

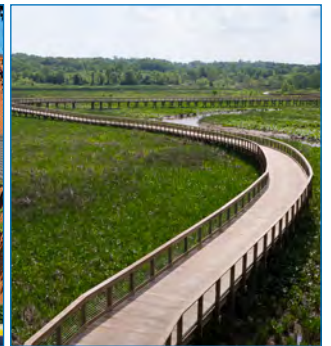


**PRINCE WILLIAM**  
— VIRGINIA —

# Community Energy and Sustainability Master Plan

Prince William County, Office of Sustainability

October 2023



**A Roadmap For Climate Mitigation and  
Resiliency**

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## Glossary

Term	Definition
<b>Adaptation</b>	The process of adjustment to actual or expected climate and its effects
<b>Carbon offset</b>	Carbon offsets represent the reduction or removal of greenhouse gas emissions that compensate for emissions emitted somewhere else
<b>Climate action</b>	An action that reduces greenhouse gas emissions or climate risk
<b>Climate change</b>	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer
<b>Climate mitigation</b>	Reducing emissions of and stabilizing the levels of heat-trapping greenhouse gases in the atmosphere
<b>Greenhouse gas reduction scenario</b>	A greenhouse gas reduction scenario represents a group of high-level technological strategies that are needed to reach a greenhouse gas reduction goal
<b>Greenhouse gas reduction strategy</b>	Greenhouse gas reduction strategies are high-level technological strategies that help meet a greenhouse gas reduction goal. Examples of technological strategies include switching electricity generation sources from fossil fuels to renewables, travel mode shifting from single-occupancy vehicles toward active and public transportation, and electrifying buildings
<b>Greenhouse gas</b>	Gases in the earth's atmosphere that trap heat
<b>Renewable energy</b>	To meet the County's renewable electricity goals, renewable electricity is being defined as electricity coming from any non-fossil fuel energy source, such as solar, wind, hydro, geothermal, and nuclear
<b>Resiliency</b>	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation
<b>Sequestration</b>	Process of capturing and storing atmospheric carbon dioxide
<b>Vehicle Miles Traveled</b>	The number of miles traveled by a vehicle
<b>Vulnerability</b>	The propensity or predisposition to be adversely affected

## Acronyms

Acronym	Definition
ASAP	Action Selection and Prioritization
°C	Degrees Celsius
CCA	Community Choice Aggregation
CESMP	Community Energy and Sustainability Master Plan
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> e	Carbon Dioxide Equivalent
CPA	Comprehensive Plan Amendments
C-PACE	Commercial Property Assessed Clean Energy
DCSM	Design and Construction Standards Manual
DRPT	Department of Rail and Public Transportation
EEA	Equity Emphasis Area
EV	Electric Vehicle
°F	Degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FY	Fiscal Year
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
HOA	Homeowners' Association
HVAC	Heating, Ventilation, Air Conditioning
IJJA	Infrastructure Investment and Jobs Act
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
JET	Joint Environmental Task Force
MTCO <sub>2</sub> e	Metric Tons Of Carbon Dioxide Equivalent
MWCOG	Metropolitan Washington Council of Governments
N <sub>2</sub> O	Nitrous Oxide
NOS	Natural Open Space
NOVEC	Northern Virginia Electric Cooperative
PPA	Power Purchase Agreement
PRTC	Potomac and Rappahannock Transportation Commission
PWC	Prince William County
PWCS	Prince William County School
PWCSA	Prince William County Service Authority

## Acronyms

Acronym	Definition
RECs	Renewable Energy Certificates
RPS	Renewable Portfolio Standard
SUP	Special Use Permits
TOD	Transit Oriented Development
ZEV	Zero-Emission Vehicle
VDOT	Virginia Department of Transportation
VMT	Vehicle Miles Traveled
VPPAs	Virtual Power Purchase Agreements
VRE	Virginia Railway Express



# Letter from County Executive



**Christopher J. Shorter - County Executive**

The time for climate action is now. The Prince William Board of County Supervisors adopted the county's Climate Mitigation and Resiliency Goals in 2020. These aspirational goals are focused on reducing greenhouse gas emissions, incorporating renewable energy, and becoming more resilient to the effects of climate change. In adopting these goals, the County committed to doing our part locally, regionally, and globally in reducing our climate impact.

The Community Energy and Sustainability Master Plan (CESMP) provides actionable steps that the county can take in striving to meet our goals. The actions recommended in this plan are ambitious to meet the moment and the level of ambition set forth by the goals. Decreasing our county's emissions by 50% by 2030 from a 2005 baseline, for example, will require an intentional shift from business as usual. However, the strategies and frameworks that these actions have been built upon are not new for Prince William. They expand upon the smart growth measures and sustainability action strategies included in our Comprehensive Plan and Strategic Plan and take them to the next step of implementation.

Sincerely,

Christopher J. Shorter  
County Executive

This plan not only lays out how we could meet our climate goals, but also how we can be resilient and adaptable to the effects of climate change. Resiliency is important for the county as a whole, but particularly for low income and minority communities who often experience the burden of climate change impacts the most, including extreme heat, flooding, and poor air quality. Knowing that Prince William is Virginia's most diverse county, it was critically important that environmental justice and equity principles were foundational in its development. The plan's Vulnerability Assessment identified the climate hazards that would most affect the county's socially vulnerable populations, and climate adaptation actions have been recommended to mitigate them.

Developing the CESMP is step one in moving towards meeting our climate goals. We view this as a living document that will continually be updated as we take advantage of new technology and policies that lead to more efficient and cost-effective strategies. We understand that we must be both adaptable in our approach and urgent to meet the time sensitive challenges of climate change.

This plan is calling for an all-hands approach to tackling climate change in Prince William. Implementation will require participation and collaboration from our government agencies, the school division, businesses, and residents. We invite you to engage in this journey together as we strive for a cleaner and greener Prince William for generations to come.



# Executive Summary

On November 17, 2020, the Prince William County (the County)<sup>1</sup> Board of County Supervisors (Board) adopted Climate Mitigation and Resiliency Goals. This plan, the Community Energy and Sustainability Master Plan (CESMP), presents recommendations on what actions the County government could take to contribute to the achievement of these goals. We recognize that climate change is not a distant problem, but one that impacts our citizens and resources directly. The increasing effects of our changing climate include, but are not limited to, more severe and persistent heat waves, poor air quality from wildfires, greater risk of power outages, more heat-related illnesses, and storm damage from flooding and high winds. This warming of our climate is caused primarily by the burning of fossil fuels to produce electricity, heat our homes and businesses, and power our vehicles. Our county's climate is changing, and it is directly related to human activities.

According to the Environmental Protection Agency, sea levels are expected to rise between one and four feet along the Virginia coast in the next century.<sup>2</sup> Climate change in Virginia manifests as erosion of its beaches and barrier islands, saltwater intrusion, intense tropical storms and hurricanes with more flooding and bigger storm surges throughout the state, increased rainfall with exacerbated coastal and inland flooding, loss of important coastal ecosystems, harmful effects on farming and fishing, and increased dangerously hot days. These effects are already being realized. Compared to 100 years ago, Virginia is experiencing 30 more evenings each year above 68 degrees Fahrenheit (°F) and Virginia's portion of the Chesapeake Bay has seen approximately 4.5 more inches of rain annually.<sup>3</sup> Virginia was affected by 82 of the 290 U.S. billion-dollar disaster events that occurred between 1980 and 2020.<sup>4</sup>

Achieving these goals would require unprecedented, aggressive action. ***This plan presents a list of actions recommended for the County government to take, with 25 actions that have been prioritized for immediate execution.***






**We recognize the time for action is now. The goals that guide our recommended actions are:**

- 1. Cut Greenhouse Gas (GHG) Emissions County-Wide by 2030: Reduce GHG emissions county-wide to 50% below 2005 levels by 2030**
- 2. Use 100% Renewable Electricity County-Wide by 2035: Source 100% of county-wide electricity from renewable sources by 2035<sup>5</sup>**
- 3. Use 100% Renewable Electricity in County Government Operations by 2030: Achieve 100% renewable electricity in the County government operations by 2030<sup>6</sup>**
- 4. Become Carbon Neutral for County Government Operations by 2050: Achieve 100% carbon neutrality in the County government operations by 2050**
- 5. Prepare for Climate Change: Become a Climate Ready Region and make significant progress to be a Climate Resilient Region by 2030**

In many cases, the actions will be initially driven by the County government but will also require strong participation by residents and businesses. Partnerships and advocacy at the regional, state, and federal levels will become crucial. The 25 high priority actions can be grouped into five topic areas in which significant action is needed: electricity, buildings, transportation, natural resources, and adaptation. These high priority actions and the goals they contribute to are listed in **Table 1** below. A longer list including medium and low priority actions is provided in **Appendix A. Complete List of CESMP Actions.**

Further analysis and legal review by county staff and the County Attorney's Office will need to take place as recommended actions are considered for implementation.

**Table 1. CESMP High Priority Climate and Resiliency Actions**

Topic Area CESMP High Priority Actions		Related Goal #
 Electricity	E.1: Acquire Clean Electricity Sources for the County	1, 2, 3, 4
	E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives	1, 2
	E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings	1, 2
	E.4: Promote Existing Green Power Products	1, 2
	E.5: Install Solar on County Government Facilities	1, 2, 3, 4
 Buildings	B.1: Encourage Energy Efficiency and Electrification Retrofits	1
	B.2: Propose Green Zoning Regulations	1
	B.3: Encourage Energy Efficient and Electric New Construction	1
	B.4: Promote Energy Efficiency and Electrification Incentives	1
	B.5: Transition to Net Zero County Government Facilities	1, 2, 4, 5
 Transportation	T.1: Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity	1
	T.2: Encourage Transit-Oriented Development	1
	T.3: Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips	1
	T.4: Upgrade Public Transit Infrastructure	1
	T.5: Encourage Zero-Emission Vehicles and Charging	1
	T.6: Expand Public EV Charging Network	1
	T.7: Adopt Zero- or Low-Emissions County Fleet	1, 4
 Natural Resources	N.1: Adopt Natural Open Space Requirements	1, 5
 Adaptation	A.1: Develop Adaptation Plans for Critical Facilities	5
	A.2: Manage Stormwater Flooding in Areas Outside of the Floodplain	5
	A.3: Improve Power Resiliency for Critical Infrastructure	5
	A.4: Implement Shoreline Protection and Nature-Based Solutions	5
	A.5: Restore Streams to Reduce Flooding	5
	A.6: Encourage Technology for Residents to Make Homes Adaptive	1, 5
	A.7: Plan Alternate Evacuation Routes for Flood-prone Areas	5

**Action Implementation and Budgeting:** Each action listed in **Table 1** is accompanied by 1) a more detail description of what the action entails (**Chapter 4 CESMP Actions**), and 2) expanded Implementation Plans. The implementations plans provided in **Appendix B**. Implementation Plan were developed by County departments leading the actions and include the first few steps needed to get the action off the ground. The high-level cost estimates listed in the plans (**Appendix B.1 Estimated Budget for CESMP High Priority Actions**) are not budget requests, but rather an estimate of what it may take to complete that action over their implementation time periods. Once approval for implementation is granted, the County lead departments would conduct further analysis and prepare detail budget requests including 1) a cost-benefit analysis and 2) a cost-saving analysis as many actions may end of saving the County and its residents money.

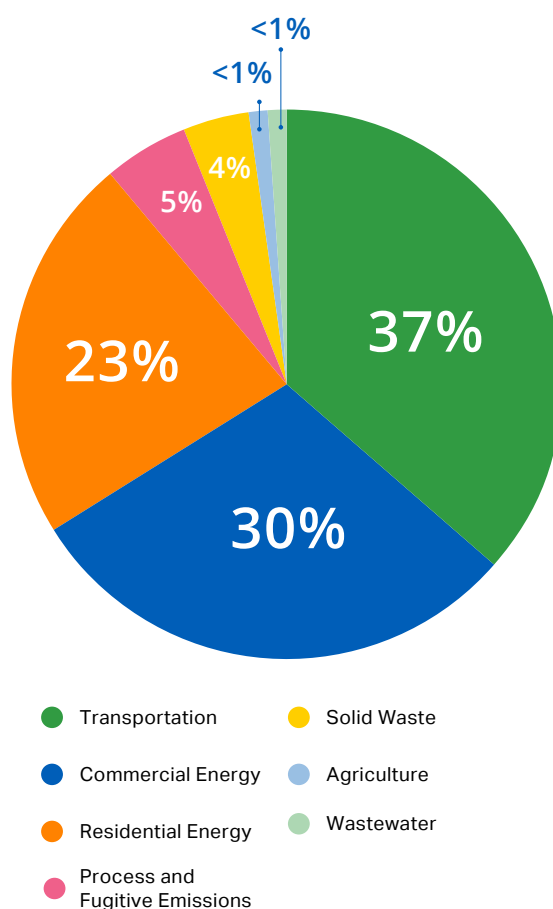
**Alignment with County Plans:** The recommended actions in the CESMP align with and contribute to meeting the goals and action strategies in our Comprehensive Plan and 2021-2024 Strategic Plan (see **Appendix C. CESMP Actions Mapped to Strategic Plan and Comprehensive Plan Action Strategies**). As part of CESMP development, county emissions were projected to 2050 utilizing the County's growth projections that were provided in the Comprehensive Plan. This included projected population, household, and jobs growth. In working towards meeting the Climate Mitigation and Resiliency Goals, the CESMP is recommending implementation of many of the Smart Growth action strategies already included in the Comprehensive Plan and Strategic Plan.

**Plan Structure:** The CESMP reviews the county's GHG emissions and climate vulnerability context, outlines what it will take for us to reach our goals, and establishes what we can do to meet these goals through local climate actions.

The CESMP divides our climate actions into climate mitigation actions, which reduce GHG emissions, and climate adaptation and resiliency actions, which reduce community-wide climate risk. Climate mitigation actions are further divided into community-wide actions that address the broader community's emissions and government actions that address County government emissions.

**GHG Emissions:** The county's GHG inventories can be used to monitor progress toward the 2030 GHG reduction goal. These inventories are created every two years by the Metropolitan Washington Council of Governments (MWCOC). A pie chart of the county's 2018 emissions inventory is shown in **Figure 1** below. A detailed explanation of why we utilized the 2018 inventory for our baseline instead of the 2020 inventory is provided in **Chapter 2 Prince William County Greenhouse Gas Emissions**.

**Figure 1. 2018 Community-wide Emissions by Sector**



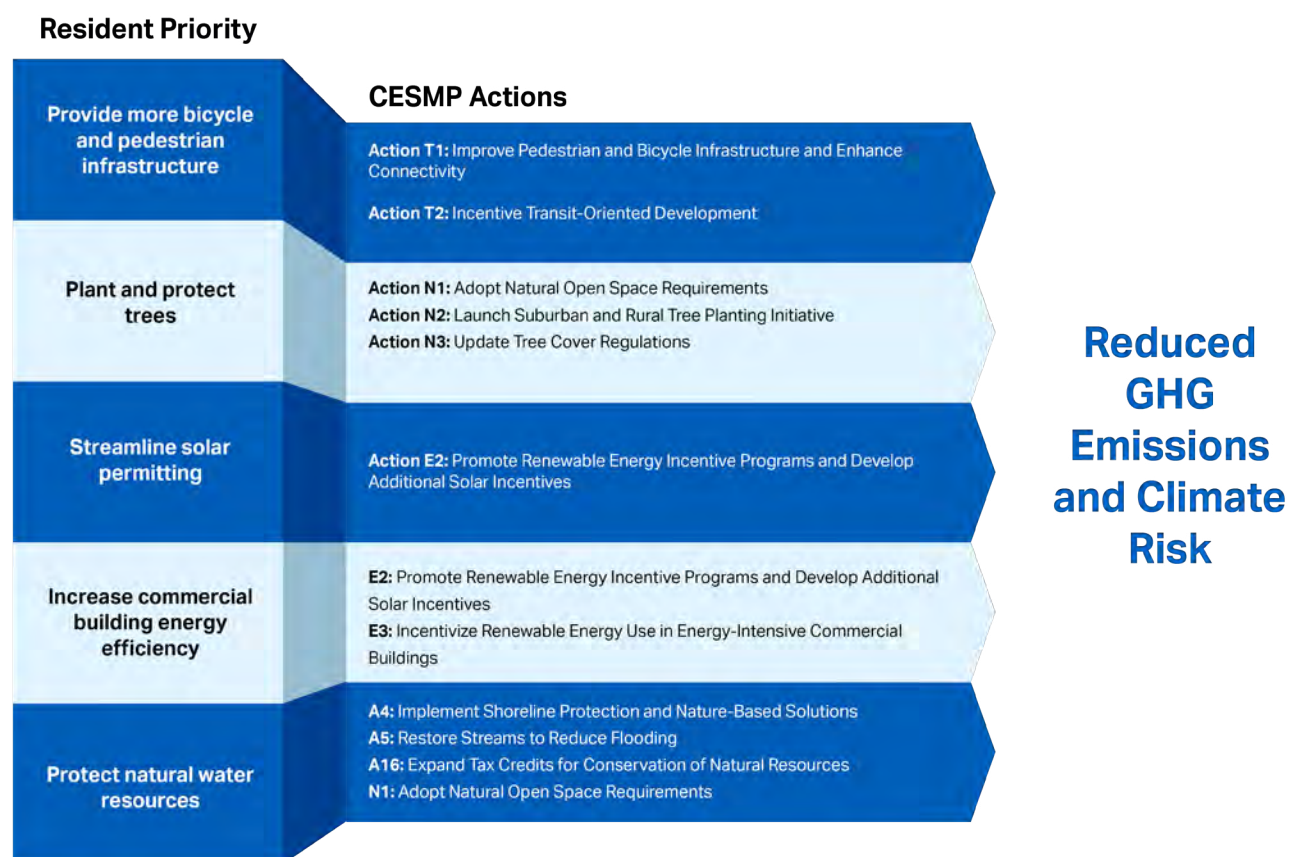
**Climate Vulnerability Assessment:** We assessed our county's vulnerability to current climate hazards from extreme temperatures, precipitation, coastal flooding and sea level rise, drought, and high winds/tornadoes. The assessment looked at future climate hazards from extreme temperatures, precipitation, and sea level rise. County assets were divided into categories, and the vulnerability of each category was rated based on its exposure, sensitivity, and adaptive capacity.

**The CESMP Actions:** Climate actions describe what we can do to reduce emissions and adapt to climate change. The first step in the action development process was to identify current policies and programs that support the 2030 GHG reduction scenario strategies and address local climate hazards, recognize limitations in our ability to influence these sectors, and determine areas of opportunity for new action development.

We then evaluated the new actions for their impact on specific evaluation criteria to provide a more holistic understanding of each action's viability and value to the community. Evaluation criteria included GHG reduction potential; climate risk reduction potential; impact on organizational diversity, equity, and inclusion; resource conservation; cost to residents and businesses; local employment; funding source identification; cost to the County government; and cost savings to the County government. After gathering stakeholder feedback, we conducted an action prioritization exercise to organize actions into high, medium, and low priority categories.

During this process, many residents expressed their priorities for climate action development and implementation. An example of how some of these priorities were addressed through CESMP actions is included in **Figure 2** below.

**Figure 2. Resident Priorities and Related Climate Actions**



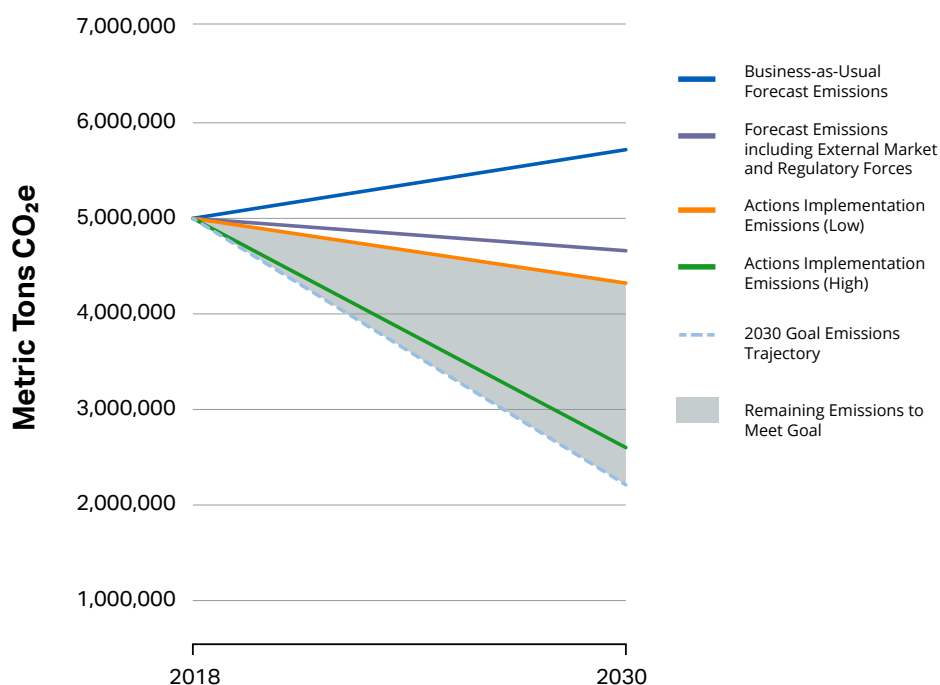
**Meeting the GHG Reduction Goal:** To understand what it would take to achieve the 2030 GHG reduction goal, we selected a set of strategies that would need to be accomplished to achieve that goal. When developing this scenario, we first evaluated how external regulatory or market forces would impact emissions over time. These forces include factors like expected electric vehicle (EV) adoption or technology improvements that are projected to help reduce emissions without additional County action. These external factors result in nearly 32% of emissions reductions needed to meet the County's 2030 GHG reduction goal.

Building on these external regulatory and market forces, we selected a set of strategies the County would need to accomplish to show what it would take to reach the 2030 GHG goal. Two important strategies identified to meet the 2030 goal include ensuring over 90% of the electricity used in the county comes from clean energy sources (e.g., solar, wind, hydropower, nuclear, and geothermal) and that half of passenger and medium-duty vehicles traveling within the county are electric or produce zero-emissions. These two strategies are estimated to produce about 80% of the total GHG reductions needed to meet the 2030 goal.

However, these strategies and their underlying implementation rates might be different than what is feasible for the County government to achieve.

With the County government's lack of control over county-wide emission sources, it will not be possible to meet all the strategies and goals through County government action alone. **Figure 3** shows the difference between the county's projected emissions levels, emissions levels after action implementation, and the emissions trajectory needed to meet the 2030 GHG reduction target. In **Figure 3**, the top line shows the county's business-as-usual emissions projections that were created using Comprehensive Plan growth factors such as population, households, jobs, and Digital Gateway growth (5,700,000 MTCO<sub>2</sub>e in 2030). The purple line shows emissions projections if external regulatory and market forces are considered (4,600,000 MTCO<sub>2</sub>e in 2030). The bottom dotted line shows the 2030 county-wide GHG reduction goal trajectory (2,100,000 MTCO<sub>2</sub>e in 2030). To meet the 2030 county-wide GHG reduction goal, the county would need to reduce emissions by about 2,500,000 MTCO<sub>2</sub>e in 2030.

**Figure 3. GHG Reduction Potential and Remaining Emissions**





The middle orange and green lines in **Figure 3** show the potential range of emissions reduction impact from implementing CESMP actions. For example, if there is high collective community participation for some actions, this may result in higher emissions reductions while less participation may result in lower emissions reductions. Looking at this range, if we implement all actions listed in the CESMP, we estimate a gap in reductions needed to meet the 2030 goal of about 500,000 – 1,400,000 MTCO<sub>2</sub>e (shown as the shaded gray area). This is because the County has limited authority or influence over these emissions sources.

This gap could potentially be bridged with the help of significant external support, such as contributions from market factors, state- and national-level regulation, incorporating forest and tree carbon fluxes into our GHG inventories, or potentially through the purchase of high-quality carbon offsets. However, it is important to emphasize that the acquisition of carbon offsets would be our last resort as the first line of action should always be focusing on direct emissions reductions.

The intent of the CESMP is to build upon what we already have been doing in energy conservation, decarbonization, and adaptation to climate change. Our county is already making progress towards the Climate Mitigation and Resiliency Goals. Among many actions, our county currently captures landfill methane to generate electricity and we are building out a new renewable natural gas facility; we established a Residential Solar Task Force to streamline the permitting processes; we began procuring EVs and building out charging infrastructure; we built an automated flood warning system; and we coordinate community outreach and preparedness engagement through the Ready Prince William program. For a full list of actions the county has already taken, see **Appendix D. Existing County Government Actions**.

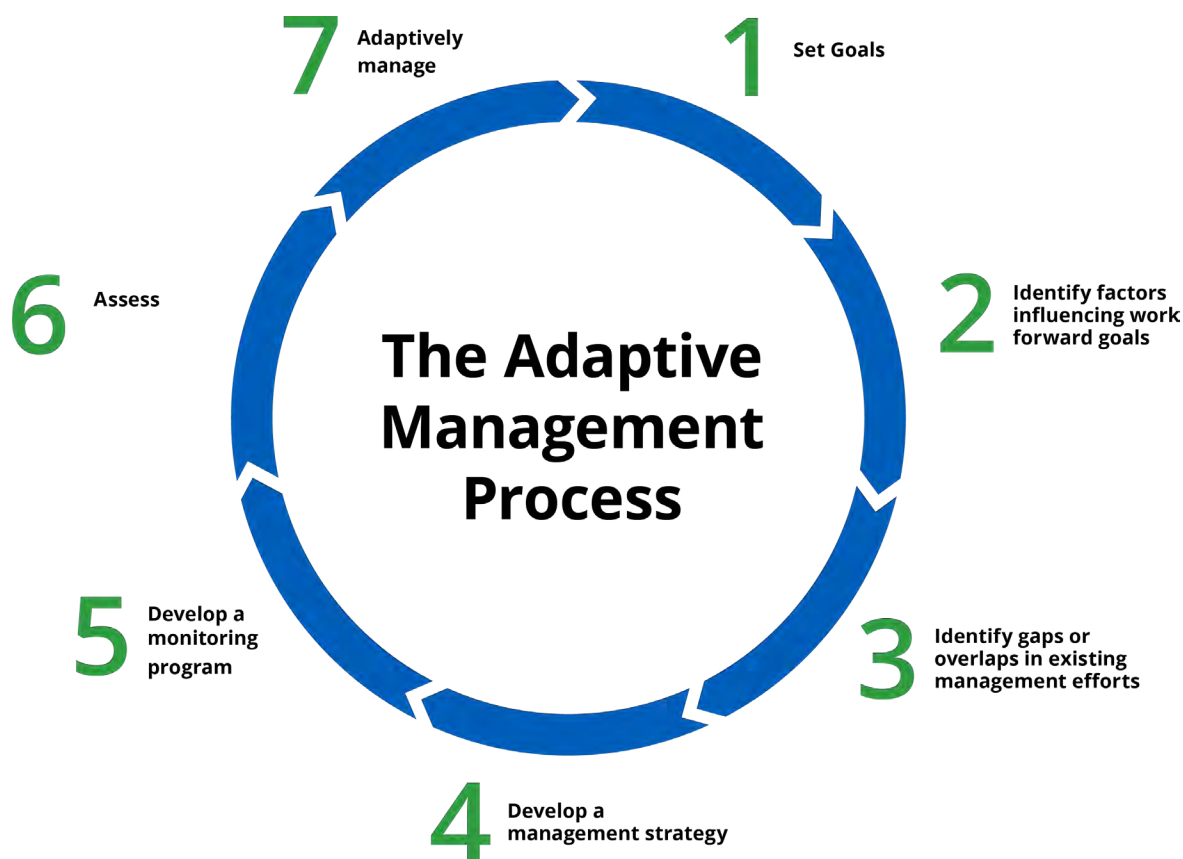
With timely implementation of the high priority actions in the CESMP, we can continue to build upon the County's successes and put ourselves in a position to strive towards meeting the Climate Mitigation and Resiliency Goals to the best of our ability.

**Next Steps:** In addition to the specific actions identified through the analysis described above, the CESMP includes three foundational program-wide sustainability initiatives designed to improve the County's ability to monitor and implement the plan:

- 1. Implementation of an “Adaptive Management” approach** that improves our ability to make decisions in the face of uncertainty and complexity
- 2. Assessments for climate mitigation and resiliency impacts** performed by the County to provide data on a project's impact on greenhouse gas emissions, renewable and fossil energy mix, and climate resiliency metrics
- 3. Institutional capacity-building** to support sustainability, including staffing capacity to pursue federal grants for green programs and capacity for communication and outreach that will engage residents and businesses in the voluntary measures recommended in the CESMP

**Adaptive Management:** Implementation of the CESMP will be a dynamic effort that will require taking an Adaptive Management approach of continuous data collection, analysis, and reassessment. Adaptive Management is an intentional and iterative approach designed for decision making in situations characterized by volatility (rapid change), uncertainty, complexity, and ambiguity. The County intends to implement the CESMP through a process similar to the one employed by the Chesapeake Bay Program shown in **Figure 4** below, to making decisions and adjustments in response to rapidly evolving technologies, policies, strategies, and funding opportunities. Note that stakeholder input is a continuous element of the process.

As a next step, we will need to develop a system for annually assessing the impact of the proposed actions towards meeting the climate mitigation and climate resiliency goals. This work has already begun through the development of Implementation Roadmaps for the 25 high priority actions (see **Appendix B. Implementation Plan**). The roadmaps identify the County government departments that will lead implementation, supporting partners, implementation steps, action cost range, and high-level performance indicators (which will form the basis of the monitoring and performance assessment steps). **Appendix B. Implementation Plan** also includes a description of additional cost saving considerations for the actions. These are general descriptions of potential cost savings as many actions would require further analysis of feasibility studies to determine exact savings. When budget requests are made for the actions, more specific cost and savings information will be included.

Figure 4. Adaptive Management Process<sup>2</sup>

The Implementation Roadmap actions are fluid and may change as the county's emission sources, funding sources, and department roles change. They are not a requirement for lead departments to complete each implementation step or a guarantee that all actions will be implemented. They are simply a recommended starting point to begin action. Given the complexity and magnitude of the systems we are managing, we need to act now with the best current information available. The Office of Sustainability will have an oversight role in guiding and tracking action implementation, but actual action implementation will be led by the respective departments.

As a part of the Adaptive Management approach, we expect that methodologies for analysis of the county's emissions will continue to evolve over time. In the future, we expect to incorporate the following into CESMP updates or as part of action implementation steps:

1. Validate and integrate forest carbon sequestration estimations into GHG inventories

2. Assess how commercial building owners and businesses may use renewable energy to reduce their carbon intensity
3. Forecast clean energy growth in the electric grid
4. Account for the effects of the Federal Inflation Reduction Act (IRA) and other legislation on the carbon intensity of the electric grid and on vehicle emissions reductions
5. Conduct a more detailed analysis of the effectiveness of smart growth measures on vehicle miles traveled and emissions reductions.

Additionally, we recommend incorporating the social cost of carbon in the methodology as a metric for quantifying action impact. The social cost of carbon is an estimation of the cost in dollars of either negative implications of adding a ton of carbon emissions to the atmosphere, or the benefit of reducing a ton of carbon emissions. For example, the EPA currently estimates the social cost of reducing a ton of carbon in 2030 to be around \$230.<sup>8</sup> If the county were to meet the 2030 goal of reducing emissions by 50% from a 2005 baseline, the benefit to society would be valued at an estimated \$575M per year.



## Assessments for Climate Mitigation and Resiliency Impacts:

The County currently conducts environmental reviews for rezonings, comprehensive plan amendments (CPAs), special use permits (SUPs), and major road projects. These reviews rate projects in terms of their conformance to goals of the Comprehensive Plan, Strategic Plan, Schools Plan, and other County planning documents, as well as compliance with environmental regulations.

In the future, County staff recommends that the Board consider amending relevant County regulations and policies, consistent with applicable law, to assess greenhouse gas emissions, to assess renewable and fossil energy mix, and to assess climate resiliency metrics. This would provide additional information about the potential environmental impacts of specific rezoning and SUP applications, Capital Improvement Program (CIP) projects, and CPAs on the community based on the Board's adopted Climate Mitigation and Resiliency Goals.

The Office of Sustainability is requesting an Environmental Analyst position to assist with developing and/or reviewing these assessments.

**Institutional Capacity:** To implement the CESMP, one of the necessary first steps is to build up institutional capacity to execute the foundational elements of the plan. This includes key activities such as increasing staff capacity to pursue federal grants for green programs and the capacity for communication and outreach that will engage residents and businesses in the voluntary measures recommended in the CESMP.

To begin implementation, the Office of Sustainability is hiring a Climate and Energy Manager to provide the necessary support to begin to stand up projects and programs for the high priority actions in the CESMP. The County will also utilize the \$1.04 million in CIP funding that has been allocated by the Board via Resolutions 21-663 and 22-573 for the CESMP to kick-start actions that are related to County infrastructure. Projects with CIP funding allocated are included below.

### Projects with CIP Funding Allocated:

- ▶ Installing solar on County buildings identified in feasibility study that will be completed December 2023 (Action E.5)
- ▶ Conduct feasibility study for electrification of County buildings (Action B.5)
- ▶ Transition of high-pressure sodium streetlights to LED (estimated 200 streetlights) (Action B.1)

We recommend consideration of CIP funds for FY25 to implement the below projects.

### FY25 CIP Fund Requests for \$10 Million:

- ▶ Begin to implement recommendations from feasibility study for electrification of County-owned buildings (Action B.5)
- ▶ Begin to implement recommendations from feasibility study to convert County fleet to low- or zero-emission vehicles that will be completed Spring 2024 (Action T.7)
- ▶ Development of greenhouse gas inventory for County government operations (Action B.5)
- ▶ Installing solar on buildings identified in feasibility study that will be completed December 2023 (Action E.5)

**In addition to the CIP funds that have already been allocated for CESMP implementation and FY25 CIP funds, the following general fund budget requests for FY25 would provide the institutional capacity needed for the first year of implementation:**

- ▶ Sustainability Communications and Outreach Manager – Manage grant writing opportunities and communications with the public, including campaigns about available resources and incentives.
- ▶ Environmental Analyst – Stand up the Adaptive Management system for analyzing progress towards the Climate Mitigation and Resiliency goals. This would include development and review of assessments for impacts of major projects on Climate Mitigation and Resiliency goals and tracking CESMP implementation costs and savings.

Lastly, we recommend that the CESMP is incorporated into the Comprehensive Plan through an amendment to the Comprehensive Plan, and that the action strategies of the CESMP are incorporated into the County's next Strategic Plan. This step would help fulfill the mandate in Board Resolution 20-773 to "incorporate into the Comprehensive Plan goals of 100% of Prince William County's electricity to be from renewable sources by 2035, for Prince William County Government operations to achieve 100% renewable electricity by 2030, and for Prince William County Government to be 100% carbon neutral by 2050." This would also support implementation of the many sustainability strategies already established in the Comprehensive Plan and 2021-2024 Strategic Plan (**Appendix C. CESMP Actions Mapped to Strategic Plan and Comprehensive Plan Action Strategies**).

# Chapter 1 Introduction

## The Purpose of this Plan

In 2008, MWCOG set a series of ambitious goals to reduce emissions in the region by 2020. In 2020, MWCOG published its 2030 Climate and Energy Action Plan that set new 2030 goals for area governments. Motivated by this plan, the County's Board of Supervisors adopted five climate and resiliency goals provided in **Table 2**. These goals demonstrate our continued commitment to protect and prepare our citizens and resources for climate change.<sup>9</sup> The primary purpose of the CESMP is to develop a pathway toward addressing these goals.

**Table 2. County Climate Goals**

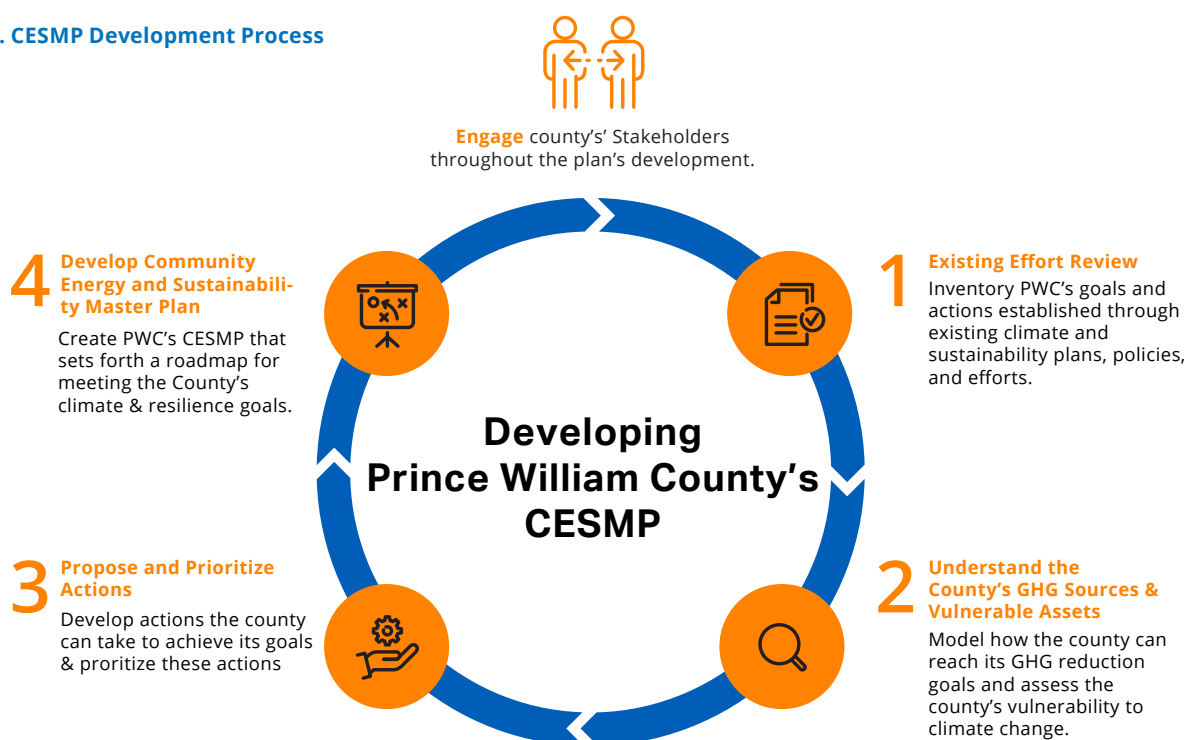
County-wide Goal	County Government Goal
Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	Achieve 100% renewable electricity in County government operations by 2030*
Become a Climate Ready Region and make significant progress to be a Climate Resilient Region by 2030	Achieve 100% carbon neutrality in County government operations by 2050
Source 100% of county-wide electricity from renewable sources by 2035*	

\* We define renewable electricity as electricity coming from any non-fossil fuel energy source such as solar, wind, hydro, geothermal, and nuclear.

## How the CESMP was Developed

The County made it a point to have an inclusive stakeholder engagement process by striving to involve representatives for all groups who may be affected by the implementation of the CESMP in the decision-making process. This approach was taken to ensure that the steps we take to achieve our objectives consider the priorities of our community. Stakeholder engagement was embedded throughout the CESMP process as shown in **Figure 5**.

**Figure 5. CESMP Development Process**



We took into consideration things like the knowledge of our local experts, the voice of the public, and any unexpected side effects of our actions. A complete list of stakeholders that were engaged during the development of the CESMP is provided in **Appendix E. List of Stakeholder Groups Involved in CESMP Development.**

The stakeholder engagement process was designed to approach stakeholder groups, introduce them to the plan development process, and provide their feedback to the County Government Core Team for consideration and incorporation at key milestones.

## Importance of Climate Action and Resiliency Planning

Recognizing the importance of resiliency in a rapidly changing world, the CESMP underscores not only our commitment to mitigating climate impacts, but also our determination to adapt and thrive in the face of adversity. We firmly believe that understanding the dynamics of climate change and fostering resiliency are key pillars of sustainability and integral to the ongoing vitality and prosperity of the county.

As it relates to climate change, GHGs function like a warm blanket around our Earth, absorbing and re-emitting heat. This natural process, known as the greenhouse effect, is vital for our survival, keeping the planet at a habitable temperature. There are many different GHGs, each with a different ability to trap heat — we call this their "global warming potential." To make sense of all these gases, we convert their quantities into carbon dioxide equivalents (CO<sub>2</sub>e) for easier comparison.

**There are several major GHGs that result from human activity and are included in U.S. and international estimates of GHG emissions:**

- Carbon Dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous Oxide (N<sub>2</sub>O)
- Nitrogen Trifluoride (NF<sub>3</sub>)
- Sulfur Hexafluoride (SF<sub>6</sub>)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)

While GHGs naturally occur at beneficial levels, maintaining the Earth's temperature, our actions have released more GHGs and have tipped the scale since the 1800s.

This disruption in balance is "climate change," a long-term shift in average global or regional weather patterns. This imbalance ushers in a host of troubles like extreme droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, devastating storms, and declining biodiversity. Human activities, such as burning fossil fuels to power our buildings or vehicles, have been the main driver of climate change.

The United Nations Intergovernmental Panel on Climate Change (IPCC) — the leading international body for assessing climate science — noted that more severe climate impacts could be avoided if global warming is limited to 1.5 degrees Celsius (°C) (or 2.7 degrees °F) above pre-industrial levels. To do this, global emissions need to fall by at least 45% from 2010 levels by 2030 and reach carbon neutrality by 2050.

"Carbon neutrality" means maximizing GHG reduction efforts through strategies like energy efficiency, clean electricity, and zero-emission technologies. Any remaining emissions are then balanced out by removing them directly from the atmosphere through natural sequestration or direct air capture technologies, among other solutions.

To tackle this challenge, world leaders developed the Paris Agreement — a legally binding, international treaty with a goal of holding the global average temperature increase to well below 2°C (3.6°F) above pre-industrial levels and pursuing efforts to limit the temperature rise to 1.5°C. The United States re-joined the Paris Agreement in 2021 and developed a nationally determined contribution of reducing net GHG emissions by 50-52% below 2005 levels by 2030.

## Relevance to Prince William County

In Prince William County, climate change is a pressing reality already impacting the community, not a distant issue for future generations to address. Our local impact mirrors a global trend where urban areas contribute significantly to the problem by generating much of the world's energy related GHG emissions.<sup>10</sup> Daily activities are part of this large puzzle. For instance, whenever we power our vehicles and buildings with fossil fuels, treat and dispose of solid waste and wastewater, leak refrigerants and natural gas, or carry out agricultural practices, we are contributing to the production of these emissions. Each action, seemingly small on its own, adds up to our collective footprint on the climate. These emissions have contributed to the dangerous levels of climate change our county experiences today.

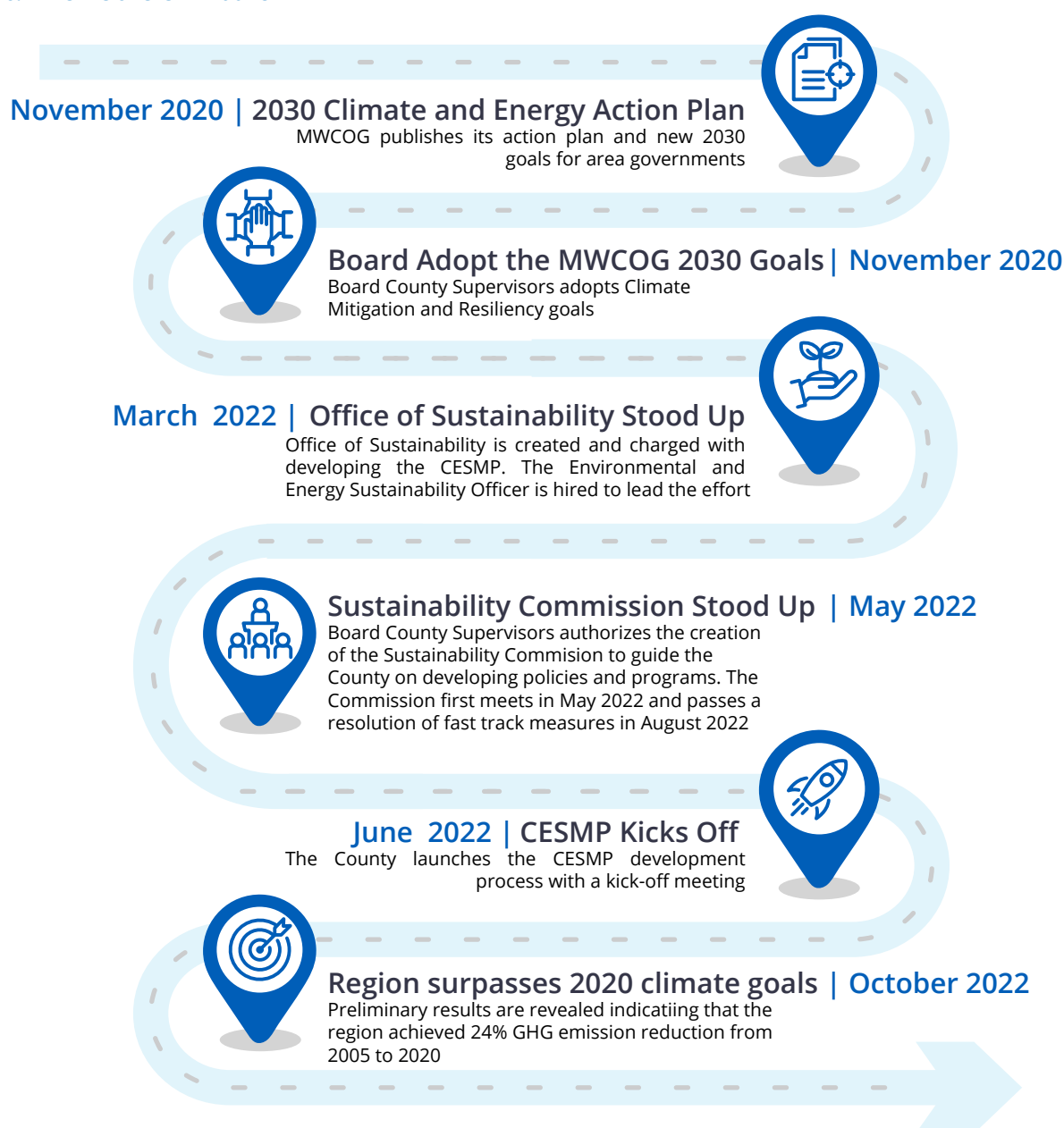
Looking back over the 20th century, our county and Virginia have experienced increased average temperatures more than 0.83°C (1.5°F) and a small upward trend in annual total precipitation with multiyear values mostly above average since 1995 based on data compiled for the National Climate Assessment.<sup>41</sup> Virginia was affected by 82 of the 290 U.S. billion-dollar disaster events that occurred between 1980 and 2020. Analysis developed for our Vulnerability Assessment (**Chapter 3 Vulnerability Assessment**) confirm these trends and project increased sea level rise throughout the 21st century. Virginia is projected to experience an increased number and intensity of extreme precipitation events

and increased intensity of droughts. This results in economic, ecologic, health, and social impacts including infrastructure damages, erosion, road closures, loss of power, saltwater intrusion, loss of important coastal ecosystems, increased dangerously hot days, and harmful effects on farming and fishing.

## Climate Actions we are Currently Taking

This CESMP is not the first step we are taking to act on this growing concern. The roadmap in **Figure 6** lays out our journey, showcasing key milestones we have hit in confronting climate change.

**Figure 6. Timeline of CESMP Launch**

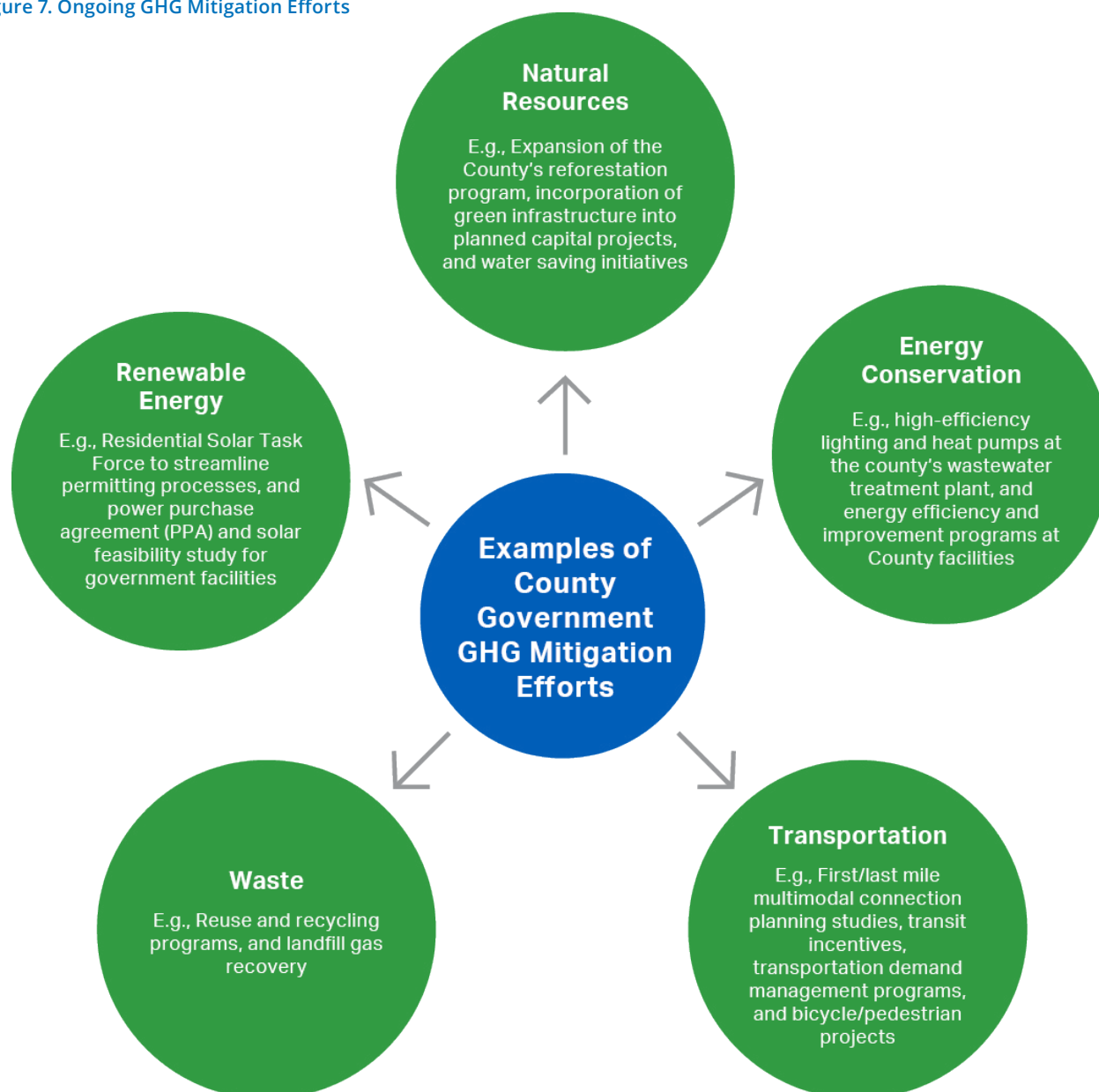


## Ongoing Progress on Climate Action

The County is already pursuing many programs, projects, and actions that benefit GHG reduction or climate adaptation. As a starting point, we reviewed established programs, policies, and actions that are already underway. We wanted to avoid developing new actions based on programs already funded and underway. We will continue to support, staff, advertise, bolster, and fund existing programs so they continue to have a positive effect toward the goals and reduction targets. However, the CESMP actions in [Chapter 4 CESMP Actions](#) largely focus on implementation and start-up of new efforts.

