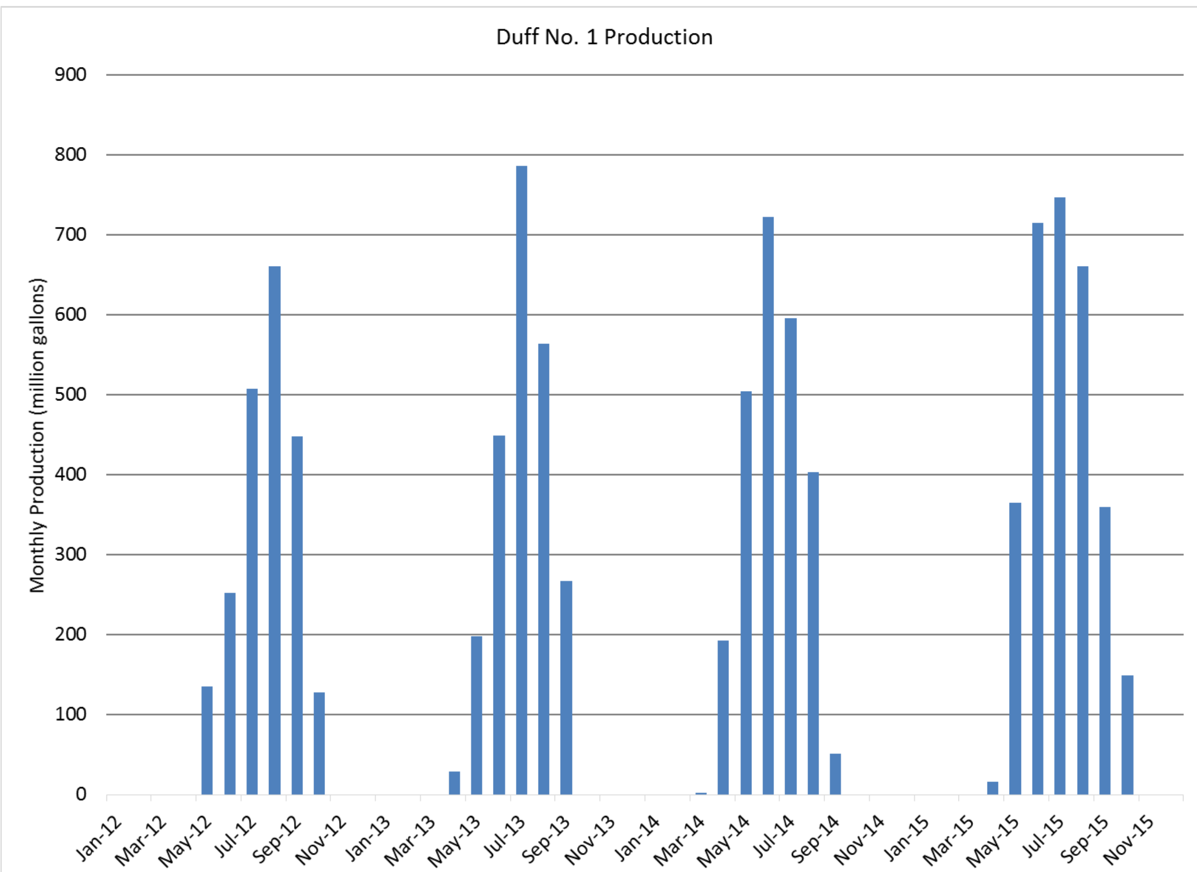

Figure 3-2. Recent Duff No. 1 WTP Production

3.5 Proposed Duff No. 1 Improvements

3.5.1 Filter Addition

A significant capital project for expanding Duff No. 1 WTP to 65 mgd is the addition of filters. MWC has preliminarily evaluated filter needs and believes that adding four filters, to increase the number from 12 to 16, is appropriate. This approach is consistent with previous expansion plans. However, MWC has also concluded that pilot testing of the system is warranted to determine the correct number and type of filters to obtain a robust yet cost-effective expansion.

Table 3-2 illustrates the filter loading rates for a range of production capacities for the existing 12 filters or an expansion to 16 filters. Each filter has an area of 528 square feet. The loading rate for the existing plant at the 45 mgd treatment capacity, with 1 of 12 filters off-line for backwash, is 5.4 gallons per minute per square foot of filter area (gpm/sf).

Table 3-2. Filter Loading Rates

Condition	River Withdrawal Rate (mgd)	Number of Filters	Filter Loading Rate (gpm/sf)
Existing plant, peak production	45.0	12	5.4
Expanded plant, peak production	65.0	12	7.8
Expanded plant, peak production	65.0	16	5.7

The peak summer filter loading rate of 5.4 gpm/sf for treating 45 mgd is reasonable for the existing filter media depth, media size, and available filter driving head. The filter rates for the existing plant provide an appropriate balance between minimizing risk and minimizing infrastructure.

The table also provides filter loading rates for the expanded plant with and without Filters 13-16. These rates are illustrated for the buildout treatment capacity of 65 mgd. If Filters 13-16 are added, the filter loading rate is 5.7 gpm/sf. This rate is similar to, though a little higher, than the current filter loading rate. Other options could be considered as well, such as adding fewer but larger area filters to achieve the expanded capacity.

If Filters 13-16 are not added, the rate for 65 mgd is high and may be unacceptable at 7.8 gpm/sf, particularly because the filters are relatively shallow. Even with the addition of approximately 12 inches of media (with modified underdrain systems that are lower in profile than the existing underdrains), the rate for 12 filters is marginal and may be too high. A third option is to install two new filters, bringing the total to 14 filters.

In addition to filter loading rate and its effectiveness for removing particles, the filter expansion needs to carefully consider plant hydraulics and ensure that the available driving head is sufficient to obtain efficient unit filter run volumes.

A pilot study would provide useful information for examining the questions surrounding the filter expansion. The filter piloting could consider issues such as floc carryover, headloss impacts in the filters, filter run times and unit filter run volumes, filter media type and depth selection, filter-to-waste times and quantities, and filtered water quality. This work could be combined with tests related to the ozonation system to look at the performance of a combined process system, as described in another section of this chapter. Particularly with pre-ozonation, MWC will wish to examine the use of biological filtration to produce a stable water quality in the distribution system.

3.5.2 Disinfection Limitations and Ozonation

Finished water is stored in two interconnected reservoirs and in the relatively small pump well located beneath the high service pump station (HSPS) room. Together, these tanks provide about 4.8 million gallons of storage that can be used for chlorine contact time following filtration. They also provide water supply for backwashing the filters. A third function they provide is a limited amount of storage to account for short-term mismatches between the plant production rate and the high service pumping rate.

Surface water treatment plants must comply with disinfection regulations by providing a chlorine residual multiplied by the chlorine contact time (CT value) equal to or greater than the CT value listed in the state and federal regulations. The regulated minimum CT value varies depending on the chlorine residual, water temperature, and pH. The regulatory tables list CT values to provide 3-log reduction of *Giardia* cysts. These values are divided by 6 to obtain the 0.5-log CT value, which is the level of disinfection that must be provided by Duff No. 1 WTP since it is considered a conventional filtration plant by the state.

The following conditions were used as being conservatively representative of seasonal conditions for Rogue River water treated in the Duff No. 1 WTP, meaning they are the conditions when high CT values are required:

- Summer: 14^{o}C, pH 7.5, 0.8 mg/L chlorine residual
- Fall: 10^{o}C, pH 7.5, 0.6 mg/L chlorine residual
- Winter: 5^{o}C, pH 7.5, 0.6 mg/L chlorine residual
- Spring: 8^{o}C, pH 7.5, 0.6 mg/L chlorine residual

They do not represent the absolute worst-case conditions but do reflect conservative values, with resulting high CT requirements. They are based on using a low temperature, a high pH, and a high chlorine residual for each season. It is possible that more extreme conditions, requiring a higher CT value, could occur on any given day.

An uncertain factor is that MWC plans to conduct a corrosion study and a possible outcome is to implement a corrosion chemical feed at the plant that would raise the pH. A higher pH would increase the required CT.

Table 3-3 summarizes the plant treatment capacity for the existing clearwell reservoir volume of 4.8 million gallons, based on meeting CT requirements. A reservoir short-circuiting factor of 29 percent was determined in July 2013 field tracer tests conducted by MWC with assistance from CH2M, and this value is used for the calculations shown in the table. The values shown in this table are based on a reservoir level of 12 feet compared to a maximum depth of 15 feet. The 3 feet reduction in depth of the reservoir accounts for the storage needed to balance plant production and high service pumping, which causes the reservoir level to fluctuate throughout the day. The water level also varies as withdrawals are made for backwashing filters. Because of these two factors, using the full volume for CT calculations is not reflective of actual operating conditions. The operators strive to maintain the minimum level at or above 12 feet but the level has dropped as low as 10 feet on occasion. The maximum treatment rates for 10 feet also are shown.

