AMENDMENT

Town of Cary Water Distribution System Master Plan

Prepared for

Town of Cary
Engineering Department

Prepared by

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Amendment to the Town of Cary Water Distribution System Master Plan: System Reliability Scenario Evaluations (September 2012)

1.0 Introduction

In June 2009, CH2M HILL completed the Water Distribution System Master Plan (2009 WDSMP) for the Town of Cary which included development of a new water distribution system hydraulic model using the InfoWorks WS software platform, as well as a system water quality model. In December 2011, the Town requested that CH2M HILL evaluate – at a high level – the Town's water distribution system under different assumptions than evaluated in the 2009 WDSMP. This work includes system evaluations under:

- Different water demands,
- Different evaluation criteria, and
- Different scenarios

These new evaluations are presented in this Amendment. This document is an Amendment to the 2009 WDSMP and is not a "stand-alone" document. All work is based on the use of information and the hydraulic system model developed by CH2M HILL for the Town of Cary WDSMP completed in 2009. The 2009 WDSMP did not include the Town of Apex.

It is critical to note that this Amendment provides results of the high-level analyses, not recommendations for specific infrastructure. These high-level analyses can be used for detailed planning efforts; additional modeling work will be required to evaluate specific operations and to develop infrastructure sizing and costs.

The work consisted of three primary tasks presented in the following sections of this Amendment:

2.0 Update Future Water Demands and Revise Evaluation Criteria

- 2.1 Update Future Water Demands
- 2.2 Revise Diurnal Demand Patterns
- 2.3 Revise System Pressure Criteria
- 2.4 Revise Storage Requirements
- 2.5 Revise Old Apex Tank Operations

3.0 Hydraulically Model Three Scenarios

- 3.1 Modifications to Southern Pressure Zone Operations
- 3.2 Evaluate Finished Water Pipe Size from Cary/Apex Water Treatment Plant along Wimberly Road into Western Pressure Zone and Ultimately to Central Pressure Zone during Extended Emergency Operations
- 3.3 Determine if a Ground Storage Tank sited near Jones Franklin Road Is Beneficial to System Operations

4.0 Initial Evaluation of Significant Changes to the 2009 WDSMP CIP Recommendations

2.0 Update Future Water Demands and Revise Evaluation Criteria

2.1 Update Future Water Demands

For the water distribution system reliability scenario evaluations, the distribution system hydraulic model water demands were updated from the 2009 WDSMP in the Town's current model, which was developed for the WDSMP (CH2M HILL, 2009) and subsequently updated for the WDSMP Addendum: Water Quality Model and Analysis (CH2M HILL, 2010). This section presents the water demands applied in these reliability scenario evaluations. In addition, these future water demands include the Town of Apex as a separate category. Table 1 outlines the 2011 annual average daily demand (ADD), the summer ADD, and the maximum day water demand (MDD) by Cary pressure zone, for the Town of Apex, and the total system. The 2011 data presented in Table 1 is based on actual pumping and pressure release valve (PRV) flow data collected by the Town through its SCADA system. The ADD and MDDs were used as the water demands within the hydraulic model and the summer ADD was used to recalculate the system water storage requirements.

TABLE 1
2011 Water Demand, by Cary Pressure Zone and for the Town of Apex[c]

	Southern Pressure Zone (SPZ)[a]	Central Pressure Zone (CPZ)[a]	Western Pressure Zone (WPZ)[a]	Town of Apex	Total System
2011 Annual ADD (mgd)[a,b]	1.3	9.8	3.2	2.9	17.3
2011 Summer ADD (mgd)	1.7	11.3	4.0	3.4	20.4
2011 MDD (mgd)[a,b]	2.1	15.7	5.2	4.6	27.6

[a] *Data Source: Actual 2011 pumping and PRV flow monitoring data*
[b] *Cary 2011 ADD and 2011 MDD water demand projections (which include non-revenue water and bulk water sales) can be compared with values in 2009 WDSMP Tables 2-11 and 2-14 (must add non-revenue to individual values). Also note that 2009 WDSMP did not include Apex demands.*
[c] *Water demand values include non-revenue water (including operational usage) and bulk water sales.*

Table 2 outlines the projected 2025 annual ADD, summer ADD, and the MDD by Cary pressure zone, for the Town of Apex, and the total system. The 2025 ADD and MDD are based on the projections presented in the LRWRP baseline water demand projection technical memorandums (CH2M HILL, 2012a and CH2M HILL, 2011) and the LRWRP water demand and wastewater flow forecasting tool (CH2M HILL, 2012b). Specific details on the methodology for the development of the 2025 ADD and MDD projections can be found in these technical memorandums. The determination of the summer ADD in 2025 was completed using the 2011 ratio of the summer ADD to the annual ADD for each pressure zone and Apex. The data for 2011 is one of three years with actual flow monitoring data by pressure zone and represents a reasonable estimate of summer ADD for use in the evaluation of the distribution system reliability scenarios. The ratios of summer ADD to annual ADD by pressure zone, and for the Town of Apex, are:

- CPZ: 1.20:1.00 (summer ADD:annual ADD)
- SPZ: 1.20:1.00

- WPZ: 1.20:1.00
- Apex: 1.20:1.00
- Total System: 1.20:1.00

The ADD and MDDs projections were used to revise the water demands within the hydraulic model and the summer ADD projections were used to revise system water storage requirement calculations.

Zonal adjustment factors, by pressure zone, were used to revise the Town's current hydraulic model ADD and MDD to the water demands presented in Table 1 and Table 2.

TABLE 2
2025 Water Demand Projections, by Cary Pressure Zone and for the Town of Apex[a,c]

	Southern Pressure Zone (SPZ)	Central Pressure Zone (CPZ)	Western Pressure Zone (WPZ)	Town of Apex	Total System
2025 Annual ADD (mgd)[b]	2.9	12.0	8.1	5.6	28.6
2025 Summer ADD (mgd)	3.8	14.4	9.7	6.7	34.6
2025 MDD (mgd)[b]	4.8	19.7	13.3	9.9	47.6

[a] *Data Source: Projections by pressure zone – CH2M HILL, 2012b, Projections for the Town of Apex – CH2M HILL, 2011*
[b] *Cary 2025 ADD and 2025 MDD water demand projections (which include non-revenue water and bulk water sales) can be compared with values in 2009 WDSMP Tables 2-11 and 2-14 (must add non-revenue to individual values). Also note that 2009 WDSMP did not include Apex demands.*
[c] *Water demand projections include non-revenue water (including operational usage) and bulk water sales.*

Zonal adjustment factors, by pressure zone, were used to revise the Town's current hydraulic model ADD and MDD to the water demands presented in Table 1 and Table 2.

Table 3 presents the projected build-out annual ADD and the MDD by Cary pressure zone, for the Town of Apex, and the total system. The build-out ADD and MDD are based on the projections presented in the 2009 WDSMP.

TABLE 3
Build-out Water Demand Projections, by Cary Pressure Zone and for the Town of Apex

	Southern Pressure Zone (SPZ)	Central Pressure Zone (CPZ)	Western Pressure Zone (WPZ)	Town of Apex	Total System
Annual ADD (mgd)	4.3	16.0	11.2	9.0	40.5
MDD (mgd)	7.1	26.2	18.3	15.3	66.9

[a] *Data Source: Projections by pressure zone – CH2M HILL, 2009; Table 5-5*
[b] *Cary Build-out ADD and Build-out MDD water demand projections (which include non-revenue water and bulk water sales) can be compared with values in 2009 WDSMP Tables 2-11 and 2-14 (must add non-revenue to individual values). Also note that 2009 WDSMP did not include Apex demands.*
[c] *Water demand projections include non-revenue water (including operational usage) and bulk water sales.*

2.2 Revise Diurnal Demand Patterns

The CH2M HILL team reviewed the diurnal demand patterns for each pressure zone for the 2011 MDD, July 28th, as well as the period leading up to and following the maximum day (July 18th through July 31st). Figures 1 through 3 present the average diurnal demand patterns by pressure zone for the reviewed data period, after the removal of Monday's (no irrigation allowed due to the Town's Alternative Day Watering ordinance) and those days with outlier data points or significant data drop outs (i.e. SCADA was down and no data was collected for a period of time). In addition, Figures 1 through 3 present the district measurement diurnal demand patterns collected for the system water quality analyses completed in 2009 (CH2M HILL, 2010). Figure 4 presents the district measurement data for the CPZ Morrisville and CPZ RDU airport measurement areas. Figure 5 presents the district measurement data for the flow to the Town of Apex through the Jenks Road and Green Level Road master meters.

For the reliability evaluations the hydraulic model continues to use the district measurement diurnal demand patterns developed for the CPZ and WPZ for the system water quality analyses (CH2M HILL, 2010). These measurements represent a greater level of detail, 4 measurement areas within the CPZ and 2 areas within the WPZ, than the 2011 patterns developed by pressure zone and the patterns are similar to the 2011 patterns. The SPZ diurnal pattern has been revised in the model to the 2011 pattern to capture the higher hourly peaks in the 2011 data. The required storage calculations have been revised based on the 2011 diurnal demand patterns.

FIGURE 1
CPZ Maximum Day Diurnal Demand Pattern – Cary
Solid line represents the district measurement data (2009 WDSMP) and the dashed line represents the 2011 SCADA data (Comparable to 2009 WDSMP Figure 4-7)

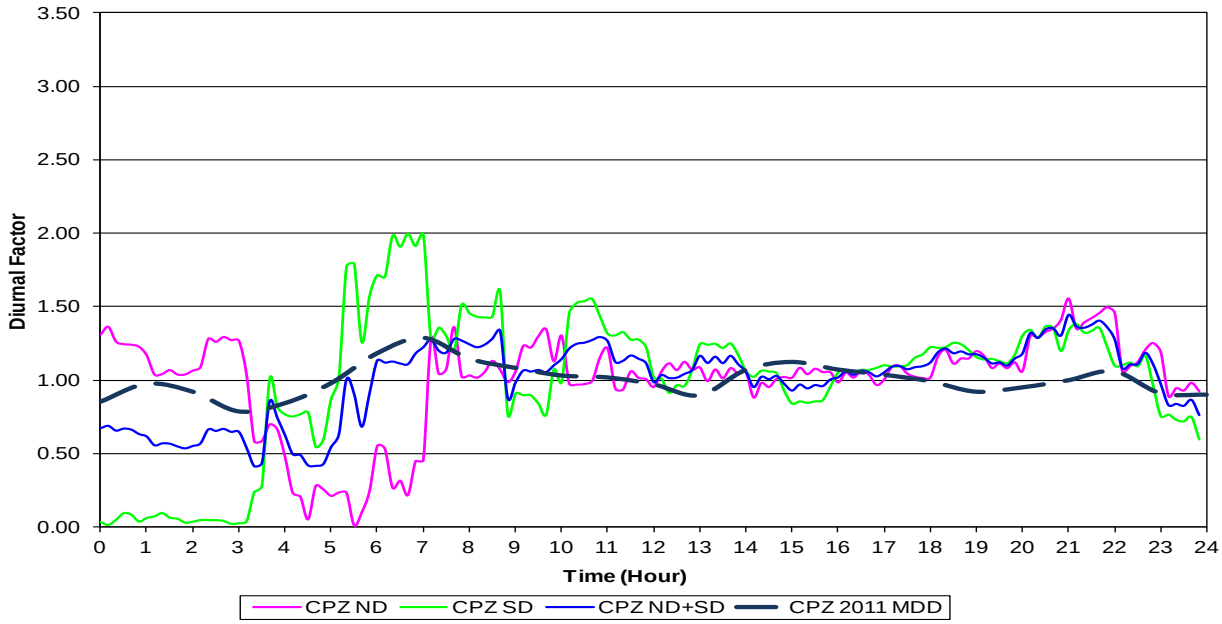


FIGURE 2
SPZ Maximum Day Diurnal Demand Pattern – Cary
Solid line represents the district measurement data (2009 WDSMP) and the dashed line represents the 2011 SCADA data (Comparable to 2009 WDSMP Figure 4-9)