Examples of our ongoing GHG mitigation efforts, by area, are described in [Figure 7](#). For a full list of our current efforts, please refer to [Appendix D. Existing County Government Actions](#).

**Figure 7. Ongoing GHG Mitigation Efforts**



The Sustainability Commission is a public advisory body appointed by the Board of Supervisors tasked with advising on CESMP development. In addition to the County's ongoing efforts, the Sustainability Commission provided recommendations for "fast-track" climate mitigation and climate resiliency measures in September 2022.<sup>12</sup> The intent of the resolution was to get a head start on some actions prior to the delivery of the CESMP. This resolution resulted in the expansion of the County's reforestation program through the FY24 budget.

To address additional elements of the Sustainability Commission fast track recommendations, the Board also issued Directive 23-07 titled "Climate Mitigation and Resilience Fast-Track Measures: Clean Energy, Solar Freedom, Energy Efficiency" that directed County staff to research actions aimed at increasing the use of solar and other renewable energy sources throughout the County.

Among the ongoing programs that relate to climate resiliency, we currently maintain eligibility in the Northern Virginia Hazard Mitigation Plan for the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program and other post-disaster federal financial assistance. The County's Hazard Mitigation Workgroup was established in 2017 to implement the county-specific mitigation strategies outlined in the Northern Virginia Hazard Mitigation Plan. The County's Office of Emergency Management facilitates this Workgroup, and it includes representatives from the Departments of Public Works, Development Services, Transportation, Information Technology, Parks, Recreation, and Tourism, Public Safety Communications, Police, the Fire and Rescue System, and the Virginia Department of Transportation. Additional agencies and partners, such as utility or transportation providers, the School Division, town representatives and others are consulted on hazard-specific and project-specific strategies, as they are identified.

To date, the Workgroup has utilized a project management framework to coordinate efforts around specific grant programs and individual mitigation strategies. As flooding is one of the top hazards in the county, recent efforts have focused on collecting data on flood stage elevations in flood-prone areas, providing enhanced warning about imminent flooding conditions, and increasing participation in the National Flood Insurance Program.

In addition, the County's Office of Emergency Management coordinates our all-hazards emergency management program which includes mitigating against, preparing for, responding to, and recovering from all natural, technological, and human caused disasters. Key activities include coordination of our Hazard Mitigation Workgroup noted above, the development and maintenance of our Emergency Operations Plan and supporting operational plans, Continuity of Operations Planning, coordinating relevant training and exercises to ensure agency partner readiness for response and recovery tasks, and coordinates community outreach and preparedness activities through the Ready Prince William program.

## Chapter 2 Prince William County Greenhouse Gas Emissions

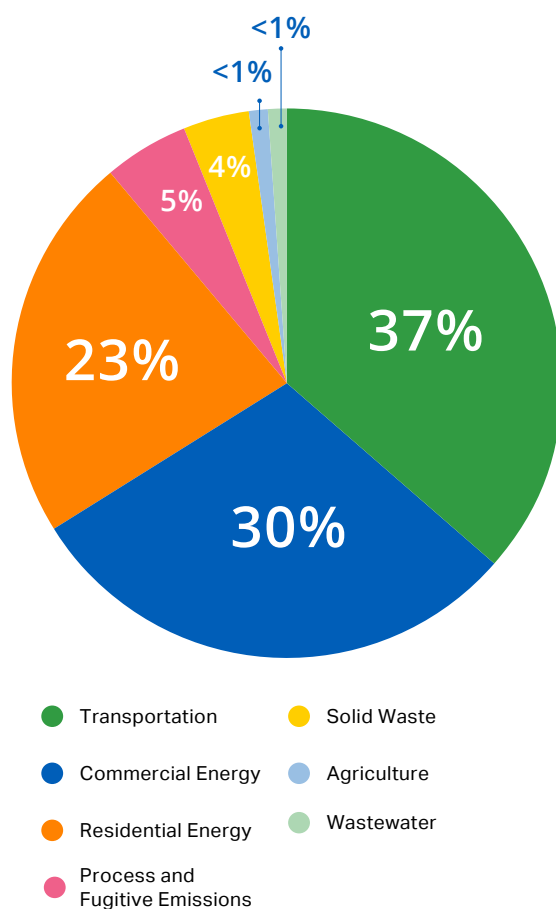
### Greenhouse Gas Inventory

One of the tools that is used to measure a community's impact on climate change is the GHG inventory. This chapter will discuss how we can use this tool to identify relevant climate actions, understand what our future GHG emissions may look like, and develop pathways to reaching GHG reduction goals.

A GHG inventory is a record of the emissions generated by a community in one year. It allows us to measure our progress, identify the largest sources of emissions, and find areas where we can make improvements. Understanding current emissions is important as we work toward achieving the climate goals.

MWCOG develops a new GHG inventory for our county every two years. **Figure 8** represents county emissions from 2018.

**Figure 8. 2018 Community-wide Emissions by Sector**





## Impact of COVID-19 on GHG Emissions

*While county emissions have been steadily increasing annually since 2005, emissions decreased by 9% between 2018 and 2020 (though emissions in 2020 were still 9% higher compared to the baseline year of 2005). The decline in emissions from 2018-2020 is most likely due to the impacts of COVID-19 restrictions, such as reduced on-road travel or non-residential building energy use, though the exact magnitude of emissions impact from these restrictions cannot be precisely measured. Additionally, studies have shown that US-wide GHG emissions are returning to pre-pandemic levels, demonstrating that COVID impacts on emissions are most likely not permanent.<sup>13</sup>*

*Therefore, while a 2020 county GHG inventory exists, the CESMP references the 2018 inventory year for forecasting and emissions reduction calculations. This represents the most recent pre-pandemic community activity levels and provides a more accurate baseline for local GHG emissions analyses. Future GHG inventories will better reflect any long-term impacts of the pandemic on county-wide emissions.*

Of our county's 2018 emissions, 37% are from transportation and mobile sources, 30% are from commercial energy, 23% are from residential energy, and the remainder are from fugitive emission sources, solid waste management, agriculture, and wastewater treatment (see [Figure 8](#)). It's important to understand that more than half of total emissions are generated by electricity used in the commercial and residential sectors. This is largely a consequence of our region's reliance on fossil fuels such as natural gas and coal for electricity generation (see [Appendix F. Greenhouse](#)

[Gas Inventory and Analysis](#)) for the regional electric grid resource mix). Additionally, on-road transportation generated about a third of total emissions. Given that the building energy and transportation sectors produce 90% of total emissions, the path to our ambitious 2030 emissions reduction goal necessitates a strategic focus on these sectors. A more detailed summary of the 2018 GHG inventory is also provided in [Appendix F. Greenhouse Gas Inventory and Analysis](#).





## Impact of Forests and Trees on the GHG Inventory

*Historically, our county's GHG inventories have included emissions from buildings, transport, waste, and agriculture. These inventories did not consider emissions or removals of CO<sub>2</sub> from other land uses such as forests. Different land use types have different levels of carbon stocks, or stores of carbon in biomass, litter, dead wood, and soils. The net GHG effect of land use is estimated based on the change in these carbon stocks. In the United States, land use is a net sink where removals of CO<sub>2</sub> exceed emissions of CO<sub>2</sub>, mostly due to forests and trees outside forests (collectively called forests and trees) that sequester carbon through photosynthesis.*

*Recent IPCC reports state that all mitigation pathways compatible with limiting global warming to 1.5°C also involve significant CO<sub>2</sub> removal from the atmosphere, highlighting the importance of maintaining and expanding the ability of forests and trees to capture and store carbon. These carbon sinks help to offset other sources of GHG emissions, including those produced by combusting fossil fuels.*

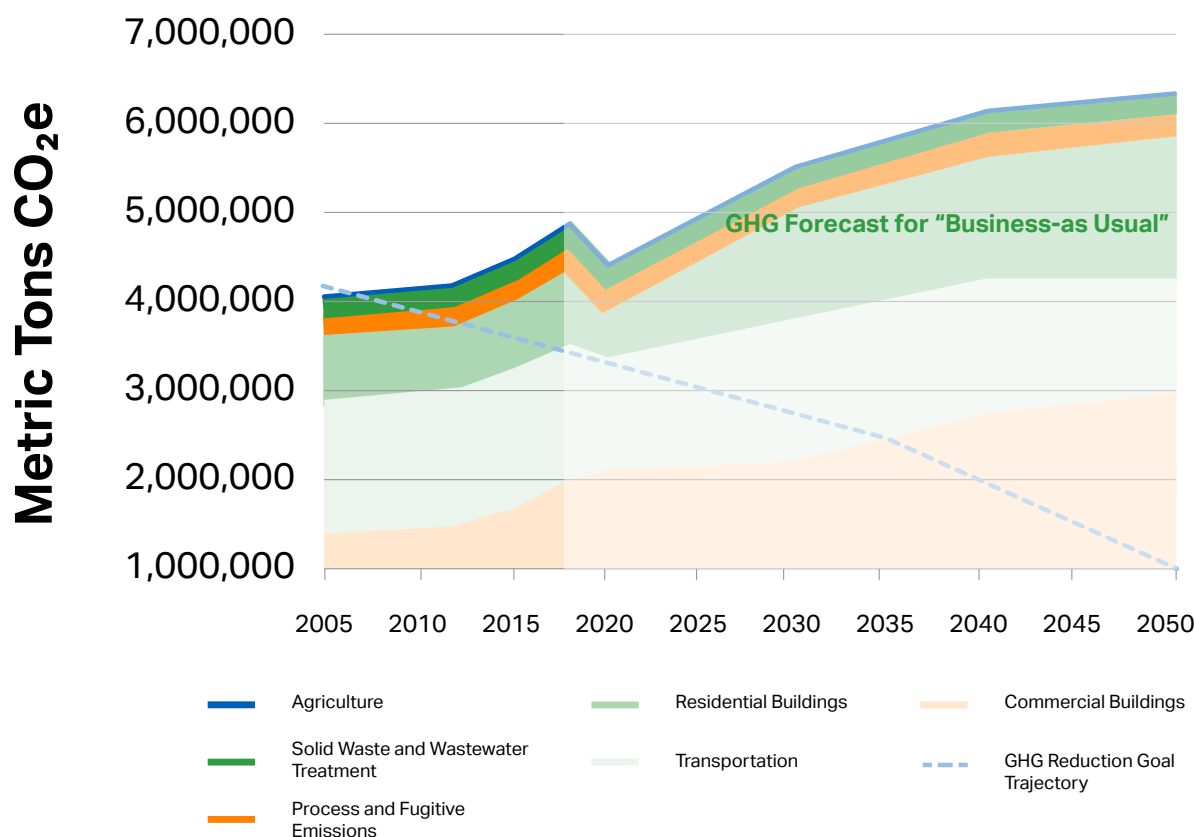
*To calculate the GHG impact of forests and trees on community GHG inventories, the average annual change (gain and loss) in forest and tree canopy as well as how much forest and tree canopy is unchanged over the GHG inventory cycle must be estimated. To enhance local GHG inventories, MWCOG calculated CO<sub>2</sub> emissions and removals due to forests and trees in our county from 2005 to 2020. The estimated CO<sub>2</sub> emissions are due to forest conversion and loss of trees while the CO<sub>2</sub> removals are due to CO<sub>2</sub> sequestration in existing forests and trees, and the addition of new forests. This data showed that including forest and tree emissions and removals in the county's GHG inventories would decrease total annual emissions through 2020 by approximately 7%, as local forest and tree CO<sub>2</sub> removals exceeded emissions.*

*However, MWCOG noted that there are significant uncertainties in the estimates for 2005-2020. Typical GHG inventories of forests using similar approaches, including the national GHG inventory, report uncertainties in the net GHG balance that can be as high as ±45% (with 95% confidence). While uncertainties can be high, the estimates still provide useful information on the relative magnitude and importance of such GHG fluxes. Forest and tree emissions data was not available until after the county-wide GHG analysis was complete. Due to the uncertainty of the data, the CESMP has not included forest and tree emissions or removals in the 2018 inventory, emissions forecasting, or primary GHG reduction scenario development. However, the plan does include actions to promote the preservation and expansion of forests and trees (see actions N.1, N.2, and N.3). Additionally, forest and tree emissions and removals were not included in the county's GHG emissions forecasts. Further discussion of forest and trees potential impact on the forecasts and meeting the 2030 GHG reduction goal is included in Chapter 5 Meeting the County Goals.*

## Greenhouse Gas Forecasts

While the 2018 inventory provides a recent snapshot of our county's GHG emissions, it's important to understand how the GHG emissions may change in the future. Our forecast in **Figure 9** below paints a picture of a "business-as-usual" emissions scenario, illustrating how emissions could evolve if no additional climate actions are initiated at either local, state, or national levels. The forecast considers regional and local growth indicators, such as increases in households, population, building square footage, employees, and vehicle miles traveled. While accurately forecasting GHG emissions is challenging due to the multitude of influencing variables, we are committed to periodically updating these forecasts as more current information becomes available. This approach allows us to continuously reassess our strategies and actions in our mission to reduce emissions.

**Figure 9. GHG Emissions Business-as-Usual Forecast and Target Trajectory**



The forecast illustrated in **Figure 9** shows how emissions in each sector are estimated to change over time in a business-as-usual scenario from 2005 to 2050. Data from 2005-2020 was provided through the MWCOG greenhouse gas inventories. Data for 2021- 2050 was forecasted through projections using the County's growth factors established in the Comprehensive Plan. The dotted line shows approximately where emissions levels should be to maintain a trajectory toward our goal of 50% GHG reductions compared to 2005 levels by 2030. The target trajectory line extends to carbon neutrality by 2050 for illustrative purposes only, as this is the target recommended by the IPCC. Though the Board has adopted a carbon neutrality target for County government operations by 2050, it has not adopted this target for the entire county.

The forecast shows that emissions are projected to increase by 37% from 2005 to 2030 and 57% from 2005 to 2050. The difference between the top forecast line (i.e., top of the colored chart) and dotted goal line demonstrates that ambitious climate action will be needed to meet our 2030 reduction goal and potential future 2050 reduction goal.



## Impact of Data Centers

*The GHG emissions forecast includes projections from our Comprehensive Plan to estimate emissions from new data centers being built in our county through the year 2050. Data centers are typically much more energy intensive than other commercial buildings as they require substantial electricity to maintain and cool their servers. However, many data centers in our county have set corporate energy and emissions reduction goals. For example, some existing data centers in the county are already procuring 100% clean electricity for their operations. Many actions in the CESMP address new data center emissions and could help data centers meet their energy and emissions goals. The actions provided in Appendix A. Complete List of CESMP Actions, including action E.1: Acquire Clean Electricity Sources for the County, action E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives, action E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings, action E.4: Promote Existing Green Power Products, action B.1: Encourage Energy Efficiency and Electrification Retrofits, action B.2: Propose Green Zoning Regulations, action B.3: Encourage Energy Efficient and Electric New Construction, action B.4: Promote Energy Efficiency and Electrification Incentives, and action B.8: Implement Building Energy Benchmarking.*

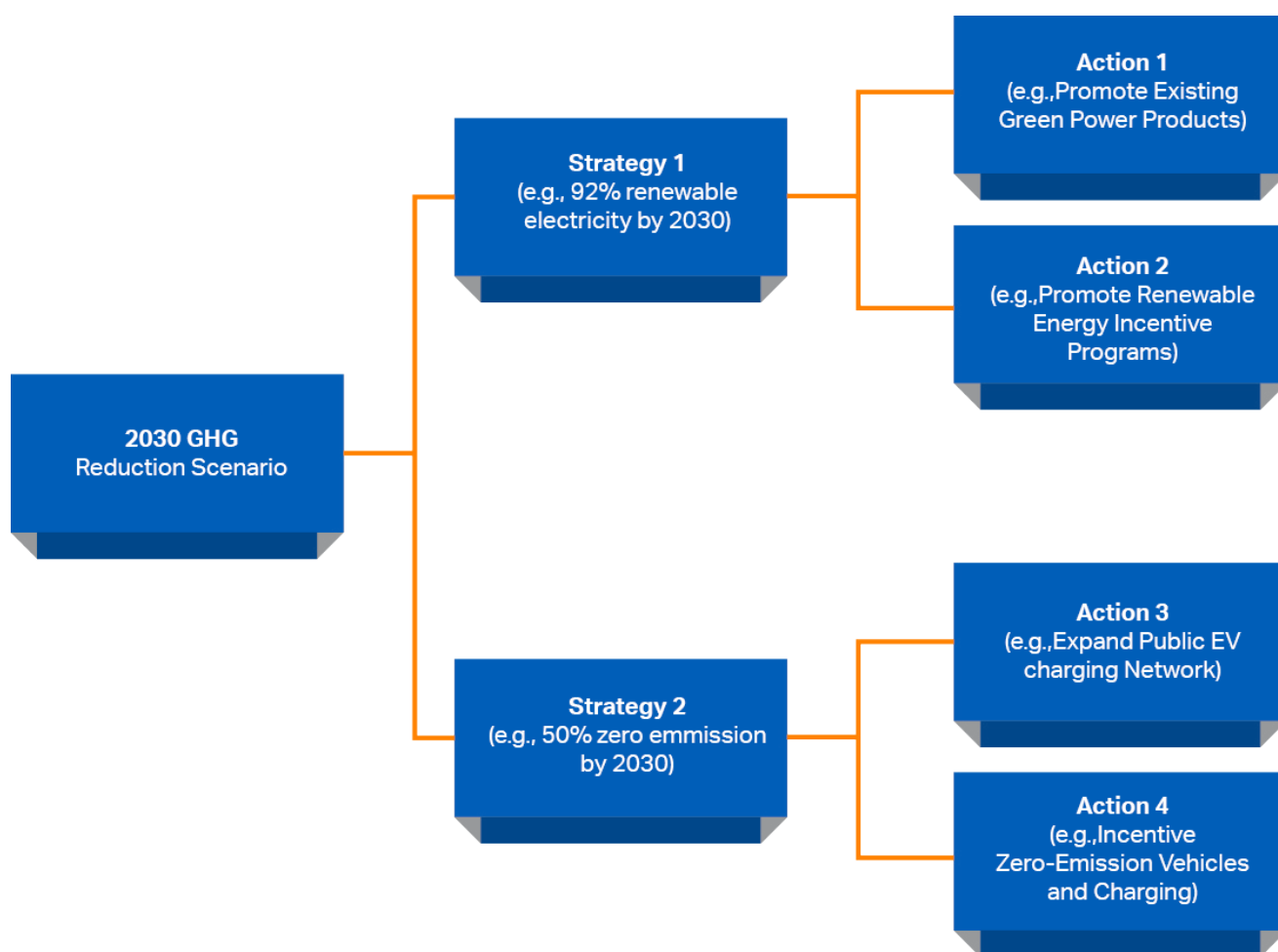
*Through a directive by the Board of County Supervisors in January 2023, County government staff have established a Data Center Ordinance Advisory Group, comprised of residents, industry representatives and other stakeholders, to advise the County government on the development of Regulatory Ordinance changes that will address data center development impacts.*



## 2030 GHG Emissions Reduction Scenario

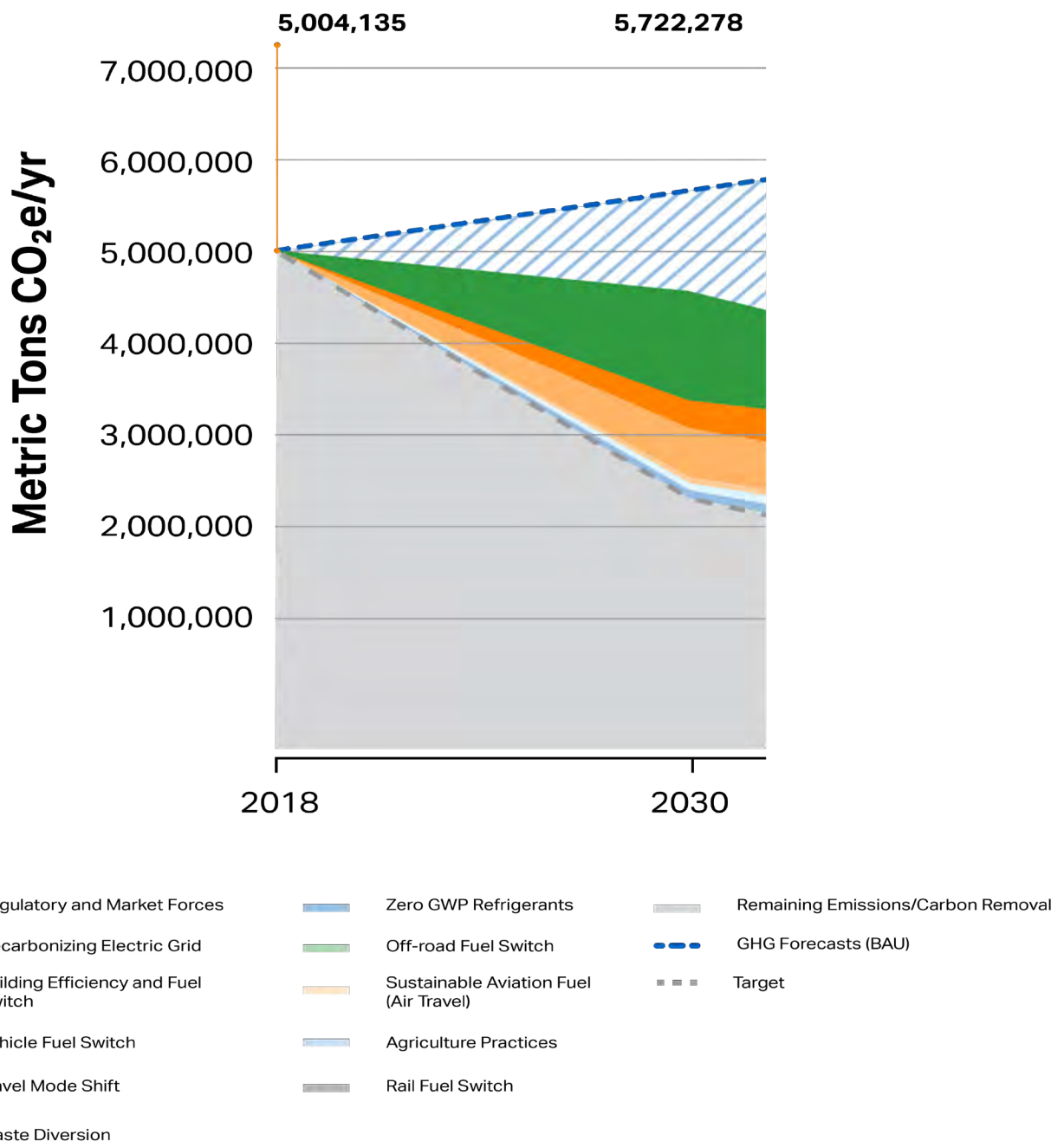
To understand what it will take to achieve the 2030 GHG reduction goal, we developed a preferred GHG reduction scenario. A GHG reduction scenario represents a group of high-level technological strategies that are needed to reach the 2030 reduction goal. Examples of technological strategies include switching electricity generation sources from fossil fuels to renewables, travel mode shifting from single-occupancy vehicles toward active and public transportation, and electrifying buildings. However, these strategies and their underlying implementation rates might be different than what is politically or financially feasible. The purpose of these scenarios and strategies is to show what it will take for us to reach our 2030 reduction goal, demonstrate where climate action is needed, and guide action development. The climate actions then show what the County government can do to meet the reduction strategies and ultimately the 2030 goal. The relationship between reduction scenario, strategies, and actions is further illustrated in an example in **Figure 10** (this graphic is an example and does not list all our strategies or actions).

**Figure 10. Example of County Strategies and Actions to Reach 2030 Goal**



GHG reduction scenarios can be represented by “wedge charts” as illustrated in **Figure 11**. The top line represents the emissions forecast and the bottom line shows the GHG goal trajectory. The colored wedges in between those two lines illustrate the magnitude of GHG reductions from each high-level technological strategy shown in the legend. Each wedge represents the emissions reduced through that strategy, with larger wedges representing greater emissions reductions. Any remaining emissions not addressed by GHG reduction strategies are shown in the grey area at the bottom of the chart.

**Figure 11. 2030 Greenhouse Gas Reduction Scenario**





The strategies included in our GHG reduction scenario, or what it will take to reach the 2030 goal, are as follows (2018 is used as the base year for comparison):

- ▶ **Decarbonize Electric Grid:** 92% of the electricity used in the county is from clean energy sources (e.g., solar, wind, hydropower, nuclear, and geothermal) — this includes the renewable energy added to the grid through Virginia's Renewable Portfolio Standard
- ▶ **Building Efficiency and Fuel Switch:** 40% of fossil fuel building systems (e.g., space or water heaters) are transitioned to highly efficient electric options (e.g., heat pumps) and 100% of lighting and appliances are highly efficient (e.g., LED lights, Energy Star appliances)
- ▶ **Vehicle Fuel Switch:** 50% of passenger and medium-duty vehicles traveling within the county are electric or zero-emission vehicles — this includes the consideration of current regulations related to electric vehicles
- ▶ **Vehicle Miles Traveled (VMT) Reduction:** 5% reduction in passenger vehicle travel by reducing the number of miles traveled or shifting to active or public transport (e.g., biking, walking, or taking the bus)
- ▶ **Waste Diversion:** 60% of solid waste produced in the county is diverted from landfill (e.g., recycled, composted, reused)
- ▶ **Zero Global Warming Potential (GWP) Refrigerants:** 57% of hydrofluorocarbons (HFCs) are replaced with low- or zero-global warming potential alternatives — this includes the reduction in HFC use under the Kigali Amendment
- ▶ **Off-road Fuel Switch:** 15% of off-road equipment is electric or produces zero emissions — this includes market forecasts for electric off-road equipment adoption
- ▶ **Sustainable Aviation Fuel:** 20% of county-related air travel emissions are reduced
- ▶ **Agricultural Practices:** 10% of agricultural emissions are reduced

The top three strategies that provide nearly 90% of the reductions needed to achieve the 2030 goal include:

- ▶ **Decarbonize Electric Grid:** 92% of the electricity used in the county is from clean energy sources (e.g., solar, wind, hydro, nuclear)

- ▶ **Vehicle Fuel Switch:** 50% of passenger and medium-duty vehicles traveling within the county are electric or zero-emission vehicles
- ▶ **Building Efficiency and Fuel Switch:** 40% of fossil fuel building systems (e.g., space or water heaters) are transitioned to highly efficient electric options (e.g., heat pumps) and 100% of lighting and appliances are highly efficient (e.g., LED lights, Energy Star appliances)

Because all other sectors and strategies contribute a relatively small amount to total emissions, there is no path to 2030 goal achievement without incredibly aggressive progress in the three areas mentioned above: clean electricity, transportation and vehicle fuels, and building energy. The methodology for developing these strategies and why certain external regulatory or market forces (e.g., the Inflation Reduction Act or the Infrastructure Investment and Jobs Act) were not integrated into the GHG reduction scenario are included in **Appendix F. Greenhouse Gas Inventory and Analysis**.

After establishing the preferred 2030 reduction scenario, we developed a list of feasible actions we could pursue to meet these strategies (see **Chapter 4 CESMP Actions**). While the GHG reduction scenario and strategies shows *what it will take* to achieve the 2030 goal, the GHG actions shows *what we can* do to achieve the strategies and ultimately the 2030 goal. However, because many of these emissions sources are out of the County government's direct control, County government action alone will not necessarily achieve the GHG strategies or the overall GHG reduction scenario to meet the 2030 goal. The ability to achieve these strategies relies on significant external support from market factors and state- and national-level regulation. We have identified where external assistance is needed to meet the GHG reduction strategies and our role in promoting these external forces through advocacy or partnerships in **Chapter 5 Meeting the County Goals**. Further discussion of how we could consider forest and tree CO<sub>2</sub> removals and carbon offsets to meet the 2030 GHG reduction goal is also included in **Chapter 5 Meeting the County Goals**.



## Addressing Goals Related to GHG Emissions

The CESMP is meant to address how we could meet the community-wide goal of 50% emissions reduction from 2005 levels by 2030 through local climate action. The Board also established three other emissions-related goals<sup>14</sup>, including:

- ▶ Sourcing 100% of county-wide electricity from renewable sources by 2035
- ▶ Achieving 100% renewable electricity in County government operations by 2030
- ▶ Achieving 100% carbon neutrality in County government operations by 2050

We define renewable electricity as electricity coming from any non-fossil fuel energy source, such as solar, wind, hydro, geothermal, and nuclear. Because the definition of renewable electricity can differ among communities, the CESMP uses the term “clean electricity” instead to mean any non-fossil fuel energy source.

Though achievement of these additional goals was not specifically analyzed in the CESMP, the climate actions developed in the plan can contribute to achievement of these goals. A qualitative discussion of how the plan actions can contribute to these goals is provided in **Chapter 5 Meeting the County Goals**.



## Chapter 3 Vulnerability Assessment

The County has committed to preparing for the impacts of climate change through our goal of becoming a Climate Ready Region by 2030. In line with this commitment, we have concentrated our efforts on understanding the susceptibility of our county's people and infrastructure to local climate hazards, paving the way for resilient action plans that meet the community's most pressing needs. The fruits of this undertaking were realized with the completion of a comprehensive vulnerability assessment in January 2023. This evaluation was designed with an emphasis on anticipating future conditions that could amplify existing vulnerabilities. A detailed report can be found in [Appendix G. Vulnerability Assessment Report](#).

In the context of our conversation, a “vulnerable asset” refers to an essential resource that forms the backbone of our community. These assets encompass a broad range of elements, including our critical infrastructures like transportation systems, public buildings, and utilities; natural resources such as parks, water bodies, and green spaces; as well as economic drivers like businesses, industries, and development projects. Moreover, these assets include the invaluable human capital that is our diverse and dynamic community members, who continually contribute to the growth and resiliency of our county.

To be a Climate Ready Region by 2030, local governments are asked to assess current and future climate risks and work to actively integrate climate planning across government plans, operations, and communications. Climate hazards exist today, will increase in severity through 2030, and these same climate hazards will pose the greatest threats to our county in the middle or late part of the twenty-first century. Any investments in infrastructure that are initiated by 2030 to meet the goal of being a Climate Ready Region, will be in-place for many years beyond that. Therefore, the vulnerability assessment evaluated climate threats for the years 2050 and 2075 as planning timelines that are more in-line with long-term infrastructure lifetimes. By making changes by 2030 with a focus towards longer-term threats, we will ensure that it is focused on projects that will provide a more resilient future.

Our vulnerability assessment methodically catalogued pertinent assets, gauged their exposure to climate hazards, and assigned ratings for each asset's sensitivity and adaptive capacity.

The succeeding chapter provides a comprehensive overview of the climate hazards relevant to our county, which assets are most prone to impacts, and offers a summary of the assessment results.

Under the leadership of our County Officials, the County remains dedicated to these climate resiliency efforts. We understand the importance of coordinated actions and continuous adaptations to face the ongoing challenges posed by climate change.

The results of the vulnerability assessment were used to assist in developing climate adaptation actions that consider natural hazards and the most vulnerable asset categories. Further details on action development, evaluation, and prioritization can be found in [Chapter 4 CESMP Actions](#).

### Climate Hazards

We reviewed the following climate hazards to assess the vulnerability of our county's assets and vulnerable populations:

- ▶ Precipitation
- ▶ Temperature
- ▶ Drought
- ▶ Coastal storms, sea level rise
- ▶ High winds/tornadoes

As part of our dedication to maintaining the well-being of the county, we diligently appraised the present-day risks posed by all climate hazards as well as future conditions for the precipitation, temperature, drought, and sea level rise climate hazards for the years 2050 and 2075. The impacts of the climate hazards can vary depending on the amount of change as well as the scale. For example, a high quantity or high intensity of precipitation will impact both the stormwater systems and overland flooding as well as streams and rivers; however, low amounts will produce similar risks as droughts. For the temperature, both high heat and extreme low temperatures were evaluated for the threat to our county. While coastal storms will produce severe impacts, they occur infrequently whereas sea level rise (which can affect the impact of coastal storms) will produce permanent inundation. The results of the climate hazard analysis were used to evaluate the vulnerability of various groups of county assets.

## County Assets

The Vulnerability Assessment groups our county's assets into categories intended to align with FEMA's Community Lifelines.<sup>15</sup> This approach aligns with the guidelines followed by the County's Office of Emergency Management.

In this study, we have integrated FEMA's energy and hazardous materials Lifeline categories. In addition, we have expanded the scope to include two more essential categories: our natural resources and socially vulnerable populations. These categories recognize the importance of our environment and underscore our commitment to inclusivity, ensuring that every resident's needs are acknowledged and addressed.

Each asset, integral to the fabric of our county, within these categories is defined and mapped out in [Appendix G. Vulnerability Assessment Report](#). Below, we delve into the types of assets that underwent evaluation in our assessment. These assets are not just mere resources but the pillars of our community, the drivers of our economy, and the protectors of our way of life.

### Types of County Assets and Infrastructure Evaluated for Vulnerability



Safety and Security



Food, Water, and Shelter



Transportation



Communications



Natural Resources



Socially Vulnerable  
Populations



Health and Medical

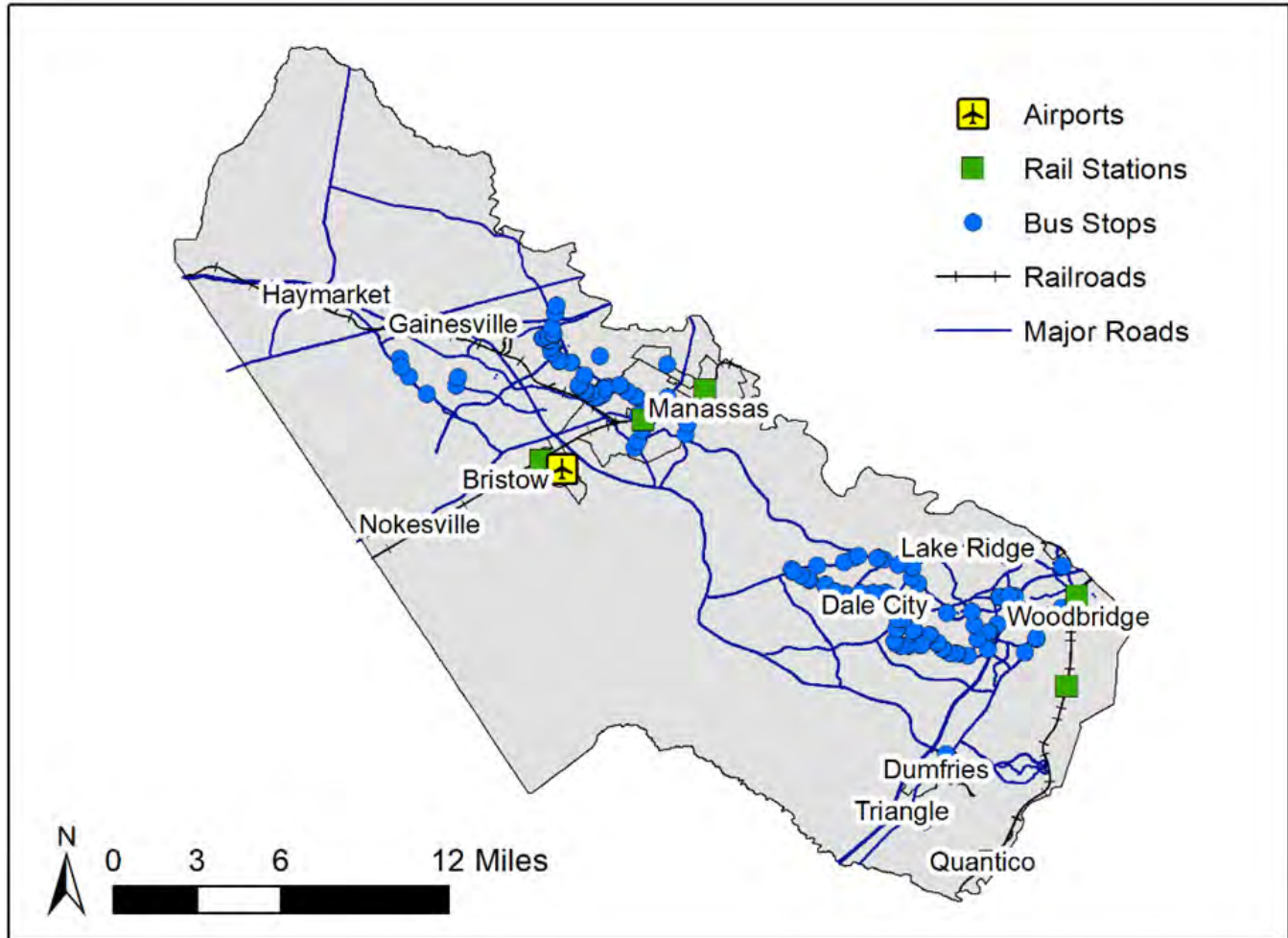


Energy and Hazardous  
Materials



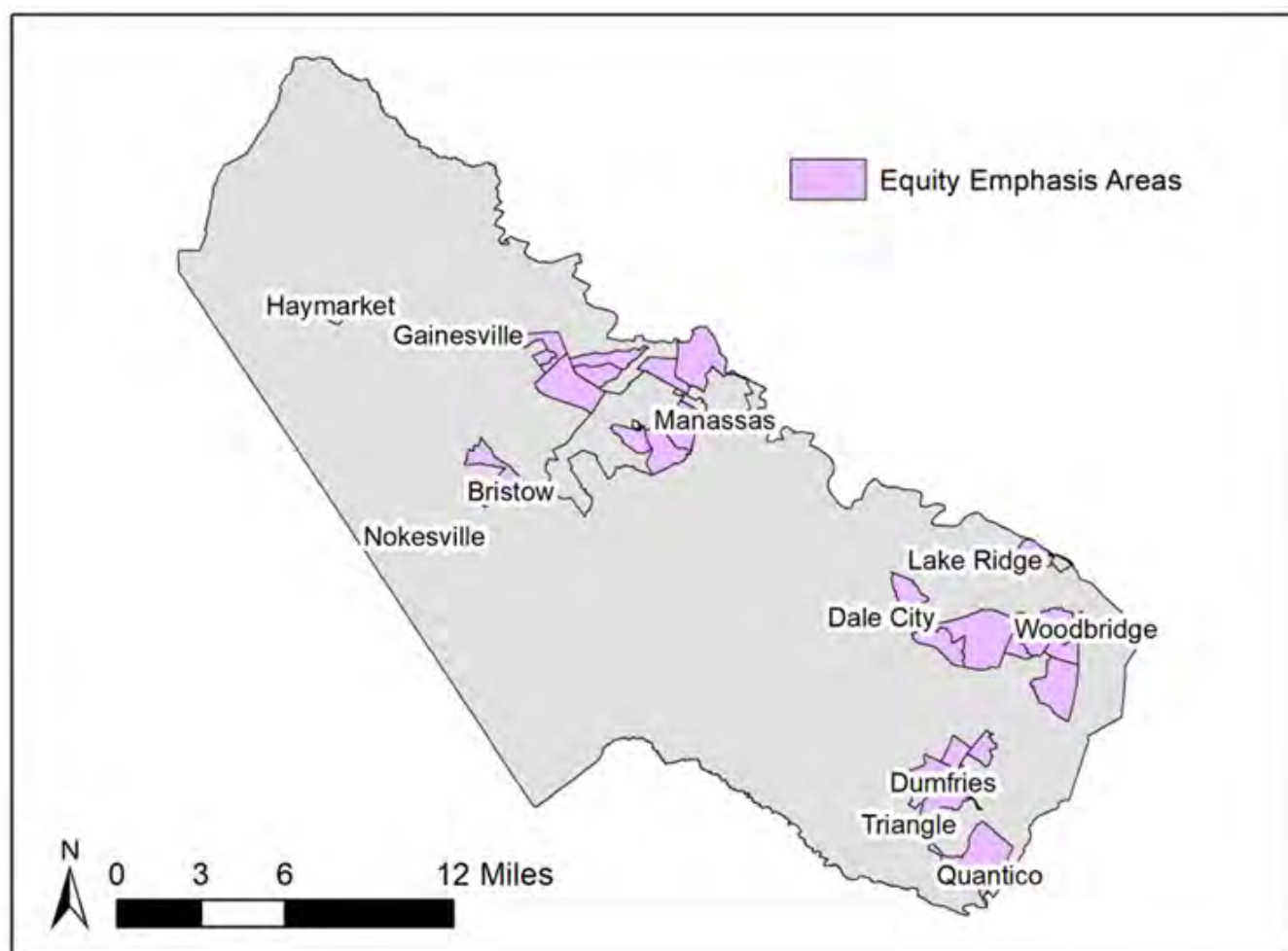
**Figure 12** below is an example graphic showing the location of transportation infrastructure evaluated for vulnerability to climate change. In addition to the airports, rail stations, railroads, bus stops, and major roads shown in the figure, minor roads, commuter parking lots, sidewalks, bridge locations, port facilities, heliport locations, stormwater management facility locations, stormwater management lines, and culvert geospatial layers were included in the analysis.

**Figure 12. Major Roads, Railroads, Bus Stops, Rail Stations, and Airports included in the Transportation Asset Category**



Though not fitting the traditional definition of an "asset" category, our assessment includes socially vulnerable populations as a crucial group. To demarcate these populations, we have adopted the use of Equity Emphasis Areas (EEAs), as delineated by a methodology developed by The National Capital Region Transportation Planning Board. The EEAs were developed using tract-level Census data to identify areas that have a significant concentration of low-income and/or minority populations. To identify areas of concentration, the tract percent of four parameters (low-income, African American, Asian, and Hispanic or Latino) were divided against its respective regional average, which resulted in a tract-level Ratio of Concentration. High Ratio of Concentration scores were used to designate EEAs.<sup>16</sup> In our continuous partnership for the prosperity of the community, both the MWCOG and the County have recognized and utilized EEAs as a valuable planning tool. These tools are instrumental in helping us identify and prioritize areas with socially vulnerable populations. The boundaries of these EEAs are illustrated in **Figure 13** is an example graphic showing the location of transportation infrastructure evaluated for vulnerability to climate change. In addition to the airports, rail stations, railroads, bus stops, and major roads shown in the figure, minor roads, commuter parking lots, sidewalks, bridge locations, port facilities, heliport locations, stormwater management facility locations, stormwater management lines, and culvert geospatial layers were included in the analysis.

**Figure 13. EEAs within Prince William County**



## Vulnerability Assessment

In our pursuit of safeguarding the county's vital assets, our Vulnerability Assessment employed a thorough process to determine risk. This process encompassed the evaluation of exposure, sensitivity, and adaptive capacity for each asset category and each natural hazard. Here is a brief description of what each of these measures entails:

- ▶ **Exposure** quantifies whether an asset is affected by a climate hazard, and if so, the degree of impact
- ▶ **Sensitivity** evaluates the extent to which an asset is impacted when exposed to a climate hazard
- ▶ **Adaptive capacity** gauges the capability of an asset to adjust, recover, or resiliently respond to damage inflicted by climate hazards

Based on these metrics, our assessment determined that the following climate hazards exert the most substantial impact on our assets today and for future projections:

- ▶ Extreme Temperatures
- ▶ Precipitation
- ▶ Strong Winds/Tornadoes

Although coastal storms and sea level rise will have a significant impact on areas of the county located along the Potomac River, the overall risk to our county was low due to the limited amount of assets in the coastal floodplain. Drought is a potential threat to the county; however, it was rated low due to the moderate drought projections countered by the projected increase in precipitation. Earthquakes were evaluated but determined to be of low risk to our county.

In our endeavor to quantify the vulnerability of the county's crucial assets, we assigned numerical values to each rating. These were then added together to calculate vulnerability scores for each asset category, considering each natural hazard and future time horizon. This gave us an assessment of potential risks and challenges we face.

To further streamline our evaluation, the vulnerability scores within each asset category were amalgamated. This collective data was used to attribute a Low, Medium, or High combined vulnerability rating. These ratings offer a clear depiction of the potential risks for two future timelines - the years 2050 and 2075. The specifics of these vulnerability ratings are presented in **Table 3**.

**Table 3. Summary of Combined Vulnerability Ratings (2050 and 2075)**

Asset Category	Combined Vulnerability Rating	
	2050	2075
Natural Resources	H	H
Socially Vulnerable Populations	H	H
Transportation	H	H
Energy & Hazardous Materials	M	H
Food, Water, and Shelter	M	M
Health and Medical	M	M
Safety and Security	L	L
Communications	L	L

The ratings detailed in **Table 3** offer us an understanding of how susceptible each asset category might be to specific future climate hazards. As a synopsis, our natural resources, socially vulnerable populations, and transportation systems emerge as the asset categories with the highest combined vulnerability ratings across all hazards. These ratings apply to both the projected scenarios of 2050 and 2075. Although these vulnerability ratings are for the future, natural resources, socially vulnerable populations, and transportation are currently the most impacted assets by climate hazards.

These findings guided us in crafting climate adaptation actions and helped assign their respective adaptation scores during the action development and prioritization process.

## Chapter 4 CESMP Actions

The CESMP is a guide to action. The actions listed and described in this plan signify a definitive step toward reducing GHG emissions and adapting to climate change. Using the goals as a guide and the analysis completed in Chapters 2 and 3 as a means of understanding our current situation, we now delve into what the actions actually are. Subsequent sections provide some background on how the actions were developed, how the actions can be used to achieve the goals, and more description of the actions themselves.

### How the Actions were Developed

The list of CESMP actions demonstrate what we can do to reduce emissions and adapt to climate change. The first step in the action development process was to identify current policies and programs that support the 2030 GHG reduction strategies discussed in **Chapter 2 Prince William County Greenhouse Gas Emissions** and address local climate hazards. This helped us understand what's already been done or what actions are currently ongoing. We then wanted to understand the limitation on how much control the County government has to make changes. Finally, we determined areas of opportunity for new action development.

Simultaneously, we identified our community's GHG emissions sources (Chapter 2) and potential vulnerabilities to future climate hazards (Chapter 3), to lay the groundwork for a detailed list of ways to address the Board of County Supervisor goals.

The complete list of new actions is provided in **Appendix A. Complete List of CESMP Actions**. If an action was already underway or in the planning phase and did not need additional support or modification, it was not included in the CESMP list of actions, but rather, considered an existing action and included in **Appendix D. Existing County Government Actions**.

## Action Evaluation and Prioritization

The initial draft list of actions underwent a rigorous evaluation process. We assessed their benefits to our community, how well the actions reduce GHG emissions, community health benefits, and improvements to quality of life. We also considered the likelihood the action could be completed considering our resources and how much authority the County government has.

The actions were evaluated using the Climate Action Selection and Prioritization (ASAP) tool. ASAP is a decision-making tool that helps users understand the trade-offs between primary benefits, co-benefits, and feasibility across a range of actions. The ASAP tool is designed to support decision-making, not make decisions itself. By leveraging tools like ASAP, we ensure that every step we take toward a sustainable future is informed, strategic, and advantageous for our community.

During this evaluation process, all actions were evaluated for their impact on specific evaluation criteria. Each evaluation criterion was divided into one of three categories: primary benefits, co-benefits, and feasibility.

- ▶ **Primary Benefits:** An estimate of GHG reduction and climate hazard risk reduction resulting from the actions
- ▶ **Co-benefits:** Benefits that actions may have in addition to the primary benefits
- ▶ **Feasibility:** How easy or difficult it is to implement the action

At the heart of our CESMP is a fundamental commitment to curb GHG emissions and mitigate climate risk. These two aspects were the primary benefits considered in our action evaluation. Additionally, the voices of our community are pivotal to our planning process. Hence, we sought extensive input from our stakeholders. Both County government staff and community members provided feedback on co-benefit and feasibility criteria that are integral to our collective values. The key criteria identified by most stakeholders are detailed in **Table 4**.



Table 4. Action Evaluation Criteria

Criteria Category	Criteria Name	Criteria Definition
<b>Primary Benefits</b>	GHG Reduction Potential	An estimate of GHG reduction potential resulting from the action.
	Climate Risk Reduction Potential	An estimate of climate hazard risk reduction resulting from the action.
<b>Co-Benefits</b>	Organizational Diversity, Equity, and Inclusion	Impact on social, environmental, or economic disparities such as disproportionate levels of air quality, health impacts, access to transit, flood risk, energy burden etc.
	Resource Conservation	Impact on natural resources, such as air, water, raw materials, and the natural environment.
	Savings to Residents and Businesses	Additional costs or savings to residents and businesses.
	Local Employment	Impact on the employment rate, physical access to jobs, income and social mobility, and/or total number of jobs.
<b>Feasibility</b>	Funding Source Identified or Secured	Has full or partial public funding for this action been secured, or has a potential funding source been identified?
	Cost to the County Government	What is the magnitude of upfront, operational, and staffing costs to the County government from the implementation year to 2030?
	Cost Savings to County Government	An initial investment that lowers costs paid by the County government such that cost savings could be used to fund other climate change/adaptation programs.

