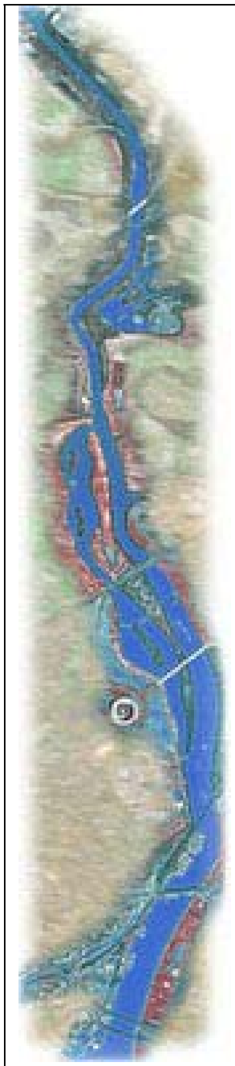

Charting a Course Toward Restoration:

A Toxic Chemical Management Strategy for the Anacostia River

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The burden of addressing problems within the Anacostia River has generally been the responsibility of the three affected jurisdictions within the Anacostia Watershed - Prince George County, Montgomery County, and the District of Columbia – which have implemented a number of actions to correct environmental problems. After reviewing several years' worth of environmental data, however, it is clear that contaminated river sediments still pose an unacceptable risk to the public and the delicate ecosystem of the river. It is also quite clear that there is no quick fix and that, because this large watershed spans several jurisdictions, no single entity has either the ability or the resources to make the river swimmable and fishable alone. Concerned stakeholders have joined together in groups such as the Anacostia Watershed Toxics Alliance (AWTA), the Anacostia Watershed Society (AWS), and the Anacostia Watershed Restoration Committee (AWRC) to pool knowledge, expertise, and resources to address the problems afflicting this beautiful river. Because of this common goal, this document, which outlines a holistic, overall approach for dealing with river toxics, with an emphasis on contaminated sediment, is jointly issued by AWTA and AWRC.

The Anacostia Watershed Toxics Alliance (AWTA) was formed in 1999 as a voluntary public-private partnership to address the toxic chemical problems in the river. The mission of the Alliance is stated as follows: "To work together in good faith as partners to evaluate the presence, sources and impacts of toxic contaminants in the Anacostia River with all stakeholders, both public and private, and other interested parties and to evaluate and take actions to enhance the restoration of the Anacostia watershed to its beneficial use to the community and ecosystem as a whole." Three primary objectives have been adopted by AWTA to carry out this mission:

- Identify and quantitatively assess risks to human health and the environment from toxic contaminants in the Anacostia River;
- Reduce risks from toxic contaminants to levels that are safe for humans and aquatic life; and
- Build effective partnerships among AWTA members, encourage public input, and promote effective restoration of the Anacostia watershed.

The Alliance represents over 25 different groups, agencies, and institutions, in addition to four (4) Divisions at EPA: Superfund, Water, ESD, and Chesapeake Bay Program. Members include the Maryland Department of the Environment, District of Columbia Department of Health, Anacostia Waterfront Initiative (AWI), Montgomery County (MD), Prince George's County (MD), U.S. Navy, Naval Research Lab, Army Corps of Engineers, U.S. Air Force, National Oceanographic and Atmospheric Administration, U. S. Fish and Wildlife Services, National Park Service, U.S. Geological Survey, General Services Administration, Agency for Toxics Substances and Disease Registry, Washington Counsel of Governments, Interstate Commission of the Potomac River Basin, Academy of Natural Sciences, District of Columbia University, Washington Gas and Light, Potomac Electric Power Company, and community representatives.

Recently, members of the Remediation Technologies Development Forum (RTDF) have begun to collaborate with AWTA as well.

AWRC was created by the Anacostia Watershed Restoration Strategy Agreement, which was signed in 1984 by the State of Maryland Department of the Environment and the District of Columbia Department of Health (MWCOG 1986), and was expanded to form the Anacostia Watershed Restoration Committee in 1987, including Prince George Department of Environmental Resources and Montgomery County Department of Environmental Protection, as well as the US Army Corps of Engineers, the U.S. Environmental Protection Agency, and the National Park Service, the Interstate Commission on the Potomac River Basin (ICPRB), and the MWCOG (administrator of the agreement) (ICPRB, 1994 and 1996). Five years later, as the centerpiece of the 1991 renewal of the Anacostia Watershed Restoration Agreement, the four jurisdictions adopted a Six-Point Action Plan. The Six-Point Action Plan identified the following six fundamental restoration goals (ICPRB 1994):

- Reduction of pollution loads
- Restoration of ecological integrity
- Improvement of fish passage
- Increase in wetland acreage
- Expansion of forest coverage
- Increase in public and private participation and stewardship

In 1999, the signatories of the *Six-Point Action Plan* reaffirmed their commitment to restore the Anacostia watershed by pursuing the Anacostia Watershed restoration goals and interim Targets for the period 1999-2000. In doing so they also agreed to adopt, through a public participation process, a suite of 50 specific, long-term restoration indicators and targets, and pledged to continue a basin-wide strategy to equitably achieve the six fundamental goals and associated targets by 2010. This latest agreement was adopted by the four Anacostia signatories (state of Maryland, District of Columbia, and Montgomery and Prince George's counties) at a highly publicized signing event on December 3, 2001.

Since 1987, actions taken by the AWRC and AWTA, affiliated organizations, environmental and business groups, and individual citizens have resulted in substantial restoration progress. To date, these groups have identified over 700 storm water retrofit, wetland creation, stream restoration, riparian restoration, combined sewer overflow abatement, trash and toxics reduction, and other restoration-related projects designed to correct environmental problems and enhance overall ecosystem quality. Of these projects, approximately one-third have either been completed or are in progress. Over the last fifteen years, roughly $35 million has been spent on restoration project implementation, with close to $30 million additional spent on land acquisition, planning, monitoring, engineering, design, and maintenance.

The Anacostia Watershed Toxics Alliance and the Anacostia Watershed Restoration Committee wish to acknowledge the following contributors to this document, without whose participation this effort would not have been possible:

U.S. Environmental Protection Agency
National Oceanic and Atmospheric Administration, Coastal Protection and Restoration Division
Prince George County
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District of Columbia
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Potomac Electric Power Company
Remediation Technology Development Forum
Washington Gas Light Company
Metropolitan Washington Council of Governments
University of District of Columbia
Academy of Natural Sciences
Interstate Commission for the Potomac River Basin
U.S. Fish and Wildlife Service
Maryland Department of the Environment

EXECUTIVE SUMMARY

- **BACKGROUND**

The Anacostia River is a freshwater tidal system draining an urban watershed that encompasses 456 km^2 in Maryland and the District of Columbia. The Anacostia River watershed has become increasingly degraded from decades of industrial and urban activities. Substantial destruction of tidal fringe wetlands and marshes has resulted in the loss of the watershed's filtering capacity. These losses have resulted in the river acting as a sink for contaminants. Ongoing contamination from many sources continues to degrade the system. Elevated concentrations of polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), lead and other trace elements, and pesticides are present in river sediments, posing a risk to humans and aquatic organisms. Even though there are currently fish advisories on the river for PCBs and pesticides, the river is still used for subsistence fishing by the local community. As a result, the Anacostia River has been designated one of three highest priority Regions of Concern within the Chesapeake Bay Region by the EPA Chesapeake Bay Program (1999).

The District of Columbia, Office of Planning has identified the potential of developing over 30,000 new residential housing units along the Anacostia waterfront over the coming 25 years. This urban revitalization opportunity will produce immeasurable local economic benefits for the communities along the shores of the Anacostia River, many of which are the poorest in the City and in the Region. Preliminary estimates identify a potential range of between $75 to $225 million dollars of new annual tax revenue for the District, resulting from the redevelopment of currently underutilized waterfront lands. Many of these sites, such as the Southeast Federal Center, Buzzard Point, Poplar Point and the Southwest Waterfront will be made much more attractive and desirable, after the environmental problems are eliminated.

Stakeholders in the river include federal, state, local governments, as well as non-governmental organizations. These stakeholders have been working to clean up sites and reducing the flow of contaminants to the river. They have repaired over 6.5 miles of leaking storm sewers, constructed 4 (four) sand filters that reduce trash and contaminant flow to the river, restored several miles of stream channels, built protective covers over 30 acres of former disposal sites to reduce contaminate migration, and removed over 7,000 gallons of coal tar, 20,000 gallons of petroleum, and 25 pounds of mercury. In addition, AWTA members have cleaned up over 27,000 tons of contaminated soil and 1 (one) million gallons of surface water and groundwater. In spite of these important advances, serious problems still exist and must be corrected.

- **VISION FOR THE RIVER**

The vision for the Anacostia River watershed is to restore this highly diverse and economically valuable natural resource to the community by making it fishable and swimmable by 2011, if funding for proposed actions is available.

- **PARTNERSHIP AND GOALS**

The Anacostia watershed spans three main jurisdictions: Prince George and Montgomery Counties in Maryland and the District of Columbia. In order to effectively address the complex environmental issues in the watershed, a phased, holistic approach has been adopted. To facilitate this innovative approach and assure successful management of this natural resource, concerned stakeholders have joined together to pool knowledge, expertise, and resources, and to work together to address the many environmental problems. These groups include the Anacostia Watershed Toxics Alliance (AWTA), Anacostia Watershed Restoration Committee (AWRC), and the Anacostia Watershed Society (AWS). This document addresses three primary objectives adopted by these groups to restore the watershed to beneficial use:

- Identify toxic contaminant sources and quantitatively assess risks to human health and the environment from toxic contaminants in the Anacostia River.
- Reduce risks from toxic contaminants to levels that are safe for humans and aquatic life, and
- Build effective partnerships among all stakeholders, encourage public input, and promote effective restoration of the Anacostia watershed.

- **CONCEPTUAL SITE MODEL**

Central to the restoration of the Anacostia is gaining an understanding of how contaminants enter, flow through, and ultimately how organisms and their predators (human and otherwise) are exposed. A Conceptual Site Model (CSM) is a basic description of how contaminants behave in a system. It provides an essential framework for determining source control requirements and addressing unacceptable risks.

Key requirements of a CSM are knowledge of contaminant sources, behavior, migration, and fate; hydrodynamics and transport factors; degradation rates; contaminant sinks; and mechanisms of exposure and uptake by ecological and human receptors. The CSM is also an important tool in helping to identify additional data needs in order to implement an effective cleanup. In addition to the semi-quantitative CSM, a quantitative mathematical model (Tidal Anacostia Model-Water Analysis Simulation Program “TAM-WASP”) has been developed for the D.C. Department of Health and is being calibrated and refined to provide predictive capability. This model will allow for the evaluation of various source identification requirements and remedial options.

The current conceptual site model is based on numerous field investigations by many different groups. These studies focused on the biological, chemical, and physical characterization within the watershed. While some data gaps still exist, the CSM presented in this document presents our current understanding of the watershed’s dynamics. The conceptual model is dynamic, subject to refinement as additional data is obtained. Hot spot locations in this document are presented for geographical representation and are not meant to imply the specific sources of contaminants. Additional locations may be identified in the future.

The Anacostia River has undergone many changes in response to industrial and agricultural activities and growing population pressures. Much of the physical change in the Anacostia is the result of soils eroding along the shoreline and from upland areas of the watershed. Development in the form of clearing and tilling have greatly accelerated the rate that water and sediment are carried to the river. However, extensive navigational dredging along the lower part of the river during this same period relocated a considerable volume of contaminated sediments from the channel to many sections of the shoreline. Much of the current pollution entering the river is not from direct "dumping" into the river, but stem from widespread low level urban and industrial pollution throughout the watershed. Non-point-source pollution represents a challenge to the way our urban areas are planned and designed. The manner in which rainwater drains from our urban neighborhoods, as well as our transportation infrastructure, must be rethought so as not to place an undue burden on the watershed's capacity to absorb toxic loadings. Municipal regulations such as zoning, building codes and civil engineering standards must all be reviewed and reconsidered with regard to runoff issues.

Contaminants bond with sediments and move together through the sewers and small creeks to the river. The contaminated sediments of the watershed eventually end up in the river, which serves as a collection area or sink for all of the urban and industrial activities that are occurring throughout the watershed.

The primary sources of toxicity in the river appear to be from chemicals widespread in the environment. Polynuclear aromatic hydrocarbons or PAHs are mainly produced by the incomplete combustion of fossil fuels such as petroleum and coal, and are present in most common petroleum products, such as oils, greases, asphalt, roofing tar, and creosote. Poor management of these materials, common in modern society, and concentrated in an urban environment, leads to the continual loading of contaminants into the river. Polychlorinated biphenyls (PCBs) were in widespread use for a variety of purposes in the watershed, such as insulating oils in electrical transmission equipment and hydraulic fluids. Even inks used in early carbonless papers contained PCBs. Although the manufacture and commercial distribution of PCBs were banned in 1976, they have yet to be completely eliminated in the Anacostia watershed.

Historically, military, industrial, and urban pollution probably began to negatively affect the river near the turn of the 20th century, perhaps reaching a peak during WWII. The historical use of PCBs by the Washington Navy Yard (now split into the Washington Navy Yard and the Southeast Federal Center) was investigated in the 1990s. PCBs were found in onsite soils and in the storm sewers that drained the property. A considerable portion of the entire storm sewer system, that is the storm water lines on the eastern portion of the former facility, was recently rehabilitated. In the system on the western portion (currently the Southeast Federal Center) of the old installation, sediments have been removed from the sewer but the line has not been rehabilitated. In addition, PCBs were used and stored at an electric power company sited along the river. The company has not been able to test all of the transformers in its power distribution area to determine if they contain PCB concentrations exceeding regulatory criteria. Data from the National Park Service, dated February 2002, shows evidence of new PCB sources entering the river from Kenilwoth Landfill.

The District has reported that coal gasification plants are known to have existed on several sites in the lower portion of the watershed. At the Washington Gas facility, free phase coal tar has been identified as a potential source of PAH's to the river. Recovery operations are currently in progress.

For some pollutants, loadings to the river may have begun tapering off with the environmental awareness and regulation of the 1970s and 1980s. However, environmental investigations are still in progress at almost all of the contaminated sites, and the contaminant loadings from these areas are largely yet to be determined. In addition, the ground water pathway to the river and its potential to contaminate the sediments is still poorly understood at most sites. As contaminated sediments from the watershed settled on the river bottom, the legacies of contamination were left behind. This is the result of sediment mixing caused by storm and dredging events; the continued deposition of contaminated sediments into the channel; and possible contamination of clean sediments by upwelling contaminated ground water. Although sediment contamination may be many feet deep, fish and other wildlife live in and are exposed to only the top few centimeters of sediments. Currently the top few inches of sediments in the Anacostia are contaminated. The few creatures that can survive there are unhealthy and may be impacting other fish that eat them. It is likely that the invertebrates that live in these sediments serve as a pathway for the transport of contaminants from sediments into fish and their predators. This is the result of sediment mixing caused by storm and dredging events; the continued deposition of contaminated sediments into the channel; and most likely the contamination of clean sediments by upwelling contaminated ground water. Moving up the food chain, this in turn poses unacceptable risks to the people who consume these fish.

In general, concerted attempts are being made to investigate, remediate and prevent contaminant loadings from the largest, most easily identified military/industrial facilities as well as from smaller operations. Further, state and local governments continue to implement controls and enforcement actions designed to prevent contaminant discharges from potential sources of urban pollution such as active and abandoned business sites, private properties, streets, parking lots and highways. However, due to budgetary constraints, all of these potential sources and others including the dumping of trash in public areas and discharges from antiquated combined sewer systems (CSOs), which currently is serving approximately one-third of the District of Columbia, continues to pose threats to human health and the environment. The CSOs are outdated systems that permit urban runoff pollution and raw sewage to bypass treatment plants during modest rain events. Averaging about 82 releases per year, the discharge volume equates to approximately 2.142 billion gallons of contaminated waste-water entering the river annually through overflows in the combined sewer system. Storm waters that bypass treatment facilities carry pollutants washed from bathrooms, streets, lawns and parking lots directly to the river. Natural, filtering wetlands and forested riparian buffer zones, which once lined the river and it's tributaries, have been largely eliminated and replaced with efficient storm drain systems, so that urban pollution often flows unimpeded from the watershed to the river. While the AWRC and its affiliates have, since 1987, made great strides in reducing uncontrolled stormwater runoff and stream channel erosion conditions in the watershed, the uppermost layers of riverbed sediment remain contaminated. During large storm events there also is likely resuspension and mixing of these riverbed sediments. While the physical appearance of the river has generally improved, the bottom sediments have not recovered and will not until point and non-point source pollution is fully addressed.

Understanding human and ecological exposure pathways is an important component of any CSM. Ultimately, exposure routes to, and uptake by biota (including humans), is of principal concern. Bioaccumulation through the food web is a significant exposure route for many organic contaminants of concern for the Anacostia. The screening level risk assessment indicated that the primary pathway for human exposure is from ingestion of contaminated fish, although other pathways are present such as the ingestion of river-water during recreational use. The primary ecological receptors at risk within the river are bottom-dwelling organisms (benthic) and fish. Benthic organisms are exposed from direct contact with sediment and water or ingestion of particulates. Fish may be exposed to contaminants from direct contact with sediment and water plus from bioaccumulation through the food chain.

Since the late 1980's, there has been a fish consumption advisory in effect for the Anacostia for PCBs and pesticides. Liver tumors, most likely from exposure to PAHs, are also very common in bottom-dwelling fish, running as high as 56% in some samples. This is evidence that elevated levels of toxics are present in the river environment and are entering the food chain.

- **GENERAL STRATEGY AND PHASED APPROACH FOR MANAGEMENT**

Watershed restoration must not be thought of as restoring to historic conditions. It must thought of as a reintroduction of watershed "riparian systems". In many instances this will translate into the reconstruction of urban infrastructure and the construction of new parks and open space areas to form new "green" infrastructures. It could reach a condition where it is still mostly filled with the muds of the past centuries, but where the uppermost layers, where animal and plant life dwell and obtain food, are clean and healthy.

Millions of gallons a year of fresh water enter the watershed and river through rainfall. The new sediments flushing into the river each year, if no longer contaminated on their journey, could lead to the river's eventual recovery. However, to achieve the goals of restoration in a timely fashion, active remedial actions will be required to manage the contaminants flowing into the river. The general strategy for watershed management is:

- Identify for elimination major contaminant sources that are impairing the watershed.
- Identify applicable, relevant and appropriate regulations.

- With the aid of analytical data, the TAM-WASP computer model and the CSM, prioritize sources in terms of significance of contribution to impairment.
- Identify and evaluate alternative strategies to address contaminant sources or pathways and conduct an alternatives analysis for the most effective strategy that minimizes net risk. Ensure that selected alternatives are consistent with overall strategy for the watershed management plan, both spatially and temporally.
- Develop a schedule and sequence of phased actions based on the alternatives analysis, which build on and expand the stormwater retrofitting, stream restortation, wetland creation and riparian reforestation activities of the AWRC and it's affiliates.
- Work with appropriate parties and stakeholders to manage upgrade actions.
- Monitor response of the watershed to each phase of action; refine the conceptual site model, and revise the next phased action as appropriate.

In 1998, EPA issued the Contaminant Sediment Management Strategy to promote the use of consistent sediment assessment practices, consistent consideration of risks, consistent risk management. The management strategy encouraged the use of resources for implementing regulatory requirements, as well as for research and technology development with respect to contaminated sediment. In 2002, EPA issued eleven management principles for contaminated sediment management. The approach outlined in this document is consistent with current guidance and the approaches being developed by regulatory and stakeholder groups focusing on contaminated sediment issues.

- **ESTIMATED COSTS TO IMPLEMENT THE REMEDIATION MANAGEMENT STRATEGY**

Total projected costs to monitor and restore the Anacostia River to its beneficial use are approximately $212 Million. This amount includes, in part, remediation of hot spots, addressing contaminated outfalls and tributaries discharging into the river, monitor tributaries to identify sources of contaminants entering the Anacostia, conducting investigations to identify ongoing releases, enhanced trash removal operations, construction of storm water management practices and stream restoration projects to reduce contaminant and sediment loadings to the river, develop new watershed education and outreach programs designed to reduce pollutant loadings at or near their source, and continue to monitor both the river and the watershed to determine the effectiveness of the remediation efforts. It does not include the cost of major sewer upgrades in the three jurisdictions. This phased approach, with watershed-wide upgrades to reduce loadings, followed by careful monitoring of the river's responses to these improvements, should save money by significantly reducing the number and magnitude of cleanup actions required to render the river as a safe and useful community asset.

A summary of currently planned phased activities is given below. Monitoring activities will be tailored to specific objectives and may include chemical, physical or biological monitoring for indicator parameters.

