Attachment A

Final Report

Climate Assessment Recommendations for Master Plans and Zoning Text Amendments in Montgomery County

Submitted to:

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1 Introduction

On July 25, 2022, the Montgomery County Council signed Bill 3-22, "Climate Assessments" into law. The bill requires assessments of climate impacts for County bills, zoning text amendments and master plans and master plan amendments (collectively referred to as master plans). As a result of the bill, the Montgomery County Planning Department (Montgomery Planning) will be responsible for conducting climate assessments for Zoning Text Amendments (ZTAs) and master plans, and the Office of Legislative Oversight will be responsible for conducting climate assessments for County bills.

Montgomery Planning hired ICF to conduct research and recommend an approach to conducting the climate assessments. This report summarizes ICF's recommendations for a method and "template" for conducting climate assessments for ZTAs and master plans, including greenhouse gas (GHG) emissions and community resilience and adaptive capacity. The recommendations are based on an earlier literature review, ongoing discussions with Montgomery Planning staff, and input from stakeholders (key findings of which are captured in the Appendix). The recommendations aim to allow Montgomery Planning staff to assess the emissions, sequestration, and resilience impacts and strike a balance between qualitative and quantitative assessment to achieve the Bill 3-22 objectives without straining Montgomery Planning staff resources and to fit within existing planning and review process timelines. This report also provides recommendations for integrating climate considerations in the master planning process. **Appendix A provides the template for preparing the climate assessments following the recommended approach outlined in this report.**

2 Recommended Approach to Climate Assessments

The sections below lay out ICF's recommended approach for Montgomery Planning to conduct the climate assessments required under Bill 3-22. This approach is a recommended starting point for the assessments and should evolve over time as additional data or methods become available, and as Montgomery Planning learns lessons through conducting the assessments over time.

The climate assessments will primarily be presented in the form of narratives detailing the potential impacts and rationale, to be determined following the recommended approach laid out below. See Appendix A for an example of the ultimate form of the climate assessments.

Detailed recommendations on the approach to complete the climate assessments are provided below, broken down into the two key required components of the climate assessments.

2.1 Assessing Impacts to Greenhouse Gas Emissions and Sequestration

Bill 3-22 defines a climate assessment as including an evaluation of the identified effects of a master plan or ZTA on GHG emissions and sequestration (also referred to in bill language as "carbon drawdown") within Montgomery County. These climate assessments are forward-looking projections based on different types of potential developments as a result of proposed ZTAs and master plans. These projections will be used to help make more informed decisions about future developments such that positive impacts on County greenhouse gas emissions can be maximized. Because the implementation of a master plan is subject to change in the future and depends heavily on the actual engineering and operation of a development, ZTA and master plan climate assessments per Bill 3-22 are not suitable for tracking progress over time. Tracking of progress is better suited to, and already is done within, the County Climate Action Planning framing. The draft recommendations in this section provide both quantitative and qualitative approaches for estimating these forward-looking effects that consider timing, data quality and availability, and existing methods and tools.

The primary limiting factors driving these recommendations are data availability and timing constraints. There is greater opportunity to quantify the GHG and sequestration effects of master plans as compared to ZTAs given the respective time periods Montgomery Planning has to review these documents, 18 months for master plans as compared to two-three weeks for ZTAs. Robust and accurate data collection and calculations with even pre-existing or proxy data sources is difficult to undertake on a two-week timescale. Therefore, **GHG emission and sequestration estimates for ZTAs are recommended to be qualitative, whereas master plan assessments will primary be quantitative with some qualitative elements.**

Ultimately the recommendations that ICF is providing will support a directional determination based on qualitative and/or quantitative analyses, if a master plan, master plan amendment or ZTA has potential effects GHG emissions and sequestration for the county (i.e., will support or hinder progress towards aching the county's GHG goals). The assessments from Bill 3-22 are just one in a portfolio of larger-scale activities the county is taking to ensure that overall positive progress is made towards goals.

It is important to keep in mind that:

- Master plans are long-term planning tools that provide a conceptual layout to guide future growth and development within a certain area – they do not indicate how a specific development (e.g., building) will be operated. Zoning text amendments regulate and guide development within an area.

- Bill 3-22 is one of a series of legislated and voluntary activities that are aimed to drive more climate-informed decision making and GHG reduction for the county. Implementation of master plans and ZTAs may inherently incorporate several requirements and recommendations that will drive GHG emission reductions (e.g., building and construction codes, Building Performance Standards, Green Bank financing for, but not limited to, energy efficiency and renewable energy activities, transportation requirements, nature-based site design, landscaping requirements).
- Inherently, new or changed development leads to additional emissions. However, new or changed development also provides multiple benefits, such as economic benefits, increased resilience and adaptative capacity (in some instances), and the ability to meet growing and changing needs in a community. The climate assessments as required by Bill 3-22 will be used as tools to help plan for how to reduce or mitigate increases in emissions due to new or changed developments. They would also help identify additional opportunities for sequestration. Therefore, one of the primary outcomes and largest factors that will drive change as a result of Bill 3-22 climate assessments will not necessarily be a specific estimate of GHG emissions or sequestration but will be the GHG mitigation options that are identified as a result of directionally assessing emission and sequestration potentials.

To prepare these draft recommendations, ICF drew upon the existing tools and data used by Montgomery Planning to quantify GHG emissions for master plans, other examples identified in the literature review, input from stakeholders, and our own experience assessing GHG emissions and sequestration.

The proposed recommendations are based on the data, approaches, and tools available today. It is highly likely these factors will evolve over time and therefore the ability to evaluate and quantify GHG emission effects will improve in the future. This could necessitate Montgomery Planning to review data and practices for GHG assessments at a regular interval (e.g., every two years).

For the purposes of this climate assessment, Montgomery Planning is applying the following definitions, which are generally used interchangeably:

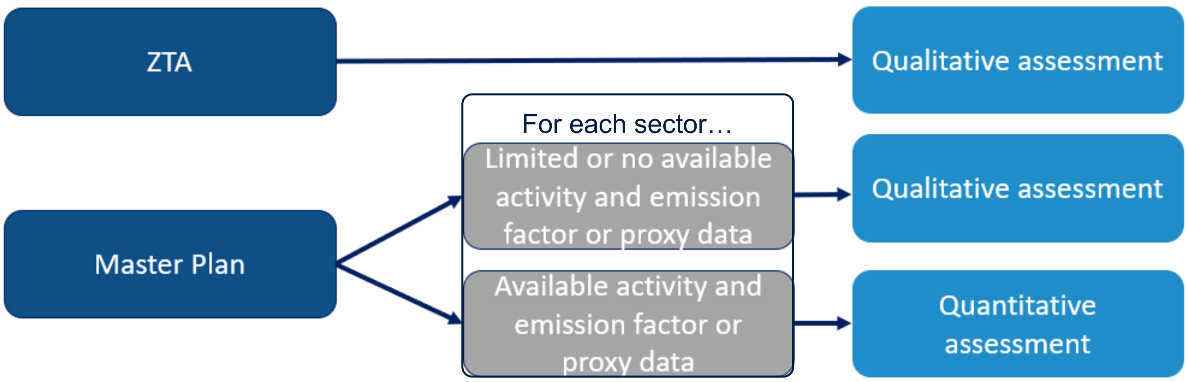
- **Carbon dioxide removal:** Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products.[1]
- **Carbon dioxide sequestration:** the process of capturing and storing atmospheric carbon dioxide.[2]
- **Carbon dioxide drawdown:** usually used as a synonym for carbon removal. It sometimes refers specifically to the use of carbon removal to reduce the atmospheric concentration of carbon dioxide, as opposed to simply slowing its increase.[3]

[1] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541-562, doi:10.1017/9781009157940.008.
[2] American University Washington, DC, Carbon Removal Law & Policy. "Carbon Removal Glossary," April 15, 2020. https://www.american.edu/sis/centers/carbon-removal/carbon-removal-glossary.cfm.
[3] U.S. Geological Survey. "What Is Carbon Sequestration?" Accessed September 27, 2022. https://www.usgs.gov/faqs/what-carbon-sequestration.

Overview of GHG emissions and sequestration approach

ICF recommends a mixed qualitative and quantitative approach to assessing ZTA and master plan GHG emissions and sequestration. This approach is summarized in Figure 1 below and provides an overarching framework that allows for directional change estimates of carbon stocks, even in the absence of appropriate data to create quantitative assessment of carbon stock impacts. ICF recommends the key sectors identified in Table 1 for the climate assessment; see the Appendix for more rationale on the sectors included and excluded in the climate assessment recommendations.

Figure 1. GHG assessment approach



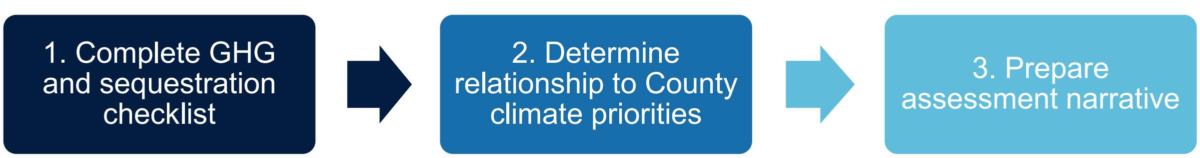
Recommendations for ZTAs

Because there is a two-to-three-week window for ZTA reviews, a quantitative assessment of the GHG emissions associated with ZTAs is not feasible. Instead, ICF is recommending Montgomery Planning undertake a qualitative review to identify the directional change in the GHG emissions associated with a ZTA.

This qualitative review asks Montgomery Planning to identify changes in activities that impact GHG emissions. The relative changes in these activities will allow Montgomery Planning to make an informed decision on the directional change in GHG emissions resulting from a ZTA.

To accomplish this assessment, we recommend the step-wise approach presented in Figure 2.

Figure 2. ZTA GHG assessment recommended approach



Step 1: Complete GHG and sequestration checklist

As the first step in a GHG emissions and sequestration assessment for a ZTA, ICF recommends an initial applicability review and directional impact assessment. This includes considering whether the ZTA will influence activities that may result in changes in GHG emissions or sequestration. It also includes an evaluation to qualify whether these activities that may be influenced may have a positive or negative impact on GHG emissions or sequestration.

Positive Impact: potential reduction in emissions or increase in sequestration
Negative Impact: potential increase in emissions or decrease in sequestration

The checklist that encompasses these elements is provided in Table 1. While the checklist below provides a starting point, it is not a comprehensive list of all potential GHG-related sectoral activities for a specific ZTA. Montgomery County Planning Department (Montgomery Planning) staff are encouraged to supplement with additional data and information as appropriate and evolve this checklist over time.

Some of the activities are reflected in both the GHG emissions and community resilience checklists (Table 1 and Table 8, respectively) and are noted with an asterisk(*). Montgomery Planning should consider the collective overall impact of these factors across both GHG emissions and community resilience and adaptive capacity to understand potential co-benefits or trade-offs (i.e., mix of positive and negative impacts).

Table 1. GHG Emissions and sequestration checklist

Does the ZTA effect any of the following activities			*If yes, is the activity likely to have a positive or negative impact on GHG emissions and sequestration?*	
Transportation	**No Impact**	**Yes**	**Positive Impact**	**Negative Impact**
Vehicle miles traveled by type (personal vehicles, commercial trucks or vehicles, rideshare, school buses, motorcycles)	☐	☐	☐	☐
Number of trips (including considering single occupancy or carpool trips)	☐	☐	☐	☐
Non-vehicle modes of transportation (scooter, bikes, walking)	☐	☐	☐	☐
Public transportation use (public bus and Metrorail)*	☐	☐	☐	☐
Electric vehicle infrastructure access (i.e., charging stations)	☐	☐	☐	☐
Building Embodied Emissions	**No Impact**	**Yes**	**Positive Impact**	**Negative Impact**
Building certifications (e.g., LEED)*	☐	☐	☐	☐
Building square footage	☐	☐	☐	☐
Building life span	☐	☐	☐	☐
Pavement infrastructure*	☐	☐	☐	☐
Material waste produced	☐	☐	☐	☐
Use of green building materials	☐	☐	☐	☐
Energy	**No Impact**	**Yes**	**Positive Impact**	**Negative Impact**
Electricity usage (including distributed and renewable energy)	☐	☐	☐	☐

Stationary fuel usage (natural gas, fuel oil, or LPG)	☐	☐	☐	☐
Electricity efficiency (kilowatt-hour per square foot)*	☐	☐	☐	☐
Stationary fuel efficiency (BTU per square foot)*	☐	☐	☐	☐
Land Cover Change & Management	**No Impact**	**Yes**	**Positive Impact**	**Negative Impact**
Area of forest*	☐	☐	☐	☐
Area of non-forest tree canopy (i.e., number of trees on the ground, or percent of tree canopy cover per acre)*	☐	☐	☐	☐
Area of green cover (i.e., meadow, grassland, turf, wetland, etc.)*	☐	☐	☐	☐
Implementation of nature-based solutions[4]* *If available, please list the relevant solutions implemented:* ________________________ ________________________ ________________________	☐	☐	☐	☐

*Overlaps with a community resilience factor

The following definitions are applicable for types of land cover:

- **Forest** – a biological community dominated by trees and other woody plants (including plant communities, the understory, and forest floor) covering a land area which is 10,000 square feet or greater and at least 50 feet wide. However, minor portions of a forest stand which otherwise meet this definition may be less than 50 feet wide if they exhibit the same character and composition as the overall stand.[5]

    Forest includes:
    (1) areas that have at least 100 live trees per acre with at least 50 percent of those trees having a 2 inch or greater diameter at 4.5 feet above the ground; and
    (2) forest areas that have been cut but not cleared.

- **Non-Forest Tree Canopy** – tree covered areas that do not meet the definition of Forest.
- **Grassland** – rangelands and pasture land that are not considered Cropland.

[4] **Nature-Based Solutions** – sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience. Examples include green rooves and bioretention.

[5] Montgomery County Forest Conservation Law, Chapter 22A, https://montgomeryplanning.org/wp-content/uploads/2017/10/Montgomery-County-Forest-Conservation-Law-2-22-21.pdf.

- **Meadow** – herbaceous covered areas that are managed for meadow habitat value.
- **Turf –** grassed areas within Settlements that are managed as non-habitat landscaping (e.g., lawns, and golf courses, etc.)
- **Wetlands** – (a) an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation; (b) is determined according to the Federal Manual [January, 1987]; (c) does not include tidal wetlands regulated under Natural Resources Article, Title 9, Annotated Code of Maryland.

The sections below provide additional guidance on how to evaluate each factor in the checklist. As these indicators are considered Montgomery Planning should do desktop research to help evaluate and provide and evidence basis for each factor.

Vehicle miles traveled (VMT) by type

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Potential to change traffic flows or people miles
- Change in number of visitors
- Change in public transportation access or availability
- Change in vehicle or other non-combustion vehicle access (i.e., new road development etc.)

For example, Montgomery Planning may want to refer to the National Capital Region Transportation Planning Board's Climate Change Mitigation Study of 2021[6] for additional indicators of VMT changes.

