TOTAL MAXIMUM DAILY LOADS
UPPER ANACOSTIA RIVER
LOWER ANACOSTIA RIVER
DISTRICT OF COLUMBIA

TOTAL SUSPENDED SOLIDS

MARCH 1, 2002

Executive Summary

The Anacostia River is listed as two segments on the District of Columbia's 1998 Section 303(d) list of impaired waters, the upper and lower segments. The upper segment extends from the Maryland border to the John Philip Sousa Bridge at Pennsylvania Avenue, and the lower segment extends from the John Philip Sousa Bridge at Pennsylvania Avenue to the confluence with the Potomac. Both segments are listed as impaired due to high concentrations of biochemical oxygen demand (BOD), fecal coliform bacteria, organics, metals, and total suspended solids (TSS). This TMDL addresses water clarity problems and associated impacts to aquatic life in the Anacostia River caused by high TSS concentrations.

The Anacostia River is a major tributary of the Potomac River (which ultimately flows into the Chesapeake Bay, and is predominately located in the District of Columbia. It flows south through the District from the confluence of the Northwest and Northeast Branches in Maryland to its confluence with the Potomac River. Its watershed is located in Prince George's County (49 percent), Montgomery County (34 percent), and the District of Columbia (17 percent).

The TMDL endpoint (less than 15 mg/l TSS as a growing-season segment median) was based on EPA's interpretation of the District's water quality standards as informed by water clarity research developed for the Chesapeake Bay and its tributaries through an extensive review of pertinent literature, application of the Chesapeake Bay Water Quality Model and light attenuation algorithms, and field studies (EPA 2001). EPA identified the primary impairment of the Anacostia River as the aquatic life use. The TAM/WASP[1] Sediment Transport Model, developed by the Interstate Commission on the Potomac River Basin (ICPRB), was used to simulate TSS concentration in the water column.

The primary TSS loading sources to the Anacostia River include (1) upstream sources (Northeast and Northwest Branches), (2) Lower Beaverdam Creek, (3) Watts Branch, (4) minor tributaries and storm water runoff (including DC's MS4 and other permitted point sources), and (5) combined sewer overflows (CSOs). Based on the District of Columbia Department of Health (DC DOH) monitoring data collected from 1994 to 1998, the highest TSS concentrations occur in the central portion of the Anacostia River, which is characterized as a mixing transport zone by NOAA.

The 1989 growing season, which represent a relatively wet year (90th percentile rainfall), was selected as the critical period. In order to meet the TMDL endpoint and protect the aquatic life use, the fine, medium, and coarse sediment loads from all sources must be reduced by 77 percent from the current

[1] Tidal Anacostia Model/Water Quality Simulation Program.

estimated loading. These reductions achieve a median growing season TSS concentration of 14.7 mg/l in the upper Anacostia River and 11.9 mg/l in the lower Anacostia River.

Glossary of Terms

Advection: The process whereby solutes are transported by the bulk mass of flowing fluid (Freeze and Cherry, 1979). See also convective transport.

Advective Transport: Physical transport of water and associated concentrations from higher to lower hydraulic potential, exclusive of dispersion / mixing.

Dispersion: Pollutant or concentration mixing due to turbulent physical processes.

Dispersivity: A geometric property of a porous medium which determines the dispersion characteristics of the medium by relating the components of pore velocity to the dispersion coefficient.

Epiphytic: Substances that grow or accumulate on the leaves of submerged aquatic plants. This material can include algae, bacteria, detritus, and sediment.

Epiphytic Algae: Algae growing on the surface of submerged aquatic vascular plants.

Hydrodynamic dispersion: The spreading (at the macroscopic level) of the solute front during transport resulting from both mechanical dispersion and molecular diffusion (Bear, 1979).

Incident Light: Light falling onto a surface, not reflected from it.

Irradiance: The rate at which radiant energy arrives at a specific area of surface during a specific time interval.

Littoral Zone: The area in and adjacent to shallow, fresh water, where light penetration extends to the bottom sediments, giving a zone colonized by rooted plants. In marine ecosystems, the shore area or intertidal zone, where periodic exposure and submersion by tides is normal.

Mean: The measure of central tendency calculated by adding all the values and dividing the sum by the number of values (often referred to as the average.)

Median: The measure of central tendency that is in the middle value when all the values are arranged in order of size. If there is an even number of values, the median is the mean of the middle two values.

Mesohaline: Describes waters with salinity between 5 and 18 ppt. These areas are typically in the middle portion of an estuary.

Oligohaline: Describes waters with salinity between 0.5 and 5 ppt. These areas are typically in the upper portion of an estuary.

Polyhaline: Describes waters with salinity between 18 and 30 ppt. These areas are typically in the lower portion of an estuary, where the ocean and estuary meet.

Secchi Depth: The mean depth of the point where a weighted white disc 20 cm in diameter disappears from view.

Tidal Fresh: Describes waters with salinity between 0 and 0.5 parts per thousand (ppt). These areas are at the extreme reach of tidal influence.

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1. Introduction

1.1 TMDL Definition and Regulatory Information

Section 303(d)(1)(A) of the Federal Clean Water Act states:

> *Each state shall identify those waters within its boundaries for which the effluent limitations required by section 301(b)(1)(A) and section 301(b)(1)(B) are not stringent enough to implement any water quality standards applicable to such waters. The State shall establish a priority ranking for such waters taking into account the severity of the pollution and the uses to be made of such waters.*

Further, Section 303(d)(1)(C) states:

> *Each state shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculations. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between the effluent limitations and water quality.*

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies which are exceeding water quality standards.

In 1996, the District of Columbia submitted the Total Maximum Daily Load (TMDL) Priority List and Report to EPA, which contains a list of waters that do not or are not expected to meet water quality standards as required by Section 303(d)(1)(A). This list of impaired waters was revised in 1998 based on additional water quality monitoring data. EPA approved each respective list. The Section 303(d) list of impaired waters contains a priority list of those waters which are the most polluted. This priority listing is used to determine which waterbodies are in need of immediate attention. For each of the listed waters, states are required to develop a TMDL which represents the maximum amount of a pollutant that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water-quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (EPA 1991a).

1.2 Impairment Listing

The District of Columbia's Section 303(d) list divides the Anacostia River into two segments. The lower Anacostia is identified as that portion of the river extending from the mouth of the river to the John Philip Sousa Bridge at Pennsylvania Avenue and the upper Anacostia from the bridge to the Maryland border. Figure 1-1 presents the impaired segments.

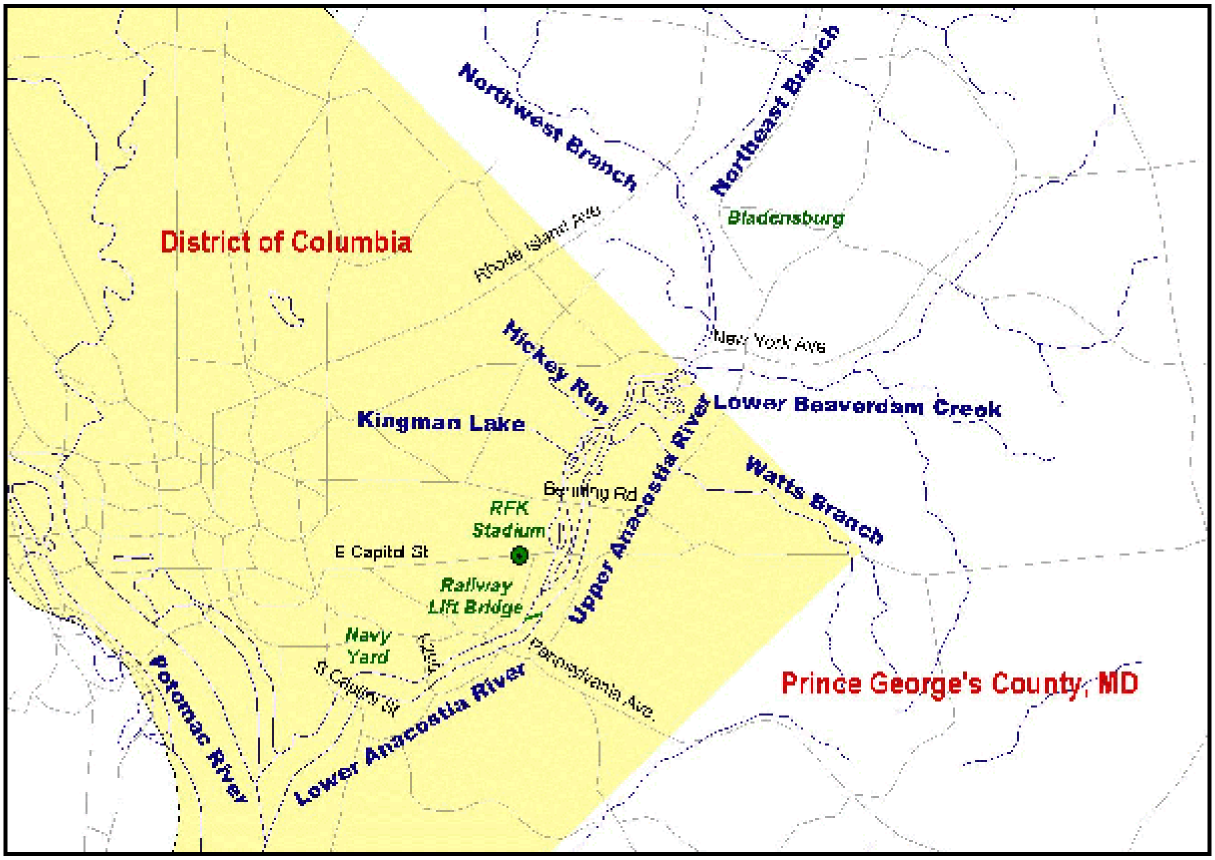

Figure 1-1 Impaired Segments

The upper and lower segments of the Anacostia River were listed as impaired on DC's 1998 Section 303(d) list as shown in Table 1-1. The DC Department of Health, Environmental Health Administration submitted a BOD TMDL report to EPA in May 2001 to address low dissolved oxygen conditions in the river (DC 2001). This TSS TMDL will address water clarity problems and associated impacts to aquatic life in the Anacostia River caused by high TSS concentrations.

Table 1-1 presents the 1996 and 1998 Section 303(d) listing information for the water quality-limited waters of the Anacostia River.

Table 1-1. Section 303(d) Listing Information

S. No.	Waterbody	Pollutants of Concern	Priority	Ranking	Action Needed
1996 Section 303(d) list					
1.	Lower Anacostia (below Pennsylvania Ave Bridge)	BOD, f. coliform and toxics in sediment and fish	High	1	Control CSO and NPS pollution
2.	Upper Anacostia (above Pennsylvania Ave Bridge)	BOD, f. coliform and toxics in sediment and fish	High	2	Control CSO and NPS pollution
1998 Section 303(d) list					
1.	Lower Anacostia (below Pennsylvania Ave Bridge)	BOD, bacteria, organics, metals, total suspended solids, and oil & grease	High	1	Control CSO, point and nonpoint source (NPS) pollution
2.	Upper Anacostia (above Pennsylvania Ave Bridge)	BOD, bacteria, organics, metals, total suspended solids, and oil & grease	High	2	Control CSO, point and nonpoint source (NPS) pollution

CSO - combined sewer outfall

1.3 Watershed Location

The Anacostia River is a major tributary to the Potomac River (which ultimately flows into the Chesapeake Bay) and the mainstem is predominantly located within the District of Columbia. It begins at the confluence of the Northeast Branch and the Northwest Branch in Maryland and flows south through the District. The watershed area is approximately 117,353 acres with 49 percent of the drainage area located in Prince George's County, 34 percent in Montgomery County, and 17 percent in the District of Columbia (Figure 1-2). The Hydrologic Unit Code (HUC) for the Anacostia River basin is 02070010.