- Conduct Human Health and Ecological Risk Assessment -2003
- Characterize contaminants and monitor storm flow of Combined Sewer Overflows (CSO) -2003
- Continued implementation of LID activities -2003-2008
- Monitor groundwater contaminant plume contribution to the river environment -2003-2004
- Conduct feasibility studies of Sediment remediation alternatives -2003-2007
- Implement Capping Pilot Demonstration and monitor for effectiveness -2003-2007
- Prioritize watershed remedial activities -2004 and on
- Implement pilot for CSO loading control (Engineered Treatment Wetlands) and monitor -2004-2005
- Implement feasibility studies of tributary sources and monitor -2005-2007
- Monitor environmental quality response to corrective measures, refine CSM and refine remedial strategies -2005-2010
- Construct Engineered Treatment Wetlands and monitor -2005 -2006
- Implement sediment remedial strategies and monitor -2005-2010
- Evaluate actions and discontinue monitoring if goals have been achieved or trends indicate success

These efforts are consistent with goals developed by AWTA and AWRC for the restoration of the Anacostia watershed, and are one of several key initiatives being planned that would collectively lead to the cleanup of the river and its restoration as an asset and source of pride to the community.

1 Introduction

1.1 OVERVIEW

This document presents a toxic chemical management strategy for the Anacostia River. It is based upon the 3-phased approach of the Anacostia Watershed Toxics Alliance (AWTA) and their synergy with the broader goals of the Anacostia Watershed Restoration Committee (AWRC). The document presents a holistic approach and projected costs for managing the toxic condition of the river. The approach provides for control of on-going sources of toxics as well as remediation for past releases. The goal is to restore the Anacostia River to a condition where it supports designated human uses and provides for ecological integrity.

Over the centuries, the Anacostia has undergone many changes due to the presence of man in its watershed. Some of these changes are irreversible physical alterations, while others are reversible impacts. These combined changes result in the depressed, degraded biological conditions observed in the river today. The river can never be returned to a condition or state close to what it would be today without man's influence. But it can and must be made safe and healthy again. With commitment, the Anacostia can once again be restored to functioning ecosystem and contribute to the economic viability and the quality of life in the surrounding communities. Improvements have been made to the Anacostia River and efforts are continuing.

The Anacostia River has been designated one of three high priority Regions Of Concern within the Chesapeake Bay Region by the Chesapeake Bay Program, partly due to the extent of sediment contamination. The District of Columbia, in consultation with the Agency for Toxic Substances and Disease Registry (ATSDR), declared several fish consumption health advisories in the 1990s with restrictions on bottom-feeding species and game fish. Also a fish consumption ban for pregnant women and children has been issued. Liver tumor prevalence in bottom-dwelling brown bullheads is as high as has been reported in contaminated areas of the Great Lakes. These lesions appear to result from exposure to carcinogens in the sediments. The strongest evidence for a specific class of chemicals has causative agents exists for PAHs. These examples illustrate the magnitude of the issues facing the river.

The ongoing discharge of pollutants to the river needs to be characterized and managed. There are several approaches recommended for reducing discharges to the river. Some are for point sources, while others are for non-point sources. Some are interim measures, while others are long-term. Some are aimed at intercepting what continues to be transported to the river just prior to discharge, while others are aimed at controlling migration throughout the watershed. Plans already exist to greatly modify the overflowing combined sewer systems to provide sufficient volume to capture, store, and treat the water from major rainstorms prior to entering the river. Large facilities that are pollutant sources must be willing to reduce their contaminant loads below regulatory standards to meet risk based standards consistent with watershed restoration goals. Contaminants and trash need to be removed from streets and parking lots before they are washed into the river. Storm waters from our streets and parking lots need to be diverted through filtering beds or basins and wetland treatment facilities, to remove oil, grease, and other urban pollutants before entering the river. The local population must take greater responsibility through careful handling of hazardous substances and recycling.

Costs associated with the remediation of contaminated sediments of the Anacostia River are expected to be beyond the means of any single group or organization. Nor can any one remedy accomplish the process of restoring the Anacostia River. It will take a combination of efforts, directed at many different sources, to affect the river's recovery, with remediation of contaminated sediment as just one of the critical elements in this process. For this reason, all available avenues will be pursued in order to secure resources necessary to implement a permanent sediment restoration strategy for the Anacostia River. The remedial actions proposed in this strategy are not final: detailed analysis of remedial alternatives will be conducted as part of planning for each action. Appropriate actions will then be chosen based upon a number of factors, including protectiveness, effectiveness, cost, and public acceptance.

The Anacostia **can** recover, not to its original condition before human intervention, but to a new, healthy condition. It could reach a condition where it is still filled with the muds of the past centuries, but where the uppermost layers once again provide clean, healthy habitat for animal and plant life. Achieving this healthy condition will take years of hard work and significant resources.

A monitoring program, timed in phases, will be designed taking into account the planned improvements and recovery processes. Signs of ultimate recovery will be tracked, but early and intermediate indicators of progress will also be measured and recorded. The monitoring program for river toxics is designed to capitalize on other existing and planned monitoring programs intended for related but different purposes.

Measurable indicators of river recovery fall into different categories, in terms of the speed at which meaningful changes can be measured. The fastest will be the physical improvements, constructed facilities, and upgrades in the watershed, such as CSO upgrades, construction of filtering wetlands, and elimination of other point discharges and active hot spots. These improvements can be directly observed. Direct assessment of their efficacy can and should be observed as part of their construction and installation process as well. As improvements are made to these systems, the benefit to overall water quality should be verifiable by direct sampling.

The second-fastest-responding indicators should be direct water quality samplings of major sources, such as dissolved and particulate inputs from certain tributaries and point discharges to the river, such as storm sewer outfalls. Observation of improvements in water quality within the main branch and major tributaries may lag however, as the level of control throughout the watershed increases. Some biological observations can serve as indicators of very rapid response to general water quality improvements as well.

The slowest indicators may be the river sediments themselves and biological receptors. These indicators include:

- The appearance of a clean layer of solids on top of the sediment column,
- The re-colonization and diversity of the community of creatures that dwell in sediments,
- The contamination levels in their tissues, and
- The health, contaminant tissue residues, and exposure indicators of fish and wildlife receptors.

These represent indicators that will respond directly to improvements. However, these parameters will respond on varying time-scales.

Reports on the progress and success of the toxics management effort will be issues on a periodic basis. In addition, refinements on the understanding of dynamic processes in the river (i.e. the conceptual model) and the remediation strategy will be made as additional information becomes available.

1.2 BACKGROUND INFORMATION

The Anacostia River (Figure 1) is a tributary of the Potomac River, which in turn flows into the Chesapeake Bay. The Anacostia River begins at the confluence of the Northwest and Northeast branches at Bladensburg, Maryland and runs less than nine miles to its confluence with the Potomac River in Washington DC. The river is completely freshwater, but tidally influenced throughout its entire run. The river's watershed drains a predominately urban area that encompasses 456 km^2 in Maryland and the District of Columbia.

Decades of industrial and urban activities throughout the watershed have increasingly degraded the river and caused the substantial loss of tidal fringe wetlands and marshes. Today, only about five percent of the original tidal wetlands remain in the Anacostia. Because of these impacts, the river can no longer filter substances and is a sink for contaminants. Development has greatly stressed the river's ecosystem and elevated the levels of hazardous substances present, negatively affecting the delicate balance of life in and around the river. Elevated concentrations of hazardous substances, including polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), lead and other trace elements, and pesticides are all present in sediment throughout the river, posing a risk to aquatic organisms and to humans. Bioaccumulation of

PCBs in fish tissues means that people may be at risk if they eat fish from the Anacostia River. With the increased bioavailability of contaminants in the river's food chains, habitats of species critical to the survival of the Anacostia River's ecosystem are in jeopardy.

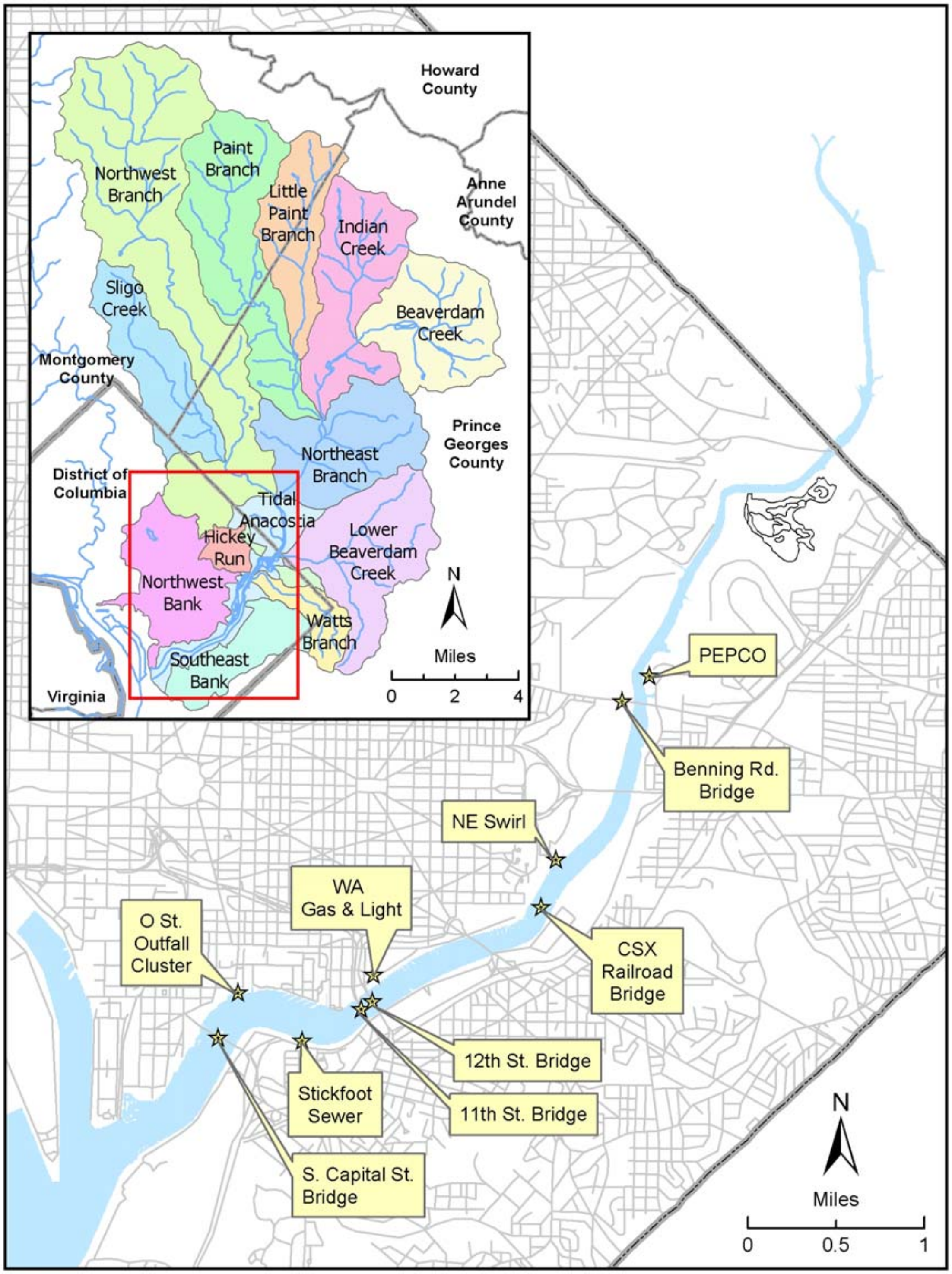

Figure 1: Anacostia River watershed showing subwatershed divisions and major tributaries.

Most of the physical change in the Anacostia involves the relocation of soils and sediments. Wetlands were intentionally filled with sediment dredged from the river channel. Even portions of the entire river course were relocated from their historical locations. After the arrival of humans, forest clearing, tilling, and development have greatly accelerated the rate at which sediment and water moved into the river. These material changes can be slowed by enlightened development and responsible land-use practices, but the river can never be put back, physically, the way it was or might have been. However, we *can* restore the biological integrity of the river in its current form.

Although chemical "pollution" makes up only one factor of the total changes in the Anacostia River, this factor makes much of the river harmful to fish and other wildlife. We must eliminate the pollution that causes toxicity so that we can restore the biological integrity of the river and make it swimmable and fishable again. While much of the historical pollution in the river was from direct "dumping" of solid and liquid wastes before most of the current environmental regulation were in place, the current problem is a result of pollution of water some distance from the river, which then flows to the river. Unseen, but no less significant, is the migration of potentially contaminated groundwater to the surface water body. The polluted water and solids flow to the river mainly through tributary streams and sewers. The pollution process is not limited to just along the river, but has occurred throughout the entire watershed. In this regard, the River serves as a gathering point or sink for what occurs throughout the watershed.

Pollution generally began in earnest at the turn of the past century, perhaps reaching a peak during and after the WWII era. Some pollution likely began tapering off with the environmental enlightenment and regulation in the 70s and 80s. As layer after layer of sediments settled on the river bottom, bands of contamination were left behind. One advantage is that although sediment contamination is many feet deep, fish and other wildlife live in and are exposed to only the top few inches of sediments. So, only a small fraction of the total pollutants are causing the current harm. But since the top few inches of sediments in the Anacostia are presently contaminated, the creatures that can survive serve as a pathway for exposure to fish and other predators. Even if all ongoing sources of pollution are eliminated, the repository of contamination present in the sediments of the river could serve as a secondary source of pollutants that needs to be addressed.

Although some pollution may have tapered off, more widespread urban pollution has not. Smaller active and abandoned business sites, private properties, streets, and highways continue to release pollutants. Development has expanded beyond the capacity for aging, "combined" sewer systems, allowing some urban pollution and sewage to bypass treatment plants during even modest rain events. Storm waters carry pollutants washed from streets and parking lots directly to the river. Natural, filtering wetlands and buffer zones, which once lined the river, have been eliminated, so urban pollution flows unimpeded from the watershed to the river. The result is that the newest, uppermost layers of sediments are hardly better than those laid down 30 or 40 years ago. While the physical appearance of the river may have improved, the bottom sediments have not recovered and will not until these present, on-going sources are curtailed.

The main causes of toxicity in the river are chemicals widespread in the environment. Polynuclear aromatic hydrocarbons or PAHs are present in most common petroleum products, such as oils and greases, and as by-products from combustion. Poor management of these materials, so common in modern society and so concentrated in an urban environment, leads to ongoing pollution of the river. PCBs were in widespread use for a variety of purposes in the watershed, such as insulating oils in electrical transmission equipment and hydraulic fluids. Even the inks used in early carbonless papers contained PCBs. PCBs are highly persistent once in the environment, and they have yet to be completely eliminated in the Anacostia watershed.

There is an advisory in effect against eating fish from the Anacostia due to their concentrations of PCBs and pesticides. Tumors are also very common in bottom-dwelling fish. This situation is unacceptable, and it is evident that elevated levels of toxics are present in the river environment and are moving to the fish.

1.3 Management Philosophy

To be able to effectively assess and manage contaminated sediments requires an understanding of both the Anacostia watershed and the river's dynamics. This includes an understanding of the hundreds of point and nonpoint sources; distributions of contaminants; fate and transport properties, including sediment transport and depositional patterns; and human and ecological resource use. This is an extensive effort, which is outside the requirements and fiscal resources of any single party

Several groups, including members of AWRC and AWTA, are working hard to restore the river. In order to accomplish this task, many parties are evaluating various aspects of the problems affecting the river (e.g., total maximum daily loadings, combined sewer overflow releases, and trash removal) and developing restoration plans, including Brownfields redevelopment. While some other rivers are being addressed nationally under Superfund, the work being done here is unique and well beyond normal operating procedures as defined in CERCLA and the NCP. The hazardous contaminants of the Anacostia watershed are being investigated, not by Superfund or potentially responsible parties, but by public and private volunteer stakeholders who are cooperatively performing this work without the issuance of any Administrative or Consent Order.

Voluntary pooling of resources to address an entire watershed's severe toxic contamination problems had not been done before. This effort is truly remarkable because of the lack of existing policy or guidance; the collective partnering approach that AWRC and AWTA took to jointly issue this document; the voluntary sharing of resources by stakeholders; and the innovative investigative methods employed by AWTA to fill in the data gaps. The participating volunteer member organizations comprise federal regulatory and resource agencies, state and local environmental agencies, industry, academia, and the public.

By pooling available fiscal and technical resources, AWRC and AWTA have successfully developed a watershed-based approach. The approach outlined in this document is consistent with current guidance, such as EPA's 1998 Contaminant Sediment Management Strategy, and approaches developed by regulatory and non-regulatory groups focusing on contaminated sediment issues. This strategy was developed to complement and supplement existing efforts. It was also developed to work with, utilize, and assist existing regulatory programs and authorities. Finally, it has adopted the goal of returning the river to a swimmable and fishable condition.

1.4 1987-2001 Anacostia Watershed Restoration Activities and Progress

Before the 1987 Anacostia Watershed Restoration Agreement was signed, much of the regional environmental concern and focus was on the larger, ailing Potomac River. However, in the years since, local, state, regional, and Federal government agencies, as well as environmental organizations, businesses, and dedicated citizens have made a increasingly concerted and focused effort to protect and restore the Anacostia watershed.

Over the past 15 years, actions taken by the AWRC, AWTA, their affiliated organizations, environmental and business groups, and numerous individual citizens have resulted in substantial restoration progress. To date, members of AWRC and AWTA plus others have identified opportunities for over 700 storm water retrofit, wetland creation, stream restoration, riparian restoration, combined sewer overflow (CSO) abatement, trash and toxics reduction, and other restoration-related projects designed to correct environmental problems and enhance overall ecosystem quality. Of these projects, approximately one-third have either been completed or are in progress. Since 1987, roughly $35 million has been spent on restoration project implementation, with approximately $30 million additional spent on land acquisition, planning, monitoring, engineering, design, and maintenance. Further, $65 million has been spent on engineering controls designed to reduce the impacts of CSOs on the tidal river and of leaking, aging sewer lines on the tributary streams.

In just the last few years, members of AWTA, such as Washington Navy Yard, National Park Service, Washington Gas Light, and the General Services Administration, have been effectively cleaning up their sites, thereby reducing the flow of contaminants to the river. They have repaired over 6.5 miles of leaking storm sewers, constructed four sand filters to reduce trash and contaminant flow to the river, built protective covers over 30 acres to reduce contaminate migration, and removed over 7,000 gallons of coal tar, 20,000 gallons of petroleum, and 25 pounds of mercury. In addition, members have also abated over 27,000 tons of contaminated soil and 1 million gallons of surface and groundwater.

There are three special appropriations from Congress signaling the beginning of cleanup of the river's sediment under AWTA's Phase III plan (A discussion of the 3 Phased Approach is included in the following section). The Anacostia Park East legislation will increase the number of wetland acres present in the watershed by about 20%. This action will provide some filtration and degradation of contaminated particulates, but will also further help to preserve important food chains and habitats critical to the Anacostia River's ecosystem.

The second appropriation initiates a Phase III LID effort. This action will demonstrate the effectiveness of LID to detain and cleanse a storm's first flush. Based upon studies from other watersheds, detaining the first flush of rain - about an inch or less- can significantly reduce the toxics loading to the river.

The third appropriation is funding a sediment reactive-capping project being developed by EPA's Hazardous Substance Research Center (HSRC). The use of reactive caps over contaminated sediment in the Anacostia is intended to reduce contaminant levels and retard migration while final remedial actions are being implemented.

1.5 AWTA 3-Phased Approach

Although numerous chemical investigations had been conducted in the river over the years, they had not been collected or analyzed in a coordinated manner sufficient for a detailed evaluation of risk, nor for evaluating remediation. AWTA was formed in 1999, to some degree, in response to this situation. During its first year, AWTA drafted its three-phase approach, and completed the Phase I activity.

The Phase I assessment involved collecting, organizing, and summarizing all relevant existing data on the Anacostia River that could be used for characterizing contamination, developing a preliminary watershed conceptual model, and assessing potential risk to humans and ecological receptors (SRC and NOAA 2000).

Screening for human health risk was conducted using conservative assumptions, which would eliminate contaminants that do not pose risk under worst-case scenarios. This conservative approach compared maximum concentrations in sediment, surface water, and fish tissue to risk-based benchmarks. Results identified 39 contaminants of potential concern (COPCs) in fish tissue. The primary chemical classes identified in fish tissue were dioxins and furans, pesticides, PCBs, and trace elements, including arsenic, cadmium, lead, and mercury. COPCs in sediment were arsenic, PCBs, and four PAH compounds. Arsenic, PCBs, and heptachlor, DDE, and DDT were identified as COPCs in surface water. Because of data limitations, significant information gaps, such as fishing and recreational use throughout the river, were noted.

