FINAL

WATER SYSTEM MASTER PLAN

Paulding County, GA

B&V PROJECT NO. 190922

PREPARED FOR

Paulding County Water System

16 MAY 2016

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ACRONYMS/ABBREVIATIONS

ADD	Average Day Demand
ARC	Atlanta Regional Commission
AWWA	American Water Works Association
BPS	Booster Pump Station
CCMWA	Cobb Cobb-Marietta Water Authority
CCWS	Cobb County Water System
CIP	Capital Improvement Plan
DIP	Ductile Iron Pipe
GA EPD	Georgia Environment Protection Division
EPS	Extended Period Simulation
FF	Fire Flow
fps	feet per second
ft	feet
gal	gallon
GIS	Geographic Information System
gpd	gallons per day
gpm	gallons per minute
HGL	Hydraulic Grade Line
HSP	High Service Pump
MNGWPD	Metropolitan North Georgia Water Planning District
MDD	Maximum Day Demand
OPB	Office of Planning and Budget
PHD	Peak Hour Demand
MG	Million Gallons
MGD	million gallons per day
psi	pounds per square inch
PVC	Polyvinyl Chloride
RCWSP	Richland Creek Water Supply Program
SCADA	Supervisory Control and Data Acquisition
TDH	Total Dynamic Head
USGS	United States Geological Survey
VFD	Variable Frequency Drive
WTP	Water Treatment Plant

Executive Summary

INTRODUCTION

The Paulding County Water System currently provides water to Paulding County with approximately 45,000 service connections and a total population close to 150,000 including both the City of Dallas and Hiram. In addition to customers within the County, the water system has a wholesale agreement to provide water to a portion of Polk County. Currently all water supplied to the water system is provided by the Cobb County-Marietta Water Authority (CCMWA) and the Cobb County Water System (CCWS) through eight interconnections on the east side of the system. The County is in the process of designing and constructing a new water supply source named the Richland Creek Water Supply Program (RCWSP). As part of this program a new reservoir, raw water intake and pump station, raw water pipeline and a new water treatment plant will be developed. The Richland Creek Reservoir (RCR) will be a 305 acre reservoir located in northern Paulding County. The Richland Creek water treatment plant is planned to have an initial capacity of 18 MGD and to be in service in 2019. This program will eventually allow the County to supply all of its water independent of other sources.

The County established the need for an updated Water System Master Plan to replace the previous 2003 version. Black & Veatch was contracted by the County to develop this *Water System Master Plan* to determine the necessary system improvements to meet level of service goals in both the existing water system and future projected demands within the service area through planning Phase 3. This planning phase aligns well with the updated demand forecasts from the Metropolitan North Georgia Water Planning District's (MNGWPD) 2016 Plan for year 2050.

OBJECTIVES AND SCOPE OF WORK

The scope of work for this Master Plan project includes the following tasks:

- Review and determination of current water system demands and usage characteristics
- Update and calibration of the system hydraulic computer model
- Water demand projections for the projected short-, mid- and long-term planning phases
- Hydraulic capacity analysis of the existing water system and future water system alternatives
- Development of a recommended Capital Improvement Plan
- Preparation of a summary Water System Master Plan report document

This Master Plan was carried out in multiple stages with the preliminary tasks for determining existing water system demands and characteristics, updating and calibrating the hydraulic model, performing demand projections and performing an initial evaluation of the future Mt. Tabor pressure zone carried out by TetraTech in 2014 and 2015. In 2016, Black & Veatch was hired by the County to perform the hydraulic evaluations of the existing and future systems, complete the Capital Improvement Plan (CIP) and prepare the Master Plan report document.

The overall goals of this project included performing capacity evaluations of the existing and future water system, including an assessment of infrastructure and water supply sources. Resulting system improvements have been recommended for the planning of the County's water system to

meet projected short-, mid- and long-term needs. The master plan was prepared with three identified planning phases which include:

- Short-term: Phase 1 – 17 MGD MDD
- Mid-term: Phase 2 – 25 MGD MDD
- Long-term: Phase 3 – 34 MGD MDD

It should be noted that these phases aligned well with the updated MNGWPD forecasts and are similar to the values from the MNGWPD years 2015, 2030 and 2050, respectively.

EXISTING SYSTEM

Water to the County is currently supplied through interconnections with surrounding water systems including CCMWA and CCWS. There are a total of eight existing interconnections on the county boundary between Cobb and Paulding County. Three of these interconnections have booster pump stations which include: Hwy 120, Macland Road and Cleburne Parkway. There are a total of three pressure zones in the system: Main, Union and Yorkville. Each pressure zone operates on a different hydraulic grade line (HGL) with Main at approximately 1,255 ft., Union at 1,445 ft. and Yorkville at 1,522 ft. All pressure zones have elevated storage tanks to help stabilize pressures and provide demand equalization, fire, and emergency storage capacity to the system. There are a total of seven storage tanks in the system with a combined capacity of 4.75 MG. In addition to the booster pump stations at the three interconnections, there are four major pump stations and four minor pump stations in the system. In total, there are approximately 975 miles of waterlines in the system ranging in diameter from 2 to 24 inches.

A hydraulic model was developed and calibrated for the existing system based on 2012 and 2013 Supervisory Control and Acquisition Data (SCADA) and field recorded pressure and flow data. Calibration was performed within American Water Works Association (AWWA) guidelines for hydraulic modeling.

DEMAND PROJECTIONS

Historical water demands were obtained from metered purchase records from wholesale suppliers and customer billing data. Historical purchase records and metered sales were evaluated to understand the County's existing annual average water use, maximum day demand and diurnal peaking factors. Over the past ten years, the County has purchased an average of 10.2 million gallons per day (MGD) of water from CCMWA and CCWS based on monthly sales records. Demands were projected in the future using the County's parcel and land use data and meeting with the County's Community Development Department to identify areas most likely to experience growth in the short-, mid- and long-term. Future residential and commercial customers were identified and demands were calculated using usage rates per acre for each customer type based on historic usage data. Recent water audit information was evaluated and it was determined that the County currently has approximately 25% total non-revenue water (NRW) with "Real Losses" estimated at less than 20%. Existing NRW was estimated at 20% while future NRW was calculated at 15% to account for water loss reduction efforts the County is currently undertaking. A summary of the water demands by category for each planning phase is provided in Table ES-1.

Table ES-1:Current and Projected Water Demands

CUSTOMER TYPE	FUTURE WATER DEMANDS (MDD)		
	PHASE 1	PHASE 2	PHASE 3
	(gpd)	(gpd)	(gpd)
COMMERCIAL	2,590,000	5,450,000	7,620,000
RESIDENTIAL	10,620,000	14,830,000	19,280,000
NON-REVENUE WATER	2,550,000	3,900,000	5,250,000
WHOLESALE_DALLAS	840,000	1,170,000	1,520,000
WHOLESALE_POLKCOUNTY	64,100	69,300	74,800
Total	**16,670,000**	**25,420,000**	**33,750,000**

SYSTEM CAPACITY ANALYSIS AND RECOMMENDED IMPROVEMENT PROJECTS

The Paulding County computerized hydraulic model was provided to Black & Veatch for use for the master plan. Multiple scenarios were simulated to examine the needs of the system under varying existing and future conditions. Evaluation criteria based on state and federal requirements and desired level of service goals by the County were developed and implemented during this evaluation. Output from this model was used to:

- Determine the location and diameter of new distribution system mains, storage tanks, pump stations and pressure zones
- Plan the timing for when improvements are necessary
- Optimize distribution system improvements

The future demand projections and hydraulic modeling results formed the basis for a detailed analysis of the County's water system infrastructure. Water production (interconnections and future Richland water treatment plant) and distribution infrastructure (pumps, tanks, and pipelines) were analyzed under a wide range of operating conditions from average to maximum day demands and fire flows. These analyses were the basis of determining the recommended timing for the future infrastructure upgrades.

The identified water production and distribution system improvements recommended through the projected long-term, Phase 3 total roughly $63.8 million in 2016 dollars. A phased plan for implementing these improvements is provided in Section 6 of this Water Master Plan report. The table below summarizes the total improvements per phase and their associated costs.

Table ES-2 Summary of Water System Improvements by Master Planning Phase

PLANNING PHASE	TOTAL CIP COSTS[1] ($)
Phase 1	$14,400,000
Phase 2 – Part 1 [2]	$14,200,000
Phase 2 – Part 2 [3]	$15,500,000
Phase 3	$19,700,000
Total CIP Cost	**$63,800,000**

[1] Capital Improvement Projects in 2016 dollars.
[2] Water Supply: Richland Creek WTP + CCMWA
[3] Water Supply: Richland Creek WTP

Master planning was selected in phases as opposed to planning years to allow the County greater flexibility to plan based on demands when they occur. It is recommended that the County evaluate these improvements and began implementation when demands reach approximately 75 percent of the estimated demand for each planning phase to provide adequate time for survey, design, permitting, bidding and construction associated with each CIP.

The actual year for CIP implementation should correspond to water system demands. As a general guideline, based on existing and forecasted demands, short-term improvements will most likely take place in the immediate future between 2016 and 2020, mid-term improvements between 2020 and 2030 and long-term improvements between 2030 and 2050. Coordination is recommended between recommended CIPs and the Department of Transportation (DOT) road improvement projects which may shift timing for some of the recommendations. To facilitate adjustments in the future to account for changes in demand or infrastructure, it is recommended that the County continue to update and evaluate the water system using the hydraulic model and modify the Master Plan document as necessary.

It should be noted that all recommendations were developed implementing the best available information at the time of this study and assumptions stated within this master planning document.

1.0 Existing Water System

1.1 WATER SUPPLY

Water is currently supplied to the County through interconnections with the Cobb County-Marietta Water Authority (CCMWA) and the Cobb County Water System (CCWS). There are a total of six interconnections with CCMWA which include: Governor's Town Club, Cedarcrest, Hwy 92, Macland Road, Hwy 120 and Cleburne Parkway. The three northern interconnections (Governor's Town Club, Cedarcrest and Hwy 92) do not have pumping while the three southern interconnections (Macland Road, Hwy 120 and Cleburne Parkway) include booster pump stations at the County boundary. In addition to these six connections to CCMWA, the County has two interconnections with CCWS at Picketts Ridge and Rutledge Road which serve isolated subdivisions in the northern part of the County's water distribution system. All of the interconnection locations are illustrated on **Figure 1** and **2** at the end of this section.

1.2 DISTRIBUTION SYSTEM

The County's existing water distribution system is comprised of waterlines, storage tanks and booster pump stations as summarized in the following section. A map of the existing system is shown in **Figure 1** with a large map provided in **Appendix A**.

1.2.1 Service Area

The water system serves Paulding County including wholesale agreements to provide water to the City of Dallas and Hiram. Outside of the County, the water system provides water via a wholesale agreement to a small portion of Polk County. In total, the system has approximately 45,000 existing water accounts serving a population close to 150,000.

1.2.2 Distribution System Piping

The County's water distribution system contains approximately 975 miles of piping ranging from 2 to 24 inches in diameter. The majority of pipes are 6 and 8 inch diameter which make up 33% and 49% of the system, respectively. A map showing the existing piping network is included in **Figure 1**. A summary of the pipes by diameter, based on data from the existing water system model provided by the County, is summarized in the following **Table 1**.

Table 1: Water Distribution System Piping Summary

DIAMETER	TOTAL LENGTH	PERCENT OF TOTAL SYSTEM
(inch)	(ft)	%
2	43,000	<1
6	1,702,000	33
8	2,500,000	49
10	411,000	8
12	148,000	3
14	11,000	<1
16	186,000	4
20	37,000	<1
24	110,000	2
Total	5,148,000	

1.2.3 Distribution System Pressure Zones

The County's existing water distribution system consists of three pressure zones including the Main Zone, Union Zone and Yorkville Zone. The Main Zone is the largest pressure zone in the County and operates on an HGL of approximately 1,255 feet. The Union Zone is located in the southwest portion of the County and is supplied from the Main Zone via the Union booster pump station (BPS) which pumps to the Union storage tank at an HGL of approximately 1,445.8 ft. The Yorkville Zone is located on the west side of the County and uses the Bell Road BPS to pump to the Yorkville tank at a HGL of approximately 1,522 ft.

1.2.4 Distribution System Pump Stations

There are eleven BPSs in the County's water distribution system including seven main stations and four minor stations. The main stations transfer water across the distribution system and maintain general system pressures. The minor stations are simply set up to boost pressure to several subdivisions.

Main Booster Pump Stations

Three of the main stations are located at county boundary and are considered boundary BPS which include: Hwy 120, Macland Road and Cleburne Parkway. Boundary BPSs are owned and maintained by the County and are used to pump water from CCMWA's system into the County.

Inside of the system, the County operates four internal BPSs which include: Braswell Mountain, Hwy 61, Union and Bell Road. Two of the internal BPSs, Braswell Mountain and Hwy 61, are located in the Main Zone. The Braswell Mountain BPS is located on Harmony Grove Church Road and is

controlled by the Braswell Mountain storage tank. This pump station is equipped with variable frequency drive (VFD) motors set to maintain a discharge pressure. The Highway 61 BPS is located on Hwy 61 south of Hiram Sudie Road and maintains the level in the New Georgia water storage tank. The Union BPS is located on Mulberry Rock Road near the New Georgia water tank close to the boundary between the Main and Union Zones. This station is controlled by the water level in Union Tank.

The Bell Road BPS is located on Bell Road near the Union and Yorkville Zone boundaries. The Bell Road station is controlled by the water level in the Yorkville storage tank.

A summary of the BPSs is provided in **Table 2**.

Table 2: Water Distribution System BPS Summary

NAME	ORIGINAL RATING PER PUMP		FIRM CAPACITY[1]	HORSE POWER (HP)	NUMBER OF PUMPS	PRIMARY CONTROLLING TANK
	Flow (gpm)	TDH (ft)	(gpm)			
INTERNAL BPS						
Bell Road	1,200	270	1,200	150	2	Yorkville
Braswell Mountain[2]	750	300	750	100	2	Braswell
Hwy 61	1,600	190	1,600	150	2	New Georgia
Union	2,500	335	2,500	400	2	Union
BOUNDARY BPS						
Cleburne	2,360	128	4,720	100	3	Shipp
Hwy 120	2,000	100	4,000	75	3	Hiram Sudie
Macland	3,000	100	3,000	100	2	Macland

[1] Based on one pump out of service
[2] Equipped with VFD motors set to maintain constant discharge pressure.

Each of the County's existing pump stations is less than 20 years old with the oldest being Macland Road which was installed in 1996. The newest, Union, was installed in 2007. A summary of the BPSs by age and manufacturer is provided in **Table 3**.

Table 3: Water Distribution System BPS Summary by Manufacturer and Age

NAME	PUMP MANUFACTURER	INSERVICE YEAR	APPROXIMATE AGE[1]
Bell Road	ITT Goulds	2003	13
Braswell Mountain	Patterson	2006	10
Hwy 61	Peerless	2006	10
Union	FloServe	2007	9
Cleburne	Weinman	2000	16
Hwy 120	Peerless	2000	16
Macland	Layne	1996	20

[1] Age based on current year 2016.

Minor Booster Pump Stations

In addition to the primary booster pump stations mentioned above, the County operates and maintains several smaller stations referred to as minor stations. Minor stations in the system are set up to boost pressure to several subdivisions near Macland and Mt. Tabor Church Road in the Main Zone. Minor stations include: Macland Township, Cowboy Trail, Evans Mill and Donna Lane.

1.2.5 Distribution System Storage Tanks

The County's existing water system contains a total of seven water storage tanks which are made up of elevated and ground tanks that range in size from 500,000 to 1,000,000 gallons. There are a total of five tanks located in the Main Zone, one tank in the Union Zone and one tank in the Yorkville Zone. Total combined storage for the system is approximately 4.75 million gallons (MG) with 3.25 MG in the Main Zone, 1.0 MG in the Union Zone and 0.5 MG in the Yorkville Zone. A summary of the storage tanks by pressure zone is provided in **Table 4**.

Table 4: Water Distribution System Storage Tank Summary by Pressure Zone[1]

TANK NAME	ZONE	TYPE (ELEVATED/ GROUND)	GROUND ELEV.	LOW WATER LEVEL (LWL) ELEV.	HIGH WATER LEVEL (HWL) ELEV.	HEAD RANGE	VOLUME
			(ft)	(ft)	(ft)	(ft)	(gallon)
Braswell Mountain	Main	Elevated	1,156.00	1223.00	1,255.00	32.0	500,000
Hiram Sudie	Main	Elevated	1,178.00	1225.00	1,258.00	33.0	1,000,000
Macland	Main	Ground	1,225.50	1225.5	1,265.50	40.0	500,000
New Georgia	Main	Ground	1215.00	1215.00	1,255.00	40.0	500,000
Shipp Road	Main	Elevated	1,076.09	1221.00	1,255.00	34.0	750,000
Union	Union	Elevated	1,340.81	1415.81	1,445.81	30.0	1,000,000
Yorkville	Yorkville	Elevated	1402.00	1484.5	1,522.00	37.5	500,000
Total							**4,750,000**

[1] Elevation data in table based on County field survey data and/or the "Water System Transmission System Assets, Tanks and Booster Pump Stations" by RJP Environmental Associates, November 2012.

The age of the County's existing storage tanks range from 13 to over 60 years old. Yorkville tank is the newest tank which was commissioned in 2003 while Shipp Road is the oldest. Shipp Road was purchased from another municipality and was originally manufactured in 1950 and put into service in the County in 1983. The existing storage tanks were supplied from a variety of manufacturers and include several tank styles including leg, pedestal and fluted column. A summary of the County's existing tanks by manufacturer, age and style is provided in **Table 5**.

Table 5: Water Distribution System Storage Tank Summary by Age and Style

TANK NAME	MANUFACTURER	YEAR COMMISSIONED	APPROXIMATE AGE[1]	STYLE
ELEVATED TANKS				
Braswell Mountain	Chicago Bridge & Iron (CB&I)	2001	15	Fluted Column
Hiram Sudie	Caldwell	1998	28	Multi Column
Shipp Road[2]	Brown Steel	1983	60+	Multi Column
Union	Caldwell	1993	23	Multi Column
Yorkville	CB&I	2003	13	Pedestal
GROUND TANKS				
Macland[3]	Unknown	1970's	40+	Steel
New Georgia	Unknown	1977	39	Steel

[1] Age based on current year 2016.
[2] Shipp Road Tank originally manufactured in 1950.
[3] Macland Tank anticipated to be replaced in 2016.

In addition to the tanks shown in Table 4 and 5, there is an existing but inactive storage tank in the Main Zone located on Mt. Tabor Church Road north of East Paulding Drive referred to as the Mt. Tabor Tank. The Mt. Tabor Tank was installed in 1988 as a ground storage tank with a total volume of 1 MG and a HWL of approximately 1,255 ft.

1.2.6 Pressure Reducing Valves (PRVs)

The water distribution system includes a total of seven pressure reducing valves (PRVs) which were installed to reduce several high pressure areas in the northeast portion of the distribution system. The PRVs were set up in the model based on locations and settings provided by the County. The PRVs are located near Cedarcrest and Harmony Grove Church Roads and serve portions of the Bentwater and Picketts Mill subdivisions. A summary of the modeled PRVs and their settings is provided in **Table 6**.

Table 6: Summary of Existing PRVs

MODEL ID	LOCATION	GROUND ELEVATION	PRESSURE SETTING
		(ft)	(psi)
PRV-1	Graves Road at Cedarcrest Road	858.64	85
PRV-2	Bentwater Drive at Cedarcrest Road	935.75	51
PRV-3	Graves Road at Harmony Grove Church Road	903.81	61
PRV-4	Golf Crest Drive at Cedarcrest	891.00	54
PRV-5	Flagstone Way at Harmony Grove Church Road	955.00	70
PRV-6	Pickett's Mill Place at Hwy 92	940.22	80
PRV-7	Mabry Lane at Seven Hills Connector	947.73	80

A map of the existing water distribution system illustrating the information provided in this section is presented in **Figure 1**. A large map of the existing system is provided in **Appendix A**. The hydraulic profile of the system is included in **Figure 2.** The profile was originally created by TetraTech (Tt) in 2014 and updated by Black & Veatch for this report using on more recent tank elevation data.

Figure 1: Existing Water Distribution System Map

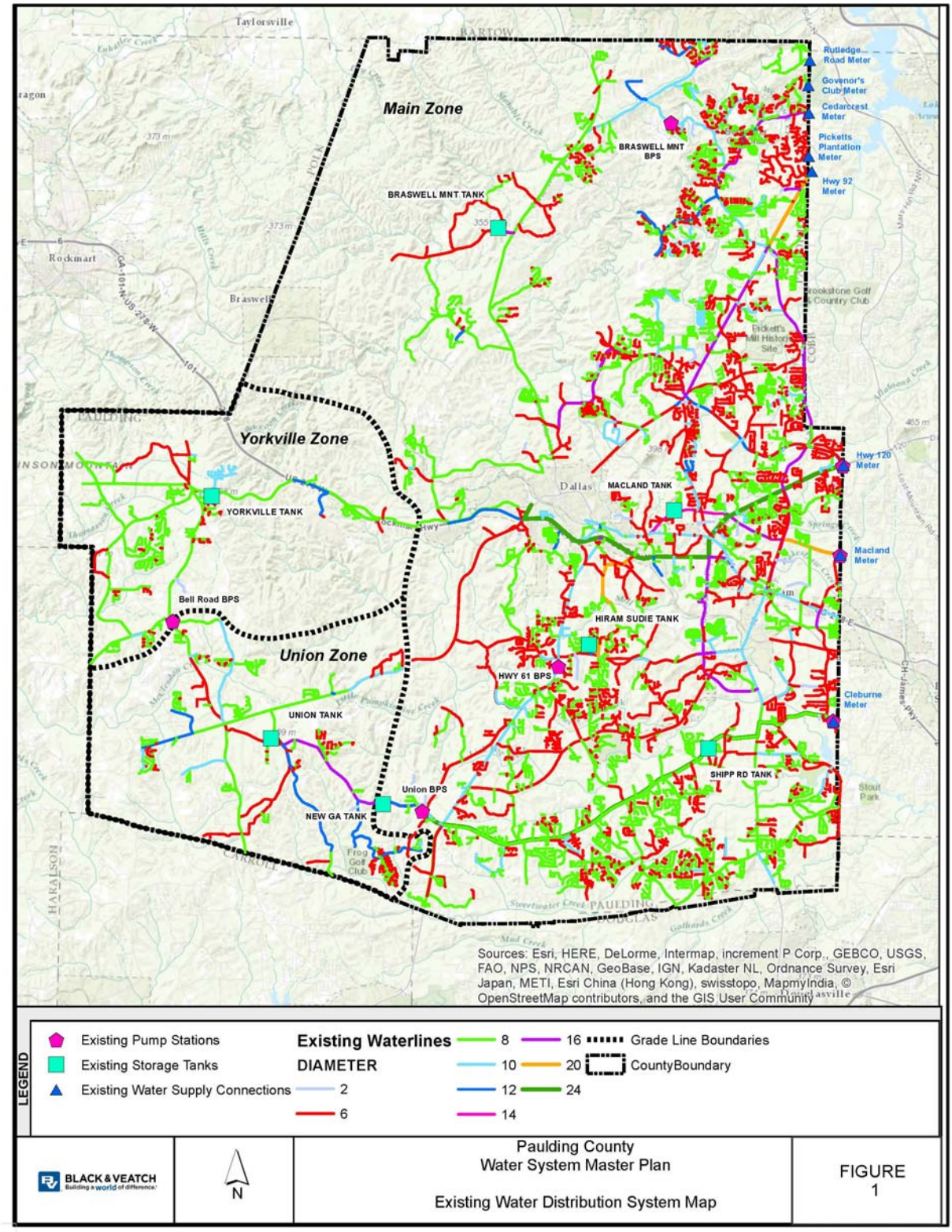
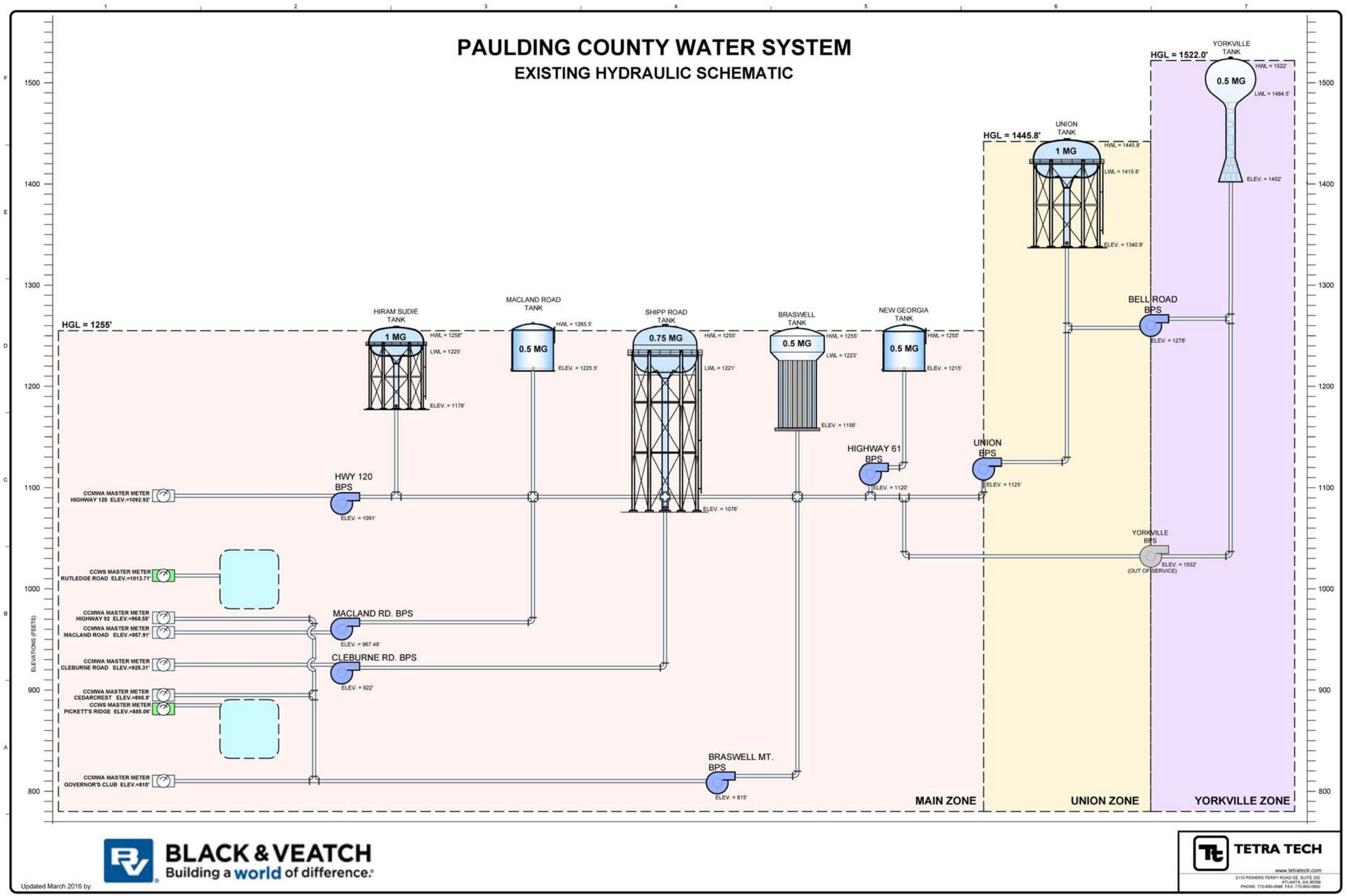


Figure 2: Existing Water Distribution System Hydraulic Profile



1.2.7 Existing Plans for Future Water Supply

As part of a separate project, the County is in the process of designing and constructing a new water supply source named the Richland Creek Water Supply Program (RCWSP). As part of this program a new reservoir, raw water intake and pump station, raw water pipeline and a new water treatment plant will be developed. The Richland Creek Reservoir (RCR) will be a 305 acre reservoir located in northern Paulding County. The Richland Creek water treatment plant (WTP) is planned to have an initial capacity of 18 million gallons per day (MGD) and to be in service in 2019. The water treatment plant is planned to be expanding in a future phase to have a total capacity of 36 MGD. This program will eventually allow the County to supply all of its water independent of other sources.

In addition to the RCR, the County will still need the option to purchase water from CCMWA and CCWS. It is anticipated that at a minimum the two connections to CCWS at Pickett's Ridge and Rutledge Road will remain in service over the long-term since these are isolated subdivisions in the northern part of the County. The remaining interconnections to CCMWA will allow the County to purchase water as needed in the future based on the difference between the system demands and WTP capacity. NOTE: Based on funding requirements for the loans provided by the Georgia Environmental Finance Authority (GEFA) for the RCR and associated infrastructure improvements, the County will pay a financial penalty in the year 2032 if it has not ceased water purchases, with certain exemptions, by this time.

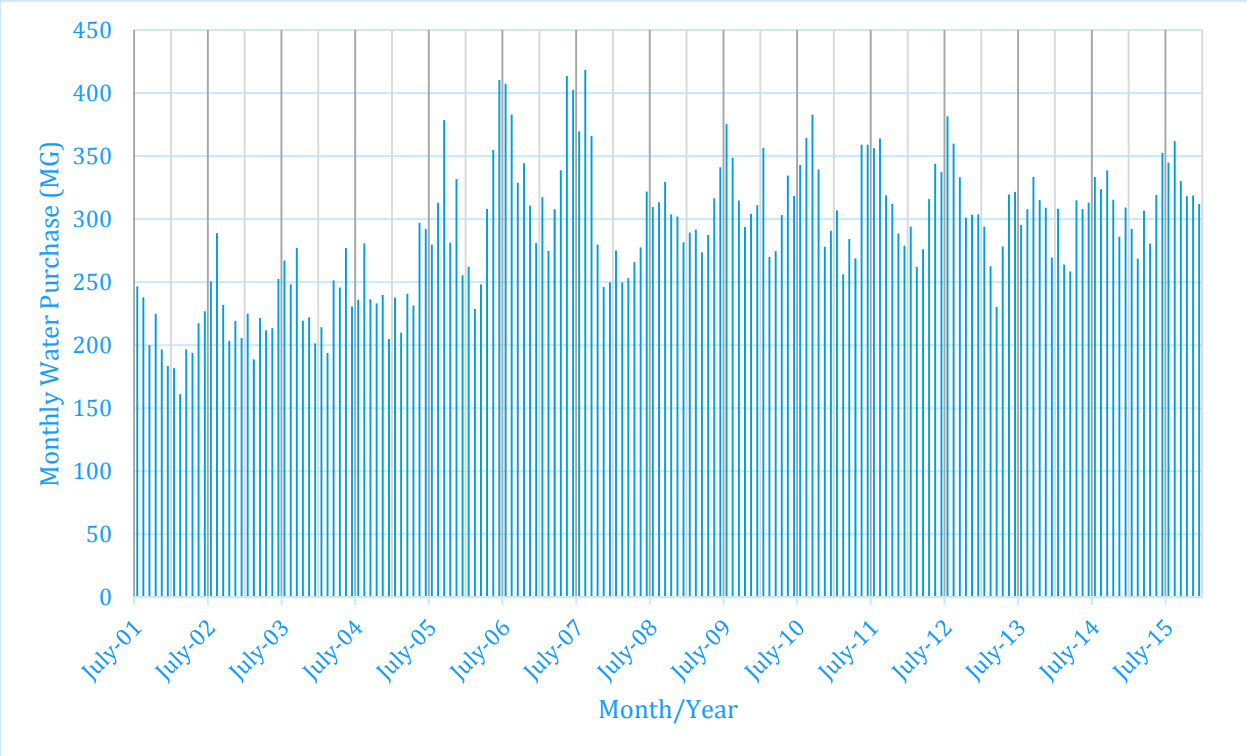
2.0 Water Demands

This section presents the County's historic water use and the development of projected water demands.

