Medford Water Commission
Planning, Design, and Construction of
Distribution System Resilience Backbone

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FINAL | October 2022

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Contents

Appendices

Tables

Figures

Abbreviations

ADD	average day demand
ASCE	American Society of Civil Engineers
BBS	Big Butte Springs
CS	control station
CSZ	Cascadia Subduction Zone
EPS	extended period simulation
FWPS	Finished Water Pump Station
HGL	hydraulic grade line
HSPS	High Service Pump Station
IBC	International Building Code
MDD	max day demand
Medford Water	Medford Water Commission
MG	million gallons
mgd	million gallons per day
O&M	operations and maintenance
psi	pounds per square inch
RP	reduced pressure
SCADA	supervisory control and data acquisition
TSD	total system demand
VFD	variable frequency drive
WDSFP	Water Distribution System Facility Plan
WTP	water treatment plant

Chapter 1

DISTRIBUTION SYSTEM RESILIENCE BACKBONE GOALS AND OBJECTIVES

1.1 Introduction

The Medford Water Commission (Medford Water) has been proactively working towards building resilience into its water system to supply critical water for customers in the event of a natural disaster. Medford Water has secured a $190 million Water Infrastructure Finance and Innovation Act loan to complete the Rogue Valley Water Supply Resiliency Project. This resiliency project initially focused on expanding and building resilience at the Robert A. Duff Water Treatment Plant (WTP) but has expanded to also include building resilience in the water distribution system, including pipelines, storage, and pumping, to deliver this water to customers. The purpose of the Distribution System Resilience Backbone project is to develop a resilience strategy that meets the short- and long-term needs of the system.

This study is not a replacement for a system-wide seismic resiliency plan. Medford Water intends to complete a full seismic resiliency plan, including identifying critical customers, as part of future planning efforts.

The purpose of this chapter is to document the goals and objectives for normal and resilient operation of the Medford Water distribution system. These goals and objectives set the basis for what improvements are needed for the system and how those improvements can be sequenced to help Medford Water transition from the current distribution system configuration to the ultimate resilient configuration.

Please note that at the time of this study, the River Zone was still called the "Reduced Pressure Zone" and Zone 1 was called Zone 1A.

1.2 Long-term Resilience Vision

A resilient water system is one that can continue to supply water for critical needs of its customers following a major natural disaster. In alignment with the Oregon Resilience Plan's goal to improve Oregon's resilience over 50 years, Medford Water developed a vision of the resilience of their water distribution system in the aftermath of a major earthquake 50 years from now. This vision is defined by Medford Water's level of service goals and critical backbone map.

1.2.1 Level of Service Goals

Medford Water's emergency level of service goals were established as part of a previous planning effort. The level of service goals related to major earthquake events are described in Table 1.1. For the City of Medford, a Klamath Falls crustal fault earthquake is likely to be more damaging than a Cascadia Subduction Zone (CSZ) earthquake based on the proximity of the epicenter.

Medford Water's goal is to be able to supply 23 million gallons per day (mgd), which is equal to Duff Water Treatment Plant's (WTP) winter capacity, within 14 days and 30 days of a CSZ earthquake or Klamath Falls crustal fault earthquake, respectively. The level of service goals acknowledge that even if the Duff WTP is producing potable water, due to main breaks in the distribution system and therefore the need for flushing and sampling, potable water will not be available throughout the system right away.

Table 1.1 Earthquake Level of Service Goals

Event Category	Event	Impacts to Medford Water System	Initial			Mid-Term			Long-Term			Discussion	Implications for Current Storage Evaluation Project
			Within X Days	Provide Flow of Y	At Water Quality Z	Within X Days	Provide Flow of Y	At Water Quality Z	Within X Days	Provide Flow of Y	At Water Quality Z		
Major West-Coast Event	CSZ earthquake (2,500-year return interval)	Loss of both BBS transmission lines, damage to the Duff WTP, damage to reservoirs and pump stations, many pipeline breaks	4 days[1]	Only container fill stations (no distribution water) 11.5 mgd	Potable	14 days[1]	23 mgd	Non-potable (treated at source)	180 days[1]	23 mgd	Potable	Initially, Medford Water will provide no water through distribution system, and only fill personal containers at select locations, Goal is to operate the Duff WTP at one-half its wintertime capacity within 60 days, then at full wintertime capacity within 180 days.	Consider operation of system with supply only from the Duff WTP.
Regional Event	Klamath Falls crustal fault earthquake (75-year return interval)	Loss of both BBS transmission lines, damage to the Duff WTP, damage to some reservoirs and pump stations, some pipeline breaks	4 days[1]	Operate container fill stations (no distribution water)	Potable	30 days[1]	23 mgd	Non-potable (treated at source)	90 days[1]	23 mgd	Potable	Similar to CSZ event, Medford Water initially would not be able to supply water through the distribution system because of broken pipes. Goal would be to repair enough lines to allow distribution of non-potable water within 30 days and potable water within 90 days.	Consider operation of system with supply only from the Duff WTP.
Rogue-Valley Event	Extended power outage (10-year return interval)	Loss of the Duff WTP and control stations for 1/2 day	1/2 day	26.4 mgd	Potable	4 days	Full	Potable				Initial operation using only BBS supply. Intermediate operations can be increased using backup generators.	
Rogue-Valley Event	Dam failure	Flooding; damage to the Duff WTP intake	1/2 day	26.4 mgd	Potable	180 days	37.9 mgd	Potable	Years?	Full	Potable	Initial operation using only BBS supply. Eventual addition of the Duff WTP at one-half wintertime capacity.	
Medford Water Supply Interruption Event	Cyber attack	Control interruptions for the Duff WTP, BBS, and distribution pump stations	1/2 day	Full	Potable							Interruptions in operations during change from automatic to manual operations.	
Medford Water Supply Interruption Event	Landslides	Loss of BBS lines	0 days	23 mgd	Potable	60 days	36.2 mgd	Potable	120 days	Full	Potable	Initially, operate only using the Duff WTP (assuming wintertime operation). Repair one, then the other BBS lines.	
Medford Water Supply Interruption Event	Public riots, worker strikes, or similar	Interruption to operation of the Duff WTP	0 days	26.4 mgd	Potable	3 days	Full	Potable				Assume interruption to the Duff WTP operations; but BBS supply remains intact. Return to full the Duff WTP operations after 3 days.	
Medford Water Supply Interruption Event	Watershed fire	No production from the Duff WTP and then limited use; BBS are only supply initially	0 days	26.4 mgd	Potable	10 days	37.9 mgd	Potable	120 days	Full	Potable	the Duff WTP shut down in case firefighting involves chemical spraying that could reach Rogue River. Then, the Duff WTP production limited by higher-than-normal turbidities during wintertime runoff.	

Notes:
(1) Oregon Resilience Plan 50-year targets: Source of supply 50-60% within 24 hours and 80-90% in 1-2 weeks; Backbone facilities (transmission facilities, pipes, pump stations, and reservoirs) 80-90% operational within 24 hours; Distribution system 50-60% operational within 1-3 days and 80-90% operational within 1-2 weeks.
Background data: CSZ earthquake definition per American Society of Civil Engineers (ASCE) 07-16 and International Building Code (IBC) 2018; Summertime the Duff WTP capacity, 45 mgd; Wintertime the Duff WTP capacity, 23 mgd; Big Butte Springs (BBS) full pipe capacity, 26.4 mgd; BBS single line capacity, 13.2 mgd; Summertime capacity of full BBS and the Duff WTP, 71.4 mgd; Wintertime capacity of full BBS and the Duff WTP, 49.4 mgd; Wintertime capacity of one BBS pipe and the Duff WTP, 36.2 mgd; Extreme high turbidity capacity of the Duff WTP is one-half of wintertime capacity, 11.5 mgd; System capacity with extreme high turbidities, 26.4 + 11.5 = 37.9 mgd.
Source: Jacobs. 2019. *Evaluation and Recommendations for Storage Improvements in Gravity and Reduced Pressure Zones*.
Abbreviations: ASCE - American Society of Civil Engineers; BBS - Big Butte Springs; IBC - International Building Code.

1.2.2 Critical Backbone

A resilient water system backbone consists of the critical components of the water system including supply sources, treatment facilities, transmission mains, control/pump stations, reservoirs, and distribution pipes that should be 80 to 90 percent operational within 24 hours after a major earthquake in order to serve critical customers. A workshop was held with Medford Water management, engineering, and operations staff on September 10, 2021, to conceptualize a water system backbone. The concept identified is shown in Figure 1.1.

This backbone system was configured to serve Medford Water's wholesale customers, Medford's major hospitals, the Rogue Valley International-Medford Airport, and the critical customers in the heart of Medford. The backbone system is supplied by the Duff WTP, which is actively being improved with expanded capacity and resilience at the time of this study. In the distribution system, the backbone system identified at the September 10, 2021, workshop is limited to the Reduced Pressure (RP) Zone and Gravity Zone, where the majority of critical water system customers are located. The backbone assumes the Capital Hill Reservoir site is a critical component for receiving supplied water from the Duff WTP and distributing it to customers. The backbone defined in this study is considered the highest criticality; additional lower priority backbone infrastructure in all pressure zones will be further refined during future system planning work.

1.2.3 Operational Objectives for Resilience

Medford Water's objective for operating its critical backbone is to make operations as simple and passive as possible. The elements of the backbone system should be designed or upgraded so they are available for the intended level of service immediately following an event. For example, the backbone should be designed or upgraded to withstand a CSZ earthquake and Klamath Falls earthquake with immediate occupancy and operation after the event.

1.3 State of the Existing System

1.3.1 Resilience of Existing System

Medford Water's priority is to seismically harden the Duff WTP so it has a resilient capacity of at least 23 mgd. This work is anticipated to be completed in the next 5 to 10 years. None of Medford Water's reservoirs or control stations are currently seismically resilient.

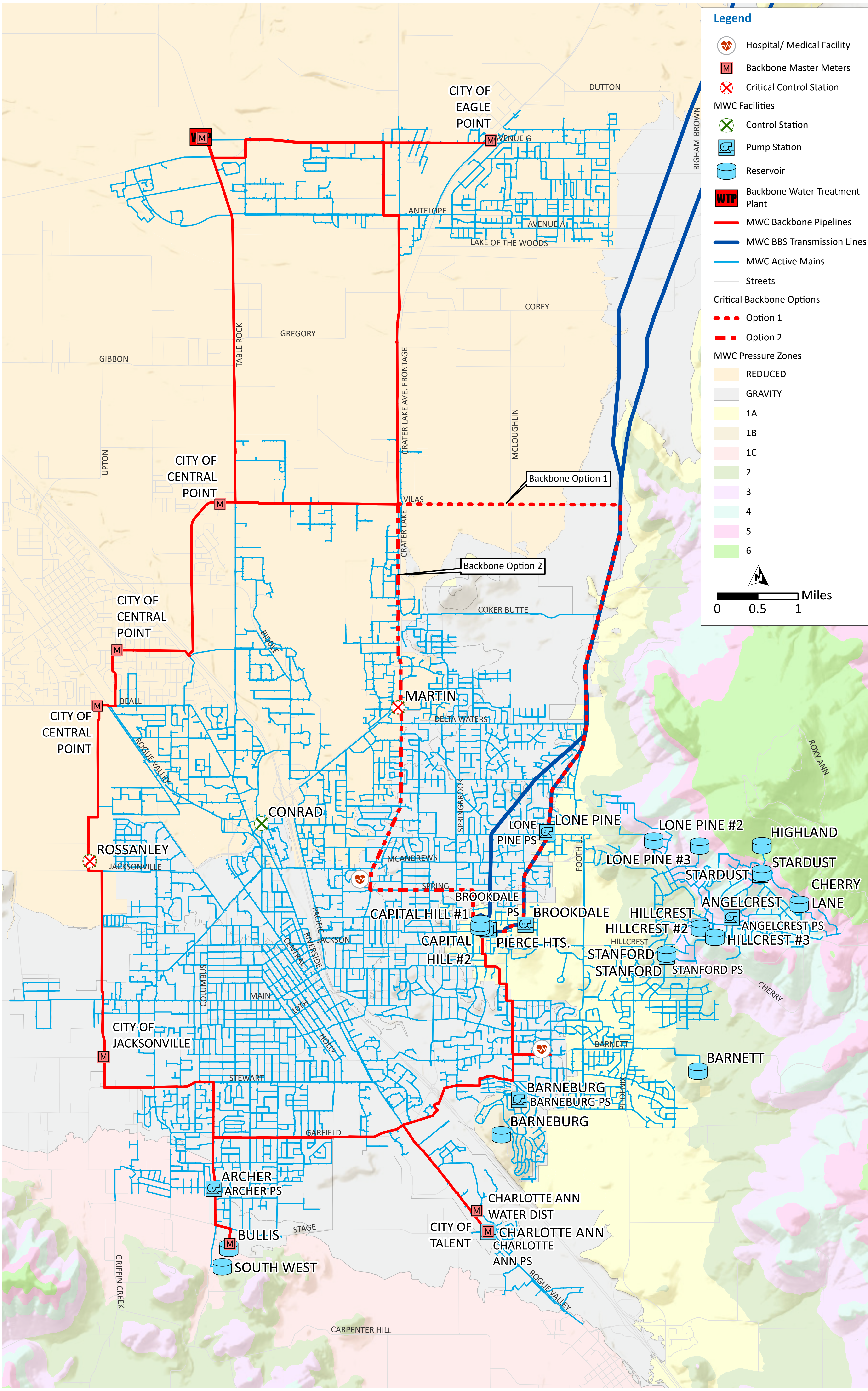


Figure 1.1 Initial Concept Critical Backbone Map

1.3.2 Operational Challenges

Operational challenges have been identified in both the RP Zone and the Gravity Zone.

1.3.2.1 Reduced Pressure Zone

Operational challenges identified in the RP Zone include lack of storage, pressure fluctuations, and limited Duff WTP production.

Lack of storage

Besides the Duff WTP clearwell with a volume of 5 mgd (which is not seismically sufficient), the RP Zone does not have any water storage. The RP Zone needs equalizing, emergency, and fire suppression storage. The addition of equalizing storage in the RP Zone would allow the Duff WTP to operate at steady-state (constant flow rate) on a day-to-day basis rather than ramp production up and down to match diurnal consumption.

Pressure fluctuations

Medford Water's RP Zone retail and wholesale customers experience wide pressure swings as the Duff WTP production ramps up and down. Customers near the control stations in particular experience wide swings in pressures as the system changes from Forward Flow (pressure reducing) to Reverse Flow (pumping). Additionally, these pressure fluctuations cause surge challenges at the control stations. The pressure fluctuations are caused in part by the lack of variable frequency drives on pumps at the Duff WTP (only one pump has a variable speed drive) and lack of control stations that allow pumping to match demand.

Limited Duff WTP Production

The Duff WTP production is limited by discharge pressures at the High Service Pump Station (HSPS) climbing to unacceptable levels. Discharge pressures of 105-108 pounds per square inch (psi) are the maximum desired levels to avoid impacting customers with sensitive fire suppression systems. The Jacobs evaluation of the HSPS found that a maximum pressure of 119 psi would be ideal for the current pump configuration.

1.3.2.2 Gravity Pressure Zone

Operational challenges identified in the Gravity Zone include BBS air entrainment, flow control, and pressure fluctuations; age of Capital Hill Reservoirs, age of Coal Mine Station, customers directly served on BBS pipes, and lack of turnover in Bullis Reservoir.

BBS Air Entrainment, Flow Control, Pressure Fluctuations

The BBS pipelines are designed to flow under gravity and pressurized conditions. Through experience, Medford Water learned to operate the pipelines in two flow modes to respond to changing demand conditions and mitigate the effects of air entrainment to customers. In one operating mode, both pipes are kept full at the BBS supply source. In the other operating mode, the BBS 1 pipeline is kept half full and BBS 2 pipeline is kept full at the supply source. When needed, control valves along the pipelines can be operated by Medford Water staff to reduce air entrainment.

Under current winter low demand periods, the Duff WTP is shut down and the BBS supply is reduced to a pipe and half supply. When demands are less than the BBS supply, and the Capital Hill reservoirs are full, water from the BBS pipelines is wasted into Lone Pine Creek through reservoir overflow valving near the Capital Hill Reservoirs due to the lack of flow control without introducing air entrainment.

Water is supplied to the City of Eagle Point by Medford Water. The water can be supplied from the RP Zone distribution system and directly from the BBS 2 pipeline. When Eagle Point takes approximately 600 gallons per minute from the BBS 2 pipeline when the Duff WTP is not operating, a drop in pressure noticed at Coal Mine Station causes operators to adjust valve setpoints to avoid air issues.

Age of Capital Hill Reservoirs

The Capital Hill Reservoirs 1, 2, and 3 were constructed in 1908, 1927, and 1945, respectively. Medford Water has invested hundreds of thousands of dollars in maintenance of these aging facilities. Multiple structural and seismic evaluations beginning in 1997 indicate that the reservoirs will not perform well in a seismic event and should be replaced.

Age of Coal Mine Control Station

Due to age and condition, the Coal Mine Control station needs to be rebuilt.

Customers Directly Served on BBS Pipes

Several direct customer connections to the BBS piping downstream of the Coal Mine Station have been added over the years and the pipes are no longer dedicated transmission mains. This creates risk for use as critical backbone infrastructure. Medford Water's goal is to have dedicated transmission piping.

Lack of Turnover in Bullis Reservoir

Due to head loss in the distribution system as water flows south, the Bullis Reservoir was set at a lower overflow level than the Capital Hill Reservoirs (1,564 feet compared to 1,588 feet). Due to the lower elevation, access to the Bullis Reservoir storage requires pumping out of the reservoir with the low lift pumps in the Archer Pump Station to meet the hydraulic grade line in the Gravity Zone. When water is not pumped out, there are water age and water quality concerns, especially when water from the Duff WTP is stored at Bullis Reservoir.

1.3.2.3 RP-Gravity Zone Interaction

Complex Control Station Operations

The Rossanley, Conrad, and Martin control stations are configured to allow for Forward Flow and Reverse flow depending on BBS and the Duff WTP production rates and RP Zone and Gravity Zone consumption rates. Operations can be particularly challenging during the "shoulder season" months when the water system transitions from BBS supply to both BBS and the Duff WTP supply and vice versa. During these periods flow may change from Forward Flow to Reverse Flow and back again, during the same day. Stabilizing suction pressures at the control stations is needed to eliminate pump cavitation issues.

Water Quality Management

Water quality management can be a challenge as supply from BBS and the Duff WTP mix. The difference in source water quality between the Duff WTP and BBS tends to decrease chlorine residual more quickly in the distribution system. Water age is a challenge in some parts of the distribution system. The Bullis Reservoir and upper-zone, east-side reservoirs are the primary locations of concern related to water age.

1.4 Project Goals and Objectives

The key objectives of the project are reflected in the purpose and need statement, which defines the project objectives that must be met for an alternative to be considered a viable option. Additional goals that are not essential to the project are incorporated into the selection criteria that are used to compare alternative projects and help Medford Water determine which alternative best meets their goals.

1.4.1 Purpose and Need Statement

The purpose of the project is to provide resilient storage for both the RP and Gravity pressure zones (totaling 25 million gallons [MG] by 2040 and 34 MG at build-out) that integrates into Medford Water's long-term resilient backbone. The objectives for the projects are as follows:

1. Allow for the replacement of the Capital Hill reservoirs.
2. Provide resilient and reliable conveyance for 23-mgd emergency flows from the Duff WTP to the Capital Hill Reservoirs.
    a. Of the 23-mgd emergency flows, 9 mgd will be consumed in the RP Zone and 14 mgd will be pumped to the Gravity Zone.
3. Allow the Duff WTP to operate at steady state and allow full pump discharge capacity for up to 65 mgd.
4. Reduce the pressure fluctuations and surges experienced by:
    a. Retail customers (acceptable pressure fluctuation is 25 psi).
    b. Wholesale customers (acceptable fluctuation is 25 psi).
    c. Control stations (CS) (if and when used to eliminate surge issues).
    d. Maintain minimum system pressure of 30 psi during normal operation.

1.4.2 Selection Criteria

The following non-economic criteria encompass Medford Water's values and goals and are used to compare potential projects and help identify which projects provide the most value to Medford Water and the community. Considering the scoring of non-economic criteria together with cost will allow Medford Water to select a preferred alternative that optimizes the value of the project and minimizes cost.

1.4.2.1 Resilience

- Resilient to emergency disruptions such as earthquakes, wildfires, and power outages.
- Integrates into Medford Water's long-term resilience backbone.
- Reliable.
- Provides distributed storage for redundancy.

1.4.2.2 Operation and Maintenance Simplicity

- Simplifies water system operations.
  - The Duff WTP operations.
  - Control station operations.
  - Shoulder season operations.
- Benefits BBS pipe flow and air entrainment challenges.
- Maximizes system efficiency.
  - Provides opportunity to implement hydropower.
- Maintains water quality.

1.4.2.3 System Compatibility

- Integrates with scheduled the Duff WTP, pipeline, and storage projects.
- Aligns with system needs as the city grows.

Chapter 2

HYDRAULIC MODEL SETUP AND CALIBRATION

2.1 Introduction

As part of the Medford Water Resilience Backbone project, the consultant team updated Medford Water's hydraulic model for current conditions and calibrated the model for extended period simulation using supervisory control and data acquisition (SCADA) data and field data collected by Medford Water staff. This chapter presents the configuration of the Medford Water system, documents the demand scenarios used for analysis, and describes the model update and calibration process undertaken during this project.

2.2 Existing Water System

The Medford Water system receives its water supply from two sources, the Rogue River through the Duff WTP and BBS. Medford Water's distribution system consists of two main pressure zones, the RP Zone and the Gravity Zone, as well as several higher, smaller pressure zones. The Duff WTP feeds into the RP Zone while BBS feeds into the Gravity Zone. The RP Zone and Gravity Zone are connected by three control stations that can pump water up to the Gravity Zone or allow water to cascade down to the RP Zone. The RP Zone does not contain any distribution system reservoirs. The Capital Hill reservoirs and the Bullis Reservoir serve the Gravity Zone. A map of the existing water distribution system configuration is shown on Figure 2.1. Because this project focused on the RP and Gravity pressure zones, Figure 2.2 presents a schematic of these two zones.

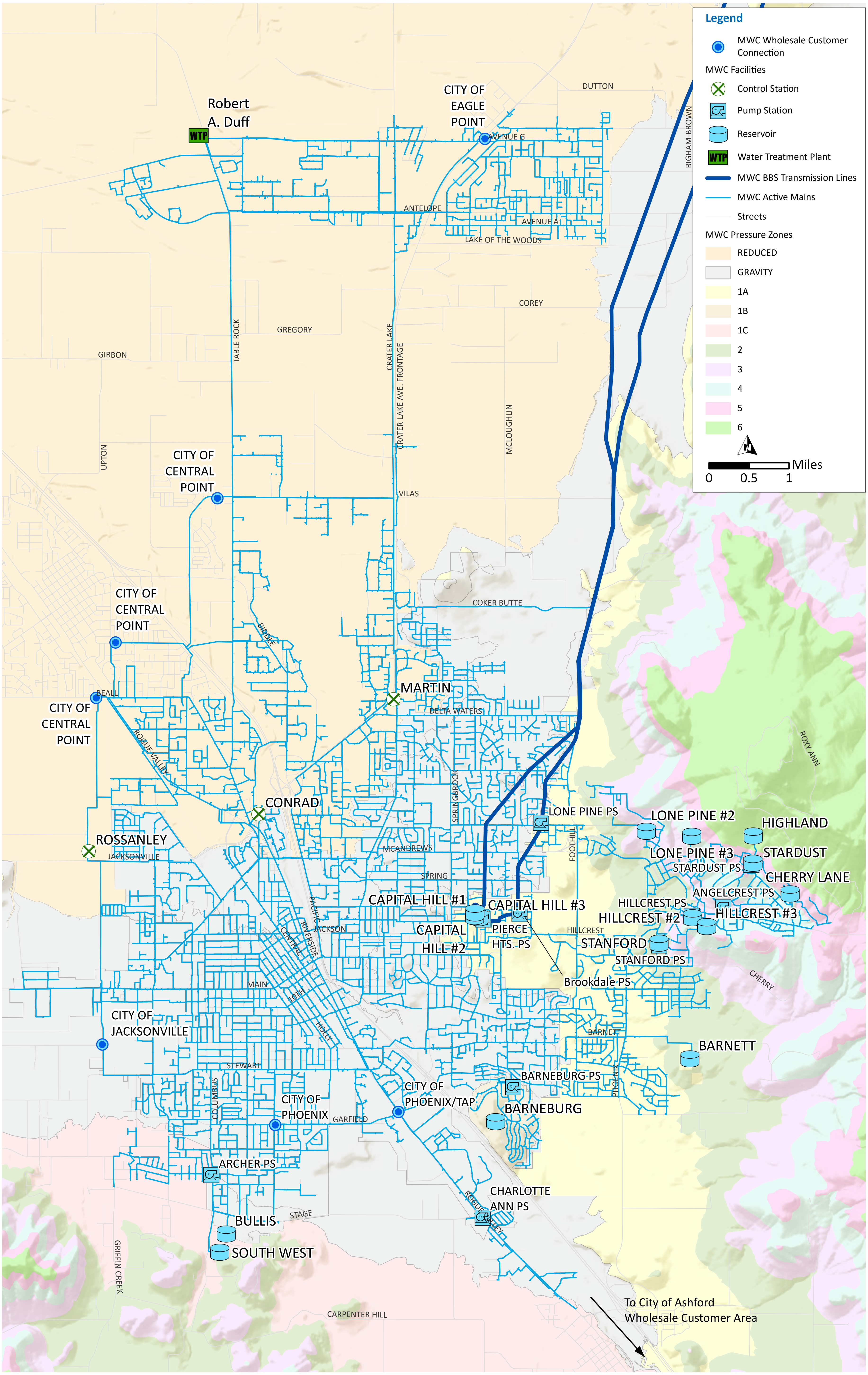


Figure 2.1 Existing Water Distribution System

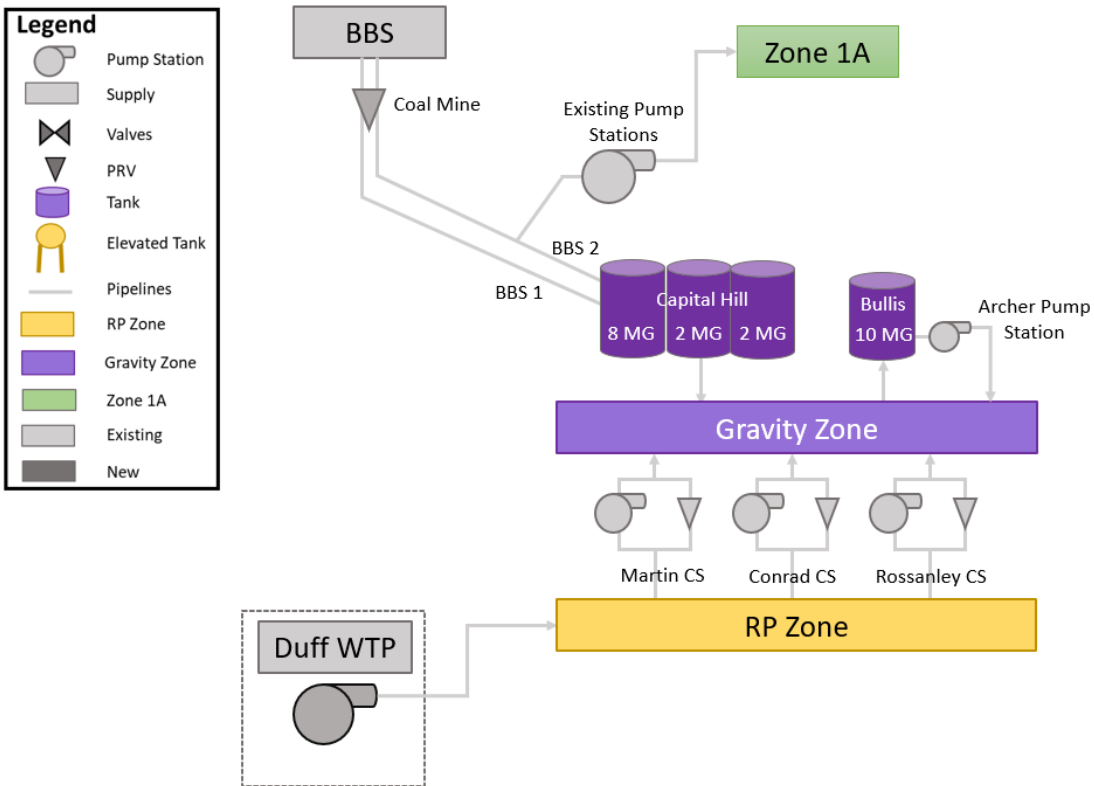


Figure 2.2 Existing RP and Gravity Zone Schematic

2.2.1 Water Supplies

2.2.1.1 Big Butte Springs

Big Butte Springs serves as the primary year-round supply for Medford Water. It is located about 30 miles northeast of Medford and flows by gravity to the Capital Hill reservoirs through two BBS transmission mains, BBS 1, and BBS 2. These pipelines are more than 70 years old and use custom pipe diameters to maintain a specific hydraulic grade line (HGL). BBS 1 is controlled at the Coal Mine Control Station and BBS 2 is controlled via a valve at Nichols' Gap. The spring's capacity varies from 25 to 35 mgd depending on rainfall, groundwater, and snowpack conditions. However, It is estimated that only 24.9 mgd can be conveyed between both pipelines, with 12.6 mgd from BBS 1 and 12.3 mgd from BBS 2. The system is operated with either full-pipe flow of 12.6 mgd through BBS 1 or half-pipe flow of 6.3 mgd through BBS 1. There are issues with air entrainment when not operated at one of these conditions.

During drought conditions the springs are less reliable and cannot always provide the full BBS pipe capacity. To simulate drought conditions, the BBS supply capacity was set to pipe and a half, meaning half-pipe flow for BBS 1 and full-pipe flow for BBS 2.

2.2.1.2 The Duff Water Treatment Plant

The Duff WTP draws water from the Rogue River and is used as a supplemental source for Medford Water during the summer months. The current capacity is 45 mgd but expansion projects are ongoing and will increase the capacity to 65 mgd. As system demands increase and if drought conditions continue to increase in severity, the Duff WTP will be required to produce large quantities of water for longer time frames. By 2036, Medford Water expects to operate Duff year-round.

2.2.2 Water Distribution System Configuration

Medford Water's distribution system consists of nine pressure zones that serve elevations from 1,250 to 2,250 feet. The two largest zones are the Gravity Zone, which serves most of the southwestern portion of the system, and the RP Zone which serves the northern part of the system. The remainder of the system is broken up into six pressure zones to the East and one pressure zone in the Southwest, which serve the higher customers of the system. This configuration is outlined on Figure 2.1 and Figure 2.2.

2.2.2.1 Storage Reservoirs

Medford Water has 16 storage reservoirs throughout the distribution system. The total storage capacity of the system, including the Duff WTP Reservoir is 36.2 MG. The Gravity zone is served by reservoirs at two locations, Capital Hill and Bullis.

The Capital Hill site is the largest storage site in Medford Water's system. At the Capital Hill site, there are three tanks with a total capacity of 12 MG. Capital 1 and 2 have 2.0 MG of storage each and Capital 3 has 8.0 MG. All three are at an overflow elevation of 1,588 feet. Jacob's 2019 *Evaluation and Recommendations for Finished Water Storage in the Gravity and Reduced Pressure Zones Report* (2019 Gravity and RP Storage Study) outlined the condition and replacement plan at Capital Hill. It was determined that all three tanks are vulnerable to failure during a seismic event and all three are in need of replacement.

Bullis provides an additional 10 MG of storage for the Gravity Zone. The Bullis Reservoir is located at the southwest corner of the distribution system. It is at an overflow elevation of 1,564 feet. Bullis fills from the Gravity Zone but due to its head, it serves the Gravity Zone through pumping.

2.2.2.2 Control Stations

Medford Water operates three control stations, Martin, Conrad, and Rossanley, that each provide both pumping and pressure reducing functions.

The three stations can pump a total of 40 mgd from the RP Zone to the Gravity Zone in. Their individual firm and total pumping capacities are shown in Table 2.1.

Table 2.1 Control Station Firm and Total Pumping Capacities

Existing Control Stations	Firm Capacity (mgd)	Total Capacity (mgd)
Martin	6	10
Conrad	5	13
Rossanley	12	17
Total	23	40

2.2.3 Water System Operations Approach

Due to seasonal variation in demands, the water system is operated differently during high demand periods (summer months) than low demand periods (winter demands).

2.2.3.1 Winter Operations

During low demand periods, Medford Water's system is served from BBS as the only supply of water. Water is delivered to the Gravity Zone and the Capital Hill site and is conveyed to the RP Zone through the PRVs at the control stations. Medford Water refers to this operational mode as forward flow.

2.2.3.2 Summer Operations

During summer operations, Medford Water's system is served from both BBS and the Duff WTP. Duff WTP pumps into the RP Zone and then water is pumped through the control stations from the RP Zone to the Gravity Zone. This operational mode is called reverse flow. During reverse flow operations, Medford Water sees significant pressure fluctuations in the RP Zone. These limitations are due to the lack of existing variable speed drives on any of the control station pumps, making it difficult for Medford Water to balance the demands in the RP Zone with the amount of flow transferred to the Gravity Zone. Therefore, greater control of flow and/or pressure into or out of the RP Zone is needed.

2.2.3.3 Shoulder Operations

In the spring and autumn months, operations switch between summer operations and winter operations, and at times, the system may operate in both forward flow and reverse flow conditions over the course of a single day as demand is ramping up. For the spring transition to summer operation, Operations has also historically reduced the flow from BBS to allow for more consistent supply from the Duff WTP until demands reach a high enough level that both supplies are used through the day and full-time reverse flow operation commences. As demand increases, shoulder operations will be shifted to winter months, and eventually will be eliminated completely.

2.3 Water Demands

Medford Water supplies demands inside and outside of the Medford city limits as well as to two other water districts and six nearby cities on a wholesale basis. Figure 2.1 shows the locations of the wholesale connections relative to the distribution system.

As presented in the Water Distribution System Facility Plan (WDSFP), from 2000 to 2015, Medford Water saw an average day demand (ADD) of 28.1 mgd and a max day demand (MDD) of 55.4 mgd. The WDSFP estimated future water demands based on a constant per capita approach assuming historical growth rates continue constantly in the future. The WDSFP projected demands for planning years 2036 and 2065, where year 2065 was considered build-out. The WDSFP build-out scenario was based on a projected 2065 population and does not correspond to a true land use-based build-out.

The WDSFP presented a conservative method for projected flows. Based on the last five years of ADD data and a decrease in demands over that period, the 2017 methodology appears overly conservative. For this Distribution System Resilience Backbone project, an annual growth rate between 0.75 percent and one percent is assumed to represent anticipated future growth of Medford Water demands more accurately, which is consistent with the demand projections used in Medford Water's 2022 *Robert A. Duff Water Treatment Plant Facility 65 mgd Expansion (Duff demand projections).* Figure 2.3 shows these two demand projection scenarios by light blue and dark blue dashed lines representing 0.75 percent annual growth and one percent annual growth, respectively.

For this evaluation, three planning horizons were used, identified as near-term, long-term, and build-out. These three planning horizons are shown on Figure 2.3 and described below.

1. Near-term. The near-term horizon corresponds to the WDSFP 2036 system-wide maximum day demand (MDD) projection of approximately 80 mgd. As seen in Figure 2.3, the less conservative Duff demand projections predict that MDD will not reach 80 mgd until approximately between 2042 and 2057.
2. Long-term. The long-term horizon corresponds to the Duff WTP operating at 65 mgd and BBS operating under drought conditions and supplying approximately 20 mgd for a total system wide MDD of 85 mgd. As seen in Figure 2.3, if demands follow the 1 percent growth rate, then demands could reach this supply limitation as soon as 2049. However, if demands occur slower, the Duff WTP expansion to 65 mgd will be sufficient to supply demands until 2065.
3. Build-out. The build-out horizon represents a system-wide MDD of approximately 110 mgd, which is consistent with the year 2065 build-out scenario from the WDSFP. Based on the less conservative Duff demand projections, Figure 2.3 shows that the build-out horizon may occur between 2078 and 2100.Note that this build-out scenario is based on a flow rate and does not represent a land use-based estimate.

The demand projections for each of the planning horizons are also presented in Table 2.2.

Table 2.2 Demand Projections

Zones	Near-term			Long-term			Build-out		
	Wholesale MDD	Zone MDD	Total MDD	Wholesale MDD	Zone MDD	Total MDD	Wholesale MDD	Zone MDD	Total MDD
RP Zone	14	17	31	15	18	33	18	21	39
Gravity Zone	8	29	37	9	31	39	12	35	47
Higher Zones	0	12	12	0	13	13	0	24	24
Total	1722	58	80	23	62	85	30	80	110

2.4 Hydraulic Model

Medford Water maintains a hydraulic model that was developed as part of the Jacobs' 2017 WDSFP. The hydraulic model is a full-pipe model of the distribution system and was calibrated during the preparation of the Facility Plan for steady state and extended period simulation (EPS) conditions. Since the preparation of the WDSFP, the Medford Water hydraulic model has been periodically updated as new pipelines and infrastructure components have been constructed or installed.

2.4.1 Hydraulic Model Updates

Updates made to the Medford Water hydraulic model for this study included allocation of 2020 water demand, incorporation of new pipelines since the last periodic update, and verification of the size and timing of planned improvements identified in the WDSFP. Discussions were also held with Medford Water operations staff to review and capture operational strategies for facilities so that the hydraulic model could be applied with automated controls that mimicked operator decisions across a range of scenarios and demand conditions. The operations discussion captured information on the operation of the BBS lines, matching flows between the Duff HSPS and the Control Stations, using the total system demand (TSD) calculation to forecast operational configurations, and ramping up/ramping down of the Duff WTP if the VFD at the Duff HSPS is ramping up/ramping down. In addition, the shift in operational philosophy around using the Bullis reservoir to support meeting customer pressures was discussed to capture the operational approach for refilling and drawing down Bullis. The slide deck from this meeting is included as Appendix A.

2.4.2 Hydraulic Model Calibration

In addition to the model updates described above, model calibration was performed with the revised demand allocation and with the new pipelines in the hydraulic model. The calibration included monitoring pressure at nine locations throughout the RP Zone and the Gravity Zone for approximately 10 days and included evaluation of model performance against the field-collected data at the pressure monitoring locations. During the time that the pressure monitors were installed, operation of the system was transitioning from reverse flow to forward flow, so there was periodic operation of the Duff Finished Water Pump Station (FWPS) and the control stations as water demand was decreasing. The locations of the pressure monitors are shown on Figure 2.4, and the time series comparisons of the field-monitored and model-predicted pressures are shown in Figure 2.5 and Figure 2.6. There was good agreement of the model-predicted pressure to the field-monitored data, and it was determined that the model could confidently be used to evaluate the new facility and operational scenarios for this study. The only modification in the model to better align the model-predicted pressures with the field-measured pressures was to review operation of the control stations. A table documenting the field-measured and model-predicted pressure results for each test hydrant is included as Appendix B.

In addition to the model calibration performed specifically for this study, the Medford Water hydraulic model performance was also compared to the system operation during a tracer study for the Duff WTP Reservoir. Under this scenario, the Duff FWPS was operated at a peak flow condition for several hours, which required coordination of control station operation and manipulation of tank levels to achieve these peak flows. The hydraulic model simulated these peak flow conditions well.

