The District of Columbia Source Water Assessment

Environmental Health Administration

Bureau of Environmental Quality

Water Quality Division

The District of Columbia
Source Water Assessment

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From the Interstate Commission on the Potomac River Basin

E.1 Scope and Purpose of the Source Water Assessment

The Potomac River is the sole source of water for the residents of the District of Columbia. The U.S. Army Corp of Engineers, through the Washington Aqueduct, operates two intakes on the Potomac River at [REDACTED] to supply water to the nation's capital. While the Aqueduct's treatment facilities have proven more than adequate to process raw water from the Potomac River, increasingly, the importance of protecting the quality of source water for drinking supplies has been recognized. Under the provisions of the 1996 Safe Drinking Water Act Amendments, each state is required to develop a Source Water Protection Program (P. L. 104-182, Section 1453). The first step in the development of such a program is a source water assessment (SWA) of the drinking water source of each water supply intake. Each SWA must contain the following four components:

1. A delineation of the watershed contributing source water to the intake;
2. An inventory of potential contaminants and their sources within the delineated watershed;
3. An analysis of the susceptibility of source water to potential contamination from these sources; and
4. Communication of the results of source water assessment to the public.

The District of Columbia's SWA takes two additional steps beyond the required components. First, watershed delineation, contaminant inventory, and the susceptibility analysis are integrated into a GIS Search and Query Tool. The Search and Query Tool enables the user to sort and rank potential sources of contaminants by type of contaminant, location, and travel time. Second, the Chesapeake Bay Program's Watershed Model was adapted for use in the SWA to evaluate the susceptibility of D.C.'s source water to contamination from sediment, nutrients, pathogens, and pesticides. The use of a recognized assessment tool like the Watershed Model will facilitate the integration of source water protection into ongoing regional environmental protection programs like the Chesapeake Bay Program.

E.2 PCS Inventory and Susceptibility Analysis

An inventory and analysis of potential point source contaminants for a source water is one of four major tasks required by the EPA SWA guidelines. Availability of these data to a community water supply can provide valuable information for decision-making processes. Knowledge of a contaminants location in relation to a water supply can be used in the evaluation of the overall risk to a water supply or can be used in the event of an accidental or intentional spill.

For the D.C. SWA's evaluation, inventory and analysis of potential contaminant sources (PCSs) within the watershed above the WAD intakes was completed and used to determine what potential contaminants were likely to impact the public (drinking) water systems (PWSs) at the surface intakes. The susceptibility analysis was was based on the delineation of time of travel boundaries upriver from the [REDACTED] intake. In addition, a GIS application was developed which used these time of travel boundaries to query and spatially analyze these data for their potential threat to the public water supply.

E.2.1 PCS Inventory

The PCS inventory includes data from federal and state sources and consists of discharge and release inventories, hazardous waste sites, landfills, underground and above ground storage tanks and other activities identified through local field surveys. The National Pollution Discharge Elimination System (NPDES) was used as a base resource to provide information on regulated sites and activities within the Potomac basin. The state and local data provided additional site-specific information on small quantity generators or facilities that are not maintained on the federal level.

E.2.2 Analysis

Due to the large number of facilities and sites within the basin, a ranking process was developed to allow for identification of PCSs, and to determine the potential risk of each site to the water supply. A time of travel analysis was used to categorize facilities within the PCS database. Travel times of 10 and 24 hours on the mainstem of the Potomac at different flow levels were used to delineate travel time boundaries (Chapter 3). Facilities falling inside these segments were considered to have a higher potential for contamination than ones falling outside these modeled boundaries (Chapter 4).

E.2.3 GIS Search and Query Tool

A GIS application was developed to facilitate this large data collection effort. Knowing that the source water assessment is the first step in developing a source water protection plan, D.C. decided to use GIS as a foundation for initial analysis and also for future modeling and analysis in the protection phase. This search and query tool was created on an ESRI ArcGIS 8.3 framework, using standard Visual Basic–Application (VBA) coding. Most of the application is form and macro driven, meaning buttons and button combinations on user forms activate internal programming to perform desired functions.

The application contains a variety of base map data layers, from county and state lines to stream reaches and roadways. Introducing the PCSs to the base layers creates an interactive map, providing the user the ability to perform spatial analysis for sites throughout the basin. The Search and Query application allows the user to perform surveys of contaminants in the time of travel segments based on the susceptibility ranking. Simple surveys can be performed using a one-click tool set or for more complex surveys a user-defined query can be performed with additional ArcView tools.

E.2.4 Susceptibility Analysis Results

Currently, all facilities in the available databases have been categorized and ranked. Approximately 5,000 sites or permitted facilities have been evaluated for their contamination potential. Based on the susceptibility analysis a list of sites was generated that could potentially affect the D.C. source water and falls into three categories.

The first category is sources of fecal contamination. This would include wastewater treatment plants(WWTPs) with a permitted discharge rating above 1MGD, combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) and large scale poultry and processing facilities. Figure E.2.1 illustrates the locations of these activities and their location relative to the D. C. intakes.

The second category includes sources of petroleum contamination. Figure E.2.2 details the locations of pipelines transporting refined product, above ground storage tanks (ASTs), and tank farms within the basin.

The third category is locations where an accidental spill can enter a receiving water in a short period of time and travel to the intakes within 24 hours. Figure E.2.3 shows locations where major roads and rivers and creeks intersect within the 24 hour time of travel boundary. The map also shows the location of the railroad along the C&O canal and could also be a source of contamination in the event of a rail accident.

Figure E.2.1. Potential sites for fecal contamination

[REDACTED]

Figure E.2.2. Potential sites for petroleum contamination

[REDACTED]

Figure E.2.3. Potential spill points within 24hr boundary

[REDACTED]

E.3 The Use of the Chesapeake Bay Program's Watershed Model in the Susceptibility Analysis for the District of Columbia's Source Water Assessment

The watershed for the District of Columbia's intakes on the Potomac River encompasses a large geographic area lying wholly outside its boundaries in four neighboring states. The District of Columbia already participates in a regional partnership to reduce pollutant loads from the Potomac River Basin that enter Chesapeake Bay—the Chesapeake Bay Program (CBP), in the interest of finding common ground between the protection of its drinking water supply and the CBP's strategies to reduce nutrient, sediment, and toxic contaminant loads to the bay. The CBP Watershed Model and the methodology behind it was used to help perform the susceptibility analysis for the source water assessment.

The Watershed Model simulates the fate and transport of nutrient and sediment loads from point and nonpoint sources throughout the Chesapeake Bay Basin. The Potomac River portion of the model is calibrated against observed flows at the [REDACTED] intake and against water quality data collected 1.2 miles downstream at Chain Bridge. The Potomac portion of the Watershed Model is, on a regional scale, a computer simulation model of water quality at D.C.'s source water intakes. It can be used to help determine the upstream sources of nutrient and sediment loads, which potentially effect source water quality.

Moreover, the sources of nutrient and sediment loads--wastewater treatment plants, septic systems, agricultural operations--are also sources of other constituents that can have an impact on source water quality. Pathogens, for example, are associated with livestock, manure disposal, failing septic systems, and wastewater treatment plants. Pesticides are applied as part of the same agronomic schedule of planting, fertilizing, and harvesting that is already represented in the Watershed Model. For this reason, the Watershed Model was extended so it can provide a regional analysis of the sources of other constituents that could adversely impact drinking water supplies. Modifying the Watershed Model to represent these other constituents extends a recognized management tool that has already been used to develop strategies for pollution reduction and prevention. It provides a way of evaluating how these strategies might impact source water quality and a common language for explaining that impact to stakeholders and regional partners in the Bay Program.

The Watershed Model was therefore used for three tasks in the susceptibility analysis:

1. The Watershed Model was used to characterize the size and sources of nutrient and sediment loads, both under current conditions and in the face of population growth;

2. The Watershed Model was modified to represent the fate and transport of fecal coliform bacteria, which serve as indicators of water-borne pathogens; and

3. The Watershed Model was modified to evaluate the susceptibility of D.C.'s source water to contamination by pesticides.

E.3.1 Current and Future Nutrient and Sediment Loads at the Source Water Intakes

Nutrient and sediment loads can adversely impact source water quality. Sediment and particulate organic matter must be removed to ensure proper treatment for drinking water. Excess nutrient loads can lead to algal growth, which in turn can lead to taste and odor problems.

The CBP 2000 Progress Scenario, which represents current conditions, was used to calculate nutrient and sediment loads delivered to the Washington Aqueduct intakes Figures E.3.1, E.3.2, and E.3.3 show the breakdown of average annual sediment, nitrogen, and phosphorus loads, respectively, by source.

According to the CBP 2000 Progress Scenario, a total of 1.6 million tons of sediment are delivered each year. Half of the load comes from crops and hay. A quarter of the load comes from pasture. Only 11% comes from forest and 14% comes from urban land. About a third of the load comes from the Shenandoah Valley, but the middle Potomac region is also a large source of sediment.

The loads of total nitrogen come from a wider variety of sources. Crops are the largest source of nitrogen, accounting for 37% of the total average annual load of 35 million pounds. Urban nonpoint source loads constitute the second largest source, accounting for 16% of the total. Nitrogen loads from pasture runoff constitute 15% of the load. Point sources, such as wastewater treatment plants, contribute 9% of the load. Agricultural sources still dominate urban sources. Fifty-six percent of the load comes from crops, pasture, or runoff from feedlots. Thirty percent of the load comes from point sources, septic systems, and urban land. Forests account for only 14% of the total delivered nitrogen loads. The sources are also more geographically diverse. The largest source of loads is the heavily urbanized lower Potomac region, just above the intakes at [REDACTED], which delivers 12% of the load. The middle Potomac region contributes almost the same load.

Crops also contribute nearly one-third of the annual total phosphorus load of 3.2 million pounds. The next largest source is pasture, delivering nearly 25% of the annual load. Point sources are the third largest source, contributing 20% of the load, and nonpoint sources from urban land contribute 16% of the load. The contribution from forests is almost negligible. Inorganic phosphorus is transported primarily bound to sediments, so it is not surprising that the 35% of the delivered load comes from the Shenandoah Valley. Point source loads from the Valley are also the highest in the basin. The Monocacy and the lower Potomac region each also deliver over 10% of the total annual load.

The CBP has projected the population growth in modeling segments for the years 2010 and 2020. The basin population of nearly 2 million is expected to increase by nearly 10% in each decade. The percent change is greatest in the Monocacy region; Frederick County in Maryland is expected to grow by over 30% in the next twenty years. The rate of growth is over 10% per decade in the lower Potomac region, which already has three-quarters of a million people, nearly 37% of the basin total.

Figure E.3.1 Simulated Average Annual Sediment Loads By Source Under Current Conditions

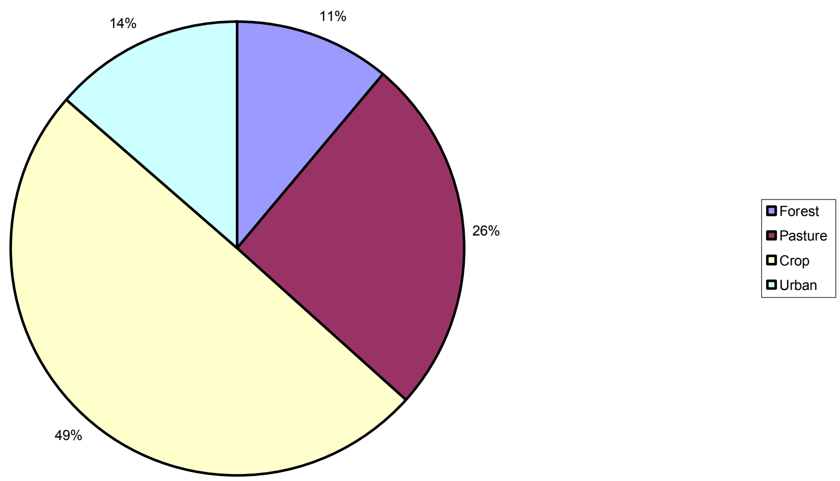


Figure E.3.2 Simulated Average Annual Total Nitrogen Loads By Source Under Current Conditions

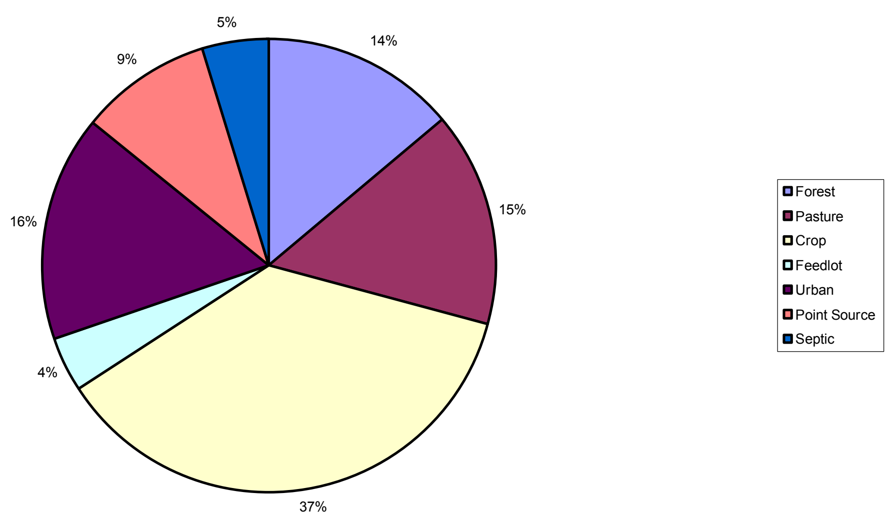
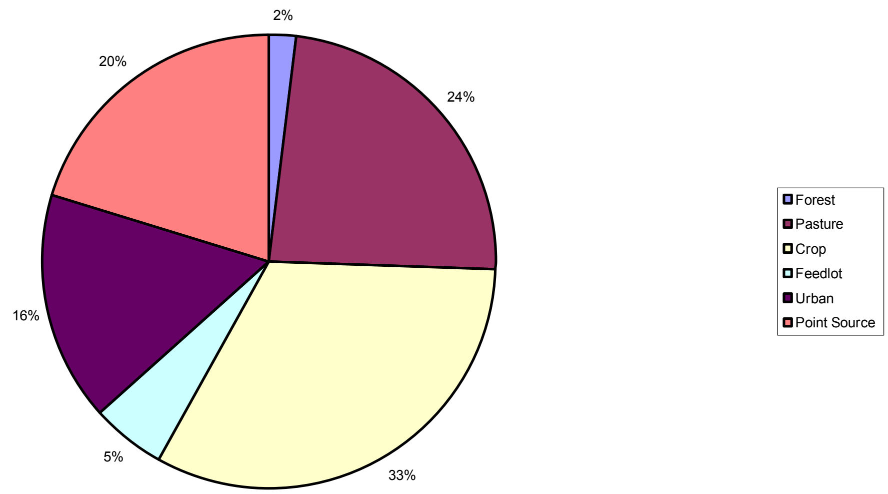


Figure E.3.3 Simulated Average Annual Total Phosphorus Loads By Source Under Current Conditions



A modeling scenario was developed to estimate nutrient and sediment loads under the population increase and land use changes projected for 2010. The scenario was intended to represent future conditions under current levels of BMP implementation for agricultural and urban nonpoint sources and current levels of point source controls.

An analysis of the impact of population growth on source water quality using the Watershed Model indicates that the growth in population upstream of the intakes will have little impact on sediment and nitrogen loads. Simulated loads from these two constituents decrease slightly under 2010 conditions. The increase in loads from urban land is balanced by a decrease in loads from agricultural land. Sediment loads remain dominated by agricultural sources.

Total phosphorus loads under 2010 conditions increase by 10%, mainly due to increased loads from point sources. The additional load from point sources more than outweighs the loss in load from the land use changes. With no additional point source controls, that trend will only increase as the population increases 2010-2020.

E.3.2 Simulation of Fecal Coliform Bacteria Using the Watershed Model

To better understand the sources of fecal coliform bacteria observed at the WAD intakes, the CBP Watershed Model was modified to simulate the fate and transport of fecal coliform bacteria. The same segmentation, land uses, and hydrology used in the reference scenario of the Watershed Model were used in the Fecal Coliform Model, and a similar methodology was used to estimate input loads of fecal coliform bacteria. The EPA guidance on developing pathogen TMDLS (2000) and numerous fecal coliform TMDLs developed in Virginia and West Virginia were also used to develop the Fecal Coliform Model.

The purpose of the Fecal Coliform Model is to help identify the sources and geographic origin of fecal coliform bacteria observed at the WAD's water supply intakes. This will help to identify the source and origin of fecal material that is a potential source of pathogens. Loads from the following sources were developed as inputs into the model:

1. Bacteria from livestock waste deposited on pasture and transported in runoff;
2. Bacteria, transported in runoff, from manure and poultry litter applied to crops and hay;
3. Bacteria in runoff from feedlots and concentrated animal operations;
4. Bacteria in runoff from urban land;
5. Bacteria in deer scat and geese droppings, deposited in forests and agricultural land and transported in runoff;
6. Bacteria loads from Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs) in the North Branch of the Potomac;
7. Bacteria discharged in effluent from wastewater treatment plants;
8. Bacteria draining directly into waterbodies from failing septic systems;
9. Bacteria from cattle directly defecating into streams; and
10. Bacteria from geese and other waterfowl directly defecating into streams.

An analysis of observed fecal coliform bacteria concentrations shows that the mean concentration at high flows tends to be larger than the mean concentration at low flows, although generally there are several orders of magnitude in the range of observed concentrations under all flow conditions. The Fecal Coliform Model was calibrated against the geometric mean of the observed data for different flow conditions at or near the outlet of each modeling segment. The model was then used to analyze the fecal coliform bacteria loads. Figure E.3.4 compares the average annual load input into the rivers and streams of the Potomac Basin by source. Figure E.3.5 shows the load actually delivered to the WAD intakes. Delivered loads represent the bacteria that are survive transport and arrive at the intakes. Figure E.3.6 shows the geographic distribution of delivered loads.

Agricultural loads dominate all other sources. In-stream deposition by cattle is the largest input source, followed by loads in runoff from pasture, cropland and feedlots. Fecal coliform bacteria from failing septic systems are the largest human source of input loads. Many of the fecal coliform bacteria which enter the streams and rivers of the Potomac Basin, however, die-off before reaching the WAD intakes. Ninety-eight percent of the delivered load occurs under storm flow conditions. The dominant sources of delivered loads are runoff form pasture, feedlots, and cropland. Because fecal coliform bacteria die-off while being transported downstream, the regions of the basin closest to the intakes tend to contribute the most to delivered loads. More than half the load comes from the lower Potomac region downstream of the confluence of the Shenandoah.

Figure E.3.4 Average Annual Fecal Coliform Loads Input into Streams and Rivers in the Potomac Basin By Source

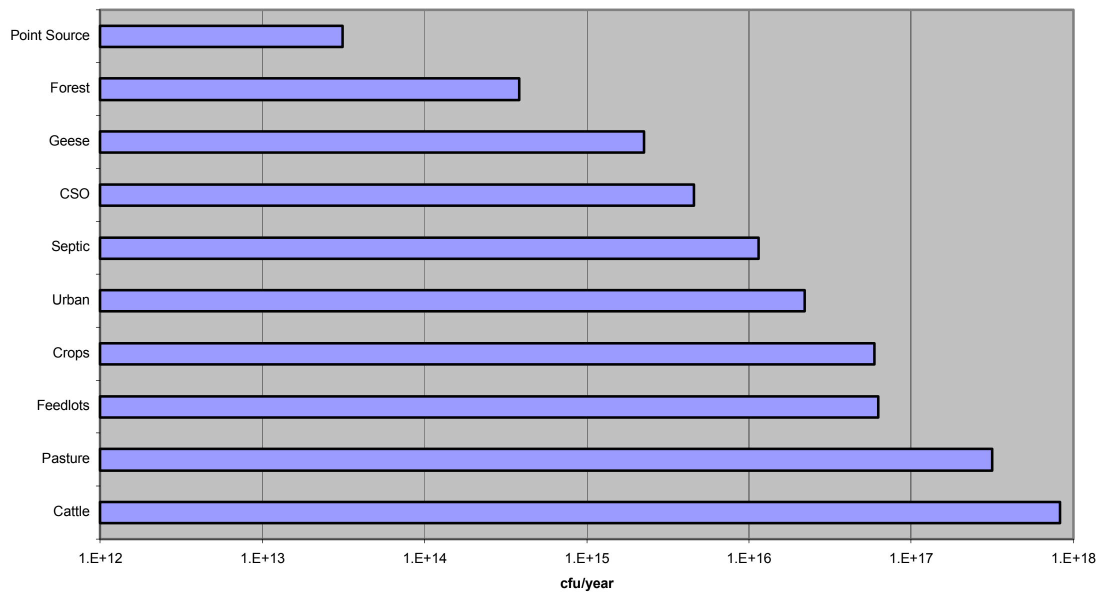


Figure E.3.5 Average Annual Fecal Coliform Loads Delivered at WAD Intakes By Source

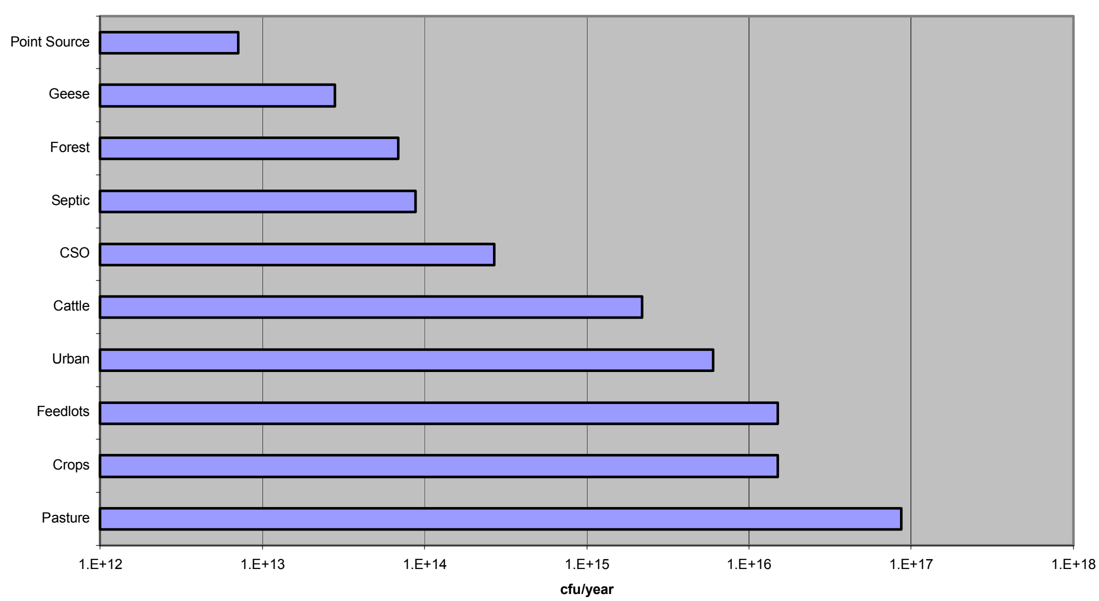
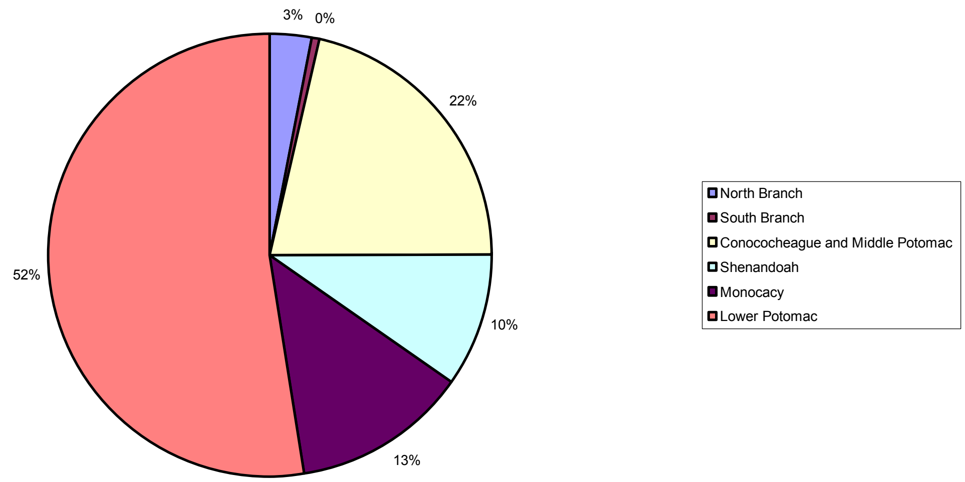


Figure E.3.6 Percent of Average Annual Delivered Fecal Coliform Load By Region



Fecal coliform bacteria are indicator organisms which are used to detect the presence of fecal material; they themselves are not pathogenic. The Fecal Coliform Model, by simulating the connection between the sources of fecal material and observed fecal coliform concentrations, provides a framework for analyzing the susceptibility of D.C. 's source water supply to water-borne pathogens. The susceptibility of D.C.'s source water to a type of pathogen contamination can be evaluated by comparing the source of the pathogens and their die-off rate in transport to the source and die-off rate of fecal coliforms. Pathogens can be distinguished by (1) whether they are specific to people or found in cattle or other animals, and (2) whether their die-off rate in the aquatic environment is less than or great than that or fecal coliform bacteria. The first factor determines which type of source is an important potential source for the pathogen. The second factor determines whether areas of the basin are potentially important sources of the pathogen. If a pathogen's decay rate is comparable to the coliform decay rate, areas in the Piedmont and the Middle Potomac region will be more important sources that the rest of the basin. If the pathogen's die-off rate is smaller, the geographic location of the source will be less important in determining the susceptibility of D.C.'s source water to specific pathogens.

Figure E.3.7 shows the classification of representative pathogens according to these criteria. Many bacteria pathogens behave like fecal coliforms and the model's simulated delivered loads will be a good guide to the relative importance of sources by type and location. The potential sources of pathogenic viruses, which only originate in human hosts and which do not die-off in the aquatic environment, are most likely to be failing septic systems, CSO, and other wastewater treatment failures. The regions with heavy cattle production, like the middle Potomac, Concocheague, and the Shenandoahs, are likely to be important potential sources of Giardia and Cryptosporidium--pathogenic protozoa that most likely die-off more slowly in rivers and streams than fecal coliform bacteria.

Figure E.3.7 Matrix For Pathogen Susceptibility Analysis

	Die-Off In Transport	No Die-Off
Human and Animal Sources	E. Coli Salmonella	Giardia Cryptosporidium
Human Sources Only	S. Typhi V. Chlorerae	Viruses

E.3.3 Pesticides

To assess the susceptibility of the District of Columbia's source water to pesticide contamination, the DOH recommended adapting the CBP Watershed Model to simulate the daily fate and transport of pesticides. The Watershed Model was modified to simulate the fate and transport of atrazine, a widely used herbicide in the Potomac River Basin.

The primary purpose of this model was to help quantify the risk posed by atrazine applications if they are applied under adverse hydrological conditions. Because atrazine is primarily transported to surface water in runoff, the risk of atrazine transport is increased if there is a storm with surface runoff following an application. The best time to apply atrazine is before a gentle rain with little runoff, so that the atrazine infiltrates into the soil. The Base Case Scenario of the model represents the recommended timing of atrazine applications.

Five additional scenarios were run, each increasing the amount of atrazine applied under hydrologically unfavorable conditions. For each model segment, dates with high runoff to rainfall ratios were chosen and atrazine application rates on those dates were increased at 20% intervals. Table E.3.1 shows for each scenario the average number of days per year on which simulated concentrations were greater than the maximum contaminant level (MCL) for atrazine of 3 ug/l.

Table E.3.1 Average Annual Simulated Violations of the Atrazine MCL

Scenario	Average Number of Days With Concentrations Above MCL of 3 ug/l
Base Case	0
20% Applied Under Hydrologically Adverse Conditions	1
40% Applied Under Adverse Conditions	7
60% Applied Under Hydrologically Adverse Conditions	22
80% Applied Under Hydrologically Adverse Conditions	33
100% Applied Under Hydrologically Adverse Conditions	51

Since the primary health risk from herbicides comes from chronic exposure, sustained concentrations at the MCL are necessary before atrazine poses a health risk. The results of these simulations suggest that the risk of sustained periods when the concentration of atrazine is above its MCL, while not negligible, are moderately low. The relatively low susceptibility of D.C.'s source water to pesticide contamination is due to dilution. The amount of herbicide applied is relatively small compared to the volume of flow in the Potomac. To sustain an atrazine concentration over the MCL in the month of June, approximately 20 to 25 percent of the atrazine applied in the basin would have to be lost from the field. Losses in the Potomac Basin can be expected to average about 1-2% annually. The susceptibility analysis for atrazine was extrapolated to two other pesticides, metolachlor and 2,4-D by comparing physical and chemical characteristics, application rates, and health action levels of these two pesticides with atrazine's. The susceptibility of D.C.'s source water was moderately low to contamination from these other pesticides as well.

E.4 Public Participation and Communication of Results

The final task as outlined in the EPA Federal Guidelines for Source Water Assessments calls for communication of results to the stakeholders through various forms of media and also through the use of public meetings. It should first be noted that the SWA Program itself was the direct result of planning and communication by the stakeholders of the District of Columbia. Prior to the implementation of the Program, numerous meetings took place in the form of citizen and technical advisory committees. These meetings provided a forum for discussion dealing with the concerns and interests of the stakeholders regarding the best method for development of a source water assessment.

E.4.1 Public Meetings and Outreach

Once the Program was approved, a first public meeting hosted by the Metropolitan Washington Council of Governments (MWCOG) was called in January of 2000 to provide information to the stakeholders on the scope of the work. A second public meeting was held in September of 2001 to discuss the progress of the assessment and to get feedback from the community on expected results from the survey. A final meeting was held to discuss the findings of the survey and to provide information on Source Water Protection within the Potomac River Basin.

A webpage was created by MWCOG to provide outreach to the citizenry of DC and to provide details of the scope and progress of the source water assessment. This webpage was updated and maintained through the public review stage of the project and was linked to DC Department of Health's website and ICPRB's website.

As an additional form of outreach, an interactive map was also created to provide locational and site-specific data on NPDES facilities throughout the basin. Users could find information on activities within their watershed and view their proximity to receiving streams and rivers or other water bodies. This service was discontinued in October of 2001 due to the potentially sensitive nature of the data.

E.5 Recommendations For Source Water Management and Protection

The purpose of this source water assessment is to determine the sources of potential pollutants that might impair the quality of Potomac River's waters, in order to better protect the District of Columbia's water supply. Given the character of the Potomac River Basin upstream of the WAD intakes, the most likely sources of potential pollutants to the intakes are toxic chemical spills, agricultural activities, and inadequate wastewater treatment. The following recommendations will help protect the quality of the District of Columbia's source water from the Potomac River:

- Real-time monitoring to detect spills and toxic chemical releases;
- More frequent monitoring of pesticide concentrations during the spring and early summer when concentrations are highest;
- Establishing an Emergency Response Network and an Emergency Response Plan to protect all water intakes on the Potomac River;
- Accelerating efforts to mitigate CSOs in the North Branch of the Potomac River;
- Assisting rural communities in identifying and repairing failing septic systems and inadequate wastewater treatment systems;
- Continuing to reduce phosphorus loads from wastewater treatment plants;

- Integrating source water protection into federal, state, and regional efforts to promote the use of agricultural BMPs such as streambank fencing, riparian buffers, soil conservation, and animal waste management; and;

- More cooperation among the basin states and among the water utilities on source water protection as well as greater integration of source water protection into other environmental programs.

