Preliminary Engineering Report for

Water and Wastewater Services to Zion Crossroads Planning Area

March 2015

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TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1
1.1 Scope of Work 1
1.2 Background 3
1.3 Information Utilized 4

2.0 WATER AND WASTEWATER DEMAND PROJECTIONS 5
2.1 Service Areas 5
2.2 Developable Area 5
2.3 Proposed Land Use Maps 5
2.4 Water and Sewer Demand Projections 10
2.5 Predicting When Demands Will Occur 11

3.0 WATER SOURCE OPTIONS 12
3.1 Groundwater 12
3.1.1 Existing Wells 12
3.1.2 New Wells 12
3.1.3 LCWA Wells 12
3.2 Surface Water 14
3.2.1 DOC Water Treatment Plant 14
3.2.2 Albermarle County – Rivanna Village area 14
3.2.3 Lake Monticello/Aqua Water System 15
3.2.4 James River and JRWA 15
3.2.5 New Fluvanna County Water Treatment Plant 16
3.2.6 New Impoundment 16
3.3 James River 16

4.0 WASTEWATER TREATMENT OPTIONS 17
4.1 DOC Wastewater Treatment Plant 17
4.2 Spring Creek WWTP (Louisa County) 17
4.3 Albermarle – Eastern WWTP 19
4.4 New Fluvanna WWTP 19
4.5 Alternative Sewer Treatment Options 20
4.6 Water Reuse 20
4.7 Alternate TMDL Options 21

5.0 WATER DISTRIBUTION SYSTEM OPTIONS 22
5.1 Water Model Development 22
5.2 Storage Capacity Requirements 22
5.3 Distribution System 25
5.4 Water Booster Station 25
5.5 Water Model Results 25
5.6 Alternate Water Source Connections 26
5.7 Phasing of Water System 26
5.8 Cost of Water System, Phase 1 26

6.0 WASTEWATER SYSTEM 28
6.1 Flow Projections 28
6.2 Gravity Sewer 30
6.3 Force Mains 30
6.4 Pump Stations 31
6.5 Phasing of Sewer System 31
6.6 Cost of Sewer System, Phase 1 31

7.0 RECOMMENDATIONS 33
7.1 Source Water, Short Term 33
7.2 Source Water, Mid Term 33
7.3 Source Water, Long Term 33
7.4 Alternate Water Source Connections 33
7.5 Wastewater Treatment, Short Term 33
7.6 Wastewater Treatment, Long Term 33
7.7 Alternate Wastewater Treatment Options 34
7.8 Water Reuse 34
7.9 Distribution System, Phase 1 34
7.10 Storage Tank Site Locations 34
7.11 Sewer System, Phase 1 34
7.12 Future Phases, Water and Sewer Systems 34
7.13 Interim Operation and Maintenance 34
7.14 Overall TMDL Plan 35
7.15 Develop Policy and Procedure Fee Structure 35

LIST OF TABLES

Table No. **Page**

2-1 Proposed Unit Flows 10
2-2 Summary of Water and Wastewater Demands 10

LIST OF FIGURES

Figure No. **Page**

1 Zion Crossroads CPA 2
2 Service Area Overview 6
3 Service Area Undevelopable Areas 7
4 Potential Land Use Eastern Service Areas 8
5 Potential Land Use Western Service Areas 9
6 Long Term Water Source Options 13
7 Long Term Wastewater Options 18
8 Proposed Water System Layout 23
9 Proposed Water System Phasing 27

10 Proposed Sewer System Layout 29
11 Proposed Sewer System Phasing 32

LIST OF APPENDICES

Appendix A – Agreements and Permits
Appendix B – Previous Studies (Key Sections)
Appendix C – Outputs and Results

1.0 INTRODUCTION

The purpose of this Preliminary Engineering Report (PER) is to present the technical options for providing water and wastewater capacity and infrastructure to the present Zion Crossroads Community Planning Area (CPA). This area represents approximately 4,700 acres based on the most recent planning area boundaries as shown in Figure 1.

This PER includes the necessary background, mapping, figures, preliminary engineering, and cost estimates for the County to be able to review short and long term options for logically moving forward with development of this area. The recommendations present a phased approach to spread capital infrastructure costs out while revenue begins to grow.

1.1 Scope of Work

Below is a brief description of each primary task included in this Report:

- **Background** – review all related internal and external studies and reports relevant to this PER along with proposals and draft agreements related to water and wastewater capacity. This information will be the basis for several of the options discussed in this Study.

- **Demand Projections** - evaluate all parcels for development potential based on wetlands, building setback requirements, and other constraints in order to provide a realistic idea of how these parcels may be served. We will provide a preliminary development map to the County. Based on this map and County feedback, we will estimate the water and sewer demands for the Service Area for the next 20 years and at full build-out. These demands will be used to determine source capacity and discharge needs along with water and wastewater infrastructure sizing.

- **Water Source Options** – evaluate the potential for ground water and surface water sources that may serve the area. Ground water sources will include existing wells, new wells, and wells through the neighboring Louisa County Water Authority (LCWA). Surface water sources will include Mechunk Creek (through Virginia DOC Women's Facility) and the James River (through the JRWA intake project). There will be two options related to the James River source, one to provide treatment directly by Fluvanna County and one to provide treatment from neighboring Louisa County (through LCWA). The evaluation of these options will be based primarily on existing information and studies as discussed in Item 1.

- **Wastewater Treatment Options** – for direct discharge to Virginia water bodies, evaluate the potential to discharge to the Department of Corrections wastewater treatment plant (WWTP) and the LCWA wastewater treatment plant located near Zion Crossroads. For comparison purposes, discuss the potential for providing a new WWTP to serve the area. We will also briefly discuss

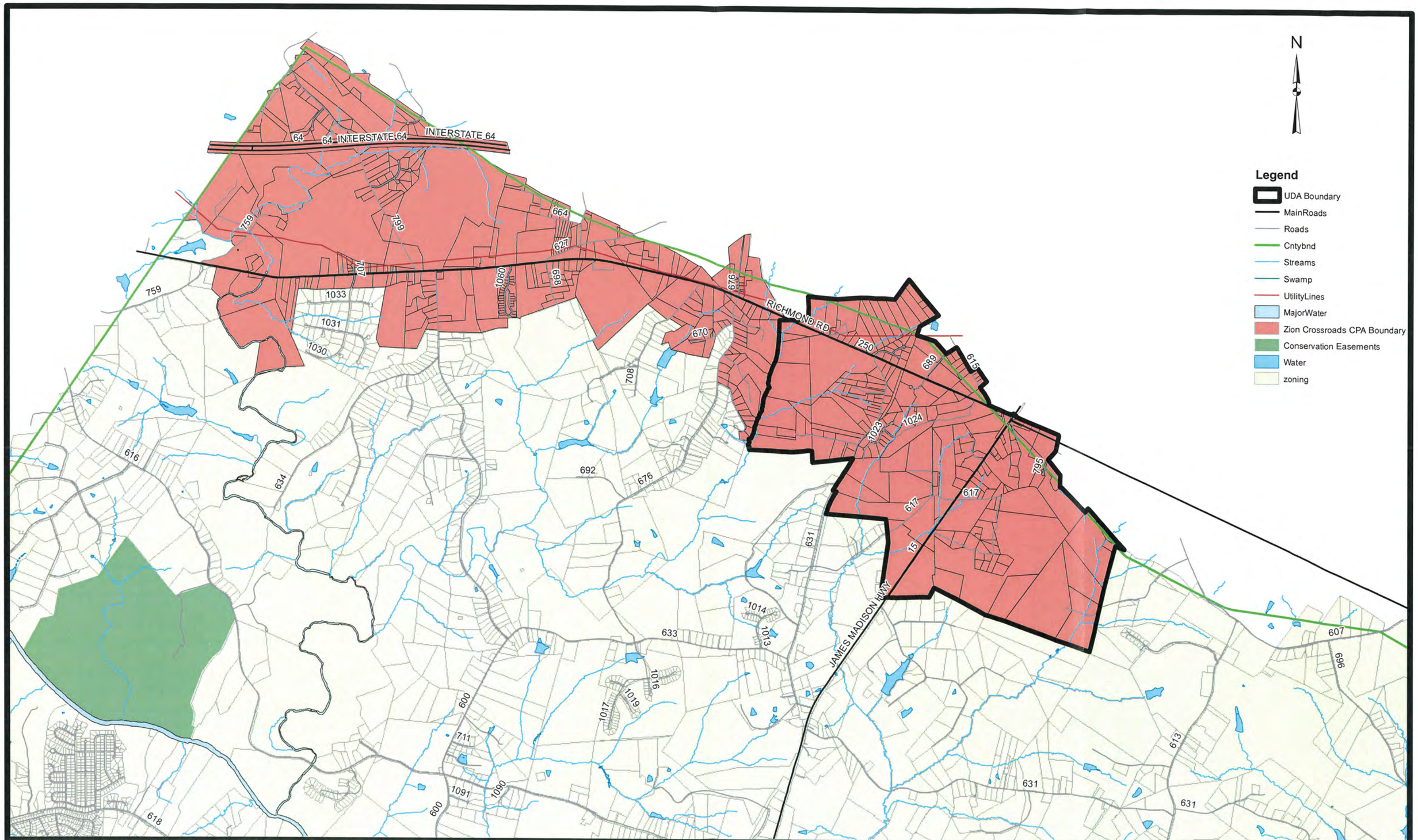

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Figure 1 - Zion Crossroads CPA

1 inch = 3,000 feet

0 1,250 2,500 5,000 Feet

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January 2015

alternative wastewater treatment and disposal options and the potential for how water reuse opportunities could address some of the capacity needs. The evaluation of these options will be based primarily on existing information and studies as discussed in Item 1.

- **Water Distribution System Options** – evaluate water system infrastructure options for connecting to the DOC water system, connecting to the LCWA water system near Route 15, and connecting to existing or new wells identified in the CPA. The infrastructure components will include water mains, booster station(s), water storage tank(s), and possibly well facilities. A preliminary water model will be developed to assist with infrastructure sizing, determine available fire flow and pressures, and assess where water quality issues may be prevalent.

- **Wastewater System Options** – evaluate wastewater system infrastructure options for connecting to the DOC wastewater system and connecting to the LCWA wastewater system. The infrastructure components will include gravity sewer, force mains and pump stations.

- **Recommendations** – provide technical recommendations for the County to procure water source capacity and wastewater discharge options. Present infrastructure recommendations with an emphasis of phasing these components so they can be used as part of a long term system.

1.2 Background

Adjacent to Fluvanna County at the intersection of Route 15 and Interstate 64 is Louisa County and their portion of the Zion Crossroads area. Louisa County has had a public water and wastewater system for over 10 years and has experienced steady growth including commercial, light industrial, retail and residential development. As of 2014, the Louisa County Water Authority is providing approximately 140,000 gallons per day of water and approximately 125,000 gallons per day of wastewater treatment to this area.

On the Fluvanna County side of the Zion Crossroads area, recent development of light industrial and commercial warehouse space has occurred. These developments are served by private wells and sanitary drain fields (or on-site treatment systems) and provide service for limited employee usage. There is existing residential throughout the area typically on larger lots (>2 acres). Without a central public water and wastewater system, the Fluvanna area will continue to be limited to similar developments.

As indicated in the Thomas Jefferson Planning District Commission (TJPDC) Zion Crossroads Guidebook, dated August 2013, the County desires to develop the Zion Crossroads area with a mixed use concept, which is the basis for the water and wastewater demand projections along with the recommended infrastructure for this report.

