

Hazen *Technical Memorandum*

September 2021

To: Rivanna Water & Sewer Authority

From: Jeremy Hise, P.E.
Aaron Duke, P.E. BCEE
Conor Brennan, P.E.
Hazen and Sawyer



Drinking Water Infrastructure Plan – Crozet Area 2021 Updated Water Demand Forecast (Supplement No. 2)

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1. Demand Forecast Update (2021)

1.1 Sources of Data for Update

Prior to updating the Crozet water demand forecasts, which were last updated in 2020, Hazen reviewed the following recent data:

- Billed Water – 2018 through April 2021 (Source: Albemarle County Service Authority, ACSA)
- Water Treatment Plant (WTP) Flows – 2018 through current (Source: RWSA)
- Water Connections – 2018 through current (Source: ACSA)
- 2019 Growth Management Report (Source: Albemarle County Community Development)
- 2021 Draft Crozet Area Master Plan (Source: Albemarle County Community Development)

The intent in reviewing this most recent data is to:

- Compare where the Demand Forecast, most recently updated in 2020, anticipated Crozet demands would be in 2021 against where they are currently.
- Review recent non-revenue percentages and determine whether the assumed non-revenue percentage, from the 2017 and 2020 Demand Forecasts, is still reasonable, or requires adjustment.
- Assess whether per capita and per employee usage rates are still accurate or require adjustment.
- Assess whether the assumed Maximum Daily Demand (MDD) to Average Daily Demand (ADD) ratio, MDD/ADD, is still reasonable or requires adjustment.
- Assess whether the previously anticipated population and employment growth curves still seem reasonable or require adjustment.
- Assess the impact to growth projections for the Crozet Service area given potential changes in zoning, land use patterns and/or buildout projections in the service area.
 - For example, it should be noted that, based on discussions with Albemarle County Community Development staff and review of the 2019 Growth Management Report, the Old Trail Village development is anticipated to be much smaller than previously anticipated. Accordingly, population forecasts and associated water demands were updated to include the prior planned growth in that development as well as a set of curves that reflected the reduction in planned units.

It is noted that the following data was not updated as a part of this effort (except for one major change as noted above for the Old Trail Village development), with the assumption being that this data has not

substantially changed since the 2017 Demand Forecast and was held constant for the recent 2020 Demand Forecast update:

- Status of any conservation or other programs that may impact demands for finished drinking water.

The updated 50-year projections presented herein have been made in 5-year increments for both average day and maximum day demands, with maximum day demands calculated using the aforementioned MDD/ADD ratio, based on the most current water production data.

1.1.1 Projection Methodology

Below is the step-by-step process by which the updated Demand Forecast was prepared.

Step 1 – Review January 2018 through April 2021 Monthly/Yearly Historical Billing Data and Production Data:

- Determine the current ADD and compare it to the demand previously projected as part of the 2020 Demand Forecast update. Assess whether growth has occurred more rapidly than anticipated.
- Determine the current non-revenue water contribution and compare against prior historical data to determine whether an update to the estimated non-revenue water contribution is warranted.
- Recommend whether an update to the MDD/ADD ratio is warranted.

Step 2 – Analyze January 2018 through April 2021 Billing Data and Assess Necessary Updates:

- Identify current per capita usage, including distribution system non-revenue water. Compare current per capita usage against prior estimates to determine whether an increase or decrease to per capita usage is warranted.
- Identify current per employee usage, including distribution system non-revenue water. Compare current per employee usage against prior estimates to determine whether an increase or decrease to per employee usage is warranted.

Note: *For the 2021 Demand Update, it was assumed that no significant change in employment projections is anticipated between the 2020 and 2021 Demand Update efforts, given the lack of significant new commercial development and associated confirmation from the Albemarle County Community Development Department, as discussed during a July 14, 2021 teleconference.*

Step 3 – Update Future Water Use Estimates:

- Update future ADD estimates
- Estimate future MDD estimates

Step 4 – Develop an Updated Growth Curve Envelope:

- Provide an updated historical growth evaluation
- Assess the potential impact of more rapid growth
- Assess the potential impact of development outside of the current service area boundary
- Assess the potential impact that increased consumer usage may have on demands
- Assess the potential impact of revised zoning in the draft Crozet Master Plan and associated increase in permitted residential building density

1.2 Updated Projections

Each step of the demand forecast update process, including the associated results, is detailed below.

1.2.1 Review of Updated Monthly/Yearly Historical Billing Data and Production Data

- Determine the current ADD and compare it to the demand previously projected as part of the 2020 Demand Forecast update

Current billing data and production data, from January 2018 through April 2021, were analyzed and the initial ADD (for the year 2020) was determined to be 0.610 mgd for these projection updates. Demands were not anticipated to reach current 2020 levels until 2023, based on the 2017 Demand Forecast. ***These findings reconfirm the observations seen in 2019 as part of the 2020 Demand Forecast update, indicating that development is occurring at a more rapid rate than originally anticipated.*** This is also supported by the rate of building permit and occupancy permit approvals issued by Albemarle County, which shows that the average approval rate of new residential dwelling units over the last 20 years is 4.2% in the Crozet Community. This falls slightly above the assumed rate of installation for approved Pipeline units for the base “planning” scenario, which will be discussed later as it relates to the updated growth curve envelopes. As will be discussed in more detail in Section 1.2.4, it is assumed that the approved Pipeline units will be completed over a 30-year period, at a rate of completion of approximately 3% per year. One of the projection scenarios utilizes the growth rate observed from the building permit data, in lieu of the growth rate from approved Pipeline units, to depict a more rapid near-term buildout of the Pipeline and the associated impact.

It is important to note this demand includes non-revenue water within the water distribution system but does not include in-plant water usage (i.e., backwash water and carrier water). This updated demand served as the starting point for the updated future growth curves presented within this Technical Memorandum.

Previously as part of the 2017 and 2020 demand projections, in-plant water usage was estimated at approximately 10% of water demand. Based on an updated review of current data (2018 through 2020), it is recommended that in-plant water usage continue to be assumed at 10% of water demand. A review of 2020 data indicated an in-plant water usage of 9%, which may fluctuate slightly based on WTP needs. The average annual in-plant usage from 2018 through 2020 is 9.3%, with the annual average high occurring in 2018 where in-plant usage was 9.5%.

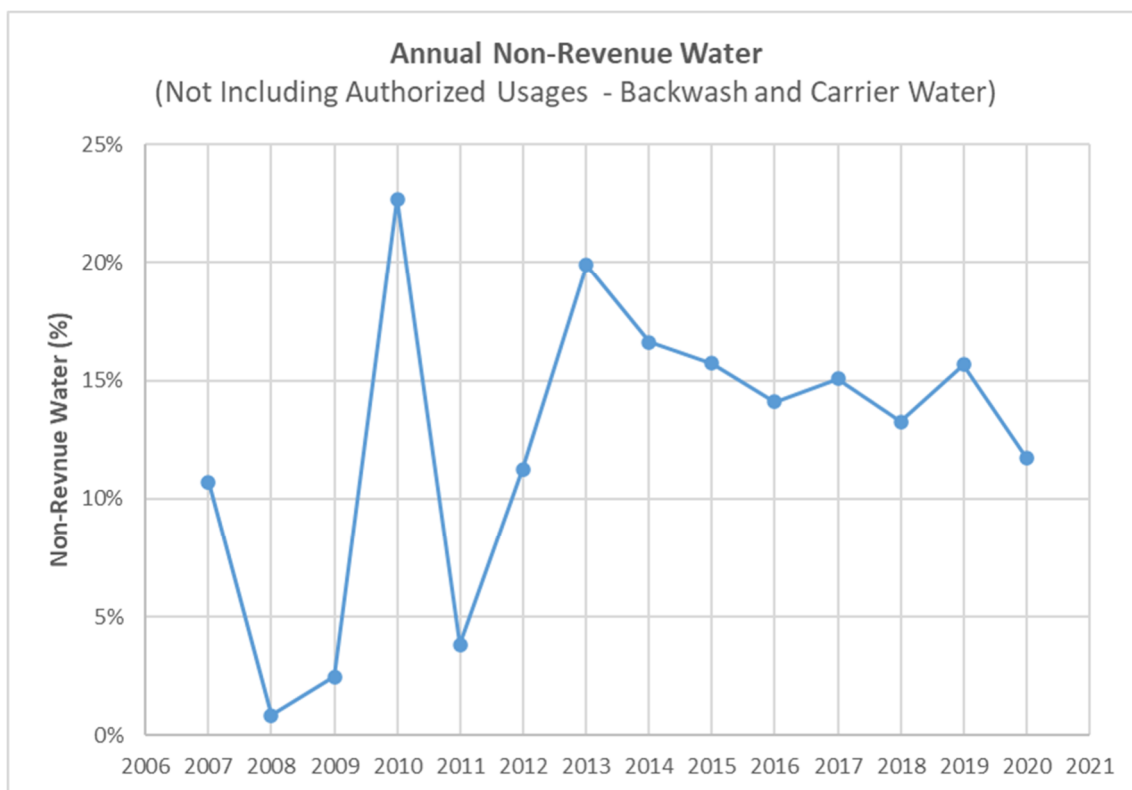
For planning purposes, it is recommended that an in-plant usage factor of 10% be added to the updated finished water demand projections to provide a conservative estimate of raw water demand.

- Determine the current non-revenue water contribution and compare against prior historical data to determine whether an update to the estimated non-revenue water contribution is warranted.

Similar to the analysis necessary to update the current ADD, updated billing data were compared to updated production data to determine whether an update to the non-revenue water percentage (%) was warranted. As part of the 2017 Demand Forecast and 2020 updates, 15% non-revenue water was recommended for future demands as non-revenue water has fluctuated over time (Figure 1, which was updated to include 2020 data). Based on an updated review of the most current data, it is recommended that non-revenue water continue to be assumed at 15% of water demand. Although current data from 2020 shows a decrease in non-revenue water from 16% in 2019 to 12% in 2020, the data set shows that non-revenue water has fluctuated between 12% and 16% over the past 6 years. The recommended 15% value continues to provide a degree of conservatism in the projections without being overly conservative.

