Richmond-Crater Multi-Regional Hazard Mitigation Plan

2017-2022

February 17, 2017 Draft

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1.0 Executive Summary

During 2003, the Commonwealth of Virginia encouraged its 21 planning districts to lead the development of local hazard mitigation plans. These plans, required by the Disaster Mitigation Act of 2000 (DMA2K) for hazard mitigation assistance (HMA) grant program eligibility, help local governments determine risks and vulnerabilities and identify projects to reduce these risks. The Richmond-Crater Multi-Regional Hazard Mitigation Plan is an update to plans approved in 2006 by the jurisdictions of the Richmond Regional Planning District Commission (PDC) and Crater PDC and the combined Richmond Regional and Crater PDC 2011 Multi-Regional Hazard Mitigation Plan.

The Richmond Regional and Crater PDCs convened a joint Hazard Mitigation Technical Advisory Committee (HMTAC) appointed by each respective locality chief administrative official to lead plan development for 26 member jurisdictions. The HMTAC met three times during the planning process and worked closely with Dewberry Consulting, LLC to develop the multi-regional plan update. Public input was sought throughout the process in accordance with DMA2K requirements.

1.1 Hazard Identification and Risk Assessment

A solid fact base is a key component of any plan. The Hazard Identification and Risk Assessment (HIRA) serves as the fact base for the regional hazard mitigation plan. The HIRA consists of three parts. Its purpose is to:

1. Identify which hazards could affect the Richmond-Crater region,
2. Profile hazard events and determine what areas and community assets are the most vulnerable to damage from these hazards, and
3. Estimate losses and prioritize the potential risks to the community.

For this plan update, certain hazards were not addressed due to the infrequency of occurrence and/or limited impact, several were combined and several added. Table 1-1 summarizes the results of the hazard identification, which are explained fully in Section 5.0, Hazard Identification and Risk Assessment.

Table 1-1. Planning Consideration Levels by Hazard Type for 2017 Update

Hazard Type	2011 Planning Consideration Level	Commonwealth of Virginia 2013 HIRA Hazard Ranking	2017 HTMAC Preliminary Ranking	2017 HIRA Ranking Analysis**
Flooding	Significant	High	Moderate	Moderate
Wind*	Moderate	Medium-High	High	Limited
Tornado*	Moderate	Medium-High	High	Significant
Hurricane*	Moderate	Not ranked	High	Significant
Winter weather	Moderate	Medium-High	High	Moderate
Thunderstorms* (including Hail and Lightning)	Moderate	Negligible	High	Moderate
Droughts (with Extreme Heat)*	Moderate	Droughts = Medium Extreme Heat = Negligible	Limited	Limited
Mass evacuation.	Moderate	Not ranked – Discussed in other Commonwealth of Virginia emergency operations plans	Limited	Limited
Wildfires	Limited	Medium	Limited	Limited
Earthquakes	Limited	Medium-Low	Limited	Limited
Landslides/shoreline erosion*	Limited	Landslide = Medium-Low Erosion = Negligible	Limited	Limited
Karst	Limited	Low	Limited	Limited

* Some event types were combined (Droughts/Heat and Landslide/Erosion) or separated (Wind/Tornado and Hurricanes/Thunderstorms) from other plans and votes to accommodate the 2017 HTMAC's current concerns for their regions.

** Ranking analysis explained in section 5.4.3 Analysis and Data Sources.

The HIRA described each of the hazards in varying levels of detail consistent with each planning consideration level. In general, the HMTAC found that winter storm, tornado, wind, hurricane and thunderstorm hazards were the most significant. Quantitative analysis using various datasets found tornado and hurricane to be the most significant with flooding, winter weather and thunderstorms to have moderate predicted impacts.

Floods occur primarily along the three major watersheds in the region: the York, James, and Chowan Rivers. Flooding seems to occur most frequently in May, August, and September but more recently localized flooding occurred during severe storms in June and July, 2016. A new method to assess flooding risk was used – FEMA's Total Exposure in Floodplains version 2.0 or TEIF 2.0 which analyzes flood risk using building footprints apportioned within regulated flood hazard areas. The TEIF 2.0 methodology uses building footprints from local jurisdictions to apportion total replacement values of buildings at the census block-level (1000 square feet units). The TEIF methodology divides building replacement values by proportionate methods (area of each respective building footprint). For example if a census block is known to have $1M of value associated with all buildings and there are a total of ten (10) buildings in the census block - each building having the same exact size – a proportional distribution would dictate that each building has a value of $100,000. After Hazus values are dispersed to the building footprints, the buildings within the Special Flood Hazard Area were identified and the portions (or percent area) of buildings within the floodplain was calculated. Ultimately, the dispersed replacement values were tallied for the dollar value associated with each respective building that is entirely or partially in the floodplain. These values are then generalized into 1000 ft^2 blocks to comply with regulations and not target individual structures or building owners.

In Table 5-14 in Section 5, each jurisdiction was evaluated and ranked in the study area using the TEIF 2.0 revised analysis (except for City of Colonial Heights, which did not have building footprints at time of analysis). The City of Richmond has the highest flood risk estimated at nearly $217M in damages.

Severe wind events, such as hurricanes and tornadoes, have historically affected the area. Generally, hurricanes tend to bring flooding rather than high winds but in Central Virginia the opposite is often true with high wind impacting areas with tree cover causing roof damage and power outages due to downed power lines. Flooding from tropical and sub-tropical storm events and severe thunderstorms tends to be localized and in many cases due to a high proportion of paved or impervious pavement in densely populated watersheds which cannot absorb high volumes of runoff during intense storms. Tornadoes recorded in the region have typically been F0 (40–72 mph; light damage) or F1 (73–112 mph; moderate damage) in intensity. A rare winter tornado event on February 24, 2016 resulted in three fatalities in the Town of Wakefield.

Winter storms can have major impacts on the region. Three winter storm events resulting in declared disasters have occurred in the Richmond-Crater region since 2011. Winter storms typically cause loss of utilities, business disruption, and road closures but not large structural impacts.

1.2 Capability Assessment

The capability assessment evaluates the current capacity of the communities of the Richmond-Crater region to mitigate the effects of the natural hazards identified in the HIRA. By providing a summary of each jurisdiction's existing capabilities, the capability assessment serves as the foundation for designing an effective hazard mitigation strategy.

Table 1-2. Mitigation Capability Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
Richmond Regional PDC	Planning High	Moderate	Moderate	N/A	Moderate
Crater PDC	Planning High	Moderate	Moderate	N/A	Moderate
Charles City County*	Moderate	Moderate	Moderate	Moderate	Moderate
Chesterfield County	High	High	High	High	High
City of Colonial Heights	Moderate	Moderate	Moderate	Moderate	Moderate
Dinwiddie County	Moderate	Moderate	Moderate	Moderate	Moderate
*Town of McKenney**	Limited	Limited	N/A	Limited	Limited
City of Emporia	Moderate	Moderate	Moderate	Moderate	Moderate
Goochland County	Moderate	Moderate	Moderate	Moderate	Moderate
Greensville County	Moderate	Moderate	Not Provided	Moderate	Moderate
*Town of Jarratt**	Limited	Limited	N/A	Limited	Limited
Hanover County*	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Ashland**	Moderate	High	N/A	Limited	Moderate
Henrico County	High	High	High	High	High
City of Hopewell	Moderate	Moderate	Moderate	Limited	Moderate
New Kent County	Moderate	High	Moderate	Moderate	Moderate
City of Petersburg	Limited	Limited	Moderate	Limited	Limited
Powhatan County	Moderate	High	Moderate	Moderate	Moderate
Prince George County	Moderate	Moderate	Moderate	Moderate	Moderate
City of Richmond	Moderate	Moderate	Moderate	Limited	Moderate
Surry County*	High	High	N/A	High	High
*Town of Claremont**	Limited	Limited	N/A	Limited	Limited
*Town of Dendron**	Limited	Limited	N/A	Limited	Limited
*Town of Surry**	Limited	Limited	N/A	Limited	Limited
Sussex County*	Moderate	Limited	N/A	Limited	Limited
*Town of Stony Creek**	Limited	Limited	N/A	Limited	Limited
*Town of Wakefield**	Moderate	Moderate	N/A	Moderate	Moderate

Table 1-2. Mitigation Capability Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
*Town of Waverly**	Limited	Limited	N/A	Limited	Limited

High: No increase in capability needed (e.g., extensive regulations on development in place).
Moderate: Increased capability desired but not needed (e.g., funding exists for mitigation but availability fluctuates).
Limited: Increased capability needed (e.g., additional staff are needed to successfully implement mitigation projects).
Source: Capability Assessment Survey Results.
*Based on 2011 Self-Assessment; 2016 Survey not returned.

1.3 Mitigation Strategy

The HMTAC aligned the updated regional mitigation goals to the six Central Virginia Emergency Management Alliance goals and added the first goal for mitigation emphasis:

Goal 1: Reduce risk exposure and vulnerabilities to hazards ranked "medium" and "high" by focusing on regional and local mitigation actions on priority hazards.

Goal 2: Prepare and protect the whole community within the Central Virginia Emergency Management Alliance (CVEMA) region through all-hazards planning staff, outreach publications and activities, and through training, and exercising volunteers and the general public.

Goal 3: Strengthen and sustain response coordination and collaboration through planning, equipment, training, and exercises to increase interoperability between all stakeholders in the CVEMA region and other regions/entities that impact interoperability within the region, to include, but not limited to voice, video, and data.

Goal 4: Provide support for public health and human service needs of the whole community through robust and coordinated sheltering capability, to include planning, resources, equipment, training, and exercises to include support of client needs tracking, family reunification services, information sharing, and public health response support.

Goal 5: In the aftermath of a catastrophic incident, provide restoration of basic services, long term housing, and revitalization of a sustainable economy that includes the health, social, cultural, historic, and environmental fabric of the community, through planning, staffing, equipment, training, and exercises.

Goal 6: Enhance and maintain public safety and incident management response capabilities to all hazard emergencies including acts of terrorism, through planning, staffing, equipment, training, and exercises.

Goal 7: Protect the critical infrastructure of the CVEMA region, and enhance the capability to disrupt criminal or terrorist threats through effective information and

intelligence gathering and sharing, outreach, planning, equipment, training, and exercises.

In addition, committee members and their jurisdiction staff identified and prioritized mitigation actions for the regional planning district commissions and each jurisdiction. Counties, cities and the Town of Ashland met with PDC representatives to update mitigation actions; towns (except Ashland) were engaged by email or phone conversations by PDC planners and/or county emergency managers. Each jurisdiction's priorities were developed from data collected on past damages, existing exposure to risk, community goals, and weaknesses identified in Section 6.0: Capability Assessment along with local knowledge of local needs.

1.4 Plan Maintenance Procedures

The plan outlines a procedure for implementation, maintenance, and plan updates. The Richmond Regional and Crater PDCs will be responsible for monitoring this plan. The PDCs will request an annual progress update from the HMTAC or the Central Virginia Emergency Management Alliance January 31 annually on implementation of local mitigation action plans. These annual progress reports will begin in 2018 and will include corrective action plans if needed, based on evaluation criteria set by the HMTAC. The annual progress reports will be consolidated by Richmond Regional and Crater PDCs and shared with the Virginia Department of Emergency Management (VDEM).

In accordance with Federal Emergency Management Agency (FEMA) regulations, a written update will be submitted to the Commonwealth and FEMA Region III every five years from the original date of the plan, unless circumstances (e.g., Presidential disaster declaration, changing regulations) require a formal update earlier. The public will be continually informed of changes to the plan as they occur.

1.5 Conclusion

This Richmond-Crater Multi-Regional Hazard Mitigation Plan embodies the continued commitment and dedication of the local governments and community members of the Richmond-Crater region to enhance the safety of residents and businesses by taking actions before a disaster strikes. While nothing can be done to prevent natural hazard events from occurring, the region is poised to minimize the disruption and devastation that so often accompanies these disasters.

2.0 Introduction

2.1 Mitigation

Mitigation is commonly defined as sustained actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects. A mitigation plan states the aspirations and specific courses of action that a community intends to follow to reduce vulnerability and exposure to future hazard events. These plans are formulated through a systematic process centered on the participation of citizens, businesses, public officials, and other community stakeholders.

A local mitigation plan is the physical representation of a jurisdiction's commitment to reduce risks from natural hazards. Local officials can refer to the plan in their day-to-day activities and in decisions regarding regulations and ordinances, granting permits, and funding of capital improvements and other community initiatives. Additionally, these local plans will serve as the basis for states to prioritize future grant funding as it becomes available.

The Richmond-Crater Multi-Regional Hazard Mitigation Plan will continue to be a useful tool for all community stakeholders by increasing public awareness about local hazards and risks, and providing information about options and resources available to reduce those risks. Educating the public about potential hazards will help each jurisdiction protect itself against the effects of future hazards, and will enable informed decision-making regarding where to live, purchase property, or locate business.

The area covered by this plan includes:

- Town of Ashland
- Charles City County
- Chesterfield County
- City of Colonial Heights
- Town of Claremont
- Town of Dendron
- Dinwiddie County
- City of Emporia
- Goochland County
- Greensville County
- Hanover County
- Henrico County
- City of Hopewell
- Town of Jarratt
- Town of McKenney
- New Kent County
- City of Petersburg
- Powhatan County
- Prince George County
- City of Richmond
- Town of Stony Creek
- Town of Surry
- Surry County
- Sussex County
- Town of Wakefield
- Town of Waverly

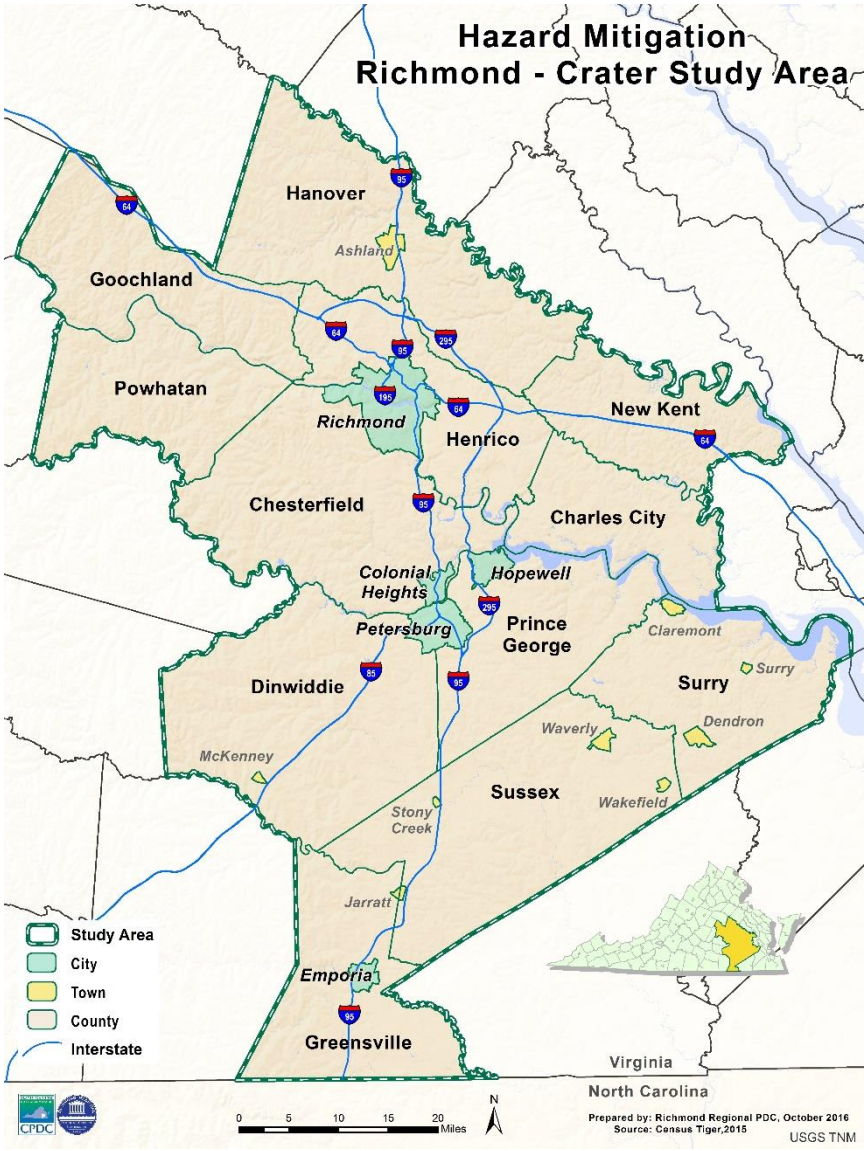

Figure 2.1 – Richmond Regional – Crater Multi-regional Hazard Mitigation Plan Update Communities

2.2 The Local Mitigation Planning Impetus

On October 30, 2000, President Clinton signed into law the Disaster Mitigation Act of 2000 (DMA2K), which required state and local mitigation plans that would help to reduce loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters.

DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act and added a new section to the law, Section 322, Mitigation Planning. Section 322 requires local governments to prepare and adopt jurisdiction-wide hazard mitigation plans for disasters declared after November 1, 2004, as a condition of receiving Hazard Mitigation Grant Program (HMGP) project grants and other non-disaster related mitigation grant assistance programs. Local governments must review and, if necessary, update their mitigation plans every five years from the original date of the plans in order to continue Hazard Mitigation Assistance (HMA) program eligibility.

The requirements for local mitigation plans are found in Section 44 Code of Federal Regulations Part 201.6. FEMA's "*Local Multi-Hazard Mitigation* Planning Guidance" issued on October 1, 2011 provides updated FEMA interpretation and explanation of local plan mitigation regulations and FEMA's expectations for mitigation plan updates. In addition, VDEM and FEMA now use the 2013 *Local Mitigation Plan Review Tool* to ensure that a plan meets FEMA's regulatory requirements as well as additional requirements identified by the Commonwealth.

2.3 Organization of the Plan

Section 3.0 – Planning Process defines the processes followed throughout the update of this plan including a description of the Richmond-Crater region's stakeholder involvement.

Section 4.0 – Community Profile provides a physical and demographic profile of the area, looking at characteristics such as geography, hydrography, development, people, and land uses.

Section 5.0 – Hazard Identification and Risk Assessment evaluates the natural hazards likely to affect the Richmond-Crater region, and quantifies whom, what, where, and how the region might be affected by natural hazards. Critical facility information has been redacted and is located in Appendix I, available upon request from the Richmond Regional and Crater Planning District Commissions.

Section 6.0 – Capability Assessment analyzes each of the local jurisdictions' policies, programs, plans, resources, and capabilities to reduce exposure to hazards in the community.

Section 7.0 – Mitigation Strategy addresses the Richmond-Crater region's issues and concerns for hazards by establishing a framework for mitigation activities and policies. The strategy includes updated goals and a range of updated mitigation actions to achieve these goals.

Section 8.0 – Plan Maintenance Procedures specifies how the plan will be monitored, evaluated, and updated, including a process for continuing stakeholder involvement after the plan is completed.

Section 9.0 – References includes a list of the reports and data used to develop this plan.

Appendices are included at the end of the plan, and contain supplemental reference materials and more detailed calculations and methodologies used in the planning process. The complete meeting and outreach support materials, history of federal disaster declarations in the region, additional HIRA data, and 2011 mitigation action status updates may all be found in the Appendices along with a detailed summary of updated information in the 2017 plan.

3.0 Planning Process

The Richmond Regional and Crater PDCs each led the development of their first regional hazard mitigation plans for the jurisdictions within their respective regions during 2005.

For the required 2011 updates, the PDCs and their participating jurisdictions decided it was in the best interest of the regions to conduct a joint planning process, resulting in the Richmond-Crater Multi-Regional Hazard Mitigation Plan. This combined effort was chosen to leverage the advantage of shared resources, and build on the success of similar multi-jurisdiction partnering agreements. This approach has been continued for the 2017 Richmond-Crater Multi-Regional Hazard Mitigation Plan with technical assistance and support provided by Dewberry Consulting, LLC.

The HMTAC worked with the consultants throughout the planning process to ensure that potential stakeholders participated in the planning process including reviewing the draft and final versions of the plan. The Richmond Regional Planning District Commission received a FEMA Pre-Disaster Mitigation program grant to support the 2017 plan update and contracted with Dewberry Consultants, LLC, on behalf of all participating jurisdictions, to update the plan during 2016 – 2017.

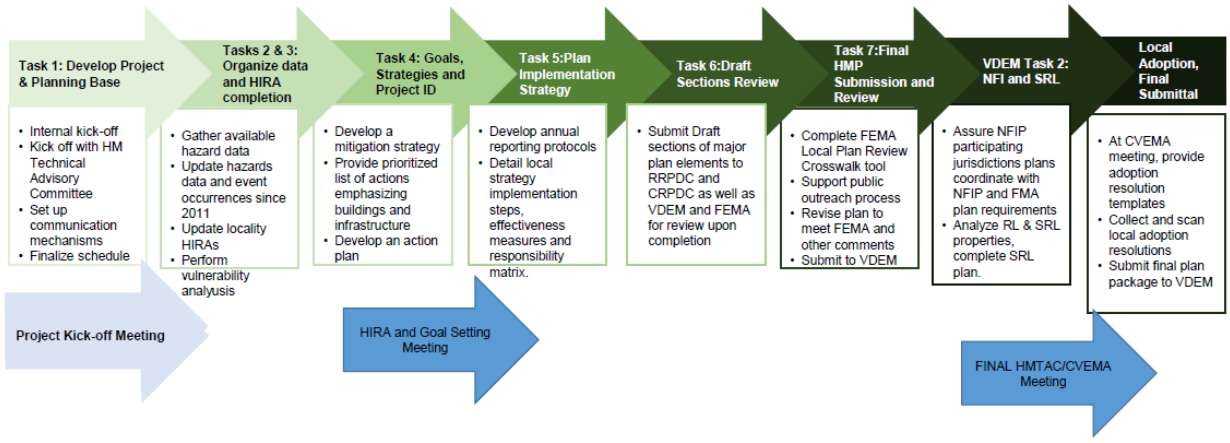

Figure 3 – 1 Mitigation Plan Update Process

The plan update followed a traditional mitigation plan update process initiated with a regional resiliency meeting on July 12, 2016, then a HMP update kick-off meeting, draft updating of the capability analysis, community profile and HIRA during August and September, 2016 while the HIRA was being updated. During late October 2016, the draft HIRA was presented to the HMTAC and new goals mirroring the Central VA Emergency Management Alliance Goals were developed.

Local meetings were conducted in November and December to create 2017 – 2022 mitigation actions responsive to the HIRA update. Outreach was conducted seeking comments on the draft HIRA during December, 2016 using multiple media and three meetings were conducted. The final plan was drafted, made available through a variety of media outlets, and submitted to VDEM for review. Stakeholder engagement was encouraged through invitations to meetings, newsletter updates, and the outreach process throughout the project beginning with the July 12, 2016 resiliency workshop. Localities also engaged stakeholders at the community level, inviting discussion whenever possible.

For the Richmond and Crater regions, the regional Planning District Commissions are composed of local jurisdictional elected officials such as members of county boards of supervisors, town council members, city council members, their appointees and chief administrative official such as the county/city/town administrator/manager. The majority of members for both the Richmond and Crater PDCs are elected offices. For all land development activity, these are the officials who make final land development decisions, approve their comprehensive plans and ultimately will adopt the 2017 Richmond-Regional – Crater PDC Multi-regional Hazard Mitigation Plan Update. Throughout the HMP Update process, beginning with application for final support through a VDEM/FEMA's Hazard Mitigation Assistance grant, each respective PDC has been updated on plan development progress in monthly reports and at monthly meetings. The approval responsibility of these elected officials connects the plan update, which they adopt upon FEMA conditional approval, to local comprehensive plan, zoning change and land use development decisions, which they also approve.

3.1 The Hazard Mitigation Technical Advisory Committee

The PDCs convened a HMTAC comprised of representatives of each participating jurisdiction and non-governmental stakeholders. The HMTAC worked with the Dewberry team and provided input at each key stage of the planning process, including reviewing the format and content of the previous plan and making decisions on what information to carry forward into the 2017 plan update. HMTAC members responded to surveys detailing plan implementation and mitigation capabilities; updated their 2011 plan actions; participated in HMTAC kick-off and HIRA/Goal Setting meetings; organized and participated in local meetings with PDC representatives to create a comprehensive menu of 2017 – 2022 mitigation actions which respond to identified priority hazard risks, reviewed document drafts and supported outreach efforts. Appendix E contains the record of changes that documents how each section in the 2011 plan was updated in the 2017 plan. Efforts to involve city, county, and town departments and community organizations that might have a role in implementation of the mitigation actions or policies included invitations to attend meetings and serve on the HMTAC, access to the project website where files could be accessed and shared among the committee, e-mail updates, mitigation action development

workshops, numerous outreach events and opportunities for input and comment on all draft deliverables.

The PDCs are grateful for the professionalism, dedication, knowledge and guidance of those who served on the HMTAC throughout the planning process and their representative departments and organizations. Table 3-1 lists contributing HMTAC members.

Table 3-1 Hazard Mitigation Technical Assistance Committee

Name	Jurisdiction/Organization	Department	Title
Zach Trogden	Charles City County	Administration	County Administrator
Emily Ashley	Chesterfield County	Emergency Management	Deputy Coordinator of Emergency Management
Heather Barrar	Chesterfield County	Planning	Principle Planner
Beverley Brandt	City of Colonial Heights	Emergency Management	Colonial Heights Fire and Emergency Medical Services (EMS) Manager
Heather S. Hunnicutt	Town of Claremont	N/A	Clerk/Treasurer
Ken Ryals	City of Emporia	Emergency Management	Emergency Management Coordinator
Benjamin Ruppert	City of Hopewell	Emergency Management	Emergency Services Coordinator
Brian Sturdivant	City of Petersburg	Emergency Management	Fire Chief
Mark Milazzo	City of Petersburg	Emergency Management	Division Chief / Deputy Emergency Coordinator
Anthony McLean	City of Richmond	Emergency Management	Emergency Management Coordinator
Bill Lawson	City of Richmond	Emergency Management	Emergency Management Planner
Jonet Prevost-White	City of Richmond	Community Development	Operations Manager
Mark Bittner	Crater PDC	Planning and IT	Director of Planning and Information Technology
Dennis Morris	Crater PDC	N/A	Executive Director
Dennis E. Hale	Dinwiddie County	Fire Department	Director of Public Safety
Bill MacKay	Goochland County	Fire and EMS	Chief
Reggie Owens	Greensville County	Emergency Management	Emergency Management Coordinator
Corey Beazley	Hanover County	Fire and EMS	Fire/EMS Lieutenant
Anna M. McRay	Henrico County	Emergency Management	Deputy Coordinator of Emergency Management
Rick Opett	New Kent County	Fire and EMS	Fire Chief
Curt Nellis	Powhatan County	Department of Emergency Management	Emergency Management Coordinator
Donald Hunter	Prince George County	Emergency Management	Deputy Emergency Coordinator
Ed Snyder	Richard Bland College		Emergency Management

Table 3-1 Hazard Mitigation Technical Assistance Committee

Name	Jurisdiction/Organization	Department	Title
Martha Sickle	Richmond Regional PDC	N/A	Executive Director
Jackie S. Stewart	Richmond Regional PDC	Administration	Project Manager
Kathy Robins	Richmond Regional PDC	Administration	Senior Emergency Management Planner
Leigh Medford	Richmond Regional PDC	Planning	GIS Coordinator
Sarah Stewart	Richmond Regional PDC	Planning	Environmental Planner
Chuck Gates	Richmond Regional PDC	Administration	Deputy Executive Director
Ervin H. Jones	Surry County	Emergency Management	Interim Emergency Services Coordinator
Eddie Vick	Sussex County	Public Safety	Public Safety Coordinator
Vandy Jones III	Sussex County	Administration	Deputy County Administrator
Danielle Progen	VDEM	Region I	All Hazards Planner, Region I
Lori Dachille	VDEM	Region I	Chief Regional Coordinator Region 1
		Invited	
Hon. George L. Edwards	Town of Claremont	N/A	Mayor
Hon. Yvonne Pierce	Town of Dendron	N/A	Mayor
Kathleen Mayes	Town of Waverly	Administration	Clerk
Hon. Arthur G. Elliott, Jr.	Town of Jarratt		Safety Officer
Hon. Charles T. Mansfield	Town of McKenney		Mayor
Hon. F. R. Jackson, Jr.	Town of Stony Creek	N/A	Mayor
Hon. Will M. Gwaltney, Jr.	Town of Surry		Mayor
Hon. C. Winston Britt	Town of Wakefield		Mayor
Hon. Walter J. Mason	Town of Waverly		Mayor

Table 3-2 Resiliency and Mitigation Partners

Name	Organization	Title
Garet Prior	Town of Ashland	Senior Planner
Ralph (Joe) Emerson	Henrico County Planning Department	Director
Stephen Yon	Henrico County Public Works Department	Director
Arthur Petrini	Henrico County Public Utilities Department	Director
Anthony McDowell	Henrico County Division of Fire	Chief
Humberto Cardounel	Henrico County Division of Police	Chief
W.M. Cox	Henrico County Division of Police	Assist. Chief, Administration
A.J. Gordon	Henrico County Division of Police	Homeland Security Liaison

Table 3-2 Resiliency and Mitigation Partners

Name	Organization	Title
David Gunn	Henrico County Department of Public Works	Floodplain Manager
Mary Beth Danuser	Henrico County Department of Planning	GIS Technician
David Calkins	Henrico County Health Department	Emergency Planner
James Beazley	Dominion Virginia Power	Governmental Liaison
Gray Corbett	Central VA Regional Healthcare Coalition	Hospital Coordinator
Andrew Slater	Central VA Regional Healthcare Coalition	Manager
Debby Byrd	Goochland County Community Development	Assistant Director
Todd Kilduff	Goochland County	Director of Utilities & Assistant County Administrator
Gary Fisher	Goochland County	Building Official
Dan Schardein	Goochland County	Deputy County Administrator
Ralph Sheldon	Powhatan County	Building Official
Ed Howland	Powhatan County	Planner & Zoning Manager
David Dameron	Powhatan County	Zoning Administrator
Jason Overstreet	Powhatan County	GIS Coordinator
Ramona Carter	Powhatan County	Director of Public Works
Johnny Melis	Powhatan County	Utilities Manager/Recovery Debris Manager
Steve Chidsey	Hanover County	Deputy Director Public Works
Mike Deiter	Hanover County	Chief Engineering Public Works
Robby Dawson	Chesterfield County	Assistant Fire Chief Community Risk Reductiion
Jerry Netherland	Chesterfield County	Police Department Captain
George Hays	Chesterfield County	Utilities Director
David Pritchard	Chesterfield County	Special Projects Manager County Administration
Heather Barrar	Chesterfield County	Planning Department Principal Planner
Chris Workman	Chesterfield County	Environmental Engineering – Inspections and Floodplain Manager
Scott Smedley	Chesterfield County	Director of Environmental Engineering
Kathleen Thompson	Chesterfield County	CDGB Budget Coordinator
Allan Carmody	Chesterfield County	Finance Director
James Worthy	Chesterfield County	Director Parks and Recreation
Tammy Ebner	Chesterfield County	Senior GIS Analyst

During July, 2016 and January, 2017 the HMTAC held three meetings and supervised work on the area's mitigation plan. The HMTAC members coordinated and consulted with other entities and stakeholders to identify and delineate natural hazards within the local jurisdictions and to assess the risks and vulnerability of public and private buildings,

facilities, utilities, communications, transportation systems, and other vulnerable infrastructure. In addition, the individual HMTAC members met with PDC planners and the consultant to review program capabilities, 2011 mitigation action status and to identify/update 2017 jurisdictional mitigation actions.

In developing the mitigation plan, a majority of necessary communication occurred through telephone calls and e-mails. The HMTAC and Dewberry chose this avenue, rather than meetings, to best accommodate budgets and schedules. A project website was hosted by the Richmond Regional PDC to document draft review and outreach material sharing. Table 3-2 documents meeting dates and their purposes. Attendance lists may be found in Appendix A.

Table 3-3. Hazard Mitigation Technical Advisory Committee Meetings

Date	Summary of Discussions
July 12, 2016	**Richmond Regional – Crater PDC Resilience Workshop:** This regional workshop, sponsored by FEMA Region III and the two planning district commissions, addressed resiliency challenges and opportunities for the central Virginia Region. Many tie-ins to hazard mitigation, including climate change, increased impact of severe storms, floodplain management, and mitigation projects were discussed in plenary presentations and by small break-out groups Many attendees are also members of the HMTAC or were involved in meetings on the local government level to determine 2011 mitigation action status, current mitigation program capability, planning processes and to develop new 2017 – 2022 mitigation actions.
August 5, 2016	**Hazard Mitigation Plan Update Project Kick-off Meeting:** Described planning process. Obtained commitment to the project and schedule. Validated list of hazards and rankings from previous plan. Discussed previous plan structure and content; decision was made to retain structure and general level of content. Discussed update process and role of HMTAC members, project schedule and desired plan outcomes.
October 26, 2016	**HIRA Results and Goals Update Meeting:** Presented results of the HIRA and after lengthy discussion concurrence to review and augment critical facilities listing keeping datasets in redacted Appendix. Reviewed and modified goals from previous plan and decided to incorporate Central Virginia Emergency Management Alliance goals. Discussed process for updating previous mitigation actions and developing new actions. Need for at least two public meetings was discussed with Richmond Regional and Crater PDCs agreeing to coordinate.
October 26 – December 5, 2016	Held individual jurisdiction meetings with counties, cities and the Town of Ashland to discuss hazard mitigation strategies. Other towns communicated with via email or calls.
TBD - 2017	**Final Project Meeting:** Combined HMTAC and the Central Virginia Emergency Management Alliance (CVEMA) meeting will include expanded public officials who attended July 12, 2016 regional resilience workshop to review 2017 Plan HIRA, Plan goals and highlighted jurisdictional mitigation actions, local plan adoption process and implementation schedule. Note: meeting date TBS based on VDEM-FEMA conditional plan approval.

Participation in various plan development activities is summarized in Table 3-3 Jurisdiction Participation in the Planning Process.

Table 3-4. Jurisdiction Participation in the HMP Update Planning Process

Jurisdiction/ Organization	Resiliency Workshop	Kick-off Meeting	Capability Survey/2011 Action Status	Data Provided	HIRA Meeting	Mitigation Actions Meeting	Outreach Activities	Final Meeting TBD (after conditional FEMA Approval)
Charles City County			X	X		X		
Chesterfield County	X	X	X	X	X	X	X	
City of Colonial Heights	X	X	X	X	X	X	X	
City of Emporia			X	X		X		
City of Hopewell		X	X	X	X	X	X	
City of Petersburg			X	X		X	X	
City of Richmond	X	X	X	X	X	X	X	
Crater PDC	X	X	X	X	X	X	X	
Dinwiddie County		X	X	X	X	X		
Goochland County	X	X	X	X		X	X	
Greensville County		X	X	X	X	X		
Hanover County	X	X	X	X		X		
Henrico County	X		X	X	X	X	X	
New Kent County		X	X	X		X	X	
Powhatan County	X	X	X	X	X	X		
Prince George County		X	X	X	X	X	X	
Richmond Regional PDC	X	X	X	X	X	X	X	
Surry County			X	X		X		
Sussex County		X	X	X		X		
Town of Ashland	X	X	X	X		X		
Town of Claremont			X			X		
Town of Dendron								
Town of Waverly								
Town of Jarratt								

Jurisdiction/ Organization	Resiliency Workshop	Kick-off Meeting	Capability Survey/2011 Action Status	Data Provided	HIRA Meeting	Mitigation Actions Meeting	Outreach Activities	Final Meeting TBD (after conditional FEMA Approval)
Town of McKenney			X	X		X		
Town of Stony Creek								
Town of Surry								
Town of Wakefield								
Town of Waverly								
VDEM	X	X	N/A		X	N/A		

3.2 Public Participation and Stakeholder Input

Three public meetings were advertised broadly throughout the combined PDC region using traditional news print media, press releases, web postings and social media such as Twitter and Face Book. ~~was~~ The purpose of these meetings, internet and press engagement was intended to garner interest and receive comment on the draft hazard identification, risk assessment and vulnerability analysis. In particular, the public participation was designed to gather information on threats of most concern. In addition, the meetings were publicized on the Planning District Commissions' websites and a variety of local jurisdiction websites. Appendix A lists media sources that advertised the meetings and includes sample screenshots of the website advertisements, photos and other outreach materials.

Meetings were conducted as follows:

Monday, December 13
6 p.m. to 8 p. m.
Appomattox Regional Library
209 East Cawson Street
Hopewell VA 23860

Friday, December 16
10 a.m. to 2 p.m.
Richmond Regional PDC
9211 Forest Hill Ave, Suite 200
Richmond VA 23235

Monday, December 19
6 p.m. to 8 p.m.
Libbie Mill Library
2100 Libbie Lake East Street
Henrico VA 23230

A brief overview of the plan update process was given to attendees as well as information on changes to risk and vulnerability. Citizen input on areas of concern and ideas for future projects to reduce the impact of natural disasters were sought. Meeting sign-in sheet scans may be found in Appendix A.

The December 13, 2016 Appomattox Regional Library meeting was conducted in Hopewell. There were no citizen stakeholders in attendance but the following HMTAC members were present:

- Chesterfield County Planning
- Hopewell Emergency Management
- Colonial Heights Emergency Management
- Richmond Regional PDC Planner
- Crater PDC Executive Director
- Dewberry – project consultant

At the Richmond Regional PDC December 16, 2016 meeting, Richmond Regional PDC staff were in attendance along with:

- City of Richmond representatives from Emergency Management, Public Utilities, and the Fire Marshall departments,
- Prince George County Fire and Emergency Management,
- Chesterfield County Emergency Management; and
- A citizen who had relocated from Florida state government supporting mitigation who was interested in how the RR-C regional conducted its plan update.

The third and final meeting was conducted at the Henrico County Libby Mill Library on December 19, 2016. In attendance were:

- Richmond Regional PDC Planners
- Henrico Emergency Management
- New Kent Fire and Rescue
- Three citizens interested in the planning process and acquisition of their floodprone property.

Additional information about the plan, process, study area, and schedule was posted and is updated on the project website at www.richmondregional.org/HMP.

The hazard mitigation plan also was discussed at several Richmond Regional and Crater Planning District Commissions meetings, which are advertised and open to the public. A project-specific brochure describing the process and outcomes was developed for the jurisdictions to publicize the final plan and may be found in Appendix A.

The final draft plan was made available on the PDCs' websites (www.richmondregional.org and www.craterpdc.org) which has been linked to some of the participating local jurisdictions' websites and widely publicized by the PDCs and some participating HMTAC jurisdictions through multiple media means like press releases, Facebook, Twitter, Next Door and emergency management newsletters.

Neighboring jurisdictions were invited to review and provide input into the plan through the Virginia Association of Planning District Commissions. These jurisdictions included:

- Southside Planning District Commission,
- Commonwealth Regional Commission,
- Thomas Jefferson Planning District Commission,
- George Washington Regional Commission,
- Middle Peninsula Planning District Commission,
- Hampton Roads Planning District Commission,
- Region 2000, and
- West Piedmont.

3.3 Incorporation of Existing Plans and Studies

The Richmond-Crater Multi-Regional Hazard Mitigation Plan update incorporates information from a number of other plans, studies, and reports. These documents include:

- 2013 Virginia State Hazard Mitigation Plan, VDEM.
- 2012 Commonwealth of Virginia Emergency Operations Plan, VDEM
- Virginia Department of Conservation & Recreation (DCR) climate reports
- Virginia Employment Commission Economic Data
- Virginia Department of Forestry wildfire data and reports

- Landslide Incidence and Susceptibility in the Conterminous United States, U.S. Geological Survey (USGS).
- Risk Mapping, Assessment, and Planning (Risk MAP) Report, Chowan River Basin, Virginia, May 2011, FEMA.
- Gap Analysis Report, Central Virginia Capabilities Assessment, September 2010, Center for Naval Analysis
- Risk Baseline Analysis, Central Virginia Capabilities Assessment, June 2010, Digital Sandbox.
- FEMA TEIF 2.0 Analysis 2014 and 2016
- Jurisdictional Comprehensive and Emergency Operations Plans
- USDA Census of Agriculture
- 2010 US Census Bureau and UVA Walden Cooper Institute population data
- 2010 – 2014 American Community Survey population estimates

Information about how these plans and studies were incorporated into in Sections 4.0, 5.0, and 6.0 is in those sections where relevant and more specific data sources and information is cited. Full reference information is provided in Section 9.0, References.

3.4 Method and Schedule for Keeping the Plan Current

The progress of plan implementation, including the monitoring schedule, evaluating progress, success and lessons learned, and updates is included in Section 8.0 Monitoring.

4.0 Community Profile

4.1 Introduction

The Richmond Regional PDC and the Crater PDC are comprised of 26 local jurisdictions, as follows.

- Charles City County
- Chesterfield County
- City of Colonial Heights
- Dinwiddie County
- City of Emporia
- Greensville County
- Goochland County
- Hanover County
- Henrico County
- City of Hopewell
- New Kent County
- City of Richmond
- City of Petersburg
- Powhatan County
- Prince George County
- Surry County
- Sussex County

Towns:

- Ashland
- Claremont
- Dendron
- Jarratt
- McKenney
- Stony Creek
- Surry
- Wakefield
- Waverly

This area encompasses approximately 4,018 square miles and is bordered generally by Fluvanna, Cumberland, Amelia, Nottoway, and Brunswick Counties to the west; Louisa, Spotsylvania, Caroline, King and Queen, and King William Counties, as well as the Pamunkey River to the north; James City, Newport News, Isle of Wight, and Southampton Counties as well as the James and York Rivers to the east; and the State of North Carolina to the south.

Based on total land mass, Dinwiddie County is the largest jurisdiction at 507 square miles. The Cities of Emporia and Colonial Heights are the smallest jurisdictions in the area at around 7 square miles each (excluding the towns), while Charles City County is the smallest county at 183 square miles.

The location of the Richmond-Crater region within the Commonwealth of Virginia is depicted in Figure 4-1.

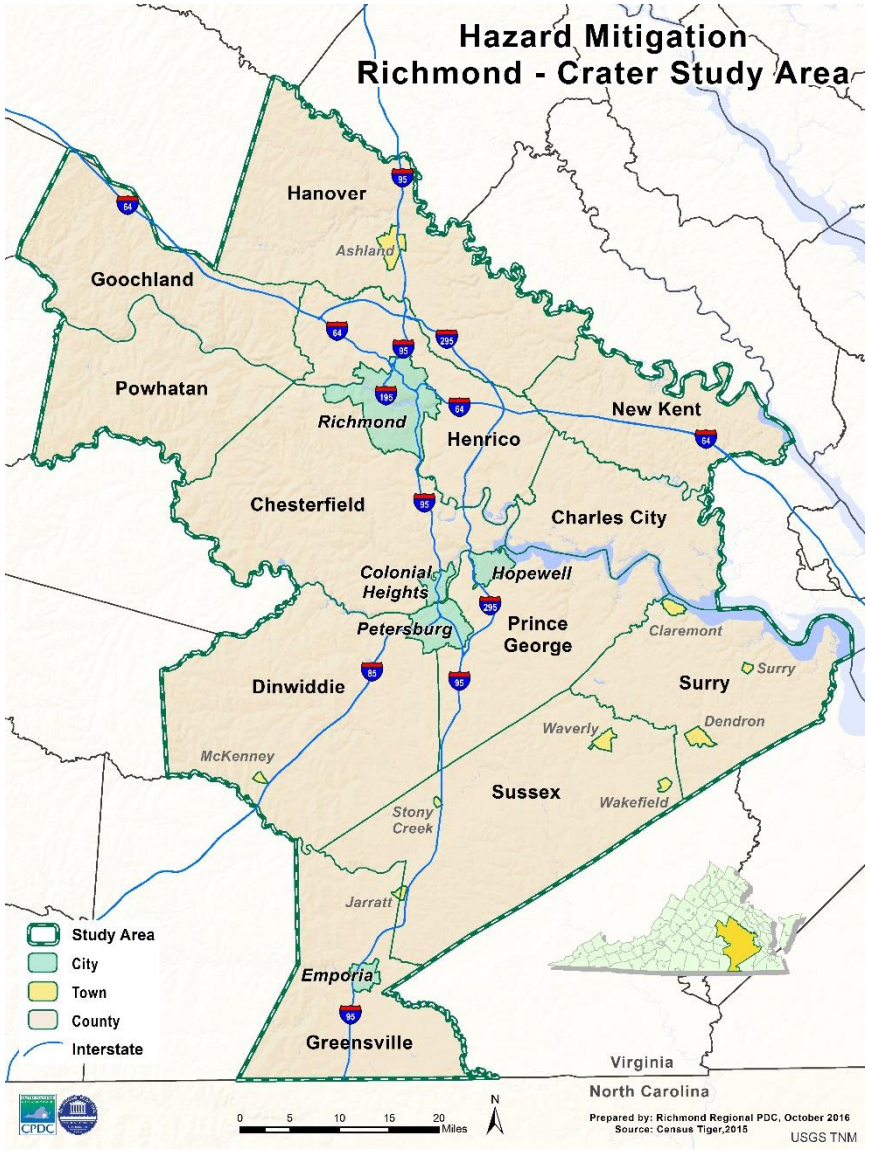

Figure 4-1. Map of Richmond-Crater Region

4.2 Physiography

The Richmond-Crater region is divided between two distinct physiographic regions, the Piedmont and the Coastal Plain, which are divided by the Fall Line. The Piedmont is characterized by deeply weathered, poorly exposed bedrock and a rolling topography. The Fall Line is the easternmost extent of rock-filled river rapids, the point at which east-flowing rivers cross from the hard, igneous, and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the flat Coastal Plain. The areas of the region in the Coastal Plain are gently dissected by streams but can be locally quite rugged where

short, high-gradient streams have incised steep ravine systems.[1] The Cities of Richmond, Petersburg, and Emporia lie approximately at the Fall Line, which is where the James, Appomattox, and Meherrin Rivers, respectively, become unnavigable west of the Fall Line.[2]

Elevations in the Richmond-Crater region vary from just at sea level to 500 feet above sea level.[3] Generally, the western portions of the region are at higher elevations.

4.3 Hydrology

The Richmond-Crater region lies within three major watersheds: the James, the York, and the Chowan. The James watershed spans 10,236 square miles, is the largest watershed in Virginia, and is fed mainly by the James River, Appomattox River, Maury River, Jackson River, and Rivanna River. The York watershed covers a much smaller area with a drainage basin of 2,669 square miles. Its main tributaries are the York River, Pamunkey River, and Mattaponi River. The Chowan River basin spans 3,675 square miles and is comprised of the Nottaway River, Meherrin River, and Blackwater River. Additional rivers include the Blackwater River, Chickahominy River, and North Anna River. The James River flows through the City of Richmond. The Meherrin River runs through the center of the City of Emporia while the Appomattox goes through the City of Petersburg. The City of Hopewell is located at the confluence of the Appomattox and James Rivers.

There are also several large creeks that run through the region. Stony Creek passes through the center of the Town of Stony Creek. Swift Creek forms the northern boundary of the City of Colonial Heights.

4.4 Climate

The present-day climate of Virginia is generally classified as humid subtropical but within-state variation of temperatures, precipitation, and length of growing season is dramatic.[4] Average temperatures in the region are about 76 degrees Fahrenheit in the summer and 39 degrees in the winter. Average annual rainfall is around 43 inches. Average snowfall ranges from 12 to 17 inches annually.

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[1] "**The Natural Communities of Virginia: Classification of Ecological Community Groups (Version 2.4)," Virginia Department of Conservation and Recreation, accessed July 18, 2011, http://www.dcr.virginia.gov/natural_heritage/ncintro.shtml..**

[2] "Physiographic Regions of Virginia," Virginia Places, accessed July 18, 2011, http://www.virginiaplaces.org/regions/physio.html.

[3] FEMA. *Flood Insurance Study. Charles City County, VA, Unincorporated Areas.* September 5, 1990. FEMA. *Flood Insurance Study. Powhatan County, VA, Unincorporated Areas.* March 1978.

[4] "**The Natural Communities of Virginia: Classification of Ecological Community Groups (Version 2.4)," Virginia Department of Conservation and Recreation, accessed July 18, 2011, http://www.dcr.virginia.gov/natural_heritage/ncintro.shtml.**

4.5 Land Use and Development Trends

The jurisdictions in the Richmond-Crater region vary dramatically from primarily rural to urban, sometimes within the same jurisdiction. While the Cities of Colonial Heights, Emporia, Hopewell, Petersburg, and Richmond have typical urban/suburban development patterns, most of the counties are rural in character. Charles City, Goochland, New Kent, and Powhatan Counties are mainly rural with some pocketed areas of suburban development. About 20% of Hanover County is planned suburban development with the remainder for rural residential and agricultural uses. Henrico County and the City of Richmond are more suburban and urban in character.

4.5.1 Charles City County

Charles City County is a rural community located between the more urban areas of Richmond and Williamsburg-Newport News metropolitan areas. The county has a wealth of historic homes and other sites reflecting its history of more than 200 years. The county is heavily forested with small residential communities scattered throughout. As of 2014, about 80% of the county was used for agricultural or forestry purposes or was otherwise in a natural state.[5] Development tends to be clustered at road intersections or along the James and Chickahominy Rivers. Much of the undeveloped land is in large tracts under single ownership.

The county is divided into three magisterial districts. Almost half of the population is concentrated in the Harrison District that covers the western portion of the county. Most of the commercial and industrial development is also located in the western part of the county. About one-third of the population lives in the central portion of the county, in the Tyler District. The remaining population is in the Chickahominy District.

Most of the housing stock in Charles City County is single-family homes. Given trends in surrounding areas and the rapid increase in the cost of stick-built homes, it is likely the number of manufactured homes in Charles City County will continue to increase.

Forests cover approximately 73% of the County's land area. The majority of the forests, about 75%, is owned by private landowners. In 2007, accessible forest area accounted for 67% of the total available land.[6] Land used for rural residential and public/semi-public uses accounted for the difference.

A Dominion Virginia Power substation provides electricity to the county, located on Chambers Road off Roxbury Road (Rout 106). Two power substations provide electricity to the county. Efforts are underway to ensure that the courthouse and municipal complex are on both grids.

[5] "Forest Inventory Data Retrieval (2002-2007)," Virginia Department of Forestry, August 26, 2009, http://www.dof.virginia.gov/resinfo/FIA_2007_StandardTables.htm.

4.5.2 Chesterfield County

Chesterfield County has been split into numerous small areas for planning purposes and the development pattern varies immensely between these areas. Portions of the county are built out at suburban densities while other portions of the county remain fairly undeveloped and rural. For instance, the western part of the Southern and Western Planning Area is designated as "rural conservation," meaning that uses should be restricted to large-lot residential, forestry, or agriculture. Closer to the City of Richmond, however, the development intensity increases. In this area, the Midlothian Turnpike corridor will continue to be one of the county's prime locations for planned light industrial, commercial, and office uses.