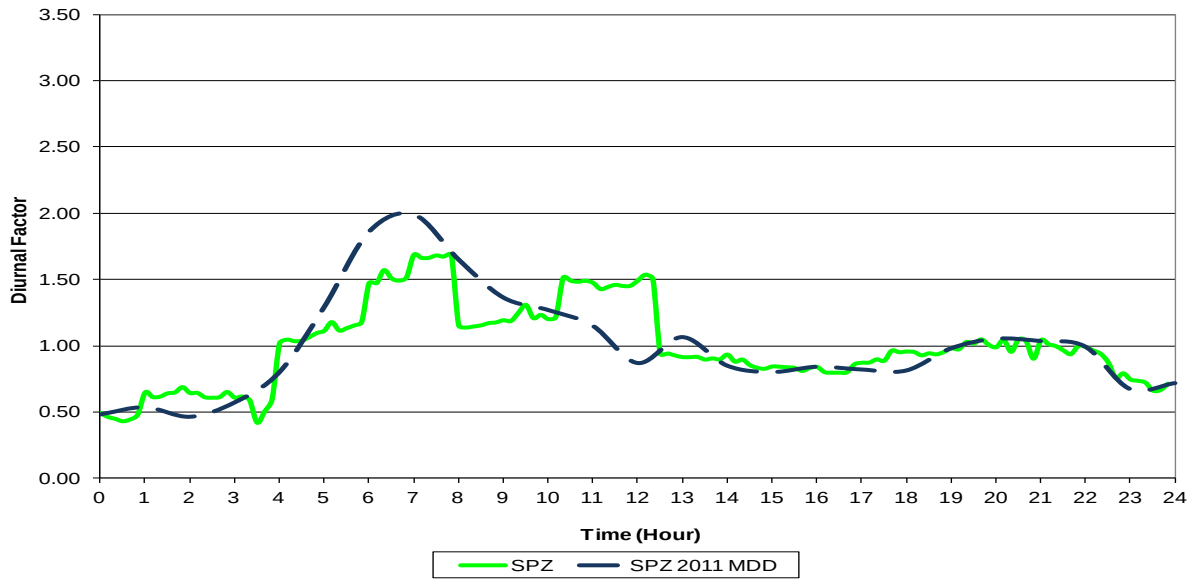


FIGURE 3
WPZ Maximum Day Diurnal Demand Pattern – Cary
Solid line represents the district measurement data (2009 WDSMP) and the dashed line represents the 2011 SCADA data (Comparable to 2009 WDSMP Figure 4-8)

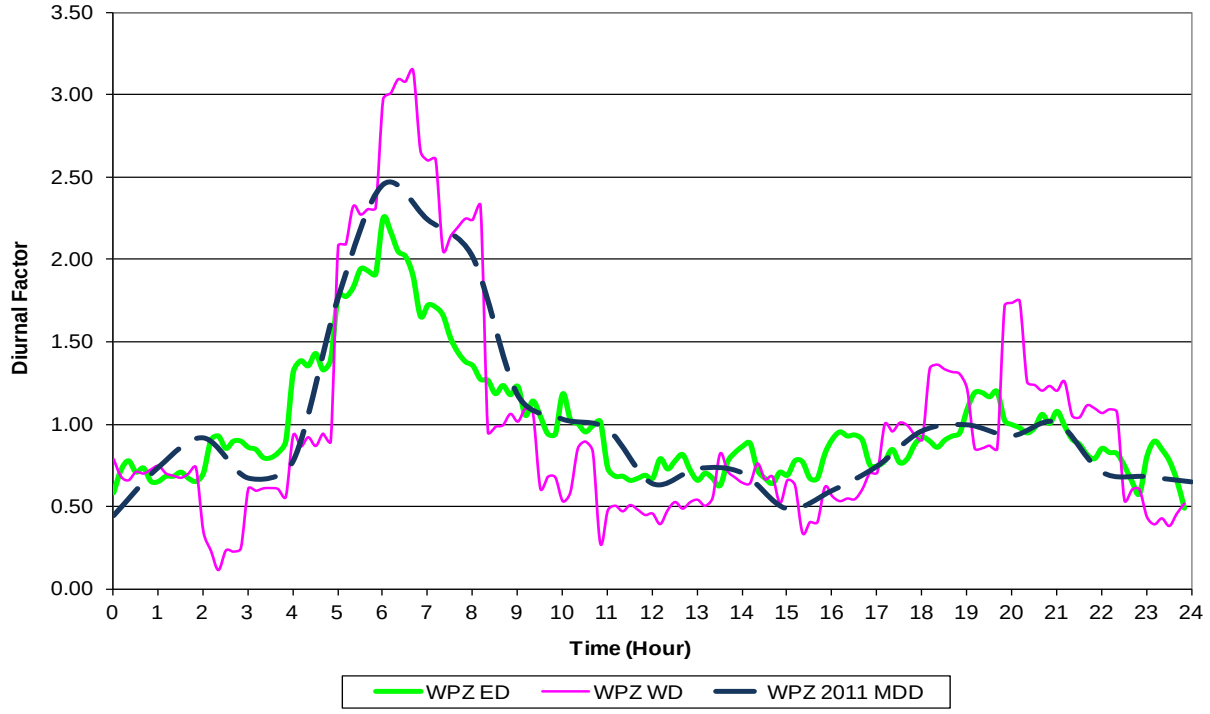


FIGURE 4
CPZ Maximum Day Diurnal Demand Pattern – Morrisville and RDU Airport
District measurement data (2009 WDSMP)

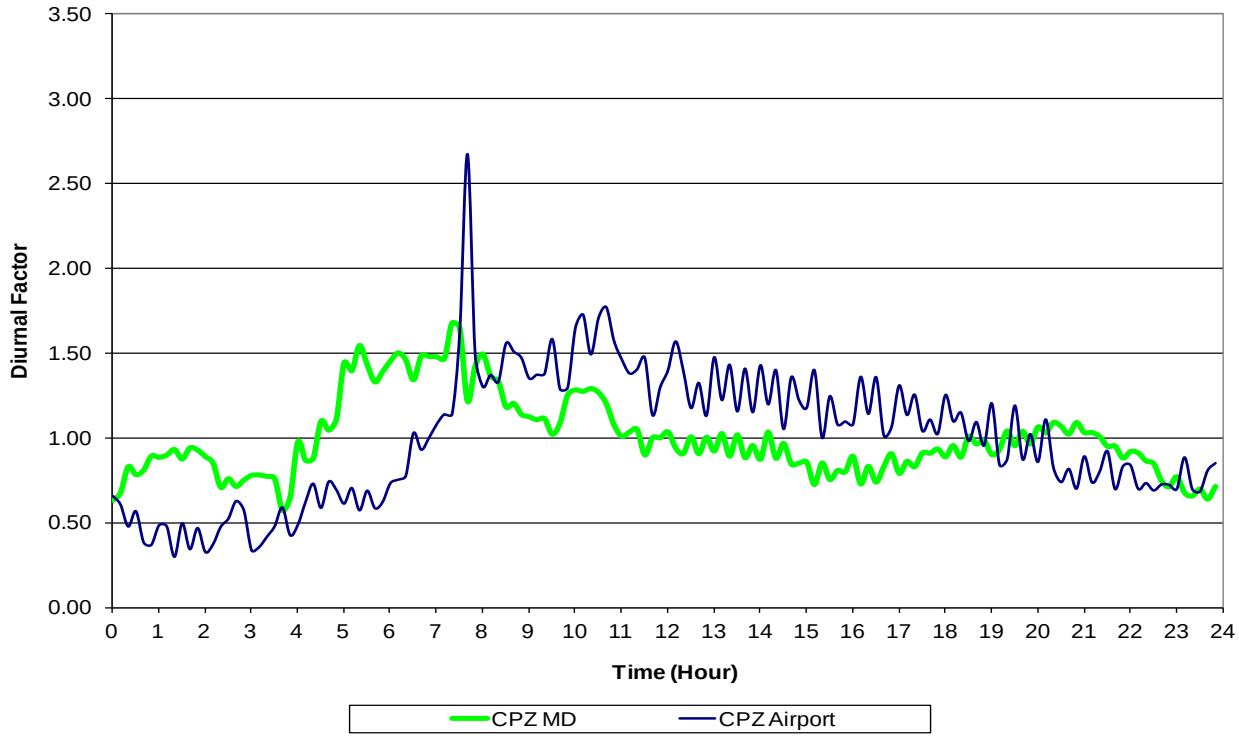
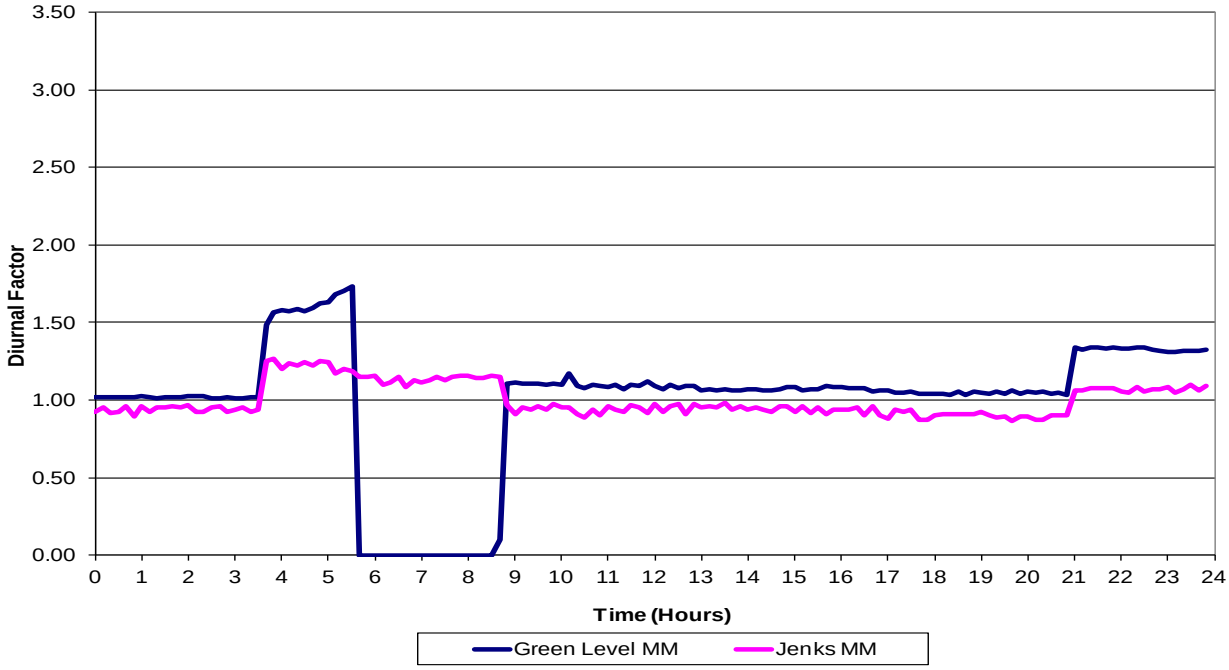


FIGURE 5
Town of Apex Maximum Day Diurnal Demand Pattern
District measurement data (2010)



2.3 Revise System Pressure Criteria (Amends 2009 WDSMP Section 5.2 and Table 5-1)

The hydraulic model is evaluated based on many criteria, including minimum node pressure. It is important to note that these node locations do not represent the pressure that an actual customer will experience at their point-of-use. Additional losses can occur through internal customer piping and service line piping, as well as elevation differences between the model node and customer elevation.

The 2009 WDSMP utilized a minimum system pressure during ADD or MDD of 40 psi. For this analysis, the Town requested that CH2M HILL evaluate revised pressure criteria in the model such that the pressure provided at the private side of a meter would be 45 psi at 10 gallons/minute (gpm). There will be pressure losses that occur through the meter and any backflow prevention devices, and therefore, the model node pressure would need to be higher than 45 psi. Cary has performed field testing of losses through the meter and backflow prevention devices that measure pressure losses at 10 gpm of flow to be in the range of 5 to 6 psi. Based on this information, a minimum model node pressure of 50 psi should be used as the criteria for evaluating system deficiencies and improvements to the water distribution system.

The AWWA M32 Manual – Computer Modeling of Water Distribution Systems (AWWA Manual M32. 2012) – states on pages 111-112 that, "The minimum pressure during peak hour refers to minimum pressure at customers' taps during normal system operation. This value is typically in the range of 35 – 50 psi and ensures that there is adequate pressure to the second story fixtures within a property if internal plumbing is configured correctly." Furthermore, on page 112 the Manual states that, "…in some communities where residential fire sprinkler systems are required by legislation, the minimum acceptable pressure is 50 psi for them to operate properly." There is a trend among the plumbing code agencies to include the residential fire sprinkler systems in new construction, and this trend may extend into North Carolina in the future.

This information further supports the application of 50 psi as a minimum node pressure in the hydraulic model. It should be noted that there may be instances in Cary's system where abnormalities or unforeseen hydraulic obstructions could cause the 50 psi minimum node pressure to be insufficient. In these cases field verification may be necessary to determine the provided pressure as well as steps that may need to be taken to increase pressure to the customer tap or reduce pressure losses on the customer side of the meter. Throughout Cary's water system model, a 50 psi minimum model node pressure should be used.