It is important to note that for demand projection purposes, non-revenue water % is not directly used in a calculation, rather it is used to assist in determining unit demands (described below). The unit demands used for future demand projections include a component for non-revenue water.

Figure 1: Non-Revenue Water Since 2007

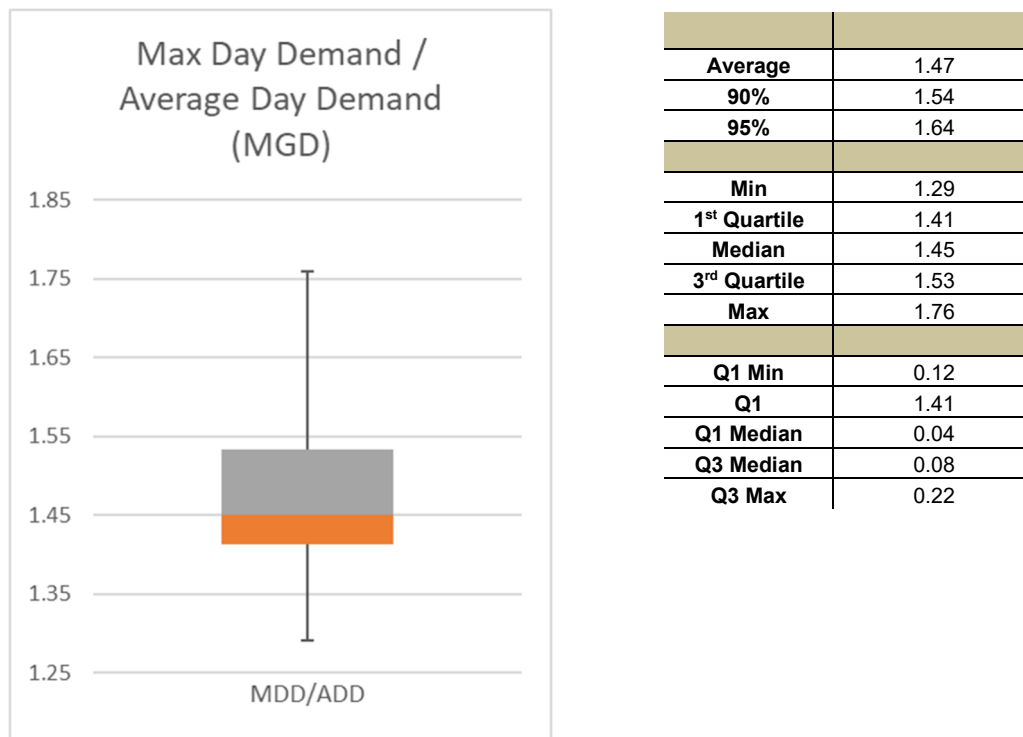


- Recommend whether an update to the MDD/ADD ratio is warranted.

Updated historical production data, as well as updated billing data, were used to perform an updated statistical analysis with the intent to determine whether a change to the MDD/ADD ratio was warranted. The analysis assessed water that was consumed by customers within the distribution system as well as non-revenue water that is supplied to the distribution system but not consumed by customers. This analysis excluded in-plant water usage (i.e., backwash water and carrier water) but did take into consideration SCADA data to assess the impact that storage has on water production.

As part of the 2017 Demand Forecast and 2020 updates, a 1.68 MDD/ADD ratio was recommended. This prior recommendation considered drought preparedness balanced with operational changes to be implemented in the future to reduce the variation in daily demands and help to mitigate higher MDD/ADD ratios from occurring. Based on a review of current data, it is recommended that the MDD/ADD ratio of 1.68 continue to be assumed for future maximum daily demands. Similar to the 2020 Demand Forecast, this ratio represents an approximate 95% confidence level over the past ten years (Figure 2). For reference purposes, the average MDD/ADD ratio is 1.47 (was 1.47 as of the 2017 Demand Forecast and 1.48 per the 2020 updates) since 2006, with the maximum being 1.76 for that same time period. MDD/ADD ratios from 2018 through 2020 ranged from 1.41 to 1.54; 2021 data was not used, as the data is only through April 2021.

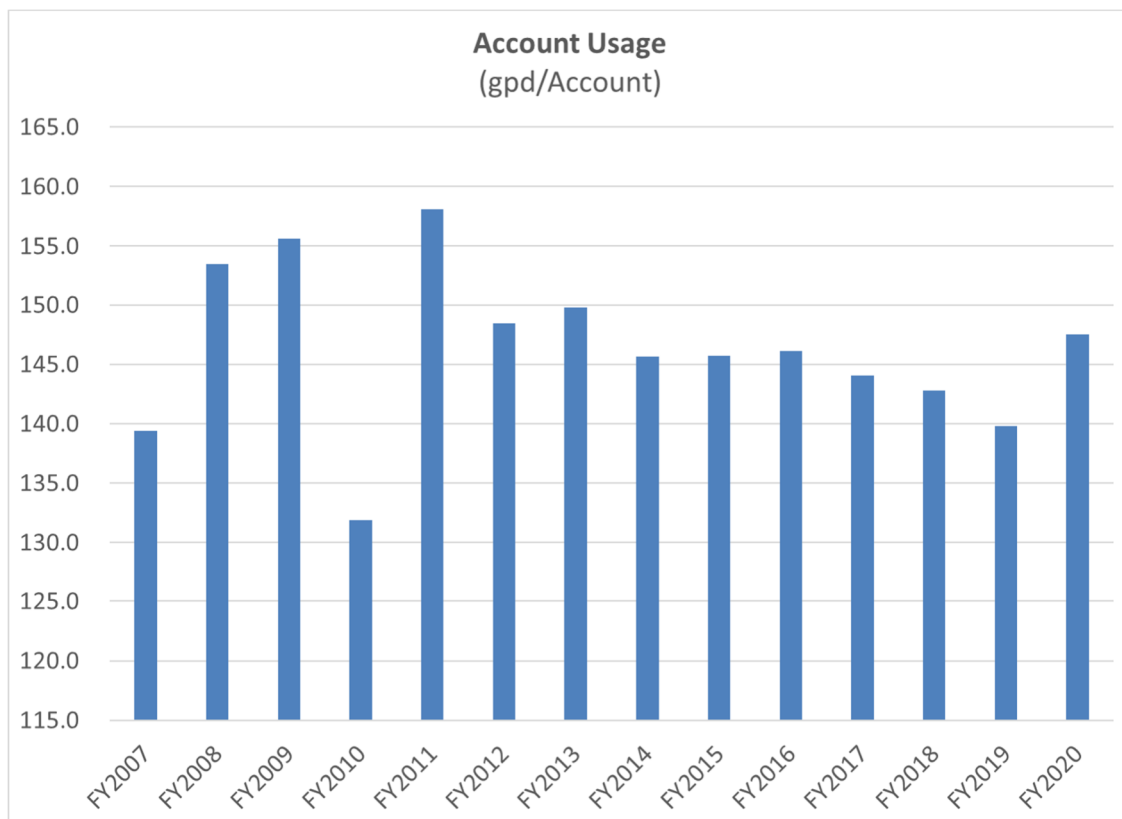
Figure 2: MDD/ADD Statistical Analysis (2006 to Current)



1.2.2 Analyze Most Recent Billing Data and Assess Necessary Updates

Updated billing data, spanning January 2019 through April 2021 from the Albemarle County Service Authority (ACSA) were analyzed in relation to billing account type to assess whether unit water demands have changed since the 2017 Demand Forecast and 2020 updates. The unit water demand considered herein is a blended unit water demand for both residential and employment uses. As can be seen in Figure 3, unit water demands had been slightly decreasing from 2016 to 2019, after experiencing a slight increase from 2014 to 2016. A measurable increase is observed from 2019 to 2020 usage where account usage increased from around 140 gallons per day (gpd) per account to 147 gpd/account. The notable increase in account usage in 2020 is likely attributed to stay at home orders as a result of the COVID-19 pandemic. As was the case in 2017 and 2020, variability in this blended unit water demand still exists.

Figure 3: Crozet System Wide Unit Water Demand (Includes Non-Revenue Water)



The updated billing data were analyzed using Microsoft Excel to identify whether unit water demands for various demand sectors have changed significantly since the 2017 and 2020 demand studies. For reference purposes, in 2017, recommended unit water demands were 65 gallons per capita per day (gpcd) for new single family residential customers, 55 gpcd for new multi-family residential customers, and 65 gallons per employee per day (gped) for new employees (note: these unit water demands included distribution non-revenue water). The 2020 Demand Forecast updates had confirmed that the 2017 unit water demands were appropriate for future demands. Similarly, a review of January 2018 through April 2021 billing data confirms that unit water demands of 65 gpcd for new single family residential customers, 55 gpcd for new

multi-family residential customers, and 65 gallons per employee per day (gped) for new employees are still appropriate for future demands.

Based on the updated analysis completed, as presented in Figure 4 and Figure 5, there has not been much change in the account class type distribution since the 2017 Demand Forecast and 2020 updates (approx. 80% residential and approx. 20% non-residential). Residential usage has stayed relatively consistent from 2019 through 2020, with a slight reduction in 2020. Employment (non-residential) unit usage has decreased steadily from 2016 to 2019, however an increase occurred in 2020. The increase in 2020 usage aligns with historical usage seen in 2017 and 2018. It is still anticipated that this usage type will have more variability than residential usage as it is highly dependent upon the type of employment (i.e., institutional (schools), industrial, commercial businesses, etc.). It is good practice to provide a bit more conservatism in employment usage estimates to ensure enough capacity is provided. As more billing data is gathered, future consideration can be given to adjusting unit water demands, if warranted.