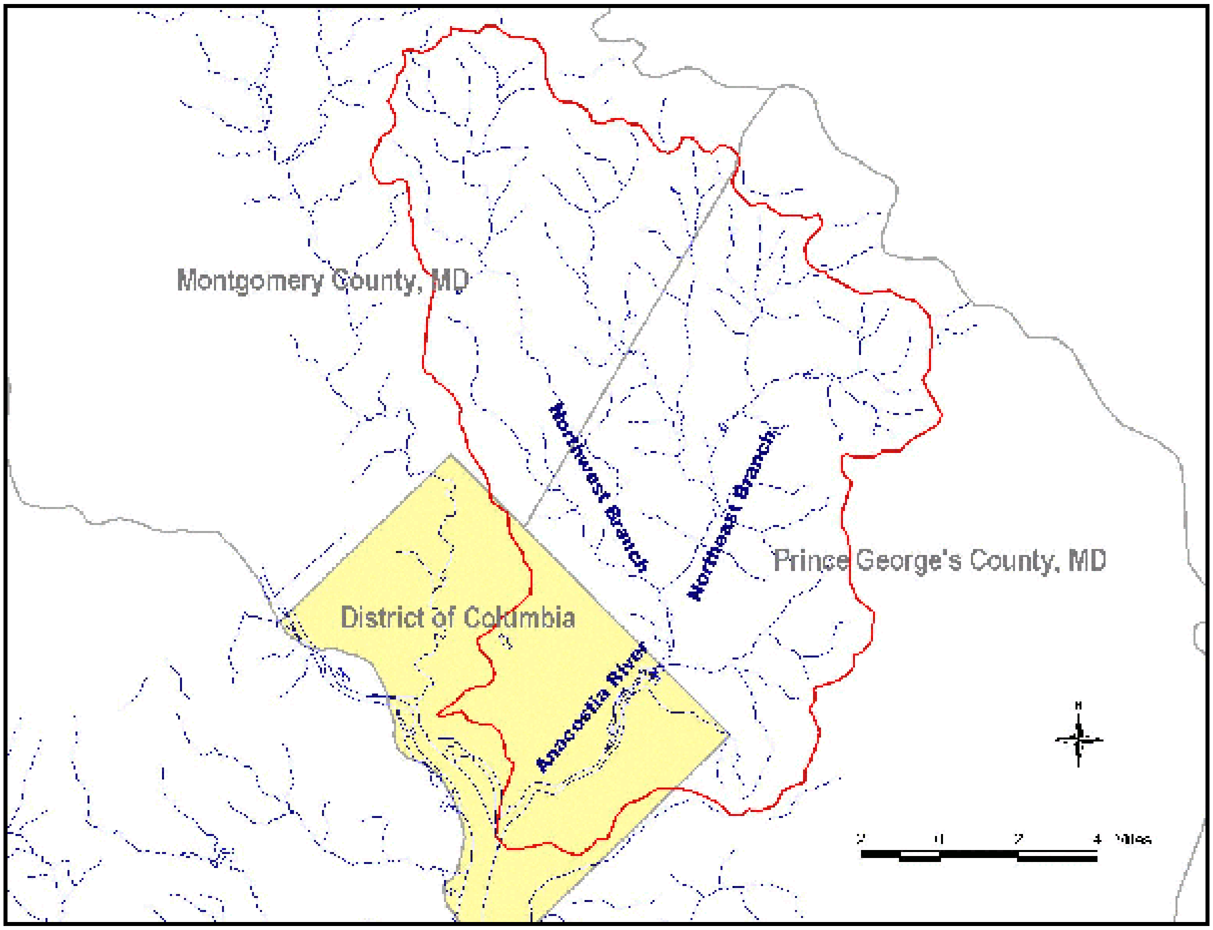

Figure 1-2 Watershed Location Map

2. Beneficial Uses and Applicable Water Quality Standards

2.1 Designated Beneficial Uses

Surface water beneficial uses and water quality standards are contained in Title 21 of the District of Columbia Municipal Regulations (DCMR), Chapter 11.

Section 1101.1 states:

> For the purposes of water quality standards, the surface waters of the District shall be classified on the basis of their (i) current uses, and (ii) future uses to which the waters will be restored. The categories of beneficial uses for the surface waters of the District shall be as follows:

Categories of Uses Which Determine Water Quality Standards	Classes of Water
Primary contact recreation	A
Secondary contact recreation and aesthetic enjoyment	B
Protection & propagation of fish, shellfish, and wildlife	C
Protection of human health related to consumption of fish & shellfish	D
Navigation	E

According to Section 1101.2, current uses of the Anacostia River include Classes B through E, designated uses include primary contact recreation (Class A). The Anacostia River does not currently support some designated uses due to violations of applicable water quality standards. In particular, the Anacostia River does not support the designated uses specified for Class C waters because of high TSS concentrations which have contributed to an overall reduction in water clarity that affects the growth of submerged aquatic vegetation (SAV) and negatively impacts other components of the biological community (Ryan, 2000, EPA, 2000).

Although the District's water quality standards do not include TSS as a pollutant, turbidity is included in the water quality standards. TSS is the main cause of turbidity in the District's waters and hence is listed as a pollutant in the District's 1998 Section 303(d) list for the Anacostia River.[2] This report, therefore, focuses on the TSS loading from point and nonpoint sources in the Anacostia River watershed.

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[2] Fact Sheet included in the District's September 29, 1998 letter to EPA submitting the draft 1998 draft Section 303(d) list of impaired waters.

2.2 Applicable Water Quality Standards

DC's Water Quality Standards include narrative and numeric criteria that were written to protect existing and designated uses. Water clarity and TSS concentrations in the Anacostia River were assessed using the following criteria.

Section 1104.1 states several narrative criteria designed to protect the existing and designated uses:

> *The surface waters of the District shall be free from substances attributable to point or nonpoint sources discharged in amounts that do any one of the following:*
>
> 1. *Settle to form objectionable deposits;*
> 2. *Float as debris, scum, oil, or other matter to form nuisances;*
> 3. *Produce objectionable odor, color, taste, or turbidity;*
> 4. *Cause injury to, are toxic to or produce adverse physiological or behavioral changes in humans, plants, or animals;*
> 5. *Produce undesirable or nuisance aquatic life or result in the dominance of nuisance species; or*
> 6. *Impair the biological community which naturally occurs in the waters or depends on the waters for their survival and propagation.*

Also, Section 1104.6 includes a turbidity maximum of 20 NTU over ambient concentration (before or upstream of source) intended for localized short-term water quality impacts[3]. TSS concentrations in the Anacostia River have been linked to high turbidity levels which adversely impact designated uses. DC's Water Quality Standards do not include numeric criteria for TSS. Turbidity levels in the Anacostia River are primarily caused by high TSS concentrations. These water quality conditions have resulted in the loss of SAV beds and other impairments to the biological community, thereby violating the narrative criteria and beneficial uses. Turbidity and TSS data collected at DC water quality monitoring stations on the Anacostia River from the New York Avenue Bridge to the confluence with the Potomac River are summarized in Section 5.

This TMDL is designed specifically to protect designated use C, protection and propagation of fish, shellfish, and wildlife, through the protection of SAV. While turbid water also interferes with recreational use and aesthetic enjoyment of water, EPA's guidance states:

[3] Letter dated February 1, 2002 from Jerusalem Bekele, Program Manager, Water Quality Division to EPA.

> Aesthetic qualities of water address the general principles laid down in common law. They embody the beauty and quality of water and their concepts may vary within the minds of individuals encountering the waterway. A rationale for these qualities cannot be developed with quantifying definitions; however, decisions concerning such quality factors can portray the best in the public interest. (Gold Book, 1986)

Likewise, EPA does not have turbidity or solids, suspended or settleable, standards specifically for the protection of recreational uses, although deceasing the TSS should make the water more desirable for swimming. This TMDL should also adequately protect the secondary contact use.

TMDLs are developed based on the best available data. The District should continue monitoring the water quality and evaluating whether uses A and B are adequately protected by this TMDL. If the District finds that additional reductions in TSS are necessary to protect uses A and B, the District should establish or revise these TMDLs accordingly.

3. TMDL Endpoint Determination

TMDL development requires the identification of the causes of impairment and the establishment of measurable endpoints that will allow for the attainment of designated uses and water quality criteria. Measurable endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Given that the District has no numerical criteria for TSS, the TMDL endpoint for the Anacostia River is based on EPA's interpretation of the District's narrative criteria to protect aquatic life uses. EPA used information on water clarity that has been developed for the Chesapeake Bay and its tributaries through an extensive review of pertinent literature, application of the Chesapeake Bay Water Quality Model and light attenuation algorithms, and field studies (EPA 2000). These requirements define the minimum light levels and water quality requirements that are necessary for SAV growth and survival in each salinity regime: tidal fresh, oligohaline, mesohaline, and polyhaline habitats.

The Anacostia River, a tidal, fresh water estuary, has historically supported the growth of SAV in the shallow littoral zone. These underwater grasses provide critical habitat for fishes and invertebrates and serve as food for waterfowl and other organisms. SAV also positively affects nutrient cycling, sediment stability, and water turbidity. The health and survival of these plant communities depend on suitable environmental conditions. Adequate water column light penetration during the growing season is a critical factor in the survival, growth, and repropagation of SAV communities. Incident light is primarily attenuated by TSS and phytoplankton (chlorophyll *a*) in most systems. Epiphytic algae and sediment particles that settle on plant leaves also limit the amount of light that reaches SAV. High nutrient and TSS concentrations increase the amount of epiphytic material which results in additional light attenuation beyond that reduced through the water column.

Percent light and water quality requirements for SAV growth and repropagation in tidal fresh waters, such as the Anacostia River, are listed in Table 3-1 (CBP 2001).

Table 3-1. SAV Light and Water Quality Requirements for Tidal Fresh Waters (CBP 2000)

SAV Growing Season	Primary Requirement Median Values	Secondary Requirements (Diagnostic Tools) Median Values				
	Minimum Light Requirement (PLL)	Water Column Light Requirement (PLW)[b]	Total Suspended Solids (mg/L)	Chlorophyll *a* (g/L)	Dissolved Inorganic Nitrogen (mg/L)	Dissolved Inorganic Phosphorus (mg/L)
April - October	>9%	>13%	<15	<15	<0.02	none

[a] PLL is defined as the percent light at the leaf

[b] PLW is defined as the percent light through water (does not account for epiphytic shading effects)

Model simulations and statistical analyses were used to develop an algorithm that explicitly relates nutrient concentrations and turbidity with epiphyte attenuation of light. Light requirements were expressed as the light attenuation coefficient (K_d), which was based primarily on observed K_d maxima or Secchi depth minima at sites with SAV. These light requirements were developed to promote the recovery of SAV in shallow waters. Accounting for the epiphytic contribution to light attenuation, minimum light requirements were calculated to be nine percent of surface irradiance (at a depth of one meter). These values represent the actual minimum light needed to support SAV growth at the leaf surface. These findings were confirmed by field studies which showed percent light at the leaf (PLL) levels at or greater than nine percent in areas with long-term SAV growth. PLL is based on K_d, and the water column concentration of TSS, dissolved inorganic phosphorus, dissolved inorganic nitrogen, and other factors.

To achieve the minimum light levels required for SAV growth, water quality requirements for TSS, chlorophyll *a*, dissolved inorganic phosphorus, and dissolved inorganic nitrogen were determined through an examination of long-term water quality data collected at various SAV sites (CBP 2000, Batiuk 1992). Maximum median concentrations of these parameters at monitoring stations near healthy or fluctuating SAV beds were used to set the water quality requirements. These requirements were originally developed and presented in Batiuk *et al.* (1992). Chesapeake Bay modeling studies and the revised light attenuation algorithm (updated to include epiphytic light attenuation) were used to predict PLL levels using these data.

The greater than nine percent PLL requirement is considered a primary requirement. A secondary requirement is the PLW, percent light that passes through the water column of greater than 13 percent. TSS is listed as a pollutant of concern on the District's 1998 Section 303(d) list for the Anacostia, therefore, a measurable endpoint for TSS is required. SAV water quality requirements include a maximum TSS concentration of less than 15 mg/l (median growing season concentration). Based on the above discussion, and in order to adequately protect aquatic life uses in the Anacostia River, EPA determines that this less than 15 mg/l TSS concentration is an appropriate numeric endpoint for the development of the TSS TMDL. Sediment load reductions from contributing sources to meet this endpoint are presented in Section 8. Once fully implemented, these load reductions coupled with the pollutant reductions specified in the Anacostia River Biochemical Oxygen Demand TMDL and other water quality improvements, will allow for the restoration of beneficial uses. As discussed above, EPA believe protection of the aquatic life use should also protect primary and secondary contact water uses.

As noted above, chlorophyll *a* and dissolved inorganic phosphorus may also contribute to TSS. These TMDLs address TSS, because TSS is considered to be the main cause of turbidity in the District's waters, the *Total Maximum Daily Loads, Anacostia River Watershed For Biochemical Oxygen Demand* (BOD TMDL) does limit nutrients to the Anacostia River. The BOD TMDL was submitted by the District's Department of Health to EPA, and approved December 14, 2001, as a phased TMDL. The Department of Health committed to re-evaluating the TMDL within one year because of the refinements made to the computer model between the time the Department of Health completed the TMDL and the time EPA approved it. The BOD TMDL requires a 90 percent reduction in CSO BOD loads; approximately 50 percent reduction in storm water biochemical oxygen demand; and an approximately 30 percent reduction in storm water total nitrogen and phosphorus loads. Reducing the nutrient loads as a result of the BOD TMDL implementation will also tend to reduce algae thus further promoting water clarity. Because the impairment of the Anacostia River for nutrients was previously addressed by the DC BOD TMDL and the Chesapeake By Agreement nutrient reductions of about 30 percent for nitrogen and phosphorous, it is unnecessary to address nutrients in this TSS TMDL.