1.1 Introduction

Since the 1850's, when the U.S. Army Corps of Engineers (ACE) first built the Washington Aqueduct (WAD), the Potomac River has served as a reliable source of drinking water for the District of Columbia. Today, the Potomac River remains the sole source of water for D. C. residents. ACE operates two water supply intakes on the Potomac River at [REDACTED] and [REDACTED] to supply water to the nation's capital. In addition to its conveyance systems, a thoroughly modernized WAD operates two treatment plants, at the Delcarlia and McMillan Reservoirs, which produce on average 180 mgd of drinking water that meets or exceeds all EPA standards for safe, potable water.

While WAD's facilities have proven more than adequate to treat raw water from the Potomac River, increasingly, the importance of protecting the quality of source water for drinking supplies has been recognized. Under the provisions of the 1996 Safe Drinking Water Act Amendments, each state is required to develop a Source Water Protection Program (P. L. 104-182, Section 1453). The first step in the development of such a program is a source water assessment (SWA) of the drinking water source of each water supply intake. This report is the District of Columbia's source water assessment for the [REDACTED] and [REDACTED] intakes of the Washington Aqueduct on the Potomac River.

1.2 The Components of the Source Water Assessment

Under the 1996 Safe Drinking Water Act Amendments, each SWA must contain the following four components:

1. A delineation of the watershed contributing source water to the intake;
2. An inventory of potential contaminants and their sources within the delineated watershed;
3. An analysis of the susceptibility of source water to potential contamination from these sources; and
4. Communication of the results of source water assessment to the public.

Chapter 2-5 and 8 of this report satisfy these requirements. Chapter 2 gives a general characterization of the intake watersheds, in addition to describing their delineation. Chapter 3 illustrates the time of travel concept for potential contaminants to the intakes under a variety of flow conditions. Chapter 4 describes the watershed delineation, contaminant inventory, and susceptibility analysis. Chapter 5 reviews existing monitoring data and analyzes the potential for source water contamination from known sources of contamination in the Potomac River Basin. Chapter 8 provides information on the steps leading up to the development of the assessment plan and details the public meetings that were held for stakeholder involvement and contribution.

1.3 The Use of the Chesapeake Bay Program Watershed Model in the Source Water Assessment

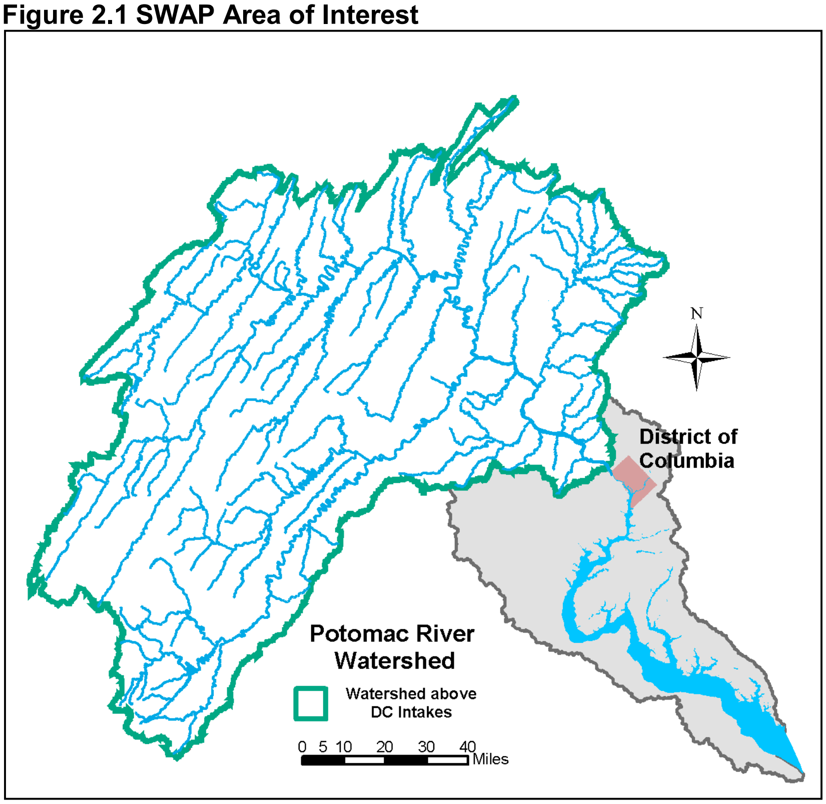
The District of Columbia faces a unique challenge in developing a source water assessment for its intakes on the Potomac River: The intakes and the contributing watershed lie wholly outside D.C.'s boundaries. The watershed covers over 11,000 square miles in the states of Maryland, Virginia, Pennsylvania, and West Virginia. Interstate cooperation is a necessity in performing the SWA and implementing any subsequent protection program.

The District of Columbia already participates in several regional programs for environmental protection, including the Chesapeake Bay Program, (CBP) a wide-ranging commitment by D.C., Maryland, Virginia, Pennsylvania, and the Federal Government to protect and enhance the waters of the Chesapeake Bay Basin. CBP has developed the Watershed Model, an HSPF model of the fate and transport of nutrients and sediment from point and nonpoint sources draining into the bay. The Watershed Model and the methodology behind it are recognized tools for assessing pollutant sources and evaluating strategies to control them. In order to better integrate source water protection into regional environmental protection programs, the Watershed Model was adapted for use in the source water assessment. Chapter 6 describes the use of the Watershed Model to evaluate the susceptibility of the District of Columbia's source water to contamination from sediment, nutrients, pathogens, and pesticides.

2.1 Source Water Delineation

One of the primary objectives for the DC source water assessment was to delineate the watershed both spatially and temporally and use this information to provide a more accurate picture of activities within the basin that might affect the water quality for the District of Columbia. The spatial boundary analysis combined with the time of travel analysis provided information that identified potential sources of contamination from stationary point sources as well as non-point activities on both a regional and a local level (Chapters 4,5,6). This information will be of value to the District of Columbia for determining potential contaminant sources within the basin as well as predicting arrival times for certain contaminants from activities that could compromise the drinking water quality (Chapter 3). The source waters for the District of Columbia water supply are the Potomac River and its tributaries within the Potomac River Basin above the intake at [REDACTED]. The Potomac River watershed includes portions of Pennsylvania, Maryland, Virginia and West Virginia. The delineations for the source water assessment are based on 11-digit USGS Hydrologic Unit Codes (HUCs). These sub-watersheds and their streams ultimately feed into the Potomac River and provide the water for which DC draws from for its water supply. Figure 2.1 shows the extent of the SWA portion of the basin in relation to the District of Columbia.

Figure 2.1 SWAP Area of Interest



2.2 General Description of Source Water

The Potomac River basin drains the eastern slopes of the Appalachian Highlands and the Coastal Plain in the Mid-Atlantic Region of the United States. The total drainage area of the source waters is approximately 11,500 square miles and extends into four states (Maryland, Pennsylvania, Virginia and West Virginia). The Potomac River extends from its source at Fairfax Stone in W. Virginia to its mouth at the Chesapeake Bay for a total of approximately 383 miles. The total length along the main stem above the intakes is approximately 270 miles.

2.2.1 Physiography

The three major tributaries are the North Branch, with a drainage area of 1,328 square miles, the South Branch, draining 1,493 square miles and the Shenandoah River Basin, with a drainage area of 3,054 square miles. In addition to these principal branches, three other large tributaries enter the main stem below Cumberland, MD; The Cacapon River, Conococheague Creek, and the Monocacy River, with a combined drainage are of 2,216 miles.
The North Branch drains the northwestern portion of the Potomac River basin in Maryland, West Virginia, and Pennsylvania. The South Branch Potomac River and Cacapon River drain the mountainous West Virginia part of the basin. The Shenandoah River drains the broad, relatively flat Shenandoah Valley in Virginia. Conococheague Creek and the Monocacy River drain the northern and northeastern parts of the basin in Maryland and Pennsylvania (Basin Facts, ICPRB). Table 2.1 and 2.2 detail the drainage characteristics for the main stem of the Potomac above the intakes as well as the larger tributaries.

Table 2.1. Major Potomac River Drainage Areas and Hydrography

Reach	Drainage Area (sq. mi.)	Length (mi.)	Average Fall (ft. / mi.)
Confluence North and South Branches of Potomac River	2,821		
Confluence North and South Braches of Potomac River to Hancock, MD	4,073	46	2.9
Hancock, MD to Harpers Ferry, WV	9,371	66	1.7
Harpers Ferry, WV to Brunswick, MD	9,420	7	7.9
Brunswick, MD to C&O Canal Feeder Dam # 2	11,390	32	1.2
C&O Canal Feeder Dam # 2 to Washington DC	11,580	18	9.8

Table 2.2. Principal Tributaries and Hydrography

Stream	Drainage Area (sq. mi.)	Length (mi.)	Average Fall (ft. / mi.)
North Branch	1,328	97	21.3
South Branch	1,493	133	11
Cacapon River	683	113.5	11.8
Conococheague Creek	563	80	18.1
Shenandoah River	3,054	181	6.4
Monocacy River	970	53	3.2

2.2.2Topography

The Potomac River basin lies in three distinct physiographic provinces. The Appalachian Province, the Piedmont Province and the Coastal Plains Province. These major provinces are sub-divided into districts; the Appalachian Province contains the Allegheny Plateau, Valley and Ridge, the Great Valley and the Blue Ridge, the Piedmont contains the Western division and Eastern Division and the Coastal Plain Province contains the Western shore and Eastern shore.

Ridges range in elevation from 1200 to over 4000 feet along the northwest and southeast boundaries. The rolling terrain west and north of the Washington Metro area, range in elevation from 200 to 1000 feet. The remainder of the basin below the fall line ranges in elevation 250 feet to sea level (Basin Facts, ICPRB).

2.3 Basin Geology

Each of the physiographic regions in the Potomac River basin presents its own geologic characteristics (figure 2.2).

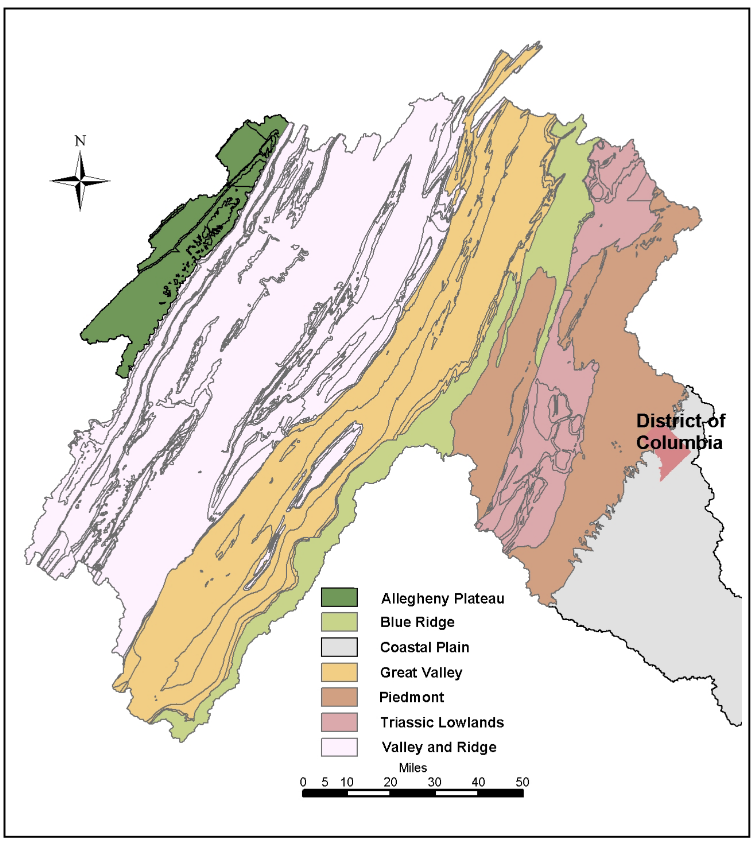
The Allegheny Plateau is a high, deeply dissected plateau formed in gently warped rocks of Upper Devonian and Mississippian age. Its high escarpment facing eastward, is known as the Allegheny Front or Allegheny Mountain. Nearly horizontally bedded shales and sandstones and shallow surface soils predominate this region.

The Ridge and Valley Province includes much more of the basin than any of the other provinces. It extends eastward from the Allegheny Front to the Blue Ridge Mountains. The ridges and valleys are roughly parallel, oriented in a northeasterly-southwesterly direction. This province is composed of intensely folded and faulted sedimentary rocks that range in age from Cambrian to Devonian. The eastern one-third or more of this province is a broad limestone valley, the Great Valley, drained by the Shenandoah River and Conococheague Creek. This valley is an area of well-developed subsurface drainage and widespread solution cavities. The western two-thirds of the Ridge and Valley Province is characterized by comparatively narrow parallel ridges and valleys with shales predominating in the valleys and the more resistant sandstones generally forming the ridges. Limestones belonging to the Helderberg formation are also present in many of the ridges and valleys.

The Blue Ridge Province is a narrow mountainous belt separating the Ridge and Valley Province from the Piedmont Plateau. This province is characterized by sharply folded quartzites, slates, phyllites and greenstones. In general, it is a single ridge composed of steeply dipping quartzites and slates of Cambrian age on the west and pre-Cambrian greenstones, schist, and granite on the east.

The Piedmont Plateau is a mature, dissected, eastward-sloping belt, within the Piedmont Province. With the exception of Catoctin Mountain and the broad Triassic Lowland immediately to the east, this Piedmont area is characterized by rounded hills an V-shaped valleys cut in pre-Cambrian schists an gneisses which have been intruded in may places by younger igneous rocks. Deep zones of soil and weathered rock are common in the valley walls and beneath the uplands (Basin Facts, ICPRB).

Figure 2.2 Basin Provinces



2.4 Land Use/Land Cover

Much of the Potomac basin outside the greater Metro area is composed of small farms and undeveloped forest. Landuse activities would include; agriculture, small-scale animal operations, surface coal mining, some light industry and timber harvesting. The numbers listed in table 2.3 represent a static look at the landuse within the basin as of 1990(CPB Model).

Table 2.3. Land usages by activity and area (sq. mi.)

Forest	High till	Low till	Pasture	Hay	PervUrb	ImpUrb	Water	Total
6163.54	370.52	642.10	1813.23	843.61	1419.50	221.62	64.92	**11539.04**

A more general analysis of the data shows that the basin is composed of roughly 53.5% forest, 32% farmland, 14% urban and the remaining 0.5% covered by water. These numbers have changed annually in the last 12 years as development continues on the periphery of the Metro boundaries within the basin. The primary change in landuse can be attributed to a growth in the regional population. As the population increases, farmland is replaced to accommodate the development activities such as housing construction and creation of suburban communities and accompanying services.

2.5 Population

Over 2 million people live upstream of the intakes (Table 2.4). Roughly half of this population lives in the greater DC Metro area of Virginia and Maryland. The remainder is scattered around the basin in rural townships and communities many located on or near the mainstem of the Potomac River or its major tributaries.

Table 2.4 Basin state demographics

State	Population (Approx)	Area (sq. mi.)
Maryland	860,000	2,430
Pennsylvania	179,000	1,585
Virginia	795,000	4,090
W. Virginia	212,500	3,500
Total	2,046,500	11,605

Pop. Estimated from Census 2000 data

2.6 General Hydrology

Average annual precipitation is least at the foothills of the Allegheny Mountains, ranging from 30 to 35 inches, but increase rapidly to 50 inches on the western divide and to 45 inches along the crest of the Blue Ridge. Monthly precipitation is generally greatest from May to August, and the smallest monthly total is likely to occur in February or November. The annual average runoff varies from 13 inches in the lower reaches of the Potomac River to about 23 inches in the North Branch. The months of greatest runoff are generally March and April while the month of least flow is usually August or September. About 43% of the annual runoff of the basin occurs during the three-month period from March through May while only 12% occurs during the three-month period from July through September. The greatest runoff occurs in the Appalachian Plateau and westernmost parts of the Valley and ridge Province. The least runoff occurs in the Shenandoah River portion of the Great Valley.

2.6.1 Streamflow Regulation

Streamflow regulation in the Potomac River Basin is minimal. The three largest impoundments in the Potomac River Basin above the intakes are the Savage River reservoir, William Jennings Randolph Lake on the North Branch Potomac River, and the Mt. Storm Lake on Stony River. William Jennings Randolph Lake and Savage River Reservoir combine to provide flood control on the North Branch and water quality control in an area affected by acid mine drainage, as well as low flow augmentation on the North Branch (USGS Report 95-4221).

2.6.2 Flow Characteristics

Maximum daily flow at Chain Bridge was 309,700 mgd and minimum daily flow was 388mgd. Flow characteristics of the basin streams are definitely related to sub-basin location and topography. The flow in small mountain tributaries varies from zero to large flood flows of short duration, and runoff in these areas is translated rapidly downstream. As a result of topographic differences and the distribution of average annual rainfall, more sustained flows are observed in the streams which enter the Potomac River from the north side, such as the Conococheague Creek, Antietam Creek and Monocacy River than those from the south. The arrangement of sub-basins within the Potomac River basin is such that tributary flood peaks often tend to synchronize and accentuate downstream flood flows. This is also characteristic of the effect of the Shenandoah River on the mainstem Potomac River states under heavy general rainfall over the entire basin.

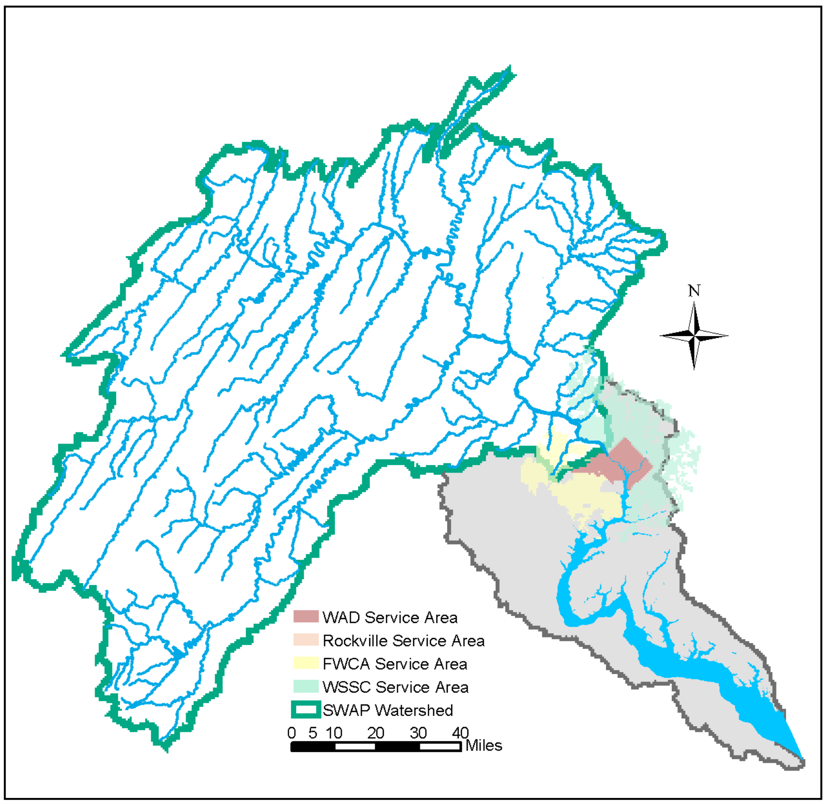
2.7 The Drinking Water System

The Washington Aqueduct is a water supplier that is owned and operated by the U.S. Army Corps of Engineers. It wholesales finished water to its three customers: the District of Columbia Water and Sewer Authority, Arlington County, and the City of Falls Church, Virginia. Washington Aqueduct through its wholesale customers serves approximately one million consumers (USACE).
The Washington Aqueduct is comprised of two water treatment plants: McMillan and Dalecarlia. Washington Aqueduct is governed by the Environmental Protection Agency (EPA) to provide safe drinking water under the Safe Drinking Water Act.

2.7.1 Other Greater Metro Water Systems

The Washington Aqueduct is not the only water supplier in the Washington metropolitan area drawing water from the Potomac River. Figure 2.3 shows the service areas of the major water utilities in the Washington metropolitan area. The Potomac River is a primary source, but not a sole source, of drinking water for the Washington Suburban Sanitary Commission (WSSC) and the Fairfax County Water Authority (FCWA). WSSC serves 1.6 million customers in Montgomery and Prince George's Counties. Their Potomac intake is located [REDACTED].
FCWA serves 1.2 million customers in northern Virginia. Their Potomac intake is located [REDACTED]. The City of Rockville also has an intake on the Potomac [REDACTED]. Their system provides water to approximately 11,000 accounts. For more information on WSSC's and FCWA's systems, see their respective SWAs (WSSC, 2002; FCWA, 2002).

Figure 2.3 Greater Washington Metro Water Service Areas



2.7.2 System Operations

The Washington Aqueduct draws water from the Potomac River as its only source water supply. The Aqueduct produces an average of 180 million gallons of water a day to a population that is generally residential and commercial. There are no major industrial customers.

On an annual basis the majority of the water is drawn from the Potomac at [REDACTED]. That water is transported to the Dalecarlia Reservoir by gravity flow in large conduits. A pumping station at [REDACTED] may be operated during high demand periods to augment the gravity flow [REDACTED]. That water also goes to the Dalecarlia Reservoir. The Dalecarlia Reservoir serves as a pre-sedimentation basin for water that is routed to either the Dalecarlia or McMillan plants for further treatment. The Washington Aqueduct utilizes conventional treatment processes consisting of coagulation, flocculation, sedimentation, filtration and disinfection (Table 2.5). The current treatment process uses alum as the coagulant. Polymers are added to enhance the coagulation and filtration processes. Fluoride is also added for the prevention of tooth decay. Occasionally carbon is added in the sedimentation basins to reduce tastes and odors caused by algae in the raw water. Both treatment plants use dual media filters for particle removal and chlorine as a primary disinfectant and chloramine as a secondary disinfectant.

Table 2.5. Filter media and site capacities for treatment facilities

Treatment Facility	Backwash frequency	No. of Filters	Filter Media Composition	Stored Water
Dalecarlia *	96	36	West filters (10)	
			Wheeler Bottom Underdrains 10" Support Gravel 12" Sand 18" Anthracite	15 mg clearwell (7mg -10mg) 30 mg clearwell (23mg - 30mg)
			East filters (26)	
			Plastic block underdrains Media retention cap 12" Sand	
			18" Anthracite	
McMillan	96	12	Block underdrains 9" Support Gravel 3" Garnet 10" Sand 20" Anthracite	North clearwell (9.5mg -14.6mg) South clearwell (16.2mg - 20.3mg)
Water Processed : 170 MGD (avg.) **Plant Capacity : 280 - 320 MGD**				

- Number and type of filter media after Filter rehabilitation (June 2002)

3.1Time of Travel Analysis

The District of Columbia SWAP segmented its source watershed areas based on travel time of stream flow to the intakes. The travel time of water in the river was used as one of the factors to assess the sensitivity of the watershed. The threshold for segmentation is the travel time that equals an estimate of the notification and response time for the treatment plant to take action in the event of an upstream spill of a contaminant. Because of an oil spill incident in March 1993 a regional spill response agreement was developed among the relevant authorities in the greater Metro area. Based on the incident and spill preparedness exercises conducted since, times of ten hours and twenty-four are viewed as appropriate for the calculation of the extent of the inner segment. The inner segment for this project is considered to be the most highly sensitive to potential contamination. The outer segment will include the rest of the watershed upstream of the inner segment.

The USGS has investigated the travel time of water in the Potomac and its sub-watersheds for several reaches at different flow conditions using dye-tracer analysis (Jack, 1984; Taylor, 1970, Taylor et al., 1985, 1986, Taylor and Solley, 1971). These results were used as the basis for development of a time of travel model maintained at ICPRB called the "Toxic Spill Model©" (Spill model) (Hogan, 1986). The ICPRB uses the spill model to determine time of travel of a toxic spill to various water supply intakes in the Washington metropolitan area, at various flow levels. ICPRB provides a 24-hour emergency spill response function as an effective tool for notification of spill events in the Potomac to water suppliers in Maryland and Virginia. This function is vital to the protection of the drinking water supply. Downstream water users are notified in time to take appropriate action, such as shutting down the intake while the contaminant passes by.

3.1.1 Methods

Two approaches were used to determine travel times in the Potomac River near the Metro DC area intakes. The first and primary approach utilized the time of travel spill model maintained at ICPRB. A second approach was used to verify the results determined by the spill model. This second approach utilized channel morphology and characteristics to determine velocity and corresponding time of travel.

The results from the USGS time of travel studies and corresponding ICPRB spill model must be interpreted with caution. The USGS provides an excellent discussion of the limitations of the assumptions and limitations of the dye tracer studies, and the circumstances by which the time of travel analysis can be applied in the field. These limitations are paraphrased below (Taylor, 1986)

The river flow during the dye studies was that of generally slowly decreasing flow. Precipitation events introduce a flood wave, or unsteady flow conditions, into the river. The effect of unsteady flow on the movement of a discrete particle of water is indeterminate by dye-tracer studies and procedures to handle such a situation were beyond the scope of the USGS studies. When a significant flood wave is present in the system added uncertainty will be introduced in the results. Because the dye tracer studies were undertaken at essentially steady flow conditions, the Spill model is best utilized when flow is neither rapidly increasing or rapidly decreasing. As flow conditions change, the spill model should be repeated iteratively to assess the effect of changing flow conditions, and to determine the most current discharge information.

Two velocities were determined for associated river flow levels for each dye tracer study. In interpolating and extrapolating the study results to assess travel times at other flow levels, a log-linear relationship was assumed. In reality, the relationship may be slightly curvilinear, but at least three measurements would be necessary to assess the curvilinear relationship.

Complete lateral mixing was assumed in development of the concentration attenuation procedures. However, these conditions are not continuously maintained because of large inflows of water from major tributaries to the Potomac. When lateral mixing is incomplete, the estimate of contaminant concentration may be higher than that actually experienced.

All calculations of contaminant concentration assume a conservative substance. No evaporation of the substance was assumed or binding to sediments with removal from the water column as the contaminant moved downstream. In actual situations, physical, chemical, or biological processes could decrease the concentrations as compared to that predicted by the spill model.

The dye study method incorporates the use of a dye that is completely soluble. The behavior of immiscible or floating substances cannot be determined by the techniques presented in the USGS report.

The dye tracer studies measure the travel time of a dye injected at several points across the river. An actual spill is unlikely to occur in this manner. More likely, such a spill would occur in a river tributary or shoreline. Travel times at a river bank are generally slower than that of the main river, so the travel times of a spill under these circumstances will generally be slower than that predicted by the model. Also, the contaminant would likely be concentrated on one side of the river. The distance required for complete lateral mixing can be substantial, in particular for rivers with a large width-to-depth ratio.

The USGS studies used in the spill model describe a minimum of two travel time analyses (dye studies) for each river reach at different flow rates. These studies provide information for the interpolation and extrapolation to travel times corresponding to a wide range of flows. Some caution is warranted in extrapolating beyond the flows used to calibrate the spill model. The flows used to calibrate the spill model for the Potomac reaches were at the 10th and 40th percentiles.

Once supplied with a description of the magnitude and timing of the spill, the model may be used to provide the time of travel of the leading edge of contaminant cloud, the time of arrival of the maximum contamination, and the time of travel of the trailing edge of the contaminant. The spill model was calibrated for three river segments of the Potomac River between Point of Rocks and Little Falls. The first segment was from Point of Rocks to Whites Ferry (12.4 mile subreach), the second from Whites Ferry to the mouth of Seneca Creek (13.2 mile subreach), and the third from Seneca Creek to Little Falls dam (16.8 mile subreach).

Table 3.1: Potomac River reaches in the Spill model

[REDACTED]

The spill model was used to provide travel times for each calibrated reach of the river at different flow regimes. The 90th percentile flow at Point of Rocks on the Potomac corresponds to 20,700 cfs, the 50th percentile flow to 5,380 cfs, and the 10th percentile flow to 1,680 cfs (R.W. James et al., 2001). Travel times for the time of arrival of the peak concentration level are provided in Table 2.

Table 3.2: Spill model travel times for calibrated reaches of the Potomac

[REDACTED]

3.1.2 Verification of Spill model approach using hydraulic equations

The spill model was verified using a second approach, which incorporated channel characteristics and stream channel geometry in hydraulic equations to determine velocity and corresponding time of travel. Physical and geometric properties of selected reaches of the Potomac River between Point of Rocks and Chain Bridge are given in Table 3.

Table 3.3: Physical and geometric properties of selected reaches of the Potomac River between Point of Rocks and Chain Bridge

Description	River Mile	Length (miles)	Slope (ft/ft)	Width of Channel (ft)	Mannings n
Point of Rocks to Mouth of Monocacy	0-6.2	6.2	0.00025	905	0.065
Monocacy to Mason Island	6.2-11	4.8	0.0002	954	0.056
Mason Island to Goose Creek	11.0-17.2	6.2	0.00015	1025	0.036
Goose Creek to Tenfoot Island	17.2-22.4	5.2	0.00015	1400	0.035
Seneca Pool	22.4-25.8	3.4	0.00006	1920	0.028
Seneca Breaks	25.8-27.2	1.4	0.0014	2015	0.09
Watkins Island	27.2-32.0	4.8	0.0007	1641	0.085
Great Falls Pool	32.0-32.9	0.9	0.0004	1760	0.04
Great Falls	32.9-35.0	2.1	0.008	300	0.069
Stubblefield Falls	35.0-37.6	2.6	0.0009	759	0.093
Cabin John	37.6-40.6	3	0.0006	965	0.081
Little Falls Pool	40.6-41.6	1	0.0002	1475	0.034
Little Falls	41.6-43.2	1.6	0.0034	321	0.09

Source: MWCOG, 1984, as cited in FCWA, 2002

Mannings equation can be used with the physical and geometric properties from Table 1 to determine time of travel. Mannings equation is:

$$V = (1.49/n)*R^{2/3}*S^{1/2} \qquad (1)$$

where

V = velocity (ft/second)
n = Mannings n, a channel roughness coefficient
R = hydraulic radius (ft)
S = channel slope (ft/ft)

The hydraulic radius is the ratio of the area in flow to the wetted perimeter (i.e., the ratio of the cross-sectional area of the channel divided by the wetted perimeter). Streamflow is the product of the cross sectional area of flow and velocity. Equation 1 can then be written as:

$$Q = VA = (1.49/n)*AR^{2/3}*S^{1/2} \qquad (2)$$

where

Q = Flow (cubic feet per second)
A = Channel area (square feet)

For a wide channel such as the Potomac in which the width is much greater than the depth, the hydraulic radius is approximately equal to the flow depth, D. If the channel shape is approximated as a wide rectangle, then equation 2 can be modified as:

$$Q = (1.49/n)*D^{5/3}*S^{1/2} \qquad (3)$$

where

D = Average channel depth (ft)

Equation 3 can be used to solve for depth if streamflow, channel roughness, and slope are known. Once depth is calculated, it can be used to solve for velocity through the relationship V = Q/A. The parameters from Table 3 were used to calculate average velocities for each river segment given different flow regimes. Table 4 shows average velocities for various river reaches in the Potomac at 90th, 50th, and 10th percentile flows.