Leapfrog development has characterized the Central Area, creating a disjointed development pattern. The types of development in the Central Area have included single-family subdivisions, scattered multi-family complexes, and small- to medium-sized shopping areas often along highway corridors, large employment centers, industrial parks, and an airport. This area is experiencing rapid growth, particularly west of U.S. Route 10.

Significant commercial and industrial development has occurred in the Eastern Area in recent years, and this trend is expected to continue. The Eastern Area also has a great deal of residential development, often adjacent to older commercial-strip zoning and uses. This pattern is particularly seen along U.S. Route 10.

4.5.3 City of Colonial Heights

Colonial Heights is located at the Fall Line, or where the Coastal Plain meets the Piedmont. The city shows a linear development pattern along U.S. Route 1. Residential uses, mainly single-family detached homes, dominate the city, comprising almost 50% of the land use. Recent residential development has come in the form of planned unit developments. Planned unit developments allow for subdivision design flexibility and a mix of housing types. Public sewer is available to most of the developed area. There are six homes along Swift Creek Lane and Pondola Lane that, because of their low-lying location, would be cost-prohibitive to run sewer lines to.

The amount of commercial and business uses have been increasing in recent years. For instance, Southpark Mall Regional Shopping Center, which is accessible from I-95, was built in the past 30 years. Industrial development is limited to the Colonial Heights Industrial Park. About 29% (1,625 acres) of the city is not developed, but the majority of the undeveloped land (983 acres) is unbuildable because of site constraints such as the presence of wetlands, floodplains, or steep slopes.

4.5.4 Dinwiddie County

Dinwiddie County, like many of the jurisdictions in the Planning District, is divided by the Fall Zone into two physiographic provinces, the Piedmont and the Coastal Plain. The major rivers that flow through this area, the Appomattox and Nottoway, occupy narrow

floodplains with only minor meandering. The portion of the county in the Coastal Plain tends to be flat and swampy, which deters development.

The county has grown in three distinct areas. The first area is along major highways such as River Road, U.S. Route 1, and U.S. Route 460. Such development occurs individually or in small strips. Clusters of development are also located in the fringe parts of the Town of McKenney and existing villages and crossroads such as Dinwiddie Courthouse and Sutherland areas. Finally, as the City of Petersburg has expanded, development has begun to cluster in its outskirts in the northeastern part of the county. Approximately 40% of county residents live in this portion of the county. It is also one of the areas where public utilities are available. Residential development patterns include single-family and duplex units, apartment complexes, and manufactured housing parks.

In Dinwiddie County, commercial development tends to occur near residential development. Most of the commercial establishments are located in the northeastern section of the county. In addition, a few businesses are located in the Courthouse area, while travel service facilities such as gasoline stations, motels, and restaurants are located mainly along U.S. Routes 1 and 460. The county has an industrial park at the municipal airport. There is also some industrial presence in the Town of McKenney.

Most of the open space land in Dinwiddie County is under the ownership of timber companies. It is estimated that 244,049 acres of land, or 73% of the county's land area, are in some sort of timber production. The timber stands are mainly located in the western half of the county.

Future growth will be centered in the urban Northeastern Area of the county and scattered throughout the rest of the county. There is concern that farmers will find it difficult to continue using their land for agricultural purposes as development increases.

4.5.5 City of Emporia

The City of Emporia is located along the Meherrin River at the Fall Line. Due to the city's location in two physiographic provinces, the slope of its waterways varies between 10 feet per mile and 1 foot per mile.

Emporia has been the historic trade center for Greensville County. It is the county seat and provides travel services for drivers on I-95. As of 2010, most of the land (57.4%) within the city limits was undeveloped. About 26% of this land had site constraints such as floodplains or steep slopes that prevented it from being developed. Of the developed portions of the city, most land was in residential use. Single-family detached homes are the most common type of residential construction in the city, though there are multi-family units scattered throughout. Many of the higher-density units are concentrated in the northeastern section of the city. New residential development is occurring in the southwest part of the city.

Industrial uses are the second most common type of development in Emporia. These uses tend to be concentrated near major transportation routes, such as adjacent to railroad tracks and near the Meherrin River Dam. There are three main retail areas. One is north of the river and is made up of a part of the central business district and the Emporia Shopping Center. The second is south of the river and is comprised of the other part of the central business district and the area near the courthouse. The third area is at the intersection of I-95 and U.S. Route 58, which is the site of a large shopping center.

The Emporia comprehensive plan states that demand for development will continue along its traditional pattern. Single-family homes will continue to be in demand as will auto-oriented commercial uses. The plan notes a focus on downtown revitalization and a desire to discourage rampant strip development.

4.5.6 Goochland County

Goochland is located approximately 30 miles west of downtown Richmond, 45 miles east of Charlottesville, and 105 miles south of Washington, D.C. Goochland County is still mostly rural and has open land that is well-suited to agriculture and forestry operations. Development has been concentrated in the eastern part of the county. These development pressures are beginning to affect the preservation of open space and important environmental features.

Since the 1970s, Goochland County has been using zoning and the comprehensive plan to implement the village concept. These land use tools have been the impetus in shaping development that supports the county's goals of preserving open space and retaining rural character. In the ideal village concept, new development is directed toward established villages and away from rural and agricultural lands.

4.5.7 Greensville County

Rolling hills give way to flat land midway through Greensville County, which is bisected by the Fall Line and I-95. Floodplains are wide in the eastern part of the county, accounting for almost half of the land in that part of Greensville. The county's population is primarily clustered around the City of Emporia, which is located in the center of Greensville County. Another population cluster is in the Towns of Jarratt and Purdy. There is some residential development scattered along the primary roads and highways in the county. Mobile homes account for more than 20% of the housing stock.

Future growth is expected in the Emporia fringe area and along the I-95/U.S. Route 301 corridor. The county plans to implement an urban services district in which capital improvements will be focused. The urbanized parts of the county are currently served by the Greensville County Water and Sewer Authority.

4.5.8 Hanover County and the Town of Ashland

Hanover County is located on the northern edge of the Richmond metropolitan area. Agricultural uses dominate the land use map of Hanover County. As of 2007, 31% of land

use was dedicated to farm use. Developed areas cluster along the I-95 corridor and within the eastern portion of the county north of I-295. These developed areas tend to be residential in nature in addition to several large concentrations of industrial uses.

Hanover County/Town of Ashland has used a phased growth plan to shape development within the county. All residential designations are contained within the Suburban Service Area boundaries. Throughout the remainder of the county – the rural area – residential development can occur at a density no greater than 1 dwelling unit for every 10 acres. Several proposed mix-use residential developments on former farms have recently been met with mixed reaction from residents, along with a proposed "village" redevelopment in the western Montpelier community. Hanover's strong school system and relatively low residential property taxes continue to attract residential development.

Business development in general has continued within the major road corridors of the county, with the majority of new businesses being located in proximity to U.S. Route 360 in the eastern part of the county.

The Town of Ashland is located in the heart of Hanover County. Established in 1858, the early growth of the town was fueled by the railroad. In more recent times, Randolph-Macon College and I-95 have influenced the town's development. The town is approximately 7 square miles. Ashland is largely developed, so an emphasis is placed on community stabilization and preservation. A FEMA Flood Insurance Rate Map (FIRM) exists for the area annexed by the town in 1996.

4.5.9 Henrico County

According to Henrico County's 2010 Land Use Plan, the majority of the land area of the county was vacant. Portions of this land are undevelopable as they include floodplains and other sensitive areas. As of 2007, out of the approximate land area of 188, 000 acres, 11% was used for farming. Development tends to be concentrated in the West End in the Short Pump – Glen Allen area with continued residential and retail growth along with a new Virginia Commonwealth University medical outpatient facility located at Short Pump Mall, redevelopment at Willow Lawn and the northern area of the County and expanded residential and retail development in the "East End." Of the developed portions of the county, residential land uses (21%) dominate followed by public or semi-public uses. The planning department has predicted that demand for retail, residential, and office space will be concentrated in the western portion of the county while industrial demand will be primarily in the eastern portion but significant residential development continues in the eastern portion of the county and a new retail shopping center opened along Laburnum Avenue during the plan update period.

4.5.10 City of Hopewell

The City of Hopewell falls entirely within the Coastal Plain (close to the western edge of the province) and the area governed by the Chesapeake Bay Preservation Act. The steepest

slopes in the county can be found along the James and Appomattox Rivers. The city is more than 400 years old and has a significant number of historic buildings and other resources.

Residential uses dominate the land use pattern of the city. Single-family homes are the main housing type, though there are some multi-family units such as apartments, townhomes, and condominiums. Much of the housing was built in the 1900s for workers. Five large subdivisions have been built since 2000.

Industrial uses are found in the northeastern part of the city along the James River and Bailey Creek. The vacant industrial land is owned by existing businesses and is reserved for their future growth. According to the comprehensive plan, a large part of the industrial development is in the floodplain.

The amount of vacant land in the city is not enough to meet future demands for growth. Infill development and redevelopment of existing parcels will have to be pursued. As of 2010, there was limited vacant land available at the new I-295 interchange for commercial development.

4.5.11 New Kent County

Rural land uses dominate New Kent County's landscape. Commercial centers are located at Bottoms Bridge, Providence Forge, and Eltham, all of which are complemented by nearby residences. There are smaller clusters of residential and commercial development at Lanexa, Barhamsville, and Quinton. New Kent Courthouse has few commercial uses but is a center for government and institutional uses with residences interspersed and nearby. Another mixed-use center, was anticipated for the Kentland development surrounding Colonial Downs which has been slow to materialize due to the closing of Colonial Downs and the recession. Several golf course residential communities and vineyards have proven attractive to residential development and have brought festival events to the county.

Residential development is clustered in a number of subdivisions of various types, but is also widely scattered along rural roads. The bulk of residential development is located in the western third of the county. Areas around Lenexa and the Descend Creek Reservoir have the greatest concentration in the eastern part of the county.

The 2012 comprehensive plan calls for concentrating development in mixed-use village centers. The exception is industrial uses, which should take advantage of the large amount of vacant property along I-64 and U.S. Route 33. According to U.S. Forest Service data from 1991, New Kent forests today cover 98,183 acres in the County representing 72% of the total land mass. Today forests cover 70% of the total county land cover.

4.5.12 City of Petersburg

The City of Petersburg has a finite amount of land for growth as annexation of county land is not an option. Developable land is limited by Chesapeake Bay Preservation Act requirements and other physical site constraints. About 3,586 acres are available for future

development (about 70% of the vacant land). Land use fragmentation is a major issue in Petersburg with incompatible uses often located side by side.

The city has two distinct residential patterns. The first is found in the "Old City," north of I-85. A mix of residential types (e.g., single family, multi-family, and duplexes) is found here. Newer developments, mainly suburban subdivisions, have sprung up south of I-85. Some infill of single-family homes and duplexes has also been seen.

Commercial development has occurred along the major thoroughfares leading from the central business district. There has been commercial infill development, and a new shopping center has been built on U.S. Route 301. A marina is planned for the area between the I-95 Bridge and the U.S. Route 1/301 bridge.

Industrial uses can be found along the Appomattox River in the central business district. New industrial parks have also been built in the southwest (near I-85 and U.S. Route 604) and southeast (I-95 and Route 632) parts of the city.

4.5.13 Powhatan County

Powhatan County is one of the fastest growing localities in the Richmond region with a population of 28,031 based on the Annual Estimates by the Population Division of the U.S. Census Bureau. In spite of the growth trends, the county strives to maintain rural character by encouraging residential development at low densities – one dwelling per five acres with higher densities allowed only where public utilities may be provided. The county has also experienced commercial and industrial growth along U.S. Route 60 where public utilities are available. With the opening of Route 288, the county should continue to experience growth across all use types in the coming years.

4.5.14 Prince George County

During the past 50 years, Prince George County has seen growth despite annexations by the Cities of Petersburg and Hopewell. The county's residents are concentrated in the Prince George Planning District, which is the northwest portion of the county between the two cities.

Approximately 89% of the county is forested or in crop production. The Virginia Department of Forestry estimates that roughly 74% of the total land area is forested, some of which is commercially owned. The remaining 11% of land is dominated by residential development. Single-family homes comprised about 74% of the housing stock followed by manufactured homes that accounted for about 12%. Most of the single-family homes are found in subdivisions near the two cities. The remainder of the residential development is scattered throughout the county. Commercial development occurs primarily as strip development along major routes.

4.5.15 City of Richmond

Land use patterns are long established and have been reinforced by city planning efforts. The city is mostly developed with limited space for new development. Residential uses dominate the city with commercial service centers spread throughout. Open spaces can also be found throughout the city.

Industrial uses are concentrated in several areas: I-95/James River corridor, west of Jefferson Davis highway to the CSX railroad, Scott's Addition and Hermitage Business parks, Manchester, Rocket's Landing and the Shockoe Valley. Scott's Addition has seen a recent resurgence since the 2011 Plan update with formerly industrial buildings converted to microbreweries, restaurants, apartments and condominiums. Residential development, restaurants and the addition of a large national microbrewery expansion at Rocket's Landing has revitalized a former abandoned industrial area on the north bank of the James River east of the Fall Line.

Since the last plan update, significant re-development and re-purposing has occurred in the Scott's Addition neighborhood north of Broad Street and west of Boulevard. The area is now characterized with a thriving micro-brewery, winery, restaurant, and apartment and condominium economy especially attractive to young, new residents. Hardywood Park microbrewery was one of the first new businesses in this area; other microbreweries have followed.

Manchester, once a separate city, has seen an uptick of revitalization perhaps started with Legend microbrewery 19 years ago. A continued influx of artisans, warehouse to condominium conversions and residential restorations, new businesses and new construction in-fill continue to support neighborhood revitalization. Rocket's Landing, in the eastern part of the city adjacent to the Henrico County border, has been revitalized with a multi-use residential development and the new eastern United States Stone Brewery complex.

Future development efforts will focus on redeveloping blighted and vacant properties. In addition, planning efforts are underway to stabilize declining neighborhoods as well as replace the Diamond baseball complex creating new development in the Boulevard corridor. The Redskins training complex, nearby, has attracted some economic activity during the three to four weeks the team conducts its summer training camp each summer. Particular attention is focused on minimizing conflicts between residential and non-residential uses.

4.5.16 Surry County

Surry County is a rural county characterized by a rolling topography that gradually becomes more level in the eastern portions of the county. Seventy-five percent of the county is forested. Traditionally, forestry and agricultural land uses have supported the majority of employment but have experienced recent decline. Surry County is the location of the

Surry Power Station, a nuclear power plant built in 1972 which is the County's main employer.

About 25% of the county lies within the area regulated by the Chesapeake Preservation Act. The county has a floodplain overlay district and relies on its floodplain management ordinance and the Uniform State Building Code to restrict development in the floodplain.

Large tracts of land are generally not available for development. The dominant development trend is the subdivision of farms into large lots. This development trend may create an inefficient land development pattern. The majority of the county is zoned agricultural-residential. Concern is expressed in the (year) comprehensive plan about the county's lack of legal authority to control manufactured home siting in the agricultural-residential district. Considering that the majority of new housing units are manufactured homes, the county is concerned about a decrease in the property tax base. The Cobham Magisterial District has seen the majority of recent growth in single-family home development.

Some pressure exists to develop along the James River shoreline. Currently, the towns of Claremont, Sunken Meadow, and Scotland Wharf have the largest concentration of development along the James River. These areas were heavily impacted by James River surge and wind damage during 2003's Hurricane Isabel. The comprehensive plan calls for future development to be concentrated in and around the historic towns and crossroads that already exist in the county.

4.5.17 Sussex County

Sussex County is primarily rural with agriculture and forestry dominating land use. Forests, agriculture, and residential uses account for more than 79% of the county. The topography is slightly rolling or relatively level with some marsh areas. The Towns of Jarratt, Stony Creek, Wakefield, and Waverly are located in Sussex County.

The county has experienced a population decline since 1950. In addition, the median age has increased since the 1960s. The majority of housing in the county is single-family detached homes. The number of manufactured homes has risen dramatically since 1990. Manufactured homes accounted for 58% of building permits issued between 1990 and 1996. In 1990, manufactured homes accounted for only 24% of the housing stock; by 1996, that percentage had risen to 40%. Most residential development is in subdivisions or as strips along the highway. This pattern preserves land for agricultural and forestry uses.

The Future Land Use Map shows a large portion of the county, including the floodplains, classified for conservation uses. Large lot, residential development is allowed in this area as is agricultural, forestry, and passive recreation. In addition, the plan calls for development to be concentrated in existing community hubs instead of scattered throughout the county.

4.6 Population

The total population of the jurisdictions included in the Richmond-Crater region is 1,200,670, as of the 2010 U.S. Census. Between 2010 and 2014, New Kent County saw the greatest increase in population with a growth rate of 4.1%. Conversely, the City of Emporia experienced a population decline of 4.1%, according to 2014 American Community Survey (ACS) data. Table 4-1 shows the population breakdown by jurisdiction with the associated growth rate and number of persons per household.

Table 4-1. Population by Jurisdiction

Jurisdiction	Estimated Population, 2014	Percentage Change in Population, 2010–2014
Charles City County	7,154	-1.41%
Chesterfield County	324,337	2.56%
City of Colonial Heights	17,542	1%
Dinwiddie County (incl. Town of McKenney)	27,993	-0.03%
City of Emporia	5,682	-4.13%
Goochland County	21,627	-0.41%
Greensville County (incl. Town of Jarratt)	11,911	-2.71%
Hanover County (incl. Town of Ashland)	100,689	0.83%
Henrico County	314,878	3%
City of Hopewell	22,375	-0.96%
New Kent County	19,187	4.11%
City of Petersburg	32,439	0.06%
Powhatan County	28,193	0.52%
Prince George County	36,792	2.99%
City of Richmond	211,063	3.35%
Surry County (incl. Towns of Claremont, Dendron, Surry)	6,885	-2.45%
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	11,923	-1.36%

Sources: 2014 American Community Survey (ACS), 2010 Decennial Census

4.6.1 Race and Sex

According to 2015 TIGER U.S. Census Bureau data, the majority of the population in the Richmond-Crater region was reported to be of a single race (98.1%). Of the total population reporting one race, 59.4% (712,965) were White and 3.2% were Asian (38,832). The percentage of the population reporting as Black or African American is about 30.4% (364,459), higher than the average for Virginia (19.7%). Only 5.1% of the population (61,110) were reported to be of Hispanic origin.

4.6.2 Language

About 7.6% (89,764) of the residents in the Richmond-Crater region were foreign-born according to 2015 TIGER U.S. Census bureau data. This statistic indicates there may be a significant portion of the community that might require special consideration when developing hazard reduction and outreach strategies for the community.

4.6.3 Age

Another type of special needs group is characterized by age. The 2015 TIGER U.S. Census Bureau data shows that about 6% (72,482) of the population in the Richmond-Crater region is under the age of five while approximately 26% (308,903) is under the age of 20. Additionally, approximately 12% (141,190) of the population is age 65 and above. These figures are similar to the state averages, with the exception of the 65 and over population, being 2.2% below the state average (14.2%).

4.6.4 Education

Data from the 2015 TIGER census estimates shows that about 82% (964,450) of residents in the region graduated from high school and more than 26% (304,789) hold bachelor's degrees or higher. These numbers, coupled with the population characteristics described in the previous paragraph, are important to keep in mind when developing public outreach programs. The content and delivery of public outreach programs should be consistent with the audiences' needs and ability to understand complex information.

The City of Emporia and Sussex County have some of the lowest percentages of people with high school diplomas, while Chesterfield County and Hanover County have the highest. The latter two jurisdictions also have the highest percentage of people with college degrees. The City of Petersburg and the City of Hopewell have the smallest percentage of people with college degrees.

4.6.5 Income

As of 2014, the average median household income in the Richmond-Crater region was approximately $54,620, about 16% less than the state average ($64,792) according to the U.S. Census. Twelve of the seventeen jurisdictions have median household incomes below the state average. About 14.6% (approximately 175,300) of residents within the Richmond-Crater study area live below the poverty line. This rate is slightly lower than that of the national rate of 14.8% in 2014 and above the state rate of 11.8%. These numbers may indicate that a significant portion of the population will not have the resources available to them to undertake mitigation projects that require self-funding. As of 2015, the national rate was reported as 13.5%.

Income levels between the jurisdictions included in the Richmond-Crater region vary greatly. Table 4-2 shows the breakdown by jurisdiction. As the table illustrates, the City of Richmond has significantly lower median incomes while Greensville County has a significantly higher poverty rate than the rest of the region.

Table 4-2. Income Characteristics by Jurisdiction

Jurisdiction	Median Household Income, 2014	Persons Living Below Poverty, 2014
Charles City County	$48,088	13.60%
Chesterfield County	$72,514	7.20%
City of Colonial Heights	$52,529	10.60%
Dinwiddie County (incl. Town of McKenney)	$52,328	13.70%
City of Emporia	$30,240	34.60%
Goochland County	$82,460	6.20%
Greensville County (incl. Town of Jarratt)	$38,933	20.00%
Hanover County (incl. Town of Ashland)	$77,550	5.50%
Henrico County	$61,438	11%
City of Hopewell	$39,156	17.70%
New Kent County	$73,030	5.40%
City of Petersburg	$33,927	27.50%
Powhatan County	$75,447	5.40%
Prince George County	$61,071	10.10%
City of Richmond	$41,331	25.50%
Surry County (incl. Towns of Claremont, Dendron, Surry)	$51,527	11.40%
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	$36,972	22.50%

Sources: 2014 American Community Survey (ACS), 2010 Decennial Census

4.7 Housing

As of 2015, there were 493,778 housing units in the study area according to the TIGER U.S. Census. The majority of the housing units are found in Henrico and Chesterfield Counties. About 70.1% of residents own their own homes, higher than the national average of 62.2% or the state average of 66.7%. The average, however, is skewed by the significantly lower rate of homeownership in the cities of Emporia, Hopewell, Petersburg and Richmond. Table 4-3 illustrates the housing characteristics of each jurisdiction in the Richmond-Crater region. When considering mitigation options, special attention should be given to the difference in capabilities between owners and renters.

Table 4-3. Housing Characteristics by Jurisdiction

Jurisdiction	Housing Units 2014	Housing Units in Multi-unit Structures 2014	Homeownership Rate 2014	Median Value of Owner-Occupied Housing Units 2014
Charles City County	3,263	1.4%	87.1%	$145,600
Chesterfield County	124,384	14.1%	79%	$225,400
City of Colonial Heights	7,817	18.3%	66.9%	$169,900
Dinwiddie County (incl. Town of McKenney)	11,504	3.5%	77.5%	$152,000
City of Emporia	2,722	26.7%	49.2%	$96,700
Goochland County	8,726	0.7%	92.5%	$307,600
Greensville County (incl. Town of Jarratt)	4,118	3.1%	74%	$82,500
Hanover County (incl. Town of Ashland)	39,026	8.2%	84.3%	$269,300
Henrico County	133,795	28.5%	67.4%	$223,500
City of Hopewell	10,185	29.5%	49.8%	$121,900
New Kent County	7,612	0.4%	88.1%	$240,800
City of Petersburg	16,475	33.5%	52%	$109,800
Powhatan County	10,195	1.0%	89.7%	$281,400
Prince George County	12,136	12.5%	70.9%	$196,300
City of Richmond	99,123	42.6%	47.3%	$192,400
Surry County (incl. Towns of Claremont, Dendron, Surry)	3,478	4.1%	73.4%	$166,900
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	4,201	7.4%	65.1%	$111,2000

Source U.S. Census Bureau, State and County Quick Facts.

4.8 Business and Labor

The diversity of the region is reflected in the business sector. While the Richmond-Crater region is home to eight Fortune 500 companies, the outlying area is primarily rural with limited commercial development. The Fortune 500 companies in the region are:

Fortune 500 Company	2016 Rank	Locality
Altria Group	149	Henrico County
Performance Food Group	185	Henrico County
CarMax	191	Goochland County
Dominion Resources	243	Richmond
WestRock	251	Richmond
Owens & Minor	291	Hanover County
Genworth Financial	306	Henrico County
Markel	476	Henrico County

Table 4-4 presents information on the top employment sectors for each jurisdiction. The ten sectors with the most employees in the Richmond-Crater region were:

- Health care and social assistance
- Retail trade
- Finance and insurance
- Accommodation and food services
- Manufacturing
- Construction
- Professional, scientific, and technical services
- Other services (except public administration)
- Administrative and Support and Waste Management
- Remediation Services
- Wholesale trade

The ten sectors with the largest annual payrolls were:

- Finance and insurance
- Health care and social assistance
- Professional, scientific, and technical services Manufacturing
- Retail trade
- Wholesale trade
- Construction
- Administrative and Support and Waste Management and Remediation Services
- Other services (except public administration)
- Accommodation and food services

According to profiles developed by the Virginia Economic Development Partnership, major employers in the Richmond-Crater region are listed by County and City below. Note that the sale of ten MARTIN'S Food Markets to Publix will shift some workers in the grocery sector as the stores are converted to Publix during the next 18 months.

Charles City County:

- Atlantic Bulk Carrier Corp.
- Branscome, Inc.
- Charles City Forest Products Inc.
- Chesapeake Engineering Corp.
- Envelopes Only, Inc.
- U.S. Remodelers Inc.
- Warrior Xpress

Chesterfield County:

- Alstom Power, Inc.
- Amazon.com
- Bon Secours Richmond Health System
- Capital One Service, Inc.
- Campofrio Food Group America
- Defense Supply Center Richmond
- E.I. DuPont de Nemours & Co., Inc.
- Food Lion, Inc.
- Hill PHOENIX, Inc.
- Honeywell International, Inc.
- HCA Virginia Health System
- MARTIN'S Food Markets
- Northrup Grumman Corporation
- Sabra Dipping Company
- The Kroger Company
- United Parcel Service
- Vangent, Inc.
- Wal-Mart Stores, Inc.

Dinwiddie County:

- Amazon.com
- Central State Hospital
- Gerdau AmeriSteel
- Richard Bland College
- Tindal Concrete Company
- Wal-Mart Stores, Inc.

Goochland County:

- Branscome, Inc.
- Capital One
- Hermitage Country Club
- Kinloch Golf Club
- Lee Highway Paving Corp.
- Performance Food Group
- The Richmond Country Club, Inc.
- Virginia Farm Bureau

Greensville County and City of Emporia:

- Ashland Chemical
- Beach Mold & Tool, Inc.
- Bell Nursery, USA, LLC.
- Boar's Head Provisions Company, LLC.
- Creative Playthings, Ltd.
- Deerfield Correctional Center
- Emporia/Greensville Manor
- Food Lion, Inc.
- Franklin Braid Manufacturing Company
- Georgia Pacific Corporation
- Greensville correctional Center
- Greensville County Public Schools
- iLuka Resources, Inc.
- Oran Safety Glass, Inc.
- Paul D. Camp Community College
- PNC Trucking
- Quality culvert, Inc.
- Sadler Enterprises
- Southampton Memorial Hospital
- Southern Virginia Regional Medical Center
- SteelFab of Virginia, Inc.
- Toll Integrated Systems, Inc.
- Valley Proteins, Inc.
- Wal-Mart Stores, Inc.

Hanover County:

- Acosta Sales & Marketing
- AMF Bowling Companies, Inc.
- Bell Nursery, LLC.
- Bon Secours Memorial Regional Medical Health Care Center
- Food Lion

- Green Top
- Hanover County Government
- Hanover County School System
- Kings Dominion
- Kroger
- MARTIN'S Food Market
- Media General
- Overland Contracting
- Owens and Minor
- Randolph-Macon College
- Sales Mark
- SuperValu
- The Home Depot
- Tyson Farms, Inc.
- Wal Mart
- White Birch/The Bear Island Paper Company
- Woodfin Oil

Henrico County:

- Altria Group, Inc.
- Anthem Blue Cross and Blue Shield
- Bank of America, N.A.
- Capital One Service, Inc.
- Cadmus Communications, Inc.
- Dominion Resources
- Fareva USA
- G.E.
- Genworth
- Hamilton Beach Brands
- Henrico Doctors Hospital Parham Campus
- Kraft Foods, Inc.
- Markel Corporation
- McKesson Medical-Surgical
- Mondelez Foods, Inc.
- Pfizer Pharmaceuticals
- Saint Mary's Hospital of Richmond, Inc.
- Sun Trust Banks, Inc.
- The Brink's Company
- Verizon Virginia, Inc.

City of Hopewell:

- Ashland Aqualon Functional Ingredients
- E.I. DuPont De Nemours & Co.
- Evonik Industries
- Honeywell
- John Randolph Hospital
- Smurfit Stone Container Corporation
- West Rock

New Kent County:

- AHS Cumberland Hospital
- Allied Pallet Company, Inc.
- CCCT Transportation LLC
- Colonial Downs
- Comfort Keepers 160
- Curtis Contracting Company
- Direct Wood Products Inc.
- Interior Specialty Construction, Inc.
- JC Pallet Co.
- New Kent County School System

City of Petersburg:

- B.I. Chemicals Inc.
- B.P. Short & Son Paving Co.
- Boar's Head Provisions
- Brenco Incorporated
- B.P. Short & Son Paving Co., Inc.
- Roper Bros. Lumbar
- Southside Regional Medical Center
- Temple-Inland Container
- Virginia State University
- Virginia T's

Powhatan County

- Central Virginia Bank
- Colony Construction
- County of Powhatan
- Elizabeth Randolph Lewis YMCA
- Food Lion
- Ellis M. Palmore Lumber, Inc.
- Kidzalat

- Powhatan Correctional Center
- Powhatan County School Board
- M. P. Barden & Sons Inc.
- Moslow Wood Products
- PIEtech
- Powhatan Correctional Center
- Powhatan County School Board
- R.C. Goodwyn & Sons Inc.
- Rapid Manufacturing
- TDU Concrete
- Wal-Mart

Prince George County

- Ace Hardware Corp.
- Ancos
- Food Lion, Inc.
- Fort Lee Army Base
- Goya Foods
- Hopewell Hardwood Sales, Inc.
- LMR (Logistical Management Resources, Inc.)
- Marc bric
- MetL-Span Inc.
- Nolan
- Oakly Logistics
- Perdue
- Reinhart Food Service
- Retro Insulation
- Service Center Metals, Inc.
- Standard Motor Products, Inc.
- Sterling Gelatin
- U.S. Merchants

City of Richmond:

- Altria Group
- Chippenham Medical Center
- Commonwealth of Virginia State Agencies
- Dominion Resources, Inc.
- Fareva
- Federal Reserve Bank of Richmond
- International Paper Company
- Maxxim Medical, Inc.
- Overnite Transportation Company
- Pfizer

- Sun Trust Banks, Inc.
- UPS Freight
- VCU Health System
- Virginia Commonwealth University
- Verizon Virginia, Inc.
- Virginia Commonwealth University

Surry County:

- Dominion Virginia Power
- Fluor Daniel
- S. Wallace Edwards & Sons, Inc.
- Seward Lumber Co. Inc.
- Windsor Mill

Sussex County:

- McGill
- Murphy Brown
- Virginia Department of Corrections
- Virginia Diner

4.9 Transportation

The Richmond-Crater region is located at a crossroads of transportation within the state of Virginia. Rail lines radiate outward from Richmond in all directions. Both passenger (Amtrak) and freight (CSX, Richmond, Fredericksburg & Potomac, and Norfolk Southern) services are available in the Richmond-Crater region. The region is served by the Richmond International Airport and numerous general aviation facilities, including the Emporia/Greensville Regional Airport, Chesterfield County Airport, Dinwiddie County Airport, Hanover County Municipal Airport, New Kent Airport, Petersburg Municipal Airport, and the Wakefield Municipal Airport. The Richmond International Airport exceeded all past volume in 2015 and then exceeded 2015's flight and passenger traffic in 2016 following years of non-competitive fares which drove travelers to Washington DC-area airports.

As described before, a number of rivers run through the Richmond-Crater region. They include the James River, the North and South Anna Rivers, the Pamunkey River, the Chickahominy River, and the York River. The James River is navigable by large ships up to the eastern portion of the City of Richmond at the Fall Line. It is served by the Port of Richmond. While the City of Richmond has developed an extensive portion of its waterfront along the James River as open space or commercial, the majority of riverfront property in the study area is undeveloped or is developed as low-density residential.

City Point Port is located in the City of Hopewell and the Port of Richmond is within a mile of the region. The Chickahominy River traverses Henrico, New Kent and Charles City counties and joins the James River at the eastern boundary of Charles City County. New Kent and Charles City Counties feature several drinking water reservoirs managed by the Newport News Watershed Authority. The Crater Planning area lies within two major watersheds – the James and the Chowan. The majority of the planning area falls in the Chowan River basin. This basin spans 3,675 square miles and is comprised of the Nottoway River, Meherrin River, and Blackwater River.

Numerous rivers flow through the Crater Planning area including the James River, Appomattox River, Blackwater River, Meherrin River, and Nottoway River. The Meherrin River runs through the center of the City of Emporia while the Appomattox goes through the City of Petersburg. The City of Hopewell is located at the confluence of the Appomattox and James Rivers.

In addition, several large creeks such as Stony Creek, which passes through the center of the Town of Stony Creek, run through the planning area. Swift Creek is impounded for the Swift Creek Reservoir in Chesterfield County and downstream to the east forms the northern boundary of the City of Colonial Heights.

Several interstates intersect the Richmond-Crater region. Interstate 64 is an east-west route extending from Norfolk to Staunton, Virginia. Interstate 95 and I-85 are north-south routes, with I-95 being the primary route along the East Coast extending from Maine to Florida and I-85 the main route between Richmond and Atlanta, Georgia. In addition, Richmond is encircled by I-195, I-895 (a toll road), and I-295 which begins north of Richmond in Henrico County, passing through Charles City County, extending through the City of Hopewell to the City of Petersburg, providing an alternative to I-95. Interstate I-95 continues to be upgraded, including bridge improvements and other minor paving and shoulder improvements/repairs. A number of large U.S. highways also service the region. They include: U.S.-460, U.S.-58, U.S.-250, U.S.-522, U.S.-33, U.S.-1, U.S.-301/SR 2, U.S.-360, and U.S.-60. The state road network is extensive throughout the region. Some of the major routes include SR-6, SR-10, SR-54, SR-156, SR-288, SR-249, SR-155, and SR-5. U.S. 460 connects the City of Petersburg area with Norfolk and the ports of Hampton Roads, and U.S. 58 passes through the City of Emporia along Virginia's southern border. Henrico County is the only county in the region that maintains its own roads. In addition, the City of Richmond maintains its own road network.

4.10 Infrastructure

4.10.1 Electric

The Richmond-Crater region is served by six electricity providers: Central Virginia Electric Cooperative, Dominion Virginia Power, Mecklenburg Electric Cooperative, Prince George

Electric Cooperative, Rappahannock Electric Cooperative, and Southside Electric Cooperative.

The western portions of New Kent County are on a "looped" scheme for electricity. If one portion of this area were to lose power, it could regain power rather easily because it is tied into the system. Virginia Power has not found it to be cost-effective to institute a similar system in the eastern portion of the county and therefore this area is prone to electrical outages.

Two power substations provide electricity to Charles City County. Efforts are underway to ensure that the courthouse and municipal complex are on both grids. In addition, Ingenco, located at the landfill, provides electricity to the power grid.

Powhatan County is served by Dominion Virginia Power (61%) and Southside Electric Cooperative (39%). Power outages primarily occur here because of ice or wind storms. Most of the Southside Electric grid is powered by one substation in the county, and the majority of the Virginia Power feeds that serve the county enter on two distribution lines from substation(s) in Chesterfield.

4.10.2 Natural Gas

Natural gas is provided to the region by the City of Richmond, Columbia Gas of Virginia, and Virginia Natural Gas.

4.10.3 Telephone

Local telephone service is provided throughout Greater Richmond by Verizon Communications Inc. AT&T and Cavalier Telephone are the largest competitive providers. An extensive fiber optic network with digital switching capability and Synchronous Optical Network (SONET) self-healing fiber optic rings insures uninterrupted service. Special Access Services (DS1, DS3, OC-12 and OC-48) are available throughout the area. Verizon can provide dual capacity. Major long-distance carriers include AT&T, Verizon, and Sprint.

4.10.4 Public Water and Wastewater

In the region, public water and wastewater treatment is available in the City of Richmond and Hanover (including the Town of Ashland), Henrico, New Kent, and Powhatan Counties. Public water is also provided by the Appomattox River Water Authority, Chesterfield County, Dinwiddie County Water Authority, City of Emporia, Greensville County Water and Sewer Authority, Town of Jarratt, Town of McKenney, Petersburg and Dinwiddie Water Authority, City of Petersburg, Prince George County, City of Richmond, Town of Stony Creek, Surry County, Sussex Service Authority, and Virginia American Water Company. Private well and septic systems serve Charles City and Goochland Counties. Portions of Hanover, Henrico, and New Kent Counties are also served by private systems.

The Powhatan Courthouse complex, including the 911 center and the junior high school, is served by a private water system. The system relies on pumps and has no generator back-

up. Following Hurricane Isabel, the loss of electrical power serving the water system in the Courthouse area had a significant negative impact on Powhatan County's ability to continue to serve the evacuation shelter and the 911 center.4.10.5 Television

Cable television service is provided within the Richmond-Crater region by Verizon FIOS, Verizon, Comcast and Cox Communication along with satellite and internet providers.

4.10.5 Internet

Level 3 serves Greater Richmond with an independent local and national fiber network. PAETEC (formerly US LEC) offers business customers an extensive line of voice, data, and IP services. Richmond providers of High-Speed Broadband Internet also include EarthLink, Cavalier, Cox Communications, Comcast, and Verizon FiOS. Wireless service providers include T-Mobile, Verizon Wireless, AT&T, and Sprint. Voice over IP providers include Verizon, Vonage and Lingo

5.0 Hazard Identification and Risk Assessment (HIRA)

The Crater Planning District Commission (PDC) and the Richmond Regional PDC, on behalf of the jurisdictions which comprise their regions, have updated the 2011 Hazard Identification and Risk Assessment (HIRA) to serve as a guide to all communities in the regions when assessing potential vulnerabilities to natural hazards. When initialing developing the plan in 2005, and updating it in 2011 and 2017, every effort was made to gather input from all aspects of the project area communities to ensure that the results of this analysis are as accurate as possible. Regional hazard and vulnerability maps are presented in this section. Appendix G contains localized maps for each jurisdiction.

The Crater PDC region includes four cities, six counties, and eight incorporated towns. The Richmond Regional PDC region includes one city, seven counties, and one incorporated town. Charles City and Chesterfield counties are members of both the Richmond Regional and Crater PDCs. The analysis in this section of the plan addresses risks and vulnerabilities to all of the cities, counties and towns in the region; results are presented on a variety of scales such as regional, county/city or county/city/town to best illustrate the available data.

The purpose of the HIRA is to:

- Identify what hazards could affect the planning regions.
- Profile hazard events and determine what areas and community assets are the most vulnerable to damage from these hazards.
- Estimate losses and prioritize the potential risks to the community.

The first step, hazard identification, identifies all natural hazards which the Hazard Mitigation Technical Advisory Committee felt might affect the PDCs. The hazards are ranked to determine what hazards are most likely to impact region's communities. Hazards determined to have significant impact are analyzed in the greatest detail to determine the magnitude of future events and the vulnerability of the community and its critical facilities. Hazards that receive a moderate impact ranking are analyzed with available data to determine the risk and vulnerability to the specified hazard. The limited impact hazards are analyzed using the best available data to determine the risk to the community.

5.1 Critical Facilities

NOTE: Specific information about critical facilities has been redacted from this public copy of the plan to address public safety concerns. This information is available to public safety officials in a redacted Appendix G.

A critical facility is defined as a facility in either the public or private sector that provides essential products and services to the general public; is otherwise necessary to preserve the

welfare and quality of life in the community; or fulfills important public safety, emergency response, and/or disaster recovery functions.

For the 2017 update, the Richmond Regional and Crater PDC staffs worked with members of the HMTAC to identify the following as the types of structures that could be consider as a critical facility.

Public Safety:

Police, Emergency Operations Centers, Sheriff, Fire, Correctional Facilities, and Emergency Management

Infrastructure:

Cell towers, fuel storage, pumping stations, water and wastewater treatment facilities, and transportation structures

Government Facilities:

Courthouses and judicial facilities, government offices and facilities

Medical Facilities:

Hospitals, nursing facilities, rehabilitation centers and outpatient centers

Education:

K – 12 public schools, colleges and universities, technical schools

This information was compiled for the region and used in the hazard analysis as well as for the vulnerability analysis and development of 2017 – 2022 regional and local mitigation actions.

5.2 Land Cover and Land Use

Based on the U.S. Geological Survey (USGS) National Land Cover Data (NLCD), there are nine main land cover definitions with the majority in the "developed" categories that include developed open space, low intensity, medium intensity, and high intensity development. A summary of the land cover categories is included in Appendix B; maps of the jurisdictions are in Appendix G.

Land use was available for the majority of the communities in the Richmond PDC but not in the Crater PDC. As a result, most of the discussion is based on current land cover from NLCD. For the communities that provided land use data or where it was included in community comprehensive plans, future land use and development trends are described in detail in Section 4.0, Community Profile. The development trends described in the Community Profile section should be considered in mitigation actions and future updates to this plan.

5.3 Data Limitations

In order to gain a full understanding of the hazards, an extensive search of historic hazard data was completed. This data collection effort used meetings with local community officials, existing reports and studies, state and national datasets, and other sources. A comprehensive list of sources used for this plan can be found in Section 9.0 of the plan update.

Whenever possible, data has been incorporated into a Geographic Information System (GIS) to aid analysis and develop area-wide maps for depicting historical hazard events, hazard areas, and vulnerable infrastructure. Critical facility data has been collected from local jurisdictions and has been supplemented from FEMA's loss estimating software, Hazus-MH.

In accordance with FEMA's mitigation planning guidance, the results of this study are based on the best available data. The amount of detailed data regarding the location of structures, characteristics of facilities, and other community-related data varies from jurisdiction to jurisdiction. For instance, Charles City County had structure point information that provides an approximate location of the structure while other jurisdictions had building footprint data (except the City of Colonial Heights) which was used for the flood TEIF 2.0 analysis.

Recognizing this deficiency in detailed local data, one ongoing strategy included as part of this mitigation plan, is to increase the quality and detail of data to prepare usable and effective hazard assessments.

Information from the National Climatic Data Center's (NCDC) Storm Event Database was used to inform the weather-related hazard analysis. The NCDC receives storm data from the National Weather Service (NWS), which in turn receives it from a variety of sources, which include but are not limited to: county, state, and federal emergency management officials, local law enforcement officials, Skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. An effort is made to use the best available information, but because of time and resource constraints, information from these sources may be unverified by the NWS. Therefore, the recurrence intervals and other historical analysis presented may not be 100% accurate but instead are based on best available data. In addition, there may be discrepancies in data reporting between jurisdictions that have similar experience or exposure to hazards (e.g., neighboring Charles City and New Kent Counties). Data is only available at a county or regional level for some hazard events including winter storms and droughts. A particular drought or winter storm event in the NCDC database may contain property or crop loss dollar figures, but the single event record may contain multiple counties with no indication of how the dollar damages were distributed. In these instances, lacking better data, the loss figures

were "normalized" by spreading losses in equal proportions to all counties listed in the event record.

The damages entered into the NCDC Storm Events database portray how much damage was incurred in the year of the event. Due to inflation and the changing value of money, the values of damages incurred have been adjusted so that they reflect their worth in 2011. This process was done by obtaining information from the Bureau of Labor Statistics, which provides a yearly index of Consumer Prices. Each value was multiplied by the index of its year of occurrence and subsequently divided by the index value in 2011, the target year.

After the data was normalized, inflation accounted for, and summary statistics calculated, the data was annualized in order to be able to compare the results on a common system. In general, this was completed by taking the parameter of interest and dividing by the length of record for each hazard. The annualized value should only be used as an estimate of what can be expected in a given year. Property and crop damage, and the number of events were all annualized in this fashion, on a per-jurisdiction basis.

Also, the NCDC events are only as valid as they are reported. Not all events are reported, and some may only be reported without damage estimates, injury, or death reports. It is important to note that this database is only an estimate of damages, which is why most figures are annualized to represent and estimate damages that could occur over the course of a year.

Another data limitation was the lack of wildfire damage estimates by jurisdiction after 2010. VDOF tracked wildfire damage in several ways for the 2010 and 2011 seasons; thereafter only occurance and acreage burned annually was available.

5.4 Hazard Identification

5.4.1 Types of Hazards

Although all types of disasters are possible for any given area in the United States, the most likely hazards that could potentially affect the communities in the planning regions were determined through research and analysis conducted for the 2011 Hazard Mitigation Plans and discussion with community officials. The hazard categories were reviewed again during the 2017 plan update and it was agreed that they still represent the main types impacting the region. These hazards include:

- Landslides
- Shoreline erosion
- Droughts
- Flooding
- Earthquakes
- Hurricanes
- Sinkholes
- Wind
- Tornadoes
- Wildfires
- Winter weather
- Thunderstorms

- Extreme heat

In addition, the HMTAC included mass evacuation to the list of hazards to be considered in the plan as was done in 2011.

5.4.2 Planning Consideration

Hazards were ranked based on analysis conducted for the 2011 update, consideration of the hazard analysis presented in the March 2013 Virginia State Hazard Mitigation Plan, input from the 2017 HTMAC, and a new analysis performed for the 2017 update to determine what hazards might have the largest impact on their communities. The results are summarized in Table 5-1. As a result of this analysis, the hazards were broken down into four distinct categories which represent the level of consideration they will receive throughout the planning process. These categories are *Significant, Moderate, Limited,* and *None*. For the 2017 update rankings only the categories of *Significant*, *Moderate*, or *Limited* were used. Certain hazards were not addressed or did not need any updating as a result of the infrequency of occurrence and/or limited impact.

Table 5-1. Planning Consideration Levels by Hazard Type for 2017 Update

Hazard Type	2011 Planning Consideration Level	Commonwealth of Virginia 2012 HIRA Hazard Ranking	2017 HTMAC Preliminary Ranking	2017 HIRA Ranking Analysis**
Flooding	Significant	High	Moderate	Moderate
Wind*	Moderate	Medium-High	High	Limited
Tornado*	Moderate	Medium-High	High	Significant
Hurricane*	Moderate	Not ranked	High	Significant
Winter weather	Moderate	Medium-High	High	Moderate
Thunderstorms* (including Hail and Lightning)	Moderate	Negligible	High	Moderate
Droughts (with Extreme Heat)*	Moderate	Droughts = Medium Extreme Heat = Negligible	Limited	Limited
Mass evacuation	Moderate	Not ranked – Discussed in other Commonwealth of Virginia emergency operations plans	Limited	Limited
Wildfires	Limited	Medium	Limited	Limited
Earthquakes	Limited	Medium-Low	Limited	Limited
Landslides/shoreline erosion*	Limited	Landslide = Medium-Low	Limited	Limited

Table 5-1. Planning Consideration Levels by Hazard Type for 2017 Update

Hazard Type	2011 Planning Consideration Level	Commonwealth of Virginia 2012 HIRA Hazard Ranking	2017 HTMAC Preliminary Ranking	2017 HIRA Ranking Analysis**
		Erosion = Negligible		
Karst	Limited	Low	Limited	Limited
* Some event types were combined (Droughts/Heat and Landslide/Erosion) or separated (Wind/Tornado and Hurricanes/Thunderstorms) from other plans and votes to accommodate the 2017 HTMAC's current concerns for their regions. ** Ranking analysis explained in section 5.4.3 Analysis and Data Sources.				

Because some of the hazards included in the hazard identification analysis are similar, some hazards will be discussed simultaneously later in this analysis. For instance, the Wind section includes hurricanes, other tropical disturbances, and thunderstorm winds while tornadoes were evaluated in their own section. A detailed discussion of the potential hazards that have been identified as *Significant* and *Moderate* events is provided in the sections that follow. A brief discussion of the *Limited* events is also included.

5.4.3 Analysis and Data Sources

Table 5-2 provides a list of the natural hazards, the analysis type and data source included in this plan. In order to focus on the most critical hazards that may affect the Planning District communities, hazards assigned a level of *Significant* or *Moderate* will receive the most extensive attention in the remainder of the planning analysis, while those with a *Limited* planning consideration level will be assessed in more general terms. The hazards with a planning level of *None* will not be addressed in this plan. The hazards assigned a ranking of *None* are not critical enough to warrant further evaluation; however, these hazards should not be interpreted as having zero probability or impact. It should also be noted that all sources, especially the NCDC and National Weather Service, only include events that are reported and may not include all events. However, they provide good databases and can help provide a better picture to help understand and mitigate damages.

Table 5-2 HIRA Overview – Hazards, Analysis and Data Source

Hazards	Analysis	Data Sources
Flooding	Covered by HIRA flood analysis	FEMA Digital Flood Insurance Rate Map (DFIRM), Q3, and FIRM Mapping; HAZUS census block values; NCDC; TEIF 2.0 analysis
Hurricanes	Covered by HIRA flood and hurricane wind analysis	FEMA DFIRM, Q3, and FIRM Mapping and American Society of Civil Engineers Design Wind Speed Maps, FEMA HAZUS model; NCDC; National Hurricane Center

Table 5-2 HIRA Overview – Hazards, Analysis and Data Source

Hazards	Analysis	Data Sources
Wind	Covered by HIRA hurricane wind analysis	FEMA HAZUS model; NCDC
Winter storms	Covered by HIRA winter storm analysis	NCDC; NWS; PRISM Climate Group; VDOT; IEM
Droughts	Covered by HIRA drought analysis	NCDC; U.S. Drought Monitor; U.S. Census Bureau 1990 Water Source Data
Tornadoes	Description and regional maps	NCDC; Severe Weather Data GIS Data; VDEM
Wildfires	Covered by HIRA wildfire analysis	VDOF; NCDC
Earthquakes	None, due to infrequency of occurrence	USGS
Landslides/ shoreline erosion	None, due to infrequency of occurrence	USGS; NCDC

The final analysis for the HIRA Ranks were established using the following Criteria in Table 5-3. This table shows what scores were given and the criteria needed to get these scores. This was based on a FEMA Hazard Priority Ranking Criteria and modified to include what information was available at the time of publishing this document.