A screening of potential risk to ecological receptors was also conducted using highly conservative assumptions that tend to eliminate contaminants that do not pose risk even under even worst-case scenarios. Risk for aquatic organisms and wildlife, grouped into categories called ecological receptors, were estimated for aquatic birds, aquatic mammals, fish, and benthic invertebrates. The benthic, or bottom-dwelling, invertebrates are considered key elements of the food chain necessary for supporting other organisms. Results indicate that sediment levels of chromium, lead, mercury, nickel, zinc, PAHs, PCBs, and several pesticides are sufficiently elevated in certain locations to be toxic to benthic invertebrates, and that sediment PAH concentrations are high enough to pose a risk to fish. Also, concentrations of PCBs in fish tissue may be high enough to impair reproductive success. Using very conservative approaches, the risk posed to aquatic birds or mammals does not appear to be significant. Given the large uncertainty associated with these conservative estimates, firm conclusions regarding the actual risk posed were not possible.

By the end of its first year and based upon results from Phase I, AWTA had identified the major gaps in information that would be required to formulate management decisions and initiated Phase II by drafting a scope of work to conduct field studies to fill these critical information needs. Some of these included:

- Spatial and temporal profiles of chemical concentrations in the sediment and water column;
- Data on chemical inputs from major point and nonpoint sources to support quantitative models of loadings to the river;
- Greater understanding of hydrodynamics and sediment transport to model spatial contaminant concentration profiles and identify high impact areas; and
- A finer-scale spatial characterization of ecological exposure and effects.

During its second year, AWTA secured funding for Phase II and implemented many of the studies that were necessary to develop management plans. Table 1 lists Phase II field investigations that have been completed or are underway.

Table 1: Field investigations and status of Phase II Studies.

Conceptual Model Component	Type of Data Proposed or Collected	Investigator	Status
Contaminant Inputs			
Ground water[a]	Groundwater discharge rates and PAH concentrations in pore water at six locations	SPAWAR	Report submitted
Storm water effluent[a]	Storm drain sampling of contaminants during base flow and storm water events	MWCOG	Will begin 2002
Modeled inputs	Mass balance model to estimate sediment and metal loads to the tidal river	ICPRB	Preliminary results available
Fate and Transport			
Hydrodynamics[a]	Bathymetry, tidal mixing, current velocities, circulation, flushing time	SPAWAR	Report submitted
	Contaminant transport, mixing, and dispersion	Limno-Tech	Report submitted
Sediment trend analysis	Grain size analysis to determine areas of erosion, stability, and deposition	GeoSea Consulting, Inc.	Report submitted
Modeled fate and transport	Mass balance model of hydrodynamics, sediment, and metals transport in the tidal river	ICPRB	Preliminary results available
Nature and Extent of Contamination			
Sediment	Field screening for contaminants	SPAWAR	Report submitted
	Definitive sampling for contaminants	ANS	Report submitted

Surface water	Field screening for contaminants	SPAWAR	Report submitted
	Definitive sampling for contaminants	ANS Velinsky	Partial data submission
Ecological Risk Exposure Pathways and Effects			
Benthic community exposure and effects	Benthic community analyses and bioassays	USFWS, UDC	Report submitted
Fish exposure and effects	Tumor prevalence in brown bullheads	USFWS	Report submitted
	Early life stage water toxicity tests	USFWS	Report submitted
	In situ bioaccumulation measurements	USFWS	Report submitted

[a] Data from these investigations will be incorporated into the mass balance modeling.

With work on Phase II nearly complete, key information gaps have been filled. Several major advancements in understanding were realized:

- River bathymetry was updated and existing river morphology was corrected. Some significant differences in river volume were noted over previous calculations.
- The first river-wide investigation of sediment transport and dynamics was conducted. Analysis from over 600 samples confirmed general downstream transport of sediment with settling in the lower river, but also indicated the small scale variations in dynamics, the influx of sediment from multiple sources, and the extent of influx of sediment from the Potomac River.
- The most comprehensive characterization of sediment contamination was conducted through two separate surveys, encompassing the entire river, with over 100 samples each.
- The first synoptic, river-wide survey of general water quality was conducted.

Results from these studies and the information gained are being used to refine the Conceptual Site Model (CSM), presented as an appendix to this document, and as a basis for the Management Strategy which begins AWTA's Phase III efforts.

Under Phase III, the AWTA/AWRC partnership will continue to develop and implement an overall remediation strategy that deals with the watershed as a whole, using a mix of short- and long-term actions as appropriate to achieve mutual restoration goals by 2011. AWTA will coordinate with the appropriate regulatory agencies to assist with incorporating point and nonpoint source assessments and source control into their programs. It will be the financial responsibility of each generator to address specific regulatory requirements. As these efforts proceed, they will:

- Identify, where practicable, current and historical sources;
- Comply with the CERCLA process, consistent with the 11 principles of EPA's Contaminated Sediment Management philosophy, when preparing for and implementing any cleanup action;
- Prepare decision documents outlining remedies necessary to address unacceptable risk situations;
- Solicit peer and public input into the process;

- Coordinate with appropriate authorities of findings for matters not Superfund-related; and,
- Identify resource requirements and develop a strategy to acquire funding and take appropriate actions to remediate negative impacts to sediment in the Anacostia Watershed.

2 Summary of the Conceptual Site Model

A conceptual site model (CSM) is a basic description of how contaminants enter a system, how they are transported around the system, and how the routes of exposure to organisms and humans occur. As such, it provides an essential framework for assessing risks from contaminants, determining unacceptable risks and the factors associated with such risks, developing remedial strategies, and determining source control requirements. Appendix A describes the current CSM for the Anacostia in detail. The conceptual model is dynamic, subject to refinement as additional data is obtained. Hot spot locations in this document are presented for geographical representation and are not meant to imply the specific sources of contaminants. Additional locations may be identified in the future. A highlight of major elements from the CSM is presented here.

Because of the complex interplay between the biological and physicochemical compartments of an ecosystem, CSM models that attempt to address every nuance and answer every scientific question can become quite complex. However, a CSM can rely on reasonable assumptions to arrive at more simplified view that is still an adequate tool for meeting objectives. More generalized results tend to be associated with broader uncertainties however. A CSM can also help identify key information gaps. When quantitative components of CSM's are developed and calibrated [such as the Tidal Anacostia Model (TAM)/Water quality Analysis Simulation Program (WASP)], they can also provide predictive capability that allows evaluation of various remedial options. The AWTA Phase I report introduced various CSM components for the Anacostia River, which helped guide the identification data gaps for Phase II. This report refines the CSM using available data from Phase II and other sources. A conceptual site model should be dynamic and incorporate new information as it becomes available. Much of the data collected under Phase II are in preliminary phases of analysis and have not yet been fully incorporated into a detailed model.

The major dynamic processes that affect contaminant fate in an urban river such as the Anacostia are illustrated in Figure 2. The primary routes for contaminants to enter any reach of the river are through surface water inputs (dissolved and/or suspended particulate form), groundwater, or sediment transport into that reach from another portion of the river. There are two main types of surface water inputs: either movement within the river from adjacent reaches (up- or downstream in the case of the Anacostia) or direct inputs to that reach from outside sources, such as tributaries, outfalls, wastewater treatment plants, permitted discharge facilities, other non-permitted sources.

Once within the river, contaminants are transported in surface water according to tidal movement, river flow and circulation, and dispersion. Because the primary contaminants of concern within the Anacostia are hydrophobic, sediment dynamics are a key element to understanding contaminant distribution. Important sediment fate and transport processes are bed load transport or deposition, sediment burial, and resuspension into the water column.

These are the major physical process that determine contaminant distribution. A CSM must also address the biological elements that determine the levels of pollutants to which animals and humans are exposed. It is just as critical to know the major routes of pollutant uptake into biota and the general structure of food webs. This knowledge helps us to identify the ecological components that may be at greatest risk from exposure to contaminants.

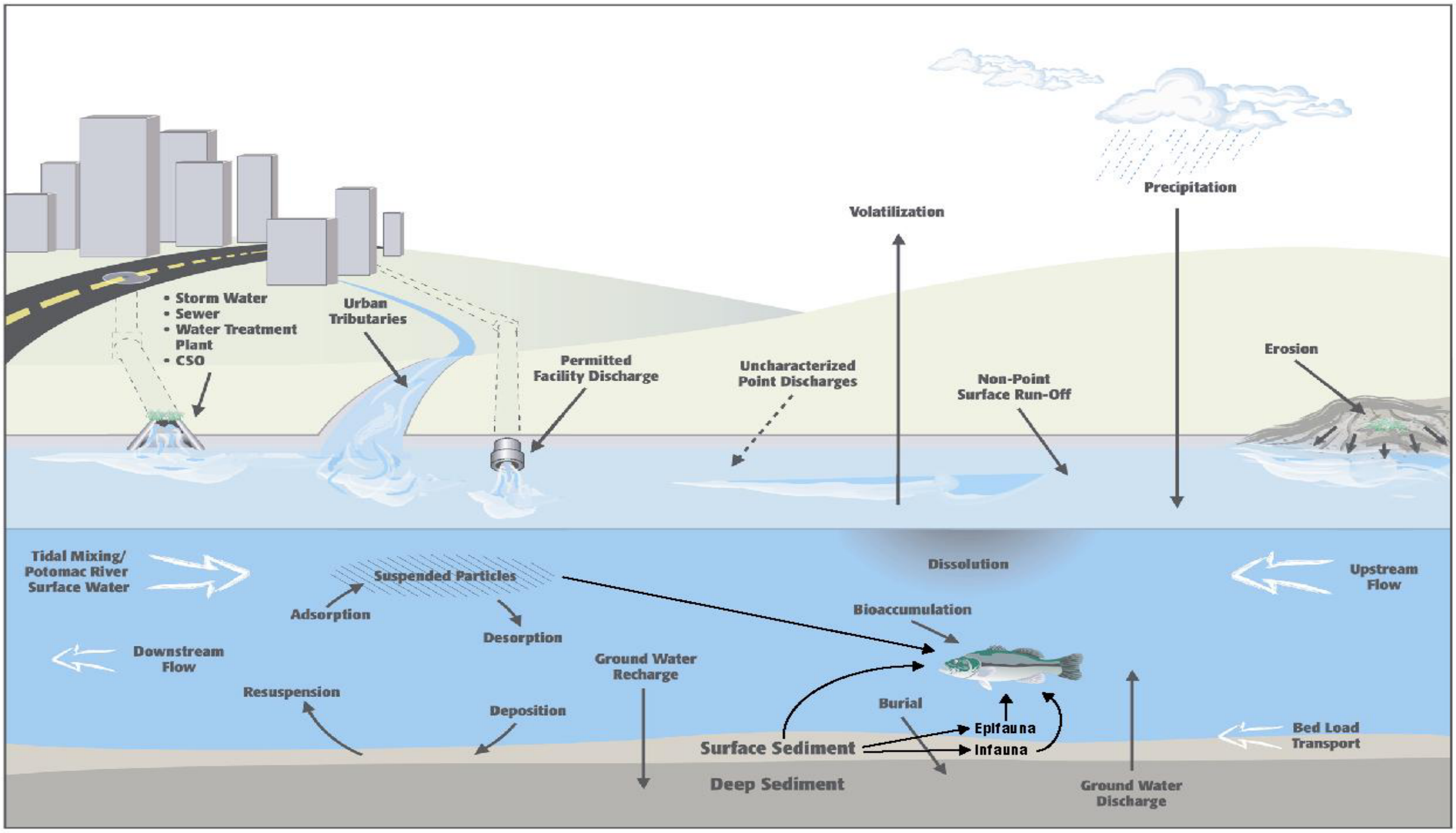

Figure 2: Schematic representation of the conceptual site model for the Anacostia River showing potential routes for contaminant mobility and fate.

The Anacostia River is generally shallow: less than a meter to two meters deep from Bladensburg to about the 12th Street Bridge, and three to six meters deep from the 12th Street Bridge to the river mouth. Water flow in the river, particularly during base flow conditions, is dominated by tides. Water levels change as a standing tidal wave, meaning that water levels rise and fall nearly simultaneously throughout the entire river. Current velocities are determined by changes in the river's cross-section and the tidal prism volume toward the head of the river, and are primarily directed along the axis of the channel and are relatively homogeneous throughout the water column. Maximum current velocities (30 cm/s) are relatively low and occur in the vicinity of the Railroad Bridge; velocities elsewhere are much lower. The water column is generally well-mixed, with little horizontal or vertical variation, although some vertical stratification in the lower river may occur after a storm event. The flushing time of the river is estimated to be between 23-28 days. A previous estimate of a 35-day flushing time (Scatena, 1986) was considered inaccurate because of an outdated river volume estimate.

The NE/NW (Northeast/Northwest) Branches account for about 60 to 70 percent of the river flow. Non-gauged flows include storm water sheet flow, CSOs, and/or groundwater. Water is entering into the groundwater system in the lower Anacostia tidal watershed through natural recharge in grassy, wooded, or otherwise unpaved areas, as well as through leaky infrastructure such as water and sewer lines. Therefore, it is either accumulating somewhere (change in storage), or it is discharging somewhere. This discharge will be to one of the two large bodies of water in the area (the Anacostia or Potomac Rivers), to local production wells (relatively less likely), to dewatering wells (possible), or to far away areas that draw on the regional groundwater system that outcrops or subcrops in the study area. Although some groundwater may be drawn out of the system by wells, much of the groundwater in areas close to the Anacostia River will eventually discharge to the river or tributaries.

With this in mind, the main information that needs to be determined is "How much groundwater is flowing into the Anacostia, how fast is it flowing, is it contaminated, and if it is, does contamination from groundwater represent a large or a small threat to the river?" The answer to these questions is unclear at this time. Several localized groundwater studies have been done, and a model to determine the shallow groundwater flux to the tidal Anacostia River was done for DC DOH (Logan 1999). The TAM/WASP model described in this document also includes an estimate of groundwater flux. There are uncertainties in both models. In addition, there are locations in the tidal watershed where groundwater contamination is suspected of having an impact on the overall contaminant load of the Anacostia River due to the proximity of potential contaminant sources or to the presence of contaminant "hot spots" within the river channel. Assuming that there are at least localized areas with contaminated groundwater, it is important to determine how prevalent the contaminated areas are, and if they will have an effect (local or regional) on the river.

Analyses from water samples at the NE/NW Branches confirm downstream migration and discharge into the river of both aqueous and particulate contaminants. Other tributaries, such as Hickey Run, Pope Branch, Fort Dupont Creek, Stickfoot Creek, etc., are also known to contribute contaminants to the Anacostia, however data for the loadings are currently not available. (This is a significant data gap which is being addressed by AWTA.) There are no combined sewers discharging into the NW or NE Branches. However, there are approximately 30 storm sewers and 17 combined sewers discharging directly into the Anacostia River (MWCOG 1997). A model constructed by the DC Water and Sewer Authority (WASA) predicted that over 93 percent of the CSO flow volume was contributed by the two CSO systems at Main and O Street and at Northeast Boundary. Although more than half of the Northeast Boundary total flow goes through a swirl concentrator, but that facility is not currently at full treatment efficiency due to disrepair. Observations of concentrations of many trace metals increasing after storm events, with the most substantial increases occurring after rainfall greater than 0.6 inches over a 24-hr period, reinforce the impact of stormwater on the chemical water quality of the Anacostia.

Deployment of clams and semi-permeable membrane devices (SPMDs) in the NE and NW Branches, and at seven other locations in the Anacostia verify that there is both an aqueous and particulate contaminant load of PCBs, PAHs, and pesticides that is bioavailable. Limited toxicity tests for survival and growth in larval fish also confirm that toxic conditions can exist . One high flow test showed diminished survival at two locations (Bladensburg and Kenilworth Marsh) compared to survival at the control and two remaining locations (CSX Railroad Bridge and James Creek). Growth was also lowest at the Bladensburg and Kenilworth Marsh locations.

Over the last two hundred and fifty years, a great deal of sediments have washed into the Anacostia River. A very detailed account of the history of the town of Bladensburg based on a book by George D. Denny, Jr. states that when the town was founded in 1742 it was "a thriving port with a depth of 40 feet of water in the river … By 1800, the shipping lane to and from the port of Bladensburg had begun to fill with silt, making passage by large ships impossible. The problem worsened over the next few decades, such that Bladensburg as a port became a thing of the past." The huge volume of sediments that began to fill in the river also posed major problems for shipping downstream. According to historical records from the U.S. Army Corps of Engineers, for many years Congress was petitioned for funds for navigational dredging to provide ships safe access to the Washington Navy Yard. The deposition, contamination and relocation of these contaminated sediments by the placement of dredge spoils along the shoreline have largely contributed to the toxic sediment problems in the river today

As noted earlier, the primary contaminants of concern within the Anacostia are hydrophobic, therefore sediment dynamics are a key element to understanding contaminant distribution in the river. Sediments in the river channel are moved by baseflow, storm events, and tides. The following discussion pertains to general sediment transport trends. Sediments in the Anacostia vary from gravelly sand in the upstream portions of the river, to mainly mud in the lower reaches. The NW and NE Branches appear to be predominant sediment sources, though there are secondary sources which have localized effects. As the two major tributaries meet, coarser material settles out and is deposited in an accretion zone in the vicinity of Bladensburg Marina. The current here is unable to transport coarser sediments, so only the fines are transported downstream. Downstream from here, coarser sediments are found only locally where smaller streams and outfalls enter.

From Bladensburg to the Railway Lift Bridge, sediments, particularly the fines, move through the system much like a conveyer belt. The higher flow velocities and shallower depths in this region appear to cause resuspension of sediment, as reflected in high Total Suspended Solids (TSS) in surface water. Between the Railway Lift Bridge and the 12th Street Bridge, the "conveyer-belt" transport zone merges with a deposition zone, which then becomes a zone of Total Deposition below the 12th Street Bridge. This is also an area where the river widens and the depth increases, allowing the currents to slow and sediment fines to settle.

The lower reaches of the river are completely depositional. About 1.5 km upstream from the mouth of the river, a downstream depositional transport regime is met by an upstream transport regime at the deepest point in the river. The sediments moving upstream are most likely driven by tidal currents and include particulates from the Potomac River.

TSS concentrations varies with tide height. A decrease in TSS concentrations at high tide, slack water suggests that some of the material may be depositing out at these low flow conditions. Preliminary calibration of the updated TAM/WASP model for sediment transport indicates that 90 percent of sediment stays within the tidal Anacostia, and that the current rate of sediment deposition is 1.4 cm/year.

The sedimentary record of contamination, as a temporal integrator of inputs, can help to identify, and prioritize, apparent loading sources to the river. Concentrations of contaminants in sediment can also be used to derive estimates of the potential for adverse biological conditions.

Based on a comparison to Threshold Effects Level (TEL) and Probable Effects Level (PEL) sediment quality guidelines, the Phase I screening-level ecological risk assessment indicated that risk may be posed to benthic invertebrates from exposure to metals, PAHs, PCBs, and several pesticides in sediment. Elevated concentrations of PAHs in sediment may pose a threat to bottom-feeding fish based on comparison to a sediment quality threshold of 2 mg/kg. The screening level Ecological Risk Assessment (ERA) found that PCBs, pesticides, and lead were present in fish tissue at concentrations that may adversely affect fish. Also, risk to birds and mammals were estimated to not be at lower risk.

Recent chemical analyses results from the extensive Phase II surveys (almost 250 samples) of sediment samples confirm that contamination of the river is widespread, but that areas of relatively greater contamination of the river represent a small portion of the river (about 5%) and are primarily oriented to depositional areas of the lower half of the river (below Kingman Lake), plus some additional, isolated locales of the river where sediment is being deposited. The results of are consistent with what has been observed previously in more limited studies and with the results of screening risk assessments, and also confirm that the primary contaminants of concern (CoCs) are two classes of chemicals- PCBs and PAHs. Metals are of lesser concern.

Consistent with predictions based upon sediment chemistry, the benthic community of the Anacostia is essentially depauparate with low diversity, low abundance, and dominance by pollution tolerant worms. Note that in some areas of the river, anoxic (low to non-oxygenated) conditions may be responsible for some of these findings. Only a limited number of sediment samples have been subjected to laboratory testing for toxicity, however, chronic impacts to growth of invertebrates in samples from the station in the vicinity of the O Street/Southeast Federal Center (SEFC)/Washington Navy Yard (WNY) area have been observed. Re-testing of sediment from this area suggest that toxicity is due primarily to organic contaminants. These observations are consistent with predictions based on the sediment trend analysis: contaminants are more likely to be observed in the lower portions of the river where sediments are fine-grained. It is also expected that contamination from upstream and localized sources should be dispersed along the mobile transport path in the mid-reaches of the river and "hot spots" from localized sources would mainly be found in the depositional parts of the river.