1.3 Information Utilized

Many studies have been conducted in past years related to providing water and wastewater services to the Zion Crossroads Planning area of Fluvanna County. There are also several proposed or formal agreements related to this study that serve as options that were considered. The main studies and agreements reviewed and utilized for this PER are listed below:

1. Zion Crossroads Guidebook, August 2013. Prepared by TJPDC in cooperation with Fluvanna County.

2. PER for the James River Water System, August 2009. Prepared by Timmons Group for Fluvanna County and Louisa County.

3. Fluvanna County Regional Water Supply Plan, April 2010. Prepared by Draper Aden Associates for Fluvanna County and Town of Columbia.

4. Zion Crossroads Service Area Master Plan, August 2004. Prepared by Dewberry for Louisa County Water Authority.

5. Louisa County Water Supply Plan, June 2011. Prepared by Gannett Fleming and Dewberry for Louisa County.

6. DOC and Fluvanna Memo Agreements dated October 2013 for Water and Wastewater Capacity.

7. James River Water Authority Agreement, October, 2013. For Fluvanna and Louisa County long term water supply from James River.

Key excerpts from these Reports and Agreements are provided in Appendices A and B.

2.0 WATER AND WASTEWATER DEMAND PROJECTIONS

As mentioned in Section 1.2, the basis for the demand projections was the Zion Crossroads Guidebook (August, 2013) and the current CPA of approximately 4,700 acres. The primary method utilized to project the potential demands is based on calculating the amount of developable acreage multiplied by a flow factor/acre of the various types of anticipated land. The methodology for projecting the demands along with a discussion as to when these demands may occur is presented in this section.

2.1 Service Areas

The current CPA was divided into 4 Areas in order to be able to better describe where specific demands may occur along with how to plan for infrastructure layout in a systematic approach. Service Area 1 is considered to be the initial target area of the Service Area and includes subareas 1A through 1D. The other areas (including subareas) 2 through 4 are not meant to be subsequent phases of development, and are arbitrarily numbered for identification purposes only. These service areas are all shown in Figure 2.

2.2 Developable Area

The developable area is considered to be the available acreage less existing land features restricting development including existing right-of-ways, streams and lakes, wetlands, wetland buffers, and steep slopes. These areas, considered undevelopable, are shown in green on Figure 3. Existing residential and commercial developments within the service areas are considered in the demand projections, but only at current demands (which are significantly reduced compared to potential development at maximum density). The DOC property is not included in the demand projections.

2.3 Proposed Land Use Maps

As mentioned previously, the Zion Crossroads Guidebook was developed by the TJPDC in cooperation with Fluvanna County and included land use types primarily for an urban mixed use concept. The proposed land use types include Office Warehouse/Tech Park, Office/Office Source, Commercial Retail, Village Mixed Use, Multi-Family and Residential. The assumed land uses in each service area are shown in Figures 4 and 5. The proposed unit flows per acre for each usage type are shown in Table 2-1:

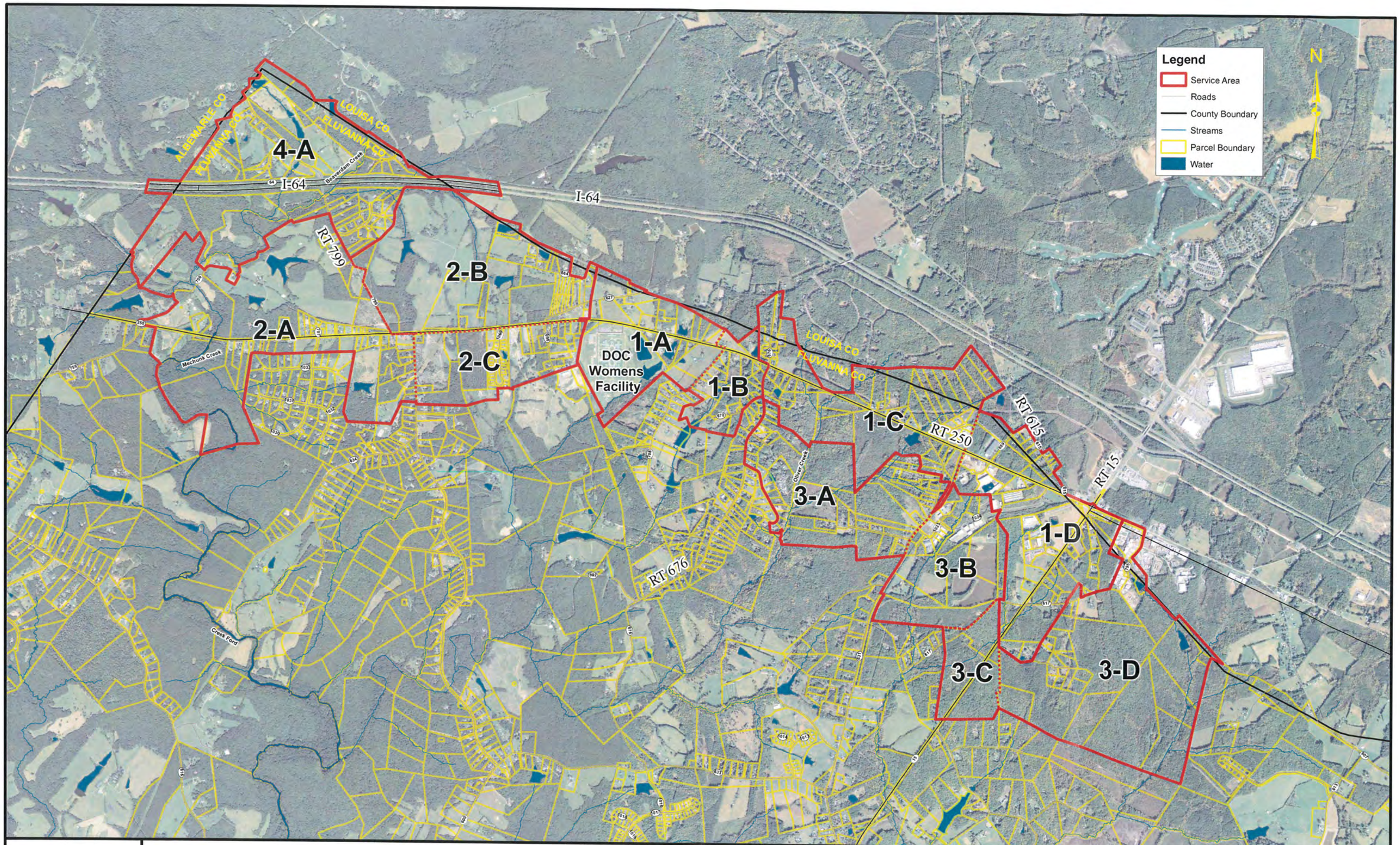

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Figure 2 - Service Area Overview

1 inch = 1,200 feet

0 1,200 2,400 4,800 Feet

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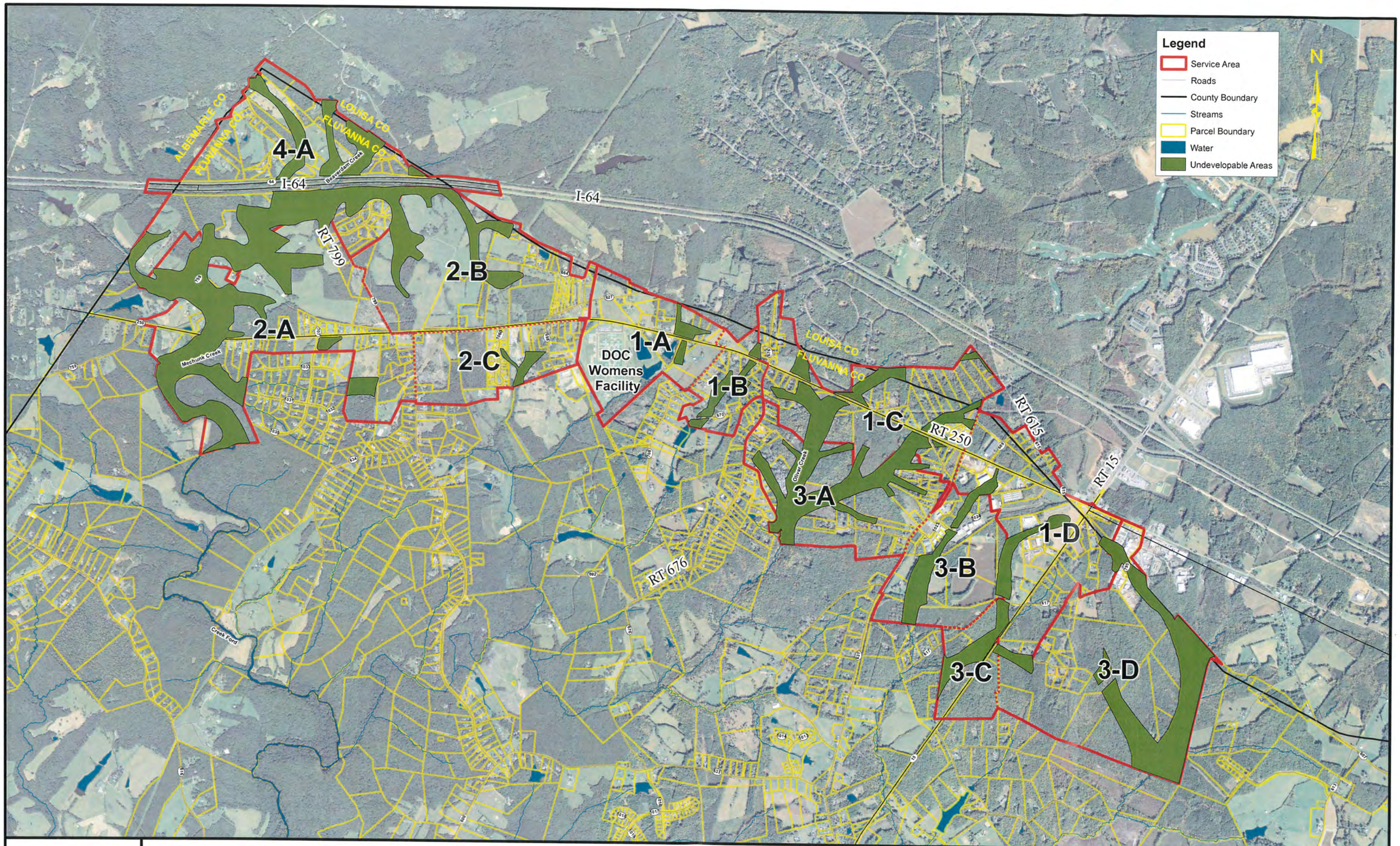

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Figure 3 - Service Area Undevelopable Areas

1 inch = 1,200 feet

0 1,200 2,400 4,800 Feet

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Figure 4 - Potential Land Use Eastern Service Area