Table 5-3. Hazard Priority Ranking Criteria for Richmond and Crater Regions

Probability	Score	Vulnerability	Score	Maximum Impact (Annual Damages)*	Score	Warning Time	Score
Unlikely - No documented NCDC occurrences with annual probability < 0.01	0.5	Limited Rank by 2017 HMTAC Preliminary Ranking	1	No NCDC data found to evaluate. Does not mean there was no damages.	0	**Extended** - Three days or more	1
Somewhat Likely - Infrequent occurrence with at least one NCDC documented event and annual probability between 0.5 and 0.01	1	Moderate Rank by 2017 HMTAC Preliminary Ranking	2	Based on NCDC data, score award by percent of total annual damages done by event. Hazard receive their percent of points from 0.01 to 3 max)	0.01 - 3	**Limited** - 2 days	2

Table 5-3. Hazard Priority Ranking Criteria for Richmond and Crater Regions

Probability	Score	Vulnerability	Score	Maximum Impact (Annual Damages)*	Score	Warning Time	Score
Likely - Frequent occurrence with at least some NCDC documented events and annual probability between 1 and 0.5	1.5					**Minimal** - 1 day	2
Highly Likely - Common events with annual probability > 1	3	High Rank by 2017 HMTAC Preliminary Ranking	3			**No Notice** - < 24 Hours	3

After scores were assigned to each hazard, the scores were then summed together and divided by 4 (because there were four categories) to find the average score. Scores between 2.5 and 3.0 were given "significant," 2.0 to 2.5 were assigned "moderate," and everything less than 2 were assigned "limited." These scores, ranks, and assigned categories for each hazard type are shown in Table 5-4. The final ranking in order from most significant to limited are shown in Table 5-5.

Table 5-4. HIRA Priority Ranking Analysis

Hazard Type	Probability\History	Vulnerability	Maximum Impact (Annual Damages)	Warning Time	2017 Analysis Score	2017 Ranking Category
Drought	3	1	2.23	1	1.81	Moderate
Earthquake	0.5	1	0	3	1.13	Limited
Flood	3	2	1.94	2	2.24	Moderate
Hurricanes	3	3	3.00	2	2.75	Significant
Karst	0.5	1	0	3	1.13	Limited
Landslide	0.5	1	0	3	1.13	Limited
Mass Evacuation	0.5	1	0	1	0.63	Limited
Thunderstorm	3	3	1.34	2	2.34	Limited
Tornado	3	3	1.92	3	2.73	Significant
Wildfire	0.5	1	0	3	1.13	Limited
Wind	1.5	3	0.68	2	1.79	Limited
Winter	3	3	1.33	1	2.08	Limited

Table 5-5. HIRA Priority Analysis Rank

Hazard Category	Rank Score	Rank	Rank Category
Hurricanes	2.75	1	Significant
Tornado	2.73	2	Significant
Thunderstorm	2.34	3	Moderate
Flood	2.24	4	Moderate
Winter	2.08	5	Moderate
Drought	1.81	6	Limited
Wind	1.79	7	Limited
Wildfire	1.13	8	Limited
Earthquake	1.13	8	Limited
Landslide	1.13	8	Limited
Karst	1.13	8	Limited
Mass Evacuation	0.63	12	Limited

From this analysis, hurricane and tornado events seem to be the most significant types of hazards for the study region. Thunderstorm, flood, and winter events were determined to be moderate events, with everything else being labeled as limited. It should be noted that wildfire, earthquake, landslide, karst, and mass evacuation events were not included in the NCDC database. This does not mean that they did not happen or cause damages, but were given 0 scores as a maximum threat because there was no data to confirm what percent of damages that they may have caused.

5.5 Major Disasters

Twenty-two major disasters have been declared which included at least one county or city within the planning region since 1965. Numerous "emergency declarations have also been declared supporting federal reimbursement for emergency categories of the Public Assistance Program. One third of the events were hurricane disasters, one quarter were associated with severe storms, one fifth were snow and ice related, a few drought and flood disasters, and several unique events were included like a West Nile Virus disaster declared on May 30, 2000, support for Huricane Katrina evacuees and the Lousia Earthquake which impacted Goochland County. It should be noted that flooding is often included in severe storm, hurricane, and coastal storm disasters.

A summary of the total events declared and what kinds are shown in Appendix B – HIRA. Appendix B-2 lists the presidentially declared disasters that have occurred in the Richmond-Crater region planning districts. The appendix further details the disaster

events and dates which where each of the communities in the planning regions were impacted by these disasters.

5.6 Flooding

5.6.1 Hazard Profile

A flood occurs when an area that is normally dry becomes inundated with water. Floods may result from the overflow of surface waters, overflow of inland and tidal waters, or mudflows. Flooding can occur at any time of the year, with peak hazards in the late winter and early spring. Snowmelt and ice jam breakaway contribute to winter flooding, and seasonal rain patterns contribute to spring flooding. Torrential rains from hurricanes and tropical systems are more likely to occur in late summer. Development of flood-prone areas tends to increase the frequency and degree of flooding.

The most significant natural hazard to affect the region is flooding. The region is relatively flat, falling in the Piedmont and Coastal Plain regions. The western portion of the study area is characterized by a more rolling topography but the part east of the Fall Line can be locally quite rugged where short, high gradient streams have incised steep ravines. Several rivers flow through the region including the James, York, Pamunkey, Chickahominy, Appomattox, and North Anna Rivers. Numerous creeks crisscross the study area.

Much of the flooding in the region is the by-product of hurricanes and tropical storms. Flooding also may occur following a period of intense or sustained rainfall. The floods caused by Tropical Storm Gaston in 2004 are characteristic of this type of flooding. The intense rainfall combined with the inability of the City of Richmond's storm water system to handle the increased flow led to a great deal of damage in the Shockoe Bottom area. The duration of flood events vary depending on the specific characteristics of the rain event. Floodwaters generally recede rapidly after the rain event has ended, but can last from a few hours to a few days.

5.6.2 Magnitude or Severity

A flood occurs when an area that is normally dry becomes inundated with water. Floods may result from the overflow of surface waters, overflow of inland and tidal waters, or mudflows. Flooding can occur at any time of the year, with peak hazards in the late winter and early spring. Snowmelt and ice jam breakaway contribute to winter flooding, while seasonal rain patterns contribute to spring flooding. Torrential rains from hurricanes and tropical systems are more likely in late summer. Development of flood-prone areas tends to increase the frequency and degree of flooding.

Flooding can range from minor street flooding to widespread inundation along and near waterways. Flood-producing storms can occur throughout the year. Historically, the most common months for significant flooding have been August and September, the height of the

hurricane season. Floods pick up chemicals, sewage, and toxins from roads, factories, and farms; therefore, any property affected by a flood may be contaminated with hazardous materials. Debris from vegetation and human-made structures may also become hazardous following the occurrence of a flood. In addition, floods may threaten water supplies and water quality, as well as initiate power outages.

If a significant flood event occurs, there is a potential for a variety of secondary impacts. Some of the most common secondary effects of flooding are impacts to infrastructure and utilities, such as roadways, water service, and wastewater treatment. Many of the roadways in the Planning District are vulnerable to damage due to floodwaters. The effect of flood damages to roadways can limit access to areas, cutting off some residents from emergency services as well as other essential services.

Floods typically are characterized by frequency, for example the "1%-annual chance flood," commonly referred to as the "100-year" flood. While more frequent floods do occur, as well as larger events that have lower probabilities of occurrence, for most regulatory and hazard identification purposes, the 1%-percent annual chance flood is used. Detailed flood data were available as Digital Flood Insurance Rate Maps (DFIRMs) for jurisdictions within the FEMA defined floodplain. This is discussed in more detail in Sectin 5.6.6.

Flood damage to property and populations can be devastating, both emotionally and financially. Flood damage to businesses could result in loss of income, wages, and tax revenues. Buildings, including homes and critical facilities, are susceptible to damage and sometimes collapse as a result of a severe flood. Floods pick up chemicals, sewage and toxins from roads, factories, and farms. Property affected by the flood may be contaminated with hazardous materials and present a health and safety risk to residents and occupants. Debris from vegetation and man-made structures also may be hazardous to drivers and pedestrians. In addition, floods may threaten water supplies and water quality, as well as initiate power outages and create health issues such as mold. Other effects include outbreaks of disease, widespread animal illnesses, disrupted utilities, water pollution, fires, washed out roads and culverts and formation of sinkholes.

Secondary Effects

Flooding can pose some significant secondary impacts to the area where the event has taken place. Some of the impacts to consider include infrastructure and utility failure, impacts to roadways, water service and wastewater treatment. Flooded roadways can cause congestion on alternative routes and lengthen travel times for emergency vehicles and school buses. Businesses that are flooded may sustain damage to the structure and its contents, resulting in economic losses from business downtime often due to business impacts as well as lost utilities preventing operation. These impacts are usually localized in the region.

5.6.3 Hazard Areas

The portions of the planning region most susceptible to flooding are those directly adjacent to the area's major waterways. However, flooding can occur along the smaller tributaries throughout the area.

Specific areas that are susceptible to flooding were determined during the initial plan kick-off meeting as well as during the 2011 update. These areas were taken into account when completing the HIRA and are available in jurisdictional executive summaries. These areas can be used to assist with mitigation actions.

Land use information was available for the Richmond PDC. Based on analysis conducted for the 2006 plan, the dominant land use inside floodplains was determined. Much of the land in the region's floodplains is designated for agricultural uses. Some localities, however, allow residential uses within agriculture areas. Agriculture is the dominant land use in Charles City, Goochland, Hanover, and Powhatan Counties. Henrico County's floodplain land use is mostly residential and the City of Richmond's is industrial or park.

5.6.4 Hazard History

Table 5-6 includes descriptions of major flood events in the region. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. When no community-specific description is given, the general description applies to the entire region.

Table 5-6. History of Flood Events and Damages, 2011–2016

Date	Damages
August 27, 2011	Hurricane Irene impacted the area with heavy rainfall and gusty winds which knocked power out to millions of people in the area. It took electrical crews several days to fully restore power in the planning area. Irene originated east of the Lesser Antilles and tracked north and northwest into the western Atlantic. The hurricane reached Category 3 intensity with maximum sustained winds of near 120 mph at its strongest point. The hurricane made an initial U.S. landfall in the eastern portions of the North Carolina Outer Banks on August 27, 2011 as a Category 1 hurricane. The storm then tracked north/northeast along the coast slowly weakening before making its final landfall in Brooklyn, New York on August 28 as a high-end tropical storm. Rainfall totals with the hurricane ranged from around two inches in western sections of the planning region to 5 to 9 inches in eastern sections closest to the coast. At its closest pass, Irene brought sustained winds of 30 to 45 mph with gusts of 60 to nearly 70 mph to the planning area. The winds downed power lines and trees throughout the area. A man was killed when a tree fell on his home near Colonial Heights. (Source: National Weather Service/Wakefield Office)
September 4, 2011	Tropical Storm Lee moved inland along the Mississippi/Louisiana Gulf Coast on September 4, 2011. The remnants of the weakening storm tracked northeast, producing rainfall over a wide swath extending from the Gulf Coast to New England. Rainfall totals generally ranged from 4 to 8 inches in the planning area with the heaviest totals falling just east of Interstate 95. The rain fell on soils saturated only days earlier with Hurricane Irene's passage. The result was widespread flooding, particularly over the eastern sections of the planning region. Gusty

Table 5-6. History of Flood Events and Damages, 2011–2016

Date	Damages
	winds in thunderstorms knocked down trees that had already been weakened from the hurricane resulting in thousands of power outages. (Source: National Weather Service/Wakefield Office)
October 1, 2015	The combination of upper divergence and lift east of the closed low, and a strong persistent low level flow off the Atlantic and associated low level moisture convergence and isentropic lift, along with a plume of tropical moisture getting entrained into the system, provided a band of heavy rain showers and a few thunderstorms that at times trained over the same areas and persisted for many hours. The heaviest rain occurred from the Columbia vicinity, southeastward across lower Richland Co, Sumter Co, Calhoun Co, Clarendon Co and lower Orangeburg Co. The heaviest rainfall occurred late Saturday night Oct 3rd into the morning hours of Sunday Oct 4th. At times, rainfall rates of 2" inches per hour affected those locations for several hours. This heavy and persistent rainfall occurred over urban areas where runoff rates were high, and over grounds already wet from recent rains. This heavy rainfall caused numerous roadway and bridge closings due to dam failures, along with culvert and pipe washouts across the region. Numerous lifesaving swift water rescues were performed. In general, a significant gradient in rainfall amounts occurred in our CWA, with 1-2 inches west of the Savannah River, 2-4 inches just on the east side of the Savannah River, with amounts ramping up to around 10 inches eastward into West Central Midlands, with 10-20 inches from Columbia SE across the Eastern Midlands. The NWS had been advertising this very heavy rainfall and flooding potential well in advance of the event. During this event, Columbia Metro Airport set a new record for both the greatest one and two day rainfall totals: • Greatest 1-day rainfall…. 6.71 inches set on October 4, 2015 • Old 1-day rainfall record….. 5.79 inches set on July 9, 1959 • Greatest 2-day rainfall….. 10.28 inches set on October 3-4, 2015 • Old 2-day rainfall record….. 7.69 inches set on August 16-17, 1949 (Source: National Weather Service)
*History from 1771-2010 in Appendix B-3	

Table 5-7 provides the number and damage costs of recorded flood events by jurisdiction. It should be noted that these results represent only those events recorded by the NCDC storm events database for flood; therefore some, particularly local, events may not be included in this table. Some of the events listed in the table may actually be regional events impacting multiple jurisdictions. Significant hurricane events resulting in flooding have been included although it should be noted that some minor hurricanes may have resulted in flooding but may not have been recorded in the NCDC as flood events; see the hurricane/wind section for information on those events. Chesterfield (22) and Surry (16) Counties have the highest number of flood events and while Greensville County had over $1M in property damages. The City of Richmond experienced over $63,000 in crop damages for the NCDC period of record (1993–2017).

Table 5-7. Flood Damage to Property and Crops, 1993 - 2016

Jurisdiction	Flood Events	Property Damages	Crop Damages
Charles City County	7	-	-
Chesterfield County	22	$287,458	$2,986
City of Colonial Heights	5	$71,663	-
Dinwiddie County (incl. Town of McKenney)	8	$12,223	$3,285
City of Emporia	3	-	-
Goochland County	5	$38,818	$11,944
Greensville County (incl. Town of Jarratt)	13	$1,065,175	-
Hanover County (incl. Town of Ashland)	9	$158,993	$25,082
Henrico County	3	-	-
City of Hopewell	6	$71,663	$47,776
New Kent County	14	$109,340	-
City of Petersburg	14	$141,487	-
Powhatan County	10	$38,966	-
Prince George County	10	-	-
City of Richmond	14	$94,711	$63,618
Surry County (incl. Towns of Claremont, Dendron, Surry)	16	$64,535	$37,014
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	15	$265,726	$62,187
Totals	**174**	**$2,420,758**	**$253,890**

Note: Only floods, not hurricanes.
Source: National Climatic Data Center.

5.6.5 Hydrology

The Richmond-Crater region lies within three major watersheds – the James, Chowan, and York. The James watershed spans 10,236 square miles, the largest in Virginia. The Chowan River basin spans 3,675 square miles. The York watershed covers a much smaller area with a drainage basin of 2,669 square miles. Numerous rivers flow through the region including:

- James
- York
- Appomattox
- Blackwater
- Meherrin
- Pamunkey
- Chickahominy
- North Anna
- Nottoway

The James River runs directly through the City of Richmond. The Meherrin River runs through the center of the City of Emporia, while the Appomattox flows through the City of

Petersburg. The City of Hopewell is located at the confluence of the Appomattox and James Rivers.

In addition, several large creeks such as Stony Creek, which passes through the center of the Town of Stony Creek, run through the region. Swift Creek forms the northern boundary of the City of Colonial Heights. Figure 5-1 illustrates the location of the major watershed boundaries for the region.

In 2009, the U.S. Army Corps of Engineers (USACE), Norfolk District, completed a stream and rain gauging network study within the Chowan River Basin. The study identified gauging station needs that would improve flood forecasts by the NWS. An additional study in 2009 evaluated water resource issues, such as environmental restoration, flood risk management, navigation, and water quality. These two studies helped to determine Risk Mapping, Assessment, and Planning (Risk MAP) program activities implemented in the Chowan River Basin. The three Risk MAP activities included:

- Assessment of basin flood hazard data.
- Establishment of local community officials' knowledge and understanding of flood risk management concepts and increasing public awareness of flood hazards and the National Flood Insurance Program (NFIP).
- Support to state and local governments to engage in risk-based mitigation planning.[6]

The Chowan River Basin report provides an in-depth assessment of the river basin and mitigation activities for understanding flood risk. Areas of concern are highlighted throughout the report; this should be used to further facilitate mitigation actions in this plan.

[6] Risk Mapping, Assessment and Planning (Risk MAP) Report. Chowan River Basin, Virginia. By USACE, Norfolk District for FEMA Region III. Final May 5, 2011.

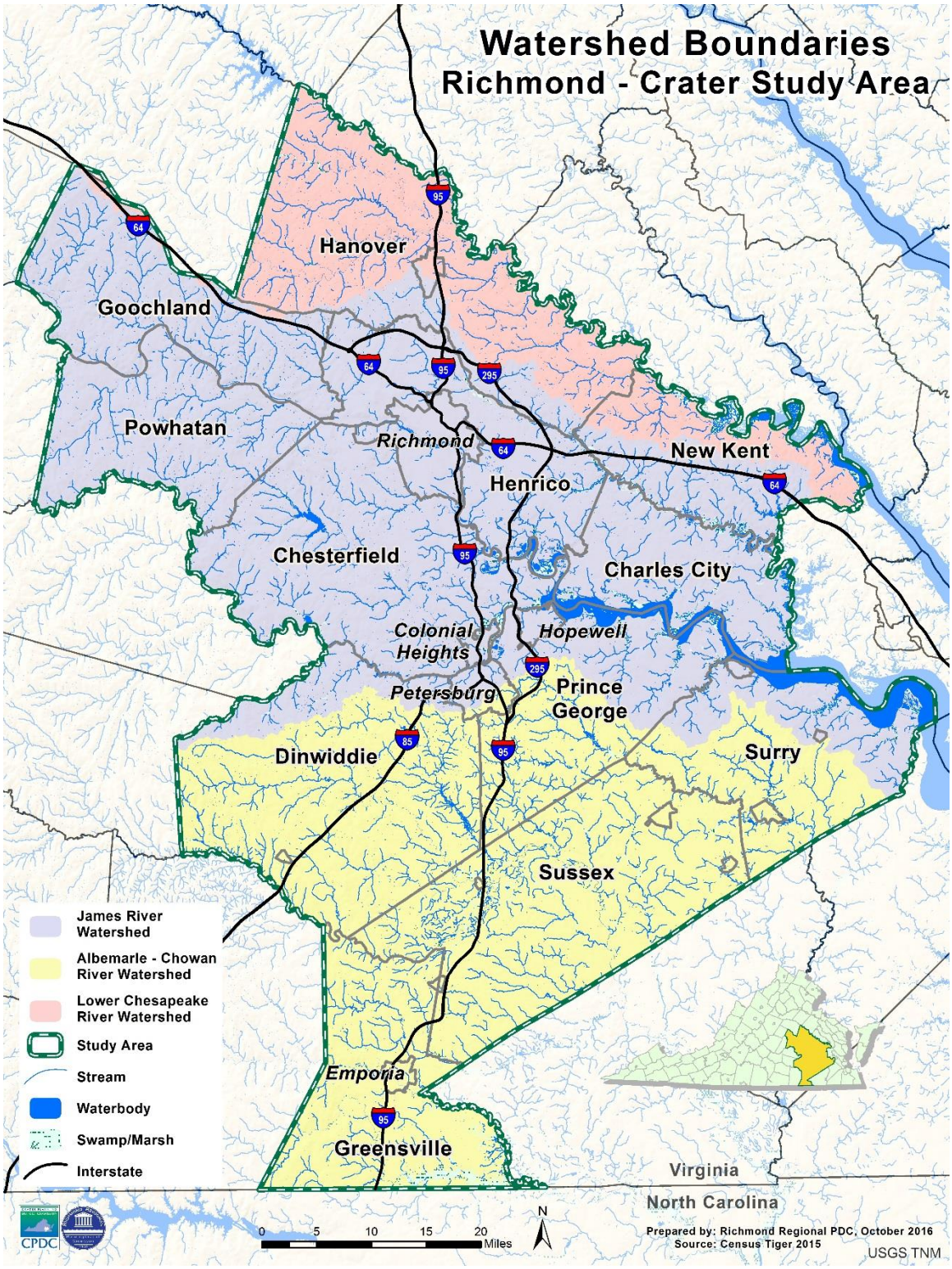


Figure 5-1. Map of Watershed Boundaries

5.6.6 Flood Maps

FEMA, through the NFIP, has developed Flood Insurance Rate Maps (FIRMs) that identify flood zones through detailed hydrologic and hydraulic studies. These flood zones represent the areas susceptible to the 1% annual chance flood (100-year flood) and the 0.2% annual chance flood (500-year flood). In most places in the region, there is little to no difference in the 100-year and 500-year floodplain. Whenever possible, FEMA also determines a base flood elevation (BFE) for the 100-year floodplain, which is the calculated elevation of flooding during this event. The BFE is a commonly used standard level for determining flood risk and managing potential floodplain development. Although each specific flood event is different, these maps provide a more definitive representation of the highest flood risks in the communities.

Since the 2006 analysis, FEMA's Digital Flood Insurance Rate Maps (DFIRMs) were made available for the majority of the region in digital format. This data was made available by VDEM as an export of the National Flood Hazard Layer (NFHL), preliminary DFIRMs and digitized FIRMs. The NFHL dataset is a compilation of effective DFIRM databases and Letters of Map Change. The NFHL is updated as studies become effective and extracts are made available to the public monthly. The preliminary DFIRMS that have been made available through FEMA and become the governing maps for the locality once adopted by the local government elected body and labeled as "effective." For jurisdictions where the digital FIRMs were not available from FEMA, this plan uses digitized versions of these maps supplied by VDEM. These are used to get a general sense of where flooding occurs for those locations and have not been attributed with the flood zones. For local planning and flood enforcement, localities should always use the effective flood data from FEMA. Figure 5-2 shows the extent of the mapped floodplains in the region; Table 5-6 shows the type of FIRM that was available for analysis.

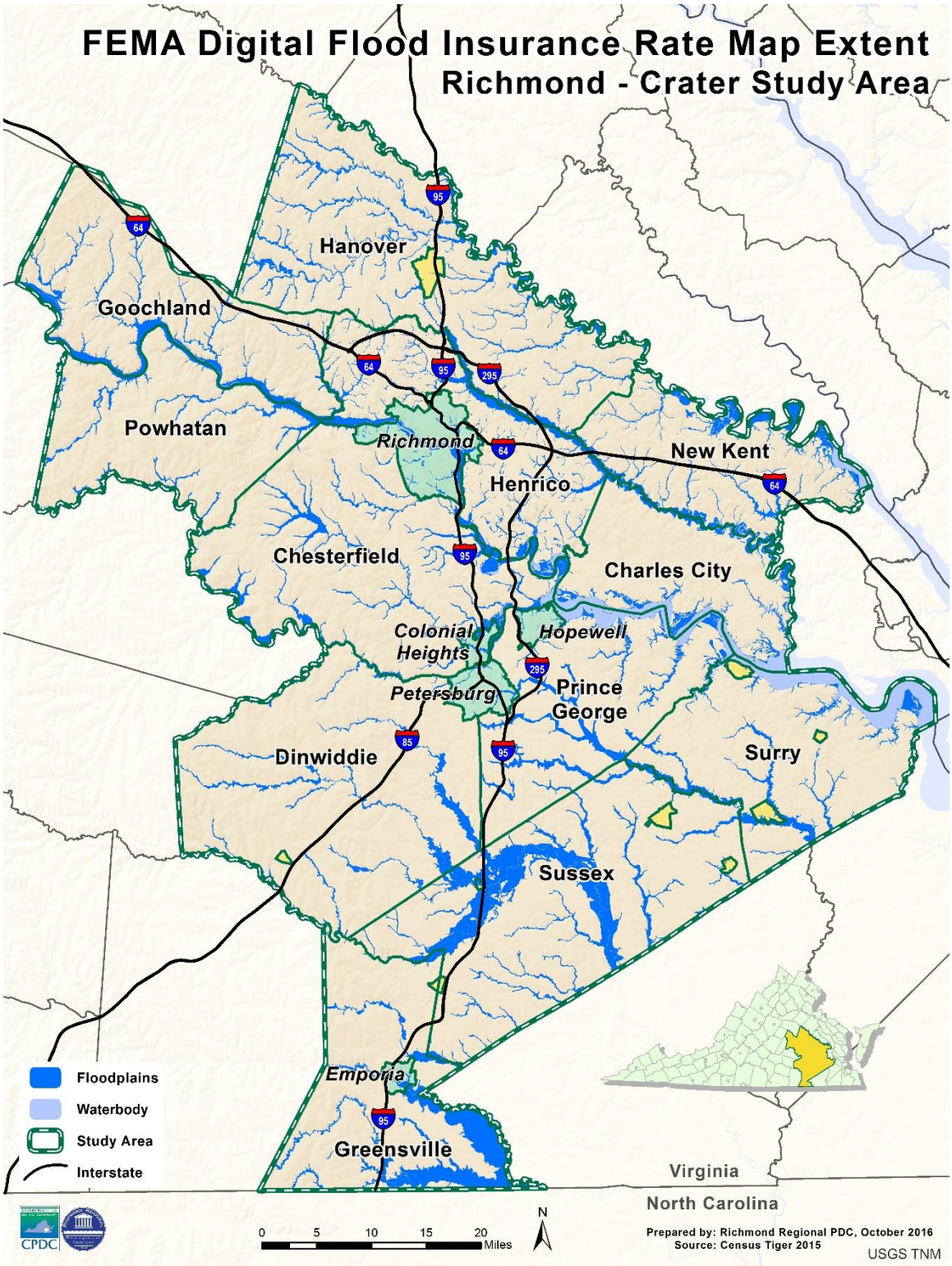


Figure 5-2. FEMA Digital Flood Insurance Rate Map Extent

5.6.7 National Flood Insurance Program

Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary.

Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly $1 billion a year through communities implementing sound floodplain management requirements, and property owners purchasing flood insurance. Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80% less damage annually than those not built in compliance.

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the nation's floodplains. Mapping of flood hazards creates broad-based awareness of these hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.

Floodplain management regulations are the cornerstone of NFIP participation. Communities that participate in the NFIP are expected to adopt and enforce floodplain management regulations. These regulations apply to all types of floodplain development and ensure that development activities will not cause an increase in future flood damages. Buildings are required to be elevated at or above the BFE. It should be noted that Chesterfield, Goochland, and Powhatan Counties all have very strong floodplain management programs.

Table 5-8 shows the dates that each of the jurisdictions were identified with Flood Hazard Boundary Maps (FHBM), the date the first Flood Insurance Rate Maps (FIRMs) became effective, the date of the current FIRMs used for insurance purposes, and the date the community entered into the NFIP. This table also shows the FIRM source that was used for the flood analysis.

Table 5-8. Communities Participating in the NFIP as of August 10, 2016

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
Charles City County	Charles City County	01/17/75	09/05/09	07/06/15	09/05/09
Chesterfield County	Chesterfield County	01/10/75	03/16/83	12/18/12	03/16/83
City of Colonial Heights	City of Colonial Heights	06/14/74	09/02/81	08/02/12	09/02/81
Dinwiddie County	Dinwiddie County	11/15/74	01/17/79	06/16/11	01/17/79
	Town of McKenney	-	*06/16/11*	*(NSFHA)*	*11/20/81*
City of Emporia	City of Emporia	07/23/76	02/02/89	07/07/09	09/30/77
Goochland County	Goochland County	02/21/75	03/01/79	12/02/08	03/01/79
Greensville County	Greensville County	12/20/74	09/29/78	07/07/09	09/29/78
	*Town of Jarratt**	*07/30/76*	*10/08/82*	*07/07/09(M)*	*10/08/82*
Hanover County	Hanover County	12/13/74	09/02/81	12/02/08	09/02/81
	Town of Ashland	*05/24/74*	*12/02/08*	*12/02/08*	*05/26/78*
Henrico County	Henrico County	11/22/74	02/04/81	12/18/07	02/04/81
City of Hopewell	City of Hopewell	06/14/74	09/05/79	07/16/15	09/05/79
New Kent County	New Kent County	01/31/75	12/05/90	08/03/15	12/05/90
City of Petersburg	City of Petersburg	05/31/74	03/16/81	02/04/11	03/16/81
Powhatan County	Powhatan County	09/13/74	09/15/78	02/06/08	09/15/78
Prince George County	Prince George County	01/24/75	05/01/80	06/02/15	05/01/80
City of Richmond	City of Richmond	12/06/74	06/15/79	07/16/14	06/15/79
Surry County	Surry County	12/06/74	11/02/90	05/04/15	11/02/90
	Town of Claremont	*04/04/75*	*11/02/90*	*05/04/15*	*10/16/90*
	*Town of Dendron***	-	-	-	-
	*Town of Surry***	-	-	-	-
Sussex County	Sussex County	06/09/78	03/02/83	07/07/09	03/02/83
	*Town of Jarratt**	*07/30/76*	*10/08/82*	*07/07/09(M)*	*10/08/82*
	Town of Stony Creek	*08/09/74*	*09/16/82*	*07/07/09*	*09/16/82*
	Town of Wakefield	*08/26/77*	*07/23/82*	*07/07/09(M)*	*03/12/14*
	*Town of Waverly***	-	-	-	-

*Town of Jarratt is listed in Greensville County in the FEMA Community Status Book Report
**Town not in FEMA Community Status Book Report
Source: http://www.fema.gov/cis/VA.html

As of June 30, 2017, there were 3,423 flood insurance policies-in-force in the region, accounting for 3.3% of the total policies in the Commonwealth. These policies amounted to more than $929 million in total insurance coverage. Approximately 1,327 claims have been filed, accounting for $21.6 million in payments. The City of Richmond makes up 49% of the

total claims payments followed by Henrico County (14%) and Chesterfield County (12%). Table 5-9 shows NFIP policy statistics for each of the participating jurisdictions in the region.

Table 5-9. NFIP Policy and Claim Statistics by Jurisdiction

County/City Name	Jurisdiction Name	Policy Statistics (as of 06/30/2016)		Claim Statistics (01/01/1978 – 06/30/2016)	
		Policies-In-Force	Insurance In-Force	Total Claims	Total Payment
Charles City County	Charles City County	20	$6,320,700	7	$42,606
Chesterfield County	Chesterfield County	864	$231,463,100	175	$2,580,112
City of Colonial Heights	City of Colonial Heights	112	$27,581,600	79	$1,061,117
Dinwiddie County	Dinwiddie County	39	$10,729,600	2	$11,979
	Town of McKenney	-	-	-	-
City of Emporia	City of Emporia	38	$5,400,900	10	$6,060
Goochland County	Goochland County	47	$14,506,100	12	$137,267
Greensville County	Greensville County	17	$3,630,900	4	$26,145
	Town of Jarratt	-	-	-	-
Hanover County	Hanover County	177	$51,675,300	23	$253,608
	Town of Ashland	*44*	*$13,629,600*	*3*	*$4,655*
Henrico County	Henrico County	986	$246,491,700	240	$2,978,970
City of Hopewell	City of Hopewell	26	$7,607,000	11	$101,018
New Kent County	New Kent County	119	$34,367,100	29	$488,862
City of Petersburg	City of Petersburg	137	$38,183,500	76	$481,948
Powhatan County	Powhatan County	30	$8,480,000	1	4867.3
Prince George County	Prince George County	94	$25,420,500	27	$223,737
City of Richmond	City of Richmond	586	$183,772,500	515	$10,666,886
Surry County	Surry County	25	$7,135,400	40	$1,172,614
	Town of Claremont	*16*	*$4,319,800*	*38*	*$1,273,693*
	Town of Dendron	-	-	-	-
	Town of Surry	-	-	-	-
Sussex County	Sussex County	24	$5,016,700	12	$47,630
	Town of Jarratt	-	-	-	-
	Town of Stony Creek	*22*	*$3,653,500*	*23*	*$96,039*
	Town of Wakefield	-	-	-	-
	Town of Waverly	-	-	-	-
Region Total		**3,423**	**$929,385,500**	**1,327**	**$21,659,816**
Virginia Total		**104,766**	**$26,627,973,200**	**44,762**	**$637,755,766.40**

5.6.8 FEMA Repetitive Loss and Severe Repetitive Loss Properties

A repetitive loss (RL) property is a property that is insured under the NFIP and has filed two or more claims in excess of $1,000 each, within a 10-year period. Nationwide, RL properties constitute 2% of all NFIP insured properties, but are responsible for 40% of all NFIP claims. Mitigation for RL properties is a high priority for FEMA, and the areas in which these properties are located typically represent the most flood prone areas of a community.

The identification of RL properties is an important element to conducting a local flood risk assessment, as the inherent characteristics of properties with multiple flood losses strongly suggest that they will be threatened by continual losses. RL properties are also important to the NFIP, since structures that flood frequently put a strain on NFIP funds. Under the NFIP, FEMA defines an RL property as "any NFIP-insured property that, since 1978 and regardless of any change(s) of ownership during that period, has experienced: a) four or more paid flood losses; or b) two paid flood losses within a 10-year period that equal or exceed the current value of the insured property; or c) three or more paid losses that equal or exceed the current value of the insured property." A primary goal of FEMA is to reduce the numbers of structures that meet these criteria, whether through elevation, acquisition, relocation, or a flood control project that lessens the potential for continual losses.

According to FEMA, there are currently 14 RL properties within the Richmond-Crater region accounting for 66 losses. The specific addresses of the properties are maintained by FEMA, VDEM, and local jurisdictions, but are deliberately not included in this plan as required by law.[7] More than $1.61 million has been paid in total repetitive losses on 66 losses with an average claim of $48,400. This is a decline of about 87% since the 2011 plan but represents the ten-year rolling period eliminating Hurricane Isabel and Gaston losses. Table 5-10 shows the total number of properties, total number of losses experienced, and losses paid for all of the communities within the planning region. The majority of the RL properties are residential.

A severe repetitive loss (SRL) property has: a) at least four NFIP claims payments of more than $5,000 each, with the cumulative amount of such claims payments exceeding $20,000; or b) at least two separate claims payments with the cumulative amount exceeding the market value of the building. Chesterfield County has one SRL property, City of Colonial Heights as two, Henrico County has five, Prince George County has one, and the Town of Claremont has one. Compared to previous mitigation plans, there are significantly less RL and SRL properties as of 2017 than were in the 2011 plan due to the rolling ten year period of the FEMA-provided lists.

[7] NFIP repetitive loss data is protected under the federal Privacy Act of 1974 (5 U.S.C. 552a) which prohibits personal identifiers (i.e., owner names, addresses, etc.) from being published in local mitigation plans.

Table 5-10. NFIP Repetitive Loss and Severe Repetitive Loss Property Claim Information										
County/City Name	**Jurisdiction Name**	**RL Buildings**	**RL Losses**	**Total Payments**	**Property value**	**SRL Buildings**	**Number of Claims**	**Building Payments**	**Average Claim**	**Property Value**
Charles City County	Charles City County	-	-	-	-	-	-	-	-	-
Chesterfield County	Chesterfield County	1	4	$70,732.52	$373,439.00	**1**	4	$70,732.52	$17,683.13	$374,439.00
City of Colonial Heights	City of Colonial Heights	2	10	$217,911.69	$1,000,000.00	2	10	$217,911.69	$43,552.34	$1,000,000.00
Dinwiddie County	Dinwiddie County	-	-	-	-	-	-	-	-	-
City of Emporia	City of Emporia	-	-	-	-	-	-	-	-	-
Goochland County	Goochland County	-	-	-	-	-	-	-	-	-
Greensville County	Greensville County	-	-	-	-	-	-	-	-	-
Hanover County	Hanover County	-	-	-	-	-	-	-	-	-
	Town of Ashland	-	-	-	-	-	-	-	-	-
Henrico County	Henrico County	6	40	$956,563.38	$2,018,327.00	5	40	$956,563.38	$138,203.73	$1,585,330.00
City of Hopewell	City of Hopewell	-	-	-	-	-	-	-	-	-
New Kent County	New Kent County	-	-	-	-	-	-	-	-	-
City of Petersburg	City of Petersburg	-	-	-	-	-	-	-	-	-
Powhatan County	Powhatan County	-	-	-	-	-	-	-	-	-
Prince George County	Prince George County	1	4	$72,822.55	$253,076.00	1	4	$72,822.55	$18,205.64	$253,076.00
City of Richmond	City of Richmond	3	4	$113,231.76	$27,500.00	-	-	-	$28,307.94	-
Surry County	Surry County	-	-	-	-	-	-	-	-	-
	Town of Claremont	1	4	$176,688.15	$204,365.00	1	4	$176,688.15	$44,172.04	$204,365.00
Sussex County	Sussex County	-	-	-	-	-	-	-	-	-
	Town of Stony Creek	-	-	-	-	-	-	-	-	-
TOTAL FOR REGIONS	**REGIONAL TOTAL**	**14**	**66**	**$1,607,950.05**	**$3,876,707.00**	**10**	**62**	**$1,494,718.29**	**$290,124.82**	**$3,417,210.00**

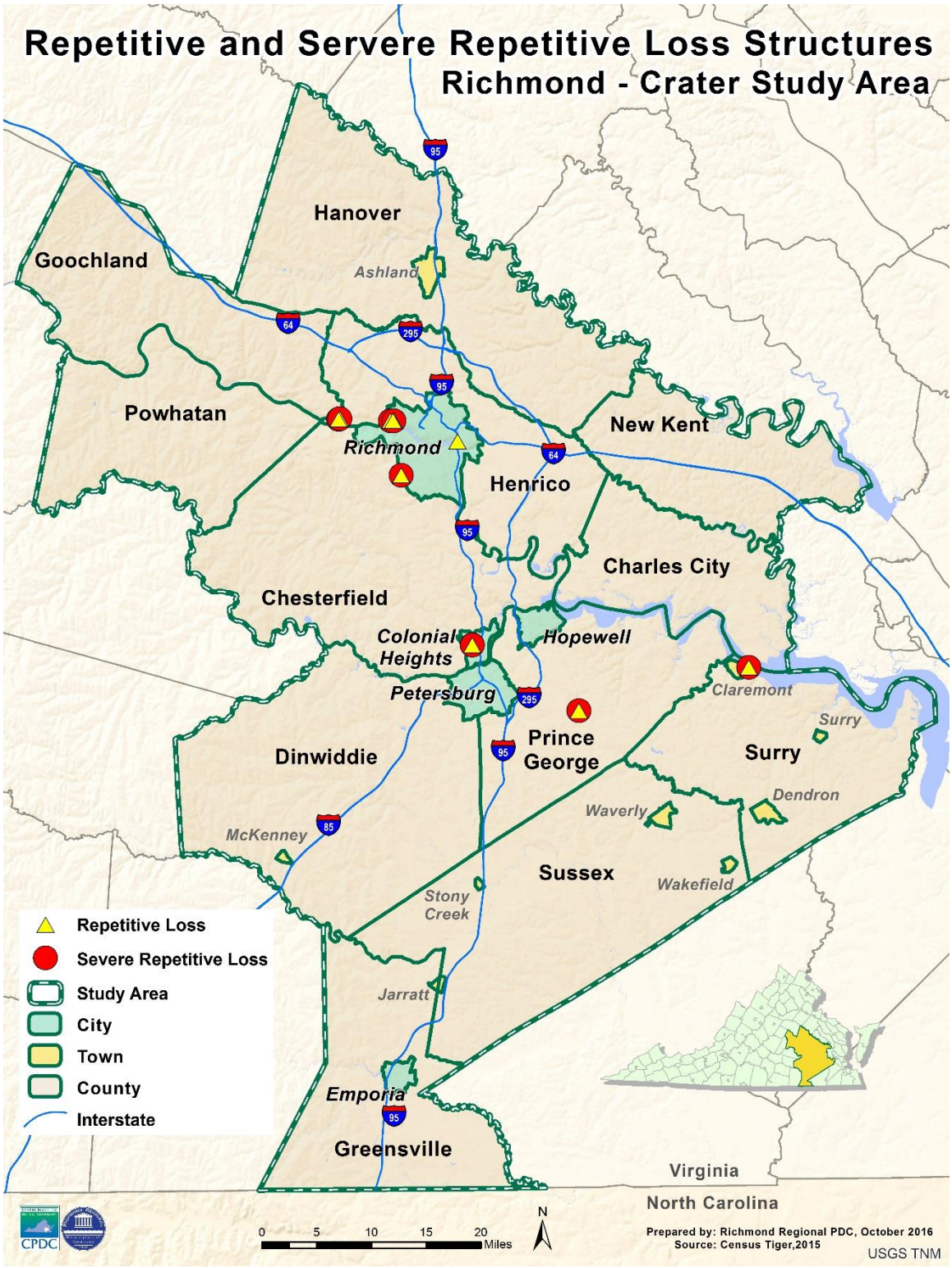


Figure 5-3. Repetitive and Severe Repetitive Loss Properties

5.6.9 Vulnerability Analysis

Probability

Floods typically are characterized by frequency, for example, the "1%-annual chance flood," commonly referred to as the "100-year" flood. While more frequent floods do occur, in addition to larger events that have lower probabilities of occurrence, for most regulatory and hazard identification purposes, the 1%-annual chance flood is used.

Impact and Vulnerability

Flooding impacts a community to the degree that it affects the lives of its citizens and overall community functions. Therefore, the most vulnerable areas of a community will be those most affected by floodwaters in terms of potential loss of life, damages to homes and businesses, and disruption of community services and utilities. For example, an area with a highly developed floodplain is significantly more vulnerable to the impacts of flooding than a rural or undeveloped floodplain where potential floodwaters would have less impact on the community.

A number of factors contribute to the relative vulnerabilities of certain areas in the floodplain. Development, or the presence of people and property in the hazardous areas, is a critical factor in determining vulnerability to flooding. Additional factors that contribute to flood vulnerability range from specific characteristics of the floodplain to characteristics of the structures located within the floodplain. The following is a brief discussion of some of these factors and how they may relate to the area.

Flood depth: The greater the depth of flooding, the higher the potential for significant damages.

Flood duration: The longer duration of time that floodwaters are in contact with building components, such as structural members, interior finishes, and mechanical equipment, the greater the potential for damage. Floodwaters may linger because of the low relief of the area, but the degree varies.

Velocity: Flowing water exerts force on the structural members of a building, increasing the likelihood of significant damage. A 1-foot depth of water, flowing at a velocity of 5 feet per second or greater, can knock an adult over and cause significant scour around structures and roadways.[8]

Elevation: The lowest possible point where floodwaters may enter a structure is the most significant factor contributing to its vulnerability to damage due to flooding. Data on the specific elevations of structures in the Richmond-Crater region has not been compiled for use in this analysis.

Construction type: Certain types of construction are more resistant to the effects of floodwaters than others. Masonry buildings, constructed of brick or concrete blocks, are

[8] FEMA. *Principles and Practices for Retrofitting Flood Prone Residential Buildings* (FEMA 259). June 2001.

typically the most resistant to flood damages simply because masonry materials can be in contact with limited depths of water without sustaining significant damage. Wood frame structures are more susceptible to flood damage because the construction materials used are easily damaged when inundated with water. The type of construction throughout the Planning District varies from area to area.

Risk Methodologies

Several methods were used to quantify vulnerability due to flooding. The following sections highlight risk and potential losses to structures, risk to critical facilities, and jurisdictional risk based on census blocks. The risk analyses completed in the 2006 mitigation plan should be referenced for comparison, but has not been kept for the flood, wind, and critical facilities evaluations. These have been updated and expanded based on best available data (structures, DFIRMs, and Census Block data). Appendix B provides a detailed summary of the analysis completed and the accompanying GIS files. This data should be referenced for specific information on structures and critical facilities at risk, and for use in potential mitigation projects.

The section on Structures at Risk for the 2006 plan was based on 10% greater than the average house value by census block; as a result, the values presented most likely underestimated vulnerability since only residential housing units were accounted for. For the 2017 analysis, a new methodology called Total Exposure in Floodplain (TEIF) version 2.0 was used. This TEIF 2.0 methodology uses the effective SFHA with building footprint, tax assessed value, and estimated contents value provided by the jurisdictions to find the annualized estimated losses from floods. These values were then generalized to 1000 ft^2 blocks to highlight potential loss areas and not target individual structures.

The section on Critical Facilities at Risk for the 2006 plan was based on data compiled from the PDCs and supplemented with HAZUS-MH, ESRI, and U.S. census data; this data was not maintained and is thought to be out of date. The 2017 plan update uses only data furnished by the localities supplemented with state databases and does not include data from HAZUS-MH, ESRI, or the U.S. Census. The Richmond Regional PDC was able to create a critical facility GIS layer, with jurisdictional input, that best represents their critical facilities. The same critical facility risk analysis was performed for the update as in the original plan. The resulting figures may be found in redacted Appendix I for local emergency management and regional planning purposes.

TEIF 2.0 Revised Analysis for 2017 Update

In support of FEMA's RiskMAP Program, FEMA endeavored to produce national-level flood risk analyses to estimate the potential losses from flooding across the Lower 48 states. This effort occurred circa 2009/2010 and produced a product known as the 2010 AAL Study Results. The 2010 AAL Study and its associated results were intended to be a mechanism for FEMA - as well as local stakeholders - to assist in the prioritization of flood mitigation activities across the lower 48 states. Further information on the 2010 AAL Results and its

use in RiskMAP Risk Assessments can be viewed in Guidance for Flood Risk Analysis and Mapping (May 2014). Notably, there were some problem areas within FEMA Region III in which the Hazus software was unable to produce valid results for the 2010 AAL Study in certain coastal areas. Lack of estimated flood damages limited the Region's ability to assess potential damage across the entirety of the regional geography. Consequently, FEMA Region III considered alternative methodologies which brought about the concept of Total Exposure in Floodplain (TEIF). The TEIF 1.0 approach was created during 2012 in FEMA Region III and a more refined enhanced method of TEIF 2.0 has been used since 2015 based on the availability of local data and local hazard mitigation plan update cycle. Each analysis type performed over recent years seeks to transcend the previous and as noted, fill analysis gaps where such gaps may exist. Chronologically the first analysis performed was the FEMA AAL Project, then TEIF1.0 and finally TEIF2.0.

FEMA Region III has performed the TEIF 2.0 analysis to help local jurisdictions supplement Hazard Mitigation Plans as well as general hazard mitigation planning efforts. A primary assumption of the planning process is that FEMA, states and local jurisdictions have limited resources and not all issues can be solved at the same time; consequently, way to define priorities (i.e. ranking) is a valuable tool to the planning process. TEIF 2.0 is an analysis methodology that estimates the exposure or replacement value of buildings that are exposed to the Special Flood Hazard Area (SFHA) and subsequently rank the estimated (or) potential losses based on what is exposed to flooding in the special flood hazard area.

The TEIF 2.0 methodology uses building footprints from local jurisdictions to subsequently disperse total replacement values of buildings at the census block-level in FEMA's Hazus software & corresponding Hazus stock data products. The TEIF methodology divides or apportions building replacement values by proportionate methods (area of each respective building footprint). For example if a census block is known to have $1M of value associated with all buildings and there are a total of ten (10) buildings in the census block - each building having the same exact size – a proportional distribution would dictate that each building has a value of $100,000. After Hazus values are dispersed to the building footprints, the buildings that intersect the SFHA can be identified and the portions (or percent area) of buildings that are within the floodplain can be calculated. Ultimately, the dispersed replacement values can be tallied (or summarized) for the dollar value associated with each respective building that is entirely or partially in the floodplain. These values are then generalized into 1000 ft^2 blocks to comply with regulations [9] and not target individual structures or building owners.

In Table 5-11, individual jurisdictions were evaluated and ranked in the study area using the TEIF 2.0 revised analysis (except for City of Colonial Heights, which did not have building footprints at time of analysis). The City of Richmond has the highest flood risk estimated at nearly $217M in damages.

[9] Federal Privacy Act of 1974 (5 U.S.C. 552a) which prohibits personal identifiers (i.e., owner names, addresses, etc.) from being published in local mitigation plans.

Table 5-11: TEIF 2.0 (Oct 2016) Flood Risk

County/City	Jurisdiction	Annual Flood Risk	RANK [3]
Richmond City	Richmond city	$216,860,946.07	1
Henrico	Henrico County	$192,425,423.55	2
Chesterfield	Chesterfield County	$148,205,562.76	3
Petersburg City	Petersburg City	$87,017,560.55	4
Hanover	Hanover County	$61,441,447.65	5
Colonial Heights City	Colonial Heights City	$56,748,000.00 [2]	6
Hopewell City	Hopewell City	$38,315,100.27	7
New Kent	New Kent County	$26,067,007.09	8
Emporia City	Emporia City	$24,920,647.06	9
Prince George	Prince George County	$24,254,929.53	10
Sussex	Sussex County	$22,090,235.97	11
Sussex	Stony Creek Town	$18,266,774.55	12
Hanover	Ashland Town	$14,059,819.51	13
Dinwiddie	Dinwiddie County	$13,507,442.21	14
Goochland	Goochland County	$12,715,952.30	15
Surry	Surry County	$7,735,588.38	16
Powhatan	Powhatan County	$7,674,751.05	17
Greensville	Greensville County	$6,613,369.74	18
Surry	Claremont town	$6,330,052.27	19
Charles City	Charles City County	$2,833,653.27	20
Sussex	Wakefield Town	$301,433.37	21
Sussex	Waverly Town	$0.00	22
Dinwiddie	McKenney Town	$0.00	22
Sussex	Jarratt Town	$0.00	22
Surry	Dendron Town	$0.00	22
Surry	Surry Town	$0.00	22

[1] FEMA Region III - TEIF 2.0 October 2016. Value represents estimated loss to buildings only; value does not include estimated loss to contents or any other element.
[2] TEIF 2.0 not performed in Colonial Heights because GIS Building Footprints were not available; value is based on Hazus Level 1 depth grid creation per discharge analyses where, flow discharges are from FEMA Flood Insurance Study (FIS 510039V000A Revised: August 2, 2012) and ground data utilized includes 10m National Elevation Dataset (NED) Digital Elevation Model (DEM) obtained October 2016.
[3] RANK- this is NOT a statewide rank only internal to Crater-Richmond PDC's.

The flood maps for the TEIF 2.0 results can be found in Appendix G.