Table 3.4: Average velocities for various river reaches in the Potomac at 90th, 50th, and 10th percentile flows

Description of river reach	Velocity (ft/sec)		
	90th percentile flow (20,700 cfs)	50th percentile flow (5,380 cfs)	10th percentile flow (1,680 cfs)
Point of Rocks to Mouth of Monocacy	1.90	1.11	0.70
Monocacy to Mason Island	1.90	1.11	0.70
Mason Island to Goose Creek	2.21	1.29	0.81
Goose Creek to Tenfoot Island	1.98	1.16	0.73
Seneca Pool	1.52	0.89	0.56
Seneca Breaks	1.90	1.11	0.70
Watkins Island	1.73	1.01	0.64
Great Falls Pool	2.24	1.31	0.82
Great Falls	8.05	4.71	2.96
Stubblefield Falls	2.41	1.41	0.89
Cabin John	2.11	1.23	0.77
Little Falls Pool	2.15	1.26	0.79
Little Falls	5.17	3.02	1.90

Given the velocities from Table 4, travel times for each river segment can be calculated since the length of each segment is known. Table 5 provides travel times for each river segment.

Table 3.5: Travel times for various river reaches in the Potomac at 90th, 50th, and 10th percentile flows

[REDACTED]

The comparison of the two approaches shows good agreement at the 50th percentile flow regime, with the hydraulic model predicting a 51.8 hour travel time from Point of Rocks to Little Falls and the Spill model predicting a 53 hour travel time.

However, the models diverge at the 10th and 90th percentile flows. At the 10th percentile flow, the hydraulic model predicts an 82.5 hour travel time between Point of Rocks and Little Falls dam, and the Spill model predicts a 121 hour travel time. The USGS has conducted dye trace studies at the 10th percentile flow. These studies show that the travel time for the peak concentration of dye between these points was 134 hours (Taylor et al., 1984), and the travel time for the leading edge of the dye was 122 hours. The dye studies suggest that more confidence be placed in the longer travel time predicted by the spill model of 121 hours for this flow regime.

At the 90th percentile flow, the hydraulic model predicts a 30.3-hour travel time between Point of Rocks and Little Falls dam, and the Spill model predicts a 20-hour travel time. Because the USGS has not conducted dye studies at the 90th percentile flow both models could not be verified at this flow regime. The Spill model value falls outside of the calibration limits of the model so the results should be interpreted cautiously. Based on this comparison, the shorter travel times predicted by the spill model at higher flows will be used for the SWA since this incorporates a greater land area and allows for more sources to be considered in the ranking process.

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4.1 Potential Point Source Pollution Sites and Contaminant Inventory

An inventory and analysis of potential point source contaminants for a source water is one of four major tasks required by the EPA SWA guidelines. Availability of these data to a community water supply can provide valuable information for decision-making processes. Knowledge of a contaminant's location in relation to a water supply can be used in the evaluation of the overall risk to a water supply or can be used in the event of an accidental or intentional spill.

For the DC source water assessment, analysis of the entire source watershed for the non-tidal Potomac River was completed and used to determine what potential contaminant sources could impact DC's public drinking water system. The susceptibility analysis included the delineation of time of travel boundaries upstream of the [REDACTED] intake. A GIS application was developed which used these time of travel boundaries to analyze the potential contaminant sources (PCSs) for their potential to threaten the public water supply.

4.1.1 Sources of Contaminants

A point source can be described as a fixed site or facility that either discharges a product to a receiving water body or has materials on site that are considered hazardous and have the potential for release to a receiving water body. Types of facilities or activities that could be included in these categories include drinking water treatment plants (WTPs), waste water treatment plants (WWTPs), combined sewer overflows (CSOs), and industrial facilities that discharge into receiving waters. Because of the very nature of their activities, WTPs and WWTPs are considered to be of a somewhat higher risk because of their proximity to a receiving water and because they are potential sources of either pathogens or by-products of treatment. Also, industrial facility dischargers (IFDs) that are located adjacent to or near a receiving water have a higher potential risk for contaminating a water supply through accidental spills. Appendix B provides a detailed listing of the types of contaminants that may be associated with different business activities.

Another critical potential source of contamination includes locations where roads, railroads or pipelines cross a stream or river. Considering the extensive network of roads that intersect streams and rivers within the basin, these sites are of particular concern because of their potential as sites for accidental or intentional release of hazardous materials. GIS analysis was used to identify and map these potential spill points (Figure E.2.3).

4.1.2 Data Sources

An inventory of potential point sources of contaminants within the Potomac basin has been compiled from existing databases and entered into a master database. Sources of these data include Federal and State agencies and consist of discharge and release inventories, hazardous waste sites, landfills, underground storage tanks (USTs), underground injection wells (UICs) and other activities identified through local field surveys. The main Federal resources for these data include the National Pollution Discharge Elimination System (NPDES), Toxic Release Inventory (TRI), Permit Compliance System (PCS), Resource Conservation and Recovery Information System (RCRIS), and the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). In addition, windshield surveys were performed by West Virginia and Virginia and provided data on small quantity generators or activities that used small amounts of hazardous substances in their operations. Table 4.1 lists the source information for the master database.

Table 4.1 Database acronyms

Database Source or Type
CERCLIS - Comprehensive Environmental Response, Compensation, and Liability Information System (Superfund)
IFD – Industrial Facilities Discharge
MINES – USGS mineral database
NPDES - National Pollutant Discharge Elimination System
RCRIS - Resource Conservation and Recovery Information System
TRI – Toxic Release Inventory
WTP – Water Treatment Plant
WWTP – Waste Water Treatment Plant
CFO – Commercial Facility Operations
IFO – Industrial Facility Operations
Harris - Harris Industrial Database
UIC Class V – Underground Injection Wells

4.2 Geographic Information Systems

As with most source water assessments throughout the United States, a geographic information system (GIS) was used as a multi-purpose tool to map, model and spatially analyze the large amounts of data that were collected. The District used ESRI’s ArcView 8.3 software to compare, categorize and rank locational and site-specific information on facilities within the basin. Because the DC SWA is a first step in watershed protection and provides only a snapshot of current activities, it will be necessary to re-examine the basin as new data becomes available. An application was created to facilitate this process and analyze these new data on a regular basis. Use of this tool will be of value to the District as it progresses into the next phase of watershed protection.

4.2.1 Search and Query Application

The DC SWA GIS application was created on an ESRI ArcGIS 8.3 framework, using standard Visual Basic –Application (VBA) coding. Most of the application is form and macro driven, meaning buttons and button combinations on user forms activate internal programming to perform desired functions.

The application contains a variety of base map data layers, from county and state lines to stream reaches and roadways. Introducing the potential contaminant sources to the base layers creates an interactive map and provides the user the ability to perform spatial analysis for sites throughout the basin. The Search and Query application allows the user to perform surveys of contaminants in the time of travel segments based on ranking. Simple surveys can be performed using a one-click tool set or for more complex surveys a user-defined query can be performed with additional ArcView tools. A manual for the use and operation of the GIS Search and Query Application can be found in Appendix C.

4.3 PCS Ranking Criteria

Due to the large number of facilities and sites within the basin, a ranking process was developed to allow for identification of PCSs, and to assess the potential risk of each site to the water supply. A time of travel analysis was used as a method for parsing the facility database. Travel times were calculated for three different flow velocities, those experienced at the 10^{th} percentile, 50^{th} percentile, and 90^{th} percentile flow levels. The 10^{th} percentile flow is a relatively low flow that is exceeded 90% of the time. The 50^{th} percentile flow, or median flow, is the flow that is exceeded 50% of the time. The 90^{th} percentile flow is a relatively high flow that is exceeded only 10% of the time. Travel times of 10 and 24 hours at the three flow velocities on the mainstem of the Potomac were used to delineate the time of travel boundaries shown in Figure 4-1.

Facilities falling inside the 10 hr-10th percentile boundary were considered to have a higher potential for contamination to the source waters. A rank of “medium” was assigned to facilities that fell outside the 10 hr -10th percentile boundary but within the 24hr - 90th percentile boundary. Facilities that were outside the 24hr – 90th percentile boundary were ranked as having a low potential for contamination.

[REDACTED]

Figure 4-1. Estimated time of travel boundaries used for the susceptibility analysis.

4.4 Analysis Results

GIS analysis of the PCSs was performed using the above time-of-travel ranking criteria. Table 4.2 details the types and rankings of the facilities located in each jurisdiction. Of the 8,025 facilities or types of activities identified in the Potomac basin upstream of Washington, D.C, 6,377 had a low ranking as a PCS, 1,165 had a medium ranking, and 477 ranked as high for the potential to impact the source waters.

Within the federal databases, Maryland showed a total of 1,420 activities or facilities in the Potomac basin, of which 406 were considered medium to high risk as potential sources of contamination. The federal databases listed 1,288 facilities or activities in Virginia, of which 278 ranked medium to high as potential sources of contamination. Of the facilities identified in Virginia's detailed state database, 958 out of 3,785 facilities or activities were considered to have medium to high potential for source water contamination based on their proximity to the [REDACTED] water supply intake. All of West Virginia's and Pennsylvania's facilities or activities are well outside the time of travel boundaries and far enough upstream that they are considered low risks as potential sources of contamination.

Table 4.2 also shows the PCSs by activity type.

Waste water treatment plants (WWTPs), combined sewer overflows (CSOs), and large agricultural operations requiring NPDES permits (NPDES Ag Operations) may be of particular concern as potential sites for fecal contamination. Figure E.2.1 maps these categories of PCSs. Petroleum contamination may also present particular concern, and the locations of petroleum pipelines, tank farms, and above ground storage tanks (ASTs) are shown in Figure E.2.2.

Table 4.2 Types of activities and susceptibility ranking

Federal Data													
States	**MD**			**MD Totals**	**PA**	**PA Totals**	**VA**			**VA Totals**	**WV**	**WV Totals**	**Basin Totals**
Activity/Ranking	HIGH	MEDIUM	LOW		LOW		HIGH	MEDIUM	LOW		LOW		
CERCLIS	2		3	5	1	1	1		4	5			11
IFD	6	21	234	261	57	57	1	6	110	117	187	187	622
MINES	21	11	137	169	88	88			39	39	93	93	389
NPDES	11	31	208	251	75	75	5	27	427	460	116	116	902
RCRIS	132	156	348	636	215	215	125	99	300	524	99	99	1479
TRIS	1	9	42	52	26	26	2	6	90	98	25	25	201
WTP/WWTP	4		42	46	20	20	2	4	35	41	15	15	122
Federal Totals	177	229	1014	1420	482	482	136	142	1005	1288	535	535	3726
State Data													
Activity/Ranking	HIGH	MEDIUM	LOW		LOW		HIGH	MEDIUM	LOW	**VA Totals**	LOW	**WV Totals**	
Airports									8	8			8
CFOs							130	512	443	1085			1085
Harris							34	281	555	870			870
IFOs									1744	1744			1744
Landfills								1	10	11			11
Tirepiles									28	28			28
UIC ClassV									39	39			39
Agriculture											117	117	117
Commercial											256	256	256
Industrial											48	48	48
Municipal											75	75	75
Residential											18	18	18
State Totals							164	794	2827	3785	514	514	4299

5.1 Sites of Known Chemical Contamination

Three facilities mentioned in the DC SWAP Plan were considered to be potential sources of chronic contamination. Listed below are descriptions of each facility, the contaminant of concern, remediation if any, and an assessment of the likelihood for downstream transport of each contaminant.

5.1.1 Background

(1) PCB contamination is associated with the AVTEX Fibers Superfund Site in Front Royal, VA. The source of contamination was probably from leaky electrical transformers used to regulate electricity and dryers that used PCBs for heat transfer during the fiber production process. Contamination of the sediments downstream of the facility most likely occurred from direct release of wastes from settling ponds during storm events and release of wastes directly to the groundwater and soil via cracks and leaks in the storm water sewers (SDMS 135739). The site has been closed since 1989 and is currently being undergoing remediation.

(2) Mercury contamination of the South Fork of the Shenandoah River stems from chemical processing activities at the DuPont Plant in Waynesboro, VA. The mercury was discharged from the plant between 1929 and 1950 and has led to contamination of the sediments downriver. No action or rehabilitation of the downstream sediments has taken place at the time of this writing and a fish consumption advisory remains in effect for the South River and the South Fork of the Shenandoah because of elevated levels of mercury.

(3) Dioxin contamination in the North Branch of the Potomac River was derived from effluent from a Westvaco paper mill in Luke, MD. Fish advisories were put in place by Maryland and West Virginia in 1990. In reaction to the advisories, Westvaco has spent 40 millions dollars putting controls in place to reduce the level of dioxins being discharged. No remediation has been performed and fish advisories remain in place as water quality monitoring continues.

5.1.2 Site Assessments

Studies have been performed at each site to address the level of contamination and to determine the potential for movement of each contaminant downstream of the source. Results are summarized below.

1) Analysis for on-site and off-site contamination of PCBs at the AVTEX facility was performed by the Virginia Department of Environmental Quality (VDEQ,2001). A separate analysis was performed by the USGS for its 1996 NAWQA study of the Potomac River Basin. Sediment and fish tissue samples in both surveys showed a reduction of PCBs with distance downstream from the facility.

Although no testing was performed on the mainstem of the Potomac River, raw water values from sampling at the intakes at [REDACTED] show no values above the detection limit. There is no MCL for PCBs.

2) Sediment and fish tissue sampling was performed for the NAWQA study to determine the level of mercury and its possible movement downstream of the outfall at the DuPont facility. An earlier study by Lawler, Matusky & Skelly Engineers performed fish tissue, sediment and water column analysis upstream and downstream of the facility to determine the level of contamination and feasibility of mercury removal from the sediments.

   A similar downward trending was observed for mercury levels in relation to the distance downstream. No testing was performed on the mainstem of the Potomac River but raw water values for samples taken at Great Falls never approached the 50% MCL and in most cases were either non-detect or below the detection limit.

3) Fish tissue studies were performed by the West Virginia Department of Fish and Game. In-house testing on outfall affluent has regularly been performed for dioxins since the controls have been put in place.

   Fish tissue studies have also shown a trending downward of dioxin levels in relation to distance downstream of the outfall. According to Westvaco, in-house laboratory analyses for dioxins have consistently reported levels at non-detect since control measures were put in place. Historic raw water values for dioxins at Great Falls have never exceeded 50% of the MCL and in most cases are below the detection limit.

5.1.3 Observations

There is no question that the mercury, PCBs and dioxins will remain in the sediments for quite some time and have the potential to be a chronic source of contamination for local aquatic biota and source waters for local downstream communities. There is also the potential for the movement and redeposition during large storm events (USGS NAWQA, VADEQ, LM&S Engineers). But, considering that much of the contaminants are sorbed onto sediment particles, and given the distance downstream to the DC intakes it would appear that the likelihood of these contaminants having a direct impact on DC's water quality is very low. As mentioned, raw water sampling is regularly conducted for dioxins, mercury and PCBs at the Washington Aqueduct and these samples consistently test below the 50% MCL or below the detection limit. So, it is suggested that the three sites of known contamination are not an immediate or direct concern to the District of Columbia for their contamination potential.

The Use of the Chesapeake Bay Program's Watershed Model in the Susceptibility Analysis for the District of Columbia's Source Water Assessment

6.1 The Watershed Model's Role in the Source Water Assessment

The Potomac River drains into the Chesapeake Bay, the largest estuary in the United States. In the face of deteriorating water quality and living resources in the bay, the states of Maryland, Pennsylvania, and Virginia, the District of Columbia, and the Federal Government entered into a partnership, the Chesapeake Bay Program, to restore water quality in the bay. Excess nutrient loads are blamed for the deterioration of water quality. Excess nutrients lead to excess algal growth; the subsequent decay of algae leads to decreases in oxygen levels in the bay. CBP has primarily focused on reducing nutrient loads to the bay from wastewater treatment plants, agricultural activities, and other nonpoint sources. Sediments, which decrease water clarity, and toxic contaminants, have also become concerns of the CBP.

CBP maintains several computer simulation models to help understand the impact of nutrient and sediment loads on water quality in the bay and to evaluate management scenarios for nutrient and sediment reduction. The Watershed Model is an HSPF (Hydrological Simulation Program--Fortran) model of all the watersheds, including the Potomac River Basin, which drains into Chesapeake Bay. The Watershed Model simulates the flow, sediment transport, and nutrient dynamics, which determine the nutrient and sediment loads to the bay. These loads are used to drive the Water Quality Model, a computer simulation model of water quality in the bay itself. The Watershed Model can also be used to predict the flows, nutrient, and sediment loads that would occur under different scenarios for nutrient reduction, or if, for example, nothing is done to limit nutrient loads as population in the basin grows. The loads from these management scenarios can then be fed into the Water Quality Model to determine the impact that the loading scenarios have on the bay.

HSPF is a flexible model. It can simulate both point and nonpoint sources. It can simulate many types of pollutants, although it has special modules for simulating sediment and nutrient dynamics. It is capable of simulating all elements of the hydrological cycle--precipitation, interception, infiltration, runoff, interflow, percolation, and ground water discharge. It also can simulate the fate and transport of pollutants through all these phases of the hydrological cycle. It is capable of simulating both pervious and impervious surfaces, and it can take the flows and the pollutant loads from these land surfaces and route them through river channels and reservoirs. HSPF also simulates the processes that occur in transport in channel reaches, such as erosion, deposition, or the uptake of nutrients by algae. Bicknell et al.(1996) provide a full description of HSPF's capabilities.

HSPF's flexibility comes at the price of complexity. It requires a great deal of information to run the model. Many parameters have to be set; many are determined by calibrating the model against observed data. Watersheds must be divided into land uses, which are treated as homogeneous areas for the sake of the simulation. Constituent loads must be determined for each type of land use. The hydrological simulation in HSPF is driven by hourly meteorological data. HSPF uses a "level pool" method of routing flow through reaches, in which the outflow of each reach is determined as a single-valued function of storage. Information must be collected on each channel to determine the routing function and other reach characteristics.

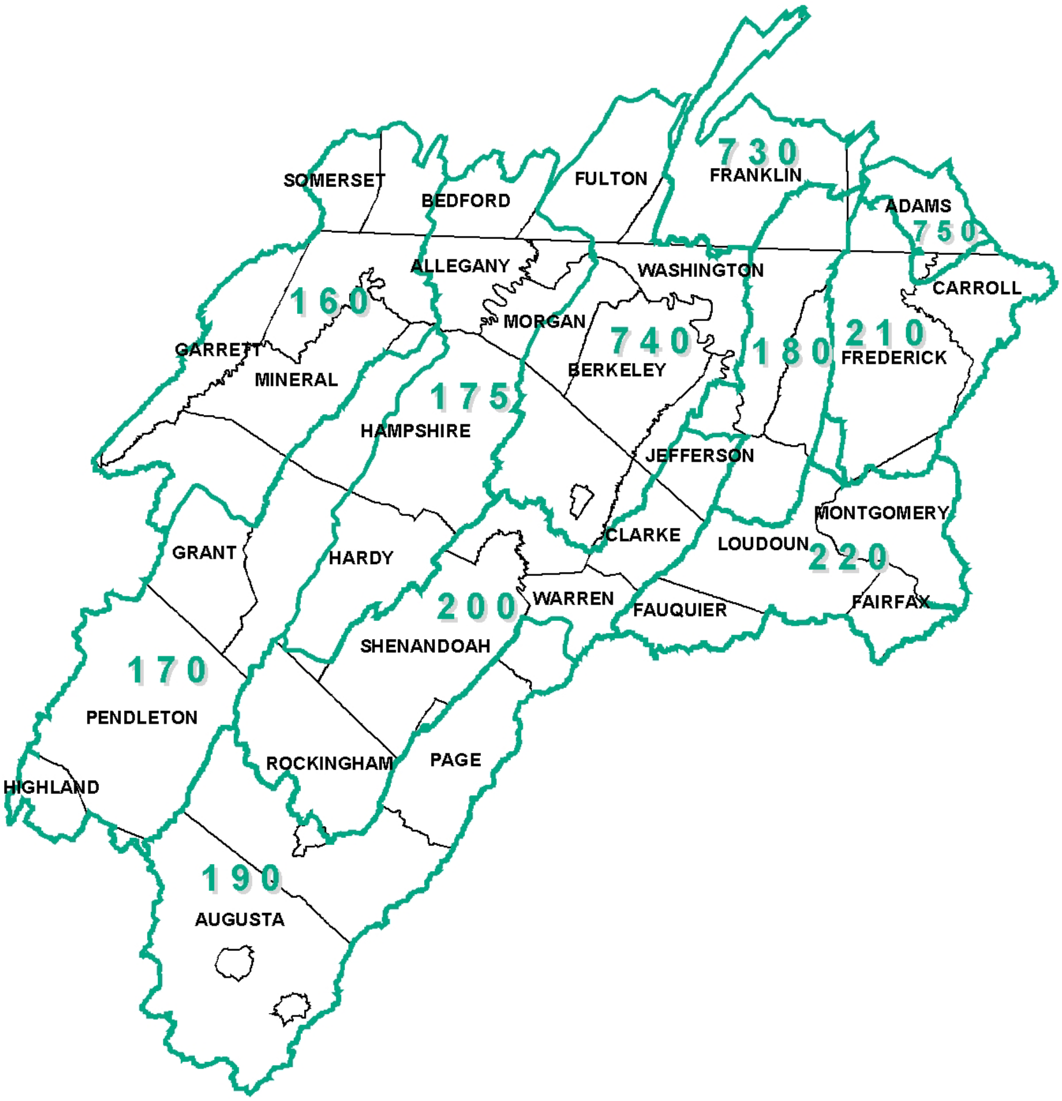
To cover an area the size of the Chesapeake Bay Basin, the size of model segments, which represent watersheds, and the river reaches draining them, is very large. There are 11 model segments in the Potomac River Basin above the Potomac fall line. Figure 6.1.1 shows the location of the model segments. Table 6.1.1 shows the watersheds associated with each segment number. The average size of a segment is almost 1000 square miles, and the corresponding river reaches range from 21.5 to 139 miles in length.

Table 6.1.1 Watershed Modeling Segments

Segment	Watershed
160	North Branch of the Potomac River
170	South Branch of the Potomac River
175	Upper Potomac River
180	Point of Rocks
190	South Fork of the Shenandoah River
200	North Fork and Mainstem of the Shenandoah River
210	Lower Monocacy River
220	Lower Potomac River
730	Conococheague Creek
740	Middle Potomac River
750	Upper Monocacy River

Six pervious and two impervious land use types are represented in each segment: forest, hay, pasture, conventional tillage (high till), conservation tillage (low till), pervious urban, impervious urban, and "manure" acres, which represent impervious areas of feedlots and concentrated animal operations that have the potential to produce runoff with high concentrations of nutrients. Calculation of how much of a segment belongs to land use type is a complicated procedure, described more fully in Appendix E of model documentation (Modeling Subcommittee, 1998). The land use is primarily based on the EPA's EMAP (Environmental Monitoring and Assessment Program) land use/land cover. Information from the U. S. Department of Agriculture's Agricultural Census was used to determine the areal extent of agricultural land uses. The Agricultural Census provides information on a county level. County acreages were apportioned among modeling segments by determining what fraction of a county's herbaceous acreage, outside of urban areas, is in a modeling segment. Herbaceous land cover is the EMAP land cover associated with crops and grassed areas like pastures and lawns. Essentially, if 25% of a county's herbaceous acres are in a segment, 25% of the acreage of crops and pasture in that county would be apportioned to that segment. For the most part, there are more acres of herbaceous land cover in the watershed than agricultural land recorded by the census. The additional herbaceous acres are classified as “mixed open” land, but simulated as urban pervious land.

Figure 6.1.1 Modeling Segments in the CBP Watershed Model



The determination of model segment characteristics on the basis of county-level information is typical of the challenge the CBP faced in developing an HSPF model on the scale of the Chesapeake Bay Basin. On the whole they have been successful in developing a methodology to account for nutrient and sediment loads in the basin from a variety of sources: wastewater treatment plants, septic systems, animal operations, crop management, and even atmospheric deposition. And on the whole, though not without some controversy, the Watershed Model has been accepted as a management tool in developing strategies for nutrient reduction in the watersheds of the basin.

The District of Columbia is interested in finding common ground between the protection of its drinking water supply and the CBP's strategies to reduce nutrient, sediment, and toxic contaminant loads to the bay. For that reason, the Watershed Model and the CBP methodology behind it were used to help perform the susceptibility analysis for the source water assessment. The Watershed Model is geared towards predicting nutrient and sediment loads entering the Potomac estuary at the fall line. It is calibrated against observed flows at the [REDACTED] intake and against water quality data collected [REDACTED] at Chain Bridge, which connects D. C. with Arlington, VA. The Potomac portion of the Watershed Model is, on a regional scale, a computer simulation model of water quality at the source water intakes. It would be negligent not to use the Watershed Model to help determine the upstream sources of nutrient and sediment loads, which potentially effect source water quality.

Second, the sources of nutrient and sediment loads--wastewater treatment plants, septic systems, agricultural operations--are also sources of other constituents that can have an impact on source water quality. Pathogens, for example, are associated with livestock, manure disposal, failing septic systems, and wastewater treatment plants. Pesticides are applied as part of the same agronomic schedule of planting, fertilizing, and harvesting that is already represented in the Watershed Model. For this reason, the Watershed Model was extended so it can provide a regional analysis of the sources of other constituents that could adversely impact drinking water supplies. Modifying the Watershed Model to represent these other constituents extends a recognized management tool that has already been used to develop strategies for pollution reduction and prevention. It provides a way of evaluating how these strategies might impact source water quality and a common language for explaining that impact to stakeholders and regional partners in the Bay Program. This is especially important, since the watershed for the intakes encompasses a large geographic area lying wholly outside the boundaries of the District of Columbia. D. C. can take advantage of its participation in a regional partnership to reduce pollutant loads which flow pass their intakes--entering the estuary less than [REDACTED] downstream.

The Watershed Model will therefore be used for three tasks in the susceptibility analysis:

1. The Watershed Model will be used to characterize the size and sources of nutrient and sediment loads, both under current conditions and in the face of

population growth;

2. The Watershed Model will be modified to represent the fate and transport of fecal coliform bacteria, which serve as indicators of water-borne pathogens; and

3. The Watershed Model will be modified to evaluate the susceptibility of D. C.'s source water to contamination by pesticides.

Version 4.3 of the Watershed Model, available through the CBP as the Community Model, was used in the susceptibility analysis. The Reference or Calibration Scenario was used as the basis for the modifications for representing fecal coliforms and pesticides. The scenarios used to analyze nutrient and sediment loads will be explained below.

6.2. Nutrient and Sediment Loads at the Source Water Intakes

Nutrient and sediment loads can adversely impact source water quality. Sediment and particulate organic matter must be removed from finished drinking water. Excess nutrient loads can lead to algal growth, which in turn can lead to taste and odor problems.

6.2.1 Current Nutrient and Sediment Loads

The CBP 2000 Progress Scenario was used to calculate nutrient and sediment loads delivered to the Potomac estuary just below Chain Bridge, [REDACTED].
The Progress 2000 Scenario is a fourteen-year simulation, using meteorology and hydrology from 1984-1997, but representing current nutrient and sediment loadings. It thus represents current conditions independent of hydrological variations that can affect the quantity of nutrient or sediment loads in any given year. Table 6.2.1 shows simulated average annual sediment loads, Table 6.2.2 shows simulated average annual total nitrogen loads, and Table 6.2.3 shows simulated average annual total phosphorus loads. The loads ten-year averages from the period 1985-1994. In the tables the nonpoint source loads from conventional till crops, conservation till crops and hay have been combined under the "crops" category; the nonpoint source loads from pervious and impervious urban land have also been combined.
As Table 6.2.1 shows, a total of 1.6 million tons of sediment are delivered each year. Half of the load comes from crops and hay. A quarter of the load comes from pasture. Only 11% comes from forest and 14% comes from urban land. About a third of the load comes from the Shenandoah Valley, Segments 190 and 200. The Middle Potomac region, Segment 740, is also a large source of sediment. Cropland in the Shenandoahs, the Middle Potomac, and the Monocacy all produce over 100,000 tons of sediment a year.

Table 6.2.1 Simulated Annual Average Sediment Loads Under Current Conditions (tons/yr)

Segment	Forest	Pasture	Crop	Urban	Total
160	17,296	26,311	18,004	10,999	72,610
170	17,297	95,479	26,973	18,274	158,023
175	16,034	49,189	30,731	15,309	111,263
180	6,361	15,992	73,239	14,878	110,470
190	21,560	89,590	154,692	28,913	294,755
200	35,109	49,000	100,785	29,360	214,253
210	6,708	12,020	100,316	19,321	138,364
220	15,719	21,615	63,581	22,114	123,030
730	9,529	8,165	73,650	11,969	103,313
740	29,554	35,720	114,740	42,037	222,051
750	1,549	2,738	28,209	4,459	36,955
Total	176,715	405,818	784,921	217,635	1,585,088

Table 6.2.2 Simulated Annual Average Total Nitrogen Loads Under Current Conditions (lbs/yr)

Segment	Forest	Pasture	Crop	Feedlot	Urban	Point Source	Septic	Total
160	1,037,212	412,485	494,983	53,243	459,590	343,404	74,979	2,875,896
170	627,448	790,415	977,509	111,340	309,083	190,302	44,443	3,050,540
175	829,318	450,314	725,171	87,089	252,898	2,544	63,298	2,410,631
180	184,204	363,038	1,605,615	159,073	450,521	365,229	212,956	3,340,636
190	277,717	618,687	700,680	97,878	331,872	328,270	112,474	2,467,578
200	361,508	697,410	1,481,107	124,671	432,231	539,119	164,029	3,800,075
210	262,261	310,612	1,839,654	68,260	540,881	511,274	276,619	3,809,562
220	324,534	531,446	1,356,321	26,563	1,379,245	399,105	283,951	4,301,167
730	224,576	375,881	1,746,416	477,199	305,514	107,027	88,503	3,325,115
740	606,948	632,983	1,271,126	106,322	961,857	395,397	313,736	4,288,369
750	44,179	64,824	511,870	31,761	106,806	24,954	34,662	819,056
Total	4,779,904	5,248,095	12,710,452	1,343,400	5,530,499	3,206,626	1,669,649	34,488,625

Table 6.2.3 Simulated Annual Average Total Phosphorus Loads Under Current Conditions (lbs/yr)

Segment	Forest	Pasture	Crop	Feedlot	Urban	Point Source	Total
160	12,402	63,992	39,359	7,312	33,027	80,645	236,737
170	9,613	112,648	68,355	15,160	22,809	40,326	268,912
175	9,695	48,107	41,254	9,934	15,352	456	124,799
180	1,351	27,857	90,736	15,720	43,856	66,173	245,693
190	5,260	218,194	155,498	24,320	75,408	177,723	656,404
200	6,000	115,970	186,993	16,753	57,966	112,062	495,745
210	3,159	39,933	161,846	7,843	63,481	73,792	350,055
220	4,118	77,985	91,566	2,538	134,099	30,678	340,985
730	2,219	18,648	89,420	55,876	18,475	28,083	212,720
740	5,809	40,879	77,392	11,418	53,335	46,907	235,739
750	715	10,743	54,827	4,195	15,579	3,156	89,216
Total	60,343	774,956	1,057,246	171,070	533,387	660,002	3,257,004

The loads of total nitrogen come from a wider variety of sources. As table 6.2.2 shows, crops are the largest source of nitrogen, accounting for 16% of the total average annual load of 35 million pounds. But urban nonpoint source loads constitute the second largest source, accounting for 15% of the total. Point sources, such as wastewater treatment plants, contribute 9% of the load. Agricultural sources still dominate urban sources. Fifty-six percent of the load comes from crops, pasture, or runoff from feedlots. Thirty percent of the load comes from point sources, septic systems, and urban land. Forests account for only 14% of the total delivered nitrogen loads. The sources are also more geographically diverse. The largest source of loads is the heavily urbanized Lower Potomac (220), delivering 12% of the load. Crops still contribute the largest share of the load in the Lower Potomac. The Middle Potomac (740) has almost the same load with less urbanization. Nonpoint source loads from crops in Conococheague (730), Middle Potomac (740), Mainstem Shenandoah (200), Point of Rocks (180), Lower Monocacy (210), and Lower Potomac all contribute more than one million pounds per year to the total nitrogen load. Among the other sources, only urban land in the Lower Potomac and forests in the North Branch (160) contribute over one million pounds per year.

