FFY10

Central Virginia Blue and Green Infrastructure Protection Planning Project
FINAL REPORT

Grant Number: NA10NOS4190205

Task Number: 12.08

This project was funded, in part, by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant FY10 #NA10NOS4190205 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its subagencies.

Richmond Regional Planning District Commission
9211 Forest Hill Ave., Ste. 200
Richmond, Virginia 23235
Phone: (804) 323-2033
Fax: (804) 323-2025
www.richmondregional.org

Richmond Regional Planning District Commission

Planning district commissions make government more efficient and effective through coordinated planning and program analysis. Virginia's General Assembly created planning districts in 1968 under the authority of the *Virginia Area Development Act*-revised as the *Regional Cooperation Act* in 1995- "to promote orderly and efficient development of the physical, social and economic elements of the districts." Through planning district commissions, now 21 in number, local governments solve mutual problems which cross boundary lines and obtain expertise from professional staff and advice on making the most of scarce taxpayer dollars through intergovernmental cooperation.

Members

Town of Ashland
Faye O. Prichard
Edward L. "Ned" Henson, III.

Charles City County
Floyd H. Miles, Sr.

Chesterfield County
Steve A. Elswick
Daniel A. Gecker
Russell J. Gulley
James M. "Jim" Holland
Millard D. "Pete" Stith, Jr.
Dorothy Jaeckle
Arthur S. Warren

Goochland County
Manuel Alvarez, Jr.
James D. Crews
Ken Peterson

Hanover County
Evan Fabricant
Angela Kelly-Wiecek
C. Harold Padgett
W. Canova Peterson

Henrico County
Thomas M. Branin
John H. Mitchell
Tyrone E. Nelson
Richard W. Glover
Davie A. Kaechele
Patricia S. O'Bannon
Frank J. Thornton

New Kent County
James Burrell
Edward W. Pollard
Ron Stiers

Powhatan County
Carson Tucker
David Williams
Richard Ayers

City of Richmond
L. Ray Ashworth
Douglas G. Conner, Jr.
Kathy C. Graziano
E. Martin Jewell
Lynn McAteer
Charles R. Samuels

Richmond Regional Planning District Commission Staff

Robert A. Crum, Jr.
Executive Director
Jo A. Evans
Asst. Executive Director
Charles E. Gates, Jr.
Communications Coordinator
Peter M. Sweetland
Finance and Contracts Administrator
Julie H. Fry
Executive Secretary
Natalie Diaz-Taylor
Receptionist
Daniel N. Lysy
Director of Urban Transportation
Barbara Nelson
Principal Planner
Lee Yolton
Principal Planner
Randy Selleck
Principal Planner
Jin H. Lee
Senior Planner
Tiffany Tran
Senior Planner
Sulabh Aryal
Senior Planner
Greta Ryan
Data Analyst

Sharon E. Robeson
Administrative Secretary
Jacqueline S. Stewart
Director of Planning
Barbara V. Jacocks*
Principal Planner
Sarah G. Stewart*
Senior Planner
Anne Darby*
Senior Planner
William Gammel
Associate Planner
Michelle E. Fults
GIS Manager
Leigh R. Medford*
Associate Planner/GIS
Tom Dunn
Principal Emergency Management Planner
Kathy Robins
Senior Emergency Management Planner
Quillia Brooks*
Administrative Secretary
Jacob Epstein*
Intern

*Principal project staff

Table of Contents

Technical Assistance Task #12.08

Executive Summary ……1

Product #1: *Title:* INTERIM REPORT ……2

Product #2: *Title:* GIS DATA AND MAPPING OF RIPARIAN CORRIDOR GREEN INFRASTRUCTURE ……3

Product #3: *Title:* RIPARIAN CORRIDOR GREEN INFRASTRUCTURE PRIORITIATION GUIDE ……....4

Product #4: *Title:* GREEN INFRASTRUCTURE ASSET IMPLEMENTATION…… 5

Appendix A: Richmond Crater Green Infrastructure Project Interim Report

Appendix B: CITYgreen Analysis Reports

Appendix C: The Value of Green Infrastructure in Land Development

Appendix D: Green Infrastructure & Low Impact Development Assessment: Fort Lee, Virginia

Appendix E: Green Infrastructure Presentations

Central Virginia Blue and Green Infrastructure Protection Planning Project FINAL REPORT

FFY10

Executive Summary

RRPDC staff and Crater PDC staff partnered on this important bi-regional project. At the commencement of the grant term, RRPDC staff and Crater PDC staff drafted and agreed on a final scope of work for the project. This scope of work is included in the Interim Report.

RRPDC staff and Crater PDC staff coordinated with local Planning Directors and other local planning staff members in designing the project and final products. It was decided that PDC staff would use sites along riparian corridors as supplied by local planning staffs. Development and re-greening scenarios of these sites would be analyzed using CITYgreen software and GIS. Sites chosen for analysis represent the spectrum of geographical features and development densities found throughout the two regions. The sites for analysis include:

- Suburban Growth Area- proximity to major transportation routes, mixed use development planned
- Urban Infill- in central city, planned for residential near community center or school
- Suburbanizing Commercial Corridor- suburbanizing area on commercial corridor, planned for big-box commercial
- Military Growth Area- near existing military facility, population and employment expected to grow in near future

Upon completion of the scenario analyses, PDC staff compiled the findings in a Prioritization Guide brochure that summarizes how green infrastructure and low impact development practices can contribute to water quality across all development types. The quantification of benefits estimated by the CITYgreen software will help planners, elected leaders, citizens, and developers to prioritize elements of future development plans given anticipated benefits to water quality. Special attention was paid to the importance of riparian buffers to water quality, particularly in instances of waterways previously identified as impaired by Virginia DEQ. The brochure document is available from RRPDC staff and will soon be posted to the RRPDC website: www.richmondregional.org

Throughout the grant project, PDC staff provided educational presentations to various interested groups, including: 1) October 2010 RRPDC Board introduction to benefits of green infrastructure and overview of products illustrating green infrastructure planning; 2) December 2010 Virginia Coastal Zone Management Program's Coastal Partners Workshop with an overview of the role of blue and green infrastructure and review of work accomplished by PDC staff; 3) January 2011, regional group of water quality, local government, and environmental stakeholder organizations to educate and inspire greater understanding of the importance of green infrastructure in the City of Richmond and to cooperate in planning and implementation efforts; 4) March 2011 Middle James Roundtable Annual Meeting for general education and lessons about green infrastructure planning that would be useful across the entire Middle James Watershed; and 5) August 2011, participation in presentation to a meeting of Northern Virginia localities at the NVRC office on green infrastructure projects that could be transferable to similar situations in Northern Virginia.

Product #1: Interim Report

At the commencement of the grant term, RRPDC staff and Crater PDC staff drafted and agreed on a final scope of work for the project. This scope of work is included in the Interim Report. Included in the report is an overview of tasks to be accomplished and a chart assigning task responsibility.

Further detail than that included was defined through meetings and conversations with local Planning Directors and other local planning staff members.

A copy of the Interim Report is included in Appendix A.

Product #2: GIS Data and Mapping of Riparian Corridor Green Infrastructure

PDC staff aimed to analyze multiple sites across the two regions using CITYgreen software and GIS. CITYgreen is a software package developed by American Forests that analyzes land cover data for quantifiable environmental value. Scenarios can also be analyzed to see how land cover changes will impact water and air quality. For example, CITYgreen can estimate the additional stormwater runoff that will occur as a result of enlarging a building or parking lot. In addition, CITYgreen software will also estimate an associated cost for the additional capacity necessary to store and treat the additional runoff.

RRPDC staff and Crater PDC staff coordinated with local Planning Directors and other local planning staff members to identify opportune sites for analysis. Development and re-greening scenarios of these sites were analyzed using CITYgreen software and GIS. PDC staff began each analysis by mapping existing blue and green infrastructure assets in proximity to each analysis site in GIS. Maps of these findings were used during consultation meetings with local planning staff where detailed elements of the development and re-greening scenarios were discussed. RRPDC staff used information gathered at these meetings to design a series of scenarios for each site.

Sites chosen for analysis represent the spectrum of geographical features and development densities found throughout the two regions. The sites for analysis included:

- Suburban Growth Area- proximity to major transportation routes, mixed use development planned
- Urban Infill- in central city, planned for residential near community center or school
- Suburbanizing Commercial Corridor- suburbanizing area on commercial corridor, planned for big-box commercial
- Military Growth Area- near existing military facility, population and employment expected to grow in near future

CITYgreen produces a report displaying the analysis findings. One report for each site scenario analyzed is produced. Copies of these analysis reports are included in Appendix B. Further explanation of the findings can be found in the Prioritization Guide, described in the next section and included as Appendix C.

Product #3: Riparian Corridor Green Infrastructure Prioritization Guide

PDC staff compiled the results of the site scenario CITYgreen analyses in a Prioritization Guide brochure that summarizes how green infrastructure and low impact development practices can contribute to water quality across all development types. The guide begins with an overview of green infrastructure and environmental planning principles. The majority of the Guide reviews the findings of the CITYgreen analyses of each site. The Guide concludes with priority statements about the measurable environmental significance of green infrastructure assets and the invaluable economic benefits it innately offers to the landscape. Special attention was paid to the importance of riparian buffers to water quality, particularly in instances of waterways previously identified as impaired by Virginia DEQ.

The quantification of benefits estimated by the CITYgreen software will help planners, elected leaders, citizens, and developers to prioritize elements of future development plans given anticipated benefits to water quality. The brochure document is included in Appendix C. Copies are also available from RRPDC staff and will soon be posted to the RRPDC website: www.richmondregional.org

Crater PDC staff used the findings of one set of site scenarios to produce a small report for use by local planners in considering anticipated population and employment growth in the vicinity of Fort Lee, Virginia. This particular set of scenarios was based on projected growth of the area. A copy of this report can be found in Appendix D.

Product #4: Green Infrastructure Asset Implementation

RRPDC and Crater PDC staff worked with locality staff to develop and present relevant and educational presentations about green infrastructure planning in the local environment, or broader as requested. In October 2010, PDC staff provided an informational presentation to the RRPDC Board on the function of green infrastructure and past work accomplished by PDC staff in the arena of green infrastructure planning. In December 2010, PDC staff presented at the Virginia Coastal Zone Management Program's Coastal Partners Workshop. The aim of the presentation was to overview the role of green and blue infrastructure with Coastal Program Partners and to review work accomplished by PDC staff. In January 2011, PDC staff presented to a large group of water quality, local government, and environmental stakeholder organizations. The aim of the meeting and presentation was to inform and inspire the organizations to understand the importance of green infrastructure in the City of Richmond and to cooperate in planning and implementation efforts. In March 2011, PDC staff presented at the Middle James Roundtable Annual Meeting. The presentation was aimed at general education and lessons about green infrastructure planning that would be useful across the entire Middle James Watershed. In August of 2011, PDC staff provided an informational presentation to a meeting of Northern Virginia localities at the NVRC office. RRPDC staff provided project specific insight that was transferable to such a project in the Northern Virginia.

Copies of the aforementioned presentations are included in Appendix E in order of date presented.

Appendix A

Central Virginia Conservation Corridor and Sustainable Community Planning Project

— Interim Report —

January 1, 2011

Richmond Regional Planning District Commission
9211 Forest Hill Avenue, Suite 200
Richmond, Virginia 23235
Phone: (804) 323-2033
Fax: (804) 323-2025
www.richmondregional.org

Crater Planning District Commission
1964 Wakefield Street
P.O. Box 1808
Petersburg, VA 23805
Phone: (804) 861-1666
Fax: (804) 732-8972
www.craterpdc.org

Project Overview

Year 1/Phase I of this multi-year project was focused on identifying and mapping natural resource features that were included in a bi-regional, prioritized green infrastructure overlay and conservation corridor system that was depicted in a widely distributed report. Year 2/Phase II of this project had a dual focus on green infrastructure implementation in rural and urban areas in the Richmond and Crater regions. For the urban focus, RRPDC staff worked with the City of Richmond staff and Green Infrastructure Center staff to identify and map blue and green infrastructure assets. PDC staff worked with a committee to prioritize assets and develop final blue and green infrastructure asset map(s) to be used by the city to implement blue/green infrastructure. For the rural implementation focus, RRPDC and Crater PDC staff provided educational training opportunities for rural localities learn about green infrastructure and its implementation. For the final phase of this project will continue to identify and analyze green infrastructure assets in the Richmond and Crater regions. The third year will continue the trend of scaling down area of analysis from region, to city, and now, to riparian corridor and site. Staff from both PDCs will work with local staff to identify priority corridors and site locations for green infrastructure asset identification and analysis. CITYgreen software and GIS will be used to quantify to ecological and economic benefits provided by green infrastructure. Scenario analyses will illustrate the benefits of green infrastructure on a site scale and along a riparian corridor; priorities enhanced green infrastructure implementation will be illustrated as well.

Project Partners

As in Phase I and II of the project, the Richmond Regional Planning District Commission (RRPDC) has joined with the Crater Planning District Commission (Crater PDC). Planning District Commissions (PDCs) are governmental subdivisions of the Commonwealth of Virginia; PDCs serve as regional planning agencies for their constituent localities. In the past two phases of this project, the Richmond Regional PDC has also joined with the Green Infrastructure Center, Inc. in Charlottesville, Virginia. The Green Infrastructure Center (GIC) is a non-profit organization that assists communities in developing strategies and tools for preserving green infrastructure resources. For this phase of the project, the GIC has obtained funding to use the City of Richmond green infrastructure asset assessment that was completed by RRPDC staff as a basis for further planning efforts in the neighborhood of Bellemeade in the City of Richmond. For more detailed information on the project(s) of the Green Infrastructure Center, see their website at www.gicinc.org. As a sign of continued cooperation between the RRPDC, the GIC and the City of Richmond, one of the locations chosen for analysis in Phase III of this project will be located in the Bellemeade neighborhood. The analysis results will be shared with the GIC and the City of Richmond to contribute to current and future planning efforts.

TASK 1: GIS Data and Mapping of Riparian Corridor Green Infrastructure

RRPDC and Crater PDC staff will work with locality staff to identify sites and riparian corridors for mapping and analysis. PDC staff will map existing conditions of the chosen sites and

corridors using data available from federal, state, and local sources. If necessary, PDC staff will create any missing data in order to create accurate maps.

TASK 2: CITYgreen Analysis

CITYgreen Overview: CITYgreen software is an extension for ArcGIS software that allows the user to perform analysis of land cover data to determine and quantify the ecosystem services of trees. RRPDC staff will use CITYgreen software to run analysis estimating the pollution reduction benefits and dollar value benefits of green infrastructure in the two regions.

CITYgreen Regional Corridor and Site Analysis: PDC staff will work with locality staff to devise a series of scenarios for analysis with CITYgreen software. The scenarios will be designed to illustrate the crucial role of green infrastructure in water quality protection and enhancement. Local planning knowledge and documents such as site plans and zoning ordinances will be sources for scenario development.

TASK 3: Riparian Corridor Green Infrastructure Prioritization Guide

The maps and analysis conducted by and for each corridor and site will be summarized in a report produced by RRPDC staff. The report will include green infrastructure asset maps, CITYgreen analysis, and examples of green infrastructure planning implementation tools. The report will be designed as an educational brochure for public officials and the public at-large. It will plainly illustrate priorities for green infrastructure enhancement among sites along riparian corridors.

TASK 4: Green Infrastructure Asset Implementation

RRPDC and Crater PDC staff will provide educational presentations describing the nature of green infrastructure and general tools for green infrastructure implementation. PDC staff will actively offer these presentations to all member localities and provide them to those interested.

Scope of Work Summary Chart:

Task	Timeframe	RRPDC	Crater PDC
Inquire with local governments about interest in green infrastructure	Throughout	X	X
Provide educational presentations on green infrastructure	Throughout	X	X
Finalize scope of work	October 2010 - January 2011	X	X
Initial meeting with localities to discuss project	January 2011	X	
Work with localities to identify sites and corridors for analysis	January 2011 - March 2011	X	X
Site 1 - Prepare initial maps for scenario development, meet with locality, develop scenarios, analyze scenarios	April 2011 - May 2011	X	
Site 2 - Prepare initial maps for scenario development, meet with locality, develop scenarios, analyze scenarios	April 2011 - May 2011	X	
Site 3 - Prepare initial maps for scenario development, meet with locality, develop scenarios, analyze scenarios	May 2011 - June 2011	X	
Site 4 - Prepare initial maps for scenario development, meet with locality, develop scenarios, analyze scenarios	June 2011 - July 2011	X	X
If needed, Site 5 - Prepare Initial maps for scenario development, meet with locality, develop scenarios, analyze scenarios	June 2011 - July 2011	X	
Create maps and images for final document	July 2011 - August 2011	X	
Text and layout for final document	July 2011 - September 2011	X	
Send out for review of participating localities	August 2011 - September 2011	X	X
final edits	September 2011	X	
Send final to printer, distribute final product	September 2011	X	

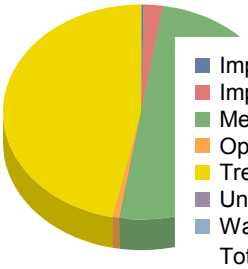
Appendix B

Analysis Report

for

East Ashland

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures	0.2	0.2%
Impervious Surfaces: Paved	3.5	2.3%
Meadow (Continuous grass, generally mowed, not grazed)	76.6	49.9%
Open Space - Grass/Scattered Trees	1.4	0.9%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	71.7	46.7%
Unclassified: Unclassified	0.0	0.0%
Water Area	0.0	0.0%
Total:	153.5	100.0%

Tree Canopy: 71.7 acres (46.7%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	128	63
Ozone:	3,706	$13,093
Nitrogen Dioxide:	958	$3,386
Particulate Matter:	1,789	$4,220
Sulfur Dioxide:	767	$662
Totals:	**7,348**	**21,424**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**3,084**
Tons Sequestered **(Annually)**:	**24**

Analysis Report

for

East Ashland

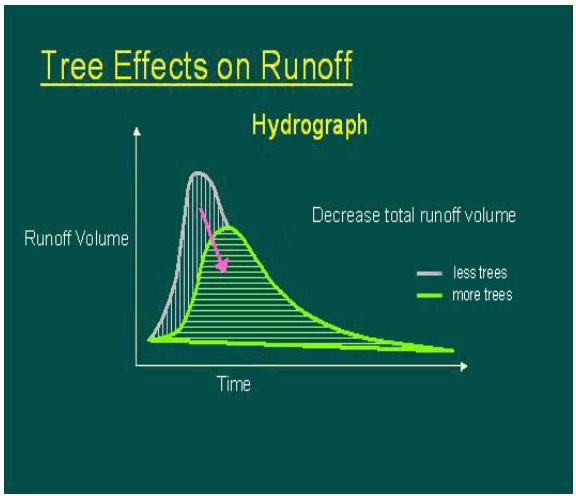
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

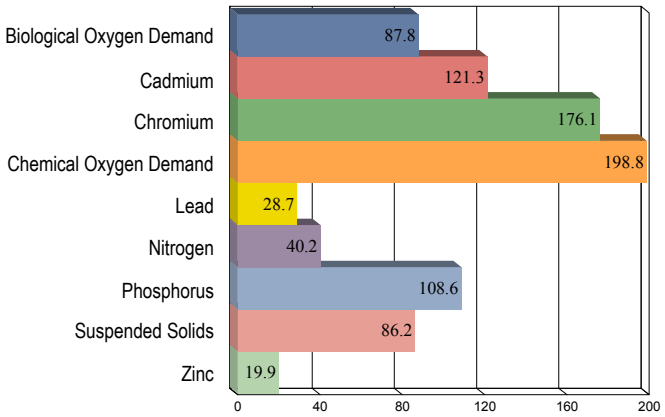
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	71
Curve Number of replacement land cover:	84
Dominant soil type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Paved	
Additional cu. ft. storage needed:	**461,351**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$922,702**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$80,445**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

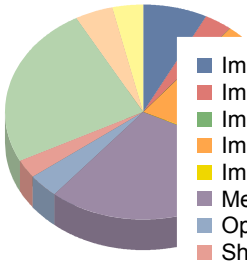


Analysis Report

for

East Ashland: Scenario 1 - East Ashland Design Guidelines

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	11.5	7.5%
Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	5.4	3.5%
Impervious Surfaces: Paved	0.0	0.0%
Impervious Surfaces: Paved: Drain to sewer	32.1	20.9%
Impervious Surfaces: Unpaved: Gravel	0.6	0.4%
Meadow (Continuous grass, generally mowed, not grazed)	44.4	29.0%
Open Space - Grass/Scattered Trees: Grass cover > 75%	5.3	3.4%
Shrub: Ground cover > 75%	4.4	2.9%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	37.6	24.5%
Trees: Grass/turf understory: Ground cover > 75%	6.7	4.3%
Trees: Impervious understory	5.6	3.7%
Total:	153.5	100.0%

Tree Canopy: 49.9 acres (32.5%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	89	44
Ozone:	2,579	$9,110
Nitrogen Dioxide:	667	$2,356
Particulate Matter:	1,245	$2,936
Sulfur Dioxide:	534	$460
Totals:	**5,113**	**14,907**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**2,146**
Tons Sequestered **(Annually)**:	**17**

Analysis Report

for

East Ashland: Scenario 1 - East Ashland Design Guidelines

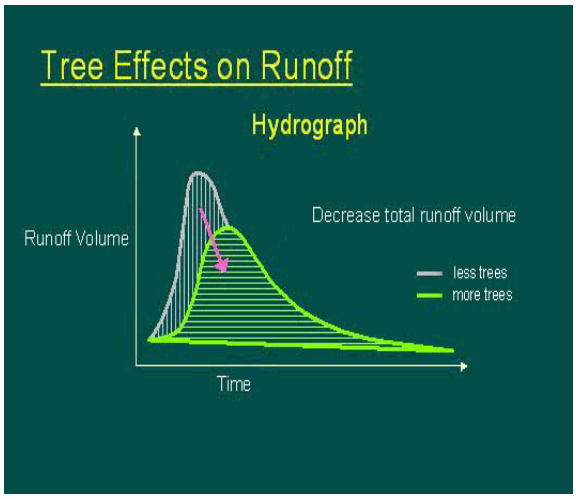
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

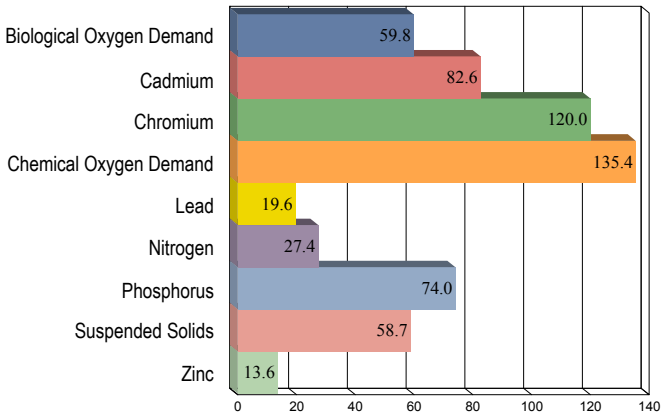
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	71
Curve Number of replacement land cover:	80
Dominant soil type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Paved	
Additional cu. ft. storage needed:	**295,331**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$590,662**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$51,497**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

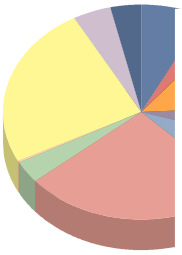
Percent change in contaminant loadings



Analysis Report

for

East Ashland: Scenario 2 - EADG with LID



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: All other buildings	11.5	7.5%
Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	5.4	3.5%
Impervious Surfaces: Paved	0.0	0.0%
Impervious Surfaces: Paved: Drain to open ditches	20.1	13.1%
Impervious Surfaces: Unpaved: Gravel	0.3	0.2%
Low Impact Development: Bioretention / Rain Gardens	8.2	5.3%
Low Impact Development: Porous Pavement - Properly Maintained	12.2	7.9%
Meadow (Continuous grass, generally mowed, not grazed)	40.4	26.3%
Open Space - Grass/Scattered Trees: Grass cover > 75%	5.3	3.5%
Shrub: Ground cover > 75%	0.3	0.2%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	37.6	24.5%
Trees: Grass/turf understory: Ground cover > 75%	6.7	4.3%
Trees: Impervious understory	5.6	3.7%
Total:	153.5	100.0%

Tree Canopy: 49.9 acres (32.5%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	89	44
Ozone:	2,579	$9,110
Nitrogen Dioxide:	667	$2,356
Particulate Matter:	1,245	$2,936
Sulfur Dioxide:	534	$460
Totals:	**5,113**	**14,907**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**2,146**
Tons Sequestered **(Annually)**:	**17**

Analysis Report

for

East Ashland: Scenario 2 - EADG with LID

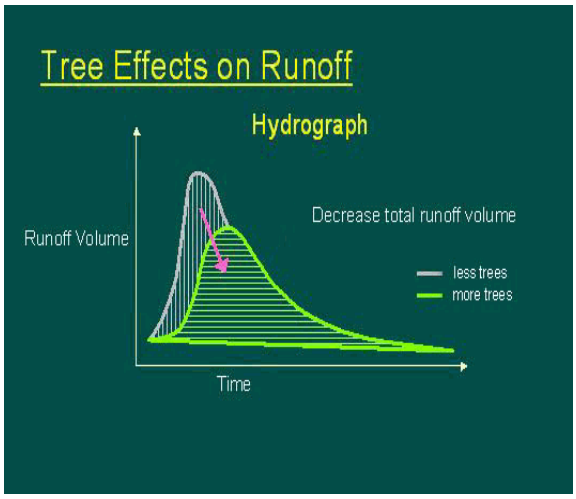
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

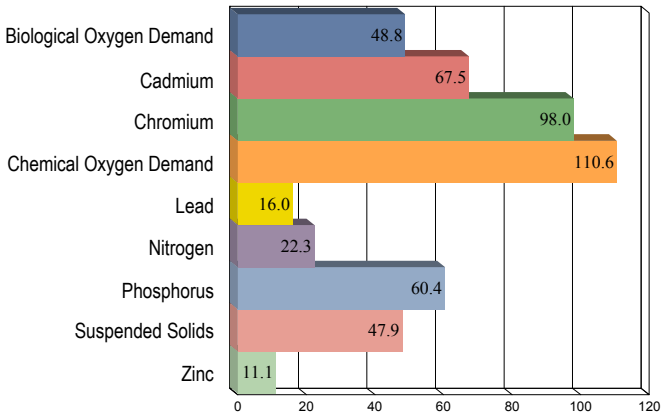
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	71
Curve Number of replacement land cover:	78
Dominant soil type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Paved	
Additional cu. ft. storage needed:	**235,380**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$470,759**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$41,043**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

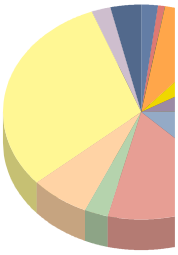
Percent change in contaminant loadings



Analysis Report

for

East Ashland: Scenario 3 - EADG with Maximum LID



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: All other buildings	2.9	1.9%
Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	1.3	0.9%
Impervious Surfaces: Paved	0.0	0.0%
Impervious Surfaces: Paved: Drain to open ditches	13.1	8.5%
Low Impact Development: Bioretention / Rain Gardens	8.1	5.3%
Low Impact Development: Green Roofs	12.6	8.2%
Low Impact Development: Porous Pavement - Properly Maintained	19.5	12.7%
Meadow (Continuous grass, generally mowed, not grazed)	25.2	16.4%
Open Space - Grass/Scattered Trees: Grass cover > 75%	4.2	2.8%
Shrub: Ground cover > 75%	10.7	6.9%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	47.1	30.7%
Trees: Grass/turf understory: Ground cover > 75%	3.3	2.2%
Trees: Impervious understory	5.4	3.5%
Total:	153.5	100.0%

Tree Canopy: 55.8 acres (36.4%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state's Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	100	49
Ozone:	2,887	$10,201
Nitrogen Dioxide:	747	$2,638
Particulate Matter:	1,394	$3,288
Sulfur Dioxide:	597	$516
Totals:	**5,725**	**16,691**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree's dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**2,403**
Tons Sequestered **(Annually)**:	**19**

Analysis Report

for

East Ashland: Scenario 3 - EADG with Maximum LID

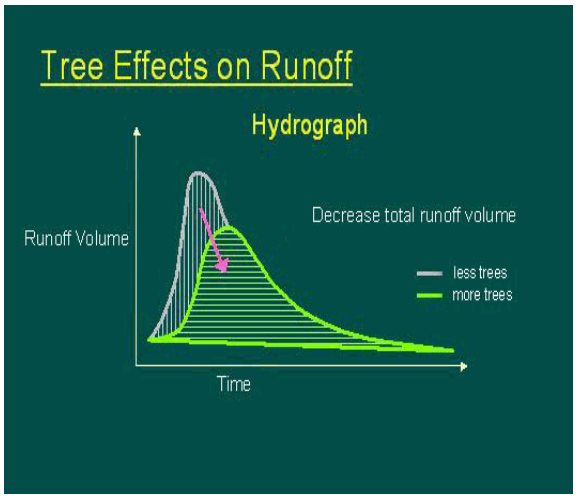
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

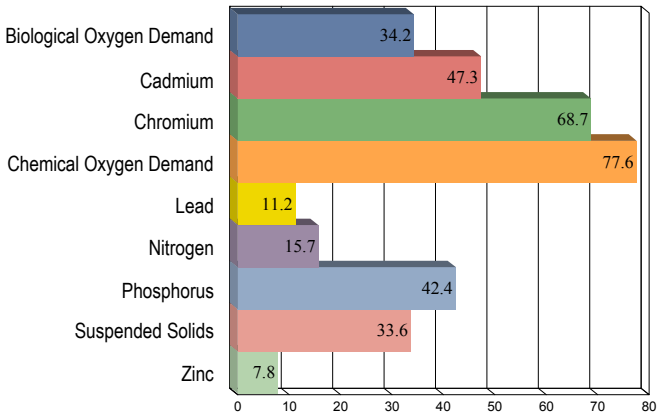
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	71
Curve Number of replacement land cover:	76
Dominant soil type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Paved	
Additional cu. ft. storage needed:	**159,829**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$319,659**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$27,869**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

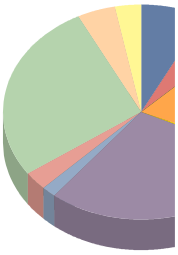
Percent change in contaminant loadings



Analysis Report

for

East Ashland: Scenario 4 - EADG Altered Parking & Density



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: All other buildings	11.5	7.5%
Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	8.3	5.4%
Impervious Surfaces: Paved	0.0	0.0%
Impervious Surfaces: Paved: Drain to sewer	28.5	18.6%
Impervious Surfaces: Unpaved: Gravel	0.6	0.4%
Meadow (Continuous grass, generally mowed, not grazed)	44.4	28.9%
Open Space - Grass/Scattered Trees: Grass cover > 75%	2.6	1.7%
Shrub: Ground cover > 75%	4.3	2.8%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	42.0	27.4%
Trees: Grass/turf understory: Ground cover > 75%	6.7	4.3%
Trees: Impervious understory	4.6	3.0%
Total:	153.5	100.0%

Tree Canopy: 53.3 acres (34.7%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	95	47
Ozone:	2,757	$9,741
Nitrogen Dioxide:	713	$2,519
Particulate Matter:	1,331	$3,140
Sulfur Dioxide:	570	$492
Totals:	**5,467**	**15,939**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**2,295**
Tons Sequestered **(Annually)**:	**18**

Analysis Report

for

East Ashland: Scenario 4 - EADG Altered Parking & Density

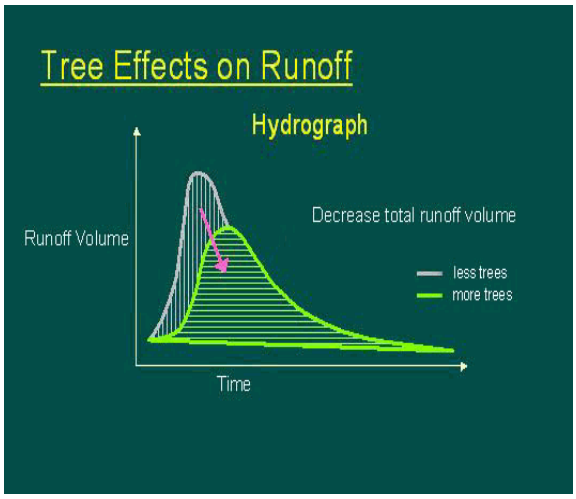
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

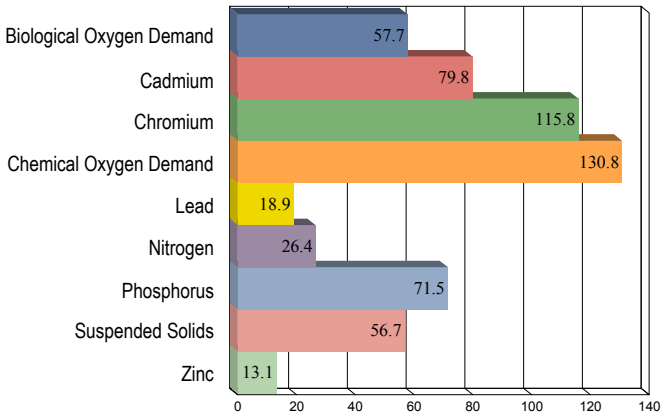
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	71
Curve Number of replacement land cover:	80
Dominant soil type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Paved	
Additional cu. ft. storage needed:	**283,810**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$567,620**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$49,488**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

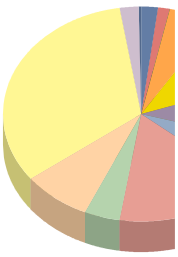
Percent change in contaminant loadings



Analysis Report

for

East Ashland: Scenario 5 - EADG Altered Parking & Density with LID



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: All other buildings	2.9	1.9%
Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	2.1	1.4%
Impervious Surfaces: Paved	0.0	0.0%
Impervious Surfaces: Paved: Drain to open ditches	8.7	5.7%
Low Impact Development: Bioretention / Rain Gardens	16.5	10.8%
Low Impact Development: Green Roofs	14.8	9.7%
Low Impact Development: Porous Pavement - Properly Maintained	10.5	6.8%
Meadow (Continuous grass, generally mowed, not grazed)	25.0	16.3%
Open Space - Grass/Scattered Trees: Grass cover > 75%	6.5	4.3%
Shrub: Ground cover > 75%	12.5	8.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	50.2	32.7%
Trees: Grass/turf understory: Ground cover > 75%	3.3	2.2%
Trees: Impervious understory	0.5	0.3%
Total:	153.5	100.0%

Tree Canopy: 54.0 acres (35.2%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state's Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	96	47
Ozone:	2,790	$9,859
Nitrogen Dioxide:	722	$2,550
Particulate Matter:	1,347	$3,178
Sulfur Dioxide:	577	$498
Totals:	**5,533**	**16,132**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree's dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**2,322**
Tons Sequestered **(Annually)**:	**18**

Analysis Report

for

East Ashland: Scenario 5 - EADG Altered Parking & Density with LID

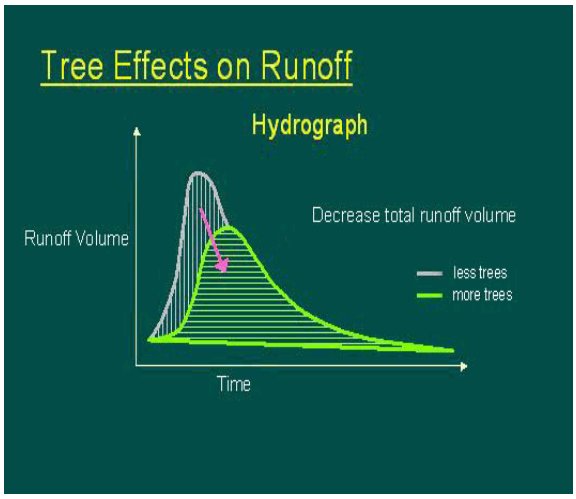
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

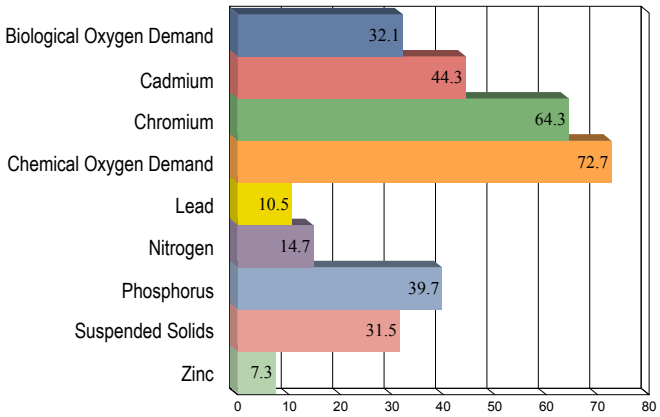
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	71
Curve Number of replacement land cover:	76
Dominant soil type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Paved	
Additional cu. ft. storage needed:	**149,011**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$298,022**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$25,983**



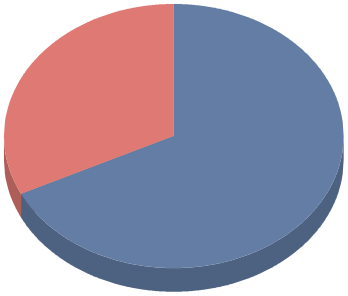
Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report
for
Bellmeade Parcel



Land cover in acres and percentages

Meadow (Continuous grass, generally mowed, not grazed)	5.1	67.7%
Trees	2.4	32.3%
Total:	7.5	100.0%

Tree Canopy: 2.4 acres (32.3%)

Air Pollution Removal

Nearest air quality reference city: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	4	$2
Ozone:	125	$443
Nitrogen Dioxide:	32	$114
Particulate Matter:	60	$143
Sulfur Dioxide:	26	$22
Totals:	**248**	**$724**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Tons Stored **(Total)**:	**104**
Tons Sequestered **(Annually)**:	**1**

Stormwater Management

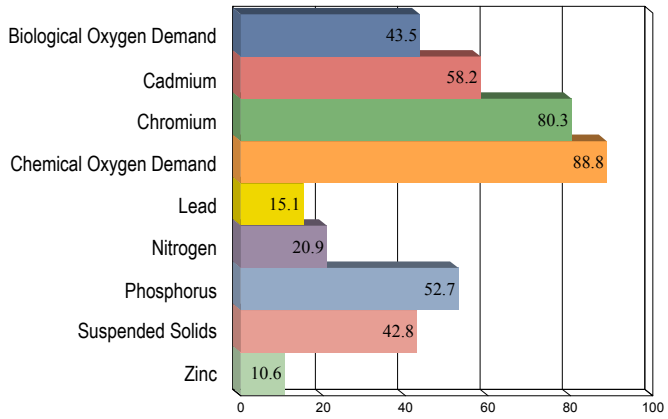
Water Quantity (Runoff Volume)

2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	73
Curve Number of replacement land cover:	80
Dominant Soil Type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**11,654**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$23,308**
Annual Stormwater Value:	**$2,032**

(based on 20-year financing at 6% interest)

Water Quality (Contaminant Loading)

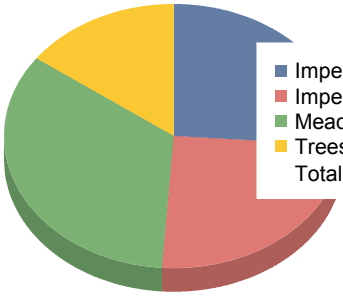
Percent change in contaminant loadings



Analysis Report

for

Bellmeade Parcel: Buildout, Fewer Trees



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	2.0	26.0%
Impervious Surfaces: Paved: Drain to sewer	1.9	25.0%
Meadow (Continuous grass, generally mowed, not grazed)	2.6	34.0%
Trees	1.1	15.0%
Total:	7.5	100.0%

Tree Canopy: 1.1 acres (15.0%)

Air Pollution Removal

Nearest air quality reference city: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	2	$1
Ozone:	58	$206
Nitrogen Dioxide:	15	$53
Particulate Matter:	28	$66
Sulfur Dioxide:	12	$10
Totals:	**116**	**$337**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Tons Stored **(Total)**:	**48**
Tons Sequestered **(Annually)**:	**0**

Stormwater Management

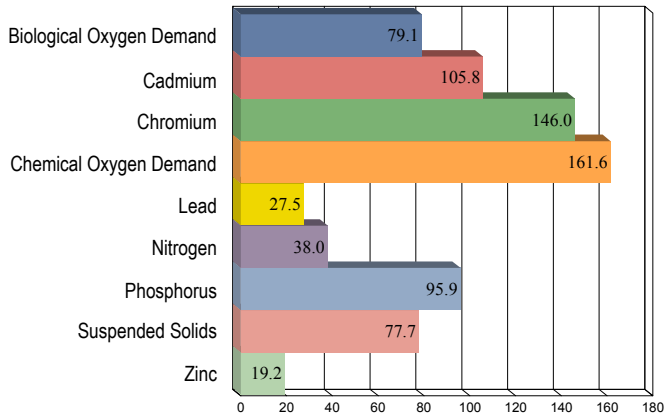
Water Quantity (Runoff Volume)

2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	73
Curve Number of replacement land cover:	86
Dominant Soil Type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**23,099**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$46,197**
Annual Stormwater Value:	**$4,028**

(based on 20-year financing at 6% interest)

Water Quality (Contaminant Loading)

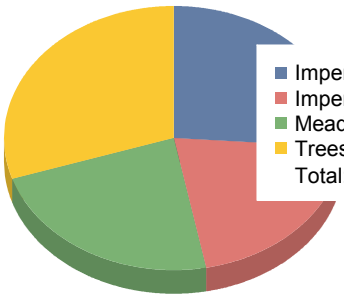
Percent change in contaminant loadings



Analysis Report

for

Bellmeade Parcel: Buildout, More Trees



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	2.0	26.0%
Impervious Surfaces: Paved: Drain to sewer	1.6	21.0%
Meadow (Continuous grass, generally mowed, not grazed)	1.7	23.0%
Trees	2.3	30.0%
Total:	7.5	100.0%

Tree Canopy: 2.3 acres (30.0%)

Air Pollution Removal

Nearest air quality reference city: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	4	$2
Ozone:	117	$412
Nitrogen Dioxide:	30	$106
Particulate Matter:	56	$133
Sulfur Dioxide:	24	$21
Totals:	**231**	**$674**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Tons Stored **(Total)**:	**97**
Tons Sequestered **(Annually)**:	**1**

Stormwater Management

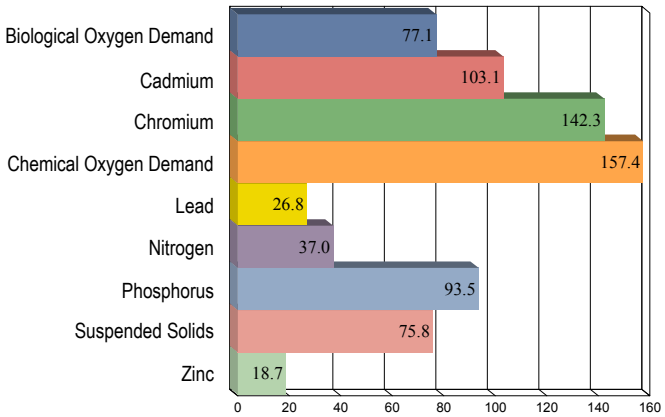
Water Quantity (Runoff Volume)

2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	73
Curve Number of replacement land cover:	85
Dominant Soil Type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**22,397**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$44,794**
Annual Stormwater Value:	**$3,905**

(based on 20-year financing at 6% interest)

Water Quality (Contaminant Loading)

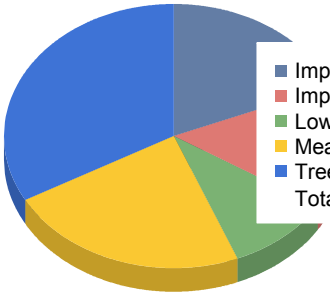
Percent change in contaminant loadings



Analysis Report

for

Bellmeade Parcel: LID Light Buildout



Land cover in acres and percentages

Impervious Surfaces: Buildings/ structures: Single-family homes, <3 stories, w/ AC	1.4	19.0%
Impervious Surfaces: Paved: Drain to sewer	1.1	15.0%
Low Impact Development	0.8	10.0%
Meadow (Continuous grass, generally mowed, not grazed)	1.7	23.0%
Trees	2.5	33.0%
Total:	7.5	100.0%

Tree Canopy: 2.5 acres (33.0%)

Air Pollution Removal

Nearest air quality reference city: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	4	$2
Ozone:	128	$453
Nitrogen Dioxide:	33	$117
Particulate Matter:	62	$146
Sulfur Dioxide:	27	$23
Totals:	**254**	**$741**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Tons Stored **(Total)**:	**107**
Tons Sequestered **(Annually)**:	**1**

Stormwater Management

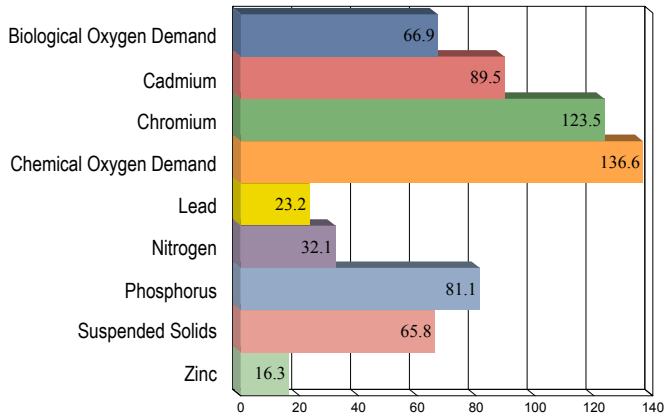
Water Quantity (Runoff Volume)

2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	73
Curve Number of replacement land cover:	84
Dominant Soil Type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**18,966**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$37,932**
Annual Stormwater Value:	**$3,307**

(based on 20-year financing at 6% interest)

Water Quality (Contaminant Loading)

Percent change in contaminant loadings

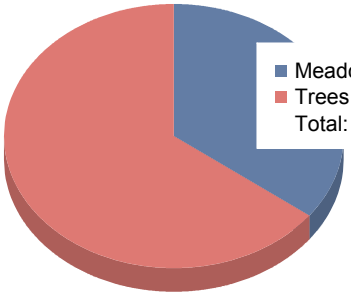


Analysis Report

for

Bellmeade Parcel: Tree Canopy Double

Land cover in acres and percentages



Meadow (Continuous grass, generally mowed, not grazed)	2.7	35.4%
Trees	4.9	64.6%
Total:	7.5	100.0%

Tree Canopy: 4.9 acres (64.6%)

Air Pollution Removal

Nearest air quality reference city: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	9	$4
Ozone:	251	$886
Nitrogen Dioxide:	65	$229
Particulate Matter:	121	$286
Sulfur Dioxide:	52	$45
Totals:	**498**	**$1,451**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Tons Stored **(Total)**:	**209**
Tons Sequestered **(Annually)**:	**2**

Stormwater Management

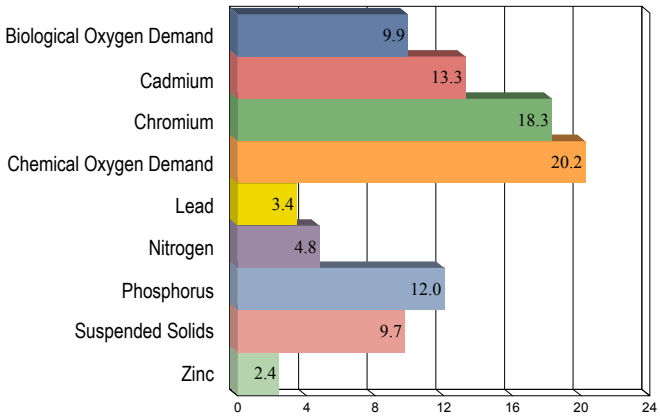
Water Quantity (Runoff Volume)

2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	73
Curve Number of replacement land cover:	74
Dominant Soil Type: **C**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**2,450**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$4,901**
Annual Stormwater Value:	**$427**

(based on 20-year financing at 6% interest)

Water Quality (Contaminant Loading)

Percent change in contaminant loadings

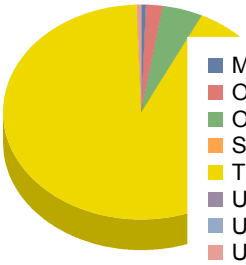


Analysis Report

for

Big Box Site

Land cover in acres and percentages



Meadow (Continuous grass, generally mowed, not grazed)	0.3	0.4%
Open Space - Grass/Scattered Trees: Grass cover < 50%	1.4	2.1%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	3.1	4.7%
Shrub: Ground cover > 75%	0.0	0.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	60.3	92.2%
Urban	0.0	0.0%
Urban: Bare	0.0	0.0%
Urban: Residential: 0.25ac Lots	0.4	0.5%
Total:	65.5	100.0%

Tree Canopy: 60.3 acres (92.2%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	108	53
Ozone:	3,120	$11,023
Nitrogen Dioxide:	807	$2,851
Particulate Matter:	1,506	$3,553
Sulfur Dioxide:	646	$557
Totals:	**6,186**	**18,037**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**2,597**
Tons Sequestered **(Annually)**:	**20**

Analysis Report

for

Big Box Site

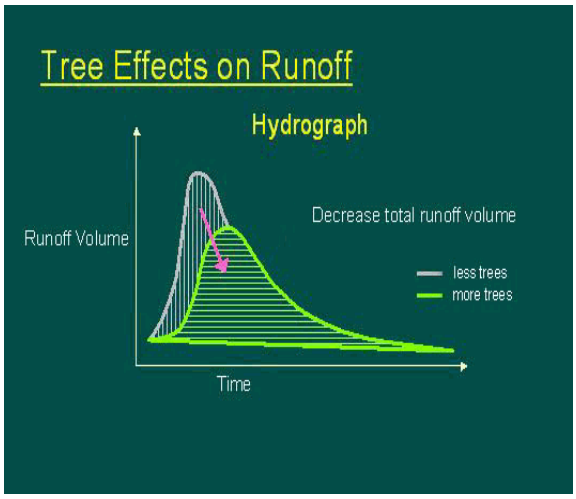
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

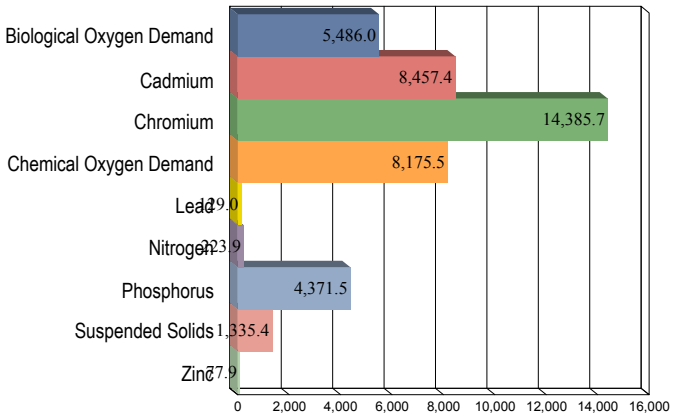
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	56
Curve Number of replacement land cover:	96
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**590,762**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$1,181,525**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$103,011**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

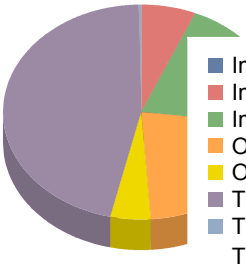


Analysis Report

for

Big Box Site: Scenario 1: Big Box, fewer trees

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures	0.0	0.0%
Impervious Surfaces: Buildings/ structures: All other buildings	4.2	6.4%
Impervious Surfaces: Paved	13.5	20.6%
Open Space - Grass/Scattered Trees: Grass cover > 75%	14.3	21.9%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	3.0	4.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	30.2	46.2%
Trees: Impervious understory	0.2	0.3%
Total:	65.5	100.0%

Tree Canopy: 30.4 acres (46.5%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	54	27
Ozone:	1,574	$5,560
Nitrogen Dioxide:	407	$1,438
Particulate Matter:	760	$1,792
Sulfur Dioxide:	326	$281
Totals:	**3,120**	**9,098**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**1,310**
Tons Sequestered **(Annually)**:	**10**

Analysis Report

for

Big Box Site: Scenario 1: Big Box, fewer trees

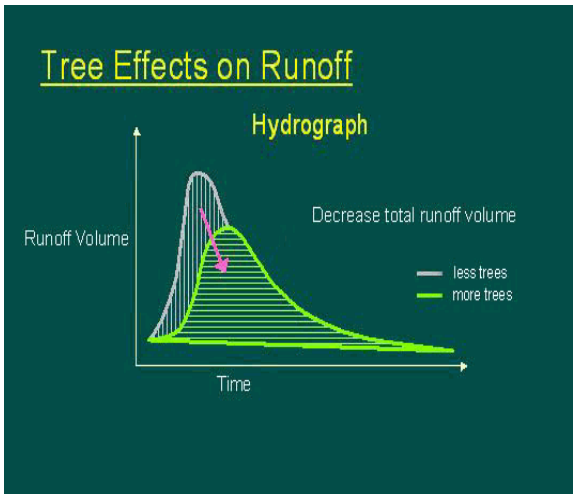
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

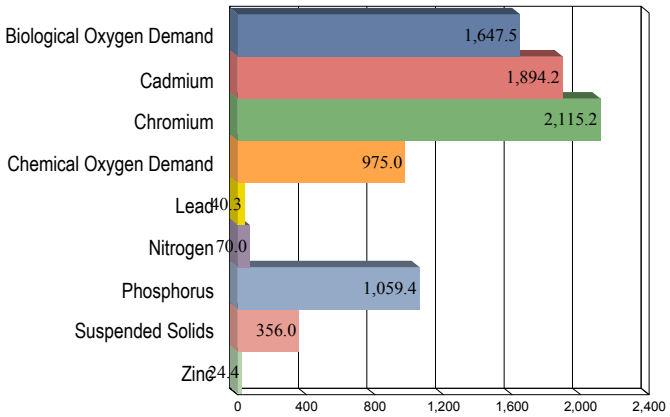
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	56
Curve Number of replacement land cover:	69
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**116,017**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$232,034**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$20,230**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

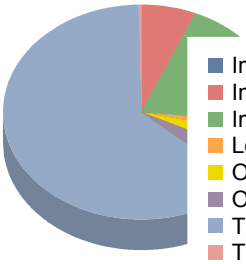


Analysis Report

for

Big Box Site: Scenario 2 - more trees, bioretention

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures	0.0	0.0%
Impervious Surfaces: Buildings/ structures: All other buildings	4.2	6.4%
Impervious Surfaces: Paved	13.5	20.6%
Low Impact Development: Bioretention / Rain Gardens	1.1	1.7%
Open Space - Grass/Scattered Trees: Grass cover > 75%	2.2	3.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	3.0	4.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	41.3	63.0%
Trees: Impervious understory	0.2	0.3%
Total:	65.5	100.0%

Tree Canopy: 41.5 acres (63.3%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	74	36
Ozone:	2,144	$7,573
Nitrogen Dioxide:	554	$1,959
Particulate Matter:	1,035	$2,441
Sulfur Dioxide:	443	$383
Totals:	**4,250**	**12,392**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**1,784**
Tons Sequestered **(Annually)**:	**14**

Analysis Report

for

Big Box Site: Scenario 2 - more trees, bioretention

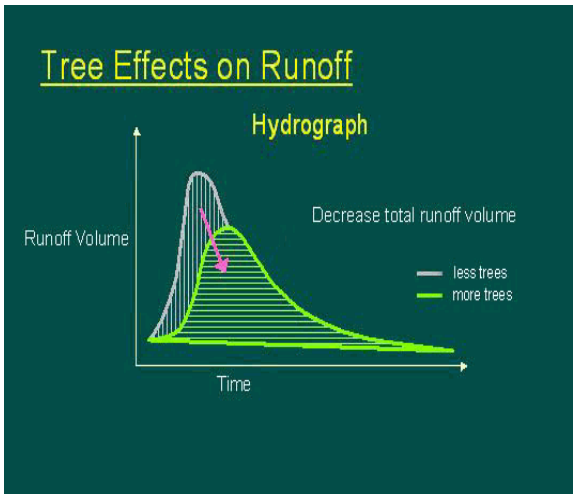
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

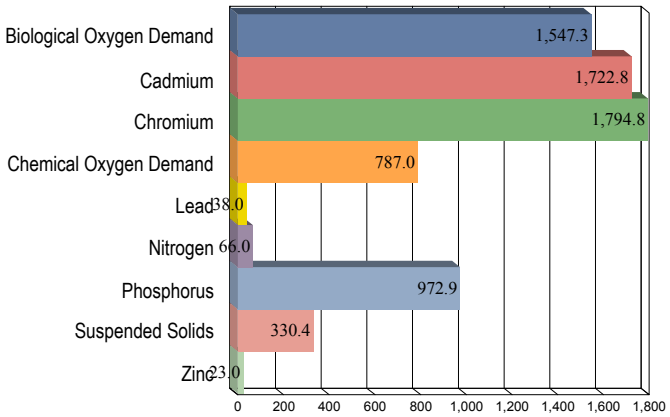
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	56
Curve Number of replacement land cover:	68
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**107,953**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$215,907**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$18,824**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

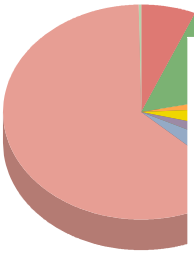


Analysis Report

for

Big Box Site: Scenario 3 - parking infiltration and Pervious Pavement

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures	0.0	0.0%
Impervious Surfaces: Buildings/ structures: All other buildings	4.2	6.4%
Impervious Surfaces: Paved	10.0	15.3%
Low Impact Development: Bioretention / Rain Gardens	1.6	2.4%
Low Impact Development: Porous Pavement - Properly Maintained	3.1	4.7%
Open Space - Grass/Scattered Trees: Grass cover > 75%	2.2	3.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	3.0	4.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	41.3	63.0%
Trees: Impervious understory	0.1	0.2%
Total:	65.5	100.0%

Tree Canopy: 41.4 acres (63.2%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	74	36
Ozone:	2,138	$7,554
Nitrogen Dioxide:	553	$1,954
Particulate Matter:	1,032	$2,435
Sulfur Dioxide:	442	$382
Totals:	**4,239**	**12,360**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**1,780**
Tons Sequestered **(Annually)**:	**14**

Analysis Report

for

Big Box Site: Scenario 3 - parking infiltration and Pervious Pavement

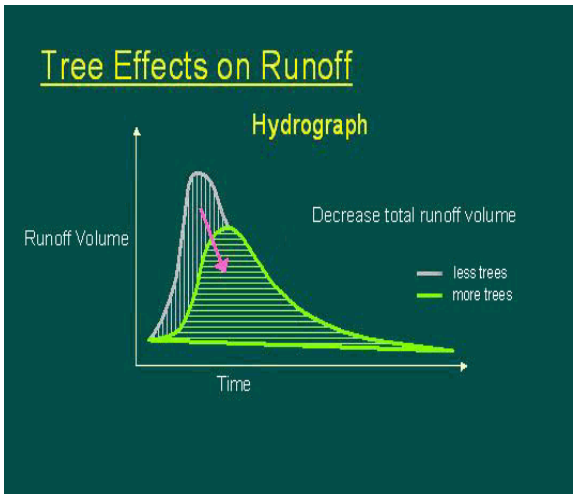
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

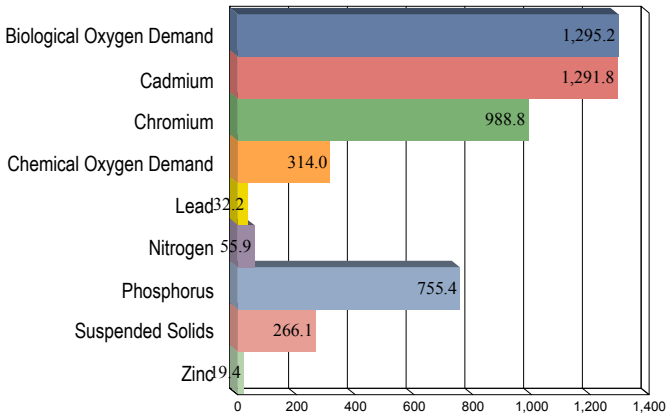
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	56
Curve Number of replacement land cover:	66
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**88,450**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$176,899**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$15,423**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area

Tree Canopy: 7,628.2 acres (29.7%)

Land cover in acres and percentages

Cropland: Row Crops	1,898.4	7.4%
Meadow (Continuous grass, generally mowed, not grazed)	450.1	1.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	301.4	1.2%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,943.8	11.4%
Pasture/Range (Continuous forage for grazing)	300.5	1.2%
Shrub	5,561.1	21.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	7,628.2	29.7%
Urban	607.8	2.4%
Urban: Residential: 0.25ac Lots	994.7	3.9%
Urban: Residential: 0.5ac Lots	3,913.4	15.2%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	13,600	6,674
Ozone:	394,393	$1,393,410
Nitrogen Dioxide:	101,998	$360,365
Particulate Matter:	190,397	$449,117
Sulfur Dioxide:	81,599	$70,422
Totals:	**781,986**	**2,279,988**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**328,254**
Tons Sequestered **(Annually)**:	**2,556**