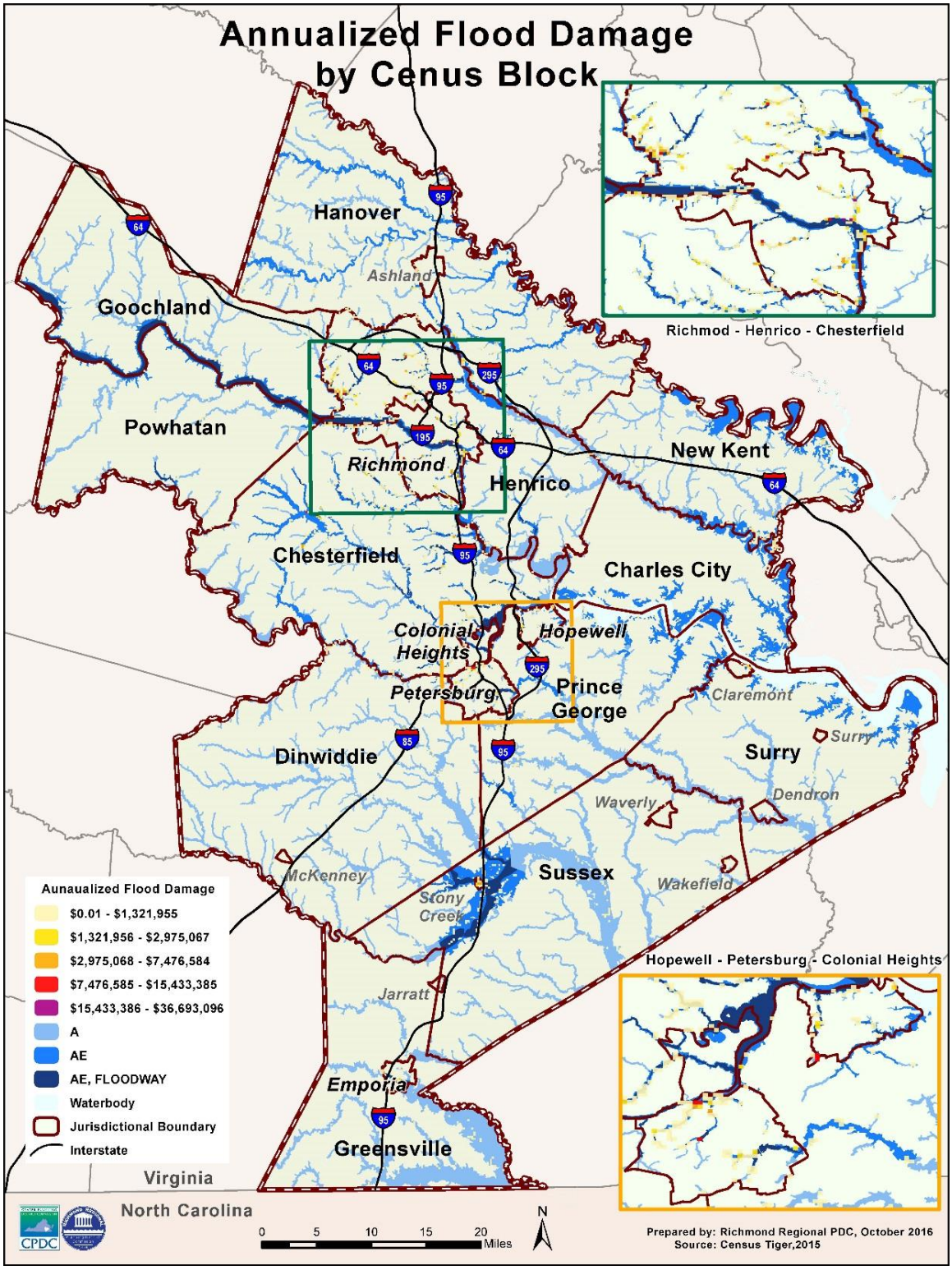


Figure 5-4. FEMA Flood Zones

Annualized NCDC Events and Damages

For comparison, the National Climatic Data Center (NCDC) flood events have been annualized and summarized in Table 5-12. Based on past occurrences, the region can expect $2.67 million in property damages as compared to the estimated $6.5 million based on the TEIF analysis.

Recurrence intervals can be estimated using the number of flood occurrences over a period of time. According to the NCDC database, there have been 174 recorded flood events for the region that have caused notable floods in the past 17 years, for a flood recurrence interval of approximately 14.5 events per year, with each event averaging about $333,000 in property and around $34,900 in crop damages, for a total of about $367,900 in damages. Greensville, Sussex, and Chesterfield Counties will likely experience the most flooding events for the region.

Table 5-12. Annualized Flood Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.29	$0	$0	$0
Chesterfield County	0.92	$287,458	$2,986	$290,444
City of Colonial Heights	0.21	$71,663	$0	$71,663
Dinwiddie County (incl. Town of McKenney)	0.33	$158,993	$25,082	$184,075
City of Emporia	0.13	$12,223	$3,285	$15,508
Goochland County	0.21	$0	$0	$0
Greensville County (incl. Town of Jarratt)	0.54	$71,663	$47,776	$119,439
Hanover County (incl. Town of Ashland)	0.38	$109,340	$0	$109,340
Henrico County	0.13	$141,487	$0	$141,487
City of Hopewell	0.25	$0	$0	$0
New Kent County	0.58	$38,966	$0	$38,966
City of Petersburg	0.58	$38,818	$11,944	$50,761
Powhatan County	0.42	$0	$0	$0
Prince George County	0.42	$94,711	$63,618	$158,329
City of Richmond	0.58	$1,065,175	$0	$1,065,175
Surry County (incl. Towns of Claremont, Dendron, Surry)	0.67	$64,535	$37,014	$101,548
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	0.63	$265,726	$62,187	$327,913
Total	**7.27**	**$2,420,758**	**$253,890**	**$2,674,649**

Source: National Climatic Data Center.

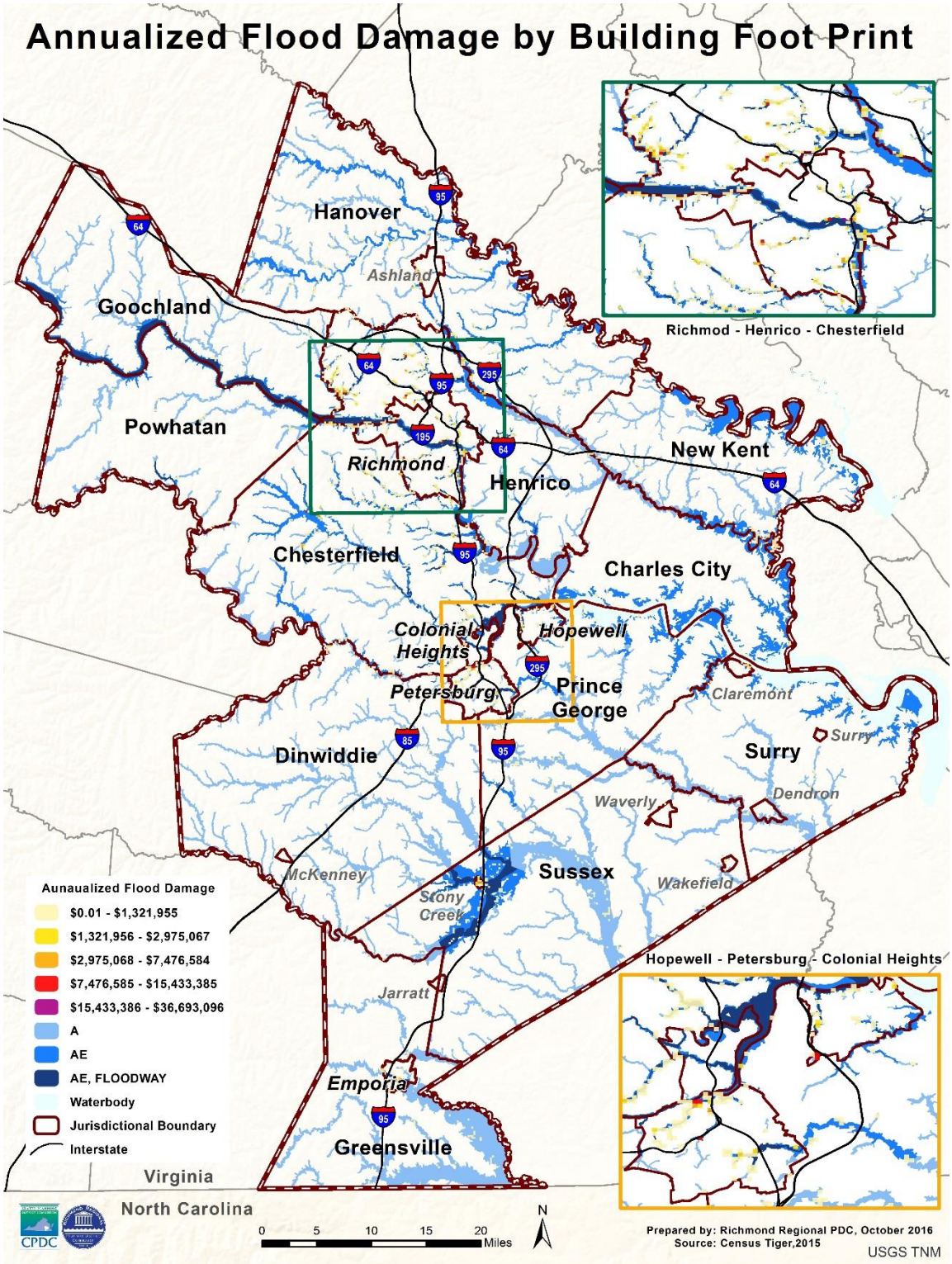


Figure 5-5. Annualized Flood Damage by Building Foot Print

5.7 Wind (including Hurricanes and Thunderstorms)

Wind can be one of the most destructive forces of nature. Strong winds can erode mountains and shorelines, topple trees and buildings, and destroy a community's critical utilities and infrastructure. The analysis in this section focuses on hurricane and tropical storm winds as the most likely type of widespread wind hazards to occur in the region, though more localized damage from high winds also can be caused by straight-line wind events, thunderstorms, and tornadoes. Thunderstorms are capable of producing multiple hazards, including flooding rainfall, hail, cloud-to-ground lightning, and damaging wind. The most frequent hazards associated with severe thunderstorms in the region are excessive winds often leading to power outages and localized flooding often due to inadequate drainage or storm water management. (See Flood section) and damaging wind gusts that are analyzed in this section. Hail and lightning are analyzed in the Thunderstorm section.

5.7.1 Hazard Profile

A tropical cyclone is the generic term for a low pressure, non-frontal synoptic scale low-pressure system over tropical or sub-tropical waters with organized convection and definite cyclonic surface wind circulation.. Tropical cyclones rotate counterclockwise throughout the Northern Hemisphere Depending on strength, these weather systems are classified as hurricanes or tropical storms. They are called tropical depressions when ind speed is less than 39 mph, but become tropical storms when their wind speeds are between 39 mph and 73 mph. When wind speeds reach 74 mph the system is classified as a hurricane. Tropical cyclones involve both atmospheric and hydrologic characteristics, such as severe winds, storm, surge flooding, high waves, coastal erosion, extreme rainfall, thunderstorms, lightning, and, in some cases, tornadoes. Storm surge flooding can push inland, and riverine flooding associated with heavy inland rains can be extensive. High winds are associated with hurricanes, with two significant effects: building damage and power outages due to airborne debris and downed trees.

The hurricane season in the North Atlantic runs from June 1 until November 30, with the peak season between August 15 and October 15. The average hurricane duration after landfall, is 12 to 18 hours. Wind speeds may be reduced by 50% within 12 hours after the storm reaches land. Tropical storms are capable of producing great amounts of in a short period of time. The region experienced more than 12 inches of rain historically during Tropical Depressions Camille, Isabel and Gaston over a shore duration. Hurricanes also can spawn tornadoes.

Storm surge flooding can push inland as was experienced in Claremont and Sunset Beach in Surry County during Hurricane Isabel. Riverine and urban flooding associated with heavy inland rains can be extensive. Many areas of the Coastal Plain region are flat, and intense prolonged rainfall tends to accumulate without ready drainage paths. High winds associated with hurricanes can have two significant effects: 1) widespread debris from damaged and downed trees and damaged buildings, and 2) power outages.

Extreme wind events pose a danger because they can result in localized or widespread power outages, property damage, and falling trees. Mobile homes can be particularly vulnerable to the high winds, especially if improperly installed. Injury or death to people can result from falling objects or flying debris. Extreme wind events can also blow over tractor trailers on the highway and make driving difficult in a high-profile vehicle or lightweight vehicle. They can turn trash cans, lawn and patio furniture, and other property into projectiles resulting in further property damage.

Most deaths in extreme wind events are caused by trees falling onto cars or homes. Dead trees or trees weakened by drought, disease, rotting, or pest infestations are the most susceptible to falling.

Secondary Hazards

Secondary hazards from a hurricane event could include high winds, flooding, high waves, and tornadoes. Once inland, the hurricane's band of thunderstorms produces torrential rains and may produce tornadoes. A foot or more of rain may fall in less than a day causing flash floods and mudslides. The rain eventually drains into the large rivers which may still be flooding for days after the storm has passed. The storm's driving winds can topple trees, utility poles, and damage buildings. Communication and electricity can be lost for days and roads can be impassable due to standing water, fallen trees and debris. Local businesses can be closed for extended periods of time due to building and content damage, loss of utilities, and transportation challenges.

Hurricane Damage Scale

Hurricanes are categorized by the Safer-Simpson Hurricane Damage Scale.

5.7.2 Magnitude or Severity

The strength of a hurricane is classified according to wind speed using the Saffir-Simpson Hurricane Damage Scale. This scale is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf in the landfall region. Table 5-13 provides a description of typical damages associated with each hurricane category.

Table 5-13. Saffir-Simpson Hurricane Damage Scale

Hurricane Category	Sustained Winds (mph)	Damage Potential	Description
1	74–95	Minimal	Minimal damage to unanchored mobile homes along with shrubbery and trees. There may be pier damage and coastal road flooding, with storm surge 4–5 feet above average.
2	96–110	Moderate	Moderate damage potential to mobile homes and piers, as well as significant damage to shrubbery and trees with some damages to roofs, doors, and windows. Impacts include flooding 2-4 hours before arrival of the hurricane in coastal and low-lying areas. Storm surge can be 6–8 feet above average.
3	111–130	Extensive	Extensive damage potential. There will be structural damage to small residences and utility buildings. Extensive damage to mobile homes and trees and shrubbery. Impacts include flooding 3-5 hours before the arrival of the hurricane cutting off the low-lying escape routes. Coastal flooding has the potential to destroy small structures, with significant damage to larger structures as a result of the floating debris. Land that is lower than 5 feet below mean sea level can be flooded 8 or more miles inland. Storm surge can be 6–12 feet above average.
4	131–155	Extreme	Extreme damage potential. Curtain wall failure as well as roof structure failure. Major damage to lower floors near the shoreline. Storm surge generally reaches 13–18 feet above average.
5	> 155	Catastrophic	Severe damage potential. Complete roof failure on residence and industrial structures, with complete destruction of mobile homes. All shrubs, trees, and utility lines blown down. Storm surge is generally greater than 18 feet above average.

5.7.3 Hazard History

Figure 5-6 shows how the frequency and strength of extreme windstorms vary across the United States. The map was produced by FEMA and is based on 40 years of tornado history and more than 100 years of hurricane history. Zone IV, the darkest area on the map, has experienced both the greatest number of tornadoes and the strongest tornadoes. As shown by the map key, wind speeds in Zone IV can be as high as 250 mph. Most of the planning region falls within Zone II (winds up to 160 mph) and is considered to be susceptible to hurricanes.

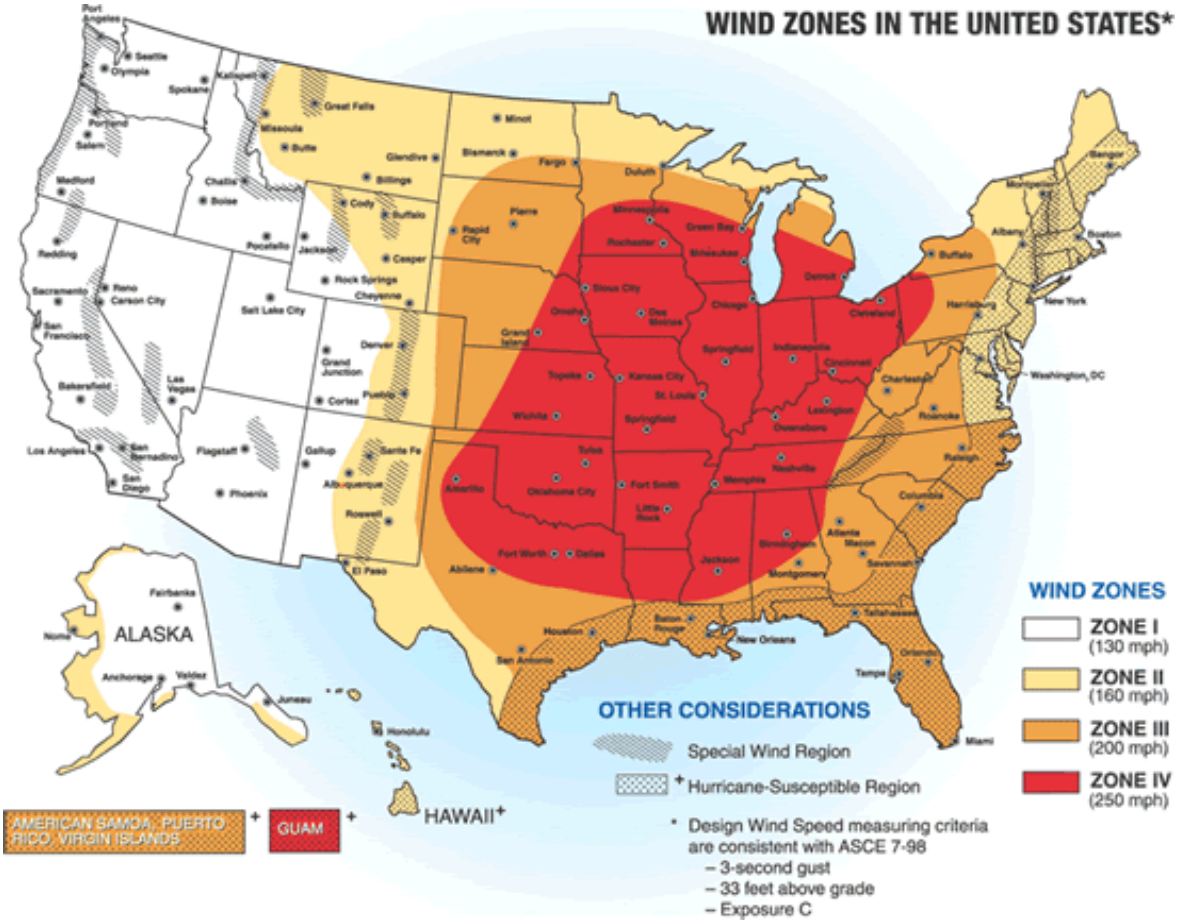


Figure 5-6. Wind Zones in the United States
Source: FEMA

The region is categorized by the American Society of Civil Engineers in its *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) as located in a 90-mph wind zone, based on a 50-year recurrence interval. Based on ASCE 7, the potential wind speed for an event with a 100-year recurrence interval was estimated to be 107% of the 50-year wind speed, or 96.3 mph. The Virginia Uniform Statewide Building Code requires a 90 mph minimum design wind speed.

High wind events have occurred in every portion of the region. There are no proven indicators to predict specifically where high winds may occur, and wind events can be expansive enough to affect the entire area. The counties on the eastern side of the region are marginally closer to the coast and might experience higher wind speeds from tropical storms or hurricanes that make landfall on the Virginia coast.

Based on NCDC historical data dating back to the mid-1990s, there have been 2 deaths and 35 injuries in the region that have resulted from wind, and approximately 8 deaths that

have resulted from hurricanes. Table 5-14 includes descriptions of tropical storm and hurricane events in the region, of which there are several. Events have been broken down by the date of occurrence and when available, by individual community descriptions. When no community-specific description is available, the general description applies to the entire region. Although NCDC and VDEM were the primary source of general descriptions, other sources are referenced where more specific information was available.

Table 5-14. History of Wind Events and Damages, 2011–2016

Date	Damages
August 27, 2011	Hurricane Irene – See full description in Flood section.
September 4, 2011	Hurricane Lee – See full description in Flood section.
June 29, 2012	A devastating line of thunderstorms known as a derecho moved east-southeast at 60 miles per hour (mph) from Indiana in the early afternoon to the Mid-Atlantic region around midnight. Winds were commonly above 60 mph with numerous reports of winds exceeding 80 mph. Some areas reported isolated pockets of winds greater than 100 mph. Nearly every county impacted by this convective system suffered damages and power outages. To make matters worse, the area affected was in the midst of a prolonged heat wave. Unlike many major tornado outbreaks in the recent past, this event was not forecast well in advance. Warm-season derechos, in particular, are often difficult to forecast and frequently result from subtle, small-scale forcing mechanisms that are difficult to resolve more than 12-24 hours in advance. (Source: http://www.nws.noaa.gov/os/assessments/pdfs/derecho12.pdf)
October 26, 2012	Hurricane Sandy made landfall along the southern New Jersey shore on October 29, 2012, causing historic devastation and substantial loss of life. The National Hurricane Center (NHC) Tropical Cyclone Report estimated the death count from Sandy at 147 direct deaths. In the United States, the storm was associated with 72 direct deaths in eight states: 2 in Virginia. The storm also resulted in at least 75 indirect deaths (i.e., related to unsafe or unhealthy conditions that existed during the evacuation phase, occurrence of the hurricane, or during the post-hurricane/clean-up phase). These numbers make Sandy the deadliest hurricane to hit the U.S. mainland since Hurricane Katrina in 2005, as well as the deadliest hurricane/post-tropical cyclone to hit the U.S. East Coast since Hurricane Agnes in 1972. (Source: http://www.nws.noaa.gov/os/assessments/pdfs/Sandy13.pdf)
*History from 1827-2010 in Appendix B-3	

The National Oceanic Atmospheric and Atmospheric Administration's (NOAA) Coastal Services Center maintains historical hurricane, tropical storm, and tropical depression track data dating back to the mid-1880s. Figure 5-7 shows all tropical system and hurricane tracks through and near the region between 1950 and 2015. Most of the tropical systems to pass directly over the region have been at either tropical storm or tropical depression strength, but several hurricanes have directly impacted the area including the Irene and Lee Hurricanes.

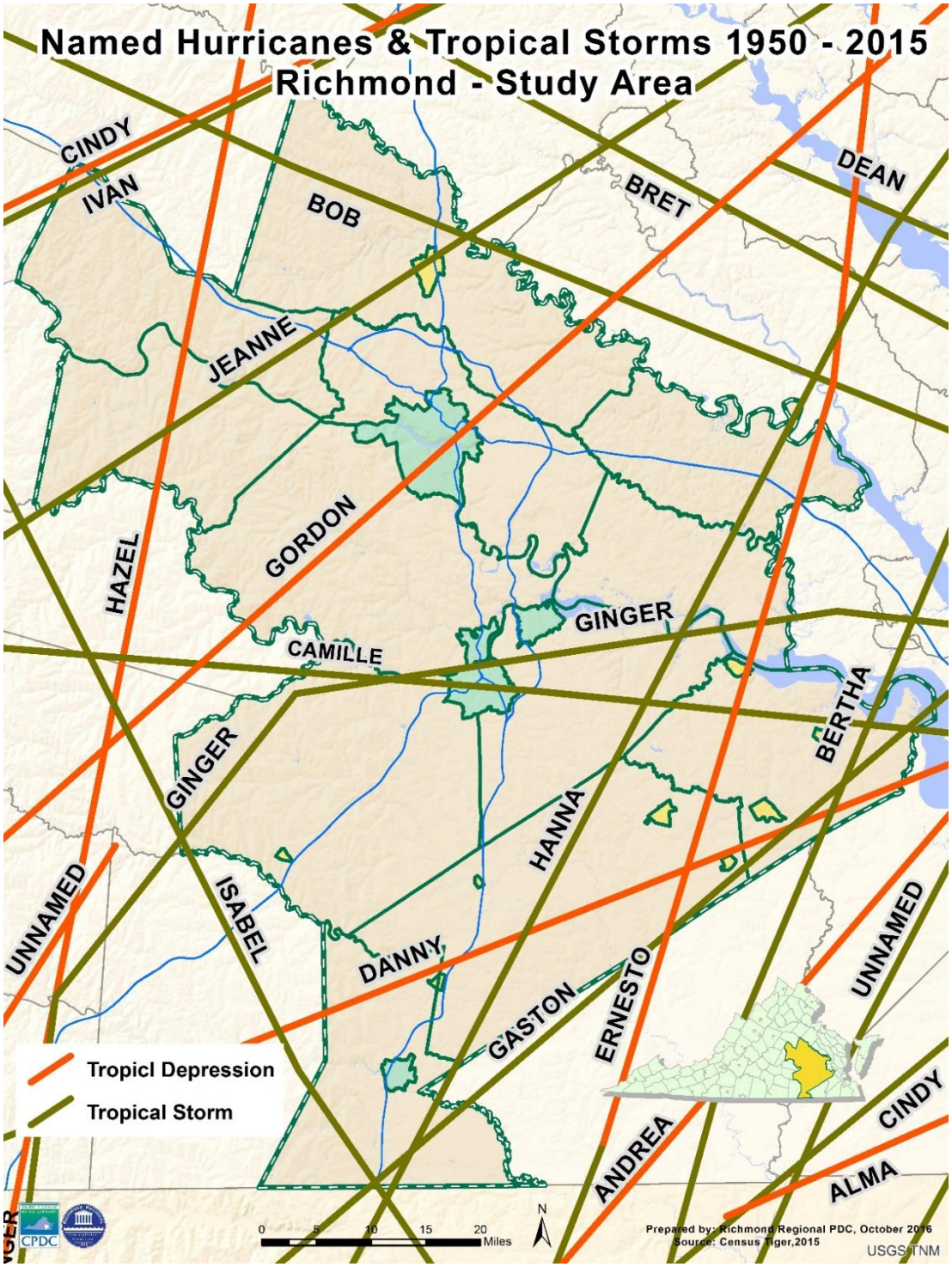


Figure 5-7. Named Hurricane and Tropical Cyclone Tracks, 1950–2015

5.7.4 Vulnerability Analysis

Probability

Hazus has used to complete the wind analysis for vulnerability and loss estimates. The Hazus software has been developed by FEMA and the National Institute of Building Sciences. Level 1, with default parameters, was used for the analysis done in this plan. For analysis purposes, the U.S. Census tracks are the smallest extent in which the model runs. The results of this analysis are captured in the vulnerability analysis and loss estimation.

Hazus-MH uses historical hurricane tracks and computer modeling to identify the probable tracks of a range of hurricane events and then assigns potential wind gusts that result. Figures 5-8 through 5-10 are individual wind speed maps (50-year, 100-year, and 1,000-year events) for the jurisdictions in the region. When a hurricane impacts these areas, these maps can be used to determine what areas are more likely to be impacted than others (at the U.S. Census track level).

Impact and Vulnerability

Results from the model were used to develop the annualized damages. The impacts of these various events are combined to create a total annualized loss or the expected value of loss in any given year. Widespread extreme thunderstorm wind events, such as those associated with well- developed squall lines, may have wind gusts of a similar magnitude to those of the 50- or 100-year hurricane wind event.

In all cases, HAZUS estimates the highest wind gusts to occur over the eastern and southeastern portions of the region, nearest the coast.

The type of building construction will have a significant impact on potential damages from high wind events. Basic Building Types in declining order of vulnerability are: manufactured, non-engineered wood, non-engineered masonry, lightly engineered and fully engineered buildings. A summary of basic building types – listed in order of decreasing vulnerability (from most to least vulnerable) is provided below.

The region includes a variety of building types. The primary residential construction type is wood framed, varying from single story to multiple stories, although some masonry and steel properties are present as well. As mentioned in the previous list, non-engineered wood-framed structures are among the most susceptible to potential damage. With the prevalence of this type of construction throughout the Richmond-Crater region, a majority of structures in the area could be classified to have a high level of vulnerability to damages due to a high wind event. Table 5-15 illustrates the building stock exposure broken down by the type of occupancy, for a total exposure of more than $79.3 billion. As seen in the table, almost 72% of the building stock for the region is considered residential, 18% of the

building stock is commercial, and almost 6% is industrial. The majority of the region's building stock is wood. The building stock type is a main parameter used by HAZUS to determine potential damages; building stock characteristics are important in determining the strength of the structure and how it withstands wind speeds produced by storm events. Specific details on HAZUS loss estimation and building stock can be found online at http://www.fema.gov/plan/prevent/hazus/hz_manuals.shtm.

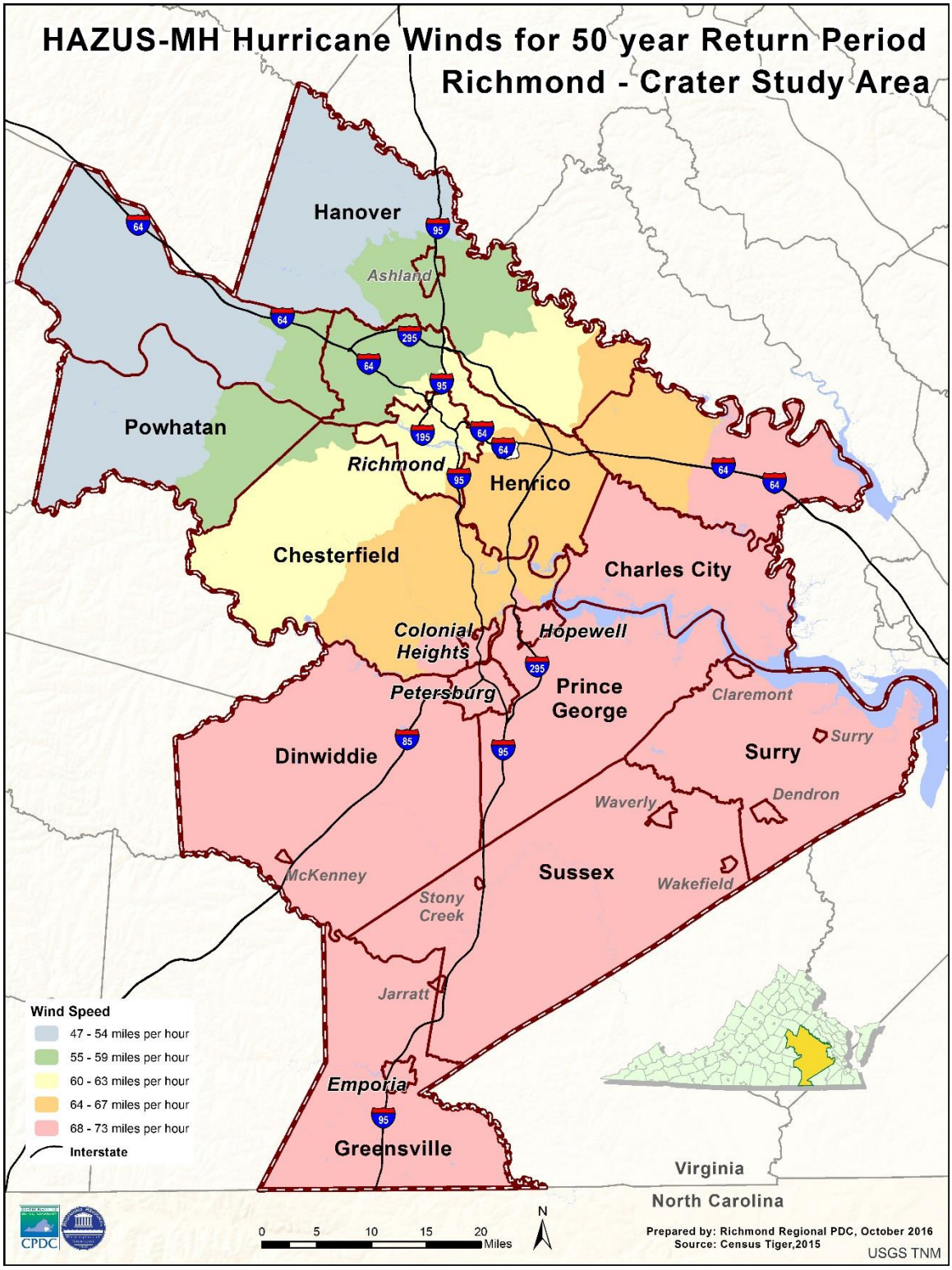


Figure 5-8. Hazus Hurricane Winds for 50-year Return Period

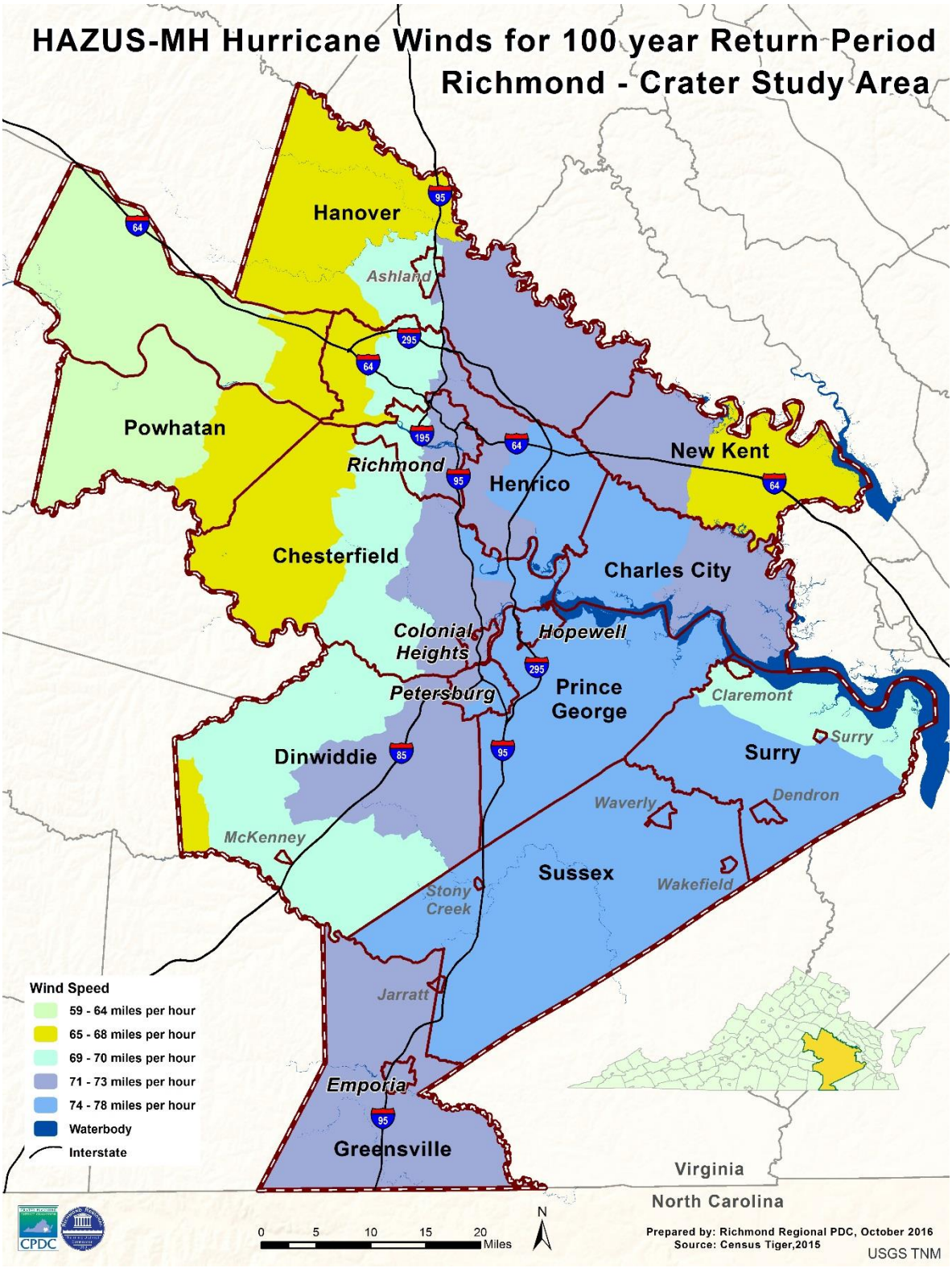


Figure 5-9. HAZUS-MH Hurricane Winds for 100-year Return Period

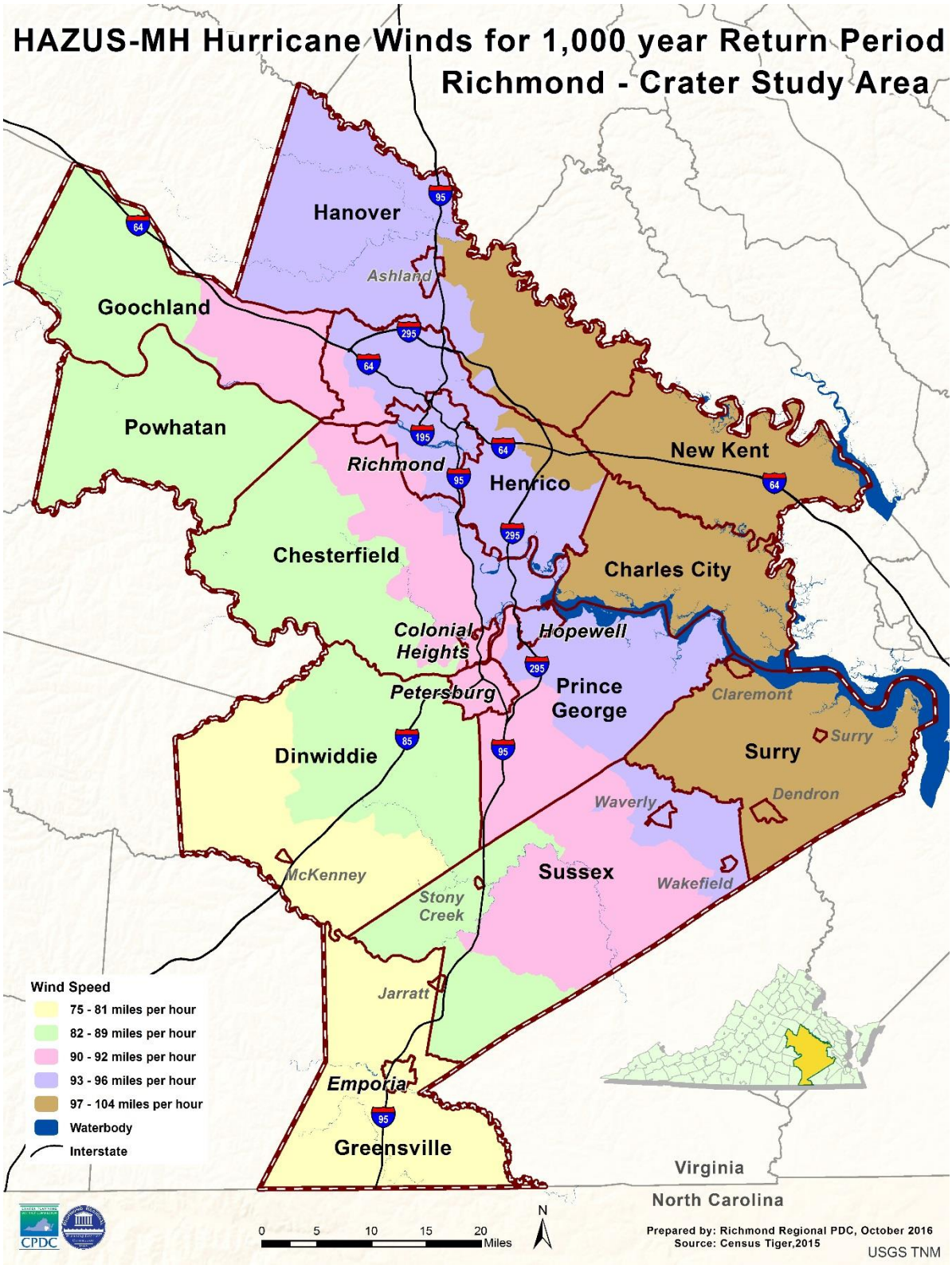


Figure 5-10. HAZUS-MH Hurricane Winds for 1,000-year Return Period

Table 5-15. HAZUS Wind Analysis Damages for 100-year event

Jurisdiction	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
Charles City County	$108,877.70	$1,661.01	$429.04	$268.30	$381.95	$239.87	$159.05	$112,016.92
Chesterfield County	$1,953,673.59	$45,387.75	$17,667.64	$1,344.37	$4,587.23	$2,646.18	$2,728.99	$2,028,035.75
Colonial Heights city	$149,680.36	$14,770.46	$873.95	$109.62	$771.20	$357.23	$343.15	$166,905.97
Dinwiddie County	$196,098.64	$3,267.09	$867.86	$332.85	$585.07	$566.84	$509.17	$202,227.52
Emporia city	$73,579.69	$7,118.41	$3,815.26	$67.38	$913.11	$274.19	$519.59	$86,287.63
Goochland County	$172,917.13	$2,409.33	$615.39	$252.85	$338.71	$153.23	$87.89	$176,774.53
Greensville County	$66,553.53	$1,141.82	$879.23	$185.52	$422.54	$14.88	$37.67	$69,235.19
Hanover County	$1,148,479.33	$22,145.97	$7,866.53	$1,120.84	$2,203.72	$649.93	$3,304.26	$1,185,770.58
Henrico County	$1,718,625.62	$76,972.87	$37,897.11	$2,022.37	$6,102.87	$2,582.52	$5,221.15	$1,849,424.51
Hopewell city	$197,915.84	$8,737.86	$3,397.54	$121.23	$1,803.42	$482.45	$673.90	$213,132.24
Jarratt town*	-	-	-	-	-	-	-	-
McKenney town*	-	-	-	-	-	-	-	-
New Kent County	$381,016.11	$2,699.79	$1,759.29	$187.16	$483.96	$314.71	$336.08	$386,797.10
Petersburg city	$272,210.70	$20,962.86	$16,551.25	$122.48	$2,499.92	$809.91	$751.52	$313,908.64
Powhatan County	$228,147.84	$1,220.43	$466.11	$127.98	$241.38	$65.80	$457.79	$230,727.33
Prince George County	$377,787.09	$6,921.27	$2,460.96	$394.47	$958.33	$1,411.10	$1,193.27	$391,126.49
Richmond city	$989,837.11	$89,028.83	$24,746.34	$772.80	$15,082.47	$8,120.71	$7,014.40	$1,134,602.66
Surry town*	-	-	-	-	-	-	-	-
Sussex County	$76,234.87	$1,698.86	$1,459.69	$277.80	$580.82	$462.84	$228.08	$80,942.96
Wakefield town*	-	-	-	-	-	-	-	-
Grand Total	**$8,111,635.15**	**$306,144.61**	**$121,753.19**	**$7,708.02**	**$37,956.70**	**$19,152.39**	**$23,565.96**	**$8,627,916.02**

Risk and Loss Estimation

As shown in Figures 5-8 through 5-10, there is a slight variation (around 10%) from the eastern to western portions of the region of wind speed in the 50-, 100-, and 1,000-year storm events. In general, critical facilities located in the eastern portion of the region will have slightly higher vulnerability than those in the western portion of the region due to a greater likelihood of higher winds associated with tropical storms and hurricanes. Building construction type will largely determine the vulnerability of a particular facility. As described previously in the section on Building Types, wood-framed structures are more vulnerable to wind than those constructed of masonry or steel.

The Hazus hurricane model only allows for analysis at the U.S. Census track level, which is smaller than most of the towns in the region. Individual maps are found in each jurisdiction's Executive Summary (Appendix G). These maps show the census blocks where hurricane losses occur.

In addition to widespread wind events associated with tropical storms and hurricanes, NCDC records show that the region experiences a significant number of other types of wind events that produce damaging wind gusts. These range from wide-scale events associated with fronts, storm systems, squall lines, or large thunderstorm complexes to smaller scale phenomena such as single-cell thunderstorm events. For example, thunderstorm winds downed numerous trees causing power outages throughout central Virginia in June and July, 2017. Numerous traffic intersections lost power to traffic signals, in one instance causing a fatal accident in Henrico County. Table 5-16 illustrates the historical annual hurricane occurrence in the region with Prince George, Chesterfield, and Henrico counties most affected by potential annual damages.

Table 5-16. Annualized Hurricane Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.08	$3,937	$28,352	$32,289
Chesterfield County	0.17	$1,951,015	$10,695	$1,961,710
City of Colonial Heights	-	-	-	-
City of Emporia	-	-	-	-
City of Hopewell	-	-	-	-
City of Petersburg	-	-	-	-
City of Richmond	-	-	-	-
Dinwiddie County	0.08	$304,949	$118,207	$423,155
Goochland County	0.04	-	$15,302	$15,302

Table 5-16. Annualized Hurricane Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Greensville County	0.17	$19,373	$4,423	$23,796
Hanover County	0.08	$4,423	$17,692	$22,115
Henrico County	0.17	$982,142	$43,258	$1,025,400
New Kent County	0.08	$1,106	$5,396	$6,502
Powhatan County	0.04	$216,288	$19,412	$235,700
Prince George County	0.25	$1,305,028	$931,931	$2,236,959
Surry County	0.17	$367,252	$115,894	$483,146
Sussex County	0.13	$4,733	$44,231	$48,964
Total	**1.46**	**$5,160,245**	**$1,354,793**	**$6,515,038**

Source: National Climatic Data Center.

5.8 Tornadoes

5.8.1 Hazard Profile

A tornado is classified as a rotating column of wind that extends between a thunderstorm cloud and the earth's surface. Winds are typically less than 100 mph, with the most violent tornado wind speeds exceeding 250 mph. The rotating column of air often resembles a funnel-shaped cloud. The widths of tornadoes are usually several yards across, and in rare events can be more than a mile wide. Tornadoes and their resultant damage can be classified into six categories using the Fujita Scale. This scale assigns numerical values for wind speeds inside the tornado according to the type of damage and degree of the tornado. Most tornadoes are F0 and F1, resulting in little widespread damage. Tornado activity normally spans from April through July but tornadoes can occur at any time throughout the year. In Virginia, peak tornado activity is in July. Hot, humid conditions stimulate tornado growth.

5.8.2 Magnitude or Severity

Strong tornadoes may be produced by thunderstorms and are often associated with the passage of hurricanes. On average, about seven tornadoes are reported in Virginia each year. The total number may be higher as incidents may occur over areas with sparse populations, or may not cause any property damage.

Tornado damage is computed using the Fujita Scale, as seen in Table 5-17. Classification is based on the amount of damage caused by the tornado, where the measure of magnitude is based on the impact.Tornadoes and their resultant damage can be classified into the six

categories using the scale. The scale assigns numerical values for wind speds inside the tornado according to the type of damage and degree of the tornado. Most torndaoes are F0and F1, resulting in little widespread damage. A tornado's intense power can destroy bui8ldings, especially manufactured homes, down power lines and can cause significant tree and crop damage.

Table 5-17. Fujita Tornado Intensity Scale

Classification	Max. Winds (mph)	Path Length (miles)	Path Width (miles)	Damage
F0	less than 73	less than 1.0	less than 0.01	Chimneys damaged, trees broken
F1	73–112	1.0–3.1	0.01–0.03	Mobile homes moved off foundations or overturned
F2	113–157	3.2–9.9	0.03–0.09	Considerable damage, mobile homes demolished, trees uprooted
F3	158–206	10–31	0.10–0.29	Roofs and walls torn down, trains overturned, cars thrown
F4	207–260	32–99	0.30–0.90	Well-constructed walls leveled
F5	261–318	100–315	1.0–3.1	Homes lifted off foundations and carried some distance, cars thrown as far as 300 feet

Source: National Weather Service.

The classification of a tornado gives an approximate depiction of what the corresponding damage will be. Hazus analysis for hurricane wind shows that wind speeds with a 1,000-year hurricane event are roughly the same as a weak to mid-range EF1 (defined below) tornado. These usually result in minimal extensive damage. The najority of tornadoes occurring in the Richmond Regional – Crater PDC are F0 and F1 on the Fujita Scale. The winds associated with Hazus jurricane wind show wind speeds at a 1,000 year hurricane event are somewhate equivalent to a weak to mid-range EF-1 tornado. Tnese events typicallty result in minimal damage which can occue over an extensive area such as damage to trees, shrubbery, signs, antennas, and some damage to roofs and unanchored trailers and manufactured homes. Low-intensity tornadoes can also cause localized transportation route disruption due to debris from trees and impacted buildings, signs, etc. Utilities can also be out of service for several days due to downed power and phone lines. An Enhanced Fujita Scale (EF Scale) was developed and implemented operationally in 2007. The EF Scale was developed to better align tornado wind speeds with associated damages. Table 5-18 provides a side-by-side comparison of the F Scale and the EF Scale.

Table 5-18. Fujita Scale Vs. Enhanced Fujita Scale

Fujita Scale			Enhanced Fujita Scale	
F Number	Fastest 1/4-mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)
0	40–72	45–78	0	65–85
1	73–112	79–117	1	86–110
2	113–157	118–161	2	111–135
3	158–207	162–209	3	136–165
4	208–260	210–261	4	166–200
5	261–318	262–317	5	Over 200

5.8.3 Hazard History

Table 5-19 includes descriptions of major tornado events that have touched down in the region since 2011. Other events are included in Appendix B. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. When no community description is available, the general description applies to the entire region. Although not comprehensive in terms of tornado fatalities and injuries, the NCDC database indicates that since 1950 there have been ten deaths and 347 injuries in the region due to tornadoes.

Table 5-19. History of Tornado Events and Damages, 2011–2016

Date	Damages
April 16, 2011	**Dinwiddie County:** A high-end EF1 tornado touched down near Doyle Road west of Glebe Road and tracked to the Five Forks area, some 8 miles east/northeast. The twister injured at least four people, downed hundreds of trees, knocked down power lines, and damaged (minor to moderate) several homes.
October 14, 2011	**New Kent County:** Preliminary information showed the tornado had 95 mph winds and was 200 yards wide. A school and a dozen homes suffered damage. One injury was reported. (Source: The Virginian-Pilot)
June 30, 2012	**Hanover County:** An EF-0 tornado traveled 4.5 miles in Mechanicsville. It reached wind speeds up to 80 mph. It was only on the ground periodically. Several roads were closed due to downed trees and power lines. (Source: http://www.nbc12.com/story/18927663/national-weather-service-confirms-tornado-in-hanover-county)
May 22, 2014	**Prince George County:** _ The tornado was confirmed near the city of Prince George. The storm intensified northwest of Richmond, then produced wind damage in the City of Richmond, with trained storm spotters periodically reporting a funnel cloud in the Metro as it raced southeast. At 5:45 p.m., a tornado touched down on Kurnas Lane, destroying a shed, snapping trees and causing minor damage to a home. The tornado was rated an EF-0, with

Table 5-19. History of Tornado Events and Damages, 2011–2016

Date	Damages
	winds of 70 mph. It was 25 yards wide, and was on the ground for 75 yards. No injuries were reported. **Sussex County:** The tornado was confirmed near Waverly in Sussex county at 6:20 p.m. The tornado developed just north of Highway 460 and south of Petersburg Road, about mile northwest of Waverly. It moved south and crossed Highway 460 just north of Waverly. It struck an auto parts store, causing minor damage. Many large trees were uprooted along Highway 460, and the highway was closed due to trees on the road. The tornado tracked southward to North Church Street, causing minor damage to the First Baptist Church. Many large trees fell into the nearby cemetery, causing damage. The tornado moved across New Street, snapping trees and damaging homes. The tornado lifted shortly after crossing Highway 460 on the west side of Waverly. This tornado was classified as an EF-0 tornado, with winds of 75 mph. It was 100 yards wide, and was on the ground for 1.5 miles. No injuries were reported. (Source: http://wtvr.com/2014/05/23/two-tornadoes-confirmed-from-may-22-storm/)
Feb 25, 2016	Virginia State Police confirmed three deaths and eight with minor injuries after a confirmed tornado hit the Town of Waverly in in Sussex County. Emergency management officials spotted the twister moving along Route 460 and into Waverly. Crews spotted a church and trailer in the storm. Snapped trees and signs were also spotted. Troopers began responding to the damage along Route 40 in Waverly around 2:40 p.m. That's where officials said a 50-year-old man, 26-year-old man and 2-year-old boy were killed when their mobile home was destroyed. The victims, whose bodies were transported to the Office of the Medical Examiner in Norfolk for positive identification, were found about 300 yards from the mobile home. Officials said four other structures suffered damage in the town." (Source: http://wtvr.com/2017/02/24/2-killed-in-wavery-tornado/) This was the first deadly tornado in Virginia since 1950. (Source: http://www.vaemergency.gov/news-local/tornado-history/)

*History from 1790-2010 in Appendix B-3

Figure 5-11. A deadly EF-1 Tornado in Waverly killed three on 25 February 2016
Source:
https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=&url=http%3A%2F%2Fwina.com%2Fnews%2F064460-nelson-buckingham-eligible-for-disaster-help%2F&psig=AFQjCNE74OiF3712rKcf1Vxrlat-acX-iQ&ust=1477429571046170

Figure 5-12 presents the results of a tornado frequency analysis performed as part of the 2013 Virginia State Hazard Mitigation Plan update. The analysis suggests that relative to the entire Commonwealth of Virginia, the region is considered to be "Medium-High" to "High" in terms of tornado frequency. Even so, annualized tornado frequency is quite low and calculated as being between 0.0000101 and 0.000316 for any particular point in the region, with no one specific jurisdiction more likely to experience tornadoes than another.