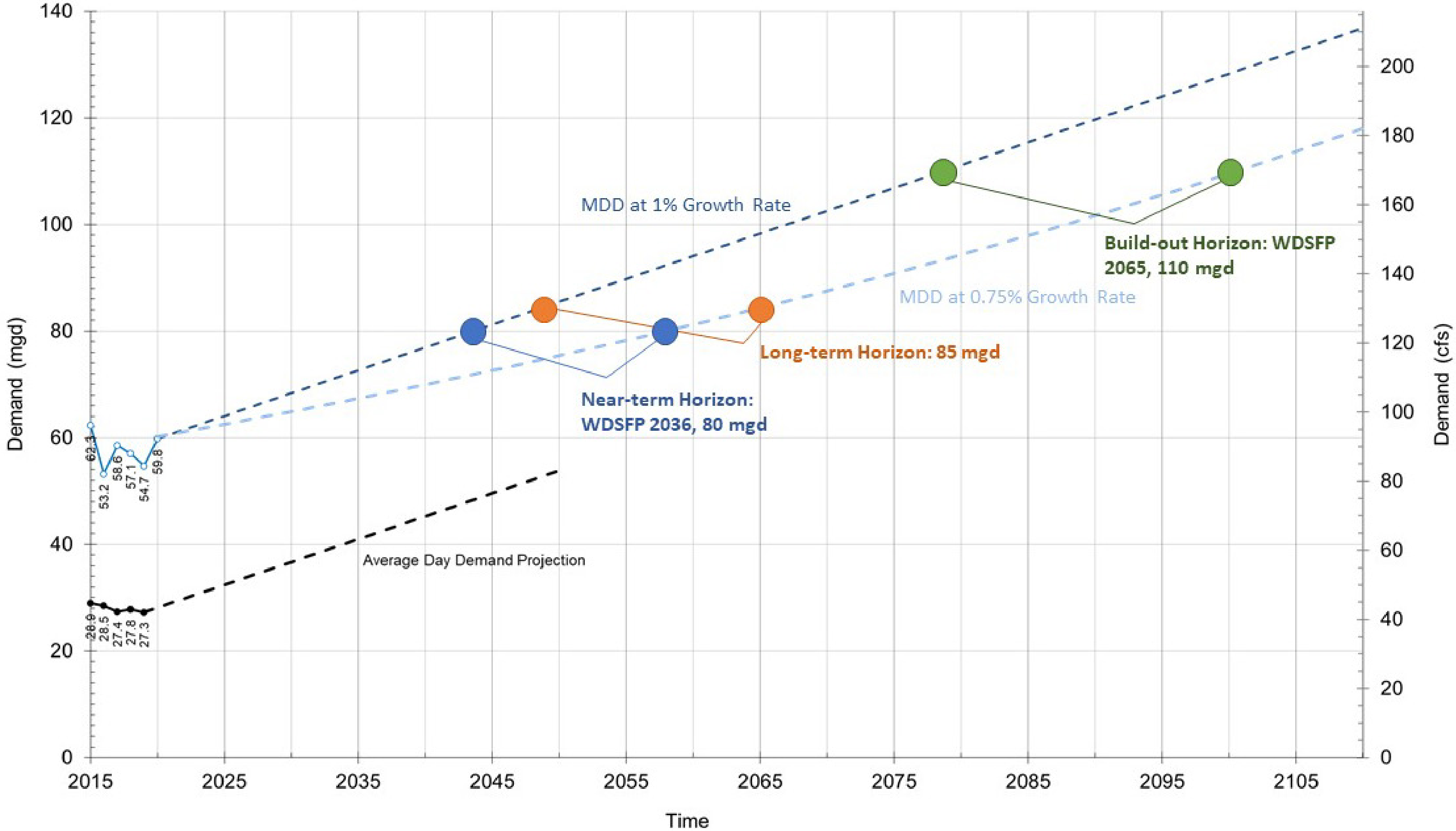


Figure 2.3 Demand Projections

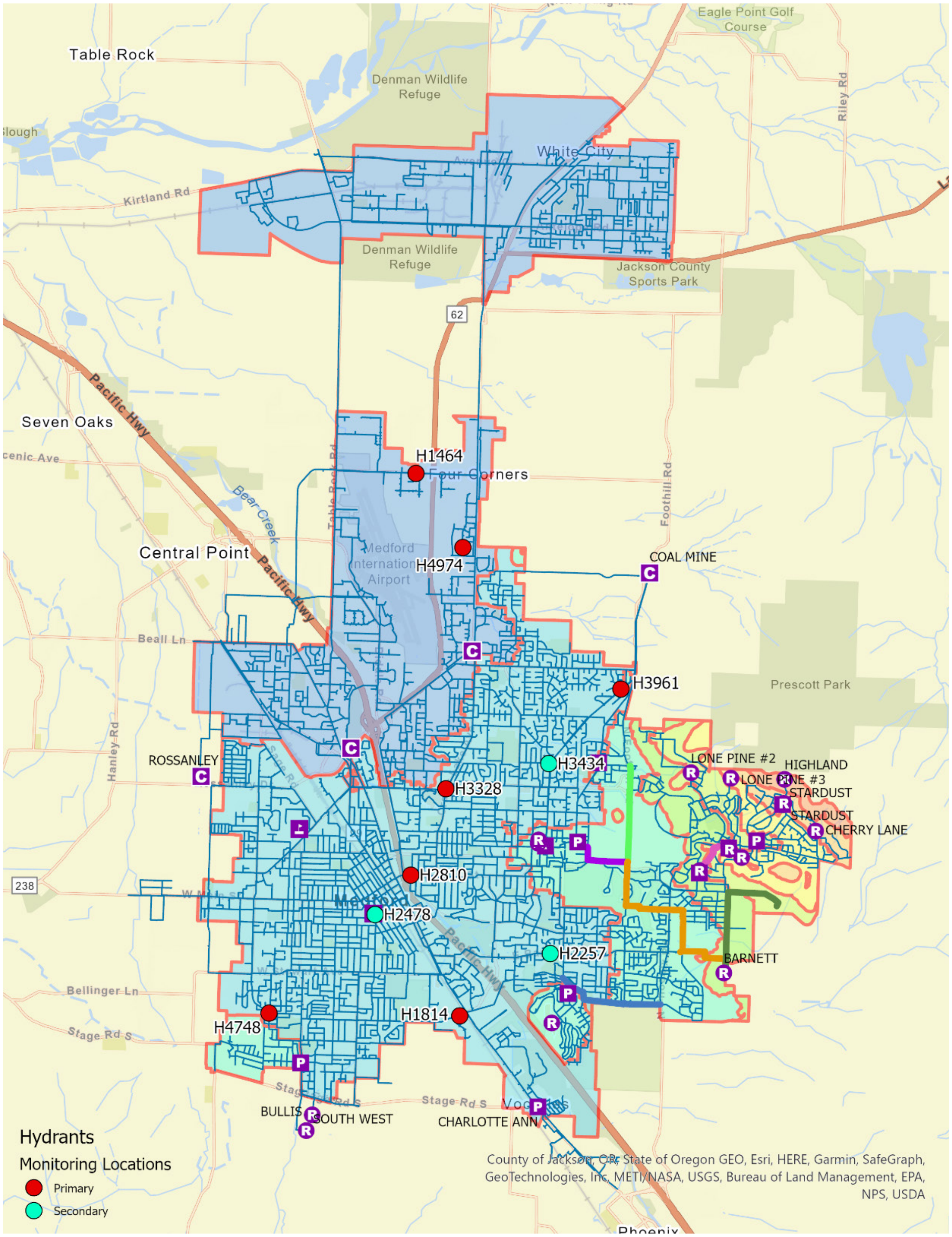


Figure 2.4 Pressure Monitoring Locations

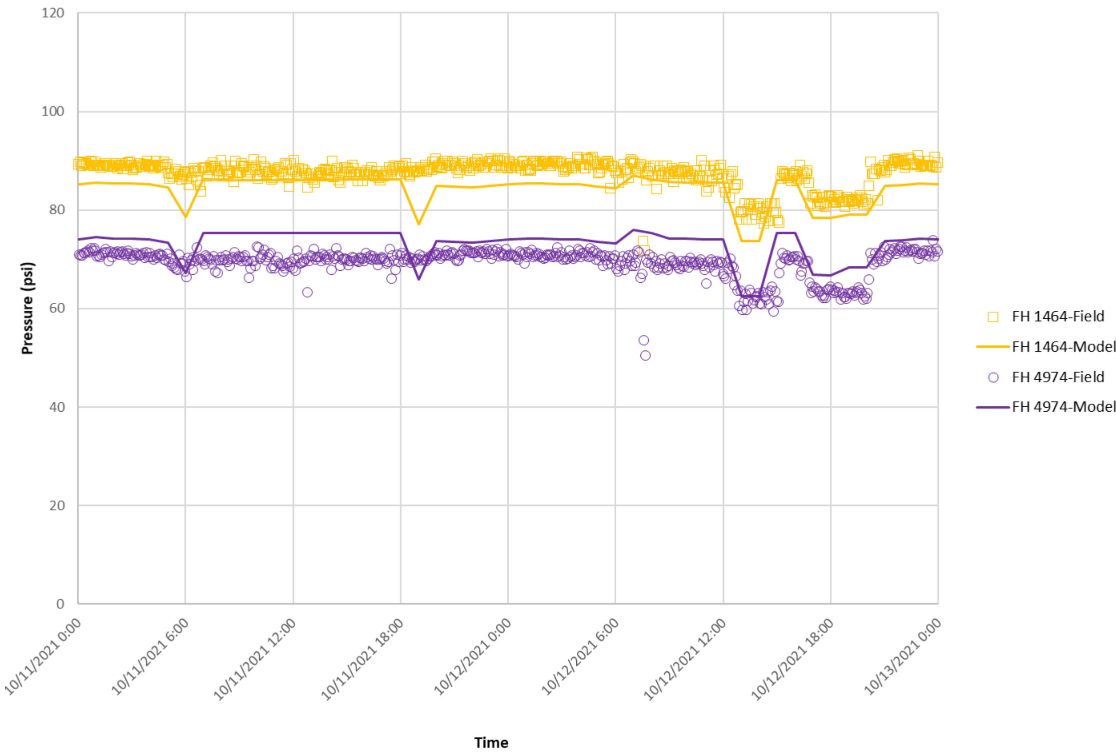


Figure 2.5 Reduced Pressure Zone Calibration: Comparison of Field Collected and Model-Predicted Pressure

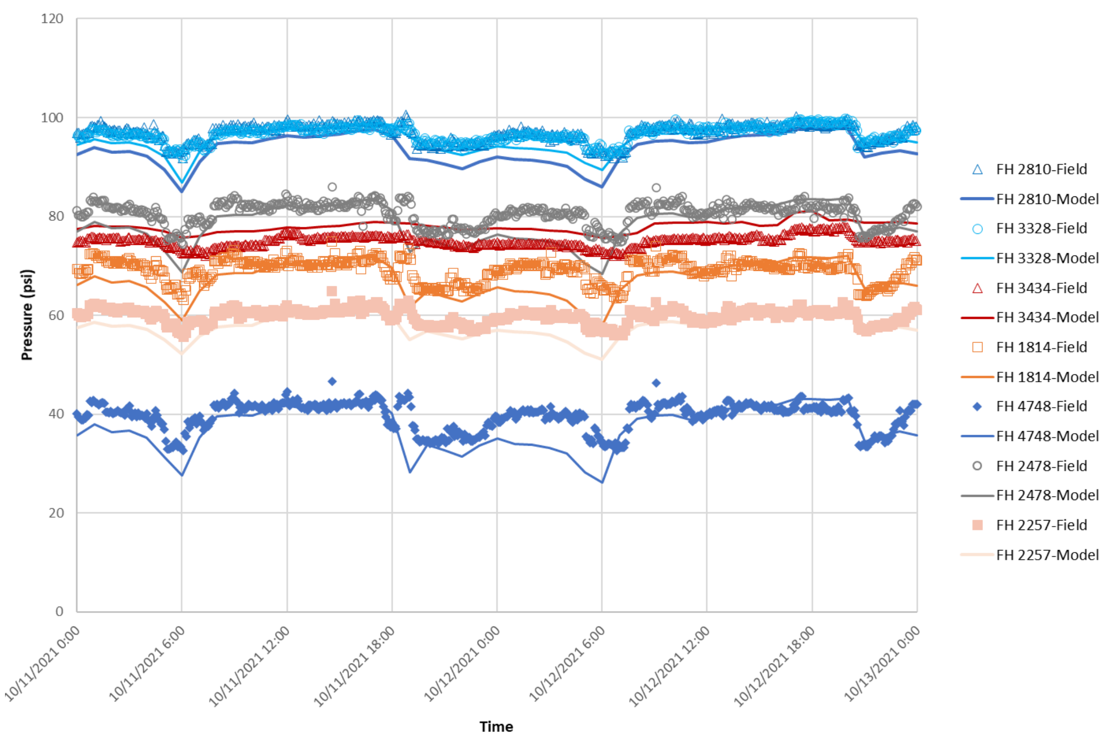


Figure 2.6 Gravity Zone Calibration: Comparison of Field Collected and Model-Predicted Pressure

Chapter 3

ALTERNATIVES TO ACHIEVE DISTRIBUTION SYSTEM RESILIENCE BACKBONE GOALS AND OBJECTIVES

3.1 Introduction

The purpose of this chapter is to document the alternatives Medford Water considered to reach their water distribution system resilience backbone goals and objectives. The alternatives are initially introduced by presenting the various storage options for the RP Zone and then separately the various options for the Gravity Zone. Then these various options are combined to develop alternatives that represent a system-wide resilient backbone. This chapter also includes the storage, pumping, and transmission main capacity requirements for all alternatives. While this chapter identifies and describes the alternatives, Chapter 4 evaluates the alternatives against the goals and objectives.

The alternatives identified throughout this project capture the ideas of Medford Water staff and the consultant team at the time of this project considering several other existing and planned improvements that could influence the resilient backbone. Throughout the evaluation, the alternatives "evolved" as more information became available.

In this chapter, we first present the various options for the RP Zone as identified by Medford Water staff and the consultant team in Section 3.2. Next, we present the Gravity Zone and Zone 1A options in Sections 3.3 and 3.4, respectively. The RP Zone options I through IV were then combined with Gravity Zone options A through D to form the eight full alternatives that were evaluated and compared against each other.

Note that the RP Zone and Gravity Zone options that made up Alternatives 1 through 4 were developed collaboratively between the consultant team and Medford Water during the October 2021 Alternatives Identification Workshop. Alternative 5A was added later before the alternative evaluation results were presented to Medford Water at the January 2022 Alternatives Evaluation Workshop. Alternatives 5B through 7 were added after the Alternatives Evaluation Workshop. This resulted in some inconsistencies with how the alternatives were developed based on when they were identified during this project.

3.2 Reduced Pressure Zone Alternatives

To allow the Duff WTP to supply water at steady state, alleviate pressure fluctuations, simplify RP Zone operations, and provide resilient storage, it is recommended that a storage reservoir be constructed that can feed the RP Zone by gravity. This recommendation is consistent with the results of the *Evaluation and Recommendations for Finished Water Storage in the Gravity and Reduced Pressure Zones* (Jacobs Engineering, 2019; "2019 Gravity and RP Storage Study"). This storage reservoir should meet the equalizing storage needs of the RP Zone at a minimum. A new storage tank in the RP Zone will benefit the system by improving operations, as noted above, and provide a more centralized storage location to the zone. Figure 3.1 offers a simple overview of the different RP Zone storage options, outlining the different locations and configurations that were considered to meet the RP Zone storage needs. The following sections describe each option.

Section 3.5 explains how the Medford Water and Consultant team set the preliminary sizing of each facility.

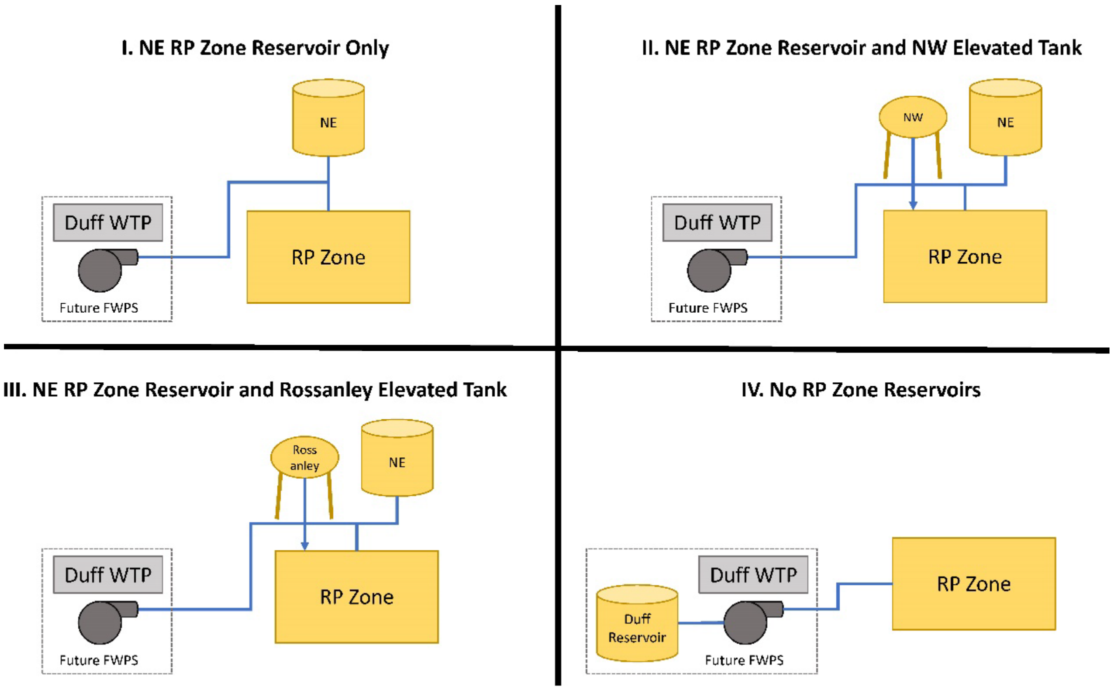


Figure 3.1 RP Zone Storage Options

3.2.1 RP Zone Option I - Northeast RP Zone Reservoir Only with New Control Station

Option I consists of adding an RP Zone ground reservoir in the northeast part of the water system at an elevation that would allow it to serve the RP Zone by gravity. Hydraulically feasible locations considered for this tank were based on the recommendations from the 2019 Gravity and RP Storage Study and are shown on Figure 3.2 and include Foothill Road, Coker Butte, and Delta Waters.

3.2.2 RP Zone Option II - Northeast RP Zone Reservoir and Northwest Elevated Tank

Option II would add an RP Zone ground reservoir in the northeast part of the system as in Option I, and also an elevated tank serving the northwest part of the water distribution system. The potential general location of the NW Elevated Tank is shown on Figure 3.2. A tank in the north part of the RP zone would be closer to the centroid of RP Zone demands, offering a more centralized and operationally efficient storage option.

3.2.3 RP Zone Option III - Northeast RP Zone Reservoir and Rossanley Elevated Tank

Option III is very similar to Option II, substituting the NW Elevated Tank with an elevated tank near the Rossanley CS. (This option still includes a northeast RP Zone ground reservoir).

3.2.4 RP Zone Option IV - No RP Zone Reservoirs

Option IV consists of relying on the Duff WTP Finished Water Reservoirs to provide equalizing storage and allow Duff WTP to operate at steady state. In this alternative, equalizing storage in the Duff WTP Reservoirs would need to be pumped into the RP Zone by the future Duff FWPS using variable frequency drives to meet the diurnal variations in demand. No additional gravity storage would be constructed in the RP Zone. RP Zone emergency and fire flow storage needs would be held in the Gravity Zone.

3.2.5 RP Zone Option V – At-Grade RP Zone Reservoir & Pump Station

Option V (not pictured in Figure 3.1) consists of constructing an at-grade reservoir in the center of the RP Zone using a new pump station to pump water out of the reservoir. This option was identified to provide a more centralized location for storage in the RP Zone and because securing land for the RP Zone Reservoir has been challenging at the elevation required for a gravity reservoir. However, this option was removed due to the additional complexity of operating an at-grade reservoir and pump station compared to the gravity storage options evaluated herein.

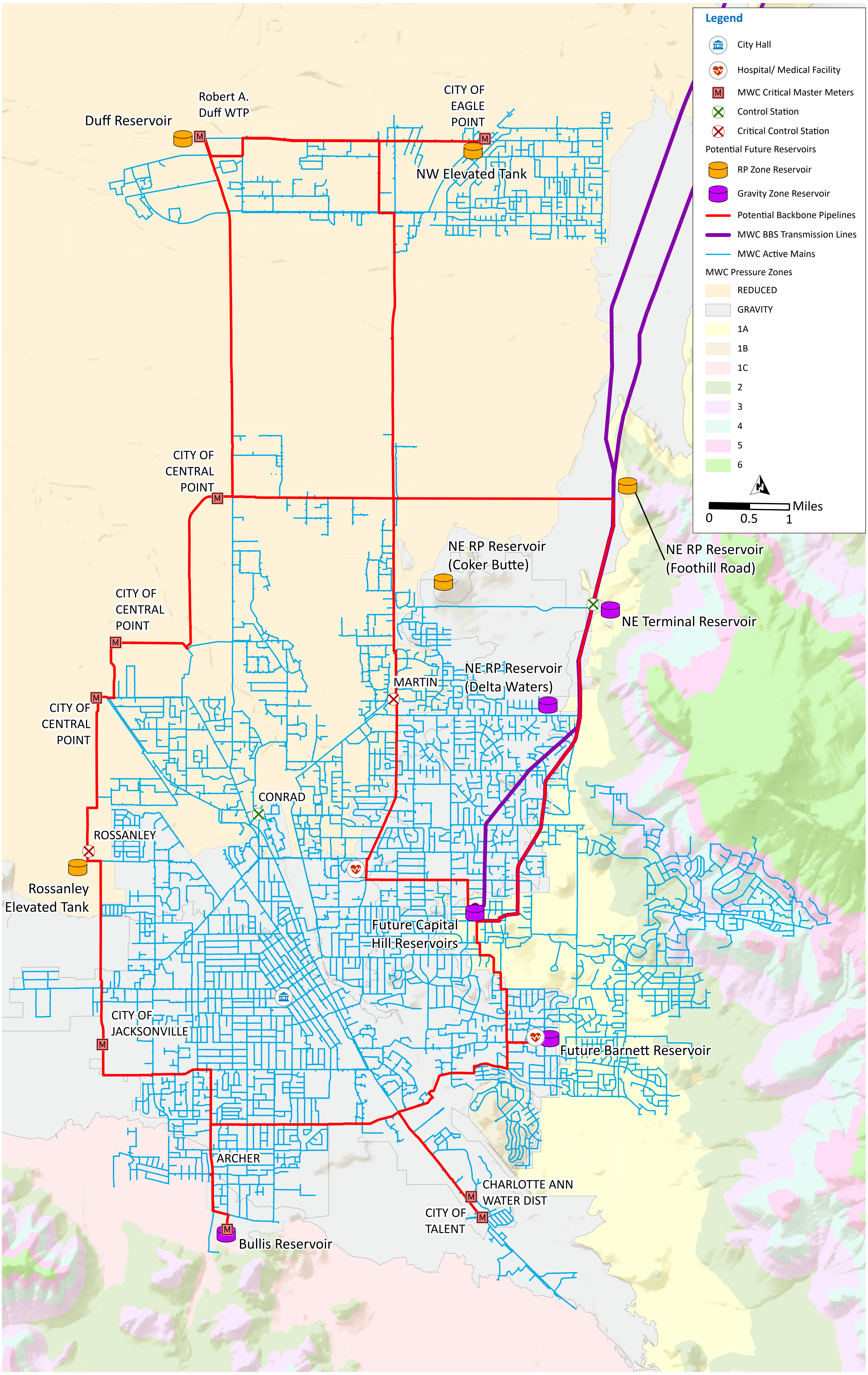


Figure 3.2 Potential Future Reservoirs Locations

3.3 Gravity Pressure Zone Alternatives

Additional storage is needed in the Gravity Zone to meet build-out demands and provide resilient storage. The Gravity Zone currently has 12 MG of storage at Capital Hill and 10 MG of storage in Bullis Reservoir. Due to significant structural concerns outlined in the 2019 Gravity and RP Storage Study, the Capital Hill Reservoirs need to be replaced in the near-term.

Medford Water staff reviewed four main reservoir sites to meet future Gravity Zone storage needs. These locations are identified in Figure 3.2 and consist of the following:

- Capital Hill: The Capital Hill Reservoir site has been a critical hub of the water distribution system since its initial construction in 1908. Due to its location and the extensive transmission and distribution piping that have been constructed to and from these reservoirs, this site is needed to continue as the central location for receiving supply from Medford's two supply sources and distributing stored water to customers throughout the city. As noted above, the existing reservoirs are in need of replacement to reduce maintenance costs and improve structural performance in the event of an earthquake. Medford Water plans to replace the reservoirs on the current site per the recommendations in the 2019 Gravity and RP Storage Study.
- Bullis Reservoir: The Bullis Reservoir is part of the Gravity Zone though it is located too low in elevation to operate by gravity. To use the water in the reservoir at the correct pressure, Medford Water has to pump out of the reservoir. Medford Water intends to continue to use the Bullis Reservoir until the end of its useful life.
- Barnett Road: a future reservoir located near Barnett Road herein referred to as the "Barnett Reservoir." This is not to be confused with the existing Barnett Reservoir that serves Zone 1. A future Barnett Reservoir was proposed in the 2019 Gravity and RP Storage Study.
- Terminal Reservoir: A terminal storage reservoir located along the BBS supply lines was identified as an option to improve operations of the BBS supply. This reservoir would be located to hydraulically "interrupt" the BBS supply on its way to Capital Hill, providing the means to eliminate air entrainment when operating at varying flow rates and simplifying pressure reducing requirements.

The first three reservoir sites are included in all the Gravity Zone options considered. The differences between the various Gravity Zone storage options consist of whether or not a northeast Terminal Reservoir will be constructed to provide Gravity Zone storage and whether or not it will have the same overflow elevation as the Capital Hill reservoirs. The Gravity Zone options are also differentiated by whether or not a new control station will be constructed to pump water from the RP Zone to the Gravity Zone. Figure 3.3 shows a simplified overview of the different Gravity Zone options. Options A, B, C, and D are described in the sections below.

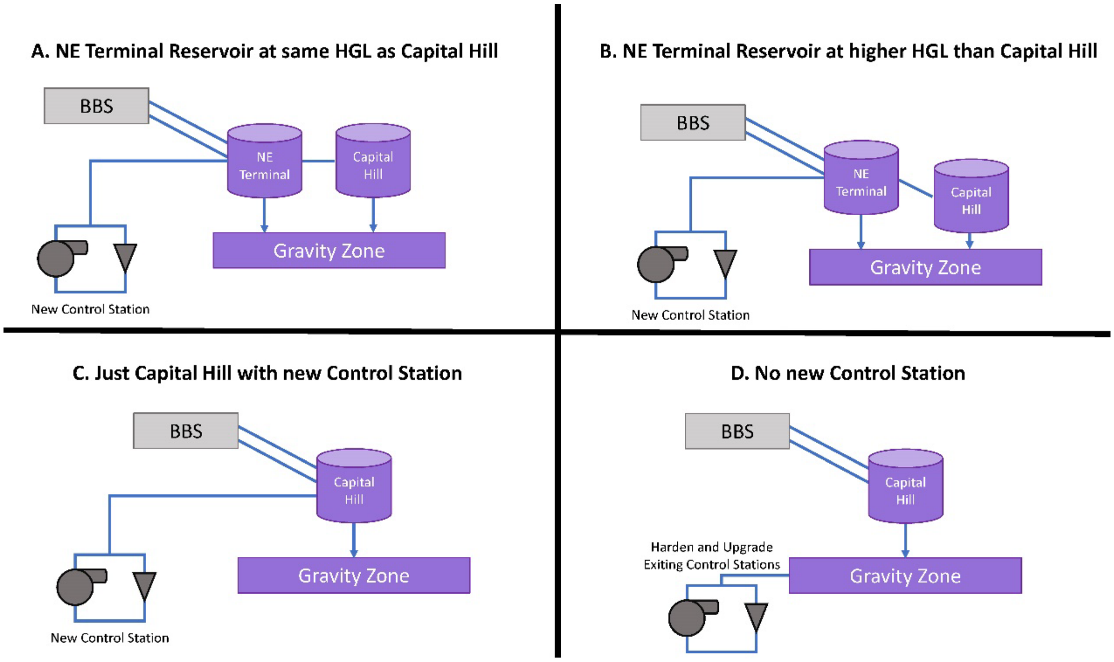


Figure 3.3 Gravity Zone Storage and Control Station Options

3.3.1 Option A - Northeast Terminal Reservoir at Same HGL as Capital Hill

Option A entails rebuilding storage at Capital Hill and adding a new northeast Terminal Reservoir at the same overflow HGL as Capital Hill Reservoirs. The goal of this option is to simplify operations by having the two Gravity Zone reservoirs at the same overflow elevation. However, the head losses associated with the BBS transmission main flow between the two reservoirs indicate a new, parallel, 60-inch transmission main would need to be constructed to convey these flows. This option was deemed infeasible and eliminated from further consideration.

3.3.2 Option B - Northeast Terminal Reservoir at Higher HGL than Capital Hill

Option B is the same as Option A except the new northeast Terminal Reservoir is considered at a higher HGL than the Capital Hill reservoirs. This option allows a Terminal Reservoir to be located at elevations consistent with available land along the BBS pipes and should not require the large pipe capacities needed by Option A between the Terminal Reservoir and Capital Hill.

3.3.3 Option C - Capital Hill Reservoir with New Pump Station

Option C consists of rebuilding the Capital Hill Reservoirs with a new control station and dedicated transmission main between the northeast RP Reservoir and the Capital Hill Reservoirs.

3.3.4 Option D - Capital Hill Reservoir Without New Pump Station

Option D would not include a northeast Terminal Reservoir or a new control station. This option would continue to rely on existing control stations to pump water from the RP Zone to the Gravity Zone. The existing control stations will need to be expanded and made resilient to meet Medford Water's future demands and resilience goals.

3.4 Pressure Zone 1A Options

An additional option involving Zone 1A supply was also considered. The idea was to reconfigure BBS 2 to supply the Zone 1A tank directly without pumping up from the Gravity Zone. This is shown as Option i in Figure 3.4.

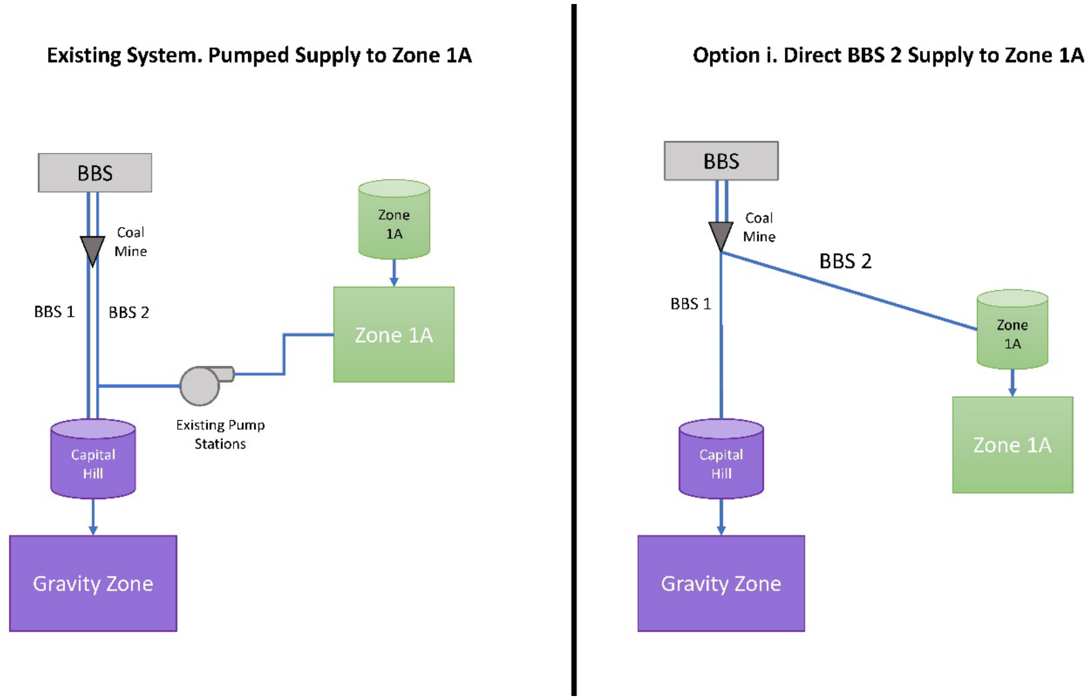


Figure 3.4 Zone 1A Options

Option i was determined to be infeasible because the HGL of the BBS transmission mains are not high enough to supply the Zone 1A tank directly. This is demonstrated in Figures 3.5 and 3.6 that were modified from Figures 4 and 5 in Jacobs' *BBS Capacity Evaluation Final Report* (March 2020). Figure 3.5 shows that the HGL of the Zone 1A tank (1,729 feet) is higher than the HGL of the BBS lines at the Coal Mine Control Station (1,700 feet). Figure 3.6 demonstrates that even if the HGL of BBS 2 was raised the maximum amount at Nichol's Gap, adequate head would still not be available to serve Zone 1A directly due to head loss in the pipe between Coal Mine Control Station and the Zone 1A tank.

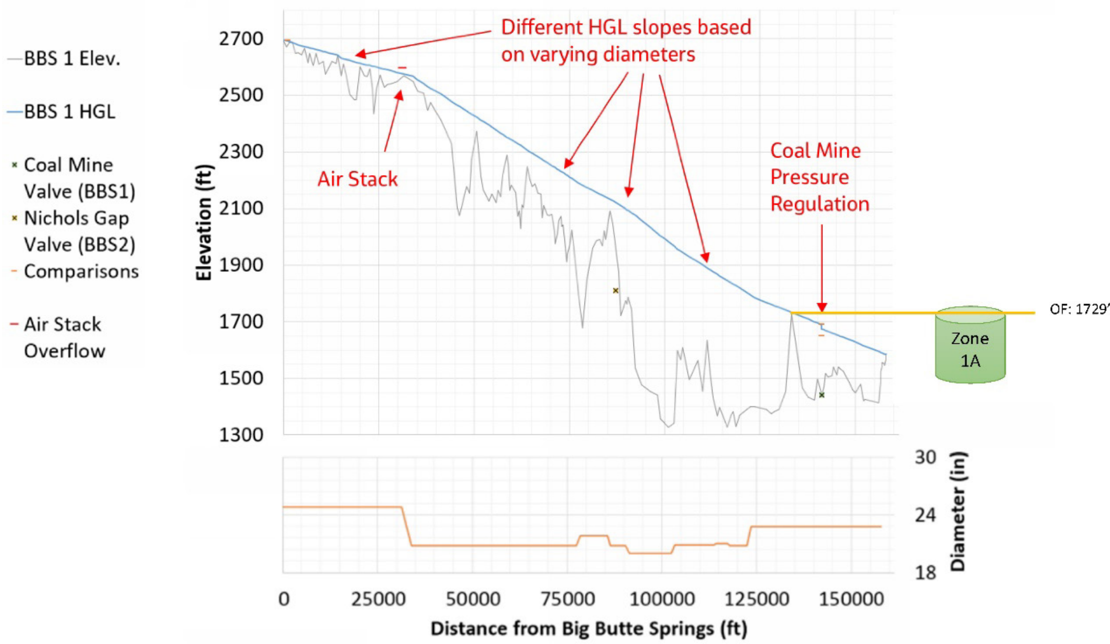


Figure 4. HGL and pipe elevation along BBS1 at 12.6 mgd.

Figure 3.5 Comparison of BBS 1 at Coal Mine Control Station and Zone 1A HGL

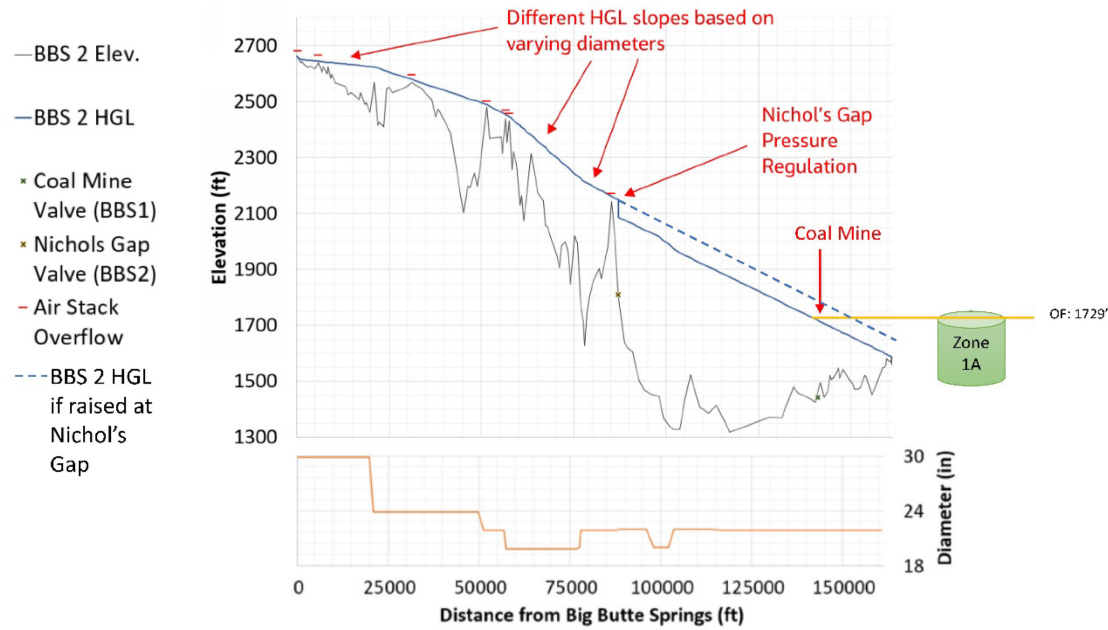


Figure 5. HGL and pipe elevation along BBS2 at 12.3 mgd.

Figure 3.6 Comparison of BBS 2 with Raised HGL and Zone 1A HGL

3.5 Preliminary Facility Sizing

This section outlines the preliminary proposed facility sizing for all proposed reservoirs, the RP to Gravity Zone control stations, and transmission mains. Three planning horizons, near-term, long-term, and build-out were considered for facility sizing as described in Chapter 2.

3.5.1 Reservoir Sizing

The storage needs for the system in the near-term horizon are broken down by pressure zone in Table 3.1. These storage assumptions were based on the storage criteria and evaluations of the WDSFP and 2019 Gravity and RP Storage Study. Medford Water's storage criteria consist of the following:

- Equalizing storage: 15 percent of Total MDD including wholesale demand. The WDSFP recommended 4.6 MG of RP Zone equalizing for the near-term horizon, corresponding to 15 percent of MDD. However, further evaluation of the equalizing storage needs of the RP and Gravity Zones performed in the 2019 Gravity and RP Storage Study indicates that through the near-term horizon, only 3.5 MG and 4.9 MG of equalizing storage are needed for the RP Zone and Gravity Zone, respectively. These lower equalizing storage volumes are used throughout this analysis and presented in Table 3.1.
- Emergency storage: 33 percent of MDD excluding wholesale demand.
- Fire storage: 4,000 gallons per minute for 4 hours in RP and Gravity Zones.