Analysis Report

for

Fort Lee Study Area

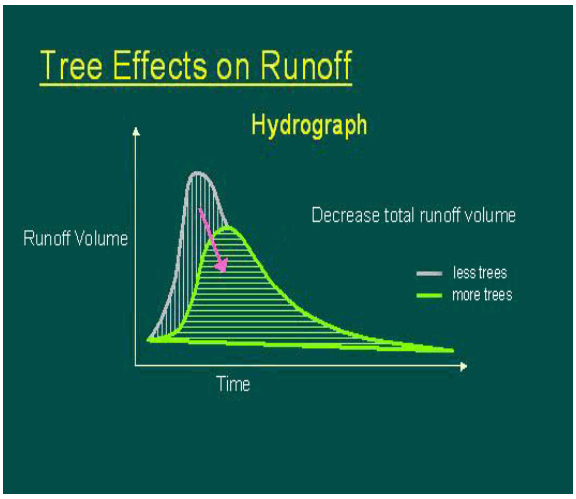
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

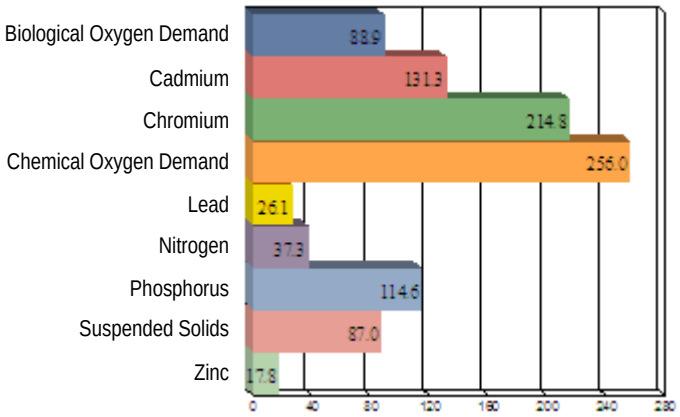
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	80
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**61,346,787**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$122,693,573**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$10,696,985**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 25% Development Increase

Tree Canopy: 5,171.4 acres (20.1%)

Land cover in acres and percentages

Cropland: Row Crops	1,285.8	5.0%
Impervious Surfaces: Buildings/ structures	0.0	0.0%
Meadow (Continuous grass, generally mowed, not grazed)	303.4	1.2%
Open Space - Grass/Scattered Trees: Grass cover < 50%	203.9	0.8%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,994.1	7.8%
Pasture/Range (Continuous forage for grazing)	203.2	0.8%
Shrub	3,769.9	14.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	5,171.4	20.1%
Urban	1,406.6	5.5%
Urban: Commercial/Business	308.6	1.2%
Urban: Industrial	1,353.3	5.3%
Urban: Residential: 0.25ac Lots	3,456.2	13.4%
Urban: Residential: 0.5ac Lots	5,143.1	20.0%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	9,220	4,525
Ozone:	267,369	$944,628
Nitrogen Dioxide:	69,147	$244,300
Particulate Matter:	129,075	$304,467
Sulfur Dioxide:	55,318	$47,741
Totals:	**530,128**	**1,545,662**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**222,532**
Tons Sequestered **(Annually)**:	**1,732**

Analysis Report

for

Fort Lee Study Area: 25% Development Increase

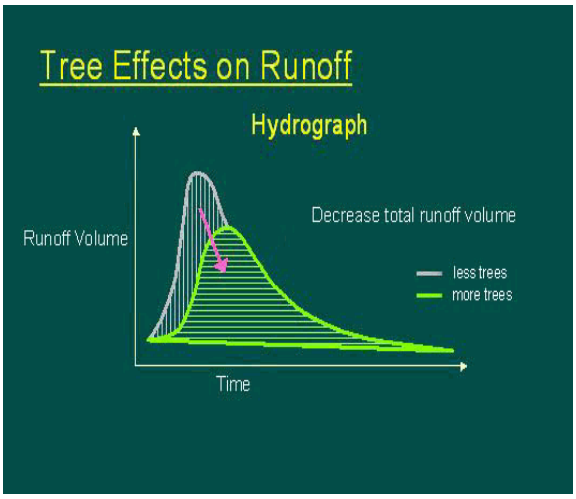
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

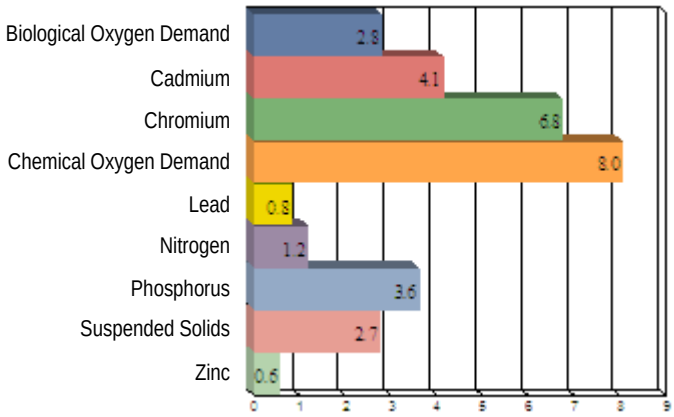
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	69
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**1,633,621**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$3,267,242**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$284,853**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 25% Increase 10% LID

Tree Canopy: 5,168.8 acres (20.1%)

Land cover in acres and percentages

Cropland: Row Crops	1,285.8	5.0%
Low Impact Development	1,157.2	4.5%
Meadow (Continuous grass, generally mowed, not grazed)	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover < 50%	205.7	0.8%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,005.8	7.8%
Pasture/Range (Continuous forage for grazing)	205.7	0.8%
Shrub	3,780.2	14.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	5,168.8	20.1%
Urban	1,260.1	4.9%
Urban: Commercial/Business	282.9	1.1%
Urban: Industrial	1,208.6	4.7%
Urban: Residential: 0.25ac Lots	3,111.6	12.1%
Urban: Residential: 0.5ac Lots	4,628.8	18.0%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	9,215	4,522
Ozone:	267,236	$944,158
Nitrogen Dioxide:	69,113	$244,179
Particulate Matter:	129,010	$304,316
Sulfur Dioxide:	55,290	$47,717
Totals:	**529,864**	**1,544,893**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**222,421**
Tons Sequestered **(Annually)**:	**1,732**

Analysis Report

for

Fort Lee Study Area: 25% Increase 10% LID

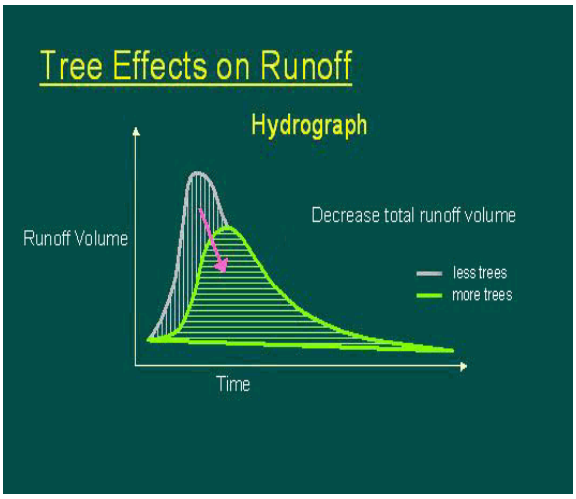
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

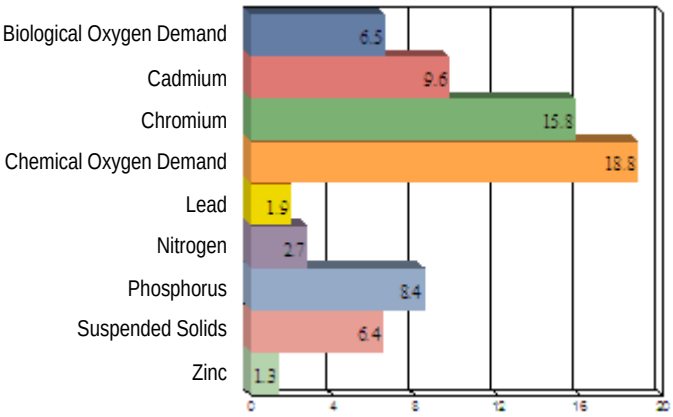
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	70
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**3,840,740**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$7,681,479**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$669,706**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 25% Increase 3% LID

Tree Canopy: 5,168.8 acres (20.1%)

Land cover in acres and percentages

Cropland: Row Crops	1,285.8	5.0%
Low Impact Development	334.3	1.3%
Meadow (Continuous grass, generally mowed, not grazed)	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover < 50%	205.7	0.8%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,005.8	7.8%
Pasture/Range (Continuous forage for grazing)	205.7	0.8%
Shrub	3,780.2	14.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	5,168.8	20.1%
Urban	1,362.9	5.3%
Urban: Commercial/Business	308.6	1.2%
Urban: Industrial	1,311.5	5.1%
Urban: Residential: 0.25ac Lots	3,343.0	13.0%
Urban: Residential: 0.5ac Lots	4,988.8	19.4%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	9,215	4,522
Ozone:	267,236	$944,158
Nitrogen Dioxide:	69,113	$244,179
Particulate Matter:	129,010	$304,316
Sulfur Dioxide:	55,290	$47,717
Totals:	**529,864**	**1,544,893**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**222,421**
Tons Sequestered **(Annually)**:	**1,732**

Analysis Report

for

Fort Lee Study Area: 25% Increase 3% LID

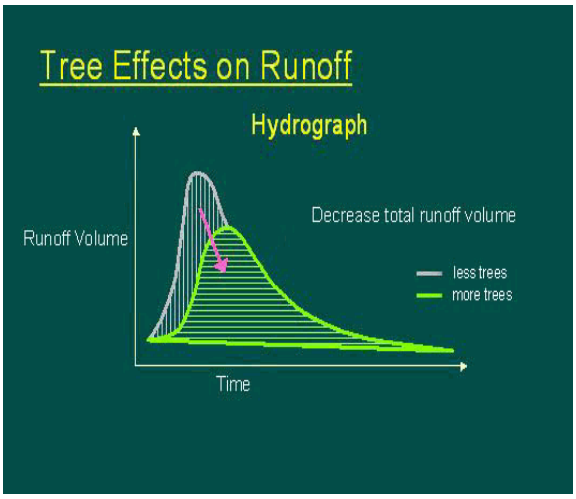
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

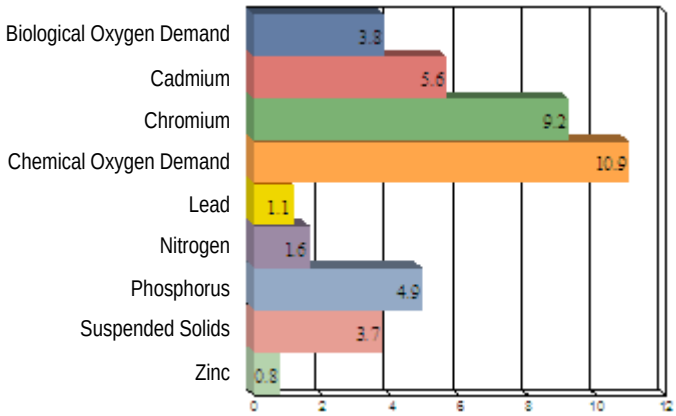
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	70
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**2,219,147**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$4,438,295**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$386,951**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 50% Development Increase

Tree Canopy: 2,713.0 acres (10.6%)

Land cover in acres and percentages

Cropland: Row Crops	673.7	2.6%
Meadow (Continuous grass, generally mowed, not grazed)	159.4	0.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	108.0	0.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,046.6	4.1%
Pasture/Range (Continuous forage for grazing)	108.0	0.4%
Shrub	1,977.5	7.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	2,713.0	10.6%
Urban	2,206.4	8.6%
Urban: Commercial/Business	614.6	2.4%
Urban: Industrial	2,705.3	10.5%
Urban: Residential: 0.25ac Lots	5,914.5	23.0%
Urban: Residential: 0.5ac Lots	6,372.3	24.8%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	4,837	2,374
Ozone:	140,266	$495,566
Nitrogen Dioxide:	36,276	$128,164
Particulate Matter:	67,714	$159,728
Sulfur Dioxide:	29,020	$25,046
Totals:	**278,113**	**810,877**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**116,743**
Tons Sequestered **(Annually)**:	**909**

Analysis Report

for

Fort Lee Study Area: 50% Development Increase

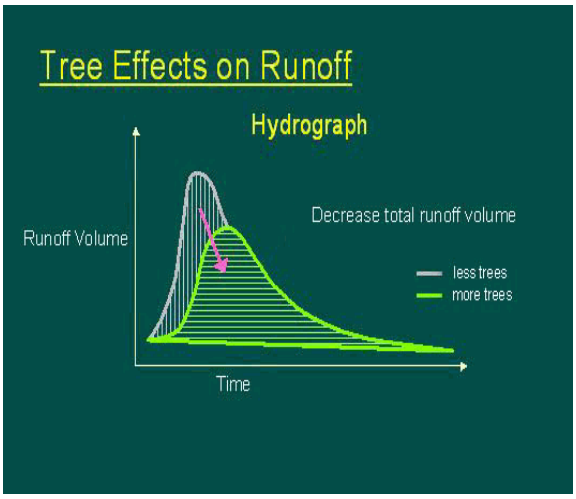
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

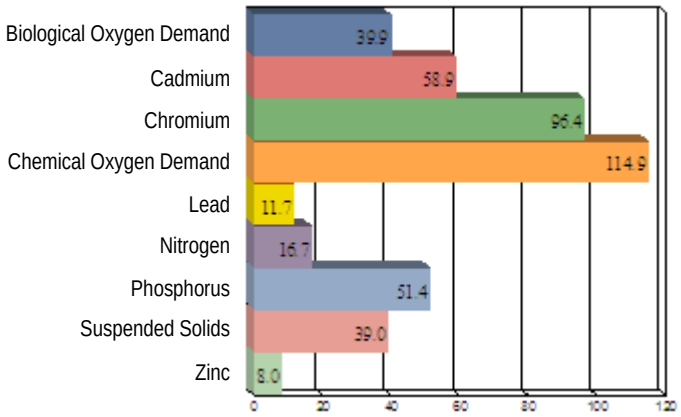
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	74
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**25,053,213**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$50,106,426**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$4,368,507**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 50% Increase 10% LID

Tree Canopy: 2,725.8 acres (10.6%)

Land cover in acres and percentages

Cropland: Row Crops	668.6	2.6%
Low Impact Development	1,774.4	6.9%
Meadow (Continuous grass, generally mowed, not grazed)	154.3	0.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	102.9	0.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,054.3	4.1%
Pasture/Range (Continuous forage for grazing)	102.9	0.4%
Shrub	1,980.1	7.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	2,725.8	10.6%
Urban	1,980.1	7.7%
Urban: Commercial/Business	565.7	2.2%
Urban: Industrial	2,443.0	9.5%
Urban: Residential: 0.25ac Lots	5,323.1	20.7%
Urban: Residential: 0.5ac Lots	5,734.5	22.3%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	4,860	2,385
Ozone:	140,930	$497,914
Nitrogen Dioxide:	36,448	$128,771
Particulate Matter:	68,035	$160,485
Sulfur Dioxide:	29,158	$25,164
Totals:	**279,431**	**814,720**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**117,297**
Tons Sequestered **(Annually)**:	**913**

Analysis Report

for

Fort Lee Study Area: 50% Increase 10% LID

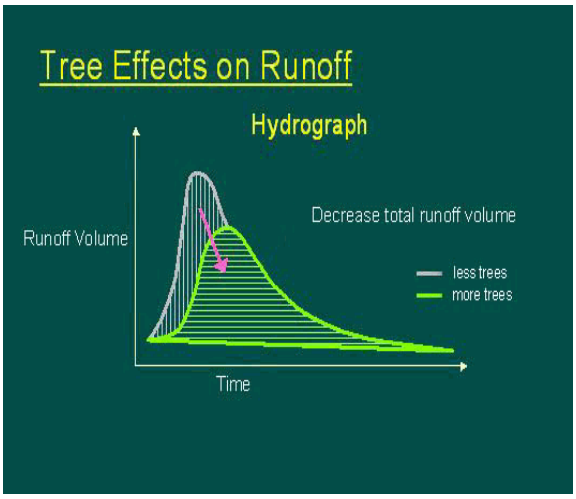
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

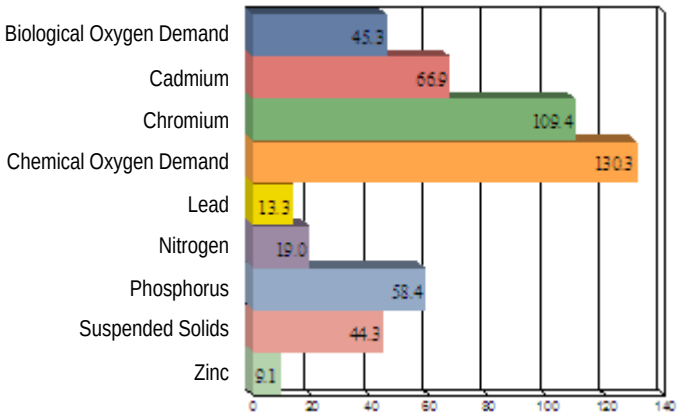
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	75
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**28,726,847**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$57,453,694**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$5,009,075**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 50% Increase 3% LID

Tree Canopy: 2,725.8 acres (10.6%)

Land cover in acres and percentages

Cropland: Row Crops	668.6	2.6%
Impervious Surfaces: Buildings/ structures	0.0	0.0%
Low Impact Development	540.0	2.1%
Meadow (Continuous grass, generally mowed, not grazed)	154.3	0.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	102.9	0.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,054.3	4.1%
Pasture/Range (Continuous forage for grazing)	102.9	0.4%
Shrub	1,980.1	7.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	2,725.8	10.6%
Urban	2,134.4	8.3%
Urban: Commercial/Business	591.5	2.3%
Urban: Industrial	2,623.0	10.2%
Urban: Residential: 0.25ac Lots	5,734.5	22.3%
Urban: Residential: 0.5ac Lots	6,197.4	24.1%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	4,860	2,385
Ozone:	140,930	$497,914
Nitrogen Dioxide:	36,448	$128,771
Particulate Matter:	68,035	$160,485
Sulfur Dioxide:	29,158	$25,164
Totals:	**279,431**	**814,720**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**117,297**
Tons Sequestered **(Annually)**:	**913**

Analysis Report

for

Fort Lee Study Area: 50% Increase 3% LID

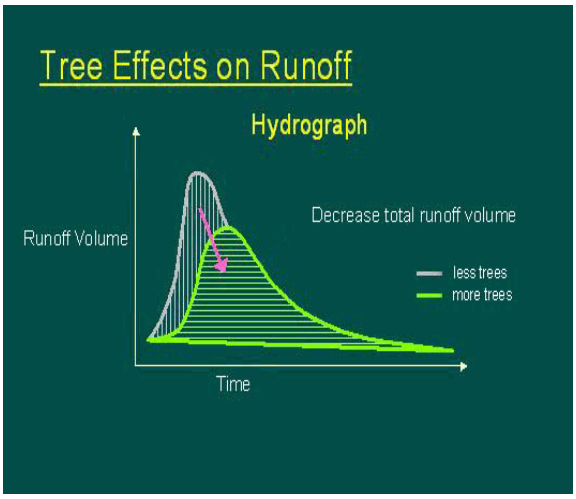
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

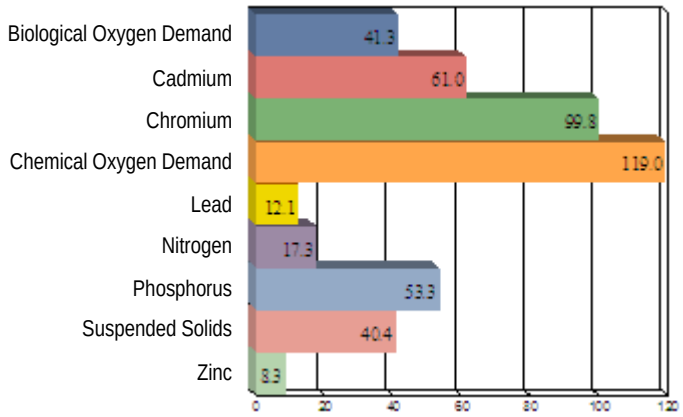
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	74
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**26,023,107**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$52,046,214**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$4,537,626**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 75% Development Increase

Tree Canopy: 254.6 acres (1.0%)

Land cover in acres and percentages

Cropland: Row Crops	64.3	0.2%
Impervious Surfaces: Buildings/ structures	0.0	0.0%
Meadow (Continuous grass, generally mowed, not grazed)	15.4	0.1%
Open Space - Grass/Scattered Trees: Grass cover < 50%	10.3	0.0%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	97.7	0.4%
Pasture/Range (Continuous forage for grazing)	10.3	0.0%
Shrub	185.2	0.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	254.6	1.0%
Urban	3,006.1	11.7%
Urban: Commercial/Business	920.6	3.6%
Urban: Industrial	4,057.9	15.8%
Urban: Residential: 0.25ac Lots	8,375.5	32.6%
Urban: Residential: 0.5ac Lots	7,601.5	29.6%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	454	223
Ozone:	13,162	$46,503
Nitrogen Dioxide:	3,404	$12,027
Particulate Matter:	6,354	$14,989
Sulfur Dioxide:	2,723	$2,350
Totals:	**26,098**	**76,092**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**10,955**
Tons Sequestered **(Annually)**:	**85**

Analysis Report

for

Fort Lee Study Area: 75% Development Increase

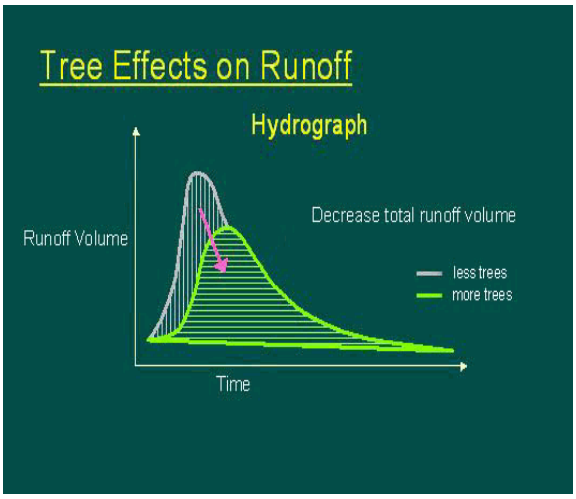
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

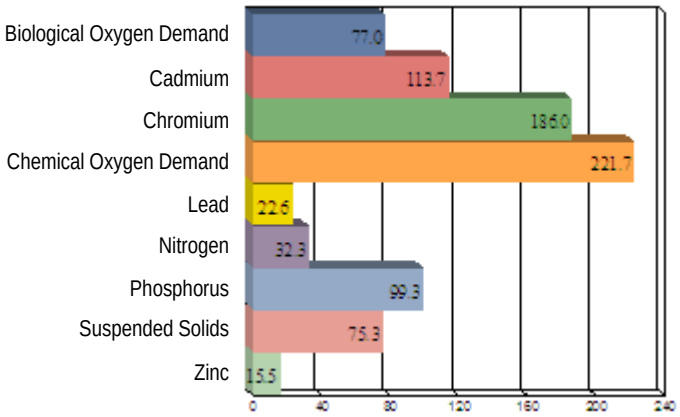
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	79
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**51,925,582**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$103,851,164**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$9,054,218**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 75% Increase 10% LID

Tree Canopy: 257.2 acres (1.0%)

Land cover in acres and percentages

Cropland: Row Crops	77.1	0.3%
Impervious Surfaces: Buildings/ structures	5.1	0.0%
Low Impact Development	2,391.5	9.3%
Meadow (Continuous grass, generally mowed, not grazed)	25.7	0.1%
Open Space - Grass/Scattered Trees: Grass cover < 50%	10.3	0.0%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	102.9	0.4%
Pasture/Range (Continuous forage for grazing)	10.3	0.0%
Shrub	180.0	0.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	257.2	1.0%
Urban	2,700.1	10.5%
Urban: Commercial/Business	822.9	3.2%
Urban: Industrial	3,651.6	14.2%
Urban: Residential: 0.25ac Lots	7,534.6	29.3%
Urban: Residential: 0.5ac Lots	6,840.3	26.6%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	458	225
Ozone:	13,295	$46,973
Nitrogen Dioxide:	3,438	$12,148
Particulate Matter:	6,418	$15,140
Sulfur Dioxide:	2,751	$2,374
Totals:	**26,361**	**76,860**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**11,066**
Tons Sequestered **(Annually)**:	**86**

Analysis Report

for

Fort Lee Study Area: 75% Increase 10% LID

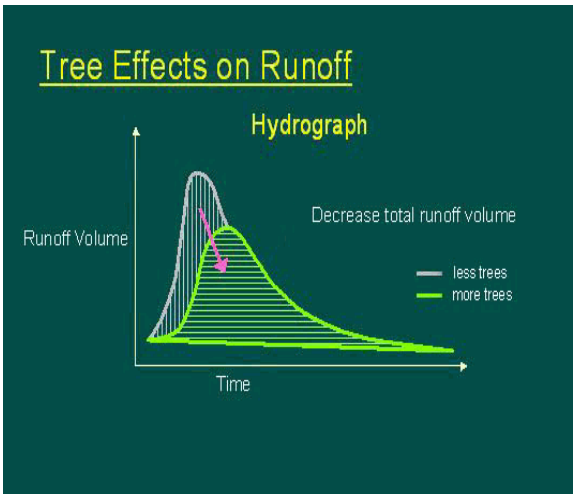
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

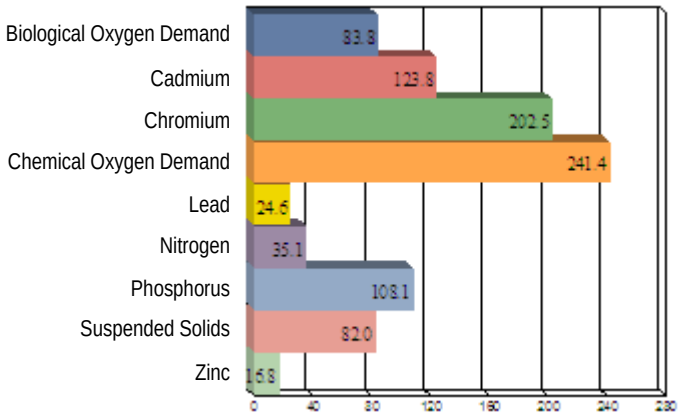
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	80
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**57,285,773**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$114,571,546**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$9,988,869**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 75% Increase 3% LID

Tree Canopy: 257.2 acres (1.0%)

Land cover in acres and percentages

Cropland: Row Crops	51.4	0.2%
Impervious Surfaces: Buildings/ structures	5.1	0.0%
Low Impact Development	720.0	2.8%
Meadow (Continuous grass, generally mowed, not grazed)	25.7	0.1%
Open Space - Grass/Scattered Trees: Grass cover < 50%	10.3	0.0%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	102.9	0.4%
Pasture/Range (Continuous forage for grazing)	10.3	0.0%
Shrub	180.0	0.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	257.2	1.0%
Urban	2,905.8	11.3%
Urban: Commercial/Business	900.0	3.5%
Urban: Industrial	3,934.5	15.3%
Urban: Residential: 0.25ac Lots	8,126.1	31.6%
Urban: Residential: 0.5ac Lots	7,380.3	28.7%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	458	225
Ozone:	13,295	$46,973
Nitrogen Dioxide:	3,438	$12,148
Particulate Matter:	6,418	$15,140
Sulfur Dioxide:	2,751	$2,374
Totals:	**26,361**	**76,860**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**11,066**
Tons Sequestered **(Annually)**:	**86**

Analysis Report

for

Fort Lee Study Area: 75% Increase 3% LID

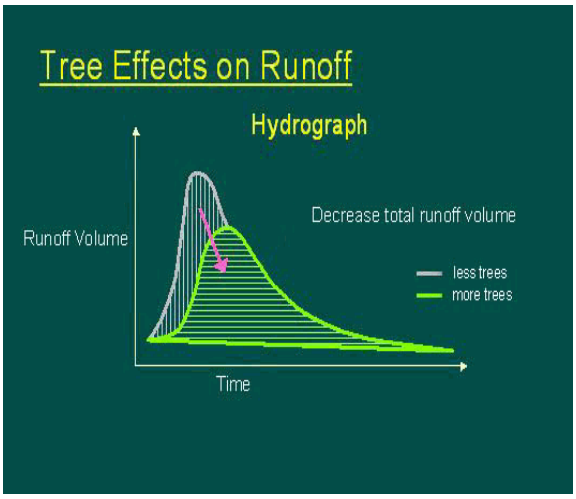
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

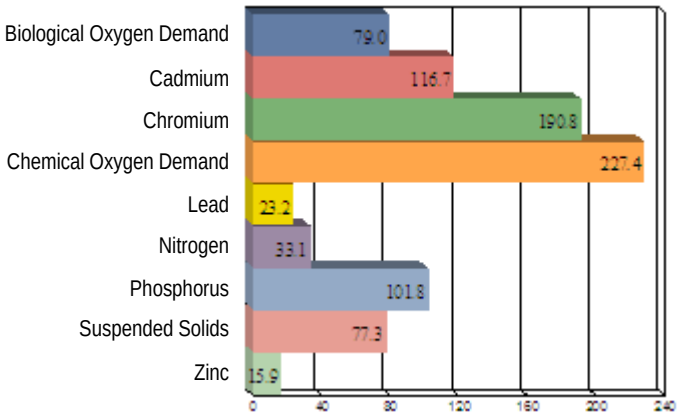
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	79
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**53,465,861**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$106,931,722**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$9,322,795**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: Current 10% LID

Tree Canopy: 7,637.5 acres (29.7%)

Land cover in acres and percentages

Cropland: Row Crops	1,902.9	7.4%
Low Impact Development	540.0	2.1%
Meadow (Continuous grass, generally mowed, not grazed)	462.9	1.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,931.6	11.4%
Pasture/Range (Continuous forage for grazing)	308.6	1.2%
Shrub	5,554.5	21.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	7,637.5	29.7%
Urban	540.0	2.1%
Urban: Residential: 0.25ac Lots	900.0	3.5%
Urban: Residential: 0.5ac Lots	3,523.0	13.7%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	13,616	6,682
Ozone:	394,871	$1,395,100
Nitrogen Dioxide:	102,122	$360,802
Particulate Matter:	190,627	$449,661
Sulfur Dioxide:	81,697	$70,507
Totals:	**782,934**	**2,282,752**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**328,652**
Tons Sequestered **(Annually)**:	**2,559**

Analysis Report

for

Fort Lee Study Area: Current 10% LID

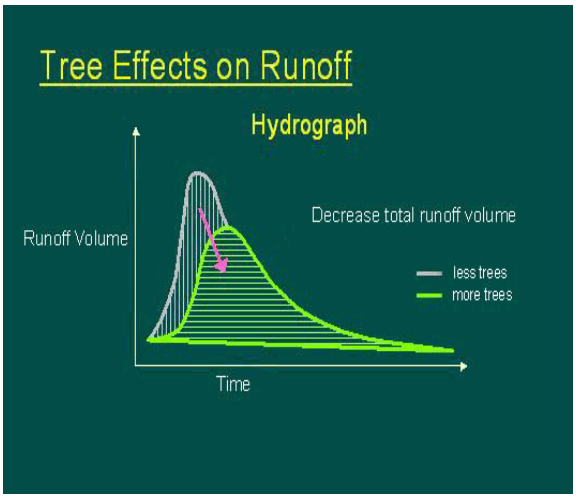
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

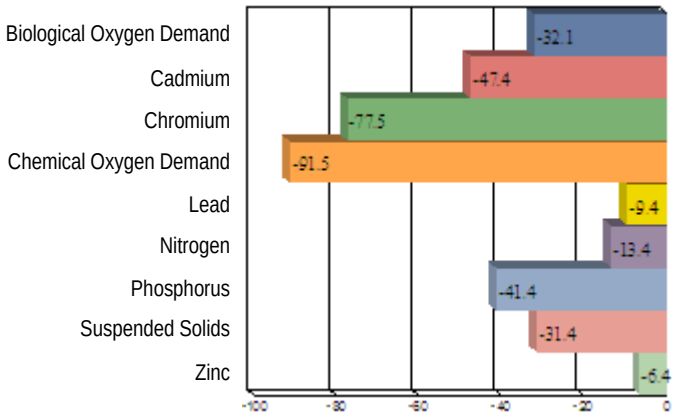
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	65
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**-17,500,229**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$-35,000,458**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$3,051,499**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: Current 3% LID

Tree Canopy: 7,637.5 acres (29.7%)

Land cover in acres and percentages

Cropland: Row Crops	1,902.9	7.4%
Low Impact Development	128.6	0.5%
Meadow (Continuous grass, generally mowed, not grazed)	462.9	1.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,931.6	11.4%
Pasture/Range (Continuous forage for grazing)	308.6	1.2%
Shrub	5,554.5	21.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	7,637.5	29.7%
Urban	591.5	2.3%
Urban: Residential: 0.25ac Lots	977.2	3.8%
Urban: Residential: 0.5ac Lots	3,805.9	14.8%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	13,616	6,682
Ozone:	394,871	$1,395,100
Nitrogen Dioxide:	102,122	$360,802
Particulate Matter:	190,627	$449,661
Sulfur Dioxide:	81,697	$70,507
Totals:	**782,934**	**2,282,752**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**328,652**
Tons Sequestered **(Annually)**:	**2,559**

Analysis Report

for

Fort Lee Study Area: Current 3% LID

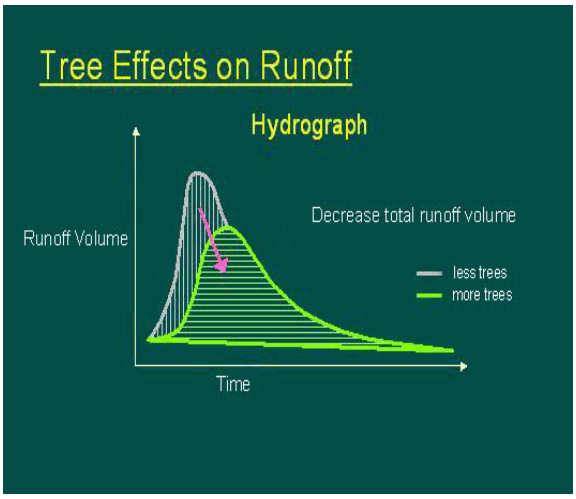
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

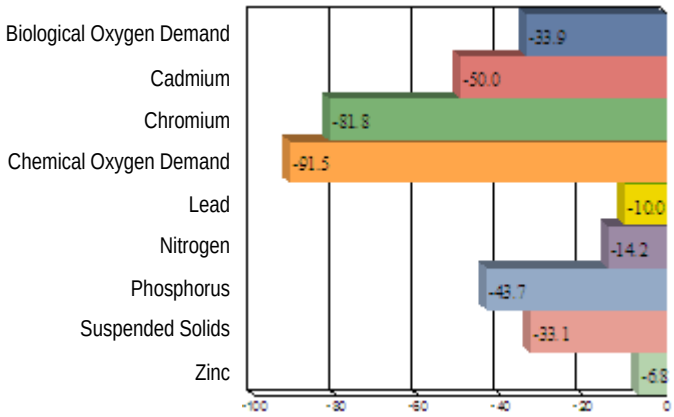
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	65
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**-18,412,139**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$-36,824,277**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$3,210,508**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Appendix C

The value of GREEN INFRASTRUCTURE in land development

PHASE III

Virginia Coastal Zone
MANAGEMENT PROGRAM

Richmond Regional Planning District Commission 1969

ACKNOWLEDGEMENTS

This project was funded, in part, by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant FY10 #NA10NOS4190205 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its subagencies.

The use of the CITYgreen© software for the site scenario analysis is limited to assessing the value of green infrastructure in terms of annual operational measures: air pollution removal, carbon storage and sequestration, stormwater quantity and quality. While both economic and ecological savings can be expressed quantitatively through such analysis, the capital costs for installing LID elements or for constructing alternative parking or land use scenarios to achieve the quantitative benefits is not a function of the CITYgreen software. Capital and operational costs and benefits would needed to determine true cost-benefit over the full life cycle of a project.

INTRODUCTION

The analysis shown in this report evaluates the environmental and economic benefits of green infrastructure assets on sites under development.

This project represents the final phase of a three-year project that focused on identifying, prioritizing, and evaluating green infrastructure assets in the Richmond and Crater Regions. During the first year, local and regional planners worked with other stakeholders to map and prioritize updated green infrastructure assets at a regional scale. The second year effort brought the project down to a smaller scale, focusing on urban green infrastructure assets in the City of Richmond. These smaller scale assets were then compared to an inventory of vacant parcels by the Green Infrastructure Center to highlight environmental, economic, and social benefits possible through the linkage of green infrastructure assets. This third year of the project concludes the scaling down process as regional planners worked with local planners to evaluate prototypical scenarios that consider green infrastructure assets in the development of four different sites, each involving a riparian corridor.

Table of Contents

What is Green Infrastructure?	1
What is Low-Impact Development?	5
Background: Phase I	9
Background: Phase II	11
Current Project: Phase III	14
Site A: Suburban Growth Area	15
Site B: Urban Infill	19
Site C: Suburbanizing Commercial	23
Site D: Military Base Expansion	27
Conclusions:	31
Appendix	

WHAT IS GREEN

Green Infrastructure is defined as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean water, and provides an array of benefits to people and wildlife. … [G]reen infrastructure is the ecological framework for environmental, social and economic health – in short, our natural life-support system." [Green Infrastructure – Linking Landscapes and Communities, Mark Benedict and Edward McMahon, 2006]

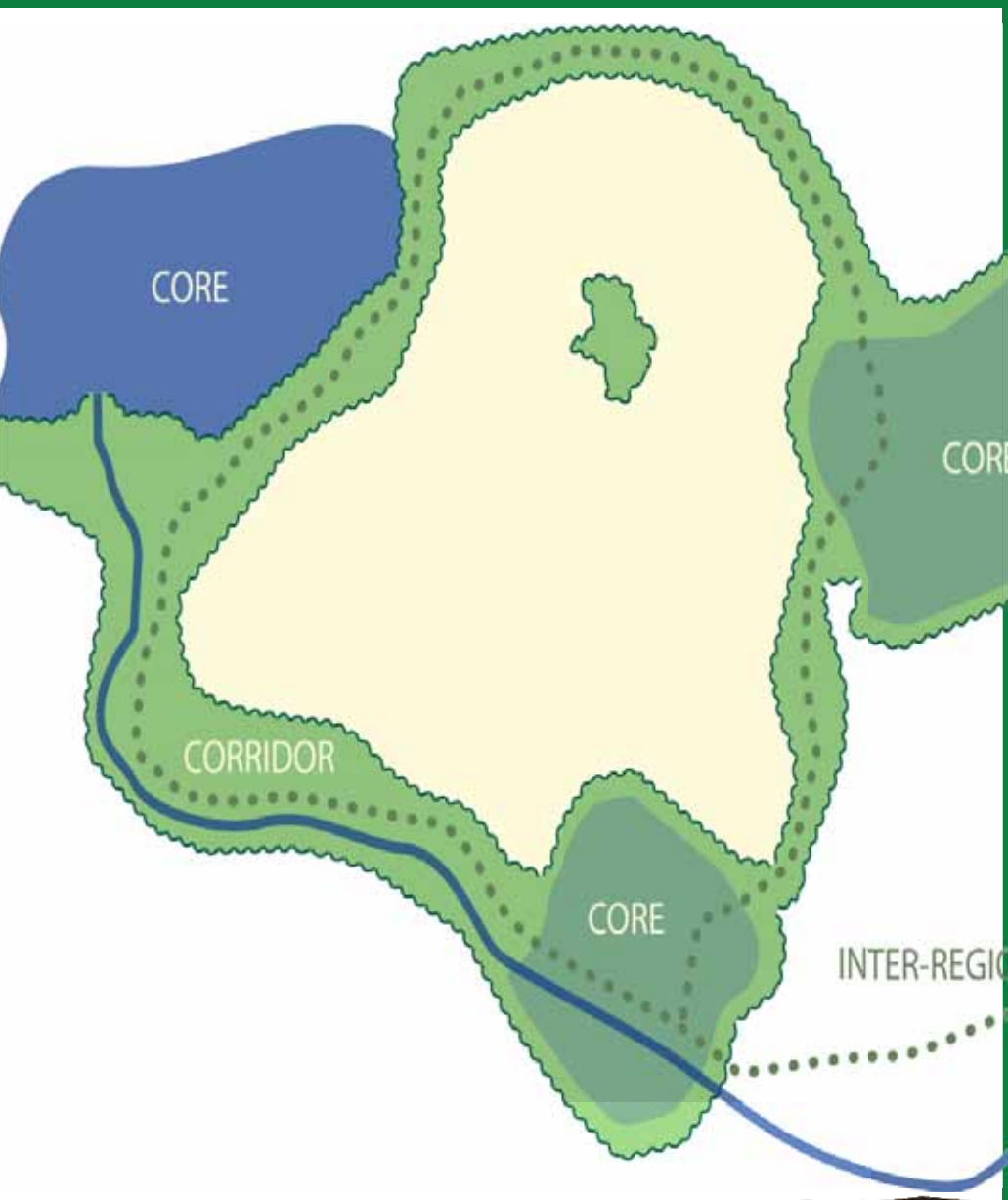
The Richmond Region is fortunate to have plentiful green infrastructure resources. Such resources include forests, wetlands, streams and waterways, wildlife areas, historic landscapes, parks and nature-based recreation areas, community gardens, and a large percentage of urban tree canopy in our central city. This fabric of green infrastructure resources is most effective when woven together by connections such as trails, forested stream buffers, and larger landscape corridors that stretch across the Richmond Region, from the hills of the eastern piedmont to the tidal marshes of the coastal plain. These green infrastructure connections span much of Central Virginia Richmond Region linking the banks of the North Anna River in the north across the James River in the City of Richmond on to the shores of the Appomattox River in the south. These connections are vital to the viability and effectiveness of the region's green infrastructure.

CONNECTIONS ARE KEY

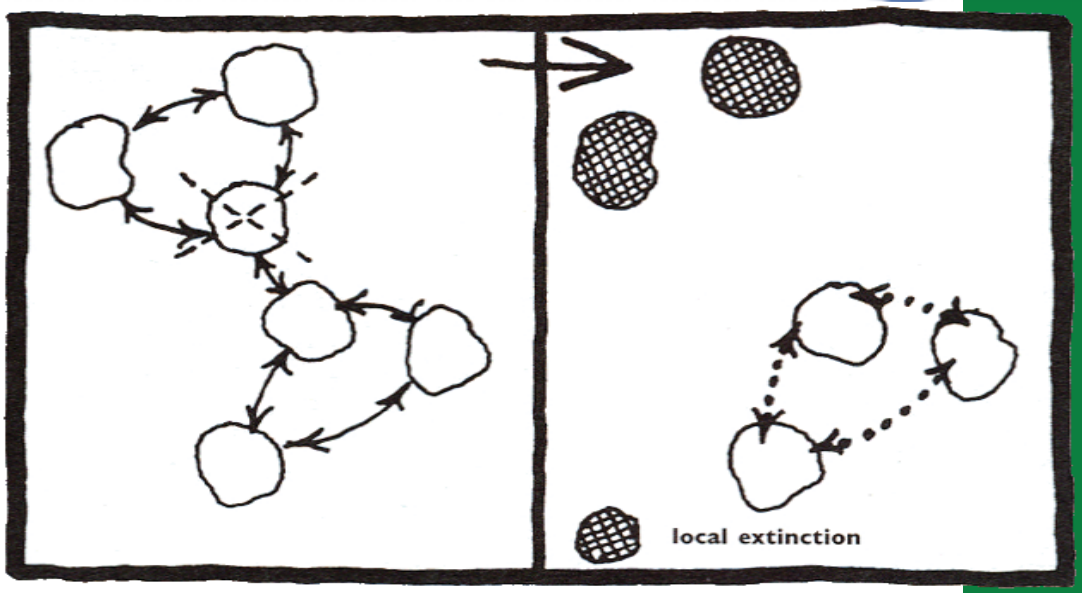
Fragmentation and disconnection of green infrastructure resources not only results in the loss of habitat and natural corridors but also to the degradation of important ecosystem functions that provide us with natural amenities like clean air and water and buffers to the impacts of natural disasters such as floods.

The deer in the photo at the left, shown crossing a residential street, is most likely traveling from one habitat (or core) to another. Providing linkages between cores will prevent animals from having to enter developed areas.

INFRASTRUCTURE?



A green infrastructure network is made up of connected core habitats and connecting corridors that help animals, seeds, and people move across the landscape.



As illustrated, when a core is removed, connectivity is lost, resulting in species extinction.

INFORMING LAND USE DECISIONS

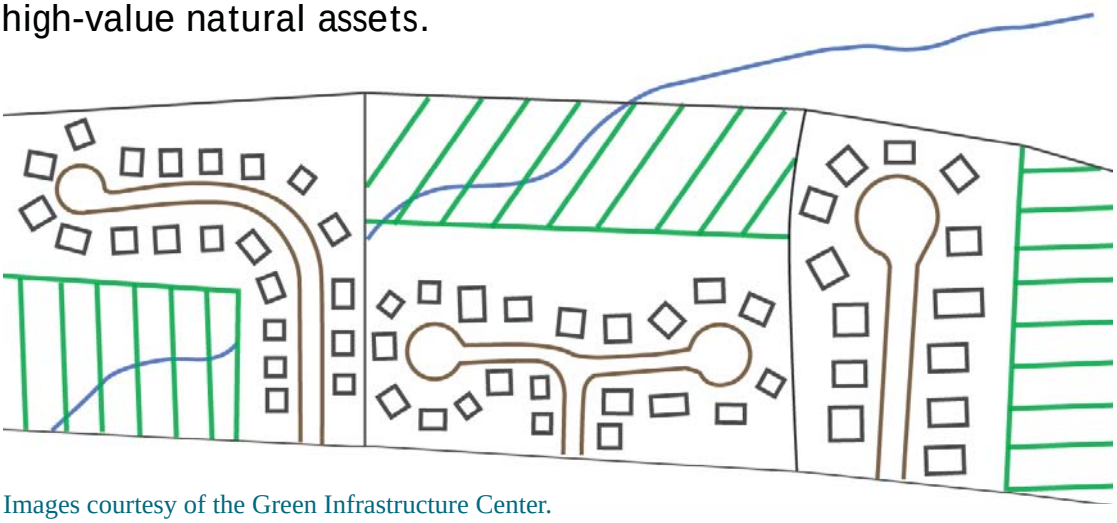
The site analyses performed as part of Phase III of the Richmond Regional Green infrastructure Project exemplify how these connections spanning vast landscapes depend on site circumstances for their existence. Development decisions and land cover changes to individual sites can have impacts far beyond the extent of the immediate area of change.

For example, look at the two development scenarios shown on the right. In the first, the landscape becomes fragmented. The natural space is disconnected and will be less effective at providing water quality benefits or acting as a larger recreational resource for residents. In the second scenario, the same number of houses are built, however, the intact natural landscape is more effective at protecting water quality and functioning as an important recreational resource across the region.

Green infrastructure

planning seeks to gather information to better enable win-win decision making. Documenting existing green infrastructure assets along with identifying opportunities for connection or expansion and assessing the value of existing and potential resources as part of the green infrastructure planning process allows planners, developers, private citizens, and elected officials to gather very valuable knowledge. This information enables these groups to participate in informed development decision-making knowing the full range of costs and benefits to society of development decisions. Sometimes small decisions can lead to large effects – positive or negative.

FRAGMENTED - Even well-intentioned land use planning approaches can result in the fragmentation of a region's high-value natural assets.



Images courtesy of the Green Infrastructure Center.

CONNECTED - A green infrastructure planning approach allows for development and growth at the same scale, while also ensuring that a region's natural assets rem

To the left is an example from our region of a core that has been fragmented by housing development.

By planning at the larger scale with green infrastructure assets in mind, the cores could have had a better chance of remaining connected, offering a myriad of environmental and market benefits.

WHAT IS LOW-IMPACT

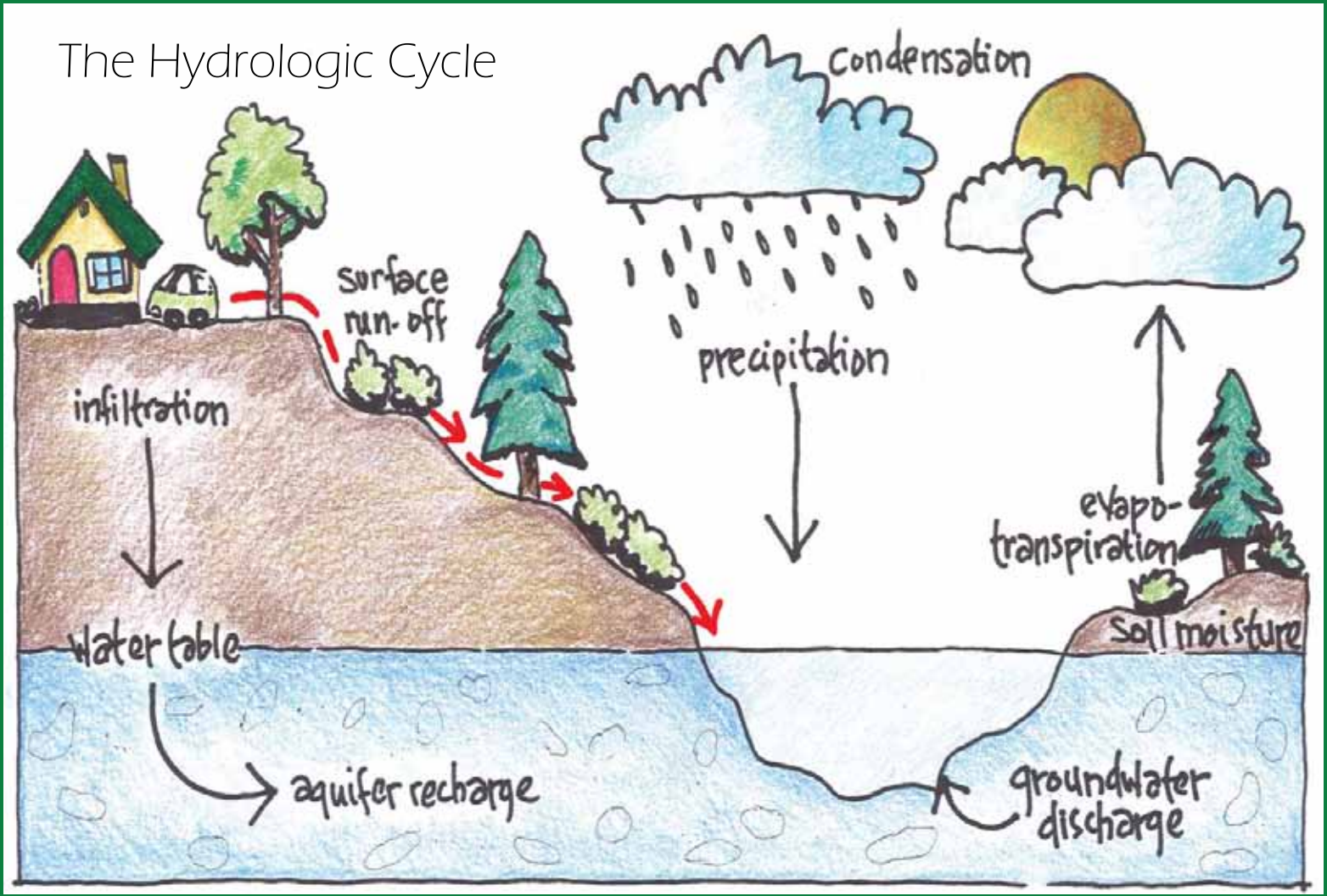
Over the past several years, "green building" techniques have gained popularity among those in the development industry as well as among the general population. One group of green building techniques that you may have encountered is "Low Impact Development" or "LID."

Low Impact Development refers to a suite of land development techniques, from site planning to stormwater engineering, that aim to reduce the flow of stormwater from a site, and therefore reduce the impact of stormwater on the environment.

Multiple aspects of the development process alter how stormwater flows on and through a site. Buildings, parking lots, sidewalks, roadways, and other impervious surfaces fully prevent water from infiltrating into the soil. Grading, vegetation removal, soil compaction, and other common elements of the development process alter water's ability to infiltrate into the soil as it otherwise would. The result of these limitations causes water to flow in greater quantities and with greater speed into nearby streams and larger waterways. Water also has increased opportunity and likelihood of collecting pollutants, chemicals, and sediment that degrade the local water quality and that of larger waterbodies beyond.

Some LID techniques, such as rain gardens and vegetated buffers (see pages 10-11), can play a role as part of the green infrastructure of a site that links to the network across a larger landscape. In scenarios analyzed in Phase III of the Richmond Region Green Infrastructure Project, LID features as land cover elements are considered by the model. In this way, it is possible to see not only the role of green infrastructure in maintaining quality of life, but also how LID and other green building techniques can compliment a green infrastructure to further enhance the livability and quality of a development.

DEVELOPMENT (LID)?



Why does it matter where stormwater goes?

The drawing above depicts the natural hydrologic, also called the water cycle or $H_2$0 cycle.

Water reaches the earth's surface in the form of precipitation. Water that falls on land is either caught by plants, trees and soil and infiltrates to recharge the aquifer, or runs off the land and into nearby waterbodies. When a significant percentage of the land area in a watershed is impervious the natural hydrologic cycle is interrupted; too much water runs off the surface, both bringing pollutants and sediment into waterbodies, and preventing the aquifer from being replenished.

SOME EXAMPLES OF LOW-IMPACT DEVELOPMENT:

RAIN GARDENS are gardens planted near a downspout or other runoff source and uses deeply rooted native plants to help the water infiltrate into the ground, keeping the water from entering the sewer system and running out of the watershed.

GREEN ROOFS: (also known as "living roofs") are roofs that are partially or fully covered in vegetation. The vegetation absorbs rainfall, improves air quality, and creates pleasant environments for insects, bird and humans. The larger image shown is the roof of Chicago's City Hall, a reknowned example. The inset shows the roof at the Queen's Botanical Garden in New York City.

VEGETATED SWALES AND BUFFERS

are vegetated channels or depressed areas that convey stormwater while reducing the speed of runoff and removing polutants. In light rain, the swales can trap water and let it seep into the soil, and in major rain events the vegetation slows the rate of runoff, allowing it an opportunity to find its way into the ground or reducing runoff per minute.

PERVIOUS PAVERS

can form patios, parking lots and driveways, but unlike traditional asphalt or concrete surfaces, they allow water to seep through, letting it find its way to the soil underneath and the aquifer and reducing stormwater runoff.

BACKGROUND: PHASE I

In the Fall of 2008, the Richmond Regional Planning District Commission (RRPDC) began a multi-year green infrastructure planning project for the Richmond Region.

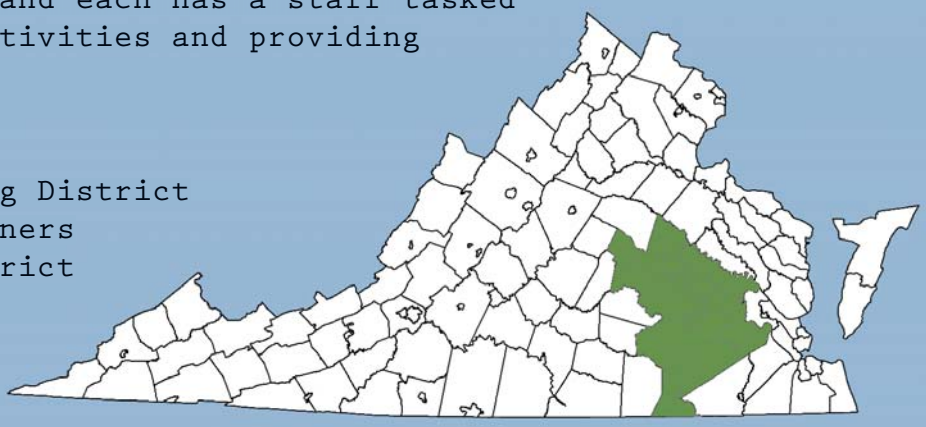
During the first year of the project, the RRPDC partnered with the Crater Planning District Commission, the Green Infrastructure Center, and the Capital Region Land Conservancy to document existing green infrastructure assets in the Richmond and Crater Regions.

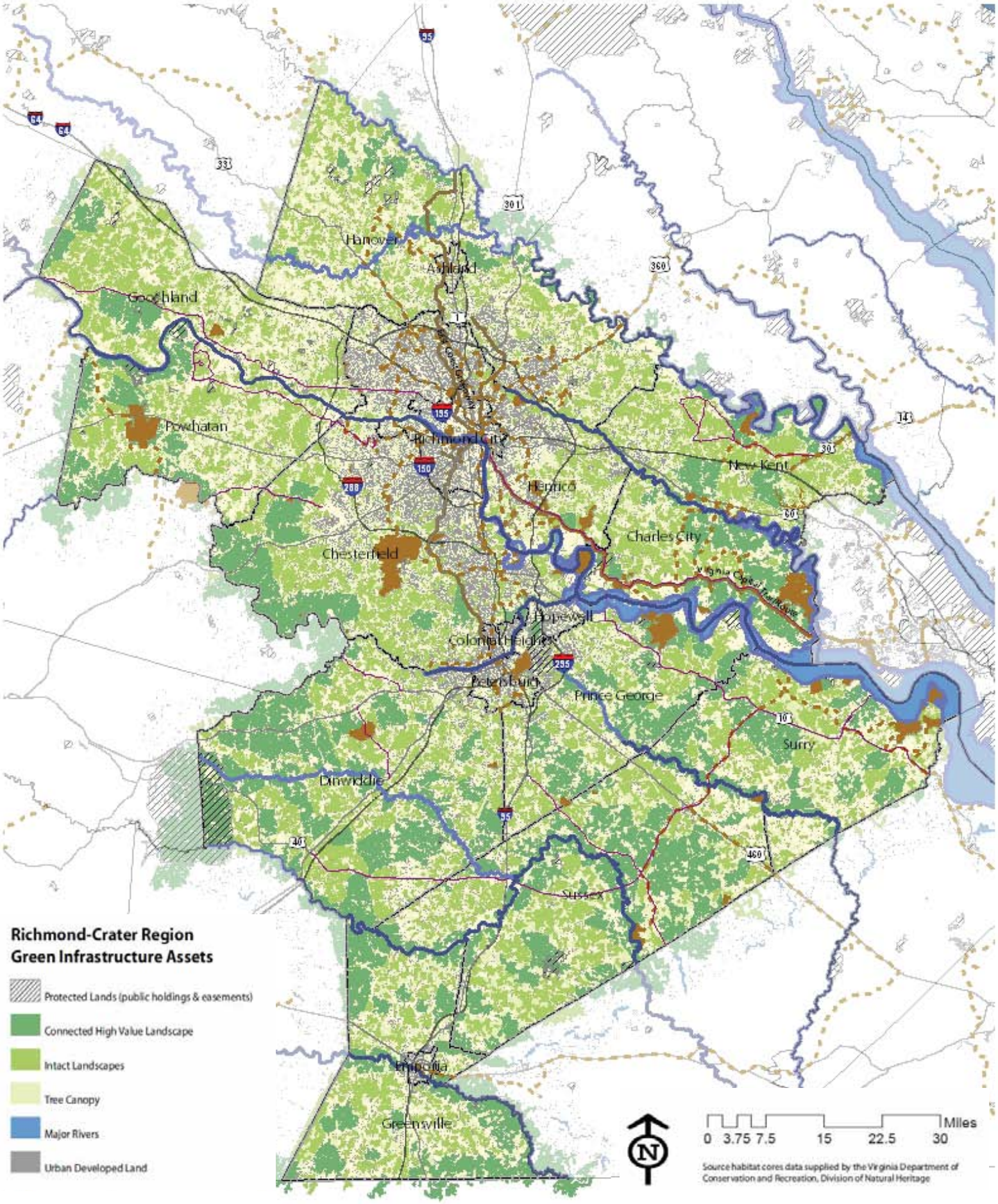
During this first phase, meetings and workshops involving local planners, state agency staff, and other interested parties led to the creation of a regional map that includes large landscape blocks of forested land, conservation easements, park and recreation facilities, and other green infrastructure asset features.

Virginia Planning District Commissions

Virginia is divided into 21 Planning District Commissions (PDCs, tasked with approaching regional planning issues. Each PDC board is made up of elected officials and citizen representatives appointed by local member governments, and each has a staff tasked with coordinating planning activities and providing information to the board.

