APPENDIX D: STATE AND DISTRICT OF COLUMBIA ANALYSES

NORTH ATLANTIC COAST COMPREHENSIVE STUDY:
RESILIENT ADAPTATION TO INCREASING RISK

STATE CHAPTER

D-9: District of Columbia

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I. Introduction

The purpose of the North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk (NACCS) is to catalyze and spearhead innovation and action by all to implement comprehensive coastal storm risk management (CSRM) strategies. Action is imperative to increase resilience and reduce risk from, and make the North Atlantic region more resilient to, future storms and impacts of sea level change (SLC). The U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration's (NOAA) Infrastructure Systems Rebuilding Principles defines resilience as the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies.

The goals of the NACCS are to:

- Provide a risk management framework, consistent with NOAA/USACE Infrastructure Systems Rebuilding Principles; and
- Support resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure.

The NACCS Main Report addresses the entire study area at a regional scale and explains the development and application of the NACCS CSRM Framework from a broad perspective. This State Coastal Risk Management Framework Appendix discusses state specific conditions, risk analyses and areas, and comprehensive CSRM strategies in order to provide a more tailored Framework for the District of Columbia. Attachments include the Middle Potomac – Washington, D.C. and Metropolitan Area Focus Area Report (FAA) Report, as well as the District of Columbia response to the USACE State Problem, Needs, Opportunities correspondence.

II. Planning Reaches

The planning reach covered within this chapter includes the District of Columbia, adjacent portions of Northern Virginia along the Potomac River, and a small portion of Prince Georges County, Maryland (Figure 1). This chapter was prepared in coordination with the District Department of the Environment (DDOE). DDOE served as the key liaison to the D.C. Silver Jackets team, coordinating with the team's Federal and District agencies to provide necessary existing information, including data, modeling, studies, plans, reports; reviewing documents, draft reports, statements, and assumptions; and providing comments and feedback throughout the study process.

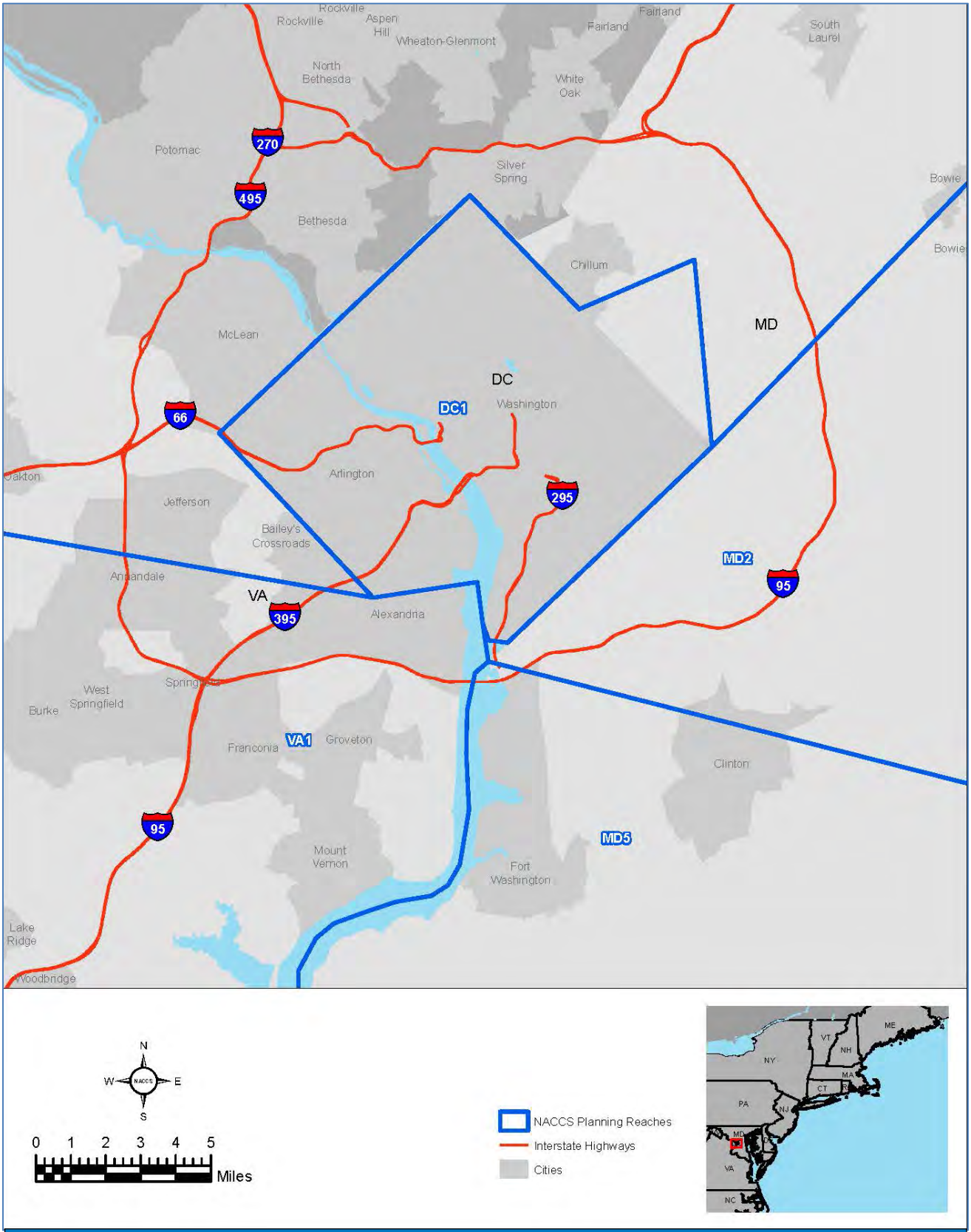

Figure 1. Planning Reach for the District of Columbia

III. Existing and Post-Sandy Landscape Conditions

III.1. Existing Condition

The existing conditions are the conditions immediately after the landfall of Hurricane Sandy. This existing conditions analysis includes consideration of the population, supporting critical infrastructure, environmental conditions, inventory of existing CSRM projects and associated project performance during Hurricane Sandy, the Federal Emergency Management Agency (FEMA) and Small Business Administration response and recovery efforts, FEMA flood insurance claims, and shoreline characteristics that were vulnerable to coastal flood risk associated with Hurricane Sandy. Development of detailed existing conditions across the study area illuminates the vulnerabilities to storm damage that exist. This process helps to identify coastal risk reduction and resilience opportunities. The existing condition serves as the base against which all proposed risk reduction and resilience are compared. Further discussion of the existing conditions is provided in Appendix C – Planning Analyses.

The existing conditions are discussed herein through an analysis of the population and supporting critical infrastructure affected by Hurricane Sandy within the study area. Figure 2 and Table 1 summarize pertinent information regarding the population affected by Hurricane Sandy.

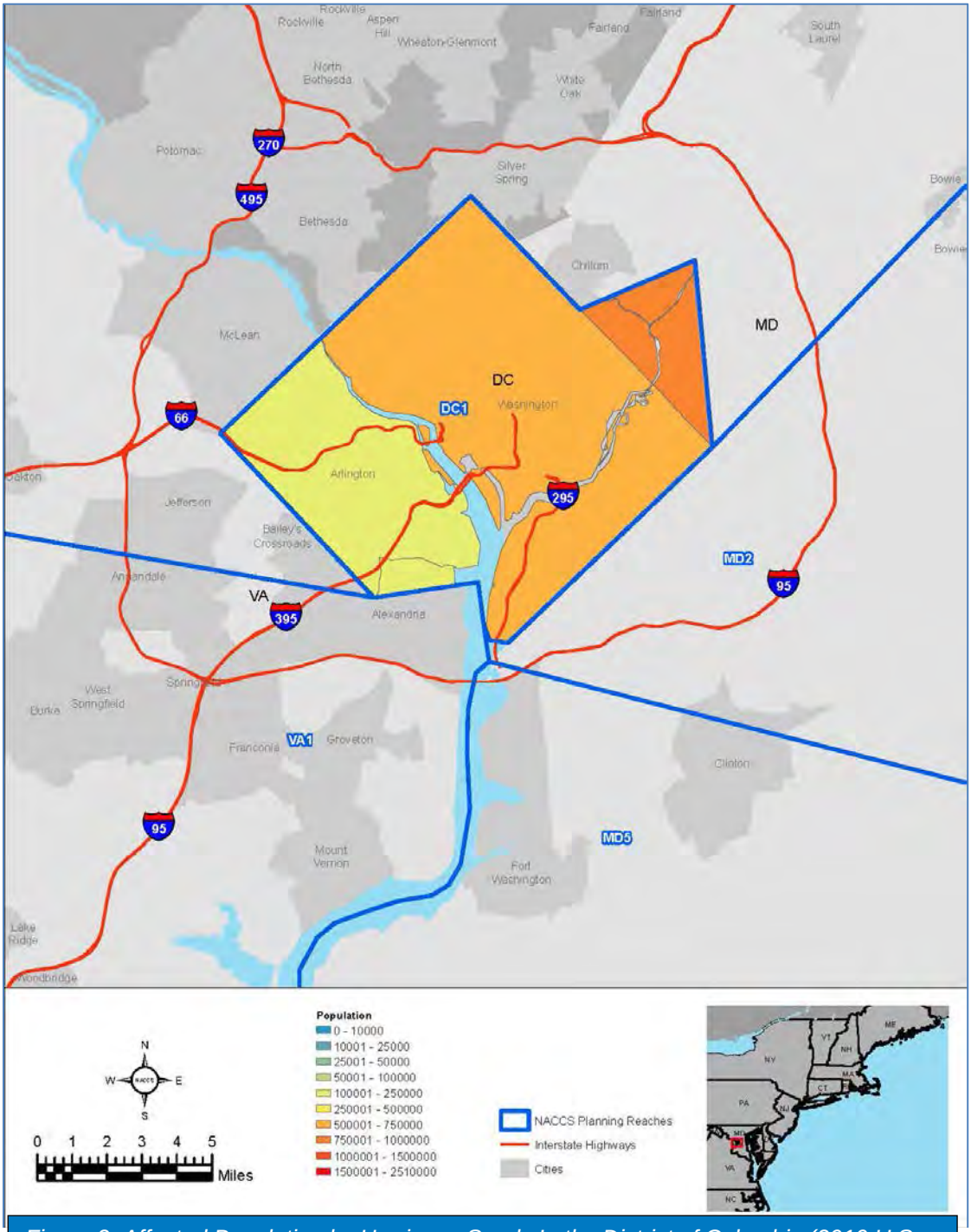

Figure 2. Affected Population by Hurricane Sandy In the District of Columbia (2010 U.S. Census Data)

Table 1. Affected Population by Hurricane Sandy in the District of Columbia

Jurisdiction	Population
District of Columbia	601,723
Total Population	601,723

Figure 3 and Table 2 summarize pertinent information regarding critical infrastructure affected by Hurricane Sandy. Critical infrastructure elements include sewage, water, electricity, academics, trash, medical, and safety.

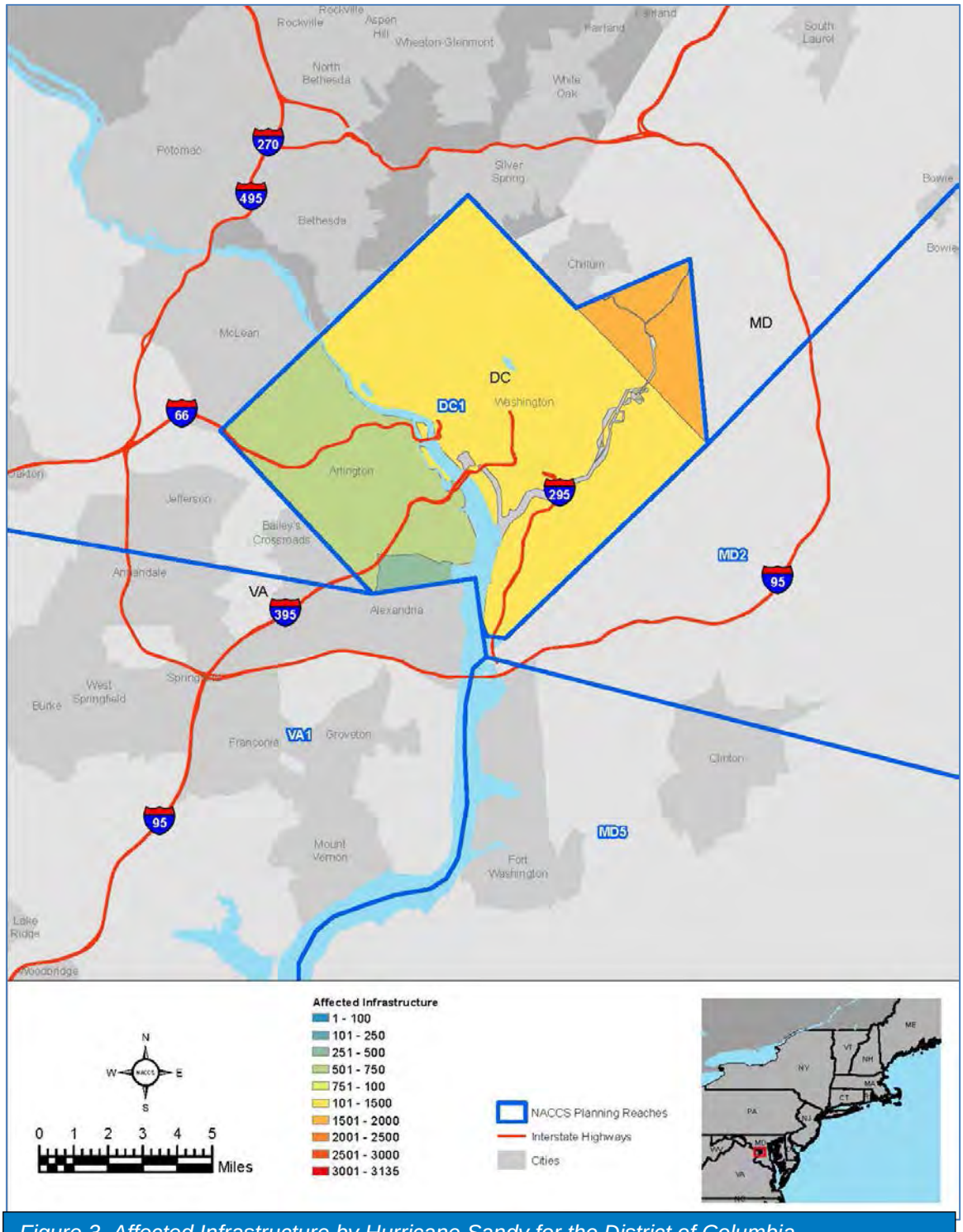

Figure 3. Affected Infrastructure by Hurricane Sandy for the District of Columbia

Table 2. Affected Critical Infrastructure by Hurricane Sandy	
Jurisdiction	**Infrastructure Count**
District of Columbia Total	1,071
Total Critical Infrastructure	**1,071**

III.2. Post-Sandy Landscape

Coastal Storm Risk Management Projects

Six existing USACE projects in the District of Columbia are included in the post-Sandy landscape condition. One of these projects is a CSRM project, one is an environmental restoration project, and four are navigation (NAV) projects (Figure 4).

The post-Sandy landscape condition also includes active (at the time of the landfall of Hurricane Sandy) state and local/communities CSRM projects in the District of Columbia. Some of these projects may have been damaged during Hurricane Sandy. USACE understands that the District of Columbia and the local communities may be rebuilding and restoring the shoreline and damaged infrastructure and property to pre-Sandy conditions under emergency authorities and programs. Given this priority, and the apparent current lack of resources to commence new CSRM efforts at this time, the USACE has assumed that the District's most likely future condition will be the pre-Sandy condition. The District of Columbia was queried with regard to the statement's accuracy in a June 5, 2013 letter, and there was no disagreement to the statement's accuracy.

There are numerous state and local studies, analyses and plans; however, no state or locally constructed projects identified in this report (Figure 5). The Huntingdon Levee project in Fairfax County, Virginia (VA) is one project currently under design phase, which was identified in the state project listing of the FAA report appended to this chapter.

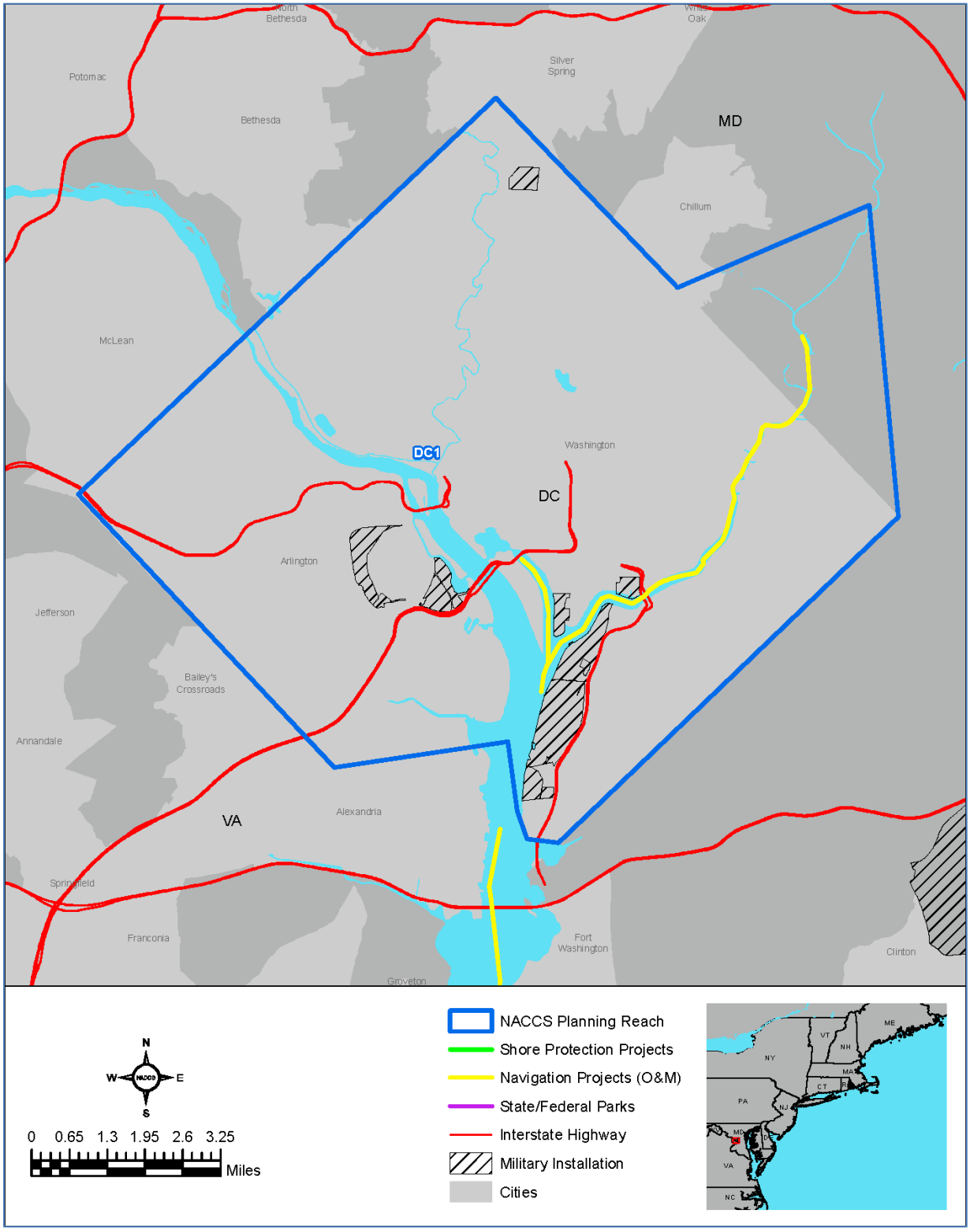

Figure 4. Federal Projects included in the Post-Sandy Landscape Condition

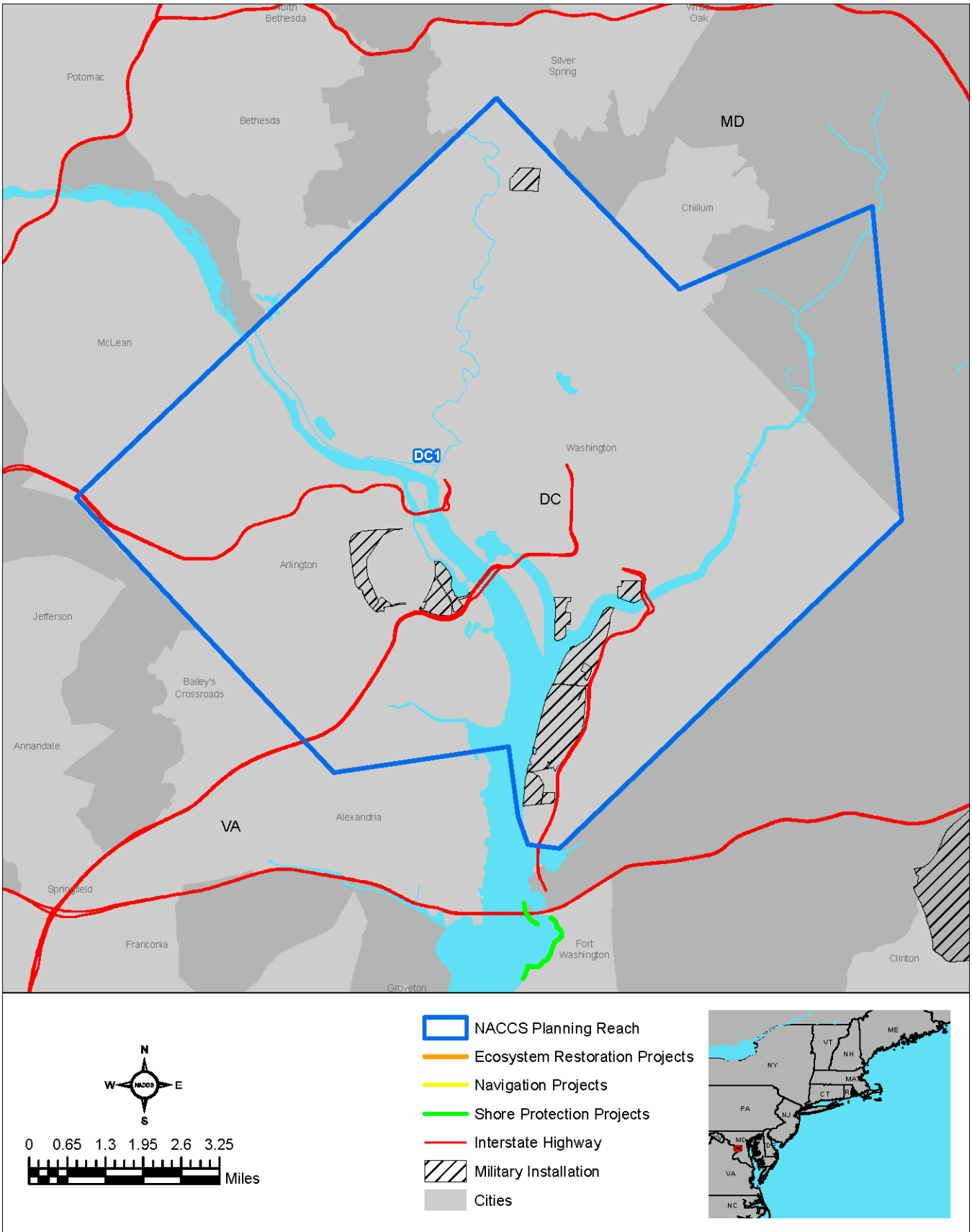

Figure 5. District Projects included in the Post-Sandy Landscape Condition

Sea Level Change

The current USACE guidance on development of sea level change (USACE, 2013) outlines the development of three scenarios: Low, Intermediate and High (Figure 5). The NOAA High scenario (NOAA, 2012) is also plotted on Figure 5. The details of different scenarios and their application to the development of future local, relative sea level elevations are discussed in Chapter IV of the Main Report.

These USACE and NOAA future sea level change scenarios have been compared to State or region specific sea level change scenarios. The scenarios presented in National Aeronautics and Space Administration's (NASA) study, which was conducted specifically for the District of Columbia, are shown in the green and red dots (Figure 6). Comparison of the USACE Low, Intermediate, and High and NOAA High relative sea level change scenarios (for the Washington, D.C. NOAA tide gauge) with the NASA scenarios for the District of Columbia indicate similar trends. Importance should be placed on scenario planning rather than on specific, deterministic single values for future sea level change. Such sea level change scenario planning efforts will help to provide additional context for state and local planning and assessment activities.

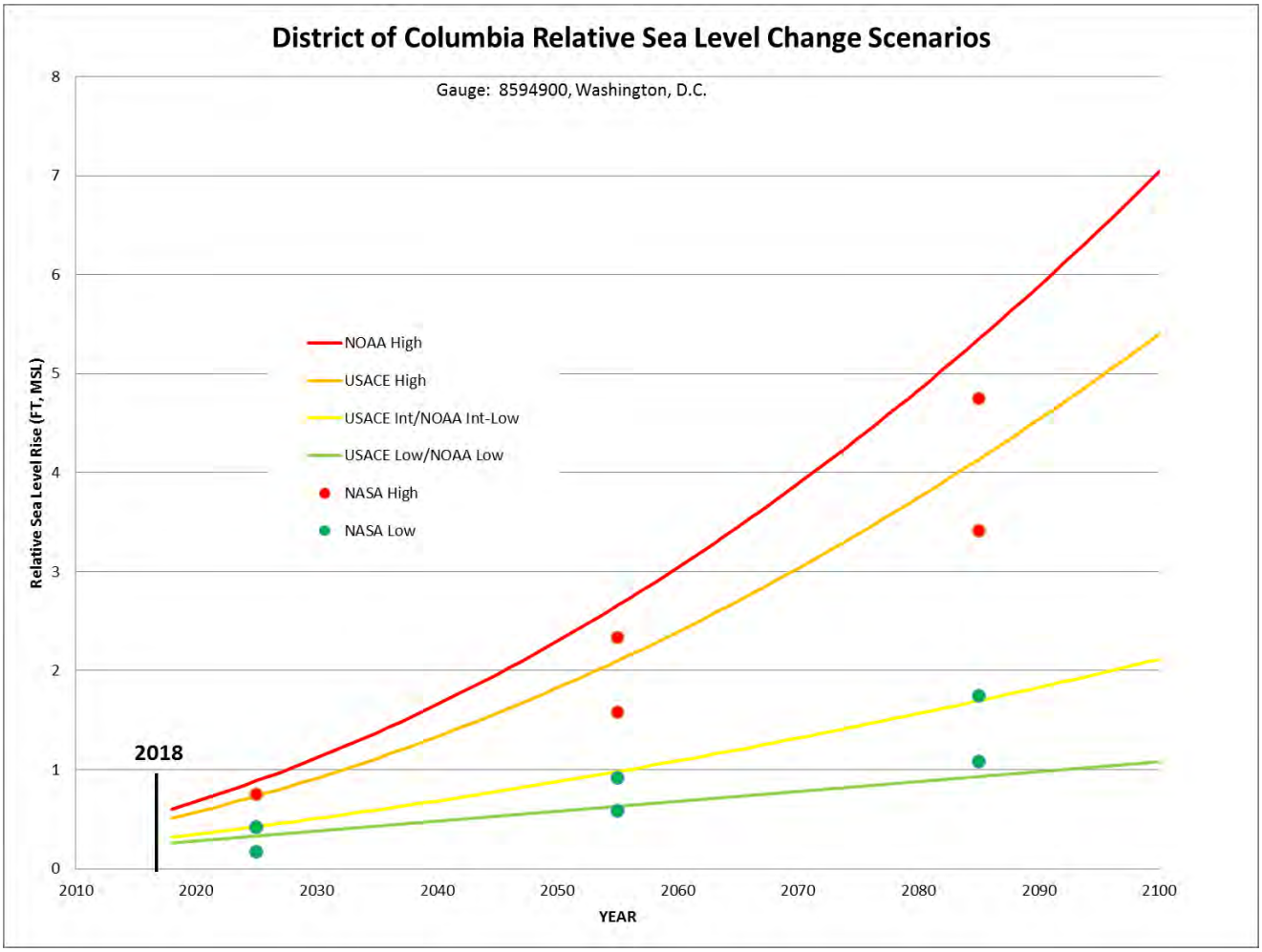

Figure 6. Relative Sea Level Change for the District of Columbia (NASA 2012 D.C. Climate Data), and for Gauge 8594900 in Washington, D.C., for USACE and NOAA Scenarios.

