Report on Flooding and Stormwater in Washington, DC

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Effects of flooding on 9th Street, NW in downtown Washington, DC in June 2006.

I. Executive Summary

At the September 2006 National Capital Planning Commission (NCPC) meeting, the Commission requested additional information on flooding. This paper provides the requested information and recommends the next steps for reducing the risk of flooding.

GEOGRAPHICAL FLOODING RISK: The District's location at the confluence of the Potomac and Anacostia Rivers, combined with three buried waterways, broad floodplains, and relatively flat elevations, renders it highly susceptible to periodic flooding. A large part of the National Mall and adjacent areas were originally underwater and were filled as L'Enfant's plan was realized. Urban development has increased impervious surfaces, reduced vegetation coverage, and further exacerbated flooding and stormwater runoff through the entire watershed. This problem is especially acute in the National Mall area given its downstream location.

NATIONAL MALL LEVEE: To keep water from the Potomac and Anacostia River systems out of the downtown business district, the Army Corps of Engineers (ACOE) erected an earthen levee along the north side of the mall, running from the Lincoln Memorial to the Washington Monument. This flood control measure relies upon temporary closures of several north-south streets, which constitute gaps in the levee. To make the levee more reliable, ACOE proposes making two of the temporary closures permanent by extending the levee to meet the higher topography to the north. To ensure the continued flow of cross-mall vehicular traffic, the 17th Street closure would remain temporary, but the barrier would be redesigned to improve its effectiveness and ease of assembly. Given the prominent location of the levee on the Mall, ACOE's improvement plan merits a careful assessment by NCPC.

COMBINED SEWER SYSTEM: Downtown DC suffers from inadequate storm sewer capacity making the area especially susceptible to interior flooding. Flooding of the magnitude experienced in June 2006 is costly and can be a security threat if critical building systems are affected and national historic and cultural resources are threatened. While flooding in downtown DC is relatively infrequent, the concentration of key federal agencies and the huge federal, local, and private costs associated with recovering from even periodic floods warrants a close examination of cost-effective solutions. Moreover, future growth will further strain the system's already limited capacity.

REGULATIONS & RESPONSIBILITIES: Numerous laws, policies, and executive orders are in place to reduce property loss and environmental degradation caused by flooding, but Washington, DC poses some unique challenges. First, the division of responsibilities among various federal and local authorities is not always clear or uniform, and federal facilities in the business district must rely on the local DC government to manage, regulate, and otherwise control stormwater. Second, flooding in the nation's capital is particularly unacceptable given the hazards it poses to the security of federal buildings and our nation's treasured historic resources.

POTENTIAL ACTION STEPS: There are a number of strategies NCPC may consider to reduce flooding risks and excess stormwater impacts. First, NCPC may review its own agency's guidelines and policies to increase the level of scrutiny for proposals within or near the floodplains. Second, NCPC may undertake a number of planning initiatives and local and regional partnerships to further evaluate flooding and stormwater issues and research new and innovative measures for stormwater management. Third, NCPC may encourage more proactive stormwater management tactics to improve the water baseline and ensure that future development does not exacerbate the situation. No one solution can eliminate the potential problem entirely, but a strategic combination, weighed by the costs and benefits, could help minimize the risk by lowering the frequency and magnitude of flooding that does occur.

At the February 2007 National Capital Planning Commission meeting, the Commission requested additional information on flooding and stormwater in the Anacostia River watershed. This paper provides the requested information and recommends the next steps.

In general, Anacostia River flooding is less of a threat to the Washington metropolitan region than Potomac River flooding because of the far greater size and reach of the Potomac watershed, and the volume of water carried by the Potomac. However, the Anacostia watershed is far more urbanized than the Potomac watershed and as a result of increased impervious surfaces, channelization of the tributaries, and wetlands destruction, even moderate amounts of rainfall can cause localized stormwater issues. Sedimentation of the Anacostia River is an ongoing problem with much of the dirt and debris originating upstream from Maryland communities. NCPC supports the restoration of floodplain values and functions whenever possible to mitigate the impact of stormwater runoff resulting from increased development and impervious surfaces.

A number of communities along the Anacostia River are protected by levees. Over the past few years, the ACOE inspected these levees and has required a number of

improvements to ensure that the communities behind the levees are protected in the event of a storm. At the same time, Federal Emergency Management Agency (FEMA) has updated the floodplain maps for the District and where the levee improvements have not been completed, the proposed floodplain maps have been revised accordingly. NCPC strongly supports levee improvements and urges the ACOE to coordinate with staff early in the design planning process. Further, NCPC urges FEMA to ensure that floodplain maps for the National Capital Region are updated in a timely manner.

In the past, Anacostia River flooding has been less problematic as most of the waterfront is publicly-owned, and a significant portion used as parkland. Recently however, there have been a number of private and public development proposals submitted for review and approval. All new development is required to determine if they are within a federally-mapped flood hazard area and if so, obtain flood insurance and meet more stringent building code requirements. Further, federal actions and approvals within the floodplain must comply with Executive Order 11988 which was designed to minimize the impacts of development on floodplains.

II. Potomac River Flood Risk Overview

The District is susceptible to four different types of flooding, three of which are caused by excess rainfall or snowmelt, and one by the level of the tide.

- OVERBANK FLOODING

Overbank flooding occurs when the river channels receive more rain than they can handle, or when the river channel is blocked and does not permit the water to flow through.

- URBAN DRAINAGE FLOODING

Urban drainage flooding occurs when the sewer system built to handle stormwater runoff is overloaded past its design capacity.

- LEVEE-CAUSED FLOODING

Areas with levees can be inundated behind the levees because they are relatively flat, and the levee serves as a block to the water flowing to the river. Channels may be built and/or pumps are installed to move the water past the levee.

- TIDAL/STORM SURGE FLOODING

Tidal flooding occurs when there is an abnormal rise in water level preceding a storm, usually a hurricane, due to the combined effects of wind and low atmospheric pressure. The Potomac, up to the base of Little Falls, is tidal, which causes the river to rise and fall with ocean tides. Normal tides have a mean range of three feet, but have been known to surge as much as 12 feet in a hurricane.

Major flooding in the Potomac basin occurred in 1889, 1936, 1937, 1942, and 1972. See Appendix A for detailed flooding history in Washington, DC.

Sea Level Rise

Flooding in Washington is exacerbated with higher sea levels. According to the U.S. Geological Survey (USGS), Chesapeake Bay sea levels are forecast to rise approximately one foot over 100 years.[1] The American Museum of Natural History forecasts that a rise in the Potomac River of one foot, combined with a major storm surge, would make the Jefferson Memorial an island and flood the National Mall up to the Reflecting Pool. Hurricane Isabel (2003) produced much more severe flooding in the region than an unnamed August 1933 hurricane that was similar in its storm track, tidal surge, maximum sustained wind speed, and minimum pressure, possibly as a result of the relative sea rise of one foot since 1933.

Washington's Hidden Hydrology

Washington has historically had at least three major streams—the Tiber Creek, James Creek, and Slash Run. Tiber Creek[2] was the largest stream system in Washington, at one time draining—along with its tributaries—2,500 acres, or nearly 43 percent of the District. Tiber Creek ran south, beginning near the Armed Forces Retirement Home, through the site of Union Station. Near the East Building of the National Gallery, it turned west and roughly ran along Constitution Avenue for the length of the National Mall. At the base of the White House lawn, where it met the Potomac River, the Tiber was between 700 and 800 feet wide.

James Creek, in Southwest Washington, DC, formed near where the Tiber turned west, and flowed southeast along South Capitol Street, broadening into a marshy area and into the Anacostia River near Fort McNair. Slash Run was a tributary of Rock Creek and ran roughly south down 18th Street, NW and entered Rock Creek near 23rd Street, NW. [3]

The mouth of the Tiber Creek showing that the White House south lawn, Federal Triangle and Mall areas once were all under water.

By the 1870s all three waterways were essentially open sewers and were impounded. The DC Board of Public Works embarked on a massive sewer construction program by enclosing the creeks[4]. Washington's present-day hydrologic problems have their roots in the burial of the

[1] The observed Chesapeake Bay sea level rate of increase is roughly twice the global average.

[2] Local farmer Francis Pope is credited with renaming Goose Creek as Tiber Creek, a more grand designation to better suit his 400-acre farm that he dubbed "Rome."

[3] Note the historical points at which these waterways enter Washington's Rivers; they indicate the critical points where the ACOE levee protects downtown DC from floodwaters.

[4] Sadly, this massive sewer capital improvement system led the District into bankruptcy and caused Congress to take over control of the city. The city was run by a Board of Commissioners appointed by the President until 1974, when, under the 1973 Home Rule Charter, the city elected a Mayor and City Council.

natural drainage system. Areas in the city plagued by chronic water problems can be located by the original drainage system maps. In 1992, the DC Water Resources Research Center reported that the gravelly deposits of the old creek beds still act as conduits for water, with the result that groundwater routinely infiltrates sewer pipes and building foundations along the former waterways.

June 2006 Flooding

On June 19, 2006, a wet weather pattern started in Washington. Soon thereafter, from June 25 through June 27, intense tropical downpours inundated the District. The heaviest rainfall fell from early evening on Sunday, June 25, through the early morning hours of June 26, with a total recorded accumulation of 7.09 inches on June 25.

The extensive flooding shut down operations at four key federal office buildings—IRS Headquarters, the Commerce Department, the Justice Department, and the National Archives. Several Smithsonian museums along Constitution Avenue also closed their doors. The National Gallery of Art closed due to a weather-related steam outage, and the National Zoo banned cars because of flooding in the parking lot. Rock Creek Parkway became impassable and had to be closed when Rock Creek overflowed its banks and flooded the road.

National Archives Building

Constitution Avenue flooded on Sunday evening, June 25. Rainwater poured down the driveways of the 7th and 9th street sides of the building and flooded the transformer vaults and the subbasement areas. The two transformer vaults were submerged in up to eight feet of water.

The freshly renovated (2004) William McGowan Theater, located under the Constitution Avenue steps, was also significant damaged. Flood water flowed down the theater steps, submerging the stage and the first two rows of seats. Electrical power went out immediately, but the sprinkler and security systems remained operational. Sump pumps continued to operate because of the emergency generator, but they were overwhelmed and had no place to pump the water. Fortunately, no original records were affected by the flood.

IRS Headquarters Building

The IRS Building sustained the greatest amount of water damage, most likely because it has the lowest elevation. Rainfall flowing down Constitution Avenue spilled into the moats surrounding the building. The IRS subbasement, which holds all of the building's electrical and maintenance equipment such as electrical transformers, electrical switchgears, and chillers, was submerged in over 20 feet of water. Virtually all major building systems were affected and most of the equipment either had to be extensively rebuilt or replaced.

The basement flooded with five feet of water. The fitness center, cafeterias, offices, systems furniture, carpet, ceiling tiles, computer equipment and vehicles garaged in the building were all destroyed.

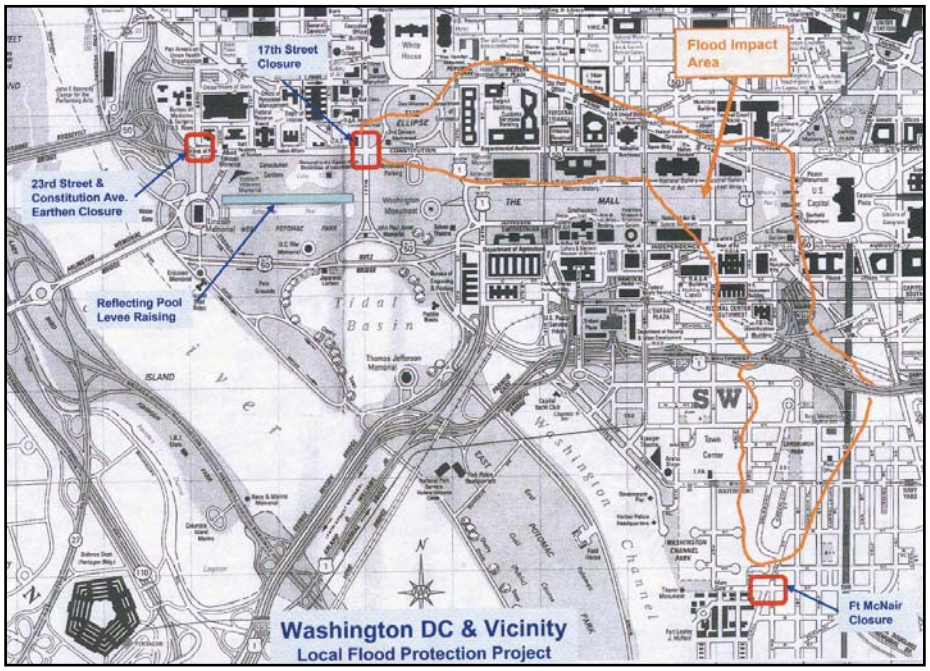
Other Flooded Federal Buildings

The Smithsonian's Natural History Museum, American History Museum, the Smithsonian Institution Building and the Castle also were closed. PEPCO shut off power to those large government buildings because some basements containing electrical switch gears were flooded, and the buildings all share the same electricity network. The National Gallery of Art also closed because flooding cut off the building's steam supply, which maintains air humidity levels necessary to preserve the artwork.