A screening-level risk assessment indicated that eating contaminated fish is the primary pathway for human exposure, although other pathways may be present as identified in the Phase I report. See Appendix A for more detail. The primary ecological receptors at risk within the river are benthic organisms and fish. Benthic organisms may be exposed from direct contact with sediment and water or ingestion of particulates. This exposure may lead to lethal effects, reduce growth, and/or community level effects. Fish may be exposed from direct contact with sediment and water plus bioaccumulation of contaminants through the food chain. This exposure may lead to reduced reproductive capacity and/or tumors which may effect survival and growth. Risks also may exist to birds and mammals through aquatic food chain exposure. Very conservative assumptions were used in evaluations of risk to birds and mammals, thus there is considerable uncertainty as to whether they are actually at risk. A more detailed baseline risk assessment will be conducted in the future to obtain a better understanding of site specific exposure and effect relationships. Probabilistic methods may be used to characterize and manage for uncertainties in the assessment.

3 Comprehensive Toxics Load Reduction and Sediment Remediation Strategy

3.1 Strategy Overview

Restoration of the Anacostia, and a return to fishable and swimmable conditions, will take time. Although actions to deal with existing contaminated sediment in the river could begin at any time, there is a need to address the possibility of significant re-contamination before such actions are taken. This will require either controlling ongoing sources, or, intercepting releases before their discharge to the river. Achieving the sort of broad, sweeping control of ongoing sources of pollution will not be accomplished by a single action. Nor will it be accomplished quickly. To achieve the restoration of the Anacostia within the desired timeframe, multiple actions will need to be taken along two tracks:

The continuing input of contaminants into the river's headwaters, plus discharges within the river basin, will need to be diminished to a level at which significant exposures to aquatic life within the river will not occur and significant re-contamination of sediment will be prevented.	Existing sediment contamination within the river system, and ongoing point sources that contribute to sediment contamination, will need to be addressed by remedial actions to reduce on-going exposures to aquatic resources from contamination already present within the sediments

These objectives are interrelated, and the success of meeting the restoration objective is obviously dependent on controlling loadings to the river. And the goal of reducing loadings to the river will depend on a great number of actions dealing with a great number of contaminant sources, both point and nonpoint releases. ***Accordingly, source control will be best accomplished by applying a broad suite of techniques, such as stream bank stabilization and Low Impact Development, designed to reduce pollutant loadings, to eliminate transport routes of contaminants in the watershed, and to intercept contaminants before they are released to the river.***

Because of the breadth of actions that will be required, it is recognized that reductions in contaminant loadings throughout the watershed and to the Anacostia will require several years. Accordingly, some interim actions will be required so that actions within the river are not unduly delayed and phased remediation of contaminated sediments can proceed. In this manner, ongoing injury to aquatic resources and limitations on the use of the river can be curtailed long before complete source control can be implemented. This will be necessary to reach restoration goal by 2011. Also, general habitat restoration efforts throughout the Anacostia watershed would be accelerated and enhanced by improvements achieved with the river. The strategy presented here also contains proposals for longer-range, elements to address contaminant loadings well into the future.

The remediation strategy is dynamic, subject to refinement as additional data is obtained. Hot spot locations in this document are presented for geographical representation and are not meant to imply the specific sources of contaminants. Additional locations may be identified in the future. Known and possible new hot spots will require additional characterization and evaluation of remedial technologies before implementation.

Although there can be major engineering issues to address during implementation, conceptually, remediation of contaminated sediment is the more straightforward proposition of the two major objectives. It has a more manageable definition of the problems and scope, and is largely predicated upon engineering and economic constraints. Experience at many contaminated sediment sites across the country indicates that there is a relatively limited universe of remedial options to choose from. However, because of the wide variety of contaminant types and contaminant sources, reducing loadings within a sub-watershed can involve a broader suite of approaches than that for dealing with contaminated sediments. Each individual situation will require its own analysis and selection of remedial approaches tailored to the specific conditions presented. It is also anticipated that within a sub-watershed, no single approach will accomplish the objective, no matter how small the area. Therefore, this management strategy presents a large menu of choices for achieving loadings reductions under the many situations that may be presented within a sub-watershed.

3.2 Institutional Changes Needed to Accomplish Source Control

Some of the techniques proposed for reduction of toxic loadings within the watershed and for remediation of sediment in the Anacostia River are relatively new and innovative. Collectively, they represent alternative approaches for doing stormwater management and environmental restoration. Education and outreach efforts are building blocks for institutional change, and critical in helping to reshape public opinion and policies. Both of these need to be long-term efforts.

Often the current state of practices are entrenched in institutional systems and are better known by agencies and by the public through past and current outreach efforts There are often several barriers to achieving changes in existing practices and systems. There can be financial barriers, psychological ones, institutional policies, and regulatory requirements (or lack thereof), which can collectively hinder incorporating the changes and improvements necessary. Changes in personal, corporate, and governmental habits will be required. Also, because management of contaminants and stormwater is codified in regulatory statutes, improvements to these institutional policies will be required.

Institutional barriers to change are often the most difficult obstacles to overcome when attempting something new. Barriers such as cost or situation uniqueness are easier to address and overcome by employing price breaks, longer financing terms, and tailoring the design to fit the situation. But decision makers are often resistant to change because of the risks involved, should it fail on their watch. Few public works engineers or administrators want to be tied to something that is viewed as risky or untested. Changes in habits or institutional policies often take more time and require both successful pilot projects and an integrated effort by multiple parties to succeed.

Below is a bulleted summary of general actions and initiatives that could help achieve the necessary changes to accomplish reductions in contaminant releases and loadings to the river:

- Pilot project studies in representative catchments or riverbed areas.
- Technical and institutional workshops comprehensively covering these alternative techniques. This would most likely include focused workshops/seminars given to financial decisions makers, technical professionals/permit regulators, public works agencies, grass roots organizations, and the construction/developer industry.
- Research grants to academia so that they can experiment with new techniques (create test bed/pilot projects).
- Pilot project articles/videos, public tours and mailings, and demonstrations (target homeowner associations and the general public).
- Media press releases/peer reviewed professional journal article.
- Tradeshow/Conference/Internet presentations.
- Brown-bag luncheons to the consulting and engineering professions.
- Curriculum/coursework additions at the university level incorporating these innovative methods.

Nonstructured outreach programs are the most difficult to address and do not readily lend themselves to a bulleted listing. These should really be termed "less" structured. The concept basically involves the old expression to "think outside the box." Nonstructured outreach programs are typically voluntary and non-regulatory. This is the area where public outreach and education can be improved in a less structured manner/program. Such voluntary things like the "adopt a highway/road" effort could incorporate steps to reduce loadings of toxics/sediment and improve stormwater management along with their primary task of removing litter from the roadways. Incentives and variances are also avenues that can promote institutional change in a less structured format.

3.2.1 Watershed Education, Outreach, and Pollution Prevention

The Anacostia River watershed includes a wide range of communities, all with different levels of knowledge and interest in issues pertaining to the river. However, many of its citizens are aware that significant threats to the river include raw sewage, contaminated sediments, and continued contamination of the Anacostia River through stormwater runoff. Citizens understand that this contamination affects the fish and other aquatic life that may ultimately become part of the human food chain. This general awareness needs to be heightened into a sense of stakeholder participation and refined to a sense of stewardship for the river. Success for restoring the river depends upon community (citizens, local businesses, municipalities, etc.) involvement and support.

This strategy proposes that grant money be provided to a coalition of AWTA/AWRC approved community representatives whose sole purpose will be to educate the broader watershed communities about the technical issues surrounding the impacts of contamination in the Anacostia River and to involve the community in formulating solutions. A Technical Assistance Grant (TAG) will require the coalition to hire a technical expert who will describe the issue of contamination in terms easily understood by community representatives. The technical expert would communicate the extensive amount of research done by AWTA and will also use other sources to give the community a broad understanding of the issue and possible solutions.

As envisioned, the technical expert and at least one member of the community coalition would also attend AWTA and AWRC meetings and serve in an advisory role. These representatives would also be responsible for relaying information back to the broader community and raising community concerns to AWTA and AWRC.

Another pollution prevention consideration may include funding for an inventory and then, if warranted, an accelerated phase-out of PCB-containing equipment. This approach has been used in the Great Lakes and should be considered for the Anacostia. Additional efforts may involve small businesses, by providing free testing and/or reduced disposal costs for PCBs and other hazardous wastes.

3.2.2 Changes in building codes, zoning, and permitting processes

Many institutional changes can actually be hampered by the regulatory systems developed to protect the environment and ensure the safety of the general public. Even in today's electronic world, building codes, zoning, permitting, and maintenance requirements are difficult to revise and are not changed overnight. These potential barriers are often formidable impediments to achieving improvement and can be used by the reluctant to halt the possibility of implementing improvements. Traditional Best Management Practices (BMPs) are codified into existing regulations (state, county, and city level), often resulting in an additional resistance or disincentive to change. Actions to address these barriers require a concerted effort from multiple parties ("top-down" and "bottom-up" approaches).

It is recognized that pilot or demonstration projects, such as the LID pilot recommended below, can only accomplish a certain, limited reduction in storm water volume and contaminant loadings. The value of pilot projects is often more in the demonstration that such approaches do achieve the desired result than the magnitude of the the actual reductions. In order for broader application of these techniques, for faster incorporation of these approaches, and for greater reductions to be achieved, it is also recognized that institutional changes must be made that require use of such practices beyond what can be accomplished through government-sponsored pilot projects.

Despite the difficulties that may be encountered while updating the institutional controls that address storm water, making these changes is paramount to achieving source reduction in a reasonable time frame. Requiring certain obvious improvements as a condition for obtaining a permit, either for new construction or for appropriate remodels, is one necessary element to achieving timely, broad-scale storm water control. For instance, Prince George's County issued over 31,000 building permits for new construction and remodels in 2001. D.C. has also implemented changes in building codes and permitting processes. If all new construction and only a fraction of remodel permits included requirements for stormwater management, a greater contribution would be made than that achieved through pilot demonstration projects. It is important to realize that the benefits that could be realized by reducing stormwater volume also carries tremendous benefits in reducing contaminant transport to the Anacostia as well.

Zoning regulations are an effective way to regulate building coverage on sites. These should be revised and refined to bring about appropriate pervious and impervious restrictions. Zoning in the District of Columbia can be revised to include sustainable design practices. These could be negotiated in the Planned Urban Development review process on large-scale redevelopment projects. New developments in urban areas such as big box retail centers and large-scale federal office buildings should all be constructed with state-of-the-art best practices such as green roofs and best practice parking lots.

This strategy recommends that grants be made available to the counties and DC at $125K each to assist with the review of their zoning, building codes, and permit processes for the integration of LID and other innovative approaches into these institutional programs. Grants would help adsorb the costs of not only changing the code, but also with the public participation process, training of staff in new approaches, educational outreach, and so on.

Actions could also include comparing and revising stormwater management, building codes, zoning, and permitting requirements for jurisdictions that have already implemented and are using the proposed source reduction techniques. Such a comparison can be used to gain knowledge from lessons learned by others, as well as reduce the effort needed to make these institutional changes.

When creating new codes, zoning, and permitting requirements, some flexibility should be incorporated to allow for the possibility of trying new and future innovations. In addition, using new source control/stormwater management techniques helps to expand the library of data available to the decision makers.

3.3 Source Identification Needs

3.3.1 Tributary and Outfall Sampling

As described in the CSM, flow from the Northeast and Northwest branches is known to carry a flux of contaminants to the Anacostia River. However, actual concentrations have only been measured at the U.S. Geological Survey gauging stations and only a few occasions in one study (Gruessner et al. 1997). In terms of understanding how to address the problem of chemical contamination in the river, an important data gap that needs to be addressed is the lack of storm water monitoring data for contaminants, necessary to quantify loads. Without an adequate characterization of loads to the river, managers will be unable to evaluate the efficacy of potential sediment remediation strategies, and will not be able to address contaminant source areas in a cost effective way. AWTA has begun to address this gap with the collection of monitoring data at six outfalls and/or tributaries during three storm events in the spring and summer, as part of Phase II investigations.

Besides the Northeast and Northwest branches, a number of tributaries to the Anacostia tidal basin drain sub-watersheds, which are primarily located within the bounds of the District of Columbia. These smaller river basin streams include ones such as Fort Chaplin, Fort Davis, Fort Dupont, Fort Stanton, Hickey Run, Nash Run, Popes Branch, Texas Avenue Tributary, and Watts Branch. In general, portions of each of these streams are open channels and other portions are enclosed (piped) channels, and stormwater runoff is conveyed to these streams primarily via the District's separate storm sewer system. Most of these tributaries are listed as "Impaired Water Bodies" (scheduled to be updated in October 2002), as indicated in Table 2. Toxic chemicals (metals and/or organics) are given as causes of impairment for all the streams listed, and as part of the District's TMDL program, TMDL allocations will be developed for these chemicals. The "potential impairment sources" for all of the streams in Table 2 is given as "nonpoint source pollution."

Table 2: Anacostia Tidal Basin streams on the District of Columbia's list of impaired water bodies.

Tributary	**Impairments**
Fort Chaplin Run	metals, pathogens
Fort Davis Tributary	metals, pathogens, BOD
Fort Dupont Creek	metals, pathogens
Fort Stanton Tributary	metals, pathogens, organics
Hickey Run	pathogens, oil and grease, organics
Lower Watts Branch	pathogens, organics, total suspended solids
Upper Watts Branch	pathogens, organics, total suspended solids
Nash Run	metals, pathogens, organics
Popes Branch (Hawes Run)	metals, pathogens, organics
Texas Avenue Tributary	metals, pathogens, organics

The DC Department of Health Water Quality Division is conducting Municipal Separate Storm Sewer System (MS4) monitoring at a number of locations as part of the requirements for the District's National Pollutant Discharge Elimination System (NPDES) permit. The DC Department of Health also conducts additional monitoring of District water bodies as part of its routine monitoring program. This monitoring program is primarily concerned with collecting data on nutrients, but samples are also analyzed for the metals listed in Table 3 (Clifford Jarmon, DC DOH, personal communication). However, as shown in the table, the detection limits employed produce censored data, relative to levels related to the protection of aquatic life, for several of the analytes.

Table 3: Metals data available (1995 and later) from DC DOH Routine Monitoring Program

Metal	Detection Limit[1] (µg/L)	Chronic Ambient Water Quality Criteria for the Protection of Aquatic Life
Arsenic	5	150
Cadmium	5	2.2 [3]
Chromium	10	11 [3]
Copper	25	9 [3]
Lead	5	2.5 [3]
Mercury[2]	0.2	0.77
Zinc	20	120 [3]
Selenium	5	5

[1] Detection limits may vary.
[2] Available for 1995 only.
[3] Hardness-dependent

Because of the high cost of doing laboratory analyses with appropriate aqueous detection limits for organic chemicals and for some metals, there is little useful information from the tidal basin streams to determine whether there are significant sources of these chemicals in the tidal basin sub-watersheds, or to determine the relative loads. There is a need for screening-level base-flow and storm-flow water quality monitoring of toxic constituents of concern, at sufficiently low detection limits to estimate loads in each of the tidal basin streams.

We propose a screening level water-quality monitoring program to estimate annual toxic chemical loads. Additional data should be collected for 6 baseflow (if appropriate) and for 12 storm events from ten additional outfalls (including CSOs) and tributaries, chosen with consideration of both sub-watershed size and likely presence of significant source areas. The estimated cost of this additional data collection effort is $625,000.

AWTA's sediment characterization of the river also provides evidence of other loads or inputs of contaminants to the Anacostia River from direct discharges within the river basin. What has been measured just before the branches discharge to the river and what is reflected within the river itself, is the cumulative flux from all the sub-watersheds of the Anacostia.

Local, state, and federal stakeholders have often had to make difficult decisions as to how and where to best employ limited monitoring resources. In order to efficiently increase efforts to control sources, more definitive identification of specific sources and sub-watersheds that contribute disproportionately to the total, overall flux to the river will be needed. Such refinement in source identification will allow for prioritizing of how limited resources should be applied. The following sections outline recommendations for enhanced source identification efforts in both the upper watershed and the river.

In addition to assisting with the identification of on-going sources, the measurements recommended, repeated over time, can form the basis for evaluating progress toward restoration of the river. Initial rounds of assessment will not only serve to help identify sources, but in some cases will form the initial baseline for future monitoring programs.

3.3.2 Recommended Watershed Survey of Bioaccumulative Contaminants

Persistant organic contaminants (PCBs and chlorinated pesticides) are major contaminants within the Anacostia and accumulate in fish tissues, resulting in fishing advisories. PAHs, which persist in invertebrates but not substantially in fish, are believed to be the primary contaminants responsible for the high prevalence of fish tumors in bottom-feeding brown bullheads. As previously stated, a broad-based, synoptic characterization of sub-watersheds, which are potential sources of persistent, bioaccumulative toxics (PBTs) is lacking. Existing field programs primarily deal with benthic and fish community measures and stream morphology as indicators of habitat conditions. Therefore, an assessment program geared to the detection of these compounds is recommended to ensure efficient, subsequent application of limited resources for source identification, control, and restoration.

The use of semi-permeable membrane devices (SPMDs) is one promising passive sampling approach to estimate the aqueous loading of non-polar and hydrophobic contaminants. SPMDs are permeable bags filled with sequestering oil that mimics the lipid membrane of organisms. As such, they estimate how much of these type of contaminants are bioavailable from the water column. As currently envisioned, passive sampling devices (semi-permeable membrane device or SPMDs) would be deployed at the mouth of 20 tributaries to the Anacostia which are representative of the major sub-watersheds which discharge to and form a substantial portion of the base flow of the Anacostia. Analysis of the SPMDs will provide indications of the average, temporally-integrated concentrations of aqueous PBTs flowing to the Anacostia.Concurrent deployment of *Corbicula* clams would complement the results from the SPMDs by reflecting the suspended particulate flux of PBTs at the same locations.

Results from this synoptic survey will provide indications as to which sub-watersheds contribute disproportionately to the combined, cumulative flux discharging to the head of the Anacostia. Additionally, congener specific analysis for PCBs may provide further qualitative information useful for the tracking and control of sources. Costs for this effort is estimated at $250K.

3.3.2.1 Groundwater

Groundwater in the lower Anacostia tidal watershed is not well characterized, and, as mentioned earlier in this document, is possibly a source of contaminants to the river. Because of the urban nature of the watershed and the long history of industrial and residential development in the area, it is likely that groundwater in the area is contaminated. However, little is known about the spatial distribution or types of non-point source contaminants in the groundwater, the characteristics of groundwater flow, or the volumetric flux of groundwater and associated contaminants to the river. Because of the many modifications to the river system (including bulkheads, dredging, filling, engineered wetlands, storm drains, and leaky infrastructure), groundwater interactions with the river are expected to be complex. It is therefore important to use a wide variety of investigative tools to help characterize the groundwater flow system, the groundwater quality, and the groundwater / surface-water interactions.

From a risk-based perspective, groundwater in the tidal Anacostia basin will not have an effect on aquatic ecological receptors until it discharges to surface water. Therefore, the best risk-based approach for investigating groundwater in the tidal Anacostia basin is to investigate the areas that are most likely to have a measurable impact on the contaminant load in the river. This would include investigating groundwater at all of the currently known contaminant hotspots within the river, as well as any future hotspots that are discovered, and installing and sampling monitoring wells down gradient of land uses (such as landfills and areas of dredge spoils) near the river that are identified as potential contaminant sources. The approach works on the premise that a systematic investigation of groundwater at the spots that are most likely to impact the river can be used to assess whether further action will be required to protect the river ecosystem from contaminated groundwater discharge.

Several contaminant hotspots within the river channel already have been identified, and the possibility exists that more hotspots will be discovered during future investigations. The source of the contaminants in these hotspots should be investigated at each location. In some cases, groundwater inputs have been investigated using innovative techniques such as seepage collectors (Chadwick 2001), and some sites (such as the Washington Navy Yard) have been extensively investigated. Therefore, the groundwater investigation could include (1) a retrospective study of available groundwater information to determine data gaps; (2) a survey of historical land uses to determine likely sources of groundwater contamination; (3) the installation and sampling of monitoring wells in suspect areas; and, (4) the interpretation of the potential impact of groundwater contamination on the Anacostia River tidal ecosystem.

The first year of the study should consist of obtaining and interpreting existing groundwater information and surveying historical land uses, with the goal of formulating a sampling and analysis strategy for groundwater that will be implemented in the second and third year of the study. The final year will be used to synthesize the data into a final report and to begin implementing remedial efforts, if they are necessary. It is anticipated that the retrospective and historical land-use studies can be completed for about $250K. The level of effort that will be required for sampling and analysis is hard to quantify at this time, but a two-year effort of $600 - $700K might suffice. The final year's effort should be on the order of $200K, for a total over the life of the investigation of about $1.15 million.

This approach is consistent with investigations presented in other parts of this document, in that it seeks to identify the most important contaminant sources or discharge areas, it is risk based, and it will be implemented in areas identified in other parts of the overall management plan. Knowledge of the groundwater component in areas slated for remediation will greatly enhance the likelihood for successful remedial activities.