The Richmond Regional Planning District Commission (RRPDC) often partners with the Crater Planning District Commission to tackle projects which affect both regions, and to share limited resources.

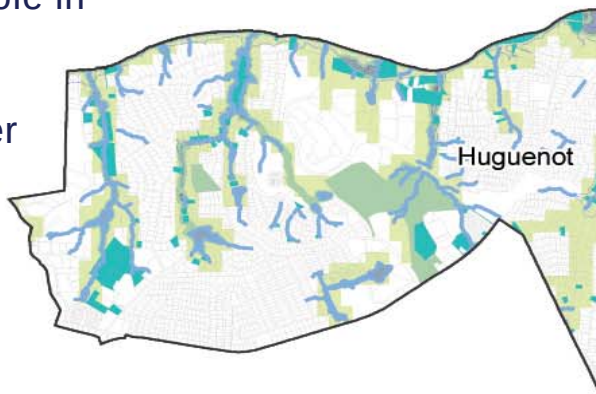



Richmond-Crater Region
Green Infrastructure Assets
Protected Lands (public holdings & easements)
Connected High Value Landscape
Intact Landscapes
Tree Canopy
Major Rivers
Urban Developed Land
Hanover
Ashland
Goochland
Powhatan
Richmond City
Henrico
New Kent
Charles City
Chesterfield
Hopewell
Colonial Heights
Petersburg
Prince George
Surry
Dinwiddie
Sussex
Emporia
Greensville
Miles
0 3.75 7.5 15 22.5 30
Source habitat cores data supplied by the Virginia Department of Conservation and Recreation, Division of Natural Heritage

BACKGROUND: PHASE II

For the second year of the green infrastructure project, the RRPDC again teamed with the Crater Planning District Commission and the Green Infrastructure Center to focus on urban green infrastructure assets.

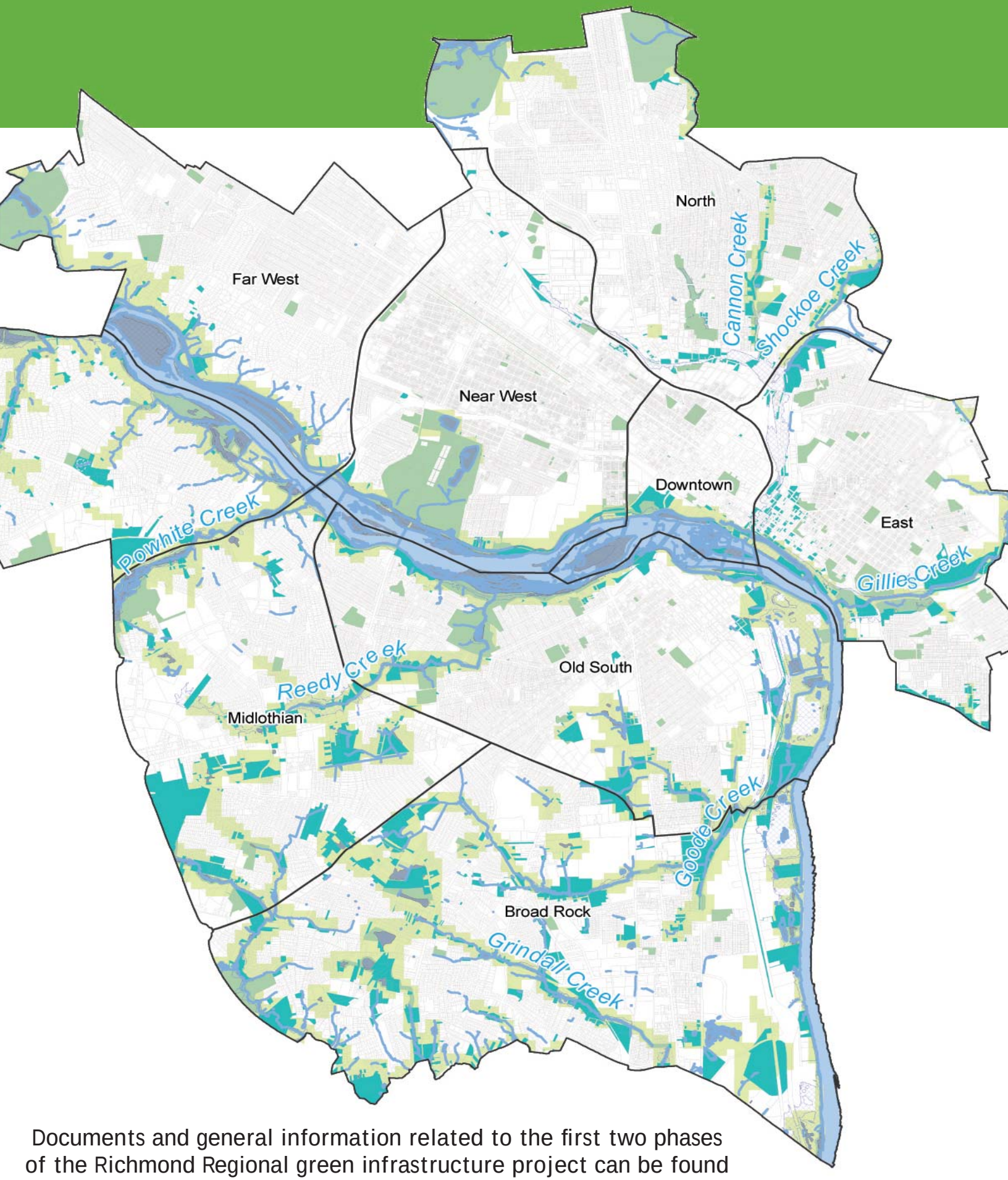
Given the scale of the regional asset map, smaller green infrastructure assets common in urban areas were not identified or included in the Phase I regional asset map. These smaller, urban green infrastructure assets play a crucial role in the livability of urban areas.



The City of Richmond joined the project team as a partner as we endeavored to create a model for identifying and mapping urban green infrastructure assets in the Coastal Plain of Virginia. A project team of regional planners, City staff from numerous departments, and Green Infrastructure Center staff created a City of Richmond green infrastructure asset map. The asset map included parks and recreation facilities, historic sites and neighborhoods, tree canopy, community gardens, wetlands, riparian buffers, and trails, among other items.

Staff from the Green Infrastructure Center used the identified green infrastructure assets with a newly created inventory of vacant parcels, to create a database for City staff to use in identifying the suitability of vacant parcels for playing multiple roles in the City's green infrastructure network.

The photo above shows the James River Park System, one of the most significant green infrastructure assets in the City of Richmond



Documents and general information related to the first two phases of the Richmond Regional green infrastructure project can be found on the RRPDC website at:
www.richmondregional.org

CURRENT PROJECT: PHASE III

For the third and final year of the project, RRPDC staff again partnered with Crater PDC staff. Continuing the theme of examining green infrastructure at smaller scales, Phase III was designed to use CITYgreen software to analyze the role and value of green infrastructure at a sub-locality, site scale. CITYgreen software uses land cover information to estimate impacts to air quality, water quality, stormwater runoff volume, and carbon sequestration. By running scenarios through the CITYgreen software, we were able to determine the importance of green infrastructure on sites within the Richmond and Crater Regions.

The storm event analyzed in this report is the "2 year, 24-hour storm", which represents the largest amount of rainfall expected over a 24-hour period during a two-year interval. This rate is often the basis for planning and design of stormwater management facilities and features.

A) Suburban Growth Area

One site is located in close proximity to major transportation corridors and existing suburban development; a stream flows through a portion of the site. The stream currently has vegetated riparian buffers on-site, extending off-site, of varying quality. The site is planned for mixed use development.

Sites chosen for analysis are intended to serve as representative models, applicable across sites with similar characteristics in all localities within the two regions.

B) Urban Infill

One site is located within the central city in an existing neighborhood; a stream runs across the site with portions buffered by vegetated riparian buffers. The site is planned for use as a residential neighborhood next to a school or community facility.

C) Suburbanizing Commercial

One site is located in a suburbanizing area along a commercial corridor. A stream runs across a lower portion of the site; the stream currently has healthy, vegetated riparian buffers. The site is planned for big-box commercial.

D) Military Growth Area

A relatively large site is located in proximity to an existing military facility that is expected to grow in future years. Several streams with riparian buffers of various quality run throughout the site. Both population and employment are expected to grow notably across the site in the next several years.

SITE A: Suburb

Site A reflects some more recent trends in large acreage greenfield development including a denser development pattern and a mix of uses including residential, commercial, and office.

Site A is approximately 150 acres located near existing development. It is located in proximity to two major transportation routes, such as an interstate, a federal highway, and/or a state highway. There is also rail line with active passenger rail service nearby. Given these location assets, the site is desirable for multiple uses and has the potential to be a vibrant extension of the existing developed community. Site A also plays a vital role in maintaining the water quality of a major river watershed in which Site A is located. A major stream that connects to a river several miles away runs through a portion of Site A. Currently, the section of the stream that runs through Site A has good water quality, however, upstream and downstream reaches of the creek have been identified as impaired.

At the time the analysis was done, Site A is undeveloped and will have to be rezoned for development. Approximately half of the Site is covered by forest and shrub growth. The remainder is largely maintained as a mowed turf. Also on the site, there is one small building with impervious parking surface associated with it. The scenarios developed for Site A began by considering full development build-out of the site according to sample design guidelines. Sample design guidelines address a development that include numerous uses (office, single-family residential, multi-family residential, commercial) across the landscape as well as within structures. The density of buildings in the Site is similar to that of a small city, a town, or an inner suburb. There are single family detached homes with small yards. These detached homes are within walking distance of single family attached dwellings, multi-story office buildings, and traditional "main street" shops and restaurants. Additional scenarios developed for Site A consider changes in parking requirements, building density, and LID practice implementation. Changes in these elements of the built landscape can contribute to drastic changes in water quality on and downstream from the site.

Site A Scenarios	
Scenario	**Description**
Current	Current conditions of the site, mostly forest or mowed turf
1	Build-out using sample design guidelines
2	Build-out with some LID implementation
3	Build-out with maximum LID implemetation allowed in model
4	Build-out with decreased parking and increased residential building density
5	Build-out including some structured parking and residential density and LID implementation

an Growth Area

CITYgreen Software:

The use of the CITYgreen© software for the site scenario analysis is limited to assessing the value of green infrastructure in terms of annual operational measures: air pollution removal, carbon storage and sequestration, stormwater quantity and quality. While both economic and ecological savings can be expressed quantitatively through such analysis, the capital costs for installing LID elements or for constructing alternative parking or land use scenarios to achieve the quantitative benefits is not a function of the CITYgreen software. Capital and operational costs and benefits would needed to determine true cost-benefit over the full life cycle of a project.

Current Conditions vs. Buildout

In the build-out scenario, Scenario 1, impervious surface increased from 2.5% to nearly 40% of land cover; meanwhile, forested land fell from over 47% of land cover to approximately 35%. Area maintained as lawns and open meadow also decreased, from about 50% to less than 30%. These changes resulted in more than 2,230 pounds a year of additional air pollutants in the atmosphere. The increase in impervious surfaces paired with the decrease in treed and vegetated land resulted in more than 166,000 additional cubic feet of stormwater from the typical storm event. Additionally, contamination of stormwater runoff with pollutants increases with these changes in land cover. The model estimates that we are likely to see a 27% increase in nitrogen concentration in the runoff and a 74% increase of the phosphorous concentration. Suspend solids are likely to increase by more than 58%. We are also likely to see substantial increases in the concentration of metals such as chromium, cadmium, lead, and zinc.

SITE A: Suburb

Using LID practices

Two scenarios added the implementation of LID practices to the build-out scenario: Scenario 2 - Design Guideline Buildout with some LID implementation and Scenario 3 - Design guidelines with Maximum LID implementation. As the results from Scenario 2 reveal, instituting some LID practices, such as using pervious pavers for portions of parking areas, walkways, and other hardscape areas and having public impervious areas such as roadways drain to bioswales or rain gardens, resulted in a reduction in needed stomwater storage and treatment capacity of about 60,000 cubic feet. This reduction translates to an approximates savings of more than $10,400 annually. The use of these LID practices also results in an average 12.1% reduction of water pollutants.

Scenario 3, designed using input from LEED and Earthcraft development standards, pushed LID implementation even further. In Scenario 3, 50% of roadways throughout the development are constructed using pervious pavement; walkways, ball courts, and other hardscape areas are constructed using pervious pavers; a general decrease of lawn area and an increase in trees and forest area occurs across all use types in the development; a portion of rooftops in the development are at least partially constructed with green roofs. Scenario 3 resulted in further reductions of stormwater runoff and stormwater pollutants that both Scenarios 1 and 2.

Scenario 3 sees annual stormwater cost savings of more than $13,000 due to reduced stormwater quantity, that is an annual savings of more than $10,000 over Scenario 2 and $23,000 over Scenario 1! A similarly dramatic decrease occurs in stormwater pollutants; pollutants decrease by an average of 28% in Scenario 3 compared to Scenario 1.

Stormwater Utility Savings

Scenario 4 looked at the effects of reducing parking area requirements and increasing residential building density compared to Scenario 1. Would the increased forest and vegetation allowed by the reduction in parking area compensate for the increase in impervious surface from more residential rooftops? As it turns out, YES! Despite a near doubling in the land area covered by residential rooftops in the development, a 20% reduction in parking area requirements for commercial and business uses replaced by landscaped and forested land resulted in a net reduction of stormwater from the site. These changes to impervious and forested area result in more than 11,500 fewer cubic feet of stormwater runoff requiring storage and treatment. This reduced stormwater treatment translates to a total savings of more than $23,000. Where possible, this additional forest area serves to expand the riparian buffer along the stream, further cleaning the stormwater runoff from impervious surfaces that does occur before it enters local streams and waterways. All pollutants were reduced by an average of 2.3% in the scenario with altered parking and residential density versus the original design guidelines scenario, Scenario 1.

Scenario 3 sees annual stormwater cost savings of more than $13,000 due to reduced stormwater quantity - an annual savings of more than $23,000 over scanario 1!

What about build-out alterations and LID practice implementation?

Scenario 5 essentially combines the principles seen in Scenario 2 and 3 with Scenario 4. In Scenario 5 some of the surface parking has been combined into a structured parking facility with a green roof. Remaining surface parking is partially constructed using pervious pavers. Much of the building roof top area is constructed with green roofs. Finally, design of the site emphasizes trees and forested ground cover as well as the use of rain gardens and bioswales to clean stormwater and infiltrate it into the ground. Scenario 5 sees the greatest stormwater quantity reduction compared to Scenario 1; necessary facility capacity for stormwater storage and treatment on the site is essentially reduced by 50%! Water pollutants area also dramatically reduced, by an average of more than 30%. Meanwhile, air pollutants are reduced by nearly 10% for an estimated annual savings of $1,200.

Site B: Urban

SITE DESCRIPTION:

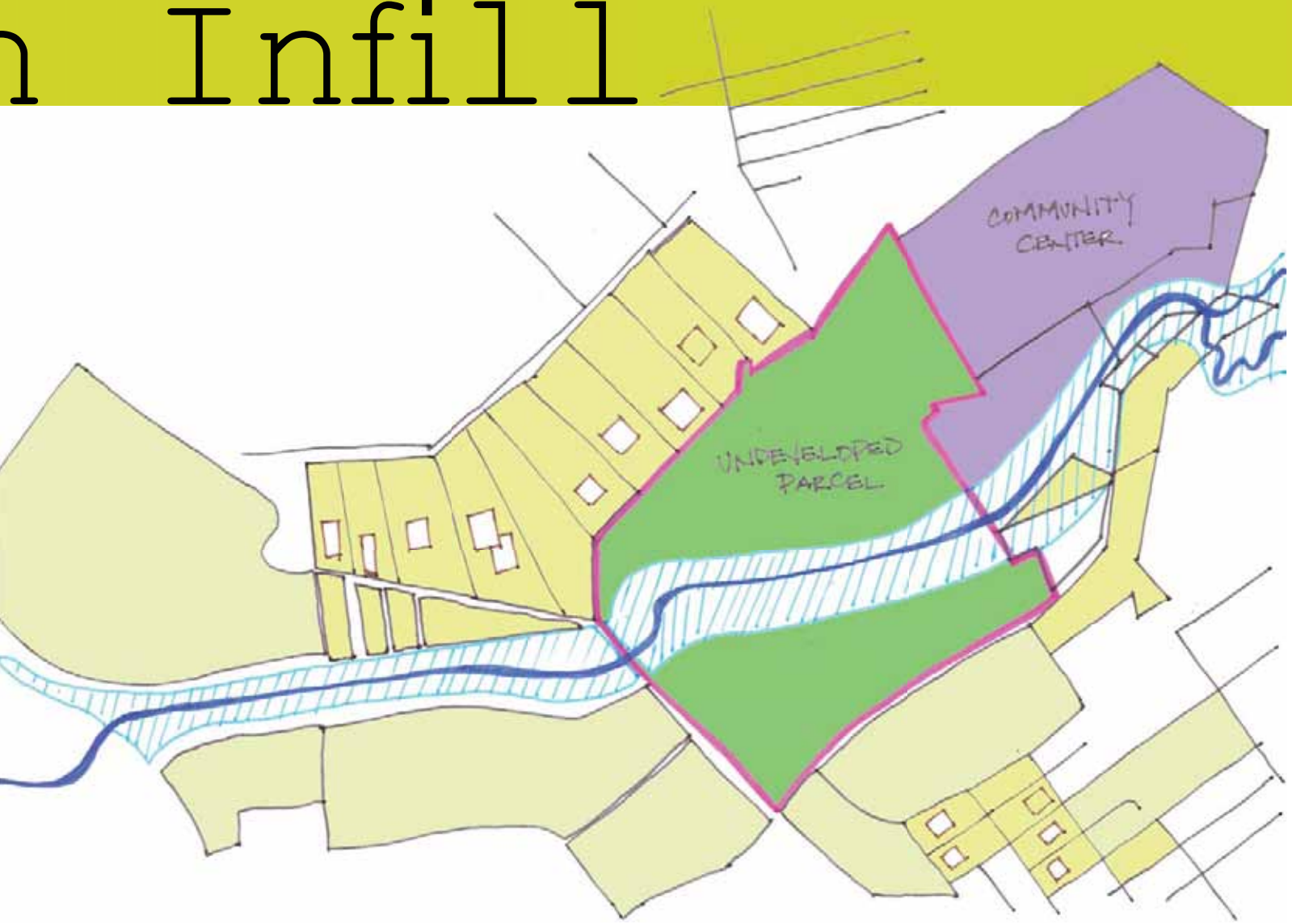
Site B depicts an urban infill opportunity in close proximity to an existing residential neighborhood and a community facility such as a school or community center. Commercial and industrial land uses are within walking or biking distance. The site is approximately 7 or 8 acres in size and is split in two by a tributary stream which runs to a major creek, and eventually to a major river. The local government has identified the watershed in which Site B is located as a priority for water quality improvements and stormwater management due to the impaired water quality of many streams in the area. Site B is zoned for single-family residential development.

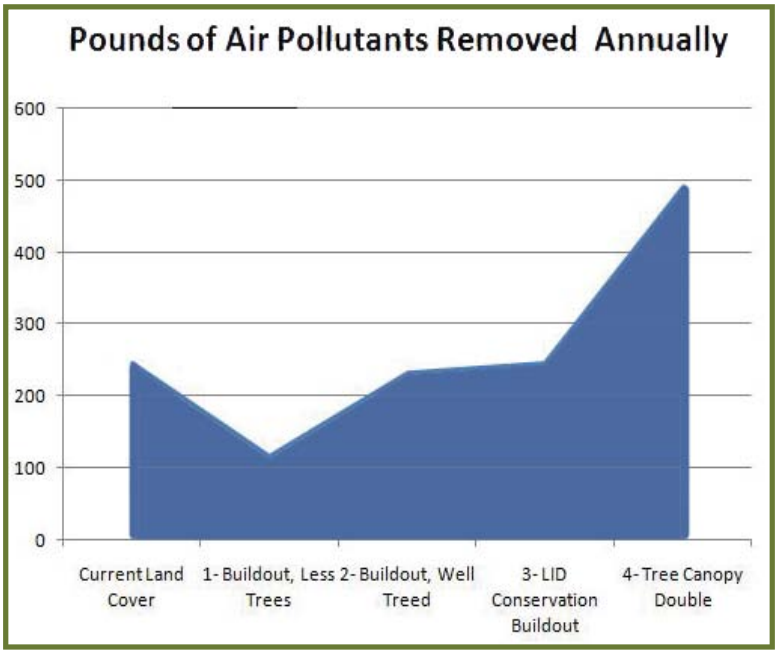
A series of development scenarios for the Site were developed using sample urban zoning districts from localities in the Richmond Region to determine lot size, building coverage, etc. The scenarios investigate what the effects of a full build-out, with the maximum number of buildable lots allowed, would be. The full build-out scenario assumes 40 potential dwelling parcels with maximum lot coverage of buildings of about 35%. Additional scenarios look at the effects of increasing tree canopy across the Site, implementing LID practices, and reducing the number of buildable lots in favor of creating a common space for the residents. In all scenarios, it is assumed that green infrastructure throughout the Site is maximized as riparian buffers are enhanced and connections to natural areas beyond the Site are created or expanded.

Currently, Site B is one-third forested while the remaining two-thirds are maintained as mowed turf. The water-area of the stream accounts for less than 1% of the site area. The chart below summarizes the scenarios analyzed.

Site B Scenarios	
Scenario	**Description**
Current	Current conditions are mostly grass turf with forest area
1	Full Build-Out, 15% tree canopy coverage
2	Full Build-Out, 30% tree canopy coverage
3	Conservation Build-Out, with LID
4	No Development, Double tree canopy

n Infill





The chart at the left depicts the pounds of air pollutants removed annually by the various development scenarios. In general, the current land cover removes around 240 pounds a year, with typical buildout removing only around 120 pounds a year. Buildout using LID practices and increased tree canopy can double the amount of air pollution removed per year.

Site B: Urban

Current Conditions versus Build-out with Less Tree Canopy

Scenario 1 removes 53% less air pollution than current conditions. Meanwhile, stormwater runoff increases by over 24,000 cubic feet per storm event and water pollution loadings increase by an average of over 106%. This is largely due to the drastic reduction in tree canopy and in the introduction of impervious surfaces on the site.

What happens when we add trees and enhance green infrastructure?

To begin seeing the effect of trees on the site, a comparison of current conditions to Scenario 4, in which no development occurs and tree canopy doubles, is useful. With tree canopy comprising just over 60% of the Site in Scenario 4, nearly 450 fewer cubic feet of stormwater runoff is produced by a storm event and almost 250 additional pounds of air pollutants are removed by the additional trees each year. How do these effects translate into Scenario 2 in which tree canopy increases across a full build-out of the Site?

Build-out with 30% tree canopy

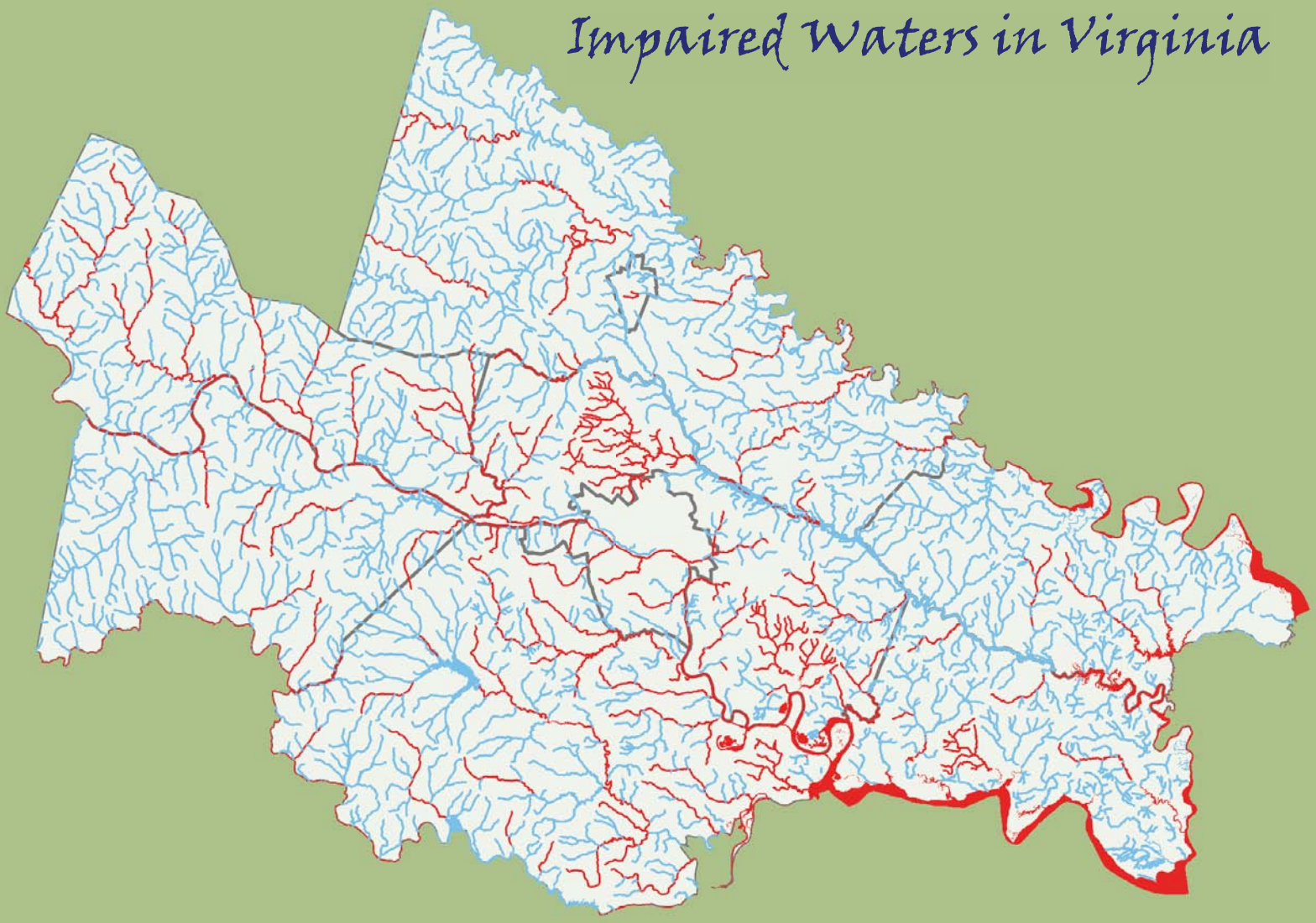
As it turns out, quite well! Doubling the tree canopy on the build-out scenario results in a 13% reduction of stormwater run off from a storm event, or over 3,000 cubic feet of stormwater. This stormwater runoff reduction equates to a savings of more than $6,000 over 20 years. Similarly positive trends are seen in air and water quality. Increasing the tree canopy on Site B results in a near doubling of the weight of air pollutants removed while water pollutant loadings decrease by an average of 11.5%.

LID Implementation and Conservation Neighborhood Design

Scenario 3 presents an altered build-out, with fewer residences and a concentration on LID and conservation. In Scenario 3, lots are smaller and a community natural space has been incorporated into the design; in addition, tree canopy has slightly increased to just more than 30% of land area. This natural space can serve as an outdoor recreation opportunity for residents and as a valuable education resource for use by the nearby school and community center. Beyond the additional community resource in this Scenario, what are the anticipated effects on air and water quality? Stormwater runoff from a storm event decreases by a little over 25% compared to the full build-out of Scenario 1. This reduction equates to more than 6,000 cubic feet of stormwater runoff, for a savings of more than $12,000 over 20 years. Air pollution removed on an annual basis also increases compared to Scenario 1, more than doubling for an additional 129 pounds per year or a total of 245 pounds per year.

n Infill

Impaired Waters in Virginia



The Virginia Department of Environmental Quality maintains a Water Quality Monitoring Program throughout the Commonwealth as required by the US Clean Water Act. The Monitoring Program identifies waters that are impaired for one or more uses: aquatic life, fish consumption, public water supplies, shellfishing, swimming/recreation, and wildlife. The process identifies waters that do not meet these standards due to pollution and establishes a plan and schedule for water quality restoration. The map above displays waters in our region that have been identified as impaired in red. This includes most of the James and Pamunkey rivers, as well as parts of the Appomattox and many tributary streams.

The natural water cleansing and quality protection abilities provided by green infrastructure can play a vitally important role in rectifying water quality impairments. The following scenarios illustrate how green infrastructure enhancements can result in water quality improvement for a fraction of the cost of man-made, engineered solutions.

SITE C: Suburban

Current Conditions

The tree cover on the site currently removes over 6,000 pounds of air pollutants each year. The trees also naturally treat almost 600,000 cubic feet of stormwater per storm event. To replace this water treatment with a man-made engineered structure would cost well over $1,180,000. Similarly, if all the trees were removed and replaced with impervious surfaces, water pollutant loadings would likely increase an average of 4,580%!

Scenario 1 versus Current Conditions

In Scenario 1, a portion of the site that will be developed separately in the future as an outparcel is covered with grass with the exception of a small buffer along the road of tress and landscaped vegetation. The area surrounding the building and parking lot is largely grass, except for a small forested buffer along the stream and back, undeveloped portions on the Site. How do these changes effect air and water quality? In Scenario 1 forested land is essentially reduced by half while impervious surfaces associations with the building and parking lot account for almost 30% of the land area and grass accounts for a little more than 20%. Accordingly, the air pollutants removed on an annual basis are reduced by half. An additional 116,000 cubic feet of stormwater is produced by a storm event, that translates to an estimated additional cost of $232,034.

Increasing Green Infrastructure and Introducing LID

Scenario 2 increases forested land on the outparcel and the area surrounding the building and parking lot. Additionally, a bioretention system is used to treat stomrwater runoff. The trees in the increased forest area improve the Site's ability to clean the air. Compared to Scenario 1, an additional 1,100 pounds of air pollutants are removed annually. Meanwhile, 8,000 additional cubic feet of stormwater are treated by landscape for a total savings of over $15,000. Some water pollutant loadings are reduced by more than 100% of their original loads.

Expanding Use of LID

In Scenario 3, the increased use of LID techniques reduces the amount of stormwater that will be produced by a storm event and require treatment. Scenario 3 produces almost 20,000 cubic feet of stormwater less than Scenario 2, just under 27,000 less cubic feet of stormwater than scenario 1. This stormwater reduction amounts to a total savings of more than $55,000 dollars. Water pollutant loadings are further reduced compared to Scenario 2; many pollutants see a reduction of between 100-200% of their original loads.

izing Commercial

Better understanding stormwater runoff, in cubic feet...

in a 2 year, 24-hour storm event, an average of 553,500,000 cubic feet of rainwater hits the ground on one acre of land. The amount of run-off depends on the green infrastructure and LID.

The Airbus A 380, a new two-story passenger jet, is 55,446 cubic feet in volume.

The Titanic was an astounding 4,632,8000 cubic feet in volume!

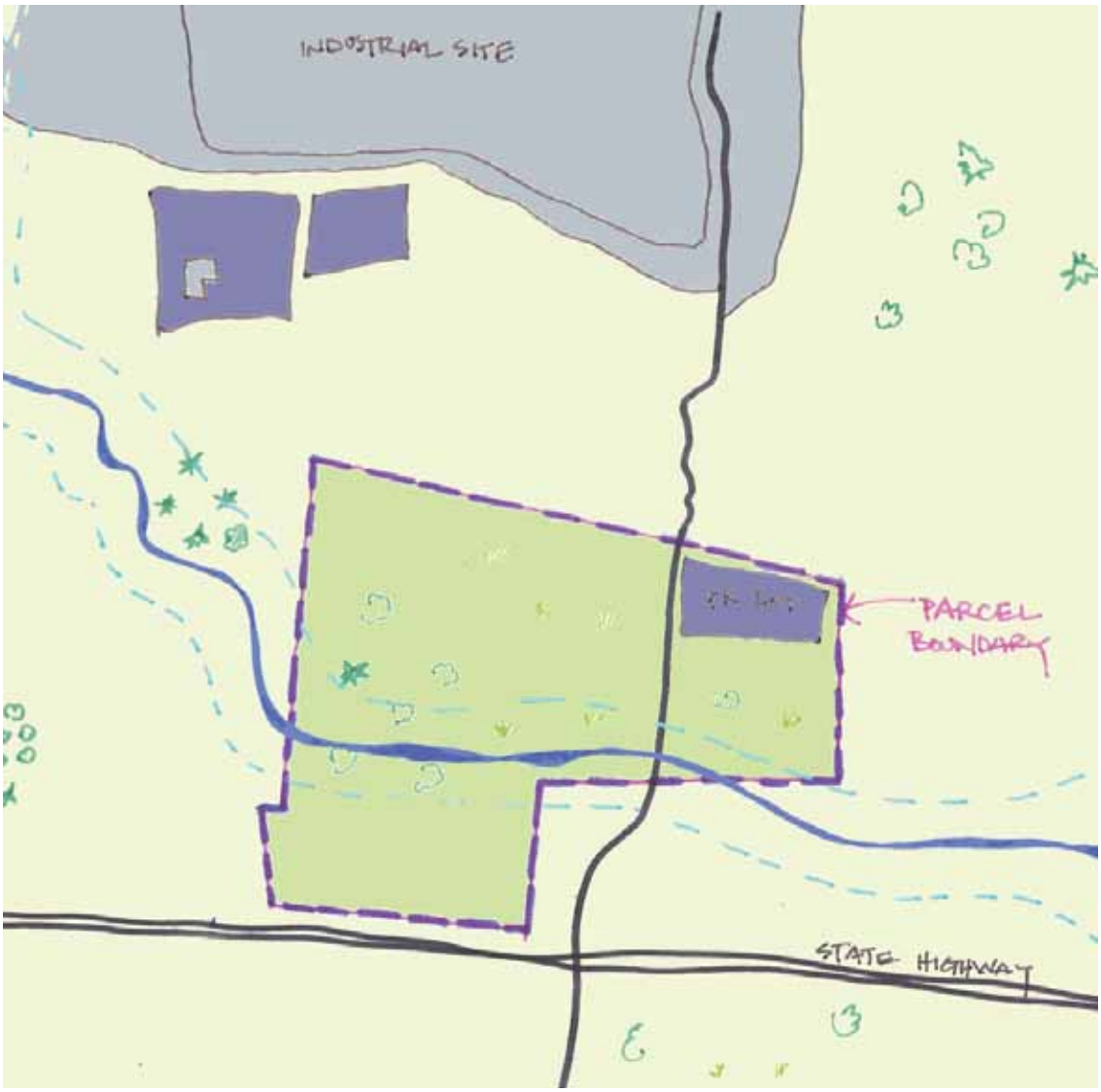
13,944 cubic feet per second pass over the Hoover Dam.

SITE C: Suburban

Site C depicts a big-box development along a commercial corridor in a suburbanizing area. Suburban growth pressures are increasing in the area as large lot subdivisions and big-box commercial sites are beginning to develop. A healthy tributary stream runs across the side and rear of the site and eventually flows into a major river. The river into which the stream flows has been identified as impaired by pollutants by the State's Department of Environmental Quality.

A series of development scenarios were developed using sample site plans for similar big-box commercial developments. In addition, the scenarios were informed using common green building standards and techniques.

Currently, Site C is more than 92% forested; the remaining land area is maintained as turf grass. The scenarios increase green infrastructure and LID practices on the site. The first scenario is the least "green." More trees than necessary are removed from the property and replaced with grass turf, only the mandated riparian buffer exists along the stream. The second scenario increases the tree canopy and forested area on the Site, especially that along the stream. Also, Scenario 2 uses bioretention systems to treat stormwater on the site.



izing Commercial

The third scenario increases LID technique implementation through the use of water infiltration in some of the parking lot island area and the use of pervious pavement on a portion of the parking.

Site C Scenarios	
Scenario	**Description**
Current	Current conditions are mostly forest with some grass
1	Big-Box, Fewer Trees
2	Big-Box, More Trees, Bioretention
3	Big-Box, Trees, Biorention & Infiltration, Pervious Pavement

What is a riparian area?

A riparian area is the intermediate area between land and a river or stream. Though loosely synomous with a riverbank or streambank, riparian areas are their own ecosystems, reflective of their proximity to both land and water. Plants, animals and soil types found there are unique to these areas.

As seen in the photograph below, constant flooding due to an increase of impervious surface within a watershed will erode the banks of the waterbody, disrupting the ecosystem and ruining habitat.

Creating vegetative buffers (called "riparian buffers" throughout this report) along the river or streambank helps absorb excess stormwater runoff, allowing it to seep into the ground and keeping it from eroding the soil and plants in the area, destroying habitat.

SITE D: Military

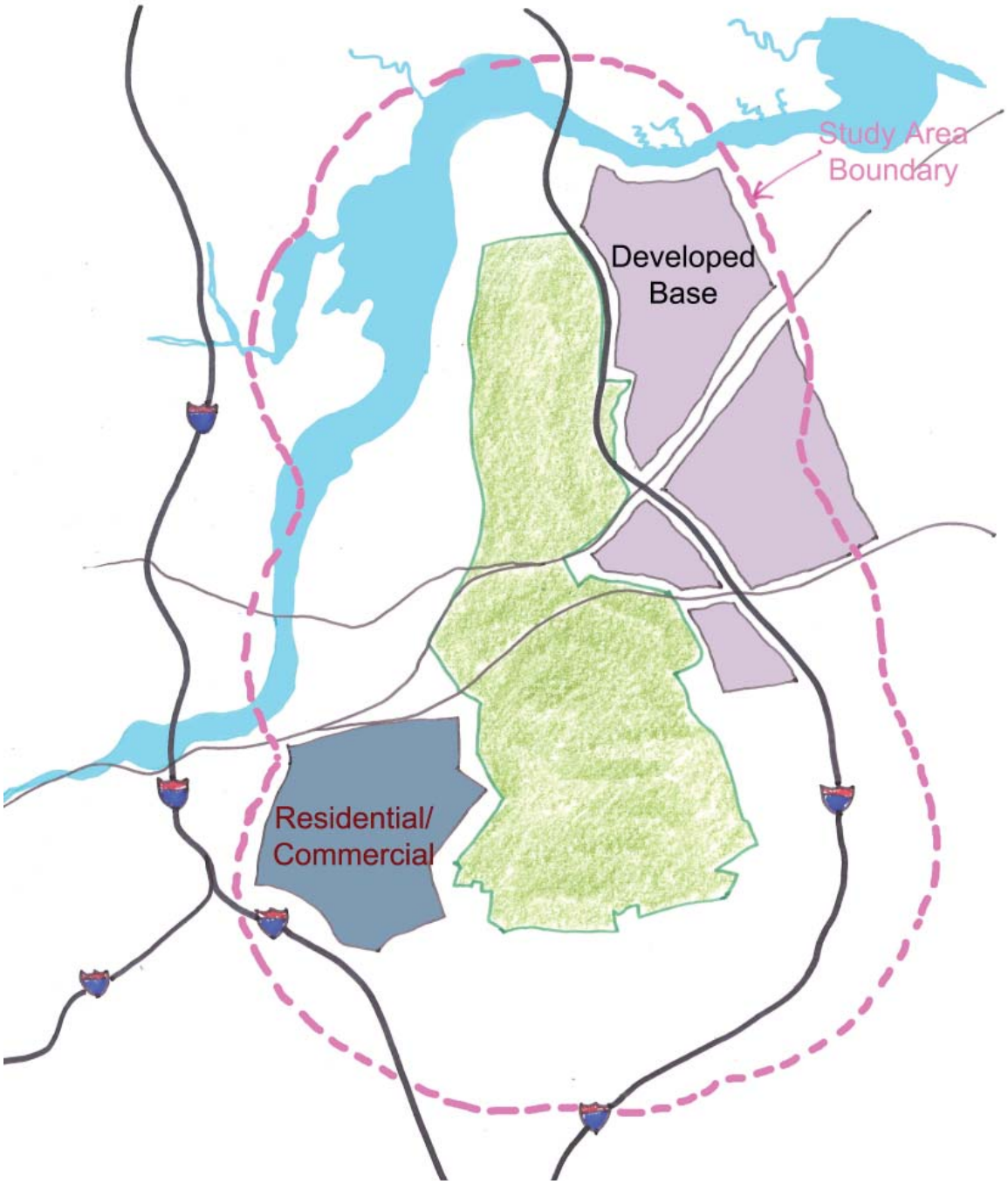
SITE DESCRIPTION:

Site D depicts the level of development that can potentially occur around a military base, college or university, or other like institution under growth pressures from a major expansion of operations. Green infrastructure can play a valuable role around such institutions. Green infrastructure produces the benefits already listed in this report; in addition, it can function as a buffer that is not only of environmental value and aesthetically pleasing, but also provides safety and security between institutional uses and unrelated uses, such as residential neighborhoods.

Site D is much larger than the other sites studied as part of this project; site D is intended to represent a large institution and the surrounding land within a 1.5 mile area vicinity. A variety of land uses exist in the vicinity of the institutional use: suburban residential, commercial, industrial, and business/office. With the expansion of the institutional use, all of these surrounding uses are expected to increase, overtaking currently undeveloped land. The confluence of two rivers is located just beyond the study area in question, however, one of the rivers flows directly through the study area as it approaches the confluence. Water quality in this area has been historically compromised due to the industrial nature of some portions, especially along the waterfront. In more recent years, expanding suburban residential and associated commercial development has continued to stress the quality of water in the area. The nature of development that occurs in conjunction with this expansion could potentially serve to hinder water quality improvements in the area if outcomes are not fully considered as part of the development process.

The scenarios developed for Site D have a stronger focus on LID practice implementation. Various aspects of the site cause this focus; namely, the massive size (well over 20,000 acres)of the land area analyzed renders detailed location decisions more difficult to model in GIS in a timely fashion. Accordingly, it is more efficient to apply specified land cover changes, such as LID implementation, across a specified percentage of the land area in question rather than focus on endless variables of stream and site specific green infrastructure features that change across the vast landscape under consideration. Additionally, in general, it is important that at least one set of scenarios focus heavily on LID implementation so that planners, developers, citizens and others are aware of the benefits in Central Virginia. However, this does not mean that green infrastructure landscape features present in urban development are not considered in the scenarios for Site D; to the contrary, rain gardens, bioswales, and forested buffers are included in these scenarios as LID practices under consideration. The scenarios assume that these LID features are used to expand existing riparian buffers or are otherwise located to best advantage water quality.

Base Expansion



Currently Site D is approximately 30% forested. About 15% of the site is maintained as open space, with mowed grass maintained as turf and scattered trees. Just under 20% of the site has been developed as quarter- and half-acre residential lots. Approximately 20% of the area is shrub land, wetlands, or other like-vegetated areas. Under 8% of the sites is used for agriculture as cropland or pasture for grazing animals. About 4% of the Site is covered by water. The remainder of the site is developed as general urbanized development such as commercial development along arterial roadways, areas with multi-family housing, and offices.

The scenarios for Site D began by considering what incremental build-out, with ultimate near complete development of the land area, of the site would look like. Three scenarios were developed. Each of these three scenarios aimed to simulate the result of increasing urban land developed as residential, commercial, business or other urban uses in 25% increments: from 25% increase and up to a 75% increase. Additional scenarios were developed that investigated the impacts of LID across the landscape. These scenarios applied LID to 3% and 10% of urban developed land.

SITE D: Military

Increasing Urban Development

In the scenarios, developed land consumes agricultural, open space, and forested land. With a 75% increase in developed land, the original 30% of land within the Site D study area that was forested has been greatly diminished; approximately 1% of land area remains as forest. Similar decreases are seen in cropland, pasture, open space, shrub land, etc; such decreases area seen in all of the natural land cover types that that can actively store and/or clean stormwater runoff. Even with trees throughout the landscape of land that has been converted to urban development, tree canopy coverage across Site D is notably reduced, thereby reducing the positive effects to of trees to air and water quality.

This decrease of tree canopy and natural land cover results in a continual decline of air pollutants removed. With a 75% increase in developed land, there is a nearly 94% decline in the pounds of air pollutants removed, such as ozone, carbon monoxide, particulate matter, sulfur dioxide, and nitrogen dioxide. Meanwhile, this ultimate decline is mirrored in stormwater treatment capacity of the land in Site D. A relatively small change is seen in seen in additional stormwater storage with a 25% increase in developed land. However, as development increase by 50% and then again by 75%, the additional stormwater storage need skyrockets to an additional 52,000,000 cubic feet in the 75% development increase scenario. The associated cost with this additional treatment capacity is approximately $9,000,000 a year; including interest, the cost estimate swells to well over 100,000,000 over 20 years. This increased stormwater is likely to be much more likely to need treatment. Water pollutant loadings are predicted to increase by an average of 92% in the 75% development increase scenario.

Site D Current Conditions	
Land Cover	**Percentage**
Forested	30%
Shrubland and Wetlands	22%
Residential: 0.5 acre lots	15%
Open Space and Grass Turf	14%
Agriculture: Cropland and Pasture	9%
Residential: 0.25 acre lots	4%
General Urban: Commercial, Business, Industrial, High Density Residential	2%
Water	4%

Base Expansion

A little LID goes a long way...

To begin the evaluation of the impacts of LID, LID techniques such as green roofs, pervious pavement, and rain gardens were applied across 3% of total urban land. This minimal application of LID across the landscape results in dramatic stormwater quantity and quality effects. For example, when 3% LID is applied across the current landscape, there is an estimated reduction of 18,000,000 cubic feet of stormwater requiring treatment, amounting to a savings of well over 36,800,000 over 20 years. This trend carries forward as development increases. Comparing the 75% development increase scenario to the 75% development increase with 3% LID, the scenario with LID implementation results in a reduction of more than 1,500,000 cubic feet of stormwater requiring treatment. This equates to a savings of over $3,000,000 over the next twenty years on required stormwater treatment facilities.

and more goes even further...

Continuing the evaluation of the impacts of LID, LID techniques were applied across 10% of total urban land. This much more sizable application of LID results in striking effects on stormwater. When 10% LID is applied across the current landscape a steady decrease in stormwater runoff can be seen. Comparing the three 75% developed land increase scenarios, first the stormwater treatment required is reduced by about 1.5 million cubic feet with 3% LID implementation. 10% LID implementation continues that decline with a further reduction of nearly 4,000,000 cubic feet of stormwater runoff; this adds up to an approximate reduction of 6,000,000 cubic feet of stormwater needing treatment compared to the no-LID scenario. The 6,000,000 cubic feet treatment capacity reduction translates to a $1,000,000 annual savings.

CONCLUSIONS

Retaining and capitalizing on the natural function of a site during the land development process will yield both environmental and financial benefits to the landowner and to the region.

Green infrastructure is a vital element of our community, and respecting its value makes good economic sense; there is a positive return on investment for every dollar invested in on-site amenities.

Most importantly, green infrastructure performs important environmental services, such as cleaning our water and air, and enriches human life by providing spaces for recreation, learning, and opportunities for appreciating the natural world that surrounds us and on which all living creatures depend. Outdoor classrooms actively educate children about science, art, and mathematics. Street trees naturally cool our cities and serve to absorb stormwater runoff. Rain gardens beautify our landscapes and allow water to infiltrate into the ground. Green infrastructure is a valuable part of land development.

The practice of Low Impact Development (LID) is one way to integrate more green infrastructure features into the built landscape. LID features are intended to enable natural systems to perform in place of man-made systems. This efficiency can often reduce costs up front and will produce operational savings over the life of the project.

The analyses performed as part of the Phase III illustrate how both large and small sites offer a variety of opportunities for green infrastructure enhancement and LID practice implementation. Similarly, the land use type(s) and composition may offer its own collection of opportunities and limitations.

Key Takeaways:

- Design and landscape decisions paired with reduced parking requirements can compensate for the increased stormwater runoff associated with increased building density
- LID implementation will result in less and cleaner stormwater runoff entering local waterways
- Development on a previously forested and/or vegetated site results in poorer air quality and detrimental effects to both the quality and quantity of stormwater run-off.
- Altering landscape and site design decisions and implementing LID practices on a site multiplies benefits to air and water quality

Green Infrastructure Benefits and Practices

This section, while not providing a comprehensive list of green infrastructure practices, describes the five GI practices that are the focus of this guide and examines the breadth of benefits this type of infrastructure can offer. The following matrix is an illustrative summary of how these practices can produce different combinations of benefits. Please note that these benefits accrue at varying scales according to local factors such as climate and population.

Benefit	Reduces Stormwater Runoff											Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Practice																		
Green Roofs	●	●	●	●	○	○	○	●	●	●	●	●	◒	●	◒	◒	●	●
Tree Planting	●	●	●	●	○	◒	○	●	●	●	●	●	●	●	●	◒	●	●
Bioretention & Infiltration	●	●	●	●	◒	◒	○	○	●	●	●	●	●	◒	◒	○	●	●
Permeable Pavement	●	●	●	●	○	◒	●	◒	●	●	●	○	○	●	○	○	○	●
Water Harvesting	●	●	●	●	●	◒	○	◒	◒	◒	○	○	○	○	○	○	○	●

● Yes ◒ Maybe ○ No

more about the CITYg

Air Pollution

CITYgreen models 5 air pollutants that contribute to poor air quality and negative health effects for humans.

- Carbon Monoxide (CO) – colorless, odorless gas emitted from the combustion process, for instance, the combustion engine of a personal vehicle. CO causes harmful effects by reducing oxygen delivery to the body's organs, like the heart and brain.
- Ozone – Ground level ozone is produced when sunlight combines with volatile organic compounds (VOCs) and nitrogen oxide; these two substances are produced by automobiles, factories, and other places where gas, natural gas, and other carbon based fuels are used. Ozone at ground level irritates the respiratory system and negatively impacts the function of human lungs.
- Nitrogen Dioxide (NO2) – NO2 forms quickly from emissions from personal vehicles and power plants. NO2 contributes to the formation ground-level ozone and fine particulate air pollution and is associated with adverse effects on the human respiratory system. Also, NO2 negatively impacts ecosystems by contributing to acid rain and eutrophication, in which oxygen levels in water are reduced producing an environment that is destructive to fish and other wildlife.
- Particulate Matter (PM) – mixture of small particles and liquid droplets including: acids (nitrates and sulfates), organic chemicals, soil, and dust; PM can be found near roadways, industrial sites, or in smoke and haze. Once in the inhaled into the lungs, larger particles can affect the heart and lungs and cause serious health effects: asthma attacks, bronchitis, lung disease, and reduced immune system.
- Sulfur Dioxide (SO2) – Forms when fuel containing sulfur (coal and oil) is burned and in other industrial processes. In humans, SO2 can aggravate existing cardiovascular disease and can contribute to respiratory disease by altering pulmonary defenses. In the environment, SO2 contributes to acid rain.

Water Pollution

CITYgreen models 9 water pollution indicators that contribute to poor air quality and negative health effects for humans.

- Biological Oxygen Demand (BOD) – the amount of oxygen consumed by microorganisms in decomposing organic matter, such as waste products, leaves, and dead organisms The greater the BOD value, the more rapidly oxygen is depleted in the stream for higher forms of aquatic life. The consequences of high BOD include increased stress to aquatic life in streams, and eventually, possible suffocation and death.

reen analysis...

- Cadmium – a naturally occurring metal used in plating and coating operations, transportation equipment, and certain types of batteries and pigments. Consumption of cadmium can lead to kidney damage, atherosclerosis, and hypertension.
- Chromium – a colorless, tasteless metal found naturally in rocks, soil, plants and animals and used in industrial processes such as steel making, chrome plating, and wood preservation. Certain forms of chromium have been found to be carcinogenic when ingested by humans.
- Chemical Oxygen Demand – unlike BOD, COD does not differentiate between organic and inorganic matter. It is a measure of the total quantity of oxygen required to oxidize all material into carbon dioxide and water. As with BOD, the greater the value, the more rapidly oxygen is depleted in a stream, leading to stress of higher forms of aquatic life.
- Lead – a heavy metal used for years in household products. Lead is still used in building construction, lead-acid batteries, and as part of solders, pewters, and fusible alloys. Consumption of lead can lead to kidney damage and high blood pressure in humans, at higher levels, it can damage the nervous system and lead to blood and brain disorders.
- Nitrogen – Nitrate, chemical units containing nitrogen, are commonly used in fertilizer. Excess consumption by infants leads to shortness of breath, "blue baby syndrome," and possibly, death. Elevated levels are also associated with adverse pregnancy outcomes and, possibly cancer.
- Phosphorus – occurs naturally in rocks and soil, but also found in fertilizer, commercial cleaning preparations, and fecal waste. An abundance of phosphorus can lead to algae blooms that produce neurotoxins (affecting the nervous system) and hepatotoxins (affecting the liver). These toxins have been responsible for human and animal deaths numerous times in the past.
- Suspended Solids – Total Suspended Solids (TSS) is a means of measuring dirt, dust, and other solid particle pollution in water. These fine particles stay suspended in water until they eventually fall as sediment. Water quality suffers as fish and aquatic habitat are degraded, navigation is impaired and flooding in increased.
- Zinc – occurs naturally in rocks and soil. Zinc is used in plating and coating, as it is resistent to corrosion; it is also used in paints, toiletries, ceramics, insecticides and fungicides, fabrics manufacturing, and batteries. Ingestion of large amounts of zinc by humans can lead to stomach cramps, vomiting and anemia.

Appendix D

GREEN INFRASTRUCTURE
&
LOW IMPACT DEVELOPMENT ASSESSMENT

FORT LEE, VIRGINIA

JANUARY 2012

CRATER PLANNING DISTRICT COMMISSION

This report was funded in part by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant #NA10NOS4190205 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended.

TABLE OF CONTENTS

Introduction	1
Study Area	1
CITYgreen Software Analysis	1
Map 1 – Study Area, Fort Lee, Virginia	2
Map 2 – CCAP Data, Fort Lee, Virginia	3
Impact of Future Development	5
Map 3 – Defense Supply Center Richmond, Chesterfield County, Virginia	6
Green Infrastructure (GI) and Low Impact Development (LID)	7
Potential Benefits	8
Further Information	11
Analysis Report for Fort Lee Study Area	12
Growing Richmond's Green Infrastructure – Green Infrastructure Toolkit	36

INTRODUCTION

On September 8, 2005, the Defense Base Realignment and Closure Commission (BRAC) recommended certain realignments occur at Fort Lee, Virginia. As a result, several new organizations have relocated or consolidated their operations to Fort Lee, including the U.S. Army Ordnance Center and School from Aberdeen Proving Grounds, Maryland, and most of the U.S. Army Transportation Center and School from Fort Eustis, Virginia.

Dozens of new classroom buildings, headquarters, fitness and dining facilities, outdoor training sites, high-rise housing projects, and more have been constructed. By 2011, the installation had acquired 6.5 million square feet of new facilities at an estimated cost of $1.5 billion. In that same timeframe the daily population rose from an estimated 32,000 to nearly 47,000. As many as 70,000 troops also pass through the Fort's classrooms each year, making it the third largest training site in the Army.

Fort Lee is located in the Tri-Cities Region of Central Virginia approximately 25 miles south of the Capital City of Richmond (see Map 1). The Tri-Cities consist of Colonial Heights, Hopewell, Petersburg, and Chesterfield and Prince George Counties. Fort Lee itself is situated in Prince George County. It is adjacent to Petersburg National Battlefield and in close proximity to the major commercial areas of the Tri-Cities.

The growth at Fort Lee has put development pressure on surrounding land. Within 1.5 miles of the Fort's borders is a significant amount of property, some of which has already developed. This growth is expected to continue in the coming years. As it continues, pollution problems typically associated with development will expand. This study will examine the potential pollution impact and recommend ways to reduce it through concepts known as Green Infrastructure (GI) and Low Impact Development (LID).

STUDY AREA

The area within 1.5 miles of the Fort is approximately 21,000 acres in size. Fort Lee itself is about 5,900 acres. The Fort's main entrance is at the intersection of Temple Avenue (Route 144) and Oaklawn Boulevard (Route 36). It straddles this intersection with the southern portion mostly developed and the northern portion mostly vacant and used for outdoor training activities.

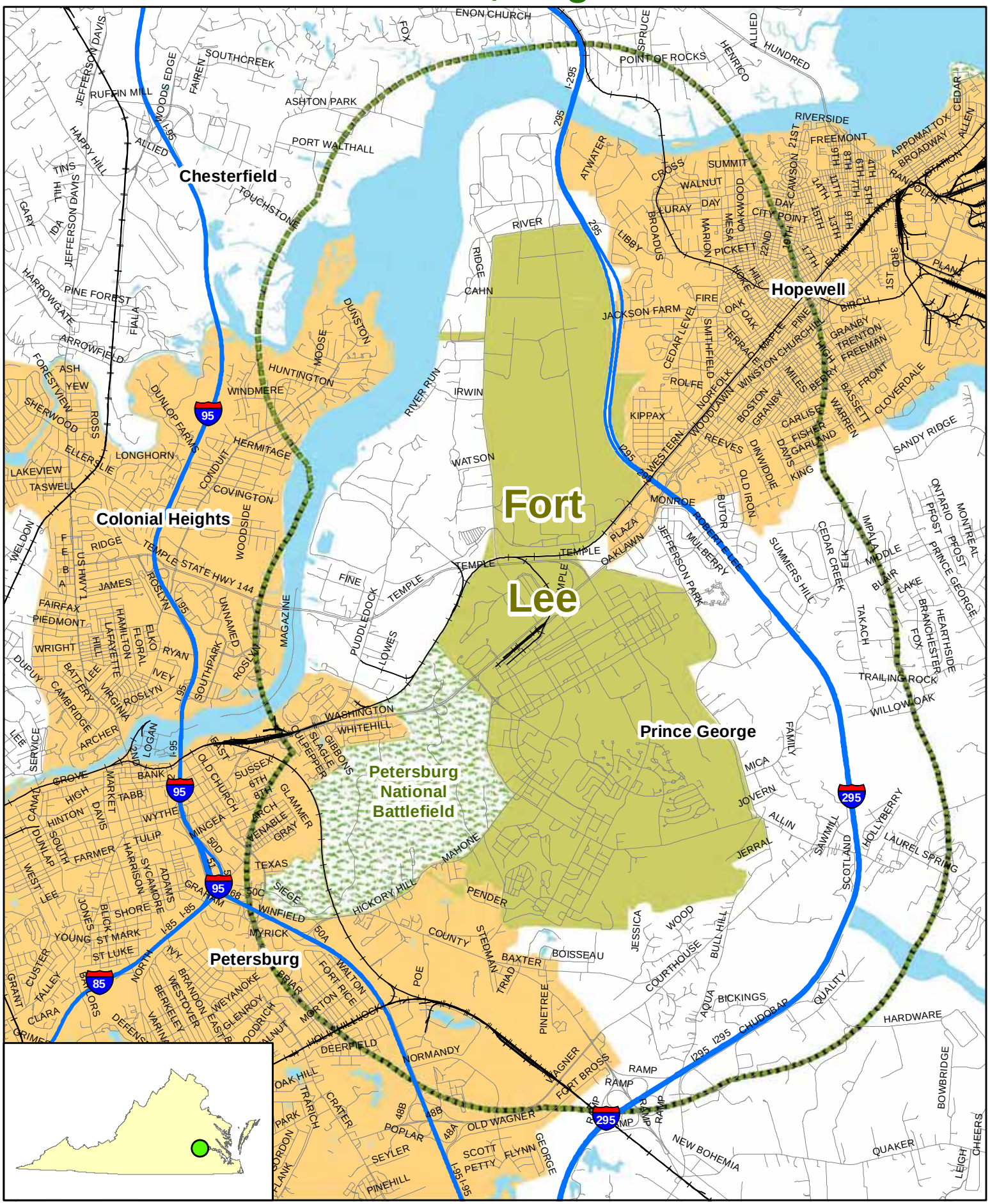
Temple Avenue and Oaklawn Boulevard are commercial corridors serving the Tri-Cities. Temple Avenue has seen significant growth the past few years with expansion of the Fort, a trend which is expected to continue. A large amount of land not along these corridors is also available for development. Most of that is expected to be residential in nature.