Because the long-term scenario presented in this report was not considered in the WDSFP or 2019 Gravity and RP Storage Study, no previous storage calculations were available for the long-term horizon. For this evaluation, near-term storage needs were scaled up using the ratio of total system demand between long-term and near-term to estimate long-term storage requirements.

3.5.2 RP Zone Reservoir Sizing

Based on Table 3.1, the RP Zone reservoirs should store a minimum of 4 MG of water to meet near- and long-term equalizing storage needs and a maximum of 14 MG to meet total RP Zone storage needs at build-out.

The Duff WTP 65 mgd expansion design is currently underway. The new Duff WTP Reservoir is currently designed to have a 3 MG capacity. As shown in Figure 3.8, which is based on analysis performed by Jacobs for the Duff WTP expansion project, about 2 MG of the Duff WTP Reservoir can be used for RP Zone equalizing storage in the near-term but will be needed for Duff WTP operations as flows increase. Further modeling analysis showed that 2 MG of equalizing storage in the Duff WTP Reservoir along with the new variable frequency drive pumps of the FWPS can meet Medford Water's near-term equalizing storage needs.

3.5.2.1 Northeast RP Zone Reservoir

Because modeling showed that operation of Medford Water's system can meet their goals and objectives with only 2 MG of storage at the Duff WTP Reservoir and no storage in the RP Zone, the alternatives evaluated include options that exclude the full recommendation of 8 MG in the RP Zone. The options include no northeast RP Zone reservoir, a 4 MG NE RP Reservoir, and an 8 MG NE RP Reservoir.

An 8 MG capacity reservoir was the largest considered for the RP Zone because this size meets Medford Water's needs for simplified shoulder season operation. RP Zone storage needs above those in the RP Zone reservoir can be located in the Gravity Zone and conveyed to the RP Zone by gravity through the control stations.

3.5.2.2 Elevated Tanks

Two (2) MG is approximately the largest storage volume that is feasible for elevated tanks. Thus, the alternatives that included elevated tanks assumed a volume of 2 MG.

3.5.3 Gravity Zone Reservoir Sizing

Replacement of the Capital Hill Reservoirs is required in the near-term due to age and condition. As Table 3.1 shows, 25 MG of RP and Gravity Zone storage are required in the near-term planning horizon. With the existing 10 MG in Bullis Reservoir and the range of RP Zone storage volumes considered from 2 MG to 8 MG, somewhere between 7 MG and 13 MG of additional storage are required in the Gravity Zone in the near term. It is assumed that within the near-term horizon, all of this storage will be constructed at Capital Hill.

Medford Water selected a preliminary Capital Hill replacement storage volume of 12 to 14 MG. The final volume will be selected based on constructability and cost.

When Alternatives 1-5a were developed and evaluated, it was assumed that Bullis Reservoir would not be part of Medford Water's build-out storage. Thus, the build-out alternative schematics in Section 3.6 show a total of 34 MG of storage to meet the build-out storage requirement, not including Bullis Reservoir. Also note that Alternative 2 shows a storage volume of 16 MG for Capital Hill Reservoirs. It is now recognized that Bullis Reservoir will remain in Medford Water's system through the long-term horizon but might be replaced by storage at a different location (to improve its operational issues) once it reaches the end of its useful life. Since the assumptions for Bullis Reservoir changed after the evaluation was done, the Bullis Reservoir volume might be counted toward Medford Water's build-out storage capacity, and the Capital Hill Reservoirs might not need to be as large as assumed in this evaluation.

Table 3.1 Storage Needs

Pressure Zone	Near-Term				Long-term				Build-out			
	Equalizing Storage (MG)	Emergency Storage (MG)	Fire Storage (MG)	Storage (MG)	Equalizing Storage (MG)	Emergency Storage (MG)	Fire Storage (MG)	Storage (MG)	Equalizing Storage (MG)	Emergency Storage (MG)	Fire Storage (MG)	Storage (MG)
RP Zone	3.5	5.6	1.0	**10**	3.7	6.0	1.0	**11**	5.9	6.9	1.0	**14**
Gravity Zone	4.9	9.4	1.0	**15**	5.2	10.0	1.0	**16**	7.1	11.6	1.0	**20**
Total	8	15	2	**25**	9	16	2	**27**	13	19	2	**34**

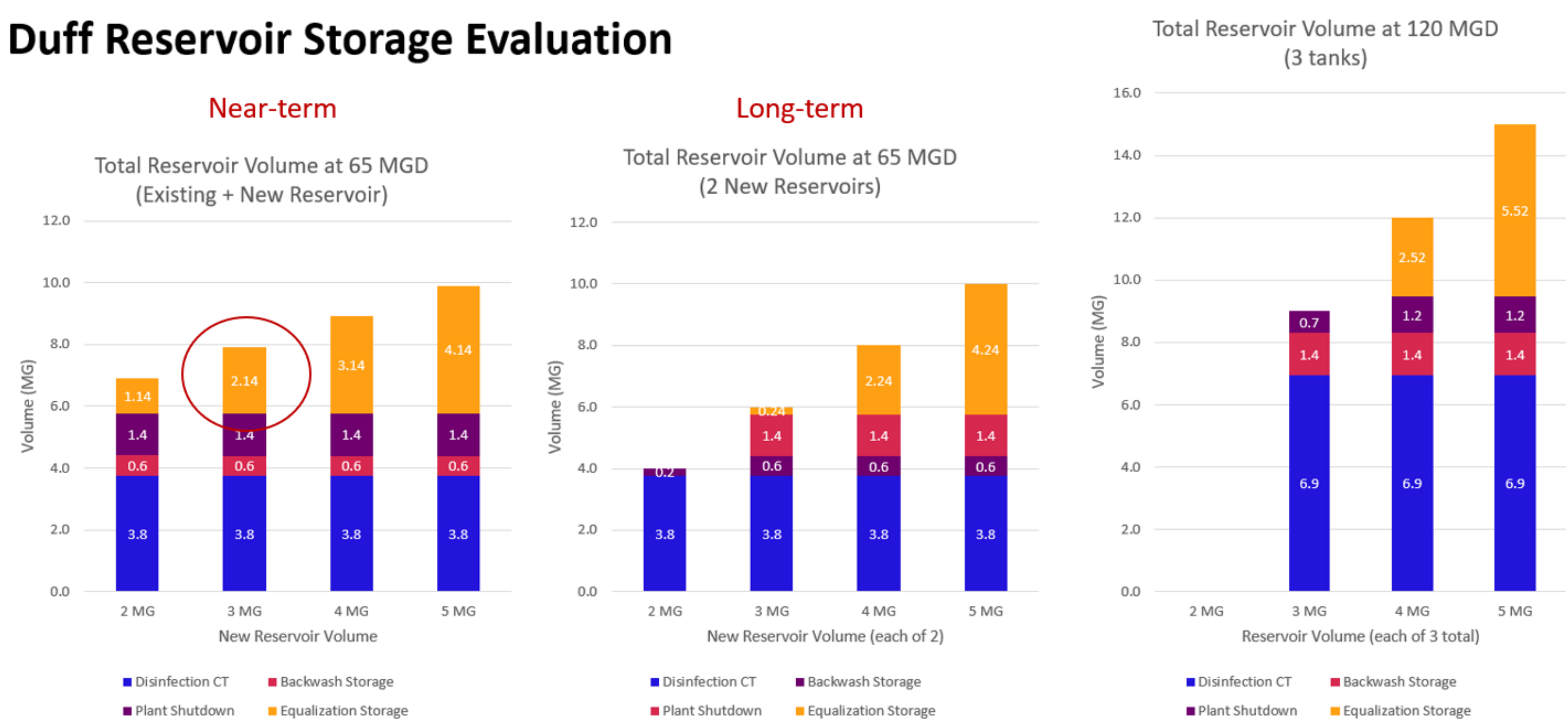


Figure 3.7 Duff Reservoir Equalizing Storage

3.5.4 Control Station Sizing

Additional resilient pumping capacity will be needed between the RP and Gravity Zones in the near-term to meet demands and provide a resilient backbone connection. Medford Water has two pumping criteria that were used to size the future control station capacities:

1. Normal Operations: Ability to pump MDD with control station firm capacity.
2. Emergency Operations: Ability to pump emergency flow with resilient capacity.

3.5.4.1 Criterion 1 – Normal Operations

Table 3.2 shows the RP to Gravity Zone firm pumping capacity required to meet MDD for each of the planning horizons. The required firm pumping capacity is calculated as the demand of the Gravity Zone and higher zones minus the available BBS supply. For the near-term and long-term horizons, BBS supply is assumed to be pipe and a half, producing approximately 20 mgd, which represents drought conditions. For the build-out scenario, severe drought conditions are assumed, which corresponds to both pipes only half full, resulting in a BBS supply as low as 13 mgd.

Table 3.2 Required RP to Gravity Zone Firm Pumping Requirements

Scenario	System-Wide MDD (mgd)	Gravity Zone and Higher MDD (mgd)	BBS Supply (mgd)	Required RP to Gravity Zone Firm Pumping Capacity (mgd)	Existing Firm Pumping Capacity (mgd)	Additional Firm Pumping Capacity Required (mgd)
Near-term	80	49	20	29	23	6
Long-term	85	52	20	32	23	9
Build-out	110	71	13	58	23	35

Three existing control stations connect the RP and Gravity Zones. Table 2.1 in Chapter 2 outlines the firm and total capacities at the Martin, Conrad, and Rossanley CS. Medford Water's existing total firm pumping capacity is 23 mgd. In the near-term, Medford Water needs approximately 29 mgd, or an additional 6 mgd of pumping capacity to meet Criterion 1. In the long-term horizon approximately 32 mgd is required, which is 9 mgd more than current pumping capacity. At build-out approximately 58 mgd is required, which means an additional 35 mgd firm pumping capacity will be needed beyond existing.

3.5.4.2 Criterion 2 - Emergency Operations

Medford Water's emergency level of service goal is to supply 23 mgd entirely from the Duff WTP after a Cascadia Subduction Zone earthquake. Table 3.3 shows how this supply would be distributed between the RP Zone and higher zones in the near-term. These numbers were calculated by distributing the emergency supply between the two parts of the system at the same ratio as the near-term demands are distributed between the RP Zone and higher zones.

Table 3.4 shows that 14 mgd of the total 23 mgd emergency supply will need to be pumped up from the RP Zone to the Gravity Zone. Medford Water does not necessarily need to meet this criterion within the near-term horizon. We recommend that Medford Water target having at least 14 mgd of resilient pumping capacity within the long-term horizon.

Table 3.3 Emergency Supply Distribution

Pressure Zone	Near-term Emergency Supply (mgd)
Total	23
RP Zone	9
Gravity Zone and Higher	14

3.5.4.3 Recommended Control Station Sizing

For alternatives that include a new control station near the BBS supply lines, the initial near-term firm capacity of the control station is set to 6 mgd to meet Criterion 1 for the near term with room to expand. Medford Water's build-out philosophy for the alternatives involving a new control station is that the new control station should be able to provide at least the emergency supply of 14 mgd to the upper zones. Because the Conrad CS has limited space for expansion or improvements, Medford Water initially assumed that at build-out Conrad CS will be out of service and the 58 mgd of pumping capacity required will be supplied roughly evenly by the Rossanley CS, the Martin CS, and the new control station at approximately 20 mgd each.

For alternatives that do not include a new control station near the BBS supply lines, the additional capacity of 6 mgd needed in the near-term will be provided by the Martin CS because it is located closest to the northeast RP Reservoir. Build-out pumping capacity would be provided primarily by Rossanley CS and Martin CS, and would require expanding Martin CS and/or replacing Conrad CS.

3.5.5 Transmission Main Sizing

The following philosophy was used to size required transmission main upgrades. For each alternative, the hydraulic model was run using the near-term demands to identify which pipes need to be upsized to convey near-term flows. Then, long-term demands were used in the hydraulic model to set future pipe sizes that can convey long-term flows.

The pipelines were sized to have a velocity no greater than 7 feet per second. The maximum allowable head loss used for sizing pipelines was 5 feet per 1,000 linear feet of pipe.

3.6 Model Scenarios and Alternative Schematics

This section describes the system-wide alternatives that were developed and modeled. These alternatives combine the RP Zone and Gravity Zone options previously discussed into feasible system-wide alternatives. Alternatives 1-4 utilize a resilient backbone pipeline along the BBS pipeline supply route in the east of the system, while Alternatives 5-7 propose a backbone in the center of the system through the Martin CS. This section describes each alternative, while Chapter 4 evaluates and compares the alternatives in depth.

Alternatives 1 through 4 and 5A were developed first and evaluation results were presented to Medford Water during a January 11, 2022, workshop. Alternatives 5B through 7 were added after the workshop and compared against each other during a March 8, 2022 workshop. Table 3.4 summarizes the project components included in each alternative.

Table 3.4 Summary of Project Components for Each Alternative

Alternative	RP Zone Storage	RP to Gravity Zone Control Stations	Gravity Zone Storage	Piping
1	• NE RP Reservoir	• New RP Control Station • Rossanley • Martin	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Harden BBS 2
2	• NE RP Reservoir	• New RP Control Station • Rossanley • Martin	• Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Pipeline parallel to BBS
3	• NE RP Reservoir • NW Elevated Tank	• New RP Control Station • Rossanley • Martin	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Harden BBS 2
4	• NE RP Reservoir • Rossanley Elevated Tank	• New RP Control Station • Rossanley • Martin	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Harden BBS 2
5a	• NE RP Reservoir	• Martin, • Rossanley • Conrad	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Piping from Martin CS to Capital Hill
5b	• 8 MG NE RP Reservoir (location different from Alternative 5a)	• Martin • Rossanley • Conrad	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Piping from Martin CS to Capital Hill
6	• 4 MG NE RP Reservoir (location and size different from Alternative 5a)	• Martin • Rossanley • Conrad	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to new NE RP Reservoir • Piping to Future Barnett Reservoir • Piping from Martin CS to Capital Hill
7	• None	• Martin • Rossanley • Conrad	• Terminal Reservoir • Capital Hill Reservoirs • Future Barnett Reservoir	• Piping to Future Barnett Reservoir • Piping from Martin CS to Capital Hill

3.6.1 Alternative 1: Terminal Reservoir

Alternative 1 includes NE RP Reservoir and a NE Terminal Reservoir. These new facilities would be connected by a 30-inch-iameter transmission main and a new control station. This alternative also includes rebuilding Capital Hill Reservoirs and building a future Barnett Reservoir. Figure 3.8 shows a schematic of what this alternative would look like at build-out. Figure 3.9 shows a plan view of Alternative 1 throughout the distribution system.

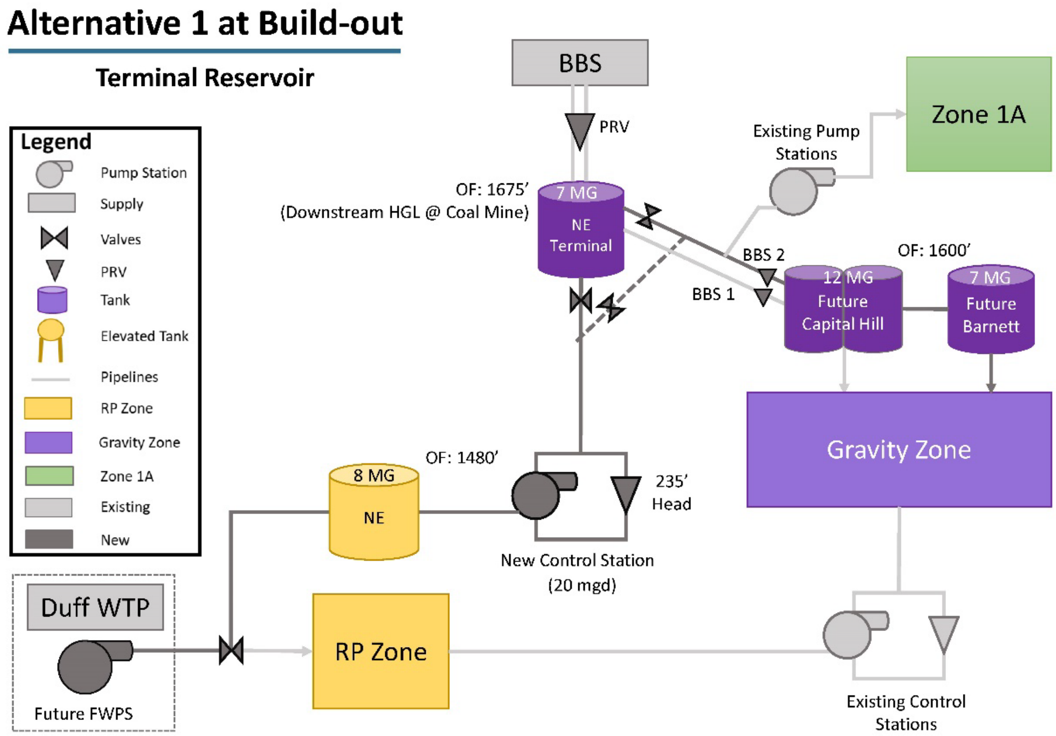
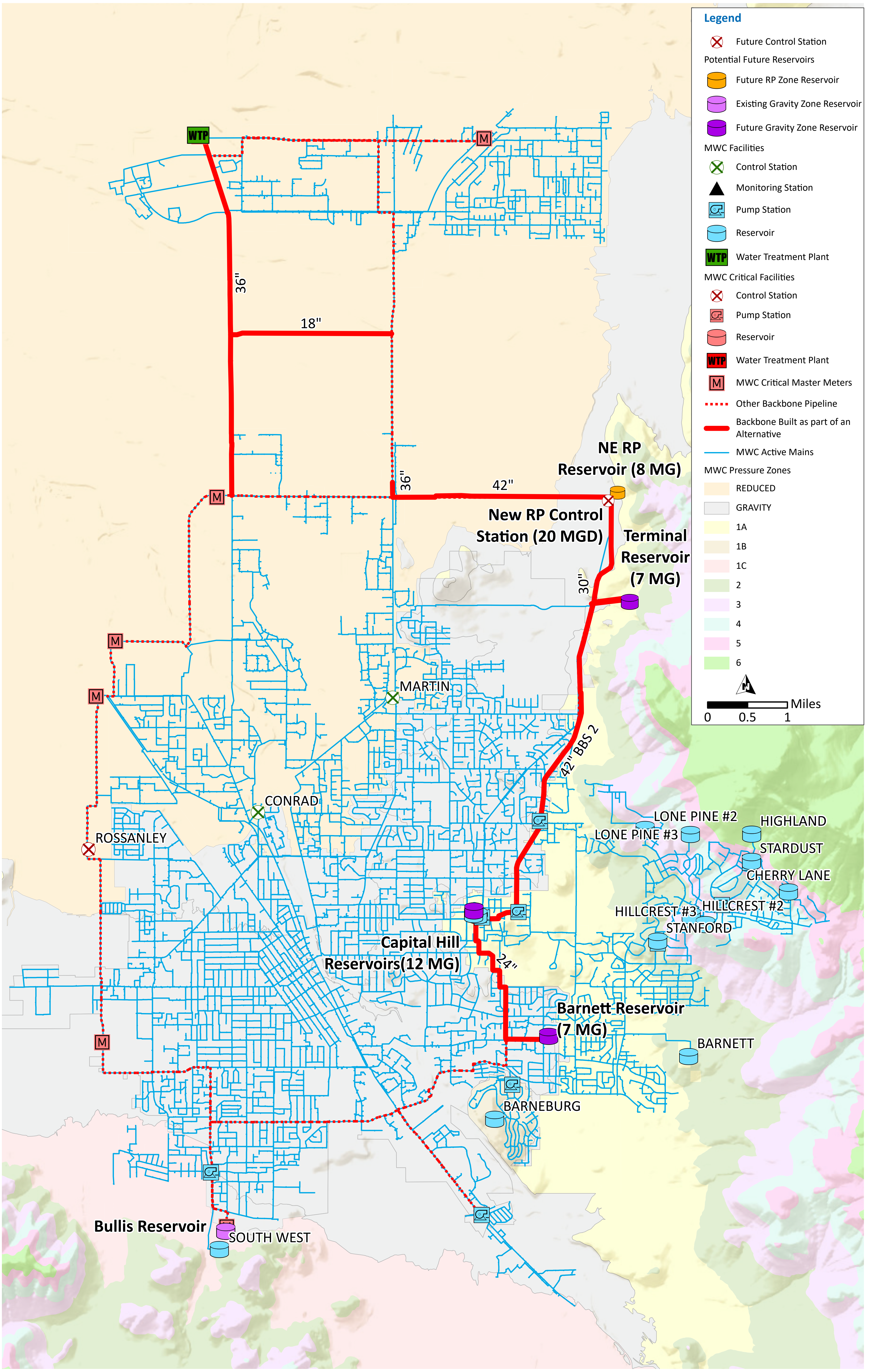


Figure 3.8 Alternative 1 Schematic


Legend
Future Control Station
Potential Future Reservoirs
Future RP Zone Reservoir
Existing Gravity Zone Reservoir
Future Gravity Zone Reservoir
MWC Facilities
Control Station
Monitoring Station
Pump Station
Reservoir
Water Treatment Plant
MWC Critical Facilities
Control Station
Pump Station
Reservoir
Water Treatment Plant
MWC Critical Master Meters
Other Backbone Pipeline
Backbone Built as part of an Alternative
MWC Active Mains
MWC Pressure Zones
REDUCED
GRAVITY
1A
1B
1C
2
3
4
5
6
Miles
0 0.5 1
WTP
36"
18"
36"
42"
NE RP Reservoir (8 MG)
New RP Control Station (20 MGD)
Terminal Reservoir (7 MG)
30"
MARTIN
42" BBS 2
CONRAD
ROSSANLEY
LONE PINE #2
LONE PINE #3
HIGHLAND
STARDUST
CHERRY LANE
HILLCREST #3
HILLCREST #2
STANFORD
Capital Hill Reservoirs(12 MG)
24"
Barnett Reservoir (7 MG)
BARNETT
BARNEBURG
Bullis Reservoir
SOUTH WEST

3.6.2 Alternative 2: No Terminal Reservoir

Alternative 2 is similar to Alternative 1, but without a new Terminal Reservoir. Instead, the transmission main from the NE RP Reservoir will connect to a rebuilt, 16 MG Capital Hill Reservoir. Figure 3.10 shows a schematic of what this alternative would look like at build-out. Figure 3.11 shows a plan view of Alternative 2 throughout the distribution system. (Note that at the time of developing this alternative, the Bullis Reservoir was assumed to be offline at build-out thus additional storage would be needed at the Capital Hill and Barnett sites to meet the Gravity Zone storage requirements).

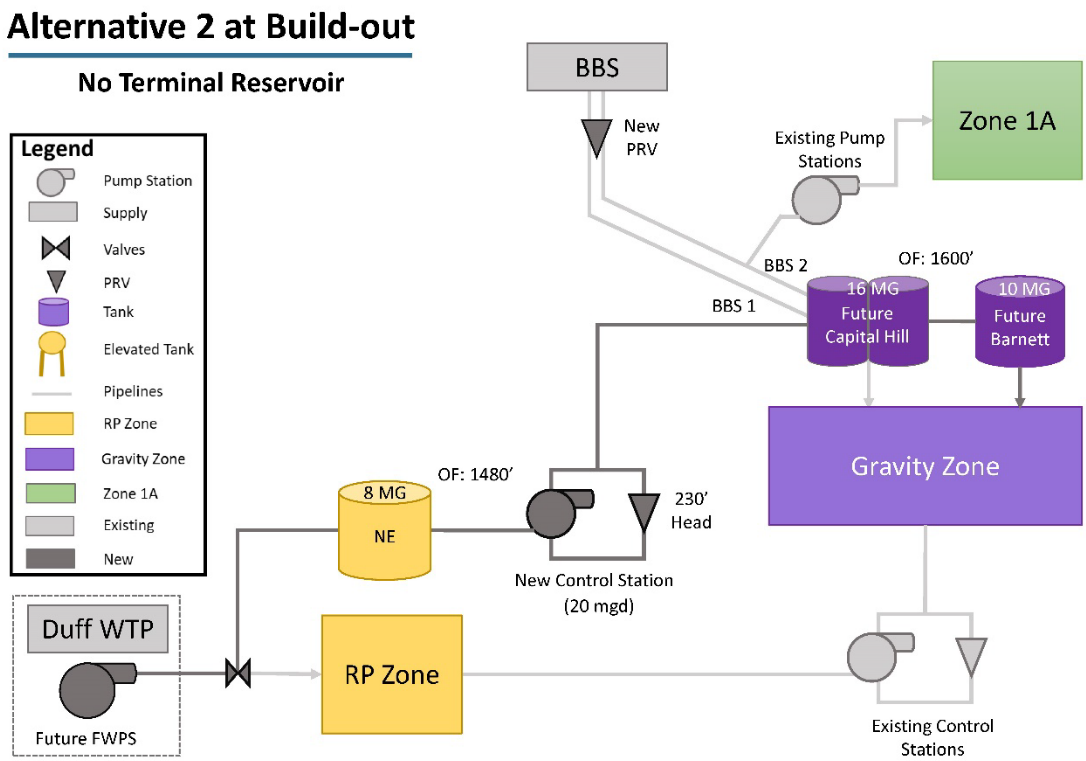


Figure 3.10 Alternative 2 Schematic

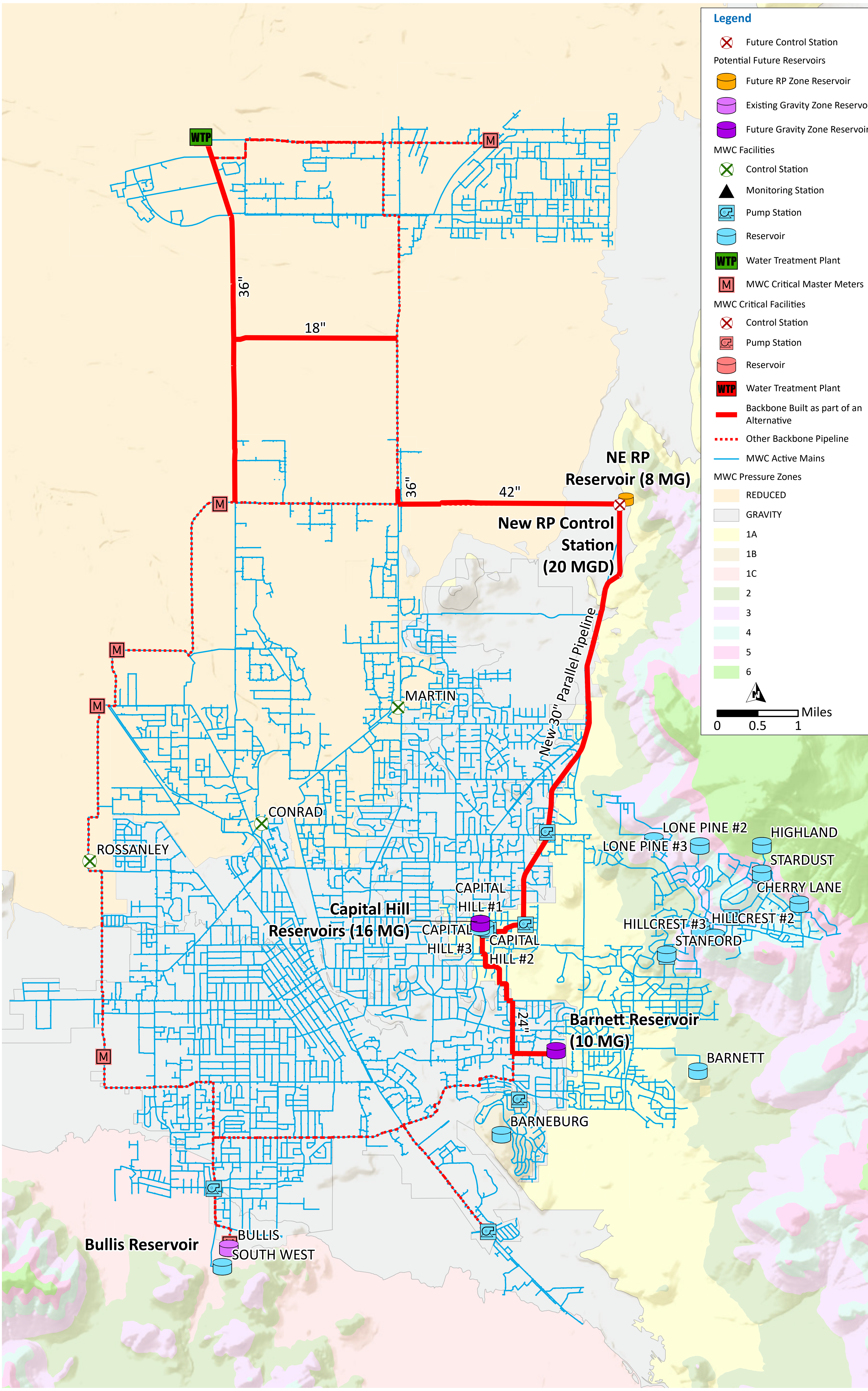


Figure 3.11 Alternative 2 Build-out

3.6.3 Alternative 3: Northwest RP Zone Elevated Tank

Alternative 3 is exactly the same as Alternative 1, with the exception of a new NW Elevated Tank in the RP Zone. This tank would offer a redundant and centralized storage option. Figure 3.12 shows a schematic of what this alternative would look like at build-out. Figure 3.13 shows a plan view of Alternative 3 throughout the distribution system.

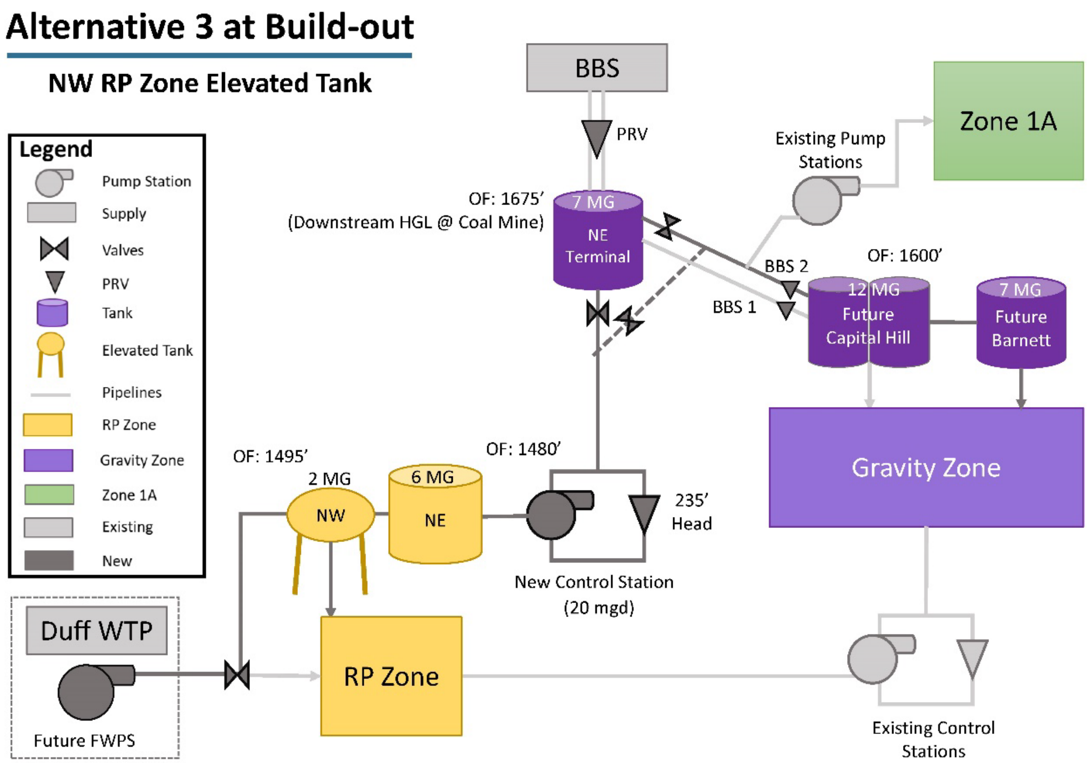


Figure 3.12 Alternative 3 Schematic

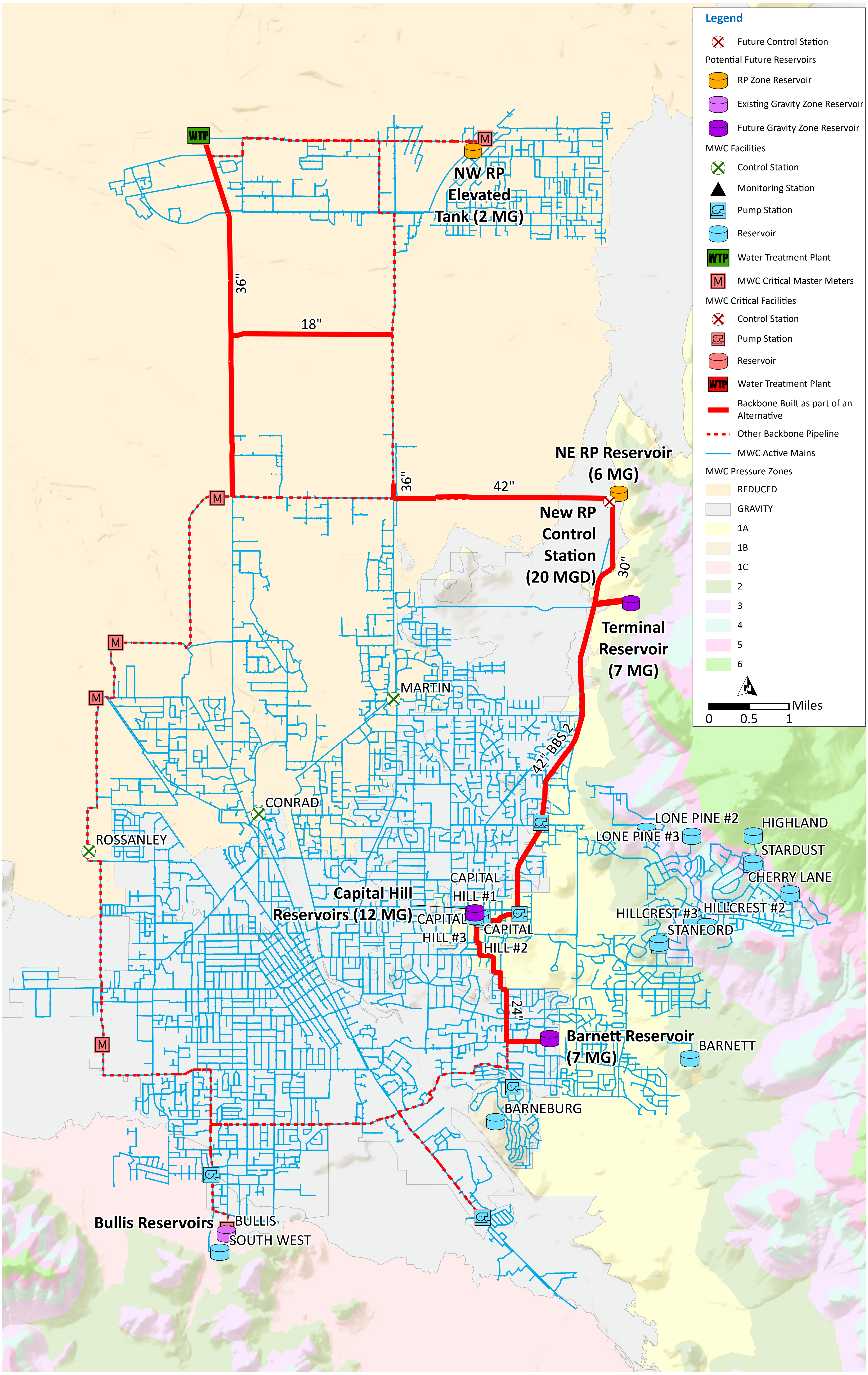


Figure 3.13 Alternative 3 Build-out

3.6.4 Alternative 4: Rossanley RP Zone Elevated Tank

Alternative 4 is similar to Alternative 3 but swaps the northwest elevated reservoir for an elevated reservoir near the Rossanley CS site. Similar to Alternative 3, this reservoir would offer a redundant and centralized storage option. Figure 3.14 shows a schematic of what this alternative would look like at build-out. Figure 3.15 shows a plan view of Alternative 4 throughout the distribution system.