3.3.3 Recommended Automated Monitoring Station Network

To address the major gaps in information on toxics and other pollutants throughout the upper watershed, a network of seven automated water quality stations is recommended. Their purpose is to provide both the stormflow and baseflow water quality data required (i.e., sediment, nutrients, toxics, organic and bacterial loads, etc) for the accurate estimation of annual pollutant loads to the river from the upper portion of the watershed. The network includes two high priority stations (i.e., existing lower Northeast and Northwest Branch USGS gauging station sites), the existing Lower Beaverdam Creek NPDES monitoring station, and four key Northeast and Northwest Branch tributary sites (i.e., Indian Creek, Paint Branch, upper Northwest Branch, and Sligo Creek). The two high priority station sites are recommended as permanent stations, to reflect the total flux to the river, whereas the other five sites are planned temporary sites (i.e., minimum two to three-year operation). Upon monitoring period completion, one or more of the temporary stations would be relocated to provide additional and more geographically-specific subwatershed water quality data. In this manner, both the total subwatershed toxics loading contribution and the relative contribution from various portions of that subwatershed may be better quantified. The anticipated monitoring data should prove invaluable for: 1) quantifying annual pollutant loads to the river at the head-of-tide, 2) determining relative subwatershed pollutant load contributions, 3) assisting local, regional, state, and federal resource management and restoration agencies in identifying subwatershed areas in greatest need of stormwater management water quality and/or quantity control, stream restoration, land use control, and/or follow up studies, and 4) the additional calibration and refinement of watershed water quality models. The estimated full implementation automated monitoring station network costs, including sampling for toxics, for the period of FY 2002-2009 are estimated at $3.4 million.

3.3.4 Biological Monitoring, Tracking, and Reporting Network

There are many elements constituting a comprehensive biological monitoring station network that are either already in place or expected to be within the next two to three years. Data are collected by each county, the state of Maryland and the District of Columbia, but with some difference, which makes interpretation difficult. As proposed by the AWRC's Anacostia Restoration Potential Workgroup (ARPW), it is recommended that the existing and planned programs become more integrated and form the basis of a comprehensive monitoring, tracking and reporting network for the entire watershed. Seventy-seven (77) stations are deemed necessary to comprise an adequate biological monitoring network.

Of the 77 recommended stations, 73 are tributary system-specific, with the remaining four comprised by representative tidal river sites. As currently proposed, monitoring frequency is as follows: 1) tidal river - annually, 2) major tributary mainstem - biennially, 3) high priority tributaries – annually, and 4) smaller tributaries - every three to five years. Tributary monitoring will employ current MBSS protocols and metrics. In addition, to the examination of fishes for the presence of deformities, erosions, lesions, and tumors (i.e., DELT's), brown bullhead's (and their barbels) have been selected as a key watershed-wide toxics sentinel species. Finally, limited water quality grab sampling and toxics screening (e.g., possible use of Microtox toxicity test) will be performed where warranted. The estimated full 2010 implementation biological monitoring station network costs are estimated to be on the order of $344,000 (Appendix 1, Table 1).

While much of the Anacostia has been developed for decades, both new and redevelopment projects are continuing to occur across the watershed. Systematically tracking these land use changes, as well as identifying the nature and extent of restoration projects and their potential applications within the watershed remains a formidable challenge. Detailed knowledge of the type and extent of impervious surfaces and associated storm drainage networks is essential. The estimated costs for tracking these preceding activities are estimated to be $200,000.

3.3.5 Monitoring the Recovery of the Anacostia River Toxic Condition

As previously noted, the physical, chemical and biological restoration and recovery of the Anacostia River will be dependent upon actions taken throughout the entire watershed. These actions will address not just the release and mobilization of toxic compounds, but stream habitat restoration, removal of fish blockages, and more. It is also the very nature of this diversified distributed approach that creates challenges for measuring success. Assessment of the progress toward reaching these goals will require a multi-tiered watershed perspective. And because the time to realize these cumulative gains is long, a multi-year assessment or monitoring program is dictated.

With the focus upon toxics, the assessment and monitoring elements recommended here will target the lower, tidally influenced river as the ultimate repository or sink of the majority of contaminants of primary concern within the watershed. This monitoring element will be complimentary and supplementary to what has been proposed for the broader objectives of the Anacostia Restoration Signatories approved Anacostia Watershed Restoration Indicators and Targets. (AWRC, 2001) This element is essentially comprised of periodic monitoring of contaminant levels in sediment and fish tissue. As ultimate sinks for contaminants like PCBs and pesticides, sediment and fish tissue present the most efficient, clearest, and unequivocal evidence for overall success in reducing sources, contaminant loadings to the river, and biological contaminant exposure. The potential uses of such information, however, are not limited. They are multiple and include uses such as measuring progress toward lifting fish consumption advisories, verification of sediment remedial actions at reducing exposure levels, evaluation of recontamination, verification of source reductions, identification of new releases, and so on.

Assessment of the toxic condition of the Anacostia does have distinct nuances that are different from the detection of on-going releases of contaminants to the river. While source identification is recognized as a vital precursor for source control and may have some overlap in terms of methodology, the recommendations made here attempt to keep the intent clear between these complimentary, but different purposes. Monitoring efforts should explicitly be directed toward assessing the progress toward specific objectives. Monitoring should not be viewed as a research program nor an activity to fill gaps, but rather the regular and repeated application of standardized investigation approaches for the detection of changes in time and space.

To address the need for a comprehensive assessment and monitoring program, AWTA and the AWRC's Anacostia Restoration Potential Workgroup (ARPW) will work cooperatively to integrate strategies, as well as in collecting, analyzing, and distributing this and other restoration-related information to their respective memberships and the general public. It should be noted that because of the inherent time lag associated with the development, funding, and implementation of monitoring and data management system protocols, programs, and initiatives, some database gaps are expected to remain for several years.

As previously stated, among the many challenges facing the Anacostia restoration effort is also the creation and maintenance of a comprehensive watershed-wide database, which permits the systematic tracking of changing physical, chemical, and biological conditions in the watershed and the river. Distribution of this information to watershed resource managers, policy makers, and the general public in a timely and effective manner is required as well.

The fundamental monitoring approach outlined herein relies on the prominence of conditions within the lower river as the ultimate sink and thus a dominant indicator of overall conditions. Since an adaptive management strategies will require having more detailed information available should the desired progress toward restoration and recovery not be observed, the assessment and monitoring recommendation are integrated and complimentary with components directed toward establishing baseline information throughout the watershed.

3.3.5.1 Monitoring of River Toxics Sediment Recovery

Because the Anacostia is an effective sediment trap and since the primary contaminants of concern are hydrophobic compounds, the sedimentary record offers clear, simple evidence of trends at a regional to sub-regional scale. Measuring contaminants in sediment at regular intervals is an efficient, cost-effective approach for monitoring the river's overall toxics condition. With sufficiently broad but high-density coverage, assessment of the sediment record indicates not only general patterns in the river, but also provides indications about specific sources or discharge points where contaminants enter the river.

In 2000, AWTA sponsored two extensive surveys of sediment contamination throughout the entire river. These ground-breaking investigations established a thorough baseline against which progress can be compared, particularly the ANS survey with its network of sampling stations in every river reach. Repetition of this basic sediment investigation is recommended as the basis for a sediment-monitoring element.

Given the depositional rates and mixing depths observed, measurable changes in contaminant concentration levels in surficial sediments are not expected to occur within a short time frame. Therefore, a three-year cycle for sediment assessment is recommended. A three-year period will balance the need for multiple observations required to detect temporal trends with the rate of change that might be expected.

Since a good baseline of sediment contamination has been established, and indications from that survey are consistent with more limited, previous efforts, there is no demand for repeating a sediment survey *until* specific actions are taken that are expected to result in decreased exposure levels. Therefore, the actual start for the first round of sediment monitoring would be tied to some future date when significant advances are reached on source control, transport reduction of contaminants to the river, or remedial actions dealing with the secondary contamination currently present in the river.

The sediment monitoring effort will also continue to contribute to identification of point source discharges or loadings within the tidal portion of the river. This monitoring plan will distribute a number of fixed stations throughout all reaches of the river, plus a limited number of “floating” stations to be relocated from one event to another. This approach to source identification relies on the detection of anomalous, elevated levels of contaminants in the sediment adjacent to a point source discharge. The “floating” stations can be targeted near specific points suspected of being discharge sources.

3.3.5.2 Monitoring of Fish Tissue Concentrations

As detailed in the CSM, bottom fish species such as eels, brown bullhead, channel catfish and carp have considerable exposure to contaminants in sediments. This is reflected in tissue contamination with PCBs and pesticides to levels that require advisories restricting human consumption.. The tissue concentrations of PCBs and chlorinated pesticides in fish have been the basis for a fish consumption advisory for many years. Samples of fish analyzed for PCBs suggest that tissue residues are sufficiently elevated enough to adversely impact reproduction. Additionally, PCBs are being transferred to eggs, which may further reduce reproductive viability. Modeling of tissue PCB residues indicates that dietary sources are the significant uptake route for the levels being observed. These dietary concentrations in turn reflect either suspended particulates or sediment.

PAHs in sediments are the chemicals that appear to be most strongly linked to the high (50-68%) prevalence of liver tumors in brown bullheads. This species also has a high (13-23%) prevalence of skin tumors and altered (missing, shortened, or clubbed) barbels (23-56%). PAHs and other polycyclic aromatic compounds bind to DNA in the liver forming adducts. This alteration in the DNA is a likely early stage in the cancer process. The concentrations of these adducts were equally high in one year old and three year old bullheads from theAnacostia.

Because the health and condition of the fish community is such a key element of restoring the function and uses of the Anacostia, direct observation of improvements in this keystone compartment are recommended. Because of the differences in how the primary contaminants of PCBs/pesticides and PAHs are metabolized by fish, assessing the condition of the fish community can offer both a long-term and short-term measurement parameter for gauging success in reducing exposures.

Because of the way that PCBs are cycled through the ecosystem, they are persistent for long periods of time. Measuring tissue residues of PCBs (and chlorinated pesticides) would provide long-term, temporally integrative indications of success toward controlling these substances. The frequency of such measurements, however, needs to be weighed against the persistence of these compounds.

PAHs on the other hand are metabolized and biologically process much faster in fish. Therefore, the measurement options for PAHs offer both a short-term (within a couple of weeks) as well as longer-term indications of exposure and effects. For instance, observations from one-year-old brown bullheads shows that they can provide early warning signs of the tumors that will be more prevalent as adults.

An assessment and monitoring program for fish which emphasizes a focus on measurement parameters that can be directly related to contamination and which complements and supplements the programs already in place or planned is recommended. The scope and frequency of this program should be compatible with the other monitoring efforts envisioned, and appropriate for the primary contaminants of concern. The program being recommended is a combination of tissue residue analysis for chlorinated compounds, plus analysis of bile metabolites and DNA adducts to address PAHs. To provide direct observation of the impact of contamination on the fish, continued assessment of the incidence of skin and liver tumors, especially in one- and two-year old fish, is also recommended. Monitoring of brown bullheads should be performed on a three or four year cycle using age 3+ year fish. This frequency is similar to that of the sediment monitoring and that of other existing monitoring efforts. This also strikes a reasonable balance between the slow response expected for tissue residues and the quick response possible for the other measurement parameters. The data generated by this focused effort on toxics can be combined with results from other existing programs dealing with the fish community to provide a broad-brush assessment of the general health of the fish community.

3.4 Comprehensive Load Reduction Approach

Much of the pollution in the river is not from “dumping” directly into the river, but a result of pollution some distance from the river, which then flows to the river. The polluted water and solids flow to the river mainly through tributary streams and sewers. The pollution process is not limited to just along the river, but has occurred throughout the entire watershed. The river then serves as a gathering point or sink for what occurs throughout the entire watershed.

Because of the variety of sources throughout the entire watershed and the number of routes of transport to the river, reducing loadings will not be accomplished through a single sort of action. Rather, many different approaches, tailored to each situation, must be applied. The following sections describe a suite of techniques that would work to reduce contaminant loadings to the river.

3.4.1 Stormwater Management Retrofitting Overview

It is widely recognized that urban runoff normally contains a myriad of pollutants, all of which contribute to the degradation of stream quality. Stormwater retrofitting, which is the placement of a stormwater management practice into an existing developed area for the purpose of either improving water quality, protecting downstream channels, reducing flooding or meeting other watershed restoration needs, has been a centerpiece of the ongoing Anacostia restoration effort. Since 1987, approximately 6,000 acres (approximately 9.4 square miles) of previously uncontrolled, developed land in the Anacostia watershed has been brought under control through the stormwater retrofitting efforts of AWRC affiliates. The stormwater retrofitting strategy proposed for reducing toxic loadings to the Anacostia River and its tributaries incorporates the six following elements:

- the employment of a comprehensive suite of stormwater retrofitting techniques, with the principal objective of targeting older, uncontrolled areas within the watershed having characteristically high pollutant loadings;
- the building upon proven successes with both traditional and non-traditional stormwater management techniques, with the recognition that institutional changes will be needed to facilitate new and emerging technologies;
- recognition that reducing stream channel erosion levels and the associated transport of sediment-attached pollutants remains a major Anacostia restoration objective;
- adherence to an overall flexible and dynamic approach which views stormwater retrofitting as part art and part science, and which also acknowledges that new techniques will arise as the stormwater management field continues to evolve;
- acknowledgment that pollution prevention and education of the citizenry is an integral component for assuring overall long-term success; and
- the incorporation of a comprehensive monitoring strategy to quantify the performance of various selected stormwater management techniques.

The following sections describe a variety of techniques that may be mixed and merged to accomplish reductions in stormwater flux of contaminants.

3.4.2 Wet Ponds

Wet ponds are retention basins featuring a permanent pool of water throughout the year. They typically feature a large, four to six feet deep portion, as well as shallower areas located along the margins, which allow for the establishment of some emergent wetland vegetation. More recent designs feature aquatic benches or shelves for the creation of fringe marsh habitat, variable topography, extensive landscaping for improved wildlife habitat and aesthetics, as well as extended detention stormwater control. Wet ponds remove stormwater borne pollutants through a combination of gravitational settling, dilution, filtration and biological uptake and retention. They may be designed as either on-stream or off-stream facilities (Figure 5) and can be designed to provide both water quality and quantity control for a wide range of drainage areas and land uses, including high pollutant generating ones (a.k.a. stormwater hot spots).

In general, a minimum drainage area of 10-25 acres is recommended for wet ponds. Also, for highly developed/ultra urban areas their employment will generally be limited due to the unavailability of requisite space. They may, however, be employed in such areas provided that an acceptable downstream site exists. Because of their relatively large space consumption and a decreasing unavailability of publicly owned land, wet pond siting in the Anacostia watershed has grown more difficult overtime. It should also be noted that wet pond facilities control approximately 40 percent of the total 6,000 stormwater retrofitted acres in the Anacostia watershed.

3.4.3 Artificial Wetlands

Artificial wetlands are retention ponds typically incorporating large, shallow-depth water areas which are ideally suited for the establishment and growth of wetland plant species (Figure 6). These stormwater wetlands are designed to maximize pollutant removal through gravitational settling, dilution, filtration, and biological uptake and retention mechanisms. They may be located either on or off-stream and can be designed to provide both water quality and quantity control for a wide array of drainage area and land use conditions, including stormwater hotspots.

Figure 5: On-Stream Wet Pond and Off-Stream Wet Pond

In general, a minimum drainage area of 10-25 acres is recommended for artificial wetlands (Schueler, 1993; Galli, 1997). It should be noted that for highly developed/ultra urban areas the employment of artificial wetlands employment may be restricted by the general unavailability of requisite open space. However, they may be used in such areas provided that a suitable downstream site exists. Finally, small off-stream wetlands may be carefully sited within riparian corridors so as to intercept and treat uncontrolled runoff from small adjacent catchments. As best exemplified by Montgomery County's upper Sligo Creek restoration initiative, small artificial wetlands may be employed in forested stream corridors so as to provide both water quality and partial water quantity control with minimal tree removal.

3.4.4 Extended Detention Dry Ponds

Extended detention dry ponds are basins whose outlet control structure has been intentionally designed so as to slowly release (i.e., generally over a 12 to 24 hour period) stormwater runoff. Because of their relative inability to remove soluble pollutants, extended detention dry ponds are generally not viewed as being primary water quality BMP's. Nevertheless, they have well-documented ability to remove particulate pollutants, as well as reducing downstream channel erosion problems (Shueler, 1994). Consequently, they are well suited for incorporation into linked BMP systems (i.e., BMP's used in series, in a complementary manner). They may be located either on or off-stream and can be designed to provide runoff control for a broad range of drainage areas and land uses, including stormwater hotspots (Figure 3).

In general, a minimum drainage area of 10 acres is recommended for extended detention dry ponds. As with all "pond" systems, their use is typically restricted in highly developed/ultra urban areas by the general unavailability of suitable open space areas. They may, however, be employed in these areas provided that an adequate downstream location exists.

Figure 3. Extended Detention Dry Pond

3.4.5 Filtration Systems

Investigating and controlling individual releases and dealing with nonpoint sources will take a great deal of time and effort. A sequential approach to dealing with source control and restoration would delay return of river function and usability far into the future. Interception of pollutants before they are discharged to the river is a key element of a load reduction strategy that will allow for restoration in a timely fashion. Filtration systems are one promising approach that can deal with the entire volume of runoff from subwatersheds and be tailored to filter or treat the specific contaminants of concern. These facilities may well become part of a longer-range solution. In fact, part of the District's plans to deal with stormwater include renovating deteriorated structures.

For the purposes of this document the term filtration systems includes, but is not limited to, the following stormwater management Best Management Practices (BMP's): sand filters (both surface and underground), bioretention, biofiltration swales, peat – sand filters, and new generation of filter media. All of these practices employ some type of filtering media designed to provide varying levels of water quality control. With the exception of biofiltration swales, which are characteristically very long linear systems, all of the preceding techniques are well suited for highly developed/ultra urban areas (Figure 4). The common use of these systems has generally been for the treatment of first flush runoff from smaller sites (i.e., drainage areas under five acres in size). However, sites as large and with complex pollutant mixes as BWI airport are now being addressed with such systems.

Figure 4. D.C. Underground Sand Filter Box and PG CO Bioretention System

Over the past few years, all three Anacostia jurisdictions have funded several new BMP filtration systems to treat runoff discharged through storm drain outfalls or streams. One large filtration project planned by the District of Columbia, is the installation of a peat-sand filter for treating stormwater runoff from an approximately 150 acre catchment draining the River Terrace community located on the Anacostia's east bank. The proposed facility also includes an artificial wetland for water polishing. Total costs for this planned project were estimated by the District at $900K. Another proposed facility is the installation of stormwater controls on the two outfalls that serve the RFK Stadium area. These two outfalls collect stormwater for the stadium parking areas and surrounding neighborhoods and then discharge to Kingman Lake . A combination oil/grit separator and a constructed wetland are proposed as end-of-the-pipe technologies to remove pollutants from the stormwater. Total project costs were estimated by the District at $1.2 million

3.4.6 Low Impact Urban Development Pilot Program

Low Impact Development (LID) is a new, cost-effective, alternative stormwater management technology that can be used to restore water quality of the streams in urban watersheds. LID combines the following six principles to protect and restore natural watershed features and improve water quality:

- Conserving existing natural and topographic features;
- Retrofitting that minimizes environmental impacts from cleared land and impervious surfaces;
- Maintaining or lengthening the pre-existing detention time of storms;
- Installing Integrated Management Practices (IMPs);
- Reducing contaminant migration and releases to surface waterways; and
- Providing education about simple to install pollution prevention measures.

LID applies small-scale, source control, Integrated Management Practices (IMPs) to each project site. LID retrofit techniques reduce runoff peak discharge, volume, and frequency, and improve the water quality of receiving streams. LID designs can easily be integrated to address critical watershed issues.

Figure 5. Retrofit of residential areas.

Figure 5 illustrates several examples of retrofitting residential areas using LID technologies. The LID unique micro-management source control concept is quite different from conventional, end-of-pipe treatment or conservation techniques. Bioretention, filtration, and other small-scale filtration and storage treatment facilities are the most common LID techniques to improve pollutant removal efficiency. Similar concepts can be used to retrofit commercial and highway developments.