Causes of the June 2006 Flooding

Shortly after the June flood, the General Service Administration (GSA) retained an independent, private consultant to ascertain its causes and to recommend solutions to prevent future flooding. The study was recently completed, although the results are not public. GSA summarized the report so that we could include the consultant's initial findings here.

In short, after interviewing DC WASA, the GSA consultant was unable to determine conclusively why the Federal Triangle area flooded so badly and so quickly. DC WASA was unable to provide an explanation as to why the flooding occurred. In categorizing the rain event, the consultant determined that over a 24-hour period the rainfall was equivalent to the expected rainfall for a 50-year storm event. However, over the most intense 6-hour period of the storm, the rainfall was equal to a 200-year storm. The capacity of the DC sewer system in the Federal Triangle area is unknown, as it was constructed before such standards were typically adopted.[5] As a result, it would be easy to conclude that the storm exceeded the capacity



This ACOE map depicts the area of Washington, DC protected by the National Mall levee.

of the sewer. However, the consultant noted that flooding started before the rainfall should have exceeded the sewer's capacity. In addition, when the flooding dissipated, it also did so at a speed greater than what would be expected.

Power outages caused the 12th Street pumping station to be inoperable, but DC WASA concluded that while a fully-functioning pumping station would have offered some relief, it would not have completely ameliorated the severe flooding. The main pumping stations were operational during the entire storm. The Potomac River remained below flood stage during the entire storm, so backflow was not a contributing cause to the interior flooding.

In summary, the flooding may have been caused by the extreme intensity of the rainfall over a very short period of time, but no one can be sure. The report to GSA includes recommendations for future flood prevention at each of the buildings that flooded. The report and these recommendations are under consideration by GSA management.

III. Existing and Proposed Flood Control Measures

River Overbank Flooding Measures

Washington, DC is particularly susceptible to overbank flooding in Potomac Park, along the Tidal Basin, and over the National Mall area up to the Reflecting Pool. These areas have the lowest elevations in DC. Most of the area with the highest risk of river overbank flooding is parkland under the jurisdiction of the National Park Service (NPS).

National Mall Levee

As a result of the 1936 Great Flood in Washington, Congress passed the Flood Control Act of 1936, which authorized the ACOE to design a solution to overbank flooding on the National Mall. In response, ACOE used landfill from the Reflecting Pool to create a levee between the Lincoln Memorial and the Washington Monument. The project began operation in 1940 to protect against a flood discharge of 700,000 cubic feet per second (cfs) on the Potomac River.[6]

[5] Well after most of the sewers in downtown were constructed, DC WASA's predecessor agency established a 15-year storm as the design standard for the system. New sewer construction is designed to this 15-year standard.

[6] It is estimated that the Potomac River's discharge during the 1942 Great Flood was 450,000 cfs when the maximum flood stage was attained. The maximum discharge of record for the Potomac River is 484,000 cfs, which occurred in March 1936. ACOE estimated that an overbank flood of 700,000 cfs has a larger percentage chance of annual occurrence (two percent) than the 15.0-foot tide, which has less than a one percent change of annual occurrence. Consequently, Congress deemed that the ACOE Washington, DC flood control measure (the levee) should be built to the 700,000 cfs design standard. According to USGS, the maximum tidal gauge height was recorded at 17.72 ft (DC MLW) on Oct. 17, 1942.

According to ACOE, a considerable portion of the levee was removed during World War II for Navy Department construction. Consequently, it is necessary to construct as much as 1,500 feet of temporary levee in three segments in the event of a major overbank flood to provide protection to the height of the permanent works now in place. See the map on page 5, which illustrates the areas protected from flooding by the current levee when the temporary closures are in place.

Washington flooded again in 1942. Congress then passed the Flood Control Act of 1946, which authorized improvements to the levee to restore the level of protection and improve the levee's operation. The levee's overall effectiveness depends on implementing the 1946 improvements; however, ACOE has not completed the improvements because Congress has not funded them. At present, the project is unable to provide the level of protection it was designed to provide because in a flood emergency the levee's effectiveness relies on timely, complete, and correct construction of the three temporary barriers.

Washington, DC Emergency Flood Procedures

In the event of a storm, National Weather Service (NWS) forecasts are posted on the Washington Area Warning Alert System (WAWAS) and the National Oceanic and Atmospheric Administration (NOAA) Weather Radio whenever a Potomac River Stage of 7.0 feet mean low water (MLW) or greater is predicted at the Wisconsin Avenue gauge. Currently, the National Park Service (NPS) is responsible for the 23rd Street and 17th Street temporary closures in the National Mall levee.

23rd Street Closure: NPS is to construct the emergency levee at 23rd Street when the Potomac River Stage of 19.0 MLW or greater is predicted at the Wisconsin Avenue gauge.

17th Street Closure: NPS is to construct the temporary levee at 17th Street. The 17th Street closure consists of two structures constructed in two phases. Phase One is a 3-foot high jersey wall barrier with sandbags and plastic sheathing and is triggered when the Potomac River is projected to rise to flood levels over 10.4 feet MLW. Phase One can be put into place relatively quickly, and provides protection up to 15.42 feet MLW. Phase Two is a temporary earth levee located 50-feet north of the Phase One closure and should be initiated immediately after the river exceeds elevation 11.42 feet MLW. Phase Two construction is complex and requires significant construction equipment and embankment material and has the greatest potential for failure.

Fort McNair - The DC Emergency Management Agency (EMA) is responsible for the Fort McNair sandbag closure at P and Canal Streets when the Wisconsin Avenue river stage exceeds 23-feet MLW.

Proposed National Mall Levee Improvements

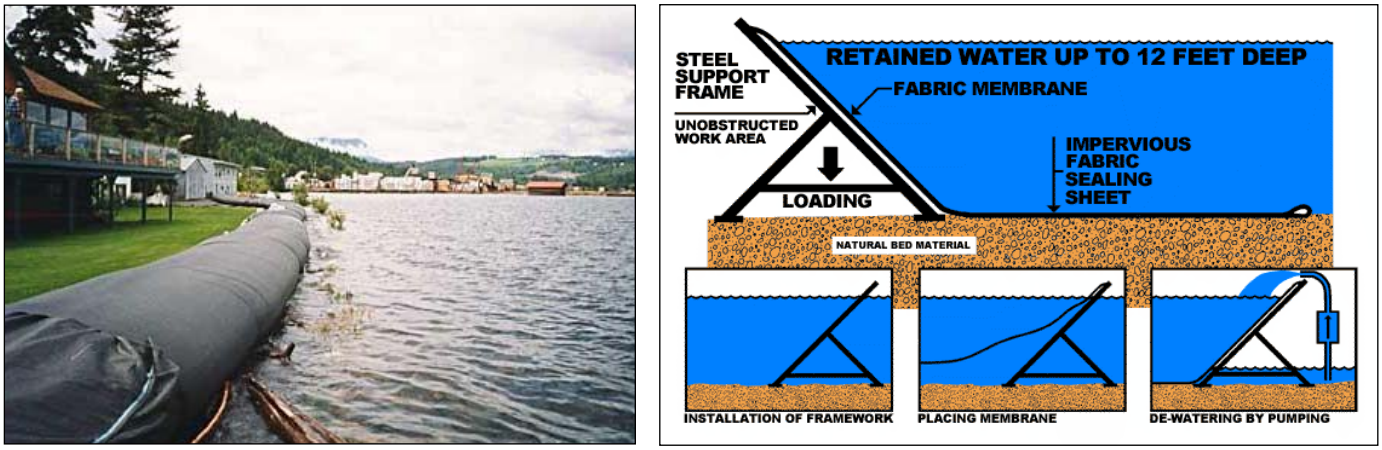
In 2000, ACOE proposed making the temporary closures at 23rd Street and Fort McNair permanent to improve the levee's design and reliability. At 23rd Street, the Corps proposed a 600-foot earth embankment with a maximum height of 3 feet that would run along 23rd Street until it met the existing embankment for the Route 50 ramp. The topographic modifications would then complete the protection line at 23rd Street. At Fort McNair, the Corps proposed a permanent earth berm that would be 1.2 feet high and extend for 570 feet.

The closure at 17th Street, NW remains temporary, but will be redesigned to improve its reliability and minimize the construction time needed during floods. Presently, there are a number of options being considered. One alternative is a "borrow pit." The Corps would excavate a portion of the Mall near 17th Street so that the hole could be refilled with aggregate material. During a storm event, NPS staff would excavate that specific location of fill and use it to create an earthen dam across 17th Street. A second alternative is an inflatable dam, known as an aquadam [See below]. A third similar option is a cofferdam, which is an A-frame structure that is erected with a light-weight steel frame and covered with a plastic membrane. [See below] Last, the Corps is considering a "post and panel" temporary dam.

The Corps also proposes to fortify the portion of the levee along the Reflecting Pool by eliminating low spots.

When all of the modifications are complete, the levee would have less than a one percent chance of being overtopped in any one year. The modifications will bring the top of the existing levee along the Reflecting Pool (between 23rd and 17th Streets) to a uniform elevation and increase the level of freeboard[7] protection provided.

[7] "Freeboard" is the vertical distance between the normal maximum level of the water surface in a channel, reservoir, tank, canal, etc., and the top of the sides of a levee, dam, etc. It is provided so that waves and other movements of the liquid will not overtop the confining structure.



The pictures above depict temporary dams, an inflatable dam (left) and a port-a-dam (right).

ACOE is waiting for Congress to appropriate construction funding for the project. The estimated total cost is $7 million; the project has received just over $3 million in prior funding. ACOE estimates that without the levee closures a major flood could cause more than $200 million in damages to museums, memorials, and office buildings. The flood control project requires NCPC review and approval.

ACOE has not yet completed final designs or construction plans for the two permanent closures and the enhanced 17th Street temporary closure. However, given the levee's prominent location along the National Mall, staff believes ACOE's plans will warrant a close review to ensure that the proposal does not adversely affect the National Mall and its environs.

Urban Drainage Flooding

Urban drainage flooding is typically caused by sewer overflows and thus is the responsibility of the DC government.[8] One-third of the District, including the entire downtown business district, has a combined sanitary and storm water system.[9] In other words, a single pipe carries both raw sewage and stormwater to the Blue Plains treatment facility. When it rains, the combined wastewater flow can easily exceed the capacity of the combined sewer system and/or the treatment facility.[10] Two harmful things can occur if the capacity of the system is exceeded.

First, excess stormwater causes untreated wastewater to flow directly into nearby rivers. Such discharge of the untreated stormwater is a violation of the Clean Water Act and consequently, the District is under a consent decree to construct storage tunnels to hold the excess untreated water. The consent decree imposes a 20-year implementation schedule for construction to be complete; however, funding is a significant issue.[11]

The project is estimated to cost $1.9 billion and current proposals provide that the entire cost be borne by the ratepayer base. Presently, DC WASA's storm-related activities are funded solely through water and sewer fees.[12]

DC WASA estimates that to finance baseline capital improvements and maintenance, in addition to the long-term plan for the combined sewer overflow (CSO), rates would need to rise annually, with at least eight rate increases above 10 percent per year for DC WASA to raise sufficient capital. DC WASA has calculated that if it receives 62 percent of the capital costs (approximately $960 million) from external sources (e.g. the federal government) that the agency would likely be able to keep rate increases at no more than 8 percent per year. Congress has made a number of dedicated appropriations to DC WASA that currently amounts to approximately $35 million.

Second, excess stormwater may be so great that that the sewer system can not even collect it, and then it floods the streets. The storage tunnel solution described above would not prevent street flooding caused by excess rainfall because the capacity of the sewers under the streets

[8] DC WASA sent comments to NCPC's draft report, noting that "urban flooding can be caused by many factors including: improper grading; inadequate location, number or size of catch basins; clogged catch basins; inadequate sewer capacity, and storms which exceed the design capacity of the system. Some of these are the responsibility of the DC Government, while others are the responsibility of DC WASA or private landowners. Other factors are caused by nature and are not the responsibility of any entity."

[9] Combined sewer systems, introduced in 1855, were a vast improvement to the open cesspools originally used to convey wastewater, and are common in most older cities. As a result, many cities still struggle with the attendant pollution from combined sewer overflows.

[10] Combined sewer overflows (CSOs) should occur only during wet weather. However, according to DC WASA's overflow predictions, in an average year, less than 0.5" of rain can cause more than 3 hours of untreated sewage to flow into the Anacostia River. Such an occurrence is predicted to occur more than 50 times in an average year.

[11] The consent decree was entered March 23, 2005.

[12] Typically, in other cities, the costs of municipal stormwater programs are funded through a combination of real property taxes, general revenues, and user fees.

remains unchanged.[13] The storage tunnel merely holds the water for future treatment once it is in the system; not increase the actual capacity of the old receiving sewer tunnels.

