Gaithersburg
A Character Counts! City

City of Gaithersburg

ENVIRONMENT AND SUSTAINABILITY

A Master Plan Element

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2009
MASTER PLAN

CITY OF GAITHERSBURG
2009 MASTER PLAN

ENVIRONMENT AND SUSTAINABILITY ELEMENT

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CITY OF GAITHERSBURG
2009 MASTER PLAN

CHAPTER 5
ENVIRONMENT AND SUSTAINABILITY

TABLE OF CONTENTS

1. Purpose and Need 1
2. Introduction 2
3. Environmental Regulations and Policies: Federal, State, and Local Mandates and Programs 3
4. Natural Resources 5
   - 4.1 Soils 5
   - 4.2 Streams, Wetlands, and Floodplains 7
   - 4.3 General Climate Characteristics 8
   - 4.4 Open Space 9
   - 4.5 Rare, Threatened, and Endangered Species 11
5. Urban Forest 13
   - 5.1 Environmental Benefits 13
   - 5.2 Social Benefits 15
   - 5.3 Economic Benefits 16
   - 5.4 City of Gaithersburg Tree Canopy Coverage 17
   - 5.5 Recommendations 23
6. Watershed and Stormwater Management 25
   - 6.1 Regulatory Framework 25
     - 6.1.1 Federal Regulations 25
     - A. The Clean Water Act and the National Pollutant Discharge Elimination System 25
     - B. Chesapeake Bay TMDL 26
     - C. Gaithersburg's MS4 Permit 27
     - D. State and Local Stormwater Regulations 29
     - E. Growth Tiers and Septic Bill 30
     - F. Accounting for Growth 32
     - G. Moving Forward 32
   - 6.2 Gaithersburg's Water Resources 32
   - 6.3 Stormwater and Impervious Cover 34
     - 6.3.1 Effects of Impervious Cover 35
     - 6.3.2 Algae and Eutrophication 38
   - 6.4 Quality of Gaithersburg's Water Resources 40
     - 6.4.1 Watershed Planning 40
   - 6.5 Recommendations 43
7. Environmental Planning, Health, and Sustainability 50

7.1 Introduction 50
7.2 Climate Uncertainty 51
7.3 Urban Heat Island Effect 53
7.4 Air Quality 56
7.5 Energy Conservation 59
7.6 Alternative Energy Sources 60
7.7 Transportation Improvements and Alternative Modes 66
7.8 Resource Efficiency 68
7.8.1 Green Procurement 69
7.8.2 Zero Waste 69
7.8.3 Sharing/Collaborative Economy 70
7.9 Environmental Justice: Access and Affordability 71
7.9.1 Access and Affordability: Healthy Food 71
7.9.2 Access and Affordability: Open Space 84
7.10 Recommendations 87
8. Environment and Sustainability Master Plan Implementation Strategies 92
9. Appendix A: Detailed Urban Tree Canopy Maps 117
10. Appendix B: Detailed Impervious Cover Maps 121
11. Appendix C: Rare/Threatened/Endangered Wildlife 125
12. Appendix D: Methods for Air Pollution Modelling 130
13. Appendix E: Solar Potential Mapping Methodology 140
14. Appendix F: Food Access Methodology 141

Index of Tables

Table 1: Existing Tree Canopy Analysis 19
Table 2: Comparison of Gaithersburg Watersheds 34
Table 3: Watershed Imperviousness in Gaithersburg 38
Table 4: Selected Characteristics of Census Tracts (or part) 75
Table 5: Household Food Access by Census Tract (or part) 76
Table 6: Location and Type of Surrogate Monitors Used for Cities with Missing Pollution Monitors 138

Index of Maps

Map 1: Erodible Soils and Steep Slopes 6
Map 2: Natural Water Resources 7
Map 3: Open Space 10
Map 4: Rare, Threatened, and Endangered Species 12
Map 5: Urban Tree Canopy 18
Map 6: Adopted Septic Tiers 31
Map 7: Water Resources 33
Map 8: Impervious Cover by Watershed 37
Map 9: Lawn and Shrub Areas 39
Map 10: Impervious Cover, Lakeforest Mall Area 55
Map 11: Areas of Medium to High Relative Solar Potential 62
Map 12: Areas of Highest Relative Solar Potential 63
Map 13: Geothermal Resource Potential 64
Map 14: Maryland 50m Wind Resources 65
Map 15: Alternative Fuel Stations 2014 67
Map 16: Food Access, USDA 72
Map 17: Food Access, 2014 74
Map 18: Food Access 2014 – Minority Majority 77
Map 19: Food Access 2014 – Low Income 78
Map 20: Food Access 2014 – Low Mobility 79
Map 21: Food Access – Southern Subject Tract 81
Map 22: Food Access – Northern Subject Tracts 82
Map 23: Parks Proximity to Dwelling Units 86

Index of Figures

Figure 1: Typical pattern of soils of the Piedmont physiographic province in Montgomery County 5
Figure 2: Temperature and Precipitation Graphs for Washington, DC 8
Figure 3: The Chesapeake Bay Watershed 26
Figure 4: Four tiers guide septic development in Maryland 30
Figure 5: Stream Health 36
Figure 6: Urban Heat Island 54
Figure 7: Ozone design value trend in Montgomery County 57
Figure 8: Ozone design value trend in the Washington Metropolitan Area 57
Figure 9: Fine Particle design value trend in the Washington Metropolitan Area 58
Figure 10: Fuel Source of Gaithersburg Electricity Supply 59
Figure 11: Olde Towne Youth Center 64
Figure 12: City Electric Vehicle (Mitsubishi iMev) 68
Figure 13: Recycling Tonnage 69
Figure 14: Heart Disease and Diabetes Mortality Rates by Census Tract 83

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1. Purpose and Need

The City of Gaithersburg is empowered, under the *Land Use Article* of the *Annotated Code of Maryland* to exercise autonomous planning and zoning powers. *Land Use* establishes the requirements of a municipal comprehensive Master Plan and its required elements, and the procedures for approving said Master Plan. Codified in *Land Use* Division I, §3-102(a)(1)(vi) *Elements-Municipal Corporations* requires the development of a Sensitive Areas Element as part of the City's comprehensive Master Plan.

A Master Plan Element, *Environment and Sustainability* is an update to both the 2003 City of Gaithersburg *Environment Element* and facets of the 2009 *Water Resources Element*. The 2009 *Environment and Sustainability Element* fulfills the requirements of the Sensitive Areas Element listed under the *Land Use Article*. The *Environment and Sustainability Element* will serve as an informational and policy document to the Mayor and City Council, the Planning Commission, other boards and committees of the City, and the residents of Gaithersburg.

This element, *Environment and Sustainability*, will present recommendations for the City's continued stewardship of its environmental resources and sustainable practices while being consistent with the State and City visions laid forth in the City's 2009 *Process and Overview Element*. *Environment and Sustainability* will discuss the connection between the natural and built environment. It will contain goals, objectives, principles, policies, and standards that are designed to both protect natural sensitive areas, such as: the urban forest, streams and their buffers, and to also guide future development, programs, and actions within the City in a sustainable manner that support the "public welfare" both locally and regionally. Ultimately, this *Element* will support the visions, policies, strategic directions, and principles of the City, as well as the other Master Plan Elements.

2. Introduction

The City of Gaithersburg occupies approximately 10 square miles and is home to more than 64,000 residents. The City's main sensitive areas and environmental resources include sensitive soils and slopes, wetlands, lakes and stream valley buffers, public parks and open space, and urban forests. Gaithersburg, through its continued urbanization, confronts many of the same environmental issues with these resources as other communities. Growth often equates to pollutants in water, air, and soil; increasing costs of energy needed to meet demand; degradation to ecosystems; and loss of natural areas that contribute to a resident's quality of life.

Gaithersburg acknowledges that all aspects of the natural environment and urban environment are interrelated. Continued growth and revitalization for the City cannot be achieved at the expense of environmental, human health, and quality of life impacts. The City has established in its Strategic Plan a Sustainability Direction with a primary mission to:

> "Meet the needs of the City in a manner that accurately reflects the community's desire for social equity, environmental health, and economic prosperity without compromising future generations' ability to meet these same needs"

Environmental impacts and sustainability issues extend well beyond Gaithersburg's city limits. Gaithersburg must continue to collaborate with regional partners, such as Montgomery County and the Metropolitan Washington Council of Governments, in devising solutions and promoting change. This is best exemplified by the City's commitment to the Region Forward Initiative.

Gaithersburg embraces its responsibility in supporting the collective good of the community by planning for the long-term impacts resulting from the actions of today. The recommendations presented in this document provide specific actions or policies that support sustainable practices that will allow the City to thrive into the future. The *Environment and Sustainability Element* presents the regulatory context that the City works within; provides an overview of the natural environmental facets within the City; presents specific chapters regarding Urban Forestry; Watershed and Stormwater Management; Environmental Planning, Health, and Sustainability; each providing recommendations in support of protecting and enhancing both the natural and urban environment.

3. Environmental Regulations and Policies: Federal, State, and Local Mandates and Programs

The City of Gaithersburg adheres to various environmental statutes, regulations and policies established at Federal, State and local levels. In addition, the City has included sustainability within the Strategic Directions upon which annual work plans are founded. The City functions within this regulatory framework that addresses topics ranging from environmental (including streams, soils, and trees) to wildlife and those topics' relationship to the development process; therefore, these standards have been identified as *Environmental and Sustainability Planning Tools* in the list below.

Environmental and Sustainability Planning Tools
Gaithersburg Environmental Standards for Development Regulation
State of Maryland 12 Planning Visions

Air Quality
Federal Clean Air Act
MD Air Quality Law (COMAR 26.11)
MD State Implementation Plan (SIP)
Montgomery County Air Quality Control Ordinance (Ch. 3)

Biodiversity
Federal Endangered Species Act
MD Wildlife Law (COMAR 08.03)
MD Threatened and Endangered Species Law (COMAR 08.03.08)

Construction Codes and Regulations
Montgomery County Planning Board Technical Noise Guidelines
Gaithersburg Offenses – Miscellaneous Ordinance (Ch. 15)
Gaithersburg Excavation of Underground Utility Facilities Ordinance (Ch. 9)
Gaithersburg Green Building Ordinance (Ch. 5)

Forest Conservation
MD Forest Conservation Law (COMAR 8.19)
Gaithersburg Trees and Vegetation Ordinance (Ch. 21)
Gaithersburg Tree Manual
Gaithersburg Trees and Forest Conservation Ordinance (Ch. 22)
Gaithersburg Tree Reforestation Policy (for Public Lands)

Land Development
Gaithersburg Adequate Public Facilities Ordinance
MD Growth Tiers
Plan Maryland
Gaithersburg Subdivision of Land (Ch. 20)
Gaithersburg Landscaping Standards of Zoning (Ch. 24)

Livability and Housing

Federal Housing Non-Discrimination Act/Fair Housing
Gaithersburg Property Maintenance Code; Health and Sanitation (Ch. 12)
Gaithersburg Refuse and Garbage (Ch. 18)

Water and Sewer Service

MD Water Supply, Sewerage, Solid Waste, and Pollution Control Planning and Funding Law (COMAR 26.03)
Washington Suburban Sanitation Commission (WSSC) (Fiscal Years 2015 – 2020 Capital Improvements Program (CIP)

Water Quality

Federal Clean Water Act
Federal Resources Conservation and Recovery Act (RCRA)
Federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
MD Water Pollution Law and Erosion and Sediment Control Law (COMAR 26.17.01)
MD Stormwater Management (Act of 2007) Law (COMAR 26.17.02)
Gaithersburg Sediment and Erosion Control and Stormwater Management Ordinance (Ch. 8)
National Pollutant Discharge and Elimination System (NPDES) Phase II Municipal Separate Storm Sewer System (MS4) Permit
National Pollutant Discharge Elimination System (NPDES) General Discharge Permit for Stormwater Associated with Industrial Activities
Maryland Fertilizer Use Act of 2011 (COMAR 15.20.10)

Wetlands and Flood Mitigation

US Army Corps of Engineers Regulations (Part 323)
MD Non-tidal Wetlands Law (COMAR 26.23)
Gaithersburg Floodplain Management Ordinance (Ch. 10)

4. Natural Resources

The following chapter discusses and graphically presents those environmental features required under the *Land Use Article* to be included in a Sensitive Areas Element. The protection of these features, such as required buffers or other methods, are defined in either the City's *Environmental Standards for Development Regulation* or governed by State or Federal regulations as listed in Chapter 3 above.

4.1 Soils

Montgomery County is located within the Piedmont physiographic region within the State of Maryland. This region is the transition area from the western mountains to the eastern coastal plain. The Piedmont, because of its geologic history, is characterized by rolling hills with deeply incised stream valleys. The soils of the Piedmont tend to have a high amount of clay with ridges or upland depressions having moderately well drained, silty or loamy soils. The City of Gaithersburg is dominated by the Glenelg-Gaila-Occoquan soil complex[1]. This complex is about 51 % Glenelg soils, 21% Gaila soils, 7% Occoquan soils, and 21% soils of minor extent. As shown in Figure 1, taken from the Soil Survey of Montgomery County Maryland,[2] Brinklow soils on slightly convex slopes and Baile soils along drainageways are commonly found.

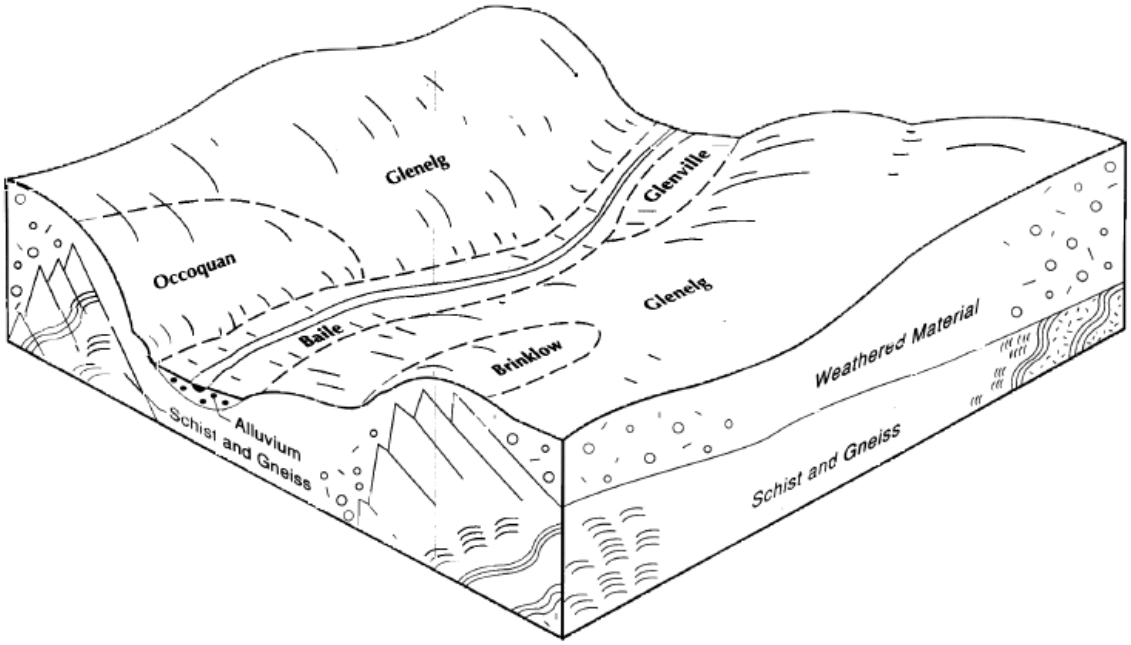


Figure 1: Typical pattern of soils of the Piedmont physiographic province in Montgomery County[3]

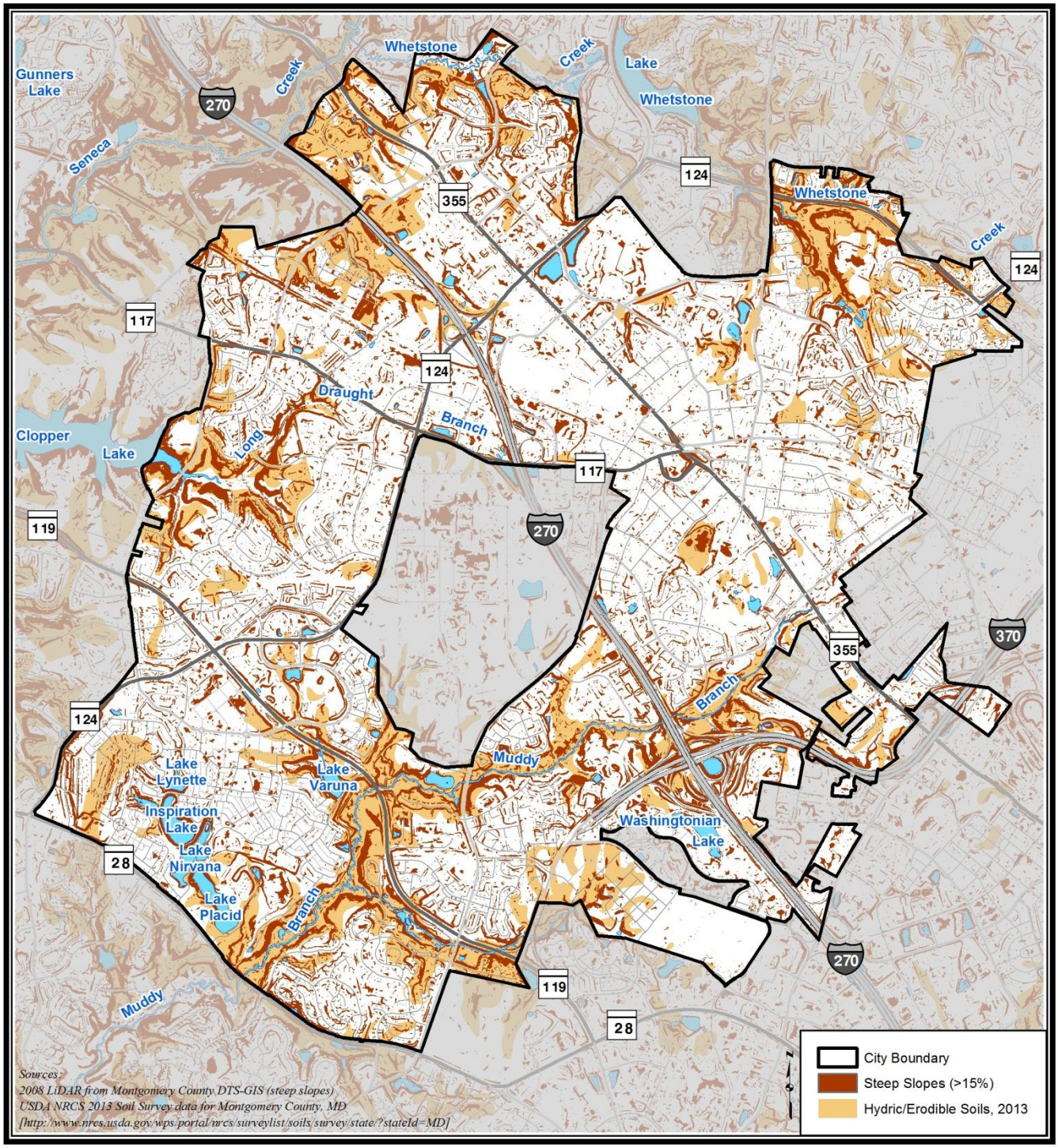
[1] US Dept. of Agriculture (USDA), Natural Resources Conservation Service (NRCS) in cooperation with Maryland Agricultural Experiment Station and Montgomery Soil Natural Conservation District, *Soil Survey of Montgomery County, Maryland*, July 1995. http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/maryland/montgomeryMD1995/montgomeryMD1995.pdf or use the NRCS application at http://websoilsurvey.nrcs.usda.gov/app/

[2] *Ibid.*

[3] *Ibid.*

The following map identifies hydric/erodible soils and the presence of slopes greater than 15%.

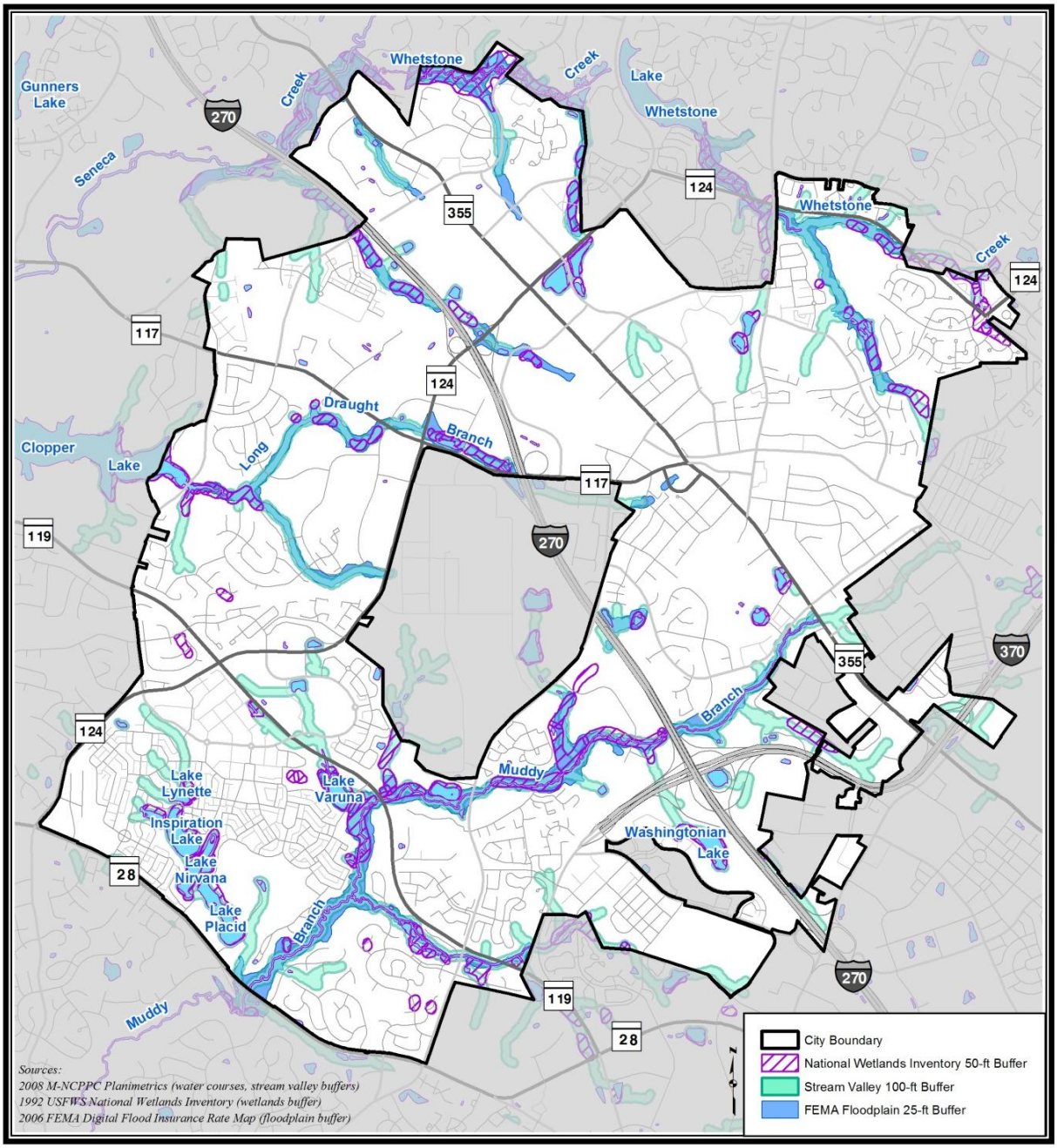
Map 1: Erodible Soils and Steep Slopes



4.2 Streams, Wetlands, and Floodplains

The following map shows the baseline watershed areas for the City. There are no tidal wetlands within the City. The non-tidal wetlands within the City (190 acres) consist of transitional areas between open water or aquatic environments and uplands. The more than 20 miles of perennial, ephemeral, and intermittent streams are shown on the map along with their associated floodplains, wetlands, and approximate buffers. The lakes shown were created during development as there are no natural lakes in Maryland. The primary stream tributaries within the City (Muddy Branch, Long Draught, Seneca Creek, and Whetstone) are shown on the map.

Map 2: Natural Water Resources



4.3 General Climate Characteristics

Gaithersburg is located in a humid subtropical climate (Cfa on the Köppen Climate Classification System), characterized by hot summers, mild winters, and moderate precipitation that is usually not seasonal in nature.[4] Weather information is not collected for Gaithersburg, but Rockville, Greenbelt, and Washington (DC) are nearby stations. Records spanning the late 1800s to the present show that the average July temperature in Washington, DC is 79.8° F, the average January temperature is 36.0° F, the average annual temperature is 58.2° F, the annual average precipitation is 39.74 inches, and the average annual snowfall is 15.4 inches.[5] Although these figures represent average climatic conditions over a period of time, climate is dynamic in nature and recent studies indicate that changes have been occurring in recent decades.[6]

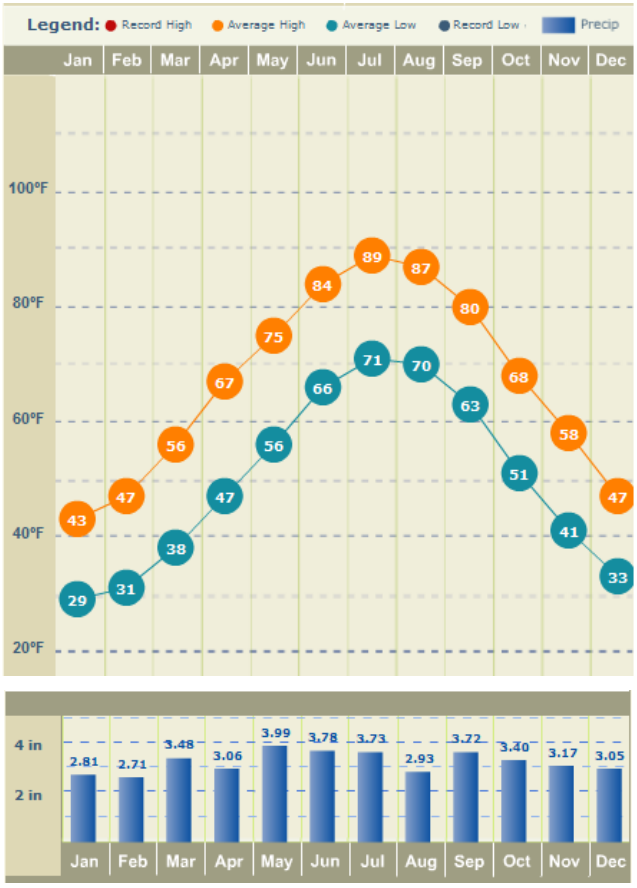


Figure 2: Temperature and Precipitation Graphs for Washington, DC

[4] M. C. Peel, B. L. Finlayson, and T.A. McMahon, "World Map of Köppen-Geiger climate classification," Australia: The University of Melbourne, http://hal.archives-ouvertes.fr/docs/00/30/50/98/PDF/hess-11-1633-2007.pdf (accessed August 15, 2014).

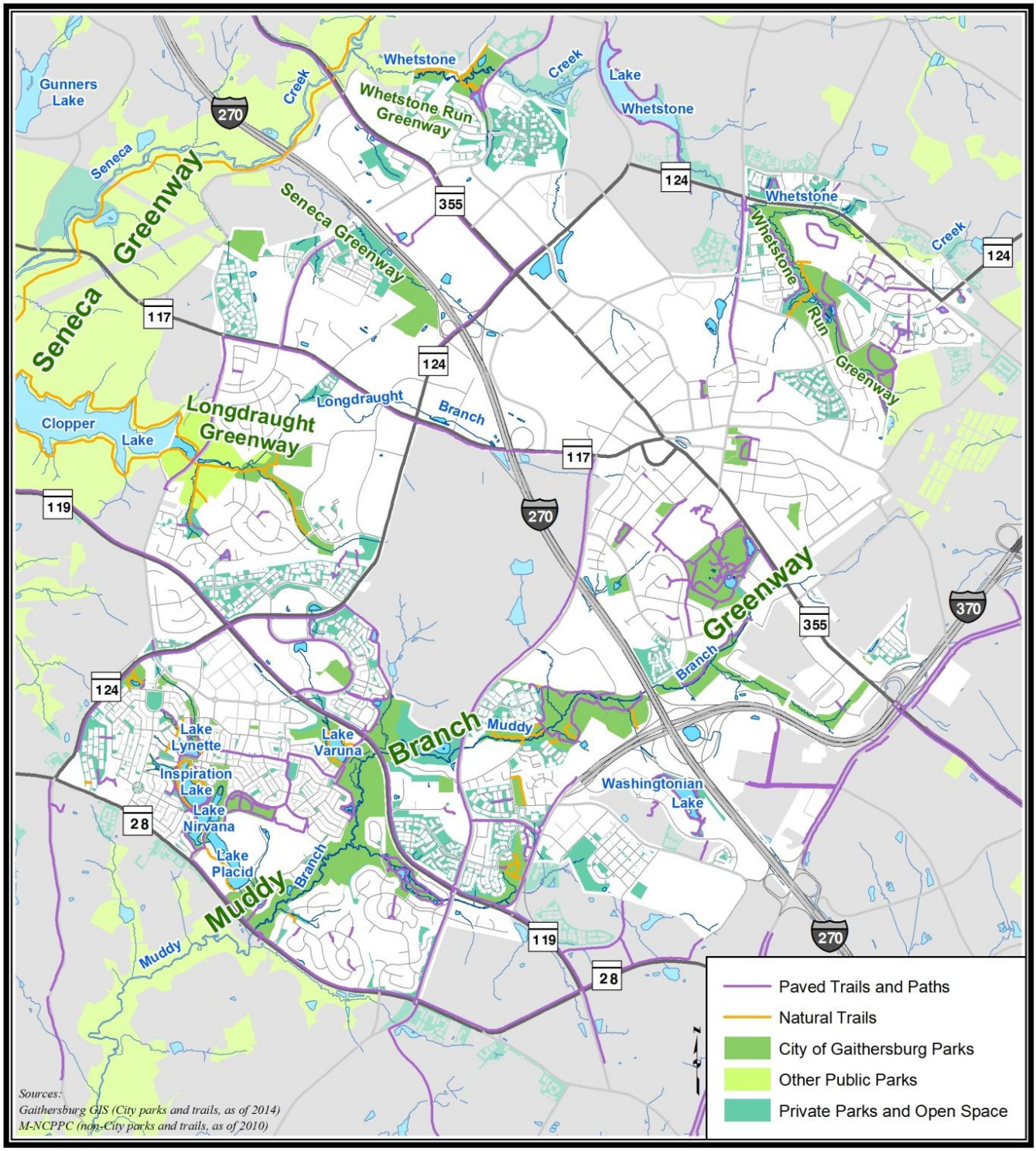
[5] Preliminary (unofficial) data from the National Weather Service, http://www.erh.noaa.gov/lwx/climate/dca/dcatemps.txt, http://www.erh.noaa.gov/lwx/climate/dca/dcaprecip.txt, and http://www.erh.noaa.gov/lwx/climate/dca/dcasnow.txt (accessed August 15, 2014)

[6] J. Walsh et. al., "Ch. 2: Our Changing Climate," in *Climate Change Impacts in the United States: The Third National Climate Assessment*, ed. J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, (U.S. Global Change Research Program: 2014), 19-67. (doi:10.7930/J0KW5CXT) http://nca2014.globalchange.gov/system/files_force/downloads/high/NCA3_Full_Report_02_Our_Changing_Climate_HighRes.pdf?download=1

4.4 Open Space

The following map shows the distribution of open space areas and corridors within the City limits. These areas are often also associated with forested or high canopy coverage lands. Areas owned by the City are identified separately from private open space areas which are under Homeowner Association (HOA) or other ownership. Public lands not owned by the City are also identified. As can be seen on the map, there are portions of the City with access to public and/or private open spaces, while other areas, namely along the Frederick Avenue Corridor, have little provision for open space. For a more in-depth analysis of existing access to open space areas, see section 7.9.2.

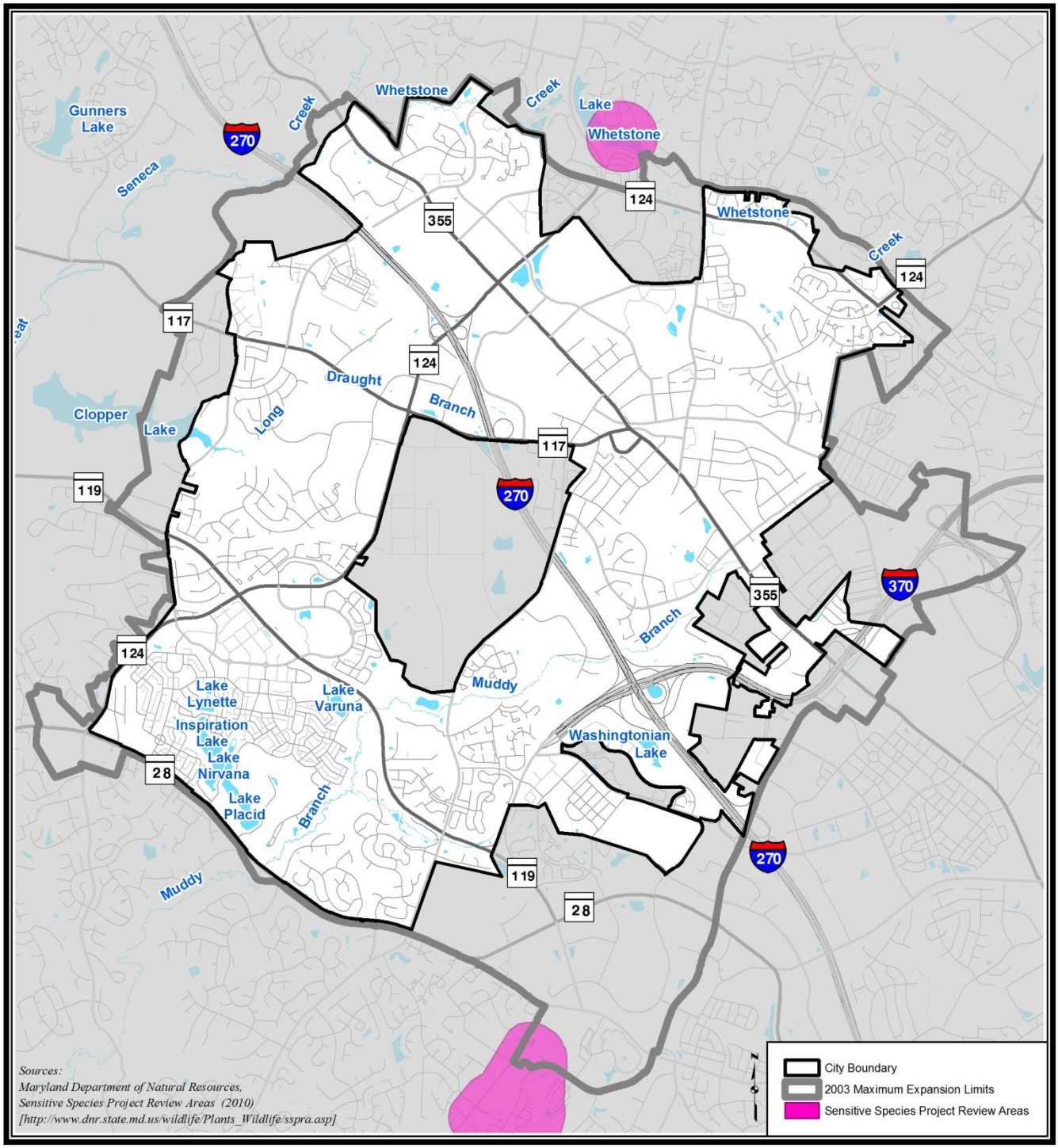
Map 3: Open Space



4.5 Rare, Threatened, and Endangered Species

The Maryland Department of Natural Resources (DNR), is the lead state agency responsible for the identification, ranking, protection, and management of nongame, rare, threatened, and endangered species (RTE) and their habitats in Maryland. The following map shows the generalized areas recommended for review for the presence of RTE species. A full listing of RTE species identified in Montgomery County is provided in Appendix C. No RTE species have been identified within the corporate limits of the City. Should a RTE species be found within the City in the future, appropriate actions in accord with federal, state and local laws and regulations would be implemented to protect both the species and its associated habitat.

Map 4: Rare, Threatened, and Endangered Species



5. Urban Forest

Aside from air and water, the most identifiable environmental resources that come to most people's minds are forests and trees. The urban forest is a large capital asset of any city. For many municipalities, urban forestry maintenance is a challenge. The desire to preserve existing forest land and create viable tree save areas is often in conflict with a community's desire for economic development and rising land values.

Goal: Gaithersburg will continue to be a Tree City and have a sustainable urban forest that contributes to the livability of our community by providing environmental, social, and economic benefits.

As urbanization and densification continues, healthy forests may become fragmented or destroyed. Forests are vital for more than aesthetic or wildlife habitat concerns. Forests provide benefits on a number of fronts and these benefits can continue to be obtained with a commitment to maintaining a healthy urban forest. In 2009, the American Planning Association expanded the Urban Forestry definition to include "a planned and programmatic approach to the development of the urban forest, including all elements of green infrastructure within the community, in an effort to optimize the resulting benefits in social, environmental, public health, economic and aesthetic terms, especially when resulting from a community visioning and goalsetting."

5.1 Environmental Benefits

The urban forest functions as a natural filter for pollutants both in the air and resulting from stormwater run-off. Trees clean the air by absorbing carbon dioxide, sulphur dioxide, nitrous oxides and other pollutants, and also shade parking lots, streets, and buildings reducing both ozone emissions from vehicles and urban heat island effects.

Studies have shown that an acre of forested trees annually absorbs the amount of carbon produced by driving a car for 26,000 miles.[7] An acre of average tree cover in an urban environment can offset automobile fuel use and emissions equivalent to driving a car between 7,200 and 8,700 miles.[8] Urban trees in fact sequester more carbon than individual trees in non-urban forests given that the more open growing structure of an urban setting allows individual trees to intercept more light and grow faster. Individual urban trees contain about four times more carbon than individual trees in forests.[9]

[7] David J. Nowak, "Benefits of Community Trees," *Brooklyn Trees*, USDA Forest Service General Technical Report (in review), no date.
[8] *Ibid.*
[9] Nowak, David, and Daniel Crane. "Carbon Storage and Sequestration by Urban Trees in the USA." Environmental Pollution 116 (2002): 381-89. http://nrs.fs.fed.us/pubs/jrnl/2002/ne_2002_nowak_002.pdf
[9] The USDA Forest Service's Urban Forestry Effects (UFORE) tool measures and calculates the many and diverse values of the urban forest. UFORE quantifies the quantity, structure, and benefits of the overall forest canopy.

An UFORE analysis[10] of the urban tree benefits of Washington, D.C.'s 1.9 million trees reported the following:

- 474,000 metric tons of Carbon stored ($10.8 million value)
- 14,600 metric tons/year of Carbon sequestered ($334,000 value)
- 490 metric tons/year total pollution removal ($3.7 million value)
- 23 metric tons/year of CO removed ($32,000 value)
- 65 metric tons/year NO2 removed ($645,000 value)
- 196 metric tons/year of O3 removed ($1.9 million value)
- 66 metric tons/year of SO2 removed ($160,000 value)
- 140 metric tons/year of PM10 removed ($928,000 value).[11]

Tree planting is one of the most cost-effective means of mitigating urban heat island effects including ozone. Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Various studies show that shaded surfaces may be 20° to 45° F cooler than the peak temperatures of unshaded surfaces. The evapotranspiration itself can help reduce peak summer temperatures by 2° to 9° F. The indirect cooling effect of evapotranspiration is greater than the direct effect of shading in mitigating the urban heat island effects. As the number of trees in an area increases, the relative combined evapotranspiration equates to overall cooling increasing. A 10% difference in canopy coverage can equate to an approximately 2º F difference in temperature.[12]

The City of Gaithersburg and the State of Maryland have renewed emphasis on reducing stormwater run-off in order to protect watersheds and ultimately the Chesapeake Bay. The urban forest can play a vital role in this endeavor. Trees divert captured rainwater into the soil, where bacteria and other microorganisms filter out impurities. This reduces urban runoff and the amount of sediment (erosion), pollutants, and organic matter that reach streams.

An urban forest can reduce annual stormwater runoff by 2% to 7%, and a mature tree alone can store 50 to 100 gallons of water during large storms.[13] For every 5% of tree cover added to a community, stormwater runoff is reduced by approximately 2%.[14] Tree plantings along with green streets and rain barrels are estimated to be 3-6 times more effective in managing stormwater per $1,000 invested than conventional methods.[15] Urban landscaping in Washington, DC, prevents more than 1.2 billion gallons of stormwater from entering the sewer system or 10% of the total volume. This results in a savings of $4.74 billion in gray infrastructure costs per 30-year

[10] The USDA Forest Service's Urban Forestry Effects (UFORE) tool measures and calculates the many and diverse values of the urban forest. UFORE quantifies the quantity, structure, and benefits of the overall forest canopy.

[11] District Department of Transportation, Urban Forestry Division, *District of Columbia Assessment of Urban Forest Resources and Strategy*, 2010. http://www.stateforesters.org/files/DC-Assess-Strategy-20100630.pdf

[12] Karen K. Dixon and Kathleen L. Wolf, "Benefits and Risks of Urban Roadside Landscape: Finding a Livable, Balanced Response" (presentation, 3rd Urban Street Symposium, Seattle, Washington, 2007). http://www.urbanstreet.info/3rd_symp_proceedings/Benefits%20and%20Risks.pdf

[13] Dr. James R. Fazio, ed., "How Trees Can Retain Stormwater Runoff," *Tree City USA Bulletin* 55 (2010). http://www.fs.fed.us/psw/programs/uesd/uep/products/11/800TreeCityUSABulletin_55.pdf .

[14] Kim Coder, "Identified Benefits of Community Trees and Forests," University of Georgia, October, 1996.

[15] Josh Foster, Ashley Lowe, and Steve Winkelman, *The Value of Green Infrastructure for Urban Climate Adaptation*, (Washington, DC: The Center for Clean Air Policy, 2011). http://ccap.org/assets/The-Value-of-Green-Infrastructure-for-Urban-Climate-Adaptation_CCAP-Feb-2011.pdf

construction cycle.[16] In New York City, street trees intercept 890 million gallons of stormwater annually with a total value of over $35 million each year.[17]

5.2 Social Benefits

The urban forest strengthens a community with more than beautification. For example, trees reduce noise pollution by absorbing sounds. A belt of trees 98 feet wide and 49 feet tall can reduce highway noise by 6 to 10 decibels.[18] Trees can promote a feeling of unity and cohesion within a neighborhood. Residents like where they are living more and they feel safer with the presence of trees. In fact a 2012 study on Baltimore City and Baltimore County found that the frequency of crimes reported in a particular block or neighborhood went down as the tree cover was increased. The study reported that a 10% increase in leaf canopy was associated with a 12% decrease in crime.[19] Street trees and landscaping can be thought of as road safety tools and have been shown to reduce accidents in Toronto by 5% to 20%, increasing pedestrian use of urban arterials.[20] Mid-block islands with trees can result in up to a 7% reduction in motor vehicle speeds.[21]

A robust urban forest can actually have a positive impact on a community's health. Residents of areas with the highest levels of greenery were three times as likely to be physically active and 40% less likely to be overweight or obese than residents living in the least green settings.[22] Researchers from Columbia University found childhood asthma rates were highest where tree density was lowest. The asthma rates fell by 25% for every extra 340 trees per square kilometer, even after accounting for differing sources of pollution, levels of affluence, and population density.[23] A July 2009 study asked 2,500 Wisconsin residents from 229 neighborhoods

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[16] Barbara Deutsch, Heather Whitlow, and Michael Sullivan. *The Green Build-out Model: Quantifying the Stormwater Management Benefits of Trees and Green Roofs in Washington, DC*, (Casey Trees and Limno Tech under EPA cooperative agreement, 2007). http://www.capitolgreenroofs.com/pdfs/Green_Infrastructure_Report.pdf

[17] Paula Peper et. al., *New York City, New York Municipal Forest Resource Analysis* (Davis, CA: USDA Forest Service, Pacific Southwest Research Station and Center for Urban Forest Research, April 2007). http://www.fs.fed.us/psw/programs/uesd/uep/products/2/psw_cufr687_NYC_MFRA.pdf

[18] New Jersey Department of Environmental Protection, Division of Parks and Forestry, *Benefits of Trees: Trees Enrich the Health and Quality of Our Environment*, http://www.state.nj.us/dep/seeds/docs/bot.pdf (accessed August 15, 2014).

[19] Austin Troya, J. Morgan Groveb, Jarlath O'Neil-Dunnea, "The Relationship Between Tree Canopy and Crime Rates Across an Urban–Rural Gradient in the Greater Baltimore Region," *Landscape and Urban Planning* Volume 106, Issue 3, (15 June 2012): 262–270

[20] Kathleen Wolf and Nicholas Bratton, "Urban Tees and Traffic Safely: Considering U.S. Roadside Policy and Crash Data," *Arboriculture & Urban Forestry* 32.4 (2006). http://www.naturewithin.info/Roadside/TransSafety_ArbUF.pdf .

[21] Boston Transportation Department, "Design Features That Reduce Operating Speeds," in *draft Boston Complete Streets Guidelines* (Boston, MA: Boston Transportation Department, December 2010). http://www.bostoncompletestreets.org/pdf/3/chap3_3_reduce_operating_speed.pdf

[22] Anne Ellaway, Sally Macintyre, and Xavier Bonnefoy, "Graffiti, Greenery, and Obesity in Adults: Secondary Analysis of European Cross Sectional Survey," *British Medical Journal* 331 (2005): 611-12. http://www.bmj.com/content/bmj/331/7517/611.full.pdf

[23] G. S.Lovasi et. al., "Children Living in Areas with More Street Trees Have Lower Prevalence of Asthma," *Journal of Epidemiol Community Health* 62 (2008): 647-49. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3415223/pdf/nihms394846.pdf

[23] Kirsten Beyer, et. al., "Exposure to Neighborhood Green Space and Mental Health: Evidence from the Survey of the Health of Wisconsin," *International Journal of Environmental Research and Public Health* 11,3 (2014): 3453 DOI: 10.3390/ijerph110303453.

to rate their symptoms of depression, anxiety and stress while analyzing how much vegetation was present in each of the Survey of the Health of Wisconsin (SHOW) subject census blocks. The study found that across all strata of society, people who lived in a neighborhood with less than 10% tree canopy were much more likely to report symptoms of depression, stress and anxiety.[24]

5.3 Economic Benefits

It is not always immediately evident, but the maintenance and expansion of the urban forest translates to real world economic benefits. The US Forest Service published a study in 2006 that estimated the net benefits for a yard and public tree summed over 40-year period.[25]

- Large Tree: $4,320 (yard) and $3,880 (public)
- Medium Tree: $1,040 (yard) and $760 (public)
- Small Tree: $280 (yard) and $40 (public)
- Conifer: $2,040 (yard) and $1,640 (public)

Street trees not only have the environmental and social benefits as mentioned previously, but can provide true economic impacts. The annual economic benefits of Washington, DC street trees in 2011 were $10.6 million, including $5.1 million for property value.[26] Street tree shade has been proven to reduce pavement fatigue, cracking, and other distress, saving on repair costs for municipalities. Tree-shaded roads can save up to 60% of repaving costs.[27] A study from UC Davis found that 20% shade on a street improves pavement condition by 11%, which is a 60% savings for resurfacing over 30 years.[28]

The benefits are not limited to the public sector. Everyone benefits from reduced energy costs. At the macro scale, 50 million shade trees planted in strategic, energy-saving locations could eliminate the need for seven 100-megawatt power plants.[29] At the micro level, a 20% tree canopy over a house results in annual cooling savings of 8% to 18% and annual heating savings of 2% to 8%.[30]

For private landowners, the economic impact is not limited to energy cost savings. Studies have found increases of up to 37% in residential property values associated with the presence of trees and vegetation on a property. Property values increase 5% to 15% when compared to properties without trees, depending on species, maturity, quantity, and location. A 1988 study

[24] Beyer, "Exposure to Neighborhood Green Space and Mental Health: Evidence from the Survey of the Health of Wisconsin," 3453.