To consider the effects of SLC on the future landscape change, future SLC scenarios have been developed by USACE (2013d) and NOAA (2012). Figure 7 shows areas that would be below mean sea level (MSL) at three future times (2018, 2068, 2100) based on the USACE High scenario. A detailed discussion of mapping basis and technique for this and other mapping is provided in Appendix C – Planning Analyses.

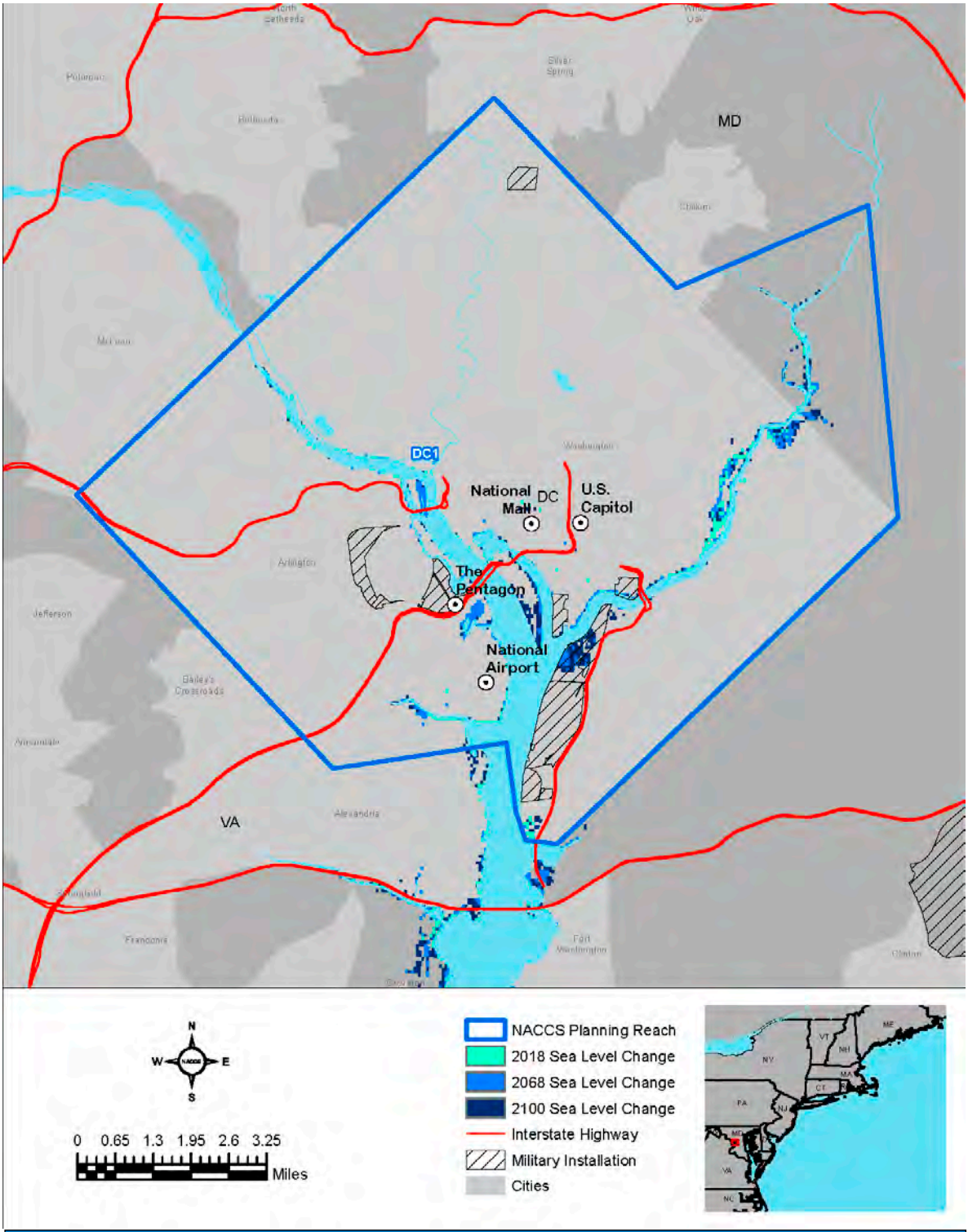

Figure 7. USACE High Scenario Future Mean Sea Level Mapping for the District of Columbia

Forecasted Population and Development Density

Using information and datasets generated as part of the U.S. Environmental Protection Agency's (EPA) Integrated Climate and Land Use Scenarios (ICLUS), inferences to future population and residential development increases by 2070 were evaluated (USEPA, 2009). Figure 8 present the USACE High scenario inundation and the forecasted increase in residential development density derived from ICLUS data for MD4. Changes to environmental and cultural resources and social vulnerability characteristics will not be considered as part of the overall forecasted exposure index assessment.

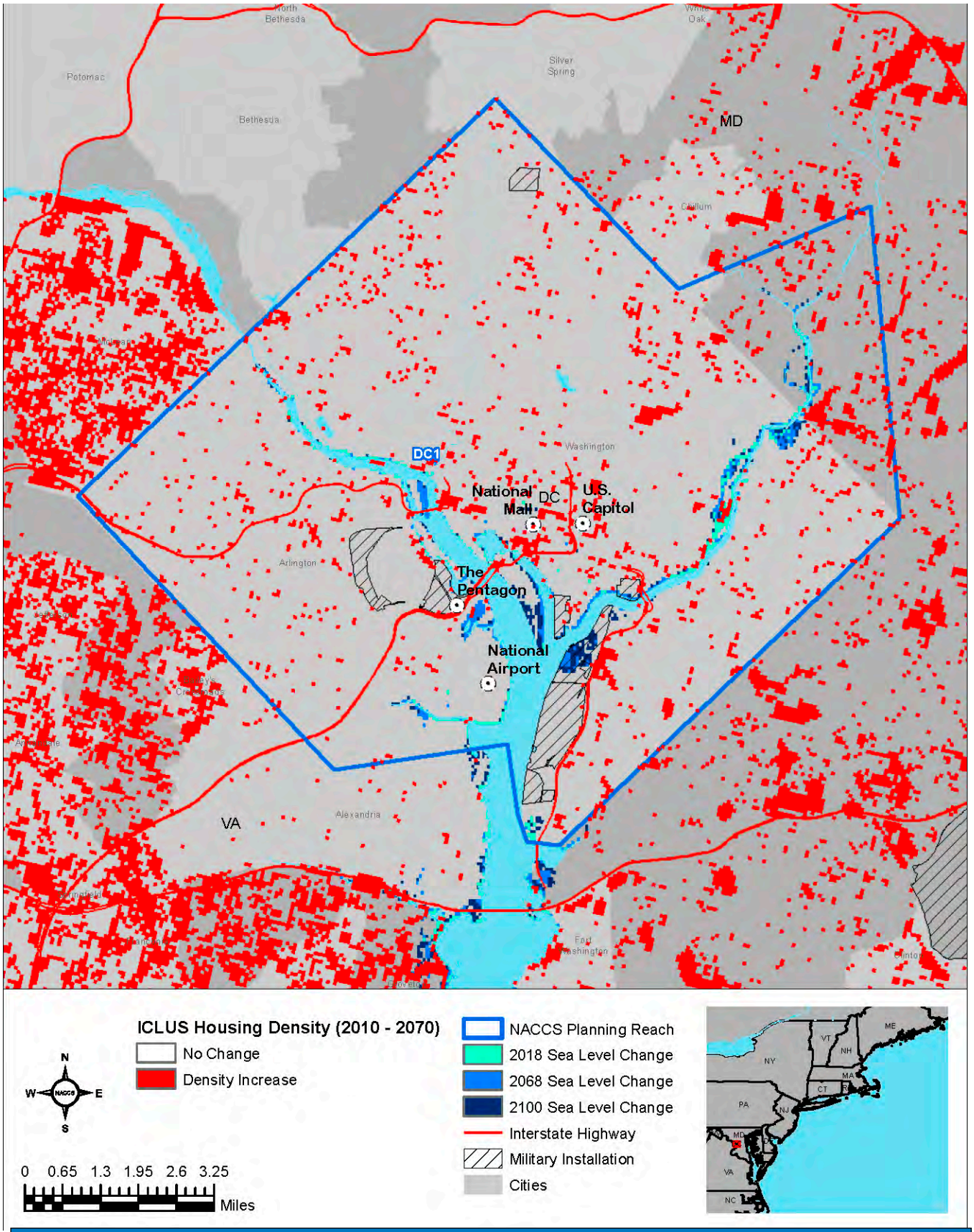

Figure 8. USACE High Scenario Future Mean Sea Level Inundation and Forecasted Residential Development Density Increase for the District of Columbia

Extreme Water Levels

As part of the Framework, the extent of coastal flood hazard was completed by using readily available 1 percent flood mapping from FEMA, preliminary 10 percent flood values from the USACE Engineer Research and Development Center (ERDC) extreme water level analysis, and the Sea, Lake, and Overland Surge from Hurricanes (SLOSH) modeling conducted by NOAA. The inundation zones identified by the SLOSH model depict areas of possible flooding from the maximum of maximum (MOM) event within the five categories of hurricanes by estimating the potential surge inundation during a high tide landfall. Although the SLOSH inundation mapping is not referenced to a specific probability of occurrence (unlike FEMA flood mapping, which presents the 0.2 percent and 1 percent flood elevation zones), a Category 4 hurricane making landfall during high tide represents an extremely low probability of occurrence but high magnitude event. Figure 9 presents the SLOSH hydrodynamic modeling inundation mapping associated with Category 1 through 4 hurricanes.

Figure 10 presents the approximate 1 percent floodplain plus 3 feet for the same area to illustrate exposed inundation levels. This is closely aligned with the USACE High scenario for projected sea level change by year 2068. Areas between the Category 4 and 1 percent plus 3-foot floodplain represent the residual risk for those areas included in the NACCS study area and Category 4 MOM floodplain.

Figure 11 presents the limit of the current 10 percent floodplain (an area with a 10 percent or greater chance of being flooded in any given year).

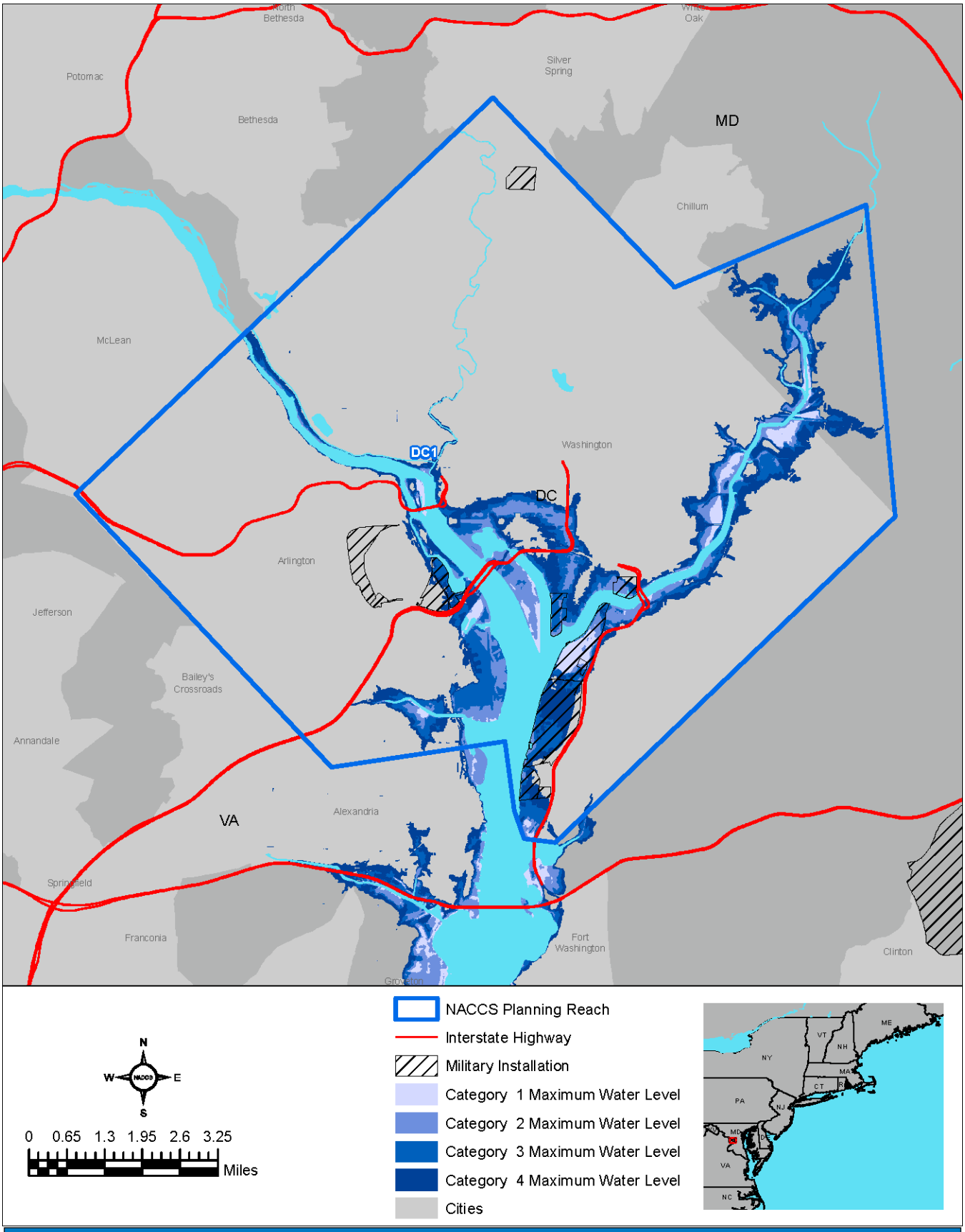

Figure 9. Impacted Area Category 1-4 Water Levels for the District of Columbia

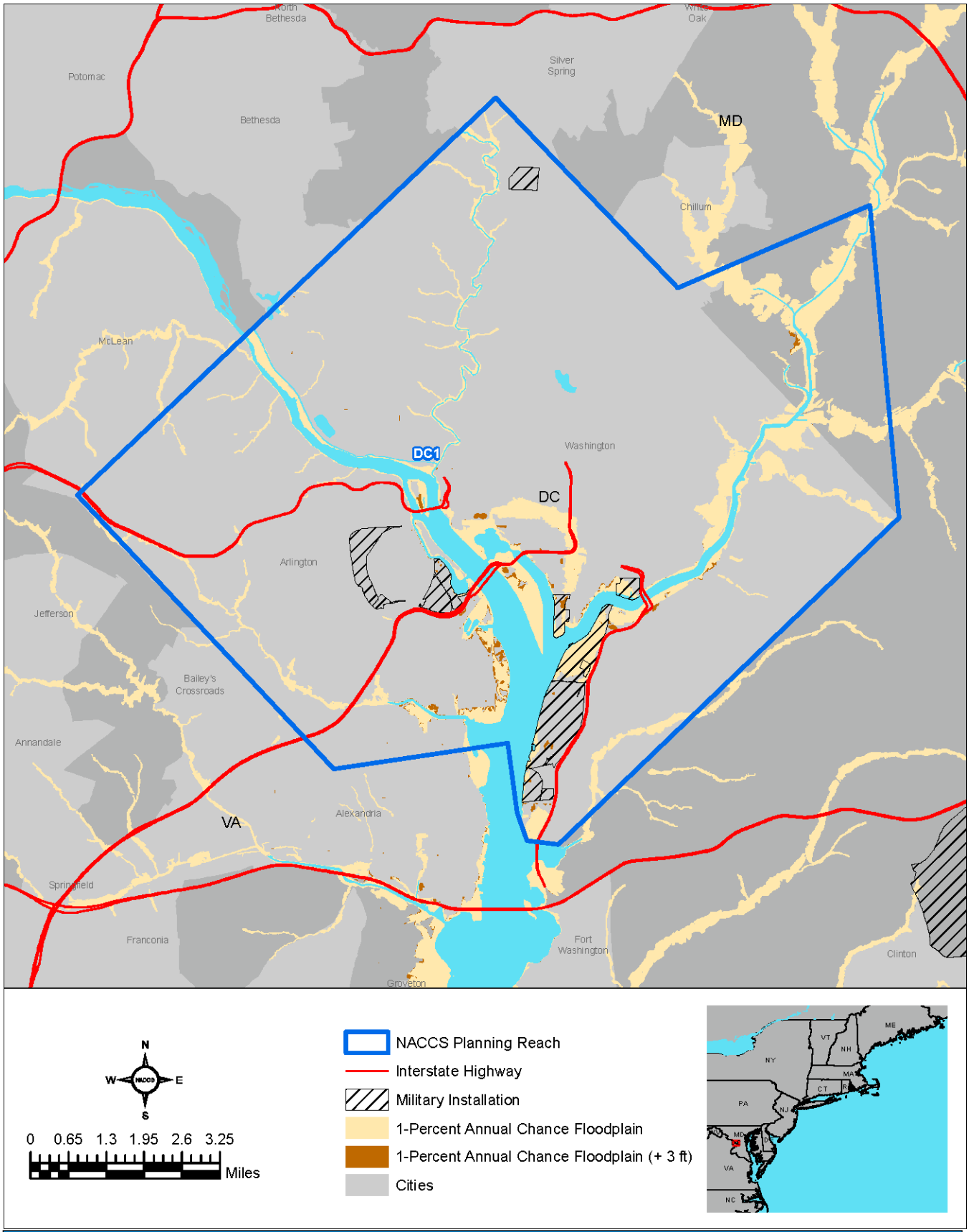

Figure 10. Impacted Area 1 percent + 3 feet Water Surface for the District of Columbia

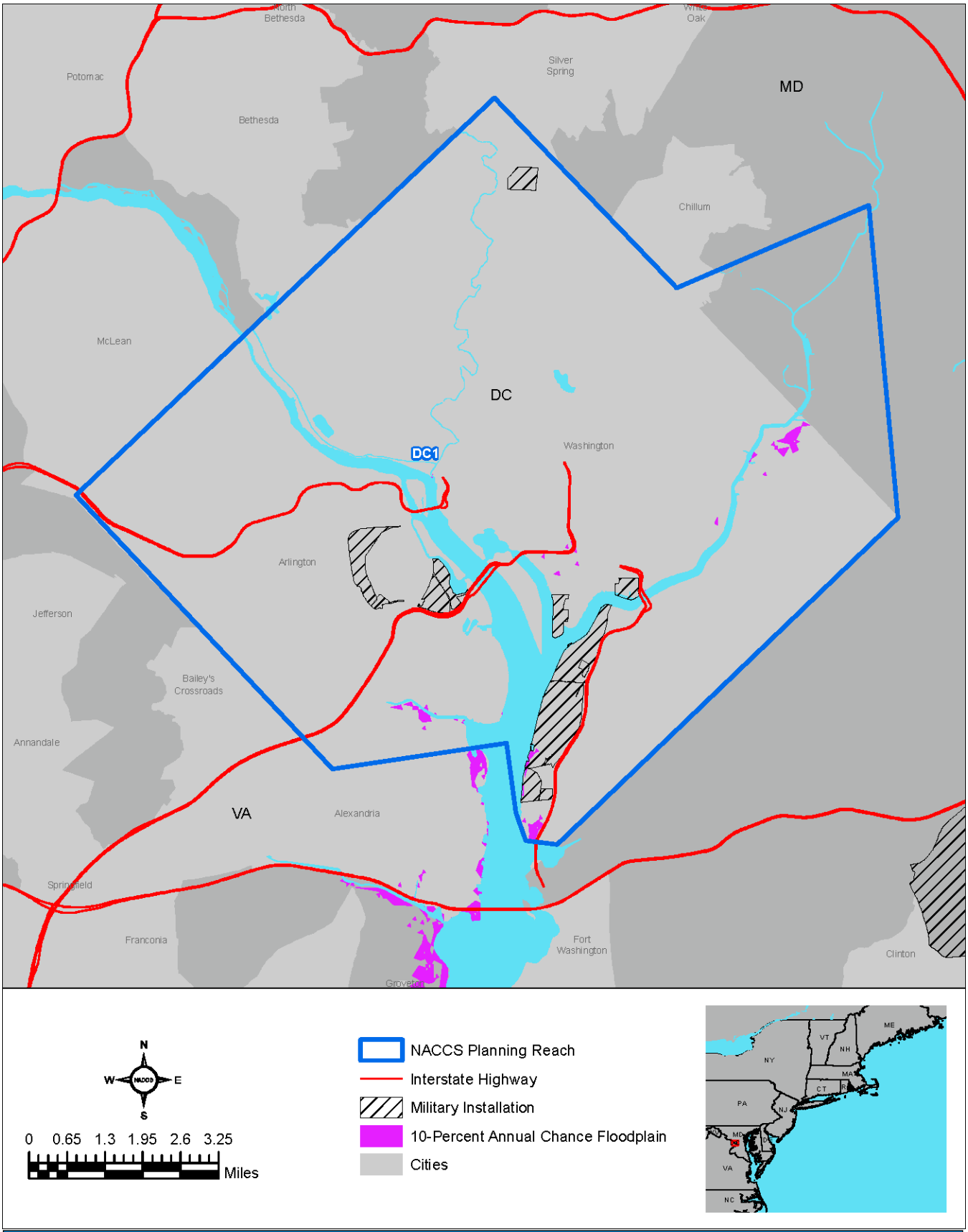

Figure 11. Impacted Area 10 percent Water Surface for the District of Columbia

Environmental Resources

There are almost 300 acres of wetlands within the District of Columbia area. These wetlands provide critical habitat for threatened and endangered species such as the Hay's Spring Amphid. Wetland parcels in the watershed would be protected by environmental regulations from direct destruction. An increase in the frequency of flooding of Rock Creek may have a negative impact on the Hay's Spring Amphid through the direct removal of individual amphipods or indirect affect through the removal of leaves and sediment that form the species' spring habitat.

It is expected that tidal conditions would gradually propagate further upstream as sea level changes.

Riparian freshwater wetlands in the District of Columbia are particularly sensitive to extreme high tides resulting from an increase in storm frequency or magnitude; these high tides can carry salts inland to salt-intolerant vegetation and soils. Because of the extent of urbanization, opportunities for migration of these freshwater tidal wetlands that would typically occur as a result of sea level change are limited. As a result, freshwater flora and fauna could be displaced by salt-tolerant species. Additionally, these wetlands will generally be unable to accrete at a pace greater or equal to relative sea level change and would eventually become open water areas.

Absent USACE involvement in non-tidal wetland restoration efforts in the stream corridor, there would likely be no change in non-tidal wetland acreage in the foreseeable future. Ongoing sediment deposition at the mouth of Four Mile Run will likely promote growth and expansion of tidal wetlands. Wetlands would grow onto areas that are now submerged aquatic vegetation (SAV) and shallow water habitat. Habitat suitable for SAV would also likely increase in area. SAV beds would be expected to maintain their area via lateral migration onto newly suitable bottom.

IV. Coastal Storm Risk – Exposure and Risk Assessments

The extent of flooding, as presented in Figures 9 to 11, was used to delineate the areas included in the coastal storm risk and exposure assessments. An exposure index was created for population density and infrastructure, social vulnerability characterization, and environmental and cultural resources. In addition, the three individual indices were combined to create a composite exposure index. The purpose of combining individual exposure indices into a composite index was to provide an illustration of example values for features of the system, with population density and infrastructure weighted at 80 percent of the total index, and social vulnerability characterization and environmental and cultural resources weighted at 10 percent each. For the purpose of the Framework, the overall composite exposure assessment identified areas with the potential for relative higher exposure to flood peril considering collectively the natural, social, and built components of the system. Additional information related to the development of the NACCS risk and exposure assessments is presented in Appendices B – Economics and Social Analyses, and C – Planning Analyses.

IV.1. NACCS Exposure Assessment

The Tier 1 assessment first required identifying the various categories to best characterize exposure. Although a myriad of factors or criteria can be used to identify exposure, the NACCS focused on the following categories and criteria, as emphasized in Public Law (PL) 113-2.

Population Density and Infrastructure Index

Figure 12 presents the population density and infrastructure exposure index. Figure 13 presents the percentages of infrastructure included within the population density and infrastructure exposure index.