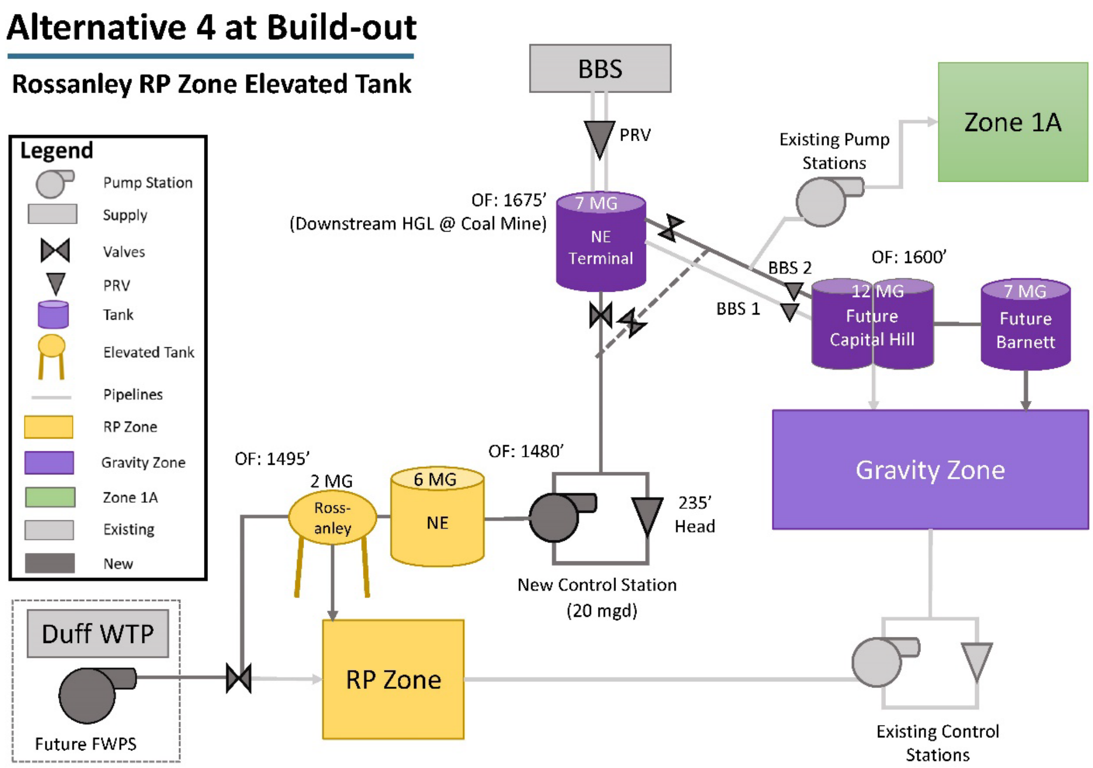


Figure 3.14 Alternative 4 Schematic

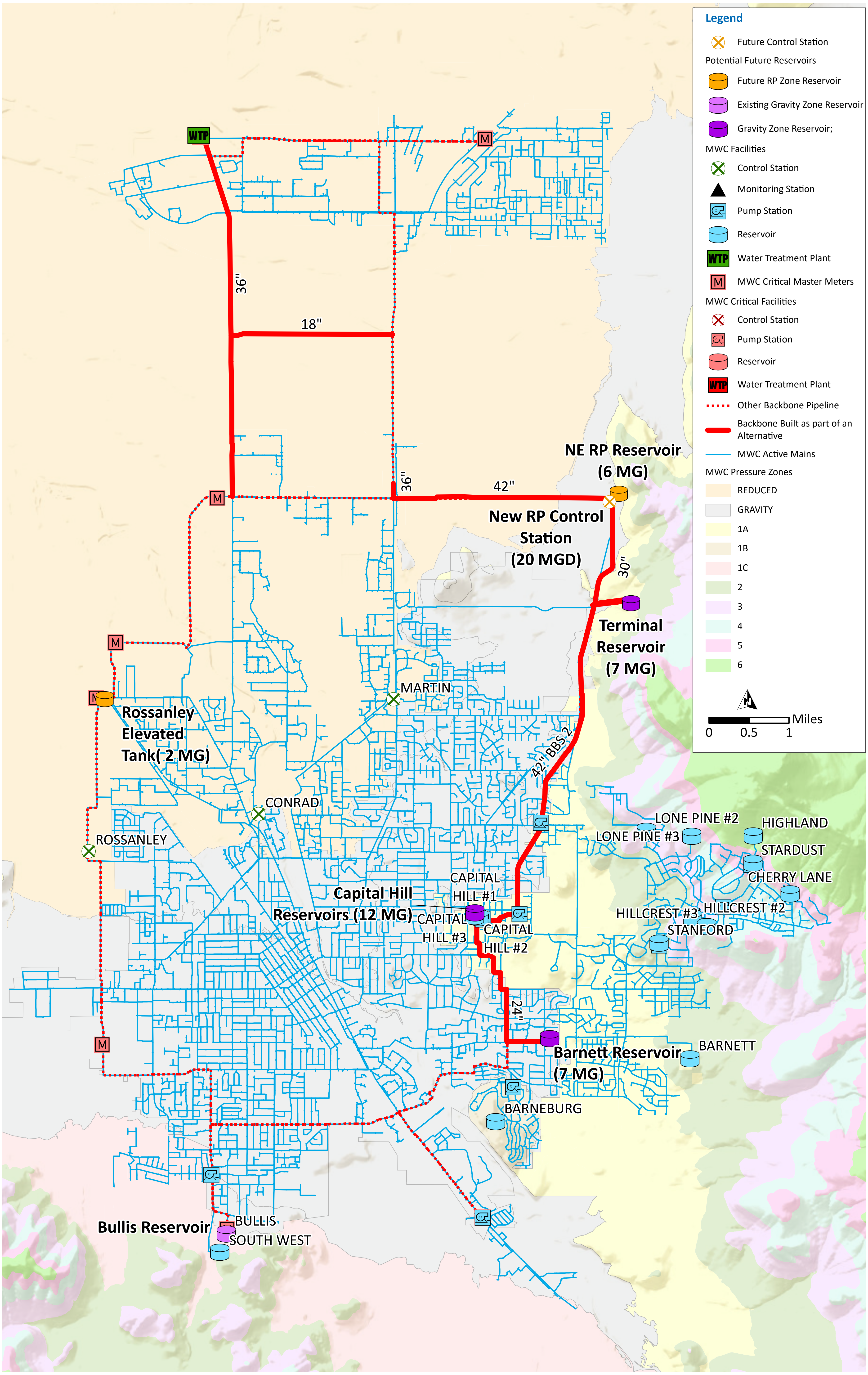


Figure 3.15 Alternative 4 Build-out

3.6.5 Alternative 5a: No New RP to Gravity Control Station, 8 MG Foothill Reservoir

Alternative 5a is similar to Alternative 1 and proposes new storage at the northeast RP Reservoir and Terminal Reservoir but does not include a new control station. Alternative 5a proposes to utilize a more centralized backbone and instead of a new control station will harden and upsize the existing Martin CS. This alternative, as compared to Alternative 5b, locates the RP Reservoir near Foothill Road and Vilas Road. Figure 3.16 shows a schematic of what this alternative would look like at build-out. Figure 3.17 shows a plan view of Alternative 5a throughout the distribution system.

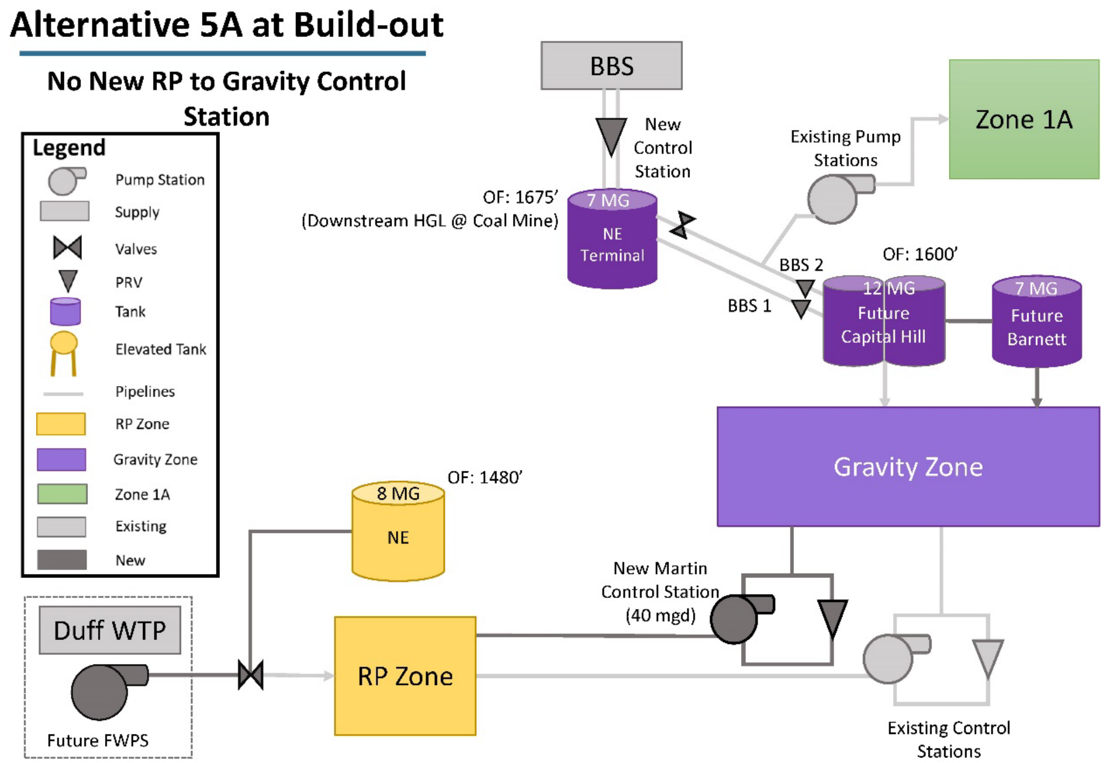


Figure 3.16 Alternative 5a Schematic

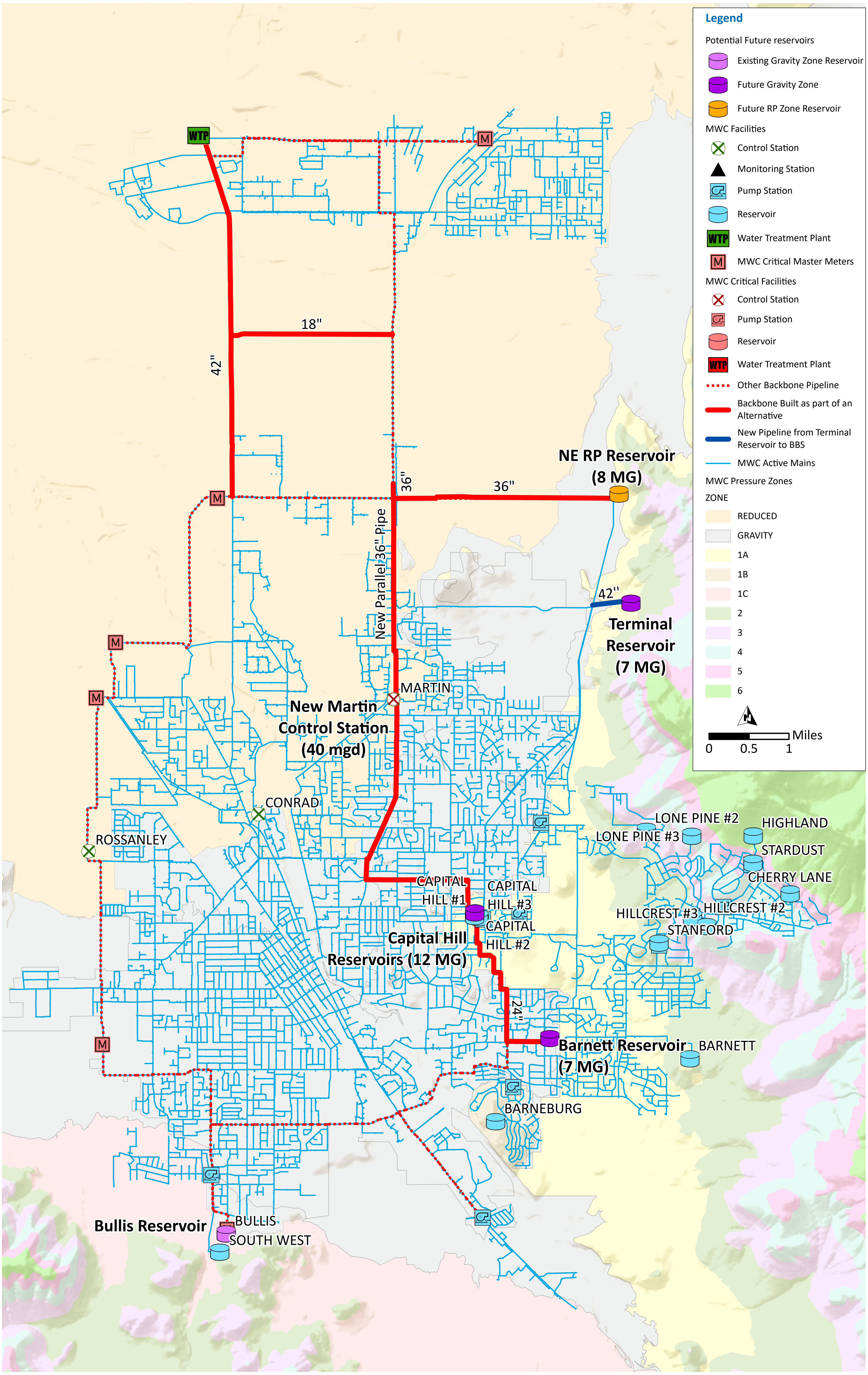


Figure 3.17 Alternative 5a Build-out

3.6.6 Alternative 5b: No New RP to Gravity Control Station, 8 MG Delta Waters Reservoir

Alternative 5b is very similar to 5a in every aspect except the location of the RP Zone Reservoir. Alternative 5b proposes an 8 MG RP Zone Reservoir at a site along Delta Waters Road. The availability of this location was not investigated at the time of this study. Figure 3.18 shows a schematic of what this alternative would look like at build-out. Figure 3.19 shows a plan view of Alternative 5b throughout the distribution system.

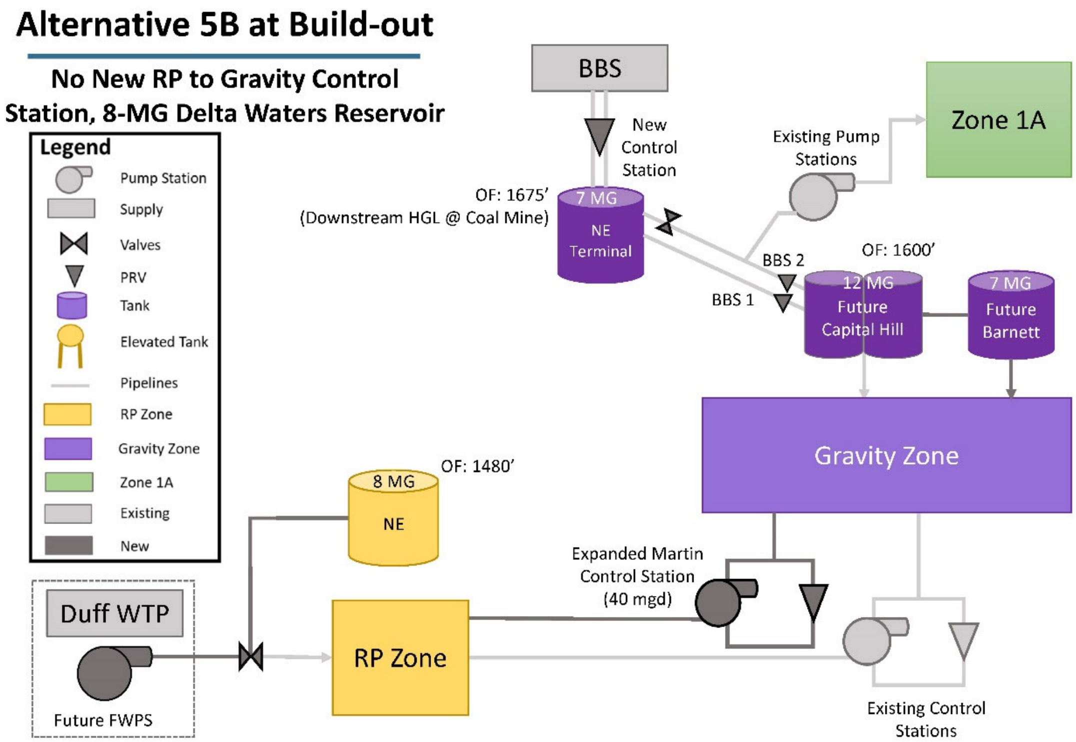


Figure 3.18 Alternative 5b Schematic

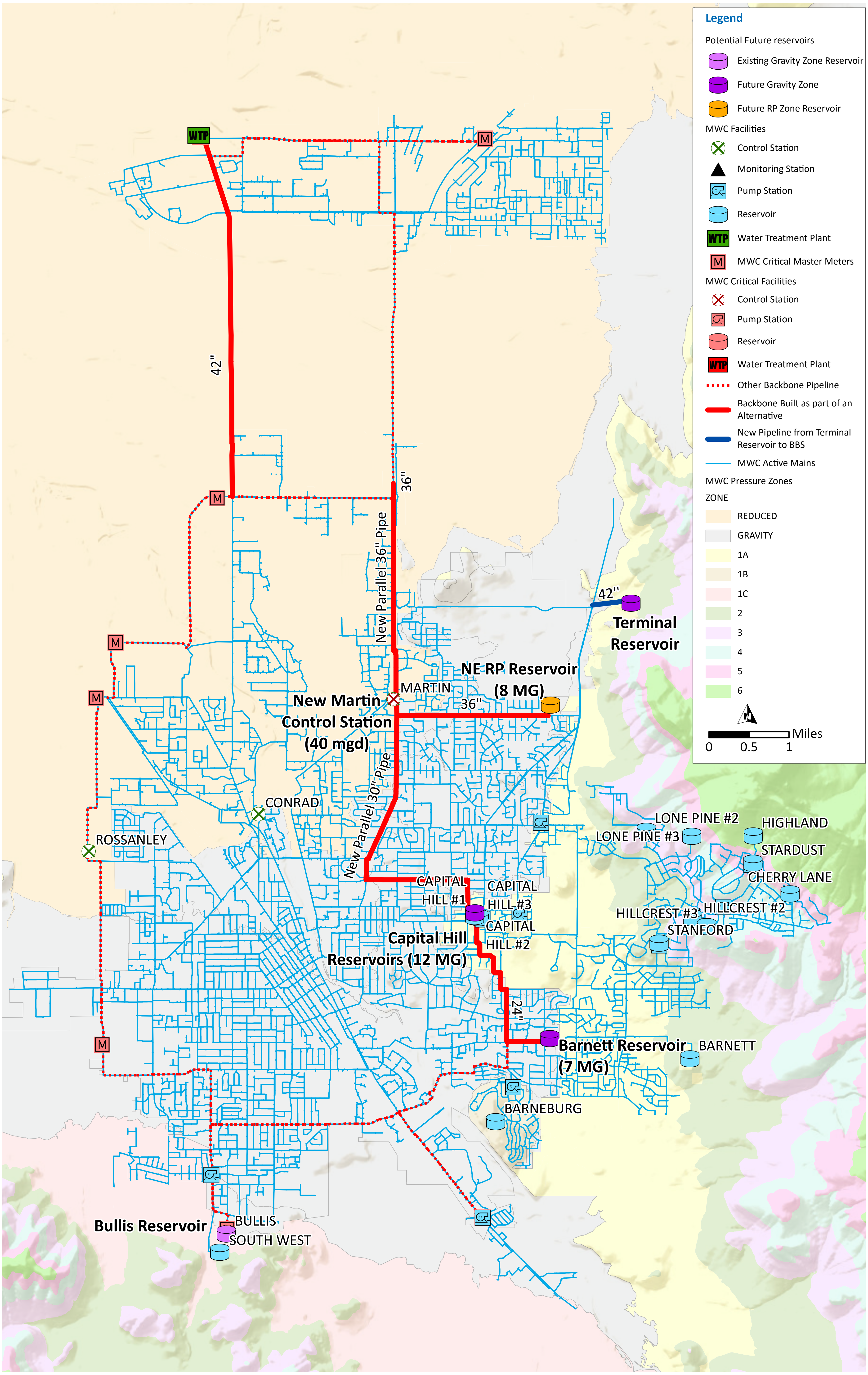


Figure 3.19 Alternative 5b Build-out

3.6.7 Alternative 6: No New RP to Gravity Control Station, 4 MG Delta Waters Reservoir

Alternative 6 is very similar to 5b except it proposes a smaller tank of 4 MG in the RP Zone and leverages 2 MG of equalizing storage at Duff. This alternative was included to reflect the possibility that adequate land may not be available to construct an 8 MG RP Zone Reservoir which would take approximately 5 acres. The size of this tank will likely be dictated by what is most feasible based on future land acquisition efforts. Figure 3.20 shows a schematic of what this alternative would look like at build-out. Figure 3.21 shows a plan view of Alternative 6 throughout the distribution system.

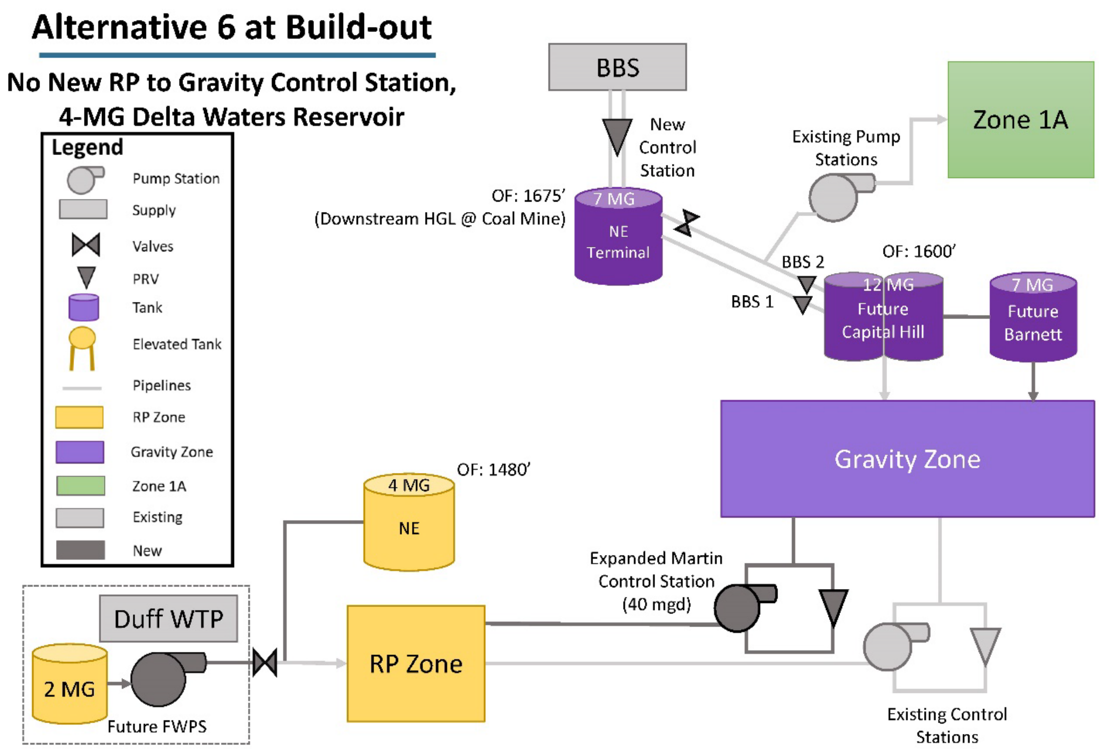


Figure 3.20 Alternative 6 Schematic

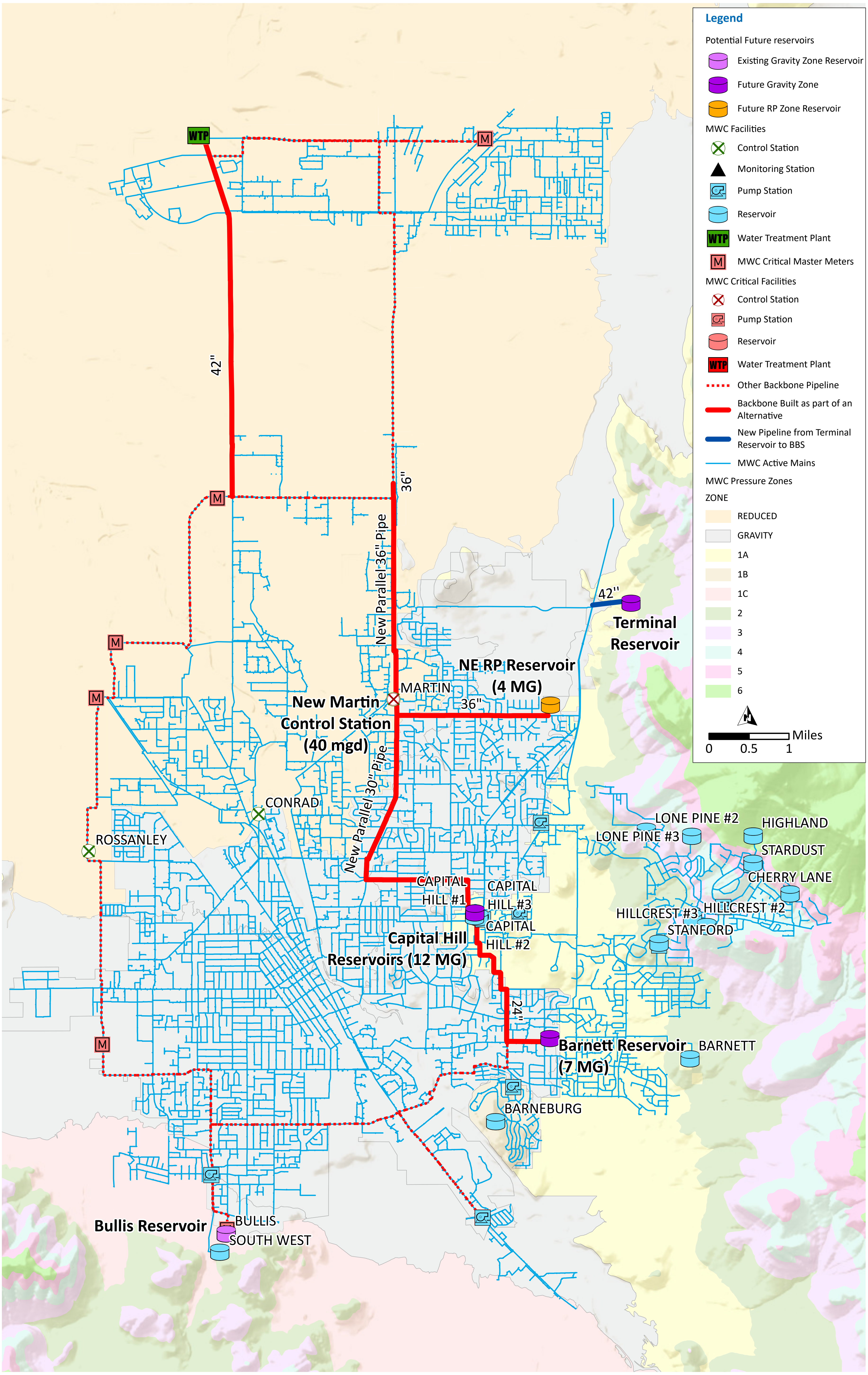


Figure 3.21 Alternative 6 Build-out

3.6.8 Alternative 7: No New RP to Gravity Control Station, No RP Zone Reservoir

Alternative 7 does not include a northeast RP Zone tank and instead leverages 2 MG of equalizing storage at Duff and emergency and fire flow storage in the Gravity Zone. This alternative was identified to evaluate if the system could meet the goals and criteria in the short-term while land is still being secured for a new RP Zone reservoir. Figure 3.22 shows a schematic of what this alternative would look like at buildout. Figure 3.23 shows a plan view of Alternative 7 throughout the distribution system.

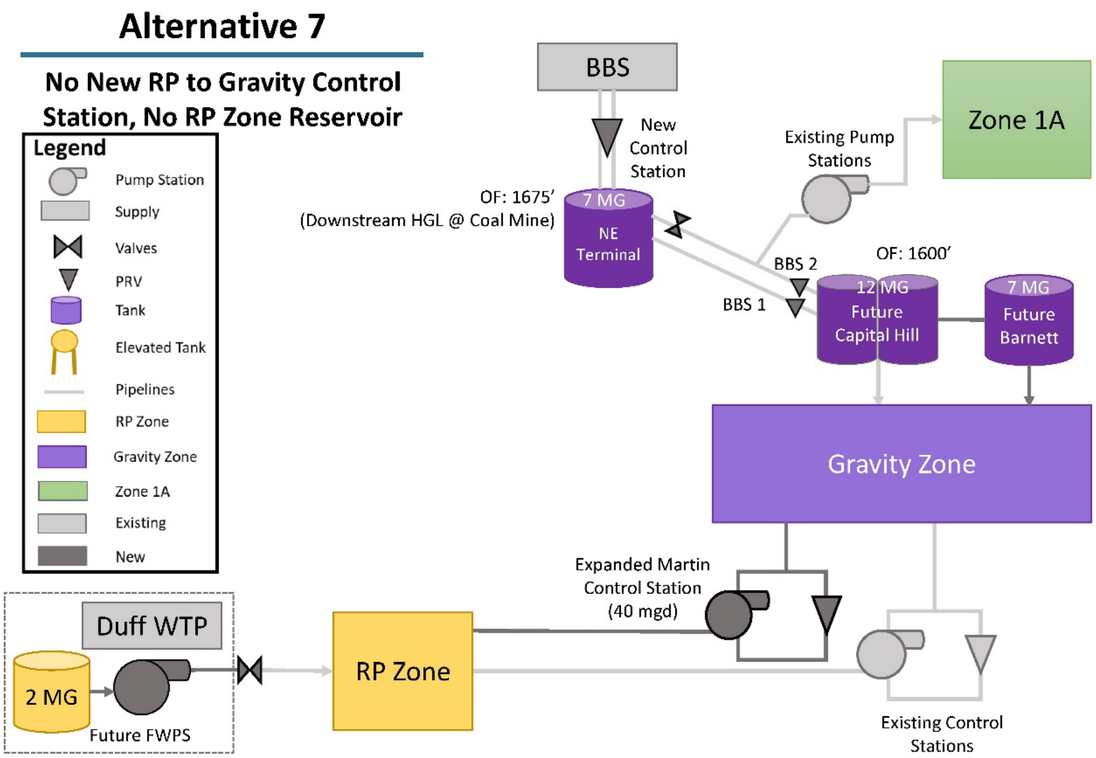


Figure 3.22 Alternative 7 Schematic

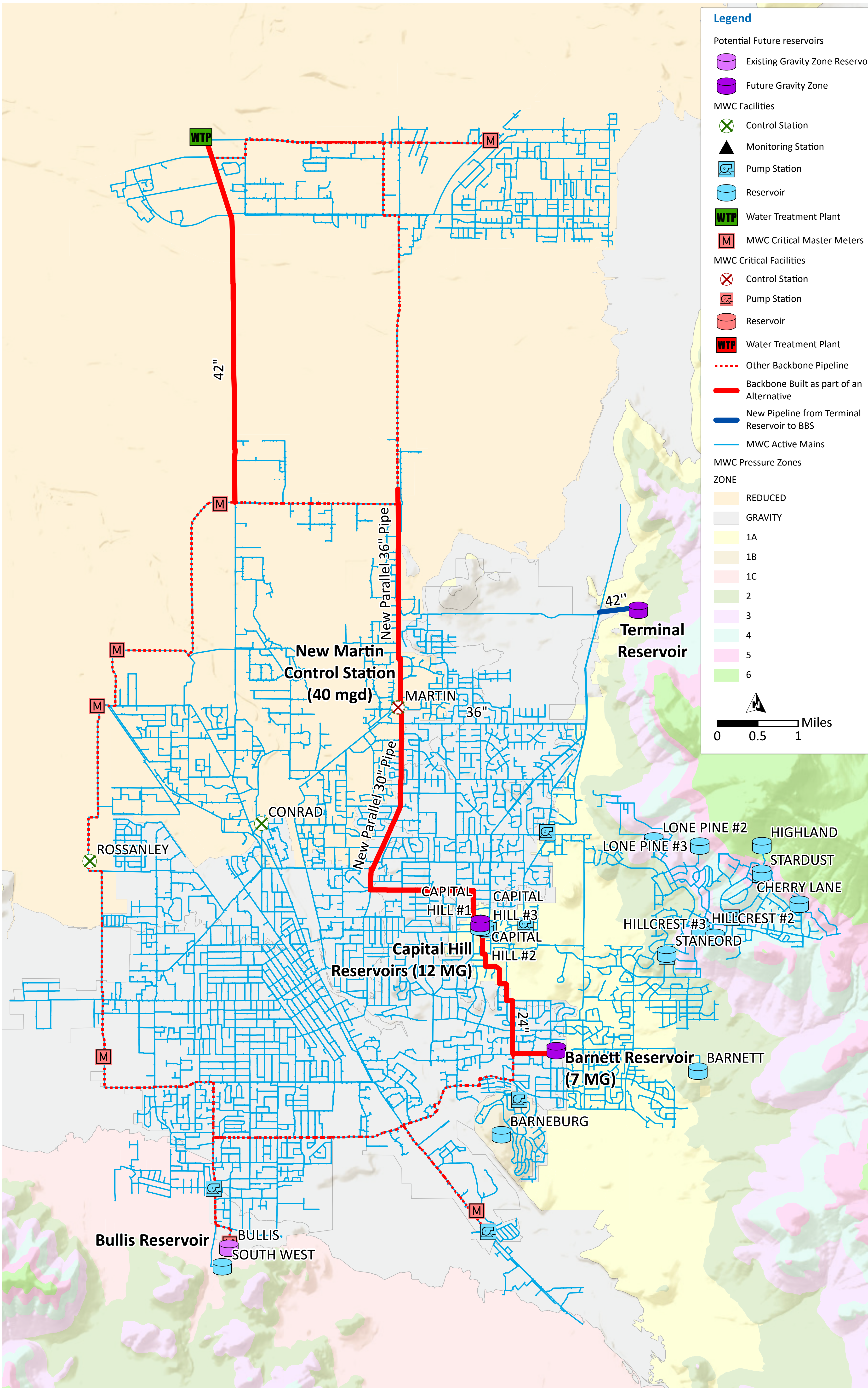


Figure 3.23 Alternative 7

Chapter 4

ALTERNATIVES EVALUATION AND PREFERRED ALTERNATIVE SELECTION

4.1 Introduction

This chapter describes how each of the eight alternatives detailed in Chapter 3 was evaluated for system response using the hydraulic model and presents the results of how well each alternative met the Medford Water resilience goals and objectives in the categories of resilience, operations and maintenance (O&M) simplicity, system compatibility, and cost. Simple schematics of the eight alternatives are provided in Figure 4.1 for reference.

Section 4.4 presents Medford Water's preferred alternative, provides a list of individual prioritized projects required to meet Medford Water's resilience goals and objectives, describes each project in detail, and presents a preliminary schedule of projects.

4.2 Alternatives Evaluation

The approach to evaluate the performance of the alternatives included developing an operational control strategy for each alternative and then assessing the improvements needed for each alternative to meet Medford Water's resilience goals and objectives. The alternatives were initially assessed for the near-term MDD scenario, which required system operation in reverse flow mode. Reverse flow mode is when Duff WTP is in operation. This mode of operation at the peak demands requires more hydraulic capacity than Forward Flow mode when BBS is the only water supply for the Medford Water system. After the near-term MDD scenario was evaluated and improvement projects identified, validation of those projects and sizing of pipelines was performed using the long-term MDD scenario demands, which correspond to Duff WTP producing 65 mgd. The recommended improvements were also validated for forward flow conditions, which is when Duff WTP is not in operation.

Modeled control strategies, tank level system response, control station flows, and pressure differentials across the system for each alternative provided a foundation for evaluating and comparing the alternatives.

4.2.1 Control Strategies

Each alternative was set up in the hydraulic model using the 2036 MDD scenario to represent near-term demand conditions. The following sections describe the control strategies modeled for each alternative, which apply to reverse flow mode (pumped flow) when the Duff WTP is in operation. The scenarios reflect use of both the Duff WTP existing pumps and planned FWPS, which is planned to be constructed prior to implementing the recommendations from this study. Similarly, the alternatives that rely on capacity from the Duff WTP Reservoirs assume that a new 3 MG reservoir will be constructed at the Duff WTP prior to implementing the recommended backbone projects.

For Alternatives 5a, 5b, 6, and 7, a Terminal Reservoir is included as an option for build-out to address BBS flow challenges. However, for these alternatives, the Terminal Reservoir is not filled by the RP Zone and is not a core component of the system in the near-term. Therefore, the Terminal Reservoir was not included in the model. In the sections below, Alternatives 51, 5b, 6, and 7 do not include a control strategy or tank level results for the Terminal Reservoir.

4.2.1.1 Alternative 1: Terminal Reservoir

Alternative 1 was set up in the model with a new northeast RP Zone Reservoir, new Terminal Reservoir, and new RP Control Station near the new RP Zone Reservoir. The control strategy used when modeling Alternative 1 is outlined in Table 4.1.

Table 4.1 Alternative 1 Control Strategy[(1)]

Facility	Controlled By	Notes
BBS Transmission Lines	Inlet control at Terminal Reservoir.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps.
	RP Zone Reservoir level (primary).	On/off of 1 pump.
	Capital Hill Reservoirs level (secondary).	On/off of 1 pump, with control stations.
Terminal Reservoir	Outlet control at Terminal Reservoir.	HGL setting based upon target flows to Gravity Zone through Terminal Reservoir. Higher HGL setting with RP Zone transfer and higher target flow from Terminal Reservoir; Lower HGL setting without RP Zone transfer and lower target flow from Terminal Reservoir.
New RP Control Station	Terminal Reservoir level.	On/Off of all pumps.
Control Stations	Constant pumping.	Primary operation.
	Capital Hill Reservoirs level (secondary).	On/Off of select pumps in coordination with the Duff WTP FWPS.

Notes:
(1) Applies to reverse flow mode.

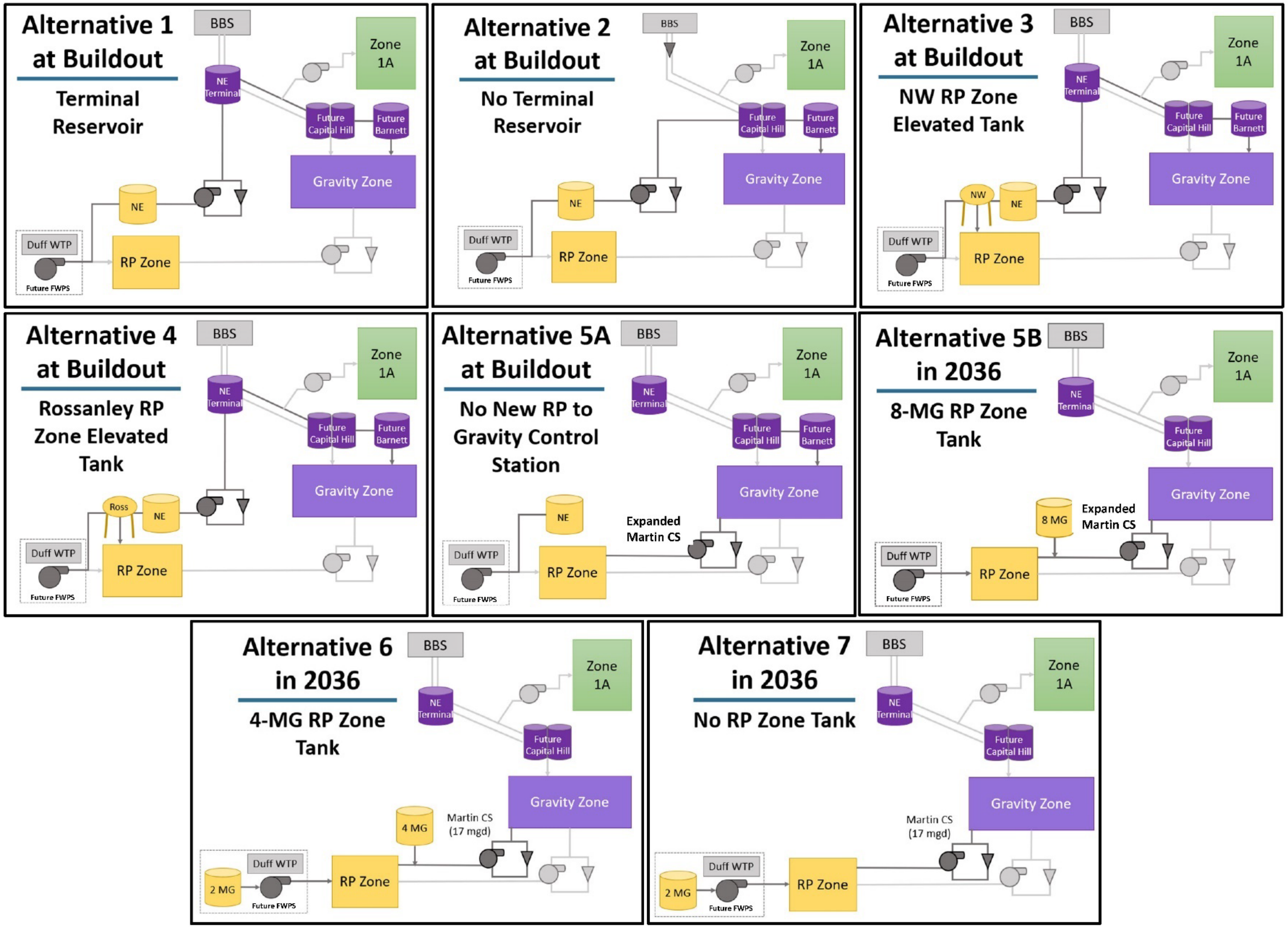


Figure 4.1 Alternative Schematics

4.2.1.2 Alternative 2: No Terminal Reservoir

Alternative 2 was set up in the model with a new NE RP Reservoir and new RP Control Station, but no Terminal Reservoir. The control strategy used when modeling Alternative 2 is outlined in Table 4.2.

Table 4.2 Alternative 2 Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Control at Nichols Gap and Coal Mine.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps.
	RP Zone Reservoir level (primary).	On/Off of 1 pump.
	Capital Hill Reservoirs level (secondary).	On/Off of 1 pump, with control stations.
New RP Control Station	Capital Hill Reservoirs level.	On/Off of all pumps. Dedicated supply to Capital.
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoirs (secondary).	On/Off of select pumps in coordination with the Duff WTP FWPS.