One additional predicament is that when the river level rises above the outfall pipes, water can back up into the system and cause reverse flooding. This should be resolved by the gates that DC WASA installed at the outfall pipes, but there have been problems with the gates in the past either being open during a storm or not functioning completely. The tide gates at the outfall pipes specifically prevent backflow of river water to Blue Plains Wastewater Treatment Plant during high river levels. This protects the plant against treating extraneous river water. However, tide gates are not typically relied upon to protect life or property during river floods.

In those situations, a positive means of shutting off flow is used, such as sluice gates or stop logs. For example, in the current ACOE Flood Emergency Manual for DC, locations are identified where stop logs are to be inserted in sewers to prevent backflow during river floods.

ACOE developed a map to illustrate the areas that would experience street flooding in a storm event that produced rainfall greater than what the sewer system could handle. The ACOE map below delineates the flooded areas corresponds almost exactly to the areas that flooded in June 2006. Consequently, it appears that interior flooding is a separate, persistent issue that needs a separate solution.

Tidal Flooding Measures

Washington is also susceptible to tidal flooding and tidal surges. Tidal flooding in the Potomac River can be caused by hurricane tidal surges that form in a number of ways. The surges produce the highest water levels in the upper Potomac when they coincide with the astronomical high tide.

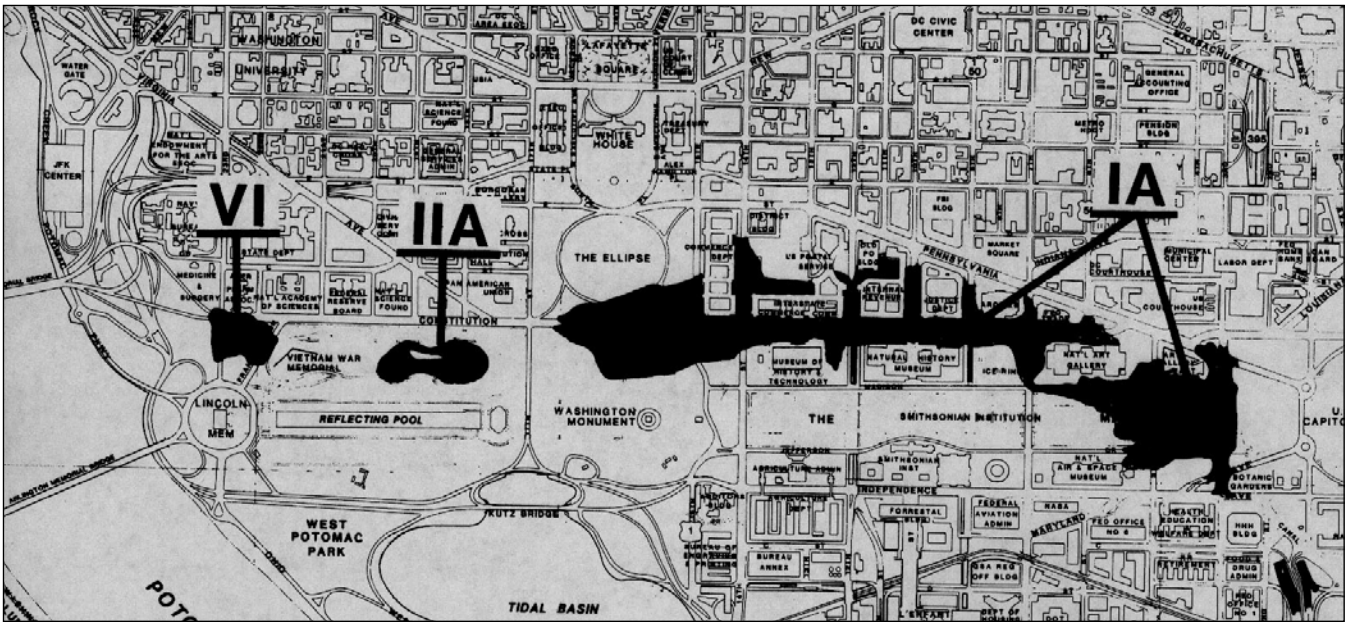
In 1955, a year after three successive hurricanes ravished the northeastern seaboard, Congress directed ACOE to evaluate cost effective structural measures to reduce the human and property losses from future hurricanes. ACOE prepared a report that evaluated the risk of tidal flooding in the Washington, DC metropolitan area and concluded that while the area was vulnerable to severe damage from hurricanes, the relief from tidal flooding by structural means could be accomplished by protective works needed for overbank flooding control.

The report concluded that effective zoning was the most important solution for reducing flood hazards:

The continuing encroachment on the tidal flats and floodplains of the Potomac River in the Washington area has seriously reduced the capacity of the stream to pass fluvial floods and absorb tidal floods without losses. Zoning regulations to stem the encroachment on the waterfronts and to establish future structures at safe elevations are needed.

ACOE has not reevaluated Washington tidal flooding since the original report, completed more than 50 years ago.

1990 ACOE MAP SHOWING AREAS OF RESIDUAL FLOODING



[13] For the Northeast Boundary area, the proposed CSO tunnels have a dual purpose: CSO control and flood relief. The LTCP is designed to provide flood relief to known flood areas in Northeast Boundary.

Flooding Conclusions

The most frequent types of flooding in Washington, DC are the consequences of river overflow and urban drainage failures. Excess stormwater can trigger either type of flooding, but they occur independently. Overbank flooding is an easier risk to manage because fairly reliable warning systems typically provide longer lead times before the flooding begins. For example, the average rate of flood crest travel time from Point of Rocks, MD to the Wisconsin Avenue gauge is approximately 11 hours. Urban drainage flooding, however, provides emergency workers with less advance warning since the onset of urban flooding is harder to pinpoint reliably, as illustrated by the June 2006 flood.

A number of factors unique to DC make flood control and stormwater management more vexing. First, while many of the riparian areas in DC are parklands that retain some of their natural floodplain functions, many priceless monuments, museums, and national structures are located in areas likely to flood. Many monuments are designed to withstand intermittent flooding, but clean-up can be costly and the impacts of repeated flooding may compound over time. For other structures, flooding can be devastating and irreversible, as would have been the case at the National Archives if the agency had been unable to mitigate the June 2006 flooding.

Second, the federal government is the largest developer, tenant, and property owner in downtown DC. This creates a significant federal interest in the cause and effect of flooding.

Moreover, a significant amount of stormwater in this area is routinely generated through runoff and de-watering at federal facilities. The federal government may, over time, be able to address some of the issues of peak period and overall runoff through individual and coordinated design and operational actions. These actions may also support larger federal goals supporting green building and environmental objectives.

Lastly, the responsibilities and jurisdiction for addressing stormwater and flooding in the District, and specifically in the downtown area, are complex. Many possible solutions, whether structural changes to the sewer system, or using low-impact development or green building design strategies, are costly or beyond the ability of a single jurisdiction to require. Therefore, developing coordinated and comprehensive strategies will require coordination between federal and local agencies alike.

IV. What is the Federal Role in Flood Prevention and Stormwater Control?

The full panoply of floodplain laws, regulations, executive orders, policies, and agency guidance, implemented over the past 100 years on federal, state, and local levels, is complex, comprehensive, and somewhat disjointed. [See Appendix C for a chart of the relevant federal laws.] The National Flood Insurance Program (NFIP), implemented by FEMA, is the most well-known federal flooding statute. The 100-year floodplain maps and the federally-mandated and subsidized insurance program are the hallmark of NFIP. However, there are a number of other federal statutes and requirements that also play a role and these are discussed in more detail below.

In addition to federal laws and regulations, the District has its own responsibilities and rules. Some of the local rules are federal requirements, such as the building regulations for construction in a FEMA-designated floodplain, while others, such as the Anacostia Waterfront Initiative's stormwater regulations, are entirely local requirements.

National Flood Control

NFIP is the key federal statute with regard to flooding. Under NFIP the federal government accepts a significant share of the responsibility for flood prevention, control, emergency response, and property loss. The statute's underlying principle is that there should be development restrictions within the floodplain for the dual purpose of reducing flood damage losses and minimizing disruption to the floodplain's natural function of storing excess water and draining water over land areas and into the floodway.[14] NFIP directs FEMA to develop maps nationwide that delineate the floodway and the floodplain.[15] A Flood Insurance Rate Map (FIRM) is the official map on which FEMA has delineated both the special flood hazard areas and the flood risk premium zones applicable to the community. Structures built before the FIRM or before 1975, whichever is later, are eligible for flood insurance with premiums that are reasonable, and if necessary, federally-subsidized.[16]

[14] "Floodway" means the regular channel of a river, stream, or other watercourse, plus the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

[15] "Floodplain" means the low area of land surrounding water bodies that holds the overflow of water during a flood.

[16] "Consequently, NFIP is one of the largest domestic fiscal costs along with Social Security, Medicare and Medicaid.

Typically the maps are developed in conjunction with the local government. Buildings within the floodplain must obtain private flood insurance. Flood insurance eligibility is based on communities adopting development restrictions that meet minimum federal requirements.

FEMA 100-Year Floodplain Maps

An enduring problem nationwide is that the FEMA-issued flood insurance maps are out-of-date. The District maps are approximately 21-years old.

The DC Department of the Environment (DCDOE) and FEMA are digitizing the 1985 DC floodplain maps. Once the maps are complete, the agency will schedule a public hearing and then they will be sent to the DC City Council for adoption. The process that leads to final adoption can last as long as a year. Once the maps are adopted, new flood insurance requirements become effective.

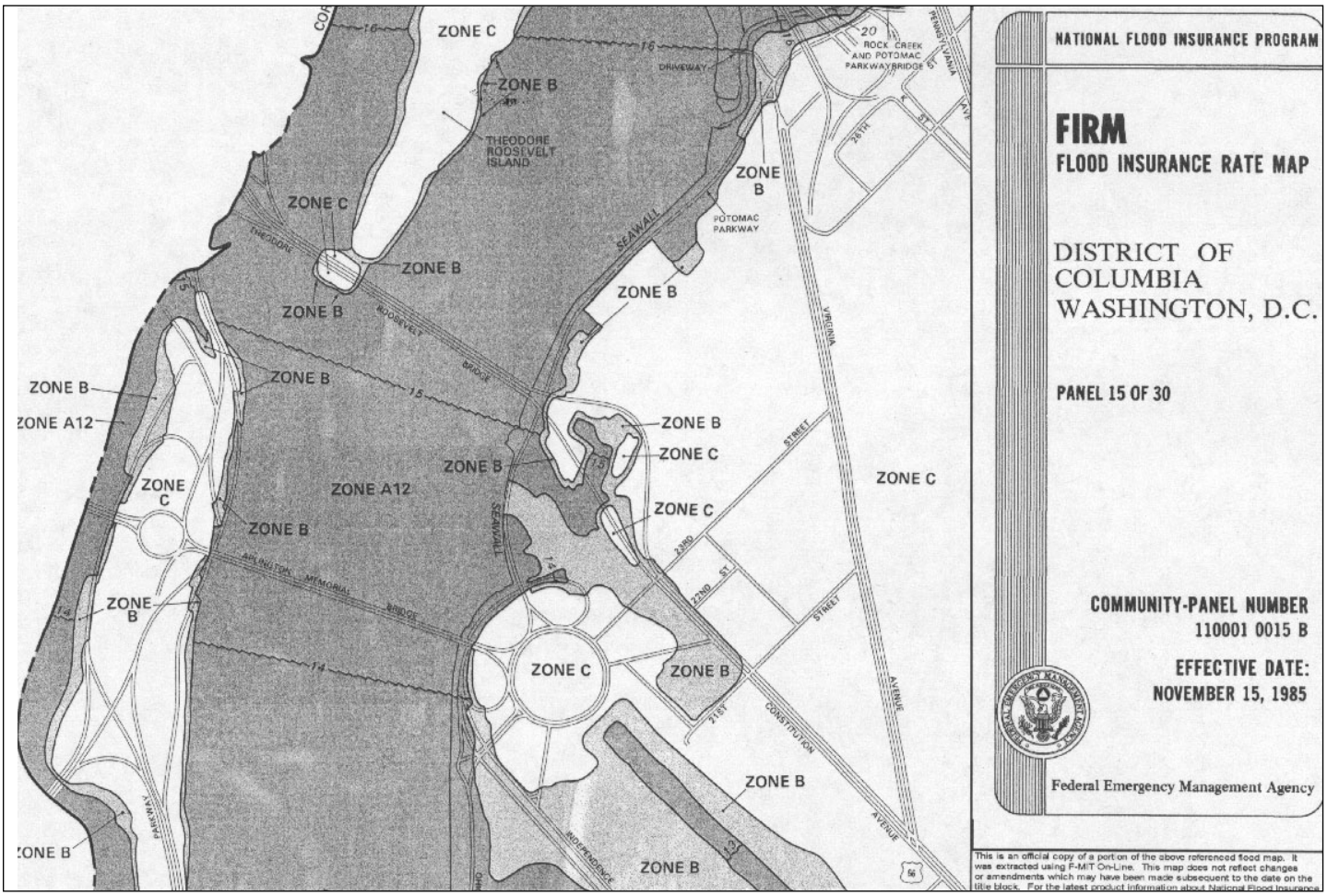
Development and impervious surface coverage within the watershed has been sizeable, which could also easily require a change in the delineation of the floodplain area. In March 2005, the Maryland Department of the Environment completed a study determining that:

In flat areas, structures located within several hundred feet or more horizontally of the 100-year floodplain line may also be at risk.[17]

However, the DC floodplain delineations will not be revised to reflect any changes in sea level or development in the watershed as part of the digitalization process. The DC Flood Emergency Manual contains maps prepared by the Corps delineating the area ACOE predicts will flood for the 100-year storm. (See Corps map that is attached to the report.) The inundated area is larger than the FIRM's 100-year boundary, and more closely corresponds to the FIRM's 500-year floodplain line.