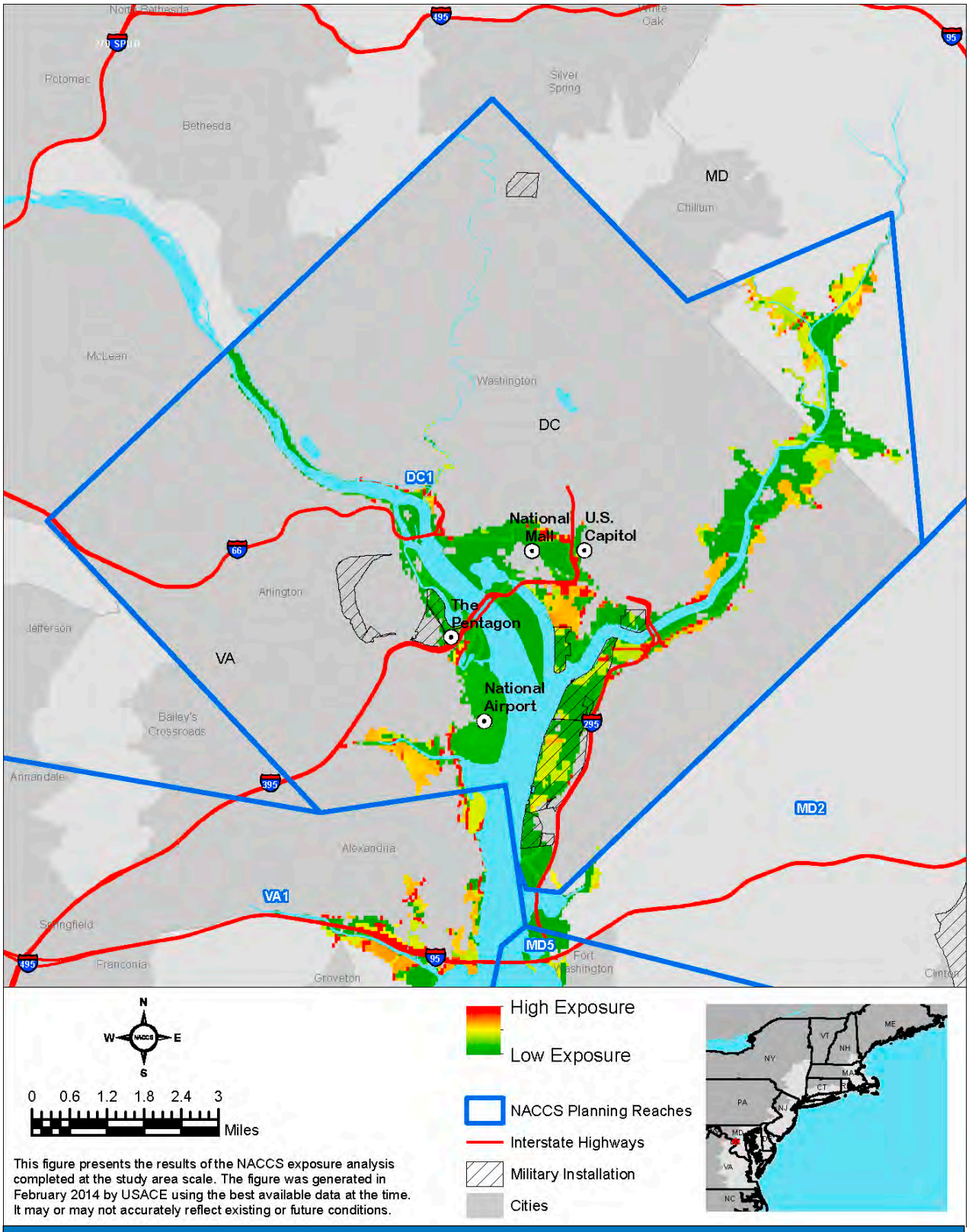

Figure 12. Population and Infrastructure Exposure Index for the District of Columbia

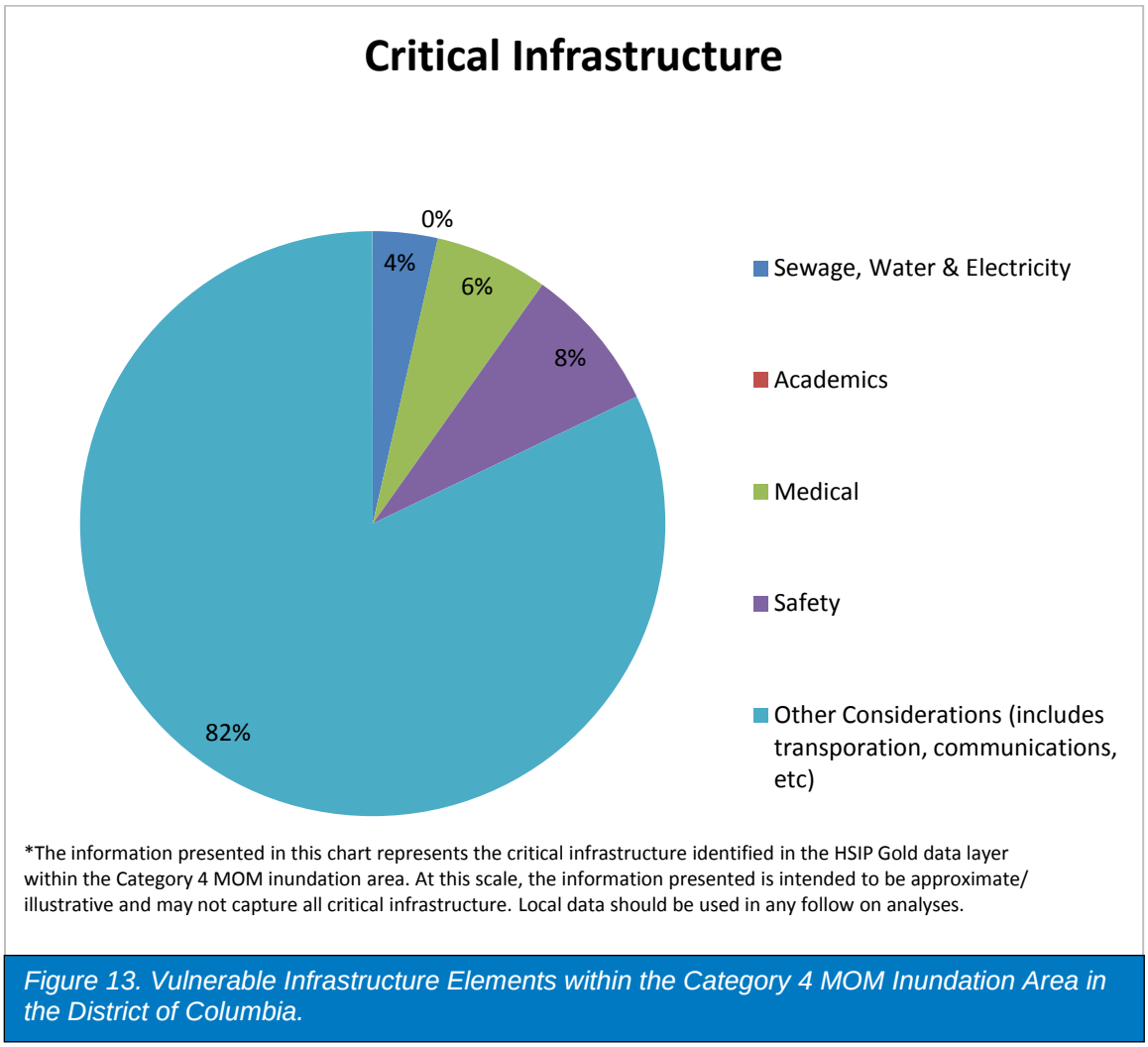

Figure 13. Vulnerable Infrastructure Elements within the Category 4 MOM Inundation Area in the District of Columbia.

Social Vulnerability Index

Figure 14 presents the social vulnerability exposure index for the District of Columbia.

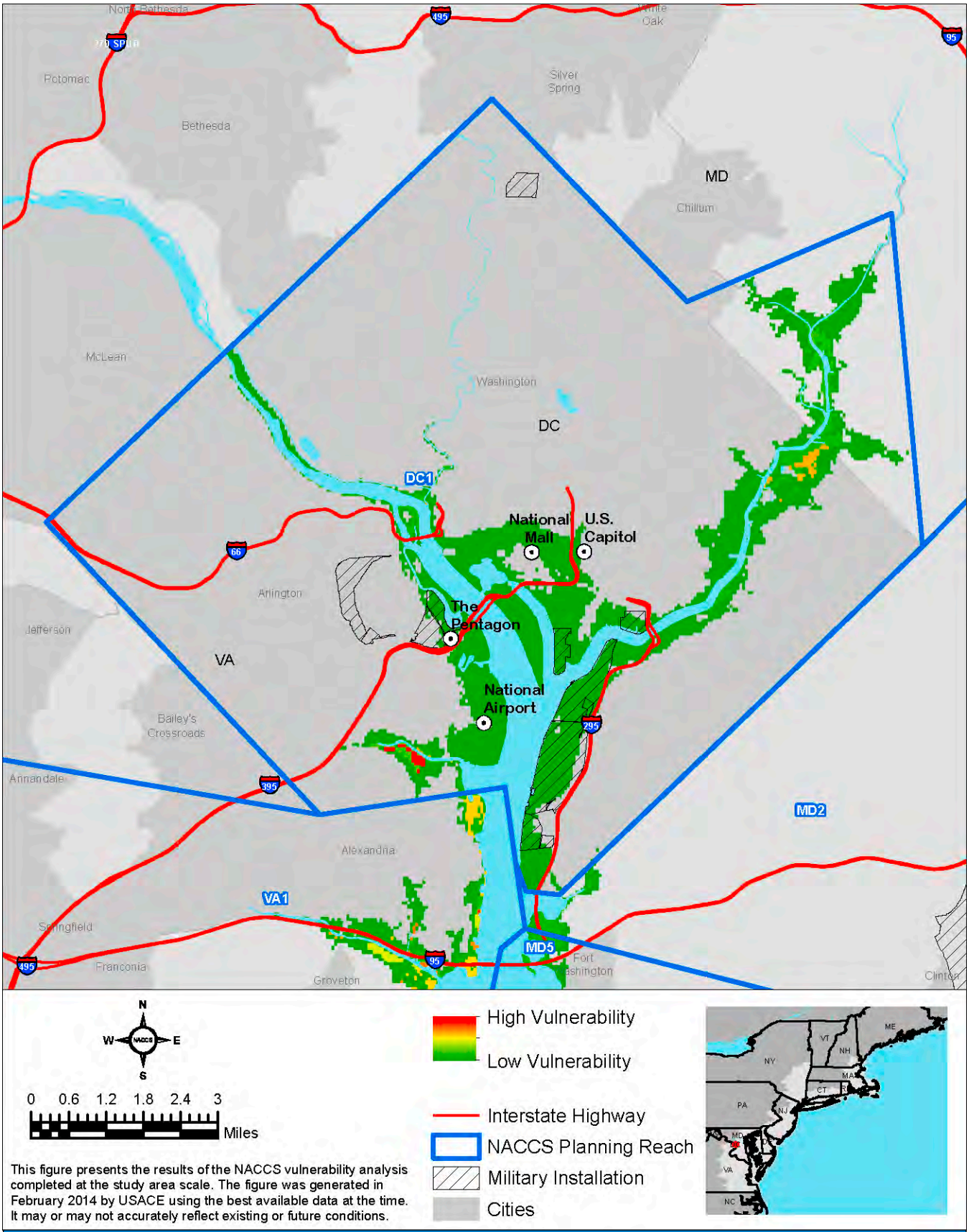

Figure 14. Social Vulnerability Exposure Index for the District of Columbia

Reach: D.C.1

Based on the social vulnerability analysis, eleven areas were identified within this reach as areas with relatively high social vulnerability. These areas were located within census tracts 2012.03 (Alexandria, VA), 68.04, 74.01, 74.06, 74.08, 74.09, 75.03, 2.01, 98.01, 109, and 98.02 (the District of Columbia). All of the census tracts, with the exception of 2012.03, were identified as vulnerable mainly due to a large percent of the population being under the poverty level. Census tract 2012.03 was identified as vulnerable due to a large percent of the population being non-English speakers. And, census tract 98.01 was also identified as vulnerable due to a considerable percent of the population under 5 years old.

Environmental and Cultural Resources Exposure Index

Environmental and cultural resources were also evaluated as they relate to exposure to the Cat 4 maximum inundation. Data from national databases, such as the National Wetlands Inventory and The Nature Conservancy Ecoregional Assessments; data provided from USFWS, including threatened and endangered species habitat and important sites for bird nesting and feeding areas; shoreline types; and historic sites and national monuments, among others were used in this analysis to assess environmental and cultural resource exposure. It should be noted that properties with restricted locations, typically archaeological sites, and certain other properties were omitted from the analysis due to site sensitivity issues.

Figure 15 depicts the environmental and cultural resources exposure index for the District of Columbia. This exposure analysis is intended to capture important habitat, and environmental and cultural resources that would be vulnerable to storm surge, winds, and erosion. It should be noted though, that mapped areas displaying high exposure index scores (shown in red and orange) may not include all critical or significant environmental or cultural resources, as indexed scores are additive; the higher the index score, the greater number of resources present at the site. Impacts and recovery opportunity would vary across areas and depending on the resource affected.

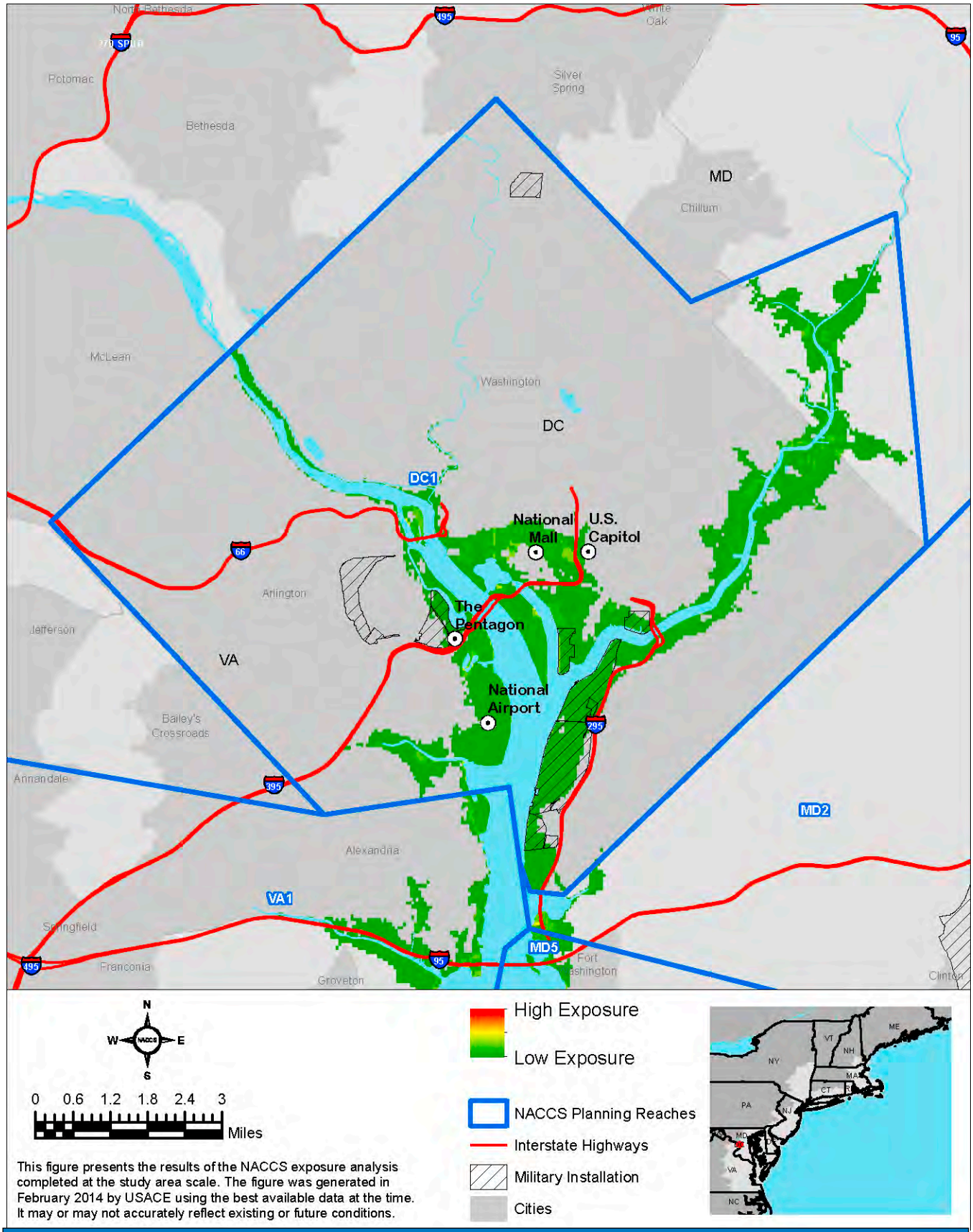

Figure 15. Environmental and Cultural Resources Exposure Index for the District of Columbia

Composite Exposure Index

All three of the exposure indices were summed together to develop one composite index that displays overall exposure. Figure 16 depicts the Composite Exposure Index for the District of Columbia.

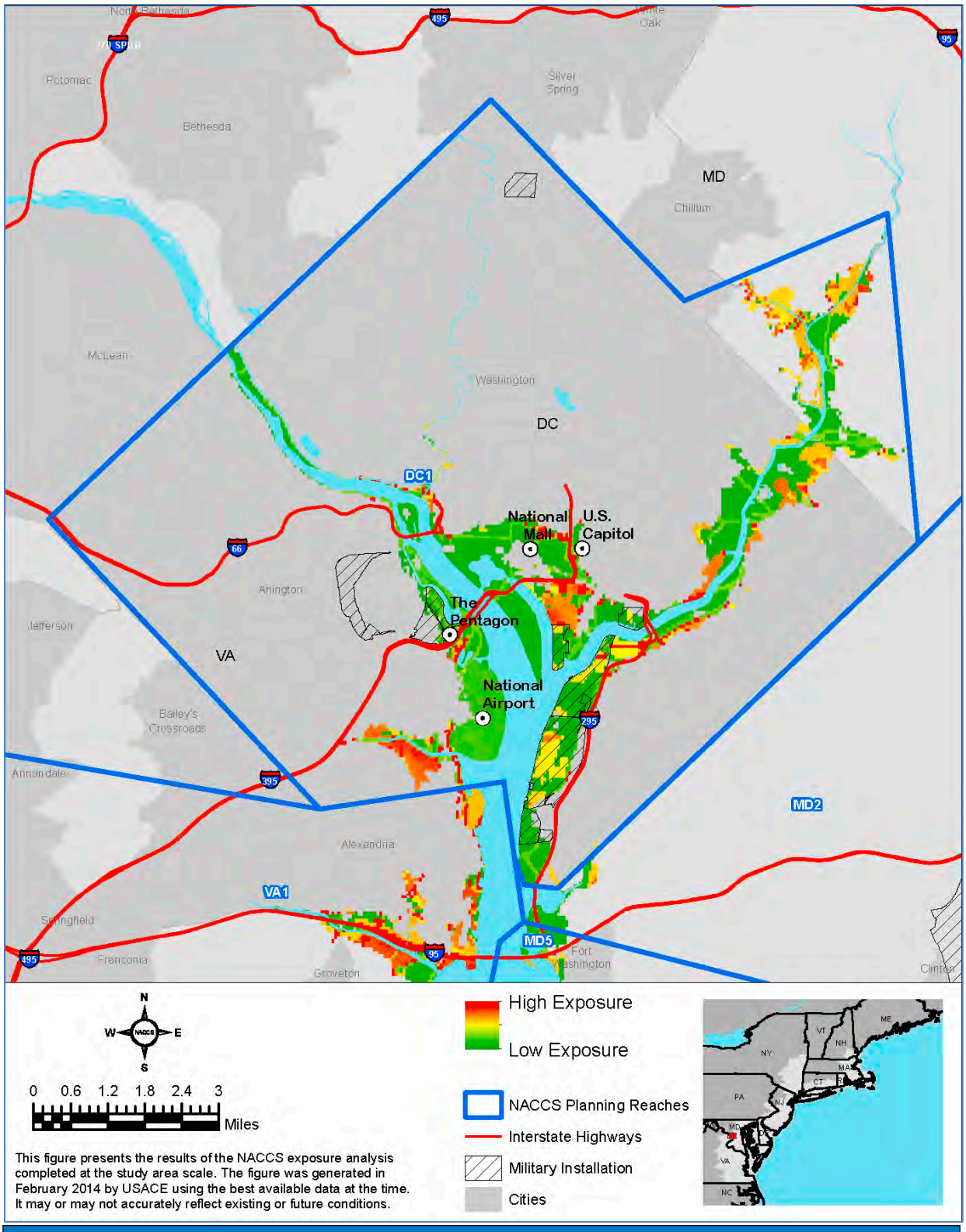

Figure 16. Composite Exposure Index for the District of Columbia

IV.2. NACCS Risk Assessment

Exposure and coastal flood inundation mapping is used to identify the specific areas at risk. Once the exposure to flood peril of any area has been identified, the next step is to better define the flood risk. The Framework defines risk as a function of exposure and probability of occurrence. For each of the floodplain inundation scenarios, Category 4 MOM, 1 percent flood plus three feet, and the 10 percent flood, three bands of inundation were created. The bands correspond with the flooding source to the 10-percent inundation extent, the 10-percent to the 1-percent plus three feet extent, and the 1-percent plus three feet to the CAT4 MOM inundation extent. The 1-percent plus three feet extent was defined as the CAT2 MOM because at the study area scale there were areas that did not include FEMA 1-percent flood mapping. This process was completed for the composite exposure assessment in order to generate the NACCS risk assessment. The data was symbolized to present areas of relatively higher risk, which based on the analysis, corresponds with the three bands that were used in the analysis. Subsequent analyses could incorporate additional bands, which would present additional variation in the range of values symbolized in the figure. Figure 17 depicts the results of the risk assessment using the composite exposure data for the District of Columbia.

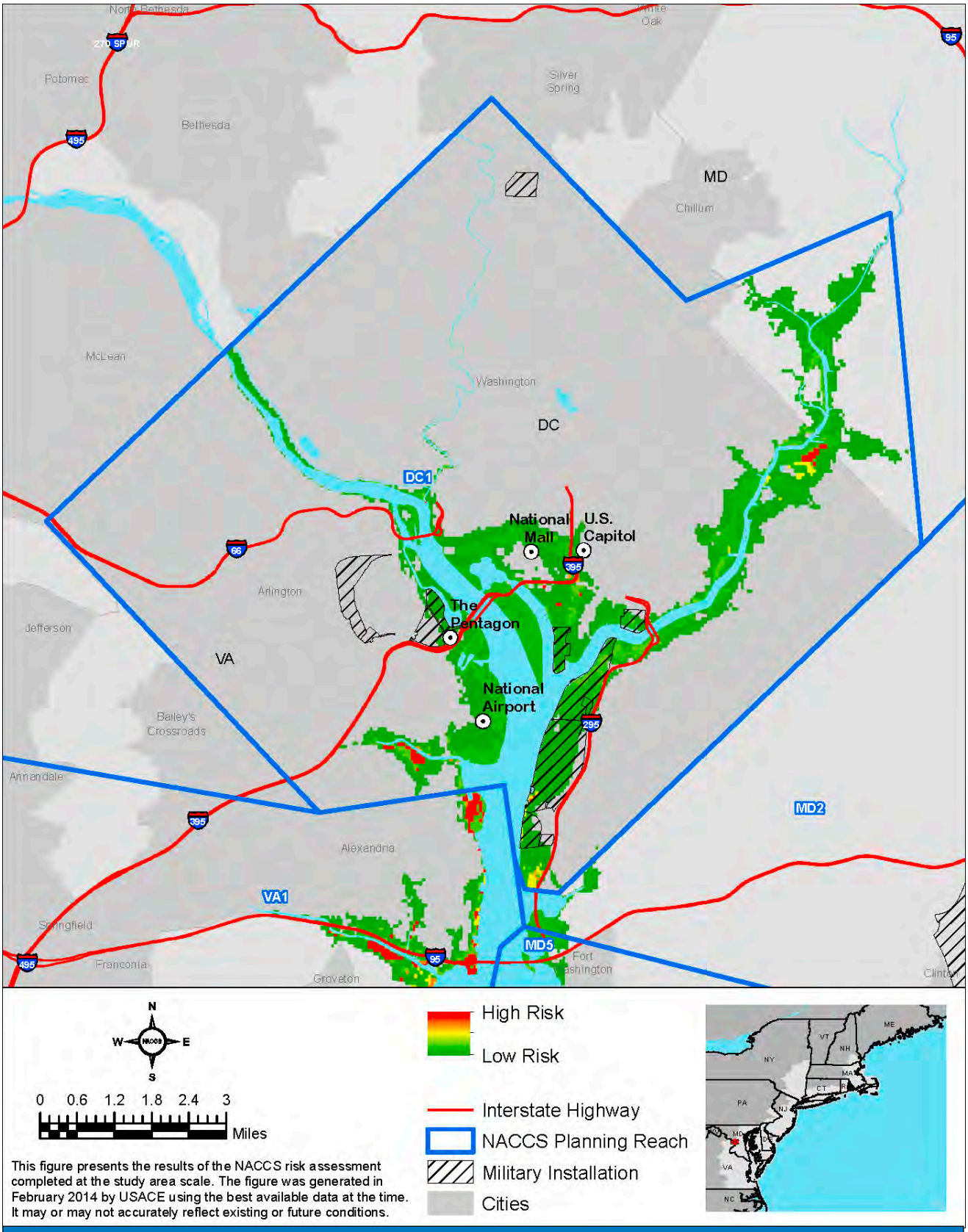

Figure 17. Risk Assessment for the District of Columbia

IV.3. NACCS Risk Areas Identification

Applying the risk assessment to the District of Columbia identified six areas for further analysis. These locations are identified in Figure 18 and are described in more detail below.

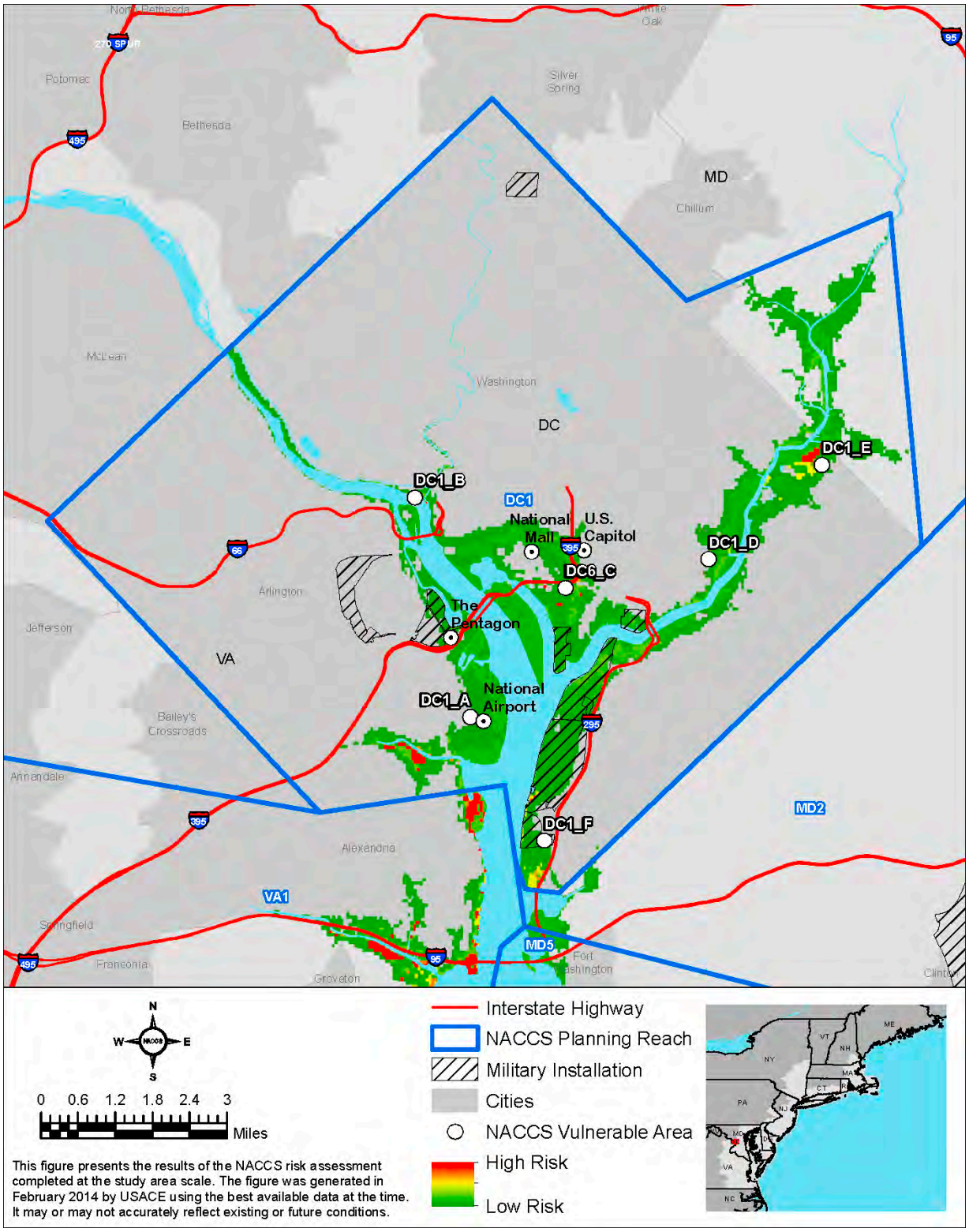

Figure 18. D.C.1 Reach Risk Areas

Reach: D.C.1

The shoreline along the Potomac and Anacostia Rivers of the District of Columbia and Arlington County, Virginia constitute the reach D.C.1. The shoreline in this area is classified as mostly urban with some vegetated banks along the Anacostia River. Six areas of relative higher risk were identified in this reach and are listed below. Area D.C.1_C: National Mall/Federal Triangle and Vicinity was selected, in coordination with the District, to be used for the illustrative example of replicating the framework.