Crops also contribute nearly one-third of the annual total phosphorus load of 3.2 million pounds. The next largest source is pasture, delivering nearly 25% of the annual load. Point sources are the third largest source, contributing 20% of the load, and nonpoint sources from urban land contribute 16% of the load. The contribution from forests is almost negligible. Inorganic phosphorus is transported primarily bound to sediments, so it is not surprising that the 35% of the delivered load comes from the Shenandoahs (190 and 200). Point source loads from the Shenandoahs are also the highest in the basin. The Lower Moncacy (210) and the Lower Potomac (220) each also deliver over 10% of the total annual load. The dominant source in the Monocacy is crops; the dominant source in the Lower Potomac is urban land.

6.2.2 Projected Population Growth and Land Use Changes

The CBP has projected the population growth in modeling segments for the years 2010 and 2020. The projection is based upon estimates by the U. S. Census Bureau and the basin states. Table 6.2.4 shows the population of each model segment in the Potomac Basin in 2000, the projected populations for 2010 and 2020, and the percent change with respect to the 2000 population. Growth is the story, at least in the downstream segments which are rapidly becoming part of the Washington metropolitan area. The basin population of nearly 2 million is expected to increase by nearly 10% in each decade. The percent change is greatest in the Lower Monocacy, Frederick County in Maryland, which is expected to grow by over 30% in the next twenty years. The rate of growth is over 10% per decade in the Lower Potomac (220), which already has three-quarters of a million people, nearly 37% of the basin total. Other segments growing by more than 10% a decade are the Middle Potomac (740) and the mainstem Shenandoah (200).

Table 6.2.4 Projected Population Changes 2010 and 2020

Segment	2000	2010	% Change	2020	%Change
160	116,427	116,832	0%	117,145	1%
170	29,659	30,687	3%	31,582	6%
175	31,062	33,297	7%	35,149	13%
180	174,256	190,291	9%	201,838	16%
190	195,750	205,076	5%	214,667	10%
200	130,347	144,682	11%	158,291	21%
210	232,364	275,914	19%	304,417	31%
220	736,917	821,212	11%	890,241	21%
730	84,536	87,913	4%	89,597	6%
740	213,705	241,043	13%	265,489	24%
750	33,160	36,225	9%	38,493	16%
Total	1,978,183	2,183,172	10%	2,346,909	19%

Table 6.2.5 shows the CBP estimates of current land use, its projections for land use in 2010, and the percent change in land use over the decade. As might be expected from the population growth, there is considerable expansion of urban land. Overall, there is a 9% increase projected in urban land, roughly consistent with the population increase. The percent of the basin that is urban land will grow from 15% to 17% over the next decade, with the addition of almost 100,000 acres. The net loss of forest is about 1%. Forest will cover just over 50% of the basin into the next decade. Loss of forest will account for at most 25% of the growth in urban land. The rest will come from agricultural land.

Superimposed on the growth in urban land is a shift in the use of agricultural land. There will be a net loss of pasture of almost 8% and a net gain in crops of 2%. Hay production will increase by 8% and conventionally-tilled crops will decrease by 18%. Conservation till will increase by 6%. The gain in acres under conservation till is less than the acres lost in conventional till. The overall net decrease in crop land, excluding hay, is about 10%.

Table 6.2.5 Projected Land Use Changes 2010

Segment	2000				2010				Percent Change			
	Forest	Pasture	Crop	Urban	Forest	Pasture	Crop	Urban	Forest	Pasture	Crop	Urban
160	627,995	86,960	58,807	86,704	625,387	82,034	65,661	87,386	0%	-6%	12%	1%
170	619,599	201,942	50,193	78,102	622,294	194,067	52,741	80,734	0%	-4%	5%	3%
175	617,543	82,018	49,306	50,558	614,637	79,975	52,858	51,956	0%	-2%	7%	3%
180	148,322	56,860	123,666	77,013	145,946	54,677	124,380	80,857	-2%	-4%	1%	5%
190	509,150	221,670	153,487	159,711	504,011	192,817	161,255	185,953	-1%	-13%	5%	16%
200	453,435	159,924	146,238	140,556	451,961	142,270	148,010	157,923	0%	-11%	1%	12%
210	184,273	46,207	170,324	99,064	176,132	34,910	174,053	114,853	-4%	-24%	2%	16%
220	208,614	89,644	105,483	189,066	203,820	89,075	98,421	208,607	-2%	-1%	-7%	10%
730	134,735	21,960	113,494	49,757	135,668	18,832	115,365	50,011	1%	-14%	2%	1%
740	439,604	96,909	160,863	170,214	438,526	87,944	160,937	180,186	0%	-9%	0%	6%
750	37,238	8,423	46,569	20,715	35,479	5,823	50,318	21,336	-5%	-31%	8%	3%
Total	3,943,269	1,064,093	1,131,861	1,100,745	3,918,382	976,601	1,153,681	1,198,466	-1%	-8%	2%	9%

6.2.3 Estimated Nutrient and Sediment Loads Under 2010 Conditions

A modeling scenario was developed to estimate nutrient and sediment loads under the population increase and land use changes projected for 2010. The scenario was intended to represent future conditions under current levels of BMP implementation for agricultural and urban nonpoint sources and current levels of point source controls. The scenario was constructed from two existing Bay Program scenarios. The first is the 2000 Progress Scenario described in section 6.2.1. The second is a scenario representing 2010 land use and population growth but no controls on point or nonpoint sources: the 2010 No BMPs Scenario. Using the Community Model pre- and post-processors, the following steps were taken to construct what might be called the 2010 Progress Scenario:

1. Land use distributions were taken from the 2010 No BMPs Scenario;
2. The level of nonpoint source controls per acre in the 2000 Progress Scenario were applied to urban and agricultural land;
3. Point source flows were taken from the 2010 No BMPs Scenario;
4. Point source loads were calculated by assuming the same concentrations as the 2000 Progress Scenario;
5. Acres under nutrient management were assumed to be the same as the 2000 Progress Scenario;
6. Loads from atmospheric deposition took into account reductions yielded by Clean Air Act; and
7. Septic system loads were taken from the 2010 No BMPs Scenario.

The simulated average annual sediment loads under 2010 conditions are shown in Table 6.2.6. Simulated average annual total nitrogen loads are shown in Table 6.2.7 and simulated average annual total phosphorus loads are shown in Table 6.2.8.

Both simulated annual sediment loads and simulated average nitrogen loads decrease slightly during 2010 conditions. Sediment loads decrease by less than 1%. The increase in loads from urban land is balanced by a decrease in loads from agricultural land. Urban loads increase by 13%, but that is an increase in overall load of about 1%. Sediment loads remain dominated by agricultural sources. Annual total nitrogen loads also decrease by about 1%. There is only a 2% increase in the load from urban nonpoint sources, but a 23% increase in loads from point sources. They now constitute 12% of the total annual load. Agricultural loads decrease by 7%. Forest loads also decrease by 8% due to the decrease in load from atmospheric deposition.

Total phosphorus loads under 2010 conditions increase by 10%. Point source loads increase by 23% and total phosphorus loads from urban nonpoint sources increase by 36%. Losses from agricultural sources decrease by only 1%.

If urban growth only converted agricultural land and forest to urban land, at a ratio of 0.75 acres of agricultural land and 0.25 acres of forest to every acre of land developed, nutrient loads would decrease. The average phosphorus loading rates on forest, agricultural, and urban lands are 0.015, 0.86, and 0.45 lbs/ac, respectively, while the average nitrogen loading rate on these lands are 1.2, 8.6, and 4.6 lbs/ac, respectively. Population growth also raises point source nutrient loads. In the case of phosphorus, the additional load from point sources more than outweighs the loss in load from the land use changes. With no additional point source controls, that trend will only increase as the population increases 2010-2020.

It is difficult to determine whether the increase in phosphorus load will have an impact on surface water quality. If algal growth in the Potomac River is phosphorus-limited, as most free-flowing streams are, then an increase in phosphorus will potentially lead to an increase in algal growth and an increase in taste and odor problems. But the TN/TP ratio in the lower Potomac, as predicted by the Watershed Model, may even be less than 10:1, suggesting if not that algal growth in the Potomac might be nitrogen limited, at least that the matter requires further investigation.

An analysis of the impact of population growth on source water quality using the Watershed Model indicates that the growth in population upstream of the intakes will have little impact on sediment loads. If algal growth in the Potomac River does turn out to be phosphorus limited, population growth may cause an increase in algae and a corresponding increase in taste and odor problems. Otherwise, the increase in phosphorus will not have adverse effects on surface water quality.

Table 6.2.6 Simulated Annual Average Sediment Loads Under 2010 Conditions (lbs/yr)

Segment	Forest	Pasture	Crop	Urban	Total
160	18,001	26,047	20,674	11,536	76,259
170	18,156	95,990	26,868	19,736	160,750
175	16,678	50,177	30,115	16,281	113,251
180	6,541	16,159	70,488	16,078	109,265
190	22,305	81,442	151,771	35,777	291,295
200	36,573	45,557	94,056	34,553	210,739
210	6,700	9,490	96,693	23,170	136,054
220	15,680	22,046	48,063	25,297	111,086
730	10,027	7,317	88,493	12,499	118,337
740	30,810	33,842	102,777	46,000	213,429
750	1,542	1,968	25,458	4,749	33,717
Total	183,013	390,035	755,456	245,676	1,574,182

Table 6.2.7 Simulated Annual Average Total Nitrogen Loads Under 2010 Conditions (lbs/yr)

Segment	Forest	Pasture	Crop	Feedlot	Urban	Point Source	Septic	Total
160	943,119	374,709	576,502	51,449	416,447	434,693	78,620	2,898,306
170	589,710	726,452	969,603	109,619	293,622	231,069	45,285	2,978,070
175	772,692	422,063	727,755	86,376	240,806	2,952	68,963	2,343,978
180	171,128	345,865	1,551,413	168,156	460,008	392,718	237,536	3,345,579
190	244,139	519,678	620,591	83,721	345,096	379,202	108,275	2,312,408
200	338,176	628,769	1,376,962	113,507	478,893	506,098	177,369	3,646,331
210	216,760	216,800	1,106,825	38,346	571,132	933,533	318,465	3,412,479
220	286,406	463,250	727,434	19,529	1,508,239	372,361	316,476	3,745,761
730	215,695	374,433	2,142,773	568,492	283,137	119,117	91,665	3,801,789
740	572,321	581,280	1,651,590	102,081	938,482	548,568	354,247	4,782,000
750	36,476	53,539	409,339	21,463	101,594	27,321	36,048	689,185
Total	4,386,622	4,706,838	11,860,787	1,362,739	5,637,456	3,947,632	1,832,949	33,955,886

Table 6.2.8 Simulated Annual Average Total Phosphorus Loads Under 2010 Conditions (lbs/yr)

Segment	Forest	Pasture	Crop	Feedlot	Urban	Point Source	Total
160	10,975	82,435	39,690	7,124	50,664	103,105	295,732
170	8,734	131,431	63,050	14,796	35,401	48,540	303,034
175	9,116	57,919	39,669	9,747	24,577	523	143,095
180	1,201	29,056	90,748	16,332	49,852	70,080	258,328
190	4,000	198,288	177,885	22,126	93,376	218,357	715,782
200	5,460	110,062	186,006	15,307	80,364	106,578	505,945
210	1,945	21,720	156,861	4,578	78,581	139,978	404,347
220	2,676	49,140	72,329	1,828	189,869	27,992	346,584
730	2,193	23,659	98,425	65,342	25,782	30,680	246,486
740	6,005	48,802	72,777	10,787	79,552	62,000	281,967
750	546	8,291	51,634	2,970	18,979	3,620	86,307
Total	52,851	760,803	1,049,074	170,937	726,997	811,453	3,587,607

6.3. Fecal Coliform Bacteria

To better understand the sources of fecal coliform bacteria observed at the WAD intakes, the CBP Watershed Model was modified to simulate the fate and transport of fecal coliform bacteria. The same segmentation, land uses, and hydrology used in the reference scenario of the Watershed Model were used in the Fecal Coliform Model, and a similar methodology was used to estimate input loads of fecal coliform bacteria. Loads from agricultural sources were derived from information available on a county level from the agricultural census, and distributed to the model segments on the basis of the fraction of a county's herbaceous land that was in each modeling segment. Loads from human sources such as wastewater treatment plants or septic systems were calculated on the basis of flows and loads already accounted for in the Watershed Model. Other sources, such as wildlife, were added on a county or regional basis.

HSPF has been used to simulate the fate and transport of fecal coliform bacteria in the development of Total Maximum Daily Load (TMDL) allocations for impaired waterbodies in Virginia (VA DEQ and VA DCR, 2000 a, b, c) and West Virginia (U. S. EPA, 1998 a, b, c, d). Tetra Tech, on behalf of West Virginia DEP and the U. S. EPA Region III, has developed fecal coliform TMDLs for the North Fork and South Forks of the South Branch of the Potomac River, their tributaries, and the Lost River, a tributary to the Cacapon River. Numerous fecal coliform TMDLs have been developed in Virginia, including TMDLs for three small tributaries to the Shenandoah River-- Mill Creek, Dry River, and Pleasant Run developed by Virginia Tech. These TMDLs were used to guide the adaptation of HSPF to the simulation of the fate and transport of fecal coliform bacteria. They were also used to guide the estimation of input loads to the model. The EPA (U. S. EPA, 2001) has also published guidance on the development of pathogen TMDLs. Every effort was made to keep the Fecal Coliform Model consistent with both the practices of the Bay Program and the methodology used in the fecal coliform TMDLs.

The purpose of the Fecal Coliform Model is to help quantify the sources and geographic origin of fecal coliform bacteria observed at the WAD's water supply intakes. This will help to identify the source and origin of fecal material that is a potential source of pathogens. Loads from the following sources were developed as inputs into the model:

8. Bacteria from livestock waste deposited on pasture and transported in runoff;
9. Bacteria, transported in runoff, from manure and poultry litter applied to crops and hay;
10. Bacteria in runoff from feedlots and concentrated animal operations;
11. Bacteria in runoff from urban land;
12. Bacteria in deer scat and geese droppings, deposited in forests and agricultural land and transported in runoff;
13. Bacteria discharged in effluent from wastewater treatment plants;
14. Bacteria draining directly into waterbodies from failing septic systems;
15. Bacteria from cattle directly defecating into streams; and

16. Bacteria from geese and other waterfowl directly defecating into streams.

An attempt was made to estimate the impact of bacteria loads from Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs) in the North Branch of the Potomac, around Cumberland, where these discharges have been documented. Loads from CSOs and SSOs are not represented in other segments.

The sources of fecal coliform bacteria fall into two groups. Some sources (1-5) only deliver loads to waterbodies in runoff. Bacteria from these sources will only appear during storm flows or high flows. The loads from other sources (6-9) are delivered almost constantly and can be expected to constitute the load observed in base flow or low flow conditions. There exists a significant amount of monitoring data for fecal coliform bacteria in the Potomac River Basin under a variety of flow conditions. As will be described more fully below, the observed data show variation in concentration with flow conditions. The mean concentration at high flows tends to be larger than the mean concentration at low flows, although generally there are several orders of magnitude in the range of observed concentrations under all flow conditions. The Fecal Coliform Model was calibrated to replicate mean concentrations at different flow conditions; it was not intended to simulate the observed data on an event-by-event basis, or even to capture the range of variability observed under different flow conditions. Demonstrating, however, that the model faithfully replicates the mean fecal coliform concentrations under different flow conditions throughout the basin will enable the model to explain the relative contribution of sources at different locations to the observed bacteria concentrations at the intakes.

The development of the model and its use to analyze the potential for pathogen contamination of source water will be described in the following six sections. The first section will describe the observed monitoring data that were used to calibrate the model. The next section will outline how HSPF was adapted to represent the processes relevant to the fate and transport of bacteria and what parameters were used to calibrate the model. It will also explain how the scale of the Watershed Model was taken into account in calibrating the model. The third section will describe the estimation of input loads. The fourth section will give the results of the calibration. The next section will analyze the relative contribution of the sources to the observed fecal coliform concentrations at the intakes. The final section will assess the susceptibility of source water to pathogens on the basis of the results of the simulation.

6.3.1. Monitoring Data

The Fecal Coliform Model was calibrated against the geometric mean of the observed data for different flow conditions at or near the outlet of each modeling segment. Using the daily discharge record for a USGS gage near the outlet of a segment, the 90th, 74th, and 50th percentile flow for the period 1984-2000 was calculated, where the 90th percentile flow is a flow which is larger than 90% of the observed flows. Table 6.3.1 shows the USGS gages that were used to make the calculations and table 6.3.2 shows the results. The gage at Hancock was used for both the Upper Potomac (175) and Middle Potomac (740) segments.

Table 6.3.1 USGS gages used to determine flow percentiles

Watershed	Segment	USGS Gage	Location
North Branch	160	1603000	North Branch Potomac River Near Cumberland, MD
South Branch	170	1608500	South Branch Potomac River Near Springfield, WV
Upper Potomac	175	1613000	Potomac River At Hancock, MD
Point of Rocks	180	1638500	Potomac River at Point of Rocks
S.Fk. of Shenandoah	190	1631000	South Fork Shenandoah River at Front Royal, VA
Mainstem Shenandoah	200	1636500	Shenandoah River at Millville, WV
Lower Monocacy	210	1643000	Monocacy River at Jug Bridge Near Frederick, MD
Lower Potomac	220	1646500	Potomac R. near Washington, D.C. Little Falls Pump Station
Conococheague	730	1614500	Conococheague Creek at Fairview, MD
Middle Potomac	740	1613000	Potomac River At Hancock, MD
Upper Monocacy	750	1639000	Monocacy River at Bridgeport, MD

Table 6.3.2 Modeling segment flow percentiles

Watershed	Segment	90th Percentile	75th Percentile	50th Percentile
North Branch	160	3,080	1,595	444
South Branch	170	3,250	1,540	292
Upper Potomac	175	9,652	4,820	1,120
Point-of-Rocks	180	22,100	11,100	2,915
S.Fk. Shenandoah	190	3,490	1,880	612
Mainstem Shenandoah	200	6,223	3,320	950
Lower Monocacy	210	2,050	1,050	236
Lower Potomac	220	27,800	13,700	2,960
Conococheague	730	1,340	708	172
Middle Potomac	740	9,652	4,820	1,120
Upper Monocacy	750	457	185	24

Fecal coliform data from monitoring stations near the outlet of each segment were collected and paired with the gaged flow for each segment. Table 6.3.3 shows the monitoring stations used for each segment. Where multiple stations were used which had observations on the same day, the arithmetic average was used as a value for the segment on that day. Each segment's observed data were then divided by the following four flow categories: (1) observations taken on days whose daily flow was greater than the 90th percentile flow, (2) observations with flows between the 75th and 90th percentile flows, (3) observations with flows between the 50th and 75th percentile flows, and (4) observations taken on days whose daily average flow was below the 50th percentile flow. These flow classes will be referred to as high, medium high, medium, and low-to-medium flows, respectively. For each segment, the geometric mean and the median of the observed data available for the period 1984-2000 was calculated for each flow class. Table 6.3.4 shows the geometric mean and median for each flow class by segment. Generally, the mean and the median value were not strikingly different.

Table 6.3.3 Monitoring stations used to calibrate the Fecal Coliform Model

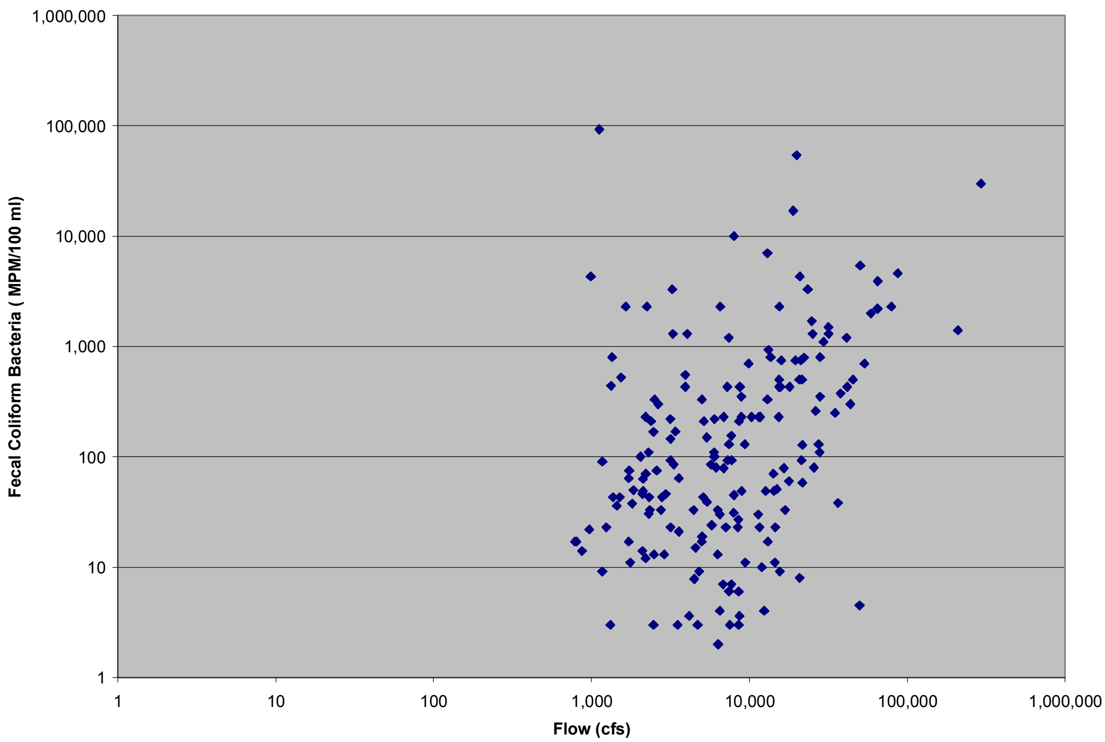
Segment	Agency	Station	Number of Observations	Location
160	DNR	NBP0023	175	West Of Moores Hollow Rd. And Route 51
170	WVDEP	550468	132	South Branch of Potomac River near Springfield
	WVDEP	WA96-P03	12	South Branch of Potomac River near Springfield
175	DNR	POT2386	178	Potomac R. At Gag Sta; 0.5m Bel Br On Rt 522
180	DNR	POT1595	137	Potomac R. E End Of Bird., U.S. Rt. 15
	DNR	POT1596	138	Potomac River VA Side Point Of Rocks
190	VADEQ	1BSSF000.19	91	Approx. 0.4 Mile Below Rt340/522 Bridge
	VADEQ	1BSSF000.58	52	Three Islands
	VADEQ	1BSSF003.56	147	Rt. 619 Bridge At Gaging Station
200	WVDEP	550471	122	Shenandoah River at Harpers Ferry, WV
	USGS	1636500	49	Shenandoah R At Millville, WV
	WVDEP	WA96-S01	12	Shenandoah River at Harpers Ferry, WV
	VADEQ	1BSHN022.63	137	Rt. 7 Bridge, Castlemans Ferry Bridge
210	DNR	MON0020	132	Monacacy R.Bridge On Md.Route 28
220	DNR	POT1184	141	Potomac R At Chain Bridge, At Wash, DC
	USGS	1646580	51	Potomac R At Chain Bridge, At Wash, DC
730	DNR	CON01830	179	Conoco. Cr. Gag. St. 0.7m. Ab. Br. On Fair.Rd
740	DNR	POT1830	136	Potomac River At Gag. Sta. Be. Br. On Rt. 34
	USGS	1618000	50	Potomac River At Gag. Sta. Be. Br. On Rt. 34
750	DNR	MON0518	132	Monocacy R At Bridgeport Br On Md Rt 97 Gag

Table 6.3.4 Geometric mean and median fecal coliform concentrations by flow condition (cfu/100 ml)

Watershed	Segment	High Flows		Medium High Flows		Medium Flows		Low-to-Medium Flows	
		Mean	Median	Mean	Median	Mean	Median	Mean	Median
North Branch	160	2,432	2,300	1,195	1,050	1,384	1,300	252	225
South Branch	170	198	185	45	63	21	10	22	10
Upper Potomac	175	687	700	275	230	141	93	50	43
Point of Rocks	180	2,019	2,325	312	280	95	75	86	60
S.Fk. Shenandoah	190	346	250	171	100	112	100	116	100
Mainstem Shenandoah	200	503	500	141	100	135	100	121	100
Lower Monocacy	210	2,705	3,000	1,072	930	325	230	162	160
Lower Potomac	220	769	1,100	270	345	74	86	64	46
Conococheague	730	1,955	1,700	692	490	379	430	312	230
Middle Potomac	740	707	495	117	93	77	75	46	49
Upper Monocacy	750	2,815	3,000	1,161	2,200	339	230	162	170

Several generalizations emerge. The mean of high flow observations are usually at least an order of magnitude higher than the mean of low-to medium observations, and generally, there is a trend toward higher observed means for higher flow classes. The strong trend towards increasing concentrations with increasing flow coexists with enormous variability in the observed data at each flow level. Figure 6.3.1 shows a scatter plot of observed fecal coliform concentrations against flow on a log-log scale for the Lower Potomac (220). There is a pronounced upward trend in concentration with flow, but concentrations have range of almost five orders of magnitude over a wide range of flows. The slope of a log-log regression line between flow and concentration is 0.7 and is strongly significant, but the coefficient of determination is only 0.14.

Figure 6.3.1 Observed fecal coliform concentrations vs. flow for Lower Potomac



Some geographic trends are also apparent from the monitoring data. Upstream portions of the basin, such as the North Branch (160), Conococheague (730), and Upper Monocacy (750), tend to higher mean fecal coliform concentrations for all flow classes than downstream segments. The South Branch(170) and the South Fork of Shenandoah (190) don't follow this trend because the mean segment concentrations represent stations near the outlet of the segment. Much of the South Branch, and many streams in the South Fork, are impaired by fecal coliform bacteria, but high fecal coliform concentrations are more rare downstream near the watershed outlet. The North Branch of the Potomac has mean concentrations of fecal coliforms above 1000 cfu/100 ml for three of the four flow classes. Downstream concentrations drop in the middle Potomac (740), however, according to monitoring data collected near Shepherdstown, WV. Fecal coliform concentrations on the Monocacy River remain high up to its confluence with the Potomac below Point of Rocks.

There is one important anomaly in the observed data. The mean high flow concentration at Point of Rocks (180) is above 2000 cfu/100 ml, despite the fact that high flow concentrations are relatively low in upstream segments on the mainstem of the Shenandoah and the Middle Potomac River. The observed concentration is inconsistent with high-flow concentrations observed upstream both at Shepherdstown on the Potomac and on the mainstem of the Shenandoah. The high-flow loads from neither of these upstream sources can explain the concentrations at Point of Rocks. The observed geometric mean of high flow concentrations in Antietam Creek, which flows into the Middle Potomac (740) downstream of Shepherdstown, is 681 cfu/100 ml, and the 90^{th} percentile flow on Antietam Creek is only about 5% of the flow at Shepherdstown. The observed concentrations on the Catoctin Creeks tend to be high, but they deliver relatively small loads because their flows are also relatively small. The observed concentration at Point of Rocks is the average of near-shoreline observations, and it is possible that they are unduly influenced by the flows from the Catoctin Creeks, which are just upstream of the monitoring station locations.

6.3.2 Modifications to the Watershed Model

Modifying the Watershed Model to represent fecal coliform bacteria is straight forward. HSPF modules are added to the Watershed Model to simulate the deposition and death of fecal coliform on the land surface, their washoff in runoff, and their transport downstream. The scale of the Watershed Model, however, poses some problems for faithfully representing the fate of fecal coliform bacteria. The observed rate at which fecal coliform die-off or disappear from a stream is as high as 15/day (Bowie et al., 1985). Transport processes in small tributaries not represented in the Watershed Model can have a large impact on the fate of bacteria. These processes need to be explicitly taken into account in the Fecal Coliform Model.

6.3.2.1 HSPF Modules for Simulating Fecal Coliform Bacteria

HSPF has been used to represent the fate and transport of fecal coliform bacteria for TMDLs in Virginia (VADEQ and VADCR, 2000 a, b, c) and West Virginia (U. S. EPA 1998 a, b, c, d). The PQUAL module of HSPF is used to represent the build-up, die-off, and wash-off of fecal coliform bacteria from the pervious land surfaces, such as cropland, forest, and pasture. That module, in the simple form in which it is used to represent bacteria, is characterized by three parameters: (1) ACQOP, the daily rate, in cfu/acre, at which bacteria accumulate on the surface in scat, livestock feces, or applied manure; (2) SQOLIM, the limit, in cfu/acre of bacteria build-up on the surface, and (3) WSQOP, the rate of surface runoff (in/hr) that removes 90% of the accumulated bacteria from the surface.

ACQOP can, and does, vary monthly. Its calculation, based on animal populations and manure applications, will be explained in the next section. SQOLIM functions as a decay rate, on the assumption that the accumulation of bacteria on the surface will reach asymptotic limit determined by a daily die-off rate. The soil decay rate used in Virginia TMDLs is approximately 0.1/day, which, by their calculations, led to a SQOLIM of nine times the application rate. In the Fecal Coliform Model, SQOLIM was set at ten times the smallest monthly application rate.