Figure 4: Blended Residential Per Capital Water Demand by Fiscal Year

Values based on residential population and residential usage (from billing records) and include 15% distribution system non-revenue water

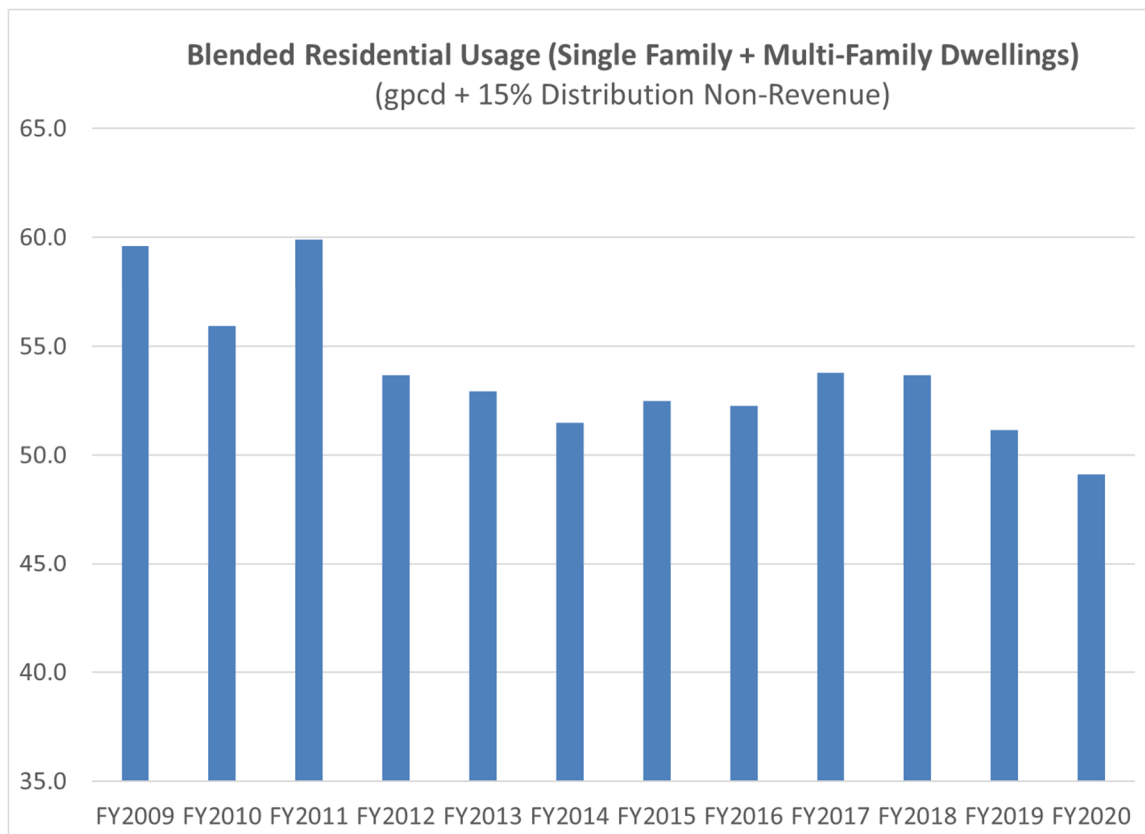
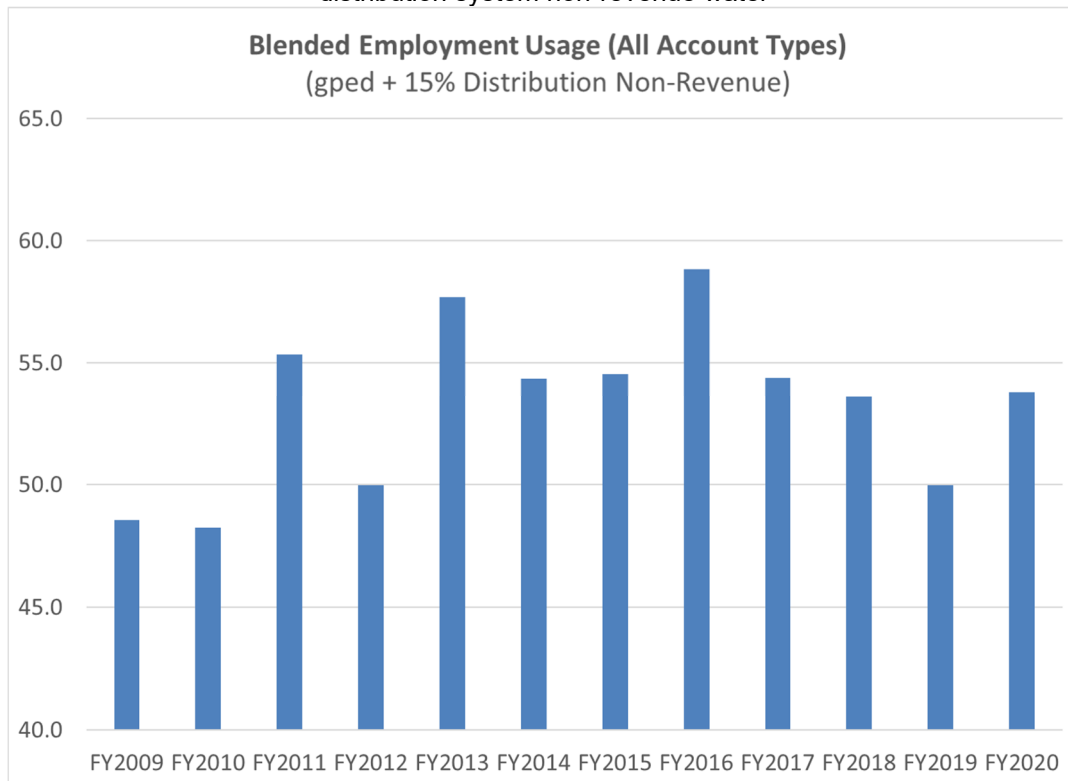


Figure 5: Blended Employment Per Employee Water Demand by Fiscal Year

Values based on employment population and employment usage (from billing records) and include 15% distribution system non-revenue water



1.2.3 Updated Future Water Use Estimates

To update future water use estimates, baseline residential and employment populations needed to be estimated. For this Demand Forecast Update, growth projections for the Crozet Service Area, including changes in zoning, land use patterns and/or buildout projections in the service area, were used as alternative growth projection scenarios that will be detailed in Section 1.2.4 below. For the 2020 Demand Forecast update, the population served (both employees and residential customers) in 2019 was estimated at 9,228 (7,306 residential and 1,922 employment), which when compared to the 2019 projected service population of 8,986 from the 2017 Demand Forecast indicated that population growth is occurring faster than that previously predicted. This observation is also supported by the growth in ADD seen within the Crozet Service Area. **The estimated residential population to be served in 2020 was determined to be 7,562 and the employment population estimated to be served was 1,951, for a total population served in 2020 of 9,513. The estimated 2020 residential and employment populations served that were determined during the 2020 Demand Forecast update were used for this effort given significant changes in residential populations were unlikely to have occurred in the last 12 months.**

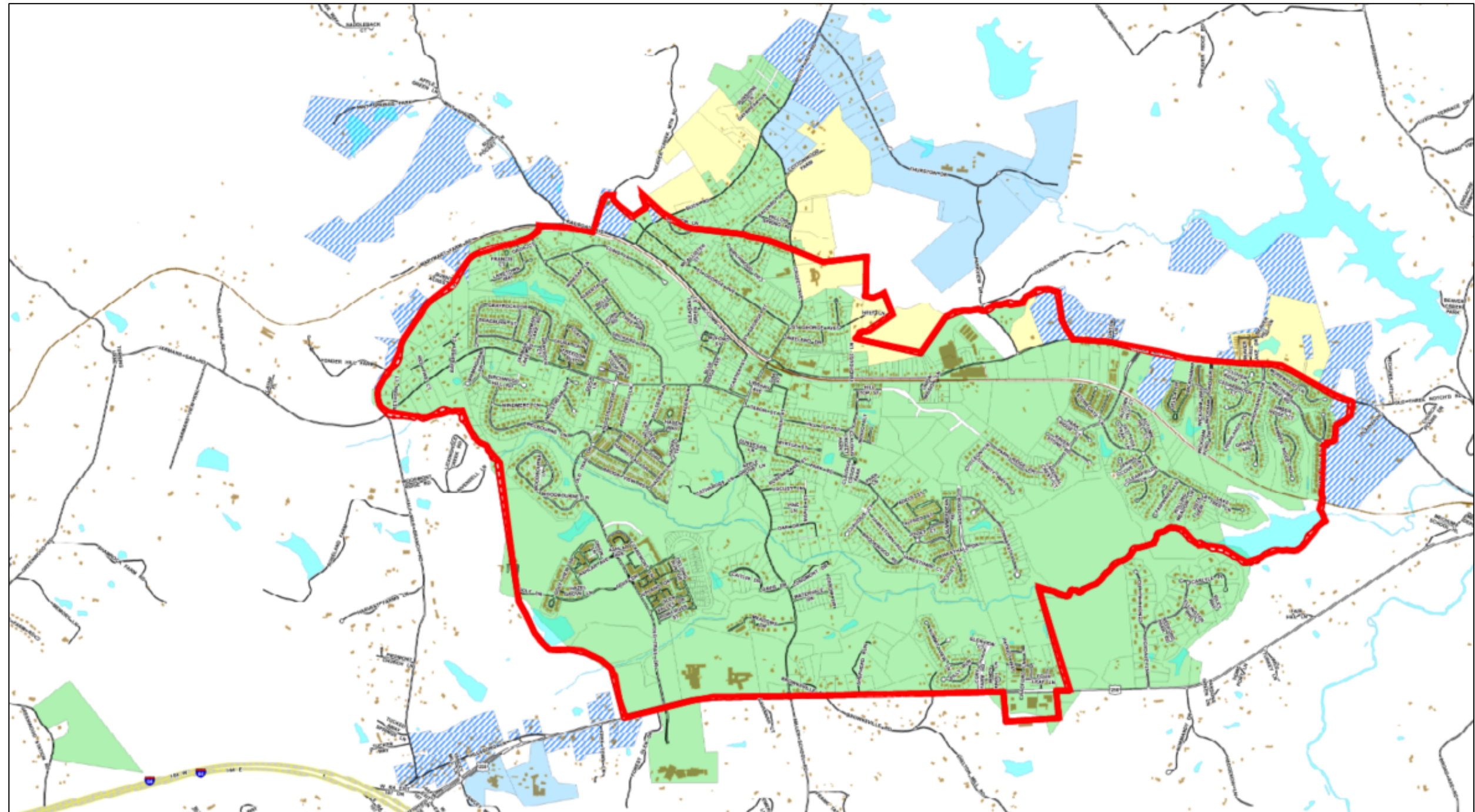
For reference purposes, it is important to note that based on a March 2020 Customer Class Report, as prepared by ACSA and provided as part of the 2020 Demand Forecast efforts, the Crozet Service Area included 4,170 water connections, estimated to equal a residential population of 10,015 (population is the