2.4 Revise Water Storage Requirements

The following revised water storage criteria were applied in these analyses, are summarized in Table 4 below and are shown in the next table, which is revised Table 5-1 from the 2009 WDSMP.

TABLE 4
Revised Water Storage Requirements from 2009 WDSMP

Evaluation Criterion	2009 WDSMP	September 2012 Amendment to 2009 WDSMP
Minimum Combined Elevated and Ground Storage Capacity	½ ADD	½ Summer ADD (Summer defined as May – September)
Equalization Volume	12-24%of ADD	5-20% of Summer ADD
Emergency Volume	25% of ADD	35% to 40% of Summer ADD
Total Storage Required	Equalization Volume + Emergency Volume + Fire Flow Volume	Equalization Volume + Emergency Volume + Fire Flow Volume
Utilization of CAWTP Clearwell for Available Storage	Utilized	Not Utilized

2.5 Revise Old Apex Tank Operation (Amends 2009 WDSMP Section 3.4 and Tables 3-3 and 3-4)

As directed by the Town (Shuyan Tian and Kelvin Creech), following are the revised operating conditions used in these analyses:

- Controls: Old Apex Tank HWL = 22 feet; LWL = 14 feet
- Pumping starts at 6:00 AM and stops when water level reaches LWL 14 feet
- Tank filling starts at 10:00 PM and stops when tank level reach HWL. Filling rate is at 3,400 gpm (per Kelvin Creech)

REVISED TABLE 5-1 FROM 2009 WDSMP (YELLOW HIGHLIGHTS INDICATE REVISIONS APPLIED IN 2012 AMENDMENT)
Water Distribution System Hydraulic Evaluation Criteria

System Parameter	Evaluation Criterion	Value	Design Standard/Guideline
Water Supply	Firm Pumping Capacity[a]	MDD[b]	Industry Standard Practice
	Firm Pumping Capacity + Elevated Storage Tank Supply	PHD[c]	Industry Standard Practice
	Firm Pumping Capacity + Elevated Storage Tank Supply	MDD + FF	Industry Standard Practice
	System Emergency Capacity[d]	Summer ADD[e]	Developed for this Master Plan
System Pressure	Minimum, during Summer ADD or MDD	50 psi to provide 45 psi at house side of meter at 10 gpm	December 22, 2011 Meeting
	Minimum, during PHD	30 psi	Town of Cary Policy Statement 129 and NCAC T15A:18C.0405(b)
	Minimum, during MDD + Fire Flow	20 psi	Town of Cary Policy Statement 129 and NCAC T15A:18C.0405(b)
	Recommended Maximum Pressure	125 psi	Developed for this Master Plan
Water Storage	Minimum Combined Elevated and Ground Storage Capacity	½ Summer ADD	December 22, 2011 Meeting
	Equalization Volume	5-20% of MDD[f]	December 22, 2011 Meeting
	Fire Flow Volume	3,500 gpm x 3 hrs	Town of Cary Master Plan (2000)
	Emergency Volume	35% to 40% of summer ADD	December 22, 2011 Meeting
	Total Storage Required = Equalization Volume + Emergency Volume + Fire Flow Volume	See "Evaluation Criterion" column	December 22, 2011 Meeting
	Available Storage shall not include CAWTP clearwell	Applicable	December 22, 2011 Meeting
Fire Flow Demand	Maximum Fire Flow[g]	3,500 gpm	Town of Cary Master Plan (2000)
	Minimum Residential Fire Flow	1,000 gpm	Town of Cary Standard Spec. Sect. 6
	Minimum Non-Residential Fire Flow[h]	1,500 gpm	Town of Cary Standard Spec. Sect. 6
Piping Hydraulics	Maximum Velocity during MDD	5 ft/sec	AWWA M32 (p. 68)
	Maximum Velocity during PHD or MDD+FF	10 ft/sec	AWWA M32 (p. 69)
	Maximum Head Loss (D<16-inch)	6 ft per 1000 ft[i]	AWWA M32 (p. 68)
	Maximum Head Loss (D>16-inch)	2 ft per 1000 ft[i]	AWWA M32 (p. 68)

REVISED TABLE 5-1 FROM 2009 WDSMP (YELLOW HIGHLIGHTS INDICATE REVISIONS APPLIED IN 2012 AMENDMENT)
Water Distribution System Hydraulic Evaluation Criteria

System Parameter	Evaluation Criterion	Value	Design Standard/Guideline

[a] Firm Pumping Capacity: Capacity of pumping facility with largest pump out of service.

[b] MDD: Peaking factor of 1.64 was selected for use in this Master Plan to calculate the maximum day demand as a function of average day demand.

[c] PHD: Peak hour demand was simulated based on diurnal demand curve; defined as the maximum volume (or flow rate) of water delivered to the system during any single hour of the MDD.

[d] System Emergency Capacity: Total capacity of all pumping facilities minus largest facility (i.e. Cary/Apex WTP High Service Pump Station CPZ pumps or 42-inch transmission main out of service) plus total emergency storage volume of storage tanks.

[e] Summer ADD: Summer average day demand (summer defined as May – September), defined as the average volume (or flow rate) of water delivered to the system or pressure zone during a single day period between May and September.

[f] Equalization factors by pressure zone: 5% (CPZ), 20% (WPZ), and 16% (SPZ); revised based on new diurnal patterns described in Section 2.2. Tanks not allowed to drop below level determined during new modeling analysis.

[g] Maximum Fire Flow: Fire flow requirement at commercial, industrial, and institutional customers when ISO "needed fire flow" information is not available.

[h] Minimum Non-Residential Fire Flow: Minimum fire flow when ISO "needed fire flow" is less than 1,500 gpm.

[i] Value shown is recommended for the design of new facilities. Existing facilities may have a higher value.

3.0 Hydraulically Model Three Scenarios

3.1 Hydraulic Modeling Scenario 1: Modify Southern Pressure Zone (SPZ) Operations (Amends Sections 4 and 5 of the April 2010 Water Quality Addendum)

This scenario analyzed the affects of raising the SPZ to the same hydraulic grade line (HGL) as the Central Pressure Zone (CPZ).

Three conditions were evaluated for Plumtree Tank operations with the potential conversion of the SPZ to CPZ pressure: 1) physically raising the tank elevation to CPZ pressure; 2) adding a pump station; and 3) taking tank off-line short term. The change in the HGL created high pressure in some pockets and multiple pressure reducing valves (PRVs) and control valves (CVs) would be needed in those areas.

Note however, that at this time, the Town of Cary is evaluating modification of the SPZ boundary and operation via a new Plumtree Tank Modifications project. That project will consider the results presented in this Amendment along with other information in order to recommend specific modifications to both the SPZ boundary and operation.

3.1.1 Raise SPZ to CPZ pressure (from HGL 595 to HGL 641) by Raising Plumtree Tank

With the raised tank level, it is difficult to refill the tank for the 2011 MDD conditions. The primary issue is that the piping around the tank creates a bottleneck because there is too much headloss which does not allow the amount of flow needed to refill the tank at the higher level with the available pressure. The tank is floating much lower than the other CPZ elevated tanks.

Figure 6 shows the flow into the area through the two control valves (set to wide-open), and the tank level in Plumtree Tank (red dashed line). Table 5 includes the planning level cost for this arrangement.

FIGURE 6
Water Level in Plumtree Tank if Raise SPZ to CPZ pressure (from HGL 595 to HGL 641) by Raising Plumtree Tank

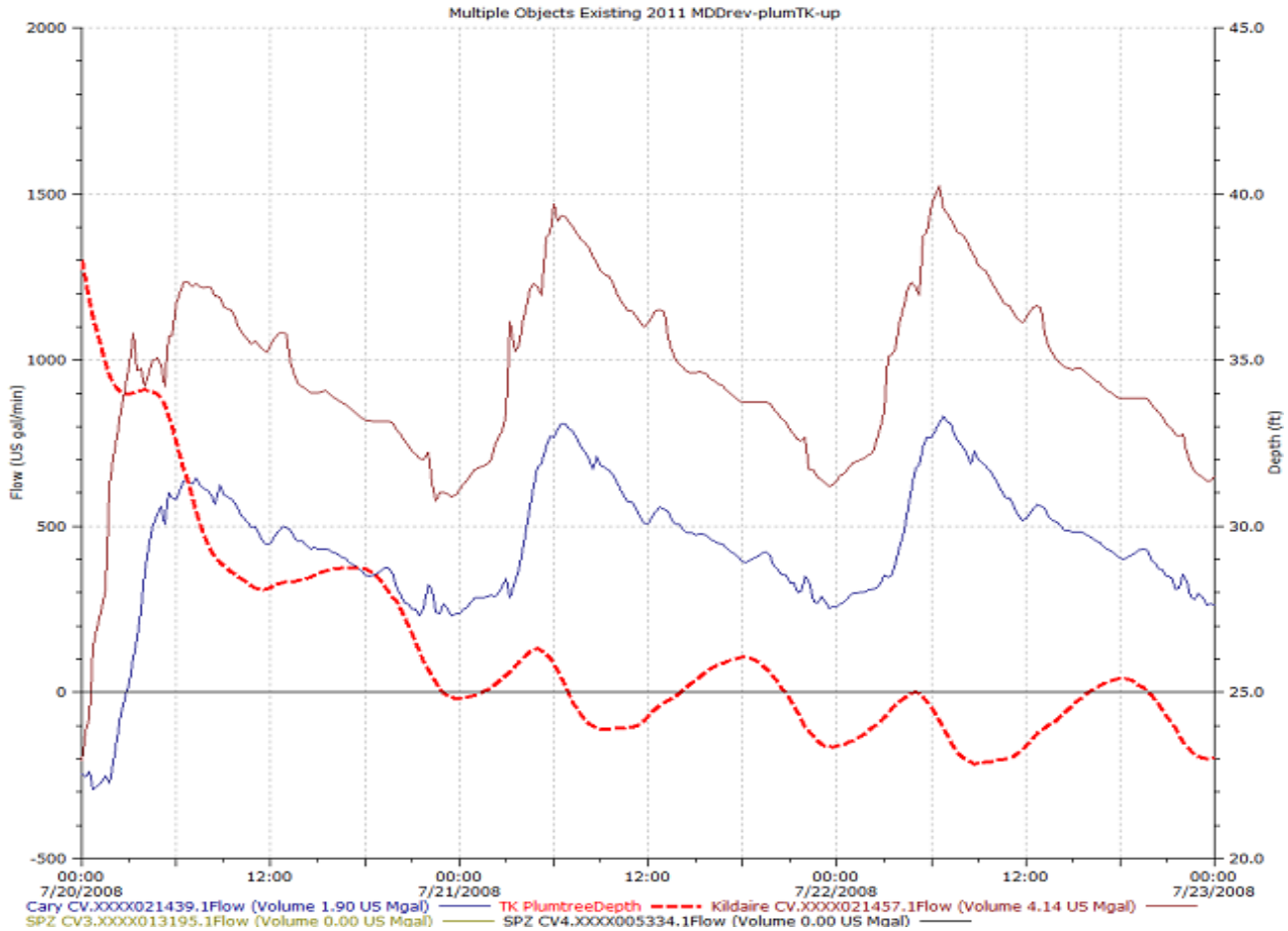


TABLE 5
Planning Level Cost – Raise SPZ to CPZ pressure (from HGL 595 to HGL 641) by Raising Plumtree Tank

CIP Item	Description	Notes	Planning Level Cost
NEW	Raise Plumtree Tank	Cost estimated by others; provided by Town of Cary	$1,000,000
SPZ-6	Highway 1 control valve (16")	Included in 2009 WDSMP	$100,000
NEW	Larger pipes to Plumtree tank	Additional analyses needed to establish sizes	
NEW	Multiple PRVs and CVs for areas with high pressure	Details of valves in Table 8 below	$258,000
		Total	$1,358,000 + cost of larger pipes to be determined

3.1.2 Raise SPZ to CPZ pressure (from HGL 595 to HGL 641) by Installing Pumping System

In this condition, a new pumping system would operate during peak hours and Plumtree Tank would refill at night. There are no detrimental effects on the Ridgeview Tank or to fire flow availability.

TABLE 6
Planning Level Cost – Raise SPZ to CPZ pressure (from HGL 595 to HGL 641) by Installing Pumping System

CIP Item	Description	Notes	Planning Level Cost
NEW	Pumping System	Cost estimated by others; provided by Town of Cary	$600,000
NEW	Multiple PRVs and CVs for areas with high pressure	Details of valves in Table 8 below	$258,000
		Total	$858,000

3.1.3 Plumtree Tank Taken Off-Line

For this analysis, the scenarios conducted for the Plumtree Tank off-line (Town of Cary; Water Distribution System Master Plan Report; Addendum: Water Quality Model and Analysis; April 2010; Section 5 – SPZ Hydraulic and Water Quality Model Update and Analysis) were rerun with the revised 2011 MDD and the revised Old Apex Tank operation. The evaluation included examining whether Plumtree Tank should be taken off-line in the short-term, which is based on demands and potential impacts to meeting fire flow requirements.