Each action was rated and scored in the ASAP tool to be compared relative to the other actions. Once scored, the results were reviewed, modified, and vetted by stakeholder groups to answer the question: what 25 actions should we begin with first?

We extended the conversation to the broader community through a public survey and a Townhall meeting, further enriching our understanding of public priority actions. This process resulted in the identification of high, medium, and low priority actions, as defined in [Table 5](#).

**Table 5. Priority Level Definitions**

Priority Level	Definition
<b>High Priority</b>	<ul style="list-style-type: none"> <li>▶ Actions we will focus on implementing immediately after CESMP adoption</li> <li>▶ Actions that are fleshed out with greater detail in this plan, including Implementation Roadmaps to guide our initial steps on implementation</li> </ul>
<b>Medium Priority</b>	<ul style="list-style-type: none"> <li>▶ Actions that scored highly for primary benefits (GHG reduction and climate risk reduction) but were not included in high priority list</li> <li>▶ Actions that can serve as a starting point for future ideas after we have meaningful progress on priority actions</li> </ul>
<b>Low Priority</b>	<ul style="list-style-type: none"> <li>▶ Actions that address emissions sources within the county and fill in potential policy/programmatic gaps, but have much lower GHG reduction or climate risk reduction impacts</li> <li>▶ Actions were not favored (or were disfavored) by stakeholder groups</li> </ul>

The following describes our method of action prioritization:

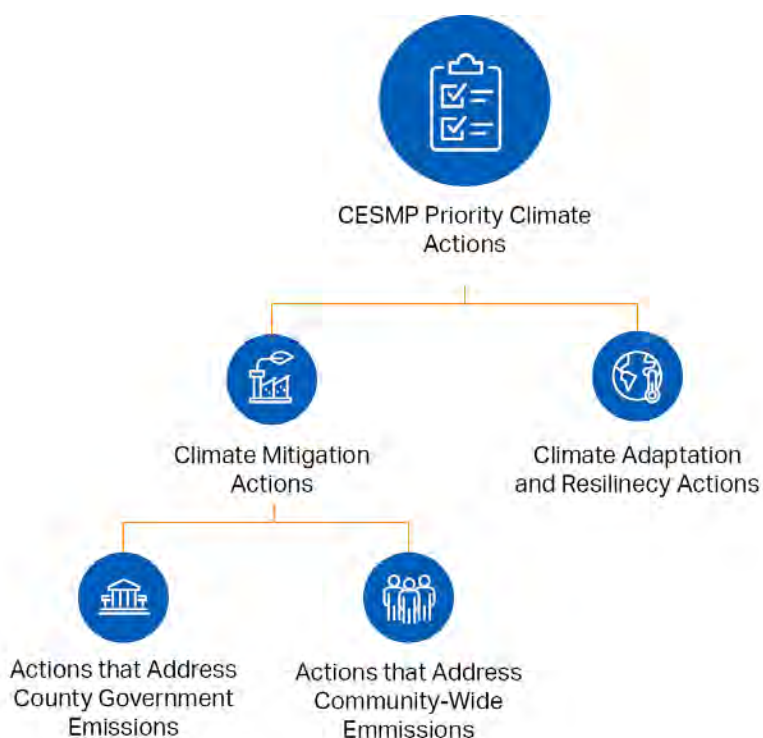
- ▶ Prioritize actions that scored highly across all evaluation categories, i.e., actions that produced high GHG or climate risk reduction, co-benefits, and feasibility scores.
- ▶ Prioritize actions that the stakeholder groups identified as high priority and integrate their feedback on prioritization considerations and methods.
- ▶ Prioritize other actions that produced high GHG reduction or climate risk reduction scores to reach 25 actions as reducing emissions and addressing climate risk are the main goals of the CESMP.

The action development process resulted in 25 high priority actions, 23 medium priority actions, and 11 low priority actions. The following sections describe the 25 high priority actions in more detail.

Additionally, Implementation Roadmaps were developed for each high priority action in [Appendix B. Implementation Plan](#).

## How to Read the List of Actions

The sections below divide the 25 high priority actions into two groups: Climate Mitigation Actions (that reduce GHG emissions) and Climate Adaptation and Resiliency Actions (that protect us from climate hazards) as shown in the graphic below. Though they are in two separate sections, Mitigation Actions may provide adaptation benefits and Adaptation Actions may provide mitigation benefits. Mitigation Actions are then further divided by the emissions sources they address (community-wide emissions or County government emissions).



Each of the 25 high priority actions are described in more detail using the following format:

<b>Action Number:</b>	<b>Action Title:</b> Short action title	
<b>E.# = Electricity</b>		
<b>B.# = Buildings</b>		
<b>T.# = Transportation</b>		
<b>N.# = Natural Resources</b>		
<b>A.# = Adaptation</b>		
<b>Action Description:</b> A paragraph description of what the action entails.		
<b>County Goals Supported:</b> <ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> <li>▶ Achieve 100% renewable electricity in County government operations by 2030</li> <li>▶ Achieve 100% carbon neutrality in County government operations by 2050</li> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030</li> </ul>		
<b>2030 GHG Reduction Strategy:</b> <ul style="list-style-type: none"> <li>▶ Source 92% clean electricity</li> <li>▶ Achieve 50% zero-emission private vehicles</li> <li>▶ Achieve 40% highly efficient and electric heating, ventilation, air conditioning (HVAC) systems and water heaters</li> <li>▶ Replace 57% HFCs with low- or zero- GWP alternatives</li> <li>▶ Shift 5% of total trips from private vehicles to active or public transport</li> <li>▶ Achieve a 60% waste diversion rate</li> <li>▶ Obtain 100% high-efficiency lighting and appliances</li> <li>▶ Achieve 15% zero-emission off-road equipment</li> <li>▶ Reduce aviation emissions by 20%</li> <li>▶ Reduce agricultural emissions by 10%</li> </ul>		<b>Action GHG Reduction Potential*:</b> <ul style="list-style-type: none"> <li>▶ <b>Very High:</b> greater than 500,000 (MTCO<sub>2</sub>e)</li> <li>▶ <b>High:</b> 50,000-500,000 MTCO<sub>2</sub>e reduced</li> <li>▶ <b>Medium:</b> 10,000-50,000 MTCO<sub>2</sub>e reduced</li> <li>▶ <b>Low:</b> less than 10,000 MTCO<sub>2</sub>e reduced</li> <li>▶ <b>Unknown:</b> Not Quantified</li> </ul> <p>*The GHG reduction potential represents the high/maximum estimate for GHG reductions</p>
<b>Climate Hazard Addressed:</b> <ul style="list-style-type: none"> <li>▶ All Climate Hazards</li> <li>▶ Precipitation</li> <li>▶ High Winds &amp; Tornadoes</li> <li>▶ Sea Level Rise</li> <li>▶ Extreme Heat</li> </ul>		

<b>Investment Level:</b> <ul style="list-style-type: none"> <li>▶ Extremely Large Cost = &gt;\$100M</li> <li>▶ Very Large Cost = \$10M-100M</li> <li>▶ Large Cost = \$1M-10M</li> <li>▶ Some Cost = \$100k-1M</li> <li>▶ Very Little Cost = \$0-100k</li> <li>▶ None = No additional costs beyond existing staff time</li> </ul>	<b>Co-Benefits:</b> <ul style="list-style-type: none"> <li>▶ Organizational Diversity, Equity and Inclusion</li> <li>▶ Resource Conservation</li> <li>▶ Savings to Residents and Businesses</li> <li>▶ Local Employment</li> <li>▶ Cost Savings to County Government</li> <li>▶ None</li> </ul> + Somewhat Positive ++ Very Positive
<b>Lead Department(s):</b> The department(s) that will lead action implementation.	<b>Primary Partners:</b> Internal or external partners that can aid in action implementation.

The complete list of 60 CESMP actions with descriptions of each action is also provided in **Appendix A.**

**Complete List of CESMP Actions.** Further analysis and legal review by county staff and the County Attorney's Office will need to take place as recommended actions are considered for implementation.

## Climate Mitigation Actions

While our 2030 GHG reduction scenario (Chapter 2 Prince William County Greenhouse Gas Emissions) shows *what it will take* for us to achieve the 2030 GHG reduction goal, the climate mitigation actions describe *what we could do* to realize this scenario. Actions that are meant to address community-wide emissions are listed separately from actions that address County government operations emissions.

### Climate Mitigation Actions for the Community

There are 15 high priority community climate mitigation actions that address community-wide emission sources (see **Table 6**). Actions that also provide climate adaptation benefits are marked with an asterisk.

**Table 6. Climate Mitigation Actions for the Community**

Sector	Climate Mitigation Actions for the Community
Electricity	E.1: Acquire Clean Electricity Sources for the County
	E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives
	E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings
	E.4: Promote Existing Green Power Products
Buildings	B.1: Encourage Energy Efficiency and Electrification Retrofits
	B.2: Propose Green Zoning Regulations
	B.3: Encourage Energy Efficient and Electric New Construction
	B.4: Promote Energy Efficiency and Electrification Incentives
Transportation	T.1: Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity
	T.2: Encourage Transit-Oriented Development
	T.3: Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips
	T.4 Upgrade Public Transit Infrastructure
	T.5: Encourage Zero-Emission Vehicles and Charging
	T.6: Expand Public EV Charging Network
Natural Resources	N.1: Adopt Natural Open Space Requirements*



## E-1

# Acquire Clean Electricity Sources for the County

### 2030 GHG Reduction Strategy:

Source 92% clean electricity

### Action GHG Reduction Potential:

Very High

### Investment Levels:

Some Costs

### Co-Benefits:

None

### Lead Department:

Office of Sustainability

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Source 100% of county-wide electricity from renewable sources by 2035
- Achieve 100% renewable electricity in County Government operations by 2030
- Achieve 100% carbon neutrality in County Government operations by 2050

### Primary Partners:

- Facilities and Fleet Management
- Finance
- Management and Budget
- Economic Development

## Action Description:

Form an opt-out community choice aggregation (CCA) program to acquire 100% clean electricity for Dominion Energy customers in the community. A CCA would allow the County to negotiate for 100% clean or renewable electricity for all the electricity customers within their jurisdiction. Through a CCA, the County can purchase and manage their community's electric power supply from a preferred mix of energy sources while the utility continues to provide distribution, billing services, and outage management. In the county, further legal review is needed to determine if a CCA could be formed in Dominion Energy's territory and NOVEC's territory. If we develop an opt-out program, energy customers would automatically be enrolled in 100% clean electricity but can opt-out to revert to their traditional service and electricity energy source mix. This action could substantially reduce county-wide electricity emissions, depending on the offered clean electricity mix and how many customers opt-out of the program.







## E-2

# Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives

### 2030 GHG Reduction Strategy:

Source 92% clean electricity

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Very Large Costs

### Co-Benefits:

- Local Employment: +
- Cost to Residents and Business: +

### Lead Department:

- Development Services
- Real Estate Assessments
- Office of Sustainability

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Source 100% of county-wide electricity from renewable sources by 2035

### Primary Partners:

- Economic Development
- Residential Solar Task Force
- Dominion
- NOVEC

## Action Description:

Provide outreach and education on programs and incentives for residents and businesses to install renewable energy systems, such as solar tax credits, community solar programs, net metering, the multifamily shared solar program, solar renewable energy certificates, and Solarize NOVA. Develop additional local renewable energy incentives, such as streamlined solar permitting, in partnership with stakeholders such as the Residential Solar Task Force and local utilities. This would include providing a centralized tool for residents and businesses to reference relevant federal, state, county, and utility incentives and programs.





## E-3

## Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings

### 2030 GHG Reduction Strategy:

Source 92% clean electricity

### Action GHG Reduction Potential:

High

### Investment Levels:

Large Cost

### Co-Benefits:

None

### Lead Department:

- Development Services Planning Office
- Economic Development

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Source 100% of county-wide electricity from renewable sources by 2035

### Primary Partners:

- Businesses and Data Centers

### Action Description:

Encourage the use of renewable energy in energy-intensive commercial buildings through a voluntary reporting program or expedited permitting. As commercial building electricity use is forecast to generate roughly 28% of county-wide emissions by 2030, encouraging emissions reductions in this sector is crucial toward meeting the 2030 GHG reduction target.



## E-4

## Promote Existing Green Power Products Commercial Buildings

### 2030 GHG Reduction Strategy:

Source 92% clean electricity

### Action GHG Reduction Potential:

High

### Investment Levels:

Some Cost

### Co-Benefits:

Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

- Development Services Planning Office
- Economic Development

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Source 100% of county-wide electricity from renewable sources by 2035
- Achieve 100% renewable electricity in County government operations by 2030
- Achieve 100% carbon neutrality in County government operations by 2050

### Primary Partners:

- Communications
- Public Works
- Dominion and NOVEC

### Action Description:

Promote purchasing utility green power options within the community. Green power products allow customers to purchase renewable or clean electricity on a month-to-month basis through an added fee on their utility bill. Both Dominion and NOVEC offer 100% renewable electricity options.





## B-1

# Encourage Energy Efficiency and Electrification Retrofits

### 2030 GHG Reduction Strategy:

- Achieve 40% highly efficient and electric HVAC systems and water heaters
- Obtain 100% high-efficiency lighting and appliances

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Large Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: +
- Savings to Residents and Business: +

### Lead Department:

Development Services –  
Building Department

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- None identified

## Action Description:

Encourage existing building energy efficiency and electrification retrofits through actions such as streamlined permitting.





## B-2

## Propose Green Zoning

### 2030 GHG Reduction Strategy:

- Achieve 40% highly efficient and electric HVAC systems and water heaters
- Obtain 100% high-efficiency lighting and appliances
- Shift 5% of total trips from private vehicles to active or public transport

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Some Cost

### Co-Benefits:

- Local Employment: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Planning Office

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- Transportation
- Housing
- Watershed
- Parks and Recreation
- Economic Development/Community Development

## Action Description:

Propose green zoning regulations to encourage energy- and water-efficient buildings, multifamily and mixed-use areas, and transit-oriented developments. Green zoning involves revising zoning policies to require or encourage developers to abide by certain sustainable development practices. Denser developments and multifamily housing units typically use less energy than other, more dispersed building types. Additionally, mixed-used and transit-oriented areas significantly reduce the need for vehicle travel, which would also reduce transportation emissions.





## B-3

# Encourage Energy Efficient and Electric New Construction Regulations

### 2030 GHG Reduction Strategy:

- Achieve 40% highly efficient and electric HVAC systems and water heaters
- Obtain 100% high-efficiency lighting and appliances

### Co-Benefits:

None

### Lead Department:

Planning Office  
Development Services

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- None Identified

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Large Cost

## Action Description:

Encourage developers to build to a more energy-efficient standard set by the County government or use all-electric systems and equipment.



## B-4

# Promote Energy Efficiency and Electrification Incentives

### 2030 GHG Reduction Strategy:

- Achieve 40% highly efficient and electric HVAC systems and water heaters
- Obtain 100% high-efficiency lighting and appliances

### Co-Benefits:

- Resource Conservation: +
- Savings to Residents and Businesses: +

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- Development Services
- Communications Office
- Economic Development
- Green Business Council

### Action GHG Reduction Potential:

Medium

### Lead Department:

Office of Sustainability

### Investment Levels:

Some Cost

## Action Description:

Provide outreach and education to residents and businesses about tools, technology, and incentives for building energy efficiency and electrification. This would include providing a centralized webpage or tool for residents and businesses to reference relevant federal, state, and utility incentives, Commercial Property Assessed Clean Energy (C-PACE) information, and County government programs, among other resources.





T-1

## Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity

### 2030 GHG Reduction Strategy:

Shift 5% of total trips from private vehicles to active or public transport

### Action GHG Reduction Potential:

High

### Investment Levels:

Very Large Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: +
- Savings to Residents and Business: +
- Organizational Diversity, Equity, and Inclusion: +

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- Planning Office
- Watershed
- Service Authority
- Virginia Department of Transportation (VDOT)\*
- Schools

### Lead Department:

- Transportation
- Parks, Recreation and Tourism

\* The County can build public roads and sidewalks which are then adopted into the state system and maintained by VDOT. Any public road/sidewalk development proposed by The County needs to be approved by VDOT and VDOT could override proposed development in any right-of-way.

## Action Description:

Improve active transportation infrastructure, sidewalk and trail connectivity, and overall safety to support walking, biking, and rolling. Improvements could include providing bike lockers, installing curb ramps, or installing traffic-calming designs like crosswalk islands or speed humps. This action would involve developing a strategic Active Transportation Plan that includes recommendations for prioritizing infrastructure improvements and outlines new active transportation policies, processes, and infrastructure.





## T-2

## Encourage Transit-Oriented Development

### 2030 GHG Reduction Strategy:

Shift 5% of total trips from private vehicles to active or public transport

### Action GHG Reduction Potential:

High

### Investment Levels:

Some Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Planning Office  
Transportation

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- Potomac and Rappahannock Transportation Commission (PRTC)
- Virginia Railway Express (VRE)
- Development Services

### Action Description:

Encourage transit-oriented development (TOD) within ½-mile of high-capacity regional transit stations. This could be done through developer incentives, streamlined permitting, or zoning amendments. The County could also explore requiring bicycle parking minimums in TOD areas.



## T-3

## Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips

### 2030 GHG Reduction Strategy:

Shift 5% of total trips from private vehicles to active or public transport

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Some Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Transportation

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Achieve 100% carbon neutrality in County government operations by 2050

### Primary Partners:

- Planning Office
- PRTC

### Action Description:

Expand and promote programs that offer transportation demand management services, reduce transit fares, and support teleworking.



## T-4

## Upgrade Public Transit Infrastructure

### 2030 GHG Reduction Strategy:

Shift 5% of total trips from private vehicles to active or public transport

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Extremely Large Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Transportation

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- Planning Office
- PRTC
- Virginia Department of Rail and Public Transportation (DRPT)
- VRE
- VDOT

## Action Description:

Partner with county transit operators and VDOT to improve and provide new public transit infrastructure and build out transit nodes. Though the County government does not operate the public buses that service the county, the County government can help provide supportive infrastructure to help increase the efficiency and frequency of bus travel. However, as most public roads and bus infrastructure are maintained by VDOT, County government will partner with VDOT to identify and develop transit priority treatments.







## T-5

## Encourage Zero-Emission Vehicles and Charging

### 2030 GHG Reduction Strategy:

Achieve 50% zero-emission private vehicles

### Action GHG Reduction Potential:

High

### Investment Levels:

Large Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: +
- Savings to Residents and Business: +

### Lead Department:

Transportation  
Development Services

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- Non Identified

### Action Description:

Encourage the development of and cost-reduction programs for residents and businesses to purchase zero-emission vehicles (ZEVs) or install charging equipment such as streamlined permitting for EV chargers, "group-buy" programs for EV chargers, or EV purchasing co-ops.



## T-6

## Expand Public EV Charging Network

### 2030 GHG Reduction Strategy:

Achieve 50% zero-emission private vehicles

### Action GHG Reduction Potential:

High

### Investment Levels:

Very Large Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: ++
- Savings to Residents and Business: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Transportation  
Facilities and Fleet  
Management

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030

### Primary Partners:

- VDOT
- VRE
- PRTC

### Action Description:

Expand public EV charging infrastructure especially along main routes and in popular destinations. This would include developing an EV Infrastructure Plan to guide community deployment and considerations for electric bike charging.



## N-1

## Adopt Natural Open Space Requirements

### 2030 GHG Reduction Strategy:

NA

### Action GHG Reduction Potential:

Unknown

### Climate Hazard

Extreme Heat

### Investment Levels:

Some Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: ++  
Savings to Residents and Business: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Public Works - Watershed  
County Arborist

### County Goals Supported:

- Resource Conservation: ++

### Primary Partners:

- Planning Office
- County Attorney's office
- Owners of open space areas (homeowners associations [HOAs], commercial owners, environmental trusts, etc.)

## Action Description:

**Establish minimum Natural Open Space (NOS) guidelines to encourage preservation of NOS, if appropriate, in new and existing development. NOS is “open space with natural resource benefits within the boundaries of a development such as native forests; topographic features; critical habitats for threatened and endangered species and species of special concern; natural creeks, streams and lakes; and natural wetlands that are set aside as an area to remain undisturbed during development and in perpetuity for the preservation of the natural resources contained therein and for the passive use and enjoyment of the residents of the development and/or the public at large.”**



## Climate Mitigation Actions for County Government

There are three high priority County government climate mitigation actions that address County government operations emission sources (see [Table 7](#)). Though not explicitly listed as an action in the CESMP, one of our initial steps will be to create a County government operations GHG inventory to better measure and track progress toward achieving carbon neutrality in County government operations by 2050. Further discussion of how actions can help meet other government GHG and renewable energy goals are described in the [Chapter 5 Meeting the County Goals](#).

**Table 7. Climate Mitigation Actions for County Government**

Climate Mitigation Actions for County Government	Sector
E.5: Install Solar on County Government Facilities	Electricity
B.5: Transition to Net Zero County Government Facilities	Buildings
T.7: Adopt Zero- or Low-Emissions County Fleet	Transportation

Electricity



**E-5**

### Install Solar on County Government Facilities

#### 2030 GHG Reduction Strategy:

Source 92% clean electricity

#### Action GHG Reduction Potential:

Low

#### Investment Levels:

Large Cost

#### Co-Benefits:

- Local Employment: +
- Cost Savings to County Government: +

#### Lead Department:

Fleets and Facilities Management

#### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Source 100% of county-wide electricity from renewable sources by 2035
- Achieve 100% renewable electricity in County government operations by 2030
- Achieve 100% carbon neutrality in County government operations by 2050

#### Primary Partners:

- Departments with facilities not managed by Facilities and Fleet:
- Community Services
  - Housing and Community Development
  - Fire & Rescue
  - Parks, Recreation & Tourism
  - Public Works
  - Adult Detention Center

### Action Description:

Develop solar projects on our County government facilities through direct ownership or third-party ownership models such as Power Purchase Agreements (PPAs).



## B-5

## Transition to Net Zero County Government Facilities

### 2030 GHG Reduction Strategy:

- Source 92% clean electricity
- Achieve 40% highly efficient and electric HVAC systems and water heaters
- Replace 57% HFCs with low- or zero- GWP alternatives
- Obtain 100% high-efficiency lighting and appliances

### Action GHG Reduction Potential:

Medium

### Investment Levels:

Very Large Cost

### Co-Benefits:

- Resource Conservation: +
- Cost Savings to County Government: ++

### Lead Department:

- Facilities and Fleet Management
- Finance – Risk and Wellness Services

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Source 100% of county-wide electricity from renewable sources by 2035
- Achieve 100% renewable electricity in County government operations by 2030
- Achieve 100% carbon neutrality in County government operations by 2050

### Primary Partners:

Departments with facilities not managed by Facilities and Fleet:

- Community Services
- Housing and Community Development
- Fire & Rescue
- Parks, Recreation & Tourism
- Public Works
- Adult Detention Center

### Action Description:

**Develop a net-zero emissions building plan for County government facilities, which will include implementing an energy benchmarking program and procuring 100% clean electricity for all County government operations.**

## Transportation



## T-7

## Adopt Zero- or Low-Emissions County Fleet

### 2030 GHG Reduction Strategy:

Achieve 50% zero-emission private vehicles

### Action GHG Reduction Potential:

Low

### Investment Levels:

Extremely Large Cost

### Co-Benefits:

- Resource Conservation: +
- Local Employment: ++
- Savings to Residents and Business: +
- Organizational Diversity, Equity, and Inclusion: +

### Lead Department:

Fleets and Facilities Management

### County Goals Supported:

- Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
- Achieve 100% carbon neutrality in County government operations by 2050

### Primary Partners:

- Non Identified

### Action Description:

**Transition County fleet to zero- or low-emissions vehicles and ensure supporting infrastructure is open to other fleets.**

## Climate Adaptation and Resiliency Actions

The climate adaptation and resiliency actions ([Table 8](#)) provide opportunities for us to address existing and future climate hazards that impact our county. Actions that also provide climate mitigation benefits through tree sequestration or reduce energy use are marked with an asterisk.

**Table 8. Climate Action and Resiliency Actions**

Climate Adaptation and Resiliency Actions	Climate Hazard Addressed
A.1: Develop Adaptation Plans for Critical Facilities	All Climate Hazards
A.2: Manage Stormwater Flooding Outside of the Floodplain	Precipitation
A.3: Improve Power Resiliency for Critical Infrastructure	High Winds & Tornadoes, Extreme Temperature
A.4: Implement Shoreline Protection and Nature-Based Solutions	Sea Level Rise
A.5: Restore Streams to Reduce Flooding	Precipitation
A.6: Encourage Technology for Residents to Make Homes Adaptive*	Extreme Heat
A.7: Plan Alternative Evacuation Routes for Flood-prone Areas	Precipitation
* Action also provides climate mitigation benefits	

### Climate Adaptation



## A-1

## Develop Adaptation Plans for Critical Facilities

### 2030 GHG Reduction Strategy:

Source 92% clean electricity

### Climate Hazards

All Climate Hazards

### Investment Levels:

Some Cost

### Co-Benefits:

- Savings to Residents and Businesses: ++
- Organization Diversity, Equity and Inclusion: +
- Cost Savings to County Government: ++

### Lead Department:

- Office of Emergency Management

### Primary Partners:

- Facilities and Fleet Management (for County facilities)
- Risk and Wellness (for some County facilities)
- External critical facility owners

### Action Description:

**Develop site-level adaptation plans for critical facilities and service areas considering current and future climate change hazards.**



## Climate Adaptation

**A-2****Manage Stormwater Flooding Outside of the Floodplain****2030 GHG Reduction Strategy:**

Source 92% clean electricity

**Climate Hazards**

Participation

**Investment Levels:**

Large Cost

**Co-Benefits:**Cost Savings to the  
County Government: +**Lead Department:**Office of Emergency  
Management**Primary Partners:**

- Public Works – Watershed
- VDOT

**Action Description:**

**Increase understanding of flooding in areas outside of the delineated FEMA floodplain through modeling and/or historic flood records. Develop and implement mitigation actions to reduce stormwater flooding.**

**A-3****Improve Power Resiliency for Critical Infrastructure****2030 GHG Reduction Strategy:**

Source 92% clean electricity

**Climate Hazards**Extreme Temperature  
High Winds & Tornadoes**Investment Levels:**

Large Cost

**Co-Benefits:**

- Local Employment: +
- Savings to Residents and Businesses: +
- Organization Diversity Equity and Inclusion: +
- Cost Savings to County Government: +

**Lead Department:**

- Office of Emergency Management
- Critical Infrastructure Owners
- County Energy Providers

**Primary Partners:**

- Facilities and Fleet Management
- Parks & Rec
- Fire

**Action Description:**

**Improve the resiliency of electrical infrastructure for publicly owned essential services and infrastructure.**

## Climate Adaptation

**A-4****Implement Shoreline Protection and Nature-Based Solutions****2030 GHG Reduction Strategy:**

Source 92% clean electricity

**Climate Hazards**

Sea level rise

**Investment Levels:**

Large Cost

**Co-Benefits:**

- Resource Conservation: ++
- Savings to Residents and Businesses: +
- Organization Diversity, Equity and Inclusion: +
- Cost Savings to County Government: +

**Lead Department:**

Public Works – Watershed

**Primary Partners:**

- Development Services - Land Development Division
- Office of Emergency Management
- Parks, Recreation and Tourism

**Action Description:**

Develop guidance to prioritize nature-based solutions for shoreline protection for coastal areas.

**A-5****Restore Streams to Reduce Flooding****2030 GHG Reduction Strategy:**

Source 92% clean electricity

**Climate Hazards**

Precipitation

**Investment Levels:**

Large Cost

**Co-Benefits:**

- Resource Conservation: ++
- Savings to Residents and Businesses: +
- Organizational Diversity, Equity and Inclusion: +
- Cost Savings to County Government: +

**Lead Department:**

Public Works – Watershed

**Primary Partners:**

- Planning Office
- Office of Emergency Management

**Action Description:**

Develop and implement stream restoration projects in support of reduced flooding outcomes.

## Climate Adaptation

**A-6**

## Encourage Technology for Residents to Make Homes Adaptive

**2030 GHG Reduction Strategy:**

Source 92% clean electricity

**Climate Hazards**

Extreme Heat

**Action GHG Reduction Potential:**

Low

**Investment Levels:**

Large Cost

**Co-Benefits:**

- Resource Conservation: ++
- Savings to Residents and Businesses: +
- Organizational Diversity, Equity and Inclusion: ++

**Lead Department:**

Office of Sustainability

**Primary Partners:**

- Development Services
- Dominion Energy

**Action Description:**

Provide additional incentives or subsidies for residents of low-income housing and rental properties to install or retrofit buildings with climate adaptive technologies to reduce energy, reduce water use, reduce waste heat, and minimize urban heat gain.

**A-7**

## Plan Alternate Evacuation Routes for Flood-prone Areas

**2030 GHG Reduction Strategy:**

Source 92% clean electricity

**Climate Hazards**

Precipitation

**Investment Levels:**

Large Cost

**Co-Benefits:**

None Identified

**Lead Department:**

Office of Emergency Management

**Primary Partners:**

- None Identified

**Action Description:**

Develop localized evaluation routes throughout the County and socialize with the public.

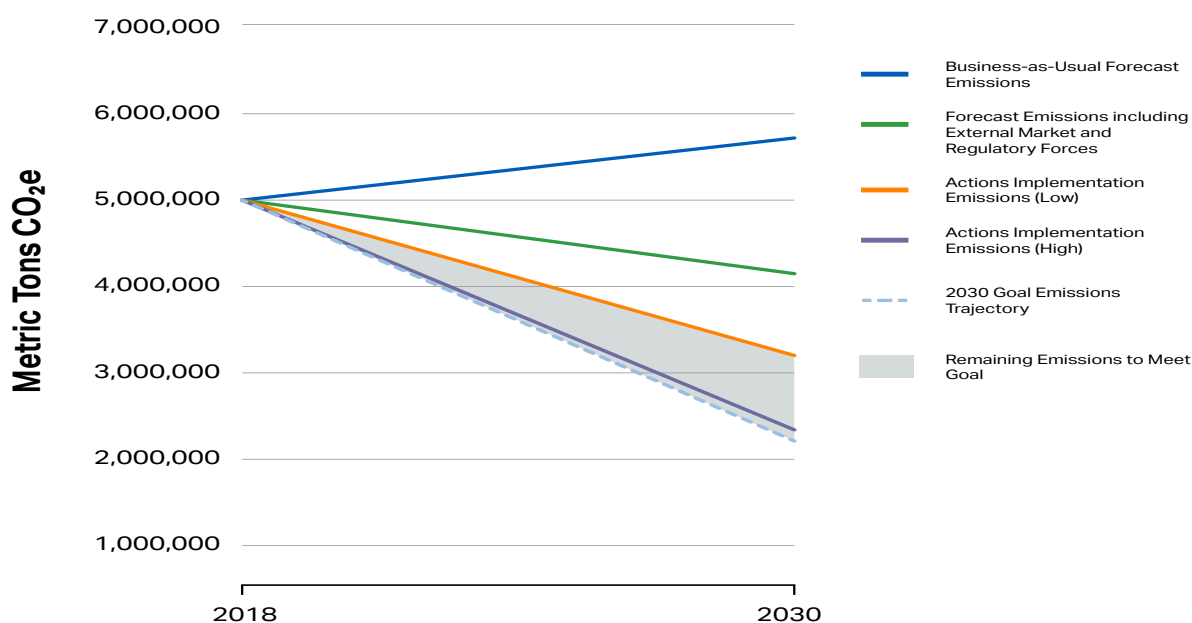
## Chapter 5 Meeting the County Goals

The CESMP provides a list of actions to address the following goals:

- 1. Cut GHG Emissions County-Wide by 2030:** Reduce GHG emissions county-wide to 50% below 2005 levels by 2030
- 2. Use 100% Renewable Electricity County-Wide by 2035:** Source 100% of county-wide electricity from renewable sources by 2035
- 3. Use 100% Renewable Electricity in County Government Operations by 2030:** Achieve 100% renewable electricity in the County government operations by 2030
- 4. Become Carbon Neutral for County Government Operations by 2050:** Achieve 100% carbon neutrality in the County government operations by 2050
- 5. Prepare for Climate Change:** Become a Climate Ready Region and make significant progress to be a Climate Resilient Region by 2030

The complete list of actions provided in **Appendix A. Complete List of CESMP Actions** indicates the goals each action supports. Our goals are aggressive. However, they are not significantly different from the broader region in Virginia.

**Figure 14. GHG Reduction Potential and Remaining Emissions**



We recognize that although meeting these goals will be challenging, we are committed to immediate action.

The sections below discuss how we may meet each of these five goals, and strategies that could be used to increase our likelihood of success.

### Goal 1: Greenhouse Gas Reduction

Our **2030 GHG Emissions Reduction Scenario** shows what it will take to achieve the 2030 goal, while the Climate Mitigation Actions show *what we can do* to achieve the reduction scenario strategies and ultimately the 2030 goal. In Virginia, counties cannot force businesses and residents (by means of law) to purchase only electric vehicles. Similarly, we cannot force all businesses and residents to use only carbon free electricity. There will always be a portion of our county's GHG emissions that we can neither control nor eliminate completely without external support. What we can do is encourage this type of behavior and make reasonable estimates (low and high) that a portion of the population will work with us on achieving these goals. So how close can we get to meeting our GHG reduction goals?

**Figure 14** shows what our 2030 county-wide emissions levels might be under different scenarios. The bottom line shows the 2030 goal trajectory, and the top line shows the effect of doing nothing. The middle lines show the effects of varying degree of actions in and outside of our control. If we were to implement all actions listed in the CESMP, there is a gap of about 500,000-1,400,000 MTCO<sub>2</sub>e shown as the shaded blue area. This includes the current and future effects of existing regulations and the impact of the market.



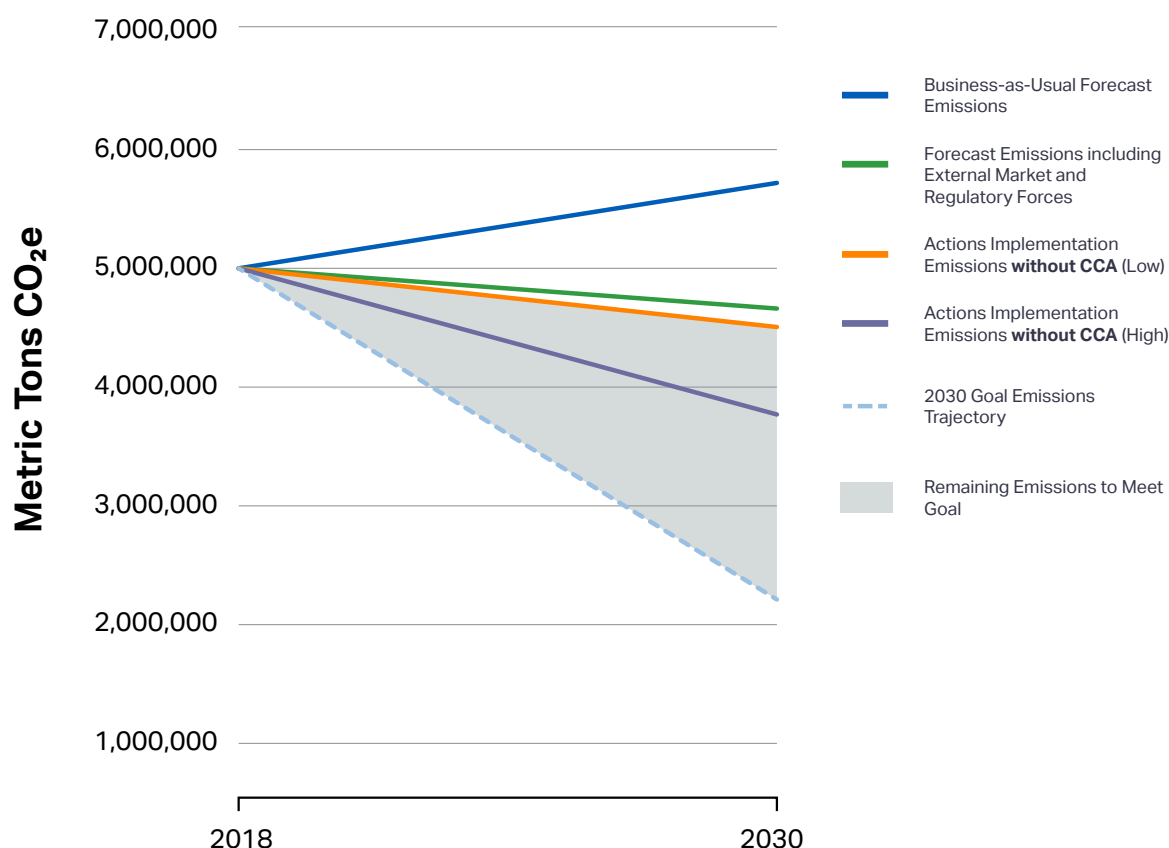
The GHG emission gap in **Figure 14** highlights the importance of implementing a CCA through action E.1: Acquire Clean Electricity Sources for the County. In the low action implementation scenario, it is assumed that a CCA is only enacted in Dominion territory, while in the high action implementation scenario, a CCA is enacted for both Dominion and NOVEC territory. The CCA action alone could generate 800,000-1,600,000 MTCO<sub>2</sub>e in emissions reductions for the county by 2030, which represents 23-46% of the reductions needed to meet the 2030 goal. Without a CCA, the other clean energy actions may only generate 2-12% of the reductions needed to meet the 2030 target, which means the emissions gap to meet the 2030 goal would be widened from 500,000-1,400,000 MTCO<sub>2</sub>e to 1,700,000-2,400,000 MTCO<sub>2</sub>e. **Figure 15** illustrates potential action implementation emissions levels if a CCA program is not implemented.

Even with the successful implementation of a CCA program, there will still most likely be additional measures needed to meet the GHG reduction goal, as shown in **Figure 14**. This gap could be met through three different but complementary strategies:

1. Gaining more County government control over actions that impact our GHG emissions through advocating for ourselves at the state and national level (see discussion in **Opportunities for External Advocacy and Action**)
2. Considering the positive effects that forests and trees have on reducing GHG emissions, and/or
3. Purchasing qualified carbon offsets

A discussion on how to integrate forests and trees into our GHG inventory and how we might consider carbon offsets are provided in the sections below.

**Figure 15. GHG Reduction Potential and Remaining Emissions without a CCA Program**



## Integrating Forests and Trees

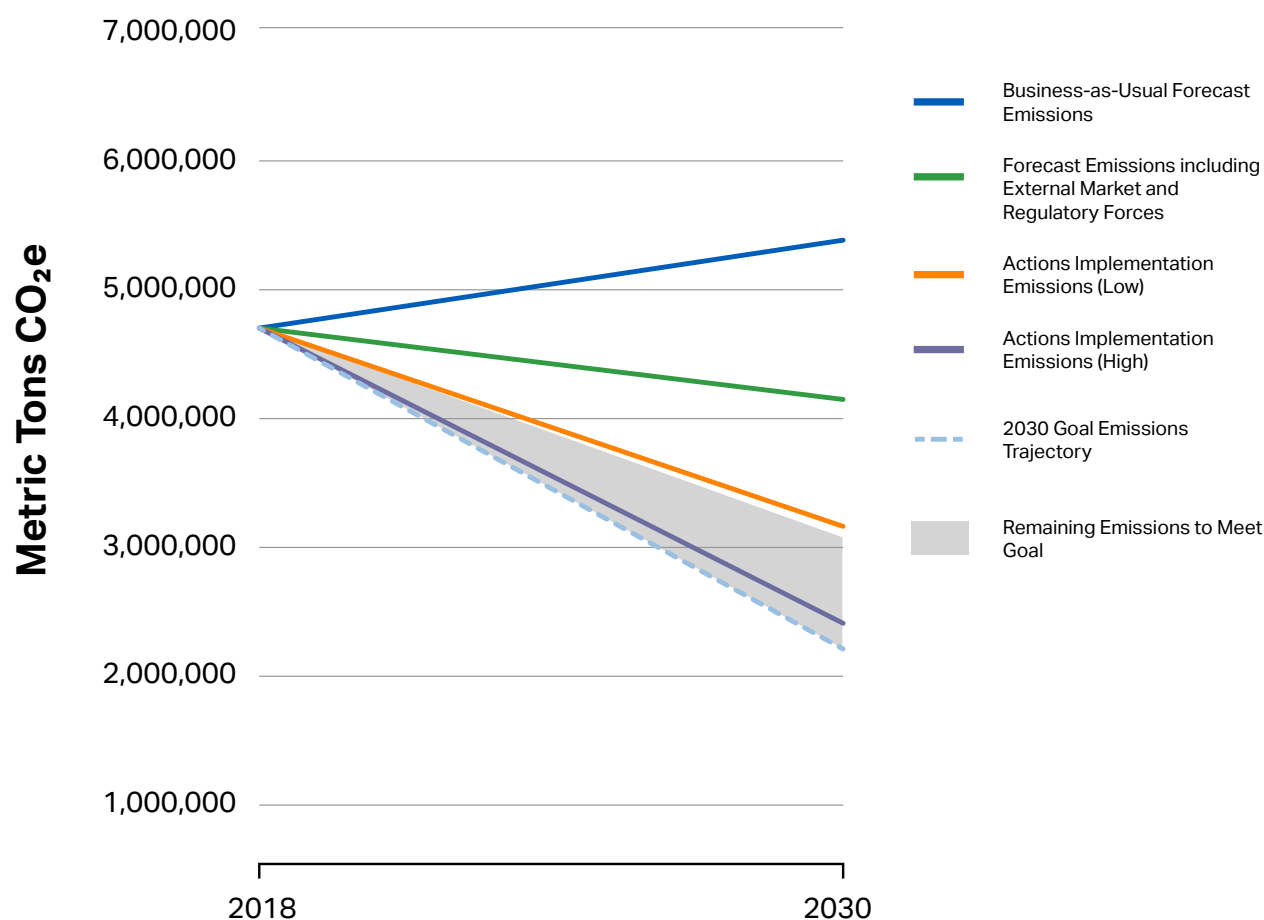
Forests and trees naturally play a positive role in reducing the effects of climate change and GHG emissions by capturing CO<sub>2</sub>. MWCOG calculated the reduction of CO<sub>2</sub> emissions due to forest and trees in the county from 2005 to 2020. This data showed that including the effects of forests and trees in our GHG inventories would decrease total annual emissions by roughly 7%. This ultimately makes it easier for us to meet our GHG reduction goals by shrinking the gap between what we need to do and what we can do.

As MWCOG noted that there are significant uncertainties in these estimates, the effects of forests and trees were not included in our inventory analysis or emissions forecasting.

Though these estimates are highly uncertain, these measurements will most likely improve in accuracy over time and can be vetted by County government staff, leading to their potential inclusion toward meeting the 2030 GHG reduction goal.

If we include forest and tree emissions flux in all of our GHG inventories, and assume that 2020 levels of forest and tree emissions flux remain constant to 2030, then the gap between the 2030 high action implementation emissions levels and the 2030 GHG reduction goal emissions levels shrinks from 500,000 MTCO<sub>2</sub>e to 260,000 MTCO<sub>2</sub>e (see **Figure 16**). Though it is not certain that these land use trends will be sustained by 2030, these emissions estimates could be incorporated into our GHG inventories in the future to help close the emissions reduction gap.

**Figure 16. GHG Reduction Potential and Remaining Emissions with Forest and Tree Emissions/Removals**



## Carbon Offsets

Another way of closing the gap between what we need to do and what we can do is by purchasing quality carbon offsets. Carbon offsets represent the reduction or removal of GHG emissions that compensates for emissions emitted somewhere else. The purchase of a carbon offset represents a one-time GHG reduction acquisition from another party creating the reductions. This purchase must be repeated on an annual basis to maintain goal achievement.

Carbon offsets can be generated by a variety of activities, including those that reduce emissions and those that remove carbon from the atmosphere. Offset projects that **reduce** emissions represent projects that would avoid potential future emissions, such as using renewable energy or cleaner cookstoves, or physically storing the carbon that would have been released, such as through carbon capture and storage systems on a fossil fuel power plant. Offset projects that **remove** emissions represent projects that remove carbon dioxide directly from the atmosphere, such as through reforestation, soil carbon enhancement, or direct air capture with carbon capture and storage. Most offsets available today represent emission reductions, which are necessary but not sufficient to achieve net zero in the long run. As carbon removals scrub carbon directly from the atmosphere, they play a hugely important role in stabilizing GHG emissions in the atmosphere. Therefore, entities should prioritize carbon removal projects over emission reduction projects when purchasing carbon offsets.

Though carbon offsets are typically used to meet a net zero goal, we are exploring using them to meet the interim 2030 GHG reduction goal. Carbon offsets are a potential “last resort” option if we cannot meet the 2030 goal through our own direct actions. Alternatively, money spent on offsets could instead be spent on local GHG reduction programs. However, we could risk not meeting the 2030 GHG reduction goal if we do not purchase offsets. If necessary, we will purchase verified carbon offsets from carbon removal projects annually to meet our 2030 reduction goal. Because there is no single governing body that certifies carbon offsets, there are a variety of non-profit third-party companies that check carbon offset claims, ensure they are valid, and certify the offsets. We will review available verified offsets, determine which ones are “high quality” (e.g., which are focused on long-term removals), and complete a cost analysis of the offset choices before purchasing.

## Goal 2 and 3: Renewable Energy Goals

Our goal is to achieve 100% clean electricity in county operations by 2030 and county-wide by 2035. One action in the CESMP would substantially contribute toward meeting both the government and county-wide goals: a community choice aggregation program (see action E.1). If we enact a community choice aggregation program, we may be able to aggregate the electric load of all Dominion electricity customers within our jurisdiction and negotiate for 100% clean or renewable electricity for those customers, but further legal review is needed. If enacted by 2030, this would represent a substantial step to meeting the government and county-wide renewable goals.

However, further legal review will need to be conducted to determine if a community choice aggregation program could be formed in NOVEC territory. If a community choice aggregation program cannot be formed, we will have to rely on other local actions to address emissions from NOVEC customers or any Dominion customers that opt-out of the program. These other actions include:

- ▶ Utility green power purchasing (action E.4),
- ▶ Local renewable installations (actions E.2 and E.5),
- ▶ Virtual Power Purchase Agreements (VPPAs), with a last resort option of purchasing Green-e Energy certified unbundled renewable energy certificates (RECs) on the open market.

PPAs are where a third-party developer installs, owns, and operates the energy system while the customer purchases the system's electric output for a predetermined period. In a VPPA, the energy system is developed off-site, and the electricity is sold into the wholesale market instead of directly consumed by the customer. RECs are a market-based instrument that certify the bearer owns one megawatt-hour of electricity generated from a renewable energy resource. Unbundled RECs are sold separately from the electricity that was generated, while bundled RECs are sold with the electricity. Green-e Energy certification ensures that the RECs are high-quality and not double-counted. To meet the community-wide renewable electricity goal, we could purchase and retire unbundled RECs on behalf of residents and businesses to cover any remaining electricity consumption that is not generated by renewable energy sources. We could follow a similar tactic of REC purchasing to meet our government operations renewable electricity goal.<sup>17</sup>

## Onsite County Government Solar Feasibility

*Even though County government electricity use is a small portion of total county-wide electricity use, the amount of space and funds needed to produce all County government electricity from onsite solar is currently infeasible. We estimated that County government operations used 64-80 gigawatt-hours of electricity in 2018 (roughly 1% of total county-wide electricity). To fully meet this electricity demand with onsite solar, we would need to install 275 acres of solar panels, or over roughly 200 football fields. If we were to directly purchase these panels, it could cost roughly \$130 million. However, the costs of renewable energy could be significantly cheaper through a PPA where a third-party developer installs, owns, and operates the energy system while the customer purchases the system's electric output for a predetermined period. Because it is unlikely that we could install enough onsite solar to meet our 100% renewable electricity goal for County government operations by 2030, we will most likely need to pursue a combination of local renewables (action E.5), utility green energy purchasing (action E.4), VPPAs, and purchasing RECs to meet this goal.*

## Goal 4: County Government Carbon Neutrality

The County set an ambitious goal of achieving carbon neutrality for County government operations by 2050. Carbon neutrality is achieved when our County government emits just as much GHG emissions as it removes/offsets. County government emissions typically include County government building and facility energy use, County government fleet and equipment fuel use, and solid waste and wastewater treatment emissions from County government waste. Though we have not yet developed a County government operations GHG inventory, local government emissions are typically a small portion of overall community emissions (likely <5%). The actions we should pursue to achieve carbon neutrality will depend on the emissions sources we include in our County government GHG inventory.

Therefore, the first step to develop a carbon neutrality pathway will be to create a baseline County government operations GHG emissions inventory. Though County government carbon neutrality achievement was not specifically analyzed in the CESMP, actions have been developed to reduce County government emissions by 2030, as listed in Climate Mitigation Actions for County Government. Additionally, achieving our goal of 100% renewable electricity for County government operations by 2030 will also greatly help in achieving the County government carbon neutrality goal.

## Alignment with Strategic and Comprehensive Plan Goals

Our 2021-2024 Strategic Plan<sup>18</sup> and 2040 Comprehensive Plan<sup>19</sup> outline goals and action strategies to guide the growth and development of the community. The Strategic Plan provides key policy guidance for service delivery and resource allocation decisions while the Comprehensive Plan articulates the goals and policies that the Board of County Supervisors relies on to make informed land use development decisions and investments in public infrastructure. Both Plans support climate-related actions that reduce GHG emissions and increase local climate resiliency. The CESMP actions have been mapped to related Strategic Plan and Comprehensive Plan action strategies in Appendix C. CESMP Actions Mapped to Strategic Plan and Comprehensive Plan Action Strategies.

## Opportunities for External Advocacy and Action

Because our County government cannot directly control or influence many community-wide emissions sources or assets, the ability to meet the 2030 emissions reduction goal and 2030 Climate-Ready Region goal may rely on significant external support from market forces, public and private entities, and state and national-level regulation.

**Table 9** below provides a list of opportunities to advocate for ourselves at the local, state and federal levels. In addition to advocacy, we strive to build and maintain strong partnerships with entities that impact our community and influence our ability to reduce GHG emissions, procure clean energy, and increase our resiliency.

