D.C. DEPARTMENT OF HEALTH
Environmental Health Administration
Bureau of Environmental Quality
Water Quality Division

DISTRICT OF COLUMBIA

FINAL
TOTAL MAXIMUM DAILY LOAD

FOR

FECAL COLIFORM BACTERIA

IN

UPPER POTOMAC RIVER, MIDDLE POTOMAC RIVER, LOWER POTOMAC RIVER, Battery Kemble Creek, Foundry Branch, and Dalecarlia Tributary

JULY 2004

Government of the
District of Columbia
Anthony A. Williams, Mayor

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INTRODUCTION

Section 303(d)(1)(A) of the Federal Clean Water Act (CWA) 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 effluent limitations and water quality.

In 1996, the District of Columbia developed a list of waters that did not or were not expected to meet water quality standards required by section 303(d)(1)(A). The list, which is submitted biannually to the Environmental Protection Agency, is called the Section 303(d) List of Impaired Waters and was revised in 1998 and 2002. The Section 303(d) List identifies those waters that are deemed impaired as they are failing to attain their applicable water quality criteria and/or uses. For each of the listed waters, states are required to develop a Total Maximum Daily Load (TMDL) which calculates the maximum amount of a pollutant that can enter the water without violating water quality standards and allocates that load to all significant sources. Pollutants above the allocated loads must be eliminated.

This TMDL is for fecal coliform bacteria for the Potomac River and its tributaries. The District of Columbia's section 303(d) list divides the Potomac into three segments: Upper Potomac, Middle Potomac, and Lower Potomac. The demarcations are used to isolate the areas not attaining the applicable standards. The same water quality standards for fecal bacteria, however, apply to the entire length of the river.

In February of 1999, the District of Columbia initiated regular technical TMDL stakeholder meetings which included the Environmental Protection Agency, Region III (EPA), the DC Water and Sewer Authority (DCWASA), the Maryland Department of the Environment (MDE), representatives of the local governments, including the Prince George's and Montgomery Counties, Metropolitan Washington Council of Governments, the Interstate Commission on the Potomac River Basin (ICPRB), and citizen and environmental advocates. The group provided significant input and coordination to the DC TMDLs. In particular, the modeling elements used in the bacteria TMDL were developed in coordination with those utilized in the DC Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) (DCWASA, 2002). This is in keeping with the 1994 EPA national Combined Sewer Overflow (CSO) policy that required municipalities and authorities to develop and submit a Long Term Control Plan (LTCP) to reduce combined sewer overflows such that water quality standards could be met.

APPLICABLE D.C.WATER QUALITY STANDARDS

The Potomac River and the tributaries are listed on DC's 303(d) lists because of excessive counts of fecal coliform bacteria. The District of Columbia Water Quality Standards (WQS), Title 21 of the District of Columbia Municipal Regulations (DCMR) Chapter 11 (Effective, January 24, 2003) specifies the categories of beneficial uses as:

1. Class A- primary contact recreation,
2. Class B- secondary contact recreation and aesthetic enjoyment,
3. Class C- protection and propagation of fish, shellfish, and wildlife,
4. Class D- protection of human health related to consumption of fish and shellfish, and;
5. Class E- navigation.

The waters are classified on the basis of current use and designated beneficial uses as follows:

Waterbody	Current Use	Designated Use
Potomac River	B,C,D,E	A,B,C,D,E
Battery Kemble Creek	B,C,D	A,B,C,D
Foundry Branch	B,C,D	A,B,C,D
Dalecarlia Tributary	B,C,D	A,B,C,D

Class A and Class B waters must achieve or exceed water quality standard for bacteria as measured by fecal coliform as an indicator organism. While most fecal coliforms, which are microbes that live in the intestinal tracts of warm-blooded animals, are not harmful themselves, their presence indicates the potential for pathogens in the water. Water quality standards are derived from EPA recommendations based on risk levels associated with swimming.

The standard for Class A waters is a maximum 30-day geometric mean of 200 MPN/100 ml, where MPN is a statistically-derived estimate of the "Most Probable Number" of bacteria colonies in a 100 ml sample. This statistical estimate is often called a "count" although it is represented as a concentration. The geometric mean is based on no fewer than five samples within the 30-day period. The standard for Class B waters is a 30-day geometric mean of 1000 MPN/100 ml. However since all the water bodies are designated as Class A waters, which have a more restrictive bacteria standard, the 200 MPN/100ml for Class A designation is used as the not-to-exceed criterion for all the waterbodies in this TMDL.

The following sections of the District of Columbia Water Quality Standards are relevant for this TMDL:

1104.3 Class A waters shall be free of discharges of untreated sewage, litter and unmarked, submerged or partially submerged, man-made structures which would constitute a hazard to the users. Dry weather discharges of untreated sewage are prohibited.

1104.4 The aesthetic qualities of Class B waters shall be maintained. Construction, placement or mooring of facilities not primarily and directly water oriented is prohibited in, on, or over Class B waters unless:

(a) The facility is for the general public benefit and service, and

(b) Land based alternatives are not available.

1105.7 Mixing zones may be allowed for point source discharges of pollutants on a case-by-case basis, where it is demonstrated that allowing a small area impact will not adversely affect the waterbody as a whole. The following conditions shall apply:

(e) The positioning of mixing zones shall be done in a manner that provides the greatest protection to aquatic life and for the designated uses of the water;

(f) Within the estuary, the maximum cross-sectional area occupied by a mixing zone shall not exceed ten percent (10%) of the numerical value of the cross-sectional area of the waterway, and the width of the mixing zone shall not occupy more than one third (1/3) of the width of the waterway;

Current use - the use which is generally and usually met in the waterbody at the present time in spite of the numeric criteria for that use not being met sometimes.

Designated use - the use specified for the waterbody in the water quality standards whether or not it is being attained.

Existing use - the use actually attained in the waterbody on or after November 28, 1975.

Mixing zone - a limited area or a volume of water where initial dilution of a discharge takes place; and where numerical water quality criteria can be exceeded but acute toxic conditions are prevented from occurring.

Primary contact recreation - those water contact sports or activities which result in frequent whole body immersion and/or involve significant risks of ingestion of the water.

Secondary contact recreation - those water contact sports or activities which seldom result in whole body immersion and/or do not involve significant risks of ingestion of the water.

Class A and B are not existing uses for the Potomac River, although Class B is listed as a current use. Class A and B are designated uses for the Potomac River. The mixing zone concept implies that even though some area of a water body does not attain the numerical criteria that the use is still attained or protected the water body. The definitions of Class A primary contact recreation and Class B secondary contact recreation make clear the there is a risk level associated with recreational activities. The EPA criteria document estimated that at a geometric mean of 200 organisms per 100 ml that there would be about 8 illnesses out of 1,000 swimmers at a recreational swimming beach. The use of a geometric mean recognizes that there will be occasions where individual samples will be higher than 200 organisms/100ml. Obviously, different types of Class A activities carry different risks, with swimming involving the highest risk. Activities such as windsurfing where the person spends most of the time out of the water but spends significant amounts of time in the water or being splashed with water runs a lesser risk. While in the case of scuba diving, because of increased pressure of the water at depths, may cause a higher prevalence of ear infections than other types of activities. Certain Class A activities may be limited by factors other than disease risk. Issues such as current velocity, floods, clarity of the water and competing uses such as navigation or fishing may restrict these activities to certain areas at certain times and most certainly winter temperatures and heavy ice create limitations. The District of Columbia water quality standards do not guarantee risk free primary contact recreation nor do they guarantee that it can occur everywhere all of the time.