[25] Gregory McPherson et. al., *Coastal Plain Community Tree Guide: Benefits, Costs, and Strategic Planting*, (Davis, CA: USDA Forest Service, Pacific Southwest Research Station,.2006). http://www.fs.fed.us/psw/programs/uesd/uep/products/2/cufr_679_gtr201_coastal_tree_guide.pdf

[26] Foster and Lowe and Winkelman, *The Value of Green Infrastructure for Urban Climate Adaptation*.

[27] Gegory McPherson and Jules Muchnick, "Effects of Street Tree Shade on Asphalt and Concrete Pavement Performance," *Journal of Arboriculture* 31.6 (2005): 303-10. http://www.fs.fed.us/psw/publications/mcpherson/psw_2005_mcpherson001_joa_1105.pdf .

[28] J.R. Geiger and S.L. Gardner, *Why Shade Trees? The Unexpected Benefits*, (Davis, CA: USDA Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research, 2006). http://www.fs.fed.us/psw/programs/uesd/uep/products/cufr_673_WhyShadeStreets_10-06.pdf

[29] E.G. McPherson and J.R Simpson, 2001. *Effects of California's Urban Forests on Energy Use and Potential Savings From Large-scale Tree Planting* (Davis, CA: USDA Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research, 2001), 35.

[30] Foster and Lowe and Winkelman, *The Value of Green Infrastructure for Urban Climate Adaptation*.

reported trees increased home sales prices in Athens, GA from $1,475 to $1,750. This increase in property value resulted in an increase of $100,000 in the city's property tax revenues.[31] Even commercial properties realize benefits. Businesses on treescaped streets show 12% higher income streams.

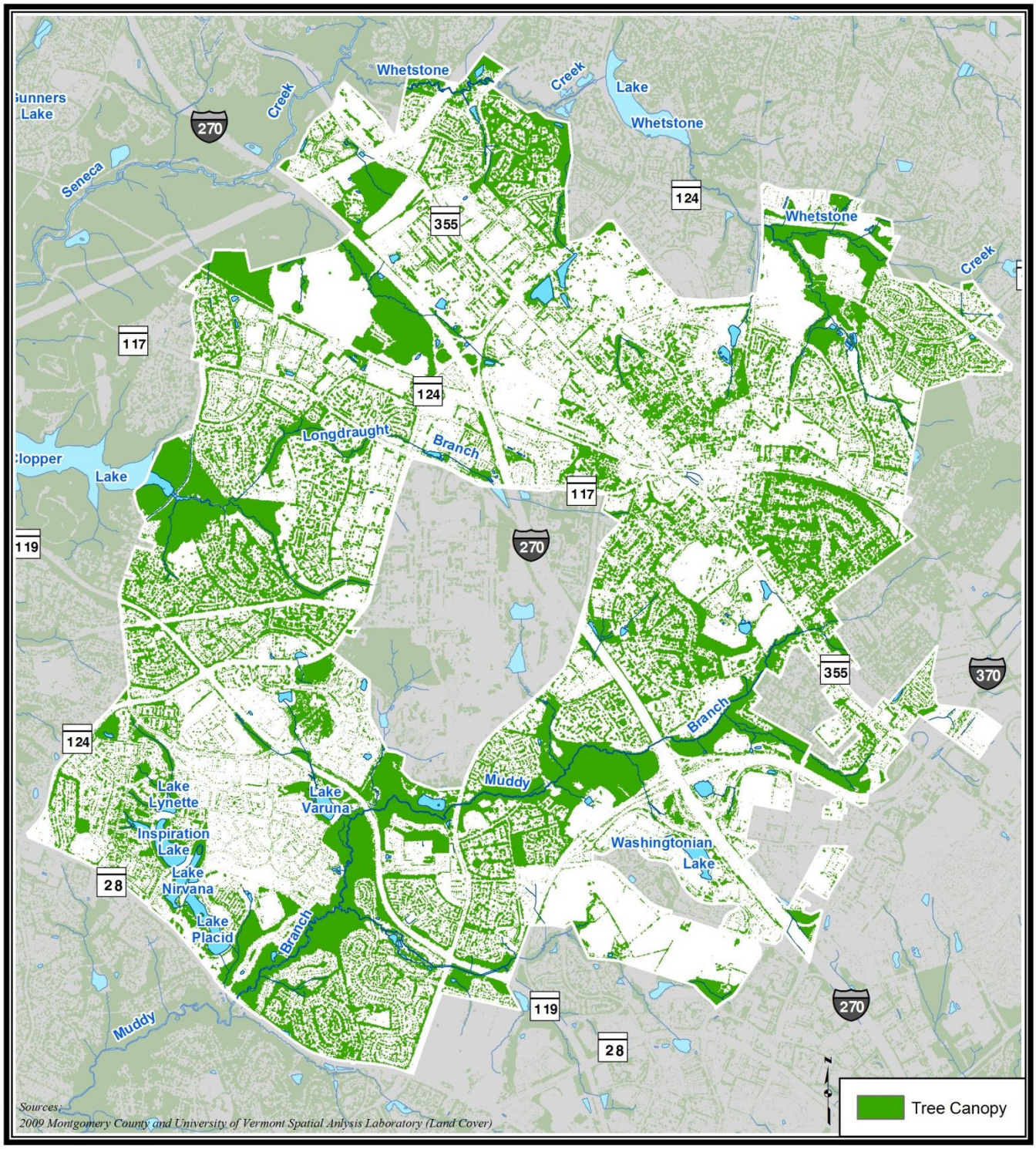
It is clearly evident that the promotion of a healthy urban forest does nothing but improve the greater community through various facets. The question is "How is the City of Gaithersburg's urban forest?"

5.4 City of Gaithersburg Tree Canopy Coverage

As shown previously, tree canopy coverage is often an accurate indicator receiving the various benefits discussed, more so than actual forest. Governor Martin O'Malley on May 2, 2013 signed into law legislation that established the State's no-net-loss policy to maintain the State's current 40% tree canopy. Using GIS data, the City performed an analysis of the City's current existing tree canopy coverage to determine the status of canopy coverage as it relates to the State's 40% goal. The following is the City's tree canopy distribution:

[31] L.M. Anderson and H.K. Cordell, "Influence of Trees on Residential Property Values in Athens,Georgia (U.S.A.): A Survey Based on Actual Sales Prices," *Landscape and Urban Planning* 15 (1988): 153-164. http://www.srs.fs.usda.gov/pubs/ja/ja_anderson003.pdf

Map 5: Urban Tree Canopy



Note: Smaller-scale maps with additional detail are provided in Appendix A.

In reviewing the distribution shown on the preceding map, the following are noted:

- The combined areas referred to as the Frederick Avenue Corridor Commercial and Employment Districts, including Lakeforest Mall and the Fairgrounds, are the largest expanse of the City lacking dense tree canopy;
- Large contiguous sections of tree canopy are associated with parks or protected open spaces resulting from Forest Conservation requirements;
- Tree canopy as shown can be expected to be reduced in the coming years as areas such as the Meadows in Quince Orchard, the properties along Metropolitan Grove Road, and the Spectrum are developed; and
- Older City neighborhoods such as Deer Park and West Riding have dense tree canopy; however, much of the canopy is located on private lots and not governed by approved landscape plans and is therefore susceptible to being removed and not replaced.

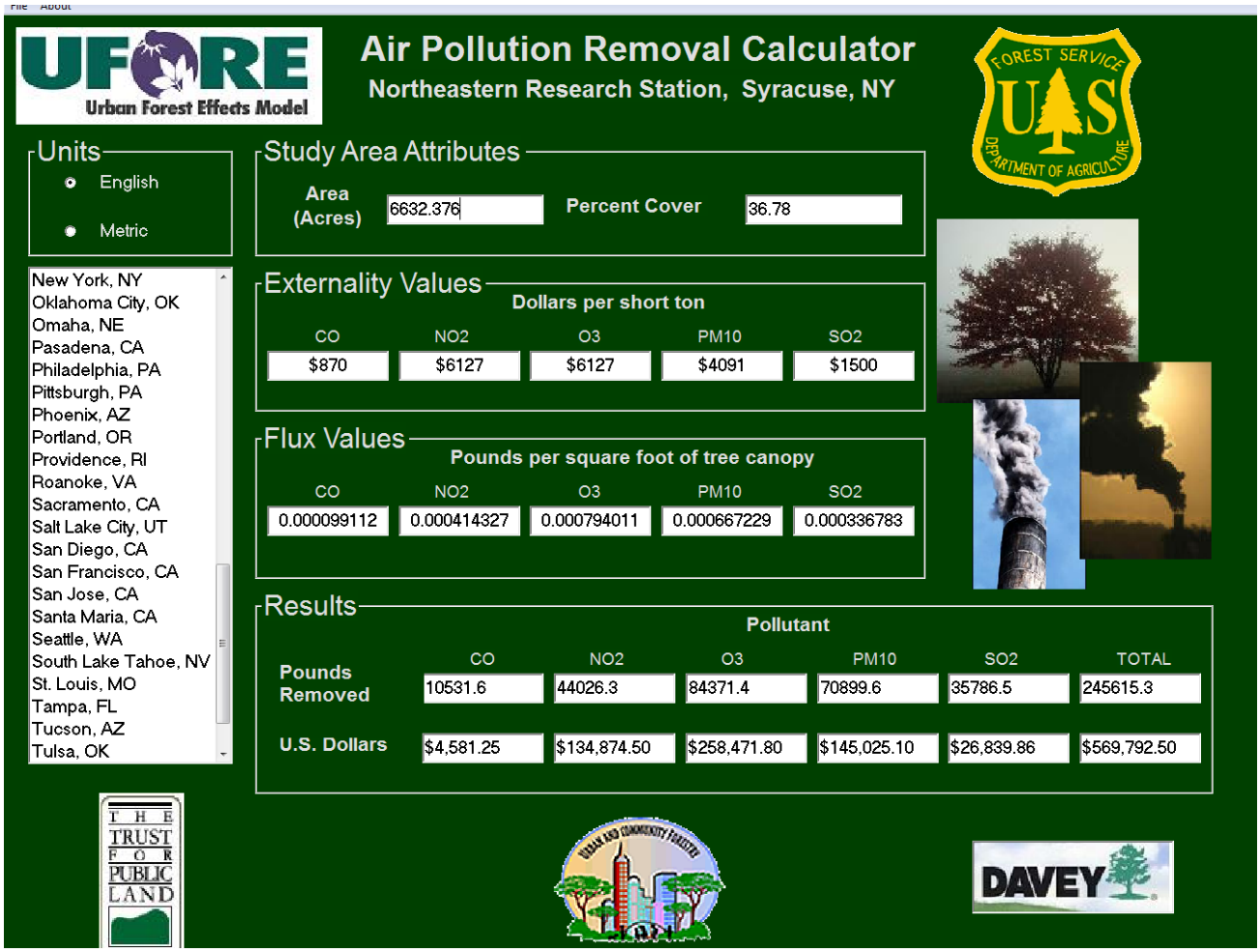
Further analysis was performed in order to identify tree canopy as being on either Residential (including HOA properties), Non-residential (including religious facilities), Public (including MCPS schools), or Right of Ways (roads and street trees). In all, the City currently has approximately 37% tree canopy coverage. The following chart provides the breakdown by sector:

Table 1: Existing Tree Canopy Analysis

	Area (sq. feet)	Area (sq. miles)	Area (Acres)	**Percent**
Tree Canopy	106,259,193	3.8115	2,439.371	**36.78**
City Area	288,906,795	10.3631	6,632.376	**100.00**

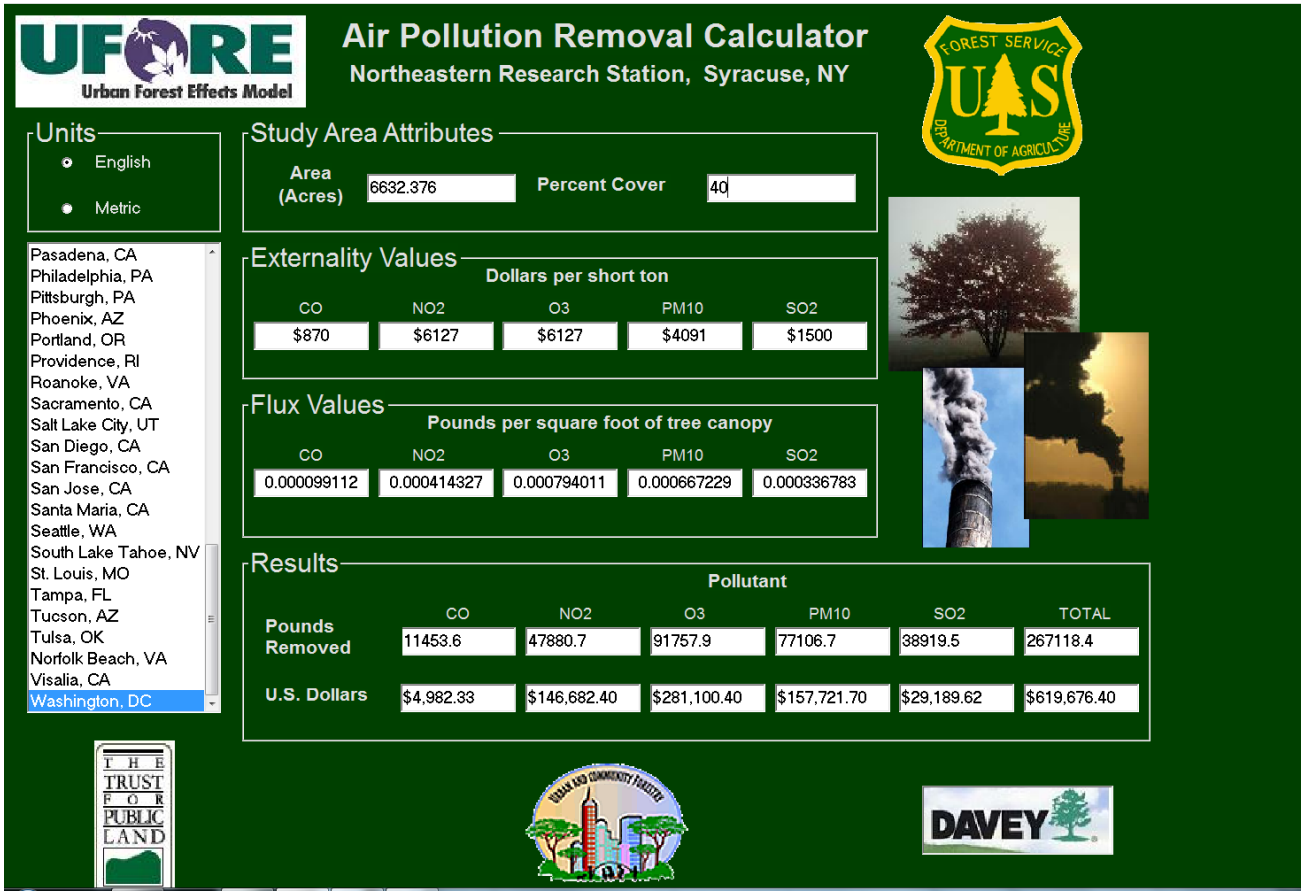
General Land Use	Area (sq. feet)	Area (sq. miles)	Area (Acres)	**Canopy Percent**	**Percent of City Land**
Residential	48,856,698	1.7525	1,121.593	**45.97**	**16.91**
Non-residential	15,574,617	0.5587	357.543	**14.66**	**5.39**
Public	28,441,872	1.0202	652.934	**26.76**	**9.84**
Right of Way	13,401,828	0.4807	307.663	**12.61**	**4.64**
Tree Canopy Total	106,275,015	3.81209542	2,439.734	**100.00**	**36.78**

The City's canopy coverage was then analyzed using the US Forest Service Air Pollution Removal Calculator -- Version 1.0 showing the amounts and value of pollutants removed[32]. The default values are 1994 median values for the United States. The calculator is based upon local data analyzed for various cities (Washington, DC in this case) with the Urban Forest Effects (UFORE) model. The current state of the City shows:

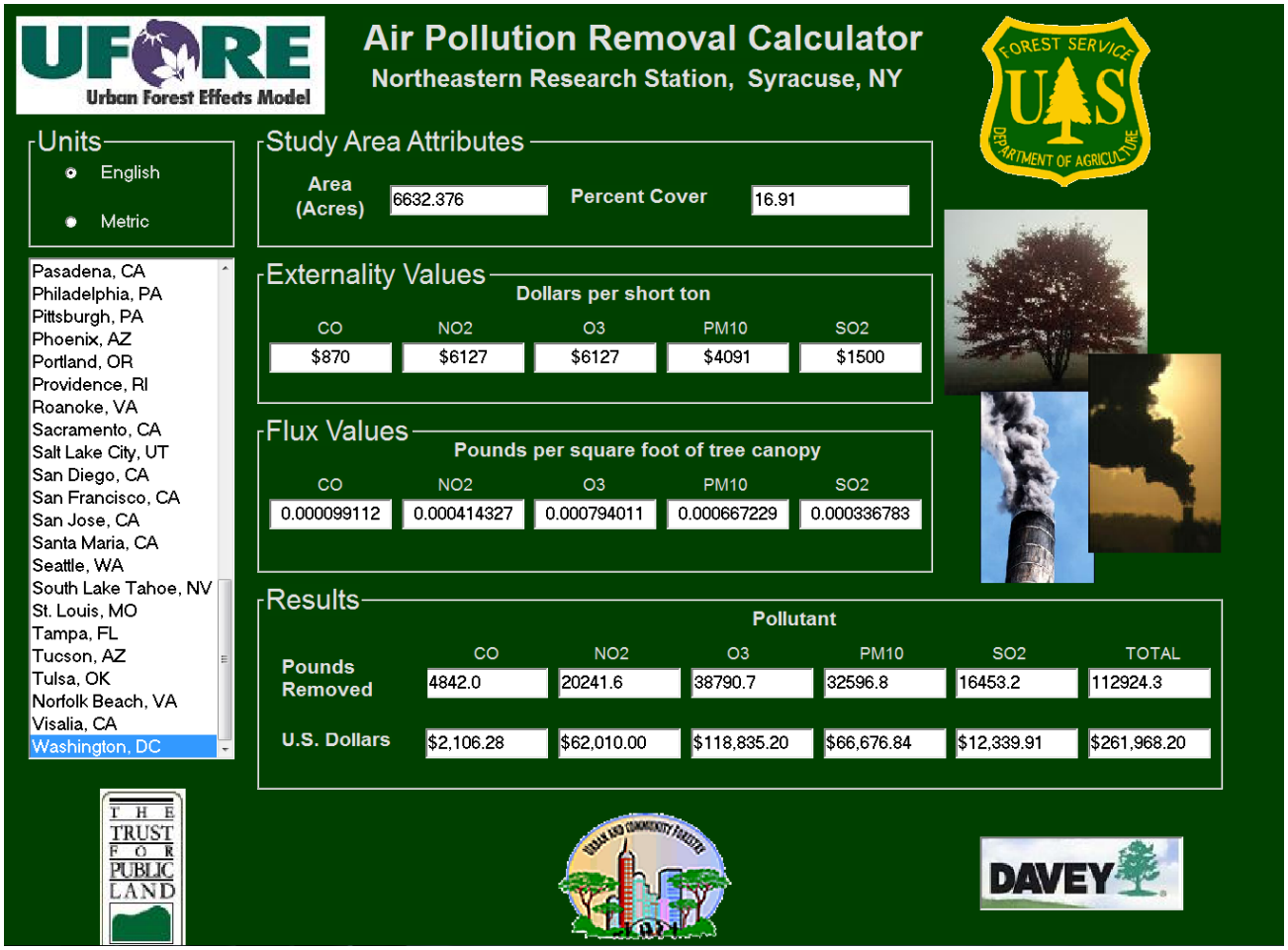


[32] Refer to Appendix D for more detailed description of UFORE Calculator methodology and Frequently Asked Questions about the UFORE model (www.ufore.org)

Should the City achieve the State goal of 40% canopy coverage, the total value of pollutants removed would equal an approximate increase of $50,000.



As discussed, 45.97% of the City's canopy coverage (16.91% of the total City land area) is sited on private residential, often unprotected, lands vulnerable to inadequate management, injury, and tree removal. This sector, as shown, provides 46% of all pollutant pounds removed.



5.5 Recommendations

A. Preserve and expand the City's tree canopy

- Achieve the State's 40% canopy coverage goal by 2025.
- Adopt a no-net-loss of canopy policy.
- Establish 40% canopy coverage goals in new residential and residential/commercial development projects in addition to or as part of forest conservation requirements.
- Establish 30% canopy coverage goals in new commercial development/redevelopment projects in addition to or as part of forest conservation requirements.
- Conduct a canopy coverage assessment on a five year cycle.
- Use canopy coverage analysis to identify and target areas for increased plantings focusing on non-residential and right of way areas.
- Review and amend the City's Tree Manual including tree canopy standards.

B. Maintain a healthy diverse urban forest

- Review "right tree, right place" practices in all planting projects.
- Achieve and maintain a species diversity in new afforestation or reforestation projects where no single genus comprises more than 20% and no single species comprises more than 10% of the total population.
- Encourage Comprehensive Landscape plans involving tree planting to include 20% conifers.
- Conduct inventory and review of the condition of forest conservation easements within the City, establish a five year cycle for continued reviews.
- Conduct and maintain a street tree inventory including City, County, and State owned roads for species diversity and condition. Use the inventory to identify planting/replanting opportunities and increase species/genus diversity. Establish a species planting plan for new or replacement trees.
- Improve stream corridors and other natural areas by incorporating expanded stream valley buffers (SVB) as part of any watershed management plan project.
- Work with private landowners to establish easements protecting SVB.
- Explore reforestation areas on private properties.
- Increase and fund disease and pest training for the City's urban forestry staff.
- Look to reduce the use of herbicides in the control of "weeds" to include practices such as native species and wildflower plantings in open spaces.

C. Preserve urban forest habitats

- Review the program for addressing invasive and exotic species on City and private properties.
- Explore opportunities for regional collaboration with other agencies related to targeting and reducing invasive populations such as the Emerald Ash Borer.
- Encourage bird boxes and native plantings of shrubs and groundcover to support populations of migratory and local birds.

- Include regional coordination in planning to ensure preservation of habitat corridors to maintain and encourage biodiversity.

D. Consider the urban forest in all planning projects

- Work with utilities, developers, State and County agencies to seek to underground overhead wires avoiding conflicts with trees and providing increased opportunities to plant large shade trees with an emphasis on major corridors.
- Identify sites that will permit the expansion of tree planting strips and tree wells to provide more suitable growing conditions for street trees.
- Establish replanting or fee-in-lieu standards for the removal of vegetation as part of requested environmental waivers not included as part of a forest conservation plan.
- Incorporate urban forest planting and goals in future Parks and Open Space Master Plans.
- Evaluate policies to develop and adopt alternative street profiles and sections that provide larger tree planting areas, more open space, increased permeable surface area, and new opportunities for stormwater management.

E. Continue to improve coordination and communication between City departments, regional agencies, policy makers and the community to improve the urban forest

- Develop guidelines for, and publically and/or privately fund, a City grant program for property owners to subsidize all or a portion of the cost of planting trees on private property. Grants should be made available to qualified homeowners, civic organizations, religious institutions, and other not-for-profit organizations.
- Work with the City Public Information Office (PIO) to increase public awareness regarding the benefit of trees by utilizing the City's website, printed literature, and other digital outlets.
- Engage residents by creating opportunities to become program volunteers to assist in completing tasks that are currently not funded or are inadequately funded for completion by City staff, such as conducting tree inventories.
- Promote the urban forest through urban agriculture where possible such as community orchards.
- Expand GIS use as a tool in the City's forestry program.
- Dedicate long-term funding streams to meet canopy and management goals.
- Explore non-traditional and technology driven funding techniques.
- Fund the purchase of new technology or applications such as the U.S. Forest Service iTree software to assist in the ongoing study and analysis of the City's urban forest.
- Explore grants from County, State, and Federal sources to extend tree planting and infrastructure improvements and encourage fundraising by interested residents or not-for-profit groups to supplement City funds.
- Establish proper tree maintenance protocols to provide to and educate both private residential and commercial property owners.

6. Watershed and Stormwater Management

The Watershed and Stormwater Management section of *Environment and Sustainability* relates to other components of Gaithersburg's Master Plan including the *Water Resources Element* (WRE), adopted in 2010. The WRE analyzes the City's expected potential growth over the coming decades with regard to its water resource capacity limits, details local watershed impairments, and facilitates the development of management strategies. The *Environment and Sustainability Element* and the *Water Resources Element* reinforce each other and provide compatible goals and strategies for the protection and sustainable use of water resources. This section of the *Environment and Sustainability Element* is intended to supplement the WRE[33].

6.1 Regulatory Framework

Managing the stormwater that runs off land surfaces is one of many challenges facing urban areas. Historically, the primary goal of stormwater management was to prevent immediate threats due to flooding. In recent decades, it has become clear that stormwater must be managed to address the serious negative impacts that high volumes of runoff and the associated nutrients, sediment, and other pollutants have on local tributaries, the Potomac River, and the Chesapeake Bay. To accomplish this objective, several Federal, State, and local regulations have been enacted to protect the region's water resources.

6.1.1 Federal Regulations

A. The Clean Water Act and the National Pollutant Discharge Elimination System

The Clean Water Act (CWA) sets an overarching environmental goal that all waters of the United States be "fishable" and "swimmable." Traditionally, national and state efforts to improve water quality focused on reducing pollutants from point source discharges such as industrial facilities and municipal sewage treatment plants. Congress amended the Clean Water Act in 1987 to add a new focus on stormwater controls. Stormwater from urban and agricultural land uses is one of several leading causes of impairment in the Chesapeake Bay watershed. According to the Chesapeake Bay Program Watershed Model, stormwater contributes 20% of the nitrogen, 2% of the phosphorus, and 39% of sediment loads to the Bay. [34] In more urbanized watersheds like Gaithersburg, stormwater runoff accounts for even greater levels of pollutant loads. The Maryland BayStat initiative estimates that stormwater runoff accounts for nearly 38% of nitrogen, 51% of phosphorus, and 72% of sediment loads entering the Middle Potomac, to which Gaithersburg's watersheds drain.[35]

The Clean Water Act provides the authority to issue Total Maximum Daily Loads (TMDLs), such as the Chesapeake Bay TMDL and those for smaller water bodies, including Clopper Lake, to which Gaithersburg's Lower Great Seneca Creek watershed drains. The CWA

[33] City of Gaithersburg, *Water Resources Element*, 2010. http://www.gaithersburgmd.gov/~/media/city/documents/government/master_plan/2010/water_resources.pdf

[34] Environmental Protection Agency, *Chesapeake Bay Phase 5.3 Community Watershed Model*, 2010, Pub. EPA 903S10002 – CBP/TRS-303-10, Annapolis, MD: US Environmental Protection Agency, December 2010. http://www.chesapeakebay.net/about/programs/modeling/53/

[35] *Ibid.* See also http://baystat.maryland.gov/causes-of-the-problems-map/

also regulates discharges to waterways through National Pollutant Discharge Elimination System (NPDES) permits. Municipalities that exceed certain population thresholds are issued permits for their stormwater runoff, called Municipal Separate Storm Sewer System (MS4) permits.

B. Chesapeake Bay TMDL

Watersheds cross jurisdictional boundaries; consequently, water resource issues can involve numerous stakeholders and have significant regional impacts. Gaithersburg is located within the Chesapeake Bay watershed, which encompasses six states and the District of Columbia, and has been the focus of a massive restoration effort in recent decades. Executive Order 13508, issued on May 12, 2009, recognized the slow progress of existing restoration efforts by Federal, State, and local governments, and charged the Federal government with developing and implementing Bay watershed rehabilitation strategies. The Environmental Protection Agency (EPA) issued the Chesapeake Bay Total Maximum Daily Load (TMDL) in 2010.

Figure 3: The Chesapeake Bay Watershed

The Chesapeake Bay TMDL, issued in 2010, established a pollution budget for the Bay, requiring significant reductions in nitrogen, phosphorus, and sediment to restore the water quality and habitat to levels prescribed by the EPA. The Bay TMDL is the largest and most complex TMDL developed, involving each of the constituent jurisdictions and impacting pollution sources throughout the 64,000 square mile watershed. The TMDL serves as a roadmap, providing targets to be met along the way to restoring the Bay and its tributaries, including the Potomac River. The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025, with at least 60% of the actions completed by 2017. The State of Maryland is a signatory to the recent Chesapeake Bay 2014 agreement. The agreement now includes goals related to toxics and climate change which may have implications for watershed and stormwater management priorities in coming years.

The total TMDL limits for the seven Bay jurisdictions are 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus, and 6.45 billion pounds of sediment per year —a 25% Reduction in nitrogen, a 24% reduction in phosphorus, and 20% reduction in sediment. [36]

[36] United States Environmental Protection Agency, *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus, and Sediment*, 2010

In addition to setting pollutant limits for each of the seven Bay jurisdictions, the TMDL requires states to develop Watershed Implementation Plans (WIPs), which steer progress towards meeting water quality standards and establish an accountability framework to ensure that restoration commitments are met. The State receives input from local jurisdictions, including Gaithersburg, when developing each WIP and providing updates for submission to the EPA. A three-phased planning approach ensures opportunity for public participation and allows for continued refinement of the plan over time:

- *Phase I*: Required states to specify reductions from major source sectors such as urban stormwater and sewage treatment plants, and propose strategies to meet the initial 2017 target (70% of the total nutrient and sediment reductions needed to meet 2025 goals). The Phase I timeline and reduction targets were revised in the Phase II WIP due to implementation concerns. The State submitted its Phase I WIP on December 3, 2010.

- *Phase II*: Further divided nonpoint source allocations into smaller geographical areas to help local governments better understand their pollution contributions and responsibilities for load reductions. Provided the strategies necessary to implement restoration practices to achieve 60% of target reductions by 2017. The State submitted its Phase II WIP on March 30, 2012.

- *Phase III*: State plans are expected to be completed in 2017 with refined actions and controls that will be implemented between 2018 and 2025 to achieve water quality standards and full restoration of the Chesapeake Bay.

Originally, the Phase I WIP was intended to be developed at the county geographic scale; however, the EPA scaled back its expectations for geographic specificity due to data and modeling limitations at fine scales. In its Phase II WIP, Maryland was able to further allocate reduction targets at the county scale using local data; however, smaller jurisdictions like Gaithersburg have not received individual wasteload allocations (WLAs) for pollutant reductions. It is expected that future stormwater regulatory permits will include provisions for small local jurisdictions to meet WIP goals

C. Gaithersburg's MS4 Permit

With a population of fewer than 100,000[37], Gaithersburg qualifies as a Phase II small Municipal Separate Storm Sewer System (MS4) operator. Gaithersburg currently operates under an administratively extended permit issued in 2003, which requires the City to implement six minimum pollution control measures:

- Public education and outreach;
- Public involvement and participation;
- Illicit discharge detection and elimination;
- Construction site stormwater runoff control;

[37] City of Gaithersburg, Planning and Code Administration. *July 2014 Dwelling Units and Estimated Population*, 2014, Gaithersburg, MD: 30 (City population estimate is shown as 64,778).

- Post-construction stormwater management; and
- Pollution prevention and good housekeeping.

Should the City's population exceed 100,000, as indicated as a possibility in the Municipal Growth Element[38], it will become a Phase I medium permittee and would be subject to more stringent permit requirements for monitoring, restoration, and achieving stormwater wasteload allocations.

Gaithersburg anticipates that its future NPDES permits will be more stringent as the State and Federal governments continue to work toward returning the Chesapeake Bay and its tributaries to a healthy condition. The Maryland Department of the Environment (MDE) has begun to issue new stormwater permits to Phase I MS4 jurisdictions in the State. Among the many new requirements in those permits, is the requirement for MS4 permit holders to provide additional stormwater treatment to 20% of impervious surface that is not currently treated to the maximum extent practicable[39] (MEP). Restoration must be accomplished using environmental site design[40] (ESD) and other nonstructural techniques, retrofits to existing structural practices, and stream restoration. This restoration requirement is the tool that NPDES permittees will use to achieve TMDL benchmarks, accounting for nutrient reductions based on established Best Management Practices (BMP) pollutant-removal efficiencies.

In Maryland's Phase II WIP report to the EPA, the State publicly announced that the 20% restoration requirement would also be found in the next generation of Phase II MS4 permits. Additionally, Montgomery County expects that future NPDES permit cycles will stipulate additional restoration requirements for remaining impervious areas not treated to the MEP.[41] As a Phase II jurisdiction, staff's best professional judgment is that Gaithersburg can expect to be subject to the restoration requirement in its next MS4 permit, with the potential for additional restoration requirements in the future.

Because Gaithersburg does not own much of the land where restoration will need to occur, the City will need to engage in creative approaches to ensure that the necessary retrofits are implemented by the end of the permit term. Potential strategies could include public-private partnerships and the creation of a credit program for private property owners who choose to implement stormwater restoration practices on their properties. In addition to the City's Municipal Separate Storm Sewer System (MS4) permit, Gaithersburg holds a NPDES permit for its Public Works maintenance facility. A new 5-year cycle of the permit, called the *General Permit For Stormwater Discharges Associated With Industrial Activity*, was issued as final with an effective date of January 1, 2014. The City has since updated its stormwater pollution prevention plan

[38] According to the City's *Municipal Growth Element*, Gaithersburg (including the MEL) will grow from 77,518 persons in 2008 to between 117,365 and 138,345 persons by 2030.

[39] Maximum extent practicable (MEP), as defined in Chapter 8 of the City Code, means designing stormwater management systems so that all reasonable opportunities for using ESD planning techniques and treatment practices are exhausted and only where absolutely necessary, a structural BMP is implemented.

[40] Environmental site design (ESD), as defined in Chapter 8 of the City Code, means using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources.

[41] Montgomery County Department of Environmental Protection, *Montgomery County Coordinated Implementation Strategy*, 2012, Baltimore, MD: Biohabitats et. al. http://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Countywide%20Implementation%20Strategy/Countywide-coordinated-implemented-strategy-12.pdf

(SWPPP) and filed a notice of intent (NOI) to apply for coverage; approval by MDE is pending at the time of this writing.

D. State and Local Stormwater Regulations

Since the adoption of the City's *Water Resources Element* (WRE), several ordinances and regulations have been implemented which protect Gaithersburg's water resources during and after the development process:

- *Chapter 8 of the City Code/Maryland Stormwater Act of 2007*: Requires enhanced stormwater management controls using environmental site design (ESD) to the maximum extent practicable (MEP) for all new development. These environmentally friendly planning techniques encourage small-scale onsite stormwater treatment to minimize the impact of land development on water resources. Though the Act initially passed in 2007, local jurisdictions had until May of 2010 to modify and implement local ordinances. Gaithersburg received approval from MDE for its revised stormwater management ordinance on April 6, 2010.

- *Environmental Standards for Development Regulation*: Provides planning guidance to developers in support of existing City environmental regulations, with the goal to create development plans in the most environmentally sound way possible. The Environmental Standards establish a "benchmark" level of environmental protection; water quality objectives include maintenance of biologically viable and diverse streams and wetlands, protection of stream water quality, improvement of degraded streams, and reduction in flood potential. The environmental standards went into effect on May 4, 2010.

- *Sediment and Erosion Control*: To address the issues associated with construction site sediment runoff, the Maryland Department of the Environment (MDE) published new erosion and sediment control regulations in 2012 designed to enhance erosion and sediment control practices across the State, improve the water quality of construction site runoff, and help in Chesapeake Bay restoration efforts. Significant changes to this section of the City Code include: establishing a maximum 20-acre grading unit for most construction sites, which limits larger earth disturbances that are more likely to cause sediment pollution; improving stabilization requirements to reduce erosion and sediment generation; and establishing grass in non-work areas. Preventing soil erosion and off-site sedimentation will reduce impacts from land-disturbing activities and assist in the overall attainment and maintenance of water quality standards. The Gaithersburg Mayor and City Council adopted the new regulations on November 5, 2012.

- *Maryland Lawn Fertilizer Law*: Maryland's lawn fertilizer law took effect on October 1, 2013, and is designed to help protect the Chesapeake Bay from excess nutrients entering its waters from a variety of urban sources, including parks, athletic fields, businesses, and lawns. The new law affects manufacturers, distributors, lawn care professionals, and homeowners. Key provisions of the law: reduce the amount of nitrogen and phosphorus that can be applied to lawns; affect the amount, frequency, and timing of fertilizer application; require certification and training in best practices by lawn care professionals; and require new formulas and labeling of application directions on packaged fertilizers sold in the state. The fertilizer law is an additional measure in helping the State to reach its nutrient reduction goals outlined in the Bay restoration Watershed Implementation Plan.

E. Growth Tiers and Septic Bill

The Sustainable Growth and Agricultural Preservation Act of 2012 limits the spread of septic systems on large-lot residential development to reduce the disproportionate impact such systems have on farm and forest land, streams, rivers, and the Chesapeake and Atlantic Coastal Bays. The primary reason for the Act is to limit nitrogen pollution to the Chesapeake Bay and its tributaries and to ensure that as Maryland grows, its waterways and water resources continue to be protected.

A system of "tiers" identifies sewered and unsewered areas, and where major residential development may occur. Each of the four growth tiers provides guidelines that direct development based on current and future sewer and septic service. By mapping future growth in tiers, the law seeks greater accountability and predictability.

As shown on the following map, Gaithersburg is designated as a Tier I area with existing public sewer, with small Tier II areas planned for public sewer within the Maximum Expansion Limits (MEL). The Maryland Department of Planning accepted Gaithersburg's PlanMaryland and Sustainable Growth and Agricultural Preservation Act designations on March 7, 2013.

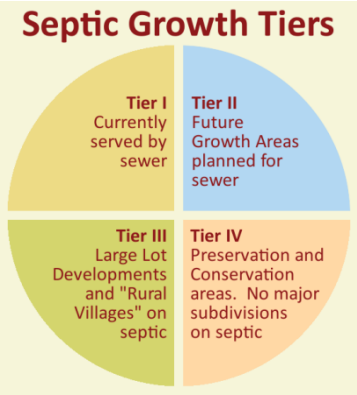
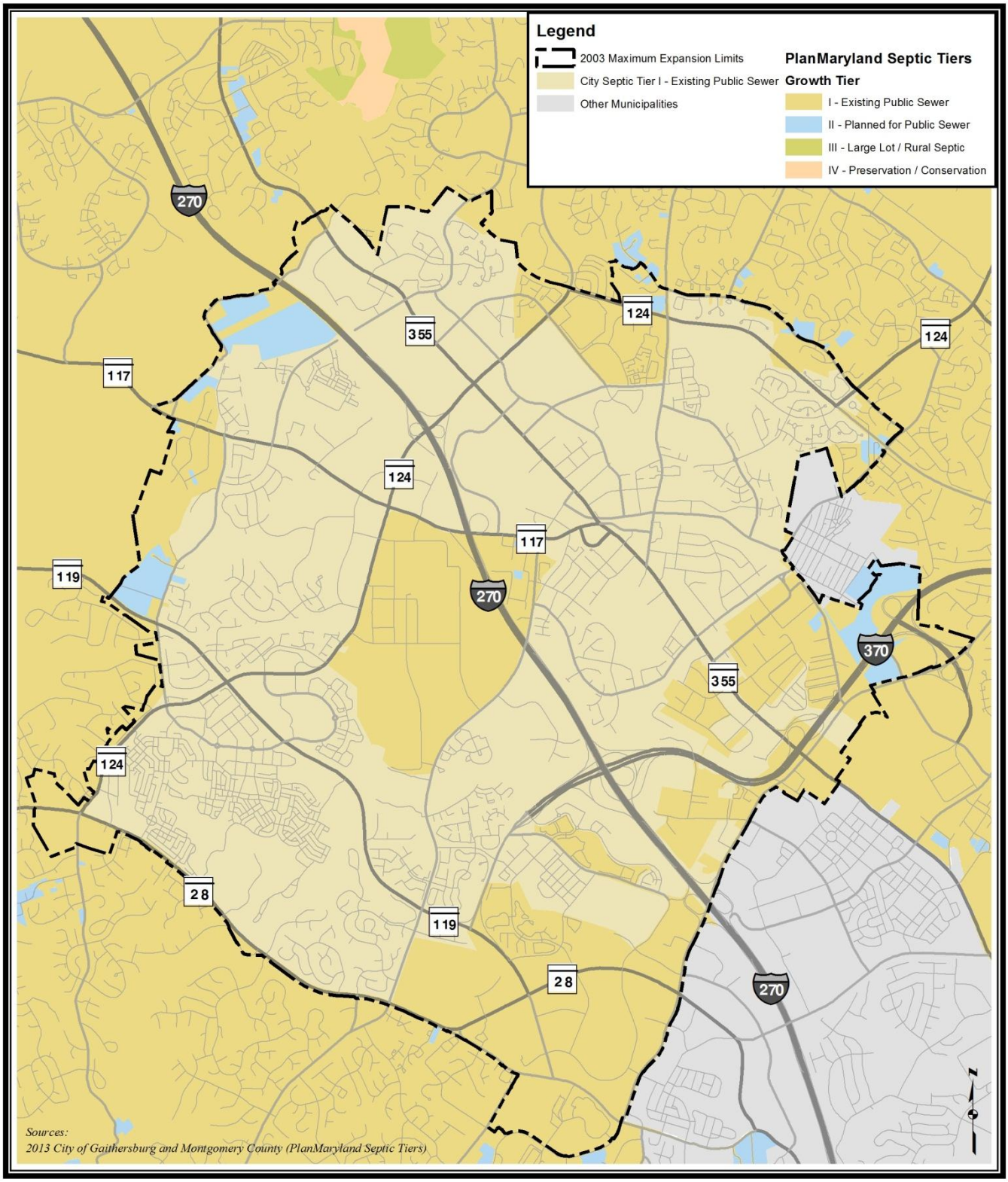


Figure 4: Four tiers guide septic development in Maryland

(Image courtesy MD Dept. of Planning)

The average household built with a septic system pollutes ten times more per household than a home on central sewer. (State of Maryland)

Map 6: Adopted Septic Tiers



F. Accounting for Growth

As required by the State's Watershed Implementation Plan (WIP), Maryland is developing strategies to address future increases in the State's pollution load from population growth and new development. To achieve Bay restoration goals, each of the watershed jurisdictions will need to reduce current nutrient loads, and also hold the line against new pollution. Maryland's *Accounting for Growth* (AfG) policy will address the pollution associated with the estimated 478,000 additional households and related infrastructure expected to be added by 2035.

The Accounting for Growth policy is expected to focus on retrofits to existing large wastewater treatment plants to accommodate population growth, and require that all new pollutant loads be offset by securing pollution credits. The State is designing the policy to allow offsets for increased loads through a combination of on-site stormwater practices and by introducing a robust nutrient trading market in Maryland. At the time of this writing, a formal policy has not been adopted.

G. Moving Forward

Gaithersburg will need to continue to be flexible in adapting to new regulations as they arise. These evolving requirements will compel the City to increase its stormwater management efforts in an incremental and sustained way. The City's challenge will be how best to reduce stormwater impacts caused by its extensive traditional urban drainage network, much of which was developed before stormwater quality and downstream impacts were a consideration.

6.2 Gaithersburg's Water Resources

The City of Gaithersburg encompasses 10.4 square miles in the heart of Montgomery County, Maryland. As stated, Gaithersburg is located within the Chesapeake Bay watershed, which stretches across more than 64,000 square miles, spanning six states and the District of Columbia. On the State level, Gaithersburg falls completely within the Potomac River watershed, and is further divided into five subwatersheds.[42] Middle Great Seneca Creek, Middle Great Seneca Creek-Whetstone Run, Lower Great Seneca Creek, Muddy Branch, and Middle Rock Creek. Two additional watersheds, Watts Branch and Upper Rock Creek-Mill Creek, fall within the City's Maximum Expansion Limits (MEL).[43] The four major tributaries include Long Draught Branch, Muddy Branch, Seneca Creek, and Whetstone Run. The City contains more than 20 miles of predominantly first and second order perennial streams, with 190 acres of non-tidal wetlands, and numerous lakes and ponds.

The following map illustrates the surface water resources and watersheds within Gaithersburg's corporate limits and the MEL. Table 2 shows land acreages and stream miles for each of the subwatersheds within the City limits and MEL. Muddy Branch is by far the City's largest watershed (48.5% of the City's area), with Middle Great Seneca Creek-Whetstone Run (20.2%) and Lower Great Seneca Creek (18.8%) the second a third largest, respectively.

[42] Since the 2010 WRE, Gaithersburg's subwatersheds have been reclassified based on revised 12-digit Hydrologic Unit Codes (HUCs) developed by the United States Geologic Survey.

[43] Gaithersburg's maximum expansion limits, established in the Municipal Growth Element, include areas that could potentially be annexed into the City by 2030.