**Table 9. External Advocacy and Action Opportunities by Sector**

Sector	Opportunities for External Advocacy and Action
<b>Buildings</b>	<ul style="list-style-type: none"> <li>▶ Advocate for a low-carbon building code/more aspirational codes and vote on energy code updates</li> <li>▶ Advocate for quicker adoption of the most recent International Energy Conservation Code in Virginia</li> <li>▶ Encourage adaptation planning for private businesses by providing examples of adaptation plans for our county's critical facilities</li> </ul>
<b>Electricity</b>	<ul style="list-style-type: none"> <li>▶ Advocate for a more aggressive state-wide Renewable Portfolio Standard</li> <li>▶ Advocate for policies to help overcome barriers to community choice aggregation program adoption in Virginia</li> <li>▶ Work with Dominion and NOVEC to develop electrification incentives and promote expansion of electrical infrastructure to accommodate growing building and vehicle electrification</li> <li>▶ Work with Dominion and NOVEC to promote grid resiliency through actions such as microgrid development or undergrounding of power wires</li> </ul>
<b>Transportation and Off-road equipment</b>	<ul style="list-style-type: none"> <li>▶ Work with Potomac and Rappahannock Transportation Commission to advocate for transit service expansion and fleet electrification</li> <li>▶ Advocate for more state and national incentives and mandates for purchasing EVs</li> </ul>
<b>Waste</b>	<ul style="list-style-type: none"> <li>▶ Advocate for the expansion of Balls Ford Road Compost Facility to accept more food waste</li> </ul>
<b>Wastewater</b>	<ul style="list-style-type: none"> <li>▶ Advocate for high-efficiency wastewater treatment processes and state-wide programs aimed at helping local wastewater treatment facilities in their decarbonization efforts</li> </ul>
<b>Land Use</b>	<ul style="list-style-type: none"> <li>▶ Advocate for a stronger state tree preservation requirement program through State Code</li> </ul>

Beyond this list, there are many additional implementation mechanisms that would require authorization at the state level before the County could enact them. The County will continue to identify these mechanisms and seek additional legislative authorization as we implement the CESMP.



## Chapter 6 Action Implementation and Monitoring

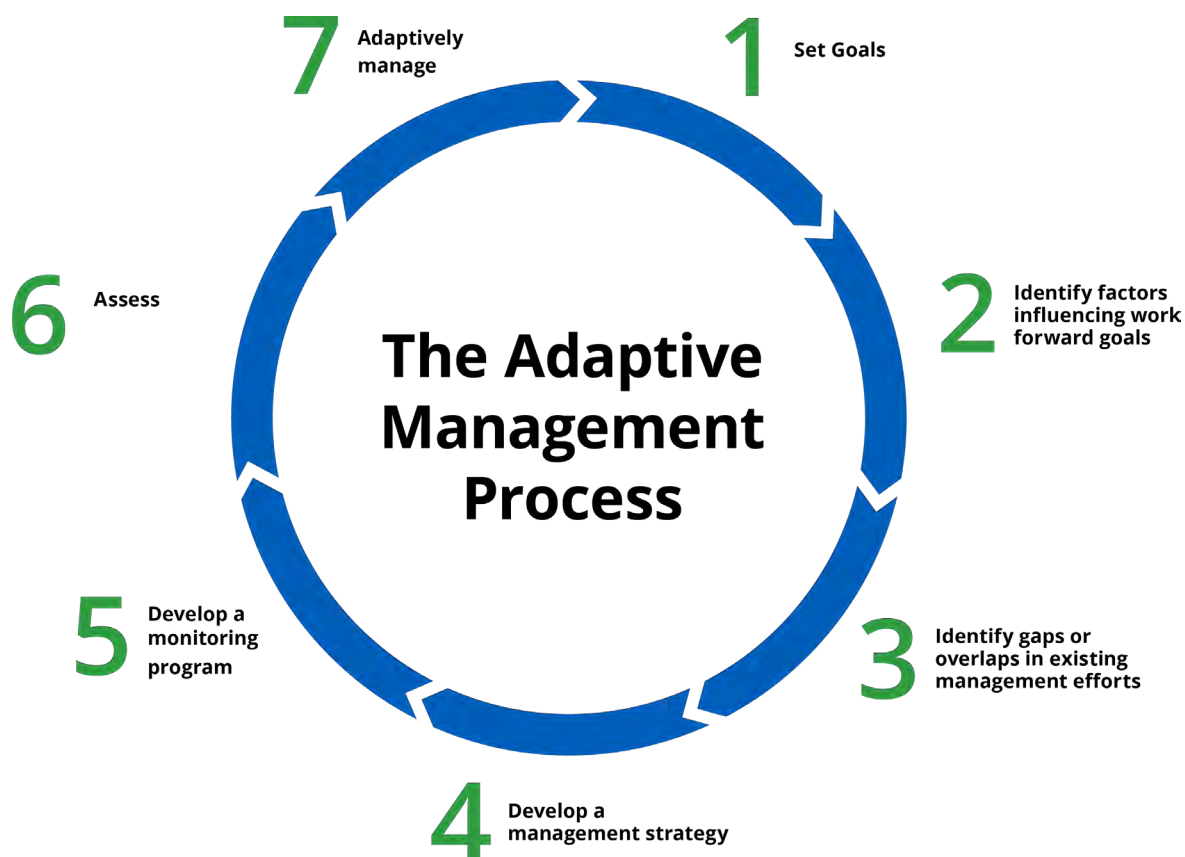
In addition to the specific actions identified through the analysis described above, the CESMP includes three foundational program-wide sustainability initiatives designed to improve the County's ability to monitor and implement the plan:

1. Implementation of an "Adaptive Management" approach that improves our ability to make decisions in the face of uncertainty and complexity
2. Assessments for climate mitigation and resiliency impacts performed by the county to provide data on a project's impact on greenhouse gas emissions, renewable and fossil energy mix, and climate resiliency metrics
3. Institutional capacity-building to support sustainability, including staffing capacity to pursue federal grants for green programs and capacity for communication and outreach that will engage residents and businesses in the voluntary measures recommended in the CESMP

### Adaptive Management

Implementation of the CESMP will be a dynamic effort that will require taking an Adaptive Management approach of continuous data collection, analysis, and reassessment. Adaptive Management is an intentional and iterative approach designed for decision making in situations characterized by volatility (rapid change), uncertainty, complexity, and ambiguity. The County intends to implement the CESMP through a process similar to the one employed by the Chesapeake Bay Program, shown in [Figure 17](#) below. This process provides a framework to make decisions and adjustments in response to rapidly evolving technologies, policies, strategies, and funding opportunities. Note that stakeholder input is a continuous element of the process.

Figure 17: Adaptive Management Process<sup>20</sup>



The Adaptive Management framework has several features that make it well-suited for the CESMP:

- ▶ **Data-Driven Decision-Making:** Adaptive Management is rooted in the scientific method, using data to inform decisions. This is crucial in a field where new data and understandings are continuously emerging.
- ▶ **Resource Optimization:** Resources for climate mitigation and adaptation are often limited. Adaptive Management allows for the continual reassessment of action plans and resource allocation to ensure that we are always employing the most cost-effective strategies.
- ▶ **Stakeholder Engagement:** Adaptive Management encourages continuous stakeholder participation, which will be crucial in a plan that requires collective action from county government, residents, and businesses.
- ▶ **Policy Alignment:** Policies at the regional, state, and federal levels are continuously evolving. An adaptive approach allows the county to quickly realign its strategies to be complementary with broader policies, optimizing the likelihood of achieving our goals.
- ▶ **Technological Advances:** The landscape of renewable energy and sustainable technologies is rapidly evolving. Adaptive Management enables the CESMP to incorporate new technologies and methods as they become available, without requiring a full restructuring of the plan.
- ▶ **Accountability and Transparency:** The regular monitoring and evaluation built into Adaptive Management will allow us to transparently track and report progress, ensuring accountability and keeping the public informed.
- ▶ **Risk Management:** By continually assessing the effectiveness of our actions in real-time, we can quickly identify and manage emerging risks, ensuring that the county remains resilient in the face of changing climate conditions.

By using an Adaptive Management approach, the County will be better equipped to meet the ambitious goals set forth in the CESMP, allowing us to quickly respond to new challenges and opportunities in our ongoing efforts to mitigate the impacts of climate change and ensure the resiliency and sustainability of the county.

As a next step, we will need to develop a system for annually assessing the impact of the proposed actions towards meeting the climate mitigation and climate resiliency goals.

This work has already begun through the development of Implementation Roadmaps for the 25 high priority actions (see **Appendix B. Implementation Plan**). The roadmaps identify the County government departments that will lead implementation; supporting partners; implementation steps; action cost range; and high-level performance indicators (which will form the basis of the monitoring and performance assessment steps). The Implementation Plans also include descriptions of additional cost saving considerations for the actions. These are general descriptions of potential cost savings as many actions would require further analysis of feasibility studies to determine exact savings. When budget requests are made for the actions, the requests will include a more in-depth analysis of costs and savings.

The Implementation Roadmaps are fluid and may change as the county's emission sources, funding sources, and department roles change. They are not a requirement for lead departments to complete each implementation step or a guarantee that all actions will be implemented. They are simply a recommended starting point to begin action. Given the complexity and magnitude of the systems we are managing, we need to act now with the best current information available. The Office of Sustainability will have an oversight role in guiding and tracking implementation, but actual implementation will be led by the respective departments.

As a part of the Adaptive Management approach, we expect that methodologies for analysis of the County's emissions will continue to evolve over time. In the future, we expect to incorporate the following into CESMP updates or as part of action implementation steps:

1. Validate and integrate forest carbon sequestration estimations into GHG inventories
2. Assess how commercial building owners and businesses may use renewable energy to reduce their carbon intensity
3. Forecast clean energy growth in the electric grid

4. Account for the effects of the Federal Inflation Reduction Act (IRA) and other legislation on the carbon intensity of the electric grid and on vehicle emissions reductions
5. Conduct a more detailed analysis of the effectiveness of smart growth measures on vehicle miles traveled and emissions reductions

Additionally, we recommend incorporating the social cost of carbon in the methodology as a metric for quantifying action impact. The social cost of carbon is an estimation of the cost in dollars of either negative implications of adding a ton of carbon emissions to the atmosphere, or the benefit of reducing a ton of carbon emissions. For example, the EPA currently estimates the social cost of reducing a ton of carbon in 2030 to be around \$230.<sup>21</sup>

## Assessments for Climate Mitigation and Resiliency Impacts

The County currently conducts environmental reviews for rezonings, comprehensive plan amendments (CPAs), special use permits (SUPs), and major road projects. These reviews rate projects in terms of their conformance to goals of the Comprehensive Plan, Strategic Plan, Schools Plan, and other County planning documents, as well as compliance with environmental regulations.

In the future, County staff recommends that the Board consider amending relevant County regulations and policies, consistent with applicable law, to assess greenhouse gas emissions, to assess renewable and fossil energy mix, and to assess climate resiliency metrics. This would provide additional information about the potential environmental impacts of specific rezoning and SUP applications, Capital Improvement Program (CIP) projects, and CPAs on the community based on the Board's adopted Climate Mitigation and Resiliency Goals.

The Office of Sustainability is requesting an Environmental Analyst position to assist with developing and/or reviewing these assessments.

## Institutional Capacity

To implement the CESMP, one of the necessary first steps is to build up institutional capacity to execute the foundational elements of the plan. This includes key activities such as increasing staff capacity to pursue federal grants for green programs and the capacity for communication and outreach that will engage residents and businesses in the voluntary measures recommended in the CESMP.

To begin implementation, the Office of Sustainability is hiring a Climate and Energy Manager to provide the necessary support to begin to stand up projects and programs for the high priority actions in the CESMP. The County will also utilize the \$1.04 million in CIP funding that has been allocated by the Board via Resolutions 21-663 and 22-573 for the CESMP to kick-start actions that are related to County infrastructure. Projects with CIP funding allocated are included below.

## Projects with CIP Funding Allocated

- ▶ Installing solar on County buildings identified in feasibility study that will be completed December 2023 (Action E.5)
- ▶ Conduct feasibility study for electrification of County buildings (Action B.5)
- ▶ Transition of high-pressure sodium streetlights to LED (estimated 200 streetlights) (Action B.1)

We recommend consideration of CIP funds for FY25 to implement the below projects.

## FY25 CIP Fund Requests for \$10 million

- ▶ Begin to implement recommendations from feasibility study for electrification of County-owned buildings (Action B.5)
- ▶ Begin to implement recommendations from feasibility study to convert County fleet to low- or zero-emission vehicles that will be completed Spring 2024 (Action T.7)
- ▶ Development of greenhouse gas inventory for County government operations (Action B.5)
- ▶ Installing solar on buildings identified in feasibility study that will be completed December 2023 (Action E.5)

In addition to the CIP funds that have already been allocated for CESMP implementation and FY25 CIP funds, the following general fund budget requests for FY25 would provide the institutional capacity needed for the first year of implementation:

- ▶ Sustainability Communications and Outreach Manager – Manage grant writing opportunities and communications with the public, including campaigns about available resources and incentives.



- Environmental Analyst – Stand up the Adaptive Management system for analyzing progress towards the Climate Mitigation and Resiliency goals. This would include development and review of assessments for impacts of major projects on Climate Mitigation and Resiliency goals and tracking CESMP implementation costs and savings.

Lastly, we recommend that the CESMP is incorporated into the Comprehensive Plan through an amendment to the Comprehensive Plan, and that the action strategies of the CESMP are incorporated into the County's next Strategic Plan. This step would help fulfill the mandate in Board Resolution 20-773 to "incorporate into the Comprehensive Plan goals of 100% of Prince William County's electricity to be from renewable sources by 2035, for Prince William County Government operations to achieve 100% renewable electricity by 2030, and for Prince William County Government to be 100% carbon neutral by 2050."

This would also support implementation of the many sustainability strategies already established in the Comprehensive Plan and 2021-2024 Strategic Plan (**Appendix C. CESMP Actions Mapped to Strategic Plan and Comprehensive Plan Action Strategies**).








# Appendix A Complete List of CESMP Actions

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Energy	<b>E.1: Acquire Clean Electricity Sources for the County</b>  <i>Form an opt-out community choice aggregation program to acquire 100% clean electricity for the community.</i>	High	●		●	●	●
	<b>E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives</b>  <i>Provide outreach and education on programs and incentives for residents and businesses to install renewable energy systems. Develop additional renewable energy incentives, such as streamlined solar permitting, in partnership with stakeholders such as the Residential Solar Task Force.</i>	High	●		●		
	<b>E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings</b>  <i>Encourage the use of renewable energy in energy-intensive commercial buildings (e.g., through expedited permitting).</i>	High	●		●		



Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Energy (cont.)	<b>E.4: Promote Existing Green Power Products</b>  <i>Promote purchasing utility green power options within the community.</i>	High	●		●		
	<b>E.5: Install Solar on County Government Facilities</b>  <i>Develop solar projects on County government facilities.</i>	High	●		●	●	●
● Buildings	<b>B.1: Encourage Energy Efficiency and Electrification Retrofits</b>  <i>Encourage existing building energy efficiency retrofits (e.g., streamlined permitting).</i>	High	●				
	<b>B.2: Propose Green Zoning Regulations</b>  <i>Propose green zoning regulations to encourage water- and energy-efficient buildings, multifamily and mixed-use areas, and transit-oriented developments.</i>	High	●				

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
 <b>Buildings (cont.)</b>	<b>B.3: Encourage Energy Efficient and Electric New Construction</b>  <i>Encourage developers to build a more energy-efficient standard set by the County government or use all-electric systems and equipment.</i>	High					
	<b>B.4: Promote Energy Efficiency and Electrification Incentives</b>  <i>Provide outreach and education to residents and businesses about the tools, technology, and incentives for building energy efficiency and electrification.</i>	High					
	<b>B.5: Create Net-Zero Plan for County Government Facilities</b>  <i>Develop a net-zero building plan for County government facilities, which will include implementing an energy benchmarking program and procuring 100% clean electricity for all County government operations.</i>	High					









Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Buildings (cont.)	<b>B.6: Create All-electric Guidelines for New Construction of County Government Facilities</b>  <i>Develop an all-electric new construction requirement for all new County government facilities.</i>	Medium	●			●	
	<b>B.7: Create Policy to Increase Energy Efficiency in County Government Facilities</b>  <i>Adopt a County government energy policy that outlines operational and purchasing requirements that increase energy efficiency.</i>	Medium	●			●	
	<b>B.8: Implement Building Energy Benchmarking</b>  <i>Implement a voluntary commercial building energy benchmarking and reporting program with the intent to transition to a building energy performance standard.</i>	Low	●				
● Transportation	<b>T.1: Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity</b>  <i>Improve active transportation infrastructure and improve sidewalk and trail connectivity to support walking, biking, and rolling, with improvements such as providing bike lockers, installing curb ramps, or installing traffic-calming designs like crosswalk islands or speed humps.</i>	High	●				






Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Transportation (cont.)	<b>T.2: Encourage Transit-Oriented Development</b>  <i>Support transit-oriented development within 1/2-mile of transit stations.</i>	High	●				
	<b>T.3: Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips</b>  <i>Work with major employers to expand the Transportation Demand Management and Transit Fare Buy Down Program (expanding Strategic Plan program) and promote teleworking.</i>	High	●				
	<b>T.4: Upgrade Public Transit Infrastructure</b>  <i>Partner with county transit operators to improve and provide new public transit infrastructure and build out transit nodes (e.g., priority bus lanes, bus stops, priority signaling).</i>	High	●				
	<b>T.5: Encourage Zero-Emission Vehicles and Charging</b>  <i>Encourage the development of cost-reduction programs for residents and businesses to purchase ZEVs or install charging equipment (e.g., through streamlined permitting or “group-buy” programs).</i>	High	●				

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Transportation (cont.)	<b>T.6: Expand Public EV Charging Network</b>  <i>Expand public EV charging infrastructure, especially along main routes and in popular destinations.</i>	High	●				
	<b>T.7: Adopt Zero- or Low-Emissions County Fleet</b>  <i>Transition County government fleet to zero-/low-emissions vehicles and ensure supporting infrastructure is open to other fleets.</i>	High	●			●	
	<b>T.8: Encourage E-Bike and E-Scooter Adoption</b>  <i>Promote the use of e-bikes and e-scooters through enhanced infrastructure and incentives.</i>	Medium	●				
	<b>T.9: Educate on Existing Zero-Emission Vehicle Incentives and Rebates</b>  <i>Provide outreach and education on existing ZEV incentives or rebates.</i>	Medium	●				
	<b>T.10: Promote Zero-Emission Bus and Rail Transition</b>  <i>Partner with public transit operators to promote the transition to zero-emission buses, including school buses, and rail systems (e.g., providing charging station infrastructure).</i>	Medium	●				









Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Transportation (cont.)	<b>T.11: Support Zero- or Low-Emissions County Government Contracting of Off-Road Equipment</b>  <i>Adopt a policy that encourages the County government to contract with businesses operating low- or zero-emission off-road equipment.</i>	Medium	●			●	
	<b>T.12: Adopt County Government Zero-Emission Off-Road Policy</b>  <i>Adopt a government zero-emissions off-road vehicles and equipment policy that requires low- or zero-emissions replacements.</i>	Medium	●			●	
	<b>T.13: Discount Transit Passes for Residents</b>  <i>Continue free local OmniRide service and offer discounts for other services such as rail.</i>	Low	●				
	<b>T.14: Launch Electric Equipment Lending Program</b>  <i>Start a lending library where residents can check out electric landscaping equipment and expand to other low-emissions tools and equipment.</i>	Low	●				

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
Natural Resources	<b>N.1: Adopt Natural Open Space Requirements</b>  <i>Establish minimum Natural Open Space (NOS) guidelines to encourage preservation of NOS, if appropriate in new development.</i>	High					
	<b>N.2: Launch Suburban and Rural Tree Planting Initiative</b>  <i>Implement a tree planting and maintenance program to expand suburban and rural tree cover.</i>	Medium					
	<b>N.3: Update Tree Cover Regulations</b>  <i>Update tree cover regulations utilizing 2008 enabling legislation to increase the percent of required tree cover for new development projects.</i>	Medium					
	<b>N.4: Support Sustainable Farming Practices</b>  <i>Provide outreach and education to the agricultural community on sustainable farming practices that reduce fertilizer use and increase soil carbon sequestration.</i>						
Waste	<b>W.1: Implement County-Wide Composting</b>  <i>Implement a county-wide composting program to provide free food waste composting services to residents, businesses, and the agricultural sector.</i>	Medium					




Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
<b>Waste (cont.)</b>	<b>W.2: Promote Sustainable Purchasing Policy</b>  <i>Develop a government sustainable purchasing policy for County government purchasing decisions to promote use of sustainable products, such as those made from recycled materials, and prohibit the use of single use plastics and Styrofoam to-go containers.</i>	Medium					
	<b>W.3: Mandate Commercial Food Waste Diversion</b>  <i>Require commercial businesses to divert food scraps either through food recovery or composting programs.</i>	Low					
<b>Adaptation</b>	<b>A.1: Develop Adaptation Plans for Critical Facilities</b>  <i>Develop site-level adaptation plans for critical facilities and service areas considering future climate change hazards.</i>	High					
	<b>A.2: Understand Stormwater Flooding in Areas Outside of the Floodplain</b>  <i>Develop plans for stormwater system upgrades based on future conditions stormwater modeling data and historic flooding information.</i>	High					

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Adaptation (cont.)	<b>A.3: Improve Power Resiliency for Critical Infrastructure</b>  <i>Improve the resiliency of electrical infrastructure for publicly owned essential services and infrastructure</i>	High		●			
	<b>A.4: Assess Shoreline Protection and Nature-Based Solutions</b>  <i>Conduct feasibility studies to evaluate shoreline protection measures against erosion and flood, encouraging nature-based solutions. Develop long-term plans to address sea level rise for at-risk public and private property.</i>	High		●			
	<b>A.5: Restore Streams to Reduce Flooding</b>  <i>Develop stream corridor restoration projects to improve conveyance and mitigate flooding.</i>	High		●			
	<b>A.6: Encourage Technology for Residents to Make Homes Adaptive</b>  <i>Provide incentives or subsidies for residents of low-income housing and rental properties to install or retrofit buildings with climate adaptive technologies to reduce energy, reduce water use, reduce waste heat, and minimize urban heat gain.</i>	High		●		●	



Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
<div>  <b>Adaptation (cont.)</b> </div>	<b>A.7: Plan Alternate Evacuation Routes for Flood-prone Areas</b>  <i>Identify alternate evacuation routes for roads and bridges identified as vulnerable to flooding and/or sea level rise.</i>	High					
	<b>A.8: Expand Building Insulation Standards to Protect Against Extreme Heat</b>  <i>Increase standards for insulation in new construction buildings and homes for resiliency against extreme heat events.</i>	High					
	<b>A.9: Protect Existing Buildings Against High Winds</b>  <i>Identify structures for high wind retrofits and implement retrofits on existing structures.</i>	Medium					
	<b>A.10: Protect County Infrastructure from Flooding</b>  <i>Identify residential and commercial infrastructure vulnerable to future flooding and evaluate if infrastructure should be elevated, relocated, or floodproofed.</i>	Medium					

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Adaptation (cont.)	<b>A.11: Encourage Nature-based Solutions to Reduce Flooding in Residential Properties</b>  <i>Develop program to provide encourage and promote rain gardens, conservation landscapes, green roofs, water harvesting, and permeable pavement for residential properties.</i>	Medium		●			
	<b>A.12: Improve Water Infrastructure for Extreme Precipitation Events</b>  <i>Update water and drainage infrastructure design standards to address the projected increase in intensity of precipitation, including the use of retrofits and/or green infrastructure in new construction.</i>	Medium		●			
	<b>A.13: Urban Heat Island Relief Program</b>  <i>Encourage urban designs that facilitate air movement to alleviate heat islands (e.g., increasing urban tree cover).</i>	Medium	●	●			
	<b>A.14: Adopt Guidelines to Use Nature-based Solutions on County Government Construction</b>  <i>Develop guidelines on how to incorporate nature-based solutions into County government projects.</i>	Medium		●			

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
<b>Adaptation (cont.)</b>	<b>A.15: Improve Grid Resiliency During Extreme Weather</b>  <i>Evaluate resilient energy systems such as microgrids or other distributed energy resources within the county to provide stable energy supply during times of extreme weather.</i>	Medium					
	<b>A.16: Expand Tax Credits for Conservation of Natural Resources</b>  <i>Expand tax credits for conservation of floodplains and natural buffers, such as wetlands and riverbank tree planting, in vulnerable areas.</i>	Medium					
	<b>A.17: Develop Plan to Preserve Estuaries and Wetlands To Reduce Flooding</b>  <i>Map projected future sea levels and identify existing wetlands that may be impacted. Develop a plan to preserve these spaces and use them to mitigate runoff and flood impacts where possible.</i>	Medium					
	<b>A.18: Training for Community Members on Climate Change and Mental Health</b>  <i>Provide professional development training for teachers, support staff and other community members to support child and youth mental health related to climate change.</i>	Medium					

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Adaptation (cont.)	<b>A.19: Increase Protection from the Sun at Childcare Centers</b>  <i>Develop guidelines for shade for schools and childcare centers' grounds.</i>	Medium	●	●			
	<b>A.20: Encourage Improved Cooling Equipment in Apartments</b>  <i>Encourage expanded access to reliable, efficient cooling for apartments.</i>	Low	●	●			
	<b>A.21: Encourage Businesses to Reduce Water Usage</b>  <i>Develop incentives, training and technical assistance programs for significant water use reductions including rainwater and greywater harvesting and onsite blackwater treatment with a focus on industrial and commercial properties.</i>	Low	●	●			

Sector	Actions	Action Priority	Cut GHG Emissions	Prepare for Climate Change	Use 100% Renewable Electricity County-Wide by 2035	Become Carbon Neutral for County Government	Use 100% Renewable Electricity in County Government by 2030
● Adaptation (cont.)	<b>A.22: Protect Electrical Infrastructure from High Winds</b>  <i>Partner with energy providers to increase resiliency of the electrical grid including hardening infrastructure and/or burying power lines where appropriate.</i>	Low		●			
	<b>A.23: Expand Community Outreach for Education on Climate Change Adaptation</b>  <i>Expand existing "Ready Prince William" Community Outreach and Preparedness Campaign to support the development of accessible technology to provide climate information to individuals and industries to enhance collective understanding.</i>	Low		●			
	<b>A.24: Support Agriculture Resiliency</b>  <i>Identify support for farmers to prepare for and recover from extreme weather, such as access to more accurate weather data, harvest support, drought resistant crops, backup generation, and livestock evacuation.</i>	Low		●			



## Appendix B Implementation Plan

- ▶ Appendix B.1 Estimated Budget for CESMP Actions
- ▶ Appendix B.2 How to Read an Implementation Roadmap
- ▶ Appendix B.3 Implementation Plans

## Appendix B.1 Estimated Budget for CESMP High Priority Actions

The following table represents estimated first year costs and an estimated high-level cost range for the years 2025 through 2030 leading up to the goal year of 2030 for the high priority actions. The actions are listed in order of low to high costs. Also noted are the estimated GHG reduction potential and additional cost considerations. Actions listed near the top with high estimated GHG reduction potential would be considered actions with a low cost per ton of GHG reduction.

These are considered high-level estimated cost ranges for action implementation. In many cases, a feasibility study or further analysis would need to be completed to determine exact costs and cost savings. When budget requests are made for the actions, more specific cost savings information will be evaluated and included for Board review. For more information on what is included in these costs, see the Implementation Plans in this Appendix.

Action Title	Estimated Year 1 Costs	2025-2030 Costs		Estimated GHG Reduction Potential	Additional Cost Considerations
		Low	High		
N.1: Adopt Natural Open Space Requirements	\$0	\$100,000	\$500,000		Provides cost savings to the County by sequestering carbon, preventing erosion, and improving water quality.
T.2: Encourage Transit-Oriented Development	\$200,000	\$200,000	\$200,000	High	Provides cost savings for residents with less reliance on single-occupancy vehicle trips.
B.2: Propose Green Zoning Regulations	\$500,000	\$500,000	\$1,000,000	Medium	
A.1: Develop Adaptation Plans for Critical Facilities	\$200,000	\$600,000	\$600,000		
E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives	\$200,000	\$1,000,000	\$1,000,000	Medium	Provides support for actions E.2, E.4 and B.4 through funding a shared outreach position.
T.3: Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips	\$200,000	\$1,000,000	\$1,000,000	Medium	Provides cost savings for residents with less reliance on single-occupancy vehicle trips.
E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings	\$0	\$1,000,000	\$10,000,000	High	

Action Title	Estimated Year 1 Costs	2025-2030 Costs		Estimated GHG Reduction Potential	Additional Cost Considerations
		Low	High		
E.4: Promote Existing Green Power Products	\$200,000	\$1,000,000	\$1,000,000	High	Provides support for actions E.2, E.4 and B.4 through funding a shared outreach position.
B.4: Promote Energy Efficiency and Electrification Incentives	\$200,000	\$1,000,000	\$1,000,000	Medium	Provides support for actions E.2, E.4 and B.4 through funding a shared outreach position.
A.3: Improve Power Resilience for Critical Infrastructure	\$0	\$1,000,000	\$5,000,000		
A.6: Encourage Technology for Residents to Make Homes Adaptive	\$200,000	\$2,400,000	\$2,400,000		Provides cost savings for qualifying residents by reducing energy bills. Outreach programs connect residents to existing weatherization and utility programs that provide services at no cost.
A.2: Manage Stormwater Flooding Outside of the Floodplain	\$0	\$3,000,000	\$3,000,000		Provides cost savings to the County and residents by preventing flood damage and improving water quality.
A.7: Plan Alternate Evacuation Routes for Flood-prone Areas	\$500,000	\$3,200,000	\$3,200,000		
E.1: Acquire Clean Electricity Sources for the County	\$1,200,000	\$4,000,000	\$5,000,000	Very High	Could result in utility savings depending on negotiations. Changes in County government electricity costs could increase or decrease electricity costs.
B.1: Encourage Energy Efficiency and Electrification Retrofits	\$200,000	\$5,000,000	\$5,000,000	Medium	Provides cost savings for residents and businesses through streamlined permitting or energy efficiency.
B.3: Encourage Energy Efficient and Electric New Construction	\$0	\$5,000,000	\$5,000,000	Medium	Provides utility cost savings.

Action Title	Estimated Year 1 Costs	2025-2030 Costs		Estimated GHG Reduction Potential	Additional Cost Considerations
		Low	High		
T.5: Encourage Zero-Emission Vehicles and Charging	\$0	\$5,000,000	\$5,000,000	High	Provides cost savings for residents and businesses by streamlining permitting for EV charging stations. An increase in public EV charging stations results in less need for residents to install personal chargers. This is a particular benefit for residents in multi-family housing.
A.4: Implement Shoreline Protection and Nature-Based Solutions	\$200,000	\$5,000,000	\$5,000,000		Provides support for actions A.4 and A.5 through funding a shared position.
A.5: Restore Streams to Reduce Flooding	\$200,000	\$5,000,000	\$5,000,000		Provides cost savings to the County by preventing erosion and improving water quality.
E.5: Install Solar on County Government Facilities	\$0	\$9,000,000	\$9,000,000	Low	Provides support for actions A.4 and A.5 through funding a shared position. Will generate \$250k annual cost savings for the first ten buildings with diminishing returns for additional buildings.
T.6: Expand Public EV Charging Network	\$200,000	\$25,000,000	\$50,000,000	High	Provides cost savings to the County by preventing erosion and stream degradation.
T.1: Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity	\$200,000	\$50,000,000	\$50,000,000	High	
T.4: Upgrade Public Transit Infrastructure	\$200,000	\$100,000,000	\$250,000,000	Medium	Provides utility cost savings for the County.
Total Estimated 2025-2030:	\$4,200,000	\$222,000,000	\$411,900,000		

The following table represents estimated first year costs and an estimated cost range for the following years 2030 through 2050 for the high priority actions that require longer implementation timelines to be completed. Action implementation timeline is 2030-2050 to meet the goal of county government operations being carbon neutral by 2050. Feasibility studies or further analysis would be especially important for these actions to determine exact costs and cost savings.

Action Title	Estimated Year 1 Costs	2025-2030 Costs		Estimated GHG Reduction Potential	Additional Cost Considerations
		Low	High		
B.5: Transition to Net-Zero for County Government Facilities	\$400,000	\$10,000,000	\$100,000,000	Medium	Provides utility cost savings for the County.
T.7: Adopt Zero- or Low-Emissions County Fleet	\$0	\$200,000,000	\$350,000,000	Low	Provides cost savings on vehicle maintenance, fuel tank maintenance, and fuel costs in comparison with internal combustion engine (ICE) vehicles. Cost estimate does not include existing vehicle replacement budget. Current estimated cost to replace an ICE vehicle fleet by 2050 is \$170,000,000. Anticipated significant improvements in specialty vehicle EV options in the next 20 years. Federal tax credits can assist with offsetting the purchase of EV's.
Total Estimated 2030-2050:	\$400,000	\$210,000,000	\$450,000,000		

Estimated costs for the high priority actions years 2025 through 2050 are summarized in the table below.

Timeline	Estimated Year 1 Costs	Low	High
Total Estimated 2025-2030	\$4,200,000	\$222,000,000	\$411,900,000
Total Estimated 2030-2050	\$400,000	\$210,000,000	\$450,000,000
Total Estimated 2025-2050	\$4,600,000	\$432,000,000	\$861,900,000



## Appendix B.2 How to Read an Implementation Map

<b>Action Title</b>	The action number and title	
<b>Action Description</b>	Description of action as reflected in the CESMP text	
<b>Related County Goal(s)</b>	County goals that the action contributes toward meeting	
<b>Climate Action Topic</b>	Climate action topic the action addresses: Electricity, Buildings, Transportation, Waste, Natural Resources, Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	<p>Action's GHG reduction potential range and/or climate hazard addressed.</p> <p>GHG Reduction Potential (represents the high/maximum estimate for GHG reductions):</p> <ul style="list-style-type: none"> <li>▶ Very High: greater than 500,000 MTCO<sub>2</sub>e reduced</li> <li>▶ High: 50,000-500,000 MTCO<sub>2</sub>e reduced</li> <li>▶ Medium: 10,000-50,000 MTCO<sub>2</sub>e reduced</li> <li>▶ Low: less than 10,000 MTCO<sub>2</sub>e reduced</li> <li>▶ Unknown: Not Quantified</li> </ul> <p>Climate Hazard:</p> <ul style="list-style-type: none"> <li>▶ All Climate Hazards</li> <li>▶ Precipitation</li> <li>▶ High Winds &amp; Tornadoes</li> <li>▶ Sea Level Rise</li> <li>▶ Extreme Heat</li> </ul>	
<b>Lead Department(s)</b>	Department(s) that will be leading action implementation	
<b>Supporting Departments/Partners</b>	Departments or other entities that can support action implementation	
<b>Implementation Steps</b>	High-level steps to implement action	
<b>Potential County Action Cost Range (2025-2030)</b>	Includes County government first year budget requests and ongoing cost considerations from 2025-2030. Does not include existing staff time costs or upfront/operational savings generated by the action. Does not consider existing funds available that would have been spent in a business-as-usual scenario if the action was not implemented (e.g., costs for purchasing fossil fuel cars versus costs for purchasing electric cars at time of replacement).	
<b>Performance Indicators</b>	Output Indicators: Measurable result of action (i.e., miles of bike lanes built, kilowatts of renewable energy installed)	Outcome Indicators: Outcomes needed to achieve the GHG reduction strategies and County goals (i.e., increase in bicycle mode share, electricity emissions reduced)

## Appendix B.3 Implementation Plans

### E.1 Acquire Clean Electricity Sources for the County

<b>Action Title</b>	E.1: Acquire Clean Electricity Sources for the County
<b>Action Description</b>	Form an opt-out community choice aggregation program to acquire 100% clean electricity for Dominion Energy customers in the community. A CCA allows local governments to negotiate for 100% clean or renewable electricity for all the electricity customers within their jurisdiction. Through a CCA, the County can purchase and manage their community's electric power supply from a preferred mix of energy sources while the utility continues to provide distribution, billing services, and outage management. In the county, further legal review is needed to determine if a CCA could be formed in Dominion Energy's territory and NOVEC's territory. If we develop an opt-out program, customers would automatically be enrolled in 100% clean electricity but can opt-out to revert to their traditional service and electricity energy source mix. This action could substantially reduce county-wide electricity emissions, depending on the offered clean electricity mix and how many customers opt-out of the program.
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> <li>▶ Achieve 100% renewable electricity in County Government operations by 2030</li> <li>▶ Achieve 100% carbon neutrality in County Government operations by 2050</li> </ul>
<b>Climate Action Topic</b>	Electricity
<b>GHG Reduction Potential/Climate Hazard</b>	Very High
<b>Lead Department(s)</b>	Office of Sustainability
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Facilities and Fleet Management</li> <li>▶ Finance</li> <li>▶ Management and Budget</li> <li>▶ Economic Development</li> </ul>
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Release request for information (RFI) which will include:               <ul style="list-style-type: none"> <li>• Study on electric grid capacity/feasibility to provide 100% clean electricity for the entire community</li> <li>• Study on potential conflicts or complications of forming a CCA with Dominion and NOVEC</li> </ul> </li> <li>▶ Develop a CCA feasibility study</li> <li>▶ Release a request for proposals (RFPs)</li> <li>▶ Hire an expert on CCA to manage contract under Office of Sustainability</li> <li>▶ Assess conflicts with County government electricity purchasing contracts</li> </ul>

<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$4M-\$5M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring new staff member: \$200k</li> <li>▶ Developing feasibility study: \$1M</li> </ul> <p>Other Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Start-up costs (\$3.7M – referenced from Loudoun County feasibility study)</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salaries</li> <li>▶ Changes in County government electricity costs (could increase or decrease electricity costs)</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % participation rate in program</li> <li>▶ % clean or renewable kWh provided to community</li> <li>▶ Cost of electricity (\$/kWh)</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ CCA electricity emissions factor</li> <li>▶ Community-wide electricity emissions</li> </ul>

## E.2 Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives

<b>Action Title</b>	E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives
<b>Action Description</b>	Provide outreach and education on programs and incentives for residents and businesses to install renewable energy systems, such as federal solar tax credits, community solar programs, net metering, the multifamily shared solar program, solar renewable energy certificates and Solarize NOVA. Develop additional local renewable energy incentives, such as streamlined solar permitting, in partnership with stakeholders such as the Residential Solar Task Force and local utilities. This would include providing a centralized tool for residents and businesses to reference relevant federal, state, County, and utility incentives and programs.
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> </ul>
<b>Climate Action Topic</b>	Electricity
<b>GHG Reduction Potential/ Climate Hazard</b>	Medium
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Development Services - Building Development Division</li> <li>▶ Development Services - Land Development Division</li> <li>▶ Real Estate Assessments</li> <li>▶ Office of Sustainability</li> </ul>
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Development Services - Building Development Division</li> <li>▶ Development Services - Land Development Division</li> <li>▶ Real Estate Assessments</li> <li>▶ Office of Sustainability</li> </ul>

<b>Implementation Steps</b>	<p>Promote Existing Incentives</p> <ul style="list-style-type: none"> <li>▶ Develop a centralized webpage or tool on County website for residents and businesses to reference relevant federal, state, County, and utility incentives and programs (PACE, tax credits, multifamily shared solar program, net metering, community solar, solar renewable energy certificates (SRECs), Solarize NOVA)</li> <li>▶ Integrate Development Services' residential solar local incentives webpage information into tool and ensure tool is periodically updated</li> <li>▶ Coordinate webpage or tool development with Action B.4: "Promote Energy Efficiency and Electrification Incentives"</li> <li>▶ Work with Solarize NOVA to promote their services (a community-based outreach initiative sponsored by the Northern Virginia Regional Commission that facilitates the deployment of solar energy to homes and businesses in Northern Virginia, through bulk purchasing and free solar site assessments)</li> <li>▶ Provide education/outreach to commercial business networks and include incentive information in County presentations to new businesses or businesses considering locating to the county</li> <li>▶ The Office of Sustainability would lead any education and outreach efforts</li> </ul> <p>Develop Additional Incentives</p> <ul style="list-style-type: none"> <li>▶ Work with Residential Solar Task Force to develop new solar incentives</li> <li>▶ Engage with SolSmart Virginia to help make commercial solar permitting faster, easier, and more affordable for businesses</li> <li>▶ Engage the development community to understand new areas of opportunity in the Zoning code</li> <li>▶ Evaluate mechanisms to reduce or exempt taxes on solar panels</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$200k-1M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ New staff member to develop new incentives</li> </ul> <p>Ongoing Cost Consideration</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Number of county solar installation permits with system size (kW) information</li> <li>▶ Number of ground-mounted versus roof solar systems</li> <li>▶ Track number of participants throughout county using Solarize NOVA data</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Residential grid electricity use</li> <li>▶ Residential building emissions</li> <li>▶ Commercial grid electricity use</li> <li>▶ Commercial building emissions</li> </ul>



## E.3 Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings

<b>Action Title</b>	E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings
<b>Action Description</b>	Encourage the use of renewable energy in energy-intensive commercial buildings through a voluntary reporting program or expedited permitting. As commercial building electricity use is forecast to generate roughly 28% of county-wide emissions by 2030, encouraging emissions reductions in this sector is crucial toward meeting the 2030 GHG reduction target.
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> </ul>
<b>Climate Action Topic</b>	Electricity
<b>GHG Reduction Potential/Climate Hazard</b>	High
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Development Services</li> <li>▶ Planning Office</li> <li>▶ Economic Development</li> </ul>
<b>Supporting Departments/Partners</b>	Businesses and Data Centers

<b>Implementation Steps</b>	<p>Reporting and Transparency</p> <ul style="list-style-type: none"> <li>▶ Collaborate with data center companies/developers to discuss the following:             <ul style="list-style-type: none"> <li>• How local government can help data centers reduce emissions, transition to clean energy sources, and reduce energy use</li> <li>• Request disclosure of clean energy generation/purchasing, emissions and offset information, and progress toward any clean energy or emissions goals</li> <li>• NOTE: There may be limitations on obtaining energy use and/or equipment information from data centers</li> </ul> </li> <li>▶ Develop a voluntary reporting program to communicate data center clean energy development/usage and emissions reduction progress to the public while emphasizing the amount of new clean energy sources added to grid</li> </ul> <p>Other Incentives</p> <ul style="list-style-type: none"> <li>▶ Determine the qualifications for buildings to apply to renewable energy incentive program (e.g., incentive only applies to commercial buildings with a minimum energy use intensity, building must procure a minimum % of renewable energy to attain incentive, etc.)</li> <li>▶ Review the legality of offering incentives to specific commercial building types and excluding other types</li> <li>▶ Evaluate the current number and projected new development of the qualified buildings in the county</li> <li>▶ Develop County goals on the percent of qualified developments that will use the incentive</li> <li>▶ Use County goals to determine the incentive type/amount and number of new staff needed to implement incentives</li> <li>▶ Evaluate the feasibility and effectiveness of different incentives for renewable energy use for commercial developments</li> <li>▶ Streamlined/expedited permitting             <ul style="list-style-type: none"> <li>• Office of Sustainability could provide funding to Building Services to expand permitting team, or new funding could be allocated to Building Services team</li> <li>• NOTE: Data centers are already granted expedited plan reviews/inspections by County as they are targeted industry/priority development</li> </ul> </li> </ul>
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$1M-\$10M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ No additional first year costs (internal staff time)</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Costs dependent on incentive pursued and if new staff are needed</li> </ul>

<b>Performance Indicators</b>	<b>Output Indicators</b> <ul style="list-style-type: none"><li>▶ % of data centers disclosing energy or emissions information</li><li>▶ % of qualified developments using incentive (either square footage or # of developments)</li><li>▶ kWh of renewable energy purchased due to incentive</li></ul>	<b>Outcome Indicators</b> <ul style="list-style-type: none"><li>▶ Commercial energy use</li><li>▶ Commercial emissions</li></ul>
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## E.4 Promote Existing Green Power Products

<b>Action Title</b>	E.4: Promote Existing Green Power Products	
<b>Action Description</b>	Promote purchasing utility green power options within the community. Green power products allow customers to purchase renewable or clean electricity on a month-to-month basis through an added fee on their utility bill. Both Dominion and NOVEC offer 100% renewable electricity options.	
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> <li>▶ Achieve 100% renewable electricity in County government operations by 2030</li> <li>▶ Achieve 100% carbon neutrality in County government operations by 2050</li> </ul>	
<b>Climate Action Topic</b>	Electricity	
<b>GHG Reduction Potential/Climate Hazard</b>	High	
<b>Lead Department(s)</b>	Office of Sustainability	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Communications</li> <li>▶ Public Works</li> <li>▶ Dominion and NOVEC</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Hire a new communications staff member through Office of Sustainability</li> <li>▶ Evaluate cost of purchasing green power from Dominion and NOVEC (both offer 100% renewable options) compared to regular utility costs</li> <li>▶ Work with Dominion and NOVEC to develop education and outreach program to promote green power product purchasing</li> <li>▶ Work with Dominion and NOVEC to understand their capacity to provide 100% renewable electricity to county customers</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: ~\$1M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring staff member: \$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salary: \$200k/year</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Customer participation rate</li> <li>▶ # or % of kWh from renewable or clean electricity sources for participating customers</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Emissions avoided through green power purchasing</li> </ul>

## E.5 Install Solar on County Government Facilities

<b>Action Title</b>	E.5: Install Solar on County Government Facilities	
<b>Action Description</b>	Develop solar projects on County government facilities through consideration of direct ownership or third-party ownership models such as PPAs.	
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> <li>▶ Achieve 100% renewable electricity in County Government operations by 2030</li> <li>▶ Achieve 100% carbon neutrality in County Government operations by 2050</li> </ul>	
<b>Climate Action Topic</b>	Electricity	
<b>GHG Reduction Potential/Climate Hazard</b>	Low	
<b>Lead Department(s)</b>	Fleets and Facilities Management	
<b>Supporting Departments/Partners</b>	<p>Departments with facilities not managed by Facilities and Fleet:</p> <ul style="list-style-type: none"> <li>▶ Community Services</li> <li>▶ Housing and Community Development</li> <li>▶ Fire &amp; Rescue</li> <li>▶ Parks, Recreation &amp; Tourism</li> <li>▶ Public Works</li> <li>▶ Adult Detention Center</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Consider language for legal evaluation</li> <li>▶ Complete solar feasibility study to identify ideal solar locations on County buildings (County already conducted a high-level feasibility study for roughly 65 facilities and identified 10 buildings that it is currently conducting a detailed solar feasibility study on)</li> <li>▶ Identify funding source for solar installations</li> <li>▶ Install solar on priority facilities identified through feasibility study</li> <li>▶ Develop plan to encourage and/or develop public/private partnerships to place solar panels on/over parking lots across the county</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: ~\$9M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Solar feasibility study already paid for and underway</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Installing solar on top 10 buildings (including construction costs): \$9M             <ul style="list-style-type: none"> <li>• NOTE: If solar is installed on the 10 buildings undergoing detailed solar feasibility study, the solar will generate \$250k annual savings in electric bills, potentially reducing total 2030 costs by \$1M.</li> </ul> </li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Size (kW) of solar installed on County facilities</li> <li>▶ Electricity (kWh) produced by government solar systems</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Government utility electricity use</li> <li>▶ Electricity emissions avoided through use of solar</li> <li>▶ Government building emissions</li> </ul>



## B.1 Encourage Energy Efficiency and Electrification Retrofits

<b>Action Title</b>	B.1: Encourage Energy Efficiency and Electrification Retrofits	
<b>Action Description</b>	Encourage existing building energy efficiency and electrification retrofits through actions such as streamlined permitting.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Buildings	
<b>GHG Reduction Potential/ Climate Hazard</b>	Medium	
<b>Lead Department(s)</b>	Development Services – Building Department	
<b>Supporting Departments/Partners</b>	None identified	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Determine the qualifications for buildings to apply to incentive program, such as a list of acceptable retrofits</li> <li>▶ Develop county goals on the percent of qualified buildings that will use the incentive</li> <li>▶ Use county goals to structure incentive type/amount and determine the number of new staff needed to implement incentive program</li> <li>▶ Evaluate potential incentives for building upgrades or high energy performance, including: <ul style="list-style-type: none"> <li>• Streamline/expedited permitting</li> <li>• NOTE: Single family residential equipment replacements typically have same day permitting review, but commercial equipment replacement does not</li> </ul> </li> <li>▶ Office of Sustainability could provide funding to Building Services to expand permitting team, or new funding could be allocated to Building Services team through increased permit fees</li> <li>▶ Consider prioritizing or offering larger incentives to low-income residents or building owners that rent to low-income families</li> <li>▶ Provide education/outreach on energy cost savings from energy efficiency/ electrification retrofits</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$5M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring staff member to coordinate/develop incentives: \$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> <li>▶ Implementing incentives</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Building permit data describing equipment replacement and fuel switching</li> <li>▶ Average permit time</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Community electricity use</li> <li>▶ Community natural gas use</li> </ul>

## B.2 Propose Green Zoning Regulations

<b>Action Title</b>	B.2: Propose Green Zoning Regulations	
<b>Action Description</b>	Propose green zoning regulations to encourage energy- and water-efficient buildings, multifamily and mixed-use areas, and transit-oriented developments. Green zoning involves revising zoning policies to require or incentivize developers to abide by certain sustainable development practices. Denser developments and multifamily housing units typically use less energy than other, more dispersed building types. Additionally, mixed-used and transit-oriented areas significantly reduce the need for vehicle travel, which would also reduce transportation emissions.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Buildings, Transportation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Medium	
<b>Lead Department(s)</b>	Planning Office	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Transportation</li> <li>▶ Housing</li> <li>▶ Watershed</li> <li>▶ Parks and Recreation</li> <li>▶ Economic Development/Community Development</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Study what changes in the zoning ordinance can be implemented to best promote green developments:</li> <li>▶ Coordinate local policy revisions to zoning and plans to allow people to live closer to jobs</li> <li>▶ Set environmental goals for green zoning regulations, for example, protect and connect green open spaces and improve ecological benefits</li> <li>▶ Conduct a green space or NOS assessment and define strategy for green/ space NOS (coordinate with Action N.1: "Adopt Natural Open Space Requirements")</li> <li>▶ Develop green zoning around green space strategy</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$500k-\$1M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring consultant, including environmental assessment: \$500k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ No additional costs beyond existing staff time</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ # of green certified buildings (e.g., LEED)</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Residential energy use and emissions</li> <li>▶ Commercial energy use and emissions</li> </ul>