2.1 HISTORIC WATER USE

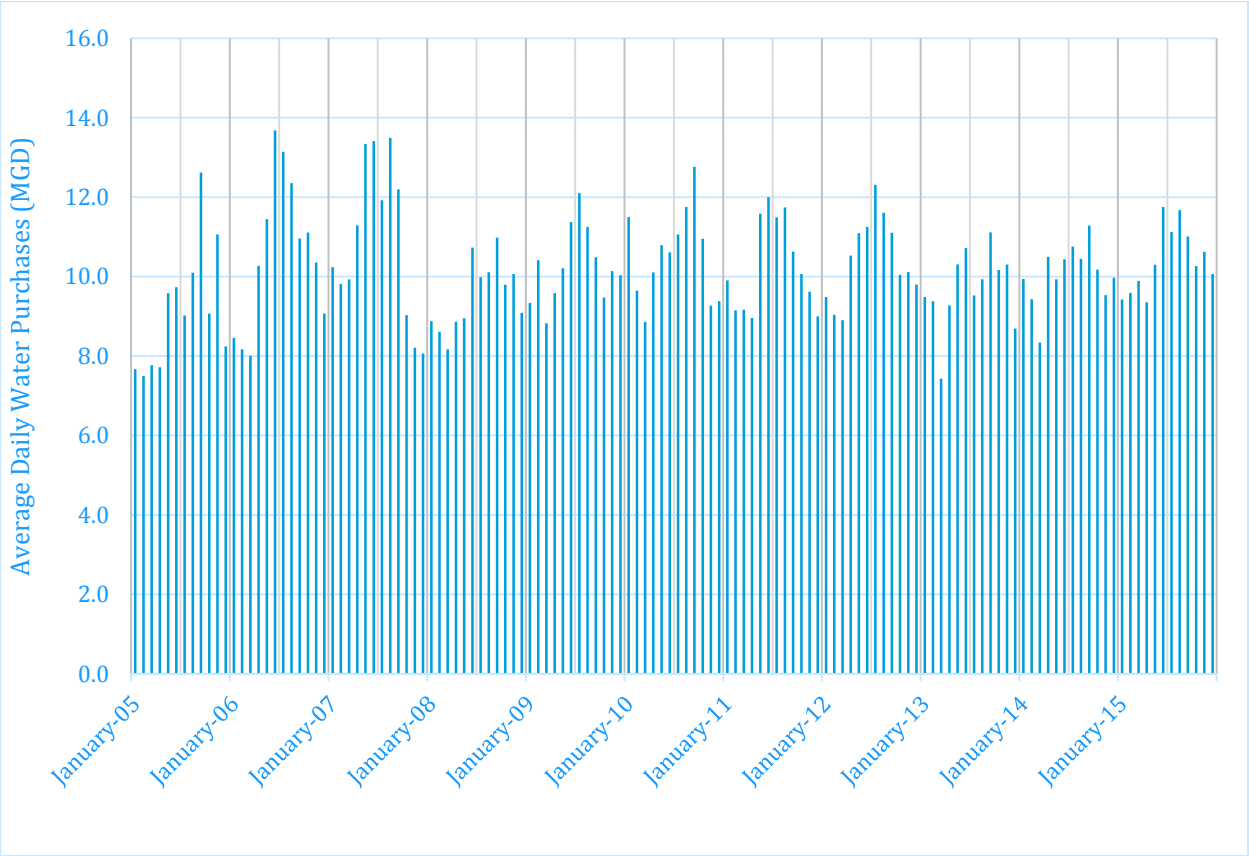
The County historically purchased all of its water from CCMWA and CCWS. Between 2001 and 2015, the County purchased an average of approximately 300 MG of water per month. A chart of the water purchases over this time period is provided in **Figure 3**.

Figure 3: Paulding County – Monthly Water Purchases 2001 – 2015



Over the past decade, the County's water demand averaged approximately 10.2 million gallons per day (MGD) based on monthly purchase records. Water demands were the highest in 2006 and 2007 and have remained lower and relatively constant between 2008 and 2015. A chart showing the average daily water demand based on monthly water purchases is provided in **Figure 4**.

Figure 4: Paulding County – Average Daily Water Demands 2005 – 2015[1]



[1] Based on monthly billing records

The average day demand (ADD) for the water system was calculated based on the above data. However, since only monthly consumption data is available for the County, it was not possible to determine daily or seasonal fluctuations in the water system such as maximum and minimum demand conditions or peak hour flow (PHF). In order to calculate the maximum day demand (MDD), which is the maximum quantity of water used on any one day of the year, it was assumed that the County has a similar factor for MDD:ADD as its wholesale supplier, CCMWA. CCMWA has adopted a factor of 1.55 MDD:ADD which is within the Georgia Environmental Protection Division (EPD) minimum standards for water systems which recommends using a factor between 1.5 and 2.0. A summary of existing demands (ADD and MDD) is provided in **Table 7**.

Table 7: Historical Water Demands

YEAR	ADD (mgd)	MDD[1] (mgd)
2005	9.2	14.2
2006	10.6	16.4
2007	10.9	16.9
2008	9.5	14.8
2009	10.3	15.9
2010	10.6	16.4
2011	10.3	15.9
2012	10.4	16.2
2013	9.7	15.0
2014	10.1	15.6
2015	10.4	16.2
Average	**10.2**	**15.8**

[1] Based on ADD:MDD factor = 1.55

2.2 FUTURE WATER DEMANDS

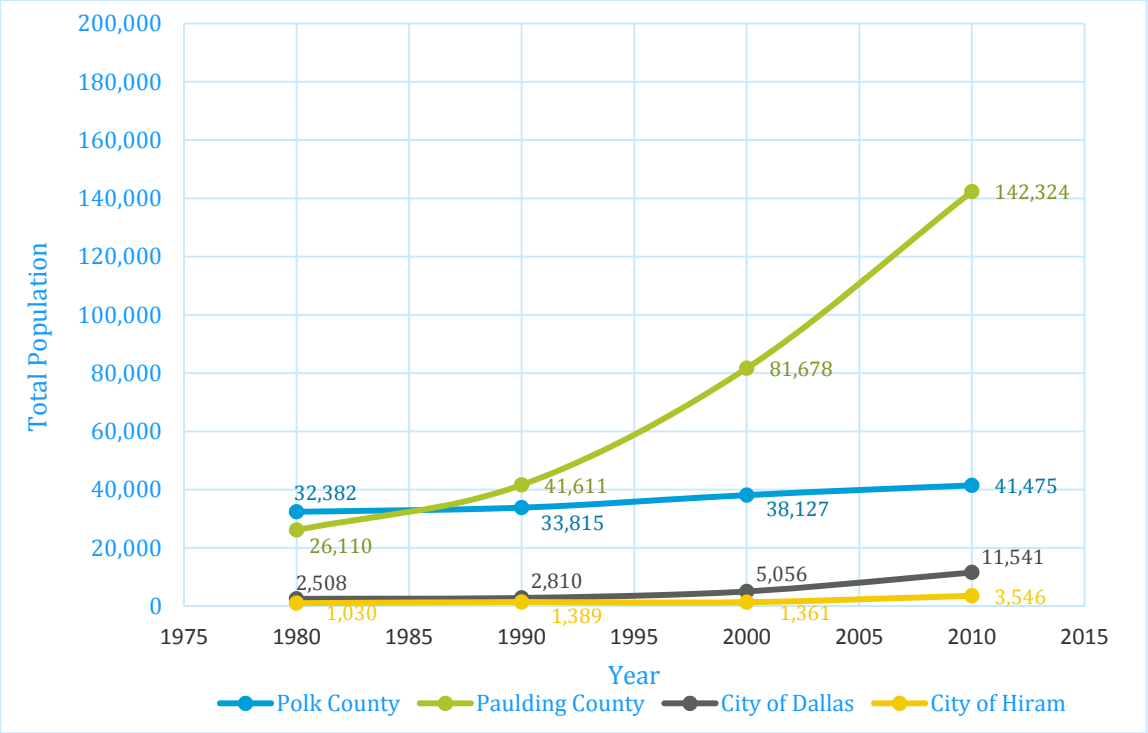
Future water demand forecasts were developed by Tetra Tech in 2015 and provided to Black & Veatch for use during this assignment. The methodology for demand forecasts are summarized in the following section. Forecasts for the water demands in the system were based on historic population and water usage data and regional sources for population and water demand projections. Sources for population and water demand projections included the following:

- United States Census Bureau (Census)
- Atlanta Regional Commission (ARC)
- The State of Georgia Office of Planning and Budget (OPB)
- Metropolitan North Georgia Water Planning District (MNGWPD)
- Paulding County's 2007 – 2027 Comprehensive Plan dated April 26, 2007
- Paulding County's "Water Supply Study and 404 Permit Application, Section 1: Forecast of Water Needs" revised October 2014 for the Richland Creek Reservoir
- Previous master planning forecasts as presented in the "Draft Technical Memorandum 3 – Water Demand Forecasts and Future Year Models" dated April 3, 2013 by RJP Environmental Associates
- Technical Memorandum "Overview of Population Projections for Water System Master Plan" prepared by TetraTech in March 13, 2014

Water demands in the system are dependent on the population and number of customers served and their associated water use. Population is one factor that needs to be considered for forecasting future demands. Historic population data for Paulding County, Polk County and the cities of Dallas

and Hiram were collected from the Census which showed significant growth in Paulding County between 1980 and 2010 as shown in **Figure 5**.

Figure 5: Historic Census Population 1980 – 2010



In September 2015, the MNGWPD prepared a draft of the 2016 Plan which provided water demand forecasts for the County through 2050. The draft MNGWPD forecasts were updated using more conservative projection techniques than the previous 2009 Plan. The 2016 Plan used population forecasts from two regional planning agencies, the ARC and the OPB (See **Figure 6**), combined with historic water usage data with conservation factors such as low-flow fixtures and greater efficiency. Based on input from the County, the MNGWPD updated forecasts were selected for this master plan. These projections were deemed reasonable based on lower growth trends experienced by the system over the past decade. Many systems in the southeast and the rest of the nation are seeing lower water production even as population increases due to greater efficiency in plumbing fixtures and conservation efforts and consumer behavior. Reviewing Paulding County's historic population growth and water demands indicate that this lower water use trend is applicable to the County.

A comparison of the County's historic water usage to the MNGWPD forecasted demands is shown in **Figure 7**. A complete summary of the MNGWPD population and water forecasts by decade is provided in **Table 8**.

Figure 6: Population Forecasts for Paulding County from MNGWPD 2016 Plan

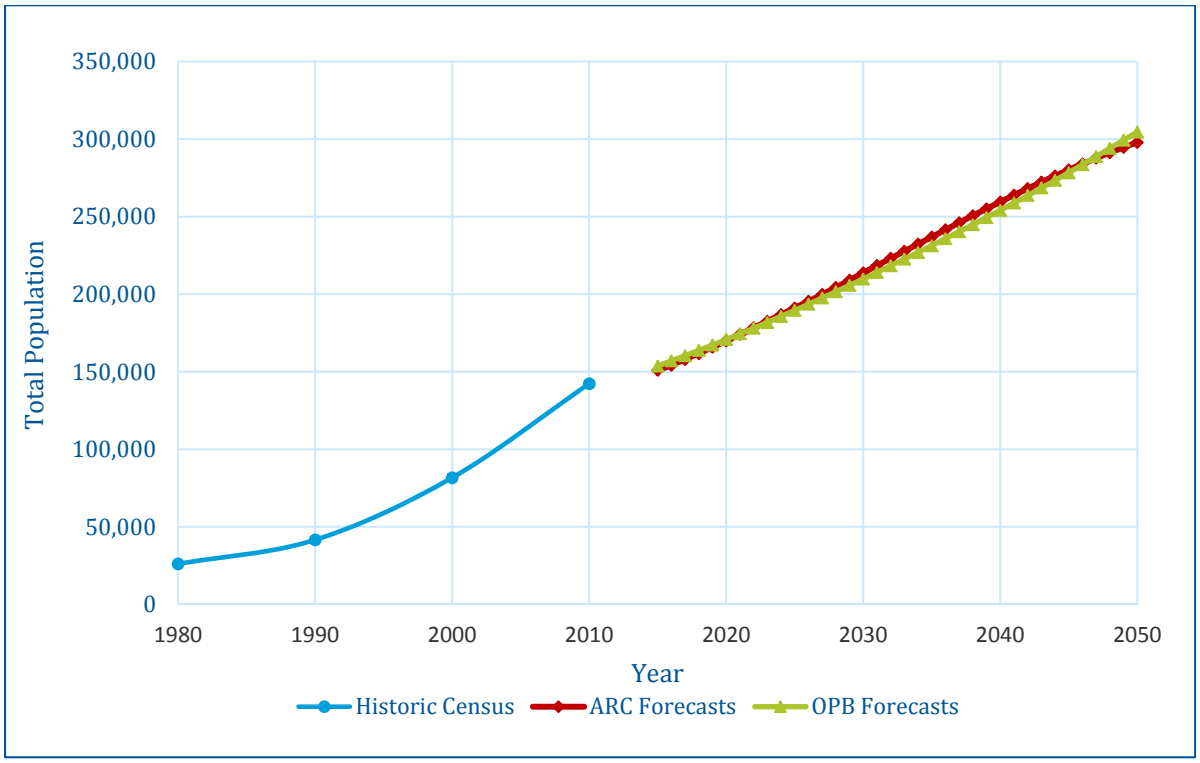
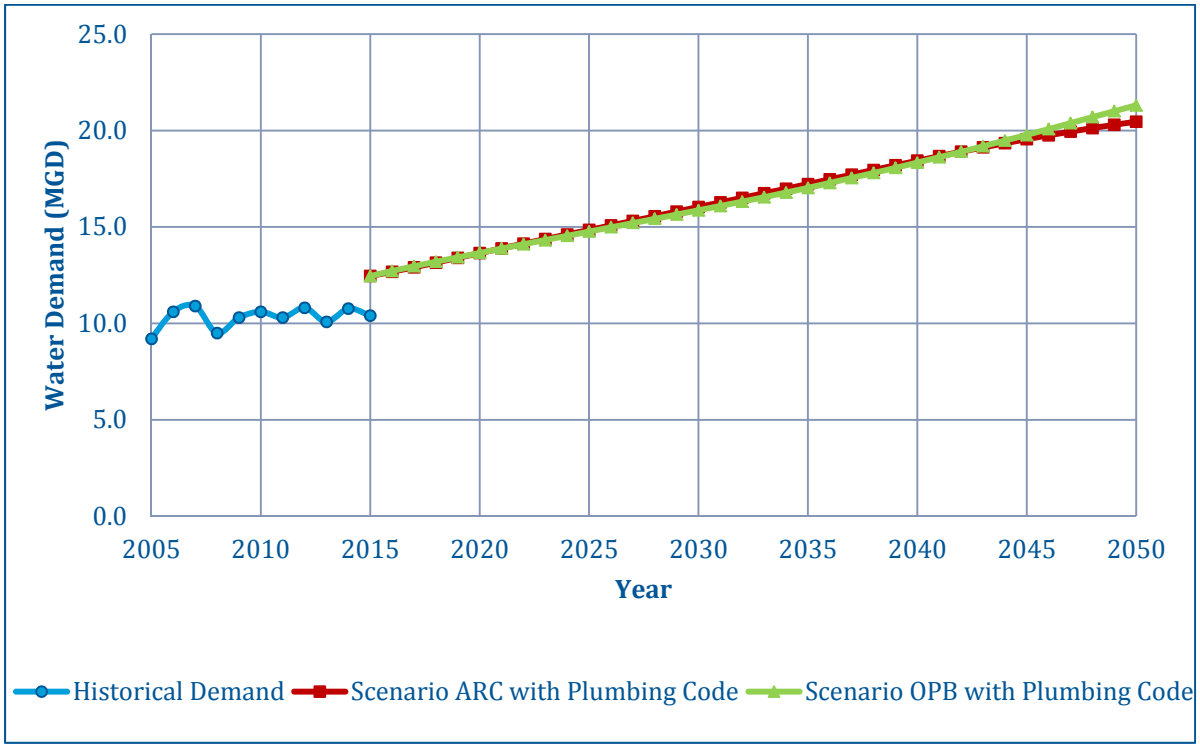


Figure 7: Historic Water Use with MNGWPD Water Demand Forecasts: ADD[1]



[1] Historic ADD calculated from monthly purchase records

Table 8: MNGWPD 2016 Plan Population and Water Demand Forecast Summary

YEAR	COUNTY POPULATION		WATER DEMAND: ADD[1]		WATER DEMAND: MDD[2]	
	OPB	ARC	OPB	ARC	OPB	ARC
2020	170,900	169,950	13.7	13.6	21.2	21.1
2030	209,745	213,899	15.9	16.0	24.6	24.9
2040	253,980	259,524	18.3	18.4	28.4	28.6
2050	304,620	297,885	21.3	20.5	33.0	31.7

[1] Source: MNGWPD Draft 2016 Plan dated September 2015
[2] Calculated for Master Plan using MDD:ADD factor = 1.55

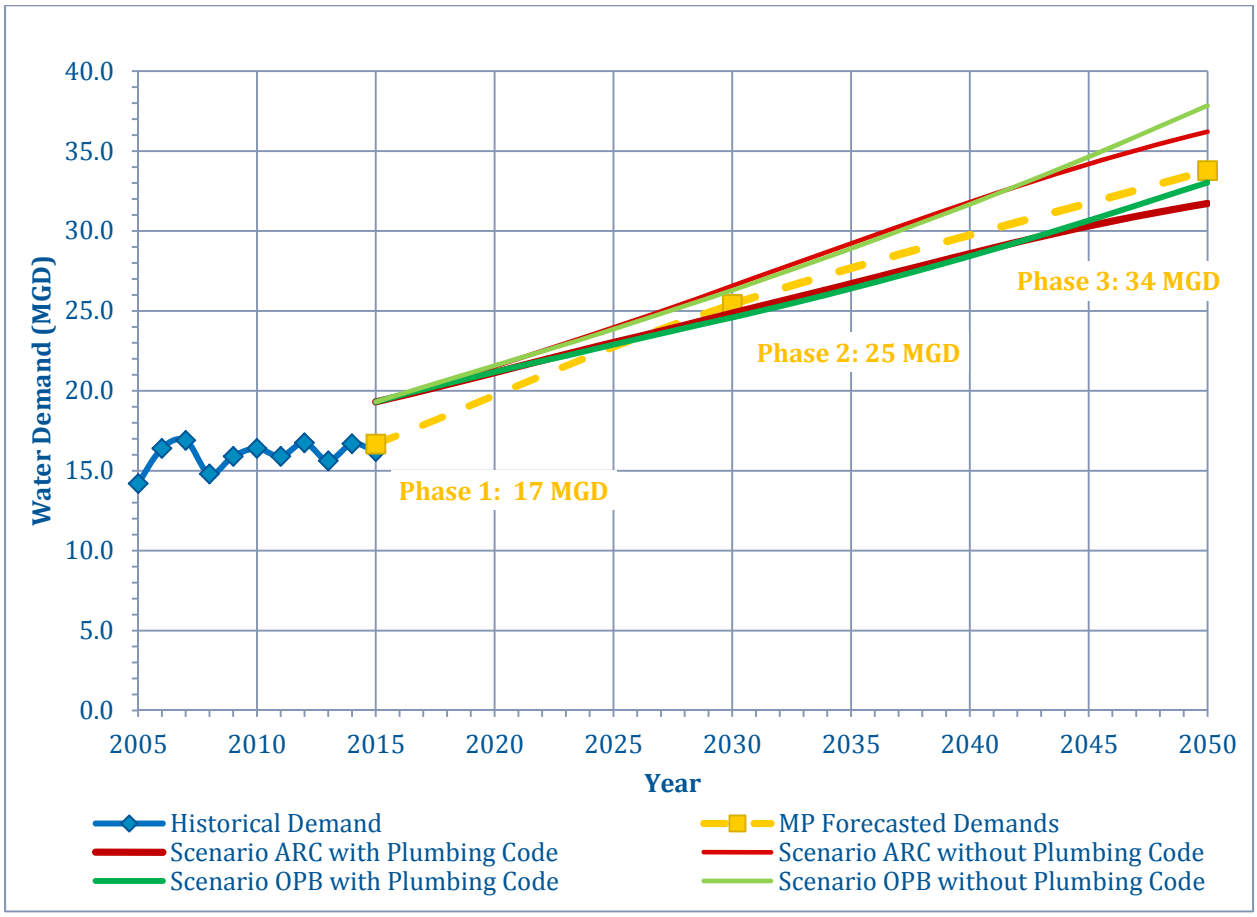
2.3 MASTER PLANNING PHASES

An evaluation was performed of the County's current and future water supplies compared to the master planning phases to align supply with demand and identify the most feasible supply alternative(s) per phase. Three planning phases were selected for the master plan based on historic water use, projected future use, WTP phasing and funding requirements which included the following:

- Short-term: Phase 1 – MDD: 17 MGD
- Mid-term: Phase 2 – MDD: 25 MGD
- Long-Term: Phase 3 – MDD: 34 MGD

Phases were chosen as opposed to planning years to allow the County greater flexibility to plan based on demands whenever they should occur. This approach also allows the County to plan in accordance with the future RCWSP planned water treatment plant capacities. Phase 1 is defined as the current demand conditions at an MDD of 17 MGD. Phase 1 was chosen to evaluate short-term capital improvements. Phase 2 is an intermediate phase between short- and long-term demands with a MDD demand at approximately 25 MGD and was selected to evaluate the mid-term needs of the water system. The third phase, Phase 3, represents the long-term demands in the system at an MDD of 34 MGD. A comparison of the master planning phases to the historic and future demand projections is provided in **Figure 8**. It should be noted that these phases aligned well with the updated MNGWPD forecasts and are similar to the values from the MNGWPD years 2015, 2030 and 2050.

Figure 8: Master Planning Phases, Historic Water Use and Water Demand Forecasts: MDD[1]



[1] Based on ADD:MDD factor 1.55

Reviewing the sequencing of the planned capacity for the Richland Creek WTP coupled with the master planning phases indicated that the initial capacity at the WTP (18 MGD) could supply ADD for Phase 1 and Phase 2, through the GEFA deadline of 2032, as shown in **Figure 9**. As previously discussed in Section 1.2.7, the requirements for the loans provided by GEFA for the RCR and associated infrastructure improvements include a provision that a financial penalty will be incurred if the County has not ceased water purchases, with certain exemptions, by the year 2032. For MDD, the initial capacity of the WTP will be exceeded near the plant startup in year 2019 as shown in **Figure 10**. Therefore, the County will need to implement an alternative water supply in addition to the Richland Creek WTP for planning phases 1 and 2 to meet MDD conditions.

Figure 9: Master Planning Phases Compared to Richland Creek WTP Capacity: ADD

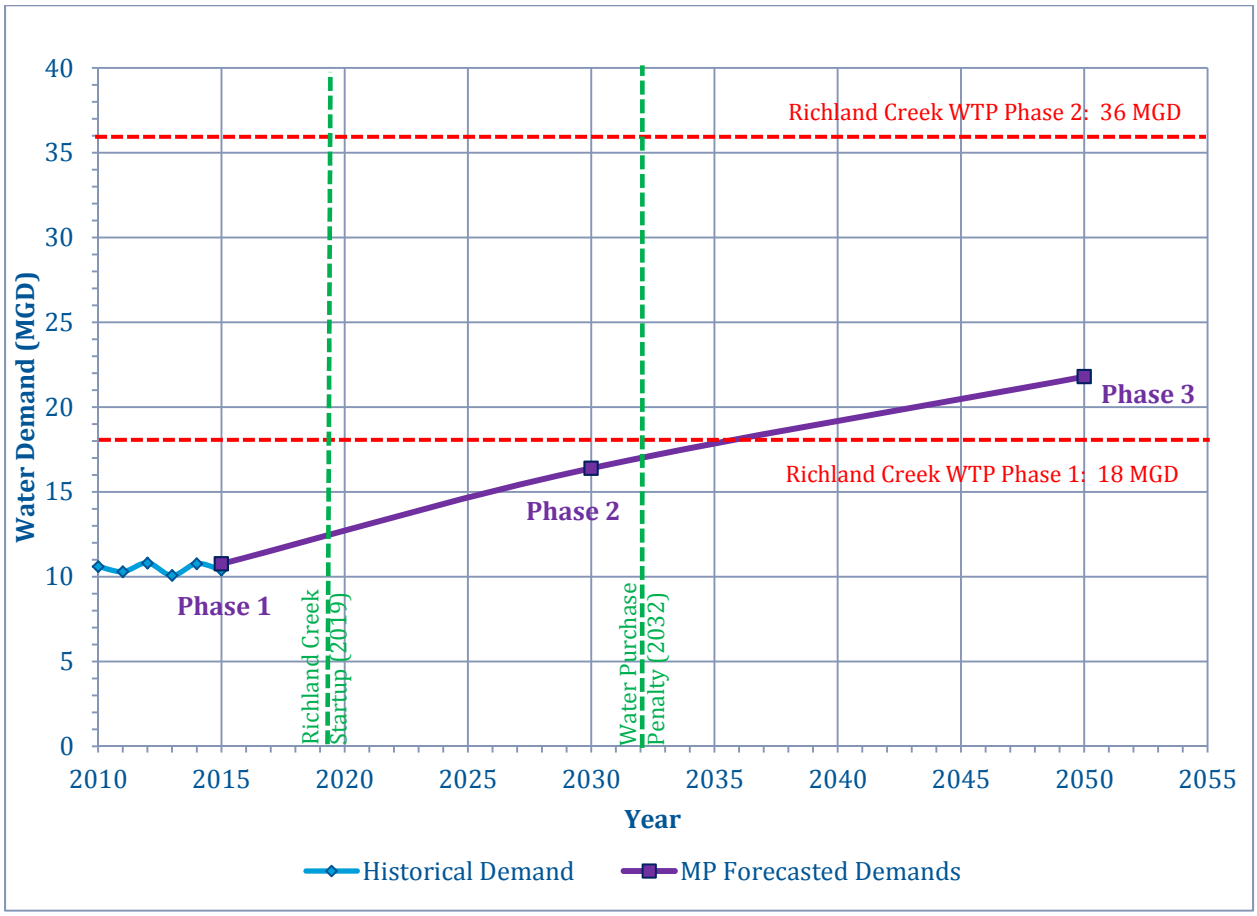
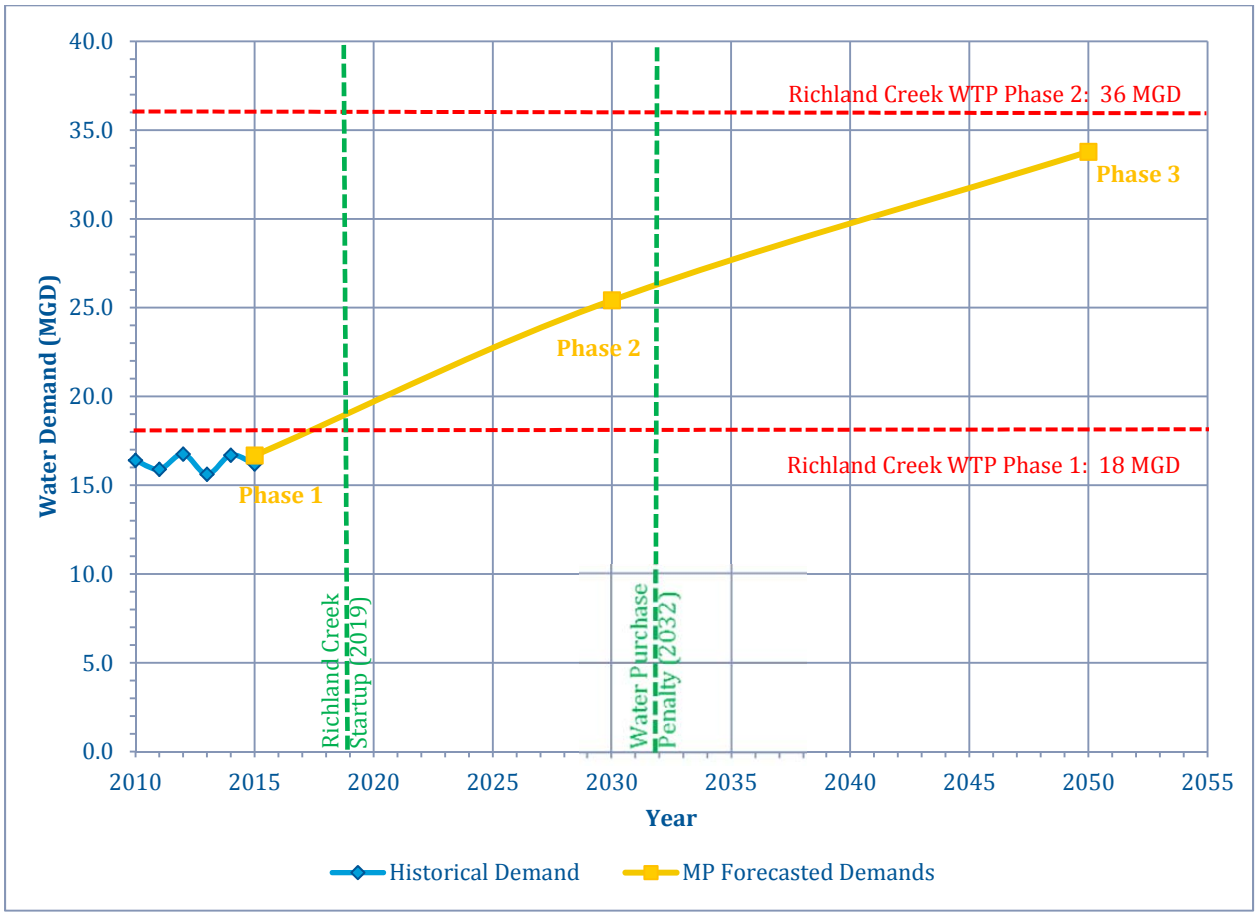


Figure 10: Master Planning Phases Compared to Richland Creek WTP Capacity: MDD[1]



[1] Based on ADD:MDD factor 1.55

3.0 Hydraulic Model Update

The County has a long history of modeling the water distribution system which dates back to 1998 - 1999 when the first water model and master plan were developed. In 2003, the water model was updated and was used to prepare a master plan for the water system. Over the next decade, the model underwent several revisions and used for subsequent studies and evaluations. In 2012, the County started the development of a new hydraulic model using GIS data for the physical system and geocoded water billing records. During 2014 – 2015, TetraTech (Tt) completed an update and calibration of the County's water model. The updated hydraulic model was provided by the County to Black & Veatch to perform system evaluations for the master plan. All modeling work for this project was conducted using Bentley WaterGEMs software.

Based on the work performed by Tt, the existing system model was updated for two time periods, based on available field data, July 2012 and March 2013 as summarized in the technical memo "Paulding County Water System Model Update and Development" dated May 29, 2014.

Previous work conducted by Tt to prepare the updated model included the following steps:

- The distribution system pipe network was updated based on GIS files;
- The system facilities (pumps, tanks and interconnections) were updated and aligned with the current information gathered from the County;
- Demands were spatially allocated using the metered sales and water purchase data;
- Diurnal patterns were assigned in the model based on customer type;
- Existing interconnections were set up based on information provided by CCMWA from their hydraulic model;
- Operational parameters were set up using SCADA records and County Staff input;
- Calibration was performed using pressure recorder, flow meter and SCADA data.

A summary of the demands included in the existing system model provided to Black & Veatch included two time periods, March 2013 and July 2012 is summarized in **Table 9**.

Table 9: Summary of Water Model Demands in the Existing Distribution System Model

CUSTOMER TYPE	WATER DEMANDS	
	MARCH 2013	JULY 2012
	(gpd)	(gpd)
COMMERCIAL	720,000	1,260,000
RESIDENTIAL	6,170,000	7,710,000
NON-REVENUE WATER	1,470,000	1,930,000
WHOLESALE_DALLAS	390,000	640,000
WHOLESALE_POLKCOUNTY	59,400	44,500
IRRIGATION	6,950	N/A[1]
Total	**8,820,000**	**11,580,000**

[1] Irrigation meter records were not available for July 2012.

Diurnal patterns were set up in the model based on customer categories which are summarized in the technical memorandum prepared by TetraTech.

The hydraulic model was also updated for future demands for phase 1 and 2 as further described in **Section 4**.

After the model was updated, it was calibrated using temporary pressure recorder and flow meter data and SCADA records.

4.0 Future Demand Allocation

Future scenarios were built into the model to simulate the projected growth in population and water demands and anticipated changes to water supply sources. This evaluation included adding demands in the system for future planning phases and the addition of the Richland Creek Reservoir and water treatment plant. Future scenarios were developed for each master planning phase as described in the following section.

To perform evaluations necessary for the master plan, the existing system model described in Section 3 was updated for future demand conditions for the three planning phases. The following section describes the process for assigning demands in the future system model.

4.1 PHASE 1: DEMAND ALLOCATION

To build the model for Phase 1 demand conditions, the existing system demands that were spatially allocated using customer records for July 2012 were left in place and were considered the base demands. July 2012 was chosen as the base demands for future conditions since it represented a historic maximum month demand verses March 2013 which was representative of a lower demand month. Future demands were added to the model using the LoadBuilder tool to assign demand to the nearest model junction. Demand allocations for Phase 1 were performed by Tt and reviewed by Black & Veatch.

Future demands for residential, commercial, wholesale and non-revenue water were added into the model using the following approach:

- Phase 1 – MDD: 17 MGD Demands
  - Base demands = July 2012
  - Residential demands:
    - Unoccupied parcels in existing subdivisions which were identified by comparing GIS records for parcels that are platted but did not show a water meter location from spatial data. In total there are 10,750 unoccupied parcels that were assigned a demand of 187.8 gallons per day. The usage rate of 187.8 gpd was calculated based on the County's water sales in July 2012 divided by the total population to get the per capita usage (63.6 gpcd) which was multiplied by 2.95 which is the County's current density per household from the Census.
    - New residential parcels were added to the system based on input provided by the County for anticipated growth areas. The number of potential homes was calculated using the County's future land use map from the 2007 Comprehensive Plan and multiplying the total acreage by the defined future land use category density, which included:
      - Rural Residential = 2 houses per acre
      - Suburban = 3 houses per acre
      - Traditional Neighborhood = 3 houses per acre

      The number of residential homes were applied a demand of 187.8 gpd per unit based on current residential demands and household density.

  - Commercial demands:
    - New commercial customers were identified based on available parcels near existing commercial areas which are mostly along major roadways and intersections. Additional commercial areas were identified with County input. Identified commercial areas were

assigned a water demand at 500 gpd per acre based on the County's typical commercial water use. This commercial usage was calculated by reviewing account data for several existing commercial areas.

- Wholesale demands:
  - City of Dallas demands were increased based on population forecasts for the City using historic census data and a per capita demand of 63.6 gpcd.
  - Polk County demands were increased using an 8% growth rate per planning phase based on the County's growth rate from historic census data.

- Non-Revenue Water: Non-revenue water was assumed at 15% of the total demands which is a slight reduction compared to 20% NRW assumed in the updated hydraulic model for 2012. This reduction reflects improvements and the efforts that the County is implementing to identify and decrease water losses. NRW was distributed uniformly throughout the model as a fixed demand assigned to each model junction.