total Single-Family and Multi-Family units using an occupancy of 2.5). By comparison, the residential population estimated to be served in 2020 in this evaluation is 7,562 and the employment population estimated to be served in 2020 in this evaluation is 1,951, for a total population served in 2020 of 9,513. The total population served (9,513) is close to the residential population noted in the ACSA Customer Class Report. Additionally, in comparing the estimated 2020 population to the 2017 Demand Forecast Projections, the 2017 study estimated the 2020 population to be 9,188 (7,378 residential and 1,810 employment). The estimated population values as defined by both the ACSA Customer Class Report and the 2017 Demand Forecasts both fall within 5% of the 2020 estimated population used for this analysis (9,513). The estimated population to be served in 2021 is estimated to be 9,708 (7,757 residential and 1,951 employment). For purposes of this evaluation and to provide a conservative approach to predicting possible water demands, it is suggested to proceed with assuming a total population served of 9,513 in 2020 (7,562 residential and 1,951 employment). This will help to ensure that infrastructure is not undersized for future needs.

For reference purposes, as part of the 2017 Demand Forecast, Hazen utilized available land and current land use Geographic Information System (GIS) data from the Albemarle County Office of Geographic Data Services (GDS) to assess the location of future developments and estimate a build out forecast for the service area (including growth outside the Development Area). Based on that analysis it was estimated that residential growth will far outweigh non-residential growth over the 50-year planning horizon, with limited non-residential growth projected to occur until after 2025. Population and employee projections were made assuming 2.54 people per residential dwelling unit (RDU), as discussed with the Community Development Department.

As part of the 2021 Demand Forecast updates, a review of current and future zoning designations was performed for the service area. Currently, the majority of the Crozet service area is zoned for residential development, and much of the land is already being developed or built out per the 2021 Draft Crozet Area Master Plan document. The Crozet Growth Area and ACSA Jurisdictional Area can be found below shown in Figure 6. The red boundary line represents the Crozet Growth Area. The colored parcels designate differing service levels across the growth area and jurisdictional area. The current Crozet Existing Conditions and Zoning map can be found below for reference as Figure 7. The Future Land Use Plan has been updated as part of an effort to bring consistency to former Land Use Plan documentation and any long-term community vision and/or approved developments. The updated 2021 Future Land Use Plan map can be found below for reference as Figure 8.

Figure 6: Crozet Growth Area and ACSA Jurisdictional Area



1. Yellow represents Limited Service parcels.
2. Blue represents Water Only parcels.
3. White and blue hatched represents Water Only to Existing Structures parcels.
4. Green represents Water and Sewer parcels.

Figure 7: Crozet Existing Conditions and Zoning Map – Current Zoning Designations

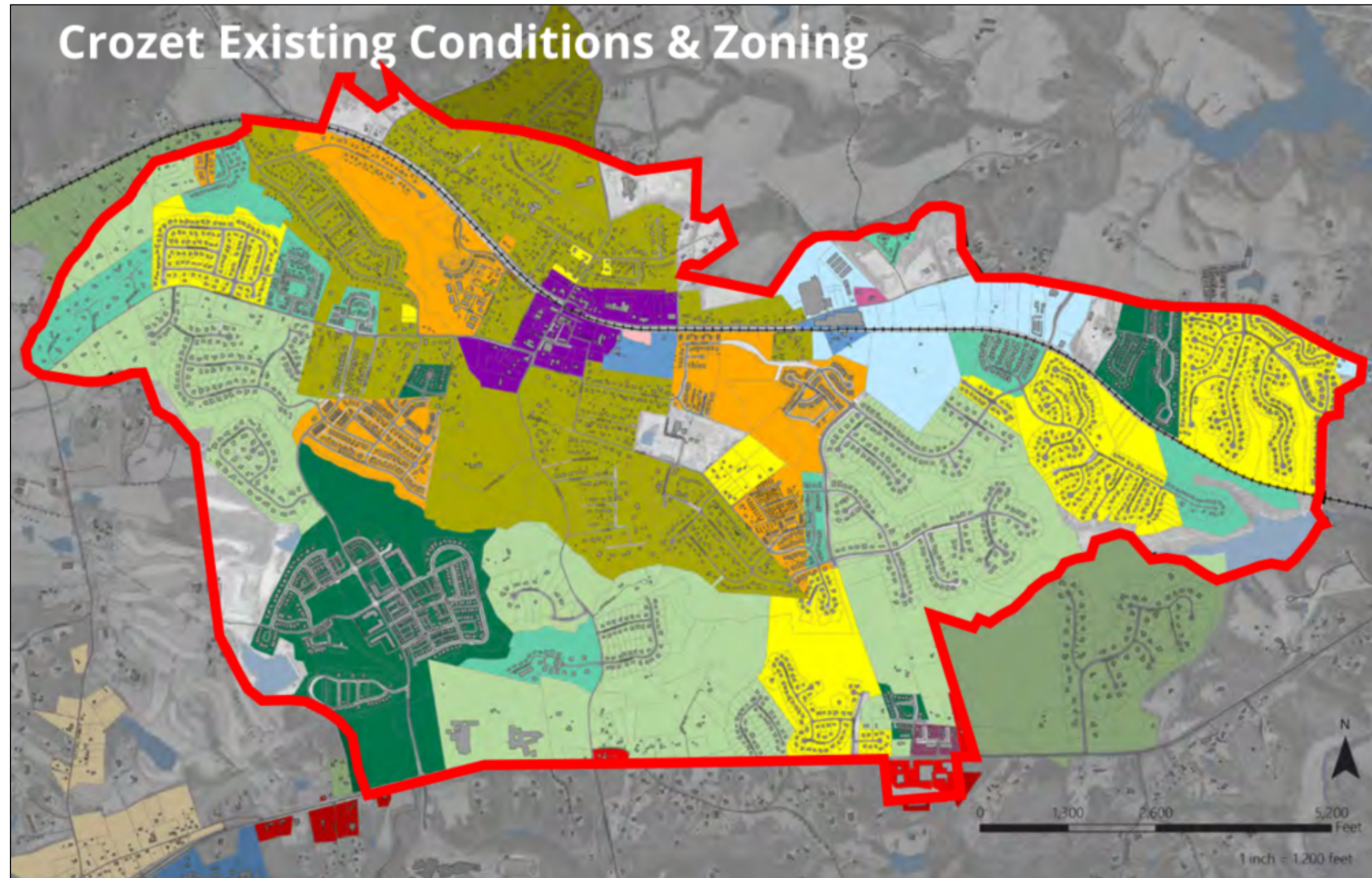
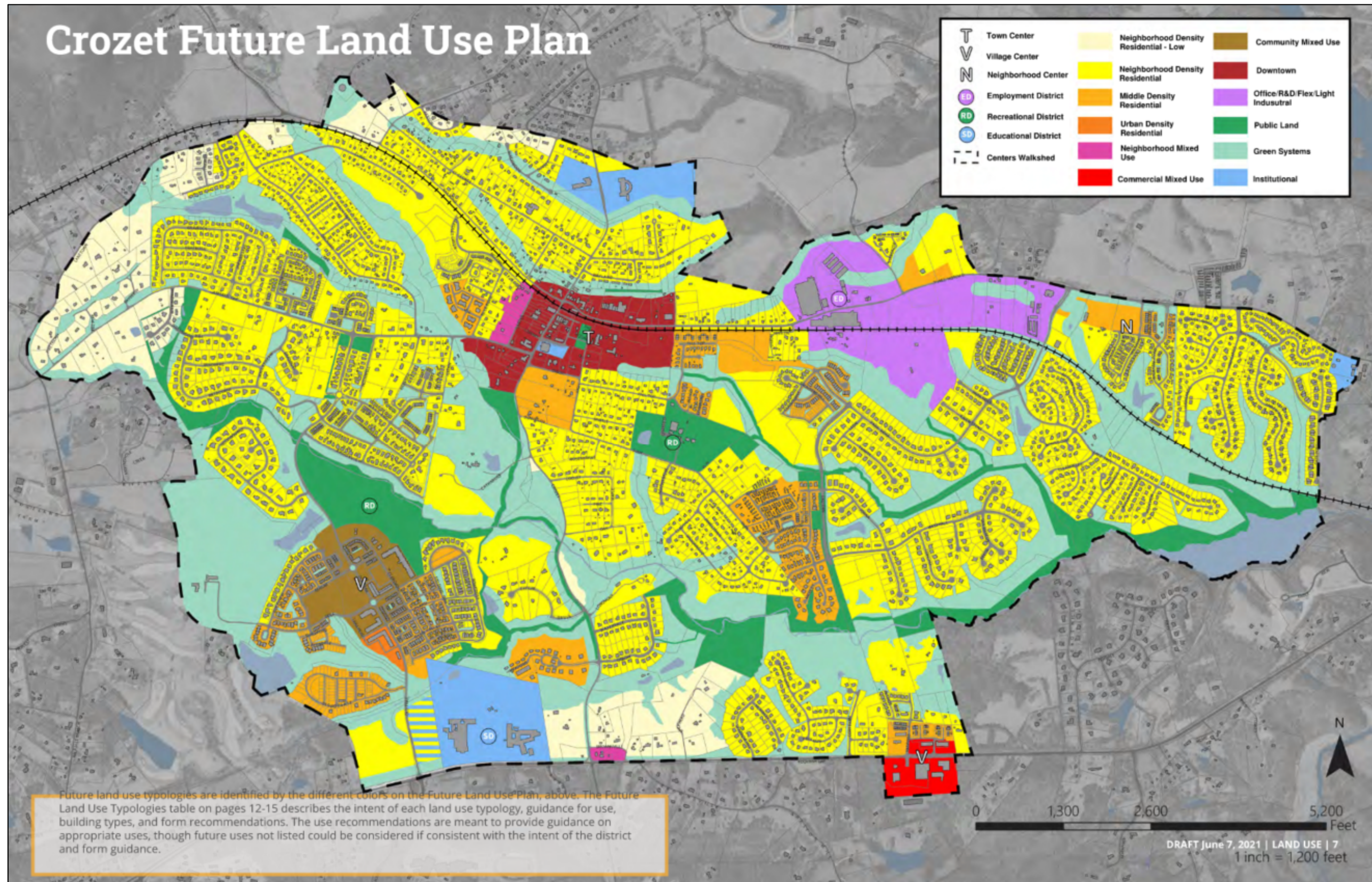