With the Plumtree Tank out of service, the hydraulic analysis revealed a slight reduction in available fire flow at the southern end of the SPZ even with the new Highway 1 control valve in service. While the available fire flow for residential properties remained above the criteria of 1,000 gpm at 20 psi residual pressure, the impact to commercial and/or institutional facilities must be evaluated on a case by case basis due to individual facility fire suppression designs. For this reason, the Town should investigate the small number of commercial and institutional properties located at the southern end of the SPZ to determine their specific fire flow and pressure requirements.

TABLE 7
Planning Level Cost – Plumtree Tank Taken Off-Line

CIP Item	Description	Notes	Planning Level Cost
SPZ-6	Highway 1 control valve (16”)	Included in 2009 WDSMP	$100,000
NEW	Multiple PRVs and CVs for areas with high pressure	Details of valves in Table 8 below	$258,000
		Total	$358,000

3.1.4 Results of Combining CPZ and SPZ Using any of the Above Evaluated Conditions

Combining the CPZ and SPZ through any of the 3 evaluated conditions described in Sections 3.1.1 through 3.1.3 will cause high pressure in two areas in the SPZ:

- South of Lochmere Drive and Lilly Atkins Road (Figure 7)
- At the south end, south of Optimist Farm Road (Figure 8)

The maximum pressure in these two areas is above the high pressure criteria of 125 psi, but is below 150 psi which may cause pipe damage. If the Town decides to reduce the high pressure in these areas, consideration of the following alternative is suggested:

- Without any pipeline improvements, and in order to keep the major water main at Kildaire Farm Road feeding Plumtree Tank, multiple PRVs/Closed Valves would be needed at the individual high pressure spots (above 130 psi) as shown in Table 8. However, the isolation will create dead-end lines which may cause water quality issues. Regular hydrant flushing would be required, especially for the south end area.
- However, with future pipeline improvements – especially the Highway 1 connection – the area through Kildaire Farm Road could be isolated as one pressure zone to reduce the number of PRVs needed, while adding a future parallel 12-inch main at Kildaire Farm Road to feed the Plumtree Tank.

FIGURE 7
Resulting High Pressure Condition South of Lochmere Drive and Lilly Atkins Road

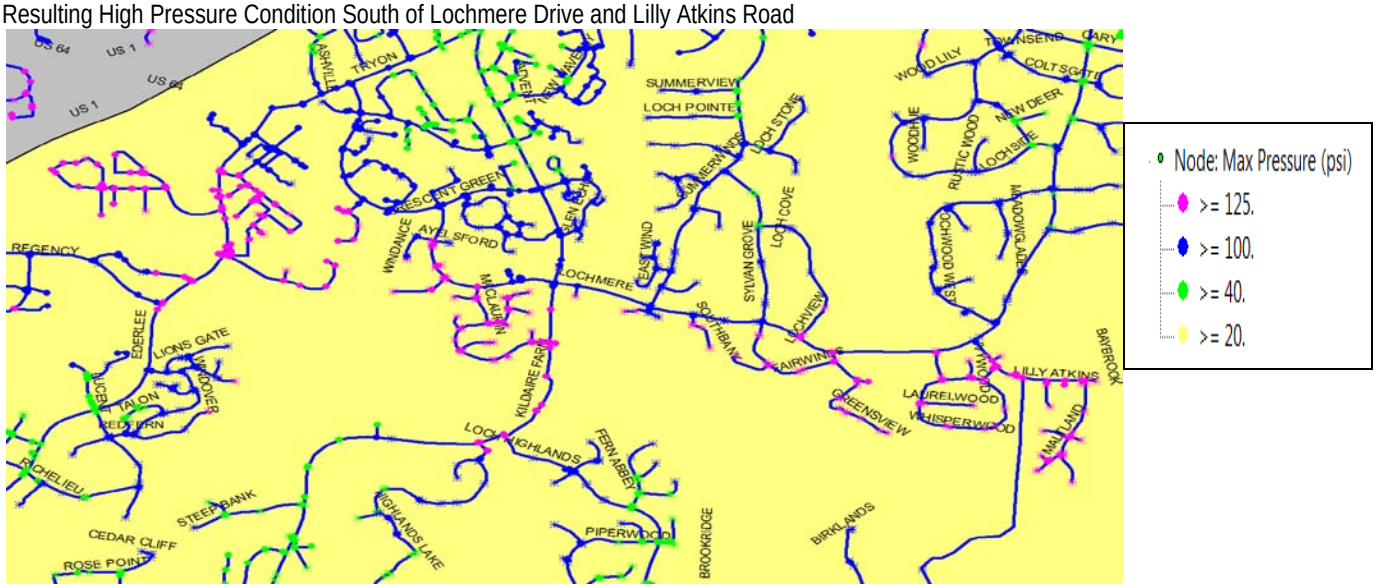


FIGURE 8
Resulting High Pressure Condition South of Optimist Farm Road

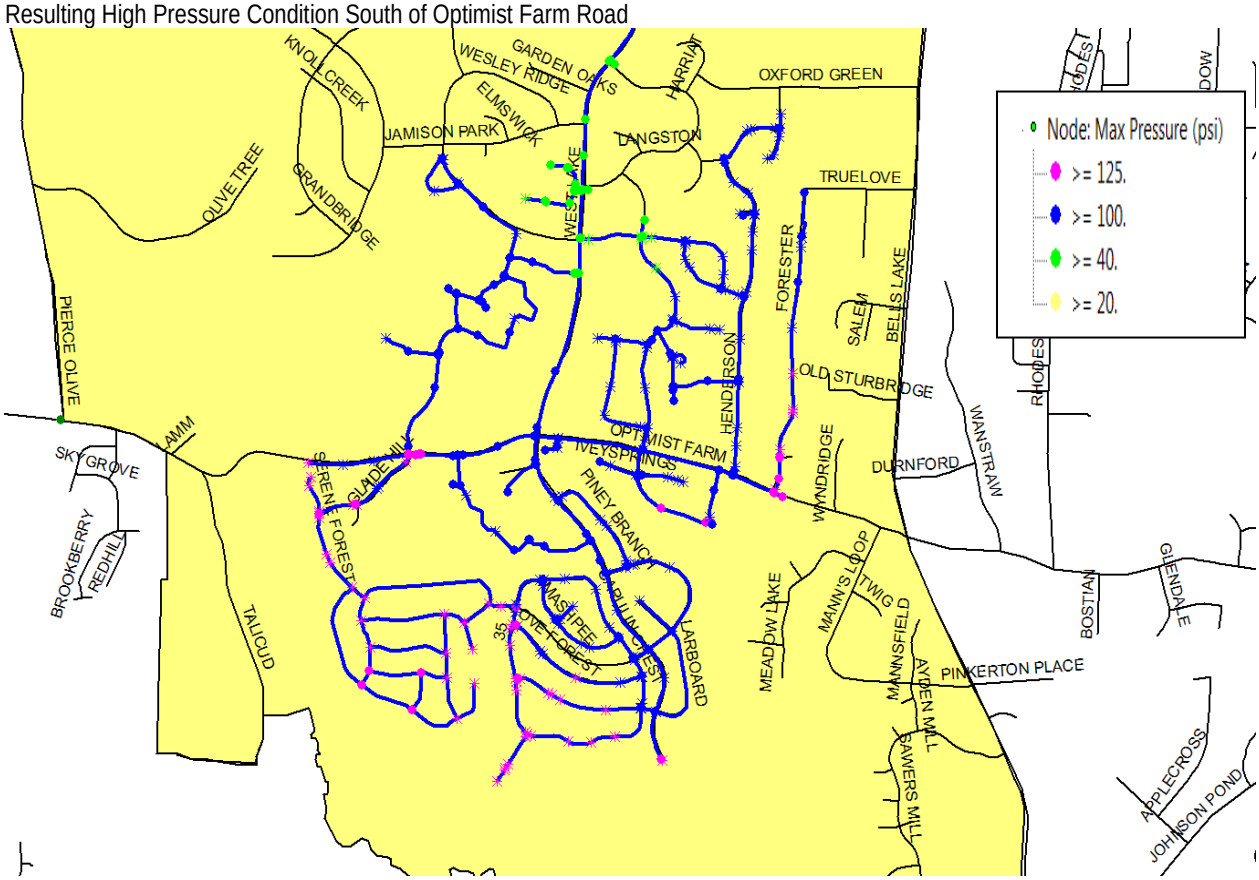


TABLE 8
Planning Level Cost – PRVs and CVs needed for any of the 3 conditions Presented in Section 3.3.1; the Locations are shown on maps in Attachment A

CIP Item	Valve Type	Setting (psi)	Size (inch)	Location	Planning Level Costs
NEW	PRV-1	100	12	Regency Forest Dr	$41,000
NEW	PRV-2	100	8	East of Regency Pkwy	$17,000
NEW	CV-1	--	8	East of Regency Pkwy	$17,000
NEW	PRV-3	100	6	East end of Windance Ct	$10,000
NEW	PRV-4	100	8	Palace Green	$17,000
NEW	CV-2	--	8	North End of MacLaurin St	$17,000
NEW	PRV-5	100	12	Heartwood Dr	$41,000
NEW	CV-3	--	6	Fairwinds Dr	$10,000
NEW	PRV-6	100	6	Lavewood Ln	$10,000
NEW	CV-4	--	6	Clubwood Ln	$10,000
NEW	PRV-7	100	8	Maltland Dr	$17,000
NEW	PRV-8	100	8	West Lake Rd	$17,000
NEW	CV-5	--	8	Piney Branch Dr	$17,000
NEW	CV-6	--	8	Glade Hill Dr	$17,000
PRV: Pressure Reducing Valve; CV: Control Valve				Total	$258,000

3.2 Hydraulic Modeling Scenario 2: Evaluate Finished Water Pipe Size from Cary/Apex Water Treatment Plant (CAWTP) along Wimberly Road into Western Pressure Zone (WPZ) and Ultimately to CPZ During Extended Emergency Operations

This analysis evaluates an extended emergency operations scenario that may last one to two weeks during which the existing 42"line from the CAWTP along Jenks Road is not operational. Under this scenario, it is assumed that the existing 30" line from the CAWTP will be connected only to the CPZ high service pumps (HSP) at the CAWTP high service pump station and will convey approximately 20 MGD to Apex and the CPZ via the existing 30" pipe at a velocity slightly greater than 6 fps; this assumption was confirmed per the meeting summary. In order to convey additional water through the WPZ and ultimately to the CPZ, it is assumed that a new booster pump station will be constructed near the intersection of Highway 55 and High House Road (NC 55 Booster Pump Station). Line sizing was evaluated for two conditions: Year 2025 and Build-out.

It is noted that potential modifications to the HSPs and the HSPS that would be required under this scenario will be evaluated in a separate analysis of the CAWTP plant expansion.

3.2.1 Year 2025

The NC 55 Booster Pump Station must deliver flow to the CPZ as shown in Table 8.

TABLE 8
NC 55 Booster Pump Station Flow Calculations – Year 2025

Item	Flow	Data Source
System MDD	47.6 mgd	Table 2
Flow through existing 30"	(20.0 mgd)	Assumption
Subtract to obtain MDD of WPZ and CPZ	27.6 mgd	Calculated
WPZ MDD	(13.3 mgd)	Table 2
Subtract to obtain CPZ MDD to be delivered by NC 55 Booster Pump Station	14.3 mgd	Calculated

For this scenario, it is assumed that the 27.6 mgd is supplied from the CAWTP WPZ HSPs. Since the existing WPZ HSPs firm capacity is only 11 mgd, new pumps were added in the model.