4.2 PHASE 2: DEMAND ALLOCATION

Phase 2 demands were assigned to the water model using Phase 1 as the base demand and adding additional residential, commercial, wholesale and NRW demands following a similar technique as Phase 1. Once identified, the Phase 2 demands were imported into the model using tools to assign them to the nearest model junction. The steps implemented to identify demands for Phase 2 are presented below. Demand allocations for Phase 2 were performed by Tt and reviewed by Black & Veatch.

- <u>Phase 2 – MDD: 25 MGD Demands</u>
  - Base demands = Phase 1
  - Residential demands:
    - New residential parcels were added to the system based on input provided by the County for anticipated growth areas. The number of potential homes was calculated using the County's future land use map from the 2007 Comprehensive Plan and multiplying the total acreage by the defined future land use category density. The number of residential homes were then applied a demand of 187.8 gpd per unit as noted for Phase 1.

  - Commercial demands:
    - New commercial customers were identified based on available parcels near existing/future Phase 1 commercial areas and assigned a water demand at 500 gpd per acre similar to Phase 1.

  - Wholesale demands:
    - City of Dallas demands were increased for Phase 2 based on population forecasts for the City using historic census data and a per capita demand of 63.6 gpcd.
    - Polk County demands were increased 8% between Phase 1 and Phase 2 based on Polk County's historic growth rate.

- Non-Revenue Water: Non-revenue water was assumed at 15% similar to Phase 1. NRW was distributed uniformly throughout the model as a fixed demand assigned to each model junction.

4.3 PHASE 3: DEMAND ALLOCATION

Future demand allocation for Phase 3 was performed by Black & Veatch using a similar technique as allocations for Phase 1 and 2. A summary of this process is provided below.

- Phase 3 – MDD: 34 MGD Demands
  - Base demands = Phase 2
  - Residential demands:
    - New residential parcels were added to the system based on input provided by the County for anticipated long-term growth areas. The number of potential homes was calculated using the County's future land use map from the Comprehensive Plan and multiplying the total acreage by the defined future land use category density. The number of residential homes were then applied a demand of 187.8 gpd per unit as noted for Phase 1 and 2.

  - Commercial demands:
    - New commercial customers were identified based on available parcels near existing/future Phase 1 and 2 commercial areas and assigned a water demand at 500 gpd per acre similar to previous phases.

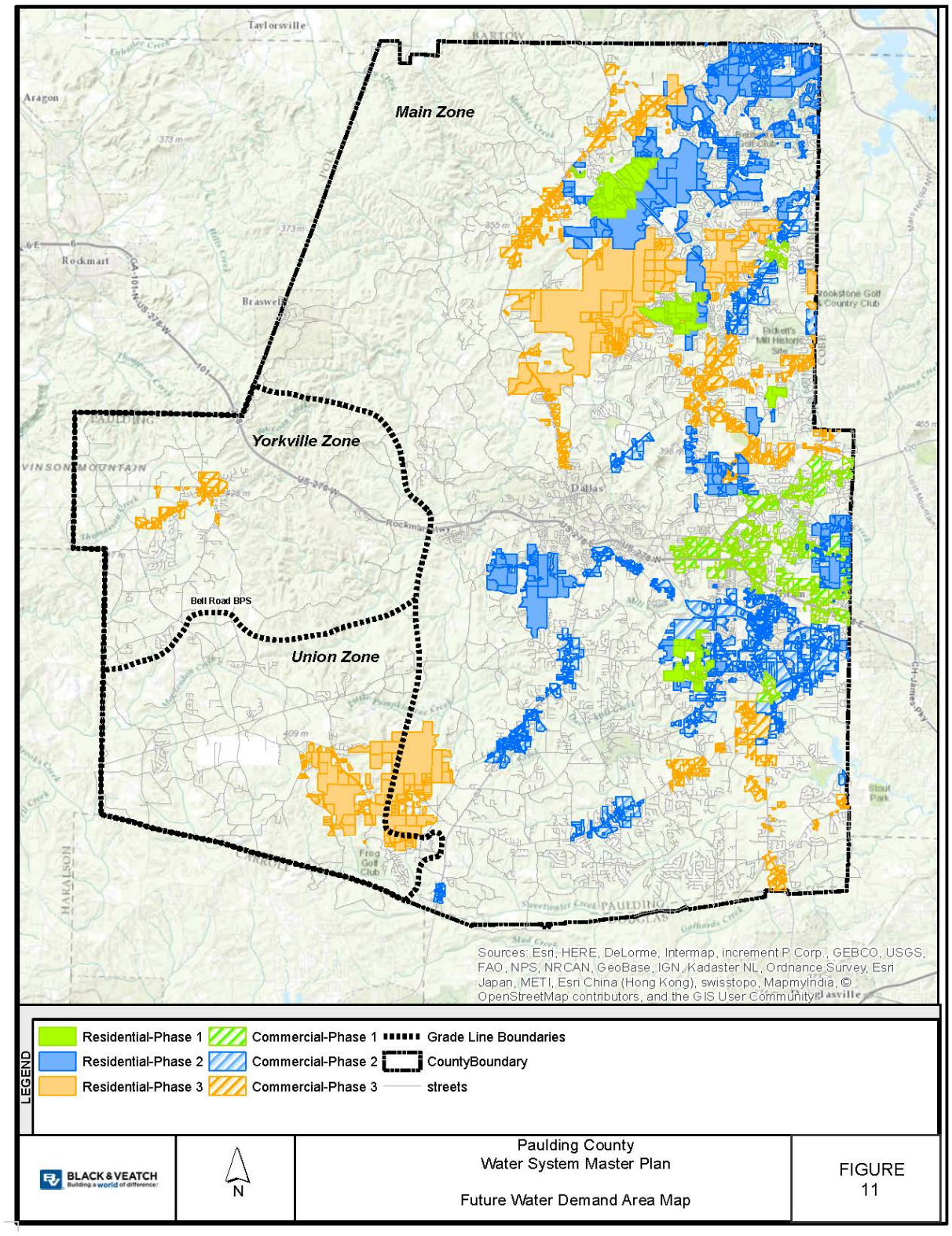
  - Wholesale demands:
    - City of Dallas demands were increased for Phase 3 based on population forecasts for the City using historic census data and a per capita demand of 63.6 gpcd.
    - Polk County demands were increased 8% between Phase 2 and Phase 3 based on Polk County's historic growth rate.

  - Non-Revenue Water: Non-revenue water was assumed at 15% similar to Phase 1 and 2. NRW was distributed uniformly throughout the model as a fixed demand assigned to each model junction.

Phase 3 demands were imported into the updated existing system model and assigned to the nearest junction. Total Phase 3 demands by customer category are provided in **Table 10**.

The future residential and commercial customer areas used to assign demands for each planning phase are presented in **Figure 11**.

Figure 11: Future Water Demand Area Map



A summary of the future water demands by phase is presented in **Table 10** below.

Table 10: Future Water Demand Summary

CUSTOMER TYPE	EXISTING WATER DEMANDS (MMD)	FUTURE WATER DEMANDS (MDD)		
	JULY 2012	PHASE 1	PHASE 2	PHASE 3
	(gpd)	(gpd)	(gpd)	(gpd)
COMMERCIAL	1,260,000	2,590,000	5,450,000	7,620,000
RESIDENTIAL	7,710,000	10,620,000	14,830,000	19,280,000
NON-REVENUE WATER	1,930,000	2,550,000	3,900,000	5,250,000
WHOLESALE_DALLAS	640,000	840,000	1,170,000	1,520,000
WHOLESALE_POLKCOUNTY	44,500	64,100	69,300	74,800
Total	**11,580,000**	**16,670,000**	**25,420,000**	**33,750,000**

5.0 System Analysis and Recommendations

Hydraulic capacity analyses were performed using the existing (2012) and future (Phase 1, 2 and 3) demand conditions in order to identify deficiencies in the existing system and to serve as the basis for identifying and sizing recommended system improvements into the future. Deficiencies were identified using the established level of service (LOS) criteria developed for the master plan project under each model scenario as presented in the following section.

5.1 SUMMARY OF ANALYSES

The following list summarizes the system analyses that were performed to identify deficiencies and recommended improvements for the water system. Each analysis included an EPS for ADD, MDD and MDD + Fire Flows.

- Existing System Evaluation – July 2012 – MMD - 11.5 MGD
- Phase 1 Evaluation – MDD – 17 MGD
- Phase 2 Evaluation – MDD – 25 MGD
- Phase 3 Evaluation – MDD – 34 MGD

5.2 SYSTEM EVALUATION CRITERIA

Criteria were developed to serve as the benchmark for evaluating the water system performance under each scenario. These criteria are based on local, state and federal requirements for water systems and include the LOS goals identified by the County. Items addressed included water supply, pumping, storage, pressure, piping and emergencies as defined in **Table 11**.

Table 11: Water System Evaluation Criteria

CRITERIA	DESCRIPTION
Water Supply	
Water Production/Wholesale Supply	Meet or exceed 100% MDD
Pump Stations	
Pump Station Capacity	Design capacity with the largest pump out of service
Booster Pump Stations	Must be sized for Peak Hour Demand (PHD) with largest pump out of service
Storage Criteria	
Overall System Storage Capacity	Must provide adequate flow and pressure at peak demands as well as fire flows and should have similar or greater volume % to ADD as existing system (i.e. 50% or greater of ADD)
Drafting and Filling Cycles	Tanks filling 100% and drafting approximately 50% every 24 hours
Pressures	
Acceptable Normal Operating Pressures[1]	35-150 psi
Pipe Criteria	
Acceptable Pipe Velocities	Maximum Pipe Velocity < 7 ft./s under MDD conditions
Pipe Sizing	Must be sized to handle maximum-hour flow
Emergency Criteria	
Fire Protection[2]	Flow Requirements: (evaluated at peak hour on MDD conditions with 20 psi residual pressure) - Residential = 500 gpm for 2 hours - Commercial/Industrial = 1,000 gpm for 2 hours

[1] Minimum pressure per GA EPD "Minimum Standards for Public Water Systems", May 2000.
[2] Fire flow per Paulding County's Development Regulations, Amended August 10, 2010

5.3 EXISTING SYSTEM MODEL ANALYSIS

The existing water system was evaluated to identify areas in the system that did not meet the defined criteria as presented in **Table 11** above. The model was simulated under July 2012 demands to determine how well the system performed during current maximum demand condition. Overall, the majority of the system showed favorable results for supply, pumping, storage and piping while some deficiencies were noted for system pressure and fire protection as summarized in the following sections.

5.3.1 Existing System Results

A visual representation of minimum and maximum system pressures and fire flows (500 gpm and 1,000 gpm) as simulated by the hydraulic model is provided in Figures 12- 15 on the following pages.

Key observations from this analysis are provided below.

- The majority of the existing system is able to meet the minimum pressure criteria (35 psi) except for high elevation areas in the Main pressure zone near Mt. Tabor Church Road and on the suction side of a few BPSs. (See Figure 12)
- The minimum pressure in the Mt. Tabor Church Road area of the system was observed to be less than 20 psi. Low pressures were confirmed by the County based on complaints from existing system customers.
- High pressures (greater than 150 psi) were noted throughout the northern half of the Main pressure zone and a small area of the Union and Yorkville pressure zones. (See Figure 13)
- The residential fire flow criterion of 500 gpm was met throughout the majority of the water system except for areas in the Union pressure zone. (See Figure 14)
- The commercial fire flow criterion of 1,000 gpm was met at the majority of the identified commercial customers locations tested in the model. (See Figure 15)

Existing System: Pressure Results

Based on the results of the updated/calibrated hydraulic model, the existing water system showed a few areas that did not meet the minimum pressure required of 35 psi. Several areas with pressures below 35 psi were noted along Mt. Tabor Church Road and East Paulding Drive northeast of the Macland Road Storage Tank. These low pressures are the result of the high elevations in the Mt. Tabor Church Road area. Several existing subdivisions in the Mt. Tabor area have booster pump stations to compensate for low pressure though there are still a large number of customers outside of these subdivisions that have low pressure. Additional low pressure areas in the system were shown on the suction side of several booster pump stations (Bell Road, Union and Hwy 61). **Figure 12** presents the model results for the existing system with junctions less than 35 psi indicated in red.

The existing water system was also evaluated to identify areas in the system that did not meet maximum pressure criteria at 150 psi. Due to the hilly terrain in Paulding County, there are several low elevation areas in the system which experience high pressures. High pressure areas over 150 psi are spread throughout the County with the highest concentrations in the northern half of the Main Zone, near The Georgian in the southeast corner of the Union Zone and the western and eastern portions of the Yorkville Zone. As previously described in Section 1, the County's existing PRVs which were installed in several subdivisions in the northeast corner of the County were included in the model and represented in the model results. The maximum pressure results for the existing system are provided in **Figure 13**.

Existing System: Fire Flow Results

To evaluate fire flows in the system, a simulation for maximum demand conditions (peak hour for July 2012) with the storage tanks half full to represent the desired emergency condition was conducted. Based on County's fire flow criteria per the 2010 Development Regulations, the required fire flows were 500 gpm for residential customers and 1,000 gpm for commercial

customers with a minimum residual pressure requirement of 20 psi. To conduct this analysis, a fire flow simulation was set up in the model to test every junction for a fire flow of 500 gpm, then a separate simulation to test fire flows at a flow of 1,000 gpm at junctions that had commercial demands. The results of this evaluation showed that the majority of the system could meet the fire flow criteria except for an area in the Union Zone along Hwy 101. **Figure 14** and **15** shows the existing system results for both residential and commercial fire flow scenarios.

Figure 12: Existing Water System: Minimum Pressure Results

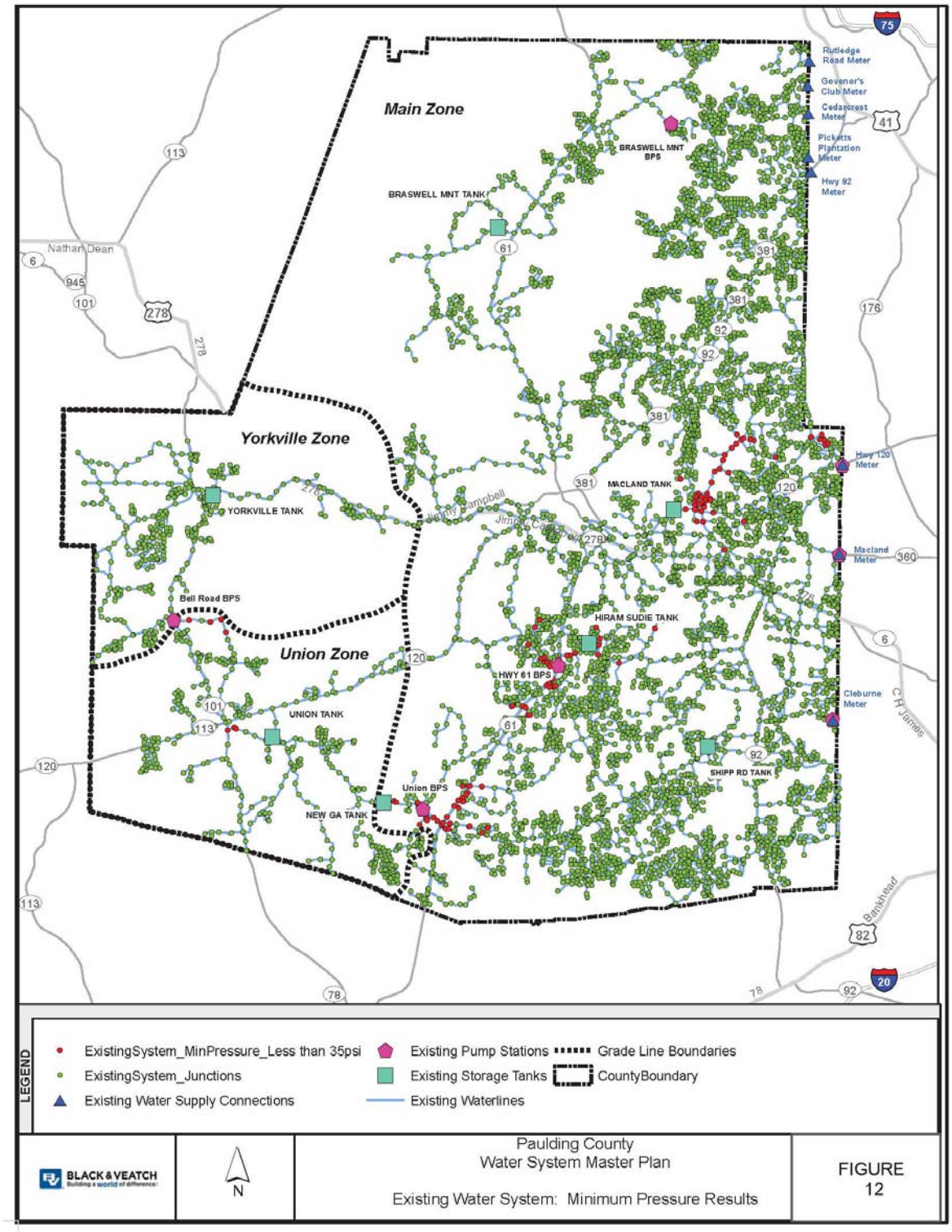
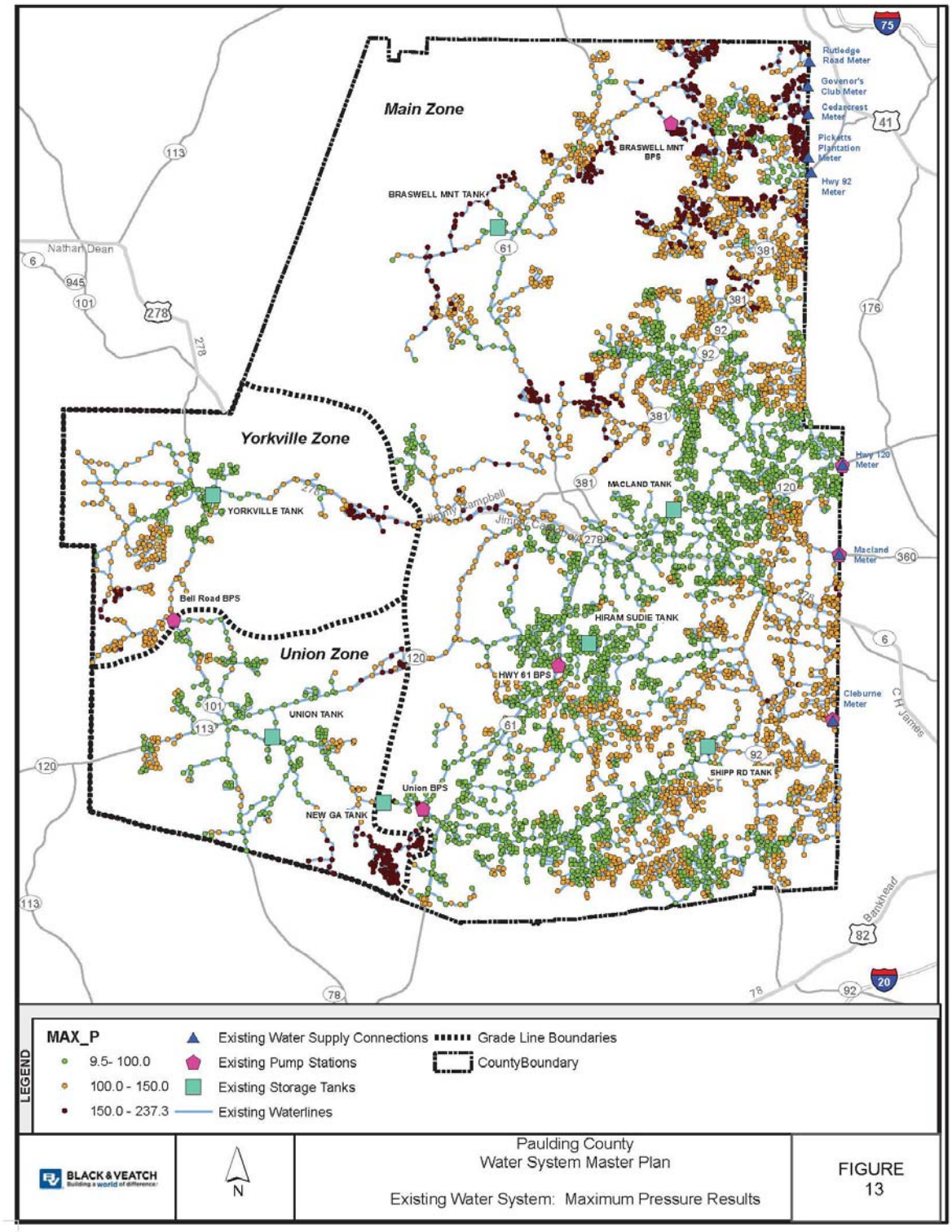


Figure 13: Existing Water System: Maximum Pressure Results[1]



[1] Results include the County's existing PRVs in northern subdivisions that were installed in 2013.

Figure 14: Existing Water System: Fire Flow Results – FF=500 gpm

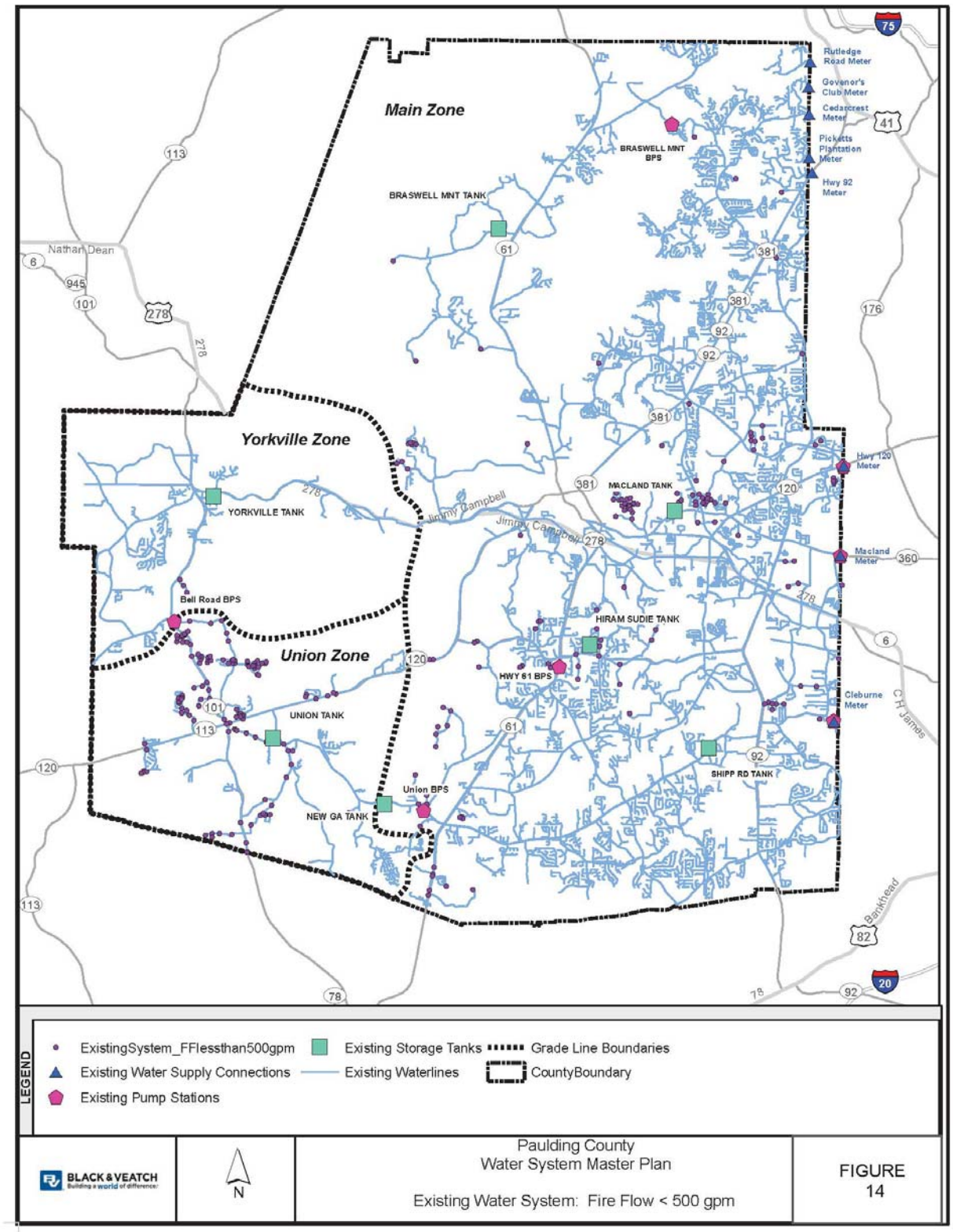
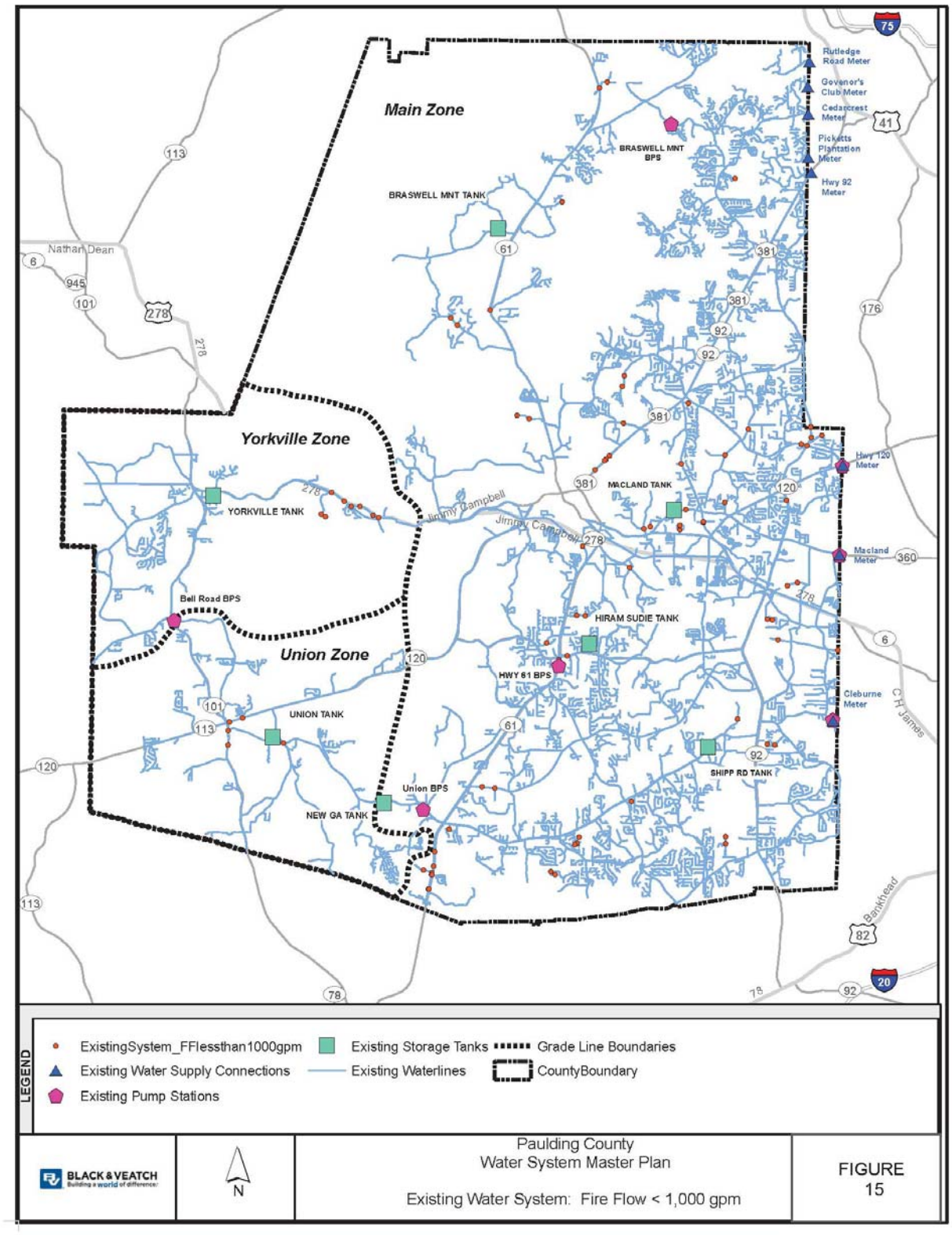


Figure 15: Existing Water System: Fire Flow Results – FF=1,000 gpm[1]



[1] Tested at model junctions with commercial demands

5.4 FUTURE SYSTEM MODEL ANALYSIS AND RECOMMENDATIONS

The future system model was evaluated to determine deficiencies and select improvement alternatives based on the defined water system criteria. This was performed for all three master planning phases 1, 2 and 3. For each phase, the model was simulated for ADD, MDD and Fire Flows. A discussion of the evaluation and results for each phase is presented in the following section.

5.4.1 Phase 1: Evaluation and Recommendations

The model was used to perform EPS for future Phase 1 demand conditions. The system was reviewed for supply, pressure, pumping, storage, piping and emergency criteria. A summary of each of these is provided below.

Water Supply

The water supply for Phase 1 includes both the future Richland Creek WTP and interconnections with CCMWA and CCWS. During Phase 1, the Richland Creek WTP will have a maximum capacity of 18 MGD based on current design plans. The high service pump station is being designed with VFDs set to a constant discharge pressure. The existing interconnections with CCWS at Picketts Plantation and Rutledge Road remained open in the model based on current HGL information provided by CCMWA for the existing system model. Existing interconnections with CCMWA were tested in the model to determine the optimum interconnections to remain in service.

During Phase 1 ADD, it is recommended that the County keep the Cleburne Parkway BPS in service to serve the storage tanks in the southern part of the Main Zone. Under Phase 1 MDD, it is recommended that the County have both the Hwy 92 and the Cleburne Parkway BPS interconnections in service. The Hwy 92 interconnection is necessary to maintain pressures on the northeast side of the system and Cleburne Parkway is needed to maintain the southern storage tanks. A summary of the recommended interconnections includes the following:

- CCWS: Picketts Plantation and Rutledge Road
- CCMWA: Cleburne BPS (ADD and MDD) and Hwy 92 (MDD)

The recommended HGL setting for the future Richland Creek WTP high service pump station (HSPS) for Phase 1 are presented in **Table 12** below.

Table 12: Phase 1: Recommended HGL supplied by the Future Richland Creek WTP

SCENARIO	SYSTEM DEMAND (MGD)	RICHLAND WTP HGL (ft)
ADD[1]	11	1,260
MDD[2]	17	1,265

[1] Includes CCMWA Cleburne Parkway BPS interconnection
[2] Includes CCMWA Hwy 92 and Cleburne Parkway BPS interconnections

Pumping

Pumping requirements for the system were evaluated during the master plan for Phase 1. This included removing the Braswell Mountain BPS which will no longer be in service once the Richland

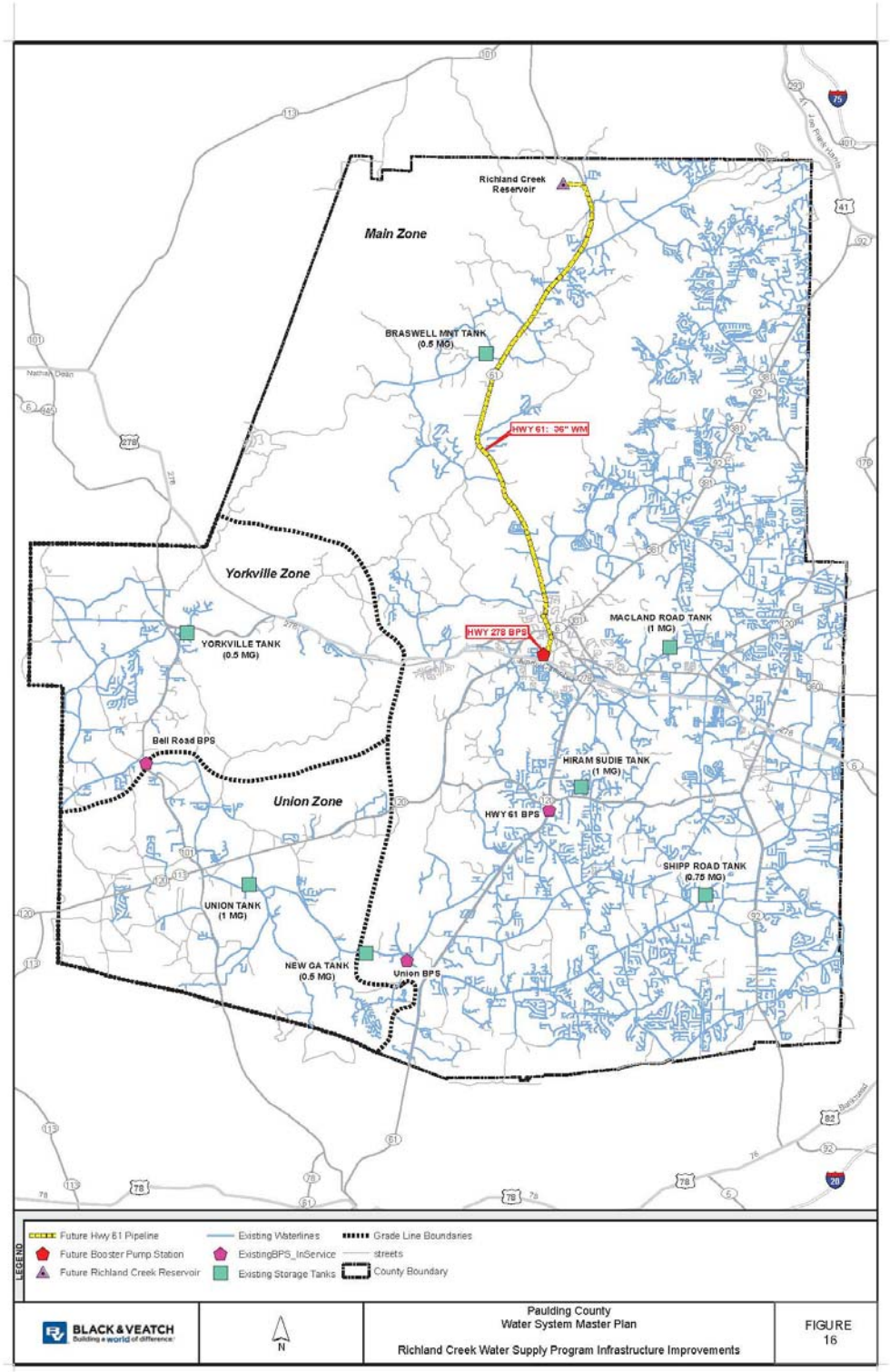
Creek WTP comes online. It also included adding a new BPS on Hwy 278 which is part of the County's RCWSP and will be located near Hwy 278 and Bethel Avenue. The Hwy 278 BPS is planned to be in service before the Richland WTP comes online in 2019. All future system models, including Phase 1, included the Hwy 278 BPS. The approximate location of this station is provided in **Figure 16** which illustrates the infrastructure improvements that are part of the RCWSP.