BACKGROUND

The District of Columbia, like many cities in the 19^{th} and early 20^{th} centuries, developed a combined sewer system, which transported both rainfall and sanitary sewage away from the developed areas and discharged them into the rivers. In the 1930s, Blue Plains Wastewater Treatment Plant (WWTP) was constructed and dry weather sewage flows were transported to Blue Plains. This is the only wastewater treatment plant and is located at southeast corner of the District of Columbia. However, wet weather flows can exceed the transmission capacity of the pump stations and piping system and result in overflows. As development expanded, sewer system construction techniques utilized two separate systems so that the storm water could be kept isolated from the sanitary sewage. Storm water is transported and discharged via individual pipe networks to the nearest stream channel, while the sanitary sewage is transported to Blue Plains WWTP for treatment. Approximately two third of the city is served by separate sewer systems. The presence of excessive fecal coliform in the Potomac River and the tributaries is caused by upstream loads, storm water runoffs, and combined sewer overflows. Although urban in nature, non-human sources of bacteria are also contributing factors.

LAND USE

Potomac River

The Potomac is the main and largest river within the District of Columbia. It is often referred to as the “Nation’s River”, because it flows through the nation’s Capital. It originates as a small spring at the Fairfax Stone in West Virginia, and winds its way through the mountains and valleys of Appalachia, past battlefields, and old manufacturing towns. As it passes through the metro D.C. area, the river flows more than 380 miles and grows to more than 11 miles wide where it reaches the Chesapeake Bay at Point Lookout, Maryland. It is the vital source of drinking water as 75 percent of the D.C. metropolitan area’s water supply comes from the Potomac and remains the sole source of public water supplies for D.C. residents. Within the District of Columbia, the river stretches about 10 miles long. There are no drinking water intakes down stream from the District of Columbia.

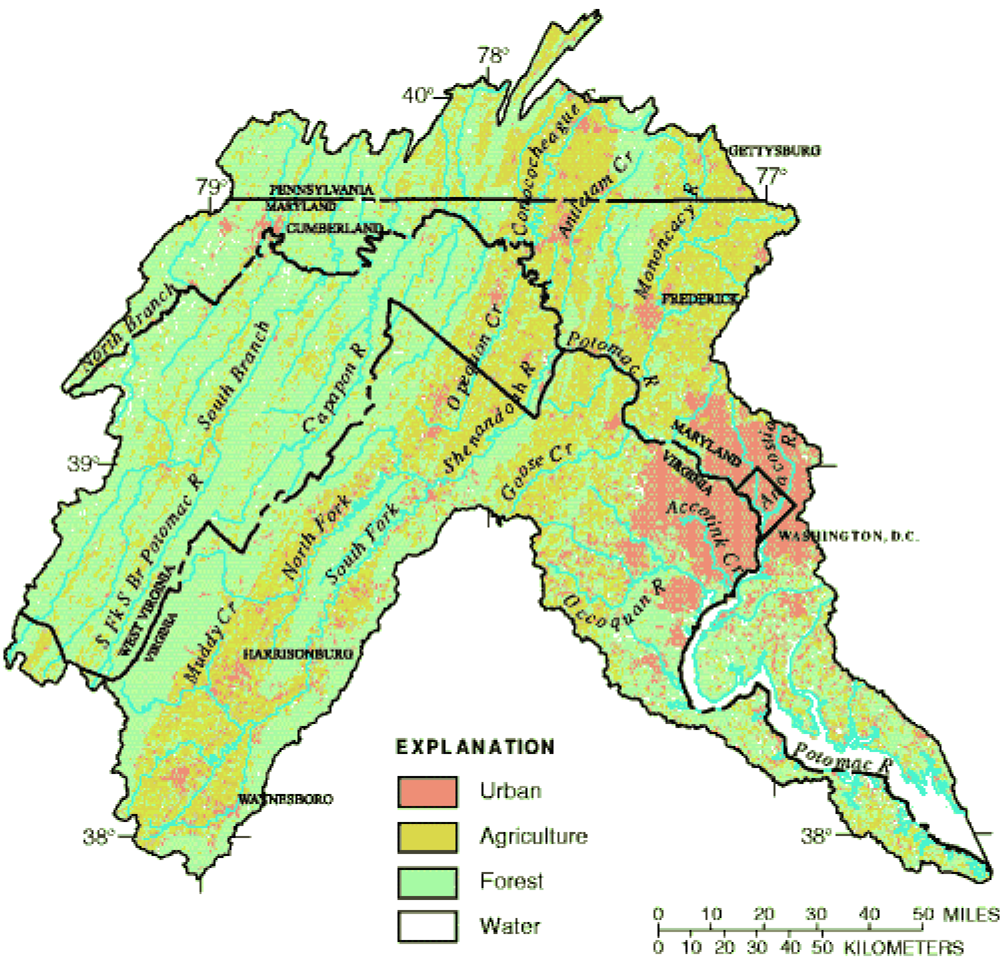
The Potomac River basin area includes a total of 14,679 square miles in four states and the District of Columbia, with 3,818 square miles in Maryland, 5,723 square miles in Virginia, 3,490 square miles in West Virginia, 1,570 square miles in Pennsylvania, and 69 square miles in the District of Columbia. In terms of statewide shares of the Basin, 100 percent of the District of Columbia, 34 percent of Maryland, 3 percent of Pennsylvania, 14 percent of Virginia, and 14 percent of West Virginia lie within the Basin (Chesapeake Bay Program, 2003).

As shown in Figure 1, land use in the Potomac River watershed is predominantly agricultural and forested. The Washington metropolitan area accounts for a significant portion of the developed lands and population in the watershed (Ator, 1998). Table 1 shows specific land use portions within the basin (Chesapeake Bay Program, 2003).

Table 1. Specific Land Use in Potomac Basin

Land Use	Developed	Agriculture	Forested	Open Water	Wetland	Barren	Total
Area (Square Miles)	701	4,663	8,451	579	165	120	14,679

Figure 1 General Land Use in Potomac Basin (Ator, 1998)



Potomac River Small Tributaries

There are three small tributaries to the Potomac in the District of Columbia. The watersheds of the Battery Kemble Creek and Foundry Branch are within the city limits of the District of Columbia. Dalecarlia tributary, however, originates in D.C. but then crosses into Maryland before discharging to the Potomac River. Characterization of the watershed for the tributaries takes into consideration of both the topographic drainage and the storm water drainage that, in some cases, cover areas outside the topographic drainage. Figure 2 shows the Potomac tributaries listed below. Appendix A contains detailed maps of the tributaries.