Table 3-3. Maximum Duff No. 1 WTP Treatment Capacity based on Current Reservoir Volume

	Maximum Treatment Rate for Compliance with Disinfection Regulations (mgd)	
Season	**For Reservoir Level = 10 feet**	**For Reservoir Level = 12 feet**
Summer (June-August)	39	47
Fall (September-October)	37	45

Table 3-3. Maximum Duff No. 1 WTP Treatment Capacity based on Current Reservoir Volume

Season	Maximum Treatment Rate for Compliance with Disinfection Regulations (mgd)	
	For Reservoir Level = 10 feet	For Reservoir Level = 12 feet
Winter (November-February)	27	33
Spring (March-May)	29	35

From this analysis, the reservoir volume is sufficient to enable the plant to meet production goals for the winter season, because even when year-round operation begins, the Duff No. 1 WTP will need only to supplement BBS. The fall treatment capacity of 37 mgd (for the 10-foot depth) is probably also sufficient. However, the values for spring (of 29 mgd for 10 feet and 35 mgd for 12 feet) may be limiting in April and May. These are treatment capacities, so the available system supply for 29 and 35 mgd would be 27 and 33 mgd, respectively.

The limitation imposed by meeting regulated CTs is definitely a factor for the summer season. A 10-foot depth in the reservoir limits treatment capacity to 39 mgd and a 12-foot depth limits it to 47 mgd. These represent deliveries to the system of 36 and 44 mgd, respectively, when water needed for backwashing filters is subtracted. The plant is currently rated at 45 mgd for summer treatment capacity so these values suggest that the reservoir is currently slightly undersized. The reservoir is definitely undersized for the planned expansion to a treatment capacity of 65 mgd.

Disinfection contact time and thus, the CT that is provided, can be increased by adding reservoir volume or by reducing short circuiting (increasing the efficiency) by adding baffles. Either option could be feasible for MWC but both would be expensive, especially adding volume. According to an estimate provided by MWC from ten years ago, the cost for baffling the existing reservoirs, updated to current dollars, is approximately $1,000,000. A new partially buried, 5 million gallon concrete reservoir, has an estimated cost of approximately $10 million, with the cost being dependent on its proximity to the existing reservoir, the pre-construction ground elevation, needed pipe connections, and other site-specific factors. The two options do not provide the same benefits. Although both may provide sufficient CT for the 65 mgd treatment capacity, the increase in storage volume addresses the current storage shortfall in the Reduced Pressure and Gravity Zones. This need is discussed in the companion 2016 *Water Distribution System Facility Plan*.

A third option for MWC is to take credit for ozone disinfection. The plant currently applies ozone for taste and odor control but does not receive primary disinfection credit for ozone because ozone is applied upstream of the filters. Oregon's rules currently do not allow for disinfection credit for ozone applied upstream of filters, but a coalition of Oregon utilities is working on a rule change request to the state to allow for such credit. Other states provide credit for ozone used in this manner and technical research has documented that turbidity levels of 5-7 ntu (as might occur for pre-filtration ozonation) have no detrimental effect on ozone's disinfection properties. If this credit is allowed by Oregon, then it may allow the Duff No. 1 WTP to provide the needed summertime CT for all conditions without adding more plant storage or improving the baffling within the existing reservoir.

The challenges faced by utilities with elevated lead levels, as discussed elsewhere in this report, are currently demanding the attention of the state's drinking water program. Therefore, a decision from the state on allowing for pre-filtration ozonation credit for primary disinfection is not expected until mid-way through 2017 at the earliest.

If the state allows for a combination of ozonation and chlorination to achieve primary disinfection, the second question is whether MWC's ozone system provides adequate capacity for this purpose. The ozone system was designed to achieve taste and odor control but an evaluation conducted in January

2001 considered its potential use for primary disinfection. The evaluation concluded that the generators were undersized to achieve a 1-log Cryptosporidium inactivation at 65 mgd. However, a carbon dioxide pretreatment system has since been added upstream of the ozonation system to lower the afternoon and evening high pH values that are caused by algae in the river. A lower pH is favorable for achieving ozonation credit for disinfection because lower pH values decrease the ozone demand and increase the half-life time for ozone residuals. In summary, the existing ozone system may be adequately sized to provide a portion of the primary disinfection credit but this warrants a more detailed evaluation than was provided in this master plan.

The potential use of the ozone system to provide a portion of the plant's primary disinfection credit underscores a significant replacement cost that is a maintenance item but has been captured in the CIP because of its magnitude, and that is the cost for replacing the two ozone generators. They are about 15 years old and for this type of equipment, a 20-25 year service life is a reasonable estimate. Particularly with their potential use for providing a portion of the primary disinfection credit, beginning to plan for their replacement is reasonable. The actual date when they need to be replaced and the appropriate size will require analysis prior to project implementation.

MWC may have another reason to examine the applied ozone dose and that is the possible presence of algal toxins from algae blooms on the Rogue River system. The Oregon Drinking Water Services program has published a best management practices guidance document for harmful algae blooms in drinking water sources.[3] As described in this document, and related publications by USEPA[4], ozonation can be effective in addressing harmful algae blooms and preventing the occurrence of algal toxins in the finished water, but ozone oxidation must also be used with caution because it may cause lysing of algal cells, thereby releasing toxins. It is recommended that the conditions for applying ozone and the applied dose for ozone for controlling harmful algae blooms be examined as part of the filter pilot testing. These tests may indicate the need to increase the applied dose. If so, modifications to the installed ozonation equipment may be required.

While obtaining credit for ozone offers a viable and potentially low-cost alternative for addressing the production limitation resulting from meeting required CT levels, the option of adding storage to allow for higher CT credit through chlorination is attractive because it would also enable more steady-state operation of the plant. More storage would allow the plant to produce water at a constant rate through a 24-hour period, with variation in finished water pumping responding to system demands and the need to refill system reservoirs. Unfortunately, the area to the south of the existing reservoir is a high-quality environment for vernal pools and the endangered fairy shrimp they support. A possible option is to relocate the electrical substation east of the reservoir to allow an addition to the tank to the east.

A detailed evaluation of alternatives for adding reservoir storage to the plant will need to be undertaken for this option to be further considered. This issue and the related topics of transmission capacity from the plant to the main areas of the system, and the possibility of adding more gravity zone storage were also considered as part of the *Water Distribution System Facility Plan*.

3.5.3 Hypochlorite Management

MWC's Duff No. 1 WTP operators have noted concerns related to maintaining the quality of the bulk sodium hypochlorite (chlorine) solution used at the plant. The plant uses liquid sodium hypochlorite for its chlorination process. Because the Duff No. 1 WTP operates seasonally, any bulk sodium hypochlorite

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[3] Best Management Practices for Harmful Algae Blooms (HABs) for Drinking Water Providers, available from the Oregon Drinking Water Services website, June 2015

[4] *Algal Toxin Risk Assessment and Management Strategic Plan*, USEPA, November 2015.

remaining at the end of the operating season must be stored until operations resume in the spring. This prolonged storage period results in aging and degradation of the hypochlorite solution.

There are two issues with bulk hypochlorite decomposition. One is the loss of chlorine strength and the other is the formation of trace contaminants as the solution degrades.

The loss of chlorine strength requires the operators to adjust the rate of hypochlorite feed to obtain the desired chlorine residual, which can be done manually or automatically based on chlorine residual analyzers. The rate of decomposition depends on chlorine concentration and the solution temperature, among other factors. For a given temperature, the higher the strength, the faster it decomposes.

An additional factor in the decomposition of hypochlorite is the level of suspended solids. Greater levels of suspended solids in the solution lead to higher rates of decomposition. Therefore, it is important to purchase only filtered, low-salt bulk hypochlorite, which has lower levels of suspended solids. The decomposition of filtered and unfiltered 12.5% sodium hypochlorite is illustrated in Figure 3-3 (based on a website calculator available on the Powell Fabrication and Manufacturing, Inc. website). The 100% concentration on this chart represents the full purchase strength for hypochlorite of 12.5%. The 89% strength (after 7 days for the unfiltered product) is approximately 11%. The filtered product drops to approximately 95% strength after 7 days or 12% concentration.