CITYgreen SOFTWARE ANALYSIS

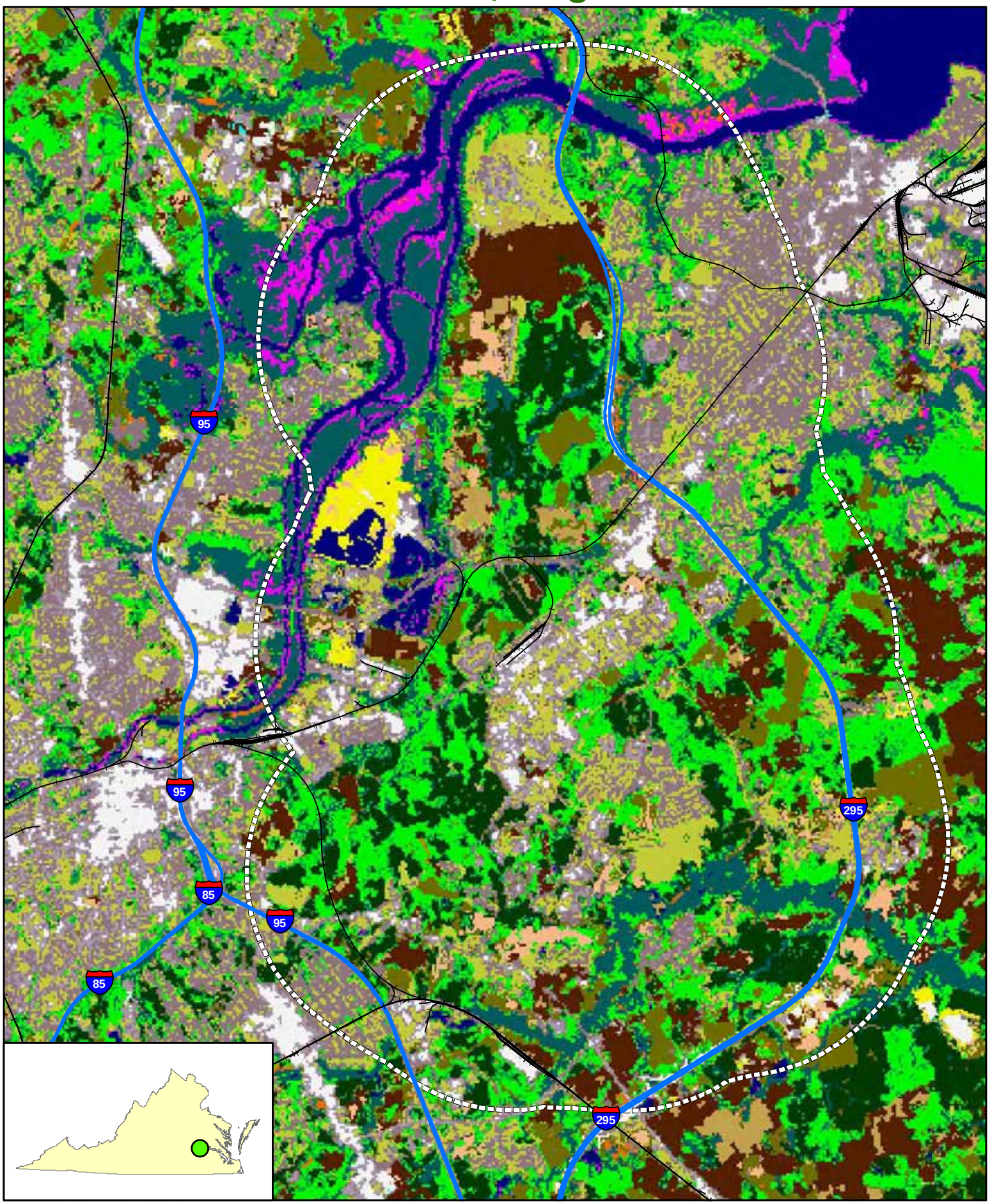
CITYgreen is a software package created by American Forests, a non-profit conservation organization. When paired with geographic information systems (GIS), CITYgreen performs a land cover based analysis of a specific study area to calculate the value of tree canopy in both economic and ecological terms. The software runs several models to produce quantitative results on the ability of trees to perform air pollution removal, carbon storage and sequestration, and stormwater management.

With the assistance of staff from the Richmond Regional Planning District Commission (RRPDC), several CITYgreen analyses were run on Fort Lee and surrounding land within 1.5 miles. They are outlined in the attached document titled **Analysis Report for Fort Lee Study Area**. The input data for this analysis was satellite photography from the Coastal Change Analysis Program (CCAP) shown on Map 2. CCAP produces a nationally standardized database of land cover and land change information for the coastal regions of the United States. More information can be found at this website:

Map 1 - Study Area
Fort Lee, Virginia



Map 2 - CCAP Data
Fort Lee, Virginia



http://www.csc.noaa.gov/digitalcoast/data/ccapregional

CITYgreen calculated that 29.7% (approximately 7,600 acres) of the study area is currently tree canopy and undeveloped. The software also estimates the effect this tree canopy area has on pollution in the immediate area. CITYgreen utilizes four different analysis measures:

1. Air Pollution Removal
2. Carbon Storage and Sequestration
3. Stormwater Quality
4. Stormwater Quantity

1. Air Pollution Removal

CITYgreen calculates the air pollution removal capabilities of trees in the study area. The calculation for weight of pollutants removed per year is based on the UFORE model developed by the U.S. Forest Service using data gathered from studies measuring the air pollution removal effects of trees in 55 cities across the United States. The calculation for the dollar value of the removal of the pollutants is based on the value of avoided costs caused by pollution. Increased public health costs and reduced tourism revenue are examples. The costs used in the UFORE model analysis are established by the Virginia State Corporation Commission.

CITYgreen estimates the current tree canopy in the study area removes **781,986 pounds** of components that make up air pollution each year. That action has a yearly economic value of **$2,279,988**.

2. Carbon Storage and Sequestration

Trees and other plants use carbon dioxide (CO2) as an input for the process of photosynthesis through which they produce sugars and oxygen. The oxygen (O2) is released into the atmosphere as a waste product while the sugars act as food for the plant. Trees and plants naturally store carbon in their plant structures as sugars are used to form new growth.

According to CITYgreen, the current tree canopy in the study area stores **328,254 tons** of carbon. Over the course of one year, the existing tree canopy stores an additional **2,556 tons** of carbon.

3. Stormwater Quality

Tree canopy in the study area helps protect water quality in nearby rivers and streams, including the Appomattox River. If the tree canopy were completely removed, there would be a marked change in various indicators of water quality. The percentage change in water quality included in the following table is determined by comparing stormwater pollution contamination with the existing tree canopy on the ground to what the stormwater contamination would be if all trees were replaced by impervious surfaces.

Contaminant Loading	Percentage Change
Biological Oxygen Demand	88.9%
Cadmium	131.3%
Chromium	214.8%
Chemical Oxygen Demand	256.0%
Lead	26.1%
Nitrogen	37.3%
Phosphorus	114.6%
Suspended Solids	87.0%
Zinc	17.8%

4. Stormwater Quantity

Stormwater can become a problem in urban areas where rainfall runs off rapidly and causes higher stream flows that carry contaminants such as oil and grease into waterways. Replacing paved and barren areas with natural land cover, such as trees, can help to mitigate runoff pollution and help avoid the need for far more expensive, engineered stormwater structures to contain urban runoff.

The CITYgreen software determines the value of trees as they relate to stormwater management by a comparison of scenarios. The dollar values listed here reflect the additional costs a locality would have to assume if the tree canopy in the study area were replaced with impervious surfaces. The total estimated value is **$122,693,573** with an annual stormwater value of **$10,696,985** based on 20-year financing at 6% interest.

IMPACT OF FUTURE DEVELOPMENT

The CITYgreen estimates to this point are all based on the *current* amount of development in the study area. It is also known this is a growing and developing area. To determine the pollution impact of future development, the amount and type of development had to be estimated. To accomplish this, the area around a similar but "built-up" installation had to be examined. Fortunately, such a site was nearby in Chesterfield County – The Defense Supply Center Richmond (DSCR).

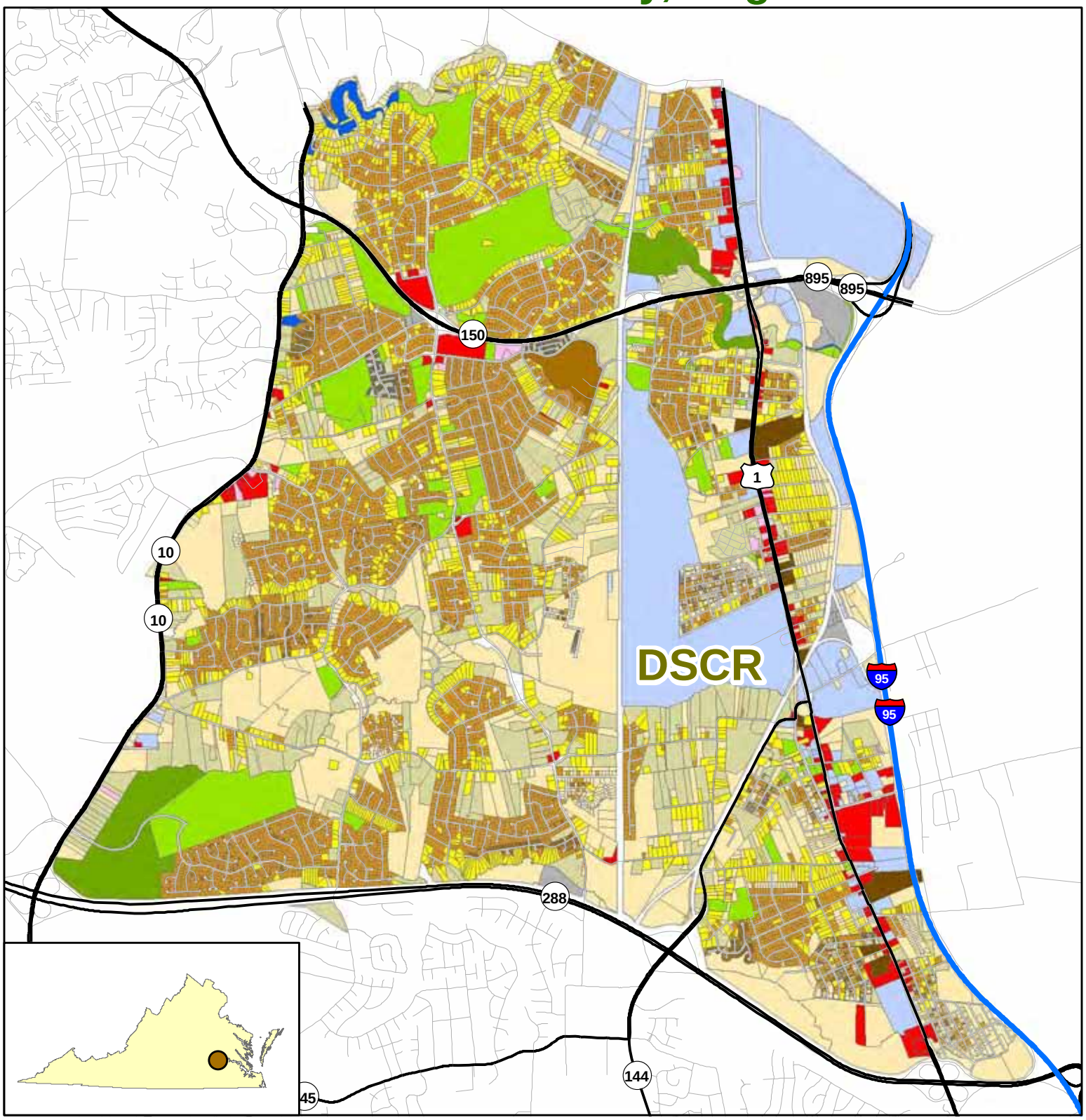
The DSCR is a Department of Defense installation that sits on just over 600 acres along Route 1 in Chesterfield County. The center and its tenant organizations employ more than 3,000 workers whose mission is to support the needs of the military services worldwide. As of 2006, that support included the acquisition of material for more than 700,000 items of supply, as well as the maintenance of a wide array of logistics information, technical specifications, and data. Currently, the DSCR's main mission is to lead the Defense Logistics Agency's aviation supply and demand chains worldwide.

The area around DSCR is almost all developed (see Map 3). The facility sits along an older commercial stretch of Route 1. Land use GIS data from Chesterfield County was examined to determine percentage splits of different land use types. The following table shows those percentages.

Land Use Type	Percentage
Agricultural/Forest/Undeveloped	24.9%
Commercial	2.6%
High Density Residential	1.6%
Industrial	13.1%
Low Density Residential	12.5%
Medium Density Residential	21.1%
Multi-Family	0.7%
Office	0.3%
Parks/Public Open Space	2.5%
Public/Semi-Public	6.7%
Rural Residential	12.8%
Utility	0.7%
Water	0.3%
Unclassified	0.1%
TOTAL	100.0%

Using these percentages, one is able to predict the type and amount of future development around Fort Lee and input it into CITYgreen for analysis. Three scenarios were constructed showing 25%, 50%, and 75% increases in the amount of development around Fort Lee. The changes in measurable pollution are illustrated in the following tables.

Map 3 - Defense Supply Center Richmond
Chesterfield County, Virginia



	Industrial	Office	Utility
Ag/Forest/Undev	Low Density Residential	Parks/Public Open Space	Water
Commercial	Medium Density Residential	Public/Semi-Public	
High Density Residential	Multi-Family	Rural Residential	

1. Air Pollution Removal

Scenario	Tree Canopy %	Yearly Pollution Removed (lbs.)	Yearly Economic Value
Current	29.7%	781,986	$2,279,988
25% Increase	20.1%	530,128	$1,545,662
50% Increase	10.6%	278,113	$810,877
75% Increase	1.0%	26,098	$76,092

2. Carbon Storage and Sequestration

Scenario	Tree Canopy %	Tons of Carbon Stored	Yearly Tons of Carbon Sequestered
Current	29.7%	328,254	2,556
25% Increase	20.1%	222,532	1,732
50% Increase	10.6%	116,743	909
75% Increase	1.0%	10,955	85

3. Stormwater Quality

Contaminant Loading	Percentage Change Current	Percentage Change 25%	Percentage Change 50%	Percentage Change 75%
Biological Oxygen Demand	88.9%	2.8%	39.9%	77.0%
Cadmium	131.3%	4.1%	58.9%	113.7%
Chromium	214.8%	6.8%	96.4%	186.0%
Chemical Oxygen Demand	256.0%	8.0%	114.9%	221.7%
Lead	26.1%	0.8%	11.7%	22.6%
Nitrogen	37.3%	1.2%	16.7%	32.3%
Phosphorus	114.6%	3.6%	51.4%	99.3%
Suspended Solids	87.0%	2.7%	39.0%	75.3%
Zinc	17.8%	0.6%	8.0%	15.5%

4. Stormwater Quantity

Scenario	Tree Canopy %	Total Stormwater Value	Annual Stormwater Value
Current	29.7%	$122,693,573	$10,696,985
25% Increase	20.1%	$3,267,242	$284,853
50% Increase	10.6%	$50,106,426	$4,368,507
75% Increase	1.0%	$103,851,164	$9,054,218

GREEN INFRASTRUCTURE (GI) AND LOW IMPACT DEVELOPMENT (LID)

Green Infrastructure (GI) is a concept that has become increasingly popular over the past twenty years in the fields of land use and environmental planning. However, the GI concept originated well over one hundred years ago with planning and conservation efforts from landscape architect Frederick Law Olmstead, various

wildlife biologists, and ecologists. These early leaders espoused the importance of an organized conservation system for the health and well-being of both humans and wildlife. Generally defined, Green Infrastructure is a strategically managed network of natural lands, working lands and other natural spaces, that provides numerous benefits – ecological and economic - to human and wildlife populations. More specifically, GI provides for habitat preservation and diversity, water filtration and storage, and improved air quality.

Low-impact development (LID) is a term used in the United States to describe a land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. LID features can be incorporated into almost every section of the urban environment including open space, rooftops, streetscapes, parking lots, sidewalks, and medians.

These concepts can be applied to new development, urban retrofits, and redevelopment projects. These features are more environmentally and economically sustainable ways to address the adverse impacts of urbanization. By managing runoff close to its source through intelligent site design, GI and LID tools can enhance the local environment, protect public health, and improve community livability.

GI and LID concepts fall into four different categories: Urban Water, Site Planning, Community Spaces, and Community Stewardship. Detailed definitions are listed in the attached document titled **Growing Richmond's Green Infrastructure**. A brief listing is shown on here.

Urban Water	**Site Planning**
• Vegetated Swales / Bioswales • Rain Gardens / Bioretention Areas • Vegetated Filter Strips • Stormwater Wetland	• Street Design • Reducing Impervious Surfaces • Vegetated Landscaping • Urban Forestry • Urban Stream Restoration • Riparian Buffers
Community Spaces	**Community Stewardship**
• Pocket Park • Informal Recreation • Meadow/Native Habitat • Outdoor Classroom • Community Garden	• Green Space Grant Programs • Land Banking • Mow-to-Own • Adopt-a-Block

POTENTIAL BENEFITS

Adoption of GI and LID concepts can lead to measurable benefits associated with a reduction in pollution. The benefits are mostly within the stormwater categories because these concepts help treat and control runoff into waterways. They do not greatly impact air pollution caused mostly by human activity.

Under two different scenarios where just three percent (3%) or ten percent (10%) of the land being developed were to establish GI and LID concepts, the pollution effect could be seen in the following tables. Detailed descriptions and results are in the attached document titled **Analysis Report for Fort Lee Study Area**.

The information presented here can provide a guide going forward for various development scenarios and assist decision-makers charged with shaping the future development of the Tri-Cities Region.

1. Air Pollution Removal – Multiple Scenarios

Scenario	Tree Canopy %	Yearly Pollution Removed (lbs.)	Yearly Economic Value
Current	29.7%	781,986	$2,279,988
Current (3% GI/LID)	29.7%	782,934	$2,282,752
Current (10% GI/LID)	29.7%	782,934	$2,282,752
25% Increase	20.1%	530,128	$1,545,662
25% (3% GI/LID)	20.1%	529,864	$1,544,893
25% (10% GI/LID)	20.1%	529,864	$1,544,893
50% Increase	10.6%	278,113	$810,877
50% (3% GI/LID)	10.6%	279,431	$814,720
50% (10% GI/LID)	10.6%	279,431	$814,720
75% Increase	1.0%	26,098	$76,092
75% (3% GI/LID)	1.0%	26,361	$76,860
75% (10% GI/LID)	1.0%	26,361	$76,860

2. Carbon Storage and Sequestration – Multiple Scenarios

Scenario	Tree Canopy %	Tons of Carbon Stored	Yearly Tons of Carbon Sequestered
Current	29.7%	328,254	2,556
Current (3% GI/LID)	29.7%	328,652	2,559
Current (10% GI/LID)	29.7%	328,652	2,559
25% Increase	20.1%	222,532	1,732
25% (3% GI/LID)	20.1%	222,421	1,732
25% (10% GI/LID)	20.1%	222,421	1,732
50% Increase	10.6%	116,743	909
50% (3% GI/LID)	10.6%	117,297	913
50% (10% GI/LID)	10.6%	117,297	913
75% Increase	1.0%	10,955	85
75% (3% GI/LID)	1.0%	11,066	86
75% (10% GI/LID)	1.0%	11,066	86

3. Stormwater Quality – Multiple Scenarios

Current Development Scenario

Contaminant Loading	Percentage Change Current	Percentage Change Current (3% GI/LID)	Percentage Change Current (10% GI/LID)
Biological Oxygen Demand	88.9%	-33.9%	-32.1%
Cadmium	131.3%	-50.0%	-47.4%
Chromium	214.8%	-81.8%	-77.5%
Chemical Oxygen Demand	256.0%	-91.5%	-91.5%
Lead	26.1%	-10.0%	-9.4%
Nitrogen	37.3%	-14.2%	-13.4%
Phosphorus	114.6%	-43.7%	-41.4%
Suspended Solids	87.0%	-33.1%	-31.4%
Zinc	17.8%	-6.8%	-6.4%

25% Development Scenario

Contaminant Loading	Percentage Change 25%	Percentage Change 25% (3% GI/LID)	Percentage Change 25% (10% GI/LID)
Biological Oxygen Demand	2.8%	3.8%	6.5%
Cadmium	4.1%	5.6%	9.6%
Chromium	6.8%	9.2%	15.8%
Chemical Oxygen Demand	8.0%	10.9%	18.8%
Lead	0.8%	1.1%	1.9%
Nitrogen	1.2%	1.6%	2.7%
Phosphorus	3.6%	4.9%	8.4%
Suspended Solids	2.7%	3.7%	6.4%
Zinc	0.6%	0.8%	1.3%

50% Development Scenario

Contaminant Loading	Percentage Change 50%	Percentage Change 50% (3% GI/LID)	Percentage Change 50% (10% GI/LID)
Biological Oxygen Demand	39.9%	41.3%	45.3%
Cadmium	58.9%	61.0%	66.9%
Chromium	96.4%	99.8%	109.4%
Chemical Oxygen Demand	114.9%	119.0%	130.3%
Lead	11.7%	12.1%	13.3%
Nitrogen	16.7%	17.3%	19.0%
Phosphorus	51.4%	53.3%	58.4%
Suspended Solids	39.0%	40.4%	44.3%
Zinc	8.0%	8.3%	9.1%

75% Development Scenario

Contaminant Loading	Percentage Change 75%	Percentage Change 75% (3% GI/LID)	Percentage Change 75% (10% GI/LID)
Biological Oxygen Demand	77.0%	79.0%	83.8%
Cadmium	113.7%	116.7%	123.8%
Chromium	186.0%	190.8%	202.5%
Chemical Oxygen Demand	221.7%	227.4%	241.4%
Lead	22.6%	23.2%	24.6%
Nitrogen	32.3%	33.1%	35.1%
Phosphorus	99.3%	101.8%	108.1%
Suspended Solids	75.3%	77.3%	82.0%
Zinc	15.5%	15.9%	16.8%

4. Stormwater Quantity – Multiple Scenarios

Scenario	Tree Canopy %	Total Stormwater Value	Annual Stormwater Value
Current	29.7%	$122,693,573	$10,696,985
Current (3% GI/LID)	29.7%	-$36,824,277	$3,210,508
Current (10% GI/LID)	29.7%	-$35,000,458	$3,051,499
25% Increase	20.1%	$3,267,242	$284,853
25% (3% GI/LID)	20.1%	$4,438,295	$386,951
25% (10% GI/LID)	20.1%	$7,681,479	$669,706
50% Increase	10.6%	$50,106,426	$4,368,507
50% (3% GI/LID)	10.6%	$52,046,214	$4,537,626
50% (10% GI/LID)	10.6%	$57,453,694	$5,009,075
75% Increase	1.0%	$103,851,164	$9,054,218
75% (3% GI/LID)	1.0%	$106,931,722	$9,322,795
75% (10% GI/LID)	1.0%	$114,571,546	$9,988,869

FURTHER INFORMATION

For more information on Green Infrastructure and Low Impact Development, please visit the following websites:

- Green Infrastructure Center: http://www.gicinc.org
- National Water-Quality Assessment (NAWQA) Program: http://water.usgs.gov/nawqa/
- EPA's Green Infrastructure Website: http://cfpub.epa.gov/npdes/home.cfm?program_id=298
- EPA's Low Impact Development Website: http://www.epa.gov/owow/NPS/lid/

Analysis Report

for

Fort Lee Study Area

Tree Canopy: 7,628.2 acres (29.7%)

Land cover in acres and percentages

Cropland: Row Crops	1,898.4	7.4%
Meadow (Continuous grass, generally mowed, not grazed)	450.1	1.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	301.4	1.2%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,943.8	11.4%
Pasture/Range (Continuous forage for grazing)	300.5	1.2%
Shrub	5,561.1	21.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	7,628.2	29.7%
Urban	607.8	2.4%
Urban: Residential: 0.25ac Lots	994.7	3.9%
Urban: Residential: 0.5ac Lots	3,913.4	15.2%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state's Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	13,600	6,674
Ozone:	394,393	$1,393,410
Nitrogen Dioxide:	101,998	$360,365
Particulate Matter:	190,397	$449,117
Sulfur Dioxide:	81,599	$70,422
Totals:	**781,986**	**2,279,988**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree's dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**328,254**
Tons Sequestered **(Annually)**:	**2,556**

Analysis Report
for
Fort Lee Study Area

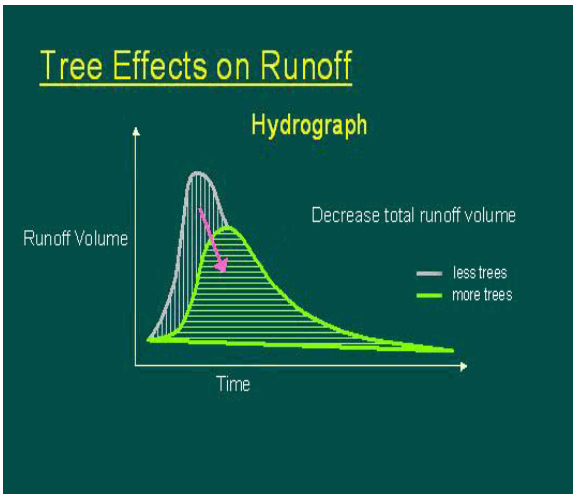
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

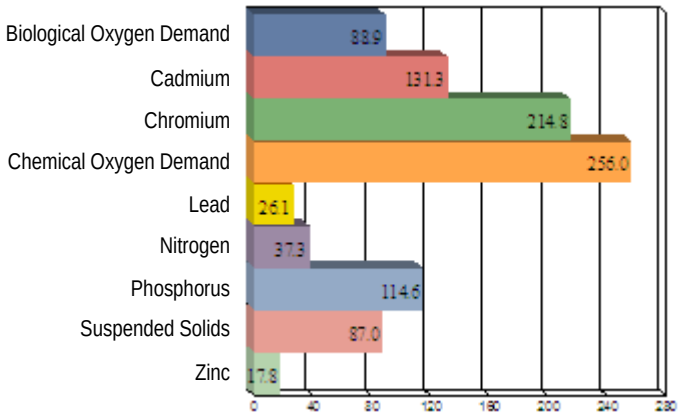
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	80
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**61,346,787**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$122,693,573**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$10,696,985**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: Current 3% LID

Tree Canopy: 7,637.5 acres (29.7%)

Land cover in acres and percentages

Cropland: Row Crops	1,902.9	7.4%
Low Impact Development	128.6	0.5%
Meadow (Continuous grass, generally mowed, not grazed)	462.9	1.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,931.6	11.4%
Pasture/Range (Continuous forage for grazing)	308.6	1.2%
Shrub	5,554.5	21.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	7,637.5	29.7%
Urban	591.5	2.3%
Urban: Residential: 0.25ac Lots	977.2	3.8%
Urban: Residential: 0.5ac Lots	3,805.9	14.8%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	13,616	6,682
Ozone:	394,871	$1,395,100
Nitrogen Dioxide:	102,122	$360,802
Particulate Matter:	190,627	$449,661
Sulfur Dioxide:	81,697	$70,507
Totals:	**782,934**	**2,282,752**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**328,652**
Tons Sequestered **(Annually)**:	**2,559**

Analysis Report

for

Fort Lee Study Area: Current 3% LID

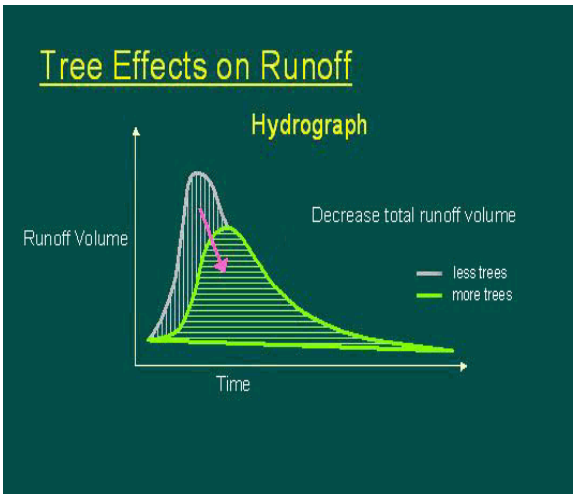
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

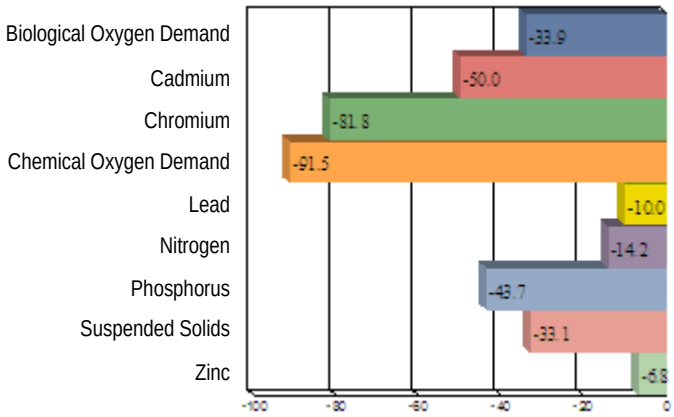
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	65
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**-18,412,139**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$-36,824,277**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$3,210,508**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: Current 10% LID

Tree Canopy: 7,637.5 acres (29.7%)

Land cover in acres and percentages

Cropland: Row Crops	1,902.9	7.4%
Low Impact Development	540.0	2.1%
Meadow (Continuous grass, generally mowed, not grazed)	462.9	1.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,931.6	11.4%
Pasture/Range (Continuous forage for grazing)	308.6	1.2%
Shrub	5,554.5	21.6%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	7,637.5	29.7%
Urban	540.0	2.1%
Urban: Residential: 0.25ac Lots	900.0	3.5%
Urban: Residential: 0.5ac Lots	3,523.0	13.7%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	13,616	6,682
Ozone:	394,871	$1,395,100
Nitrogen Dioxide:	102,122	$360,802
Particulate Matter:	190,627	$449,661
Sulfur Dioxide:	81,697	$70,507
Totals:	**782,934**	**2,282,752**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**328,652**
Tons Sequestered **(Annually)**:	**2,559**

Analysis Report

for

Fort Lee Study Area: Current 10% LID

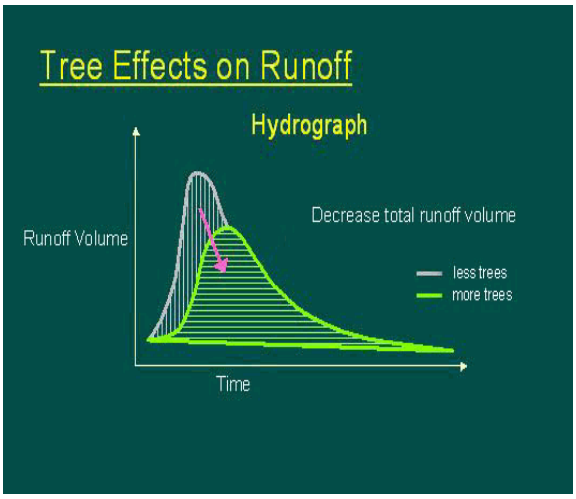
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

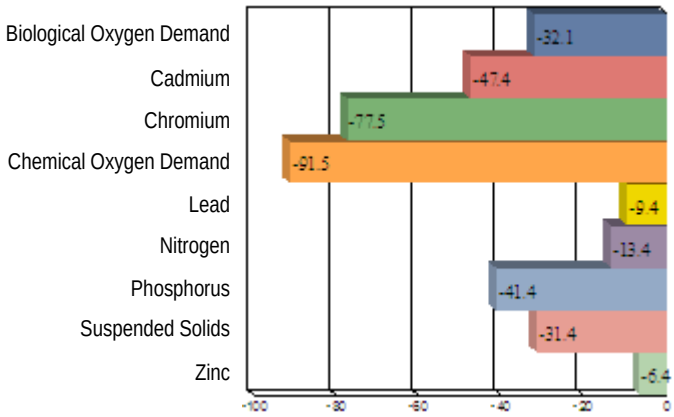
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	65
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**-17,500,229**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$-35,000,458**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$3,051,499**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 25% Development Increase

Tree Canopy: 5,171.4 acres (20.1%)

Land cover in acres and percentages

Cropland: Row Crops	1,285.8	5.0%
Impervious Surfaces: Buildings/ structures	0.0	0.0%
Meadow (Continuous grass, generally mowed, not grazed)	303.4	1.2%
Open Space - Grass/Scattered Trees: Grass cover < 50%	203.9	0.8%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,994.1	7.8%
Pasture/Range (Continuous forage for grazing)	203.2	0.8%
Shrub	3,769.9	14.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	5,171.4	20.1%
Urban	1,406.6	5.5%
Urban: Commercial/Business	308.6	1.2%
Urban: Industrial	1,353.3	5.3%
Urban: Residential: 0.25ac Lots	3,456.2	13.4%
Urban: Residential: 0.5ac Lots	5,143.1	20.0%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	9,220	4,525
Ozone:	267,369	$944,628
Nitrogen Dioxide:	69,147	$244,300
Particulate Matter:	129,075	$304,467
Sulfur Dioxide:	55,318	$47,741
Totals:	**530,128**	**1,545,662**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**222,532**
Tons Sequestered **(Annually)**:	**1,732**

Analysis Report

for

Fort Lee Study Area: 25% Development Increase

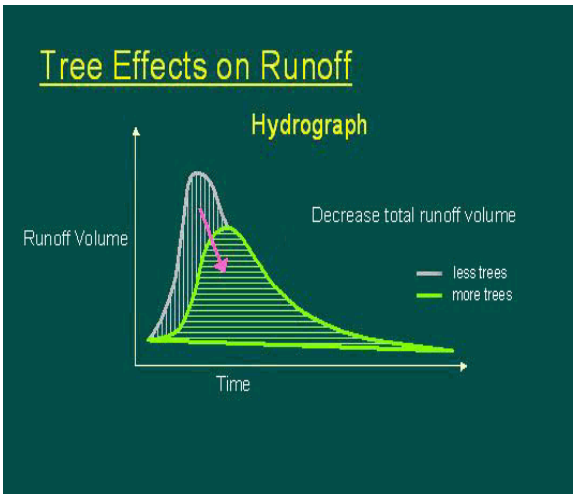
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

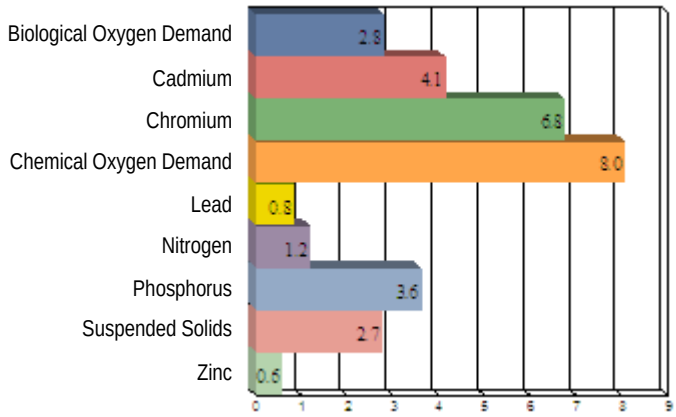
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	69
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**1,633,621**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$3,267,242**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$284,853**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 25% Increase 3% LID

Tree Canopy: 5,168.8 acres (20.1%)

Land cover in acres and percentages

Cropland: Row Crops	1,285.8	5.0%
Low Impact Development	334.3	1.3%
Meadow (Continuous grass, generally mowed, not grazed)	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover < 50%	205.7	0.8%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,005.8	7.8%
Pasture/Range (Continuous forage for grazing)	205.7	0.8%
Shrub	3,780.2	14.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	5,168.8	20.1%
Urban	1,362.9	5.3%
Urban: Commercial/Business	308.6	1.2%
Urban: Industrial	1,311.5	5.1%
Urban: Residential: 0.25ac Lots	3,343.0	13.0%
Urban: Residential: 0.5ac Lots	4,988.8	19.4%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	9,215	4,522
Ozone:	267,236	$944,158
Nitrogen Dioxide:	69,113	$244,179
Particulate Matter:	129,010	$304,316
Sulfur Dioxide:	55,290	$47,717
Totals:	**529,864**	**1,544,893**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**222,421**
Tons Sequestered **(Annually)**:	**1,732**

Analysis Report

for

Fort Lee Study Area: 25% Increase 3% LID

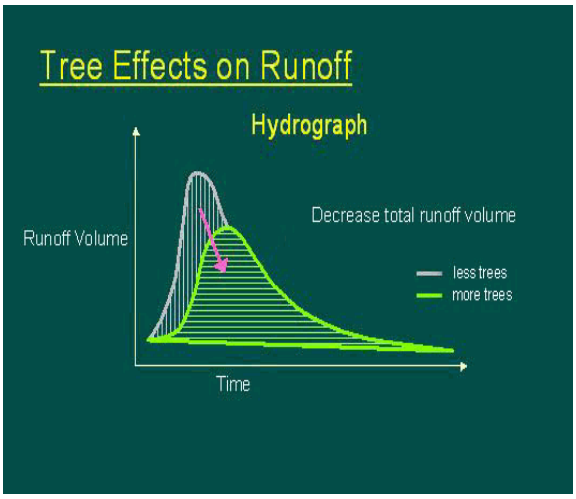
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

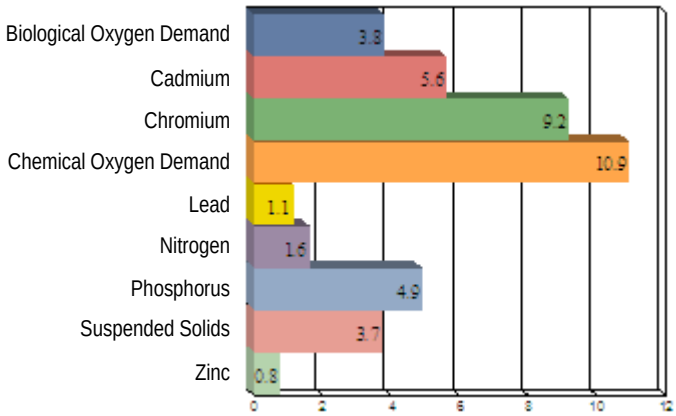
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	70
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**2,219,147**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$4,438,295**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$386,951**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 25% Increase 10% LID

Tree Canopy: 5,168.8 acres (20.1%)

Land cover in acres and percentages

Cropland: Row Crops	1,285.8	5.0%
Low Impact Development	1,157.2	4.5%
Meadow (Continuous grass, generally mowed, not grazed)	308.6	1.2%
Open Space - Grass/Scattered Trees: Grass cover < 50%	205.7	0.8%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	2,005.8	7.8%
Pasture/Range (Continuous forage for grazing)	205.7	0.8%
Shrub	3,780.2	14.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	5,168.8	20.1%
Urban	1,260.1	4.9%
Urban: Commercial/Business	282.9	1.1%
Urban: Industrial	1,208.6	4.7%
Urban: Residential: 0.25ac Lots	3,111.6	12.1%
Urban: Residential: 0.5ac Lots	4,628.8	18.0%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	9,215	4,522
Ozone:	267,236	$944,158
Nitrogen Dioxide:	69,113	$244,179
Particulate Matter:	129,010	$304,316
Sulfur Dioxide:	55,290	$47,717
Totals:	**529,864**	**1,544,893**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**222,421**
Tons Sequestered **(Annually)**:	**1,732**

Analysis Report

for

Fort Lee Study Area: 25% Increase 10% LID

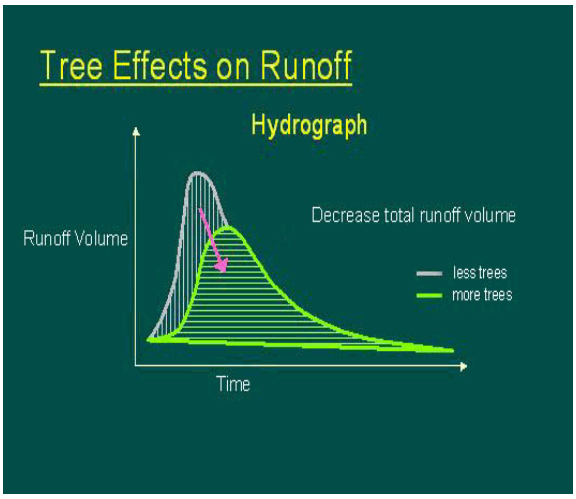
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

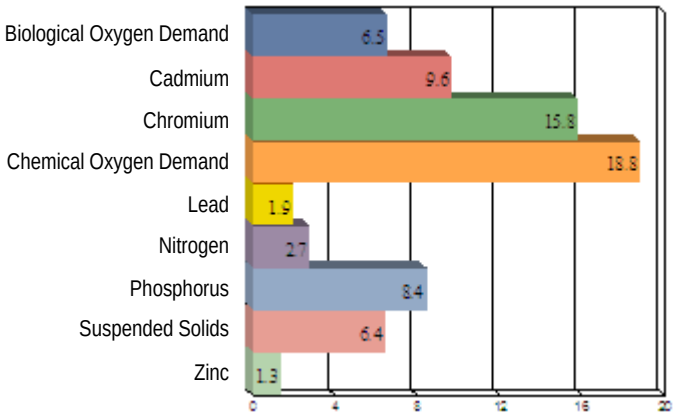
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	70
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**3,840,740**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$7,681,479**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$669,706**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 50% Development Increase

Tree Canopy: 2,713.0 acres (10.6%)

Land cover in acres and percentages

Cropland: Row Crops	673.7	2.6%
Meadow (Continuous grass, generally mowed, not grazed)	159.4	0.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	108.0	0.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,046.6	4.1%
Pasture/Range (Continuous forage for grazing)	108.0	0.4%
Shrub	1,977.5	7.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	2,713.0	10.6%
Urban	2,206.4	8.6%
Urban: Commercial/Business	614.6	2.4%
Urban: Industrial	2,705.3	10.5%
Urban: Residential: 0.25ac Lots	5,914.5	23.0%
Urban: Residential: 0.5ac Lots	6,372.3	24.8%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state's Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	4,837	2,374
Ozone:	140,266	$495,566
Nitrogen Dioxide:	36,276	$128,164
Particulate Matter:	67,714	$159,728
Sulfur Dioxide:	29,020	$25,046
Totals:	**278,113**	**810,877**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree's dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**116,743**
Tons Sequestered **(Annually)**:	**909**

Analysis Report

for

Fort Lee Study Area: 50% Development Increase

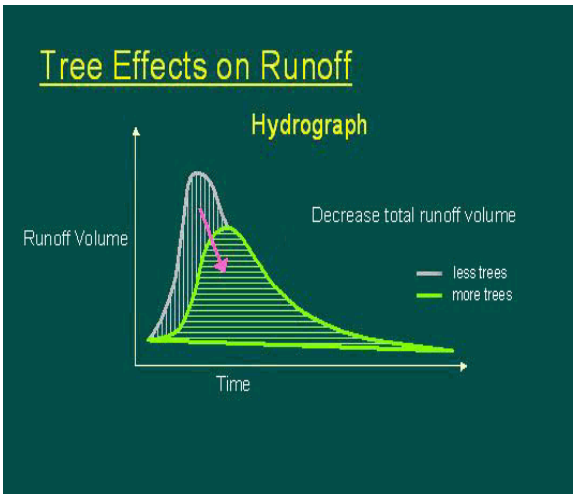
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

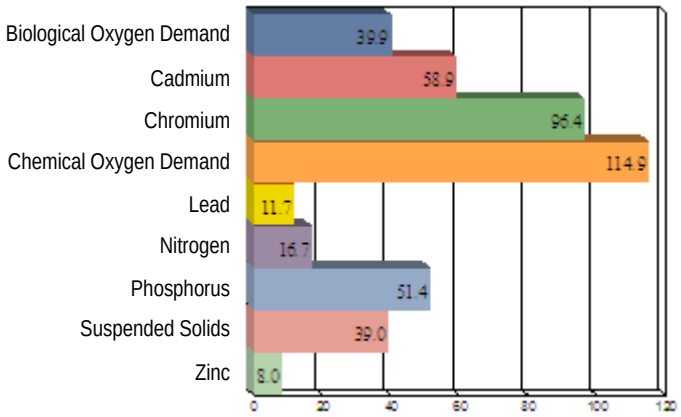
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	74
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**25,053,213**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$50,106,426**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$4,368,507**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 50% Increase 3% LID

Tree Canopy: 2,725.8 acres (10.6%)

Land cover in acres and percentages

Cropland: Row Crops	668.6	2.6%
Impervious Surfaces: Buildings/ structures	0.0	0.0%
Low Impact Development	540.0	2.1%
Meadow (Continuous grass, generally mowed, not grazed)	154.3	0.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	102.9	0.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,054.3	4.1%
Pasture/Range (Continuous forage for grazing)	102.9	0.4%
Shrub	1,980.1	7.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	2,725.8	10.6%
Urban	2,134.4	8.3%
Urban: Commercial/Business	591.5	2.3%
Urban: Industrial	2,623.0	10.2%
Urban: Residential: 0.25ac Lots	5,734.5	22.3%
Urban: Residential: 0.5ac Lots	6,197.4	24.1%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	4,860	2,385
Ozone:	140,930	$497,914
Nitrogen Dioxide:	36,448	$128,771
Particulate Matter:	68,035	$160,485
Sulfur Dioxide:	29,158	$25,164
Totals:	**279,431**	**814,720**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**117,297**
Tons Sequestered **(Annually)**:	**913**

Analysis Report

for

Fort Lee Study Area: 50% Increase 3% LID

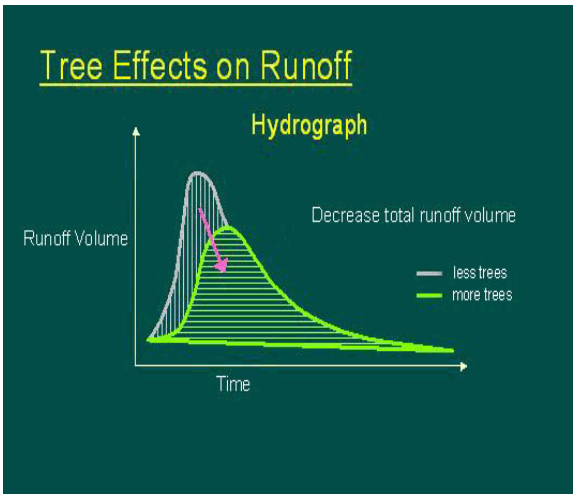
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

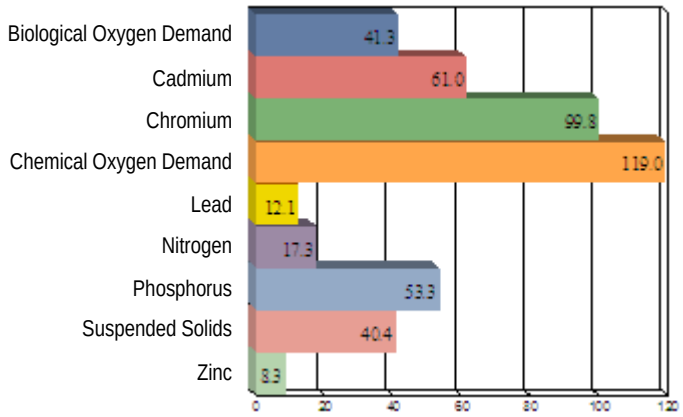
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	74
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**26,023,107**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$52,046,214**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$4,537,626**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 50% Increase 10% LID

Tree Canopy: 2,725.8 acres (10.6%)

Land cover in acres and percentages

Cropland: Row Crops	668.6	2.6%
Low Impact Development	1,774.4	6.9%
Meadow (Continuous grass, generally mowed, not grazed)	154.3	0.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	102.9	0.4%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	1,054.3	4.1%
Pasture/Range (Continuous forage for grazing)	102.9	0.4%
Shrub	1,980.1	7.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	2,725.8	10.6%
Urban	1,980.1	7.7%
Urban: Commercial/Business	565.7	2.2%
Urban: Industrial	2,443.0	9.5%
Urban: Residential: 0.25ac Lots	5,323.1	20.7%
Urban: Residential: 0.5ac Lots	5,734.5	22.3%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	4,860	2,385
Ozone:	140,930	$497,914
Nitrogen Dioxide:	36,448	$128,771
Particulate Matter:	68,035	$160,485
Sulfur Dioxide:	29,158	$25,164
Totals:	**279,431**	**814,720**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**117,297**
Tons Sequestered **(Annually)**:	**913**

Analysis Report

for

Fort Lee Study Area: 50% Increase 10% LID

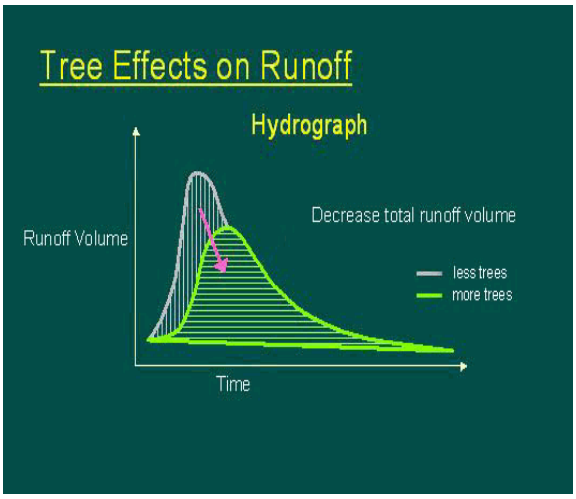
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

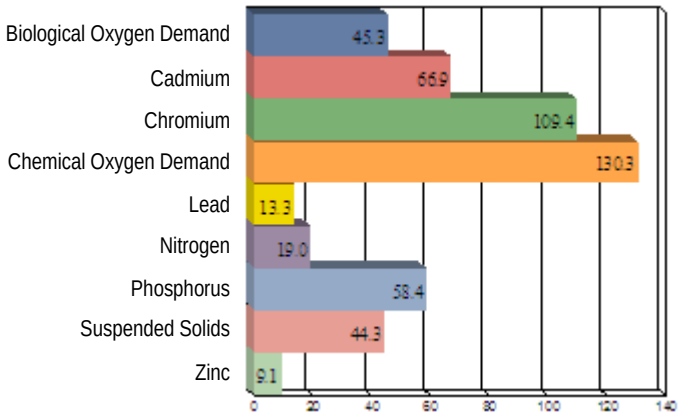
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	75
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**28,726,847**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$57,453,694**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$5,009,075**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 75% Development Increase

Tree Canopy: 254.6 acres (1.0%)

Land cover in acres and percentages

Cropland: Row Crops	64.3	0.2%
Impervious Surfaces: Buildings/ structures	0.0	0.0%
Meadow (Continuous grass, generally mowed, not grazed)	15.4	0.1%
Open Space - Grass/Scattered Trees: Grass cover < 50%	10.3	0.0%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	97.7	0.4%
Pasture/Range (Continuous forage for grazing)	10.3	0.0%
Shrub	185.2	0.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	254.6	1.0%
Urban	3,006.1	11.7%
Urban: Commercial/Business	920.6	3.6%
Urban: Industrial	4,057.9	15.8%
Urban: Residential: 0.25ac Lots	8,375.5	32.6%
Urban: Residential: 0.5ac Lots	7,601.5	29.6%
Water Area	1,116.0	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	454	223
Ozone:	13,162	$46,503
Nitrogen Dioxide:	3,404	$12,027
Particulate Matter:	6,354	$14,989
Sulfur Dioxide:	2,723	$2,350
Totals:	**26,098**	**76,092**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**10,955**
Tons Sequestered **(Annually)**:	**85**

Analysis Report

for

Fort Lee Study Area: 75% Development Increase

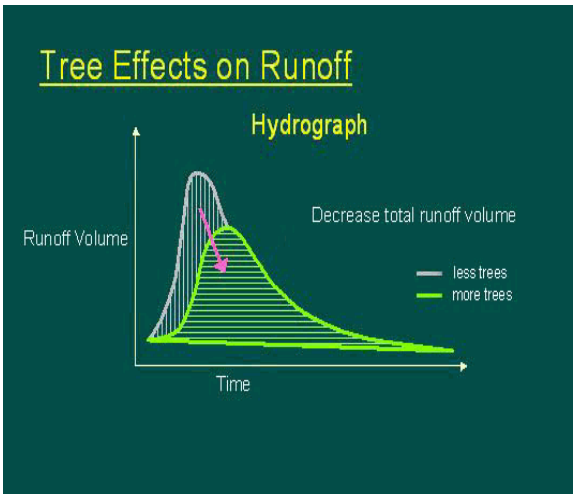
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

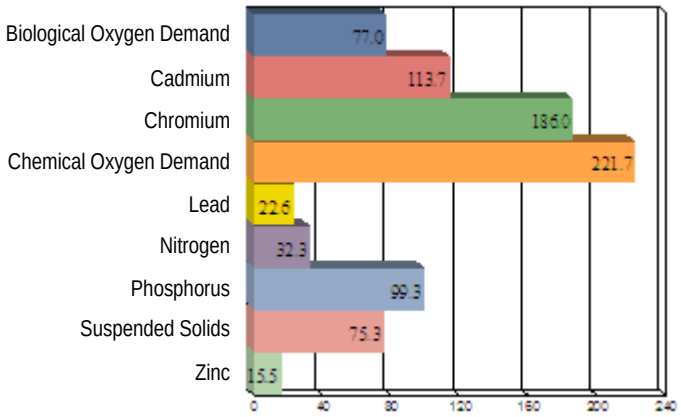
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	79
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**51,925,582**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$103,851,164**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$9,054,218**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 75% Increase 3% LID

Tree Canopy: 257.2 acres (1.0%)

Land cover in acres and percentages

Cropland: Row Crops	51.4	0.2%
Impervious Surfaces: Buildings/ structures	5.1	0.0%
Low Impact Development	720.0	2.8%
Meadow (Continuous grass, generally mowed, not grazed)	25.7	0.1%
Open Space - Grass/Scattered Trees: Grass cover < 50%	10.3	0.0%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	102.9	0.4%
Pasture/Range (Continuous forage for grazing)	10.3	0.0%
Shrub	180.0	0.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	257.2	1.0%
Urban	2,905.8	11.3%
Urban: Commercial/Business	900.0	3.5%
Urban: Industrial	3,934.5	15.3%
Urban: Residential: 0.25ac Lots	8,126.1	31.6%
Urban: Residential: 0.5ac Lots	7,380.3	28.7%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	458	225
Ozone:	13,295	$46,973
Nitrogen Dioxide:	3,438	$12,148
Particulate Matter:	6,418	$15,140
Sulfur Dioxide:	2,751	$2,374
Totals:	**26,361**	**76,860**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**11,066**
Tons Sequestered **(Annually)**:	**86**

Analysis Report

for

Fort Lee Study Area: 75% Increase 3% LID

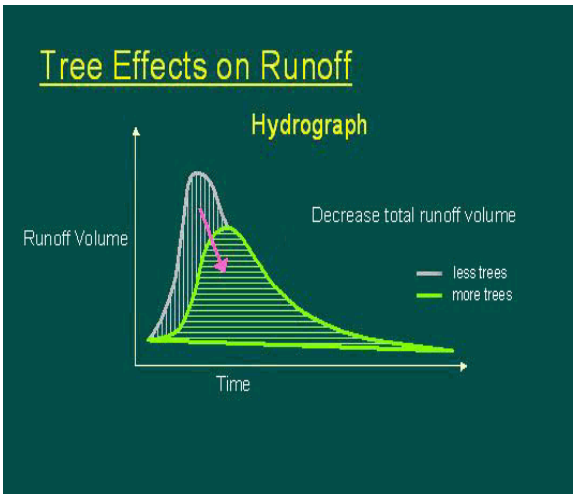
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

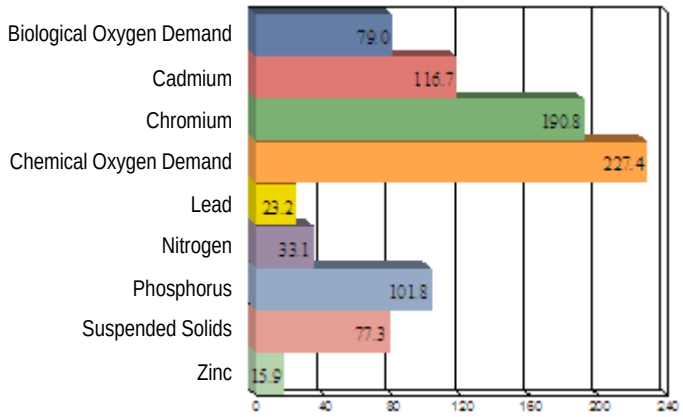
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	79
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**53,465,861**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$106,931,722**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$9,322,795**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Analysis Report

for

Fort Lee Study Area: 75% Increase 10% LID

Tree Canopy: 257.2 acres (1.0%)

Land cover in acres and percentages

Cropland: Row Crops	77.1	0.3%
Impervious Surfaces: Buildings/ structures	5.1	0.0%
Low Impact Development	2,391.5	9.3%
Meadow (Continuous grass, generally mowed, not grazed)	25.7	0.1%
Open Space - Grass/Scattered Trees: Grass cover < 50%	10.3	0.0%
Open Space - Grass/Scattered Trees: Grass cover 50% - 75%	102.9	0.4%
Pasture/Range (Continuous forage for grazing)	10.3	0.0%
Shrub	180.0	0.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	257.2	1.0%
Urban	2,700.1	10.5%
Urban: Commercial/Business	822.9	3.2%
Urban: Industrial	3,651.6	14.2%
Urban: Residential: 0.25ac Lots	7,534.6	29.3%
Urban: Residential: 0.5ac Lots	6,840.3	26.6%
Water Area	1,105.8	4.3%
Total:	25,715.4	100.0%

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Virginia Beach***

	Lbs. Removed/yr	Dollar Value/yr
Carbon Monoxide:	458	225
Ozone:	13,295	$46,973
Nitrogen Dioxide:	3,438	$12,148
Particulate Matter:	6,418	$15,140
Sulfur Dioxide:	2,751	$2,374
Totals:	**26,361**	**76,860**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**11,066**
Tons Sequestered **(Annually)**:	**86**

Analysis Report

for

Fort Lee Study Area: 75% Increase 10% LID

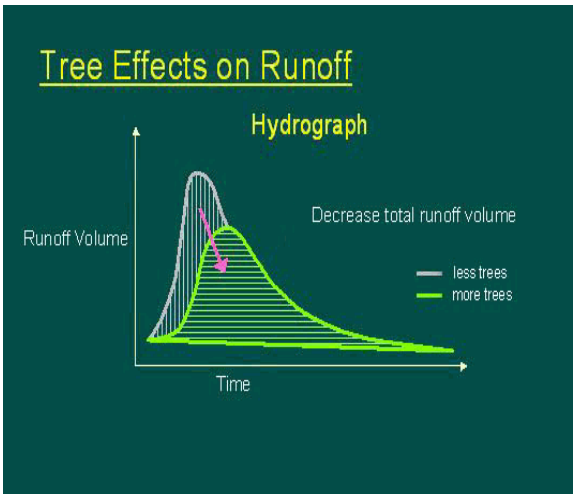
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

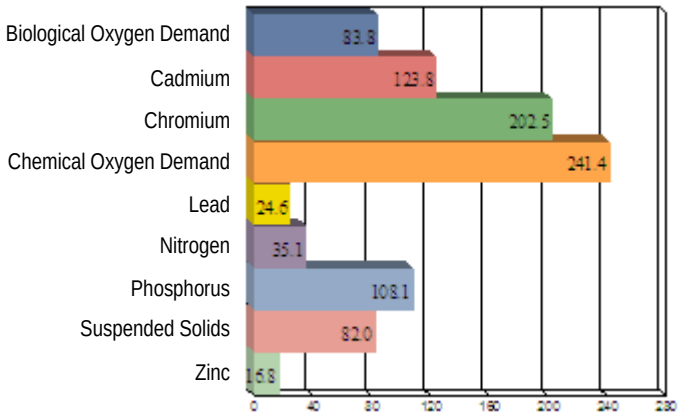
2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	69
Curve Number of replacement land cover:	80
Dominant soil type: **B**	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**57,285,773**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$114,571,546**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$9,988,869**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings



Growing Richmond's Green Infrastructure

Green Infrastructure Toolkit

- Urban Water
- Site Planning
- Community spaces
- Community stewardship

Developed by E² Inc. for the Green Infrastructure Center and the City of Richmond

Green Infrastructure Toolkit
Urban Water and Site Planning

Low impact development (LID) features that help manage stormwater can be incorporated into almost every section of urban environments including open space, rooftops, streetscapes, parking lots, sidewalks, and medians. This versatile approach can be applied to new development, urban retrofits, and redevelopment / revitalization projects. These features are more environmentally and economically sustainable ways to address the adverse impacts of urbanization. By managing runoff close to its source through intelligent site design, these green infrastructure tools can enhance the local environment, protect public health, and improve community livability.

Urban water

Vegetated swales/bioswales

Rain gardens/bioretention ares

Vegetated filter strips

Stormwater wetland

Site planning

Street design

Reducing impervious surfaces

Vegetated landscaping

Urban forestry

Urban stream restoration

Riparian buffers

Source for LID practices: Low Impact Development Center, Inc.

Vegetated swales/bioswales

Vegetated swales, sometimes referred to as bioswales, are broad, shallow channels designed to convey and infiltrate stormwater runoff. Swales reduce stormwater volume and improve water quality through infiltration and vegetative filtering. They also reduce runoff velocity by increasing flow path lengths and channel roughness.

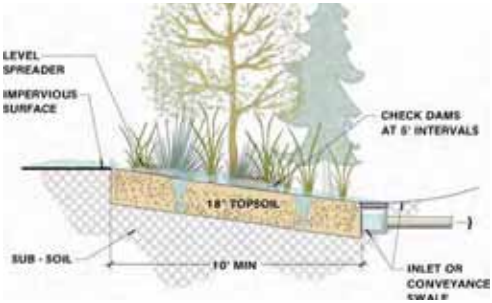
Swales can be planted with grasses, perennials, shrubs and trees to provide a neighborhood amenity with aesthetic and habitat value.