DC 1985 Flood Insurance Rate Map

ZONE A: Would flood in 100-year event ZONE B: Would flood in 500-year event



[17]Emphasis added.

Executive Order for Floodplains

In 1977, President Carter, faced with ever increasing flood costs, issued Executive Order (EO) 11988 to hold federal agencies to a higher standard than the NFIP rules.

Executive Order 11988 affirms that the federal government should not encourage floodplain development in all of its actions and funding mechanisms. The President's statement that accompanied the EO noted that flood losses and adverse alteration to floodplains arise mainly from "unwise land use practices." Further, it states, "Floodplain development … is simply a bad Federal investment and should be avoided." The EO required all executive branch agencies to develop compliance procedures. As a result, on September 17, 1981, NCPC adopted floodplain management procedures that apply to all actions that "have the potential for adversely impacting floodplains…or which are subject to potential harm by location in floodplains." According to the procedures, if NCPC finds that an action meets the above test, then the Commission is required to (1) identify the full range of potential direct or indirect adverse impacts, and (2) identify and evaluate practicable alternatives outside the floodplain including the "no action" alternative. The procedures require public notice for any plans, proposals, or actions in floodplains followed by a 30-day review and comment period. A Statement of Findings is required for all plans, proposals, or actions in floodplains and must include why the action is proposed to be in the floodplain; whether the action conforms to applicable state and local floodplain management standards; the list of alternatives considered, a list of mitigation measures; and a map delineating the proposal's location and its relationship to its environs.

NCPC's procedures also amend NCPC submission guidelines for federal agency projects to require a copy of the submitting agency's Statement of Findings pursuant to EO 11988 if the proposed project is within a floodplain.

In theory, the National Environmental Protection Act (NEPA) environmental review can satisfy the EO's requirements. However, to avoid floodplain harm, the EO requires more affirmative action than NEPA.

The National Environmental Protection Act

The NEPA also plays a role in flooding, floodplain management, and stormwater control. NEPA requires federal agencies to assess potential environmental impacts before undertaking any federal building projects or site changes that significantly affect the quality of the human environment. The environmental review should discuss whether any proposal would be affected by flooding, as well as whether the proposed action would likely increase flooding. Floodplain development is typically scrutinized more closely for adverse impacts than development outside the floodplain. Stormwater runoff and its potential impacts are also likely to be part of an environmental review assessment. In general, the submitting agency is responsible for ensuring that a thorough and comprehensive environmental assessment is completed for each proposed action, and that alternatives are considered, before final action is taken. However, as a federal agency, NCPC has an independent obligation under NEPA to assure this information is available before it makes any decisions about a project. Moreover, when analyzing the proposal and alternatives, federal agencies must consider the direct or indirect consequences—that is, connected, similar, and cumulative actions. These actions should be incorporated into the description of the proposal and alternatives.[18]

The Clean Water Act

The Clean Water Act (CWA) regulates stormwater discharges from industrial activities (which include construction activities and municipal sewer system discharges) under the National Pollutant Discharge Elimination System (NPDES) permit program. NPDES regulates water quality. Municipal sewage system operators, private developers, and the federal government are all required to comply with the NPDES permitting program.[19]

EPA administers the CWA and NPDES program and in many instances delegates permitting authority to the states. However, the District is not a delegated state and EPA retains NPDES permitting authority with regard to both construction activities and municipal sewer discharge in DC.[20] For construction, stormwater runoff is regulated both during construction and after construction is complete. Consequently, a developer in DC is required to prepare a stormwater pollution prevention plan in accordance with the EPA General Permit, submit the

[18] For an EIS, 40 CFR § 1502.16 which incorporates the definitions from 1508.7 and 1508.8 and for an ES, 1508.9(b) which also incorporates the definitions from 1508.7 and 1508.8. Also, see generally NCPC Environmental Submission Guidelines Section 10 and Appendix B, Section 3(A).

[19] The CWA specifically mandates that all departments or agencies of the executive, legislative, and judicial branches of the federal government comply with Federal, State, interstate, or local stormwater regulations. Further, EO 12088, "Federal Compliance with Pollution Control Standards," directs each executive agency to develop annual plans for the control of pollution and to ensure that sufficient funds for compliance are requested from OMB in the agency budget.

[20] In fact, the consent decree for the sewer storage tunnels was developed to settle an enforcement action brought by the United States against DC WASA because it is in violation of the NPDES permit EPA issued to it.

plan to EPA, and file a notice of intent to start construction. The stormwater plan governs runoff for the period of construction and then for the building once construction is complete.

Review of National Capital Planning Actions

Staff reviewed a number of executive director's reports and environmental documents prepared for projects in the monumental core to better understand how flooding and stormwater issues have been considered. While many, but not all, of the documents do include information on stormwater and flooding issues, the analyses have not always been consistent in either the range of issues reviewed, the scope of the evaluation, or the final conclusions reached. Further, the analyses that we reviewed focused on specific impacts to projects, and there was typically little discussion on how development might increase the likelihood of flooding. We have not identified any documents discussing the cumulative impact of development on stormwater and flooding in this area.

In addition, to assist our review, the National Park Service provided details to NCPC on how a number of memorials located within or near the floodplain have dealt with potential flooding issues (See Appendix B). We also spoke with a number of federal agencies regarding flooding and stormwater, and found that all of the agencies were aware of flooding and stormwater issues specific to their own facilities. Many of the agencies expressed an interest in better understanding how other agencies were addressing flooding and stormwater, as well as looking more comprehensively at the issue in the downtown area.

V. What is the District of Columbia's Role with Regard to Flood Prevention and Stormwater Control?

District Stormwater Laws and Requirements

In the District, stormwater management is a responsibility shared jointly among four District agencies: the DC Department of Health (DC DOH), the DC Water and Sewer Authority (DC WASA),[21] the DC Department of Public Works (DC DPW),[22] and the District Department of Transportation (DDOT). Recently, DC DOH's flood and watershed responsibilities, including stormwater, were transferred to the newly formed Department of the Environment (DC DOE). In February 2007, DC DOE will take over all responsibilities of managing the MS4 permit-related activities (described below) that DC WASA previously handled.

DC DOE is responsible for monitoring water quality in the Anacostia and Potomac Rivers. DC DOE is also responsible for reviewing developers' plans for compliance with DC's stormwater management and erosion and sediment control regulations, monitoring implementation with management plans through inspections, and investigating illegal discharges to the sewers. Developers cannot obtain a building permit from the Department of Consumer and Regulatory Affairs (DCRA) until DC DOE ascertains that the developer has complied with DC stormwater rules. Construction activities that do not disturb more than 5,000 square feet of land area are exempt. Federal agencies follow the same procedure as private entities to comply with DC's stormwater rules. Federal agencies, such as GSA, submit their stormwater management plans to DCRA for DC DOE to review and approve the plan, even though GSA does not ultimately need a local building permit.

Stormwater plans must meet several requirements, including an important directive that stormwater flow from the site will not increase after development over the pre-construction baseline.

DC WASA is responsible for maintaining the District's sewer system, and cleaning the catch basins.

DC Floodplain Requirements

The District promulgated development regulations, known as the DC Flood Hazard rules, for buildings proposed to be constructed in a floodplain.[23] These rules, mandated by NFIP for a community to be eligible for federal flood insurance, restrict uses, activities, and development in areas subject to flooding (generally within the 100-year floodplain). If development is permitted in an area likely to flood, it must be flood-proofed. The Flood Hazard rules are triggered when an applicant seeks a building permit in the District.

[21] Unlike the other three agencies, DC WASA is an independent authority that was formed to assure that the money collected for the purpose of maintaining the water and sewer system would not be transferred into the DC General Fund.

[22] DC DPW's responsibility is primarily street sweeping, waste collection, litter control, and road repair.

[23] As approved by FEMA.

DC Clean Water Act Requirements

The District is required to obtain two NPDES permits for its stormwater discharge as a municipality: one for the Municipal Separate Stormwater Sewer System (MS4) which drains storm water from approximately two-thirds of the city into the rivers, and one which covers the Blue Plains Wastewater Treatment Plant and the combined sewer system.

Anacostia Waterfront Initiative

The Anacostia Waterfront Corporation (AWC) had proposed additional stormwater requirements that are stringent and comprehensive. AWC proposed that any development that receives AWC financing or is on AWC-controlled property must adhere to stringent stormwater guidelines, which require retention and on-site reuse of stormwater. Since the initial publication of this report, the AWC was absorbed into the District Office of Planning. The federal government's stance on the more stringent guidelines has not yet been determined.

DC Flood Emergency Plan

Atypically, the ACOE developed the Flood Emergency Plan for the District. Generally ACOE is responsible for developing emergency flood plans for the dam structures; while the local government entity is responsible for developing a local flood emergency plan. The first DC plan was developed in the late 70s and is revised periodically. [24]

ACOE is responsible for flood control measures nationwide, and consequently has designed and provided construction oversight of the National Mall levee since Congress authorized it. FEMA recently asked ACOE to certify the levee as the line of delineation for the 100-year flood event. The significance of this certification is that private development on the other side of the levee (in the downtown district) would not need to obtain flood insurance and would not need to meet the DC Flood Hazard regulations.[25] While ACOE has not responded officially in writing, ACOE stated it will not certify the levee to FEMA because it believes the temporary closures do not sufficiently ameliorate the flooding risk. Once the ACOE decision is transmitted in writing it is likely that there will be increased pressure on Congress to fund the permanent levee closures so that ACOE can certify the levee and exempt private development from needing flood insurance and flood-proofing requirements.

With or without the ACOE proposed modifications, urban drainage flooding nonetheless remains an unmitigated flooding risk.

VI. Next Steps/ Action Plan for Monumental Core

In short, our research led us to three key conclusions. First, while the definitive cause of the June 2006 flooding may not be determinable, the rainfall totals in Washington, DC, were extraordinary and at times equal to a 200-year storm event. However, even though the rainfall was much greater than normal, it exposed our second finding—that flooding poses a risk to the federal government in the Federal Triangle and National Mall areas. Flooding is a risk to the national cultural and historic resources in the area, a financial risk for the property damage, and a security risk given the concentration of key federal functions. Last, even in amounts far below flood stage levels, stormwater control is an ongoing issue for which there is not a long-term federal or local management plan in this important area. NCPC could play a leadership role in the development of such a plan, if the Commission chooses. At a minimum, the Commission can consider revisions to our project review procedures and adding stormwater considerations to our relevant planning initiatives.

[24] DC reviews the ACOE Flood Emergency Plan and may provide input to ACOE.

[25] Recall that ACOE was criticized heavily for certifying the levees in New Orleans. Consequently, many of the homes that flooded after the levees failed did not have insurance because it was not required. Certification deemed them "outside" the 100-year floodplain and they were believed to be safe from flooding because the levees would protect them.

VII. Anacostia River Flood Risk Overview

Anacostia River Hydrology and Geography

The Anacostia River originates in Bladensburg, Maryland, where the Northwest and Northeast Branches meet, and flows southward for 8.4 miles until it runs into the Potomac River at Hains Point in Washington, DC. The Anacostia is tidal from its headwaters, and has a 2.9-foot average tide. It flows languidly toward the District, and with a 0.22 percent average mainstem gradient it can take more than 30 days for water to flow from Bladensburg to the Potomac. As a result of the sluggish flow, sediment, debris, and pollutants are not easily flushed downstream.

The Anacostia watershed is small and highly urban. The watershed spans approximately 170 square miles in its entirety (compared to the Potomac watershed which covers 14,679 square miles), 120 miles of which are located in Prince George's and Montgomery counties, with the remainder in the District of Columbia. The watershed is home to more than 800,000 residents, and is one of the most urbanized watersheds in the United States. Urbanization and other impacts have altered the Anacostia River and its tributary streams causing floods to be 10 times more frequent and summer flows much lower than historical statistics. [26]

According to the ACOE, the federal government owns 17 percent of the land in the watershed. However, in the District more than 90 percent of the river's immediate shoreline is in public ownership, with the National Park Service (NPS), the Navy Department, the General Services Administration (GSA), and the District as the major landowners.