D.C.1_A: Reagan National Airport and Vicinity

Risk area D.C.1_A is located southwest of the District of Columbia and includes the Reagan National Airport. The area is surrounded by the Potomac River and is intersected by the Four Mile Run tributary which lies within Category 2 MOM. The closest counties surrounding the vulnerable area are Arlington County which is located northwest of the vulnerable area and Alexandria County located southwest of the vulnerable area. The area was flagged due to its relatively higher level of infrastructure and social vulnerability.

D.C.1_B: East of Georgetown

Risk area D.C.1_B is located in the northwest corridor of the District of Columbia. At least half of the risk area is located on the Potomac River and is intersected by the Rock Creek tributary. The area was flagged for higher risk due to the infrastructure present and because at least 90 percent of the vulnerable area lies within the Category 2 MOM.

D.C.1_C: National Mall/Federal Triangle and Vicinity

Risk area D.C.1_C is located in the southern portion of the District of Columbia. At least half of the risk area lies within the Category 2 MOM. The area was flagged due to its high level of infrastructure and social vulnerability. Within this area are numerous bridges, tunnels, fire stations, law enforcement, bus stations, national shelter system facilities, and pharmacies. The West Potomac Park Levee portion of the USACE's Washington, D.C. and Vicinity flood risk management project is located in this area. The 17th Street Closure (part of the Potomac Park Levee) was completed in 2014. It should also be noted that in 2013 Feasibility Plans and Specification were completed to raise the West Potomac Park Levee to its authorized level of 700,000 cubic feet per second. Also within the area are numerous cultural, civic, and historic structures and institutions. This area includes the National Mall, Smithsonian Institution, numerous Federal government office buildings, and District of Columbia offices. The District, in coordination with the National Capital Planning Commission (NCPC) and other Federal agencies, has conducted a study on the Federal Triangle area and the area is considered a high priority for flood risk management efforts.

D.C.1_D: RFK Stadium and Vicinity

Risk area D.C.1_D is located northwest of Route 295 and includes an area northeast of District of Columbia. The area was flagged due to its high level of infrastructure and social vulnerability. At least half the area lies within the Category 2 MOM and is located along the Anacostia River.

D.C.1_E: Northeast D.C.: Kenilworth Area

Risk area D.C.1_E is located in the northeast corridor of the District of Columbia. The area was flagged due to its high level of infrastructure and social vulnerability. The entire area is located within Category 2 MOM and is intersected by Watts Branch Creek and Hickey Run tributaries. The area includes mostly parks and residential areas.

D.C.1_F: Joint Base Anacostia-Bolling and Vicinity

Risk area D.C.1_F is located south of the District of Columbia, and includes the southern portion of Joint Base Anacostia-Bolling and is bisected by Interstate 295. The area was flagged as higher risk due to its elevated level of infrastructure and social vulnerability. Half of the area lies within the Category 2 MOM. Also within the area is the Blue Plains Advanced Wastewater Treatment Plant, the largest advanced wastewater treatment plant in the world, which treats wastewater from more than two million Washington metro area customers. The Washington, D.C. and Vicinity project also includes the levee system on Joint Base Anacostia-Bolling. This levee is no longer accredited by FEMA due to the lack of maintenance and poor condition of the original floodwall. National critical infrastructure is located at this facility, which is at risk to coastal surge and flooding.

The District of Columbia's Unique Challenges

It is worth noting that the District of Columbia and adjacent coastal communities like the City of Alexandria and Arlington County face challenges beyond coastal flooding and storm surge. The District of Columbia and adjacent communities are situated along both the Potomac and Anacostia Rivers and their tributaries. Many of these areas are low-lying, highly developed, and very susceptible to coastal flooding, as well as fluvial and stormwater flooding. Future effects of sea level change, which range from 2-4 feet by 2100 based on NACCS and NASA forecasts, could exacerbate the already complex flooding issues the District faces. Current stormwater infrastructure will not be able to handle the amounts of water that could flow into the city. As described in the FAA that follows this chapter, the Washington, D.C. Metropolitan Area has sustained many significant flood events over the past century and will continue to be vulnerable in future from the effects of sea level change and climate change. Although it is not assessed in this report, the Washington, D.C. Metropolitan Area is a prime example of why there is still a need to consider how stormwater and fluvial flood components of watersheds interact with storm surge and forecasted sea level change scenarios.

The District of Columbia also faces unique risks due to the number of nationally-significant government functions located within the District, and particularly the Federal Triangle area. National landmarks of significance include the U.S. Capitol, National Mall, National Airport, and Pentagon, to name a few. According to the District of Columbia Inventory of Historic Sites 2009 Inventory, there are more than 700 designated Historic Sites encompassing nearly 25,000 properties in the District. More information on the cultural resources of significance in the District of Columbia can be found in the Environmental and Cultural Resources Conditions Report.

The District has already taken many steps to mitigate flood risk to the city. The District has a formal Silver Jackets team, which is discussed under Agency Coordination and Collaboration, and also has a group through the NCPC dedicated to climate change, called the Monumental Core Climate Change Adaptation Working Group. The District is provided some protection to riverine flooding from the Washington, D.C. & Vicinity project, and specifically the West Potomac Park Levee, which has the authorization already in place to be raised possibly in the future to address changes in risk due to

forecasted sea level change. The NCPC and other Federal and District agencies conducted a stormwater drainage study for the Federal Triangle area that was completed in 2011. A summary of the study can be found in the Agency Coordination and Collaboration section. The NCPC also conducted a Federal Triangle Floodproofing Seminar in the fall of 2011. Other efforts include the Washington Metropolitan Area Transit Authorities work to evaluate Metro access points to ensure critical infrastructure is floodproofed to promote resilience, and D.C. Water's flood risk mitigation report on the Blue Plains Wastewater Treatment Plant. The report was also completed in 2011 and was accompanied by extensive surveying and mapping. Additional information about the District's efforts can be found in the FAA appended to this chapter.

The District Department of the Environment (DDOE) is the floodplain administrator and the State National Flood Insurance Program (NFIP) coordinating agency for the District of Columbia. DDOE has been actively participating and coordinating with other District and federal agencies in many working groups, including the Federal Triangle Stormwater Drainage Study, to address flooding risk and climate adaptation planning. DDOE has a strong relationship with those agencies not only in the regulatory effort, but also in promoting and implementing flood risk mitigation in the District. DDOE played a major supporting and advisory role in addressing flood threats during recent flood emergency events, such as Hurricane Irene and Hurricane Sandy.

V. Coastal Storm Risk Management Strategies and Measures

V.1. Measures by Shoreline Type

The structural and NNBF measures were further categorized based on shoreline type for where they are best suited according to typical application opportunities and constraints and best professional judgment (Dronkers et. al, 1990; USACE 2014). Shoreline types were derived from the NOAA Environmental Sensitivity Index Shoreline Classification dataset (NOAA, n.d.). Figure 19 presents the location and extent of each shoreline type in the District of Columbia. Table 3 summarizes the measures' applicability based on shoreline type. It is assumed non-structural measures could be considered in all geographic contexts, subject to further evaluation at a smaller scale.

Additionally, a conceptual analysis of geographic applicability of NNBF measures presented in Table 4 was completed, including beach restoration, beach restoration with breakwaters/groins, living shorelines, reefs, submerged aquatic vegetation, and wetlands. The geographical information systems (GIS) operations that were used for the NNBF screening analysis are described in the Use of Natural and Nature-Based Features for Coastal Resilience Report (Bridges et. al., 2015). In addition to the NOAA Environmental Sensitivity Index Shoreline Classification dataset (NOAA n.d.), other criteria considered were habitat type, impervious cover, water quality, and topography/bathymetry. Consistent with the theme of the Framework, further evaluation of the results would be required at a smaller scale and with finer data sets. Figure 20 presents the location and extent of NNBF measures based on additional screening criteria. Additional information associated with the methodology and results of the analysis is presented in the Planning Analyses Appendix

Table 4 displays a summary of shoreline type by length by reach for the State of District of Columbia. The lengths of shoreline type on an individual reach basis are provided in Figure 21.

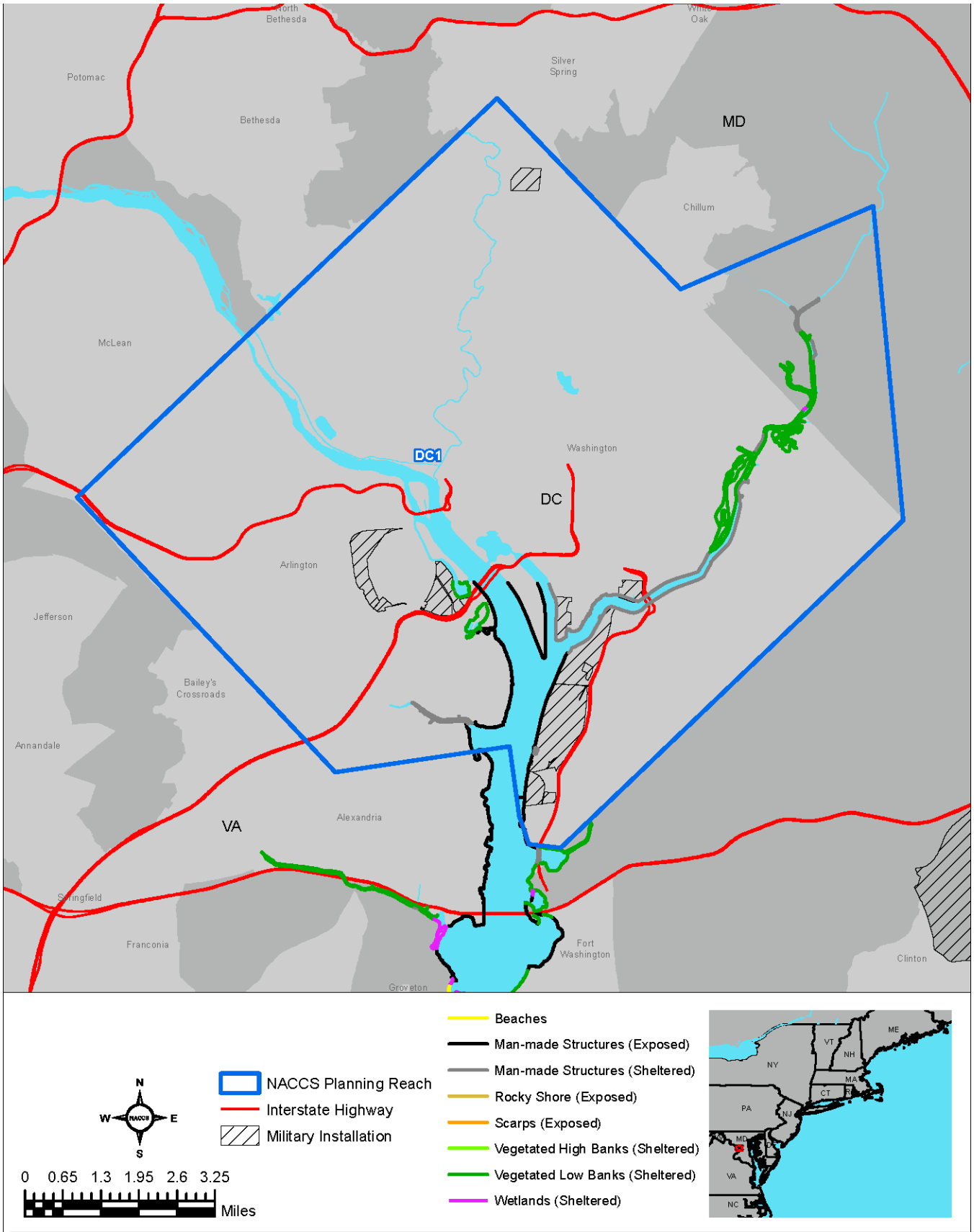

Figure 19. Shoreline Types for the District of Columbia

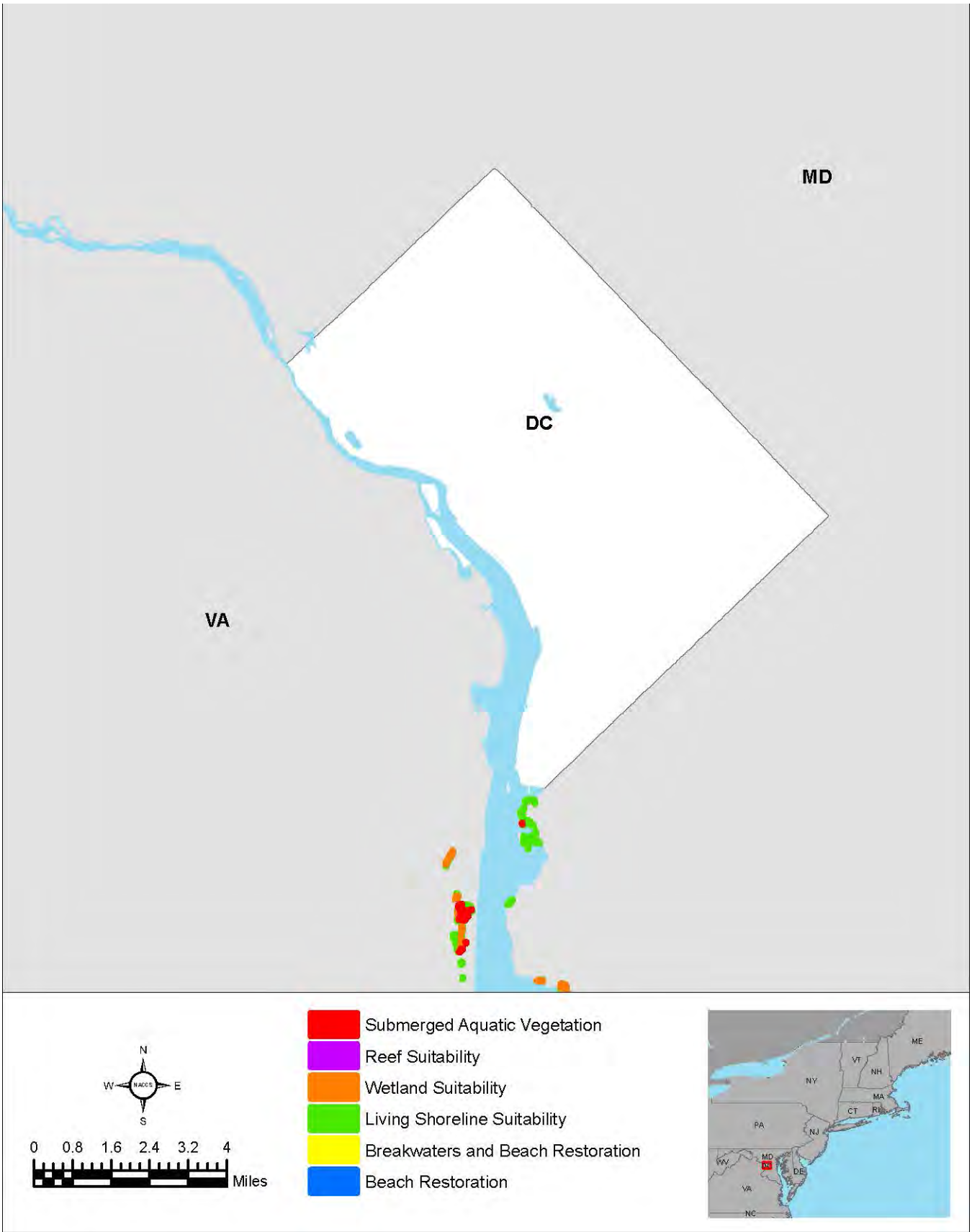

Figure 20. NNBF Measures Screening for the District of Columbia

Table 3. Structural and NNBF Measure Applicability by NOAA-ESI Shoreline Type

Measures	Rocky shores (Exposed)	Rocky shores (Sheltered)	Beaches (Exposed)	Manmade structures (Exposed)	Manmade structures (Sheltered)	Scarps (Exposed)	Scarps (Sheltered)	Vegetated low banks (Sheltered)	Wetlands/Marshes/ Swamps (Sheltered)
Structural									
Storm Surge Barrier[1]									
Barrier Island Preservation and Beach Restoration (beach fill, dune creation)[2]			x						
Beach Restoration and Breakwaters[2]			x						
Beach Restoration and Groins[2]			x						
Shoreline Stabilization						x	x	X	
Deployable Floodwalls					x				
Floodwalls and Levees		x			x			X	
Drainage Improvements	x	x	x	x	x	x	x	X	x
Natural and Nature-Based Features									
Living Shoreline						x	x	X	x
Wetlands							x		x
Reefs	x	x				x			x
Submerged Aquatic Vegetation[3]									x
Overwash Fans[4]									
Drainage Improvements	x	x	x	x	x	x	x	X	x

[1] *The applicability of storm surge barriers cannot be determined based on shoreline type. It depends on other factors such as coastal geography.*

[2] *Beaches and dunes are also considered Natural and Nature-Based Features*

[3] *Submerged aquatic vegetation is not associated with any particular shoreline type. Initially assumed to apply to wetland shorelines.*

[4] *Overwash fans may apply to the back side of barrier islands which are not explicitly identified in the NOAA-ESI shoreline database.*

Table 4. Summary of Shoreline Length (feet)				
High Risk Areas	**Manmade Structures (Exposed)**	**Manmade Structures (Sheltered)**	**Vegetated Low Bank (Sheltered)**	**Total**
D.C.1_A	16,536	13,498	1,657	31,691
D.C.1_B				No shoreline data available
D.C.1_C		783		783
D.C.1_D		8,129	6,602	14,731
D.C.1_E			9,427	9,427
D.C.1_F	11,656	3,722	1,552	16,930
Total	**28,494**	**26,123**	**19,239**	**73,865**

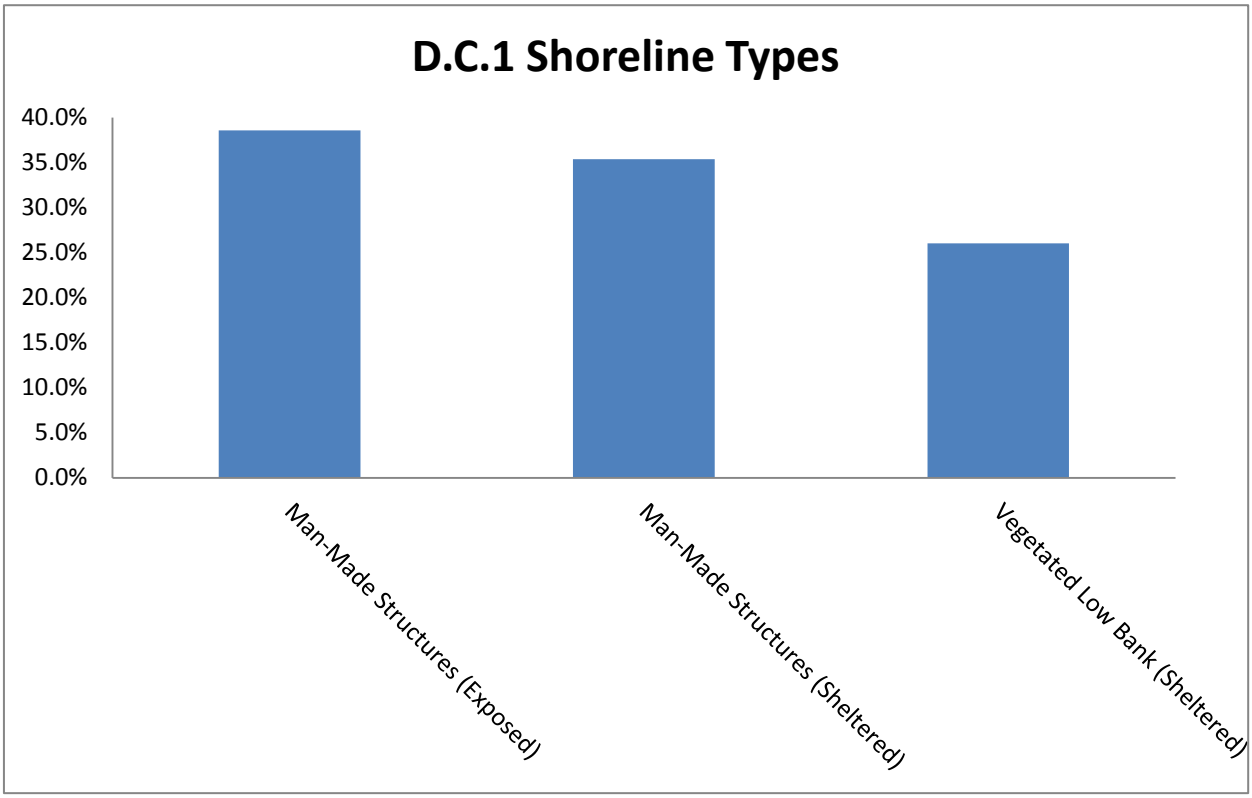

Figure 21. D.C.1 Shoreline Types

V.2. Parametric Costs Considerations

Conceptual design and parametric cost estimates were developed for the various CSRM measures were representative, concept designs were developed for each measure together with quantities and parametric costs (typically per linear foot of shoreline) based on a combination of available cost information for existing projects and representative unit costs for all construction items (e.g., excavation, fill, rock, plantings) based on historical observations. Additional information on the various measures is included in Appendix C – Planning Analyses.

VI. Tier 1 Assessment Results

Table 5 presents the results of the District of Columbia risk areas and the comparison of management measures. The reference to the level of risk reduction in the table relates to the flooding attribute of the storm damage reduction and resilience storm damage reduction function presented in Table 1 of the overview section. The level of risk reduction (High or Low) is based on a 1 percent chance flood plus three feet (High) or 10 percent chance flood (Low) level. For each shoreline type within the risk area presented in Table 5, the numerical sequence of the measures for each shoreline type within the respective risk area relates to the change in risk and the parametric unit cost estimates for the applicable measures. Nonstructural measures could be considered in all geographic contexts, subject to further evaluation at a smaller scale. As a result, Table 5 only presents the change in risk and the parametric unit cost estimates for structural measures, including NNBF.

Table 5. Comparison of Measures within NACCS Risk Areas in the District of Columbia

Risk Areas	Shoreline	RR	Beach Restoration with Dunes	Beach Restoration with Breakwaters	Beach Restoration with Groins	Shoreline Stabilization	Deployable Floodwall	Floodwall	Levee	Living Shoreline	Wetlands	Reefs	SAV Restoration
D.C.1_A	Manmade Structures (Exposed)												
D.C.1_C	Manmade Structures (Sheltered)	High					3	2	1				
D.C.1_D	Manmade Structures (Sheltered)	High					3	2	1				
D.C.1_D	Vegetated Low Banks (Sheltered)	High						2	1				
D.C.1_D	Vegetated Low Banks (Sheltered)	Low				2				1			
D.C.1_E	Vegetated Low Banks (Sheltered)	High						2	1				
D.C.1_E	Vegetated Low Banks (Sheltered)	Low				2				1			
D.C.1_F	Manmade Structures (Exposed)												
D.C.1_F	Manmade Structures (Sheltered)						3	2	1				
D.C.1_F	Vegetated Low Banks (Sheltered)	High						2	1				
D.C.1_F	Vegetated Low Banks (Sheltered)	Low				2				1			

VII. Tier 2 Assessment of Conceptual Measures

The NACCS Tier 1 assessment for the District of Columbia identified areas of risk to the flood hazard, and various management measures applicable to the shorelines within the risk areas by using the aggregated measure matrices presented in Table 4 of the State Appendix Overview. To apply the principles associated with the NACCS CSRM Framework, the NACCS Tier 2 analysis considers the three strategies to address coastal flood risk, including: 1) avoid, 2) accommodate, and 3) preserve.

As part of the Tier 2 assessment for the District of Columbia, and in coordination with the D.C. Silver Jackets Team including DDOE and NCPC representatives, the Federal Triangle and Vicinity was selected as an example area to further evaluate flood risk as part of the Framework. Defined as Risk Area D.C.1-C, the Federal Triangle and Vicinity includes portions of northwest and southwest Washington, D.C. The area includes the East Potomac Golf Course, Fort McNair, and Nationals Park to the south, many significant museums, monuments, and Federal agency offices including the National Archives from the south to the northwest corridor, as well as West Potomac Park just south of Route 66. This area was selected for additional analysis due to the risk to infrastructure of National significance, as well as the overall need for enhanced coastal resilience to surrounding facilities, Federal agencies, and structures of historic significance. Also important to note is that this area is at risk to inundation from storm surge, the Potomac and Anacostia Rivers, and standing water from high rainfall events. Although the interaction between fluvial and coastal flooding is not addressed in the NACCS, the District of Columbia is a prime example of why these interactions need to be better understood in future studies.

The identification of measures are based upon several natural and physical characteristics including shoreline type (Table 4) land use/development, topography, sea level change inundation, extreme water levels and existing CSRM projects and aerial photography. As demonstrated in Table 7, this area of relatively higher risk was subdivided into three sub-regions. Each sub-region offers a unique set of CSRM measures which may act as an example for similar geomorphic settings in the District of Columbia by state and local agencies, and non-profit organizations.

Table 6 presents the results of the Tier 2 analysis. The Tier 2 analysis evaluates the relative costs associated with management measures included in the three primary strategies for CSRM for this particular area. For each of the areas identified, management measures were selected based on general knowledge and data available, including shoreline type, topography, extent of development from online aerial photography, and flood inundation mapping. The risk reduction associated with the management measures corresponds to the qualitative evaluation of measures presented in Table 5, such as high for a 1 percent flood plus 3 feet and low for a 10 percent flood. The cost index was derived from parametric unit cost estimates divided by the highest parametric unit cost of all the management measure in the area. The higher the cost index the greater the relative costs. This enables the users to compare the measures associated with the risk management strategy in order to evaluate affordability and ultimately leading to an acceptable level of risk tolerance. The combination of measures leading to a selection of a plan as described in the NACCS Framework would further quantify risk reduction, and evaluate and compare the change in the risk based on the total cost of the plan. This would be completed at a smaller scale, Tier 3, which would be able to incorporate refined exposure and vulnerability, and evaluation of other risk management measures, as well as refined costs.

Table 6. Tier 2 Example Area Relative Cost/Management Measure Matrix for the DC1

				Risk Management Strategies (DC)									
				Preserve				***Accommodate***				***Avoid***	
				Structural Measures (100yr plus 3')		Regional/ Gates (500yr)		NNBF (10yr)		Non-Structural (10yr)		Acquisition (10-year floodplain)	
Revised Polygon	Description	Existing Project - 2018 Post Sandy	Estimated LOP	Description	Cost Index	Description	Cost Index	Description	Cost Index	Description	Cost Index	Description	Cost Index
1	Washington DC & Vicinity Levee area; urban area	Washington DC & Vicinity Levee (for riverine flooding)	100 year	Raise levee to 700,000 cfs or the ~ 500 year event (as authorized)	1.00	N/A	N/A	N/A	N/A	No structures within 10yr floodplain	N/A	N/A	N/A
2	National Mall and Federal Triangle area; urban area along Washington Channel	None	N/A	Floodwall and Levee	1.00	N/A	N/A	N/A	N/A	No structures within 10yr floodplain	N/A	N/A	N/A
3	Area from 66 to south end of East Potomac Park (along the Washington channel); open space	None	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The first sub-region includes the area protected by the West Potomac Park Levee. Possible measures identified for this sub-region include structural measures, including raising the existing levee system to its authorized level of protection. It should also be considered whether the authorized level of protection is sufficient, which could be assessed in a future study at a more refined scale. Nonstructural measures such as floodproofing are also plausible alternatives and could be implemented in addition to structural solutions for added resilience. The second sub-region includes the National Mall and Federal Triangle area, also including the shoreline along the Washington Channel. Structural alternatives include floodwalls or levees, and nonstructural measures such as floodproofing, drainage improvements, and an early warning system are best suited for the area. Drainage improvements and an early warning system are two alternatives that were considered in the 2011 Federal Triangle Stormwater Drainage Study, which is summarized later in this chapter. The final sub-region includes the area from Route 66 to the south end of East Potomac Park, along the Washington Channel. NNBF such as a living shoreline or wetlands are plausible alternatives for this area. However, the shoreline is currently bulkhead so NNBF measures were not considered as part of the Tier 2 analysis.