4. Watershed Characterization

The Anacostia River drainage area covers 117,353 acres (approximately 176 square miles) in the District of Columbia and Maryland. Forty-nine percent of the drainage area is located in Prince George's County, with 34 percent located in Montgomery County, and the remaining 17 percent located in the District of Columbia. The basin lies within two physiographic provinces, the Atlantic Coastal Plain and the Piedmont. The division between the provinces lies roughly along the boundary between Prince George's County and Montgomery County. The basin is highly urbanized, with a population of 804,500 and a population density of 4,570 per square mile in 1990 (Warner *et al.*, 1997). Only 25 percent of the watershed is forested and another 3 percent is wetlands. The non-tidal portion of the Anacostia River is divided into two branches, the Northeast Branch and the Northwest Branch. Their confluence is at Bladensburg, MD. For all practical purposes the tidal portion of the Anacostia River can be considered to begin at their confluence, although the Northeast and Northwest Branches are tidally-influenced up to the location of the USGS gages on each branch: Station 01649500 at Riverdale Road on the Northeast Branch and Station 01651000 at Queens Chapel Road on the Northwest Branch.

The length of the tidal portion of the Anacostia River is 8.4 miles. The average tidal variation in water surface elevation is 2.9 feet all along the tidal river. At Bladensburg, the average depth is six feet, while the average depth at the Anacostia's confluence with the Potomac River is 20 feet. The average width of the river increases from 375 feet at Bladensburg to 1,300 feet at the mouth. Average discharge to the tidal river from the Northeast and Northwest Branches is 133 cubic feet per second (cfs). Under average flow conditions, the mean volume of the tidal river is approximately 415 million cubic feet. Detention time in the tidal Anacostia under average conditions is thus over 36 days and longer detention times can be expected under low-flow conditions in summer months.

Just over 25 percent of the Anacostia Watershed drains into the tidal river below the confluence of the Northwest and Northeast Branches. Much of this drainage is controlled by storm sewers or combined storm and sanitary sewers. The two largest tributaries are Lower Beaverdam Creek (15.7 sq. mi.drainage area), and the Watts Branch (3.8 sq. mi. drainage area). Table 4-1 shows the breakdown of land uses in the drainage areas of the Northwest Branch, the Northeast Branch, Lower Beaverdam Creek, and the Watts Branch.

Land use in the Anacostia River watershed is mostly residential and forested (Table 4-1). There are 30 percent park and forest lands evenly dispersed throughout the watershed, such as the National Park Service, the National Arboretum, Greenbelt Park, and Beltsville Agricultural Research Center. The industrial and manufacturing land use is largely confined to the tidal area of the basin such as Hickey Run, Lower Beaverdam Creek, and Indian Creek. These sub-watersheds contain impervious areas as high as 80 percent. (See Figure 4-1.) A more detailed description of the water body is available in *An*

Existing Source Assessment of Pollutants to the Anacostia Watershed (Metropolitan Council of Governments, 1996).

Table 4-1 Land Use in the Anacostia River Basin (acres)

Watershed	Residential	Commercial	Industrial	Parks	Forest	Agriculture	Other
NW Branch	14,044	1,437	117	2,155	6,592	2,428	1,908
NE Branch	16,086	2,333	1,391	1,393	14,445	4,978	5,897
Lower Beaverdam Creek	4,374	314	314	314	2,296	429	364
Watts Branch	1,691	116	23	190	289	0	96

(ICPRB, 2000)

CSOs drain over eight square miles of the Basin in the District of Columbia, and 17 CSO outfalls drain directly into the tidal Anacostia River. Appendix B contains Table 2-2 from the draft sediment transport model (Schultz, 2001) with locations of the CSOs.

The two largest CSOs are the Northeast Boundary CSO, which drains into the Anacostia near RFK Stadium, and the "O" Street Pump Station, just below the Navy Yard.

The management of CSOs is currently the responsibility of the District of Columbia Water and Sewer Authority (WASA), an independent agency of the District's government, which is responsible for the District's combined sanitary and storm sewers, sanitary sewers, and the Blue Plains Waste Water Treatment Plant. WASA submitted a Draft Long Term Control Plan (LTCP) for the District's CSOs to EPA for review and comment. As part of the LTCP, a computer simulation model of the District's combined sewer system was constructed. The model was used to simulate current conditions and alternative management plans, and, as part of WASA's assessment of alternative control plans, the TAM/WASP[4] model was used to assess the impact of CSOs on water quality in the Anacostia River.

[4] Tidal Anacostia Model/Water Quality Simulation Program.

5. TSS Data Analysis

DC DOH maintains a system of 29 water quality monitoring stations in the tidal portion of the Anacostia River, extending from New York Avenue Bridge to the confluence with the Potomac River shown in Figure 5-1. Water quality data are collected monthly and are available for stations ANA01 through ANA29 from January 1984 to December 1998 and for station ANA30 from April 1990 to December 1998. The TSS data are provided in Appendix A.

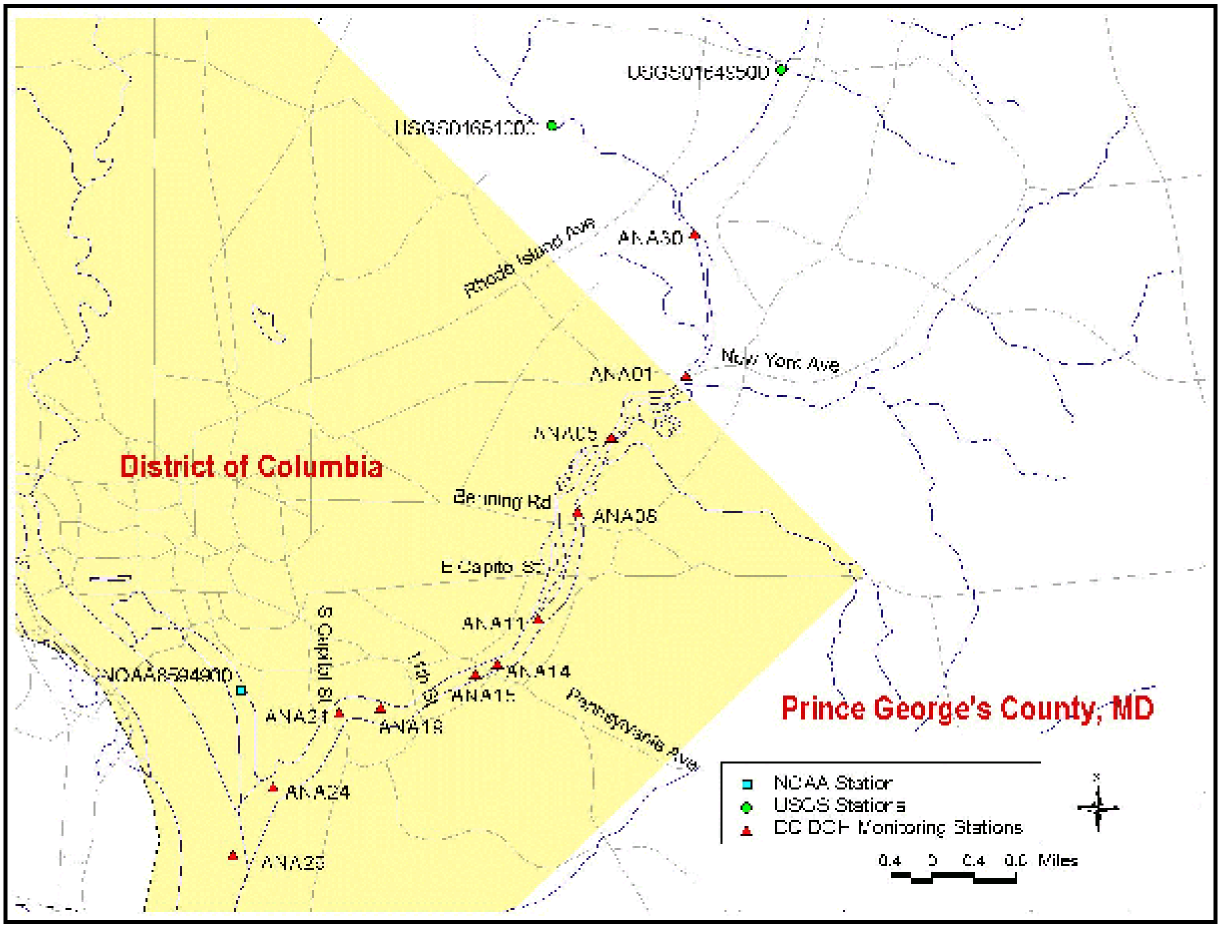

Figure 5-1 DC DOH, USGS, and NOAA Monitoring Stations on the Anacostia and its Tributaries

As part of the Anacostia Watershed Toxics Alliance's (ATWA[5]) initiative to identify and quantitatively assess risks to human health and the environment from toxic contaminants in the Anacostia River, NOAA has developed a compilation of existing information describing the hydrodynamics and river

[5] AWTA is a public-private partnership formed in March 1999 to address the problem of toxic sediments in the tidal Anacostia River.

bed characteristics of the Anacostia River. Preliminary results show a depositional zone of courser sediments exists from the confluence of the two branches to the vicinity of the Bladensburg Marina which is located just upstream of the Maryland/DC line. Finer sediments are transported further down stream and diverted to a depositional zone in Kingman Lake, located to the west of the river between monitoring stations ANA11 and ANA05, or through a depositional / transport zone between the Railway Lift Bridge and I-295 to a depositional zone below I-295. (NOAA 2001) The mean, median, minimum and maximum TSS concentrations at selected DC DOH monitoring stations are presented in Figure 5-2 and represent long-term trends.

The highest mean and median TSS concentrations are observed at stations ANA08 and ANA11, which are located in the central portion of the Anacostia River at the Benning Road power plant south stack and at Kingman Island south. The highest observed TSS concentration is located at station ANA14, which is located at the marina south dock adjacent to Pennsylvania Avenue. These stations represent the depostional / transport zone in the central portion of the Anacostia River.

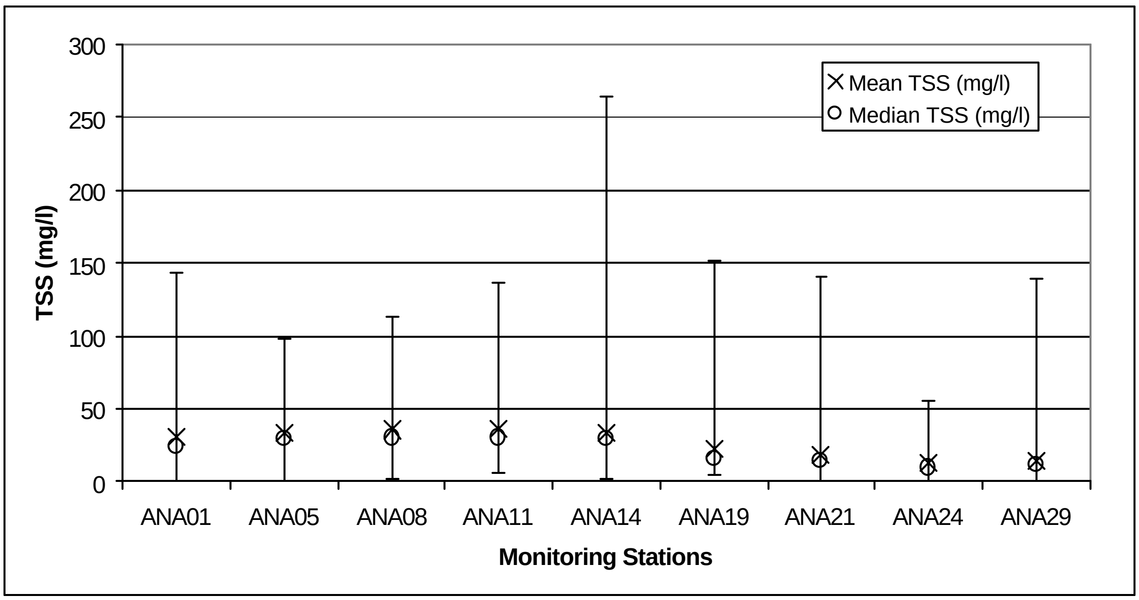

Figure 5-2. Minimum, Mean, Median, and Maximum TSS Concentrations at DC DOH Stations

Short-term trends in TSS concentration vary depending on the flow conditions in the Anacostia River. During non-storm events the TSS concentration parallels the long-term trend, with the highest TSS concentrations observed in the central reach. TSS concentrations observed on December 6, 1988, representative of non-storm conditions, are shown in Figure 5-3. In this situation, a peak TSS concentration of 21 mg/l occurs at monitoring station ANA14.

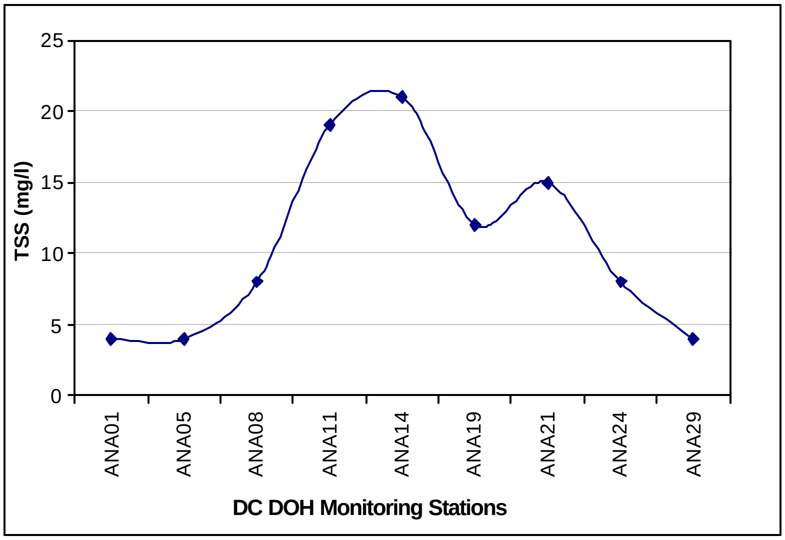

Figure 5-3 Non-Storm TSS Concentrations: 12/6/1988

During storm events, however, the flow is dominated by upstream inputs and the highest concentration of TSS is observed in the upper reach of the Anacostia. TSS concentrations observed on 11/14/88, representative of storm conditions, are shown in Figure 5-4. In this situation, a peak TSS concentration of 60 mg/l occurs at monitoring station ANA01.