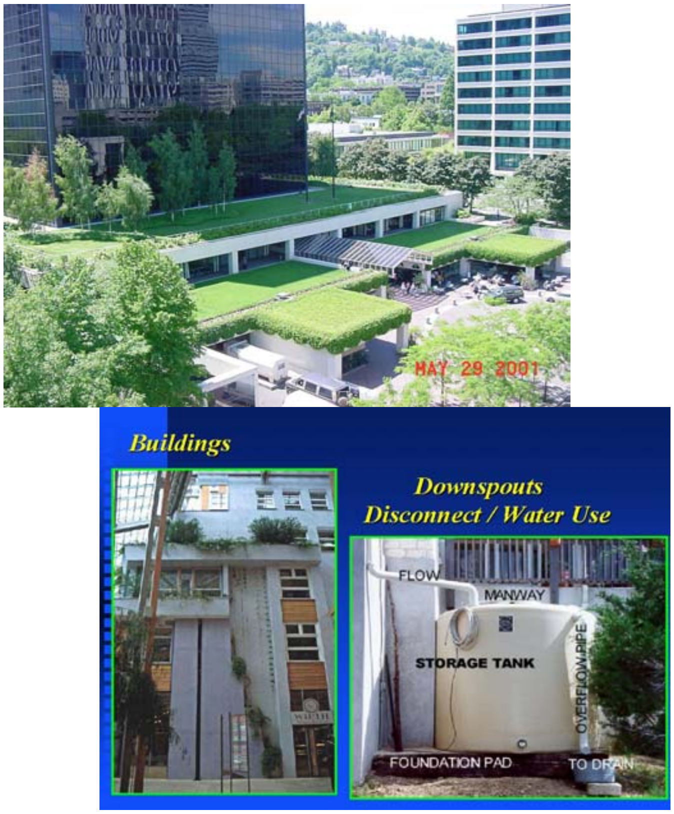

Figure 6. Retrofit of commercial developments.

Essentially, all aspects of the urban landscape can be designed to be multi-functional to treat urban runoff. Examples of practical and affordable LID projects include:

- Bioretention/rain gardens
- Strategic grading
- Amended soils
- Resource conservation
- Flatter wider swales
- Flatter slopes
- Tree/shrub depression/filtration
- Turf depression storage
- Landscape island storage/filtration
- Rooftop detention/retention
- Roof leader disconnection
- Parking lot/street storage/filtration
- Alternative surfaces and building materials
- Reduce impervious surface
- Surface roughness technology
- Rain barrels/cisterns/water use
- Catch basins/seepage pits
- Sidewalk storage
- Infiltration swales and trenches
- Tree box filters
- Trash collectors
- Maximize sheet flow
- Tree planting and landscaping
- reforestation

- Smaller culverts, pipes and inlets
- Pollution prevention

Figure 7. Parking lot and court yard retrofits.

An Anacostia LID demonstration project is recommended to address runoff in all three Anacostia jurisdictions, from each of the following four (4) land use types: residential, commercial, industrial, and institutional areas. This proposed LID urban retrofit program will be modeled after programs and techniques pioneered through the Prince George County's Port Town Environmental Restoration Program. The demonstration project would encompass initial tasks, such as convening initial program meetings, all the way through construction, to monitoring effectiveness.

A total of fifteen (15) critical sub-watersheds will be selected within the three jurisdictions. On average, approximately 225 sites will be chosen for each watershed depending on watershed characteristics. Each LID site will control an average drainage area of approximately 1.0 acre. The total program cost is estimated to be $30,000,000. WASA has already targeted $2.8 million for LID development as part of their Long Term Control Plan to help control CSOs.

3.4.7 Street Sweeper Program

Despite the best efforts at minimizing the generation of pollutants, there will be some sources that escape control, particularly at the watershed scale. Deposition of soot, smoke particulates, exhaust, oil, fuels and so on within an urban landscape will undoubtedly continue. These types of sources – petroleum products and combustion by-products- are significant sources of PAHs, one of the major pollutants of the Anacostia. Collection of particulates from roadways, plus oil and grease, prior to their wash off is yet another approach to reducing contaminant loadings to the river.

While both conventional stormwater management techniques and LID are viewed as generally being effective at reducing the impacts of stormwater runoff on urban rivers and streams, new high-efficiency street sweepers, while not reducing runoff volumes, have been shown to yield significant and generally cost effective water quality benefits by removing fine (i.e., ≤10 micron diameter) particles before they are mobilized and transported off-site by rainwater (EPA 1999).

There are several types of modern vacuum sweepers on the market today. Among the most efficient are regenerative-air sweepers, which dislodge and collect particles using a combined high velocity blower and vacuum system, and vacuum assisted dry sweepers. Independent studies of sweepers in Oregon and Washington have demonstrated that a 99.6 percent reduction in particulates over 10 microns is possible. Weekly sweepings yielded a 76 percent reduction in suspended solids reaching receiving waters (EPA 1999). Other evaluations of dry vacuum sweepers have shown 35 to 80 percent reductions in nonpoint source pollutants (Runoff Report, 1998). Recent estimates suggest that the new vacuum assisted dry sweeper might achieve a 50 to 88 percent overall reduction in the annual suspended solids loading for a residential street, depending on sweeping frequency (Bannerman, 1999).

Unlike surface and subsurface stormwater control solutions, which are often constrained by space limitations, implementation of street sweeping is limited primarily by the availability of funding. Implementation and long-term maintenance costs are highly variable, depending on curb mileage, whether sweepers are purchased or lease financed, and whether municipal staff or private contractors operate and maintain the machines. Equipment leasing can reduce program startup costs, while privatization of sweeping programs can eliminate the need for maintenance and can result in a significant reduction in sweeping costs per curb mile (NAPA 1995). Current sweeping costs range from approximately $10 to $70 per curb mile depending on frequency and program size (Table 4). Vacuum assisted sweepers typically last approximately eight years and range in cost from $80,000 to $250,000 each. Emerging sweeper technologies are expected to bring smaller, more maneuverable, and less costly sweepers to the market in the near future. The total estimated cost for implementing this alternative is $6.6 million dollars.

The effectiveness of street sweeping programs at removing both roadside trash and fine particles is heavily dependent upon sweeping frequency. Since optimal sweeping frequency is closely related to rainfall frequency and the rate of pollutant accumulation, it varies widely from city to city (see City of Alameda study). In many areas, weekly, year-round sweeping has been found to be both feasible and highly effective. It is also vital that sweepers have unimpeded access to curbs and gutters. This can be accomplished through the modification and strict enforcement of street parking regulations. Thus, it is important that sweeping schedules be widely and prominently posted through street signage and that the benefits of street sweeping be advertised.

In the Anacostia, street sweeping is currently performed with varying levels of frequency and success in portions of the District of Columbia, the City of Takoma Park, Silver Spring, and other Maryland municipalities. Perhaps the most effective is the Silver Spring Urban District's public-private partnership sweeping program, which sweeps 26 curb miles three times a week using a regenerative-air sweeper. The District of Columbia also uses modern mechanical-vacuum sweepers on many of its streets, but has encountered significant maintenance problems and interference from parked cars. Furthermore, the program ceases operation on its regular routes each year between January and March.

While these local street sweeping programs continue to remove amounts of trash, debris, and sediment from local streets, each would benefit from additional funding for newer equipment, additional staff training, street signage, and enforcement of parking restrictions.

Table 4: Examples of Street Sweeping Programs

Location	Sweeper Type	Cost/Curb Mile	Frequency
Silver Spring, MD	Regenerative-Air	$14.79	3 times /week
Plymouth Township and Livonia, Michigan	Mechanical & Vacuum	$68.00 (average of two cities)	No data
Lakeland, FL	Vacuum Assisted	$33.38[1]	No data
Greeley, CO	Mechanical & Vacuum	$32.86	Arterial 18/yr Local 5/yr Parking 12/yr
Kansas City, MO	Mechanical & Vacuum (leased)	$28.62	Arterial 15/yr Residential 7/yr
Decatur, IL	Mechanical & Vacuum Assisted	$10.21	2 times /week
		$10.87	2 times /month

[1]Cost includes sweeper purchase, maintenance, salary (excluding benefits), and waste disposal

3.4.8 Water Quality Inlet Pilot Program

It is well known that stormwater runoff entering curbside and street inlets includes floatable, particulate (course and fine), and dissolved contaminants. Capture of these contaminants at their entry into the storm sewer system is another approach for reducing loadings to the river. Catchment basin inserts have been accepted as Best Management Practices (BMPs) for dealing with runoff in jurisdictions all across the country. This section focuses on the implementation of a demonstration project of catch basin retrofits and inserts (hence referred to as water quality inlet systems) that targets the improvement of water quality by reducing sediment and trash transport at the small watershed level.

Studies performed for New York City (Hydroqual 1995) revealed that generally less than ten percent (by weight) of the solids entering the storm sewer system is large enough to be retained by a 10-mesh screen. The passing debris is predominately dust, dirt, sand and small gravel. Since contaminants are more likely to adhere to smaller grain size particles, there is a limited emphasis on the prevention of trash entering the storm sewer system within this pilot program. However, areas that routinely require cleaning of trash would be candidates for screening of curb inlets to prevent trash entry.

Contamination in the storm runoff originates during rain events where impervious surfaces are washed free of the accumulated particulates and oil. Dissociation of the chemicals in the storm water occurs rather quickly, generally reaching equilibrium within the water by the time storm water has reached a catch basin. Therefore, water quality inlet retrofits or inserts require proper design to address the site-specific ration of dissolved phase contamination to particulate contamination.

A review of technology and current practice will yield a good foundation on which to build a credible program to apply this evolving technology. Both the effectiveness and application of catch basin technology and an assessment of the local and standard practice within the industry will improve the program success. Data can then be extracted from these sources and placed within the context of existing information on the watershed.

In early designs, many storm drain inlets were limited in their ability to capture and retain small to medium-sized solids. The scouring affect caused by the hydraulic forces tended to continually mobilize any small grain particles and can even transport the larger settled particles during heavy rain events. Typically, routine maintenance involving removal of sediment is on a fairly limited schedule (once or twice a quarter) or on an as needed basis. While benefits to solids removal are evident during operation, failure to clean many inlets can render them ineffective for any beneficial effect. Various manufacturers have been working to address some of these issues with design changes to produce promising new water quality inlet systems and inserts. A partial listing of water quality inlet objectives and insert system solutions is provided as Table 5.

Table 5: Partial Listing of Water Quality Inlet and Insert Systems

Objectives	**Technology or Practice**
Reduce load of particles re-entrained	1) Vortex hood 2) Increased catch basin cleaning frequency 3) Appropriate design or filter material
Eliminate trash transport to next catch basin	Vortex hood
Reduce load of particles entering the catch basin	1) Increased frequency of street sweeping 2) Inlet strainers/filters
Reduce trash load entering catch basin	Curb screens
Reduce Oil an Grease loading	Sorbant filter media, sock, or cartridges
Odor reduction from sewer gas	1) Vortex hood 2) Appropriate design

The water quality inlet demonstration project recommended is a phased, public/private storm drain-based approach designed to maximize effectiveness and reduce cost. Implementing a water quality inlet demonstration project that targets one tributary of the Anacostia can verify design assumptions, improve the accuracy of cost design, installation, and operation costs.

Training and awareness and community involvement are also important aspects of the program. The objective is to raise interest and present opportunities to property owners to maximize participation. The possibility of granting storm water utility credits should also be explored as a means to increase participation. Training on operations and maintenance as well as procurement will be included.

The costs presented here are for budgetary use: assumptions and unit costs will be updated after the demonstration project is complete. The unit costs include assumptions based on site specific information obtained at the time of generation. Approximately $1.5 million would be required to implement the pilot water quality inlet demonstration project

Based on current information, one leading subwatershed candidate for this proposed water quality inlet system demonstration project is Hickey Run. This subwatershed is approximately 40 percent impervious and has a mix of land uses and storm drain inlet types. Extensive water quality data also exists in this tributary since it is also regulated under an NPDES permit. In older, highly developed areas lacking stormwater management controls, trash and particulate loading to the river can often be reduced through the installation of water quality and/or trash reduction devices at the point of entry into the storm drain system. In addition to the broader installation of water quality inlets to reduce floatable and sediment loading, devices that remove dissolved contaminants at certain inlets may also be required. The types of contamination typically present in the water column include suspended solid, total metal, oil and grease and other organic-based compounds. From these data, designs which can be implemented and is scaleable to encompass the full watershed can be performed.

3.4.9 Trash Management

Figure 8: Discarded Debris

It is estimated that over 20,000 tons of trash and debris enter the Anacostia River annually (PG DER, 1994). Of this amount, at least 165.5 tons of floatables (e.g., plastic bottles, styrofoam cups, plastic bags, aluminum cans, etc.) enter the river annually from the Maryland portion of the watershed (MWCOG, 2001). The 2001 Anacostia Watershed Society's annual trash collection event removed over 10 tons of trash from the river in just one day. WASA operates skimmer boats just for the removal of trash from the river. However, access throughout the river is an issue for these boats. Without question, floatable trash remains one of the watershed's most highly visible and aesthetic problems. Although trash is not generally thought of as presenting a significant threat from a toxic constituents perspective, trash and non-woody debris can have chemical and biological impacts on receiving waters including: interference with the establishment of aquatic plants; leaching of toxics from certain types of trash, such as used oil quart containers and filters, batteries; plus hazards to wildlife through ingestion of or entanglement in floating debris (Herson-Jones et al., 1994). Trash *does* impact overall efforts to restore the Anacostia

River. The occurrence of trash, especially floatables, degrades the perception the river's value of both residents and visitors and thus impacts the willingness to make changes necessary to restore the river.

Due to the long residence time for water in the river, the Anacostia is highly retentive of trash and other pollutants. Because of its tidal nature though, the Anacostia River presents some special challenges to trash control efforts. The fluctuations in flows and the daily, tidally-influenced movement of trash and other floating debris up and downriver generally make the installation of cross-river floating trash booms at many locations impractical. Another issue is the inaccessibility of existing mechanical trash collection technologies (i.e., deep-draft skimmer boats) to access emergent fringe wetland areas and shallow pocket embayments. The presence of the railroad crossing bridge downstream of New York Avenue further restricts access to otherwise accessible upstream trash accumulations by the DC-WASA trash skimmer boats. In addition to the large quantity of trash entering the river via its many tributaries and storm drain outfalls, 11 major Combined Sewer Overflow (CSO) outfalls flowing from the District of Columbia's CSO system (which dates from the 1880s) have proven to be significant conveyances of trash into the river.

Like many other issues facing the Anacostia, trash will not be dealt with by a single approach. Trash control will only likely be accomplished by a suite of techniques that range from reducing trash generation through community education, to interception before its discharge to the river, to enhanced recovery once in the river.

3.4.9.1 Trash Interception at Anacostia Floodway Levee Pumping Station Facilities

Prince George's County, in conjunction with the State of Maryland Department of the Environment, has recently installed two mechanically cleaned trash screens at the Colmar Manor Pumping Station Facility. The pumping stations are responsible for pumping stormwater flows from an approximately 1500-acre area along the urbanized-side of the levee to the riverside of the Levee. Stormwater runoff from the urbanized areas carries a significant load of floatable trash and debris. Prior to the installation of the mechanically cleaned trash screens, the stormwater runoff, with its floatable trash and debris, would be pumped directly to the Anacostia River. Since the completion of the Pilot Demonstration Project, the floatable trash and debris are now captured by the trash screens prior to the stormwater entering the pumping stations. Once the trash is captured, the trash is automatically removed by the mechanical trash screen cleaner and dumped into a trash dumpster. As a result, it is estimated that approximately 5-10 tons of trash will be prevented from entering the Anacostia River each year.

This demonstration project illustrates that trash catching and removal systems can be a viable tool to combat floatable debris in the river, and, that such approaches can be accomplished within very limited land. Based upon the success of this demonstration project, the County is currently seeking additional grant funding to pursue the installation of additional mechanically cleaned trash screens at its other pumping station facilities.

3.4.9.2 Pilot Trash Control Project At Selected Stormwater and CSO Outfalls

As already noted, storm drain systems, in general, represent major conveyors of floatable trash. While curbside screening and street sweeping may capture some trash, debris will still be swept off the streets and through street inlets and storm drain systems and ultimately transported to the receiving stream or river. Trash netting systems, designed to capture this floatable material, are generally placed either within the storm drain system or directly below its outfall. In the tidal Anacostia River, one floating net system was recently installed near the Sousa Bridge (CSO 018) by DC-WASA as a demonstration project. Results from the nine-month long evaluation period have been favorable and DC-WASA expects to install other similar trash reduction systems.

Prince George's County is about to enter into a Memorandum of Understanding with the State of Maryland's Department of the Environment to identify and install a pilot system to control floatable debris at selected stormwater outfalls in the Anacostia River. This trash reduction project calls for the following:

- Planning study to evaluate trash reduction options at storm drain outfalls and inlets.
- Identify selected trash reduction options to be implemented at specific outfall and/or inlet areas.
- Design selected trash reduction options at site–specific locations for installation.
- Advertise selected trash reduction options for construction and installation.
- Award contract for construction and installation of selected trash reduction options.
- Complete contract for construction and installation of selected trash reduction options.

Trash netting systems have also been modified to work for trash interception on streams. Three District of Columbia streams have been identified in this plan as potential locations suitable for the installation of trash nets. Pending final results of the current demonstration project, it is recommended that these devices be installed at Hickey Run, Watts Branch, and Lower Beaverdam Creek. Installation, maintenance, and evaluation costs for three systems would total approximately $750K.

3.4.9.3 Municipal Trash Management Program

Prince George's County also has a Municipal Trash Program to reduce the amount of trash entering storm drains in all municipalities in the County. The Program selects an intersection in one of the municipalities and retrofit several storm drain inlets with devices that will capture trash before it enters the storm drain system (Figure 9). In addition, street sweeping is implemented on a weekly basis. This program provides funding for storm drain retrofits in problem trash areas and to purchase or lease street sweepers.

Figure 9. Examples of Municipal Trash Management Devices and Removal Techniques

3.4.9.4 Anacostia Trash Steering Committee

Maryland Department of the Environment's (MDE) Anacostia Trash Steering Committee (MDE, 2001) has identified various options for tidal river trash removal, which include, but are not limited to, the establishment of a multi-jurisdictional trash removal program involving several lead agencies from the state, counties, and District. One option includes the expansion of mechanical skimmer boat operations above the CSX railroad bridge to serve Maryland/District of Columbia waters. This could be accomplished through the creation of a second skimmer boat program based at the Anacostia Waterfront Park at Bladensburg. The purchase of additional skimmer boats, including shallower-draft skimmer boats, should increase the effectiveness of such programs. Another option includes the expansion of annual volunteer river shoreline clean up efforts, with an increase in the number of boats provided by MDE, M-NCPPC, the District of Columbia, and others at such events. The development of new technologies and techniques for removing shoreline trash could also yield solutions to the problem of trash removal from otherwise inaccessible or hard to reach stretches of shoreline.

The Anacostia Trash Steering Committee has also suggested that the strategic placement of floating booms, netting systems, and other trash catching devices at strategic sites including tributaries such as Lower Beaverdam Creek, Watts Branch, Hickey Run, and key CSO outfalls, be evaluated and pursued.

The demands of the above mentioned programs and facilities would necessitate the employment of a full time trash removal/river maintenance staff supported by dedicated funding sources. Secondary benefits to having staff on the river full time would also accrue.

This Management Strategy acknowledges that trash is not a primary issue related to the toxic contamination of the river. Nor does it presume that these efforts will completely solve the trash issue. However, it cannot ignore the psychological impacts, physical impacts to wildlife, and chemical constituent aspects related to trash. Therefore, it is recommended that complementary efforts be taken to intercept and remove trash. In keeping with the Anacostia Trash Steering Committee's recommendation for additional trash interception devices at tributaries and outfalls, it is recommended that trash catching systems be installed at various strategic locations.

Because successful restoration of the Anacostia will require the involvement and long-term support of the public as stakeholders in the process, the public perception of the river is a key element. An educational campaign, such as the effort by the Anacostia River Business Coalition, should also be actively pursued.

3.4.10 Stream Stabilization and Buffer Wetland Restoration

Increases in stormwater runoff associated with watershed development have significantly contributed to stream erosion, habitat loss, and sedimentation damage in the Anacostia watershed. These impacts started with the clearing of land hundreds of years ago for timber and agricultural purposes and have continued as the nature of watershed development shifted to residential and commercial uses to accommodate population growth and regional economic development needs. In the recent past, the shift in watershed densities and increases in impervious areas to accommodate urban and suburban land uses was not accompanied by stormwater controls to mitigate the effects of increased peak runoff flows and reduced replenishment of groundwater to support stream base flows. The result was devastating in terms of stream channel erosion and the sediment damages to stream habitat able to support diverse biological life.

Figure 10: Examples of stream channel erosion and undercutting which require stabilization.

Figures 14 through 16 track the progression of stream impacts from a stable channel through the increasing impacts of channel widening and down-cutting as the stream attempts to readjust to accommodate the radical changes in hydrology that can accompany major watershed changes. It has been estimated that up to two-thirds of sediment loadings generated in developed urban and suburban areas are caused by accelerated channel erosion rather than from upland overland flow sources, as traditionally thought. Erosion may also be a significant source of nutrient loadings impacting waters.