The future Hwy 278 BPS was reviewed under Phase 1 conditions and it is recommended that the pumps operate near a design point of 9,700 gpm @ 125 ft. The future Hwy 278 BPS will be operated based primarily on the level in the Macland storage tank and alternatively could be operated based on levels in the Hiram Sudie storage tank. Allowing the Hwy 278 BPS to be operated by either of these tanks is similar to how the County operates the existing Macland and Hwy 120 BPSs.

Additionally a new pump station will be required for the recommended Mt. Tabor pressure zone which is later described in this section. As a cost effective option, it is recommended that the County retrofit the existing Cowboy Trail subdivision booster pump station which is located on Cowboy Path near Macland Road. The building will be reused with the pumps and discharge piping being replaced and upgraded. For Phase 1 conditions, it is recommended that this pump operates near a design point of 700 gpm @ 90 ft. This pump station will be operated based on the level in the future Mt. Tabor storage tank. It should be noted that the station should be equipped with a pump to meet emergency fire flow criteria for 1,000 gpm. A summary of pump station recommendations for Phase 1 include:

- Existing Braswell Mt. BPS decommissioned
- Existing Hwy 61, Union and Bell Road BPSs remain in service
- Existing boundary BPS at Cleburne Parkway remains in service
- Existing boundary BPSs at Hwy 120 and Macland Road remain in service but only to serve as emergency connections
- New Hwy 278 BPS at an approximate capacity of 9,700 gpm @ 125 ft. TDH
- New Mt. Tabor BPS at an approximate capacity of 700 gpm @ 90 ft. TDH and additional pumping capacity required to meet commercial fire flows at 1,000 gpm.

Figure 16: Richland Creek Water Supply Program: Future Infrastructure Improvements



Storage

Storage evaluations were performed based on the system criteria established for this project and included the 4 MG of system storage that will be provided at the Richland Creek WTP clearwell. Based on the age and condition of the County's existing Shipp Road storage tank, it should be removed from service in the short-term. A study performed by Atkins in April 2011 evaluated the condition and rehabilitation options for the Shipp Road tank and recommended that it be removed from service due to the tank's age (+50 years), above average height (179 ft), hazardous materials in the existing interior and exterior coatings and non-typical aluminum roof. A new tank to replace the Shipp Road tank was evaluated near the current tank location on Ridge Road. A tank site near the intersection of Dallas Nebo Road and Ridge Road was selected and referred to as the Ridge Road storage tank. Based on system pressures, flow equalization and emergency conditions, it is recommended that the County construct this tank at 1.5 MG. The Ridge Road tank will be located at a ground elevation of approximately 1,110 ft. resulting in a height of 150 ft. verses 179 ft. for the existing Shipp Road storage tank. A proximity map showing the potential Ridge Road tank location, contours and parcel boundaries is provided in **Figure 17**.

It is also recommended that the County build a new storage tank for the Mt. Tabor pressure zone which is further described later in this section. The most practical option for a tank in the Mt. Tabor Zone is at the County's existing Mt. Tabor storage tank site. The existing Mt. Tabor tank is a ground tank that is currently out of service and will need to be demolished. The future Mt. Tabor tank will be an elevated tank at a ground elevation of approximately 1,194 ft. and an overflow elevation of approximately 1,340 ft. The total future tank height will be close to 150 ft. A proximity map showing the potential Mt. Tabor tank location at the existing tank site with contours and parcel boundaries is provided in **Figure 18**.

A summary of the tank recommendations for Phase 1 include:

- Existing Shipp Road Tank decommissioned
- New Ridge Road Storage Tank at 1.5 MG
- New Mt. Tabor Tank at 0.5 MG

With the additional storage improvements listed above, the total system storage will increase from the existing 4.75 MG to 6.5 MG. Including the 4 MG of storage designated for the system in the future Richland Creek WTP clearwell, total storage in the system for Phase 1 is approximately 10.5 MG or approximately 98% of the projected ADD, which meets the established storage criteria of 50%.

Model results for Phase 1 storage tanks under ADD and MDD conditions are included in **Appendix D**.

Figure 17: Phase 1 – Future Ridge Road Tank Location

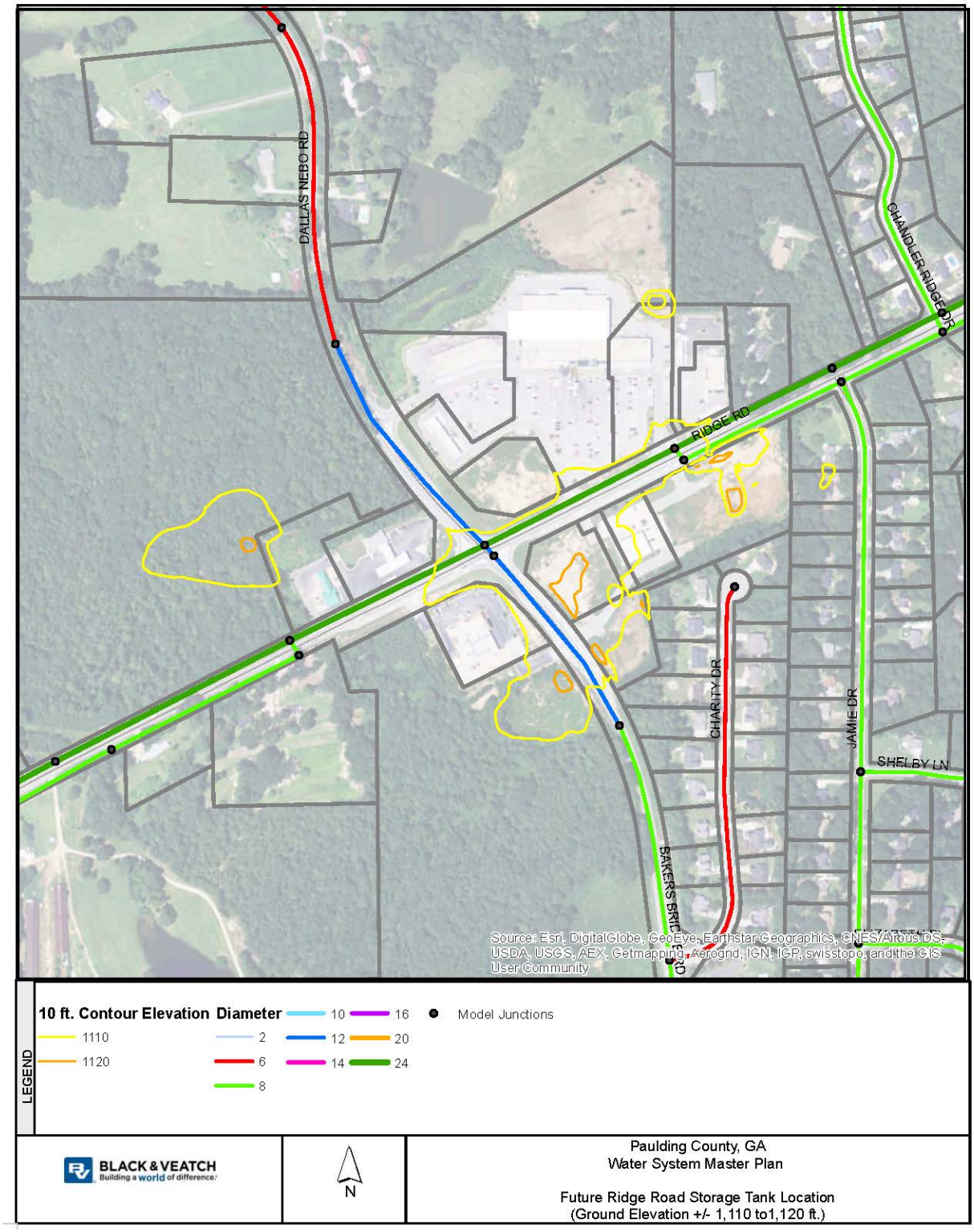
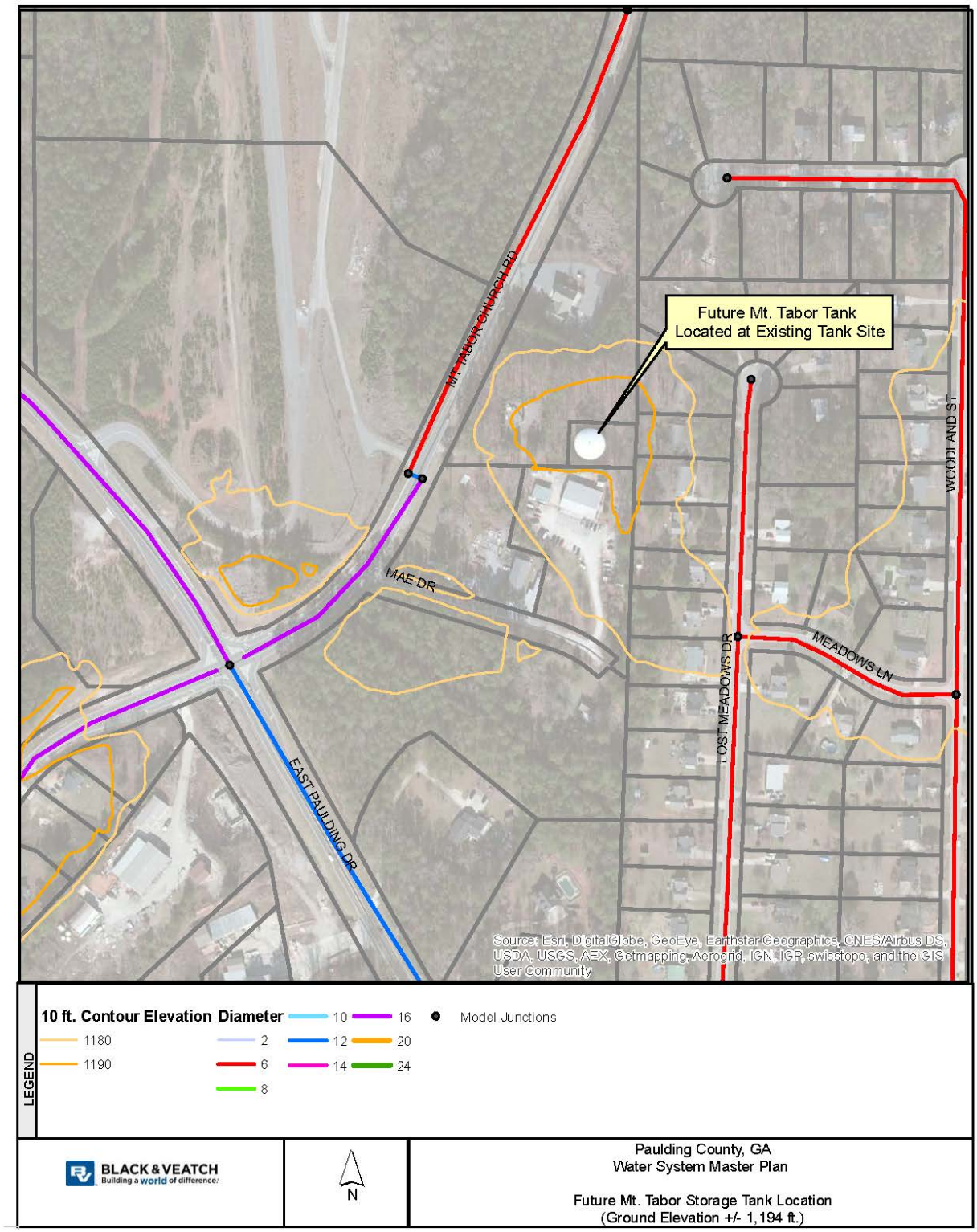


Figure 18: Phase 1 – Future Mt. Tabor Tank Location



Pressures

Pressures in the system were evaluated in the model and compared to existing system conditions to identify necessary improvements to augment existing and future high and low pressures.

Based on low pressures (below 35 psi) noted in the existing water system near Macland and Mt. Tabor Church Road, it is recommended that the Phase 1 improvements include a new pressure zone, referred to as the Mt. Tabor Pressure Zone. The Mt. Tabor Pressure Zone was previously evaluated by TetraTech in 2015 and a summary technical memorandum of this evaluation was dated August 24, 2015. Black & Veatch reviewed this technical memorandum and the used the future system model to update recommendations for the Mt. Tabor Zone. Low pressures noted in this area under existing conditions did not improve under future conditions which further drove the need for this pressure zone. The new analysis included expanding the zone further to the east which was necessary to increase low pressures along East Paulding Drive.

This zone includes some of the highest elevations in the current Main pressure zone and low pressures are the result of high ground elevations. The County's topographic data was reviewed to delineate the pressure zone boundary and incorporate as many of the existing customers with low pressure as feasible. This pressure zone will cover roughly 3,400 acres or 5.2 square miles with an approximate zone boundary shown in **Figure 19**.

Based on geocoded billing data, the County currently serves over 1,000 water customers in the Mt. Tabor Pressure Zone with the majority being residential customers. There are also several commercial/governmental customers including the C. A. Roberts Elementary School located on Mt. Tabor Church Road, a large retirement community named Amberly on Macland Road, East Paulding High School on E. Paulding Drive, Wal-Mart Super Center near Hwy 120 and the new County Water System building currently under design on Macland Road. Existing large customers in the Mt. Tabor Zone are included in **Figure 19**.

The hydraulic model was used to evaluate the recommended improvements including different alternatives for pumping, piping and storage in accordance with the system criteria identified in **Table 11**. The recommended system improvements for the Mt. Tabor pressure zone are provided in **Figure 20**.

Figure 19: Phase 1 – Mt. Tabor Pressure Zone Boundary

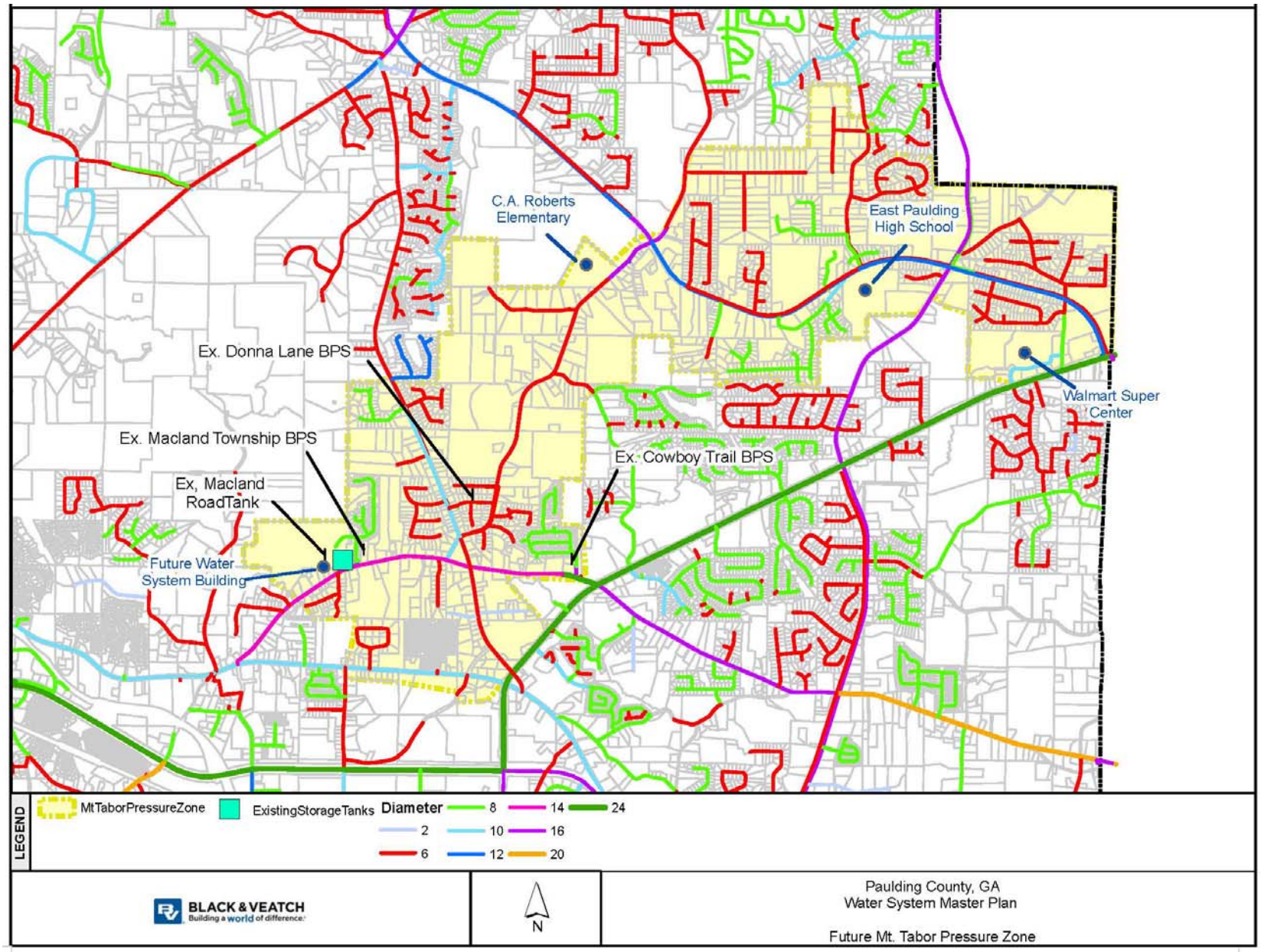
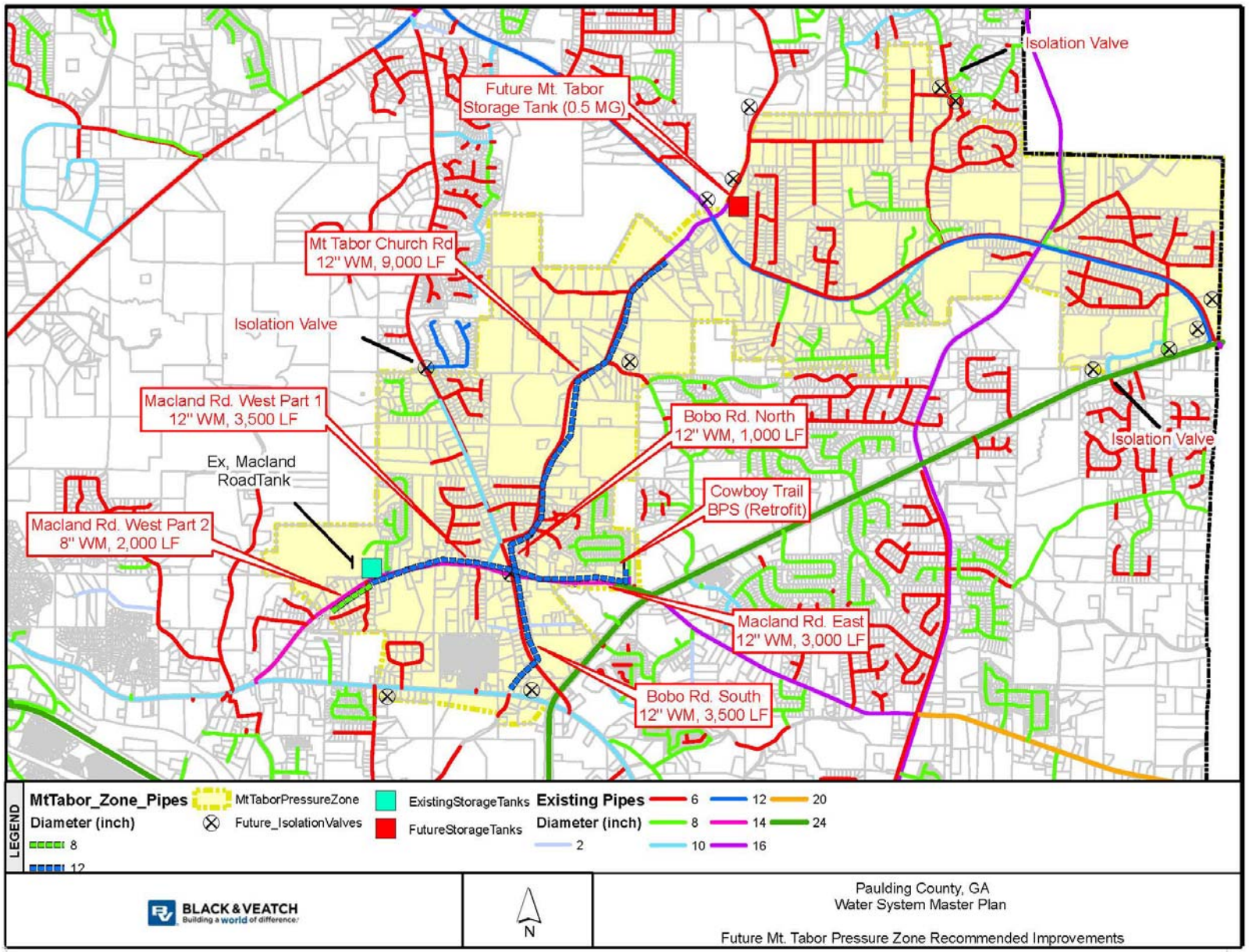


Figure 20: Phase 1 – Mt. Tabor Pressure Zone Recommended Improvements



Piping

A new finished water pipeline will be installed as part of the GEFA funded improvements for the RCWSP. The finished water pipeline will be 36-inches in diameter with a total length of approximately 65,000 linear feet (lf) and will be located between the Richland WTP to the future Hwy 278 BPS. Most of the finished water pipeline route will be along Hwy 61. This pipeline will be designed and constructed along with the Hwy 278 BPS and is anticipated to be in service before the Richland WTP comes online in 2019; therefore all future scenarios, including Phase 1, included this pipeline. Though the Hwy 61 pipeline is included in the analyses performed for the master plan, it is not considered a master plan improvement since it is being designed and constructed as part of the Richland Creek Program. The approximate waterline route is provided in the previous **Figure 16**.

To meet fire flow requirements, it is recommended that the County include pipeline improvements in the Union pressure zone. This includes a 16 inch waterline referred to as Mulberry Rock which is located on Mulberry Rock Road for approximately 7,500 lf between Orchard Drive (tying in at ex. 16 inch) and the intersection of Old Yorkville Road and Hwy 101, and a new 12 inch waterline on Hwy 101 between the future Mulberry Rock WM and the Bell Road BPS referred to as the Union Loop which includes approximately 15,000 ft. between Old Yorkville Road and Bell Road.

Emergency Criteria

Emergency conditions in the future Phase 1 scenario were reviewed for both fire flow conditions for a residential (500 gpm) and commercial (1,000 gpm) fire flow requirement. Fire flow results were similar to the existing system, therefore additional piping was added where necessary to satisfy fire flow criteria.

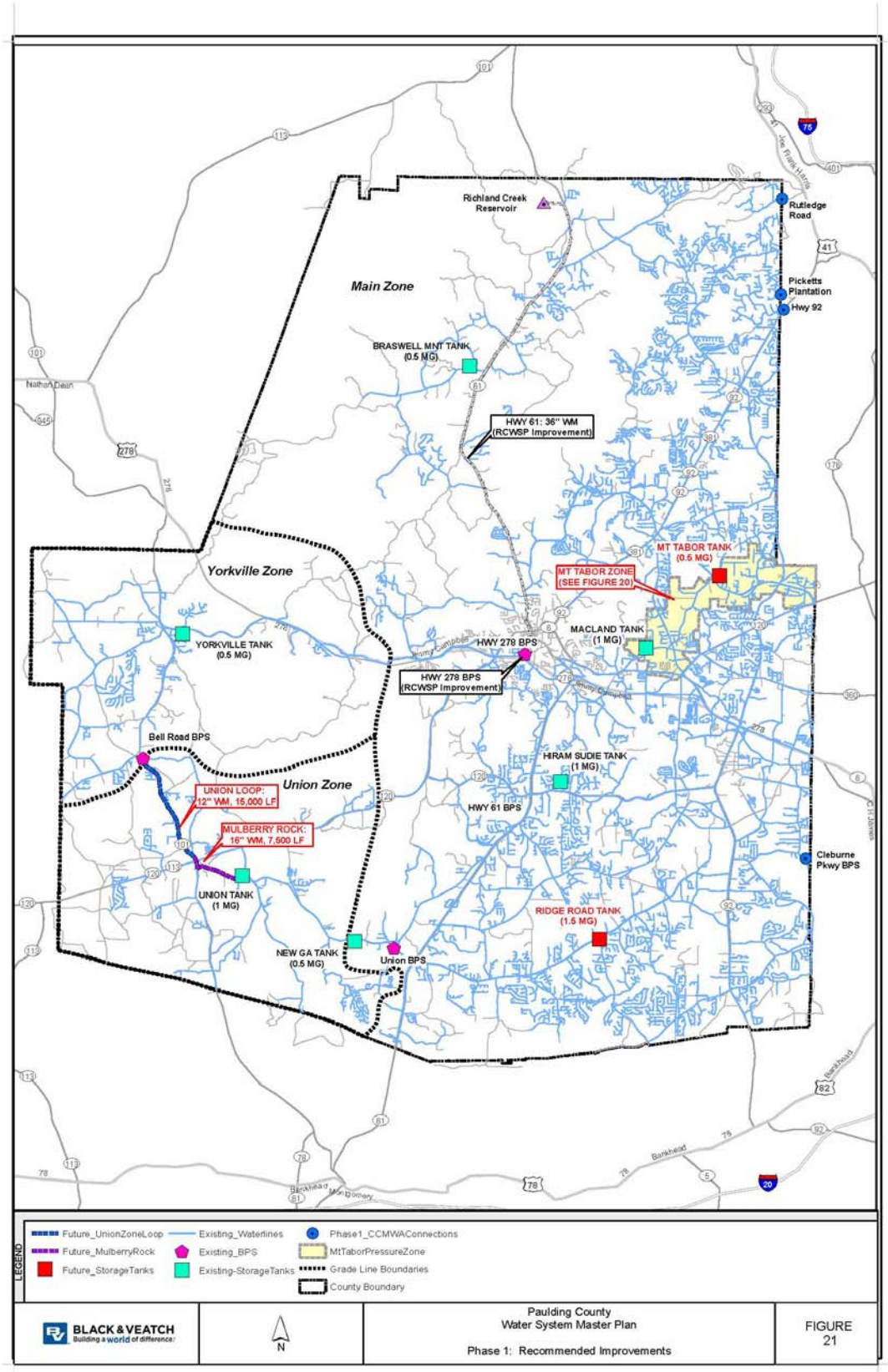
Phase 1 – Recommendation Summary

A complete summary for the Phase 1 recommendations is provided in **Table 13** and **Figure 21**.

Table 13: Phase 1 – Improvement Summary

PHASE 1 IMPROVEMENTS		
Water Supply		
Name	**Source**	**Notes**
Richland Creek WTP	Richland Creek Reservoir	HSPs set to fixed discharge HGL
Cleburne BPS	CCMWA	BPS set to Ridge Road Tank level
Hwy 92	CCMWA	20-inch waterline connection
Pumping		
Name	**Total Flow (gpm)**	**Total Dynamic Head (ft)**
Hwy 278 BPS	9,700	125
Mt. Tabor BPS	700	90
Storage		
Name	**Type**	**Total Volume (MG)**
Ridge Road Tank	Elevated	1.5
Mt Tabor Tank	Elevated	0.5
Pressure Zones		
Name	**Service Area (sq. miles)**	**HGL (ft)**
Mt Tabor Zone	**5.2**	1,340
Piping		
Name	**Pipe Diameter (Inches)**	**Pipe Length (ft)**
Mulberry Rock	16	7,500
Union Loop	12	15,000
Mt. Tabor Zone	12	20,400
	8	2,000

Figure 21: Phase 1 - Recommended System Improvements



5.4.2 Phase 2: Evaluation and Recommendations

The model was simulated for future Phase 2 demands at an MDD of 25 MGD. The system was reviewed for supply, pressure, pumping, storage, piping and emergency criteria. A summary of each of these is provided below.

Water Supply

The water supply for Phase 2 includes two options dependent on the timing of the expansion of the Richland Creek WTP from 18 MGD to 36 MGD. Part 1 of Phase 2 assumed that the County will continue to purchase water from both CCWS and CCMWA in addition to the Richland Creek WTP prior to the water treatment plant expansion. Part 1 interconnections with CCMWA were evaluated to determine the most optimum source points. The second part of Phase 2 included an analysis of supplying the demand by Richland Creek WTP independent of CCMWA. Part 2 would require the Richland WTP to expand to the next planned capacity of 36 MGD.

Based on evaluations performed with the hydraulic model, recommended connections for Part 1 ADD conditions include the Cleburne Parkway BPS. Due to the Richland Creek WTP being limited to 18 MGD capacity, it is recommended that the County operated the boundary booster pump station at Hwy 120 along with the Cleburne BPS and the connection on Hwy 92 to meet MDD conditions. Controls at the Hwy 120 and Hwy 278 BPSs will need to be adjusted to limit pumping from the Hwy 278 BPS to keep supply from the Richland Creek WTP within acceptable limits. It is assumed that the County will utilize storage in the 4 MG clearwell to augment flows above 18 MGD, as necessary. The Hwy 92 connection is recommended to keep pressures above minimum criteria on the east side of the system and the high elevation point on Old Cartersville Road. A summary of the interconnections recommended for Phase 2, Part 1 include the following:

- CCWS: Picketts Plantation and Rutledge Road
- CCMWA:
  - Cleburne BPS (ADD and MDD)
  - Hwy 120 BPS (MDD)
  - Hwy 92 (MDD)

Once the County expands the Richland Creek WTP to an anticipated 36 MGD capacity, the County will be able to meet all of the Phase 2 demand needs independent of other water supply sources.

The model was used to determine the recommended HGL provided by the future Richland Creek WTP HSPs under Part 1 and Part 2 for Phase 2 as provided in **Table 14**.

Table 14: Phase 2: Recommended HGL supplied by the Future Richland Creek WTP

SCENARIO	SYSTEM DEMAND (MGD)	RICHLAND WTP HGL (ft)
Part 1: Richland + CCMWA		
ADD[1]	16	1,265
MDD[2]	25	1,275
Part 2: Richland		
ADD	16	1,280
MDD	25	1,305

[1] Includes CCMWA Cleburne Parkway BPS interconnection
[2] Includes CCMWA Hwy 92 and Cleburne Parkway BPS and Hwy 120 BPS interconnections

Pumping

Pumping needs were evaluated for Phase 2 scenarios and included recommendations for the Hwy 278 BPS and Mt. Tabor BPS. Recommendations for the station capacities were developed for both Part 1 and Part 2 conditions, as provided in **Table 15** and **16**. During Part 1 MDD, with CCMWA interconnection at Hwy 120 BPS, Cleburne BPS and Hwy 92, it is recommended that the controls at the Hwy 278 BPS and Hwy 120 are adjusted to allow enough flow from CCMWA to keep the supply from the Richland Creek WTP within its 18 MGD capacity limit, utilizing an additional 4 MG of stored finished water in the clearwell as needed. A summary of pump station recommendations for Phase 2 include:

Part 1 - Interconnections:

- Existing Hwy 61, Union and Bell Road BPSs remain in service
- Existing boundary BPS at Cleburne Parkway and Hwy 120 remain in service
- Existing boundary BPS at Macland Road remains in service but only to serve as emergency connection
- Increase capacity at Hwy 278 BPS to 11,200 gpm @ 150 ft. TDH
- Increase capacity at Mt. Tabor BPS at an approximate capacity of 870 gpm @ 110 ft. TDH and additional pumping capacity required to meet commercial fire flows at 1,000 gpm.

Part 2 – Richland Creek WTP:

- Existing Union and Bell Road BPSs remain in service
- Existing Hwy 61 BPS out of service*
- Existing boundary BPS at Cleburne Parkway, Hwy 120 and Macland Road remain in service but only to serve as emergency connections
- Increase capacity at Hwy 278 BPS to 16,700 gpm @ 175 TDH

- Increase capacity at Mt. Tabor BPS at an approximate capacity of 870 gpm @ 110 ft. TDH and additional pumping capacity required to meet commercial fire flows at 1,000 gpm.

* Hwy 61 BPS will be out of service under Phase 2, Part 2 though it could be retrofitted in the future to serve the southern portion of the system to maintain pressures and/or storage, as needed.