## B.3 Encourage Energy Efficient and Electric New Construction

<b>Action Title</b>	B.3: Encourage energy efficient and electric new construction	
<b>Action Description</b>	Encourage developers to build to a more energy-efficient standard set by the County government or use all-electric systems and equipment.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Buildings	
<b>GHG Reduction Potential/Climate Hazard</b>	Medium	
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ Development Services</li> </ul>	
<b>Supporting Departments/Partners</b>	None identified	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review incentivizing/promoting certain fuel types in new construction</li> <li>▶ Consider using an energy use intensity metric instead of specific fuel-related requirement</li> <li>▶ Establish the type of new developments that should qualify for incentive (e.g., all new developments, developments over a certain size, etc.)</li> <li>▶ Evaluate the projected new development of qualified buildings in the county</li> <li>▶ Develop County goals on the percent of qualified developments that will use the incentive to build all-electric</li> <li>▶ Use County goals to determine the incentive type/amount and number of new staff needed to implement expedited permitting or other incentives</li> <li>▶ Evaluate potential incentives for all-electric new construction, such as: <ul style="list-style-type: none"> <li>• Streamlined/expedited permitting for all-electric construction</li> <li>• Office of Sustainability could provide funding to Building Services to expand permitting team, or new funding could be allocated to Building Services team through increased permit fees elsewhere</li> </ul> </li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$5M</p> <p>First Year Budget Requests:</p> <ul style="list-style-type: none"> <li>▶ No additional first year costs (internal staff time)</li> </ul> <p>Ongoing Cost Considerations:</p> <ul style="list-style-type: none"> <li>▶ Potential additional staff to implement incentive programs</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % of new construction that is all-electric (use # of permits for all-electric new construction and permits for mixed-fuel new construction)</li> <li>▶ Average permit time</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Community electricity use</li> <li>▶ Community natural gas use</li> </ul>

## B.4 Promote Energy Efficiency and Electrification Incentives

<b>Action Title</b>	B.4: Promote Energy Efficiency and Electrification Incentives	
<b>Action Description</b>	Provide outreach and education to residents and businesses about tools, technology, and incentives for building energy efficiency and electrification. This would include providing a centralized webpage or tool for residents and businesses to reference relevant federal, state, and utility incentives, C-PACE information, and County programs, among other resources.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Buildings	
<b>GHG Reduction Potential/ Climate Hazard</b>	Medium	
<b>Lead Department(s)</b>	Office of Sustainability	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Development Services</li> <li>▶ Communications Office</li> <li>▶ Economic Development</li> <li>▶ Green Business Council</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Develop a centralized webpage or tool for residents and businesses to reference relevant federal, state, and utility incentives, C-PACE information, and County programs, and provide consumer information on available technology and products such as high efficiency heat pumps and replacement of existing air conditioners with higher efficiency units.</li> <li>▶ Assign a dedicated staff member to maintain and regularly update webpage and conduct outreach to businesses and residents</li> <li>▶ Coordinate with other departments to report new incentives to dedicated staff member</li> <li>▶ Coordinate webpage or tool development with Action E.2: "Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives"</li> <li>▶ Develop a physical/virtual Guidebook for incentives (as incentives change regularly, Guidebook can direct to website)</li> <li>▶ Collaborate with HOAs to promote adaptive technologies in residential communities</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: ~\$1M</p> <p>First Year Budget Requests:</p> <ul style="list-style-type: none"> <li>▶ Hiring staff member: \$200k</li> </ul> <p>Ongoing Cost Considerations:</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ # of residents/businesses reached through program</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Community electricity use</li> <li>▶ Community natural gas use</li> </ul>

## B.5 Transition to Net-Zero County Government Facilities

<b>Action Title</b>	B.5: Transition to Net Zero County Government Facilities
<b>Action Description</b>	Develop a net-zero emissions building plan for County government facilities, which will include implementing an energy benchmarking program and procuring 100% clean electricity for all County government operations.
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Source 100% of county-wide electricity from renewable sources by 2035</li> <li>▶ Achieve 100% renewable electricity in County Government operations by 2030</li> <li>▶ Achieve 100% carbon neutrality in County Government operations by 2050</li> </ul>
<b>Climate Action Topic</b>	Electricity, Buildings
<b>GHG Reduction Potential/ Climate Hazard</b>	Medium
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Facilities and Fleet Management</li> <li>▶ Finance – Risk and Wellness Services</li> </ul>
<b>Supporting Departments/Partners</b>	<p>Departments with facilities not managed by Facilities and Fleet:</p> <ul style="list-style-type: none"> <li>▶ Community Services</li> <li>▶ Housing and Community Development</li> <li>▶ Fire &amp; Rescue</li> <li>▶ Parks, Recreation &amp; Tourism</li> <li>▶ Public Works</li> <li>▶ Adult Detention Center</li> </ul>
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Develop a government operations GHG inventory</li> <li>▶ Hire consultant to develop Net Zero Plan</li> <li>▶ Develop a plan that includes the following elements: <ul style="list-style-type: none"> <li>• Conduct a feasibility study for facility electrification</li> <li>• Prioritize buildings for net-zero transition - identify buildings that would be exempt from full electrification</li> <li>• Evaluate cost of purchasing 100% green power from Dominion and NOVEC</li> <li>• Explore PPA and VPPA options (consider partnering with other local governments to establish VPPAs)</li> </ul> </li> <li>▶ Hire employee to manage green power purchasing and energy benchmarking program</li> <li>▶ Develop mandatory energy benchmarking program by streamlining existing bill capture program</li> <li>▶ Conduct staff training for new technologies or processes for facilities (e.g., heat pumps)</li> </ul>



<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$10M-\$100M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring staff member: \$200k</li> <li>▶ Developing plan: \$200k <ul style="list-style-type: none"> <li>• NOTE: Energy Efficiency and Conservation Block Grant Program funds can be applied toward developing Plan</li> </ul> </li> </ul> <p>Ongoing Cost Considerations (costs are dependent on results on net-zero study and green power options pursued)</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> <li>▶ Implementing Net Zero for All Facilities: \$30M <ul style="list-style-type: none"> <li>• Cost includes all facilities transitioning to net-zero (may not occur before 2030)</li> <li>• Does not consider existing equipment replacement budget and any additional cost or savings from replacing equipment with electric options</li> </ul> </li> <li>▶ Ongoing cost of purchasing clean electricity through Dominion or NOVEC: \$5-10M <ul style="list-style-type: none"> <li>• Purchasing electricity through VPPA/PPA would be much cheaper and even generate revenue</li> </ul> </li> <li>▶ Implementing energy benchmarking program: &lt;\$200k</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % of new public buildings built to net-zero energy standards</li> <li>▶ % of total net-zero public buildings</li> <li>▶ % building participation rate in benchmarking program</li> <li>▶ % of kWh used that are from clean or renewable sources</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Government building emissions</li> <li>▶ Government natural gas and fuel oil use</li> </ul>

## T.1 Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity

<b>Action Title</b>	T.1: Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity
<b>Action Description</b>	Improve active transportation infrastructure, sidewalk and trail connectivity, and overall safety to support walking, biking, and rolling. Improvements could include providing bike lockers, installing curb ramps, or installing traffic-calming designs like crosswalk islands or speed humps. This action would involve developing a strategic Active Transportation Plan that includes recommendations for prioritizing infrastructure improvements and outlines new active transportation policies, processes, and infrastructure.
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030
<b>Climate Action Topic</b>	Transportation
<b>GHG Reduction Potential/ Climate Hazard</b>	High
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Transportation</li> <li>▶ Parks, Recreation and Tourism</li> </ul>
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ Watershed</li> <li>▶ Service Authority</li> <li>▶ VDOT*</li> <li>▶ Schools</li> </ul>

<p><b>Implementation Steps</b></p>	<p>Coordination</p> <ul style="list-style-type: none"> <li>▶ Coordinate with other entities that are developing active transportation programming/infrastructure to align all efforts (e.g., PWCS, Parks department, Transportation department, Planning department, and other supporting partners such as Watershed department and Service Authorities)</li> <li>▶ Continue coordination with the COG Bike and Ped subcommittee to complete the National Capital Bike Trail Network to increase access to opportunities and other activities via non-motorized modes</li> </ul> <p>Planning</p> <ul style="list-style-type: none"> <li>▶ Hire an active-mobility planning consultant to develop a strategic Active Transportation Plan that includes recommendations for prioritizing infrastructure improvements and outlines new active transportation policies and processes</li> <li>▶ Ensure Active Transportation Plan development process includes extensive community engagement</li> <li>▶ Evaluate expansion of County-wide Trails Plan in Comprehensive Plan <ul style="list-style-type: none"> <li>• Review Trails and Blueways Council's Aspirational Trails Map and identify additional facilities to include</li> <li>• Ensure elements of Active Transportation Plan are also incorporated into update of County-wide Trails Plan</li> </ul> </li> <li>▶ Incorporate the Trails and Blueways Council's Aspirational Trails Map into the forthcoming Parks, Recreation and Tourism Master Plan</li> <li>▶ Use forthcoming Transportation app to crowd-source data on barriers to pedestrian and bicyclist access to schools and transit and identify priority actions</li> <li>▶ Identify existing private facilities/community destinations that need bicycle facilities and evaluate incentives that could be provided to encourage visitor bicycle facilities</li> <li>▶ Evaluate use of counters to track usage of bicycle/pedestrian facilities or hire consultant develop bicycle/pedestrian facility usage counts</li> </ul> <p>Incentives and Resources</p> <ul style="list-style-type: none"> <li>▶ Coordinate with developers on improving bicycle and pedestrian connectivity</li> <li>▶ Update the DCSM to include mobility requirements</li> <li>▶ Continue to implement Comprehensive Plan in formation of trails as part of development projects</li> <li>▶ Create a bike facility map that notes bike parking, lockers, and showers throughout the county</li> <li>▶ For new projects, ensure considerations for future trails projects</li> <li>▶ Evaluate different types of districts as an alternate funding mechanism for streetscape infrastructure that VDOT does not need to approve</li> </ul>
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<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: ~\$50M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring consultant: \$200k (consultant will develop cost estimate to implement Active Transportation Plan strategies)</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Dependent on results of the Plans, could include maintenance (mowing) and repair/replacement (bike stations, water fountains, etc.)</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Miles of dedicated bike lane</li> <li>▶ Miles of trails</li> <li>▶ # or % of nodes connected</li> <li>▶ # of bike racks approved as part of new developments</li> </ul>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Commuting travel mode splits from the Census</li> <li>▶ # or % of students walking or biking to school (through Schools tracking)</li> <li>▶ Pedestrian and bicyclist morbidity and mortality (Health Authority)</li> <li>▶ On-road transportation emissions</li> </ul>
<p>*The County can build public roads and sidewalks which are then adopted into the state system and maintained by VDOT. Any public road/sidewalk development proposed by the County needs to be approved by VDOT and VDOT could override proposed development in any right-of-way.</p>		

## T.2 Encourage Transit-Orientated Development

<b>Action Title</b>	T.2: Encourage Transit-Oriented Development	
<b>Action Description</b>	Encourage TOD within 1/2-mile of high-capacity regional transit stations. This could be done through developer incentives, streamlined permitting, or zoning amendments. The County could also consider requiring bicycle parking minimums in TOD areas.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Transportation	
<b>GHG Reduction Potential/ Climate Hazard</b>	High	
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ Transportation</li> </ul>	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ PRTC</li> <li>▶ VRE</li> <li>▶ Development Services</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Develop a TOD Action Plan</li> <li>▶ Identify new incentives that would promote TOD, such as streamlined permitting</li> <li>▶ Explore zoning amendments that would promote TOD</li> <li>▶ Update the DCSM to: <ul style="list-style-type: none"> <li>• Establish parking maximums and reduce parking minimums for TOD areas</li> <li>• Enhance bike facilities within multifamily developments</li> </ul> </li> <li>▶ Require bike parking minimums in TOD areas</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$200k</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring a consultant for TOD Action Plan: \$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ No additional costs beyond existing staff time</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % of qualified developments using incentive (using either square footage or # of developments)</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Commuting travel mode splits from the Census</li> <li>▶ Transit ridership levels</li> <li>▶ On-road transportation emissions</li> </ul>

### T.3 Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips

<b>Action Title</b>	T.3: Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips
<b>Action Description</b>	Expand and promote programs that offer transportation demand management services, reduce transit fares, and support teleworking.
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Achieve 100% carbon neutrality in County Government operations by 2050</li> </ul>
<b>Climate Action Topic</b>	Transportation
<b>GHG Reduction Potential/Climate Hazard</b>	Medium
<b>Lead Department(s)</b>	Transportation
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ PRTC</li> </ul>
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Support PRTC/OmniRide's Transportation Demand Management Strategic Plan (Plan includes strategies for working with local employers)</li> <li>▶ Evaluate opportunities to enhance the County Transportation Demand Management Program by updating the Design and Construction Standards Manual</li> <li>▶ Continue to promote the Transit Fare Buy Down Program and support reduced transit fares</li> <li>▶ Evaluate pursuing grant opportunities for additional transit fare reduction programs or expand existing programs</li> <li>▶ Continue to work with VDOT to expand park and ride lots and encourage carpooling/ridesharing</li> <li>▶ Promote the Transportation Planning Board's Commuter Connections program which encourages and incentivizes telework and transit use through employer-provided transit benefits, expanding telework options, providing transit and carpool benefits to employees, alternative work schedules, providing parking cash-outs for employees that drive and receive free paid parking, and reducing subsidized parking at work</li> <li>▶ Update Comprehensive Plan to support development of infrastructure to aid in teleworking (e.g., rural broadband, free Wi-Fi hotspots)</li> <li>▶ Work with private sector to encourage development to provide adequate infrastructure to support teleworking</li> <li>▶ In the Design and Construction Standards Manual update, explore providing parking reduction to developers who commit to providing a certain % of teleworking employees</li> <li>▶ Coordinate high speed internet infrastructure upgrades with transportation infrastructure projects</li> </ul>
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$200k-1M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ New staff member</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> </ul>



<b>Performance Indicators</b>	<b>Output Indicators</b> <ul style="list-style-type: none"><li>▶ % utilization of commuter lots (through periodic snapshots)</li></ul>	<b>Outcome Indicators</b> <ul style="list-style-type: none"><li>▶ Commuting travel mode splits from Census</li><li>▶ Transit ridership</li><li>▶ On-road transportation emissions</li></ul>
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## T.4 Upgrade Public Transit Infrastructure

<b>Action Title</b>	T.4: Upgrade Public Transit Infrastructure	
<b>Action Description</b>	Partner with county transit operators and VDOT to improve and provide new public transit infrastructure and build out transit nodes. Though the County government does not operate the public buses that service the county, County government can help provide supportive infrastructure to help increase the efficiency and frequency of bus travel. However, as most public roads and bus infrastructure are maintained by VDOT, County government will partner with VDOT to identify and develop transit priority treatments.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Transportation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Medium	
<b>Lead Department(s)</b>	Transportation	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ PRTC</li> <li>▶ Virginia DRPT</li> <li>▶ VRE</li> <li>▶ VDOT</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Work with transit operators and VDOT to develop Transit Improvement Study</li> <li>▶ Work with VDOT to identify corridors for transit priority treatments (e.g., priority bus lanes, dedicated or shared bus lanes, priority signaling, etc.)</li> <li>▶ Identify grants to build out mobility hubs or transit centers</li> <li>▶ Work with OmniRide and the broader community to identify priority locations for bus stops</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$100-200M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Feasibility study for transit infrastructure: \$100-200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Implementing feasible range of improvements by 2030: \$100-250M</li> <li>▶ Implementing all priority treatments/improvements past 2030: \$250-500M</li> <li>▶ May incur maintenance costs for mobility hubs and transit centers, but not other priority treatments maintained by VDOT</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Miles of dedicated transit lanes</li> </ul>	<ul style="list-style-type: none"> <li>▶ Outcome Indicators</li> <li>▶ Commuting travel mode splits from Census</li> <li>▶ Transit ridership</li> <li>▶ On-road transportation emissions</li> </ul>

## T.5 Encourage Zero-Emission Vehicles and Charging

<b>Action Title</b>	T.5: Encourage Zero-Emission Vehicles and Charging	
<b>Action Description</b>	Develop incentives for residents and businesses to purchase ZEVs or install charging equipment, such as through streamlined permitting for EV chargers, "group-buy" programs for EV chargers, or EV purchasing co-ops.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Transportation	
<b>GHG Reduction Potential/Climate Hazard</b>	High	
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Transportation</li> <li>▶ Development Services</li> </ul>	
<b>Supporting Departments/Partners</b>	None identified	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Establish a Workgroup to identify priority ZEV incentives</li> <li>▶ Evaluate implementing streamlined permitting for EV chargers</li> <li>▶ Consider making EV chargers a "permitted accessory use" so they do not require site plan review. Consider changes to EV site plan approval process that would help streamline or expedite the process.</li> <li>▶ Evaluate creating "group-buy" programs for charging stations or vehicles or establishing EV purchasing cooperatives</li> <li>▶ Evaluate integrating EV charging standards into Design and Construction Standards Manual update</li> <li>▶ Consider integrating electric bike purchasing and charging incentives</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$5M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ No additional first year costs (internal staff time)</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Funding for group-buy programs or cooperatives</li> <li>▶ Potential additional staff</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ City EV charger installation permit data</li> <li>▶ # of incentive program participants</li> <li>▶ Average permitting time</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ On-road transportation emissions</li> <li>▶ # of registered EV/ZEVs in county (EV Hub website)</li> </ul>

## T.6 Expand Public EV Charging Network

<b>Action Title</b>	T.6: Expand Public EV Charging Network	
<b>Action Description</b>	Expand public EV charging infrastructure especially along main routes and in popular destinations. This would include developing an EV Infrastructure Plan to guide community deployment and considerations for electric bike charging.	
<b>Related County Goal(s)</b>	Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030	
<b>Climate Action Topic</b>	Transportation	
<b>GHG Reduction Potential/Climate Hazard</b>	High	
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Transportation</li> <li>▶ Facilities and Fleet Management</li> </ul>	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ VDOT</li> <li>▶ VRE</li> <li>▶ PRTC</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Develop EV Infrastructure Plan for community deployment</li> <li>▶ Conduct regional EV gap analysis to identify most critical gaps in EV charging network</li> <li>▶ Install EV charging at publicly owned facilities</li> <li>▶ Incentivize newly constructed buildings in the community to accommodate EV charging</li> <li>▶ Implement combined solar and EV charger buying cooperatives (see Arlington County)</li> <li>▶ Coordinate County-installed public EV charging with VDOT's National Vehicle Infrastructure Plan</li> <li>▶ Identify source of grant matching funds (no dedicated funding currently)</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$25-50M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ EV Study: \$100-\$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Charger maintenance</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ # public EV chargers installed</li> <li>▶ % utilization rate</li> <li>▶ % of chargers currently working (i.e., uptime)</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ On-road transportation emissions</li> <li>▶ # of registered EV/ZEVs in county (EV Hub website)</li> </ul>

## T.7 Adopt Zero- or Low-Emissions County Fleet

<b>Action Title</b>	T.7: Adopt Zero- or Low-Emissions County Fleet	
<b>Action Description</b>	Transition County fleet to zero- or low-emissions vehicles and ensure supporting infrastructure is open to other fleets.	
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Achieve 100% carbon neutrality in County Government operations by 2050</li> </ul>	
<b>Climate Action Topic</b>	Transportation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Low	
<b>Lead Department(s)</b>	Fleets and Facilities Management	
<b>Supporting Departments/Partners</b>	None identified	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Hire a consultant to develop an EV Fleet Transition Study</li> <li>▶ Hire a consultant to develop an EV Charging Infrastructure Study (for both community-wide and County fleet charging)</li> <li>▶ Evaluate if hybrid electric vehicles and plug-in hybrid electric vehicles should be included in fleet transition</li> <li>▶ Identify funding source and tax incentives for EVs</li> <li>▶ Purchase and install EVSE</li> <li>▶ Purchase zero or low emissions vehicles</li> <li>▶ Conduct staff training on vehicle use</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$200-350M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ EV Fleet Transition Study: \$200k</li> <li>▶ EV Charging Infrastructure Study: \$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Installing charging infrastructure</li> <li>▶ Transitioning fleet <ul style="list-style-type: none"> <li>• Cost does not consider existing vehicle replacement budget and any additional cost or savings from replacing vehicles with low or zero emissions options</li> </ul> </li> <li>▶ Maintaining charger stations</li> <li>▶ Annual EV fuel costs will be lower than gas or diesel vehicle fuel costs</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % total fleet that is low or zero-emission</li> <li>▶ GHGs offset, kWh used, # of sessions (from ChargePoint Chargers data)</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Gasoline and diesel used by government fleet</li> <li>▶ County fleet emissions</li> </ul>

## N.1 Adopt Natural Open Space Requirements

<b>Action Title</b>	N.1: Adopt Natural Open Space Requirements
<b>Action Description</b>	<p>Establish minimum natural open space (NOS) guidelines to encourage preservation of NOS, if appropriate, in new and existing development.</p> <p>NOS is “open space with natural resource benefits within the boundaries of a development such as native forests; topographic features; critical habitats for threatened and endangered species and species of special concern; natural creeks, streams and lakes; and natural wetlands that are set aside as an area to remain undisturbed during development and in perpetuity for the preservation of the natural resources contained therein and for the passive use and enjoyment of the residents of the development and/or the public at large.”</p>
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> <li>▶ Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030</li> </ul>
<b>Climate Action Topic</b>	Natural Resources, Climate Adaptation
<b>GHG Reduction Potential/ Climate Hazard</b>	Unknown
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Public Works - Watershed</li> <li>▶ County Arborist</li> </ul>
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ County Attorney's office</li> <li>▶ Owners of open space areas (HOAs, commercial owners, environmental trusts, etc.)</li> </ul>
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review legal guidance with County Attorney regarding this action</li> <li>▶ Explore the ability to incorporate NOS requirements for a larger variety of zoning districts instead of just an open space requirement</li> <li>▶ Consider developing a NOS corridor overlay for the entire county and identify areas that should be targeted for preservation of substantial tracts to create wildlife habitat and facilitate safe wildlife movement</li> <li>▶ Translate the new Conservation Residential concept that was approved with the updated Comp Plan into specific standards in the Zoning Ordinance – this would help to codify standards in those districts for requiring undisturbed open space that preserves forests. This district should also have standards for restoration of forests for open fields that will not be used for farming</li> <li>▶ Prioritize minimizing land disturbance during construction and leaving terrain in a natural state</li> <li>▶ Evaluate initiating more robust tree-save rules in the Zoning Ordinance and the Design and Construction Manual</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>



<b>Potential County Action Cost Range (2025-2030)</b>	TOTAL: \$100-500k  First Year Budget Requests ▶ No additional first year costs (internal staff time)  Ongoing Cost Considerations ▶ Potential costs from legal fees	
<b>Performance Indicators</b>	Output Indicators  ▶ Total area or % of NOS in the county ▶ Total area or % of open space in the county ▶ Acres of wildlife corridors ▶ Tree Cover Inventory	Outcome Indicators  ▶ Land use emissions ▶ Average carbon sequestration potential per acre of NOS ▶ Loss/gain of tree cover

## A.1 Develop Adaptation Plans for Critical Facilities

<b>Action Title</b>	A.1: Develop Adaptation Plans for Critical Facilities	
<b>Action Description</b>	Develop site-level adaptation plans for critical facilities and service areas considering current and future climate change hazards.	
<b>Related County Goal(s)</b>	Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030	
<b>Climate Action Topic</b>	Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	All Climate Hazards	
<b>Lead Department(s)</b>	Office of Emergency Management	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Facilities and Fleet Management (for County facilities)</li> <li>▶ Risk and Wellness (for some County facilities)</li> <li>▶ External critical facility owners</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review existing list of critical facilities in the county and determine which facilities the County's Office of Emergency Management has authority to create adaptation plans for</li> <li>▶ Review any existing adaptation plans for critical facilities within the county</li> <li>▶ Develop adaptation plan framework(s) for different types or groups of critical facilities</li> <li>▶ Complete adaptation plans for critical facilities that the County has authority over</li> <li>▶ Provide GIS data and technical support to encourage adaptation plan development for critical facilities that the County does not have the authority to create</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$600k (consider starting goal around 2027 and completing in 3 years)</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Hiring staff to review work and develop template: \$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Staff Support (Senior Emergency Management Planner): \$200K/year</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % of county's critical facilities with adaptation plans</li> <li>▶ # of technical assistance requests from external critical facility owners that the County supported each year</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ # of critical facilities that begin acting on completed adaptation plans</li> </ul>

## A.2 Manage Stormwater Flooding Outside of the Floodplain

<b>Action Title</b>	A.2: Manage Stormwater Flooding Outside of the Floodplain	
<b>Action Description</b>	Increase understanding of flooding in areas outside of the delineated FEMA floodplain through modeling and/or historic flood records. Develop and implement mitigation actions to reduce stormwater flooding.	
<b>Related County Goal(s)</b>	Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030	
<b>Climate Action Topic</b>	Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Precipitation	
<b>Lead Department(s)</b>	Office of Emergency Management	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Public Works – Watershed</li> <li>▶ VDOT</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review work done in this area by the County's Office of Emergency Management (including ongoing flood resiliency plan which will include data development and filling in gaps in flood mapping)</li> <li>▶ Develop mitigation actions for areas that are identified as vulnerable to stormwater flooding (including stormwater improvements, transportation infrastructure updates, building adaptation, etc.)</li> <li>▶ Implement mitigation actions</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$3M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ No initial funding needed <ul style="list-style-type: none"> <li>• \$1.2M has already been allocated for the flood resiliency assessment</li> <li>• \$150K has been allocated for mitigation measures in FY23</li> <li>• \$600K requested for FY24 for implementation for mitigation measures</li> </ul> </li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Implementation (will depend on the mitigation actions determined in the flood resiliency assessment): \$500K/year</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Key performance indicators in the flood resiliency plan (will get updated as the plan progresses)</li> <li>▶ Status of implementation on items that come out of the plan</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Reduction in closed roads and swift water rescues</li> </ul>

### A.3 Improve Power Resiliency for Critical Infrastructure

<b>Action Title</b>	A.3: Improve Power Resiliency for Critical Infrastructure	
<b>Action Description</b>	Improve the resiliency of electrical infrastructure for publicly owned essential services and infrastructure.	
<b>Related County Goal(s)</b>	Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030	
<b>Climate Action Topic</b>	Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Extreme Temperature; High Winds/Tornadoes	
<b>Lead Department(s)</b>	<ul style="list-style-type: none"> <li>▶ Office of Emergency Management</li> <li>▶ Critical Infrastructure Owners</li> <li>▶ County Energy Providers</li> </ul>	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Facilities and Fleet Management</li> <li>▶ Parks &amp; Rec</li> <li>▶ Fire</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review work done in this area by the County's Office of Emergency Management including the existing list of county buildings without available backup power</li> <li>▶ Rank county buildings by criticality</li> <li>▶ Complete electrical assessment studies</li> <li>▶ Develop plan to fund backup power and/or micro grids</li> <li>▶ Purchase and implement backup power for county facilities in order of criticality, as funding is available</li> <li>▶ Use low-carbon alternatives to diesel wherever possible</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: \$1-5M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Electrical assessment by existing staff: \$250K-\$500K</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ Dependent on selected projects</li> <li>▶ Purchase/installation for all facilities and annual maintenance of 5-10% of total cost: \$1M-\$5M</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ % of critical infrastructure implemented with backup power</li> <li>▶ # of mission essential / primary mission essential functions supported with backup power</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Reduced downtime for critical facilities</li> </ul>

## A.4 Implement Shoreline Protection and Nature-Based Solutions

<b>Action Title</b>	A.4: Implement Shoreline Protection and Nature-Based Solutions	
<b>Action Description</b>	Develop guidance to prioritize nature-based solutions for shoreline protection for coastal areas.	
<b>Related County Goal(s)</b>	Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030	
<b>Climate Action Topic</b>	Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Sea level rise	
<b>Lead Department(s)</b>	Public Works – Watershed Team	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Development Services - Land Development Division</li> <li>▶ Office of Emergency Management</li> <li>▶ Parks, Recreation and Tourism</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Compile available information and studies on existing and planned shoreline protection and nature-based solutions within the county including existing implementation progress for county properties</li> <li>▶ Fund and implement nature-based solutions on existing County property in coastal areas</li> <li>▶ Fund and implement incentive program to encourage coastal shoreline protection and nature-based solutions on existing private property</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$5M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ One FTE to review existing studies/projects and develop plan for implementing nature-based solutions on existing County properties in the coastal zone: \$200K</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Shoreline miles where projects have been completed</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Decreased emergency shoreline stabilization projects</li> </ul>

## A.5 Restore Streams to Reduce Flooding

<b>Action Title</b>	A.5: Restore Streams to Reduce Flooding	
<b>Action Description</b>	Develop and implement stream restoration projects in support of reduced flooding outcomes.	
<b>Related County Goal(s)</b>	Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030	
<b>Climate Action Topic</b>	Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Precipitation	
<b>Lead Department(s)</b>	Public Works – Watershed Team	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Planning Office</li> <li>▶ Office of Emergency Management</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review existing stream restoration projects, develop lessons learned, and develop a list of potential stream restoration project areas on County-owned property with focus on flood mitigation potential</li> <li>▶ Secure funding for stream restoration projects</li> <li>▶ Implement stream restoration projects with focus on flood mitigation</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$5M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ One FTE to evaluate current stream restoration projects and determine flood mitigation potential: \$200K</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> <li>▶ Funding from stormwater fee and DEQ grant funding supports current work</li> <li>▶ For additional ramp-up current staff could support additional work, but need consultant for implementation</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ Stream miles restored</li> <li>▶ Flood conveyance capacity (acres) added since start of project</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ None identified</li> </ul>



## A.6 Encourage Technology for Residents to Make Homes Adaptive

<b>Action Title</b>	A.6: Encourage Technology for Residents to Make Homes Adaptive	
<b>Action Description</b>	Provide additional incentives or subsidies for residents of low-income housing and rental properties to install or retrofit buildings with climate adaptive technologies to reduce energy, reduce water use, reduce waste heat, and minimize urban heat gain.	
<b>Related County Goal(s)</b>	<ul style="list-style-type: none"> <li>▶ Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030</li> <li>▶ Reduce GHG emissions county-wide to 50% below baseline 2005 levels by 2030</li> </ul>	
<b>Climate Action Topic</b>	Buildings, Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	High Heat	
<b>Lead Department(s)</b>	Office of Sustainability	
<b>Supporting Departments/Partners</b>	<ul style="list-style-type: none"> <li>▶ Development Services</li> <li>▶ Dominion Energy</li> </ul>	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Identify technology that the County would encourage use of to make homes adaptive</li> <li>▶ If possible, identify buildings that have highest energy bills compared to other buildings of the same size/age. Or consider starting with older buildings to help prioritize outreach</li> <li>▶ Review existing State/National funding programs that residents could use and advertise this available funding</li> <li>▶ Develop new County-run incentive programs to encourage the use of adaptive technology</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: &gt;\$2.4M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ One FTE to support implementation (would include assessments and plan development for the first year): \$200k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ New staff salary</li> <li>▶ Grant funding: \$200k/year</li> <li>▶ One FTE salary: \$200K/year</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ # of households contacted/year</li> <li>▶ % of residences (that have been identified as having the most benefit from adaptive technology) within the county that have been granted the incentive/grant</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ Residential energy consumption</li> </ul>

## A.7 Plan Alternate Evacuation Routes for Flood-prone Areas

<b>Action Title</b>	A.7: Plan Alternate Evacuation Routes for Flood-prone Areas	
<b>Action Description</b>	Develop localized evaluation routes throughout the county and socialize with the public.	
<b>Related County Goal(s)</b>	Become a Climate Ready Region and making significant progress to be a Climate Resilient Region by 2030	
<b>Climate Action Topic</b>	Climate Adaptation	
<b>GHG Reduction Potential/ Climate Hazard</b>	Precipitation	
<b>Lead Department(s)</b>	Office of Emergency Management	
<b>Supporting Departments/Partners</b>	None Identified	
<b>Implementation Steps</b>	<ul style="list-style-type: none"> <li>▶ Review flood-prone areas that affect evacuation routes</li> <li>▶ Develop alternative evacuation routes</li> <li>▶ Develop plan to implement road closures and rerouting</li> <li>▶ Implement plan</li> <li>▶ Utilize Equity and Inclusion Screening Assessment Tool to understand demographic impacts as action is being implemented</li> </ul>	
<b>Potential County Action Cost Range (2025-2030)</b>	<p>TOTAL: ~\$3.2M</p> <p>First Year Budget Requests</p> <ul style="list-style-type: none"> <li>▶ Gap analysis, vulnerability assessment, data pull and tool development: \$500k</li> </ul> <p>Ongoing Cost Considerations</p> <ul style="list-style-type: none"> <li>▶ One FTE salary: \$200K/year</li> <li>▶ Recurring costs (including data systems): \$250k</li> </ul>	
<b>Performance Indicators</b>	<p>Output Indicators</p> <ul style="list-style-type: none"> <li>▶ # of evacuation routes established</li> </ul>	<p>Outcome Indicators</p> <ul style="list-style-type: none"> <li>▶ None identified</li> </ul>

# Appendix C CESMP Actions Mapped to Strategic Plan and Comprehensive Plan Action Strategies

Actions	Comprehensive Plan Action Strategies	Strategic Plan Action Strategies
E.1: Acquire Clean Electricity Sources for the County	H5.9	SG2: C., SG2: E
E.2: Promote Renewable Energy Incentive Programs and Develop Additional Solar Incentives	H5.4, H5.6, H5.7, H5.9	SG2: C., SG2: E, SG2: F
E.3: Encourage Renewable Energy Use in Energy-Intensive Commercial Buildings	H5.9	SG2: C., SG2: E
E.4: Promote Existing Green Power Products	H5.9	SG2: C., SG2: E
E.5: Install Solar on County Government Facilities	H5.9	SG2: C., SG2: E
B.1: Encourage Energy Efficiency and Electrification Retrofits	H5.4	SG2: E
B.2: Propose Green Zoning Regulations	LU8.1, LU8.3, H5.2, H5.3, H5.4, H5.4, H5.10	SG2: B., SG2: E
B.3: Encourage Energy Efficient and Electric New Construction	H5.3, H5.4, H5.7	SG2: B., SG2: E
B.4: Promote Energy Efficiency and Electrification Incentives	H5.4, H5.7	SG2: E
B.5: Transition to Net Zero County Government Facilities		SG2: A., SG2: B., SG2: E
B.6: Create All-electric Guidelines for New Construction of County Government Facilities		SG2: A., SG2: B., SG2: E
B.7: Create Policy to Increase Energy Efficiency in County Government Facilities		SG2: A., SG2: B., SG2: E
B.8: Implement Building Energy Benchmarking		SG2: E
T.1: Improve Pedestrian and Bicycle Infrastructure and Enhance Connectivity	G3.9, G3.10, LU8.2, LU8.4	SG2: E, TM2: A
T.2: Encourage Transit-Oriented Development	G3.9, G3.10, LU8.1, LU8.2, LU8.4, LU8.5, H5.2, H5.10	SG2: E
T.3: Expand Existing Programs that Reduce Single-Occupancy Vehicle Trips	G3.9, G3.10, LU8.2	SG2: E, TM4: A
T.4: Upgrade Public Transit Infrastructure	G3.9, G3.10, G3.11, LU8.2	SG2: E
T.5: Encourage Zero-Emission Vehicles and Charging	G3.9, G3.10, RP3.1	SG2: E
T.6: Expand Public EV Charging Network	G3.9, G3.10, RP3.1	SG2: D., SG2: E
T.7: Adopt Zero- or Low-Emissions County Fleet	G3.9, G3.10, RP3.1	SG2: D., SG2: E
T.8: Encourage E-Bike and E-Scooter Adoption	G3.9, G3.10, LU8.2	SG2: E
T.9: Educate on Existing Zero-Emission Vehicle Incentives and Rebates	G3.9, G3.10, RP3.1	SG2: E
T.10: Promote Zero-Emission Bus and Rail Transition	G3.9, G3.10, G3.11, RP3.1, LU8.2	SG2: E
T.11: Support Zero- or Low-Emissions County Government Contracting of Off-Road Equipment	G3.9, G3.10, RP3.1	SG2: E
T.12: Adopt County Government Zero-Emission Off-Road Policy	G3.9, G3.10, RP3.1	SG2: D, SG2: E

Actions	Comprehensive Plan Action Strategies	Strategic Plan Action Strategies
T.13: Discount Transit Passes for Residents	G3.9, G3.10, LU8.2	SG2: E
T.14: Launch Electric Equipment Lending Program		SG2: E
N.1: Adopt Natural Open Space Requirements	H5.2, H5.11	SG2: E, EC1: A, EC1: B, EC1: C
N.2: Launch Suburban and Rural Tree Planting Initiative		SG2: E
N.3: Update Tree Cover Regulations		SG2: E, EC1: A, EC1: B
N.4: Support Sustainable Farming Practices		SG2: E
W.1: Implement County-Wide Composting		SG2: E
W.2: Promote Sustainable Purchasing Policy		SG2: E
W.3: Mandate Commercial Food Waste Diversion		SG2: E
A.1: Develop Adaptation Plans for Critical Facilities	H5.2	
A.2: Manage Stormwater Flooding Outside of the Floodplain		EC5: B, EC5: C
A.3: Improve Power Resiliency for Critical Infrastructure	H5.7	
A.4: Assess Shoreline Protection and Nature-Based Solutions		EC5: B
A.5: Restore Streams to Reduce Flooding		EC5: B
A.6: Encourage Technology for Residents to Make Homes Adaptive		SG2: B, SG2: E
A.7: Plan Alternate Evacuation Routes for Flood-prone Areas		EC5: B
A.8: Expand Building Insulation Standards to Protect Against Extreme Heat		SG2: E
A.9: Protect Existing Buildings Against High Winds	H5.12	
A.10: Protect County Infrastructure from Flooding		EC5: B, EC5: C
A.11: Encourage Nature-based Solutions to Reduce Flooding in Residential Properties	H5.2	
A.12: Improve Water Infrastructure for Extreme Precipitation Events	H5.2	
A.13: Urban Heat Island Relief Program	H5.2	SG2: E
A.14: Adopt Guidelines to Use Nature-based Solutions on County Government Construction	H5.2	
A.15: Improve Grid Resiliency During Extreme Weather	H5.7	
A.16: Expand Tax Credits for Conservation of Natural Resources		EC1: A
A.17: Develop Plan to Preserve Estuaries and Wetlands To Reduce Flooding		EC1: A
A.18: Training for Community Members on Climate Change and Mental Health		EC5: D
A.19: Increase Protection from the Sun at Childcare Centers		SG2: E
A.20: Encourage Improved Cooling Equipment in Apartments	H5.4	SG2: B, SG2: E
A.21: Encourage Businesses to Reduce Water Usage	H5.4	SG2: B, SG2: E

Actions	Comprehensive Plan Action Strategies	Strategic Plan Action Strategies
A.22: Protect Electrical Infrastructure from High Winds	H5.7	
A.23: Expand Community Outreach for Education on Climate Change Adaptation		EC5:D
A.24: Support Agriculture Resiliency		

## Comprehensive Plan Action Definitions

H5.2	Promote mixed-use, well connected, and walkable neighborhoods that are resilient communities with lower carbon emissions. Consider enhanced Design and Construction Standards Manual (DCSM) requirements to mitigate impacts from the construction and infrastructure projects, especially on water quality.
H5.3	Promote construction design options to build sustainable, green neighborhoods. Explore funding opportunities, design implications, and practical solutions to reduce residents' energy cost burden and encourage the housing industry to build environmentally sustainable housing.
H5.4	Research energy-conserving building design standards and incentivize implementation of any adopted standards. Energy-efficient affordable housing focused on sustainability and the reduction of utility costs benefits renters and homeowners. To avoid rising rents, consider energy saving cost reduction measures to support both property owners in fixed rent situations and homeowners.
H5.6	Streamline County approval of solar panels installed at private homes and businesses.
H5.7	Support coordination between County and state departments and agencies and utility companies to improve outreach and access to funding that supports home/improvement and maintenance, including energy efficient audits, upgrades and retrofits, weatherization assistance, solar panel installation, and age in place maintenance and construction.
H5.9	Increase percentage of renewable energy utilized by the County to support reduction of greenhouse gas emissions. Implement MWCOG targets to reduce greenhouse gas emissions from all sources within the county to 50% of 2005 level by 2030, and to be carbon-neutral by 2050.
H5.10	Reduce auto-centric development patterns to reduce transportation costs and HOUSING Page   17 environmental impacts. Support future housing growth at transit supportive densities, with a variety of housing types, especially in designated activity centers and corridors. Track the number of new dwelling units proposed and/or built inside and outside of activity centers as a measure of sustainability growth and to enhance funding opportunities.
H5.12	Support cultural and civic facilities (libraries, firehouses, museums, state and County parks, landmarks, and County facilities) as disaster preparedness and relief centers that provide emergency social services in times of distress (cooling station, food distribution, widespread power outage, or hurricane/tornado relief shelter).
G3.9	Coordinate with the County's Office of Sustainability on supporting the CESMP and ensure that mobility projects support the County's Climate Mitigation and Resiliency Goals.
G3.10	Develop short-term and long-term mobility policies to support the County's adopted regional Climate Mitigation and Resiliency Goals.
G3.11	Coordinate with regional partners to identify programs and initiatives that support reduction of greenhouse gas emission goals in support of climate resiliency.

<b>LU8.1</b>	Support higher-density residential uses in transit-oriented developments such as Town Centers, Activity Centers, Redevelopment Corridors, and near employment areas. Higher residential densities are encouraged to be located near or with access to mass transit stations like the Virginia Railway Express, bus routes, and other transit nodes and facilities.
<b>LU8.2</b>	Support affordable housing incentives with appropriate buffering and design in accordance with the bonus density applicable to each transect.
<b>LU8.3</b>	Consider travel modes other than the automobile to better connect and integrate residential uses with non-residential uses.
<b>LU8.4</b>	Strategically designate residential land use to encourage development of housing to accommodate the population growth projections with consideration for expanding affordable housing and multigenerational households.
<b>LU8.5</b>	Adopt Complete Streets policies that improves safety and mobility in new residential development and study existing neighborhoods that need to improve the local street and pedestrian connections to enhance the community.
<b>RP3.1</b>	Promote the utilization of vehicles that use alternative fuels and other measures, including electricity, to reduce air quality and noise impacts.

## Strategic Plan Action Definitions

<b>SG2: A</b>	Ensure the County leads by example by implementing energy-conserving building design standards for future county infrastructure and facilities and retrofit county infrastructure and facilities as opportunities arise.
<b>SG2: B</b>	Establish energy-conserving building design standards and incentivize and encourage implementation in public and private buildings.
<b>SG2: C</b>	Increase and incentivize the usage and implementation of alternative and renewable energy sources throughout the county.
<b>SG2: D</b>	Implement incorporation of environmentally sustainable vehicles, such as hybrid and/or electric vehicles, into the county's fleet and encourage the installation of vehicle recharge stations.
<b>SG2: E</b>	Implement MWCOG targets to reduce greenhouse gas emissions from all sources within the county to 50% of 2005 level by 2030, and to be carbon-neutral by 2050.
<b>SG2: F</b>	Streamline County approval of solar panels being installed at private homes and businesses.
<b>TM2: A</b>	Improve connectivity of sidewalks and trails (paved and unpaved) for pedestrians and cyclists.
<b>TM4: A</b>	Continue and expand telework options for County employees.
<b>EC1: A</b>	Prioritize minimizing land disturbance during construction and leaving natural terrain in a natural state. When not feasible, evaluate alternatives such as tree-banking programs.
<b>EC1: B</b>	Evaluate initiating tree-save rules in the Zoning Ordinance/DCSM.
<b>EC1: C</b>	Promote reforestation and meadow development with native plants on county land and on private land.
<b>EC5: B</b>	Continue to update maps and monitor flood prone locations in the county.
<b>EC5: C</b>	Work with local, state, and federal agencies to identify funding for projects that would reduce or eliminate the risk of repetitive flooding.
<b>EC5: D</b>	Work with emergency management agencies to create and implement flood risk education programs.



## Appendix D Existing County Government Actions

The following is a list of actions, programs, and projects that we already have underway. These actions either try to mitigate GHG emissions or improve climate resiliency and hazard mitigation in the county.

Existing GHG Mitigation Actions
<p>Natural Resources</p> <ol style="list-style-type: none"> <li>1. The County recently secured annual funding and a full-time employee to expand upon an existing reforestation program. The program is now expanded to allow 10-acre non-agricultural lots to apply which is expected to substantially increase participation in the county.</li> <li>2. In response to recent regulations, the County is currently working with the State on tree preservation requirements for new development.</li> <li>3. Plant effluent water reuse is utilized within the water treatment plant which helps to reduce potable water usage by 1.5 million gallons per day.</li> <li>4. Ongoing customer water savings initiatives are in place such as public education and flyers inserts in bills. An ongoing recommended watering program is in place which directs even and odd address for homes to water on different days.</li> </ol>
<p>Energy Conservation</p> <ol style="list-style-type: none"> <li>1. In 2022, the County's wastewater treatment plant's inefficient electric-resistance heating and conventional lighting was converted to high-efficiency lighting and high-efficiency heat pumps.</li> <li>2. The County is actively applying for Federal Energy Efficiency and Conservation Block Grant (EECBG) to be applied to energy efficiency programs for our facilities.</li> <li>3. The County has achieved 82% LED lighting in its general government facilities and is striving towards 100% LED lighting. LED lighting retrofit projects completed to date offset 1,466 metric tons of CO<sub>2</sub>e annually.</li> <li>4. The County is striving to achieve LEED Gold accreditation in new and future building designs.</li> <li>5. The County monitors and benchmarks energy consumption of general government operations and reassesses annually the priorities for energy conservation improvements.</li> <li>6. The County has completed energy audits at 35 facilities since 2018 and continually hires outside consultants to assist with development of energy conservation measures.</li> <li>7. The County shares energy management strategy and provides training for the personal development of facilities maintenance personnel.</li> <li>8. The County leverages building automation to implement advanced energy conservation strategies in its largest facilities.</li> <li>9. The County uses analytics to ensure automation strategies are implemented properly and sustained. Analytics also identify new building automation deficiencies as they arise in real time.</li> </ol>

## Existing GHG Mitigation Actions

### Transportation

1. There is a Commuter Choice funded Transportation Demand Management marketing campaign for the I-66 corridor and Transit Fare Buy Down Program for 5 OmniRide Bus Routes.
2. There are sidewalk and trail improvement efforts covered in the Capital Improvement Program. The current program includes three standalone bike/pedestrian projects and thirteen transportation projects that include bike/pedestrian facilities.
3. A First/Last Mile Study is being conducted at Neabsco Commuter Garage via MWCOG. A consultant did an analysis of a 1-mile walkshed of the garage and provided recommendations to provide pedestrian improvements and cost estimates. Various recommendations included exploring micro-mobility: e-bikes/e-scooters, sidewalk connectivity, sidewalk improvements to include safety features, and desired paths (putting in trails where people are naturally walking).
4. Yorkshire Corridor Improvements Study grant received via MWCOG tasks the consultant to provide actionable recommendations to build off existing planned improvements to make Route 28 a more walkable, transit-oriented corridor. This will include a gap analysis of first/last mile connections, review of planned project scopes and existing and future land use and recommendations for prioritized pedestrian, bicycle and/or micro-mobility connections and transit supportive infrastructure. This project will include coordination with the City of Manassas, the City of Manassas Park and OmniRide, which operates bus services on the corridor.
5. The Board recently approved providing a local match to the Woodbridge Pedestrian Bridge that will connect the Woodbridge VRE to a new development on the other side of Route 1. Transportation is beginning the design process of a pedestrian bridge over Route 15 in Gainesville. Staff is looking to find other sources of funding to allow the project to proceed beyond the design stage.
6. The County is adopting a new Mobility Chapter of the Comprehensive Plan which aims to reduce lane miles and focus on transit and non-motorized transportation.
7. The County is updating the Transportation chapter of the Design and Construction Standards which will be informed by a Green Infrastructure planning study.
8. The County has hired a consultant to conduct a fleet right sizing study to develop a long-term fleet renewal plan. Once the initial plan is developed, a modified fleet sustainability plan will be developed that will identify opportunities to replace conventionally fueled vehicles (CFV) with alternative fuel vehicles (AFV) with an emphasis on zero or possibly low emission vehicles.
9. The County has purchased five electric vehicles for our fleet and have been installing charging stations to support them. There are plans to continue to purchase more EVs.
10. A Green Infrastructure Study grant received through MWCOG tasks a consultant to provide a clear roadmap to implementing green infrastructure into planned capital projects in the county, many of which already have dedicated funding. The project will also inform long term policy decisions through the review and recommendation of applicable policies, specifically into the Prince William Design and Construction Standards Manual. This will allow the County to include green infrastructure recommendations in future projects and help secure funding for the enhanced project scopes.

## Existing GHG Mitigation Actions

### Waste

1. There are reuse and clothing and shoe collection programs at the Prince William County Landfill and the Balls Ford Road Compost facilities. The reuse program was recently reinstated in July 2022. The clothing program has collected 4,500 pounds through Calendar Year 2022.
2. There is a public outreach program promoting source reduction and reuse as part of ongoing outreach and education programs. The County partners with Keep Prince William Beautiful on Fix-It Fairs.
3. The County promotes “grasscycling” (leaving grass clippings on the lawn) and backyard composting.
4. The County promotes backyard composting including the sale of low-cost compost bins, with a total of 31 bins sold in Fiscal Year 2022.
5. The County has plans to promote a food scraps recovery program with the commercial sector, expand residential organics collection to include food scraps, and expand our glass recycling drop-off collection program. A draft plan for this work was presented to the Board in Fall 2022.
6. Starting in October 2021, the County began implementing a year-round residential yard waste collection program. As of Calendar Year 2022, the yard waste program has diverted more than 2,000 tons from our county landfill to the Balls Ford Road Compost facility.
7. The implementation of five glass recycling drop-off centers has increased glass recycling from 17 to 575 tons from Calendar Year 2018 to 2021.