0 1,200 2,400 4,800 Feet

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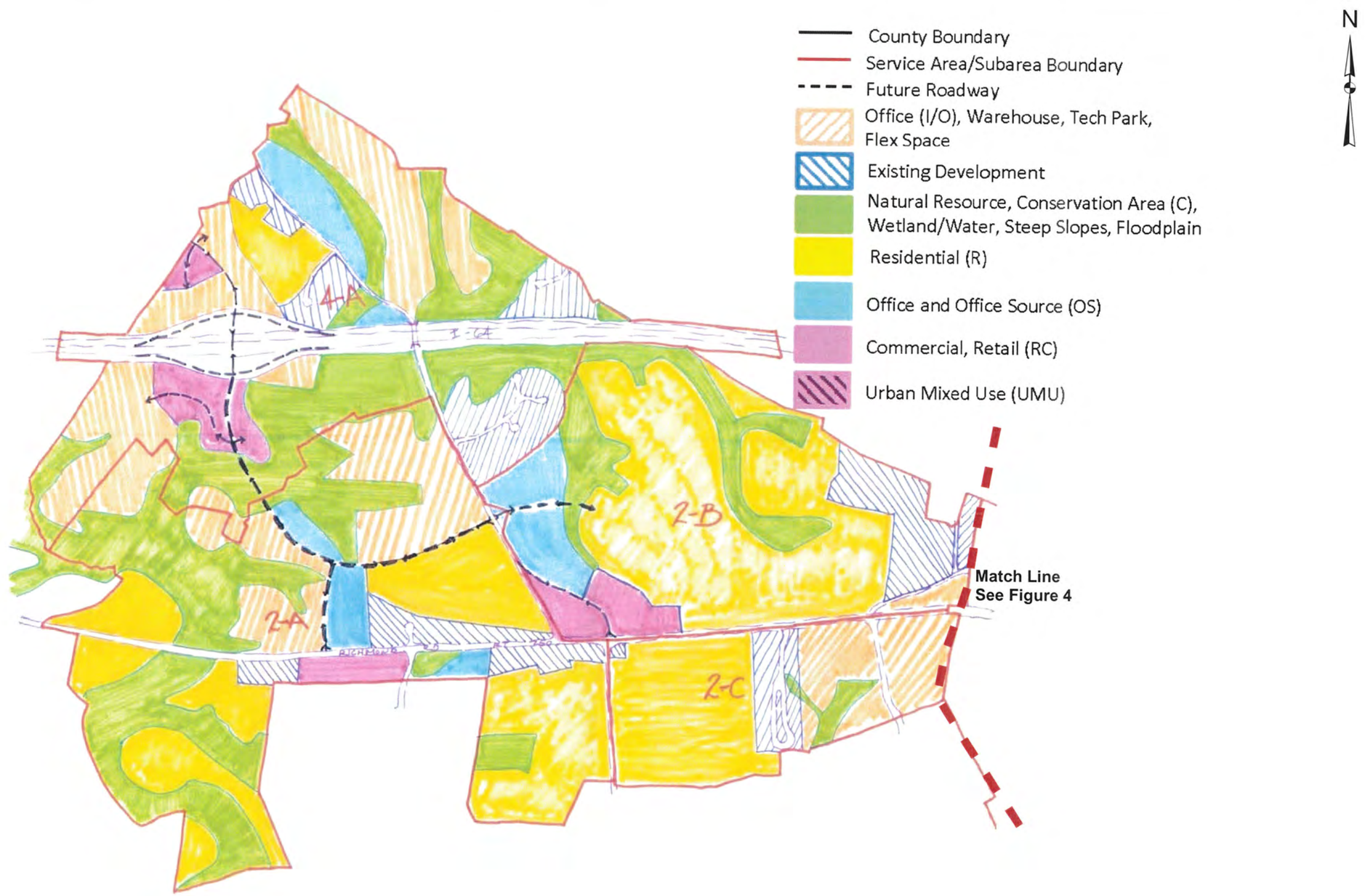

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Figure 5 - Potential Land Use - Western Service Area

0 1,200 2,400 4,800 Feet

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Land Use (acres)	Unit Flow (gal/day/acre)
Existing Development	100
Residential, R-1	500
Residential, R-2	800
Office, Warehouse, Tech Park, Flex Space, (I/O1)	800
Office, Warehouse Tech Park, Flex Space, (I/O2)	1,200
Commercial, Retail (RC)	1,000
Residential, Mixed Use (MU1)	1,500
Residential, Mixed Use (MU2)	2,000

Table 2-1 – Proposed Unit Flows

2.4 Water and Sewer Demand Projections

The water and sewer demands for these parcels were based on the County standards for these zoning types. The flow density demands range from 500 gallons per day/acre to 2,000 gallon per day/acre. Considering conservation measures and most flows will be for employee use, the selected values reflect the lower end of values traditionally used. Should the County desire a higher use industry, the flow estimates should be revisited or the potential for utilizing reuse/recycled water should be explored.

Using the factors discussed in this section, the water and sewer demands were calculated for all 4 service areas for 100 percent of property build-out and 50 percent of property build-out. Table 2-2 shows the total flow of all basins along with individual flow demands for all sub-basins.

Service Area	Build Out Flow (Gals/Day)	50% Build Out Flow (Gals/Day)	Upper Build Out Flow (Gals/Day)	50% Build Out Flow (Gals/Day) - Upper
1	571,023	285,512	773,831	386,915
2	606,501	303,250	880,690	440,345
3	517,420	258,710	774,656	387,328
4	227,667	113,834	306,256	153,128
Total	**1,922,611**	**961,306**	**2,735,433**	**1,367,717**

Table 2-2 – Summary of Water and Wastewater Demands

The shaded values in Table 2-2 for 50 percent build-out were used to determine existing water and wastewater infrastructure size because this is a reasonable design point for a brand new system. It is unlikely that the 50 percent design flow will be achieved in the next 20 years. As growth occurs, it is reasonable to expect redundant or new infrastructure will be installed in the service areas that allow for the 100 percent build-out to occur.

It is important to note that for this Report it has been assumed that water demand projections will equal wastewater demand projections. In reality, especially as a new system is in its early stages (less than 25% build-out), it is not uncommon for wastewater demands to be 10 to 15 percent less than water demands. This is because water systems require periodic flushing to maintain water quality. There are also other uses, such as irrigation and evaporation from cooling towers, that do not require a sewer discharge.

One factor that could decrease some of the water demand would be if industries and commercial businesses utilize gray water or reuse water (from wastewater treatment) in lieu of potable water. However, this is difficult to predict for a new system.

As the long term water source and wastewater treatment options continue to develop, each of the specific demand categories should be independently evaluated to account for some of the above factors mentioned.

For economic development purposes, upper level demand projections are also provided. These projections were accomplished by increasing unit flow densities for the Residential (R-2), Office/Tech Park (I/O2), and Mixed Use categories (MU-2). The flow demands for this scenario are also shown in Table 2-2. These demands can be used as a guide to increase long term source capacity and wastewater treatment needs should more flexibility be desired for the Zion Service Area.

The detailed flow demands are included in Appendix C.

2.5 Predicting When Demands Will Occur

As indicated in Section 2.2, it is estimated that between 1.9 MGD and 2.7 MGD of water and wastewater demand may be required at complete build-out of the Zion Crossroads Service Area. As to when this will occur is dependent on a variety of considerations including economic, political, and regional factors.

Several past studies including the 2010 Regional Water Supply Plan and the 2009 James River Water System PER present a population based growth model for estimating when demand projection flows may occur. As the title implies, this method involves tying population growth in a certain area to how that area will develop. This method does not always work well for a CPA such as the Zion Crossroads Area since commercial, industrial and retail uses may be less dependent on population growth within the immediate area. However, this method does have some merit for planning purposes. The 2009 JRWS study predicts an initial service area flow of 34,000 gallons per day (2015), a flow demand of 137,000 gallons per day at year 2025, and a flow demand of 360,000 gallons per day at year 2040.

It is likely that complete build-out will not occur for at least 50 years and even the 50% build-out projections may take at least 25 to 30 years. However, some of the Service Area zones could achieve higher percentages of growth compared to the others depending on development size. Depending on location, a few large developments occurring on adjacent parcels could significantly change the development potential for the entire area. For this reason, it is still very important to plan for some of the larger demands in terms of infrastructure, source water, and wastewater treatment potential.

3.0 WATER SOURCE OPTIONS

Several surface water and ground water options were evaluated for the potential to serve the area. Ground water sources include existing wells, new wells, and wells through the neighboring Louisa County Water Authority (LCWA). Surface water sources include the Department of Corrections (from Mechunk Creek) and the James River (through the JRWA intake project). There will be two options related to the James River source, one to provide treatment directly by Fluvanna County and one to provide treatment by neighboring LCWA. Other options discussed are connection to the Lake Monticello system and the eastern Albemarle County system. Figure 6 is presented to show the long term water source options that are included in this section.

3.1 Groundwater

3.1.1 Existing Wells

From the available information in the 2010 Water Supply Plan, there are no known wells in excess of 30 gallons per minute in the Zion Crossroads service area. For informational purposes, a 30 gpm well translates into a 24,000 gal/day production well based on Virginia Department of Health regulations. **Utilizing existing wells in the Zion Crossroads area does not appear to be a viable water source option for this system.**

3.1.2 New Wells

Although this area of the County is known for low yielding wells, many of them may not have been drilled deep enough to reach their full yield potential. There are some old wells on Department of Corrections property that experienced some yield, albeit they were relatively shallow and not very productive. This does not necessarily mean that a larger quantity of water does not exist on DOC property at greater depths. Fluvanna County has hired Draper Aden Associates to identify prime locations for potential wells. Once this field testing is conducted, if some significant yield is encountered, potentially this could be used to increase the safe yield of the existing on site water impoundment. The VDH indicated there is not an issue with pumping groundwater into a surface water impoundment and believe the existing DOC water treatment plant would most likely perform very well. **Should this potential be realized, it could help increase the yield of the DOC Water Plant and in turn postpone the need for a long term alternative.**

3.1.3 LCWA Wells

The Louisa County Water Authority drilled and tested 6 wells near the Spring Creek development collectively offering over 800 gallons per minute of yield. In addition to the high yielding wells, the wells offer good water quality and requiring minor chemical treatment (for disinfection and corrosion protection). Unfortunately, the residents that live near these wells have taken issue with the pumping of these wells and it has been very expensive from a legal standpoint to address increasing public issues. Therefore, if Fluvanna County were to request additional supply from these wells through the LCWA, it