Notes:
(1) Applies to reverse flow mode.

4.2.1.3 Alternative 3: NW Zone RP Zone Elevated Tank

Alternative 3 was set up in the model the same as Alternative 1, with the addition of the RP Zone NW Elevated Tank. The control strategy used when modeling Alternative 3 is outlined in Table 4.3. The NW Elevated Tank floats with the NE RP Reservoir.

Table 4.3 Alternative 3 Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Inlet control at Terminal Reservoir.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps.
	RP Zone Reservoir level (primary).	On/Off of 1 Pump. NW RP Elevated Tank floats with RP Zone Reservoir. NW RP Elevated Tank Overflow: 1495 feet.
	Capital Hill Reservoirs level (secondary).	On/Off of 1 Pump, with control stations.
Terminal Reservoir	Outlet control at Terminal Reservoir.	HGL setting based upon target flows to Gravity Zone through Terminal Reservoir. Higher HGL setting with RP Zone transfer and higher target flow from Terminal Reservoir; Lower HGL setting without RP Zone transfer and lower target flow from Terminal Reservoir.

Facility	Controlled By	Notes
New RP Control Station	Terminal Reservoir level.	On/Off of all pumps.
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoirs level (secondary).	On/Off of select pumps in coordination with the Duff WTP FWPS.

Notes:
(1) Applies to reverse flow mode.

4.2.1.4 Alternative 4: Rossanley RP Zone Elevated Tank

Alternative 4 was set up in the model the same as Alternative 1, with the addition of the Rossanley RP Elevated Tank. The control strategy used when modeling Alternative 4 is outlined in Table 4.4. The Rossanley elevated tank floats with the NE RP Reservoir.

Table 4.4 Alternative 4 Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Inlet Control at Terminal Reservoir.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps.
	RP Zone Reservoir level (primary).	On/Off of 1 Pump. Rossanley RP Elevated Tank floats with RP Zone Reservoir. Elevated Tank overflow: 1485 feet.
	Capital Hill Reservoir level (secondary).	On/Off of 1 pump, with control stations.
Terminal Supply to Capital	Outlet control at Terminal Reservoir.	HGL setting based upon target flows to Gravity Zone through Terminal Reservoir. Higher HGL setting with RP Zone transfer and higher target flow from Terminal Reservoir; Lower HGL setting without RP Zone transfer and lower target flow from Terminal Reservoir.
RP Control Station	Terminal Reservoir level.	On/Off of all pumps.
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoirs level (secondary).	On/Off of select pumps in coordination with the Duff WTP FWPS.

Notes:
(1) Applies to reverse flow mode.

4.2.1.5 Alternative 5a: No New RP-to-Gravity Control Station, 8 MG Foothill Reservoir

Alternative 5a was set up in the model with a new 8 MG NE RP Reservoir on Foothill Road as well as a new Terminal Reservoir. The control strategy used when modeling Alternative 5a is outlined in Table 4.5.

Table 4.5 Alternative 5a Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Control at Nichols Gap and Coal Mine.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps.
	RP Zone Reservoir level (primary).	On/Off of 1 pump.
	Capital Reservoirs level (secondary).	On/Off of 1 pump, with control stations.
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoirs level (secondary).	On/Off of select pumps in coordination with the Duff WTP FWPS.

Notes:
(1) Applies to reverse flow mode.

4.2.1.6 Alternative 5b: No New RP Control Station, 8 MG Delta Waters Reservoir

Alternative 5b is similar to Alternative 5a, except for the location of the NE RP Reservoir. For Alternative 5b a new 8 MG NE RP Reservoir is located along Delta Waters Road. The control strategies used when modeling Alternative 5b are outlined in Table 4.6. The control strategy applied for Alternative 5b varies from Alternative 5a to assess the performance of the RP Zone Reservoir with a near-constant supply from the Duff WTP FWPS. In this alternative, pumps at the Duff WTP FWPS are operated continuously, and the new pumps are operated with a flow setpoint. The flow setpoint was defined based upon the amount of water supply that was needed from the Duff WTP FWPS.

Table 4.6 Alternative 5b Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Control at Nichols Gap and Coal Mine.	Constant supply.
Duff WTP FWPS	Constant operation.	3 existing pumps + New Duff FWPS operated at target flow(2)
	RP Zone Reservoir level (primary).	On/Off of 1 small pump
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoirs Level (secondary).	On/Off of 1 pump at Martin

Notes:
(1) Applies to reverse flow mode.
(2) Target flow for new FWPS was 17.3 mgd for 2036 MDD simulation.

4.2.1.7 Alternative 6: No New RP Control Station, 4 MG Delta Waters Reservoir

Alternative 6 was set up in the model with a new 4 MG NE RP Reservoir. The control strategy used when modeling Alternative 6 was similar to that of Alternative 5b with constant pump operation at the Duff WTP FWPS. The difference in Alternative 6 was that the new Duff WTP FWPS pumps do not include a flow setpoint. The control strategy is outlined in Table 4.7.

Table 4.7 Alternative 6 Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Control at Nichols Gap and Coal Mine.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps + new Duff FWPS
	RP Zone Reservoir level (primary).	On/Off of 1 small pump
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoir Level (secondary).	On/Off of select pumps.

Notes:
(1) Applies to reverse flow mode.

4.2.1.8 Alternative 7: No New RP Control Station, No RP Zone Reservoir

Alternative 7 was set up in the model with no NE RP Reservoir. The control strategy used when modeling Alternative 7 is outlined in Table 4.8. In this scenario, the pumps at the new Duff WTP FWPS will have variable frequency drives (VFD) that allow them to operate automatically to maintain a constant discharge pressure setpoint over a wide range of flow requirements to meet diurnal demands with the storage volume in the Duff WTP Reservoirs.

Table 4.8 Alternative 7 Control Strategy(1)

Facility	Controlled By	Notes
BBS Transmission Lines	Control at Nichols Gap and Coal Mine.	Constant supply.
Duff WTP FWPS	Constant operation.	3 pumps (2 Large + 1 Small) + new Duff FWPS with pressure setpoint of 115 psi.
Control Stations	Constant operation.	Primary operation.
	Capital Hill Reservoirs Level(secondary).	On/Off of select pumps.

Notes:
(1) Applies to reverse flow mode.

4.2.2 System Response

The system response to the near-term MDD scenario was considered for each alternative to determine how well pressure criteria are met throughout the system and how the alternative affects control station and reservoir operations. As documented in Chapter 1, Section 1.4, Medford Water's goal is to keep pressure swings within 25 psi.

4.2.2.1 Alternative 1: Terminal Reservoir

The modeling results for Alternative 1 are presented in Figures 4.2, 4.3, and 4.4. Figure 4.2 presents the tank levels for a 72-hour simulation event run and the RP, Capital Hill, and Terminal tanks all cycle as expected. Figure 4.3 presents the 3 existing control stations in the system, the potential RP Control Station, and the Duff WTP pump stations. After future piping capacity improvements of a new 42-inch pipeline in Table Rock Road, the Duff WTP will be able to better operate at steady state due to improved conveyance to the Control Stations. Figure 4.4 shows the pressure differentials throughout the system predicted by the model to reflect diurnal variations in demand and pumping operations following the controls described for the scenario. All pressure swings are under 25 psi, are lower than the pressure swings that would occur without the identified improvements and are an improvement over existing system pressure swings as shown in Figure 4.5. The swings generally worsen from east to west and are the largest in the RP Zone and the northwest portion of the Gravity Zone. Overall, the system has an adequate system response and is within performance criteria.

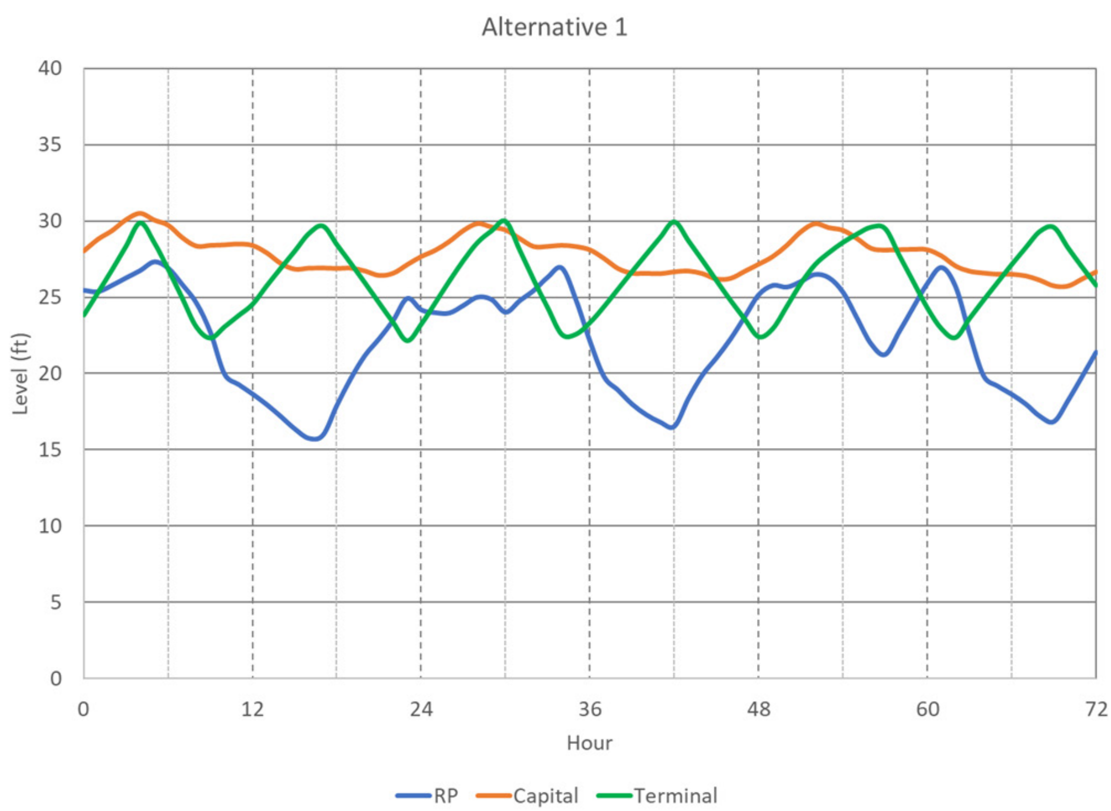


Figure 4.2 Alternative 1 Storage Levels

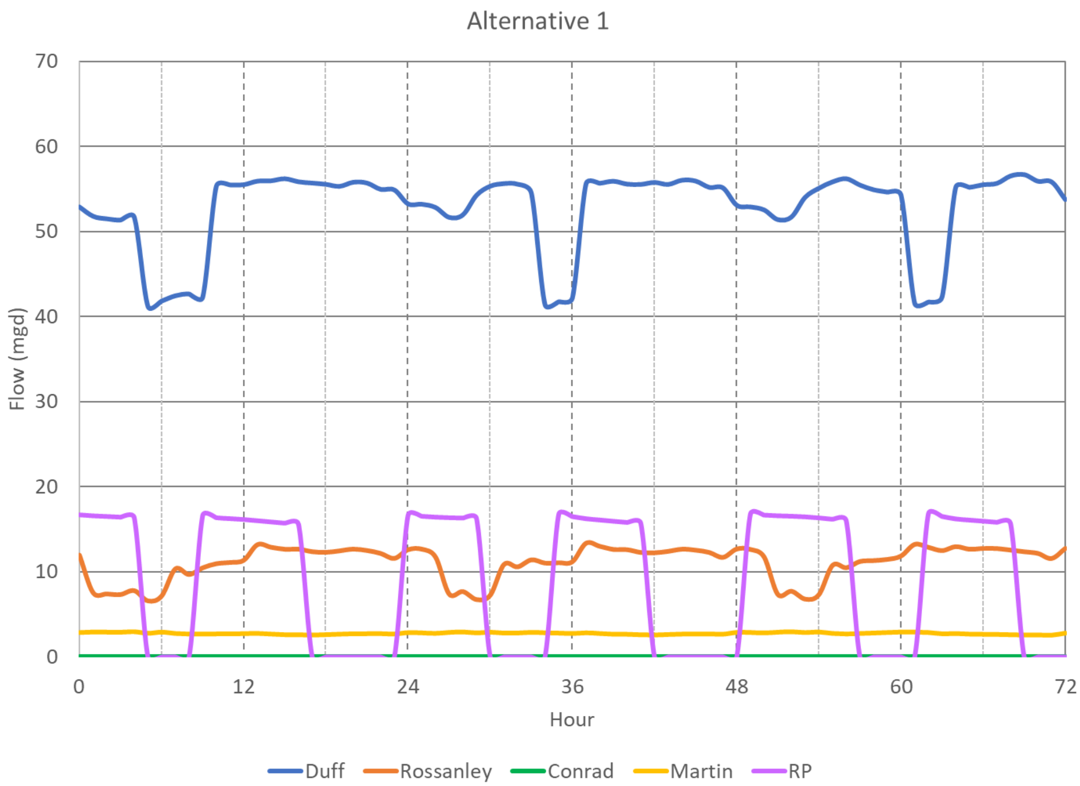


Figure 4.3 Alternative 1 Pump Station Flows

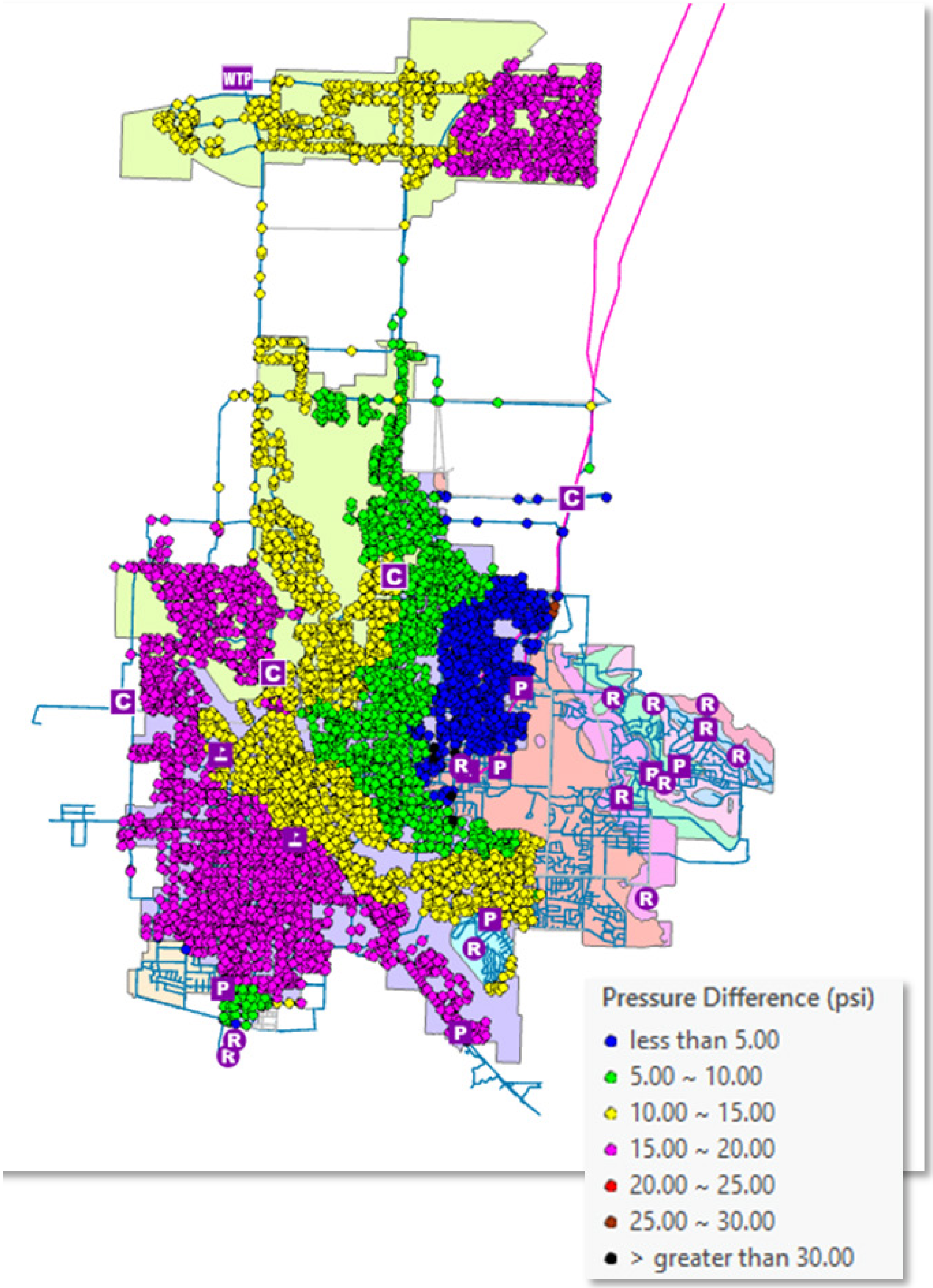


Figure 4.4 Alternative 1 System Pressure Swings

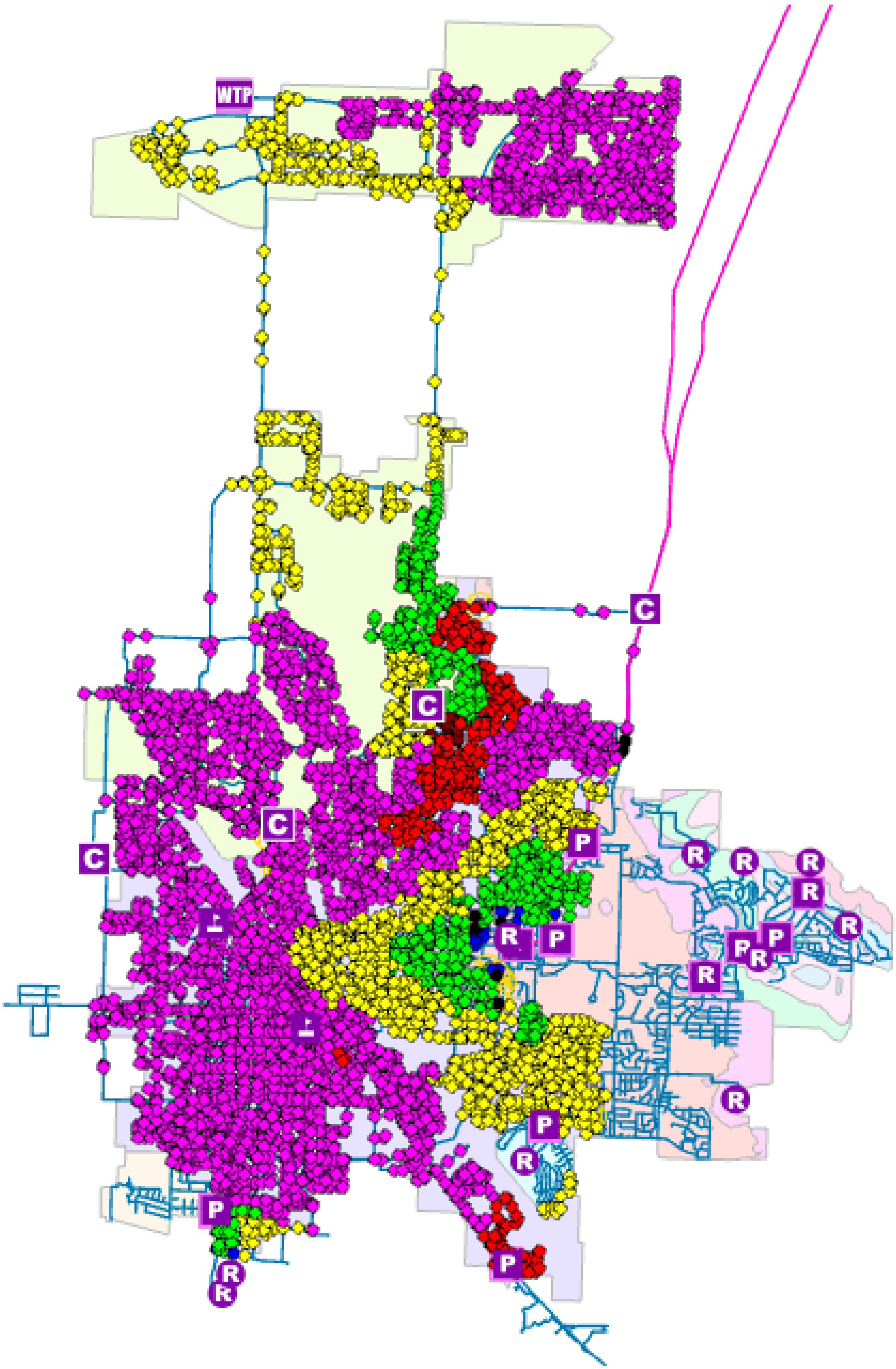


Figure 4.5 Existing System Pressure Swings

4.2.2.2 Alternative 2: No Terminal Reservoir

The modeling results for Alternative 2 are presented in Figures 4.6, 4.7, and 4.8. Figure 4.6 presents the NE RP Reservoir and Capital Hill Reservoir tank levels for the 72-hour simulation. Figure 4.6 presents the three control stations in the system and RP and Duff pump stations. The Duff WTP operates closer to steady state for this alternative than Alternative 1 due to a wider range of operation of the RP Reservoir. This wider range of operation is caused by the new RP Control Station pumping at a higher rate when filling the Capital Hill Reservoirs than when filling the Terminal Reservoir in Alternative 1. Figure 4.8 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, within Medford Water's criteria. The swings generally worsen from east to west and are the largest in the RP Zone and the west portion of the Gravity Zone. Alternative 2 results in slightly higher-pressure swings in both pressure zones than Alternative 1.

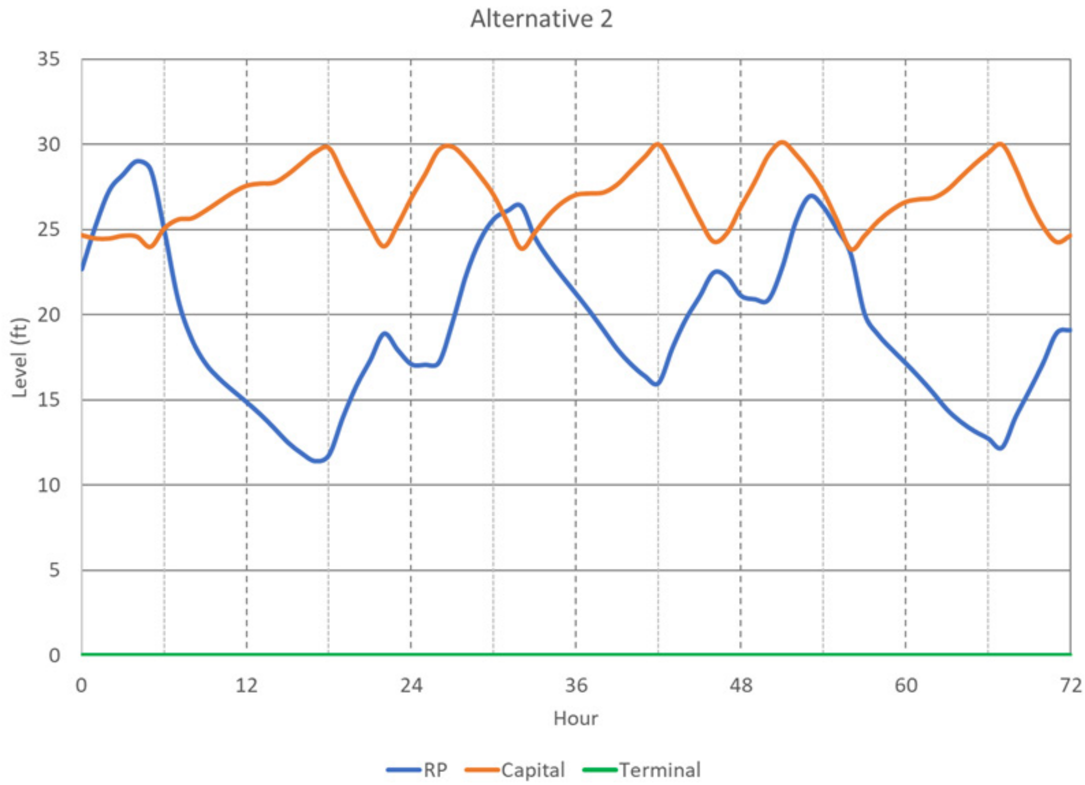


Figure 4.6 Alternative 2 Storage Levels

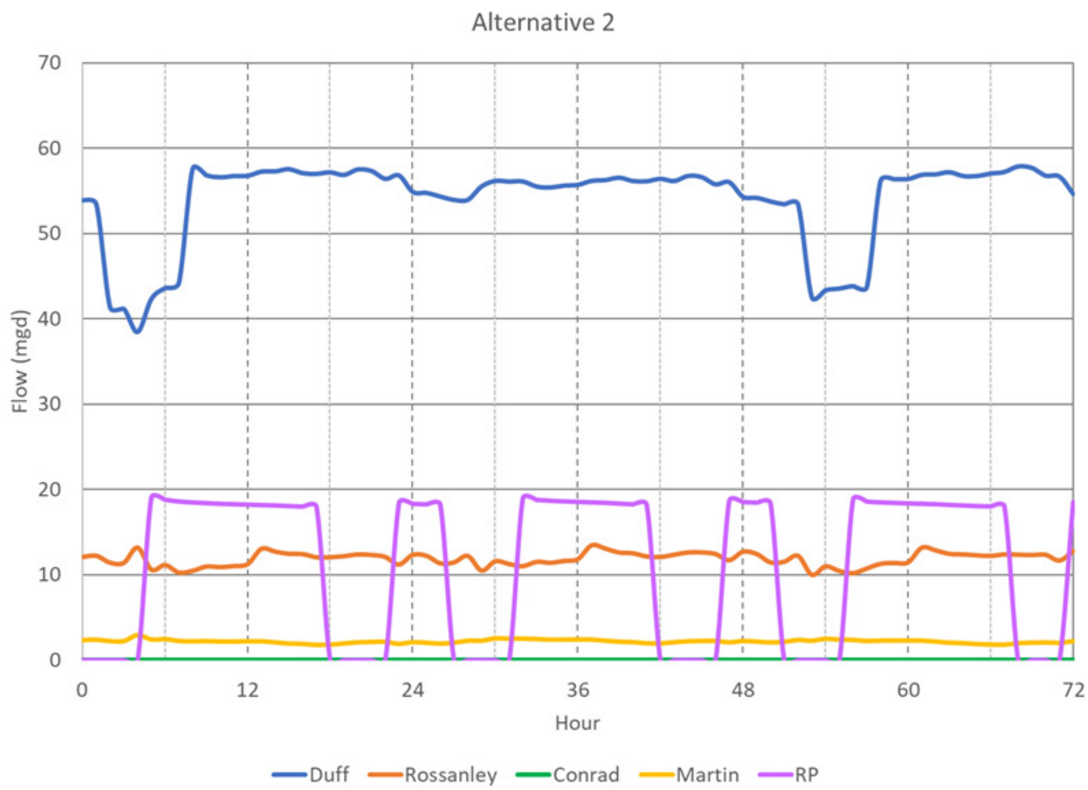


Figure 4.7 Alternative 2 Pump Station Flows

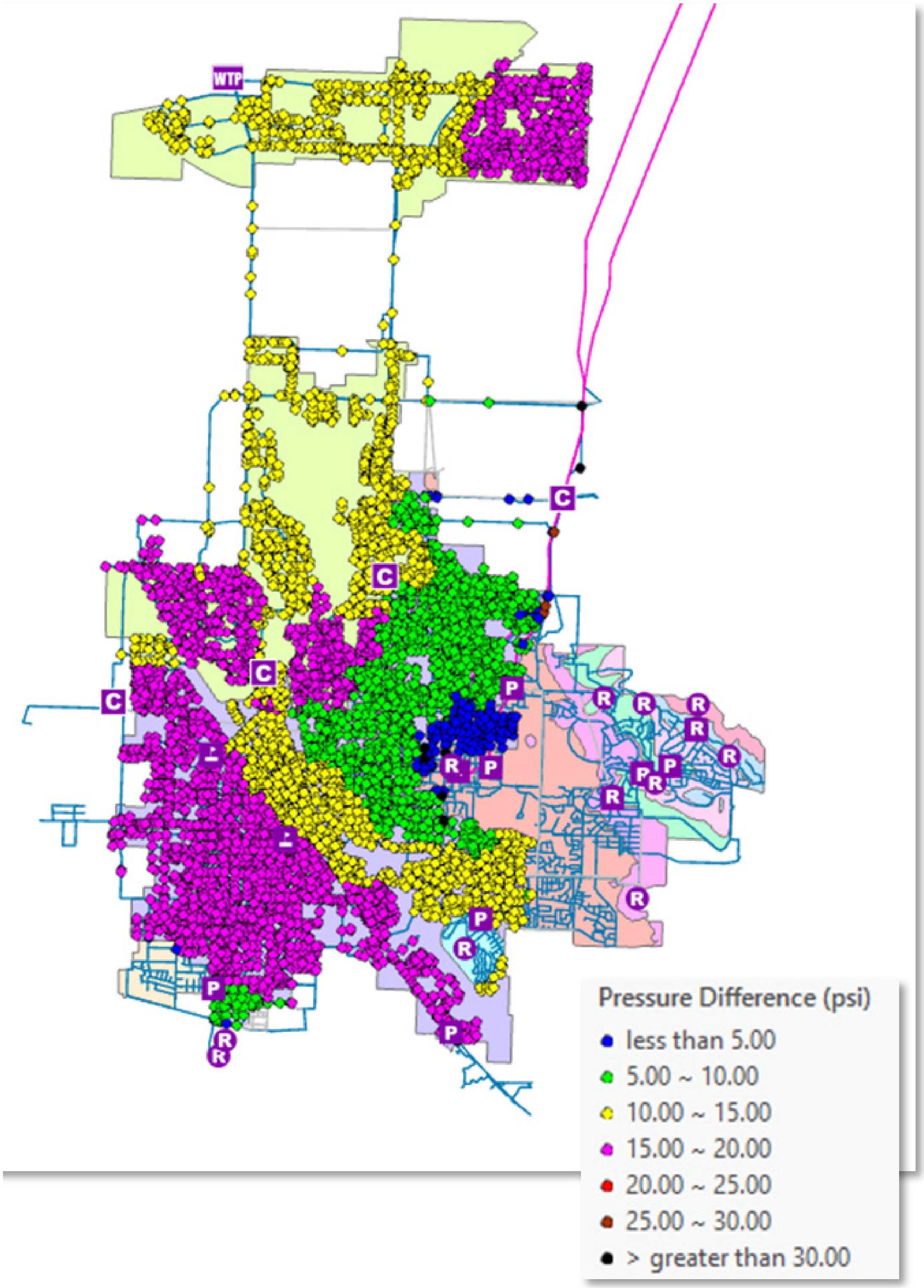


Figure 4.8 Alternative 2 System Pressure Swings

4.2.2.3 Alternative 3: NW RP Zone Elevated Tank

The modeling results for Alternative 3 are presented in Figures 4.9, 4.10, and 4.11. Figure 4.9 presents the NE RP Reservoir, NW Elevated Tank, Terminal Reservoir and Capital Hill Reservoir tank levels for the 72-hour simulation. Figure 4.10 presents the three existing control stations in the system, potential RP Control Station, and the Duff WTP pump station. Figure 4.9 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, within Medford Water's criteria. The addition of the NW Elevated Tank improves the pressure swings in the RP Zone.

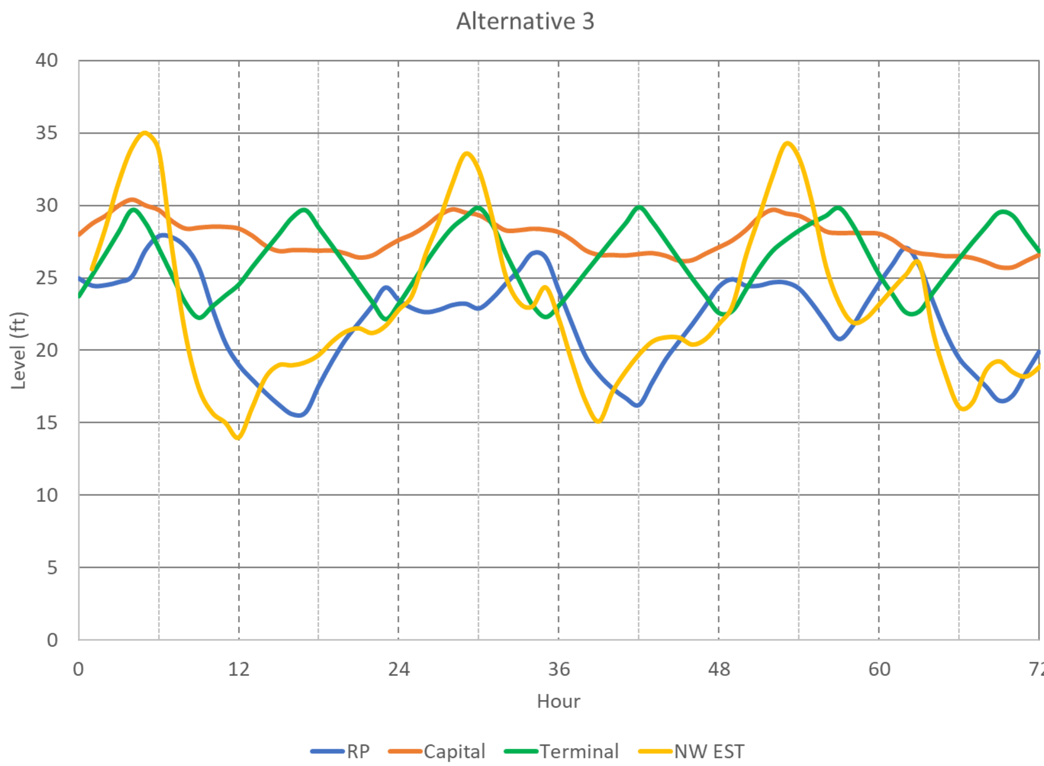


Figure 4.9 Alternative 3 Storage Levels

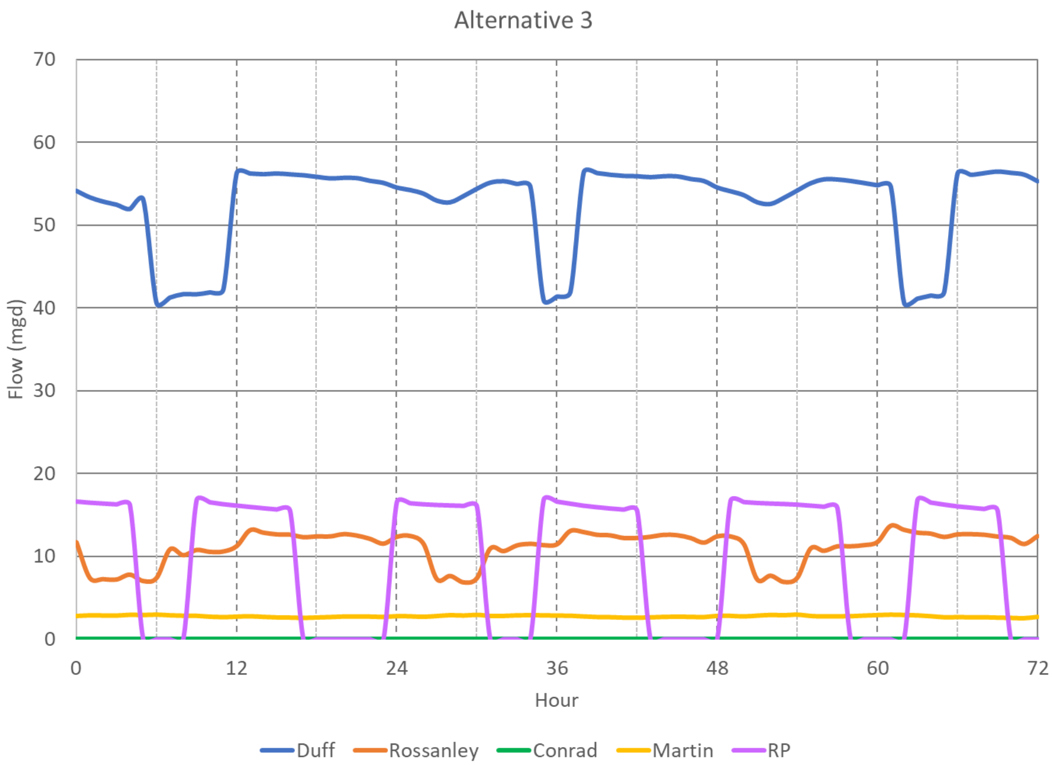


Figure 4.10 Alternative 3 Pump Station Flows

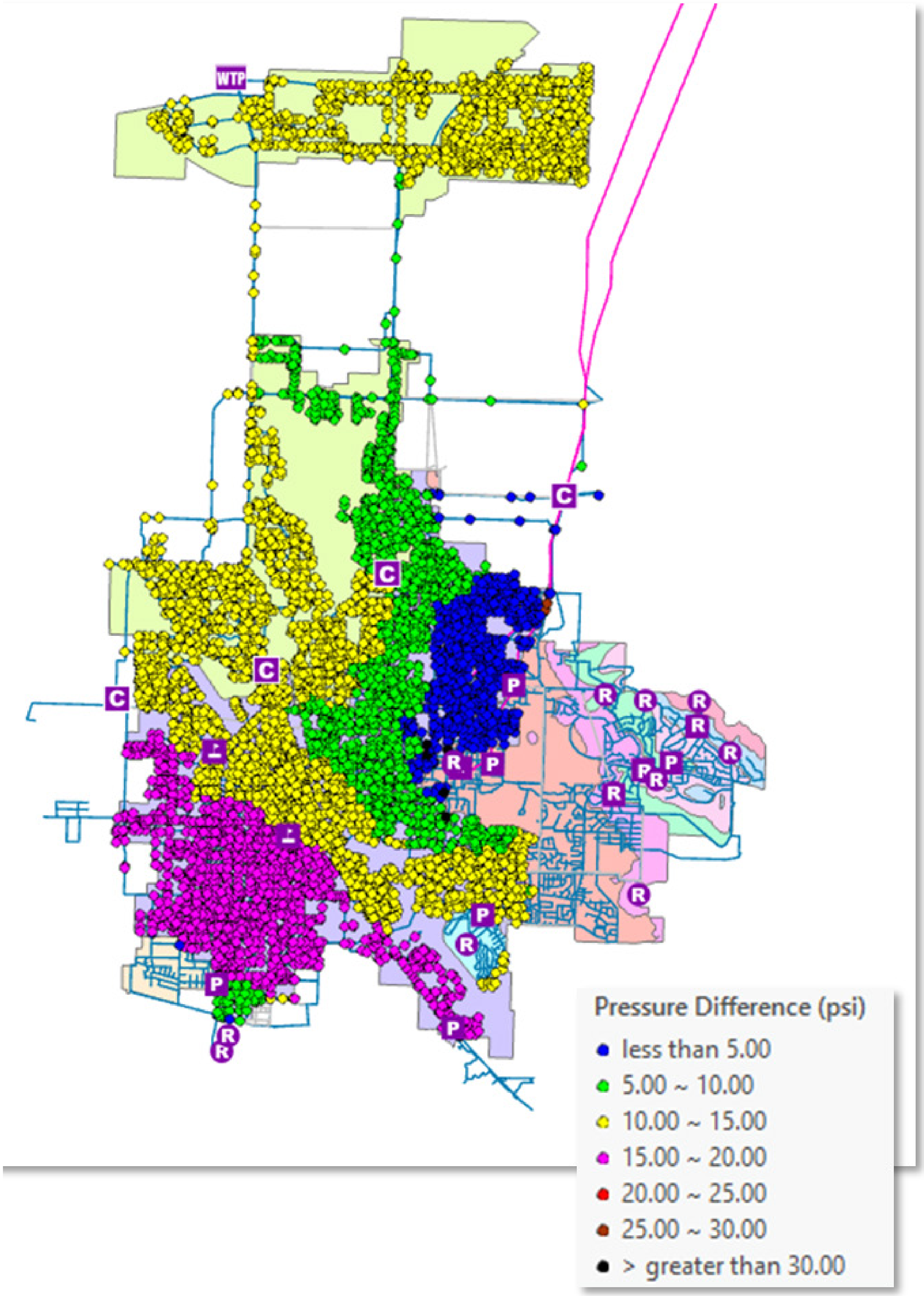


Figure 4.11 Alternative 3 System Pressure Swings

4.2.2.4 Alternative 4: Rossanley RP Zone Elevated Tank

The modeling results for Alternative 4 are presented in Figures 4.12, 4.13, and 4.14. Figure 4.12 presents the NE RP Zone Reservoir, Rossanley Elevated Tank, Terminal Reservoir, and Capital Hill Reservoir tank levels for the 72-hour simulation. The large range of operation of the elevated tank shown in Figure 4.12 is influenced by the smaller volume of storage for the elevated tank as compared to the NE RP Reservoir, the geometry of the elevated tank, and the more direct influence of the Rossanley CS operation on the elevated tank response. Figure 4.13 presents the three control stations in the system, the proposed RP Control Station, and the Duff WTP pump stations. Figure 4.14 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, and within Medford Water's criteria. The swings look very similar to Alternative 3, even though the elevated tank is in a different location.