Map 7: Water Resources

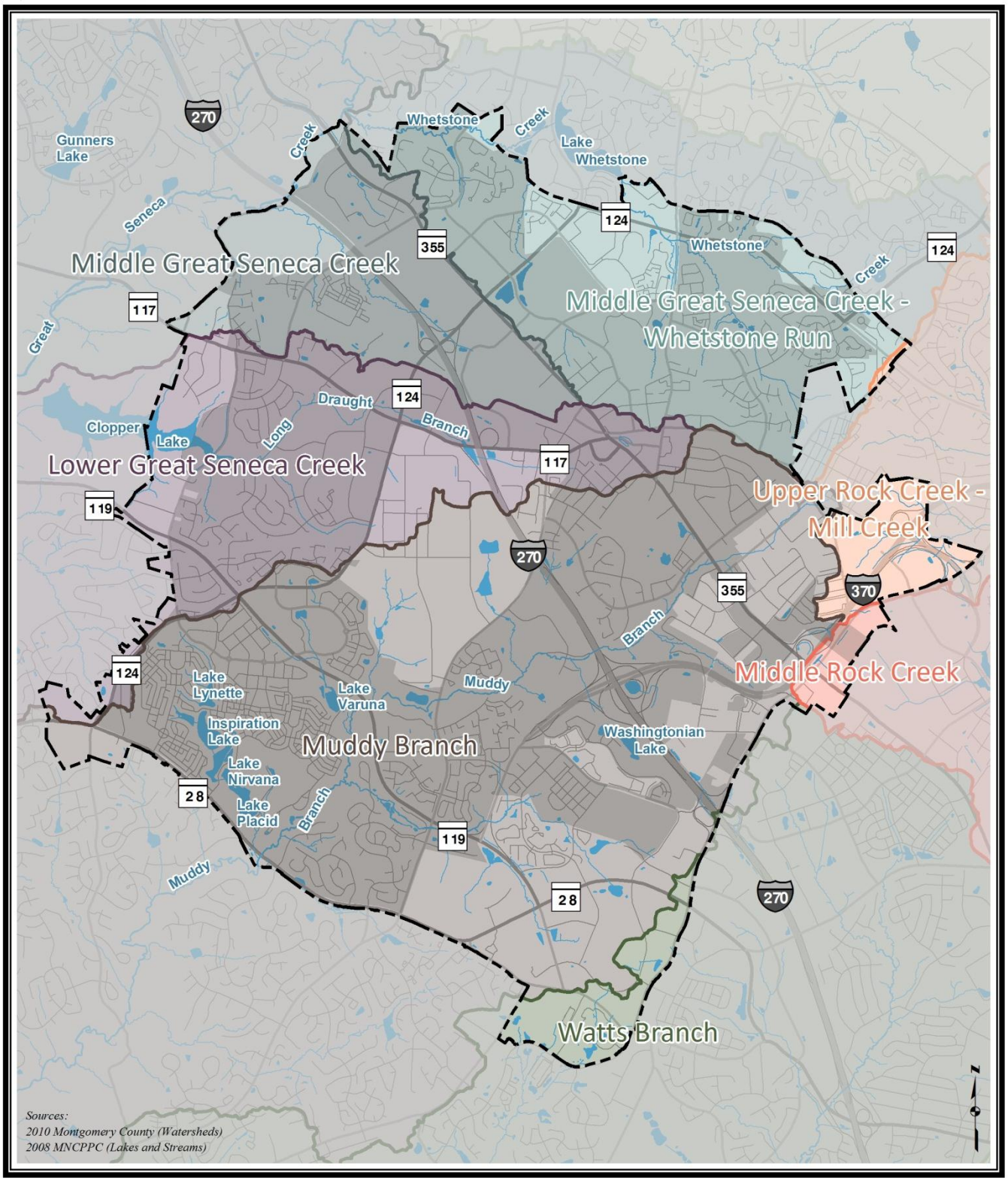


Table 2: Comparison of Gaithersburg Watersheds

Watershed	Area within City Limits (acres)	Area within MEL (acres)
Middle Great Seneca Creek	808	1007
Middle Great Seneca Creek - Whetstone Run	1340	1717
Lower Great Seneca Creek	1247	1741
Muddy Branch	3218	4936
Watts Branch	<1	238
Middle Rock Creek	19	92
Upper Rock Creek - Mill Creek	<1	251
Total Citywide	**6632**	**9981**

Gaithersburg's water resources are subject to a variety of pollution sources, which affect the water quality, habitat, and physical condition of local tributaries. Because Gaithersburg is an urbanized environment, a majority of pollutants come from urban stormwater and other discharges to the stormwater conveyance system.

6.3 Stormwater and Impervious Cover

According to the EPA, polluted stormwater runoff is currently the leading cause of water quality impairment in the United States.[44] The majority of stormwater comes from precipitation that falls on impervious surfaces such as paved streets, parking lots, and rooftops, with a smaller amount originating from pervious surfaces (such as grass) during large storms. Impervious cover seals the soil surface, eliminating rainwater infiltration and natural groundwater recharge. The excess water runs off and flows into the storm drainage system before reaching local water bodies. Uncontrolled stormwater runoff from impervious areas causes a variety of problems characterized by three main factors: water quality, runoff volume, and runoff rate.

- *Water Quality* — As runoff flows across roads and other impervious surfaces, it picks up pollutants like oil, fertilizer, pesticides, animal waste, and sediment, and transports them directly into the nearest water body. Untreated, these pollutants, which may include temperature changes, can adversely impact a stream's water quality and ability to support aquatic life.

- *Runoff Volume* — In forests and other natural areas, most rainfall infiltrates into the ground. In urban regions, where there are large areas of impervious surface, much less rainwater infiltrates into the remaining pervious areas, resulting in a large amount of stormwater runoff. High stormwater volumes can cause flooding, stream bank erosion, and harm to aquatic insects, fish, and animals that depend on the stream for their food and habitat.

[44] Environmental Protection Agency, Office of Water, *2000 Water Quality Inventory*, August 2002, Pub. EPA-841-R-02-001, Washington, DC: ES-3. http://water.epa.gov/lawsregs/guidance/cwa/305b/2000report_index.cfm

- *Runoff Rate* — Runoff rate refers to the speed at which stormwater runs off into the storm drain system and local tributaries. In areas with high percentages of impervious surface, runoff flows faster and causes erosive damage to stream channels and pervious areas that cannot withstand the heightened runoff velocity.

The increase in stormwater runoff can overwhelm the natural drainage system. As a result, the natural drainage system is often redesigned to rapidly collect runoff and quickly convey it away from the site, using curb and gutter systems, enclosed storm sewers, and lined channels. Stormwater that is diverted into storm drains usually bypasses wetlands and riparian forest buffers that naturally slow and filter runoff.

Land use is a major contributing factor to the type and intensity of stormwater pollution. Urban land uses in particular, like Gaithersburg's, tend to have higher concentrations of impervious surface, which is associated with a wide range of negative impacts to stream hydrology, stream morphology, biological habitat, and water quality. Impervious areas greatly impact stream health, groundwater recharge, temperature, drought hydrology conditions, water quality, and aquatic ecosystems. Most development in Gaithersburg occurred before any regulatory requirements were in place to control the quality and quantity of stormwater runoff. As a result of the lack of stormwater controls combined with urbanized growth, Gaithersburg's streams have been heavily affected by stormwater runoff and pollution.

6.3.1 Effects of Impervious Cover

The problems caused by stormwater are exacerbated by high levels of impervious surface. Figure 5 demonstrates the impacts on water quality due to the percentage of watershed imperviousness. Research has shown that sensitive stream elements are lost when impervious cover exceeds 10% or more of the land's surface.[45] Further research shows that once imperviousness reaches 25% to 30%, most streams become poor in quality due to erosion, channel instability, severe habitat degradation, and decreased biological integrity.

[45] Center for Watershed Protection, Inc. (CWP), *Watershed Treatment Model (WTM) 2001 User's Guide*, 2001, http://www.stormwatercenter.net/monitoring%20and%20assessment/watershed_treatment_model.htm (accessed August 15, 2014).

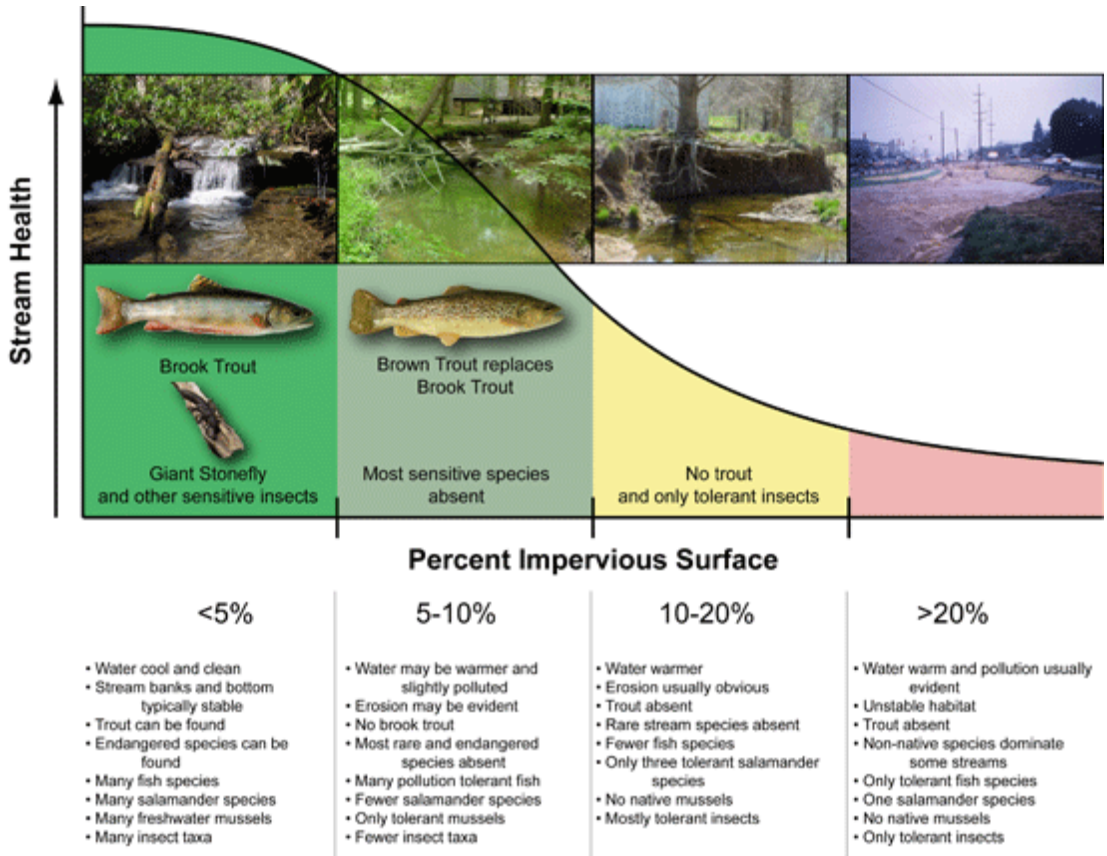


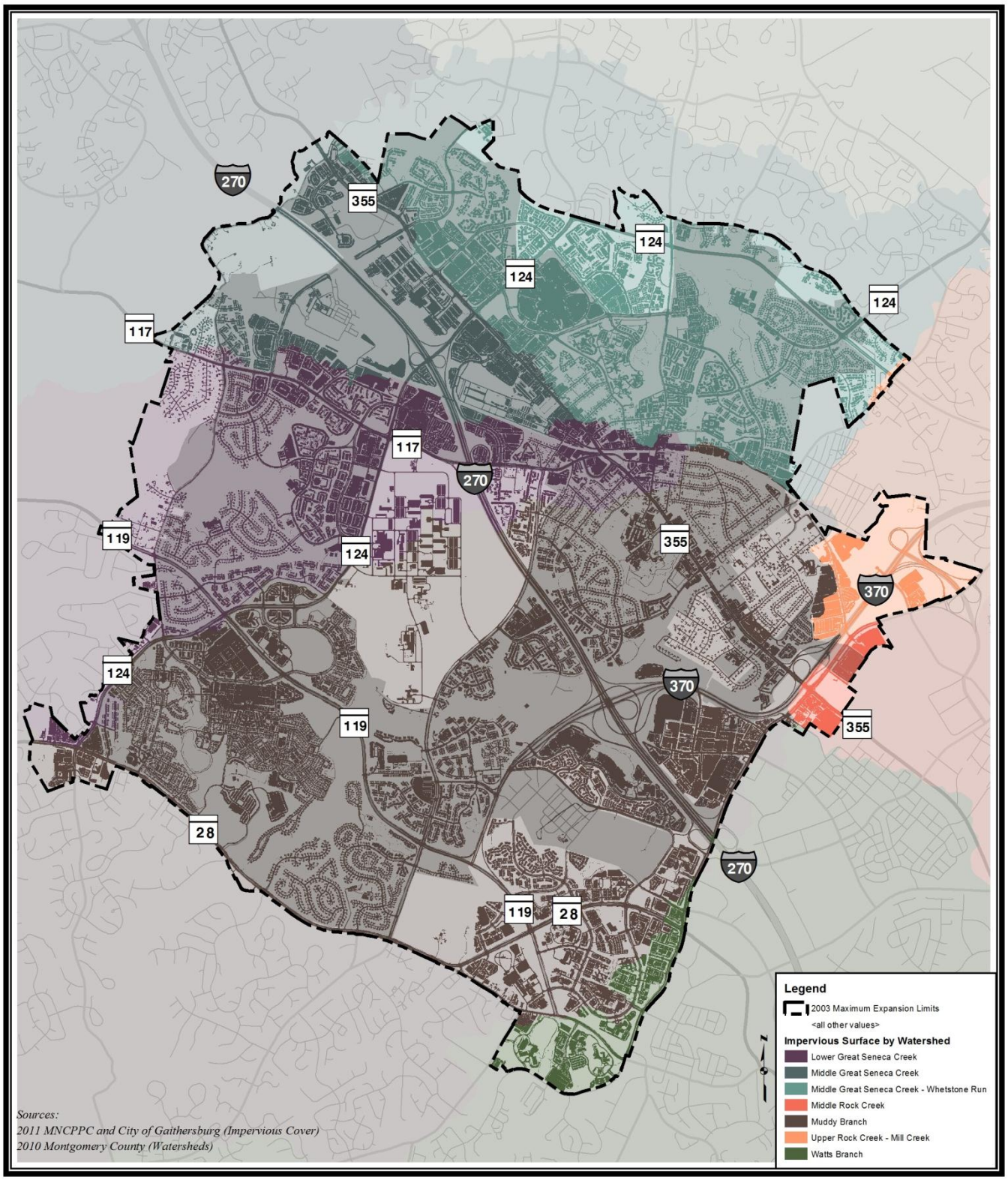
Figure 5: Stream Health

(Image courtesy State of Maryland)

Gaithersburg is an urbanized area with a high concentration of impervious surface. Watersheds within the City generally exceed the 30% imperviousness threshold and recent stream quality indicators range from poor to fair.[46] As illustrated in the following map and table, the watershed areas within the City limits have, conservatively, the following impervious cover: Middle Great Seneca Creek—40%, Middle Great Seneca Creek-Whetstone Run—43%, Lower Great Seneca Creek—44%, Muddy Branch—37%, and Middle Rock Creek—75%.

[46] URS Corporation, *Middle Great Seneca Creek Watershed Study* (Germantown, MD: URS Corporation, 2013). http://www.gaithersburgmd.gov/services/environmental-services/watershed-planning

Map 8: Impervious Cover by Watershed



Note: Smaller-scale maps with additional detail are provided in Appendix B.

Table 3: Watershed Imperviousness in Gaithersburg

Watershed	Impervious Surface in City Limits		Impervious Surface in MEL	
	Acres	Percent	Acres	Percent
Middle Great Seneca Creek	332	40	346	34
Middle Great Seneca Creek - Whetstone Run	581	43	731	43
Lower Great Seneca Creek	550	44	668	38
Muddy Branch	1182	37	1803	37
Watts Branch	<1	-*	115	48
Middle Rock Creek	14	75	56	60
Upper Rock Creek - Mill Creek	<1	-*	78	31
Total Citywide	**2650**	**40**	**3739**	**38**

*Insufficient data for accurate analysis

As a State-designated Priority Funding Area, where targeted growth and economic development are encouraged, Gaithersburg is unlikely to remove substantial areas of impervious surface. However, redevelopment offers the opportunity to reduce expansive parking lots and large building footprints, and provide stormwater controls where none previously existed. Additionally, Gaithersburg will begin to retrofit existing impervious surface with stormwater best management practices (BMPs) under the anticipated MS4 requirements. Green roofs, pervious pavement, and other environmental site design (ESD) practices also provide the opportunity to reduce or eliminate areas of impervious surface.

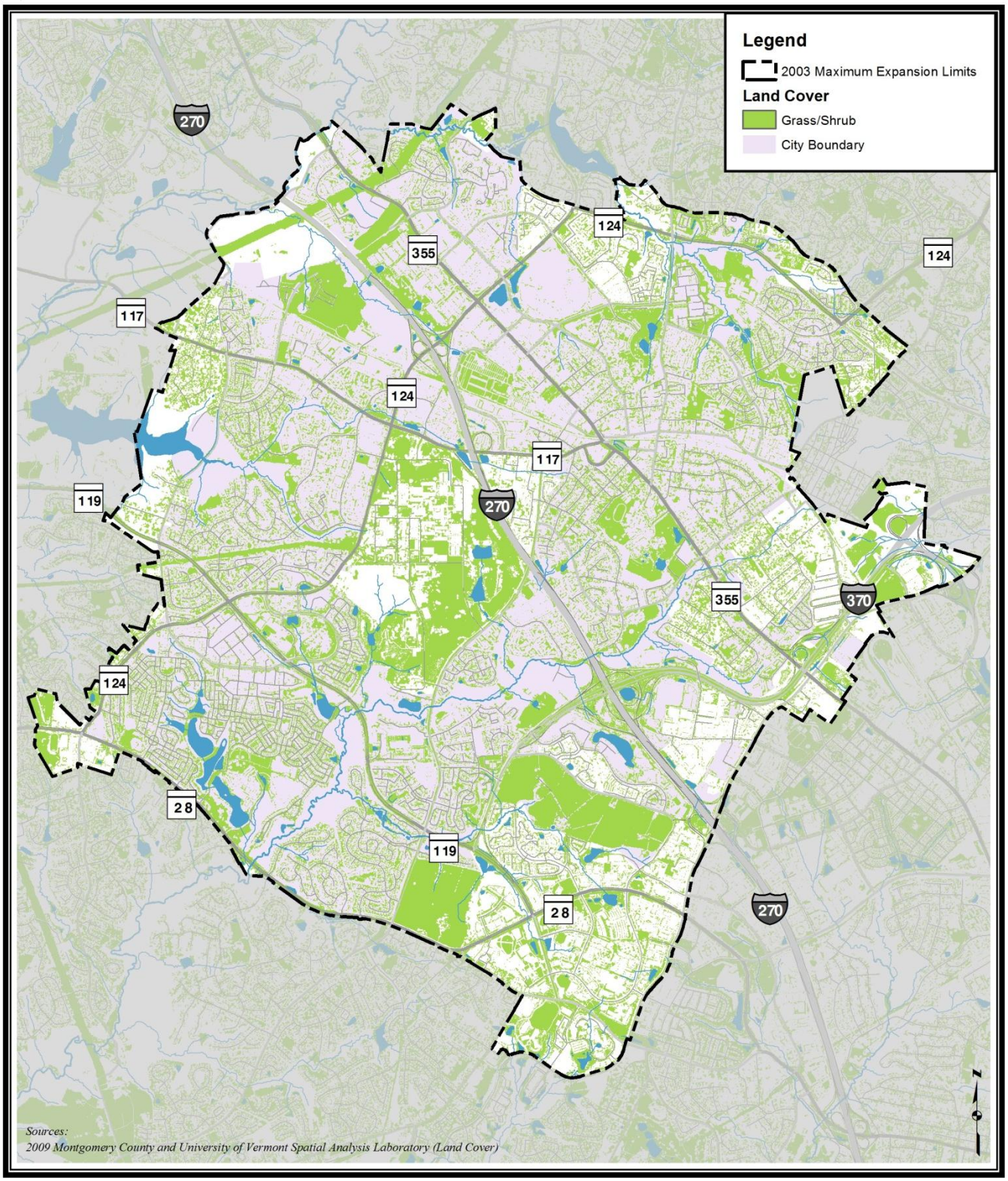
6.3.2 Algae and Eutrophication

Excess nutrients entering slow moving waters such as lakes and ponds fuel the growth of dense algae blooms that block sunlight and eventually deplete the water of dissolved oxygen. Low dissolved oxygen in the water can severely affect water quality, aquatic habitat, and can result in fish kills. Downstream of Gaithersburg, the Chesapeake Bay and its tidal waters suffer from "dead zones" caused by excessive algae blooms. Many of the City's lakes and ponds receive drainage from fertilized lawn areas, and are therefore subject to the effects of eutrophication. The following map shows the distribution of lawn and shrub areas throughout the City. Maryland's new lawn fertilizer law reduces the amount of nitrogen and phosphorus that can be applied to lawn areas, and will significantly help reduce nutrient runoff. Targeted education programs to promote responsible fertilizer use and the requirements of the new fertilizer law can help to further mitigate the problem within the City.

Despite the persistent problem, efforts to improve nutrient pollution in local water quality have progressed in recent years. Great Seneca Creek was previously listed by the Maryland Department of the Environment as impaired by nutrient pollution. In a 2009 report on eutrophication in Seneca Creek, MDE determined that dissolved oxygen and chlorophyll levels now meet water quality criteria, and delisted the nutrient impairment.[47]

[47] Maryland Department of the Environment, *Water Quality Analysis of Eutrophication for the Seneca Creek Basin in Montgomery County, Maryland*, 2009, http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Documents/www.mde.state.md.us/assets/document/Seneca_Creek_Nutrients_WQA_08-17-09_final.pdf (accessed August 15, 2014)

Map 9: Lawn and Shrub Areas



6.4 Quality of Gaithersburg's Water Resources

Watershed and stream health are well correlated with intensity and age of urbanization; watershed health declines with increased density and older age of development. Many of Gaithersburg's neighborhoods developed before the era of stormwater volume and quality treatment. The large volume of untreated runoff caused stream bank erosion and degraded habitat. In the 1980s, large regional ponds were employed to treat stormwater via an extended detention period, then slowly release large volumes of water into the stream channel, reducing erosion due to lack of stormwater controls. Newer stormwater management techniques, known as environmental site design (ESD), encourage both the volume reduction and quality improvement via onsite infiltration.

6.4.1 Watershed Planning

The City understands the importance of stormwater management and the role it plays in preserving Maryland's water resources. In addition to actively maintaining existing streams and stormwater management facilities, the City anticipates future regulations to increase in stringency. To meet the demands of current and future regulations, Gaithersburg has undertaken to complete plans for all City watersheds to assess the efficiency of existing infrastructure, and better prepare the City to address future requirements.

Watershed plans provide a framework for achieving local watershed protection and restoration goals and ensure that efforts build upon and complement one another. Plans identify priority restoration areas and include stewardship activities, water quality project opportunities, and estimates of implementation costs. Watershed studies enable the City to determine the overall health of the streams and their tributaries within the City, and provide ideas for improvements to stormwater infrastructure and for stream restoration projects.

Comprehensive watershed plans for each of the City's five subwatersheds will serve as a roadmap to meet restoration goals. The benefits are environmental as well as societal; updated stormwater management practices will limit pollution to the Potomac River and Chesapeake Bay as well as provide the local community with vegetated areas that enhance livability, cohesion, and property value.

The goals of the City's watershed plans are to:

- *Assess the current condition of the watershed, its streams, and tributaries;*
- *Identify feasible best management practices (BMPs) to treat stormwater runoff;*
- *Quantify the area treated by BMPs and the amount of pollutants they can remove from stormwater runoff before entering the City's streams, rivers, and lakes;*
- *Determine the restoration potential for each subwatershed and evaluate the ability to meet NPDES permit and TMDL requirements;*
- *Proactively identify projects and programmatic solutions to reduce pollutants in the watershed to help the City comply with regulatory requirements; and*
- *Provide a schedule and cost estimate for implementing recommended retrofits.*

Middle Great Seneca Creek and Middle Great Seneca Creek-Whetstone Run

In 2013, Gaithersburg completed a watershed study for the Middle Great Seneca Creek subwatershed[48]. Since the time of the published study, the Middle Great Seneca Creek (MGSC) watershed in Gaithersburg was further subdivided into the Middle Great Seneca Creek and Middle Great Seneca Creek-Whetstone Run subwatersheds.[49] The 2013 study includes stream health data and restoration proposals for the two combined subwatersheds. Streams in the MGSC watersheds contribute to Seneca Creek, a tributary of the Potomac River, which discharges into the Chesapeake Bay.

The Middle Great Seneca Creek watershed study includes an analysis of existing land use, impervious area, soils, development and redevelopment plans, and the natural resources of the watershed. The full seven miles of streams were assessed, with detailed stream assessments completed for ten study sites according to the following methods:

- In-stream habitat was assessed according to the Maryland Biological Stream Survey (MBSS) protocol and Montgomery County methods to develop physical habitat index (PHI) site scores;
- Biological indicators of stream health were assessed using the Rapid Stream Assessment Technique (RSAT)[50] of macroinvertebrate sampling; and
- Stream bank stability and erosion resistance were calculated using the Bank Erosion Hazard Index (BEHI) methodology.

Lower Great Seneca Creek

Although the Lower Seneca Creek watershed is the City's smallest watershed, it has the greatest percentage of impervious cover (44%)[51] within the City's portion of the watershed, and has the least amount of developed area treated with stormwater management controls. This watershed flows into Clopper Lake, a 90 acre impoundment built for recreation and flood control. The Maryland Department of the Environment (MDE) established a Total Maximum Daily Load (TMDL) to limit phosphorus and sediment loading into Clopper Lake. Subsequently, this watershed presents a challenge as well as an opportunity for retrofit projects.

Gaithersburg's watershed studies make recommendations using the following management strategies:

- *Retrofit existing stormwater management facilities*
- *Stream restoration*
- *Reforestation*
- *Repair and maintenance of stormwater management facilities*
- *Innovative alternatives*
- *Public outreach and education*

As part of Gaithersburg's comprehensive watershed management program, the City is working with neighboring jurisdictions and property owners within untreated areas of the Long

[48] URS Corporation, *Middle Great Seneca Creek Watershed Study* (Germantown, MD: URS Corporation, 2014). http://www.gaithersburgmd.gov/services/environmental-services/watershed-planning

[49] See Map 6 (Water Resources)

[50] Galli, F. J. 1996a. Appendix A, Final Technical Memorandum: Rapid Stream Assessment Technique (RSAT) Field Methods. Prepared for Montgomery County Department of Environmental Protection. Metropolitan Washington Council of Governments, Washington, DC. 36 pp.

[51] Excluding the single parcel that makes up the Middle Rock Creek watershed within Gaithersburg.

Draught Branch watershed to incorporate stream restoration and stormwater management projects through redevelopment, facility retrofits, and ESD improvements, where practicable. These projects are essential to help restore streams and meet water quality regulatory requirements. The Lower Great Seneca Creek watershed study[52] includes additional restoration concepts, and was completed in August 2014.

Muddy Branch and Middle Rock Creek

Gaithersburg's largest watershed, the Muddy Branch, originates in the City's historic district, and flows southwest for approximately 13 miles before joining the Potomac River. High levels of impervious cover combined with a lack of stormwater management and stream buffers have severely impacted the streams, particularly in the headwaters and along major transportation corridors, such as Route 355, Interstate 270, and the CSX railroad. The Muddy Branch watershed contains many areas that were developed prior to modern stormwater regulations.

Gaithersburg's watershed management efforts are expected to have a positive effect on the health of the macroinvertebrate community—an important indicator of stream health.

Montgomery County completed a study of the entire Muddy Branch watershed in 2010. The majority of stream resource conditions in Muddy Branch were assessed as "Fair" and "Good." However, tributaries in the upper portion of the watershed received "Fair" ratings, which are attributed to the increased level of development in the Gaithersburg area. The Muddy Branch watershed in Gaithersburg has 37% impervious surface, which helps to explain the findings in the Montgomery County study. Many older developed areas in this watershed are good candidates to be retrofitted with stormwater practices to provide channel protection, improve water quality, and promote groundwater recharge. Gaithersburg's Muddy Branch watershed study was completed in November 2014. The study's results are in line with Montgomery County's findings; the Muddy Branch headwaters in Gaithersburg consistently score low ratings for the biological and physical characteristics that were included as part of the study[53].

Additionally, the single commercial property that extends into the Middle Rock Creek watershed was incorporated as part of the Muddy Branch watershed assessment. Though the property is currently 75% impervious, redevelopment plans will incorporate ESD practices to treat stormwater onsite and meet current stormwater management regulations.

[52] URS Corporation, *Lower Great Seneca Creek Watershed Study* (Germantown, MD: URS Corporation, 2014). http://www.gaithersburgmd.gov/services/environmental-services/watershed-planning

[53] URS Corporation, *Muddy Branch Watershed Study* (Germantown, MD: URS Corporation, 2014). http://www.gaithersburgmd.gov/services/environmental-services/watershed-planning

6.5 Recommendations

A. Sustain or engage in Watershed Planning on a scale allowing for a holistic approach to local water resource protection.

- Conduct watershed studies designed to look at the entire watershed by linking upland sources with stream impacts. Continue on a ten-year study cycle to assess the effectiveness of capital projects and examine long-term trends in the City's water quality.
- Use the watershed studies to evaluate stormwater program initiatives such as targeted outreach and enforcement. Modify these programs if needed. Use the results to identify future high-priority Capital Improvement Program (CIP) projects.
- Implement the stormwater management and stream restoration projects recommended by each of the watershed plans. Develop a list of all potential projects, including those for which concept plans were not drafted. Pursue grant funding to complete the recommended retrofits.
- Incorporate stormwater management installation as a condition of new annexation agreements when new properties are brought into the City through annexations.

B. Maintain a robust Capital Improvement Program (CIP) in support of the City's stormwater infrastructure network.

- Use the watershed study process to identify potential stream restoration candidates and stormwater management facility retrofits, both regional and site-specific. Work with engineering and environmental staff, design consultants, and the community to identify which projects are most feasible and prioritize projects accordingly.
- Create a master list of CIP projects and an accompanying timeline for implementation.
- Implement retrofits to existing stormwater management facilities, where appropriate, to bring them into compliance with current stormwater regulations and provide credit towards the City's Total Maximum Daily Load (TMDL) requirements.
- Continue to implement new watershed retrofits according to the City's priorities and as opportunities arise.
- Maximize stormwater benefits as new City projects are developed to achieve the greatest possible nutrient reduction and/or treatment acreage credits.
- Continue to implement a capital project repair and replacement program schedule for failing stormwater management infrastructure. Complete a systematic study of the current condition of storm drain infrastructure as a first step to ensuring long-term capacity.
- Explore the use of capacity studies to identify and prioritize large-scale storm conveyance projects for both infrastructure maintenance and to ensure adequate flow volume capacity.
- Develop a plan to complete a full inventory of pipes and a replacement schedule for corrugated metal pipes (CMP) and/or terra cotta storm sewer pipes throughout the City, which are nearing the end of and/or have exhausted their useful life.

- Set aside funds each year for future maintenance and replacement costs associated with all Best Management Practice (BMP) facilities.
- Develop a comprehensive green streets policy and explore options for stormwater treatment during implementation of other capital projects. Implement green street projects during development or road reconstruction where possible to treat water quality, and obtain National Pollutant Discharge Elimination System (NPDES) credits.
- Continue to develop design, construction, and maintenance standards for City stormwater management facilities, with a focus on environmental site design (ESD).
- Acquire property or easements for streams as stream restoration capital projects are implemented, for the purpose of gaining access for restoration projects.
- Install pervious pavement for walkways and other traditionally impervious surfaces in new City projects, where feasible.
- Research the use of a stream monitoring station network to track existing water quality conditions and post-restoration conditions.

C. Develop and implement a City stormwater infrastructure inspection and maintenance program.

- Evaluate current enforcement programs to ensure they have the regulatory foundation, funding, staff, implementation tools/process and management support to be effective. Develop and implement improvements identified during the evaluation.
- Review the City's preventative maintenance program and ensure it is effective at identifying, prioritizing, and tracking cleaning and repair actions for storm drain infrastructure and treatment facilities.
- Use an adaptive management methodology to improve the existing preventative maintenance program. Elements of this program could include: inspection equipment and tools; inspection data management and analysis; action prioritization; cleaning and repair methods; performance tracking; performance measures identification; evaluation; and program modification if needed.
- Explore the option of third-party certified BMP inspections for private facilities to minimize the City's liability risks and require facility owners to take responsibility for their own inspections.
- Create maintenance fact sheets for owners of stormwater management facilities. Help owners understand the function of their facilities, and how best to maintain them in order to minimize costly major retrofits.
- Transition to a digital notification and inspection program with the ability to email inspection notifications, with eventual expansion to online reporting and information sharing.
- Remain flexible about the inspection and maintenance program's structure in order to incorporate new best practices and improve program efficiency.

D. Provide for enhanced stormwater data and asset management.

- Purchase software for improved stormwater asset management, assessment, inspection tracking, and maintenance.
- Redesign the City's stormwater geodatabase to reflect the anticipated reporting requirements under the Maryland Department of the Environmant's (MDE) new reporting geodatabase tool.
- Develop new data layers to track the list of anticipated stream restoration sites, stormwater retrofit projects, and potential stormwater restoration opportunities.
- Continue to update the City's existing inventory of all public and privately owned stormwater assets, including streams, stormwater management facilities, and storm conveyance infrastructure, and update Geographic Information System (GIS) attribute tables.
- Reassess the amount of impervious surface using aerial photography on a regular basis (every few years). This data will allow staff to better gauge the future growth of impervious surface in Gaithersburg and help inform stormwater utility fee billing levels. Incorporate building plan information to allow for more frequent small-scale updates to impervious data, as new projects are implemented.
- Track stormwater related enforcement actions and drainage complaints by frequency and location (using GIS), to better determine hotspots and help target responses.
- Ensure databases are in place and maintained to track new Municipal Separate Storm Sewer System (MS4) and TMDL requirements, particularly for crediting retrofits, stream restorations, and other practices that will affect achieving the permit's anticipated restoration requirement.
- Complete a comprehensive analysis of the condition of the City's MS4 infrastructure and impervious cover, including quality of and connections between infrastructures. Complete updated analyses periodically to track changes and improvements to the system.
- Prioritize the creation and maintenance of BMPs and their associated drainage areas in GIS. These updates could be based on new facilities, retrofits, correcting erroneous data, and added maintenance data. This information is necessary for the evaluation of adequately treated areas and the areas that do not have stormwater management.
- Track the location and timing of street sweeping and catch basin cleanouts for easy calculation of permit credits for pollutant reduction for this practice.
- Explore software options to track nonstructural stormwater program elements. Examples of nonstructural data that should be tracked include education and outreach techniques.

E. Ensure stormwater management practices are integrated early and to the fullest extent within the planning process.

- Develop mitigation requirements for use during the planning process that address development impacts to stream valley buffers and other sensitive areas.

- Accommodate growth through concentrated redevelopment and infill to provide the opportunity for improved water quality, especially in areas built before stormwater management was required.
- Acquire easements or land adjacent to streams and other water resources as opportunities arise. Apply conservation easements to sensitive areas, where possible, to protect the City's source waters.
- Integrate the planning, engineering, and maintenance aspects of stormwater to ensure smooth and comprehensive project design and review.

F. Practice good housekeeping and best management practices for internal operations to minimize water pollution resulting from City facilities and operations.

- Explore the use of alternative treatments for road and sidewalk de-icing during the winter months.
- Use native plants to reduce the need for irrigation, watering, and fertilizer.
- Reduce fertilizer and pesticide use in City operations by creating and implementing a formalized lawn chemical usage reduction plan, which incorporates the City's existing integrated pest management (IPM) policy.
- Implement the revised Public Works Stormwater Pollution Prevention Plan (SWPPP) once it is approved by the Maryland Department of the Environment, to maintain minimal stormwater pollution from the Public Works maintenance yard.
- Continue using hybrid and electric vehicles to reduce oil, fluid, and air emissions into streams, and explore opportunities to expand the use of hybrid and electric technology for lawn equipment and other motorized tools.
- Review the effectiveness of street sweeping and catch basin cleaning programs and target program implementation to maximize efficiency and effectiveness.

G. Provide sustained stormwater management community outreach and education.

- Develop newsletters and other resources for BMP owners, including seasonal tips for maintenance (particularly for ESD techniques).
- Facilitate partnerships with local watershed groups to help with outreach and implementation of MS4 permit requirements.
- Publicize stormwater facilities in residential or other pedestrian-friendly areas using signage to educate the public about stormwater management and local treatment facilities.
- Continue to provide incentive programs like the Rainscapes Rewards program to encourage private property owners to manage stormwater runoff more effectively.
- Continue to reevaluate and expand the Rainscapes Rewards program to include new participants and techniques to meet the needs of residents and achieve City goals.
- Publicize the work the City is doing in stormwater using annual fact sheets, poster presentations at public events, and annual progress reports explaining how funds were used to administer the program.

- Explore the option to create an "Adopt-A-Facility" program to engage local watershed groups and other trained volunteers in the monitoring and maintenance of small-scale stormwater facilities.
- Develop welcome letters and maintenance information to send to new owners of stormwater facilities that exist on newly-purchased parcels.
- Create a trash hotspot resident reporting program to help City staff identify problem areas and focus cleanup efforts in those areas.
- Continue to support rigorous volunteer water quality monitoring programs.
- Continue outreach activities across all forms of media to inform and educate a broad spectrum of City constituents about the City's environment and the important role constituents can play in protecting our water resources.
- Continue programs that effectively use volunteers and other non-City resources.
- Explore public-private partnerships as a way to achieve TMDL and MS4 goals by implementing new stormwater controls in cooperation with local businesses and other private groups.
- Create various outreach programs for Gaithersburg residents and businesses to address stormwater pollution. Such programs could include best practices for automobile repair, lawn and garden care, and pet waste removal.
- Work with DNR and local watershed groups through the Streamwaders volunteer stream monitoring program to continue gathering water quality data for City watersheds.
- Create a landscape stewardship outreach program to encourage responsible use of fertilizers by homeowners and City businesses.
- Utilize social media and other outreach methods to enlist volunteers for implementing, maintaining, and monitoring stormwater projects throughout the City.

H. Develop public programs and policies in response to evolving State and Federal regulations.

- Participate in the public involvement process to influence development of Chesapeake Bay total maximum daily loads (TMDLs) issued by the U.S. Environmental Protection Agencey (EPA), new Federal and State stormwater regulations, and the reissuance of NPDES general permits for Phase II MS4 communities.
- Consistently reevaluate and expand the Rainscapes Rewards program to include additional incentives for eligible property owners to implement stormwater management. Possible expansions may include practices such as rain gardens, bioretention, permeable or grass pavers, green roofs, tree planting, floating wetlands, and dry wells.
- Explore the possibility of an online Rainscapes Rewards application process as the program expands.
- Work with Montgomery County to adapt its existing materials to Gaithersburg's program, and create outreach materials for any additional practices for rebate.
- Continue supporting the Montgomery County bag fee, which has reduced the amount of plastic and paper bags in the City's watersheds and stormwater system.

I. Engage in and promote regional coordination to share knowledge and reduce costs associated with watershed restoration:

- Continue to actively participate in the Alice Ferguson Foundation's Trash Free Potomac Initiative. Trash reduction is a key element of the City's MS4 permit, and participation in this regional cooperative program aids in public education and sharing of best practices.
- Continue to work with the City of Rockville, Montgomery County, and the State Highway Administration to achieve water quality goals within shared watersheds. Explore partnerships for the implementation of stormwater management along County and State roads, as transportation is a major land use in the City and increased transportation land use is expected in future development.
- Continue to work with groups such as the Izaak Walton League, Muddy Branch Alliance, and Seneca Creek Watershed Partners to obtain grants for community outreach projects.
- Participate in regional watershed planning efforts through the Metropolitan Washington Council of Governments (MWCOG) and the State Watershed Implementation Plan (WIP) process. Share watershed assessment results with County, State, and local agencies to enhance cooperative restoration efforts.
- Explore cost-sharing opportunities and the potential to ride on existing agency contracts as a means to meet stormwater requirements in a cost-effective manner.

J. Identify and reduce flooding risks to areas prone to regular flooding.

- Continue to support the Federal initiative to update floodplain maps as new information becomes available to reflect the best available information about potential flood risks, and keep the City's GIS data current.
- Explore the potential to complete a storm sewer capacity analysis for all of the watersheds in Gaithersburg's system, using appropriate hydraulic and hydrologic modeling tools to evaluate areas with greater flood risk.
- Implement stormwater management projects in flood-prone areas as a means of diverting flow or reducing flood levels.
- Continue to investigate potential flood control projects and small-area drainage issues to reduce the risk of flooding, including acquisition of affected property as necessary.

K. Continue to allocate dedicated and sustainable funding sources to guarantee the stormwater program's continued viability.

- Provide the funds necessary to meet MS4 permit and Bay TMDL requirements and to address other important stormwater infrastructure needs, such as ensuring adequate capacity for flood control, replacing aging infrastructure, and performing preventive maintenance on all City stormwater management facilities.

- Reassess the Stormwater Program Management Fee (SPMF) rates on a regular basis to ensure that the income generated adequately covers program needs without placing an impractical burden on rate payers.
- Develop an informational manual to explain the methodology behind the SPMF rate calculation and provide credit opportunities to rate payers. A robust credit program may help incentivize rate payers to implement stormwater projects that will help the City meet its water quality goals.

7. Environmental Planning, Health, and Sustainability

7.1 Introduction

The stewardship of environmental resources has been and continues to be a key goal of the City, as exemplified in Gaithersburg's Strategic Directions. The City's history includes natural resource stewardship and prevention of air and water pollution. In more recent years, the City has also been delving into sustainability topics such as green building, energy conservation, and improvements to the transportation network. Sustainable development and practices in the City contribute a positive economic benefit by creating a desirable environment in which to live and work. Through surveys conducted, residents have voiced the value they place regarding City leadership on environmental and sustainability initiatives.[54] It has been demonstrated that economics, equity, and the environment are linked and dependent upon one another in maintaining a high quality of life.[55]

The concept of sustainability extends to considerations surrounding environmental, economic and societal progress. Gaithersburg relies heavily on resident input in the development of community investments (parks, facilities, and policies) and has a variety of long-standing committees which provide a means for resident leadership and a more broad representation in City governance. Recent research indicates that resident involvement in local government leads to an increase in the social resilience of a place.[56] Equity within sustainability is an essential component as the community is interconnected with the ability to thrive by all groups creating a more resilient City. It follows that taking care of the environment in all facets locally and globally implies taking care of the residents of the City and the planet, with the reverse being true as well.

The City broached the topics of environmental progress, sustainability, and energy efficiency in the previous *Environment Element* of the Master Plan. Some of the actions that the Mayor and City Council have acted on since the last *Environment Element*, adopted in 2004, include:

- Legislating green building requirements for residential and commercial properties, including requiring Leadership in Energy and Environmental Design (LEED) Silver certification for all future occupied municipal buildings. At the time of writing, there are nine certified or higher level US Green Building Council Leadership in Energy and Environmental Design (LEED) buildings within the City.

- Developed a new Strategic Direction focusing on sustainability goals for the City's *Strategic Plan*.

[54] City of Gaithersburg, Biennial City Survey Results 2013, 2011. http://www.gaithersburgmd.gov/news/press-releases/20140128-gaithersburg-releases-results-of-biennial-citizen-survey (accessed August 15, 2014).

[55] S. Srinivasan, L. R. O'Fallon, and Allen Dearry, "Creating Healthy Communities, Healthy Homes, Healthy People: Initiating a Research Agenda on the Built Environment and Public Health," *American Journal of Public Health* 93.9 (2003): 1446-1450. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447991/pdf/0931446.pdf

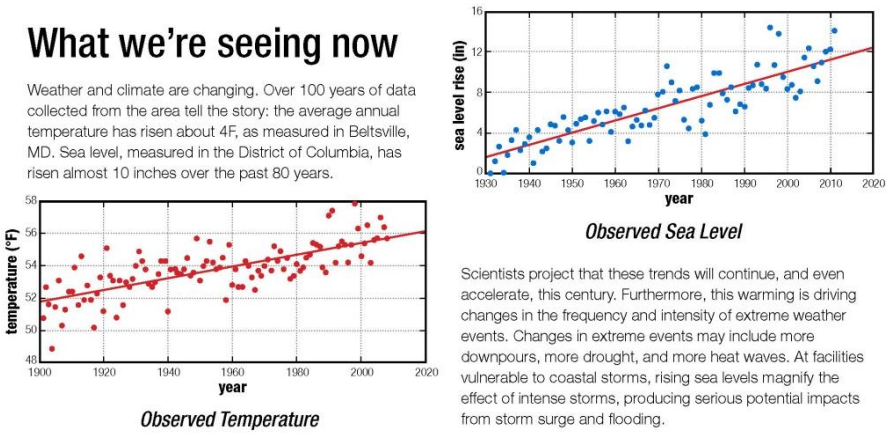
[56] Judith Rodin, "What is the business case for improving the resilience of cities?" *The Guardian.* September 2, 2013. http://www.theguardian.com/sustainable-business/business-case-improving-resilience-cities (accessed August 15, 2014).

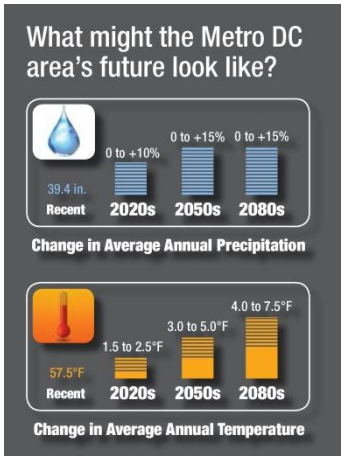
- Adopted the Adequate Public Facilities and Affordable Housing ordinances.
- Signed off on a Three-Year Green Team Action Plan through the Sustainable Maryland Certified (SMC) certification process.

7.2 Climate Uncertainty

Gaithersburg, along with the rest of the Mid-Atlantic region, can anticipate changes in temperature, rainfall patterns, water supply, snow levels, and air quality as a result of the changing climate.[57] As of 2010, CO_2 has risen by 37% and the temperature of the Chesapeake Bay has risen by more than 2 degrees since the 1960's.[58] Local governments are responding to new demands on infrastructure as well as impacts to natural resources related to weather instability and a changing, uncertain climate.

The following climatic projections and illustrations were created from the use of more than 100 years of site-specific data (measured at Beltsville, MD, approximately 18 miles from Gaithersburg) by climate scientists at NASA's Goddard Institute of Space Studies.[59] The climate scientists used climate modeling to create temperature projections for the DC Metropolitan region. The observed temperature at the site in Beltsville has risen by approximately 4° F since recording began.[60] Scientists project that the warming trend will continue and actually accelerate during the coming century with increases in the frequency and disruptiveness of extreme weather events, such as the June 29, 2012 derecho and the October, 2012 Hurricane Sandy.