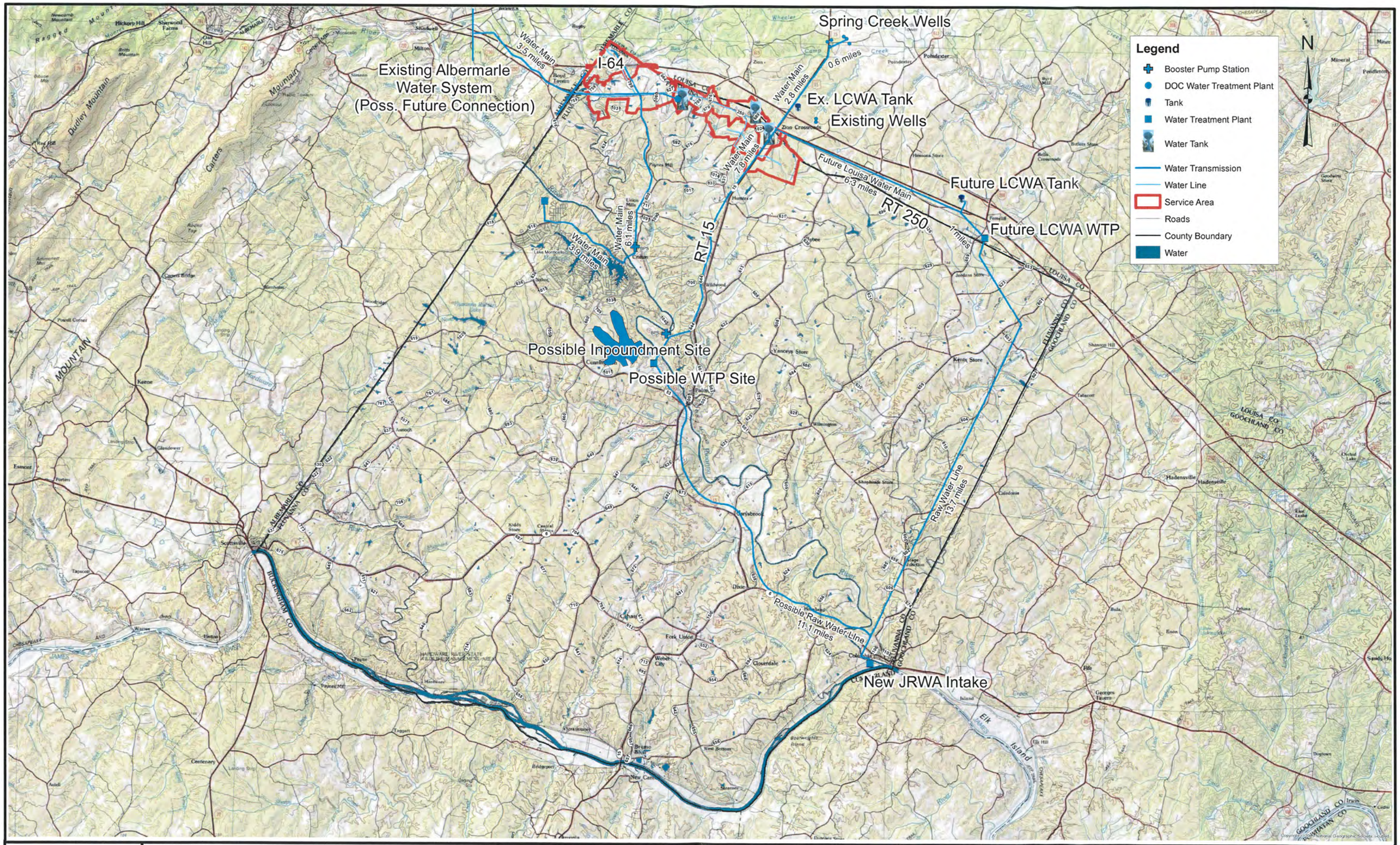

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Figure 6 - Long Term Water Source Options

1 inch = 6,000 feet

0 6,000 12,000 24,000 Feet

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is likely cost prohibitive and politically challenging to utilize this supply. Additionally, the LCWA is presently proceeding with the James River Water project which may impact their use of these wells in the future. **It does not appear that the LCWA wells will be a good water source option for Fluvanna County.**

3.2 Surface Water

3.2.1 DOC Water Treatment Plant

The Fluvanna Correctional Center for Women waterworks consists of a raw water intake and pump station on Mechunk Creek, a 40 million gallon raw water storage impoundment, a pre-oxidation chemical feed system, a flocculator, clarifiers, dual rate gravity sand filters, chlorine disinfection and corrosion control treatment. The design capacity of the facility is 250,000 gallons per day, of which approximately 150,000 gallons per day is utilized by the DOC campus. The infrastructure and treatment facility are less than 20 years old and are in good condition. The VDH and DOC operations staff has mentioned that the treated water quality has been good and reliable. This treatment plant does have the capabilities to treat up to 400,000 gallons per day, provided that the source water supply can be increased. At present, because Mechunk Creek experiences low flows during dry conditions, the VDH cannot increase the yield of this plant. However, if a supplemental water source, such as ground water wells, can be located and pumped to the existing impoundment, it is possible to increase the treatment capacity. The VDH Engineering Description Sheet and Mechunk Creek withdrawal permit are included in Appendix A.

In October, 2013, Fluvanna County and DOC entered into a Memorandum of Agreement for the DOC to provide up to 75,000 gallons per day of treated water to the County. The cost of the water will initially be $1.50 per thousand gallons of metered water. The infrastructure to pump from the DOC system along with any piping, etc. will need to be the responsibility of the County. **Since the facility is already within the proposed Service Area, this appears to be a very cost effective option for the County to provide an initial water source to the Service Area.**

In comparison to current LCWA water rates, the cost to business and industry is $5.50 per thousand gallons. This does not include any capital improvement cost or connection fee costs.

3.2.2 Albemarle County – Rivanna Village area

The nearest public water supply system in Albemarle County to the Zion Crossroads service area is near the area of Glenmoore. This system receives their water from surface water sources and treatment facilities. The approximate distance from the County line to the existing system is 3.5 miles. The cost for a 3.5 mile water main along with the maintenance of the main to keep the water fresh would be significant. However, as the service area grows westward, it may be beneficial to consider requesting a connection to Albemarle County. **This could serve as a supplemental long term supply as well as an emergency water source, should the primary County source have periodic issues with quality or quantity.**

3.2.3 Lake Monticello/Aqua Water System

The Lake Monticello waterworks, owned and operated by Aqua Virginia, Inc., consists of a conventional, high rate surface water treatment plant with a design capacity of 1.4 MGD. Raw water is pumped from an intake structure located in the Rivanna River. The safe yield at this intake location is 10 MGD, but the permit is limited to a maximum daily withdrawal rate of 2.6 MGD. For this reason, there is some available treatment capacity at this facility.

In May, 2012, Aqua Virginia submitted a Design/Build proposal to Fluvanna County to provide water to the Zion Crossroads service area. The scope of this project was to construct an 8.5 mile potable distribution main, include the necessary pumping facility and storage capacity, along with operation of the system. The capacity of water to be supplied with this proposal was up to 500,000 gallons per day.

The total project cost for this proposal was approximately $9.0 Million. This was to be financed into 20 annual payments of $950,000. This cost would include up to 127,000 gallons per day of water. For any usage beyond 127,000 GPD, the cost would be $2.95/thousand gallons. There are other items included in the cost of this proposal such as easement acquisition and permitting costs.

Although it is difficult to do a direct comparison of this proposal to the DOC agreement, it is very evident that the Aqua proposal would have been much more costly to Fluvanna County. One of the reasons is probably the long distance of the transmission main along with the pumping cost.

A copy of the Aqua proposal is included in Appendix A.

3.2.4 James River and JRWA

The James River Water Authority (JRWA) was created by action of both Boards of Supervisors of Louisa and Fluvanna Counties in 2009. The purpose of the joint authority is to provide treated water to both Counties in order to meet their long term needs. The James River Withdrawal Permit (see Appendix A) allows for a maximum daily withdrawal of 5.7 million gallons.

The JRWA has entered into a PPEA Design Build contract to construct a new river intake structure, pumping station, and a portion of the raw water line. It is our understanding that the JRWA and the Louisa County Water Authority are working on a second PPEA Design Build contract that will install the remainder of the raw water main to Louisa, construct a new Water Treatment Plant (near Ferncliff), and a potable transmission main that will feed back to their Zion Crossroads system (see Figure 6).

This phase of the project will offer a very good long term solution for Fluvanna County to purchase additional water to meet the demand projections for the Zion Crossroads Service Area. According to the agreement with Louisa County, the cost for water between the 2 entities is to be based primarily on actual costs so this should give Fluvanna a viable long term option.

3.2.5 New Fluvanna County Water Treatment Plant

According to the JRWA Agreement, Fluvanna County also has the right to construct its own raw water line once it is pumped out of the James River. The 2009 PER for the James River System recommended the Pleasant Grove site in Palmyra as a good option for a County Water Treatment Plant. The PER indicated that a new 3 MGD treatment plant at this site along with other infrastructure improvements would be in the range of $45 Million. Additionally, the raw water line to go from the Intake line to Palmyra is approximately 11 Miles, so this cost would need to be taken into account.

The details of this option are included in more detail in Appendix B.

3.2.6 New Impoundment – Pleasant Grove Site

The 2009 PER for the James River System also evaluated the benefit of a possible impoundment in Fluvanna County in order to assist with storage and pretreatment of the James River source. The recommended site was Site R-5, located on the Pleasant Grove Site, and adjacent to the new High School. Should the County desire to consider a future Water Treatment Plant at this location, the impoundment may want to be studied further. It could also be a source of recreation for County residents.

Information regarding the impoundment site is included in Appendix B and is also shown on Figure 6.

4.0 WASTEWATER TREATMENT OPTIONS

The options evaluated include direct discharge to Virginia water bodies, the potential to discharge to the Department of Corrections wastewater treatment plant (WWTP) and the LCWA wastewater treatment plant located near Zion Crossroads. A discussion of other options including a regional facility in Palmyra is also discussed. Figure 7 is presented to show the long term wastewater options that are included in this section.