Rain gardens/bioretention areas

Rain gardens, also known as bioretention cells, are vegetated depressions that store and infiltrate runoff. Rain gardens are designed to encourage vegetative uptake of stormwater to reduce runoff volume and pollutant concentrations. A well designed rain garden has engineered soil which maximizes infiltration and pollutant removal, while avoiding stormwater ponding for longer than 24 hours.

Vegetated filter strips

Filter strips are linear vegetated areas that treat sheet flow and increase water quality from adjacent impervious areas. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal.



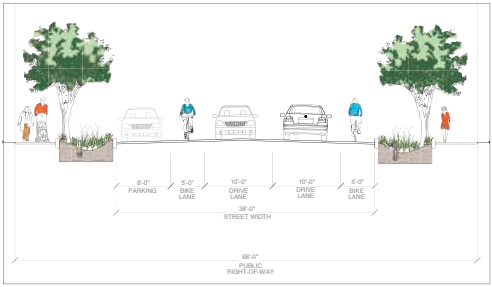
Stormwater wetland

Stormwater wetlands are constructed wetland systems designed to control stormwater volume and facilitate pollutant removal. These wetlands generally have less biodiversity than natural wetlands, but still provide habitat. They require a base flow through the wetland to support the aquatic vegetation present. Pollutant removal in these systems occurs through the settling of larger solids and coarse organic material and also by uptake in the aquatic vegetation.

Street design

"Complete" streets are streets designed to safely accommodate all users - pedestrians, bicyclists, motorists, transit riders and drivers of motor vechicles, and people of all ages and abilities, including children, older adults, and people with disabilities.

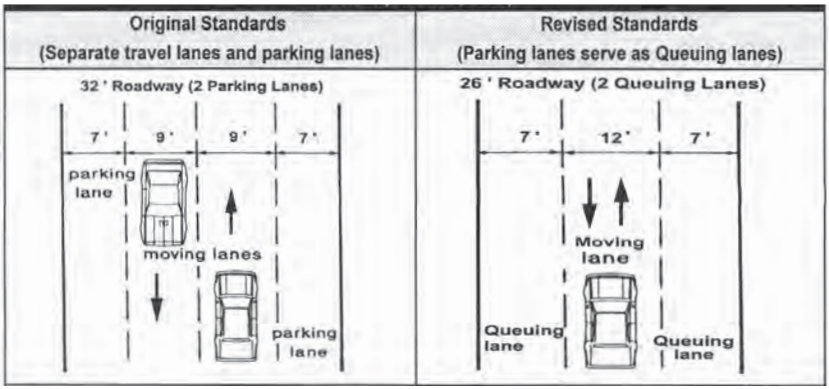
In addition to supporting neighborhood sustainability through alternative transportation, innovative street design can include design mechanisms, such as curb cuts, tree plantings and adjacent bioswales, to manage stormwater and improve the health of urban watersheds.



Reducing impervious surfaces

This best management practice reduces the amount of impervious cover by narrowing streets where possible to one lane for parking and selecting porous materials for places that have been traditionally paved. The recommended width of a narrow street is 24-26 feet.

Porous concreate and permeable asphalt have proven viable alternatives to reduce stormwater runoff volume, rate, and pollutants.



Vegetated landscaping

Natural and reintroduced vegetation provides stormwater management and pollutant removal. Vegetated areas intercept and infiltrate rainfall, decreasing stormwater volumes. Plants, trees, and other vegetation remove pollutants from infiltrated stormwater through root zone uptake. Incorporating vegetation into the landscape is a stormwater management technique that utilizes environmentally beneficial mechanisms that occur naturally in the environment.

Urban forestry

Trees reduce runoff volume through evapotranspiration (ET) and interception and improve the infiltration capacity of the soil, thereby reducing runoff potential. Afforestation involves planting trees in an area where they were absent for a significant period of time (e.g. a riparian buffer). Reforestation is the planting of trees in an area that was forested in the recent past (e.g. an area that was cleared for residential development).

Many city tree planting programs have proven effective ways to increase the urban tree canopy and citizen involvement.

Urban stream restoration

Many urban streams and creeks have been neglected over the centuries, especially in older post-industrial cities. Development has heavily impacted streams: many have been buried in underground pipes, and urban land uses contribute harmful impacts to the stream system, which becomes eroded and channelized.

Urban stream restoration projects transform these damaged and neglected places into healthy, resilient, and functional natural systems. These restoration projects also create a community asset, as they often occur as a part of a larger parks and open space plan or community development initiative. Restored urban streams provide a valuable asset to surrounding neighborhoods, increase property values, and can stimulate economic development and redevelopment.

Riparian buffers

Riparian buffers are vegetated areas on either side of a river, stream, or creek. These corridors of plants enhance watershed health by moderating water quantities and improving water quality.

Riparian buffers intercept, absorb, and infiltrate surface runoff. This replenishes the groundwater table, which ensures a more constant flow of water in the adjacent stream channel. This also moderates the peak runoff rates during rain events, which reduces erosion and sedimentation of the stream channel.

Riparian buffer plantings remove pollutants, contaminants, and sediments before surface water enters the stream. They also also mitigate the unnaturally high water temperatures that are common in urbanized areas.

Community Spaces

Cities, organizations, neighborhoods and community volunteers can transform vacant urban parcels into green spaces that increase the aesthetic, community and ecological values of the landscape. Cleveland's *Reimagining Cleveland Pattern Book** demonstrates several low cost ways to create neighborhood assets from vacant and underutilized properties.

Examples of community spaces include:

- Pocket park
- Informal recreation
- Meadow/native habitat
- Outdoor classroom
- Community garden

Design concepts for vacant land in *Reimagining Cleveland.*

* *Reimagining Cleveland Pattern Book* is accessible here: http://www.neighborhood-progress.org/uploaded_pics/patternbookFINAL_lo-res_file_1241529170.pdf

Pocket park

Scuffletown Park, Richmond, VA

Overview

Pocket parks are small green spaces in neighborhoods that provide a safe area for residents to gather for play, quiet outdoor space or social interaction. Often too small for physical activities, pocket parks provide greenery, a place to sit outdoors, and sometimes a children's playground. They may be created around a monument, historic marker or art project.

How to

- A municipality may identify land to develop and maintain as a pocket park.
- A neighborhood group may initiate the formation of a pocket park as a citizens' project, often soliciting sponsorship from the city or other associations and volunteers for development and maintenance.
- Grants are often available to support these projects.

Benefits

- Improved aesthetic and ecological value of land
- Can stimulate social interaction and community building

Resources

- Enrichmond: http://www.enrichmond.org
- How-to-guide: http://www.kibi.org/pp_how-to

Informal recreation

Pickup soccer game, Maine

Overview

Vacant lots can be planted with low maintenance turf grass to provide space for informal recreation such as soccer, frisbee or neighborhood gatherings. Limited maintenance (mowing) could be provided by the city or neighborhood volunteers.

How to

- Community members work with landowner(s) to arrange interim use.
- Community members seek support from neighborhood, city, or grant programs for initial planting resources and ongoing maintenance.

Benefits

- Creates opportunity for outdoor recreation and community interaction
- Encourages exercise and fitness activities

Meadow/native habitat

Urban Meadow, Brooklyn, NY

Overview

Vacant parcels can be planted as meadows: low-maintenance plantings that bring verdant change and seasonal blooms during the spring, summer and fall.

How to

- Community members work with landowner(s) to arrange interim use.
- Community members seek support from neighborhood, city, or grant programs for initial planting resources and ongoing maintenance.

Benefits

- Neighbrohood beautification
- Stormwater infiltration
- Native habitat for plant and animal species
- Educational and social opportunities for the community

Resources

- Brooklyn Urban Meadow: http://urbanmeadowbrooklyn.blogspot.com/
- Virginia Department of Natural Resources: http://www.dcr.virginia.gov/natural_heritage/index.shtml

Outdoor classroom

Tremont School, OH

Overview

Outdoor classrooms can be created on vacant parcels close to schools to provide an extension of the classroom outdoors for a variety of environmental learning opportunities. Some outdoor classrooms may just consist of gardens, while others may include structures such as benches and pavilions.

How to

- Schools and landowners can work together to coordinate use of the vacant parcel.
- A school or parents organization may solicit volunteers, resources and sponsorships from local building supply and service businesses.

Benefits

- Hands-on education opportunities
- Increasing familiarity with native species of plants and flowers
- Alternative learning environment

Community garden

Tricycle Gardens, Bainbridge and 9th Street, Richmond, VA

Overview

Community gardens are plots of land cared for and cultivated by members of the community. The land, often owned in trust by local government or non-profit organizations, is typically open for the public involvement. Community gardens often provide fresh produce and plants as well as satisfying labor, neighborhood improvement, sense of community and connection to the environment.

How to

- Community members can work with landowners to plan a garden.
- Non-profit organizations, such as Tricycle Gardens in Richmond, often work with communities to form groups and develop resources to start and maintain community gardens.

Benefits

- Provide a catalyst for neighborhood and community development
- Stimulate social interaction, encourage self-reliance, beautify neighborhoods
- Produce nutritious food, reduce family food budgets, and conserve resources
- Create opportunities for recreation, exercise, therapy and education

Resources

- Tricycle Gardens: http://tricyclegardens.org/gardens/community-gardens/
- American Community Gardening Association: http://www.communitygarden.org/

Community Stewardship

Changing industry and settlement patterns have led to an increase in vacant and underutilized properties in urban areas across the U.S. To confront the challenges to quality of life, property value and safety created by growing vacancies, many cities have developed neighborhood stabilization strategies directed at making vacant properties productive and safe assets for communities. Innovative policies and programs provide support, resources and/or guidance for organizations and community members to become stewards of vacant properties.

Examples of some of those policies and programs include:

- Green space grant programs
- Land banking
- Mow-to-own
- Adopt-a-block

Green space grant programs

Many cities have partnered with local corporations and organizations to sponsor grants and support programs for neighborhood volunteers. Indianapolis' *Keep Indianapolis Beautiful* program offers Greenspace grants to neighborhoods willing to transform blighted areas into community assets, from pocket parks to community gardens.

Resources

- Keep Indianapolis Beautiful: http://www.kibi.org/greenspace

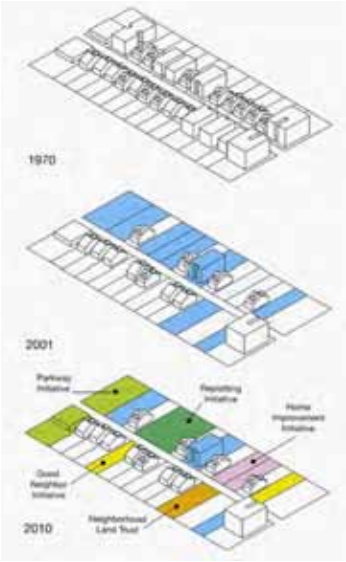
Land banking

A growing number of communities have created a dedicated public authority, known as a land bank, to streamline property reuse activities, assemble developable parcels, and manage the redevelopment process to serve the community's goals.

A land bank generally involves public acquisition of abandoned property; the land is then transferred to a nonprofit third party for redevelopment. Land banks attempt to unlock the potential value of properties and sites, with the goal of returning them to productive use.

Resources

- Housing Policy.org: http://www.housingpolicy.org/toolbox/strategy/policies/abandoned_properties.html?tierid=155#lb
- Detroit: http://kirwaninstitute.org/research/projects/vacpropreform/index.php



Detroit land banking diagram. Source, *Shrinking Cities*.

Mow-to-own

Vacant lots can be absorbed into residential neighborhoods by encouraging adjacent property owners to acquire and maintain these sites as an expansion of their own properties.

Cleveland's proposed Mow-to-Own program enables residents to earn the ownership of a neighboring or nearby property (from a landbank) in exchange for providing good maintenance of these properties according to city-established standards.

http://www.cudc.kent.edu/shrink/Images/reimagining_final_screen-res.pdf

Adopt-a-block

The Adopt-a-Block program created in Indianapolis provides a support structure, resources, and tools for neighbors who work together to keep a block clean and maintained in the city. A block leader coordinates the volunteer effort, and the city provides training, tools, trees and other plants to support the neighborhood's efforts.

http://www.kibi.org/adopt-a-block

Additional resources and references:

http://www.epa.gov/owow/NPS/lid/ - U.S. EPA website for Low Impact Development and Green Infrastructure. Numerous resources, references, and information are compiled at this extensive website.

"Catching the Rain: A Great Lakes Guide to Natural Stormwater Management." American Rivers 2004.

http://baltimorecity.gov/Government/AgenciesDepartments/RecreationandParks/TreeBaltimore.aspx

Davis, Lynn. "Urban forestry: Engineering cities into natural systems," Research Magazine, (Winter 2004). http://www.research.vt.edu/resmag/2004resmag/forestry.html.

Georgia Forestry Commission. "Tree Benefits: Environmental benefits of trees." http://www.gfc.state.ga.us/CommunityForests/TreeBenefits.cfm.

"Why Shade Streets? The Unexpected Benefits." Center for Urban Forest Research, (2006). http://www.fs.fed.us/psw/programs/cufr/products/cufr_673_WhyShadeStreets_10-06.pdf.

Akbari, H., M. Pomerantz, H. Taha. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. 2001. Solar Energy, Vol. 70, No. 3.

Georgia Forestry Commission. "Tree Benefits: Environmental benefits of trees." http://www.gfc.state.ga.us/CommunityForests/TreeBenefits.cfm.

Georgia Forestry Commission. "Tree Benefits: Environmental benefits of trees." http://www.gfc.state.ga.us/CommunityForests/TreeBenefits.cfm.

"A Citizen's Streambank Restoration Handbook." Firehock, Karen and Doherty, Jacqueline. A publication of the Save Our Streams Program: Izaak Walton League of America, Inc. 1995.

"A Stream Corridor Protection Strategy for Local Governments." Institute for Environmental Negotiation, Department of Urban and Environmental Planning of the School of Architecture at the University of Virginia, 2002.

Growing Richmond's Green Infrastructure

Green Infrastructure Toolkit

Urban Water

Vegetated swales/bioswales

Rain gardens/bioretention areas

Vegetated filter strips

Stormwater wetland

Site Planning

Green street design

Reducing impervious surfaces

Vegetated landscaping

Urban forestry

Urban stream restoration

Riparian buffers

Community spaces

Pocket park

Informal recreation

Meadow/native habitat

Outdoor classroom

Community garden

Community stewardship

Green space grant programs

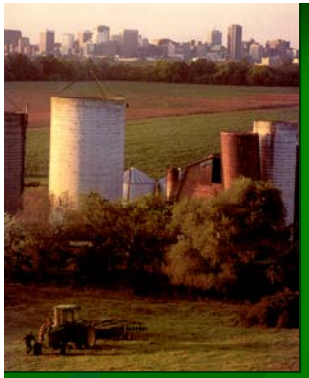
Land banking

Mow-to-own

Adopt-a-block

Developed by E² Inc. for the Green Infrastructure Center and the City of Richmond
October 6, 2010

Appendix E

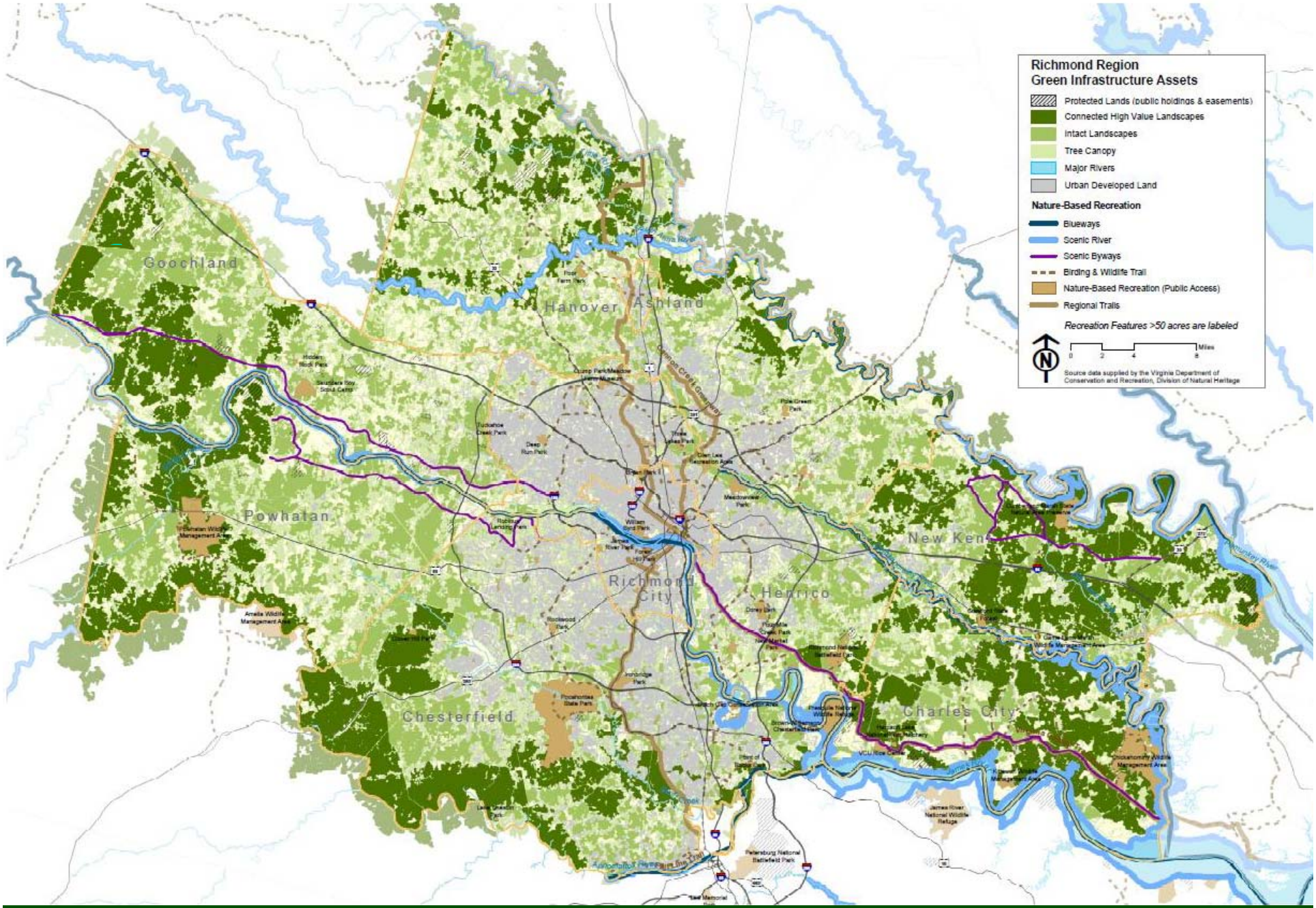


City of Richmond
2010 Technical Assistance Project: A Green Print Pilot Program

What is Green Infrastructure?

"the interconnected natural systems and ecological processes that provide clean water, air quality, and wildlife habitat; green infrastructure sustains a community's social, economic and environmental health"

It's all about connecting the green infrastructure assets of a community!


Richmond Region
Green Infrastructure Assets
Protected Lands (public holdings & easements)
Connected High Value Landscapes
Intact Landscapes
Tree Canopy
Major Rivers
Urban Developed Land
Nature-Based Recreation
Blueways
Scenic River
Scenic Byways
Birding & Wildlife Trail
Nature-Based Recreation (Public Access)
Regional Trails
Recreation Features >50 acres are labeled
N
0 2 4 8 Miles
Source data supplied by the Virginia Department of Conservation and Recreation, Division of Natural Heritage
Goochland
Hanover
Ashland
Powhatan
Richmond City
Henrico
New Kent
Chesterfield
Charles City

What Are A Community's Green Infrastructure Assets?

- Water Resources
- Conservation Lands
- Sustainable Features, Parks & Recreation
- Transportation
- Heritage & Culture

Image Source: Millennium Ecosystem Assessment

Connectivity is Key

- Removal of existing green space can have a detrimental impact on the ecological, aesthetic, and economic benefits of the network

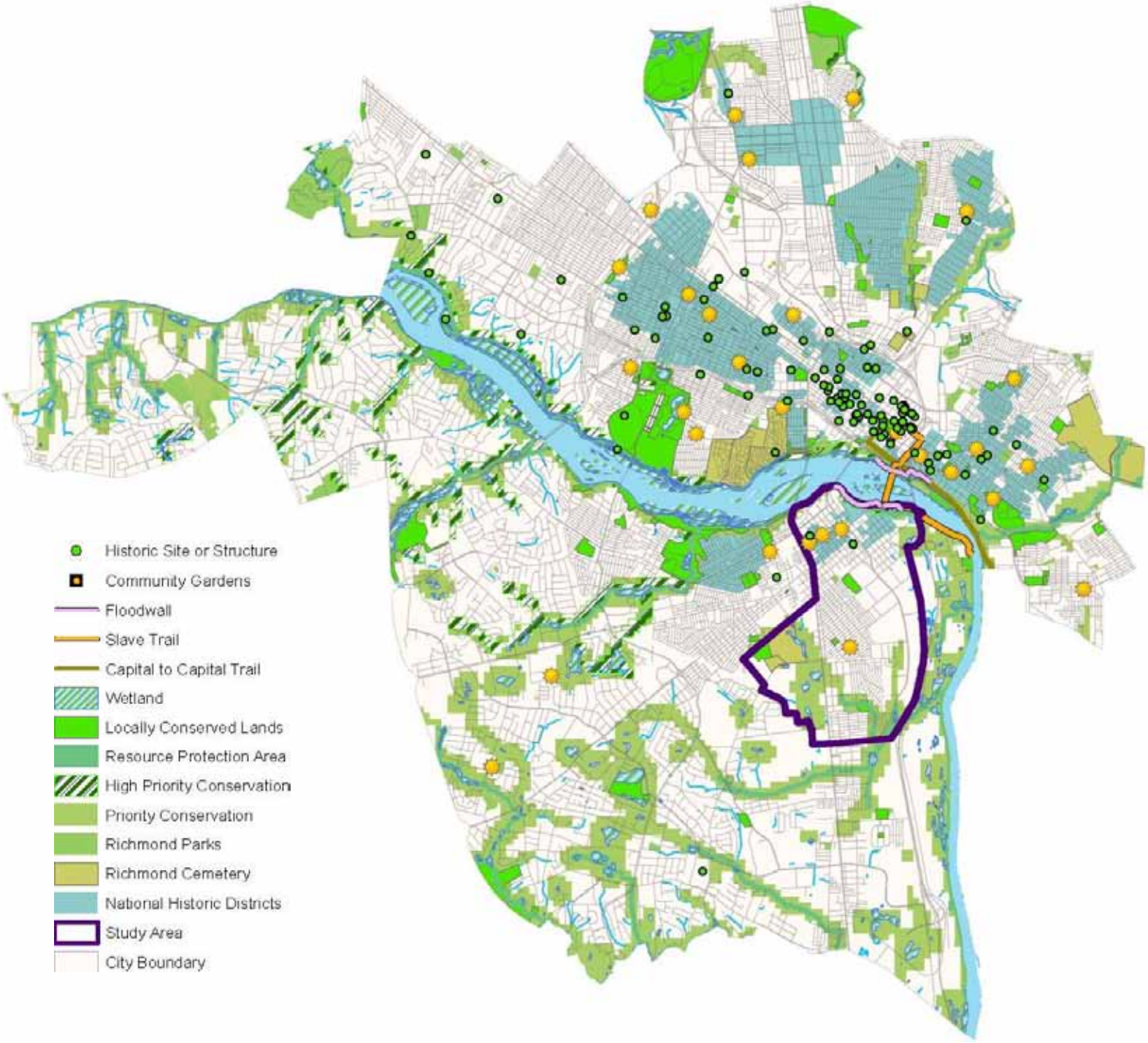
- With green infrastructure, more connections are always better. It maximizes a community's resources.

- Aggregation of smaller natural areas can yield greater economic and ecological benefits for humans and wildlife populations

Purpose of City Green Infrastructure Assessment

Focus on a smaller geographic area at an urban scale:

- To identify existing assets and opportunities (Green Print)
- To provide quantifiable measures of improvement resulting from green asset enhancement
- Begin to identify vacant, underutilized parcels (Brown Print) to create a greener, healthier city


Historic Site or Structure
Community Gardens
Floodwall
Slave Trail
Capital to Capital Trail
Wetland
Locally Conserved Lands
Resource Protection Area
High Priority Conservation
Priority Conservation
Richmond Parks
Richmond Cemetery
National Historic Districts
Study Area
City Boundary

City-wide Urban Tree Canopy

42% Tree Canopy
23% Non-Tree Vegetation
24% Non-Building Vegetation
11% Building Impervious

Source: Virginia Department of Forestry, October 2010

Selection of a Study Area

- **Amount of viable intact habitat**
- **Amount of vacant/ underutilized parcels**
- **Amount of existing park land**
- **Highest watershed priority area**

Neighborhoods of Manchester, Blackwell, Oak Grove, Maury, Bellemeade, Hillside Court and Ancarows Landing

Identify Existing Conditions

Land Cover Analysis:

20%* Tree Canopy
31% Non Tree Vegetation
34% Non-Building Impervious
15% Building Impervious

Source: Virginia Department of Forestry
Urban Tree Canopy(UTC) analysis

CITYgreen© Analysis

Sets up a Model for Testing Alternative Future Scenarios for Development or Redevelopment to Measure:

- **Air pollution removal**
- **Carbon storage & Sequestration**
- **Stormwater Quality**
- **Stormwater Quantity**

Key Findings for the Study Area

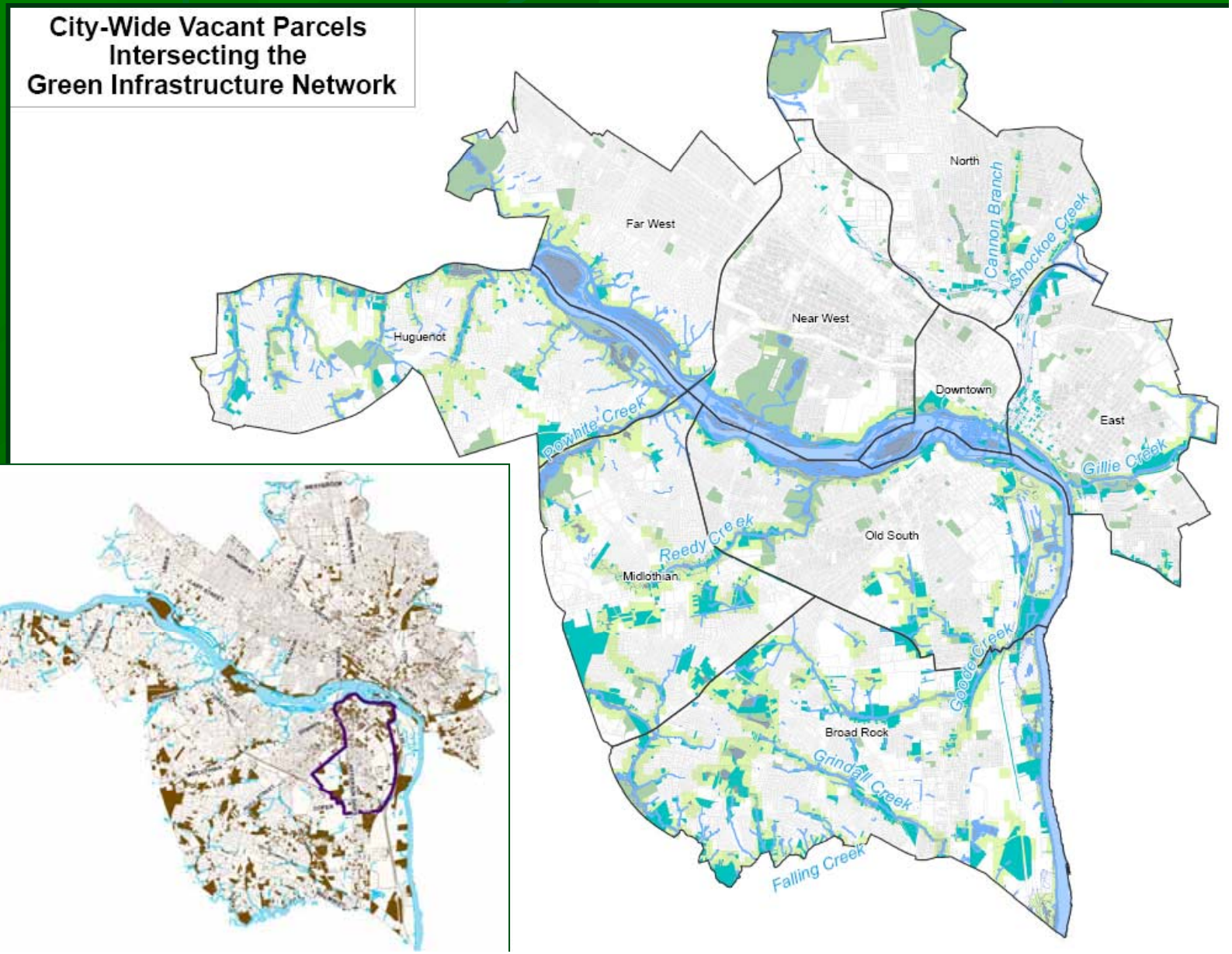
An increase of existing Tree Canopy to City-wide levels would result in economic benefits:

- $500,000 annual savings in reduced stormwater treatment loads
- 10% reduction in nitrogen and 17% reduction in phosphorous from stormwater runoff
- 147% increase in air pollution removal
- Additional 21,000 tons of carbon stored

Green Infrastructure continued…

Green Infrastructure Center

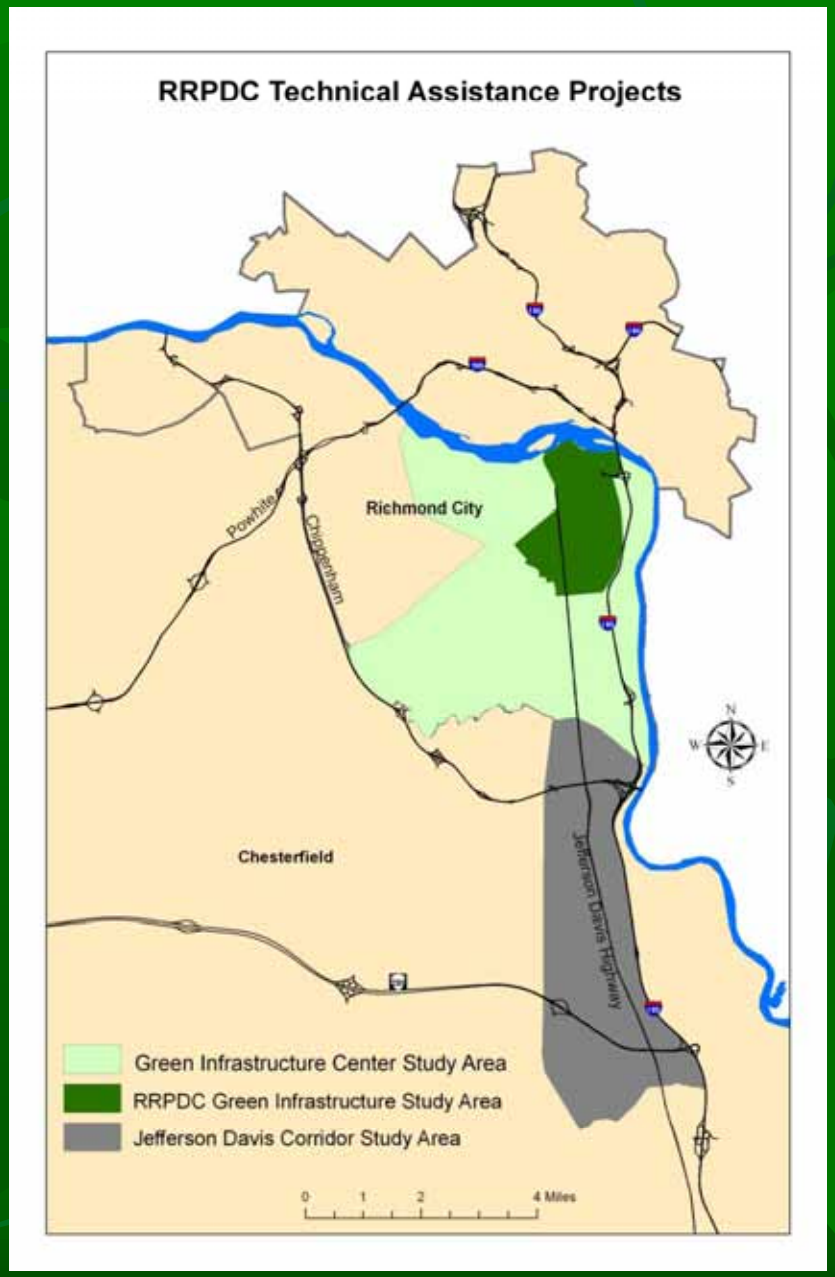
Vacant Land Database



City of Richmond Deliverables

- Green Infrastructure Assessment Phase I: A Green Print Pilot Program for Richmond Report
- Comprehensive Green Asset Inventory
- CITYgreen Analysis of Manchester Case Study
- Urban Tree Canopy Analysis by Virginia Department of Forestry
- Updatable Vacant Lands database

City of Richmond to Chesterfield County



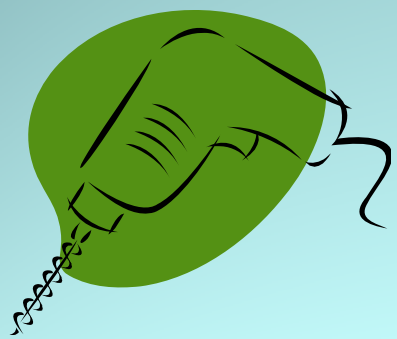
Coastal Partners Workshop

Virginia Coastal Zone Management Program

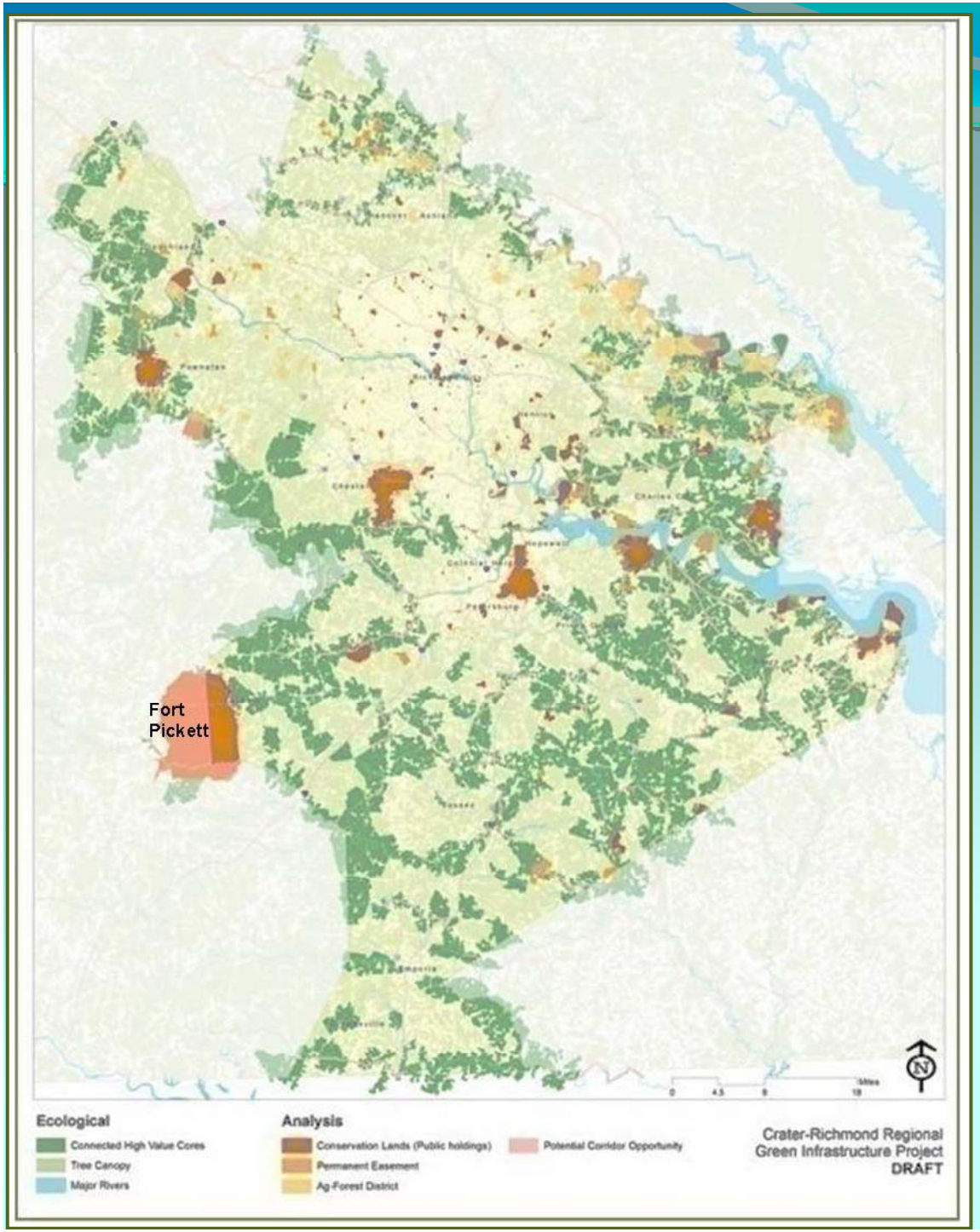
Richmond, Virginia
December 7, 2010

Richmond-Crater Green Infrastructure Project

Drilling Down…



- Phase I – Regional Inventory & Priorities
- Phase II – Urban Green Infrastructure
- Phase III – Riparian Corridor Site Analysis



Blue-Green Infrastructure Theme

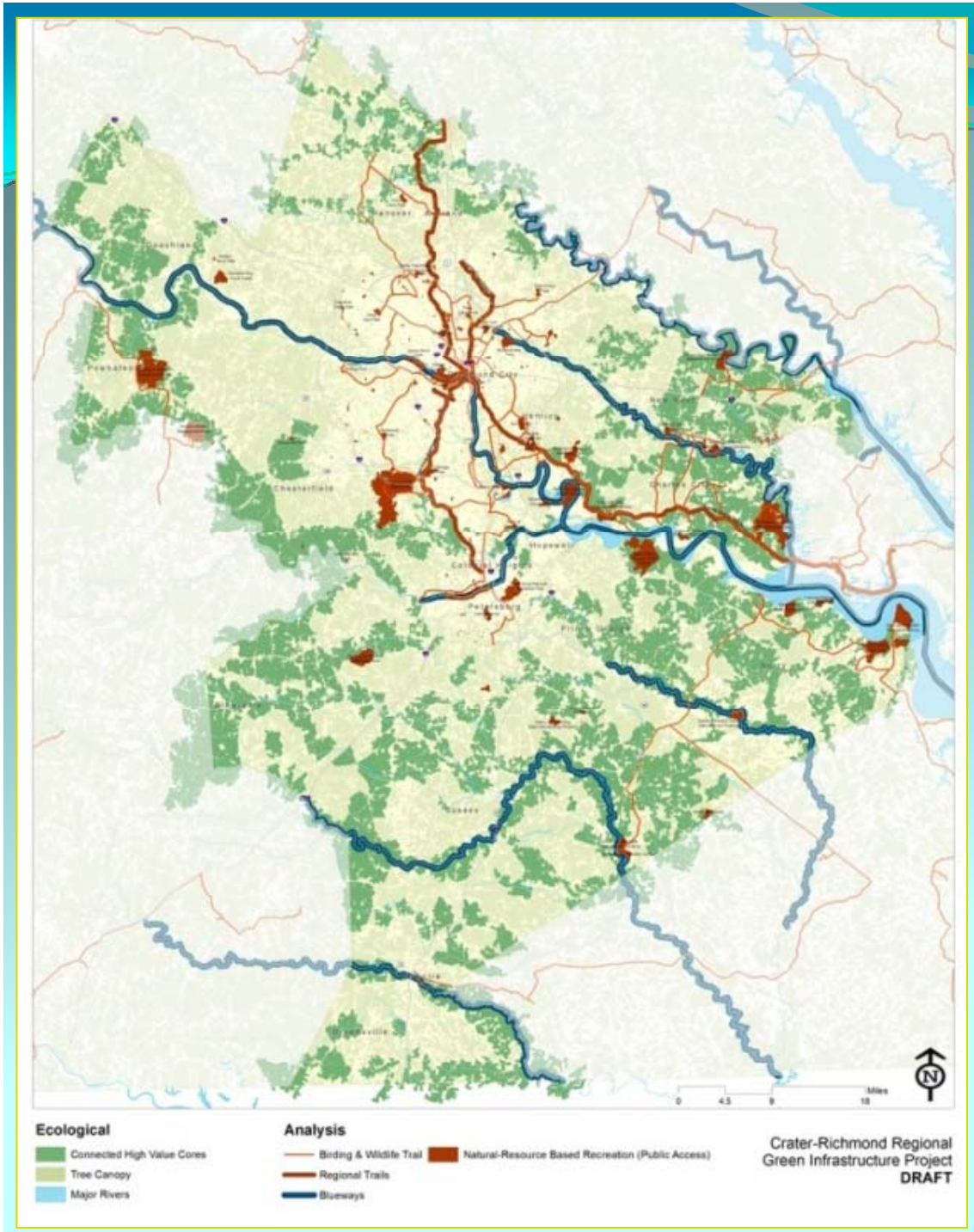
Ecological Integrity and Conservation

Blue-Green Infrastructure Themes

Water Resources

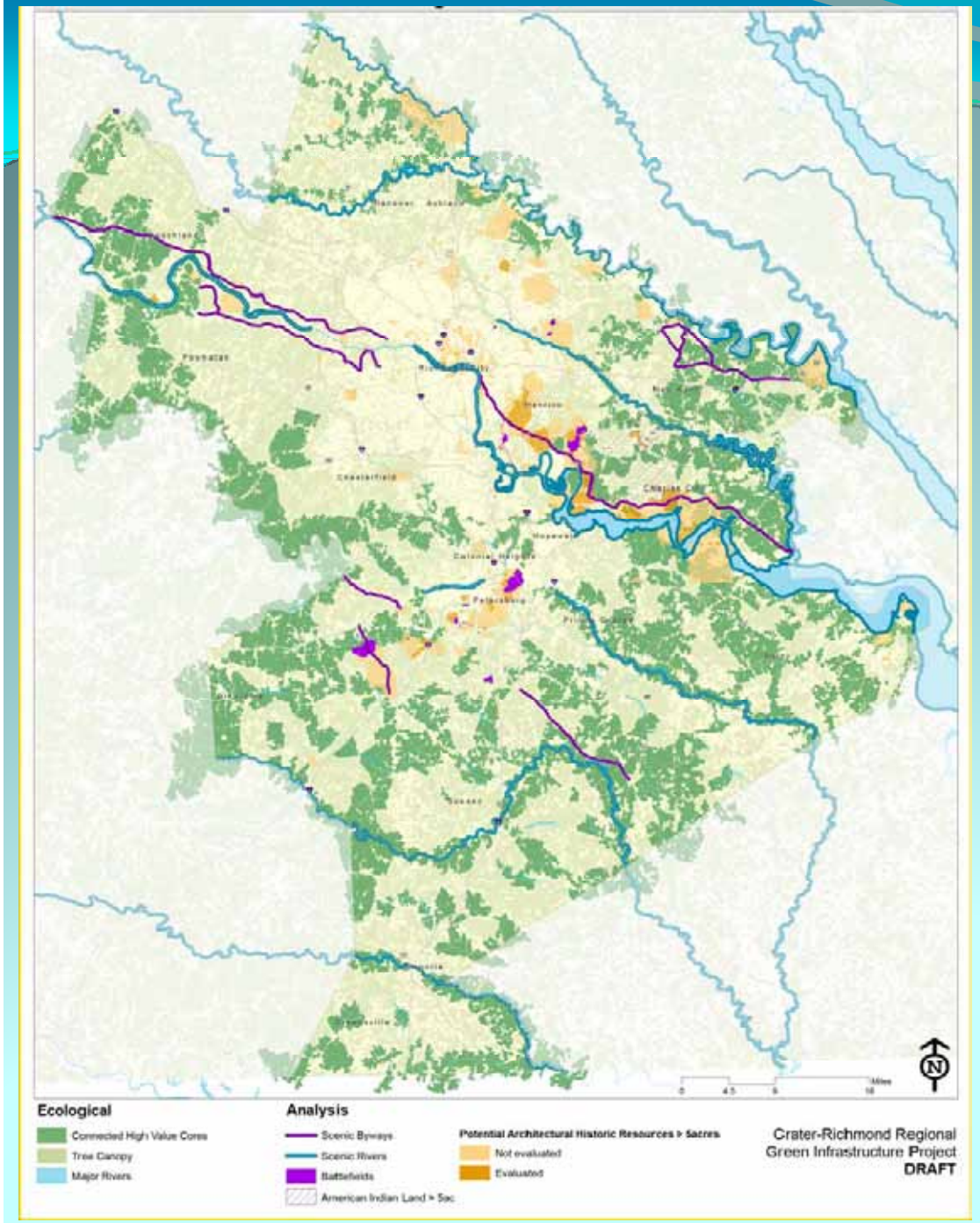
Blue-Green Infrastructure Themes

Natural Resource Based Recreation

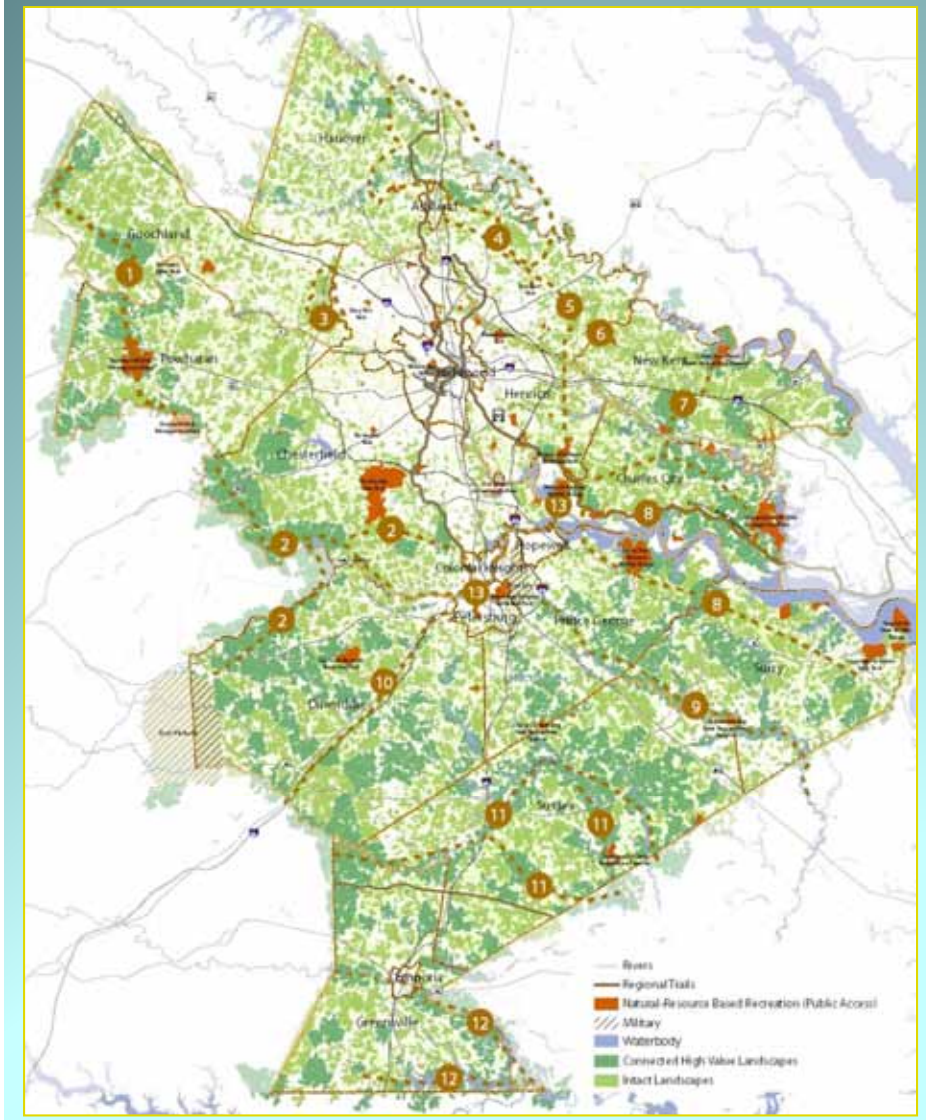


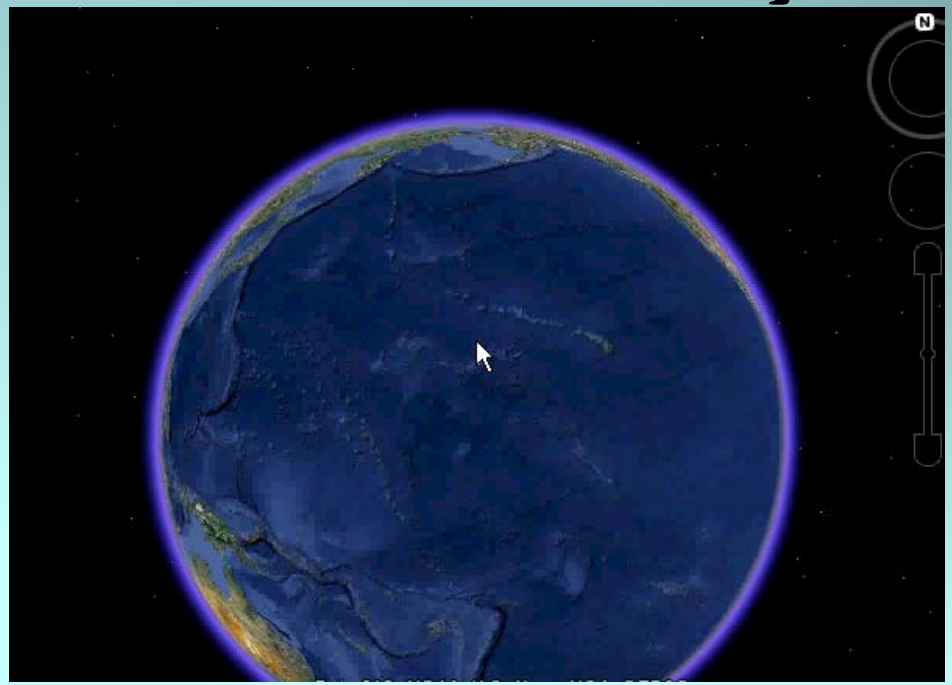
Blue-Green Infrastructure Themes

Heritage Resources



Opportunities For Connectivity





From Mapping
to
Lessons for Moving Forward…

Inter-Locality Collaboration

Friends of the Lower Appomattox (FOLAR)

FRIENDS OF THE LOWER APPOMATTOX RIVER

CPDC

Public and Private Coordination

Petersburg Area Regional Tourism

Green Infrastructure Pays

Virginia Capital Trail

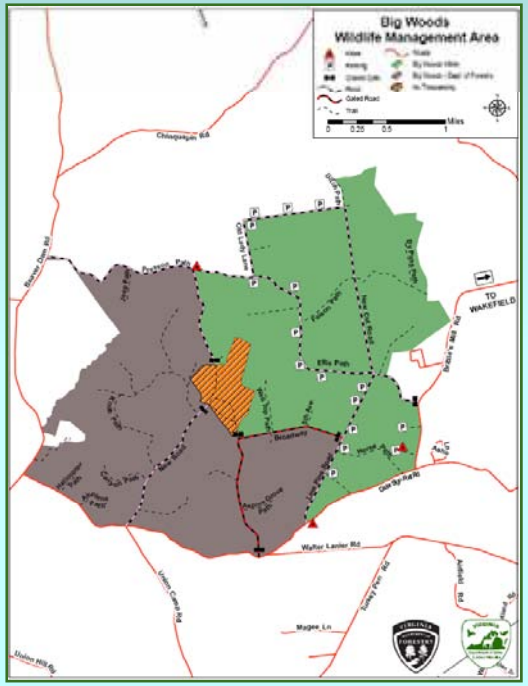
VIRGINIA CAPITAL TRAIL FOUNDATION

CPDC

Green Infrastructure Respects Property Owners

Brown & Williamson Conservation Area

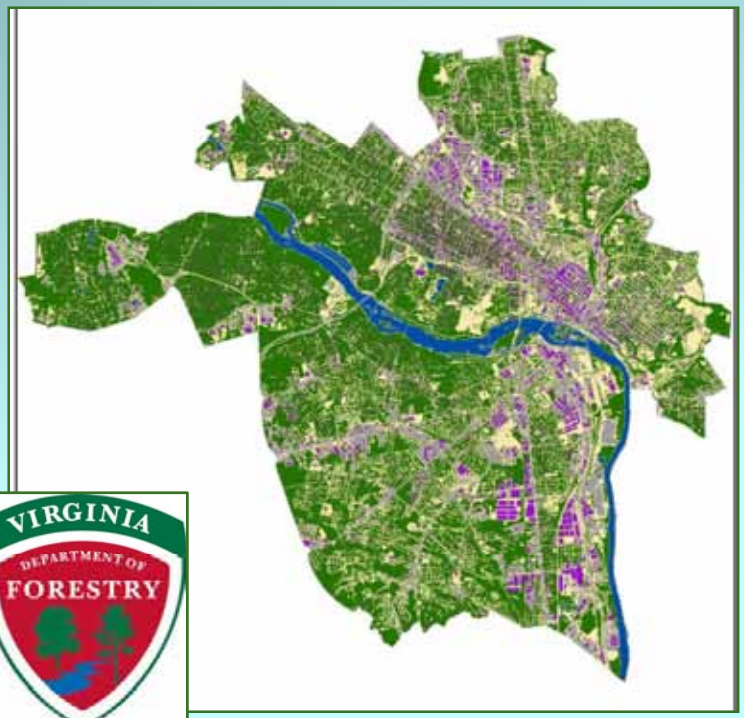
Big Woods State Forest & WMA



VCU Rice Center

New Data & Tools

City of Richmond
Urban Tree Canopy



GIS Tools

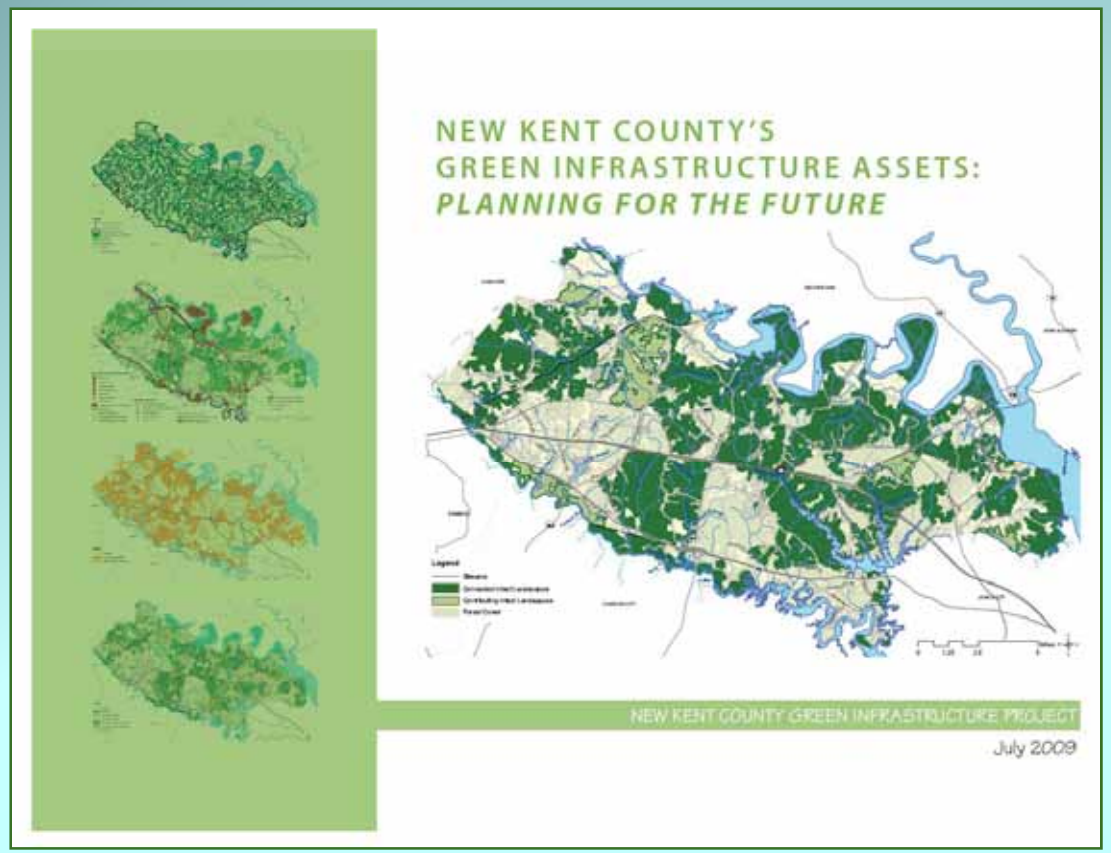
CITYgreen
calculating the value of nature

AMERICAN FORESTS®
americanforests.org

communityviz®

Enhancing Traditional Tools

New Kent County Comprehensive Plan

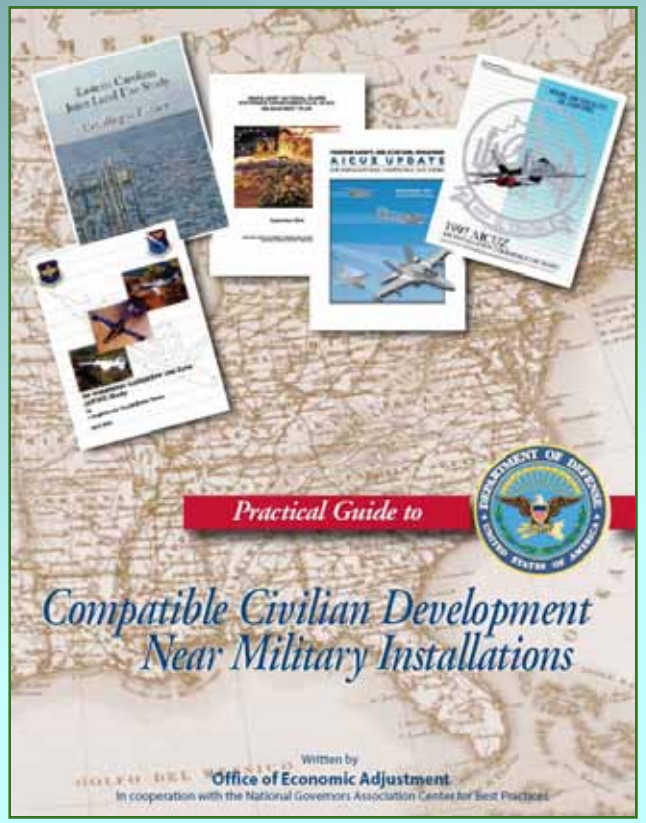


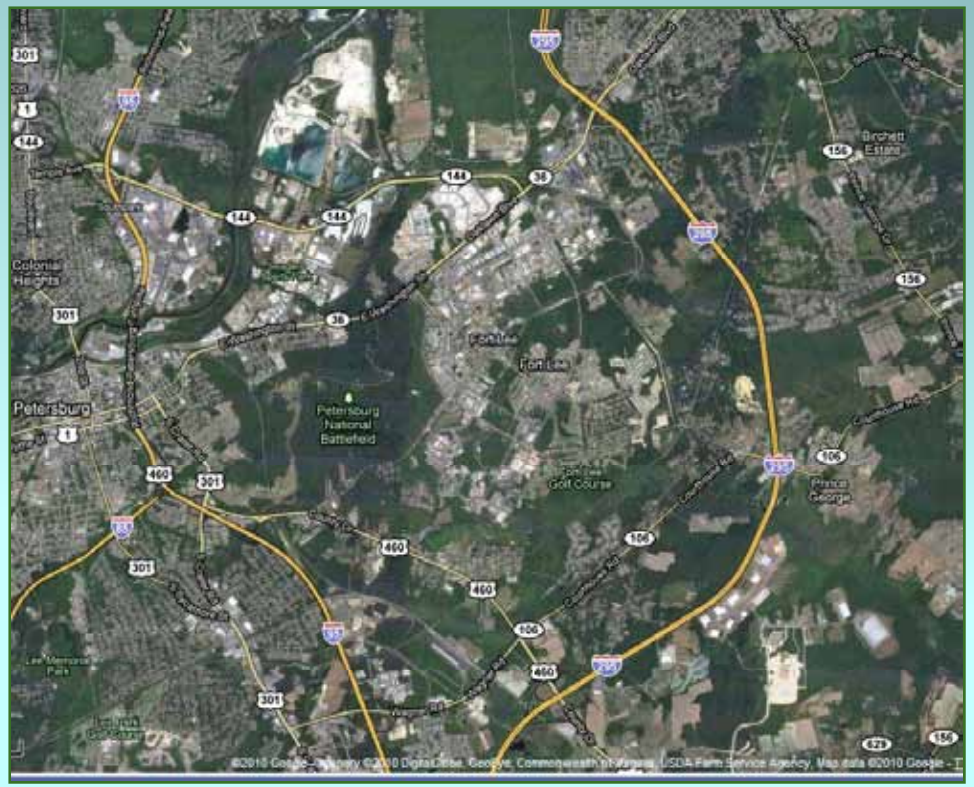
New Kent
COUNTY
VIRGINIA

CPDC

Green Infrastructure in Concert with Other Planning Tools

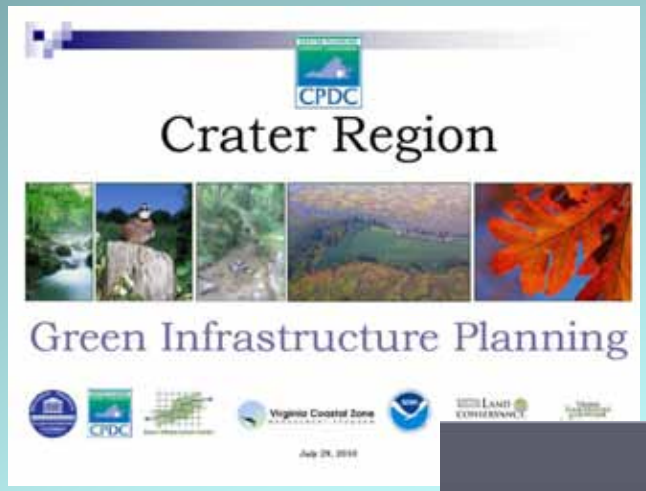
Crater – Fort Lee Joint Land Use Study

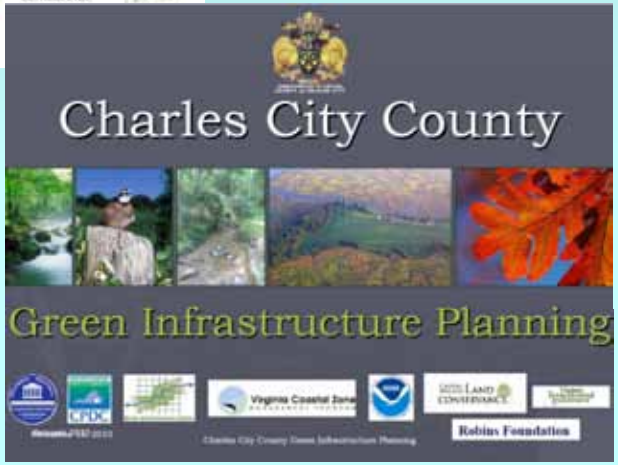


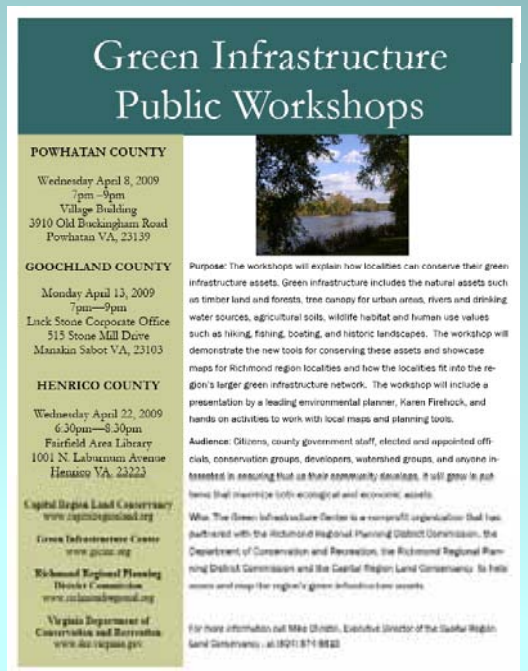


Education, Outreach & Engagement

Local Presentations & Workshops







Green Infrastructure
Public Workshops

POWHATAN COUNTY

Wednesday April 8, 2009
7pm –9pm
Village Building
3910 Old Buckingham Road
Powhatan VA, 23139

GOOCHLAND COUNTY

Monday April 13, 2009
7pm—9pm
Lock Stone Corporate Office
515 Stone Mill Drive
Manakin Sabot VA, 23103

HENRICO COUNTY

Wednesday April 22, 2009
6:30pm—8:30pm
Fairfield Area Library
1001 N. Laburnum Avenue
Henrico VA, 23223

Capital Region Land Conservancy
www.capitalregionland.org

Green Infrastructure Center
www.gicinc.org

Richmond Regional Planning District Commission
www.richmondregional.org

Virginia Department of Conservation and Recreation
www.dcr.virginia.gov

Purpose: The workshops will explain how localities can conserve their green infrastructure assets. Green infrastructure includes the natural assets such as timber land and forests, tree canopy for urban areas, rivers and drinking water sources, agricultural soils, wildlife habitat and human use values such as hiking, fishing, boating, and historic landscapes. The workshop will demonstrate the new tools for conserving these assets and showcase maps for Richmond region localities and how the localities fit into the region's larger green infrastructure network. The workshop will include a presentation by a leading environmental planner, Karen Firehock, and hands on activities to work with local maps and planning tools.