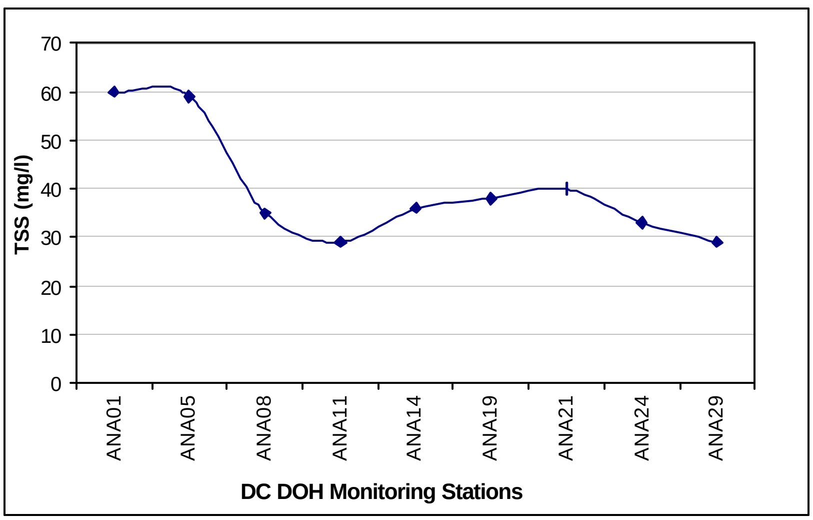

Figure 5-4 Storm TSS Concnetrations: 11/14/1988

6. Source Assessment

Point and nonpoint sources of sediment (TSS) were identified and assessed to support TMDL development. The assessment provided a basis for model development and calculation of TMDL allocation options. The primary sources of sediment into the system include: tributaries, storm drains, MS4[6] outfalls, other NPDES storm water outfalls, CSOs, direct surface runoff, in-stream sources, and facility discharges.

6.1 Assessment of Non-point Sources

6.1.1 Major Tributaries

The major tributaries discharging into the Anacostia River include: upstream sources (Northeast and Northwest Branches), Lower Beaverdam Creek, and Watts Branch. Fifty-three percent of the Watts Branch watershed lies within Maryland and 53 percent of Watts Branch storm water is assigned to Maryland. Land use in the watershed of each tributary is predominately residential with significant forested areas in the Northeast and Northwest Branches (Table 4.1). Residential lands consist of both pervious and impervious areas. Pervious areas which may have limited vegetative cover are susceptible to erosion and wash-off of sediment. Impervious areas, such as paved roads and parking lots, contribute quantities of sediment and solids to surface waters through the surface accumulation and eventual wash-off of soil particles, dust, debris, and other accumulated materials. An additional source of sediment within the major tributaries is in-stream erosion of the river bank or river bed, not only of the Anacostia River but also within the upstream watershed and the District's tributaries to the Anacostia.

6.1.2 Storm Water Runoff, Minor Tributaries, and CSOs

Storm water runoff, CSOs, and minor tributaries are fed by highly urbanized areas in and adjacent to the District of Columbia. There are approximately 30 storm sewers and 17 CSOs discharging directly to the Anacostia River. These sewers drain an area of approximately 14 km^2 (5.4 mi^2) (MWCOG 1997) or approximately three percent of the Anacostia River watershed. The storm sewers are a combination of outlets permitted under the MS4 or facility storm water permits, and outfalls not subject to permitting. Combined sewers discharge into the river even after moderate storm events, with precipitation as low as 0.27 inches producing overflow events (TAM/WASP model). There are no combined sewers discharging into the Northwest or Northeast Branches. With CSOs, minor tributaries, and storm water runoff draining predominately impervious areas significant contributions of soil particles, dust, debris, and other accumulated materials are transported to the Anacostia River.

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[6] Municipal Separate Storm Water Sewer System

6.2 Assessment of Point Sources

There are 30 municipal and industrial facilities in the Anacostia watershed holding NPDES permits (MWCOG 1997). The sediment load from permitted facility discharges has been estimated using the waste stream characterizations reported by the facilities. The combined loadings from all of the permitted facilities in the area are estimated to account for less than 0.1 percent of the annual totals TSS (MWCOG, 1997) and are not considered significant for this TMDL. Discharges from CSOs are covered by the District's Blue Plains NPDES permit, DC0021199, while the MS4 outfalls are covered by NPDES permit, DC0000221.

7. Technical Approach

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Anacostia watershed.

7.1 Model Framework Selection

Selection of the appropriate approach or modeling technique required consideration of the following:

- expression of water quality criteria,
- dominant sources, and
- key receiving water processes.

The TSS TMDL endpoint, described in Section 2, is expressed as TSS concentration in the water column designed to ensure the protection of aquatic life uses. This dictates that the methodology predict the TSS concentration in the water column of the receiving water. Compliance with the TSS endpoint is evaluated as a seasonal segment median in the upper and lower segments of the Anacostia River. The approach or modeling technique must permit representation of TSS concentration over an extended time period and under a variety of flow conditions.

The dominant sources contributing to TSS impairments in the Anacostia watershed include: (1) the upstream Northeast and Northwest Branches in Maryland , (2) storm water runoff , (3) large local tributaries, including Watts Branch and Lower Beaverdam, and (4) CSOs. Key in-stream factors that must be considered include tidal hydrodynamics and transport, deposition, resuspension, and grain size distribution of solids. Based on the considerations described above, the Interstate Commission on the Potomac River Basin (ICPRB, 2001) developed the TAM/WASP sediment transport modeling framework, which is capable of representing sediment transport in the Anacostia River and simulating key receiving water processes.

7.2 TAM/WASP Framework Overview

The TAM/WASP model was developed by the Interstate Commission on the Potomac River Basin (ICPRB) to support TMDL development and long-term water quality studies in the Anacostia. It has two distinct components:

- the Tidal Anacostia Model (TAM) hydrodynamic sub-model, and
- the EPA WASP TOXI5 model - modified by ICPRB to simulate sediment transport.

This modeling framework simulates the hydrodynamic processes, sediment load inputs, and chemical and physical processes necessary to estimate TSS concentration in the water column. Unless otherwise noted, the description of the TAM/WASP model framework is based on *TAM/WASP Sediment Model Preliminary Draft Report* (dated October 12, 2001 and provided by the ICPRB) and personal communication with ICPRB staff.

7.2.1 TAM Hydrodynamic Sub-Model

The TAM model was developed by the Metropolitan Washington Council of Governments (COG) in the late 1980s to evaluate the Combined Sewer Abatement Program and support long-term water quality studies in the Anacostia river. TAM is based on the Virginia Institute of Marine Science's Hydrodynamic Ecosystem Model (HEM). HEM consists of a one-dimensional hydrodynamic model linked to a water quality model and was originally developed to represent small tidal embayments. The HEM hydrodynamic sub-model was incorporated into the TAM/WASP framework to simulate hydrodynamic processes in the Anacostia.

The TAM hydrodynamic model predicts the water volume, water surface elevation, flow rate and cross-sectional area of specified stream segments based on a finite difference solution to continuity and momentum equations. The width of each transect is assumed to remain constant. Primary hydrodynamic inputs include (1) segment geometry, (2) tidal gage heights near the downstream boundary, (3) contributions from the two upstream tributaries (Northeast and Northwest Branches), and (4) contributions into each segment (including local stormwater flow, CSOs, Watts Branch, and Lower Beaverdam Creek.).

The Anacostia River is represented as a one-dimensional system extending from Bladensburg Road in Prince Georges County, Maryland, to the confluence of the Anacostia and Potomac Rivers in the District of Columbia. The segment geometry was modified from a 15-segment system to a 36-segment system by ICPRB to incorporate information from a 2000 dye study. The Maryland portion of the Anacostia River is represented by segments 1 to 6 and the DC portion of the Anacostia River is represented by segments 7 to 36. The upper Anacostia River is represented by segments 7 to 22. The lower Anacostia River is represented by segments 23 to 35. Kingman Lake is represented as segment 36 which joins the mainstem Anacostia at segment 19. A map of the revised 35-segment geometry is presented in Figure 7-1 and a schematic of the 36-segment geometry is presented in Figure 7-6.

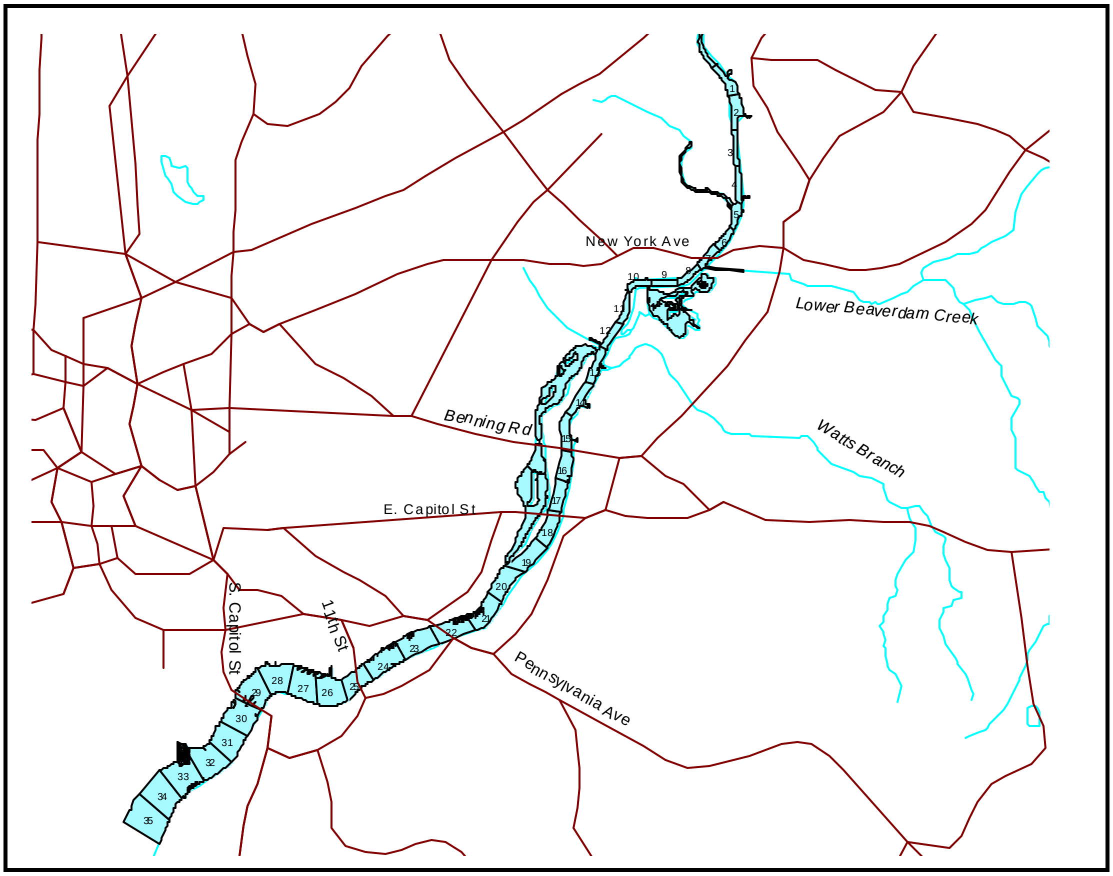

Figure 7-1 Model Segment Geometry for the Anacostia River

7.2.2 WASP TOXI5 Sediment Transport Model

The WASP TOXI5 model, modified by ICPRB, simulates advective and dispersive transport and deposition and erosion patterns in the tidal Anacostia River. It predicts sediment concentration in the water column. The sediment transport model uses output generated by the TAM hydrodynamic model described in Section 7.2.1.

Sediments are modeled as three grain-size fractions (Table 7-1). Sediment load values are based on available tributary, storm sewer, and CSO monitoring data for TSS concentration in the water column. The relative proportions of sediment size fractions were estimated from bed sediment grain size data collected by GeoSeas for the Anacosita Watershed Toxics Alliance (AWTA) and adjusted based on model calibration results.