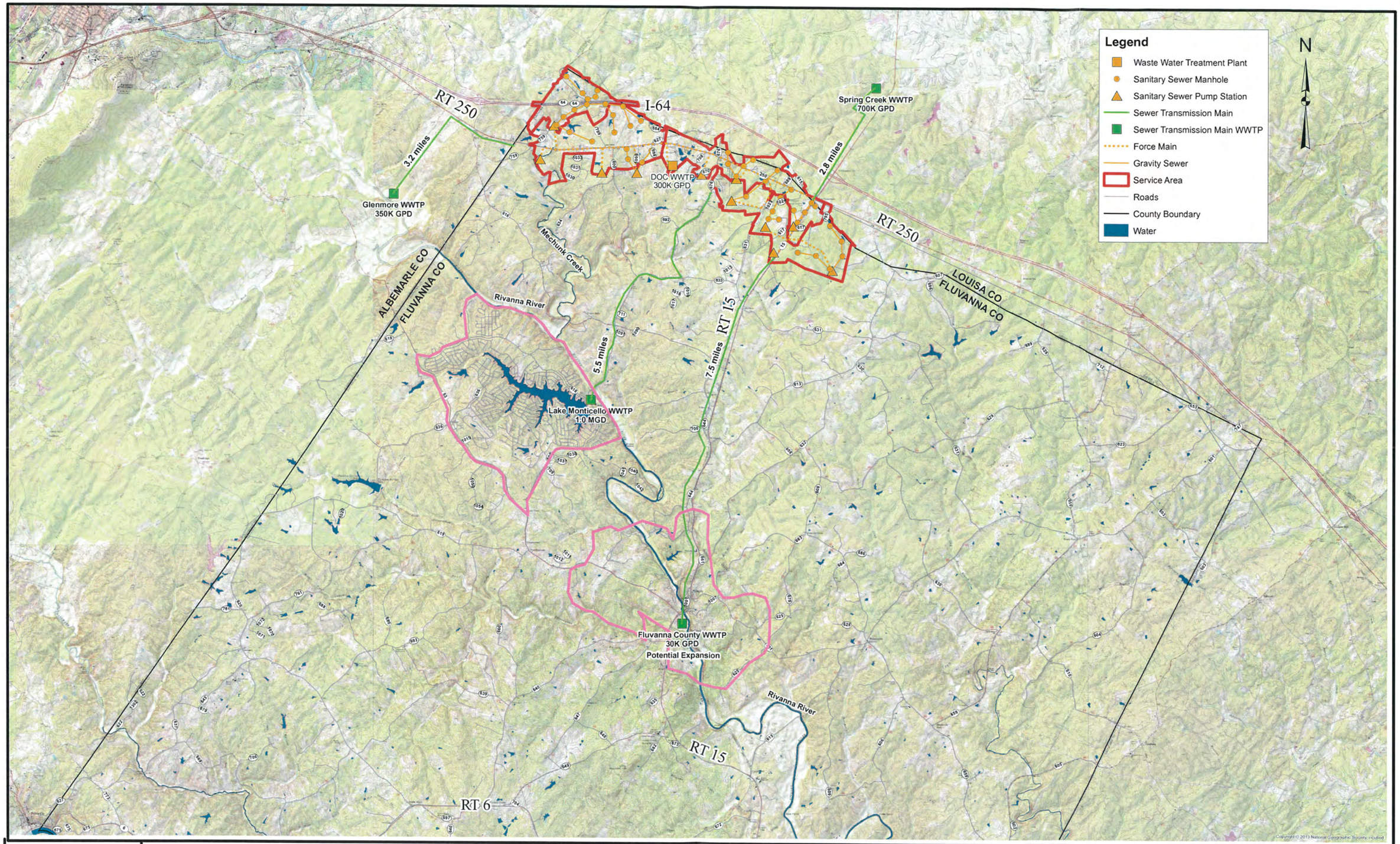
4.1 DOC Wastewater Treatment Plant

Fluvanna County currently has an Agreement with the DOC to treat up to 100,000 gallons per day of wastewater. Additionally, the DOC has implied that an additional 25,000 gallons per day is available upon request. The current DOC wastewater treatment facility was constructed in the mid 1990's and features a proven technology utilizing Sequential Batch Reactors (SBRs) as its primary treatment scheme. These type of facilities have significant storage capacity to address peak capacities so the design capacity of 300,000 gallons per day (150,000 gpd each) should not be too difficult to achieve. Upon a brief visit to the WWTP, the facility is well kept and operators noted minimal compliance issues. The cost per thousand gallons (per agreement) is $1.50/thousand gallons, which is a very good cost compared to average and surrounding County rates. One item that will need to be addressed by DOC is they will need to increase from an 8 hour shift to a 16 hours shift as influent flows increase. Finding qualified operators has proven challenging, suggesting additional personnel may be a cost impact to Fluvanna County. **However, this is a very good option for initial wastewater treatment (up to 125,000 GPD) for the Zion Crossroads service area and this opportunity should be strongly considered.**

There does appear to be space to add additional SBRs and other equipment so it may be possible to add some capacity at this location. However, permitting and compliance requirements to increase capacity beyond 500,000 gallons per day (additional 200,000 GPD of capacity) will likely prove challenging because it discharges into a relatively small stream. The problem with small stream discharges is that the permits can have very low limits for toxic components such as heavy metals (copper, zinc) and ammonia resulting in a long term compliance issue.

4.2 Spring Creek WWTP (Louisa County)

The LCWA owns and operates a relatively new wastewater treatment facility just north of the Zion Crossroads interchange in a large planned development called Spring Creek. It was permitted and constructed to occur in 3 stages of capacity (0.1 MGD, 0.70 MGD, 1.5 MGD), as the service area continues to grow. The current flow to the facility is approximately 130,000 gallons per day. It is our understanding that the plant has been upgraded to Stage 2 for design capacity (0.70 MGD), but is only permitted to 300,000 gallons per day. After flow exceeds 311,000 gpd, the requirements for nitrogen and phosphorus removal will increase, which will require additional operational and monitoring expenses.



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REDUCED PLOT NOT TO SCALE

Figure 7 - Long Term Wastewater Options

1 inch = 4,000 feet

0 4,000 8,000 16,000 Feet

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Zion Crossroads Planning Area
January 2015

Another item that will need to be considered is that Fluvanna County would most likely need to install a pump station and force main from the Route 250/15 intersection to a distance of approximately 2.8 miles in order to access a portion of the 18 inch trunk sewer. Unfortunately, it does not appear that the gravity sewer closest to Fluvanna County will accommodate any additional flow (due to size limitations).

The LCWA is also in the process of relocating the current outfall from a small creek to the South Anna River, which will allow for permit compliance with other compounds that have been a problem in the past.

Although there are some significant cost implications for the above items, it is possible that this is still a less costly option then developing a new County facility, or at least delays the need for a new Facility for another 10 to 20 years. The current LCWA sewer rates are $8.29 per thousand gallons for business and industry. These rates will probably increase as the WWTP expands. This cost does not include any capital improvement cost or connection fee costs.

Some additional information on the current and proposed sewer infrastructure for the Zion Service Area (in Louisa) is provided in Appendix B.

4.3 Albemarle – Eastern WWTP

As shown on Figure 7, there is an existing wastewater treatment facility that serves the Glenmore development and the Rapidan village area. This facility is permitted for 350,000 gallons per day and was designed primarily to serve this community. **The distance from the Fluvanna County line to the facility is approximately 3.2 miles, so it is unlikely that this distance combined with the lower available capacity (if any) would be a cost effective option for Fluvanna County.** However, the County may still desire to investigate this possibility further by scheduling a meeting with the Rivanna Water and Sewer Authority.

4.4 New Fluvanna WWTP

The County presently owns and operates a 30,000 gallon per day wastewater treatment plant that discharges to the Rivanna River. While this plant would not serve as a regional facility in its current state, the discharge location is very desirable when considering the location for a larger facility that could treat the larger demands that are projected from the Zion Crossroads Service Area. A regional facility could also serve the Lake Monticello community, surrounding Palmyra, and the Fork Union area.

As mentioned for the other options in this study, once the DOC Facility option is no longer viable due to increasing demands, there are no other inexpensive options. It therefore makes sense to consider a regional Facility at some point in time.

A new regional facility will require a very high level of treatment. However, that is required for most new facilities to meet current standards to discharge to the Chesapeake Bay and its tributaries, so this is to be expected. The more difficult challenge is in meeting the nutrient requirements for nitrogen and

phosphorus. It will probably take a combined approach of nutrient exchange, creation of alternate nutrient reductions (discussed in Section 4.7), alternative sewer disposal, and water reuse.

4.5 Alternative Sewer Treatment Options

Since discharging large flows to a stream or river will continue to have stringent permitting requirements, alternative treatment systems should be considered to manage a portion of the service area flow. Alternative treatment systems typically still require a reasonable level of treatment, but in lieu of discharging to a stream or river, they discharge to the subsurface such as a drainfield, drip irrigation system, or injection type system. **It is recommended that the County conduct an evaluation to determine the feasibility of utilizing alternative wastewater treatment and disposal systems (in the next couple of years).**

4.6 Water Reuse

Several years ago, Virginia adopted Water Reuse regulations which allow treated wastewater to be utilized for beneficial use purposes in lieu of discharging to a State water body. Water reuse has a potential to reduce the amount of direct discharge of treated wastewater that will go directly to a surface water source. It also has the benefit of reducing the total amount of nutrients (nitrogen and phosphorus) that will need to be discharged.

There are many Water Reuse systems that have been constructed and are now in operation in Virginia with a variety of beneficial applications. The Reuse Regulations have two (2) levels of treatment that must be met depending on use and risk to the user/environment. Type 1 requires a more stringent level of treatment and monitoring and Type 2 is slightly less stringent. Examples of the types of applications are presented below:

Type 1

- Residential Lawn Watering
- Toilet Flushing (Non-res)
- Fire Fighting / Protection (Non-res)
- Commercial Car Wash
- Commercial Air Conditioning Systems
- Irrigation of Food Crops (Consumed Raw)
- Landscape Impoundments
- Commercial Laundries

Type 2

- Irrigation of Food Crops (Commercially Processed)
- Irrigation of Non-food Crops
- Landscape Impoundments
- Construction (Compaction / Dust Control / Concrete)
- Livestock Watering
- Data Center Non-Contact Cooling
- Street Washing
- Cooling Towers

It is recommended that Fluvanna County evaluate the potential for water reuse in the proposed service area, possibly with the next Comprehensive Plan update.

4.7 Alternate TMDL options

As wastewater flows increase to the Service Area and less nutrient credits are available to meet annual nitrogen and phosphorus TMDL (Total Maximum Daily Loadings) requirements, it will be important to find alternative, long term solutions. Some alternate TMDL options will involve evaluating existing and prospective County owned property for alternate methods of controlling these nutrients from entering the Chesapeake Bay watershed. These alternative methods may be through stormwater management, agricultural management, or silvicultural (forests) management. **It is recommended that Fluvanna County evaluate these alternate TMDL options in conjunction with further evaluation of the long term wastewater treatment options.**

5.0 WATER DISTRIBUTION SYSTEM

This section presents an evaluation for water system infrastructure options for connecting to the DOC water system with an option of connecting to the LCWA water system near Route 15. The infrastructure components will include water mains, booster station(s), and a water storage tank. A preliminary water model was developed to assist with infrastructure sizing, determine available fire flow and pressures, and assess where water quality issues may be prevalent.

5.1 Water Model Development

The water model program used for this evaluation was the *Bentley WaterCAD version 8.1* model. The primary distribution system and nodes shown in Figure 8 were utilized as the basic infrastructure in the model. Demands were input to select nodes in each Service Area sub-basin based on the 50 percent build-out flows on a peak day. Pipe sizes were selected based on peak demands and desired fire flow availability. A water booster station and two possible elevated tank locations were also considered in the model.

Elevation and Tank Location – The western portion of the service area (Areas 2 and 4) are lower in elevation than those to the East (1 and 3). An elevated storage tank would therefore be required to serve the eastern portion. It is advisable to locate an elevated tank on the highest point available thereby reducing the required tank height and associated cost. A potential location for the tank is near the intersection of Route 250 and Route 15 with a base elevation of approximately 520 feet. This will also allow for the elevated tank to be on the same overflow elevation as the Louisa County tank (elevation 663), should the systems be connected in the future.

The input data for the water model is included in Appendix C.

5.2 Storage Capacity Requirements

Storage is an essential part of any water system. In general, the purpose of storage within a water distribution system is to:

- Equalize supply and demand
- Provide for peak hourly demand periods
- Level out pumping requirements
- Provide water during source or pump failure
- Provide water to meet fire demands
- Meet state regulatory requirements

The demand for water changes throughout a 24-hour period. During the day, it is common for tanks to be emptying; while at night, the tanks refill again for the next day's peaks. If treated water is not available