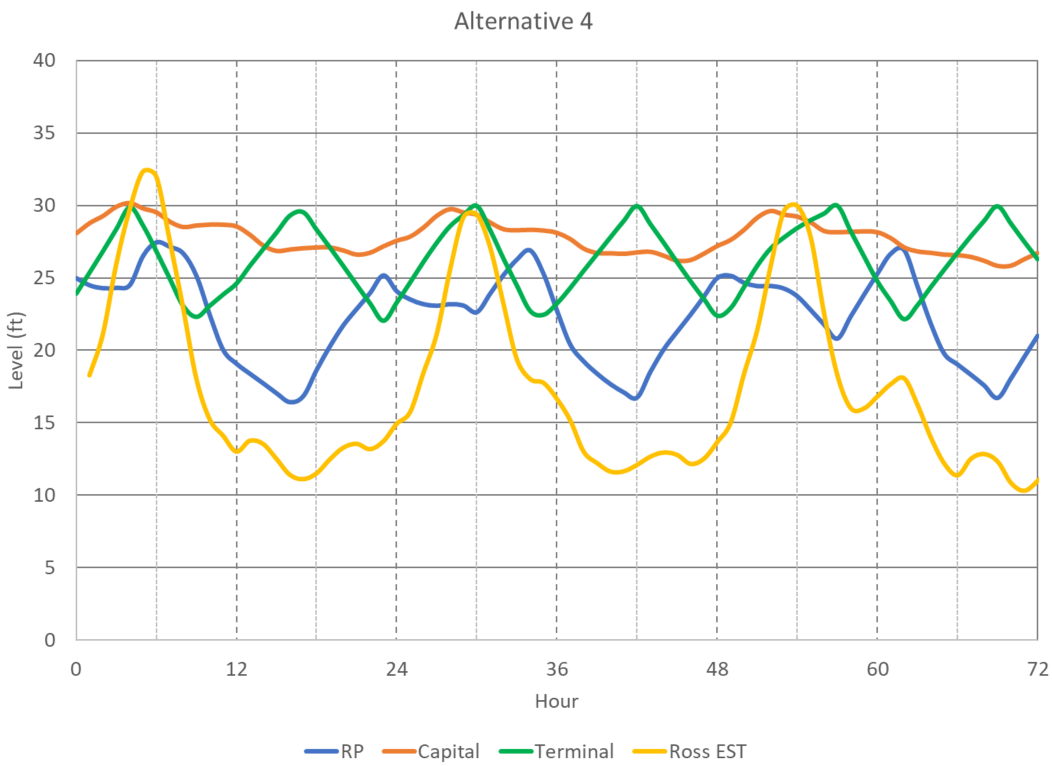


Figure 4.12 Alternative 4 Storage Levels

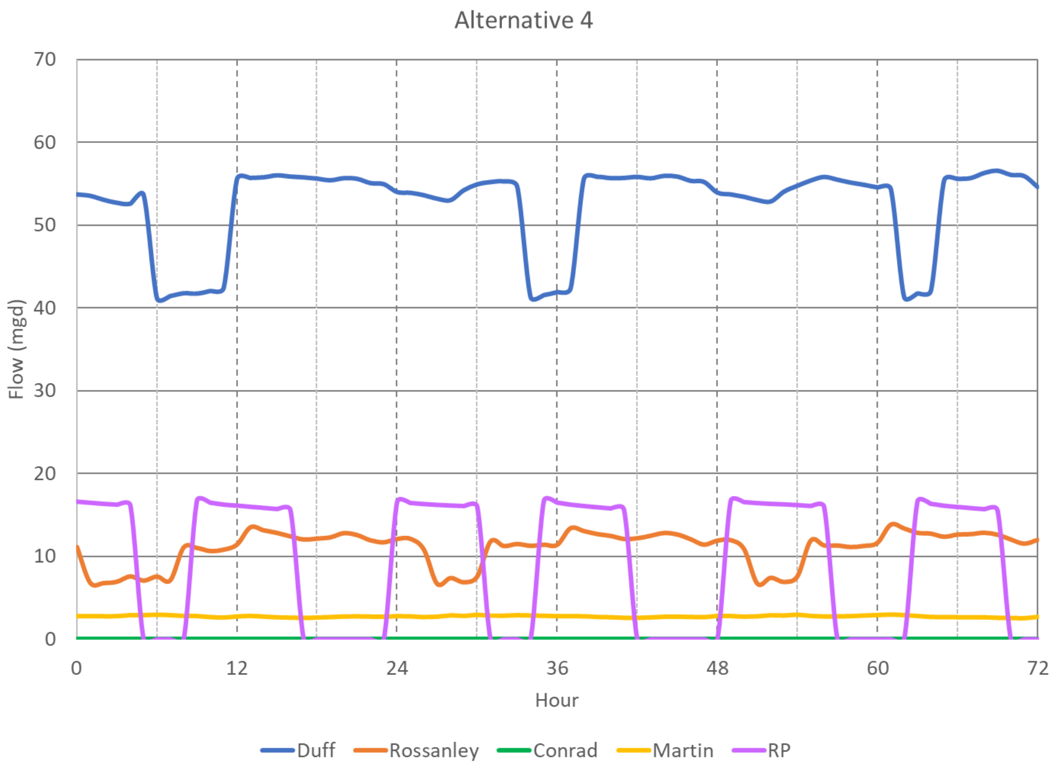


Figure 4.13 Alternative 4 Pump Station Flows

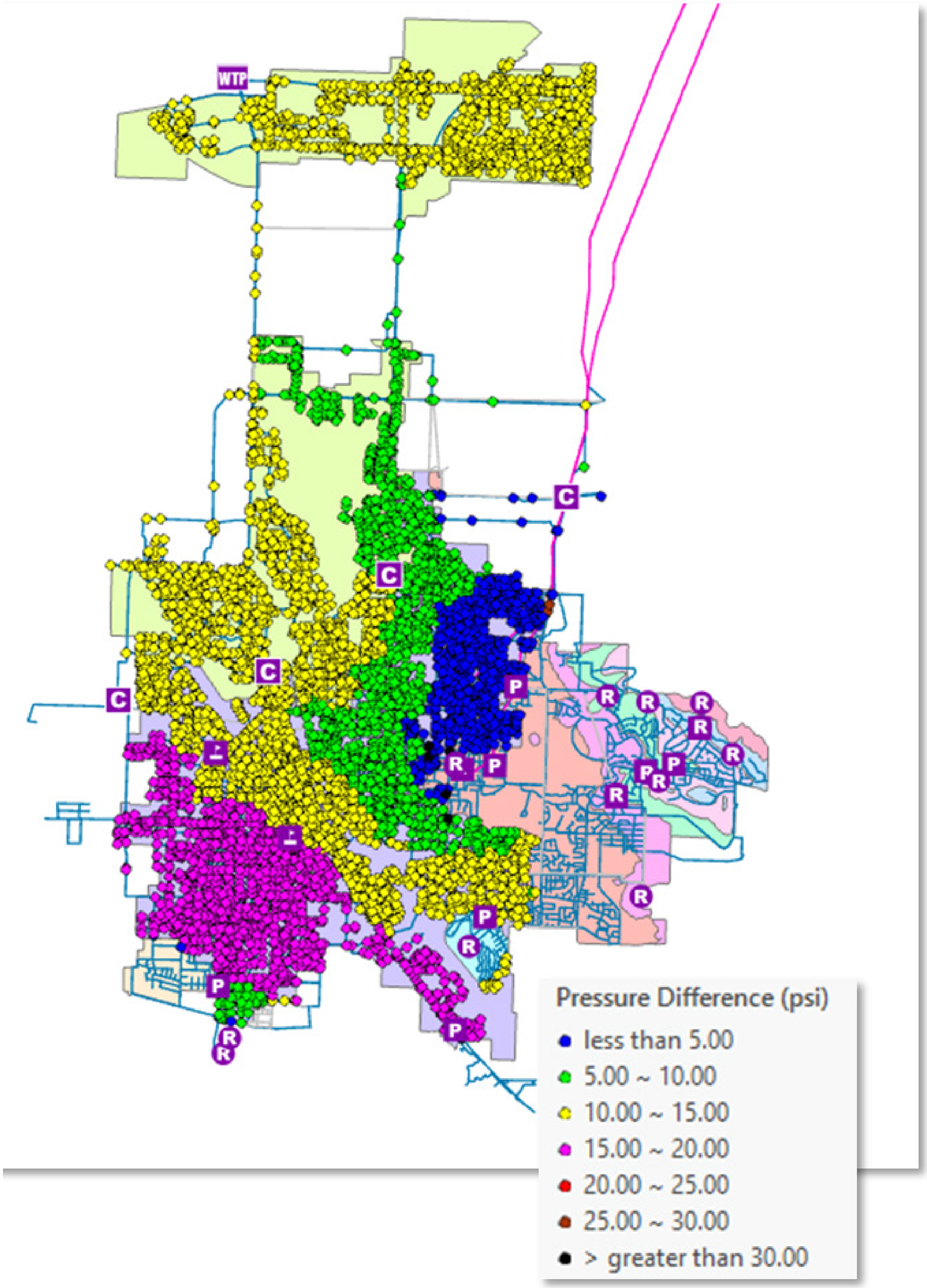


Figure 4.14 Alternative 4 System Pressure Swings

4.2.2.5 Alternative 5a: No New RP Control Station, 8 MG Foothill Reservoir

The modeling results for Alternative 5a are presented in Figures 4.15, 4.16, and 4.17. Figure 4.15 presents the NE RP Zone Reservoir, Terminal Reservoir, and Capital Hill Reservoir tank levels for the 72-hour simulation. Without a new RP Control Station, the Terminal Reservoir does not draw and fill, and the Martin CS and Conrad CS are operated at higher flows to account for the flow that was transferred by the RP Control Station in earlier alternatives. With the additional operation of existing control stations as compared to the RP Control Station, controls for the Duff WTP FWPS were updated to align with the additional pumping at the control stations. Figure 4.16 presents the three existing control stations in the system, RP Control Station, and the Duff WTP FWPS. Figure 4.17 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, and within Medford Water's criteria. The swings generally worsen in the western portion of the Gravity Zone and are more significant than Alternatives 3 and 4 due to the additional pumping at the Conrad CS.

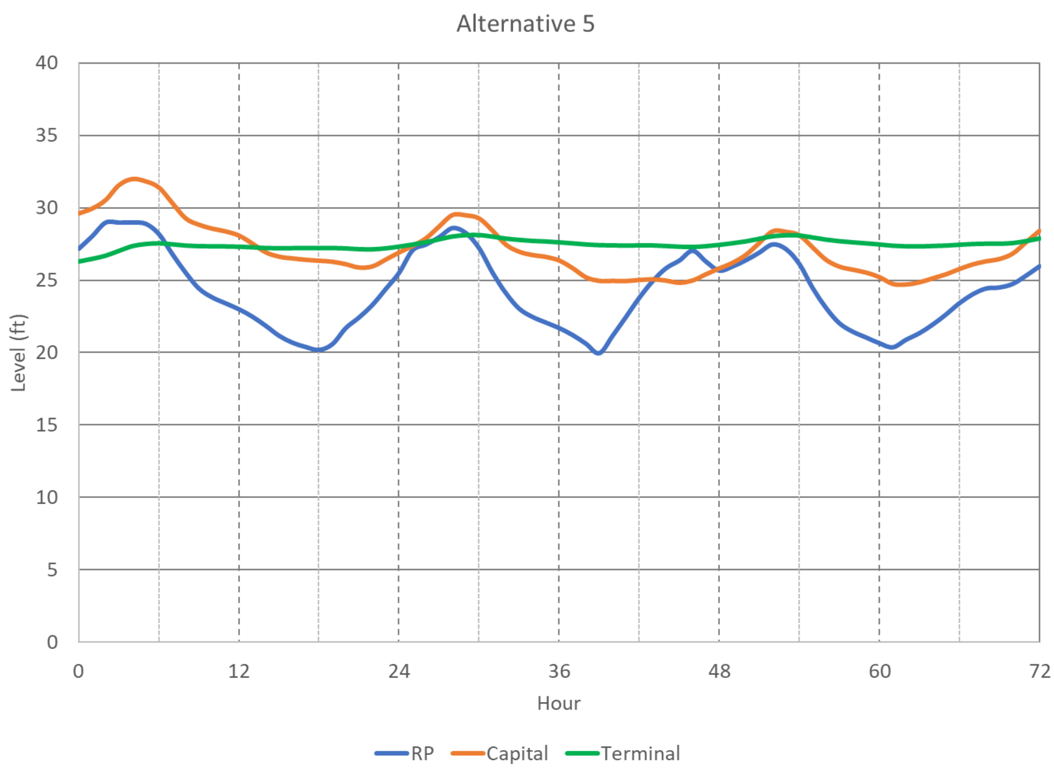


Figure 4.15 Alternative 5a Storage Levels

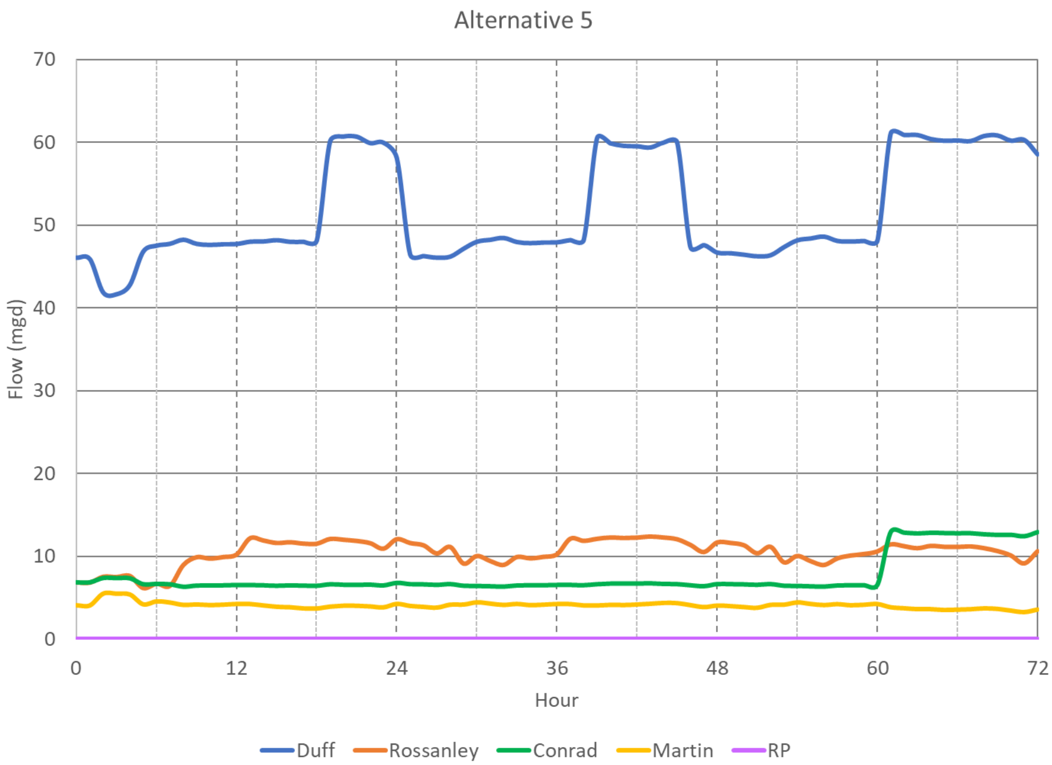


Figure 4.16 Alternative 5a Pump Station Flows

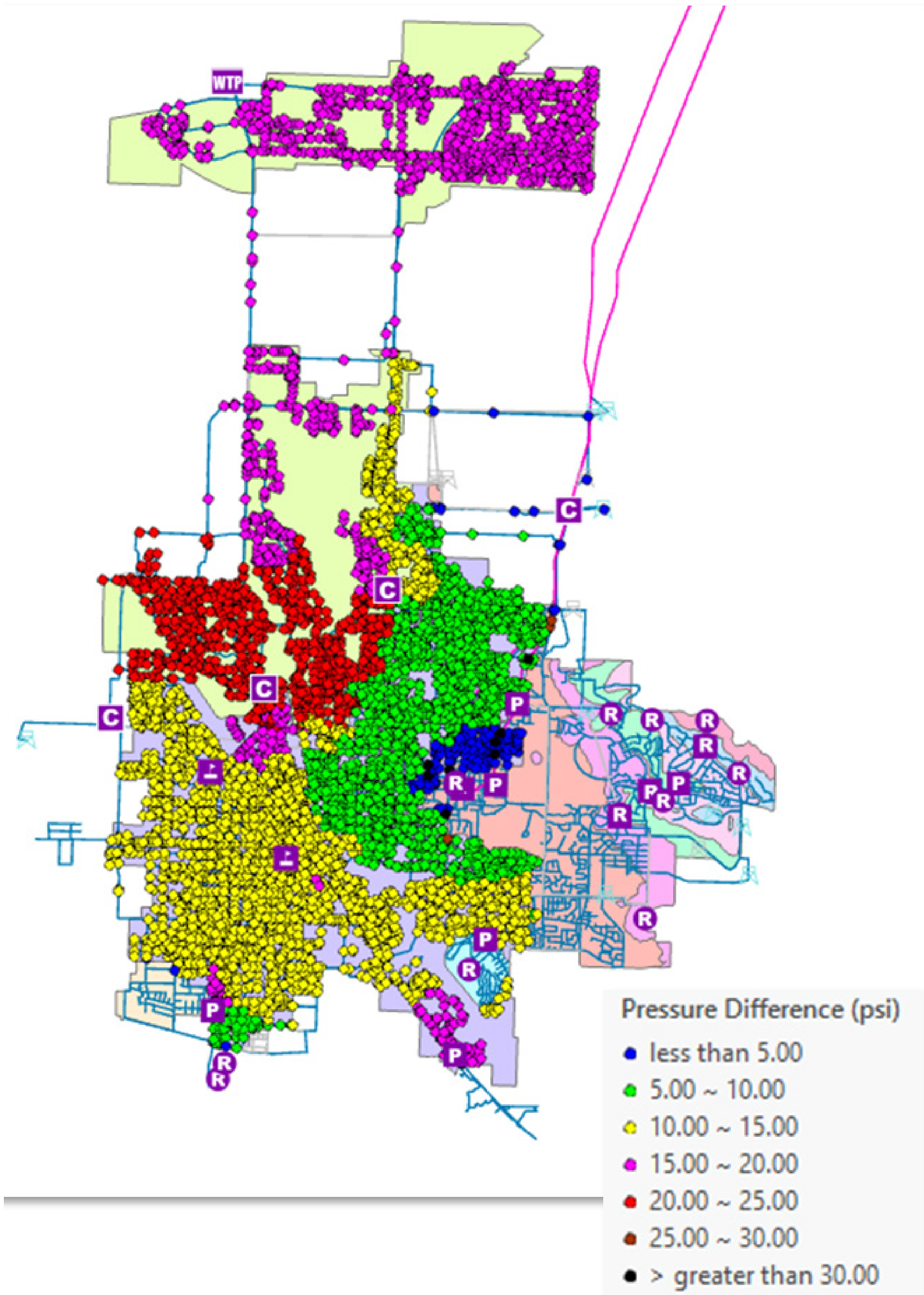


Figure 4.17 Alternative 5a System Pressure Swings

4.2.2.6 Alternative 5b: No New RP Control Station, 8 MG Delta Waters Reservoir

The modeling results for Alternative 5b are presented in Figures 4.18, 4.19, and 4.20. Figure 4.18 presents the tank levels for the 72-hour simulation. As noted in the control strategy description, the controls for the Duff WTP FWPS were updated for Alternative 5b to assess the performance if a flow set point were used for the new Duff WTP FWPS VFD pumps. This flow set point was used to demonstrate and assess the opportunity for baselining flow from the Duff WTP to minimize the use of the Duff WTP Reservoir volume.

Between the development of Alternatives 1 through 5a and the development of Alternatives 5b through 7, Medford Water decided that Bullis Reservoir will be a part of their long-term storage for the Gravity Zone. Therefore, Bullis Reservoir and Duff WTP Reservoir levels were added to the results presented for alternatives 5b, 6, and 7. Figure 4.19 presents the three existing control stations in the system and the Duff WTP FWPS. Figure 4.20 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, within Medford Water’s criteria. Alternative 5b’s pressure swings in the RP Zone are less significant than 5a due to the NE RP Reservoir location.

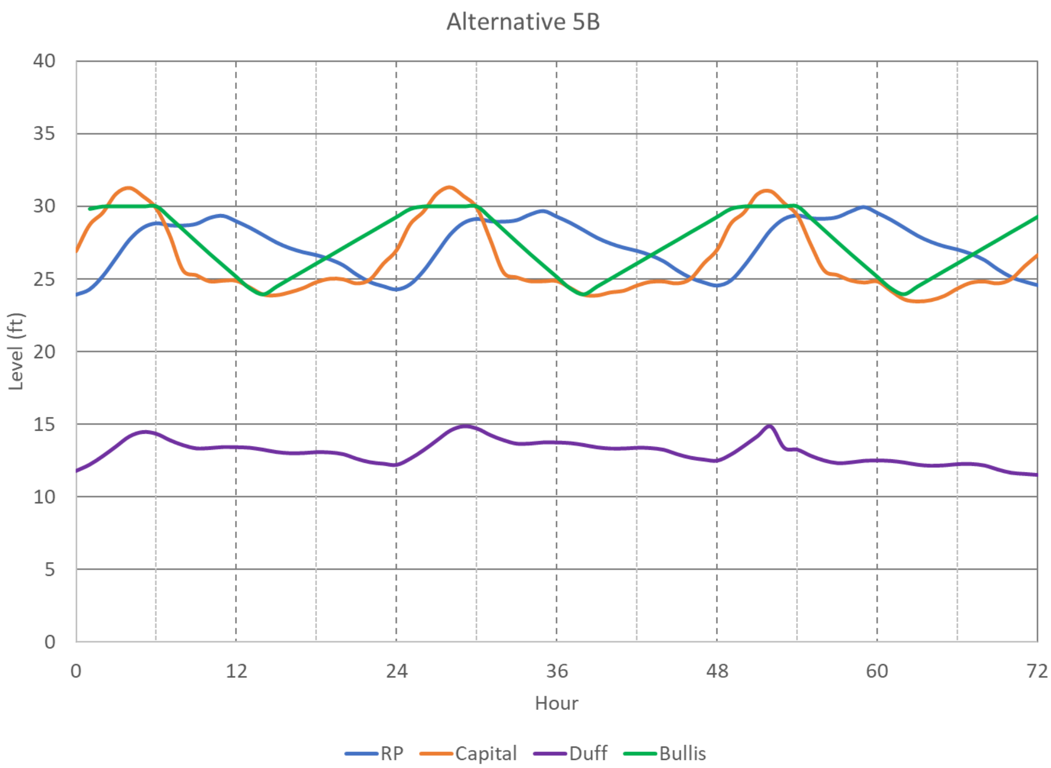


Figure 4.18 Alternative 5b Storage Levels

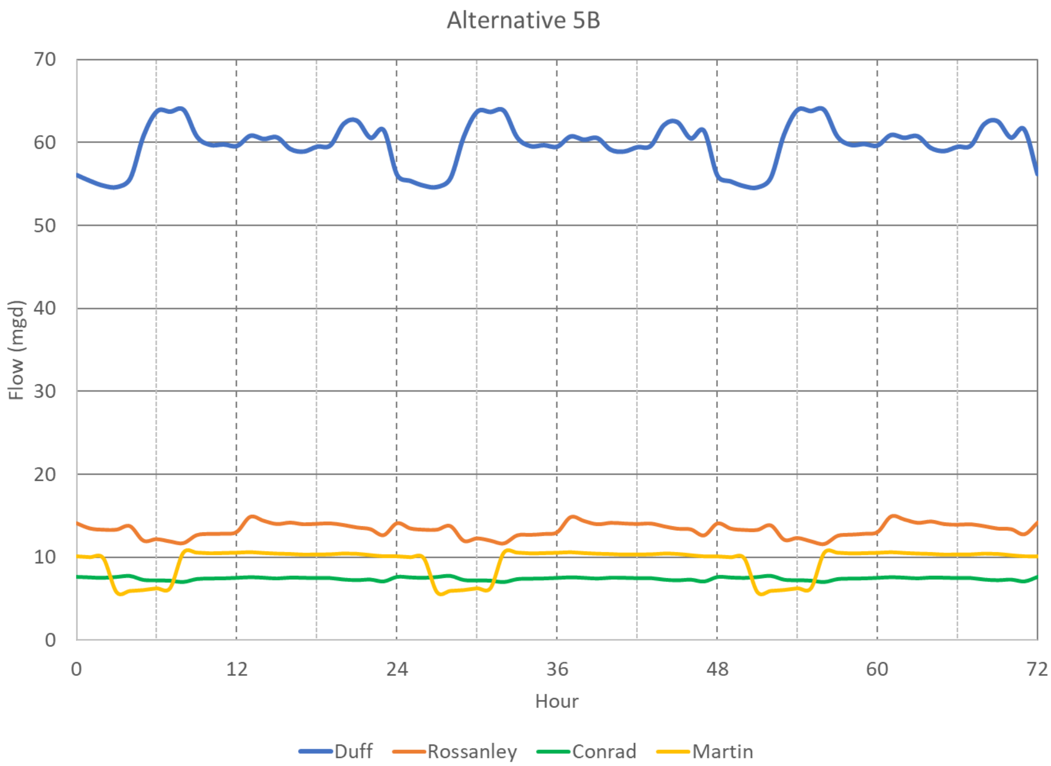


Figure 4.19 Alternative 5b Pump Station Flows

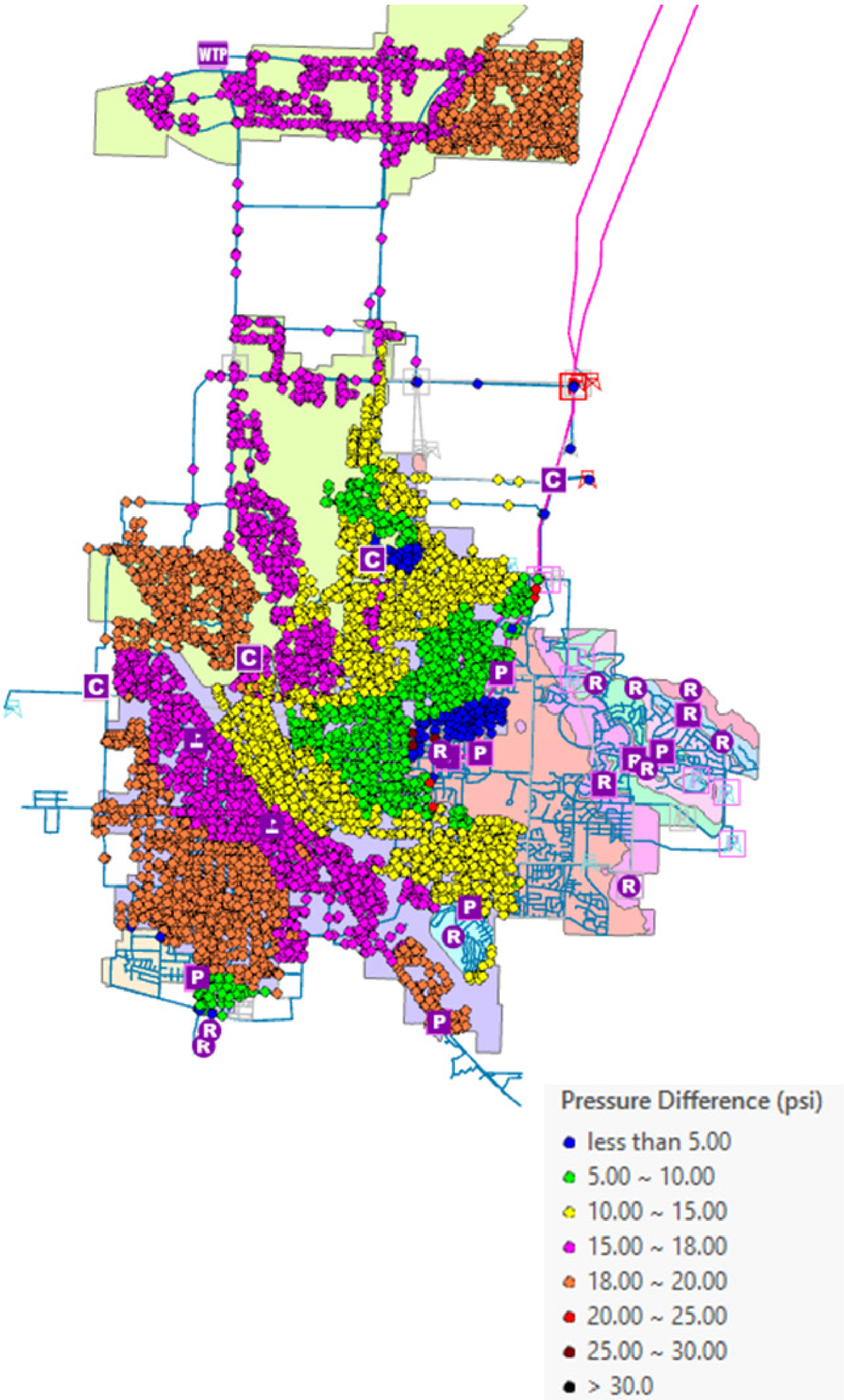


Figure 4.20 Alternative 5b System Pressure Swings

4.2.2.7 Alternative 6: No New RP Control Station, 4 MG Delta Waters Reservoir

The modeling results for Alternative 6 are presented in Figures 4.21, 4.22, and 4.23. Figure 4.21 presents the tank levels for the 72-hour simulation. Compared to Alternatives 5a and 5b, the Duff WTP Reservoir cycles more deeply with less storage in the RP Zone indicating that equalizing storage is coming from the Duff WTP Reservoirs as expected in this scenario. Figure 4.22 presents the three existing control stations in the system, the RP Control Station, and the Duff WTP FWPS. Figure 4.23 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, within Medford Water's criteria.

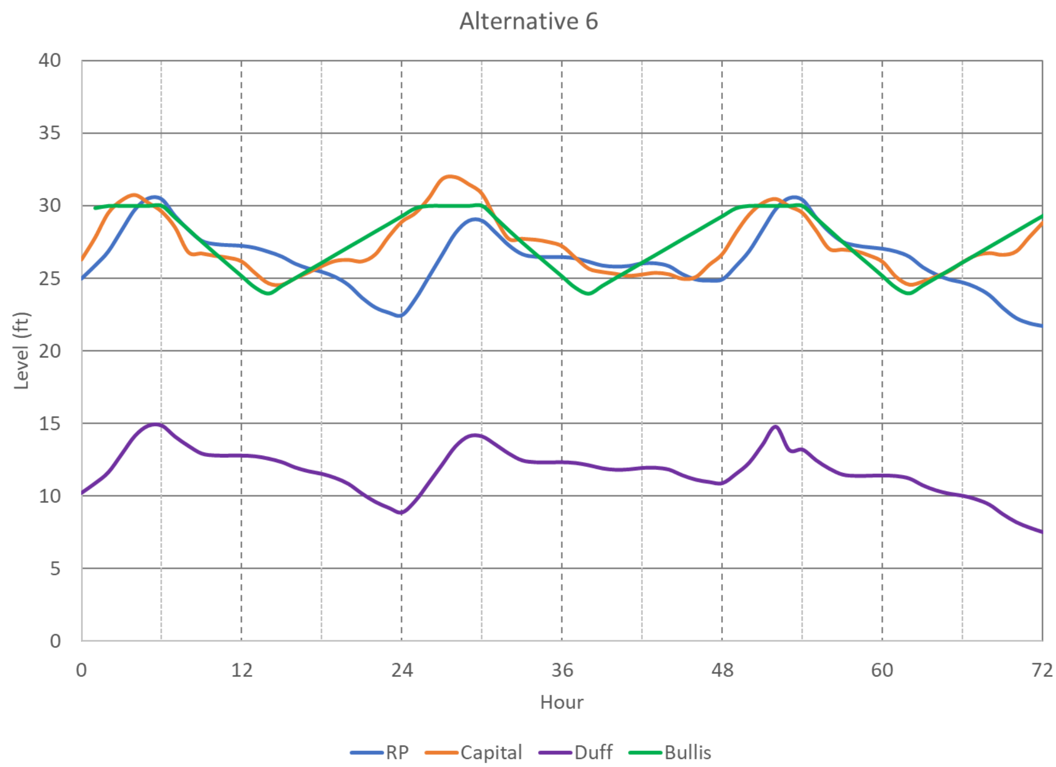


Figure 4.21 Alternative 6 Storage Levels

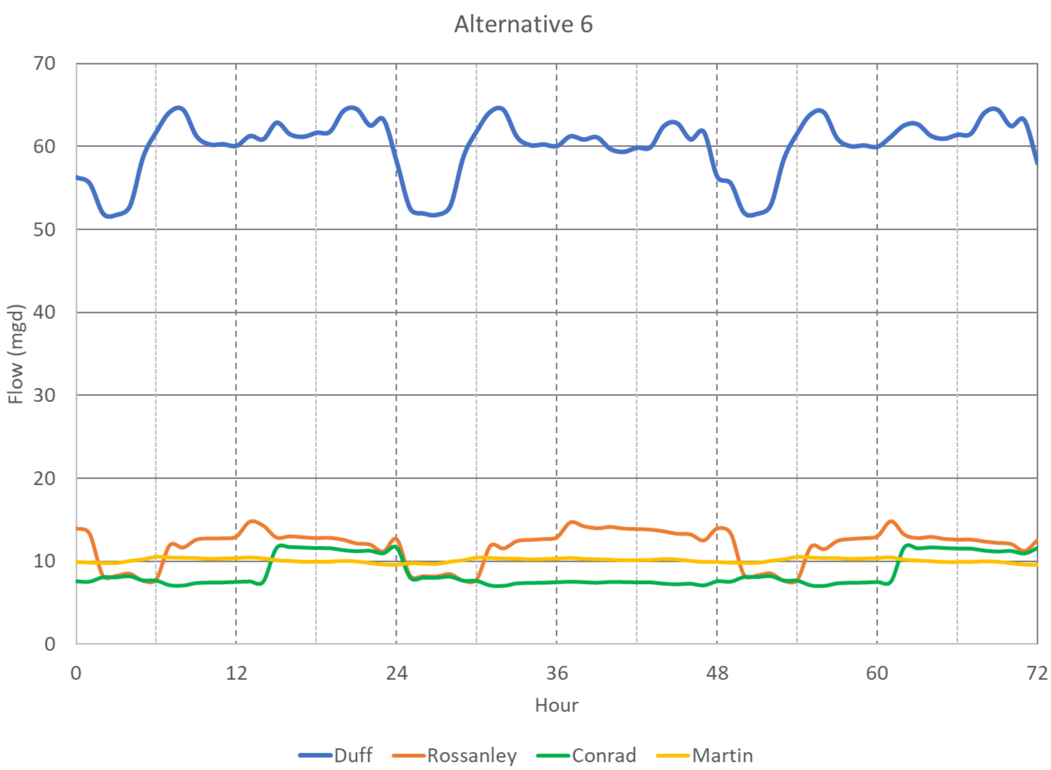


Figure 4.22 Alternative 6 Pump Station Flows

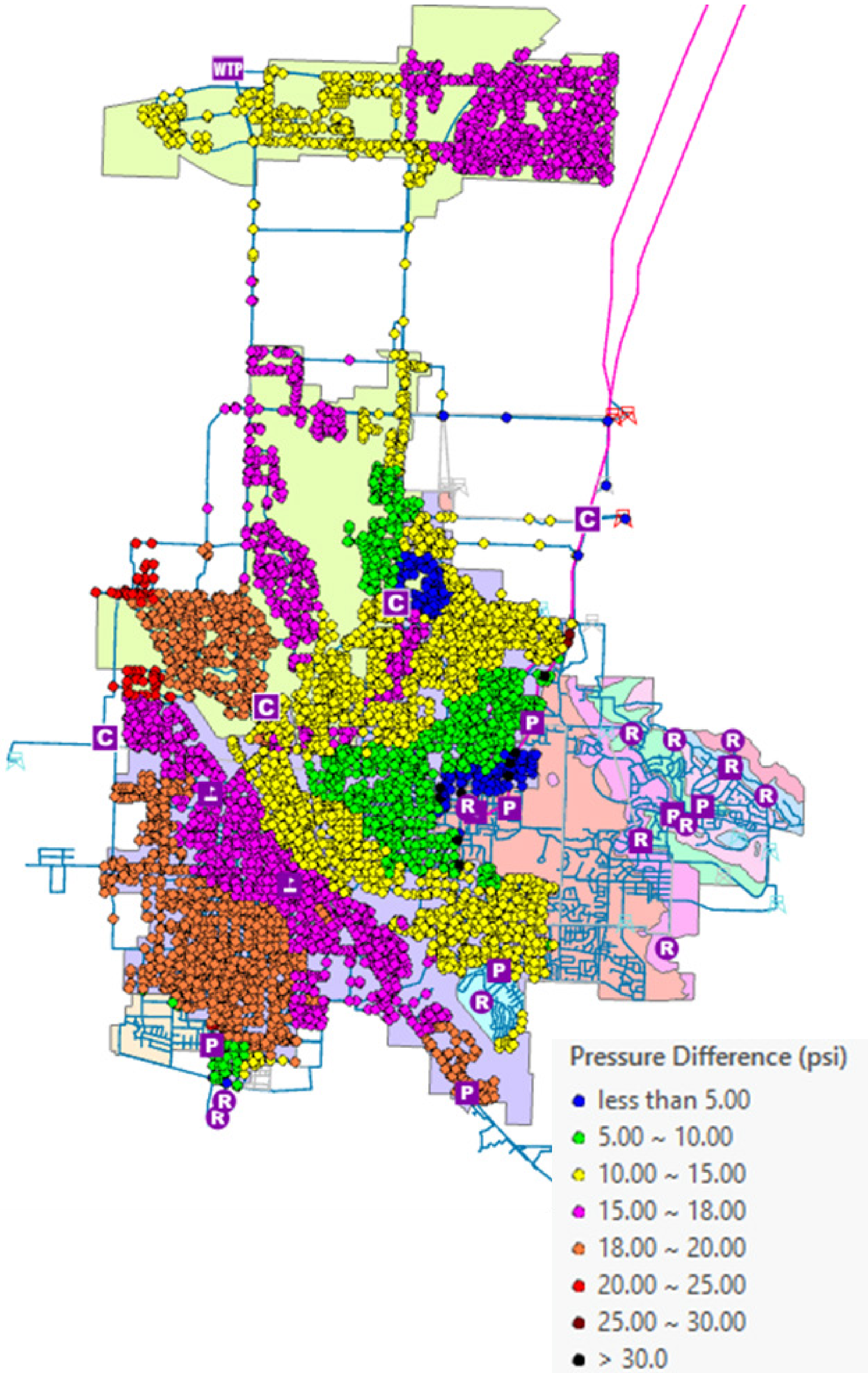


Figure 4.23 Alternative 6 System Pressure Swings

4.2.2.8 Alternative 7: No New RP Control Station, No RP Zone Reservoir

The modeling results for Alternative 7 are presented in Figures 4.24, 4.25, and 4.26. Figure 4.24 presents the tank levels for the 72-hour simulation. The Duff WTP, Bullis, and Capital Hill Reservoirs all cycle well during the period; however, the Duff WTP Reservoirs cycle deeper than desired. During this simulation, the distribution system uses 2.7 MG of Duff WTP Reservoir storage for equalizing storage, which is more than the 2 MG of storage that is anticipated to be available for equalizing storage.