How this factor affects Transportation Emissions: An increase in VMT implies that more vehicles are combusting fossil fuels. Therefore, there is a direct relationship between VMT and GHG emissions impacts. However, as the penetration of electric vehicles increases over time, an increase in VMT may not imply as high of an emissions impact. But the direct relationship between VMT and GHG emissions will still remain for some time. To help facilitate reductions in GHG emissions despite potential increases in VMT the county can consider providing more access to electric vehicle charging stations and/or providing non-financial incentives (e.g., better parking locations).

Number of trips

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in purpose of location (i.e., why are trips taken to the location, and how often?)
- Change in number of visitors, workers, or residents
- Change in accessibility of location (i.e., greater access via vehicle, bike, foot etc.)

How this factor affects Transportation Emissions: An increase in number of trips is likely to be positively correlated with GHG emissions. While the slope of this correlation depends on the

[6] "TPB Climate Change Mitigation Study of 2021 | Metropolitan Washington Council of Governments." Accessed November 1, 2022. https://www.mwcog.org/tpb-climate-change-mitigation-study-of-2021/.

transportation type used by visitors, workers, or residents (i.e., fossil-fuel combustion vehicle vs. no-emissions biking), there is still likely to be at least some proportion of visitors, workers, or residents using fossil fuel energy for transportation that may result in an increase in emission. To help reduce emissions the county can consider if there are alternative ways to locate specific types of development that facilitate non-vehicle modes of travel or increase access to public transportation.

Non-vehicle modes of transportation

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in non-vehicle transportation access (e.g., more bike paths or sidewalks etc.)
- Change in access to non-vehicle transportation options (e.g., scooters or bike share stations)
- Change in purpose of location that could affect non-vehicle modes of transportation (e.g., a park may entail more visitors using non-vehicle modes of transportation than a commercial building)
- Change in the desirability of non-vehicle transportation infrastructure (e.g., adding shade or landscaping, public art installations, benches, or other measures designed to enhance the user experience and make using the facility more attractive)

How this factor affects Transportation Emissions: An increase in non-vehicle modes of transportation lowers the overall emissions associated with transportation as compared to the use of internal combustion vehicles. Additional access or incentives to use non-vehicle transportation is a mechanism to lower GHG emissions.

Public transportation use

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in public transportation availability (e.g., expansion of bus routes, metro stops)
- Change in public transportation affordability
- Change in vehicle access or affordability
- Change in the desirability to use public transportation (e.g., newer and cleaner buses, increased public transportation safety)

How this factor affects Transportation Emissions: The increased use of public transportation lowers the total emissions per individual compared to the use of single-family internal combustion vehicles. Different types of transportation may have different related GHG emissions, for example, an internal combustion bus may have greater direct GHG emissions that an electric vehicle bus (depending on the fuel mix of the electricity grid), however, overall, the emissions per individual remains lower than that of single-family internal combustion vehicles.

Electric vehicle infrastructure access

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in number of electric vehicles charging stations
- Change in type of charging equipment at charging stations (i.e., DC Fast Chargers versus Level 2 or 1 EV Chargers)

- Change in number of EVSE ports per station location (an EVSE port provides power to charge only one vehicle at a time)

Refer to the National Renewable Energy Laboratory's (NREL's) Alternative Fuels Database Center (AFDC) for greater information on electric vehicle charging infrastructure[7].

How this factor affects Transportation Emissions: Greater electric vehicle access incentivizes greater use of electric vehicles. While the emissions benefits of electric vehicles depend on the fuel mix of the energy grid, today electric vehicles already are lowering emitting than traditional fossil based internal combustion engines – this will only improve over time as the electric grid becomes cleaner.

Building certifications

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- LEED certification at any level
- ENERGY STAR certifications
- Other relevant certifications

How this factor affects Building Embodied Emissions: The LEED 4.1 guidelines consider embodied emissions. Since 2019, "The LEED rating system takes a holistic approach to evaluating building products and materials."[8] If a building is LEED certified this is an indication that overall embodied carbon would be relatively lower. Other building certifications and frameworks also are moving in this direction, and in many instances these principles are being evaluated as a part of building energy code updates and evolution. There is good general correlation between certified buildings and lower emissions. While a master plan or ZTA does not get into the actual engineering design of a building, recommendations can be made through climate assessments to both ensure that the buildings meet the county's Building Performance Standard and are certified by a nationally recognized body.

Building square footage

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Construction of new buildings, building additions, or building alterations
- Demolition of existing buildings or building structures
- Addition of building retrofits that would change overall building square footage

How this factor affects Building Embodied Emissions: An increase in building square footage implies an increase in the materials used to construct building additions, construction activities and additional energy use in buildings, all of which will increase emissions. To mitigate these emissions options could include looking at building materials, building certifications (e.g., LEED which requires materials sourced from within a certain distance) and alternative approaches for development to create smaller building footprints.

[7] "Alternative Fuels Data Center: Developing Infrastructure to Charge Electric Vehicles." Accessed November 1, 2022. https://afdc.energy.gov/fuels/electricity_infrastructure.html.

[8] "How LEED v4.1 addresses embodied carbon emissions." May 2019. https://www.usgbc.org/articles/how-leed-v41-addresses-embodied-carbon

Building life span

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Addition of building retrofits or alterations that would extend the lifetime of the building
- Change in intended purpose of the location that would require demolition of existing building structures
- Repurposing of existing building that would extend the usable life of the building and reduce loss of embodied emissions (might be included in Material Waste Produced section below)

How this factor affects Building Embodied Emissions: A shorter building lifetime implies a greater turnover of buildings and a higher new building construction rate. This would increase the total embodied emissions associated with new building constructions. Therefore, a longer building lifetime implies less overall embodied emissions associated with new building construction. However, some older buildings can take significant work to retrofit to accommodate more efficient and lower carbon technologies (e.g., wiring may need to be upgraded in buildings to accommodate electric heat pumps, a common measure for reducing GHG emissions). Therefore, mitigations options may be more of a specific circumstance and depend on the building(s) in question and whether retrofits or knock-down/new development would result in more or less GHG emissions.

Pavement infrastructure

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in vehicle accessibility (i.e., via paved roadways)
- Change in parking lot infrastructure
- Building type and new construction (i.e., new construction of a residential building that will likely include a driveway)

How this factor affects Building Embodied Emissions: The manufacturing and use of pavement to create roadways have associated GHG emissions. Therefore, an increase in the use of pavement is associated with an increase in GHG emissions. There are lower carbon pavement options that could be used to reduce the overall environmental impact of new or modified pavement infrastructure (e.g., through the Inflation Reduction Act the Federal Highways Administration has been directed to work with the Environmental Protection Agency to develop a program to certify low carbon road materials). Additionally, through a planning process, alternative design and approach to minimize new pavement in favor of green areas could be considered.

Material waste produced

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Construction of new buildings, building additions, alterations, or structures
- Demolition of existing buildings or building structures
- Innovative design that reduces lumber use and waste (such as advanced house framing[9])

[9] https://www.energy.gov/energysaver/advanced-house-framing

- Change in building residents or visitors (i.e., more people entail more waste)
- Change in building purpose that would change the amount of waste production (i.e., a previously residential building that is instead used for commercial manufacturing)

How this factor affects Building Embodied Emissions: Material waste is usually sent to a combination of recycling, landfilling, and waste combusting facilities. An increase in material waste entails an increase in GHG emissions. Refer to the Environmental Protection Agency's (EPA's) site on Waste Management[10] for more details. Through operational practices material waste emissions can be reduced. Additionally, Montgomery County could consider ways to minimize materials use as a result of development to reduce emissions.

Use of green building materials

Key indicators of activity changes: Depending on the nature of the ZTA or master plan, information may be available on the following key indicators of activity changes as a result of the ZTA or master plan:

- Construction using recycled materials
- Construction using lower-emissions materials (i.e., fly ash concrete as opposed to traditional concrete)
- Use of any of the following codes during building development
    - International Code Council's *2012 International Green Construction Code* (IgCC)
    - ANSI/ASHRAE/USGBC/IES Standard 189.1-2011: *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings* (ASHRAE 189.1)
- Any of the following certifications or ratings:
    - ICC 700-2012: *2012 National Green Building Standard* (ICC 700)
    - Green Globes
    - US Green Building Council's *Leadership in Energy and Environmental Design* (LEED)
    - The International Living Future Institute's *Living Building Challenge*
- Any other relevant certifications

Refer to EPA's Green Building Standards[11] website for more information on the noted green building codes and certifications.

How this factor affects Building Embodied Emissions: The use of lower emissions materials in building construction reduces the overall building embodied emissions.

Electricity usage

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Efficiency of electricity usage
- Onsite or offsite renewable resources
- Electricity chosen as an energy resource over fossil fuels (e.g., for cooking or heating)
- Use of electricity as compared to gasoline or diesel alternatives (e.g., if a building or area includes and electric vehicle charger(s)).

[10] US EPA, OCSPP. "Waste Management." Data and Tools, November 26, 2018. https://www.epa.gov/trinationalanalysis/waste-management.

[11] US EPA, OP. "Green Building Standards." Overviews and Factsheets, September 30, 2014. https://www.epa.gov/smartgrowth/green-building-standards.

How this factor affects Energy Emissions: In considering above, if the ZTA or master plan enables or plans for the use of lower carbon, efficient technologies this would directionally lead to a decreasing trend in county emissions. As the electric grid decarbonizes, this will inherently lead to lower emissions despite increases in energy use.

Stationary fuel usage

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in energy efficiency of building (i.e., building insulation, double-paned windows etc.)
- Change in building function (i.e., a warehouse requires less heating / cooling than a data center or a residential building)

How this factor affects Energy Emissions: Stationary fuel usage refers to the use of stationary combustion equipment for generating steam or providing useful heat or energy for industrial, commercial or institutional use. Stationary fuel usage results in the direct emissions of GHGs.

Electricity efficiency

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Change in the window-to-wall ratio
    - More windows increase natural lighting and reduce the need for electricity-powered bulbs but are not great insulators. According to Al-Hamoud and Mohammad (1997),[12] a window-to-wall ratio of about 15% is optimal for commercial and residential buildings.
- Use of energy efficient LED bulbs
- Use of cool roofs[13] or other passive solar home design[14] options
- Efficient building orientation for passive lighting and heating. (This must be combined with well-designed window shading features to minimize excessive solar heat gain in summer.)

Refer to the Department of Energy's Energy Efficiency site[15] for more information on related electricity efficiency indicators.

How this factor affects Energy Emissions: Greater electricity efficiency capabilities reduces the need for electricity consumption and the GHG emissions associated with the production of that electricity.

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[12] Al-Homoud, Mohammad S. "Optimum Thermal Design of Office Buildings." *International Journal of Energy Research* 21, no. 10 (1997): 941–57. https://doi.org/10.1002/(SICI)1099-114X(199708)21:10<941::AID-ER302>3.0.CO;2-Y.

[13] Cool rooves use highly reflective materials to reflect more light and absorb less heat from sunlight, which keeps homes cooler during hot weather. See here for more information: https://www.energy.gov/energysaver/cool-rooves

[14] Energy.gov. "Passive Solar Home Design." Accessed November 1, 2022. https://www.energy.gov/energysaver/passive-solar-home-design.

[15] Energy.gov. "Energy Efficiency." Accessed November 1, 2022. https://www.energy.gov/eere/energy-efficiency.

Stationary fuel efficiency

Key indicators of activity changes: Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Changes in heating efficiency of building (e.g., increased building insulation, double-paned windows, weatherstripping exterior doors)
- Building retrofits that reduce the need for stationary fuel (e.g., the installation of heat pumps)
- Change in building function (e.g., a warehouse requires less heating / cooling than a data center or a residential building)

Refer to the Department of Energy's Energy Efficiency site[16] for more information on related stationary fuel efficiency indicators.

How this factor affects Energy Emissions: Greater stationary fuel efficiency capabilities reduce the need for stationary fuel combustion, which directly releases GHG emissions.

Area of forest and non-forest tree canopy

Key indicators of activity changes:
Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Tree planting
- Tree removal

How this factor affects Land Cover Change & Management Emissions or Sequestration: Increasing forest and non-forest tree canopy and the total treed area on the landscape increases ecosystem carbon sequestration.

Area of other green cover

Key indicators of activity changes:
Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Creation/expansion of parks
- Creation of greenways
- Creation/restoration of meadows or wetlands
- Creation of lawns
- Creation of golf courses

How this factor affects Land Cover Change & Management Emissions or Sequestration: Creation of turfed areas in locations that were previously developed or barren will increase carbon sequestration on the landscape.

Area of other nature-based solutions

Key indicators of activity changes:

[16] Energy.gov. "Energy Efficiency." Accessed November 1, 2022. https://www.energy.gov/eere/energy-efficiency.

Depending on the nature of the ZTA (or master plan), information may be available on the following key indicators of activity changes as a result of the ZTA (or master plan):

- Installation of other nature-based solutions such as green roofs, bioretention, etc.

How this factor affects Land Cover Change & Management Emissions or Sequestration: Installation of other nature-based solutions (such as green roofs) may reduce energy consumption by providing insulation (in the case of green roofs) and reducing the urban heat island effect. They will also increase ecosystem carbon sequestration in the urban landscape.

Step 2: Determine relationship to County climate priorities

As a next step, ICF recommends that Montgomery Planning staff assess whether each applicable activity factor for a ZTA (or master plan) relates to a core GHG reduction or sequestration action within the most recent version of the County Climate Action Plan, and note if that action has a relatively high or low reduction potential as evaluated within the Climate Action Plan. The full list of Climate Action Plan GHG reduction actions, their assessed GHG reduction potentials (from the Climate Action Plan) and the relationship to identified ZTA or master plan GHG impacting activities (see Table 1) is provided in Table 2.