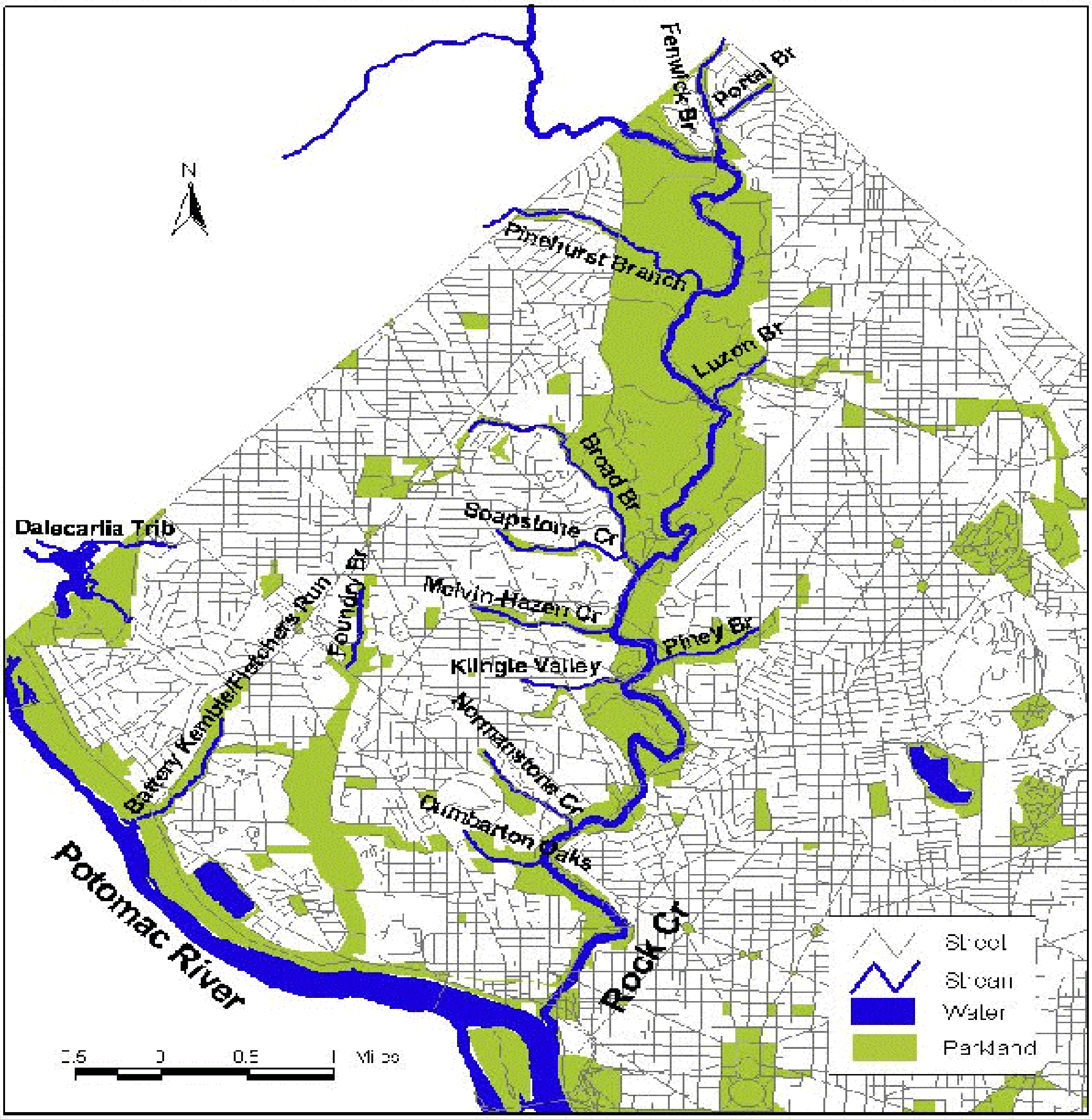


Figure 2. Potomac River Tributaries

Battery Kemble Creek/Fletchers Run

Battery Kemble Creek is a tributary of the Potomac River that drains Battery Kemble Park. The stream originates at Nebraska Avenue and Foxhall road. The watershed area is 239 acres, of which 60 percent is parkland and forest with the remaining area as residential. The stream is buffered on both sides by about 300 feet of forested parkland.

Dalecarlia Tributary

Dalecarlia is a tributary of Little Falls Run in Maryland that flows to the Potomac. The stream's watershed measures 1111 acres and lies almost entirely (97.3%) in the District of Columbia with a small portion of its lower reaches falling in Maryland prior to entering a stream that flows into Little Falls Run. West of Delacarlia Parkway, the tributary flows through sloping parkland accounting for one-quarter of the stream's watershed. The remainder of the watershed is suburban type residential housing.

Foundry Branch

Foundry Branch is a tributary of the Potomac, which is now largely enclosed in storm water pipe. The watershed measures 168 acres. About 80% of the watershed is residential and light commercial property. The remaining 20% is forested parkland operated by the National Park Service. The surface portion of the stream flows for about 2,050 feet through a forested section of Glover-Archibold Park giving the stream a forested buffer of approximately 200 feet on each side.

STREAM FLOW

Potomac River

The Potomac River is a very large river, with considerably more flow than the Anacostia and Rock Creek. The total flow of the main-stem Potomac River above the Fall Line has been measured at the stream-gauging station, located at Little Falls near Chain Bridge. Maximum daily flow at Chain Bridge was 309,700 million gallons per day (479,106 cubic feet per second) and minimum daily flow was 388 million gallons per day (600 cubic feet per second) (Vann, et al., 2002). The average flow at this location is about 6,975 million gallons per day (10,790 cubic feet per second). Although tidal throughout the District of Columbia, generally the large flux of water across the fall line ensures that reverse flows up the river do not occur. However, flow reversal occurs when flow is less than 4,202 million gallons per day (6,500 cubic feet per second). The Potomac River, as it stretches from the Fall Line in the Northwest to Wilson Bridge in the Southeast within the District of Columbia, receives flows from the Anacostia River and other smaller tributaries such as Rock Creek and Oxon Run in Maryland and Four Mile Run in Virginia. Anacostia River and many other tributaries in D.C. receive significant flows from upstream areas in Maryland, before eventual discharge to the Potomac River. The average flow in the Anacostia River and Rock Creek is approximately 139 cubic feet per second and 63.7 cubic feet per second, respectively. The average tidal range is about three feet in the District of

Columbia. By contrast to the Anacostia River, the large volume of the Potomac River and the high flow rates result in higher dilution and flushing rates for pollutants that enter the waterway.

Potomac River Small Tributaries

Stream flows in the smaller tributaries described earlier are comparatively very low. A number of storm water outfalls discharge to the streams increasing the flows by several folds during rainfall. Estimated base flow for Foundry Branch is about 0.9 cubic feet per second.

SOURCE ASSESSMENT

The sources of fecal coliform are ubiquitous. Any means by which fecal matter can be transported to the receiving waters are a potential source. These sources include combined sewer overflows (CSOs); separate sanitary sewer overflows (SSOs), which can result from leaky or undersized sanitary sewer pipes; stormwater runoff, which includes overland flow and flow conveyed through storm sewer pipes, and direct deposits of feces into the water from wildlife sources. A bacteria source tracking study is currently being conducted to help identify these sources, however since the water quality standards do not differentiate between sources, these TMDLs do not address sources directly. In order to assess point and non-point sources, it is necessary to describe how storm runoff and sanitary sewage is collected, transported, treated and discharged in the District of Columbia.

Within the District of Columbia, there are three different types of sewer networks. Originally, a combined sewer system was installed that collected both sanitary waste and storm water and transported it to the wastewater treatment plant. When storm water caused the combined flow to exceed the pipe capacity leading to the treatment plant, the excess untreated flow is discharged, called combined sewer overflows (CSOs), through a number of outfalls to different receiving waters. Approximately one third of the District of Columbia is served by the combined sewer system.

The remaining two thirds of the District of Columbia is served by a separate sanitary system that collects only sanitary sewage, while storm water is transported and discharged via individual pipe networks to the nearest stream channel. The separate sanitary sewer line should have no storm water inlets to the system and it flows directly to the wastewater treatment facility. Even though sanitary pipes are only intended to carry wastewater flow, they are influenced by rainfall. Infiltration and inflow of stormwater into sanitary pipes has the potential to cause surcharging and overflows. These overflows can reach the storm sewer system or the receiving waters directly. For this TMDL, sanitary sewer overflows were not modeled explicitly, as it was assumed that any bacteria from a routine SSO would be represented by the quality of the storm water.

Separate storm water networks collect storm water from streets and parking lots. Storm runoffs are then directly discharged to nearby rivers or streams. In general, the primary sources of bacteria to the storm water are wildlife and pets. Storm sewer pipes should have no sanitary sewer laterals entering the system. However, as in many old cities, illicit and cross connections do exist and can be a significant source of bacterial contamination to the waterways. Currently, DCWASA has active programs to identify and remove illegal connections. For this TMDL, illicit connections were not modeled explicitly.