## Existing Renewable Electricity Actions

1. The County has recently established a Residential Solar Task Force with industry members to provide education, receive feedback on permitting processes, and define opportunities to improve the processes. Recommendations from the task force will directly inform our streamlining actions.
2. A consultant is analyzing the feasibility of solar installations for ten government facilities. The consultant is developing County Government standards for photovoltaic (PV) solar design to be used in future solar installation Requests for Proposals (RFP). The consultant is assessing county government options for financing PV systems on government facilities.
3. A PV solar array on the McCoart Administrative Building offsets 15 metric tons of CO<sub>2</sub>e annually.
4. Our county landfill currently captures methane and uses it to produce approximately 6.7 MW of electricity to NOVEC annually. We plan to retire the generators and work with a private company to build a new facility to use captured methane more efficiently by converting it into renewable natural gas.
5. The Board authorized a Fee Reduction Program for residential solar projects that waives all home solar project fees from September 1, 2023, through June 30, 2024.

## Existing Adaptation/Resiliency Actions

### All Hazards

1. The County Emergency Operations Plan outlines all aspects of response and recovery for the community to include all aspects of mass care, survivor support, public information, damage assessment, public reporting, etc. All aspects of the Emergency Operations Plan should continue to be supported and enhanced, where necessary to continue to support the community's needs.
2. The Ready Prince William community outreach and engagement program seeks to integrate existing community partners and volunteering efforts in preparedness, response, and recovery. The County is actively working to enhance this program.
3. The County's Office of Emergency Management coordinates with other County, Regional, and State agencies to provide technical assistance resources for specific facilities, including universities, schools, day care centers, assisted living facilities, healthcare facilities, etc. This can include information on hazard risk, information for facility emergency action plans, and routinely participates in plan reviews, stakeholder meetings, trainings, and exercises, as requested by facilities.

### Flooding

1. FEMA manages floodplain mapping for the county. The Office of Emergency Management and Department of Public Works are conducting a Flood Resiliency Plan and supporting "small area plans" that develop mitigation actions for flooded areas and communities. This will also address, where able, future flooding risk and assessing community vulnerability to flooding risk.
2. Storm surge zones have already been mapped by FEMA and existing data shows critical infrastructure within this zone and the rest of the special flood hazard area.
3. The backbone of a County Automated Flood Warning System is now operational with four water depth gauges at key areas of riverine flooding. The system will gauge adjusted rainfall rates to identify flooding trends for each basin. There are future plans to add rain gauges, weather stations, and additional water level sensors to expand county-wide coverage. The system will support early warning capabilities and data collection to determine county-wide flooding trends. We are using several grant funding sources to continue the build out of the rest of the system.
4. The County actively participates in FEMA's Community Rating System. The County recently advanced from CRS Class 7 rating to Class 6, meaning that the county residents and businesses will see a 20 percent discount on their flood insurance premiums issued or renewed from Oct. 1, 2023, an increase from 15 percent last year. The County plans to continue to participate in the Community Rating System program and actively find ways to maintain and enhance all eligible program areas to increase resiliency and provide flood insurance discounts for residents who live in a special flood hazard area.
5. The County's Office of Emergency Management coordinates community outreach and engagement through the Ready Prince William program. Flood preparedness and flood insurance outreach efforts routinely occur through this program, including providing a detailed flood preparedness brochure in the annual real estate tax mailing, a targeted campaign for Dam Safety Day to ensure all homeowners who live downstream from a dam understand the flood risk associated with the Dam, and proclamation of Flood Awareness Week in the Spring each year.
6. Many hazard risk assessment programs already exist in the county regarding technical assistance for specific facilities, including universities, schools, day care centers, assisted living facilities, healthcare facilities, etc.

## Existing Adaptation/Resiliency Actions

### Extreme Heat

1. The Office of Emergency Management has established warming and cool centers coupled with triggers and escalation levels. These locations are primarily the libraries throughout the community, but the Office of Emergency Management has also established additional locations identified if libraries are not suitable to the needs of the incident, including the use recreation centers and other facilities. Extreme Heat procedures are currently in place. A comfort center plan for extreme heat/cold mass care support is in development for the County. If a resident signs up for PWC Alerts, and opts into weather watches and warnings, they will receive notifications for heat advisories. This is supported by the County's Emergency Operations Plan.

### Tornadoes

1. Community tornado safe rooms are targeted by FEMA for states and communities in tornado alley and other areas that have significant early warning of a tornado coming to allow individuals time to go to a community safe room. This is not feasible in our county, as tornadoes are relatively rare in this area and there is a very short working time as they can occur very quickly from a severe thunderstorm cell. The preparedness messaging used instead is focused on teaching individuals how to identify a safe room in their house, place of work, etc. that they can quickly and safely get to should a tornado pop up quickly.

## Existing Adaptation/Resiliency Actions

### Infrastructure Resiliency

1. The Prince William County Service Authority (PWCSA) and Virginia American Water is in coordination with Fairfax Water to secure supply, leading to better regional resiliency of water supply.
2. Action Strategy G3.5 in the Comprehensive Plan aims to prioritize improvements to vulnerable infrastructure as identified by VTrans Vulnerability Assessment. This consideration is currently included as prioritization factor for transportation projects submitted for state funding. DOT has an active project, the Route 28 Bypass, in an area with existing flooding and is pursuing enhanced stormwater management measures to better prepare the area for future floods. Impact projects are funded by SMART SCALE (beginning Round 5 which funds projects in Fiscal Years 2026-2027) through the Virginia Office of Intermodal Planning and Investment.
3. The County implements watershed studies, stormwater retrofits, and small drainage improvement projects as needed. We have undertaken several stream restoration projects to improve the quality of our local streams and waterways. We stream restoration program identifies projects through field inspections and watershed studies.
4. Public Works' is seeking funding to conduct detailed watershed studies for flood control to implement climate adaptation strategies, assess the adequacy and capacity of existing stormwater infrastructure, and propose DCSM changes for changes in precipitation patterns over the years.
5. PWCSA has an established pipe cured in-place pipe lining and Infiltration and Inflow Reduction program to keep 1,150 miles of sanitary sewers operating at capacity.
6. PWCSA works with county businesses to prevent Fats, Oil and Grease from entering the sewer where it can cause blockage. The program conducts periodic inspections of business to maintain compliance and ensure routine maintenance of grease traps and interceptors.
7. PWCSA includes nutrient management plans in landscape contracts to reduce nutrient runoff.
8. PWCSA is in the design phase of a large design-build project for facility-wide improvements at the H.L. Mooney Advanced Water Reclamation Facility to replace/renew/refurbish assets. The project includes a new headworks to increase peak flow capacity at the plant.
9. The County maintains a Mutual Aid Debris Removal Operations Plan and Prince William County Debris Management Plan. We maintain a contractor for debris management emergency response services. We also maintain primary and secondary Monitoring Debris Management Contractors.



# Appendix E List of Stakeholder Groups Involved in CESMP Development

**Figure E.1** describes the composition and roles of the five primary stakeholder groups engaged throughout the plan development process. The County's Office of Sustainability, as a member of the County Government Core Team, led the development of the plan and facilitated the stakeholder engagement.



**Figure E.1: Primary Stakeholders**

**Figure E. 2** outlines the members of the County Government Core Team that participated in the development of the CESMP.

**Figure E.2: County Departments Involved in Developing the CESMP**



## The Joint Environmental Task Force

*Communication between the County Government and the Prince William County School (PWCS) system was important throughout the CESMP development process. Because the PWCS system operates separately from our County government operations, PWCS operations are not considered under the County government's direct influence. Therefore, PWCS energy use and emissions are not included under our County government climate goals of 100% renewable energy by 2030 or carbon neutrality by 2050. However, as PWCS emissions are included in the county-wide goals of 50% GHG emissions reduction by 2030 and 100% renewable energy by 2035, they were still a critical partner to engage in CESMP development. PWCS representatives were invited to participate in the CESMP Workgroups. Notably, the Joint Environmental Task Force (JET) was developed to foster the relationship and increase communication channels to address climate change and environmental sustainability proactively and equitably. The creation of the JET was authorized on June 22, 2021, by the Board of County Supervisors and stood up in February 2023. The JET provides a forum for informing, advising, collaborating, and addressing county-wide issues and aligning institutional policies and practices pertaining to climate change and environmental sustainability through the equity lens being continuously applied by both the county and the PWCS. This task force will also recommend to the Board of County Supervisors and to the School Board funding priorities that are identified by the CESMP.*

Figure E.3: Complete List of Technical Workgroup Participants

# Workgroup Participants



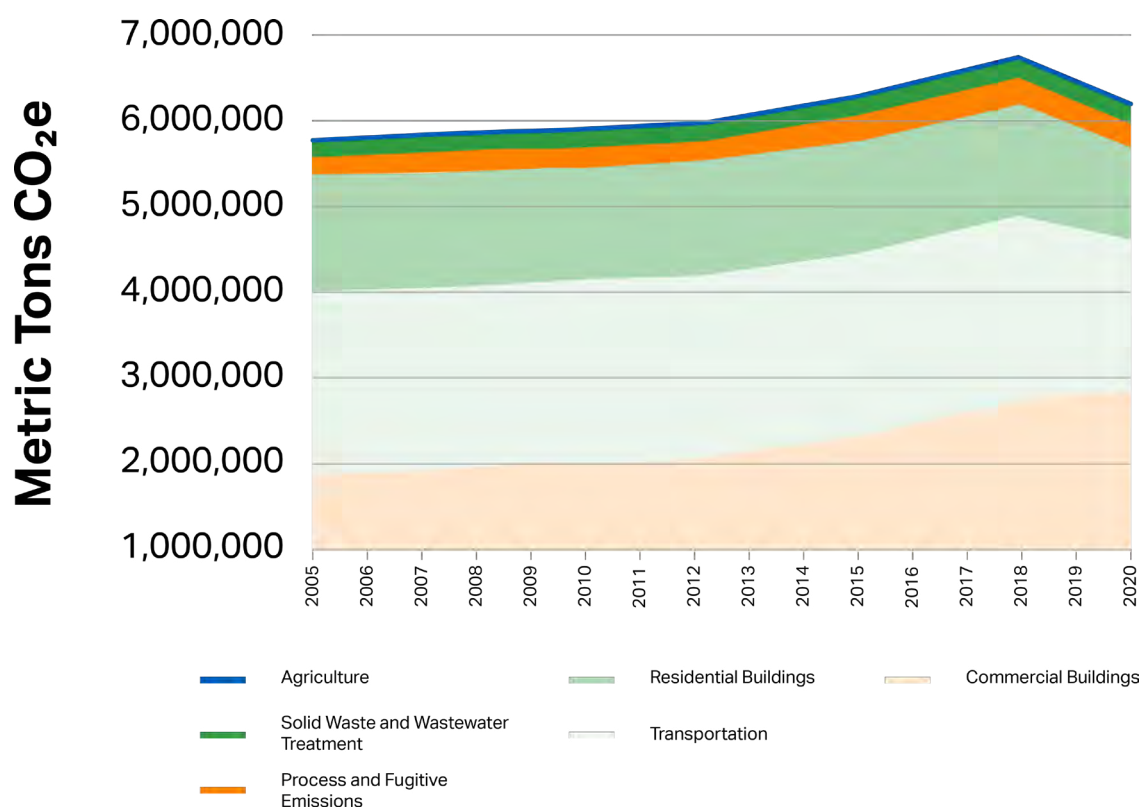
## Appendix F Greenhouse Gas Inventory and Analysis

- ▶ Appendix F.1 Greenhouse Gas Inventory
- ▶ Appendix F.2 Electric Grid Resource Mix
- ▶ Appendix F.3 Greenhouse Gas Reduction Strategies
- ▶ Appendix F.4 Method for Developing GHG Emission Reduction Strategies

## Appendix F.1 Greenhouse Gas Inventory

MWCOG develops our GHG inventories every two to three years following guidance from the U.S. Community Protocol – an inventory reporting protocol to guide U.S. local governments in calculating and reporting their community's GHG emissions.<sup>22</sup> MWCOG previously developed the inventories for 2005, 2012, 2015, 2018, and 2020. As our goal is to reduce county-wide GHG emissions by 50% from a 2005 baseline by 2030, the 2005 inventory represents the GHG emissions baseline against which we measure our emissions reduction progress. Total emissions in 2005 were 4,190,056 MTCO<sub>2</sub>e. In 2018, we generated approximately 5,044,135 MTCO<sub>2</sub>e – a 20% increase from 2005 levels. To progress toward the 50% reduction goal by 2030, 2018 county-wide emissions needed to show a 26% decrease below 2005 levels – which means emissions are not currently on track for goal achievement.

**Figure F.1: Prince William County GHG Emissions 2005-2020**



**Table F.1: 2018 County GHG Emissions Inventory**

Emissions Type	Emissions Activity or Source	2018 Emissions MTCO <sub>2</sub> e)	% of Total Emissions
Residential Energy	Electricity	724,067	14%
	Natural Gas	412,703	8%
	Fuel Oil	9,889	<1%
	Liquefied Petroleum Gas	7,150	<1%
Commercial Energy	Electricity	1,359,354	27%
	Natural Gas	157,959	3%
	Fuel Oil	2,621	<1%
	Liquefied Petroleum Gas	1,246	<1%
Transportation and Mobile Emissions	On Road Transportation	1,636,658	32%
	Passenger Air Travel	62,539	1%
	Rail Transportation	2,598	<1%
	Off Road Mobile Sources	164,404	3%
Process and Fugitive Emissions	Hydrofluorocarbon & Refrigerant Emissions	238,364	5%
	Natural Gas Fugitive Emissions	16,625	<1%
Solid Waste Treatment	Landfill Waste	214,717	4.3%
Agriculture	Enteric Fermentation	13,397	<1%
	Manure Management	1,461	<1%
	Agricultural Soils	15,051	<1%
Wastewater Treatment	Septic System Emissions	1,502	<1%
	Sewer System Treatment Emissions	1,160	<1%
	Sewer System Effluent Discharge Emissions	668	<1%
TOTAL		5,044,135	



## Appendix F.2 Electric Grid Resource Mix

The information below is from the EPA eGRID data for the SERC Virginia/Carolina subregion.<sup>23</sup>

Generation Resource Mix (%)											
	Coal	Oil	Gas	Other Fossil	Nuclear	Hydro	Biomass	Wind	Solar	Geo-thermal	Other Unknown/ Purchased Fuel
<b>2018</b>	19.1%	0.6%	34.6%	0.1%	37.8%	2.3%	2.8%	0.4%	2.2%	0.0%	0.1%
<b>2021</b>	13.4%	0.2%	38.1%	0.2%	38.8%	1.9%	2.3%	0.4%	4.7%	0.0%	0.1%

## Appendix F.3 Greenhouse Gas Reduction Strategies

2030 Greenhouse Gas Reduction Strategy	Percent of 2030 GHG Reductions Needed to Meet Goal
92% clean electricity	57%
50% of passenger and medium-duty vehicles are ZEV	24%
40% of HVAC systems and water heaters are highly efficient and electric	8%
57% HFCs replaced with low- or zero-GWP alternatives	4%
5% reduction in passenger vehicle travel by reducing the amount of VMT or shifting to active or public transport	2%
60% waste diversion rate	2%
100% high-efficiency lighting and appliances	1%
15% zero emissions off-road equipment	1%
20% reduction in aviation emissions	<1%
10% reduction in agriculture emissions	<1%

## Appendix F.4 Method for Developing GHG Emission Reduction Strategies

The first step in developing the GHG reduction scenarios was to evaluate how external regulatory, or market forces would impact emissions over time. Reductions from these forces are reflected in the blue hatched wedge at the top of the chart in **Figure 11**. These external forces include:

- ▶ Virginia's Renewable Portfolio Standard (RPS), which requires electricity generation from 30% renewables by 2030 for Phase I utilities and 41% for Phase II utilities.
- ▶ Market forecasts for EV adoption, where approximately 17% of passenger vehicles are assumed to be EVs 2030.
- ▶ Reductions in hydrofluorocarbons use under the Kigali Amendment, where industrialized nations like the United States must reduce production and consumption of HFCs to about 15% of 2012 levels by 2036.
- ▶ Market forecasts for electric off-road construction equipment, which are assumed to be 10% electric by 2030.

These external factors result in roughly 32% of the emissions reductions needed to meet the 2030 goal. The impact of these external forces may be large, but local action is still necessary to meet the 2030 goal.

Building upon these external regulatory and market forces, multiple 2030 GHG reduction scenarios were developed to demonstrate what it will take to achieve our 2030 GHG reduction goal. After reviewing these scenarios, we selected the preferred 2030 reduction scenario to show what it will take to reach the 2030 goal and guide climate action development.

### Emissions Impact of Other External Regulatory and Market Forces

*The emission impact of certain external regulatory or market forces, such as impacts from the Inflation Reduction Act (IRA) or the Infrastructure Investment and Jobs Act (IIJA), were not integrated into our GHG reduction scenario but could help to further reduce local emissions, especially in the electricity, buildings, and transportation sectors.*

*Enacted in 2022, the IRA is a federal law which aims to curb inflation by investing into domestic energy production while promoting clean energy, among other actions. The IIJA is a federal law enacted in 2021 that directs spending toward transportation, electric, and other infrastructure improvements. Because the IRA and IIJA provide US-wide funding and financing opportunities and do not require a discrete number of emissions reductions or clean energy use, the emissions impact of these laws was not quantified in the emissions forecasts or included in the 2030 GHG reduction scenario. However, both the IRA and IIJA will likely help to reduce emissions in the county due to their promotion of clean energy, electric vehicles, and public transit. Studies have estimated the IRA will have minimal impact on transportation emissions by 2030 but could decrease emissions in the US power sector by roughly 50-60% by 2030 as compared to business-as-usual emissions.<sup>24,25</sup> However, these studies do not specifically analyze how these reductions will interact with any state's RPS, which requires a certain percentage of renewable energy and will therefore also decrease power sector emissions. Another study found that the IIJA could increase or decrease transportation emissions +/- 1% in 2030 compared to a base case scenario depending on the direction of investment.<sup>26</sup> At the time of our 2030 GHG reduction scenario development, IRA and IIJA impacts were not integrated into the EV market forecast study that was used to forecast external impacts on our transportation emissions. In the future, IRA and IIJA impacts may be integrated into both EV forecasts and Virginia renewable energy forecasts and could be used in county emissions forecasting updates. This could help us better understand the overall impact of these laws on our future emissions and GHG reduction scenario.*

*Though the IRA and IIJA will most likely help spur clean energy integration into the regional electrical grid and improve transportation infrastructure, they will not be enough to guarantee that we achieve our 2030 GHG reduction goal or 2035 renewable energy goal. Therefore, including potential emissions reductions from the IRA, IIJA or other forces in the 2030 reduction scenario would not change the focus of actions presented in the CESMP. Because the CESMP is a living document, the emission impacts of new measures and regulations can be monitored and incorporated in future GHG forecasting updates.*

# Appendix G. Vulnerability Assessment Report

# Vulnerability Assessment Report

Prince William County

January 9, 2023

## Quality information

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## Revision History

Revision	Revision date	Details	Name	Position
0	11/7/22	Original	Tauhirah Abdul-Matin	Project Manager
1	1/6/2023	Final	Tauhirah Abdul-Matin	Project Manager



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## Executive Summary

Prince William County is located in the Washington, DC metropolitan area and is a fast-growing county currently home to over 482,000 people as of the 2020 census. The Draft 2022 Northern Virginia Hazard Mitigation Plan and the Metropolitan Washington Council of Governments 2030 Climate and Energy Action Plan each provide an assessment of natural hazard risks within the region and Prince William County. This report strives to provide an overview of the vulnerability of Prince William County's assets to climate hazards with a particular focus on how future conditions will exacerbate existing vulnerabilities. At the county-level, this report categorizes the relevant assets, evaluates their exposure to climate hazards, and rates each assets' sensitivity and adaptive capacity. Vulnerability assessments are an essential part of the planning process as they help identify the areas of greatest need within the community and can help to focus resiliency planning efforts on the most beneficial projects.

Hazards reviewed in this report include precipitation, temperature, drought, coastal flooding, sea level rise, earthquakes, and high winds/tornadoes. Future conditions were only assessed for the precipitation, temperature, drought, and sea level rise hazards. Two future climate scenarios were evaluated for the years 2050 and 2075. The future climate scenarios to predict precipitation, temperature and drought changes represent a scenario where greenhouse gas emissions continue to increase through the middle of the 21<sup>st</sup> century and are then stabilized and another scenario that is a business-as-usual or worst-case scenario with GHG emissions increasing throughout the 21<sup>st</sup> century. Sea level rise (SRL) future scenarios were based on the National Oceanic and Atmospheric Administration's (NOAA's) 2017 SRL estimates (Sweet, 2017).

Assets within the county were grouped to align with the Federal Emergency Management Agency's (FEMA's) Community Lifelines, which are also used by the Prince William County Office of Emergency Management (PWC EM). The FEMA Lifeline categories are safety and security; food, water and shelter; health and medical; communications; transportation; energy; and hazardous materials. For this study, the energy and hazardous materials lifeline categories have been combined and two additional categories have been included in this analysis which are: natural resources and socially vulnerable populations.

The vulnerability assessment calculated risk based on the exposure, sensitivity, and adaptive capacity of each asset category to each natural hazard. Ratings were assigned numerical values and summed to determine vulnerability scores for each asset category, time horizon, and hazard. Each asset category's vulnerability ratings for each timeline and climate hazard are shown in Table E-1. Vulnerability scores within each asset category were combined and used to assign a Low, Medium, or High combined vulnerability rating for each of the two future timelines (2050 and 2075) as shown in Table E-2.

Overall, assets in Prince William County were determined to be most vulnerable to Extreme Temperatures followed by Precipitation and Strong Winds/Tornadoes. Socially Vulnerable Populations, Transportation, and Natural Resources were the most vulnerable asset categories followed by Energy & Hazardous Materials. The most vulnerable asset categories were determined to be the Socially Vulnerable Populations, Transportation, and Natural Resources categories, which had High combined vulnerability ratings in both 2050 and 2075. Energy & Hazardous Materials received a Medium combined vulnerability rating for 2050 and a High combined vulnerability rating for 2075. Food, Water, and Shelter and Health and Medical asset categories received Medium combined vulnerability ratings for both 2050 and 2075 while Safety and Security and Communications asset categories received Low vulnerability ratings for both 2050 and 2075.

**Table E-1. Summary of Vulnerability Ratings for All Climate Hazards**

Climate Hazard	Asset Category															
	Safety and Security		Food, Water, and Shelter		Health and Medical		Communications		Transportation		Energy & Hazardous Materials		Natural Resources		Socially Vulnerable Populations	
	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075
Precipitation	L	L	M	M	M	M	L	L	H	H	M	M	H	H	H	H
Extreme Temperature	M	M	M	H	M	M	M	M	M	H	M	M	M	H	H	H
Drought	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	H
Coastal Flooding and SLR	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	M
Earthquakes	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	M
Strong Winds/Tornadoes	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	M

**Table E-2. Summary of Combined Vulnerability Ratings**

Asset Category	Combined Vulnerability Rating	
	2050	2075
Safety and Security	L	L
Food, Water, and Shelter	M	M
Health and Medical	M	M
Communications	L	L
Transportation	H	H
Energy & Hazardous Materials	M	H
Natural Resources	H	H
Socially Vulnerable Populations	H	H

# 1. Introduction

Prince William County is located in the Washington, DC metropolitan area and is a fast-growing county currently home to over 482,000 people as of the 2020 census. The county is bounded on the north by Loudoun and Fairfax Counties, west by Fauquier County, on the south by Stafford County, and on the east by the Potomac River. As reported in the Draft 2022 Northern Virginia Hazard Mitigation Plan, the county currently faces risks from many natural hazards including: High Wind/Severe Storms, Winter Weather, Floods/Flash Floods, Tornados, Earthquakes, Droughts, Extreme Temperatures, Wildfires, Landslides, Karst/Sinkholes. The Metropolitan Washington Council of Governments 2030 Climate and Energy Action Plan includes an assessment of climate hazards for the region including extreme heat, drought, lightning and thunderstorms, flash and riverine flooding, coastal flooding, and extreme winter conditions (2020).

While these documents provide an overview of climate risk for the region, this Climate Vulnerability Assessment for Prince William County provides a more in-depth review of climate risks for specific asset categories within the County. This includes an analysis of present-day risks for: precipitation, extreme temperature, drought, coastal flooding, earthquakes, and strong winds and tornadoes. Future conditions are considered for precipitation, extreme temperature, drought, and sea level rise. The hazards are discussed in more detail in Section 2 of this report. Prince William County's assets are described in Section 3. Section 4 discusses the vulnerability assessment methodology, which focuses on exposure, sensitivity, and adaptive capacity. This section also discusses the vulnerability of each hazard for each asset category. A rating system is established to quantify the risk from each hazard for each asset category and the final ratings and vulnerability are discussed in Section 5. References are included in Section 6.

## 2. Climate Hazards

Climate hazards are environmental phenomena that have the potential to impact societies and the human environment. Prince William County and its residents are exposed to many natural hazards including riverine and coastal flooding, extreme temperatures, droughts, strong winds, tornadoes, and even earthquakes. Climate hazards that have been determined to have the highest risk of causing harm are discussed. For some climate hazards, only present-day conditions and assessments are available, but for some climate hazards, future conditions for the years 2050 and 2075 are discussed. The Forecasting Local Extremes (FLEX) tool is used for some of the future assessments and is discussed in more detail in Section 2.1.2

### 2.1. Future Conditions Methodology

#### 2.1.1. Scenarios

To better quantify the climate hazard risks, the Prince William County team analyzed climate hazards by comparing projected climate threats from 2050 and 2075 to a historical climate baseline (based on a “baseline” period of analysis from 1950 through 2005). The Prince William County greenhouse gas emissions forecasts include the years 2030 and 2050. The 2030 timeline is considered too near-term to see substantial changes in the climate compared with today's conditions, so the 2050 time was selected as the first projected time. The 2075 time was selected to represent a longer-term climate scenario, which aligns with the approximate useful life of many transportation and residential building assets if they were built within the next 5 years. For each future timeline, two different climate scenarios were evaluated. The first climate scenario called the Representative Concentration Pathway (RCP) 4.5 represents a stabilization scenario through greenhouse gas (GHG) mitigation strategies and technological interventions that produce a moderate GHG emissions increase until the middle of the twentieth century followed by a leveling off of these emissions. A second scenario (RCP 8.5) represents a business-as-usual or worst-case scenario with GHG emissions increasing throughout the 21<sup>st</sup> century (van Vuuren, et al., 2011). These two scenarios are commonly used to provide a most likely range of possible future climate conditions.



## 2.1.2. Forecasting Local Extremes (FLEx) Tool

AECOM conducted post-processing of the localized constructed analogs (LOCA) dataset to calculate future temperature, precipitation, and drought statistics using the Forecasting Local Extremes (FLEx) tool. Developed by AECOM, the FLEx tool uses general circulation model (GCM) output that has been downscaled by research scientists to achieve higher spatial resolutions for future climate scenarios. The FLEx tool efficiently condenses the data into a few key indicators that help describe future hazard exposure for a local area.

The future conditions statistical analyses performed for this study are driven by gridded observed data and statistically downscaled GCM outputs developed by the Bureau of Reclamation. The dataset provides a high spatial resolution (6-kilometer x 6-kilometer) of daily downscaled maximum/minimum temperature and precipitation data from 32 GCMs through the LOCA statistical downscaling method (Pierce, et. al, 2014).

In the future conditions assessment, all 32 GCMs were equally weighted as an ensemble and analyzed to capture the full range of model variability, based on guidance from the United Nations Intergovernmental Panel on Climate Change (IPCC) that an ensemble average of several GCMs is expected to outperform the results of individual ensemble members and provide an improved “best estimate” forecast (IPCC, 2007). Statistics were calculated separately for each grid cell that intersects with the County boundary and then averaged.

## 2.1.3. Indicators

This section defines each of the indicators used in the future conditions analyses. All indicators are calculated separately for each model and then averaged equally to create a single ensemble-average value. Generally, average annual and seasonal values represent an understanding of long-term trends such as a tendency for wetter or warmer conditions. On the other hand, the values tied to 95th and 99th percentiles, days above a temperature threshold (e.g., 95° F) and maximum 3-day/5-day events demonstrate trends in more extreme events or volatility. Long-term trends can show more or less rainfall on average while the volatility represents short-term extremes.

### Precipitation

- **Average Annual Maximum:** the maximum annual daily precipitation value averaged across the time horizon
- **Average Annual Total:** the sum of annual precipitation averaged across the time horizon
- **95<sup>th</sup>/99<sup>th</sup> Percentile:** the 24-hour precipitation depth that is greater than or equal to 95%/99% of storm events across the time horizon
- **Average Annual Maximum 5-Day Event:** the maximum annual precipitation event lasting 5 days averaged across the time horizon
- **Epoch Maximum 3-Day/5-Day Event:** the maximum precipitation event lasting 3/5 days which occurs during the time horizon
- **Autumn/Winter/Spring/Summer:** the sum of precipitation occurring during each season averaged across the time horizon
- **Number of Days Equal to or Above 95<sup>th</sup>/99<sup>th</sup> Percentile:** the number of days each year that precipitation was greater than or equal to the 95<sup>th</sup>/99<sup>th</sup> Percentile from the baseline period averaged across the time horizon
- **Fraction of Rain due to 95<sup>th</sup>/99<sup>th</sup> Percentile:** the sum of precipitation depths each year from days with precipitation greater than or equal to the 95<sup>th</sup>/99<sup>th</sup> Percentile from the baseline period divided by the sum of all precipitation for each year; averaged across the time horizon

### Temperature

- **Average Annual Maximum:** the maximum annual daily temperature value averaged across the time horizon
- **Average Annual Minimum:** the minimum annual daily temperature value averaged across the time horizon
- **95<sup>th</sup>/99<sup>th</sup> Percentile:** the daily maximum temperature value that is greater than or equal to 95%/99% of daily maximum temperature values across the time horizon

- **Autumn/Winter/Spring/Summer:** the average maximum/minimum daily temperature occurring during each season averaged across the time horizon
- **Number of Days Equal to or Above 95° F/105° F:** the number of days each year that maximum daily temperature was greater than or equal to 95° F/105° F averaged across the time horizon
- **Number of Days Equal to or Above 95<sup>th</sup>/99<sup>th</sup> Percentile:** the number of days each year that maximum daily temperature was greater than or equal to the 95<sup>th</sup>/99<sup>th</sup> Percentile from the baseline period averaged across the time horizon
- **Number of Days Equal to or Below 75° F:** the number of days each year that minimum daily temperature was less than or equal to 75° F averaged across the time horizon

## Drought

- **Average Change in the Average Number of Months per Year with Mild/Moderate/Severe/Extreme Drought:** the change in the average number of months each year with PDSI values within the range for each severity rating (Mild/Moderate/Severe/Extreme Drought as described in Section 2.4.2) averaged across the time horizon

## 2.2. Precipitation

### 2.2.1. Current Conditions

Prince William County has a temperate climate with rainfall occurring throughout the year. The County has been impacted by tropical storms, hurricanes, and severe winter storms/nor'easters. There have been 9 major disaster declarations due to tropical storms or hurricanes<sup>1</sup> for the County as recorded by the Federal Emergency Management Agency (FEMA) between 1972 and 2021 as well as 242 recorded flood events<sup>2</sup> and 134 winter storm events<sup>3</sup> as recorded by the National Oceanic and Atmospheric Administration (NOAA) from 1996 to 2021. Over \$4 million in National Flood Insurance Program (NFIP) claims were paid out from 1978 to 2015 including over \$1.7 million in repetitive loss properties. In the most recent Northern Virginia Hazard Mitigation Plan (2022), flooding was identified as one of the highest risk hazards for Prince William County. Prince William County participates in the Virginia Stormwater Management Program (VSMP), managed by the state Department of Environmental Quality, which provides guidelines for managing water from the municipal storm sewer system and construction activities.

### Nuisance Flooding and Road Closures

Prince William County has had 60 reported Swift Water Rescue events and 178 reported VDOT road closures since 2018 due to intense precipitation events. Locations of these events are shown in Figure 1. Detailed stormwater modeling is needed to better understand how flooding occurs throughout the County during precipitation events and to better understand the limitations of existing stormwater infrastructure.

<sup>1</sup> FEMA Disaster Declarations for Hurricanes and Tropical Storms, Virginia, 1972 – 2021.

<sup>2</sup> NOAA, NCEI Storm Events Database, 1950 to June 30, 2021. The search encompassed a cross-section of NCEI flood-related categories: flood; coastal flood; flash flood; heavy rain; thunderstorm wind; heavy rain; storm surge/tide; and tropical storm. County reported events include impacts in towns, where applicable.

<sup>3</sup> NOAA, National Centers for Environmental Information, Storm Events Database, 1996–June 30, 2021  
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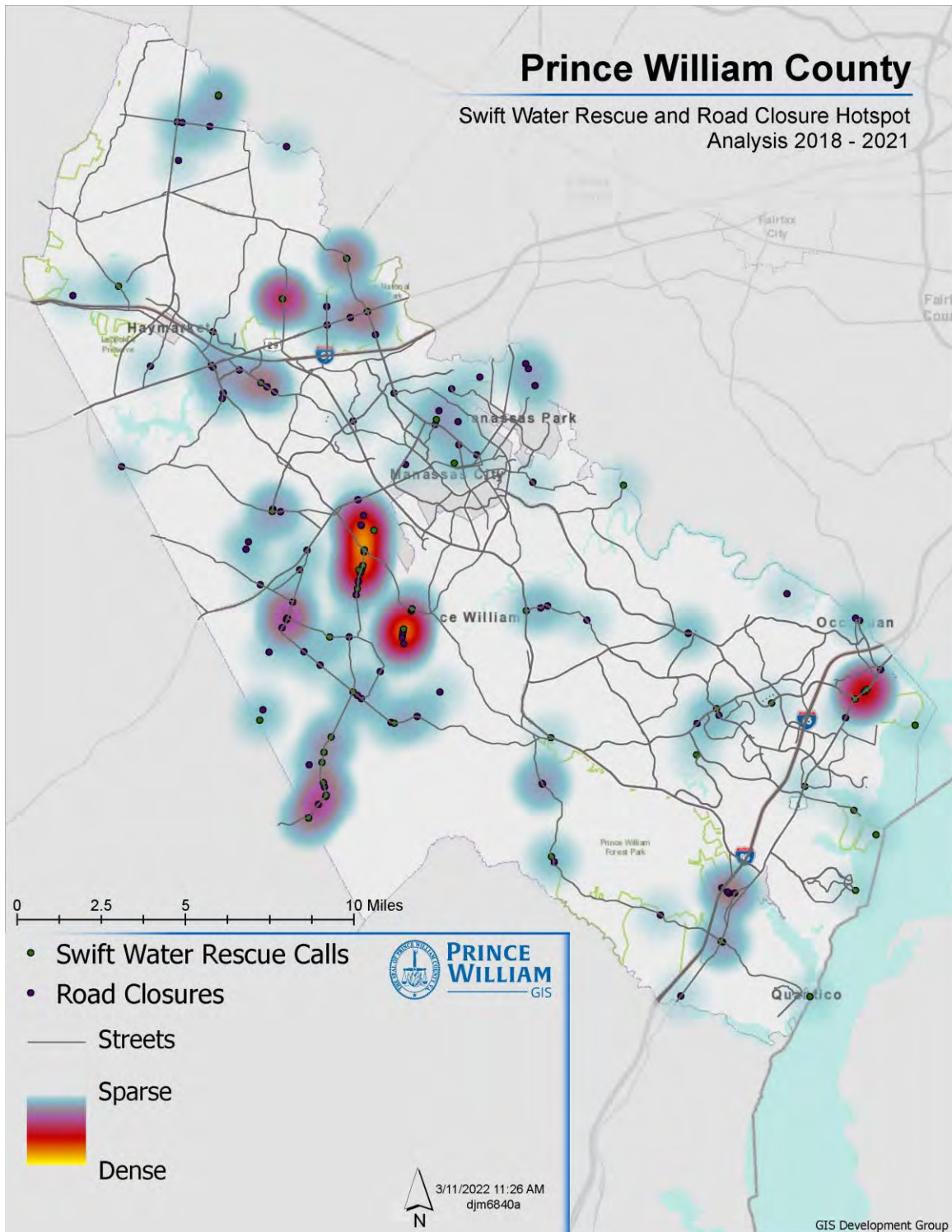


Figure 1. Swift Water Rescue and Road Closures from 2018 - 2021

## 2.2.2. Future Conditions

Changes in precipitation can be measured using multiple indicators to understand different aspects of the future climate. Change in the average seasonal total precipitation as well as a change in the average annual total precipitation help provide an idea of how the typical year is expected to change. Changes to the maximum 3- and 5-day events, annual maximum precipitation, and changes to the 95<sup>th</sup> or 99<sup>th</sup> percentile storms show how extreme precipitation is expected to change on average each year. The 95<sup>th</sup> and 99<sup>th</sup> percentile storms represent the average 24-hour precipitation depth that is greater than or equal to 95% and 99% of storm events, respectively, for a given time period. In other words, these are extreme events that occur infrequently. These statistics are shown for the years 2050 and 2075 for the RCP4.5 and RCP8.5 scenarios in Table 1.

**Table 1. Future Average Seasonal and Annual Precipitation Indicators**

Precipitation Indicators	RCP4.5 <sup>4</sup>				RCP8.5 <sup>5</sup>			
	Average 2050 Change (Inches)	Average 2075 Change (Inches)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (Inches)	Average 2075 Change (Inches)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Average Annual Maximum	0.10	0.12	5	6	0.11	0.19	6	10
Average Annual Total	2.24	2.87	6	7	2.38	3.33	6	8
95th Percentile	0.05	0.07	6	7	0.06	0.09	7	11
99th Percentile	0.08	0.11	6	7	0.10	0.16	7	11
Average Annual Maximum 5-Day Event	0.23	0.31	6	8	0.28	0.41	7	11
Epoch Maximum 3-Day Event	0.13	0.33	1	3	0.33	0.60	3	6
Epoch Maximum 5-Day Event	0.12	0.46	1	5	0.59	0.67	5	6
Autumn	0.34	0.39	4	4	0.33	0.38	3	4
Winter	0.73	0.96	9	12	0.75	1.23	9	15
Spring	0.79	1.05	8	10	0.91	1.17	9	12
Summer	0.42	0.52	4	5	0.44	0.62	4	6

Projections for Prince William County show a small to moderate increase in seasonal and average annual precipitation indicators. The most significant increases in seasonal precipitation occur in Winter and Spring (9%-15%) while average annual total precipitation as well as average annual maximum daily precipitation are projected to increase by approximately 5% to 6% by 2050 and 6% to 10% by 2075.

Increases to annual extreme precipitation indicators such as the 95th and 99th percentiles of average annual daily precipitation are projected to be between 6% and 7% by 2050 and 7% to 11% by 2075 which suggest a moderate increase in storm intensities.

Table 2 shows the change in the average number of days per year with precipitation greater than or equal to the baseline 95th and 99th percentile which are projected to increase by approximately 1 day (17% - 29%) by 2050 and 2 days (23% - 48%) by 2075. These changes indicate a small increase to the frequency of extreme events. Similarly, Table 3 shows that the average annual fraction of precipitation which occurs during events that are equal to or above the 95th and 99th percentile is projected to increase by 11% to 20% in 2050 and 15% to 33% by 2075 which indicates

<sup>4</sup> Representative Concentration Pathway 4.5 (See Section 2.1.1)

<sup>5</sup> Representative Concentration Pathway 8.5 (See Section 2.1.1)

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that more of the annual total precipitation will occur during extreme events. Table 4 shows small to moderate increases to return period storm events. Storm return period refers to the average recurrence interval associated with a particular storm intensity and duration. For example, the 10-year, 24-hour storm has an average recurrence interval of 10 years and a duration of 24 hours; the recurrence interval corresponds to an annual chance of exceedance (ACE) equal to 10% (1/10) so this event can also be called the 10%-annual-chance-exceedance (10% ACE) event. It is important to note that nuisance flooding and flash floods are not well represented by daily precipitation data as these events typically occur on a sub-daily scale. Thus, the results of this analysis do not fully capture the increases which are likely to occur on a sub-daily scale and may result in increased flash floods and stormwater/nuisance flooding.

**Table 2. Future Number of Days Equal to or Above the Baseline 95th/99th Percentile**

Precipitation Indicators	RCP4.5				RCP8.5			
	Average 2050 Change (Days)	Average 2050 Percent Change (%)	Average 2075 Change (Days)	Average 2075 Percent Change (%)	Average 2050 Change (Days)	Average 2050 Percent Change (%)	Average 2075 Change (Days)	Average 2075 Percent Change (%)
Number of Days Equal to or Above 95th Percentile	1.2	17	1.5	23	1.4	22	2.1	31
Number of Days Equal to or Above 99th Percentile	0.3	26	0.5	35	0.4	29	0.6	48

**Table 3. Future Average Annual Fraction of Precipitation due to events equal to or above the Baseline 95th/99th Percentile**

Precipitation Indicators	RCP4.5				RCP8.5			
	Average 2050 Change	Average 2075 Change	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change	Average 2075 Change	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Fraction of Rain due to 95th Percentile	0.024	0.032	11	15	0.032	0.047	15	21
Fraction of Rain due to 99th Percentile	0.012	0.016	17	23	0.014	0.022	20	33

**Table 4. Future Return Period Storms**

Return Period Storm	RCP4.5				RCP8.5			
	Average 2050 Change (Inches)	Average 2075 Change (Inches)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (Inches)	Average 2075 Change (Inches)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
100% ACE (1-yr)	0.05	0.08	5	8	0.08	0.09	7	8
50% ACE (2-yr)	0.10	0.13	6	7	0.11	0.18	7	10
10% ACE (10-yr)	0.13	0.14	5	5	0.13	0.26	5	9
4% ACE (25-yr)	0.14	0.13	4	4	0.13	0.30	4	9
1% ACE (100-yr)	0.15	0.12	3	3	0.14	0.39	3	8



## 2.3. Extreme Temperature

### 2.3.1. Current Conditions

Historically, both extreme heat and extreme cold events have occurred in Prince William County. According to NOAA, at least 33 extreme heat and 39 extreme cold events occurred between January 1950 and June 2021<sup>6</sup> and were documented to have resulted in crop losses as well as over 100 reported injuries (Mitigation Advisory Committee, 2022). In the most recent Northern VA Hazard Mitigation Plan (2022), Prince William County was identified as being at medium risk to impacts from extreme temperatures.

### 2.3.2. Future Conditions

Average annual temperatures for Prince William County are projected to increase in the future. Table 5 shows projected average changes to seasonal and annual maximum and minimum temperature indicators. Most maximum temperature indicators show an increase of approximately 2°C (3.6°F) by 2050 and 3°C (5.4°F) to 4°C (7.2°F) by 2075 while minimum temperatures are also expected to increase by approximately 2°C (3.6°F) to 3°C (5.4°F) by 2050 and 2°C (3.6°F) to 5°C (9°F) by 2075.

As shown in Table 6, extreme temperatures are also projected to increase as shown by the increases to the 95<sup>th</sup> and 99<sup>th</sup> percentile as well as the number of extreme heat and cold days. The 95<sup>th</sup> and 99<sup>th</sup> percentile maximum temperatures represent the average maximum daily temperature that is greater than or equal to 95% and 99% of daily maximum temperatures, respectively, for a given time period. The average annual number of extreme heat days increases by approximately two weeks in 2050 and approximately three weeks to one month by 2075. Accordingly, the average number of days with minimum temperatures below 75°F is projected to decrease by 4 to 5 days by 2050 and 9 to 18 days by 2075. It is important to note that while the general trend is towards increasing temperatures it will continue to be possible to have extreme cold events though the likelihood decreases over time.

#### Tree Cover and the Urban Heat Island Effect

Approximately 54% of Prince William County has some form of tree cover. Tree cover can help naturally mitigate high temperatures and is essential in combating the urban heat island effect. Urban heat islands can be defined as developed urban areas that experience consistently higher temperatures than surrounding areas with lower population density and more pervious ground cover (unpaved area that allows water to flow through) and vegetation. The urban heat island effect is the result of multiple factors often associated with urbanization, such as a concentration of construction materials that absorb and store more heat than the natural environment and then re-emit that heat when temperatures would normally decrease; minimal or no evapotranspiration (transfer of water from land to the atmosphere) due to lack of exposed soil and vegetation; concentrated heat generation from air conditioning and vehicle exhaust; and diminished wind flow due to building placement and concentration. The urban heat island effect was not directly quantified as a part of this Vulnerability Assessment, but it would likely increase extreme temperature experienced in urban parts of the County

<sup>6</sup> National Oceanic and Atmospheric Administration (2021). National Center for Environmental Information Storm Events Database, 1950-June 30, 2021 [Data set]. <https://www.ncdc.noaa.gov/stormevents/>  
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**Table 5. Future Average Seasonal and Annual Temperature Indicators**

Maximum Temperature Indicators	RCP4.5				RCP8.5			
	Average 2050 Change (°C)	Average 2075 Change (°C)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (°C)	Average 2075 Change (°C)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Average Annual Maximum	2.1	3.1	6	9	2.4	4.1	7	12
95th Percentile	2.0	2.9	6	9	2.3	4.0	7	12
99th Percentile	2.2	3.1	6	9	2.5	4.4	7	12
Autumn	1.9	2.7	9	13	2.0	3.5	10	18
Winter	1.5	2.3	21	32	1.7	3.0	24	41
Spring	1.6	2.3	8	12	1.6	2.9	9	15
Summer	1.8	2.7	6	9	6.8	3.6	7	12
Minimum Temperature Indicators	Average 2050 Change (°C)	Average 2075 Change (°C)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (°C)	Average 2075 Change (°C)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
	Average 2050 Change (°C)	Average 2075 Change (°C)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (°C)	Average 2075 Change (°C)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Average Annual Minimum	2.7	4.1	17	26	3.0	5.0	19	31
Autumn	1.7	2.5	23	33	1.9	3.3	25	44
Winter	1.7	2.4	50	60	1.9	3.1	56	94
Spring	1.5	2.2	27	38	1.6	2.8	28	48
Summer	1.6	2.4	9	14	1.8	3.3	10	19

**Table 6. Future Number of Extreme Heat and Cold Days**

Maximum Temperature Indicators	RCP4.5				RCP8.5			
	Average 2050 Change (Days)	Average 2075 Change (Days)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (Days)	Average 2075 Change (Days)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Number of Days Equal to or Above 95° F	13	21	296	499	15	32	351	763
Number of Days Equal to or Above 105° F	0.3	1.0	-	-	0.5	2.9	-	-
Number of Days Equal to or Above 95th Percentile	22	35	123	191	25	48	139	262
Number of Days Equal to or Above 99th Percentile	12	20	318	540	14	31	377	831
Minimum Temperature Indicators	Average 2050 Change (Days)	Average 2075 Change (Days)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (Days)	Average 2075 Change (Days)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Number of Days Equal to or Below 75° F	-4	-9	-1	-2	-5	-18	-1	-5

## 2.4. Drought

### 2.4.1. Current Conditions

NOAA records contain 12 drought events for Prince William County from 1950 to 2021<sup>7</sup>. Drought conditions have resulted in crop failures as well as water restrictions and the need for upstream dam releases to supplement drinking water supplies. In the most recent Northern VA Hazard Mitigation Plan (2022), the County was found to be at medium risk for drought impacts.

### 2.4.2. Future Conditions

Future changes to drought were evaluated by calculating the monthly Palmer Drought Severity Index (PDSI) and then calculating the average annual number of months of mild, moderate, severe, and extreme drought. These types of droughts are defined by the National Oceanic and Atmospheric Administration (NOAA) using the following PDSI values:

- PDSI 1 to -2 = Mild Drought
- PDSI -2 to -3 = Moderate Drought
- PDSI -3 to -4 = Severe Drought
- PDSI -4 or less = Extreme Drought

Table 7 shows the average change in the number of months per year projected for each drought type. Mild droughts increase by 2050 but by 2075 begin to decrease as more intense droughts become more common. Moderate,

<sup>7</sup> National Oceanic and Atmospheric Administration (2021). National Center for Environmental Information Storm Events Database, 1950-June 30, 2021 [Data set]. <https://www.ncdc.noaa.gov/stormevents/>  
Prepared for Prince William County

Severe, and Extreme droughts all show significant increases by 2050 and 2075. Drought conditions can be affected by a multitude of climate processes operating at local, regional, and even global scales and the development and relief of drought conditions can span weeks, months or even years. The indicator used in this assessment should not be understood to imply that drought will necessarily occur on an annual basis. Rather, this analysis shows an overall trend of increases to both frequency and severity of drought in the future. Increases in both temperature and precipitation extremes discussed earlier in this report are drivers of increased drought. The combined trends of large increases in extreme precipitation indicators combined with relatively small increases in average annual precipitation indicators suggest that precipitation will fall in more intense bursts followed by longer dry periods which may result in drought.