Table 2. ZTA activity factor relationships to GHG reduction actions from the 2021 County Climate Action Plan

Climate Action Plan action	Climate Action Plan assessed GHG reduction potential	Relevant ZTA / master plan checklist GHG activities
E-1: Community Choice Energy Program	High	Electricity usage
E-2: Private Building Solar Photovoltaic Code Requirements	Medium	Electricity usage
E-3: Promote Private Solar Photovoltaic Systems	Medium	Electricity usage
E-4: Public Facility Solar Photovoltaic Installations and Groundwork	Low	Electricity usage
B-1: Electrification Requirements for Existing Commercial and Public Buildings	High	Electricity usage, Stationary fuel usage, Efficiency
B-2: Electrification Requirements for Existing Residential Buildings	High	Electricity usage, Stationary fuel usage, Efficiency
B-3: Energy Performance Standard for Existing Commercial and Multifamily Buildings	High	Electricity usage, Stationary fuel usage, Efficiency
B-4: Electrification Incentives for Existing Buildings	High	Electricity usage, Stationary fuel usage, Efficiency
B-5: All-Electric Building Code for New Construction	High	Electricity usage, Stationary fuel usage, Efficiency
B-6: Disincentivize and/or Eliminate Natural Gas in New Construction	High	Electricity usage, Stationary fuel usage, Efficiency
B-7: Net Zero Energy Building Code for New Construction	High	Building certifications, Electricity usage, Stationary fuel usage
T-1: Expand Public Transit	Medium	Vehicle miles traveled, number of trips, Public transportation use
T-2: Expand Active Transportation and Micromobility Network	Medium	Vehicle miles traveled, number of trips, Non-vehicle modes of transportation
T-3: Private Vehicle Electrification Incentives and Disincentives	Medium	Electric vehicle infrastructure access, Electricity usage
T-4: Constrain Cars in Urban Areas, Limit Major New Road Construction	Medium	Vehicle miles traveled, number of trips
T-5: Zero Emissions Public Buses and School Buses	Medium	Public transportation use, Electric vehicle infrastructure access, Electricity usage

T-6: Electrify County and Public Agencies Fleet	Medium	Electric vehicle infrastructure access, Electricity usage
T-7: Expand the Electric Vehicle Charging Network	Medium	Electric vehicle infrastructure access, Electricity usage
T-8: Transportation Demand Management and Telework Strategies	Low	Vehicle miles traveled, number of trips, Non-vehicle modes of transportation
T-9: Traffic Management Systems	Low	Vehicle miles traveled, number of trips, Non-vehicle modes of transportation
T-10: Electric Vehicle Car Share Program for Low-Income Communities	Low	Electric vehicle infrastructure access, Electricity usage
T-11: Off-Road Vehicle and Equipment Electrification	Low	Electricity usage
S-1: Retain and Increase Forests	Not assessed (NA)	Area of forest
S-2: Retain and Increase Tree Canopy	NA	Area of non-forest tree canopy
S-3: Restore and Enhance Meadows and Wetlands	NA	Area of green cover, Nature-based solutions
S-4: Regenerative Agriculture	NA	Not assessed for ZTAs and master plans
S-5: Restore Soil Fertility, Microbial Activity, and Moisture Holding Capacity	NA	Not assessed for ZTAs and master plans
S-6: Whole-System Carbon Management and Planning	NA	Area of green cover, Nature-based solutions

Note: GHG reduction potentials were assessed in the June 2021 County Climate Action Plan. Within this plan the following definitions for reductions are used: High: >1,000,000 MT CO_2e, Medium: 500,000-1,000,000 MT CO_2e, and Low: <500,000 MT CO_2e. Actions that had no associated GHG reduction potential are not included in the table above. Carbon sequestration potentials were not assessed for the actions outlined in the County Climate Action Plan. Note that the Climate Action Plan does not include actions that explicitly address reducing embodied GHG emissions for buildings. https://www.montgomerycountymd.gov/climate/Resources/Files/climate/climate-action-plan.pdf

Step 3. Prepare assessment narrative

Finally, Montgomery Planning should create a narrative for the climate assessment that summarizes the information developed through the steps above. This would include a discussion of:

- The relevant activities that may positively or negatively impact GHG emissions and sequestration, and any uncertainties or considerations used in the assessment
- Options to mitigate GHG emissions
- Timeline of the ZTA and relevant implications for emissions impacts and mitigation options (i.e., how these may be distributed over the relevant timeline)
- Relevant papers or resources used in the assessment
- A qualitative discussion about how the ZTA contributes to or relates to the County's Climate Action plan GHG reduction strategies

Recommendations for master plans

To assess emissions impacts of master plans, ICF recommends a combined qualitative and quantitative approach. The qualitative aspects of the assessment are like that developed for ZTAs above, however there are additional quantitative methods to characterize GHG emissions and sequestration effects of a master plan.

Quantification Tool Development

ICF recommends that Montgomery Planning build on existing tools and data sources to develop a new tool that quantifies GHG emissions and sequestration for master plans. A quantified GHG climate assessment as outlined below will be conducted according to the specifications of the GHG quantification tool developed by Montgomery Planning. As such, ICF has provided its recommendations for the greenhouse gas quantification tool first. The tool is referenced as “GHG Quant Tool” in this section and in the GHG climate assessment recommendations below.

ICF recommends that Montgomery Planning start with the King County GHG Tool currently used for carbon footprint analyses, with modifications to increase the applicability to master plan climate assessments. Below we provide three types of recommendations:

1. Revisions and additions to current sector calculations and emission factors
2. Sequestration calculations: land cover, land cover change and forestry
3. Other recommendations

These recommended changes will require a new tool to be developed that leverages the existing King County tool used by Montgomery Planning. ICF recommends this tool still be maintained in Microsoft Excel for accessibility purposes.

Revisions and additions to current sector calculations and emission factors

ICF reviewed and evaluated the tool and data currently being used by Montgomery Planning to develop carbon footprints for master plans. Based on this evaluation ICF recommends updates and additions to the methodology within the tool (see Table 3) and the emission factors used (see Table 4). Note that the King County GHG Tool bases the timeline of its estimated emission factor impacts on the estimated lifetime of the relevant infrastructure (buildings) associated with the master plan’s development. ICF is proposing that the updated tool use a similar methodology, with an updated building lifetime assumption. Using updated data sources (from the year 2020), ICF has recalculated an updated average building lifetime for the United States’ Northeast region of approximately **90 years**. We are still evaluating this number and will finalize it during tool development.

Table 3. Methodology / calculation revisions or additions

Sector	Current Calculations	Recommended Calculation Revisions / Additions
Embodied Emissions	• Based on building type, square footage (commercial) or number of units (residential), building life span, and life span related embodied GHG emissions. • Also include the embodied emissions associated with pavement (for the entire assumed lifetime of the building).	• Add the upstream and end of life emissions associated with embodied emissions (i.e., production, transportation, and disposal of different types of materials used for construction).
Energy Emissions	• Based on the building type identified, the tool assumes the average floorspace, carbon coefficient, energy consumption, and lifespan to develop a lifespan energy related emissions per thousand square foot estimate.	• Montgomery Planning may optionally enter the projected floorspace that will be affected by the master plan if known. • Montgomery Planning may optionally enter the projected energy consumption if known, or the energy use intensity based on the building code vintage the building will comply with.

Sector	Current Calculations	Recommended Calculation Revisions / Additions
		• Montgomery Planning may enter data associated with the IGCC or other energy efficiency credentials of the building which would result in emission reductions, embodied energy, etc.
Transportation Emissions	• Calculates combustion emissions associated with transportation based on building type, assumed people in the unit or building, square footage, life span of the building, and Maryland state vehicle related GHG emissions.[17]	• Include life cycle/ upstream emissions associated with the fuel combusted (i.e., fossil fuel production and transportation). • Allow Montgomery Planning to enter an estimated total number of estimated building residents or daily occupants (i.e., employees). • Breakout emissions by transportation mode and vehicle type. Allow for Montgomery Planning to enter the vehicle types that are most likely to be impacted. • Include assumptions of future EV penetration and fuel mix rates.

Table 4. Recommended emission factor or assumption revisions[18]

Sector	Current Emission Factors and Assumptions	Recommended Revisions	Recommended Additions
Embodied Emissions	• Building materials and amenity assumptions (i.e., number of walls, windows roofs etc.): Buildings Energy Data Book 2001 • Residential floorspace per unit and building types: EIA Residential Buildings Energy Consumption Survey (RBECS) 2001 • Commercial building type definitions: Commercial Buildings Energy Consumption Survey (CBECS)	• Building materials and amenity assumptions: 2018 CBECS; 2020 RECS • Residential floorspace per unit and building types: RECS 2015 • Commercial building type definitions: 2018 CBECS • Embodied emission factors of average materials in buildings: EC3 - Find & Compare Materials (buildingtransparency.org)	• Assumptions related to upstream emissions associated with building materials (can see Roadway Construction Emissions Model, or Asphalt Pavement Embodied Carbon Tool - asPECT).

[17] This is calculated by dividing the 2006 Annual Washington State VMT by the total 2006 population to get VMT per person per year. Then the tool multiplies the weighted national average fuel efficiency for all cars and light trucks in 2005 to have a gallons of gasoline estimate per person per year and then uses an emission factor to convert this to GHG emissions per person per year.
[18] The climate assessments will use state or county specific values, where available.

Sector	Current Emission Factors and Assumptions	Recommended Revisions	Recommended Additions
	• Floorspace per building: EIA 2003 CBECS • Average window size: EIA 1993 • Pavement embodied emissions: based on four older life cycle assessments[19]	(includes average materials and average window size). • Floorspace per building: 2018 CBECS • Pavement embodied emissions: can develop this emission factor using GREET and reasonable input assumptions. • Building energy efficiency, renewable energy, and waste management: reference the most recent building code for this information.	
Energy Emissions	• Energy consumption for residential buildings: Building Energy Data Book 2007 • Energy consumption and floorspace per building for commercial buildings: EIA 2003 • Carbon Coefficient for buildings: Buildings Energy Data Book 2005 • Residential floorspace per unit: EIA 2001 • Average life span of residential buildings (also used for commercial buildings)[20]: Census 2001, Residential Energy Consumption Survey 2001	• Energy consumption for residential buildings: 2020 RECS • Energy consumption and floorspace per building for commercial buildings: 2018 CBECS • Carbon co-efficient for buildings: Building Performance Database (lbl.gov) (has emissions intensities based on building types) • Residential floorspace per unit: RECS 2015 • Recalculate the average life span of residential buildings using more	• Develop an average life span of commercial buildings that is separate from residential buildings (i.e., avoid using the same assumption for both residential and commercial buildings).

[19] Meil, J. A Life Cycle Perspective on Concrete and Asphalt Roadways: Embodied Primary Energy and Global Warming Potential. 2006. Available: http://www.cement.ca/cement.nsf/eee9ec7bbd630126852566c40052107b/6ec79dc8ae03a782852572b90061b914/$FILE/ATTK0WE3/athena%20report%20Feb.%202%202007.pdf
Park, K, Hwang, Y., Seo, S., M.ASCE, and Seo, H. , "Quantitative Assessment of Environmental Impacts on Life Cycle of Highways," Journal of Construction Engineering and Management , Vol 129, January/February 2003, pp 25-31, (DOI: 10.1061/(ASCE)0733-9364(2003)129:1(25)).
Stripple, H. Life Cycle Assessment of Road. A Pilot Study for Inventory Analysis. Second Revised Edition. IVL Swedish Environmental Research Institute Ltd. 2001. Available: http://www.ivl.se/rapporter/pdf/B1210E.pdf
Treloar, G., Love, P.E.D., and Crawford, R.H. Hybrid Life-Cycle Inventory for Road Construction and Use. Journal of Construction Engineering and Management. P. 43-49. January/February 2004.
[20] Average lifespan of residential buildings is manually calculated using the sources listed in the table. It is calculated by dividing the national average of existing housing stock in 2001 by the national average of new housing construction in 2001 to develop a replacement time estimate of buildings.

Sector	Current Emission Factors and Assumptions	Recommended Revisions	Recommended Additions
		recent housing data from New Residential Construction (census.gov) or under_cust.xls (live.com), newresconst.xls (live.com) (new housing stock), and 2020 RECS (existing housing stock). • Future Grid Resource Mix: use the 2030 GGRA Plan Modeling Data, refer to the Electricity Emissions – GGRA tab, row 88.	
Transportation Emissions	• Number of people per unit: Washington State Estimates 2007 • Residential Floorspace per unit: Residential Energy Consumption Survey 2001 • Number of employees per thousand square feet: Commercial Building Energy Consumption Survey 2003 • Vehicle-related GHG emissions estimates: • 2006 Washington State Annual VMT • 2006 Washington State Population • 2006 Transportation Energy Book - National Average Fuel Efficiency • Life-cycle fuel-related emission factors, RENew Northfield 2006	• Number of people per unit: 2020 RBECS, Montgomery Planning's Research and Special Project's Division may also have information on this. • Employees per thousand square feet: 2018 CBECS, Montgomery Planning's Research and Special Project's Division may also have information on this. • Use more accurate and recent fuel efficiency and fuel emission factors from NREL (average annual fuel use by vehicle type, fuel efficiency by vehicle type) • Use the most recent MWCOG transportation data to source annual VMT (from the MOVES model) and vehicle type distribution. • Use the most recent census for the Maryland population, or MWCOG	• Use VMT breakdown estimates based on vehicle type developed by NREL to distribute emissions across more vehicle types and fuel types.

Sector	Current Emission Factors and Assumptions	Recommended Revisions	Recommended Additions
		data for Montgomery County population. • Include life cycle/ upstream emissions associated with the fuel combusted (i.e., fossil fuel production and transportation): GREET tool and reasonable fuel mix / vehicle assumptions • Future EV Penetration Rates: use the 2030 GGRA Plan Modeling Data, refer to the ZEB LDVs Stock by Scenario tab, which conveys different penetration curves for types of vehicles.	

Sequestration calculations: land cover and management

ICF recommends the development of a new component within the GHG Quant Tool that can quantify changes in ecosystem carbon due to changes in area of forest, non-forest tree canopy, and green space. Ecosystem carbon changes can be calculated using land cover datasets, such as the National Land Cover Database (NLCD), and the IPCC Guidelines for National Greenhouse Gas Inventories. The guidelines provide global emission factors, carbon stock densities, and carbon stock change factors that can be combined with the NLCD land cover data to create an inventory of carbon stock and stock changes due to land cover through time and due to changes in land cover (e.g., expansion of forest). This method can be used to provide estimates of carbon stock changes associated with changes to tree canopy (both forests and non-forest) and green space. The IPCC methodology can be refined to reflect a region's landscape more accurately by first acquiring emission factors specific to that region and combining them with the IPCC provided equations (e.g., using localized and regional information such as that from the 2020 study evaluating the role of forests and trees in Montgomery County's GHG inventory[21]).

Additionally, there are multiple tools available to calculate both retrospective and projected emissions/carbons stocks associated with land cover and land cover change. For example, identified tools of interest are the ICLEI Land Emissions and Removals Navigator, which quantifies the greenhouse gas implications of land cover/cover change, and the IPCC based LEARN tool, which is being used by the World Resources Institute to update the GHG Inventory for Forests and Trees Outside Forests Summary Report for Montgomery County. Other resources are also under consideration as to how they can be

[21] "Examining the Role of Forests and Trees in Montgomery County's Greenhouse Gas Inventory." July 2020. https://www.montgomerycountymd.gov/climate/Resources/Files/climate/workgroup-recommendations/Examining%20the%20Role%20of%20Forests%20and%20Trees%20in%20Montgomery%20Countys%20Greenhouse%20Gas%20Inventory%20(July%202020).pdf

used to develop a simplified approach for sequestration calculations such as the Conservation Innovation Center (CIC) Land cover/Land Cover Data Project[22].

Finally, there is significant uncertainty in carbon sequestration from nature-based solutions. Since implementation of nature-based solutions is unlikely to change the effect of a master plan from net positive to negative (or vice-versa) and there is insufficient activity to accurately quantify either the effect or magnitude of their implementation, it is recommended that quantification for implementation of nature-based solutions be omitted from the tool refinement at this time.

Other recommendations

Along with the above recommendations, ICF recommends that the GHG Quant Tool:

- Include a better dashboard in the tool that can provide the graphics needed to be included in the final climate assessment report for a master plan.
- Include new spaces for better documentation of assumptions and data sources.
- Be updated at a regular interval to ensure that calculation methods, assumptions, and emission factors are recent and capture leading science and industry standards.
    - This includes working with MWCOG, regional research centers, and the State of Maryland to obtain additional data resources for future use, where feasible.

Table 5 below summarizes the required and optional inputs and outputs for the GHG Quant Tool.