VIII. Focus Area Analysis

One FAA has been developed for the District of Columbia, titled the Middle Potomac – Washington, D.C. and Metropolitan Area FAA Report. The purpose of the FAA is to determine if there is an interest in conducting further study to identify structural, non-structural, NNBF, and policy/programmatic CSRM strategies and opportunities. The complete FAA is provided in Attachment A to this state chapter.

IX. Agency Coordination and Collaboration

IX.1. Coordination

As part of PL 113-2, Federal agencies received appropriations for various purposes within the agencies' mission areas in response to Hurricane Sandy. As part of the NACCS authorizing language, the NACCS was conducted in coordination with other Federal agencies and state, local, and tribal officials to ensure consistency with other plans to be developed, as appropriate. Extensive collaboration occurred as part of the NACCS, which is presented in the Agency Coordination and Collaboration Report.

Interagency points of contact and subject matter experts were asked in early 2013 to assist in preparing the scope for the NACCS and to be engaged in data gathering and development of analyses as part of the NACCS. This coordination complements the NACCS website located at http://www.nad.usace.army.mil/CompStudy.aspx and webinars for several coastal resilience topics. Several letters to the DDOE, commencing in mid-2013, requested feedback with respect to the preliminary problem identification; the post-Sandy "Most-Likely Future Conditions;" vulnerability mapping; and problems, needs, and opportunities for future planning initiatives. The DDOE also conducted a review in April 2014 and in June 2014 of previous drafts of this District of Columbia Chapter.

As part of coordination of the relatively higher risk areas described in Section IV, the DDOE provided feedback related to risk area identification, focusing on the Federal Triangle, Bloomingdale neighborhood, Joint Base Anacostia-Bolling, and the Blue Plains Wastewater Treatment Plant.

Coordination for the FAA also identified several areas of concern with respect to coastal storm damage, sea level change, and more specifically, fluvial flooding. Additional areas of concern beyond DDOE's initial feedback included the District's metro system, D.C. Water facilities, the National Harbor area, as well as Cameron Run in Fairfax County, VA, the City of Alexandria, and Arlington County, VA.

A visioning meeting conducted by the USACE Baltimore District was held at the NCPC in the District of Columbia on Monday, February 10, 2014. Attendees included representatives from the D.C. Silver Jackets team and the District's Monumental Core Climate Change Adaptation Working Group. Both groups include representatives from Federal and District agencies.

The meeting was kicked off with a presentation on the NACCS, followed by a presentation on the NACCS sea level change analysis. After the presentations, the group split up to discuss the primary focus of the meeting, which was sea level change and how it could impact the various agencies operating within the District. The full visioning session report for the District of Columbia is included in Attachment 7 to the NACCS Agency Coordination and Collaboration Report.

The D.C. Silver Jackets team (formerly the D.C. Flood Risk Management team) has been updated and coordinated with frequently throughout the NACCS. The D.C. Silver Jackets team meets bi-monthly and is comprised of over 20 Federal, District, and regional agencies. The group has organized four task groups to address the following focus areas and priorities:

(1) Potomac Park Levee/17th Street Closure Certification and Accreditation;

(2) Flood Inundation Mapping Tool for the Potomac and Anacostia Rivers;

(3) Flood Emergency Planning; and

(4) Flood Preparedness Communication.

Frequent coordination with the D.C. Silver Jackets team helped guide and inform the problems, needs, and opportunities presented in the District's chapter.

In a letter dated May, 2014 (Attachment B of this state chapter) the District Department of the Environment (DDOE) stated the risks that the District faces due to sea level change and climate change, which will increase riverine and interior flooding in already vulnerable areas. The letter outlines specific problems such as the Bloomindale and LeDroit Park neighborhoods, as well as the National Mall, the monumental core, and downtown. The letter also states that no single agency has all of the solutions and emphasizes the need for enhanced coordination and more holistic approaches to flood risk management.

IX.2. Related Activities, Projects, and Grants

Figure 22 presents proposed projects (including DOI grant projects that were not selected to receive grant funding because those that were not selected to receive grant funding represent an opportunity to potentially receive funding in the future) and other ongoing Federal actions using PL 113-2 funding. Additional information regarding Federal, and NGO projects and plans applicable to the entire NACCS Study Area are discussed in Appendix D: State and District of Columbia Analyses, while additional information regarding the alignment of interagency plans and strategies is discussed in the Agency Collaboration and Coordination Report.

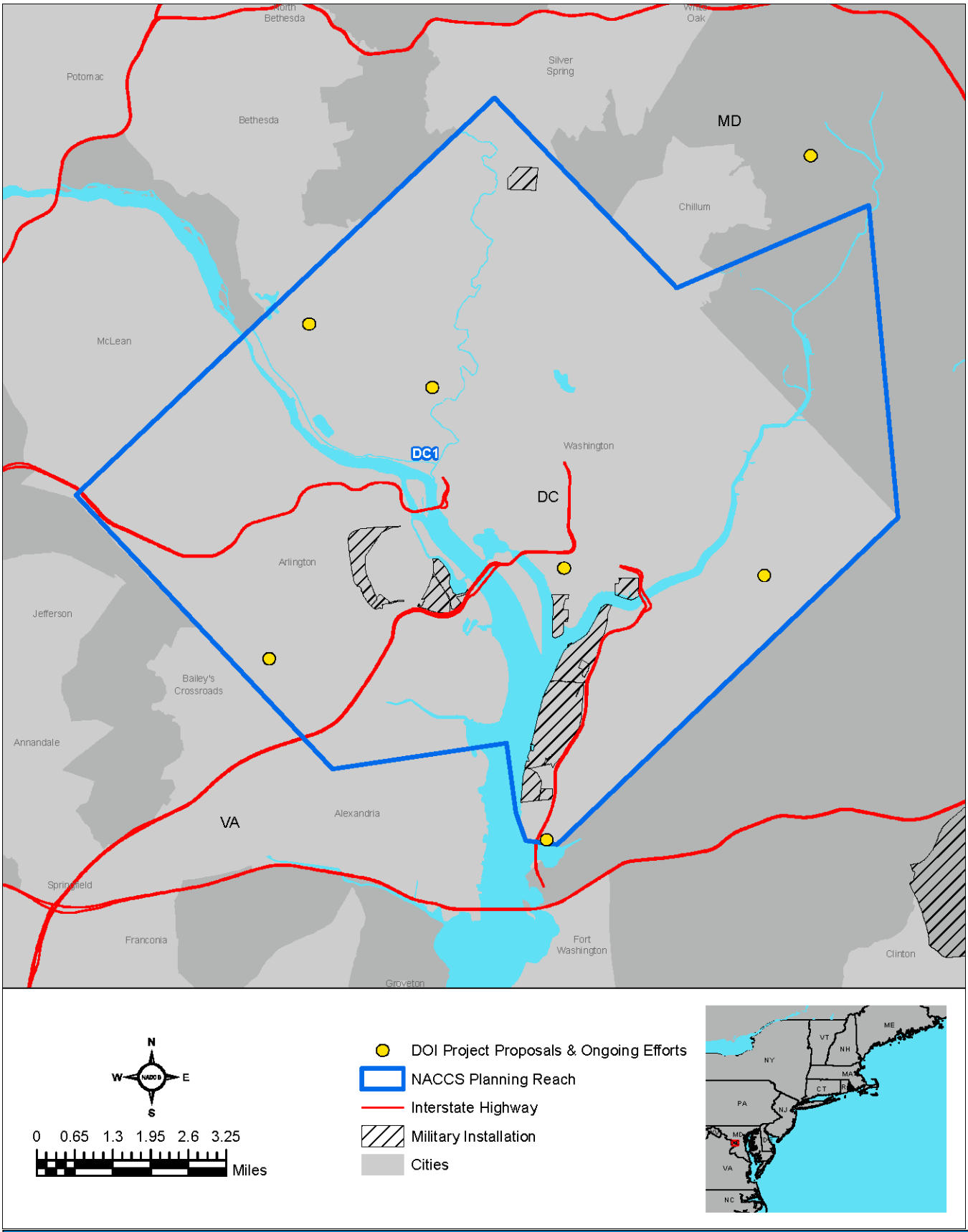

Figure 22. DOI Project Proposal Locations in the District of Columbia

IX.3. Sources of Information

A synopsis of two major studies conducted for the Federal Triangle and the Bloomingdale neighborhood are included in the following table.

Table 7. Information Resource

Resource	Source/Reference	Key Findings Synopsis
Mayor's Task Force Report on the Prevention of Flooding in Bloomingdale and LeDroit Park	http://oca.dc.gov/node/415132	As mandated by the Mayor's Task Force on the Prevention of Flooding in Bloomingdale and LeDroit Park, this report identifies the causes of surface flooding and sewer backups that occurred in Bloomingdale and LeDroit Park in 2012, and provides recommendations on short, medium, and long term mitigation measures. Seven short term, 9 medium term, and 1 long term measures to mitigate flooding were evaluated. In addition, 6 regulatory topics and 6 storm preparation and response activities were explored. From these, the Task Force developed a list of recommendations that should be implemented over the short, medium and long term to mitigate flooding in this area. The recommendations include: Engineering Components, Regulatory Components, Code Revision Components, and Operation and Maintenance Components. Three major construction projects to update the sewer system are included in the engineering initiatives, which will reduce flooding in this area.
Federal Triangle Stormwater Drainage Study	http://www.ncpc.gov/DocumentDepot/Publications/federal_triangle_stormwater_drainage_study_full.pdf	This study, completed after the volume of water from the June 24 through 26, 2006 rain storm exceeded the capacity of the sewer system in the Federal Triangle area, evaluates potential improvements to the sewer system to reduce the risk of flooding due to interior rains in this area. The study identifies 10 alternatives to prevent flooding in the Federal Triangle, which were then narrowed down to 3 viable options for preventing flooding plus 2 non-standalone options. The 3 viable solutions are: 1) Alternative E, Storage of storm water beneath the National Mall; 2) Alternative F, New Pumping Station serving the National Mall; 3) Alternative G, Sewer Tunnel connected to the Main and O Street Pumping Stations. The 2 solutions that could be used along with another alternative to prevent flooding are: 1) Alternative B, LID Strategies (Green Infrastructure) and 2) Alternative C, Storm Water Storage Upstream of the Federal Triangle Area.

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ATTACHMENT A

Focus Area Analyses Report

ATTACHMENT A

The Middle Potomac – Washington, D.C. and Metropolitan Area Focus Area Report

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List of Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLOMR	Conditional Letter of Map Revision
DCA	Reagan National Airport
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FWOP	Future Without Project
NACCS	North Atlantic Coast Comprehensive Study
NBI	Nature-Based Infrastructure
NCPC	National Capital Planning Commission
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
PL	Public Law
POC	Point of Contact
RSM	Regional Sediment Management
SLOSH	Sea, Lake, and Overland Surges
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1. Study Authority

The focus area analysis presented in this report are being conducted as a part of the North Atlantic Coast Comprehensive Study (NACCS) authorized under the Disaster Relief Appropriations Act of 2013 (Public Law [PL]113-2), Title X, Chapter 4 approved 29 January 2013.

Specific language within PL 113-2 states*, "…as a part of the study, the Secretary shall identify those activities warranting additional analysis by the Corps*." This report identifies coastal storm risk management activities warranting additional analysis that could be pursued in the Middle Potomac - Washington, D.C. and Metropolitan Area. Public Law 84-71 is a plausible method for further investigation.

The Washington, D.C. Metropolitan area has an existing authorization from Congress:

The Potomac River and Tributaries authority is a resolution of the U.S. Senate Committee on Environment and Public Works, dated July 6, 1959; and resolution of the U.S. Senate Committee on Environment and Public Works, dated May 23, 2001.

"That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Potomac River and Tributaries in Maryland, Virginia, and Pennsylvania published in House Document 343, ninety-first Congress, second session, and other pertinent reports, with a view to conducting a study, in cooperation with the States of Maryland and West Virginia, the Commonwealths of Pennsylvania and Virginia, and the District of Columbia, their political subdivisions and agencies and instrumentalities thereof, other Federal agencies and entities, for improvements in the interest of the ecosystem restoration and protection, flood plain management, and other allied purposes for the middle Potomac River watershed."

2. Study Purpose

The purpose of the focus area analysis is to capture and present information regarding the possible cost-shared, future phases of study to provide structural and/or non-structural coastal storm risk management, flood risk management, ecosystem restoration, and other related purposes for the Middle Potomac – Washington, D.C. and Metropolitan study area.

The focus area report will:

- Examine the Middle Potomac - Washington, D.C. and Metropolitan Area to identify problems, needs, and opportunities for improvements relating to coastal storm risk management, flood risk management, and related purposes.
- Identify a non-Federal sponsor(s) willing to cost-share the potential future investigation.

3. Location of Study / Congressional District

The study area encompasses Washington, D.C. and the surrounding metropolitan area along rivers and other waterways that are subject to flooding, storm surge, and damages. The impacts of Hurricane Sandy in the study area were relatively minimal compared to the large-scale destruction experienced from Hurricane Isabel in 2003 and other past storm events.

The study area was defined based upon the predicted storm surge extent from the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model along the Potomac and Anacostia River watersheds.

The study area encompasses those areas located adjacent to the Potomac and Anacostia Rivers, including portions of the following: Washington, D.C.; Montgomery County, MD; Prince George's County, MD; Arlington County, VA; Fairfax County, VA; and Alexandria County, VA. The northern boundary along the Anacostia River is Hyattsville, MD, and the northern boundary along the Potomac River is Little Falls Dam. The southern boundary is at the Potomac River near Fort Washington, MD. The study area covers more than 57 square miles. A map of the study area is included as **Figure 1**.

The study area contains parts of the 4th (Representative Donna Edwards) and 8th (Representative Chris Van Hollen, Jr.) Maryland Congressional Districts and parts of the 8th (Representative James Moran, Jr.) and 10th (Representative Frank Wolf) Virginia Congressional Districts. In addition, Congressional interest in the study area lies with Maryland Senators Barbara Mikulski and Benjamin Cardin, and Virginia Senators Mark Warner and Timothy Kaine. Delegate Eleanor Holmes-Norton represents the District of Columbia in the House of Representatives.

4. Prior Studies and Existing Projects

This focus area report will identify problems and opportunities within the study area as they relate to coastal storm risk management and related purposes. The occurrence of flooding within the study area is well documented, and a number of prior studies and existing projects in the study area were reviewed for relevancy in this report. Types of projects and studies include those related to coastal storm risk management, ecosystem restoration, navigation, and water resource management.

Community resilience is also an increasingly relevant topic included for consideration in projects and studies. The intent of community resilience is to consider past, present, and future exposure to hazards, such as coastal flooding, and to influence and improve the capacity to withstand and recover from adverse situations.

All of these projects and studies illustrate the importance of balancing competing coastal system interests with needs to preserve the surrounding environment. These projects and studies provide useful information as future flood risk management measures are considered for the Middle Potomac – Washington, D.C. and Metropolitan study area.

Table 1 summarizes various studies and projects undertaken by Federal, state, and, local agencies. Sections 4.1 through 4.2 provide brief descriptions of selected studies and projects.

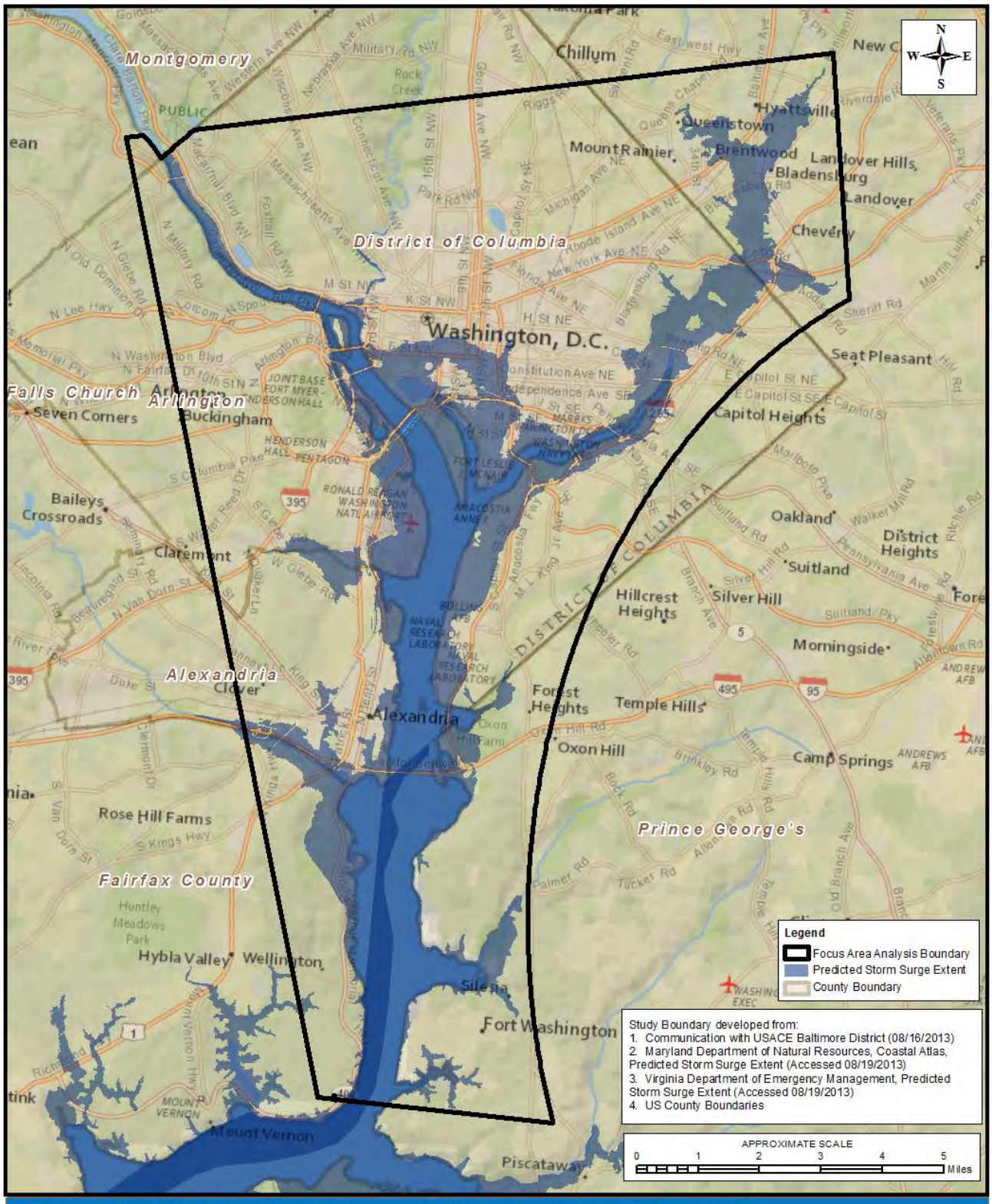

Figure 1. Middle Potomac - Washington, D.C. and Metropolitan Area Focus Area Analysis Boundary

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Table 1. Summary of Prior Studies and Existing Projects

Study / Report	Focus Area	Structural / Non-Structural	Time Frame [Ongoing / Proposed Short Term / Proposed Long Term]	Status	Navigation	Coastal Storm Risk Management	Flood Risk Management	Ecosystem Restoration	Water Resource Management	Community Resilience
Federal										
Hurricane Survey: Washington, D.C. Metropolitan Area	Washington, D.C.	S	LT	1963 Survey of Flood Controls			X			
Washington, D.C. and Vicinity Local Flood Protection (in coordination with National Park Service and Joint Base Anacostia-Bolling)	Washington, D.C. and Vicinity	S	ST	Construction			X			X
Washington Aqueduct	Washington, D.C. and Northern Virginia	S	Ongoing	Capital Improvement Plan					X	X
Potomac Park Levee Project	Washington, D.C.	S	Ongoing	Corrective Action Plan, 2012		X	X			X
Four Mile Run Flood Control Project (Levee System)	Alexandria and Arlington, VA	S	Ongoing	Constructed			X			X
Little Falls Dam Fishway/Fish Passage	Potomac River	S	Ongoing	Constructed				X		X
Middle Potomac River Watershed Assessment	Middle Potomac (MD, PA, VA, WV)	N	LT	Feasibility Study			X	X	X	X
Middle Anacostia Watershed Restoration	Montgomery and Prince George's County, MD	N	LT	Feasibility Study				X		X

Study / Report	Focus Area	Structural / Non-Structural	Time Frame [Ongoing / Proposed Short Term / Proposed Long Term]	Status	Navigation	Coastal Storm Risk Management	Flood Risk Management	Ecosystem Restoration	Water Resource Management	Community Resilience
Kenilworth Marsh, Kingman Marsh, Anacostia River Fringe Wetlands Restoration	Anacostia River	N	Ongoing	Kenilworth completed in 1993; Kingman in 2000; Fringe Wetlands in 2003				X		X
Paint Branch Fish Passage, Prince George's County, MD	Anacostia River	S/N	Ongoing	Construction				X		X
Forest Heights Levee System	Prince George's County, MD	S	Ongoing	Constructed			X			X
Prince George's County Levee, MD - Anacostia Levees Flood Risk Management Project (includes pump stations in Colmar Manor, Brentwood, Bladensburg, Edmonston)	Prince George's County, MD	S	Ongoing	Plan Approval for Prince George's County Levee System Evaluation Reports, 2013			X			X
Final Flood Damage Reduction Analysis for Belle Haven Watershed	Fairfax County, VA	S	LT	Feasibility Study			X			X
Washington Harbor, D.C.	Navigation Maintenance	S	Ongoing	O&M	X					
Potomac and Anacostia Rivers, Collection and Removal of Drift	Navigation Maintenance	S	Ongoing	O&M	X					
FEMA Flood Insurance Study	Washington, D.C.	N	ST	Study			X			X

Study / Report	Focus Area	Structural / Non-Structural	Time Frame [Ongoing / Proposed Short Term / Proposed Long Term]	Status	Navigation	Coastal Storm Risk Management	Flood Risk Management	Ecosystem Restoration	Water Resource Management	Community Resilience
Report of Flooding and Stormwater in Washington, D.C.	Washington, D.C.	N	LT	2008 Study			X			
State/Local										
The Comprehensive Plan of the National Capital	Washington, D.C.	N	LT	2006 Plan			X			X
Interior Drainage Analysis (Study for Potomac Park)	Washington, D.C.	NS	LT	Analysis			X			
Federal Triangle Stormwater Drainage Study	Federal Triangle	N	LT	2011 Study			X			
2011 Maryland State Hazard Mitigation Plan Update	Maryland	S/N	LT	2011 Plan		X	X		X	X
Northern Virginia Hazard Mitigation Plan	Northern Virginia	S/N	LT	Plan			X			X
June 2006 Flood Investigation for Cameron Run	Fairfax County, VA	N	ST	Study			X			
Huntington Flood Drainage Reduction Study	Fairfax County, VA	S	LT	2009 Study			X			X
Huntington Levee	Fairfax County, VA	S	ST	Design			X			
Floodplain Management Plan Progress Report	Fairfax County, VA	S/N	LT	Plan			X			X
Fairfax County Comprehensive Plan	Fairfax County, VA	S/N	LT	Plan					X	X

Study / Report	Focus Area	Structural / Non-Structural	Time Frame [Ongoing / Proposed Short Term / Proposed Long Term]	Status	Navigation	Coastal Storm Risk Management	Flood Risk Management	Ecosystem Restoration	Water Resource Management	Community Resilience
2013 Montgomery County Hazard Mitigation Plan	Montgomery County, VA	S/N	LT	2013 Plan			X			X
Prince George's County City of Laurel Maryland Hazard Mitigation Plan	Prince George's County, MD	N	LT	Plan		X	X			X
Potomac River Waterfront Flood Mitigation Study	Alexandria, VA	S	LT	Study			X			
Alexandria Waterfront Small Area Plan	Alexandria, VA	S	LT	Plan			X	X	X	
Four Mile Run Restoration Project	Alexandria, VA and Arlington County, VA	S/N	LT	Study			X	X	X	
Storm Water Master Plan (1996)	Arlington County, VA	N	LT	Plan			X		X	

4.1 Federal

Flood Risk Management

USACE has several previous and ongoing studies and projects in the study area related to flood risk management, ecosystem restoration, navigation, and water resource management. Selected studies and projects are summarized below.

In 1963, USACE published a document entitled Hurricane Survey: Washington, D.C. Metropolitan Area summarizing existing flood risk management measures and estimated tidal flooding for the Washington, D.C. study area.

The Washington, D.C. and Vicinity Local Flood Protection Project includes the existing levee systems in Potomac Park and along the eastern banks of the Anacostia and Potomac Rivers. The ongoing 17th Street Closure Project is a component of the National Park Service levee system intended to reduce flooding risk of downtown Washington, D.C. from the Potomac River. The existing earthen levees are in need of rehabilitation based on an evaluation by USACE.

The Middle Potomac River Watershed Assessment, which includes portions of the study area along the Potomac River, is a feasibility-level study to identify and evaluate ecosystem and hydraulic restoration, flood risk management, and water resource management. The Middle Anacostia Watershed Restoration Study identifies a specific restoration plan to protect, improve, and restore the watershed which covers portions of Washington, D.C., and Montgomery and Prince George's Counties in Maryland.

The Four Mile Run Restoration Project is a constructed, local flood risk management project in a tributary to the Potomac River in the City of Alexandria and Arlington County, VA. The primary purpose of this project is to manage risk from riverine flooding. The existing project features levees and floodwalls with interior drainage facilities, an improved channel, and the augmentation of several highway and railroad bridges. Following construction of the flood risk management project, a reconnaissance phase and feasibility phase study were conducted to assess the potential restoration of a historical natural structure, enhancement and restoration of aquatic habitat and natural stream channels, and reduction of incidental flood damages while maintaining the authorized level of flood risk management.

The Final Flood Damage Reduction Analysis for Belle Haven Watershed Study was performed to determine potential flood risk management alternatives for a portion of Fairfax County, VA adjacent to the Potomac River. In addition to the Belle Haven Study, USACE conducted two studies at the request of Fairfax County related to a 2006 flood event in the Huntington Subdivision along Cameron Run. Cameron Run is located between the borders of Fairfax County and the City of Alexandria on the western portion of the study area.

- The June 2006 Flood Investigation for Cameron Run Study (2007) was conducted to determine the specific causes of higher than expected flood levels during the June 2006 event. Potential causes included channel sedimentation, construction activities, and land development within the floodplain.

- The Huntington Flood Damage Reduction Study (2009) was conducted in response to the 2006 flood event in the Huntington Subdivision. This study identified and evaluated alternative solutions to manage future flood risk and selected a preferred alternative, which included a levee and pump station. As a result of these two studies, the Huntington Levee Project was implemented and is currently in Phase I of Design. Fairfax County anticipates design and construction of the levee to take approximately 5 to 7 years.

The Report of Flooding and Stormwater in Washington, D.C. was prepared by the National Capital Planning Commission (NCPC) in 2008. This study describes flooding of the Anacostia and Potomac Rivers, existing conditions, and proposed flood risk management measures.

Navigation

USACE provides operation and maintenance (dredging) for several authorized navigation channels in the study area in the Potomac and Anacostia Rivers. Current USACE navigation projects include the Potomac River south of Washington D.C. and the Washington Harbor Federal Navigation Project (a 24-foot deep navigation channel in the Potomac River).