Table 5-20 presents a calculation of annualized tornado occurrence by jurisdiction based on NCDC tornado data. The annual tornado frequency, a reasonable predictor of future tornado probability, ranges from 0.27 to 0.02 which roughly correlates to a tornado occurring every 4 to 50 years.

Table 5-21 and Figure 5-13 show tornado occurrences in the region since 1950.

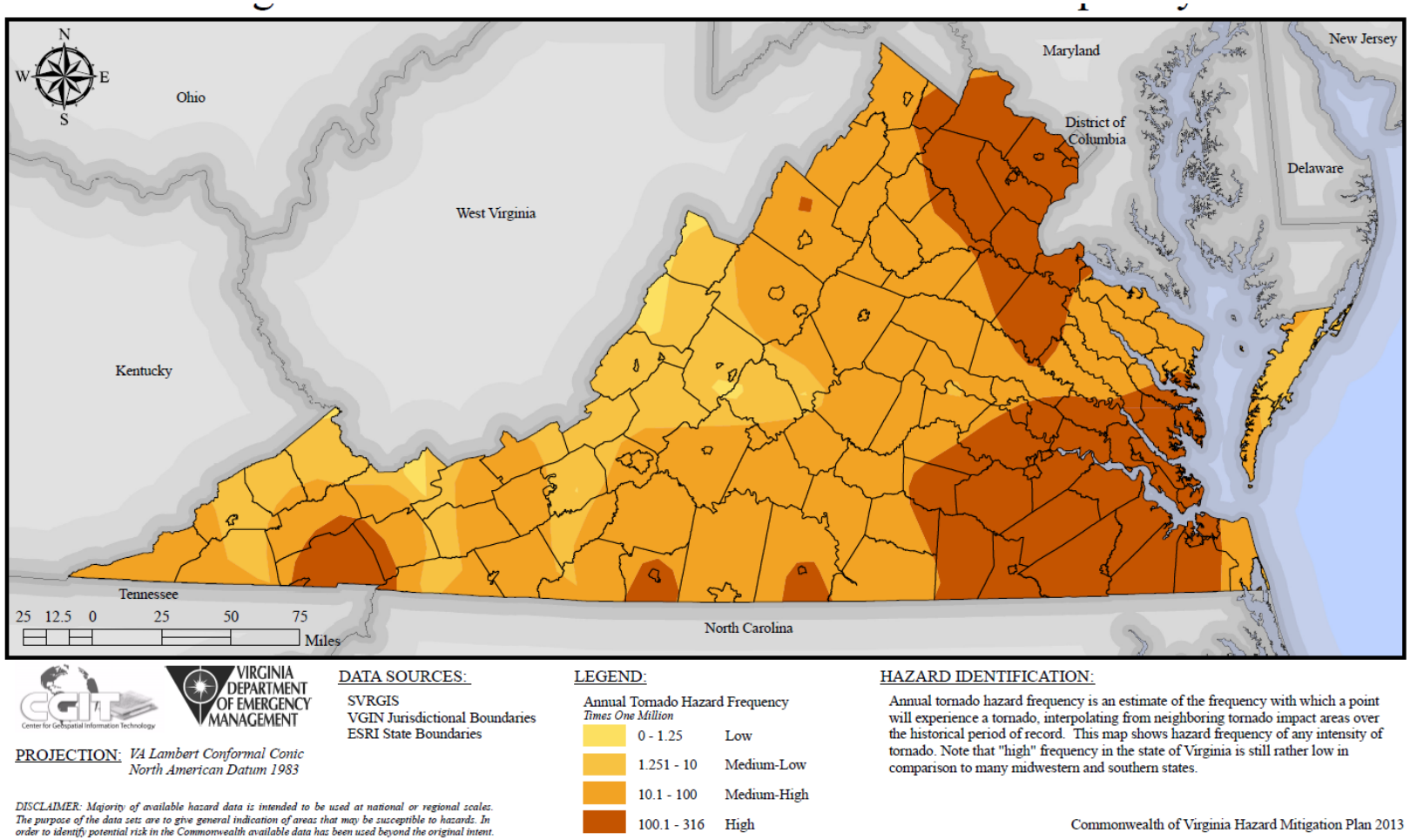


Figure 5-12. Historical Tornado Hazard Frequency Analysis
Source: 2013 Virginia State Hazard Mitigation Plan

Table 5-20. Annualized Tornado Events and Losses, 1950 - 2016

Jurisdiction	Annualized Number of Tornado Events	Annualized Property Damages	Annualized Crop Damages	Annualized Total Losses
Charles City County	0.03	$13,988	-	$13,988
Chesterfield County	0.26	$201,639	-	$201,639
City of Colonial Heights	0.02	$33,106	-	$33,106
Dinwiddie County (incl. Town of McKenney)	0.03	$3,337	-	$3,337
City of Emporia	0.06	$85,942	-	$85,942
Goochland County	0.08	$891,490	-	$891,490
Greensville County (incl. Town of Jarratt)	0.14	$73,980	-	$73,980
Hanover County (incl. Town of Ashland)	0.14	$1,272,733	-	$1,272,733
Henrico County	0.14	$24,560	-	$24,560
City of Hopewell	0.09	$18,033	-	$18,033
New Kent County	0.29	$27,280	-	$27,280
City of Petersburg	0.18	$114,430	-	$114,430
Powhatan County	0.08	$16,581	-	$16,581
Prince George County	0.05	-	-	-
City of Richmond	0.15	$20,546	-	$20,546
Surry County (incl. Towns of Claremont, Dendron, Surry)	0.12	$21,636	-	$21,636
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	0.14	$75,448	-	$75,448
Total	**2**	**$2,894,729**	**$0**	**$2,894,729**

*Particularly damaging tornado events in 1984 and 1993 play a significant role in this loss estimate.

Source: National Climatic Data Center.

Table 5-21. Tornado Touchdowns by Fujita Rating, 1950 - 2017

County	EF0	EF1	EF3	F0	F1	F2	F3	F4	Total
Charles City County					2				**2**
Chesterfield County	1			3	8	3			**15**
City of Colonial Heights		1							**1**
Dinwiddie County (incl. Town of McKenney)				1		1			**2**
City of Emporia				1			1		**2**
Goochland County	1	1				1	1		**4**
Greensville County (incl. Town of Jarratt)		1		3	1	2			**7**

Table 5-21. Tornado Touchdowns by Fujita Rating, 1950 - 2017

County	EF0	EF1	EF3	F0	F1	F2	F3	F4	Total
Hanover County (incl. Town of Ashland)		1		1	4		1	1	**8**
Henrico County	1	1		1	3	1			**7**
City of Hopewell		2		1	1				**4**
New Kent County	5	1		5	1		1		**13**
City of Petersburg		1		4	6				**11**
Powhatan County	1	1		2	1				**5**
Prince George County				1					**1**
City of Richmond	1	1		3		3			**8**
Surry County (incl. Towns of Claremont, Dendron, Surry)		2	1	2	2		1		**8**
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	2	1		1	2	1	1		**8**

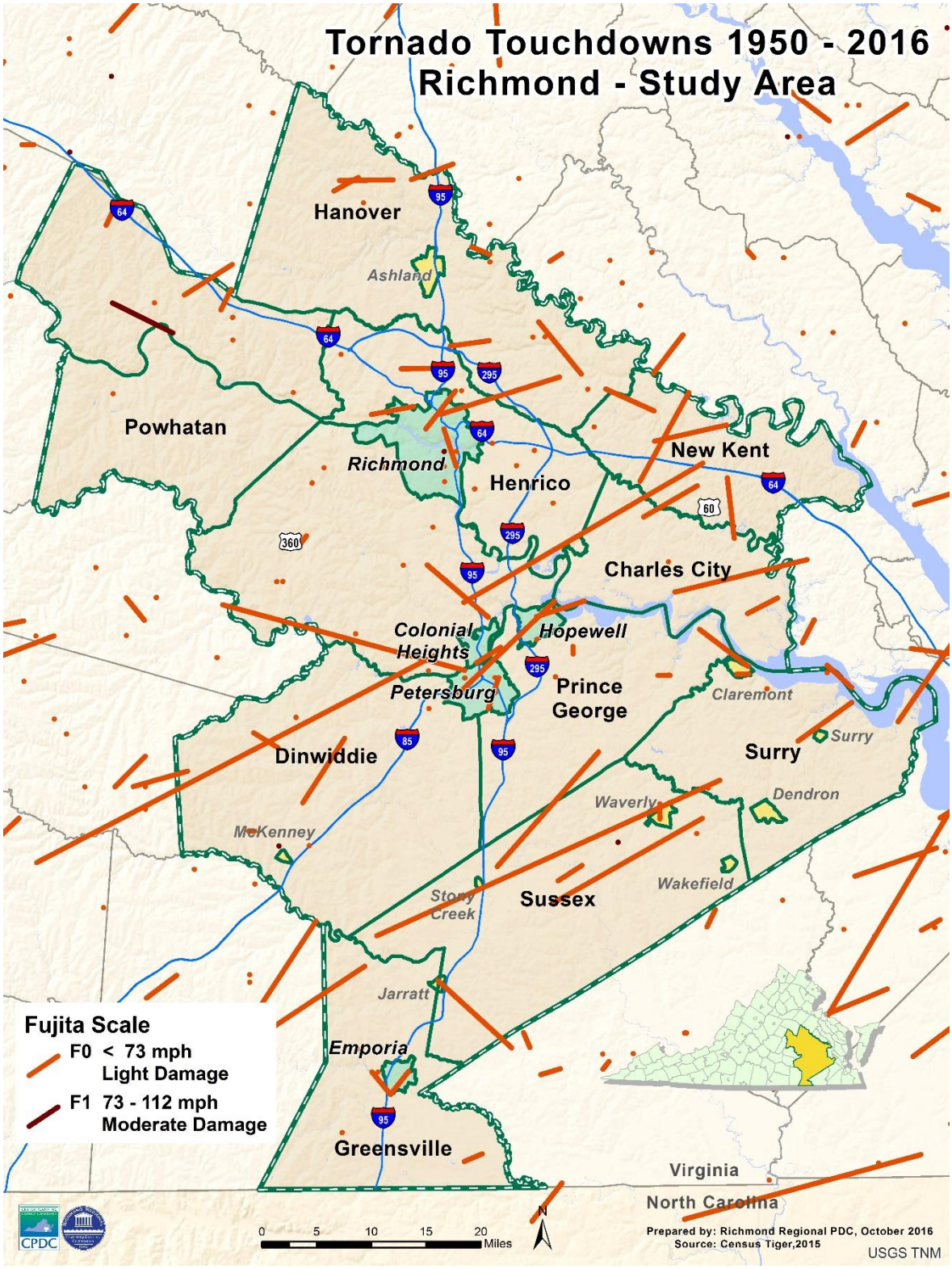


Figure 5-13. Tornado Touchdowns, 1950–2016

5.8.4 Vulnerability Analysis

Probability

Tornadoes are considered to be low-frequency, high-impact events. Electrical utilities and communications infrastructure are vulnerable to tornadoes. Damage to power lines or communication towers has the potential to cause power and communication outages for residents, businesses, and critical facilities. In addition to lost revenues, downed power lines present a threat to personal safety. Further, downed wires and lightning strikes have been known to spark fires.

Impact and Vulnerability

A structure's tornado vulnerability is the same as that for other types of extreme wind events and is based in large part on building construction and standards as discussed previously in greater detail in the section on building types (within the Wind Hazard section). Other factors such as location, condition, and maintenance of trees also play a significant role in determining vulnerability. A tornado will bring about severe damage or destruction to any structure in its path. Clusters of mobile homes may be more vulnerable to tornadoes, Proper anchoring can reduce damage exposure, but not entirely as these structures are extremely vulnerable to damage from downed trees and a tornado's effect on the structure of the manufactured home itself.

Human vulnerability is based on the availability, reception, and understanding of early warnings of tornadoes (e.g., tornado warnings issued by the NWS) and access to safe, substantial indoor shelter. While one might generalize that areas of high population are more vulnerable due to exposure of more people, property and infrastructure, Table 5-21 Tornado Touchdowns by Jurisdiction demonstrates the historical occurrence dominated in both rural and more urban jurisdictions of the Plan area. In some cases, despite having access to technology (computers, radio, television, cell phones, outdoor sirens, etc.) that allow for receiving warnings, language differences may prevent some individuals from understanding them. Once warned of an impending tornado hazard, to seek shelter indoors on the lowest floor of a substantial building away from windows is recommended as the best protection against bodily harm.

Risk and Loss Estimation

Although historical data indicates that there has been some small variation in the distribution of tornadoes across the region, the probability of experiencing a tornado is roughly equal for all of the jurisdictions. With this being the case, the vulnerability of critical facilities across the area is largely determined by construction type of each particular facility. Wood-framed structures are generally considered to be more vulnerable to tornado damage than steel, brick, or concrete structures.

Table 5-26 illustrates that based on the historical record, two tornado events occur annually in the region resulting in about $2.9 million in damages. This loss figure is skewed by two particularly damaging tornado events that occurred on August 6, 1993 (which impacted multiple jurisdictions) and May 8, 1984. The City of Petersburg was hit hard in both instances and has a very high annualized tornado loss estimate as a result.

Jurisdictional executive summaries highlight hazards and vulnerability within the community.

5.9 Thunderstorms (including Hail and Lightning)

5.9.1 Hazard Profile

Thunderstorms are caused when air masses of varying temperatures and moisture content meet. All thunderstorms produce lightning. Droplets of water in a thunderstorm may get picked up in the storm's updraft, a column of rising air. The updraft can carry the droplets to levels of the atmosphere where temperatures are below freezing. The frozen droplets, now hail, may then fall due to gravity injuring people, property and animals.

5.9.2 Magnitude or Severity

A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning can remain in-cloud or can contact the ground or other surfaces. A cloud-to-ground bolt of lightning can sometimes strike locations 10 or more miles away from the parent thunderstorm, producing the effect that the lightning came from 'out of the blue' or without warning. In the past 30 years, lightning has killed an average of 58 people per year in the United States.[10]

Hail can be smaller than a pea, or as large as a softball, and can be very destructive to automobiles, glass surfaces (e.g., skylights and windows), roofs, siding, plants, and crops.[11]

5.9.3 Hazard History

Virginia averages 40 to 50 thunderstorm days per year.[12] Thunderstorms can occur at any time during any season, but are most common in the late afternoon and evening hours during the summer months. In addition to flooding rainfall, damaging winds, and sometimes tornadoes thunderstorms might also produce large hail and deadly lightning.

Past occurrences of thunderstorm events that produced damage, injuries, or fatalities as a result of hail or lightning are listed in Table 5-22. The NCDC database shows that at least two people in the region have been killed and three others injured as a result of lightning

[10] http://www.weather.gov/os/lightning/overview.htm; NWS; retrieved April 11, 2011.
[11] *Talking About Disaster*.
[12] Sammler, William. Personal interview, September 15, 2005. (National Weather Service, Warning Coordination Meteorologist, Wakefield, Virginia office.)

since 1993. The database did not indicate any deaths or injuries in the region during this period as a result of hail.

Table 5-22. History of Hail/Lightning Events and Damages, 2010–2016

Date	Damages
August 12, 2010	**Hanover County:** Hail, two inches in diameter, damaged vehicles in the county east of Old Cold Harbor.
June 29, 2012	The June 2012 Mid-Atlantic and Midwest derecho was one of the most destructive and deadly fast-moving severe thunderstorm complexes in North American history. The progressive derecho tracked across a large section of the Midwestern United States and across the central Appalachians into the mid-Atlantic states on the afternoon and evening of June 29, 2012, and into the early morning of June 30, 2012. It resulted in 20 deaths, widespread damage and millions of power outages across the study region. (Source: https://en.wikipedia.org/wiki/June_2012_North_American_derecho)
June 13, 2013	On the morning of the 13, another linear complex of severe storms developed along a line near the southern border of Ohio. The storms eventually strengthened into a powerful derecho and raced to the south and east. Fatalities and injuries occurred as a result of falling trees and power lines as the storms ripped through Virginia, along with numerous reports of damaging winds and power outages. The derecho downed numerous tress and damaged structures winds up to 80 mph (130 km/h) in some areas. (Source: https://en.wikipedia.org/wiki/June_12%E2%80%9313,_2013_derecho_series)
May 22, 2014	A large Hail and Thunderstorm event came through the region. Some hail was reported to be as large as ping pong balls. Several areas were affected from fallen electric lines. The NCDC data reports that 12 direct deaths in the study region resulted from this event. (Source: NCDC data & http://www.nbcwashington.com/news/local/Severe-Thunderstorms-DC-Area-May-22-260300391.html)
February 24, 2016	This storm started in the north eastern states and traveled down through Virginia and south. During the thunderstorm, hail in some parts of the region were as large as 3 inches in diameter. (Source: http://www.weather.gov/akq/Feb24-2017TOR)

5.9.4 Risk Assessment

Probability

Although most frequent in the Southeast and parts of the Midwest, thunderstorms are a relatively common occurrence across the region and have been known to occur in all calendar months. No one portion of the central Virginia region is deemed more likely to experience thunderstorms than another. Table 5-23 indicates the annualized number of hail and damaging lightning events by jurisdiction based on NCDC data.

Impact and Vulnerability

Electrical utilities and communications infrastructure are vulnerable to lightning. Damage to power lines or communication towers due to direct lightning strikes have the potential to cause power and communication outages for residents, businesses, and critical facilities. In addition to lost revenues, downed power lines present a threat to personal safety. Further, downed wires and lightning strikes have been known to spark fires.

A structure's thunderstorm vulnerability is based in large part on building construction and standards. Other factors, such as location, condition, and maintenance of trees also plays a significant role in determining vulnerability. Windows, roofs, and siding are most vulnerable to the impacts of large hail.

Human vulnerability is based on the availability and reception of early warnings of significant thunderstorm events (i.e., Severe Thunderstorm Warning issued by the NWS) and access to substantial indoor shelter. Seeking shelter indoors on the lowest floor of a substantial building away from windows is recommended as the best protection against thunderstorm-related hazards.

Risk and Loss Estimation

A quantitative assessment of critical facilities at risk for hail and lightning damage was not feasible for this plan update. It is important to note, however, that not all critical facilities have redundant power sources and may not even be wired to accept a generator for auxiliary power. Future plan updates should consider including a more comprehensive examination of critical facilities that are vulnerable to these hazards.

Table 5-23 is based on NCDC historical data; on average, the region experiences approximately six to seven hail storms annually and one damaging lightning event every two years. In terms of damages, roughly $1,600 in losses is attributed to hail and about $23,900 to lightning annually.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Table 5-23. Annualized Thunderstorm (with Hail and Lightning) Events and Losses, 1956 - 2016

Jurisdiction	Annualized Thunderstorm Events	Annualized Property Losses	Annualized Crop Damages	Annualized Total Losses
Charles City County	0.95	$1,535	-	$1,535
Chesterfield County	3.98	$15,640	-	$15,640
City of Colonial Heights	0.59	$4,370	-	$4,370
Dinwiddie County (incl. Town of McKenney)	0.54	$1,408	-	$1,408
City of Emporia	0.70	$1,199	-	$1,199
Goochland County	0.82	$3,764	-	$3,764
Greensville County (incl. Town of Jarratt)	1.41	$3,673	-	$3,673
Hanover County (incl. Town of Ashland)	2.03	$10,713	$1	$10,714
Henrico County	2.03	$2,972	-	$2,972
City of Hopewell	1.13	$2,513	-	$2,513
New Kent County	3.16	$15,037	-	$15,037
City of Petersburg	4.26	$36,087	-	$36,087
Powhatan County	1.54	$5,979	-	$5,979
Prince George County	1.80	$4,538	-	$4,538
City of Richmond	2.74	$6,247	-	$6,247
Surry County (incl. Towns of Claremont, Dendron, Surry)	1.38	$2,224	-	$2,224
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	1.80	$3,418	-	$3,418
Total	**30.86**	**$121,316**	**$1**	**$121,317**

Source: National Climatic Data Center.

5.10 Winter Weather

5.10.1 Hazard Profile

Winter weather comes in many forms ranging from sub-freezing temperatures and dangerously low wind chills to an assortment of precipitation including freezing rain, sleet and snow. Winter storms can vary in size and strength throughout the region and can even include embedded thunerstroms. Snow typically maintains its crystalline structure from the clouds in which it forms until it reaches the surface. Freezing rain, on the other hand, may have started in the clouds as either rain or snow, but reaches the surface as liquid that freezes on contact with surfaces (power lines, tree limbs, the ground) with temperatures below freezing. Freezing rain can accrete on these surfaces resulting in an ice coating. Sleet reaches the surface in the form of clear pellets of ice that bounce upon contact. Extremely cold termperatures accompanied by strong winds can result in wind chills that cause harm and injury such as frostbite and rarely in the region death. A variety of weather phenomena and conditions:

1. Ice Storm Warning is issues when a period of freezing rain is extected top roduce ice accumution of ¼" or greater or can cause significant disruptions to travel or utility function.
2. Heavy Sleet Warning is issued when a period of sleet is expected to produce ice accumulation of 1" or greater, or causes significant disruption to travel or utilities.
3. Heavy Snow Warning is issued when snow is expected to accumulate four inches or more in a 12 hour period or six inches in more than 24 hours.
4. A Winter Storm Warning is issued for a winter weather event in which there is more than one hazard present, and one of the warning criteria listed above is expected to be met.
5. A Blizzard Warning is issued for sustained wind or frequent wind gusts greater than or equal to 35 mph accompanied by falling and/or blowing snow, frequently reducing visibility to less than ¼ mile for three hours or more. Watches are issued when conditions may be met 12 to 48 hours in the future.

Source: National Weather Service.

5.10.2 Magnitude or Severity

The impacts of winter storms are usually minimal in terms of property damage and long-term effects. The most notable impact from winter storms is damage to power distribution networks and utilities. Severe winter storms have the potential to inhibit normal functions of the community. Government costs for these events include overtime personnel wages and equipment or contractors for road clearing. Private-sector losses are attributed to time lost when employees are unable to travel. Homes and businesses suffer damage when electric service is interrupted for long periods of time. Several utility companies and cooperatives provide service to the region, which can make power restoration complicated.

Health threats can become severe when frozen precipitation makes roadways and walkways very slippery, when prolonged power outages occur, and when fuel supplies are jeopardized. Occasionally, buildings may be damaged when snow loads exceed the design capacity of their roofs or when trees fall due to excessive ice accumulation on branches. The water content of snow can vary significantly from one storm to another and can drastically impact the degree to which damage might occur. In snow events that occur at temperatures at or even above freezing, the water content of the snowfall is generally higher. Higher water content translates into a heavier, "wet" snowfall that more readily adheres to power lines and trees, increasing the risk of their failure. Roof collapse is also more of a concern with wetter, heavier snowfall. Clearing of roadways and sidewalks is usually easier with a drier, more powdery snow which is also less likely to accumulate on power lines and trees. This type of snow generally occurs in temperatures below freezing, as water content decreases with temperature. The primary impact of excessive cold is increased risk for frostbite, and potentially death as a result of over-exposure to extreme cold.

Secondary effects of extreme/excessive cold include danger to livestock and pets as well as frozen water pipes in homes and businesses.

Primary Impacts

The impacts of winter storms are minimal in terms of property damage and long-term effects. The most notable impact from winter storms is the damage to power distribution networks and utilities. Severe winter storms have the potential to inhibit normal functions of the community. Governmental costs for this type of event are a result of the needed personnel and equipment for clearing streets. Private sector losses are attributed to lost work when employees are unable to travel. Homes and businesses suffer damage when electric service is interrupted for long periods of time (see Table V-34. Estimated Losses due to Electricity Outage for Residential Structures). Six utility companies provide service to the region, which can make power restoration complicated.

Health threats can become severe when frozen precipitation makes roadways and walkways very slippery and also due to prolonged power outages and if fuel supplies are jeopardized. Occasionally, buildings may be damaged when snow loads exceed the design capacity of their roofs or when trees fall due to excessive ice accumulation on branches. The water content of snow can vary significantly from one storm to another and can significantly impact the degree to which damage might occur. In snow events that occur at temperatures at or even above freezing, the water content of the snowfall is generally higher. Higher water content translates into a heavier, 'wet' snowfall that more readily adheres to power lines and trees, increasing the risk for their failure. Roof collapse is also more of a concern with wetter, heavier snowfall. On the other hand, clearing roadways and sidewalks is considerably easier for a drier, more powdery snow. A dry, fluffy snow is less likely to accumulate on power lines and trees. This type of snow generally occurs in temperatures below freezing with water content decreasing with temperature. The primary impact of excessive cold is increased potential for frostbite, and potentially death as a result of over-exposure to extreme cold.

Secondary Effects

Some of the secondary effects presented by extreme/excessive cold are threats to the health of livestock and pets, and frozen water pipes in homes and businesses.

Predictability and Frequency

A winter storm is a weather event that can include a combination of heavy snowfall, high winds, freezing rain, ice and extreme cold. Winter weather typically impacts the state of Virginia between the months of November and April, with varied intensities. Analysis from the previous plan(s) was reviewed and determined to still represent relative winter storm risk for the region.

To determine the geographic distribution and frequency with which major snow or ice events impact the region, issued National Weather Service warnings and advisories were examined (see Table V-7; also see Previous Occurrences in Appendix B1).

Specifically, the number and types of warnings and advisories issued was analyzed for each county and city and a weighting system was applied that factored the 'severity' of an event implied by a particular warning or advisory type. *Note: National Weather Service warnings/advisories for winter weather are issued at a county level. The warnings/advisories apply to all towns and cities located within a particular county.* In the case of snowfall for example, issuance of a Blizzard Warning implies a more significant event than that of a Snow Advisory. A higher weight was thereby applied to the Blizzard Warning.

5.10.3 Hazard History

Table 5-24 includes descriptions of major winter storm events in the region. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. When no community description is available, the general description applies to the entire region. All descriptions are based on NCDC and VDEM data unless otherwise noted. Although very limited in terms of winter weather-related fatalities and injuries, the NCDC database indicates that since 1993 there has been one death and five injuries in the region due to winter storm events.

Table 5-24. History of Winter Storm Events and Damages, 2010–2016

Date	Damages
December 25, 2010	A 4- to 10-inch snowfall blanketed the region with the heaviest amounts falling over the south and eastern sections. Amounts ranged from 4 inches northwest of the City of Richmond, 6 to 7 inches in the Cities of Petersburg and Emporia, and around a foot near the Town of Wakefield.
February 10, 2014	This was a major ice and snow storm that affected the entire region and elsewhere in the Eastern United States. This event produced devastating amounts of freezing rain and snow along and east of Interstate 95 all the way down to the coast. Overall temperatures throughout the winter were much colder in 2014. This was rated as 3 (Major) on the NESIS scale. A Presidential Disaster event was declared in Chesterfield. (Source: http://www.weather.gov/phi/02132014)
January 22, 2016	What transpired was reasonably close to what was forecast, with a major snowstorm for our entire region, which also included a mix of some sleet across portions of the area as well as small amounts of freezing rain. NOAA ranks Northeast U.S. storms according to overall impact, part of which is dependent on societal and economic factors, thus population density is a key component. This particular storm was ranked as a 4 on the "NESIS" scale of 1-5, or "crippling". It is now 4th on the list of historic storms that have been ranked on the NESIS scale, with only two storms ever ranked as a 5 ("extreme). Presidential Disasters for this study region were declared for Sussex and Henrico Counties. (Source: http://www.weather.gov/media/rnk/past_events/2017_01_2223_Winter.pdf)
*History from 1940-2010 in Appendix B-3	

As part of the 2006 analysis, gridded climate data was obtained from the Climate Source and through the Virginia View program. This data was developed by the Oregon State University Spatial Climate Analysis Service using PRISM (Parameter-elevation Regressions on Independent Slopes Model). This climate mapping system is an analytical tool that uses point weather station observation data, a digital elevation model, and other spatial datasets to generate gridded estimates of monthly, yearly, and event-based climatic parameters.

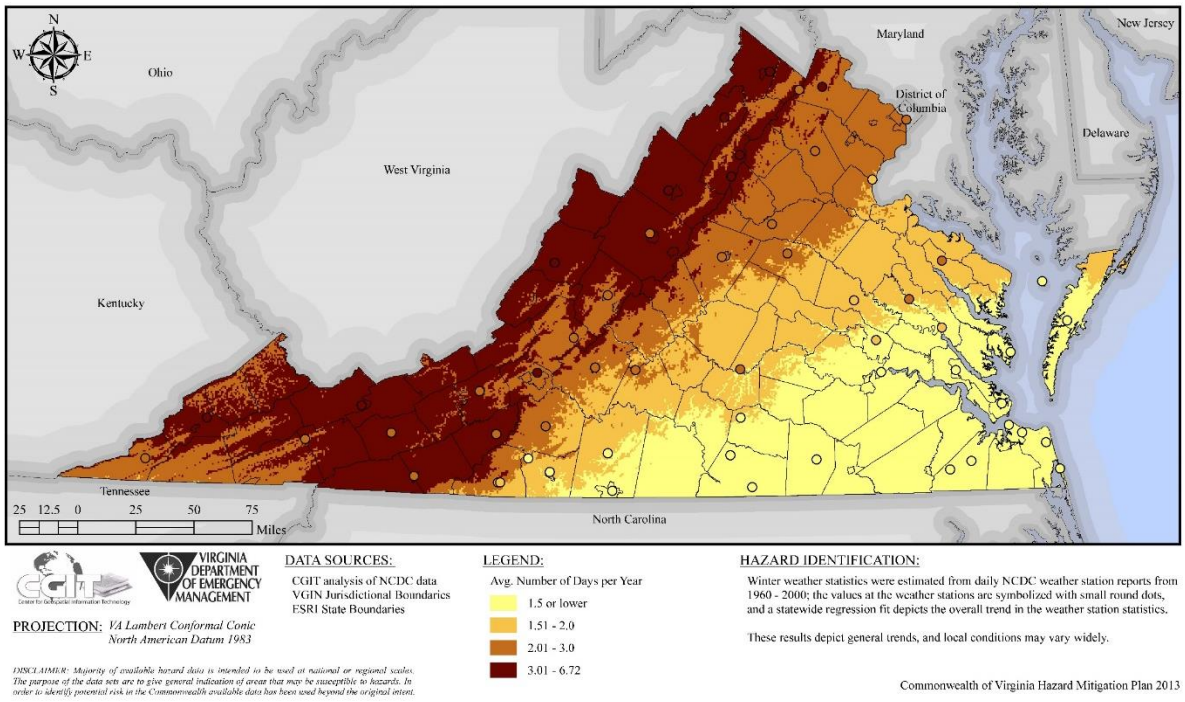
The mean annual days map reveals the 30-year average of the number of days that a location will receive greater than 1 inch of snowfall in a 24-hour period in a given year.

A criterion of greater than 1 inch was selected for winter snowfall severity assessment because this depth will result in complete road coverage that can create extremely dangerous driving conditions and will require removal by the local community. This amount of snowfall in a 24-hour period can also lead to business closures and school delays or cancellation.

Figure 5-14 shows the average number of days with snowfall greater than 1 inch for the state. The analysis shows that the highest frequency of days with greater than 1 inch of snow is found in the higher elevations of western portions of the commonwealth. On the flip side, southern and southeastern portions of the commonwealth typically only experience one day or fewer where snowfall accumulates to more than an inch. Availability of new data through PRISM is now somewhat restricted due to that program's limited remaining funding. This circumstance prevented a similar or updated analysis for this plan's update. Even so, the previous analysis is based on long-term records and is still considered valid.

The Virginia Tech Center for Geospatial Information and Technology performed analyses of weather station daily snowfall data for the Commonwealth of Virginia's 2013 Hazard Mitigation Plan Update. Station-specific statistics were used as the basis for a seamless statewide estimate based on multiple linear regressions between the weather statistics (dependent variable) and elevation and latitude (independent variables). Figure 5-15 shows that the average number of days with at least 3 inches of snowfall ranges from 1.51 to 2 days over northwestern portions of the region, including portions of Hanover, Goochland, Powhatan, and Henrico Counties to 1.5 days or fewer over the remainder of the area.

Figure 5-14. Virginia Average Number of Days with Snowfall > 3 Inches



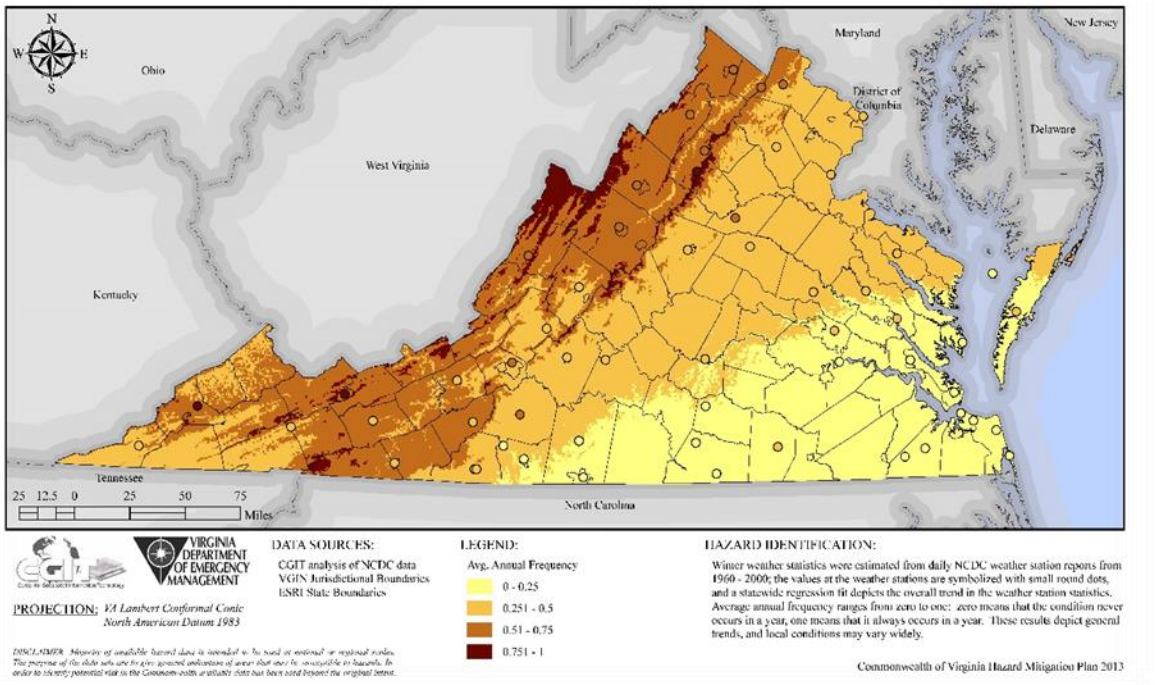


Figure 5-15. Average Number of Days with at Least 3 Inches of Snowfall
Source: 2010 Virginia State Hazard Mitigation Plan

5.10.4 Ice Potential

Another challenge with winter weather in the region is the amount of ice that often accompanies the winter season. Ice in winter storms takes two primary forms:

Sleet is rain that freezes into ice pellets before it reaches the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.

Freezing rain (also known as an ice storm) is rain that falls onto a surface that has a temperature below freezing. The cold surface causes the rain to freeze, so surfaces such as tree branches, utility wires, vehicles, and roads become glazed with ice. Even small accumulations of ice can cause significant hazards to people, especially to pedestrians and motorists, as well as to property.[13]

Ice from freezing rain can accumulate on trees, power lines, and communication towers causing damage and leading to power and communication outages that can last for days, and in the most severe cases, for weeks. Even small accumulations of ice can be severely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

The debris created by the trees can also blocks roadways and impact emergency services. Clean-up of the debris is often complicated because responsibility is shared by the Virginia Department of Transportation (VDOT) and private utility companies.

5.10.5 Vulnerability Analysis

Probability

Winter storms can be a combination of heavy snowfall, high winds, ice, and extreme cold. Winter weather typically impacts the state of Virginia between the months of October and April, with varied intensities.

To determine the geographic distribution and frequency with which major snow or ice events impact the region, the Iowa Environmental Mesonet (IEM) obtains data from cooperating members that have observing networks. Watch, Warning, and Advisory events were collected and examined between 1986 and 2017 (see Table 5-25 and 5-26). The events were sorted into the following categories: Freeze, Freezing Fog, Freezing Rain, Frost, Heavy Snow, Snow, Winter Storm, and Winter Weather. (Data was collected from: http://mesonet.agron.iastate.edu/vtec/search.php)

The most alerts between 1986 and 2016 were for Goochland County, followed next by Hanover and Powhatan Counties. The fewest alerts were given for Charles City, Sussex, and Prince George Counties. The most common type of events for all counties were the Winter Weather, Winter Storm, Freeze, and Frost type events.

It should be noted that the number of reported events from the IEM and NCDC collections were slightly different. With the number of annual IEM events being 49.3 and the NCDC

[13] *Talking About Disaster.*

annual winter events being around 45.9. Because of the difference in collection criteria, agencies, and time frames of the reported events, the 7% difference between the two annualized events reported was not significant.

Table 5-25. National Weather Service Winter Alerts, 1986 - 2016

Jurisdiction	Watch Events	Warning Events	Advisory Events	Total Events	Annualized Events
Charles City County	20	36	59	**115**	**3.71**
Chesterfield County	21	38	63	**122**	**3.94**
City of Colonial Heights	-	-	-	**-**	**-**
Dinwiddie County	22	39	66	**127**	**4.10**
City of Emporia	-	-	-	**-**	**-**
Goochland County	33	45	73	**151**	**4.87**
Greensville County	21	37	62	**120**	**3.87**
Hanover County	26	41	77	**144**	**4.65**
Henrico County	22	38	64	**124**	**4.00**
City of Hopewell	-	-	-	**-**	**-**
New Kent County	22	34	65	**121**	**3.90**
City of Petersburg	-	-	-	**-**	**-**
Powhatan County	32	46	65	**143**	**4.61**
Prince George County	19	38	62	**119**	**3.84**
City of Richmond	-	-	-	**-**	**-**
Surry County (Incl. Towns of Claremont, Dendron, Surry)	22	34	62	**118**	**3.81**
Sussex County (Incl. Towns of Stony Creek, Wakefield, Waverly)	22	37	65	**124**	**4.00**
Totals	**282**	**463**	**783**	**1528**	**49.3**

Table 5-26 Annualized Winter Alert Types, 1986 - 2016

Jurisdiction	Freeze	Freezing Fog	Freezing Rain	Frost	Heavy Snow	Snow	Winter Storm	Winter Weather	Total Annualized Events
Charles City County	0.87	0.03	-	0.48	-	0.06	0.94	1.32	**3.7**
Chesterfield County	0.77	0.03	0.03	0.48	0.03	0.03	1.1	1.45	**3.92**
City of Colonial Heights	-	-	-	-	-	-	-	-	
Dinwiddie County	0.97	0.03	0.03	0.48	-	0.06	1	1.52	**4.09**
City of Emporia	-	-	-	-	-	-	-	-	
Goochland County	0.94	0.03	0.19	0.35	0.03	0.03	1.55	1.74	**4.86**
Greensville County	0.97	0.03	-	0.48	-	0.06	0.9	1.42	**3.86**

Table 5-26 Annualized Winter Alert Types, 1986 - 2016

Jurisdiction	Freeze	Freezing Fog	Freezing Rain	Frost	Heavy Snow	Snow	Winter Storm	Winter Weather	Total Annualized Events
Hanover County	0.81	0.03	0.13	0.45	0.03	0.06	1.32	1.81	**4.64**
Henrico County	0.77	0.03	0.03	0.52	0.03	0.03	1.13	1.45	**3.99**
City of Hopewell	-	-	-	-	-	-	-	-	
New Kent County	0.84	0.03	-	0.48	-	0.06	0.97	1.52	**3.9**
City of Petersburg	-	-	-	-	-	-	-	-	
Powhatan County	0.94	0.03	0.16	0.39	0.03	0.03	1.55	1.48	**4.61**
Prince George County	0.94	0.03	-	0.52	-	0.06	0.9	1.39	**3.84**
City of Richmond	-	-	-	-	-	-	-	-	
Surry County (Incl. Towns of Claremont, Dendron, Surry)	0.94	0.03	-	0.52	-	0.1	0.87	1.35	**3.81**
Sussex County (Incl. Towns of Stony Creek, Wakefield, Waverly)	0.97	0.03	-	0.52	-	0.06	0.94	1.48	**4**
Totals	**10.73**	**0.36**	**0.57**	**5.67**	**0.15**	**0.64**	**13.17**	**17.93**	**49.22**

Impact and Vulnerability

Winter storm vulnerability can be expressed by impacts to people, property, and societal function. For example, exposure of individuals to extreme cold, falls on ice-covered walkways, carbon monoxide poisoning from generators and automobile accidents is heightened during winter weather events. According to NCDC records dating back to 1993, at least one fatality was officially recorded resulting from a winter storm event in the area. NCDC storm event records typically do not contain traffic fatalities blamed on wintry weather, and although details were not provided, the fatality took place during a severe snow storm on January 25, 2000.

Property damage due to winter storms includes damage done by and to trees, water pipe breakage, structural failure due to snow loads, and injury to livestock and other animals. The average amount of total damages due to winter events is $40,000 per year (1993-2017) for the region (adjusted for inflation to 2017 dollars). The counties most affected from winter events over the years are Prince George ($9,089/yr.), Henrico ($8,948/yr.), and Chesterfield ($7,962/yr.). Disruption of utilities and transportation systems, as well as lost business and decreased productivity represent societal vulnerability.

Vulnerability to winter storm damages varies due to specific factors; for example, proactive measures such as regular tree maintenance and utility system winterization can minimize property vulnerability. Localities accustomed to winter weather events or with resources to take proactive preventive measures are typically more prepared to deal with them and therefore less vulnerable than localities that rarely experience winter weather.

Risk and Loss Estimation

A quantitative assessment of critical facilities for winter storm risk was not feasible for this plan update. Even so, it is apparent that transportation structures are at great risk from winter storms. In addition, building construction variables – particularly roof span and construction method, are factors that determine the ability of a building to perform under severe stress weights from snow. Finally, not all critical facilities have redundant power sources and many are not wired to accept a generator for auxiliary power. Future plan updates should consider including a more comprehensive examination of critical facility vulnerability to winter storms.

Table 5-27 summarizes NCDC historical data for winter weather events since 1993. Based on this information, on average, the region experiences approximately two winter weather events annually, of which some rare winter storms have historically included significant accumulations of ice (due to freezing rain). In terms of annualized damages, roughly $40,411 per year in losses is attributed to winter weather events, 57% of which is attributed to ice storms.

Table 5-27. NCDC Annualized Winter Weather Events, 1993 - 2016

Jurisdiction	Number of Winter Weather Events	Annualized Property Damages	Annualized Crop Damages	Annualized Total Losses
Charles City County	2.38	$1,444	-	$1,444
Chesterfield County	6	$7,962	-	$7,962
City of Colonial Heights	-	-	-	-
City of Emporia	-	-	-	-
City of Hopewell	-	-	-	-
City of Petersburg	-	-	-	-
City of Richmond	-	-	-	-
Dinwiddie County	2.42	$2,600	-	$2,600
Goochland County	3.5	$3,004	-	$3,004
Greensville County	4.17	-	-	-
Hanover County	3.54	$3,030	-	$3,030
Henrico County	6.08	$8,948	-	$8,948
New Kent County	2.5	$1,444	-	$1,444
Powhatan County	3.04	$2,889	-	$2,889
Prince George County	7.88	$9,089	-	$9,089
Surry County	2.08	-	-	-
Sussex County	2.29	-	-	-

Table 5-27. NCDC Annualized Winter Weather Events, 1993 - 2016

Jurisdiction	Number of Winter Weather Events	Annualized Property Damages	Annualized Crop Damages	Annualized Total Losses
Total	**45.88**	**$40,411**	**$0**	**$40,411**

Source: National Climatic Data Center.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

5.11 Droughts and Extreme Heat

5.11.1 Hazard Profile

A drought can be characterized in several different ways depending on the impact. The most common form of drought is agricultural. Agricultural droughts are characterized by unusually dry conditions during the growing season. Meteorological drought is an extended period of time (six or more months) with precipitation of less than 75% of normal precipitation. Severity of droughts often depends on the community's reliance on a specific water source. The probability of a drought is difficult to predict given the number of variables involved. As seen in the Table 5-32, drought conditions appear to make an appearance at least once a decade.

5.11.2 Magnitude or Severity

Many problems can arise at the onset of a drought, some of which include diminished water supplies and quality, undernourishment of livestock and wildlife, crop damage, and possible wildfires. Secondary impacts from droughts pose problems to farmers with reductions in income, while food prices and lumber prices could drastically increase.

High summer temperatures can exacerbate the severity of a drought. When soils are wet, a significant portion of the sun's energy goes toward evaporation of the ground moisture. However, when drought conditions eliminate soil moisture, the sun's energy heats the ground surface and temperatures can soar, further drying the soil. The impact of excessive heat is most prevalent in urban areas, where urban heat-island effects prevent inner-city buildings from releasing heat built up during the daylight hours. Secondary impacts of excessive heat are severe strain on the electrical power system and potential brownouts or blackouts.

Extreme heat combined with high relative humidity slows evaporation, limiting the body's ability to efficiently cool itself. Overexposure may result in heat exhaustion or stroke, which could lead to death. The Centers for Disease Control and Prevention state that

excessive heat exposure caused 8,015 deaths in the United States between 1979 and 1999.[14] The Virginia Department of Health reports that between 1999 and 2004 there were three deaths from extreme heat in the Richmond region. All three deaths occurred in Hanover County. Newer data is not available while central Virginia record high seasonal and annual temperatures have been set during the past five years quantitative impacts have not been recorded.

Table 5-28 provides a summary of drought categories and impacts produced by the U.S. Drought Monitor. The U.S. Drought Monitor classification used both science and subjectivity, the result of which is a drought severity classification table for each dryness level. Notice that water restrictions are usually initiated as "voluntary" and can evolve to "mandatory."

Table 5-28. Drought Severity Classification and Possible Impacts

Category	Description	Possible Impacts
D0	Abnormally dry	Going into a drought: short-term dryness slows planting, growth of crops or pastures; fire risk above average. Coming out of a drought: some lingering water deficits; pastures or crops not fully recovered.
D1	Moderate drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low; some water shortages develop or are imminent; voluntary water use restrictions requested.
D2	Severe drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed.
D3	Extreme drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions.

Source: U.S. Drought Monitor.

For excessive heat, the NWS uses heat index thresholds as criteria for the issuance of heat advisories and excessive heat warnings. NWS heat advisory bulletins inform citizens of forecasted extreme heat conditions. The bulletins are based on projected or observed heat index values and include:

- Excessive Heat Outlook when there is a potential for an excessive heat event within three to seven days.
- Excessive Heat Watch when conditions are favorable for an excessive heat event within 12 to 48 hours but some uncertainty exists regarding occurrence and timing.
- Excessive Heat Warning/Advisory when an excessive heat event is expected within 36 hours.

These products are usually issued when confidence is high that the event will occur. A warning implies that conditions could pose a threat to life or property, while an advisory is

[14] National Center for Environmental Health, Centers for Disease Control. *About Extreme Heat*. Retrieved from http://www.cdc.gov/nceh/hsb/extremeheat/

issued for less serious conditions that may cause discomfort or inconvenience, but could still lead to threat to life and property if caution is not taken.

5.11.3 Hazard History

There have been a number of significant droughts recorded in Virginia since 1900. An extended period of abnormally dry weather occurred during a period of four years, from 1998 to 2002. This period saw rainfall levels well below normal and caused many communities throughout the state to institute water restrictions. In the most recent planning cycle, periods of dry weather have mostly had superficial landscaping impacts rather than impacts to crops and water supplies.

Table 5-29 includes descriptions of major droughts that have occurred in the Crater region. Drought conditions generally occur over a region or larger area rather than in a single jurisdiction.

Table 5-29. History of Drought Events and Damages, Richmond-Crater Region, 1976–2016

Date	Damages
November 1976 – September 1977	The region experienced ten months of below average precipitation. The drought began in November 1976 when rainfall totaled only 50% to 75% of normal. During the rest of the winter, storms tracked across the Gulf. During the spring and summer storms tracked across the Great Lakes. These weather patterns created significant droughts throughout most of Virginia.
June – November 1998	A heat wave over the Southeast produced warm and dry conditions over much of Virginia. Unusually dry conditions persisted through much of the fall. The drought produced approximately $38.8 million in crop damages over portions of central and south-central Virginia.
December 2001 – November 2004	Beginning in the winter of 2001, the Mid-Atlantic began to show long-term drought conditions. The NWS issued reports of moisture-starved cold fronts that would continue throughout the winter. Stream levels were below normal with record lows observed at gauges for the York, James, and Roanoke River basins. By November 2002, the U.S. Secretary of Agriculture had approved 45 counties for primary disaster designation, while 36 requests remained pending.
2007	Unusually dry conditions persisted through a significant portion of the year through much of southern and central Virginia. Virginia as a whole experienced its tenth driest year on record.
July 21,2011	This was one of the hottest July's in the last 75 years, breaking records for multiple. According to the NCDC data, all counties were recorded as having excessive heat waves and drought throughout the entire month. (Source: https://www.ncdc.noaa.gov/sotc/national/201107)
July 5, 2012	Another year of record setting highs and ties throughout the states. These high were accompanied with droughts and heat waves. (Source: https://en.wikipedia.org/wiki/Summer_2012_North_American_heat_wave)

5.11.4 Vulnerability Analysis

Probability

Based on historical frequency of occurrence using NCDC, an annual determination of probability of future drought events can be made. Table 5-30 indicates that drought events of some significance affect any jurisdiction in the region from the NCDC database. The annualized event occurrence and damages are shown for the study area.