Table 5. Summary of recommended GHG Quant Tool inputs for each sector

Sector	Required Inputs	Optional Inputs (for greater specification)	Proxy Data / Assumptions Available	Output
Embodied Emissions	Building types (residential or principal activity)	Number of units or square footage values; estimated building life span	Number of units or square footage values based on building type, life span embodied emissions (either per unit or per square foot)	Total and per square foot embodied GHG emissions
Energy Emissions	Building types	Square footage or total units; energy consumption per building per year	Square footage or total units; energy consumption per building per year	Total and per square foot energy GHG emissions; energy
Transportation Emissions	Building types	Number of people per unit or building, square feet per building, vehicle types	Number of people per unit or building, square feet per building, vehicle types	Total and annual transportation-related GHG emissions
Land Cover and Management	Area of tree cover planted, or removed	Carbon stock in above ground live biomass, below ground live biomass,	Carbon stock in above ground live biomass, below ground live biomass,	Carbon stocks and stock change for forest, non-forest tree cover, & green space

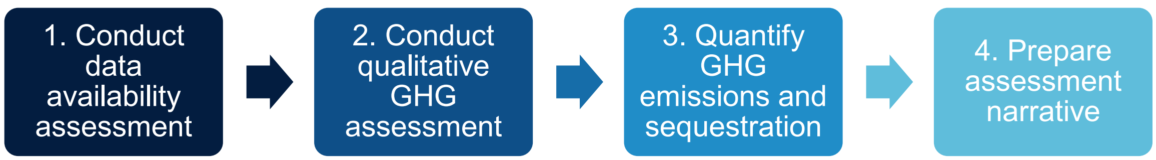
[22] Chesapeake Bay Program Land cover/Land Cover Data Project - Chesapeake Conservancy

	Area green cover created, restored, or removed	and soil organic carbon	and soil organic carbon	

GHG Climate Assessment for Master Plans

To accomplish master plan assessments, ICF recommends a step-wise approach to the assessments, presented in Figure 3.

Figure 3. Master plan GHG assessment recommended approach



Step 1. Conduct data availability assessment

For each type of activity data, Montgomery Planning should assess the available activity and emission factor data and document these using the framework in Table 6. As a part of this assessment Montgomery Planning should indicate:

- If the activity is applicable to the master plan (e.g., if there are no changes to forests or non-forest tree cover or canopy that activity can be confidently removed from the GHG and sequestration assessment)
- If all required data inputs are available, use the GHG Quant Tool to calculate emissions before continuing with the qualitative assessment.
- If there are missing required data inputs, but proxy data are or could be available for those missing data inputs, use the GHG Quant tool to calculate emissions before continuing with the qualitative assessment.
- If there are missing required data and no proxy data available, continue with the qualitative assessment.

Table 6. Applicability and data availability assessment framework

Sector	Required and Optional Data Inputs	**Applicability** to the Mater Plan (Yes/No, and reason)	Available Activity and Emission Factor Data (Yes/No)	Data Sources / Notes (List and link)	Proxy Data Available? (Yes/No)
Transportation	VMT				
	Number of trips				
	Non-vehicles modes of transportation				
	Public transportation use				
	Electric vehicle infrastructure access				
Building Embodied Emissions	Building certifications				
	Building square footage				
	Building life span				

	Pavement infrastructure
	Material waste produced
	Use of green building materials
Energy	Electricity usage
	Stationary fuel usage
	Electricity efficiency
	Stationary fuel efficiency
Land Cover & Management	Area of forest
	Area of non-forest tree canopy
	Area of green cover
	Implementation of nature-based solutions

Table 7 lists the relevant activities associated with each sector that is evaluated through both a qualitative and/or quantitative GHG assessment. While these checklists provide a starting point, they are not a comprehensive list of all potential GHG-related sectoral activities for a specific master plan. Montgomery Planning Staff are encouraged to supplement with additional data and information as appropriate.

Table 7. Activity data associated with each sector

Sector	Activity Data
Transportation	• Vehicle miles traveled by type (personal vehicles, commercial trucks or vehicles, rideshare, school buses, motorcycles) • Number of trips (including considering single occupancy or carpool trips) • Non-vehicle modes of transportation (scooter, bikes, walking) • Public transportation use (public bus and Metrorail) • Electric vehicle infrastructure access
Buildings	• Building certifications (e.g., LEED) • Building square footage • Building life span • Pavement infrastructure • Material waste produced • Types of building construction materials
Energy	• Electricity usage (including distributed and renewable energy) • Stationary fuel usage (natural gas, fuel oil, or LPG) • Electricity efficiency (kilowatt-hour per square foot) • Stationary fuel efficiency (BTU per square foot)
Land Cover and Management	• Area of forest expanded/removed • Area of non-forest tree canopy expanded/removed • Area of green cover installed or removed • Area of nature-based solutions installed or removed

Step 2. Conduct qualitative GHG assessment

For activities for which data or proxy data truly are not available the qualitative approach provided for ZTAs can be used to assess GHG emissions and sequestration effects of a master plan. This assessment should be done in a targeted manner for those activities or sectors that cannot use quantification methods and the results should be presented separately from the quantitative assessment.

Step 3. Quantify GHG emissions and sequestration

For activities for which source and emission factor data or proxy data are available Montgomery Planning should use the GHG Quant Tool to calculate GHG emissions and sequestration. These outputs should be summarized in a tabular and visual format. ICF recommends that the GHG Quant Tool include a dashboard that effectively produces and displays this information.

Step 4. Prepare assessment narrative

Montgomery Planning should provide:

- A quantitative summary of the master plan’s contribution to sectoral and total GHG emissions and sequestration, placed in the context of the county’s most recent GHG inventory and County, MWCOG, and Maryland GHG reductions goals but also noting differences in emission boundaries, timelines, and scopes
- A summary of the data sources and vintage of data used, as well as any assumptions made, or data gaps filled
  - Assumptions related to future changes in EV penetration, energy efficiency, and grid fuel mix should be included here
- Options to mitigate GHG emissions
- Timeline of the master plan and relevant implications for emissions impacts and mitigation options (i.e., how these may be distributed over the relevant timeline)
- To contextualize the qualitative assessment if conducted, Montgomery Planning should follow the recommendations within Step 3 (narrative) for ZTAs

The narrative should be written in plain language accessible to non-specialists.

2.2 Assessing Impacts to Community Resilience and Adaptive Capacity

ICF recommends a two-step approach to assess the potential impacts of ZTAs or master plans on community resilience and adaptive capacity. The recommended approach is primarily qualitative, but allows for quantification where possible.

The approach to assessing impacts to community resilience and adaptive capacity strives to simultaneously enable:

- Efficient assessment of ‘no impacts’ in the case of potential ZTAs unrelated to climate resilience issues
- Thorough consideration of potential impacts where they occur
- A range of qualitative and quantitative approaches to evaluate those potential impacts

With these goals in mind, ICF the climate assessment template provides:

- **A streamlined checklist** of considerations for Montgomery Planning to review to quickly determine potential positive or negative impacts to community resilience and adaptive capacity impacts from proposed ZTAs and master plans, **paired with**
- **More detailed guidance** and example climate assessment text Montgomery Planning can build upon to craft a narrative explaining each ZTA or master plan’s effects on community resilience and adaptive capacity

See Table 8 for this checklist, and the Explanation of resilience factors section (beginning on page 30) for the guidance.

For the purposes of this climate assessment, Montgomery Planning is applying the following definitions:

- **Community resilience**: The sustained ability of a network of people to use available resources to withstand, respond, recover, and adapt to future climate hazards

- **Adaptive capacity:** The capacity of people, systems, and a network of assets to cope with a climate hazard

In other words, adaptive capacity is one component of community resilience. Community resilience is the inverse of vulnerability, so the checklist of considerations is organized into the core components of vulnerability (and resilience), namely *exposure* (the level of contact people, systems, and assets have with a climate hazard – such as number of people in a hazard area), *sensitivity* (the potential severity of impact to people, systems, and assets if exposed to a climate hazard), and *adaptive capacity.* There is intentional overlap across factors in the checklist, and list of factors in the checklist is not intended to be comprehensive, but prompt Montgomery Planning staff to consider how any ZTA or master plan could influence community resilience and adaptive capacity from multiple angles.

ICF drew upon the literature review (largely captured in the synthesis work of the National Academies of Sciences *Building and Measuring Community Resilience* report[23]), the state of the practice reflected in ICF's work for a range of clients and in canvassing the American Society of Adaptation Professionals (ASAP) and Urban Sustainability Directors Network (USDN), and the causal linkages to drivers of community resilience, adaptive capacity, and vulnerability in Montgomery County, specifically building on the work done in the county's most recent vulnerability assessment. In determining the list of factors, we also sought to strike an appropriate level of detail so that the factors are detailed enough for Montgomery Planning to readily identify the effects and have a repeatable, transparent approach but not too detailed that it is cumbersome to complete. With this list we want to ensure Montgomery Planning is prompted to consider a comprehensive set of potential community resilience drivers and impacts, including allowing for flexibility for that set of factors to include items not identified today. Pairing this set of factors with additional information about each is intended to offer Montgomery Planning a way to quickly assess the evidence base for determining potential impacts.

Recommended approach for ZTAs and master plans

For both ZTAs and master plans, ICF recommends the following two-step process.

Step 1. Complete community resilience and adaptive capacity checklist

To determine potential positive or negative impacts to community resilience and adaptive capacity, Montgomery Planning staff should use the checklist in Table 8 and accompanying guidance in the Explanation of resilience factors section (beginning on page 30) to assess each resilience factor. As mentioned above, community resilience is the inverse of vulnerability, so the resilience factors are organized into the three core components of vulnerability: *exposure* (factors that influence the level of contact people, systems, and assets have with a climate hazard), *sensitivity* (factors that increase or decrease the severity of impacts to people, systems, and assets from a climate hazard), and *adaptive capacity* (factors that increase or decrease people or society's ability to cope with adverse impacts). Some factors in the checklist may have applications across multiple components of vulnerability and the checklist is also not intended to be comprehensive, rather designed to prompt Montgomery Planning staff to consider multiple dimensions of how a ZTA or master plan could affect resilience.

The current list of factors focuses on community resilience and adaptive capacity links that are most likely to be applicable to ZTAs and master plans. For master plans, information on many of these factors may already be being collected through the Existing Conditions Assessments stage of the master planning

[23] National Academies of Sciences, Engineering, and Medicine 2019. *Building and Measuring Community Resilience: Actions for Communities and the Gulf Research Program.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25383.

process. The “other” option is meant to capture additional or more tailored factors that may be relevant to a specific ZTA or master plan. When completing the checklist, Montgomery Planning should consider whether to use the “other” option to add additional factors with resilience or adaptive capacity links (e.g., change to access to health care, change to pest prevalence, change in disease vectors, change to agricultural reserve) as appropriate for the specific ZTA or master plan. If Montgomery Planning finds they are repeatedly adding certain “other” factors, they should consider formally adding those factors to the template.

Some of the factors are reflected in both the GHG emissions and community resilience checklists (Table 1 and Table 8, respectively) and are noted with an asterisk(*). Montgomery Planning should consider the collective overall impact of these factors across both mitigation and community resilience and adaptive capacity to understand potential co-benefits or trade-offs (i.e., mix of positive and negative impacts).

Table 8. Community resilience and adaptive capacity checklist

Does the ZTA/Master Plan concern any of the following factors:			*If yes, are changes to that factor expected to have a positive or negative impact on community resilience?*	
Exposure-Related Factors	**No Impact**	**Yes**	**Positive Impact** (change reduces people or infrastructure experiencing a hazard)	**Negative Impact** (change increases people or infrastructure experiencing a hazard)
Activity in flood risk areas	☐	☐	☐	☐
Activity in urban heat island	☐	☐	☐	☐
Exposure to other hazards (e.g., storms, wind, drought)	☐	☐	☐	☐
Other: _______________	☐	☐	☐	☐
Sensitivity-Related Factors	**No**	**Yes**	**Positive Impact** (change reduces impact severity)	**Negative Impact** (change increases impact severity)
Change to forest cover*	☐	☐	☐	☐
Change to non-forest tree canopy*	☐	☐	☐	☐
Change to quality or quantity of other green areas (e.g., wetlands, meadows, turf)*	☐	☐	☐	☐
Change to impacts of heat (e.g., cool pavements, cool roofs, air conditioning, energy efficiency improvements)*	☐	☐	☐	☐
Change in perviousness*	☐	☐	☐	☐
Change in stormwater management system treatments	☐	☐	☐	☐
Change to water quality or quantity	☐	☐	☐	☐
Change to air quality	☐	☐	☐	☐
Infrastructure design decisions (e.g., sizing, materials)*	☐	☐	☐	☐

Other: ____________________	☐	☐	☐	☐
Adaptive Capacity Factors	**No**	**Yes**	**Positive Impact** (change increases ability to respond and bounce back)	**Negative Impact** (change reduces ability to respond and bounce back)
Change to accessibility or prevalence of community and public spaces (e.g., libraries, air-conditioned cooling centers)	☐	☐	☐	☐
Change to emergency response and recovery capabilities	☐	☐	☐	☐
Change in access to transportation	☐	☐	☐	☐
Change to accessibility or prevalence of local food sources and other goods	☐	☐	☐	☐
Change in availability or distribution of economic and financial resources (e.g., employment, income equality, business size and diversity)	☐	☐	☐	☐
Change to community connectivity (e.g., social connections, sense of place and belonging)	☐	☐	☐	☐
Change in distribution of resources and support	☐	☐	☐	☐
Other: ____________________	☐	☐	☐	☐

*Overlaps with a greenhouse gas emissions sector or activity

Step 2. Prepare assessment narrative

Based on the results of applying the checklist, Montgomery Planning should prepare the climate assessment narrative describing the potential impacts on community resilience and adaptive capacity and document assumptions, drawing from the explanations of resilience factors below as appropriate. The narrative should describe:

- Overall potential impacts on community resilience and adaptive capacity, and rationale for the assessment
- Consideration of potential timing of impacts as known and appropriate
- Any assumptions driving the consideration of potential impacts, with sources cited as appropriate
- Knowledge gaps or limitations related to the impact assessment
- Options to reduce potential negative impacts (several examples are embedded within each of the factor descriptions)

The narrative should be written in plain language accessible to non-specialists.

The explanations of resilience factors below may provide a starting point for Montgomery Planning to use in crafting the narratives. The impact of each individual factor as well as the collective set of applicable factors should be considered carefully, as some ZTAs and master plans may have mixed effects on resilience. For example, a master plan that aims to redevelop a wetland into affordable housing and commercial space will enhance a community's economic and social resilience but will decrease the community's environmental resilience by removing a natural carbon sink and flood buffer zone. The change in surface cover may also have implications for flood risk. Montgomery Planning should note these considerations and tradeoffs in the narrative.

Explanation of resilience factors

This section serves as companion guidance to the above checklist. For each factor in the checklist, ICF has provided:

(1) An overview of options to quantify (if possible) or qualitatively describe the effects of the ZTA or master plan on that factor.
(2) Narrative explaining the relationship between climate change impacts, community resilience and adaptive capacity, and the factor.