Table 7-1 Sediment Grain Size Fractions Simulated

Size Fraction	Diameter (µm)	Relative Proportion of Bed Sediment	Description
Fine grained sediments	<30	0.54	Clays and fine silts
Medium grained sediments	30 < X < 120	0.24	Fine silts to very fine sands
Course grained sediments	X > 120	0.22	Fine sands to gravel

(ICPRB 2001)

Transport of fine and medium grained sediments are simulated as cohesive sediments as a function of bed shear stress. Erosion occurs when shear stress exceeds critical shear stress and is proportional to the extent it exceeds critical shear stress. Deposition occurs when shear stress is less than critical shear stress and is proportional to the extent it is less than critical shear stress. Bed shear stress is a function of the water velocity.

Transport of coarse grained sediments, sand and gravel, is simulated as a function of the carrying capacity of the flow, which is dependent on the hydrodynamic properties of the flow. The carrying capacity is modeled as a power function of the average segment flow velocity. If the carrying capacity of flow exceeds the concentration of coarse sediments in the water column, coarse sediments will be eroded from the bed. If the carrying capacity is exceeded by the concentration of coarse sediments in the water column, coarse sediments will be deposited on the bed.

Daily loads of TSS are represented as the product of the daily flow and the estimated mean TSS concentration for storm and non-storm events for each loading source. Daily flow values were separated into non-storm and storm components using the local minimum method in the USGS hydrograph separation program (HYSEP). Northeast and Northwest Branch event mean concentrations of TSS were based on provisional monitoring data from District of Columbia Water and Sewer Authority / Council of Governments Long Term Control Plan (WASA/COG LTCP). CSO event mean concentrations of TSS were derived from preliminary results of the WASA/COG LTCP. Watts Branch storm estimated mean concentration was based on results from estimation of nonpoint source loads to the Anacostia River in DC for the total maximum daily load process prepared by COG. Watts Branch non-storm estimated mean concentration of TSS was derived from DC DOH monitoring data from station TWB01. Lower Beaverdam Creek daily TSS loads were derived from Prince George's County's Lower Beaverdam Creek HSPF model.

The downstream boundary condition (at the confluence of the Anacostia and Potomac Rivers) represents the concentration of TSS carried by tidal flows from the Potomac River to the Anacostia River. TSS concentrations at the downstream boundary condition of 12 mg/l fine grained, 2 mg/l medium grained, and 0 mg/l coarse grained are based on suspended sediment size fraction composition and concentration data from monitoring station ANA29.

7.3 Model Calibration

The TAM hydrodynamic model was run with parameters determined in past calibration and validation efforts performed by Sullivan and Brown (1988) and LTI (1992a). The model was originally calibrated using observed data from 1985 and verified against observed data from 1984. The hydrodynamic sub-model was also calibrated against data from a 1970 EPA dye study of the Anacostia.

The WASP TOXI5 Sediment Transport Model was calibrated for the time period January 1,1988 to December 31, 1990. Model calibration was based on the B1 scenario, which does not include Phase I improvements specified in the WASA/COG LTCP,[7] and approximates conditions for the time period January 1, 1988 to December 31, 1990. The capacities of the Main and Potomac Pumping Stations were 200 mgd and 265 mgd, respectively.

This period was selected because it represents a relatively dry year (10th percentile rainfall, 1988), relatively wet year (90th percentile rainfall, 1989), and average year (38th percentile rainfall, 1990). Average annual flows for each of these years into the Anacostia River from the Northwest and Northeast Branches are presented in Table 7-2.

Table 7-2 Total Annual Precipitation and Average Annual Flows

Year	Total Precip (in)	Days of Precip	Average Northwest Branch Flow (cfs)	Average Northwest Branch Flow (cfs)	Average Lower Beaverdam Flow (cfs)	Average Watts Branch Flow (cfs)	Average B1 Scenario CSO Flow (cfs)
1988	31.7	107	72.4	43.9	19.6	4.0	6.1
1989	50.3	128	111.3	67.0	33.7	7.4	11.7
1990	40.8	127	93.2	60.4	25.2	5.4	9.6

[7] The District of Columbia Water and Sewer Authority submitted the *Draft Combined Sewer System Long Term Control Plan*, dated June 2001, for EPA review and comment. The Draft LTCP identifies the following scenarios; scenario B1, prior to Phase I controls represents conditions from January 1, 1988 through December 31, 1990; scenario C2 represents conditions after implementation of Phase I controls in 1991; and scenario C3 represents Phase I control with pump stations rehabilitation. Phase I controls provide in-system storage by the use of inflatable dams and the Northeast Boundary Swirl Facility.

The calibration was performed by adjusting critical model parameters and some model inputs to reach a reasonable match between observed and predicted results. In order to simulate the TSS concentration in the water column, the WASP TOXI5 Sediment Transport Model uses: (1) four primary parameters for medium and fine sediments, (2) two user-defined constants for coarse sediments, and (3) flow velocities simulated by the TAM Hydrodynamic sub-model. The final calibrated parameters and constants are shown in Table 7-3.

Table 7-3 WASP/TOXI5 Model Parameters and Constants

Model Parameter	**Coarse Sediments**	**Medium Sediments**	**Fine Sediments**
Critical bed shear stress for erosion (N/m^2)	N/A	0.20	0.10
Critical bed shear stress for deposition (N/m^2)	N/A	0.02	0.02
Zero-flow settling velocity (m/day)	N/A	20	2
Erosion velocity (m/day)	N/A	0.00004	0.00001
User-determined Constant 1	4.0	N/A	N/A
User-determined Constant 2	50.0	N/A	N/A

Note: N/A = not available (ICPRB, 2001)

Adjustments to the following model inputs were also made: (1) estimated mean storm concentrations for the Northeast and Northwest Branches, (2) size fraction concentrations of sediment loads and (3) downstream boundary conditions. An analysis of water quality and flow data of the Northeast and Northwest Branches was conducted and the estimated mean storm concentrations were adjusted to 404 mg/l and 294 mg/l respectively. The relative proportions of the size fractions in TSS was initially estimated from bed sediment data and adjusted during the model calibration runs. The downstream TSS concentration boundary condition was initially set based on monitoring data from the DC DOH monitoring data. The boundary condition was adjusted by ICPRB to improve model simulation results to bed sediment composition data. The final downstream boundary condition used is 0 mg/l, 2 mg/l and 20 mg/l for coarse, medium and fine sediments, respectively.

ICPRB's *Calibration of the TAM/WASP Sediment Transport Model - Draft Report,* October 2001 describes in detail the source of flow and concentration data used in calibration. The CSO load file representing pre-Phase I controls provided by WASA to ICPRB was used for model calibration.

Predicted TSS concentrations were compared to monitoring data from the DC DOH routine monitoring program. Time series calibration graphs of TSS concentration in the water column are presented in Figures 7-2 to 7-5 for model segments 7, 15, 22, and 29 and their respective monitoring stations (ANA01, ANA08, ANA15, and ANA21). Precipitation data from Reagan National Airport is presented in the figures. The predicted TSS concentrations follow base and peak flow TSS trends. The model results are often higher during storms, because the observation data, collected monthly, are generally representative of baseline values, not storm maximums.

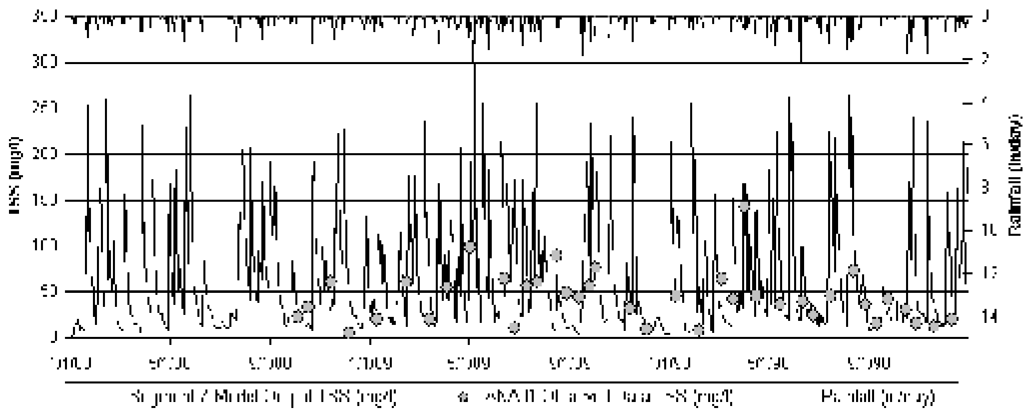

Figure 7-2 Calibration Results for Segments 7 ANA01 Observation Data

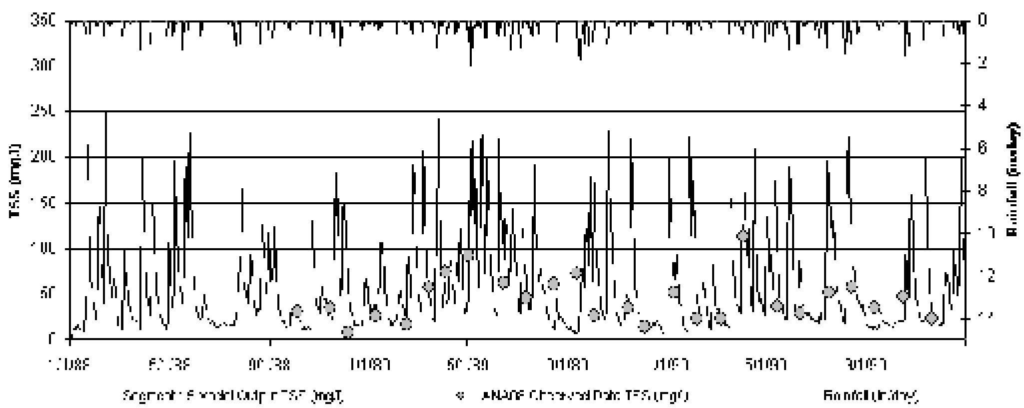

Figure 7-3 TSS Calibration Results for Segment 15 and ANA08 Observation Data

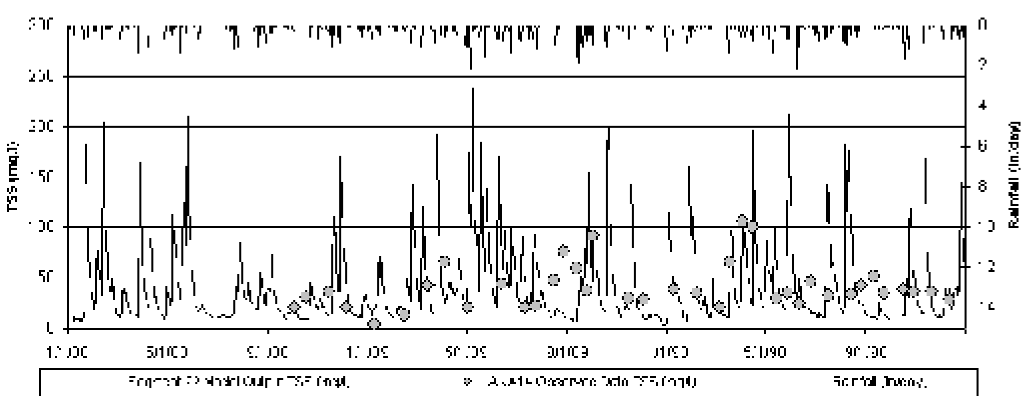

Figure 7-4 Calibration Results for Segment 22 and ANA15 Observation Data

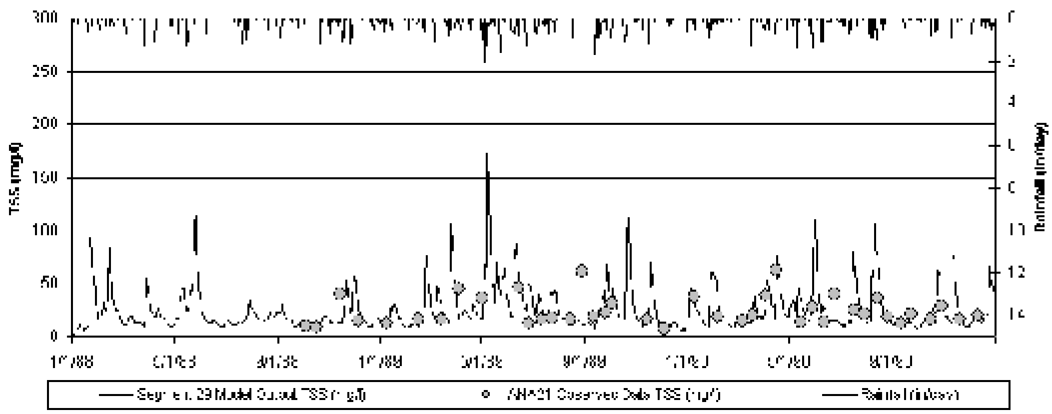

Figure 7-5 TSS Calibration for Segment 29 and ANA21 Observation Data

7.4 Model Runs

After fully calibrating the hydrodynamic and sediment models, a series of model runs were performed to arrive at the final TMDL. These runs included existing conditions and a series of hypothetical load reduction or allocation scenarios. Existing conditions and allocation conditions were based on the TAM/WASP C2 scenario[8], which includes phase I improvements specified in the WASA/COG LTCP, and approximates current conditions. The phase I improvements include the addition of inflatable dams for in-system storage and the Northeast Boundary Swirl Facility. Total precipitation and average flows during the growing season, April 1st to November 31st, are shown in Table 7-4. The critical conditions used for TMDL development were determined based on an assessment of the model results.