USACE also operates and maintains tide gates in Washington Harbor. The gates provide limited flood risk management; however, they could potentially be overtopped during a major flood event.

The Anacostia Federal Navigation Project is an 8-foot deep authorized navigation channel in the Anacostia River from 15th Street to Bladensburg, MD. Due to funding constraints, these channels are not maintained to the fully authorized depths.

FEMA Studies

The Federal Emergency Management Agency (FEMA) developed a Flood Insurance Study (FIS), revised in 2010, that includes results from a USACE hydrologic and hydraulic analyses for the study area. The FIS delineates flood zones in communities for flood insurance rates, regulatory purposes, and is the summary of the FEMA Flood Insurance Rate Map (FIRM).

4.2 State and Local

Washington, D.C.

The Comprehensive Plan of the National Capital was initially released in 2007 and recently amended in 2011. The Comprehensive Plan is comprised of two parts: the District Elements and the Federal Elements. The District's Comprehensive Plan constitutes the District Elements. The NCPC develops the Federal Elements. The Federal government, represented by the NCPC, shares responsibility for flood risk management with the DC Office of Planning. The plan contains information regarding maps, policies, and socio-economic issues related to physical development of the study area. It also includes a brief conceptual discussion on flooding and addresses the need to maintain seawalls, reduce shoreline erosion, replace undersized culverts, and clear streambeds of debris.The Interior Drainage Analysis Study was conducted for Washington, D.C. in 2008 as part of the Conditional Letter of Map Revision (CLOMR) request related to the West Potomac Park levee improvements included in the previously mentioned Washington, D.C. and Vicinity Local Flood Protection Project. The study was performed to assess and quantify residual flooding that would be incorporated into the FEMA flood insurance rate maps for the area.

The Federal Triangle Stormwater Drainage Study, a joint Federal and state/local study, was conducted in 2011 in response to flooding of several Federal buildings in the Federal Triangle area along Constitution Avenue during a 2006 event. The study includes a hydrologic analysis and identifies

structural alternatives to manage flooding due to interior drainage issues. The three feasible options identified in the study include providing stormwater storage beneath the National Mall, constructing a pumping station, and constructing a new sewer tunnel.

Maryland and Virginia

The study area also includes a small portion of Maryland and northern Virginia, both of which have hazard mitigation plans. A hazard mitigation plan lists planning objectives and future recommendations to reduce impacts of natural hazards to people, property, infrastructure, and critical facilities. Both plans feature comprehensive natural hazard identification, a risk assessment, and vulnerability analysis ranking hazard risks for their entire respective state. The plans also include mitigation strategies to address the identified vulnerabilities. The 2011 Maryland State Hazard Mitigation Plan Update serves as guidance for hazard mitigation for the State of Maryland, a portion of which is included at the northern edges of the study area. The 2006 Northern Virginia Hazard Mitigation Plan includes portions of the study area in Fairfax County, Arlington County, and the City of Alexandria.

Fairfax County, VA

The Fairfax County Comprehensive Plan, amended in 2013, is a broad plan that includes detailed maps, policies, and discussion related to development in Fairfax County, Virginia. The plan divides the county into four areas and reviews existing land use, transportation, housing, heritage resources, and public facilities for each individual area. The plan also discusses environmental concerns and watershed-related information for each area.

Fairfax County also developed a progress report on the implication of flood risk reduction actions specific to the county as proposed in the Northern Virginia Hazard Mitigation Plan. Actions included floodproofing, collecting data related to flood monitoring, improving flood warnings and emergency action plans, assessing and upgrading dams and drainage structures, property buyouts, stormwater management, assisting FEMA in developing flood risk maps, developing and implementing public engagement plans, preventing development in undeveloped floodplains, implementing building and development standards, and supporting flood risk management of floodprone structures. The county summarized its progress on specific actions and discussed proposed actions for long-term goals.

Montgomery and Prince George's Counties, MD

Montgomery County and Prince George's County, Maryland both developed local versions of hazard mitigation plans. Both plans identify hazards for the areas and provide goals, objectives, and actions for hazard mitigation.

The portion of Montgomery County included in this study area is the southernmost section of the county along the Potomac River. The Montgomery County Hazard Mitigation Plan addresses flooding by outlining flood risk management solutions for existing structures, expanding community awareness and engagement, and evaluating and modifying storm drains.

The coastal and riverine flood hazards identified for the portion of the study area in Prince George's County are flooding of the Potomac River in Prince George's County and the Anacostia River in the northeast portion of the study area. The Prince George's County Hazard Mitigation Plan identifies public facilities and infrastructure susceptible to flooding, outlines watershed management actions, National Flood Insurance Program (NFIP) participation, public engagement, flood map modernization, flood warning activities, elevation certification, and residential/commercial floodproofing.

Arlington County, VA

The study area includes portions of Arlington County, Virginia located on the western bank of the Potomac River. Arlington County developed a Storm Water Master Plan in 1996 and is currently updating the plan. The purpose of the plan is to manage damages from flooding, improve runoff quality, preserve and improve stream valleys, and preserve groundwater resources. The 1996 plan does not, however, identify major flooding issues in the county. The plan states that "damages from flood are generally at a low level" and there are "isolated instances of pipe/culvert constrictions and inadequate inlets".

Alexandria, VA

The study area includes portions of the City of Alexandria, Virginia within the storm surge extent along the Potomac River in East Alexandria and along Cameron Run at the southeast boundary of Alexandria.

The Potomac Waterfront Mitigation Study (2010) evaluates and recommends flood risk management measures, such as elevating walkways, floodproofing, constructing floodwalls, updating floodplain zoning, elevating supplies and goods, and improving sandbag programs. The study also identifies potential Federal funding sources to implement the flood risk management measures.

The City of Alexandria has also developed a Waterfront Small Area Plan that outlines its long-term goals for the waterfront along the Potomac River. The plan provides a framework for revitalizing Alexandria's waterfront by expanding and enhancing public spaces, improving access and connectivity, including arts and cultural elements, and ensuring compatible development. The plan includes bulkheads and other improvements to the waterfront for flood risk management.

Four Mile Run Restoration Project is another project proposed by the City of Alexandria, in conjuction with Arlington County and the Northern Virginia Regional Commission. This project includes wetland, stream bank, and riparian habitat restoration along Four Mile Run stream, which drains into the Potomac River.

5. Plan Formulation

Six planning steps in the Water Resource Council's Principles and Guidelines are followed to focus the planning effort and recommend a plan for potential future investigation. The six steps are:

- Identifing problems and opportunities
- Inventorying and forecasting conditions
- Formulating alternative plans
- Evaluating effects of alternative plans
- Comparing alternative plans
- Selecting a recommended plan

The iterations of the planning steps typically differ in the emphasis that is placed on each of the steps.

This focus area report emphasizes identification of problems and opportunities. The sections that follow present the results of the initial iterations of the planning steps conducted during this focus area analysis. This information will be refined in future iterations of the planning process that will be accomplished during future study phases.

5.1 Problems and Opportunities

Flooding is a persistent concern in the Washington, D.C. area, along both the Potomac and Anacostia Rivers and their tributaries. The riverbanks and tidally influenced sections of Washington, D.C. and surrounding areas are low in elevation, highly urbanized, and subject to various types of flooding. Both the Anacostia and Potomac Rivers have been channelized, dredged, and otherwise altered for centuries to accommodate development. Overbank riverine flooding, urban stormwater drainage issues, and impacts from storm surge compounded by seasonal high tides are problems that face this study area. The Anacostia and Potomac Rivers have experienced significant flooding due to storm surge in the past and are vulnerable to the effects of climate change and sea level change in the future. Additionally, both rivers are subject to shoaling that could exacerbate flooding.

The study area includes large portions of Washington, D.C., the seventh-largest metropolitan area in the country, and the largest metropolitan area in the U.S. Census Bureau's Southeast region. As home to the Federal government, this area is critical due to the numerous Federal government office buildings, national landmarks such as the National Mall, and Smithsonian Institution, among many others, that lie within the study area. There is also significant critical infrastructure throughout the entire study area, including but not limited to electrical substations, and the Blue Plains Advanced Wastewater Treatment facility, the largest of its kind, serving more than 2 million customers in the metropolitan area. When wastewater treatment facilities are inundated, partially treated or untreated sewage which is often released, can impact water quality. Similarly, inundation of sites identified through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), otherwise referred to as Superfund sites, or other hazardous waste sites may also severely impact water quality.

Flooding from stormwater drainage and related problems is an issue for some portions of the study area. The Anacostia River has experienced localized stormwater issues during moderate rainfall events as well as flooding during major flood events on the Potomac River. In addition to the two major rivers, the study area includes several buried waterways conveyed through culverts. Several creeks were enclosed in the 19th and 20th centuries, and as a result, the buried creek beds cause hydrologic problems. These conduits can cause damage to building foundations, exacerbate infiltration and exfiltration of sewer pipes, and provide seepage pathways during flood events. Several locations in northern Virginia have also experienced and documented flooding along the Potomac River and its tributaries. Flooding problems documented by local entities include flooding of the Potomac River waterfront in Alexandria, Virginia and flooding in Fairfax County, Virginia along Cameron Run, which drains into the Potomac River.

Between 1889 and 2006, 18 major flooding events were recorded for Washington, D.C. These 18 flood events were attributed to rainfall events and storm surge in both the Potomac and Anacostia River basins. In 2003, Hurricane Isabel caused isolated flooding and wind damage within the study area. The Potomac and Anacostia Rivers exceeded flood stage due to the combination of high tides and storm surge. FEMA estimated the damages in Washington, D.C. from Hurricane Isabel to be $125 million. High waters along the Anacostia River caused flooding of many historic buildings in the Navy Yard, the National Park Service National Capital Park East headquarters, and the U.S. Park Police Anacostia Operations Facility in Washington, D.C. High water levels on the Potomac River caused flooding of several roadways and flood damage to over 50 buildings in Prince George's County, MD. In 2006, a rainfall event flooded a large portion of the Federal Triangle along Constitution Avenue and caused damages to several Federal office buildings. The 2006 event also caused flooding of the Huntington Subdivision in Fairfax County, Virginia along Cameron Run.

As part of this focus area report, plan formulation will include the identification of potential measures to help these vulnerable areas become more resilient to coastal storm and other flood-related damages.

In order to collect data on problems and opportunities in the Middle Potomac – Washington, D.C. and Metropolitan study area, stakeholder meetings and webinars were conducted with USACE, state, and local agencies. **Appendix A** includes a list of points of contact (POCs) invited to participate in meetings and webinars and a list of meeting materials. **Appendix B** includes meeting minutes with a list of participants, and **Appendix C** includes comments received from agencies and stakeholders that were unable to attend meetings and/or webinars or from attendees that provided additional feedback following meetings and webinars. Stakeholder input was incorporated into the development and analysis of potential measures for this focus area analysis. A summary of stakeholder input is included in **Table 2.**

Table 2. Summary of Stakeholder Input - Problems

Problem Area	Problems Identified	Reference
Bloomingdale neighborhood, Washington, D.C.	Stormwater management/drainage issues	D.C. Flood Risk Management Team Meeting August 2013
Federal Triangle, Washington, D.C.	Interior drainage issues behind Potomac Park levee	Report of Flooding and Stormwater in Washington, D.C.; Interior Drainage Study for Potomac Park; Federal Triangle Stormwater Drainage Study; Modifications to Washington, D.C. and Vicinity Flood Protection Project - Final General Design Memorandum 1992 and various addendums.
Metro, Washington, D.C.	Need to protect critical infrastructure in the Federal Triangle and Archives (raise parapet walls)	D.C. Flood Risk Management Team Meeting August 2013; Modifications to Washington, D.C. and Vicinity Flood Protection Project - Final General Design Memorandum 1992 and various addendums.
D.C. Water Facilities, Washington, D.C.	Secondary effects of coastal flooding i.e. critical Infrastructure	D.C. Flood Risk Management Team Meeting August 2013
Blue Plains WWTP, Washington, D.C.	Limited seawall construction and vulnerability to coastal flooding	D.C. Flood Risk Management Team Meeting August 2013
National Harbor Area, Washington, D.C.	New development susceptible to sea level change	D.C. Flood Risk Management Team Meeting, August 2013
Cameron Run, Fairfax County, VA	Inundation from flooding	USACE Focus Area Analysis Kick Off Meeting and D.C. Flood Risk Management Team Recap, August 2013; Huntington Flood Damage Reduction Study, Fairfax County, VA April 2009

Problem Area	Problems Identified	Reference
City of Alexandria and Arlington County, VA	Vulnerability to coastal flooding; inadequate levee height	USACE Focus Area Analysis Kick Off Meeting and D.C. Flood Risk Management Team Recap, August 2013
Arlington County, VA	Multiple: inland/landside drainage, vulnerability, climate adaptation	1996 Storm Water Master Plan and unreleased updates; possible flood risk reduction needed at WWTP and Reagan National Airport

5.2 Objectives

The national or Federal objective of water and related land resources planning is to contribute to National Economic Development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to National Economic Development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

USACE also has a National Ecosystem Restoration (NER) objective in response to legislation and administration policy. This objective is to contribute to the nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amounts and values of habitat.

Projects which produce both NED benefits and NER benefits will result in a "best" recommended plan so that no alternative plan or scale has a higher excess of NED benefits plus NER benefits over total project costs. This plan shall attempt to maximize the sum of net NED and NER benefits, and to offer the best balance between two Federal objectives. Recommendations for multipurpose projects will be based on a combination of NED benefit-cost analysis, and NER benefits analysis, including cost effectiveness and incremental cost analysis.

In addition to Federal water resources planning objectives, the main goals of the NACCS under which this focus area analysis is being conducted, are to:

1) Reduce risk to vulnerable coastal populations.
2) Ensure a sustainable and robust coastal landscape system, considering future sea level change and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure.

Specific objectives for this focus area analysis are to:

1) Manage risk from storm surge.
2) Manage flood risk.
3) Provide adaptive and sustainable solutions for future development that account for future changes such as sea level change, land subsidence and climate change.
4) Maintain or improve ecosystem goods and services provided (social, economic and ecological balance).

5) Incorporate opportunities for nature-based infrastructure, alone and in combination with traditional measures.
6) Maintain economic viability of the working coastline.
7) Improve emergency response and evacuations by improving the transportation systems before and during flood events.
8) Incorporate problems, needs, and opportunities identified by stakeholders to manage flood risk.
9) Manage erosion occurring along the shoreline.
10) Manage risk to National Register of Historic Places and other cultural resources

5.3 Planning Constraints

Planning constraints are both institutional (policy/programmatic, legislative, and funding-related) and physical (such as sensitive ecosystem areas, land use, etc.).

5.3.1 Institutional Constraints

1) Complying with all Federal laws and executive orders, such as the National Environmental Policy Act (NEPA), the Clean Water Act, the Endangered Species Act, and Executive Order 11988.
2) Avoiding an increase in the flood risk to surrounding communities and facilities.
3) Avoiding solutions that cannot be maintained, whether due to expense or complicated technologies, by the non-Federal sponsors.
4) Complying with local land use plans and regulations.
5) Difficulty in funding long-term operation and maintenance costs.
6) Permitting with Federal, state, and local agencies.
7) Acquiring real estate and easements.

5.3.2 Physical Constraints

1) Limited amount of space available for staging and constructing a project within the highly urbanized and densely populated study area .
2) Avoiding additional degradation of water quality, which would put additional stress on aquatic ecosystems.
3) Avoiding impacting or exacerbating existing hazardous, toxic, and radioactive wastes (HTRW) that have been identified within the project area.
4) Minimizing the impact to authorized navigation projects.
5) Minimizing the impact to other projects, protected areas, sensitive wetlands, wildlife management areas, etc.
6) Minimizing effects on cultural resources and historic structures, sites, and features.
7) Loss of streetscape character and potential economic losses from elevation of structures or placement of floodwall/levee.

5.4 Future Without Project Condition

The future without project (FWOP) condition is the most likely condition expected to exist in the future in the absence of proposed projects. The FWOP condition is the baseline against which all project plans are evaluated. FWOP conditions, including sea level change considerations, will be developed along with the no-action alternative during the future phases of study.

5.5 Measures to Address Identified Planning Objectives

This section identifies a broad range of potential solutions (measures) to address the study area objectives. Many of these measures are outlined in "Coastal Risk Reduction and Resilience: Using the Full Array of Measures" (USACE, September 2013). Any of these potential measures will be weighed against a "No-action Plan" in the future phases of study.

5.5.1 Structural Measures

Structural measures are used to control flood waters. Broad-based structural measures identified include:

1) Seawall/Revetment: Seawalls are built parallel to the shoreline with the purpose of reducing overtopping and consequent flooding of areas behind the seawall due to storm surge and waves. Revetments are onshore sloping structures which manage shoreline erosion. Areas immediately seaward of seawalls or revetments may be impacted because of isolation from an inland sediment source.

2) Detached Breakwaters: The primary function of a detached breakwater is to reduce beach erosion by reducing wave heights in the lee of the structure. The reduction in wave heights reduces longshore and cross-shore sediment transport. Detached breakwaters are built nearshore, in shallow water, and generally parallel to the shoreline. They are low-crested structures which decrease wave energy and help promote an even distribution of material along the coastline. Since detached breakwaters can impact the transport of beach material, there can be erosional impacts in downdrift areas. In addition, detached breakwaters, when submerged, can cause a non-visible hazard to boats and swimmers.

3) Berms / Levees: Berms, levees, or dunes can be constructed along the shoreline, tying into high ground or surrounding an area entirely, to reduce risk of storm surge, wave run-up, and erosion to the landward shoreline. These measures have a large footprint, since their stability is partially dependent on a maximum side slope from the top to the toe, and are often composed of earthen materials. Levees or berms also need to be constructed to prevent or control underseepage of floodwaters through the existing soils. They may need to include pumping stations to remove interior stormwater drainage. Roads sometimes need to be ramped to cross these features.

4) Multipurpose Berms/Levees: Berm and levee features require a large footprint to remain stable. However, it is possible to incorporate features in the design of the levees, such as parking areas/garages, commercial or residential development, recreational greenways, etc., to take advantage of the increased elevation.

5) Floodwalls and Bulkheads: Floodwalls or bulkheads can be constructed along the shoreline, tying into high ground or surrounding an area entirely to reduce risk of storm surge, wave run-up, and erosion to the landward shoreline. These measures have smaller footprints than berms and levees but require concrete or steel pilings for stability to withstand force from floodwaters,

including waves. Floodwalls must also be designed to prevent or control underseepage in the existing soils. Floodwalls may need to include pumping stations to remove interior stormwater drainage and often include floodgates to allow for access roads to any waterside property.

6) Flood/Tide Gates: A flood or tide gate can be constructed across a waterway to provide risk reduction from coastal inundation upstream of the gate. Flood and tide gates are constructed with openings to allow for recreational or industrial uses of a tributary to continue and also to allow for some connectivity of the ecosystem. There are several types of flood gates; two types include an Obermeyer Gate and a Steel Gate. The Obermeyer gate lifts a steel gate flap to close the gate, whereas a Steel gate slides horizontally into closing position. Inflatable dams can also be used as a gate, as they can be filled with air or water to inflate and act as a closed gate.

   If the watershed upstream of the flood or tide gate does not have enough natural floodplain storage to hold increases in water level due to precipitation runoff, then either additional storage will need to be created and/or pumping stations will need to be added to remove interior drainage upstream of a flood or tide gate.

7) Portable Floodwalls: Portable floodwalls are a potentially viable measure when complete portability is necessary and no permanent fixings or structures are desired. Portable floodwalls are typically constructed of lightweight aluminum and rely on the weight of the water to press down and stabilize the wall to create a water tight seal. Temporary floodwalls can vary in height to accommodate the change in existing elevation and optimize cost. However, installation of a system of portable floodwalls may need to begin several days prior to a pending event depending on available resources. Therefore, portable floodwalls may not be suitable for some events and areas when installation time exceeds event warning time. Additionally, portable floodwalls are not applicable where subject to storm wave action.

8) Portable Berms/Cofferdams: Portable cofferdams are another rapidly deployable, temporary method that can be used for flood risk management. The cofferdam, made of commercial grade vinyl coated polyester, is a water inflated dam, which consists of a self-contained single tube with an inner restraint baffle/diaphragm system for stability. The dam has the ability to stand alone as a positive water barrier without any additional external stabilization devices. The system can be installed easily in the field when needed and removed when the threat is over. Once laid out, it can be inflated using any available water source. Each unit is up to 100 feet long and 8 feet high. Portable cofferdam units can be joined together by overlapping end to end at any angle to provide risk reduction to large areas.

   Temporary pumps are required to fill the cofferdam units; however, the pumps can be used as temporary pump stations to pump trapped water on the “dry” side of the cofferdam and discharge the water into the “wet” side.

9) Storm Surge Barrier: Storm surge barriers are often coupled with levees to prevent storm surge from propagating up waterways. Storm surge barriers generally consist of a series of movable gates that are normally open to let flow pass, but will close when storm surge exceeds a certain water level.

10) Road, Rail, or Light Rail Raises: Roads can be raised on berms or levees. The advantage of raising a road is two-fold. First to raise main evacuation routes so they will not be flooded during a coastal and heavy precipitation event. Secondly, existing easements can provide some of the

property needed for the footprint for building a berm or levee. However, main routes in the Washington, D.C. area are heavily developed. In order to raise existing main routes, a large amount of property along the roadways likely will need to be acquired and this could have a major impact for the main business corridors. Additionally, the side roads leading to these main roads would need to be ramped for access.

Another option is raising existing rail or light rail lines on berms or levees. A road, rail, or light rail line raise may create interior drainage problems if stormwater storage is insufficient. Additional storage space and/or pumping stations may be required to remove interior stormwater drainage.

11) Stormwater System Improvements: Existing stormwater systems can be improved by increasing capacity, through additional piping and stream channelization, increasing pipe sizes and inlets and adding more storage areas, adding gates to outfall pipes to prevent storm surge from entering the storm sewer system, and pumping water from the storm system.

12) Bridge Trash Racks: Trash racks can be installed upstream of critical bridges to collect debris during a flood event to help preserve the structural integrity of the bridge support structure.

5.5.2 Non-Structural Measures

Nonstructural measures modify the ways that a floodplain is used and can provide places for floodwaters to go while avoiding damage to communities. Broad-based non-structural measures identified include:

1) Acquisition / Buyouts: Homes that are subject to repetitive loss from flooding and are outside of an area proposed for a structural flood risk management project are ideal candidates for buyouts or relocations. A buyout occurs when the homeowner is paid fair market value for the property, and moves to a new location. Relocations can occur when the homeowner has a parcel large enough that a home can be moved to higher ground on the existing parcel or a home can be relocated to a different parcel entirely. Acquisitions and buyouts restore the natural floodplain in the location of previous development.

2) Early Warning Systems: Flood warning systems are important to notify citizens of a flooding event. Coastal storms typically have a several-day timeframe where the community is aware of the possibility of impact, but last minute changes in speed and direction can alter the level of impact dramatically, and evacuations need to be planned well in advance for these types of storms in flat coastal areas. It is important for the community to have the means to reach out to their citizens before and during a large storm event. Large precipitation events from storms other than coastal storms may develop with little notice. Road signs that indicate flooded areas using real-time communications from citizens are one way to alert the community of these issues.

3) Elevating Structures: involves raising the building in place so that the lowest floor is above the flood level for which floodproofing is provided. The building is jacked up and set on a new or extended foundation.

4) Floodproofing: There are two types of floodproofing techniques: dry floodproofing and wet floodproofing. Dry floodproofing keeps the floodwaters from entering the structure, while wet floodproofing allows the floodwaters to enter the building, but minimizes the damages.

Dry floodproofing involves sealing the walls of structures such as buildings with waterproofing compounds, impermeable sheeting, or other materials and using closures for covering and protecting openings from floodwaters. Dry floodproofing is most applicable in areas of shallow, low-velocity flooding.

Wet floodproofing allows the structure to flood inside while ensuring minimal damage to the building and any contents. By allowing the force of the water to pass through a building, the interior flooding allows hydrostatic force on the inside of the building walls to equally counteract the hydrostatic force on the outside, thus eliminating the chance of structural failure. Wet flooding practices include installation of flood vents in the ground floor or crawl space to allow flood water to flow through the building without causing structural damage or conversion of ground floor living space to non-inhabitable space such as a carport or open garage.

5) Increase Storage: In order to reduce flooding from precipitation events, natural storage of the watershed can be restored or additional storage can be added. Restoration of natural storage includes restoring wetlands and returning floodplains to undeveloped states in riverine areas. Increasing natural storage in stormwater systems includes reducing impervious areas to allow infiltration of runoff from precipitation events. Additional storage can be added through detention ponds and on a more localized basis through rain barrels or cisterns. A major component of increasing natural infiltration in stormwater management includes the use of green stormwater management.

6) Public Engagement and Education: A community can aid in flood risk management by educating its citizens about the existing flooding hazards and what can be done to protect their property. Additionally, if a flood risk project is constructed, educating the community on residual project risk must occur

7) Relocating Utilities and Critical Infrastructure: A community can protect its own public infrastructure by relocating utilities underground and moving critical infrastructure out of floodplain areas. Examples of critical infrastructure include hospitals and shelters.

8) Preservation Land preservation programs should be developed to place environmentally sensitive land in permanent easements to better protect watersheds and their interrelated systems.

9) Resilience Performance Standards: Develop resilience performance standards for infrastructure to be used when making investment decisions. These standards may include information such as the recurrence interval of a storm that infrastructure should be designed to withstand, how long different end users can be without power, or how and when to include climate change or sea level change into design standards.

10) Emergency Response Systems: Emergency response systems include preparation for floods in anticipation of the flood event and flood-fighting plans to assist after the fact. The plans should include contingencies and emergency floodproofing. They must be properly integrated with emergency evacuation plans.

11) Modify / Remove Structures for Better Channel Function: Channel alterations such as modifying or removing features or widening/deepening channels can help reduce flooding by improving channel function.

12) Design or Redesign and Location of Services and Utilities: Services and utilities can be relocated to areas of low risk or to higher areas not subject to flooding. Additionally, existing services/features can be elevated above the flood elevation or can include flood-proofing features in the design.

13) Surface Water / Stormwater Management: Management of stormwater and surface water systems can improve water quality, decrease erosion, and increase storage in the event of a storm which minimizes flood risks. The development of a surface water or stormwater management plan can help facilitate best management practices of the systems.

14) Building Codes and Zoning: Climate change and coastal hazard considerations should be incorporated into building and zoning codes. Building codes can promote construction techniques that reduce damages to future construction or to areas of redevelopment. Some examples include requiring new structures to be raised above flooding elevations and structures to be built on pier foundations in areas of wave action. Zoning can be used to avoid activities on the floodplain other than those compatible with periodic flooding.

15) Strategic Acquisition: Purchase of undeveloped land for flood risk management.

16) Emergency Plans/Hazard Mitigation Plans: Emergency planning allows a community to be prepared for storm events, such as flood inundation from coastal storms. Hazard mitigation plans are developed to document hazards a community is exposed to and determine mitigation measures a community would like to implement to manage risk from these hazards. It is important for both of these plans to be kept up to date with local issues in order to prepare and recover after a flooding event.

17) Retreat: Consider managed retreat, allowing wetlands and beaches to take over undeveloped land that is dry. Include land use and zoning appropriate for coastal storm risk management.

18) Wetland Migration: Adjust zoning laws for wetland migration

19) Regional Sediment Management (RSM): Continuation of RSM practices in place and identifying new opportunities.

20) Coastal Zone Management: Coastal Zone Management regulates activities within the “Coastal Zone” to ensure that development is accomplished with the least amount of damage to the coastline.