Exposure-Related Factors

Activity in flood risk areas

Potential evaluation approaches: This factor evaluates whether the ZTA or master plan could change the amount of people or infrastructure located in a flood risk area. To do this, Montgomery Planning should review available flood risk maps for the relevant planning area to determine the extent of flood risk in that area. Montgomery Planning should also overlay the county's equity focus areas to determine whether socially vulnerable populations may be affected. Available flood risk data in Montgomery County is rapidly evolving, and the Montgomery Planning staff should coordinate with Montgomery County DEP to ensure access to the latest available. Currently, Montgomery County's floodplain districts are delimited by the Federal Emergency Management Agency (FEMA)'s 100-year floodplain, which indicates areas that have a 1% chance each year of flooding, as well as waterways with a drainage area of 30 acres or more plus a 25-acre buffer mapped by the Maryland-National Capital Park and Planning Commission (M-NCPPC). The FEMA and the M-NCPPC floodplains can be viewed in MC Atlas under Environmental Features. Montgomery Planning could also consider current and projected future populations, including the possibility that climate change may increase the likelihood of in-migration to Montgomery County from low-lying areas.

How this factor affects community resilience: Activity in the floodplain could increase the amount of people or infrastructure located in a flood risk area and negatively affect community resilience. Development in the floodplain is already heavily regulated by the County.[24] If the development falls outside of the floodplain and buffer area, there may be lower risk. However, increased intense precipitation events may affect buildings and infrastructure that lie outside of the current floodplain.[25] Socially vulnerable groups in these areas may be disproportionately impacted by flood risk, such as populations that reside in dense metro areas, low-lying areas within floodplains, neighborhoods with little or no green spaces to help capture stormwater, and areas that have received less flood protection investment in the past.[26] Furthermore, vulnerable communities in urban areas often reside in basement apartments, which are more likely to be flooded during extreme precipitation events.[27] Vulnerable communities also tend to have fewer resources to repair damages to homes following flood events.[28] In

[24] Montgomery County Department of Permitting Services. "Floodplain District Permits." Accessed October 31, 2022. https://www.montgomerycountymd.gov/DPS/Process/ld/floodplain-district-permit.html
[25] "Montgomery County Climate Action Plan," June 2021, pp.54. https://www.montgomerycountymd.gov/green/Resources/Files/climate/climate-action-plan.pdf.
[26] "Montgomery County Climate Vulnerability Assessment," December 10, 2020, pp. 61.
[27] "Montgomery County Climate Action Plan," June 2021, pp. 27.
[28] "Montgomery County Climate Action Plan," June 2021, pp. 27.

flood-prone areas, existing emergency shelters, homeless shelters, and cooling centers can be relocated, elevated, or expanded to decrease flood exposure.[29]

Requiring new development to meet stricter floodplain standards, such as limiting new development to the 500-year floodplain or floodproofing to a certain amount above the base flood elevation, are examples in which a ZTA or master plan can enhance community resilience to flooding.

Activity in urban heat island

Potential evaluation approaches: This factor evaluates whether the ZTA or master plan could change the amount of people or infrastructure located in an urban heat island. Generally, development in urban parts of the county will increase the urban heat island effect, while the creation of parks or green spaces will reduce the urban heat island effect. Using MC Atlas or a different geospatial tool, Montgomery Planning should overlay the proposed area for new development with temperature data from the Climate Action Plan or the city's urban heat island map once available to determine if the proposed ZTA or Master Plan will affect areas that already experience higher than average temperatures. Montgomery Planning should overlay the county's equity focus areas to determine whether socially vulnerable populations may be affected. Montgomery Planning could also consider current and projected future populations, including the possibility that climate change may increase the likelihood of in-migration to Montgomery County from vulnerable areas.

How this factor affects community resilience: Activity in areas of the county that already experience higher temperatures or new development that may increase the urban heat island effect would negatively affect community resilience by increasing the amount of people exposed to heat. Certain populations (e.g., young children, the elderly, and those with asthma or pre-existing conditions), can be especially sensitive to extreme heat. Development that replaces natural, cooling surfaces with materials that absorb, store, and re-emit heat (e.g., asphalt, concrete) exacerbates the urban heat island effect.[30] [31] The urban heat island effect can be reduced by incorporating green infrastructure into street upgrades, incorporating nature-based design into all landscapes, planting trees and vegetation in urban areas, building green roofs, and increasing forest and non-forest tree canopy cover.[32]

Exposure to other hazards

Potential evaluation approaches: This factor evaluates whether the ZTA or master plan could change the amount of people or infrastructure exposed to other climate hazards like severe storms, wind, and drought. Montgomery Planning should refer to the county's climate vulnerability assessment to consider exposure and vulnerability to these hazards.[33] Montgomery Planning should also compare the county's equity focus areas to determine whether socially vulnerable populations may be affected. Montgomery Planning could also consider current and projected future populations, including the possibility that climate change may increase the likelihood of in-migration to Montgomery County from vulnerable areas.

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[29] "Montgomery County Climate Action Plan," June 2021, pp. 211.
[30] EPA. "Learn About Heat Islands." Accessed October 31, 2022. https://www.epa.gov/heatislands/learn-about-heat-islands
[31] "Montgomery County Climate Vulnerability Assessment," December 10, 2020, pp. 63. https://www.montgomerycountymd.gov/climate/Resources/Files/climate/climate-action-plan-appendix-c-climate-vulnerability-assessment.pdf
[32] EPA. "Reduce Urban Heat Island Effect." Accessed October 31, 2022. https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect
[33] "Montgomery County Climate Vulnerability Assessment," December 10, 2020.

How this factor affects community resilience: Severe storms and wind can negatively affect public safety (e.g., flying debris) and cause damage and disruptions to critical infrastructure (e.g., loss of power).[34] High winds can discourage sustainable forms of transportation such as biking and walking. Drought is mainly a concern for agricultural areas in the county and how that may impact the food supply.[35] There may be water supply concerns as well. Adaptive measures can be taken to help mitigate negative impacts from these hazards such as using wind-resistant building materials or designs and using irrigation techniques or planting more drought-tolerant crops.

Other

Finally, Montgomery Planning should consider whether there are any other factors that might influence the ZTA or master plan's impact on community resilience and adaptive capacity, such as factors that could influence the exposure of people or infrastructure to climate or climate-related hazards. For example, if a ZTA or master plan could change the number of people close to an air pollution source (e.g., highways, industrial facilities), that could increase overall exposure to an existing hazard that is exacerbated by climate change).

Sensitivity-Related Factors

Change to forest cover

Potential evaluation approaches: Depending on the nature of the ZTA or master plan, Montgomery Planning may be able to determine quantitatively how the ZTA or master plan could change forest cover. The Montgomery County Tree Canopy Explorer provides percent tree canopy (both forest and non-forest) for any selected area in the county in 2009 and 2018.[36] The USDA Forest Service also offers various tools to map and assess forest cover in the state of Maryland.[37] This data could be used as a baseline to evaluate to what extent any ZTA or master plan may change forest cover. Additionally, percent forest cover is a valuable indicator because it can be mapped over large contiguous areas using aerial imagery and other similar monitoring techniques. This data could be relevant to both ZTAs and master plans in that Montgomery Planning can look at the percent forest cover over a ZTA area in relation to land covers proposed and in relation to specific elements of a master plan. More frequent and current data collection would be required to determine any trends in percent forest cover.

Qualitative considerations for how a ZTA or master plan could affect forest cover include:
Does the ZTA or master plan…

- Protect existing forests and maintain existing forest cover
- Encourage expansion of forest cover
- Encourage features to safeguard existing forest from natural damage (e.g., loss of trees from a severe wind or storm event, as well as wildfires, pests, or invasive species)

How this factor affects community resilience: Increases in forest cover can increase community resilience by reducing impacts related to extreme heat (e.g., by reducing local temperatures and improving air quality). Forest cover also provides significant GHG reduction benefits by sequestering carbon in wood and soil.[38] Forest cover is an asset to communities, providing a variety of co-benefits,

[34] Montgomery County Climate Vulnerability Assessment," December 10, 2020, pp. 37.
[35] Montgomery County Climate Vulnerability Assessment," December 10, 2020, pp. 63.
[36] "Montgomery County Tree Canopy Explorer." Accessed September 29, 2022. https://mcplanning.maps.arcgis.com/apps/MapJournal/index.html?appid=b71564815e4942389e78a5183bb7176e.
[37] "Forest Inventory and Analysis National Program," accessed October 31, 2022, https://www.fia.fs.usda.gov/.
[38] "Montgomery County Climate Action Plan," June 2021, pp. 183.

such as improved water quality, improved stormwater management, and enhanced biodiversity.[39] Retention and increases in forest cover are vital for communities, as increased access to nature improves mental health and strengthens community and social ties.[40] Furthermore, forest conservation and management efforts increase economic prosperity by providing new job opportunities in a range of areas, including forest planning and pest management.[41]

Change to non-forest tree canopy

Potential evaluation approaches: Depending on the nature of the ZTA or master plan, Montgomery Planning may be able to determine quantitatively how the ZTA or master plan could change non-forest tree canopy (e.g., area with changes in non-forest tree canopy, number of trees to be planted or removed). The Montgomery County Tree Canopy Explorer provides percent tree canopy (both forest and non-forest) for any selected area in the county in 2009 and 2018.[42] This data could be used as a baseline to evaluate to what extent any ZTA or master plan may change non-forest tree canopy. Additionally, percent non-forest tree canopy is a valuable indicator because it can be mapped over large contiguous areas using aerial imagery and other similar monitoring techniques. This data could be relevant to both ZTAs and master plans in that Montgomery Planning can look at the percent non-forest tree canopy over a ZTA area in relation to land covers proposed and in relation to specific elements of a master plan. More frequent and current data collection would be required to determine any trends in percent non-forest tree canopy changes.

Qualitative considerations for how a ZTA or master plan could affect non-forest tree canopy include: Does the ZTA or master plan…

- Protect existing non-forest tree canopy, particularly in vulnerable areas, as well as large, mature non-forest canopy trees
- Avoid significant net decrease in non-forest tree canopy (e.g., through increased development)
- Encourage new planting of trees to increase the total percent non-forest tree canopy
- Encourage features to safeguard existing trees from natural damage (e.g., loss of trees from a severe wind or storm event)

How this factor affects community resilience: Increases in non-forest tree canopy can increase community resilience by reducing impacts related to extreme heat and the urban heat island effect. For example, extreme heat can lead to heat-related illnesses or exacerbate existing health conditions like asthma. Increased non-forest tree canopy helps to provide more shaded cover and reduce local temperatures. In areas with abundant natural areas summer temperatures are reportedly 10-16°F cooler than surrounding areas with no trees.[43] Non-forest tree canopy is an asset to communities and provides significant GHG reduction benefits (through carbon sequestration) and co-benefits.[44] Non-forest tree canopy in urban areas can also help reduce energy consumption by reducing local summer temperatures and providing windbreaks during the winter.[45] For example, planting trees in residential areas can reduce energy bills by 3 to 30 percent, depending on factors such as tree size, location, and type.[46] Furthermore,

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[39] "Montgomery County Climate Action Plan," June 2021, pp. 186.
[40] "Montgomery County Climate Action Plan," June 2021, pp. 187.
[41] "Montgomery County Climate Action Plan," June 2021, pp. 186-7.
[42] "Montgomery County Tree Canopy Explorer." Accessed September 29, 2022. https://mcplanning.maps.arcgis.com/apps/MapJournal/index.html?appid=b71564815e4942389e78a5183bb7176e.
[43] "Planting Trees In Our Changing Climate | University of Maryland Extension." Accessed September 29, 2022. https://extension.umd.edu/resource/planting-trees-our-changing-climate.
[44] "Montgomery County Climate Action Plan," June 2021, pp. 102.
[45] "Montgomery County Climate Action Plan," June 2021, pp. 184.
[46] "Planting Trees In Our Changing Climate | University of Maryland Extension." Accessed September 29, 2022.

non-forest tree canopy reduces stormwater runoff and improves quality of life and wildlife habitats. Retention and increases in non-forest tree canopy are vital for communities, especially in areas that are more vulnerable to the urban heat island effect (e.g., high-density residential areas with fewer trees and more impervious area).[47]

Change to quality or quantity of green cover

Potential evaluation approaches: Depending on the nature of the ZTA or master plan, Montgomery Planning may be able to determine quantitatively how the ZTA or master plan could affect areas of green cover (e.g., meadows and wetlands). Montgomery Planning can refer to existing geospatial datasets describing environmental resources to determine which natural areas could be affected by the ZTA or master plan. For example, the National Wetlands Inventory provides county-level wetland data and maps for the state of Maryland.[48] More frequent and current data collection would be required to determine any trends in percent wetland area, and additional databases would be required to map other types of non-wetland natural areas.

How this factor affects community resilience: Increases in the amount or health of non-forest natural areas can increase community resilience by reducing impacts related to extreme precipitation and flooding (e.g., by reducing stormwater runoff) and extreme heat (e.g., reducing urban heat island effect). Non-forest natural areas, such as meadows and wetlands, help absorb excess water and reduce stormwater runoff during extreme precipitation events.[49] These areas are essential for communities as they reduce flooding and improve water quality. Furthermore, non-forest natural areas help sequester carbon and consequently improve air quality.[50] They also help restore and build soils in addition to providing vital habitats for declining species. The conservation of existing non-forest natural areas is especially important because it is difficult to create these natural ecosystems.[51]

Change to impacts of heat

Potential evaluation approaches: This factor describes to what extent the ZTA or master plan may affect the impacts of high temperatures, such as the presence of the urban heat island or residents' Ability to cope with heat. This is particularly relevant to low-income, disabled, and elderly populations as well as those with asthma or other pre-existing conditions, who may be more vulnerable to extreme heat.[52] Montgomery Planning should use the heat map from the Climate Action Plan or the county's urban heat island map to determine if the proposed ZTA or master plan covers an area with higher average temperatures and socially vulnerable populations, and also consider the following to determine whether the ZTA or master plan might contribute to or reduce the urban heat island effect:
Does the ZTA or master plan:

- Preserve/increase/decrease tree and vegetative cover?
- Replace asphalt or concrete with cool pavements that are either reflective or permeable?
- Promote the installation of cool roofs or green roofs?
- Replace paved roads or buildings with natural vegetation, wetlands, or green space? (see description for heat exposure)

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[47] "Montgomery County Climate Vulnerability Assessment," December 10, 2020, pp. 63.
[48] "Maryland Wetlands - Wetlands (National Wetlands Inventory)," accessed October 31, 2022, https://data.imap.maryland.gov/datasets/209f2ea6b146475d91bef53422a019fc_2.
[49] "Montgomery County Climate Action Plan," June 2021, pp. 190.
[50] "Montgomery County Climate Action Plan," June 2021, pp. 190.
[51] "Montgomery County Climate Action Plan," June 2021, pp. 190.
[52] Nayak et al. "Development of a Heat Vulnerability Index for New York State" *Public Health,* Volume 161, 2018, Pages 127-137, ISSN 0033-3506, https://doi.org/10.1016/j.puhe.2017.09.006.