HSPF determines the fraction of accumulated bacteria removed from the surface at a runoff rate R (in/hr) by the formula:

$$1.0 - EXP(-2.3*R/WSQOP)$$

In the Fecal Coliform Model WSQOP was determined by calibration.

The in-stream processes used to represent fecal coliform bacteria are also quite simple. Bacteria are represented as a dissolved substance subject to temperature-corrected, first-order decay. The decay rate of bacteria for any given time step is determined by multiplying FSTDEC, the decay rate at 20 degrees Celsius, by the factor, $THST^{T-20}$, where T is the water temperature in degrees Celsius, calculated by HSPF. The decay rate, FSTDEC, was determined by calibration. Following Virginia's TMDLs, the temperature correction term, THST, was set at 1.05.

6.3.2.2 Travel Time Corrections for Low-Flow Sources

Low-flow sources, such as wastewater effluent, failing septic systems and the direct deposition of cattle and goose feces, are input directly into model reaches as external time series. Most large wastewater facilities discharge into or close to the river reaches explicitly represented in the model. The loads from cattle, geese, and failing septic systems, however, are usually transported in smaller tributaries that are not explicitly represented in the Watershed Model. The travel time from smaller tributaries to the mainstem of the Potomac or the main channel of the larger tributaries represented in the model can be considerable, and, consequently, a considerable number of the bacteria deposited in the smaller tributaries can be expected to die off before entering the main channel river reaches.

The travel time from small tributaries to the represented river reaches, and the resulting die-off of bacteria, were explicitly taken into account in the Fecal Coliform Model. An average travel time from small tributaries to river reaches was calculated using information provided in the EPA's River Reach File version 1 (RF1). RF1 is a nation-wide GIS representation of this country's stream network. The stream network is divided into reaches. RF1 contains a considerable amount of information about reach segments. Among the attributes assigned reaches in RF1 are segment length and velocity at mean flow. These attributes were used to calculate a travel time through the reach. The travel time from the RF1 reach to the reach of the segment represented in the Watershed Model was calculated and associated with the centroid of the reach.

The centroids of the RF1 reaches provide a point coverage, which was then contoured using the ArcView GIS software. This yielded a contour map of travel times to Potomac Watershed Model segments under mean flow conditions. An area-weighted travel time for each model segment was then calculated. The results are shown in Table 6.3.5.

Table 6.3.5 Travel times and annual input loads for low-flow loads

[REDACTED]

The fraction of the load which arrives at the model segment reach from failing septic systems and the direct deposit of fecal material into streams by cattle and waterfowl was calculated using the average travel time and a temperature-corrected, first-order decay rate. The temperature correction term used the same value as the model segment reach. The time series of simulated water temperature from the Lower Potomac (220) was used to calculate the temperature correction term. The base first-order decay rate was a calibration parameter.

6.3.3 Fecal Coliform Bacteria Input Loads

The information for the quantification of fecal coliform bacteria input loads comes from three sources: (1)The EPA guidance document, <u>Protocol for Developing Pathogen TMDLs</u> (USEPA 2001), (2) existing Virginia and West Virginia fecal coliform TMDLs (VADEQ and VADCR 2001 a, b, c, and USEPA 1998 a, b, c, d) and (3) the CBP methodology for tracking animal waste (Jeff Sweeney, personal communication). Key to the quantification of almost all loads is the animal per capita fecal coliform generation, in cfu/day. Table 6.3.6 gives the number of fecal coliform bacteria generated per day by animal. USEPA (2001) is the source for all these estimates, except for geese, where the EPA's per capita rate seemed unusually high. The geese fecal coliform per capita production rate was derived from the TMDL for Mill Creek (VADEQ and VADCR, 2000b). As the table shows, beef and dairy cattle have the highest per capita fecal coliform generation rate, more than two orders of magnitude higher than humans. The estimates used here generally follow the average weight of the species. It should be noted that published estimates of fecal coliform generation rates can vary by two orders of magnitude.

Table 6.3.6 Per capita fecal coliform generation rates, storage fractions, and storage decay rates

Animal Name	Fecal Coliform Generation Per Capita (cfu/day)	Fraction on Pasture	Fraction Confined And Stored	Fraction Confined But not Stored	Decay Rate in Storage (1/day)
Beef	1.04E+11	80 - 100%	0	0 - 20%	0.863
Dairy	1.01E+11	20%	40%	40%	0.115
Swine	1.08E+10	0%	85%	15%	0.787
Poultry	1.36E+08	0%	100%	0%	0.081
Turkeys	9.30E+07	0%	100%	0%	0.081
Deer	5.00E+08	NA	NA	NA	NA
Geese	7.99E+08	NA	NA	NA	NA
Humans	2.00E+09	NA	NA	NA	NA

6.3.3.1 Accumulation Rates on Forest, Cropland, Hay, and Pasture

The daily accumulation rate for forest, cropland, hay, and pasture from livestock was calculated using the Bay Program's methodology for tracking animal waste products, with one difference: Animal populations were based solely on the 1992 Agricultural Census and kept constant throughout the simulation; no attempt was made to change deposition rates by estimating changes to the animal population throughout the simulation period. Table 6.3.7 gives the animal population for each segment. County animal populations, as reported in the 1992 Census, were proportioned to the model segments based on the fraction of a county's herbaceous acres, as given by the MRLC land cover layer, that were in the model segment. Poultry populations are larger than any other species except in the Lower Potomac (220), where people dominate. Table 6.3.8 shows the total daily fecal coliform generated by species for each modeling segment. Poultry produce the largest amount of fecal coliform bacteria in every segment except 220, where beef cattle dominate. Beef cattle generally produce the second largest total of fecal coliform per day, followed by dairy cattle everywhere except 220, where the human population ranks third.

Table 6.3.7 Human and animal populations by modeling segment

Segment	Beef	Dairy	Poultry	Turkeys	Swine	Deer	Geese	Human Population
160	24,358	5,270	1,281,367	61,040	2,572	62,971	1,748	114,179
170	47,641	713	5,877,942	1,158,129	4,654	63,165	1,928	28,606
175	27,596	3,266	2,393,273	7,222	4,504	62,396	1,627	28,267
180	41,015	23,389	590,678	14,666	16,453	24,122	827	152,924
190	156,878	25,184	15,685,491	3,990,569	12,825	39,894	2,058	183,490
200	101,262	17,450	9,030,176	2,370,513	10,038	51,531	1,833	114,613
210	41,058	30,961	884,440	63,394	8,736	20,479	5,078	178,694
220	42,268	4,332	3,431	107	1,493	30,256	5,938	631,651
730	33,685	28,906	1,417,590	38,159	48,573	13,272	650	79,867
740	54,600	16,946	323,757	47,447	33,146	50,487	1,755	182,218
750	7,746	3,775	695,916	175,939	8,750	4,984	1,150	29,507

Total	578,108	160,193	38,184,059	7,927,185	151,743	423,557	24,594	1,724,016

Table 6.3.8 Daily total fecal coliform generation by species (cfu/day)

Segment	Beef	Dairy	Poultry	Turkeys	Swine	Deer	Geese	Human	Total
160	2.5E+15	5.3E+14	1.4E+16	8.3E+12	2.4E+11	3.1E+13	1.4E+12	2.3E+14	1.7E+16
170	5.0E+15	7.2E+13	6.3E+16	1.6E+14	4.3E+11	3.2E+13	1.5E+12	5.7E+13	6.9E+16
175	2.9E+15	3.3E+14	2.6E+16	9.8E+11	4.2E+11	3.1E+13	1.3E+12	5.7E+13	2.9E+16
180	4.3E+15	2.4E+15	6.4E+15	2.0E+12	1.5E+12	1.2E+13	6.6E+11	3.1E+14	1.3E+16
190	1.6E+16	2.5E+15	1.7E+17	5.4E+14	1.2E+12	2.0E+13	1.6E+12	3.7E+14	1.9E+17
200	1.1E+16	1.8E+15	9.8E+16	3.2E+14	9.3E+11	2.6E+13	1.5E+12	2.3E+14	1.1E+17
210	4.3E+15	3.1E+15	9.6E+15	8.6E+12	8.1E+11	1.0E+13	4.1E+12	3.6E+14	1.7E+16
220	4.4E+15	4.4E+14	3.7E+13	1.5E+10	1.4E+11	1.5E+13	4.7E+12	1.3E+15	6.2E+15
730	3.5E+15	2.9E+15	1.5E+16	5.2E+12	4.5E+12	6.6E+12	5.2E+11	1.6E+14	2.2E+16
740	5.7E+15	1.7E+15	3.5E+15	6.5E+12	3.1E+12	2.5E+13	1.4E+12	3.6E+14	1.1E+16
750	8.1E+14	3.8E+14	7.5E+15	2.4E+13	8.1E+11	2.5E+12	9.2E+11	5.9E+13	8.8E+15
Total	6.0E+16	1.6E+16	4.1E+17	1.1E+15	1.4E+13	2.1E+14	2.0E+13	3.4E+15	4.9E+17

The fate of animal waste is depends on the type of animal and model segment. Animals are either confined or in pasture. Pastured animals deposit wastes with fecal coliform bacteria on pasture land daily. The waste from confined animals is either stored or unstored. If the waste is unstored, it is applied to crops and hay on a daily basis. If it is stored, it is applied to crops only in the spring (April, May) before planting or in the fall (October, November) after harvesting and before planting a winter cover crop. Fecal coliform bacteria in manure or litter in storage are subject to decay. Table 6.3.6 gives the fraction of animal waste that is stored, unstored, or deposited in pasture for each animal type. It also gives the decay rate in storage for each type of animal waste. According to CBP assumptions, all poultry wastes are stored. For the most part, beef cattle are in pasture, though about 20% of the cattle are confined in the upper Potomac segments. Most of the waste from hogs is stored. Twenty percent of the waste from dairy cattle is deposited in pasture; half of the rest is stored.

The contribution of domestic animals to fecal coliform accumulation rates is calculated as follows. The pasture loading rate is equal to the number of animals of each type in pasture in a model segment, times their per capita fecal coliform generation rate, divided by the number of acres in the model segment. The pasture loading rate is corrected monthly to take into account the fecal material directly deposited by cattle into a stream, as will be explained below. Table 6.3.9 gives the total amount of fecal coliform bacteria applied on pasture annually in each segment. Almost of the load comes from beef cattle, with a smaller contribution from dairy cattle.

Table 6.3.9 Annual fecal coliform application rates (cfu/yr)

Segment	Stored				Unstored				
	Pasture	High Till	Low Till	Hay	High Till	Low Till	Hay	Geese	Deer
160	7.5E+17	2.6E+15	1.8E+15	3.7E+15	8.4E+16	6.0E+16	1.2E+17	3.8E+14	1.1E+16
170	1.4E+18	9.3E+15	6.5E+15	6.9E+15	1.5E+17	1.1E+17	1.1E+17	4.2E+14	1.2E+16
175	8.3E+17	4.2E+15	4.0E+15	2.1E+15	1.1E+17	1.0E+17	5.2E+16	3.6E+14	1.1E+16
180	1.7E+18	3.8E+15	9.7E+15	5.0E+15	7.3E+16	1.9E+17	9.6E+16	1.8E+14	4.4E+15
190	5.9E+18	1.9E+16	4.6E+16	1.3E+16	9.4E+16	2.2E+17	6.3E+16	4.5E+14	7.3E+15
200	3.8E+18	1.1E+16	2.6E+16	1.1E+16	5.9E+16	1.4E+17	6.2E+16	4.0E+14	9.4E+15
210	1.7E+18	6.7E+15	1.3E+16	4.9E+15	1.3E+17	2.4E+17	9.2E+16	1.1E+15	3.7E+15
220	1.6E+18	6.6E+14	1.4E+15	9.4E+14	1.4E+16	3.1E+16	2.0E+16	1.3E+15	5.5E+15
730	1.4E+18	8.4E+15	1.2E+16	5.0E+15	1.5E+17	2.2E+17	8.8E+16	1.4E+14	2.4E+15
740	2.1E+18	2.8E+15	5.7E+15	5.2E+15	5.6E+16	1.1E+17	1.0E+17	3.8E+14	9.2E+15
750	3.1E+17	1.9E+15	2.3E+15	1.3E+15	2.0E+16	2.6E+16	1.5E+16	2.5E+14	9.1E+14
Total	2.2E+19	7.0E+16	1.3E+17	5.9E+16	9.3E+17	1.5E+18	8.2E+17	5.4E+15	7.7E+16

Unstored animal waste is applied daily to conventional tillage cropland, conservation tillage cropland, and hay land according to a CBP formula for dividing animal manure among the land uses. The total number of bacteria in unstored waste is calculated for a model segment. It is simply the product of the population of animals with unstored waste times their per capita fecal coliform generation rate. The bacteria are then proportioned among the land uses by the CBP formula. The daily application rate is calculated by dividing the bacteria from unstored waste generated daily for each land use type by the number of acres of each land use. Table 6.3.9 gives the total number of bacteria from unstored waste applied to each land use annually by model segment. Almost all of the unstored waste comes from dairy cattle, except in the North Branch (160), South Branch (170), and Upper Potomac (175) segments, where 70%, 96%, and 80% of waste, respectively, comes from beef cattle.

It is assumed that stored waste asymptotically approaches a limiting fecal coliform population determined by dividing the daily accumulation rate by the decay rate. According to that formula, the die-off rate for fecal coliform bacteria in stored beef, dairy, swine, and poultry rate is 99%, 95%, 97%, and 93%, respectively. The remaining population is then apportioned among the land uses according to the CBP formula, and a daily rate is determined by dividing the apportioned population by the area of each land use over 61 days, to take into account the two-month, twice-a-year application period. Table 6.3.9 shows the daily application rate for each land use by model segment. Bacteria from dairy cattle waste constitute the largest fraction of stored load in the Lower Potomac (220), Lower Monocacy (210), Point of Rocks (180), Middle Potomac (740), and Conococheague (730) segments, accounting for 98%, 87%, 87%, 86%, and 77% of the stored coliforms, respectively. Coliforms from poultry are predominant in the remainder of the segments, accounting for 54% of the bacteria in the North Branch (160), 98% in the South Branch (170), 77% in the Upper Potomac (175), 77% in the South Fork of the Shenandoah (190), and 73% in the remainder of the Shenandoah watershed (200). The contribution from swine was greater than 1% only in segments 730 (4%), 740 (6%), and 750 (4%). The source of the remainder of the stored load in segment 750, the Upper Monocacy, is split evenly between poultry and dairy cattle. It should be noted that the application rate for stored waste is another order of magnitude smaller the rate for unstored waste, and the pasture application rate is usually an additional order of magnitude higher than the rate for unstored waste. Beef cattle, and to a lesser extent, dairy cattle, have surpassed poultry as the dominant source of fecal coliform bacteria applied to agricutural lands.

Wildlife can also deposit wastes on cropland and pasture, as well as forest. Deer and geese are thought to be the largest contributors to wildlife fecal coliform loads. Deer populations were estimated by county for each state. In Virginia, DGIF supplied county deer population estimates. Pennsylvania also supplied county deer population estimates (Christopher S. Rosenberry, personal communication). In West Virginia and Maryland, deer populations were estimated from the buck harvest. According to a rule of thumb, used in West Virginia TMDLs (U.S. EPA 1998 a, b, c,d), the deer population is roughly equal to ten times the number of bucks harvested. All deer populations are estimates for 2000. Since deer populations have been increasing, this overestimates the fecal coliform load from during the 1984-1997 simulation period, but should help compensate for the fact that no other mammalian wildlife species is represented in the model. The county deer population was assumed to be homogeneously divided across all land uses. Model segment deer populations were calculated by apportioning the county deer population by the fraction of the county in each model segment. Table 6.3.7 shows the deer population in each segment. Table 6.3.9 gives the daily loading rate from deer, which was applied to forest, pasture, and cropland. As the table shows, the contribution from deer is not significant on agricultural land.

The geese population for each model segment was estimated on the basis of waterfowl survey conducted by a consortium of state conservation agencies (Heusmann and Sauer, 2000). Geese densities were estimated to be 0.01 geese/acre in the Piedmont (Segments 750, 210, and 220) and 0.002 geese/acre elsewhere, spread evenly over all land uses. The geese population was doubled in the months of November, December, and January to take into account migratory geese and other waterfowl. Table 6.3.7 shows the resident goose population by model segment. Other species of waterfowl may be significant contributors to fecal coliform loads, especially since high per capita fecal coliform generation rates are attributed to ducks and other waterfowl. On the other hand, other species of water fowl, like wood ducks, tend to be highly seasonal. The geese densities used in the Fecal Coliform Model also are higher than estimates used in any of the fecal coliform TMDLs in Virginia and West Virginia. It is hoped that generous estimates of the geese population will account for the contribution of other species of waterfowl, which are present in most of the basin in far smaller numbers than geese. In Virginia TMDLs, it is assumed that 25% of waterfowl feces are deposited directly into waterbodies; the rest is deposited on cropland, pasture, and forest. This assumption was adopted in the Fecal Coliform Model. Table 6.3.9 gives the goose load applied to forest, cropland, and pasture. It is smaller than the deer load and again, insignificant on agricultural land.

To summarize, the fecal coliform load on pasture is about 15 times the load from unstored animal waste, more that 150 times the load from stored animal wastes, and almost 300 times the load from geese and deer. Beef and dairy cattle are responsible for most of the bacteria deposited on pasture or applied on fields as unstored waste. Poultry generate more coliform bacteria than any other species; However, because poultry waste is stored and is subject to decay before being applied to fields, fewer bacteria from poultry waste are applied to the fields where they are subject to runoff. The number of fecal coliform bacteria from wildlife applied on agricultural land is small compared to the number from domestic animals.

6.3.3.2 Low-Flow Loads From Small Tributaries

Failing septic systems and the direct deposition of feces by cattle and waterfowl contribute fecal coliform bacteria loads during low-flow conditions. Section 6.3.2 already described how these loads are input into the model as a time series with a temperature-corrected first-order decay rate based on the estimated average travel time from smaller tributaries to the main channel of the modeling segment. Septic system loads were calculated on the basis of the per capita human fecal coliform generation rate and the CBP estimates of the population served by septic systems in a model segment. A failure rate of 2.5%, which was used in West Virginia TMDLs, was assumed. Table 6.3.5 shows the annual septic system load by model segment before correcting for travel time.

As explained above, it was assumed that 25% of the fecal coliform bacteria from geese were deposited directly into waterbodies. The annual low-flow load from a model segment was calculated on the basis of the geese population shown in Table 6.3.7. Table 6.3.5 shows the annual low-flow load from geese by model segment before correcting for travel time. The goose population, and therefore the load, was assumed to double during the months of November, December, and January.

Direct deposition of fecal coliform bacteria to waterbodies by cattle was assumed to be proportional to the time cattle spent in stream. The assumptions used in Virginia TMDLs were adopted. Cattle spend 3.5 hours a day in streams during June, July, and August, 1.0 hour/day in May and September, 0.75 hours/day in April and October, and 0.5 hours/day the remainder of the year. Table 6.3.6 shows the annual fecal coliform load attributable to cattle by model segment, before the travel time correction.

6.3.3.3 Fecal Coliform Loads in Wastewater, Urban Runoff, and Drainage from Confined Animal Operations

Wastewater treatment plants are usually permitted to discharge effluent with concentrations up to 200 cfu/100 ml, but most discharge much less than that under normal operations. Most of the fecal coliform effluent concentrations reported to MDE under state permitting process were 20 cfu/100 ml or less, so on that basis the concentration of fecal coliforms in wastewater was set at 20 cfu/100 ml. The Watershed Model already represents wastewater flows by model segment as an input time series for those plants with flows 0.5 mgd or greater.

The Watershed Model estimates runoff from feedlots and other types of confined animal operations. The estimate is based on assigning each model segment a number of impervious acres proportional to the animal population in the segment. The simulated runoff from the manure acres carries with it a concentration of nitrogen and phosphorus. This nutrient load is not subtracted from the total nutrients generated by animals in confinement. In the Fecal Coliform Model, a fecal coliform concentration of 1.35×10^6 cfu/100 ml (EPA, 2001) was assigned to runoff from feedlots and confined animal operations. The fecal coliform load from confined animals was not corrected for these losses. In general the losses represent less than 5% of the fecal coliform bacteria generated by confined animals.

Urban sources of fecal coliform bacteria include fecal wastes from pets, waterfowl, and wildlife, as well as sanitary sewer overflows and cross-connections between storm water and sanitary sewers. Distinct types of sources, however, were not represented in the Fecal Coliform Model. The low-flow urban load, attributable to waterfowl, is already represented as part of the base flow load. The fecal coliform load from urban sources during storm water events was represented by assigning a fixed concentration to the simulated runoff from both pervious and impervious urban land. The concentration of fecal coliform bacteria in urban runoff was determined by the methodology used by Gruessner et al. (1997) in estimating the load of toxic chemicals in urban runoff for the CBP Toxics Loading Inventory. For the Toxics Loading Inventory, all of the monitoring data available from NPDES stormwater application permits for communities in the Chesapeake Bay basin were collected into a single database. The geometric mean of all observations in the database was used to represent the concentration of a constituent in urban stormwater in the Chesapeake Bay basin. The geometric mean of observed fecal coliform bacteria concentrations in the database was 1775 cfu/100 ml, and that number was used in the Fecal Coliform Model to represent the fecal coliform concentration in urban storm water.

Combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) are a known problem in the North Branch of the Potomac in a near Cumberland, MD. MDE maintains a database of reported CSOs and SSOs, but it was not possible to find a simple relationship between reported CSO or SSO volumes and either precipitation or simulated urban runoff. Annual reported overflow volumes were approximately 67 million gallons for 1996, 45 million gallons for 1997, 41 million gallons for 2000, and 90 million gallons, January through May of 2001. The annual overflow volume for 1996 could be approximated if it were assumed that every inch of daily urban runoff over 0.3 inches produced 2 million gallons of overflow. This assumption does not capture reported volumes on a daily basis. A time series of overflow volumes was developed for the simulation period 1984-1997 using this assumption. The overflow load was calculated by assuming that the concentration of fecal coliforms in CSOs is $4.2x10^6$ cfu/100 ml (U. S. EPA, 2001).

SSOs are not explicitly represented in other model segments and may not be captured by the urban runoff concentration developed from stormwater monitoring data. It would be helpful to incorporate a simple model of SSO flows into the Fecal Coliform Model to better determine the relative magnitude of the contribution of SSOs to fecal coliform loads.

6.3.4 Model Calibration

The Fecal Coliform Model was calibrated by adjusting the pervious land washoff rate, WSQOP, the main channel first-order decay rate, FSTDEC, and the low-flow decay rate until the geometric means of simulated fecal coliform concentrations matched the geometric means of observed concentrations at the four different flow classes. In general, WSQOP controls the high flow class concentrations, the low-flow decay rate controls the medium-to-low flow class concentrations, and the fit to the other flow classes was controlled by the main channel decay rate.

Table 6.3.10 compares the observed and simulated geometric means of the four flow conditions. Figure 6.3.2 shows the same information graphically. Overall, good agreement was achieved between observed and model values, with two exceptions. Observed fecal coliform concentrations in the North Branch (160) remain above 1000 cfu/100 ml in the medium flow class, where the simulated values fall to 400. The high concentrations at all flows above the 50th percentile probably represents the influence of CSO and SSO loads that are not being fully captured by the model. The model also fails to capture the high flow class concentration at Point of Rocks. As discussed in section 6.3.2, the observed fecal coliform concentrations during high flows at Point of Rocks seem to be an anomaly.

Table 6.3.10 Comparison of simulated and observed geometric mean fecal coliform concentrations by flow class

Segment	Observed vs. Simulated	High	Medium-High	Medium	Medium-to-Low
160	OBSERVED	2,432	1,195	1,384	252
	SIMULATED	2533	1044	400	248
170	OBSERVED	198	45	21	22
	SIMULATED	202	52	18	11
175	OBSERVED	687	275	141	50
	SIMULATED	716	271	105	56
180	OBSERVED	2,019	312	95	86
	SIMULATED	993	319	150	76
190	OBSERVED	346	171	112	116
	SIMULATED	355	145	134	118
200	OBSERVED	503	141	135	121
	SIMULATED	489	199	140	118
210	OBSERVED	2,705	1,072	325	162
	SIMULATED	2,633	1,161	342	160
220	OBSERVED	769	270	74	64
	SIMULATED	768	244	117	63
730	OBSERVED	1,955	692	379	312
	SIMULATED	1959	517	322	332
740	OBSERVED	707	117	77	46
	SIMULATED	692	218	89	38
750	OBSERVED	2,815	1,161	339	162
	SIMULATED	2,887	1,001	286	165

Figure 6.3.2. Comparison of observed and simulated concentrations

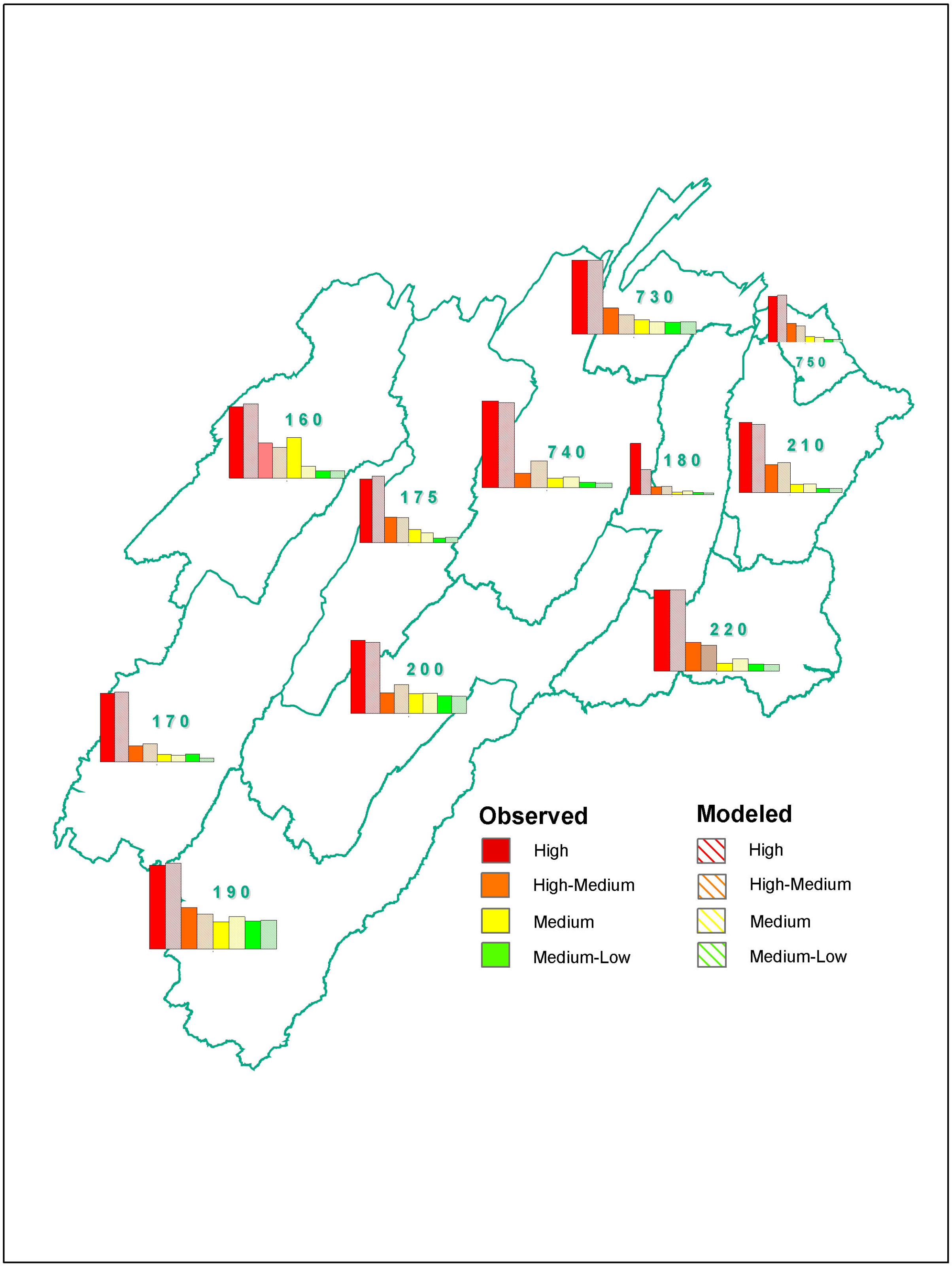


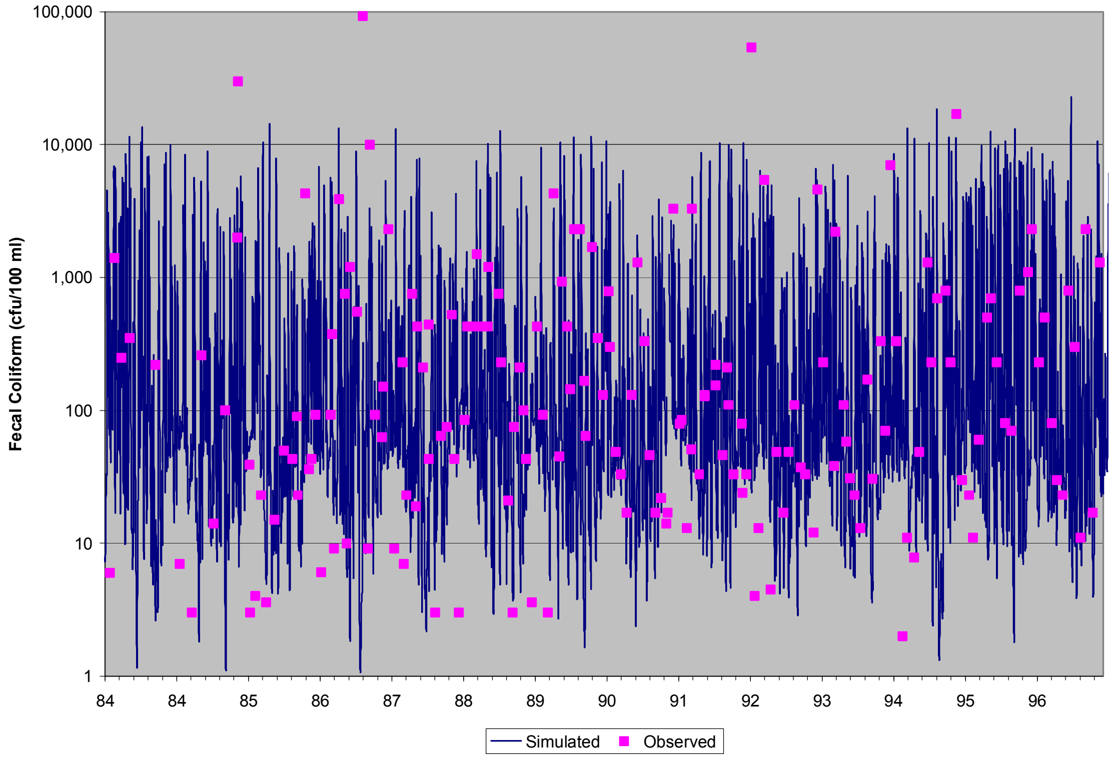
Table 6.3.11 shows the parameters used in the calibration. The main channel decay rates vary between 0.42 and 1.7 /day, tending toward high values in the mainstem of the Potomac. Low-flow tributary decay rates varied between 0.51 and 1.42 /day. Both sets of decay rates are within the observed range. The washoff parameter, WSQOP, varies more widely, from 5 in to 230 inches/hour. All other things being equal, high values of the washoff rate indicate smaller contributions to fecal coliform loads from runoff from forest and agricultural land. The higher the value, the higher the runoff rate necessary to remove equivalent amounts of bacteria from the surface, or in other words, the higher the washoff rate, the less load from the same amount of runoff. An 1 inch/hour runoff rate will wash off 37% of the bacteria accumulated on the surface when WSQOP equals 5, but only 1% when WSQOP equals 230. Most segments have washoff rates between 20 and 75, with corresponding removal rates for 1 in/hr of runoff of 10% and 3%, respectively.