5.5.3 Natural and Nature-Based Infrastructure

Nature-Based Infrastructure (NBI) refers to the planned use of natural and engineered features to produce engineering functions in combination with ecosystem services and social benefits. Natural and nature-based features include a spectrum of features, ranging from those that exist due exclusively to the work of natural process to those that are the result of human engineering and construction. The built components of the system include nature-based and engineered structures that support a range of objectives, including coastal storm risk management (e.g., seawalls, levees), as well as infrastructure providing economic and social functions (e.g., navigation channels, ports, harbors, residential housing). Natural coastal features take a variety of forms, including reefs (e.g., coral and oyster), barrier islands, dunes, beaches, wetlands, and maritime forests. The relationships and interactions among the natural and built features comprising the coastal system are important variables determining coastal vulnerability, reliability, risk and resilience.

1) Green Stormwater Management: Management practices can be used to reduce impervious areas and increasing storage on a localized basis for stormwater. Some examples include bio-swales, rain gardens, green roofs, rain barrels or cisterns. Natural and nature-based infrastructure practices that involve plantings also allow for evapotranspiration of stormwater, and provide for an aesthetic component. Reducing impervious areas allows for infiltration of stormwater which reduces runoff quantity and improves runoff quality. Natural and nature-based infrastructure can also allow for opportunities to add public recreational features and provide for ecosystem restoration, while providing for wave attenuation and stormwater storage.

2) Salt Marshes: Salt marshes can provide sediment stabilization to an area, and can dissipate and/or attenuate oncoming wave action. Depending on the cross-shore width of a salt marsh, it has the potential to reduce storm surge effects. The traditional rule of thumb (USACE, 1963) was that for every 2.7 miles of marsh, storm surge is reduced by one foot; however, the degree of risk management that wetlands provide from storm surge is extremely complicated.

3) Freshwater Wetlands: Freshwater wetlands can provide flood management by detention and/or storage for floodwaters. Infiltration through a freshwater wetland to an aquifer below can assist in groundwater recharge and provide water quality benefits. Freshwater wetlands also provide sediment stabilization benefits.

4) Maritime Forests / Shrub Communities: The dense vegetation of maritime forests and shrub communities helps to stabilize soils while dissipating wave action and slowing the inland transfer of storm water.

The broad measures identified herein, structural, non-structural, and natural/nature-based, have the potential for further development to target specific areas for coastal storm risk management. The goal of measures development is to achieve the objectives by combining one or more measures while avoiding constraints. Measures identified will be further evaluated, screened and used in combination (as appropriate) in future phases of study to determine area-specific project viability to meet the planning objectives.

5.5.4 Area Specific Measures

Several of the previously described broad-based measures (structural, non-structural, and nature-based) are applicable to some areas within the study area. Specific area-focused measures provided through stakeholder input and/or otherwise derived from previous studies. particularly any existing hazard mitigation plans, are listed below. This subsequent list includes some measures that are beyond the purview of USACE. Potential measures that could be evaluated as part of future study phases are included herein.

1) Structural

- Improve the tide gates in Washington, D.C. to provide a higher level of flood risk management.
- Complete the design and construct a flood risk management levee for Huntington Subdivision in Fairfax County, Virginia.
- Improve storm water management and flood risk management for the Federal Triangle Area in Washington, D.C. This measure includes additional evaluation and potential rehabilitation

of the current Washington, D.C. Levee, part of the Potomac Park Levee System, which was authorized at a 700,000 cubic feet per second flow rate. An exception is the 17th Street Closure project, which is currently underway.

- Evaluate additional flood risk management measures for critical and historical government infrastructure along the riverfront such as Washington Harbor, Navy Yard, Joint Base Anacostia-Bolling, and National Park Service. This measure includes additional evaluation of the current levee system along the east bank of the Anacostia and Potomac Rivers that is currently in unacceptable condition and cannot be certified in its current condition.
- Evaluate flood risk management measures for wastewater treatment facilities in Arlington County, VA.
- Evaluate flood risk management measures, including urban drainage improvements near Reagan National Airport (DCA) in Arlington County, VA.
- Evaluate additional flood risk management measures for the Potomac River waterfront in Alexandria, VA.

2) Non-structural:

- Operate and maintain the 17th Street closure to protect the National Mall from Potomac River flooding.
- Retrofit existing buildings in the 100-yr floodplain to increase resilience.
- Evaluate existing USACE flood risk management projects under a range of future conditions, considering climate change impacts and projected sea level change.
- Develop integrated flood risk management systems using structural (engineering) and non-structural (wetlands) measures.
- Enhance and strengthen waterfront zoning and permitting.
- Strengthen city codes to integrate anticipated climate changes.
- Enhance building codes that regulate building within a floodplain or near the waterfront.
- Integrate natural buffer requirements, such as wetlands and soft shorelines, into new development or re-development.
- Encourage the integration of climate change and natural hazards into private and State planning documents, systems, operations, and maintenance.

3) Nature-Based:

- Encourage the use of permeable pavement in non-critical areas, such as low-use roadways, sidewalks, parking lots and alleys.
- Evaluate green corridors and parks as part of any proposed improvements for flood risk management.
- Incorporate urban landscaping requirements and permeable surfaces into community managed open spaces.
- Manage watershed forests to provide maximum benefits for water quality and to maintain resilience during extreme weather events.
- Preserve and protect natural drainage corridors.

6. Preliminary Financial Analysis

Given the size (57 square miles) and the various jurisdictions within the study area, there could be more than one study and multiple non-Federal sponsors.

The potential non-Federal sponsors identified in **Table 3** would be required to provide 50 percent of the cost of the potential future investigation. Up to 100% of the non-Federal sponsor's share could be work in-kind. The non-Federal sponsors are also aware of the cost sharing requirements for potential project implementation. A letter of support from the non-Federal sponsors stating willingness to pursue potential future investigation and to share in its cost and an understanding of the cost sharing that is required for project construction will be required.

7. Summary of Potential Future Investigation

Based on the identified measures, potential alternative plan development, and future screening of alternatives, there appears to be an array of potential projects that are likely to be economically justified, environmentally acceptable, addressable through viable engineering solutions, and consistent with USACE policies and the Infrastructure Systems Rebuilding Principles (NOAA and USACE, 2013).

Table 3 summarizes the potential non-Federal sponsors with potential interest in future study phases to address coastal storm risk management for Middle Potomac – Washington, D.C. and Metropolitan study area. Other studies not listed in this table could also be pursued under this authority.

Table 3. Potential Future Investigation and Non-Federal Sponsors

Potential Non-Federal Sponsor	Area of Interest	Navigation	Coastal Storm Risk Management	Flood Risk Management	Nature-based	Water Resource Management	Community Resilience
Washington, D.C. [1]	National Mall Flood Risk Management		X	X			
National Capital Planning Commission [2]	Federal Triangle Flood Risk Management		X	X			
Arlington County, Virginia	Flood risk management for wastewater treatment facilities		X	X			
Arlington County, Virginia/*Reagan National Airport (DCA)* [1]	Drainage and flood risk management improvements to DCA		X	X		X	
City of Alexandria, Virginia	Potomac waterfront flood risk management		X	X	X	X	
Fairfax County, Virginia	Flood risk management for Huntington Subdivision		X	X		X	X
Arlington County, Virginia/City of	Four Mile Run Restoration		X	X	X	X	X

Potential Non-Federal Sponsor	Area of Interest	Navigation	Coastal Storm Risk Management	Flood Risk Management	Nature-based	Water Resource Management	Community Resilience
Alexandria, Virginia							

[1] *Sponsors may include many of Washington, D.C.'s agencies and/or private entities.*

[2] *For purposes of this report, NCPC was listed because of feedback provided on problems and opportunities. It is recognized that a Federal agency cannot be the non-Federal sponsor for potential future investigation.*

8. Views of Other Resource Agencies

Limited coordination was conducted with other Federal agencies. USACE continues to coordinate quarterly with U.S. Fish and Wildlife Service (USFWS), and previous and ongoing studies in the vicinity require frequent dialog and communication. Coordination with other resource agencies is also being conducted as part of the overall NACCS. Additional coordination would occur during the future phases of study.

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APPENDIX A

STAKEHOLDER INQUIRY LETTER AND EMAIL TRANSMISSION
LIST OF CONTACTS – MIDDLE POTOMAC – WASHINGTON, DC AND METROPOLITAN AREA

STAKEHOLDER INQUIRY LETTER:

CENAB-PL-P 28 August 2013

Dear Stakeholder,

The United States Army Corps of Engineers (USACE) is conducting the North Atlantic Coast Comprehensive Study (NACCS) under the authority of Public Law 113-2, the Disaster Relief Appropriations Act of 2013, Chapter 4, which authorized USACE investigations as follows:

- *"That using up to $20,000,000 of the funds provided herein, the Secretary shall conduct a **comprehensive study** to address the flood risks of **vulnerable coastal populations** in areas that were affected by Hurricane Sandy within the boundaries of the North Atlantic Division of the Corps.*

- *"….as a part of the study, the Secretary shall **identify those activities warranting additional analysis by the Corps**".*

The goals of the NACCS are to:

- Promote resilient coastal communities with sustainable and robust coastal landscape systems, considering future sea level rise and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure; and

- Provide a risk reduction framework (reducing risk to which vulnerable coastal populations are subject) consistent with USACE-NOAA Rebuilding Principles.

To identify those activities warranting additional analysis, USACE is conducting a Reconnaissance-Level Analysis (RLA) for the Middle Potomac – Washington, D.C. and Metropolitan Area. The area that will be studied as part of this RLA is shown in Figure 1 (attached).

The purpose of the RLA is to determine if there is a Federal (USACE), interest in participating in a cost-shared feasibility study to formulate and evaluate specific coastal flood risk management projects in the Middle Potomac – Washington, D.C. and Metropolitan study area. Possible coastal flood risk management measures could include: structural, non-structural, natural, nature-based, and policy and programmatic measures or a combination of them, if a feasibility study is initiated.

To conduct the RLA**, USACE requests feedback from your jurisdiction** on related problems and potential opportunities to address these issues such as those experienced during Hurricane Sandy and other storm**s.**

Specific feedback requested is as follows:

1) **Problem identification for your area:**
   a. Did your area experience storm surge?
   b. Be specific on particular areas and water bodies within your jurisdiction that experienced storm surge.
   c. What factors, if any, exacerbated damages from storm surge?

2) **Description of damages for your area:**
   a. Provide a narrative including the types of infrastructure damaged or temporarily out of use, structure (building) damages, personal injuries/fatalities.
   b. Provide a map depicting the spatial extent of damages.

3) **Prior related studies or projects (local, state, federal) in the damaged area.**

4) **List measures that your jurisdiction has considered to address the problem** (for documentation purposes, should there be a follow-on study).

Responses should be emailed to:

Ginger Croom, croomgl@cdmsmith.com (USACE Contractor)

Or faxed to Ginger Croom at 617-452-6594

Due to the aggressive schedule to complete the RLA and to meet the Congressional mandate to complete the NACCS, please provide responses to these questions by **September 10, 2013.**

If you have any questions related to this request, please contact Ginger Croom, CDM Smith (USACE Contractor) at 617-452-6594 or me at 410-962-8156.

For more information on the NACCS, please visit:

http://www.nad.usace.army.mil/Missions/CivilWorks/HurricaneSandyCoastalRecovery/

NorthAtanticComprehensiveStudy.aspx

Sincerely,

Andrew Roach

USACE, Baltimore District

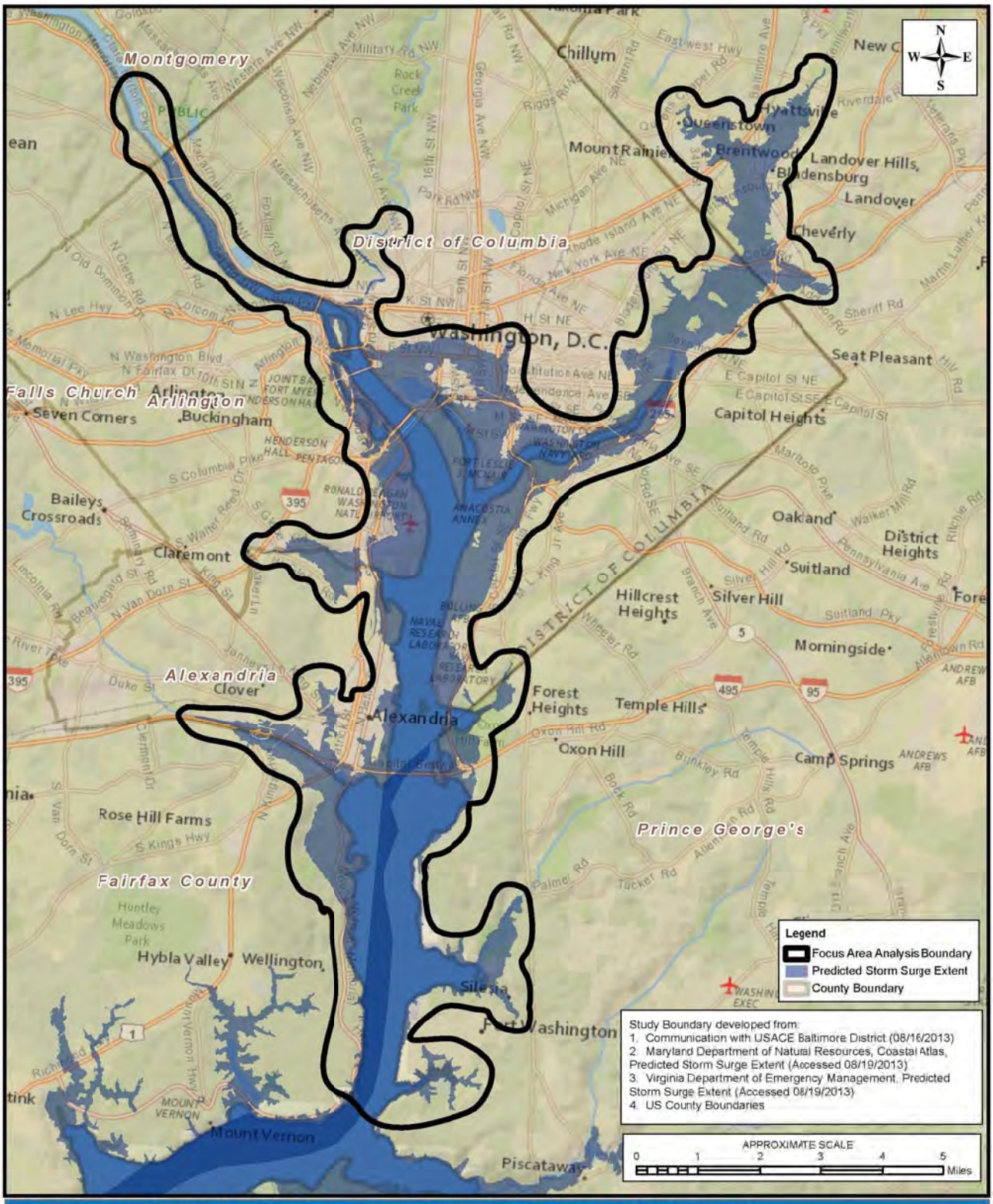

Figure 1. Middle Potomac - Washington, D.C. and Metropolitan Area Focus Area Analysis Boundary

EMAIL TRANSMISSION:

From: Croom, Ginger

Sent: Friday, August 30, 2013 2:44 PM

To: amy.tarce@ncpc.gov; hsema@dc.gov; Robyn.johnson@dc.gov; dpw@dc.gov; ddoe@cd.gov; Jonathan.Reeves@dcwater.com; william.skrabak@alexandriava.gov; richard.baier@alexandria.gov; Rashad.young@alexandria.gov; Allison.Silberberg@alexandriava.gov; countymanager@arlingtonva.us; gemanual@arlingtonva.us; bbloomer@arlintonva.us; cnewby@arlingtonva.us; dleach@arlingtonva.us; OPA703fairfax@fairfaxcounty.gov; Justin.Pistore@FairfaxCounty.gov; ocr@co.pg.md.us; countyexecutive@co.pg.md.us; mkmcclean@co.pg.md.us; rsdeguzman@co.pg.md.us; dhnixon@co.pg.md.us

Cc: Roach, Andrew A NAB; Robbins, David W NAB; Bierly, Daniel M NAB; Roberts, Karla NAB; Newman, Martha P NAB; Bartel, Jamie M.; Bui, Frances; Klonsky, Lauren S.

Subject: USACE NACCS - Reconnaissance-Level Analysis for Middle Potomac - Washington, D.C. and Metropolitan Area

Attachments: Middle Potomac - Washington, D.C. and Metropolitan Area RLA.pdf; Figure_1_DC_RLA.pdf

Dear Stakeholder,

Please see attached letter and map sent on behalf of the United States Army Corps of Engineers (USACE).

A meeting will be held on **Thursday, September 5 at 2 pm,** either in Washington, D.C. or in Fairfax, VA. The meeting location is being finalized and further details will be sent on Tuesday, September 3 (latest). The purpose of the meeting is to provide a summary of the North Atlantic Coast Comprehensive Study, and the Reconnaissance-Level Analysis that is being conducted for the Middle Potomac - Washington, D.C. and Metropolitan Area.

Please contact Andrew Roach, USACE Baltimore at 410-962-8156, or me with any questions regarding this request.

Please send any information in response this request directly to me (USACE Contractor).

Thank you.

Ginger Croom, PE

Associate

CDM Smith

50 Hampshire Street

Cambridge, MA 02139

617-452-6594 (ph and fax)

617-999-9631 (mobile)

POINTS OF CONTACTS:
Middle Potomac - Washington, D.C. and Metropolitan Area

Jurisdiction	Entity	First Name	Last Name	Phone	eMail	Address
DC	National Capital Planning Commission	Amy	Tarce	202.482.7241	amy.tarce@ncpc.gov	
DC	Office of Emergency Management			202-727-6161	hsema@dc.gov	
DC	Office of Emergency Management				Robyn.johnson@dc.gov	
DC	Dept of Public Works			202-673-6833	dpw@dc.gov	
DC	Environmental			202-535-2600	ddoe@cd.gov	
DC	DC Water- Emergency Response and Planning Coordinator	Jonathan	Reeves	202.787.7695	Jonathan.Reeves@dcwater	
DC	Other - NAB to provide other contacts with whom they've met previously					
Alexandria	City Engineer, Transportation & Environmental Services			703.746.4045		301 King Street, Room 3200, Alexandria, VA 22314
Alexandria	Department of Transportation & Environmental Services, Office of Environmental Quality--Director	William	Skrabak		william.skrabak@alexandriava.gov	301 King Street, Room 3200, Alexandria, VA 22314
	Department of Transportation & Environmental Services, Office of Environmental Quality--Head of Public Works	Richard	Baier		richard.baier@alexandriava.gov	301 King Street, Room 3200, Alexandria, VA 22314
Alexandria	City Manager	Rashad	Young		Rashad.young@alexandriava.gov	
Alexandria	Mayor	William	Euille			
Alexandria	Vice Mayor	Alison	Silberberg		Allison.Silberberg@alexandriava.gov	
Arlington	County Manager	Barbara	Donnellan		countymanager@arlingtonva.us	
Arlington	Director of Environmental Services	Greg	Emanual	(703) 228-5022	gemanual@arlingtonva.us	
Arlington	Deputy Director of Facilities & Engineering	Bo	Bloomer	(703) 228-7940	bbloomer@arlingtonva.us	
Arlington	Deputy Director of Operations	Carl	Newby	(703) 228-6494	cnewby@arlingtonva.us	
Arlington	Deputy Director of Transportation & Development	Dennis	Leach	(703) 228-0588	dleach@arlingtonva.us	
Fairfax	County Executive	Edward	Long, Jr		OPA703fairfax@fairfaxcounty.gov	

Fairfax	OEM					
Fairfax	Public Works and Environmental					
Fairfax	Dept Public Works and Environmental Services, Watershed Projects Implementation Branch, Stormwater Planning Division	Justin	Pistore	703.324.5685	Justin.Pistore@FairfaxCounty.gov	12000 Government Center Parkway, Suite 449, Fairfax, VA 22035
Prince Georges	Office of Community Relations			301.952.4729	ocr@co.pg.md.us	
Prince Georges	Executive Branch			(301) 952-4131	countyexecutive@co.pg.md.us	
Prince Georges	Public Works and Transportation			301.883.5600	mkmcclean@co.pg.md.us	
Prince Georges	Office of Homeland Security	Shai	Cooper	301.780.8313		
Prince Georges	Department of Permitting, Inspections and Enforcement (DPIE)	Rey	De Guzman		rsdeguzman@co.pg.md.us	
Prince Georges	Department of Environmental Resources (DER)	Dawn	Hawkins-Nixon		dhnixon@co.pg.md.us	

APPENDIX B

MEETING DOCUMENTATION FROM KICK-OFF/STAKEHOLDER MEETINGS

KICK-OFF MEETING:

NAB RLAs – Baltimore and D.C. Study Areas
16 Aug 2013
11 am
Kickoff Meeting/Telecon

Attendees:
Dave Robbins – NAB PM
Dan Bierly - NAP Planning
Martha Newman – NAB Planning
Andrew Roach will be main POC – in training this week
Jamie Bartel, Frannie Bui, Ginger Croom – CDM Smith

Washington, D.C. Study Area

1. **General**
   Previous meetings D.C. Flood Risk Management Committee, (NAB staff, CDM Smith participated via conference call).

2. **Study Areas**
   Discussed study areas and need to include contiguous areas (portions of several counties) surrounding D.C. This includes portions of planning reaches that are identified as part of the study area effort, **ACTION: CDM Smith will provide updated draft maps (by 8/20).**

3. **Relevant existing projects/studies**
   - Existing levee projects – Potomac Park levee
   - 17th street closure, construction contract to complete a closure – not an issue for recon but ongoing effort to be aware of
     - Levee itself is existing project, but was not constructed to level of protection for which it was originally authorized
     - Have had problems with construction contractor, construction not complete
     - Current design flow is 700,000 cfs (Potomac, which includes tidal influence). 65% design is completed, but not built, currently built to level that does not meet 100-year level of protection. Authorized budget is insufficient to raise the levee, would need higher project cost/budget to be authorized. If 700,000 cfs is not high enough then need to factor that into our analyses
   - Bloomingdale neighborhood – area characterized by stormwater drainage issues. Current CSO long-term control plan (LTCP) is ongoing (DC Water project). This ongoing project may inadvertently address these local drainage issues and alleviate local flooding in this neighborhood.

NOTE: As with Bloomingdale, stormwater management issues will likely be recurring theme in many watersheds or communities (729 watershed assessment)- How do we address these in the RLAs? Decide we will include mention of stormwater management issues in the RLAs.

   - Federal Triangle – stormwater issue behind Potomac Park levee (existing USACE project) study completed that identified recommendations to install cisterns under mall (NPS project) – may be an opportunity to address/reference. There is a potential opportunity to consider pump station(s) in

this area. Pump stations and/or related improvements could be considered as a potential opportunity in the RLA.

- DC Metro – considering raising Metro parapet walls in the Triangle and the Archives (incorporate as potential problem) – reference NY subway flooding problems post-Sandy. Need to protect critical infrastructure components similar to those damaged in Sandy.
- Reference Jonathon Reeves comment that was submitted post meeting—several secondary effects of coastal flooding/inundation in the area that USACE may be able to address for mitigation - want to be pro-active and address secondary effects of coastal flooding, addressing critical infrastructure
- Blue Plains WWTP – ongoing construction of seawall, associated with enhanced nitrogen removal system (part of the Chesapeake Bay restoration efforts). However, the seawall is only confined to that new construction area, leaving other areas exposed. FEMA Maps (2010) – show that a portion of the facility would be inundated. Again, theme is to address problem areas with a need to protect critical infrastructure.
- Existing USACE levee project, City of Alexandria and Arlington Co., susceptible to sea-level rise; levee height likely not adequate
- Cameron Run – another problem area with inundation – various other areas across Potomac, Fairfax County and City Alexandria – USACE has existing general investigation (GI) in the watershed (CDM Smith does much work for FFX County – will
- National Harbor area – look at this also, it is a new development area on the river susceptible to seal level rise

4. **POCs /list of potential sponsors**
   - Pat Mano at the district could assist in contact efforts/reaching out to groups
   - D.C., Prince George (PG) County, Fairfax County, Arlington Co., Alexandria, NGOs? **ACTION: CDM Smith to contact NoVA entities and PG County**
   - Contact Stacy Underwood (relevant to NGO question).
   - Need meeting(s) with Fairfax, Arlington, P.G. Counties, Alexandria and D.C.

5. **Communication**
   - Weekly status calls with NAB – would be primarily with Andrew, but cc: Dan, Dave, Karla, Martha

<u>Baltimore Study Area</u>

1. **General**
   Previous meetings – Baltimore County and City of Baltimore (NAB staff participated, **ACTION: NAB to provide CDM Smith meeting notes for record)**

2. **Study Areas**
   Discussed study areas and need to include contiguous areas (portions of several counties) surrounding Baltimore. This includes portions of planning reaches that are identified as part of the study area effort, **ACTION: CDM Smith will provide updated draft maps (by 8/20).**

3. **Relevant existing projects/studies/problem areas**

Baltimore County

Andrew Roach held a meeting with Baltimore County previously. Baltimore City and County are well aligned with the process of identifying respective hazard mitigation plans (HMPs)/projects; problem areas were identified as they relate to future climate change impacts and considered damages incurred from Hurricane

Isabel (2003). CDM Smith will use the draft HMP as a reference source. **ACTION - need POC from NAB to get HMP report.**

Baltimore City

NAB (Dave Robbins, Dan Bierly, others) met today 16 Aug. **ACTION: NAB to provide CDM Smith meeting notes for record.**

- 4 primary areas or "hot spot" areas to address in RLA

1) Port – critical infrastructure, need to evaluate area for problems/opps – include private terminals also due to concern of potential damages

2) Fells Point – historic district susceptible to tidal flooding, City is going to look to a contractor to separately evaluate potential problems in the specific area (low point with dense development close to the water's edge) – storm drainage, storm surge are problems. Flooding problems during Isabel, no interest in a flood wall, but still should mention/consider as a potential opportunity in the RLA.

3) Middle Branch, Patapsco – waterfront areas, prime for re-development, one area in particular is already starting re-development (developer already started but went out of business). Area very susceptible to storm surge. **Opps for green-infrastructure here (however not building into water due to wetlands restoration ongoing).**

4) Downtown/inner harbor – business attractions in area; much info in HMP on this area

5) Existing study authorities – Baltimore Metropolitan Water Resources Authority

Anne Arundel County

1) Sparrows Point (community by the bridge); Curs Creek, Curs Bay—all areas susceptible to wave action/fetch
2) Primarily residential areas as indicated on map
3) Less far along with their work to identify problem areas

4. POCs

- Baltimore City office of sustainability – Planning Division, contact them for information on HMPs (POC – will provide information on this modeling/report) – NAB should have existing contact (met with on 16 Aug)
- Baltimore County – NAB has contact (Andrew met previously)
- Maryland Port Administration (MPA) – **ACTION: CDM Smith to contact on behalf of NAB, coordinate with NAB existing contacts**
- Harford and Anne Arundel Counties – need to contact –ACTION – **CDM Smith to contact on behalf of NAB**
- Discussed meeting with ALL 4-5 Baltimore stakeholders – 1 meeting

5. Communication

- Weekly status calls with NAB – would be primarily with Andrew, but cc: Dan, Dave, Karla, Martha

6. Miscellaneous

- DEP has HAZUS data, DP3

Summary of Action Items

CDM Smith

- Provide updated maps based on today's discussion 20 Aug
- Contact NoVA entities and PG County, week of 19 Aug for overall coordination and meeting set-up
- Contact Fairfax County to get additional information on Cameron Run – both problem and potential solutions County would like to see addressed
- Contact Stacey Underwood (relevant to NGO question).
- Contact MPA (coordinate with NAB on existing contact for dredging projects)
- Contact Harford and Anne Arundel Counties

NAB

- Provide CDM Smith meeting notes from Baltimore County and Baltimore County meetings
- Provide CDM Smith both Baltimore City and Baltimore County POCs for overall coordination, and so CDM Smith can request HMP.