- Promote taking public transportation over driving (e.g., adding bus stops, metro stations, bikeways, or walkways)? (see descriptions for land cover change)

How this factor affects community resilience: Temperatures are expected to increase in Montgomery County, posing a growing threat to human and animal health, natural resources, agriculture, and infrastructure.[53] Equity is important when considering how a ZTA or master plan will affect heat distribution. Researchers have found in counties across the nation that areas with more low-income and non-white residents are exposed to higher average temperatures.[54] These areas are usually more built-up and have less vegetation (parks and trees) than cooler parts of cities. The Montgomery Climate Action Plan found that socially vulnerable communities in the county have a high percentage of impervious surfaces when compared to the county average, which likely means they experience higher temperatures and are more likely to experience extreme flooding.[55] A ZTA or master plan that exacerbates the urban heat island by increasing impervious surface cover or using building materials that absorb, rather than reflect, heat will heighten the risk of heat-related illness and disease in residents least equipped to deal with heat impacts and decrease community resilience. Many of the solutions for flood control and prevention will also reduce heat impacts, such as green roofs, increasing tree and vegetation cover, installing bioretention devices, and permeable pavements and gardens.

Change in perviousness

Potential evaluation approaches: This factor describes to what extent the ZTA or master plan may increase or decrease perviousness in the area. Depending on the nature of the ZTA or master plan, information may be available that quantifies the change in perviousness, such as percent change in impervious area, or an indication of the amount of land area that could increase or decrease in perviousness.

Additionally, percent impervious cover is a valuable indicator because it can be mapped over large contiguous areas from historic periods to present day using aerial imagery and other similar monitoring techniques. This feature of the data means it can be relevant to both ZTAs and master plans in that Montgomery Planning can look at the percent impervious cover and trend of changes in percent impervious over a ZTA area in relation to land covers proposed and in relation to specific elements of a master plan.

How this factor affects community resilience: Increases in pervious surfaces (e.g., permeable pavement, soil, turf, etc.) typically contribute to community resilience by increasing the ground's capacity to absorb water and, as a result, reduce flooding.[56] Increases in nature-based solutions and green infrastructure can also reduce flood risk by absorbing excess water and reducing stormwater runoff.[57] Changes in perviousness can also affect heat sensitivity (see the descriptions for changes in different surface cover types (e.g., forest cover) and change to impacts of heat for more details. Furthermore, increasing pervious surface reduces pollutant concentrations in runoff and improves water quality (see description of change to water quality to quantity).[58] On the flip side, increase in impervious surface (e.g., pavement) can contribute to flooding and lower resilience, unless paired with countervailing measures to

[53] "Montgomery County Climate Action Plan," June 2021, pp. 202.
[54] Benz, Susanne Amelie and Jennifer Anne Burney. 2021. "Widespread Race and Class Disparities in Surface Urban Heat Extremes Across the United States." *Earth's Future*, 9 (7) DOI: 10.1029/2021EF002016.
[55] "Montgomery County Climate Action Plan," June 2021, pp. 217.
[56] "Montgomery County Climate Action Plan," June 2021, pp. 217..
[57] "Montgomery County Climate Action Plan," June 2021, pp. 214.
[58] "Pervious Surfaces | Thousand Oaks, CA." Accessed October 28, 2022. https://www.toaks.org/departments/public-works/sustainability/water/landscaping-and-lawns/pervious-surfaces.

alleviate stormwater impacts.[59] Extreme precipitation can have a major impact on community resilience by threatening lives and causing extensive flooding of roads, buildings, and other critical infrastructure.[60] Impervious areas cause a greater volume of water to runoff into stormwater systems and at faster rates. Consequently, areas with higher percent impervious cover are more likely to encounter stormwater flooding during heavy rainfall because the additional runoff can cause stormwater infrastructure to overflow onto the surrounding streets and sidewalks and into homes and other buildings (see description of change in stormwater management system treatments).[61]

Change in stormwater management system treatments

Potential evaluation approaches: This factor evaluates whether the ZTA or master plan could affect the type of stormwater treatments within the affected area. Qualitative considerations for how a ZTA or master plan could affect stormwater management system treatments include:
Does the ZTA or master plan…

- Improve or upgrade existing stormwater management systems and grey infrastructure to decentralize stormwater management and increase runoff capture storage, especially in vulnerable areas
- Encourage green infrastructure to reduce stormwater runoff and flooding, such as bioswales, rain gardens, and green roofs
- Indirectly increase or decrease stormwater management capacity, such as through changes to surface cover (see descriptions of land cover and perviousness)

How this factor affects community resilience: Changes to stormwater management system treatments can increase community resilience by reducing impacts related to extreme precipitation and flooding (e.g., by reducing stormwater runoff). Stormwater management systems can be especially vulnerable to extreme precipitation and flooding due to undersized pipes, accumulations of sediment and debris, as well as insufficient water-holding capacity (e.g., management ponds can be overtopped or bioretention facilities can be washed out).[62] Efficient and resilient stormwater management systems are vital for communities, especially for populations who are more susceptible to flood-related impacts (e.g., populations residing in dense metro areas or low-lying areas within floodplains).[63] Upgrades to stormwater management systems and investment in new infrastructure can increase the resilience of these systems to extreme precipitation events. For example, green infrastructure components such as rain gardens and bioswales can help decentralize stormwater management and consequently distribute runoff capture storage.[64] Furthermore, investment in regular maintenance and debris removal can help prevent choke points within pipes, which decrease flow in stormwater management systems and consequently lead to greater rates of flooding, as well as increased costs due to post-storm repairs.[65] Increases in stormwater management capacity can also offset adverse impacts related to decreases in pervious areas.

[59] “Montgomery County Climate Action Plan,” June 2021, pp. 217.
[60] “Montgomery County Climate Vulnerability Assessment,” December 10, 2020, pp. 49.
[61] “Montgomery County Climate Action Plan,” June 2021, pp. 64.
[62] “Montgomery County Climate Vulnerability Assessment,” December 10, 2020, pp. 39.
[63] “Montgomery County Climate Vulnerability Assessment,” December 10, 2020, pp. 50.
[64] “Montgomery County Climate Vulnerability Assessment,” December 10, 2020, pp. 50.
[65] “Montgomery County Climate Vulnerability Assessment,” December 10, 2020, pp. 39, 50.

Change to water quality or quantity

Potential evaluation approaches: Depending on the nature of the ZTA or master plan, Montgomery Planning may be able to qualitatively determine how the ZTA or master plan could change water quality or quantity.

How this factor affects community resilience: Improvements in water quality or increases in water quantity can increase community resilience by reducing a variety of climate change impacts, including extreme heat, drought, and heavy precipitation and precipitation. Extreme heat events can lead to drought conditions and wildfires, causing water shortages. Extreme precipitation events can increase stormwater runoff, contaminating water with pollutants and sediment. Flood events can also increase the risk of mold and cause health impacts. Improving water quality and access will benefit public health and critical health and sanitation services. Clean water is also essential for the mental and physical health of communities.[66] Tree trenches and other green infrastructure can be used to store and filter stormwater runoff, providing both improved water quality and other runoff reduction benefits (see description of stormwater management system treatments).[67] Extended detention wetlands can also improve water quality in addition to reducing flood risk and providing ecological benefits (see description of change to quality or quantity of green cover).[68] Recycling greywater can increase water quantity by making more finished water available for other uses. Raising dams and removing sediment in reservoirs can also increase water supply by increasing water storage capacity.[69]

Change to air quality

Potential evaluation approaches: This factor relates to whether the ZTA or master plan has the potential to affect outdoor or indoor air quality. In the absence of quantitative information, qualitative considerations for how a ZTA or master plan could improve community resilience through infrastructure design include:

Does the ZTA or master plan…

- Electrify transit buses, especially those that run through neighborhoods disproportionately exposed to air pollution?
- Support tree-planting and forest retention? (see descriptions for non-forest and forest cover change)
- Incentivize electrification or other emissions-reducing technologies for heating, ventilation, cooking, water heating, or HVAC systems in homes or buildings?
- Improve or expand public transportation?
- Provide incentives or subsidies to socially vulnerable communities to retrofit or install climate adaptive and energy efficient technologies?
- Create green spaces or promote green infrastructure and nature-based design (e.g., understory trees, rain gardens, vegetated rights-of-way)?

How this factor affects community resilience: Exposure to air pollution can lead to higher rates of premature birth and cancer and increased risk of respiratory illness and cardiovascular disease.[70] Socially

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[66] "Why Is Clean Water Important to Communities?," Healing Waters, January 22, 2021, https://healingwaters.org/why-do-communities-need-clean-water/.
[67] OP US EPA, "Adaptation Actions for Water Quality," Overviews and Factsheets, May 10, 2016, https://www.epa.gov/arc-x/adaptation-actions-water-quality.
[68] OP US EPA, "Adaptation Actions for Water Quality," Overviews and Factsheets, May 10, 2016.
[69] OP US EPA, "Adaptation Actions for Water Quality," Overviews and Factsheets, May 10, 2016
[70] Wong M, et al." Community-Engaged Air Monitoring to Build Resilience Near the US-Mexico Border." *Int J Environ Res Public Health*. February 2020, 9;17(3):1092. doi: 10.3390/ijerph17031092.

vulnerable communities are disproportionately exposed to sources of air pollution because they are located closer to ports, freeways, and industrial facilities. Research shows residents in communities with higher rates of air pollution are also exposed to higher temperatures[71] (see description for *change in impacts to heat*). Air pollution can be reduced by electrifying vehicles and buildings, which reduces on-site fossil fuel combustion, or reducing indoor pollutants from gas stoves and water heaters.[72] Air pollution can also be mitigated by planting trees and vegetation to purify the air and encouraging public transportation to reduce car emissions.[73] However, low-income households or small and minority owned businesses may not be able to afford to electrify their appliances. If the ZTA or master plan incentivizes electrification by providing subsidies to homeowners or building owners to electrify heating, ventilation, and HVAC systems, it will improve air quality and enhance community resilience. The Climate Action Plan details ways in which the county can integrate equity considerations into electrification incentives.[74]

Infrastructure design decisions

Potential evaluation approaches: This factor evaluates whether the ZTA or master plan could affect infrastructure design within the affected area which could potentially influence resilience to climate hazards. Depending on the nature of the ZTA or master plan, Montgomery planning may be able to determine qualitatively or quantitatively how the ZTA or master plan could affect infrastructure design decisions. (For infrastructure siting decisions, see descriptions for the exposure-related factors to consider impacts to vulnerable populations). Quantitative decisions will factor engineering projections (e.g., amount of stormwater conveyed by enlarging a culvert or drainage pipe) into the decision-making process. In the absence of quantitative information, qualitative considerations for how a ZTA or master plan could improve community resilience through infrastructure design include:
Does the ZTA or master plan…

- Require infrastructure to be built to higher flood elevation standards
- Enlarge pipes and culverts so they can carry larger amounts of stormwater during extreme precipitation events
- Promote the use of nature-based solutions or green infrastructure to reduce heat and flood risk
- Promote the use of cooling materials and other solutions to reduce urban heat island effect
- Physically harden critical facilities, such as water and wastewater pumps and fire stations, from flooding and extreme heat
- Ensure backup power is available to all critical facilities

How this factor affects community resilience: Infrastructure design has a large bearing on whether that infrastructure might be affected if exposed to a climate hazard. For example, a building without air conditioning or with suboptimal orientation could be greatly affected by high temperatures when another building and its occupants may be minimally affected. Infrastructure that designed to be more resilient to natural hazards improves community resilience because it would be better able to function during extreme events. For example, residents will be able to cross a bridge that was elevated above the 100-year storm height for 2100, while a bridge designed to the 100-year storm height for the present-day may be inundated.

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[71] US EPA. "Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts." September 2021. https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf
[72] "Montgomery County Climate Action Plan," June 2021, pp. 131.
[73] "Montgomery County Climate Action Plan," June 2021, pp. 35.
[74] "Montgomery County Climate Action Plan," June 2021, pp. 136, 207.

Other

Montgomery Planning should consider whether there are any other factors that might influence the ZTA or master plan's impact on community resilience and adaptive capacity, such as factors that could influence the severity of potential adverse impacts from climate hazards including flooding, extreme temperatures, severe storms, heavy winds, or drought. Potential other factors may relate to change to pest prevalence, change in disease vectors, change to agricultural reserve, and others.

Adaptive Capacity Factors

Change to accessibility or prevalence of community and public spaces

Potential evaluation approaches: This factor evaluates to what extent the ZTA or master plan will influence the accessibility or prevalence of community and public spaces that could be used, for example, for refuge during heat waves (i.e., as cooling spaces) or as community support points or centers for shelter during power outages.

How this factor affects community resilience: Community spaces are generally associated with increased community resilience and adaptive capacity. For example, air-conditioned community spaces such as libraries can be used as cooling centers (formally or informally) during heat waves, promoting public health by reducing extreme heat-related mortality and illness.[75] Resilience hubs also increase the resilience of a community to power outages, extreme weather events, and other natural disasters. A resilience hub leverages existing infrastructure (such as schools, libraries, and community centers) through the construction of microgrids, which can provide continuous power during outages, as well as potable water, heating, and cooling.[76] Such hubs can be lifesaving resources for communities, especially more vulnerable populations, such as homeless and displaced people.[77] Designated community and public spaces allow communities to strengthen their bonds and provide social support and stability, which can be a key determining factor for post-disaster recovery.[78] Individuals tend to rely on community to address disaster-related demands and challenges, and according to a 2012 study, individuals suffer less from Post-Traumatic Stress in communities with high social capital.[79]

Change to emergency response and recovery capabilities

Potential evaluation approaches: This factor considers to what extent the ZTA or master plan will influence the accessibility or prevalence of emergency response and recovery capabilities. Example indicators that can be used to qualitatively assess the change to emergency response and recovery capabilities are…

Does the ZTA or master plan:

- Improve first responders' ability to operate and access residents in case of an emergency?
- Increase/decrease the number of hospitals, shelters, or care facilities?
- Increase/decrease the number of professionals with medical professional capacity?
- Increase/decrease the percentage of the population with health insurance?

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[75] "Montgomery County Climate Action Plan," June 2021, pp. 205.
[76] "Montgomery County Climate Action Plan," June 2021, pp. 211-12.
[77] "Montgomery County Climate Action Plan," June 2021, pp. 211-12.
[78] Goldmann, E., and Galea, S. "Mental Health Consequences of Disasters." *Annual Review of Public Health*, 2014, 35(1), 169-183. Retrieved from https://www.annualreviews.org/doi/pdf/10.1146/annurev-publhealth-032013-18243.
[79] Wind, T. and I. Komproe. "The mechanisms that associate community social capital with post-disaster mental health: A multilevel model." *Social Science & Medicine*, 2014, 75(9): p. 1715- 1720.

How this factor affects community resilience: Expanding emergency response and recovery capabilities is generally associated with decreased community resilience and adaptive capacity. For example, the more emergency responders available during a flood event or storm, the more people that can be dispatched to check on vulnerable residents and the higher the chances are of being able to help them.[80] Similarly, with more emergency shelters and resources (e.g., food, blankets, beds) available during a natural hazard event, more of the population can shelter safely. Apart from disaster response and recovery, a FEMA study to identify commonly used indicators of community resilience found access to medical professionals and services and the percentage of the population with health insurance were strong indicators of the community's overall physical and mental health.[81]

Change in access to transportation

Potential evaluation approaches: This factor evaluates whether the ZTA or mast plan could influence access to transportation routes and services.
Example indicators that can be used to quantitatively assess the change in accessibility to transportation routes and services are:
Does the ZTA or master plan:

- Reduce the number of households without a vehicle?
- Expand access to public transit, either by building a new station or expanding routes (i.e., reducing distance to a station or stop)?
- Increase affordability of transportation?