Table 5-30. Annualized Drought Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.17	-	$131,417	$131,417
Chesterfield County	0.25	-	-	-
City of Colonial Heights	-	-	-	-
Dinwiddie County (incl. Town of McKenney)	-	-	$402,556	$402,556
City of Emporia	-	-	-	-
Goochland County	-	-	$122,077	$122,077
Greensville County (incl. Town of Jarratt)	-	-	-	-
Hanover County (incl. Town of Ashland)	0.25	-	$500,830	$500,830
Henrico County	0.21	-	$244,153	$244,153
City of Hopewell	0.25	-	-	-
New Kent County	0.25	-	$69,428	$69,428
City of Petersburg	0.5	-	-	-
Powhatan County	0.13	-	$378,381	$378,381
Prince George County	0.25	-	$223,161	$223,161
City of Richmond	0.5	-	-	-
Surry County (incl. Towns of Claremont, Dendron, Surry)	0.13	-	-	-
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	0.13	-	-	-
Total	**3.02**	**$0**	**$2,072,003**	**$2,072,003**

Source: National Climatic Data Center.

Impact and Vulnerability

If a significant drought event were to occur, it could bring economic, social, and environmental impacts to the study area. Commonly, one of the most significant economic effects to a community is agricultural impact. Other economic effects could be felt by businesses that rely on adequate water levels for their day-to-day business, such as carwashes and Laundromats.

Droughts can also create conditions that enable the occurrence of other natural hazard events such as wildfires or wind erosion. The likelihood of flash flooding is increased if a period of severe drought is followed by a period of extreme precipitation. Low-flow conditions also decrease the quantity and pressure of water available to fight fires, while the dry conditions increase the likelihood that fires will occur.

Environmental drought impacts include those on both human and animal habitats and hydrologic units. During periods of drought, the amount of available water decreases in lakes, streams, aquifers, soil, wetlands, springs, and other surface and subsurface water sources. This decrease in water availability can affect water quality such as oxygen levels, bacteria, turbidity, temperature increase, and pH changes. Changes in any of these levels can have a significant effect on the aquatic habitat of numerous plants and animals found throughout the study area.

Low water flow can result in decreased sewage flows and subsequent increases in contaminants in the water supply. Decrease in the availability of water also decreases drinking water supply and the food supply as food sources become scarcer. This disruption can work its way up the food chain within a habitat. Loss of biodiversity and increases in mortality can lead to increases in disease and endangered species.

Table 5-31 provides an overview of the agricultural products that could be affected by a drought. These numbers are based on the 2007 Census of Agriculture conducted by the U.S. Department of Agriculture. The numbers show all of the counties with significant agricultural sectors that could be impacted by droughts. Hanover County, in particular, had approximately $43 million in products sold, most of which were crops.

Table 5-31. Value of Agricultural Products Potentially Affected by Drought

Jurisdiction	Number of Farms 2012 (% change from 2007)	Total Value of Agricultural Products Sold
Charles City County	79 (-1.3%)	$23,680,000
Chesterfield County	197 (-11.7%)	$6,400,000
Dinwiddie County	383 (2.3%)	$24,798,000
Goochland County	315 (-20.3%)	$16,562,000
Greensville County	151 (5.3%)	$9,884,000
Hanover County	600 (-4.2%)	$55,272,000
Henrico County	117 (-52.1%)	$9,371,000
New Kent County	137 (11.7%)	$7,003,000
Powhatan County	250 (8.8%)	$10,009,000
Prince George County	167 (-11.4%)	$10,763,000
Surry County	127 (4.7%)	$27,723,000
Sussex County	123 (-22.8%)	$37,277,000
Total	**2646 (-6%)**	**$238,742,000**

Source: United States Department of Agriculture, Virginia Agricultural Statistics Service. 2007 Census of Agriculture. County Profiles.

The elderly, small children, the chronically ill, livestock and pets are most vulnerable to extreme heat.

Risk and Loss Estimation

Except for potential water supply issues associated with a prolonged drought, droughts have little impact on critical facilities.

The data shows recurrence of drought conditions, of varying magnitude, on a relatively regular basis. With records dating back to 1993, the NCDC database indicates that drought events of some significance occur roughly three times annually in the region (see Table 5-33). Based on historical data, it is reasonable to assume that drought events will continue to impact the region with some regularity and may even increase with climate change into the future. Annual regional crop losses associated with drought events are more than $2.7M.

5.12 Mass Evacuation

5.12.1 Hazard Profile

Mass evacuations from urban areas can strain a community's resources and cause gridlock on major transportation routes, overcrowding of hospitals and shelters, and increased load on local utilities' infrastructures leading to potential failure.

VDOT has worked with the localities to develop incident plans that include evacuation routes. When an event occurs, the Emergency Alert System (EAS) provides the latest information on evacuation. The majority of the Richmond and Crater regions are within the Richmond Extended EAS area. Surry County is an exception and is part of the Eastern Virginia EAS area.

Many of the region's community emergency operations plans outline the concerns surrounding mass evacuation, in terms of jurisdictional evacuation, evacuation of other areas in which the locality acts as a "host," or as a transit route locale.

5.12.2 Hazard History

A mass evacuation of significant proportions has not impacted the area in the past decade. In anticipation of Hurricane Floyd in September 1999, more than three million people were evacuated from Florida to the North Carolina coastline, and to a lesser extent from the Virginia coast. Although the majority of these evacuations were from North and South Carolina coasts to inland areas of those states, some limited impact was likely experienced in the planning region.

5.12.3 Vulnerability Analysis

Probability

The probability of a mass evacuation impacting the planning region includes factors such as the probability and location of the hazard (e.g., terrorist incident, hurricane, etc.) that would make such an evacuation necessary, as well as sociological considerations. Determining the probability of a mass evacuation was not quantified for this plan update. Future plan updates should consider potential methods and data that might allow such an analysis.

Impact and Vulnerability

An influx of evacuees as a result of a mass evacuation has the potential to overload infrastructure and support systems. Impacted segments might include transportation, public safety, medical facilities and shelters, utilities, and depending on the duration of the evacuation, potentially the education sector. Although vulnerability is difficult to quantify, jurisdictions located along major evacuation routes (interstates and major highways) are more likely to be impacted than those away from such routes.

Risk and Loss Estimation

Mass evacuations do not necessarily pose a structural risk to critical facilities, but rather have the potential to strain critical services and resources by overwhelming response systems. Such risks were not quantified in terms of dollar losses for this plan update.

A major concern for the region is the possibility of a mass evacuation of the coastal areas of Virginia and North Carolina due to a hurricane threat, or from the Northern Virginia/Washington, D.C. metro area due to a potential or actual terrorist attack.

A project termed the U.S. Route 460 Corridor Improvements Project is proposed to create a four-lane divided limited access highway between the Cities of Petersburg and Suffolk in Virginia. The highway could potentially serve as a route for those evacuating the coast due to a hurricane threat.

Researchers at the Institute for Infrastructure and Information Assurance, which is part of James Madison University, have conducted preliminary studies to determine the possible number of displaced residents that may need to be temporarily housed in the region, and the impact resulting from the increased traffic flow on Interstates 64, 66, and 81. The Institute has developed a Rural Citizen's Guide for Emergency Preparedness that provides citizens with information on threats facing rural areas and ways to prepare for emergencies (natural and human-made). Terrorism-related issues for Northern Virginia and adjacent regions will require extensive intra-regional planning and cooperation in the future.

Some localities have detailed evacuation routes in the Warning, Evacuation, and Emergency Transportation Annex of their emergency operations plans. These jurisdictions have established traffic control measures and routes to enhance the rate of evacuation and

to provide security for evacuated areas, critical facilities, and resources. The emergency operations plans address evacuation from the locality, and touch on the potential impacts caused by a mass evacuation. The type and scale of event that warrants evacuation will drive the type of response the localities will implement. To assist and mitigate against mass evacuation, jurisdictions should include additional detail in their plans regarding secondary evacuation routes, coordination between and among neighboring jurisdictions, the number and location of potential shelters, and what needs the communities foresee in their capacity as "host" communities.

5.13 Wildfires

5.13.1 Hazard Profile

Wildfires can be classified as either wildland fires or urban-wildland interface (UWI) fires. The former involves situations where a wildfire occurs in an area that is relatively undeveloped except for the possible existence of basic infrastructure such as roads and power lines. An urban-wildland interface fire includes situations in which a wildfire enters an area that is developed with structures and other human developments. In UWI fires, the fire is fueled by both naturally occurring vegetation and the urban structural elements themselves. According to the National Fire Plan issued by the U.S. Departments of Agriculture and Interior, the urban-wildland interface is defined as "…the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildlands or vegetative fuels."

A wildfire hazard profile is necessary to assess the probability of risk for specific areas. Certain conditions must be present for a wildfire hazard to occur. A large source of fuel must be present; the weather must be conducive (generally hot, dry, and windy); and fire suppression sources must not be able to easily suppress and control the fire. After a fire starts, topography, fuel, and weather are the principal factors that influence wildfire behavior. According to the Virginia Department of Forestry (VDOF), there are several factors that influence an area's risk to the occurrence of wildfires. These include, but are not limited to:

- Historical wildfire data
- Land cover
- Percent slope of topography
- Slope orientation
- Population density
- Distance to roads
- Railroad buffer
- Road density and developed areas

5.13.2 Severity or Magnitude

A wildfire can range from a very localized and containable burn to an out-of-control blaze that can spread quickly and is capable of scorching thousands of acres of land over many days. The Virginia wildfire season is normally in the spring (March and April) and then again in the fall (October and November). During these months, the relative humidity is

usually lower and the winds tend to be higher. In addition, the hardwood leaves are on the ground, providing more fuel and allowing the sunlight to directly reach the forest floor, warming and drying the surface fuels.

As fire activity fluctuates during the year from month to month, it also varies from year to year. Historically, extended periods of drought and hot weather can increase the risk of wildfires. Some years with adequate rain and snowfall amounts keep fire occurrences low; while other years with extended periods of warm, dry, and windy days exhibit increased fire activity.

Long-term climate trends as well as short-term weather patterns play a major role in the risk of wildfires occurring. For instance, short-term heat waves along with periods of low humidity can increase the risk of fire, while high winds directed toward a fire can cause it to spread rapidly.

There are numerous secondary effects that could impact the study area due to wildfires. Areas that have been burned due to wildfires have an increased risk of flooding and landslides in the event of heavy rains. Additional secondary impacts due to wildfires include a degradation of air and water quality, as well as a threat to wildlife habitat including endangered species.

5.13.3 Hazard History

Most of Virginia's wildfires were caused by humans either intentionally or unintentionally. Due to the growth of the population of the commonwealth, there has been an increase in people living in the urban-wildland interface, as well as an increase in use of the forest for recreational purposes. Historical records of wildfire events specific to the study area are limited, and not all wildfires are reported.

The VDOF website provided fire incidence data for the years between 2002 and 2017. The fire incidence data provided from 1995 to 2001 came from the 2011 Hazard Mitigation study that used VDOF data for those years. The data provided by VDOF was summarized into the following tables. Table 5-32 shows the number of wildfires per jurisdiction per year from VDOF. Tables 5-36 and 5-37 provide a summary of the number of acres burned and total damages associated with wildfires in the region. According to VDOF records from 1995 to 2008, there were 1,849 wildfires that burned approximately 24,800 acres and caused nearly $3.9 million in damages in the region during the period. Another 435 fires occurred in the region from 2010 to 2017, averaging to 72 fires per year. Dinwiddie County experienced the most occurrences and acres burned. The City of Richmond has the highest dollar amount of damages due to the hazard.

Table 5-32. Number of Wildfires by Fire Year, 1995–2016

Jurisdiction Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010-2016	Total
Charles City County	12	2	17	8	10	7	20	24	5	6	15	9	11	18	7	71	**242**
Chesterfield County	33	18	28	22	29	11	22	3			1	2		3	11	37	**220**
City of Colonial Heights							1										**1**
Dinwiddie County	14	11	6	11	12	10	31	33	3	16	15	26	25	23	2	56	**294**
Town of McKenney																	
City of Emporia					1		1									3	**5**
Goochland County	21	15	15	14	11	8	18	6	2	6	5	10	7	7	2	42	**189**
Greensville County	6	4	11	3	6	4	16								3	42	**95**
Town of Jarratt						1											**1**
Hanover County	19	6	4	11	16	8	11	7	2	7	6	17	15	21	10	43	**203**
Town of Ashland																	
Henrico County	13	4	13	4	5	8	8	8	2	5	6	2	3	5		11	**97**
City of Hopewell							1										**1**
New Kent County	14	8	13	5	7	4	15								8	65	**139**
City of Petersburg							1	39	5	26	28	35	26	33			**193**
Powhatan County	26	16	24	14	19	5	27									13	**144**
Prince George County	12	4	9	7	8	6	17								11	11	**85**
City of Richmond			1			1		28	11	20	19	27	29	19			**155**
Surry County	11	3	6	5	7	2	4	9	1	3	4	4	5	7	3	14	**88**
Town of Claremont																	
Town of Dendron																	
Town of Surry																	
Sussex County	22	9	11	13	12	2	21	9	4	8	13	10	13	12	3	27	**189**
Town of Jarratt						1											**1**

Table 5-32. Number of Wildfires by Fire Year, 1995–2016

Jurisdiction Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010-2016	Total
Town of Stony Creek																	
Town of Wakefield																	
Town of Waverly					1		1										**2**
Total	**203**	**100**	**158**	**117**	**144**	**78**	**215**	**166**	**35**	**97**	**112**	**142**	**134**	**148**	**60**	**435**	**2344**

5.13.4 Vulnerability Analysis

Probability

The probability of wildfires is difficult to predict and is dependent on many things, including the types of vegetative cover in a particular area, and weather conditions, including humidity, wind, and temperature. Analysis of VDOF data indicates that on an annual basis, roughly 132 wildfires impact the region.

Impact and Vulnerability

VDOF used a Geographic Information System (GIS) to develop a statewide spatial Wildfire Risk Assessment model to identify areas where conditions are more conducive and favorable for wildfires to occur and advance. This model incorporated the factors listed in the Hazard Profile section and weighted them on a scale of 0 to 10, with 10 representing the characteristic of each factor that has the highest wildfire risk. With this model VDOF identified areas of the study area as having a wildfire risk level of High, Medium, or Low. The results are shown on the maps included at the end of this section (Figure 5-16). New Kent and Charles City Counties have the largest proportion of high risk areas while Henrico County and the City of Richmond have the least amount.

Hurricanes Isabel and Irene downed thousands of trees in both New Kent and Charles City Counties in 2003 and 2011, respectively. While the counties removed the most hazardous trees from public facilities and many homeowners have removed trees from their property, thousands still remain. These trees provide an easy source of fuel for wildfires and create a high risk across these counties.

Goochland County has been working with VDOF to promote best management practices among landowners in the county. The department and the county have offered joint courses on forestry management and wetlands protection. In addition, the county has thinned more than 160 acres as part of instituting best management practices on county-owned property.

Risk and Loss Estimation

There is a table (redacted Appendix G) that shows the percentages of critical facilities in fire risk zones, with 44.33% in the high-risk category. This was based on the VDOF Burn Probability analysis for the Richmond and Crater Regions. The burn probability data has categories 1-10, with 1 being the lowest risk and 10 being the highest. Because all critical facilities were only within the 1-3 range, 1 was set as low, 2 as medium, and 3 as high risk. Facilities not in a burn probability zone were assumed to be zero, or have no risk. The structures that had the highest risk were 8 cell towers (Dinwiddie, Goochland, Henrico, and Powhatan Counties), 2 combined Fire/EMS facilities (Town of McKenney and Hanover County), and 1 Fire Facility (Prince George County).

Jurisdictional Risk

VDOF defines woodland home communities as clusters of homes located along forested areas at the wildland-urban interface that could possibly be damaged during a nearby wildfire incident. Table 5-33 illustrates the number of woodland communities while Table 5-34 illustrates the number of homes in woodland communities, as designated by the Virginia Department of Forestry. The data indicates that approximately 46% of woodland home communities in the region are located in a high-fire-risk area. Of the 132,218 homes in woodland home communities, approximately 33% are located in a high-fire-risk area.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Table 5-33. Number of Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Charles City County	0	6	36	42	86%
Chesterfield County	82	140	189	411	46%
City of Colonial Heights	0	0	1	1	100%
Dinwiddie County	1	5	4	10	40%
Town of McKenney	1	0	0	1	0%
City of Emporia	5	0	0	5	0%
Goochland County	4	93	79	176	45%
Greensville County	1	5	0	6	0%
Town of Jarratt	0	0	2	2	100%
Hanover County	10	184	79	273	29%
Town of Ashland	2	3	1	6	17%
Henrico County	54	67	74	195	38%
City of Hopewell	1	0	0	1	0%
New Kent County	0	8	47	55	85%
City of Petersburg	5	2	4	11	36%
Powhatan County	0	31	73	104	70%
Prince George County	2	7	24	33	73%
City of Richmond	23	2	4	29	14%
Surry County	0	0	1	1	100%
Town of Claremont	0	0	1	1	100%
Town of Dendron	0	0	0	0	0%
Town of Surry	0	0	0	0	0%
Sussex County	0	0	1	1	100%

Table 5-33. Number of Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Town of Jarratt	0	0	2	2	100%
Town of Stony Creek	0	0	0	0	0%
Town of Wakefield	0	0	0	0	0%
Town of Waverly	0	0	0	0	0%
Totals	**191**	**553**	**622**	**1,366**	**46%**

Table 5-34. Number of Homes in Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Charles City County	0	136	855	991	86%
Chesterfield County	20,697	27,146	25,142	72,985	34%
City of Colonial Heights	0	0	75	75	100%
Dinwiddie County	135	144	253	532	48%
Town of McKenney	31	0	0	31	0%
City of Emporia	240	0	0	240	0%
Goochland County	138	3,099	2,720	5,957	46%
Greensville County	85	149	0	234	0%
Town of Jarratt	0	0	76	76	100%
Hanover County	981	7,278	3,342	11,601	29%
Town of Ashland	255	312	14	581	2%
Henrico County	13,700	4,409	3,761	21,870	17%
City of Hopewell	65	0	0	65	0%
New Kent County	0	293	1,829	2,122	86%
City of Petersburg	555	104	271	930	29%
Powhatan County	0	713	3,204	3,917	82%
Prince George County	415	199	1,397	2,011	69%
City of Richmond	7,595	65	185	7,845	2%
Surry County	0	0	15	15	100%
Town of Claremont	0	0	21	21	100%
Town of Dendron	0	0	0	0	0%

Table 5-34. Number of Homes in Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Town of Surry	0	0	0	0	0%
Sussex County	0	0	43	43	100%
Town of Jarratt	0	0	76	76	100%
Town of Stony Creek	0	0	0	0	0%
Town of Wakefield	0	0	0	0	0%
Town of Waverly	0	0	0	0	0%
Totals	**44,892**	**44,047**	**43,279**	**132,218**	**33%**

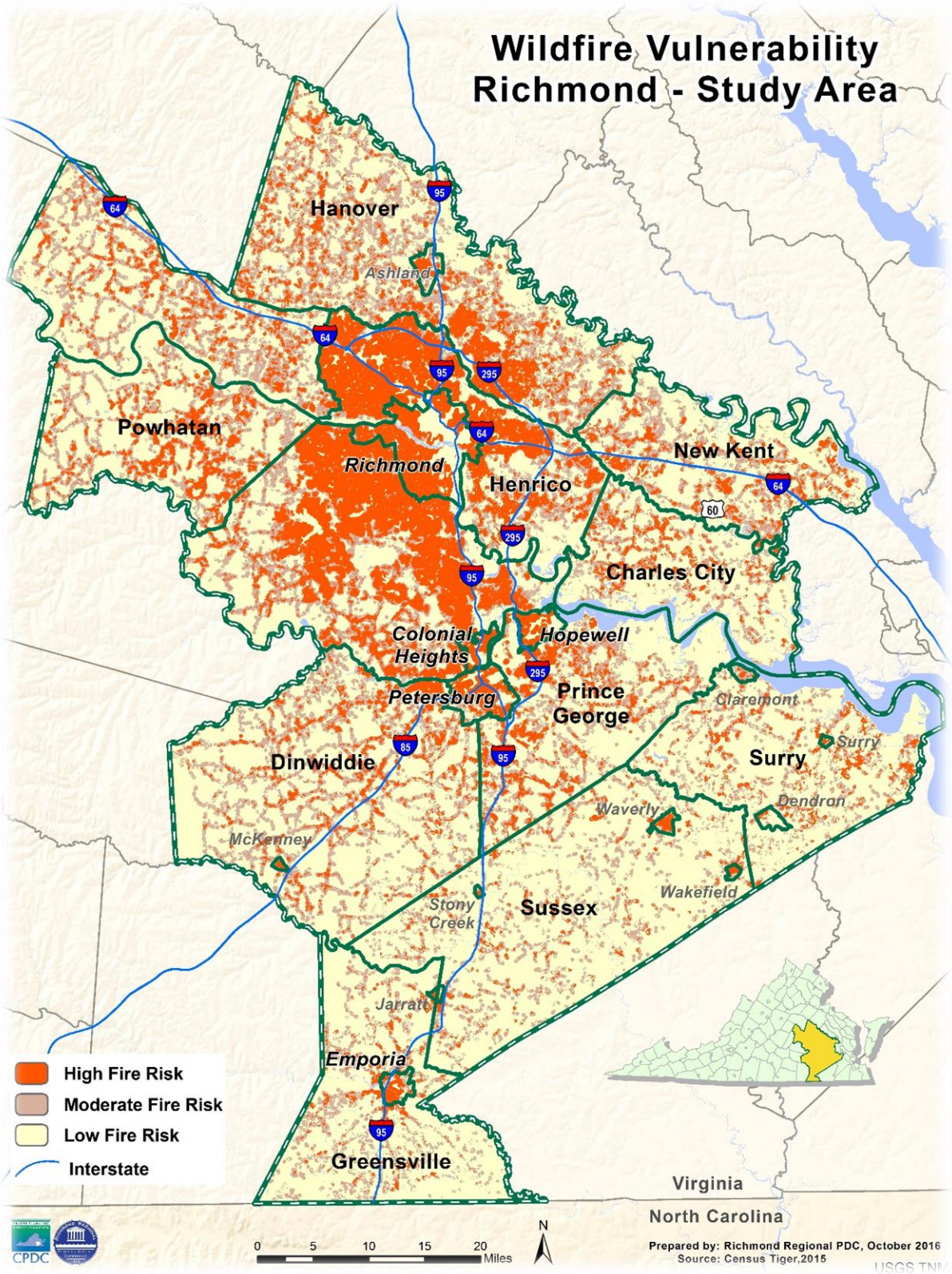


Figure 5-16. Wildfire Vulnerability
Source: Virginia Department of Forestry

In summary, based on the VDOF historical record (1995–2008; refer to Table 5-35), the region experiences approximately 132 fires per year that result in approximately $152,941 in damages. The past is a reasonable predictor of the future. It should be expected that the region will continue to battle wildfires from time to time, particularly during extended periods of dry and windy weather.

Table 5-35. Wildfire Events and Losses, 1995–2008

Jurisdiction Name	Total		Annualized	
	Total Acres	Total Damage	Number of Events	Losses
Charles City County	392.5	$71,100	10.31	$5,469
Chesterfield County	631.2	$53,675	18.92	$4,129
City of Colonial Heights	3	$500	0.08	$38
Dinwiddie County	13,227.05	$868,350	17.38	$66,796
Town of McKenney	0		0.00	$0
City of Emporia	2.25	$100	0.23	$8
Goochland County	232.1	$120,100	10.15	$9,238
Greensville County	1,758.3	$359,175	6.54	$27,629
Town of Jarratt	0.5		0.08	$0
Hanover County	432.8	$133,840	10.92	$10,295
Town of Ashland	7.5	$1,200	0.31	$92
Henrico County	328.5	$28,040	6.46	$2,157
City of Hopewell	0.1		0.08	$0
New Kent County	199.1	$11,150	11.69	$858
City of Petersburg	26.4		0.31	$0
Powhatan County	167.4	$167,100	11.92	$12,854
Prince George County	533.6	$22,990	9.62	$1,768
City of Richmond	6	$100	0.15	$8
Surry County	656.7	$45,700	5.15	$3,515
Town of Claremont	0		0.00	$0
Town of Dendron	0		0.00	$0
Town of Surry	0		0.00	$0
Sussex County	1,175.1	$104,040	11.85	$8,003
Town of Jarratt	0.5		0.08	$0
Town of Stony Creek	0		0.00	$0
Town of Wakefield	1.5	$1,000	0.08	$77
Town of Waverly	0.2	$75	0.15	$6
Total	**19,781**	**$1,988,235**	**132.46**	**$152,941**

Source: Virginia Department of Forestry.

5.14 Landslide and Shoreline/Coastal Erosion

5.14.1 Hazard Profile

Landslides

The term "landslide" describes many types of downhill earth movements ranging from rapidly moving catastrophic rock avalanches and debris flows in mountainous regions to more slowly moving earth slides.[15]

Shoreline/Coastal Erosion

NOAA describes shoreline/coastal erosion as a process whereby large storms, flooding, strong wave action, sea level rise, and human activities, such as inappropriate land use, alterations, and shore protection structures, wear away beaches and bluffs. Erosion undermines and often destroys homes, businesses, and public infrastructure.[16]

5.14.2 Magnitude or Severity

The severity of a landslide is dependent on many factors including the slope and width of the area involved and any structures or infrastructure directly in the path of the slide. Impacts of a landslide can range from a minor inconvenience to a life-threatening situation when automobiles and buildings are involved. The extent or severity of erosion is related to a number of factors: composition of the shoreline (rock, sand, clay, marsh, or human-made structures), fetch, orientation to prevailing wind direction, and relative sea level rise.[17]

5.14.3 Hazard History

Landslides

The greatest landslide hazards are found in the higher elevations of western and southwestern Virginia. Analysis of the hazards here is limited by the availability of data. There is no comprehensive database documenting all landslide occurrences within the commonwealth. Landslides have the potential to cause serious damage to buildings and infrastructure and may result in injuries or even fatalities. The expansion of urban development can increase the damages caused by a landslide. Damages sustained by roads and highways during a landslide can result in long-term loss of use of certain transportation routes, and contribute to increased traffic and emergency response times in the affected region. The soil movement that occurs during a landslide can destabilize structural supports for pipelines potentially resulting in pipeline ruptures and decreased or loss of service in a region.

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[15] National Disaster Education Coalition. Talking About Disaster: Guide for Standard Messages. Washington, D.C., 2004.
16 NOAA. (2011) http://coastalmanagement.noaa.gov/hazards.html#erosion
17 Virginia Department of Mine Minerals and Energy. (2011) http://www.dmme.virginia.gov/DMR3/coastalerosion.shtml

Local officials from the City of Richmond reported that a number of areas in the city were affected by landslides triggered by the rains of Tropical Storm Gaston in August 2004. The Church Hill and Riverside Drive sections of Richmond experienced 14 inches of rain in eight hours. Church Hill features numerous caves and unstable geologic formations which were stressed by saturation effects of the storm. One home in Church Hill was severely impacted by the landslide and was ultimately condemned and purchased by the City. Nearly tennis courts were also impacted. The Riverside Drive area features steep embankments along the south shore of the James River and abandoned granite quarries. During Gaston localized landslides occurred near Forest Hill Park.

Although no significant landslide occurrences have been reported for the rest of the region, the following map from the 2010 Virginia State Hazard Mitigation Plan (Figure 5-17) shows landslide susceptibility and incidence for the region based on U.S. Geological Survey (USGS) analysis and data. A strip of High Susceptibility and Moderate Incidence runs through portions of Henrico County and the City of Richmond and touches portions of Chesterfield and Prince George Counties and the Cities of Hopewell, Petersburg, and Colonial Heights (Figure 5-18).

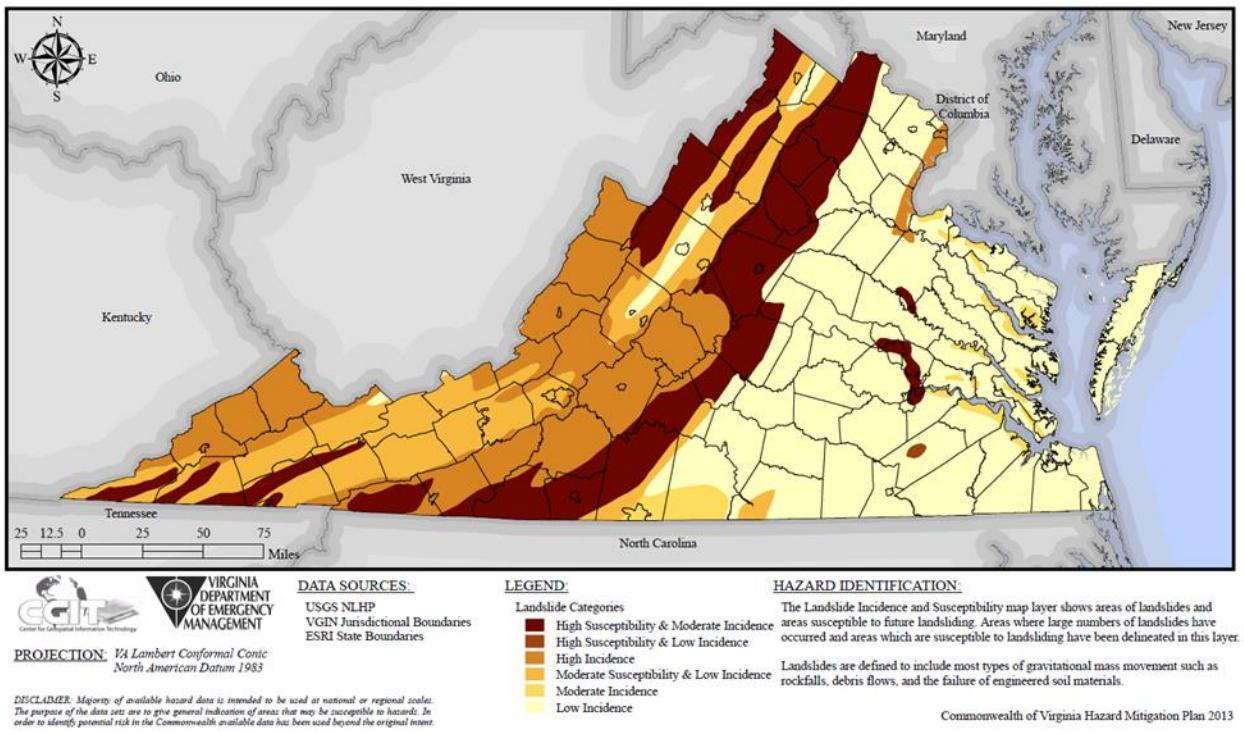

Figure 5-17. U.S. Geological Survey Landslide Susceptibility and Incidence
Source: 2013 Virginia State Hazard Mitigation Plan

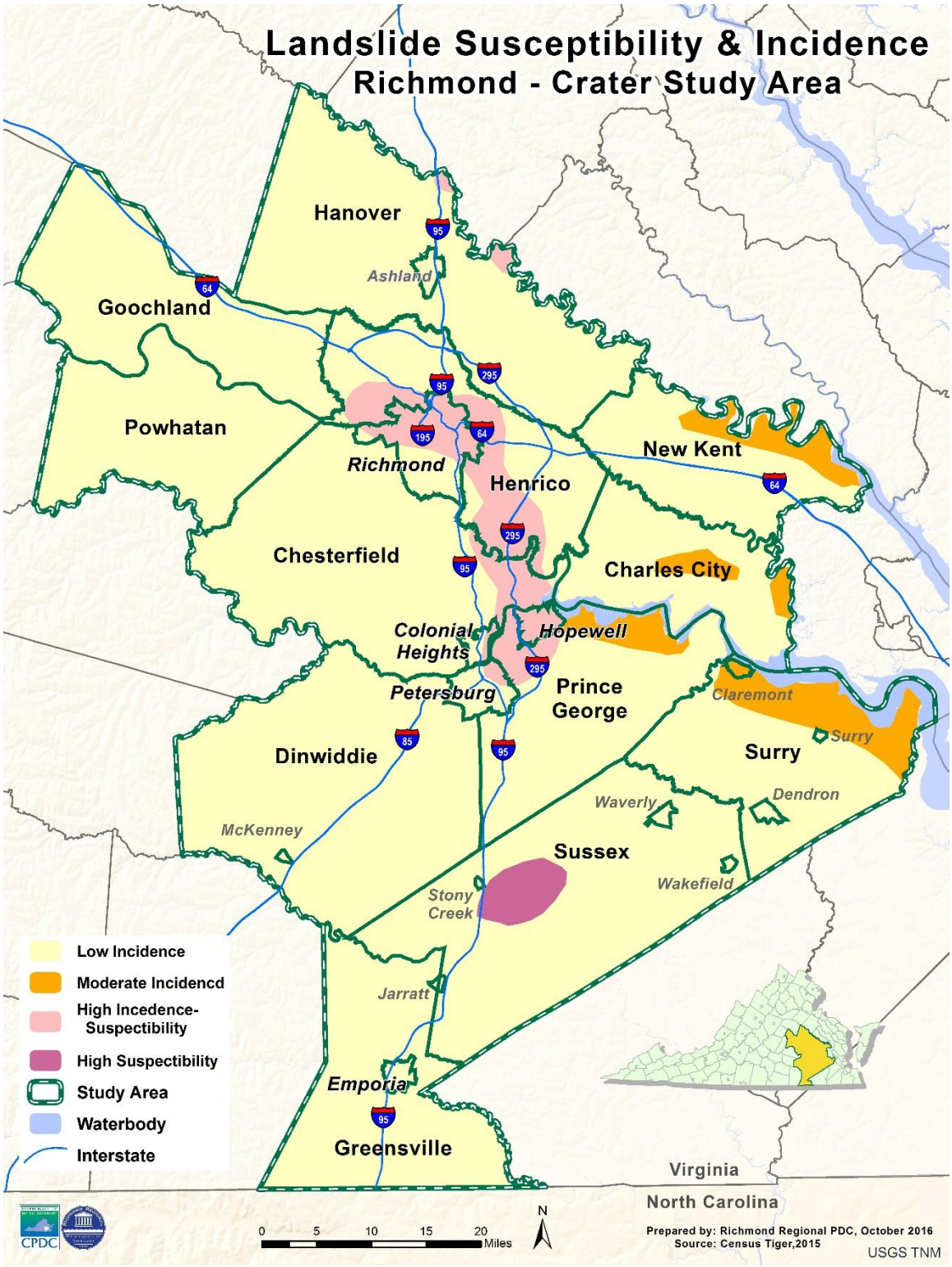

Figure 5-18. U.S. Geological Survey Landslide Susceptibility and Incidence for Region

Shoreline/Coastal Erosion

The shoreline areas of the region are consistently undergoing coastal erosion. However, severe storms that increase wave activity, such as hurricanes, tropical storms, and nor'easters, sea level rise, and shoreline development can increase occurrences of erosion. The banks of the James River have historically experienced substantial erosion (varying rates) from storm events. However, data regarding specific events that resulted in substantial erosion is lacking.

5.14.4 Vulnerability Analysis

Landslides

The probability of a landslide is difficult to ascertain given the lack of data available to perform such an analysis. Even so, landslide events in the region are considered to be a low-probability event, but with the potential to have a significant impact when and where they do occur.

The USGS first developed a national landslide incidence map in 1982. This national map was used as a basis for the maps in this analysis. The map shows areas where large numbers of landslides have been recorded (incidence) and areas that may be susceptible to landslides because of their geologic composition (susceptibility). According to the report that accompanies the incidence map, "susceptibility is not shown where it is comparable to incidence – for example, where areas of the highest category of incidence are assumed to have high susceptibility and where areas of the lowest category are assumed to have low susceptibility."[18]

The report goes on to state, "The map was prepared by evaluating formations or groups of formations shown on the geologic map of the United States and classifying them as having high, medium, or low landslide incidence (number of landslides) and being of high, medium, or low susceptibility to landslides. Those map units or parts of units with more than 15 percent of their area involved in landslides were classified as having high incidence; those with 1.5 to 15 percent of their area involved in landslides, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence. This classification scheme was modified where particular lithofacies are known to have variable landslide incidence or susceptibility."

The susceptibility categories are largely subjective because insufficient data was available for precise determinations. Because the map is highly generalized, was created at a national scale, and is based on relatively old and imprecise data, it should not be taken as an absolute guide to landslide incidence and susceptibility and should not be used for site selection purposes.

While the majority of the region has low landslide incidence, high susceptibility and moderate incidence is located in portions of Prince George County, City of Hopewell, City of

[18] Radbruch-Hall, Dorothy H. et al. United States Geologic Survey. *Landslide Overview Map of the Conterminous United States.* U.S. Geological Survey Professional Paper 1183. 1982.

Colonial Heights, City of Petersburg, Chesterfield County, City of Richmond, Henrico County, and Hanover County. High susceptibility and low incidence is located in Sussex County. Moderate incidence is located in New Kent County, Charles City County, Prince George County, and Surry County.

As noted in the previous section, landslides have occurred in the City of Richmond following high rainfall but have generally been limited in scope and/or extent. The primary area of concern noted by city officials is Government Road. At the time of this report, this is the best available data; no other historical data is available.

The impact of landslides on jurisdictions in the region has historically been that of inconvenience resulting from partially blocked roadways. Data regarding landslide risk in the region is limited. Depending on the scale of a landslide event and the damage it inflicts, losses could potentially range into the thousands or perhaps millions of dollars in an extreme event. The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Shoreline/Coastal Erosion

The probability of shoreline erosion is difficult to quantify, but is a near-certainty along the region's shorelines. The Harrison Point subdivision, along the James River, experiences recurrent flooding. In addition, the river banks experience substantial erosion from storm events and are considered to be vulnerable for ongoing erosion.

The coastal portion of the region is protected by the Virginia Coastal Zone Management Program. Surry, Prince George, Chesterfield, Henrico, New Kent, Hanover, and Charles City Counties, and the Cities of Richmond, Colonial Heights, Hopewell, and Petersburg are all part of Virginia's Coastal Management Program. The program aims to reduce the likelihood of erosion and the effects of erosion on Virginia's shoreline by emphasizing land use best practices. Figure 5-19 shows the boundary of Virginia's Coastal Zone.[19]

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

[1919] Virginia Department of Environmental Quality. (2011) http://www.deq.virginia.gov/coastal/coastmap.html

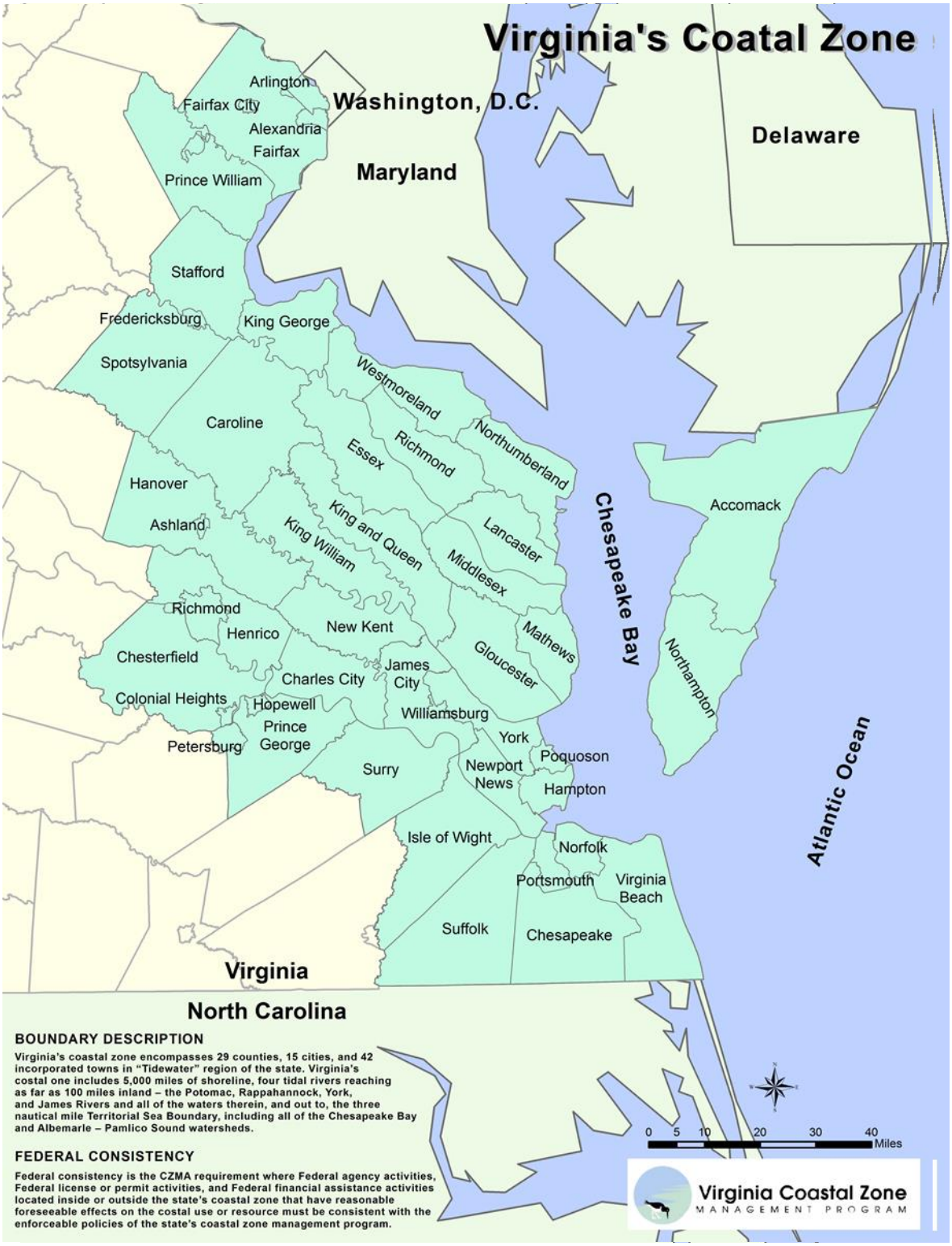

Figure 5-19. Jurisdictions included in the Virginia Coastal Zone Management Program

5.15 Land Subsidence/Karst/Sinkholes

5.15.1 Hazard Profile

Karst topography can be described as a landscape formed over limestone, dolomite, or gypsum, and is characterized by sinkholes, caves, and underground drainage. The collapse of land in the karst topography creates sinkholes.

Sinkholes are classified as natural depressions of the land surface and are caused when the acidic groundwater dissolves the surrounding geology. Most of these events are triggered by human activity in the karst environment. Excessive pumping of groundwater from karst aquifers may rapidly lower the water table and cause a sudden loss of buoyant forces that stabilize the roofs of cavernous openings. Human-induced changes in surface water flow and infiltration also may cause collapse. Most sinkholes that form suddenly occur where soil that overlies bedrock collapses into the pre-existing void.

5.15.2 Magnitude or Severity

Depending on its size, sinkholes can cause damage to bridges, roads, railroads, storm drains, sanitary sewers, canals, levees, and private and public buildings. Another problem associated with karst topography is its impact on aquifers and potential for groundwater contamination. The greatest impact occurs when polluted surface waters enter karst aquifers. This problem is universal among all populated areas located in areas of karst. The groundwater problems associated with karst are accelerated with the advent of (1) expanding urbanization, (2) misuse and improper disposal of environmentally hazardous chemicals, (3) shortage of suitable repositories for toxic waste (both household and industrial), and (4) ineffective public education on waste disposal and the sensitivity of the karstic groundwater system.

Areas over underground mine workings are also susceptible to subsidence. Mine collapses have resulted in losses of homes, roadways, utilities, and other infrastructure. Subsidence is often exacerbated by the extensive pumping of groundwater associated with underground mining. Abandoned coal mines occur in Henrico, Chesterfield, and Goochland Counties in the Richmond coal basin and Buchanan, Dickenson, Lee, Scott, Russell, Tazewell, Wise, Montgomery, and Pulaski Counties in southwest Virginia.

In addition to areas of karst and underground or abandoned mine sites, aging or crumbling infrastructure is another potential source of sudden sinkholes. This can occur anywhere and is difficult to predict.

5.15.3 Hazard History

Dramatic collapses of land that swallow homes or persons have happened in Virginia, but generally are rare. Although there have been a few in the region, the most notable incidents occurred in western Virginia in the City of Staunton. On August 11, 1911, parts of several homes and the firehouse were lost in a series of sinkholes on Baldwin Street and

Central Avenue, and on October 28, 2001, a 45-foot-deep chasm opened up on Lewis Street.[20]

According to the 2013 Virginia State Hazard Mitigation Plan, there have been no Federal Declared Disasters or NCDC recorded events for karst-related events in the commonwealth. Land subsidence is very site-specific. There is no comprehensive long-term record of past events in Virginia. Several documented occurrences have been included in Table 5-36. Future plan updates and/or mitigation strategies might include working with VDOT to determine those roadways and areas most susceptible to sinkholes.

Table 5-36. History of Sinkhole Damages, January 2010 – March 2011

Date	Damages
January 4, 2010	**City of Richmond:** The ramp from I-95 North to Broad Street in downtown Richmond was closed because of a sinkhole. Reports say that what started as a pothole quickly became a gaping hole in which the ground collapsed, with about 5 feet of earth underneath it washed away. (Source: WWBT-TV NBC 12 Richmond, VA; http://www.nbc12.com/story/11763653/update-sinkhole-closes-i-95-downtown-exit?redirected=true)
August 2010	**Chesterfield County:** Sinkholes in the Scottingham neighborhood were reported around storm drain infrastructure. (Source: WWBT-TV NBC 12 Richmond, VA)
March 2011	**City of Richmond:** A sinkhole closed the intersection of Grove and Stafford Avenues in Richmond. (Source: Richmond Times-Dispatch)

5.15.4 Risk Assessment

In Virginia, the principal area affected by sinkholes is the Valley and Ridge province, an extensive karst terrain underlain by limestone and dolomite, but the narrow marble belts in the Piedmont and some shelly beds in the Coastal Plain are also pocked with sinkholes. A majority of the karst regions in Virginia follow I-81, as seen in Figure 5-20. These areas are broadly defined and mapped with a general understanding of karst hazard risks.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

[20] Virginia Department of Mines Minerals and Energy; http://www.dmme.virginia.gov/DMR3/sinkholes.shtml.

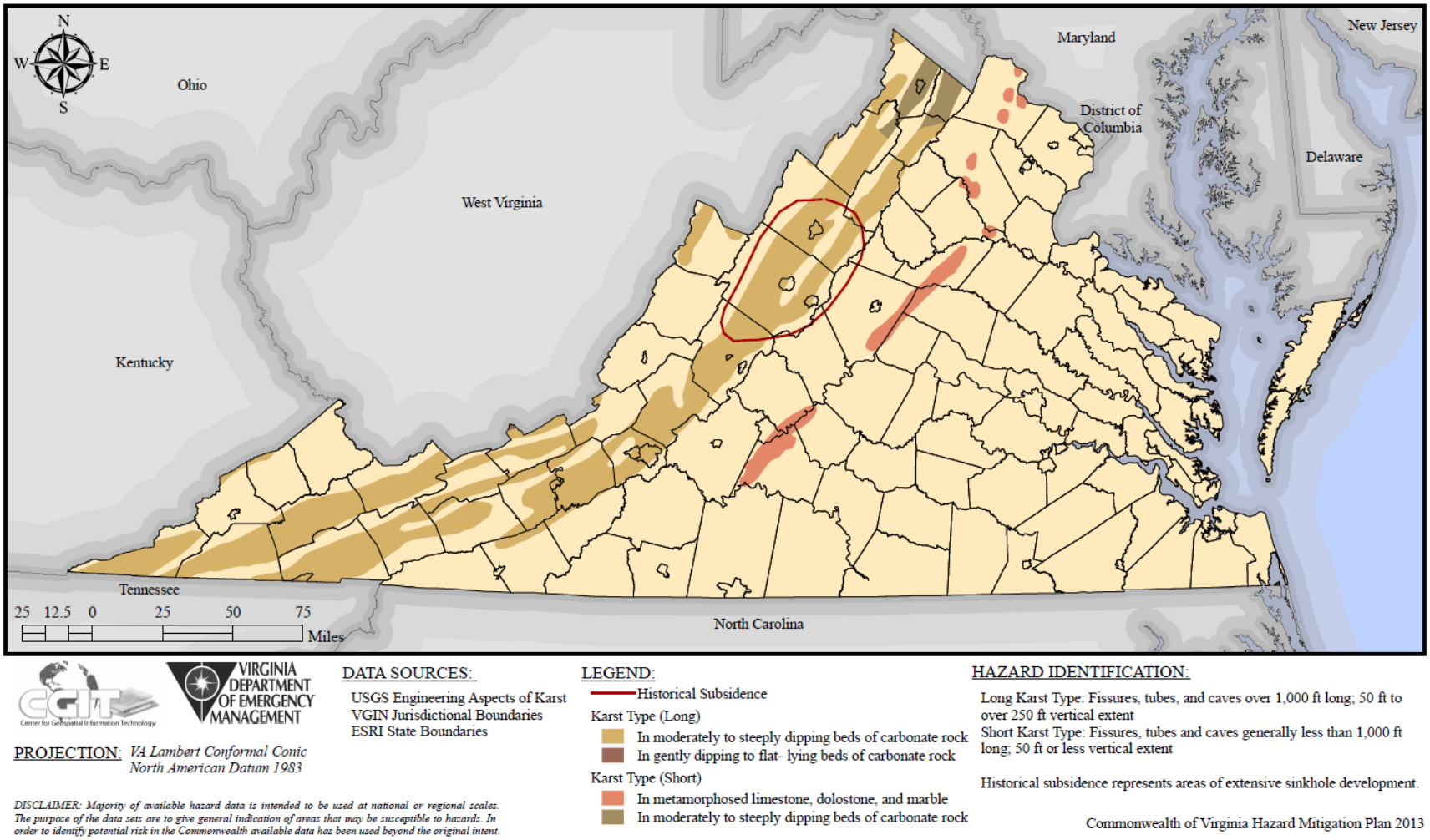

Figure 5-20. Karst Areas in the Commonwealth of Virginia
Source: 2013 Virginia State Hazard Mitigation Plan

Based on the previous maps, the Richmond Regional – Crater Planning District Commissions region does not have a karst-like environment. However, abandoned coal mines do exist in the region and, as stated previously, areas over underground mine workings are also susceptible to subsidence. Maps of historic mining activities are available for a majority of the region, including Powhatan, Goochland, Hanover, New Kent, Charles City, Chesterfield, and Henrico Counties, as well as the Cities of Richmond and Hopewell. The maps can be found at the following website: http://www.dmme.virginia.gov/DMR3/abandonedmines.shtml.