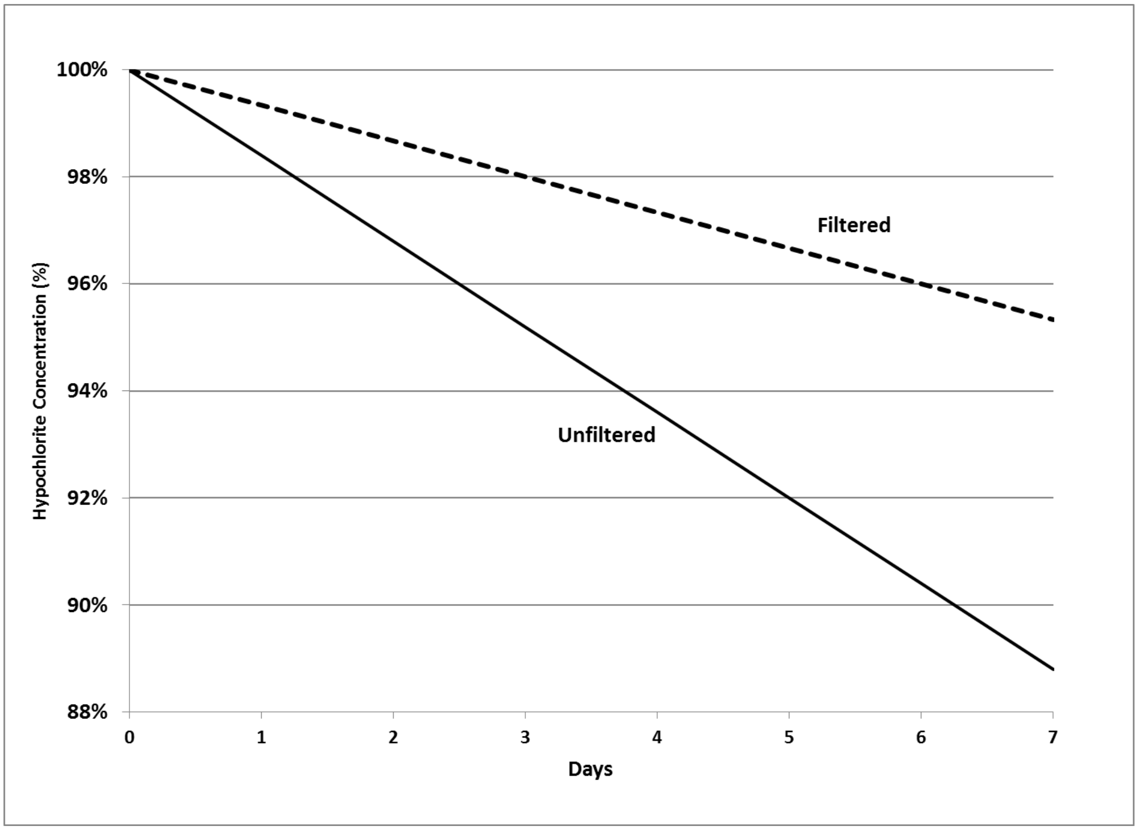

Figure 3-3. Decomposition of 12.5% Bulk Hypochlorite

The second issue is the formation of trace contaminants. MWC has monitored the hypochlorite solution and identified trace levels of by-products that form during the winter off-line period.

Contaminants may form in the solution as hypochlorite ages. Since only a small amount of hypochlorite is added to drinking water, about 1 part chlorine to 1 million parts water, the contaminants are highly diluted in the finished water. Nevertheless, since the regulatory limits may be set at less than a milligram per liter level, they can be a concern when using hypochlorite. The two contaminants of concern are the following:

- Chlorate (ClO_3); included in the third Unregulated Contaminant Monitoring Rule, which may result in a setting of a Maximum Contaminant Level (MCL); an MCL goal of 0.8 mg/L (800 µg/L) was set by EPA; California has set a proposed action level of 0.2 mg/L
- Perchlorate (ClO_4); interim Health Advisory Level set at 15 µg/L; Massachusetts set an MCL of 2.0 µg/L and California set an MCL of 6 µg/L; as of June 2016, the USEPA did not regulate perchlorate in drinking water. In 2011, the USEPA proposed regulating perchlorate by 2013 but that process has been delayed and it is unknown when and if an MCL will be issued.

The contaminant currently drawing the most attention is perchlorate because its regulatory process is farther along than for chlorate. According to a recent publication[5], perchlorate is a common contaminant in hypochlorite and its concentration increases significantly during storage. The article noted wide variations in hypochlorite and finished water perchlorate levels depending on the bulk hypochlorite supplier and even from one shipment to the next from the same supplier. All utilities monitored for the study met the 15 µg/L Health Advisory Level; however, two did not comply with the Massachusetts standard of 2 µg/L standard.

The findings presented in the journal article were similar for chlorate. There was wide variation in the chlorate levels in the hypochlorite solution and in the finished water for bulk hypochlorite systems. Two systems had finished water with chlorate levels that exceeded the California proposed action level of 0.2 mg/L.

Bromate can also be a concern in onsite hypochlorite generation systems but is not a concern for purchased bulk hypochlorite systems such as MWC's.

The study concluded that with proper manufacture, storage conditions, and handling, the formation of perchlorate and chlorate can be minimized. The recommendations included the following:

- Store hypochlorite solution at lower temperatures because higher temperatures speed up the decomposition of hypochlorite and the subsequent formation of chlorate and perchlorate.
- Require suppliers of bulk hypochlorite to supply a product with a pH between 11 and 13. Higher levels of chlorate are formed when the pH falls below 11 and higher levels of perchlorate are formed with the pH exceeds 13.
- Minimize storage times.
- Always purchase filtered hypochlorite solution, as is MWC's current practice. Further benefit is provided by purchasing the high-strength, low-salt hypochlorite which is available from some suppliers.

The article also recommends diluting bulk hypochlorite when deliveries are received. Dilution slows down decomposition and subsequent formation of chlorate and perchlorate. This works in theory but the practicalities of dilution often makes it infeasible. It is necessary to use softened water to prevent scaling and precipitation when diluting hypochlorite. This requires a large quantity of softened water, which represents a significant expense and complication to the system.

The stored hypochlorite volume sets a limit for how long the plant can operate before the next delivery is received. It becomes a challenging balancing act for the operators—ensuring there is enough hypochlorite stored at the plant to provide resiliency, but limiting the time it is stored to limit the production of chlorate and perchlorate.

In addition to carefully specifying the quality of the purchased product, MWC has three alternatives for reducing degradation and by-product formation. One is to control its inventory as carefully as possible,

[5] Stanford, BD, *Perchlorate, bromate, and chlorate in hypochlorite solutions: Guidelines for utilities*, Journal American Water Works Association, June 2011

so as to minimize holding times for the chemical, a practice which the operators already strive to optimize. A further inventory control measure is to provide space and connections to allow for the use of 300-gallon totes and to use these toward the end of the production season rather than refilling the bulk tanks. This would require some capital investments at the plant. A tote facility needs to be carefully thought through so the reliability of the system is not compromised.

A second option is to dilute the hypochlorite when received from 12.5 percent to a more stable 5 percent. The by-products would not form at this concentration. Dilution needs careful consideration before implementation, both regarding the impact of storage volumes and the process of dilution. A soft dilution water is necessary to avoid scale formation. MWC's water supplies are relatively soft, but the question is whether the water is soft enough to prevent appreciable scale formation. Water quality testing, including bench-scale testing, is recommended to examine this concern. If softening is needed, it could represent a significant capital and operating investment. This option may also require replacement of the chemical metering pumps to provide the higher flow rates needed for a lower strength solution.

The plant already has reasonably optimum storage conditions, so conditioning the space was not investigated. During the off-season, the typical temperature in the storage area is 55-63°F.

Based on discussions with MWC staff during preparation of this plan, MWC intends to implement the dilution option. The operators will implement dilution only toward the end of the summer operating period, and intend to accomplish this using a small softener and recirculation pump for mixing softened water into the hypochlorite solution. The plan is to locate the recirculation pump in the containment area, if space allows, to prevent uncontrolled spills. The softener would be located nearby, outside of the containment area. Some design effort and purchase of equipment will be necessary but these items probably can be covered through maintenance budgets rather than as an identified capital improvements project.

3.5.4 Chemical Unloading Area

A non-process issue for the plant is the need to add chemical containment for the truck unloading area in the parking lot. Currently, the drain from the parking lot leads to the river via a ditch. A chemical truck unloading area with a containment system, as would be commonly used for a new water treatment plant design, is recommended to prevent possible spills to the river. The containment should be sized for a full truck delivery of 7,000 gallons. This project is included in the capital improvements plan.

3.5.5 Solids Handling

Although the solids handling systems for the plant have recently been upgraded, the operators have found that they are challenged to provide adequate dewatering and drying of backwash waste flows. The current changes to the plant of adding improved pretreatment with solids collection and more frequent solids discharge will impact the waste handling as well as the planned expansion to 65 mgd. Further solids handling improvements are warranted.

One recommended approach is to separate out the filter-to-waste (FTW) flows from sedimentation basin decant and backwash waste flows. The FTW flows have very low solids loadings and it would be advantageous to keep these flows separated from other waste flows to facilitate recycling. Similar plants have installed a dedicated storage tank to which FTW flows are directed, with a recycle system to return these flows to the raw water inlet to the plant. The tank is necessary to capture and hold the short-duration, high flow rates during a FTW event, allowing for a lower constant rate of flow for the water returned to the plant inlet. This type of system is often cost-effective, and provides the dual advantages of more efficiently using water withdrawn from the river and of reducing flows to the solids handling basins.

MWC installed four new solids handling lagoons at the Duff No. WTP in 2010 at a cost at that time of approximately $4.2 million. With the FTW improvements as described, it may be acceptable to add two additional lagoons to accommodate the full buildout of Duff No. 1 WTP to 65 mgd.

Although a detailed predesign is needed, the capital improvements plan includes the addition of the FTW capture tank plus recycle pump station, and the addition of two additional solids handling lagoons. Rather than expanding solids handling basins in kind, MWC may also wish to evaluate options to improve the efficiency of existing or new basins, to decrease the required area. One such option would be the use of vacuum assisted drying beds.