How this factor affects community resilience: Access to transportation routes and services enables communities to access evacuation routes, rescue services, and resources in the case of an emergency. Communities where fewer families have access to a vehicle are less likely to be able to evacuate during a disaster and will be stuck dealing with the aftermath. Equity is an important consideration, as poor communities in urban areas have less vehicle ownership and are more likely to rely on public transportation as their primary mode of transportation.[82] As the County works towards its 2035 net zero target, it aims to reduce automobile usage by expanding walking, biking, and micro mobility services and incentivize the adoption of zero emissions technologies.[83] Expanding affordability and access to public transit stops will enhance community resilience and help the County reduce emissions.

Change in accessibility or prevalence of local food sources and other goods

Potential evaluation approaches: This factor evaluates whether the ZTA or master plan could influence the accessibility or prevalence of local food sources and other goods.
Example indicators that can be used to qualitatively assess the change in accessibility or prevalence of local food sources are…
Does the ZTA or master plan:

- Expand access to grocery stores in socially vulnerable neighborhoods?
- Support local farmers?

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[80] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 46-48. https://www.fema.gov/sites/default/files/documents/fema_2022-community-resilience-indicator-analysis.pdf
[81] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 47.
[82] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 40. https://www.fema.gov/sites/default/files/documents/fema_2022-community-resilience-indicator-analysis.pdf
[83] "Montgomery County Climate Action Plan," June 2021, pp. 147.

- Reduce access to fast food or junk food?
- Expand access to community gardens, edible forests, etc.?

How this factor affects community resilience: Expanding the accessibility and prevalence of local food sources enhances community resilience, especially for socially vulnerable groups. Local and regional food systems can have a multitude of benefits, including reducing greenhouse gas emissions, providing jobs, enhancing the economy, and improving food sovereignty.[84] Local food systems can also strengthen social networks and enhance social capital because they offer ways for local farmers and consumers to interact and build relationships.[85] Local food sources have been found to improve the nutrition and health within communities by increasing access to healthful foods (e.g., locally grown fruits, vegetables, and locally processed food products).[86] In addition, as climate change may influence other non-food supply chains, there may be opportunities for ZTAs or master plans to influence the county's dependence on goods and service coming from outside county borders. Changes that reduce dependence on global supply chains may increase community resilience. Examples may include green/circular economy business parks, business focused on green products or services, or worker-owned businesses.

Change in availability or distribution of economic and financial resources

Potential evaluation approaches: Montgomery Planning can describe what extent the ZTA or master plan will influence the accessibility or distribution of economic and financial resources. Example indicators that can be used to measure the distribution of economic and financial resources are
Does the ZTA or master plan:

- Increase/decrease the percent of the population above the poverty line (Increase = positive, decrease = negative)
- Increase/decrease median household income (Increase = positive, decrease = negative)
- Increase/decrease the percent of the labor force that is employed (Increase = positive, decrease = negative)
- Increase/decrease the difference between male and female median income (Increase = negative, decrease = positive)
- Increase/decrease the percent of the workforce employed in diverse sectors (Increase = positive, decrease = negative)

How this factor affects community resilience: Community economic vitality is one measure of the population's ability to be prepared for, absorb, and recover from climate-related economic impacts and disasters. There is a strong correlation between financial resources and resilience. Lower income residents are more likely to live in low-quality housing that will get damaged during a disaster and have fewer resources available to support recovery.[87] Economic diversity is important for long-term economic stability as it ensures both individuals and the community have access to resources, so high employment

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[84] Hammon, M. and Currie, C. "Local Food Systems Key to Healthy, Resilient, Equitable Communities". *American Planning Association Magazine*, February 1, 2021. https://www.planning.org/planning/2021/winter/local-food-systems-key-to-healthy-resilient-equitable-communities/

[85] McDaniel, T., Soto Mas, F., and Sussman, A. "Growing Connections: Local Food Systems and Community Resilience", *Society & Natural Resources*, 2021. DOI: 10.1080/08941920.2021.1958965.

[86] Lucan, S.C. "Local Food Sources to Promote Community Nutrition and Health: Storefronts Businesses, Farmers' Markets, and a Case For Mobile Food Vending." J *Acad Nutr Diet.* 2019, Jan;119(1):39-44. doi: 10.1016/j.jand.2018.09.008.

[87] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 51. https://www.fema.gov/sites/default/files/documents/fema_2022-community-resilience-indicator-analysis.pdf

among different socioeconomic groups aids economic stability.[88] A diverse range of employers and industries is also important for economic resilience. If a large percentage of the population is employed by one industry, the economy will suffer if climate change or a natural disaster undermines the industry.[89] In a diverse economy, if one industry fails there are others that can provide employment and sustain the local economy.

Change in community connectivity

Potential evaluation approaches: Montgomery Planning can describe to what extent the ZTA or master plan will influence community connectivity, such as social connections and sense of place and belonging). Qualitative considerations for how a ZTA or master plan could improve community resilience through community connectivity include:

Does the ZTA or master plan…

- Enhance civic infrastructure and promote civic engagement
- Preserve or improve existing infrastructure that are crucial for community connectivity (e.g., community and public spaces, resilience hubs, spaces for social and religious organizations)
- Significantly increase or decrease the population in a specific community

How this factor affects community resilience: Community connectivity is associated with increased resilience and adaptive capacity, especially during extreme weather events and natural disasters. Studies show that social cohesion and community connectivity are directly linked with resilience and often help strengthen post-disaster recovery efforts.[90, 91] Existing social networks are critical for the quick mobilization of resources and dissemination of information following a natural disaster.[92] For instance, individuals are more likely to check on their neighbors and offer assistance or comfort during a heat wave or after a severe hurricane if they already have strong social bonds. Furthermore, community connectivity can reduce mental health challenges and Post-Traumatic Stress for individuals impacted by natural disasters.[93] One way to increase community connectivity is to start or join "villages" in different neighborhoods, in which individuals can volunteer to support their neighbors in a variety of ways.[94,95] Community connectivity can also be enhanced by community and public spaces, which provide opportunities to make social connections, as well as resources and support during natural disasters and extreme weather events (see description of accessibility and prevalence of community and public spaces). The presence of civic, social, and religious organizations can increase community connectivity by providing a sense of belonging and opportunities to develop social bonds.[96] Changes in population can also impact community connectivity, as residents who have lived in a community for an extended period

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[88] Cutter, S., Ash, K., and Emrich, C. "The Geographies of Community Resilience." *Global Environmental Change,* 2014, Volume 29, pp. 65-77. https://doi.org/10.1016/j.gloenvcha.2014.08.005.

[89] Cutter, S., Ash, K., and Emrich, C. "The Geographies of Community Resilience." *Global Environmental Change,* 2014, Volume 29, pp. 65-77.

[90] Goldmann, E., and Galea, S. "Mental Health Consequences of Disasters." *Annual Review of Public Health*, 2021, 35(1), 169-183. https://www.annualreviews.org/doi/pdf/10.1146/annurev-publhealth-032013-18243.

[91] Ronak B. Patel and Kelsey Gleason, "The Association between Social Cohesion and Community Resilience in Two Urban Slums of Port Au Prince, Haiti," *International Journal of Disaster Risk Reduction*, 2017.

[92] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 56. https://www.fema.gov/sites/default/files/documents/fema_2022-community-resilience-indicator-analysis.pdf.

[93] Wind, T. and Komproe, I. *The mechanisms that associate community social capital with post-disaster mental health: A multilevel model.* Social Science & Medicine, 2012. 75(9): p. 1715- 1720.

[94] "Montgomery County Climate Action Plan," June 2021, pp. 282.

[95] Montgomery County Department of Health and Human Services. "Join a Village." 2022.

[96] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 22.

tend to have greater place attachment and are consequently more invested in the well-being of a community, both before and after a disaster.[97]

Change in distribution of resources and support

Potential evaluation approaches: This factor considers whether the ZTA or master plan could influence the equitable distribution of resources (such as County services) across the county.

How this factor affects community resilience: Programs and policies that provide resources and support, especially to vulnerable communities, enhance community resilience. These programs and policies bring institutional knowledge and experience that can help communities before, during, or after disasters.[98] For example, they can implement training and capacity building programs to help communities prepare for disasters, or expertly distribute resources in the wake of a natural disaster. Equity is an important element of resources and support. Communities where socially vulnerable groups are supported by various policies and programs are more resilient and have stronger social stability than communities with fewer resources and less support. Coordination at the local and regional level plays a large role in ensuring residents benefit from available resources and support. Thus, ZTAs and master plans that encourage or enhance coordination and collaboration with city governments and the state to implement programs and disseminate information can play a critical role in enhancing community resilience.

Other

Montgomery Planning should consider whether there are any other factors that might influence the ZTA or master plan's impact on community resilience and adaptive capacity, such as factors that could influence individuals or a community's ability to cope with adverse impacts, such as access to health care or other specific resources not mentioned in the checklist.

[97] FEMA. "Community Resilience Indicator Analysis: Commonly Used Indicators from Peer-Reviewed Research." September 2022, pp. 58.
[98] Cutter, S., Ash, K., and Emrich, C. "The Geographies of Community Resilience." *Global Environmental Change,* 2014, Volume 29, pp. 65-77. https://doi.org/10.1016/j.gloenvcha.2014.08.005.

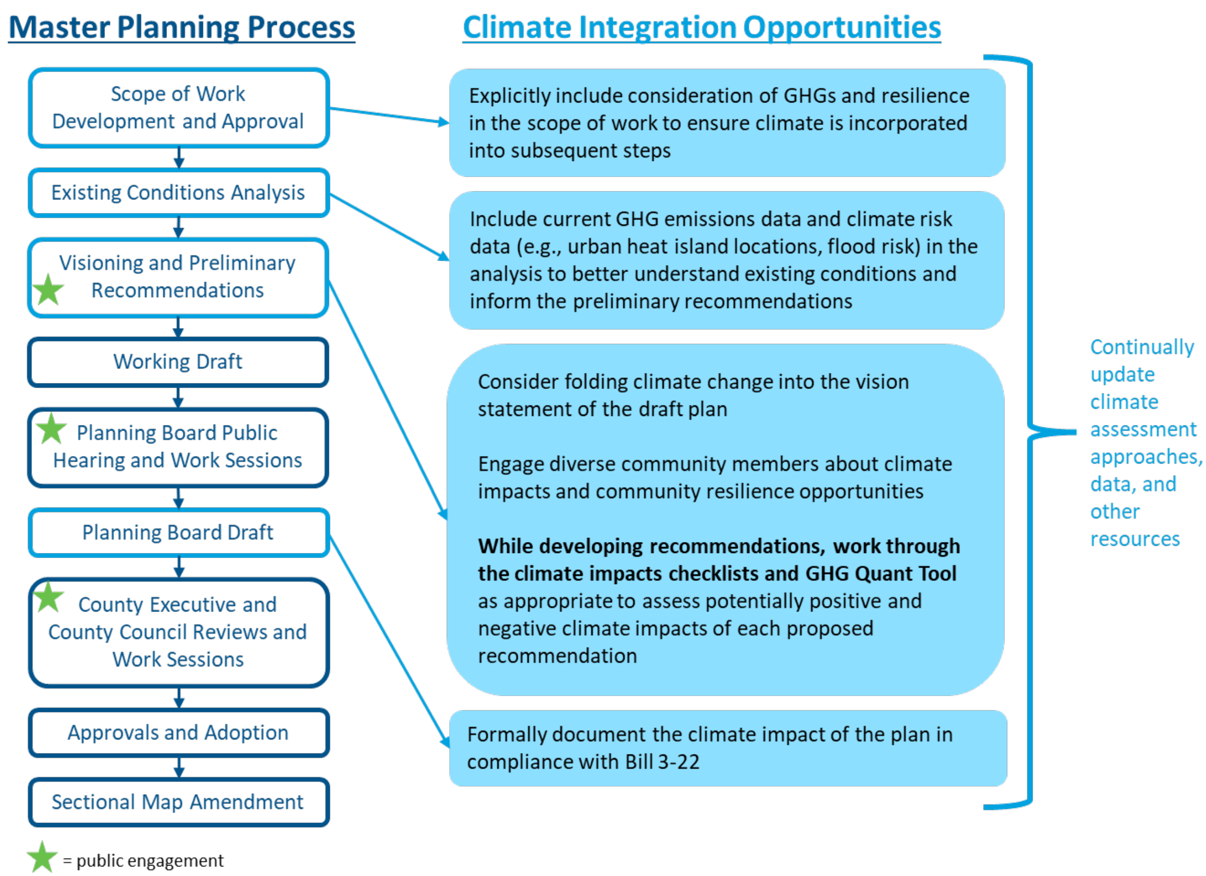
3 Recommendations to Incorporate Climate Assessment Principles into Master Planning Process

Master planning is a multi-year process, and thus presents an opportunity for Montgomery Planning to use the climate assessments as a tool in the planning process to evaluate alternatives and otherwise craft a master plan that maximizes climate benefits, both in terms of greenhouse gas emissions and community resilience.

Figure 4 summarizes Montgomery Planning's typical master planning process. ICF identified four key opportunities to integrate climate considerations into the process. For example, Montgomery Planning often identifies the potential for certain properties to develop or redevelop at the beginning of master planning, and starts to look at zoning and other tools to shape future development. Montgomery Planning could start to identify the attributes of these properties as they currently exist—existing conditions, imperviousness, soils and vegetation, stormwater management, etc.—to begin to assess potential for impacts on resilience, positive and negative, in the master plan. In addition, the existing conditions analysis looks at a broad range of environmental and other factors. Some of these relate to the factors considered in the climate assessments, or the climate assessments also provide an opportunity to broaden what factors are evaluated in the existing conditions analysis.

This process would not only benefit the master plan but would also position Montgomery Planning staff to more easily and efficiently assess climate impacts of the final master plan in compliance with Bill 3-22.

Figure 4. Opportunities to integrate climate change considerations and assessments into the master planning process



Appendix A: Example Template for Climate Assessments

Following the template process and tools (e.g., GHG Quant Tool, checklists) described above, Montgomery planning staff would then draft the climate assessments. Below is an example outline of what those climate assessments should include. [XXX] indicates the name of the ZTA or master plan.

Summary

The Montgomery County Planning Board anticipates that [XXX] could have a [significant or insignificant] impact on the county's climate goals as [insert reason why].

This section will serve as an executive summary of the climate assessment, for easier digestion of information provided. It will summarize the key information presented in the literature review section and the anticipated impacts, including any overlaps or tradeoffs between greenhouse gas emissions and resilience considerations. If recommended amendments are included in the assessment, they will be stated here as well.

Background and Purpose of [XXX]

Insert plain language description of the ZTA or master plan, including description of geographic area covered.

Anticipated Impacts

If no impacts, why that is the case – e.g., completed both checklists and identified no potential impacts.