Results for this modeled scenario are shown in Figure 9 (for two different pipe velocities) and planning level costs are shown in Table 9 below. For the purposes of cost estimating, the following assumptions are made for the NC 55 Booster Pump Station:

- Pumps will be horizontal, split-case centrifugal pumps with medium voltage motors
- Station will be a masonry building
- A generator will be necessary and will be provided with an outdoor enclosure, sound attenuation and belly-mounted fuel tank

TABLE 9
Planning Level Cost – Finished Water Pipe Size from CAWTP along Wimberly Road into WPZ and Ultimately to CPZ During Extended Emergency Operations – Year 2025 Demands

CIP Item	Description	Notes	Planning Level Cost	
NEW	NC 55 Booster Pump Station (BPS)	14.3 mgd @ 150' TDH; 2 pumps, pump station building, generator	$2,300,000	$2,300,000
NEW	Pipe from NC 55 BSP along High House Road to CPZ	Not sized at this time	-	-
WPZ-1	36-inch pipe along Wimberly Road	10,530 LF; 27.6 mgd @ approx 6 fps	$10,900,000	$10,900,000
WPZ-2	Pipe along White Oak Church Rd:	5,110 LF	-	-
	36-inch	27.6 mgd @ 6 fps	$5,700,000	-
	42-inch	27.6 mgd @ 4.4 fps	-	$6,700,000
WPZ-23	Pipe along Green Level West Rd:	10,430 LF	-	-
	32-inch	22 mgd @ 6 fps	$6,700,000	-
	36-inch	23 mgd @ 5 fps	-	$11,200,000
		Total (*)	$25,600,000	$31,100,000

(*) Does not include cost of additional WPZ HSPS pumps required to deliver 27.6 mgd.

3.2.2 At Build-out

The NC 55 Pump Station must deliver flow to the CPZ as shown in Table 10.

TABLE 10
NC 55 Booster Pump Station Flow Calculations – At Build-out

Item	Flow	Data Source
System MDD	Cary = 51.6 mgd	Table 3
	Apex = 15.3 mgd	
	Total = 66.9 mgd	Calculated
Flow through existing 30"	(20.0 mgd)	Assumption
Subtract to obtain MDD of WPZ and CPZ	46.9 mgd	Calculated
WPZ MDD (18.3 mgd) - 9% non-revenue water	(16.8 mgd)	Table 3
Subtract to obtain CPZ MDD to be delivered by NC 55 Booster Pump Station	30.1 mgd	Calculated

It is assumed that the 46.9 mgd is supplied from the CAWTP WPZ HSPs. Since the existing WPZ HSPs firm capacity is only 11 mgd, new pumps were added in the model.

Results for this modeled scenario are shown in Figure 10 (for two different pipe velocities) and planning level costs are shown in Table 11 below. For the purposes of cost estimating, the following assumptions are made for the NC 55 Booster Pump Station:

- Pumps will be horizontal, split-case centrifugal pumps with medium voltage motors

- Station will be a masonry building
- A generator will be necessary and will be provided with an outdoor enclosure, sound attenuation and belly-mounted fuel tank

TABLE 11
Planning Level Cost – Finished Water Pipe Size from CAWTP along Wimberly Road into WPZ and Ultimately to CPZ During Extended Emergency Operations – Build-out Demands

CIP Item	Description	Notes	Planning Level Cost	
NEW	NC 55 Booster Pump Station (BPS)	30.1 mgd @ 150' TDH; 2 pumps, pump station building, generator	$3,200,000	$3,200,000
NEW	Pipe from NC 55 BSP along High House Road to CPZ	Not sized at this time	-	-
WPZ-1	48-inch pipe along Wimberly Road	10,530 LF; 47 mgd @ 6 fps	$25,100,000	$25,100,000
WPZ-2	Pipe along White Oak Church Rd:	5,110 LF	-	-
	48-inch	45.3 mgd @ 6 fps	$13,100,000	-
	54-inch	45.5 mgd @ 4.5 fps	-	$15,900,000
WPZ-23	Pipe along Green Level West Rd:	10,430 LF	-	-
	42-inch	38.8 mgd @ 6 fps	$13,200,000	-
	48-inch	39.8 mgd @ 5 fps	-	$25,800,000
		Total (*)	$54,600,000	$70,000,000

(*) Does not include cost of additional WPZ HSPS pumps required to deliver 46.9 mgd

3.2.3 Town of Cary Currently Planned Actions

At this time, the Town of Cary is planning to evaluate alternatives to this "transmission line only" approach to include storage and re-pumping infrastructure and will also evaluate modifying the CPZ boundary via the West Cary Water Storage Tank (WT1189) Project. Considerations for these evaluations are described in Attachment B to this Amendment (Project Kick-off Summary, Scenarios 4, 5, 6 and 7). That project will consider the results presented in this Amendment along with other information in order to recommend specific modifications to the boundary, system piping, storage and pumping.

FIGURE 9 – Year 2025 MDD - Finished Water Pipe Size from CAWTP along Wimberly Road into WPZ and Ultimately to CPZ During Extended Emergency Operations

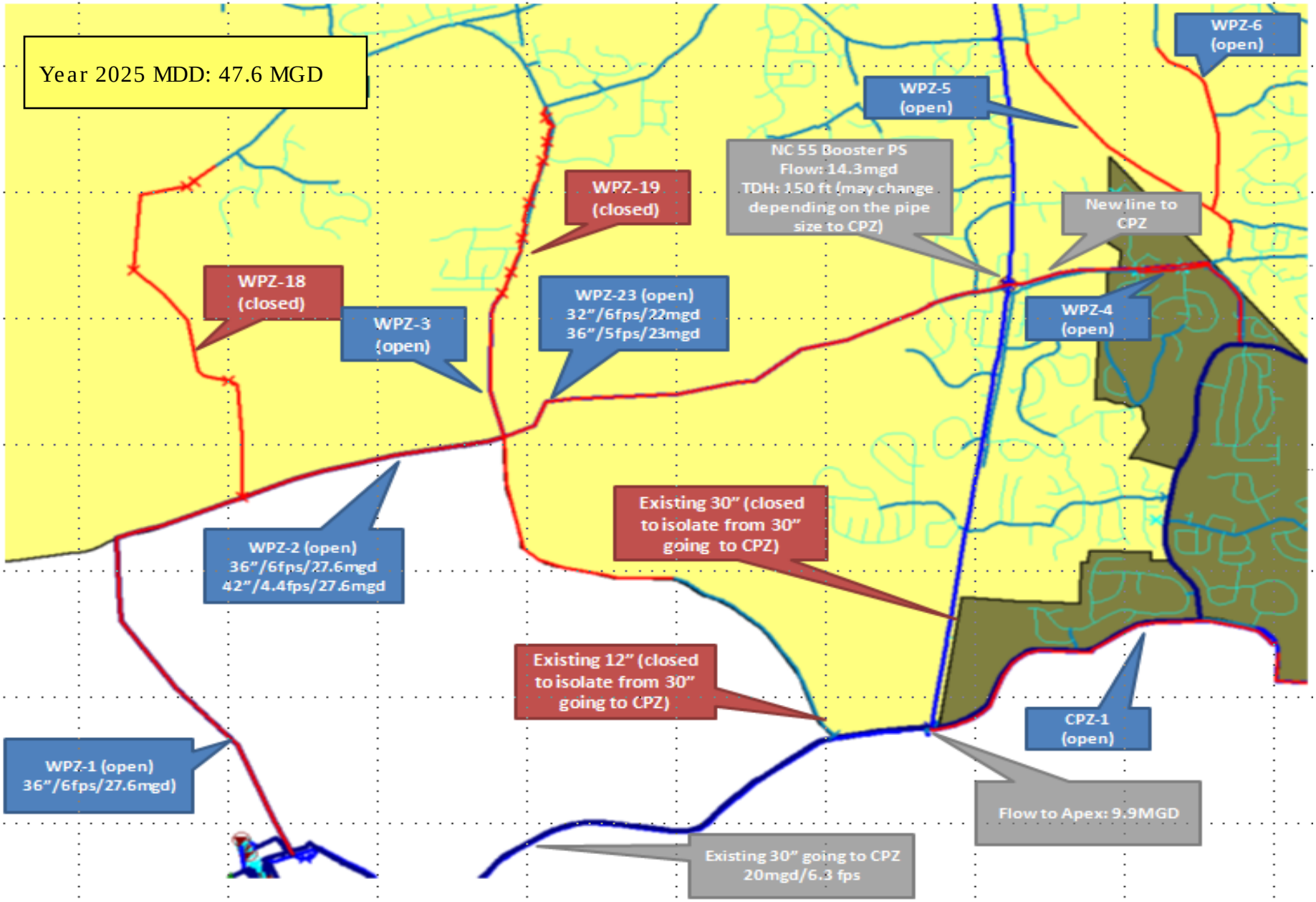
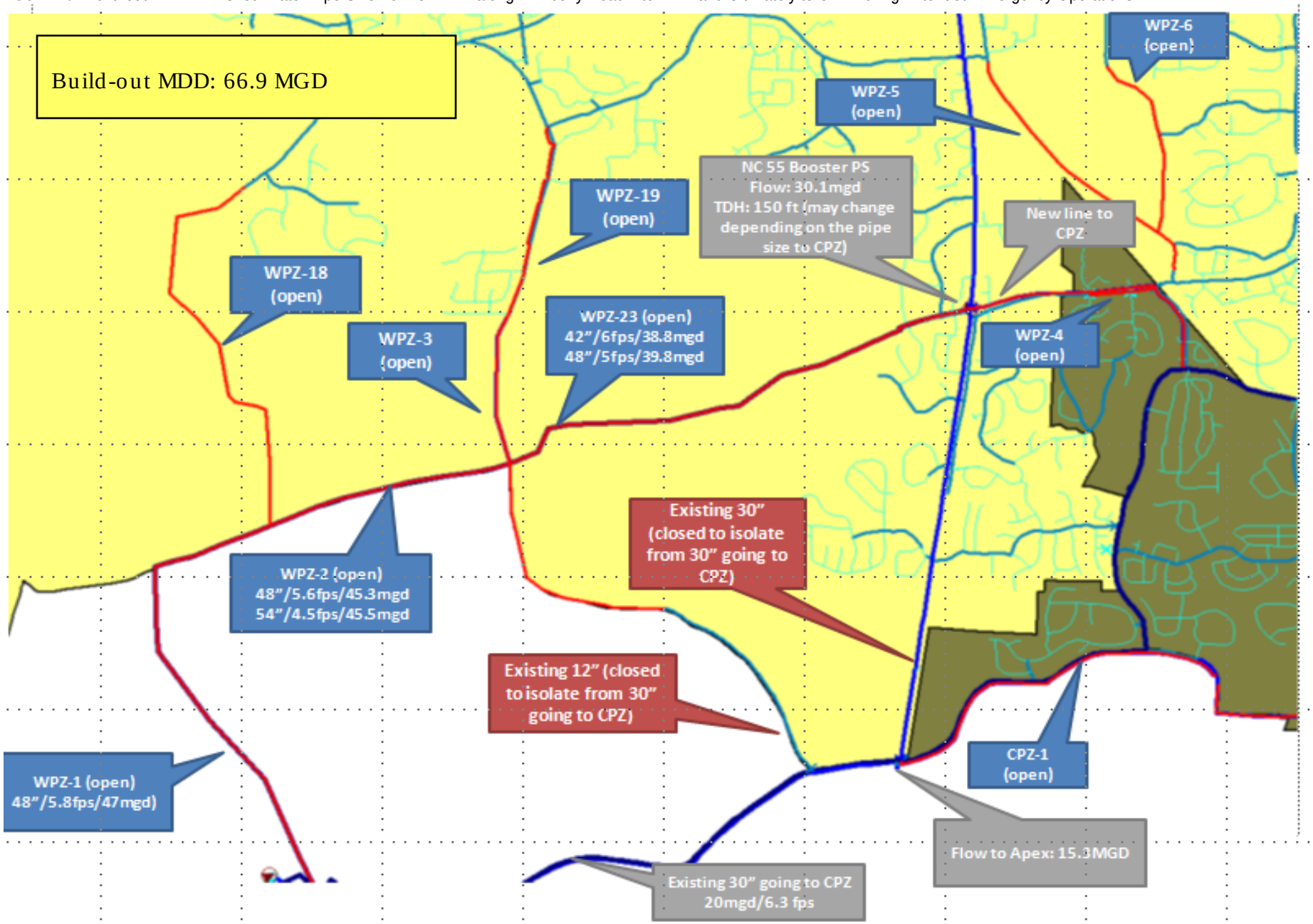


FIGURE 10 - Build-out MDD - Finished Water Pipe Size from CAWTP along Wimberly Road into WPZ and Ultimately to CPZ During Extended Emergency Operations



3.3 Hydraulic Modeling Scenario 3: Determine if Ground Storage Tank Sited near Jones Franklin Road is Beneficial to System Operations

The Town has acquired a site near Jones Franklin Road and requested an analysis to determine if a ground storage tank (GST) of approximately 3 million gallons (MG) sited at that location would be beneficial to system operations.