Audience: Citizens, county government staff, elected and appointed officials, conservation groups, developers, watershed groups, and anyone interested in ensuring that us their community develops, it will grow in ways that maximize both ecological and economic assets.

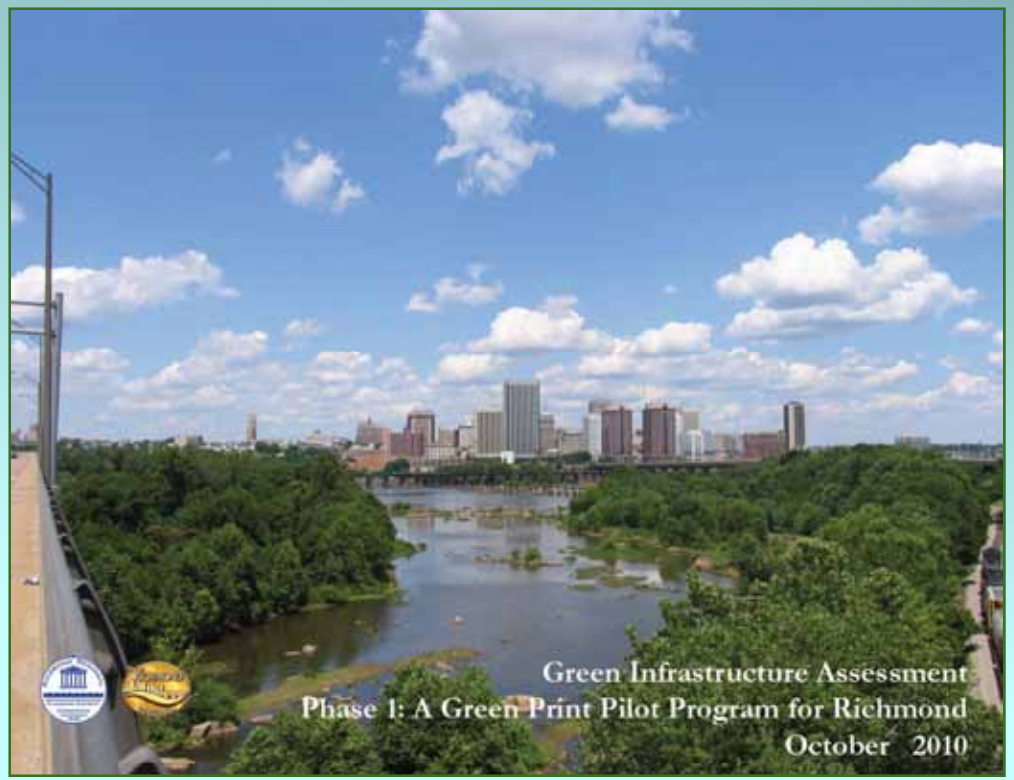
Who: The Green Infrastructure Center is a nonprofit organization that has partnered with the Richmond Regional Planning District Commission, the Department of Conservation and Recreation, the Richmond Regional Planning District Commission and the Capital Region Land Conservancy. to help assess and map the region's green infrastructure assets.

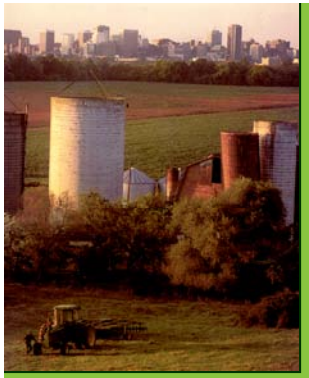
For more information call Mike Dunn, Executive Director of the Capital Region Land Conservancy, at (804) 874-8820

Next Steps…

Recently Completed Phase II

Beginning Phase III





City of Richmond
Green Infrastructure Assessment
A Green Print Pilot Program

What is **Green Infrastructure?**

"the interconnected natural systems and ecological processes that provide clean water, air quality, and wildlife habitat; green infrastructure sustains a community's social, economic and environmental health"

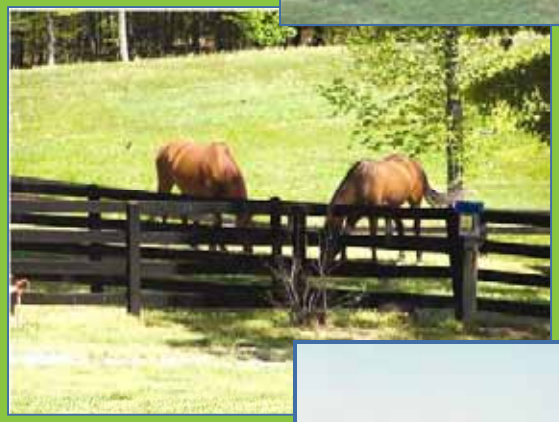
It's all about connecting the green infrastructure assets of a community!

Connectivity is Key

- Removal of existing green space can have a detrimental impact on the ecological, aesthetic, and economic benefits of the network
- With green infrastructure, more connections are always better. It maximizes a community's resources.
- Aggregation of smaller natural areas can yield greater economic and ecological benefits for humans and wildlife populations

Green Infrastructure Assets

- Working Lands
  - Farms
  - Forests
  - Fisheries
- River & Stream Corridors
- Wetlands
- Meadows & Pastures
- Parks



Green Infrastructure Assets

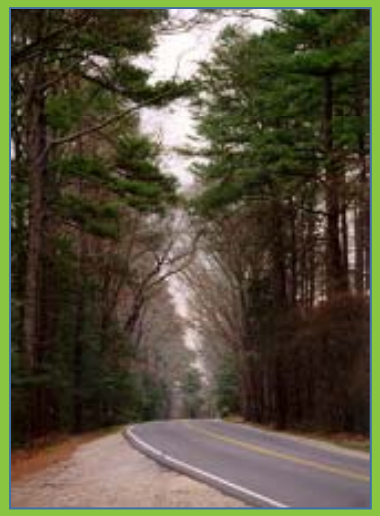
- Cultural Sites
- Historic Resources
- Trails
- Viewsheds
- Scenic Rivers
- Scenic Byways
- Watersheds
- Birding and Wildlife Trails

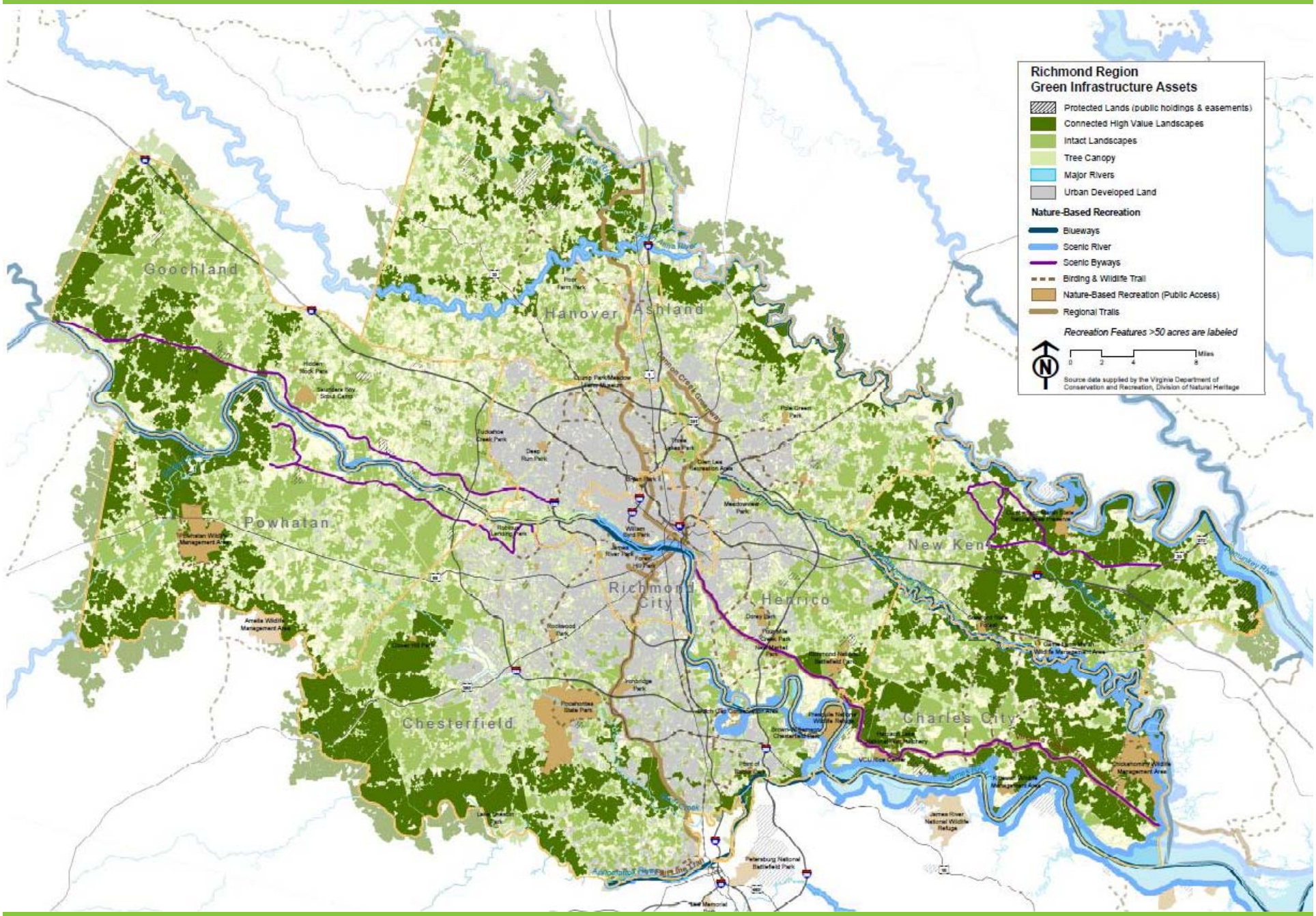
Green Infrastructure Benefits

- Protection of water quality and supply
- Stormwater management, hazard mitigation
- Carbon Sequestration
- Air Quality Protection
- Temperature Moderation: Heat Island Effect

Green Infrastructure Benefits

- Preserves biodiversity and wildlife habitat
- Conserves historic landscapes
- Protects working lands, forests and farms
- Improves quality of life and fitness through access to recreation
- Preserves rural character




Richmond Region
Green Infrastructure Assets
Protected Lands (public holdings & easements)
Connected High Value Landscapes
Intact Landscapes
Tree Canopy
Major Rivers
Urban Developed Land
Nature-Based Recreation
Blueways
Scenic River
Scenic Byways
Birding & Wildlife Trail
Nature-Based Recreation (Public Access)
Regional Trails
Recreation Features >50 acres are labeled
0 2 4 8 Miles
Source data supplied by the Virginia Department of Conservation and Recreation, Division of Natural Heritage
Goochland
Hanover
Ashland
Powhatan
Richmond City
Henrico
New Kent
Chesterfield
Charles City

Purpose of City Green Infrastructure Assessment

Focus on a smaller geographic area at an urban scale:

1. Identify existing assets and opportunities (Green Print)
2. Provide quantifiable benefits from green asset enhancement (CITYgreen)
3. Identify vacant, underutilized parcels (Brown Print) to be added to a greener, healthier city

What Are City of Richmond's Green Infrastructure Assets?

- Water Resources
- Conservation Lands
- Sustainable Features
- Parks & Recreation
- Transportation
- Heritage & Culture Resources

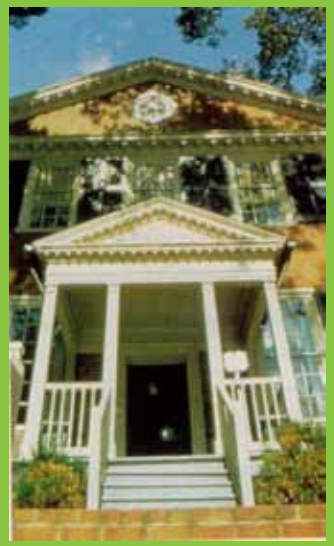
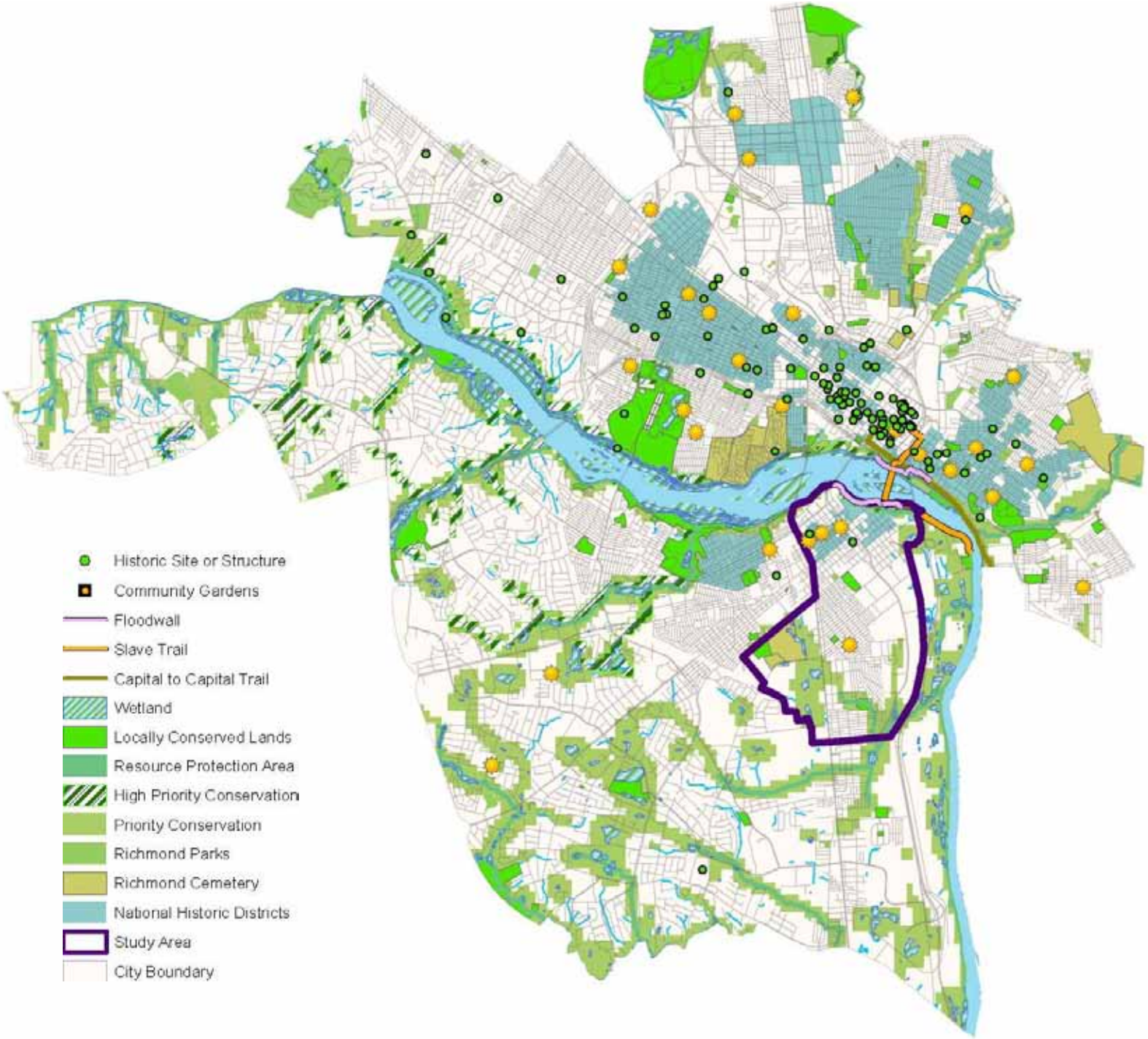


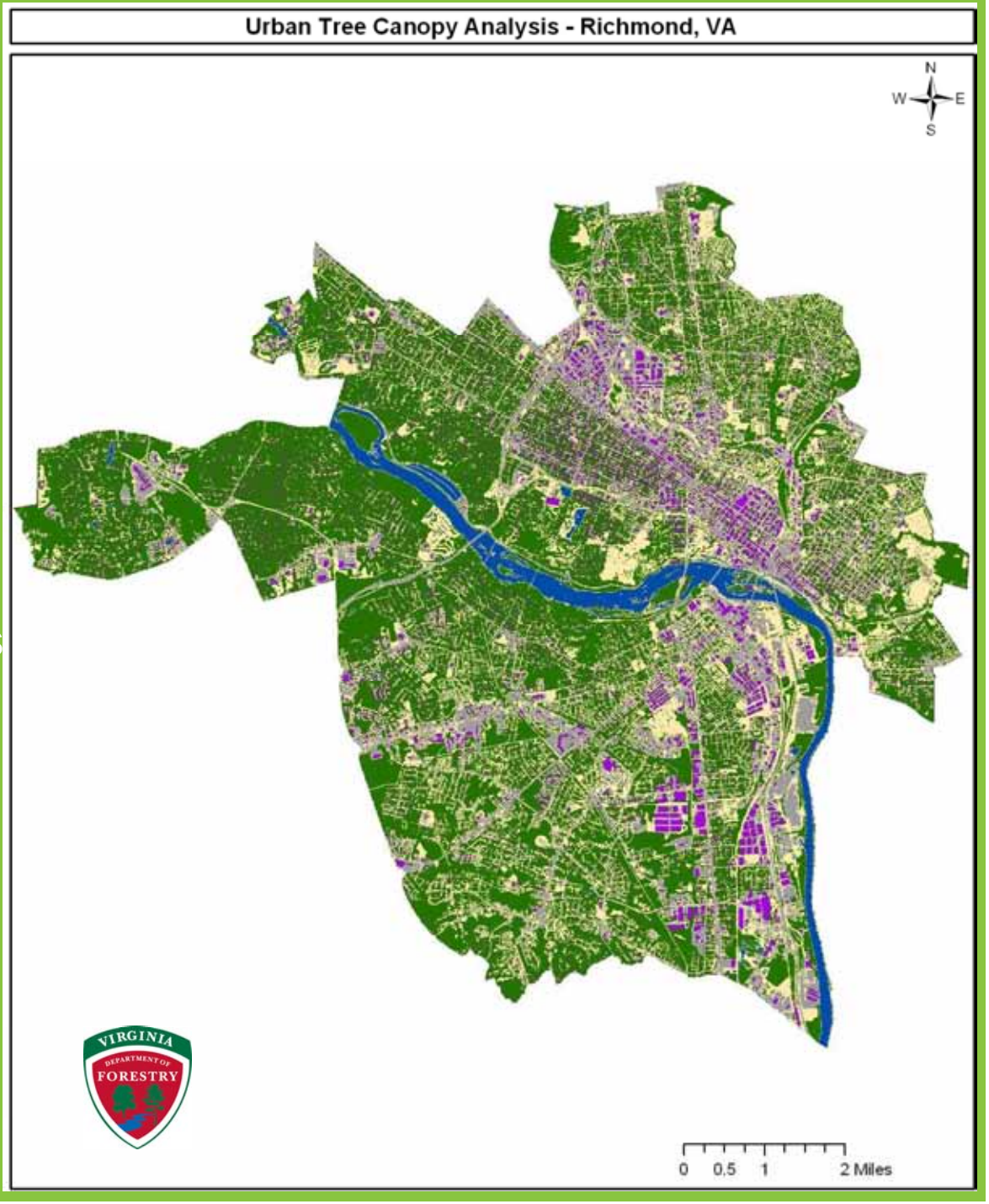
Image Source: Millennium Ecosystem Assessment


Historic Site or Structure
Community Gardens
Floodwall
Slave Trail
Capital to Capital Trail
Wetland
Locally Conserved Lands
Resource Protection Area
High Priority Conservation
Priority Conservation
Richmond Parks
Richmond Cemetery
National Historic Districts
Study Area
City Boundary

City-wide Urban Tree Canopy

42% Tree Canopy
23% Non-Tree Vegetation
24% Non-Building Impervious
11% Building Impervious

Source: Virginia Department of Forestry, October 2010



Selection of a Study Area

- Amount of viable intact habitat
- Amount of vacant/ underutilized parcels
- Amount of existing park land
- Highest watershed priority area

Neighborhoods of Manchester, Blackwell, Oak Grove, Maury, Bellemeade, Hillside Court and Ancarows Landing

Identify Existing Conditions

Land Cover Analysis:

20% Tree Canopy
31% Non Tree Vegetation
34% Non-Building Impervious
15% Building Impervious

Source: Virginia Department of Forestry
Urban Tree Canopy(UTC) analysis

CITYgreen© Analysis

Models for Testing Alternative Future Scenarios for Development or Redevelopment

general neighborhood scale to site specific…

- Land use & density changes
- Increasing tree canopy
- Low Impact Development
  - rain gardens
  - green roofs
  - porous pavement
  - Vegetated buffers & swales

Key Findings for the Study Area

An increase of existing tree canopy in the study area to City-wide levels would result in benefits:

- **$500,000 annual savings** in reduced stormwater treatment loads

- **10% reduction in nitrogen** and **17% reduction in phosphorous** from stormwater runoff

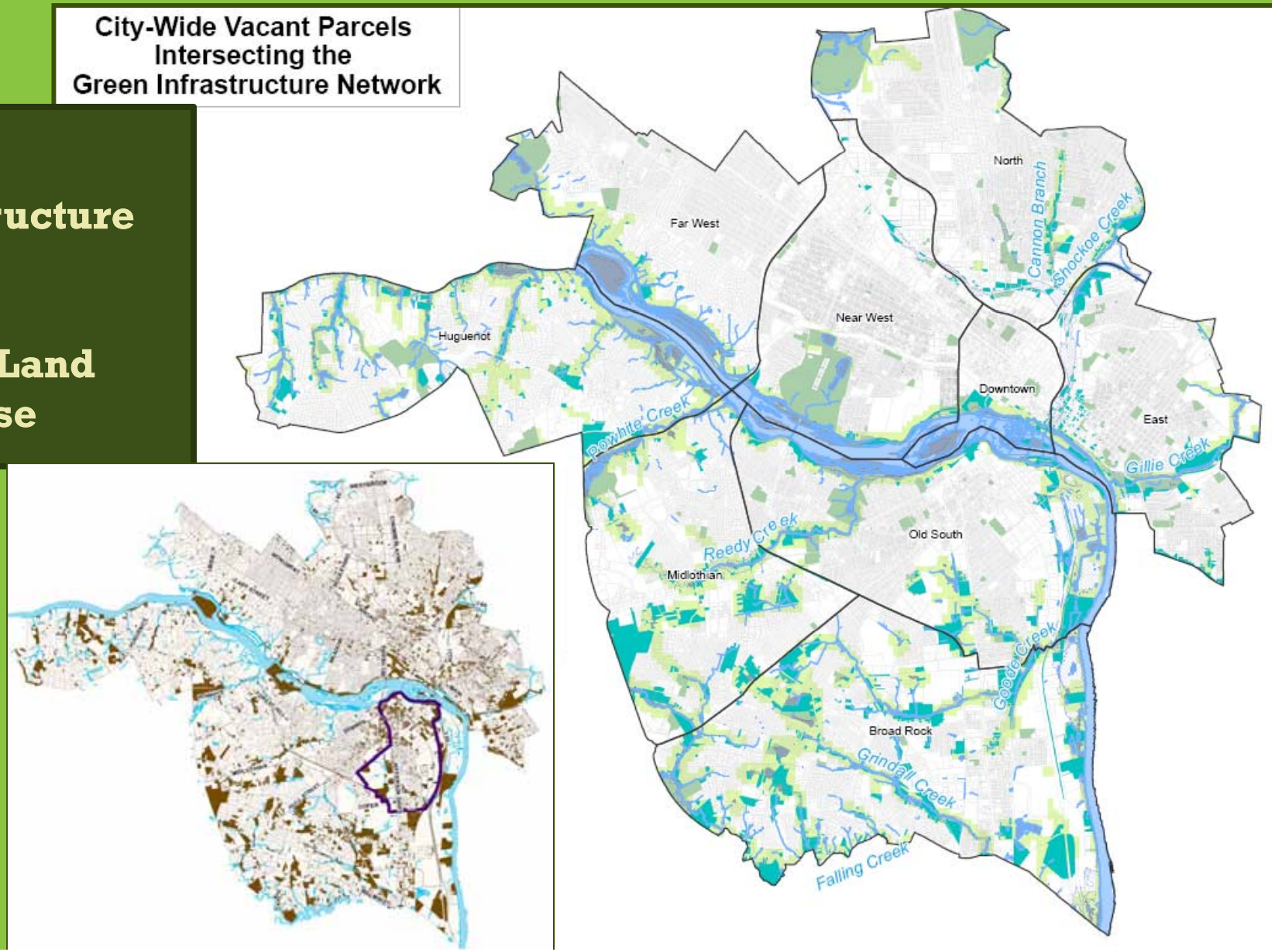
- 99% increase in **air pollution removal**

- Additional **18,000 tons of carbon stored**

Green Infrastructure continued…

Green Infrastructure Center

Vacant Land Database

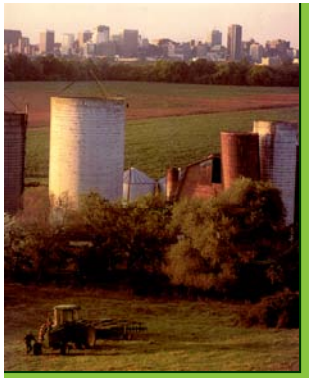


Green Infrastructure Assessment
Phase I: A Green Print Pilot Program for Richmond

Sarah Stewart
Senior Planner
Richmond Regional Planning District Commission

(804) 323-2033 ext. 119
sstewart@richmondregional.org

www.richmondregional.org



Richmond Region Green Infrastructure Assessment

Richmond Regional Planning District Commission 1969

Virginia Department of Forestry

NOAA

Altria

Richmond Virginia

Green Infrastructure Center

skeo Solutions

Crater Planning District Commission CPDC

Virginia Coastal Zone Management Program

Overview

Green Infrastructure Definition and Benefits

Regional Green Infrastructure Assessment

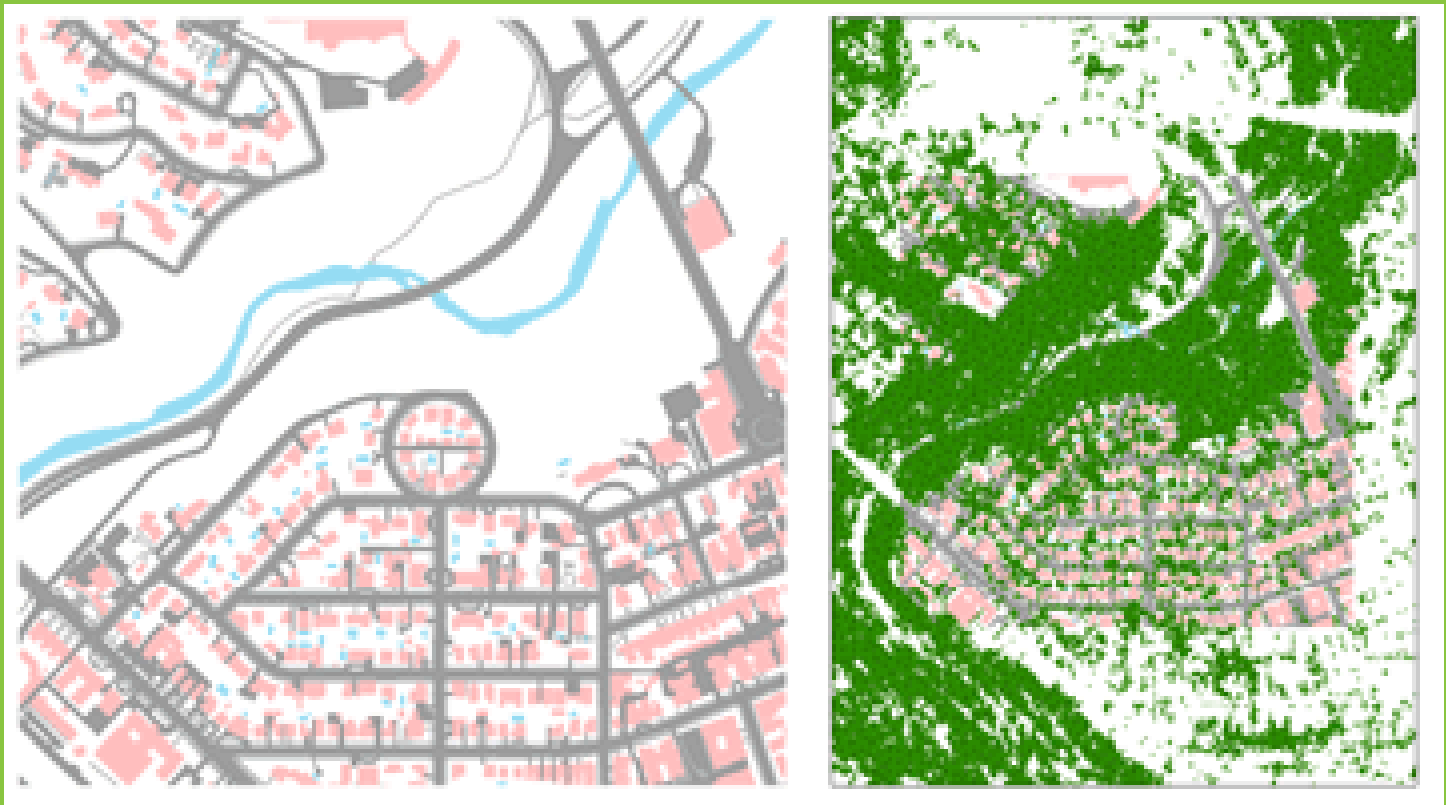
City of Richmond Green Infrastructure Assessment

Phase III

Infrastructure: What's In a Name?

Infrastructure (n): the substructure or underlying foundation...on which the continuance and growth of a community or state depends.

What is Green Infrastructure ?



A planimetric map of a Washington DC shows a neighborhood's gray infrastructure including buildings and roads (left). Classified high-resolution satellite imagery adds a green infrastructure data layer (trees and other vegetation) (right).
Source: American Forests

Green Infrastructure Principles

"An interconnected network of a wide range of landscape elements that

support native species,

maintain natural ecological processes,

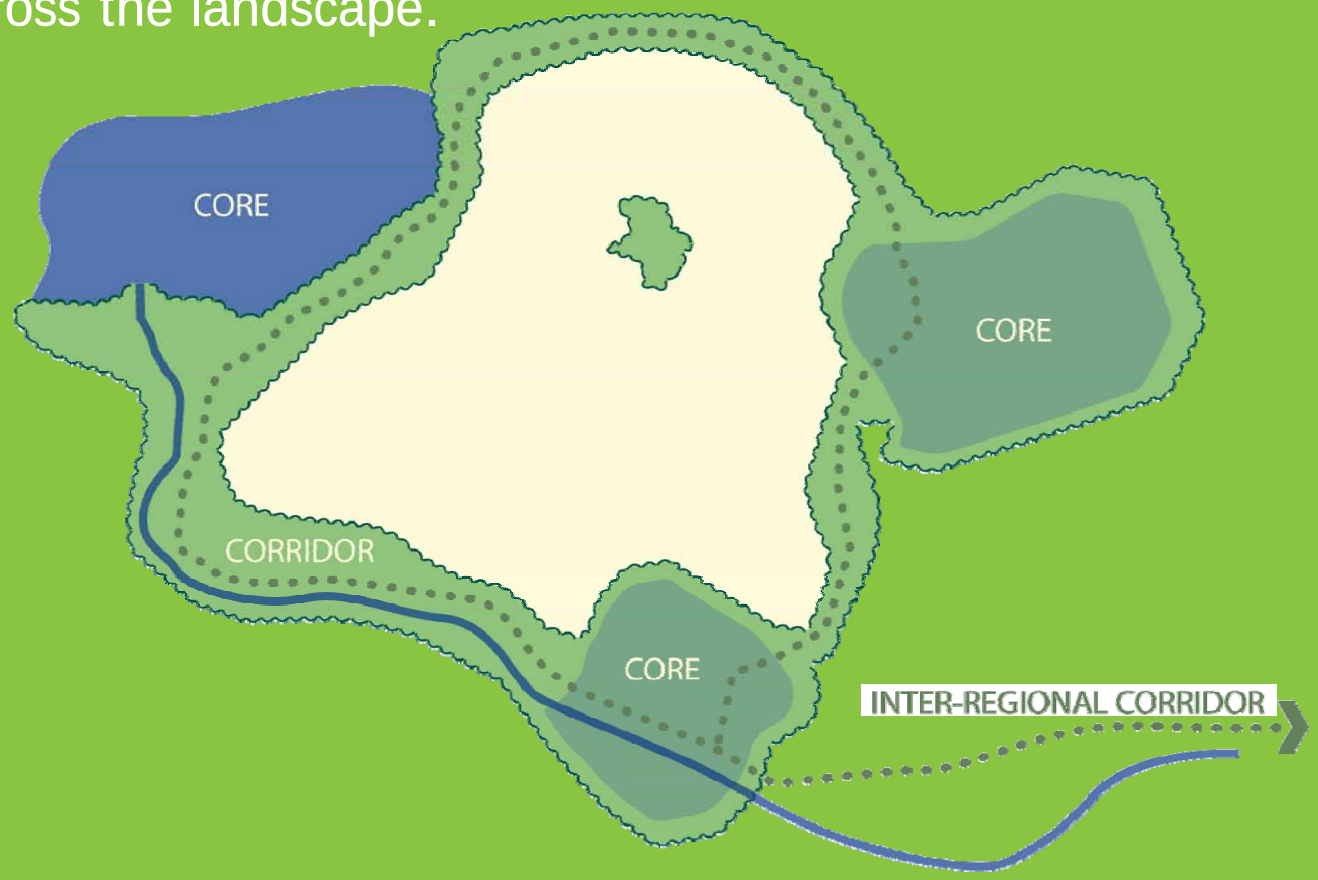
sustain air and water resources, and

contribute to the health and quality of life for communities and people."

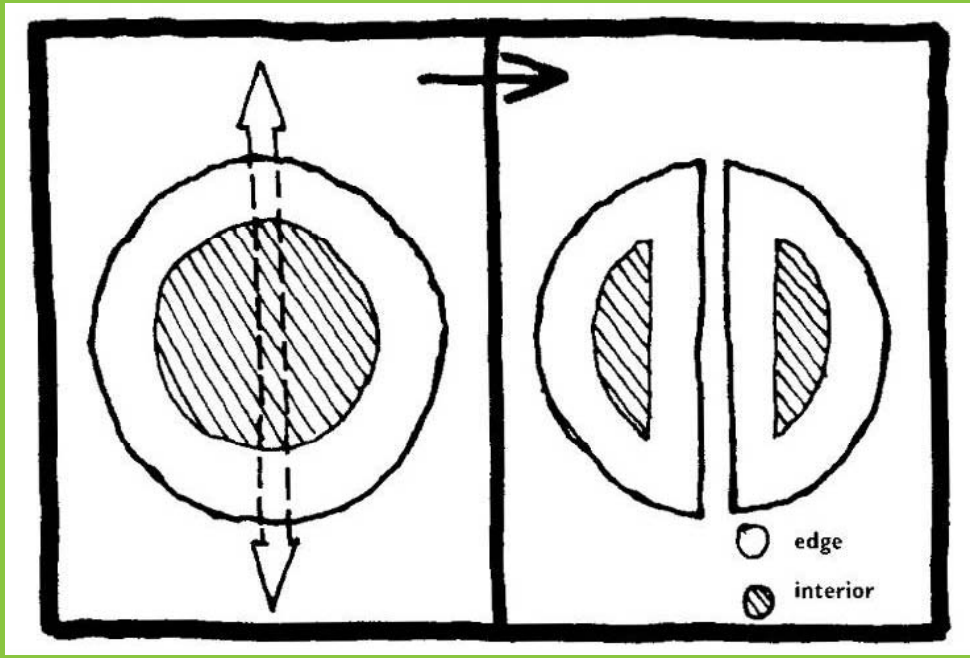
Source: Green Infrastructure: Linking Landscapes and Communities, Benedict and McMahon (2006)

Green Infrastructure Networks

A green infrastructure network is made up of connected core habitats and connecting corridors that help animals, seeds, and people move across the landscape.



Dividing a Large Forest Into Two Smaller Forests …



Brown headed cow birds like edges! They put their eggs in other birds nests!

- Removes interior habitat
- Reduces interior species population
- Reduces diversity of interior species

- So whenever we can – we should keep forests intact!

Image source: Dramstad, Wenche E., et al. *Landscape Ecology Principles in Landscape Architecture and Land Use Planning*. Washington D.C., Island Press, 1996.

Green Infrastructure Assets

- Working Lands
  - Farms
  - Forests
  - Fisheries
- River & Stream Corridors
- Wetlands
- Meadows & Pastures
- Parks

Green Infrastructure Assets

- Cultural Sites
- Historic Resources
- Trails
- Viewsheds
- Scenic Rivers
- Scenic Byways
- Watersheds
- Birding and Wildlife Trails

Why Is Green Infrastructure Development Different?

Traditional Development	Green Infrastructure Based-Development
Plan for grey infrastructure first (roads, stormwater pipes)	First, assess natural features and functions and protect them.
Green spaces in leftover lands (e.g. steep slopes and floodplains)	Plan for parks, trails, habitat connections before siting buildings.
Work within confines of parcel = pocket parks, inner trails, gated systems	Connect land and water habitats to region and across ownerships

Benefits of GI …

- Combats global warming (carbon sequestration) and improving air quality.
- Protects and preserves water quality and supply.
- Provides stormwater management, hazard mitigation.
- Preserves biodiversity and wildlife habitat.
- Improves quality of life and fitness by access to recreation.

Urban Heat Islands

Aug. 14, 2002, a very hot NY City Day

Thermal (top) and vegetation (bottom) infrared satellite data measured by
NASA's Landsat7 Enhanced Thematic Mapper Plus shows where vegetation is dense, temperatures are cooler.

NY City determined that highest cooling potential per area =

- ✓Street Trees
- ✓Living (green) roofs
- ✓Light colored surfaces and
- ✓Open space planting

Tree Canopy Values

Provide more attractive areas for development, historic districts, commercial areas and opportunities for people to interact with nature.

A study by the University of Washington found that people shopped longer and more often in tree-lined retail areas and *spent about 12 percent more* money.

National Association of Realtors study showed 57% of voters are more likely to purchase a home near green space and 50% will pay 10% more!

Green Assets: for job development

Small companies, especially those that are have well paid and skilled workforce place a strong importance on the “green” of the local environment. Crompton Love and Moore, 1997

The creative class: artists, media, lawyers, analysts, make up 30 percent of the U.S. workforce and they place a premium on outdoor recreation and access to nature. Florida, 2002

The Origins of the Project

- Coastal Zone Management Program Grant – Sustainable Communities
- Create a regional green infrastructure asset map and prioritized green infrastructure opportunities
- “Update” state model data

The State Model

- Identification
- Inventory: Map existing assets
- Rank & Prioritize areas to protect
  - Function
  - Significance
  - Vulnerability

State Modeling Tools

- VA Natural Landscape Assessment – Forest Habitats
- Cultural Model – Historic Resources
- Vulnerability Model – Growth Predictions and Trends
- Forest Economics Model – Economically viable forest
- Agricultural Model – Lands suitable for farming
- Recreation Model – Trails, Parks, Hunting and Fishing
- Watershed Integrity Model
- Ecological Integrity

VA Conservation Lands Needs Assessment:

Core Prioritization in Virginia

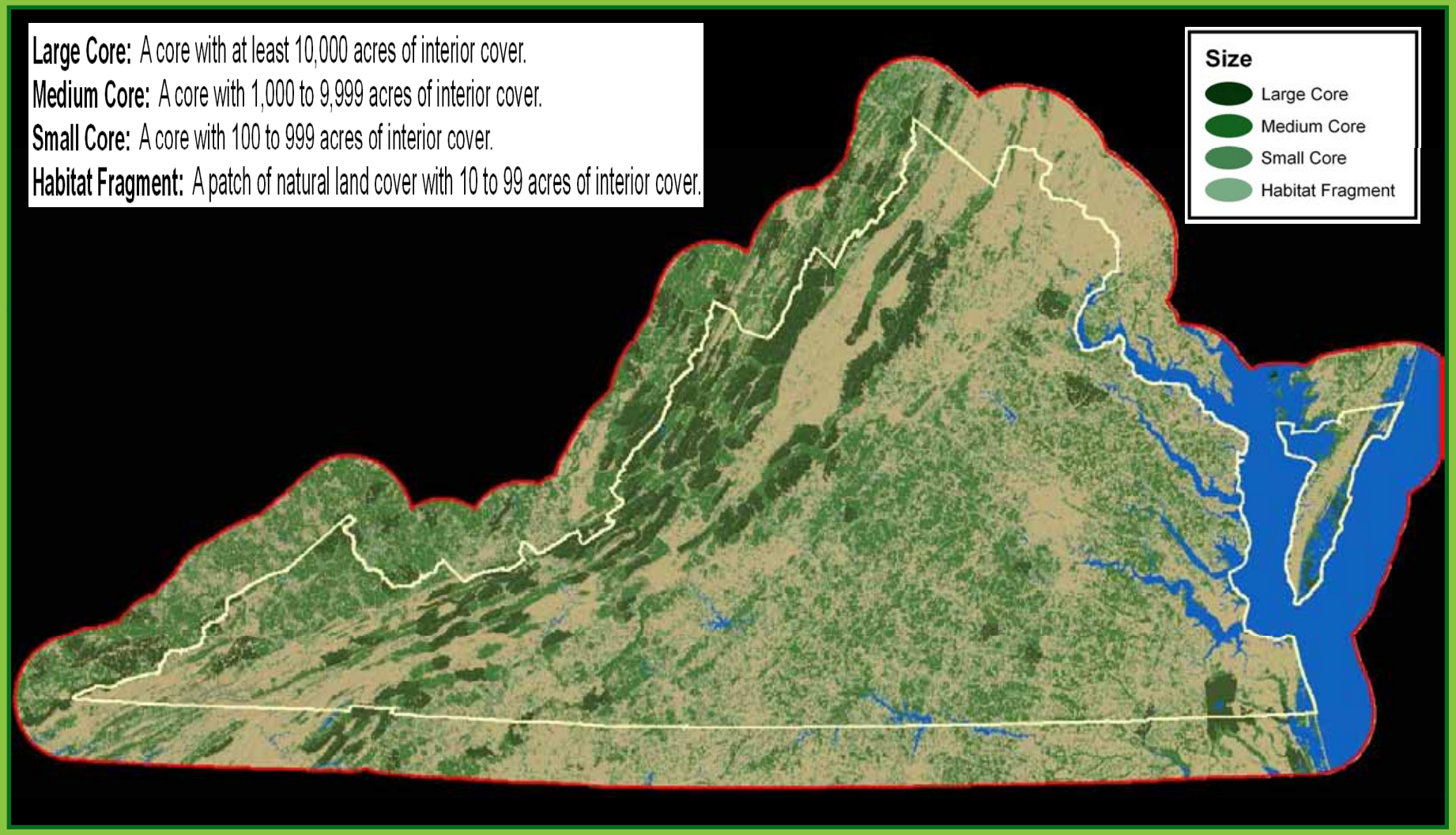


Image Courtesy VA Dept. of Conservation and Recreation

State Model Factors

Ecological Composite Model = Ecological Integrity Ranking 1 - 5

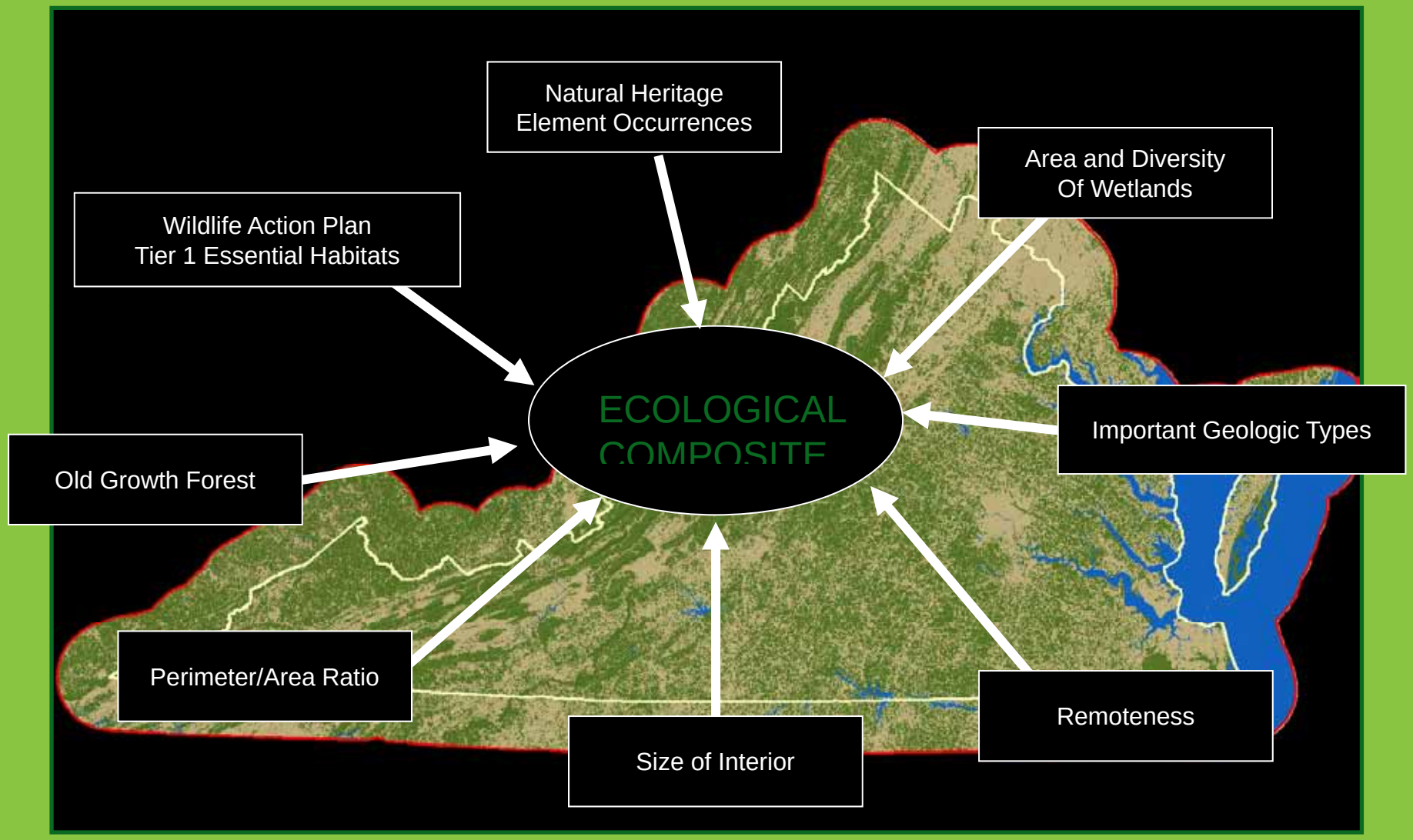
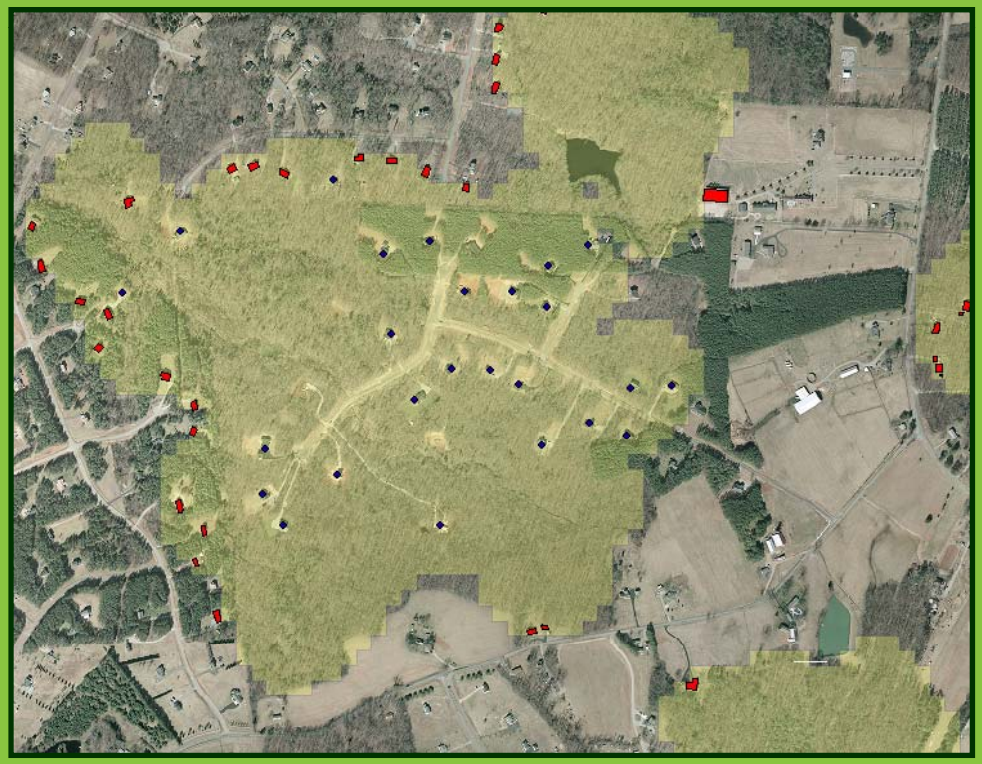


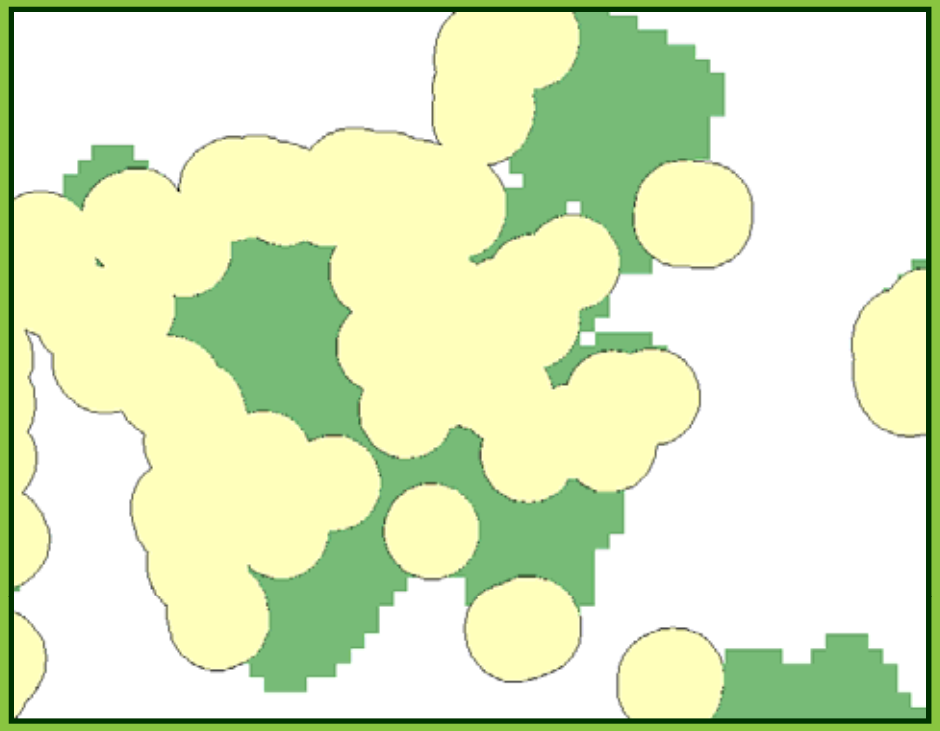
Image Courtesy VA Dept. of Conservation and Recreation

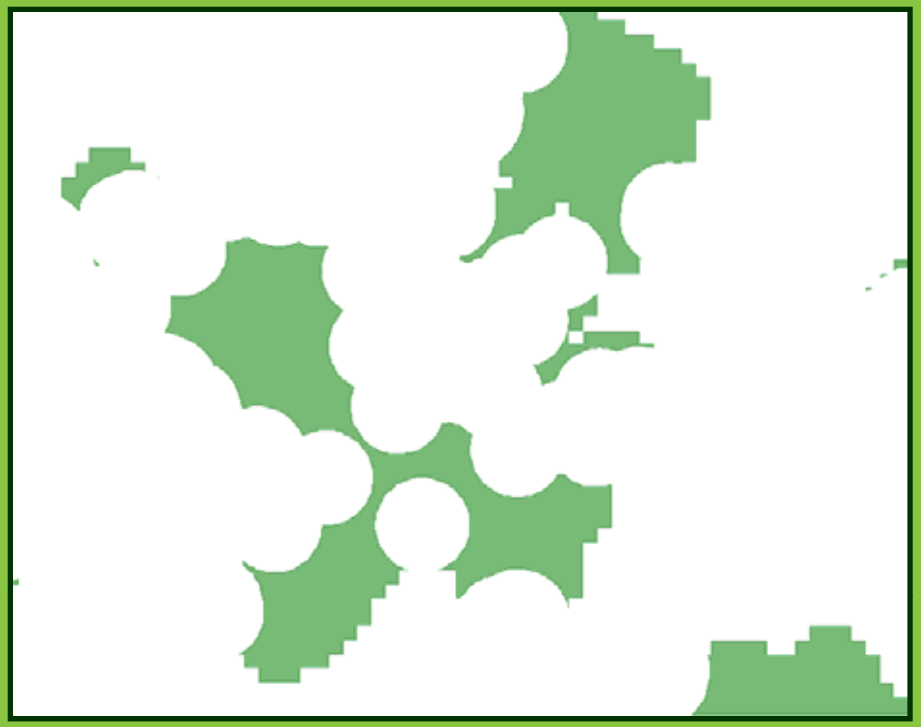
Method to Update Cores

1. Use existing structure data, aerial photography and ecological core GIS data to identify new structures not accounted for in the model data
2. Digitize points over new structures identified from aerial photography.