Table 6.3.11 Calibration parameter values

Segment	Washoff Rate (in/hr)	Main Channel Decay Rate (1/day)	Tributary Decay Rate (1/day)
160	17	0.42	0.63
170	75	1.7	0.95
175	50	1.45	1.15
180	5	0.42	1.15
190	70	1.3	0.51
200	50	0.425	0.86
210	70	0.425	1.10
220	22	1.6	0.91
730	230	0.5	1.30
740	9	1.7	0.74
750	38	0.425	1.42

Figure 6.3.3 compares the time series of individual observed fecal coliform concentrations at Chain Bridge, [REDACTED], with simulated values. The model fails to capture either the highest or lowest observed values, but does capture the general range and trend of the observed concentrations well.

Figure 6.3.3 Observed vs.simulated fecal coliform bacteria concentrations in Lower Potomac



6.3.5 Analysis of Simulated Fecal Coliform Bacteria Loads

Simulated fecal coliform loads can be identified at three phases of the simulation. The first phase loads are the input loads discussed in Section 6.3.3. The second phase loads are the loads delivered to the main channel reaches from the land surface or from the tributaries under low-flow conditions. These are called edge-of-stream loads. They represent the simulated loads in runoff from the land surface and the low-flow loads from smaller tributaries corrected for die-off during time of travel to the main channel. Table 6.3.12 shows the average annual simulated edge-of-stream loads for land uses and major components of low-flow load. Average values were determined from the entire 14-year simulation period. The load from hay land, conventional-tilled cropland, and conservation-tilled cropland have been combined. The annual simulated CSO load in the North Branch (16), not shown on the table, is 4.6E+15 cfu. Pasture loads are the largest source of fecal coliform bacteria in all segments except the Conococheague (730), where feedlots are the largest source of loads. Generally, feedlot runoff and cropland are the next largest source of loads during high flow periods, although the annual CSO/SSO load is comparable to the feedlot load in the North Potomac (160). Loads in urban runoff are less than runoff loads from feedlots and cropland everywhere except in the Lower Potomac (220). Loads in forest runoff are always less than either urban or agricultural loads. On an annual basis, the load from cattle in streams is the largest source of loads during low-flow periods. It is roughly an order of magnitude smaller than the load in urban runoff. The load from cattle in streams is highly seasonal: during the summer months cattle are the dominant source of fecal coliform bacteria during low flow periods, while during the winter months the load from geese and failing septic systems is comparable to the load from cattle.

Table 6.3.12 Annual edge-of-stream fecal coliform loads (cfu/yr)

Segment	Forest	Geese	Pasture	Crop	Feedlots	Cattle	Septic	Point Source Load	Urban Load
160	1.5E+14	1.8E+13	3.1E+16	1.1E+16	3.1E+15	1.4E+15	6.1E+13	1.0E+13	2.6E+15
170	1.7E+13	2.7E+12	8.3E+15	2.1E+15	3.2E+15	2.8E+14	3.9E+12	2.5E+11	1.3E+15
230	3.1E+13	4.0E+11	9.0E+15	2.6E+15	2.5E+15	2.7E+13	8.2E+11	1.8E+10	9.9E+14
180	3.2E+13	1.3E+12	6.7E+16	1.8E+16	7.2E+15	3.7E+14	1.7E+13	3.3E+12	1.1E+15
190	4.2E+12	8.9E+12	2.4E+16	1.9E+15	1.1E+16	4.2E+15	6.1E+13	4.8E+12	2.6E+15
200	3.6E+12	2.5E+12	1.4E+16	1.2E+15	6.4E+15	7.6E+14	1.5E+13	1.1E+12	1.4E+15
210	7.9E+12	1.1E+13	1.4E+16	3.8E+15	9.3E+15	5.5E+14	3.2E+13	3.9E+12	2.2E+15
220	2.4E+13	3.3E+13	3.9E+16	1.6E+15	2.0E+15	1.5E+15	7.8E+13	2.3E+12	4.8E+15
730	1.7E+12	1.1E+12	4.6E+15	1.6E+15	1.1E+16	3.6E+14	9.3E+12	1.7E+12	1.4E+15
740	1.1E+14	3.8E+12	1.0E+17	1.5E+16	5.8E+15	6.7E+14	3.5E+13	3.2E+12	3.3E+15
750	3.6E+12	3.3E+12	4.8E+15	9.7E+14	1.6E+15	1.3E+14	6.6E+12	6.5E+11	5.0E+14

Table 6.3.13 Annual delivered fecal coliform loads (cfu/yr)

Segment	Forest	Geese	Pasture	Crops	Feedlots	Cattle	Septic	Point Source	Urban	Total
160	1.2E+13	1.4E+12	2.5E+15	8.7E+14	2.6E+14	1.1E+14	5.0E+12	8.4E+11	2.2E+14	4.0E+15
170	6.1E+11	9.7E+10	3.0E+14	7.7E+13	1.1E+14	1.0E+13	1.4E+11	9.2E+09	4.7E+13	5.5E+14
175	3.2E+12	4.1E+10	9.3E+14	2.7E+14	2.6E+14	2.8E+12	8.4E+10	1.9E+09	1.0E+14	1.6E+15
180	1.4E+13	6.0E+11	3.0E+16	7.9E+15	3.2E+15	1.7E+14	7.5E+12	1.5E+12	5.0E+14	4.1E+16
190	4.1E+11	8.7E+11	2.3E+15	1.9E+14	1.0E+15	4.1E+14	6.0E+12	4.7E+11	2.5E+14	4.3E+15
200	1.1E+12	8.0E+11	4.4E+15	3.8E+14	2.0E+15	2.4E+14	4.6E+12	3.5E+11	4.5E+14	7.5E+15
210	3.4E+12	4.7E+12	6.1E+15	1.6E+15	4.0E+15	2.4E+14	1.4E+13	1.7E+12	9.4E+14	1.3E+16
220	1.2E+13	1.7E+13	2.0E+16	8.3E+14	1.0E+15	7.6E+14	4.1E+13	1.2E+12	2.5E+15	2.5E+16
730	2.4E+11	1.6E+11	6.6E+14	2.4E+14	1.6E+15	5.2E+13	1.3E+12	2.5E+11	2.0E+14	2.7E+15
740	2.0E+13	6.9E+11	1.9E+16	2.7E+15	1.1E+15	1.2E+14	6.4E+12	5.8E+11	5.9E+14	2.3E+16
750	1.3E+12	1.2E+12	1.8E+15	3.6E+14	6.0E+14	5.0E+13	2.5E+12	2.4E+11	1.9E+14	3.0E+15
Total	6.9E+13	2.8E+13	8.7E+16	1.5E+16	1.5E+16	2.2E+15	8.8E+13	7.1E+12	6.0E+15	1.3E+17

Table 6.3.13 shows the fecal coliform bacteria load delivered to the intakes. The delivered load is calculated from the ratio of inflow loads to outflow loads for each main channel reach. The delivery ratio for a segment is the product of the ratio of inflow to outflow loads from segments downstream of segment. Table 6.3.14 shows the ratio of inflow to outflow loads for each segment, and the segment delivery ratio. The inflow-to-outflow ratio is a function of the main channel decay rate and the residence time of flow in the reach.

Table 6.3.14 Inflow-to-outflow ratios and delivery ratios

Segment	Inflow-to-Outflow Ratio	Delivery Ratio
160	0.79	0.06
170	0.48	0.04
175	0.62	0.08
180	0.63	0.32
190	0.54	0.12
200	0.70	0.22
210	0.83	0.42
220	0.51	0.51
730	0.79	0.10
740	0.41	0.13
750	0.86	0.36

The model predicts a perhaps unrealistically large delivered load from Point of Rocks; nevertheless, some broad conclusions can be drawn from an analysis of the delivered loads. The bulk of the simulated delivered fecal coliform, about 98% of the total load, is from runoff. Two-thirds of the load is from runoff from pasture. The largest sources of fecal coliform bacteria are from agricultural land in the Piedmont and Middle Potomac, Segments 220, 210, 750, 180, and 740. Under base flow conditions, on an annual basis, cattle in stream are the largest source of fecal coliform bacteria seen at the intakes. The largest source of these bacteria is in the Lower Potomac, but the second largest source is in the South Fork of the Shenandoah. The North Fork and mainstem of the Shenandoah (200) and the Monocacy (210) are also large sources. Human sources, point sources, failing septic systems, and urban runoff (which also contains bacteria from pets and wildlife)--delivers only 5% of the fecal coliform bacteria seen at the intakes. Almost all of this load comes from urban runoff. The largest sources of fecal coliform bacteria from septic systems are in the Lower Potomac and the Moncacy. These may be significant contributors to low-flow loads during the winter months, when cattle are not spending much time in streams. In general forests are a not significant source of fecal coliform bacteria. Geese and other wildfowl in the Lower Potomac and Monocacy may be a significant source of fecal bacteria at the intakes in the winter months.

6.3.6 Susceptibility of Source Water Supply to Pathogen Pollution

Fecal coliform bacteria are indicator organisms. Their natural habitat is the digestive system of warm-blooded animals. They are found in water primarily when fecal waste is transported there. Fecal coliforms are used to detect the presence of fecal material but they themselves are not pathogenic. There is some controversy whether fecal coliform bacteria are the best indicators of water-borne pathogens. The EPA currently recommends using *E. coli* and enterococci bacteria as indicators of pathogens, because they have been better correlated with incidences of wateborne illnesses (U.S. EPA, 2001). Nevertheless, the Fecal Coliform Model, by simulating the connection between the sources of fecal material and observed fecal coliform concentrations, provides a framework for analyzing the susceptibility of D. C.'s source water supply to water-borne pathogens.

Table 6.3.15 provides a list of pathogens, the diseases they cause, their symptoms, the species, which are potential sources, and the per capita generation rate from infected individuals. Water-borne pathogens can be divided into three classes: bacteria, viruses, and protozoans. The susceptibility of D. C.'s source water to each class of pathogen contamination can be evaluated by comparing the source of the pathogens and their die-off rate in transport to the source and die-off rate of fecal coliforms. In general, pathogens can be distinguished by whether they are specific to people or found in cattle or other animals, and whether their die-off rate in the aquatic environment is less than or great than that or fecal coliform bacteria. The first factor determines which type of source is an important potential source for the pathogen. The second factor determines whether areas of the basin are potentially relatively important sources of the pathogen. If a pathogen's decay rate is comparable to the coliform decay rate, areas in the Piedmont and the Middle Potomac region will be more important sources that the rest of the basin. If the pathogen's die-off rate is smaller, the geographic location of the source will be less important in determining the susceptibility of the District's source water to specific pathogens.

Table 6.3.15 Characteristics of waterborne pathogens

Pathogen	Disease	Symptoms	Sources	Infectious Dose (organisms)	Generation Rate (organisms/day)
Bacteria					
Escherichia coli (pathogenic)	Gastroenteritis	Vomiting, diarrhea	humans, cattle		
Salmonella typhi	Typhoid fever	High fever, diarrhea, intestinal ulcertion	humans	$>10^3$	$10^4 - 10^{10}$
Salmonella	Salmonellosis	Diarrhea, dehydration	animals, humans		
Shigella	Shigellosis	Bacillary disentery	humans	$>10^3$	$10^8 - 10^{10}$
Vibrio chorerae	Chlolera	Heavy diarrhea, dehydration	humans	$10^2 - 10^8$	$10^8 - 10^9$
Yersinia enterolitica	Yersinosis	Diarrhea	humans, animals		
Viruses					
Adenovirus	Respiratory disease	Various effects	humans		
Enterovirus	heart disease, meningitis, gastroenteritis	Various effects	humans	<50	$10^8 - 10^9$
Hepatitis A	Infectious hepatitis	Jaundice, fever	humans	<50	$10^8 - 10^{10}$
Reovirus	Gastroenteritis	Vomiting, diarrhea	humans		
Rotavirus	Gastroenteritis	Vomiting, diarrhea	humans	< 50	$10^{11} - 10^{12}$
Calicivirus	Gastroenteritis	Vomiting, diarrhea	humans		
Astrovirus	Gastroenteritis	Vomiting, diarrhea	humans		
Protozoans					
Cryptosporidium	Crytpsporidiosis	Diarrhea, possibly death	humans, animals		
Entamoeba histolytica	Amoebic dysentery	chronic diarrhea, abscesses of liver and intestine	humans		
Giardia lamblia	Giardiasis	diarrhea, nausea, indigetion	humans, animals	<50	10^5

Sources: Battigelli, 2002; Moe, 2002

6.3.6.1 Bacteria

Pathogenic bacteria have die-off rates comparable to fecal coliforms. Typically, they are thought to be able to survive up to 60 days in the aquatic environment (Battigelli, 2002). Thomann and Mueller report, for example, that the decay rate in storm water for salmonella is 1.1 /day for the first three days and 0.1/day thereafter (U.S. EPA, 2001). Thus the Piedmont and Middle Potomac Region are more likely to have a potential impact on susceptibility. For those bacteria found in both humans and animals, such as *salmonella* and *escherichia coli*, runoff from pasture and feedlots are likely to be the dominant source of bacteria during high-flow conditions, and the in-stream deposition of waste by cattle is likely to be the dominant source during low-flow conditions. For those bacteria found only in humans, runoff from urban areas in the Lower Potomac and failing septic systems in the Lower Potomac and the Monocacy are likely to be the most important potential sources of contamination.

6.3.6.2 Viruses

Viruses have low reported decay rates and are thought to be able to survive up to five months in rivers and streams (Battigelli, 2002). Since infections can occur by ingesting only a few organisms, dilution also plays less of a factor in reducing the risk of infection, and potential sources in the basin shouldn't be distinguished solely by their location. Since humans are the primary source of viruses, the largest human sources, without regard to decay or travel time, pose the greatest potential risk. CSOs and SSOs in the North Potomac are an important potential source of viral pathogens, as well as stormwater runoff from developed areas in the Monocacy, Lower Potomac, and the South Fork of the Shenandoah.

6.3.6.3 Protozoa

Giardia and *cryptosporidium* are increasingly recognized as posing a risk to water supplies, in part due to the fact that they transported from host to host as cysts that are able to resist treatment by chlorination. Craun (1981) documented that giardiasis was the most frequently identified cause of waterborne illness in the United States in the 1970's. *Cryptosporidium* has been implicated in the outbreak of waterborne illness in major water supply systems in Milwaukee, Las Vegas, and Waterloo, Ontario. In Milwaukee there were 400,000 clinical case of cryptosporidiosis and several deaths (Sattar et al., 1999).

The factors affecting the fate and transport of *giardia* and *cryptosporidium* are not well known. U.S. EPA (2001) reports a relatively low die-off rate of 0.024/day at 15 degrees Celsius for cryptosporidium. Satter et al.(1999) tested the survival of *cryptosporidum* and *giardia* cysts in natural river water from five locations. They found a substantial die-of in *giardia* cysts after two days, but a substantial number of *cryptosporidium* cysts survived up to 30 days. The potential exists, therefore, for the transport of at least *cryptosporidium* from all reaches of the basin. Areas with high edge-of-stream loading rates for pasture and feedlot runoff, like the Conococheague and the South Fork of the Shenandoah, may contribute significantly to the susceptibility of D. C.'s source water to pathogen contamination.

6.3.7 Nutrient Reduction and Environmental Protection

Of all potential contaminants, the District of Columbia's source water is probably most susceptible to pathogens. Extensive beef and dairy cattle operations, failing septic systems, CSOs and SSOs all contribute in different ways to this susceptibility. Some of the measures promoted by Chesapeake Bay Program to reduce nutrient loads to the bay can also help reduce the potential for pathogen contamination. Better storage and handling of manure and livestock waste can reduce the number of bacteria in runoff from feedlots. The storage of animal waste, in itself, reduces the number of bacteria applied to fields. Other agricultural BMPs, like riparian buffers, may also reduce the potential for pathogen transport in runoff from crops and pasture. Perhaps more could be done to repair failing septic systems and prevent SSO and CSOs.

It was possible to use the Watershed Model and the methodology of the CBP to estimate fecal coliform loads because the sources of fecal coliform bacteria in the basin are also sources of nutrients. Programs to control nutrients also help control the potential for pathogen transport. It is important for the public to recognize that the protection of the District of Columbia's source water is not a separate problem from controlling nutrient and sediment loads to Chesapeake Bay, and that all environmental cost and benefits should be taken into account when charting the future course of environmental protection in the Potomac River Basin.

6.4. Pesticides

Pesticide contamination of surfacewaters is a major concern for the protection of human health by public drinking water utilities (Knappe et al., 1999). In the Potomac River Basin, which is the sole source of water for the District of Columbia, pesticide usage in agricultural regions has resulted in measurable concentrations of pesticides at surfacewater and groundwater monitoring stations throughout the basin (see Fisher, 1997; Ator and Ferrari, 1997; Ferrari et al., 1997; Donnelly and Ferrari, 1998; Hall, Jr. et al., 1999). In some cases, pesticide concentrations in untreated water have exceeded EPA health action levels (HALs) and/or maximum contaminant levels (MCLs).

At present, little is known regarding the potential for pesticide contamination at the intakes on the Potomac River Basin. It is generally understood that elevated concentrations of pesticides in the Potomac River Basin typically occur in pulses during the period from May through July following the application of pesticides to farm fields and residential lawns (Fisher, 1995). Furthermore, the highest concentrations are measured during periods of high streamflow following storm events (Fisher, 1995; Ferrari et al., 1997; Hyer et al., 2001). The period from May through July represents the critical period for pesticide contamination at the water intakes.

To assess the susceptibility of the District of Columbia's source water to pesticide contamination, the CBP Watershed Model was adapted to simulate the daily fate and transport of pesticides. The Watershed Model was modified to simulate the fate and transport of atrazine, a widely used herbicide, in the Potomac River Basin. The model was used to analyze what hydrologic conditions and general management practices would result in elevated pesticide concentrations at the water intakes. The analysis is described in the next four sections. The first section summarizes pesticide usage in the Potomac River Basin. The next section describes some of the general features of the fate and transport of atrazine and two other widely used pesticides, metolachlor and 2,4-D. It also summarizes the monitoring data available. The third section describes how of the Watershed Model was modified to simulate the fate and transport of atrazine. The last section uses the results of the simulation to evaluate the susceptibility of D.C.'s source water to pesticide contamination.

6.4.1 Pesticide Use in the Potomac River Basin

Pesticide use in the Potomac River Basin plays an important role in controlling unwanted organisms such as weeds and insects. Approximately 4.94 million pounds of pesticides are applied annually in the Potomac Basin for agricultural purposes (Gianessi and Puffer, 1990; 1992a-b). In 1997, agricultural pesticide use accounted for 75 percent of the total pesticide usage nationwide (Asplin and Grube, 1999). Herbicides were the most widely applied pesticides in the basin and are used to control the growth of weeds on cropland and lawns. For agricultural use, the two most frequently applied herbicides were atrazine and metolachlor (Gianessi and Puffer, 1990; 1992a-b). For nonagricultural pesticide use (e.g. lawncare), which is more difficult to quantify in terms of annual application (Donnelly and Ferrari, 1998), the most applied pesticide was 2,4-

D, another herbicide (Asplin and Grube, 1999). 2,4-D is also used on small grains and hay. Because atrazine, metolachlor, and 2,4-D represent three of the most utilized pesticides in the Potomac River Basin, they will be the focus of the susceptibility analysis.

6.4.1.1 Methods and Timing of Application for Atrazine, Metolachlor, and 2,4-D

The methods and timing of pesticide application are critical to the overall efficacy of their use. Pesticides are typically applied using one of three general methods (Scholtz and Van Heyst, 2001):

1. Soil incorporation into top 10 cm of soil
2. Spray application
3. Soil application into furrows at depths greater than 10 cm

When pesticides are applied during inappropriate weather conditions or applied in the wrong amounts, regardless of the method chosen, they are susceptible to release into the environment and may not accomplish the desired effect (U.S. Congress, 1990). Table 6.4.1 summarizes the general characteristics and recommended timing of application for atrazine, metolachlor, and 2,4-D.

Table 6.4.1: General characteristics and recommended timing of application for atrazine, metolachlor, and 2,4-D

Pesticide	Regulatory Status	Formulation	Pests Controlled	Timing of Application
Atrazine	Restricted Use	Dry flowable, flowable liquid, granular, and wettable powder	Broadleaf and Grassy Weeds	Pre-emergent[A]
Metolachlor	General Use	Emusulfiable concentrate and granular	Broadleaf and Grassy Weeds	Pre-emergent[A]
2,4-D	General Use	Emulsion, aqueous solutions, and dry flowable	Broadleaf Weeds	Pre-emergent[A] or Post-emergent[B]

Sources: EXTOXNET, 2002 and Hofstader, 2002

[A] Herbicide is applied after the crop is planted but before it emerges from the ground (Ritter et al., 2001).

[B] Herbicide is applied to the foliage of the weeds after the crop has emerged from the ground (Ritter et al. 2001).

The beginning of the growing season in the Potomac River Basin is generally during late April and early May. Because atrazine, metolachlor, and 2,4-D are usually applied prior to the emergence of crops, this represents the period during which the majority of herbicide application occurs on agricultural lands. The next critical step was to determine the typical application rates and trends for atrazine, metolachlor, and 2,4-D.

6.4.1.2 Atrazine, Metolachlor, and 2,4-D Application Rates and Trends

Information on pesticide use and trends in the Potomac River Basin can be obtained from a variety of sources. The individual states monitor pesticide application rates and report them as part of the USDA National Agricultural Statistics Service (NASS). Information on pesticide application can also be obtained from Cooperative Extension offices located within each state university system. In Maryland, the Department of Agriculture conducts surveys of pesticide users throughout the state on a triennial basis and publishes statistical summary reports on county level pesticide use. Because these sources typically vary in terms of the level of information that can be obtained, three major sources were consulted to summarize information of pesticide application rates and trends for the Potomac River Basin. The sources used were the Chesapeake Bay Program, the United States Geological Survey (USGS), and the National Center for Food and Agricultural Policy (NCFAP).

Tables 6.4.2 through 6.4.5 show statewide (PA, WV, MD, and VA) pesticide use information for atrazine, metolachlor, and 2,4-D organized by type of crop. This information is summarized from the NCFAP Pesticide Use Database (NCFAP, 2001), which is a national database for pesticide use on cropland. The database was compiled using surveys of farmers and expert opinions from cooperative extension service specialists. The USDA, EPA, and USGS have used the database extensively to conduct analytical studies concerning trends in pesticide use and regulation. For some states, this database represents the only available statewide information on pesticide use.

Table 6.4.2: 1997 pesticide use in crop production in Pennsylvania

Pesticide	Crop	Acres Planted	% Acres Treated	Application Rate (lbs/acre AI*)	Acres Treated	Amount Applied (lbs AI*)
Atrazine	Corn	1,455,846	91	1.14	1,324,820	1,510,295
	Sweet Corn	18,318	20	1.00	3,664	3,664
Metolachlor	Cabbage	1,577	40	1.50	631	946
	Corn	1,455,846	57	1.57	829,832	1,302,837
	Grn. Beans	7,458	60	1.50	4,475	6,712
	Potatoes	12,597	80	2.16	10,078	21,768
	Soybeans	347,981	50	2.43	173,990	422,797
	Sweet Corn	18,318	80	1.50	14,654	21,982
	Sw. Peppers	953	40	1.50	381	572
	Tomatoes	4,328	25	1.50	1,082	1,623
2,4-D	Apples	32,903	45	1.40	14,806	20,729
	Barley	63,782	15	0.30	9,567	2,870
	Cherries	1,587	25	1.49	397	591
	Corn	1,455,846	11	0.40	160,143	64,057
	Oats	144,456	30	0.43	43,337	18,635
	Pasture	1,259,965	8	0.50	100,797	50,399
	Peaches	5,851	16	1.54	936	1,442
	Pears	946	6	2.01	57	114
	Rye	7,308	5	0.50	365	183
	Seed Crops	3,813	10	0.50	381	191
	Soybeans	347,981	7	0.50	24,359	12,179
	Strawberries	1,409	50	1.20	704	845
	Wheat	167,488	20	0.25	33,498	8,374

*AI = Active Ingredient

Table 6.4.3: 1997 pesticide use in crop production in West Virginia

Pesticide	Crop	Acres Planted	% Acres Treated	Application Rate (lbs/acre AI*)	Acres Treated	Amount Applied (lbs AI*)
Atrazine	Corn	63,141	85	1.25	53,670	67,087
	Sweet Corn	874	50	1.10	437	481
Metolachlor	Corn	63,141	65	2.00	41,042	82,083
	Soybeans	13,132	31	1.75	4,071	7,124
	Sweet Corn	874	70	1.40	612	857
2,4-D	Apples	10,362	42	1.50	4,352	6,528
	Barley	1,577	15	0.30	237	71
	Corn	63,141	10	0.30	6,314	1,894
	Oats	2,720	5	0.46	136	63
	Other Hay	470,644	7	0.62	32,945	20,426
	Pasture	1,666,124	2	0.62	33,322	20,660
	Peaches	1,516	20	1.50	303	455
	Wheat	7,620	40	0.25	3,048	762

*AI = Active Ingredient

Table 6.4.4: 1997 pesticide use in crop production in Maryland

Pesticide	Crop	Acres Planted	% Acres Treated	Application Rate (lbs/acre AI*)	Acres Treated	Amount Applied (lbs AI*)
Atrazine	Corn	498,568	85	1.25	423,783	529,728
	Sweet Corn	11,332	50	1.10	5,666	6,233
Metolachlor	Corn	498,568	65	2.00	324,069	648,138
	Grn. Beans	6,350	70	1.25	4,445	5,556
	Green Peas	3,130	29	1.19	908	1,080
	Potatoes	2,219	80	2.20	1,775	3,905
	Soybeans	509,683	45	1.75	229,357	401,375
	Spinach	966	10	0.75	97	72
	Sweet Corn	11,332	70	1.40	7,932	11,105
	Tomatoes	1,969	25	1.50	492	738
2,4-D	Apples	3,221	50	1.20	1,610	1,933
	Barley	47,405	10	0.25	4,740	1,185
	Corn	498,568	10	0.25	49,857	12,464
	Oats	5,611	10	0.25	561	140
	Other Hay	168,877	10	1.00	16,888	16,888
	Pasture	287,215	20	1.00	57,443	57,443
	Peaches	1,328	34	1.06	452	479
	Sod	4,048	100	0.88	4,048	3,562
	Strawberries	369	50	1.20	184	221
	Sweet Corn	11,332	1	0.60	113	68
	Wheat	199,351	10	0.25	19,935	4,984

*AI = Active Ingredient

Table 6.4.5: 1997 pesticide use in crop production in Virginia

Pesticide	Crop	Acres Planted	% Acres Treated	Application Rate (lbs/acre AI*)	Acres Treated	Amount Applied (lbs AI*)
Atrazine	Corn	461,424	95	1.40	438,353	613,694
	Sweet Corn	2,790	50	1.10	1,395	1,535
Metolachlor	Corn	461,424	40	1.00	184,570	184,570
	Cotton	98,244	1	0.75	982	737
	Green Beans	5,441	87	1.25	4,734	5,917
	Peanuts	74,687	65	2.50	48,547	121,366
	Potatoes	5,925	36	1.50	2,133	3,200
	Soybeans	487,001	31	1.75	150,970	264,198
	Sweet Corn	2,790	70	1.40	1,953	2,734
	Tomatoes	3,822	6	0.94	229	216
	Watermelons	1,839	10	0.94	184	173
2,4-D	Apples	22,886	20	1.50	4,577	6,866
	Barley	51,096	20	0.50	10,219	5,110
	Corn	461,424	20	0.40	92,285	36,914
	Oats	5,216	5	0.46	261	120
	Other Hay	1,077,455	7	0.62	75,422	46,762
	Pasture	3,186,225	15	0.50	477,934	238,967
	Peaches	2,223	20	1.50	445	667
	Soybeans	487,001	5	0.30	24,350	7,305
	Strawberries	503	14	1.20	70	85
	Wheat	257,063	40	0.25	102,825	25,706

*AI = Active Ingredient

From the information presented in the tables, it is clear that for all states in the Potomac River Basin, atrazine is used exclusively on corn and sweet corn. Metolachlor is used primarily for soybeans and corn and then is also used on a variety of vegetable crops in smaller amounts. 2,4-D is applied to primarily to pasture and hay lands as well as to wheat and small grain crops. 2,4-D is also applied to various fruit crops, especially to apples. Maryland's county-level survey of pesticide applications confirms the prevalence of the metolachlor and atrazine use in the counties in the Potomac River Basin (MD Dept of Agriculture, 1999). 2,4-D was the most heavily applied pesticide in Montgomery County, where D. C. 's water supply intakes are located.

While the statewide information was useful in determining the types of crops that received the most pesticides, a summary of pesticide use for the Potomac drainage basin was also helpful. A study by the USGS used information from the NCFAP database to summarize pesticide usage for its National Water Quality Assessment (NAWQA) program. The Potomac River Basin was one of the study units in NAWQA and the information is presented below for summary purposes (Table 6.4.6).

Table 6.4.6: Pesticide usage information for the Potomac River Basin

Pesticide	Rank in Herbicide Usage	Amount Applied (lbs AI*)	Area Treated (Acres)	Application Rate (lbs/acre AI*)	% of Reported Use in Basin
Metolachlor	1	417,324	220,804	1.89	9.68
Atrazine	2	377,874	279,091	1.35	8.77
2,4-D	4	161,023	274,636	0.59	3.74

*AI = Active Ingredient
Source: Thelin and Gianessi, 2000

The prevalence of atrazine, metolachlor, and 2,4-D application is supported by a study of pesticide usage conducted by the Chesapeake Bay Basin Toxics Loading and Release Inventory (CBP, 1999). Metolachlor and atrazine were ranked first and second in their estimate of 1996 pesticide usage in the Chesapake Bay Basin. 2,4-D was less widely applied, but was the most heavily applied pesticide to small grains. In addition to summarizing application rates for atrazine, metolachlor, and 2,4-D, historical trends in pesticide use from 1990 to 1996 were reviewed to determine the factors that control their use and application. Pesticide usage was variable from year to year and showed no detectable trends. The primary controlling factors in pesticide use were weather, the amount of pest pressure, product availability, price, and regulatory concerns (Maurer, 1999).