Point Sources

According to DCWASA's current NPDES permit, there are a total of 10 active and 2 abandoned CSO outfalls, and 2 wastewater treatment outfalls on the Potomac River. Approximately 953 million gallons of CSOs discharged per average year to the Potomac River under the Phase I control (DCWASA, 2002).

In addition to the CSOs, the major point source within the District of Columbia is the effluent from Blue Plains Wastewater Treatment Plant. The facility is rated for an average flow of 370 million gallons per day, and the treatment process includes primary and secondary treatments, nutrient removal, disinfection, and dechlorination before discharging back to the Potomac River. The disinfection process reduces the coliform counts well below those for CSOs or storm sewer runoffs.

Nonpoint Sources

The Potomac watershed in the District of Columbia and surrounding areas are highly urbanized. Direct runoffs from parklands flanking the water bodies and not serviced by storm water sewers also occur along the Potomac River and its tributaries. Therefore, during wet weather events, there is a combination of direct storm water runoff and storm water being carried by pipes to receiving water bodies. Historically considered nonpoint source, storm water runoff discharged from separate storm water systems (SSWS) are permitted under the National Pollution Discharge Elimination System.

Upstream and Tributary Sources

The Potomac River at its upstream boundary near Chain Bridge receives flows from an area of approximately 11,560 square miles in several states. As it stretches from the Fall Line in the Northwest to Wilson Bridge in the Southeast within the District of Columbia, the Potomac receives flows from the Anacostia River and other smaller tributaries such as Rock Creek, Four Mile Run and Hunting Creek.

In addition to Blue Plains Wastewater Treatment Plant in D.C., the treatment plants in Arlington and Alexandria discharges to Potomac tributaries in Virginia. Although the District of Columbia and the City of Alexandria have the combined sewer systems in the watershed, water quality analyses indicated that storm sewer loads are a significant source of fecal coliform. As a result, in addition to D.C.'s CSO and nonpoint loads, loads from upstream and other tributary sources contribute significantly to the bacteria problem in the Potomac River.

TMDL ANALYTICAL APPROACH

Water Quality Standards and TMDL End Points

The majority of the Potomac watershed lies in Maryland and Virginia upstream of the District of Columbia. In addition as the river passes through D.C., it is bounded by Virginia to the west. Therefore in addition to the District of Columbia water quality standards, Maryland and Virginia water quality standards have also been considered for this TMDL. The following table summarizes D.C., Maryland and Virginia Bacteria Standards.

D.C., Maryland and Virginia Water Quality Standards – Fecal Coliform (MPN/100ml***)

D.C.		
Class of Use	A	B
Fecal coliform – maximum 30-day geometric mean for 5 samples	200	1000
Maryland*		
Bacteriological	Public Health	
Fecal coliform – maximum log mean based or not less than 5 samples over any 30 day period, or	200	
Fecal coliform – maximum value which may be exceeded during any 30-day period by less that 10% of total number of samples taken	400	
Virginia**		
Fecal coliform - Maximum geometric mean for two or more samples over a calendar month	200	
Fecal coliform – not more than 10% of the total samples taken during any calendar month can exceed this number	400	

*COMAR 26.08.02.03-3
**62.1-44.15(3a) of the Code of Virginia, August 27, 2003
*** MPN is the statistical estimate of the number of fecal coliform colonies likely to be found in a 100 ml sample.

The purpose of this TMDL is to determine the limit to which fecal coliform counts must be reduced to achieve and maintain the WQS for bacteria. The criteria must be achieved for all flow conditions. Since fecal coliforms are not measured in traditional concentrations (mass/volume), the TMDL is not a true maximum load, but rather a statistical estimate of the most probable number of coliform colonies that can be assimilated into the receiving waters without violating the WQS. Computationally, however, this parameter can be represented like a traditional pollutant and so for this TMDL it will be referred as a fecal coliform load. The criterion of 200 MPN/ml in D.C. water quality standards was used as the end point for this TMDL. In addition, Maryland and Virginia's 400 MPN/ml criterion was considered as a supplement to the analysis.

Seasonal Variations and Critical Conditions

Because of the episodic nature of rainfall and storm water runoff, developing a daily load is not an effective means of determining the assimilative capacity of the receiving waters. Rather, looking at total loads over a range of conditions is a more relevant way to determine the maximum allowable loads. A statistical analysis of rainfall records over a period of fifty years was conducted and a dry year, a wet year, and an average rainfall year, were identified based on total annual rainfall and other factors such as average intensity and number of events per year (DCWASA, 2002a). The consecutive years of 1988, 1989, and 1990, represent a relatively dry year, a wet year, and an average precipitation year, respectively. These three years were considered the period of record for determining compliance with the water quality standards for the TMDL analysis. Determination of compliance with the water quality standards was based on the frequency of violations as calculated by the simulation model for these three years.

Modeling

The framework for this TMDL was established through a rigorous discussion by stakeholders on all aspects of the watershed processes and interpretation of the loadings and receiving water responses to those loadings. The modeling approach applied included two components. The models used to generate loads from the drainage basin, convey them through drainage systems, and then predict their contribution to the receiving waters were formulated as part of the CSO LTCP and called Land Models. The in-stream processes were simulated using the EPA's Dynamic Estuary Model (DEM) model.

Land Models

Two land models were used for simulating loads from drainage basins served by sewer systems: one for the combined sewer system and another for the separate storm sewer system. The models were developed by the DC Water and Sewer Authority (DCWASA) as part of the CSO Long Term Control Plan (LTCP). The models can generate rainfall runoff based on various hydrologic input parameters of the drainage basin, including precipitation, land use, and soil characteristics, and route the runoff through a collection system.

The models were calibrated and verified using data collected for the LTCP between October 1999 and June 2000. The details of the models, including calibration and verification can be found elsewhere (DCWASA, 2002b; DCWASA, 2002c). The models were run for a three-year simulation period of 1988 to 1990, and hourly outputs from the models were input into the Potomac Model. The combined sewer system model was also used to determine loads from Blue Plains Wastewater Treatment facility for the same period.

Potomac Model

The Potomac River was simulated using the EPA's Dynamic Estuary (Potomac) Model (DEM), a one-dimensional model that simulates both hydrodynamics and water quality explicitly (USEPA, 1979). The DEM model simulates the entire tidal portion of the Potomac River, from the head of tide at Little Falls pumping station to the confluence with the Chesapeake Bay, however the TMDL only focuses on the District of Columbia's portion of the river.

The model inputs include loads from upstream, CSOs, SSWS, direct overland and tributary flows. Direct in-stream deposit from wildlife is insignificant, therefore, not considered in the modeling. The upstream boundary condition is represented by flows measured at the USGS gage at the Little Falls pumping station near D.C./Maryland boundary, and concentrations derived from long-term monitoring data near Chain Bridge. Among the tributaries, the Rock Creek load was determined using a model developed for Rock Creek as a part of the LTCP project (DCWASA, 2002d). As originally developed, the tidal Anacostia River is a part of the DEM model. The loads from other lateral tributaries were estimated using available flows and concentrations in some of the tributaries. The model was calibrated with the data collected for the LTCP project between October 1999 and June 2000. Details of the calibration and verification of the Potomac Model can be found elsewhere (DCWASA, 2000e).

Potomac River Small Tributaries Model

Potomac River small tributaries were evaluated using a simple mass balance model that predicts daily water column concentrations of fecal coliform in the tributaries (ICPRB, 2003). The model, called the DC Small Tributaries TMDL Model and developed by the Interstate Commission for the Potomac River (ICPRB), treats each tributary as a "bathtub" which, receives a volume of water representing storm water runoff and a volume of water representing base flow from groundwater infiltration, and assumes completely mixed condition. Daily estimates of baseflow and stormflow volumes for each tributary is based on ICPRB's Watts Branch HSPF model (Mandel and Schultz, 2000). An HSPF model simulates hydrologic processes, such as infiltration, evapotranspiration, surface runoff, and ground water flow, from a watershed based on land use within the shed boundaries and on local precipitation and other climatic data. The storm and base flow concentrations are based on available monitoring data from several studies and/or monitoring programs in the District of Columbia. The model was simulated using precipitation records for the three-year period of 1988 to 1990.