**Table 7. Future Drought Indicators**

Drought Indicators	RCP4.5				RCP8.5			
	Average 2050 Change (Months)	Average 2075 Change (Months)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)	Average 2050 Change (Months)	Average 2075 Change (Months)	Average 2050 Percent Change (%)	Average 2075 Percent Change (%)
Mild Drought (PDSI between -1 and -2)	0.034	0.030	2	1	0.057	-0.110	3	-4
Moderate Drought (PDSI between -2 and -3)	0.417	0.543	43	56	0.462	0.790	39	67
Severe Drought (PDSI between -3 and -4)	0.289	0.462	114	182	0.320	0.743	151	350
Extreme Drought (PDSI less than -4)	0.114	0.244	201	434	0.152	0.563	393	1534

## 2.5. Coastal Flooding and Sea Level Rise

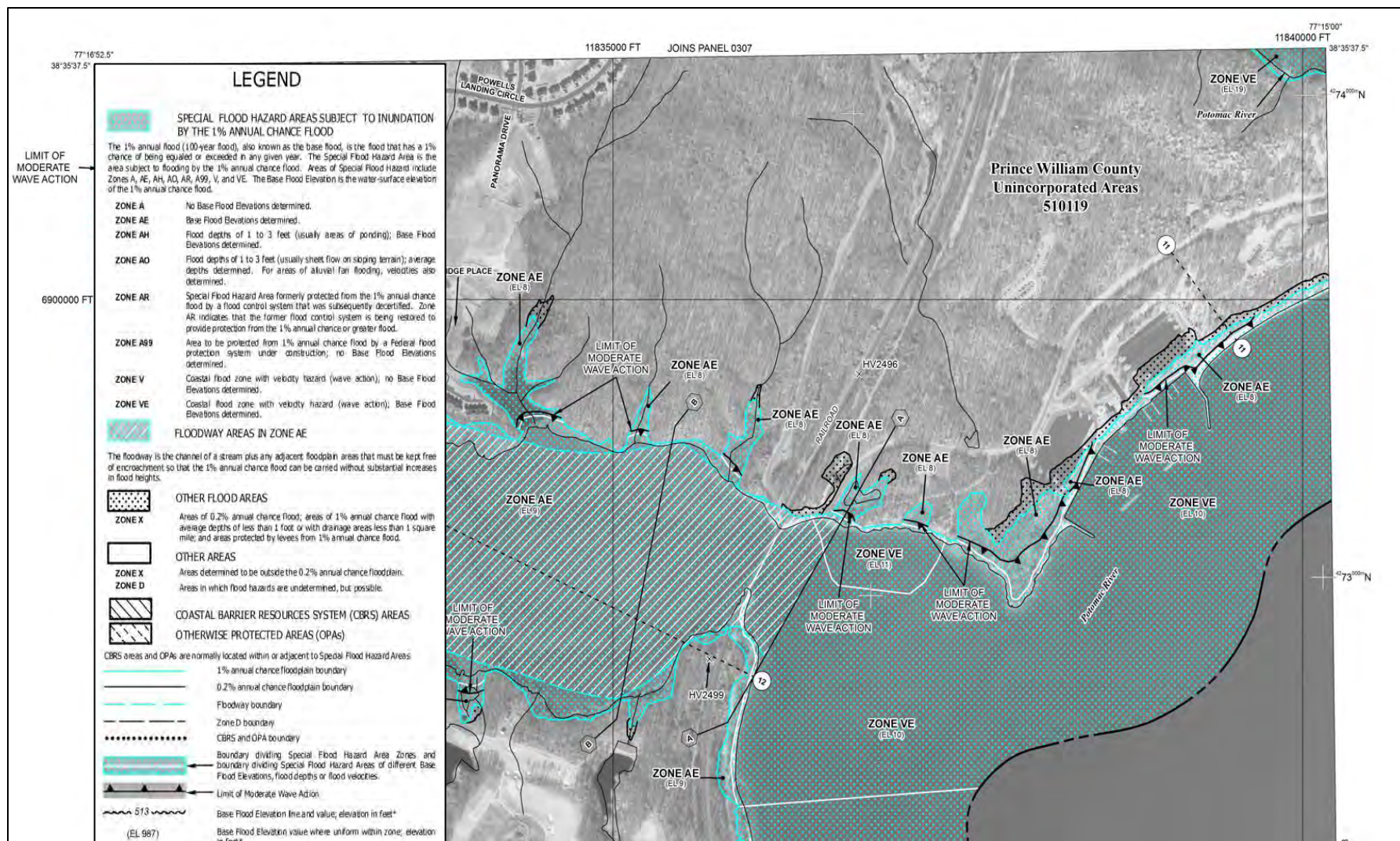
### 2.5.1. Current Conditions

Coastal flooding is a present-day risk for areas along the Potomac River and tributaries. FEMA delineates the risk of the 1-percent-annual-chance coastal flood event (including storm surge and wave effects) on the Flood Insurance Rate Maps (FIRMs). Figure 2 shows a portion of a FIRM for Prince William County (effective date: August 3, 2015). The image shows coastal flood areas with high waves (Zone VE) and moderate to low waves (Zone AE) with a 1-percent-annual-chance of occurrence. Additionally, the 0.2-percent-annual-chance coastal floodplain is shown as an area with black dots.

The FEMA FIRMs are considered present-day conditions and include any sea level rise (SLR) that has occurred since the last Flood Insurance Study for the county, but do not include a prediction of future conditions.

#### High Coastal Hazard Areas

Most coastal areas in Prince William County are undeveloped and not of significant concern for coastal flooding. There are however some notable exceptions to this that should be noted though they do not figure prominently in the County-wide assessment. Woodbridge has several developed coastal areas near Marumsco Creek, the Occoquan River, and Featherstone National Wildlife Refuge that are located within the effective FEMA 1%-ACE (100-year) and 0.2%-ACE (500-year) floodplains. These areas include commercial and residential properties, including socially vulnerable populations, as well as marinas and piers all of which are likely to be impacted significantly by storm surge. Other critical assets that are near the coastal shoreline but currently outside the Effective FEMA floodplains include the County's primary wastewater treatment facility for the County, located on Neabsco Creek Dominion Energy's Possum Point facility, and the Marine Corps Base Quantico may be impacted by coastal flooding and sea level rise.





## 2.5.2. Future Conditions

Projecting hurricane patterns for the future has been a challenge for scientists. Factors to predict hurricane sizes, numbers, strength, etc. depend on competing factors such as increase sea surface temperature which is favorable to hurricanes and increased vertical wind shear which is unfavorable to hurricanes; however, some statistical downscaling methods have shown a likely increase in large-scale (i.e., Hurricane Katrina-type) events (Grinstead, et al., 2013). Other recent studies demonstrate challenges in predicting future hurricane patterns as the future scenarios seem highly correlated with greenhouse gas emissions (Murakami and Wang, 2022). Due to the complexity and uncertainty in predicting future hurricane patterns, along with the modeling effort needed to downscale this information for Prince William County, no future condition storm surge modeling has been conducted.

Storm surge is a low-frequency event (meaning the occurrence is relatively rare), that causes short-term inundation of flood waters (usually on the order of a day). While these events can be catastrophic, this assessment will focus instead on higher-frequency flooding caused by tides that are amplified by SLR. This SLR flooding can also cause permanent inundation even at a low tide level. To determine future SLR scenarios, several reports and data sources were reviewed.

Several sources of SLR estimates were reviewed including the U.S. Army Corps of Engineers (USACE) 2013 data (USACE, 2013), the U.S. Department of Defense (DoD) 2016 Coastal Assessment Regional Scenario Working Group (CARSWG) estimates (Hall et al, 2016), the National Oceanic and Atmospheric Administration's (NOAA's) 2017 data (Sweet, et al. 2017), and the NOAA 2022 data (Sweet, et al. 2022).

The NOAA 2017 projections were produced with the dual purposes of updating scenarios of global mean sea level (GMSL) rise and integrating the global scenarios with regional factors contributing to sea level change for the entire U.S. coastline. This data was also used in the recently published VTrans: Virginia's Transportation Plan Trends Analysis: VTrans Vulnerability Assessment (VTrans 2021).

The NOAA 2022 projections were published most recently and build upon the NOAA 2017 projections to provide updated timing and exceedance probabilities based on different levels of global warming. The new report is based on the latest generation of GCMs and the IPCC Sixth Assessment Report (AR6) and uses a longer observational record as well as an improved understanding of ice-sheet dynamical processes. Therefore, this data was chosen as the sea level change projection for this assessment. The nearby Washington, D.C. tide gage was used to provide an adjustment for regional subsidence.

The NOAA projection include the 17<sup>th</sup>, 50<sup>th</sup>, and 83<sup>rd</sup> percentile levels for each of five scenarios: low, intermediate-low, intermediate, intermediate-high, and high. Each scenario describes future potential conditions to support decision-making under conditions of uncertainty. The 83<sup>rd</sup> percentile values were selected for this assessment as the most conservative estimate for planning purposes. The projected sea-level change values are shown in Table 8.

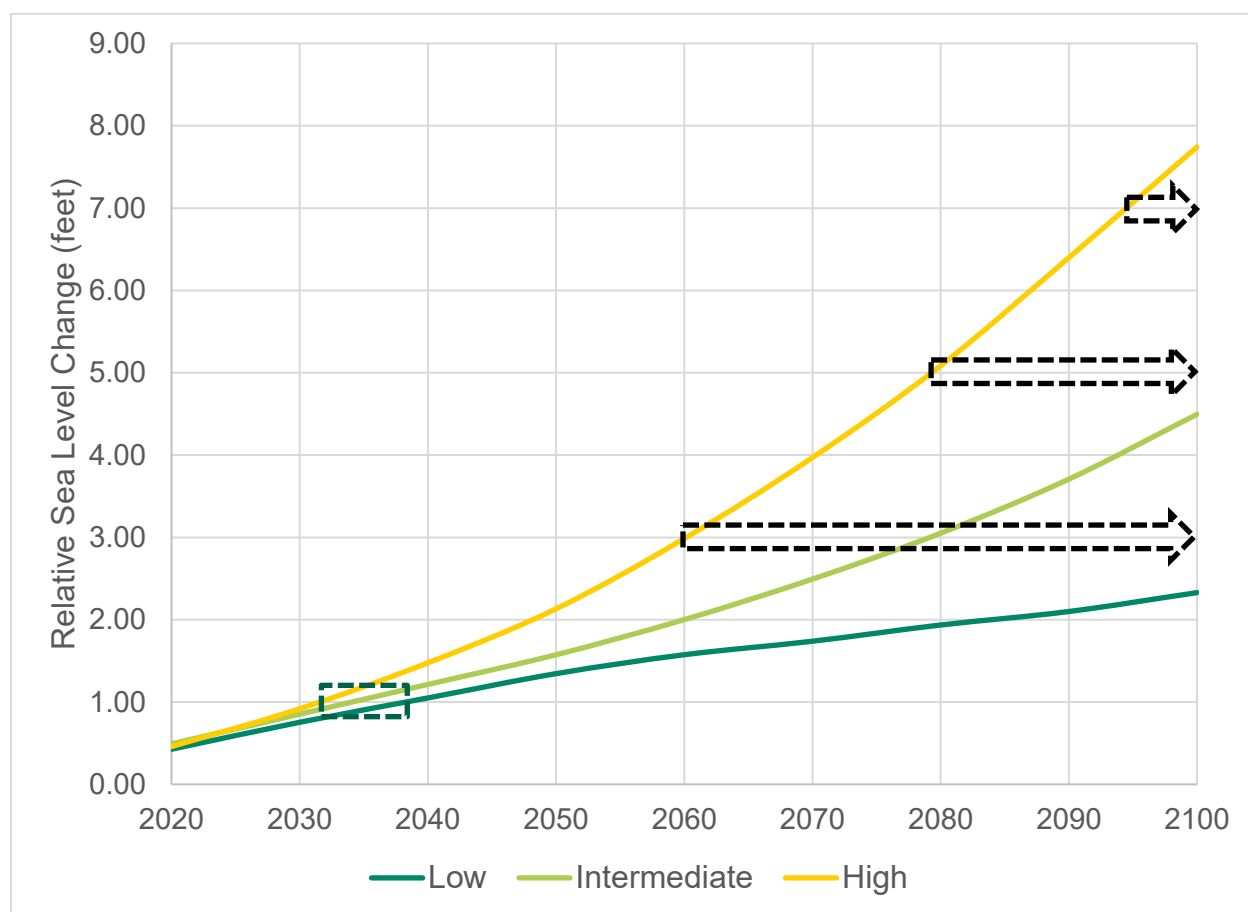
**Table 8. NOAA 2022 projected sea-level change values (feet) at Washington, DC gage (83<sup>rd</sup> Percentile)**

Year	Low	Intermediate-Low	Intermediate	Intermediate-High	High
2020	0.43	0.49	0.49	0.49	0.46
2030	0.75	0.82	0.85	0.89	0.92
2040	1.05	1.15	1.21	1.35	1.48
2050	1.35	1.44	1.57	1.94	2.13
2060	1.57	1.74	2.00	2.59	2.99
2070	1.74	2.03	2.49	3.35	3.97
2080	1.94	2.33	3.05	4.20	5.09
2090	2.10	2.62	3.71	5.05	6.40
2100	2.33	2.99	4.49	6.00	7.74

The NOAA et al. 2022 low, intermediate, and high projections were used to estimate ranges of years that will results in 1-ft increments of SLR. The approximate sea level change projection timings are presented in Table 9. These sea level change for these three projections along with boxes highlighting the range of years where the 1ft, 3ft, 5ft, and 7ft increases occur is illustrated in Figure 3.

**Table 9. Approximate sea level change projection time horizons for increments of 1 to 7 feet of sea level rise based on NOAA et al. 2022 projection**

Sea Level Change (feet)	Approximate SLC Projection Timing		
	<i>Earliest (High)</i>	<i>Intermediate</i>	<i>Latest (Low)</i>
<b>+1</b>	2031	2034	2038
<b>+2</b>	2048	2060	2084
<b>+3</b>	2061	2079	>2100
<b>+4</b>	2071	2094	>2100
<b>+5</b>	2079	>2100	>2100
<b>+6</b>	2087	>2100	>2100
<b>+7</b>	2095	>2100	>2100



**Figure 3. NOAA 2022 Sea Level Change with 1ft, 3ft, 5ft, and 7ft of Expected Sea Level Rise at Washington, DC Gage**

NOAA's SLR Viewer allows users to specify sea level rise values in 1 ft increments and displays the corresponding water levels in the map viewer. The viewer illustrates the scale of potential flooding but does not account for erosion, subsidence, future construction, or impacts of aging or inadequate stormwater infrastructure (NOAA, 2022). The



extent of +2 ft of sea-level change roughly corresponds to a time horizon of 2050 with an intermediate SLR projection. Due to the relatively steep shoreline, there are relatively small differences in the extent of inundation from 1 to 7 ft of increase as shown in Figure 4.

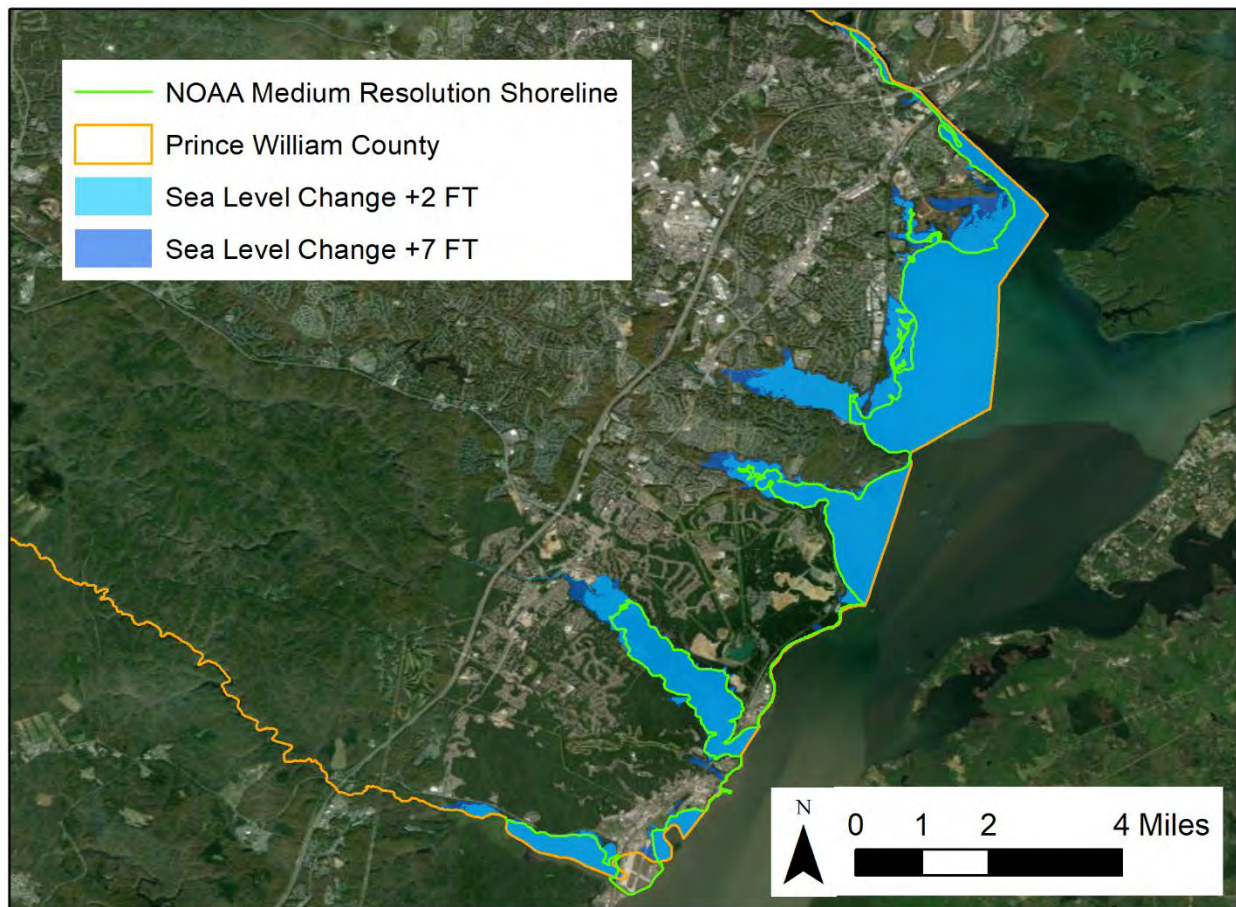


Figure 4. Sea-level change of +2 ft and +7 ft according to NOAA Sea Level Change Viewer in Prince William County, VA.

## 2.6. Earthquakes

### 2.6.1. Current Conditions

Prince William County has the potential to be impacted by earthquakes in the Central Virginia Seismic Zone. The largest recorded event in this area likely occurred in 1875. Although this was before the invention of effective seismographs, the event was estimated to be a 4.8 on the Richter scale. More recent earthquakes were felt in December 2003 and August 2011. The National Risk Index Community Report for Prince William County lists the earthquake risk for the county as “very low” compared to other areas of the United States (FEMA, 2021b) while the 2022 Northern VA Hazard Mitigation Plan identifies the County as being at medium risk of earthquake impacts due to the fact that infrastructure and buildings are not explicitly designed to withstand seismic events. The expected annual loss is “relatively low” with an expected annual loss of \$389,799 out of an exposure of buildings, people, and agricultural land of over \$3.1 Trillion (or approximately 0.00001%).

### 2.6.2. Future Conditions

Changes in earthquake patterns in the future due to a changing climate will not be evaluated in this report as clear trends have not yet been established in the academic literature.

## 2.7. Strong Wind/Tornadoes

### 2.7.1. Current Conditions

Strong winds can affect the region in the form of a Derecho, straight line winds, a tornado, winds from a thunderstorm, or hurricanes. In June 2012, a Derecho impacted the Washington, D.C. metro region causing power outages affecting more than 1.5 million people in Northern Virginia (MWCOG, 2020).

The National Risk Index ranks the risk to Prince William County from strong winds as “very low” and the risk from tornadoes as “relatively low.” The expected annual loss for strong winds is “relatively moderate” while the loss from tornadoes is considered “relatively high” with a project annualized loss value of \$520,401 due to strong wind and \$3,787,493 from tornadoes out of a total exposure of buildings, people, and agricultural land of over \$3.1 Trillion. The 2022 Northern VA Hazard Mitigation Plan found the County to be at high risk of impacts due to High Winds/Severe Storms and at medium risk of impacts due to Tornadoes.

### 2.7.2. Future Conditions

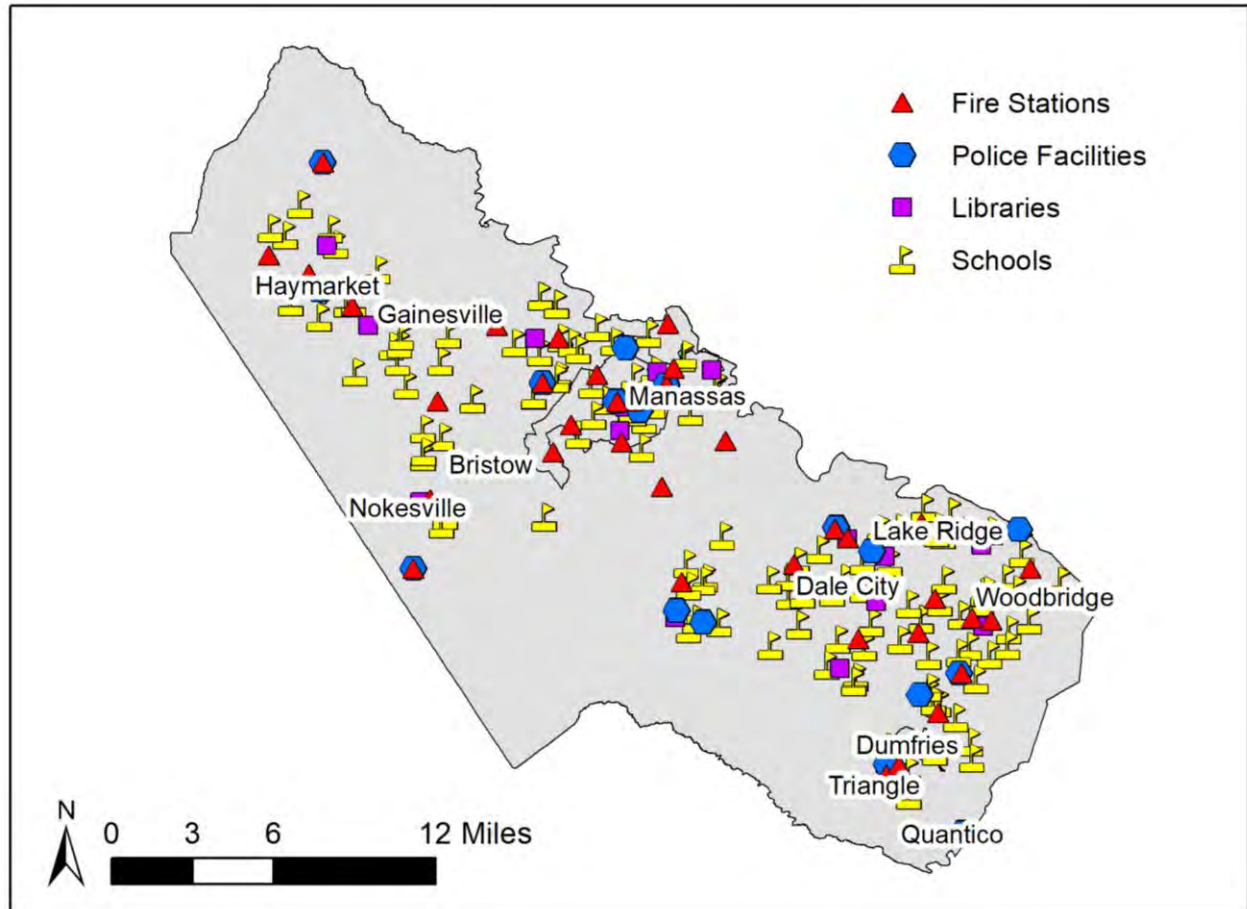
Changes in strong winds and tornado patterns in the future due to a changing climate will not be evaluated in this report as clear trends have not yet been established in the academic literature.

## 3. County Asset Definition

Assets have been collected into categories that align with FEMA's Community Lifelines. Lifelines are the most fundamental services that a community has, and when stabilized, promote expansion of other aspects of society. The FEMA Lifeline categories are safety and security; food, water and shelter; health and medical; communications; transportation; energy; and hazardous materials. While these lifelines were developed to support response planning and operations, the concept resonates with preparedness planning and resilience and has been embraced by the Prince William County Office of Emergency Management (PWC EM). For this study, the energy and hazardous materials lifeline categories have been combined and two additional categories have been included in this analysis which are: natural resources and socially vulnerable populations. The assets discussed in the Vulnerability Assessment are all within Prince William County, but most are not owned by the County. The following sections further describe the assets included in each of the Lifeline categories plus the two additional asset categories.

## 3.1. Safety and Security

The Safety and Security Community Lifeline category includes a range of sites from police and fire stations to schools and government buildings. The Prince William County Geospatial Technology Services Program manages and maintains the County's geospatial data, which includes the following layers that apply to this Lifeline category: police stations, fire stations, libraries, schools. Additionally, government buildings are included in this category, but the County does not maintain a geospatial layer of these building locations.



*Note: Government buildings are not shown on this map.*

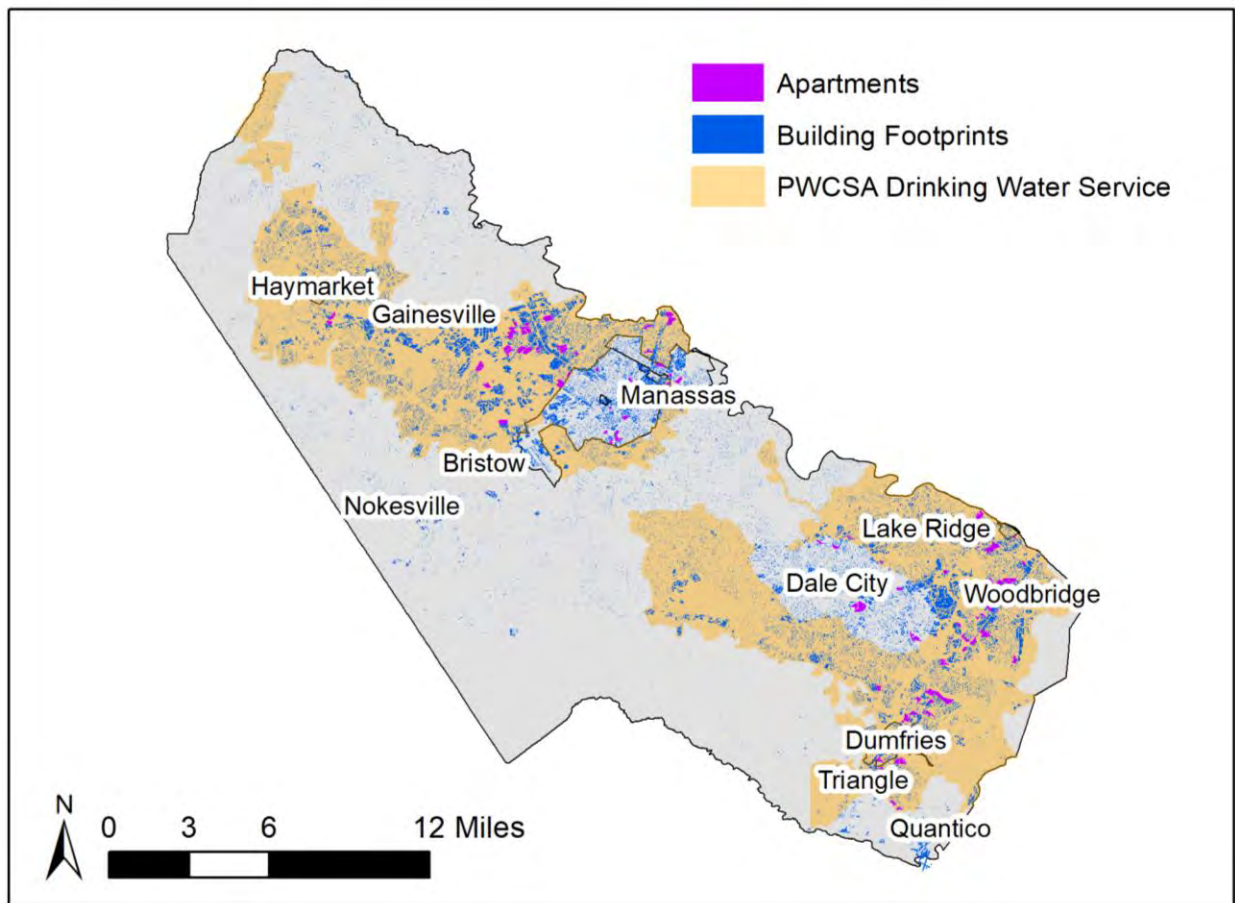
**Figure 5. Safety and Security Assets within Prince William County**

## 3.2. Food, Water, and Shelter

The Food, Water, and Shelter asset category includes resources that provide stability to our day-to-day lives. This includes all housing units which are available from the Prince William County Geospatial Technology Services Program as layers of building footprints and apartments. Building footprints include but are not limited to commercial and non-commercial structures, parking lots and recreation areas. Food is included in this asset category as grocery stores and food markets though geospatial data was not available. Drinking water is provided to County residents by either of two service providers (Virginia American Water or Prince William County Service Authority (PWCSA)) or through well water. Drinking water support infrastructure and wastewater pump station locations were not available geospatially, Natural sources of water such as streams and lakes that have been created behind dams are covered in Section 4.8: Natural Resources.

### Climate Change and Food Security

The U.S. Global Change Research Program recognizes the challenge for food security as the climate-driven changes affect all in their 2015 report *Climate Change, Global Food Security and the U.S. Food System*. Climate change affects agricultural production as well as food processing, packaging, transportation, storage, waste and consumption and should be considered in planning efforts for Prince William County.



Note: Drinking water data, drinking water support infrastructure, and wastewater pump station locations are not shown on this map.

**Figure 6. Food, Water, and Shelter Assets within Prince William County**

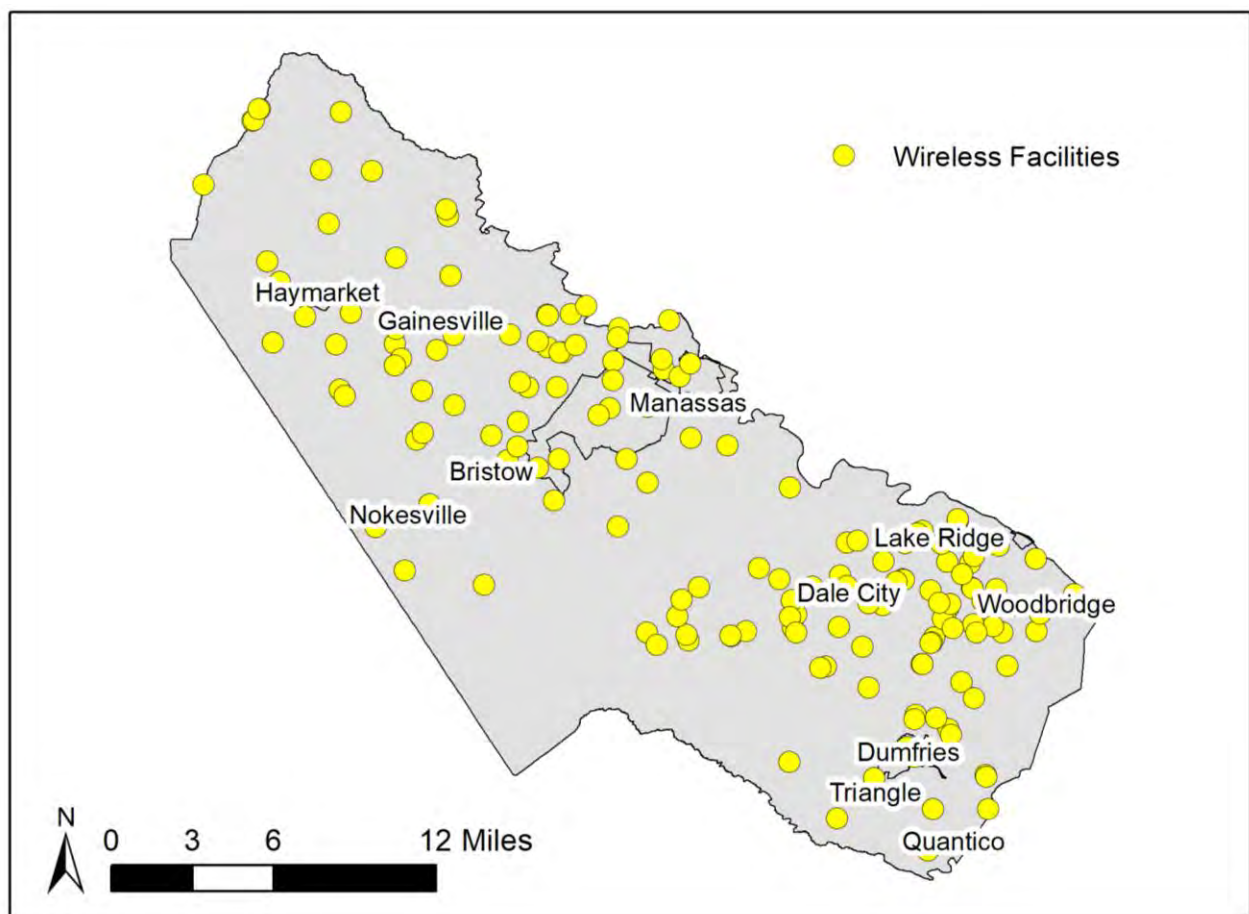


### 3.3. Health and Medical

The Health and Medical asset category includes hospitals and other medical centers, long-term care facilities, dialysis centers, and pharmacies. Hospital locations are available through the Prince William County Geospatial Technology Services Program as a geospatial deliverable and includes one hospital in the City of Manassas that services Prince William County. The other types of medical care facilities were supplied by PWC EM as a list of addresses. Due to limited availability of geospatial data, no maps were prepared for this asset category.

### 3.4. Communications

For FEMA's definition of the Communications lifeline, many non-structural aspects are included such as alert and warning systems and first responder communications. For this study, the Communications asset category will focus on the infrastructure components of communication including radio towers, data centers, financial service locations (e.g., banks), cable systems and broadcast facilities, and wireless service towers. Only the wireless facilities locations are available as geospatial data from the Prince William County Geospatial Technology Services Program. All other asset locations are available as addresses in a list from PWC EM.



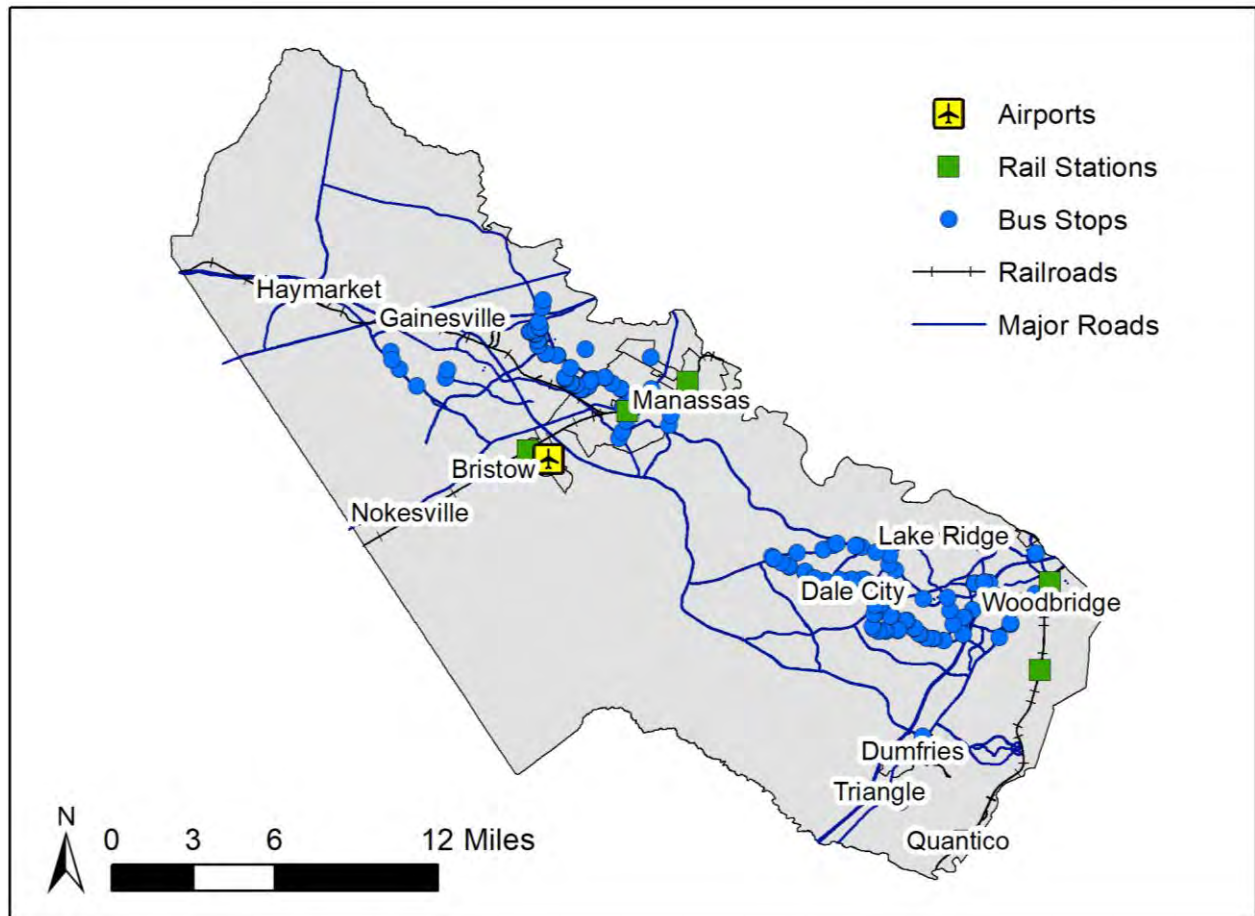
*Note: Radio towers, data centers, financial service locations (e.g., banks), cable systems and broadcast facilities are not shown on this map.*

**Figure 7. Communication Assets within Prince William County**

### 3.5. Transportation

Transportation systems are important for the residents and visitors of Prince William County and include roads, mass transit, railways, aviation, maritime, and pedestrian. Through the Prince William County Geospatial Technology Services Program, geospatial data is available that includes bus stops, commuter parking lots, rail stations, railroads, roads, and sidewalks. Additionally, PWC EM has compiled a list of bridge locations (for roads and railroads), port facilities, marinas, and airport and heliport locations. All ports in the County are privately owned and maintained.

Similarly, most transportation assets within the County are not owned by the County but rather are owned and maintained by the Virginia Department of Transportation (VDOT) or private entities. To better understand the impacts of flooding on roads, the stormwater system and culverts are included in the Transportation asset category. The Stormwater management facility locations, stormwater management lines, and culverts are available as geospatial data and has been provided by the Prince William County Geospatial Technology Services Program.



*Note: Commuter parking lots, sidewalks, bridge locations (for roads and railroads), port facilities, heliport locations, stormwater management facility locations, stormwater management lines, and culverts are not shown on this map.*

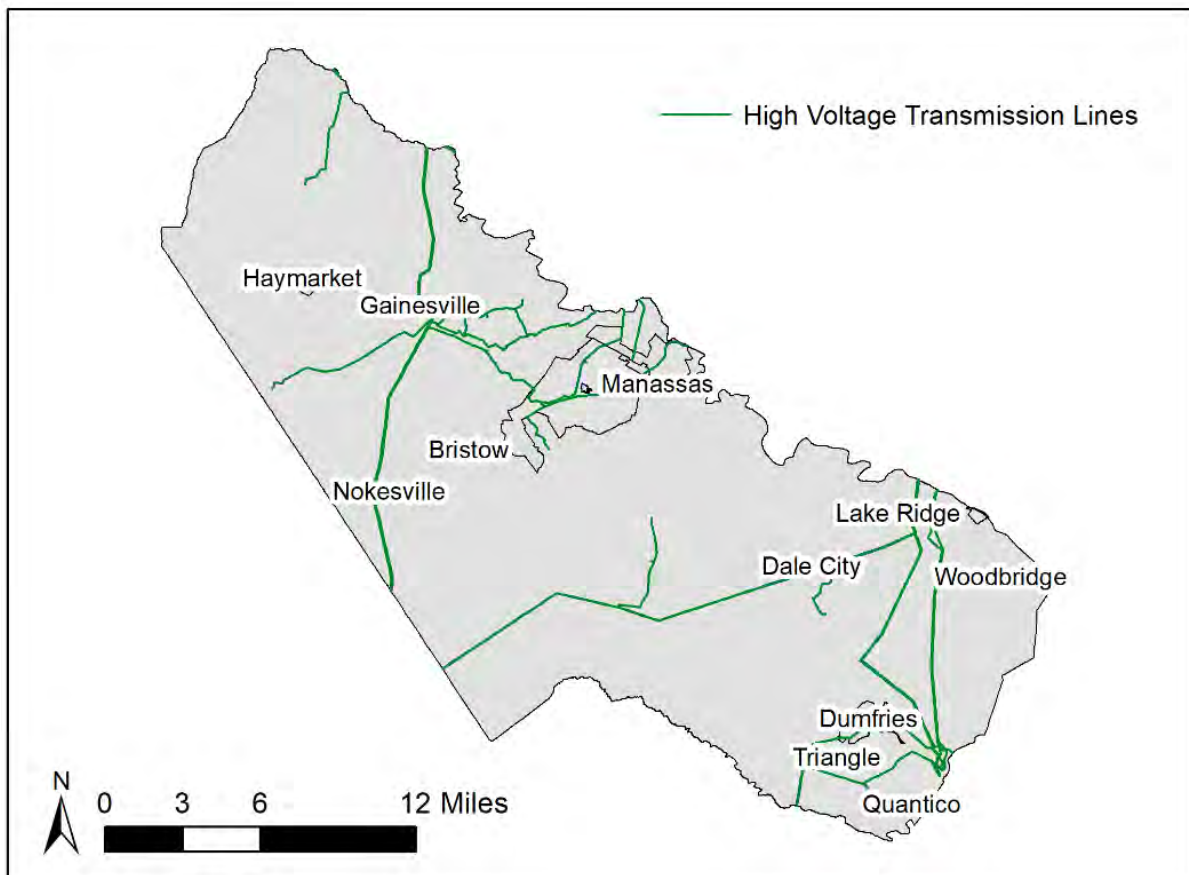
**Figure 8. Transportation Assets within Prince William County**

## 3.6. Energy and Hazardous Materials

### Climate Change and Energy Supply

The U.S. Global Change Research Program's *Fourth National Climate Assessment* includes a chapter on Energy Supply, Delivery, and Demand which recognizes that the Nation's energy system is already affected by extreme weather events and that climate change will increase the threat. The report details the state of the Nation's energy sector and provides suggestions for improving resilience including hardening measures (including physical barriers, protective casing or other upgrades) and development and deployment of new technologies to enhance system resilience.

The Energy and Hazardous Materials lifeline categories have been combined into a single asset category for this study. This category includes electrical lines, power generation plants and substations, County-run fuel distribution centers, natural gas pipelines, and hazardous materials storage sites. The Prince William County Geospatial Technology Services Program has geospatial data for the electrical power line locations. All other asset locations are available from PWC EM as a list of addresses.



Note: Power generation plants and substations, County-run fuel distribution centers, natural gas pipelines, and hazardous materials storage sites are not shown on this map.

**Figure 9. Energy and Hazardous Materials Assets within Prince William County**



## 3.7. Natural Resources

Natural Resources are not considered a Lifeline category, but are important to healthy, resilient communities, and thus, are included as an asset category. Included in this assessment are streams, resource protection areas, trees, agricultural areas, and tree cover. Resource protection areas are defined as any land within 100 feet of a perennial stream bank or edge of wetlands adjacent to the perennial stream and are protected under state law and local ordinances. Additionally, dams were included in this category due to the lakes that are associated with these man-made features. All data layers are available geospatially from the Prince William County Geospatial Technology Services Program.

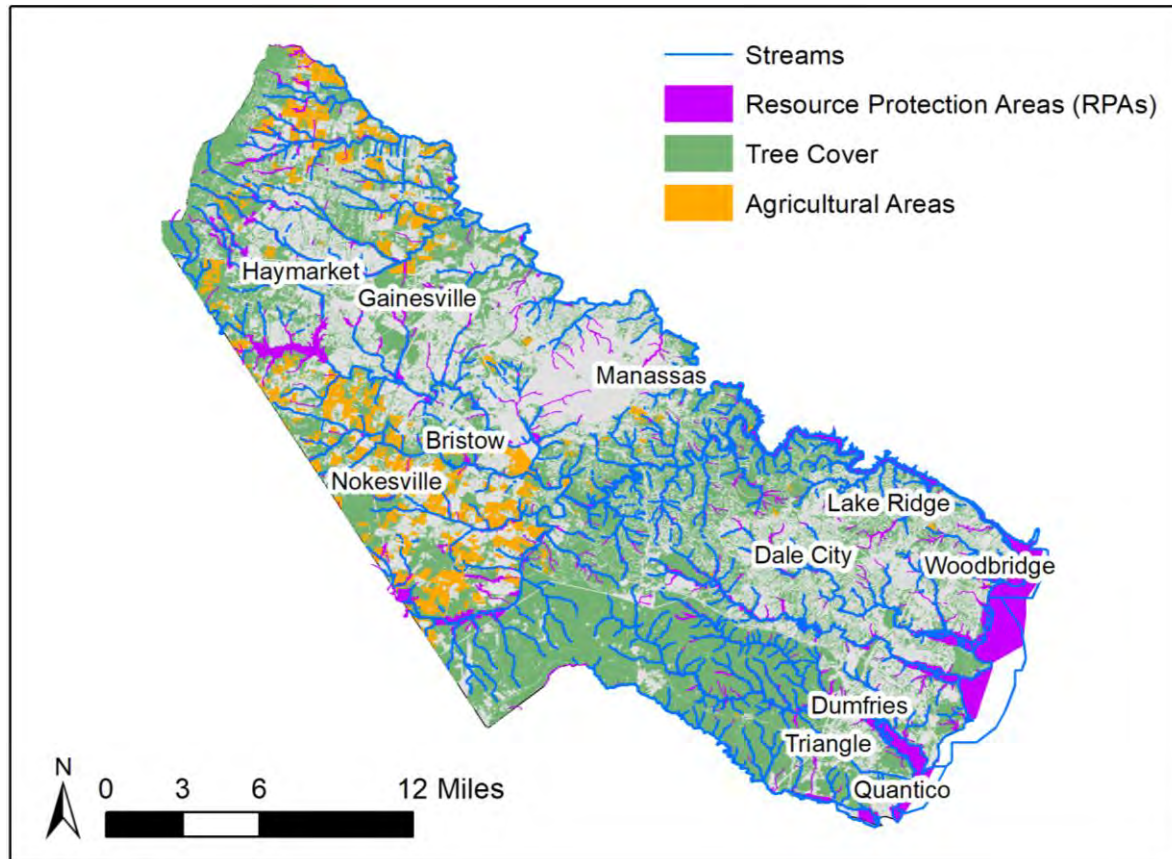


Figure 10. Natural Resources Assets within Prince William County

### Dams

Prince William County contains 21 dams as listed in the Virginia Department of Conservation and Recreation (DCR) Dam Safety Inventory System including 5 that are classified as having significant hazard potential. While some dams are County-owned, most dams in Prince William County are privately-owned. The Upper Occoquan Dam, owned by the Fairfax County Water Authority, and the T. Nelson Elliott Dam, owned by the City of Manassas, are the largest dams in the area. The Upper Occoquan Dam is used for hydroelectric power generation, and both are used for water supply. These dams have significant drainage areas and would result in catastrophic flooding in the event of a dam break. Both are inspected annually and most recently have been found to be in satisfactory condition.

## 3.8. Socially Vulnerable Populations

The National Capital Region Transportation Planning Board (TPB) developed a methodology for determining Equity Emphasis Areas (EEAs). Tract-level Census data was used to identify communities that have a high concentration of low-income individuals and/or traditionally disadvantaged racial and ethnic population groups as well as a higher share of households who rent, individuals with disabilities, and workers without telecommuting options compared to neighboring communities (National Capital Region Transportation Planning Board, 2018). The Metropolitan Washington Council of Governments and Prince William County have adopted the same definition of Equity Emphasis Areas (EEAs) as a planning tool to help define areas with socially vulnerable populations. These areas will be used to better understand climate impacts on socially vulnerable populations within Prince William County and are shown in Figure 11

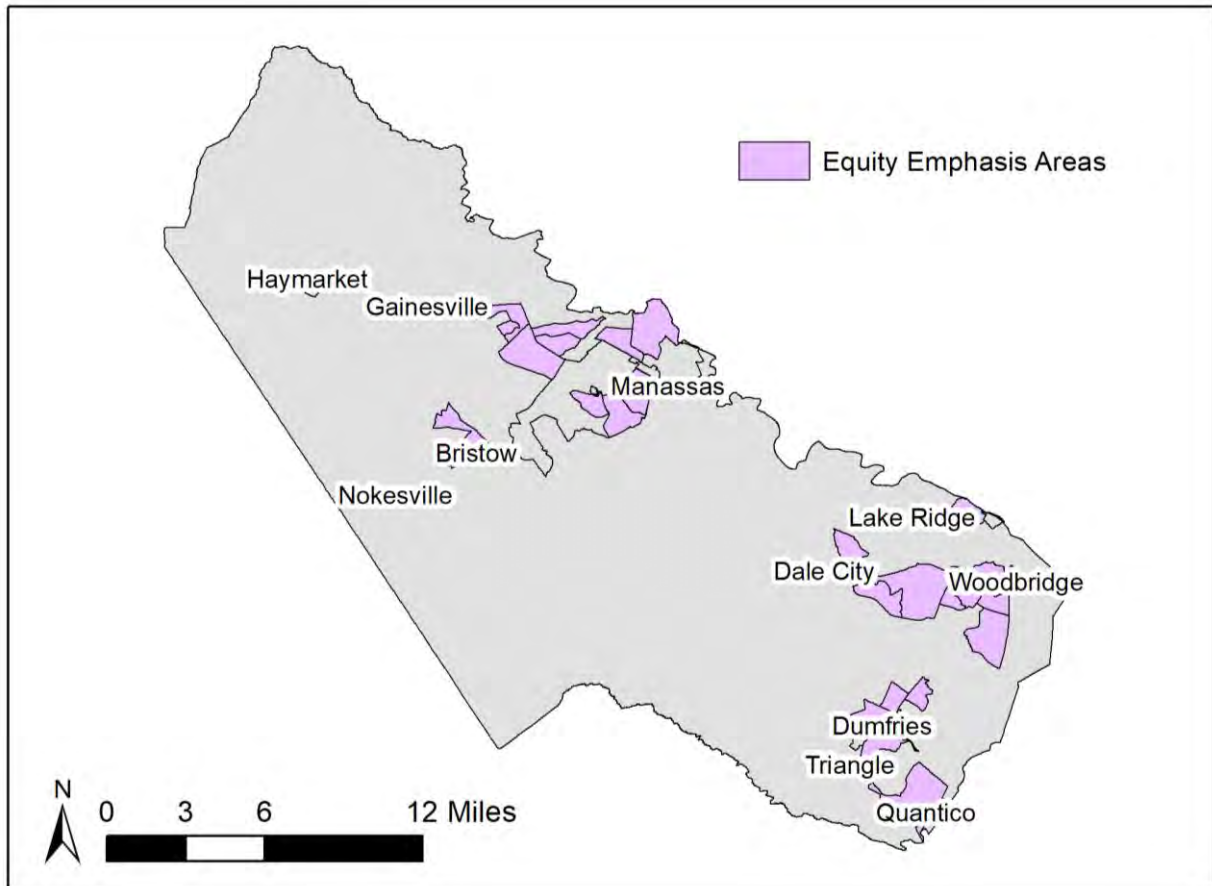


Figure 11. Socially Vulnerable Population Assets within Prince William County

## 4. Asset Vulnerability Assessment

### 4.1. Vulnerability Assessment Methodology

The vulnerability assessment analyzes the impacts of the climate hazards on a variety of community asset categories. This assessment broadly identifies asset groups that are expected to be adversely impacted by changing climate hazards through an evaluation of the Exposure, Sensitivity, and Adaptive Capacity of the assets within each category. The methodology, asset category definitions, and detailed discussion of vulnerability for each asset category and each hazard are provided in the following sections.