Table 7-4 Total Precipitation and Average Flows during the Growing Season

Year	Precip (in)	Days of Precip	Average Northwest Branch Flow (cfs)	Average Northwest Branch Flow (cfs)	Average Lower Beaverdam Flow (cfs)	Average Watts Branch Flow (cfs)	Average C2 Scenario CSO Flow (cfs)
1988	17.18	63	58.8	39.0	14.4	3.1	1.4
1989	36.26	72	129.0	77.6	39.6	9.0	5.1
1990	27.12	70	90.9	59.8	25.5	5.8	3.6

7.4.1 Critical Conditions

[8] The CSO load file was provided by WASA.

Adequate water column light penetration during the growing season is a critical factor in the survival, growth, and repropagation of SAV communities. The growing-season segment median TSS was calculated for each model run for 1988, 1989, and 1990. This period was selected because it represents a relatively dry year (1988), relatively wet year (1989), and average year (1990). In all cases the TSS concentration median was greatest during the 1989 simulations. Based on these considerations, EPA determined that the 1989 growing season, April through October, is the appropriate critical period.

Table 7-5 Median TSS

C2 Scenario Model Results	Upper Anacostia Segment Median TSS (mg/l)	Lower Anacostia Segment Median TSS (mg/l)	Anacostia in DC Median TSS (mg/l)
1988 to 1990 Growing Season	39.3	20.4	25.9
1988 Growing Season	33.8	18.7	21.4
1989 Growing Season	58.2	24.6	36.9
1990 Growing Season	28.8	19.1	22.2

7.4.2 Existing Conditions

The spatial representation of the Anacostia River, its upstream sources (Northeast and Northwest Branches), Watts Branch, Lower Beaverdam Creek, storm water flow and minor tributaries, and CSOs is shown in Figure 7-6. This figure represents the inputs as approximated by the model and may not correspond to the exact location of the inputs along the Anacostia River. The simulated current conditions TSS loads for 1989 are presented in Figure 7-7 and Table 7-4. Based on the model results, it is apparent that upstream sources (Northeast and Northwest Branches) are the dominant TSS loading source to the Anacostia River.

In running the model with reduced input loads, it was disclosed that running the model three times in succession, *i.e.*, the output from the first three-year run used as input for the second three-year run, etc., produced a greater reduction in TSS concentration for a given input load reduction than the one three-year model run produced. Therefore, this TMDL requires a smaller reduction in loads than the January 4, 2002, draft TMDL required while achieving the same endpoint.

Table 7-6 shows the existing growing season TSS loads to the Anacostia River by model segments. Appendix C, Table C-1, shows the existing TSS loads divided into the three size groups.

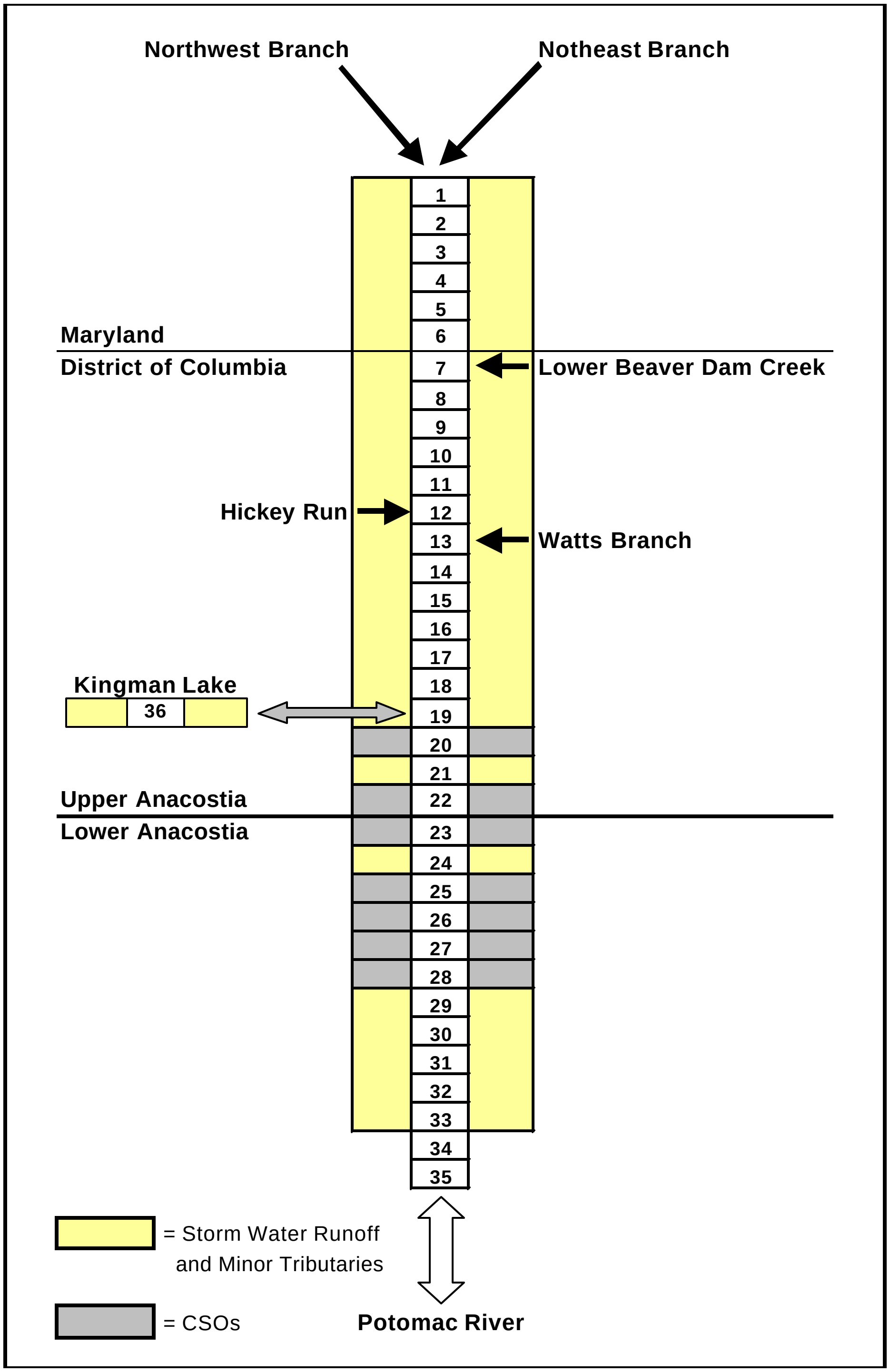

Figure 7-6 Model Loading Sources

Table 7-6 Simulated Existing (Scenario C2) Growing Season TSS Loads (lbs) to the Anacostia River for 1989

Segment	Stormwater & Minor Tributaries	Northeast & Northwest Branches	Lower Beaverdam Creek	Watts Branch	CSO	
1	16,401	25,382,100	-	-	-	Maryland
2	50,577	-	-	-	-	
3	16,025	-	-	-	-	
4	13,899	-	-	-	-	
5	85,472	-	-	-	-	
6	2,889	-	-	-	-	
7	2,016	-	709,313	-	-	Upper Anacostia River
8	1,663	-	-	-	-	
9	2,208	-	-	-	-	
10	155,393	-	-	-	-	
11	2,077	-	-	-	-	
12	129,466	-	-	-	-	
13	6,893	-	-	623,441	-	
14	14,878	-	-	-	-	
15	5,045	-	-	-	-	
16	62,662	-	-	-	-	
17	5,000	-	-	-	-	
18	97,024	-	-	-	-	
19	75,279	-	-	-	-	
20	55,622	-	-	-	499,989	
21	24,463	-	-	-	-	
22	27,637	-	-	-	4,239	
23	21,425	-	-	-	17,601	Lower Anacostia River
24	48,386	-	-	-	-	
25	5,508	-	-	-	39,940	
26	9,463	-	-	-	13,001	
27	75,530	-	-	-	30,844	
28	7,357	-	-	-	293,433	
29	14,978	-	-	-	-	
30	54,721	-	-	-	-	
31	10,472	-	-	-	-	
32	37,446	-	-	-	-	
33	12,724	-	-	-	-	
34	-	-	-	-	-	
35	-	-	-	-	-	
36	24,760	-	-	-	-	

Although Watts Branch discharges to the lower Anacostia River, 53 percent of its watershed lies within Maryland, therefore, 53 percent of Watts Branch storm water is attributed to Maryland sources.

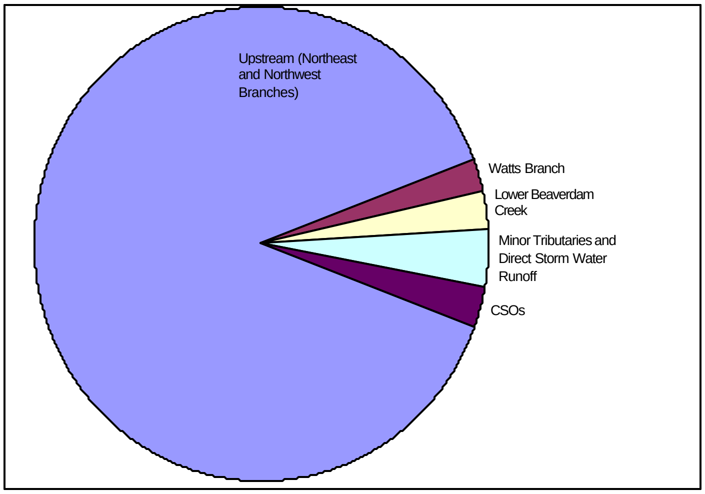

Figure 7-7 Existing Annual TSS Load Distribution for 1989

The minimum, maximum, and median TSS concentration for each model segment, based on the daily TSS concentrations simulated from April 1, 1989 to October 31, 1989, is presented in Figure 7-8. The median TSS concentration for the upper and lower segments, calculated from the daily values in each model segment within the upper and lower segments, are 58 mg/l and 25 mg/l, respectively. These plots show that the largest component of the total TSS load is the clay size fraction. Appendix C, Table C-2, shows the existing median TSS concentrations for the 1988, 1989, and 1990 growing seasons. Table C-3 is an example of the daily TSS concentration by segment.

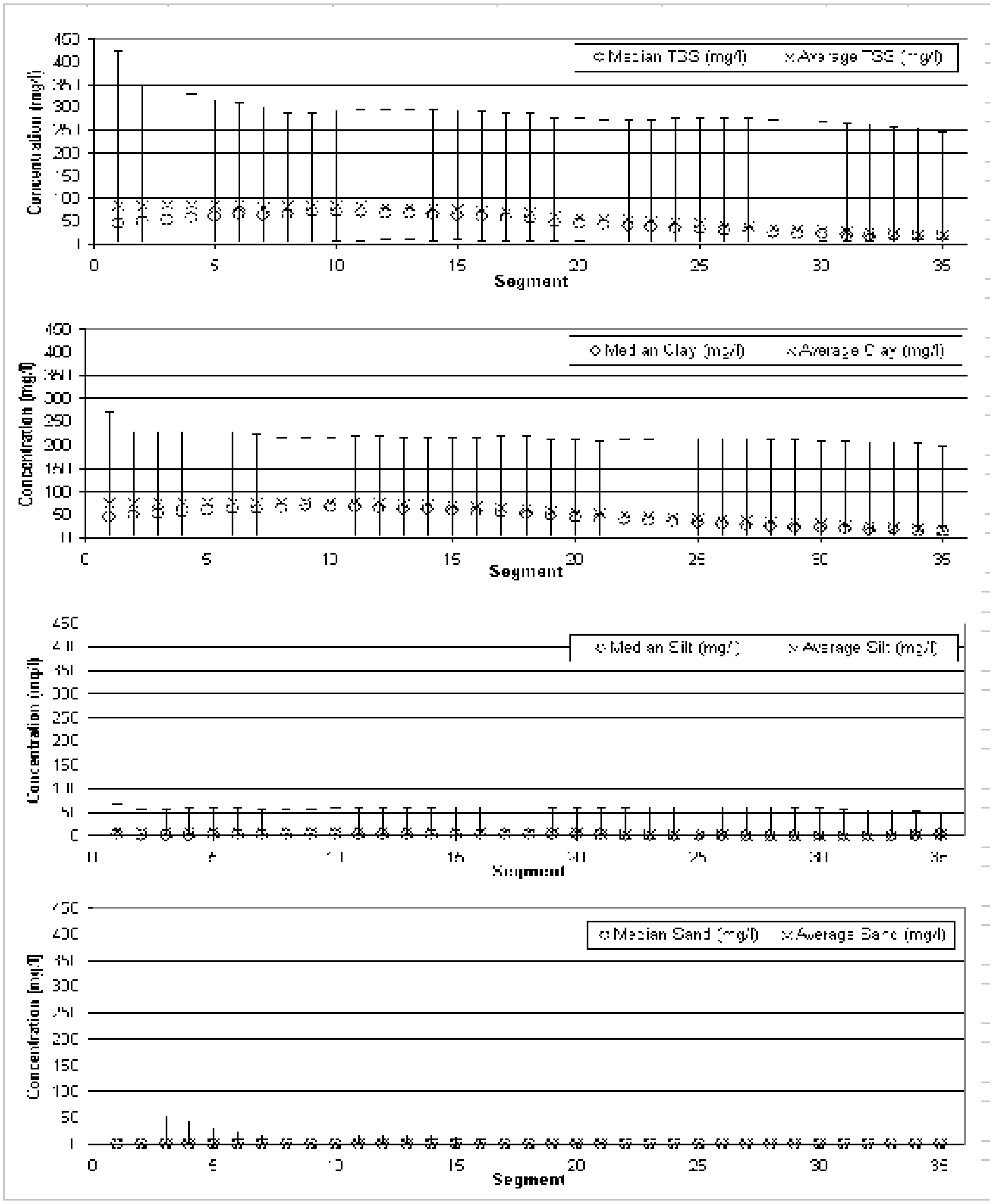

Figure 7-8 Existing Conditions Minimum, Maximum, Median, and Average TSS, Clay, Silt, and Sand Concentrations