TOTAL EXISTING LOADS

The existing fecal coliform loads are calculated for various sources by different models described earlier. The annual loads are an average estimation over the period of analysis of 1988 to 1990. Annual existing load is determined by averaging loads for the three-year analysis period.

The Potomac River is divided into upper, middle and lower segments in D.C.'s 303(d) list, where the upper Potomac extends from the D.C./Maryland boundary near Chain Bridge to Key Bridge, the middle Potomac from Key Bridge to Hains Point, and the lower Potomac extends from Hains Point to the D.C./Maryland boundary near Wilson Bridge (see Figure 3).

The average loads listed below are broken down by sources: upstream sources representing the in-stream and watershed loads delivered at the District of Columbia boundary near Little Falls for the upper Potomac; direct storm runoff loads includes direct runoffs into the Potomac from the District of Columbia, Maryland (MD) and Virginia (VA) shorelines as well as direct lateral flows from tributaries in the corresponding jurisdictions into the Potomac, except for the Rock Creek and Anacostia loads. The lower Potomac loads for Virginia and Maryland include loads from the Middle/Lower Potomac boundary to Hunting Creek, i.e., beyond the downstream DC/MD boundary near Wilson Bridge to take tidal influence into consideration; and separate storm water and CSO representing the DC portion of the loads from separate storm sewers and combined sewer overflows, respectively.

Potomac River Existing Average Annual Loads for Fecal Coliform

Source	Upper Potomac Annual Load (MPN)	Middle Potomac Annual Load (MPN)	Lower Potomac Annual Load (MPN)
Upstream	2.731E+16	3.002E+16	6.713E+16
CSO	1.009E+15	3.312E+16	0.000E+00
Separate Storm Water	1.197E+15	6.316E+13	1.350E+15
Direct Storm Runoff - DC	3.563E+13	1.399E+14	8.153E+13
- VA	4.631E+14	5.597E+14	2.006E+15
- MD*	NA	NA	6.616E+14
Blue Plains WWTP	NA	NA	6.420E+15
Rock Creek	NA	3.230E+15	NA
Anacostia River	NA	NA	5.858E+16
Total	3.002E+16	6.713E+16	1.362E+17

NA – not applicable; * includes the entire Oxon Run watershed load as well as other MD direct runoff loads.

Potomac River Tributaries Existing Average Annual Loads for Fecal Coliform

Battery Kemble Creek (MPN)	Foundry Branch (MPN)	Dalecarlia Tributary (MPN)	
		DC	MD
5.57E+12	5.67E+12	3.40E+13	9.47E+11

TOTAL MAXIMUM DAILY LOAD AND ALLOCATION

Overview

This section summarizes the scenarios that were explored using the models. The assessment investigates water quality responses assuming different loading conditions. Subsequent sections present the modeling results, allocate the TMDL between point sources and nonpoint sources, and describe the rationale for margin of safety.

Scenarios

To set the TMDL, a series of computer simulations were run to determine the amount of reduction of loads that would be needed to meet water quality standards. Water Quality Standards (WQS) are considered to be met if no model segment within the District of Columbia had a maximum 30-day geometric mean exceeding the 200 MPN/100 ml Class A, standard. Exceedance is expressed in the number of months exceeding the geometric mean.

The simulation scenarios consist of model runs made for certain percent reductions for each of the four sources (i.e., upstream, lateral/direct runoff, CSO, and storm water sources). A large number of scenarios for a combination of reductions can be constructed and analyzed. For this TMDL, the models were run over a range of reductions in the storm water given a number of CSO scenarios. Two sample scenarios are presented in this report. The geometric mean was calculated for each of the 36 calendar months in the three-year period. Sensitivity runs were conducted based on a rolling 30-day geometric mean, rather than the calendar month. Figure 3 shows the model segments for the TMDL analysis. The location of the segments and the number of months WQS was exceeded at selected segments is summarized in the tables below. Figures showing the results for each month are included in Appendix B.

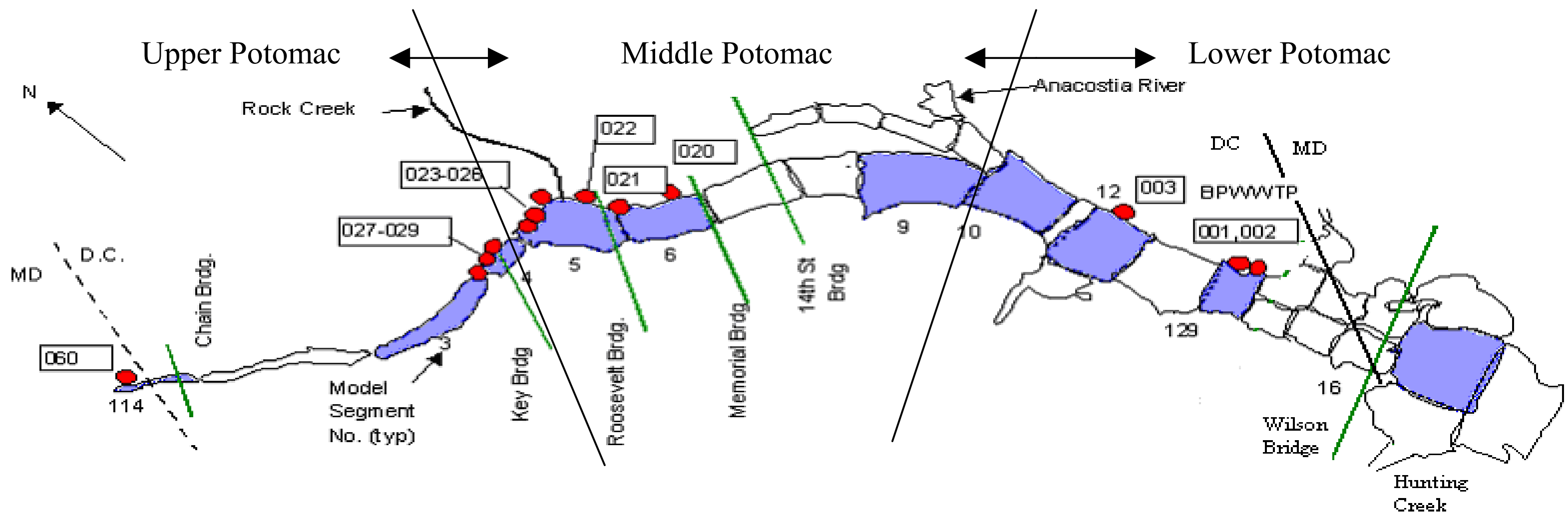


Figure 3: Potomac River Model Segments

Scenario 1 – 84 percent reduction in CSO, 0% reduction in all other sources per average year

Number of Months Exceeding WQS

Criteria	Model Segment									
	114	3	4	5	6	9	10	12	129	16
No. of Months Geomean > 200/100ml	8	1	1	1	1	0	0	0	0	0
No. of Months Geomean > 1000/100ml	0	0	0	0	0	0	0	0	0	0

Scenario 2 – 92 percent reduction in CSO, 0% reduction in all other sources per average year

Number of Months Exceeding WQS

Criteria	Model Segment									
	114	3	4	5	6	9	10	12	129	16
No. of Months Geomean > 200/100ml	8	1	1	1	0	0	0	0	0	0
No. of Months Geomean > 1000/100ml	0	0	0	0	0	0	0	0	0	0

ALLOCATIONS, REDUCTIONS, MARGIN OF SAFETY, AND THE TMDL

The total allowable load of fecal coliform reflects the reduction needed to meet the 30-day geometric mean during the three-year (1988, 1989 and 1990) period of analysis. For the Potomac River TMDL analysis, the load reductions needed to meet water quality standards were from the upstream and direct lateral loads, storm water loads and combined sewer flows. The allocation is based on 91.7 percent reduction for CSOs, and 50 percent reduction for upstream, storm water and direct runoff sources. The overall reduction to loads from Rock Creek and the Anacostia River are 67 percent and 74 percent, respectively. A uniform reduction is considered for all separate storm sewers and direct runoffs. For CSOs and the Blue Plains Treatment Plant, the recommended long-term control plan scenario (DCWASA, 2002) was used for the selected TMDL analysis.