3.3.1 Evaluate Need for Pump Station and Storage

Based on revised storage calculations presented in this Amendment, a 1.3 MG storage deficit exists for emergencies at the 2011 demand, and a 4.5 MG deficit exists at the 2025 demand. A new 3MG GST would help relieve the emergency storage deficit. For the GST operation, the tank could not be filled at the same time as the Old Apex GST, or the Ridgeview Tank water level will drop. Operationally therefore, the two GST must be filled at different times. If this GST were utilized, it is suggested that it be dedicated to the SPZ with new pipelines (identified as SPZ-7, 1, and 5 in the 2009 WDSMP). In particular, this would help fill the Plumtree Tank if the tank were to be physically raised as described in Section 3.1.1 of this Amendment.

3.3.2 Evaluate Benefits of the Potential GST

If an emergency connection with the City of Raleigh is considered at this location along with possibly the storage of water from Raleigh using the same pumps, the pipe size on Walnut Street (or on another alignment) may need to be increased. If this GST were utilized, it would help fill both the Ridgeview Tank and the Plumtree Tank without stressing the CPZ.

- It is noted that other potential benefits of the proposed interconnection with the City of Raleigh are being further evaluated via the current Holly Springs Road waterline project and a FY14 proposed Crossroads Ground Storage Tank and Booster Pump Station project.

3.3.3 Evaluate the Impact on Ridgeview Tank Operations

Filling this GST would drain the Ridgeview Tank. One control valve would be needed at the Ridgeview Tank to avoid the tank emptying while the GST is filling. The Ridgeview Tank filling problem is caused by the small pipeline between the 30-inch pipe and the tank. The tank would be floating lower than the other CPZ elevated tanks. To solve the Ridgeview Tank operation issues, the new large pipelines as recommended in the 2009 WDSMP would be required.

TABLE 12
Planning Level Cost – Infrastructure Needed to Avoid Draining Ridgeview Tank if Utilizing New Jones Franklin Road GST

CIP Item	Description	Notes	Planning Level Cost
NEW	Control valve at Ridgeview Tank (24”)		$170,000
CPZ-1	24-inch pipe along Holt Rd	7,710 LF	$2,700,000
CPZ-2	24-inch pipe along Holt, Powell and Farm Pond Rd	3,780 LF	$2,400,000
CPZ-3	24-inch pipe along W. High St	1,850 LF	$900,000
CPZ-4	20-inch pipe along Cary Pkwy	3,550 LF	$1,200,000
CPZ-12	16-inch pipe along SW Cary Pkwy	4,940 LF	$1,800,000
		Total	$9,170,000

- It is noted that the Town of Cary has eliminated or will soon eliminate many of the impacts to the Ridgeview Tank by the construction of the CIP projects listed in Table 12. Most of the projects have been constructed and/or are currently under design.

4.0 Initial Evaluation of Long Term Impacts to 2009 WDSMP CIP

After completing the analyses described in Section 3 above, a high-level evaluation was conducted to determine if there are any significant impacts to the 2009 WDSMP CIP recommendations through the Year 2025.

4.1 Potential CIP Impacts Resulting from the 3 Hydraulic Modeling Scenarios

In addition to the potential changes to CIP Projects WPZ-1, WPZ-2 and WPZ-23 as described in this Amendment, it is possible that the CIP projects described in the 2009 WDSMP and listed in Table 13 may need further analysis to determine if modifications are needed.

TABLE 13
Potential CIP Projects from 2009 WDSMP Needing Further Analysis to Determine if Modifications are Necessary

2009 WDSMP CIP Item	Description
WPZ-9	NC 55 Water Line Extension (at Petty Farm Road Tank [identified as new I-540 Tank in the 2009 WDSMP]); Town of Cary CIB No. WT1097
WPZ-12	Alston Avenue Water Line (at Petty Farm Road Tank)
WPZ-13	NC 540 Water Line (potential feed to CPZ from Petty Farm Road Tank)
WPZ-17	New I-540 Tank
WPZ-25	New High Service Pump for WPZ
CPZ-13	Ridgeview Tank Reinforcement Water Line
CPZ-20	New High Service Pump for CPZ

The WPZ projects are all related to the new West Cary Water Storage Tank (WT1189) discussed in Section 3.2.3 above.

Overall, there are no significant changes to the previous CIP recommendations thru 2025 based on the revised information from Task 2.

4.2 Impacts Resulting from the Increase in System Pressure from 40 PSI to 50 PSI

As described in Section 2.3 of this Amendment, a minimum model node pressure of 50 psi should be used as the criteria for evaluating system deficiencies and improvements to the water distribution system, based on the Town's criteria to provide a pressure of 45 psi at the private side of a meter at 10 gpm.

Utilizing the new pressure criteria of 50 psi, the model indicates that there a few locations with pressures lower than 50 psi as shown in Figures 11, 12 and 13. All of the pressures are greater than 40 psi and most are greater than 45 psi. Most locations are in the SPZ under both Year 2025 MDD and Build-out MDD. A few locations in the WPZ and the CPZ show similar lower pressures at the Build-out MDD.

Note that the majority of the locations with pressures lower than 50 psi in the current WPZ and SPZ are within the areas subject to potentially being moved into the CPZ pressure zone, as described in Section 3.2.3 above.

FIGURE 11
Year 2025 MDD at Minimum Node Pressure of 50 PSI *in SPZ*; Areas of Pressure > 40 PSI but < 50 PSI

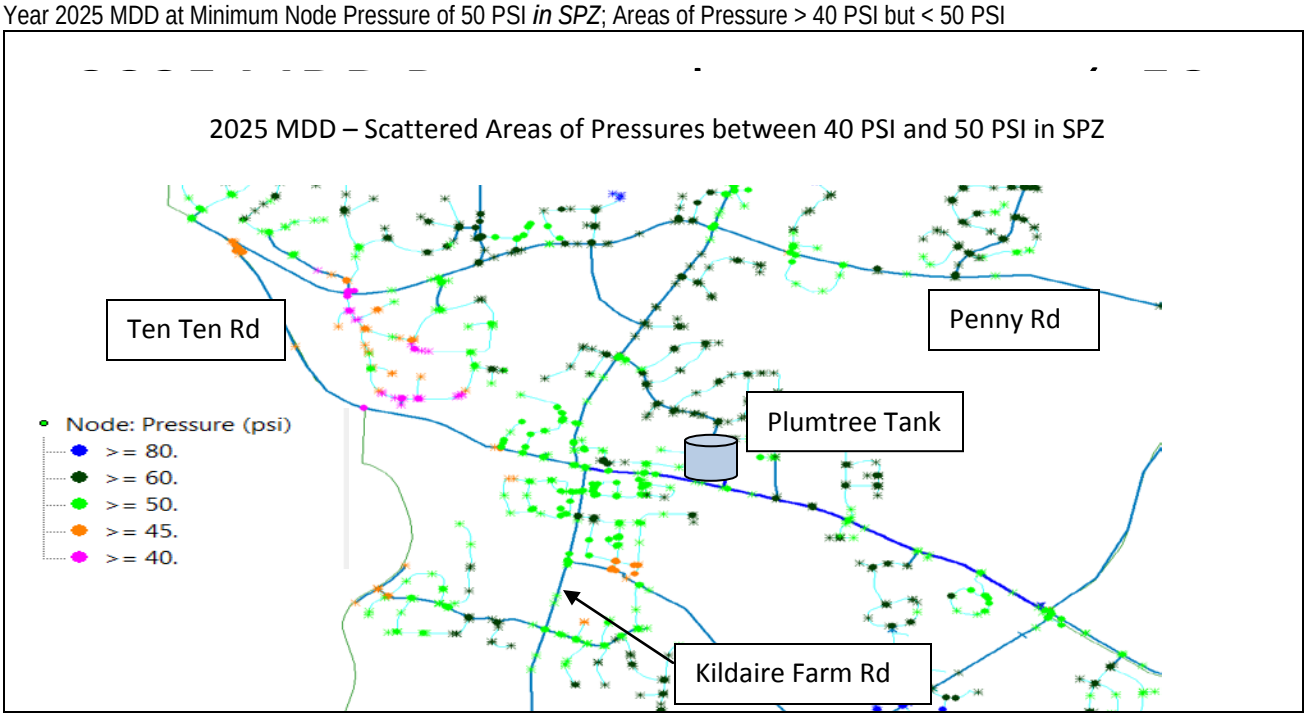


FIGURE 12
Build-out MDD at Minimum Node Pressure of 50 PSI *in SPZ*; Areas of Pressure > 40 PSI but < 50 PSI

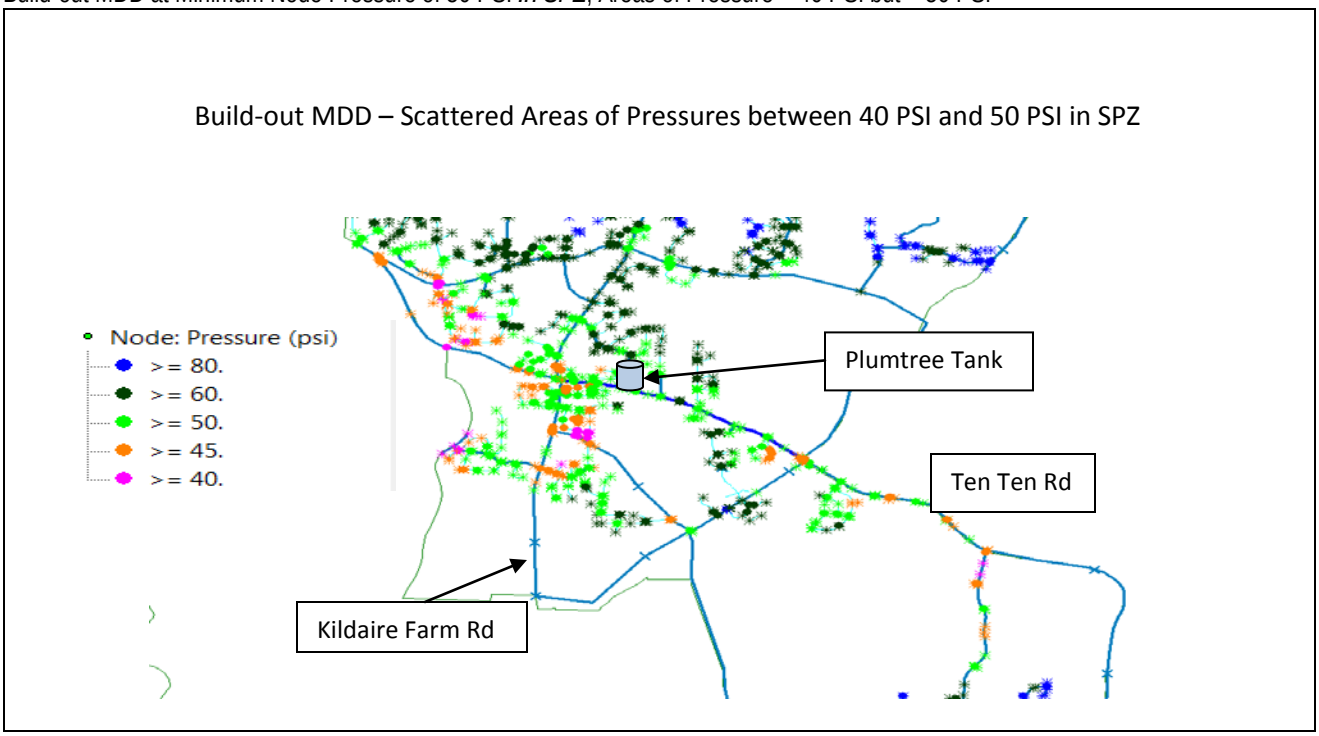
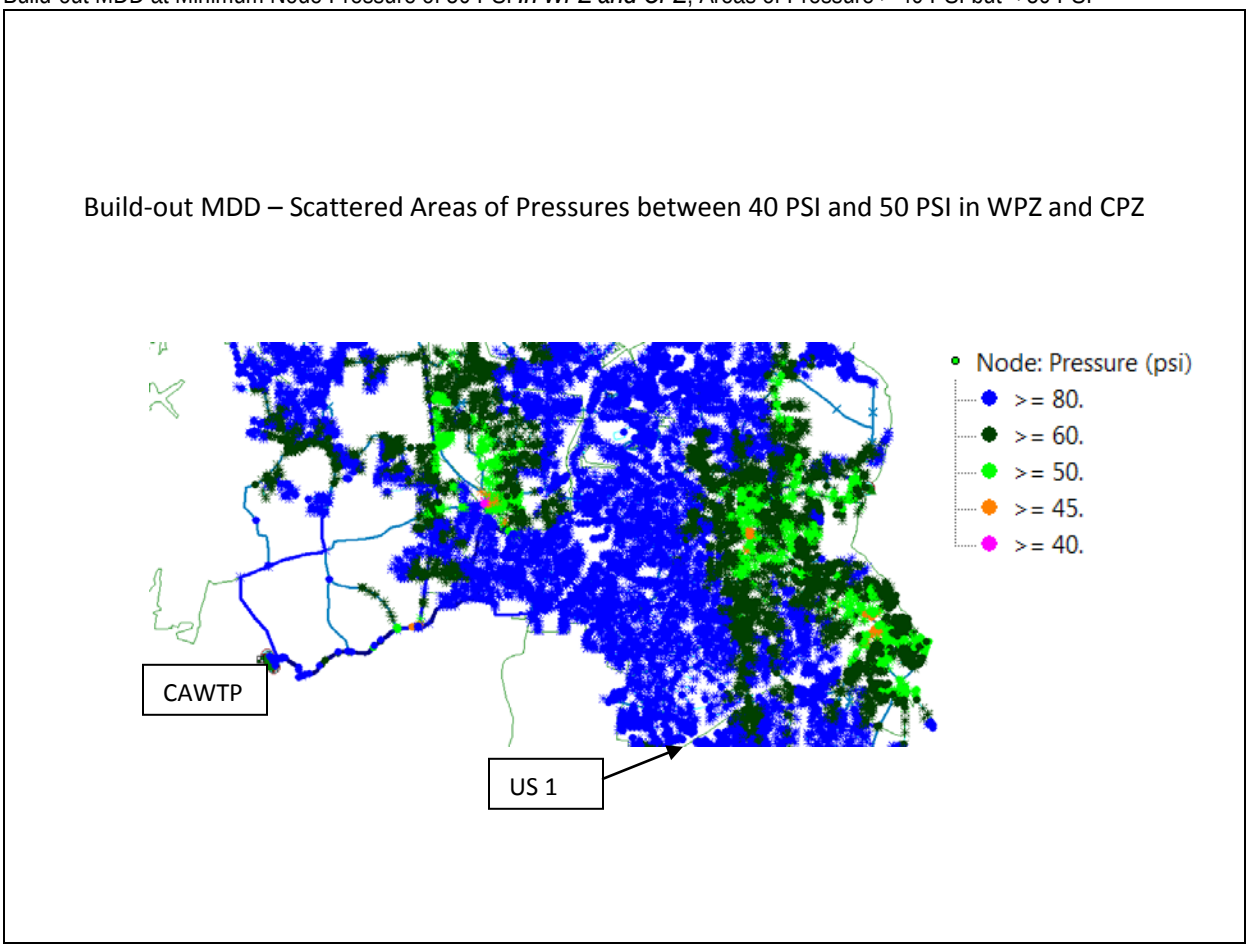