Figure 4.25 presents the output of the three control stations as well as the Duff WTP FWPS. Figure 4.26 shows the pressure differentials throughout the system. All pressure swings are under 25 psi, within Medford Water's criteria, and are less significant than shown in Alternative 5 and 6, particularly in the north and west portions of the system. This demonstrates that using a pressure setpoint for the New Duff FWPS limits high pressures during lower flow periods, reducing pressure fluctuations throughout the system.

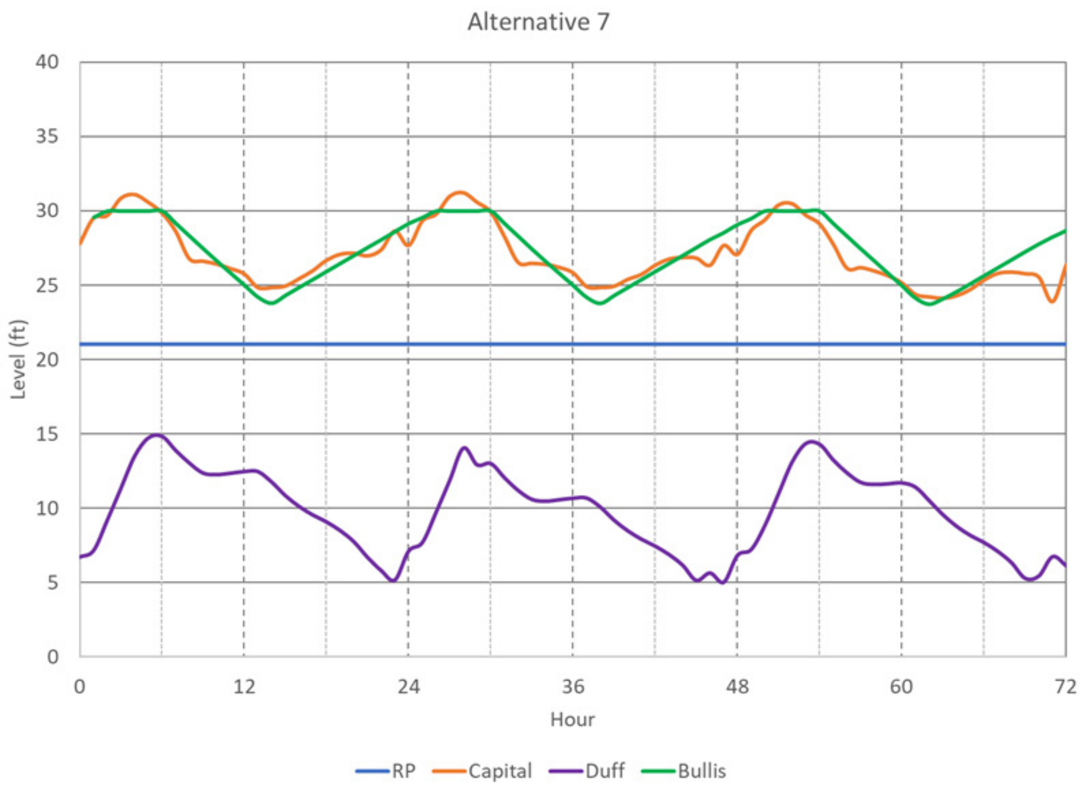


Figure 4.24 Alternative 7 Storage Levels

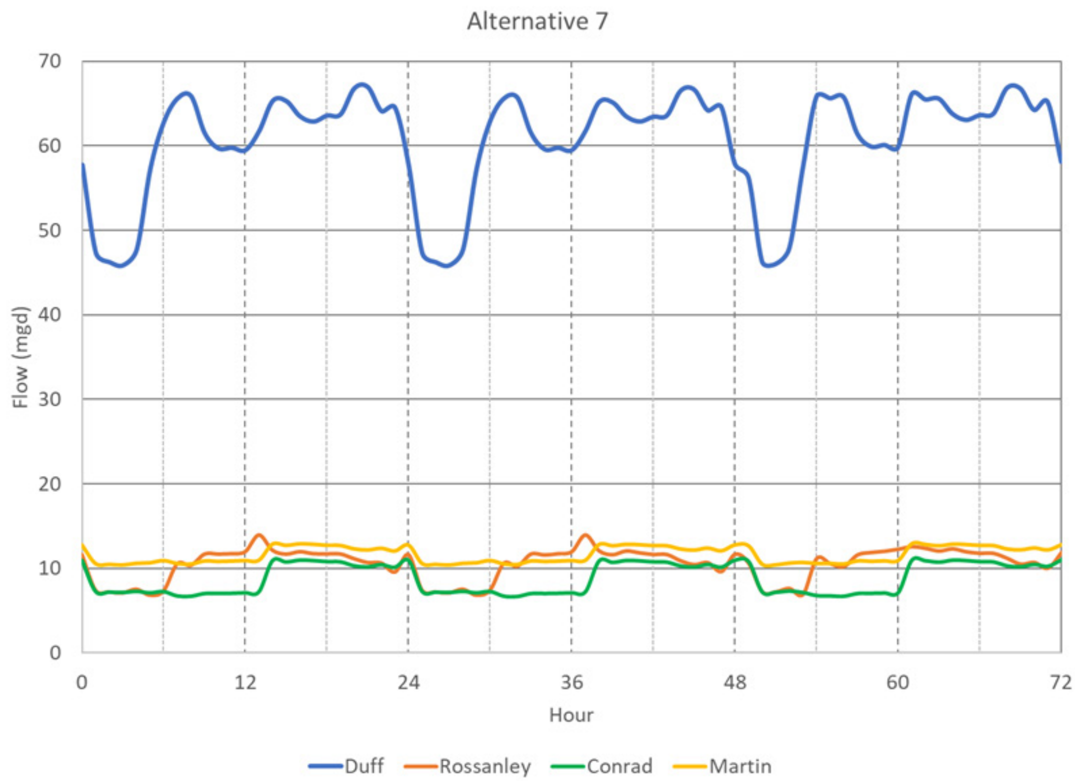


Figure 4.25 Alternative 7 Pump Station Flows

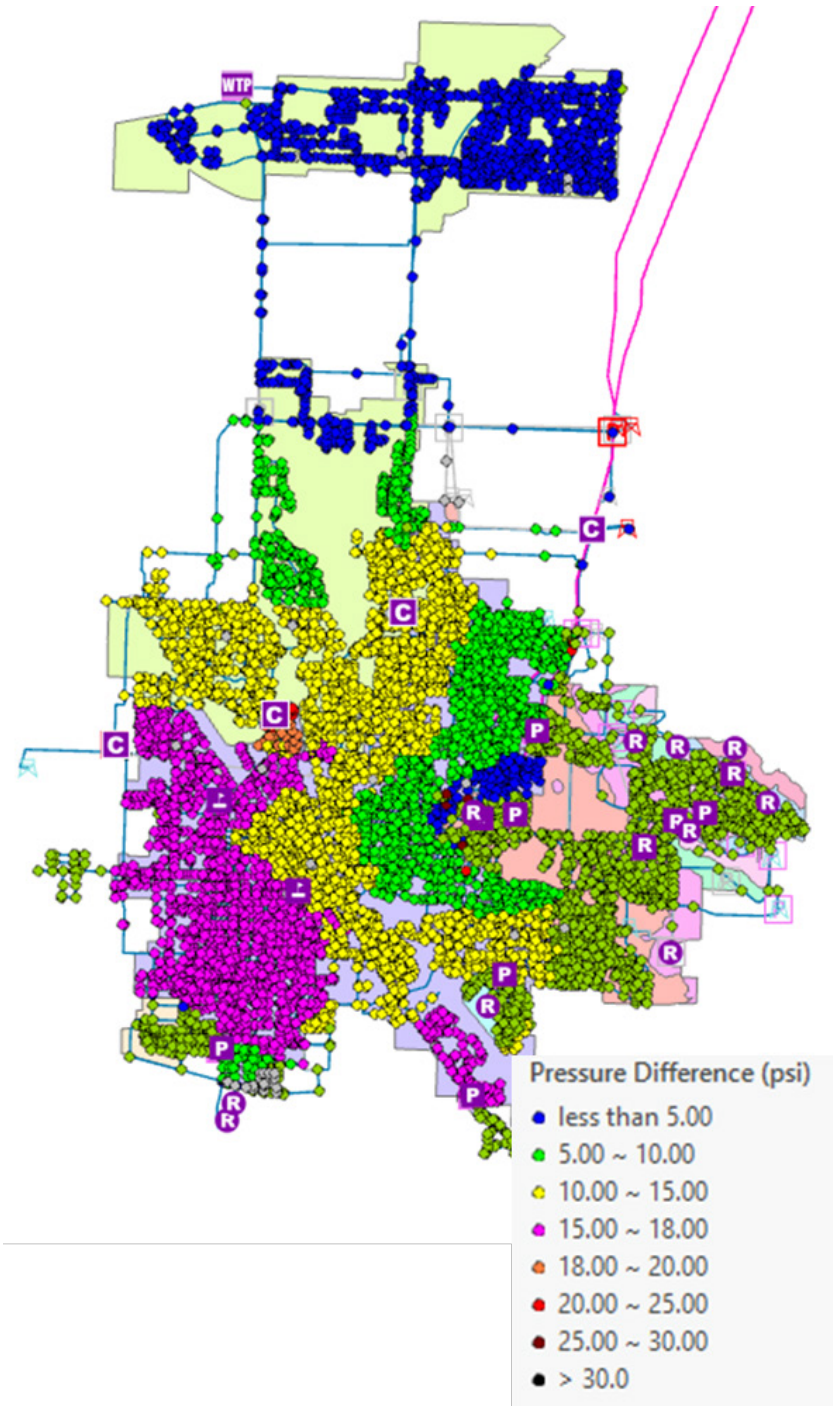


Figure 4.26 Alternative 7 System Pressure Swings

4.3 Alternatives Comparison

The eight alternatives were compared to each other on the basis of overall resilience, system compatibility, O&M simplicity, and cost. The comparison of these elements is presented in the following sections. Tables document the benefits and challenges of each alternative for each category.

4.3.1 Resilience

The resilience category considered whether the alternative is resilient to emergency distributions such as earthquakes, wildfires, and power outages; is reliable; integrates into Medford Water's long-term resilience backbone; and offers distributed storage for redundancy. Table 4.9 shows the benefits and challenges of each alternative regarding its resilience. (It is assumed that any infrastructure constructed under the alternatives will be built to be resilient).

Table 4.9 Resilience Alternatives Comparison

Alternative	Benefits	Challenges
Alternative 1	• Three (3) distributed resilient Gravity Zone storage locations. • Dedicated resilient pipe from Duff WTP to Capital Hill Reservoirs. • Resilient BBS 2 supplies upper zones. • Operational flexibility in an emergency.	• No distributed storage in RP Zone.
Alternative 2	• Two (2) distributed resilient Gravity Zone storage locations. • Dedicated resilient pipe from Duff to Capital Hill.	• No distributed storage in RP Zone.
Alternative 3	• Three (3) distributed resilient Gravity Zone storage locations. • Dedicated resilient pipe from Duff to Capital Hill. • Distributed resilient storage in RP Zone.	
Alternative 4	• Three (3) distributed resilient Gravity Zone storage locations. • Dedicated resilient pipe from Duff to Capital Hill. • Distributed resilient storage in RP Zone.	
Alternative 5a	• Three (3) distributed resilient Gravity Zone storage locations. • Backbone through Martin CS close to critical customers. • Can build resilient pipe from Duff WTP to Capital Hill through Martin CS location. • NE RP Reservoir supplies emergency storage to zone by gravity.	• Terminal Reservoir is not connected to backbone. BBS Pipes are not part of backbone system.
Alternative 5b	• Three (3) distributed resilient Gravity Zone storage locations. • Backbone through Martin CS close to critical customers. • Can build resilient pipe from Duff WTP to Capital Hill through Martin CS location. • NE RP Reservoir supplies emergency storage to zone by gravity.	• Terminal Reservoir is not connected to backbone. BBS Pipes are not part of backbone system.
Alternative 6	• Three (3) distributed resilient Gravity Zone storage locations. • Backbone through Martin CS close to critical customers.	• Emergency storage for RP Zone is located in Gravity Zone.
Alternative 7	• Three (3) distributed resilient Gravity Zone storage locations. • Backbone through Martin CS close to critical customers.	• Emergency storage for RP Zone is located in Gravity Zone.

4.3.2 O&M Simplicity

The O&M simplicity category considers how well the alternative simplifies water system operations, benefits BBS flow and air entrainment challenges, maximizes system efficiency, and maintains water quality. Table 4.10 shows the benefits and challenges of each alternative regarding O&M simplicity.

Table 4.10 O&M Simplicity Comparison

Alternative	Benefits	Challenges
Alternative 1	• Terminal Reservoir enhances control of BBS flow and reduces air entrainment. • NE RP Reservoir improves operations of Duff WTP to operate at consistent flow rates. • Enhances operational flexibility (specifically turnover) of NE RP Reservoir from Terminal Reservoir.	• Need to adjust Nichols Gap setting for BBS 2 to discharge to Terminal Reservoir at the appropriate pressure. • Increases operational controls between new facilities and Capital Hill Reservoirs.
Alternative 2	• NE RP Zone Reservoir improves operations of Duff WTP to operate at consistent flow rates.	• Miss opportunity to enhance control of BBS flow. • Miss opportunity for NE RP Reservoir operational flexibility from Terminal Reservoir.
Alternative 3	• Terminal Reservoir enhances control of BBS flow and reduces air entrainment. • RP Zone reservoirs improve operations of Duff WTP to operate at consistent flow rates.	• Elevated tank adds operational complexity. Should not add tank until the Duff WTP is in-service year-round. • Need to adjust Nichols Gap setting for BBS 2 to discharge to Terminal Reservoir at the appropriate pressure.
Alternative 4	• Terminal Reservoir Enhances control of BBS flow and reduces air entrainment. • RP Zone reservoirs improve operations of Duff WTP to operate at consistent flow rates.	• Elevated tank adds operational complexity. Should not add tank until the Duff WTP is in-service year-round. • Need to adjust Nichols Gap setting for BBS 2 to discharge to Terminal Reservoir at the appropriate pressure.
Alternative 5a	• Terminal Reservoir enhances control of BBS flow and reduces air entrainment. • NE RP Reservoir improves operations of Duff WTP to operate at consistent flow rates. • Could install pressure reducing valves (PRV) from BBS to RP Zone Reservoir for winter operation. • Simpler than adding a new control station.	• New control station not near NE RP Reservoir; adds operational complexity because the reservoir may not turn over as frequently, and the control station will not have consistent suction pressure from the reservoir.

Alternative	Benefits	Challenges
Alternative 5b	• Terminal Reservoir enhances control of BBS flow and reduces air entrainment.	• Alternative 5b
Alternative 6	• Terminal Reservoir enhances control of BBS flow and reduces air entrainment. • NE RP Reservoir improves operations of Duff WTP to operate at consistent flow rates (but not as much as other alternatives). • Could install PRV from BBS to RP Zone Reservoir for winter operation.	• Most complicated operations. • Requires additional storage in the Gravity Zone for emergencies. • Equalizing storage needs may impinge on Duff treatment operations, especially in the long-term.
Alternative 7	• Terminal Reservoir enhances control of BBS flow and reduces air entrainment. • Control by pressure may be simple with new VFDs.	• Requires additional storage in the Gravity Zone for emergencies. • Equalizing storage needs may impinge on Duff treatment operations, especially in the long-term. • A transient analysis should be run on the system for the new Duff FWPS during design because there is no RP Zone storage.

4.3.3 System Compatibility

The system compatibility category considers how well each alternative aligns with the system needs as the City of Medford grows, and if it integrates with the scheduled Duff WTP, pipeline, and storage projects. Table 4.11 shows the benefits and challenges of each alternative regarding system compatibility.

Table 4.11 System Compatibility Comparison

Alternative	Benefits	Challenges
Alternative 1	• New resilient BBS 2 pipe feeds upper zones.	• New Terminal Reservoir and RP Control Station not located near expected growth areas.
Alternative 2	• Gravity Zone storage located where growth will occur.	• Missed opportunity to make BBS 2 part of resilient backbone and feed upper zones. • Without Terminal, more storage needed at Capital Hill increasing footprint and construction complexity.
Alternative 3	• New resilient BBS 2 pipe feeds upper zones. • Reduces pressure swings for Central Point and Eagle Point.	• New Terminal Reservoir and RP Control Station not located near expected growth areas.
Alternative 4	• New resilient BBS 2 pipe feeds upper zones. • Reduces pressure swings for Central Point and Eagle Point.	• New Terminal Reservoir and RP Control Station not located near expected growth areas.
Alternative 5a	• Focuses investment on existing assets that are close to customers.	• Missed opportunity to make BBS 2 part of resilient backbone and feed upper zones.
Alternative 5b	• Focuses investment on existing assets that are close to customers.	• Missed opportunity to make BBS 2 part of resilient backbone and feed upper zones.
Alternative 6	• Focuses investment on existing assets that are close to customers.	• Missed opportunity to make BBS 2 part of resilient backbone and feed upper zones. • More storage needed at Capital Hill increasing footprint and construction complexity.
Alternative 7	• Focuses investment on existing assets that are close to customers.	• Missed opportunity to make BBS 2 part of resilient backbone and feed upper zones. • More storage needed at Capital Hill increasing footprint and construction complexity. • Would require larger Duff WTP pumping and transmission piping capacity.

4.3.4 Capital Cost

Very high-level, comparative capital cost estimates were developed for Alternatives 1 through 5a. The cost estimates for each component of the various alternatives are presented in Table 4.12. The total cost of each alternative presented in Table 4.13 includes a contingency of 20 percent. (Cost estimates were not prepared for Alternatives 5b, 6, and 7 as these alternatives were evaluated separately after cost estimates were prepared.) Chapter 3, Table 3.4 summarizes which components are included in each alternative.

Alternative 2 is the lowest cost option because it does not include building a northeast Terminal Reservoir. Alternatives 1 and 5a came out to be approximately the same cost. The cost of building a new RP Control Station and hardening BBS 2 is about the same as upgrading Martin CS and hardening the pipelines to Capital Hill Reservoir through Martin CS. Alternatives 3 and 4 had the highest cost due to building elevated tanks in the RP Zone.

Table 4.12 Cost Estimate of Project Components

Alternative	Cost (Million Dollars)
NE RP Reservoir and Piping (6 MG/8 MG)	$18/21
Capital Hill Reservoir (10 MG/16 MG)	$20/26
NE Terminal Reservoir (7 MG) with New RP Control Station	$22
NE Terminal Reservoir without New RP Control Station	$17
Barnett Reservoir and Piping (7 MG/8 MG)	$15/17
RP Zone Elevated Tank (2 MG)	$8
New RP Control Station and Piping to Capital Hill	$19
Harden BBS 2 from Terminal to Capital Hill	$23
Expand Martin CS and Harden Pipelines to Capital Hill	$25

Notes:
(1) Costs were not developed for alternatives 5b, 6, and 7.

Table 4.13 Total Capital Cost Comparison(1)

Alternative	Cost (Million Dollars)
Alternative 1	$120
Alternative 2	$100
Alternative 3	$130
Alternative 4	$130
Alternative 5a	$120

Notes:
(1) Costs were not developed for alternatives 5b, 6, and 7.

4.4 Preferred Alternative

Given the additional operational complexity, and specific high costs to construct new piping between a Terminal Reservoir and Capital Hill Reservoirs, the alternatives that include a new RP Control Station and Terminal Reservoir (Alternatives 1 through 4) were eliminated. Medford Water staff recognize the benefits of using existing transmission piping and control stations as resilient backbone facilities (Alternatives 5 through 7) that connect the Duff WTP to Capital Hill Reservoirs. The Martin Control Station and associated piping was identified to provide the primary resilient backbone that connects the RP Zone to the Gravity Zone. This routing was also selected because the piping connecting the Martin Control Station and Capital Hill Reservoirs is already identified as a capital improvement to increase capacity and replace aging pipes.

After considering an alternative that excludes a NE RP Reservoir, Medford Water staff also recognize the benefits of a NE RP Reservoir. Within the next decade, a NE RP Reservoir is still recommended to meet storage requirements and improve operations. Having emergency storage near the RP Zone customers is more resilient. Resilience is also increased by having more than one site of resilient storage in the water system. Having equalizing storage in the NE RP Reservoir will also reduce demands and simplify operations at the Duff WTP. Finally, RP Zone storage will allow the control stations to pump at more constant rates, which can be seen by comparing Figure 4.19 to Figure 4.25.

Although Medford Water's preferred alternative includes eventually building storage in the RP Zone (Alternatives 5a/5b), budget constraints and difficulties with site acquisition have caused Medford Water to delay the implementation of RP Zone storage. The new Duff WTP Reservoir, FWPS, and transmission piping will allow Medford Water to replace the Capital Hill Reservoirs in the short-term without RP Zone storage while meeting the established criteria. Therefore, Medford Water's selected resilience strategy is Alternative 7 in the short-term, with the plan to construct 8 MG of RP storage when possible (Alternative 5a/5b depending on site selection).

4.4.1 Immediate Improvements Under Selected Alternative

Under the selected alternative, the immediate improvements include the following:

- Duff WTP expansion projects (specifically including a new FWPS, and a new 3 MG reservoir),
- Duff WTP transmission mains (including a 42-inch transmission main in Table Rock Road ("PL-1") and a 24-inch pipeline in Merriman Road ("PL-9"),
- Replace the Capital Hill Reservoirs (with approx. 13 MG),
- Expand and harden the Martin Control Station, and
- Construct a transmission line in Crater Lake Avenue between Martin Control Station and Capital Hill Reservoirs (previously recommended in the 2016 WDSFP as "PL-7").

These projects have all been vetted by Medford Water staff and are budgeted for capital improvements. Medford Water will also continue to pursue property acquisition for the NE RP Reservoir. These improvements and additional improvements that are recommended within the near-term planning horizon are identified in Section 4.4.2.

Prior to the results of this study, Medford Water staff was planning to construct PL-11, a recommended pipeline in East Gregory Road that connects Duff WTP transmission piping from Table Rock Road to Crater Lake Highway. This pipeline was recommended in the 2016 WDSFP. However, the results of the hydraulic modeling show that this pipeline is not as critical as the transmission pipeline in Crater Lake Avenue (PL-7), thus it is delayed until the long-term.

4.4.2 Immediate Operations

Not immediately constructing the NE RP Reservoir requires relying on the new infrastructure being constructed at the Duff WTP. The pumps at the FWPS will have VFDs that allow them to operate automatically to maintain a constant discharge pressure. As shown by the modeling results of Alternative 7 (Figure 4.26), this improvement should significantly minimize the pressure fluctuations currently experienced by RP Zone customers. Additionally, the new Duff WTP Reservoir along with the existing reservoir will provide up to 2 MG of equalizing storage for the RP Zone in the near-term. (The plant will require the full amount of constructed storage for other purposes as demands increase). Not immediately having RP Zone storage also requires RP Zone peak hour demands to be conveyed through the new Duff WTP transmission mains.

Emergency storage for the RP Zone will continue to be stored in the Gravity Zone until an RP Zone reservoir is built. Medford Water plans to replace the Capital Hill Reservoirs as soon as possible with new, resilient reservoirs with a capacity between 12 and 14 MG, depending on constructability on the site. As shown in Table 4.14, 13 MG is the storage needed at Capital Hill for Medford Water to meet its RP Zone and Gravity Zone near-term storage requirement of 25 MG.

Table 4.14 Proposed RP Zone and Gravity Zone Storage Volume (MG)

Timing	Near-Term	Long-Term	Build-out
Volume Required	25	30	34
Total Volume Proposed	25	31	34
RP Zone			
Duff WTP Reservoir	2	0	0
NE RP Reservoir	0	8	8
Gravity Zone			
Capital Hill	13	13	13
Bullis	10	10	0
Future Reservoirs	0		13

4.4.3 Near-Term Improvements

Beyond the immediate improvements listed above, the selected resilient backbone requires additional near-term improvements including the NE RP Reservoir and additional transmission capacity to and from the reservoir and Martin Control Station in Crater Lake Highway (depicted on Figure 4.27). The timing and "triggers" of the near-term recommended improvements were evaluated using the hydraulic model under future demand conditions.

Figure 4.26 depicts the water system's capacity limitations without and with RP Zone storage. Once the new Duff Reservoir is constructed as part of the Duff WTP expansion project, approximately 2 MG of it's storage will be available as equalizing storage for the RP Zone. However, once Duff's max day production reaches 55 mgd that equalizing storage is no longer available because it needs to be used for Duff WTP operations. Therefore, Duff reaching a production rate of 55 mgd is the trigger for needing RP Zone storage as depicted by the purple horizon in Figure 4.26. Therefore, the NE RP Reservoir should be constructed by the time Duff WTP max day production reaches 55 mgd or system-wide MDD reaches approximately 75 mgd, which corresponds to somewhere between year 2043 and 2058 (depending on demand growth rates).

Another driver for needing RP Zone storage is that without storage in the zone, the distribution system must convey peak hour demand. By building RP Zone storage including equalizing storage, the distribution system only needs to convey MDD, which is much lower. Thus, building RP Zone storage extends the amount of time that the RP Zone distribution system capacity is adequate to meet demands.

The blue horizon on Figure 4.26 represents the limit of the RP Zone distribution system capacity before upsizing the pipeline in Crater Lake Highway. The Crater Lake Highway pipeline should be upgraded before system-wide MDD reaches 80 mgd, which corresponds to sometime between year 2043 and 2057 (depending on demand growth rates). This analysis assumes that pipeline projects that are currently on Medford Water's capital improvement plan are completed before RP Zone storage is constructed. These pipeline projects include the Table Rock Road Pipeline (PL-1), the Crater Lake Avenue Pipeline (PL-7), and the Merriman Road Pipeline (PL-9).

Because Medford Water's pipeline sizing approach is to size for the long-term horizon (system-wide MDD of 85 mgd), the orange horizon in Figure 4.26, which corresponds to the long-term horizon, represents the limit of the RP Zone distribution system's capacity with both RP Zone storage and the recommended pipeline improvements.

Based on these results, Medford Water intends to construct the NE RP Reservoir as soon as possible in the near-term to avoid reliance on the Duff WTP equalizing storage in the near- and long-term, and then plans to construct the Crater Lake Highway pipeline before system-wide MDD exceeds 80 mgd. With this combination of improvements, the RP Zone infrastructure should have capacity up to 85 mgd, at which time other improvements can be evaluated beyond this study.

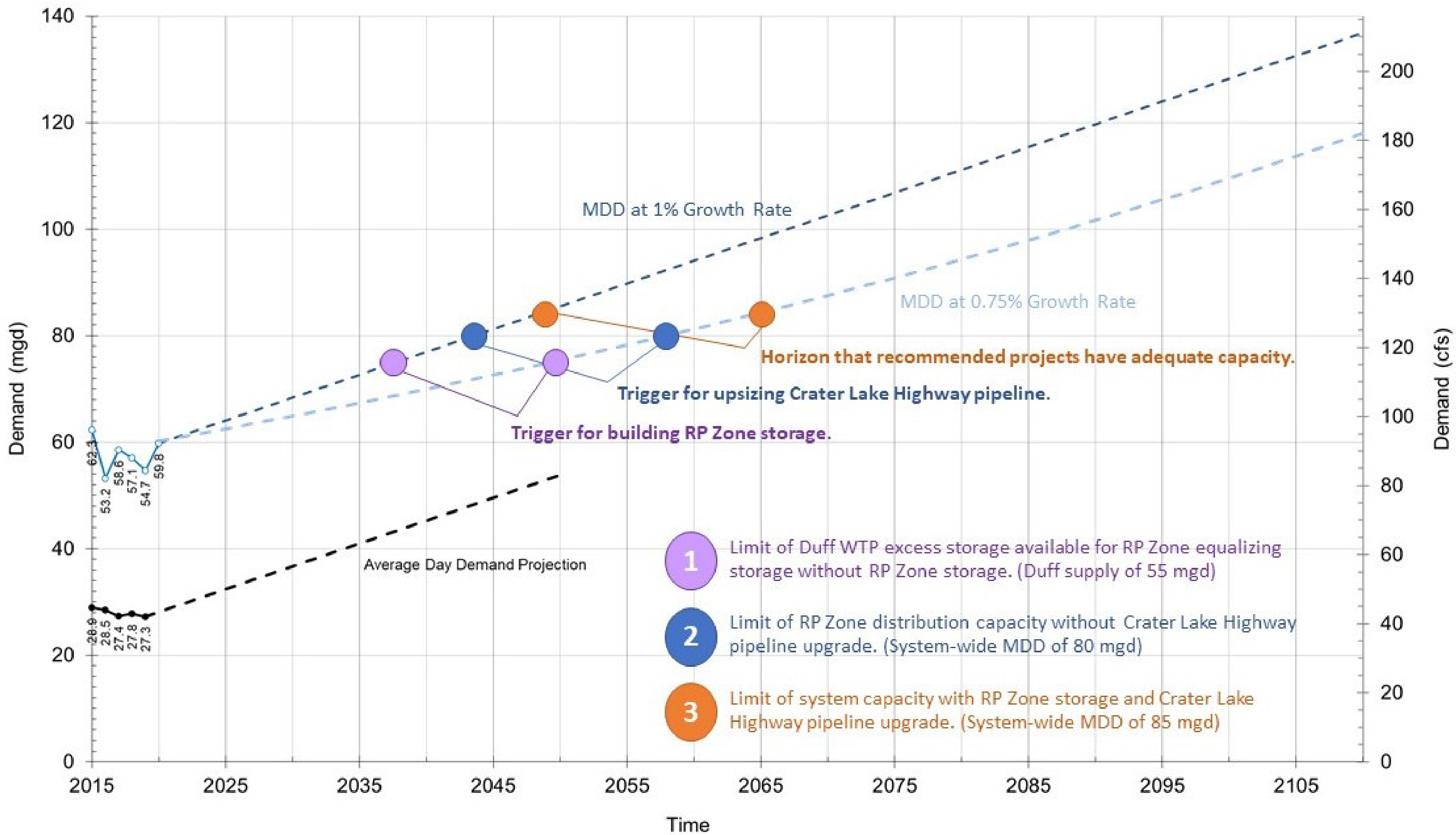


Figure 4.27 Horizons for Capacity of the RP Zone Distribution System without and with RP Zone Storage

4.4.4 Resilient Backbone Project Priority List

The following projects are proposed to implement Medford Water's preferred resilient backbone alternative, ensure Medford Water's resilience goals and objectives are met, and meet the needs of growth. Figure 4.27 shows the location of each project on a system map and identifies the projects as needed before 2040 or after 2040. Each project is described in detail in Appendix C Resilience Approach Summary.

By 2040:

1. Martin CS Pump Upgrade.
2. Backup Power at Martin CS.
3. Table Rock Road Pipeline (PL-1).
4. New Duff WTP Reservoir & Finished Water Pump Station No. 2.
5. Replace Capital Hill Reservoirs (approx. 12 to 14 MG).
6. Crater Lake Avenue Pipeline (PL-7).
7. Merriman Road Pipeline (PL-9).
8. RP Zone Reservoir and Pipeline.
9. Crater Lake Highway Pipeline.
10. Martin CS No. 2.
11. Spring Street Pipeline.

Beyond 2040:

12. Expand Rossanley CS.
13. Additional Gravity Zone Storage (timing to be considered further in future master planning work).
14. Harden remaining Backbone Pipeline.
15. Increase Duff Reservoir Capacity.

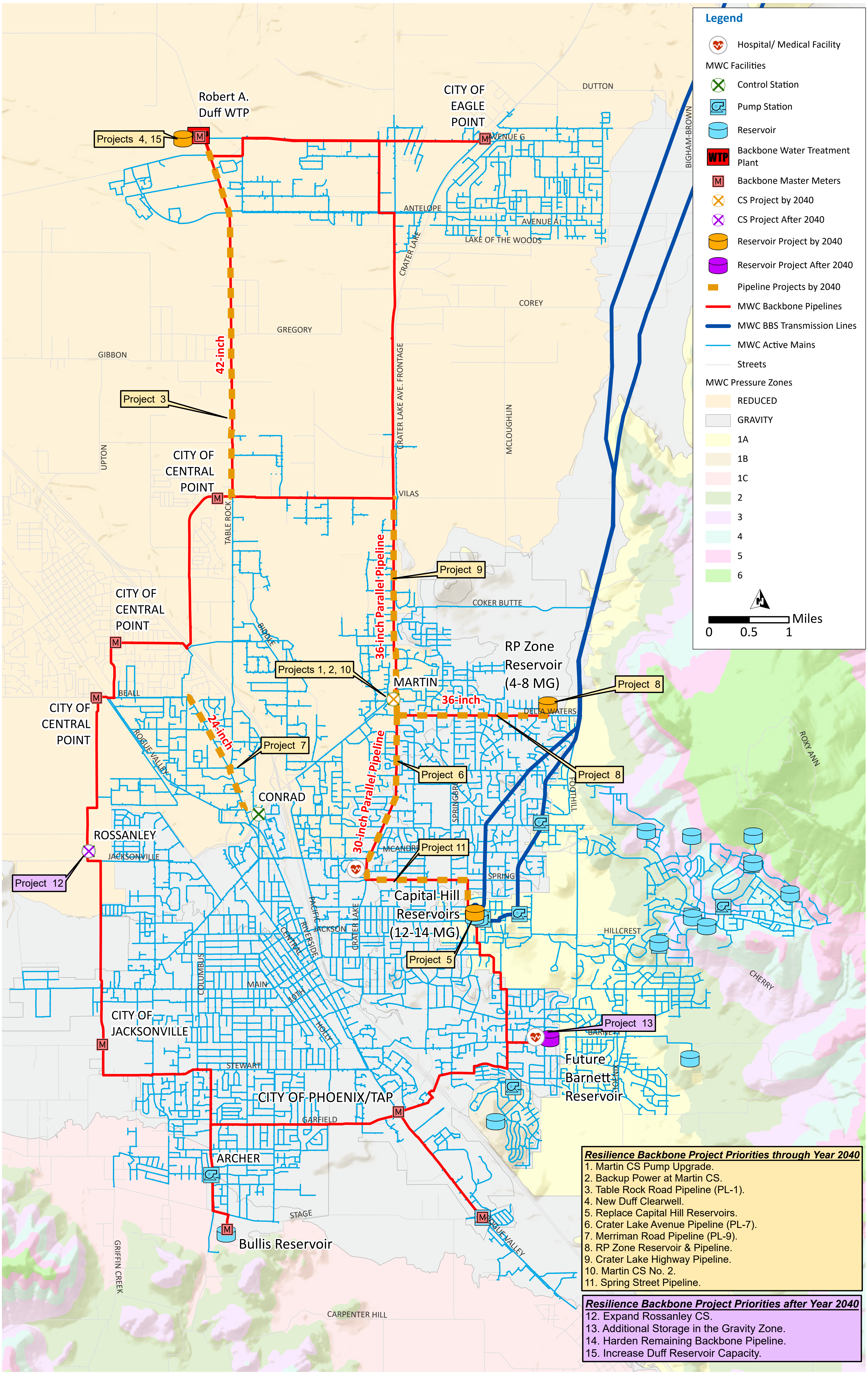


Figure 4.28 Prioritized Resilience Backbone Projects

Appendix A

OPERATIONS DISCUSSION SLIDES

Challenging today.
Reinventing tomorrow.

Operations Discussion

1

Agenda

1. Introductions. **(5 min)**
2. Discuss operational scenarios. **(80 min)**
   a. Demand Levels
   b. Operations of Big Butte Springs system
      i. Full Pipe
      ii. 1/2 PIpe
      iii. 3/4 Pipe
   c. Operations of Duff WTP and Control Stations.
      i. Primary Pumps/Control Stations
      ii. Capital
      iii. Operation with Southwest
      iv. Operation with Bullis
      v. Zone 1 Pump Stations
3. Pressure logger installation. **(15 min)**
4. Review Next Steps and Action Items. **(15 min)**

2

Demand Levels

- Forward Flow
- Shoulder Season
- Reverse Flow

- Operationally—when do you have the most challenges?