Selected Allocation Scenario

The selected allocation scenario meets the District of Columbia Water Quality Standards of 200MPN/100ml for Class A waters. In the analysis, the rolling 30-day geometric mean was used to determine compliance. Under the simulation scenario for load allocation, the number of months where the maximum 30-day geometric mean exceeds 200 MPN/100ml must be zero. The results of the selected scenario run are shown below.

Scenario 3 – Allocation Run - Number of Months Exceeding WQS

Criteria	Model Segment									
	114	3	4	5	6	9	10	12	129	16
No. of Months Geomean > 200/100ml	0	0	0	0	0	0	0	0	0	0
No. of Months Geomean > 1000/100ml	0	0	0	0	0	0	0	0	0	0

In selecting the allocation scenario, the number of days that fecal coliform count of 400 MPN/100ml is exceeded was also considered. In examining several scenario runs, it is noted that upstream loads at DC/MD boundary near Little Falls bear significantly on the exceedances in the upper segments of the River within the District of Columbia. The table below shows the number of days that fecal coliform count of 400 MPN/100ml is exceeded for the selected allocation scenario.

Number of Days Exceeding 400 MPN/100ml

	FECAL COLIFORM # of days >400 MPN/100ml									
Month	Segment No									
	114	3	4	5	6	9	10	12	129	16
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	<1	<1	1	1	1	1	1
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	1	1	<1	1	1	<1
8	0	0	0	1	1	1	1	1	1	<1
9	0	0	0	<1	<1	0	0	0	0	0
10	0	0	0	<1	<1	1	1	1	1	1
11	0	0	0	<1	1	<1	<1	0	0	0
12	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	3	4	3	3	3	4	2
% Year	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%

Allocated Loads

The total allocations for CSOs, upstream, separate storm water and direct lateral loads established for this TMDL are as shown below. Annual average load allocation for the tributaries are also listed:

TMDL for Fecal Coliform Bacteria in Potomac River (Average Annual Loads)

Source	Upper Potomac Annual Load (MPN)	Middle Potomac Annual Load (MPN)	Lower Potomac Annual Load (MPN)
Upstream	1.353E+16	1.440E+16	1.825E+16
CSO	3.688E+13	2.435E+15	3.487E+14
Separate Storm Water	5.927E+14	3.126E+13	6.685E+14
Direct Storm Runoff - DC	1.764E+13	6.926E+13	4.036E+13
- VA	2.293E+14	2.770E+14	9.938E+14
- MD*	NA	NA	3.275E+14
Blue Plains WWTP	NA	NA	9.294E+15
Rock Creek	NA	1.061E+15	NA
Anacostia River	NA	NA	1.497E+16
1% MOS	1.451E+14	1.600E+14	3.560E+14
Total	1.455E+16	1.843E+16	4.525E+16

NA – not applicable; * includes the entire Oxon Run watershed load as well as other MD direct runoff loads.

Potomac River Tributaries Annual Average Load Allocation for Fecal Coliform

	Total Load (MPN)	MOS (MPN)	Storm Water (MPN)	Direct Runoff (MPN)
Battery Kemble Creek	8.91E+11	3.34E+11	5.38E+11	1.91E+10
Foundry Branch	8.50E+11	2.83E+11	5.22E+11	4.44E+10
Dalecarlia Tributary – DC	4.76E+12	1.36E+12	3.40E+12	0.00E+00
Dalecarlia Tributary – MD	1.33E+11	3.79E+10	9.47E+10	

Other Sources and Reserve

The allocation of fecal coliform to boats, ships, houseboats, and floating residences is zero. The allocation of fecal coliform to reserve is also zero.

Margin of Safety

An explicit margin of safety of one percent is provided for all sources except CSOs. There is implicit margin of safety regarding CSOs. It is the recognized “first flush” effect during storms. Although the combined sewer model assumes a constant average concentration all the time, in reality capturing over 90 percent of the volume will capture initial highly concentrated flows, leaving flows that are less concentrated and diluted. In addition, there is additional implicit margin of safety for allocated loads as conservative approach in selecting number of days exceeding 400 MPN/ml was considered in addition to the rolling geomean criteria of 200 MPN/ml. For the tributaries, the allocation requires 84 to 86% reduction. However, with a margin of safety the loads to all tributaries are reduced by 90%.

Beneficial Use

The allocation will achieve the District of Columbia's water quality Standards for Class A- Primary Contact recreation and Class B- Secondary contact recreation.

The DC Water Quality Standards Section 1104.3 provides narrative criteria for Class A use. The TMDL requires about 92 % reduction of CSOs to the Potomac River. The LTCP deals with the degree of treatment provided and indicates that 99% of the time the Potomac River will be free from CSO overflows. According to the LTCP, there will be a total capture of the first flush loads containing the most concentrated combined sewage as well as screening of floatables and large solids prior to discharge. The Department of Health interprets the remaining CSO discharges to be "partially treated sewage." The Department of Health does not advocate swimming nor complete prolonged immersion in the discharge plume or mixing zone or near vicinity of any point source discharge whether sewage or industrial pollutant. Some Class A uses may occur which have a lower risk. However, the fact that for a few areas for a few days of the year the risk will be higher than other days and other areas does not negate the attainment of the designated use of the waterbody. This variation in risk is implicit in the criteria adoption as a regulation of the District of Columbia. Installation of signs and warning lights concerning CSOs will further guide users in managing and reducing risks. The majority of the high-risk days are caused by storm flows propagation into the District of Columbia waters from Maryland and upstream sources.

IMPLEMENTATION

On June 28, 2000, D.C. Mayor Williams, Maryland Governor Glendening, U.S. EPA and others signed the new Chesapeake Bay Agreement. The goals of the agreement include:

"Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health"

and

"By 2010, correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act"

Thus, an agreement is in place that clearly demonstrates a commitment to the restoration of the river by the year 2010. This establishes a completion 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

Maryland has committed to a 40% nitrogen and phosphorus reduction in the Bay Agreement and has developed tributary strategies that will achieve that reduction. Both Prince Georges and Montgomery Counties have aggressive and effective stormwater management programs. These storm water management programs include various BMPs, which will reduce and improve runoff quality, consequently reducing bacteria pollution.

CSO Load Reductions

The DC WASA is currently engaged in the implementation of the following CSO reduction programs.

1. Nine Minimum Controls Plan.
2. East side interceptor cleaning to remove sedimentation and restore transmission capacity.
3. Pump station rehabilitation to increase transmission capacity to the treatment plant.
4. Inflatable dam rehabilitation to restore the dam's ability to hold sewage inside the pipe, hence reduce overflows.
5. Swirl concentrator rehabilitation and performance enhancements to improve treatment.

In addition to the above, the DC WASA has proposed several storage systems for the combined sewer system in the Final CSO LTCP to reduce CSOs. The CSO LTCP has been approved by DCDOH.