FIGURE 13
Build-out MDD at Minimum Node Pressure of 50 PSI *in WPZ and CPZ*; Areas of Pressure > 40 PSI but < 50 PSI



5.0 References

AWWA Manual M32, 3rd Ed., 2012. Pages 111-112. American Water Works Association (AWWA) Manual M32 – Computer Modeling of Water Distribution Systems.

CH2M HILL. 2012. Long Range Water Resources Plan: Town of Cary, Morrisville, and RTP South Baseline Water Demand and Wastewater Flow Projections Technical Memorandum. Prepared for the Town of Cary.

CH2M HILL. 2012b. Long Range Water Resources Plan: Town of Cary, Morrisville, and RTP South Water Demand and Wastewater Flow Forecasting Tool. Prepared for the Town of Cary.

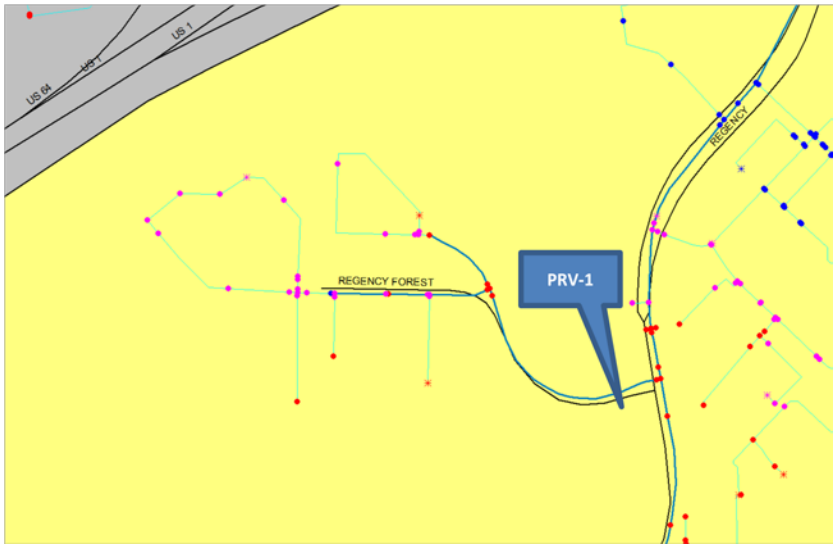
CH2M HILL. 2011. Long Range Water Resources Plan: Town of Apex Baseline Water Demand and Wastewater Flow Projections Technical Memorandum. Prepared for the Town of Apex.

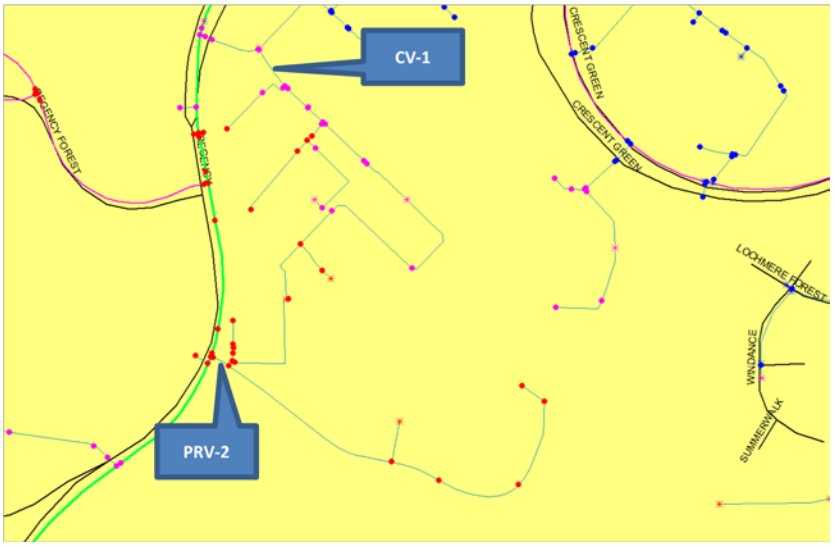
CH2M HILL. 2010. Water Distribution System Master Plan (WDSMP) Addendum: Water Quality Model and Analyses. Prepared for the Town of Cary.

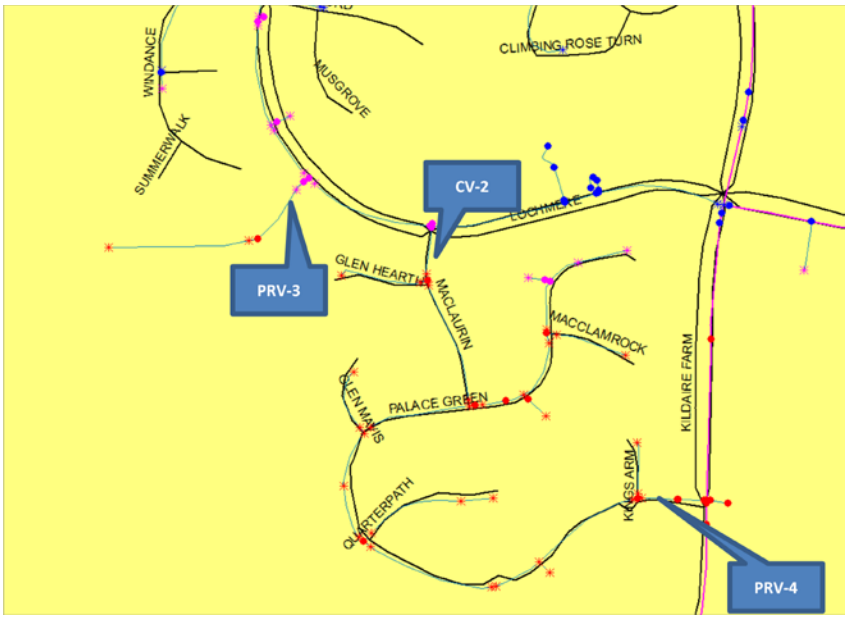
CH2M HILL. 2009. Water Distribution System Master Plan (WDSMP). Prepared for the Town of Cary.

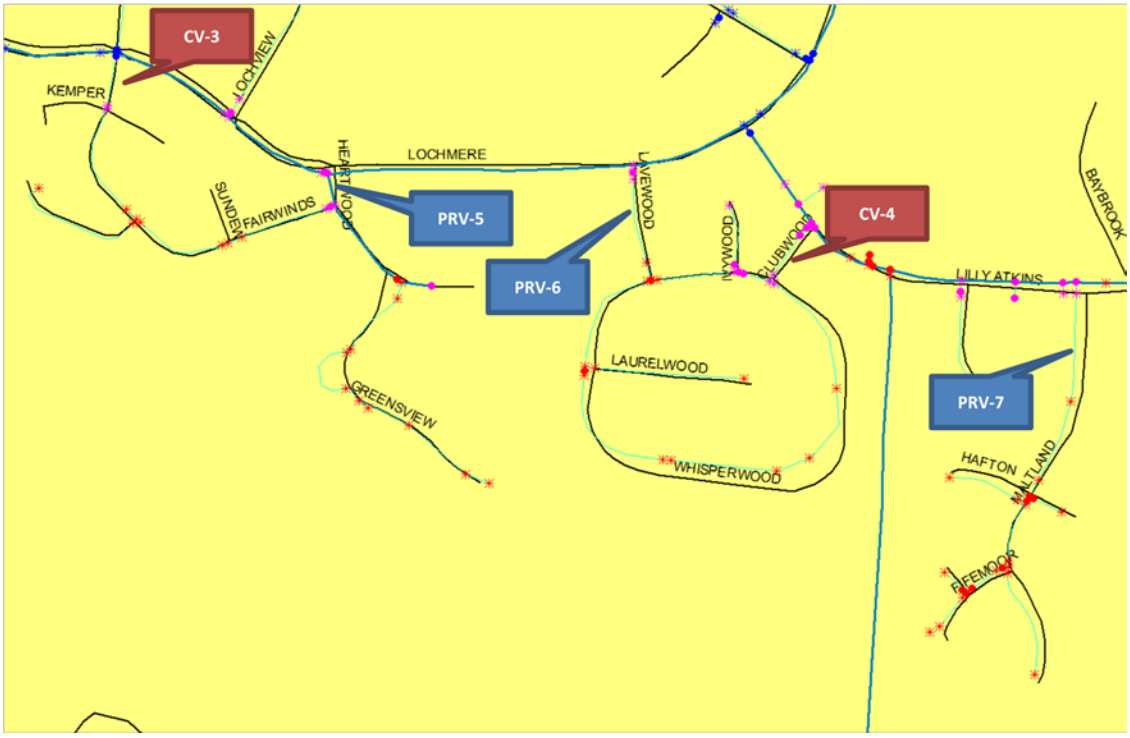
Attachment A

Figures showing locations of PRVs and CVs needed for any of the 3 scenarios presented in Table 8






WINDANCE
SUMMERWALK
MUSGROVE
CLIMBING ROSE TURN
CV-2
LOCHMERE
PRV-3
GLEN HEARTH
MACLAURIN
MACCLAMROCK
KILDAIRE FARM
GLENMAYS
PALACE GREEN
QUARTERPATH
KINGS ARM
PRV-4