8. Allocation Analysis

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$TMDL = \quad WLAs + \quad LAs + MOS$$

The CSOs are permitted point sources or WLAs. Storm water that is not subject to permitting is a nonpoint source or LA. However, much of the storm water runoff in the District is subject to permitting, either under the MS4 permit[9] or a facility storm water permit. Data from NPS and PS storm water were combined in the data collection and modeling phase of the TMDL. Based on the way data were collected and modeled, unpermitted outfalls cannot be separately identified. The LA Required storm water load reductions are the same whether or not the reduction is required by a permit, therefore, this TSS TMDL will be expressed as:

$$TMDL = \quad CSOs + \quad SW + MOS$$

The goal of each load reduction (allocation) scenario was to meet the TSS TMDL endpoint, identified as a median of 15 mg/l, in the upper Anacostia (model segments 6 to 22) and the lower Anacostia (model segments 23 to 35) during the critical period, identified as the growing season in 1989. The LA thus combines NPS and PS contributions (excluding the CSOs).

Equal load reductions were made at 10 percent increments starting from 50 percent for (1) upstream sources (the Northeast and Northwest Branches), (2) Watts Branch, (3) Lower Beaverdam Creek, and (4) minor tributaries and direct storm water runoff. CSO loads were reduced by the same percentage, consistent with DC DOH's decision. During TMDL allocation runs, the downstream boundary condition (at the confluence of the Anacostia and Potomac Rivers, was adjusted to 15 mg/l. This assumes that the Potomac River SAV requirements are the same as for the Anacostia River, and that the Potomac River will need to meet the same endpoint target as the Anacostia River.

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[9]Municipal Separate Storm Sewer System permit.

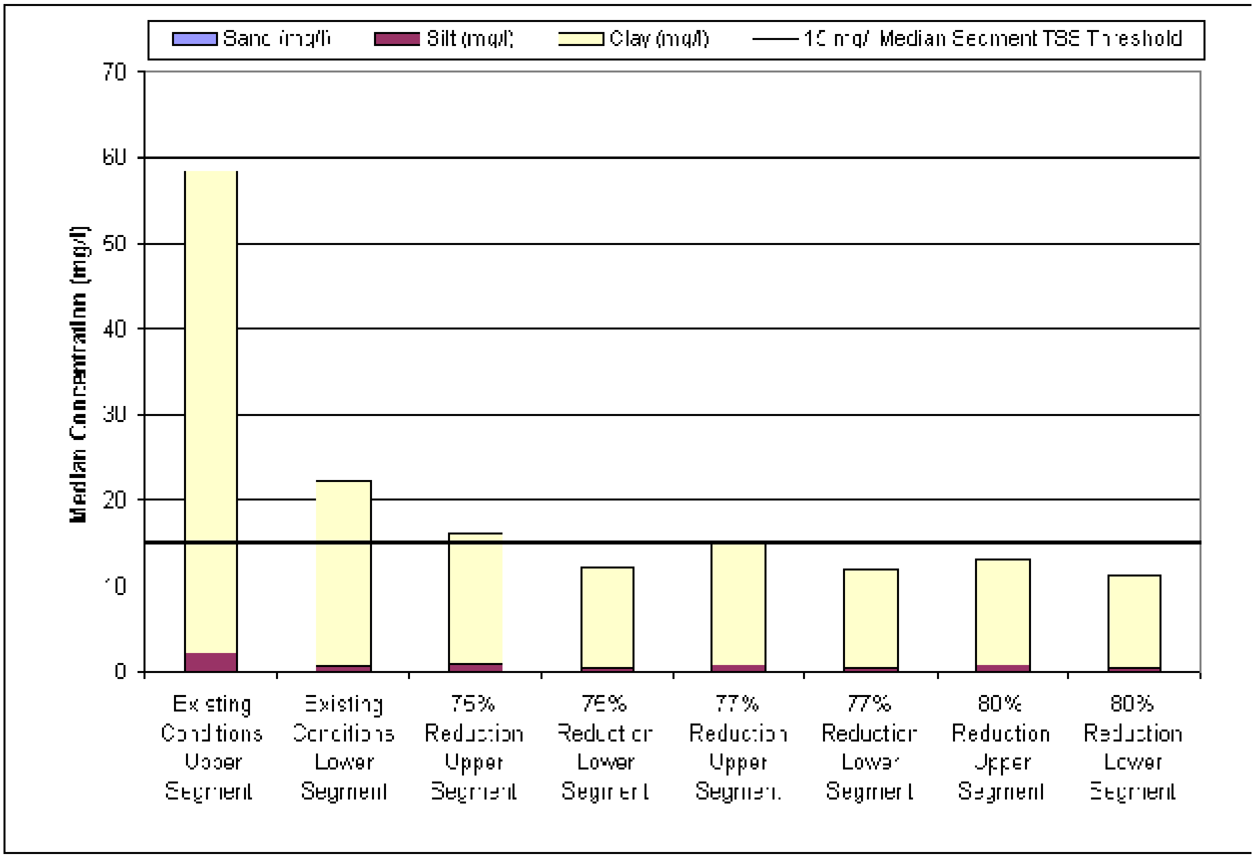

Figure 8-1 Load Reduction Model Results

The results of the preliminary runs are shown for the year 1989 in Figure 8-1. The results represent in-stream values, which should be compared to the seasonal segment median threshold of 15 mg/l. Model runs with load reductions of 80 percent and 90 percent resulted in median seasonal TSS concentrations below the 15 mg/l threshold in both the upper and lower Anacostia River segments. Additional runs were made and the 77 percent scenario was selected and the TMDL scenario.

8.1 Load Allocation

The allocations required to ultimately achieve existing water quality standards for TSS in the upper and lower Anacostia River are expressed as the growing season load for each of the loading sources: (1) upstream sources (Northeast and Northwest Branches), (2) Watts Branch, (3) Lower Beaverdam Branch, (4) storm water flow and minor tributaries (including MS4 and other NPDES outfalls), and (5) CSOs. Meeting the endpoint in the lower segment is dependent on endpoints being met in the upper segment. The allocated loads from each of the sources to the upper and lower Anacostia River are presented in Table 8-1. Appendix C, Table C-4, shows the allocated TSS load divided into the three size fractions, clay, silt, and sand.

Segment	Stormwater & Minor Tributaries	Northeast & Northwest Branches	Lower Beaverdam Creek	Watts Branch	CSO	
1	3,772	5,837,883	-	-	-	
2	11,633	-	-	-	-	Maryland
3	3,686	-	-	-	-	
4	3,197	-	-	-	-	
5	19,659	-	-	-	-	
6	664	-	-	-	-	
7	464	-	163,142	-	-	
8	383	-	-	-	-	
9	508	-	-	-	-	
10	35,740	-	-	-	-	Upper Anacostia River
11	478	-	-	-	-	
12	29,777	-	-	-	-	
13	1,585	-	-	143,391	-	
14	3,422	-	-	-	-	
15	1,160	-	-	-	-	
16	14,412	-	-	-	-	
17	1,150	-	-	-	-	
18	22,315	-	-	-	-	
19	17,314	-	-	-	-	
20	12,793	-	-	-	114,998	
21	5,627	-	-	-	-	
22	6,357	-	-	-	975	
23	4,928	-	-	-	4,048	
24	11,129	-	-	-	-	
25	1,267	-	-	-	9,186	
26	2,176	-	-	-	2,990	Lower Anacostia River
27	17,372	-	-	-	7,094	
28	1,692	-	-	-	67,490	
29	3,445	-	-	-	-	
30	12,586	-	-	-	-	
31	2,408	-	-	-	-	
32	8,612	-	-	-	-	
33	2,926	-	-	-	-	
34	-	-	-	-	-	
35	-	-	-	-	-	
36	5,695	-	-	-	-	

Table 8-1 Growing season allocation loads calculated based on 77% Reductions to all sources to the Anacostia River for 1989 (lbs)

The TMDLs for the Anacostia River are summarized in the following table:

Table 8-2 TMDL loads (tons) based on 1989 Loads

TMDL	Background	CSO	SW	MOS
Maryland				
3,059.8	--	--	--	Implicit
Upper Anacostia River				
3,231.1	3,059.8	58.0	113.3	Implicit
Lower Anacostia River				
3,310.8	3,231.1	45.4	34.3	Implicit

The median TSS, clay, silt, and sand concentration for each model segment, based on the daily TSS, clay, silt, and sand concentrations simulated from April 1, 1989 to October 31, 1989, is presented in Figure 8-2. The median TSS concentrations for the upper and lower segments, calculated from the daily values in each model segment within the upper and lower segments, are 14.7 mg/l and 11.9 mg/l. Again, these plots show that the largest component of the allocated total TSS load is the clay size fraction. Appendix C, Table C-5, shows the allocated median TSS concentrations for the 1988, 1989, and 1990 growing seasons. Table C-6 is an example of the daily TSS concentration by segment.

While Tables 8-1 and 8-2 present the allocated TSS as total weight based on a 77 percent reduction in loads, Figure 8-2 and the Appendix C tables disclose that the clay size fraction is responsible for turbidity. Therefore, load reductions to achieve and maintain the selected endpoint must include specified reduction in the clay size fraction.

The loads in Table 8-2 are presented as total loads for the critical year, 1989. The growing season, April 1 through October 31, is 213 days. The growing season loads may be divided by 213 to obtain a daily loads. However, as the loads are all precipitation driven, for permitting purposes, neither the daily loads nor the growing season loads are readily enforceable. A possible permitting approach is to recognize that loads are equal to volume (or flow) times the concentration and to limit source concentrations to the value used in the sediment transport model. ICPRB's *Calibration of the TAM/WASP Sediment Transport Model - Draft Report*, October 2001, identifies the TSS concentration used in the modeling by each source. If all source concentrations are reduced by 77 percent, it is presumed that the TMDL endpoint will be achieved.

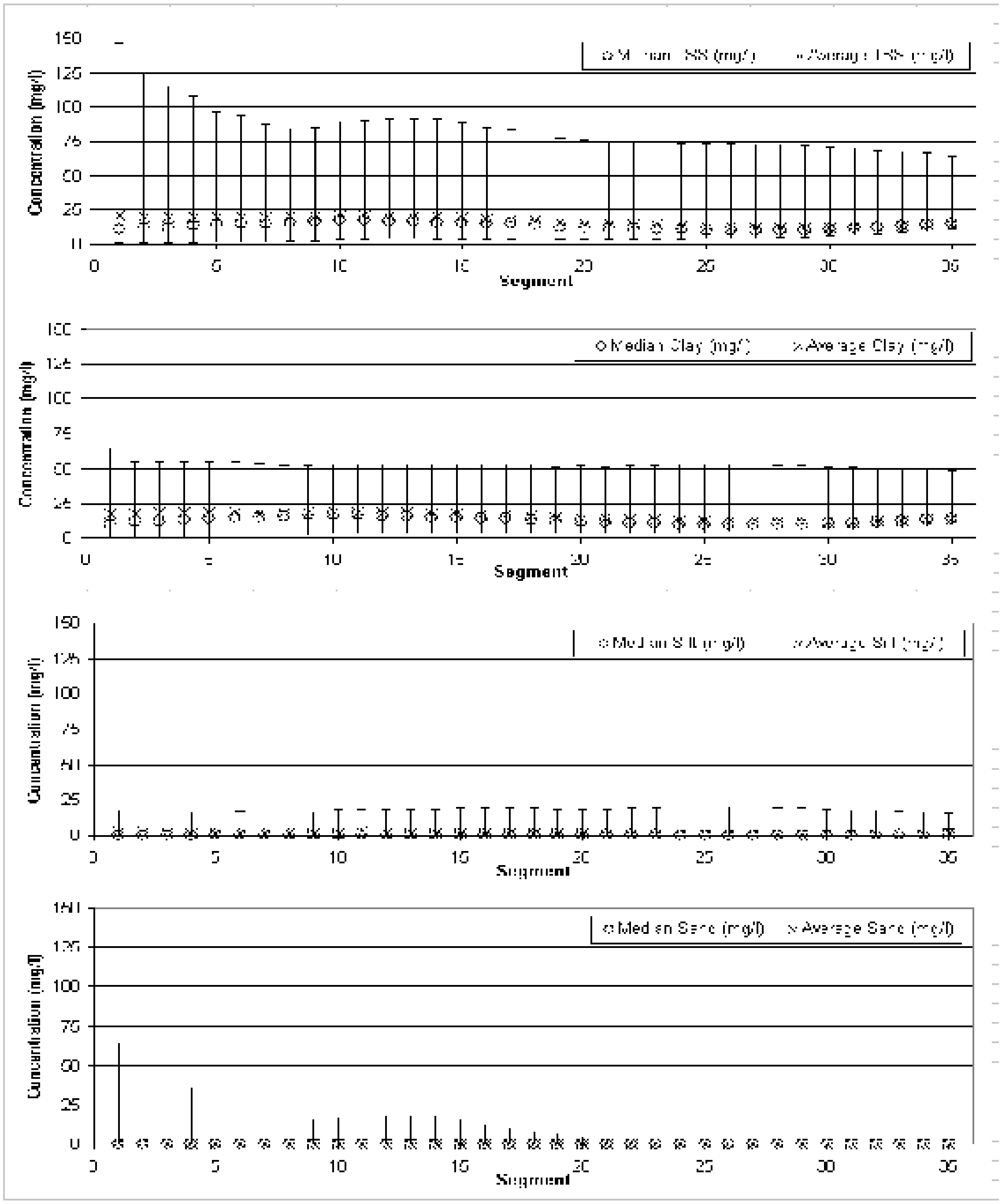

Figure 8-2 Allocation Scenario Minimum, Maximum, Median, and Average TSS, Clay, Silt, and Sand Concentrations