Storm Water Load Reductions

The District of Columbia Water Pollution Control Act (DC Law 5-188) authorizes the establishment of the District of Columbia'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 DC Department of Health has an extensive storm water management, sediment, and erosion control program for construction activities. It also has a Nonpoint Source Management Plan to address the reduction of nonpoint source pollution.

A number of activities to reduce pollutant runoff are carried out as part of the Municipal Separate Storm Sewer Permit for the District of Columbia. The most pertinent of these are contained in the storm water management plan. The plan provides additional mechanisms for achieving the load reductions needed.

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

1. Street sweeping programs by the Department of Public Works.

2. Requirements for storm water treatment on all new development and earth disturbing activities such as road construction.
3. Regulatory programs restricting illegal discharges to storm sewers
4. RFK BMPs- The goal of this project is to install stormwater management facilities at the end of two stormwater outfalls. The outfalls are located along the RFK Stadium parking lot. The purpose of these facilities will be to filter pollutants from the stormwater before the water is discharged into the Anacostia River.
5. 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 stormwater flows into Fort Dupont. A stormwater management facility will be constructed to remove sediment, oil and grease, and other street runoff pollutants as well as stem stormwater flows causing erosion in Fort Dupont creek. The second phase will restore in stream habitat and determine additional methods for managing stormwater within Fort Dupont Park and will be cost shared with and implemented by the USACE. These efforts should provide some benefit to bacteria reductions, though the extent is likely small.
6. 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 River. This project is also examining the possibility of reforming the stream to better accommodate stormwater 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. These efforts should provide some benefit to bacteria reductions, though the extent is likely small.
7. Popes 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 Popes 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 of Columbia. As part of this project, D.C. has funded a study of Popes Branch to determine restoration options within the watershed. These efforts should provide some benefit to bacteria reductions, though the extent is likely small.
8. 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. This program should provide bacteria reduction benefits.
9. Environmental education and citizen outreach programs to reduce pollution causing activities.
10. DC WASA has launched a citywide Sanitary Sewer System Investigation. The activities under this program will eliminate infiltration of sanitary sewer to the storm water system.

Various Anacostia River and Rock Creek initiatives will provide significant reduction of fecal coliform bacteria loads to the Potomac River.

Boat Discharges

The Potomac Rivers have been allocated a Zero Discharge from watercraft in this document. In 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 bacteria to the water column. DOH has funded pump out stations at every marina in the Potomac and Anacostia Rivers.

Monitoring

The Department of Health maintains an ambient monitoring network that includes the Potomac and Anacostia Rivers and Rock Creek. Data is collected on fecal coliform typically monthly. The tributaries are monitored on a monthly basis.

BIBLIOGRAPHY

Ator, S.W., Blomquist, J.D., Brakebill, J.W., Denis, J.M., Ferrari, M.J., Miller, C.V., and Zappia, H., 1998, Water Quality in the Potomac River Basin, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia, 1992-96: U.S. Geological Survey Circular 1166, on line at <URL: http://pubs.water.usgs.gov/circ1166>, updated June 10, 1998

Chesapeake Bay Program, 2003, U.S. Environmental Protection Agency, Annapolis, Maryland.

DC WASA, 2002, Combined Sewer System Long Term Control Plan, prepared by Greeley and Hansen, LLC for the District of Columbia Water and Sewer Authority, Washington, D.C.

DCWASA, 2002a, Study Memorandum LTCP-3-2: Rainfall Conditions, Washington, D.C.

DCWASA, 2002b, Study Memorandum LTCP-5-4: CSS – Model Documentation, Washington, D.C.

DCWASA, 2002c, Study Memorandum LTCP-5-7: SSWS – Model Documentation, Washington, D.C.

DCWASA, 2002d, Study Memorandum LTCP-6-6: Rock Creek Model Documentation, Washington, D.C.

DCWASA, 2002e, Study Memorandum LTCP-6-5: Potomac River Model Documentation, Washington, D.C.

District of Columbia Water Quality Standards, 21 DCMR 1100 Chapter 11, Effective January 24 2003, Washington, D.C.

ICPRB, 2003, District of Columbia Small Tributaries Total Maximum Daily Load Model – Final Draft Report, prepared by Interstate Commission on the Potomac River Basin for DOH, Washington, D.C., June 2003.

Mandel, R., and C.L. Schultz. 2000. The TAM/WASP Model: A Modeling Framework for the Total Maximum Daily Load Allocation in the Tidal Anacostia River - Final Report. Prepared by the Interstate Commission on the Potomac River Basin for the District of Columbia, Department of Health, Environmental Health Administration. Washington, DC.

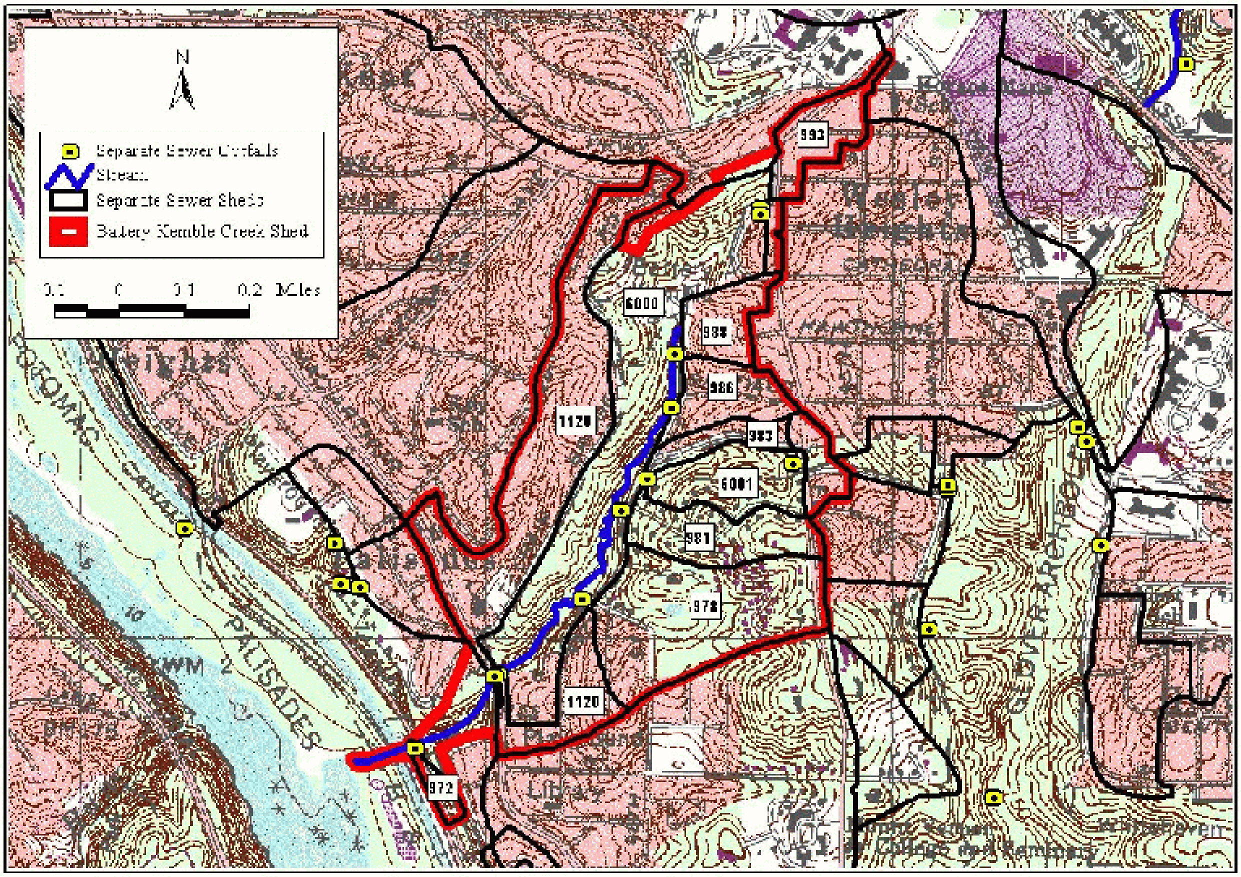
USEPA, 1979, User's Manual for the Dynamic (Potomac) Estuary Model. Annapolis Field Office, Annapolis, MD.