Historically, the Anacostia was broad, deep, and meandering with thousands of acres of fully functional freshwater tidal marshes. In 1790, Bladensburg was a deepwater port receiving ocean-going vessels. But less than 100 years later, sediment from agricultural activities in the surrounding area clogged the river channel and closed the river to navigation.

During the past century, channel dredging and the consequent wetlands "reclamation" significantly altered the tidal river system's morphology. A stone seawall was built along much of the river's edge creating a hard line between the dredged river channel and the deposited fill material behind the seawall.

Today, the hydrology of the Anacostia tributary system is "flashy" (i.e., it has a quick flow response to rainfall) with intense flow conditions even in moderate rainfall events. Channelization of the Anacostia's tributaries, along with urbanization, results in higher runoff volumes that flow quickly into the mainstem. Conversely, in dry weather, the tidal river portion is sluggish, and water can languish for 100 to 110 days in drought periods. Average daily inflow into the tidal river is approximately 138 cubic feet per second (roughly 61,934 gallons per minute).

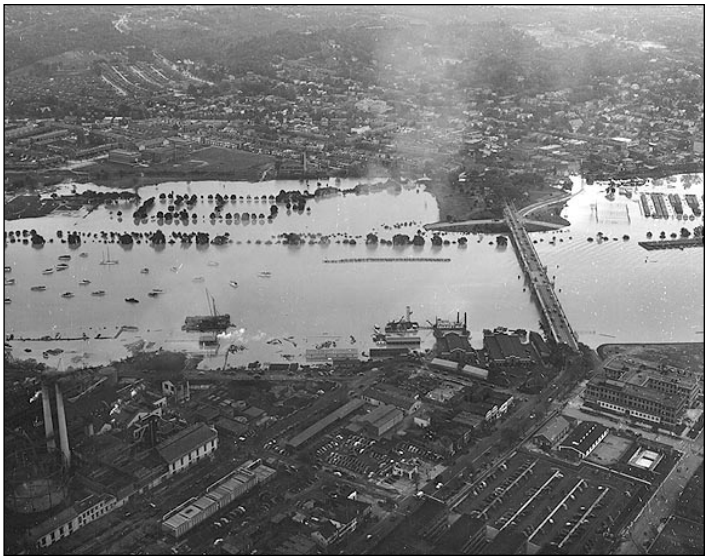
Anacostia River Flooding

In comparison to the Potomac River, there is less historical flood data and river flow measurements for the Anacostia River because the Anacostia is tidal for its entire length. Due to the tidal effect on the Anacostia River's water level, the USGS can not collect stream flow data from the river's rise in the way that it is collected for a non-tidal river channel. USGS is currently experimenting with new and innovative ways to measure stream flow in tidal river channels, such as using acoustics to measure velocity and calculate stream flow on tidal rivers. However, these new methods have not yet been implemented along the Anacostia. Second, there are only three river gauges in the entire Anacostia watershed, one for the Northeast Branch, one for the Northwest Branch, and one in Watts Stream (located 200 feet upstream from Minnesota Avenue). In addition, USGS reports that the costs of their research and data collection efforts are typically funded 50 percent by the local jurisdiction, and the District has neither requested nor funded research and data collection for the Anacostia River to the extent that other local jurisdictions have requested data for the Potomac River.

According to the USGS, another reason for extensive research and data on the Potomac River is that the Potomac is considered the "big gorilla" of the Washington metropolitan region.[27] Flooding along the Anacostia River usually only occurs when the Potomac floods and not independently. Potomac River flooding, because of the far greater size and reach of its watershed and stream volume, is a far greater threat to its surrounding area. Therefore, it has been monitored more closely in the past. Storm events that cause flooding along the Potomac River will affect the Anacostia River and cause flooding in the Anacostia watershed. Therefore, research and monitoring of the Potomac informs expected flooding on the Anacostia, making Anacostia River monitoring somewhat redundant. Moreover, during a storm, the flooding on the Anacostia River will subside more quickly than along the Potomac River.

[26] USGS "Effects of Urban Development on Floods," Fact Sheet FS-076-03 November 2003.

[27] Phone interview with Dan Souder of USGS.



Photos Courtesy of Naval Historical Center

Eastern end of Washington Navy Yard during the October 1942 flood

Washington Navy Yard during the October 1942 flood

A number of notable flooding incidents on the Anacostia River correspond to Potomac River overbank flooding. In August 1933, an unnamed hurricane hit Washington, DC, causing the Anacostia River to rise over the seawall. Intense storms in 1936 and 1942 flooded the Potomac River and led Congress to pass the Flood Control Act that authorized the National Mall levee. These same storms also flooded the Anacostia River, as depicted in these photos of a flooded Washington Navy Yard.

Hurricane Isabel

Hurricane Isabel had a notable impact on the Anacostia shoreline when the river surged over the seawall and flooded many historic buildings in the Navy Yard. Hurricane Isabel's storm surge produced higher than usual tides along both the Potomac and Anacostia river coastlines. According to the NPS, high waters on the Anacostia River severely damaged 12 offices in the NPS National Capital Park East's headquarters and in the US Park Police's adjacent Anacostia Operations Facility.

In Prince George's County, high waters closed three roads. Fifteen buildings sustained major damage, and 53 additional buildings were flooded. When two of the largest Maryland sewage treatment plants lost power, 96 million gallons of sewage overflowed directly into the county's waterways, and presumably downstream into the District.

VIII. Existing and Proposed Flood Control Measures

Role of the Army Corps of Engineers

The ACOE has been involved with the Anacostia River for more than a century. Past and present activities include flood control, navigation, debris-removal, and aquatic vegetation management.

In the late 19th century ACOE began channelization of the river and seawall construction to aid navigation and control flooding. Poor agricultural practices throughout the upper watershed rendered the Bladensburg seaport impassable and created extensive mud flats densely covered with grasses that trapped sewage and other waste. The Chief of Engineers attributed the prevalence of malarial disease bordering the Anacostia to the mud flats. As a result, Congress directed the ACOE to dredge the River and deposit the sediment on the mud flats to reclaim the land, provide sanitation, and promote navigation and commerce. In 1902, ACOE dredged the tidal Anacostia River up to the Anacostia Navy Yard, plus a smaller channel upstream to the District line, and deposited the dredged material on the flats below St. Elizabeths, creating Poplar Point and much of the land currently occupied by Bolling Air Force Base. Dredging continued through the 1920s, with the material held in place with a seawall. ACOE estimates that from 1900 to 1960, their activities destroyed approximately 2,600 acres of wetlands,[28] 99,000 linear feet of aquatic habitat, and 700 acres of bottomland hardwood in the Anacostia watershed. Today, only 100

[28] 98 percent of the tidal wetlands and 75 percent of the basin's freshwater wetlands had been destroyed by 1987.

acres of tidal emergent wetlands[29] remain along the Anacostia River between Bladensburg and Hains Point.

As we now know, channelizing the Anacostia (along with its tributaries) increased the speed and volume of the water during heavy rainfall. Increased riverflow, in combination with a stone seawall which provided a conspicuous line of demarcation between the river and the shore, as opposed to the broad natural wetlands areas, probably increased the severity of flood events from heavy rainfall. The ensuing Anacostia floods of 1933, 1936, and 1942, along with flooding in other areas of the country, helped build support for a national legislative solution.

The Flood Control Act of 1950 authorized flood control measures along the Anacostia that would afford protection against a flood considerably greater than the maximum flood of record, which occurred on August 23, 1933. In that flood, the maximum discharge of the Northeast Branch was computed as 10,500 cfs and the maximum discharge of the Northwest Branch was computed as 8,000 cfs.[30]

ACOE built five levee systems, two in Maryland and three in the District, as a result of the legislation. In Maryland, there is a levee system on the Northeast Branch and one on the Northwest Branch. Channel improvements also were implemented along both branches, although the navigation channel extends upstream only to Bladensburg.[31]

In the District, the National Mall levee, discussed in Section II, protects the downtown monumental core from Potomac and Anacostia river flooding. Specifically, the portion of the levee in Fort McNair, which currently requires a temporary closure at Canal and P streets, SW, protects the downtown business area from flood waters rising from the Anacostia. Fort McNair also is surrounded by an ACOE-built seawall that is jointly maintained by the Department of Defense and ACOE. In addition, there are two levees on the east side of the Anacostia that protect upland areas from Anacostia River flooding: the Potomac Park levee and the US Naval Air Station levee.

Anacostia River Flood Control Projects

A two-section flood protection levee is located on the east bank of the Anacostia River and extends approximately 1.84 miles from Poplar Point to the southwest corner of the Navel District Washington Anacostia Annex. Most of the levee is an earthen berm, however, approximately 1,200 feet is a concrete flood wall. There are also two stop-log closures, four pump stations, and various gates on storm drains and sewers. Aerial maps showing the location of the flood control projects are attached to this.

This levee was authorized in 1936[32] and completed in 1944. The levee was constructed under ACOE supervision using Works Progress Administration (WPA) labor and contractor equipment and materials. The Anacostia levee system was designed to provide flood protection to the Naval Air Station and Bolling Field from a Potomac River flow of 600,000 cfs.[33] The total project cost for the National Mall levee and the Anacostia levee system was $339,227. ACOE estimates that replacement of the levee system located on Anacostia Naval Station and Bolling AFB could reasonably be expected to exceed $20 million in 2007.

As a result of new post-Katrina rules, ACOE has documented a number of serious structural issues along the entire length of the levee. Previously, ACOE would merely downgrade a levee's rating because of trees growing in the earthen portion of any levee, however, because trees were one of the major factors in the breach of New Orleans' levees, new ACOE criteria require that the levee be deemed unacceptable. If a levee is deemed unacceptable, FEMA can not consider it as protection from a flood event, and the area within which private property owners are required to obtain flood insurance may increase accordingly. FEMA currently is modernizing flood maps nationwide. In a number of locations, including the District of Columbia, the new maps have been adjusted to reflect that the ACOE has not certified the levee.

[29] Tidal wetlands are vegetated lands bordering, or lying beneath, tidal waters which are subject to regular or periodic tidal action. Emergent wetlands, commonly called marshes and meadows, are dominated by herbaceous (non-woody) plants such as grasses, sedges, and forbs (broad-leaved plants) that "emerge" from the water while their roots remain submerged.

[30] Given that there is no gauge on the Anacostia River, the maximum discharge was estimated as 15,000 cfs, or approximately 80 percent of the maximum discharge of the two branches.

[31] The navigation channel is 80 feet wide and authorized to a depth of 8 feet but normally maintained at 5 feet, plus 1 foot allowable over-depth. This is considered adequate for existing navigation. A few areas near Kingman Island have been dredged to a depth of 10-feet to supply fill material for the Kingman Island wetlands restoration project.

[32] Congress authorized the Anacostia portion of the levee in the same legislation as the National Mall levee in 1936.

[33] This flow is in excess of the flows expected during the 100 year flood on the Potomac River. Flood protection measures along the lower portion of the Anacostia are designed to a protection level to account for forecasted flood stages on the Potomac as opposed to the flood stage on the Anacostia because the Potomac's flooding abilities far exceed the Anacostia's.

The upper portion of the levee that protects Poplar Point is overgrown with mature trees and is in disrepair. The levee is on NPS property; therefore NPS is responsible for its maintenance and repair.[34] NPS currently is working with ACOE to remove the vegetation and trees. Once the trees are removed NPS will need to back-fill the levee to shore up the line of protection. The upper section is relatively small compared to the entire length of the levee system; however, both sections were designed to work together as a system to keep Anacostia flood waters out of the Naval Station and Bolling Air Force Base. This portion of the levee is contained within the 150-acre parcel to be transferred to the District of Columbia as a result of the recently approved federal land transfer legislation.[35] NPS is working with ACOE to make the necessary repairs before the land transfer is to take place. NCPC would have review and approval authority over these capital improvements.

The lower portion of the levee for the Anacostia Naval Station and Bolling Air Force Base is an earth berm approximately 11,600 linear feet long, with an elevation of 15 feet mean sea level. In addition to the earthen levee, this flood protection system consists of approximately 1,200 linear feet of concrete flood wall, two stop log closures, four pump stations and various gates on storm drains and sewers. The concrete flood wall was designed with an opening of 328 feet to allow seaplane access to a hanger located just inside the line of protection on the Naval Station. Originally, this opening in the line of protection was to be closed by a portable dam system, but has since been permanently closed with a concrete flood wall.

Near the Anacostia naval facility, ACOE officials observed trees growing into the sides of the levees. To date, Navy officials have removed all of the vegetation and trees and are beginning to address the more significant issues with the seawall along their property. During the 1996 flood and during Hurricane Isabel in 2003 under-seepage[36] was observed at the flood walls. ACOE's inspection of the walls is incomplete, but ACOE is working with the Naval Station. Inspectors also found that stormwater drainpipes could pose a problem during a flood if water from the river were to back-up to the other side of the levee. ACOE suggested that gates be added to the stormwater drain pipes so water could flow only in one direction. The Naval District has informed ACOE that they will look into this recommendation. The Navy expects to undertake the necessary structural levee repair work in the near future. NCPC would have review and approval authority over these capital improvements.