Storage

Future storage needs of the system were reviewed to meet the system criteria and to provide flow equalization and flexibility for the operation of the future Richland Creek WTP. Additional storage needs were evaluated and included in the Phase 2 improvement recommendations. For flow equalization and to maintain system pressures, it is recommended that the County add an additional 1 MG of storage to the Macland Road storage tank which increases the total storage at Macland from 1 MG to 2 MG.

Storage in the system, including the additional 1 MG at Macland Road, increases from 6.5 MG for Phase 1 to 7.5 MG for Phase 2. Calculating total storage with the 4 MG planned at the Richland Creek WTP clearwell, equals 11.5 MG for total storage which is approximately 70% of the projected ADD demand and meets the established system criteria for storage requirements.

Model results for Phase 2 storage tanks under ADD and MDD conditions are included in **Appendix E**.

Pressures

Pressures in the future system were evaluated for minimum and maximum criteria. The Phase 2 model simulations included the Phase 1 recommended Mt. Tabor Pressure Zone. No additional improvements are recommended for pressure modifications.

Piping

Additional piping needs, beyond those made in Phase 1, were evaluated for both Phase 2 water supply Part 1 and Part 2.

Recommended piping for both Part 1 and Part 2 included adding piping on Old Harris Road to reinforce piping between the future Hwy 278 BPS and the Macland Road storage tank. This pipeline referred to as Macland Loop I consists of 4,000 lf of 24 inch diameter pipe along Old Harris Road between Hwy 278 and Macland Road. As an alternate route, this pipeline could be constructed along Butler Industrial Drive between Hwy 278 and Macland Road.

Also included in Phase 2, Part 1 and Part 2, is additional piping on Hwy 92 to connect the existing 24 inch on Hwy 92 at Pine Valley Road to the existing 16 inch on Bill Carruth Parkway. This additional piping on Hwy 92 improves redundancy to the southern part of the system. Both parts of Phase 2 include piping on Cedarcrest and Harmony Grove Church Road referred to as the East Loop. The East Loop improves the County's ability to serve the east side of the system from the Richland Creek WTP. The East Loop starts on Harmony Grove Church Road at Hwy 61 to the north and ends on Cedarcrest Road at Hwy 92 to the south for a total estimated length of 37,500 lf. This route is currently scheduled for a road widening project in the year 2022 which will facilitate the construction of the East Loop waterline.

During Part 2, when the County is independent of the water supply from CCMWA, additional piping is recommended to serve the southern half of the system. This piping is recommended along Hwy 61 between Hwy 278 and Ridge Road and is named Hwy 61 South. The Hwy 61 South waterline will be 24 inches in diameter and approximately 43,000 lf in length. These improvements also include a new parallel waterline on Hwy 278 which is needed to keep the velocities in the existing 24 inch pipeline on Hwy 278 below the criteria of 7 fps. This will be the first of two phases of Hwy 278 piping and is referred to as Hwy 278: Part I. This pipeline will be located on Hwy 278 between the future Hwy 278 BPS to the connection with the future Hwy 61 South pipeline for a total length of approximately 8,000 lf.

Emergency Criteria

Emergency conditions in the future Phase 2 scenario were reviewed for both fire flow conditions for a residential (500 gpm) and commercial (1,000 gpm) fire flow requirement.

Phase 2 – Recommendation Summary

The results from the hydraulic evaluation performed for Phase 2 were used to review and select capital improvements for the water system for mid-term conditions. Capital improvements for Phase 2 include both Part 1 with connections to CCMWA and Part 2 with the County independent from other water supplies. Improvements associated with Part 1 are shown in **Figure 22** while improvements for Part 2 are provided in **Figure 23**. A summary of the improvements for both scenarios is presented in **Table 15** and **16**.

Table 15: Phase 2: Part 1 (Richland + CCMWA) – Improvement Summary

PHASE 2 IMPROVEMENTS		
PART 1		
Water Supply		
Name	**Source**	**Notes**
Richland Creek WTP	Richland Creek Reservoir	HSPs set to fixed discharge HGL
Cleburne BPS	CCMWA	BPS set to Ridge Road Tank level
Pumping		
Name	**Total Flow (gpm)**	**Total Dynamic Head (ft)**
Hwy 278 BPS (Upgrade)	11,200	150
Mt. Tabor BPS (Upgrade)	870	110
Storage		
Name	**Type**	**Total Additional Volume (MG)**
Macland	Ground	1
Piping		
Name	**Pipe Diameter (Inches)**	**Pipe Length (ft)**
Macland Loop I	24	4,000
Hwy 92	24	4,500
East Loop	24	37,500

Figure 22: Phase 2 - Recommended System Improvements: Part 1 – Richland WTP + CCMWA Connections

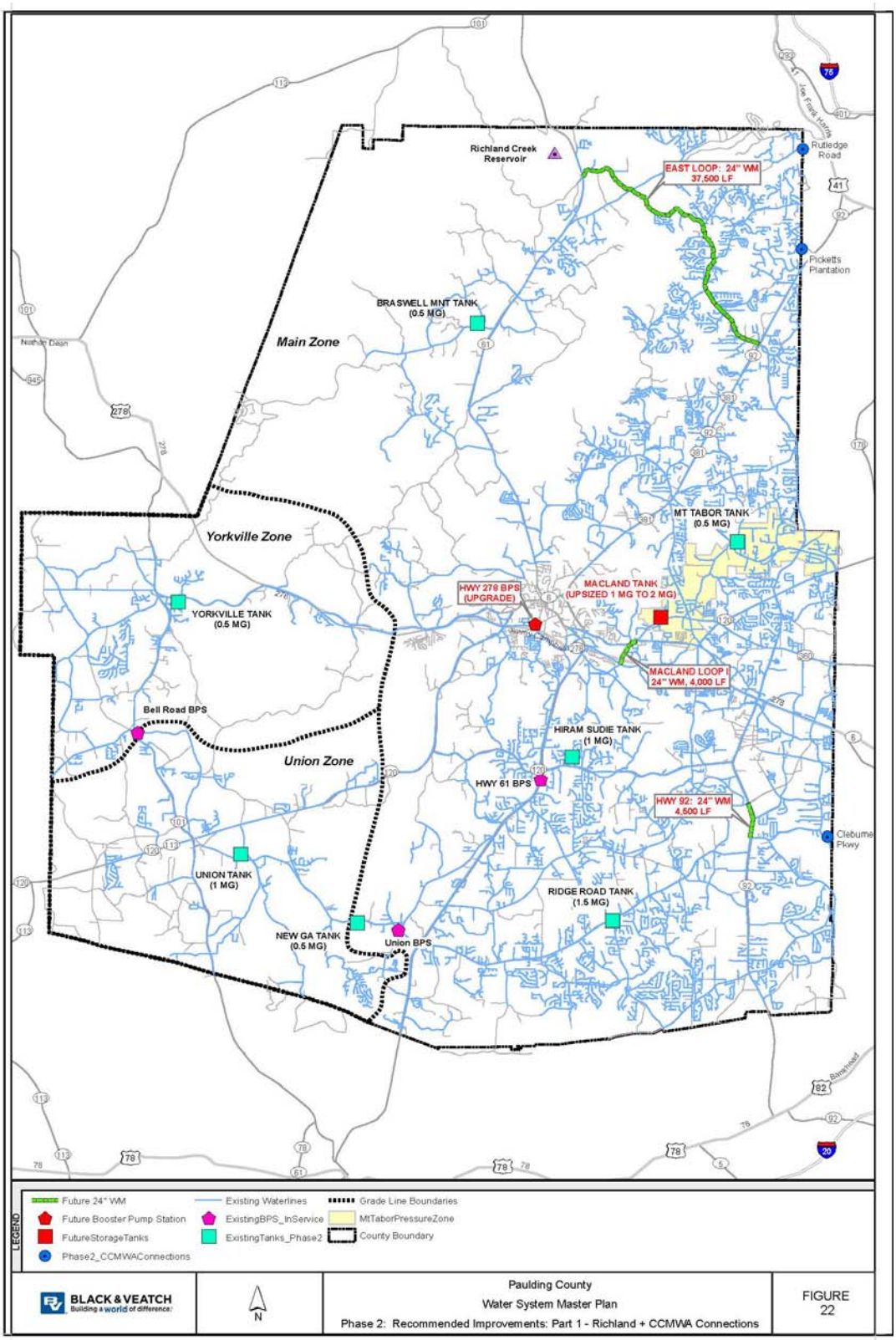
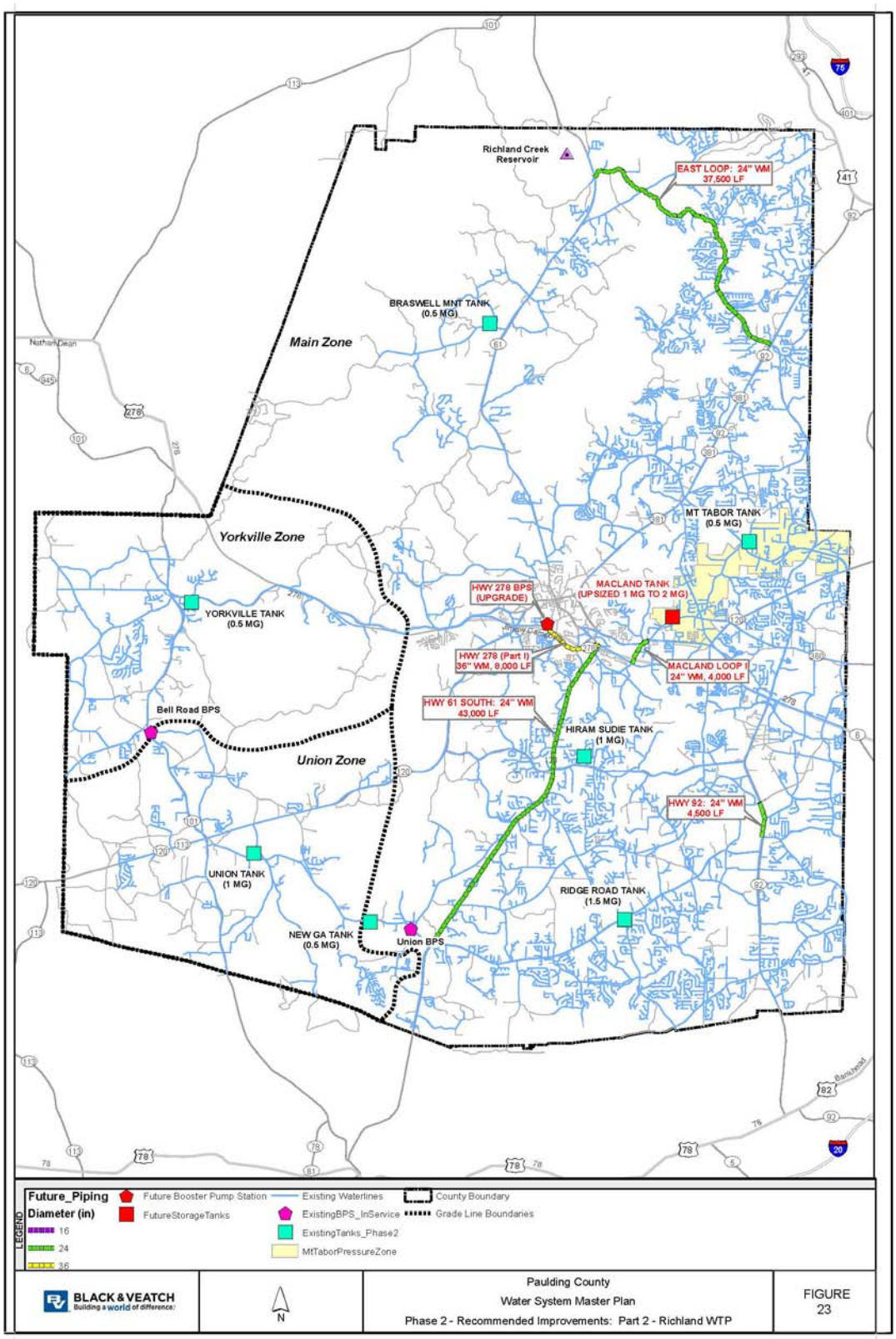


Table 16: Phase 2: Part 2 (Richland) – Improvement Summary

PHASE 2 IMPROVEMENTS		
PART 2		
Water Supply		
Name	**Source**	**Notes**
Richland Creek WTP	Richland Creek Reservoir	HSPs set to fixed discharge HGL
Pumping		
Name	**Total Flow (gpm)**	**Total Dynamic Head (ft)**
Hwy 278 BPS (Upgrade)	16,700	175
Mt. Tabor BPS (Upgrade) [1]	870	110
Storage		
Name	**Type**	**Total Additional Volume (MG)**
Macland [1]	Ground	1
Piping		
Name	**Pipe Diameter (Inches)**	**Pipe Length (ft)**
Macland Loop I [1]	24	4,000
Hwy 92 [1]	24	4,500
East Loop [1]	24	37,500
Hwy 61 South [2]	24	43,000
Hwy 278: Part I [2]	36	8,000

[1] Phase 2, Part 1 recommended improvement
[2] Phase2, Part 2 recommended improvement

Figure 23: Phase 2 - Recommended System Improvements: Part 2 – Richland WTP



5.4.3 Phase 3: Evaluation and Recommendations

The model was simulated for future Phase 3 demands at an MDD of 34 MGD. The system was reviewed for supply, pressure, pumping, storage, piping and emergency criteria. A summary of each of these is provided below.

Water Supply

The water supply for Phase 3 was set up with the Richland Creek WTP independent of interconnections to CCMWA assuming that the plant will be expanded to 36 MGD between Phase 2 and 3. Therefore, no interconnections with CCMWA were modeled though the two connections to CCWS at Picketts Plantation and Rutledge Road remain active.

During Phase 3, the County will be supplying its own water from the Richland Creek WTP. Based on the evaluations preformed, the recommended HGL discharged from the Richland Creek WTP HSPs for Phase 3 is provided in **Table 17**.

Table 17: Phase 3: Recommended HGL supplied by the Future Richland Creek WTP

SCENARIO	SYSTEM DEMAND (MGD)	RICHLAND WTP HGL (ft)
ADD	22	1,290
MDD	34	1,330

Pumping

Pumping needs were evaluated for Phase 3 scenarios and included recommendations for the Hwy 278 BPS and Mt. Tabor BPS. Recommendations for the station capacities are provided in **Table 18**. A summary of pump station recommendations for Phase 2 include:

- Existing Hwy 61 BPS out of service*
- Existing Union and Bell Road BPSs remain in service
- Existing boundary BPS at Cleburne Parkway, Hwy 120 and Macland Parkway remain in service but only to serve as emergency connections
- Increase capacity at Hwy 278 BPS to 19,500 gpm @ 225 ft. TDH
- Increase capacity at Mt. Tabor BPS at an approximate capacity of 1,100 gpm @ 120 ft. TDH

* Hwy 61 BPS will be out of service under Phase 3 though it could be retrofitted in the future to serve the southern portion of the system in the event of low pressures or to support storage tanks, as needed.

Storage

Future storage needs of the system were reviewed to meet the system criteria and to provide flow equalization and flexibility for the operation of the future Richland Creek WTP. This included the planned 8 MG of system storage at the Richland Creek WTP and the Phase 1 and Phase 2 storage

recommendations. Additional storage for flow equalization and emergency conditions was evaluated using the hydraulic model.

To provide greater flow equalization in the system during Phase 3 demand conditions, it is recommended that the County increase the storage volume at the Macland Road from 2 MG to 4 MG. This additional storage is beneficial to balancing the flows between the treatment plant and the rest of the water system.

System storage, including an additional 2 MG at Macland Road, increases from 7.5 MG in Phase 2 to 9.5 MG for Phase 3. The total system storage calculated with 8 MG at the future 36 MGD Richland WTP clearwell equals 17.5 MG or approximately 80% of the projected ADD for Phase 3 which is above the selected minimum criteria.

Model results for Phase 3 storage tanks under ADD and MDD conditions are included in **Appendix F**.

Piping

Several piping improvements were generated based on the model analyses of future Phase 3 scenarios. These improvements will help the County create additional looping and redundancy in the system and maintain pipe velocities within an acceptable range. Model analyses indicated that future velocities in the 36 inch discharge piping from the Richland Creek WTP will be above the maximum velocity criteria and may create excessive head loss at 36 MGD plant production. To plan for long-term conditions, it is recommended that a 36 inch parallel pipe be installed between the Richland WTP HSPs and the connection to the East Loop which is currently recommended near Hwy 61 at Harmony Grove Church Road.

Additional high velocities were noted in the existing 24 inch waterline on Hwy 278; therefore Part II of the Hwy 278 pipeline is recommended which includes a parallel 24 inch starting at the 36 inch pipeline for Part I near Hwy 61 to Old Harris Road, approximately 5,000 lf.

To improve pressures and increase the County's ability to loop flow in the system, several pipelines are recommended in the central part of the system including a future 24 inch on Bobo Road and Macland Road. Additional piping is recommended to improve looping in the southern part of the system with the 24 inch Southeast Loop along Hwy 278 and Hwy 92.

Emergency Criteria

Emergency conditions in the future Phase 3 scenario were reviewed for a residential (500 gpm) and commercial (1,000 gpm) fire flow requirement. Any improvements recommended from Phase 1 and Phase 2 were included in Phase 3 to meet fire flow criteria.

Phase 3 – Recommendation Summary

The summary of total Phase3 improvements is presented in **Table 18** and **Figure 24**. A map of the overall improvements for all three planning phases is provided in **Figure 25**.

Table 18: Phase 3 – Improvement Summary

PHASE 3 IMPROVEMENTS		
Water Supply		
Name	**Source**	**Notes**
Richland Creek WTP	Richland Creek Reservoir	HSPs set to fixed discharge HGL
Pumping		
Name	**Total Flow (gpm)**	**Total Dynamic Head (ft)**
Hwy 278 BPS	19,500	225
Mt. Tabor BPS	1,100	120
Storage		
Name	**Type**	**Total Additional Volume (MG)**
Macland	Ground	2
Piping		
Name	**Pipe Diameter (Inches)**	**Pipe Length (ft)**
Macland Loop II	24	10,500
Bobo Road	24	15,000
Southeast Loop	24	23,000
Hwy 278: II	24	5,000
Richland Parallel Pipe	36	5,500

Figure 24: Phase 3 - Recommended System Improvements

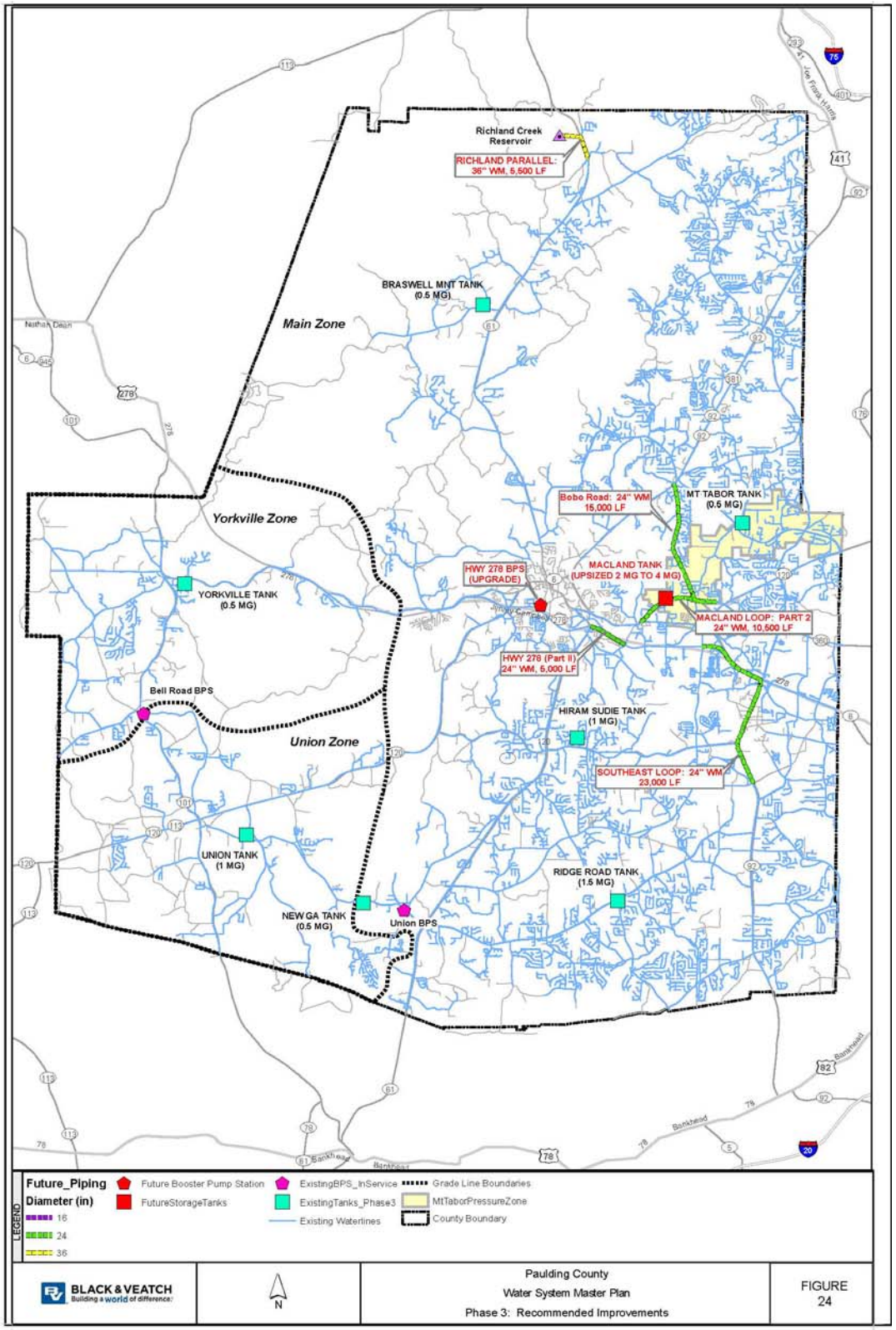
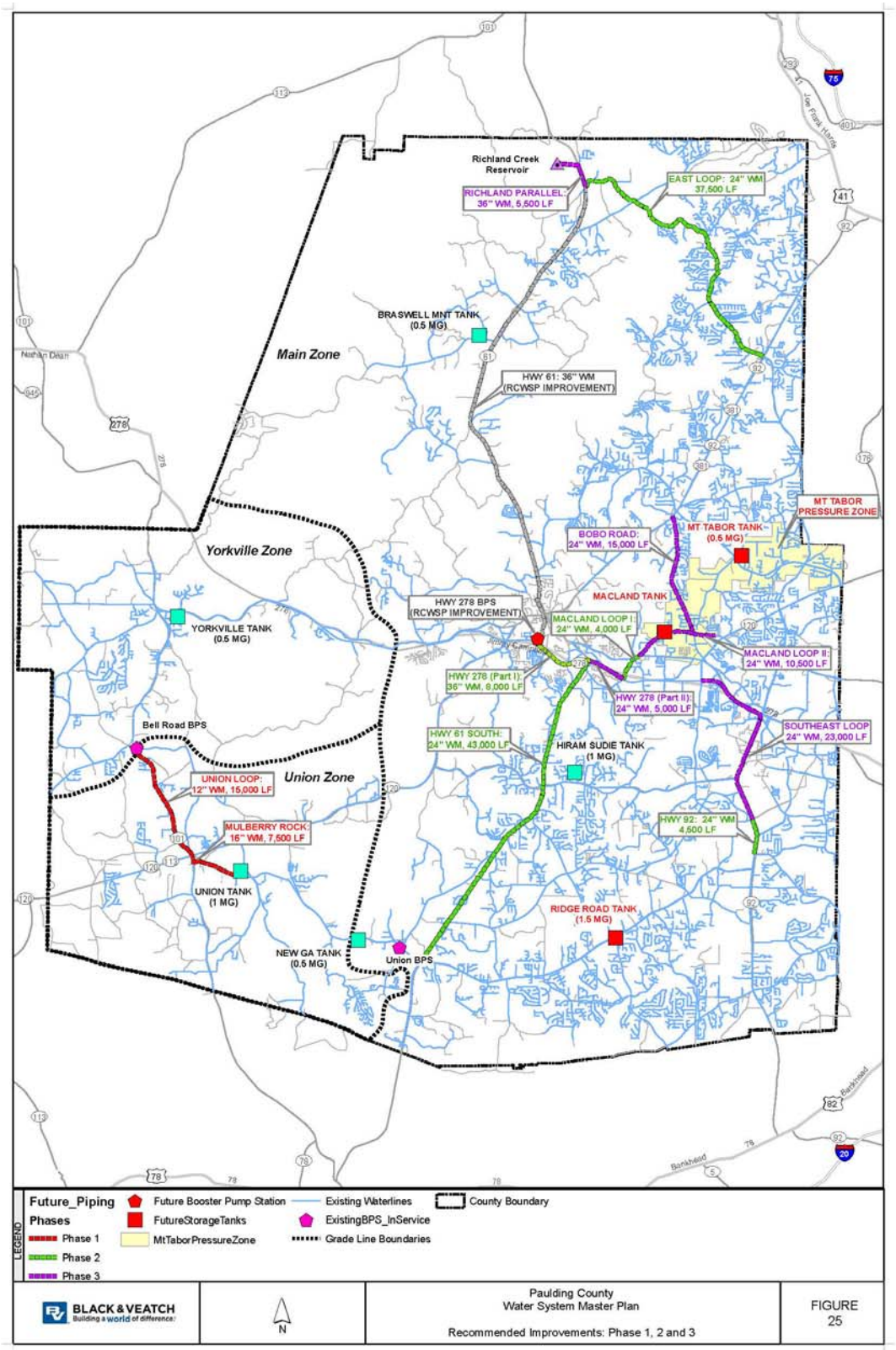


Figure 25: Recommended System Improvements: Phase 1, 2 and 3



6.0 Capital Improvement Plan

The results of the system analyses and recommended improvements presented in Section 5 were reviewed with County staff to discuss the drivers and benefits associated with the recommended improvement projects and to prioritize each project into the following categories:

- Phase 1 - Short-term
- Phase 2 - Mid-term
- Phase 3 - Long-term

Black & Veatch developed planning-level opinions of probable project costs for each of the CIP projects. These project costs are based upon a combination of quantity take-offs, vendor quotations, and recent construction bid information from Black & Veatch projects. All costs include an allowance for engineering/design and contingencies, presented in 2016 dollars. The costs are presented at a level of accuracy considered acceptable for master planning; actual project costs would depend on current labor and material costs, competitive market conditions, the final project scope, bid date, and other variable factors. The CIP in each phase is shown in **Figure 25** in Section 5 and a large map is provided in **Appendix B**.

Based on the discussions with County staff, a prioritized capital improvement plan (CIP) with cost estimates was developed and is included in **Table 19** at the end of this chapter. Improvement recommendations and costs specific for the Mt Tabor Pressure Zone are provided in **Table 20**. It should be noted that all recommendations were developed by implementing the best available information at the time of this study and assumptions stated within this document. Supporting material for the basis of these cost estimates is provided in **Appendix C**.

6.1 PHASE 1: SHORT-TERM

Short-term improvements include the recommended projects developed for Phase 1. This includes the development of the Mt. Tabor pressure zone to serve customers near Mt. Tabor Church Road, East Paulding Drive and Macland Road that experience pressures lower than the minimum requirements per the GA EPD (i.e. less than 35 psi). In addition to this zone, it is recommended that the County replace the existing Shipp Road storage tank with a new tank referred to as the Ridge Road tank. A total of 22,500 lf of piping is recommended in the Union Zone on Mulberry Rock Road and Hwy 101 to meet fire flow requirements in this area and reduce low pressures on the suction side of the Bell Road BPS. In summary, Phase 1 improvements include the following:

- Storage: Ridge Road Storage Tank: 1.5 MG
- Pressure Zone: Mt. Tabor Pressure Zone improvements :
  - Mt. Tabor Storage Tank: 0.5 MG
  - Retrofitting Ex. Cowboy Trail Subdivision (Cowboy Path) BPS
  - 20,400 lf of 12 inch waterlines
  - 2,000 lf of 8 inch waterlines
- Piping: Waterline improvements in the Union Zone:
  - 7,500 lf of 16 inch waterlines
  - 15,000 lf of 12 inch waterlines

Based on input from the County, these recommendations were ranked for priority with the first priority to resolved the low pressures in the system by developing the Mt. Tabor Pressure Zone, second priority is to improve the fire flows in the system by constructing the waterline improvements in the Union Zone and the third priority to replace the existing Shipp Road Tank with the future Ridge Road Tank.

The total estimated cost for short-term improvements is approximately $14,400,000 in 2016 dollars.

6.2 PHASE 2: MID-TERM

Mid-term improvements include the recommended projects identified for Phase 2. This includes improvement recommendations in two parts, Part 1 will occur when the Richland Creek WTP is at an initial capacity of 18 MGD and water in excess of the plant capacity will be provided by interconnections with CCMWA. Part 2 of Phase 2 encompasses when the Richland Creek WTP has expanded to 36 MGD treatment capacity and all water is supplied by the County independent of CCMWA. Once the County has a completely independent water supply, additional piping will be needed in the southern part of the system which is recommended as the Hwy 61 South pipeline.

- Storage: Macland Road Tank: 1.0 MG additional volume
- Pumping:
  - Upgrade at Hwy 278 BPS
  - Upgrade at Mt. Tabor BPS
- Piping:
  - Part 1
    - 46,000 lf of 24 inch waterlines
  - Part 2
    - 43,000 lf of 24 inch waterlines
    - 8,000 lf of 36 inch waterlines

The total estimated costs for mid-term improvements Part 1 is approximately $14,200,000 while the total cost for Part 2 is $15,500,000 in 2016 dollars. Total Phase 2, with Part 1 and Part 2, improvement costs are estimated at $29,700,000.

Prioritization of these CIPs will be determined by the County at a future date during the initial planning for Phase 2 improvements.

6.3 PHASE 3: LONG-TERM

Long-term improvements were identified during the Phase 3 evaluation. For this phase, the County will supply all if its own water from the Richland Creek WTP. Additional piping and storage is recommended to meet the water system criteria to maintain pressures, meet velocity requirements and provide flow equalization and emergency conditions.

- Storage: Macland Road Tank: 2.0 MG additional volume
- Pumping:
  - Upgrade at Hwy 278 BPS
  - Upgrade at Mt. Tabor BPS
- Piping:
  - 53,500 lf of 24 inch waterlines
  - 5,500 lf of 36 inch waterlines

The total estimated cost for long-term improvements is approximately $19,700,000 in 2016 dollars.

6.4 CIP IMPLEMENTATION

Phases were chosen based on demands as opposed to set planning years to allow the County greater flexibility to plan based on demand conditions as they occur. It is recommended that the County evaluate these improvements and begin implementation when demands reach approximately 75 percent of the estimated demand for each planning phase to provide adequate time for survey, design, permitting, bidding and construction associated with each CIP.

The actual year for CIP implementation should correspond to water system demands. As a general guideline, based on existing and forecasted demands, short-term improvements will most likely take place in the immediate future between 2016 and 2020, mid-term improvements between 2020 and 2030 and long-term improvements between 2030 and 2050.

Coordination is recommended between recommended CIPs and the Department of Transportation (DOT) road improvement projects which may shift timing for some of the recommendations. To facilitate adjustments in the future to account for changes in demand or infrastructure, it is recommended that the County continue to update and evaluate the water system using the hydraulic model and modify the Master Plan document as necessary.