Figure 8: Crozet Future Land Use Plan – 2021 Updated Land Use Designations



These two land use maps were compared to each other using georeferencing tools, coupled with County land use shapefiles, to investigate the changes in land use designation in the service area. Parcel delineations were available for the current land use maps, enabling Hazen GIS analysts to compare the land use designations and quantify the estimated changes in land use area. Some of the residential type land use designations saw a reduction in total zoning area across the service area, from the current to the future map. This can be attributed to map accuracy updates or anticipated re-zoning changes. Other residential type land use designations saw an increase in total zoning for the same reasons. Overall, it was determined that an additional 30 acres of total residential land use (all residential zoning types) is expected across the service area per the updated Crozet Future Land Use Plan map.

To estimate the impact the change in area might have, it was assumed that the residential density of this change in area would be 18 RDUs per acre. This value represents the residential density assigned to the Neighborhood Mixed Use future land use typology per the 2021 Draft Crozet Area Master Plan document. The density value also falls within the range provided for the Urban Density future land use typology, also provided in the draft Master Plan, which defines the upper and lower density bounds as 12 to 34 units per acre. Using these data, it is estimated that the updates to the Land Use Plan maps due to long-term planning decisions and future development might add an additional 540 RDUs that are not accounted for in approved Pipeline or future Buildout unit counts. The use of this data will be detailed further in Section 1.2.4.1, as it will be used as an alternative scenario modifier as part of the Updated Growth Curve Envelope discussion.

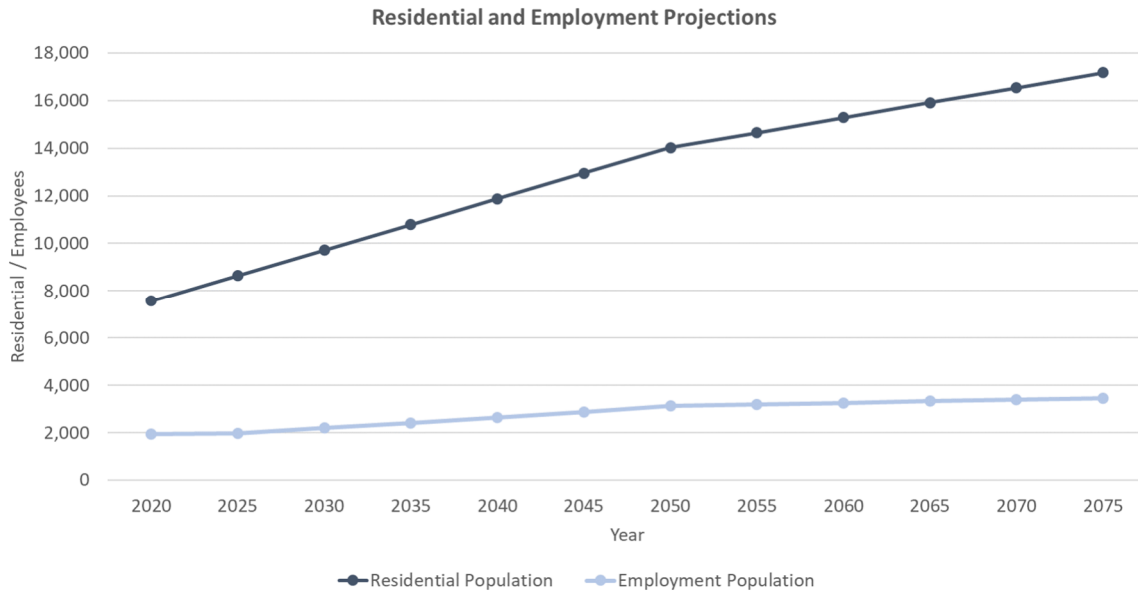
1.2.3.1 *Estimated Population and Employment Growth*

As was the case in the 2017 Demand Forecast and 2020 updates, growth in population and employees was assumed to be linear between the following planning horizons. Next to each planning horizon is the portion of the Crozet Service Area that is assumed to develop within that timeframe.

- **2020 to 2050** – Approved units in the “Pipeline” per the Albemarle County 2019 Growth Management Report.
 - Pipeline units, per the 2019 GMR, include RDUs approved by:
 - Special Use Permit/Zoning Map Amendments (Since 2001)
 - Site Plan / Subdivision Plat (By-Right).
 - Unless otherwise stated for the water projection scenarios, the number of approved RDUs in the Pipeline includes full buildout of the planned Old Trail Village community (2,200 approved units).
- **2050 to 2075** – Utilization of vacant and infill lots creating anticipated future “Buildout” scenario for the service area.
 - Low and High Buildout scenarios for vacant and infill lots are detailed in the 2019 GMR.
 - The High Buildout scenario for vacant and infill lots from the County’s Comprehensive Plan were used for Buildout.
 - The service area is assumed to reach buildout capacity in 2075.

Figure 9 depicts the residential and employment projection for the 2021 Demand Forecast updates.

Figure 9: Residential and Employment Projections



1.2.3.2 Update Demand Forecasts

Unit water demands identified in Section 1.2.2 were multiplied by the changes in population described above and then added to current 2020 demands (0.610 mgd) to project annual average water demands in future planning years. The results of this analysis are shown below in Table 1 and represent the updated future ADD.

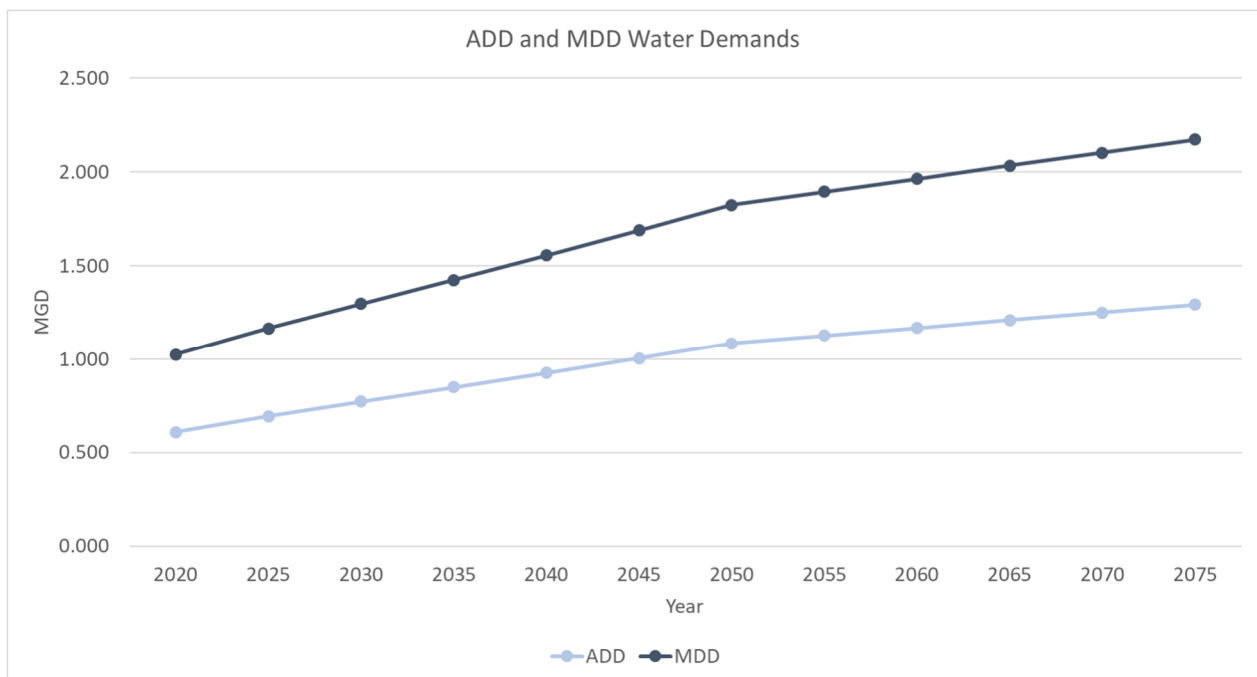
The updated ADD at each future planning year was then multiplied by the MDD/ADD ratio identified in Section 1.2.1 to project maximum daily water demands in future planning years. The results of this analysis are also shown below in Table 1 and represent the updated MDD. Figure 10 shows both the ADD and MDD growth in 5-year increments through the year 2075.