STAKEHOLDER MEETING:

–

-

On Thursday, September 5, the U.S Army Corps of Engineers (USACE) met with representatives from Arlington County, the City of Alexandria and the National Capital Planning Commission (NCPC) and CDM Smith to discuss the North Atlantic Coast Comprehensive Study (NACCs) Middle Potomac – Washington, D.C. and Metropolitan Area Focus Area Analysis. Seven people attended the one-hour meeting (4 in-person, and 3 via teleconference).

Andrew Roach from USACE provided introductions and the meeting purpose – Middle Potomac – Washington, D.C. and Metropolitan Area Focus Area Analysis.

Andrew Roach from USACE presented handouts of a PowerPoint presentation which provided information on the overall NACCS, and the focus area analysis, as well as information that is being requested from various stakeholders pertinent to complete the focus area analysis. A Power Point presentation was emailed to those meeting attendees who participated via teleconference.

US Army Corps of Engineers

North Atlantic Coast Comprehensive Study

Middle Potomac – Washington, D.C. and Metropolitan Area

Focus Area Analysis

Stakeholder Meeting

September 5, 2013

2:00 PM – 3:00 PM

Location: CDM Smith Fairfax Office

3201 Jermantown Road, Fairfax, VA

Attendees: Andrew Roach – Planner at USACE (Focus Area Study Manager)

Dave Robbins – NACC Project Manager at USACE (via phone)

Martha Newman – Planner at USACE

Brian Rahal – Civil Engineer at City of Alexandria, Engineering Division, Transportation and Environmental Services

Allen Rowley – Planner, Stormwater Infrastructure, Office of Sustainability and Environmental Management, Arlington County Department of Environmental Services

Ginger Croom – Project Manager at CDM Smith

Meeting Minutes:

- Introductions and Overview
  - **Andrew Roach**, USACE, addressed the meeting participants and provided an overview of the study area and purpose of the focus area analysis.

- Presentation
  - **Andrew Roach**, USACE, went through a presentation on the NACCS with the meeting participants.

Feedback on Sandy Impacts by Jurisdiction:

- **Allen Rowley, Arlington County** – Arlington County did not experience significant storm surge from Hurricane Sandy, however, there was significant storm surge from Hurricane Isabel (2003). Vulnerable areas in Arlington are the Water Pollution Control Plant (Arlington County), Regan National Airport (Federal) and the George Washington Memorial Highway (National Park Service). During Isabel, surge briefly entered one of the secondary aeration tanks at the Water Pollution Control Plant (although their operation was not affected). Arlington County is in the process of updating their stormwater master plan this year. Allen to provide CDM Smith a current draft of report.
- **Brian Rahal, City of Alexandria** – The City of Alexandria did not experience significant surge from Sandy, though the City did have significant flooding from Isabel. Areas of Alexandria are inundated even by tidal fluctuation (documented in Potomac Waterfront Flood Study). The City has a project currently underway to design for nuisance flood mitigation on the Alexandria waterfront.
- **Amy Tarce, NCPC** – Other major storm events include the June 2006 storm, which had record rainfall, and caused major flooding of Federal Triangle. Flooding was caused primarily by interior drainage issues,

and most of water came through Federal Triangle.

- **General comment** - Add Metro as a stakeholder. CDM Smith to get POC (for overall NACCS) from Dave Robbins. Metro has already provided some feedback as to improvements needed (through DC Flood Risk Management Meeting)

Prior Studies/Reports to consider as part of current study:

- Ginger Croom, CDM Smith, went over the list of previous studies/reports compiled this for the focus area analysis.
- Amy Tarce, NCPC, noted a report on impacts of 2006 Federal Triangle Study – CDM Smith to check to make sure they are referencing both reports (both GSA and Smithsonian reports).
- Amy Tarce, NCPC – noted Federal triangle stormwater study from 2010 – NPS

Measures already being considered by stakeholders:

Alexandria

- Raised walkway
- Policy/programmatic - currently match VA building code at BFE +1, no changes currently being considered

Arlington

- Levees around WWTP – check for studies (consideration for levees is more in response to overall SLR/climate change),
- Other facilities that may be risk – Reagan National Airport and George Washington Parkway (Crystal City area), not sure if they are being looked at by others - both are Federal facilities, not Arlington County facilities
- Policy/programmatic – currently match VA building code at BFE + 1, no changes currently being considered

Washington, D.C.

- Considering 3 alternatives for stormwater storage: tunnel underneath mall – pump to Blue Plains, P/S underneath mall; build cisterns under mall, use water to irrigate the mall
- ROM for all 3 alternatives

Other Questions/Discussion:

Q: Amy Tarce, NCPC, The analysis referenced in this meeting will be looking at higher-level, not as detailed as work already completed. So what benefit will this analysis provide?

A: Dave Robbins, USACE. Any previous analyses will incorporated into overall framework to help document existing risks.

Q: Amy Tarce, NCPC, Washington, D.C. (Federal Triangle area) has very specific projects that agencies are interested in doing. She is specifically interested in how USACE can participate in these projects. Does USACE have any flexibility in spending resources towards next step? Particularly since alternatives have already been evaluated to high degree of detail.

A: Dave Robbins, USACE, these analyses may provide opportunities for additional resources/potential funding to further projects

---End of Minutes---

APPENDIX C

STAKEHOLDER FEEDBACK

Original Message-----

From: Tarce, Amy [mailto:amy.tarce@ncpc.gov]

Sent: Tuesday, August 20, 2013 3:05 PM

To: Robbins, David W NAB

Cc: Miller, Elizabeth D.; Saum, Christine L.; Sherman, Mike A.; Dettman, Shane

Subject: [EXTERNAL] FW: North Atlantic Coast Comprehensive Study - requesting your feedback

David,

Thank you for the opportunity to comment on the North Atlantic Coast Comprehensive Study. Below are NCPC's responses to the four questions you posed to the DC Floor Risk Management group.

1. What are water resource problems to be solved?

a. Interior drainage flooding along Constitution Avenue is prevalent, even for small storm events. The affected area includes the Federal Triangle, the National Gallery of Art, and the Smithsonian buildings along Constitution Avenue.

b. Tidal flooding often affects National Park Service land, including East Potomac Park and Anacostia Park. Sea level rise will exacerbate the flooding problem in these parks, and could potentially inundate the existing trails along the park shorelines permanently.

c. Storm surge and sea level rise could also adversely impact three military facilities - the Pentagon, Joint Base Anacostia Bolling, Fort McNair, the Naval Research Laboratory, and the Navy Yard.

d. Storm surge with sea level rise could overtop the existing levees and result in considerable damage to areas around the National Mall that are predominantly occupied by federal buildings. It is our understanding that these levees were deemed "unacceptable" during the USACE's inspection for compliance with its Levee Safety Program. We are concerned that even without sea level rise, the areas behind the levees will be vulnerable to extreme storm events.

2. Is there a viable engineering solution to the problems?

The Federal Triangle Stormwater Drainage Study identified 3 viable engineering solutions to address flooding along Constitution Avenue and the vicinity of the National Mall. They include:

a) installing a pumping station in the National Mall

b) constructing a stormwater collection vault underneath the National Mall to collect excess stormwater and reuse for irrigating the Mall

c) constructing a stormwater tunnel to connect to the future stormwater tunnels that are currently being designed by DC Water as part of the DC Long Term Control Plan

A study to mitigate storm surge with sea level rise and flooding on National Park Service land and the military installations mentioned above should be conducted to determine system-wide viable solutions for the National Capital.

3. Are there potential National Economic Development (NED) benefits associated with a potential project?

The Federal Triangle Stormwater Drainage Study did not include a cost-benefit analysis. We would be interested in working with the Corps of Engineers to conduct a cost-benefit analysis of all 3 viable solutions listed above.

4. Is there a need/interest for Federal (USACE) participation and is there a qualified non-Federal sponsor?

There are several non-Federal entities who might be interested in working with the USACE, including:

* The Government of the District of Columbia, specifically the DC Office of Planning, DC Dept. of Transportation and the District Department of the Environment

* Smithsonian Institution

* Capitol Riverfront Business Improvement District

We would like to stress that a majority of properties that will be impacted by storm surge and flooding, and any USACE projects proposed in Washington, DC, will inadvertently involve federal properties. As the central planning agency for the federal government in the National Capital Region, we would like to be included as a major stakeholder for the North Atlantic Coast Comprehensive Study.

Regards,

Amy Tarce, AICP

Urban Planner

National Capital Planning Commission

401 9th Street, N.W., Suite 500

Washington, DC 20004

(202) 482-7241

www.ncpc.gov <http://www.ncpc.gov>

Name	Jonathan Reeves
Community / Agency	DC Water
Title	Emergency Response and Planning Coordinator
E-Mail	jonathan.reeves@dcwater.com
Telephone	202-787-7695

Comment

DC Water has identified a number of potential issues that could be addressed by the USACE to mitigate Coastal Flooding
- Flood wall protection at the O and Main street Pumpstation. This facility pumps sewer from the city to the Blue Plains treatment plant. If lost the District would flood with Sewer. We have similar issues along the Anacostia with several other Pump Stations

From: Allan Rowley [mailto:Arowley@arlingtonva.us]
Sent: Tuesday, September 10, 2013 5:01 PM
To: Croom, Ginger
Cc: Jeff Harn
Subject: USACE NACCS, Middle Potomac Washington, D.C. and Metropolitan Area Reconnaissance-Level Analysis Stakeholder Meeting

Ginger,

Thanks for your help getting set up for the webinar last week. The attached map shows the locations of documented complaints from the storm of June 25, 2006. Purple dots indicate storm drainage / flooding issues; green dots indicate sanitary sewer backups; yellow dots indicate that both occurred. You will notice some storm basins are highlighted: those are the basins that were studied in the Capacity Study (notice that most of the documented complaints are covered by this study). County staff will model other basins on an on-going basis. I have also included Council of Government presentation on climate adaptation for your reference.

Here is the link to Capacity Study (part of our Stormwater Master Plan due to be adopted later this year, or early next year).

http://www.arlingtonva.us/departments/EnvironmentalServices/Sustainability/page89756.aspx

If you are interested, the environmental components of our updated Stormwater Master Plan can be found at this link:

http://www.arlingtonva.us/departments/EnvironmentalServices/Sustainability/page74076.aspx

Here are the answers to your specific questions:

1) Problem identification for your area:

   a) Did your area experience storm surge? There was no significant storm surge from Hurricane Sandy, however, there was significant storm surge from Hurricane Isabel in September, 2003. Areas in Arlington potentially threatened are the Water Pollution Control Plant (Arlington County), Regan National Airport (federal) and the George Washington Memorial Highway (National Park Service). I have no information about the airport or the George Washington Memorial Highway, but the surge did enter (briefly) one of the

secondary aeration tanks at the Water Pollution Control Plant (although their operation was not effected). If the surge had been a couple of feet higher, or if there had been significant rainfall, the impact would have been significant.

b) Be specific on particular areas and water bodies within your jurisdiction that experienced storm surge. The Potomac River and Four Mile Run.

c) What factors, if any, exacerbated damages from storm surge? None.

2) Description of damages for your area:

a) Provide a narrative including the types of infrastructure damaged or temporarily out of use, structure (building) damages, personal injuries / fatalities. There was no damage from storm surge; however, there was one fatality and damages on private property associated with the storm event of June 25, 2006. The fatality was a man crossing Four Mile Run during the storm who was swept away and drowned. Damages were caused by backups of the storm sewer system overflowing into homes, or causing flooding streets (to the extent of cars floating), and by sanitary sewer backups into homes. Capacity issues of both the storm and sanitary sewers are being addressed in our Capital Improvement Program.

b) Provide a map depicting the spacial extent of damages. Included as an attachment.

3) Prior related studies or projects (local, state, federal) in the damaged area. A federal flood control project for Four Mile Run (between Shirlington Road in south Arlington and the Potomac River) was completed in 1980. This area of Arlington along Four Mile Run had flooded relatively routinely before this project was built.

4) List measures that your jurisdiction has considered to address the problem (for documentation purposes, there should be a follow-on study). The County is increasing the capacity of its storm sewer system as it implements its Stormwater Master Plan. The first major project at John Marshall Drive and Lee Highway has been completed. We are also increasing the capacity of our sanitary sewer collection system. The following sanitary sewer projects have been completed:

a) A sanitary sewer relief line was constructed downstream of I-395 along Four Mile Run between I-395 and South Glebe Road. This relief line reduces the risk of sanitary sewer backups along South Cleveland Street and along South Four Mile Run Drive just downstream of I-395 (see cluster of green dots just downstream of I-e95 on the attached map).
b) A backwater valve was installed on the local sanitary sewer collection system at the intersection of South Troy Street and South Glebe Road.
c) Approximately 30% of our sanitary sewer collection system has been rehabilitated by cure-in-place-pipe over the past 20 years.
d) A project has been initiated to install bolt down sanitary sewer manhole covers on all sanitary sewer manholes in the 100-year floodplain to help reduce infiltration / inflow in the sanitary sewer collection system.

e) There has been some discussion of measures to protect the Water Pollution Control Plant from the effects of sea level rise and climate change.

Please feel free to contact me if you need anything else.

Thanks,

Allan

Allan J. Rowley

Planner

Stormwater Infrastructure

Office of Sustainability and Environmental Management

Arlington County Department of Environmental Services

2100 Clarendon Blvd., Suite 705

Arlington, VA 22201

(703) 228-6542

(703) 228-7134 (fax)

arowley@arlingtonva.us

USACE Baltimore District
Washington D.C. Reconnaissance-level Evalulation
8/13/2013

Name	**Doug Curtis**
Community / Agency	National Park Service
Title	Hydrologist
E-Mail	Doug_Curtis@nps.gov
Telephone	202 339 8328

Comment

NPS has numerous buildings, roads, and other facilities susceptible to flooding

Return via email to:
David Robbins, David.W.Robbins@usace.army.mil or
Ginger Croom, Croomgl@cdmsmith.com
Or Fax to 617-452-6594

Prince Georges County provided the following documentation:

1) Document : Unified Storm Surge Profile Methodology For the Tidal Portions of the Potomac River
2) Map showing impacted household in Harbour Circle

ATTACHMENT B

USACE State Problems, Needs, and Opportunities Correspondence with Individual State Responses

GOVERNMENT OF THE DISTRICT OF COLUMBIA

District Department of the Environment

Office of the Director

May 9, 2014

Amy M. Guise
Chief, Planning Division
U.S. Army Corps of Engineers, Baltimore District
P.O. Box 1715
Baltimore, MD 21203-1715

Re: North Atlantic Coast Comprehensive Study: District of Columbia Problems, Needs, and Opportunities for Future Planning Initiatives

Dear Ms. Guise:

On behalf of the District Department of the Environment (DDOE), I am submitting specific input on the District of Columbia's (District's) problems, needs, and opportunities related to future planning initiatives with respect to coastal storm risk management and resilience.

The District is at risk of flooding and will face extreme consequences if preventative measures and better coordination among key stakeholders are not in place. With the effects of climate change, sea-level rise and more intense and frequent storm surges will increase riverine and interior flooding in vulnerable areas of the District.

The existing 2011 Federal Triangle Stormwater Drainage Study identified structural alternatives to address flooding in the Federal Triangle area. Further study of the feasibility of each alternative is needed; however, no funding has been identified. In addition, the flood mitigation study for high-density residential neighborhoods along Watts Branch, where 100-year floodplain areas have been identified, is needed to assess existing and future flood risk and provide individual and watershed-wide recommendations and strategies to mitigate flood damages.

The DC Silver Jackets Team, which was recently established, provides an opportunity for future coordination and collaboration in flood risk management and has the capability to support the U.S. Army Corps of Engineers' (USACE's) future planning initiatives in the District.

PROBLEMS:

The District is situated on the banks of the Potomac River, bordering Maryland and Virginia.

Our nation's capital is one of the most densely populated cities in our country and contains vital historical resources, which are at a considerable risk for flood damage.

The District is at risk of both riverine flooding, caused when excessive river water flows into a floodplain area, and interior flooding, caused when stormwater drainage systems are overwhelmed during large precipitation events. Specifically, low-lying areas of the District are near sea level and are subject to major Potomac River floods, hurricane storm surge floods from the Chesapeake Bay, and interior floods.

According to flooding information compiled by the DC Silver Jackets Team,

> *The District has a long history of floods, dating back to the 19th Century. The most significant riverine flood of record was in 1942, when the Potomac River stage reached 17.7 feet. Floodwaters covered Maine Avenue and reached the steps of the Jefferson Memorial. Other major riverine floods occurred in 1936, 1937, and twice in 1996—the latter after Hurricane Fran.*
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> *Tidal flooding in the District also has a lengthy history. In August 1933, the Chesapeake/Potomac Hurricane brought an 11.3-foot storm surge and caused 18 deaths and $79 million (adjusted in 1969) in damages. In 1972, Hurricane Agnes became one of the costliest natural disasters in U.S. history with $2.1 billion in damages. Two lives were lost in Washington, DC as almost 12 inches of rain fell in a 24-hour period. The tidal surge in Agnes was only around 4.5 feet, but when combined with the riverine flooding, the Potomac River stage reached 15.5 feet at the Wisconsin Avenue gauge.*
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> *The worst tidal flood in recent memory was caused by Hurricane Isabel in 2003. The peak storm surge was nearly 8 feet, resulting in a level over 11 feet at Wisconsin Avenue and over 10 feet at Southwest Waterfront. Water levels this high—from freshwater or tidal—have not been experienced since.*

Areas vulnerable to riverine flooding have been identified by District and federal flood risk managers. The Federal Emergency Management Agency produced flood hazard maps, namely Flood Insurance Rate Maps (FIRM), to identify high- and moderate-to-low-risk areas of riverine flooding. In the District and other communities, FIRMs are used to accomplish several measures to prevent flood damage. They can be used to regulate development in the 100-year floodplain, known as the Special Flood Hazard Area; require mandatory purchase of flood insurance; and determine flood insurance premium rates in compliance with the National Flood Insurance Program (NFIP). The effective FIRM for the District identifies multiple residential, commercial, public, and private properties at risk of riverine flooding, as well as neighborhoods along Watts Branch, Oxon Run, Rock Creek, the Georgetown waterfront, and Southwest neighborhoods.

Interior flooding that is due to intense storm events, inadequate sewer and conveyance systems, or both can cause damage to properties, hurt business, disrupt public transportation networks, and require emergency evacuation routes. Examples of interior flooding in the District include the 2006 flood event in the Federal Triangle area and 2012 flooding events in the Bloomingdale and LeDroit Park neighborhoods.

In 2012, intense rainfall events in the District resulted in significant flooding and sewer system backups in the Bloomingdale and LeDroit Park neighborhoods. In response, the Mayor formed a task force to investigate the causes of these long-standing problems and to develop recommendations for actions that may be taken by the District of Columbia Water and Sewer Authority (DC Water), other District agencies, and residents to reduce the future likelihood of flooding and sewer system backups in these neighborhoods. The Mayor's Task Force Report on the Prevention of Flooding in Bloomingdale and LeDroit Park was issued in December 2012 with recommendations on engineering, regulatory, code changes, operation & maintenance, and public outreach components.

The Task Force developed many short-, medium-, and long-term measures to mitigate flooding in these neighborhoods. In the short term, District agencies are coordinating and implementing several programs, including providing home engineering consultation and flood proofing, rebates for backwater valves, and a rain barrel and green infrastructure program. In the medium term, DC Water is implementing significant engineering projects: (1) transforming cells of the abandoned sand filtration facilities at McMillan Reservoir to capture stormwater; and (2) constructing a stormwater storage tunnel under First Street NW, which is scheduled to be complete soon. As a long term measure, DC Water began construction on the $2.6 billion Clean Rivers Project to build large storage tunnels from Blue Plains all the way to these neighborhoods. In 2022, the tunnel system will meet up and tie into the First Street tunnel.

One vulnerable area in the District includes the National Mall, the monumental core, and downtown. USACE constructed the Potomac Park levee system to protect this area. This levee system is located along the Lincoln Reflecting Pool, extending eastward from 23rd Street NW (north of the Lincoln Memorial) to the raised mound on which the Washington Monument stands. It also includes the 17th Street closure system project (17th Street Levee), which is under construction and will provide more secure closure across 17th Street using a post-and-panel barrier system connected to masonry walls that tie into adjacent higher grounds.

Levee closures need to be implemented in advance of a Potomac River or hurricane storm surge flood. During flood events, the levee system requires temporary closing measures at 23rd Street NW, 17th Street NW, P Street SW, and 2nd Street SW (Fort McNair), which currently include sandbags, Jersey barriers, and an earthen dam. Failure, or overtopping, of the Potomac Park levee system could result in billions of dollars of damage, loss of life, and major disruption to numerous federal agencies and the District's City Hall in the Federal Triangle complex, as well as flooding of the National Mall, District agency buildings, and hundreds of residential and commercial properties in Southwest neighborhoods. Through multi-agency coordination and collaboration, the DC Silver Jackets Team is working together to complete all components of the 17th Street Levee project.

No single agency has all the solutions to address the District's flood risk issues, prepare for the impacts of climate change, and build climate resilience. Addressing flooding, which is the most costly natural disaster in the U.S., will be even more challenging due to climate change consequences, such as sea-level rise, hurricane storm surge, and extreme storm events. Each federal agency has its own long-established mission, goals, and approaches. Many agency authorities stop short in addressing flood risk in a holistic approach. Managing flood risk falls

not only under floodplain management, but also emergency management, stormwater management, natural resources management, public health administration, community development, land-use planning, and many other programs within various local and federal agencies.

NEEDS:

Preventative measures, including structural and non-structural, and better coordination among federal and District agencies are needed to protect the District and reduce the risk of costly and dangerous flood events. One major challenge facing the effort to mitigate flood risk in the District is that there is lack of established authority to address flood risk in a holistic approach. There are two areas that USACE's future planning initiative could be considered in greater detail through studies:

(1) Conducting a Feasibility Study of Proposed Alternatives in the 2011 Federal Triangle Stormwater Drainage Study

On June 26, 2006, several days of heavy rain were capped off by a six-hour deluge that caused extensive flooding in the District. Operations, buildings, and infrastructure of key federal agencies, historic landmarks, and tourist destinations within the Federal Triangle were affected. The National Archives, the Internal Revenue Service, the U.S. Department of Commerce, numerous Smithsonian Museums, and Metrorail all suffered damage from the storm and the ensuing high water. In response to this event, several federal, regional and District agencies joined together to fund and support the Federal Triangle Stormwater Drainage Study (Study). DDOE is a member of the Study working group.

The Study, through the interagency working group, examined the effectiveness and cost of six system-wide, structural alternatives:

(1) Capturing stormwater in the upstream watershed through low-impact development, such as green roofs and bioswales;
(2) Storing stormwater upstream of the study area;
(3) Utilizing the 48-inch gravity condensate line at Constitution Avenue;
(4) Collecting and reusing stormwater beneath the National Mall;
(5) Providing a pumping station on the National Mall; and
(6) Constructing a new sewer tunnel to the Main and O Street Pumping Station.

Of the six alternatives analyzed in this Study, the working group concluded that the first three are not able to adequately mitigate an intense flood. The last three alternatives can viably control a high-volume, short-duration flood event and have short- and long-term impacts. They require, however, large capital investments, estimated in the range of $300–$500 million, which has not yet been identified. The Study does not identify a preferred alternative for an area-wide solution. Therefore, it is necessary to conduct further study of the feasibility of each alternative.

(2) Conducting Flood Mitigation Study for Neighborhoods along Watts Branch in Northeast DC

In the northeast corner of the District, neighborhoods along Watts Branch, a tributary of the Anacostia River, have been identified as a high-risk flood zone or 100-year floodplain according to FIRM. These neighborhoods consist of high-density residential and non-residential structures and critical infrastructure with dense and vulnerable population. In comparison between the historic 1985 FIRM and the effective 2010 FIRM, significant areas along Watts Branch were newly identified as a high-risk flood zone. Floodplain or high-risk flood zone areas will likely expand even further with future development in the watershed and the effects of climate change. This means that more residents and property owners will be at risk.

Currently, there is no holistic approach to address flood risk in the neighborhood in terms of structural and non-structural flood mitigation measures. There is a need for a flood mitigation study to look into future condition flood risk, especially the frequency and intensity of coastal storm impact on the neighborhoods, and provide individual and watershed-wide strategies and recommendation to mitigate future flood damages.

OPPORTUNITIES:

DC Flood Risk Management (DC Silver Jackets) Team Effort

There are multiple existing programs within federal, state, local, and tribal governments that can be leveraged to provide a cohesive solution to manage flood risk. Representatives from federal, District, and regional agencies have been meeting approximately every two months since April 2012 to better prepare for floods along the Potomac River. Following Hurricane Sandy, these agencies created a post-Hurricane Sandy, lessons-learned document. Their efforts have made improvements in flood monitoring, flood forecasting, inundation mapping, and public awareness.

These agencies believed that formalizing their existing coordination efforts via the USACE Silver Jackets program would sanction and strengthen the already well-functioning group. Previously named the Potomac River Flood Coordination Group, the DC Flood Risk Management Team, and now DC Silver Jackets Team, this group is focusing on all types of potential flooding in the District.

The DC Silver Jackets Team (Team), which was formally established in March 2014, is dedicated to working collaboratively to develop and implement solutions to flood hazards in the District by combining available agency resources, which include funding, programs, and technical expertise. DDOE, as the floodplain administrator and the NFIP coordinator for the District, is the lead of the Team. For more information on Team members, visit http://www.nfrmp.us/state/factDC.cfm.

The Team established a continuous inter-governmental collaboration that works with other agencies and organizations to accomplish the following:

(1) Facilitate strategic, integrated life-cycle mitigation actions to reduce the threat, vulnerability, and consequences of all types of flooding in the District;
(2) Create or supplement a continuous mechanism to collaboratively solve District-prioritized flood risk issues;
(3) Increase and improve flood risk communication, awareness, and outreach to other organizations and the general public;
(4) Foster leveraging of available resources and information among federal and District agencies;
(5) Provide suggestions for comprehensive flood risk management policies and strategies;
(6) Advocate changes to existing policies and processes that will improve life-cycle flood risk reduction; and
(7) Promote wise stewardship of the taxpayers' investments through the use of benefit-cost analysis.

Four DC Silver Jackets Team task groups are current working together on the following focus areas and priorities:

(1) Potomac Park Levee/17th Street Closure Certification and Accreditation (http://www.ncpc.gov/DocumentDepot/LeveeFactSheet.pdf);
(2) Flood Inundation Mapping Tool for the Potomac and Anacostia Rivers (http://water.usgs.gov/osw/flood_inundation/);
(3) Flood Emergency Planning; and
(4) Flood Preparedness Communication.

Each Team member commits staff time to attend meetings, develop scope of work on projects, and provide in-kind support to complete tasks. The Team's activities will strengthen interagency coordination and collaboration in addressing coastal storm risk management and resilience in the District.

DDOE appreciates the opportunity to be part of the North Atlantic Coast Comprehensive Study and provide specific input related to the District of Columbia's flood risk issues. We look forward to our continued collaboration on this urgent matter. If you have any questions or require more information, please contact Phetmano Phannavong, DC-NFIP Coordinator, at phetmano.phannavong@dc.gov or at (202) 439-5715.

Sincerely,

Keith A. Anderson
Director