Table 19: Water System Capital Improvement Plan: Phase 1 -3

Phasing	Project Type	Description/	Size / Capacity	Unit	Length / #	Unit	Driver	Benefit	Unit Cost		Material costs	Survey/ Engineering (15%)	Contingency (30%)	Project Cost
Short-Term: Phase 1	Pressure	Mt. Tabor Zone	(See Table 20)				Low Pressures	Meets minimum pressures in Mt. Tabor	-	-		-	-	$6,240,000
	Piping	Mulberry Rock Road	16	inch	7,500	Feet	Fire Flow	Meets FF requirements/Min. pressures	$129	$/ft	$967,500	$145,125	$290,250	$1,400,000
	Piping	Union Loop	12	inch	15,000	Feet	Fire Flow	Meets FF requirements/Min. pressures	$103	$/ft	$1,545,000	$231,750	$463,500	$2,200,000
	Storage	Ridge Road Tank	1.5	MG	1	LS	Shipp Road Replacement	Flow equalization	$3,000,000	$/LS	$3,000,000	$450,000	$900,000	$4,500,000
	Storage	Ex. Shipp Road (Demo)	0.75	MG	1	LS	Shipp Road Replacement	Removes aged tank from system	$50,000	$/LS	$50,000	$7,500	$15,000	$70,000
												Subtotal	**(Phase 1)**	**$14,400,000**
Mid-Term: Phase 2 Part 1	Piping	Macland Loop I	24	inch	4,000	Feet	Future Transmission	Improvement between Hwy 278 BPS and Macland Tank	$194	$/ft	$776,000	$116,400	$232,800	$1,100,000
	Piping	Hwy 92	24	inch	4,500	Feet	Future Transmission	Improves flow to Southeast	$194	$/ft	$873,000	$130,950	$261,900	$1,300,000
	Piping	East Loop	24	inch	37,500	Feet	Future Transmission	Improves flow between Richland WTP and East	$194	$/ft	$7,275,000	$1,091,250	$2,182,500	$10,500,000
	Storage	Macland Tank	1	MG	1	LS	Increased Storage	Flow equalization	$750,000	$/LS	$750,000	$112,500	$225,000	$1,090,000
	Pumping	Mt. Tabor BPS (Upgrade)	1.3	MGD	1	LS	Additional Pumping Needed	Serves Mt. Tabor Tank	$125,000	$/LS	$125,000	$18,750	$37,500	$180,000
												Subtotal	**(Phase 2: Part 1)**	**$14,200,000**
Part 2	Piping	Hwy 278 I	36	inch	8,000	Feet	Future Transmission	Meets velocity criteria on Hwy 278	$291	$/ft	$2,328,000	$349,200	$698,400	$3,400,000
	Piping	Hwy 61 South	24	inch	43,000	Feet	Service to South	Improves Reliability and Redundancy to south	$194	$/ft	$8,342,000	$1,251,300	$2,502,600	$12,100,000
												Subtotal	**(Phase 2: Part 2)**	**$15,500,000**
												Subtotal	**(Phase 2)**	**$29,700,000**
Long-Term: Phase 3	Piping	Macland Loop II	24	inch	10,500	Feet	Future Transmission	Improvement between Hwy 278 BPS and Macland Tank	$194	$/ft	$2,037,000	$305,550	$611,100	$3,000,000
	Piping	Bobo Road	24	inch	15,000	Feet	Future Transmission	Improves flow to Southeast	$194	$/ft	$2,910,000	$436,500	$873,000	$4,200,000
	Piping	Southeast Loop	24	inch	23,000	Feet	Future Transmission	Improves flow between Richland WTP and East	$194	$/ft	$4,462,000	$669,300	$1,338,600	$6,500,000
	Piping	Hwy 278 II	24	inch	5,000	Feet	Future Transmission	Improves flow to Southeast	$194	$/ft	$970,000	$145,500	$291,000	$1,400,000
	Piping	Richland Parallel Pipe	36	inch	5,500	Feet	Future Transmission	Improves flow between Richland WTP and East	$291	$/ft	$1,600,500	$240,000	$480,000	$2,300,000
	Storage	Macland Tank	2	MG	1	LS	Increased Storage	Flow equalization	$1,110,000	$/LS	$1,110,000	$166,500	$333,000	$1,600,000
	Pumping	Hwy 278 BPS (Upgrade)	28	MGD	1	LS	Additional Pumping Needed	Serves Macland and Hiram Sudie Tanks	$375,000	$/LS	$375,000	$56,250	$112,500	$500,000
	Pumping	Mt. Tabor BPS (Upgrade)	1.6	MGD	1	LS	Additional Pumping Needed	Serves Mt. Tabor Tank	$125,000	$/LS	$125,000	$18,750	$37,500	$180,000
												Subtotal	**(Phase 3)**	**$19,700,000**
													Total	**$63,800,000**

Table 20: Water System Capital Improvement Plan: Mt Tabor Pressure Zone[1]

ITEM	TYPE	DESCRIPTION	SIZE/CAPACITY	UNIT	LENGTH (FT)	QUANTITY	UNIT COST	PROJECT COST
I.1	Piping	Mt Tabor Church Road	12"	LF	9,000		$103	$927,000
		Macland Road (west): Part 1	8"	LF	2,000		$64	$127,000
		Macland Road (west): Part 2	12"	LF	3,500		$103	$360,500
		Macland Road (east): Eastside of Bobo Road	12"	LF	3,000		$103	$309,000
		Bobo Road (north)	12"	LF	1,000		$103	$103,000
		Cowboy Trail BPS Discharge	12"	LF	400		$103	$41,200
		Bobo Road (south)	12"	LF	3,500		$103	$360,500
I.2	Pipe Changes at Intersections	E. Paulding/Antioch Road		LS		1	$25,000	$25,000
		Bobo Road/Macland Road		LS		1	$25,000	$25,000
		E. Paulding/Hwy 92		LS		1	$25,000	$25,000
I.3	Connecting Ex. Pipe to New Pipes	Ida Way/Macland Road	6"	LS		1	$15,000	$15,000
		Macland Township/Macland Road	8"	LS		1	$15,000	$15,000
		Brock Drive/Macland Road	6"	LS		1	$15,000	$15,000
		McClure Drive/Bobo Road	8"	LS		1	$15,000	$15,000
		Lost Meadows/East Paulding	6"	LS		1	$15,000	$15,000
		Bobo Road/Wheelan School Road	2"	LS		1	$15,000	$15,000
		Bobo Road/Turner Hollow Road	2"	LS		1	$15,000	$15,000
		Ex. Piping on Mt. Tabor Church to new 12"	6"	LS		3	$15,000	$45,000
		Reece Road/E. Paulding	8" and 10"	LS		2	$15,000	$30,000
		Brooks Rackley Road/E. Paulding	8" and 6"	LS		2	$15,000	$30,000
		Cooper Stem Dr./E. Paulding	8"	LS		1	$15,000	$15,000
		Antioch Road/Hwy 92	6"	LS		1	$15,000	$15,000
1.4	Booster Pump Station	Cowboy Trail BPS (Reuse Ex. Building)	Upgrade	LS		1	$200,000	$200,000
1.5	Storage Tank	Mt Tabor Elevated Tank	500,000 Gal	Ea.		1	$1,500,000	$1,500,000
		Demo Existing Storage Tank						$50,000
							Construction Total	**$4,300,000**
	Surveying & Design Engineering						15%	$650,000
	Contingencies						30%	$1,290,000
							Budget Total	**$6,240,000**

[1] Updated from Tt's Mt. Tabor Technical Memorandum based on system evaluation and RS Means Pipe Costs for 2016, Atlanta, GA

Appendix A

Existing Water System Map

Appendix B

Future Water System Recommended Improvements Map

Appendix C

Cost Estimate Support Documents

C.1: Pipe Costs

Table C-1.1: Ductile Iron Pipe Costs

DIAMETER (INCH)	COST PER LINEAR FOOT ($/lf)
8	63.5[1]
12	103[1]
16	129[1]
24	194[1]
36	291[2]

[1] Based on RS Means, 2016 Atlanta, GA, ductile iron pipe, mechanical joint, class 50, with overhead and profit (Table C-1.2)
[2] Calculated from 24 inch based on cost per inch diameter multiplied by 36 inch

Table C-1.2: Ductile Iron Pipe Costs - RS Means Atlanta, GA 2016

2016 Costs for Atlanta, GA (301)

tribution Piping

		33 11 13 Public Water Utility Distribution Piping	Crew	Daily Output	Labor Hours	Unit	Bare Mat.	Bare Labor	Bare Equip.	Bare Total	Total Incl. O&P
15	0010	WATER SUPPLY, DUCTILE IRON PIPE									
	0011	Cement lined									
	0020	Not including excavation or backfill									
	2000	Pipe, class 50 water piping, 18' lengths									
	2020	Mechanical joint, 4" diameter	B21A	200	.200	L.F.	27.50	6.60	2.28	36.38	43
	2040	6" diameter	B21A	160	.250	L.F.	28.50	8.25	2.85	39.60	47.50
	2060	8" diameter	B21A	133.33	.300	L.F.	40	9.90	3.41	53.31	63.50
	2080	10" diameter	B21A	114.29	.350	L.F.	52.50	11.50	3.98	67.98	80.50
	2100	12" diameter	B21A	105.26	.380	L.F.	71	12.55	4.32	87.87	103
	2120	14" diameter	B21A	100	.400	L.F.	83.50	13.20	4.55	101.25	117
	2140	16" diameter	B21A	72.73	.550	L.F.	85	18.10	6.25	109.35	129
	2160	18" diameter	B21A	68.97	.580	L.F.	113	19.15	6.60	138.75	163
	2170	20" diameter	B21A	57.14	.700	L.F.	114	23	8	145	171
	2180	24" diameter	B21A	47.06	.850	L.F.	126	28	9.70	163.70	194
	3000	Push-on joint, 4" diameter	B21A	400	.100	L.F.	13.90	3.29	1.14	18.33	22
	3020	6" diameter	B21A	333.33	.120	L.F.	16.35	3.97	1.37	21.69	25.50
	3040	8" diameter	B21A	200	.200	L.F.	24.50	6.60	2.28	33.38	40.50
	3060	10" diameter	B21A	181.82	.220	L.F.	32.50	7.25	2.51	42.26	50.50
	3080	12" diameter	B21A	160	.250	L.F.	34	8.25	2.85	45.10	53.50
	3100	14" diameter	B21A	133.33	.300	L.F.	34	9.90	3.41	47.31	57
	3120	16" diameter	B21A	114.29	.350	L.F.	37	11.50	3.98	52.48	63.50
	3140	18" diameter	B21A	100	.400	L.F.	41	13.20	4.55	58.75	71
	3160	20" diameter	B21A	88.89	.450	L.F.	42.50	14.95	5.15	62.60	75.50
	3180	24" diameter	B21A	76.92	.520	L.F.	53	17.05	5.95	76	92
	8000	Piping, fittings, mechanical joint, AWWA C110									
	8006	90< bend, 4" diameter	B20A	16	2	Ea.	139	64		203	254
	8020	6" diameter	B20A	12.80	2.500	Ea.	205	80		285	355
	8040	8" diameter	B20A	10.67	2.999	Ea.	405	96		501	600
	8060	10" diameter	B21A	11.43	3.500	Ea.	555	116	40	711	835
	8080	12" diameter	B21A	10.53	3.799	Ea.	790	125	43	958	1,125
	8100	14" diameter	B21A	10	4	Ea.	1,075	132	45.50	1,252.50	1,450
	8120	16" diameter	B21A	7.27	5.502	Ea.	1,375	181	62.50	1,618.50	1,850
	8140	18" diameter	B21A	6.90	5.797	Ea.	1,900	191	66	2,157	2,475
	8160	20" diameter	B21A	5.71	7.005	Ea.	2,375	230	80	2,685	3,075
	8180	24" diameter	B21A	4.70	8.511	Ea.	3,775	282	97	4,154	4,675
	8200	Wye or tee, 4" diameter	B20A	10.67	2.999	Ea.	335	96		431	525
	8220	6" diameter	B20A	8.53	3.751	Ea.	505	120		625	745
	8240	8" diameter	B20A	7.11	4.501	Ea.	805	144		949	1,125
	8260	10" diameter	B21A	7.62	5.249	Ea.	1,175	173	60	1,408	1,625
	8280	12" diameter	B21A	7.02	5.698	Ea.	1,525	188	65	1,778	2,050

C.2 Ground Storage Tank Cost Estimates

Table C-2.1: Future Water System Ground Tanks

Phase	Volume (Gal.)	Type	Cost Est. [1]	Electrical	Instrumentation & Controls	Total Materials
Macland (Ground Tank)						
Phase 2	1,000,000	Prestressed Concrete	$713,000	$20,000	$20,000	$750,000
Phase 3	2,000,000	Prestressed Concrete	$1,041,000	$20,000	$20,000	$1,110,000

[1] Ground Storage Costs Table: RS Means Atlanta, GA 2016 (Table C-2.2)

Table C-2.2: Ground Tank Costs - RS Means Atlanta, GA 2016

2016 Costs for Atlanta, GA (302)

ion Equipment

	33 12 19 Water Utility Distribution Fire Hydrants	Crew	Daily Output	Labor Hours	Unit	Bare Mat.	Bare Labor	Bare Equip.	Bare Total	Total Incl. O&P
010	FIRE HYDRANTS									
520	3'-6" bury	B21	10	2.800	Ea.	730	85.50	13.35	828.85	960
540	4' bury	B21	9	3.111	Ea.	730	95.50	14.80	840.30	975
3 16	Water Utility Storage Tanks									
	33 16 13 Aboveground Water Utility Storage Tanks									
010	STEEL WATER STORAGE TANKS									
910	Steel, ground level, ht./diam. less than 1, not incl. fdn., 100,000 gallons				Ea.				178,500	216,000
000	250,000 gallons				Ea.				261,000	286,000
200	500,000 gallons				Ea.				368,000	405,000
250	750,000 gallons				Ea.				475,000	522,500
300	1,000,000 gallons				Ea.				492,500	640,500
500	2,000,000 gallons				Ea.				921,000	1,013,500
600	4,000,000 gallons				Ea.				1,873,000	2,060,000
800	6,000,000 gallons				Ea.				2,733,000	3,006,500
850	8,000,000 gallons				Ea.				3,592,000	3,951,500
910	10,000,000 gallons				Ea.				4,459,000	4,904,500
100	Steel standpipes, ht./diam. more than 1,100' to overflow, no fdn.									
200	500,000 gallons				Ea.				482,500	530,000
400	750,000 gallons				Ea.				638,000	701,500
500	1,000,000 gallons				Ea.				936,500	1,030,500
700	1,500,000 gallons				Ea.				1,544,500	1,698,000
800	2,000,000 gallons				Ea.				2,054,500	2,259,500
010	PRESTRESSED CONC. WATER STORAGE TANKS									
020	Not including fdn., pipe or pumps, 250,000 gallons				Ea.				264,000	291,000
100	500,000 gallons				Ea.				430,000	473,500
300	1,000,000 gallons				Ea.				624,500	713,000
400	2,000,000 gallons				Ea.				946,500	1,041,000
600	4,000,000 gallons				Ea.				1,506,500	1,657,500
700	6,000,000 gallons				Ea.				2,001,000	2,201,500
750	8,000,000 gallons				Ea.				2,582,000	2,839,500
800	10,000,000 gallons				Ea.				3,119,500	3,431,500
010	PLASTIC-COATED FABRIC PILLOW WATER TANKS									
000	Water tanks, vinyl coated fabric pillow tanks, freestanding, 5,000 gallons	4 Clab	4	8	Ea.	3,300	212		3,512	3,975
100	Supporting embankment not included, 25,000 gallons	6 Clab	2	24	Ea.	11,800	635		12,435	14,000
200	50,000 gallons	8 Clab	1.50	42.667	Ea.	16,600	1,125		17,725	20,100
300	100,000 gallons	9 Clab	.90	80	Ea.	37,900	2,100		40,000	45,300
400	150,000 gallons	9 Clab	.50	144	Ea.	54,500	3,800		58,300	66,000
500	200,000 gallons	9 Clab	.40	180	Ea.	67,500	4,750		72,250	82,000
600	250,000 gallons	9 Clab	.30	240	Ea.	94,500	6,325		100,825	114,500

C.3 Elevated Storage Tank Cost Estimates

Table C-3.1: Future Elevated Tanks - Vendor Quote Summary Table

Manufacturer	Volume (Gal.)	Height (ft)	Type	Cost Est. from Manufacturer
Mt Tabor Tank (Elevated)[1]				
Caldwell	250,000	150	Multi-Column	$745,000
Caldwell	250,000	150	Pedesphere	$949,000
CB&I	250,000	150	Watersheroid	$1,307,000
CB&I	250,000	150	Hydropillar	$1,343,000
Caldwell	500,000	150	Composite	$1,465,000
Caldwell	500,000	150	Multi-Column	$1,225,000
Caldwell	500,000	150	Pedesphere	$1,395,000
CB&I	500,000	150	Watersheroid	$1,491,000
CB&I	500,000	150	Hydropillar	$1,619,000
Ridge Road Tank (Elevated)[2]				
Caldwell	1,500,000	150	Composite	$2,871,000
Caldwell	1,500,000	150	Multi-Column	$3,102,000
CB&I	1,500,000	150	Watersheroid	$2,791,000
CB&I	1,500,000	150	Composite	$2,724,000
CB&I	1,500,000	150	Hydropillar	$2,870,000
Caldwell	1,000,000	150	Composite	$2,352,000
Caldwell	1,000,000	150	Multi-Column	$2,000,000
Caldwell	1,000,000	150	Pedesphere	$2,919,000

[1] Mt. Tabor Tank Quotes Dated 6/18/15 from Caldwell and 6/19/15 from Chicago Bridge & Iron (CB&I)
[2] Ridge Road Tank Quotes dated 2/23/16 from Caldwell and 2/16/16 from CB&I

Table C-3.2: Future Ridge Road Tank – Additional Costs

Description	Volume/Size	Units	Length	Quantity	Est. Cost per Unit	Total Cost
Ridge Road Storage Tank						
New Inlet Pipe, DIP	24	inch	500		$194	$97,000
Electrical		LS		1	$20,000	$20,000
I&C		LS		1	$20,000	$20,000
					Total	**$140,000**

C.4: Pump Costs

Table C-4.1: Mt. Tabor BPS Estimate Table

Item	Description	Volume/Size	Units	Length	Quantity	Est. Cost per Unit	Total Cost
I.	**Mt. Tabor BPS**						
Phase 1	Demo/Remove Ex. Pumps and Piping	N/A	LS		1	$5,000	$5,000
	New Booster Pumps (1 duty, 1 standby)	40 HP	EA		2	$30,000	$60,000
	New Fire Pumps (1 duty, 1 standby)	40 HP	EA		2	$30,000	$60,000
	Discharge Header Valves and Appurtenances	N/A	LS		1	$20,000	$20,000
	New Discharge Piping, DIP	12	inch	100		$103	$10,300
	Electrical		LS		1	$20,000	$20,000
	I&C		LS		1	$20,000	$20,000
						Total	**$200,000**
II	**Mt. Tabor BPS**						
Phase 2	Demo/Remove Ex. Pumps and Piping	N/A	LS		1	$5,000	$5,000
	New Booster Pumps (1 duty, 1 standby)	40 HP	EA		2	$30,000	$60,000
	Discharge Header Valves and Appurtenances	N/A	LS		1	$20,000	$20,000
	Electrical		LS		1	$20,000	$20,000
	I&C		LS		1	$20,000	$20,000
						Total	**$125,000**
III	**Mt. Tabor BPS**						
Phase 3	Demo/Remove Ex. Pumps and Piping	N/A	LS		1	$5,000	$5,000
	New Booster Pumps (1 duty, 1 standby)	50 HP	EA		2	$30,000	$60,000
	Discharge Header Valves and Appurtenances	N/A	LS		1	$20,000	$20,000
	Electrical		LS		1	$20,000	$20,000
	I&C		LS		1	$20,000	$20,000
						Total	**$125,000**

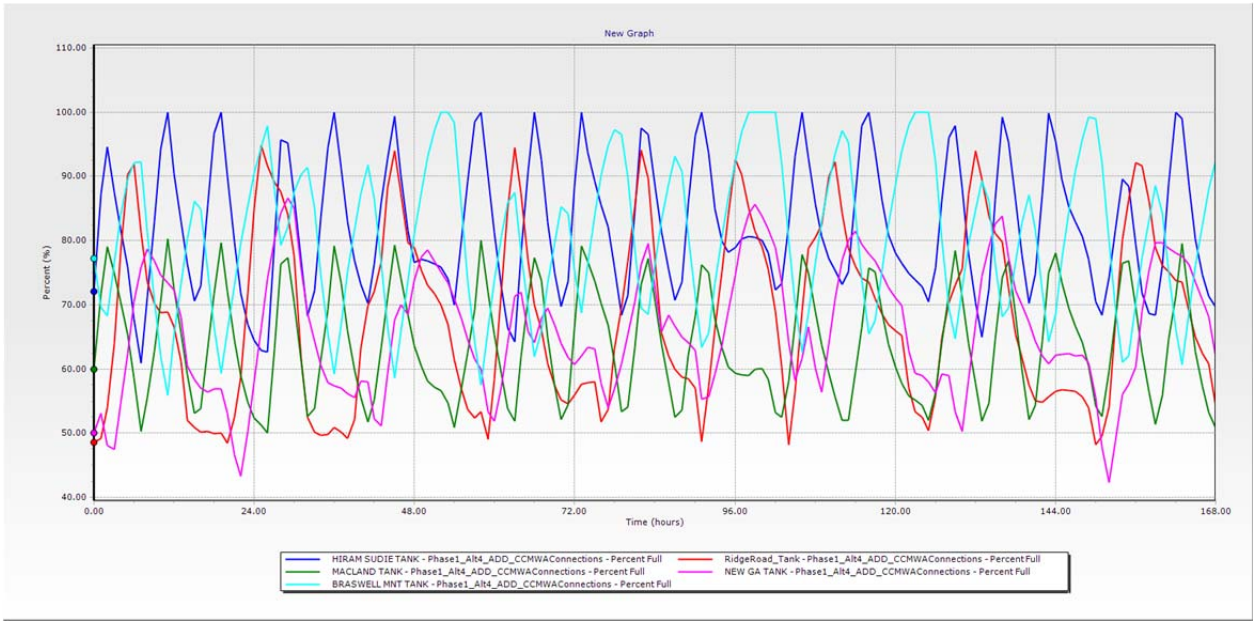
Table C-4.2: Hwy 278 BPS Estimate Table

Planning Phase	Total Flow (gpm)	Total Flow (MGD) (MGD)	TDH (ft)	Total Cost	Notes
Hwy 278 BPS					
1	9,700	14.0	125	$0	Cost not included in Master Plan since pump station is part of RCWSP Improvements
2.1	11,200	16.1	150	$0	Assumed pumps for Phase 1 will be sized through 2.1 and 2.2 with minimum changes
2.2	16,660	24.0	175	$0	Same comment as above
3	19,500	28.1	225	$375,000	Per Patterson estimate on 4/22/2016 for building addition and new pump and drive (material cost only)

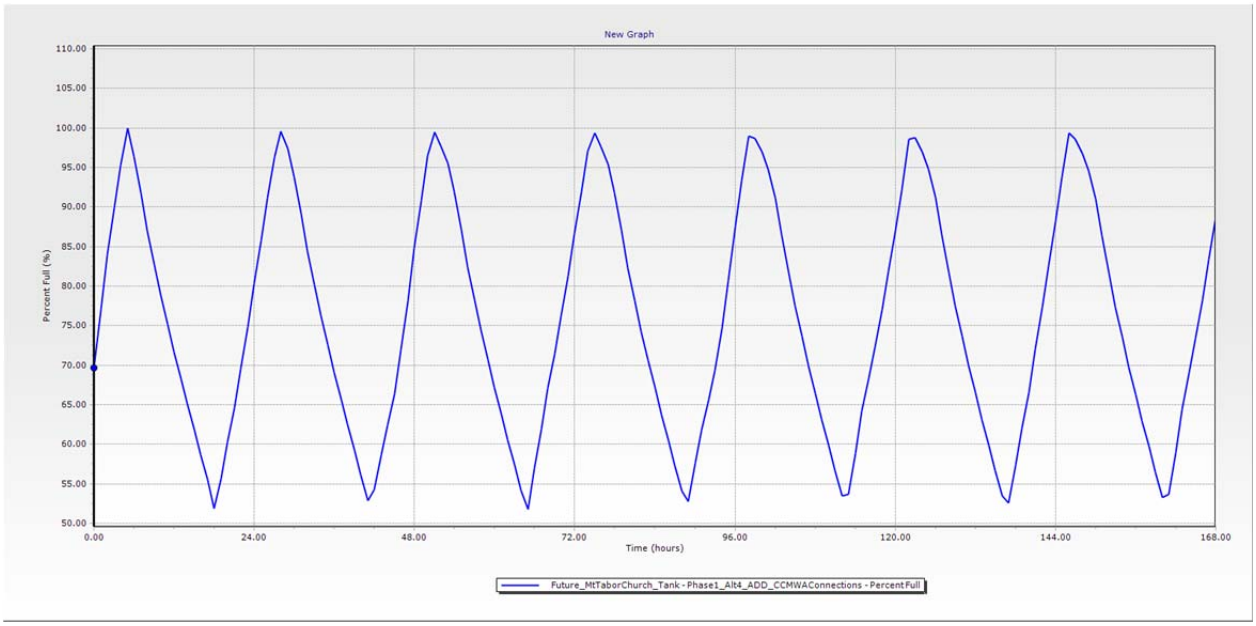
Appendix D

Future System Model Results: Phase 1

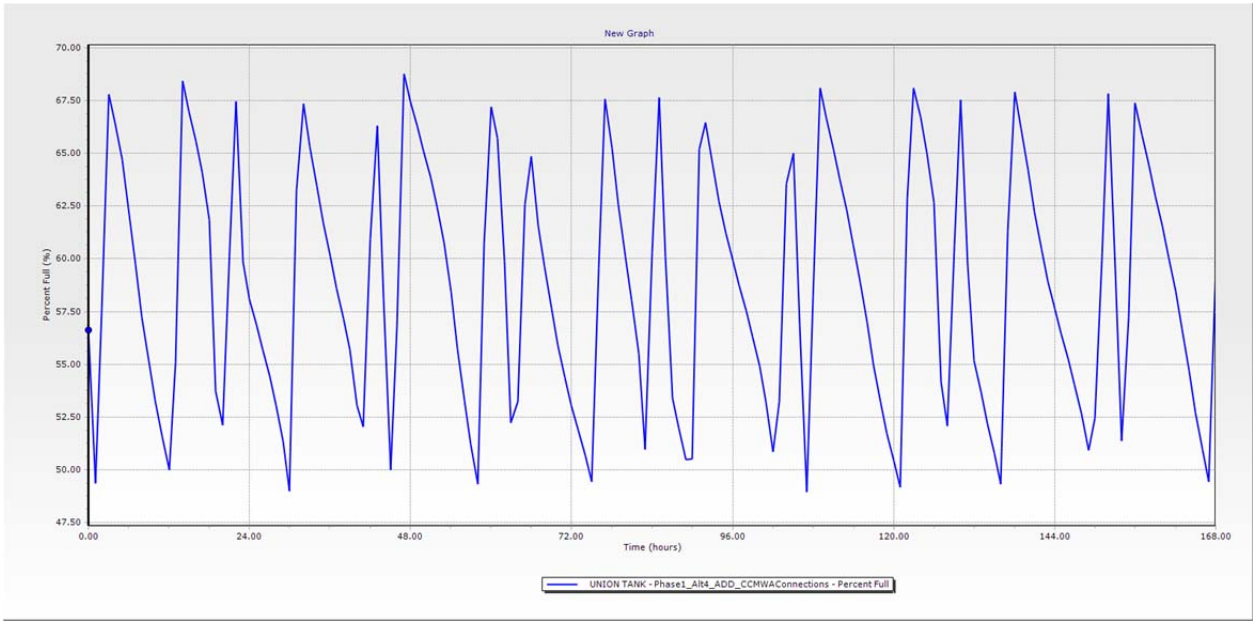
Phase 1: ADD
Main Zone Tank Results (% Full)



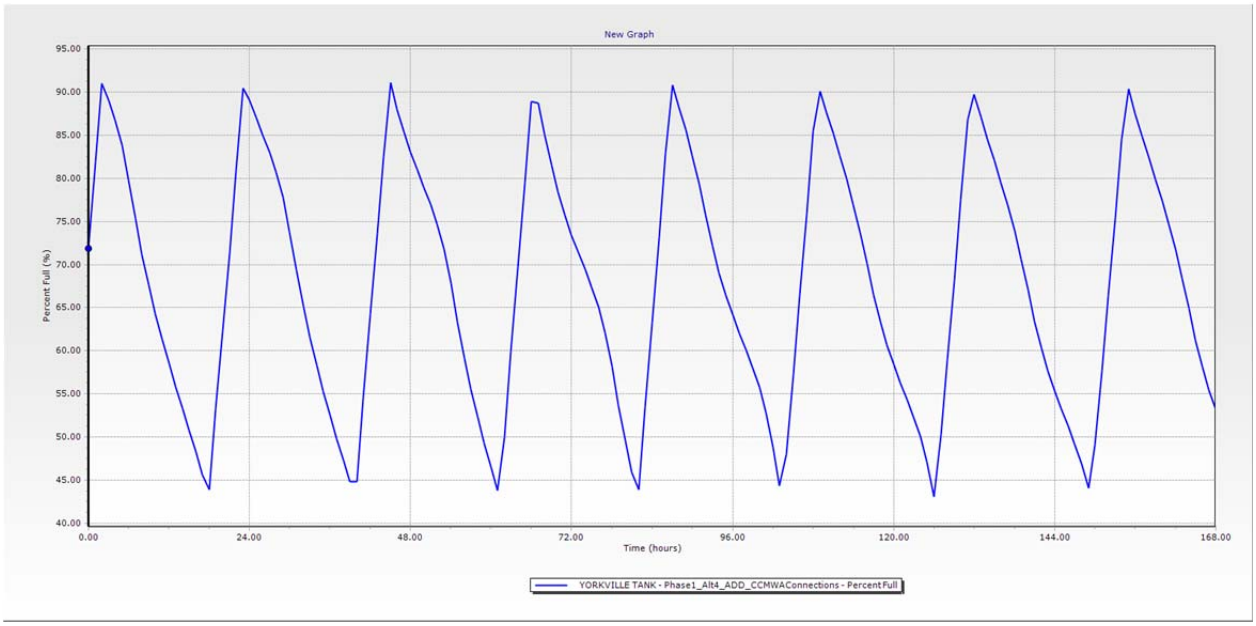
Phase 1: ADD
Mt. Tabor Tank Results (% Full)



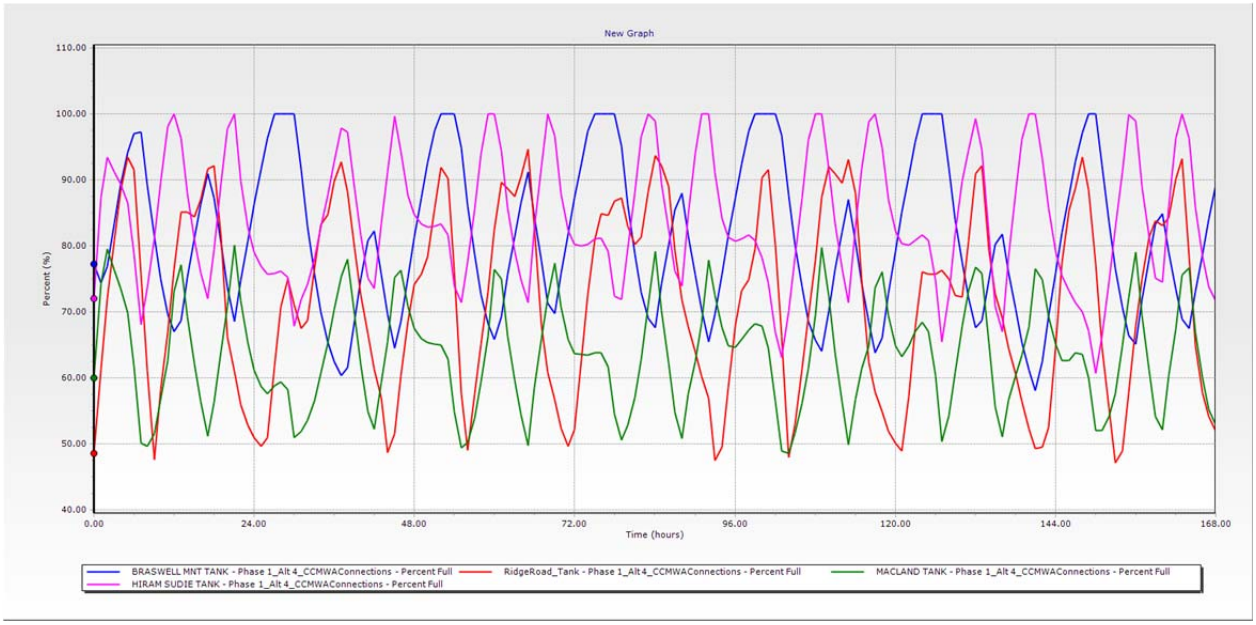
Phase 1: ADD
Union Tank Results (% Full)



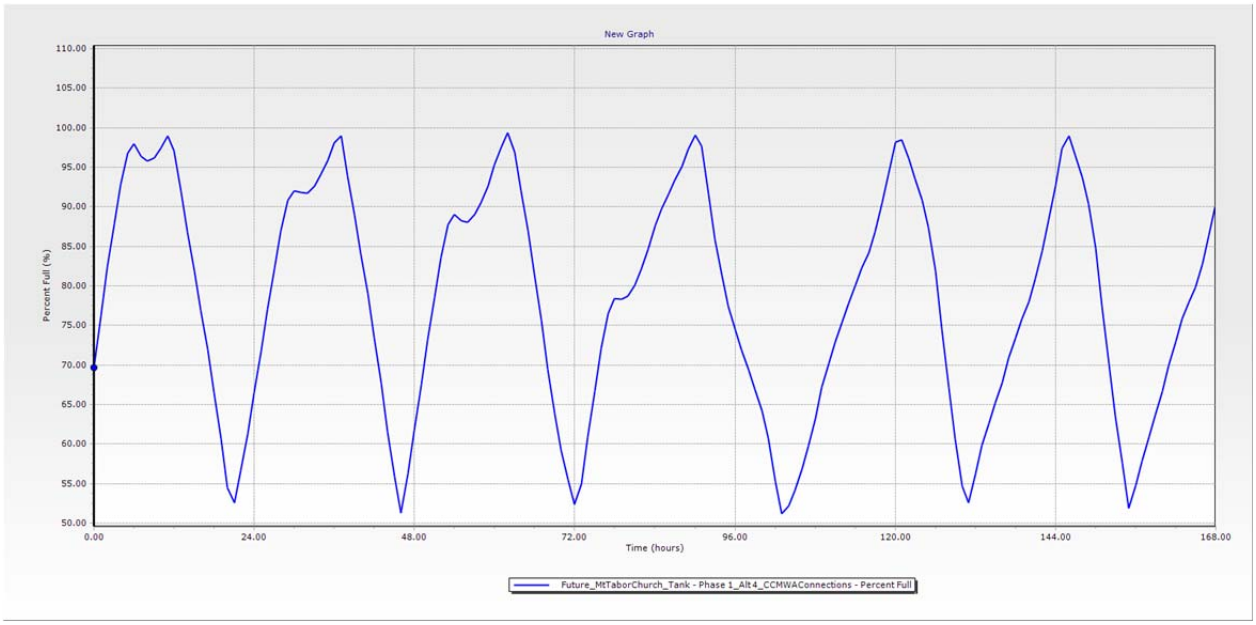
Phase 1: ADD
Yorkville Tank Results (% Full)