Table 1: ADD and MDD (in mgd) Water Demand Projections⁴ Through 2075

Year	Residential Population Projection	Additional Residential Flow (mgd) ¹	Employment Population Projection	Additional Employment Flow (mgd) ¹	Total ADD Demand (mgd) ²	Total MDD Demand (mgd) ^{2, 3}
2020	7,562	0.017	1,951	0.002	0.610	1.025
2025	8,539	0.066	1,980	0.004	0.694	1.166
2030	9,516	0.120	2,200	0.018	0.772	1.296
2035	10,493	0.180	2,403	0.031	0.848	1.425
2040	11,470	0.246	2,624	0.046	0.926	1.556
2045	12,447	0.318	2,866	0.061	1.006	1.689
2050	13,424	0.398	3,130	0.079	1.086	1.825
2055	13,995	0.432	3,194	0.083	1.127	1.894
2060	14,566	0.468	3,259	0.087	1.169	1.964
2065	15,137	0.505	3,325	0.091	1.210	2.033
2070	15,708	0.543	3,392	0.096	1.252	2.103
2075	16,279	0.583	3,461	0.100	1.293	2.173

1. Determined using unit demand of 65 gpccd.
2. Does not include 10% in-plant water use.
3. Determined using an MDD/ADD ratio of 1.68.
4. Represents data from the “planning” forecast scenario.

Figure 10: Projected Water Demands (ADD and MDD)¹ – through 2075



1. Represents data from the “planning” forecast scenario.

1.2.4 Updated Growth Curve Envelope

In addition to the updated “planning” growth curve developed in Section 1.2.3, various alternative growth projection scenarios were considered to develop an updated growth curve envelope. As was the case during the 2017 Demand Forecast and 2020 updates, the following assumptions were carried forward as a part of this Demand Forecast Update:

- Unit water demands (gpcd and gped) would not decrease over time – if unit demands were anticipated to decline over time, projected demands would be lower than those presented herein. The residential unit water demands within the Crozet Service Area continue to be in line with other systems in Virginia that have similar infrastructure age and home size and represent the water efficiency of new construction.
- Non-revenue water % will remain constant over time. The Crozet Service Area has a relatively low non-revenue water % when compared to similarly sized systems. Some of this may be attributed to the relative age of Crozet’s infrastructure (newer system).
- Non-revenue water is distributed throughout the Crozet service area based on demand.

1.2.4.1 Updated Growth Projection Curves

The following growth projection scenarios were considered, which include the same scenarios used for the 2017 Demand Forecast and 2020 updates, as well as various new scenarios. As shown in Figure 11 and Figure 12, some of these alternative growth curves fall above and some fall below the baseline “planning” growth curve from Section 1.2.3 (Scenario A – ADD and Scenario A – MDD on the figures). Collectively they represent a range of plausible future water demands that could occur over the next 54 years (through 2075). As was the case in 2017 and in 2020, the recommended growth curve should balance water industry trends, current Crozet billing data, and a level of conservatism that addresses the importance to a water system in meeting its obligation to provide drinking water to its customers. The range of growth curves also balance changes in allowable zoning contemplated in the draft Crozet Master Plan and realistic planned development for pipeline projects (e.g., the known reduction in planned Old Trail Village units). The additional growth projection scenarios used in preparing the growth curve envelope for ADD and MDD are detailed below:

- **Scenario A – Planning** (from Section 1.2.3) – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 through 2050.
 - Buildout units (1,124) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - Total Number of New Units: 3,432 RDUs

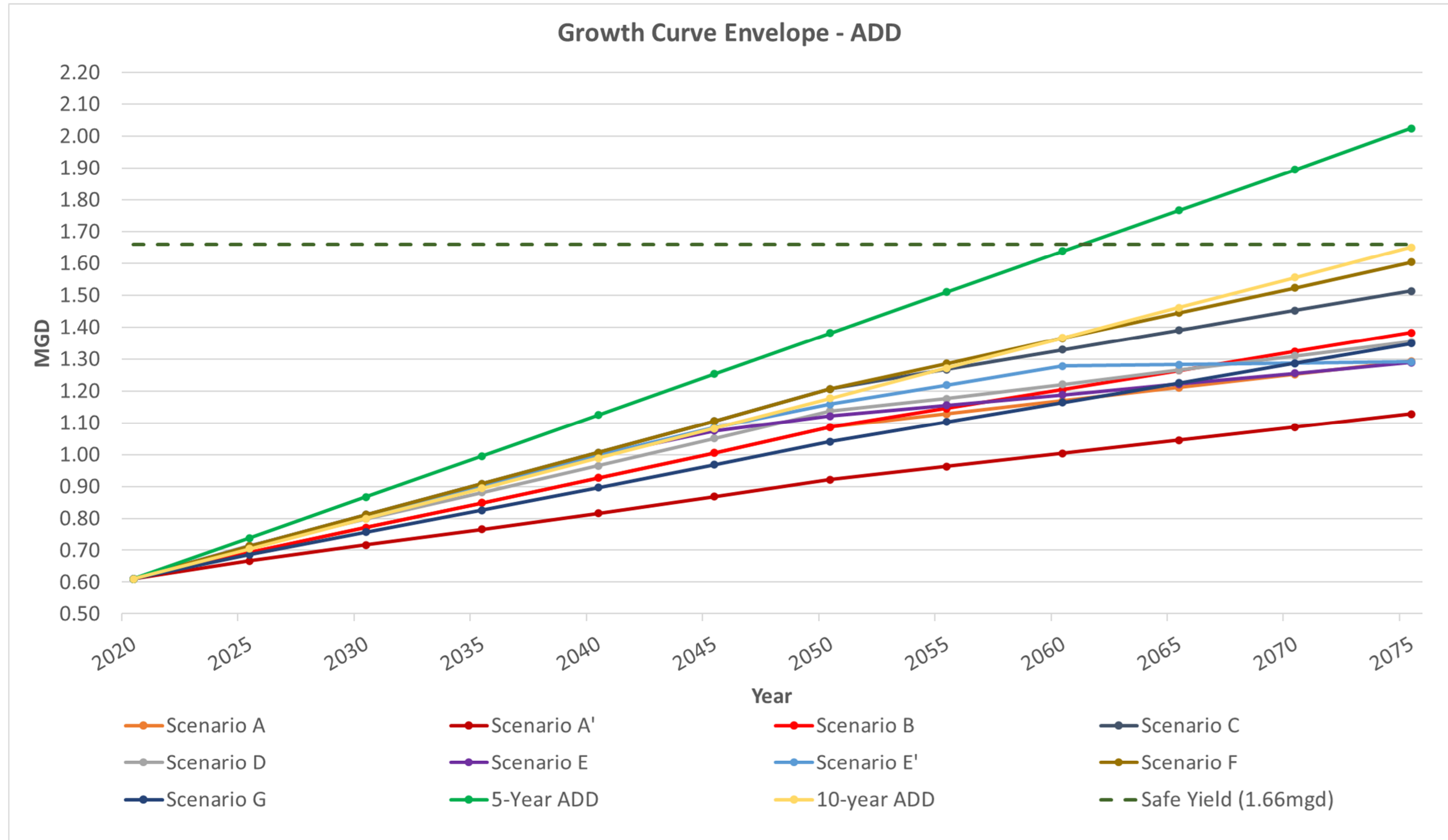
- **Scenario A'** – Planning Low – represents growth projections driven by:
 - Approved Pipeline units (1,308) being built starting in 2020 and completed by 2050. This represents a scenario when only 1,200 of the approved Old Trail Village units are constructed (2,200 approved).
 - Buildout units (1,124) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - Total Number of New Units: 2,432 RDUs
- **Scenario B** – Planning at Increased Density – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 through 2050.
 - Buildout units (1,666) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes. Additionally, this number represents a scenario where an additional 542 buildout units are included along with the 1,124 units following a GIS investigation where current and future land use maps were compared and the maximum permitted density in the draft Crozet Master Plan is applied (e.g., 18 RDUs per acre assuming 30 acres of additional residential land use).
 - Total Number of New Units: 3,974 RDUs
- **Scenario C** – Planning with Growth Outside of the Service Area – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 through 2050.
 - Buildout units (1,124) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - An additional 0.2 mgd is included accounting for development outside of the current Crozet Development Area within water parcels only, remaining consistent with projections provided as part of the 2020 Demand Forecast update.
 - Total Number of New Units: 3,432 RDUs

- **Scenario D** – Planning at Increased Unit Water Demand – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 through 2050.
 - Buildout units (1,124) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - The baseline unit water demand for residential and employment usage is increased from 65 gpcd to 70 gpcd.
 - Total Number of New Units: 3,432 RDUs
- **Scenario E** – Planning at Increased Pipeline Rate – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 and completed by 2043. Pipeline units are installed at an increased rate, based on historical Building Permit rates, achieving Pipeline buildout sooner than 2050.
 - Buildout units (1,124) being built starting in 2043 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - Total Number of New Units: 3,432 RDUs
- **Scenario E'** – Planning at Increased Pipeline Rate and 2060 Buildout – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 and completed by 2043. Pipeline units are installed at an increased rate, based on historical Building Permit rates, achieving Pipeline buildout sooner than 2050.
 - Buildout units (1,124) being built starting in 2043 and completed by 2060. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - Total Number of New Units: 3,432 RDUs

- **Scenario F** – Planning at Increased Density with Growth Outside of the Service Area – represents growth projections driven by:
 - Approved Pipeline units (2,308) being built from 2020 through 2050.
 - Buildout units (1,666) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes. Additionally, this number represents a scenario where an additional 542 buildout units are included along with the 1,124 units following a GIS investigation where current and future land use maps were compared and the maximum permitted density in the draft Crozet Master Plan is applied (e.g., 18 RDUs per acre assuming 30 acres of additional residential land use).
 - An additional 0.2 mgd is accounted for development outside of the current Crozet Service Area within water parcels only.
 - Total Number of New Units: 3,974 RDUs
- **Scenario G** – Planning Low with Growth Outside of the Service Area – represents growth projections driven by:
 - Approved Pipeline units (1,308) being built starting in 2020 and completed by 2050. This represents a scenario when only 1,200 of the approved Old Trail Village units are constructed (2,200 approved).
 - Buildout units (1,124) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes.
 - An additional 0.2 mgd is accounted for development outside of the current Crozet Service Area within water parcels only.
 - Total Number of New Units: 2,432 RDUs