3.5.6 High Service Pump Expansion and Surge Control Modifications

The existing high service pump station room houses the two backwash pumps and five high service pumps. All are vertical turbine pumps, drawing supply from the clearwell beneath the pump room. Of the five high service pumps, the two smaller ones have 450 horsepower (hp) motors and have capacities of approximately 5,800 and 5,400 gpm (approximately 8 mgd). Pumps 3, 4, and 5 have motors of 800 and 900 hp and pump approximately 10,500 gpm (15 mgd) each. The total pumping capacity is approximately 60 mgd. The firm capacity, with one of the largest pumps out of service, is 45 mgd. Additional pumps or replacement of one or more pumps will be necessary to obtain a firm capacity of 65 mgd.

The existing pump room is congested, with narrow walking spaces between pumps and piping. The space limitations make maintenance difficult and less safe than desirable. During the summer months, the time when pumping is at a maximum, the existing heating/ventilation/air conditioning (HVAC) system is unable to sufficiently cool the room, making it a challenging environment for the operators and increasing the wear caused by heat on the pump motors.

The expansion goal is to achieve a capacity of at least 65 mgd and a firm capacity of 60 mgd to match the expanded, sustained withdrawal and treatment capacity of Duff No. 1. A related item is to make the associated needed improvements to the surge control system. The plant currently has surge control provided by a connection from the high service pump discharge line through a 12-inch pipeline to a buried 25,000 gallon tank.

Expansion alternatives were developed in the previous plan and have been further discussed in the intervening years. The following three alternatives are considered possible approaches:

- **Alternative 1**. Replace Pumps 1 and 2 with 10,500 gpm (15 mgd) pumps and motors, which will bring the firm capacity to 60 mgd. It is the least expensive option but increases the congestion in an already crowded room and will add to the heat load. This is not a recommended option.
- **Alternative 2.** Expand the existing pump room to the east. It may be possible to expand the room by moving the east wall by about 25 feet and installing two new, larger high service pumps in vertical pump suction columns ('cans') that are connected to the pump well. This will require careful analysis of pump hydraulics to ensure it does not compromise the performance of the existing or new pumps. The room expansion would conflict with the existing buried surge tank and possibly with other buried utilities. It may also be difficult to develop this expansion into an architecturally pleasing front appearance. Although this option may be feasible, it introduces several questions and is not recommended unless no other option is feasible.
- **Alternative 3.** Install a second high service pump building to the east of the plant reservoir. Three high service pumps and the replacement or additional surge control tanks could be installed in a new, separate high service pump building. The pumps would draw suction from the reservoir through a new connection and would discharge through a new, parallel header pipe. This is illustrated in Figure 3-4. This is the recommended approach to provide a safe and efficient expansion of the high service pumping facilities, and has been included in the capital improvements plan.

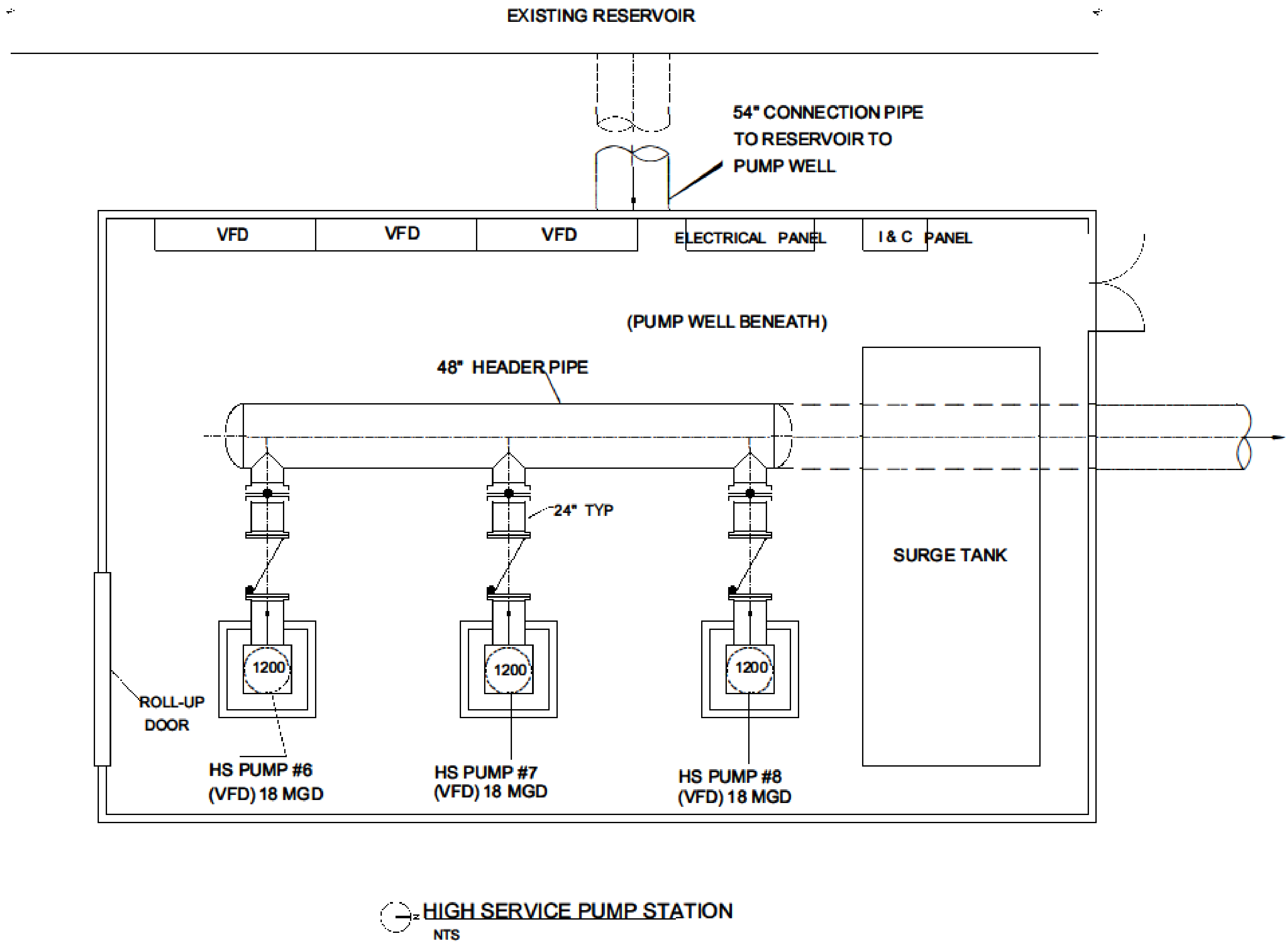

Figure 3-4. High Service Pump Station Improvements Plan

3.5.7 Surge Analysis

The proposed expansion of the high service pumping warranted an evaluation of the surge protection system. Surge refers to short-term pressure transients that can occur with a sudden stoppage of pumps, as may happen when the incoming power supply is interrupted. The existing HSPS is protected with a buried hydropneumatic tank of approximately 25,000 gallons volume connected to the discharge pipeline with a 12-inch diameter pipeline. The analysis evaluated whether this system is adequate for the buildout of Duff No. 1 WTP to a 65 mgd capacity.

The surge analysis made use of the distribution system hydraulic model, which was updated and applied to the distribution system master plan prepared at the same time as this plan. The distribution model, including proposed future transmission improvements, formed the input file for analyses using Bentley's Hammer software.

Four scenarios were evaluated, each with a 60 mgd discharge flow from the Duff No. 1 WTP HSPS and two pumps running at each of the three control stations, with each scenario simulating a power failure to the high service pumps. The modeled conditions represent a future summertime, peak hour demand, a worst-case scenario for surge pressures. The 60 mgd HSPS flowrate is equal to the 65 mgd buildout treatment capacity of the plant minus the water used for backwashing filters. The four scenarios were the following:

1. No surge protection in place. This represents a case where the plant has been expanded to 65 mgd treatment capacity with the existing surge system off-line. It provided a base case for comparing other results.
2. The existing surge system operating, with no expansion.
3. Expanded surge protection system.
4. Expanded surge protection system and automatic, rapid shut down of control station pumps. The findings are summarized in the following subsections.

3.5.7.1 Scenario 1. No Surge Protection

The maximum pressure in the system spikes to 630 psi and the minimum pressure drops to -14 psi. Pressures equal to -7 psi or less are representative of a vacuum condition. Clearly, these are unacceptable results and illustrate the importance of maintaining an active surge protection system.

3.5.7.2 Scenario 2. Existing Surge System with No Expansion

The operation of the existing surge tank lowers the maximum pressure spike to 190 psi but this maximum is still high enough to damage pipes, fittings, and equipment. The minimum pressure drops to -14 psi, representing a vacuum condition.

3.5.7.3 Scenario 3. Expanded Surge Protection System

Based on preliminary model runs, it was determined that the surge tank volume for 60 mgd would need to be equal to approximately double the existing 25,000 gallon volume. The system was modeled as though there was a surge tank with a total volume of 7,000 cubic feet (52,000 gallons) connected to the discharge pipe with a 24-inch diameter pipe. This lowers the maximum pressure spike to an acceptable value of 150 psi but still allows the minimum to reach a vacuum. The minimum occurs because the control station pumps do not shut down quickly enough after the power failure at the HSPS. The minimum pressure occurs over a much smaller area of the system than in the previous two runs, so while it is a concern, it may not cause any system damage.