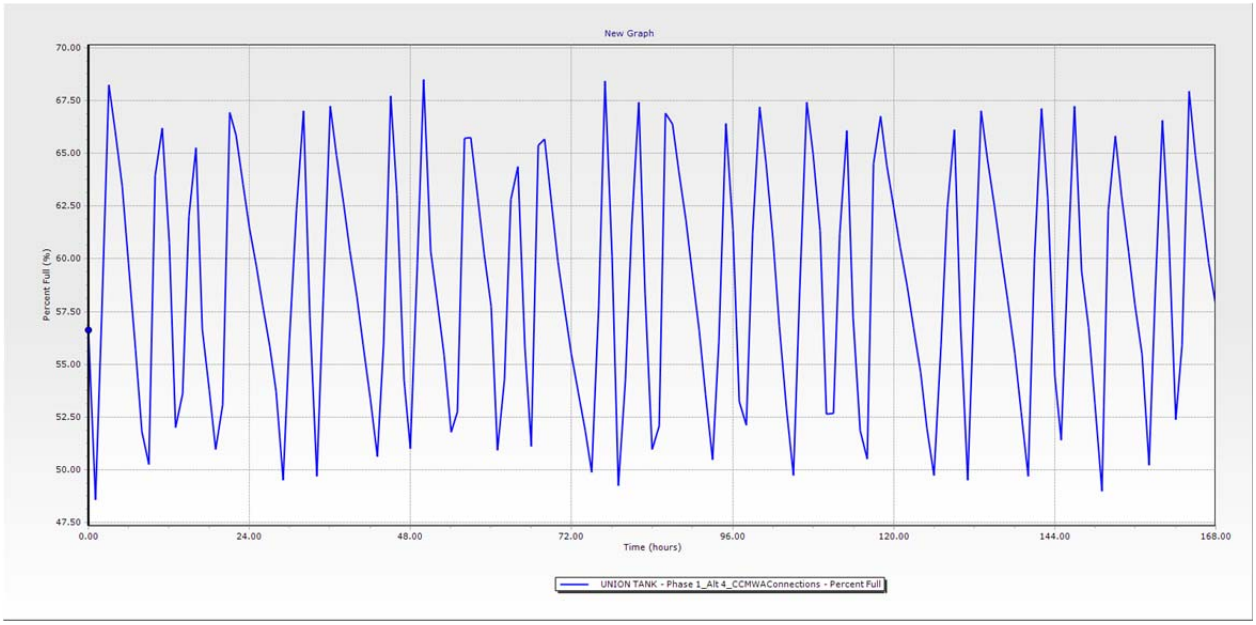
Phase 1: MDD
Main Zone Tank Results (% Full)



Phase 1: MDD
Mt. Tabor Tank Results (% Full)

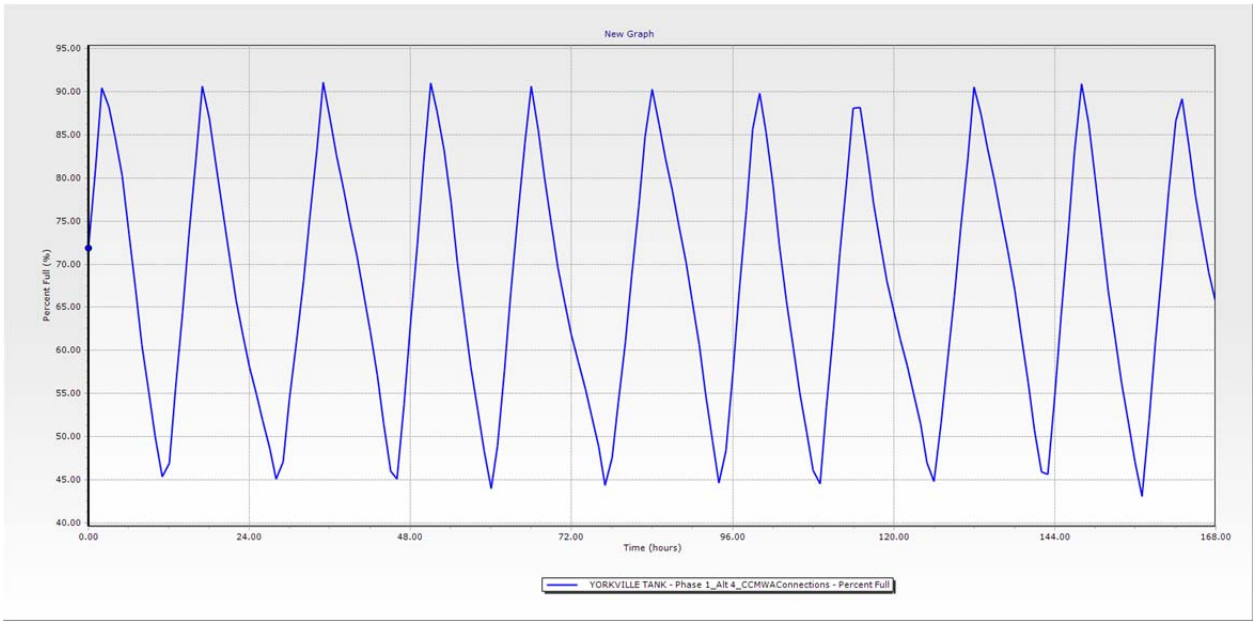


Phase 1: MDD
Union Tank Results (% Full)*



* Based on similar controls at Union BPS as existing system in order to maintain pressures in the southwest corner of the Main Zone. i.e. Union BPS on at Union Tank level 15 ft. and off at Union Tank level 20 ft.

Phase 1: MDD
Yorkville Tank Results (% Full)

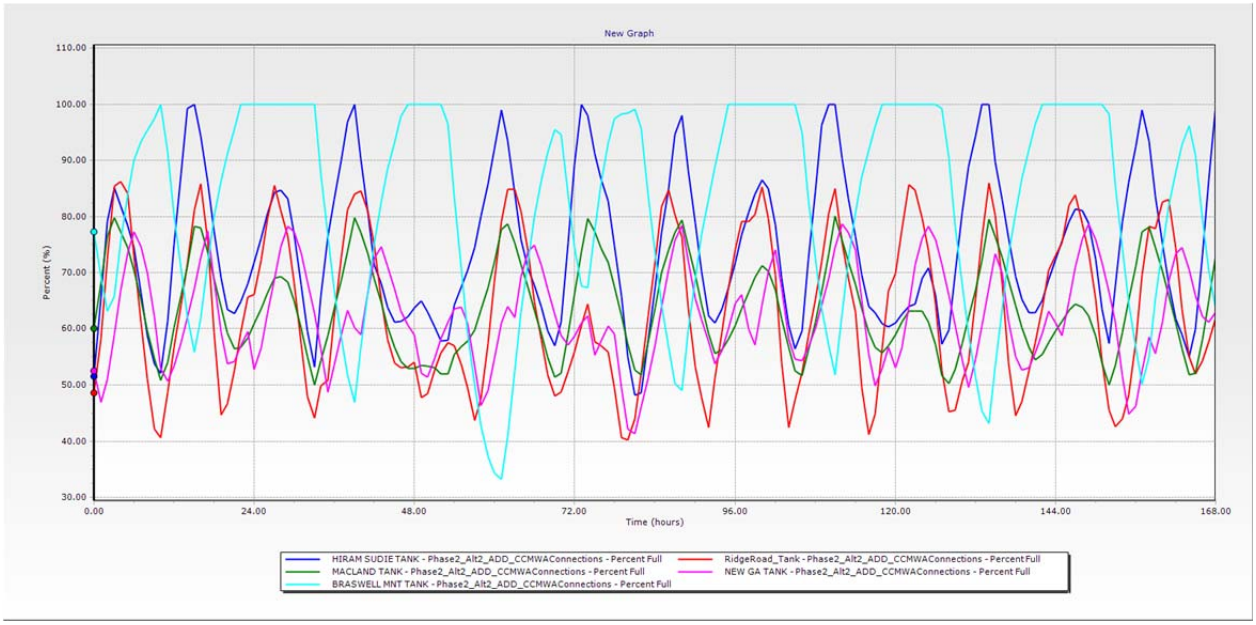


Appendix E

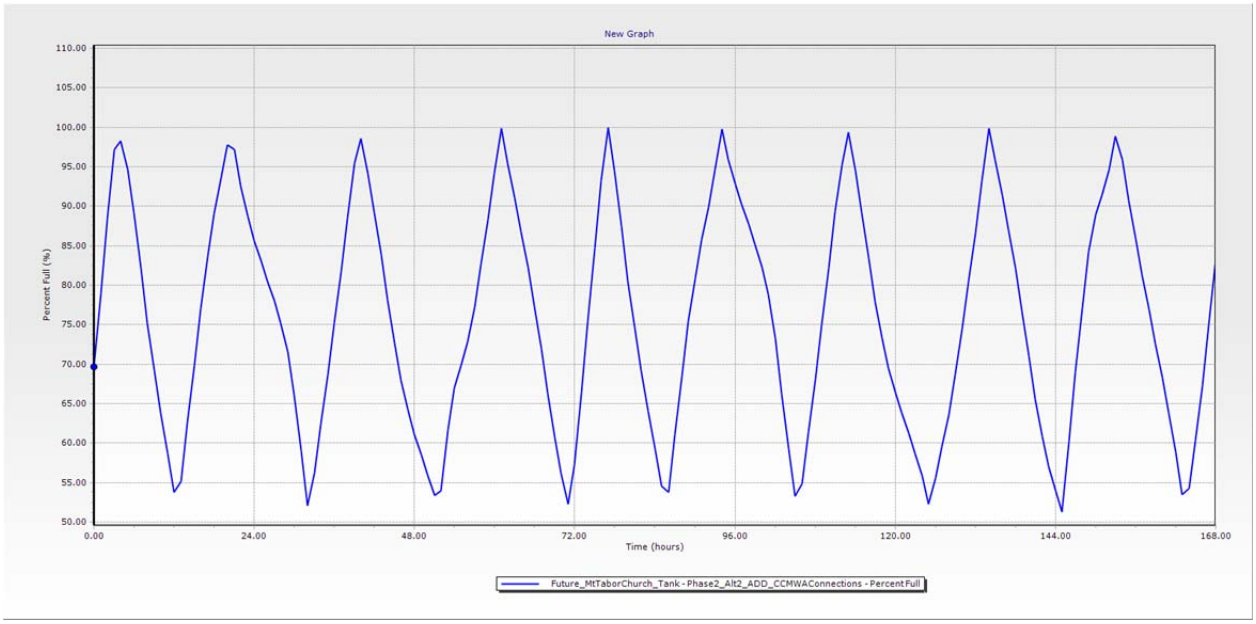
Future System Model Results: Phase 2

PHASE 2 – PART 1. INTERCONNECTIONS: MODEL RESULTS

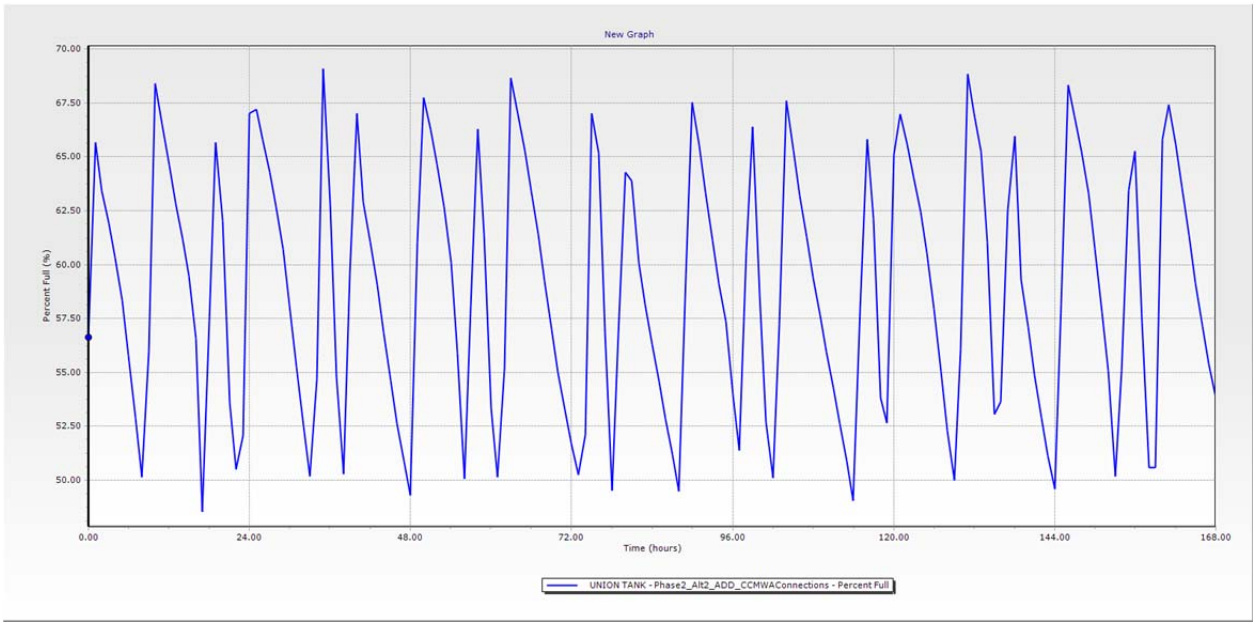
Phase 2 - Part 1. Interconnections: ADD
Main Zone Tank Results (% Full)



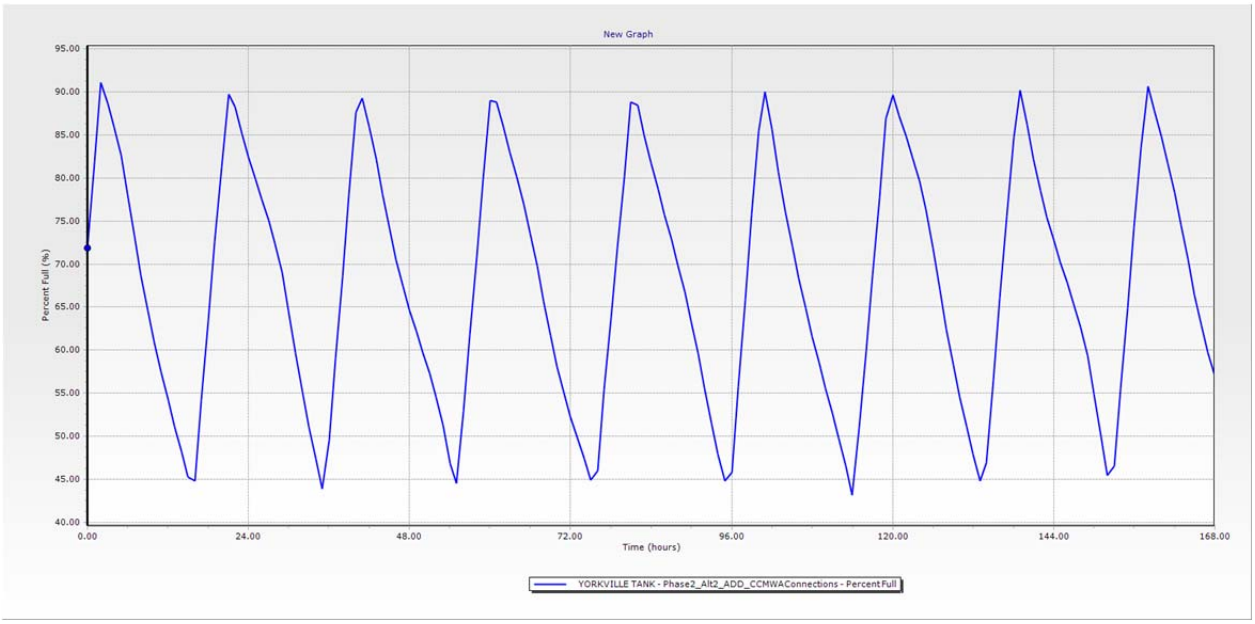
Phase 2 - Part 1. Interconnections: ADD
Mt. Tabor Tank Results (% Full)



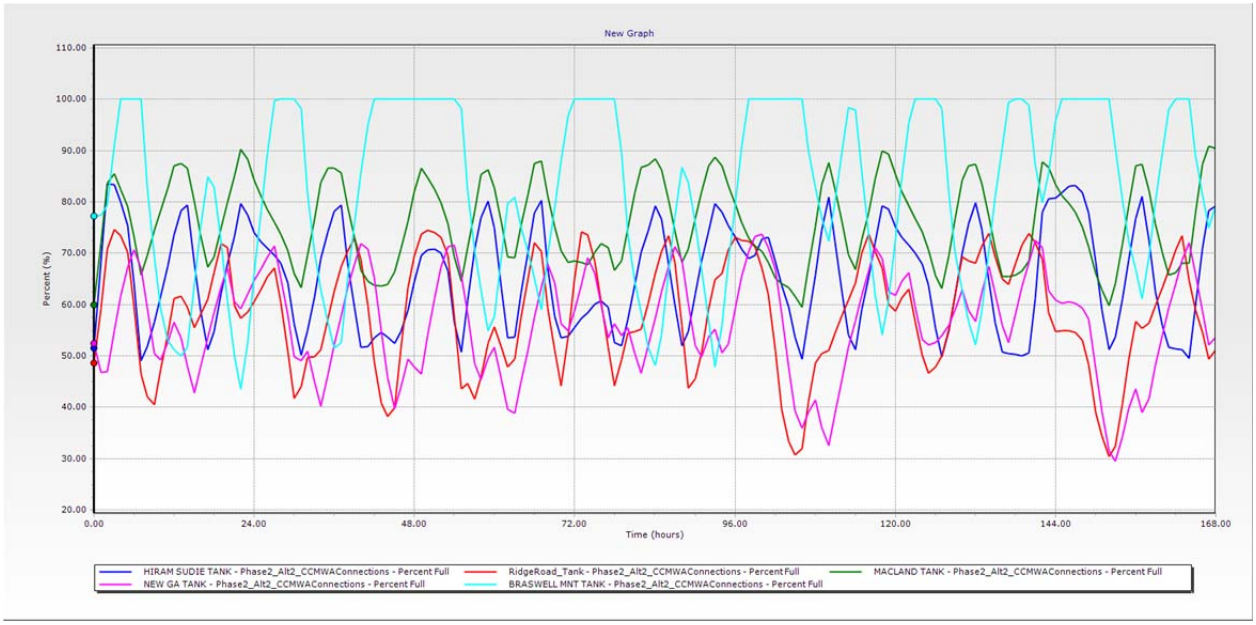
Phase 2 - Part 1. Interconnections: ADD
Union Tank Results (% Full)



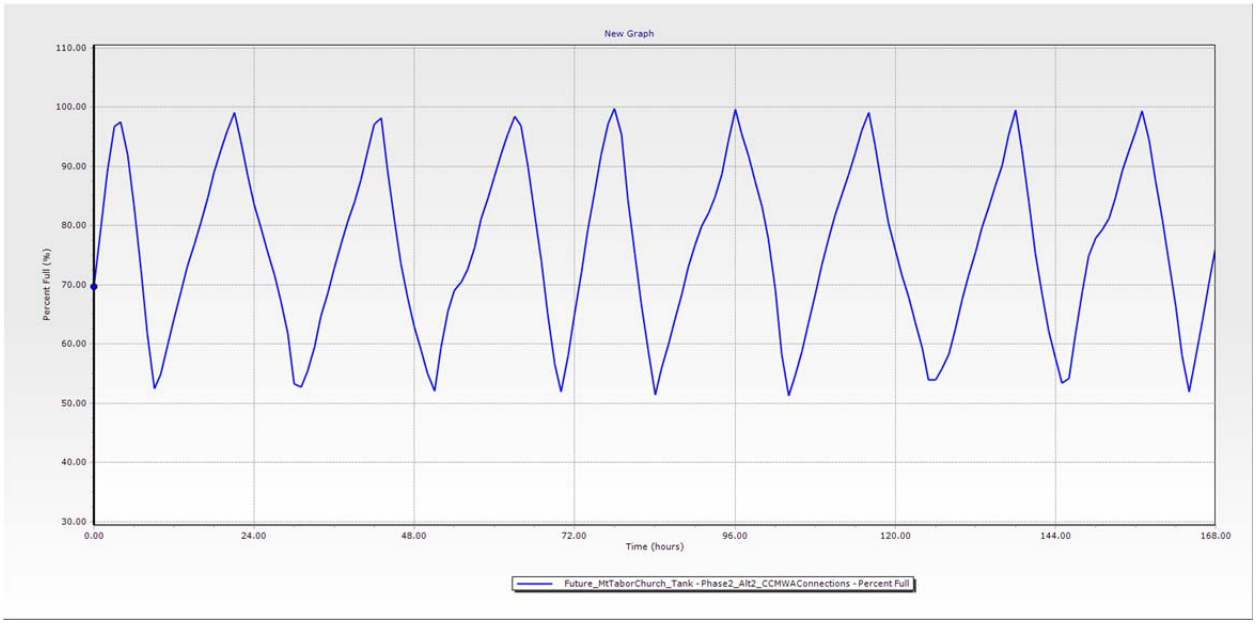
Phase 2 - Part 1. Interconnections: ADD
Yorkville Tank Results (% Full)



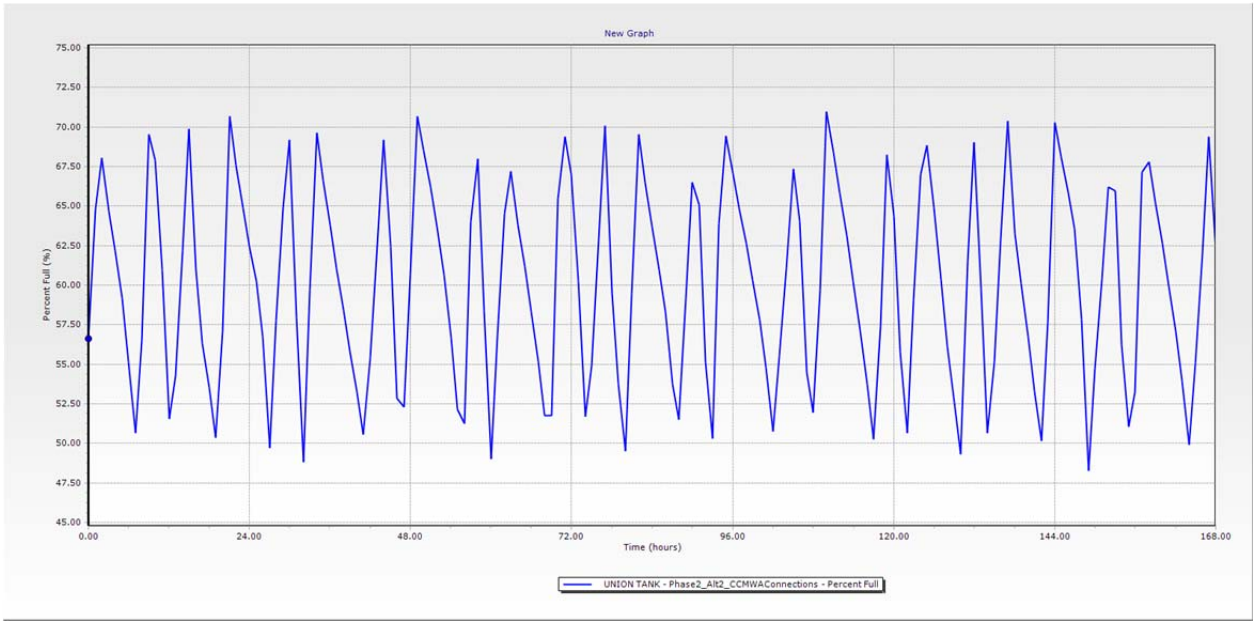
Phase 2 - Part 1. Interconnections: MDD
Main Zone Tank Results (% Full)



Phase 2 - Part 1. Interconnections: MDD
Mt. Tabor Tank Results (% Full)

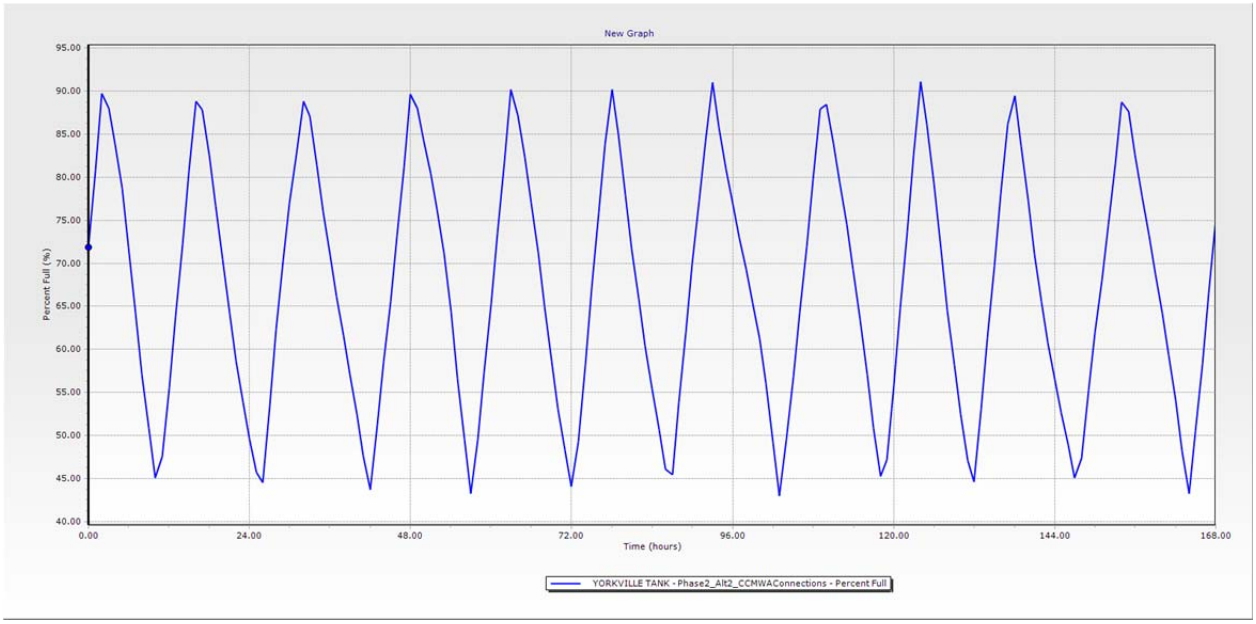


Phase 2 - Part 1. Interconnections: MDD
Union Tank Results (% Full)*



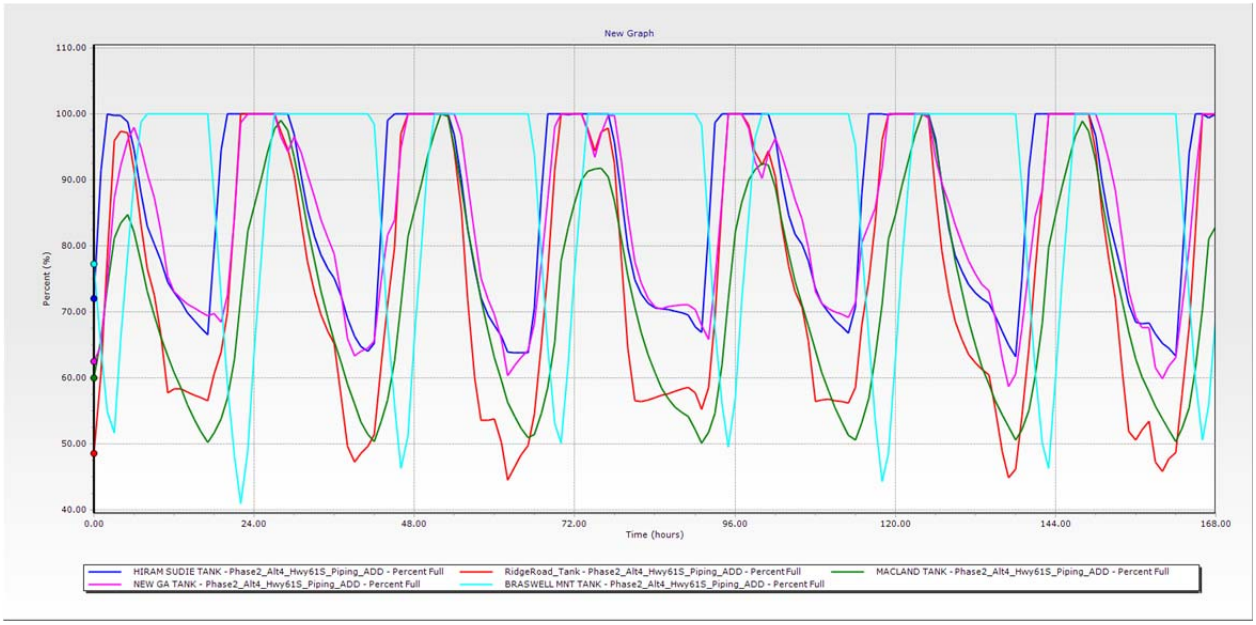
* Based on similar controls at Union BPS as existing system in order to maintain pressures in the southwest corner of the Main Zone. i.e. Union BPS on at Union Tank level 15 ft. and off at Union Tank level 20 ft.