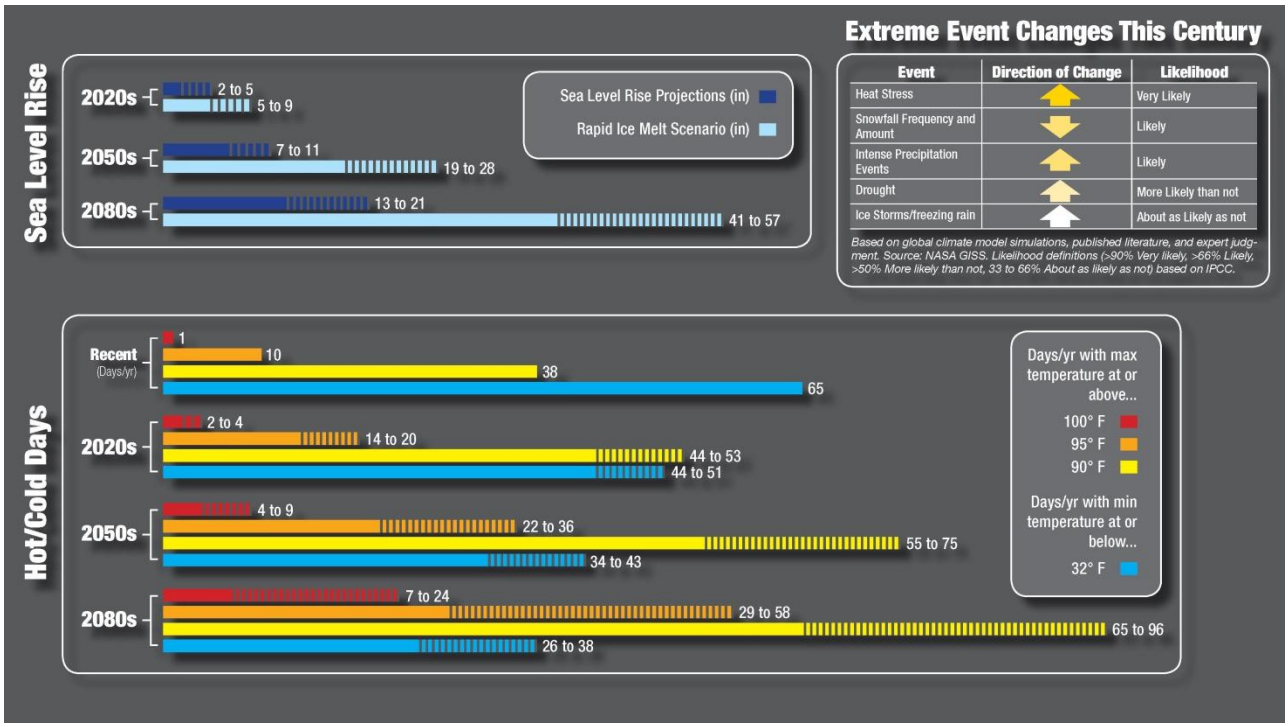


[57] Gary G. Allen, "Climate Action at the Local Level," *Municipal Maryland*, (April 2010). http://dnr.maryland.gov/CoastSmart/pdfs/Allen_ClimateAction.pdf

[58] D. F. Boesch, ed., (2008). *Global Warming and the Free State: Comprehensive Assessment of Climate Change Impacts in Maryland* (Cambridge, MD: University of Maryland Center for Environmental Science, 2008). http://www.umces.edu/sites/default/files/pdfs/global_warming_free_state_report.pdf

[59] C. Rosenzweig, R. M. Horton, D. A. Bader, M. E. Brown, R. DeYoung, O. Dominguez, et al, "Enhancing Climate Resilience at NASA Centers: A Collaboration between Science and Stewardship," *Bulletin of the American Meteorological Society* (2014) [doi: 10.1175/BAMS-D-12-00169.1].

[60] Observed climate data are from National Oceanic and Atmospheric Administration (NOAA; http://www1.ncdc.noaa.gov/pub/data/ushcn/v2.5/) and the Permanent Service for Mean Sea Level (PSMSL; http://www.psmsl.org/). Projection methods are described in Rosenzweig et al., 2014.



Extreme weather events can bring about many risks, such as disrupting transportation systems, threatening life and property, exposing individuals to contaminants through flooding, and degrading natural habitats including streams. With a changing local climate, heat waves may occur with greater frequency, placing additional stress on public health and energy generation. A compound heat-related challenge can occur during certain weather events, such as the June 2012 North American derecho. This rare weather event impacted power generation during a heat wave and led to at least 17 heat-related deaths in Maryland.[61] While some may feel more or less concerned about climate change, it has observable local, regional, and global impacts. The most recent National Climate Assessment for the Northeast region reflects an increase of 71% in very heavy precipitation events due to the changing climate (from 1958 to 2012).[62] The City can take steps to address local impacts and increase preparedness.

Strategies to mitigate and adapt to the effects from extreme weather events and climate change include advanced emergency preparations to ensure the safety of residents and advanced infrastructure planning to anticipate potential damages to City investments and natural systems. Current examples of actions taken in response to extreme weather include the Alert Gaithersburg notification system and the opening of City facilities as hot/cold weather shelters. Future actions that the City could take to increase the City's resiliency include researching projected climate changes regionally for effects to local streams, hydrology, and risk to City infrastructure.

[61] State of Maryland, Department of Health and Mental Hygiene (DHMH), *2013 Heat-related Illness Surveillance Report*, 2013, Baltimore: MD DHMH, 10-01-2013. http://dhmh.maryland.gov/extremeheat/reports/Documents/2013%20Summary%20Heat%20Report%20100113.pdf

[62] U.S. Global Change Research Program. *2014 National Climate Assessment*, 2014, http://nca2014.globalchange.gov/report (accessed August 15, 2014).

7.3 Urban Heat Island Effect

Urban heat island effect is a localized phenomenon resulting from the built environment and the transportation network that supports it. The increased surface and near-surface temperature in urban and suburban areas compared to a surrounding rural area is considered the urban heat island effect. Urban heat islands (UHI's) occur in urbanized areas due to the increased density of the impervious surfaces (with heat absorbent surfaces such as asphalt) and a reduction in vegetated areas. Waste heat from vehicles and air conditioning units contributes to the effect. Low density, highly vegetated areas, such as surrounding countryside and regional parks, retain less heat compared to concrete and asphalt surfaces found in commercial areas. This temperature differential can be seen in Figure 6, which depicts the late afternoon temperature in a variety of settings. The negative impacts of urban heat islands include:

- Health consequences from heat-related medical conditions such as heat stroke, especially during heat waves when heat effects are compounded.
- Heat and resulting poor air quality can be especially problematic for vulnerable populations – old, young, those with existing medical conditions, and for those who struggle to afford air conditioning.
- Warming of stormwater runoff into local waterbodies leading to negative impacts on aquatic life dependent on cooler stream and river temperatures and higher oxygen levels.
- Higher energy consumption due to an increase in cooling needs.
- Increased air pollution due to increases in power plant output and increases in ground level ozone from warmer temperatures.
- Increased crime, as high temperatures in urban environments have been linked to increases in aggression and violence.[63]

[63] B. Rule, B. Taylor, and A. Dobbs, "Priming Effects of Heat on Aggressive Thoughts," *Social Cognition* 5 (1987):131-143.

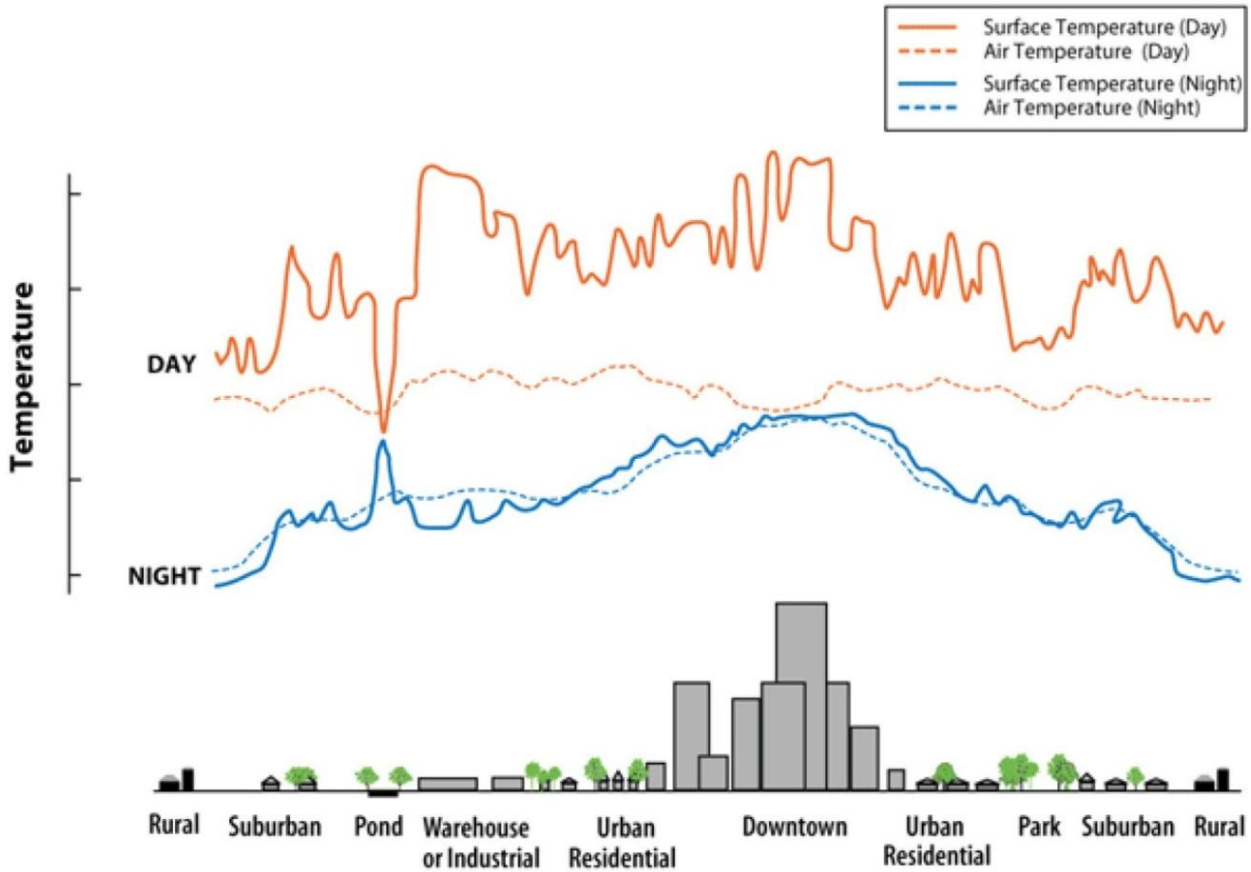


Figure 6: Urban Heat Island

(Image courtesy Environmental Protection Agency)

The developed portions of Gaithersburg can expect heightened heat when compared to surrounding forested rural areas. Research suggests a 6° to 8° difference between the temperatures in rural areas compared to urbanized areas.[64]

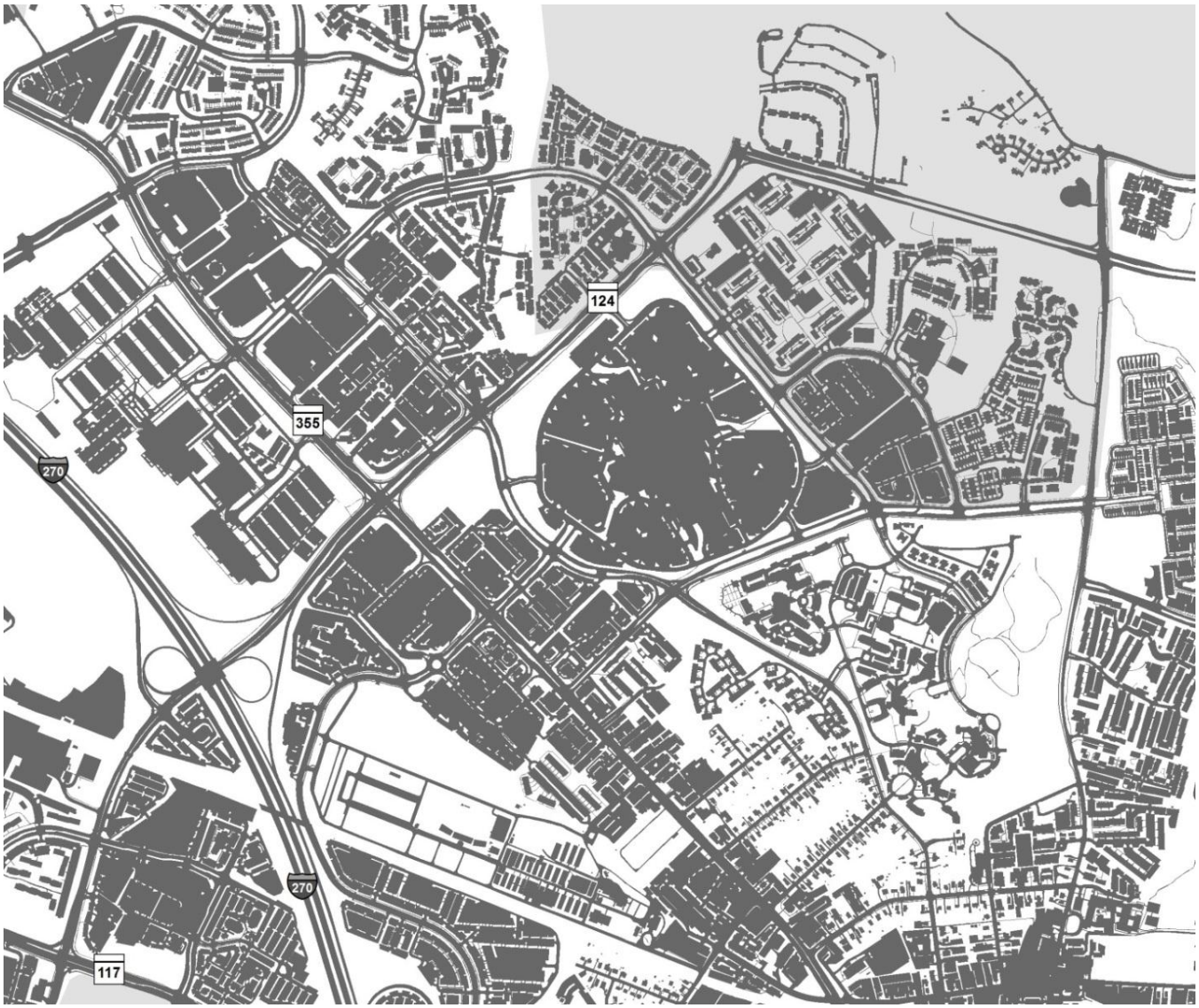
The Centers for Disease Control and Prevention estimates that from 1979–2003, excessive heat exposure contributed to more than 8,000 premature deaths in the United States.

An area of concentrated impervious surfaces can be seen in the following map, surrounding the intersection of Frederick Avenue and Montgomery Village Avenue. This area includes auto dealership and shopping plaza development from the 1970's and 1980's with large amounts of pavement (typically an impervious surface) and minimal amounts of open/green space. Prior development during the early years of the City did not include as much landscaping or wetland and

[64] Houston Advanced Research Center, *Dallas Urban Heat Island: Dallas Sustainable Skyline Initiative*, prepared for US Environmental Protection Agency (March 2009), http://www.visionnorthtexas.org/NTAF/Documents/Dallas_Urban_Heat_Island_Report.pdf (accessed August 15, 2014).

forest area preservation as current regulations require. Retrofitting highly impervious developments to mitigate the effects of the urban heat island could include the addition of green or cool roofs[65], increasing open space areas, installing cool and/or permeable pavements, increasing or improving landscaping areas, and increasing tree canopy coverage. Further, a proactive reduction in impervious areas will equate to a lowered stormwater fee for the property owner. Replacement of aging HVAC systems could also reduce the urban heat island effect. Some community measures could include public outreach on the locations of cooling centers and installation of water spray parks.

Map 10: Impervious Cover, Lakeforest Mall Area



Impervious areas data shown on map was collected in 2011.

[65] A cool roof is a roof with high solar reflectance, or low albedo and high thermal emittance. These properties enable cool roofs to absorb less heat and remain cooler during the warm summer months.

7.4 Air Quality

The Metropolitan Washington Air Quality Committee (MWAQC) is funded by members of the Metropolitan Washington Council of Governments (MWCOG), of which Gaithersburg is a member. The MWAQC is the designated air quality planning entity for the Washington Metropolitan area.

The Washington Metropolitan area was identified by the US EPA as a "Marginal" nonattainment Area for the ground-level ozone National Ambient Air Quality Standard (NAAQS, 75 ppb) published in 2008. The region needs to meet this NAAQS by the end of 2015. The region was also designated by the US EPA as a nonattainment area for the annual fine particle (PM2.5) NAAQS (15.0 $\mu g/m^3$) in 2005. However, the region submitted a request to US EPA to redesignate it to attainment based on the observed fine particle data since 2005. The region also submitted a maintenance plan as part of the requirements for redesignation. US EPA approved the redesignation request on October 6, 2014 with an effective date of November 5, 2014.

Figures 7, 8, and 9 demonstrate the levels of ozone and fine particles within the Montgomery County and the Washington Metropolitan Area. These levels are described in terms of design value, which is a parameter used by US EPA to designate an area for attainment (or nonattainment) for a particular pollutant. Design values for both ozone and fine particles are based on three consecutive years of monitored data (See notes in Figures below for specific definitions).

Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Ozone can reach unhealthy levels on hot sunny days . Ozone can also be transported long distances by wind. Ground-level ozone pollution is seasonal in nature and is of concern from May to September, the same time of year that heat waves occur and when urban heat island effects are most pronounced. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC.

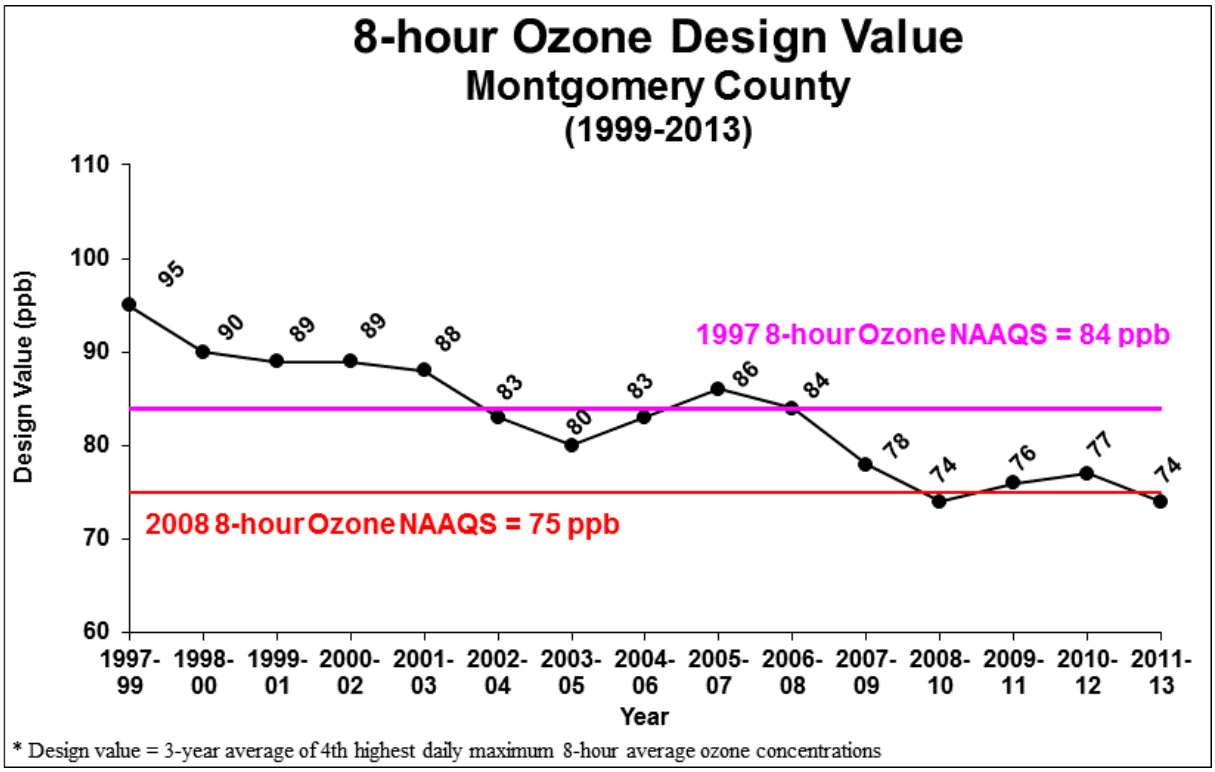


Figure 7: Ozone design value trend in Montgomery County

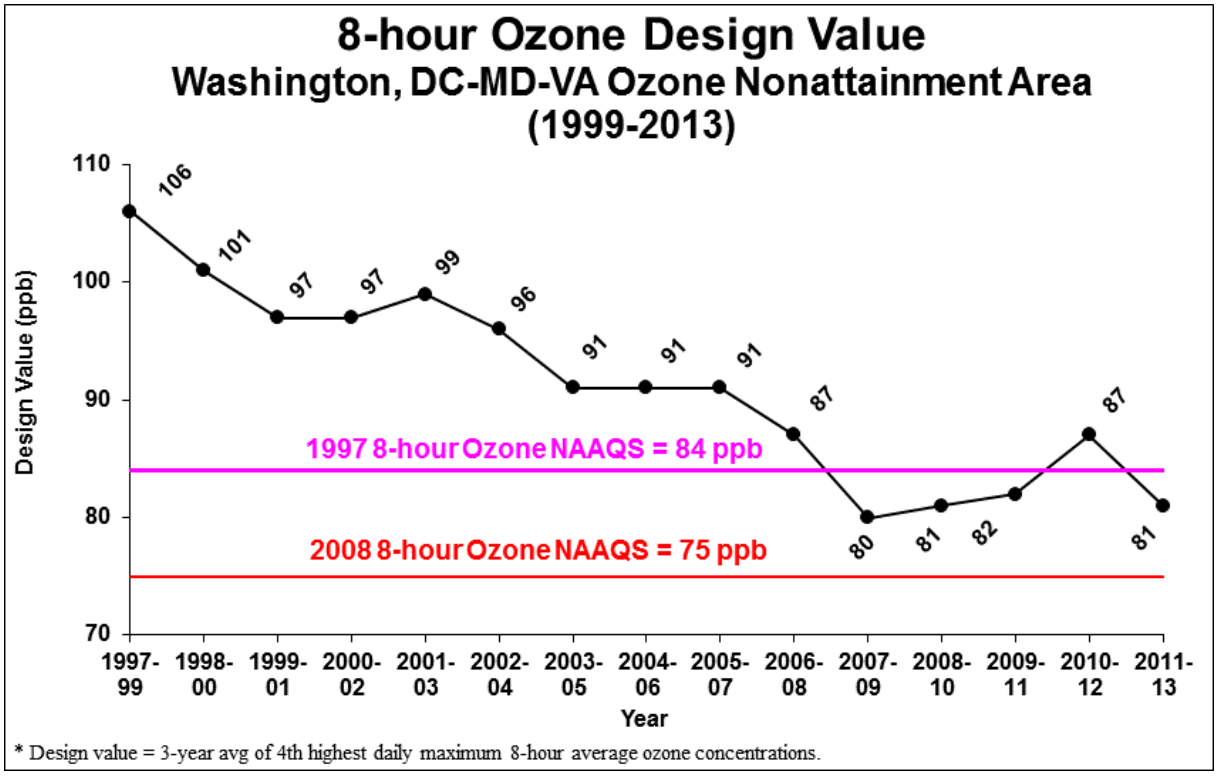
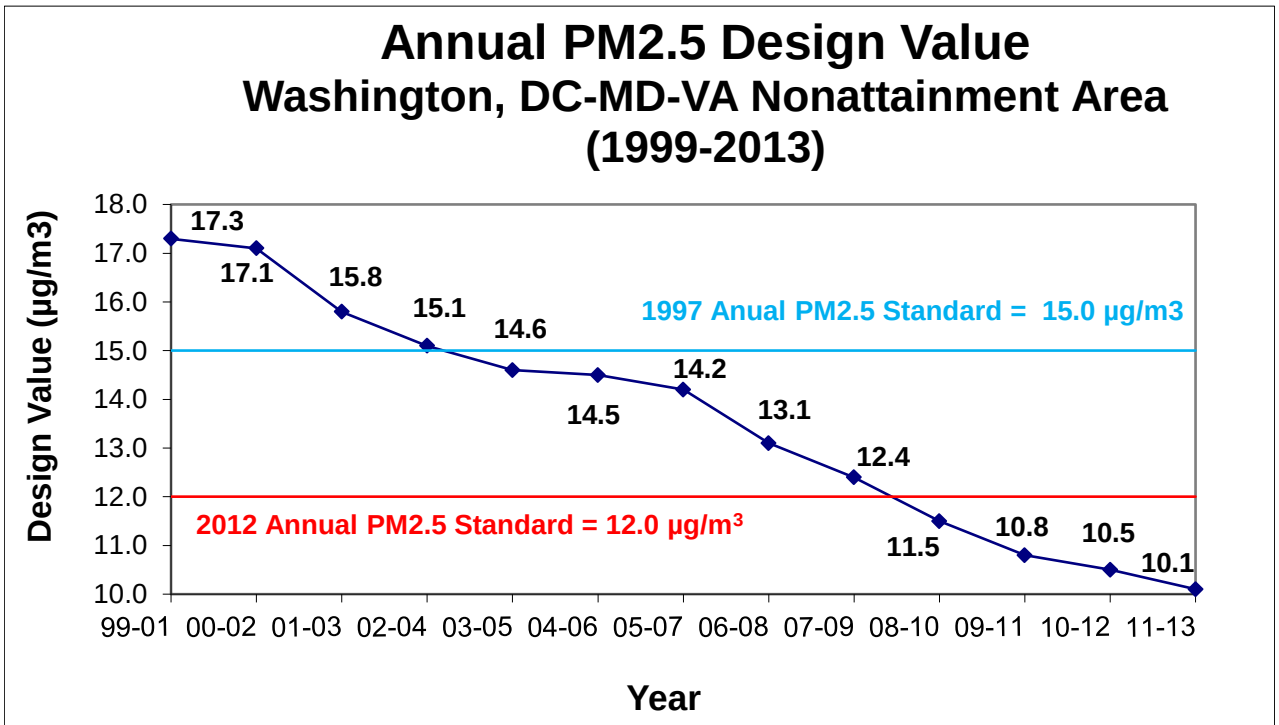


Figure 8: Ozone design value trend in the Washington Metropolitan Area

(Images courtesy Metropolitan Washington Council of Governments)



* Design value = 3-year avg of annual mean PM2.5 concentrations.

Figure 9: Fine Particle design value trend in the Washington Metropolitan Area

(Image courtesy Metropolitan Washington Council of Governments)

Fine particles (PM2.5), such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air. One method of reducing wintertime particle pollution is to replace inefficient and polluting fireplaces with new, cleaner wood-burning fireplaces or by retrofitting existing fireplaces.

In nearby Baltimore, researchers estimated that trees remove approximately 14 tons of pollution annually. As a result of this, they conclude that there is one less premature death, nearly 140 fewer asthma attacks and 240 cases of labored breathing avoided in Baltimore yearly. [66]

As poor air quality can exacerbate health problems and reduce visibility, the City benefits from continuous improvements to air quality locally and regionally. The issue of air quality is regional in nature and necessitates Federal and State action. Gaithersburg will continue to be subject to air pollution originating from other regions (Ohio Valley, etc.) and from interstate vehicular, rail, and air traffic. The City can assist with efforts to bring the region's air quality into compliance with Federal standards by encouraging multi-modal and less pollutant-emitting

[66] Wheeler, Timothy B., "Trees can help with soot pollution, study finds ~ Though diminished, Baltimore's canopy helps reduce ER visits, deaths," *The Baltimore Sun*, July 14, 2013.

transportation choices, purchasing renewable energy, conducting public outreach, and supporting an increase to the urban tree canopy.

7.5 Energy Conservation

The City, by moving towards renewable and economically viable long-term sources of energy, increases green job opportunities, lowers energy cost burdens, and reduces dependence on volatile fossil fuel based energy sources. Conservation of energy and practicing resource efficiency benefit the environment and save public money. For example, the City of Baltimore estimates that it will save more than $60 million during a 15 year time period through energy and operational improvements across 50 City buildings.[67]

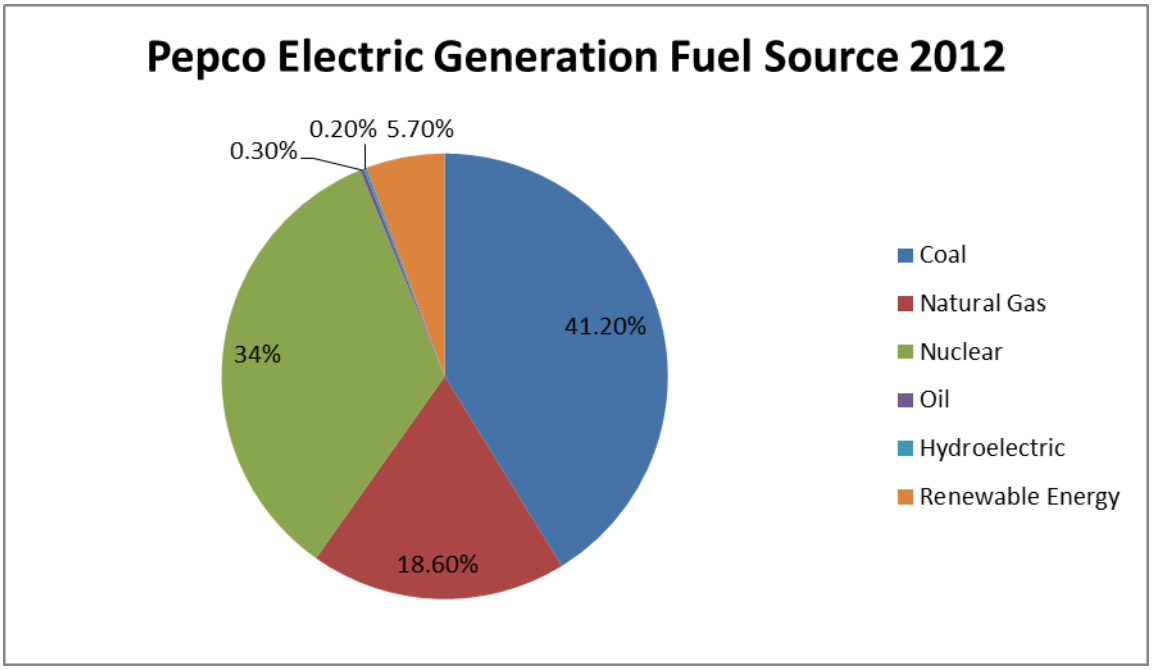


Figure 10: Fuel Source of Gaithersburg Electricity Supply

Nearly 60% of Maryland's electricity needs are met by coal,[68] a non-renewable fossil fuel which, through coal-fired power plants, is also the biggest source of man-made carbon emissions. To reduce any potential impact to global temperatures and climate change, carbon emissions should be reduced. At the local level, as can be seen in Figure 9, the energy supplier (Pepco) for Gaithersburg purchased a majority of coal (41.2%) in their reported 2012 fuel mix.[69] The State's energy use reduction program, EmPOWER Maryland, has set a goal for a 15% per capita energy reduction by 2015. This program is being implemented through various programs by the

[67] Johnson Controls, *Make Your Buildings Work*, http://www.makeyourbuildingswork.com/case-studies/city-of-baltimore/ (accessed August 15, 2014).
[68] Maryland Energy Administration, *Energy 101 – Energy Basics (#2)*, http://energy.maryland.gov/energy101/index.html (accessed August 15, 2014).
[69] Pepco, *Maryland Environmental Information for Standard Offer Service*, May 2013, http://www.pepco.com/uploadedFiles/wwwpepcocom/PEPCO-MD-ENV-FUEL-MIX.pdf (accessed August 15, 2014).

individual electricity utilities through a surcharge on customers' bills. In 2013, the City was accepted into the EPA's Green Power Partnership through the purchase of 100% wind-generated Renewable Energy Certificates (REC's), which offset 30% of the energy consumed by the City.

Running the hot water faucet for 5 minutes uses about the same amount of energy as burning a 60-watt bulb for 14 hours. (U.S. Environmental Protection Agency)

An additional step towards reducing energy waste and fossil fuel demand would be to set a goal for increased green power generation at City facilities and to commit to purchasing renewable energy directly, as opposed to purchasing Renewable Energy Certificates. Additionally, it could be more cost effective for the City to focus on energy conservation, as in one study it was demonstrated that utilities spent 2-3 times less to save electricity than to generate it, including both the dirtiest and the cleanest forms of energy production.[70]

7.6 Alternative Energy Sources

Increasing usage of renewable energy sources lessens the ecological impacts associated with energy consumption. Replacement of earlier energy technology with alternative energy sources would move the City towards reducing reliance on polluting, fossil fuel based energy sources. In 2011, 33% of US greenhouse gas emissions were from the generation of electricity, primarily from coal-fired power plants and natural gas.[71] Utilizing renewable energy (solar, hydro, geothermal, and wind) can lead to a reduction in air pollution compared to conventional fossil-fuel energy sources such as coal-fired power plants. By increasing the City's renewable energy resources, the fluctuating costs associated with fossil-fuel derived energy can be minimized. Cities set a powerful example to the community and boost the local renewable energy marketplace by investing in alternative energy sources. One challenge for smaller jurisdictions and pay-as-you-go communities such as Gaithersburg is to overcome the upfront installation costs of innovative energy technologies to capitalize on the long-term energy benefits of renewable energy.

Austin, Texas has achieved more than $170 million in customer utility savings since their decision in 2011 to avoid future fossil fuel generation by focusing on efficiency and renewable energy first. (austinenergy.com)

As a recent example, the City's Olde Towne Youth Center utilizes solar photovoltaic panels to help offset the electrical load. The system has a capacity of 5 kW and produces 5,989 kWh of clean energy annually, saving 8,577 pounds of carbon dioxide emissions each year. The Youth Center also saves $300 per year in utility bills.

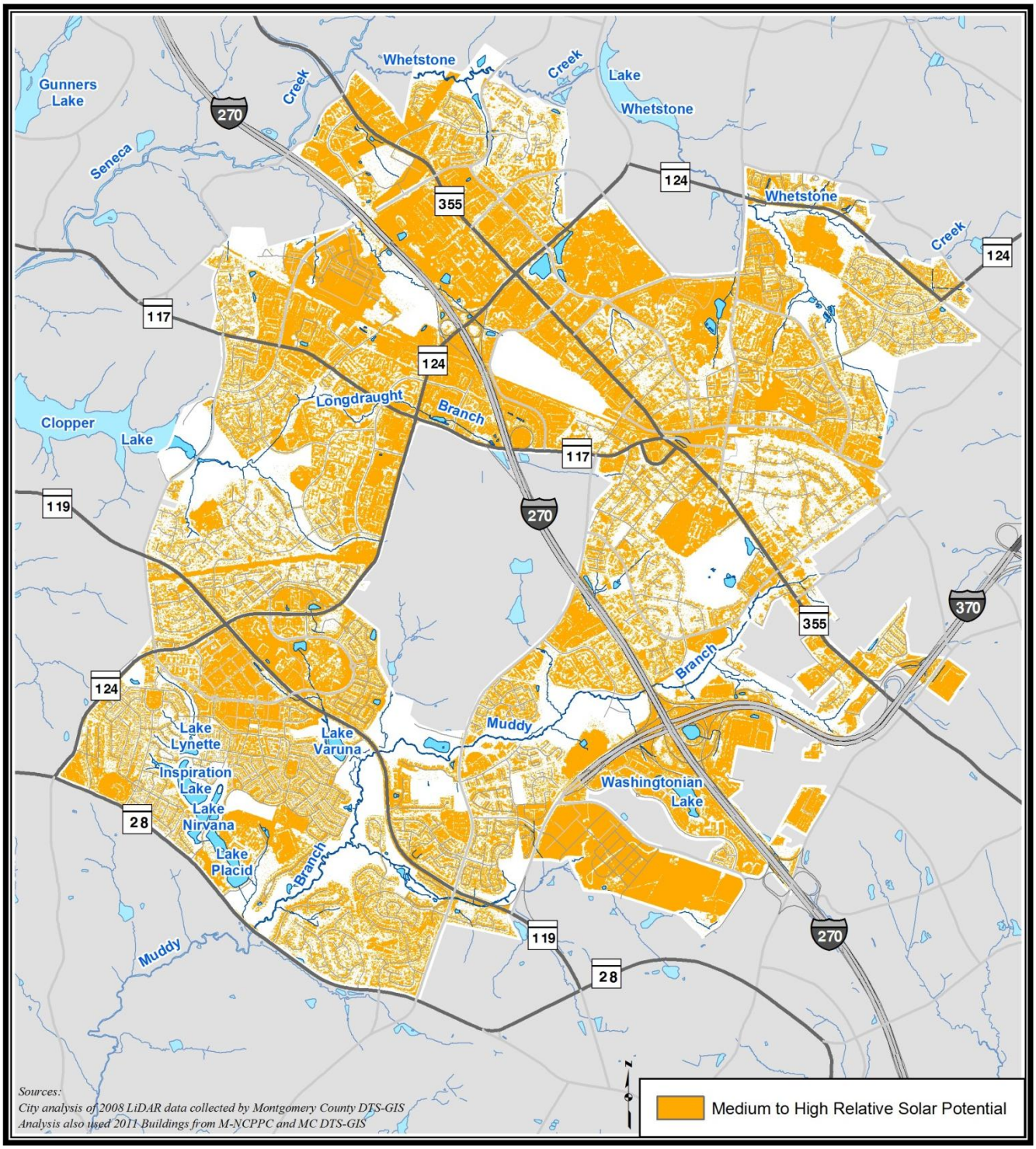
[70] American Council for an Energy-Efficient Economy (ACEEE), *The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs* (Washington, DC: ACEEE, 2014). http://www.aceee.org/research-report/u1402

[71] U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gases and Sinks*, 2011, Pub. EPA 430-R-14-003. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Main-Text.pdf

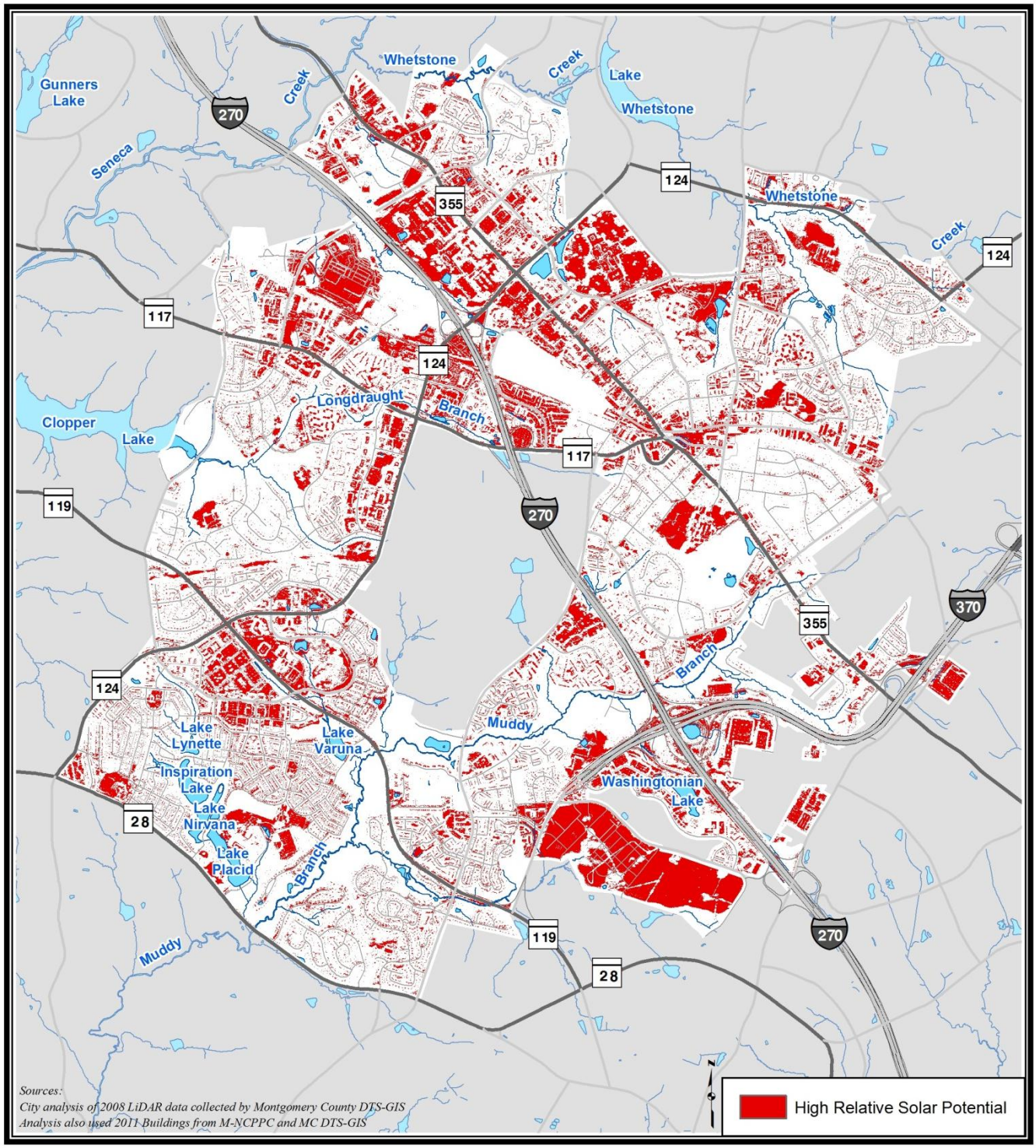
The following two maps show the areas of greatest relative solar potential within the City. The first map identifies the areas of medium to high relative solar potential,[72] while the second map identifies areas with the highest relative solar potential. These maps exclude major roadways, streams, lakes and parks. As aerial elevation data from 2008 was utilized in the creation of these maps, buildings constructed after 2009 were not factored into the analysis of solar potential. Certain existing buildings are more suited to the addition of solar than other locations, based on tree coverage, type of roof, building and utility conflicts, and building orientation. Solar-ready homes are equipped to easily add solar panels at a later date by the homeowner. To accomplish solar-readiness, homes are prepared with electrical conduit to allow later installation of a photovoltaic (PV) system to provide electricity and advanced plumbing designed to allow later installation of a solar hot water system. Including the solar-readiness of a new home as part of the building permit also enables expedited installation at such time that solar components are added to an existing home.

[72] The complete methodology utilized is described in the document in Appendix E, *Solar Potential Mapping Methodology.*

Map** 11**: Areas of Medium to High Relative Solar Potential



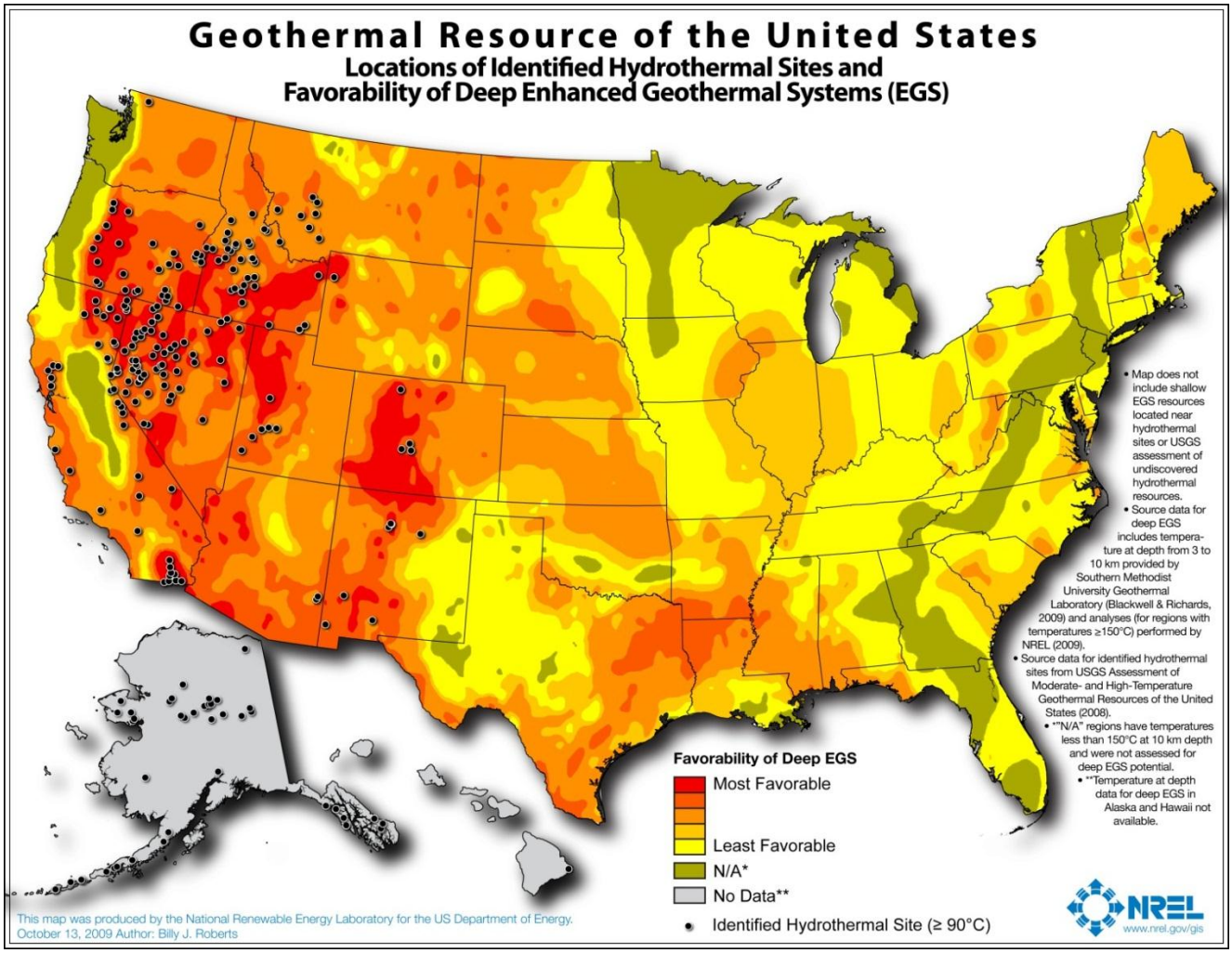
Map 12: Areas of Highest Relative Solar Potential



Use of geothermal resources[73] for heating and cooling of buildings reduces the use of fossil-fuel derived energy and reduces greenhouse gas emissions. As shown in the map below, the Piedmont region of Maryland, within which Gaithersburg falls, does not have identified deep geothermal resources;[74] however, shallow resources for individual sites for geothermal (ground source) heat exchange are available. The City's Olde Towne Youth Center is a certified LEED Platinum facility and includes a green roof, PV system, and ground source heating and cooling.