3.5.7.4 Scenario 4. Expanded Surge Protection System and Rapid Shutdown of Control Station Pumps

A 20-second ramped shutdown of the control station pumps, beginning one second after the power failure at the HSPS, prevented vacuum conditions from occurring in the model simulation. The maximum pressure of 150 psi remains the same as for the previous run. The minimum pressure anywhere in the system is held to -4 psi.

3.5.7.5 Recommendation

Based on these findings, the recommendation is to include an additional 25,000 gallon surge tank as part of the HSPS expansion. This is approximately the size shown in Figure 3-4. It should be connected to the discharge line from the HSPS with a 24-inch or larger diameter pipeline to facilitate rapid water movement into and out of the tank. Additionally, it is recommended that the SCADA system logic included an immediate shutdown of the control station pumps in the event of a sudden shutdown of the Duff No. 1 WTP HSPSs.

3.5.8 Finished Water Meter Improvements

The Duff No. 1 WTP operators have noted inaccurate or at least questionable data generated by the two existing insertion meters on the finished water pipelines leaving the plant. The proposed upgrade is to replace each one with a full flow magnetic meter. Assuming that no significant changes are needed in the piping or vaults, an allowance of $50,000 has been included for this capital project.

3.5.9 Raw Water Pump Improvements

Further expansion of the raw water pumps at the Duff No. 1 intake will be needed to enable the plant to achieve a firm river withdrawal capacity of 65 mgd. Of the five existing pumps, two have flow capacities of 7.5 mgd, one has a capacity of 15 mgd, and two have capacities of 22.5 mgd. This provides a total capacity of 75 mgd and a firm capacity of 52 mgd.

The proposed improvement is to replace Pump No. 5 with a pump capable of 22.5 mgd, along with a 500-hp motor. This will increase the total capacity to about 90 mgd and the firm capacity to about 65 mgd. The proposed replacement pump shall use a variable speed drive, like Pump No. 2, to provide the operators with flexibility on pumping rates.

3.5.10 Electrical Supply Improvements

Duff No. 1 is currently fed by a single electric utility service line (a single primary feed). The plant also has a small, trailer-mounted standby 125 kilowatt (kW) generator. The standby generator provides sufficient power to operate the building services (lights and heat) and plant control system, but insufficient power for water production. These two factors—a single primary feed and insufficient generator capacity for production—make Duff No. 1 vulnerable to shutdowns from an electrical supply failure. The electrical supply system in the Medford area has historically been very reliable resulting in only short duration, infrequent outages. The risk has proven to be acceptable, in part because MWC's BBS source, which reliably supplies 26.4 mgd, is sufficient to meet wintertime demands and to mitigate much of the lost Duff WTP production even during the summer months. In the event of a long-term electrical failure during summer periods when Duff No. 1 WTP is operating, MWC can implement curtailment measures to reduce demands to wintertime levels.

As demands grow and Duff No. 1 WTP begins year-round operation, the consequences of an unplanned electrical shutdown of the plant will become more significant. Wintertime demands represent primarily indoor water use. While some indoor uses are non-essential, there is generally less opportunity for curtailment reductions than during the summer when a significant portion of water use is for outdoor purposes. MWC can weigh the risks versus the costs for standby power as wintertime operations for Duff No. 1 WTP begins, and decide at that time whether the addition of standby power is warranted.

Duff No. 1 obtains electric power from Pacific Power (a division of PacifiCorp, Inc.) via a single primary feed line. Pacific Power reported to MWC staff in January 2016 that the looping of the grid that serves Duff No. 1 WTP is not in their 5-year plan at this time. However, a secondary feed line may eventually be added by Pacific Power; this consideration should be part of MWC’s evaluation for adding a larger generator.

If MWC wanted to obtain a second primary feed before Pacific Power’s planned expansion, the power utility suggested that the cost would be greater than $1,000,000. The actual amount is uncertain. Pacific Power was unwilling to provide a specific estimate because the upgrade work has not been defined. The CIP included in this plan does not include a cost for this secondary electrical supply because of the high degree of uncertainty associated with it.

The project team discussed the needed plant production from a standby generator during the workshops conducted for the 2008 plan. MWC staff suggested targeting a minimal production equal to the capacity of a single raw water pump and a single high service pump. Although the current small pumps have a capacity of approximately 7.5 mgd, the plans call for replacement of these with 15 mgd pumps. It was decided that a 15 mgd standby capacity is a reasonable goal. The approach of providing a backup generator to enable production of 15 mgd from Duff No. 1 WTP was reconfirmed as a project that should be included in the capital plan during preparation of this facility plan.

The preliminary generator sizing is based on operating the following equipment: one 500-HP raw water pump, one 900-HP high service pump, coagulant and chlorine feed pumps, filter valves, plant lights, heat, and controls. A 2000 kW generator appears to be sufficient to power this equipment, although the sizing should be confirmed during a preliminary design.

This generator sizing does not include operation of the ozonation system. A significantly larger generator would be required to operate the ozone system. The option of sizing the standby generator for operating the ozone system should be reconsidered during preliminary design.

The plant is served by a single 12.47 kilovolt (kV) utility feeder to a medium-voltage switchgear assembly. To provide backup power to the plant, an automatic transfer switch (ATS) would need to be installed upstream of the medium voltage switchgear. The utility power would be diverted to the normal side of the ATS and a standby generator would be connected to the alternate side of the ATS. The load side of the ATS would be connected to the existing medium voltage switchgear.

This scenario would allow all equipment connected to the plant to be connected to the standby generator. The plant SCADA system would need to be programmed to lock out all equipment that is not desired to run when the generator is in operation. Additional hardwire interlocks may be required for equipment which is not controlled by the PLC but need to be locked out when the generator is in operation, such as panel boards, HVAC equipment or other miscellaneous loads.

The estimated construction cost for purchasing and installing a 2000 kW generator and ATS of $1.6 million has been included in the capital improvements plan.

3.6 Duff No. 2

A detailed analysis of options for meeting demands beyond the buildout of Duff No. 1 WTP was conducted during preparation of the 2008 plan. It was decided that Duff No. 2 WTP should also draw water from the Rogue River and the plant should be located directly north of Duff No. 1 WTP. It would be sized for a buildout treatment capacity of 60 mgd, bringing MWC’s total withdrawal capacity from the Rogue River to 125 mgd.

A wide range of process alternatives were considered during the 2008 plan. The project team scored each alternative using weighted criteria. The goal was to select a cost-effective treatment process that would meet MWC's objectives for the Rogue River supply. The following boundary conditions were established for the Duff No. 2 WTP:

1. The proposed development of Duff No. 2 WTP is in three stages, each sized at 20 mgd increments. The size of these increments could be reconsidered depending on the rate of demand growth.
2. Duff No. 2 WTP shall provide ozonation for taste and odor control and for removal of organics, such as cyanotoxins, that may be in the source water
3. Duff No. 2 WTP shall operate as a year-round facility so its design shall be appropriate for the higher wintertime solids and TOC levels of the Rogue River
4. Duff No. 2 WTP shall be a parallel facility to Duff No. 1 WTP but the two plants shall share facilities where appropriate and beneficial
5. There may be benefits to using two different core treatment processes at the two plants to provide redundancy—the processes selected for Duff No. 2 WTP should not be limited by those in use at Duff No. 1 WTP
6. The development of Duff No. 2 WTP must avoid the high quality habitat area of MWC's property, which is generally located to the south of Duff No. 1 WTP
7. Treatment technologies will continue to advance in the interim before Duff No. 2 is constructed, so the preliminary selection of a treatment process should not be considered a constraint when Duff No. 2 WTP is implemented.

The selected process alternative in the previous plan was pretreatment by flocculation and plate sedimentation, ozonation, and membrane filtration. Membranes with pretreatment provide a robust system that will reliably produce high quality water even as the raw water quality fluctuates. Membranes also provide an advantage by allowing for rapid starting and stopping or rate adjustments without an impact to the quality of the finished water. However, the use of membrane filtration is a significant departure from Duff No. 1 WTP. There are favorable and unfavorable aspects to both media and membrane filtration, and the decision of which to use warrants careful consideration.

MWC has initiated permitting for Duff No. 2 WTP to reserve the property for the plant facilities and to evaluate needs and constraints for a second withdrawal point on the Rogue River. The permitting efforts were underway while this facility plan was being prepared.

Further thought will also need to be given to the integration of the two plants. The pretreatment improvements currently underway at Duff No. 1 WTP may position that plant to reliably operate year-round and thus, Duff No. 2 WTP could be considered as the summer peaking plant. This may impact process selection, if Duff No. 2 WTP will not generally operate during the higher turbidity, colder water winter season. Another central aspect of integration is the finished water storage and pumping. Currently, the limited finished water storage for Duff No. 1 WTP impedes steady-state operation of the plant. Additional improvements in finished water storage will be needed to allow for the higher production from Duff No. 2 WTP.

SECTION 4

Water Quality and Regulations

MWC's highest priority is providing safe, high-quality drinking water to its customers. The water delivered by MWC's system has without fail complied with all state and federal drinking water quality standards.