Table 8-4 Median TSS concentrations for TMDL loads

Simulation Period	Median TSS in Upper Segment (mg/l)	Median TSS in Lower Segment (mg/l)	Median TSS for Upper and Lower Segments (mg/l)
1988 Growing Season	10.26	10.05	10.13
1989 Growing Season	14.72	11.87	12.75
1990 Growing Season	8.67	10.68	9.57
1988 to 1990 Growing Season	10.96	10.87	10.90

8.3 Margin of Safety

An implicit MOS was included in TMDL development through application of a dynamic model for simulating daily loading over a wide range of hydrological and environmental conditions. In addition to this implicit MOS, an additional explicit MOS was incorporated into the load allocation based on the predicted median TSS concentration of 14.7 mg/l and TMDL endpoint of 15 mg/l. The proposed allocations allow for 0.3 mg/l or 2.0 percent explicit MOS in the River.

8.4 Seasonality

The TMDL allocation addresses seasonal considerations through a number of mechanisms. First, the TMDL endpoint was selected based on supporting designated uses during the growing season, or the critical part of the year for SAV. Second, the models were run for multiple years representing different hydrologic conditions. Model results for the entire modeling period were assessed, and the critical period was selected for determining the TMDL.

9. Reasonable Assurances and Monitoring

The District has several programs in place to control the effects of storm water runoff and promote nonpoint source pollution prevention and control. Because nonpoint source pollution problems are best addressed on a watershed-wide basis, the District also has joined with the State of Maryland, Prince George's and Montgomery Counties, the Army Corps of Engineers, and other federal agencies to form the Anacostia Watershed Restoration Committee, whose goal is to coordinate efforts to improve water quality in the Anacostia Watershed. The District is also a signatory to the Chesapeake Bay Agreement, pledging to reduce nutrient loads to the Bay by 40 percent or more by the year 2010.

The following information was supplied by the District.

On May 10, 1999, Mayor Williams signed a new Anacostia Watershed Restoration Agreement with Maryland, Prince George’s County, Montgomery County, and U.S. EPA to increase efforts to improve water quality. The Agreement has six major goals. The first one pertains to this TMDL:

Goal #1: dramatically reduce pollutant loads, such as sediment, toxics, CSOs, other nonpoint inputs and trash, delivered to the tidal river and its tributaries to meet water quality standards and goals.

On June 28, 2000, Mayor Williams, Governor Glendening, U.S. EPA and others signed the new Chesapeake Bay Agreement which states:

> By 2010, the District of Columbia, working with its watershed partners, will reduce pollution loads to the Anacostia River in order to eliminate public health concerns and achieve the living resources, water quality, and habitat goals of this and past agreements.

Thus, an agreement is in place which clearly demonstrates a commitment to the restoration of the river by the year 2010. This establishes a target date for implementation of those activities necessary to achieve the load reductions allocated in this TMDL.

Source Control Plan

Upstream Target Load Reductions for Maryland

Based upon the best available information, load reductions for TSS from Maryland sources were selected to achieve DC WQS for clarity at the District/Maryland line. Maryland has committed to a 40 percent nitrogen and phosphorus reduction in the Bay Agreement and has developed tributary strategies that will achieve that reduction in the Anacostia basin. The District estimates that the controls needed to achieve the nutrient reductions will concomitantly achieve at least an 80 percent reduction of the TSS loads. As a Chesapeake Bay signatory, Maryland should assign load reductions for sediment for each of its tributaries within the next year. Maryland will also adopt water clarity standards that are conducive to the growth and propagation of SAV in the tidal Anacostia River above the District. Mitigation measures for Woodrow Wilson Bridge will include the rehabilitation of wetlands in the Anacostia basin in Maryland, which will function as a removal mechanism for TSS. Both Prince Georges and Montgomery Counties have stormwater management programs.

CSO Load Reductions

WASA is currently engaged in the following CSO reduction programs:

1. Nine Minimum Controls Plan.
2. Development of the Long-Term Control Plan for CSOs which meets the requirements of this TMDL. The completion of the LTCP is contingent upon approval by U.S. EPA and DC DOH. The LTCP must also meet the requirement of the BOD TMDL.
3. East side interceptor cleaning to remove sedimentation and restore transmission capacity.
4. Pump station rehabilitation to increase transmission capacity to the treatment plant.
5. Inflatable dam rehabilitation to restore the dam’s ability to hold sewage inside the pipe, hence reduce overflows.
6. Swirl concentrator rehabilitation and performance enhancements to improve treatment.

Storm Water Load Reductions

The District’s Department of Health issued the Nonpoint Source Management Plan II in June 2000. The plan contains descriptions of the current programs and activities that are performed by District Government to reduce nonpoint source pollution.

In April 2000 the U.S. EPA issued MS4 NPDES Permit to the District to control the discharge of pollutants from separate storm sewer outfalls. In addition to implementing the current storm water management plan (SWMP), the MS4 permit requires the District to evaluate and revise its SWMP by April 2002. The plan should provide additional mechanisms for achieving the load reductions identified in this TMDL.

Major currently operating programs in DC which reduce loads are as follows:

1. Street sweeping programs by the Department of Public Works.Requirements for storm water treatment on all new development and earth disturbing activities such as road construction.
2. Regulatory programs restricting illegal discharges to storm sewers and enforcing the erosion control laws.
3. Kingman Lake –This project restored over 40 acres of freshwater tidal wetlands in the Kingman Lake area in order to increase plant and animal diversity. These wetlands will improve water quality by reducing the amount of sediment in the water by an estimated 1,600,000 pounds per growing season. This project was completed in 2000. Monitoring efforts are continuing in connection with other wetlands that have been restored in Kenilworth Park. Funding for this project was cost shared by the USACE, Maryland and USEPA.
4. River Fringe Wetlands -The goal of this project is to restore 15 acres of tidal wetlands along the shores of the Anacostia River above Kingman Island. As with the Kingman Lake wetlands, these wetlands will increase the number of beneficial plants and fish in the river and will reduce the amount of sediment in the water an estimated 369,000 pounds per growing season. The USACE has completed the design for this project. Construction is scheduled for Spring 2002. Funding for this project was cost shared with the USACE and USEPA.
5. Kenilworth Marsh Restoration- This project was constructed in a cooperative effort by the Department of Health, USACE and USNPS. The project involved the restoration of 33 acres of wetlands and it is estimated that they remove 2,720,000 pounds of sediment per growing season.
6. Kingman Island- The goal of this project is to restore the southern half of the island as a natural park recreational area. This project is being closely coordinated with Office of Planning and Department of Parks Recreation. The USACE has completed preliminary sampling for contaminants on both Heritage and Kingman Island and is currently completing a feasibility study of the islands. The USACE is also assisting the District in meeting the National Environmental Policy Act, a legal requirement when the land was transferred back to the District. The USACE Aquatic Restoration program is designing the habitat component of this project. Design and implementation is cost shared: 65 percent federal, 35 percent District. Habitat restoration efforts on Heritage Island are scheduled for implementation by the USACE in FY02. EHA also funded and facilitated the reconstruction of the pedestrian bridges by the US Navy (completed April 2001).
7. River Terrace & RFK BMPs- The goal of this project is to install storm water management facilities at the end of two storm water outfalls. The outfalls are located along the RFK Stadium parking lot and the River Terrace community. The purpose of these facilities will be to filter pollutants from the storm water before the water is discharged into the Anacostia River. Currently, the USACE is conducted a feasibility study to determine different design options. Cost sharing and funding is provided by the USACE and USEPA for these projects.

8. Fort Dupont-The goal of this project is to restore habitat in and the flow conditions of the Fort Dupont stream. The project is being conducted in phases. The initial phase was funded by the US Geological Service and reviewed by the National Park Service. This phase included a study of the physical, chemical, and biological conditions and a preliminary design for reducing storm water flows into Fort Dupont. A storm water management facility will be constructed to remove sediment, oil and grease, and other street runoff pollutants as well as stem storm water flows causing erosion in Fort Dupont creek. The second phase will restore in stream habitat and determine additional methods for managing storm water within Fort Dupont Park and will be cost shared with and implemented by the USACE.
9. Fort Chaplin-The goal of this project is to completely restore the Fort Chaplin tributary by stabilizing the stream banks and reducing amount of sediment entering the stream and the Anacostia. This project is also examining the possibility of reforming the stream to better accommodate storm water flows. This project will be implemented after the restoration of Fort Dupont. The USACE is currently conducting a feasibility study of the stream to determine design options.
10. Pope Branch-The goal of this project is to restore habitat and improve water quality in the lower Anacostia Park. Restoration efforts will include planting of native trees, restoring tidal and non-tidal wetlands, and opening a portion of Pope Branch that is currently piped under the Park. The US Army Corps of Engineers Aquatic Restoration program is currently designing this project. Design and implementation is cost shared: 65% federal, 35% District. As part of this project, the District has funded a study of Pope Branch to determine restoration options within the watershed.
11. Hickey Run- The objective of this project is to improve water quality and habitat conditions of Hickey Run. Improvements include installation of a stormwater management facility where Hickey Run enters the National Arboretum. This facility will filter pollutants such as oil and grease originating from industrial areas north of New York Avenue. Funding has been transferred to the Arboretum for this facility. This project will also rebuild channelized portions of the stream to a more natural flow pattern to better control sediments and protect fish and other wildlife. Partners on this project include US National Arboretum and USEPA, Chesapeake Bay Program.
12. Environmental education and citizen outreach programs to reduce pollution causing activities.
13. Stickfoot Creek- This small stream will be daylighted and wetlands will be rehabilitated to provide water quality and aquatic life improvements. The project is scheduled for completion in 2004.

Federal lands encompass approximately 18 percent of the land inside DC that contribute flow to storm water to the Anacostia River. Consequently, load reductions are assigned to the federal government to achieve. The Washington Navy Yard, GSA-Southeast Federal Center, and Anacostia Naval Air Station have or will have storm water permits issued by U.S. EPA and certified by DC DOH. Under these permits, the federal facilities are required to have storm water management plans to control storm water runoff. The remaining federal facilities such as the National Park Service and National Arboretum will need to develop storm water management plans to reduce their loads and implement those plans. Any DC NPDES permit reissued to discharge into the District's portion of the Anacostia River must be consitent with the WLAs set forth in this TMDL (expressed as percent reductions from "existing" loads).

The District of Columbia Water Pollution Control Act (DC Law 5-188) authorizes the establishment of the District's Water Quality Standards (21 DCMR, Chapter 10) and the control of sources of pollution such as storm water management (21 DCMR, Chapter 5). The storm water management regulations require the hydraulic control of the once in 15 years storm and the water quality treatment of the first one half inch of rainfall.

Boat Discharges

The Anacostia River has been allocated a Zero Discharge from watercraft in this document. The Chesapeake Bay 2000 Agreement, which was signed by the signatory states, the District of Columbia and US EPA, has a provision that by 2003 there will be no discharge of human waste from any boats. These wastes contribute TSS to the water column. The Department of Health has funded pump out stations at every marina in the Anacostia River.

Construction and Dredging

Activities authorized under section 404(e) such as dredging can generate TSS loads which affect clarity. These activities are normally restricted to periods when fish spawning activities are at a minimum. In addition, the criterion for turbidity of less than a 20 NTU increase above ambient applies to these types of activities. The Department of Health will consider the impact of these activities during the water quality certification process.

Monitoring

The Department of Health maintains an ambient monitoring network which includes the Anacostia River and tributaries. Data are collected on clarity, TSS and algae at least monthly.

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