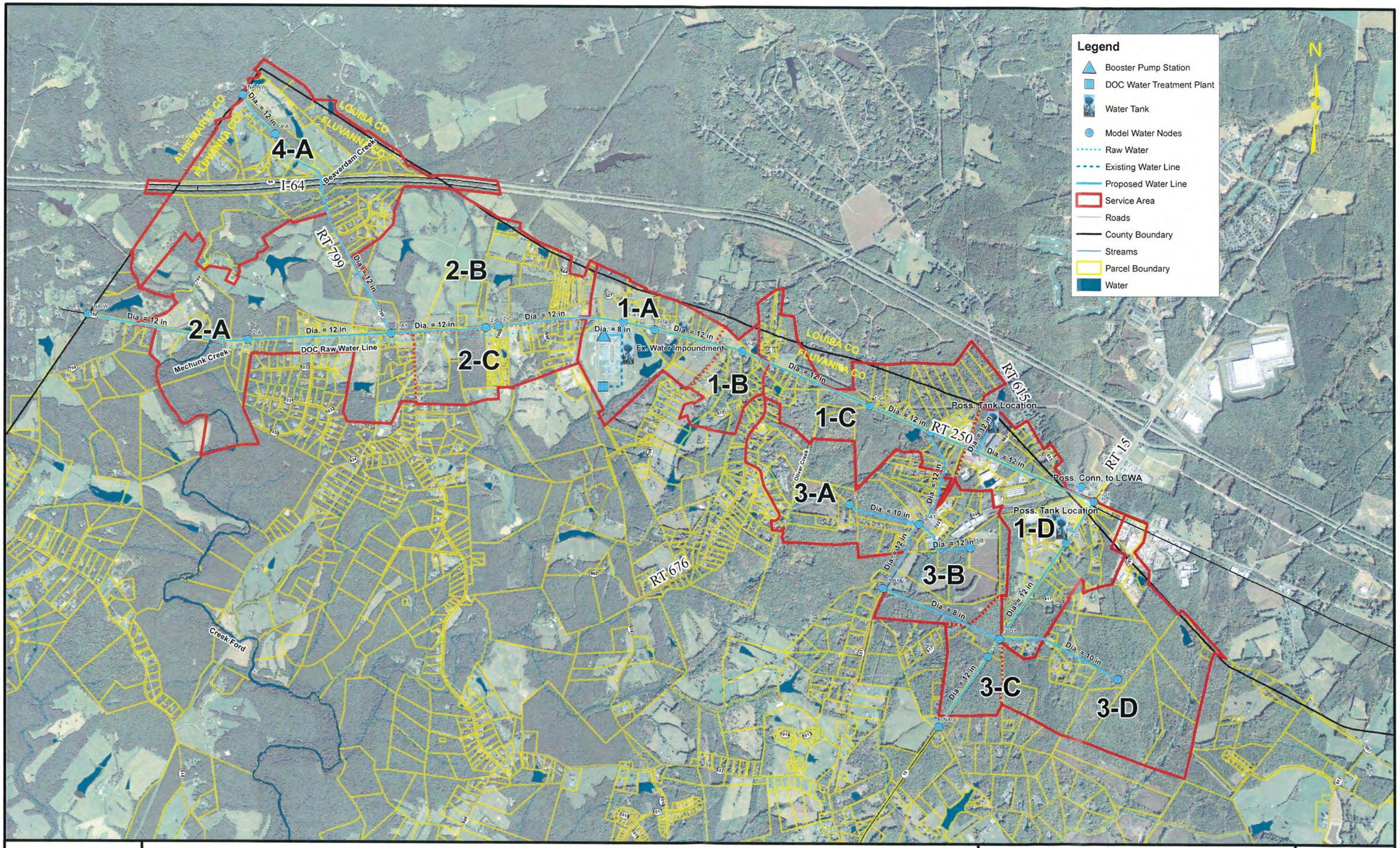

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Figure 8 - Proposed Water System Layout

1 inch = 1,200 feet

0 1,200 2,400 4,800 Feet

COUNTY OF FLUVANNA
PER FOR WATER/WASTEWATER SERVICES

Zion Crossroads Planning Area
January 2015

from storage, pumps have to be large enough to meet the peak hour demand. Since demand changes from hour to hour and day to day, without storage, pumps would have to meet an excessively wide range of operating conditions. The pumps would cycle frequently or be left on constantly causing increased wear on pump controls and motors, as well as increasing operations and maintenance costs. Storage allows the bulk of the pumping activity to occur during off peak hours reducing pumping costs by taking advantage of rate structures for electrical power.

System redundancy is increased with storage allowing short-term uninterrupted water system flows for times when full pump capacity may not be available due to power failure, mechanical breakdown, or preventive maintenance. Sudden increases in demand can be caused by line breaks, broken hydrants, fire or similar problems. In addition, the maximum output of water from the treatment plant or well sources may not be available for the same reason as the pumps or at the instantaneous capacity needed by the system. The well sources may have to be shut down due to raw water quality issues, maintenance or emergency repairs. Emergency storage provides flexible system capacity to accommodate such situations.

One of the major purposes for distribution system storage is meeting fire demands. Although fire demands may not occur frequently or require a long duration, they are much greater than consumer peak demands. In most cases, water systems, including storage, are designed to provide fire demand in addition to normal consumer needs. Fire demand can account for as much as 20% - 50% of the total capacity of a storage system.

In Virginia, the State Health Department requires a water system provide at least 200 gallons of "effective" storage per water connection. The term "effective" storage is used to exclude a quantity of storage that cannot provide a pressure of at least 20 psi throughout the distribution system under all conditions of flow. This means that unless a tank can provide at least 20 psi during a peak day and fire flow condition while it is empty, that tank cannot be considered 100% effective.

For the initial phase of the water system, a 500,000 gallon storage tank should provide enough capacity to meet the County's needs for close to 20 years. The required tank volume is determined by 3 primary components: fire flow, peak day equalization, and peak day usage. For a 2 hour fire flow at 1,500 gals/minute, this equates to 180,000 gallons of storage. The remaining 320,000 gallons will be used to meet the other objectives.

The storage tank capacity analysis is included in Appendix C. This analysis includes the required storage capacity at 10% of build-out flows, 50% of build-out flows, and 100% of build-out flows. Additionally, the upper demand projections were also analyzed for storage requirements based on the same percent build-outs. The results indicate that a 500,000-gallon storage tank will meet the requirements beyond the 20% build-out demands (for normal). This may not occur for 20 to 30 years, at such time, an additional elevated storage tank should be added to the system.

Although an elevated storage tank is recommended for the County, ground storage can also be utilized but will require a second water pump station. The pumps will need to be large enough to meet the fire flow

objectives of 1,500 gpm. In our opinion, this type of system is not as reliable as an elevated tank and requires more operational components. However, the construction cost of a ground tank/booster pump system is likely 20-30% less than an elevated tank. A reliable backup power system (or emergency generator) will also be required for this option.

5.3 Distribution System

Fire flow requirements are a large factor in the design of a water system. As discussed in the previous section, necessary fire flow capacity is a large part of the total tank storage capacity. Fire flows are also an important factor in the sizing of water mains. The larger the flow is though a water main, the greater the energy loss will be due to friction loss in the pipe corresponding to a loss of pressure in the system. A well designed system will be able to deliver the necessary fire flow plus the maximum day demand while maintaining a minimum of 20 psi at all points in the system. For the initial system, a 12 inch water main for the primary transmission lines along Route 250 and Route 15 were determined to be suitable. Sizing determination of the distribution system will be discussed further in Section 5.5.

5.4 Water Booster Station

A water booster pump station will be necessary to deliver water from the DOC water system to the new Zion Crossroads system. This is required because the new system will require a higher pressure to serve the eastern portion of the Service Area (approximately 30 psi higher). The booster station will be an above ground structure, most likely a 20 foot by 20 foot prefabricated building. The pumps (2 minimum) should be sized to deliver between 500 and 600 gallons per minute to the system and will operate when the water tank needs to be filled. Electronic monitoring and communication should be included to control the booster station and water tank automatically featuring both on site and remote access options by utility operators.

5.5 Water Model Results

Utilizing the components discussed previously in this section, a Steady State water model scenario was run for the 50% peak build-out demands. Below is a summary of pressure and fire flow results for each portion of the Service Area (Eastern and Western).

- Eastern Zone (Service Areas 1 and 3) – normal system pressures will range between 50 psi (Node 1D) and 80 psi (Node 1A), with available fire flow being over 2,000 gpm at 20 psi residual. These results will meet or exceed the system goals.
- Western Zone (Service Areas 2 and 4) – normal system pressures will range between 80 psi (Node 2-A1) to over 100 psi (Node 2-A). This is due to the lower ground elevations compared to the eastern zone. For normal system pressures above 80 psi, it is recommended to install pressure reducing valves (PRVs). This can either occur on the distribution system (near node 2B), or can be installed on future lines connecting to the transmission main. The available fire flow is between 1,300 gpm and 2,000 gpm in the western zonewith the lower flows due to the distance

from the new elevated tank. Considering the model results, the system is only slightly below the goal of 1,500 gpm at the far reaches of Zones 2A and 4A.

In summary, the water model indicates a 12 inch distribution main along the primary roads combined with 8 inch looping in other areas will provide a very good backbone for the water system. This statement assumes that an elevated tank will be constructed in Zone 1D and a water booster station will be constructed at the DOC property.

All water model results are presented in Appendix C.

5.6 Alternate Water Source Connections

It is recommended that Fluvanna County discuss a possible connection to the LCWA system near Route 250 and Route 15. Even if the available quantity is limited by LCWA, it would serve as an emergency backup supply benefitting both Counties and would also provide suitable pressures and a reasonable level of fire protection, should Fluvanna County need to delay the construction of a new storage tank. As the service area grows westward, it may also be beneficial to consider requesting a connection to Albemarle County. This could serve as a long term supplement as well as an emergency water source, should the primary County source have periodic issues.

5.7 Phasing of Water System

As part of this PER, a phased approach for construction of the improvements serving the area is recommended. The initial phase considers construction of the 12 inch diameter distribution main between the DOC and the intersection of Route 250 and 15 at Zion Crossroads. It also includes a portion of the distribution main running south. The total transmission main distance to serve Areas 1A thru 1D is approximately 25,000 linear feet. The first phase also includes the construction of the water booster station at DOC property and a new 500,000 gallon elevated storage tank near the intersection of Route 250 and Route 15. As other service areas develop, the transmission main and water loops shown should be constructed.

5.8 Cost of Water System, Phase 1

For budgeting purposes, preliminary cost estimates have been developed to provide the County with a sense of what it may cost to develop the water infrastructure that is shown in Figure 9. These cost numbers include engineering, inspection, property/easements, permitting and construction costs. The total project cost of a 12 inch water main from the limits of subarea 1D (Node 3-D1) to the DOC system is approximately $2.4 Million. The total project cost of a new 500,000 gallon elevated storage tank is approximately $2.1 million and the cost of a water booster station at DOC property is approximately $0.6 Million. The total project cost of these 3 components is approximately $5 Million. These costs can be further developed in the preliminary design phase once alignments and parcels are identified.

A summary of the project cost estimates is provided in Appendix C.