The jurisdiction and ownership of the very top segment of the levee that runs under the Frederick Douglass Bridge (South Capitol Street) is unclear. ACOE cited trees on the levee and the lack of a gate to seal a gap in the levee during storms. A seawall along this stretch also needs maintenance. It is unclear under whose jurisdiction this parcel falls and which entity ultimately has responsibility for repairs and maintenance. However, ACOE stated that it is probably in the best interest of the Naval District to maintain this portion of the levee as it is designed to protect their facility from Anacostia floodwaters.

Prince George's County, Maryland, Flood Control Project

ACOE also designed and constructed flood protection measures upstream in Prince George's County, Maryland. The Anacostia Local Flood Protection and Navigation Project was completed in the 1950s. To manage drainage on the land-side of the levees and protect against levee-caused flooding, ACOE installed four pumping stations. Prince George's County operates and maintains the pumping stations, and in coordination with the Corps, conducts an annual inspection of the levees, floodway channel, and pumping stations.

In 1993, the Maryland Department of Natural Resources (MDNR), Water Management Division, completed a watershed study for the Prince George's County portion of the Anacostia. The study identified 2,500 flood-prone structures located behind the existing levee system and more important, found that the existing levee system does not meet FEMA's current safety criteria. The study determined that the levee should be raised approximately two to five feet to meet FEMA's criteria. It is unclear if this work has been completed; no one in either the state or county offices is familiar with the study or its recommendations.

Additionally, MDNR provided funding to Prince George's County to install an automatic flood warning system for the lower half of the Anacostia watershed. The system, completed in 2003, electronically monitors rain and stream level information at 19 sites strategically located throughout the watershed. The system automatically transmits the information to the Prince George's County Public Safety and Communications Office to warn of possible flooding. In the event of a major flood or other flood-related hazard, individuals registered in the system are notified via phone, fax, e-mail, or pager. Unfortunately,

[34] Levees typically fall into three categories. (1) They can be built and maintained by ACOE. (2) They can be built by the ACOE and transferred to a local owner to operate and maintain. (3) Non-federal levee projects can be built by a local community. The latter two categories, if properly maintained and operated by the owner, are eligible for federal rehabilitation assistance. In the case of the National Mall levee and the Poplar Point levee, ACOE built the levees, but NPS is expected to maintain them.

[35] The legislation requires the District to complete a land-use plan for Poplar Point that identifies a minimum of 70 acres, including wetlands, to be maintained in perpetuity as a park.

[36] Under-seepage occurs when levees are built on pervious foundations. Seepage beneath the levee (under-seepage) during floods can produce pressure and flow conditions capable of initiating subsurface erosion leading to levee failure.

this notification system is not connected in any way to the District to provide early warning notification for flooding downstream. However, the National Weather Service would notify the District in the event any of the gauges indicated flooding was possible.

On February 1, 2007, ACOE deemed the Anacostia levees in Prince George's County unacceptable because of trees. ACOE claimed that the dozens of trees growing on or near the levees might cause the levee to fail if an uprooted tree should pull apart the earthen barriers. This determination surprised county officials because the trees had been growing on and along the levee for years, and some trees even pre-dated the levees.

Because there were so many sizeable trees to remove and the work could not be completed before the ground froze for the winter, Prince George's County decided to remove the trees in two phases. First, contractors cut the trees down to a stump flush to ground level. With that phase complete, County contractors will remove the root balls and repair and reconstruct the earthen levee where necessary. Prince George's County officials also reported that ACOE guidelines were revised a number of times delaying the contract process and tree removal.

According to Prince George's County staff, the Anacostia Watershed Society planted many of the trees and was understandably upset when the trees were removed. Just as many local environmentalists and residents found the tree-loss distressing, many communities nationwide have had to implement the new ACOE tree policy and face significant tree removal to retain ACOE levee certification. In Sacramento, 5,100 mature trees were removed as a result of the new levee maintenance policy.

ACOE levee certification is particularly important given that FEMA is in the midst of a nationwide floodplain map modernization initiative. If ACOE does not certify a levee to FEMA, the revised floodplain maps must indicate the potential 100-year flood as if the levee did not exist. This is discussed in more detail in the next section.

At the same time that Prince George's County is repairing the levees to ACOE standards, county officials have also embarked on flood control improvements, both physical and technical. For example, the Edmondson Flood Control Pumping Station upgraded its capacity by 300 percent to ensure sufficient capacity in the event of a flood. The County is also updating floodplain information for all of their watersheds using GIS-based hydrologic and hydraulic models.

IX. Urbanization, Channelization, and Sedimentation Impacts

Impacts from Anacostia Tributaries on Flooding

Significant alterations of the Anacostia tributaries from channelization, floodplain loss, and urbanization increase flooding risks in the entire watershed. In general, these alterations cause flashy storm flows with a low base flow between storm events. Urbanization increases impervious surfaces, which causes the storm flow to have higher peaks and greater volumes. Greater stream flow, in combination with channel modifications, increasingly deepens the stream channels, and cuts the stream off from the floodplain and its flood-mitigating functions. The increased flow and the deeper channel within the tributaries have an even greater capability to mobilize stream sediment and reduce or eliminate river bed features that help dissipate flow energy and slow the water down. However, because the Anacostia River is flatter in elevation than the Potomac River, alterations to its tributaries that cause sediment to become waterborne are a more significant problem. The sediment remains in the Anacostia River's streambed rather than washing further downstream, and, therefore, increases the flooding risk in the surrounding communities.

According to the USGS, the frequency with which daily discharge exceeded 1,000 cfs on the Northeast Branch of the Anacostia increased from once or twice a year during the 1940s and 1950s (about the same time the Anacostia River was channelized, the levees constructed, and the wetlands filled) to as much as six times per year in the 1990s. Thus, in recent years the Anacostia River has had to carry much greater volumes of water more frequently than in the past.

Anacostia Sedimentation

Sedimentation is a great cause for concern. The existing levees were designed to protect Anacostia from a 100-year storm event. However, ACOE's baseline assumptions were for a deeper river channel with less sedimentation then exists today. ACOE has not completed a full Anacostia assessment since the 1950s, and the Anacostia has not been dredged for years. Near the town of Bladensburg, the Anacostia River is frequently more riverbed than river, with

no more than a trickle of water. Present-day river conditions are far removed from the 40-foot-deep shipping channel it once was. Over the years, the riverbed has been silted in with dirt and debris carried by stormwater runoff from Montgomery and Prince George's counties. Sedimentation of the stream channel means that the riverbed can only contain a small volume of water. Rainfall or river flow displaced by the sedimentation will flood over the top of the riverbank. In other words, even moderate rainfall has the potential to cause overbank flooding because the excess stormwater can not be conveyed downstream in the river channel.

In January 2007, ACOE released a report on its investigation of the June 2006 flooding of Cameron Run in Virginia. The report concluded that channel sedimentation considerably affected flood levels. The report found that in the 25 years or so since the FEMA flood maps were last updated, between five to six feet of sediment accumulated in the Cameron Run Channel. As a result, flooding in the Huntington neighborhood was up to two feet higher than it would have been. It was estimated that much of the sediment originated from the development of Fairfax County upstream from the flooded neighborhoods. It is reasonable to assume that given the Anacostia's propensity for sedimentation, and the significant upstream development in Prince George's County, that sedimentation in the Anacostia would likely result in higher flood levels in a storm event than previous events would indicate.

There are two solutions to directly deal with the increased flooding risks resulting from sedimentation. First, ACOE or the relevant local municipalities could conduct a field investigation and model various storm simulations. This would determine if the existing levees provide a sufficient amount of protection (typically the levee would protect against a 100-year storm event) given the current level of sedimentation in the Anacostia River. These models could also determine which improvements, such as increasing the height of the levees, might be necessary to provide communities behind the levees with a sufficient amount of protection.

Second, dredging can remove sediment from the riverbed of the Anacostia and restore the deeper channel. The Navy supports a recommendation to dredge the Anacostia because existing sedimentation prevents larger naval ships from coming up the Anacostia. As a result, the Navy incurs steep docking fees for its ships at a private port in Alexandria when their ships are in town. However, dredging is not a straightforward solution. It is expensive under ideal circumstances and very difficult to complete when a disposal site is needed for any contaminated sediment spoils, which is likely from the river areas surrounding Poplar Point and the Navy Yard. Additionally, ACOE favors dredging projects that are part of a larger ecosystem restoration project so that uncontaminated soils can be used for wetlands creation.

Urban Drainage Flooding

Urban drainage flooding is typically caused when the sewer system's capacity is exceeded. While one-third of the District, including the entire downtown business district, has a combined sanitary and stormwater system, most of the area east of the Anacostia has separate sewers. Separate systems have two independent piping systems: one system for sanitary sewage and one system for stormwater. Separate systems for stormwater and sanitary sewage can't ensure that an area will not flood, but the additional sewer capacity can help mitigate heavy rainfall. A portion of the District along the west side of the Anacostia River falls within the combined sewer area. Presumably this area would be more susceptible to flooding from excess stormwater. However, there have not been reports of urban drainage flooding in this area.

Potential Impacts on Recent and Proposed Waterfront Development

Until recently, there has been little development along the Anacostia riverfront within the District as most of the waterfront is publicly owned. In the last few years, however, development pressure has increased substantially throughout the District, especially along the waterfront. In addition, a number of land development transactions have led to more waterfront land slated for private development. This increased development pressure and concurrent interest in areas along the Anacostia Riverfront warrants further attention.

The Yards is one recent development proposed along the Anacostia River. GSA granted Forest City the opportunity to redevelop a 42-acre riverfront property site with mixed-use redevelopment including 2,800 residential units, 1.8 million square feet (SF) of office space, up to 300,000 SF of retail space, and a riverfront public park. The Yards mostly avoided developing within the 100-year floodplain by proposing to raise the site's elevation above floodplain levels. This is a common and permissible development technique that is employed as a means of avoiding the costly construction, insurance, and regulatory requirements typically associated with building in a floodplain. Raising the site's base elevation helps protect the site by keeping water out that would otherwise have inundated the site in a

storm. It is important to note that while this methodology is both customary and allowable, elevating the base elevation by placing fill within the floodplain can make flooding impacts worse elsewhere in the watershed, particularly from the cumulative impacts when a number of projects in the same watershed use this means.

Poplar Point is another prominent site slated for development. Congress authorized the site to be transferred from NPS to the District, and the Mayor's Office has been considering a number of development proposals for the site. While no specific development proposal has been selected for the site, because the 100-year floodplain extends over much of the site, it is likely that any proposed development would raise the elevation of the site above the base flood elevation to avoid additional costs. Again, it is unlikely that this methodology would result in greater flooding impacts within the immediate area; however, staff would recommend that District planners consider the potential floodplain impacts when the site plans are submitted for review and approval. The Commission also will have an opportunity to review any proposed development for the site and will need to apply the NCPC floodplain guidelines in its review.

X. Restoration and Remediation Efforts

Below is a short summary of some recent federal efforts along the Anacostia River to restore water quality. This summary is not all encompassing and does not include all the remediation efforts that have been undertaken. Instead it is intended to illustrate efforts to restore the river's natural flood control characteristics and other ecological functions.

Washington Navy Yard Storm Sewer Rehabilitation

The Washington Navy Yard, established in 1799, is the nation's oldest naval shore facility. The Navy Yard's industrial operations ended in the 1960s; however, the former military activities left behind hazardous waste. The Navy has undertaken numerous cleanups to remediate environmental damage at the Navy Yard. In particular, sewer remediation and innovative stormwater management techniques have helped reduce a small portion of the stormwater pollution that ends up in the Anacostia River.

In March 1998, to settle a civil lawsuit alleging that contaminated stormwater from the Navy Yard contributed to Anacostia River pollution, the Navy agreed to specific cleanup actions, including storm sewer cleaning and rehabilitation. One of the remedial actions was the rehabilitation of nearly six miles of stormwater and sanitary sewer pipes.

During Phase One, 20,000 linear feet of storm sewer lines were cleaned and inspected with video cameras. About 30 percent of the sewer lines were crushed or obstructed. During Phase Two, storm sewer lines were repaired, renovated, or replaced, as needed. When possible, the Navy renovated existing pipes by placing a new impervious liner inside them, which eliminates groundwater seepage into the pipes and allows more efficient stormwater flow within the pipes. More than 50 percent of the pipes were too damaged for lining and had to be replaced.

Last, the Navy installed a number of small-scale, sustainable stormwater management structures (known as Low-Impact Development or LID). LID reduces stormwater pollutants from being discharged into the Anacostia River. In heavy storms, LID also helps control the peak stormwater velocity and volume in the storm sewer system. The Navy Yard LID measures are often cited as a notable local effort to reduce Anacostia stormwater pollution.