Phase 2 - Part 1. Interconnections: MDD
Yorkville Tank Results (% Full)

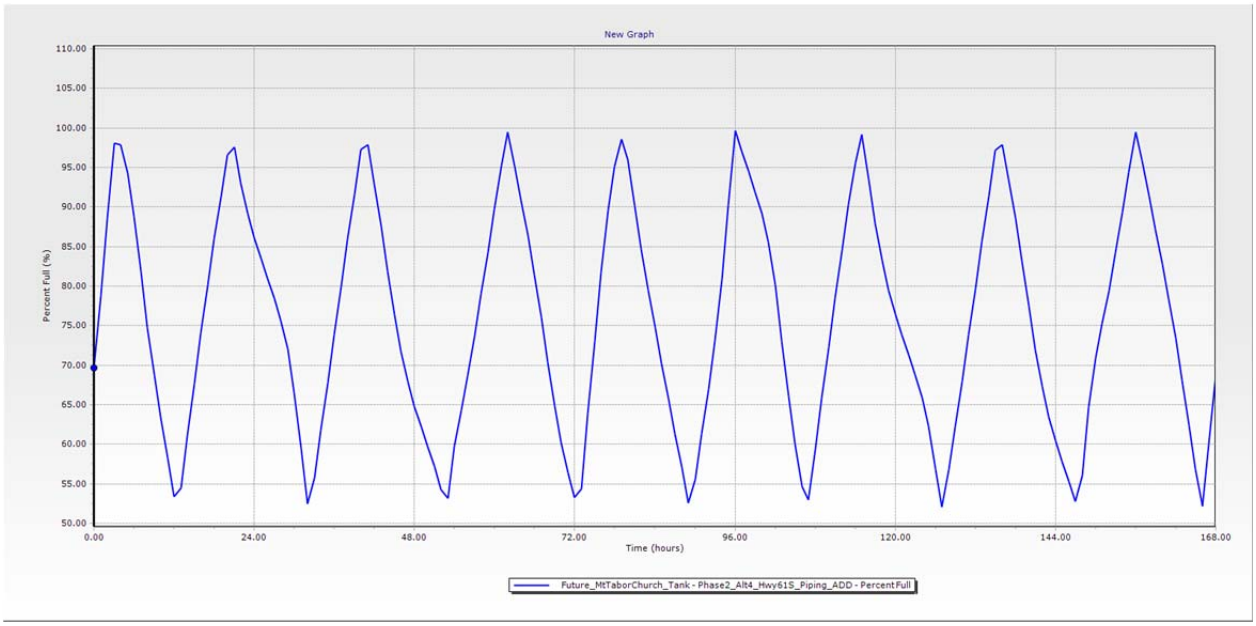


PHASE 2 – PART 2: MODEL RESULTS

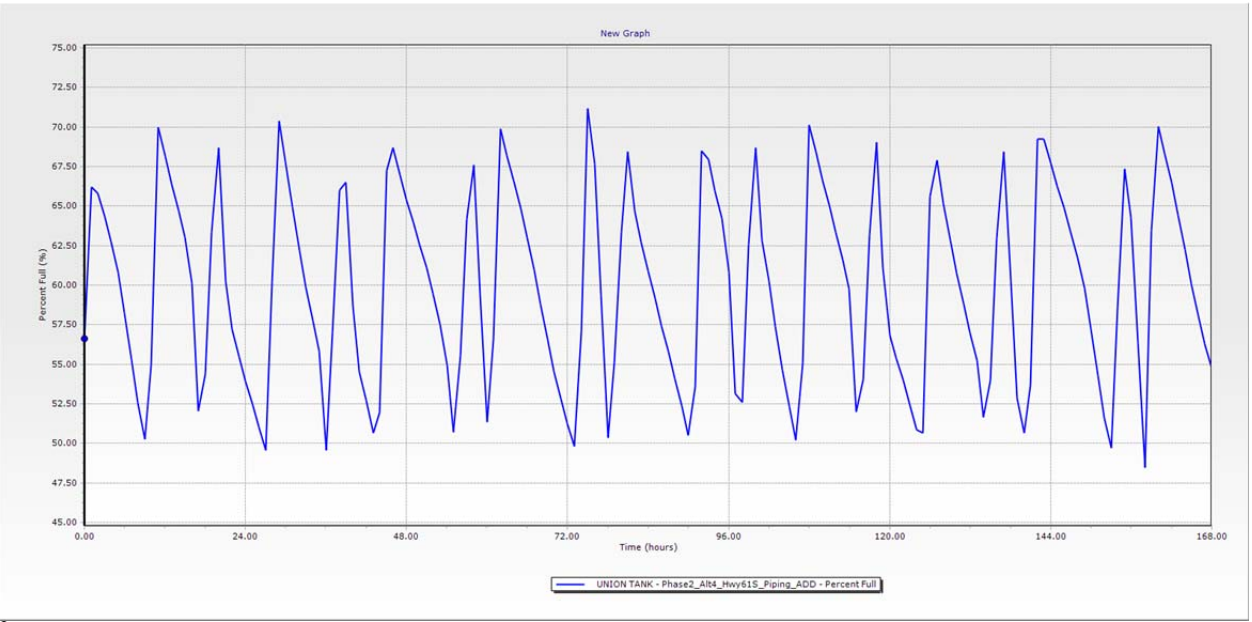
Phase 2 - Part 2: ADD
Main Zone Tank Results (% Full)



Phase 2 - Part 2: ADD
Mt. Tabor Tank Results (% Full)

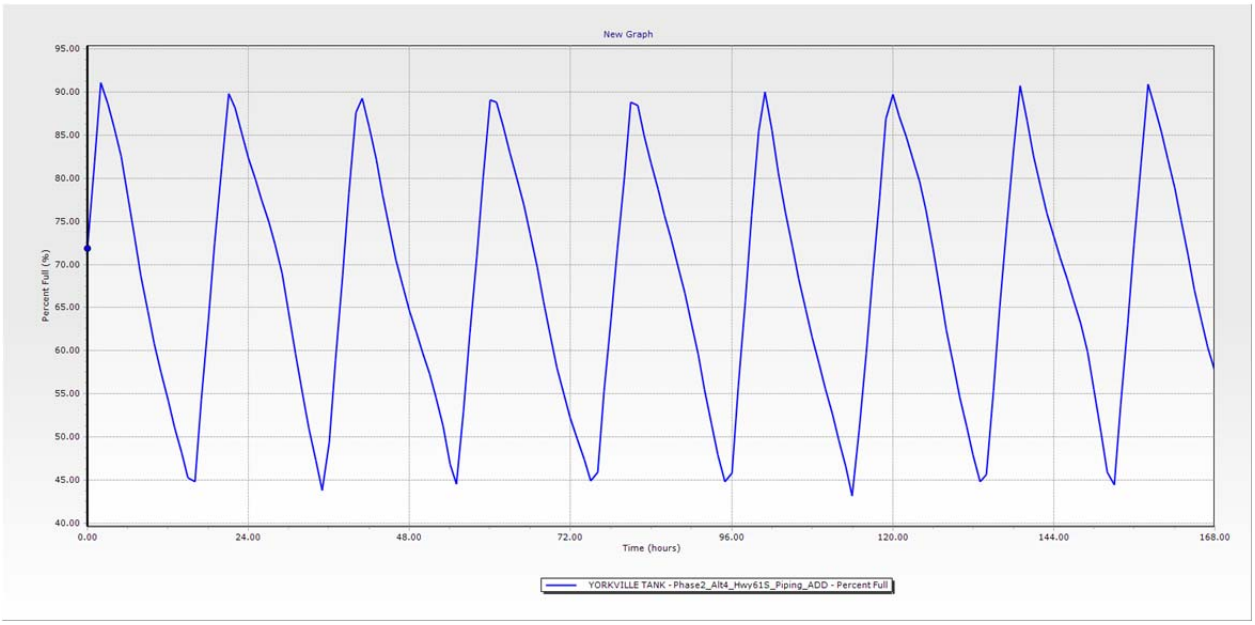


Phase 2 - Part 2: ADD*
Union Tank Results (% Full)

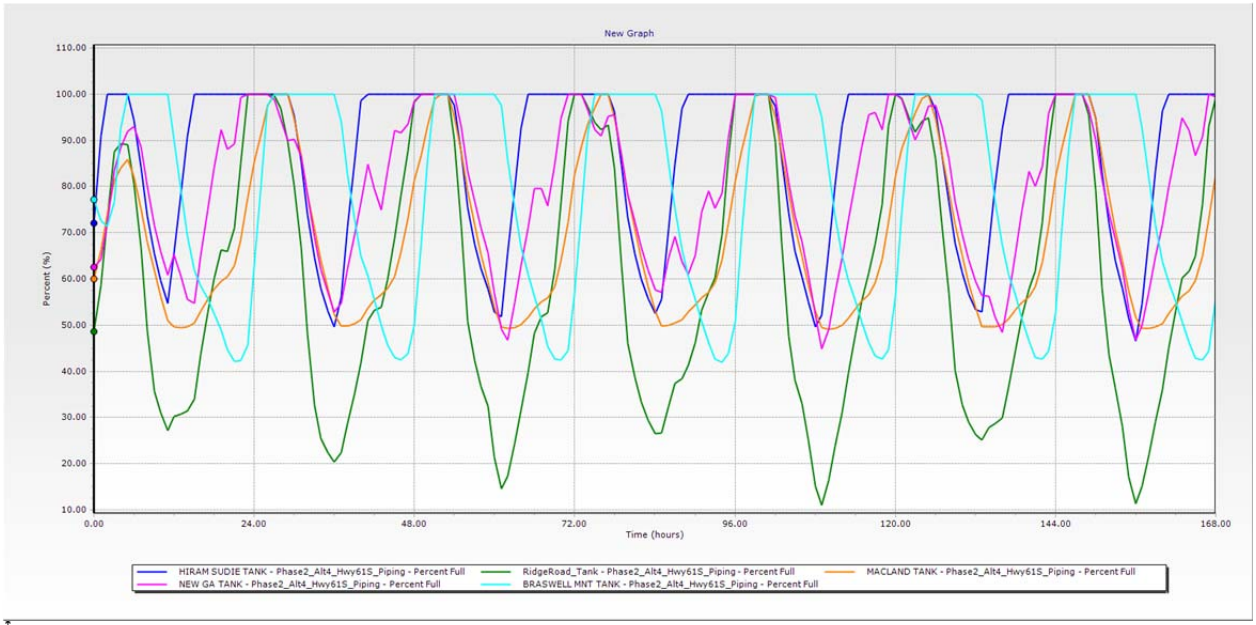


* Based on similar controls at Union BPS as existing system in order to maintain pressures in the southwest corner of the Main Zone. i.e. Union BPS on at Union Tank level 15 ft. and off at Union Tank level 20 ft.

Phase 2 - Part 2: ADD
Yorkville Tank Results (% Full)

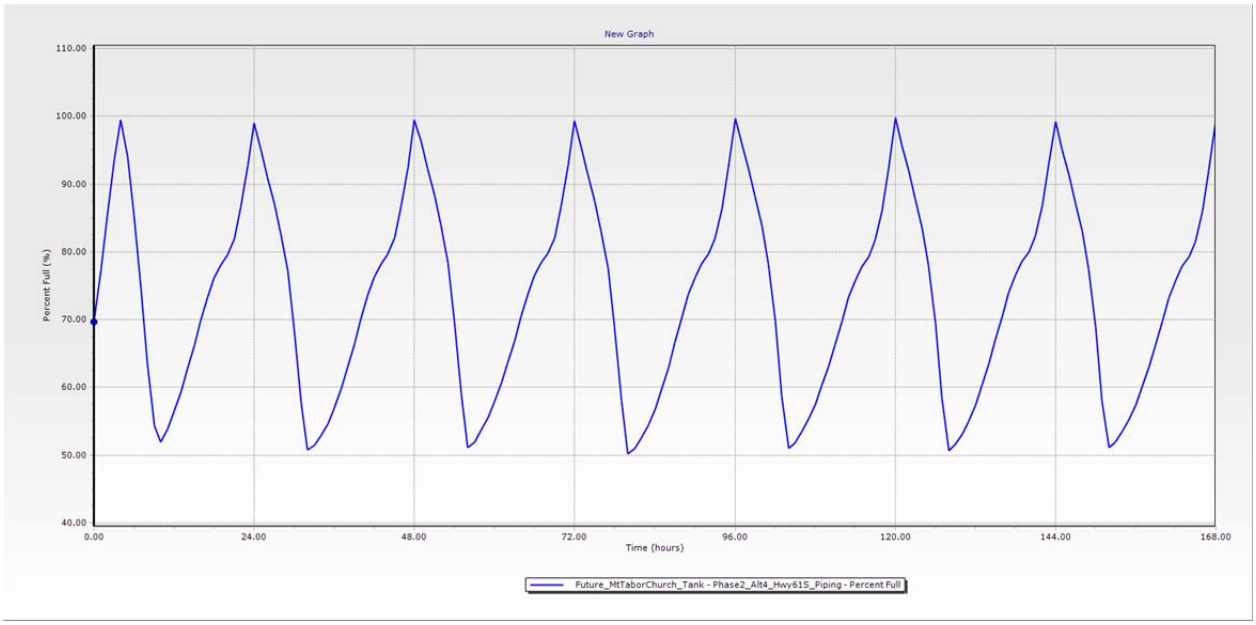


Phase 2 - Part 2: MDD
Main Zone Tank Results (% Full)*

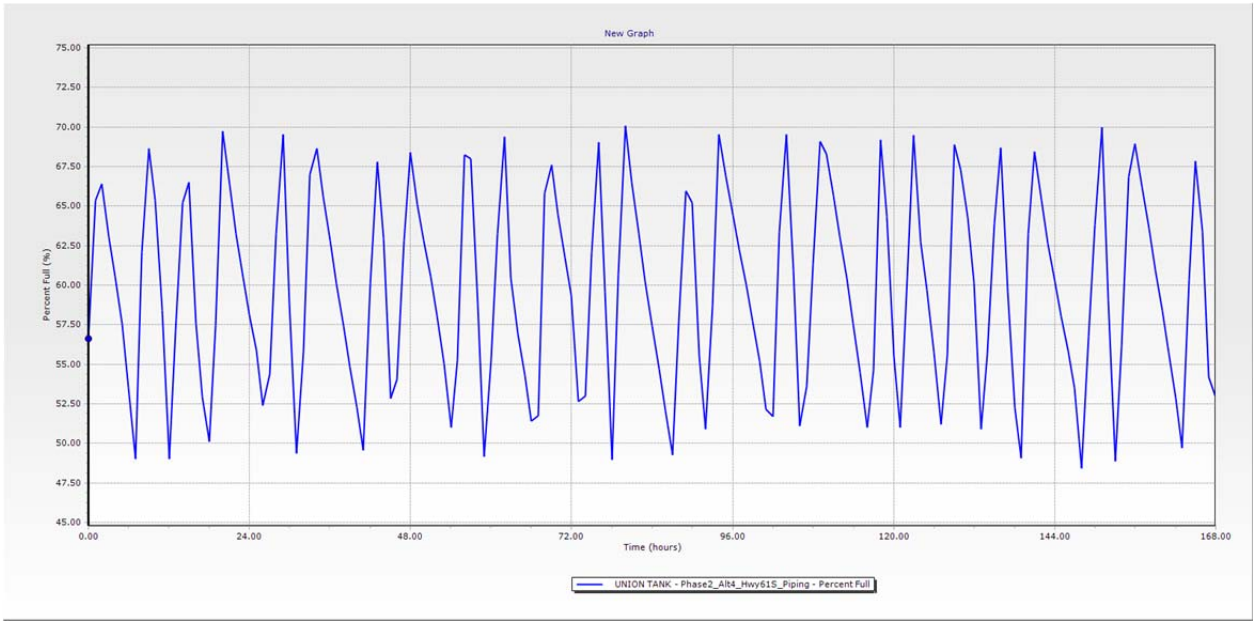


* Ridge Road Tank drafts below 50% during MDD but refills to 100% daily; therefore considered acceptable.

Phase 2 - Part 2: MDD
Mt. Tabor Tank Results (% Full)

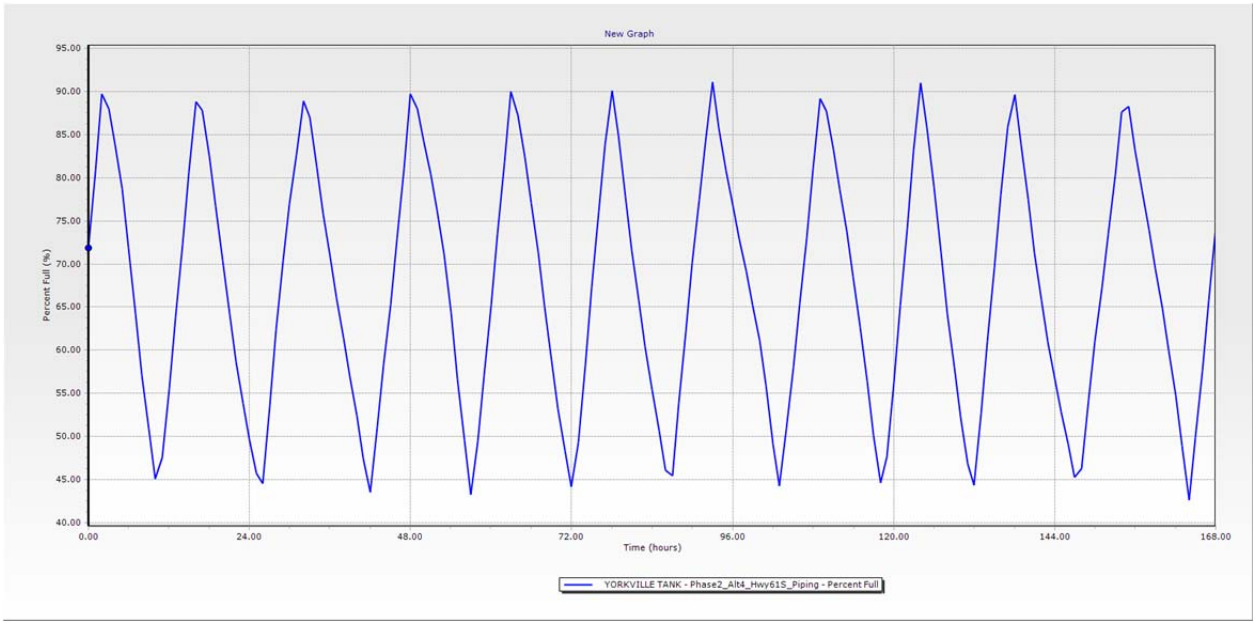


Phase 2 - Part 2: MDD
Union Tank Results (% Full)*



* Based on similar controls at Union BPS as existing system in order to maintain pressures in the southwest corner of the Main Zone. i.e. Union BPS on at Union Tank level 15 ft. and off at Union Tank level 20 ft.

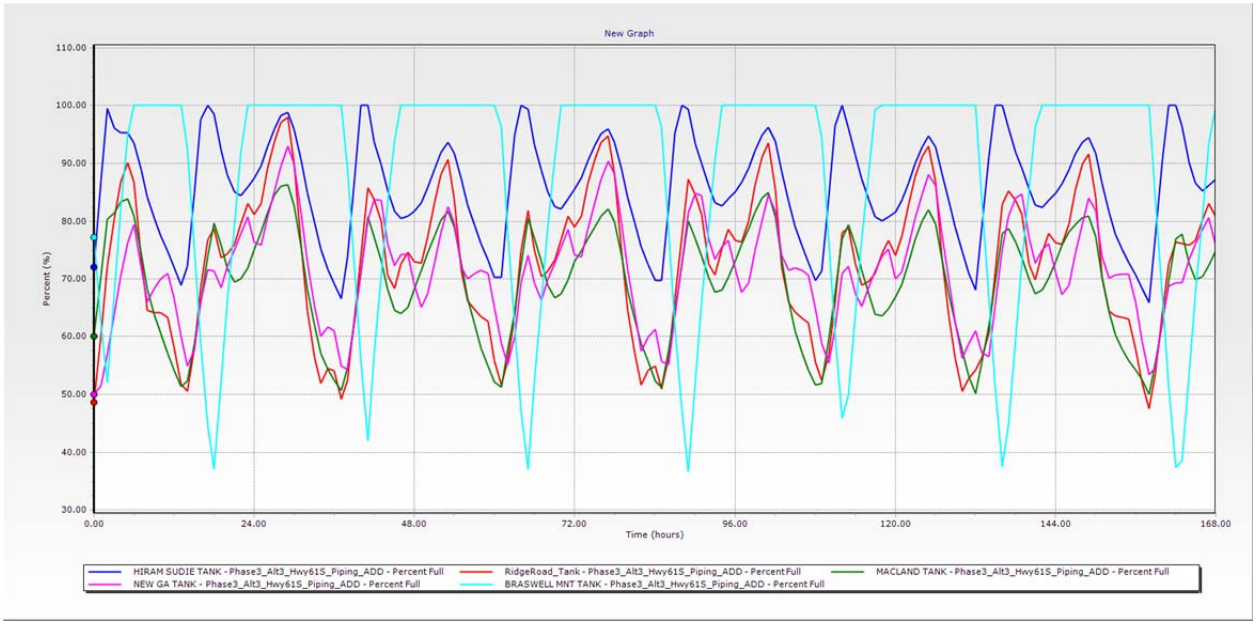
Phase 2 - Part 2: MDD
Union Tank Results (% Full)



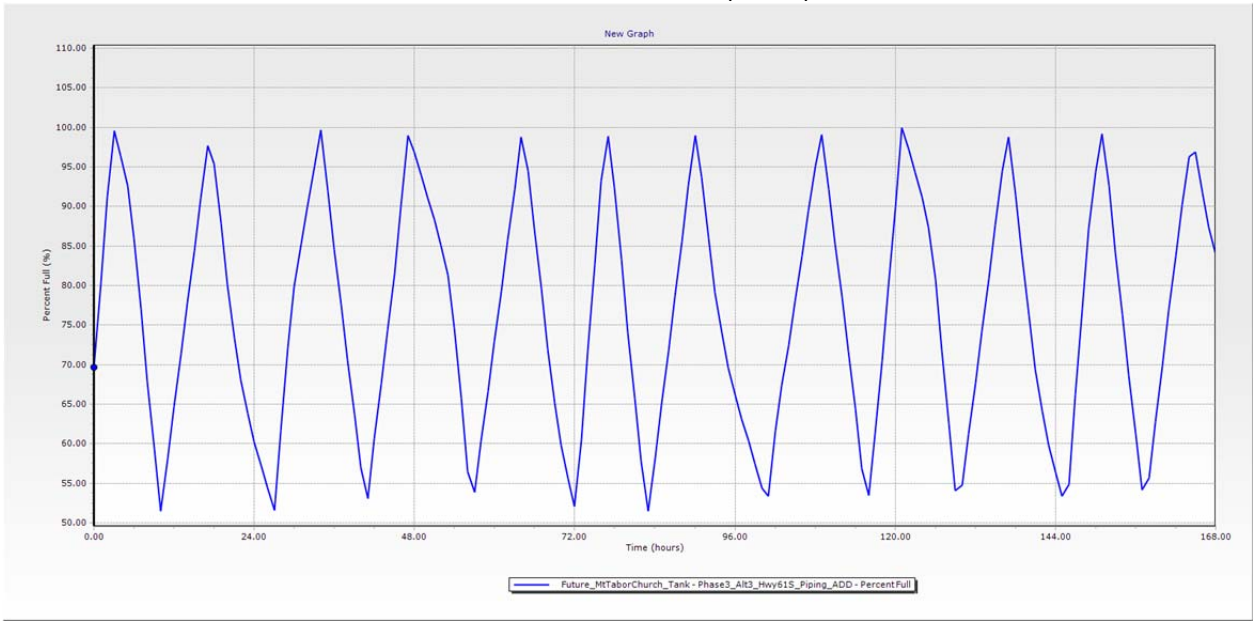
Appendix F

Future System Model Results: Phase 3

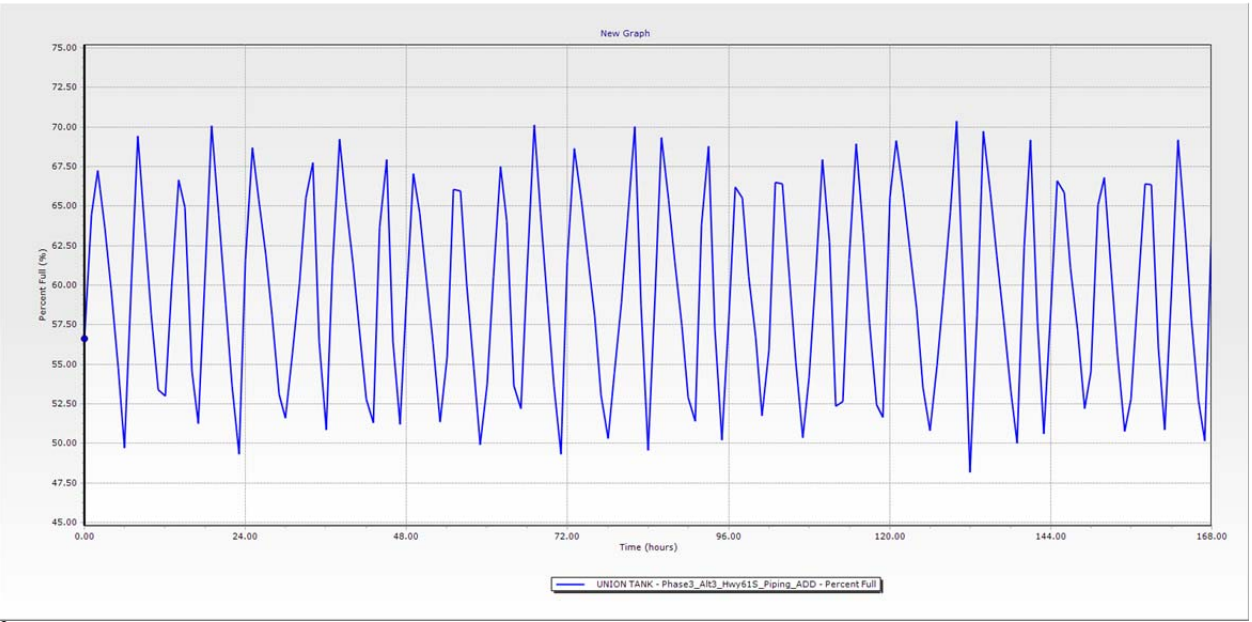
Phase 3: ADD
Main Zone Tank Results (% Full)



Phase 3: ADD
Mt. Tabor Tank Results (% Full)

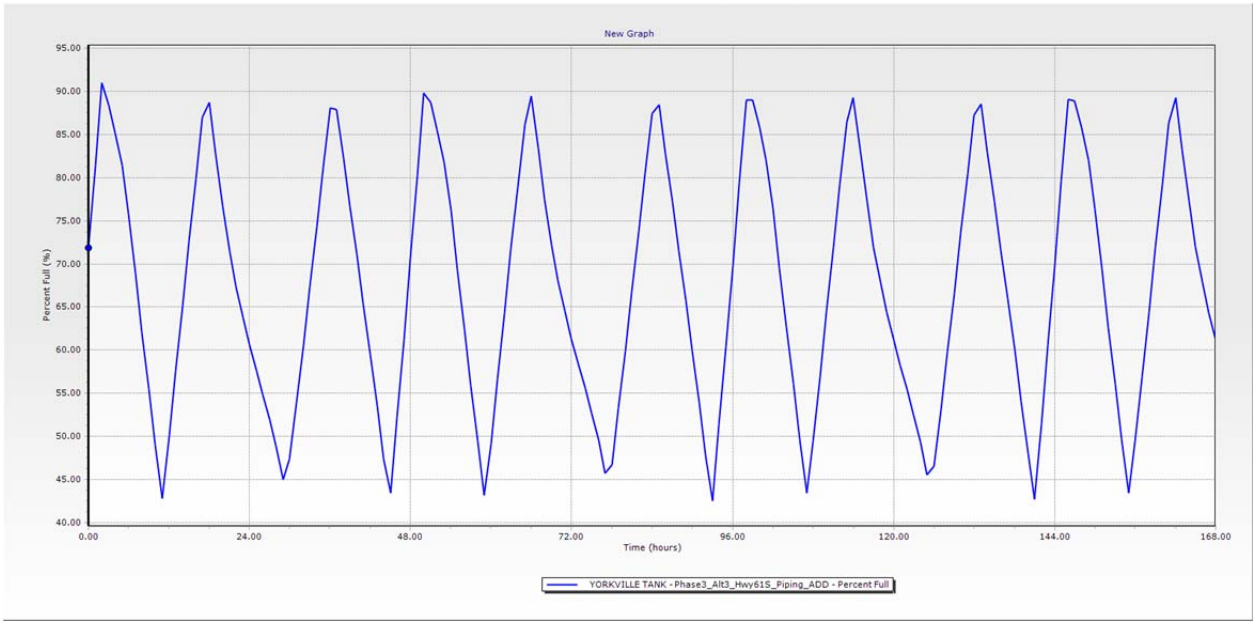


Phase 3: ADD*
Union Tank Results (% Full)

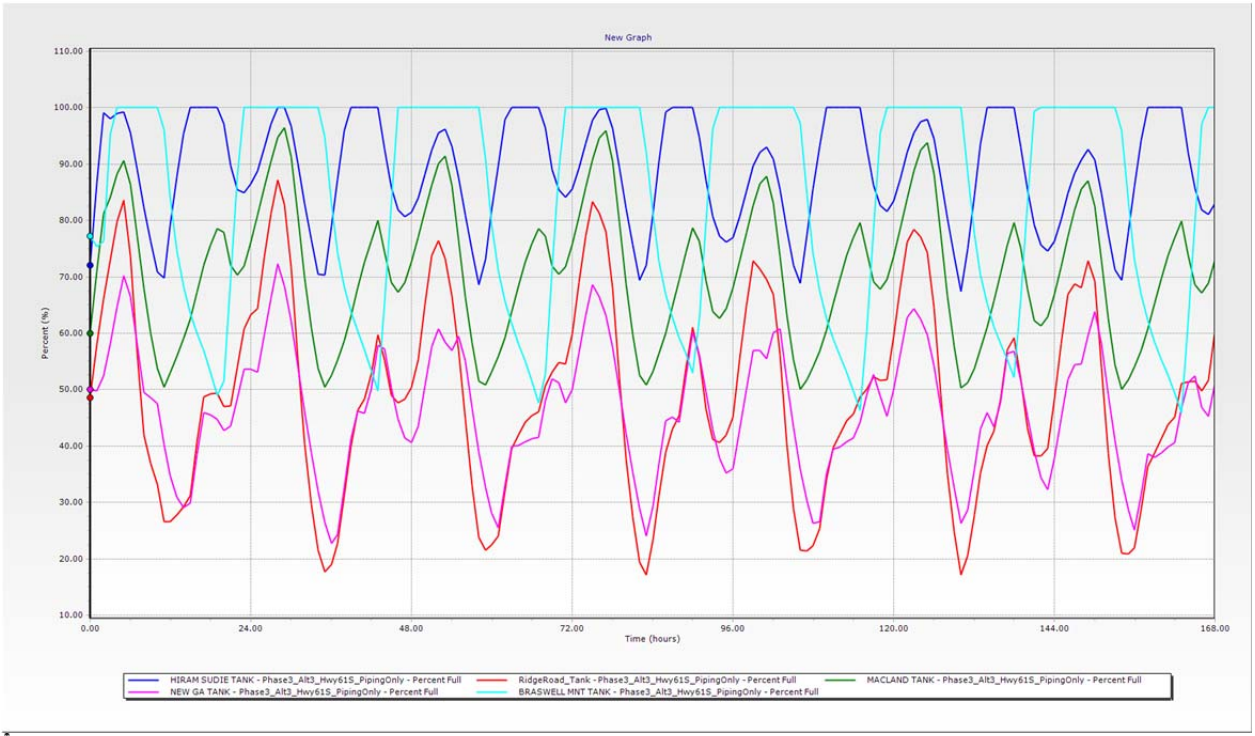


* Based on similar controls at Union BPS as existing system in order to maintain pressures in the southwest corner of the Main Zone. i.e. Union BPS on at Union Tank level 15 ft. and off at Union Tank level 20 ft.

Phase 3: ADD
Yorkville Tank Results (% Full)

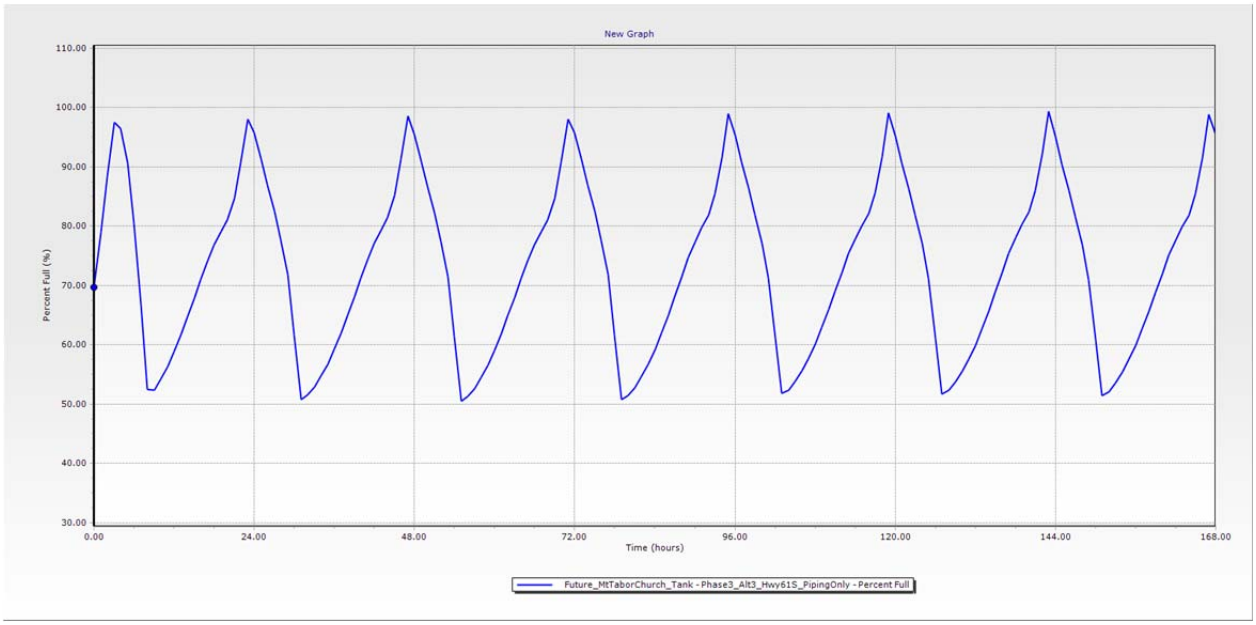


Phase 3: MDD
Main Zone Tank Results (% Full)*

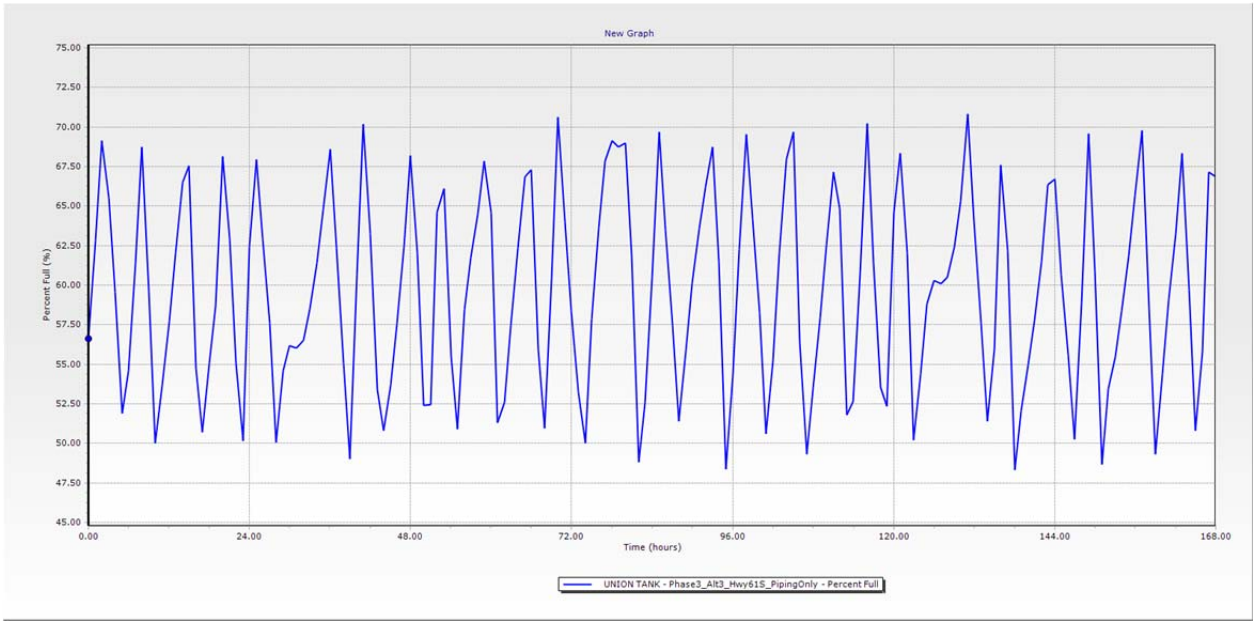


* Ridge Road and New Georgia Tanks draft below 50% during MDD but refill daily; therefore considered acceptable for MDD.

Phase 3: MDD
Mt. Tabor Tank Results (% Full)



Phase 3: MDD
Union Tank Results (% Full)*



* Based on similar controls at Union BPS as existing system in order to maintain pressures in the southwest corner of the Main Zone. i.e. Union BPS on at Union Tank level 15 ft. and off at Union Tank level 20 ft.

Phase 3: MDD
Yorkville Tank Results (% Full)