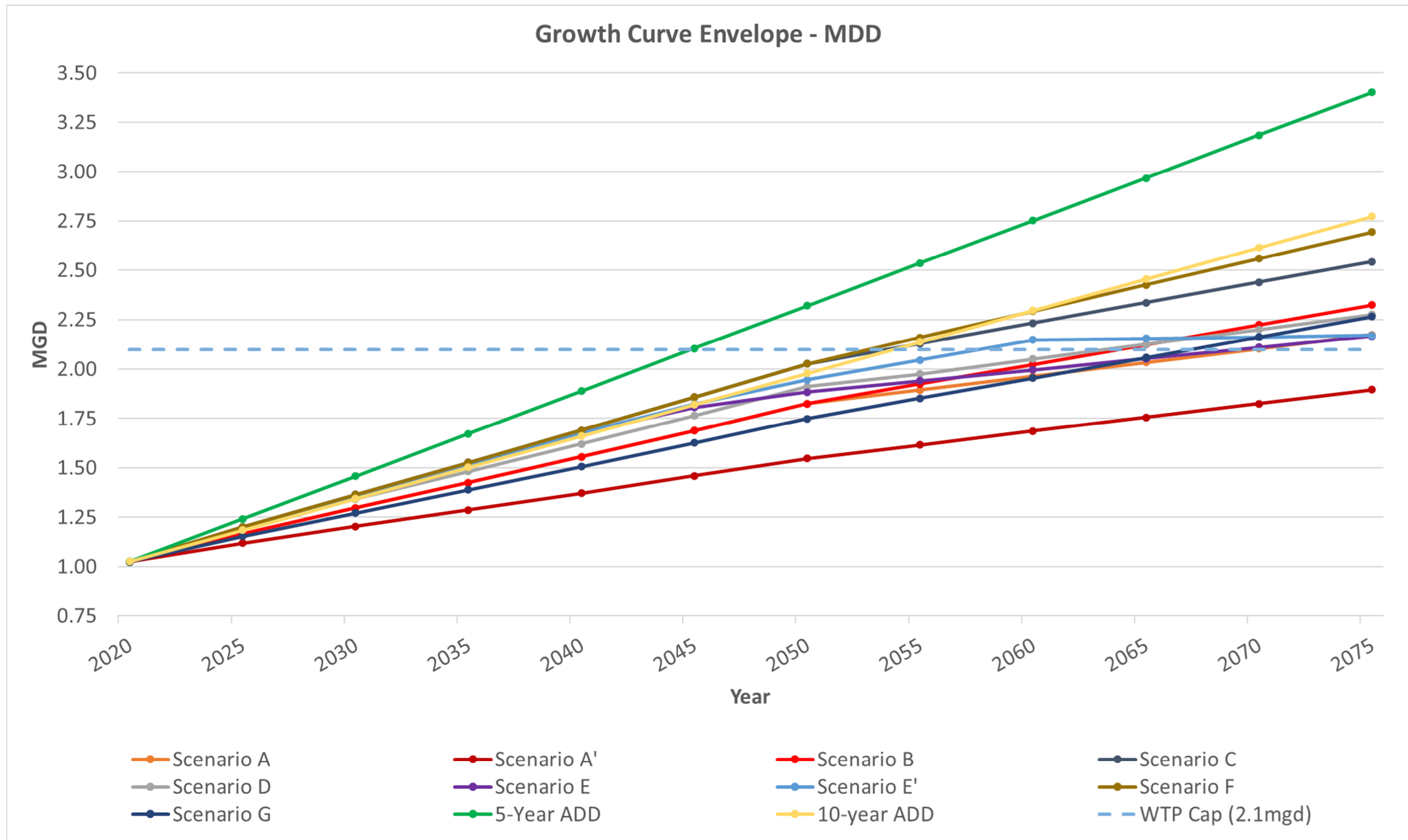
- **Scenario H** – Planning Low at Increased Density with Growth Outside of the Service Area – represents growth projections driven by:
 - Approved Pipeline units (1,308) being built starting in 2020 and completed by 2050. This represents a scenario when only 1,200 of the approved Old Trail Village units are constructed (2,200 approved).
 - Buildout units (1,666) being built starting in 2050 and completed by 2075. This number represents 602 vacant units from the High Buildout scenario of the 2019 GMP and 522 infill units from the High Units Estimate of the Master Plan representing future land use changes. Additionally, this number represents a scenario where an additional 542 buildout units are included along with the 1,124 units following a GIS investigation where current and future land use maps were compared and the maximum permitted density in the draft Crozet Master Plan is applied (e.g., 18 RDUs per acre assuming 30 acres of additional residential land use).
 - An additional 0.2 mgd is accounted for development outside of the current Crozet Service Area within water parcels only.
 - Total Number of New Units: 2,974 RDUs
- **Historical Usage** – 5-year and 10-year linear regression (Updated with data from January 2018 through April 2021)

Figure 11: Projected ADD Growth Envelope (2.54 residents/RDU)



1. The dashed horizontal line presents the Safe Yield of Beaver Creek Dam (1.66 mgd) per the 2019 DWIP report.

Figure 12: Projected MDD Growth Envelope (2.54 residents/RDU)



1. The dashed horizontal line presents the WTP capacity (2.1 mgd) per the 2019 DWIP report.

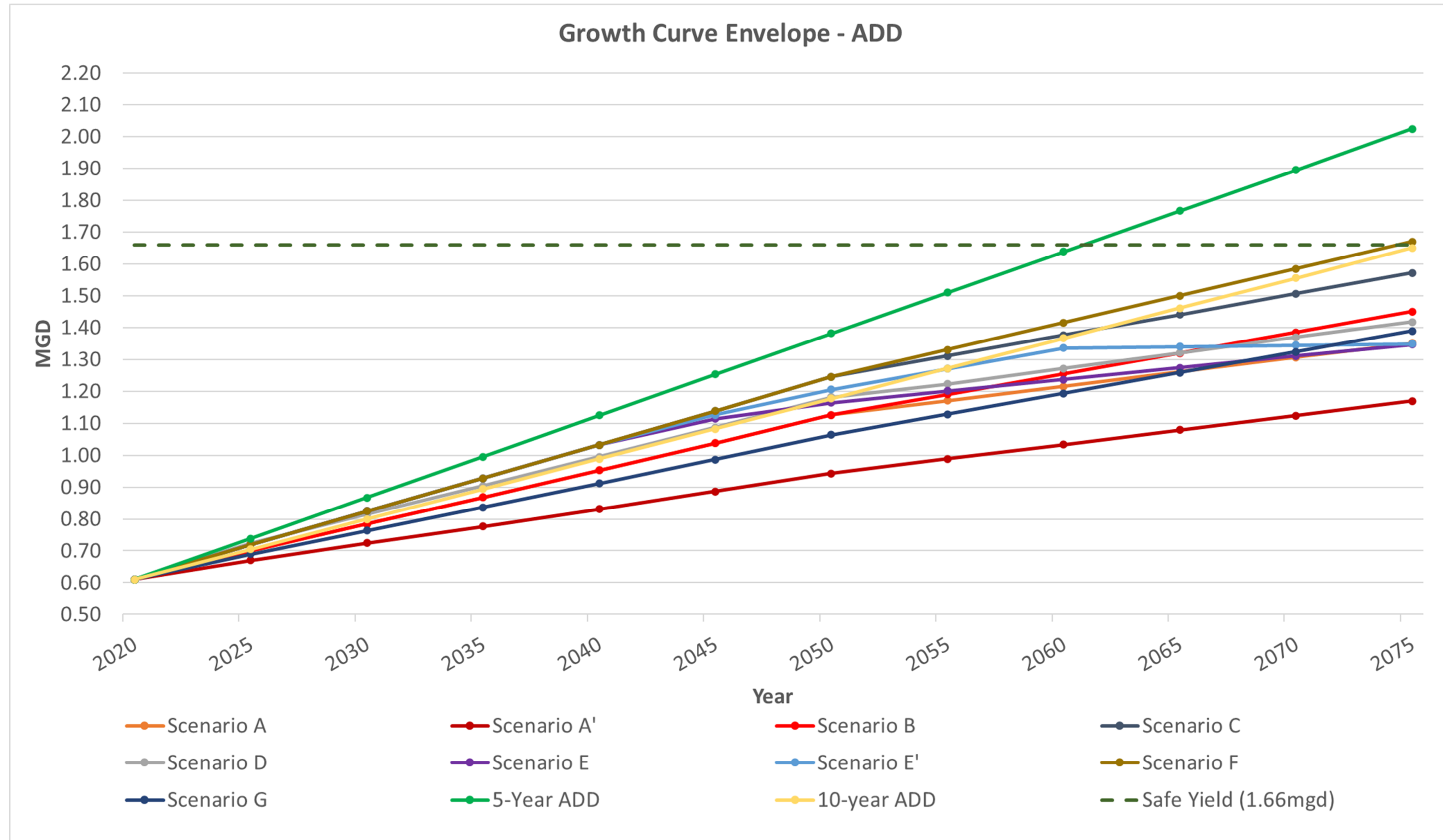
Given the range of projections, for planning purposes it was recommended that the buildout ADD (in 2075) would be 1.51 mgd and the MDD would be 2.54 mgd (compared to 1.5 mgd and 2.5 mgd from the 2017 Demand Forecast, which represents a slight increase in demand projections). This buildout 2075 ADD represents growth outside of the current Crozet Service Area within water only parcels (Scenario C). Scenario C was selected because it offers a balance of conservatism. As can be seen in the figures above, there is a potential that lower growth might occur given the range of scenarios investigated. This is largely driven by the number of units assumed as part of the approved Pipeline projects. Scenario C carries the assumption that all of Old Trail Village will be built out, but does not project as high as Scenario F. However, the inclusion of full Old Trail buildout, knowing that this may not occur, offers a conservative justification to use Scenario C for planning purposes.