BBS have been MWC's primary source of drinking water since 1927. BBS provides high-quality water at flows of up to 26.4 mgd. The water from BBS is consistently cold and clear with characteristics of groundwater. The flows from the individual springs are collected underground and therefore, protected from contamination. No man-made contaminants have ever been detected in the spring's water. There have been low level, detections of naturally occurring arsenic, strontium, vanadium, chromium, and chromium 6, in each case below the MCL where MCLs have been established. BBS water requires no filtration or treatment other than disinfection, which is accomplished with chlorination. The current treatment facility was completed in 1993.

During the peak-use summer months, water from the Rogue River is used to supplement the springs supply. The river water is also of high quality but additional treatment performed at the Duff No. 1 WTP is required to meet drinking water standards. Treatment of this surface water supply consists of carbon dioxide addition for pH adjustment, ozonation, flocculation, coagulation, settling, and filtration, followed by disinfection. The addition of ozone in 2002 provided a dramatic reduction in musty taste and odors occasionally found in the river water. Ozonation also provides additional disinfection benefits, although to date, the state does not provide any credit for primary disinfection from using ozone. Duff No. 1 WTP uses high rate multimedia filters and chlorine for primary disinfection. Turbidity, a measure of the particulates in the water, is one of the fundamental standards for a surface water treatment plant. Duff No. 1 WTP produces water with a turbidity of less than 0.05 nephelometric turbidity units (ntu), which is well below the regulatory standard of 0.3 ntu. The plant currently can treat up to 45 mgd. The intake facility is located on the Rogue River and consists of a concrete structure on the edge of the river with cylindrical tee screens for river withdrawal.

BBS and Rogue River water are similar in chemical characteristics; both are classified as soft and neutral in pH. Hardness ranges from 32 to 45 parts per million (ppm) and sodium content varies from 4 to 6 ppm in both sources. The alkalinity of both sources is low, less than 45 mg/L.

When both sources are used, the water is blended within the distribution system, although some areas receive more water from one source or the other. The finished water from both supplies is very similar, with temperature and chlorine taste and odor being the most detectable difference. MWC receives more taste and odor complaints for water traced to the Rogue River supply than for BBS water. The blend varies depending on system demands, storage levels, pumping rates, and other factors.

Monitoring the quality of the water supply is performed on a regular basis. This includes testing of the raw source water, the treated water at the entry points to the distribution system, water in the distribution network, and in some cases, water from customers' taps.

Sampling ensures that the distributed water meets the criteria established by the Environmental Protection Agency (EPA). The EPA sets strict standards for drinking water quality and requires monitoring for more than 120 potential contaminants. Regular testing is performed for organic and inorganic chemicals, volatile organic compounds, radioactive substances, microbiological contaminants, disinfection by-products, and a variety of other chemical and physical water quality parameters. Many parameters are monitored continuously both at the treatment plant and in the distribution system. The Oregon Drinking Water Services section of the Oregon Health Authority is responsible for compliance and enforcement of these standards. The water supplied by MWC has always exceeded all health-based standards at required monitoring locations.

MWC annually publishes the federally mandated Water Quality Report (Consumer Confidence Report or CCR), which is delivered to all water users in the service area. This publication includes the latest annual water quality test results along with detailed explanatory material and resources.

MWC received the “Outstanding Performer” status from the Oregon Drinking Water Services following the state’s last two system surveys conducted in September 2009 and June 2014. A water system survey is an on-site review of a system’s sources, treatment, storage facilities, distribution system, operation and maintenance procedures, monitoring, and management, for the purpose of evaluating the system’s capability of providing safe water to the public.

The criteria for outstanding performance were the following:

1. No Maximum Contaminant Level (MCL), Action Level, or Treatment Technique violations in the last 5 years;
2. No more than one Monitoring and Reporting violation in the last 3 years.
3. The one violation must be resolved (results submitted);
4. No significant deficiencies or rule violations identified during the current water system survey; and
5. Has not had a waterborne disease outbreak attributable to the water system in the last 5 years.

Two significant drinking water regulations were adopted in recent years. One is the Long Term 2 Enhanced Surface Water Treatment Rule. This rule imposes additional treatment requirements depending on the level of *Cryptosporidium* found in the raw surface water source. MWC’s first round of *Cryptosporidium* monitoring placed the Rogue River source in the lowest treatment category, with no additional treatment requirements necessary. MWC began the second round of *Cryptosporidium* monitoring in October 2015. This initial sample found zero Oocysts/L, again suggesting that no treatment changes will be necessary. Six additional samples are planned for 2016 and five for 2017, so the final results of the second round will not be known until the fall of 2017.

The second important new rule is the Stage 2 Disinfection Byproduct Rule. This rule increased the monitoring requirements and imposes more stringent compliance standards for trihalomethanes and haloacetic acids, two compounds that are formed when chlorine reacts with naturally occurring organic compounds. MWC is currently in full compliance with this rule. According to data listed on the Oregon Public Health Drinking Water Data Online website, the locational running annual averages (LRAAs) of total trihalomethanes (TTHMs) for January 2015 through September 2016 have ranged from 2 to 13 µg/L. This range is well below the MCL of 80 µg/L.

The monitoring results for haloacetic acids have been similarly low. The LRAAs for haloacetic acids for January 2015 through September 2016 have ranged from 1 to 8 µg/L, well below the MCL of 60 µg/L.

Since the Duff WTP has not operated during the winter months, its performance with respect to wintertime DBP levels is unknown. MWC has documented that treated Rogue River water has higher levels of DBPs than BBS water because of the greater prevalence of DBP precursors in the river water. As the Duff No. 1 WTP begins year-round operation, and supplies a greater and greater percentage of the water supply as demands grow (since the capacity of BBS is fixed), system DBP levels are likely to rise. Data collected to date suggest this increase will be relatively minor.

4.1 Lead and Copper Rule

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 2015. Lead is almost never present in measurable levels in source waters. Rather, it is introduced into public water supplies through internal pipe corrosion. Small amounts of lead may be used in plumbing fixtures or in older solder compounds for copper pipe. Additionally, MWC knows of some locations, installed prior to 1946, where lead pipe was used to make connections from the water mains to customer meters. These are referred to as lead pigtails or goosenecks. As internal pipe corrosion occurs, lead may be dissolved into the water. MWC was actively searching for the presence of lead pigtails and replacing them as this report was being prepared.

All of MWC's monitoring results for lead and copper have complied with current standards. The system is currently required to conduct sampling at 30 homes that are classified as the highest risk locations once every three years. These "high risk" sites are single family homes built between January 1, 1983, and June 30, 1985. This pool does not take into consideration the older areas of town where lead connection pipes have been used, older homes with leaded fixtures, schools and public buildings that may have fixtures or drinking fountains with lead components, or newer copper plumbing. The last monitoring was conducted in August 2016. The results for 2016, from 30 sample locations, showed a 90^{th} percentile lead level of 0.0009 mg/L, which is less than one-tenth the action level of 0.015 mg/L for lead. The 90^{th} percentile copper level was found to be 0.842 mg/L, below the copper action level of 1.3 mg/L. The previous sampling results were similar to the values for 2016.

At the time this report was being prepared, the public across the U.S. was alarmed by the experience in Flint, Michigan, where a change in water sources without proper evaluation of corrosion control treatment resulted in higher corrosion rates, leading to higher lead levels. This problem was compounded by a failure to take action by some or all of the city, state, and federal employees and regulators. Primarily as a result of this highly publicized incident, the EPA implemented short-term changes to the Lead and Copper Rule (LCR) and proposed additional long-term changes. The short-term changes were the following:

- Changes to sampling procedures (no pre-flushing, no removal of aerators, run water as if filling up a glass to drink when collecting sample (not at low flow), use wide mouth bottles.
- Complete materials inventory – including lead service line locations and lead plumbing material in the distribution system. Remove all lead lines. Update maps to show lead locations
- Be transparent – Post all lead and copper results. Update website with lead information. Public outreach. Collaborate with other organizations.
- Re-evaluate high risk sample locations.
- Optimize corrosion control treatment to minimize the leaching of metals into the drinking water (the intent of the lead and copper rule).

MWC's planned startup of the new flocculation-sedimentation basins will constitute a treatment change and has been reported to the state in compliance with the LCR. MWC should also report the change to year-round use of the Rogue River supply when that modification to system operations is implemented.

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

- Separation of lead and copper sampling from one another, meaning they may have different location and frequency requirements.
- For those systems with water quality that is susceptible to copper corrosion, they may need to monitor at newly constructed houses or conduct pipe loop tests.
- Broaden the extent of lead monitoring sites. The current LCR provides a good overview of corrosion rates and lead levels, but there is concern that it may overlook some locations with high levels.