As discussed previously, sinkholes are relatively uncommon events in the region. The existing soil types are not conducive to creating natural sinkholes. There are no known sources of data for determining sinkhole probability for the region. Based on previous instances, likely the result of aging infrastructure, and the fact that abandoned mines exist, there is at least a low probability of future sinkhole occurrences in the region.

Limited data prevents a detailed vulnerability analysis at the jurisdictional level. Those jurisdictions with underground infrastructure in need of replacement or repair and those sitting on top of abandon mine locations are at an elevated risk from sinkholes as compared to those without such risk factors.

The potential impacts of land subsidence depend on the type of subsidence that occurs (regional or localized, gradual or sudden) and the location in which the subsidence occurs. The impacts of subsidence occurring in non-urban areas are likely to be less damaging than subsidence that occurs in heavily populated locations. The amount of structural damage depends on the type of construction, the structure location and orientation with respect to the subsidence location, and the characteristics of the subsidence event (sag or pit).

Potential impacts from land subsidence could include damage to residential, commercial, and industrial structures; damage to underground and above-ground utilities; damage to transportation infrastructure, including roads, bridges, and railroad tracks; as well as damage to or loss of crops. Potential damage and loss due to sinkholes or land subsidence is nearly impossible to assess because the nature of the damage is site- and event-specific.

5.16 Earthquakes

5.16.1 Hazard Profile

The earth's outer surface is broken into pieces called tectonic plates, which move away from, toward, or past each other. Because the continents are part of these plates, they also move. An earthquake occurs when the stresses caused by plate movements are released. The abrupt release of stored energy in the rocks beneath the earth’s surface results in a sudden motion or trembling of the earth. The epicenter is the point on the Earth's surface directly above the source of the earthquake.

5.16.2 Magnitude or Severity

Smaller earthquakes occur much more frequently than larger earthquakes. These smaller earthquakes generally cause little or no damage. However, very large earthquakes can cause tremendous damage and are often followed by a series of smaller aftershocks lasting for weeks after the event. This phenomenon, referred to as "minor faulting," occurs during an adjustment period that may last for several months.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale (Table 5-37). The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology, as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Table 5-37. The Richter Scale

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5–5.4	Often felt, but rarely causes damage.
Under 6.0	At most, slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1–6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0–7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally, total destruction. Although numerous intensity scales have been developed in the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli Intensity Scale. It was developed in 1931 by American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals as

shown in Table 5-38. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.

The Modified Mercalli Intensity value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude because intensity refers to the effects actually experienced at a particular place.

The lower numbers of the intensity scale deal with the manner in which people feel the earthquake. The higher numbers of the scale are based on observed structural damage. Structural engineers usually contribute information for assigning intensity values of VIII or above.

Table 5-38. Modified Mercalli Intensity Scale for Earthquakes

Scale	Intensity	Earthquake Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	<4.2
III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	<4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves	<5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures; poorly constructed buildings damaged	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	>8.1

5.16.3 Hazard History

Significant earthquakes were first recorded in Virginia in 1774. Virginia has had more than 160 earthquakes since 1977, of which 16% were felt. This averages to approximately one earthquake every month, with two felt each year.[21] Figure 5-21 shows the significant earthquakes that have impacted Virginia from 1568 to 2009. There have been four significant earthquakes centered in the region. There is quaternary faulting in the Central Virginia Seismic Zone, running through Powhatan, Goochland, Fluvanna, and Cumberland Counties. Quaternary faults and folds are believed to be sources of earthquakes greater

[21] Virginia Tech Seismological Observatory. (2010) http://www.geol.vt.edu/outreach/vtso/quake.html

than magnitude 6 in the past 1,600,000 years; however, the USGS reports that only liquefaction features are evidence of strong shaking and that individual faults in the Central Virginia Seismic Zone remain unidentified.[22]

Of the four significant earthquakes that have been recorded in the region, one was centered near the City of Petersburg, two near Goochland County, and one near Powhatan County. Historical earthquake occurrences, which have affected the region and are summarized in the following paragraphs, are based on available records from the Virginia Tech Seismological Observatory, Seismicity of the United States (USGS Paper 1527), and Earthquakes in Virginia and Vicinity 1774 – 2004 (USGS Paper 2006 1017).

The first earthquake (4.5 on the Richter Scale) occurred on February 21, 1774, near the City of Petersburg and Prince George County. The earthquake was felt in much of Virginia and southward into North Carolina. Many houses were moved considerably off their foundations in the cities of Petersburg and Blandford. The shock was described as "severe" in Richmond and terrified residents about 50 miles north in the City of Fredericksburg, but caused no damage in those areas. The total felt area covered about 57,900 square miles.

On August 27, 1833, an earthquake near Goochland County (4.5 on the Richter Scale) was felt from Norfolk to Lexington and from Baltimore, Maryland, to Raleigh, North Carolina – about 52,110 square miles. In Charlottesville, Fredericksburg, Lynchburg, and Norfolk, windows rattled violently, loose objects shook, and walls of buildings were visibly agitated.

Although it did not occur within the region, an earthquake (4.3 on the Richter Scale) was observed on November 2, 1852, with the epicenter in Buckingham County, Virginia. Chimney damage was reported in Buckingham and the earthquake was reported to be the strongest in Fredericksburg and Richmond, and the Town of Scottsville.

Centered near Goochland County, a series of shocks (4.8 on the Richter Scale) in quick succession were felt throughout the eastern two-thirds of Virginia and a portion of North Carolina on December 23, 1875. The highest intensities from this earthquake occurred mainly in towns near the James River shoreline in Goochland and Powhatan Counties, and in Louisa County. In Richmond and Henrico Counties, the most severe damage was sustained in the downtown business and residential areas adjacent to the James River. Damage included bricks knocked from chimneys, fallen plaster, an overturned stove, and several broken windows. Waves "suddenly rose several feet" at the James River dock in Richmond, causing boats to "part their cables" and drift below the wharf. At Manakin, about 20 kilometers west of Richmond, shingles were shaken from a roof and many lamps and chimneys were broken. The total felt area was about 50,180 square miles.

On February 11, 1907, an earthquake reaching 4 on the Richter Scale affected the Town of Arvonia and Buckingham County. The earthquake was also felt strongly from Powhatan to Albemarle Counties.

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[22]USGS. (2011) http://geohazards.usgs.gov/cfusion/qfault/qf_web_disp.cfm?qfault_or=1235&qfault_id=2653

The December 9, 2003, Powhatan County earthquake (4.5 on the Richter Scale) was a complex event consisting of two sub-events occurring 12 seconds apart and causing slight damage nearest the epicenter. The quakes were felt in much of Maryland and Virginia; in north-central North Carolina; and in a few areas of Delaware, New Jersey, New York, Pennsylvania, and West Virginia.

A 5.8 magnitude quake centered near Mineral, VA occurred at 1:51 pm EDT on August 23, 2011. The earthquake was reportedly felt as far north as Boston, as far south as Georgia and as far west as Chicago. Effects of the earthquake were reported to the USGS through its online survey from over 8,434 zip codes, and ranged from weak intensity to very strong. In terms of damage, particularly hard-hit were brick and unreinforced structures and infrastructure near the quake's epicenter. In addition to cracks and buckling, some buildings were knocked off of their foundations. Minor injuries were reported as a result of the damage and debris. The earthquake forced the North Anna Power Station nuclear power plant offline pending an all-clear from a Nuclear Regulatory Commission review. Aftershocks of a lesser magnitude continued to plague the area for several weeks after the event. The strongest aftershock measured 4.5 and occurred on August 25 at 1:08 am EDT.

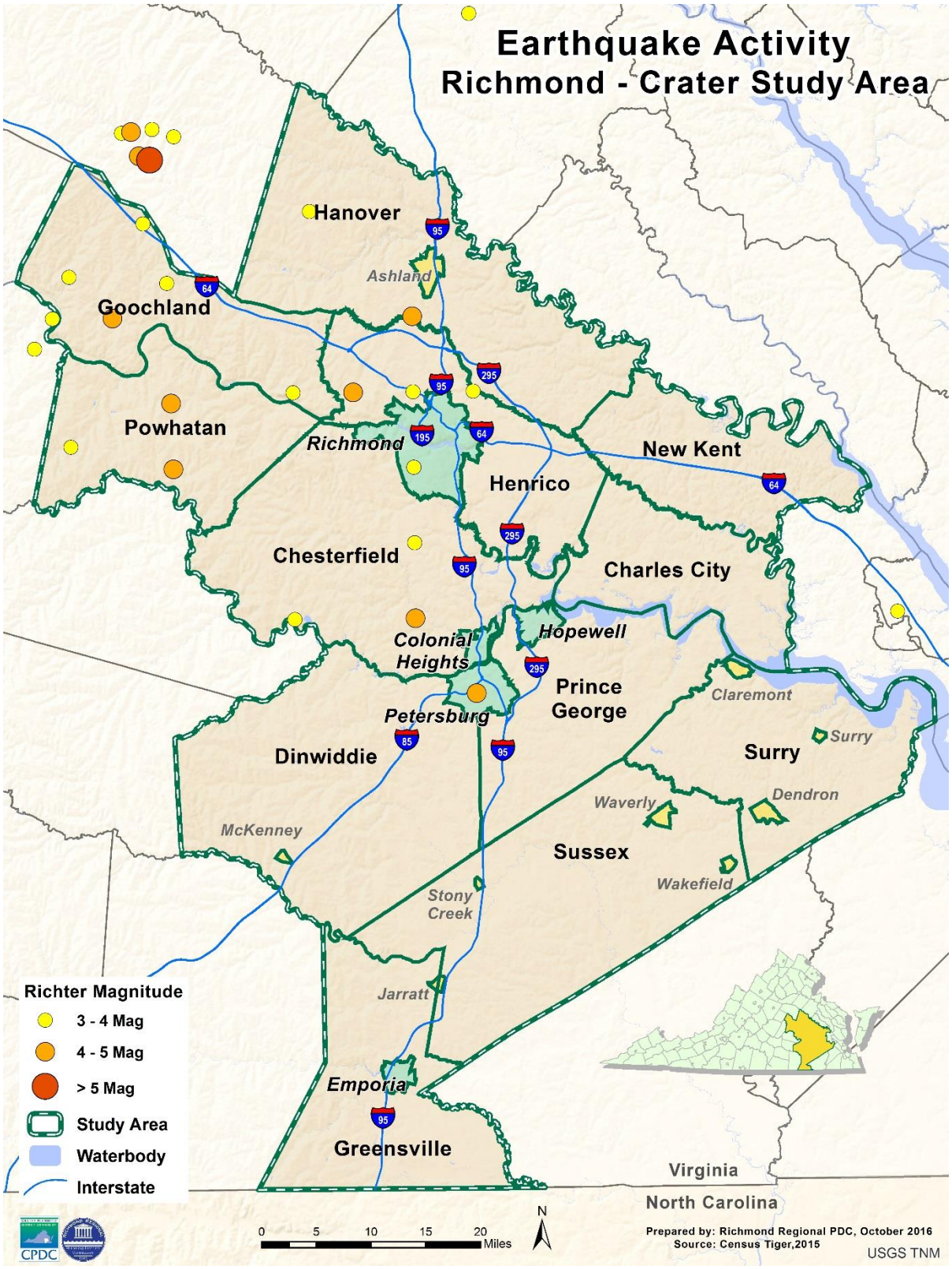

Figure 5-21. Earthquake Activity and Seismic Hazard Map

5.16.4 Vulnerability Analysis

Probability

Because earthquakes have a limited ranking for the region, calculation of probability was not performed for this analysis. Earthquakes are high-impact, low-probability events. With the few historical incidents throughout the region and limited data, the probability is low.

Impact and Vulnerability

Impacts from earthquakes can be severe and cause significant damage. Ground shaking can lead to the collapse of buildings and bridges, and disrupt gas, lifelines, electric, and phone service. Death, injuries, and extensive property damage are possible vulnerabilities from this hazard. Some secondary hazards caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure.

Risk and Loss Estimation

Because earthquakes have a limited ranking for the region, analysis for critical facilities was not performed. The HAZUS-MH earthquake model estimates damages and loss to buildings, lifelines, and essential facilities from scenario and probabilistic earthquakes.

For the 2013 Virginia State Hazard Mitigation Plan, probabilistic earthquake events were modeled using HAZUS-MH MR3. HAZUS-MH was used to generate damage and loss estimates for the probabilistic ground motions associated with each of eight return periods (100-, 250-, 500-, 750-, 1,000-, 2,000-, and 2,500-year return periods). The building damage estimates were then used as the basis for computing direct economic losses. These include building repair costs, contents and business inventories losses, costs of relocation, and capital-related wage and rental losses.

Annualized loss was computed in the 2011 update in HAZUS, by multiplying losses from eight potential ground motions by their respective annual frequencies of occurrence, and then summing the values. Table 5-39 shows the HAZUS results for the jurisdictions in the region. These results were extracted directly from the 2013 Virginia State Hazard Mitigation Plan. Based on this analysis, Henrico County would be expected to see the greatest losses on an annual basis in the region, followed closely by the City of Richmond and Chesterfield County.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Table 5-39. Annualized Earthquake Losses (Hazus 2011)

Jurisdiction	Annualized Losses
15 Charles City County	$7,849
2 Chesterfield County	$596,915
8 City of Colonial Heights	$42,257
11 Dinwiddie County (incl. Town of McKenney)	$35,223
14 City of Emporia	$11,286
6 Goochland County	$58,031
Greensville County (incl. Town of Jarratt)	$10,862
4 Hanover County (incl. Town of Ashland)	$215,922
1 Henrico County	$726,316
10 City of Hopewell	$35,637
12 New Kent County	$16,193
5 City of Petersburg	$78,970
7 Powhatan County	$55,723
9 Prince George County	$42,008
3 City of Richmond	$591,619
Surry County (incl. Towns of Claremont, Dendron, Surry)	$5,523
13 Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	$11,465
Total	**$2,541,799**

Source: http://www.vaemergency.gov/webfm_send/865/Section3-9-WinterWeather.pdf

5.17 Hazard Identification and Risk Assessment Summary

A variety of hazards, both natural and human caused, have the potential to impact the region. Data analysis presented in the preceding sections and input from the MAC indicate that flooding has the most significant and frequent impacts on the region and its citizens.

In addition to the potential for injury or loss of life and damage to property and crops, hazards have the potential to cause disruption of utilities, communication and transportation systems, which can contribute to lost business and decreased productivity. Table 5-40 provides a summary of potential annualized losses by hazard for which losses could be determined. Tables 5-41 and 5-42 are summarized annual total damages and events for each county. Tables 5-43, 5-44, and 5-45 show the individual scores and ranks of each of the hazards analyzed for each of the Jurisdictions. The scores were based on a similar analysis shown in Section 5.4.3, except for being compared as totals for the study area, hazards were compared within each jurisdiction to determine the ranks for each hazard.

It is important to point out that data limitations prevent a full accounting of past or potential future losses. This is particularly true in the case of the wildfire, earthquake, landslides, and karst hazards, as there was no applicable data found from the NCDC and historical data may have been supplemented. Also, the NCDC database recognizes that it may not contain every event or damages and should only be considered as estimates.

The jurisdictional executive summaries in Appendix G highlight hazards and vulnerability within each community.

NOTES: *Data for some hazards is only available at the city and/or county level.
**Loss data for the Towns are incorporated into their larger counties for consistency with the NCDC dataset.

Table 5-40. Potential Annualized Losses

Jurisdiction	Total Annualized Losses	Largest Event Property Damages	Largest Property Damages Event Type	Largest Event Crop Damages	Largest Crop Damages Event Type
Charles City County	$180,743.34	$13,987.96	Tornado	$131,416.88	Drought
Chesterfield County	$2,479,939.80	$1,951,015.48	Hurricanes	$10,694.79	Hurricanes
City of Colonial Heights	$109,139.03	$71,663.27	Flood	-	N/A
City of Emporia	$20,252.60	$12,223.05	Flood	$3,284.57	Flood
City of Hopewell	$87,141.27	$85,942.05	Tornado	-	N/A
City of Petersburg	$946,015.13	$891,490.10	Tornado	$11,943.88	Flood
City of Richmond	$1,142,827.00	$1,065,174.56	Flood	-	N/A
Dinwiddie County	$2,295,987.73	$1,272,732.68	Tornado	$402,556.43	Drought
Goochland County	$167,949.85	$24,560.15	Tornado	$122,076.69	Drought
Greensville County	$163,994.86	$71,663.27	Flood	$47,775.51	Flood
Hanover County	$677,733.31	$109,340.00	Flood	$500,830.07	Drought
Henrico County	$1,571,013.91	$982,142.37	Hurricanes	$244,153.37	Drought
New Kent County	$139,018.00	$38,965.66	Flood	$69,427.79	Drought
Powhatan County	$621,507.27	$216,288.04	Hurricanes	$378,380.68	Drought
Prince George County	$2,654,799.45	$1,305,027.80	Hurricanes	$931,930.92	Hurricanes
Surry County	$608,554.11	$367,251.73	Hurricanes	$115,894.15	Hurricanes
Sussex County	$455,933.42	$265,726.39	Flood	$62,186.96	Flood

Table 5-41. Summary of Annualized Total Damages for each HIRA Category

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Wildfires*	Earthquake*
Charles City County	$0	$1,535	$70	$1,444	$13,988	$131,417	$32,289	$5,469	$7,849
Chesterfield County	$290,444	$15,640	$2,545	$7,962	$201,639	$0	$1,961,710	$4,129	$596,915
City of Colonial Heights	$71,663	$4,370	$0	$0	$33,106	$0	$0	$38	$42,257
City of Emporia	$15,508	$1,408	$0	$0	$3,337	$0	$0	$8	$11,286
City of Hopewell	$0	$1,199	$0	$0	$85,942	$0	$0	$0	$35,637
City of Petersburg	$50,761	$3,764	$0	$0	$891,490	$0	$0	$0	$78,970
City of Richmond	$1,065,175	$3,673	$0	$0	$73,980	$0	$0	$8	$591,619
Dinwiddie County	$184,075	$10,714	$154	$2,600	$1,272,733	$402,556	$423,155	$66,796	$35,223
Goochland County	$0	$2,972	$34	$3,004	$24,560	$122,077	$15,302	$9,238	$58,031
Greensville County	$119,439	$2,513	$214	$0	$18,033	$0	$23,796	$27,629	$10,862
Hanover County	$109,340	$15,037	$102	$3,030	$27,280	$500,830	$22,115	$10,387	$215,922
Henrico County	$141,487	$36,087	$508	$8,948	$114,430	$244,153	$1,025,400	$2,157	$726,316
New Kent County	$38,966	$5,979	$117	$1,444	$16,581	$69,428	$6,502	$858	$16,193
Powhatan County	$0	$4,538	$0	$2,889	$0	$378,381	$235,700	$12,854	$55,723
Prince George County	$158,329	$6,247	$469	$9,089	$20,546	$223,161	$2,236,959	$1,768	$42,008
Surry County	$101,548	$2,224	$0	$0	$21,636	$0	$483,146	$3,515	$5,523
Sussex County	$327,913	$3,418	$190	$0	$75,448	$0	$48,964	$8,086	$11,465
Totals	$2,674,649	$121,317	$4,403	$40,411	$2,894,729	$2,072,003	$6,515,038	$6,515,038	$6,515,038

*Data used from 2011 Plan Update and were not from NCDC dataset

Table 5-42. Summary of Annualized Events for each HIRA Category

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires*	Earthquake	Landslide	Karst
Charles City County	0.29	0.95	0.02	2.38	0.03	0.17	0.08	-	10.31	-	-	-
Chesterfield County	0.92	3.98	0.10	6.00	0.25	0.25	0.17	-	18.92	-	-	-
City of Colonial Heights	0.21	0.59	0.00	0.00	0.01	0.00	0.00	-	0.08	-	-	-
City of Emporia	0.33	0.54	0.00	0.00	0.03	0.00	0.00	-	0.23	-	-	-
City of Hopewell	0.13	0.70	0.00	0.00	0.06	0.00	0.00	-	0.08	-	-	-
City of Petersburg	0.21	0.82	0.00	0.00	0.07	0.00	0.00	-	0.31	-	-	-
City of Richmond	0.54	1.41	0.00	0.00	0.13	0.00	0.00	-	0.15	-	-	-
Dinwiddie County	0.38	2.03	0.05	2.42	0.13	0.25	0.08	-	17.38	-	-	-
Goochland County	0.13	2.03	0.02	3.50	0.13	0.21	0.04	-	10.15	-	-	-
Greensville County	0.25	1.13	0.07	4.17	0.09	0.25	0.17	-	6.62	-	-	-
Hanover County	0.58	3.16	0.07	3.54	0.28	0.25	0.08	-	11.23	-	-	-
Henrico County	0.58	4.26	0.26	6.08	0.18	0.50	0.17	-	6.46	-	-	-
New Kent County	0.42	1.54	0.02	2.50	0.07	0.13	0.08	-	11.69	-	-	-
Powhatan County	0.42	1.80	0.00	3.04	0.04	0.25	0.04	-	11.92	-	-	-
Prince George County	0.58	2.74	0.20	7.88	0.15	0.50	0.25	-	9.62	-	-	-
Surry County	0.67	1.38	0.00	2.08	0.12	0.13	0.17	-	5.15	-	-	-
Sussex County	0.63	1.80	0.07	2.29	0.13	0.13	0.13	-	12.16	-	-	-
Totals	7.27	30.86	0.88	45.88	1.90	3.02	1.46	-	0.00	-	-	-

*Data used from 2011 Plan Update and were not from NCDC dataset

Table 5-43. HIRA Analysis Scores for Ranking

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires	Earthquake	Landslide	Karst
Charles City County	0.75	1.08	0.88	1.58	1.08	1.88	1.20	0.19	1.45	0.33	0.31	0.31
Chesterfield County	1.13	1.64	0.88	1.57	1.07	0.57	2.19	0.19	1.44	0.41	0.31	0.31
City of Colonial Heights	2.06	1.14	0.69	0.63	1.36	0.38	0.69	0.19	0.69	0.51	0.31	0.31
City of Emporia	2.06	1.18	0.69	0.63	1.22	0.38	0.69	0.19	0.69	0.55	0.31	0.31
City of Hopewell	0.75	1.08	0.69	0.63	2.25	0.38	0.69	0.19	0.69	0.45	0.31	0.31
City of Petersburg	0.82	1.07	0.69	0.63	2.25	0.38	0.69	0.19	0.69	0.34	0.31	0.31
City of Richmond	2.25	1.63	0.69	0.63	1.03	0.38	0.69	0.19	0.69	0.49	0.31	0.31
Dinwiddie County	0.94	1.64	0.88	1.57	2.25	0.98	1.31	0.19	1.45	0.32	0.31	0.31
Goochland County	0.75	1.66	0.88	1.59	1.20	1.88	1.04	0.19	1.46	0.47	0.31	0.31
Greensville County	2.06	1.65	0.88	1.57	1.14	0.57	1.14	0.19	1.51	0.34	0.31	0.31
Hanover County	1.22	1.66	0.88	1.57	1.01	1.88	0.93	0.19	1.44	0.45	0.31	0.31
Henrico County	1.12	1.67	0.88	1.57	1.08	0.88	2.19	0.19	1.44	0.54	0.31	0.31
New Kent County	1.49	1.74	0.88	1.59	1.25	1.88	1.00	0.19	1.44	0.39	0.31	0.31
Powhatan County	0.75	1.64	0.69	1.57	0.94	1.88	1.69	0.19	1.45	0.36	0.31	0.31
Prince George County	1.03	1.63	0.88	1.57	0.95	0.69	2.19	0.19	1.44	0.32	0.31	0.31
Surry County	1.21	1.63	0.69	1.57	1.00	0.57	2.19	0.19	1.44	0.32	0.31	0.31
Sussex County	2.25	1.64	0.88	1.57	1.24	0.57	1.07	0.19	1.45	0.32	0.31	0.31

Table 5-44. Individual County HIRA Analysis Ranking (High, Moderate, or Low)

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires	Earthquake	Landslide	Karst
Charles City County	Low	Moderate	Low	High	Moderate	High	Moderate	Low	High	Low	Low	Low
Chesterfield County	Moderate	High	Low	Moderate	Moderate	Low	High	Low	Moderate	Low	Low	Low
City of Colonial Heights	High	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
City of Emporia	High	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
City of Hopewell	Moderate	Moderate	Low	Low	High	Low	Low	Low	Low	Low	Low	Low
City of Petersburg	Moderate	Moderate	Low	Low	High	Low	Low	Low	Low	Low	Low	Low
City of Richmond	High	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
Dinwiddie County	Low	High	Low	Moderate	High	Low	Moderate	Low	Moderate	Low	Low	Low
Goochland County	Low	High	Low	High	Moderate	High	Moderate	Low	High	Low	Low	Low
Greensville County	High	High	Low	High	Moderate	Low	Moderate	Low	High	Low	Low	Low
Hanover County	Moderate	High	Low	High	Moderate	High	Low	Low	High	Low	Low	Low
Henrico County	Moderate	High	Low	Moderate	Moderate	Low	High	Low	Moderate	Low	Low	Low
New Kent County	High	High	Low	High	Moderate	High	Low	Low	High	Low	Low	Low
Powhatan County	Low	High	Low	High	Low	High	High	Low	High	Low	Low	Low
Prince George County	Moderate	High	Low	Moderate	Low	Low	High	Low	Moderate	Low	Low	Low
Surry County	Moderate	High	Low	High	Moderate	Low	High	Low	Moderate	Low	Low	Low
Sussex County	High	High	Low	Moderate	Moderate	Low	Moderate	Low	Moderate	Low	Low	Low

Table 5-45. Individual County HIRA Analysis Ranking (1 Highest - 12 Lowest)

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires	Earthquake	Landslide	Karst
Charles City County	8	5	7	2	6	1	4	12	3	9	10	10
Chesterfield County	5	2	7	3	6	8	1	12	4	9	10	10
City of Colonial Heights	1	3	4	7	2	9	4	12	6	8	10	10
City of Emporia	1	3	4	7	2	9	4	12	6	8	10	10
City of Hopewell	3	2	4	7	1	9	4	12	6	8	10	10
City of Petersburg	3	2	4	7	1	8	4	12	6	9	10	10
City of Richmond	1	2	4	7	3	9	4	12	6	8	10	10
Dinwiddie County	7	2	8	3	1	6	5	12	4	9	10	10
Goochland County	8	2	7	3	5	1	6	12	4	9	10	10
Greensville County	1	2	7	3	6	8	5	12	4	9	10	10
Hanover County	5	2	8	3	6	1	7	12	4	9	10	10
Henrico County	5	2	7	3	6	8	1	12	4	9	10	10
New Kent County	4	2	8	3	6	1	7	12	5	9	10	10
Powhatan County	7	3	8	4	6	1	2	12	5	9	10	10
Prince George County	5	2	7	3	6	8	1	12	4	9	10	10
Surry County	5	2	7	3	6	8	1	12	4	9	10	10
Sussex County	1	2	7	3	5	8	6	12	4	9	10	10

6.0 Capability Assessment

6.1 Introduction

A "capability assessment" qualitatively summarizes the current and anticipated future capacity of the communities within the Richmond Regional Planning District Commission (PDC) and the Crater PDC to mitigate the effects of the natural hazards identified in Section 5.0 of this plan. The capability assessment includes a comprehensive examination of the following local government capabilities:

- *Administrative Capability* – describes the forms of government in the region, including the departments that may be involved in hazard mitigation.
- *Technical Capability* – addresses the technical expertise of local government staff.
- *Fiscal Capability* – examines budgets and currently used funding mechanisms.
- *Policy and Program Capability* – describes past, present, and future mitigation projects in the region and examines existing plans (e.g., emergency operations plan, comprehensive plan).
- *Legal Authority* – describes how jurisdictions in the region use the four broad government powers (i.e., regulation, acquisition, taxation, and spending) to influence hazard mitigation activities.

The purpose of a capability assessment is to identify resources which will support implementation of potential hazard mitigation opportunities available to the Richmond Regional Planning District's local governments, specifically the Town of Ashland; the Counties of Charles City, Goochland, Hanover, Henrico, New Kent, and Powhatan; and the City of Richmond; and also to the local governments of the Crater Planning District including the Counties of Chesterfield, Dinwiddie, Greensville, Prince George, Surry, and Sussex; the Cities of Colonial Heights, Emporia, Hopewell, and Petersburg; and the Towns of Claremont, Dendron, Jarratt, McKenney, Stony Creek, Surry, Wakefield, and Waverly. For the most part, the towns in the Richmond Regional - Crater PDC region with the exception of Ashland are extremely small with many functions like building inspections or public safety supported or performed by their corresponding county. To the extent information regarding towns was available, it is included in the capability assessment.

Careful analysis should detect any existing gaps, shortfalls, or weaknesses within existing government activities that could exacerbate a community's vulnerability. The assessment also will highlight positive measures already in place or being taken at the local level, which should continue to be supported and enhanced, if possible, through future mitigation efforts.

The capability assessment serves as a foundation for designing an effective hazard mitigation strategy. It not only helps establish the goals and mitigation actions for the Richmond-Crater region communities to pursue, but assures that those goals and actions are realistically achievable by communities.

A master Capability Assessment matrix table which summarizes each jurisdiction's programs may be found in Appendix I. Elements of the master table and a capability assessment survey may be found later in this section.

6.2 Staff and Organizational Capability

As described previously, the Richmond Regional Planning District region is comprised of six counties, one city and one town. The counties operate under a Board of Supervisors – County Administrator/Manager system. In this form of government, the elected board of supervisors hires a county administrator/manager who oversees daily operations of the county. Charles City County has the smallest board with three members. Goochland, Henrico, New Kent, and Powhatan Counties each have five board members. Hanover County's board is the largest in the region with seven members.

The City of Richmond operates under the Mayor-Council system of government. The nine members of the council and the mayor are elected. The mayor appoints, with council approval, a chief administrative officer who oversees daily business operations of the city.

The Crater region is comprised of six counties (which include eight towns) and four cities. Within the Crater region, the size of the Board of Supervisors also varies from jurisdiction to jurisdiction. Greensville has the smallest board with four members, Dinwiddie has a five-member board, and the remaining counties have six-member boards. The cities in the Crater region operate under the City Council –City Manager system. The city council is an elected body. Emporia has an eight-member council and the other cities have seven-member councils. The council, in turn, appoints a city manager who acts as the city's chief executive officer.

Incorporated towns in the Commonwealth of Virginia also have an elected governing body. Towns have zoning and planning authority though most choose to use the county planning commission as their town planning commission. Towns have the ability to issue general obligation and revenue bonds. In addition, towns of more than 5,000 residents may appoint an emergency services director and exercise emergency powers separate from the county. Ashland is the only town in the Richmond-Crater region to exercise that power.

Under the county administrator/manager, city mayor/manager, or town manager/mayor, each jurisdiction has numerous departments and boards that are responsible for the various functions of local government. Table 6-1 highlights the departments in each jurisdiction that could facilitate the implementation of this hazard mitigation plan. The departments that have been assigned responsibilities to carry out mitigation activities or hazard control tasks for a specific jurisdiction are set in bold. Representatives of these departments have been involved in the development of this mitigation plan in order to identify gaps, weaknesses, or opportunities for enhancement with existing mitigation programs.

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
Charles City County	• **County Administrator's Office** • Fire • Public Safety and Code Compliance • **Planning** • Public Works/Utilities • Recreation • Sheriff
Chesterfield County	• Fire and EMS • Planning • Police • **Emergency Management**
City of Colonial Heights	• Building Inspections • **Fire and EMS** • Planning and Community Development • Public Works • Police
Town of Dendron	• Town Administration • **Surry County Emergency Management** • Volunteer Fire • Sheriff's Office
Dinwiddie County	• Building Permits • Code Enforcement • Economic Development • Parks and Recreation • Planning and Zoning • **Public Safety/EMS/Emergency Services**
Town of McKenney	• Town Administration • **Dinwiddie Fire and EMS** • Town Fire • Sheriff's Office
City of Emporia	• Building Official • Code Enforcement • **Emergency Services** • City Manager • Facilities Management • Fire Chief • Public Utilities • Public Works • Zoning Administrator
Goochland County	• Building Inspections • Economic Development • Public Utilities • **Fire and Rescue** • Parks and Recreation • Planning • Public Works

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
Greensville County	• County Administration • Building • **Emergency Services** • Planning
Town of Jarratt	• Town Administration • **Sussex County Emergency Management** • Fire • Sheriff's Office • VA Department of Corrections Police
Hanover County	• Building Inspections • Economic Development • **Fire/EMS** • Parks and Recreation • Planning • Public Utilities • Public Works • Sheriff
Town of Ashland	• Fire • **Planning and Community Development** • Public Works • **Police**
Henrico County	• Community Revitalization • Economic Development Authority • **Fire and Emergency Management** • Planning • Police • Public Utilities • Public Works
City of Hopewell	• City Administration • **Emergency Management** • Development • Fire • Public Works
New Kent County	• Economic Development • Parks and Recreation • Planning • **Public Safety** • Public Utilities • Public Works
City of Petersburg	• Economic Development • **Fire, Rescue, and Emergency Services** • Planning • Public Works
Powhatan County	• Building • Economic Development • **Emergency Management** • Fire • Planning and Community Development

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
Prince George County	• County Administration • **Fire, EMS, and Emergency Management** • Building Officials Office • Economic Development • Parks and Recreation • Planning Office
City of Richmond	• Community Development • Economic Development • **Emergency Management** • Fire • Parks and Recreation • Public Utilities • Police • Public Works
Surry County	• County Administration • Building Inspections • **Emergency Management** • Parks and Recreation • Planning and Community Development • Social Services
Town of Claremont	• Town Administration • **Surry County Emergency Management** • Town Volunteer Fire
Town of Dendron	• Town Administration • **Surry County Emergency Management** • Town Volunteer Fire
Town of Surry	• Town Administration • **Surry County Emergency Management** • Town Volunteer Fire
Sussex County	• **County Administration** • Building Inspections • Planning
Town of Stony Creek	• Town Administration • **Surry County Emergency Management** • Fire • Sheriff's Office
Town of Wakefield	• Town Administration • **Sussex County Emergency Management** • Fire • Town Police
Town of Waverly	• Town Administration • **Sussex County Emergency Management** • Fire • Town Police

Note: The departments that have been assigned responsibilities to carry out mitigation activities or hazard control tasks for a specific jurisdiction are set in boldface type.
Sources: Community websites; 2016 Capability Assessment Surveys.

While exact responsibilities differ from jurisdiction to jurisdiction, the general duties of the departments highlighted in Table 6-1 are described as follows:

Building Inspections offices enforce the Virginia Uniform Statewide Building Code (VUSBC). This code includes implications for building construction and floodplain management to insure that new construction and construction exceeding 50% substantial improvement in the Special Flood Hazard Area (regulated floodplain) is compliant with the locality's floodplain management ordinance.

Departments of Emergency Management/Fire/EMS/Public Safety is responsible for the mitigation, preparedness, response, and recovery operations that deal with both natural and human-caused disaster events. These departments are typically categorized as first responders and encompass emergency response, emergency management, and fire safety. In addition, Fire/EMS departments provide medical aid and fire suppression at the scene of accidents and emergencies. These departments are often responsible for responding to hazardous materials incidents, water rescues, and entrapments. Members of the Richmond Regional – Crater PDC Hazard Mitigation Technical Advisory Committee were made up of each participating jurisdiction's emergency management staff. These staff will have the primary role of assuring that their vulnerability analysis and mitigation actions are integrated into appropriate jurisdictional comprehensive plan updates, zoning and floodplain management regulatory or policy changes, emergency operations plan updates, disaster recovery plans and resiliency planning as these plans and policies are updated and renewed.

The Police or Sheriff's department is responsible for public safety and evacuation activities that might occur prior to events and assists in the response and recovery operations that deal with both natural and human-made disaster events. The agency also works to ensure the safety and security of citizens and businesses as well as personal property during the immediate recovery period.

Parks and Recreation departments may be responsible for space programs. If acquisition projects are undertaken, coordination with this department becomes critical.

The Planning Department (or Department of Development/Community Development) addresses land use planning. Planning departments, depending on the jurisdiction, may enforce the National Flood Insurance Program (NFIP) floodplain management ordinance requirements and other applicable local codes. Two communities, the City of Richmond and the Town of Ashland, participate in the FEMA Community Rating System which national flood insurance program insurance policy holders within the regulated floodplain a discount on their flood insurance policy premium. Planning and Community Development departments are typically responsible for managing grant programs funded by the U.S. Department of Housing and Urban Development but some larger jurisdictions may have separate housing departments or authorities who manage some HUD-funded programs. These grant programs provide assistance to low- and moderate-income persons for needed home improvements. These departments also may develop residential and commercial

revitalization plans for older areas, serve as a resource for housing and community development issues, and manage special redevelopment projects.

Economic Development departments concentrate on ensuring the growth and prosperity of existing businesses. These departments often administer small business loan programs, state economic development programs, and workforce training programs. In smaller jurisdictions, such as Charles City County, this function is managed through the County Administrator's office. They are also increasingly involved in recruiting new businesses.

Public utilities departments or cooperatives, in some jurisdictions, oversee community potable water treatment, and natural gas services. More rural areas may be served by rural electric cooperatives which are not for profit, while a large extent of the region is served by Dominion Resources. In some jurisdictions, Public Works Departments oversee maintenance of infrastructure including roadways, stormwater management, sewer, and waste water treatment facilities. These departments may also review new development plans, ensure compliance with stormwater management and erosion and sediment control regulations, and work with VDOT on road issues. Depending on the jurisdiction, departments of Planning, Public Works, Engineering or Zoning may enforce the NFIP requirements.

GIS staff, vital in their support of mitigation with tools such as multiple data sets and mapping capability providing data as requested to various local government departments and citizens. GIS staff may be located in several departments depending on the local government organizational structure or within an independent agency.

For the most part, it was determined that the local governments serving more populated counties and the City of Richmond are adequately staffed, trained, and funded to accomplish their missions while more rural counties and small towns along with the City of Petersburg are experiencing resource gaps due in part to lingering budget issues related to the Great Recession.

6.3 Technical Capability

The Richmond-Crater region realizes that mitigation cuts across disciplines. For a successful mitigation program, it is necessary to have a broad range of staff involved with diverse backgrounds. Planners, engineers, building inspectors, emergency managers, floodplain managers, people familiar with Geographic Information Systems (GIS), and grant writers are all integral in supporting successful mitigation actions. Table 6-2 provides information on each jurisdiction's technical capabilities.

All localities have GIS capabilities or receive technical support from their county (in the case of most towns) or their planning district commission. Most local governments have incorporated basic GIS systems into their existing planning and management operations. Several of the larger localities are expanding their GIS capabilities to provide more enhanced assistance to first responders and to improve mitigation techniques. Several

counties now track various storm and damage data in GIS. For instance, Chesterfield County used the information to examine power outages to communities dependent on well water to identify where people with private wells during power outages were located. The fire department was then able to prioritize delivery of drinking water to these homes. The county also uses their GIS system to link data to damage assessment photos. Prince George and Dinwiddie Counties also do some limited data tracking of damage assessment. Most localities are interested in working to expand this capacity to help better identify areas of risk before an event occurs and to help in the recovery after an event has occurred. Sussex County has just obtained Arc GIS software and new computer equipment and will begin to integrate GIS into planning and eventually emergency management programs. None of the towns, except Ashland, have their own GIS system and rely on the county for assistance.

Staff members in all of the jurisdictions have Internet access. Most local governments use social media; fire, police, and emergency managers leverage Facebook pages and Twitter feeds for messaging. Some localities keep these sites active year-round while others activate them only during emergencies to relay vital information to the public.

Table 6-2. Technical Capability Matrix by Jurisdiction

Jurisdiction	Mitigation Assigned to Specific Department	GIS	Adequate Zoning Staff	Dedicated Floodplain Management Staff	Building Inspectors	Overall Technical Capabilities
Charles City County	Planning	Yes	Yes	No	Yes	Moderate
Chesterfield County	Environmental Engineering Planning Building Inspections	Yes	Yes	Yes	35	Moderate
City of Colonial Heights	Engineering Public Works Fire Department Building Official	Yes	Yes	1	3	Moderate
Dinwiddie County	Public Safety/ Emergency Services	Yes	Yes	Yes	3	Moderate
Town of McKenney	County handles mitigation	Yes	Yes	No	N/A	Limited

Table 6-2. Technical Capability Matrix by Jurisdiction

Jurisdiction	Mitigation Assigned to Specific Department	GIS	Adequate Zoning Staff	Dedicated Floodplain Management Staff	Building Inspectors	Overall Technical Capabilities
City of Emporia	City Manager/Emergency Management	Yes	Yes	Yes	2	Moderate
Goochland County	Fire and Rescue	Yes	Yes	No	3	Moderate
Greensville County	No	Yes	Yes	Yes	2	Moderate
Town of Jarratt	County handles mitigation	Yes	Yes	No	N/A	Limited
Hanover County	Planning Fire/EMS	Yes	Yes	No	4	Moderate
Town of Ashland	Planning Police	Yes	Yes	No	Yes	High
Henrico County	Emergency Management	Yes	Yes	Yes	35	High
City of Hopewell	Safety/Risk Manager	Yes	Yes	Yes	2	Moderate
New Kent County	Fire , Sheriff and Social Services	Yes	Yes	No	Yes	Moderate
City of Petersburg	Fire/Rescue; Public Works	Moderate	No	No	2	Moderate
Powhatan County	Emergency Management	Yes	Yes	No	Yes	Moderate
Prince George County	All Departments	Yes	No	No	6	Limited
City of Richmond	Emergency Management/ Police/Fire	Yes	Yes	Yes	Yes	High
Surry County	Emergency Services Planning and Development	Yes	Yes	Yes	1	High
Town of Claremont	County handles mitigation	Surry County	Surry County	Surry County	Surry County	Limited

Table 6-2. Technical Capability Matrix by Jurisdiction

Jurisdiction	Mitigation Assigned to Specific Department	GIS	Adequate Zoning Staff	Dedicated Floodplain Management Staff	Building Inspectors	Overall Technical Capabilities
Town of Dendron	County handles mitigation	Surry County	Surry County	Surry County	N/A Surry County	Limited
Town of Surry	County handles mitigation	Surry County	Surry County	Surry County	Surry County	Limited
Sussex County	Public Safety Planning and Zoning	Yes	No	No	2	Limited
Town of Stony Creek	County handles mitigation	Sussex County	Sussex County	No	Sussex County	Limited
Town of Wakefield	County handles mitigation	Sussex County	Sussex County	No	Sussex County	Limited
Town of Waverly	County handles mitigation	Sussex County	Sussex County	No	Sussex County	Limited
High: No increase in capability needed. Moderate: Increased capability desired but not needed. Limited: Increased capability needed.						

6.4 Fiscal Capability

For Fiscal Year 2017, the budgets of the participating jurisdictions which could be determined through on-line documents or community capacity surveys range from $27,600,000 (City of Emporia) to $700,125,553 (city of Richmond). (City of Emporia

The counties and cities receive most of their revenue through local real estate tax, state and local sales tax, local services, and restricted intergovernmental contributions (federal and state pass-through dollars).

Since 1998 Virginia has provided a 20% match on all eligible Hazard Mitigation Grant Program (HMGP) projects, and the allowance of in-kind matches can help to reduce the local requirement to less than 5% cash match. It is unlikely that any of the counties, cities, or towns could easily afford to provide the full 25% non-federal match for the existing hazard mitigation grant programs. Considering the current budget deficits at both the state and local government level in Virginia, combined with the apparent increased reliance on local accountability by the federal government, this is a significant and growing concern.

Table 6-3. Fiscal Capability Matrix by Jurisdiction

Jurisdiction	Total FY17 Budget	Public Safety FY17 Budget
Richmond Regional PDC	$2,300,000,000	$N/A
Crater PDC	N/A	N/A
Charles City County	$22,400,000	N/A
Chesterfield County	$1,350,000,000	$158,000,000
Colonial Heights	$78,037,047	$8,516,542
Dinwiddie County	$89,101,682	$8,831,340
City of Emporia	$276,000,000	$3,722,716
Goochland County	$72,881,798	$9,258,866
Greensville County	N/A	N/A
Hanover County**	$428,3000,300	$55,250,750
Henrico County	$1,311,569,642	$170,483,485
City of Hopewell	$49,930,358	$4,526,003
New Kent County	$62,123,094	$3,040,100
City of Petersburg**	$101,985,000	$17,452,641
Powhatan County	$56,794,921	$733,000
Prince George County**	$112,000,000	$112,000,000
City of Richmond	$700,125,553	$44,932,033
Surry County**	$52,151,000	$3,318,715
Sussex County*	$34,712,259	$1,393,895

Sources: Jurisdictional budget offices; websites.

**FY 2017–2018 budget; Public Safety includes fire and police.

Most communities in the Richmond-Crater region use capital improvement plans and general obligation bonds to plan and fund large-scale public expenditures. Most jurisdictions in the study area also use intergovernmental agreements to leverage resources.

Past participation in federal funding programs may mean that jurisdictions have the capacity to undertake the grant-matching requirements, the capability to seek and administer federal grants, and the familiarity with the grant process and requisites. A lack of participation, however, does not mean communities cannot or will not seek or receive future funding. As seen in Table 6-4, three jurisdictions in the region have received HMGP

funds in the past and only one jurisdiction has received Severe Repetitive Loss (SRL) Program grants. Four communities have received grants from or participated in projects with the U.S. Army Corps of Engineers (USACE). It should be noted that the region is not an area of priority planning and project focus of the USACE, particularly after planning and construction of the James River Floodwall in the City of Richmond.

Table 6-4. Participation in Federal Mitigation Funding Programs by Jurisdiction, 2002 to Present

Jurisdiction	HMGP	SRL	USACE
Charles City County	No	No	Unknown
Chesterfield County	Yes	Yes	No
City of Colonial Heights	No	No	Yes (study)
Dinwiddie County	No	No	Yes
City of Emporia	No	No	No
Goochland County	No	No	Unknown
Greensville County	No	No	No
Hanover County	Yes	No	Unknown
Town of Ashland	No	No	No
Henrico County	No	No	Unknown
City of Hopewell	No	No	No
New Kent County	No	No	Unknown
City of Petersburg	No	No	Yes (dredging)
Powhatan County	No	No	Unknown
Prince George County	No	No	Yes (wetlands impact)
City of Richmond	Yes	No	Floodwall installed in early 1990's
Surry County	Yes	No	No
Sussex County	No	No	No

6.5 Policy and Program Capability

6.5.1 Previous Mitigation Efforts

The region does not actively participate in VDEM/FEMA Hazard Mitigation Assistance Programs with the exception of the City of Richmond, though some highlights of past grant-funded projects and other mitigation projects is presented below. Many of the 2011 mitigation actions were implemented through staff activities or other programs as detailed in the 2011 Mitigation Actions Status tables by jurisdiction which may be found in Appendix C.

Charles City County

Charles City County tests emergency service delivery processes biannually as an integral part of the Virginia Department of Emergency Services' test response to Surry nuclear power plant emergencies. All community critical facilities have adequate generator capabilities. The county has established an effective emergency operations center within its new Judicial Center. Emergency communications are being enhanced by the addition of a communication tower in the vicinity of the Judicial Center.

Chesterfield County

Chesterfield County has acquired four repetitive loss properties along Beach and Old Beach Road in the central part of the county. FEMA mitigation grant funds were used for this project.

Goochland County

Goochland County has been working with VDOF to promote best management practices among landowners in the county. The department and the county have offered joint courses on forestry management and wetlands protection. In addition, the county has thinned more than 160 acres of flammable pine plantations vulnerable to wildfire and insect infestation while instituting best management practices on county-owned property.

Hanover County

Fire Station #5, the location of the Hanover County Emergency Operations Center, has been updated since the first regional hazard mitigation plan to address its electrical power capacity issues. The county also used the proceeds of a bond to improve its communication system and its interoperability. However, the basement of the Hanover County Sheriff's Office is still subject to flooding through the windows. This flooding could affect the emergency communications ability of the Sheriff's Office. Hanover County has also used FEMA mitigation funds for minor, localized drainage improvement projects.

Henrico County

Henrico County has implemented higher standards in floodplain management, including a prohibition on new residential structures in identified floodplains. As a FEMA Cooperative

Technical Partner, the county has mapped floodplain drainage areas in 100 acre units, providing far more discrete floodplain modeling than industry standards of 1 square mile (640 acres). Development or redevelopment is prohibited if it will cause a rise in the base flood elevation (or 100-year flood level). In addition, the lowest floor of new development and substantially improved structures must be one foot above the base flood elevation. Finally, through the Chesapeake Bay Preservation Act, a mandatory stream buffer further prohibits development adjacent to streams and wetlands.

In 2005, the county purchased several properties in the Bloomingdale neighborhood along with the property at the intersection of Brook and Lakeside Avenues that were high- risk repetitive damage sites.

City of Richmond

Following numerous floods from the 1970's through 1990's, the US Army Corps of Engineers performed a study and ultimately constructed a flood wall to protect the Shockoe Bottom area and a small area of the south bank from James River flooding. The City of Richmond has been very active since 2011 with new mitigation projects and programs to help reduce its vulnerability to future events. The city received about 14 inches of rain from Tropical Storm Gaston, which the stormwater system was not able to manage effectively. Drainage features such as the East Gravity Outlet, which are part of the floodwall project, were actually found to contribute to increased damages on the protected side of the floodwall. The occurrence of back-to-back flooding brought attention to the city's older infrastructure system and its need for a dedicated source of funding. Using Capital Improvement Program (CIP) funds in 2008–2010, the city completed many improvements to the Shockoe Bottom area.

During the additional budget cycles, the City of Richmond added three gate structures on the Northeast Interceptor to prevent the transfer of flow from the Arch Sewer to the main Box Sewer, which is the primary sewer collector in the Shockoe Bottom area. The city also installed or modified approximately 100 curb inlets to improve the capture of stormwater from the steeper slopes leading to the Shockoe Bottom watershed, helping to prevent flooding in the lowest parts of the Shockoe Bottom area. In addition, the city redesigned the storm drainage system in Pine Alley to capture a significant portion of the stormwater that would normally enter the alley and flood area businesses. Separation of the East Gravity Outlet from the combined sewer overflow system was also done to eliminate the need for gate operations to minimize interior flooding, increase the reliability of both the flood-reduction system and environmental protection system, and allow the operation of the system with a fail-safe mode. City contractors also connected the Box Sewer to the East Gravity Outlet to provide a high-rate overflow, and restored the Upper Shockoe Creek Retention Basin to further improve the capacity of the Shockoe Bottom Drainage system.

The major improvements in the Shockoe Bottom area were facilitated by the creation of a stormwater utility controlled by the Department of Public Utilities in 2009. This new utility transferred maintenance and improvements of the city's stormwater system from

Public Works to Public Utilities and created a long-term source of funding. The new utility now creates an annual CIP list of projects and has begun working to improve the various systems throughout the city to reduce the potential loss of life and damages from future events.