Figure 11: Olde Towne Youth Center

Map 13: Geothermal Resource Potential

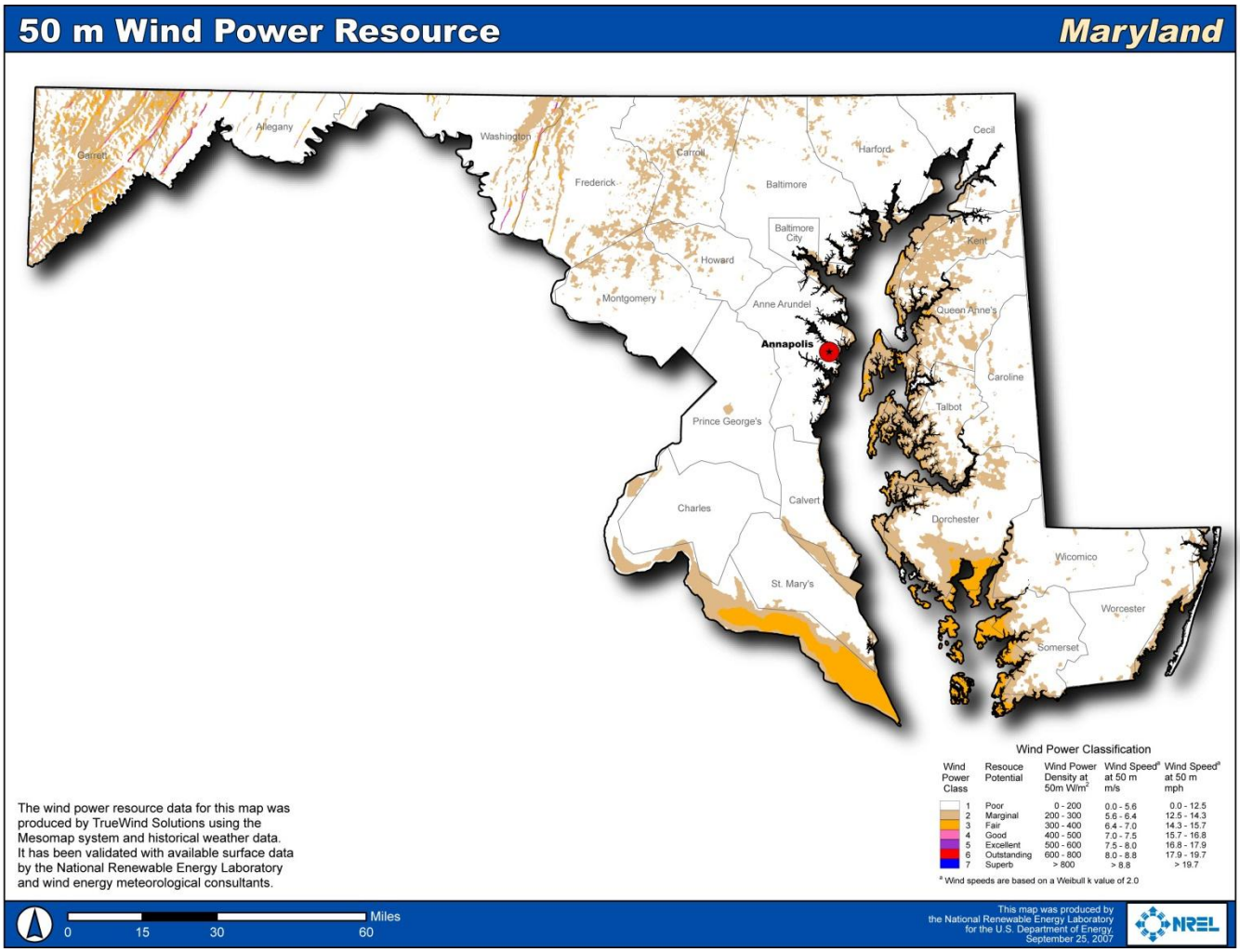


[73] Geothermal resources include the thermal energy contained in the rock and fluid in the earth's crust.

[74] Billy Roberts, "Geothermal Resource Potential Map," *Dynamic Maps, GIS Data, & Analysis Tools.* National Renewable Energy Laboratory, published 10-13-2009, http://www.nrel.gov/gis/images/geothermal_resource2009-final.jpg (accessed August 15, 2014).

While Gaithersburg is not a likely candidate for large-scale wind capture,[75] as shown in the map below, wind generation has potential at a smaller scale and can offset and supplement conventional energy supplies. Challenges to increasing wind capture may occur due to existing height restrictions on buildings; therefore existing codes and regulations may need adjustment to better accommodate the growth potential for this form of renewable energy.

Map 14: Maryland 50m Wind Resources



[75] National Renewable Energy Laboratory, *Map Search*, published 09-25-2007, http://prod-http-80-800498448.us-east-1.elb.amazonaws.com/w/images/5/59/NREL-eere-wind-maryland.jpg (accessed August 15, 2014).

7.7 Transportation Improvements and Alternative Modes

The *Transportation Element* of the City's 2009 Master Plan was developed in 2010 and contains recommendations for overall improvements to the City's transportation infrastructure. The consideration of the transportation network in the *Environment and Sustainability Element* is related to its impacts on energy consumption, air pollution, and public health/quality of life.

Transportation Demand Management (TDM) strategies are mentioned in the *Transportation Element* and include ride-share or shuttle programs, transit subsidies, telecommuting and flex-time policies, and dedicated bicycle parking. Through an increase in multi-modal transportation options and encouragement of TDM strategies, the City can reduce energy usage and carbon emissions, reduce traffic congestion, and increase the quality of life for residents. Projects such as the Corridor Cities Transitway (CCT) and the Countywide Bus Rapid Transit (BRT) Network, with their associated bicycle/pedestrian facilities, will add another means of travel for residents and can be expected to reduce traffic congestion.

Motor vehicles were responsible for 55% of nitrogen oxide emissions and 16% of fine particle emissions in 2007 in the Metropolitan DC region. [76]

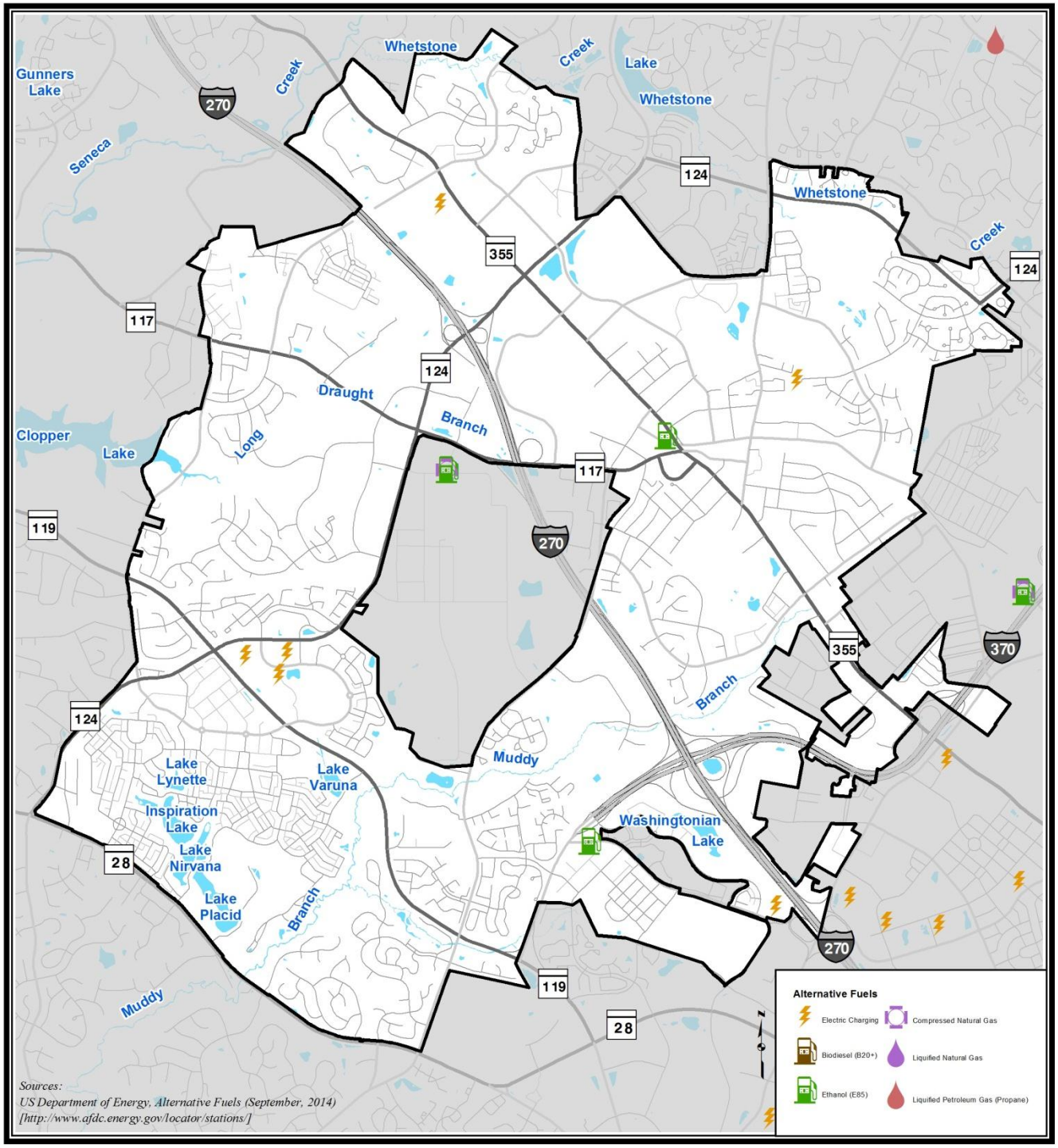
Recommendations in the *Transportation Element* include increasing the amount of and improving the safety of bicycle and pedestrian facilities in the design of new developments and along existing corridors. Safe bicycle and pedestrian facilities can increase the accessibility and connectivity of areas and reduce the necessity of vehicular travel. Air quality and health benefits can be realized with increased biking and walking. Bicycle travel by City residents as a means for transportation to work (0.001%) is very small compared to vehicular transport (79%).[77] Improved facilities, however, may change this dynamic.

While there are existing conditions that impede development and use of the bicycle/ pedestrian network (limited crossings of Interstate 270 and the railroad, major Federal facilities [NIST] with no through-access, seasonal and regional climate variation), there are ways that the City can look to exert influence. The addition of roadway safety features, such as improved signage and wayfinding with safe and well-lit connections to nearby residential and commercial areas, dedicated bicycle paths, bike-share opportunities, and encouragement of development that promotes "live where you work," will contribute to a likely increase in bicycle mode share. Additionally, while some residents may not be able to use bicycles for commuting, the City can work to promote recreational bicycle usage, thereby reducing vehicle emissions and traffic congestion while encouraging an increase in public health.

[76] Metropolitan Washington Council of Governments (MWCOG), *Regional Transportation Priorities Plan for the National Capital Region*, approved January 15, 2014. http://www.mwcog.org/uploads/pub-documents/vF5cWFc20140219085242.pdf

[77] United States Census Bureau (USCB), *3-Year American Community Survey*, 2010-2012, Washington, DC: USCB.

Map** 15**: Alternative Fuel Stations 2014



Along with increased use of transit and bicycle/pedestrian facilities, alternative fuel vehicles, including electric vehicles (EV's) reduce air pollution and reliance on fossil fuels. Battery-only electric vehicles emit no tailpipe emissions, which can reduce regional pollutants in the air, and do not produce unhealthy local concentrations of emissions as compared to internal

combustion vehicles. Alternative fuel vehicles can also provide cost savings to consumers. A study by the Union of Concerned Scientists indicated that drivers in the DC region could save approximately $950 annually in fuel costs when compared to internal combustion vehicles, depending on fuel prices, electricity rates, and miles driven.[78] As can be seen in the preceding map, electric vehicle charging stations have been installed in various areas within the City. The City currently has a use agreement for three EV's and is installing three Level II charging stations to more quickly charge these vehicles. Electric Vehicles are limited in their driving range based upon factors including individual vehicle make, driving conditions, and how they are driven. However, since the City is roughly ten square miles in size, EV's do not pose a range issue for those driving within or near the City. Additional charging stations and technological advances in battery development may lead to an increase in the use of EV's. Electric vehicle technology enables significant operational savings, including fuel costs over conventional vehicles, and has great potential to reduce the carbon footprint of transportation. The local utility provider, Pepco, recently initiated a pilot program for plug-in vehicle charging for Maryland customers, which is intended to bring down the cost of electricity for charging EV's by incorporating off-peak hour charging. The Greater Washington Regional Clean Cities Collaborative (GWRCCC) is providing technical assistance in implementing electric vehicle readiness in the greater Washington region. Also, in 2014, the Maryland Energy Administration (MEA) created the Microgrid Task Force, to explore legal, technical, and financial barriers and opportunities for microgrid deployment. MEA is focusing on public purpose microgrids to increase community resilience and energy reliability. MEA also intends to issue grants to support communities and private entities pursuing public purpose microgrids in the state, which Gaithersburg could consider utilizing.

Figure 12: City Electric Vehicle (Mitsubishi iMev)

7.8 Resource Efficiency

For the purposes of this section, resource efficiency will be reviewed in light of the role it plays with regards to sustainability. A novel and increasingly more in-depth look at the role of materials and access to those materials has emerged as a tenet of sustainable living. Planetary resources are interconnected and demand a holistic view of the life-cycle process of material usage, including production, recycling, upcycling, reuse, and retirement. The types of products purchased have an impact on our health and that of the planet. Therefore, the long cradle-to-grave view of resource production has merit for entities from local governments to state governments – to residents and businesses as well. As populations increase both locally and world-wide, resource efficiency will become a concern that will become increasingly more problematic if ignored.

[78] Don Anair and Amine Mahmassani, *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States* (Cambridge, MA: Union of Concerned Scientists, 2012). http://www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf

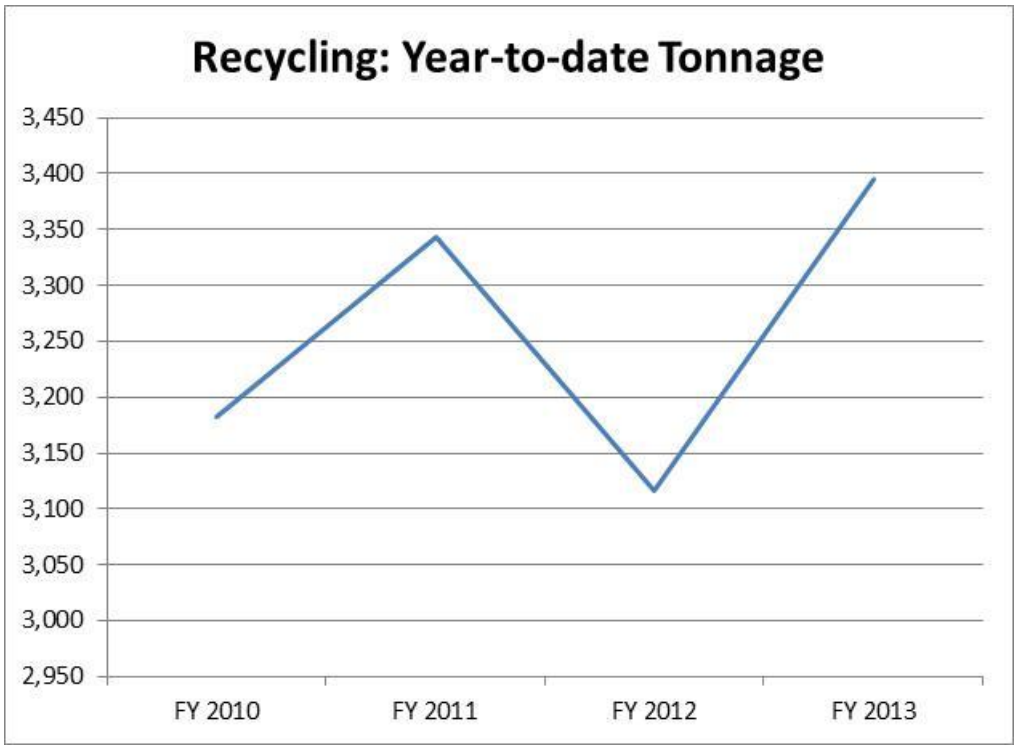


Figure 13: Recycling Tonnage

7.8.1 Green Procurement

Sustainable or green procurement seeks to identify environmental impacts involved with purchasing decisions. It includes a host of concepts, including creating policies regarding which items are to be purchased for everyday use, construction materials used in City buildings, the cleaning of City facilities, and fuel choices, as well as issues such as fair trade and social justice. Emissions of hazardous air pollutants (HAPs) and volatile organic compounds (VOCs) that may affect employees and visitors to City facilities can be avoided through policies that do not permit the purchase of cleaning products that include HAPs and VOCs. Green procurement can decrease waste through packaging reduction and use of recycled materials (key components of zero waste goals) and can increase energy efficiency through purchase of more energy efficient computers and fleet vehicles.

7.8.2 Zero Waste

The Governor of Maryland has set an ambitious goal to embrace zero waste (the near elimination of solid waste sent to landfills or incinerators) by 2030 (defined as 85% waste diversion goal) in the State's Greenhouse Gas Reduction Plan. A concerted effort will be required for the State to reach this goal. Food waste composting is one new direction towards zero waste that local governments have been researching. This component of waste reduction has potential for improvement, as only 5.1% of food scraps were recycled in 2010 in Maryland.[79] At this time, there are no local, high-capacity composting facilities for Gaithersburg residents to send food scraps to be composted. There are some residents who compost their food waste on their own

[79] Maryland Department of the Environment, *Maryland Greenhouse Gas Reduction Act Plan*, October, 2013. http://climatechange.maryland.gov/site/assets/files/1392/mde_ggrp_report.pdf (accessed August 15, 2014).

property for use in private gardens and/or to serve as backyard chicken feed. Unwanted pests can pose a challenge with backyard composting of food waste and can necessitate vigilance on the part of the homeowner to discourage pests such as rodents. The City presently offers single-stream recycling and yard waste pick-up to residents and offers leaf pick-up in the fall. As can be seen in Figure 12, recycling participation has generally grown over the past few years. It should be noted that recycling data can be misleading as people who make it a point to consume less and purchase more items in bulk naturally create less waste – both in terms of recyclable and traditional landfill or incinerator-bound waste.

7.8.3 Sharing/Collaborative Economy

Since the economic downturn in 2008, many individuals have sought ways to save money. Many people are exploring sharing or renting items, rather than purchasing them outright. In a recent report from the American Planning Association, the shared economy was identified by 59% of general respondents and 79% of Millennials to be "somewhat to extremely important" to them.[80] Bike, car, and ride sharing may be the most recognizable examples of the sharing economy which includes the benefits of saving money, conserving resources, and building community. In one survey, of those very interested in sharing, repair and maintenance tools (garden, automotive, and bike tools) were ranked the second highest in interest out of eight categories, after physical media (books, DVD's, etc.).[81] A majority of the survey respondents (69%) identified the statement "borrowing would lessen their environmental impact" as a factor in their decision to borrow an item. Of particular interest, some respondents identified reasons they would prefer to borrow an item from a community organization as opposed to a peer, including:

- unavailability of friends/neighbors
- worry about damaging items belonging to a friend/neighbor
- expectations for future recompense from a friend/neighbor
- lack of quality items from a friend/neighbor
- ability to find multiple items in one space

The average power drill is used only 6 to 13 minutes in its lifetime. [82]

Technology, including web-based sites and applications, has advanced in recent years to enable convenient methods for entrance into the sharing economy. Sharing items can also enable users to gain access to higher quality items that they may not purchase outright as they would not have rationalized the purchase of a high cost but quality item for the limited use anticipated by one user. Some challenges with certain explorations of sharing and collaboration have occurred.

[80] American Planning Association (APA), 5/2014. *Investing in Place for Economic Growth and Competitiveness – A Research Summary*, https://www.planning.org/policy/polls/investing/pdf/pollinvestingreport.pdf (accessed August 15, 2014).
[81] Conducted by *the sharing project* in Vancouver.
[82] The Center for a New American Dream, *New Dream Community Action Kit*, 2014, http://www.newdream.org/programs/collaborative-communities/community-action-kit (accessed August 15, 2014).

Questions have arisen including how to license people sharing private vehicles and homes. Equity concerns have been voiced by licensed operators such as taxi companies and hotels. Zoning standards may not include newer uses contemplated such as vacation housing and short-term rentals nor any unintended consequences of introducing semi-commercial uses into residential zoning districts.

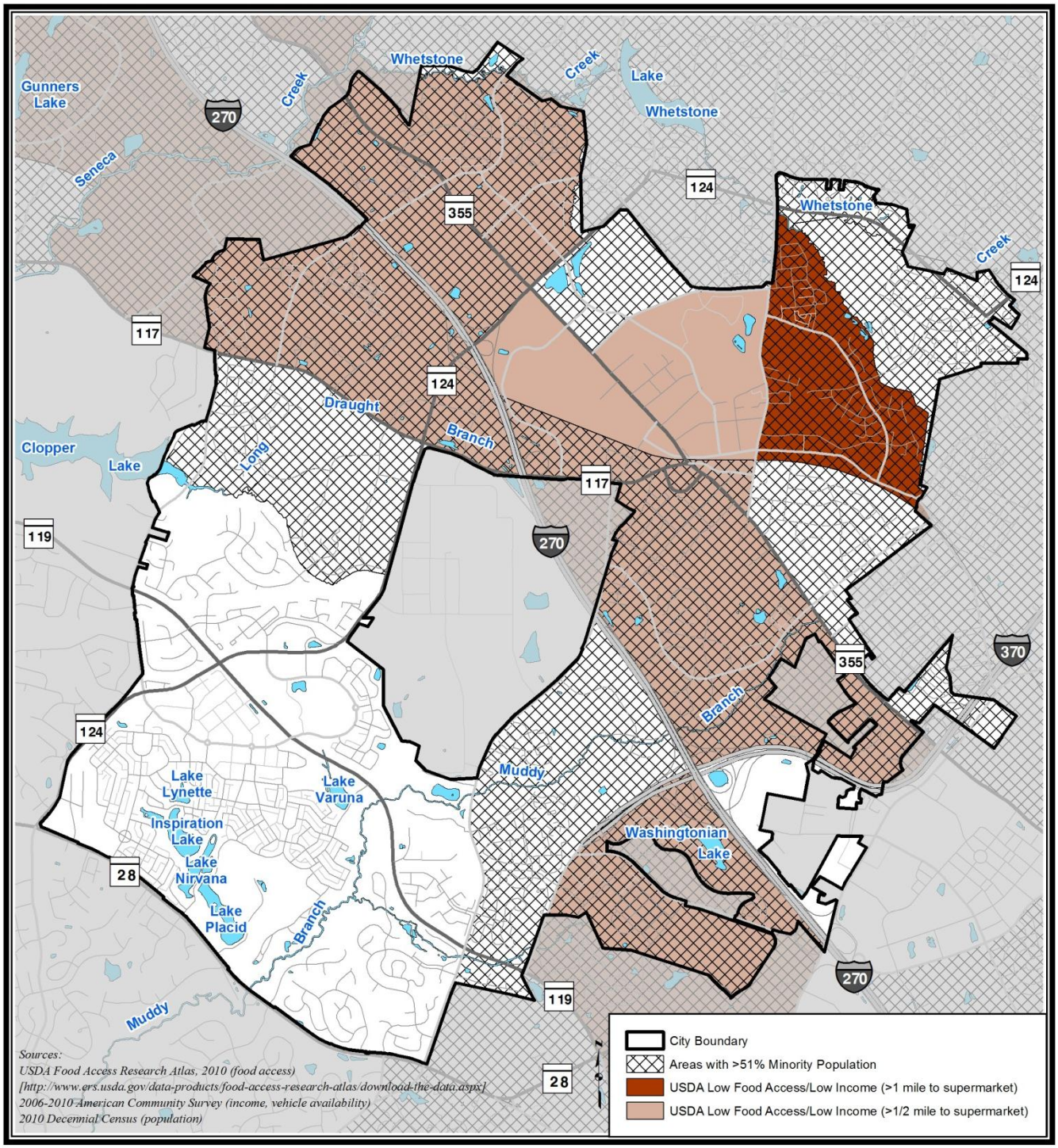
7.9 Environmental Justice: Access and Affordability

Gaithersburg has stated its commitment to housing for all people through both its Housing Policy and its affordable housing program. While housing for all populations is indeed a priority, the sections to follow explore the topic of environmental justice through the lens of quality of life for all residents. A strong commitment to ensuring equitable access to both food and recreational opportunities for all residents should be a goal of the City.

7.9.1 Access and Affordability: Healthy Food

In considering the regional context for locally produced foods, the boundary for Montgomery County's Agricultural Reserve begins less than two miles from the City limits of Gaithersburg. More than 920 farms and horticultural operations are active in the County's Agricultural Reserve. The Agricultural Reserve is a local resource for seasonal produce and animal products. The following map, based on US Department of Agriculture (USDA) data, shows that many Gaithersburg residents have choices regarding where they will purchase fresh, healthy food; however, 30% of City households reside in the areas between 1/2 mile and one mile to the nearest grocery store (light red on the map), while 11% reside in the areas greater than one mile from a grocery store (darker red on the map), based on 2010 Census data summarized by Census tract/part within place/remainder (summary level 80). The USDA Food Access map shows that low income households have limited access to grocery stores within a reasonable travel distance (1/2 mile). Having to travel in excess of 1/2 mile to reach a grocery store is one indicator used to identify food desert status. A food desert is generally defined as a geographic area where resident access to affordable, healthy food options (especially fresh fruits and vegetables) is restricted or nonexistent due to the absence of grocery stores within a convenient travelling distance. Access to fast food restaurants and corner stores may be the only viable option for residents within a food desert due to limited transportation options.

Map 16: Food Access, USDA



The USDA mapping methodology has limitations in that the data is not as frequently updated and includes narrow factors for categorization as a grocery store. However, it can be useful to have an established and standardized approach when comparing food access amongst different localities at the national scale.

Recognizing the limitations of the USDA map, staff delved deeper to analyze the food access situation in Gaithersburg with more current data, enabling a more focused and richer local analysis on certain Census tracts within the City. The localized maps include full-service grocery stores, as defined by the USDA,[83] as well as future grocery stores and limited service[84] grocery stores (specialized stores that do not carry either produce, meats, or dairy products) Limited service grocery stores can add to the variety for customers however, they cannot by themselves meet the nutritional demands of customers like a full-service grocery store. Comparing the USDA map to the localized overview map, the following can be seen:

- The areas which exceed one mile to a full-service grocery store comprise less than 2% of the City's households. The areas that fall within this 2% are on the fringes of the City and are bounded by either a roadway and/or natural features such as being adjacent to a State Park or stream tributary/Lake.
- 28% of City households are between 1/2 mile and 1 mile of a full-service grocery store.
- 36% of City households are between 1/4 mile and 1/2 mile of a full-service grocery store.
- 34% of City households are within a 1/4 mile of a full service grocery store.

Following the comprehensive Food Access 2014 map and associated tables are three separate maps that individually identify the low income (less than 80% of DC Metro Median Family Income, currently $85,241), low mobility (more than 100 households with no access to a vehicle), and Majority Minority (less than 49% of the population is White Non-Hispanic) Census tracts within the City. In looking at the low mobility Census tracts, there are 5 tracts[85] in which more than 100 households do not have access to a vehicle.

[83] Full service grocery stores are defined by the USDA as having annual sales in excess of $2,000,000 and carrying all of the following: fresh meat and poultry, produce, dairy, dry and packaged foods, and frozen foods.

[84] For the purposes of the City's detailed analysis, limited service grocery stores are defined as those which carry some, but not all of the following: fresh meat and poultry, produce, dairy, dry and packaged foods, and frozen foods. Full service grocery stores are defined in the City's analysis as those which carry all of the following: fresh meat and poultry, produce, dairy, dry and packaged foods, and frozen foods.

[85] The five tracts are 7008.26, 7008.16, 7007.19, 7007.23, and 7007.22

Map 17: Food Access, 2014

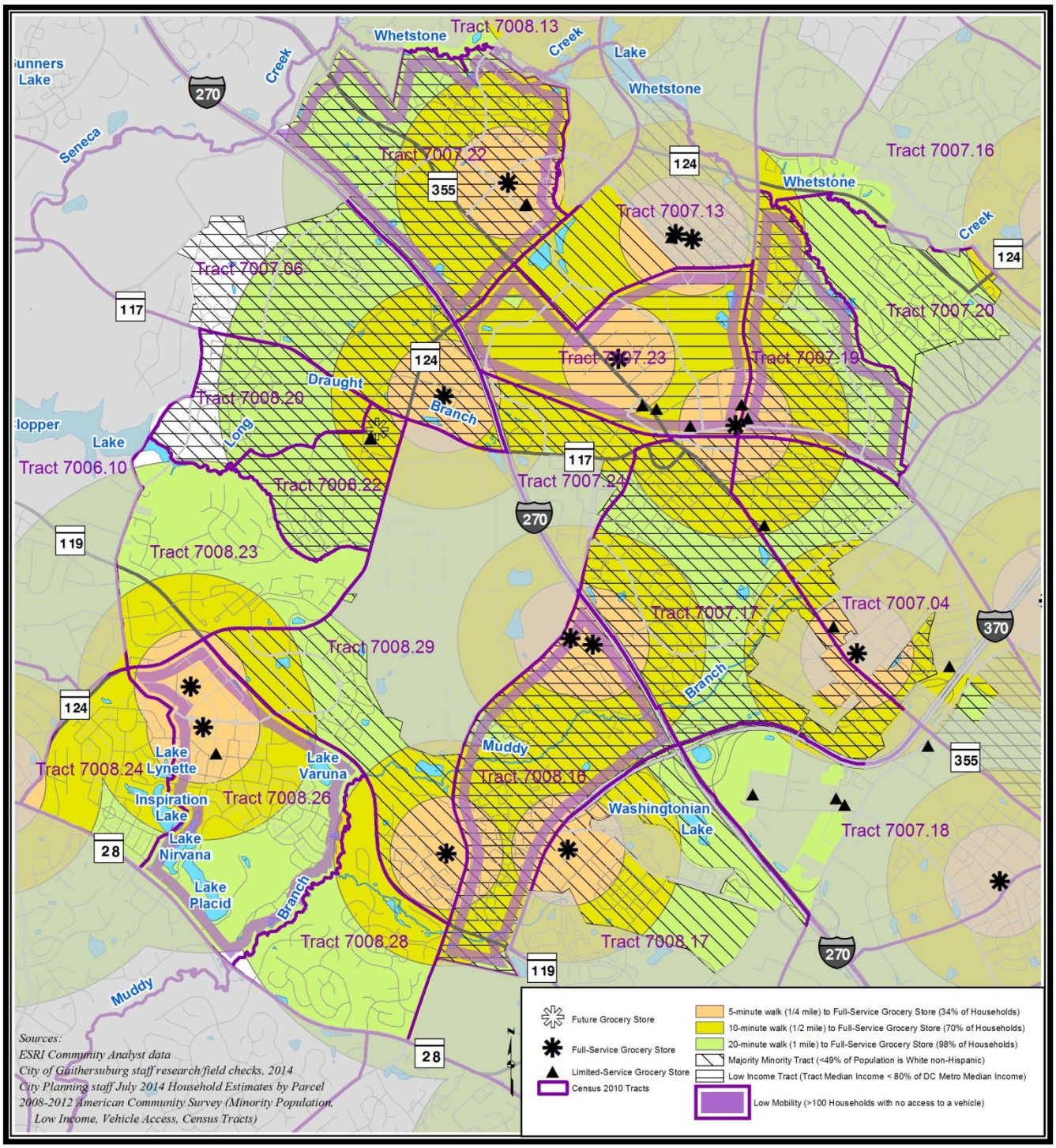


Table 4: Selected Characteristics of Census Tracts (or part)

	2008-2012 American Community Survey								Census 2010
	City Criteria			USDA Criteria					
Tract ID	House Holds (HHs)	Minority Pop.	% HHs with no car	USDA Low Mobility	# HHs with no car	USDA Low Income	Persons in Poverty	Median Family Income	House Holds
700610	*0*	*0.0%*	*0.0%*	*N*	0	*N*	*0.0%*	*$0*	0
700820	*0*	*0.0%*	*0.0%*	*N*	0	*N*	*0.0%*	*$0*	0
700823	*0*	*0.0%*	*0.0%*	*N*	0	*N*	*0.0%*	*$0*	0
700704	793	67.2%	7.4%	N	59	Y	9.2%	$60,417	748
700706	1314	68.1%	7.4%	N	97	Y	8.1%	$74,653	1203
700713	31	100.0%	0.0%	N	0	N	0.0%	$0	19
700716	129	23.7%	0.0%	N	0	N	0.0%	$152,222	149
700717	1863	75.5%	4.5%	N	83	Y	8.1%	$68,902	1789
700718	*0*	*0.0%*	*0.0%*	*N*	0	*N*	*0.0%*	*$0*	0
700719	2486	82.1%	13.3%	Y	330	Y	16.0%	$61,028	2333
700720	732	56.9%	5.1%	N	37	N	5.8%	$125,278	783
700721	13	0.0%	0.0%	N	0	N	0.0%	$0	58
700722	1618	62.3%	6.5%	Y	105	Y	5.4%	$80,539	1664
700723	1831	38.6%	26.9%	Y	492	Y	19.4%	$72,321	1819
700724	67	90.9%	0.0%	N	0	Y	0.0%	$47,083	64
700813	*0*	*0.0%*	*0.0%*	*N*	0	*N*	*0.0%*	*$0*	0
700816	2834	74.4%	9.0%	Y	254	Y	7.7%	$84,268	2708
700817	142	87.5%	0.0%	N	0	N	6.3%	$198,299	119
700820	1026	69.0%	3.0%	N	31	Y	8.3%	$69,236	955
700822	687	61.2%	4.9%	N	34	Y	24.5%	$55,625	640
700823	1200	41.2%	0.0%	N	0	N	3.9%	$116,442	1193
700824	1096	28.1%	1.7%	N	19	N	1.6%	$162,700	1014
700826	2560	26.7%	6.5%	Y	166	N	1.5%	$162,617	2635
700828	876	26.8%	8.0%	N	70	N	2.5%	$165,833	864
700829	1176	52.4%	0.0%	N	0	N	2.0%	$136,830	1243
Gaithersburg	22474	58.7%	7.9%		1777		8.1%	$101,275	22000
Washington-Arlington-Alexandria, DC-VA-MD-WV Metro Area								$106,551	

Sources:

2008-2012 American Community Survey, Census tract (or part) within place/remainder (or part) [summary level 80]

2010 Decennial Census, Census tract (or part) within place/remainder (or part) [summary level 80]

Tracts with no permanent population or households

USDA Low Food Access/Low Income Tract, >1/2 Mile to grocery store

USDA Low Food Access/Low Income Tract, >1 Mile to grocery store

Table 5: Household Food Access by Census Tract (or part)

Census 2010 Tract ID	City Households within 1.0 mile of a Full-Service Grocery Store	City Households within 0.5 mile of a Full-Service Grocery Store	City Households within 0.25 mile of a Full-Service Grocery Store
24031700610	N/A	N/A	N/A
24031700704	100.0%	56.6%	12.7%
24031700706	77.8%	54.6%	35.1%
24031700713	N/A	N/A	N/A
24031700716	100.0%	29.9%	0.0%
24031700717	100.0%	83.1%	23.7%
24031700718	N/A	N/A	N/A
24031700719	100.0%	77.6%	19.7%
24031700720	100.0%	1.4%	0.0%
24031700722	100.0%	81.6%	38.1%
24031700723	100.0%	100.0%	96.3%
24031700724	100.0%	72.2%	0.0%
24031700813	N/A	N/A	N/A
24031700816	100.0%	96.2%	59.7%
24031700817	100.0%	51.7%	0.0%
24031700820	88.6%	27.9%	0.0%
24031700822	100.0%	0.0%	0.0%
24031700823	100.0%	37.2%	3.9%
24031700824	100.0%	84.1%	9.5%
24031700826	100.0%	82.2%	50.0%
24031700828	100.0%	39.2%	0.0%
24031700829	100.0%	59.0%	36.0%
Entire City	98.1%	69.6%	33.5%

Sources:

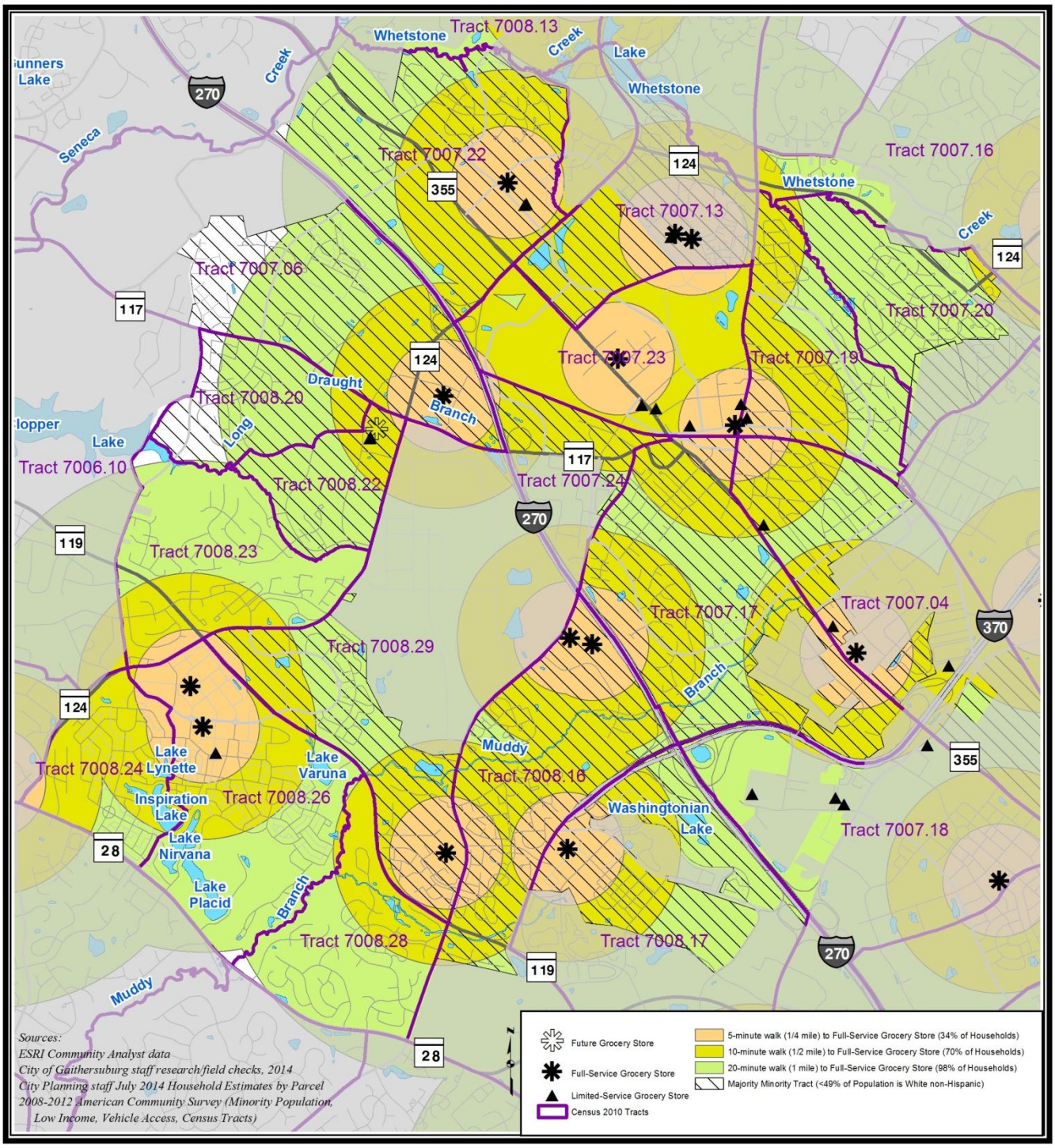
July 2014 Gaithersburg City Planning Household and Population estimates by parcel

2010 Decennial Census Tract Boundaries

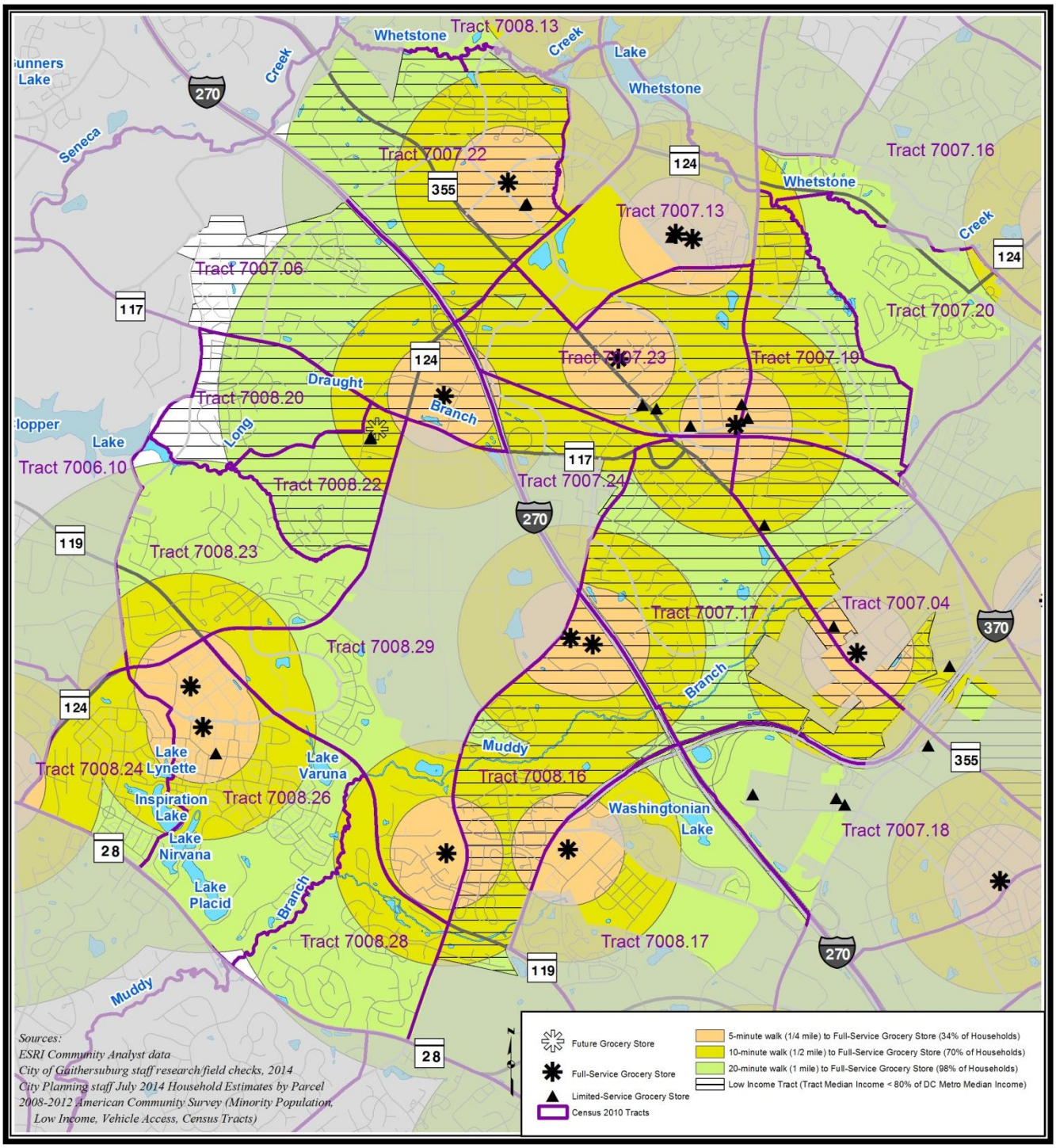
Low Income/Low Mobility/Majority Minority Tracts

Low Income/Low Mobility Tracts

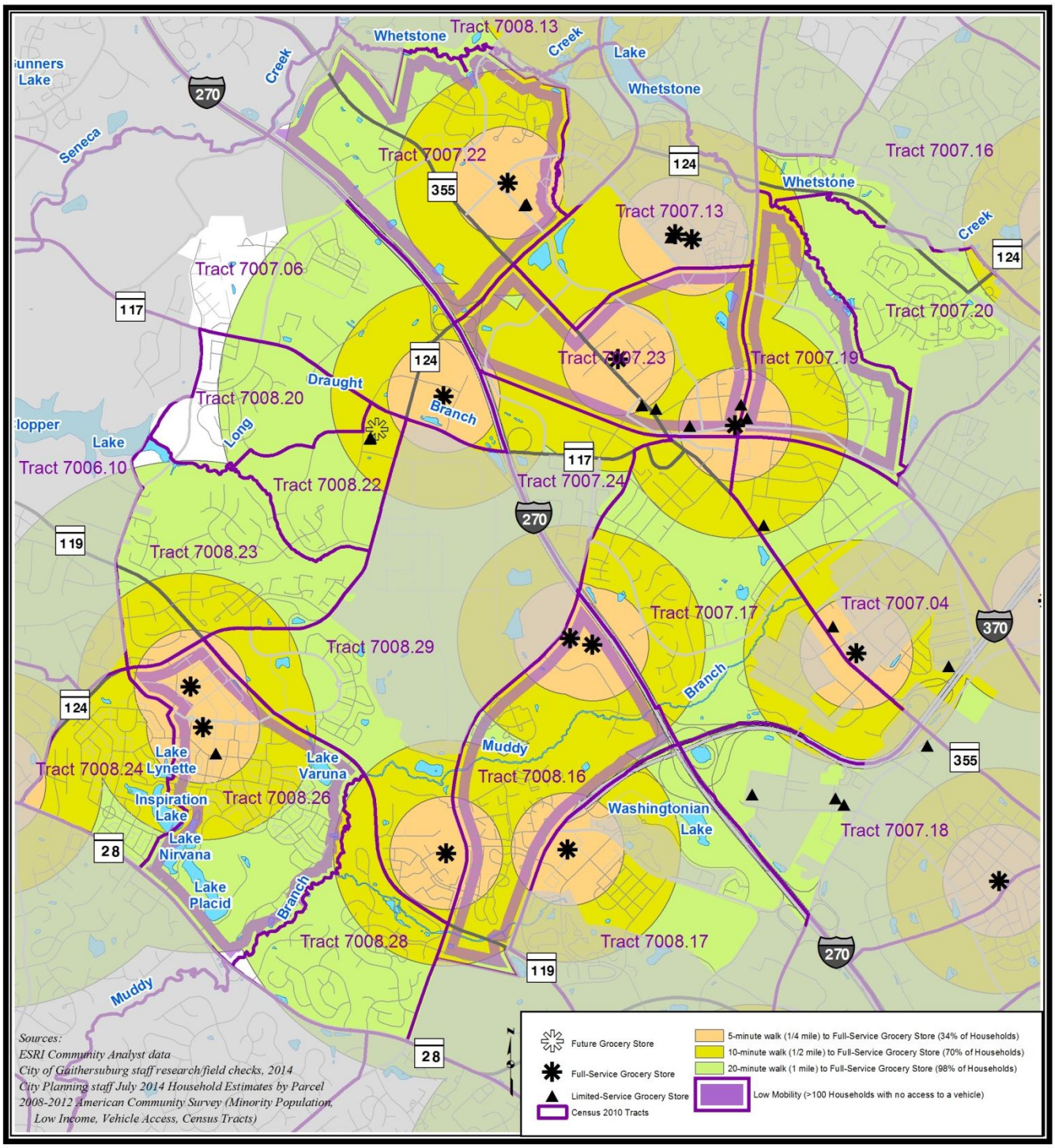
Map 18: Food Access 2014 – Minority Majority



Map 19: Food Access 2014 – Low Income



Map 20: Food Access 2014 – Low Mobility



Further analysis was performed on the 4 tracts[86] that contain a greater percentage of both low mobility households and low income households. Nonresidential areas were also identified to better illustrate how the residential land use pattern is laid out within the tracts. Aside from the areas in white designating distance in excess of one mile, the areas shown in green are those that have the longest distances (one mile) from full-service grocery stores.