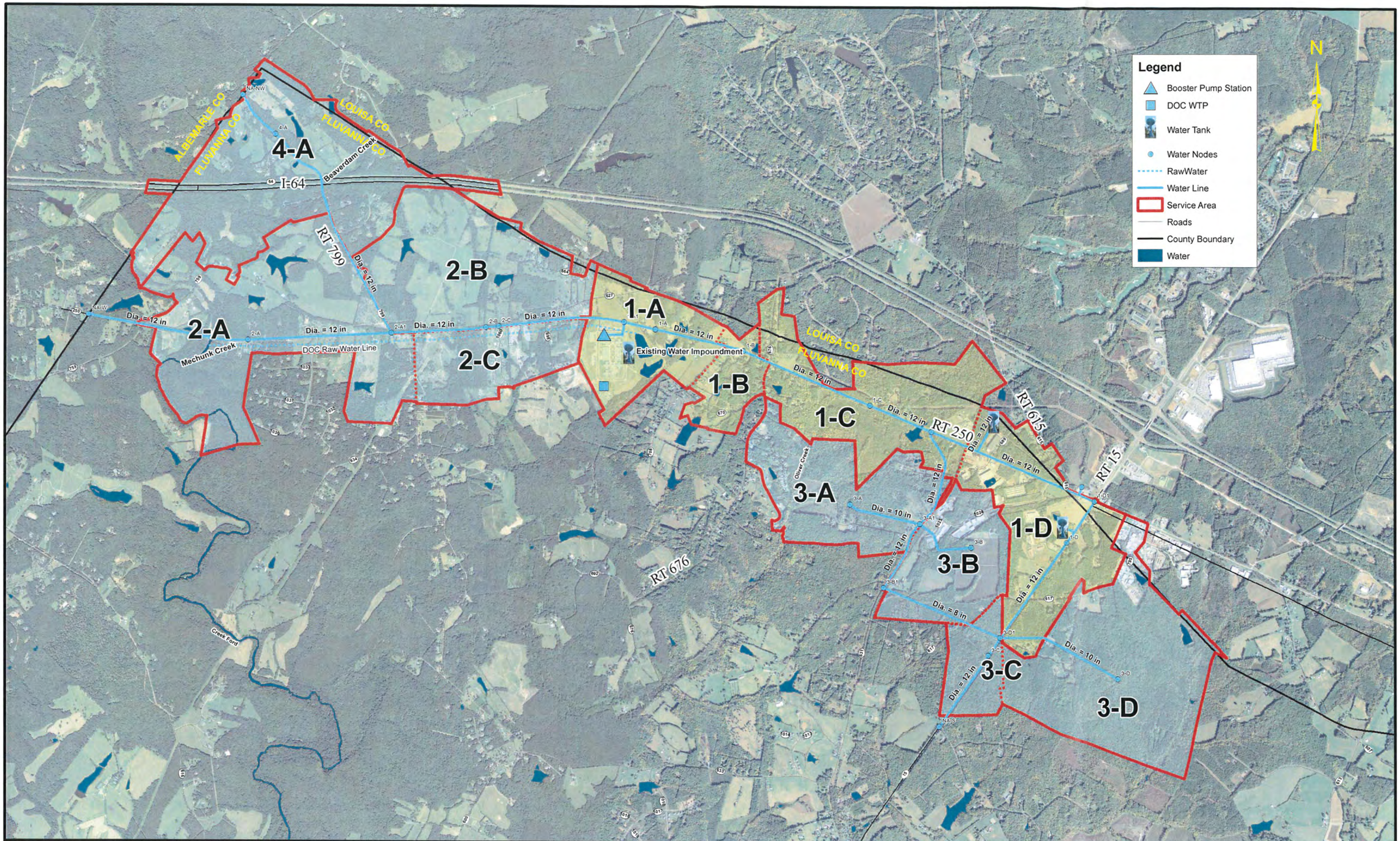

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Figure 9 - Water System Phased Improvements

1 inch = 1,200 feet

0 1,200 2,400 4,800 Feet

COUNTY OF FLUVANNA
PER FOR WATER/WASTEWATER SERVICES

Zion Crossroads Planning Area
January 2015

6.0 WASTEWATER SYSTEM

A preliminary layout of the primary sewage collection system components is presented as Figure 10. The system consists of gravity sanitary sewer collection mains serving the parcels in the Zion Crossroads Service Area as defined in previous figures. The gravity sewers convey flows to pumping stations discharging to smaller pressurized mains connected to a larger main. The larger main, which typically follows the primary roads of Route 250 and Route 15, conveys flows from the subareas to the centralized wastewater treatment facility. Considering the boundaries of the Area, the collection system should offer system-wide flexibility.

A preliminary sanitary sewer system layout is presented as Figure 10. Gravity sewer is depicted by the orange lines, pump stations by triangle symbols, and force mains are indicated in green. The pressure force main system is divided into two types of mains including:

- Force Mains – Smaller diameter force mains conveying flows from individual pump stations to a larger interceptor main. Considering the system layout, all pressure mains not aligned along Route 250 or 15 are considered force mains.
- Interceptor Main – Typically larger pressure mains conveying flows from multiple pump stations to the centralized wastewater treatment facility. Considering the system layout, the pressure mains aligned along Route 250 and 15 are considered interceptor mains.

As discussed in the Wastewater Treatment Options section, multiple alternatives are available for wastewater treatment. Initially, the DOC will likely be used to provide treatment for the Area until another alternative can be fully evaluated and implemented. This will require conveyance of all flows generated in the area presented in Figure 9 to the DOC. Considering the area with the greatest initial potential for development is near the I-64/Route 15 interchange, the bulk of the sewage generated in the Area will be conveyed westerly from Zion Crossroads to the DOC. As the Area develops and flow rates exceed the allotted DOC capacity, a supplemental or replacement alternative will require implementation. Considering the future system may involve a new facility in Palmyra requiring flow conveyance south along Route 15 or LCWA to the north of Zion Crossroads, the section of force main between the DOC and Zion Crossroads will be reversed conveying flows easterly. The sections between the DOC and Zion Crossroads were sized to convey flows in either direction minimizing future system upgrades. Given the wastewater treatment options, operational flexibility is critical for the section of force main between the DOC and Zion Crossroads.

6.1 Flow Projections

The flow projections summarized in Table 2-2 were utilized for the design of the initial design of this system. The flow projections consider development in accordance with the land use as presented in Figures 4 and 5. A unit flow (gpd/ac) was assigned to each land use category in each subarea. The unit flow was multiplied by the developable acreage to determine the total average flow for a complete

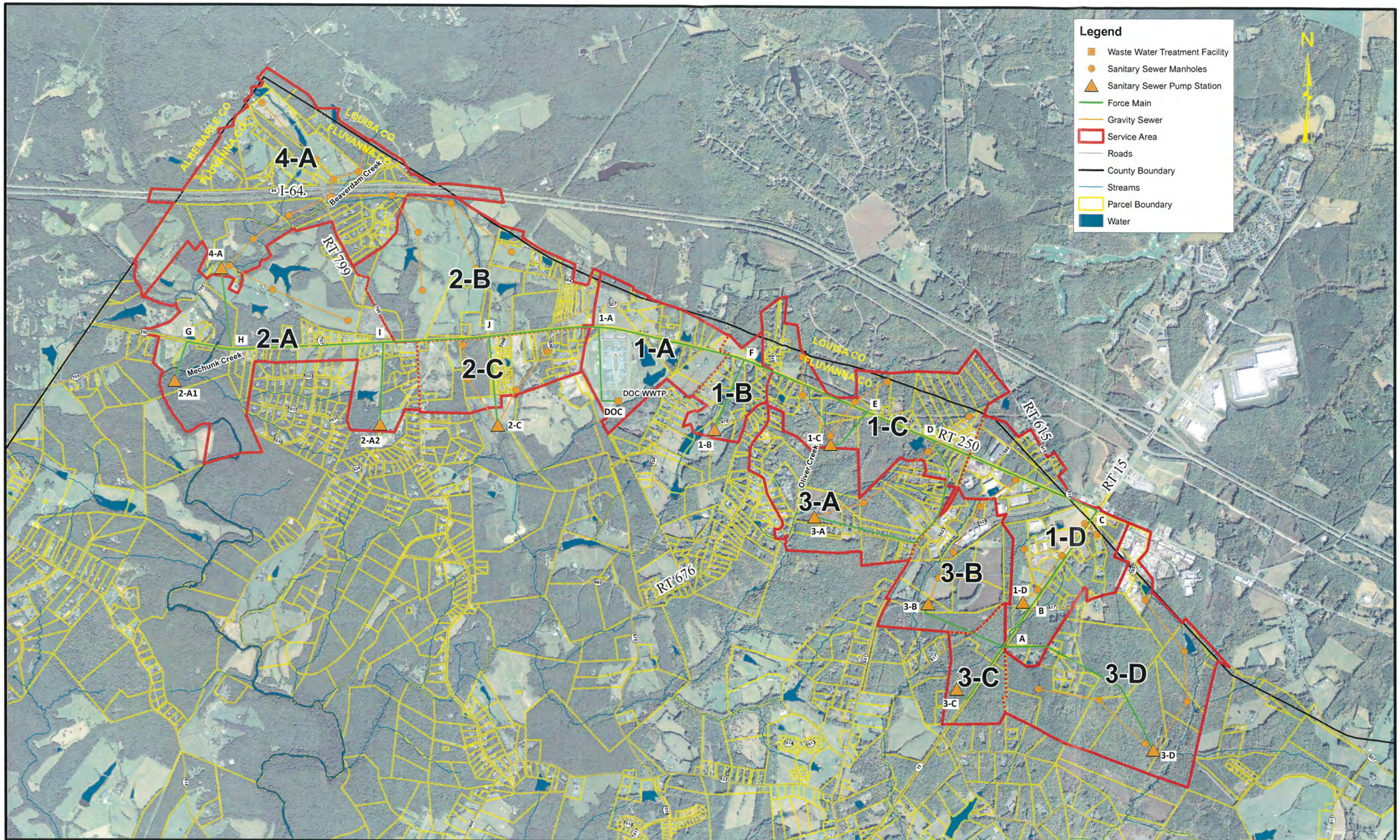

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Figure 10 - Proposed Sewer System Layout

1 inch = 1,200 feet

0 1,200 2,400 4,800 Feet

COUNTY OF FLUVANNA
PER FOR WATER/WASTEWATER SERVICES

Zion Crossroads Planning Area
January 2015

area wide build out condition. A sewer peaking factor of 2.5 was applied to the total average flow to determine peak flow values.

6.2 Gravity Sewer

A preliminary layout of the gravity sewer collection system trunk lines is presented in Figure 9. Construction of any gravity sewer improvements is not anticipated with Phase I of the improvements for the area, but should be installed once significant developments have begun. The trunk lines are considered the larger components of the gravity sewer system conveying flows collected in the smaller gravity sewer sections serving small groups of parcels to the pump stations. The trunk lines are typically aligned along creeks or ravines and sloped in the same direction as the surrounding grades in order to collect flows from a larger area. Reviewing estimated flows, gravity sewer sizes are expected to range in diameter from 8 to 12-inch with the potential for somewhat larger trunk lines depending on the size of the subarea and needs of the development.

6.3 Force Mains

The force main will be sized to accommodate the peak flow from each basin plus the average daily flow from the other basins. The summary spreadsheets show the force main sizes and total head conditions for each of the five basins are shown in Appendix C. The optimal force main size is 6-inch through 10-inch. The minimum pumping rate to achieve scouring velocity of 2 feet/second in a 6-inch force main is 180 gpm, 320 gpm in an 8-inch force main and 500 gpm in a 10-inch force main.

As shown in Appendix C, multiple flow conditions were examined to size the force main system including:

- Full Build Out WW Peak Flow – Considers peak flow from a full area-wide build out with a 2.5 peaking factor
- 50% of Build Out WW Flow – Considers 50% flow from a full area-wide build out
- 50% of Build Out WW Peak Flow – Considers 50% flow from a full area-wide build out with a 2.5 peaking factor

Considering the potential for a complete area-wide build out is unlikely, the 50% flow values were used to select pipe sizes based on calculated pipe velocities. Velocities in the range of 2-8 feet per second are desirable for sewer force mains.

A preliminary layout of the pressure and interceptor mains is presented in Figure 10. Construction of an 8 inch or 10 inch interceptor main between DOC and Zion Crossroads is recommended as part of the initial phase of the improvements. Construction of force mains serving individual pump stations is not anticipated with Phase I of the improvements for the area, unless specific development agreements have been established. Reviewing estimated flows, pressure main sizes are expected to range in diameter from

6 to 10-inch. Force mains serving individual pump stations will likely be 6 to 8-inch diameter mains depending on the size of the subarea and needs of the development.