When in-plant water use is considered (i.e., adding in an additional 10% of production on top of the projected values), the required water withdrawal from Beaver Creek Reservoir and the required water treatment capacity at the Crozet WTP under average and maximum conditions would be 1.66 and 2.80 mgd, respectively (compared to 1.65 mgd and 2.75 mgd from the 2017 Demand Forecast), which represents a slight increase in demand projections. The 2075 ADD (Scenario C), accounting for 10% in-plant use, falls directly on the safe yield (with a 60-day reserve storage) of Beaver Creek Reservoir as defined in the 2019 Drinking Water Infrastructure Plan (DWIP).

Focusing on the MDD growth curves presented in Figure 12, if the existing water treatment plant (WTP) capacity of 2.1 mgd is compared to the projected MDD for Scenario C, the system will hit 80% of the WTP capacity (1.68 mgd) in the year 2041, which occurs slightly later than the 2020 updated projections, but will be discussed below. This represents the point at which VDH would require initiation of capacity upgrade planning. The treatment capacity required at buildout is estimated to be 2.80 mgd. The 2.80 mgd treatment rate is based on the maximum day demand projection in the year 2075 (2.54 mgd), with an additional 10% for in-plant use.

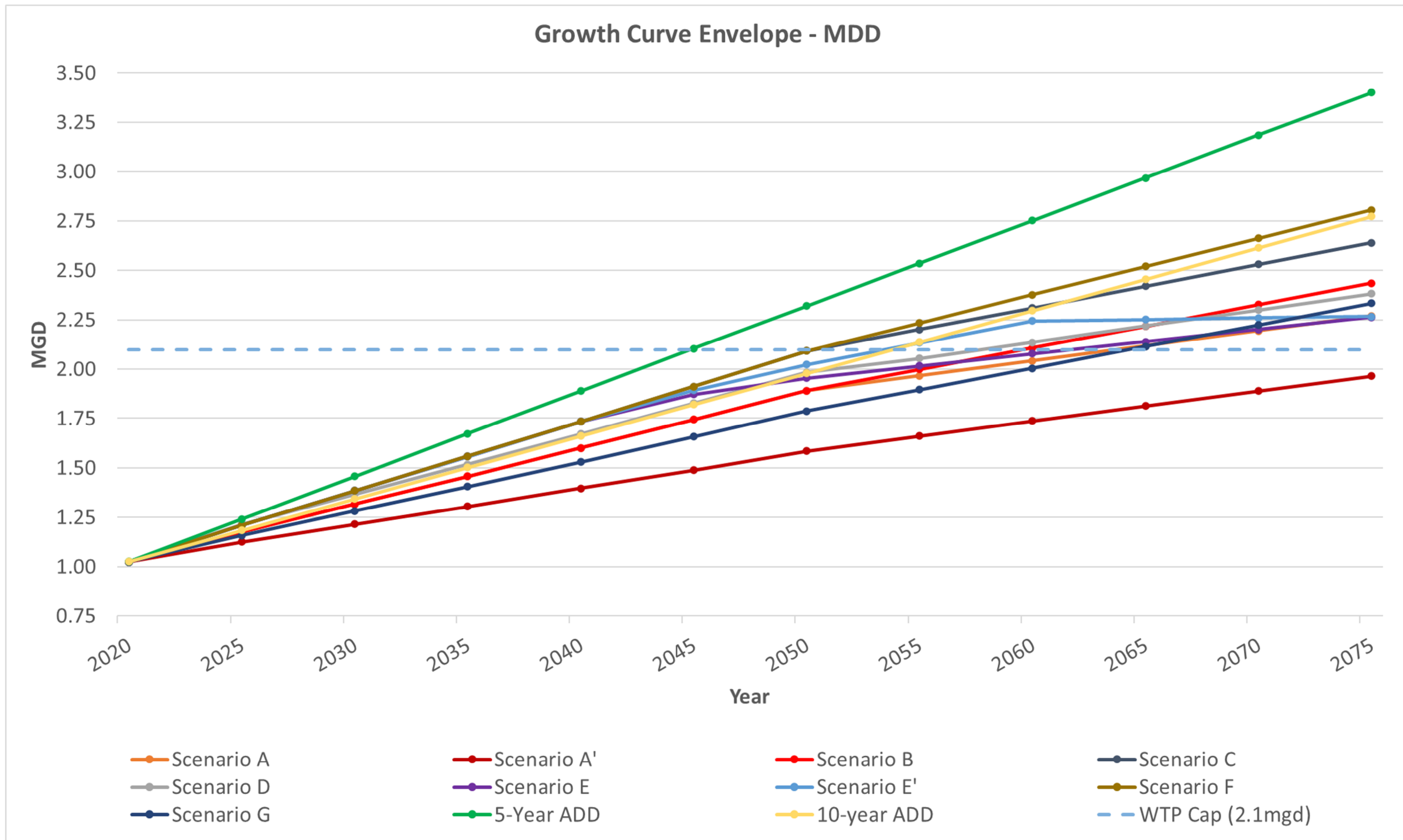
It is important to note that the 2021 Demand Forecast updates discussed above represent a marginal decrease (0.4%) in the projected demands for the same growth projection alternative (Scenario C) performed as part of the 2020 Demand Forecast. This can be attributed to a more aggressive estimated growth pattern for the service area in the 2020 effort. The 2021 projections assume a more gradual growth projection based on the addition of approved and anticipated future residential development. The projections account for an estimated 2.54 residents/RDU (as defined by the 2019 GMP) for both the approved Pipeline units as well as the Buildout units. To investigate a more conservative growth envelope, the above analysis was also performed assuming 2.8 residents/RDU (typically used for Single Family Dwelling Units) for both approved Pipeline units as well as the Buildout units to assess the impact. The results of this revision are shown in Figures 13 and 14.

Figure 13: Updated Projected ADD Growth Envelope (2.8 residents/RDU)



1. The dashed horizontal line presents the Safe Yield of Beaver Creek Dam (1.66 mgd) per the 2019 DWIP report.

Figure 14: Updated Projected MDD Growth Envelope (2.8 residents/RDU)



1. The dashed horizontal line presents the WTP capacity (2.1 mgd) per the 2019 DWIP report.

While the projected values are largely similar, the water demands fall higher in 2075 given the increase in the assumed number of residents per RDU (from 2.54 to 2.8). If Scenario C were to be investigated again for comparison, the updated buildout ADD (in 2075) would be 1.57 mgd and the MDD would be 2.64 mgd (compared to 1.52 mgd and 2.55 mgd from the 2020 Demand Forecast, which represents a 3.1% and 3.4% increase in ADD and MDD demand projections respectively). When in-plant water use is considered (i.e., adding in an additional 10% of production), the required water withdrawal from Beaver Creek Reservoir and the required water treatment capacity at the Crozet WTP under average and maximum conditions would be 1.72 and 2.90 mgd, respectively (compared to 1.67 mgd and 2.81 mgd from the 2020 Demand Forecast, which represents a slight increase in demand projections).

Focusing again on the MDD growth curves presented in Figure 14, if the existing water treatment plant (WTP) capacity of 2.1 mgd is compared to the projected MDD for Scenario C, the system will hit 80% of the WTP capacity (1.68 mgd) in the year 2039, which aligns with the 2020 updated projections. The treatment capacity required at buildout, under these conditions, is estimated to be 2.90 mgd. The 2.90 mgd treatment rate is based on the maximum day demand projection in the year 2075 (2.64 mgd), with an additional 10% for in-plant use.

1.2.5 COVID-19 Impacts

As a part of this Demand Forecast Update, we continued to investigate the impact that COVID-19 response measures have had on water demands through a comparison of 2019 and 2020 demands. Based on this assessment, water demands have increased 3.1% from 2019 to 2020. Although not all data is yet available for 2021, in comparing water demands from January to May for 2020 and 2021 respectively, the data indicate a 9.0% increase in demand. Given the high proportion of residential demand in the Crozet Service Area, coupled with stay-at-home orders, it is not surprising that an increase in water demand has been observed. Early monitoring of water demands from other communities since COVID-19 response measures took hold indicate increased residential demands and reduced commercial sector demands. However, water demand increases within the Crozet Service Area may not be completely related to COVID-19. For reference, ADD from 2017 to 2018 grew 0.07% and from 2018 to 2019 grew 11.6%; both data points occurred well before the COVID-19 outbreak. In reviewing the most recent data available, ADD from 2019 to 2020 grew 2.76% in comparison, representing a more moderate increase when compared to the previous year's sharp increase. Another factor that might have contributed to the variation of ADD observed over this time is precipitation. The amount of precipitation in 2018 makes it one of the wettest years on record for many towns and cities across Virginia. Given the volume of rainfall observed, outdoor water use such as irrigation, may have also caused an impact.

A comparison of average water demands from January and February 2019 to average demands from January and February 2020 was made as part of the 2020 Demand Forecast update to get an estimate of the portion of water demand increase that is due to continued development and the portion due to COVID-19 response. The comparison showed a 3.5% reduction in water demands. Using updated average water demand data available, a comparison of average water demands from January and February 2020 to average demands from January and February 2021 show a 7.7% increase in demands. If the data range for the comparison is extended to January through May for 2020 and 2021 respectively (2021 data only through May), the data show a 9.6% increase in demands. If that same comparison is once again investigated for January through

May of 2019 and 2020 respectively, only a 1.1% increase in demand is observed. Taken collectively, the data continues to support the supposition that a majority of the recent water demand increases can be attributed to COVID-19 and the associated behavioral changes (i.e., remote work, increased water use for sanitation, etc.).

The results, which continue to show a marked increase in water demands, indicate the importance of water supply resiliency for the Crozet Service Area. Water demand increases are likely directly impacted by the current account class type distribution, where residential accounts far outweigh non-residential accounts, creating an atypical scenario where residential usage has a greater influence on demands than non-residential account usage in a typical urban environmental. Although it is anticipated this water demand increase will be temporary, the duration of this temporary increase is still unknown. **However, this data supports a more conservative approach with respect to water supply need projections, such as those presented herein.**