6.4.2 Pesticides and Drinking Water Quality in the Potomac River Basin

The application of atrazine, metolachlor, and 2,4-D on agricultural lands in the Potomac River Basin is important to control weeds and to improve supply of agricultural goods. However, when these chemicals are applied to the ground, they can meet a variety of fates, one of which is transport into streams and rivers that may be used for drinking water supply. This section presents an overview of the fate and transport of atrazine, metolachlor, and 2,4-D in surface and groundwater. Upon understanding how these chemicals can be transported to streams and rivers in the Potomac River Basin, a summary of water quality monitoring data is then presented to characterize where, how much (e.g. concentrations and loads), and how often these pesticides are detected throughout the Potomac River Basin.

6.4.2.1 Fate and Transport of Atrazine, Metolachlor, and 2,4-D

A suite of factors controls the fate and transport of atrazine, metolachlor, and 2,4-D. The factors are affected by the individual properties of each pesticide as well as the site characteristics (soil type, climate, management practices, etc.) into which the pesticide was introduced. Pesticide properties are the most important for the determination of risk to surface and groundwater supplies and are listed below (Trautmann and Porter, 1998):

1. Solubility in water
2. Volatilization to the atmosphere

3. Adsorption to soils
4. Degradation into chemical daughter products

Solubility in water is important because pesticides that are highly soluble are more likely to be transported by surface runoff or infiltration. Volatilization measures the tendency of a compound to become a gas. At higher vapor pressures, pesticides are lost to the atmosphere, meaning that less pesticide remains available for leaching and transport by runoff, though volatilized pesticides can be transported to surfacewater.

Soil adsorption determines a how strongly a pesticide will adhere to soil particles. It is characterized using two different parameters. The first is called the adsorption partition coefficient (K_d), which is the ratio of the pesticide concentration in the adsorbed phase to that in solution. Partition coefficients for soils are a function of the percent organic matter in the soil by weight. The second parameter, the organic carbon partition coefficient (K_{oc}), gives the partition coefficient between the pesticide and organic carbon. Generally, the K_d of a soil for a pesticide is the product of K_{oc} and the fraction of organic matter in the soil. The organic carbon partition coefficient thus gives a soil-independent method for characterizing a pesticide's sorption to soil.

The degradation of a pesticide determines the rate of chemical breakdown. The longer it takes a pesticide to breakdown, the longer it can remain available for leaching and transport by runoff. Pesticides are broken down via photolysis (exposure to sunlight), hydrolysis (reaction with water), and oxidation (chemical and biological reactions in soil). The most common measure of pesticide degradation is field dissipation half-life, which determines empirically the amount of time it takes for half of the pesticide to disappear. The value for half-life takes into account physical, chemical, and biological degradation, but it can vary greatly due to soil conditions, climatic factors, and the types of organisms present in the soil (Trautmann and Porter, 1998). Typical ranges for solubility, vapor pressure, adsorption, and degradation are presented in Table 6.4.7. An indication of the relative persistence of each pesticide is also given. The longer the half-life of a pesticide, the more persistent it is (Rao and Hornsby, 1989).

Table 6.4.7: Chemical properties and relative persistence of atrazine, metolachlor, and 2,4-D

Pesticide	Water Solubility (mg/L at 20°C)	Vapor Pressure (mm Hg at 20°C)	K_{oc} (mL/g)	Field Half-Life (days)	Persistence
Atrazine	33[A]	2.89 x 10-7[A]	100[A]	60[A]	Mod. Persistent[C]
Metolachlor	530[B]		200[B]	120[C]	Persistent[C]
2,4-D	890[A]	8.00 x 10-6[A]	20[A]	10[A]	Nonpersistent[C]

[A]Source: Agricultural Research Service, 1995
[B]Source: EXTOXNET, 2002
[C]Source: National Research Council, 1993

From the table, it is evident that atrazine, metolachlor, and 2,4-D behave very differently once exposed to the environment. Metolachlor is the most persistent of the three pesticides, has the longest half-life, and also sorbs the most strongly to soil particles. 2,4-D is the least persistent, has the shortest half-life, and does not adsorb very strongly to soils. The method of application must also be taken into account because 2,4-D is

frequently applied in an emulsification, which increases binding to the soil and reduces the risk of transport in runoff.
The transport of pesticides in surfacewater is the primary potential pathway for pesticide contamination at the intakes on the Potomac River. Transport of herbicides into surfacewater typically occurs within a critical period of about 2 to 6 weeks after application and is maximized during storm events that follow application (Ng and Clegg, 1996). Herbicides are transported to surfacewater in runoff or overland flow and in interflow or soil-water flow (Ng and Clegg, 1996; Hyer et al., 2001). Pesticide properties play an important role in determining the type of transport that occurs. Ng and Clegg (1996) found that atrazine was much more likely to be transported in surface runoff as compared to metolachlor, due to the fact that atrazine had a lower adsorption coefficient. Conversely, the loss of metolachlor was found to be dominated by soil-water transport and thus resulted in higher stream baseflow concentrations. This was also due to the differences in adsorption coefficient for metolachlor and atrazine. 2,4-D, which was not addressed in either study, has the lowest adsorption coefficient and therefore would be most likely dominated by surface transport mechanisms.

6.4.2.2 EPA Drinking Water Standards for Atrazine, Metolachlor, and 2,4-D

The use of pesticides and their subsequent transport into the Potomac River Basin presents a contamination risk to drinking water supplies. The EPA has set maximum contaminant levels (MCLs) and health action levels (HALs) for atrazine, metolachlor, and 2,4-D for a variety of health risks that are possible when exposed to elevated concentrations of these pesticides over a period of time. Table 6.4.8 presents the EPA MCLs and HALs as well as potential human health effects due to pesticide exposure. The values in the table will be important reference points throughout the remainder of the chapter when comparing historical water quality monitoring data as well as model output for the risk analysis.

Table 6.4.8: EPA MCLs and HALs for atrazine, metolachlor, and 2,4-D

Pesticide	MCL (µg/L)	HAL (µg/L)	Potential Health Effects
Atrazine	3[A]	3[B]	Cardiovascular system or reproductive problems, Suspected carcinogen[A]
Metolachlor	None	100[B]	Kidney or liver problems, Suspected carcinogen[C]
2,4-D	70[A]	70[B]	Kidney, liver, or adrenal gland problems[A]

[A]Source: EPA, 2001
[B]Source: van Es and Trautmann, 1990
[C]Source: EPA, 1995

If concentrations of pesticides exceed the established MCL values for finished drinking water for a period of 4 consecutive days, then the Safe Drinking Water Act mandates that water utilities must either actively treat the water to reduce the concentrations or find an alternate water supply (Sutton, 1997). If pesticide contamination is detected at a water treatment plant and the episode lasts for a series of days, several treatment options are available. Removal of pesticides at water treatment plants is typically

accomplished through the use of granular activated carbon (GAC), powdered activated carbon (PAC), or reverse osmosis (Knappe et al., 1999).
The treatment plants operated by WSSC and WAD use PAC to remove pesticides when concentrations become elevated (O'Melia, 2002). The current operating rule is to begin treating the water with PAC upon notification that pesticide concentrations are above the drinking water standards in raw water (Brown, 2002).

6.4.2.3 Water Quality Monitoring for Atrazine, Metolachlor, and 2,4-D

Monitoring for pesticides in surfacewater and groundwater has been conducted throughout the Potomac River Basin to determine the extent of pesticide occurrence in surfacewater and groundwater resources. The USGS conducted the most extensive monitoring as part of its NAWQA program. Four studies were published by the USGS using data from NAWQA to characterize the occurrence of pesticides in the Potomac River Basin. The results from the studies stated that atrazine and metolachlor were the two most detected pesticides in surfacewater and groundwater samples (Fisher, 1995; Ator and Ferrari, 1997; Ferrari et al., 1997; Donnelly and Ferrari, 1998). Atrazine was detected in 88 percent of the samples analyzed and metolachlor was detected in 85 percent of the samples. The maximum reported concentration of atrazine was 25 µg/l; the 90th percentile concentration was 0.730 µg/l. For metolachlor, the maximum and 90th percentile concentrations were 23 and 0.990 µg/l, respectively. 2,4-D was detected less frequently. Only 20 percent of the samples analyzed had detectable concentrations. The maximum observed concentration was 2.8 µg/l and the 90th percentile concentration was 0.34 µg/l.

Table 6.4.9 shows the minimum, median, and maximum concentrations of atrazine, metolachlor, and 2,4-D observed at key monitoring stations in the Potomac River Basin during the USGS NAWQA study from 1993-1996. The highest concentrations occurred in the heavily agricultural upper Monocacy watershed, where concentrations of atrazine and metolachlor above 1 ug/l were not uncommon. Values of both these pesticides above 20 ug/l were observed. Three atrazine observations on Conococheague Creek were above the 3 ug/l MCL. Two of those occurred during the same storm in June 1996. Of 11 atrazine samples collected by the USGS at Chain Bridge between 1994 and 1996, two samples, both in June 1996, had concentrations above 3 µg/L. The maximum observed concentration was 4.1 µg/l and the median value was 0.039 µg/l.

Table 6.4.10 summarizes the data from a NAWQA study, which attempted to characterize geographically the prevalence of pesticides in surface waters in the Potomac River Basin. Twenty-three streams were sampled for pesticides during June 5 through 16, 1994. The table shows that atrazine and metolachlor were detected throughout the Potomac River Basin, though at concentrations that were typically less than the MCLs and/or HALs for both pesticides.

Table 6.4.9 Summary of Observed Pesticide Concentrations from the USGS NAQWA Study, 1993-1996 (concentrations in μg/l)

Pesticide		**South Branch**	***Conococheague***	**Shenandoah**	**Monocacy at Bridgeport**	**Chain Bridge**
Atrazine	Minimum	.007	.27	.014	.001	.032
	Median	.0085	.66	.064	.21	.28
	Maximum	.012	7.5	1.0	25.0	4.1
Metolochlor	Minimum	.001	.022	.014	.002	.031
	Median	.005	.515	.059	.31	.28
	Maximum	.006	4.1	.4	23.0	2.7
2,4-D	Minimum	No Data	.035	.035	.035	.035
	Median			.035	.035	
	Maximum			.11	2.8	

Table 6.4.10: Summary of surfacewater atrazine and metolachlor concentrations in the Potomac River Basin, June 5-16 1994

USGS Station Name	Drainage Area	Land Use (percent)			Flow (cfs)	Concentration (µg/L)	
		Forest	Agriculture	Urban		Atrazine	Metolachlor
N.Br. Potomac River at Pinto, MD	596	83	12	2	435	< 0.017	< 0.009
N.Br. Potomac River near Cumberland, MD	875	82	13	3	590	< 0.017	< 0.009
S.Br. Potomac River near Petersburg, WV	642	79	21	0	226	< 0.017	< 0.009
S.Fk. S.Br. Potomac River near Moorefield, WV	283	85	14	<1	52	< 0.017	< 0.009
S.Br. Potomac River near Springfield, WV	1,480	78	22	<1	435	< 0.017	< 0.009
Cacapon River near Great Cacapon, WV	677	82	18	<1	219	< 0.017	< 0.009
Conococheague Creek at Fairview, MD	494	36	60	4	342	0.730	0.600
Opequon Creek near Martinsburg, WV	272	24	70	6	165	0.190	0.078
Antietam Creek near Sharpsburg, MD	281	24	69	7	302	0.300	0.088
North River at Burketown, VA	379	59	34	7	154	0.094	0.028
Middle River near Grottoes, VA	375	31	60	8	163	0.049	0.015
South River at Harriston, VA	212	59	30	11	104	0.028	< 0.009
S.Fk. Shenandoah River near Luray, VA	1,377	50	42	8	640	0.069	0.023
S.Fk. Shenandoah River at Front Royal, VA	1,642	51	40	8	776	0.078	0.033
N.Fk. Shenandoah River at Mt. Jackson, VA	506	55	40	5	170	0.140	0.290
N.Fk. Shenandoah River near Strasburg, VA	768	54	40	6	297	0.065	0.086
Shenandoah River at Millville, WV	3,040	51	41	7	1,350	0.150	0.300
Catoctin Creek at Olive, MD	112	26	71	2	38	0.230	0.060
Catoctin Creek at Taylorstown, VA	90	18	81	1	24	0.120	0.150
Monocacy River at Bridgeport, MD	173	20	78	2	31	0.570	0.700
Monocacy River near Frederick, MD	817	23	73	3	312	0.510	< 0.009

Source: Fisher, 1995

6.4.3 Development and Validation of the Atrazine Pesticide Model

To help determine the susceptibility of the District of Columbia's source water supply to pesticide contamination, the Watershed Model was modified to represent the fate and transport of atrazine. The primary purpose of this model, hereafter referred to as the Pesticide Model, was to help quantify the risk posed by atrazine applications if they are applied under adverse hydrological conditions. Because atrazine is primarily transported to surface water in runoff, the risk of atrazine transport is increased if there is a storm following an application with surface runoff. The best time to apply atrazine is before a gentle rain with little runoff, so that the atrazine infiltrates into the soil.

The Base Case Scenario of the model represents the recommended timing of atrazine applications. It assumes that on a basin-wide scale, applicators apply atrazine under favorable conditions. The model was parameterized and, to a certain extent, calibrated so that the results of the base case scenario matched the observed data, the underlying assumption being that for the most part, applicators apply atrazine at the proper time. The observed data does not always support this assumption. Subsequent scenarios were used to determine the risk posed by applying atrazine under adverse conditions, when a significant amount of the applied atrazine is transported in runoff.

6.4.3.1 Model Development

HSPF has a special module, PEST, for representing the fate and transport of pesticides on pervious surfaces like cropland. PEST simulates the partitioning of the pesticide between soil and pore water, the decay of a pesticide in the soil, and its transport in runoff, infiltration, interflow, and ground water discharge. Only the transport of atrazine in runoff was simulated in the Pesticide Model. The GQUAL module, which can represent the fate and transport of almost any constituent, was used to simulate the fate and transport of atrazine in river reaches. The only in-stream processes represented in the Pesticide Model are first-order decay and partitioning between sediment and the water column.

The model was parameterized using values from documentation of the modeling performed by the U.S. EPA's Office of Pesticides for the proposed reregistration of atrazine (U.S. EPA, 2001b). Table 6.4.11 gives the parameter values.

Table 6.4.11 Important parameter descriptions and values used in the pesticide model

Parameter	Description	Units	Value
CMAX	Maximum dissolved concentration	μg/L	33.0
K1	First order partition coefficient	L/mg	1.3
SDGCON	Aerobic soil decay rate	Day^{-1}	4.75 E-3
UDGCON	Aerobic soil decay rate	Day^{-1}	4.75 E-3
LDGCON	Anaerobic soil decay rate	Day^{-1}	4.36 E-3
ADGCON	Anaerobic soil decay rate	Day^{-1}	4.36 E-3
FSTDEC	First order instream decay rate	Day^{-1}	2.44 E-3
ADPM(1,1)	Partition coefficient for suspended sand	L/mg	7.82 E-6
ADPM(2,1)	Partition coefficient for suspended silt	L/mg	1.756 E-6
ADPM(3,1)	Partition coefficient for suspended clay	L/mg	4.389 E-6
ADPM(4,1)	Partition coefficient for bed sand	L/mg	7.82 E-6
ADPM(5,1)	Partition coefficient for bed silt	L/mg	1.756 E-6
ADPM(6,1)	Partition coefficient for bed clay	L/mg	4.389 E-6

6.4.3.2 Input Loads

An atrazine loading rate of 1.1 pounds per acre was applied on 90 percent of all corn acreage in the basin. This application rate falls within the range of application rates cited in Tables 6.4.2 through 6.4.6 and was also approved by Randy Shenk (2002) of Virginia Department of Agriculture and Rob Hofstader (2002) of the Maryland Department of Agriculture. Table 6.4.12 shows the number of corn acres by modeling segment for the Potomac portion of the Watershed Model. Soybean and grain (sorghum, wheat, oats, and barley) acres are also presented for reference purposes because they receive applications of metolachlor and 2,4-D.

Table 6.4.12: Cropland, corn, soybeans, and grain acres in the Potomac River model segments

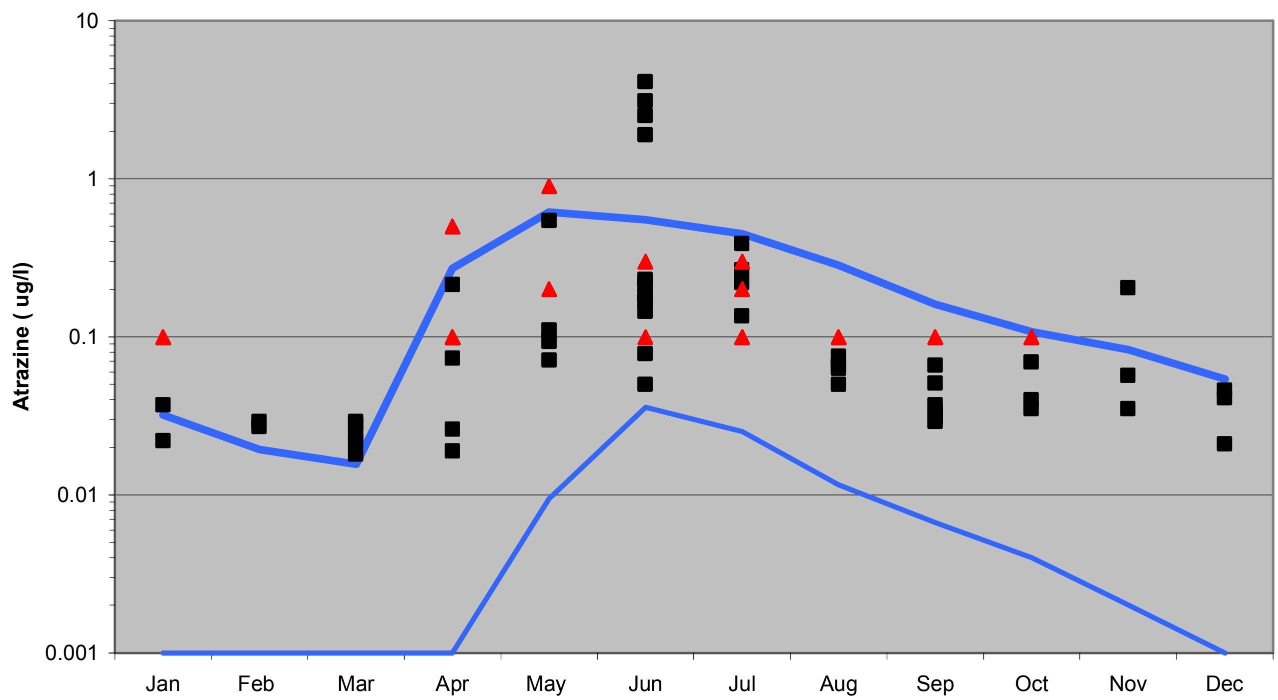
River Reach	Segment	Cropland (acres)	Corn (Acres)	Soybeans (Acres)	Grain (Acres)
Upper Potomac River	160	21,807	8,105	0	1,912
	170	14,719	7,557	0	510
	175	20,702	9,726	153	1,959
Shenandoah River	190	65,912	22,895	2,397	3,729
	200	61,176	20,902	3,798	5,214
Middle Potomac River	180	86,724	32,653	10,275	15,420
	730	77,810	46,145	67	8,428
	740	78,296	31,118	3,299	12,584
Lower Potomac River	210	121,654	40,607	26,246	24,572
	220	72,305	18,977	14,329	10,589
	750	26,970	10,803	1,037	5,204

The base run of the Pesticide Model is supposed to represent the suggested application procedures recommended by agricultural extension experts. Atrazine was applied just prior to the growing season during the months of April and May. Three application dates per model segment were chosen on days with a low ratio of runoff to rainfall and the application rate was divided evenly among them. Thus, atrazine was applied during “good” days when losses due to surface runoff would be minimized.

6.4.3.3 Model Calibration

Simulated atrazine concentrations from the Lower Potomac (220) were compared with the range of concentrations observed by the USGS at Chain Bridge and by WAD in their finished water. The HSPF model parameter representing the depth of the surface layer was adjusted until there was reasonable agreement with the range of observed concentrations on a monthly basis. Figure 6.4.1 shows the observed concentrations and the monthly maximum and minimum simulated concentrations. Overall, the base case model captures the seasonal range of values quite well. About 85% of the observed values lie between the maximum and minimum simulated values. The base case model tends to underpredict the range of observed winter values, when concentrations are low.

Figure 6.4.1 Monthly Range of Simulated Base Case Atrazine Concentrations vs. Observed Concentrations at Chain Bridge and Delcarlia Reservior



Black Squares: Atrazine Concentrations observed by USGS at Chain Bridge 1993-2000.
Red Triangles: Atrazine Concentrations observed by WAD in Delcarlia Reservoir 1995-2001.
Blue Lines: Monthly minimum and maximum simulated atrazine concentrations for Pesticide Model Base Case Scenario.

It is important to recognize that the Base Case Scenario does not represent actual conditions: to simulate actual conditions, the actual application dates for atrazine would have to be known basin-wide. Several observed values lie above the maximum range of the base case model. In particular, there are four observations above 1 µg/l in June, two of which are above the MLC of 3 µg/l. These observations all occurred in 1996 over a period of four days during a large storm event. They indicate that a significant amount of atrazine can be washed into the Potomac by runoff and probably represent the impact of atrazine applied under hydrologically unfavorable conditions.

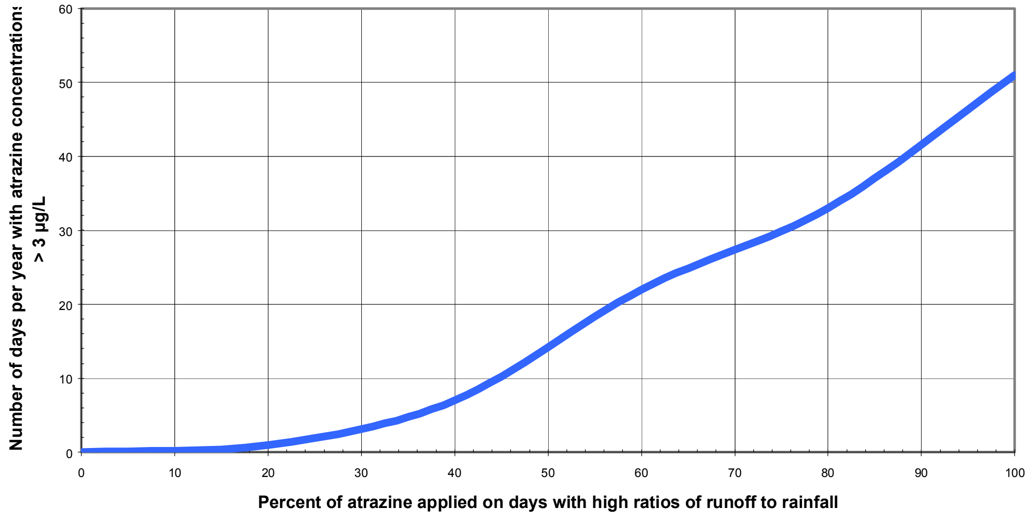
6.4.3.4 Risk Assessment Scenarios

To estimate the risk of atrazine contamination at the intakes, five scenarios were run, each increasing the amount of atrazine applied under hydrologically unfavorable conditions. For each model segment, dates with high runoff to rainfall ratios were chosen. Atrazine application rates on those dates were increased by the following amounts:

1. 20 percent applied on a date with high runoff
2. 40 percent applied on a date with high runoff
3. 60 percent applied on a date with high runoff
4. 80 percent applied on a date with high runoff
5. 100 percent applied on a date with high runoff

Thus, a determination could be made about the risk of atrazine contamination at the intakes given poor pesticide application and the influence of hydrological events in the Potomac River Basin. The results of the risk assessment scenarios are summarized in Figure 6.4.2. The figure illustrates both the hydrological and the management implications of poor pesticide application and what impact that would have at the surfacewater intakes near [REDACTED]. If 20 percent of the pesticide users in the Potomac River Basin applied atrazine on days with runoff, there would be only about one or two days per year with atrazine concentrations greater than the MCL of 3 µg/L at Chain Bridge. If 50 percent of pesticide users applied on days with high runoff, then anywhere from 10 to 15 days may have atrazine concentrations higher than 3 µg/L. In the unlikely event that 100 percent of pesticide users in the basin applied atrazine on days with high runoff, then about 50 days of atrazine concentrations greater than 3 µg/L could be expected. This represents the “worst case” scenario.

Figure 6.4.2: Number of days per year with atrazine concentrations greater than 3 µg/L versus the percent of atrazine applied on days with high ratios of runoff to rainfall.



The results of this analysis indicate that the risk of atrazine contamination at the surfacewater intakes is moderately low. The risk is not zero, but it is not likely that a long period of elevated atrazine concentrations would occur at the intakes.

6.4.4 Susceptibility Analysis for Pesticides

The results of the Pesticide Model simulations suggest that the risk of sustained periods when the concentration of atrazine is above its MCL, while not negligible, are moderately low. The results of the simulation can be extrapolated to metolachlor by comparing the characteristics of the two pesticides. Metolachlor partitions more strongly on the soil and decays more slowly in the soil than atrazine. For equal application rates, concentrations of metolachlor should be initially lower, but more persistent, than atrazine concentrations. Metolachlor application rates tend to be higher than that of atrazine, but its HAL is over 30 times larger than that of atrazine. Therefore the chances of observing sustained concentrations of metolachlor over its HAL are low.

Similar arguments can be used to show that the risk of sustained concentrations of 2,4-D are low. 2,4-D partitions less strongly to the soil than atrazine. The concentration of 2,4-D in runoff after application is typically higher than atrazine. 2,4-D is usually applied in an emulsion, which lowers runoff losses (North Carolina Cooperative Extension Office, 1984). Because it decays quickly in the soil, initially high concentrations in runoff would not be expected to persist. 2,4-D is applied at a lower rate than atrazine, and currently, it is applied on fewer acres than atrazine. Moreover, its HAL is more than twenty time higher than atrazine's. The chances of seeing sustained concentrations of 2,4-D over its HAL are also low.

The relatively low susceptibility of the District of Columbia's source water to pesticide contamination is due to dilution. The primary health risk from herbicides comes from chronic exposure. Sustained concentrations at the MCL or HAL are necessary before herbicides pose a health risk. The amount of herbicide applied is relatively small compared to the volume of flow in the Potomac. Table 6.4.13 shows the average monthly flow volumes in the Potomac, and the herbicide load necessary to sustain concentration at the HAL. To sustain an atrazine concentration over the MCL in the month of June, when the highest concentrations of atrazine are observed, approximately 20 to 25 percent of the atrazine applied in the basin, according to Table 6.4.6, would have to be lost from the field. By comparison, the amount of atrazine lost in the June 1996 storm, which has the highest observed atrazine concentrations, was approximately 1.5%. Sustained concentrations of metolachlor or 2,4-D above their HALs are even less likely. According to the application rates in Table 6.4.6, the amount of metolachlor or 2,4-D necessary to sustain concentrations at the HAL are larger than the amount applied annually in the basin.

A study by Capel and Larson (2001) helps put the size of the losses necessary to sustain atrazine concentrations above the MCL in perspective. They calculated the annual atrazine load as a percent of use (LAPU) for 408 watersheds. The watersheds varied in size from experimental plots to the Mississippi Basin. LAPU was relatively invariant with watershed size, although it was slightly larger for large watersheds. The mean LAPU for large watersheds is 1.82%. The median value is 1.30%. The Shenandoah River, which was one of the watersheds they studied, had a LAPU of 0.92%.

The use of atrazine and metolachlor has been on the decline since the mid-1980s and can be expected to decrease in the future (Betty Marose, 2002). As Section 6.2.2 demonstrated, CBP land use projections predict a decrease in the amount of cropland in the next decade. The application rate of these pesticides has been steadily decreasing, as farmers try to limit their pesticide use to economically efficient application rates. The use of 2,4-D has also been declining since the mid-1980s, although the next decade will see an increase in suburbanization and the cultivation of hay, trends that tend to potentially increase the opportunities for its use in weed control.

Table 6.4.13: Pesticide loading rates necessary to sustain HAL concentrations at intakes

Month	**Avg. Monthly Flow (cfs)**	**Mass of Herbicide (lb) needed to Average HAL**		
		Atrazine **(HAL = 3µg/L)**	**Metolachor (HAL = 100 µg/L)**	**2,4-D (HAL = 70 µg/L)**
January	682,997	342,606	11,420,191	7,994,134
February	560,754	255,880	8,529,319	5,970,524
March	989,198	496,203	16,540,088	11,578,062
April	638,267	309,840	10,328,007	7,229,605
May	434,464	217,936	7,264,544	5,085,181
June	247,514	120,153	4,005,110	2,803,577
July	151,869	76,181	2,539,358	1,777,551
August	158,911	79,713	2,657,109	1,859,976
September	204,777	99,407	3,313,565	2,319,496
October	187,852	94,231	3,141,023	2,198,716
November	255,636	124,096	4,136,533	2,895,573
December	419,964	210,663	7,022,089	4,915,462

6.4.5 Additional Pesticide Monitoring to Lower Risk

The risk of pesticide contamination at the surfacewater intakes near [REDACTED] was evaluated for atrazine, metolachlor, and 2,4-D. Pesticide contamination risk was determined to be moderately low for all three pesticides. This assumes that pesticides continue to be applied on dates with low runoff and that application rates remain constant and/or decrease into the future. The fact that past monitoring data has suggested that concentrations of pesticides, especially atrazine, can occur and that the pesticide model did not indicate a zero risk of elevated atrazine concentrations points to a need for pesticide monitoring, especially during the critical period from May through July when elevated concentrations would be most likely. Thus, a general recommendation would be to increase the frequency of water quality monitoring efforts for pesticides of concern during that time each year to assure that raw water and finished water at the District of Columbia’s water intakes maintains concentrations of pesticides below the EPA MCLs.

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Appendix E: Phase IV Watershed Land Use and Model Linkages to the Airshed and Estuarine Models. EPA 903-R-97-019. CBP/TRS 180/9.
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7.1 Recommendations For Source Water Management and Protection

The Potomac River has proven itself a good source of drinking water for the District of Columbia. The purpose of this source water assessment is to determine the sources of potential pollutants that might impair the quality of Potomac River's waters, in order to better protect D. C.'s water supply.

The contributing watershed above D. C.'s intakes is large--over 11,000 square miles in the states of Maryland, Virginia, Pennsylvania, and West Virginia. Over half the watershed is forest, but about a third is used for pasture, cropland, or other agricultural operations. Beef, dairy cattle, and poultry are raised in large numbers in concentrated animal operations throughout the watershed.

About two million people live in the watershed and approximately half of that population live in the fast-growing suburbs west and northwest of Washington, much of the rest in small cities and towns along the Potomac and Shenandoah Rivers. There is relatively little industry or manufacturing that impacts water quality, but the watershed is crisscrossed by oil and gas pipelines and major transportation corridors.

Given the character of the Potomac River Basin upstream of the Washington Aqueduct intakes, the most likely sources of potential pollutants to the intakes are toxic chemical spills, agricultural activities, and inadequate wastewater treatment. Table 7.1 lists the pollutants to which D. C.'s source water is most susceptible and their sources. Specific recommendations for each type of source are described below.