6.4 Pump Stations

A preliminary layout of the pump station locations are presented in Figure 10. Construction of any gravity sewer improvements including pump stations is not anticipated with Phase I of the improvements for the area. Pump stations are typically located in relatively low areas (i.e. along creek beds or ravines) to accommodate gravity sewer flows from higher elevations to the pump station through the trunk lines. Reviewing estimated flows, pump station sizes are expected to range in capacity from approximately 100 GPM to 600 GPM depending on the size of the subarea and needs of the development. Considering the estimated flow rates, a typical pump station will likely feature two pumps with 40 horsepower or less. Discharge flow rates from the pump stations are required by Virginia regulations to have a minimum of 2 feet/second velocity to prevent the accumulation of solids in the force mains.

6.5 Phasing of Sewer System

As part of this PER, a phased approach for construction of the improvements serving the area is recommended. The initial phase considers construction of the interceptor main between the DOC and the intersection of Route 250 and 15 at Zion Crossroads. It also includes a portion of force main running south. The total interceptor force main distance to serve Areas 1A thru 1D is approximately 23,000 linear feet. Construction of gravity sewers, pump stations and force mains are development driven. As parcels develop, construction of gravity sewer, a pump station and a small force main conveying flows to the interceptor main will be necessary. Pump station location, gravity sewer and force main alignment and capacity will be as needed to serve the immediate development and any estimated development in the subarea. Funding, design and construction of these facilities will depend on the development requirements, County's policy on funding improvements and any agreements the County may have with a developer for use of the property.

6.6 Cost of Sewer System, Phase 1

For budgeting purposes, preliminary cost estimates have been developed to provide the County with a sense of what it may cost to develop the sewer infrastructure that is shown in Figure 11. The cost to provide a primary force main (approximately 23,000 linear feet) from the limits of 1D (node A) to the DOC WWTP (Node 2C) is approximately $2 Million. This does not include any cost for an initial pump station or gravity sewer. For budgeting purposes, an allowance of $1 Million would provide some of these components. These costs can be further developed in the preliminary design phase, once alignments and parcels have been identified along any potential conflicts that may impact cost.

A summary of costs is initial sewer system is provided in Appendix C.

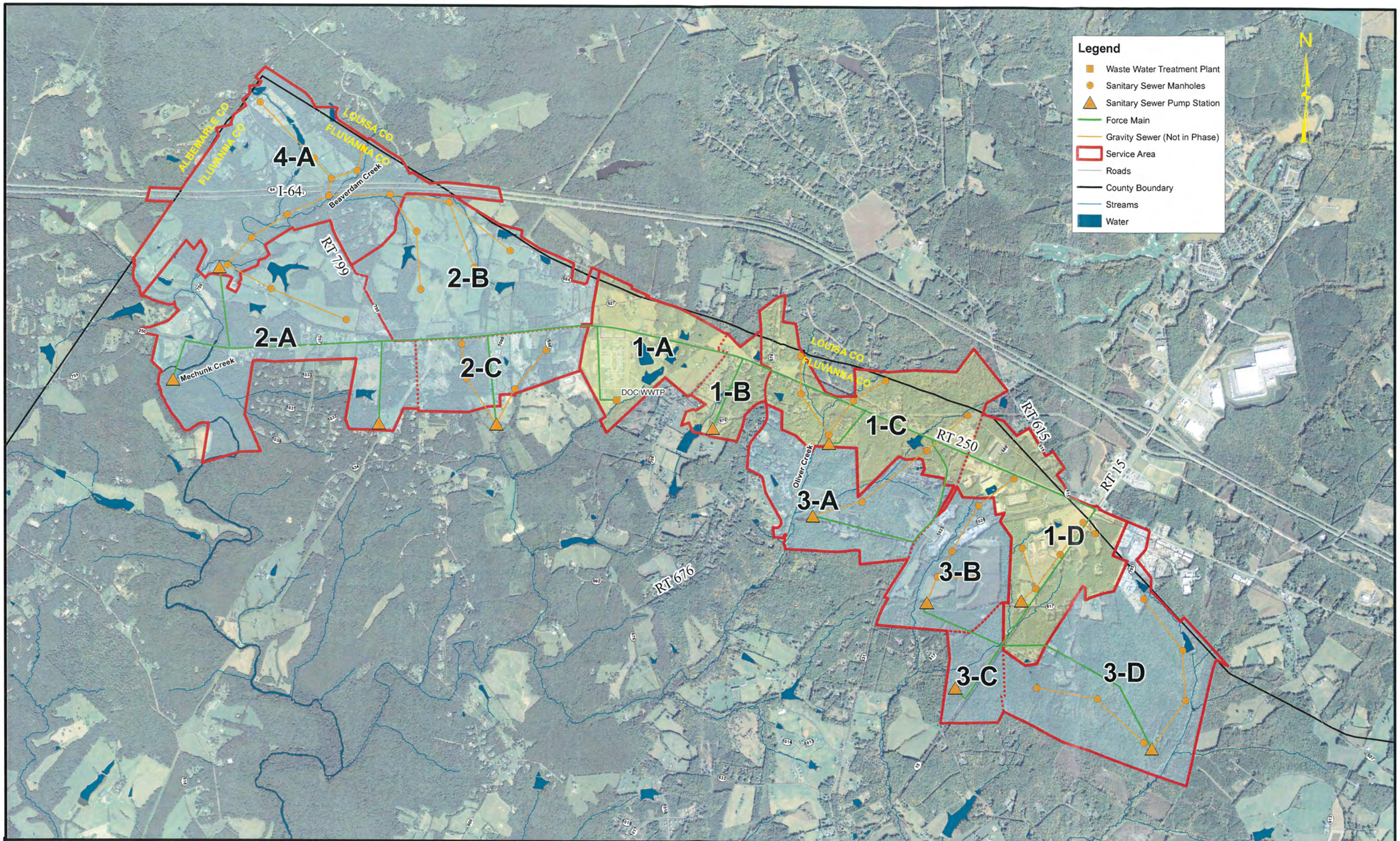

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Figure 11 - Sewer System Phased Improvements

1 inch = 1,200 feet

0 1,200 2,400 4,800 Feet

COUNTY OF FLUVANNA
PER FOR WATER/WASTEWATER SERVICES

Zion Crossroads Planning Area
January 2015

7.0 RECOMMENDATIONS

Based on the information provided in this report, the following recommendations are offered for Fluvanna County in order to establish a water and wastewater system for the Zion Crossroads Area.

7.1 **Source Water, Short Term -** It is recommended that the County proceed with the Agreement with the Department of Corrections to obtain up to 75,000 gallon per day of treated water. This is the most cost effective short term option and offers an established water source located within the central part of the proposed service area.

7.2 **Source Water, Mid Term -** It is recommended that the County continue to investigate locations for supplemental ground water supply wells in the area of the DOC facility. Should a suitable yielding well(s) site be identified, these should be considered as a supply to the existing DOC impoundment. By increasing quantity to the impoundment, it is likely that the Virginia Department of Health will increase the permitted treatment capacity of the DOC facility, which may delay the need for a long term source.

7.3 **Source Water, Long Term** – It is recommended that Fluvanna County discuss the opportunity to purchase long term potable water from the LCWA water treatment facility and transmission main that are planned for construction to serve the Zion Crossroads area.

7.4 **Alternate Water Source Connections** – It is recommended that Fluvanna County discuss a possible connection to the LCWA system near Route 250 and Route 15. Even if the available quantity is initially limited by LCWA, it would serve as an emergency backup supply and would also provide suitable pressures and a reasonable level of fire protection should Fluvanna County need to delay the construction of a new storage tank. As the service area grows westward, it may also be beneficial to consider requesting a connection to Albemarle County. This could serve as a supplemental long term and emergency water source, should the primary County source have periodic issues.

7.5 **Wastewater Treatment, Short Term** – It is recommended that the County proceed with the Agreement with the Department of Corrections to obtain up to 100,000 gallons per day of wastewater treatment. This is the most cost effective, short term option and offers a reliable wastewater treatment facility located within the central part of the proposed service area. The County should also consider requesting additional capacity even if per gallon costs increase, as this may help delay the need for a longer term option that is likely to be much more costly.

7.6 **Wastewater Treatment Long Term** – there does not appear to be a clear, inexpensive option for wastewater treatment of the proposed service area as flows begin to exceed a few hundred thousand gallons. One option is to construct a regional facility in Palmyra, most likely near the site of the current 30,000 gallon per day facility. Due to the lack of nutrients (nitrogen and phosphorus) permitted for discharge, an added expense in addition to a very high level of treatment will be to purchase nutrient credits from an exchange bank or the Couny may be able to create their own nutrient credits through other County owned property/projects. The other option

is to request capacity from Louisa County Water Authority and their Spring Creek WWTP. This facility is capable to be expanded significantly (up to 1.5 MGD), so it is possible that some capacity could be purchased by Fluvanna County.

7.7 **Alternative Wastewater Treatment Options** – It is recommended that the County conduct an evaluation to determine the feasibility of utilizing alternative wastewater treatment and disposal systems (in the next couple of years). Since discharging large flows to a stream or river will continue to have stringent permitting requirements, alternative treatment systems should be considered to manage a portion of the service area flow. Alternative treatment systems typically still require a reasonable level of treatment, but in lieu of discharging to a stream or river, they discharge to the subsurface such as a drainfield, drip irrigation system, or injection type system.

7.8 **Water Reuse** - It is recommended that the County conduct a water reuse feasibility study in order to reduce the amount of wastewater needed for surface discharge (in the next couple of years). The water reuse study should also evaluate the potential to use gray water as a means to reduce wastewater discharge.

7.9 **Distribution System, Phase 1** - In order to provide suitable water service to the initial target area for development (Service Area 1), it is recommended that the water distribution system along Route 250 and Route 15 be constructed (see Figure 11). A water booster station will also be necessary at DOC property to pump from their existing water tank to the new system (which will be at a higher pressure). It is also recommended that a 500,000 gallon elevated storage tank be constructed, should budgeting allow. See recommendation 7.3 for a possibility to delay storage for a short period. The initial estimated project cost for this system is $5 Million.

7.10 **Storage Tank Site Locations** - There are many land parcels in Service Area 1-D suitable for an elevated tank location. It is recommended that these sites be explored by the County before further development might limit options.

7.11 **Sewer System, Phase 1** - In order to provide suitable sewer service to the initial target area for development (Service Area 1), it is recommended that a sewer force main system along Route 250 and Route 15 be constructed (see Figure 12). This represents approximately 23,000 linear feet of force main (6 inch thru 10 inch), with an initial project cost estimate of $2.0 Million. This does not include any initial pump stations or gravity sewer.

7.12 **Future Phases, Water and Sewer Systems** – once the initial water and sewer infrastructure becomes available, development interests should increase throughout the service area. As development plans and/or rezoning requests are submitted to the County, the expansion of the water and sewer systems should be considered.

7.13 **Interim Operation and Maintenance** – until the flows in the system reach a reasonable level of capacity (25% and above), it will be necessary to maintain the new infrastructure in a proactive manner to maintain water quality and sewer reliability. An Interim Operations and Maintenance Plan should be developed with during the preliminary engineering phase of the project.

7.14 Overall TMDL Plan – It is recommended that the County evaluate several alternate Total Maximum Daily Load (TMDL) options for reduction of nitrogen and phosphorus that can enter the Chesapeake Bay. Some of these options include stormwater management, agricultural management, and forest management. The TMDL Plan should be considered while developing the next update to the County Comprehensive Plan.

7.15 Develop Policy and Procedure Fee Structure – It is recommended that the policies, governance, organizational structure, and fee requirements be determined prior to construction and start-up of the new water and sewer systems. This will allow the County to advertise the cost of service to prospective customers and the development community.