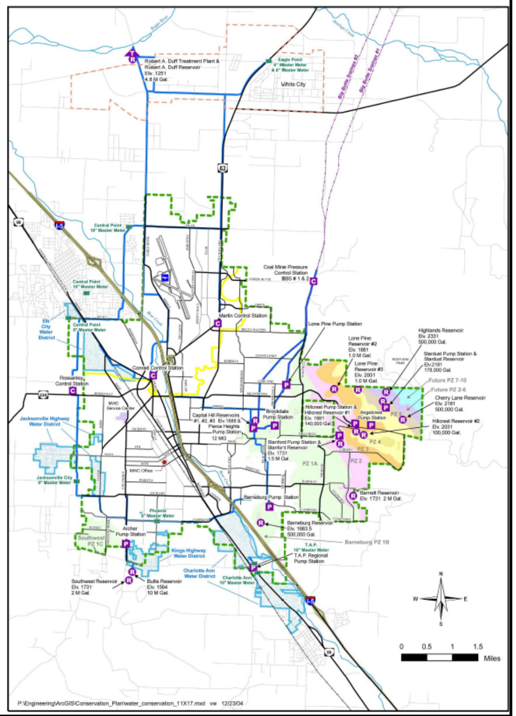
Operations of Big Butte Springs system

- Full Pipe
- 1/2 PIpe
- 3/4 Pipe

- Conditions/settings that are applied at Stations along Springs Lines
- Description of thought process/review of operations
- Observations of wholesale customer usage and issues on BBS Operation

Operations of Duff WTP and Control Stations

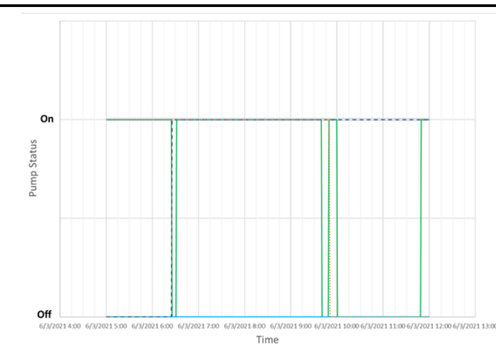
- Primary Pumps/Control Stations
- Capital
- Operation with Southwest
- Operation with Bullis
- Zone 1 Pump Stations

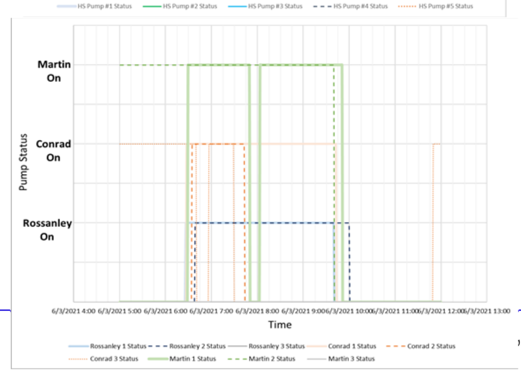


Operation of Duff with Control Stations

- What are your primary triggers to move water into Gravity?
  - Capital
  - Southwest
  - Zone 1 Stations?
  - Water age (Bullis)
- Describe step by step process

- Modeling has tried to automate operation for peak conditions
  - Capital level control
  - Triggers multiple control stations and Duff to balance pressure conditions at Duff





Primary Goals/Operation

- Many variables to consider
- Match flows (Duff and Control Stations)
- Forecast Southwest and Zone 1 operation
- "Chasing Capital"
- TSD used to forecast; previously did not have capability to view upper zones
  - Temperature is used as a guidance for what to expect day over day
- Facility operation at Duff is limited to Duff and Control Stations (not eastside pump stations) but view of eastside stations is now available
- Operational changes are at least 4x/day due to diurnal demand changes
- Control Station selection of operation
  - Depends on the level of flow change desired/needed
  - Small flows: Martin (trim flows)
  - Mid range/larger step flows: Conrad
  - Large flows: Rossanley
  - Suction pressure at control stations also used for guidance
    - Target 50 psi for suction pressures
    - Duff operation ramped down if VFD is ramping down
- Water age—considers source of water also because of the differing wq between BBS and Duff (Cl residual) in the SW
- Operational/equalization storage: What is limiting the operation of using Bullis for equalization?
  - Mathematical solution shows that there should be sufficient eq

Primary Goals/Operation

- Bullis Operation:
  - Historically the operation was driven by WQ
  - Now used for supporting meeting customer pressures
    - Start early morning and pump out to early afternoon
    - Refill night at low demand
    - Daily operation
    - Drawdown 4 – 5 feet
    - If high temps forecasted, philosophy is to keep storage in tanks in the event of an emergency condition
- Duff Operation
  - 12 – 4
    - 2 -3 raw water
    - 3 – 4 HSPS
  - 4 – 10
    - Add pumps
  - 10 – 6
    - Reduce pump (generally 1 at each)
  - 6- 10
- VFD Operation
  - Flow from VFD pump can drop to 60 – 70 % of full speed
  - 105 psi set point

Shoulder Season Operation

- Main goal is to not overflow Capital
- Use demand history and weather/demand forecast to identify water balance and forecast supply needed and volume of water from Duff
  - Temp threshold: 50 degrees overnight
- Bullis
  - If used periodically during Shoulder season, Operators know that Duff will need to be operated harder to refill
- When refilling Bullis during fall shoulder season, goal to fill with BBS water to have better longevity of WQ
  - Don't run Ross

Winter

- Operation of Bullis is handed off for winter
  - Duff to Distribution
  - Similar handoff occurs in spring (Bullis to Duff)
- Periodic pump down of Bullis
  - History has shown that a delay of 3 days provides sufficient time for water from Bullis to be consumed
  - Lasting residual at Bullis during winter
- Capital overflow/ constraints based upon capability to control BBS flows
- Can hydraulic conditions of the BBS lines be changed with terminal storage to manage the flows
  –

BBS Operation

- Benefit to pressures along BBS?
  - Consider data loggers at current locations with manual pressure gauges
- Level at stacks?

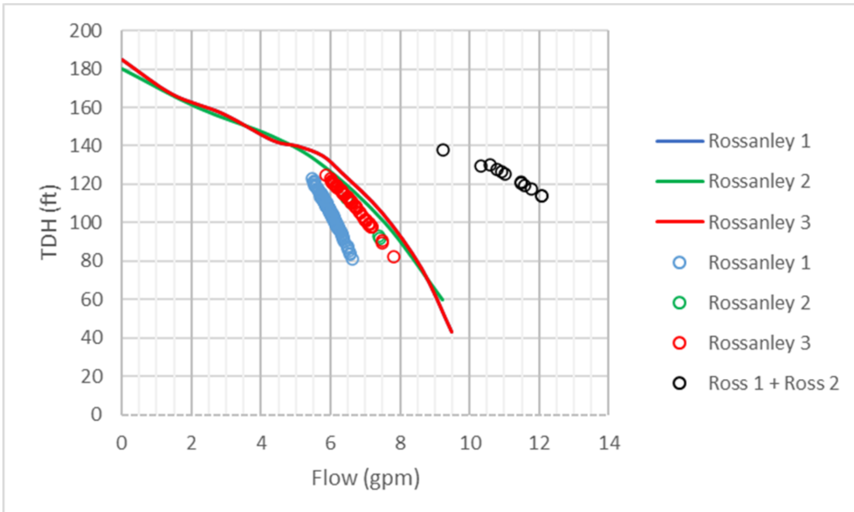
- Full Pipe
  - July – End of Season (when BBS can supply system)
  - December (ish)
    - Transition to "1 1/2 pipe"
- Half Pipe
  - From transition until demands start ramping up
  - Duff initiates partial operation

- BBS 1
  - to Coal Mine
    - US 105-108 psi
    - DS 90 psi
- BBS 2
  - To Nicholls Gap
    - PSV/PRV (Ken to provide valve info)
    - US 148 psi
    - DS 105 psi
    - Blends with BBS 1 at Coalmine
    - Some modifications happen if stacks observe to overflow
- BBS1/BBS2 combine after control valve on BBS1 at Coal Mine
- Adjustments if in OF condition include slight valve setting adjustments
- AI: Profile of BBS lines to Capital

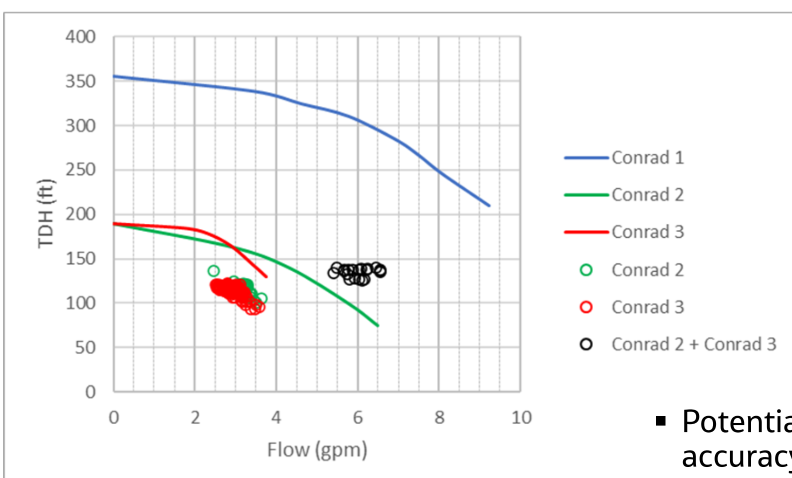
BBS Operation

- Eagle Point takeoff on BBS 2
  - Not in TSD
  - When Eagle Point receiving flow, pressure is impacted at Coal Mine (BBS 1 pressure)
- Small customers along pipeline do not impact operation
- Zone 1 PS Influences
  - Lone Pine
  - Pierce Heights
  - Brookdale

Control Station Performance: Rossanley

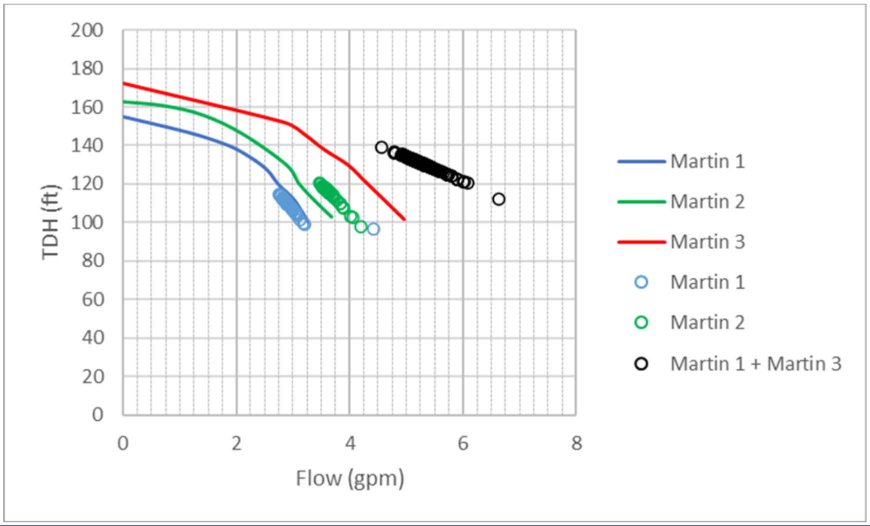


Control Station Performance: Conrad



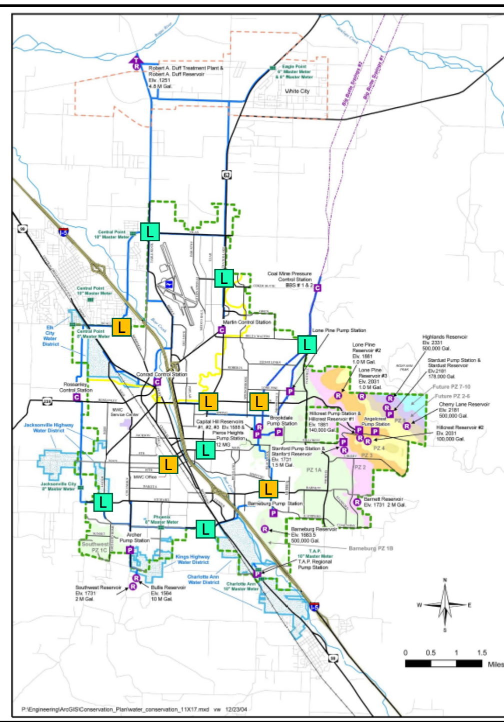
- Potential for metering accuracy to impact assessment

Control Station Performance: Martin



Pressure Logger Installation

- Capture HGL trend through Reduced Pressure and Gravity
- Leverage existing installations at Control Stations and other facilities
- Preliminary sites shown



Challenging today.
Reinventing tomorrow.

Appendix B

HYDRANT TEST DATA

Reslient Backbone Project
Hydrant Test Data Comparison

	FH 4974-Model	FH 4974-Field	FH 1464-Model	FH 1464-Field	FH 1814-Model	FH 1814-Field	FH 4748-Model	FH 4748-Field	FH 2478-Model	FH 2478-Field	FH 3328-Model	FH 3328-Field	FH 2810-Model	FH 2810-Field	FH 3434-Model	FH 3434-Field	FH 3961-Model	FH 3961-Field	FH 2257-Model	FH 2257-Field
Average	73	69	84	87	67	69	37	40	78	81	96	97	94	97	78	75	59	52	58	60
Max	76	72	87	90	72	72	43	43	84	83	100	99	98	99	81	78	63	56	61	62
Min	63	62	74	80	58	65	26	34	68	76	87	93	85	93	76	73	56	50	51	57
Time																				
10/11/21 12:00 AM	74	71	85	89	66	70	36	40	77	81	94	96	92	97	77	75	58	52	57	61
10/11/21 1:00 AM	74	71	86	89	68	72	38	42	79	83	96	97	94	98	78	76	59	53	59	62
10/11/21 2:00 AM	74	71	85	89	67	71	36	40	78	82	95	97	93	97	78	75	59	53	58	61
10/11/21 3:00 AM	74	71	85	89	67	70	37	40	78	81	95	97	93	97	78	75	59	53	58	61
10/11/21 4:00 AM	74	71	85	89	66	69	35	39	77	80	94	96	92	96	78	75	58	52	57	60
10/11/21 5:00 AM	73	69	85	87	63	65	31	34	73	76	92	94	90	93	77	74	58	50	55	58
10/11/21 6:00 AM	67	70	79	87	59	67	28	37	69	78	87	94	85	95	76	73	56	50	52	58
10/11/21 7:00 AM	75	70	86	89	65	68	35	39	76	79	93	95	91	96	76	73	57	50	56	59
10/11/21 8:00 AM	75	70	86	88	68	71	39	42	80	83	97	97	95	98	77	74	58	51	58	61
10/11/21 9:00 AM	75	70	86	89	69	71	40	42	80	82	97	97	95	98	77	74	58	51	58	61
10/11/21 10:00 AM	75	70	86	88	69	70	40	41	80	82	97	97	95	98	77	74	58	51	58	60
10/11/21 11:00 AM	75	69	86	88	70	71	41	42	81	82	97	98	96	98	77	76	58	53	59	61
10/11/21 12:00 PM	75	69	86	87	71	71	42	42	82	82	98	98	96	98	78	76	59	54	60	61
10/11/21 1:00 PM	75	70	86	87	70	70	41	41	82	82	98	97	96	98	78	75	58	53	60	60
10/11/21 2:00 PM	75	70	86	88	70	71	42	42	82	83	98	98	96	98	78	76	59	53	60	61
10/11/21 3:00 PM	75	70	86	88	71	71	42	42	82	82	98	98	97	99	78	76	59	53	60	61
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10/11/21 8:00 PM	74	71	85	89	65	65	34	35	75	77	94	95	91	94	78	75	59	52	57	58
10/11/21 9:00 PM	73	71	85	89	64	66	33	36	74	78	93	95	91	95	78	74	58	51	56	58
10/11/21 10:00 PM	73	71	85	89	63	65	31	35	73	77	92	95	90	95	77	74	58	51	55	57
10/11/21 11:00 PM	74	71	85	90	64	67	34	37	75	79	93	95	91	95	77	74	58	52	56	58
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10/12/21 3:00 AM	74	71	85	90	64	70	33	40	75	81	93	96	91	97	77	74	58	52	56	60
10/12/21 4:00 AM	74	71	85	89	63	70	32	40	74	81	93	96	90	96	77	74	58	52	55	60
10/12/21 5:00 AM	74	71	85	90	60	70	28	40	70	81	91	96	88	96	76	74	57	51	52	60
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10/12/21 7:00 AM	76	69	87	88	65	65	36	34	76	76	94	93	92	93	76	73	57	50	56	57
10/12/21 8:00 AM	75	66	86	86	68	68	39	37	80	79	96	95	95	95	77	73	57	50	58	58
10/12/21 9:00 AM	74	69	86	88	69	70	40	41	80	82	98	97	95	98	79	74	60	53	59	60
10/12/21 10:00 AM	74	69	86	88	69	71	40	42	81	83	98	98	95	98	79	75	60	53	59	61
10/12/21 11:00 AM	74	69	86	87	68	71	39	42	80	83	98	98	95	98	79	75	60	54	58	61
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10/12/21 2:00 PM	63	62	74	80	70	70	42	42	82	82	98	98	96	98	79	76	60	54	60	60
10/12/21 3:00 PM	75	62	86	80	71	71	42	42	82	82	98	98	97	99	78	76	59	54	60	61
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10/12/21 11:00 PM	74	72	85	90	67	66	37	36	78	78	96	96	93	96	79	75	60	52	58	58
10/13/21 12:00 AM	74	72	85	89	66	70	36	40	77	81	95	97	93	97	79	75	59	53	57	60

Represents an instantaneous pressure difference of 6 psi or more

Appendix C

RESILIENCE APPROACH SUMMARY

PROJECT MEMORANDUM

DISTRIBUTION SYSTEM RESILIENCE BACKBONE PROJECT

Date:	October 31, 2022
Project No.:	200534-00

Medford Water Commission

Prepared By:	Alena Thurman and Max Mozer
Reviewed By:	Matt Huang, Jennifer Henke
Subject:	Resilience Approach Summary

Introduction

The Medford Water Commission (Medford Water) teamed with RH2 Engineering, Inc., Carollo Engineers, Inc., and Jacobs Engineering Group, Inc. to define their resilient backbone water system that will provide at least 23 million gallons per day (mgd) to wholesale and critical customers in the Reduced Pressure (RP) and Gravity Zones during an emergency. This memorandum presents a prioritized list of resilient backbone projects and describes each project. Medford Water aims to complete the first 11 projects by year 2040. The last three projects are scheduled for after 2040.

Please note that at the time of this study, the River Zone was still called the "Reduced Pressure Zone" or "RP Zone" and Zone 1 was called "Zone 1A."The objectives of the resilient backbone projects to be completed by 2040 are as follows:

1. Provide resilient and reliable conveyance for 23 mgd from the Duff Water Treatment Plant (Duff WTP) to the Capital Hill Reservoirs. Of the 23 mgd resilient supply from Duff WTP, 14 mgd is anticipated to meet emergency demands in the Gravity Zone and all other upper zones.
2. Provide resilient storage in the RP and gravity zones totaling at least 25 mgd.
3. Allow the Duff WTP to operate at steady state and allow full pump discharge capacity for up to 65 mgd.
4. Reduce the pressure fluctuations and surges experienced by:
    a. Retail customers (acceptable pressure fluctuation is 25 pounds per square inch (psi).
    b. Wholesale customers (acceptable fluctuation is 25 psi).
    c. Control stations (CS) (to eliminate surge issues).

Various project alternatives were evaluated and compared using the following selection criteria that capture MWC's additional project goals:

1. Resilience:
    a. Resilient to emergency disruptions such as earthquakes, wildfires, and power outages.
    b. Integrates into Medford Water's long-term resilience backbone.
    c. Reliable.
    d. Distributed storage for redundancy.

2. Operations and Maintenance Simplicity:
    a. Simplifies water system operations.
        i. Duff WTP operations.
        ii. Control stations.
        iii. Shoulder season operational complexity.
    b. Benefits Big Butte Springs flow and air entrainment challenges.
    c. Maximizes system efficiency:
        i. Provides opportunity to implement hydropower.
    d. Maintains water quality.
3. System Compatibility:
    a. Integrates with scheduled Duff, pipeline, and storage projects.
    b. Aligns with system needs as City grows.
4. Capital Cost.

Resilient Project Priority List

The following projects are needed to ensure Medford Water's resilience backbone goals and objectives are met. Figure 1 in Attachment A shows the location of each project on a system map and identifies the projects as needed before 2040 or after 2040.

By 2040:

1. Martin CS Pump Upgrade.
2. Backup Power at Martin CS.
3. Table Rock Road Pipeline (PL-1).
4. New Duff WTP Reservoir & Finished Water Pump Station No. 2.
5. Replace Capital Hill Reservoirs (approx. 12 to 14 million gallons).
6. Crater Lake Avenue Pipeline (PL-7).
7. Merriman Road Pipeline (PL-9).
8. RP Zone Reservoir & Pipeline.
9. Crater Lake Highway Pipeline.
10. Martin CS No. 2.
11. Spring Street Pipeline.

Beyond 2040:

12. Expand Rossanley CS.
13. Additional Gravity Zone Storage (timing to be considered further in future master planning work).
14. Harden remaining Backbone pipeline.
15. Increase Duff Reservoir Capacity.

Project Descriptions

The summary of each project in the sections below provides the project description, trigger for when the project is needed, and funding source. Attachment B outlines a preliminary schedule of projects through 2040.

Project 1: Martin CS Pump Upgrade

a. **Project ID:** N/A.
b. **Project Name:** Martin CS Pump Upgrade.

c. **Description:** This is an existing capital improvement program (CIP) project to replace a pump at Martin CS with a larger pump to maximize the firm capacity of the pump station to approximately 7-mgd. Increased capacity helps balance supply from the RP Zone to the Gravity Zone. A variable frequency drive (VFD) will be used with the new pump to continue to allow operators to convey a low flow through Martin CS during the shoulder seasons.
   i. **Why project is needed:** Age/condition, capacity to meet future demands.
   ii. **Location:** Existing Martin CS just North of Delta Waters Road along Crater Lake Avenue.
   iii. **Pumping capacity:** Martin CS firm pumping capacity will be approximately 7 mgd, total pumping capacity will be approximately 11 mgd.

d. **Trigger:** A VFD at Martin CS will also support providing a wide range of flows for the Gravity Zone, including some equalizing storage when the Capital Hill Reservoirs are out of service while building new replacement reservoirs for the Gravity Zone. A VFD at Martin CS is also needed to continue to provide the required range of flows across the CS during shoulder seasons when lower flows are delivered from the RP Zone to Gravity..

e. Funding:
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. System development charges (SDC) eligible?: Yes.

Project 2: Backup Power at Martin CS

a. **Project ID:** N/A.

b. **Project Name:** Backup Power at Martin CS.

c. **Description:** Installation of backup generator at Martin CS to make the pump station more reliable. Martin CS is the priority CS for reliably moving water from the RP Zone to the Gravity Zone in an emergency.
   i. **Why project is needed:** System upgrade for reliability.
   ii. **Location:** Existing Martin CS just North of Delta Waters Road along Crater Lake Avenue.
   iii. **Capacity:** Able to run the entire existing 11-mgd capacity of Martin CS. Medford Water may want to consider oversizing the generator to be able to run the future 14-mgd resilient capacity of the Martin CS and Martin CS No. 2.

d. **Trigger:** Meet MWC's Seismic level of service (LOS) goals for reliably moving water to Capital Hill Reservoirs in the event of a power outage following an earthquake. Currently, no control stations have backup power and this is a high priority.

e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: No.

Project 3: Table Rock Road Pipeline (PL-1)

a. **Project ID:** PL-1.

b. **Project Name:** Reduced Pressure Zone North South Conveyance.

c. **Description:** Upsize pipeline along Table Rock Road to provide additional conveyance capacity from Duff WTP to the distribution system and reduce head loss across the RP Zone. Pipeline is sized to meet 85-mgd system-wide maximum day demand (MDD) and convey 65 mgd from Duff WTP.
   i. **Why project is needed:** Capacity, resilience.
   ii. **Location:** Along Table Rock Road from Duff WTP to Vilas Road.

   iii. **Diameter:** 42-inches.
   iv. **Length:** 18,000 linear feet (LF).

d. **Trigger:** This pipeline project is needed to take Capital Hill Reservoirs out of service to allow higher flow rates to meet peak demands while storage capacity is reduced.

e. Funding:
   i. Part of Rogue Valley Water Resiliency Supply Program?: Yes.
   ii. SDC eligible?: Yes.

Project 4: New Duff WTP Reservoir & Finished Water Pump Station No. 2

a. **Project ID:** Duff 65-MGD Expansion

b. **Project Name:** New Duff WTP Reservoir and Finished Water Pump Station (FWPS) No. 2

c. **Description:** Construction of a new 3-MG finished water reservoir at Duff WTP and FWPS No. 2 consisting of three (3) pumps with VFDs. Approximately 2 MG of the Duff WTP Reservoir will be available for RP Zone equalizing storage before constructing the RP Zone Reservoir. The Duff WTP will be able to provide 23 mgd of resilient supply.
   i. **Why project is needed:** Capacity to meet growth, provide resilient supply, and develop equalizing storage to RP Zone. FWPS No. 2 VFDs simplify system operations.
   ii. **Location:** Duff WTP.
   iii. **Capacity:** 3 MG of storage, 30 mgd firm pumping capacity.

d. **Trigger:** Needed for replacement of Capital Hill Reservoirs. Provides resilient finished water pumping capacity from the Duff WTP. To be completed as a part of Duff WTP expansion and provide the additional capacity required and operational flexibility to meet system demands and required equalizing storage when the Capital Hill Reservoirs are being replaced.

e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: Yes.
   ii. SDC eligible?: Yes.

Project 5: Replace Capital Hill Reservoirs

a. **Project ID:** N/A

b. **Project Name:** Replace Capital Hill Reservoirs.

c. **Description:** Project consists of demolishing the existing Capital Hill Reservoirs and replacing with new seismically resilient reservoirs at a higher hydraulic grade line (HGL). This project will be done in phases to be coordinated with Duff WTP Reservoir, the RP Zone Reservoir, and available funding.
   i. **Why project is needed:** Age/condition of reservoirs, resilience.
   ii. **Location:** Capital Avenue.
   iii. **Capacity:** 12-14 million gallons (MG).

d. **Trigger:** As soon as possible due to condition of existing Capital Hill Reservoirs.

e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: Yes.
   ii. SDC eligible?: No.

Project 6: Crater Lake Avenue Pipeline (PL-7)

a. **Project ID:** PL-7.
b. **Project Name:** Crater Lake Avenue Pipeline.
c. **Description:** Add new parallel pipeline along Crater Lake Avenue downstream of Martin CS to provide additional conveyance capacity. Pipeline is sized to meet both the Martin CS flow capacity assumptions under the 85-mgd system-wide MDD condition and to meet resilient supply flows needed from the RP Zone to Gravity Zone (14 mgd). The pipeline size is driven by MDD flow requirements.
   i. **Why project is needed:** Capacity, resilience.
   ii. **Location:** Along Crater Lake Ave from Martin CS to Spring Street.
   iii. **Diameter:** 30-inch parallel pipe.
   iv. **Length:** 8,300 LF.
d. **Trigger:** Upsize required to convey new firm 7-mgd capacity of Martin CS.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: Medford Water to determine.
   ii. SDC eligible?: Yes.

Project 7: Merriman Road Pipeline (PL-9)

a. **Project ID:** PL-9.
b. **Project Name:** Conrad CS Suction Pipeline.
c. **Description:** Upsize pipeline along Merriman Road and Table Rock Road to provide additional conveyance capacity and alleviate suction pressure issues in the vicinity of Conrad CS. Pipeline is sized to meet capacity needs under the 85 mgd system-wide MDD condition.
   i. **Why project is needed:** Capacity to deliver water under Duff WTP 65-mgd expansion and future conditions.
   ii. **Location:** Merriman Road from Beal Lane to Conrad CS.
   iii. **Diameter:** 24-inches.
   iv. **Length:** 7,100 LF.
d. **Trigger:** Needed to improve suction pressures for current pumping requirements at Conrad CS and support operation of a modified Pump No 1 at Conrad CS.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: Yes.
   ii. SDC eligible?: Yes.

Project 8: RP Zone Reservoir and Pipeline

a. **Project ID:** RP Zone Reservoir
b. **Project Name:** RP Zone Reservoir.
c. **Description:** Construct an RP Zone reservoir in the Northeast (NE) part of the water distribution system to simplify operations; provide resilient emergency, fire flow and equalizing storage to the RP Zone; and extend the capacity of the RP Zone infrastructure to meet diurnal demands. Without an RP Zone reservoir, the Duff WTP finished water pumps and RP Zone pipelines must convey peak hour flows, attenuated as much as possible by equalizing storage available at Duff WTP. Having equalizing storage within the RP Zone means that only MDD must be conveyed, thus extending the time that the distribution system will have adequate capacity

by 10 to 15 years. This project also includes constructing a 36-inch pipeline to connect the reservoir to the distribution system.

   i. **Why project is needed:** Operations, storage requirements, resilience.
   ii. **Location:** Possible locations include Delta Waters Road or Foothill Road.
   iii. **Capacity:** 4 to 8 MG.

d. **Trigger:** Needed when any of the following triggers apply:
   i. Existing Duff WTP Reservoir is replaced and less than 2 MG of equalizing storage is available at Duff.
   ii. With 2 MG of equalizing storage available in the Duff WTP Reservoirs, Duff max day supply reaches 55 mgd. Distribution system will no longer have capacity to convey peak hour demands.
   iii. With more than 2 MG of equalizing storage available in the Duff WTP Reservoirs, Duff max day supply reaches 60 mgd. Distribution system will no longer have capacity to convey peak hour demands.

e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: Yes.
   ii. SDC eligible?: Yes.

Project 9: Crater Lake Highway Pipeline

a. **Project ID:** N/A.

b. **Project Name:** Crater Lake Hwy Pipeline.

c. **Description:** Install parallel 36-inch pipeline along Crater Lake Highway between Vilas Road and the Martin CS to provide additional conveyance to the RP Zone Reservoir and Martin CS. Pipeline is sized to meet 85 mgd system wide MDD conditions and 17 mgd of emergency supply through Martin CS.
   i. **Why project is needed:** Capacity, resilience.
   ii. **Location:** Along Table Rock Road.
   iii. **Diameter:** 36-inch parallel pipeline.
   iv. **Length:** 8,300 LF.

d. **Trigger:** Needed after RP Reservoir is online and system wide MDD is 80 mgd.

e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: Yes.

Project 10: Martin CS No. 2

a. **Project ID:** N/A.

b. **Project Name:** Martin CS No. 2.

c. **Description:** Build a Martin CS No. 2 in the vicinity of the existing Martin CS to provide a resilient pumping capacity of 14 mgd. Of the 23 mgd resilient supply from Duff WTP, 14 mgd is the resilient supply that needs to be pumped to the Gravity Zone. Martin CS No. 2 should have backup power for resilience.
   i. **Why project is needed:** Resilience, capacity.
   ii. **Location:** Near the existing Martin CS.
   iii. **Capacity:** 14 mgd total capacity.

d. **Trigger:**
   i. Needed to convey 14 mgd of resilient supply to Gravity Zone.
   ii. Needed when RP Zone to Gravity Zone firm pumping requirement exceeds 24 mgd, which is approximately equivalent to a system wide MDD of 70 mgd.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: Yes.

Project 11: Spring Street Pipeline

a. **Project ID:** N/A.
b. **Project Name:** Spring Street Pipeline.
c. **Description:** Replace the pipeline along Spring Street that feeds the Capital Hill Reservoirs to be seismically resilient and adequately sized to convey resilient supply. Pipe has experienced multiple leaks.
   i. **Why project is needed:** Resilience to connect Duff WTP to Capital Hill Reservoirs, age/condition.
   ii. **Location:** Spring Street from Crater Lake Ave to Capital Hill Reservoirs.
   iii. **Diameter:** Further evaluation needed for sizing.
d. **Trigger:**
   i. Next priority for hardening the resilience backbone from Duff WTP to Capital Hill Reservoirs.
   ii. Pipe repair and replacement program prioritizes replacement.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: TBD.

Project 12: Expand Rossanley CS

a. **Project ID:** N/A.
b. **Project Name:** Expand Rossanley CS.
c. **Description:** Upgrade Rossanley CS to be seismically resilient and increase capacity to meet future RP Zone to Gravity Zone firm pumping requirements.
   i. **Why project is needed:** Capacity, resilience.
   ii. **Location:** Rossanley CS.
   iii. **Total Capacity:** TBD.
d. **Trigger:** Needed when RP Zone to Gravity Zone firm pumping requirement exceeds 38 mgd, which is approximately equivalent to a system-wide MDD of 95 mgd.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: Yes.

Project 13: Additional Storage in the Gravity Zone

a. **Project ID:** N/A.
b. **Project Name:** Additional Storage in the Gravity Zone.
c. **Description:** Construct a new resilient reservoir in the Southeast part of the distribution system to provide storage for growth in that part of the system.
   i. **Why project is needed:** Capacity, resilience.

   ii. **Location:** Near the intersection of Barnett Road and Murphy Road.
   iii. **Capacity:** TBD.

d. **Trigger:** Needed to meet long-term storage needs. Timing and capacity depend on the capacities of the Capital Hill Reservoirs, RP Zone Reservoir, and Bullis Reservoir. Total RP Zone and Gravity Zone build-out storage needs are 34 MG.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: Yes.

Project 14: Harden Remaining Backbone Pipeline

a. **Project ID:** N/A.
b. **Project Name:** Harden Remaining Backbone Pipeline.
c. **Description:** Harden the remaining pipeline that is part of the resilience backbone system to be able to provide resilient supply to Medford Water's critical customers and wholesale customers.
   i. **Why project is needed:** Resilience.
   ii. **Length:** TBD, likely on the order of 150,000 LF..
d. **Trigger:** Should be complete by approximately 2063 to meet the Oregon Resilience Plan 50-year timeline.
e. **Funding:**
   i. Part of Rogue Valley Water Resiliency Supply Program?: No.
   ii. SDC eligible?: No.

Digitally signed by Alena M. Thurman
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Date: 2022.10.31 09:57:25-07'00'

Alena M Thurman

REGISTERED PROFESSIONAL
ENGINEER
94763
OREGON
MAY 14, 2019
ALENA M. THURMAN
EXPIRES: 06/30/24

Prepared by:

Alena Thurman, P.E.

Attachment A

PRIORITIZED RESILIENCE BACKBONE PROJECTS

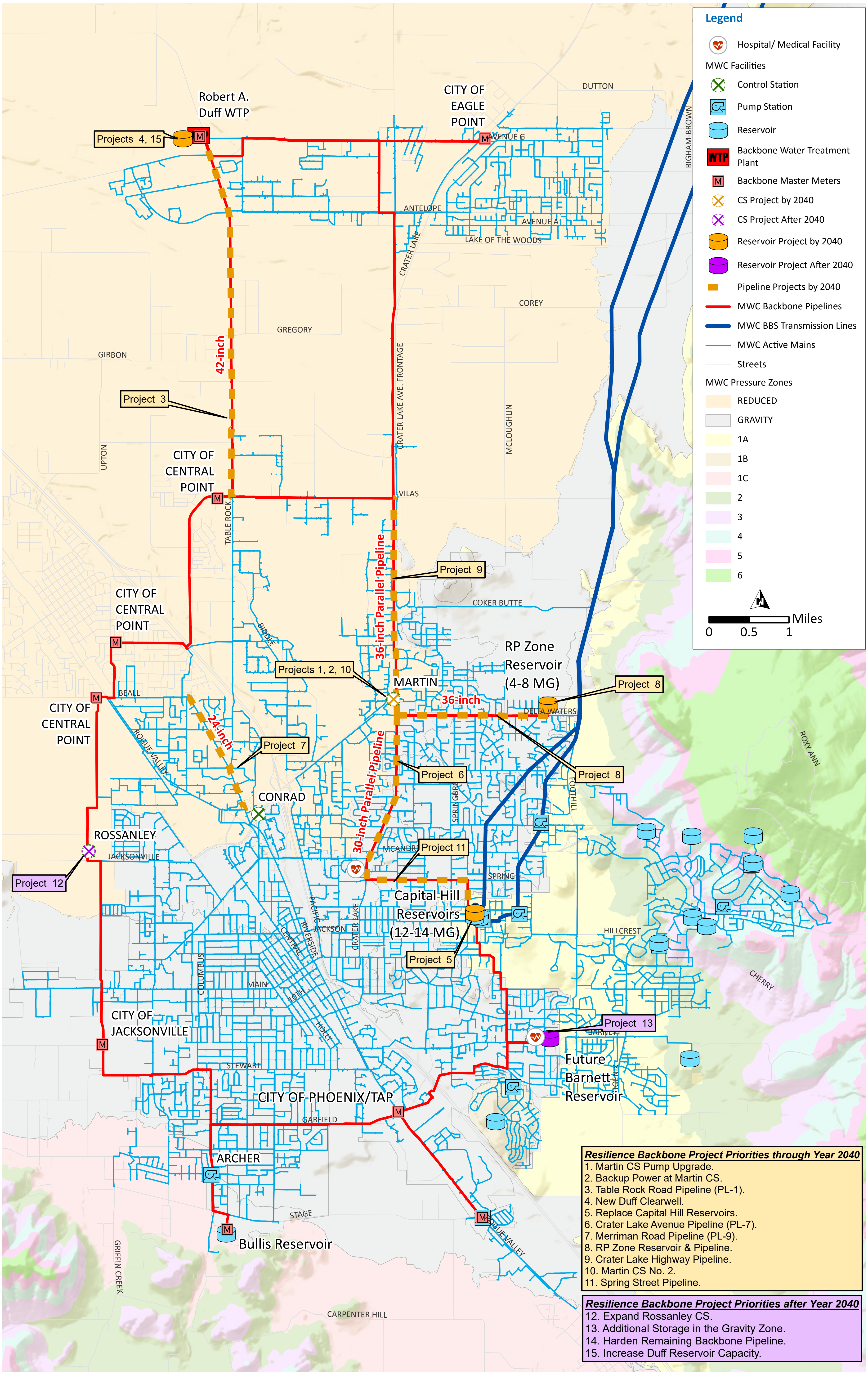

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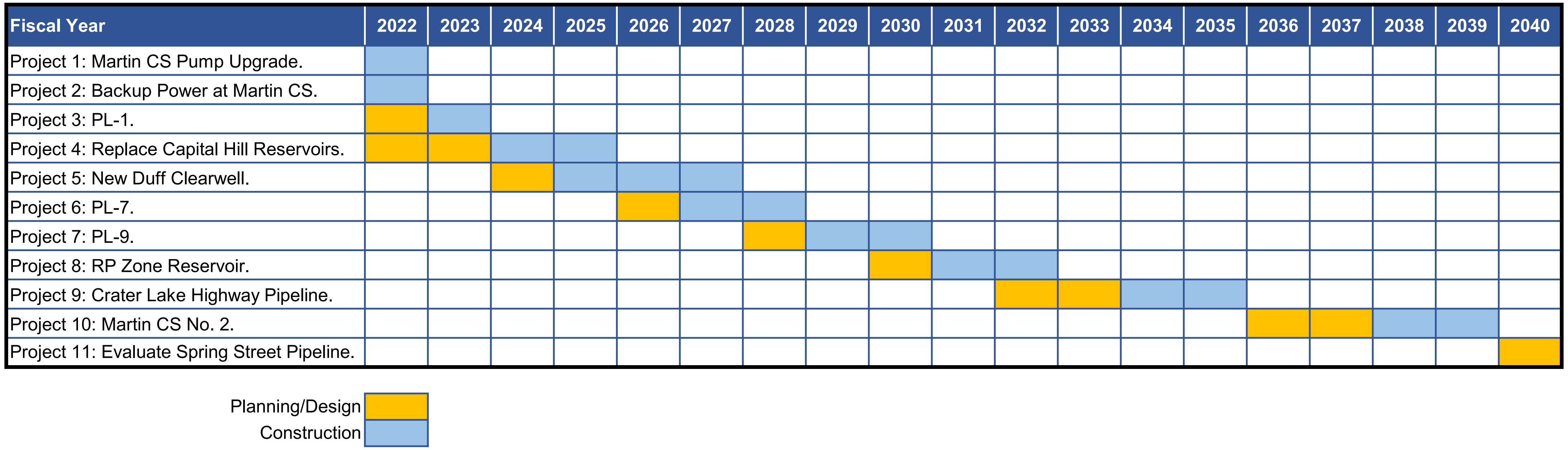
Figure 1 Prioritized Resilience Backbone Projects

Attachment B

SCHEDULE


Fiscal Year
2022
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Project 1: Martin CS Pump Upgrade.
Project 2: Backup Power at Martin CS.
Project 3: PL-1.
Project 4: Replace Capital Hill Reservoirs.
Project 5: New Duff Clearwell.
Project 6: PL-7.
Project 7: PL-9.
Project 8: RP Zone Reservoir.
Project 9: Crater Lake Highway Pipeline.
Project 10: Martin CS No. 2.
Project 11: Evaluate Spring Street Pipeline.
Planning/Design
Construction