Looking at the Southern Subject Tract Food Access Map, there are no areas in white designating distance in excess of one mile from a full-service grocery store. However, there are two full service grocery stores within Census Tract 7008.16 and no limited service stores, with 57.7% of the households in this tract outside 1/4 mile of a full-service grocery store. Each of the other Low Mobility/Low Income Census tracts contain one or more limited service stores which may meet some, but not all of the households food needs.

Looking at the Northern Subject Tracts Food Access Map, although a significant area within Census tract 7007.22 is a nonresidential use, 18.4% of the households within this tract do live more than 1/2 mile from a full-service grocery store. Tract 7007.22 does contain a small area that is in excess of one mile from a full-service grocery store, but there are no households living there as it is a non-residential area. Tract 7007.19 contains the highest percentage of City households (22.4%) in a low mobility and low income Census tract living beyond the 1/2 mile distance to a full-service grocery store. The majority of the area highlighted in green is residential in this tract (7007.19). While there are two tracts (7007.22 and 7007.19) that have 18.4% and 22.4% of households respectively without a full-service grocery store within 1/2 mile, the methodology used for this analysis has limitations and cannot show if these households are the same ones within these Census tracts that do not have access to vehicles. There are two small portions of tract 7007.23 near Perry Parkway with a greater than 1/2 mile distance to a full-service grocery store, however, there are no households living within them. This tract (7007.23) has two full service grocery stores and four limited service stores.

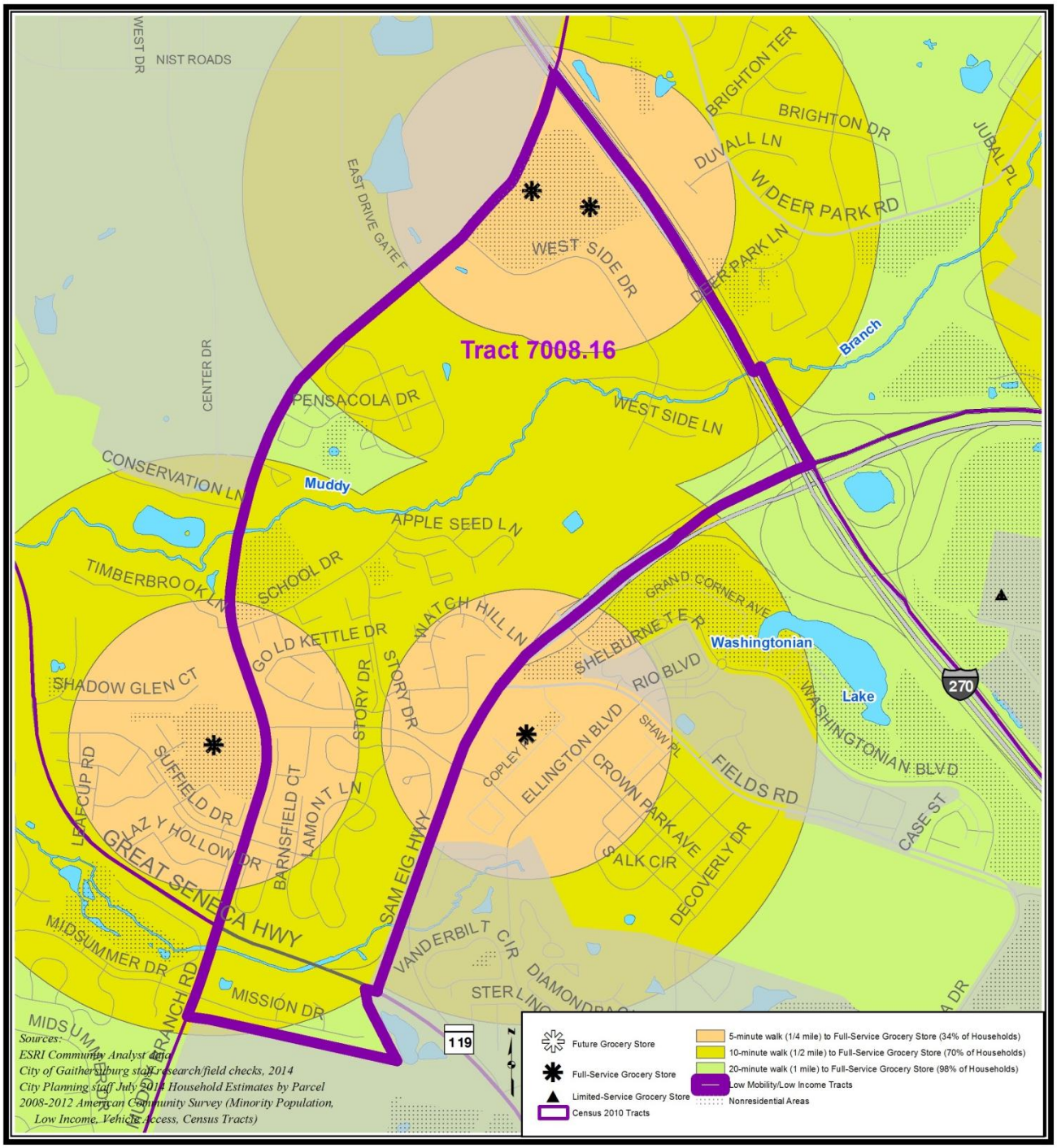
In summation, while the USDA data shows that 41% of the City households have limited access (have to travel in excess of 1/2 mile) to full-service grocery stores, the more detailed City analysis shows that 30% of City households have limited access. Additionally, the City analysis shows that 4 low-income tracts within the City also contain high numbers of households who do not own a vehicle (1,181); thereby making food access more difficult. While these additional maps provide more detailed information than the USDA overview map, a more comprehensive City food analysis could delve into further analyses of the issues affecting food access in Gaithersburg.

As with many food deserts, healthy food can be more difficult to access than alcohol, tobacco, fast food, and candy, all of which may be readily available and affordable. Bicycle and pedestrian safety can play a role in making access to providers of healthy foods more difficult. Lack of direct bus service routes can also increase the difficulty in accessing grocery stores. There are many components which determine placement of grocery stores including economic considerations, historical land use patterns, zoning, natural features/barriers, and roadway patterns. While unhealthy eating may be economically cheaper and easier to access in the short-term, the consequences of long-term constrained access to healthier foods is one of the main reasons that

[86] The four tracts are 7008.16, 7007.19, 7007.23, and 7007.22

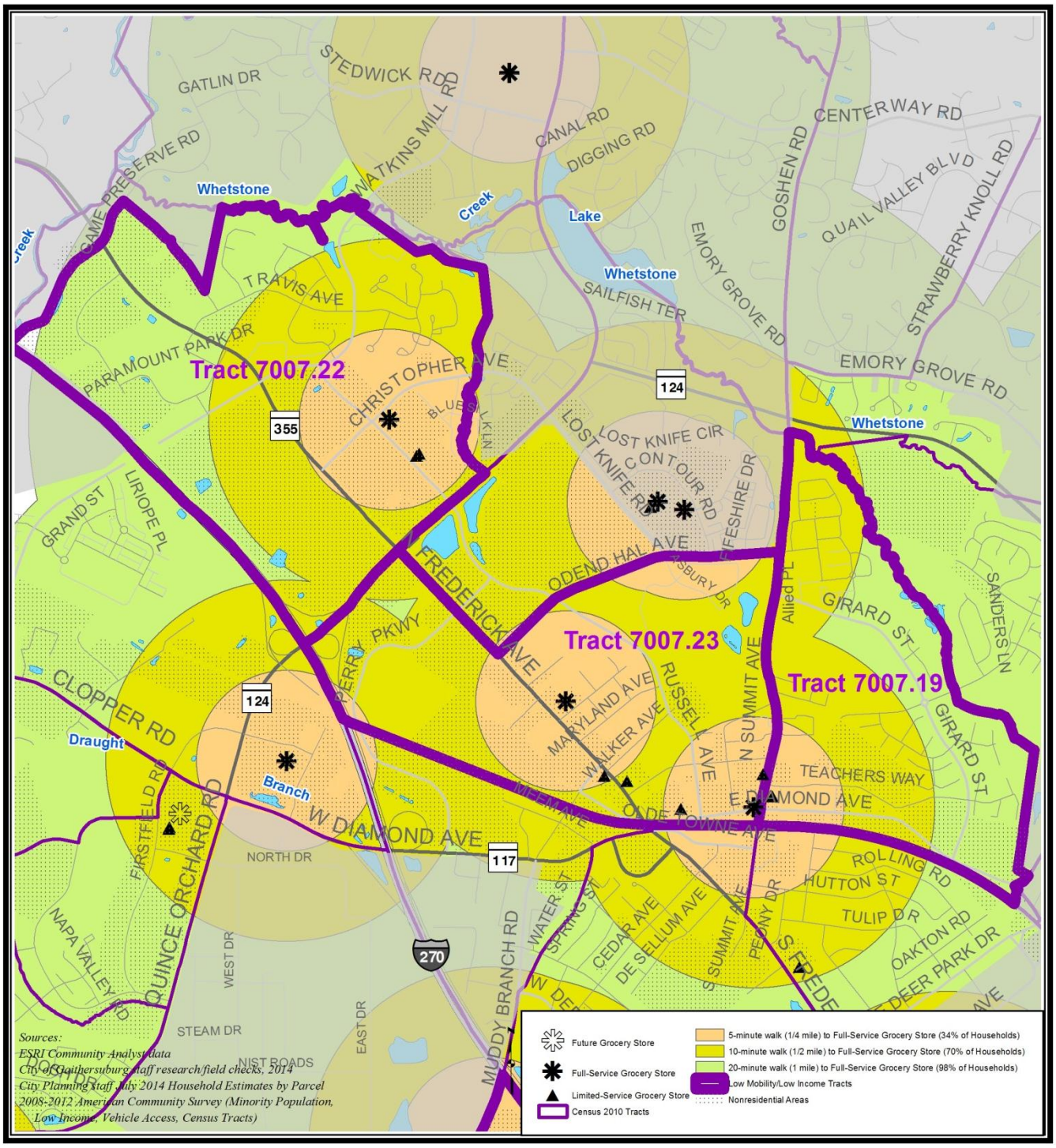
minority and low-income populations suffer from statistically higher rates of obesity, type 2 diabetes, cardiovascular disease, and other diet-related conditions than the rest of the population.[87]

Map 21: Food Access – Southern Subject Tract



[87] Mari Gallagher, *Examining the Impact of Food Deserts on Public Health in Chicago* (Study commissioned by LaSalle Bank), 2006, http://www.marigallagher.com/projects/4/

Map 22: Food Access – Northern Subject Tracts



A recent study has indicated that eating seven or more portions of fruit and vegetables a day reduces your risk of death at any point in time by 42% compared to eating less than one portion.[88] Cost can be a limiting factor in availability to healthy foods. Results from a study published by the American Heart Association found that incentives to make healthier food more affordable is one of the most effective government interventions to support an increase in public health.[89] Four out of seven of the elementary schools in Gaithersburg have 50% or more of their student population receiving free or reduced meals (based on 2012-2013 MCPS data). St. Martin of Tour's food bank distributes to an average of 200 families per week, the Lord's Table Soup Kitchen serves approximately 60 people each day, and the City funded the distribution of emergency food to more than 10,000 individuals in FY13. Analysis of causes of health disparities, health outreach, and nutrition education may be needed in areas of the City suffering higher health mortality rates. Local health issues can be seen from looking at geographic data compiled by Johns Hopkins University. Comparing two census tracts within the City in Figure 13, the Census Tract north of East Diamond Avenue has a higher heart disease mortality rate and diabetes mortality rate compared to the tract located south of East Diamond Avenue (age-adjusted rate from 2004-2008; Census 2000 boundaries). It should be noted that the data only shows evidence of a health disparity and does not delve into the cause(s) of the issue.[90]

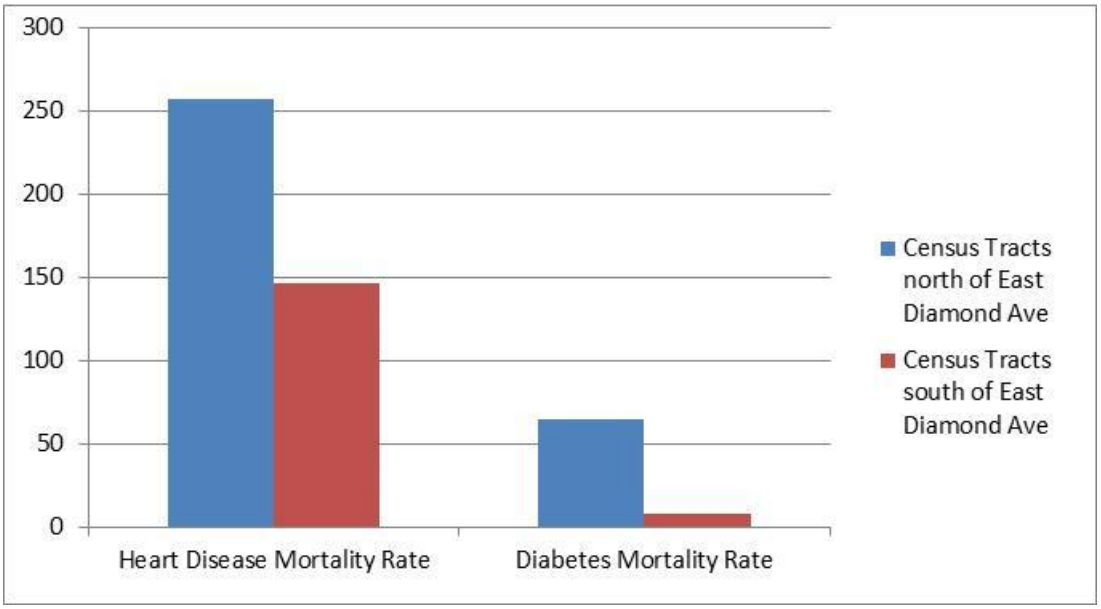


Figure 14: Heart Disease and Diabetes Mortality Rates by Census Tract

[88] University College London. (2014, March 31). *New evidence linking fruit and vegetable consumption with lower mortality.* ScienceDaily. Retrieved April 9, 2014 from www.sciencedaily.com/releases/2014/03/140331194030.htm

[89] Mozaffarian D, Afshin A, Benowitz NL, Bittner V, Daniels SR, Franch HA, Jacobs DR Jr, Kraus WE, Kris-Etherton PM, Krummel DA, Popkin BM, Whitsel LP, Zakai NA. Population approaches to improve diet, physical activity, and smoking habits: a Scientific Statement from the American Heart Association. Circulation. 2012;126:1514-63. Epub 2012 Aug 20.

[90] Health disparities are differences in health outcomes amongst different groups of people.

In looking at the 2009 Pediatric Nutrition Surveillance System (PedNSS), nearly one-third of the 3.7 million low-income children aged two to four surveyed in the U.S., were obese or overweight, and 541,000 were obese.[91] According to the most recent Census information,[92] 10% of the City's population fell below the poverty line during the 2010-2012 timeframe. The City has signed on to *Let's Move! Cities, Towns and Counties*, a major component of First Lady Michelle Obama's *Let's Move!* initiative. The City is also part of the *Healthy Eating, Active Living (HEAL)* Cities and Towns campaign. Through a strategic partnership with the Virginia Municipal League and the Maryland Municipal League, the HEAL Cities and Towns Campaign provides free coaching and technical assistance to municipal leaders to adopt local policies that promote access to healthy, affordable foods, convenient access to opportunities for physical activity and recreation, and workplace wellness.

For an average investment of $70 to establish a food garden, there is a return on investment of $530. [93]

Low-income and other populations are able to access healthy, fresh local foods at the City's Fulks Corner Farmers Market in Olde Towne (operating from May through November) and the Main Street Farmers Market in Kentlands (operating all year). Select farmers at both of the markets now accept electronic SNAP (Supplemental Nutrition Assistance Program) payments and WIP (Women, Infants, and Children Program), FVC (Fruit and Vegetable Check Program), and FMNP (Farmers Market Nutrition Program) checks, further encouraging healthy eating amongst lower income populations. Through a Federal grant, the City provides a hot, nutritious lunch at the Gaithersburg Upcounty Senior Center during weekdays and a free breakfast at certain summer camp locations. Many jurisdictions such as Montgomery County have permitted community gardens and orchards on unused municipal property. Community gardens enable residents living in multi-family housing and others to grow affordable, fresh food during the summer months. Several recreational centers host classes on gardening, as well as canning and preserving fresh foods to encourage year-round healthy options. Improvements in public transportation and roadway/bikeway access can also increase the ease with which residents can access both farmers markets and conventional grocery stores.

7.9.2 Access and Affordability: Open Space

One way to combat obesity and high mortality rates is through access to programmed or recreational open spaces, which enable healthy activity and relaxation. It has been shown that people who live within a 5-minute walking distance (1/4 mile) of a park are 25% more likely to meet their minimum weekly exercise recommendation.[94] The likelihood of a resident visiting a

[91] Centers for Disease Control and Prevention. *Obesity Among Low-Income Preschool Children*. http://www.cdc.gov/obesity/data/childhood.html (accessed August 15, 2014).
[92] United States Census Bureau, *2010-2012 American Community Survey (ACS)*, accessed via *The American Fact Finder*, http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml (accessed August 15, 2014).
[93] National Gardening Association, *Home Gardening in the U.S.*, June 6, 2011, http://www.mnn.com/your-home/organic-farming-gardening/stories/infographic-home-gardening-in-the-us (accessed August 15, 2014).
[94] L. Frank et al. "Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ." *American Journal of Preventative Medicine* Vol. 28, Issue 2 (2005): 117-125.

park can also be impacted by real or perceived perceptions of crime.[95] As can be seen in the following map, there are gaps, also known as park deserts, in the distribution of programmed private and public open spaces within the City.[96] The map differentiates between access to programmed City Parks/Public Schools and access to Programmed Homeowner's Association (HOA) parks. While 91% of City households have access to City Park/School and/or HOA sites within 1/4 mile, a lesser number (76%) have access within 1/4 mile to City Park/School sites. Furthermore, while 15% of City households are within 1/4 mile of HOA parks, not all of these households live within these HOA communities and may not be permitted legally and/or may not feel comfortable accessing HOA parks intended for residents of the HOA. A parent may also choose to not visit a park if the walking distance is more than 1/4 mile as they may be pushing a child in a stroller or carrying a child part of the way there.

As can be seen on the map, meaningful open space and recreation areas are lacking adjacent to some of the areas with the highest percentages of low income residents along Frederick Avenue. This corridor has been mentioned previously as also containing a large amount of impervious surface and lower percentage of canopy coverage compared to other areas within the City. Lack of access to programmed park spaces and/or perceived or real perceptions of crime at park spaces discourage residents from utilizing exercise and relaxation opportunities.

The white areas on the map, comprising 9% of City households, indicate where households have to travel in excess of 1/4 mile to a school and/or HOA park,. Some of the same vulnerable low income populations identified in the food access analysis also have low access to parks. Older developments, such as those within the Frederick Avenue section and the area north of Clopper Road, were developed without pocket park amenities that newer developments include. There may be vacant parcels or surplus property which could potentially be redeveloped into parkland through a public/private partnership. Some of the areas shown in white on the map are non-residential and one is under development (Crown Farm) with planned HOA facilities and/or City parks. Another one of these white areas is bounded by a stream/tributary and/or major roadway which isolates the area further from accessing a park.

Bicycle/pedestrian access plays a role in the likelihood with which residents will choose to access certain sites even if they fall within the 1/4 mile radius. Major transportation corridors, such as I-270, Frederick Avenue, and the railroad, could be seen as barriers to access, due to real or perceived perceptions of difficulty and safety, as well as actual limited physical connections and crossings. The City can take steps to increase safety along roadways, however, regional and State partners would need to be involved in the conversations as the City does not control County and State roadways or the railroad.

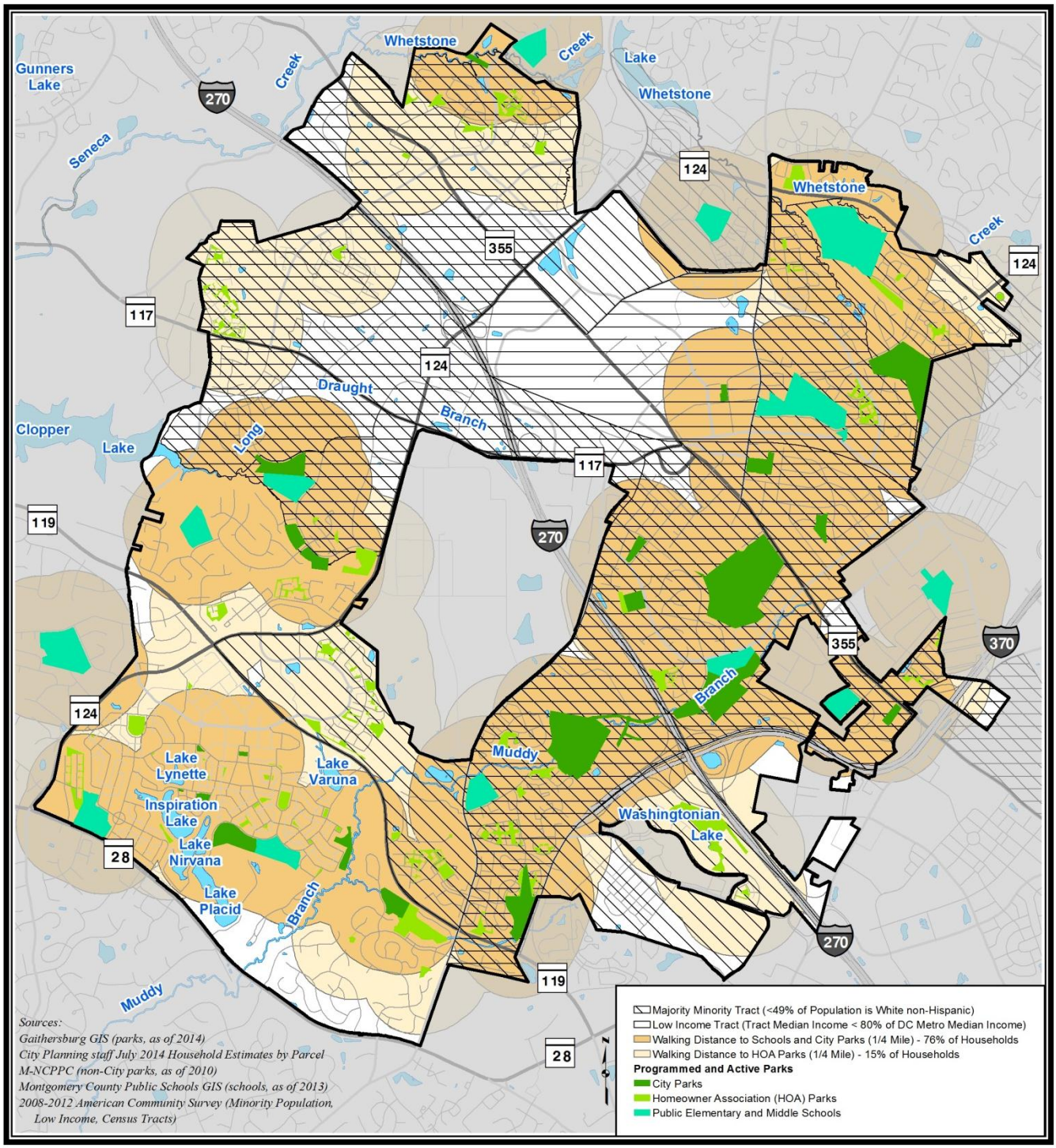
The City could address the dual issues of access to healthy food and to programmed open spaces by adding programming, such as community gardens, that include healthful activities and provide access to affordable and fresh local produce. When Lakeforest Mall and the Montgomery County Agricultural Center (Fairgrounds) are ultimately redeveloped, an opportunity to add programmed park space in an area of the City where it is lacking may come about. In areas where

[95] J. Schweitzer, J. Kim, and J. Mackin, "The Impact of the Built Environment on Crime and Fear of Crime in Urban Neighborhoods," *Journal of Urban Technology* 6, no. 3 (1999): 59-73.

[96] The map includes a ¼ mile radius from programmed open spaces. Elementary and Middle School properties are shown, but High Schools properties are not shown. Both private and public recreational spaces (City parks and HOA parks) are included in the map, but private gated parks and areas without recreational programming, such as passive parks and stream corridors, are not shown.

there is a perception of crime, the City could introduce group outdoor programming such as nature walks or group jogs and possibly create a park crime watch program and/or add security features to parks.

Map 23: Parks Proximity to Dwelling Units



7.10 Recommendations

A. Address local effects of climate change

- Research projected climate changes regionally for effects to local streams, hydrology, and risk to City infrastructure.
- Research what is entailed in creating a resilience plan (a plan to increase the resilience of the City by analyzing water and solid waste management, keeping businesses running after disasters, implementation of smart grid technology, transit viability after a set-back and increasing transportation options).
- Include provisions for responding to compounded weather events (a weather event combined with another disaster event, such as a power outage) in Emergency Management plans.
- Improve the ability of critical infrastructure to be habitable when the power or water is out or access to fuel is limited.

B. Mitigate impacts of urban heat island effects

- Research development of strategies to mitigate the negative effects of urban heat islands including cool/porous pavement, cool roofs (possibly with reflective materials or colors), green roofs/walls, and weatherization.
- Expand Rainscapes Rewards program to include tree planting and rain gardens.
- Impervious surfaces should be reduced to the extent possible by encouraging buildings with reduced building footprints, thereby enabling a greater portion of the site to be reserved for open space, treatment of stormwater runoff, and open amenity areas.
- Explore reductions in parking requirements or flexibility in height requirements to reduce impervious paving or building footprints.
- Establish 40% canopy coverage goals in new residential and residential/commercial development projects in addition to or as part of forest conservation requirements.
- Establish 30% canopy coverage goals in new commercial development/redevelopment projects in addition to or as part of forest conservation requirements.

C. Strive to improve local and regional air quality

- Continue to work with surrounding local governments to establish similar air quality programs to improve air quality standards.
- Explore incentives for installation of EPA-certified wood heaters or approved wood-burning appliances.
- Research grants to support hosting a gas-powered lawn equipment (mowers, blowers, chainsaws, etc.) buy-back and/or discounted purchase event.
- Evaluate the effectiveness of the existing anti-idling policy for City vehicles.

- Continue to serve as a good example by using hybrid and electric vehicles in the City fleet and explore the use of hybrid and electric technology for lawn equipment and other tools.

D. Encourage energy conservation

- Explore and evaluate membership in various programs to encourage energy conservation. (MEA Smart Energy Communities, EPA Green Power Community Partners).
- Explore opportunities for District heating and cooling/cogeneration, power purchase agreements, and microgrids.
- Promote weatherization, energy audits and conservation measures, including retrofits to community and City buildings and street lighting LED conversion.
- Encourage development that increases energy conservation through passive techniques that consider orientation, shading, increased insulation, and super tight construction.
- Promote natural shading by trees to reduce energy consumption in both residential and commercial settings.
- Partner with the County and other government entities to educate the public about energy efficiency campaigns.
- Enhance employee awareness of energy efficiency by offering training and periodic notifications on energy saving techniques in the workplace.
- Pursue development of an Energy Plan and a Greenhouse Gas Emissions Reduction Plan and consider the preparation of an annual report card on the City's progress towards Greenhouse gas emissions reduction.
- Track legislation and opportunities to offer residential or commercial Property Assessed Clean Energy (PACE) financing programs.
- Create a voluntary program to track energy disclosure data on private properties to encourage benchmarking of energy consumption and release energy consumption data for municipal facilities to demonstrate City progress towards energy reductions.
- Increase the amount of green power generation at City facilities to offset conventional energy usage and to support renewable energy.
- Continue to conduct public outreach efforts by engaging the community on issues such as greenhouse gas emission reductions, purchase of alternative fuel vehicles, green purchasing, and energy retrofits (appliance replacement, insulation/window upgrades, lighting replacement, green or water roofs/walls, etc.).
- Identify and promote techniques to conserve energy as a result of conserving water, i.e. energy is conserved when less hot water is used.
- Work with developers, State /County agencies, and utility companies to implement LED street light conversions.
- Continue to support cooperatively procuring green power with other Maryland jurisdictions.

- Promote state and utility energy programs such as EmPOWER Maryland, utility rebates, Home Performance with Energy Star, etc.

E. Promote the use of alternative and renewable energy sources

- Work with Homeowner's Associations to establish guidelines to better facilitate incorporation of solar and wind power to homes.
- Work with the Historic District Commission to create guidelines to review the addition of solar and wind energy to historic structures.
- Promote solar energy and cool roof opportunities for City and community buildings, especially as roof retrofit projects are undertaken.
- Encourage new homes to be Solar Ready.
- Research building codes and/or zoning restrictions to find ways to reduce barriers to implementation of small wind systems.
- Explore feasibility of retrofitting existing City buildings with ground source heating/cooling systems.
- Identify and address potential challenges to increased implementation of renewable energy alternatives.
- Continue to explore and diversify cutting-edge or new technologies and stay abreast of new, promising technologies with regards to alternative and renewable energy sources.
- Continue to support gas capture from landfills and sewage treatment plants.
- Continue to support the availability of Ethanol, Biodiesel, Compressed Natural Gas (CNG), and other alternative fuels.
- Continue to use Biodiesel for certain City vehicles and explore expanding its use.
- Continue to support the use of CNG in transit buses and encourage the use of CNG and Biodiesel in public school buses.

F. Promote and implement multi-modal transportation improvements

- Promote and support the use of alternative fuel vehicles, including EVs, in the City's fleet as appropriate. Explore and research the feasibility of a Green Fleet Policy.
- Explore and create public/private partnerships to advance the deployment of alternative refueling infrastructure, including EV charging stations, for City fleet and public (non-governmental) use.
- Participate in cooperative purchase programs or contract riders for alternative fuel vehicles and alternative refueling stations when possible.
- Encourage vehicle and bike-sharing programs within the City and region.
- Explore methods to increase non-automobile mode share.
- Offer smart bike programs to City employees and incorporate bike friendly infrastructure to City facilities.

- Support efforts to expand regional transit options such as Bus Rapid Transit or MARC expansion.
- Implement bicycle and pedestrian safety measures.
- Promote bicycle storage and commuter services (showers, etc.).
- Research and explore restrictions to electric vehicles and associated infrastructure within the City to determine if there are barriers which may be reduced.
- Encourage electric vehicle charging stations as part of new development.
- Continue to include bicycle and pedestrian facilities in development plans.

G. Encourage resource efficiency

- Create an Environmentally Preferred Purchasing (EPP) policy to guide City purchasing decisions.
- Explore green cooperative purchasing with other members of MWCOG and the State of Maryland.
- Promote increased participation in recycling by employees, residents, businesses, and at City events.
- Research zero waste, including possibilities for composting food waste locally.
- Promote car and bike sharing programs and other opportunities for reuse of materials.
- Review potential zoning barriers to sharing activities.
- Support entities in starting new sharing programs.
- Research the benefits and measure the demand for supporting a tool library for City residents to borrow tools such as power and garden tools as well as bicycle repair tools.

H. Continue to consider equity in the development of policies and programs

- Examine the Code to determine if there are zoning barriers to the creation of community gardens.
- Explore public/private partnerships for grants to neighborhoods to create community gardens.
- Create a community garden pilot program on City park property. The City should work with local non-profits to determine the level of interest in establishment of a community garden on undeveloped City-owned land.
- Evaluate starting a grant program to introduce community gardens at residential properties.
- Research the creation of a City orchard pilot program.
- Promote and encourage private investment for reduction of impervious surface areas for creation of community gardens on private property.Continue to consider open space through the site development plan review process.
- Promote and encourage home gardening.
- Partner with local organizations to host gardening, nutrition, canning, and food preservation classes.

- Seek to analyze equity in distribution of open space availability and explore opportunities to increase fair distribution of open space.
- Consider partnering with property owners with sites to be redeveloped that fall within areas identified as lacking sufficient access to programmed and active parks to provide more open space and recreational opportunities.
- Increase quality of existing public open space areas.
- Research methods to increase access to amenities and services for lower income and special needs residents.
- Analyze existing healthy food availability and distribution of unhealthy food.
- Research methods to increase the perception of safety in outdoor programmed open spaces.
- Consider developing a sustainability tracking tool to evaluate prosperity, quality of life and the value of natural and human capital.[97]
- Provide nature programming and brochures.
- Continue efforts with the HEAL Cities & Towns Campaign.

[97] The State of Maryland has a Genuine Progress Indicator (GPI) that can be downscaled to the municipal level and used to evaluate alternative policy and spending options: http://www.dnr.maryland.gov/mdgpi/

8. Environment and Sustainability Master Plan Implementation Strategies

The following matrix identifies mechanisms/strategies to implement the various recommendations included within the Element. The matrix illustrates that certain recommendations may be implemented through multiple independent means. Each identified method may by itself or in tandem with other identified methods accomplish the associated recommendation. The matrix does not weigh each strategy as to its effectiveness related to another strategy nor does it define a timetable for action; only broad means of action for success. The matrix identifies seven methods/strategies of implementation:

Policy Action: This method involves the establishment of policies or guidance by City officials, such as the City Council, Planning Commission, et al. that do not result in changes to the City Code or formalized regulations. Examples include the annual Strategic Plan and the Process & Overview Element to the Master Plan.

Code/Regulatory Action: This method includes instances when a City policy results in the establishment of regulatory, binding requirements that must be adhered to. Examples include the Forest Conservation Ordinance, City technical manuals, Traffic Impact Statement Regulation, and the City Public Reforestation Policy.

Capital Improvement Plan (CIP)/ Budget: This method involves dedicated funding of a specific project or program that will accomplish the associated recommendation. Examples include stream restoration projects, the purchase of software, and the hiring of technical consultants.

City Staff: While all methods involve City Staff, this method reflects an action solely accomplished by staff members. Examples include research and analysis efforts, grant writing, and site plan review.

Interagency Cooperation: This method involves cooperative City efforts, studies, and projects conducted or cost-shared with other Public Sector or quasi-Public Sector organizations or agencies such as Metropolitan Washington Council of Governments, Maryland Department of the Environment, and WSSC. Also included in this category are the utilities such as Pepco and Washington Gas.

Public-Private Partnerships: This method involves cooperative City efforts, studies, and projects conducted or cost-shared with Private Sector entities. These groups may include the business community, Homeowners' Associations, Non-Governmental Organizations, Non-Profit Organizations, and religious institutions.

Private Involvement and Action: This method reflects actions taken by individual City of Gaithersburg residents, the development community, Homeowners' Associations, Non-Governmental Organizations, Non-Profit Organizations, and religious institutions outside of City programs and projects. Examples include household recycling, donation of land to land trusts, and community volunteer activities.

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Urban Forest Recommendations							
Preserve and expand the City's tree canopy.							
Achieve the State's 40% canopy coverage goal by 2025.	●						
Adopt a no-net-loss of canopy policy.	●						
Establish 40% canopy coverage goals in new residential and residential/commercial development projects in addition to or as part of forest conservation requirements.	●	●					
Establish 30% canopy coverage goals in new commercial development/redevelopment projects in addition to or as part of forest conservation requirements.	●	●					
Conduct a canopy coverage assessment on a five year cycle.			●	●			
Use canopy coverage analysis to identify and target areas for increased plantings focusing on non-residential and right of way areas.				●			
Review and amend the City's Tree Manual including tree canopy standards.		●		●			
Maintain a healthy diverse urban forest.							
Review "right tree, right place" practices in all planting projects.				●			●
Achieve and maintain a species diversity in new afforestation or reforestation projects where no single genus comprises more than 20% and no single species comprises more than 10% of the total population.	●	●	●				●
Encourage Comprehensive Landscape plans involving tree planting to include 20% conifers.		●					●
Conduct inventory and review of the condition of forest conservation easements within the City, establish a five year cycle for continued reviews.			●	●			
Conduct and maintain a street tree inventory including City, County, and State owned roads for species diversity and condition. Use the inventory to identify planting/replanting opportunities and increase species/genus diversity. Establish a species planting plan for new or replacement trees.				●	●		

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Improve stream corridors and other natural areas by incorporating expanded stream valley buffers (SVB) as part of any watershed management plan project.			●	●	●	●	●
Work with private landowners to establish easements protecting SVB.				●		●	●
Explore reforestation areas on private properties.				●			●
Increase and fund disease and pest training for the City's urban forestry staff.			●	●			
Look to reduce the use of herbicides in the control of "weeds" to include practices such as native species and wildflower plantings in open spaces.	●			●			●
Preserve urban forest habitats.							
Review the program for addressing invasive and exotic species on City and private properties.				●			●
Explore opportunities for regional collaboration with other agencies related to targeting and reducing invasive populations such as the Emerald Ash Borer.				●	●		●
Encourage bird boxes and native plantings of shrubs and groundcover to support populations of migratory and local birds.				●			●
Include regional coordination in planning to ensure preservation of habitat corridors to maintain and encourage biodiversity.				●	●	●	●
Consider the urban forest in all planning projects.							
Work with utilities, developers, State and County agencies to seek to underground overhead wires avoiding conflicts with trees and providing increased opportunities to plant large shade trees with an emphasis on major corridors.			●	●	●	●	
Identify sites that will permit the expansion of tree planting strips and tree wells to provide more suitable growing conditions for street trees.				●			
Establish replanting or fee-in-lieu standards for the removal of vegetation as part of requested environmental waivers not included as part of a forest conservation plan.	●	●					
Incorporate urban forest planting and goals in future Parks and Open Space Master Plans.	●			●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Evaluate policies to develop and adopt alternative street profiles and sections that provide larger tree planting areas, more open space, increased permeable surface area, and new opportunities for stormwater management.	●	●		●			
Continue to improve coordination and communication between City departments, regional agencies, policy makers, and the community to improve the urban forest.							
Develop guidelines for, and publically and/or privately fund, a City grant program for property owners to subsidize all or a portion of the cost of planting trees on private property. Grants should be made available to qualified homeowners, civic organizations, religious institutions, and other not-for-profit organizations.	●		●			●	●
Work with the City Public Information Office (PIO) to increase public awareness regarding the benefit of trees by utilizing the City's website, printed literature, and other digital outlets.				●			●
Engage residents by creating opportunities to become program volunteers to assist in completing tasks that are currently not funded or are inadequately funded for completion by City staff, such as conducting tree inventories.				●		●	●
Promote the urban forest through urban agriculture where possible such as community orchards.				●		●	●
Expand GIS use as a tool in the City's forestry program.				●			
Dedicate long-term funding streams to meet canopy and management goals.	●		●				
Explore non-traditional and technology driven funding techniques.				●		●	
Fund the purchase of new technology or applications such as the U.S. Forest Service iTree software to assist in the ongoing study and analysis of the City's urban forest.			●				
Explore grants from County, State, and Federal sources to extend tree planting and infrastructure improvements and encourage fundraising by interested residents or not-for-profit groups to supplement City funds.				●	●	●	
Establish proper tree maintenance protocols to provide to and educate both private residential and commercial property owners.		●		●		●	●

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Watershed & Stormwater Management Recommendations							
Sustain or engage in Watershed Planning on a scale allowing for a holistic approach to local water resource protection.							
Conduct watershed studies designed to look at the entire watershed by linking upland sources with stream impacts. Continue on a ten-year study cycle to assess the effectiveness of capital projects and examine long-term trends in the City's water quality.			●	●			
Use the watershed studies to evaluate stormwater program initiatives such as targeted outreach and enforcement. Modify these programs if needed. Use the results to identify future high-priority Capital Improvement Program (CIP) projects.			●	●			
Implement the stormwater management and stream restoration projects recommended by each of the watershed plans. Develop a list of all potential projects, including those for which concept plans were not drafted. Pursue grant funding to complete the recommended retrofits.			●				
Incorporate stormwater management installation as a condition of new annexation agreements when new properties are brought into the City through annexations.	●						
Maintain a robust Capital Improvement Program (CIP) in support of the City's stormwater infrastructure network.							
Use the watershed study process to identify potential stream restoration candidates and stormwater management facility retrofits, both regional and site-specific. Work with engineering and environmental staff, design consultants, and the community to identify which projects are most feasible and prioritize projects accordingly.			●				●
Create a master list of CIP projects and an accompanying timeline for implementation.	●			●			●
Implement retrofits to existing stormwater management facilities, where appropriate, to bring them into compliance with current stormwater regulations and provide credit towards the City's Total Maximum Daily Load (TMDL) requirements.			●				

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Continue to implement new watershed retrofits according to the City's priorities and as opportunities arise.	●		●				
Maximize stormwater benefits as new City projects are developed to achieve the greatest possible nutrient reduction and/or treatment acreage credits.	●		●	●			
Continue to implement a capital project repair and replacement program schedule for failing stormwater management infrastructure. Complete a systematic study of the current condition of storm drain infrastructure as a first step to ensuring long-term capacity.			●	●			
Explore the use of capacity studies to identify and prioritize large-scale storm conveyance projects for both infrastructure maintenance and to ensure adequate flow volume capacity.			●	●			
Develop a plan to complete a full inventory of pipes and a replacement schedule for corrugated metal pipes (CMP) and/or terra cotta storm sewer pipes throughout the City, which are nearing the end of and/or have exhausted their useful life.			●	●			
Set aside funds each year for future maintenance and replacement costs associated with all Best Management Practice (BMP) facilities.	●		●				
Develop a comprehensive green streets policy and explore options for stormwater treatment during implementation of other capital projects. Implement green street projects during development or road reconstruction where possible to treat water quality, and obtain National Pollutant Discharge Elimination System (NPDES) credits.	●	●	●				
Continue to develop design, construction, and maintenance standards for City stormwater management facilities, with a focus on environmental site design (ESD).		●		●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Acquire property or easements for streams as stream restoration capital projects are implemented, for the purpose of gaining access for restoration projects.			●			●	●
Install pervious pavement for walkways and other traditionally impervious surfaces in new City projects, where feasible.	●		●				
Research the use of a stream monitoring station network to track existing water quality conditions and post-restoration conditions.			●	●	●		
Develop and implement a City stormwater infrastructure inspection and maintenance program.							
Evaluate current enforcement programs to ensure they have the regulatory foundation, funding, staff, implementation tools/process, and management support to be effective. Develop and implement improvements identified during the evaluation.		●		●			
Review the City's preventative maintenance program and ensure it is effective at identifying, prioritizing, and tracking cleaning and repair actions for storm drain infrastructure and treatment facilities.				●			
Use an adaptive management methodology to improve the existing preventative maintenance program. Elements of this program could include: inspection equipment and tools; inspection data management and analysis; action prioritization; cleaning and repair methods; performance tracking; performance measures identification; evaluation; and program modification if needed.		●	●	●			
Explore the option of third-party certified BMP inspections for private facilities to minimize the City's liability risks and require facility owners to take responsibility for their own inspections.		●		●			●

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Create maintenance fact sheets for owners of stormwater management facilities. Help owners understand the function of their facilities, and how best to maintain them in order to minimize costly major retrofits.				●			●
Transition to a digital notification and inspection program with the ability to email inspection notifications, with eventual expansion to online reporting and information sharing.			●	●			
Remain flexible about the inspection and maintenance program's structure in order to incorporate new best practices and improve program efficiency.				●			
Provide for enhanced stormwater data and asset management.							
Purchase software for improved stormwater asset management, assessment, inspection tracking, and maintenance.			●	●			
Redesign the City's stormwater geodatabase to reflect the anticipated reporting requirements under the Maryland Department of the Environmant's (MDE) new reporting geodatabase tool.				●			
Develop new data layers to track the list of anticipated stream restoration sites, stormwater retrofit projects, and potential stormwater restoration opportunities.				●			
Continue to update the City's existing inventory of all public and privately owned stormwater assets, including streams, stormwater management facilities, and storm conveyance infrastructure, and update Geographic Information System (GIS) attribute tables.				●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Reassess the amount of impervious surface using aerial photography on a regular basis (every few years). This data will allow staff to better gauge the future growth of impervious surface in Gaithersburg and help inform stormwater utility fee billing levels. Incorporate building plan information to allow for more frequent small-scale updates to impervious data, as new projects are implemented.			●	●	●		
Track stormwater related enforcement actions and drainage complaints by frequency and location (using GIS), to better determine hotspots and help target responses.				●	●		●
Ensure databases are in place and maintained to track new Municipal Separate Storm Sewer System (MS4) and TMDL requirements, particularly for crediting retrofits, stream restorations, and other practices that will affect achieving the permit's anticipated restoration requirement.				●			
Complete a comprehensive analysis of the condition of the City's MS4 infrastructure and impervious cover, including quality of and connections between infrastructures. Complete updated analyses periodically to track changes and improvements to the system.			●	●			
Prioritize the creation and maintenance of BMPs and their associated drainage areas in GIS. These updates could be based on new facilities, retrofits, correcting erroneous data, and added maintenance data. This information is necessary for the evaluation of adequately treated areas and the areas that do not have stormwater management.				●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Track the location and timing of street sweeping and catch basin cleanouts for easy calculation of permit credits for pollutant reduction for this practice.				●			
Explore software options to track nonstructural stormwater program elements. Examples of nonstructural data that should be tracked include education and outreach techniques.			●	●			
Ensure stormwater management practices are integrated early and to the fullest extent within the planning process.							
Develop mitigation requirements for use during the planning process that address development impacts to stream valley buffers and other sensitive areas.	●	●					
Accommodate growth through concentrated redevelopment and infill to provide the opportunity for improved water quality, especially in areas built before stormwater management was required.	●	●					●
Acquire easements or land adjacent to streams and other water resources as opportunities arise. Apply conservation easements to sensitive areas, where possible, to protect the City's source waters.	●					●	●
Integrate the planning, engineering, and maintenance aspects of stormwater to ensure smooth and comprehensive project design and review.				●			
Practice good housekeeping and best management practices for internal operations to minimize water pollution resulting from City facilities and operations.							
Explore the use of alternative treatments for road and sidewalk de-icing during the winter months.	●		●	●			
Use native plants to reduce the need for irrigation, watering, and fertilizer.	●			●			●

Reduce fertilizer and pesticide use in City operations by creating and implementing a formalized lawn chemical usage reduction plan, which incorporates the City's existing integrated pest management (IPM) policy.	●			●			
Implement the revised Public Works Stormwater Pollution Prevention Plan (SWPPP) once it is approved by the Maryland Department of the Environment, to maintain minimal stormwater pollution from the Public Works maintenance yard.				●			
Continue using hybrid and electric vehicles to reduce oil, fluid, and air emissions into streams, and explore opportunities to expand the use of hybrid and electric technology for lawn equipment and other motorized tools.	●		●	●			
Review the effectiveness of street sweeping and catch basin cleaning programs and target program implementation to maximize efficiency and effectiveness.				●			
Provide sustained stormwater management community outreach and education.							
Develop newsletters and other resources for BMP owners, including seasonal tips for maintenance (particularly for ESD techniques).				●	●	●	
Facilitate partnerships with local watershed groups to help with outreach and implementation of MS4 permit requirements.				●	●	●	
Publicize stormwater facilities in residential or other pedestrian-friendly areas using signage to educate the public about stormwater management and local treatment facilities.				●		●	●
Continue to provide incentive programs like the Rainscapes Rewards program to encourage private property owners to manage stormwater runoff more effectively.	●		●			●	●
Continue to reevaluate and expand the Rainscapes Rewards program to include new participants and techniques to meet the needs of residents and achieve City goals.	●		●	●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Publicize the work the City is doing in stormwater using annual fact sheets, poster presentations at public events, and annual progress reports explaining how funds were used to administer the program.				●			
Explore the option to create an "Adopt-A-Facility" program to engage local watershed groups and other trained volunteers in the monitoring and maintenance of small-scale stormwater facilities.				●		●	●
Develop welcome letters and maintenance information to send to new owners of stormwater facilities that exist on newly-purchased parcels.				●			
Create a trash hotspot resident reporting program to help City staff identify problem areas and focus cleanup efforts in those areas.				●			●
Continue to support rigorous volunteer water quality monitoring programs.				●	●	●	●
Continue outreach activities across all forms of media to inform and educate a broad spectrum of City constituents about the City's environment and the important role constituents can play in protecting our water resources.				●			●
Continue programs that effectively use volunteers and other non-City resources.				●	●	●	●
Explore public-private partnerships as a way to achieve TMDL and MS4 goals by implementing new stormwater controls in cooperation with local businesses and other private groups.						●	
Create various outreach programs for Gaithersburg residents and businesses to address stormwater pollution. Such programs could include best practices for automobile repair, lawn and garden care, and pet waste removal.	●		●				

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Work with DNR and local watershed groups through the Streamwaders volunteer stream monitoring program to continue gathering water quality data for City watersheds.					●	●	●
Create a landscape stewardship outreach program to encourage responsible use of fertilizers by homeowners and City businesses.	●						●
Utilize social media and other outreach methods to enlist volunteers for implementing, maintaining, and monitoring stormwater projects throughout the City.				●		●	●
Develop public programs and policies in response to evolving State and Federal regulations.							
Participate in the public involvement process to influence development of Chesapeake Bay total maximum daily loads (TMDLs) issued by the U.S. Environmental Protection Agencey (EPA), new Federal and State stormwater regulations, and the reissuance of NPDES general permits for Phase II MS4 communities.				●	●		
Consistently reevaluate and expand the Rainscapes Rewards program to include additional incentives for eligible property owners to implement stormwater management. Possible expansions may include practices such as rain gardens, bioretention, permeable or grass pavers, green roofs, tree planting, floating wetlands, and dry wells.		●	●	●			
Explore the possibility of an online Rainscapes Rewards application process as the program expands.				●			
Work with Montgomery County to adapt its existing materials to Gaithersburg's program, and create outreach materials for any additional practices for rebate.				●	●		
Continue supporting the Montgomery County bag fee, which has reduced the amount of plastic and paper bags in the City's watersheds and stormwater system.	●						

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Engage in and promote regional coordination to share knowledge and reduce costs associated with watershed restoration.							
Continue to actively participate in the Alice Ferguson Foundation's Trash Free Potomac Initiative. Trash reduction is a key element of the City's MS4 permit, and participation in this regional cooperative program aids in public education and sharing of best practices.				●	●	●	
Continue to work with the City of Rockville, Montgomery County, and the State Highway Administration to achieve water quality goals within shared watersheds. Explore partnerships for the implementation of stormwater management along County and State roads, as transportation is a major land use in the City and increased transportation land use is expected in future development.					●		
Continue to work with groups such as the Izaak Walton League, Muddy Branch Alliance, and Seneca Creek Watershed Partners to obtain grants for community outreach projects.						●	●
Participate in regional watershed planning efforts through the Metropolitan Washington Council of Governments (MWCOG) and the State Watershed Implementation Plan (WIP) process. Share watershed assessment results with County, State, and local agencies to enhance cooperative restoration efforts.	●			●	●		
Explore cost-sharing opportunities and the potential to ride on existing agency contracts as a means to meet stormwater requirements in a cost-effective manner.			●	●	●		
Identify and reduce flooding risks to areas prone to regular flooding.							