- Depending on monitoring results, a system may need to develop an optimal corrosion control plan and receive approval for the plan from the state. The plan may require review and approval every few years.
- Remove all lead pigtail lines (the short connection piece owned by MWC between the distribution main and the customer meter) by 2050.
- Increased monitoring

It remains to be seen if EPA's proposed changes will be adopted, as the Flint problems have prompted public and political discussions and proposals. In late April 2016, U.S. Congressman Kildee introduced a House bill that would reduce the lead action level from the current level of 15 micrograms per liter (µg/L) to an eventual level of 5 µg/L, being phased in over the course of a decade. MWC's 2016 reported lead levels, at the 90^{th} percentile value, have been about one-fifth of the lowest value of 5 µg/L that was proposed. While it appears that MWC may comply with this proposed rule change, MWC intends to conduct a corrosion study in 2017 to further understand and if necessary, to optimize corrosion control treatment. The issue has alerted water utilities to the need for a thorough examination of their systems to ensure that high lead and copper levels are not being overlooked and, even if the system complies with the LCR, to determine if there are critical locations such as schools where elevated lead levels are occurring.

4.2 Proposed New Drinking Water Regulations

The EPA, which sets water quality standards that are then adopted by states, continues to review existing regulations for possible revisions and to examine potential drinking water contaminants for possible regulation. The newest regulation issued by EPA is the Revised Total Coliform Rule, which eliminated an MCL for total coliform but kept the MCL for *E. coli*. *E coli* has been found to be a better indicator than total coliform of the microbiological safety of drinking water. A total coliform positive now triggers system evaluation requirements rather than an MCL violation. This rule has no significant impacts on MWC's operations.

4.2.1 Algal Toxins

The forthcoming rule that may have the greatest impact on MWC is the potential regulation of cyanotoxins, also known as algal toxins, which are toxins introduced into water supplies by cyanobacteria blooms. Cyanobacteria are photosynthetic bacteria, formerly known as blue-green algae. The State of Oregon issued Health Advisories for algal toxins and EPA released similar Health Advisories in June 2015. Health Advisories are non-regulatory values that serve as informal guidance to assist state regulatory agencies and managers of public water systems in their role of protecting public health.

EPA issued Health Advisories for Microcystin and Cylindrospermopsin as follows:

- For children under 6 years of age, the 10-day Health Advisories levels are 0.3 µg/L for Microcystin and 1.6 µg/L for Cylindrospermopsin
- For children 6 years and above and adults, the 10-day Health Advisory levels are 0.7 µg/L for Microcystin and 3.0 µg/L for Cylindrospermopsin

On August 7, 2015, President Obama signed into law the Drinking Water Protection Act that amends the Safe Drinking Water Act with the intent to control harmful algal blooms in drinking water. The legislation required EPA to submit a plan to Congress by November 2015 to evaluate algal toxins' risk to human health and to recommend feasible treatment options to mitigate any adverse public health effects. EPA's plan was essentially a compilation of ongoing and planned research needs, noting that many questions remain about occurrence levels, health effects, and treatment approaches.

The EPA has listed three algal toxins on the Candidate Contaminant List 3: Anatoxin-a, Microcystin-LR, and Cylindrospermopsin. According to EPA's current timetable, regulations for algal toxins will not occur until 2025. However, EPA's Administrator has the authority to issue an emergency regulation if circumstances warrant such action.

The World Health Organization (WHO) has established a health-based drinking water guideline of 1.0 ppb for one algal toxin, Microcystin-LR. The Australian standard is 1.3 ppb for total microcystins, while Health Canada has proposed a similar standard of 1.5 ppb for total microcystins.

The State of Oregon Health Authority, Drinking Water Program has developed guidance for water systems that recommends monitoring for algal toxins when algal counts are above a certain level, or if a public health advisory has been issued. If algal toxins are detected in the finished water above threshold levels (Microcystin >1.6 μg/L, Anatoxin-a >3 μg/L, Cylindrospermopsin >3 μg/L and Saxitoxin > 1.6), the guidance says to issue an immediate "Do Not Drink" public notice.

In addition to the guidelines issued by WHO and Oregon, short-term exposure recommendations have been developed by United Kingdom Water Industry Research. This organization has developed Short-term No Adverse Response Levels for three algal toxins, which may be more representative of levels of concern for a short-term algal bloom such as might occur in the Rogue River. The 24-hour and 7-day SNARLs are shown in Table 4-1.

Table 4-1. Short-Term No Adverse Response Levels from United Kingdom Water Industry Research

Algal Toxin	24-hour Health-based SNARL	7-day Health-based SNARL
Microcystin-LR	12 μg/L	6 μg/L
Anatoxin-a	3 μg/L	1.5 μg/L
Cylindrospermopsin	9 μg/L	4.5 μg/L

The Duff No. 1 WTP includes ozonation, and ozonation has been demonstrated to be the most consistently efficient process for destruction of both intra- and extracellular Microcystins. The use of ozone can rapidly achieve nearly complete destruction of Microcystins, Nodularin and Anatoxin-a at low doses and contact times, provided ozone is applied at levels exceeding the ozone demand. MWC's current ozonation practices may already achieve this goal. The ozone system was initially sized for taste and odor control using bench-scale tests to determine the demand and decay rate. In light of a new goal to use ozone to protect against algal toxins, in addition to its use for controlling taste and odors and possibly for disinfection credit, it is recommended that MWC perform further bench-scale tests. This would enable MWC to determine if the existing ozone system has sufficient capacity to meet these goals and at what concentration ozone should be applied.

4.2.2 Cybersecurity

One other regulatory area that may have implications for MWC is cybersecurity. Cyber-criminals have invaded highly secured federal and private networks, such as the U.S. State Department and Sony Corporation, so the vulnerability of water utilities is certainly a legitimate concern. To date, water utilities have not been a target of terrorist cyber-attacks; it is uncertain if they will become a target in the coming years.

The federal Critical Infrastructure Partnership Advisory Council issued the Water Sector Cybersecurity Strategy report in April 2015. The American Water Works Association (AWWA) has since issued guidance and tools to support the water industry's voluntary application of the CIPAC recommendations. MWC is not required to take cybersecurity actions but it would be prudent to monitor AWWA's continuing efforts in this field and to continue improving the cybersecurity of the MWC system.

4.2.3 Contaminants of Potential Concern

Since the 1980's, researchers have investigated the occurrence of traces of inorganic and organic contaminants in water. These contaminants, called contaminants of potential or emerging concern (CPC) or micro-constituents, include industrial chemicals, metals, natural or synthetic hormones, pharmaceuticals, household chemicals, and personal care products. Very few studies have investigated the effect of these trace contaminants on human health. The contaminants of greatest current concern are a class of compounds called endocrine disruptors. Endocrine disrupters have been shown to cause adverse effects in a variety of animal species. Only some of the CPCs are endocrine disrupters.

CPC's enter source water from both point (effluent pipe) and non-point (overland runoff) sources. MWC source water has limited exposure to point source introduction of CPCs because only two small wastewater treatment plants, Shady Cove and Butte Falls, discharge upstream of the Duff intake. These flows represent only a small fraction of the overall river flows. A compound of particular concern, N-Nitrosodimethylamine (NDMA), is formed when municipal wastewater which contains ammonia, is chlorinated for disinfection.

Ozone is effective at oxidizing a wide range of organic contaminants. The ozone system was originally installed at Duff No. 1 to reduce the concentrations of taste and odor-causing compounds and any algal toxins that might occur in Lost Lake Reservoir. The system has the added benefit of also reducing or eliminating a variety of CPCs. Ozone is not, however, effective in reducing levels of NDMA. If MWC's sampling program identifies NDMA as a concern, adjustments to the treatment process may need to be implemented.

4.2.4 Unregulated Contaminants Monitoring Rule

The 1996 Safe Drinking Water Act amendments require that once every five years EPA issue a new list of no more than 30 unregulated contaminants to be monitored by public water systems. The third Unregulated Contaminant Monitoring Rule was published on May 2, 2012, and includes the following five contaminants that could pertain to MWC: strontium, chromium, chromium 6, chlorate, and vanadium. EPA will make a determination about regulating these contaminants based on health effects and occurrence levels in public water systems.

Capital Improvements Plan

Table 5-1 summarizes the CIP for the BBS, Duff No. 1 WTP, and Duff No. 2 WTP. Costs are generally listed for construction, only, unless the project only involves an engineering analysis. Appropriate allowances need to be added for construction projects to account for engineering, contingencies, and soft costs such as for permitting or easements. Costs have been estimated for 2016 and also escalated to the proposed date of construction using an inflation rate of 2 percent per year. The estimates for individual projects were developed with MWC's input, through comparisons with recent similar projects, and by using CH2M's in-house water infrastructure sizing and costing software.

BBS continues to provide an economical source of water supply for the MWC system. The CIP includes relatively low-cost water quality and rehabilitation projects for the springs. The table lists a project to replace sections of the BBS transmission lines but no cost has been assigned to this item for this master plan update. It is included as a placeholder for future plans.

The final projects to expand Duff No. 1 WTP to 65 mgd include addition of filters, a new high service pump facility, and other study and construction projects. Figure 5-1 illustrates these planned investments, with costs shown as escalated to the planned date of implementation. A cost for the Duff No. 2 intake and the first phase of the plant have been included in Table 5-1.