Figure 11: Severe down-cutting of stream channel has exposed utility features.

Figure 12: Examples of severe undercutting of stream channels.

Montgomery County has an aggressive program to mitigate the effects of peak runoff and reduced groundwater infiltration on streams. Since 1927, a comprehensive park acquisition and subdivision review program has purchased or reserved, as conservation easements, protective stream buffer areas for most of the large and small Anacostia tributaries in Montgomery County. These buffer areas help filter pollutants in runoff and provide habitat cover for fish and wildlife. The County now also employs a diverse array of stormwater infiltration and detention controls, along with improved site planning, to help mitigate the impacts of impervious area increases that can so radically affect stream hydrology and degrade stream habitat. These controls capture and treat runoff to address both the peak flow quantity impacts on streams and reduce pollutant loadings contained in the runoff. Increasingly effective efforts at construction site sediment control and stormwater runoff control have been in effect since the early 1970s to mitigate the stormwater impacts of new development.

Table 6: Montogmery County's Commitment to Regional Anacostia Restoration Efforts

Project Type	Completed or Under Construction	Underway or In Design
Storm water retrofit	1,917 acres in 11 projects	813 acres in 11 projects
Stream Restoration	5.4 miles in 6 projects	12.55 miles in 24 projects
Watershed study	Upper Paint Branch; NE Branch (37.5 sq. miles)	Lower Paint Branch (7.3 sq. miles)

Since 1990, Montgomery County's Department of Environmental Protection has also instituted proactive measures to address runoff impacts and degraded stream conditions generated in areas of the county that developed before runoff controls were required. This award-winning ***Countywide Stream Protection Strategy*** has received extensive local and national recognition for its progressive, comprehensive approach and emerging success. The above table (Table 6) quantifies the extent of Montgomery County's efforts to build storm water retrofit and stream restoration projects that stabilize stream channel erosion and restore stream habitat.

Thus far, recently completed watershed feasibility planning studies cover some 45 square miles of Montgomery County's Anacostia watershed drainage. These projects led to the identification of many opportunities for retrofitting stormwater controls and restoring degraded sections of Anacostia tributaries. The following photographs show examples of the Anacostia projects constructed thus far. Some of these projects have been carried out with cooperation and support from COG and the Maryland-National Capital Park and Planning Commission. Some have also been carried out in partnership with the U.S. Army Corps of Engineers. Many projects have also received cost-share grant assistance from the State of Maryland.



To date, the County Department of Environmental Protection (DEP) has built or has under design over 2,700 acres of stormwater retrofit controls (22 projects) and 18 miles of restored streams (30 stream restoration projects). Projects have been built or under design in Sligo Creek, Northwest Branch, Paint Branch, and the Little Paint Branch. Some of the restoration projects also included new wetlands at the end of storm drain outfalls to mitigate water quality impacts and recreate lost habitat for frogs and salamanders. DEP's work in the Sligo Creek watershed is the most extensive. Monitoring since 1989 indicates that the stream now is able to support eleven native fish species, where degraded habitat conditions in the past were only able to support two species. Benthic community diversity has also improved. In the upper Paint Branch, temperature reductions have been achieved in the Upper Gum springs tributary that seem to be extending the quality and range of the brown trout habitat.

 

Collectively, these projects are significantly improving habitat support for aquatic life. They are substantially reducing the extent of new sediment loads delivered from the artificially accelerated stream channel erosion that has been stimulated by uncontrolled or inadequately controlled stormwater runoff. The increased biological diversity that can be supported through restored stream habitat can also supplement upland stormwater controls to uptake nutrient loadings that would otherwise be delivered downstream to further stress conditions in the Anacostia mainstem. Other projects have also diverted storm flows or taken other measures to reduce stream temperature impacts associated with watershed development. These latter efforts have focused on protecting fragile headwater areas of the Upper Paint Branch where protection of the naturally propagating brown trout fishery is of primary concern.

there are many further opportunities to continue these types of enhancements. These projects not only enhance and restore habitat, but also substantially reduce pollutant flux primarily by trapping sediments. Two such projects are being proposed within Prince George's County. Streambank stabilization and wetland restoration is recommended for sites on Paint Branch and Cabin Branch Creek. These projects will reduce suspended sediment by approximately 75 per cent and trace metals by 40 percent from the drainage areas totaling approximately 3 square miles. The cost for these projects is estimated at $845,000. More projects may be developed in the future.

3.4.11 Stream Channel Stabilization and Riparian Buffer Restoration

Increases in stormwater runoff associated with watershed development have had a significant impact on stream erosion, habitat loss, and sedimentation damages in the Anacostia watershed. These impacts started with the clearing of land hundreds of years ago for timber and agricultural purposes and have continued as the nature of watershed development shifted to residential and commercial uses to accommodate population growth and regional economic development needs. In the recent past, the shift in watershed densities and increases in impervious areas to accommodate urban and suburban land uses was not accompanied by stormwater controls to mitigate the effects of increased peak runoff flows and reduced replenishment of groundwater to support stream base flows. The result was devastating in terms of stream channel erosion and the sediment damages it caused to stream habitat able to support diverse biological life.

The accompanying illustrations (Figures 24-26) track the progression of stream impacts from a stable channel through the increasing impacts of channel widening and down-cutting as the stream attempts to readjust to accommodate the radical changes in hydrology that can accompany major watershed changes. It has been estimated that up to two-third of sediment loadings generated in developed urban and suburban areas are caused by accelerated channel erosion rather than from upland overland flow sources, as traditionally thought. Erosion may also be a significant source of nutrient loadings impacting waters.

Urban streams are often buried in pipes and culverts or are otherwise covered to facilitate development or to channel stormwater. In recent years, restoring streams to their natural biological and physical functions is an issue that is becoming increasingly popular as the environmental, social, and even economic benefits of natural drainage patterns and stream channels are recognized.

Stream rehabilitation projects range from trash removal to daylighting. The term daylighting applies to projects that expose some or all of the flow of buried waterways. The daylighting process may be combined with re-naturalization projects such as recreating floodplains, establishing riparian vegetation, and creating ponds or wetlands. Although daylighting projects can be rather expensive and require extensive planning and community education, their potential benefits are manifold, ranging from improved water quality and stream channel capacity to restored habitats and beautified public spaces.

Daylighting can be a means of routing runoff from combined sewer systems, thereby reducing the incidences of combined sewer overflows, decreasing loads reaching wastewater treatment facilities, and lowering maintenance costs of stormwater infrastructures. The hydraulic performance of a restored stream and floodplain may be vastly improved over that of an enclosed waterway, and erosion and flooding may be reduced because runoff is slowed by channel sinuosity and roughness. The associated vegetation can improve water quality by slowing and infiltrating stormwater, trapping sediment, and filtering organic and inorganic pollutants. Moreover, restored aquatic, riparian, and wetland habitats provide valuable living space for fish and wildlife. A re-naturalized area may also become the focal point in a community park, contribute to urban greenways, create leisure activities such as fishing, and provide learning opportunities for local school children.

Since 1987, the AWRC and its affiliates have employed aggressive programs designed to mitigate the effects of peak runoff and reduced groundwater infiltration on Anacostia streams. Since 1927, the Maryland-National Capital Park and Planning Commission (M-NCPPC) has had a comprehensive park acquisition and subdivision review program and has acquired or reserved, as conservation easements, protective stream buffer areas for most of the large and small Anacostia tributaries in Montgomery and Prince George's Counties. These riparian forest buffer areas help filter pollutants in runoff and provide habitat cover for fish and wildlife. All three Anacostia jurisdictions now employ a diverse array of stormwater infiltration and detention controls along with improved site planning to help mitigate the impacts of impervious area increases that can so radically affect stream hydrology and degrade stream habitat. These controls are typically designed to capture and treat runoff to address peak flow quantity impacts on streams and reduce pollutant loadings contained in the runoff. Increasingly effective efforts at construction site sediment control and stormwater runoff control have generally been in effect since the 1970s and 1980s to mitigate the stormwater impacts of new development.

An example of a comprehensive watershed-based approach is Montgomery County's Department of Environmental Protection's award-winning 1999 ***Countywide Stream Protection Strategy.*** This strategy has received extensive local and national recognition for its progressive and comprehensive approach toward addressing runoff impacts and degraded stream conditions. It is also being used as a successful model for restoration activities in of the Anacostia watershed.

The following section exemplifies Montgomery County's and the AWRC's efforts to build both stormwater retrofit and stream restoration projects in the Anacostia that improve water quality, stabilize stream channel erosion and restore stream habitat.

Thus far, recently completed watershed feasibility planning studies cover some 45 square miles of Montgomery County's Anacostia watershed drainage. These projects led to the identification of many opportunities for retrofitting stormwater controls and restoring degraded sections of Anacostia tributaries. Figures 27-29 show examples of the Anacostia projects constructed thus far. Some of these projects have been carried out with cooperation and support from COG and the Maryland-National Capital Park and Planning Commission and some in partnership with the U.S. Army Corps of Engineers. Many projects have also received cost-share grant assistance from Maryland.

To date, the County Department of Environmental Protection (DEP) has built or has under design over 2700 acres of stormwater retrofit controls (22 projects) and 18 miles of restored streams (30 stream restoration projects). Projects have been built or under design in Sligo Creek, Northwest Branch, Paint Branch and the Little Paint Branch. Some of the restoration projects also included the implementation of new wetlands at the end of storm drain outfalls to mitigate water quality impacts and recreate lost habitat for frogs and salamanders. DEP's work in the Sligo Creek watershed is currently the most extensive.

Sligo Creek monitoring, which has been underway since 1989, indicates that the stream now is able to support 14 native fish species, where degraded habitat conditions in the past were only able to support three species. Benthic community diversity has also improved. In the upper Paint Branch, temperature reductions have been achieved in the Upper Gum springs tributary through the employment of a parallel pipe storm drainage system. Initial monitoring results strongly suggest that this system seems to be extending the quality and range of the brown trout habitat.

Collectively, these projects are significantly improving habitat support for aquatic life and substantially reduce the extent of new sediment loads delivered from the artificially accelerated stream channel erosion that has been stimulated by uncontrolled or inadequately controlled stormwater runoff. The increased biological diversity that can be supported through restored stream and riparian habitats can also supplement upland stormwater controls to uptake nutrient and toxic loadings that would otherwise be delivered downstream to further stress conditions in the Anacostia main stem. Other projects have also diverted storm flows or taken other measures to reduce stream temperature impacts associated with watershed development. These latter efforts have focused on protecting fragile headwater areas of the Upper Paint Branch where protection of the naturally propagating brown trout fishery is of primary concern.

Many further opportunities exist to continue these sorts of enhancements. These sort of projects not only serve to enhance and restore habitat, but also can achieve substantial reductions in pollutant flux primarily by trapping sediments.

As part of its ongoing stream restoration program, the Watershed Protection Division of DC DOH is in the process of evaluating several sub-sheds to determine the feasibility of creating new habitat in the tidally influenced portion of the Anacostia basin. Habitat creation possibilities under consideration include stream daylighting, wetlands creation, augmentation of the riparian buffer zone, and removal of blockages to fish passageways. So far, a preliminary survey of the Fort Chapin tributary has indicated that stream daylighting will probably not be feasible in this sub-shed. Surveys of the sub-sheds of three other Anacostia tributaries, the Watts Branch, Fort Dupont, and Pope Branch, are currently under way. Each of these tributaries alternates between an open channel and an enclosed (piped) channel along its course, and the potential for stream daylighting exists at a number of locations along each channel. The implementation phase of the habitat creation effort is likely to begin in late 2002, though the habitat creation techniques eventually chosen will depend on the outcome of the surveys and the associated cost/benefit analyses. Because stream daylighting and wetlands creation are in general extremely expensive undertakings in urban areas, the availability of funding will be an important factor in determining the extent to which these habitat restoration techniques will be utilized in the Anacostia basin.

The Stickfoot Sewer sub-shed is another area that is being considered for daylighting. The Stickfoot sewer drainage basin roughly extends from the St. Elizabeth Hospital to the Anacostia River and includes the Popular Point area. It has been envisioned by the DC Department of Health and NOAA that the culverted section of the Stickfoot Sewer in the Popular Point area be daylighted and combined with the creation of an intertidal wetland, with the ultimate goal of creating spawning and rearing habitat for anadromous fish. A funding source has been identified for this project. However, the ultimate use of the Poplar Point area and the fate of the Stickfoot sewer will not be decided until input from all interested stakeholders has been considered.

Because of the potential benefits of stream daylighting to urban water quality, we propose that funding be provided for stream daylighting in the Anacostia tidal sub-basin, including a comprehensive monitoring program to evaluate the impact on water quality. Eight tidal basin tributaries are listed on the District's 303(d) list of water bodies with water quality impairments due to toxic chemicals. Additionally, many storm sewer lines are known to convey flow along former small stream beds. We propose stream daylighting and associated monitoring in six small tributary or separate storm sewer sub-sheds in the Anacostia tidal sub-basin (in addition to the proposed daylighting of the Stickfoot sewer, for which District of Columbia Government funding is being made available). Until sub-shed surveys are completed, it is not possible to do a detailed cost estimate for each project. However, assuming that approximately ¼ mile of buried channel is daylighted in each of three sub-sheds, and assuming that the average cost per linear foot is approximately $1000, the total estimated cost of the proposed daylighting is $4,000,000. In addition, the estimated cost of associated water quality monitoring, assuming that inflow and outflow are monitored for five base-flow and five storm events (with three samples per storm event) at each of three locations, and assuming a cost per sample of approximately $1200, is $97,000.

There are also other potential opportunities within the upper watershed of the Anacostia for stream daylighting with wetland creation as well. Therefore, it is recommended that approximately $100,000 be used for conducting a comprehensive stream daylighting evaluation for the Montgomery County, and Prince George's County portions of the watershed.

3.4.12 Tidal Wetland Restoration

Wetlands, and stream corridors, are the mix of land, plants, animals, and network of waterways, which perform a number of valuable ecologic functions, such as providing habitat for aquatic and terrestrial plants and animals. But these areas also provide important and economically valuable physical functions such as modulating stream and river flow, storing stormwater, removing harmful materials from the water, trapping particulates, groundwater recharge and so on.

Over 90% of tidal wetlands in the Anacostia have been lost: The Army Corps of Engineers estimates that, between Bladensburg and river's mouth, approximately 2,500 acres of tidal emergent wetlands have been destroyed, leaving less than 100 acres. Moreover, the restoration at Kenilworth Marsh constitutes about 32 of these remaining 100 acres.

To address this degradation and loss of valuable wetlands, the State of Maryland, the counties, and the District have signed various agreements committing each other to restoration goals. Several projects have been initiated to achieve these goals, and additional ones are planned. For instance, the District is working with the U.S. Army Corps of Engineers (US ACOE) and the National Park Service (NPS) to develop plans to restore 31 acres of wetlands in a fringe area downstream of New York Avenue where mudflats form along the bulkhead. The District also wants to explore allowing the continued deterioration of bulkheads, while allowing voluntary re-establishment of fringe emergent wetland plants. The District of Columbia proposed to fund this task for $300,000.

There are several other locations along the shoreline where mud flats have formed along the seawall in response to the sediment load from tributaries and the altered hydrodynamics of the river. With proper design of elevations, planting of wetland species, and possibly design of hydraulic control structures, many of these areas may be amenable to restoration of tidal wetlands. It is recommended that $500K be used to assess these areas and develop specific plans for wetland restoration projects as appropriate.

Factors that must be considered for any wetland restoration include ensuring a clean source of sediment that will not contribute to contamination; projects are suitable for their proposed sites and provide for adequate vegetation planting; wildlife habitat enhancement; long-term monitoring and contingency plans for maintenance; and, public participation in and education about wetland protection programs.

3.5 Sediment Remediation

3.5.1 Remediation Strategy Overview

Results from the preliminary risk screening, predictions based upon the Phase II comprehensive characterization of sediment contamination, observations from other Phase II work, the observations of other investigators working on the Anacostia, and the continued fish consumption advisory all indicate that there is unacceptable risk associated with the contamination of sediments within the Anacostia. To address these risks, the investigators developed proposals for potential sediment remedial actions. As its primary objectives, these actions would reduce risk to benthic organisms and fish from contaminants (primarily PAHs and PCBs) in sediment and to reduce risk to humans from contaminants in fish tissue.

The approach adopted incorporates all available information and integrates an understanding of the river system as developed through the updated Conceptual Site Model. It assumes the interception of significant loadings to the river as a prerequisite necessary to minimize the potential for recontamination, and also that ultimately the identification and control of point and nonpoint sources will be accomplished. Additionally, the requisite long-term monitoring needed to assess remedial and source control effectiveness as well as recovery has been included.

Natural attenuation of hot spot sediments by deposition of cleaner sediment on top of more contaminated sediment is not necessarily a stand-alone remedy. Natural recovery by deposition of clean solids is expected to occur for 90+% of the river sediments. However, this 10+ year recovery process will not abate unacceptable risks rapidly enough for certain hot spot areas of the river. Therefore these hot spot areas have been identified for potential active remediation in the shorter term. Once these hot spots have been actively addressed, they will continue to recover along with the remainder of the river as ongoing sources are controlled. Until source loadings are reduced, minor recontamination may occur in these remediated areas. At the very least, the surface sediment concentrations of hazardous substances will be consistent with the levels in the remainder of the river. Therefore, this management strategy focuses on active, integrated, remedial actions, such as capping, *in situ* treatment, dredging, and so on.

Given the economic, logistical, technological and ecological constraints involved with removal and either disposal or treatment technologies for sediment, there may be significant advantages to managing contaminants in place wherever possible. Treatment in place, capping, and capping with reactive barriers are all approaches that are considered for possible application. Any such technology being considered will undergo full pilot evaluation and feasibility study prior to its selection as a remedial action. The investigators have chosen those technologies that have been applied elsewhere or appear most promising, and evaluated their appropriateness and scale of application simply for cost-estimating purposes at this time. The following section details a pilot-scale evaluation program to evaluate reactive barrier capping in the Anacostia that has been funded by Congress. This sort of evaluation is exemplary of the investigation and feasibility study that would be applied before selection of any approach.

3.5.2 Pilot Evaluation of Innovative Capping Approaches

Subaqueous capping involves placement of a covering or cap of clean isolating material over a deposit of contaminated sediment to physically and chemically isolate it from the aquatic environment. Innovative *active* capping techniques, offering both containment *and* treatment, however, have not been attempted on any significant scale but can be an effective, low-cost means of managing the sediments that endanger health. The goal of such a cap is to ensure that any contaminants that may migrate through a cap will be sorbed, chemically bound, or degraded before release into the overlying water, while working within the confines of navigational issues. The operation of such a cap is similar in function to reactive barrier technologies that have proven successful in managing migration of groundwater contaminants.

A pilot evaluation program has been funded to provide site-specific preliminary design information on the application of innovative technologies to the Anacostia River where historic industrial, municipal, and military activities have resulted in potentially hazardous levels of PAHs, PCBs, metals, and other contaminants. The project will also demonstrate, on a field scale, the ability to design and construct caps that will provide treatment of sediment contaminants while simultaneously providing containment. The project will advance the implementation and acceptance of these under-utilized technologies by validating their efficacy at a well-characterized field site.

The project approach is to place and monitor several different types of sediment caps in small pilot cells. These caps will include designs to actively control seepage of contaminants into the river through permeability control, physically or chemically bind chemical contaminants or encourage degradation of chemical contaminants. The objective is to demonstrate the ability to place these caps and evaluate/demonstrate their effectiveness in achieving their design goals of chemical containment and/or treatment. The project will be conducted in two phases, each composed of several tasks. The first phase is to conduct laboratory treatability tests to ensure feasibility and expected effectiveness of selected cap technologies in the Anacostia River. Also, the first phase will involve finer-scale characterization of candidate placement locations, design of the caps, and preparation for field mobilization. Phase Two will start with construction of the pilot caps, evaluation of placement effectiveness, and then proceed to evaluation of the cap effectiveness.

3.5.3 Preliminary Identification of Areas Potentially Requiring Active Remediation

This section presents a preliminary identification of areas of the river that are recommended for potential active remediation based on locations showing the greatest risk to aquatic organisms due to elevated concentrations of PAHs and PCBs, and, on having river dynamics conducive to remedial actions. The selection of these areas draws upon factors that combine to define the area's suitability for potential active remedial strategies. A spatial evaluation of contaminant concentrations was performed using the GIS-based Anacostia Watershed Project. Figure 13 shows areas of elevated concentrations of PAHs and PCBs identified by current data. Further evaluation will be conducted to verify and characterize these locations. The sediment dynamics at these locations are also considered to determine what remedial actions might be appropriate and whether the site-specific sediment stability would lend itself to effective, long term remediation. For instance, areas where sediment dynamics of erosion or dynamic equilibrium were not considered amenable to standard remedial approaches. Placement of a standard cap in an erosional zone would not provide long-term protection. Due to the potential depth of contaminated sediments, dredging could involve removal of substantial volumes to reach acceptable concentrations. Alternatively, minimal dredge cuts, deep enough to be protective of benthic organisms, could be backfilled (capped) with clean material. Although this approach may be feasible in parts of the river, in an erosional zone this approach could not be expected to provide long-term protection because of potential erosion of the cap.