Continue to support the Federal initiative to update floodplain maps as new information becomes available to reflect the best available information about potential flood risks, and keep the City's GIS data current.				●	●		
Explore the potential to complete a storm sewer capacity analysis for all of the watersheds in Gaithersburg's system, using appropriate hydraulic and hydrologic modeling tools to evaluate areas with greater flood risk.			●	●			
Implement stormwater management projects in flood-prone areas as a means of diverting flow or reducing flood levels.			●				
Continue to investigate potential flood control projects and small-area drainage issues to reduce the risk of flooding, including acquisition of affected property as necessary.			●	●	●	●	
	Policy Action	**Code/Regulatory Action**	**Capital Improvement Plan (CIP)/Budget**	**City Staff**	**Interagency Cooperation**	**Public-Private Partnerships**	**Private Involvement and Action**
Continue to allocate dedicated and sustainable funding sources to guarantee the stormwater program's continued viability.							
Provide the funds necessary to meet MS4 permit and Bay TMDL requirements and to address other important stormwater infrastructure needs, such as ensuring adequate capacity for flood control, replacing aging infrastructure, and performing preventive maintenance on all City stormwater management facilities.	●		●				
Reassess the Stormwater Program Management Fee (SPMF) rates on a regular basis to ensure that the income generated adequately covers program needs without placing an impractical burden on rate payers.	●	●		●			
Develop an informational manual to explain the methodology behind the SPMF rate calculation and provide credit opportunities to rate payers. A robust credit program may help incentivize rate payers to implement stormwater projects that will help the City meet its water quality goals.	●	●		●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Environmental Planning, Health, & Sustainability Recommendations							
Address local effects of climate change.							
Research projected climate changes regionally for effects to local streams, hydrology, and risk to City infrastructure.				●	●		
Research what is entailed in creating a resilience plan (a plan to increase the resilience of the City by analyzing water and solid waste management, keeping businesses running after disasters, implementation of smart grid technology, transit viability after a set-back and increasing transportation options).				●			
Include provisions for responding to compounded weather events (a weather event combined with another disaster event, such as a power outage) in Emergency Management plans.		●		●			
Improve the ability of critical infrastructure to be habitable when the power or water is out or access to fuel is limited.	●		●		●		
Mitigate impacts of urban heat island effects.							
Research development of strategies to mitigate the negative effects of urban heat islands including cool/porous pavement, cool roofs (possibly with reflective materials or colors), green roofs/walls, and weatherization.				●			
Expand Rainscapes Rewards program to include tree planting and rain gardens.	●	●	●				
Impervious surfaces should be reduced to the extent possible by encouraging buildings with reduced building footprints, thereby enabling a greater portion of the site to be reserved for open space, treatment of stormwater runoff, and open amenity areas.	●	●		●			
Explore reductions in parking requirements or flexibility in height requirements to reduce impervious paving or building footprints.				●			
Establish 40% canopy coverage goals in new residential and residential/commercial development projects in addition to or as part of forest conservation requirements.	●	●					

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Establish 30% canopy coverage goals in new commercial development/redevelopment projects in addition to or as part of forest conservation requirements.	●	●					
Strive to improve local and regional air quality.							
Continue to work with surrounding local governments to establish similar air quality programs to improve air quality standards.	●	●			●		
Explore incentives for installation of EPA-certified wood heaters or approved wood-burning appliances.				●	●		●
Research grants to support hosting a gas-powered lawn equipment (mowers, blowers, chainsaws, etc.) buy-back and/or discounted purchase event.				●			●
Evaluate the effectiveness of the existing anti-idling policy for City vehicles.	●			●			
Continue to serve as a good example by using hybrid and electric vehicles in the City fleet and explore the use of hybrid and electric technology for lawn equipment and other tools.	●		●	●			
Encourage energy conservation.							
Explore and evaluate membership in various programs to encourage energy conservation. (MEA Smart Energy Communities, EPA Green Power Community Partners).				●			
Explore opportunities for District heating and cooling/cogeneration, power purchase agreements, and microgrids.				●	●	●	
Promote weatherization, energy audits and conservation measures, including retrofits to community and City buildings and street lighting LED conversion.	●		●				●

Encourage development that increases energy conservation through passive techniques that consider orientation, shading, increased insulation, and super tight construction.	●	●		●			●
Promote natural shading by trees to reduce energy consumption in both residential and commercial settings.	●			●			●
Partner with the County and other government entities to educate the public about energy efficiency campaigns.					●		
	Policy Action	**Code/Regulatory Action**	**Capital Improvement Plan (CIP)/Budget**	**City Staff**	**Interagency Cooperation**	**Public-Private Partnerships**	**Private Involvement and Action**
Enhance employee awareness of energy efficiency by offering training and periodic notifications on energy saving techniques in the workplace.				●		●	●
Pursue development of an Energy Plan and a Greenhouse Gas Emissions Reduction Plan and consider the preparation of an annual report card on the City's progress towards Greenhouse gas emissions reduction.	●	●		●			
Track legislation and opportunities to offer residential or commercial Property Assessed Clean Energy (PACE) financing programs.				●			
Create a voluntary program to track energy disclosure data on private properties to encourage benchmarking of energy consumption and release energy consumption data for municipal facilities to demonstrate City progress towards energy reductions.	●			●			
Increase the amount of green power generation at City facilities to offset conventional energy usage and to support renewable energy.	●		●	●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Continue to conduct public outreach efforts by engaging the community on issues such as greenhouse gas emission reductions, purchase of alternative fuel vehicles, green purchasing, and energy retrofits (appliance replacement, insulation/window upgrades, lighting replacement, green or water roofs/walls, etc.).				●		●	
Identify and promote techniques to conserve energy as a result of conserving water, i.e. energy is conserved when less hot water is used.				●			●
Work with developers, State /County agencies, and utility companies to implement LED street light conversions.	●		●		●	●	
Continue to support cooperatively procuring green power with other Maryland jurisdictions.	●		●		●		
Promote state and utility energy programs such as EmPOWER Maryland, utility rebates, Home Performance with Energy Star, etc.	●			●	●		●
Promote the use of alternative and renewable energy sources.							
Work with Homeowner's Associations to establish guidelines to better facilitate incorporation of solar and wind power to homes.				●	●	●	●
Work with the Historic District Commission to create guidelines to review the addition of solar and wind energy to historic structures.	●	●		●			
Promote solar energy and cool roof opportunities for City and community buildings, especially as roof retrofit projects are undertaken.	●		●	●		●	●
Encourage new homes to be Solar Ready.				●			●

Research building codes and/or zoning restrictions to find ways to reduce barriers to implementation of small wind systems.				●			
Explore feasibility of retrofitting existing City buildings with ground source heating/cooling systems.				●			
Identify and address potential challenges to increased implementation of renewable energy alternatives.		●		●			
Continue to explore and diversify cutting-edge or new technologies and stay abreast of new, promising technologies with regards to alternative and renewable energy sources.				●			
Continue to support gas capture from landfills and sewage treatment plants.	●						
Continue to support the availability of Ethanol, Biodiesel, Compressed Natural Gas (CNG), and other alternative fuels.	●		●				●
Continue to use Biodiesel for certain City vehicles and explore expanding its use.	●		●	●	●		
Continue to support the use of CNG in transit buses and encourage the use of CNG and Biodiesel in public school buses.	●			●	●		
Promote and implement multi-modal transportation improvements.							
Promote and support the use of alternative fuel vehicles, including EVs, in the City's fleet as appropriate. Explore and research the feasibility of a Green Fleet Policy.	●		●				
	Policy Action	**Code/Regulatory Action**	**Capital Improvement Plan (CIP)/Budget**	**City Staff**	**Interagency Cooperation**	**Public-Private Partnerships**	**Private Involvement and Action**
Explore and create public/private partnerships to advance the deployment of alternative refueling infrastructure, including PEV charging stations, for City fleet and public (non-governmental) use.	●		●	●	●	●	
Participate in cooperative purchase programs or contract riders for alternative fuel vehicles and alternative refueling stations when possible.	●		●		●		
Encourage vehicle and bike-sharing programs within the City and region.				●	●	●	●
Explore methods to increase non-automobile mode share.				●			
Offer smart bike programs to City employees and incorporate bike friendly infrastructure to City facilities.	●		●				

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Support efforts to expand regional transit options such as Bus Rapid Transit or MARC expansion.	●			●	●	●	
Implement bicycle and pedestrian safety measures.	●		●				
Promote bicycle storage and commuter services (showers, etc.).	●	●		●			●
Research and explore restrictions to electric vehicles and associated infrastructure within the City to determine if there are barriers which may be reduced.				●			
Encourage electric vehicle charging stations as part of new development.	●			●			●
Continue to include bicycle and pedestrian facilities in development plans.	●	●		●			
Encourage resource efficiency.							
Create an Environmentally Preferred Purchasing (EPP) policy to guide City purchasing decisions.	●	●			●		
Explore green cooperative purchasing with other members of MWCOG and the State of Maryland.				●	●		
Promote increased participation in recycling by employees, residents, businesses, and at City events.				●			●
Research zero waste, including possibilities for composting food waste locally.				●			
Promote car and bike sharing programs and other opportunities for reuse of materials.	●			●		●	●
Review potential zoning barriers to sharing activities.				●			
Support entities in starting new sharing programs.	●		●			●	
Research the benefits and measure the demand for supporting a tool library for City residents to borrow tools such as power and garden tools as well as bicycle repair tools.				●			●

Continue to consider equity in the development of policies and programs.							
Examine the Code to determine if there are zoning barriers to the creation of community gardens.				●			
Explore public/private partnerships for grants to neighborhoods to create community gardens.	●					●	
Create a community garden pilot program on City park property. The City should work with local non-profits to determine the level of interest in establishment of a community garden on undeveloped City-owned land.	●		●		●	●	●
Evaluate starting a grant program to introduce community gardens at residential properties.				●			
Research the creation of a City orchard pilot program.				●			
Promote and encourage private investment for reduction of impervious surface areas for creation of community gardens on private property.Continue to consider open space through the site development plan review process.				●		●	●
Promote and encourage home gardening.				●			●
Partner with local organizations to host gardening, nutrition, canning, and food preservation classes.					●	●	●
Seek to analyze equity in distribution of open space availability and explore opportunities to increase fair distribution of open space.				●			
Consider partnering with property owners with sites to be redeveloped that fall within areas identified as lacking sufficient access to programmed and active parks to provide more open space and recreational opportunities.			●		●	●	
Increase quality of existing public open space areas.	●		●				
Consider methods to increase access to amenities and services for lower income and special needs residents.				●			
Analyze existing healthy food availability and distribution of unhealthy food.				●			

	Policy Action	Code/Regulatory Action	Capital Improvement Plan (CIP)/Budget	City Staff	Interagency Cooperation	Public-Private Partnerships	Private Involvement and Action
Research methods to increase the perception of safety in outdoor programmed open spaces.				●			
Consider developing a sustainability tracking tool to evaluate prosperity, quality of life and the value of natural and human capital.	●			●			
Provide nature programming and brochures.			●	●			●
Continue efforts with the HEAL Cities & Towns Campaign.	●			●	●		●

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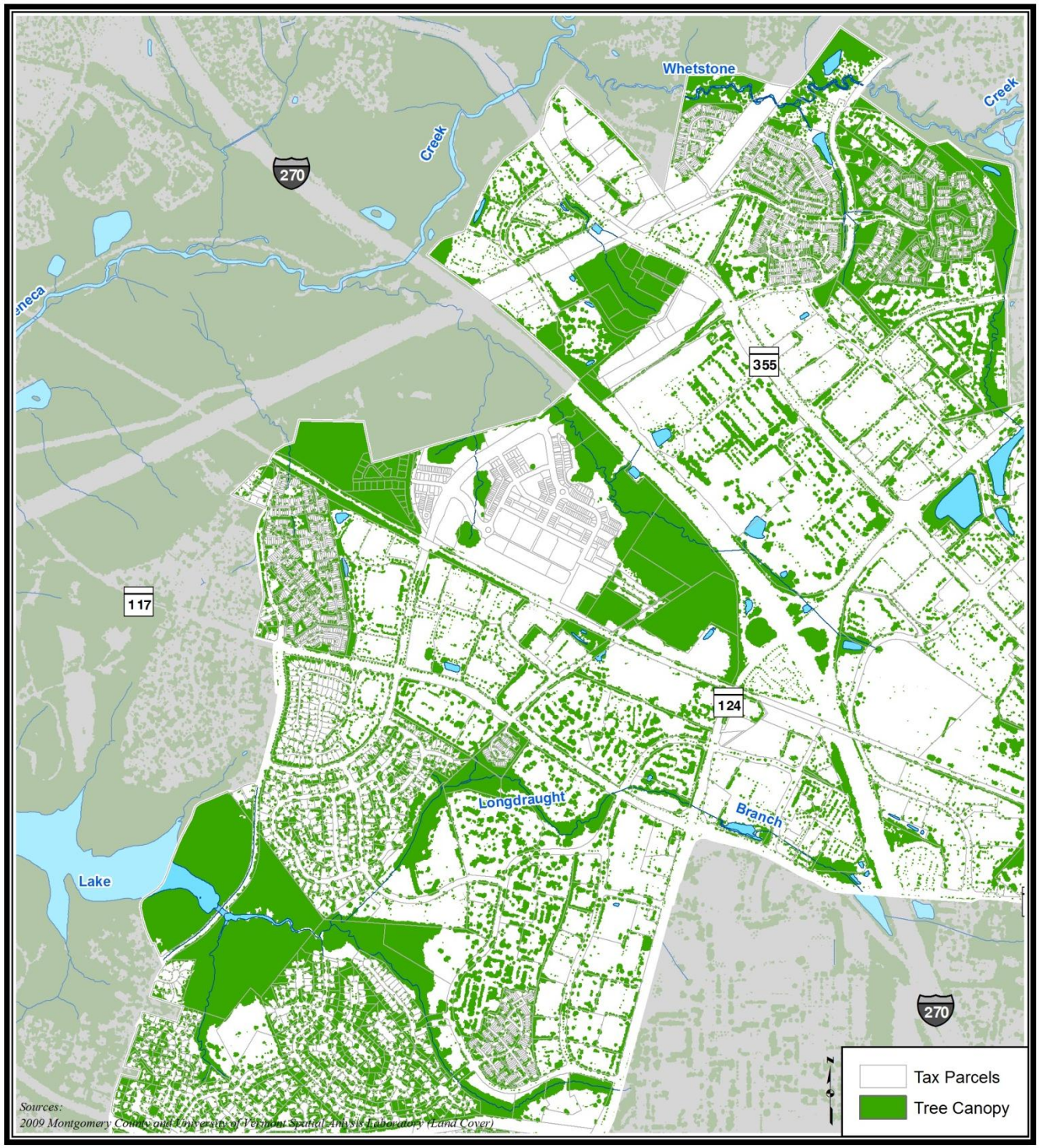
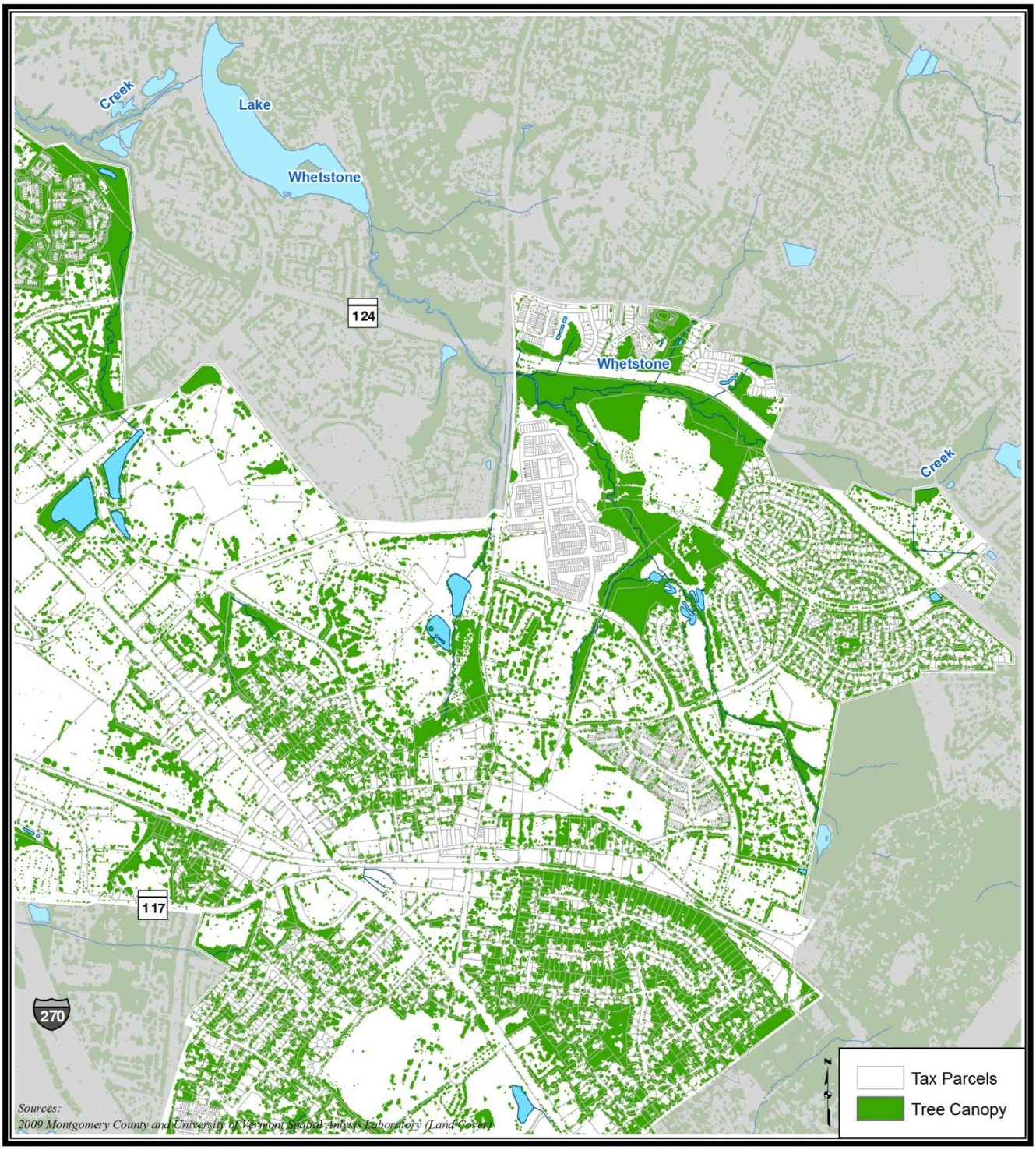
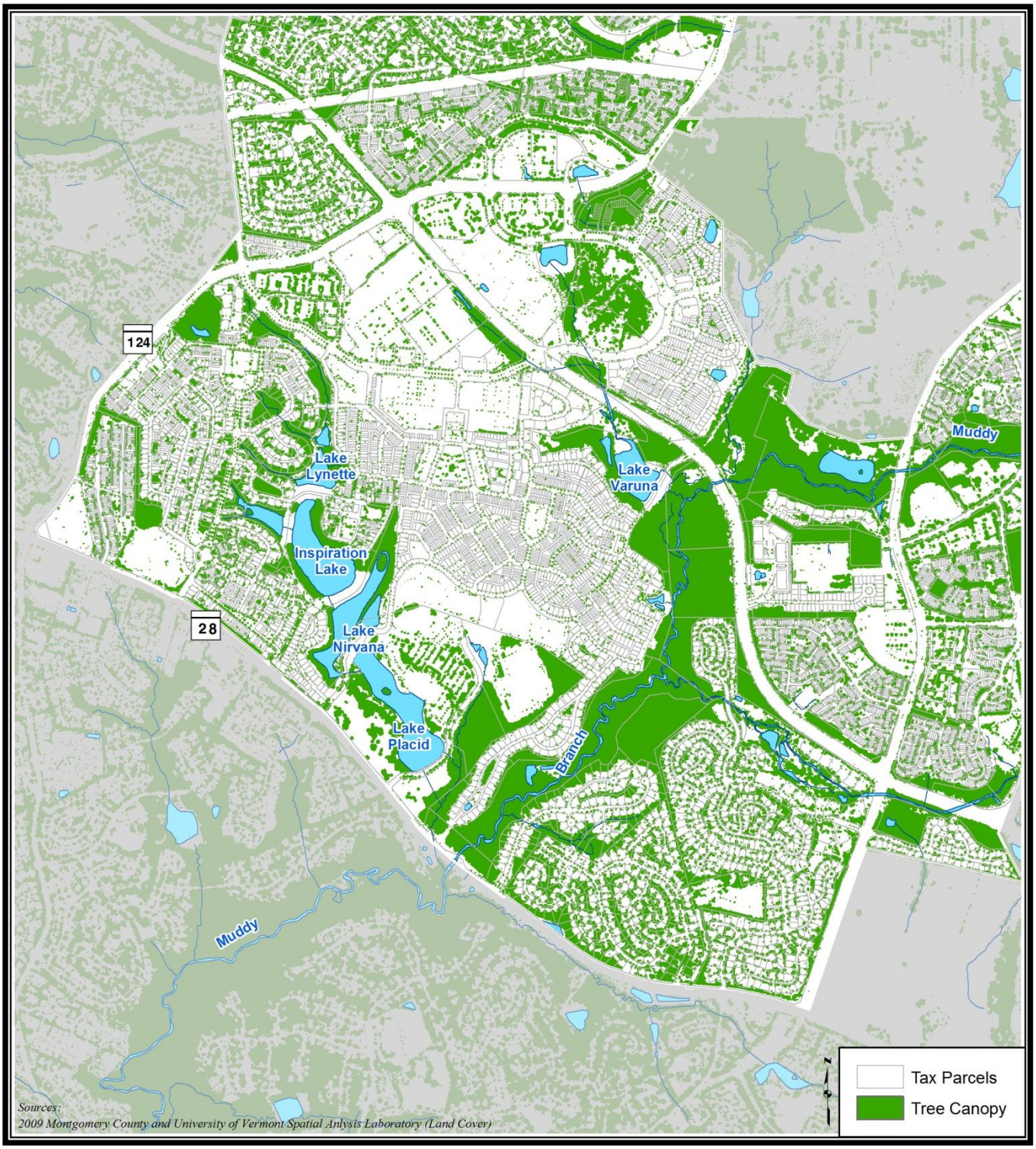
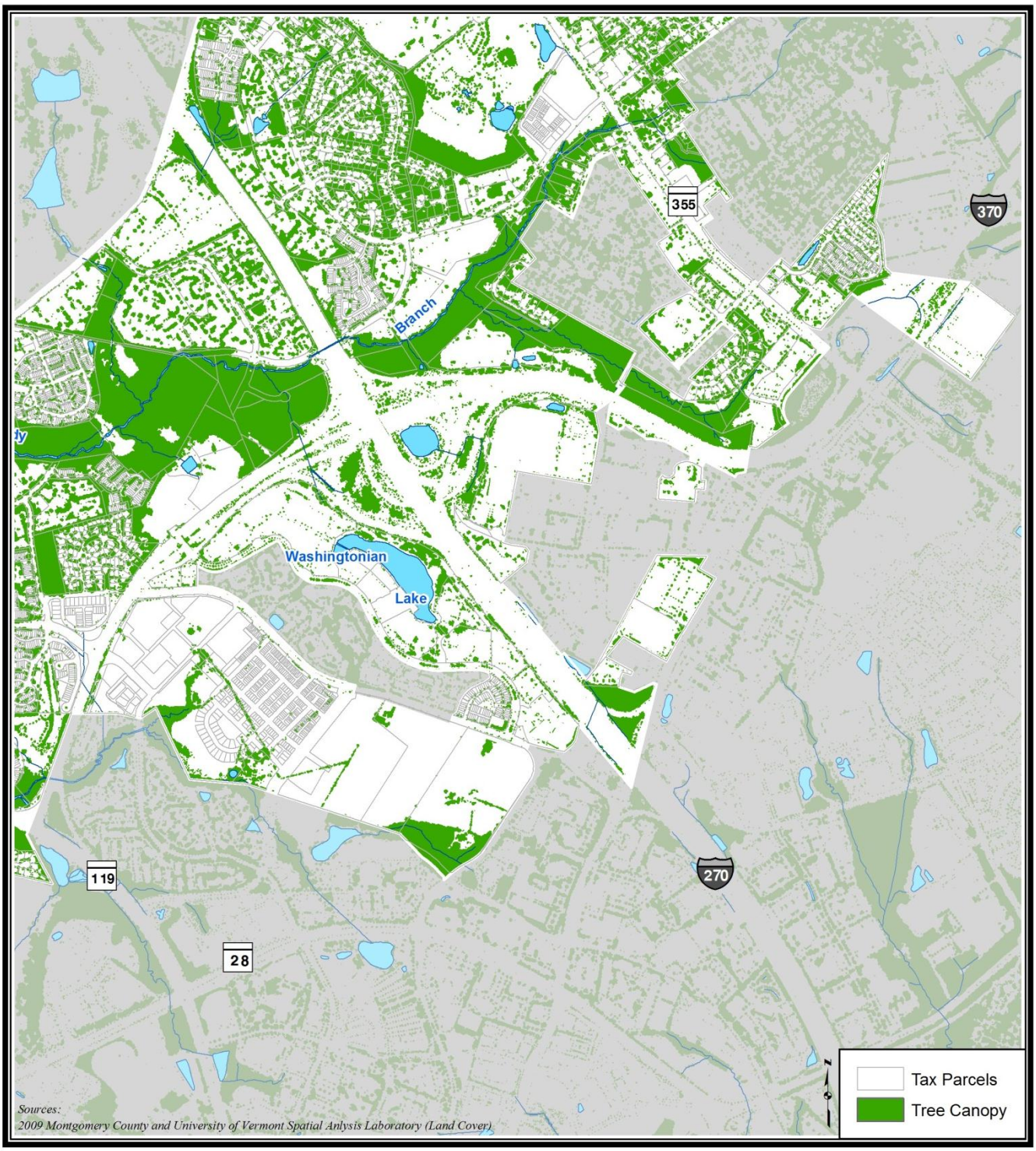
9. Appendix A: Detailed Urban Tree Canopy Maps

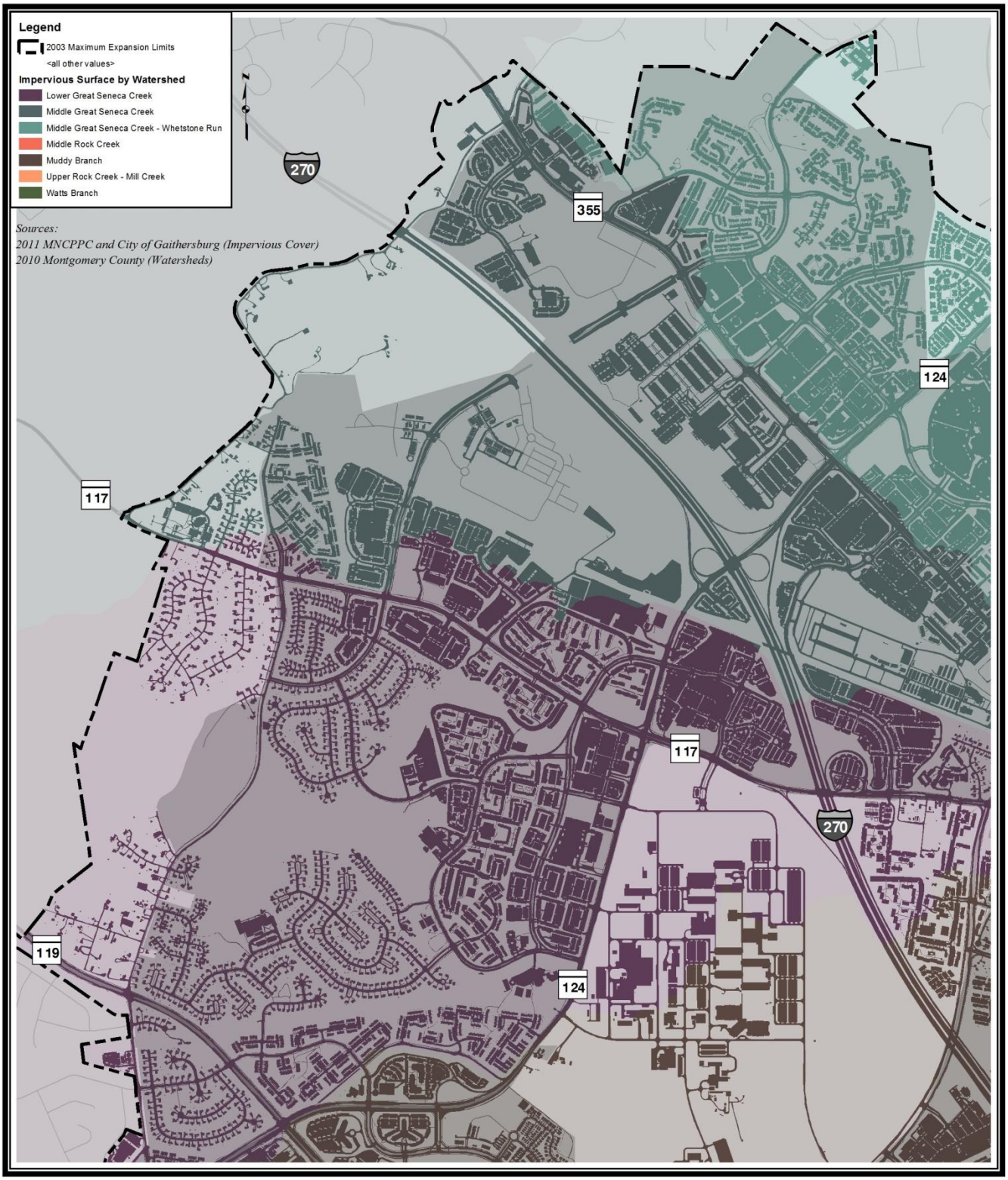


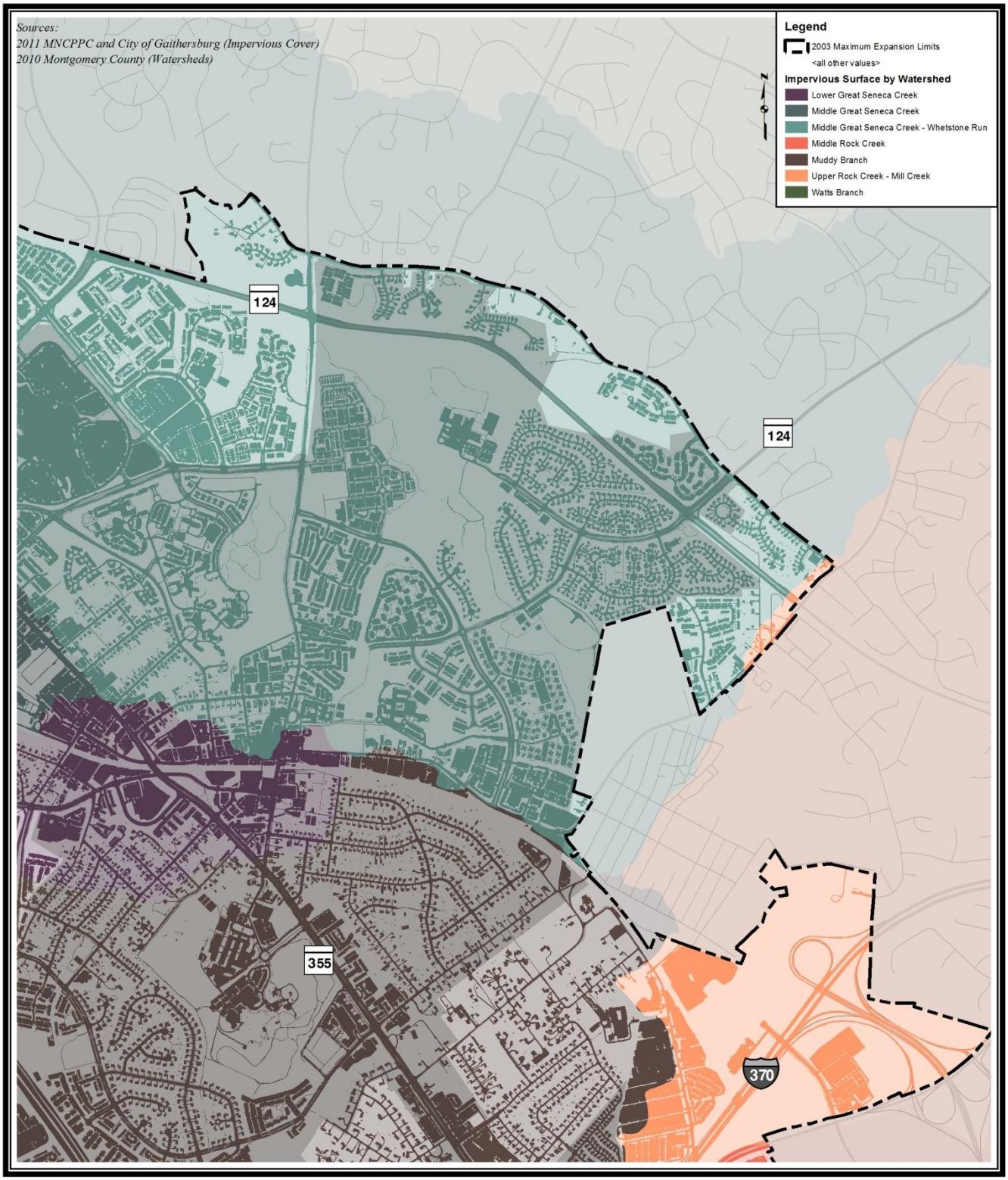

Creek
Lake
Whetstone
124
Whetstone
Creek
117
270
Tax Parcels
Tree Canopy
Sources:
2009 Montgomery County and University of Vermont Spatial Analysis Laboratory (Land Cover)

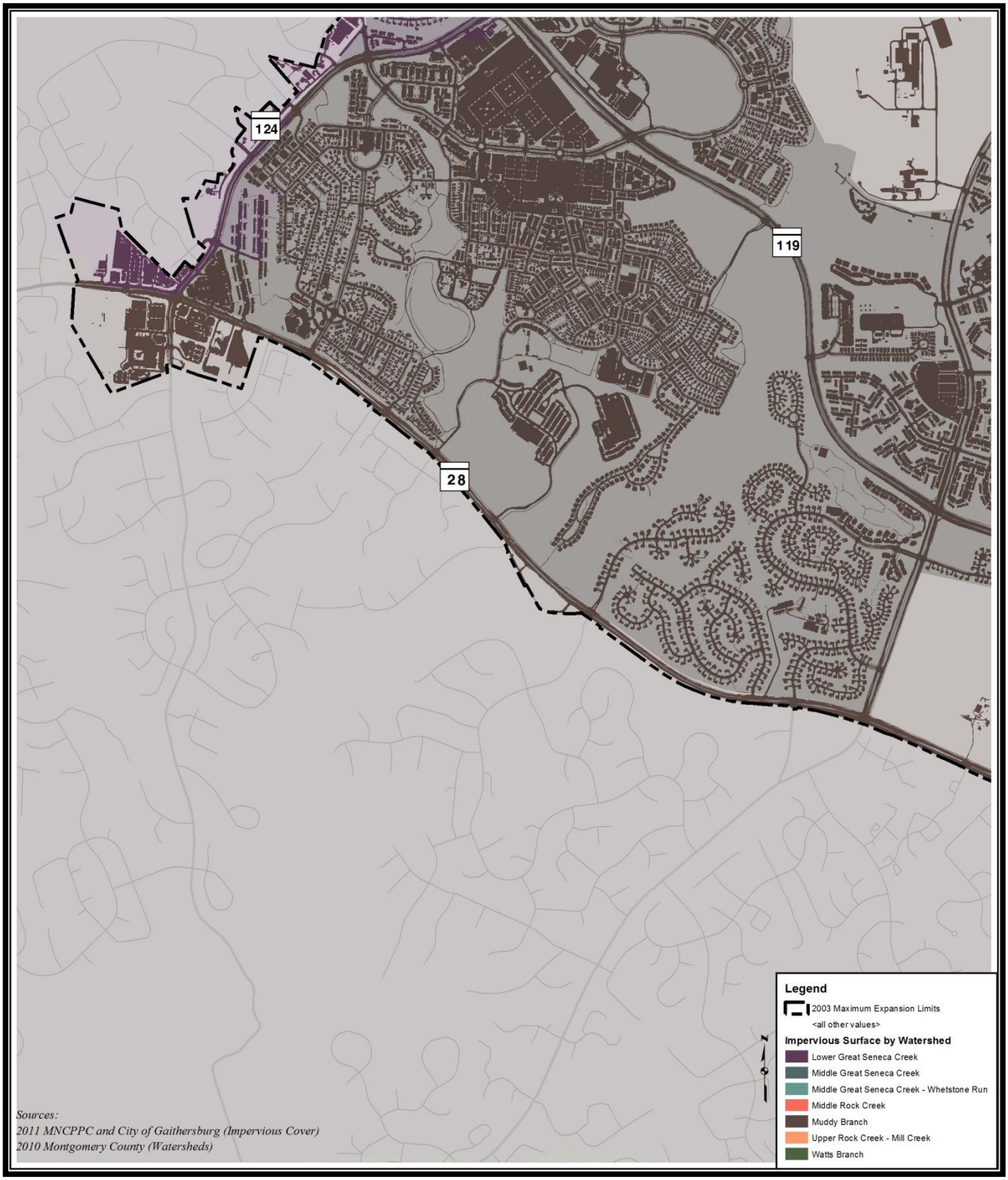

124
28
Lake Lynette
Inspiration Lake
Lake Nirvana
Lake Placid
Lake Varuna
Muddy
Branch
Muddy
Tax Parcels
Tree Canopy
Sources:
2009 Montgomery County and University of Vermont Spatial Anlysis Laboratory (Land Cover)


355
370
Branch
Washingtonian
Lake
119
28
270
Tax Parcels
Tree Canopy
Sources:
2009 Montgomery County and University of Vermont Spatial Anlysis Laboratory (Land Cover)

10. Appendix B: Detailed Impervious Cover Maps




Sources:
2011 MNCPPC and City of Gaithersburg (Impervious Cover)
2010 Montgomery County (Watersheds)
Legend
2003 Maximum Expansion Limits
<all other values>
Impervious Surface by Watershed
Lower Great Seneca Creek
Middle Great Seneca Creek
Middle Great Seneca Creek - Whetstone Run
Middle Rock Creek
Muddy Branch
Upper Rock Creek - Mill Creek
Watts Branch
N
124
124
355
370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119
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Legend
2003 Maximum Expansion Limits
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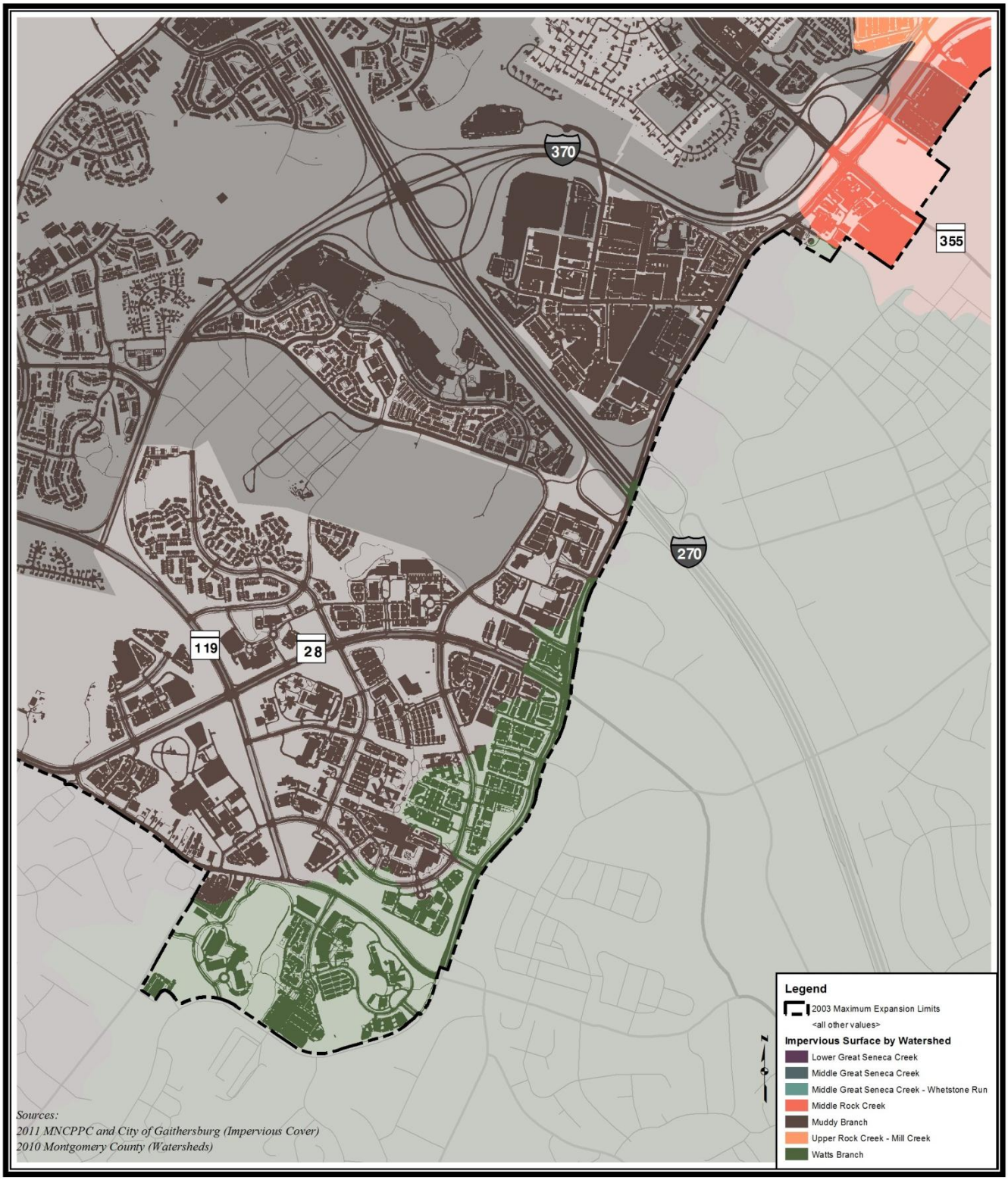
Impervious Surface by Watershed
Lower Great Seneca Creek
Middle Great Seneca Creek
Middle Great Seneca Creek - Whetstone Run
Middle Rock Creek
Muddy Branch
Upper Rock Creek - Mill Creek
Watts Branch
N
Sources:
2011 MNCPPC and City of Gaithersburg (Impervious Cover)
2010 Montgomery County (Watersheds)


370
355
270
119
28
Legend
2003 Maximum Expansion Limits
<all other values>
Impervious Surface by Watershed
Lower Great Seneca Creek
Middle Great Seneca Creek
Middle Great Seneca Creek - Whetstone Run
Middle Rock Creek
Muddy Branch
Upper Rock Creek - Mill Creek
Watts Branch
N
Sources:
2011 MNCPPC and City of Gaithersburg (Impervious Cover)
2010 Montgomery County (Watersheds)

11. Appendix C: Rare/Threatened/Endangered Wildlife

Current and Historical Rare, Threatened, and Endangered Species Of Montgomery County, Maryland*