Vann, et al., 2002, The District of Columbia Source Water Assessment, Draft Report, Environmental Health Administration, Department of Health, Washington, D.C.

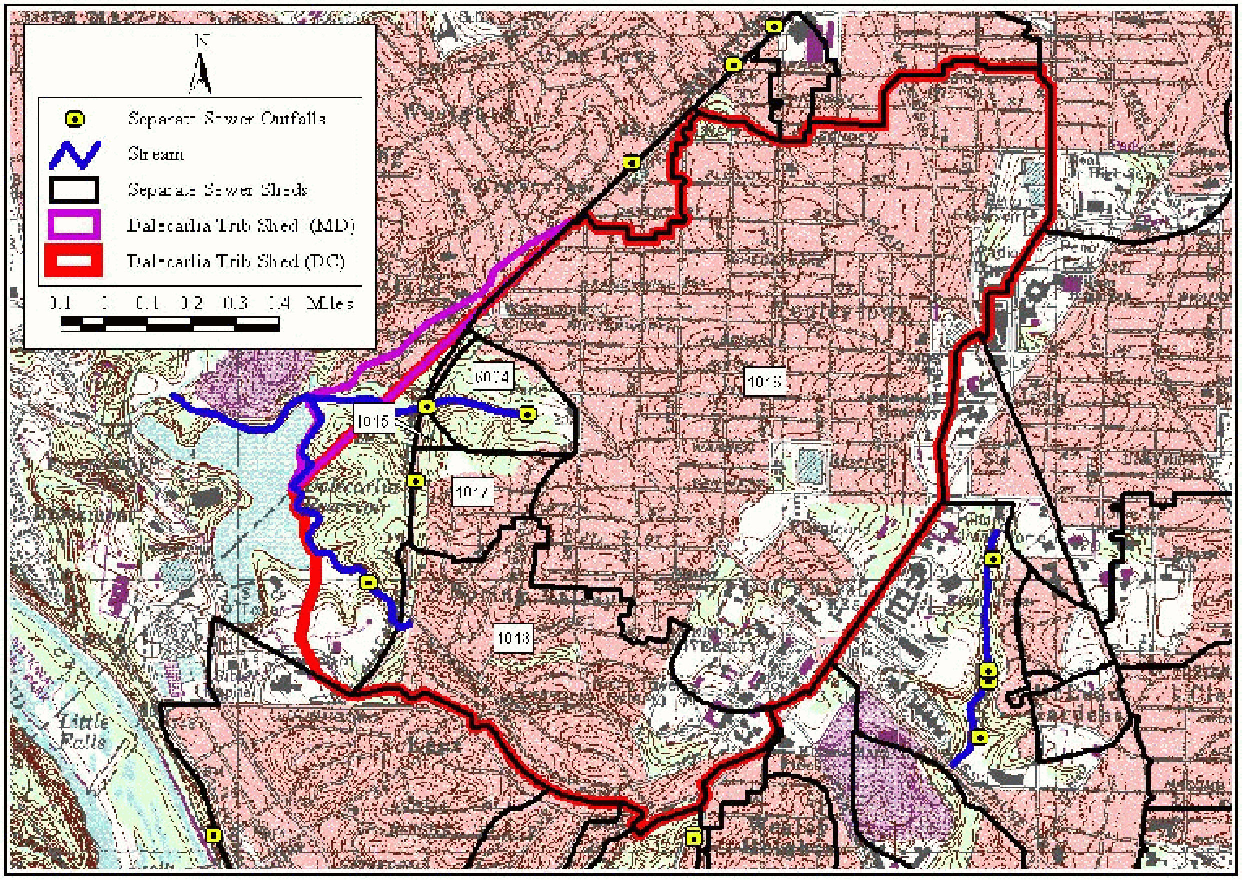
APPENDIX A

Potomac Tributary Maps

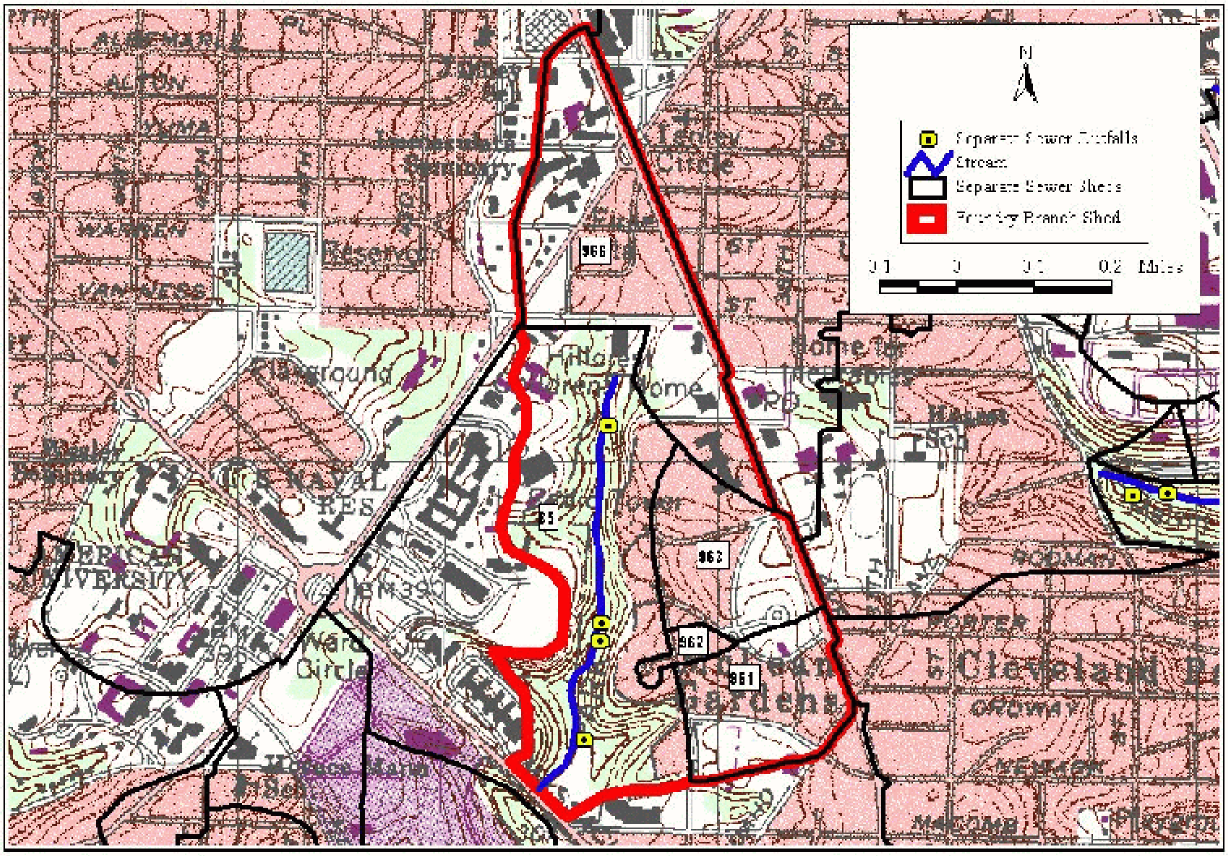
BATTERY KEMBLE CREEK/ FLETCHERS RUN



DALECARLIA TRIBUTARY



FOUNDRY BRANCH



APPENDIX B

Scenario Run Results