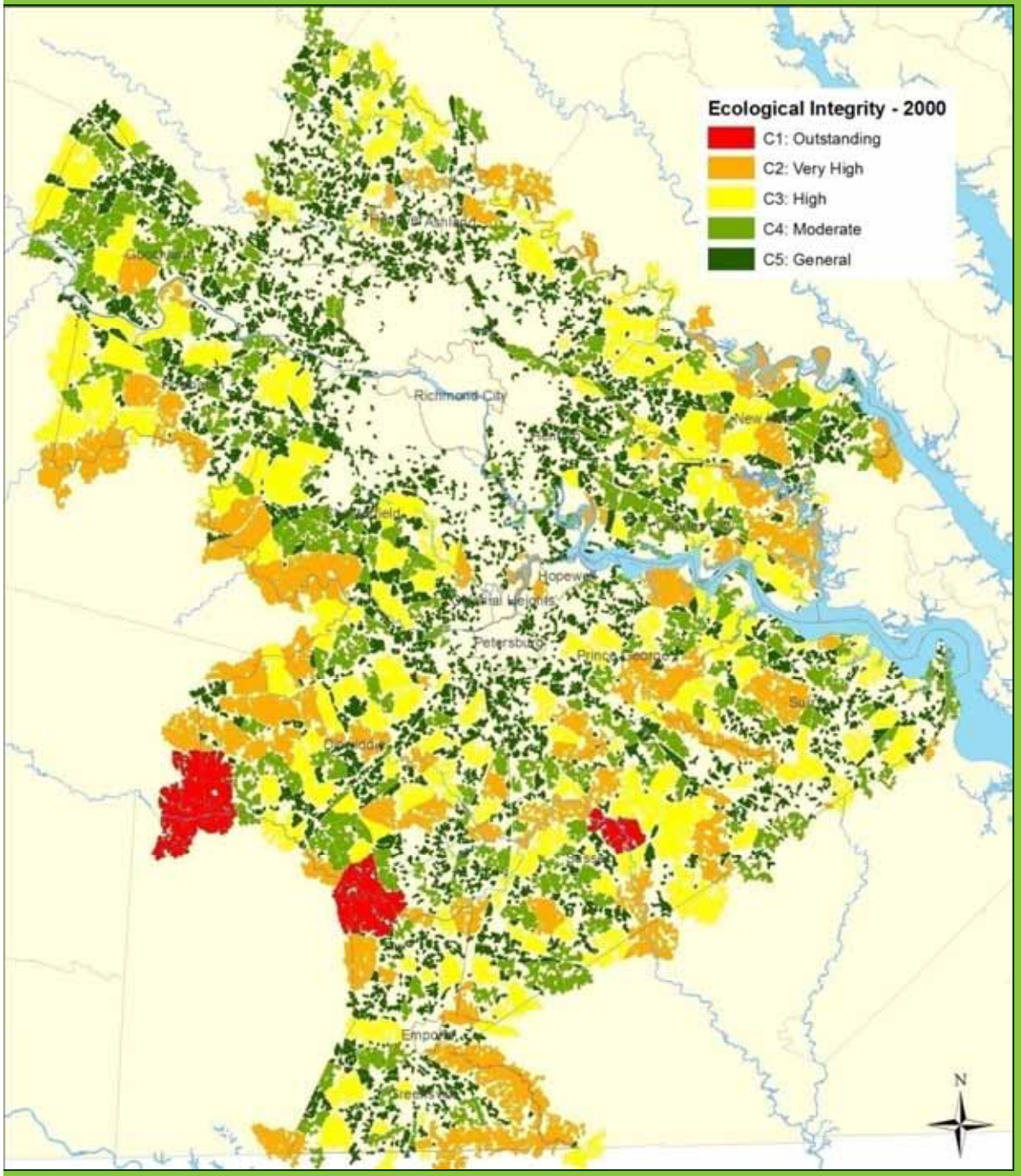


3. Add 100 meter buffer around structures that intersect the ecological cores.



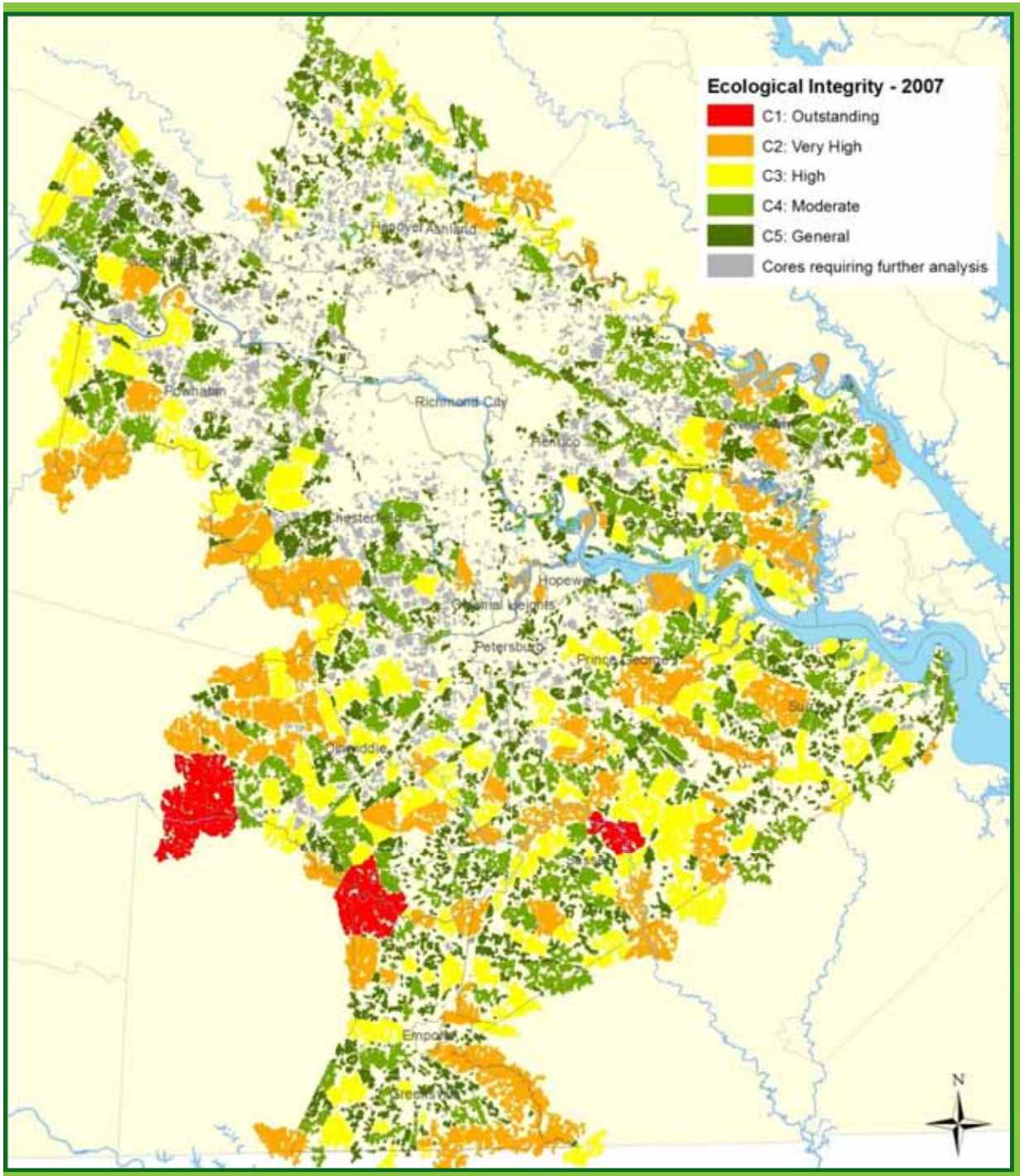


4. Remove structure buffers from ecological cores.
5. Recalculate core acreage, eliminate remaining core fragments below acreage threshold.
6. Recalculate ecological integrity score.



Original

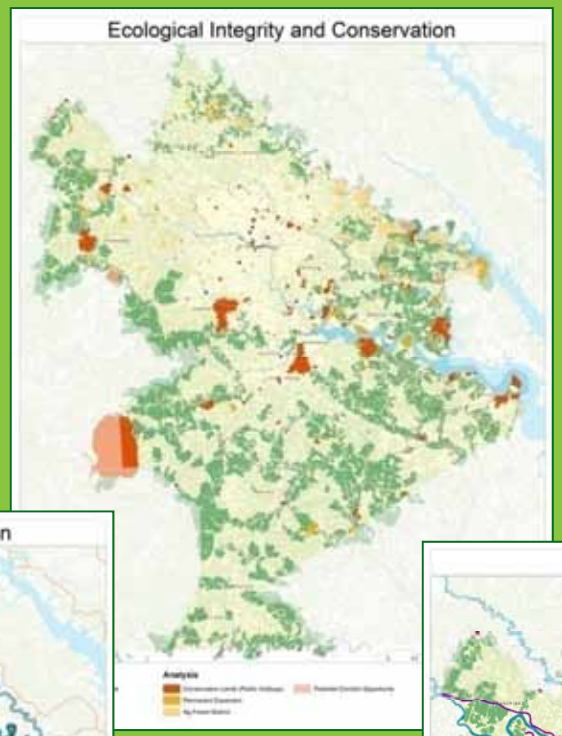
Richmond & Crater Region Intact Cores



2007

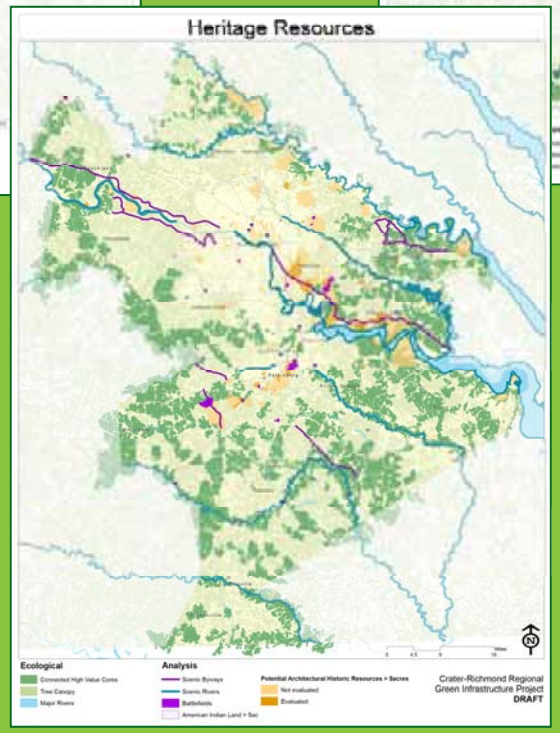
Richmond & Crater Region Intact Cores

Theme Maps


Ecological Integrity and Conservation
Analysis

Water
Lower Chesapeake
James
Albemarle-Chowan
Crater-Richmond Regional Green Infrastructure Project
DRAFT

Natural Resource Based Recreation
Ecological
Analysis
Crater-Richmond Regional Green Infrastructure Project
DRAFT


Heritage Resources
Ecological
Connected High Value Cores
Tree Canopy
Major Rivers
Analysis
Scenic Byways
Scenic Rivers
Battlefields
American Indian Land + Sac
Potential Architectural Historic Resources + Sacres
Not evaluated
Evaluated
Crater-Richmond Regional Green Infrastructure Project
DRAFT

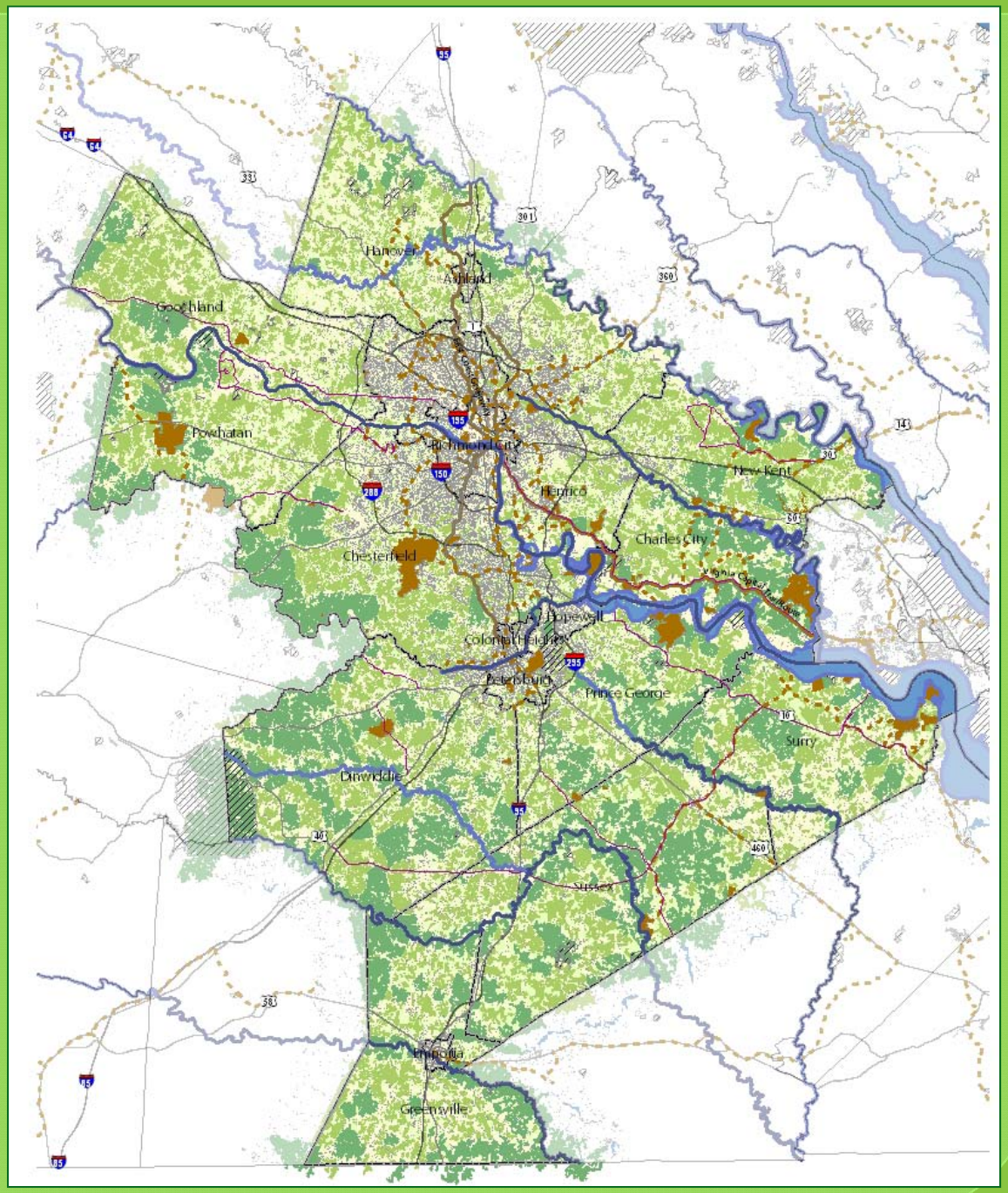
Regional Green Infrastructure Assets

Richmond-Crater Region Green Infrastructure Assets

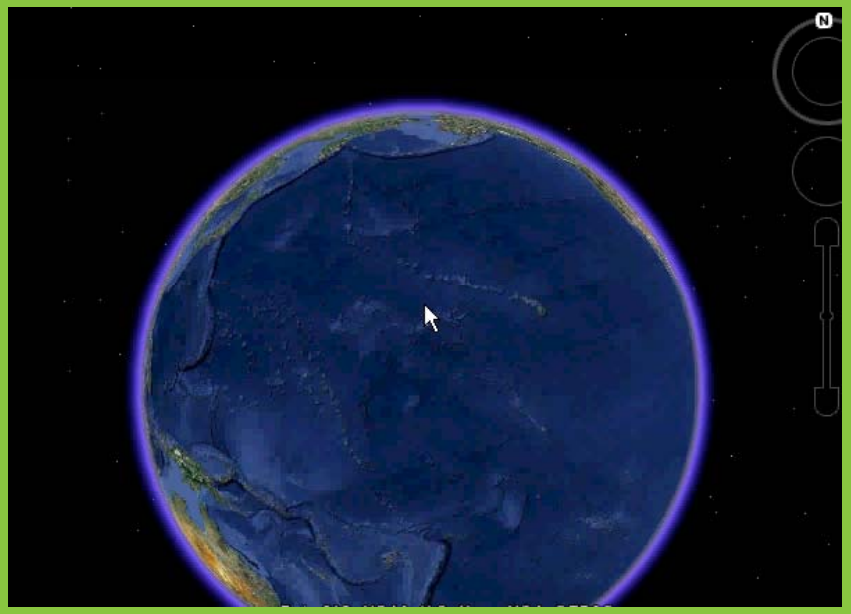
- Protected Lands (public holdings & easements)
- Connected High Value Landscape
- Intact Landscapes
- Tree Canopy
- Major Rivers
- Urban Developed Land

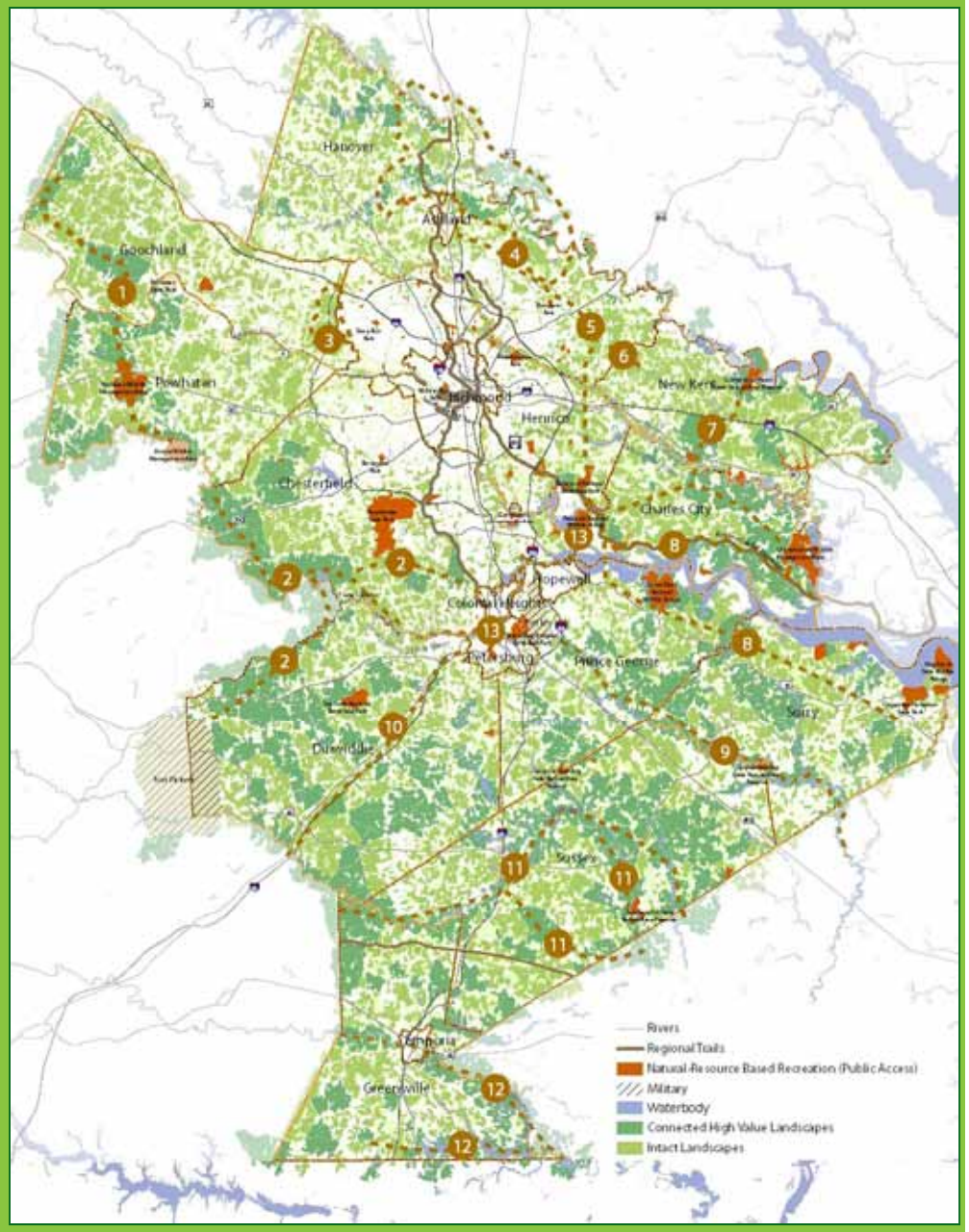
Nature-Based Recreation

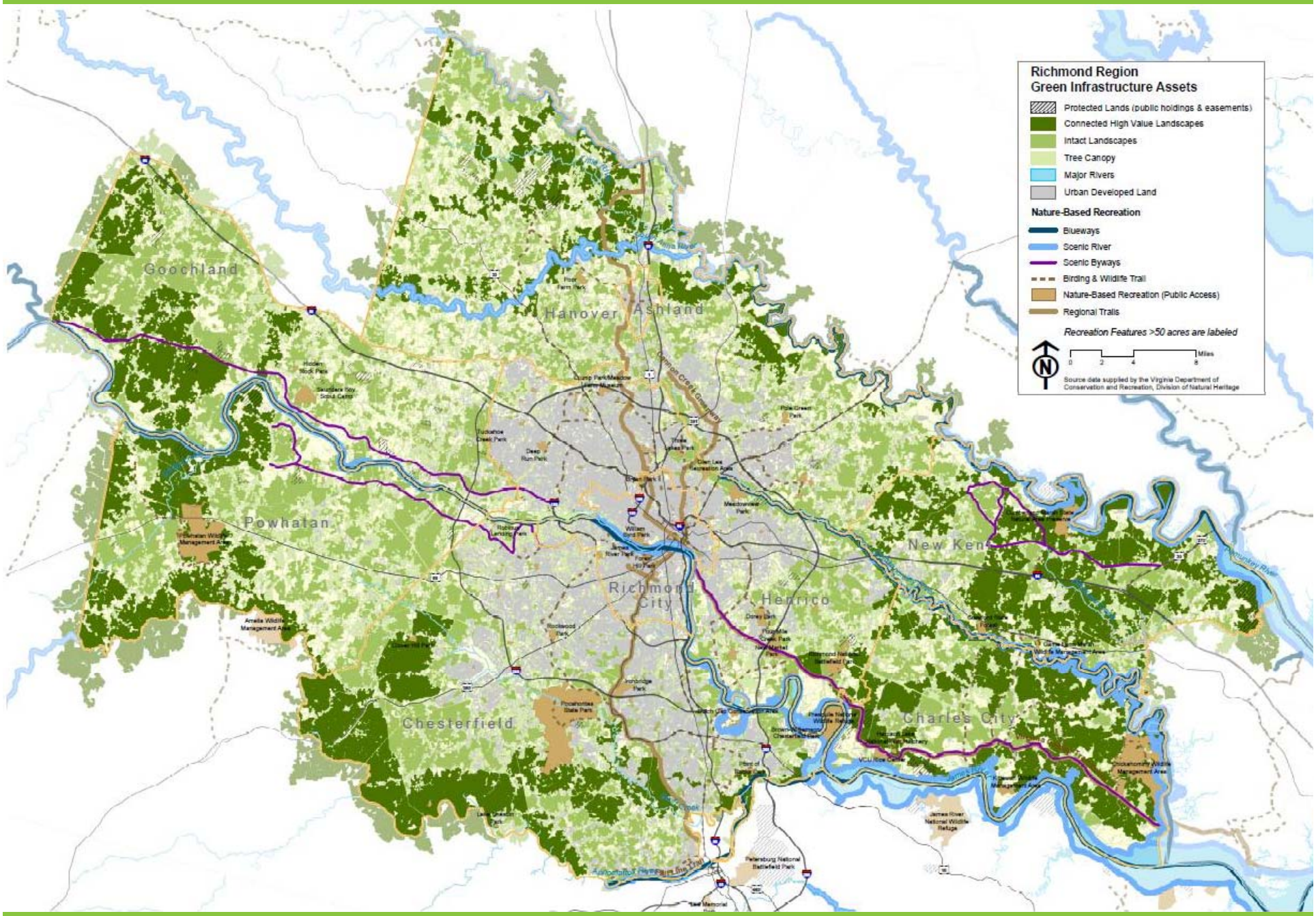
- Blueways
- Scenic Rivers
- Scenic Byways
- Birding & Wildlife Trail
- Regional Trails
- Nature-Based Recreation (Public Access)



Regional Green Infrastructure Opportunities






Richmond Region
Green Infrastructure Assets
Protected Lands (public holdings & easements)
Connected High Value Landscapes
Intact Landscapes
Tree Canopy
Major Rivers
Urban Developed Land
Nature-Based Recreation
Blueways
Scenic River
Scenic Byways
Birding & Wildlife Trail
Nature-Based Recreation (Public Access)
Regional Trails
Recreation Features >50 acres are labeled
0 2 4 8 Miles
Source data supplied by the Virginia Department of Conservation and Recreation, Division of Natural Heritage
Goochland
Hanover
Ashland
Powhatan
Richmond City
Henrico
New Kent
Chesterfield
Charles City

Green Infrastructure Assessment

Phase 1: A Green Print Pilot Program for Richmond

October 2010

City of Richmond **Green Infrastructure Assessment**

Focus on a smaller geographic area at an urban scale:

1. Identify existing assets and opportunities (Green Print)

2. Provide quantifiable benefits from green asset enhancement (CITYgreen)

3. Identify vacant, underutilized parcels (Brown Print) to be added to a greener, healthier city

What Are City of Richmond's Green Infrastructure Assets?

- Water Resources
- Conservation Lands
- Sustainable Features
- Parks & Recreation
- Transportation
- Heritage & Culture Resources

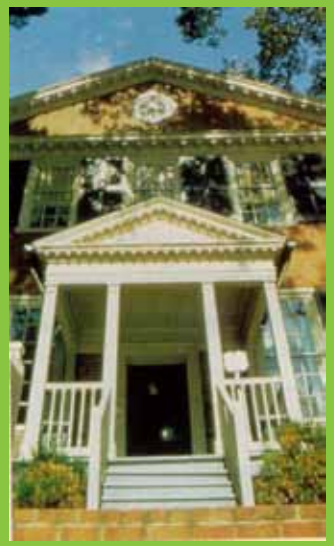
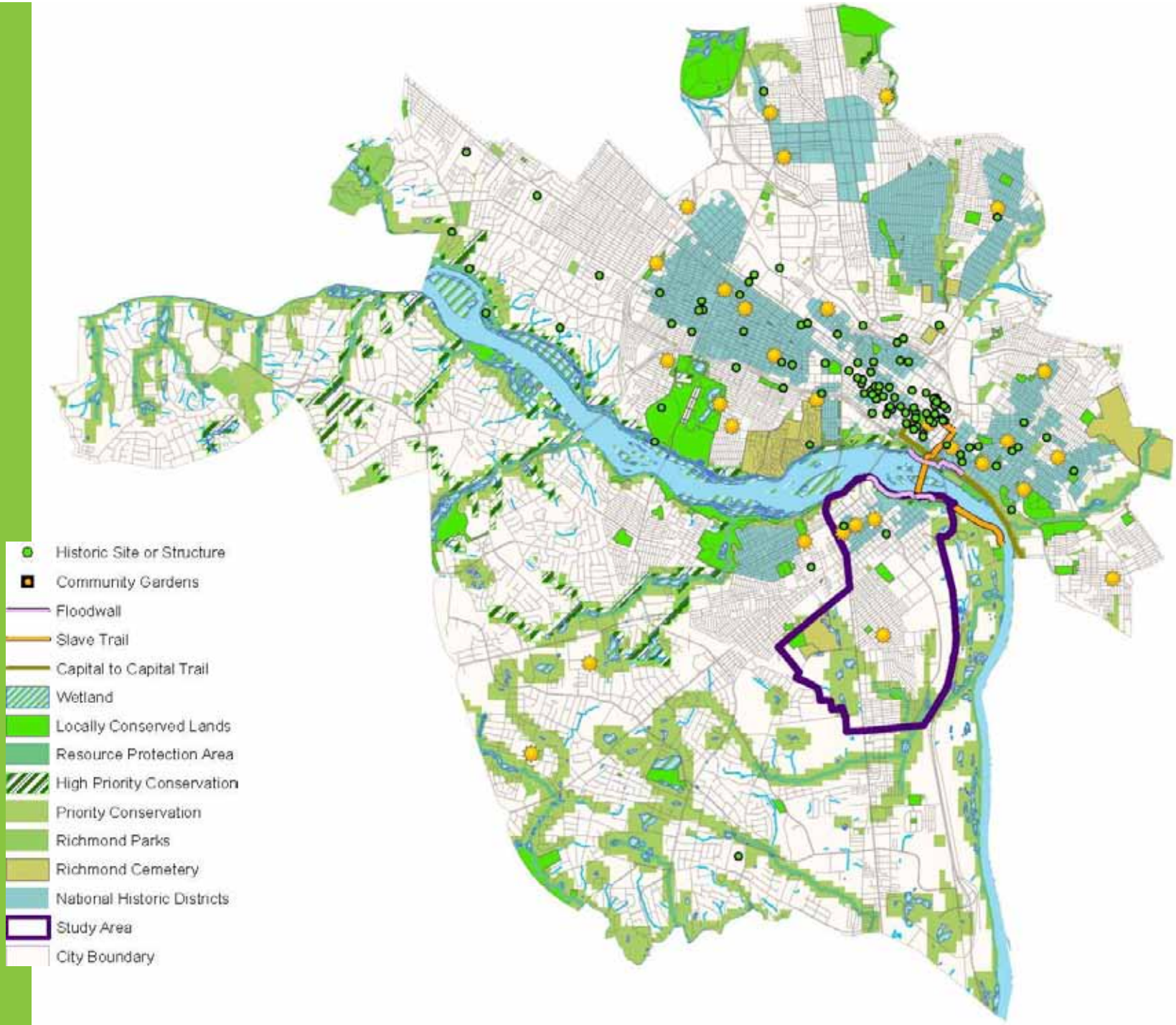


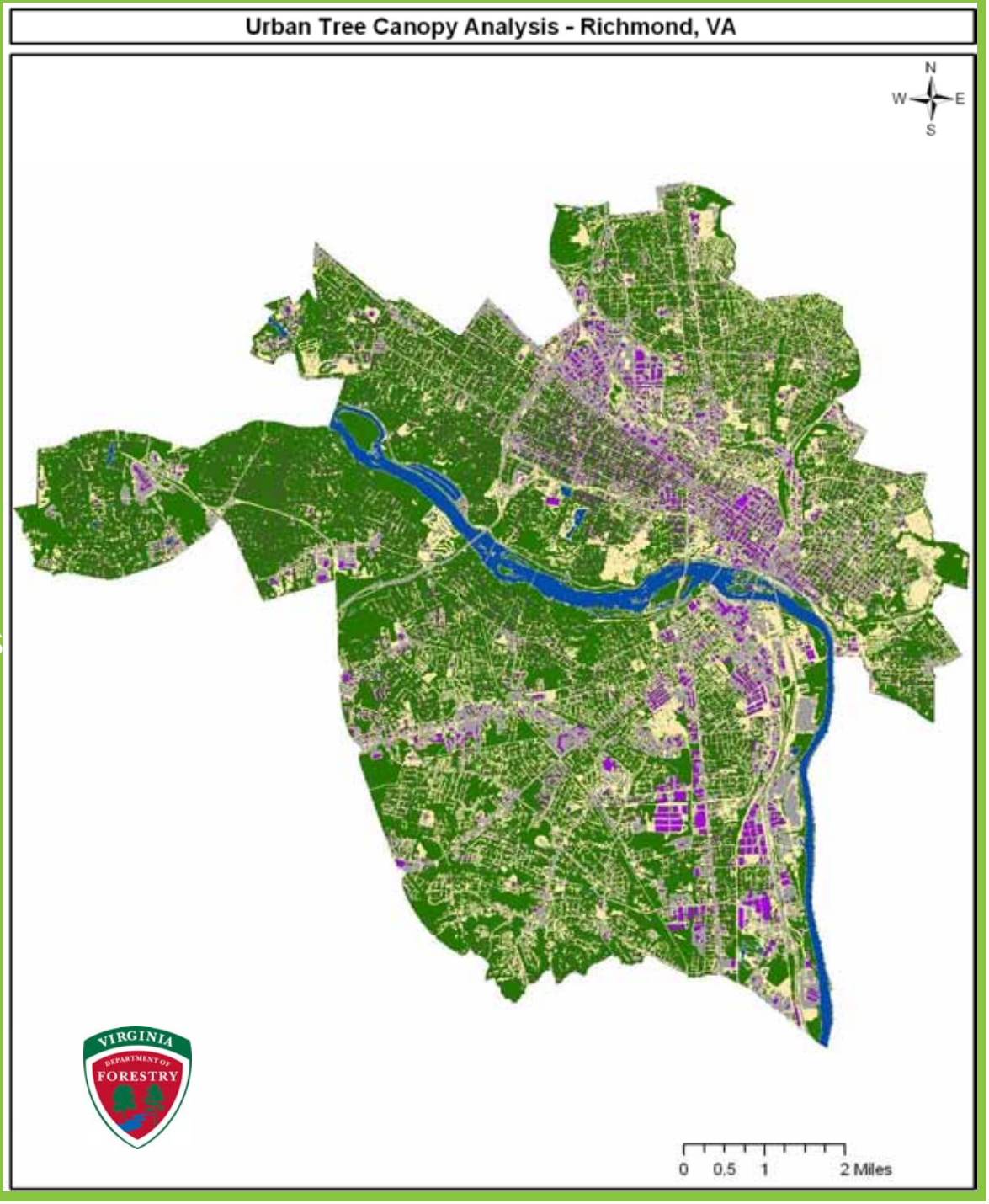
Image Source: Millennium Ecosystem Assessment


Historic Site or Structure
Community Gardens
Floodwall
Slave Trail
Capital to Capital Trail
Wetland
Locally Conserved Lands
Resource Protection Area
High Priority Conservation
Priority Conservation
Richmond Parks
Richmond Cemetery
National Historic Districts
Study Area
City Boundary

City-wide Urban Tree Canopy

42% Tree Canopy
23% Non-Tree Vegetation
24% Non-Building Impervious
11% Building Impervious

Source: Virginia Department of Forestry, October 2010



Selection of a Study Area

- Amount of viable intact habitat
- Amount of vacant/ underutilized parcels
- Amount of existing park land
- Highest watershed priority area

Neighborhoods of Manchester, Blackwell, Oak Grove, Maury, Bellemeade, Hillside Court and Ancarows Landing

Identify Existing Conditions

Land Cover Analysis:

20% Tree Canopy
31% Non Tree Vegetation
34% Non-Building Impervious
15% Building Impervious

Source: Virginia Department of Forestry
Urban Tree Canopy(UTC) analysis

CITYgreen© Analysis

Models for Testing Alternative Future Scenarios for Development or Redevelopment

general neighborhood scale to site specific…

- Land use & density changes
- Increasing tree canopy
- Low Impact Development
  - rain gardens
  - green roofs
  - porous pavement
  - Vegetated buffers & swales

Key Findings for the Study Area

An increase of existing tree canopy in the study area to City-wide levels would result in benefits:

- **$500,000 annual savings** in reduced stormwater treatment loads

- **10% reduction in nitrogen** and **17% reduction in phosphorous** from stormwater runoff

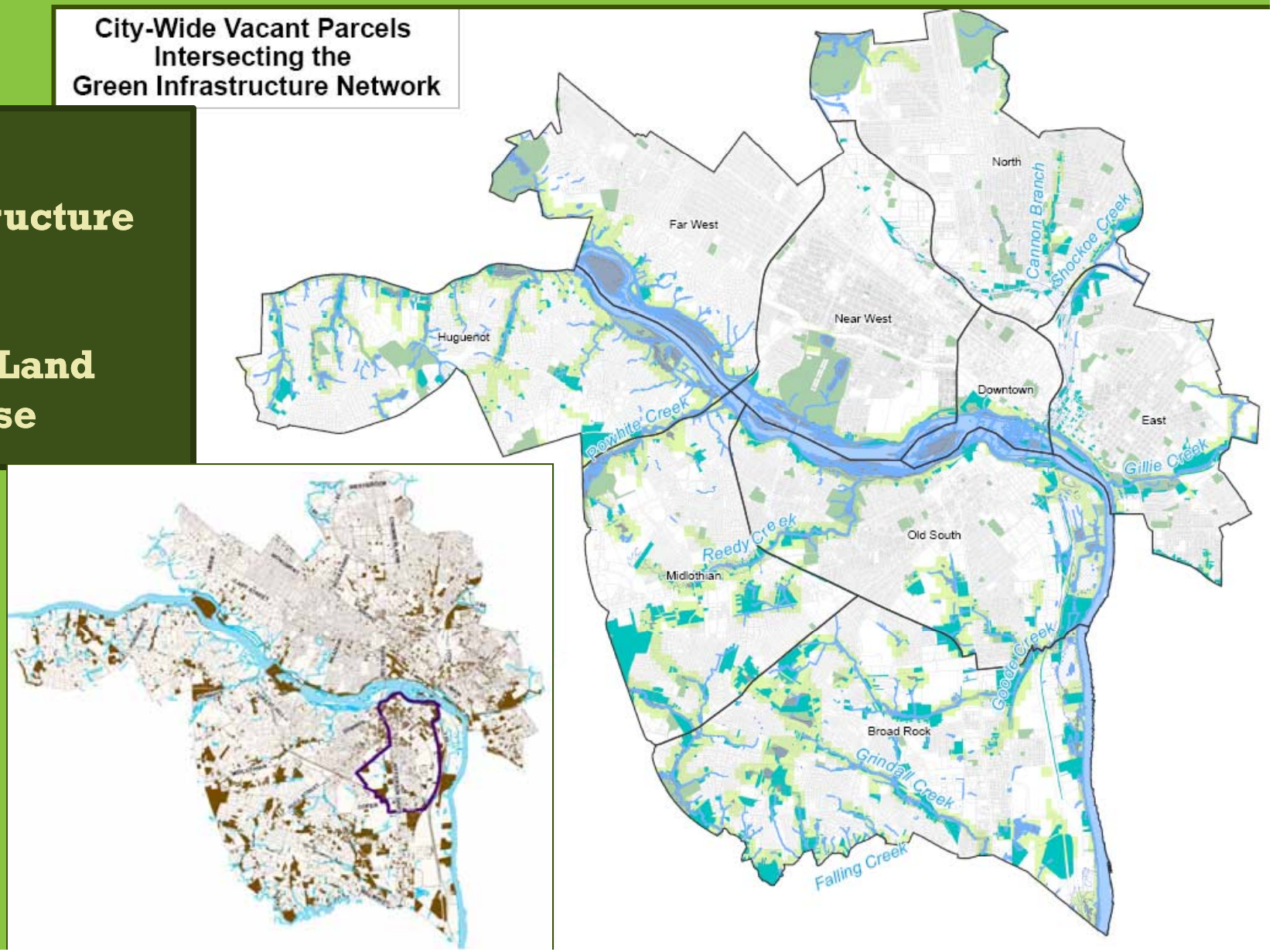
- 99% increase in **air pollution removal**

- Additional **18,000 tons of carbon stored**

Green Infrastructure continued…

Green Infrastructure Center

Vacant Land Database



Richmond Green Infrastructure Assessment

Produced by the Green Infrastructure Center and E² Inc. for the City of Richmond, Virginia

December 2010

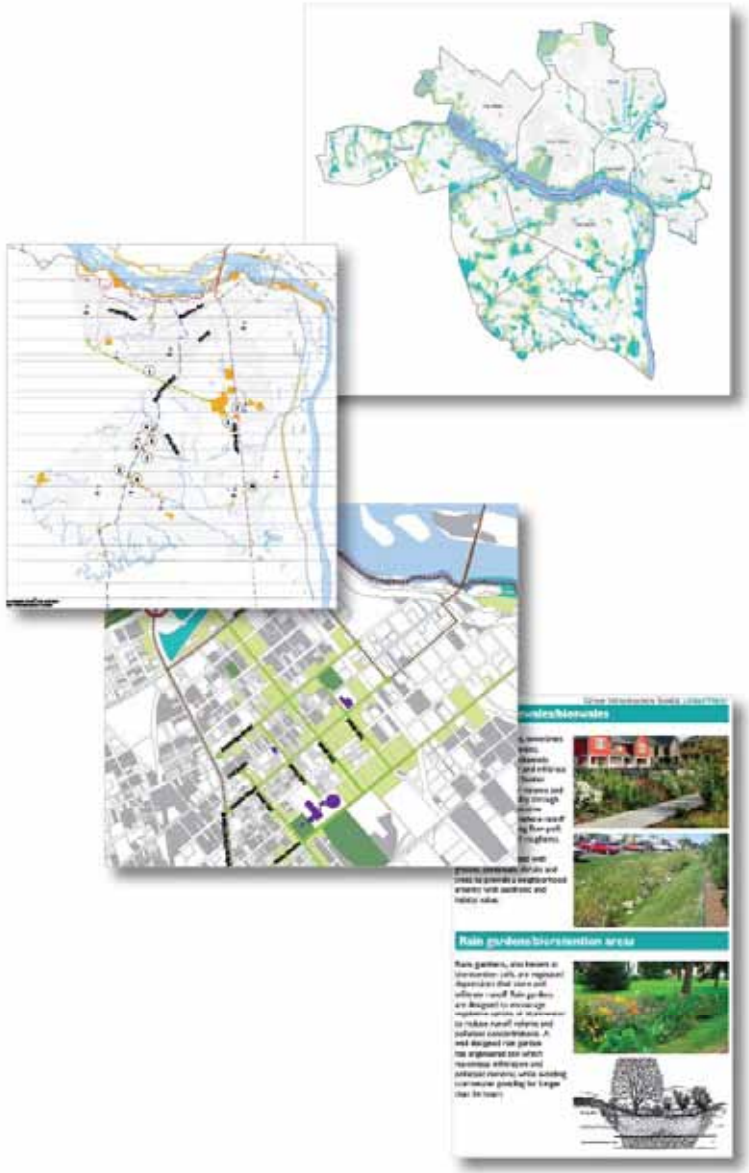
Approach Planning Across Scales

City: Develop citywide green infrastructure network based on suitability of vacant parcels.

Planning District: Create interactive database to evaluate suitability of vacant parcels for various goals.

Neighborhood: Develop concept plans and prototypes to connect neighborhoods to the city's green infrastructure network.

Project: Provide case studies and strategies that can be implemented to enhance Richmond's green infrastructure network.



District Programmatic Suitability

- Vacant lands inventory analysis
- Parcel suitability evaluation for green infrastructure programming
- Parcel ranking capabilities
- Vacant lands database

Hypothetical Suitability Ranking Map

District Suitability: Watershed Health

Vacant parcels with increased potential to mitigate stormwater runoff, based on their location within a Resource Protection Area or within 100 feet of a stream.

Watershed Health Suitability Map

Broad Rock and Old South

Vacant Land Characterization Features

- Vacant Parcels within 100' of a Stream
- Vacant Parcels Intersecting RPA

Green Infrastructure Resources

- Streams
- Resource Protection Area (RPA)

Watersheds in Broad Rock and Old South

1. James River Park
2. Westover Hills
3. Semmes Avenue
4. Bainbridge
5. Blackwell
6. Brander Street
7. Sewage Treatment Plant
8. McGuire Hospital
9. Broad Rock Creek
10. Grindall Creek
11. Falling Creek
12. Pocosham Creek
13. Pocoshock Creek

Other Urban Features

- Primary Road
- Interstate Highway
- Parcels

RPAs are designated under the Chesapeake Bay Protection Act to protect environmentally sensitive lands alongside waterways. Only a portion of the city is covered by the Bay Act.

District Suitability: Access to Public Parks

Identifies vacant parcels that may be suitable candidates for increasing access to public parks for city residents.

District Suitability: Connecting Conserved Lands

Identifies vacant parcels adjacent to conserved lands that have a strong potential to contribute to the existing conservation network due to their high ecological value.

Broad Rock and Old South

Vacant Land Characterization Features

- Vacant Parcels (Within 100' of Conserved Land)

Green Infrastructure Features

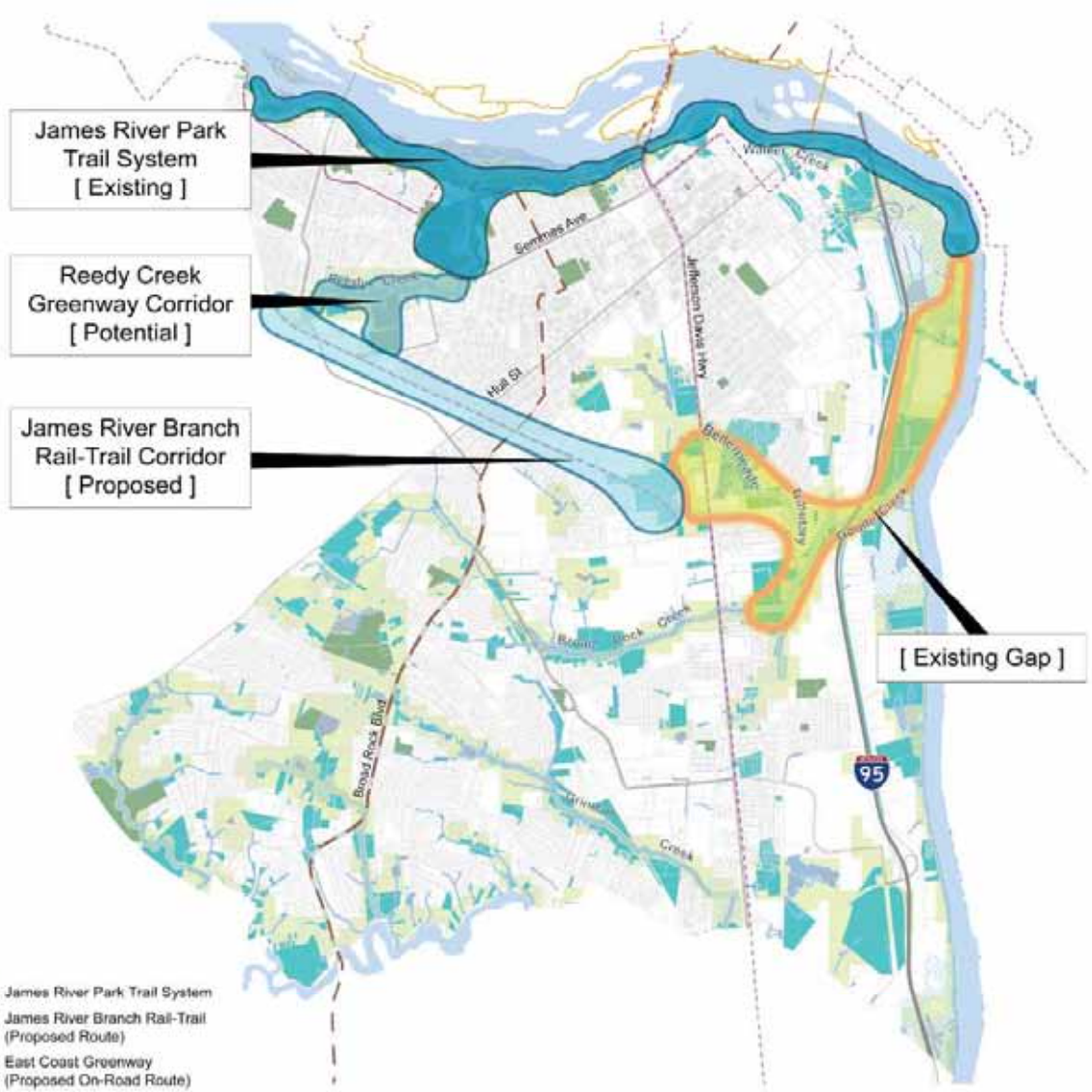
- All Conserved Lands
- Unconserved Lands of Ecological Value
- James River

Other Urban Features

- Primary Road
- Interstate Highway
- Parcels

District A Connected Network Strategy

- Use vacant lands to connect existing and proposed greenways
- Reconnect neighborhoods to the James River
- Increase access to recreation opportunities and James River Trail System



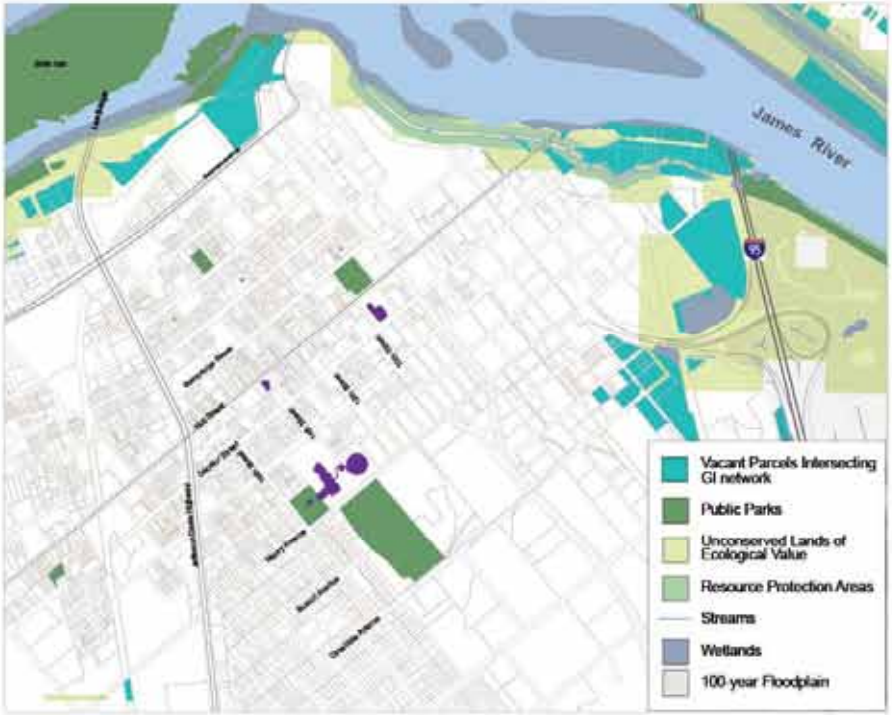
Vacant Parcel GI Network
City of Richmond Public Parks
Unconserved Lands of Ecological Value
Resource Protection Areas
Streams
James River
Wetlands
100-year Floodplain
James River Park Trail System
James River Branch Rail-Trail (Proposed Route)
East Coast Greenway (Proposed On-Road Route)
James River Heritage Trail (Proposed On-Road Route)

Neighborhood Concept Plans

Blackwell Green Links: a green infrastructure strategy for a dense urban neighborhood in transition.

Bellemeade Creek Corridor: a green infrastructure strategy for improving water quality in neighborhood.

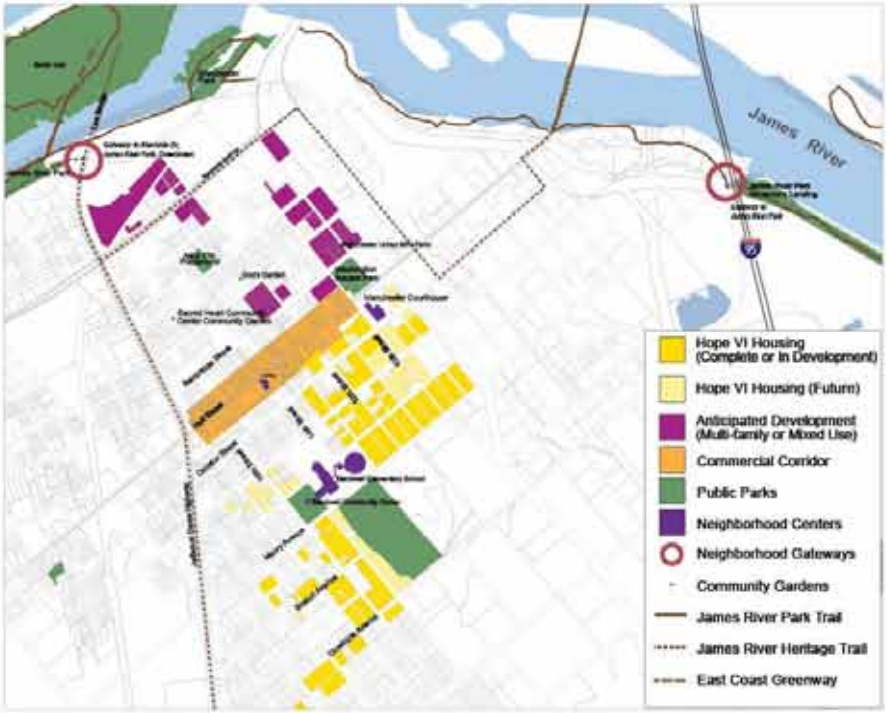
Neighborhood Blackwell Green Links



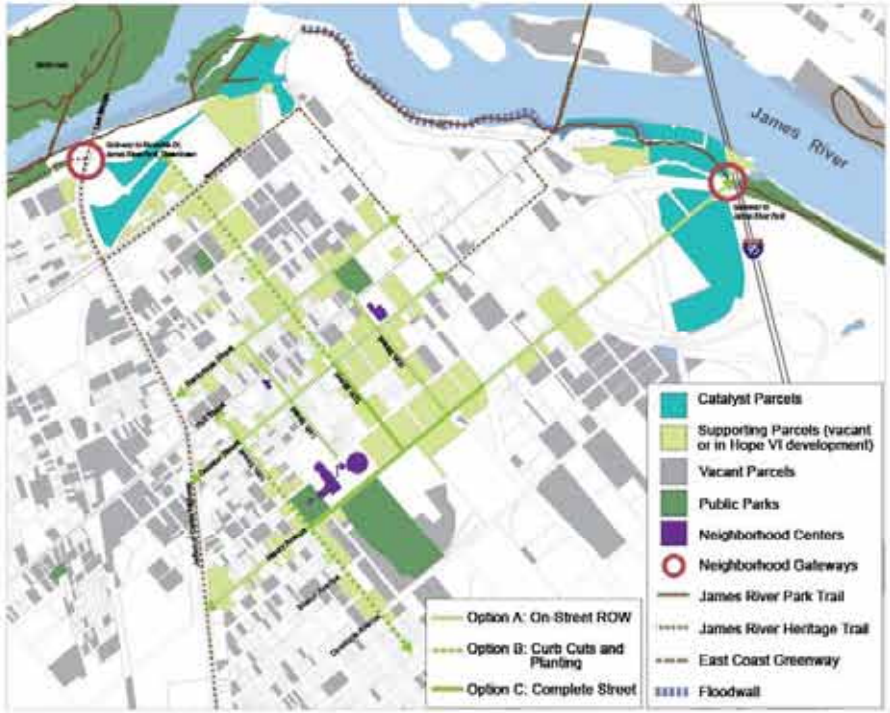
Vacant Parcels with Ecological Value

Vacant Parcels with Urban Tree Canopy

Neighborhood Blackwell Green Links



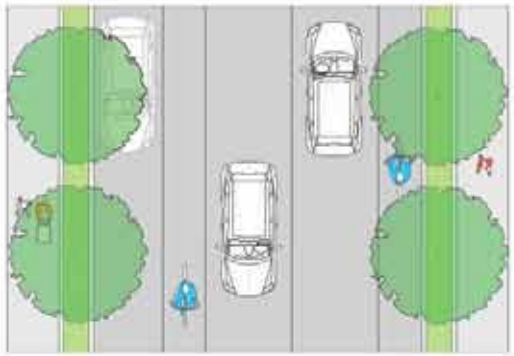
Cultural Assets and Anticipated Development

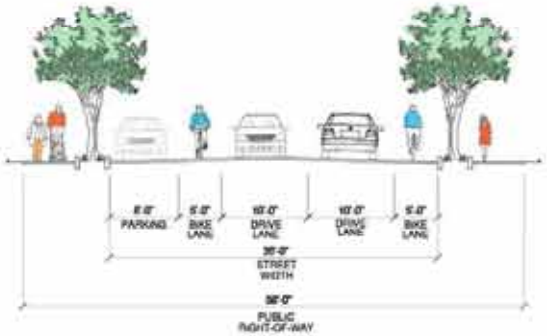


Green Links Street Menu

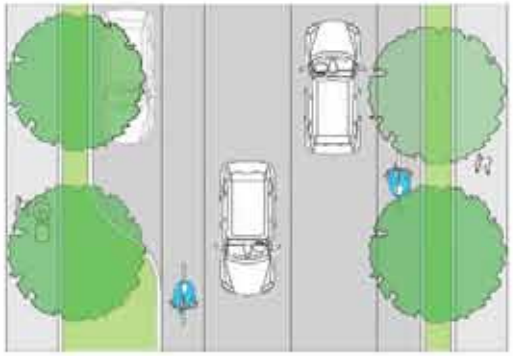
Neighborhood Green Links Street Treatments

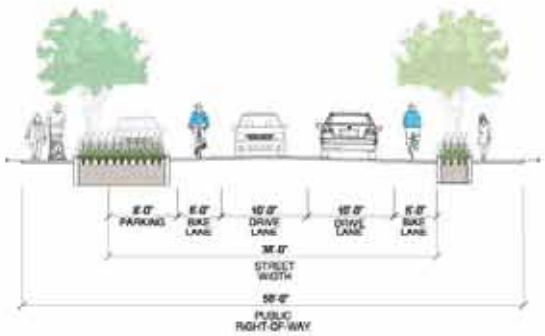
Option A: On-Street ROW



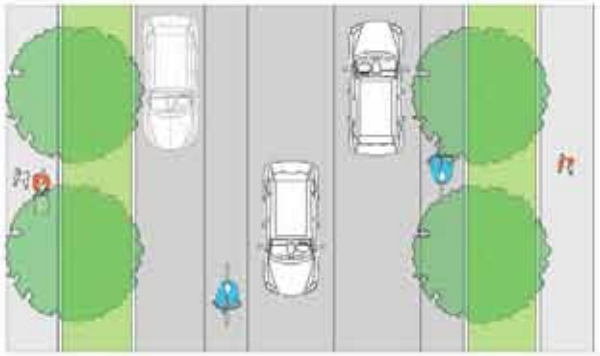


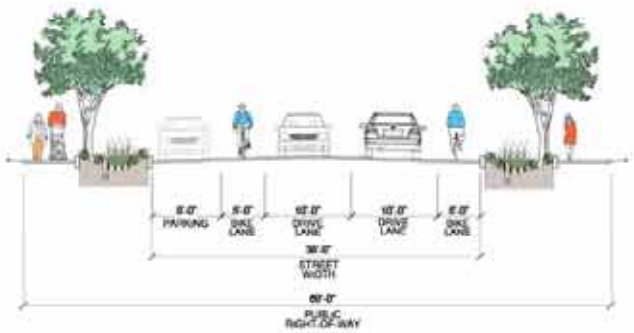
Option B: Curb Cuts and Planting





Option C: Complete Street



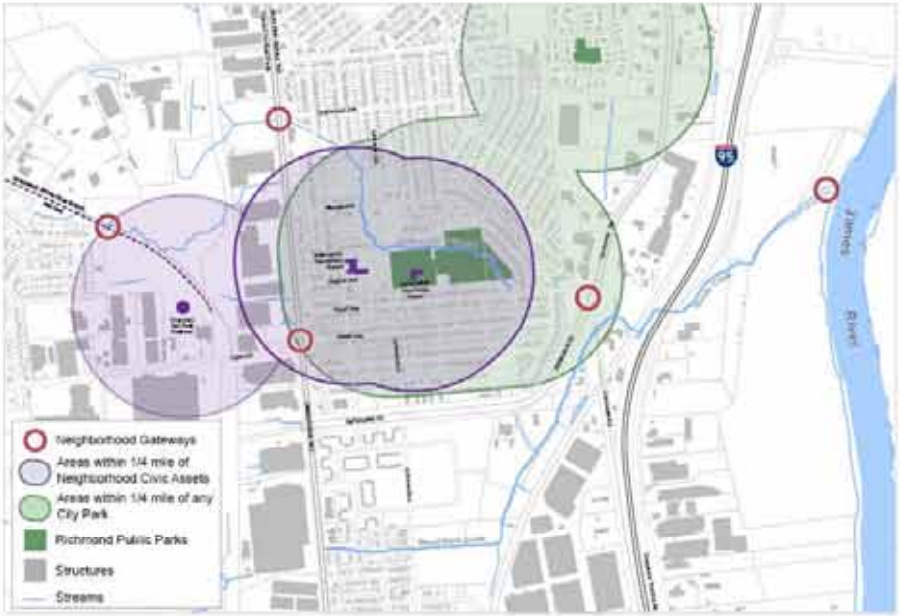


Neighborhood Bellemeade Creek Corridor

Vacant Parcels with Ecological Value

Vacant Parcels with Urban Tree Canopy

Neighborhood Bellemeade Creek Corridor

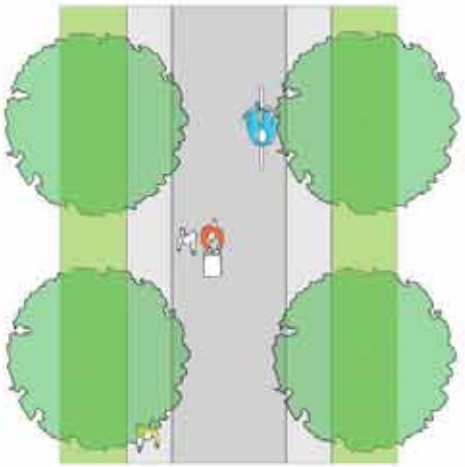


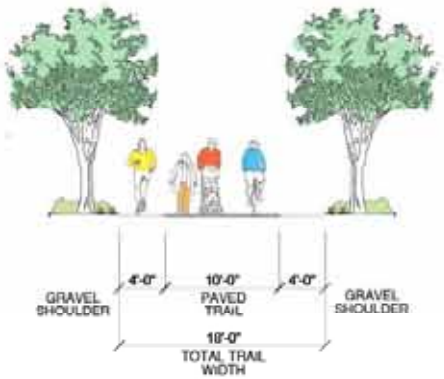
Cultural Assets

Street and Trail Treatment Prototypes

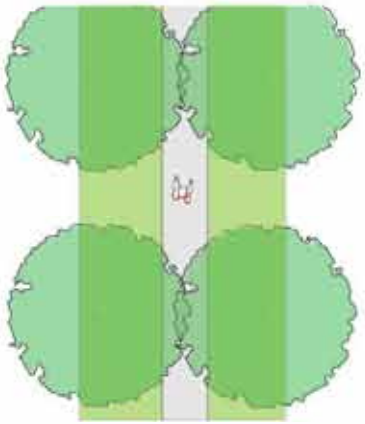
Neighborhood Trail Treatments

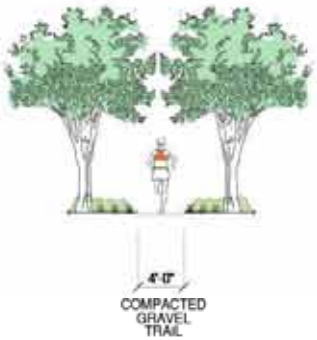
Option D: Greenway





Option E: Trail/Footpath





GIA Next Phase of Study 2011

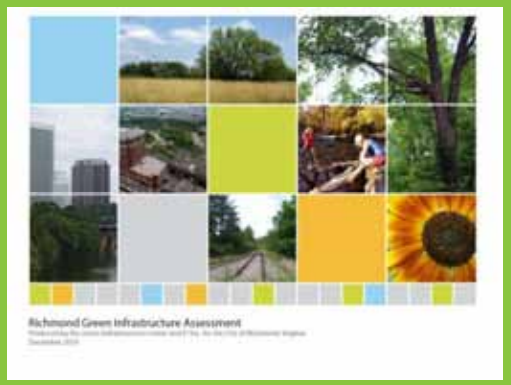
- Bellemeade neighborhood
- Water quality improvement at small watershed scale
- Replicable, scalable strategies for mitigating polluted stormwater runoff

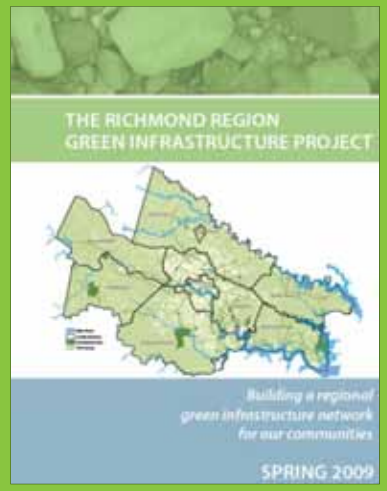
Richmond Region Green Infrastructure Assessment

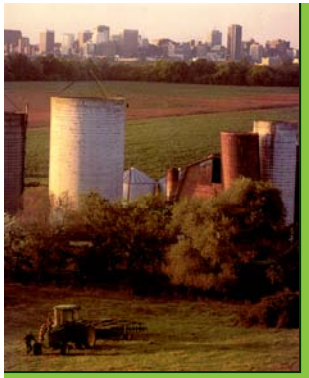
Sarah Stewart
Senior Planner
Richmond Regional Planning District Commission

sstewart@richmondregional.org

www.richmondregional.org







City of Richmond
Green Infrastructure Assessment

Sarah Stewart
Senior Planner
Richmond Regional Planning District Commission

What is **Green Infrastructure?**

"the interconnected natural systems and ecological processes that provide clean water, air quality, and wildlife habitat; green infrastructure sustains a community's social, economic and environmental health"

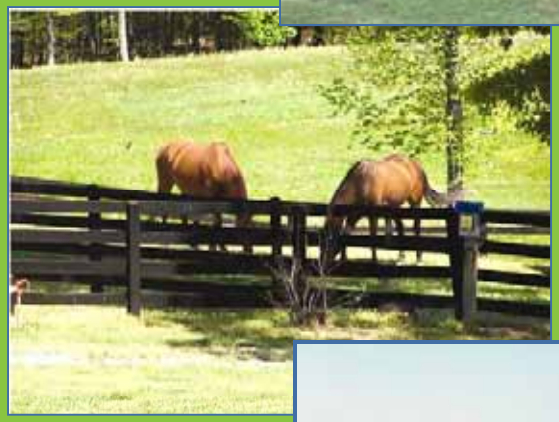
It's all about connecting the green infrastructure assets of a community!