April 2010

Maryland Department of Natural
Resources Wildlife and Heritage Service

Animals

Scientific Name	Common Name	Global Rank	State Rank	State Staus	Federal Status
Aeshna verticalis	Green-striped Darner	G5	S2		
Aimophila aestivalis	Bachman's Sparrow	G3	SHB	X	
Alasmidonta heterodon	Dwarf Wedge Mussel	G1G2	S1	E	LE
Alasmidonta undulata	Triangle Floater	G4	S1	E	
Alasmidonta varicosa	Brook Floater	G3	S1	E	
Ammodramus henslowii	Henslow's Sparrow	G4	S1S2B	T	
Ankylocythere tridentata	An Entocytherid Ostracod	GNR	SH		
Attheyella spinipes	A Harpacticoid Copepod	GNR	SU		
Autochton cellus	Golden-banded Skipper	G4	SH	X	
Bartramia longicauda	Upland Sandpiper	G5	S1B	E	
Botaurus lentiginosus	American Bittern	G4	S1S2B	I	
Caecidotea sp. 4	An Isopod	GNR	S1		
Circus cyaneus	Northern Harrier	G5	S2B		
Cistothorus platensis	Sedge Wren	G5	S1B	E	
Diacyclops palustris	A Cyclopoid Copepod	GNR	SU		
Dryobius sexnotatus	Six-banded Longhorn Beetle	GNR	S1	E	
Elliptio lanceolata	Yellow Lance	G2G3	SU		
Elliptio producta	Atlantic Spike	G3Q	S2	I	
Empidonax alnorum	Alder Flycatcher	G5	S2B	I	
Epitheca spinosa	Robust Baskettail	G4	S1S2		
Erpetogomphus designatus	Eastern Ringtail	G5	S2		
Farancia erytrogramma	Rainbow Snake	G4	S1	E	
Gallinula chloropus	Common Moorhen	G5	S2B	I	
Gomphus quadricolor	Rapids Clubtail	G3G4	S2	I	
Gomphus ventricosus	Skillet Clubtail	G3	SH	X	
Haliaeetus leucocephalus	Bald Eagle	G5	S3B		
Lampsilis cariosa	Yellow Lampmussel	G3G4	SU		
Lampsilis radiata	Eastern Lampmussel	G5	SU		
Lanius ludovicianus	Loggerhead Shrike	G4	S1B	E	
Lasmigona subviridis	Green Floater	G3	S1	E	
Leptodea ochracea	Tidewater Mucket	G3G4	S1S2		
Lophodytes cucullatus	Hooded Merganser	G5	S1B		
Mustela nivalis	Least Weasel	G5	S2S3	I	
Myotis leibii	Eastern Small-footed Bat	G3	S1	E	

Neotoma magister	Allegheny Woodrat	G3G4	S1	E
Nyctanassa violacea	Yellow-crowned Night-heron	G5	S2B	
Ophiogomphus rupinsulensis	Rusty Snaketail	G5	S2	
Papilio cresphontes	Giant Swallowtail	G5	S2	I
Percopsis omiscomaycus	Trout-perch	G5	SX	X
Phyciodes batesii	Tawny Crescent	G4	SH	X
Podilymbus podiceps	Pied-billed Grebe	G5	S2B	
Sorex hoyi winnemana	Southern Pygmy Shrew	G5T4	S2	
Speyeria idalia	Regal Fritillary	G3	SH	X
Sphodros rufipes	Red-legged Purse-web Spider	G4	S1S2	
Spiza americana	Dickcissel	G5	S2B	
Strophitus undulatus	Creeper	G5	S2	I
Stygobromus pizzinii	Pizzini's Cave Amphipod Pizzini's Cave Amphipod	G3G4	S1	
Stygobromus sp. 14	Roundtop Amphipod	GNR	S1	

Plants

Scientific Name	Common Name	Global Rank	State Rank	State Staus	Federal Status
Agalinis auriculata	Auricled Gerardia	G3	S1	E	
Agalinis obtusifolia	Blunt-leaved Gerardia	G4G5Q	S1	E	
Agalinis setacea	Thread-leaved Gerardia	G5?	S1	E	
Amelanchier nantucketensis	Nantucket Shadbush	G3Q	S1	T	
Amelanchier stolonifera	Running Juneberry	G5	S2		
Ammannia coccinea	Scarlet Ammannia	G5	SU		
Antennaria solitaria	Single-headed Pussytoes	G5	S2	T	
Arabis hirsuta	Hairy Rockcress	G5	SU		
Arabis missouriensis	Missouri Rockcress	G5?Q	S1	E	
Aristida lanosa	Woolly Three-awn	G5	S1	E	
Armoracia lacustris	Lake Cress	G4?	S1	E	
Arnica acaulis	Leopard's-bane	G4	S1	E	
Asclepias rubra	Red Milkweed	G4G5	S1	E	
Asplenium pinnatifidum	Lobed Spleenwort	G4	S1	E	
Astragalus canadensis	Canada Milkvetch	G5	S1	E	
Astragalus distortus	Bent Milkvetch	G5	S2	T	
Baptisia australis	Wild False Indigo	G5	S2	T	
Botrychium simplex	Small Grape-fern	G5	SH	X	
Bouteloua curtipendula	Side-oats Grama	G5	S2		
Bromus latiglumis	Broad-glumed Brome	G5	S1	E	
Bromus nottowayanus	Nottoway's Brome	G3G5	S1S2		
Buchnera americana	Blue-hearts	G5?	SH	X	
Cacalia muehlenbergii	Great Indian-plantain	G4	SH	X	
Calystegia spithamaea	Low Bindweed	G4G5	S2		
Cardamine pratensis	Cuckooflower	G5	S1		
Carex buxbaumii	Buxbaum's Sedge	G5	S2	T	
Carex careyana	Carey's Sedge	G4G5	S1	E	
Carex davisii	Davis' Sedge	G4	S1	E	
Carex decomposita	Cypress-knee Sedge	G3	S1	E	

Carex hitchcockiana	Hitchcock's Sedge	G5	S1	E	
Carex lupuliformis	Hop-like Sedge	G4	S2		
Carex meadii	Mead's Sedge	G4G5	S1	E	
Carex pellita	Woolly Sedge	G5	S2?		
Carex planispicata	A Sedge	G4Q	S1S2		
Carex projecta	Necklace Sedge	G5	S2		
Carex shortiana	Short's Sedge	G5	S2	E	
Carex sparganioides	Burr-reed Sedge	G5	S1S2		
Carex tenera	Slender Sedge	G5	SH	X	
Carex tetanica	Rigid Sedge	G4G5	SH	X	
Carya laciniosa	Big Shellbark Hickory	G5	S1	E	
Castanea dentata	American Chestnut	G4	S2S3		
Celtis laevigata	Sugarberry	G5	SU		
Ceratophyllum echinatum	Prickly Hornwort	G4?	S1	E	
Chamaesyce vermiculata	Hairy Spurge	G5	SH		
Corallorhiza wisteriana	Wister's Coralroot	G5	S1	E	
Coreopsis tripteris	Tall Tickseed	G5	S1	E	
Cuscuta coryli	Hazel Dodder	G5?	SH	X	
Cuscuta polygonorum	Smartweed Dodder	G5	S1	E	
Cyperus refractus	Reflexed Cyperus	G5	S2?		
Cyperus retrofractus	Rough Cyperus	G5	S2		
Desmodium humifusum	Trailing Tick-trefoil	G1G2Q	SH	X	
Desmodium rigidum	Rigid Tick-trefoil	GNRQ	S1	E	
Dichanthelium aciculare	Bristling Panicgrass	G5	S2?		
Dichanthelium laxiflorum	Lax-flowered Witchgrass	G5	S1?		
Dichanthelium oligosanthes	Few-flowered Panicgrass	G5	S2S3		
Dichanthelium scabriusculum	Tall Swamp Panicgrass	G4	S1	E	
Diplazium pycnocarpon	Glade Fern	G5	S2	T	
Dirca palustris	Leatherwood	G4	S2	T	
Echinodorus cordifolius	Upright Burhead	G5	S1	E	
Erythronium albidum	White Trout Lily	G5	S2	T	
Eupatorium maculatum	Spotted Joe-pye-weed	G5	SU	X	
Euphorbia obtusata	Blunt-leaved Spurge	G5	S1	E	
Eurybia radula	Rough-leaved Aster	G5	S1	E	
Gentiana andrewsii	Fringe-tip Closed Gentian	G5?	S2	T	
Gentiana villosa	Striped Gentian	G4	S1	E	
Geum aleppicum	Yellow Avens	G5	S1	E	
Goodyera tesselata	Tesselated Rattlesnake-plantain	G5	SH	X	
Hasteola suaveolens	Sweet-scented Indian-plantain	G4	S1	E	
Helianthus occidentalis	Mcdowell's Sunflower	G5	S1	T	
Houstonia tenuifolia	Slender-leaved Bluets	G4G5	S1		
Ilex decidua	Deciduous Holly	G5	S2		
Iresine rhizomatosa	Bloodleaf	G5	S	E	
Iris cristata	Crested Iris	G5	S1	E	
Isotria medeoloides	Small Whorled Pogonia	G2	SH	X	LT
Juglans cinerea	Butternut	G4	S2S3		
Juncus longii	Long's Rush	G3Q	S1	E	
Krigia dandelion	Potato Dandelion	G5	S1	E	
Lactuca hirsuta	Hairy Lettuce	G5?	SH	X	
Lathyrus palustris	Vetchling	G5	S1	E	

Linum floridanum	Florida Yellow Flax	G5?	SH	X
Lipocarpha micrantha	Small-flowered Hemicarpha	G5	S1	E
Lithospermum latifolium	American Gromwell	G4	S1	E
Lycopodiella caroliniana	Carolina Clubmoss	G5	S1	E
Lygodium palmatum	Climbing Fern	G4	S2	T
Lysimachia hybrida	Lowland Loosestrife	G5	S2	T
Lythrum alatum	Winged Loosestrife	G5	S1	E
Matelea obliqua	Climbing Milkweed	G4?	S1	E
Matteuccia struthiopteris	Ostrich Fern	G5	S2	
Mecardonia acuminata	Erect Water-hyssop	G5	S1	E
Melanthium latifolium	Broad-leaved Bunchflower	G5	S1	E
Melica mutica	Narrow Melicgrass	G5	S1	T
Muhlenbergia capillaris	Long-awned Hairgrass	G5	S1	E
Najas gracillima	Thread-like Naiad	G5?	SU	X
Nelumbo lutea	American Lotus	G4	S2	
Oligoneuron rigidum	Hard-leaved Goldenrod	G5	SH	X
Onosmodium virginianum	Virginia False-gromwell	G4	S1	E
Orthilia secunda	One-sided Pyrola	G5	SH	X
Panicum flexile	Wiry Witch-grass	G5	S1	E
Paronychia virginica var. virginica	Yellow Nailwort	G4T1Q	S1	E
Paspalum fluitans	Floating Paspalum	G5	S1	E
Pellaea glabella	Smooth Cliffbrake	G5	S1	E
Phacelia covillei	Coville's Phacelia	G3	S2	E
Phlox glaberrima	Smooth Phlox	G5	S1	E
Phlox pilosa	Downy Phlox	G5	S1	E
Platanthera flava	Pale Green Orchid	G4	S2	
Platanthera peramoena	Purple Fringeless Orchid	G5	S1	T
Platanthera psycodes	Small Purple Fringed Orchid	G5	SH	X
Polygala polygama	Racemed Milkwort	G5	S1	T
Polygala senega	Seneca Snakeroot	G4G5	S2	T
Potamogeton foliosus	Leafy Pondweed	G5	S1	E
Potamogeton spirillus	Spiral Pondweed	G5	S1	
Potamogeton zosteriformis	Flatstem Pondweed	G5	S1	E
Potentilla arguta	Tall Cinquefoil	G5	SU	
Prunus pumila	Eastern Dwarf Cherry	G5	SU	
Pycnanthemum clinopodioides	Basil Mountain-mint	G2	SH	
Pycnanthemum torrei	Torrey's Mountain-mint	G2	S1	E
Pycnanthemum verticillatum	Whorled Mountain-mint	G5	S1	E
Pycnanthemum virginianum	Virginia Mountain-mint	G5	S2	
Pyrola virens	Greenish-flowered Pyrola	G5	SH	X
Quercus macrocarpa	Mossy-cup Oak	G5	S1	
Quercus shumardii	Shumard's Oak	G5	S2	T
Ranunculus ambigens	Water-plantain Spearwort	G4	SH	X
Ranunculus flabellaris	Yellow Water-crowfoot	G5	S1	E
Ruellia humilis	Hairy Wild-petunia	G5	S1	E
Ruellia purshiana	Pursh's Ruellia	G3	S1	E
Ruellia strepens	Rustling Wild-petunia	G4G5	S1	E
Rumex altissimus	Tall Dock	G5	S1	E
Sagittaria australis	Long-beaked Arrowhead	GNRQ	SU	
Sagittaria engelmanniana	Engelmann's Arrowhead	G5?	S2	T

Sagittaria rigida	Sessile-fruited Arrowhead	G5	S1	E
Salix exigua	Sandbar Willow	G5	S1	E
Salix humilis var. tristis	Dwarf Prairie Willow	G4G5	S1	
Sanguisorba canadensis	Canada Burnet	G5	S2	T
Schoenoplectus smithii	Smith's Clubrush	G5?	SU	X
Scleria reticularis	Reticulated Nutrush	G4	S2S3	
Scutellaria galericulata	Common Skullcap	G5	S1	
Scutellaria leonardii	Leonard's Skullcap	G4T4	S2	T
Scutellaria nervosa	Veined Skullcap	G5	S1	E
Scutellaria saxatilis	Rock Skullcap	G3	S1	E
Sida hermaphrodita	Virginia Mallow	G3	S1	E
Silene nivea	Snowy Campion	G4?	S1	E
Smilacina stellata	Star-flowered False Solomon's-seal	G5	S1	E
Smilax pseudochina	Halberd-leaved Greenbrier	G4G5	S2	T
Solidago rupestris	Rock Goldenrod	G4?	SH	X
Solidago simplex var. racemosa	Riverbank Goldenrod	G5T3?	S1	T
Solidago speciosa	Showy Goldenrod	G5	S2	T
Spermacoce glabra	Buttonweed	G4G5	S1	E
Sphenopholis pensylvanica	Swamp-oats	G4	S2	T
Spiranthes lucida	Wide-leaved Ladys' Tresses	G5	S1	E
Spiranthes ochroleuca	Yellow Nodding Ladys' Tresses	G4	S1	E
Sporobolus asper	Long-leaved Rushgrass	G5	S1	
Sporobolus clandestinus	Rough Rushgrass	G5	S2	T
Stachys aspera	Rough Hedge-nettle	G4?	S1	E
Stachys nuttallii	Nuttall's Hedge-nettle	G5?	S1	
Stenanthium gramineum	Featherbells	G4G5	S1	T
Symphyotrichum depauperatum	Serpentine Aster	G2	S1	E
Symphyotrichum drummondii	Drummond Aster	G5	S1	
Talinum teretifolium	Fameflower	G4	S1	T
Thelypteris simulata	Bog Fern	G4G5	S2	T
Trachelospermum difforme	Climbing Dogbane	G4G5	S1	E
Trichophorum planifolium	Bashful Bulrush	G4G5	S2S3	
Trichostema setaceum	Narrow-leaved Bluecurls	G5	S1	
Trifolium reflexum	Buffalo Clover	G3G4	SH	X
Triosteum angustifolium	Narrow-leaved Horse-gentian	G5	S1	E
Triphora trianthophora	Nodding Pogonia	G3G4	S1	E
Valeriana pauciflora	Valerian	G4	S1	E
Valerianella chenopodiifolia	Goose-foot Cornsalad	G5	S1	E
Valerianella umbilicata	Tall Cornsalad	G3G5	SH	X
Veronica scutellata Vitis rupestris	Marsh Speedwell Sand Grape	G5 G3	S1 S1	E
Zanthoxylum americanum	Northern Prickly-ash	G5	S1	E

* This report represents a compilation of information in the Wildlife and Heritage Service's Biological and Conservation Data system as of the date on the report. It does not include species considered to be "watchlist" or more common species.

Source: http://www.dnr.state.md.us/wildlife/Plants_Wildlife/rte/pdfs/rtemont.pdf

12. Appendix D: Methods for Air Pollution Modelling

Frequently Asked Questions about the UFORE model (www.ufore.org)

What is UFORE?

UFORE, which stands for Urban Forest Effects, is a science-based, peer-reviewed computer model designed to calculate urban forest ecosystem services and values based on field data inputs and available data sets from external sources (e.g., weather and pollution data sets). UFORE can calculate urban forest structure and several ecosystem services and values for any area of any size.

UFORE is a compilation of three programs:

1) Field plot selector -- allows users to easily locate field plots on maps using GIS.
2) Data collection program -- a field data collection program for use on a personal digital assistant (PDA) running Windows CE.
3) UFORE application – an interface that allows the user to operate the two programs cited above, collect and enter field data (either through the PDA or on paper forms), have data analyzed, and generate and export standard graphs and tables. A user's manual is also available through the help menu.

Why was UFORE developed?

UFORE was developed in the 1990s to standardize a protocol for collecting and analyzing data in urban areas. The need for this tool became apparent following the first urban ecosystem assessment studies in Oakland, Chicago, and other U.S. cities.

What does UFORE calculate?

- Urban forest structure by strata (e.g., land-use types), including species composition, tree density, diameter distribution, tree health, leaf and tree biomass, and species diversity.
- Amount of pollution removed (hourly) by the urban forest, and associated percent improvement in air quality. Pollution removal is calculated for carbon monoxide, nitrogen dioxide, ozone, particulate matter (< 10 microns), and sulfur dioxide.
- Volatile organic compounds (VOC) emissions from the urban forest (hourly) and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year.
- Total carbon stored and net annual carbon sequestration by the urban forest.
- Tree effects on building energy use and consequent emissions from power plants.
- Compensatory value of the forest, air pollution removal value, and carbon storage and sequestration values.
- Potential impact of infestations by gypsy moth, Asian longhorned beetle, Dutch elm disease, and emerald ash borer.
- Changes in streamflow (hourly) due to urban trees and impervious surfaces.

- Changes in water quality (hourly) due to urban trees and impervious surfaces, including total nitrogen, nitrate and nitrite, total Kjeldahl nitrogen, total phosphorus, dissolved phosphorus, total suspended solids, dissolved solids, lead, copper, zinc, cadmium, chromium, nickel, biological dissolved oxygen, chemical dissolved oxygen, alkalinity, and oil and grease.

Who uses UFORE?

UFORE has a diverse group of users, from scientists and university students who want to study the effects of urban forests on the environment, to local city planners who are exploring the use of trees on pollution mitigation and mapping underserved areas of their communities where trees would be the most useful, to managers who want to know and better manage their resource, to public groups that want to understand the values of urban forests and bolster support for urban tree planting and urban forestry programs.

Why should I use UFORE?

UFORE provides necessary information on the urban forest resource and its ecosystem services to improve urban forest management and garner support for urban forestry programs. Data on urban forest structure and health can aid in establishing appropriate budget levels and workload allocation, while information on tree cover can help define areas where new tree plantings would be more beneficial. Pest information can help detect existing vulnerabilities to insects and pathogens that could devastate the urban forest. The ecosystem service results can be used to determine the value of the resource and support integrating urban forest programs in larger regulatory efforts to improve environmental quality.

How can UFORE be used in regulatory efforts to improve environmental quality?

Results from UFORE also can help determine the effect of trees on aspects of the environment that are regulated by the U.S. Environmental Protection Agency. As the Clean Air and Clean Water Acts impose regulations that affect urban areas, the regulations affect urban development, funding, and management at local and state levels. As trees affect the environment, the ability to quantify these effects could lead to the incorporation of urban vegetation management strategies (and potential funding) to help meet these environmental regulations. Urban trees can be incorporated as an emerging measure with State Implementation Plans to meet clean air regulations (www.fs.fed.us/ne/syracuse/Emerging%20Measures%20Summary.pdf).

Urban trees also could be used to potentially meet clean water regulations associated with Total Maximum Daily Loads (www.epa.gov/owow/tmdl/intro.html) and storm water programs (www.epa.gov/region6/water/npdes/sw/ms4/).

How have UFORE results helped communities?

Numerous communities, both nationally and internationally, have used UFORE to assess ecosystem services and aid in improved urban forest management. One of the best examples of how UFORE results have helped a community comes from New Jersey. There, based in part on UFORE results, Conectiv Electric Utility negotiated to have a $1 million air pollution fine

donated to the New Jersey Tree Foundation for a massive Urban Air-shed Reforestation project in the Camden area. Trained volunteers are planting 3-inch caliper shade trees in the communities most affected by the air pollution (www.na.fs.fed.us/urban/states2003/nj/nj.htm).

How does UFORE work?

UFORE uses locally collected field data along with readily available external data sources (e.g., weather and pollution data) to quantify basic tree functions and ecosystem services. However, some basic field measurements that are used to quantify urban forest structure must be collected on the ground (e.g., species, diameter, crown height and width, crown condition) from randomly located plots. Data from the plots are then statistically extrapolated upward to estimate totals and standard errors for the entire study area or strata (e.g., land-use types) within the study area.

Is field data collection necessary?

Yes. Field data are necessary to accurately quantify the urban forest structure. Quantifying carbon, VOC emissions, energy effects, and other services require data on individual trees for accurate estimates. Quantifying ecosystem services only with aerial data would provide only coarse estimates of these services. Using local field data along with local weather and pollution data sets provides a more accurate assessment of the local urban forest structure and services.

Is there any new functionality planned for UFORE?

Updates to the functionality of UFORE will be available via the Internet as UFORE will be continually developed and refined with new capabilities through time. There are three new modules in development.

1) UFORE-Hydro. This is a GIS-based program that estimates changes in streamflows and water quality based on changes in tree cover and impervious surface cover attributes within a watershed. The model is calibrated against actual streamflow data and is designed specifically to estimate vegetation effects.
2) UFORE-Species. This is a functional species selection program that was developed in cooperation with Horticopia (www.horticopia.com). From a database with information on thousands of trees, trees are rated for their relative ability for air pollution removal, VOC emissions, air quality improvement, carbon storage, air temperature reduction, shading, building energy conservation, and allergenicity. Users are asked to rate the importance of each of these functions to determine the best species given the users' ratings. The program rankings are based on relative tree functions at maturity and local hardiness zone to aid in tree selection in the area to maximum ecosystem services from trees and improve environmental quality in cities.
3) UFORE Growout. This program uses the output from UFORE to project future tree population totals, canopy cover, and carbon storage based on user inputs of estimated mortality rates. Populations can be projected over a 100-year period. The program also can be used to determine annual tree planting/establishment rates needed to sustain a specific tree canopy cover.

What cities have been analyzed using UFORE?

Atlanta, GA
Baltimore, MD
Beijing, China
Boston, MA
Brooklyn, NY
Calgary, Alberta
Freehold, NJ
Fuenlabrada, Spain
Greenville-Spartanburg, SC
Houston, TX
Hefei, China
Jersey City, NJ
Kent, OH
Minneapolis, MN
Morgantown, WV
Moorestown, NJ
New York, NY
Ningbo, China
Oakville, Ontario
Philadelphia, PA
Porto Alegre, Brazil
San Francisco, CA
San Juan, PR
Santiago, Chile
Syracuse, NY
Toronto, Ontario
Washington, DC
Wilmington, DE
Woodbridge, NJ

Current cities being analyzed are:
Baton Rouge, LA

Fredericton, New Brunswick
Gainesville, FL

Scranton, PA
Shenzhen, China

How much does UFORE cost?

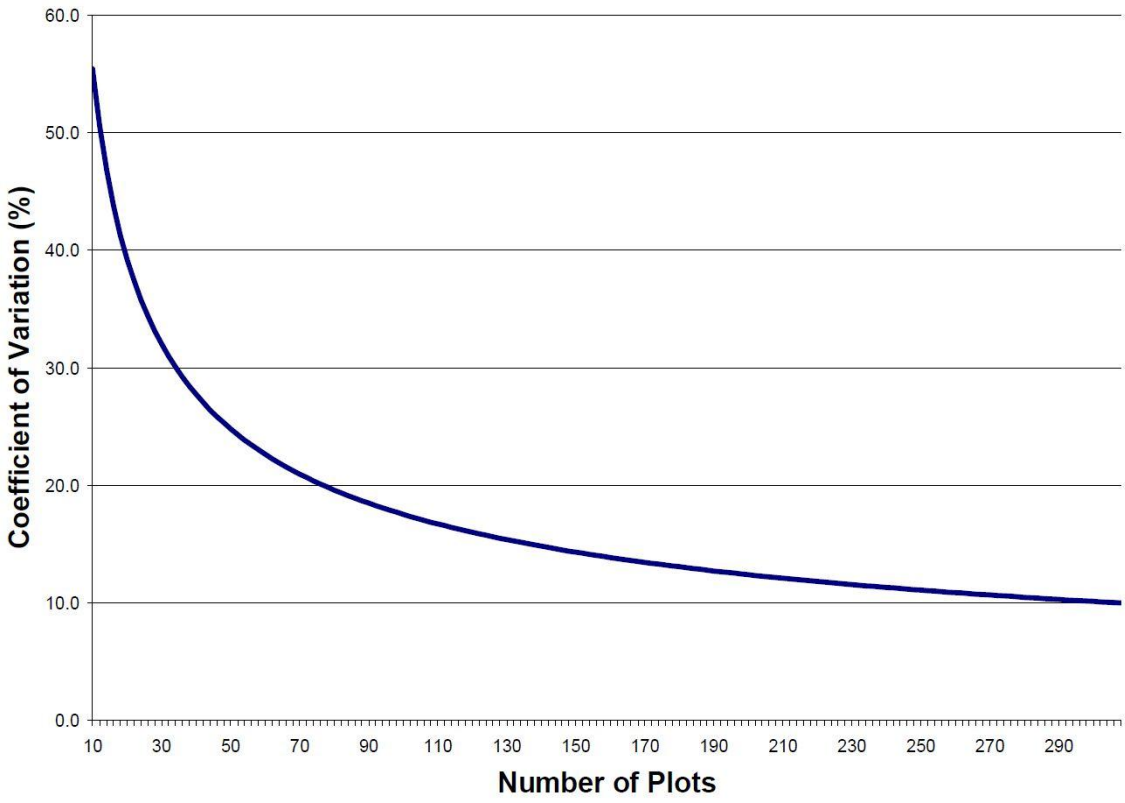
UFORE is a public-domain program distributed at no-cost.

What does the typical city analysis cost?

As a general rule, a two-person crew can collect data on 150 to 200 one-tenth acre plots during a 3-month summer season. The cost for the data collection would depend on how much the crew is paid and the local transportation cost to get to the plots. Other costs incurred by conducting an analysis relate to equipment and local office support costs for project setup, analysis, and reporting. Some costs are incurred for quality assurance measures (training and plot data checks).

How many field plots will I need to analyze my city?

The number of plots is up to the user. Increasing the number of plots and/or size of the plots will typically lead to lower variances and increased certainty in the results, but it also tends to increase the cost of the project. The following is a rough estimate of the coefficient of variation (standard error divided by total expressed as a percentage) of the total number of trees in a city based on the number of plots sampled.



What do I have to do to run a UFORE analysis?

Read the i-Tree Software Suite User's Manual found under the UFORE program help menu or at the Resource/Learning Center on the i-Tree website (www.itreetools.org) to determine the data collection and analysis procedures. The basic steps are:

1) Determine your study area
2) Distribute sample points for plot location
3) Collect the field data
4) Use UFORE to analyze the data
5) Use UFORE to generate tables and charts
6) Export data for local report generation

Training sessions and technical support are available. (see www.itreetools.org).

Can I use existing inventory data?

Existing inventory data can be used if the proper crown parameters are measured on each tree, along with information on species, diameter at breast height (4.5 feet), and crown condition (see i-Tree Software Suite User's Manual). Species codes must also be converted to UFORE species codes (see www.itreetools.org).

Can UFORE data be mapped?

Yes. Examples of types of GIS maps that can be produced using UFORE data are given within the UFORE program.

Does UFORE calculate cost-benefit ratios?

No. UFORE estimates dollar benefits of ecosystem services based on economic literature. To estimate the cost-benefit ratio, good estimates of management costs of the entire urban forest would be needed. These data are not yet available, but UFORE-Growout is being developed to project costs and benefits through time based on user inputs of costs.

Can UFORE be used for street trees and non-urban areas?

Yes. UFORE has been used to assess street trees and nonurban areas. If proper tree data are collected, UFORE can calculate leaf area and biomass, air pollution removal, VOC emissions, carbon storage and sequestration, and compensatory value on a per-tree basis. However, the STRATUM model is designed to analyze street tree populations and can be used to assess this resource.

As UFORE is designed to calculate tree effects based on an area sample, the model can be used for nonurban areas of any size. One limitation of using the model outside of urban areas is that some local input data sets (e.g., pollution and weather data) are more limited outside of urban areas.

Who developed UFORE?

UFORE was developed by a team of scientists and technicians from the Forest Service's Northeastern Research Station, Davey Resource Group, SUNY College of Environmental Science and Forestry, and Clemson University with support from these partner groups and Forest Service State and Private Forestry's Urban and Community Forestry and Northeastern Area programs.

Where can I obtain additional information about UFORE?

For additional information, visit www.itreetools.org, www.ufore.org, or www.fs.fed.us/ne/syracuse/Tools/UFORE.htm

Methodology Explanation

Methods and analyses conducted for this program are based on the Urban Forest Effects (UFORE) model developed by Nowak and Crane (2000). For each city, the pollutant flux (F; in g m^{-2} s^{-1}) is calculated as the product of the deposition velocity (V_d; in m s^{-1}) and the pollutant concentration (C; in g m^{-3}):

$$F = V_d \cdot C$$

Deposition velocity is calculated as the inverse of the sum of the aerodynamic (R_a), quasi-laminar boundary layer (R_b) and canopy (R_c) resistances (Baldocchi et al. 1987):

$$V_d = (R_a + R_b + R_c)^{-1}$$

Hourly meteorological data from local airports were used in estimating R_a and R_b. The aerodynamic resistance is calculated as (Killus et al. 1984):

$$R_a = u(z) \cdot u_*^{-2}$$

where u(z) is the mean windspeed at height z (m s^{-1}) and u_* is the friction velocity (m s^{-1}).

$$u_* = (k \cdot u(z-d))[\ln((z-d) \cdot z_o^{-1}) - \psi_M((z-d) \cdot L^{-1}) + \psi_M(z_o \cdot L^{-1})]^{-1}$$

where k = von Karman constant, d = displacement height (m), z_o = roughness length (m),

ψ_M = stability function for momentum, and L = Monin-Obuhkov stability length. L was estimated by classifying hourly local meteorological data into stability classes using Turner classes (Panofsky and Dutton 1984) and then estimating L^{-1} as a function of stability class and z_o (Zannetti 1990). When L < 0 (unstable) (van Ulden and Holtslag 1985):

$$\psi_M = 2\ln[0.5(1+X)] + \ln[0.5(1+X^2)] - 2\tan^{-1}(X) + 0.5\pi$$

where X = $(1 - 28\ z\ L^{-1})^{0.25}$ (Dyer and Bradley 1982). When L > 0 (stable conditions):

$$u_* = C_{DN} \cdot u\{0.5 + 0.5[1-(2u_o / C_{DN}^{\frac{1}{2}} \cdot u))^2]^{\frac{1}{2}}\}$$

where $C_{DN} = k\ (\ln\ (z/z_o))^{-1}$; $u_o^2 = (4.7\ z\ g\ \theta_*)\ T^{-1}$; g = 9.81 m s^{-2}; $\theta_* = 0.09\ (1 - 0.5\ N^2)$; T = air temperature (K°); and N = fraction of opaque cloud cover (Venkatram 1980; EPA 1995). Under stable conditions, u_* was calculated by scaling actual windspeed with a calculated minimum windspeed based on methods given in EPA (1995).

The quasi-laminar boundary-layer resistance was estimated as (Pederson et al. 1995):

$$R_b = 2(Sc)^{\frac{2}{3}}(\mathrm{Pr})^{-\frac{2}{3}}(k \cdot u_*)^{-1}$$

where k = von Karman constant, Sc = Schmidt number, and Pr is the Prandtl number.

In-leaf, hourly tree canopy resistances for O_3, SO_2, and NO_2 were calculated based on a modified hybrid of big-leaf and multilayer canopy deposition models (Baldocchi et al. 1987; Baldocchi 1988). Canopy resistance (R_c) has three components: stomatal resistance (r_s), mesophyll resistance (r_m), and cuticular resistance (r_t), such that:

$$1/R_c = 1/(r_s + r_m) + 1/r_t$$

Mesophyll resistance was set to zero s m^{-1} for SO_2 (Wesely 1989) and 10 s m^{-1} for O_3 (Hosker and Lindberg 1982). Mesophyll resistance was set to 100 s m^{-1} for NO_2 to account for the difference between transport of water and NO_2 in the leaf interior, and to bring the computed deposition velocities in the range typically exhibited for NO_2 (Lovett 1994). Base cuticular resistances were set at 8,000 m s^{-1} for SO_2, 10,000 m s^{-1} for O_3, and 20,000 m s^{-1} for NO_2 to account for the typical variation in r_t exhibited among the pollutants (Lovett 1994).

Hourly inputs to calculate canopy resistance are photosynthetic active radiation (PAR; µE m^{-2} s^{-1}), air temperature (K^o), windspeed (m s^{-1}), u_* (m s^{-1}), CO_2 concentration (set to 360 ppm), and absolute humidity (kg m^{-3}). Air temperature, windspeed, u_*, and absolute humidity are measured directly, or calculated, from measured hourly NCDC (National Climatic Data Center) meteorological data. Total solar radiation is calculated based on the METSTAT model with inputs from the NCDC data set (Maxwell 1994). PAR is calculated as 46% of total solar radiation input (Monteith and Unsworth 1990).

As CO and removal of particulate matter by vegetation are not directly related to transpiration, R_c for CO was set to a constant for in-leaf season (50,000 s m^{-1}) and leaf-off season (1,000,000 s m^{-1}) based on data from Bidwell and Fraser (1972). For particles, the median deposition velocity from the literature (Lovett 1994) was 0.0128 m s^{-1} for the in-leaf season. Base particle V_d was set to 0.064 based on a LAI of 6 and a 50% resuspension rate of particles back to the atmosphere (Zinke 1967). The base V_d was adjusted according to in-leaf vs. leaf-off season parameters.

Each city was assumed to have a tree/shrub leaf area index within the canopy covered area of 6 and to be 10% evergreen (Nowak, 1994). Regional leaf-on and leaf-off dates were used to account for seasonal leaf area variation. Particle collection and gaseous deposition on deciduous trees in winter assumed a surface-area index for bark of 1.7 (m^2 of bark per m^2 of ground surface covered by the tree crown) (Whittaker and Woodwell 1967). To limit deposition estimates to periods of dry deposition, deposition velocities were set to zero during periods of precipitation.

Hourly pollution concentration data (1994) from each city were obtained from the US Environmental Protection Agency (EPA). Hourly ppm values were converted to µg m^{-3} based on measured atmospheric temperature and pressure (Seinfeld 1986). Missing hourly meteorological or

pollution-concentration data are estimated using the monthly average for the specific hour. In some locations, an entire month of pollution-concentration data may be missing and are estimated based on interpolations from existing data. For example, O_3 concentrations may not be measured during winter months and existing O_3 concentration data are extrapolated to missing months based on the average national O_3 concentration monthly pattern. For some cities local pollution data were not available for some pollutants, so data from other regional monitors were used [Table 1].

Total pollutant flux (g m^{-2} of tree canopy coverage per year) is multiplied by tree-canopy coverage (m^2) (supplied by the model user) to estimate total pollutant removal by trees in the study area. The monetary value of pollution removal by trees is estimated using the median externality values for the United States for each pollutant. These values, in dollars per metric ton (t) are: NO_2 = \$6,752 t^{-1}, PM10 = \$4,508 t^{-1}, SO_2 = \$1,653 t^{-1}, and CO = \$959 t^{-1} (Murray et al. 1994). Externality values for O_3 were set to equal the value for NO_2.

Table 6: Location and Type of Surrogate Monitors Used for Cities with Missing Pollution Monitors

City Name	*Surrogate Monitor*	*Pollutants*
Albany, NY	Buffalo, NY	NO2
Albuquerque,NM	El Paso, NM	SO2
Chico, CA	Sacramento, CA	SO2
Columbus, OH	Cincinnati, OH	SO2
Fresno, CA	San Diego	SO2
Omaha, NE	Kansas City, MO	NO2
Pasadena, CA	Los Angeles, CA	O3, PM10, SO2
Santa Maria, CA	San Jose, CA	CO, NO2, SO2
Seattle, WA	Portland, OR	NO2
South Lake Tahoe, CA	Sacramento, CA	SO2
Visalia, CA	Fresno, CA	SO2

References

Baldocchi, D. “A multi-layer model for estimating sulfur dioxide deposition to a deciduous oak forest canopy.” *Atmospheric Environment* 22 (1988): 869-884.

Baldocchi, D., B. B. Hicks, and P. Camara. “A canopy stomatal resistance model for gaseous deposition to vegetated surfaces.” *Atmospheric Environment* 21 (1987): 91-101.

Bidwell, R. G. S. and D. E. Fraser. “Carbon monoxide uptake and metabolism by leaves.” *Canadian Journal of Botany* 50 (1972): 1435-1439.

Dyer, A. J. and C.F. Bradley. 1982. “An alternative analysis of flux gradient relationships.” *Boundary-Layer Meteorology* 22 (1982): 3-19.

Hosker, R. P., Jr. And S. E. Lindberg. 1982. “Review: atmospheric deposition and plant assimilation of gases and particles.” *Atmospheric Environment* 16, no. 5 (1982): 889-910.

Killus, J. P., J. P. Meyer; D. R. Durran, G. E. Anderson, T. N. Jerskey, S. D. Reynolds, and J. Ames. 1984. *Continued research in mesoscale air pollution simulation modeling. Volume*

V: refinements in numerical analysis, transport, chemistry, and pollutant removal. (*Publ. EPA/600/3-84/095a)* Research Triangle Park, NC: U.S. Environmental Protection Agency.

Lovett, G. M. "Atmospheric deposition of nutrients and pollutants in North America: an ecological perspective." *Ecological Applications* 4 (1994): 629-650.

Maxwell, E. L. "A meteorological/statistical solar radiation model." In *Proceedings of the 1994 annual conference of the American Solar Energy Society*, 421-426. San Jose, CA: American Solar Energy Society, 1994

Monteith, J. L. and M. H. Unsworth. 1990. *Principles of environmental physics.* New York, NY: Edward Arnold, 1990.

Murray, F. J., L. Marsh, and P. A. Bradford. 1994. *New York State energy plan, vol. II: issue reports.* Albany, NY: New York State Energy Office, 1994.

Nowak, D. J. "Urban forest structure: The state of Chicago's urban forest." In *Chicago's urban forest ecosystem: results of the Chicago Urban Forest Climate Project* (General Technical Report NE-186), edited by E.G. McPherson, D. J. Nowak, and R. A. Rowntree, 3-18. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, 1994.

Nowak, D. J. and D. E. Crane. "The Urban Forest Effects (UFORE) Model: quantifying urban forest structure and functions." In *Integrated tools for natural resources inventories in the 21st century: proceedings of the IUFRO conference* (General Technical Report NC-212), edited by M. Hansen and T. Burk, 714-720. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station, 2000.

Panofsky, H. A. and J. A. Dutton. 1984. *Atmospheric Turbulence*. New York: John Wiley, 1984.

Pederson, J. R.; W. J. Massman, L. Mahrt, A. Delany, S. Oncley, G. den Hartog, H. H. Neumann, R. E. Mickle, R. H. Shaw, K. T. Paw U, D. A. Grantz, J. I. MacPherson, R. Desjardins, P. H. Schuepp, R. Pearson, Jr.; and T. E. Arcado. "California ozone deposition experiment: methods, results, and opportunities." *Atmospheric Environment*. 29, no. 21 (1995): 3115-3132.

Seinfeld, J. H. *Air pollution*. New York: John Wiley, 1986.

U.S. Environmental Protection Agency. 1995. *PCRAMMIT user's guide*. 1995, Research Triangle Park, NC: U.S. Environmental Protection Agency.

van Ulden, A. P. and A. A. M. Holtslag. "Estimation of atmospheric boundary layer parameters for diffusion application." *Journal of Climatology and Applied Meteorology* 24 (1985): 1196-1207.

Venkatram, A. "Estimating the Monin-Obukhov length in the stable boundary layer for dispersion calculations." *Boundary-Layer Meterology* 19 (1980): 481-485.

Wesely, M. L. "Parameterization for surface resistance to gaseous dry deposition in regional-scale numerical models." *Atmospheric Environment* 23 (1989): 1293-1304.

Whittaker, R. H. and G. M. Woodwell. "Surface area relations of woody plants and forest communities." *American Journal of Botany* 54 (1967): 931-939.

Zannetti, P. *Air pollution modeling***.** New York: Van Nostrand Reinhold, 1990.

Zinke, P.J. "Forest interception studies in the United States." In: *Forest Hydrology*, edited by W. E. Sopper and H.W. Lull, 137-161. Oxford, UK: Pergamon Press, 1967.

13. Appendix E: Solar Potential Mapping Methodology

General Methodology

The creation of the initial solar potential map began with research of existing methodology, standards, and previously established estimates of incoming solar insolation in the Gaithersburg area. Once these were established, a number of methods were tested until one was deemed suitable to accurately portray actual values. The following methodology was chosen for the map creation:

- Conversion of LIDAR (elevation) data for the city into a raster (image) format to create a Digital Surface Model (DSM)
- Clipped raster to 200ft outside of City boundary
- Added buildings built after the LIDAR collection to the raster
- Ran Solar Analysis tool using tested values for variables
- Extracted values of potential for buildings for overlay

The spatial values present on the final map are indicative of relative potential. Minimum values of required incoming solar insolation for cost payback have not yet been calculated as they require a significant investment of time for research into electricity type and cost, cost inflation, and solar panel types. The map displays solar potential by standard deviation. Within one standard deviation from the mean signifies a value is "typical" generally. Standard deviations of above 1 and below -1 generally signify values with higher degrees of variance. The map therefore displays areas with high variance for potential. Potential is determined by a combination of azimuth, slope, and shading. Changing one of these factors (e.g. construction, tree planting) will affect the results.

Potential Disclaimers

- The LIDAR (Elevation) data used in creating this map was the most recent available. This data was collected in 2008.
- The map values for solar potential are displayed in units of standard deviation. This provides an idea of <u>relative</u> solar potential for the City of Gaithersburg only.
- Buildings constructed after 2008 may be missing. Most of these buildings were added to the DSM using the building heights creating generalized building shapes. This may affect the accuracy of the calculated solar potential for those buildings.
- This map was created to show general solar potential of the land surface. Variables, such as azimuth, slope, and shading affect these calculations and may change over time and affect actual results.
- Solar potential is represented as potential through an entire year (January – December).

14. Appendix F: Food Access Methodology

City staff reviewed the Food Access Research Atlas information from the US Department of Agriculture (USDA)[98] and noted that the census data was from 2010 and the underlying study[99] did not include smaller-volume grocery stores nor those opened after 2010. A review of the USDA methodology showed that it was appropriate for a nation-wide analysis, but would need refinement if used as a basis for a city-level analysis of food access. Below is a summary of the USDA and City methodologies, with similarities and differences noted.

Criteria	USDA Methodology[100]	City staff Methodology
Census Tract	Entire Census 2010-defined tract boundary, summary level 140; includes areas outside of the City limits as well as all areas within the City limits	Census 2010-defined tract (or part) within place/remainder (or part), summary level 80; includes only those portions of the Census tract that are within the City limits
Food Desert definition	Census tracts that satisfy both the low income and low access definitions	Criteria not used in City staff methodology; criteria are shown individually so that food access can be evaluated more generally
Grocery Store definition	Supermarkets, supercenters, and large grocery stores that sell all major categories of food (fresh meat & poultry, produce, dairy, dry & packaged foods, frozen foods) and have annual sales of at least $2 million; the list was compiled from (1) stores authorized to accept SNAP benefits and (2) a proprietary store directory from Trade Dimensions TDLinx®	Any grocery store that is open for business in 2014 and, based upon field or other verification by City staff, offers all of the following items (regardless of annual sales),: fresh meat & poultry, produce, dairy, dry & packaged foods, and frozen foods; an initial list was compiled from ESRI's Community Analyst and a Google Maps search for "grocery store"
Low Income census tract definition	Census tract's poverty rate >20% or tract's median family income ≤80% of Washington DC Metropolitan Area median family income (Treasury Department's New Markets Tax Credit low-income definition), based on 2006-2010 ACS data	Similar methodology as the USDA, except that the 2008-2012 American Community Survey (ACS) census data was used to determine poverty rates and median family incomes

[98] U.S. Department of Agriculture, Economic Research Service, *Food Access Research Atlas*, http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx (accessed Dec. 11, 2014).

[99] Michele Ver Ploeg et al., *Access to Affordable and Nutritious Food: Updated Estimates of Distance to Supermarkets Using 2010 Data*, 2012, Pub. ERR-143, Washington, DC: U.S. Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/publications/err-economic-research-report/err143.aspx

[100] U.S. Department of Agriculture, Economic Research Service, *Food Research Atlas Documentation*, http://www.ers.usda.gov/data-products/food-access-research-atlas/documentation.aspx (accessed Dec. 11, 2014).

Criteria	USDA Methodology[101]	City staff Methodology
Low Access census tract definition	At least 100 households are >0.5 miles from the nearest supermarket and have no access to a vehicle, based on 2006-2010 ACS data that was distributed from the census tract level to the ½ km grid cell level	Criteria not used in City staff methodology
Low Mobility census tract definition (USDA calls this "low vehicle availability")	At least 100 households have no access to a vehicle, based on 2010 data that was distributed from the census tract level to the ½ km grid cell level	At least 100 households have no access to a vehicle, based on 2008-2012 ACS data
Distance from households to the nearest grocery store	(1) the entire nation is divided into ½ kilometer grid cells; (2) grocery store locations are assigned to each grid cell and households are distributed from the census tract total to each grid cell, based on housing units shown in aerial photos; (3) the distance between households and the nearest grocery store is measured between the geographic center of each grid cell	(1) each grocery store is mapped as a point at the approximate entrance door; (2) each store point is buffered at 0.25, 0.50, and 1.0 miles; (3) each buffer is overlaid (intersected) with tax parcel polygons, which include an estimate of the number of households per parcel and the census tract in which the parcel is located; (4) the total number of parcels that intersect each buffer is then summarized by census tract to create an estimate of the total number of households in each census tract within each buffer distance
Number of Households	Based on Census block data from the 2010 Census of Population and Housing	Based on an estimate of the number of households for each tax parcel, using the City's July 2014 Dwelling Units and Estimated Population Report methodology
Minority Majority definition	Criteria not used in USDA methodology	Census tract with <49% of the population identified as white, non-Hispanic, based on 2008-2012 ACS census data

[101] U.S. Department of Agriculture, Economic Research Service, *Food Research Atlas Documentation*, http://www.ers.usda.gov/data-products/food-access-research-atlas/documentation.aspx (accessed Dec. 11, 2014).