The vulnerability assessment is based on a review of the exposure to natural hazards, the sensitivity of the asset to those hazards, and the ability to enact change to manage and adapt to those hazards. This approach is based on the Federal Highway Administration's (FHWA's) Vulnerability Assessment Scoring Tool (VAST) framework that uses exposure, sensitivity, and adaptive capacity to create a holistic view of vulnerability to future climate change. The sections below further explain the methodology to determine the exposure, sensitivity, and adaptive capacity of each asset category.

The rating system gives each asset category a Low, Medium, or High rating for each hazard and each of the evaluation criteria (Exposure, Sensitivity, and Adaptive Capacity). Every category has been setup so that a Low rating means that there is less vulnerability and should be a lower concern for Prince William County when determining how to focus adaptation measures. A Medium rating means that some vulnerability exists for this asset. The High rating shows a high vulnerability and should be a focus of adaptation measure for the County. This assessment is primarily focused on assets located within Prince William County, including the people that may work or live within or in proximity to physical assets, and does not consider broader regional systems which may affect the hazard impacts.

#### 4.1.1. Exposure

The most fundamental component of an asset's vulnerability is whether it is exposed to a climate hazard. The exposure component of the vulnerability assessment measures if an asset is affected by a climate hazard and, if so, to what extent. Exposure is a prerequisite for vulnerability so assets that have effectively no likelihood of exposure to a climate hazard are not assessed for sensitivity or adaptive capacity of that climate hazard. To facilitate a quantification of the vulnerability from exposure to the hazards, each asset class will be given a rating (Low, Medium, or High) to correspond to the exposure likelihood and extent from each climate hazard and future scenario (2050 and 2075). Due to the large number of individual assets within each category, exposure is considered relative to the total body of assets within each category. As a result, while exposure for some individual assets may be high, the asset category may be rated lower if most assets within the category are not exposed or have low exposure. A summary of how exposure ratings were assigned is shown in Table 10.

Precipitation exposure ratings were estimated based on asset proximity to effective FEMA riverine floodplains and frequently flooded areas. Detailed stormwater, riverine, or coastal flood modeling of future scenarios was not within the scope of this assessment. Review of available sea level rise and coastal storm surge floodplains revealed that most County assets were unlikely to be exposed coastal flooding; thus, all assets received a Low exposure rating for Sea Level Rise.

For other climate hazards, the scale of hazard exposure is greater than the county so it is assumed that assets within the county will be exposed to the hazard uniformly. Accordingly, the exposure rating is applied consistently across all asset categories. Exposure to extreme temperatures for all assets is rated as Medium for 2050 and High for 2075 as projections clearly show a warming trend in the local climate (see Section 2.3.2). Drought exposure for all assets was rated as Low for 2050 and Medium for 2075 based on increases in frequency and severity of drought events discussed in Section 2.4.2. As future changes to earthquake and strong wind/tornado exposure were not considered in this assessment, exposure ratings for 2050 and 2075 were both scored as Medium for strong winds/tornadoes and Low for earthquakes which approximately represents present day exposure.

**Table 10. Exposure Criteria**

Climate Hazard	Vulnerability Rating - Exposure	
	2050	2075
<b>Precipitation</b>	<p>L- less than 10% of assets are within effective 100-year riverine floodplain or within 100 ft of frequently flooded area</p> <p>M – 10-50% of assets are within effective 100-year riverine floodplain or within 100 ft of frequently flooded area</p> <p>H- more than 50% of assets are within effective 100-year riverine floodplain or within 100 ft of frequently flooded area</p>	<p>L – less than 10% of assets are within effective 500-year riverine floodplain or within 250 ft of frequently flooded area</p> <p>M – 10-50% of assets are within effective 500-year riverine floodplain or within 250 ft of frequently flooded area</p> <p>H – more than 50% of assets are within effective 500-year riverine floodplain or within 250 ft of frequently flooded area</p>
<b>Extreme Temperature</b>	All assets scored M	All assets scored H
<b>Drought</b>	All assets scored L	All assets scored M
<b>Sea Level Rise</b>	All assets scored L	All assets scored L
<b>Earthquakes</b>	All assets scored L	All assets scored L
<b>Strong Winds/Tornadoes</b>	All assets scored L	All assets scored L

Abbreviations: L=Low; M=Medium; H=High

### 4.1.2. Sensitivity

Sensitivity measures how an asset is affected by exposure to a climate hazard. Given the broad nature of asset categories used in this assessment (See Section 3), asset sensitivity is focused on the most sensitive assets present in Prince William County within each category as well as the functions each asset category is meant to perform during normal conditions. Similar to the rating of exposure, assets are assigned a High, Medium, or Low rating for sensitivity. High sensitivity rating is given if exposure would result in complete asset failure; Medium sensitivity rating is given if an exposed asset would remain partially functional; and Low sensitivity rating is given when an exposed asset is fully or close to fully functional during asset exposure. Detailed explanations of sensitivity ratings are included in the respective asset vulnerability sections of this report below.

### 4.1.3. Adaptive Capacity

Adaptive capacity measures the ability of an asset to adjust, repair, or flexibly respond to damage caused by climate hazards. Redundancy is a key measure of adaptive capacity considered in this assessment, but the rating also considers Prince William County's authority to enact adaptive measures, the range of adaptation measures that could be implemented, and types of adaptation actions that could be implemented.

Generally, high adaptive capacity means that an asset has high resiliency, high redundancy and can be easily adapted to deal with climate hazards. However, this is inconsistent with the rating system for Exposure and Sensitivity. In those rating systems, a "High" rating implies high asset vulnerability. The Adaptive Capacity rating system measures the contribution to asset vulnerability instead of the adaptive capacity itself which may appear counter-intuitive. To avoid confusion, the Adaptive Capacity rating is called a "Vulnerability Rating for Adaptive Capacity" and ratings are defined as follows:

- Low = low vulnerability due to high adaptive capacity
  - Medium = medium vulnerability due to medium adaptive capacity
- High = high vulnerability due to low adaptive capacity

## 4.2. Safety and Security Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Safety and Security Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 11.

**Table 11. Vulnerability Ratings for Safety and Security Assets**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	L	L	M	L
Extreme Temperature	M	H	M	L
Drought	L	M	L	L
Coastal Flooding and SLR	L	L	M	L
Earthquakes	L	L	M	L
Strong Winds/Tornadoes	L	L	M	L

Abbreviations: L=Low; M=Medium; H=High

### 4.2.1. Safety and Security – Precipitation

The percent of each asset within the Safety and Security asset category exposed to precipitation hazards in 2050 and 2075 is shown in Table 12. Exposure in both 2050 and 2075 is classified as Low due to the low percent of Safety and Security assets exposed to precipitation hazard.

**Table 12. Safety and Security Asset Exposure to Precipitation Hazard**

Safety and Security Asset	Number of Assets	2050 Percent Exposed to Precipitation Hazard	2075 Percent Exposed to Precipitation Hazard
Police Facilities	19	5%	11%
Fire Facilities	38	0%	5%
Libraries	16	6%	19%
Schools	126	0%	0%

The sensitivity of Safety and Security assets to precipitation hazards is Medium because flooding of these assets may cause some damage and disruption to functionality, but parts of the assets should still be operational. Safety and Security Assets were assigned a Low Vulnerability Rating for Adaptive Capacity due to the relatively high redundancy among the buildings in this asset category as well as the availability of technology that allows for some functions to be performed remotely when climate hazard events may limit access to buildings.

### 4.2.2. Safety and Security - Temperature

As extreme temperatures rise across the county, Safety and Security assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Safety and Security assets received a Medium Sensitivity rating for extreme temperatures. The Medium Sensitivity rating was assigned because Safety and Security assets in Prince William County are currently exposed to extreme temperatures and can maintain at least partial functionality. As temperatures increase, buildings in this asset category will experience increased energy demands and stress on air conditioning systems, particularly libraries which are used as cooling centers during extreme heat events. Additionally, this asset category includes groups of people that typically spend at least part of the day outdoors. Extreme temperature events may limit the amount of time individuals can spend outside and may require some restructuring of how some functions are performed with the understanding that students and employees may have higher individual sensitivities to extreme temperatures than the overall asset category. The Vulnerability Rating for Adaptive Capacity was rated Low due to the relatively high redundancy among the buildings in this asset category and the ability for the County to incorporate adaptation measures to decrease energy demand for these assets.

### 4.2.3. Safety and Security - Drought

Drought Exposure throughout the County is rated Low for 2050 and Medium for 2075. Safety and Security assets received a Low Sensitivity rating for drought and a Low Vulnerability Rating for Adaptive Capacity. A Low Sensitivity rating was assigned because Safety and Security assets can maintain functionality during most drought conditions.



Drought conditions can still impact Safety and Security assets particularly when conditions persist for extended periods and may make buildings inhospitable for students and employees if drought is associated with water restrictions and increased heat.

#### 4.2.4. Safety and Security – Coastal Flooding and Sea Level Rise

Safety and Security assets received a Low Exposure rating for coastal flooding and sea level rise because none of the assets available as spatial data were within the present-day FEMA coastal floodplain or the 3 ft sea level rise area, which corresponds to the intermediate estimate for 2075. Sensitivity is rated as Medium because any Safety and Security assets that may be impeded by coastal flooding and sea level rise would likely still be partially functional. Safety and Security Assets were assigned a Low Vulnerability Rating for Adaptive Capacity due to the relatively high redundancy among the buildings in this asset category as well as the availability of technology that allows for some functions to be performed remotely when climate hazard events may limit access to buildings.

#### 4.2.5. Safety and Security – Earthquakes

The National Risk Assessment ranks the exposure of Safety and Security assets within Prince William County as a Low risk. During both the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA, minimal damage was reported to buildings within Prince William County. However, earthquakes of this size originating closer to the County have the potential to cause structural damage to Safety and Security assets so the sensitivity of this asset category to earthquakes was considered to be Medium. Safety and Security assets within the County are assumed to be built to current structural standards and there is some existing redundancy in the location of police, fire, schools, and other Safety and Security assets. There are also opportunities to increase resilience to earthquake hazards through retrofitting buildings to higher earthquake resilience standards. The Vulnerability Rating for Adaptive Capacity has been given a Low rating based on the relatively high redundancy among the buildings in this asset category as well as the availability of technology that allows for some functions to be performed remotely when climate hazard events may limit access to buildings. Additionally, structural modifications could be made to most Safety and Security assets to increase resilience to earthquake hazards.

#### 4.2.6. Safety and Security - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes leading to an Exposure rating of Low for this Vulnerability Assessment. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes demonstrating an average Sensitivity ranking of Medium. There is some redundancy in the Safety and Security assets and there are some measures (such as wind retrofits for roofs) that can be taken to enhance resilience. Life safety is usually a consideration when aiming for increased resilience from tornadoes and safe rooms can be built in public spaces such as schools to provide a safe place of shelter. Due to the relatively low risk of needing to close safety and security assets due to high winds due to redundancy in the system, the Vulnerability Rating for Adaptive Capacity of Safety and Security assets is Low.

### 4.3. Food, Water, and Shelter Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Food, Water, and Shelter Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 13.

**Table 13. Vulnerability Ratings for Food, Water, and Shelter Assets**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	L	L	M	M
Extreme Temperature	M	H	H	M
Drought	L	M	H	M

<b>Coastal Flooding and SLR</b>	L	L	M	M
<b>Earthquakes</b>	L	L	M	M
<b>Strong Winds/Tornadoes</b>	L	L	M	M

Abbreviations: L=Low; M=Medium; H=High

### 4.3.1. Food, Water, and Shelter – Precipitation

The percent of the area of each asset within the Food, Water, and Shelter asset category exposed to precipitation hazards in 2050 and 2075 is shown in Table 14. Exposure in both 2050 and 2075 is classified as Low because the percentage of Food, Water, and Shelter assets exposed is relatively small.

**Table 14. Food, Water, and Shelter Asset Exposure to Precipitation Hazard**

<b>Food, Water, and Shelter Asset</b>	<b>Number of Assets</b>	<b>2050 Percent of Area Exposed to Precipitation Hazard</b>	<b>2075 Percent of Area Exposed to Precipitation Hazard</b>
<b>Apartments</b>	534	5%	6%
<b>Building Footprints</b>	200,310	2%	4%

The Sensitivity of Food, Water, and Shelter assets to precipitation hazards is Medium because flooding of these assets may cause some damage, but they will remain partially functional. Food, Water, and Shelter assets were assigned a Medium Vulnerability Rating for Adaptive Capacity as housing, water, and grocery stores/food markets have some redundancy within the County and though they are not easily relocated they can be retrofitted to improve resilience.

### 4.3.2. Food, Water, and Shelter - Temperature

As extreme temperatures rise across the county, Food, Water, and Shelter assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Food, Water, and Shelter assets received a High Sensitivity rating for extreme temperatures and a Medium rating for Vulnerability Rating for Adaptive Capacity. A High Sensitivity rating was assigned because Food, Water, and Shelter assets in Prince William County can be severely impacted by extreme temperature events. Sudden temperature shifts, timing, and duration of seasons, as well as extended periods of extreme temperature can make drinking water resource management significantly more challenging. Additionally, shelter assets will increase in demand as will the demand for climate-controlled environments. Extreme temperature events may limit the amount of time individuals and machinery can work outside and may require some restructuring of how some functions are performed.

### 4.3.3. Food, Water, and Shelter - Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Food, Water, and Shelter assets received a High Sensitivity rating for drought and a Medium Vulnerability Rating for Adaptive Capacity. A High Sensitivity rating was assigned because water resources are significantly impacted by drought conditions. When drought conditions persist for extended periods, drinking water restrictions may be triggered.

### 4.3.4. Food, Water, and Shelter - Coastal Flooding and Sea Level Rise

Food, Water, and Shelter assets received a Low Exposure rating for coastal flooding and sea level rise because less than 1% of assets available as spatial data were within the 3 ft sea level rise area, which corresponds to the intermediate estimate for 2075. The Sensitivity of Food, Water, and Shelter assets to coastal flooding and sea level rise hazards is Medium because flooding of these assets may cause some damage, but they will remain partially functional. Food, Water, and Shelter assets were assigned a Medium for the Vulnerability Rating for Adaptive Capacity rating because while water resource management practices can be modified to increase resilience to climate hazards, these assets lack significant redundancy and have inherent limitations to their ability to adapt to a changing climate (e.g., reservoir storage).



#### 4.3.5. Food, Water, and Shelter – Earthquakes

The National Risk Assessment ranks the exposure of Food, Water, and Shelter assets within Prince William County as a Low risk. Large earthquakes could have an impact on the built infrastructure such as housing or water treatment plants. However, the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, resulted in no major impacts being recorded, so the sensitivity is determined to be Medium. Overall, the Vulnerability Rating for Adaptive Capacity for Food, Water, and Shelter assets was determined to be Medium. This is a combination of the structural modifications that could be made to increase resiliency of many apartments, single family homes, and other dwellings, and the moderate redundancy in water treatment facilities.

#### 4.3.6. Food, Water, and Shelter - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes demonstrating an average Sensitivity ranking of Medium for housing. The overall Sensitivity rating for this category is Medium based on the potential housing damages. The Vulnerability Rating for Adaptive Capacity is Medium. This is due to a combination of the structural modifications that could be made to increase resiliency of many apartments, single family homes, and other dwellings, and the moderate redundancy in water treatment facilities.

## 4.4. Health and Medical Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Health and Medical Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 15.

**Table 15. Vulnerability Ratings for Health and Medical Assets**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	L	L	M	M
Extreme Temperature	M	H	M	M
Drought	L	M	M	M
Coastal Flooding and SLR	L	L	M	M
Earthquakes	L	L	M	M
Strong Winds/Tornadoes	L	L	M	M

Abbreviations: L=Low; M=Medium; H=High

### 4.4.1. Health and Medical - Precipitation

Exposure of Health and Medical assets to precipitation hazard in both 2050 and 2075 is classified as Low. None of the three hospitals which comprise the asset category are exposed to precipitation hazard. The Sensitivity of Health and Medical assets to precipitation hazard is Medium because flooding of these assets may cause some damage and disruption to functionality, but parts of the assets should still be operational. Health and Medical assets were assigned a Medium Vulnerability Rating for Adaptive Capacity. The County has three major hospitals which provide some limited redundancy and coordination with larger hospital systems outside of the County on a regional level may add to this redundancy; however, health and medical assets are limited in their ability to adapt because their functions can only be performed in certain controlled environments and require significant resources to maintain normal operations.

### 4.4.2. Health and Medical - Temperature

As extreme temperatures rise across the county, Health and Medical assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Health and Medical assets received a Medium Sensitivity rating for extreme temperatures and a Medium Vulnerability Rating for Adaptive Capacity. A Medium Sensitivity rating was assigned because Health and Medical assets can maintain most functionality during extreme temperature events. Extreme temperature events simultaneously increase the demand for medical assets while also making it more difficult for medical personnel to commute to hospitals and medical facilities. Energy and human resource demands are likely to increase with rising temperatures.

### 4.4.3. Health and Medical - Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Health and Medical assets received a Medium Sensitivity rating for drought and a Medium Vulnerability Rating for Adaptive Capacity. A Medium Sensitivity rating was assigned because Health and Medical assets can maintain most functionality during droughts. Drought conditions inherently impact human health and will thus inevitably impact Health and Medical assets by limiting resources and increasing demand.

### 4.4.4. Health and Medical - Coastal Flooding and Sea Level Rise

Exposure of Health and Medical assets to coastal flooding and sea level rise hazard in both 2050 and 2075 is classified as Low. None of the three hospitals which comprise the asset category are exposed to a sea level rise of 3 ft corresponding to the intermediate estimate for 2075. The Sensitivity of Health and Medical assets to coastal flooding and sea level rise is Medium because flooding of these assets may cause some damage and disruption to

functionality, but parts of the assets should still be operational. Health and Medical assets were assigned a Medium Vulnerability Rating for Adaptive Capacity. The County has three major hospitals which provide some limited redundancy; however, health and medical assets are limited in their ability to adapt because their functions can only be performed in certain controlled environments and require significant resources to maintain normal operations.

#### 4.4.5. Health and Medical - Earthquakes

The National Risk Assessment ranks the Exposure of Health and Medical assets within Prince William County as a Low risk. Large earthquakes could have an impact on the built infrastructure such as hospitals and other health care facilities. However, the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, resulted in no major impacts being recorded, so the sensitivity is determined to be Medium. Health and Medical assets were assigned a Vulnerability Rating for Adaptive Capacity of Medium due to the relatively low redundancy in terms of available patient space if one or more hospitals within the county are damaged or other medical facilities were unsafe to occupy after an earthquake. However, structural modifications could be made to many buildings within this asset category to increase resilience to earthquake hazards.

#### 4.4.6. Health and Medical - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes resulting in an average Sensitivity ranking of Medium for Health and Medical Facilities. The Vulnerability Rating for Adaptive Capacity is Medium due to the low redundancy in hospitals and other medical facilities, but the likelihood that a strong wind or tornado would damage on a small section of the county during an event.

### 4.5. Communications Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity Communications Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 16.

**Table 16. Vulnerability Ratings for Communications Assets**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	L	L	M	L
Extreme Temperature	M	H	M	L
Drought	L	M	L	L
Coastal Flooding and SLR	L	L	M	L
Earthquakes	L	L	M	L
Strong Winds/Tornadoes	L	L	M	L

Abbreviations: L=Low; M=Medium; H=High

#### 4.5.1. Communications – Precipitation

Exposure of Communications assets to precipitation hazard in both 2050 and 2075 is classified as Low since the percent of spatially available Communications assets exposed to precipitation hazard is 3% and 5%, respectively. The Sensitivity of Communications assets to precipitation hazard is Medium because flooding of these assets may cause some damage and disruption to functionality, but parts of the assets should still be operational. Communication assets are given a Low Vulnerability Rating for Adaptive Capacity. This low rating means that this category has a low vulnerability due to the high redundancy of assets in this category and the ease of relocation of assets for future resiliency.

## 4.5.2. Communications – Temperature

As extreme temperatures rise across the county, Communication assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Communications assets received a Medium Sensitivity rating for extreme temperatures and a Low Vulnerability Rating for Adaptive Capacity. A Medium Sensitivity rating was assigned because communications assets in Prince William County are currently exposed to extreme temperatures and can maintain at least partial functionality. Extended extreme temperature events may negatively impact communications assets which are typically located outdoors; however, since these assets are designed to function outdoors, they are resilient to extreme temperature exposure. Extreme temperature events may limit the amount of time maintenance workers can spend outside and may require some restructuring of how some tasks are performed.

## 4.5.3. Communications – Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Communications assets received a Low Sensitivity rating for Drought and a Low Vulnerability Rating for Adaptive Capacity. A Low Sensitivity rating was assigned because communications assets can continue to operate normally during drought conditions.

## 4.5.4. Communications - Coastal Flooding and Sea Level Rise

Exposure of Communications assets coastal flooding and sea level rise is classified as Low since none of the spatially available Communications assets are exposed to this hazard. The Sensitivity of Communications assets to coastal flooding and sea level rise is Medium because flooding of these assets may cause some damage and disruption to functionality, but parts of the assets should still be operational. Communication assets are given a Low Vulnerability Rating for Adaptive Capacity. This Low rating means that this category has a low vulnerability due to the high redundancy of assets in this category and the ease of relocation of assets for future resiliency.

## 4.5.5. Communications – Earthquakes

The National Risk Assessment ranks the Exposure of Communication assets within Prince William County as a Low risk. Large earthquakes could have an impact on the built infrastructure such as cell phone towers, telephone poles, etc. However, the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, resulted in no major impacts being recorded. The Sensitivity is determined to be Medium as damages from large earthquakes could impact much of the communications infrastructure. Communication assets were assigned a Vulnerability Rating for Adaptive Capacity of Low due to the relative redundancy of communication systems and the ability to further stabilize communication towers to increase resilience to earthquake hazards.

## 4.5.6. Communications - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes demonstrating an average Sensitivity rating of Medium for the Communication assets. The Vulnerability Rating for Adaptive Capacity is Low due to the relative redundancy of communication systems.

# 4.6. Transportation Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Transportation Assets. The justifications for these ratings are further explained in the subsections below and summarized in

Table 17.

**Table 17. Vulnerability Ratings for Transportation Assets**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075

Precipitation	M	M	H	H
Extreme Temperature	M	H	M	H
Drought	L	M	L	H
Coastal Flooding and SLR	L	L	H	H
Earthquakes	L	L	M	H
Strong Winds/Tornadoes	L	L	L	H

Abbreviations: L=Low; M=Medium; H=High

### 4.6.1. Transportation – Precipitation

The percent of each asset class exposed to precipitation hazards in 2050 and 2075 within the Transportation asset category is shown in Table 18. Exposure in both 2050 and 2075 is classified as Medium due to the relatively high percentage of railroads and major roads exposed to precipitation hazards in both 2050 and 2075. Railroads and major roads have the greatest exposure to this hazard.

**Table 18. Transportation Asset Exposure to Precipitation Hazard**

Transportation Asset	Number of Assets (or Length)	2050 Percent Exposed to Precipitation Hazard	2075 Percent Exposed to Precipitation Hazard
Airports	1	0%	0%
Bus Stops	156	3%	4%
Rail Stations	6	0%	0%
Railroads	80 (miles)	6%	8%
Major Roads	432 (miles)	4%	6%

The Sensitivity of Transportation assets to precipitation hazard is High because there are major disruptions to the functionality of these assets during heavy precipitation events. Transportation assets were assigned a High Vulnerability Rating for Adaptive Capacity due to the limited redundancy within the County as well as difficulty in relocating or creating new assets.

### 4.6.2. Transportation – Temperature

As extreme temperatures rise across the county, Transportation assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Transportation assets received a Medium Sensitivity rating for extreme temperatures and a High Vulnerability Rating for Adaptive Capacity. A Medium Sensitivity rating was assigned because Transportation assets in Prince William County are currently exposed to extreme temperatures and can maintain at least partial functionality. Transportation assets are designed to function outdoors, but during extended extreme temperature events some assets may deteriorate or fail. Accordingly, operation of rail and other transportation assets are typically suspended or significantly delayed during extreme temperature events (both extreme heat and extreme cold). Extreme temperature events may also limit the amount of time maintenance workers can spend outside and may require some restructuring of how some tasks are performed.

### 4.6.3. Transportation – Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Transportation assets received a Low Sensitivity rating for drought and a High Vulnerability Rating for Adaptive Capacity. A Low Sensitivity rating was assigned because transportation assets can continue to operate normally during drought conditions.

### 4.6.4. Transportation - Coastal Flooding and Sea Level Rise

Exposure of Transportation assets coastal flooding and sea level rise is classified as Low. Only 1% of major roads and 4% of railroads are potentially exposed to sea level rise of 3 ft corresponding to the intermediate estimate for 2075, and some may already be elevated enough to not be exposed. No airports, bus stops, or rail stations are exposed to sea level rise of 3 ft. The Sensitivity of Transportation assets to coastal flooding and sea level rise is High because there are major disruptions to the functionality of these assets during heavy precipitation events.

Transportation assets were assigned a High Vulnerability Rating for Adaptive Capacity due to the limited redundancy within the County as well as difficulty in relocating or creating new assets.

#### 4.6.5. Transportation – Earthquakes

The National Risk Assessment ranks the exposure of Transportation assets within Prince William County as a Low risk. Large earthquakes could have an impact on the built infrastructure such as roads and mass transit. However, the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, resulted in no major impacts being recorded, so the sensitivity is determined to be Medium.

#### 4.6.6. Transportation - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes; however, that mostly applies to buildings and other similar structures. For transportation assets, high winds and tornadoes may result in suspension of operations or impact roads and rail lines with fallen trees and debris. A Sensitivity rating of Low for Transportation assets for strong winds/tornadoes was assigned due to the relatively minor impact of these events to overall asset functionality.

### 4.7. Energy and Hazardous Materials Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Energy and Hazardous Materials Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 19.

**Table 19. Vulnerability Ratings for Energy and Hazardous Materials Assets**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	L	L	M	H
Extreme Temperature	M	H	L	H
Drought	L	M	L	H
Coastal Flooding and SLR	L	L	H	H
Earthquakes	L	L	M	H
Strong Winds/Tornadoes	L	L	M	H

Abbreviations: L=Low; M=Medium; H=High

#### 4.7.1. Energy and Hazardous Materials – Precipitation

Energy and Hazardous Materials assets received a Low Exposure rating for precipitation hazard. Although power lines cross over precipitation-vulnerable areas, they are expected to be elevated and therefore will not be exposed to the hazard. Some areas in the County also have underground power lines but these typically have minimal impact from precipitation events and are often made to operate in submerged conditions where they are buried under the water table. A Medium Sensitivity rating was assigned because Energy and Hazardous Materials assets may be damaged by precipitation hazards but are expected to remain partially operational. Energy and Hazardous Materials assets were assigned a High Vulnerability Rating for Adaptive Capacity due to the limited redundancy within the County as well as difficulty in relocating or creating new assets.

#### 4.7.2. Energy and Hazardous Materials – Temperature

As extreme temperatures rise across the county, Energy and Hazardous Materials assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Energy and Hazardous Materials assets received a Low Sensitivity rating for extreme temperatures and a High Vulnerability Rating for Adaptive Capacity. A Low



Sensitivity rating was assigned because Energy and Hazardous Materials assets in Prince William County are currently exposed to extreme temperatures and can function without interruption. Energy and Hazardous Materials assets are designed to function outdoors, but during extended extreme temperature events some assets may deteriorate more quickly and require increased maintenance. Extreme temperature events may limit the amount of time maintenance workers can spend outside and may require some restructuring of how some tasks are performed.

### 4.7.3. Energy and Hazardous Materials – Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Energy and Hazardous Materials assets received a Low Sensitivity rating for drought and a High Vulnerability Rating for Adaptive Capacity. A Low Sensitivity rating was assigned because Energy and Hazardous Materials assets can continue to operate normally during drought conditions.

### 4.7.4. Energy and Hazardous Materials - Coastal Flooding and Sea Level Rise

Energy and Hazardous Materials assets received a Low Exposure rating for coastal flooding and sea level rise. Although power lines cross over areas with sea level rise of 3 ft, they are expected to be elevated and therefore will not be exposed to the hazard. A High Sensitivity rating was assigned because Energy and Hazardous Materials assets may be severely damaged by coastal flooding and sea level rise. Energy and Hazardous Materials assets were assigned a High Vulnerability Rating for Adaptive Capacity due to the limited redundancy within the County as well as difficulty in relocating or creating new assets.

### 4.7.5. Energy and Hazardous Materials – Earthquakes

The National Risk Assessment ranks the Exposure of Energy and Hazardous Materials assets within Prince William County as a Low risk. Large earthquakes could have an impact on the built infrastructure such as electrical lines, power generation plants and substations, County-run fuel distribution centers, natural gas pipelines, and hazardous materials storage sites. However, the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, resulted in no major impacts being recorded, so the Sensitivity is determined to be Medium. Energy and Hazardous Material assets were assigned as having High Vulnerability Rating for Adaptive Capacity, due to two factors. First, most of the Energy and Hazardous Materials assets are outside the domain of Prince William County leaving the county with limited ability to enact change. Additionally, a solution to increased resiliency of power lines is to take them underground to avoid the risk of damage from high wind events, but this strategy can put the lines at higher risk to damage from earthquakes.

### 4.7.6. Energy and Hazardous Materials - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes resulting in an average Sensitivity rating of Medium for Energy and Hazardous Materials. The Vulnerability Rating for Adaptive Capacity is High due to the lack of redundancy for the energy and hazardous materials systems.

## 4.8. Natural Resources Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Natural Resources Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 20

Table 17.

**Table 20. Vulnerability Ratings for Natural Resources**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	H	H	H	M
Extreme Temperature	M	H	H	M
Drought	L	M	H	M
Coastal Flooding and SLR	L	L	H	M
Earthquakes	L	L	M	M
Strong Winds/Tornadoes	L	L	M	M

Abbreviations: L=Low; M=Medium; H=High

### 4.8.1. Natural Resources – Precipitation

The percent of each asset within the Natural Resources asset category exposed to precipitation hazards in 2050 and 2075 is shown in Table 21. Exposure in both 2050 and 2075 is classified as High since the percent of Natural Resources assets exposed to precipitation hazard ranges from 10-90% and 11-90%, respectively. Dams, streams, and resource protection areas are all highly vulnerable to precipitation hazard.

**Table 21. Natural Resources Asset Exposure to Precipitation Hazard**

Natural Resources Asset	Number of Assets (or Length/Area of Assets)	Unit of Exposure Measurement		2050 Percent Exposed to Precipitation Hazard	2075 Percent Exposed to Precipitation Hazard
Dams	10	Number Exposed		90%	90%
Streams	1,040 miles	Length Exposed		59%	59%
Resource Protection Areas	50 square miles	Area Exposed		42%	43%
Tree Cover	187 square miles	Area Exposed		10%	11%
Agricultural Areas	36 square miles	Area Exposed	14%	15%	

Sensitivity of Natural Resources assets to precipitation hazards is considered High since the hazard could potentially cause irreparable damages to these assets. Natural Resources were assigned a Medium Vulnerability Rating for Adaptive Capacity rating as most have some tolerance for climate hazards as well as redundancy.

### 4.8.2. Natural Resources – Temperature

As extreme temperatures rise across the county, Natural Resources assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Natural Resources received a High Sensitivity rating for extreme temperatures and a Medium Vulnerability Rating for Adaptive Capacity. A High Sensitivity rating was assigned because Natural Resource assets can be severely impacted by extreme temperature events. Sudden temperature shifts, timing, and duration of seasons, as well as extended periods of extreme temperature can devastate crops as well as animal and plant life which reside exclusively outdoors. Extreme temperature events may limit the amount of time individuals and machinery can work outside and may require some restructuring of how some maintenance and rehabilitation functions are performed. As the climate shifts, agricultural techniques and even the types of crops grown may need to change to account for shifts in seasonality and temperature. Animal and plant species may migrate into and out of areas within the County, adding or removing natural resource assets and changing the way these resources are managed.

### 4.8.3. Natural Resources – Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Natural Resources received a High Sensitivity rating for drought and a Medium Vulnerability Rating for Adaptive Capacity. A High Sensitivity rating was assigned because both flora and fauna are significantly impacted by drought conditions. When drought conditions persist for extended periods, crops can fail and species populations may be decimated or forced to migrate out of the County.

### 4.8.4. Natural Resources - Coastal Flooding and Sea Level Rise

The percent of each asset within the Natural Resources asset category exposed to coastal flooding and sea level rise hazards in 2050 and 2075 is shown in Table 22. Exposure in both 2050 and 2075 is classified as Low. Resource protection areas experience the greatest exposure to coastal flooding and sea level rise since they are currently located in coastal areas.

**Table 22. Natural Resources Asset Exposure to Coastal Flooding and Sea Level Rise**

Natural Resources Asset	Number of Assets (or Length or Area of Assets)	Unit of Exposure Measurement	Exposed to Sea Level Rise of 2 ft	Exposed to Sea Level Rise of 3 ft
Dams	10	Number Exposed	0%	0%
Streams	1,040 miles	Length Exposed	6%	6%
Resource Protection Areas	50 square miles	Area Exposed	20%	20%
Tree Cover	187 square miles	Area Exposed	0%	1%

Sensitivity of Natural Resources assets to coastal flooding and sea level rise is considered High since the hazard could potentially cause irreparable damages to these assets by significantly changing the natural environment in which they reside. Natural Resources were assigned a Medium Vulnerability Rating for Adaptive Capacity as most have some tolerance for climate hazards as well as redundancy.

### 4.8.5. Natural Resources – Earthquakes

The National Risk Assessment ranks the Exposure risk to Prince William County from earthquakes as a Low risk. Although earthquakes usually don't cause extensive damage for natural resources, this category includes dams (as the dams create the natural resource of a lake. During the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, there was no major damage reported in Prince William County except for the dam at Lake Jackson. Damage from this earthquake cause loss of water in the lake and officials released water from the dam to relieve pressure to avoid collapse of the structure. The dam rehabilitation cost was approximately \$900,000. Although most of the natural resources in this category are not very sensitive to earthquakes, due to the documented damage to the Lake Jackson Dam, the Sensitivity is rated Medium. The Vulnerability Rating for Adaptive Capacity is Medium. For Natural Resources, the Adaptive Capacity considerations are focused mostly on dams. The Medium rating for this category is due to the challenge to reinforce dams (or other natural resources) for earthquake hazards.

### 4.8.6. Natural Resources - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Based on the projected annual damages to the agriculture sector in the National Risk Assessment due to strong winds and tornadoes the sensitivity to these hazards is ranked Low. High winds and tornadoes can cause extensive tree loss or other damage to natural resources resulting in a Sensitivity rating of Medium. The Vulnerability Rating for Adaptive Capacity is Medium. For Strong Winds and Tornadoes, the Adaptive Capacity considerations are focused mostly on tree cover. The Medium rating for this category is due to the high redundancy of tree cover while acknowledging that the loss of large, established trees can be hard to replace.

## 4.9. Socially Vulnerable Populations Asset Vulnerability

This section describes the Exposure, Sensitivity, and Vulnerability Rating for Adaptive Capacity for Transportation Assets. The justifications for these ratings are further explained in the subsections below and summarized in Table 23.

**Table 23. Vulnerability Ratings for Socially Vulnerable Populations**

Climate Hazard	Exposure Rating		Sensitivity Rating	Vulnerability Rating for Adaptive Capacity
	2050	2075	2050 & 2075	2050 & 2075
Precipitation	H	H	H	H
Extreme Temperature	M	H	H	H
Drought	L	M	H	H
Coastal Flooding and SLR	L	L	H	H
Earthquakes	L	L	M	H
Strong Winds/Tornadoes	L	L	H	H

Abbreviations: L=Low; M=Medium; H=High

### 4.9.1. Socially Vulnerable Populations – Precipitation

Socially Vulnerable Populations received a High Exposure rating for precipitation hazards, as 24 of 26 Equity Emphasis Areas are impacted by the hazard in both 2050 and 2075 scenarios. Socially Vulnerable Populations have a High Sensitivity rating to precipitation hazards, as precipitation-related damages may significantly impact the wellbeing of individuals in Equity Emphasis Areas. Socially Vulnerable Populations were assigned a High Vulnerability Rating for Adaptive Capacity as they have limited resources and access to resources that would facilitate adaptation to climate hazard exposure.

### 4.9.2. Socially Vulnerable Populations – Temperature

As extreme temperatures rise across the county, Energy and Hazardous Materials assets were given a Medium Exposure rating for 2050 and a High Exposure rating for 2075. Socially Vulnerable Populations received a High Sensitivity rating for extreme temperatures and a High Vulnerability Rating for Adaptive. A High Sensitivity rating was assigned because Socially Vulnerable Populations can be severely impacted by extreme temperature events due to limited access to climate-controlled environments. Extended periods of extreme temperature can create or exacerbate health conditions.

### 4.9.3. Socially Vulnerable Populations – Drought

Drought Exposure throughout the County is rated Low of 2050 and Medium for 2075. Socially Vulnerable Populations received a High Sensitivity rating for drought and a High Vulnerability Rating for Adaptive Capacity. A High Sensitivity rating was assigned because Socially Vulnerable Populations are more severely impacted by drought conditions as they have fewer resources available to alleviate drinking water restrictions and may have increased water demand due to increased exposure to extreme temperatures that often accompany drought conditions.

### 4.9.4. Socially Vulnerable Populations - Coastal Flooding and Sea Level Rise

Socially Vulnerable Populations received a Low Exposure rating for coastal flooding and sea level rise, as 5 of 26 Equity Emphasis Areas are impacted by the hazard in both 2050 and 2075 scenarios. Socially Vulnerable Populations have a High Sensitivity rating to coastal flooding and sea level rise, as related damages may significantly impact the wellbeing of individuals in Equity Emphasis Areas. Socially Vulnerable Populations were assigned a High Vulnerability Rating for Adaptive Capacity as they have limited resources and access to resources that would facilitate adaptation to climate hazard exposure.

#### 4.9.5. Socially Vulnerable Populations – Earthquakes

The National Risk Assessment ranks the Exposure of all assets within Prince William County as a Low risk. Large earthquakes could have an impact on the built infrastructure, which is likely to impact socially vulnerable populations more severely than other residents of Prince William County. However, the 5.8 magnitude earthquake out of Mineral, VA and 4.2 magnitude aftershock earthquake outside of Fredericksburg, VA in August 2011, resulted in no major impacts being recorded, so the Sensitivity is determined to be Medium. The Vulnerability Rating for Adaptive Capacity is rated High due to the limited ability for Socially Vulnerable Populations to be able to make changes to their built environment to better adapt to earthquake hazards.

#### 4.9.6. Socially Vulnerable Populations - Strong Winds/Tornadoes

Prince William County has experienced multiple high wind events from hurricanes and straight-line winds as well as tornadoes; however, the National Risk Assessment ranks the Exposure of the county to these types of events as Low for strong winds and Relatively Low for tornadoes. Projected damages due to these events are ranked Relatively Moderate for strong winds and Relatively High for tornadoes; however, Socially Vulnerable Populations generally have fewer options in terms of housing when they are displaced due to natural hazard events including strong wind or tornadoes resulting in a Sensitivity rating of High. The Vulnerability Rating for Adaptive Capacity is High due to the lack of redundancy in affordable housing.

## 6. Vulnerability Ratings and Conclusions

An asset category's vulnerability to a particular climate hazard can be defined as the combination of the asset category's exposure, sensitivity, and adaptive capacity to the climate hazard. The development of exposure, sensitivity, and adaptive capacity ratings in Section 4 lay the foundation for the evaluation of climate hazard vulnerability presented in this section. The rating system has been set up such that Low scores mean there is a lower vulnerability, and High scores mean that there is a higher vulnerability and that adaptation actions should be focused in these areas.

Summaries of exposure, sensitivity, and adaptive capacity ratings are shown in Table 24, Table 25, and Table 26, respectively. Exposure, sensitivity, and adaptive capacity ratings were assigned scores and summed to determine vulnerability ratings for each climate hazard and combined vulnerability ratings for each asset category. High exposure, sensitivity, or adaptive capacity ratings received a score of 3, Medium ratings received a score of 2, and Low ratings received a score of 1. Vulnerability scores for each climate hazard were calculated by adding the exposure, sensitivity, and adaptive capacity scores for each time horizon. Total scores of 3 – 4 received a Low vulnerability rating, total scores of 5 – 7 received a Medium vulnerability rating, and total scores of 8 – 9 received a High vulnerability rating as shown in Table 27.

Vulnerability scores for each climate hazard were then added together to determine combined vulnerability scores for each asset category and time horizon. Total hazard scores of 18 – 27 received a Low combined vulnerability rating, total hazard scores of 28 – 36 received a Medium combined vulnerability rating, and total hazard scores of 37 – 54 received a High combined vulnerability rating as shown in Table 28.

Vulnerability scores can be used to understand how vulnerable an asset category is to a particular future climate hazard. Overall, assets in Prince William County were determined to be most vulnerable to Extreme Temperatures followed by Precipitation and Strong Winds/Tornadoes though most vulnerability scores are Medium or Low. The Safety and Security and Communications asset categories received Low vulnerability ratings for all future climate hazards except for Medium ratings for both 2050 and 2075 for extreme temperatures. Energy & Hazardous Materials; Food, Water, and Shelter; and Health and Medical asset categories received Medium vulnerability ratings for all hazards with the notable exception of a High extreme temperature vulnerability rating for Food, Water, and Shelter assets in 2075. Socially Vulnerable Populations received the highest vulnerability ratings with High ratings for precipitation and extreme temperature in 2050 and 2075 and a High vulnerability rating for drought in 2075. All other ratings for Socially Vulnerable populations were Medium. Similarly, Natural Resources and Transportation assets received Medium ratings for all hazards with the exceptions of High ratings for precipitation in 2050 and 2075 and extreme temperature in 2075.

Combined vulnerability scores can be used to summarize overall vulnerability for each asset category. Socially Vulnerable Populations, Transportation, and Natural Resources were the most vulnerable asset categories with High combined vulnerability ratings in both 2050 and 2075. Energy & Hazardous Materials received a Medium combined vulnerability rating for 2050 and a High combined vulnerability rating for 2075. Food, Water, and Shelter and Health and Medical asset categories received Medium combined vulnerability ratings for both 2050 and 2075 while Safety and Security and Communications asset categories received Low vulnerability ratings for both 2050 and 2075.

### County-wide versus individual asset vulnerability

The results of this vulnerability assessment are generalized and while they provide valuable information on the County-wide scale, individual assets may score differently than the overall asset category. For example, while most of the County has almost no coastal flood vulnerability, there are homes and businesses located along the coastline that will likely be impacted by rising sea levels. This report did not include detailed modeling of how changing precipitation would impact riverine or overland flooding or the performance of the County's stormwater management system, which could be included in a more detailed study focused on areas of the county that are already being impacted by frequent flooding events.

**Table 24. Summary of Asset Exposure Ratings**

Climate Hazard	Asset Category															
	Safety and Security		Food, Water, and Shelter		Health and Medical		Communications		Transportation		Energy & Hazardous Materials		Natural Resources		Socially Vulnerable Populations	
	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075
Precipitation	L	L	L	L	L	L	L	L	M	M	L	L	H	H	H	H
Extreme Temperature	M	H	M	H	M	H	M	H	M	H	M	H	M	H	M	H
Drought	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M
Coastal Flooding and SLR	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Earthquakes	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Strong Winds/Tornadoes	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

**Table 25. Summary of Asset Sensitivity Ratings**

Climate Hazard	Asset Category							
	Safety and Security	Food, Water, and Shelter	Health and Medical	Communications	Transportation	Energy & Hazardous Materials	Natural Resources	Socially Vulnerable Populations
Precipitation	M	M	M	M	H	M	H	H
Extreme Temperature	M	H	M	M	M	L	H	H
Drought	L	H	M	L	L	L	H	H
Coastal Flooding and Sea Level Rise	M	M	M	M	H	H	H	H
Earthquakes	M	M	M	M	M	M	M	M
Strong Winds/ Tornadoes	M	M	M	M	L	M	M	H



**Table 26. Summary of Asset Adaptive Capacity Vulnerability Ratings**

Asset Category	Vulnerability Rating of Adaptive Capacity
Safety and Security	L
Food, Water, and Shelter	M
Health and Medical	M
Communications	L
Transportation	H
Energy & Hazardous Materials	H
Natural Resources	M
Socially Vulnerable Populations	H

**Table 27. Summary of Vulnerability Ratings for All Climate Hazards**

Climate Hazard	Asset Category															
	Safety and Security		Food, Water, and Shelter		Health and Medical		Communications		Transportation		Energy & Hazardous Materials		Natural Resources		Socially Vulnerable Populations	
	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075	2050	2075
Precipitation	L	L	M	M	M	M	L	L	H	H	M	M	H	H	H	H
Extreme Temperature	M	M	M	H	M	M	M	M	M	H	M	M	M	H	H	H
Drought	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	H
Coastal Flooding and SLR	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	M
Earthquakes	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	M
Strong Winds/Tornadoes	L	L	M	M	M	M	L	L	M	M	M	M	M	M	M	M

**Table 28. Summary of Combined Vulnerability Ratings**

Asset Category	Combined Vulnerability Rating	
	2050	2075
Safety and Security	L	L
Food, Water, and Shelter	M	M
Health and Medical	M	M
Communications	L	L
Transportation	H	H
Energy & Hazardous Materials	M	H
Natural Resources	H	H
Socially Vulnerable Populations	H	H

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## End Notes

- 1 Capitalized “County” will be used when referring to the County government as an entity. Lowercase “county” will be used when referring to the geographic area that is Prince William County
- 2 <https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-va.pdf>
- 3 <https://www.chesapeakebay.net/news/blog/a-new-report-gives-virginia-a-realistic-view-of-the-future>
- 4 <https://statesummaries.ncics.org/chapter/va/>
- 5 For renewable electricity goals, we define renewable electricity as electricity coming from any non-fossil fuel energy source, such as solar, wind, hydro, geothermal, and nuclear
- 6 The County does not consider the county's schools a part of County government operations
- 7 Source: <https://www.chesapeakebay.net/what/what-guides-us/decisions>
- 8 “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review”: EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances
- 9 <https://www.pwcva.gov/assets/2022-05/13-D.pdf>
- 10 World Resources Institute, C40 Cities Climate Leadership Group, & ICLEI - Local Governments for Sustainability. (2014) Global protocol for Community-Scale Greenhouse Gas Emission Inventories
- 11 <https://statesummaries.ncics.org/chapter/va/>
- 12 <https://www.pwcva.gov/assets/2022-09/Res%20022-007%20Fast%20Track%20Sustainability%20Recommendations.pdf>
- 13 <https://rhg.com/research/us-greenhouse-gas-emissions-2022/>
- 14 <https://www.pwcva.gov/assets/2022-05/13-D.pdf>
- 15 <https://www.fema.gov/emergency-managers/practitioners/lifelines>
- 16 <https://www.mwcog.org/assets/1/6/methodology.pdf>
- 17 Currently, MWCog uses a location-based method to calculate electricity emissions, which uses an average electricity emissions factor that reflects energy sources used throughout the regional grid. Alternatively, the market-based method allocates electricity emissions from energy generators to consumers based on “contractual instruments.” The emissions reduction impact of any clean electricity purchasing recommendation in the CESMP, such as community choice aggregation or purchasing RECs, would not be reflected through the location-based accounting method, but would be reflected through the market-based method. The County will work with MWCog to determine if the market-based electricity emissions can be calculated along with location-based emissions in the future.
- 18 [https://www.pwcva.gov/assets/2021-09/2021-2024\\_Strategic\\_Plan-FINAL.pdf](https://www.pwcva.gov/assets/2021-09/2021-2024_Strategic_Plan-FINAL.pdf)
- 19 <https://www.pwcva.gov/department/planning-office/prince-william-County-comprehensive-plan>
- 20 Source: <https://www.chesapeakebay.net/what/what-guides-us/decisions>
- 21 “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review”: EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances
- 22 <https://www.mwcog.org/documents/2022/12/09/greenhouse-gas-emissions-inventories-methodology-guide-climate--energy-greenhouse-gas>

- 23 <https://www.epa.gov/egrid/historical-egrid-data>
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- 25 Sherlock, M. F. (2023). Tax Credits for “Clean Electricity”—Projected Effects on CO2 Emissions and the Generation Mix. Congressional Research Service. <https://crsreports.congress.gov/product/pdf/IN/IN12082>
- 26 Georgetown Climate Center. (2021, 12 16). Georgetown Law. Retrieved from <https://www.georgetownclimate.org/articles/federal-infrastructure-investment-analysis.html>