Greenhouse Gas Emissions, Carbon Sequestration, and Drawdown

Narrative description of potential impacts, including quantitative estimates where possible. First sentence states whether there is a significant positive/negative impact, insignificant impact or indeterminant impact on the measures above. Include discussion of:

- *The relevant activities that may positively or negatively impact GHG emissions and sequestration, and any uncertainties or considerations used in the assessment*
- *Options to mitigate GHG emissions*
- *Timeline of the ZTA or master plan and relevant implications for emissions impacts and mitigation options (i.e., how these may be distributed over the relevant timeline)*
- *Relevant papers, data, or resources used in the assessment*
- *A qualitative discussion about how the ZTA or master plan contributes to or relates to the County's Climate Action plan GHG reduction strategies*
- *A qualitative discussion about how the ZTA or master plan contributes to or slows progress towards GHG reduction goals for the County, MWCOG, and Maryland*

Community Resilience and Adaptive Capacity

Narrative description of potential impacts. First sentence states whether there is a significant positive/negative impact, insignificant impact or indeterminant impact on the measures above.
As applicable, include initial resilience checklist, and explanations of how impacts were determined for each of the factors. The narrative should describe:

- *Overall potential impacts on community resilience and adaptive capacity, and rationale for the assessment*
- *Consideration of potential timing of impacts as known and appropriate*
- *Any assumptions driving the consideration of potential impacts, with sources cited as appropriate*
- *Knowledge gaps or limitations related to the impact assessment*

- *Options to reduce potential negative impacts (several examples are embedded within each of the factor descriptions)*

Recommended Amendments

Describe recommended amendments to address impacts.

Sources of Information, Assumptions, and Methodologies Used

Note any key assumptions and methodology relevant to the assessment, drawing from applicable sections of guidance document.

Greenhouse Gas Emissions, Carbon Sequestration, and Drawdown

…

Community Resilience and Adaptive Capacity

…

Appendix B: Key Insights from Literature Review and Stakeholder Input

The recommendations presented in this report are based on the earlier literature review, and ongoing discussions with Montgomery Planning staff and input from stakeholders. Key insights from these activities that informed recommendations are summarized below.

Context for GHG Assessments in Montgomery County

Montgomery County has been working with stakeholders and partners for more than a decade to quantify County GHG emissions and carbon footprints for master plans. This work has evolved and improved over time as more data becomes available and there are methodological advancements. Accordingly, and to also capture future changes this climate assessment framework is a living document that will be subject to updates in the future as more information becomes available and baseline assumptions change. The recommendations provided in this memo draw from and build upon this work, including:

- The County GHG emissions inventory
- The County Climate Action Plan
- Master plan carbon footprints

County-Wide GHG Inventory

Every three years the Montgomery County Department of Environment Protection works with the Metropolitan Washington Council of Governments (MWCOG) to prepare a County-wide GHG emissions inventory. This inventory is developed using the ICLEI ClearPath tool and is aligned with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).[99] The purpose of this inventory is to assess overall community emissions and it is prepared using county-level activity data, such as overall utility energy usage for the county, or vehicles miles traveled within the county.

The GPC distinguishes between emissions that physically occur within the county (Scope 1), from those that occur outside the county but are driven by activities taking place within the county's boundaries (Scope 3), and from those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (Scope 2). The GPC defines scopes of emissions across six sectors, including:

- stationary energy
- transportation
- waste
- industrial processes and product use
- agriculture, forestry, and other land cover
- other scope 3

Due to data availability and limitations the county inventory does not currently include emission and sequestration estimates from all scopes and sectors of emissions. Generally, it includes Scope 1 and 2

[99] "Global Protocol for Community-Scale Greenhouse Gas Inventories: An Accounting and Reporting Standard for Cities Version 1.1." https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

emissions[100]. The County Climate Action Plan (CAP) [101] notes a few areas for improvement within the GHG inventory around embodied emissions (typically other scope 3 emissions) and sequestration (agriculture, forestry, and other land cover). These types of emissions present a range of data and consistency challenges; hence most counties and cities use high level proxy methods or exclude these estimates from their inventories.

County Climate Action Plan

The county's goals laid out in the CAP are to reduce GHG emissions 80% by 2027 and 100% by 2035 from 2005 emission levels. The 2005 GHG inventory sets a base year Scope 1 and Scope 2 emission estimate and includes in the following subsectors within the key primary sectors discussed above: residential energy; commercial energy; transportation and mobile sources; water and wastewater; solid waste; process and fugitive emissions; and agriculture, forestry, and other land covers. The 2012, 2015, and 2018 GHG inventories measured the County's Scope 1 and Scope 2 emissions reduction progress against the 2005 baseline, with total county emissions dropping 19% from 2005 to 2018.

The 2018 GHG inventory is the base year used for the CAP to evaluate priority emission reduction opportunities and estimate the expected emission reductions from proposed climate actions. Using MWCOG's 2015-2030 emissions forecast analysis, Montgomery County developed a business-as-usual emissions scenario which forecasts emissions in both 2027 and 2035. In this scenario, emissions are estimated to decrease 2% by 2027 and 3% by 2035, as compared to 2018 levels. Most of the county's future emissions are estimated to come from residential and commercial building energy consumption, including electricity use (56% of emissions in 2035), and on-road vehicle use (28% of emissions in 2035), which are the county's biggest reduction opportunity areas.

Master Plan Carbon Footprints

Since 2008, Montgomery County Code Section 33A-14 has required Montgomery Planning to develop a carbon footprint analysis for master plans, which includes potential GHG emissions, options to reduce VMT and minimize overall GHG emissions. These carbon footprints look at the lifetime emissions of an area of development (as opposed to the county GHG inventory in which emissions are estimated annually). These carbon footprint analyses are currently conducted *after* the master plan is developed. Within the context of Bill 3-22, however, Montgomery Planning may conduct GHG assessments during master plan development and review to inform the planning process (see specific recommendations in Section 2.13).

Montgomery Planning staff currently use a version of the GHG emissions modeling spreadsheet created by King County, WA[102] to quantify the carbon footprint analyses. The model estimates GHG emissions from embodied energy, building energy use and transportation used by residents/workers in the master plan area. Montgomery Planning staff also compare the estimated emissions from the master plan recommendations for land cover, zoning, development density and transportation systems using existing conditions.

[100] "GHG Inventory Data Spreadsheet." Retrieved September 30, 2022 at https://www.montgomerycountymd.gov/climate/progress.html

[101] "Montgomery County Climate Action Plan," June 2021. https://www.montgomerycountymd.gov/green/Resources/Files/climate/climate-action-plan.pdf.

[102] "Green Building and Sustainable Infrastructure Guidelines: Carbon Calculators and Mitigation Strategies." November 2021. https://kingcounty.gov/~/media/depts/dnrp/solid-waste/green-building/documents/emissions-guidelines.ashx?la=en

The boundaries of the King County tool are notably different in some respects than the county GHG inventory (the main mechanism used to track progress towards Montgomery County's GHG reduction goal). Specifically, the King County tool, which is developed to look more specifically at an individual project, includes some Scope 3 GHG emissions such as those from construction or other embodied emissions for buildings. Data to support the quantification of these emissions at the project level is more accurate and readily available due to project planning and specification documents.

Table 9 summarizes and compares the emissions activities included in the county GHG inventory to the emission activities that are recommended for inclusion in the climate assessments for ZTAs and Master Plans. Additional emission activities that are included in the climate assessment recommendations but not in the county inventory are noted in **blue**.

Table 9. GHG Inventory and Climate Assessment Scope Alignment

GHG Inventory Sector	County GHG inventory scope	MNCPPC Master plan/ZTA climate assessment scope recommendations
Transportation	On-road mobile emissions (includes passenger cars, trucks, motorcycles, school buses, transit buses, intercity buses, motor homes, and commercial trucks)[103], air travel, off-road equipment (e.g., forklifts), rail (only including Amtrak)	On-road mobile emissions and off-road equipment (e.g., forklifts)
Buildings	Residential and commercial building onsite combustion (natural gas, fuel oil and liquified petroleum gas (LPG)) and electricity use	**Buildings Sector: Embodied emissions** (including materials lifecycle and construction) **Energy:** residential and commercial building onsite combustion and electricity use
Land Cover Change and Management[104]	Forestry and land cover emissions and removals are not included in the official inventory	Area of forest and non-forest tree canopy, area of other green cover (i.e., meadow, turf, wetland, etc.), area of other nature-based solutions such as green roofs
Other (Recommended to be Assessed within One Grouping)		
Industrial Processes & Product Use (IPPU)	Onsite combustion (natural gas, fuel oil, and LPG) and electricity use, and process-related emissions	IPPU emissions are only 5% of total County emissions.[105] Solid waste emissions are only 2% of total County emissions. Wastewater emissions are only 0.11% of total County emissions. Fugitive emissions are only 0.57% of total County emissions. Agricultural emissions are 0.35% of total County emissions. Unless there is an explicit or very relevant application within a ZTA or master plan, it is recommended that this sector not be included in climate assessments.
Solid Waste	Landfill waste generation, combustion of solid waste	
Wastewater	Fugitive emissions from septic systems, nitrification/denitrification process N_2O emissions from wastewater treatment, process N_2O from effluent discharge to rivers and estuaries	
Agriculture	Enteric fermentation, manure management, and agricultural soil emissions	
Fugitive Emissions	Hydrofluorocarbon & refrigerants, fugitive emissions from natural gas	

[103] See Appendix F of the Metropolitan 2030 Climate and Energy Action Plan
[104] Emissions and removals from the Forestry and Land cover sector were not part of the official greenhouse gas inventory, but were included in an additional analysis titled "Examining the Role of Forests and Trees in Montgomery County's Greenhouse Gas Inventory."
[105] According to the 2020 GHG Inventory conducted by Metropolitan Washington Council of Governments (MWCOG) for Montgomery County's 2018 emissions.

Literature Review

The goal of the literature review was to identify potentially useful or applicable methods, tools, or approaches that Montgomery Planning can use or build upon to comply with Bill 3-22 requirements moving forward. ICF undertook a desktop scan to identify jurisdictions in the U.S. and Canada that have similar requirements as Bill 3-22. ICF compiled a list of relevant examples of policies/requirements and assessment tools related to GHG emissions calculations and screenings, and community resilience and adaptive capacity. Overall key takeaways from the literature review included:

- There are **no examples of other jurisdictions requiring directly comparable climate assessments for master plans and ZTAs**, but some examples exist that provide potential approaches to developing the climate assessments.
  - A **combination of applicable approaches will likely need to be used**; there is no one existing approach, method or tool that achieves these objectives.
- Some calculation requirements for GHG emissions assessments are more specific than others.
- Most methods/tools for GHG emissions or sequestration assessments reviewed require data collection & modeling, which can be time intensive activities and may not work for ZTA assessments specifically.
- It is common to allow for a mix of quantitative and qualitative GHG and community resilience assessment methods depending on available data, emission factors, and tools.

Stakeholder Input

Stakeholder workshop

Montgomery Planning held its first stakeholder engagement workshop on September 12, 2022, to discuss the development of climate assessments in response to Bill 3-22. Stakeholders representing the Climate Action Plan (CAP) Coalition, Nature Forward (previously Audubon Naturalist Society), and 350 Montgomery County attended, along with other engaged Montgomery County residents. Key comments that emerged from this workshop included:

- Qualitative vs. quantitative review:
  - Underscored the importance of quantifying as much of the greenhouse gas impact that is feasible given the existing data and timing constraints.
  - Additionally emphasized that qualitative assessments are important, especially when understanding how decisions impact health and well-being.
  - Therefore, a healthy mix of both approaches should be used in the climate assessments.
- Noted that the Montgomery Planning should also create these climate assessments to model how climate considerations should be integrated in decision making for other jurisdictions.
- Supported that Montgomery Planning is looking to use assessments during the master plan development process, and not just as a final review after the development process has finished.
- Flagged that data inputs and assumptions / proxy data should be updated regularly and incorporate the best available data.

Additional workshops were held on October 11, 2022, to present and discuss draft recommendations, and on November 14, 2022, to present and discuss draft final recommendations.

Climate Action Plan (CAP) Coalition comments

The CAP Coalition submitted additional written comments to Montgomery Planning after each of the three stakeholder workshops. The feedback included:

- Recommendations to use flow charts to guide climate assessments – this recommendation has been incorporated as appropriate
- Suggestions for specific tools to consider for incorporation into the climate assessment process – these tools have been reviewed and incorporated as appropriate

- Emphasis that the climate assessments should use appropriate data inputs (e.g., CO_2 equivalence factors) and transparently describe any data sources and vintages, methods, and assumptions used – these recommendations have been incorporated
- Suggestions to evaluate data for transportation beyond vehicle miles traveled – this has been assessed and incorporated based on the availability of quality data
- Suggestions for several supplemental analyses or resources that would be valuable, including a visualization tool, scenario analyses, social cost assessment, analysis of progress toward CAP and other relevant goals, and evaluation of the potential health and other social impacts of climate hazards and/or benefits of resilience measures. These are all valuable suggestions, though not all may be appropriate for inclusion in the ZTA/master plan climate assessments themselves due to the particular scope of ZTAs and master plans as land cover planning tools as well as time constraints for ZTAs. These suggestions may be better situated within Montgomery County's continued CAP implementation and reporting efforts (e.g., CAP progress reports).
- Suggestions that the climate assessments should be used to measure progress towards achieving the county's climate goals– the already established CAP annual progress reporting process is the most appropriate place for measuring cumulative progress, but the climate assessments will indicate whether any given ZTA or master plan would help Montgomery County achieve its climate goals.
- Suggestions to include an estimation of the timeline of the master plan or ZTA and related emissions impacts – these recommendations have been incorporated into the climate assessment guidelines and the quantitative calculations (via future assumptions and the time period over which emissions impacts are estimated). As the development and use of the climate assessments is an iterative process, greater consideration of different timelines and relevant impacts may be developed in the future.
- Suggestions to consider additional factors in the community resilience and adaptive capacity assessment, and to clarify the organization of the factors. Additional factors have been added, including exposure to other hazards (e.g., storms, wind, drought), change in air quality, change in water quality and quantity, access to transportation, and breaking change in tree canopy down into three distinct factors: forest cover, non-forest tree canopy, and non-forest natural areas. In addition, other suggestions that related to factors already included in the draft lists were further explained within the descriptions of each factor (e.g., how to evaluate exposure to urban heat islands or buildings' potential role in cooling vs. exacerbating the urban heat island). Additional framing was provided to explain the list of factors and how they are organized, some factors were recategorized for clarify, and additional guidance provided for how Montgomery Planning Staff should interpret and enhance the set of factors as needed.
- Suggestion to consider the potential for environmental refugees and in-migration from low-lying and other vulnerable areas in the community resilience and adaptive capacity assessment. This consideration has been included in the exposure factors that evaluate the number of people exposed to a particular hazard. The potential for in-migration should also be considered when evaluating change in number of people exposed.
- Suggestion to incorporate data mapping into the community resilience and adaptive capacity assessment. Mapping of available data is included in the "potential evaluation approaches" content of applicable factors.
- Suggestions to clarify where and how the Planning Department should evaluate any tradeoffs or overlaps between GHG emissions and community resilience – this has been addressed in the example form and throughout the template guidance.

- Suggestions to clarify how the narratives will be developed and what they will include – this has been incorporated throughout the template guidance.
- Suggestions to better align the climate assessments with the County Climate Action Plan where feasible.

Overall, stakeholders endorsed the approach to integrating climate assessments in the master planning process.