Table 5-1. Capital Improvements Plan

No.	Planned Date of Implementation	Project	Description	Basis of Need	2016 Cost Estimate[a]	Cost Escalated to Planned Date of Implementation[b]
Big Butte Springs						
BBS1	2017-2018	Rancheria Spring	Rebuild Rancheria Spring collection system	Water quality	$200,000	$210,000
BBS2	Uncertain	Corrosion control	Possible addition of a corrosion control chemical, pending the outcome of the corrosion control study.	Water quality	Uncertain	Uncertain
BBS3	2018-2019	Meters	Replace meters on the two transmission pipelines with magnetic meters	Rehabilitation	$50,000	$60,000
BBS4	2019-2020	Electrical and communications lines	Bury electrical supply and communications lines from Fish Lake Highway to the main chlorination and controls building	Rehabilitation	$300,000	$320,000
BBS5	Future	Transmission	Replace portions of the transmission lines as coatings and joints begin to fail. Project undefined at this time.	Rehabilitation	Unknown	Unknown
				TOTAL BIG BUTTE SPRINGS	**$550,000**	**$590,000**
Duff No. 1 Water Treatment Plant						
D1	2016-2018	Floc/Sed basins	Complete construction of flocculation-sedimentation basin improvements	Growth	$14,000,000	$14,280,000
D2	2017-2018	Hypochlorite system	Add water softener, recirculation pump, and modify controls to allow for dilution	Rehabilitation	$34,000	$40,000
D3	Uncertain	Corrosion control	Possible addition of a corrosion control chemical, pending the outcome of the corrosion study.	Water quality	Uncertain	Uncertain
D4	2016-2017	Finished water meters	Replace existing meters with magnetic meters to provide greater accuracy	Rehabilitation	$50,000	$60,000
D5	2018-2019	Maintenance building	Add maintenance building	Growth / Rehabilitation	$600,000	$640,000

Table 5-1. Capital Improvements Plan

No.	Planned Date of Implementation	Project	Description	Basis of Need	2016 Cost Estimate[a]	Cost Escalated to Planned Date of Implementation[b]
D6	2017-2018	Filter and ozone piloting	Pilot testing in advance of filter additions; evaluate ozonation, biological filtration, corrosion control	Growth	$300,000	$320,000
D7	2018-2019	Primary disinfection evaluation	Evaluate opportunity and costs for using ozone for primary disinfection against benefits and options for adding plant reservoir storage. Consider property availability, plant hydraulics, finished water pumping, and related factors. Consider impacts of possible corrosion control changes on disinfection requirements.	Growth	$100,000	$110,000
D8	2019-2021	Rehabilitate filters 5-8	Replace underdrains, media, and repair/recoat concrete filter boxes	Rehabilitation	$1,370,000	$1,490,000
D9	2017-2018	Chemical unloading	Add containment area and drain system for outside chemical truck unloading	Rehabilitation	$50,000	$60,000
D10	2018-2021	Filter addition	Addition of four filters to achieve 65 mgd capacity	Growth	$5,000,000	$5,500,000
D11	2020-2022	Raw water pumps	Replace Pump No. 5 with 15,600 gpm (22.5 mgd) variable speed pump and 500 hp motor to enable 65 mgd capacity	Growth	$320,000	$360,000
D12	2020-2022	Ozone generators replacement	Replace ozone generators with two new 600 ppd generators (size to be confirmed beforehand in primary disinfection evaluation); also replacement of some related equipment (cooling system pumps, instrumentation, destruct units, etc.)	Growth / Rehabilitation	$4,100,000	$4,530,000
D13	2020-2022	High service pumps	Add new pump building, pumps, and surge protection	Growth	$5,400,000	$5,970,000

Table 5-1. Capital Improvements Plan

No.	Planned Date of Implementation	Project	Description	Basis of Need	2016 Cost Estimate[a]	Cost Escalated to Planned Date of Implementation[b]
D14	2020-2022	Solids handling	Add 2 solids handling basins to allow for 65 mgd capacity (the addition of 4 basins may be needed if the filter-to-waste recycle project is not implemented)	Growth	$3,000,000	$3,320,000
D15	Future	Filter-to-waste	Add filter-to-waste capture tank and pump station to return flow at metered rate to plant inlet	Growth	$900,000	$1,000,000
D16	Future	Backup generator	Install 2000 kW generator and automatic transfer switch, with associated control improvements, to enable 15 mgd standby treatment capacity	50% Growth, 50% Reliability	$1,600,000	$1,810,000
				TOTAL DUFF NO. 1 WATER TREATMENT PLANT	**$22,800,000**	**$25,200,000**

No.	Planned Date of Implementation	Project	Description	Basis of Need	2016 Cost Estimate	Cost Escalated to Planned Date of Implementation[a]
Duff No. 2 Water Treatment Plant						
2D1	2024-2026	Duff No. 2 intake	Install 60 mgd Intake No. 2 on Rogue River, prior to expiration date of permit.	Growth	8,000,000	9,600,000
2D2	2038-2043	Duff No. 2 plant	Install initial 20 mgd phase of Duff No. 2 WTP, together with 60 mgd intake facility. Cost estimate based on escalating the estimate developed in the 2008 plan.	Growth	$74,000,000	$120,000,000
			TOTAL DUFF NO. 2 WATER TREATMENT PLANT		**$82,000,000**	**$129,600,000**

[a] Costs are generally listed for construction, only, unless the project only involves an engineering analysis. Appropriate allowances need to be added for construction projects to account for engineering, contingencies, and soft costs such as for permitting or easements.

[b] Costs are escalated using 2 percent per year inflation.

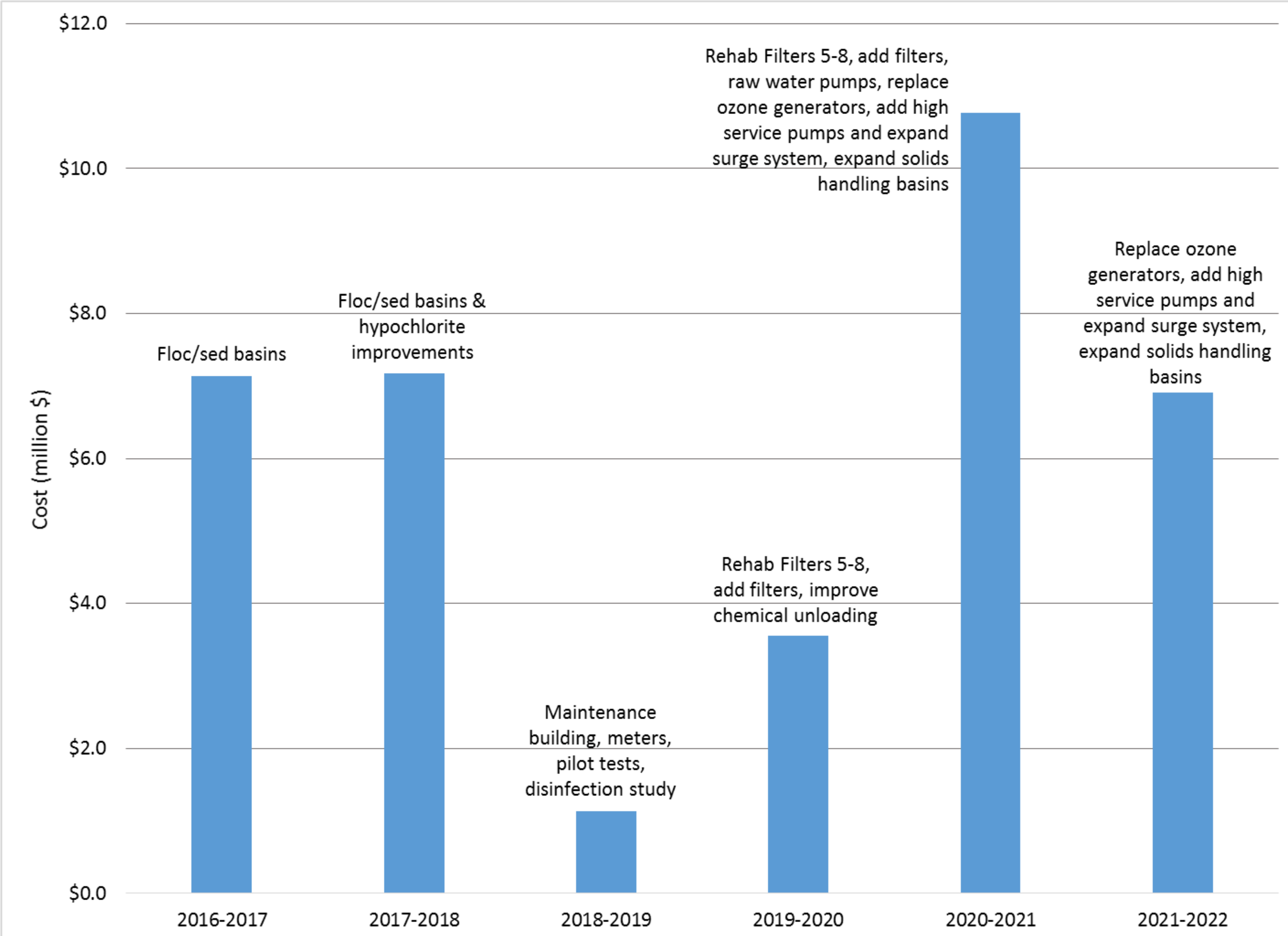

Figure 5-1. Cash Flow Projections for Expansion of Duff No. 1 Water Treatment Plant to 65 mgd