It should be emphasized that it is premature to make conclusions regarding the scope for any actual remedial actions before the risk assessments have been finalized, and before a more detailed evaluation of alternatives has been conducted. The investigators make their proposals based upon certain assumptions and the best available information to date, and do so to provide a basis for cost estimates.

The identification of areas contaminated to such a degree that they pose unacceptable risk was initially estimated by comparison of sediment chemistry to benchmarks for protection of ecological resources. For PCBs, the benchmarks applied were the freshwater Threshold Effect Levels and Probable Effect Levels (TELs/PELs; 34 and 277 ppb respectively) that are indicative of a low and high probability of risk to the benthic community, respectively. These values draw upon synoptic chemical analyses with observations not only from bioassays with several freshwater species, but also from observations of several benthic community metrics. Because of the broad basis for their derivation, these values are considered more robust than benchmarks derived from single measurement endpoints. For PCBs, guidelines for sediment have yet to be established for the protection of fish by bioaccumulation. Completion of the full risk assessment may indicate that lower sediment PCB concentration are required so that food web exposure routes to fish are reduced sufficiently such that tissue levels decrease below human health and ecological risk values. Values assessed by Doelling-Brown in her food web model were also evaluated geographically. She estimated bioaccumulation at the average PCB concentration of 286 pp and at half of that value.

For PAHs that are metabolized by higher-level organisms (fish for example), two benchmarks were used:

- A freshwater sediment TEL of 1.7 ppm, which is protective of the benthic community, and

- A sediment guideline of 2 ppm, which is a risk threshold for benthic fish.

These initial screenings indicate that PAHs in sediments exceed the benchmarks throughout the entire river. Also, PCBs throughout the entire river exceeded the TEL, suggesting the potential for toxicity. Because of the extent of the areas that exceeded benchmarks based upon toxicity, additional evaluations were conducted to help determine those areas potentially in need of active remediation. A preliminary spatial evaluation of contaminant data was conducted to identify those areas that indicated the greatest degree of contaminant enrichment.

This assessment, together with the sediment dynamics consideration, resulted in identifying six areas to target for consideration of active remediation (Figure 13).

- Area 1: near O Street/SEFC/WNY (PCBs, PAHs, and metals)
- Area 2: just upstream from CSX lift bridge (PCBs and PAHs)
- Area 3: between the 11th Street and CSX bridges (PAHs)
- Area 4: off Poplar Point (PAHs and some PCBs)
- Area 5: upstream from the PEPCO Benning Road facility (PCBs)
- Area 6: the area in between the "hot-spots" and within the depositional zone of the lower river extending roughly between the South Capitol and 12th Street Bridges.

Although it should be stressed that sediment contamination throughout the entire river exceeded toxicity benchmarks for both PAHs and PCBs, the influence of hot spots should not be overlooked. For instance, the distribution of PCBs as an example tends to reinforce the utility of dealing with "hot spots." Although the PCB average observed in discrete sediment samples is 0.286 ppm, only 13% of the river bottom is predicted to have values above this figure. And the area of the "hot spots" identified below is approximately only 5% of the river bottom. Preliminary evaluation of the data in the GIS-based Anacostia Watershed Project by NOAA (unpublished), reducing exposure levels within this 5% of the river would result in average sediment exposures across the entire river being cut nearly in half. Comparison of this value (0.286 ppm) to the median PCB concentration of suspended particulates of 0.171 ppm reported by Doelling-Brown (2001), or even the lower range measured in suspended sediment loads from the NE/NW Branches of 0.02 to 0.06 ppm would tend to infer that major recontamination issues are limited in scope to areas near localized sources.

3.5.4 Potential Remediation Approaches

The most common approaches for remediation of contaminated sediment typically applied at other contaminated sediment sites have been limited to:

- dredging to remove sediment (with several disposal variations);
- capping to isolate contaminants;
- natural attenuation with monitoring of natural recovery over time; or

- thin-layer amendment or augmentation with clean sediments to accelerate recovery, followed with monitoring.

The proposed approaches considered for the Anacostia River includes these standard approaches, but also leaves open the possibility of applying innovative methods for addressing contamination in place, some of which have only had limited testing on a full-scale basis.

AWTA has been coordinating with the Sediments Remediation Action Team, under the Remediation Technologies Development Forum (RTDF), and with others to identify appropriate innovative alternatives. These innovative in-situ methods can be more cost effective than standard techniques (dredging and disposal). Additionally, their use in the Anacostia River would provide opportunities for research and demonstration of promising new technologies and would eliminate the additional risks associated with re-mobilization of contaminated material.

An evaluation of the constraints and applicability of each of these emerging technologies identified was conducted. This was done partly to verify that they were amenable to the conditions and contaminants present, but also to form the basis of cost estimates should full feasibility studies support their application.

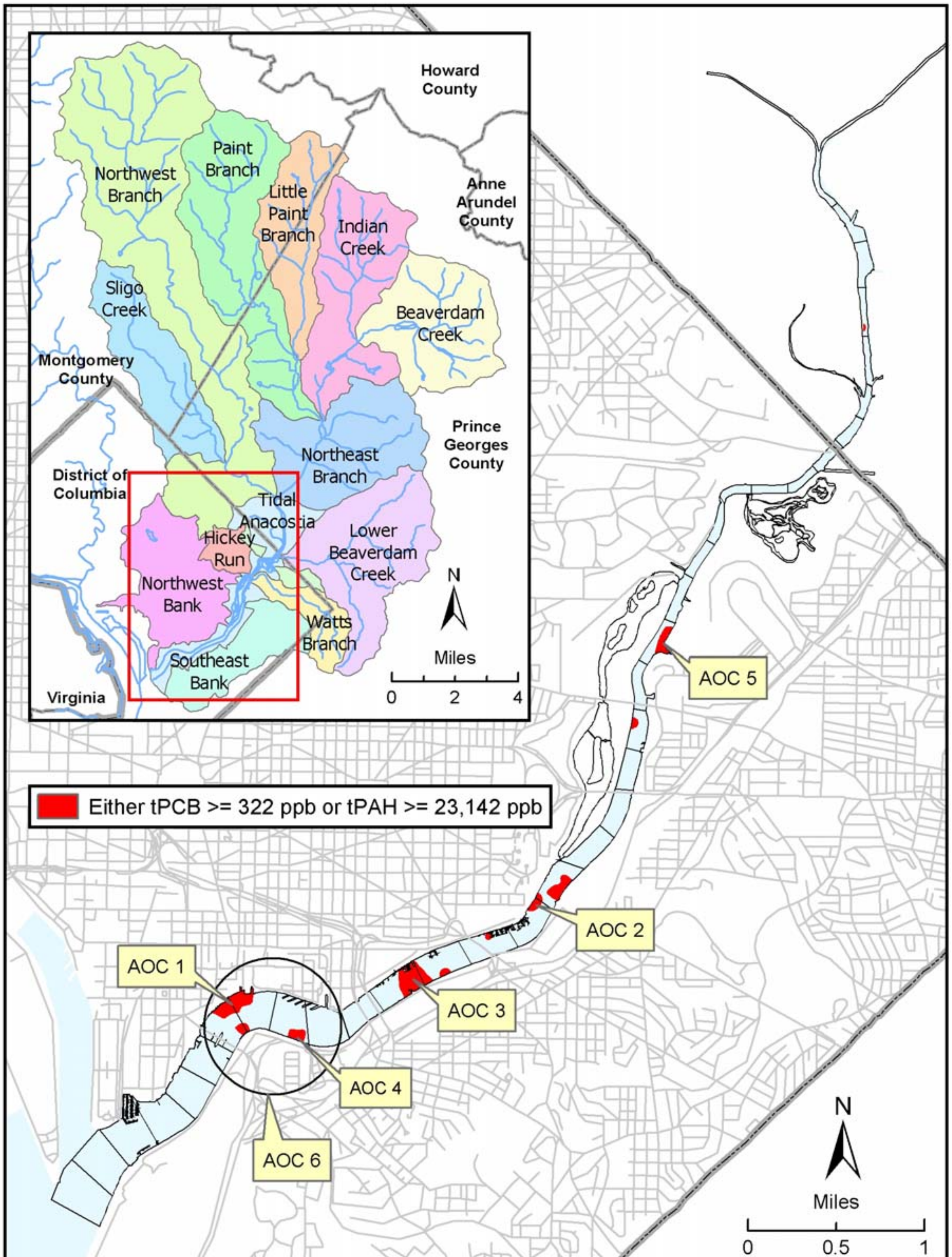

Figure 13 Areas identified for potential active remedial actions.

It must be stressed that this evaluation does not constitute presumptive remedies for these areas of concern. Full evaluation of each approach, which may entail pilot scale field trials, and alternatives would be conducted before any final approach is selected. Discussion of each Area and the proposed approach to be further evaluated follows.

3.5.4.1 Dredging

There are two areas that have been identified as potentially appropriate for dredging: Area 1 and Area 4. Area 1 is in the vicinity of O Street/SEFC/WNY, while Area 4 is off Poplar Point.

Area 1 covers about 15 acres near O Street/SEFC/WNY. A standard dredging will be considered to remove this hot spot of contamination. The degree of contamination, the range of contaminants observed (PCBs, PAHs, and metals), the temporal consistency of contamination at this locale, plus the prospects for source control are all factors for considering removal for this area.

Capping for isolation typically involves placement of a three foot cap. Addition of this depth of material may be problematic given the already shallow depths present in Area 1. Therefore, capping alone is not likely feasible. What is recommended is the removal of three feet of surficial material. Because this depth of removal is not expected to reach clean sediments, we propose that the dredge cuts be replaced or backfilled (capped essentially) with clean material. Since the depth of contaminated material at this location is unknown, this approach of removal and replacement is recommended as a more cost-effective alternative to complete removal by dredging down to baseline levels.

Costs for dredging only are estimated at \$15/ yd^3, based on recent dredging costs for the Kingman Lake wetland restoration project conducted in 2000. The Kingman Lake cost per cubic yard was based on mobilization/demobilization, new work/maintenance dredging, and water tube dike construction for movement of 186,000 yd^3 of material (O'Neill 2001, personal communication). This cost is comparable to a general estimate of \$15 to \$20/ yd^3 for removing and transporting contaminated sediments cited in a recent report summarizing contaminated sediment management and technology issues (Committee on Contaminated Marine Sediments 1997). These cost estimates encompass dredging and transport only; they do not include transport out of the area or disposal.

Within Area 1, the total volume of sediment, assuming a dredging depth of 3 feet, is approximately 73,000 yd^3, for a total dredging cost of \$1.5 million. Again, this figure does not include disposal costs. Because capping would involve acquiring clean material from outside the area and placing it, minimal costs for capping of the area of 73,000 yd^2 are expected to be approximately the same as for dredging, transporting and placement costs associated with Kingman Lake, or another \$1.5 million. If a no-cost source for clean fill could be found from outside the Anacostia (maintenance dredging along the Potomac, for instance), costs for capping would entail transporting (by barge most likely) and placement. Capping of an area this size is quite feasible. For instance, interim remedial actions at one Superfund site heavily contaminated with creosote involved a dispersal cap of 65 acres in water depths from 3 to 20 feet.

Disposal costs can be highly variable depending on site conditions and the degree of contamination. For cost estimating purposes, a figure of $300/yd^3 has been applied. This would result in total disposal costs of $21.9 million.

Area 4 lies in a depositional environment along the southern shoreline off Poplar Point and appears to stem from releases at the Stickfoot Sewer outfall. Planned restoration of Stickfoot Creek may address on-going contaminant flux from this apparent source. The area has elevated levels of primarily PAHs, but a smaller area of finer-grained material upstream from the outfall sandbar also contains PCBs. The surficial area covers 40,000 to 90,000 yd^2 of sediment, depending on definition of the "hot-spot."

Depth of contamination within this area is not well known. Additionally, the general Anacostia Waterfront Initiative effort has preliminary plans for renovation of the shoreline in this region that may entail construction of a boat ramp and other water-related facilities, and greater use of the waterfront. However, the area is currently quite shallow. To address risk concerns with this area as well as facilitate re-development, an aggressive combination of remedial approaches may be appropriate.

Dredging of three feet is identified as a potential remedial approach for the cost estimate for this area. Cost figures from Area 1 above are applied to the maximal coverage of this area at 90,000 yd^2. With combined estimates of $315 for dredging and disposal, total costs to dredge this area are estimated to be $28.4 million, although further characterization of the exact coverage of this area could reduce this figure.

Because sediments exposed after dredging may likely not be clean enough to pass risk screening, additional contingency measures are planned. This area may be appropriate for thin layer capping with innovative materials as an additional measure. The use of Aquablok™ is one such approach. AquaBlok is a patented, composite-aggregate technology resembling small stones and comprised of a dense aggregate core, clay or clay sized materials, and polymers. For typical product formulations, AquaBlok's clay component consists largely of bentonite clay. AquaBlok particles expand when hydrated, with the degree of expansion determined largely by the product formulation and salinity of the hydrating water. When a mass of discrete and relatively hard AquaBlok particles is hydrated, the mass transforms into a continuous and relatively soft body of material. Once developed, the hydrated AquaBlok material can act as an effective physical, hydraulic, and chemical environmental barrier. In addition to acting as an effective environmental barrier, AquaBlok can also provide adequate substrate for wetland vegetation as well as habitat for some macroinvertebrate organisms, particularly when additional organic materials (food) is provided as part of the product formulation. The AquaBlok technology can also act as a vector for delivery of wetland seeds as well as chemical reagents to facilitate in situ treatment of environmental contaminants.

There are several parameters that would influence how this technology might be applied for Area 4. The spatial coverage, depth of material, type of material, venting, proximity of railroad access, et cetera would affect overall costs. Applying some broad assumptions, costs for Area 4 have been estimated at $2 million.

3.5.4.2 Reactive Capping and/or in situ Treatment

There are three areas which may be amenable to innovative remedial approaches, either as reactive barrier caps or in situ treatment. Costs for various innovative techniques are often somewhat similar. Therefore, although specific ideas for each area have been explored in this strategy, the derived cost is considered generic enough for estimating purposes and allows for the flexibility to select an approach based on final feasibility studies for each area.

Area 3, located in a depositional environment in the vicinity of Washington Gas (WG) and Stewart Petroleum, contains elevated PAH concentrations in an area of approximately 44,400 yd^2. Measures to control offsite releases from the WG facility are being implemented. This area also stretches across the river to a large storm sewer outfall. The area is at the head of the depositional zone of the lower river. Sediment dynamics are a mix of total deposition and dynamic equilibrium.

An innovative technology called Limnofix may be considered on a preliminary basis for this area. Limnofix injects oxidants into the sediment to enhance bioremediation of PAHs. The Limnofix technology involves pumping calcium nitrate through an injection boom directly into the sediments (Senefelder 2001 personal communication). The Limnofix in situ treatment technology has been used in both pilot-scale and full-scale applications. Field demonstrations have been conducted at two Great Lakes areas of concern contaminated with PAHs - the Hamilton Harbor and St. Mary's River sites. A full-scale application has been conducted at a former manufactured gas plant site in Massachusetts with substantial reductions in PAH concentrations. Assuming a treatment depth of 1 meter, the total cost would be approximately $2.1 million with additional marginal costs for pilot scale testing.

Area 2, located just upstream from the CSX railroad lift bridge is an area with elevated concentrations of both PAHs and PCBs. This area is within a depositional sediment environment. The outfall from the NW Boundary swirl facility is one apparent source within this reach of the river and source control measures are being pursued for this facility (see Section 3.4.1).

Because contamination is a mix of organics, an innovative technology using electrochemistry might be considered for Area 2. The technology has been tested on a large scale in Europe, and has been field-tested in the United States. Further evaluation of this technology will be required. Area 2 would need to be adequately characterized to determine if this approach would apply to the sediment type at that location. The estimated volume of sediment to be treated at Area 2 is 15,000 yd^3.

Area 5 is the embayment in the vicinity of the northern, upstream boundary of the PEPCO Benning Road facility, where sediments contain PCBs. Sediments in the mainstream of the river at this location are in dynamic equilibrium, though the embayment of interest is more likely depositional.

One technology that may be amenable here is the *in situ* dechlorination of PCBs by the addition of reactive iron. Reports from bench-scale tests have demonstrated that colloidal sized palladium/iron mixtures yielded extremely fast kinetics for dechlorination reactions, with slightly slower reactions with iron alone (Wang and Zhang 1997). Yak et al. (1999) demonstrated dechlorination of PCBs using zero-valent iron in subcritical water. Research efforts are currently underway to investigate the efficacy of this approach for in situ treatment of PCBs (Gardner personal communication).

Pending successful completion of further bench testing and a possible pilot scale test, this technique may be appropriate for treatment of PCBs within Area 5. This approach would have the benefit of not mobilizing PCBs from this area downstream. Bio AquaBlok capping may also be a viable alternative for this area. Due to uncertainties, firm cost estimates cannot be generated for remedial actions for this area as yet. Using costs for other approaches as a guideline, $1 million is estimated for potential implementation of this technique.

3.5.4.3 Area 6

Area 6 is defined as all the contaminated sediments within the lower river, roughly from the South Capital Street Bridge and the 12th Street Bridge not already encompassed by one of the other areas of concern. Sediments within this area appear to be contaminated by a mix of localized as well as upstream sources, but to a more moderate degree than those within the adjacent hot spots. Levels still are significant enough to pose unacceptable ecological risks when compared against benchmarks. These sediments are also all within a zone of depositional sediment dynamics which increases the likelihood that an active remedial action would have long-term stability. The total area from bridge to bridge, including “hot-spots” is about 100 acres.

As upstream source reduction and habitat restoration occurs, it is anticipated that there will be a reduction in suspended particulate loadings to the Anacostia. Therefore, sediment deposition rates within this region of the river, currently estimated to be on the order of 1½ cm per year (less than one inch per year), will be even lower. This reduced rate must be contrasted with the depth to which benthic organisms may burrow, disturb and mix sediment, referred to as the bioturbation depth, to evaluate whether natural burial processes would be sufficient within the desired timeframe to achieve restoration goals. Since bioturbation depths of healthy benthic communities typically extend from 10 to 20 cm, this deposition rate is not great enough to make natural attenuation of contaminated sediments within this area a viable alternative within the desired 2010 restoration time frame.

Since this area is depositional, accelerated burial of contaminated sediments may be a viable approach to achieve remedial goals within a reasonable time frame. Broadcast distribution of a thin layer of clean sediment over contaminated sediments is an approach that has been applied at other sediment sites around the country as an alternative to dredging and removal. Providing cleaner substrate also can accelerate recovery of benthic communities.

This approach to dealing with such an area assumes that a source of clean material of appropriate grain size would be available from dredging projects in the Potomac River and could be barged to the Lower Anacostia for dispersal. Existing projects have shown that broadcast distribution can be easily and cheaply performed by simply washing sediments off barges with hydraulic force. This technique also results in a more uniform layer than other placement approaches.

This action would essentially be chosen as a final "polishing step," subsequent to many other load reduction actions, should those actions and the remediation of the local hot spots not provide sufficient reductions in exposures to meet restoration goals. Because of the complex interaction of local sources and those throughout the entire watershed, it is not possible at this time to determine the likelihood of requiring such an action to meet the 2010 restoration goal. For estimating purposes, an amount of $5 million dollars has been budgeted for this action.

4 Total Costs for Toxics Reduction and Sediment Remediation

Category / Activity		Cost (% millions)
Non-point Source Reduction		
	Storm water retrofit	
	Retention/Detention facilities	32.0
	Low Impact Development (LID)	30.0
	Water Quality Inlets	1.5
	Filtration Devices	2.1
	Building Code/Institutional changes	0.4
	Sub-total	65.5
	Non-storm water Retrofit	
	Stream Restoration	22.0
	Tidal wetland Creation	7.2
	Street sweepr Programs	6.6
	Trash Reduction Systems	15.0
	Pollution Prevention/Watershed Outreach	10.0
	Sub-total	61.6
Poiont Source Reduction		
	End-of-pipe Controls	10.0
Tidal River Sediment Remediation		
	Anacostia Remediation Sites	65.0
Monitoring, Tracking, Reporting and Coordination		
	Automated Water Quality Monitoring Network	3.9
	Fish Tissue Sampling	0.6
	Bioaccumulative Flux	0.2
	SPMDs	0.2
	Groundwater Sampling	1.1
	Watershed tracking, reporting, coordination	5.0
	Sub-total	11.0
GRAND TOTAL		$212.6

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