Connectivity is Key

- Removal of existing green space can have a detrimental impact on the ecological, aesthetic, and economic benefits of the network
- With green infrastructure, more connections are always better. It maximizes a community's resources.
- Aggregation of smaller natural areas can yield greater economic and ecological benefits for humans and wildlife populations

Green Infrastructure Assets

- Working Lands
  - Farms
  - Forests
  - Fisheries
- River & Stream Corridors
- Wetlands
- Meadows & Pastures
- Parks



Green Infrastructure Assets

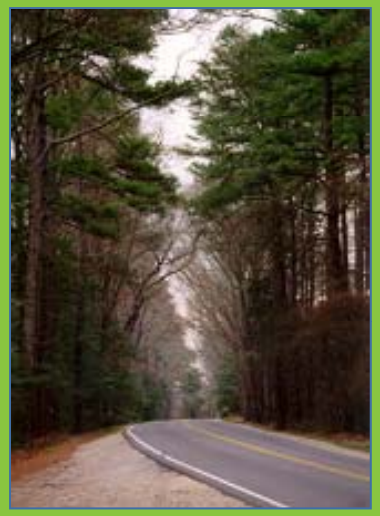
- Cultural Sites
- Historic Resources
- Trails
- Viewsheds
- Scenic Rivers
- Scenic Byways
- Watersheds
- Birding and Wildlife Trails

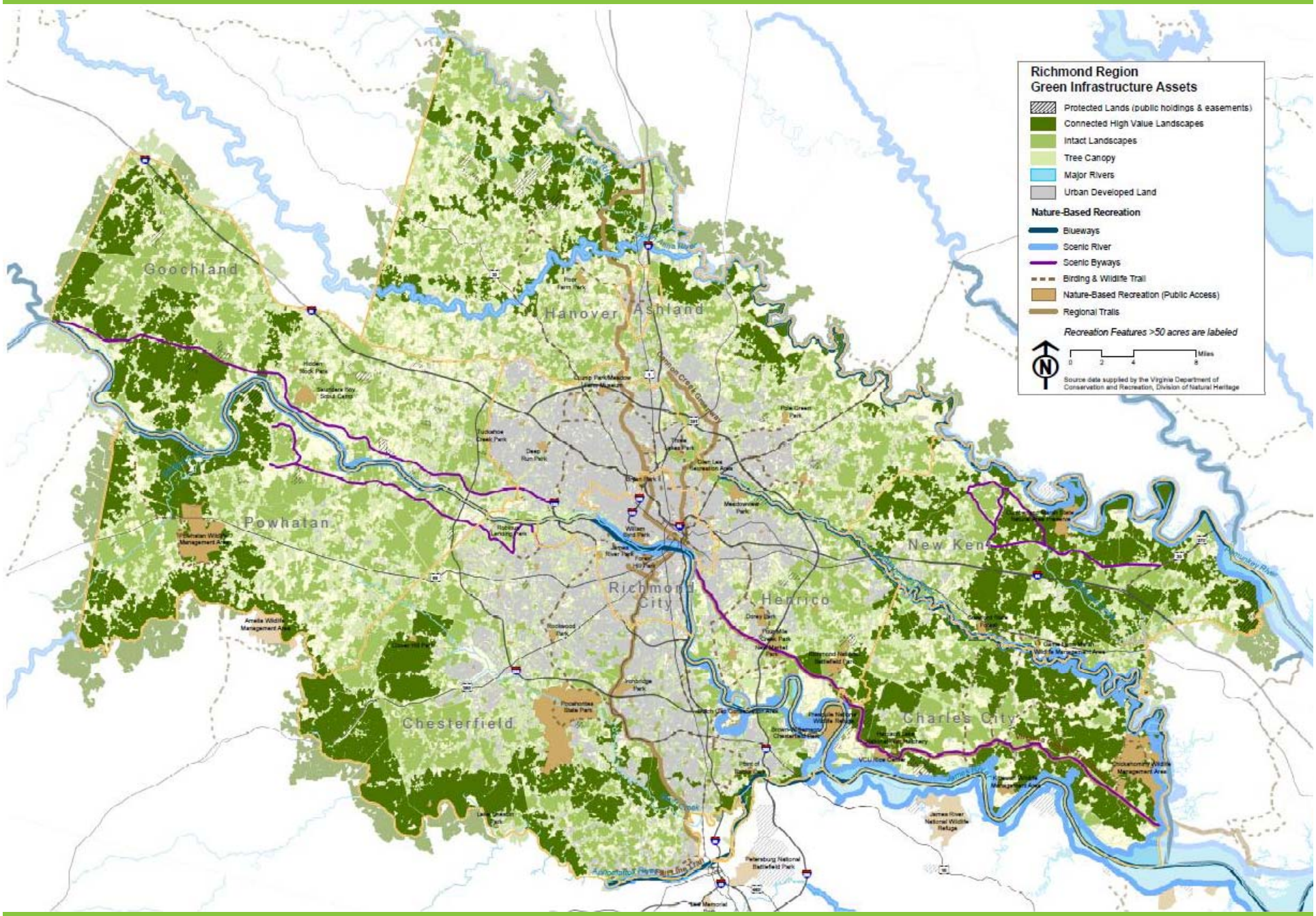
Green Infrastructure Benefits

- Protection of water quality and supply
- Stormwater management, hazard mitigation
- Carbon Sequestration
- Air Quality Protection
- Temperature Moderation: Heat Island Effect

Green Infrastructure Benefits

- Preserves biodiversity and wildlife habitat
- Conserves historic landscapes
- Protects working lands, forests and farms
- Improves quality of life and fitness through access to recreation
- Preserves rural character




Richmond Region
Green Infrastructure Assets
Protected Lands (public holdings & easements)
Connected High Value Landscapes
Intact Landscapes
Tree Canopy
Major Rivers
Urban Developed Land
Nature-Based Recreation
Blueways
Scenic River
Scenic Byways
Birding & Wildlife Trail
Nature-Based Recreation (Public Access)
Regional Trails
Recreation Features >50 acres are labeled
0 2 4 8 Miles
Source data supplied by the Virginia Department of Conservation and Recreation, Division of Natural Heritage
Goochland
Hanover
Ashland
Powhatan
Richmond City
Henrico
New Kent
Chesterfield
Charles City

Purpose of City Green Infrastructure Assessment

Focus on a smaller geographic area at an urban scale:

1. Identify existing assets and opportunities (Green Print)
2. Provide quantifiable benefits from green asset enhancement (CITYgreen)
3. Identify vacant, underutilized parcels (Brown Print) to be added to a greener, healthier city

What Are City of Richmond's Green Infrastructure Assets?

- Water Resources
- Conservation Lands
- Sustainable Features
- Parks & Recreation
- Transportation
- Heritage & Culture Resources

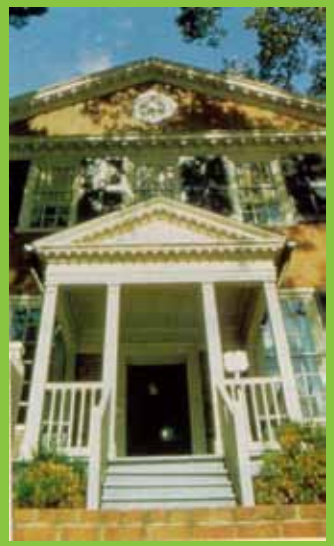
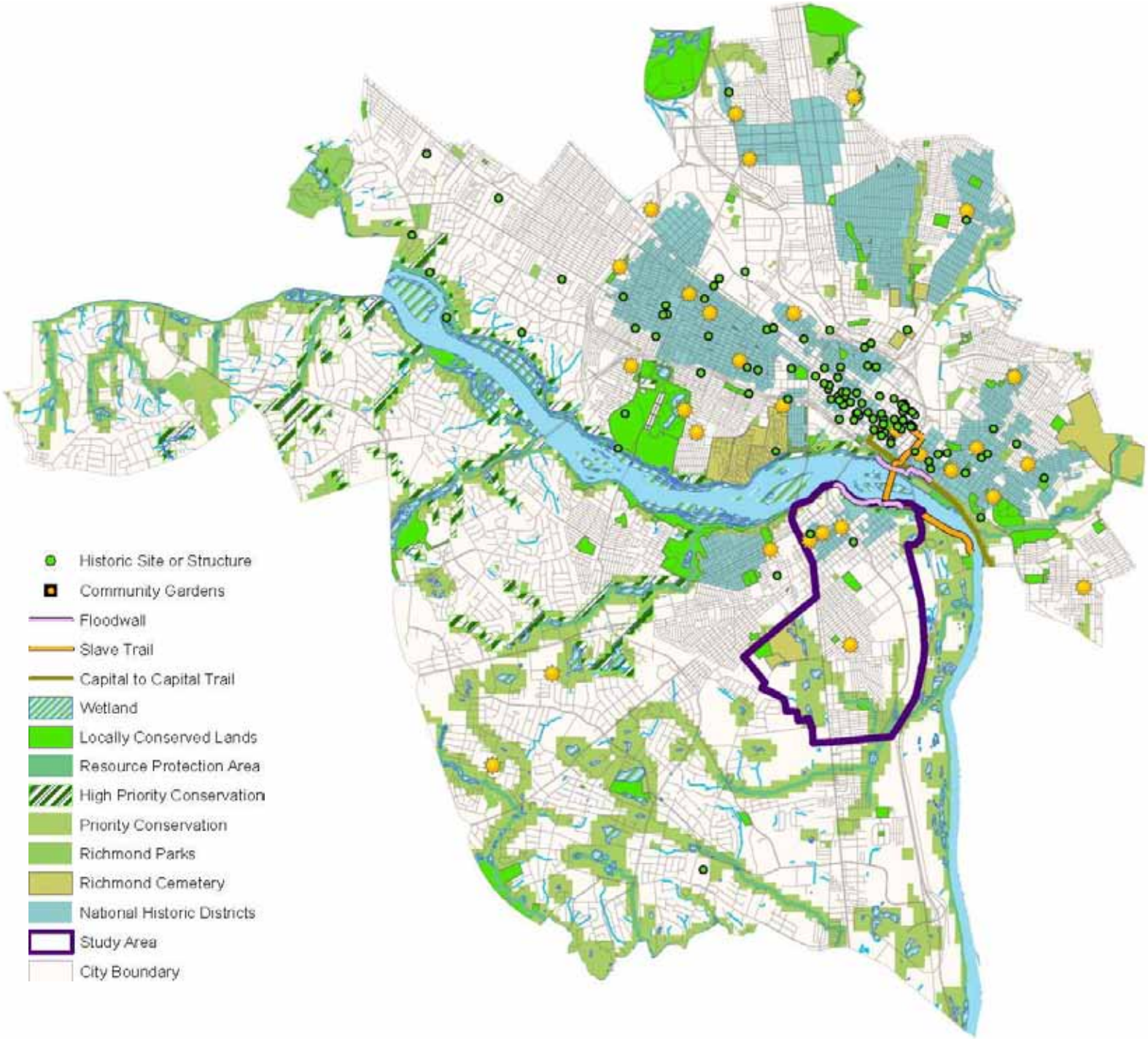


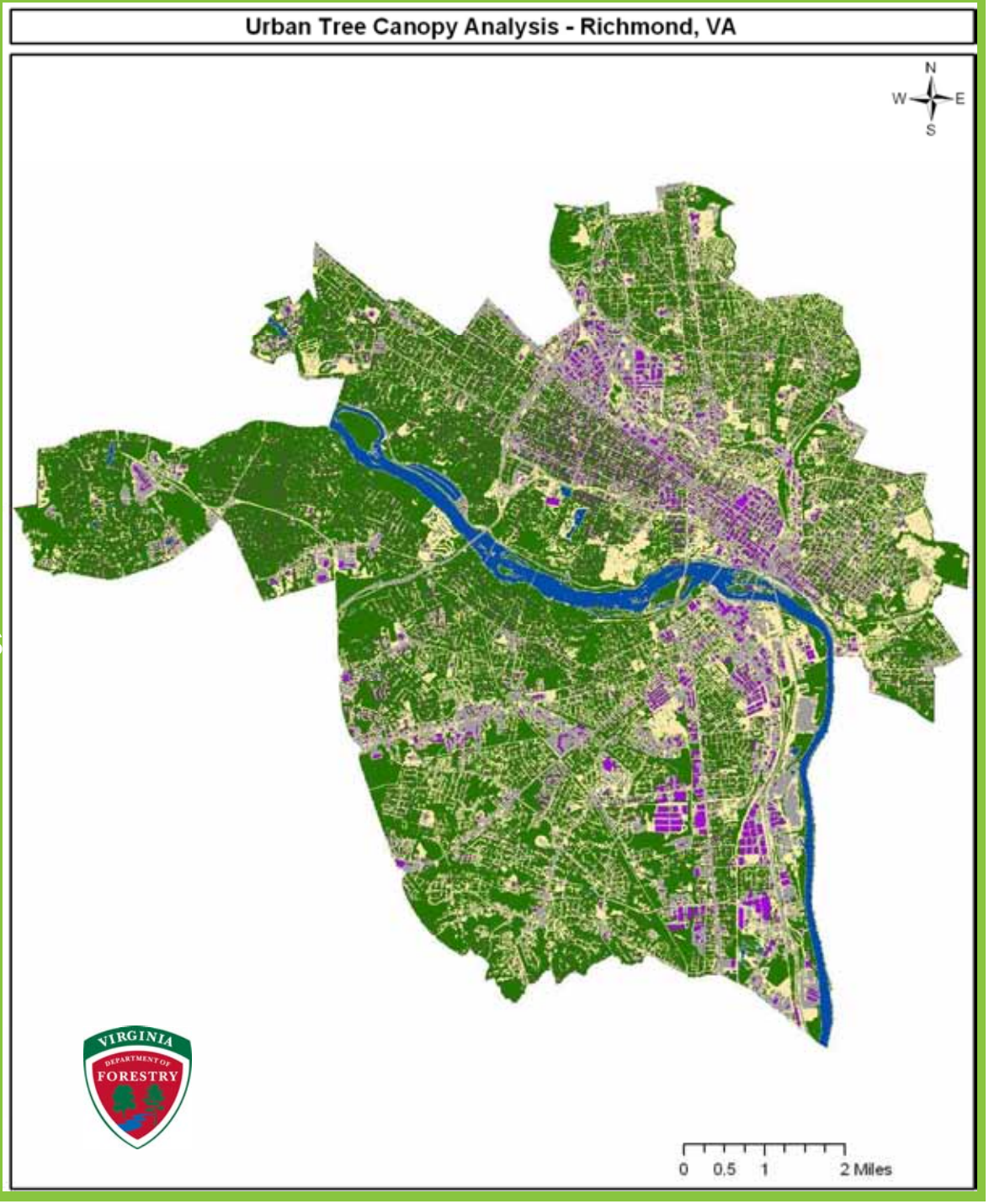
Image Source: Millennium Ecosystem Assessment


Historic Site or Structure
Community Gardens
Floodwall
Slave Trail
Capital to Capital Trail
Wetland
Locally Conserved Lands
Resource Protection Area
High Priority Conservation
Priority Conservation
Richmond Parks
Richmond Cemetery
National Historic Districts
Study Area
City Boundary

City-wide Urban Tree Canopy

42% Tree Canopy
23% Non-Tree Vegetation
24% Non-Building Impervious
11% Building Impervious

Source: Virginia Department of Forestry, October 2010



City scale - A "**Green-print**" for the future

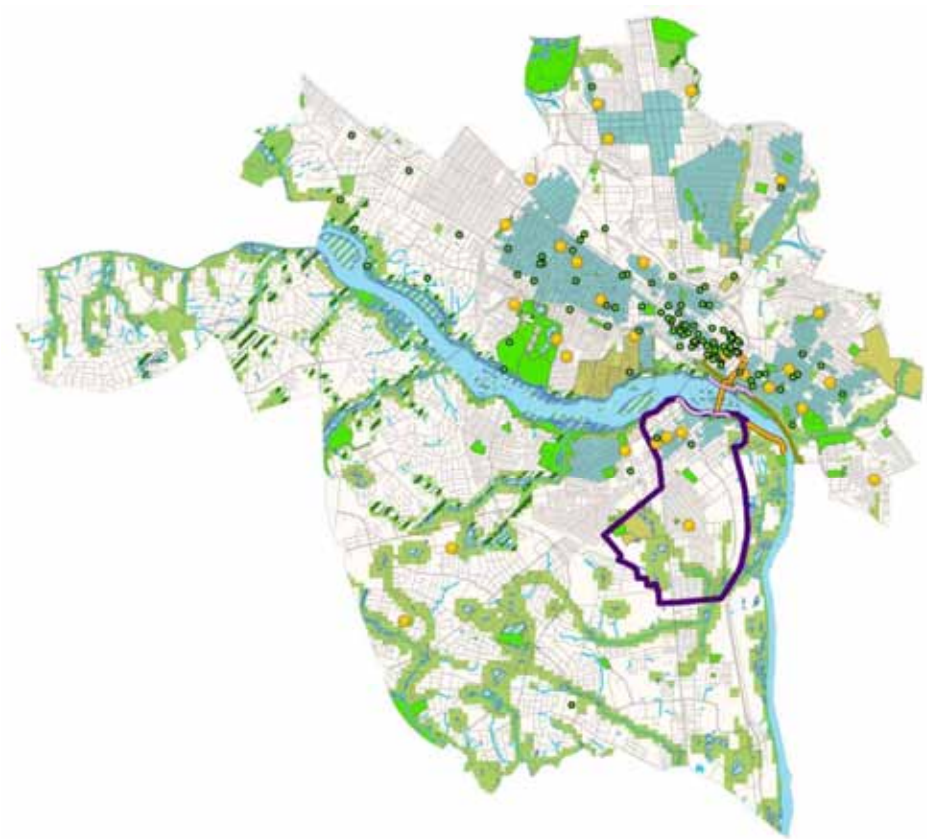
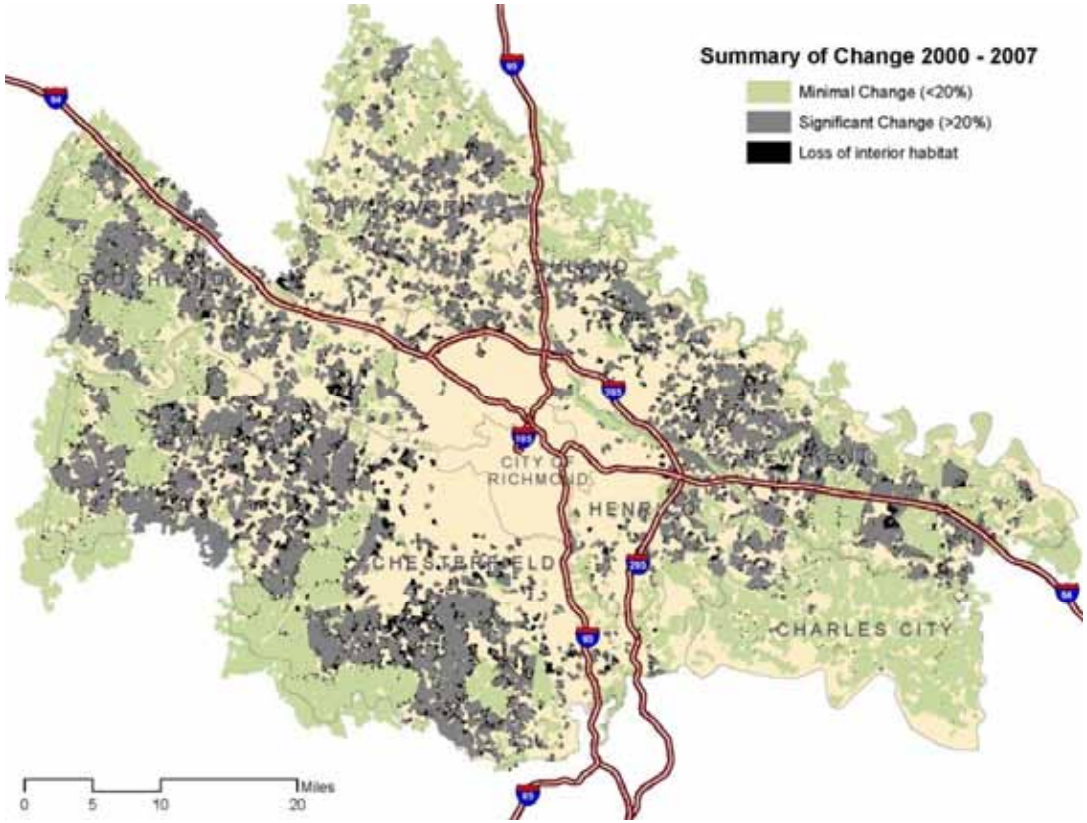


Figure 3. Richmond Conserved Environmental Assets

This map identifies Richmond's existing network of conserved lands.

City scale - A "**Green-print**" for the future

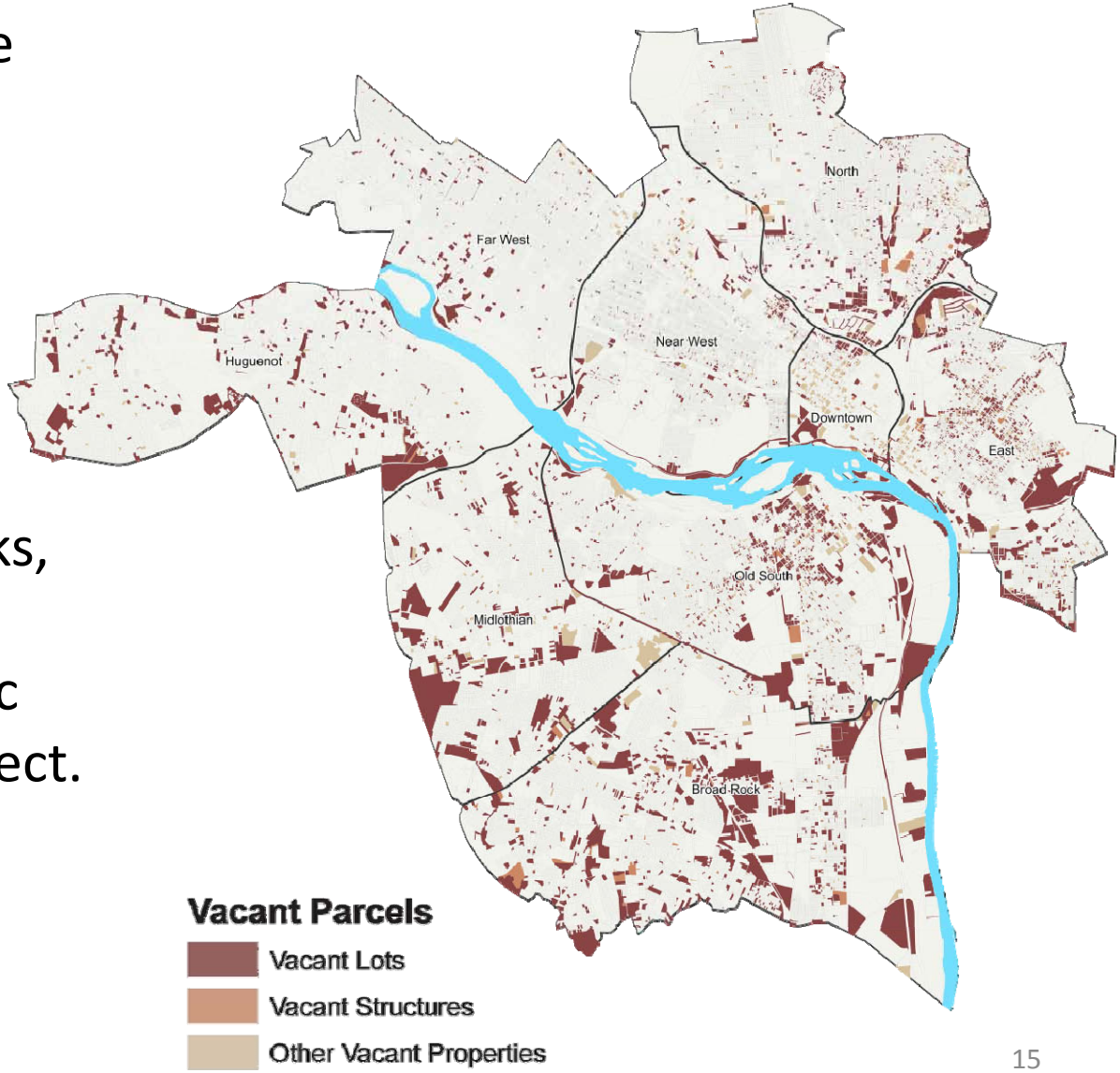
- The regional assessment revealed significant decline in regional green infrastructure assets due to suburban development.
- In contrast, the City of Richmond includes over 9,000 vacant parcels.



Citywide Vacant Parcel Inventory

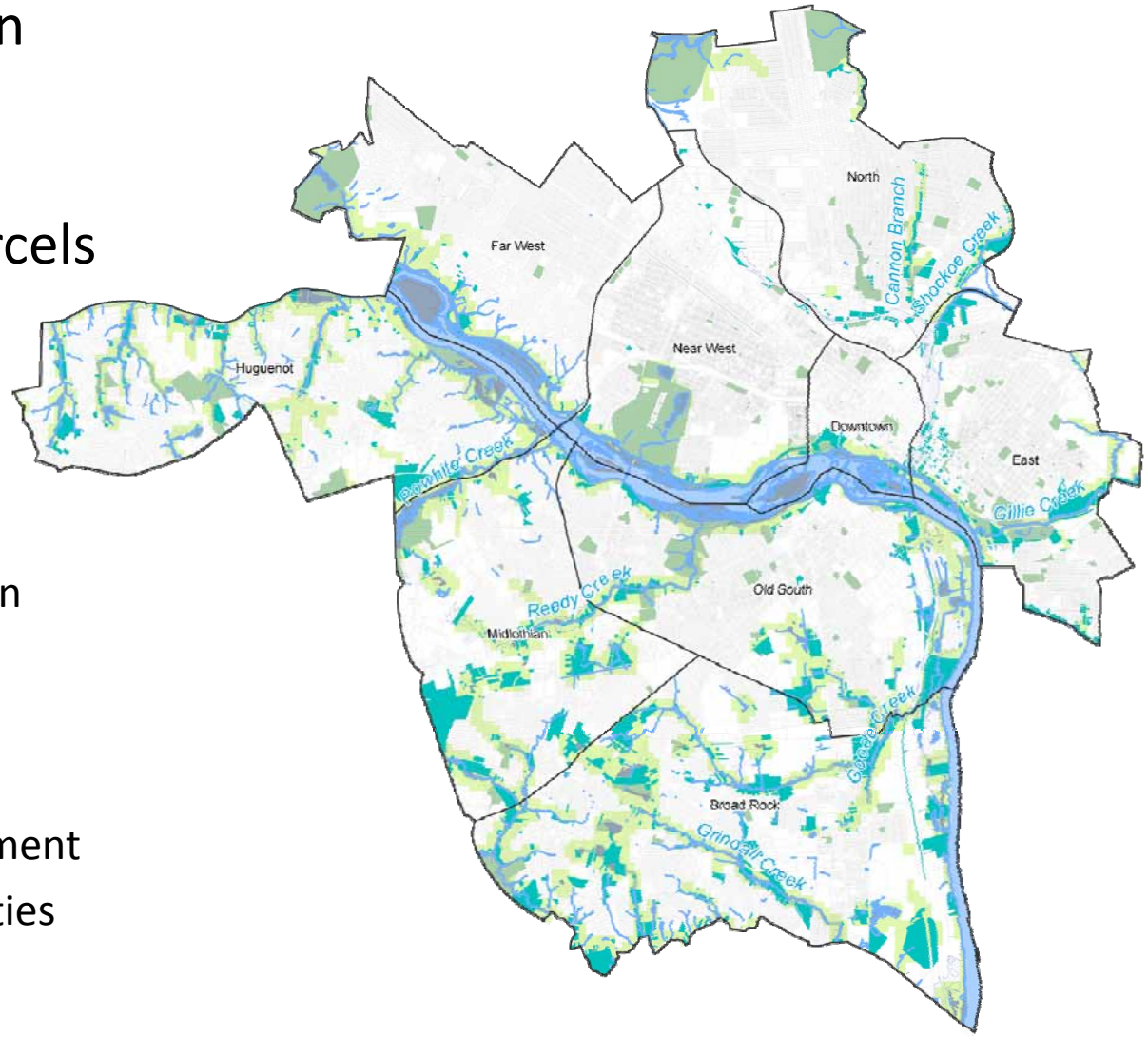
The first comprehensive inventory of over 9,000 vacant parcels

The project brought together a cross-departmental team including planning, parks, housing, economic development and public works to guide the project.



Citywide Green Infrastructure Network

Potential citywide green infrastructure network based on ecological suitability of vacant parcels



These parcels met criteria that supports the following goals:

- Protect Priority Conservation Areas
- Improve water quality
- Increase park access
- Support greenway development
- Identify network opportunities

Approach: Planning Across Scales

The inventory provided a foundation for building a green infrastructure framework at multiple scales:

City: Develop a"green-print" – highlighting an open space network for the future.

Planning District: Prioritize investments to increase equitable access to open space.

Neighborhood: Develop concept plans to connect underserved neighborhoods to the city's existing green infrastructure network.

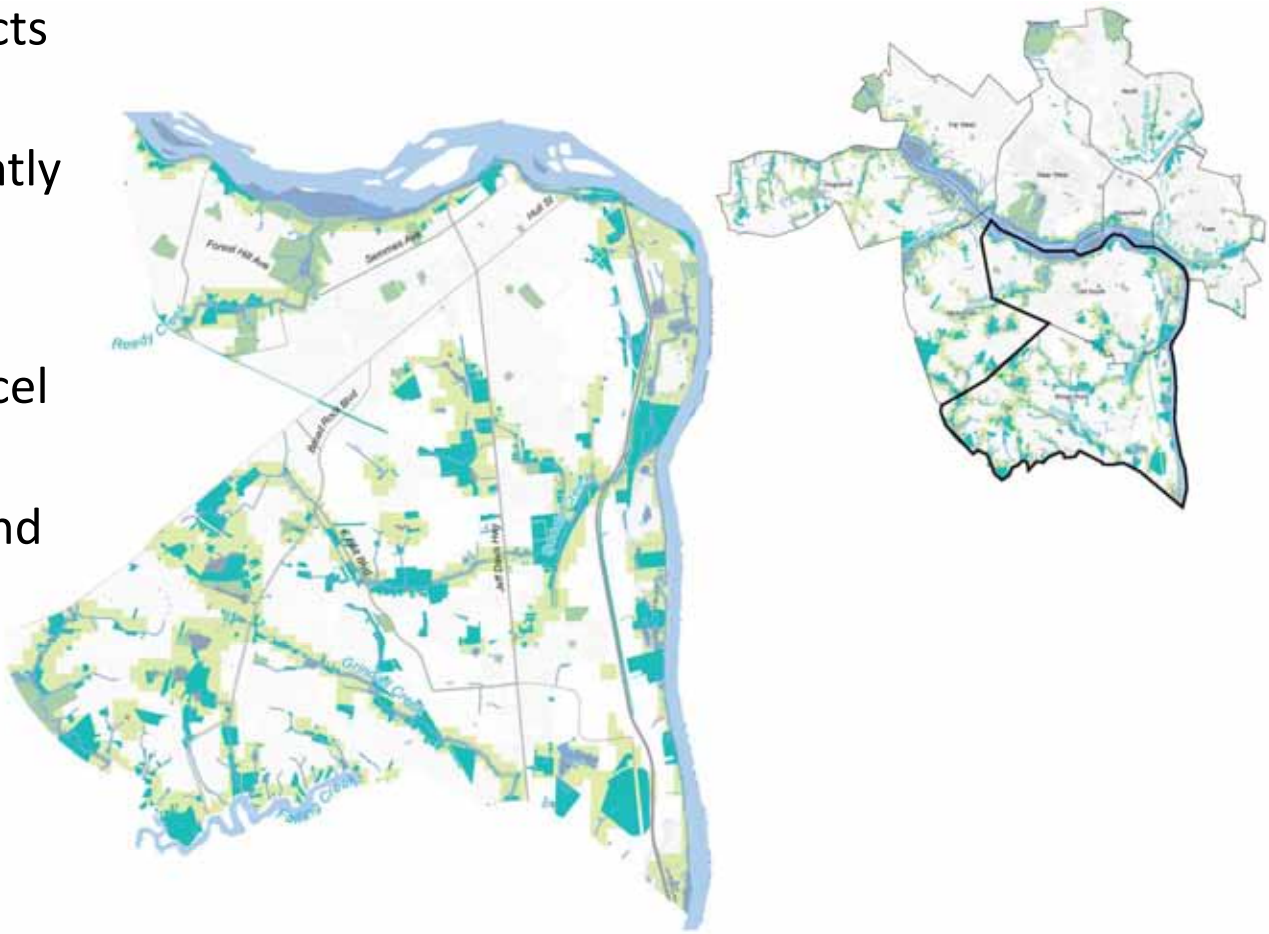
Project: Identify catalyst sites and strategies to kick-start implementation in underserved neighborhoods.

District scale: Suitability Assessment

Used the vacant land inventory to identify two Southside Planning Districts to focus on.

These two districts currently have:

- Less park land
- Extensive vacant parcel acreage
- Significant habitat, and the
- Highest watershed priorities



District scale: Suitability Assessment

The team evaluated the vacant parcel inventory to identify suitable locations to improve green infrastructure amenities for the Southside:

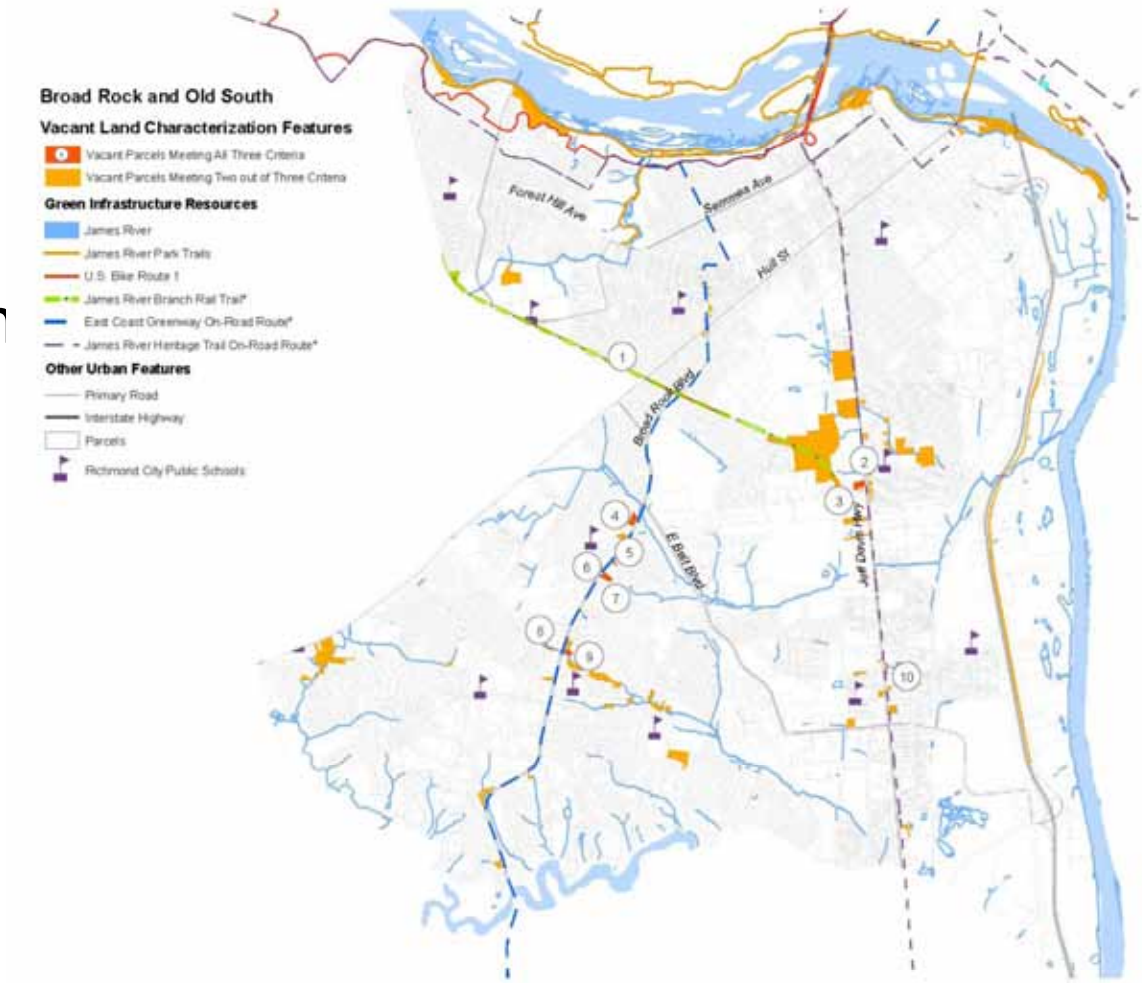
- Increased park access
- Outdoor learning
- Improved water quality
- Community gardens
- Trail connectivity

Expand Park Access | Support Outdoor Classrooms | Enhance Watershed Health

Parcels suitable for outdoor classrooms

District scale: Suitability Assessment

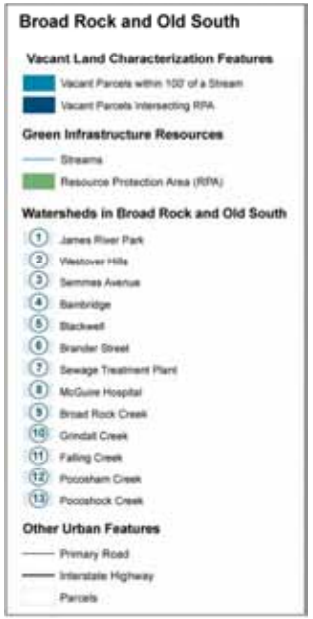
- Vacant lands inventory analysis
- Parcel suitability evaluation for green infrastructure programming
- Parcel ranking capabilities
- Vacant lands database



Hypothetical Suitability Ranking Map

District scale: Watershed Health

Vacant parcels that have increased potential to improve stormwater runoff due to their location within a designated Resource Protection Area or within 100 feet of a stream.

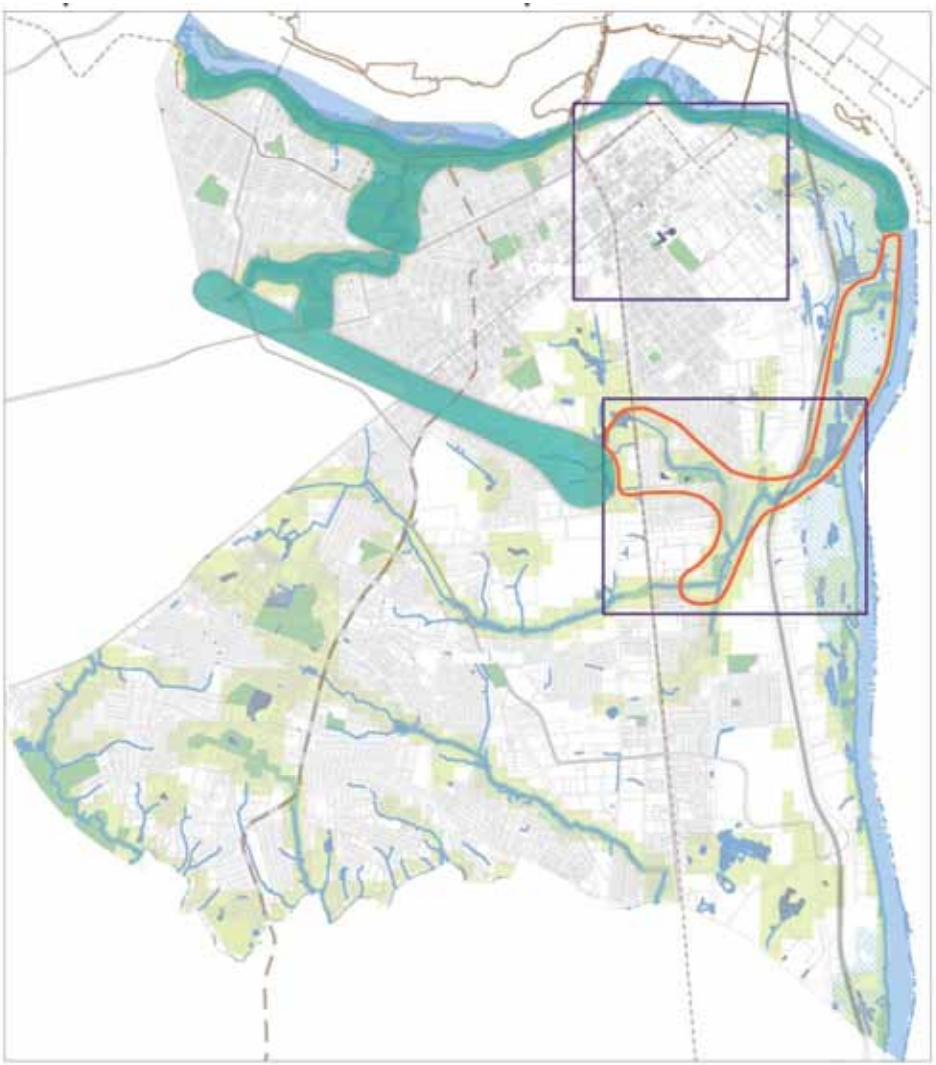


Neighborhood scale: Concept Plans

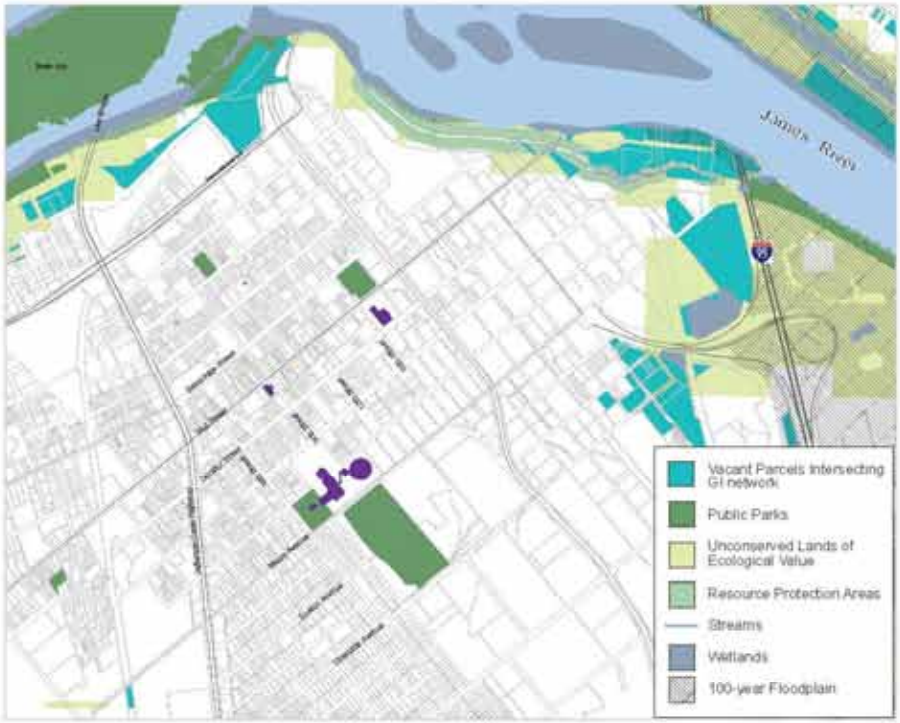
The team identified two underserved neighborhoods for a closer look at green infrastructure opportunities:

Blackwell Green Links:
a historic, urban neighborhood in transition.

Bellemeade Creek Corridor:
an informal watershed neighborhood.



Neighborhood: Blackwell Green Links



Vacant Parcels with Ecological Value

Vacant Parcels with Urban Tree Canopy

Neighborhood: Blackwell Green Links

Blackwell Green Links Concept Plan

Opportunity Sites

In October 2010, the Project Team held a working session with the project partners to present the neighborhood concept plans and identify potential catalyst sites that could initiate the implementation of a neighborhood green-print that could grow and connect to the citywide green infrastructure network. The Blackwell-Manchester workgroup identified the following opportunities corresponding with Figure 22:

1. Increase accessibility to city-owned riverfront and trail network for the growing residential population east of Commerce Street.

2. Leverage Lee Bridge city-owned parcel and 12th Street as a gateway connecting the neighborhood to the James River and the Belle Isle trail network.

Examples of riverfront amenities (left, Dayton, OH; right, Guadelupe River Park).

3. Enhance park across from Blackwell Elementary School to increase use and provide an anchor site along the green street network.

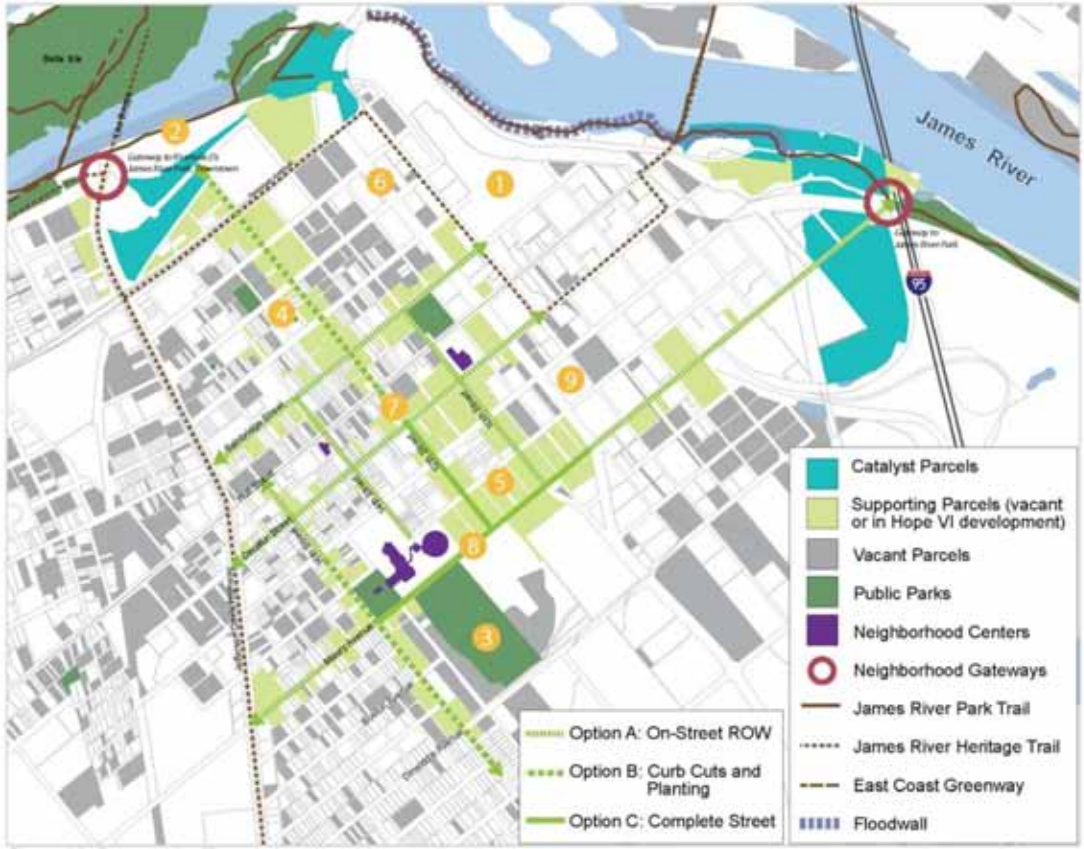


Figure 22. Opportunity Sites.

4. Collaborate with developers to develop and implement a shared green street vision north of Hull Street that leverages public and private investment.

5. Coordinate with Richmond Redevelopment and Housing Authority (RRHA) to integrate green infrastructure components into future developer bids, with potential interim community programming in the near-term.

Neighborhood: Bellemeade Creek Corridor

Vacant Parcels with Ecological Value

Vacant Parcels with Urban Tree Canopy

Neighborhood: Bellemeade Creek Corridor

Bellemeade Creek Concept Plan

Opportunity Sites

During the project partner working session held in October 2010, the Bellemeade workgroup identified the following potential opportunities that correspond to Figure 27:

1. Enhance the riparian corridor, strategic access and stewardship of the Bellemeade tributary through environmental education offered by the Bellemeade Elementary School and Community Center.

School parking lot retrofitted as rain garden (example).

Neighborhood riparian planting project (example).

2. Convert select streets with drainage ditches to green streets with swales and enhanced pedestrian access.

Green street examples. Green streets can accommodate alternative transportation, increase aesthetic value and improve water quality.

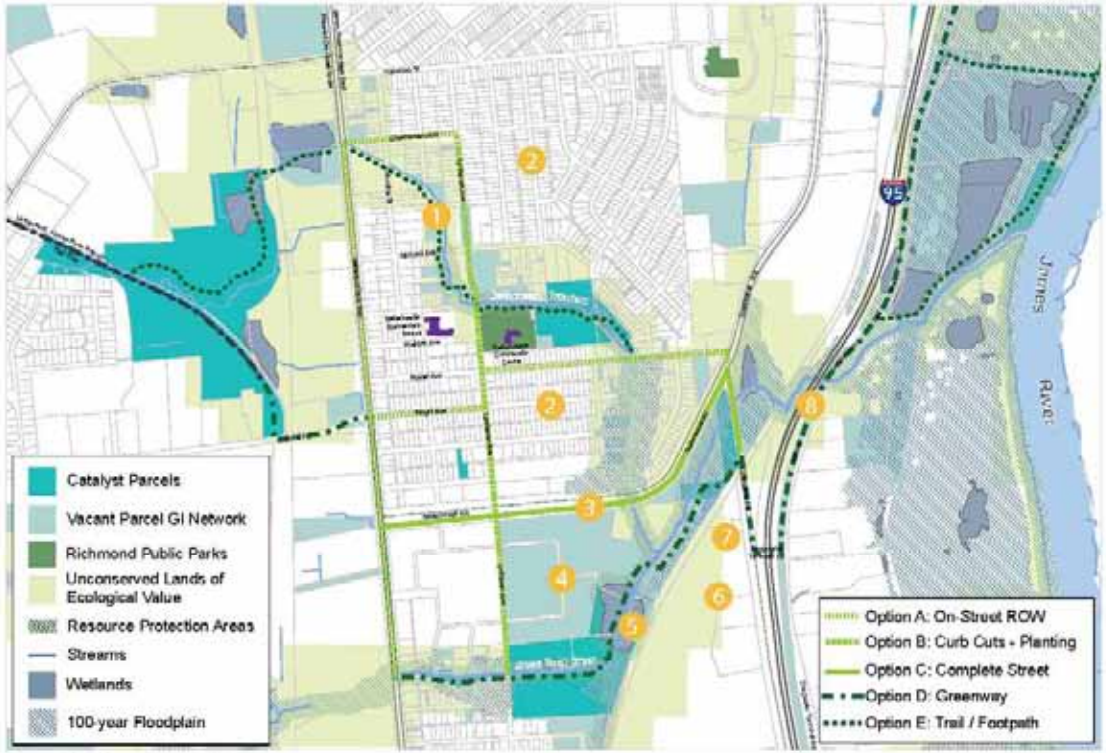


Figure 27. Opportunity Sites.

3. Evaluate a concept plan for converting Bellemeade Road to a green street to extend the proposed James River Branch Rail Trail.

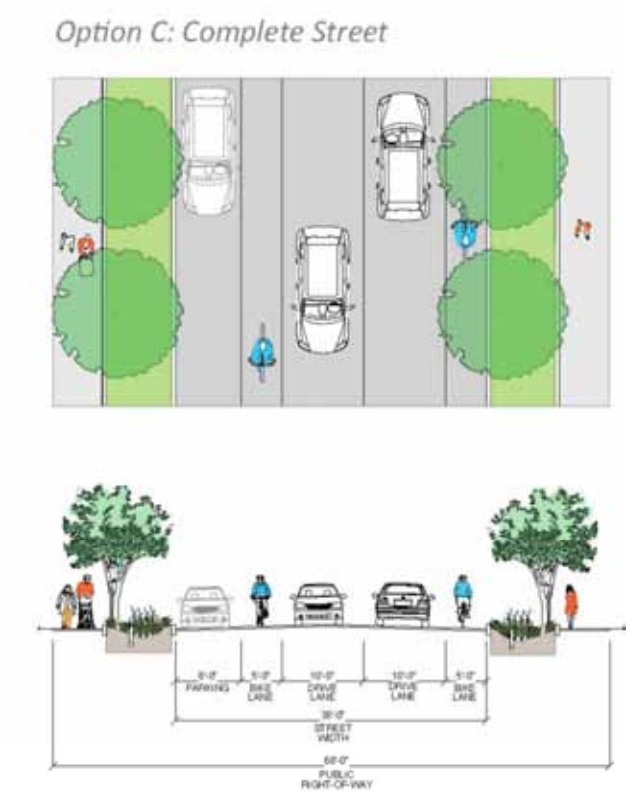
Example of planted boulevard with pedestrian/bicycle path.

4. Coordinate the mixed-use development plan in the Windsor neighborhood with future use for adjacent city parcels to enhance Broad Rock Creek.

High Point development's natural drainage network improves water quality and provides recreational amenities.

Opportunities

Street menu options



Stormwater wetlands

Project: Green Infrastructure Toolkit

Urban Water

- Vegetated swales/bioswales
- Rain gardens/bioretention areas
- Vegetated filter strips
- Stormwater wetland

Community Spaces

- Pocket park
- Informal recreation
- Meadow/native habitat
- Outdoor classroom
- Community garden

Site Planning

- Green street design
- Reducing impervious surfaces
- Vegetated landscaping
- Urban forestry
- Urban stream restoration
- Riparian buffers

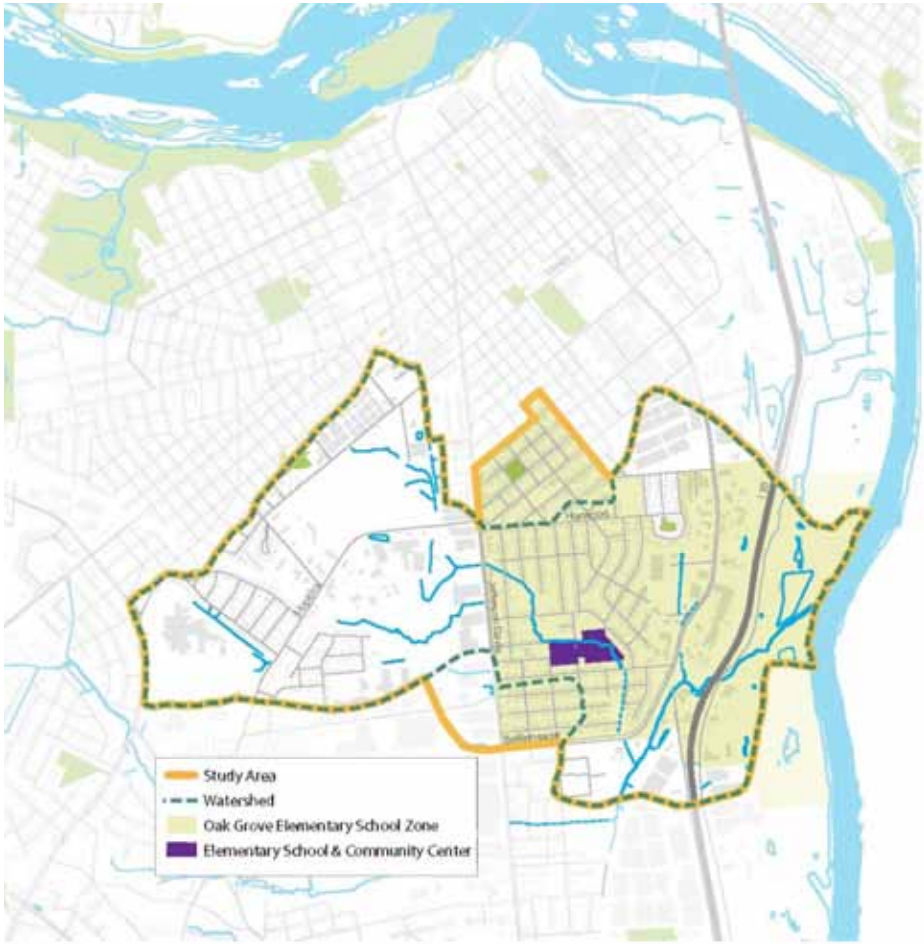
Community Stewardship

- Green space grant programs
- Land banking
- Mow-to-own
- Adopt-a-block

Next Phase: Walkable Watershed

City Stormwater Department is using the vacant land inventory to prioritize city-owned properties for stormwater mitigation opportunities.

Bellemeade Walkable Watershed pilot project will combine community outreach and technical analysis to identify strategies that can improve the health of the watershed and the neighborhood.



Contact

Sarah Stewart

Senior Planner

Richmond Regional Planning District Commission

804.323.2033 ext. 119

sstewart@richmondregional.org

www.richmondregional.org

Alisa Hefner

Senior Designer

Skeo Solutions

434.975.6700 ext. 235

ahefner@skeo.com

www.skeo.com | ww.gicinc.org

Richmond Green Infrastructure Assessment

Produced by the Green Infrastructure Center and Skeo Solutions for the City of Richmond, Virginia
December 2010