CV-3
KEMPER
LOCHVIEW
LOCHMERE
HEARTWOOD
SUNDEW
FAIRWINDS
PRV-5
PRV-6
LAVEWOOD
IVYWOOD
CLUBWOOD
CV-4
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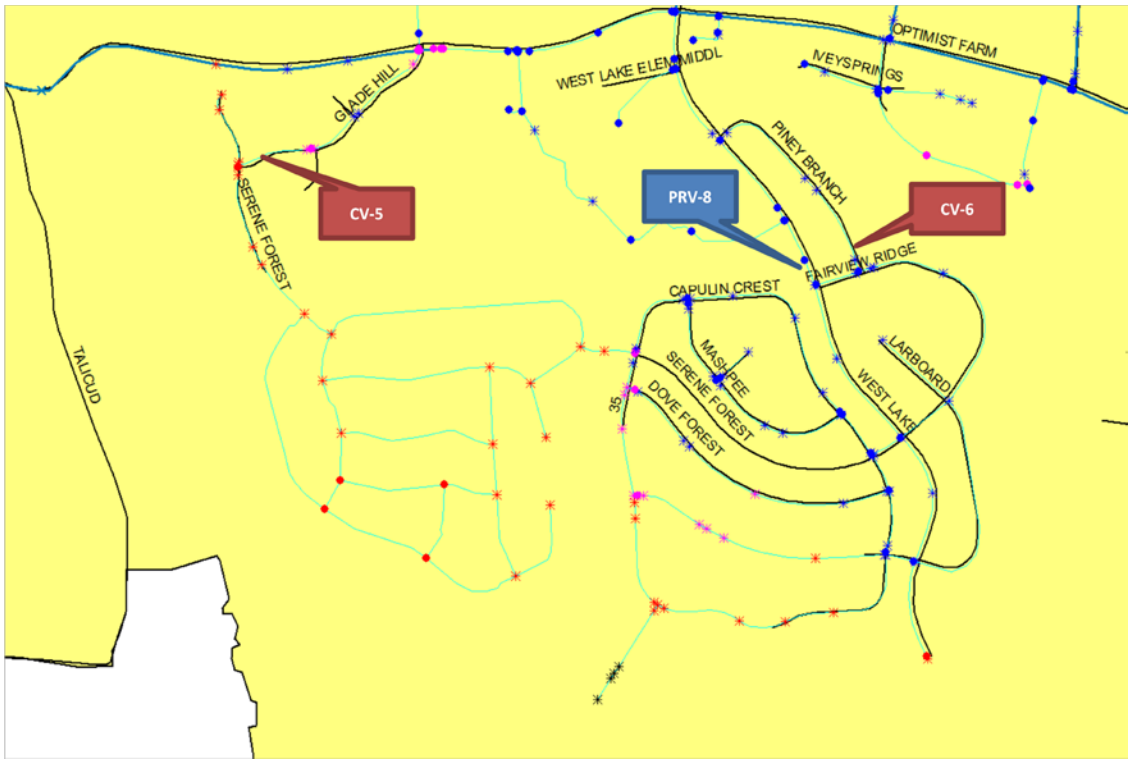
GREENSVIEW
WHISPERWOOD
PRV-7
HAFTON
WATLAND
FEEMOOR


OPTIMIST FARM
IVEYSPRINGS
WEST LAKE ELEM MIDDL
GLADE HILL
PINEY BRANCH
CV-5
PRV-8
CV-6
SERENE FOREST
FAIRVIEW RIDGE
CAPULIN CREST
LARBOARD
MASHREE
WEST LAKE
SERENE FOREST
DOVE FOREST
35
TALIQUD

Attachment B

Town of Cary Water Distribution System Reliability Evaluation – Kickoff Meeting Summary – December 22, 2011

MEETING SUMMARY CH2MHILL

Town of Cary Water Distribution System Reliability Evaluation – Kickoff Meeting Summary

ATTENDEES:	**Town of Cary:**		**CH2M HILL:**
	Glen Harrell	Ken Schuster	Helen Lu
	Tim Bailey	Sydney Miller	Brian Skeens
	Jamie Revels	JDArnold	JD Solomon
	Shuyan Tian		Francine Durso
DATE:	December 22, 2011; 1 – 5 PM		

1. Background

In June 2009, CH2M HILL completed the Water Distribution System Master Plan (WDSMP) for the Town of Cary (TOC) which included development of a new water distribution system hydraulic model using the InfoWorks WS software platform, as well as a system water quality model. In December 2011, the Town sought to evaluate the reliability of the Town's water distribution system under differing conditions including the different demands and revised evaluation criteria as defined in this meeting summary.

2. Project Goals and Objectives

The primary project goals and objectives identified were:

A. Determine infrastructure and/or operations needs to meet Town Council and water system customer expectations for water service; water pressure is the primary concern.

B. With the goal in mind to create a more reliable water distribution system, the needs may include increased storage, ability to transfer water between pressure zones easily, and managing system water quality in ways such as by tank mixing, taking tanks offline in the winter, or other approaches.

C. Better utilization of range of storage in storage tanks.

D. Become less dependent on pumping from Cary/Apex Water Treatment Plant (CAWTP) as primary means to meet system hourly peaks.

E. Better intrasystem interconnections needed to transfer more water between zones and by redundant lines.

F. Better use of system interconnections with Durham, OWASA (via Durham), Raleigh and Apex.

It was noted that the document resulting from the study is not expected to be a stand-alone document but it will be an addendum to the WDSMP with additional scenarios evaluated under revised evaluation criteria.

3. Revised Evaluation Criteria

The following revised criteria were established for system modeling:

A. System Pressure -
   - Calculation methodology:
     (1) 45 psi at house side of meter at 10 gpm.
     (2) Plus losses through meter using actual check valves in line – approx 5-6 psi (verify or adjust based on Cary's recent service line test results and residential system model).
   - Provide recommendation for minimum node pressure that will provide the desired "45 psi at 10 gpm" condition at the delivery point (the private side of a meter).

B. Storage
   - To be based on summer average day demand (summer ADD) with summer defined as May through September.
   - Clearwell storage at the CAWTP is not to be considered in storage calculations.
   - Previous equalization factors by pressure zone to be adjusted by peak hour factor based on new diurnal patterns developed from information supplied by Town of Cary.
   - Emergency volume = 35% to 40% of summer ADD (determine the number of hours of storage available under this condition).

4. Revised Water Demands

A. Develop summer ADD; summer is defined as May through September

B. Review most recent summer ADD from 2010 and 2011

C. With Town, identify revised summer ADD and revised summer peak hour demands to be used for these analyses

D. Include new service area in Chatham County west to Highway 751(does not apply to Scenarios 1 through 3; applies to some of the other scenarios); TOC to provide this information

E. Globally adjust demands in hydraulic model

5. New Evaluation Scenarios

The following scenarios are to be evaluated; they are listed in priority order. Scenarios 1, 2 and 3 are time sensitive as noted.

❖ Scenario 1: Modify Southern Pressure Zone (SPZ) Operations

- **Time sensitive – must define a project for this year's CIP (need information in Feb/March timeframe)**

A. Raise SPZ up to Central Pressure Zone (CPZ) pressure (from HGL 595 to HGL 641)

- Raise Plumtree Tank (cost approx $1 million), or
- Install pumping system (cost approx $600,000) but reliability is diminished due to dependence on power so a generator would be needed at this location
- If this creates high pressure in some pockets, create a subzone by using PRVs (or consideration of a tank at a lower elevation) to reduce pressure in those specific areas
- Scenario will impact CPZ tanks also; evaluate impact on Ridgeview Tank

B. If keep Plumtree Tank in system, must resolve these issues:

- Currently operate such that have only 5 feet of effective storage; must make better use of volume
- Water quality concerns – pilot tank mixing system may be demonstrated on this tank
- In the short -term determine if Plumtree Tank be taken off-line altogether
  - This will be based on demands

❖ Scenario 2: Evaluate Finished Water Pipe Size from Cary/Apex Water Treatment Plant (CAWTP) along Wimberly Road into Western Pressure Zone (WPZ)

- **Time sensitive – project is under design**

A. Existing 30″ line to WPZ has only approximately 20 MGD capacity

B. Want redundancy with new line routed as per recommended in Water Distribution System Master Plan (WDSMP):

- CIP Project No. WPZ (1) from CAWTP north along Wimberly Road
- CIP Project No. WPZ (2) along Green Level West Road to Green Level Church Road
- CIP Project No. WPZ (23) along Green Level West Road to Highway 55

C. New line continuing from Highway 55 along High House Road to CPZ at Jenks Carpenter Road including required storage and booster pumping; evaluation to include sizing to meet all demands in WPZ plus supplement the capacity of the existing 30″ line along Jenks Road if converted to CPZ pressure to offset the loss of the existing 42″ line.

❖ Scenario 3: Determine if Ground Storage Tank sited near Jones Franklin Road Is Beneficial to System Operations (site acquired by Town)

- **Time sensitive – must define a project for this year's CIP (need information in Feb/March timeframe)**

A. Need pump station and storage (approx 3 million gallons?)

B. Provide water to CPZ only (connection to system at HGL 641)

C. Define how GST would operate

D. What benefits would it provide

  – Emergency connection with Raleigh and storage for Raleigh water using same pumps (note that pipe size on Walnut Street (or on another alignment) may need to be increased)

E. Evaluate the impact on Ridgeview Tank operations

F. Provide recommendation on benefit of GST at this location

❖ Scenario 4: Modify Central Pressure Zone Boundaries and Storage

A. Move CPZ western boundary to west

  — CPZ to be bounded on west by location of CSX railroad and bounded to north by Morrisville-Carpenter Road

  — Evaluate use of Davis Drive PRV

  — Include new service area in Chatham County west to Highway 751; demand for this area and timing will be provided by TOC

B. Clearwell storage at the CAWTP is not to be considered in storage calculations

C. Use effective capacity of storage

D. Conduct new CPZ storage analysis using new criteria

E. Keep in mind that Maynard Road Tank may be replaced by new 1 million gallon tank approximately 1 block north of Cary Towne Center Blvd. & west of Maynard Road (Cary has this site already).

F. Possibly site 1 or 2 tanks since CPZ is relied upon to serve SPZ and WPZ; verify possible locations at Cary Parkway near US 1

G. Evaluate pumping from WPZ to CPZ, via ground storage and booster pumping at alternative sites: Petty Farm Road, existing Carpenter tank site, or High House Road at CPZ boundary.

❖ Scenario 5: Evaluate Overall System Storage Volume

A. Capacity now is only for several hours of storage in system
   - Use revised storage criteria for this analysis
   - Want to increase storage volume to meet demands in the short-term in an emergency while waiting to get water from interconnections
   - Takes 8-12 hours to get water from Raleigh
   - Takes 4 hours to get water from Durham
   - Maintenance on 42″ line is time consuming and there is not enough storage to take line out of service (except during a very small window at lowest demand season in winter)

B. Make better use of effective storage

C. Make better use of Ridgeview Tank

❖ Scenario 6: Evaluate New WPZ Tank or Pumping (needs further clarification)

A. Evaluate new tank or use of pipe/pumping system

B. Look at in light of Scenario 2 which will provide for line directly from CAWTP into WPZ and CPZ

C. Provide ability to get more water into WPZ from CPZ

D. Must also have ability to pump to CPZ (possibly at Petty Farm Road)
   - Consider use of same pumps to send water from Durham into CPZ

❖ Scenario 7: Water Transfer to Durham

A. Evaluate how much water could be pumped to Durham (approx 10 MGD?) in the summer from the CPZ and WPZ
   - Without causing pressure issues in the Town's system
   - Without violating the new criteria

6. Key New Information to be Developed/Defined with Town

The following information must be developed and agreed upon with the Town prior to proceeding with the evaluations:

A. Summer ADD and peak hour demands. JD Arnold will provide CAWTP data for every 30 minutes from May through September for 2010 and 2011. CAWTP data will include CPZ and WPZ pumping, all tank levels, and flows to/from Durham and Apex. CH2M HILL will determine summer ADD and summer peak hour demands and submit to TOC for approval.

B. New service area in Chatham County west to Highway 751 (Glen Harrell will provide this information based on data available from the currently ongoing joint effort).
   - Summer ADD and peak hour demands

— Timing of demand

C. For residential homes, calculate losses through meter using actual check valves in the line (anticipated to be approximately 5-6 psi but this is to be verified or adjusted based on Cary's recent service line test results and residential system model). The TOC will review recommendation for minimum node pressure that will provide the desired "45 psi at 10 gpm" condition at the delivery point (the private side of a meter) provided by CH2M HILL.

7. Other

A. Work also includes demand updates and storage analysis.

B. It was agreed that water demands will be adjusted globally in the hydraulic model and that demands will not be adjusted for individual parcels.

C. The equalization factors by pressure zone will be modified based upon new diurnal curve data to be provided by the Town.

D. In mid-January 2012, a report about using the full storage capacity of the Old Apex Ground Storage Tank (prepared by others) will be available for use in this study. Noted that the model should be updated for re-pump facilities based on changes in operations since the model was finalized. This information will be provided by Jamie Revels/Kelvin Creech.

8. Next Steps

A. The Town will review this Meeting Summary and provide comments.

B. After revision and approval of this Meeting Summary, it is anticipated that the Town will request that CH2M HILL provide a cost estimate to provide services to evaluate Scenarios 1, 2 and 3 which are time sensitive. The cost estimate will include development of the revised water demands as well as the revised storage conditions.

C. Upon approval of the cost estimate, CH2M HILL will begin work on Scenarios 1, 2 and 3.