Wetlands Restoration

Progress is also being made in wetland creation and restoration. Wetlands restoration confers many environmental benefits, such as providing a new wildlife and waterfowl habitat, and beautifying the shoreline. Wetlands are not only beautiful, they are functional and help mitigate the impacts of heavy rainfall. They help prevent flooding, flush out stormwater pollutants, and improve water quality.

More than 100 acres of wetlands have been reclaimed or created in the Anacostia basin. In 1993, ACOE reconstructed approximately 30 acres of freshwater tidal marshes in the Kenilworth Marsh area near the last remaining stand of original tidal marshes. Adjacent to this wetland is the Kenilworth Aquatic Garden, operated by NPS. The District and ACOE are restoring a 46-acre marsh near Kingman Lake. Immediately upstream from the New York Avenue Bridge, approximately 20 acres of wetlands are being created and 30 acres of freshwater wetland sites have been identified for the Northeast Branch.

Unfortunately, while there is widespread support for additional wetlands creation in the District, it is unlikely to happen until a solution can be found for the originally migrant, and now permanent, Canadian geese population that was responsible for eating half of the newly installed wetland plants at the Kingman Marsh wetland restoration project near Robert F. Kennedy Stadium. The geese previously stopped temporarily in the District en route either north or south but recently stopped migrating to take advantage of the plentiful food and lack of natural predators in the District. Local and federal agencies do not have a management strategy for the geese, and lethal control is likely to be unpopular. This past July, NPS held a public scoping meeting for the Anacostia Park Wetlands Restoration Plan to develop resident geese management strategies on NPS wetlands. Until the environmental review is complete and a resident geese management strategy selected, wetlands restoration in the District is likely to be put on hold.

The Anacostia East Wetland Mitigation Project is located on Maryland National Capital Park and Planning Commission (M-NCPPC) property near Bladensburg. Just upstream from the Washington, DC, border, approximately 55 acres along the Anacostia River's eastern shore are being transformed into a tidal wetland. The project includes a series of aquatic zones that will provide a fish habitat and promote the growth of various wetland plant species. Approximately 25 acres of the restoration project is a mitigation site for the Woodrow Wilson Bridge Replacement Project. The two-year contract was awarded in March 2007.

In Poplar Point, wetlands have developed in several areas since the Architect of the Capitol's nursery activities ceased, and stormwater has been allowed to collect in topographically low areas.[37] Presently, there are four federally mapped wetland areas on the site. As part of the redevelopment of Poplar Point, the District plans to restore wetlands more fully and bring Stickfoot Creek, which is currently submerged through a drainage pipe, back to the surface.[38]

XI. FEMA Floodplain Map Modernizations

FEMA develops maps nationwide that delineate floodways and the floodplains.[39] A Flood Insurance Rate Map (FIRM) is the official map on which FEMA has delineated both the special flood hazard areas and the flood risk premium zones applicable to a community. Buildings within the 100-year floodplain must obtain flood insurance and meet more stringent building codes. Buildings within the 100- to 500-year floodplain are not required to obtain flood insurance, but may do so at a preferred risk-rate.

In the District, FEMA develops the maps in conjunction with the District Department of the Environment (DDOE). Like most communities nationwide, the District floodplain maps, last revised in 1985, are outdated. Over the past few years at the urging of Congress, FEMA has embarked on a substantial initiative to update the maps nationwide. The map modernization process took on increased urgency after Hurricane Katrina when the levees in New Orleans failed. Numerous property owners sustained damage to their homes but did not have flood insurance to cover their financial losses. In the past, the floodplain did not extend to the landward side of the levees because the assumption was that the levee would hold the floodwater back. Due to the New Orleans levee failure, FEMA required ACOE to inspect all levees. If a levee is deemed insufficient to withstand a storm event, FEMA will delineate the floodplain area without benefit of the levee's protection.

[37] Excess stormwater previously was pumped from the site when it was in operation as a nursery.

[38] Stickfoot Sewer runs under the eastern portion of the site and conveys both stormwater and Stickfoot Creek from areas south of the site to the Anacostia River.

[39] "Floodplain" is the low area of land surrounding water bodies that holds the water overflow during a flood.

REVISED FEMA FLOODPLAIN MAPS

On September 26, 2007, FEMA published notice in the Federal Register for a 90-day public review and comment period on proposed revised floodplain maps for the District. The proposed maps are significantly different from the existing maps largely because the ACOE has not certified any of the levees in the District. The lack of ACOE certification requires FEMA to note the location of the levees on the map but to treat them as if they do not exist for purposes of mapping where the floodwater would inundate for a 100-year storm. (See map on page 23.) Consequently, most of the monumental core area is within the 100-year floodplain because the proposed maps assume that floodwaters from the Potomac and Anacostia rivers would flood the downtown area via 17th Street, NW, and near Fort McNair. Similarly, areas east of the Anacostia River beyond the existing levee structures are within the 100-year floodplain because ACOE did not certify the Poplar Point and Naval District levees.

As we noted earlier, the impact of being within the 100-year floodplain is two-fold. First, all private development must secure flood insurance. Second, all new public and private development must comply with more stringent building codes designed to protect the structures from flood damage. The federal government has an additional requirement to comply with Executive Order 11988, which was implemented to reduce the potential impact of federal decisions on floodplains, and requires federal agencies to consider alternative actions outside of the floodplain where possible.

There are a number of large federal installations near the Anacostia River that are within the proposed 100-year floodplain, including Bolling Air Force Base, the Navy Yard, Fort McNair, and much of the NPS riverfront parkland. Fortunately, the proposed floodplain designation should not adversely impact any of these facilities or their day-to-day operations. Representatives from the Navy Yard and Bolling report that due to past flooding, numerous procedures and measures are already in place to handle overbank flooding. Existing precautions include, but are not limited to, prohibiting critical equipment on ground floor locations and keeping sufficient pumps on hand at all times to ensure that operations are only minimally affected in a flood event. Many NPS properties, such as the FDR Memorial, have been designed to withstand periodic river flooding because of their location in the floodplain, on the river-side of the levee.

These riverfront installations are unlikely to be impacted by the proposed broader 100-year floodplain designations because they have either been designed or retrofitted to accommodate occasional flooding. However, numerous federal headquarters, offices, museums, and other important federal facilities within the monumental core are within the proposed enlarged 100-year floodplain as a result of the ACOE failure to certify the levee along the National Mall. The impacts on these federal facilities are less obvious. The flood insurance requirement would not affect federally owned buildings because the federal government is self-insured. However, federal agencies seeking to renew office leases, or agencies that need to procure new leased space may face higher rents because private building owners will need to obtain flood insurance that previously was not required.

New federal construction may also be more costly because all new development, private and public, will have to adhere to more stringent building requirements if the property falls within the expanded floodplain. Building modernizations also may cost more as GSA likely will consider such additional renovation measures as moving key building operations equipment from basement areas to avoid the risk of flooding. Last, all federal agencies, including NCPC, will need to comply with EO 11988 which requires federal agencies to consider the impact of their decisions on the 100-year floodplain. Among other considerations, EO 11988 requires that agencies consider potential alternatives to locations within the floodplain.

FEMA and DDOE have been collecting public comments through January 3, 2008 on the accuracy of the maps. Members of the public can protest the map delineations if they believe they are based on erroneous data. Presumably, because the repairs to the east of the Anacostia levees are almost complete, ACOE might be able to certify their line of protection and have FEMA revise the maps before they are made final. However, because the design of the improvements to the National Mall levee has not started and Congress has yet to appropriate the funds for the improvements, it is unlikely that ACOE will be able to certify the National Mall levee before the maps are finalized. Consequently, it is very likely that the maps will proceed with an extensive floodplain covering much of the monumental core.

XII. Next Steps/Action Plan for Anacostia River

Based on our research, NCPC has taken the following actions. First, staff has submitted a comment letter to FEMA and the District Department of the Environment (DDOE) on the proposed flood map revisions that makes four requests. (1) NCPC requests that DDOE and FEMA confirm, in writing and by public notice, the reasons for the proposed map revisions. (2) NCPC urges DDOE and FEMA to provide increased and creative public notice to property owners affected by the map revisions because most property and building owners would not expect to be within the 100-year floodplain. (3) NCPC urges FEMA and DDOE to determine an expedited process to update the flood maps as soon as the National Mall and Anacostia levee improvements are complete as it is unacceptable for the maps to remain incorrect if the next round of map revisions will not occur for another 25 years. (4) NCPC urges FEMA and DDOE to continue to research whether urbanization within the Anacostia and Potomac watersheds, and expected sea level increases, would warrant further map revisions. In addition, staff recommends that the Commission encourage FEMA to consider whether Anacostia River sedimentation will alter the floodplain delineations because the reduced capacity of the river channel could cause higher flood levels.

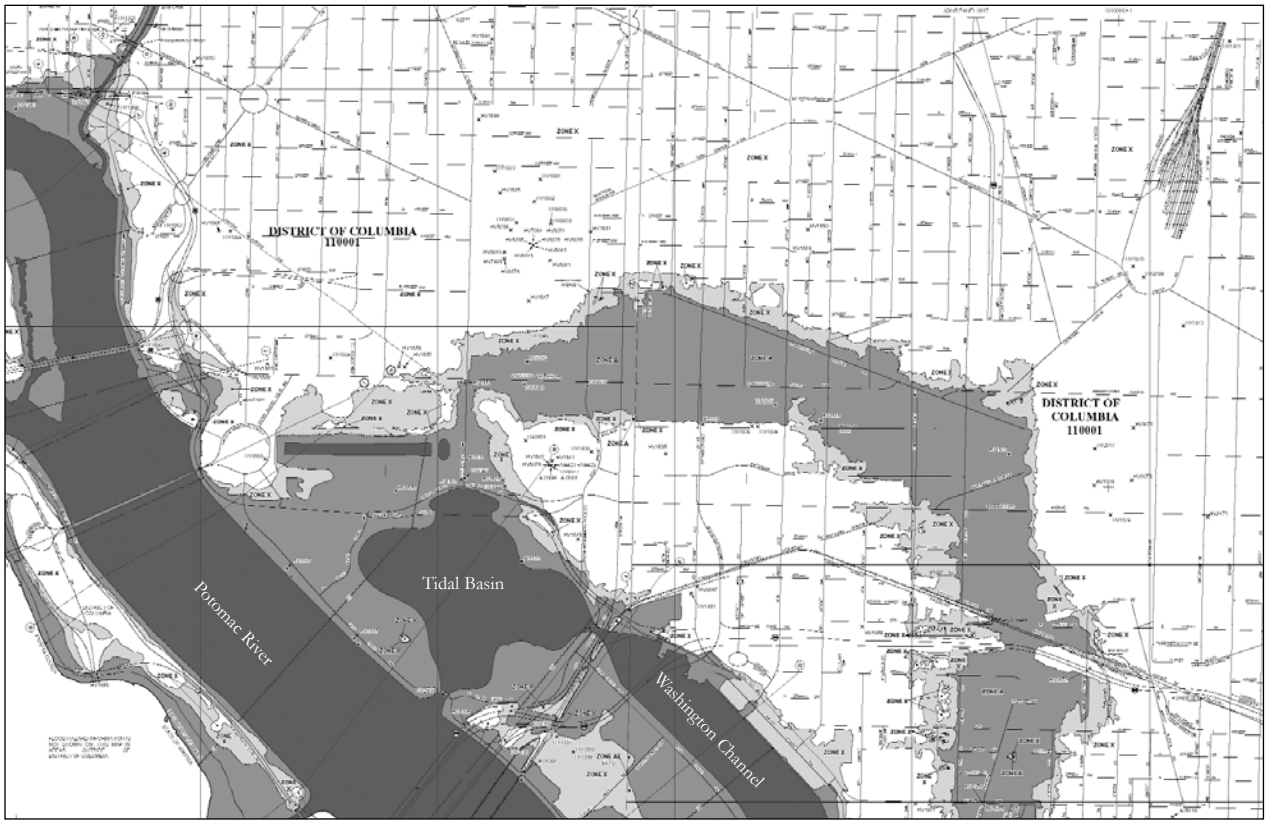
NCPC also continues to support strongly ACOE-proposed improvements to the National Mall levee as a critical measure to protect the National Mall and its environs, the art and artifacts housed in the Smithsonian buildings and the National Archives, and critical federal functions in the monumental core. Any modifications would require NCPC review, and, due to the levee's location, any improvements would need to be developed carefully to protect the historic, cultural, and aesthetic attributes of the National Mall. The letter indicates that NCPC staff encourages ACOE to schedule consultation meetings about the proposed levee improvements as early in the design process as possible.

NCPC staff will continue to coordinate with other federal agencies and organizations to understand the potential short- and long-term impacts of the revised floodplain maps and provide assistance, when necessary, to comply with federal rules and policies. This approach is consistent with agency policy outlined in the *Comprehensive Plan for the Nation's Capital: Federal Elements*, which states that federal actions in the region should support the restoration of floodplain values and functions whenever possible.