Tropical Storms Gaston and Ernesto also led the City of Richmond to complete two large residential mitigation projects that helped reconstruct and remove homes from the floodplain. The first was Broad Rock Creek Floodway Mitigation Project. This project assisted in the acquisition, demolition, and relocation of several homes. The project also identified other structures in the city that were then reconstructed to move their systems out and above the base flood elevation (BFE). All of the properties were located in the Broad Rock Creek floodway and were adjacent to a 100-year floodplain that sustained severe damage as a result of the remnants of Tropical Storm Gaston in 2004.

The second project occurred with the acquisition and relocation of families in the Battery Park community. The historic city park and several homes immediately adjacent to it sustained heavy damage during Tropical Storm Ernesto in 2006. The project resulted in the removal of homes from the floodplain and the creation of new parkland.

Richmond successfully used HMGP grant funds to add several stream monitoring gaging stations to augment its flood warning system. These are tied to the Commonwealth's IFLOWs system.

Sussex County

Following the early 2016 tornado which killed three in Waverly, a Waverly Tornado Recovery Urgent Needs Study focused on long term recovery efforts for the Pocahontas Neighborhood through initiation of a Neighborhood Improvement Study. Meetings were conducted in late 2016 with the objective of submission of HUD grant applications to support neighborhood recovery and manufactured housing rehabilitation/mitigation.

6.5.2 Emergency Operations Plan

A comprehensive emergency management operations plan (or emergency operations plan) typically predetermines actions to be taken by government agencies and private organizations in response to an emergency or disaster event. The plan describes the jurisdiction's capabilities to respond to emergencies and establishes the responsibilities and procedures for responding effectively to the actual occurrence of a disaster.

Hazard mitigation is included as a functional annex to some of the emergency operations plans developed by the participating jurisdictions in the Richmond-Crater region. These annexes describes the responsibilities of various departments and agencies, private businesses, and the public. The annex will outline a concept of operations that explains what activities will be undertaken before and after a disaster. Specific tasks are assigned to the Board of Supervisors/City Council (or other local governing body), Department of Emergency Services, Department of Health, Building Officials/County Engineer/Planning and Zoning, Law Enforcement, Fire Department and Emergency Crew, Superintendent of Schools, and Public Information Officer. Emergency operations plans in the Richmond-

Crater region address mitigation in varying detail or simply reference the Richmond-Crater PDC mitigation plan. "Pull-outs" summarizing the counties and cities in the region's demographics, hazard vulnerability and mitigation actions were produced during the 2011 combined PDC plan update and will be updated as part of the 2017 plan update process.

The counties and cities participating in the 2011 plan update process adopted that plan as well as the 2006 Richmond Regional or Crater PDC mitigation plans respectively. Additionally, Ashland, Claremont and Stony Creek adopted hazard mitigation plans in 2011 and 2006.

6.5.3 Floodplain Management

Communities that regulate development in floodplains are able to participate in the NFIP. In return, the NFIP makes federally backed flood insurance policies available for properties in the community. Table 6-5 shows the history of NFIP jurisdiction participation. The table also provides current Flood Insurance Rate Map (FIRM) in effect for each community. The maps were developed by FEMA or its predecessor (HUD) and show the boundaries of the one-percent (100-year) and 0.2% (500-year) predicted floods. As the table shows, most of the FIRMs have been updated since the 2011 plan update. The FIRM updates incorporated new modeling which documented existing development, in many cases extensive since the first FIRMs were produced.

Table 6-5. Communities Participating in the NFIP as of August 10, 2016

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
Charles City County	Charles City County	01/17/75	09/05/09	07/06/15	09/05/09
Chesterfield County	Chesterfield County	01/10/75	03/16/83	12/18/12	03/16/83
City of Colonial Heights	City of Colonial Heights	06/14/74	09/02/81	08/02/12	09/02/81
Dinwiddie County	Dinwiddie County	11/15/74	01/17/79	06/16/11	01/17/79
	Town of McKenney	-	*06/16/11*	*(NSFHA)*	*11/20/81*
City of Emporia	City of Emporia	07/23/76	02/02/89	07/07/09	09/30/77
Goochland County	Goochland County	02/21/75	03/01/79	12/02/08	03/01/79
Greensville County	Greensville County	12/20/74	09/29/78	07/07/09	09/29/78
	*Town of Jarratt**	*07/30/76*	*10/08/82*	*07/07/09 M*	*10/08/82*
Hanover County	Hanover County	12/13/74	09/02/81	12/02/08	09/02/81
	Town of Ashland	*05/24/74*	*12/02/08*	*12/02/08*	*05/26/78*
Henrico County	Henrico County	11/22/74	02/04/81	12/18/07	02/04/81
City of Hopewell	City of Hopewell	06/14/74	09/05/79	07/16/15	09/05/79
New Kent County	New Kent County	01/31/75	12/05/90	08/03/15	12/05/90
City of Petersburg	City of Petersburg	05/31/74	03/16/81	02/04/11	03/16/81
Powhatan County	Powhatan County	09/13/74	09/15/78	02/06/08	09/15/78
Prince George County	Prince George County	01/24/75	05/01/80	06/02/15	05/01/80

Table 6-5. Communities Participating in the NFIP as of August 10, 2016

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
City of Richmond	City of Richmond	12/06/74	06/15/79	07/16/14	06/15/79
Surry County	Surry County	12/06/74	11/02/90	05/04/15	11/02/90
	Town of Claremont	*04/04/75*	*11/02/90*	*05/04/15*	*10/16/90*
	Town of Dendron	11/15/74	11/02/90	04/02/09	12/02/92(S)
	Town of Surry	-	-	-	-
Sussex County	Sussex County	06/09/78	03/02/83	07/07/09	03/02/83
	Town of Jarratt	*07/30/76*	*10/08/82*	*07/07/09 M*	*10/08/82*
	Town of Stony Creek	*08/09/74*	*09/16/82*	*07/07/09*	*09/16/82*
	Town of Wakefield	08/26/77	07/23/82	07/07/09(M)	*03/12/2014*
	Town of Waverly	-	-	-	-

(M) No elevation determined

(S) Sanctioned; NFIP flood insurance not available

Source: Federal Emergency Management Agency, Community Status Book.

The Commonwealth of Virginia statutes provide cities, counties and town with land use authority. In particular, issues such as floodwater control are empowered through §15.2-2223 and §15.2-2280. All of the jurisdictions in the region have adopted a local floodplain ordinance as a requirement of participation in the NFIP. Table 6-5 shows whether the community has adopted a stand-alone ordinance or if it has incorporated floodplain regulations into its zoning ordinance.

The Towns of Surry, McKenney and Wakefield did not have initial identified floodplain management boundaries as shown on Table 6-5. Several other towns in the region are not NFIP participants due to a lack of FEMA-identified flood hazards.

Each community has designated staff who enforce their floodplain management ordinance, in some cases which is included in the zoning ordinance. The Department of Conservation and Recreation's Floodplain Management Program, including their NFIP Coordinator and his staff, conduct Community Assistance Visits or Community Assistance Calls (CACs) to review program administration locally on about a two year rotation. During the planning period, numerous communities in the region received preliminary Flood Insurance Studies and Flood Insurance Rate Maps which initiated a formal local public review process which the community supported with DCR and FEMA Region III through public display of the new flood hazard products and public meetings prior to revision of local floodplain management ordinances and adoption of the revised ordinance, Flood Insurance Study and Flood Insurance Rate Maps by the elected governing body.

The Community Rating System (CRS), administered by FEMA, was implemented in 1990 as a program for recognizing and encouraging community floodplain management activities

that exceed the minimum NFIP standards. Residents of communities that participate in the CRS receive a reduction in flood insurance premiums. There are ten CRS classes: class 1 requires the most credit points and gives the largest premium reduction; class 10 receives no premium reduction. None of the jurisdictions in this hazard mitigation plan are members of the CRS.

One of the CRS requirements is a community floodplain management plan. The City of Richmond and the Town of Ashland are the only jurisdiction participants in the Community Rating System. The Richmond-Crater Multi-Regional Hazard Mitigation Plan is intended to fulfill the CRS planning requirement should any additional participating jurisdictions decide to enter the CRS. Several communities added mitigation actions for this planning cycle to explore joining the CRS.

6.5.4 Comprehensive Plans

A community's comprehensive plan provides the future vision for the community regarding growth and development. However, many of the plans include land use or environmental protection goals that could support future mitigation efforts. For example, limiting development in the floodplain (which is considered mitigation) may also help meet open space goals laid out in a comprehensive plan. Several comprehensive plans address mitigation, resiliency and long-term community sustainability. These are new inclusions, and as communities continue to update their comprehensive plans it is anticipated that mitigation and resiliency issues will be more comprehensively addressed.

For the most part, these strategies address development in the floodplain or otherwise flood-prone areas. In addition, the plans indicate that communities in the Richmond-Crater region are experienced with and willing to use growth management tools such as zoning, subdivision regulations, and preferential tax assessment. Section 4.0 Community Profile includes summaries of comprehensive plan status in each participating county and city.

Table 6-6. Local Planning Mechanisms and Their Relationship to Hazard Mitigation

Locality	Disaster Recovery Plan	Comprehensive Plan	Floodplain Management Plan	Stormwater Mgmt. Plan	Emergency Operations Plan	Other
Charles City County	Moderate	Moderate	Moderate	None	High	Chesapeake Bay Preservation Program
Chesterfield County	Limited	Under development	High	None	High	Continuity of Operations (COOP) Evacuation plan

Table 6-6. Local Planning Mechanisms and Their Relationship to Hazard Mitigation

Locality	Disaster Recovery Plan	Comprehensive Plan	Floodplain Management Plan	Stormwater Mgmt. Plan	Emergency Operations Plan	Other
Chesterfield County	Limited	Under development	High	None	High	Wetlands preservation program and open space program Riparian buffers
City of Colonial Heights	High	Under development	High	Yes	High	Historic preservation ordinance Chesapeake Bay Preservation Program (wetlands)
Dinwiddie County	None	Moderate	None	None	High	
City of Emporia	None	Moderate	None	None	High	Transportation plan, 1984
Hanover County**	Moderate	Moderate	High	High	High	Chesapeake Bay Preservation Program
*Town of Ashland***		Moderate	High (CRS)		High	
Henrico County	Moderate	Moderate	High	High	High	Chesapeake Bay Preservation Program
Goochland County	Moderate	High	Moderate	Moderate	High	
Greensville County	Limited	High	No	None	High	Erosion control and sediment ordinance
City of Hopewell	High	Moderate	High	Moderate	High	COOP, 2001 Evacuation plan
New Kent County	None	Moderate	Moderate	High	High	Chesapeake Bay Preservation Program
City of Petersburg	Low	Moderate	Low	Low	Low	Transportation plan

Table 6-6. Local Planning Mechanisms and Their Relationship to Hazard Mitigation

Locality	Disaster Recovery Plan	Comprehensive Plan	Floodplain Management Plan	Stormwater Mgmt. Plan	Emergency Operations Plan	Other
City of Petersburg						Chesapeake Bay Preservation Program Riparian buffers Open space program and plan
Prince George County	Moderate	High	High	Moderate	High	Chesapeake Bay Preservation Program Riparian buffers
City of Richmond	Moderate	Limited	High (CRS)	High	High	Chesapeake Bay Preservation Program
Surry County**	None	Moderate	High	None	High	Chesapeake Bay Preservation Program Evacuation plan
Sussex County**	None	High	High	None	High	Evacuation plan Transportation plan, 1997

High = Specifically includes hazard mitigation.

Moderate = Elements could be used to support hazard mitigation.

Limited = No mention of hazard mitigation. Does not contain elements that would support hazard mitigation or includes elements that would hinder hazard mitigation.

Localities** - 2011 HMP Update Ranking; 2016 Capacity Survey not returned.

6.6 Legal Authority

Local governments in Virginia, including those in the Richmond-Crater region, have a wide range of tools available to them for implementing mitigation programs, policies, and actions. A hazard mitigation program can use any or all of the four broad types of government powers granted by the State of Virginia, which are (a) regulation, (b) acquisition, (c) taxation, and (d) spending. The scope of this local authority is subject to constraints; however, as all of Virginia's political subdivisions must not act without proper delegation from the state. All power is vested in the state and can only be exercised by local governments to the extent it is delegated (in accordance with Dillon's Rule). Thus, this portion of the capabilities assessment will summarize Virginia's enabling legislation that grants the four types of government powers within the context of available hazard mitigation tools and techniques.

6.6.1 Regulation

General Police Power

Virginia's local governments have been granted broad regulatory powers in their jurisdictions. Virginia State Statutes bestow the general police power on local governments, allowing them to enact and enforce ordinances that define, prohibit, regulate or abate acts, omissions, or conditions detrimental to the health, safety, and welfare of the people, and to define and abate nuisances (including public health nuisances). Since hazard mitigation can be included under the police power (as protection of public health, safety, and welfare), towns, cities, and counties may include requirements for hazard mitigation in local ordinances. Local governments also may use their ordinance-making power to abate "nuisances," which could include, by local definition, any activity or condition making people or property more vulnerable to any hazard.

All of the jurisdictions located in the Richmond-Crater region have enacted and enforce regulatory ordinances designed to promote the public health, safety, and general welfare of its citizenry.

Land Use

Regulatory powers granted by the state to local governments are the most basic manner in which a local government can control the use of land within its jurisdiction. Through various land use regulatory powers, a local government can control the amount, timing, density, quality, and location of new development. All these characteristics of growth can determine the level of a community's vulnerability in the event of a natural hazard. Land use regulatory powers include the power to plan, enact and enforce zoning ordinances, floodplain ordinances, and subdivision controls. Each local community in the Richmond-Crater region possesses legal authority to prevent unsuitable development in hazard-prone areas.

Planning

According to State Statutes, local governments in Virginia may create or designate a planning agency. The planning agency may perform a number of duties, including:

- making studies of the area;
- determining objectives;
- preparing and adopting plans for achieving those objectives;
- developing and recommending policies, ordinances, and administrative means to implement plans; and
- performance of other related duties.

The importance of the planning powers of local governments is illustrated by the requirement that zoning regulations be made in accordance with a comprehensive plan. While the ordinance itself may provide evidence that zoning is being conducted "in accordance with a plan," the existence of a separate planning document ensures that the government is developing regulations and ordinances that are consistent with the overall goals of the community.

All but one of the cities and counties (City of Emporia) within the Richmond-Crater region have planning departments and comprehensive plans. Most of the towns in the region, with the exception of Ashland, have no formal planning and limited zoning authority; these small towns rely on the county in which they are located to enforce most planning and zoning regulations.

FEMA Region III, in partnership with the Central Virginia Emergency Management Alliance made up of most Richmond Regional and Crater PDC jurisdictions, conducted a Resiliency Workshop on July 12, 2016 in Chesterfield, Virginia. The workshop promoted the concept that resilient communities have the ability to "bounce back" from hazardous events, successfully respond to stressors, and adapt well to change. During the interactive, day-long workshop, participants discussed priorities that informed not just how communities can respond to hazardous events, but also identified actions to spur future activities or projects to build resilience and reduce risk. Some of these actions, particularly regarding infrastructure hardening, are included as local 2017 – 2022 mitigation actions.

The workshop included an *Open House* segment where participants informally discussed programs, funding opportunities, and resources with a variety of local, State, and Federal agencies. It was attended by local, regional and state agency professionals across disciplines who shared information through formal presentations and afternoon informal break-out sessions. Planners, environmental, emergency management, transportation, and economic development professionals and local, State, and Federal agency representatives were among the attendees who are working in or are interested in hazard mitigation, comprehensive and community planning, risk reduction, and sustainable community development. The Central

Virginia Resiliency Workshop was the first of six conducted throughout the Commonwealth.

Zoning

Zoning is the traditional and most common tool available to local governments to control the use of land. Broad authority is granted for municipalities and counties in Virginia to engage in zoning. Land "uses" controlled by zoning include the type of use (e.g., residential, commercial, and industrial) as well as minimum specifications that control height and bulk such as lot size, building height and setbacks, and density of population. Local governments are authorized to divide their territorial jurisdiction into districts, and to regulate and restrict the erection, construction, reconstruction, alteration, repair or use of buildings, structures, or land within those districts. Districts may include general-use districts, overlay districts, and special-use or conditional-use districts. Zoning ordinances consist of maps and written text.

As shown in Table 6-5, most jurisdictions in the Richmond-Crater region implement floodplain regulations via the zoning ordinance. An overlay district is used to impose additional requirements on properties within the designated floodplain area; in most cases this is done through the Chesapeake Bay Preservation Act buffer areas with restrictive stream buffers. Some jurisdictions implement floodplain regulations as stand-alone ordinances.

Subdivision Regulations

Subdivision regulations control the division of land into parcels for the purpose of building development or sale. Flood-related subdivision controls may prohibit the subdivision of land subject to flooding unless flood hazards are overcome through filling or other measures. Subdivision regulations, however, generally prohibit filling of floodway areas. The regulations also typically require that sub-dividers, once construction begins, install adequate drainage facilities and design water and sewer systems to minimize flood damage and contamination.

All Richmond Regional PDC jurisdictions continue enforcement of their adopted subdivision ordinances and in many instances have updated those ordinances during the past five years. Some of the ordinances contain floodplain-specific provisions. For instance, Powhatan County requires a 100-foot natural vegetative buffer along all perennial streams as well as setbacks for residential structures from the floodplain. In New Kent County, new subdivisions with 50 or more homes are required to have at least two ingresses and egresses. This requirement will allow an alternate route if one is blocked in case of emergency. Since subdivisions of four lots or more trigger major subdivision review standards in Charles City County, most subdivisions are smaller to avoid these more rigorous standards.

Likewise, the jurisdictions in the Crater PDC have adopted subdivision ordinances. The majority of the ordinances require that land be suited for development, and specifically,

that land platted for residential use not be subject to flooding. The City of Emporia and Surry County require that utilities be buried underground. Greensville and Sussex Counties and the City of Emporia require stormwater management or flood control plans.

Floodplain Management Regulations

All communities with a FEMA-designated Special Flood Hazard Area (SFHA) in the Richmond-Crater region have adopted floodplain management regulations. Powhatan County's regulations have been in place since 1973, prior to joining the NFIP. The other jurisdictions adopted floodplain regulations after joining the NFIP (see Table 6-5 for date of entry).

Generally, the regulations adopted by the study communities do not go beyond the minimum standards of the NFIP. Goochland and Powhatan Counties restrict uses in the floodplain. Henrico County prohibits new development in the floodplain and restricts redevelopment or rehabilitation projects from having any impact on the base (100-year) event. The majority of communities set design criteria for utilities and other public infrastructure.

Goochland County and the City of Richmond prohibit manufactured homes in all or portions of the floodplain. Chesterfield County prohibits new manufactured home parks while Greensville County prohibits new manufactured homes unless located in an existing park. Hanover County requires manufactured homes to be elevated and anchored.

Twelve of the ordinances in the Richmond-Crater region describe procedures for structures built before the regulations were in place. All localities that allow development in the floodplain require at least a 1-foot freeboard for development with some localities having higher freeboard requirements. The City of Hopewell requires a 2-foot freeboard for all new and substantially reconstructed homes in the floodplain, Greensville County requires 18 inches of freeboard in its ordinance, and Surry County includes a 1-foot freeboard. Goochland County has the highest freeboard with a level of 3 feet above the base flood elevation for construction within the regulated floodplain. The Town of Ashland and the City of Richmond are FEMA Community Rating System communities; this designation gives flood insurance policy holders a discount on their annual flood insurance premiums based on evaluation of the community's enhanced floodplain management program.

Resiliency

The Commonwealth of Virginia has begun to address resiliency issues to reduce impacts of climate change, sea level rise, emergencies and disasters upon communities and the state. Resilient Virginia, a collaborative project of the Virginia Municipal League in cooperation with the Virginia Association of Counties was created ten years ago to foster resiliency concepts with local governments. A Resiliency Checklist to the GoGreen Virginia initiative which allows local governments to compete in the "Go Green Challenge" (gogreenva.org) which encourages implementation of environmental policies and practical actions to reduce

carbon emissions and save local funds. The Resiliency Checklist is organized into the following six sections:

(1) Policy & Leadership; (2) Preparation for Natural & Man-Made Hazards; (3) Energy Security; (4) Strengthening Critical Infrastructure; (5) Strengthening the Local Economy; and (6) Health & Well Being

While all sections have relevance to a local hazard mitigation plan, (2) Preparation for Natural & Man-made Hazards and (4) Strengthening Critical Infrastructure track to a mitigation plan analysis. The Cities of Petersburg and Richmond were certified Platinum, the highest ranking, during 2015.

North Atlantic Coast Comprehensive Study

The U.S. Army Corps of Engineers recently completed a report detailing the results of a two-year study to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure affected by Hurricane Sandy in the United States' North Atlantic region.

This, the North Atlantic Coast Comprehensive Study, is designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. It builds on lessons learned from Hurricane Sandy and attempts to bring to bear the latest scientific information available for state, local, and tribal planners.

The conclusions of the study, as detailed in the final report, include several findings, outcomes, and opportunities, such as the use of a nine-step Coastal Storm Risk Management Framework that can be customized for any coastal watershed. The study ranked localities risk impacts as to High, Medium or Low Impact. With the Richmond Regional – Crater PDC area, Henrico, Charles City, Chesterfield, Prince George and Sussex Counties were ranked “Low” and Surry County was ranked “Medium.” This comprehensive study can provide planners with additional information on long-term impacts of coastal storms.

Other Ordinances

The State of Virginia encourages local governments to adopt stormwater regulations under land use authorities. Stormwater regulations are most often used to control runoff and erosion potential that results from small-scale development of less than 5 acres. In the Richmond-Crater region, Chesterfield, Dinwiddie, Goochland, Hanover (including the Town of Ashland), Henrico, New Kent, Powhatan, and Prince George Counties and the Cities of Colonial Heights, Emporia, and Richmond have regulations that deal with stormwater management. Charles City County does not have these types of regulations.

Virginia is also a signatory to the Chesapeake Bay Agreement, a unique regional partnership aimed at restoring the Chesapeake Bay. Communities in certain parts of the state are required to implement local land use controls to minimize runoff and other adverse impacts that degrade the water quality of the bay. Five of the seven jurisdictions

in the Richmond region are considered part of the Tidewater area and therefore are required to implement local Chesapeake Bay Preservation Program requirements. These jurisdictions are Charles City, Hanover (including the Town of Ashland), Henrico, and New Kent Counties, and the City of Richmond. Goochland and Powhatan Counties are not considered to be part of the Chesapeake Bay area. In the Crater region, six of the ten jurisdictions are considered part of the Tidewater area and therefore are required to adhere to locality Chesapeake Bay Preservation Program requirements. These jurisdictions are Chesterfield, Prince George, and Surry Counties and the Cities of Colonial Heights, Hopewell, and Petersburg. Dinwiddie and Greensville Counties and the City of Emporia are not in the Chesapeake Bay Watershed.

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act (Bay Act) was enacted by the Virginia General Assembly in 1988 as a critical element of Virginia's non-point source management program.

The Bay Act program is designed to improve water quality in the Chesapeake Bay and other waters of the State by requiring the use of effective land management and land use planning.

Virginia designed the Bay Act to enhance water quality with continued reasonable development. The Bay Act balances state and local economic interests and water quality improvement by creating a unique cooperative partnership between state and Tidewater local governments to reduce and prevent nonpoint source pollution. Local governments retain the primary responsibility for land use decisions, expanding local government authority to manage water quality, and establishing a more specific relationship between water quality protection and local land use decision-making.

The Bay Act Program is the only program in Virginia state government that deals comprehensively with the relationships between water quality, and land use planning and development. It is also the only program that assists local governments with land use planning needs to meet water quality goals: the development of land use regulations, ordinances and comprehensive plans.

The Chesapeake Bay Preservation Area Designation and Management Regulations were originally adopted in 1989 and were amended in 1991, 2001 and in 2012 as part of the Integration Bill. The Bay Act charges the State Water Control Board with the following responsibilities:

- *Promulgating and keeping current regulations that establish criteria for local Bay Act programs*
- *Ensuring that local government comprehensive plans, zoning ordinances, and subdivision ordinances are in compliance with the Bay Act regulations*
  - These land use ordinances and plans comprise the local Bay Act program and must meet the requirements of the regulations.

- *Providing technical and financial assistance to Tidewater local governments*
  - Technical assistance has been provided in a number of ways, including: publications, research projects, provision of computer equipment, providing training for local government planners and engineers, and other direct staff assistance. Financial assistance has been provided through (1) a competitive grants program for localities and planning district commissions that began in 1990, and (2) a grant program for Soil and Water Conservation Districts in Tidewater to develop agricultural soil and water quality conservation plans on farmlands within Chesapeake Bay Preservation Areas.
- *Providing technical assistance and advice to regional and state agencies on land use and water quality protection*
  - Bay Act staff help the board and Tidewater local governments, planning district commissions, and Soil and Water Conservation Districts participating in the program. The staff also provides assistance in other regional efforts, including the development of watershed restoration plans and participation on committees and work groups of the Chesapeake Bay Program.

Local Bay Act programs include:

1. A map generally depicting Chesapeake Bay Preservation Areas.
2. An ordinance containing performance criteria pertaining to the use, development and redevelopment of land.
3. A comprehensive plan or revision that incorporates the protection of Chesapeake Bay Preservation Areas and of the quality of state waters.
4. A zoning ordinance that incorporates measures to protect the quality of state waters.
5. A subdivision ordinance that incorporates measures to protect the quality of waters of the state.
6. A plan of development process prior to the issuance of a building permit to assure that the use and development of land in Chesapeake Bay Preservation Areas is accomplished in a manner that protects the quality of state waters.

Localities within the plan update region who participate in the program include Charles City, Chesterfield, Hanover, Henrico, New Kent, Prince George, Surry and Sussex Counties, the Cities of Colonial Heights, Hopewell, Petersburg and Richmond and the towns of Ashland, Claremont, and Surry.

Building Codes and Building Inspection

Many structural mitigation measures involve constructing and retrofitting homes, businesses, and other structures according to standards designed to make the buildings more resilient to the impacts of natural hazards. Many of these standards are imposed through building codes.

All of the jurisdictions have adopted the 20012 Virginia Statewide Uniform Building Code effective July, 2014. While municipalities and counties may adopt codes for their respective areas if approved by the state as providing "adequate minimum standards," none of the participating jurisdictions have chosen to do so.

Local governments in Virginia are also empowered to carry out building inspections. The Code of Virginia directs cities and counties to create an inspection department, and enumerates its duties and responsibilities, which include enforcement of state and local laws relating to the construction of buildings; installation of plumbing, electrical, and heating systems; building maintenance; and other matters. Each of the Richmond-Crater PDC region jurisdictions has established either a building inspections or code compliance office to carry out its building inspections.

Fire Codes

Virginia has a statewide fire code. The code establishes statewide standards to safeguard life and property from the hazards of fire or explosion arising from the improper maintenance of life safety, and fire prevention and protection of materials, devices, systems, and structures. The Virginia State Fire Marshal's Office is charged with enforcement of the code statewide except in those localities that choose to enforce the code locally. Those localities that choose to enforce the code locally must employ their own certified fire official.

6.6.2 Acquisition

The power of acquisition can be a useful tool for pursuing local mitigation goals. Local governments may find that the most effective method for completely "hazard-proofing" a particular piece of property or area is to acquire the property (either in fee simple or a lesser interest, such as an easement), thus removing the property from the private market and eliminating or reducing the possibility of inappropriate development. Virginia legislation empowers cities, towns, and counties to acquire property for public purpose by gift, grant, devise, bequest, exchange, purchase, lease, or eminent domain (Code of Virginia 15.2-1901).

The City of Richmond completed acquisition projects after 2006's Tropical Depression. Ernesto in both the Broad Rock Creek and Battery Park neighborhoods. All projects were completed without using FEMA mitigation funds; Virginia Urgent Needs block grant funds were used following Tropical Depression Ernesto to acquire and demolish flood-damaged properties. Once the structures were demolished the lots were dedicated to permanent open space. Chesterfield County acquired a number of repetitive loss properties along Beach and Old Beach Roads using FEMA Hazard Mitigation Grant Program funds following Hurricane Isabel. Development of an acquisition program is proposed in the City of Petersburg Comprehensive Plan. The City of Colonial Heights is considering a voluntary acquisition program along high-risk creeks to eliminate repetitive flood claims in the city.

6.6.3 Taxation

The power to levy taxes and special assessments is an important tool delegated to local governments by Virginia law. The power of taxation extends beyond merely the collection

of revenue, and can have a profound impact on the pattern of development in the community. Communities have the ability through special legislation to set preferential tax rates for areas that are more suitable for development in order to discourage development in otherwise hazardous areas (Code of Virginia 15.3-2404).

Local governments also have the ability to levy special assessments on property owners for all or part of the costs of acquiring, constructing, reconstructing, extending, or otherwise building or improving flood protection works within a designated area (Code of Virginia 15.2-1104). This can serve to increase the cost of building in such areas, thereby discouraging development. Because the usual methods of apportionment seem mechanical and arbitrary, and because the tax burden on a particular piece of property is often quite large, the major constraint in using special assessments is policy-oriented. Special assessments seem to offer little in terms of control over land use in developing areas. They can, however, be used to finance the provision of necessary services within municipal or county boundaries. In addition, they are useful in distributing the costs of the infrastructure required by new development to the new property owners.

According to the Code of Virginia 58.1-3389, local governments are authorized to levy taxes on real property with no upper limit imposed. Additionally, Section 58.1-3201 requires that an assessment be 100% of fair market value. A building that increases in value of more than $500 due to repairs or additions must be assessed as new (Code of Virginia 58.1-3291). At the same time, the code allows the abatement of local real estate taxes for buildings unusable for at least 30 days during the year (Code of Virginia 58.1-3222). Real estate tax is a significant source of local revenue.[23]

According to the State Corporation Commission, "the E911 tax is imposed by localities to pay for the cost of an emergency response communications system that identifies both the caller and the location of the call. The tax rate is set by the locality. The General Assembly also authorized a 75¢ per month charge on wireless and wired telephone customers. This money will pay for highly sophisticated equipment that pinpoints, by satellite, the location of a wireless 911 caller."[24]

6.6.4 Spending

The fourth major power that has been delegated from the Virginia General Assembly to local governments is the power to make expenditures in the public interest. Hazard mitigation principles should be made a routine part of relevant spending decisions made by the local government, including the adoption of annual budgets and the Capital Improvement Plan (CIP).

A CIP is a schedule for the provision of municipal or county services during a specified period of time. Capital programming, by itself, can be used as a growth management

[23] Knapp, John L. and Stephen C. Kulp. *Tax Rates in Virginia's Cities, Counties, & Selected Towns: 2003 Tax Rates.* December 2003. Retrieved from www.virginia.edu/coopercenter/vastat/taxrates2003/taxrates03.html

[24] Virginia Department of Taxation. Tax *Facts*. Retrieved on July 1, 2011 from http://www.tax.virginia.gov/site.cfm?alias=communicationstaxes

technique, with a view to hazard mitigation. By tentatively committing itself to a timetable for the provision of capital to extend services, a community can control growth to some extent, especially in areas where the provision of on-site sewage disposal and water supply are unusually expensive.

In addition to formulating a timetable for the provision of services, a local community can regulate the extension of and access to services. A CIP that is coordinated with extension and access policies can provide a significant degree of control over the location and timing of growth. These tools can also influence the cost of growth. If the CIP is effective in directing growth away from environmentally sensitive or high-hazard areas, for example, it can reduce environmental costs.

The majority of the jurisdictions in the Richmond-Crater region have some form of a CIP. The construction or renovation of capital facilities, such as schools, municipal offices, and police/fire stations is often a highlight of their capital improvements. Investments in stormwater and sewer systems are included in the capital improvements program for most municipalities. Some jurisdictions also have included open space and other park acquisition costs as part of their CIP.

6.7 Summary

Most of the information in the capability assessment was provided by the jurisdictions in the study area through a capability assessment survey. Table 6-7 summarizes the self-reported capability and priority assessment; note that several jurisdictions did not return the 2016 update capability assessment survey. Full result may be found on a table in Appendix I.

Table 6-7. Mitigation Capability & Priority Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
Richmond Regional PDC	Planning High	Moderate	Moderate	N/A	Moderate
Crater PDC	Planning High	Moderate	Moderate	N/A	Moderate
Charles City County*	Moderate	Moderate	Moderate	Moderate	Moderate
Chesterfield County	High	High	High	High	High
City of Colonial Heights	Moderate	Moderate	Moderate	Moderate	Moderate
Dinwiddie County	Moderate	Moderate	Moderate	Moderate	Moderate
*Town of McKenney**	Limited	Limited	N/A	Limited	Limited
City of Emporia	Moderate	Moderate	Moderate	Moderate	Moderate
Goochland County	Moderate	Moderate	Moderate	Moderate	Moderate
Greensville County	Moderate	Moderate	Not Provided	Moderate	Moderate

Table 6-7. Mitigation Capability & Priority Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
*Town of Jarratt**	Limited	Limited	N/A	Limited	Limited
Hanover County*	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Ashland**	Moderate	High	N/A	Limited	Moderate
Henrico County	High	High	High	High	High
City of Hopewell	Moderate	Moderate	Moderate	Limited	Moderate
New Kent County	Moderate	High	Moderate	Moderate	Moderate
City of Petersburg	Limited	Limited	Moderate	Limited	Limited
Powhatan County	Moderate	High	Moderate	Moderate	Moderate
Prince George County	Moderate	Moderate	Moderate	Moderate	Moderate
City of Richmond	Moderate	Moderate	Moderate	Limited	Moderate
Surry County*	High	High	N/A	High	High
*Town of Claremont**	Limited	Limited	N/A	Limited	Limited
*Town of Dendron**	Limited	Limited	N/A	Limited	Limited
*Town of Surry**	Limited	Limited	N/A	Limited	Limited
Sussex County*	Moderate	Limited	N/A	Limited	Limited
*Town of Stony Creek**	Limited	Limited	N/A	Limited	Limited
*Town of Wakefield**	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Waverly**	Limited	Limited	N/A	Limited	Limited

High: No increase in capability needed (e.g., extensive regulations on development in place).
Moderate: Increased capability desired but not needed (e.g., funding exists for mitigation but availability fluctuates).
Limited: Increased capability needed (e.g., additional staff are needed to successfully implement mitigation projects).
Source: Capability Assessment Survey Results.
*Based on 2011 Self-Assessment; 2016 Survey not returned.

7.0 Mitigation Strategy

The hazard mitigation planning process conducted by the HMTAC used a typical problem-solving methodology:

- Describe the problem (Hazard Identification).
- Estimate the impacts the problem could cause (Risk Assessment).
- Assess what safeguards exist that might already or could potentially lessen those impacts (Capability Assessment).
- Using this information, determine what, if anything, can be done, and select those actions that are appropriate for the community in question (Mitigation Strategy).

This section of the hazard mitigation plan describes the most challenging part of any such planning effort – the development of a mitigation strategy. It is a process of:

- setting mitigation goals,
- selecting mitigation actions, and
- Developing a mitigation action plan.

7.1 Setting Mitigation Goals

When a community decides that certain risks are unacceptable and that certain mitigation actions may be achievable, the development of *goals* and *actions* takes place. *Goals* are long-term and general statements. *Actions* are detailed and specific methods to meet the goals.

The HMTAC reviewed the goals from the 2006 Crater Regional Hazard Mitigation Plan and the Richmond Regional Hazard Mitigation Plan at a meeting on October 26, 2016. The committee discussed whether to modify or add a resiliency goal as well as a goal to incorporate the new THIRA into the mitigation plan. It was decided to realign the goals with the Central Virginia Emergency Management Alliance. The goals are broad and applicable to the regions served by the Richmond Regional and Crater Planning District Commissions and mirror the goals of the Central Virginia Emergency Management Alliance:

1. Reduce risk exposure and vulnerabilities to hazards ranked “medium” and “high” by focusing on regional and local mitigation actions on priority hazards.

2. Prepare and protect the whole community within the Central Virginia Emergency Management Alliance (CVEMA) region through all-hazards planning staff, outreach publications and activities, and through training, and exercising volunteers and the general public.

3. Strengthen and sustain response coordination and collaboration through planning, equipment, training, and exercises to increase interoperability between all stakeholders in the CVEMA region and other regions/entities that impact interoperability within the region, to include, but not limited to voice, video, and data.

4. Provide support for public health and human service needs of the whole community through robust and coordinated sheltering capability, to include planning, resources, equipment, training, and exercises to include support of client needs tracking, family reunification services, information sharing, and public health response support.

5. In the aftermath of a catastrophic incident, provide restoration of basic services, long term housing, and revitalization of a sustainable economy that includes the health, social, cultural, historic, and environmental fabric of the community, through planning, staffing, equipment, training, and exercises.

6. Enhance and maintain public safety and incident management response capabilities to all hazard emergencies including acts of terrorism, through planning, staffing, equipment, training, and exercises.

7. Protect the critical infrastructure of the CVEMA region, and enhance the capability to disrupt criminal or terrorist threats through effective information and intelligence gathering and sharing, outreach, planning, equipment, training, and exercises.

7.2 Selecting Mitigation Actions

Actions are detailed and specific methods to meet the goals. The actions from the 2011plans formed a basis for discussion about mitigation actions for the 2017 plan. The status of the actions from the previous plans was discussed and is documented in Appendix C. In addition, a range of new action alternatives were identified by each jurisdiction in individual local government meetings. These alternatives are presented in Appendix D. Generally, the jurisdiction representatives evaluated the actions for inclusion in the plan with the following criteria:

- Time – Can the strategy be implemented quickly?
- Ease to implement – How easy is the strategy to implement? Will it require many financial or staff resources?
- Effectiveness – Will the strategy be highly effective in reducing risk?
- Lifespan – How long will the effects of the strategy be in place?

- Hazards – Does the strategy address a high-priority hazard or does it address multiple hazards?

Some jurisdictions selected fewer actions than in the 2011 plans, which will allow them to be more focused on their implementation of the actions. Other jurisdiction with expanded local resources added actions to their 2017 suite of mitigation actions. After the 2017 actions were selected, the STAPLE/E (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) criteria (Table 7-1) were used to inform prioritization the most appropriate actions for the Richmond-Crater communities. This methodology requires that social, technical, administrative, political, legal, economic, and environmental considerations be taken into account when reviewing potential actions for the area's jurisdictions to undertake. This process was used to help ensure that the most equitable and feasible actions would be undertaken based on a jurisdiction's capabilities.

Table 7-1. STAPLE/E Prioritization Criteria for Actions to be Taken

Social
• Is the proposed action socially acceptable to the community(s)? • Are there equity issues involved that would mean that one segment of a community is treated unfairly? • Will the action cause social disruption?
Technical
• Will the proposed action work? • Will it create more problems than it solves? • Does it solve a problem or only a symptom? • Is it the most useful action in light of other community(s) goals?
Administrative
• Can the community(s) implement the action? • Is there someone to coordinate and lead the effort? • Is there sufficient funding, staff, and technical support available? • Are there ongoing administrative requirements that need to be met?
Political
• Is the action politically acceptable? • Is there public support both to implement and to maintain the project?

Table 7-1. STAPLE/E Prioritization Criteria for Actions to be Taken

Legal
• Is the community(s) authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? • Are there legal side effects? Could the activity be construed as a taking? • Is the proposed action allowed by a comprehensive plan, or must a comprehensive plan be amended to allow the proposed action? • Will the community(s) be liable for action or lack of action? • Will the activity be challenged?
Economic
• What are the costs and benefits of this action? • Do the benefits exceed the costs? • Are initial, maintenance, and administrative costs taken into account? • Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? • How will this action affect the fiscal capability of the community(s)? • What burden will this action place on the tax base or local economy? • What are the budget and revenue effects of this activity? • Does the action contribute to other community goals, such as capital improvements or economic development? • What benefits will the action provide?
Environmental
• How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and state regulatory requirements? • Are endangered or threatened species likely to be affected?

As part of the STAPLE/E criteria, the anticipated level of cost-effectiveness of each measure was a primary consideration when developing mitigation actions. Because mitigation is an investment to reduce future damages, it is important to select measures for which the reduced damages over the life of the measure are likely to be greater than the project cost. For structural measures, the level of cost-effectiveness is primarily based on the likelihood of damages occurring in the future, the severity of the damages when they occur, and the level of effectiveness of the selected measure. Although a detailed analysis was not conducted during the mitigation action development process, these factors were of primary concern when selecting measures. For those measures, such as public education and outreach, that do not result in a quantifiable reduction of damages, the relationship of the probable future benefits and the cost of each measure was considered when developing the mitigation actions.

Priority was assigned based on a relative score using the STAPLE/E criteria with strong emphasis on the economic criteria. For the most part, local jurisdictions did not rank mitigation actions high if the financial likelihood of action implementation was low. Each criterion was assigned a rating using the following scale: 2=Very beneficial, 1=Favorable, 0=None/Not applicable, -1=Not Favorable. The numbers were summed and then a priority assigned using the scheme shown in Table 7-2.

Table 7-2. Priority Scoring System

Priority	Score Range
Limited	0 to 4, long-term implementation 7 – 10 years, high cost.
Medium	5 to 8, 5 – 7 year implementation, moderate cost
High	9 to 12, short-term implementation within 5 years, lower cost

In addition to the actions identified by the individual jurisdictions, the Regional PDCs identified regional actions for each specific PDC to support plan implementation or their jurisdictions.

7.3. Developing a Mitigation Action Plan

Mitigation action plans were developed for all of the identified actions. Each mitigation action plan includes:

- the goal(s) it is intended to help achieve,
- the hazard(s) it is designed to mitigate,
- the agency assigned responsibility for carrying out the strategy,
- general resources needed,
- a timeframe for completion, and
- Priority level for its implementation (high, medium, or low).

The timeframes are defined in Table 7-3 and mirror those used in the 2010 Richmond Regional – Crater Hazard Mitigation Plan Update.

Table 7-3. Timeframes Defined

Timeframe	Definition
Short-term	Less than three years
Long-term	More than three years
As funding becomes available	Project timeline is dependent on funding
Ongoing	Project is continuous with no designated end date

The mitigation action plans for each jurisdiction follow in alphabetical order for the Richmond Regional and Crater Planning District Commissions may be found in Appendix D.

8.0 Plan Maintenance Procedures

The long-term success of the 2017 Richmond-Crater Multi-Regional Hazard Mitigation Plan depends on routine monitoring, evaluating, and updating of the plan so that it will remain a current, flexible tool for regional and community use.

8.1 Formal Plan Adoption

Twenty-six local governments in central Virginia participated in this planning process and formally adopted this plan by resolution of their governing board. The adoption process took several months, as significant coordination by the HMTAC was necessary to: 1) place the plan review and adoption on the appropriate meeting agendas in each jurisdiction, 2) produce and provide copies in official meeting packets, 3) facilitate the actual adoption, 4) collect the adoption resolutions, and 5) incorporate the adopted resolutions into the final hazard mitigation plan.

8.2 Implementation

Upon adoption, the plan faces its biggest test: ***implementation***. While this plan includes many worthwhile and "High" priority recommendations, the decision of which action to pursue first will be the primary issue that the Richmond-Crater communities face.

Each participating jurisdiction is responsible for incorporating their own actions into various planning documents, processes and budgets pursuant to locally-administered governing policies and procedures. Each action is assigned a responsible department or departments that will work together to implement designated actions.

There are always resource considerations that impact implementation and funding always seems to be central to this. Therefore, pursuing low- or no-cost, high-priority recommendations may be a way to achieve progress sooner rather than later while allowing time to strategize on possible grant funding or future resource allocations to implement more challenging actions. An example of a low-cost, high-priority recommendation would be to install flood level markers on bridges to warn motorists, pedestrians and cyclists of high water levels.

Another implementation approach is to prioritize those low-cost actions that can be completed in a relatively short amount of time. Being able to publicize accomplishment of a successful project can build momentum to implement the other parts of the plan. An example of an effective but easy-to-implement strategy is to distribute brochures from localities, the PDCs, FEMA and VDEM on mitigation and preparedness topics.

It is important to the long-term implementation of the plan that its underlying principles are incorporated into other community plans and mechanisms, such as:

- comprehensive planning
- resiliency planning

- disaster recovery planning and
- Capital Improvement Program (CIP) budgeting.

Section 4.0 Community Profile provides insight into the comprehensive plan status for each community. Members of the HMTAC representing each jurisdiction will provide an electronic link to this plan to their planning department to make them aware that the plan has been finalized and adopted by their governing board, and to begin the conversation of how best to incorporate appropriate information from the 2017 mitigation plan into the next update of the jurisdiction's comprehensive plan. Information from the HIRA, as well as mitigation goals and actions may be directly included as a comprehensive plan element or included in other local government programs and policies as appropriate. Projects that require large investments, such as acquisition or road retrofits, are candidates for inclusion in capital improvement plans. Hazard vulnerability analysis can be incorporated into local emergency operations plans, debris management, and disaster recovery plans. Floodplain management data and mitigation actions can be used to leverage Community Rating System (CRS) program participation or a better CRS rating.

Mitigation is most successful when it is incorporated within the day-to-day functions and priorities of government and development. This integration is accomplished by a constant effort to network and to identify and highlight the multi-objective, "win-win" benefits to each program, the communities, and their constituents. This effort is achieved through monitoring agendas, attending meetings, and providing routine updates on the status and progress of mitigation efforts.

Simultaneous to these efforts, it is important to constantly monitor funding opportunities that can be used to implement some of the higher cost recommended actions. This includes creating and maintaining a repository of ideas on how any required local match or participation requirement can be met. Then, when funding does become available, the Richmond-Crater communities will be in a position to take advantage of an opportunity. Funding opportunities that can be monitored include special pre- and post-disaster funds, special district-budgeted funds, state or federal ear-marked funds, and grant programs, including those that can serve or support multi-objective applications.

With adoption of this plan, the Richmond-Crater communities commit to:

- Pursuing the implementation of the high-priority, low/no-cost recommended actions;
- Keeping the concept of mitigation in the forefront of community decision-making by identifying and stressing the recommendations of the hazard mitigation plan when other community goals, plans, and activities are discussed and decided upon;
- Maintaining a constant monitoring of multi-objective, cost-share opportunities to assist the participating communities in implementing the recommended actions of this plan for which no current funding or support exists;

- Incorporate hazard risk information, and priority mitigation actions into appropriate local initiatives and programs through collaborative interaction between all related community departments and staff; and
- Evaluating and assessing regional mitigation plan goal and local jurisdiction action effectiveness to reduce hazard risk exposure.

In addition, the communities of the Richmond-Crater region remain committed to the NFIP. They will continue to enforce floodplain regulations and undertake other actions to remain in compliance with the program such as continued flood hazard risk evaluation, participation in Community Assistance Visits (CAV's) with the Commonwealth of Virginia NFIP staff, and education and outreach activities directed at flood-prone residents and businesses.

8.3 Maintenance

Plan maintenance requires an ongoing effort to monitor and evaluate the implementation of the plan, and to update the plan as progress, roadblocks, or changing circumstances are recognized. The Richmond Regional and Crater Planning Districts will be responsible for monitoring this plan for the jurisdictions within their boundaries. They will work with the HMTAC or the Central Virginia Emergency Management Alliance or any appropriate regional multi-jurisdiction successor, to coordinate information gathering from the participating jurisdictions.

The Richmond Regional and Crater Planning Districts in conjunction with the HMTAC or CVEMA, within 60 days of adoption of the plan, will modify the monitoring processor schedule as drafted in Section 8.3 if necessary to allow monitoring and evaluation of plan implementation progress.

The Richmond Regional and Crater Planning District planning staff will make an annual request to the HMTAC members in November for an update to be provided by January 31, on the progress of the implementation of their mitigation actions. Annual review will include review of local and PDC mitigation action implementation, opportunities to incorporation plan information into relevant local and regional plans, documents and projects, lessons learned and outreach opportunities. Opportunities for member communities to leverage plan participation into Resilient Virginia or the Community Rating System, as appropriate, will also be explored.

PDC staffs will initiate the annual update in consultation with the Central Virginia Emergency Management Alliance during November at their regular meeting. These updates will begin in 2018 and will include corrective action plans if needed, based on the evaluation criteria set by jurisdiction leadership. PDC staff will consolidate this information into a progress report and make the report available to VDEM. PDC staff or designee will offer to present this information at a VDEM Regional Coordinator's meeting. Figure 8-1 shows a sample update form.

Jurisdiction:		
Updated through:		
Action number:	Status: Not started In progress (percent complete___) Completed for purposes of this plan Ongoing Activities Successes Effectiveness	Notes (e.g., changes in action/funding/responsible department/timeframe):
Action number:	Status: Not started In progress (percent complete___) Completed for purposes of this plan Ongoing Activities Successes Effectiveness	Notes (e.g., changes in action/funding/responsible department/timeframe):

Figure 8.1 Sample Update Form

Ongoing evaluation of implementation progress for the mitigations actions will be achieved by monitoring changes in the vulnerability identified in the plan. Changes in vulnerability can be identified by noting:

- lessened vulnerability as a result of implementing recommended actions;
- increased vulnerability as a result of failed or ineffective mitigation actions; and/or
- increased vulnerability as a result of new development/re-development.

The Richmond Regional and Crater Planning District Commissions, with the HMTAC in consultation with CVEMA, will determine annually if a more formal update of the plan is needed and the mechanism for doing so. Major changes to the plan will be submitted to VDEM and to ultimately to FEMA Region III with subsequent local re-adoption by each jurisdiction, as necessary. Factors to consider when determining if a formal update is necessary include:

- decreased vulnerability as a result of implementing recommended actions;

- increased vulnerability as a result of failed or ineffective mitigation actions;
- increased vulnerability as a result of new development (and/or annexation);
- new state/federal laws, policies, or programs; and/or changes in resource availability.

Ongoing Public Outreach will continue and public participation will be encouraged, at a minimum, through available web postings and press releases to the local media outlets, primarily newspapers and radio stations. In addition, progress reports of the mitigation actions will be considered as part of Survivor Day training, a free, half-day preparedness class that is offered in multiple locations across the region each year. Local government staffs will also provide routine updates to their governing body.

Table 8-1 Richmond Regional – Crater Multi-Regional Hazard Mitigation Plan Update Maintenance Schedule

Timeframe	Activity	Leadership
2017	Jurisdictions Adoption	Local jurisdictions; Richmond Regional PDC submit to FEMA
2018	Annual implementation review	HMTAC or CVEMA
2019	Annual implementation review	HMTAC or CVEMA
2020	Annual implementation review	HMTAC or CVEMA
2021	Annual implementation review; seek FEMA HMA funding for 2022 plan update	HMTAC or CVEMA; Richmond Regional PDC
2022	Initiate 2022 Plan update process	HMTAC, Richmond Regional and Crater PDC

9.0 References

Note: some of this source material for the 2011 plan had not been updated and was used as background material for the 2017 Plan update.

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