DC 2007 Preliminary Flood Insurance Rate Map

ZONE A: Would flood in 100-year event

ZONE B: Would flood in 500-year event



APPENDIX A: Major Flood Events in Washington, DC

Flood Year	Hurricane Name	Flooding Elevation*/ Peak Discharge	Comments	Recurrence Interval (Years)
1889			Potomac crested at 12.5' above flood stage	50->100
1933	Unnamed	+11.0' LWD	Most destructive hurricane on record for Chesapeake Bay and DC Storm surge highest of record on Bay and Potomac; superimposed on astronomical high tide	
1936		28.10 484,000 cfs — Little Falls	Thick Ice, snowmelt and intense rainfall runoff	90
1937		23.30 40,100 cfs	Huge storm over entire northeast	
1942		25.88 394,200 cfs	Floodwaters reach the Lincoln Memorial steps Rainfall 6.27" Rainfall 10-15" to west	
1954	Hazel	+8.7' LWD	Second most destructive storm Storm surge of 5.6' imposed on astronomical high tide	25 to >100
1955	Connie	+6.6' LWD	Tidal surge of 5.6' on astronomical low tide Would have reached +10' LWD if superimposed on high tide	5 to 10
1955	Diane	+7.0' LWD	Surge approximately 4.5' Heavy rainfall increased damage and flooding after Diane passed through the area	
1972	Agnes	22.03 359,000 cfs — Little Falls	Greatest Maryland flood More death and property damage in Maryland than DC	50 to >100
1996		19.29 317,000 cfs — Little Falls	Potomac rose 85' in 48 hours Fifth largest flood in DC	30
2001			7" rain fell on DC	
2003	Isabel		Washington Harbor Flood gates raised, Levee closed Potomac above flood stage	
June 2006		86,2000 cfs (6/29/06)	Short period of excessive rainfall	1.5

* Flood Stage at the Wisconsin Avenue gauge is 10.0 feet. Sea Level Conversion (SLC) at this gauge is 37.95. To convert to sea level, add the SLC to the river stage to determine if a property is in danger of flooding.

APPENDIX B: Information on Memorials Submitted to NCPC by National Park Service

MEMORIAL	NPS COMMENTARY
Background	Before West Potomac Park was completed the topography of lower Northwest DC formed the shoreline. Higher ground elevations were present at the Naval Hospital site, Square 63 and Square 88, but the squares east of 21st Street were low and subject to tidal action. The architectural walls that separate the garden forecourt to the Federal Reserve, Interior South and the Pan American Union Annex buildings built between 1931 and 1945 are set at elevations between 21.40 and 23.75. Elevation 19.1 represents the level of the 250 year storm event.
Korean War Veterans Memorial	The civil engineering analysis by ACOE determined that the memorial (based on the November 1985, DC Federal Emergency Management Agency Map, Panel Number 11001-0015B) is located outside the limits of the 100-year floodplain, but within the 500-year flood. No significant site modifications were required. There is a mechanical room with an area way entrance whose top elevation is between 13.5 and 14.5 that would be below the 15.6 foot 100-year event. This space will be protected by a temporary barrier of sand bags in the event of a 100-year event.
Franklin Delano Roosevelt Memorial	The granite walls of the memorial are built to elevation 19.5 and at critical equipment areas to elevation 22.50 and elevation 22.95. The park grounds around the memorial are between elevation 8.5 and 12.0 and subject to a 100-year event of elevation 15.6. The Entry Building at the FDR Memorial has a floor elevation of approximately 11.0 and is managed to be cleared in the advance of predicted flooding.
World War II Memorial	The centerline of the memorial on 17th Street, SW is at elevation 8.7 feet, while the original Rainbow Pool was at elevation 5.6 feet, and is subject to impact by a 100-year storm event elevation of 15.6 feet. The location of the memorial just outside the existing levee's protection area was noted in a May 1998 Environmental Assessment. The memorial was designed to withstand the impacts of flooding so that significant property damage and potential environmental impacts would not occur. The equipment room of the WW II Memorial is designed to be sealed from flood waters, while the memorial itself can be flooded and subsequently flushed of debris and deposited sediments.
Vietnam Veterans Memorial	The memorial is protected by the National Mall levee.

APPENDIX C: Relevant Laws and Regulations for Flooding and Stormwater Management

Federal Laws/ Responsibilities	Federal Agency Overview	NCPC	NPS	FEMA	ACOE	GSA
National Flood Insurance Program (NFIP)	FBMA has implementation responsibility Other federal agencies must evaluate actions in 100-year floodplain		While not directly from NFIP, NPS implements temporary flood control closures on the Mall at 17th and 23rd Street	Develops DC FIRM, approves DC Flood Hazard Rules, works with DC Emergency Management.	Designed and constructed National Mall levee	
EO11988– Floodplains	Federal agencies should avoid floodplain development—agencies must evaluate actions in floodplains to disclose if action will occur in a floodplain, and if so, what alternatives were considered to avoid adverse effects and incompatible development.	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives
NEPA	Agencies must conduct an Environmental Assessment or Environmental Impact Statement for any proposed action that may significantly affect the human environment; disclose unavoidable adverse impacts; and consider alternatives	NCPC's NEPA submission guidelines require discussion of environmental impacts of proposal & alternatives on floodplains, flooding and stormwater impacts	NPS must evaluate environmental impact of its actions and alternatives on floodplains, flooding, and stormwater impacts		Must evaluate environmental impacts of flood control measures and alternatives on floodplains, flooding, and stormwater impacts	GSA must evaluate environmental impacts of its actions and alternatives on floodplains, flooding, and stormwater impacts
Clean Water Act	Regulates stormwater discharges from construction activities and sewer system discharges		As developer and property owner must comply with CWA			As developer and building owner must comply with CWA
Miscellaneous Considerations			Costs from flooding impacts on memorials borne by NPS	Called to action when federal disaster area declared		As landlord, responsible for such flood clean-up and prevention

Appendix D: Acronyms and Abbreviations

100-year flood	A flood that has a 1-percent chance of being equaled or exceeded in any given year. A base flood may also be referred to as a 100-year storm and the area inundated during the base flood is sometimes called the 100-year floodplain.
ACOE	U.S. Army Corps Engineers
AWC	Anacostia Waterfront Corporation
cfs	cubic feet per second - the common unit of measure for the flow of a river
CSO	combined sewer overflow - what happens when an excess of stormwater and / or sewage exceeds the systems capacity and flows without treatment into the rivers
CWA	Clean Water Act
DC DOE	DC Department of the Environment
DC DOH	DC Department of Health
DC DPW	DC Department of Public Works
DC EMA	DC Emergency Management Agency
DCRA	Department of Consumer and Regulatory Affairs
DC WASA	DC Water and Sewer Authority
DDOT	DC Department of Transportation
EPA	U.S. Environmental Protection Agency
EO	Executive Order
FCIP	Federal Capital Improvement Plan, prepared by NCPC
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map - prepared by FEMA, required by NFIP, shows 100-year and 500-year floodplain
GSA	General Service Administration
LEED	Leadership in Energy and Environmental Design - the green building system of the U.S. Green Building Council
LTCP	Long Term Control Plan
MLW	Mean low water- the average height of the low tides over a 19-year period
MOU	Memorandum of Understanding
MS4 Permit	Municipal Separate Stormwater System Permit, required by CWA for municipal stormwater systems
NEPA	National Environmental Protection Act
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NWS	National Weather Service
OMB	Office of Management and Budget
USGS	U.S. Geological Survey
WAWAS	Washington Area Warning Alert System

APPENDIX E: Flood Stages for the Potomac River from USGS

24.1	Water begins to inundate Constitution Avenue near the Lincoln Memorial at the low spot on Henry Bacon Drive.
22.2	Water begins to reach the Pentagon East parking area.
20.5	Water begins to inundate the north end of the North-South runway at Reagan National Airport.
19.0	Water begins to flood the south end of the North-South runway at Reagan National Airport.
17.0	Water approaches the Southeast end of the Northwest-Southeast runway at Reagan National Airport.
16.7	Water begins to inundate the Kennedy Center for Performing Arts at Rock Creek and Potomac Parkway.
16.0	Water approaches low spots of the 14th Street Bridge approach on the DC side of the river. Water also reaches George Washington Memorial Parkway south of Reagan National Airport near Four Mile Run.
15.0	Water inundates portions of Maine Avenue.
13.7	Water approaches East Potomac Park at the railroad bridge.
13.0	Wisconsin Avenue and K Street are flooded.
12.0	The parking lot at the foot of Wisconsin Avenue in Georgetown floods.
11.0	There are no longer tidal effects. The river will rise to crest then fall, not seeing the separate high and low tides again until the water drops below 11 feet.
10.5	Water approaches Independence Avenue at 17th Street and the George Washington Memorial Parkway at the railroad bridge north or Reagan National Airport.
10.0	Water approaches K Street in Georgetown near Washington Harbor.
7.0	Water begins to inundate Washington Harbor.
6.0	Water reaches bulkhead along Washington Harbor.

APPENDIX F: Aerial Maps of Flood Control Projects

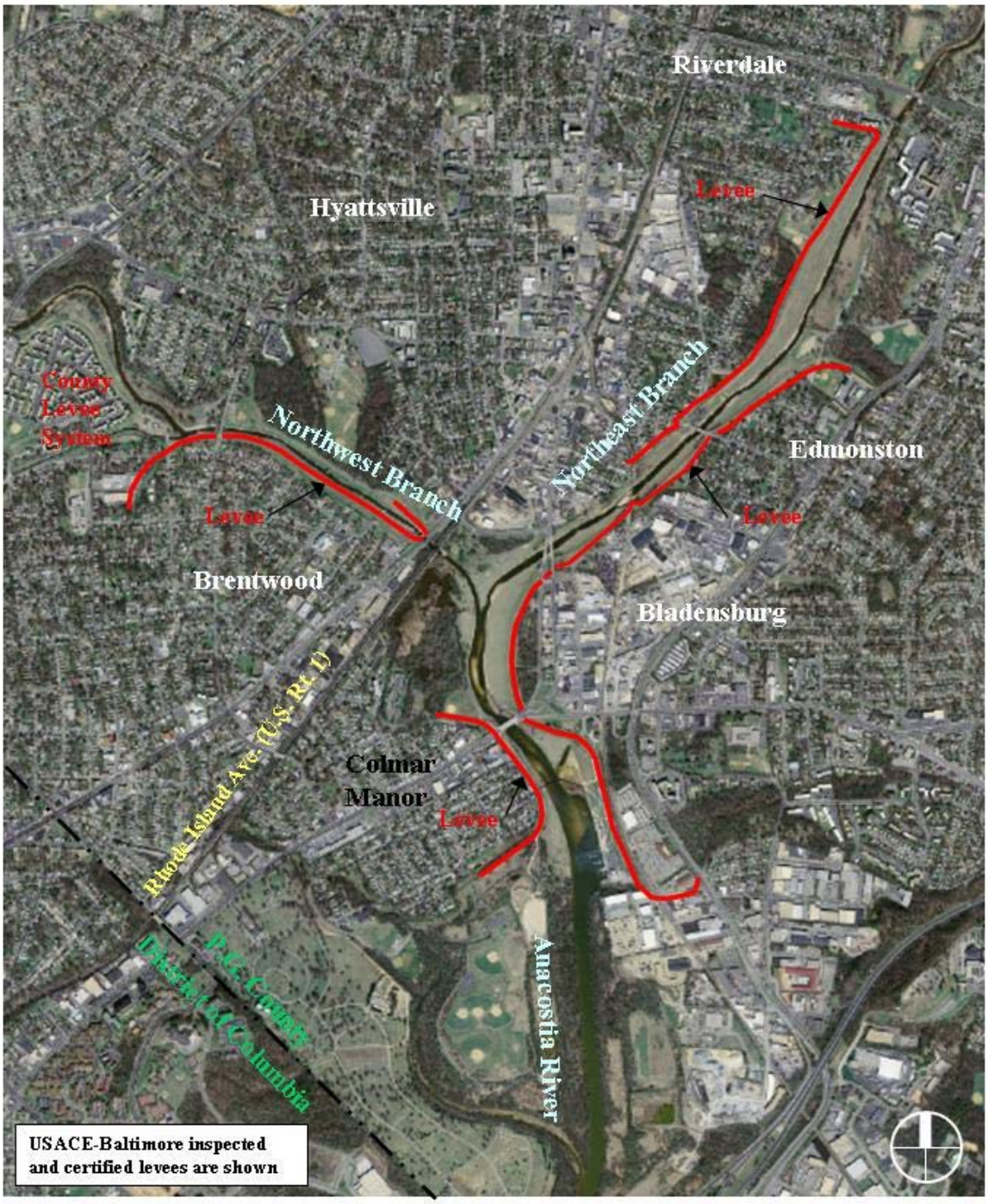
Figure 1

LOCAL FLOOD PROTECTION
ANACOSTIA RIVER

Washington, D.C.

APPENDIX F: Aerial Maps of Flood Control Projects

Figure 2



LOCAL FLOOD PROTECTION & NAVIGATION
ANACOSTIA RIVER

Prince George's County, Maryland