Table 7.1 Potential Pollutants of the DC Water Supply and their Primary Sources

Potential Pollutant	Primary Sources	Cause for Concern
Sediment	Crop production	1. Increased water treatment costs. 2. Lowers effectiveness of treatment of other constituents.
Nitrogen and Phosphorus	Crop production Livestock waste Wastewater treatment	1. Increased algal growth and associated taste and odor problems. 2. Production of THMs and other toxic by-products of the water treatment process from organic material associated with nitrogen and phosphorus loads.
Pathogens	Livestock waste Wastewater treatment	1. Waterborne illnesses caused by bacterial, viruses, and protozoa.
Toxic Chemicals	Spills from transport of material by truck, rail or pipeline	1. Temporary shutdown of water supply. 2. Contamination of water supply.

7.1.1 Toxic Chemical Spills

Given the rural character of most of the watershed and regulatory oversight of known dischargers, D.C.'s source water is not chronically susceptible to chemicals associated with commercial and industrial activities. D.C.'s source water is susceptible, however, to the accidental or illegal discharge of material into the Potomac River and its tributaries. The threat of these spills comes primarily through the transport of chemicals by truck, rail, or pipeline through the basin, and secondarily through spills or discharges associated with small suburban generators, such as dry cleaners or service stations, of the heavily suburbanized zone within 24 hour travel time of the intakes. Such spills have occurred on the Potomac, impacting water supplies. A break in the Colonial Pipeline in March 1993 released 400,000 gallons of oil into Sugarland Run, a tributary which drains into the Potomac [REDACTED] above a water supply intake for the Fairfax County Water Authority. High flows quickly moved the spill past the Washington Aqueduct intakes, although the FCWA Potomac intake was closed for several days.

Currently D.C. has an emergency response plan for dealing with water supply problems within the confines of the district, but it does not address problems that may arise from its source water above the [REDACTED] intakes. Since D.C.'s source water comes from outside its boundaries, it is imperative that a plan be devised to deal with accidental or intentional spills that may occur above the intakes at the Washington Aqueduct.

The focus of the plan would be on the development and implementation of a emergency spill response network with member jurisdictions and devising methods to deal with different types of spills, both large quantity single event spills as well as continuous small quantity generating sites within the basin. The plan would also detail actions to be taken in the event the intakes have to be shut down or in the event of a total loss of supply due to contamination. A key component for a successful spill response plan would be the development of a real-time monitoring system to detect a variety of contaminants that may enter the Potomac River and its tributaries.

7.1.2 Recommendations

First, it is recommended that a cooperative mechanism should be established between the basin states and the District of Columbia to deal with these types of events. This mechanism could take the form of a basin-wide emergency spill response plan. The plan could be carried out through the use of an interstate agency or commission whose job or purpose would be to act as intermediary in establishing the network as well as being a central repository for GIS and modeling data to support the response system. With this cooperative framework in place and the citizens of DC be more assured in the quality of the water that is delivered at the tap.

Secondly, a real-time early warning monitoring system should developed based on data analysis from the source water assessment. The system would be set up to test for specific contaminants based on geographically related activities. The system would also be arranged to provide protection to all the water service areas that draw water from the Potomac River above Great Falls. Strategic placement of the sensors would provide the means to respond in a timely fashion and give the water utilities and it's customers added assurance that their water is safe and of a high quality.

7.1.2 Wastewater Treatment

Permitted discharge rates from wastewater treatment plants above the intakes average about 93 MGD. There are over 600,000 people using septic systems in the basin. The primary purpose of wastewater treatment plants and septic systems is to reduce the threat of waterborne illnesses by eliminating pathogens from the wastewater stream. When they function well, they are an essential element in the public health system. But they do not always function well. Septic system failures can lead to wastewater entering into nearby rivers and streams. Cumberland and other towns along the North Branch have combined sewer systems which discharge millions of gallons of untreated waste into the river each year. Wastewater treatment systems suffer from sanitary sewer overflows, spills, and plant shutdowns which release untreated sewage into the basin's streams and rivers. This was vividly demonstrated by shutdown of the Hagerstown wastewater treatment February of 2002. The plant was forced to shut down its secondary treatment operations after industrial solvents killed the bacteria in the treatment process.

Untreated or partially treated wastewater contributes to the susceptibility of D.C.'s source water to pathogen contamination. It is the primary potential source of waterborne viruses. Small cities, towns, and rural communities in the basin upstream of the Washington metropolitan area often do not have the resources to address the possibility for treatment failures like sanitary sewer overflows or to inspect, maintain, and replace septic systems. The estimated cost for mitigating CSOs at Cumberland is 30 million dollars.

As the population of the basin grows, the volume of wastewater treated will also increase. The increase in wastewater flows may increase the risks of spills or sewer overflows in small treatment plants. Phosphorus loads are predicted to increase by 10% over the next ten years primarily due to an increase flows from wastewater treatment plants.

The following steps are recommended to reduce the susceptibility of D. C.'s source water to pollution from wastewater treatment systems and failing septic systems:

- Accelerate the effort to significantly reduce CSOs from Cumberland and other Allegany County sewer systems;
- Identify sewer systems with significant sanitary sewer overflows and provide assistance to mitigate SSOs.

- Reduce phosphorus loads from wastewater treatment plants serving growing populations; and
- Provide assistance to rural communities to identify and repair failing septic systems.

7.1.3 Agriculture

Sediment and nutrient losses in runoff from cropland and pasture are the major nonpoint source constituents in D.C.'s source water. Runoff from pasture, cropland, and feedlots, as well as the presence of cattle in streams, are the largest potential sources of many pathogens, such as *giardia lamblia* and *cryptosporidium*.

Under the auspices of the Chesapeake Bay Program, a significant effort is underway to reduce nutrient and sediment loads entering the Chesapeake Bay from the Potomac River Basin. The District of Columbia is a partner in that effort with the neighboring states of Maryland, Pennsylvania, and Virginia. West Virginia, while not officially a member of the Bay Program, is participating in the effort to reduce nutrient and sediment loads in the Potomac Basin. Each of the basin states has committed itself to promoting the adoption of agricultural BMPs such as nutrient management, soil conservation, riparian buffers, and animal waste management. Many of the sources of agricultural nutrient and sediment loads were also potential sources of pathogens, and the measures used to reduce nutrient and sediment loads could also help to reduce the threat of pathogen contamination of D. C.'s raw water from agricultural sources. Source water protection should be integrated into Bay Program's nutrient and sediment reduction strategies, and in particular, that the ability of agricultural BMPs to reduce the possibility of pathogen contamination of the source water should be recognized. The Potomac River is the source of drinking water not only for the District of Columbia, but for the residents of Northern Virginia and suburban Maryland as well as many communities upstream. Regional and interstate cooperation will be necessary to protect drinking water supplies, but the benefits will also be widespread.

Although the source water assessment has shown that pesticides were not a critical threat to D. C.'s source water, additional monitoring during the spring and early summer, when pesticides are most widely applied, would help eliminate the risk that sustained pesticide concentrations above the levels critical for human health are entering the water supply.

7.2 Integrating Source Water Protection into Environmental Protection

The Potomac River is a source of drinking water not just for the District of Columbia, but for millions of residents of suburban Maryland and Virginia who are customers of WSSC and FCWA, and for residents of many smaller communities upstream throughout the basin. There exists a common interest for the states in the basin to work together with the District of Columbia to protect the quality of source water from the Potomac and its tributaries. Since many of the factors which effect source water quality also have other environmental impacts, it would be cost-effective to integrate source water protection into other cooperative efforts on regional environmental issues, like the Chesapeake Bay Program. Cooperation among the basin states and among WAD, WSSC, FCWA and other water utilities is the most effective way to preserve the Potomac River as a reliable source of safe drinking water for years to come.

8.1 Public Participation

The EPA's Guidance on State Source Water Assessment and Protection Programs emphasized the importance of public involvement in the development of SWAP plans. To meet this requirement, MWCOG, working under contract to the ICPRB, convened and provided staff support to a Citizens Advisory Committee, solicited additional public comment on the draft Plan and provided coordination with the public outreach efforts of SWAP development in neighboring Maryland and Virginia. MWCOG also hosted several public meetings during the course of the assessment. These meetings were held to update the stakeholders on the status of the program and to receive feedback on the direction and progress of the assessment.

8.1.1 Citizen Advisory Group Efforts

MWCOG sent letters soliciting interest in helping to develop the District of Columbia's SWAP Plan to more than 100 individuals. These people included all of those who attended a public meeting on drinking water issues in Washington, D.C., held by EPA Region III in March 1996. It included other representatives of civic and environmental organizations in the city, the chairs of the 29 Advisory Neighborhood Commission subdistricts in the city, and representatives of various city government agencies or other organizations involved in drinking water and public health issues.

Twenty-two people attended an organizational meeting for the Advisory Committee held November 17, 1998. The group received background information on source water protection efforts in general and plans for developing the District of Columbia plan. The participants agreed to form an advisory committee and discussed funding and communication issues. (A roster of those who subsequently attended Committee meetings or expressed an interest in continuing to review Committee materials is attached as part of Appendix D; the roster includes members of the ICPRB's Technical Advisory Committee, staff from EPA Region III and MWCOG staff.)

The Committee held additional meetings on December 17, 1998, and January 20, 1999. The Committee reviewed a draft outline and a portion of the Plan text at the December 17 meeting and further discussed funding and communications issues. At the January 20 meeting, the Committee provided comments on the full draft of the Plan, which was originally distributed to members on January 8, 1999. (See attached meeting summaries in Appendix D for a record of Committee comments.)

Comments on technical aspects of the Plan by individual Committee members are addressed in the body of this Plan or in Appendix D. In addition to these comments, the Committee as a group endorsed the recommendation that its role in providing public input into the source water assessment process should continue during the actual Assessment phase rather than end with submission of the Plan to EPA. The Committee also supported a continuing role for ICPRB and MWCOG in the project, as well as having the US Geological Survey involved in technical aspects of the Assessment.

8.1.2 Public Involvement

In addition to the Advisory Committee efforts, MWCOG and ICPRB made the following efforts to obtain public input on the draft Plan:

- MWCOG issued a press release on January 7, 1999 to publicize the developing Plan and invite comments on it at a public meeting January 20 (to be held in conjunction with the Advisory Committee meeting).
- MWCOG distributed a flyer advertising the public meeting to all branch libraries in the District of Columbia along with Advisory Neighborhood Commissions and District of Columbia government offices.
- Copies of the draft Plan were made available for review at public library branches and the MWCOG Information Center prior to the public meeting.
- Copies also were available through e-mail, in response to a recommendation from the Advisory Committee.
- The ICPRB also posted the draft Plan on its World Wide Web site at: www.potomacriver.org.
- An initial public meeting was held on January 15th , 2000 to notify the stakeholders of the scope and progress of the SWA.
- A second meeting was held on September 9th, 2001 to report mid-project status and take input from the stakeholders on the direction and progress of the project.
- A website was established with the DC DoH to provide general information on the SWAP. An interactive map with information on NPDES facitilies and their spatial relation to subwatersheds and receiving waters was provided to the general public to search and query.

8.1.3 Technical Advisory Committee

A Technical Advisory Committee was formed to advise on the more technical aspects relating to the preparation of this Plan. The membership included representatives from the following entities:

District of Columbia, Department of Health
Washington Aqueduct Division of the Corps of Engineers
District of Columbia, Water and Sewer Authority
US Geological Survey
US Environmental Protection Agency, Region III
Virginia Department of Health
Maryland Department of the Environment
Fairfax County Water Authority
Washington Suburban Sanitary Commission

Members of the Technical Advisory Committee participated in the advisory meetings organized by MWCOG, and they submitted comments on the written drafts of the Plan.

8.2. Final Presentation of Results

A final meeting to present the results of the assessment was held in May 2003.

National Primary Drinking Water Regulations (NPDWRs or primary standards) are legally enforceable standards that apply to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in public water systems. The tables below divides these contaminants into Inorganic Chemicals, Organic Chemicals, Radionuclides, and Microorganisms.

Contaminants	MCLG[1] (mg/L)	MCL[2] or TT[3] (mg/L)[4]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Inorganic Chemicals				
Antimony	0.006	0.006	Increase in blood cholesterol; decrease in blood glucose	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	none[5]	0.05	Skin damage; circulatory system problems; increased risk of cancer	Discharge from semiconductor manufacturing; petroleum refining; wood preservatives; animal feed additives; herbicides; erosion of natural deposits
Asbestos (fiber >10 micrometers)	7 million fibers per Liter	7 MFL	Increased risk of developing benign intestinal polyps	Decay of asbestos cement In water mains; erosion of natural deposits
Barium	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	0.004	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
Cadmium	0.005	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	0.1	0.1	Some people who use water containing chromium well in excess of the MCL over many years could experience allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	Action Level=1.3; TT[6]	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. Those with Wilson's Disease should consult their personal doctor if their water systems exceed the copper action level.	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
Cyanide (as free cyanide)	0.2	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories

Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth.	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
Lead	zero	Action Level=0.015 ; TT[6]	Infants and children: Delays in physical or mental development. Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Inorganic Mercury	0.002	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland
Nitrate (measured as Nitrogen)	10	10	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Nitrite (measured as Nitrogen)	1	1	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.002	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and pharmaceutical companies
Organic Chemicals				
Acrylamide	zero	TT[7]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/wastewater treatment
Alachlor	zero	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops
Atrazine	0.003	0.003	Cardiovascular system problems; reproductive difficulties	Runoff from herbicide used on row crops
Benzene	zero	0.005	Anemia; decrease inblood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills
Benzo(a)pyrene	zero	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines
Carbofuran	0.04	0.04	Problems with blood or nervous system; reproductive difficulties	Leaching of soil fumigant used on rice and alfalfa
Carbon tetrachloride	zero	.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities
Chlordane	zero	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide
Chlorobenzene	0.1	0.1	Liver or kidney problems	Discharger from chemical and agricultural chemical factories
2,4-D	0.07	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops
Dalapon	0.2	0.2	Minor kidney changes	Runoff from herbicide used on rights of way

1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
o-Dichlorobenzene	0.6	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories
p-Dichlorobenzene	0.075	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories
1,2-Dichloroethane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
1-1-Dichloroethylene	0.007	0.007	Liver problems	Discharge from industrial chemical factories
cis-1, 2-Dichloroethylene	0.07	0.07	Liver problems	Discharge from industrial chemical factories
trans-1,2-Dichloroethylene	0.1	0.1	Liver problems	Discharge from industrial chemical factories
Dichloromethane	zero	0.005	Liver problems; increased risk of cancer	Discharge from industrial chemical factories
1-2-Dichloropropane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
Di(2-ethylhexyl)adipate	0.4	0.4	General toxic effects or reproductive difficulties	Leaching from PVC plumbing systems; discharge from chemical factories
Di(2-ethylhexyl)phthalate	zero	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories
Dinoseb	0.007	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories
Diquat	0.02	0.02	Cataracts	Runoff from herbicide use
Endothall	0.1	0.1	Stomach and intestinal problems	Runoff from herbicide use
Endrin	0.002	0.002	Nervous system effects	Residue of banned insecticide
Epichlorohydrin	zero	TT[7]	Stomach problems; reproductive difficulties; increased risk of cancer	Discharge from industrial chemical factories; added to water during treatment process
Ethylbenzene	0.7	0.7	Liver or kidney problems	Discharge from petroleum refineries
Ethelyne dibromide	zero	0.00005	Stomach problems; reproductive difficulties; increased risk of cancer	Discharge from petroleum refineries
Glyphosate	0.7	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use
Heptachlor	zero	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide
Heptachlor epoxide	zero	0.0002	Liver damage; increased risk of cancer	Breakdown of hepatachlor
Hexachlorobenzene	zero	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories
Hexachlorocyclopentadiene	0.05	0.05	Kidney or stomach problems	Discharge from chemical factories
Lindane	0.0002	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on catttle, lumber, gardens

Methoxychlor	0.04	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune difficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfils;discharge of waste chemicals
Pentachlorophenol	zero	0.001	Liver or kidney problems; increased risk of cancer	Discharge from wood preserving factories
Picloram	0.5	0.5	Liver problems	Herbicide runoff
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Styrene	0.1	0.1	Liver, kidney, and circulatory problems	Discharge from rubber and plastic factories; leaching from landfills
Tetrachloroethylene	zero	0.005	Liver problems; increased risk of cancer	Leaching from PVC pipes; discharge from factories and dry cleaners
Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
Total Trihalomethanes (TTHMs)	none[5]	0.10	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (Silvex)	0.05	0.05	Liver problems	Residue of banned herbicide
1,2,4-Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
1,1,1-Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
1,1,2-Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories
Trichloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from petroleum refineries
Vinyl chloride	zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories
Radionuclides				
Beta particles and photon emitters	none[5]	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits
Gross alpha particle activity	none[5]	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits
Radium 226 and Radium 228 (combined)	none[5]	5 pCi/L	Increased risk of cancer	Erosion of natural deposits
Microorganisms				

Giardia lamblia	zero	TT[8]	Giardiasis, a gastroenteric disease	Human and animal fecal waste
Heterotrophic plate count	N/A	TT[8]	HPC has no health effects, but can indicate how effective treatment is at controlling microorganisms.	n/a
Legionella	zero	TT[8]	Legionnaire's Disease, commonly known as pneumonia	Found naturally in water;multiplies in heating systems
Total Coliforms (including fecal coliform and E. Coli)	zero	5.0%[9]	Used as an indicator that other potentially harmful bacteria may be present[10]	Human and animal fecal waste
Turbidity	N/A	TT[8]	Turbidity has no health effects but can interfere with disinfection and provide a medium for microbial growth. It may indicate the presence of microbes.	Soil runoff
Viruses (enteric)	zero	TT[8]	Gastroenteric disease	Human and animal fecal waste

National Secondary Drinking Water Regulations

National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards. See Table X1.

Table X1.

Secondary Drinking Water Regulations	
Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Notes:

[1] Maximum Contaminant Level Goal (MCLG) - The maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health effect of persons would occur, and which allows for an adequate margin of safety. MCLGs are non-enforceable

public health goals.

[2] Maximum Contaminant Level (MCL) - The maximum permissible level of a contaminant in water which is delivered to any user of a public water system. MCLs are enforceable standards. The margins of safety in MCLGs ensure that exceeding the MCL slightly does not pose significant risk to public health.

[3] Treatment Technique - An enforceable procedure or level of technical performance which public water systems must follow to ensure control of a contaminant.

[4] Units are in milligrams per Liter (mg/L) unless otherwise noted.

[5] MCLGs were not established before the 1986 Amendments to the Safe Drinking Water Act. Therefore, there is no MCLG for this contaminant.

[6] Lead and copper are regulated in a Treatment Technique which requires systems to take tap water samples at sites with lead pipes or copper pipes that have lead solder and/or are served by lead service lines. The action level, which triggers water systems into taking treatment steps if exceeded in more than 10% of tap water samples, for copper is 1.3 mg/L, and for lead is 0.015mg/L.

[7] Each water system must certify, in writing, to the state (using third-party or manufacturer's certification) that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows:Acrylamide = 0.05% dosed at 1 mg/L (or equivalent)
Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent)

[8] The Surface Water Treatment Rule requires systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water to meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

Giardia lamblia: 99.9% killed/inactivated
Viruses: 99.99% killed/inactivated
Legionella: No limit, but EPA believes that if Giardia and viruses are inactivated, Legionella will also be controlled.
Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples for any two consecutive months.
HPC: NO more than 500 bacterial colonies per milliliter.

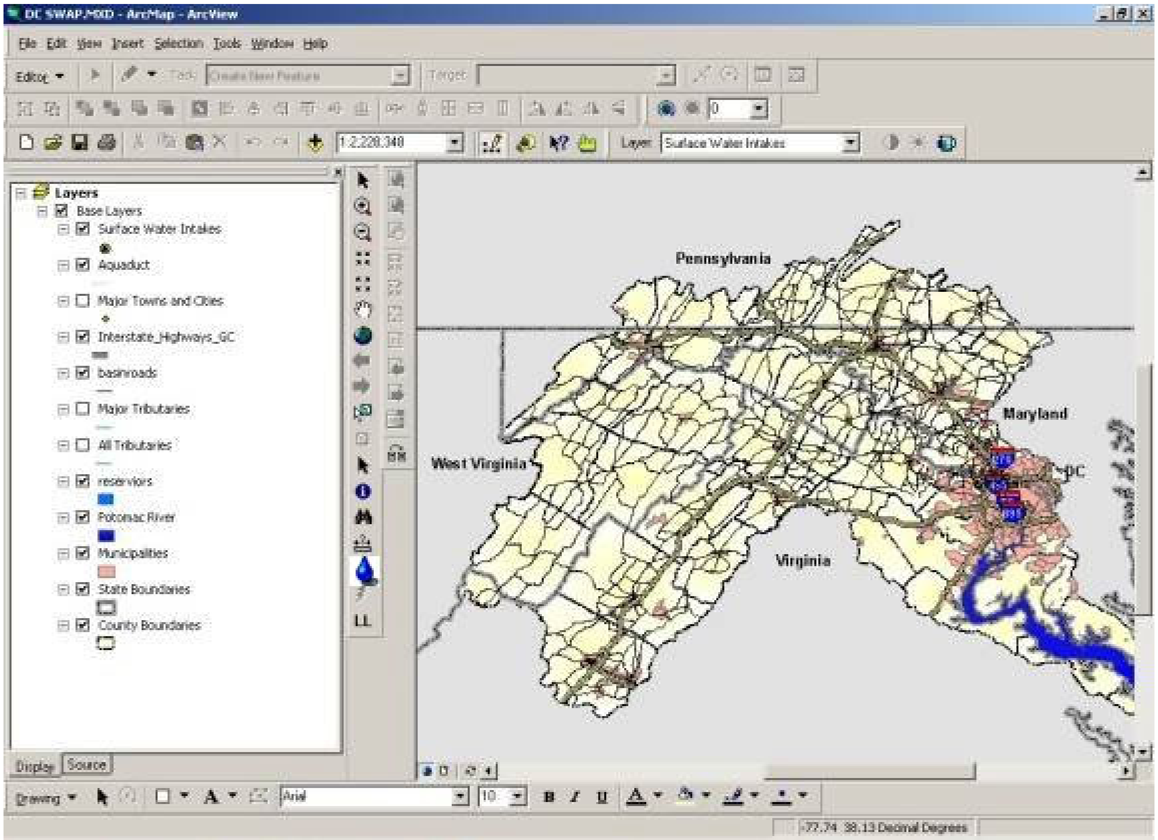
[9] No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive). Every sample that has total coliforms must be analyzed for fecal coliforms. There cannot be any fecal coliforms.

[10] Fecal coliform and E. coli are bacteria whose presence indicates that the water may be contaminated witih human animal wastes. Microbes in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms.

Appendix C:
GIS Search and Query Application Operations Manual

DC SWAP GIS Application
Operations Manual

The DC SWAP GIS application was created on an ESRI ArcGIS 8.3 framework, using standard Visual Basic – Application (VBA) coding. Most of the application is form and macro driven, and requires ESRI ArcGIS 8.3. ArcGIS is not included in this application but may be obtained from ESRI at http://www.esri.com



System Requirements
1. PC loaded with functional ESRI ArcGIS 8.3. This program has only been tested with ArcGIS version 8.3. Proper function may not be assured with higher or lower versions than these, as the program has not been tested on these other versions.
2. CD-ROM: This program may be run directly from CD, or may be copied to a local or network hard drive. The program will likely run faster if copied and run from a local hard drive.

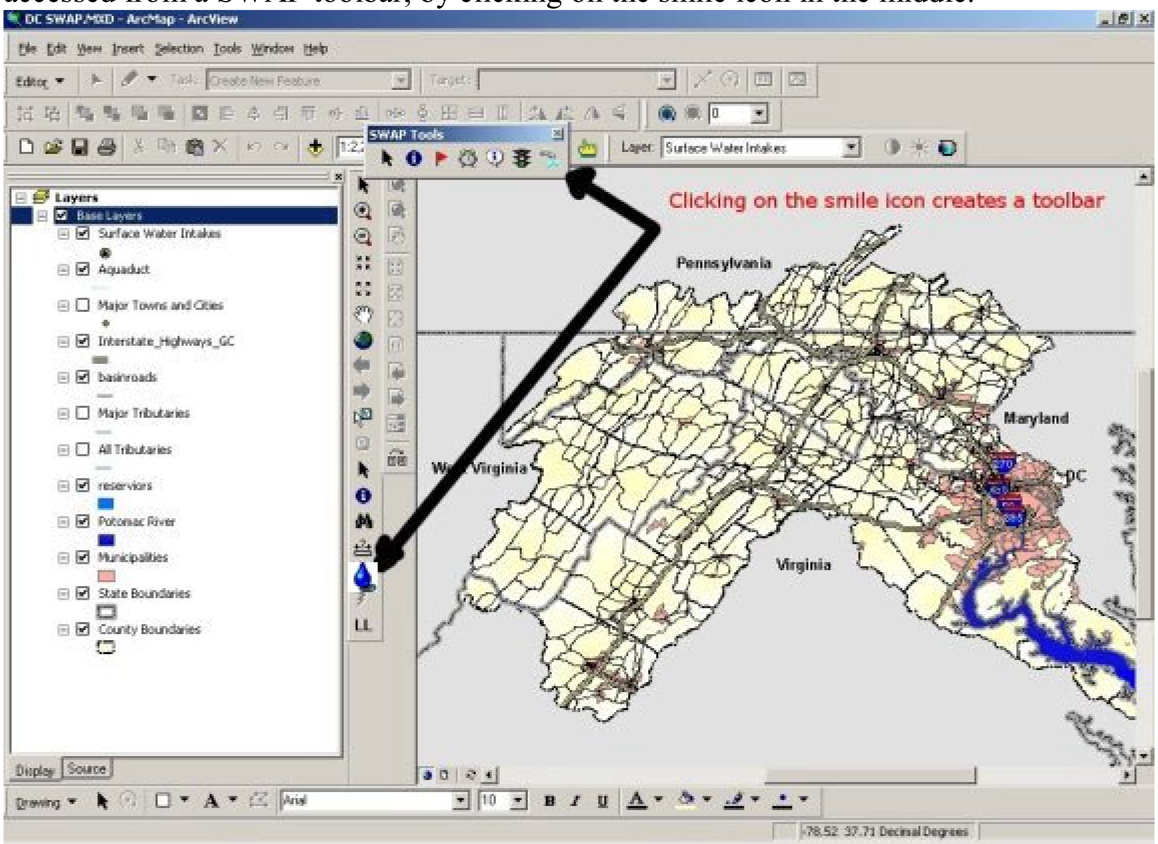
Contents

Overview

The DC SWAP GIS Application is provides simple access to basic information about Potential Sources of Contamination (PSC) using a geographic information system (GIS). The application contains a variety of base map data layers, from county and state boundaries to streams and roads. The user is then able to introduce point sources of potential contamination to provide a spatial analysis is sites throughout the basin. The search and query application allows the user to perform surveys of PCS's within specified time of travel boundaries and to view PCS's by susceptibility rankings and type of facility.

Application Interface

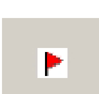
The SWAP GIS application has tools built into the general ArcGIS interface. These tools are accessed from a SWAP toolbar, by clicking on the smile icon in the middle.



The SWAP Tools Toolbar contains all the tools the user needs to perform a contaminant survey of the basin:

Selection Pointer: Allows user to select data elements in legend.

 **Information Pointer**: Allows user to select data points to obtain information.

 **Add Locational Data**: Creates interface that allows user to plot potential contaminant sources on the map.

 **Time of Travel**: Creates interface that allows user to add time of travel boundaries to the base map.

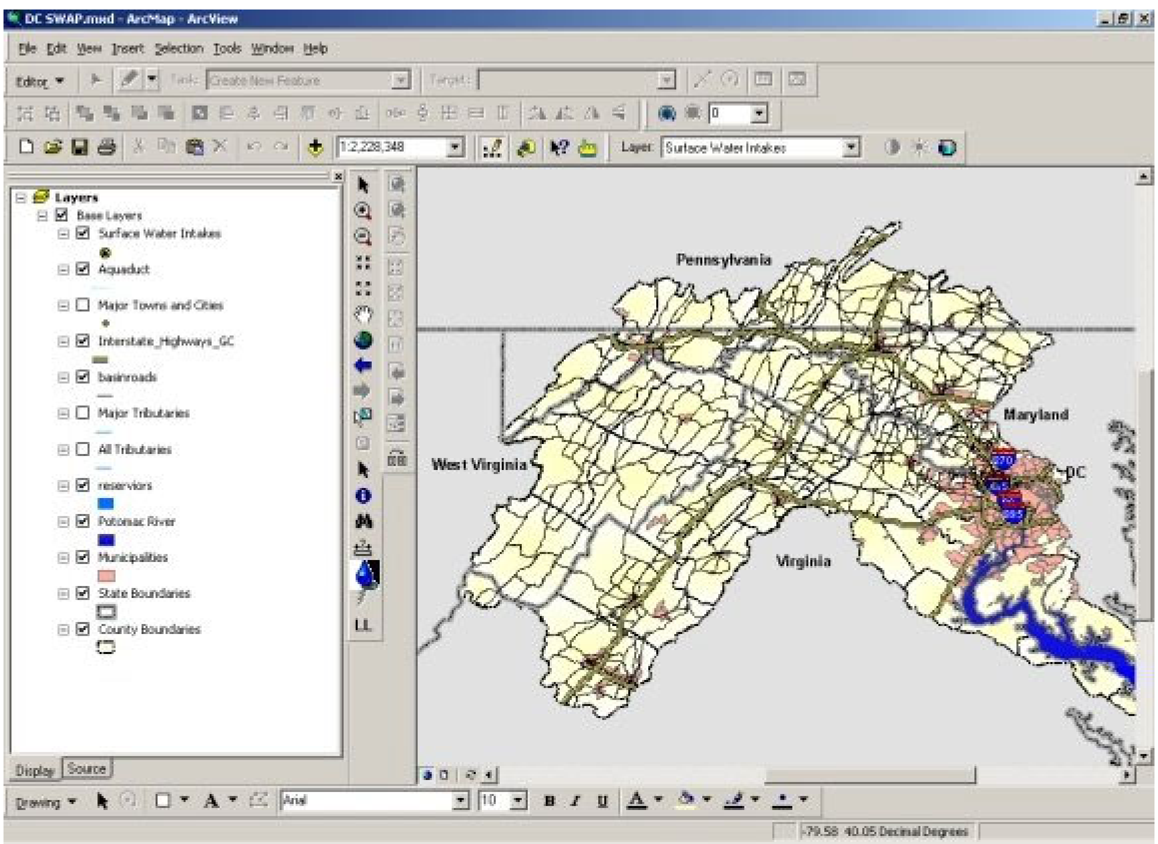
 **Spatial Query**: Selects all Potential Contaminant Sources (PCS's) inside a time of travel boundary.

 **Susceptibility Evaluation**: Allows user to query sites based on susceptibility ranking.

Running a PCS Analysis

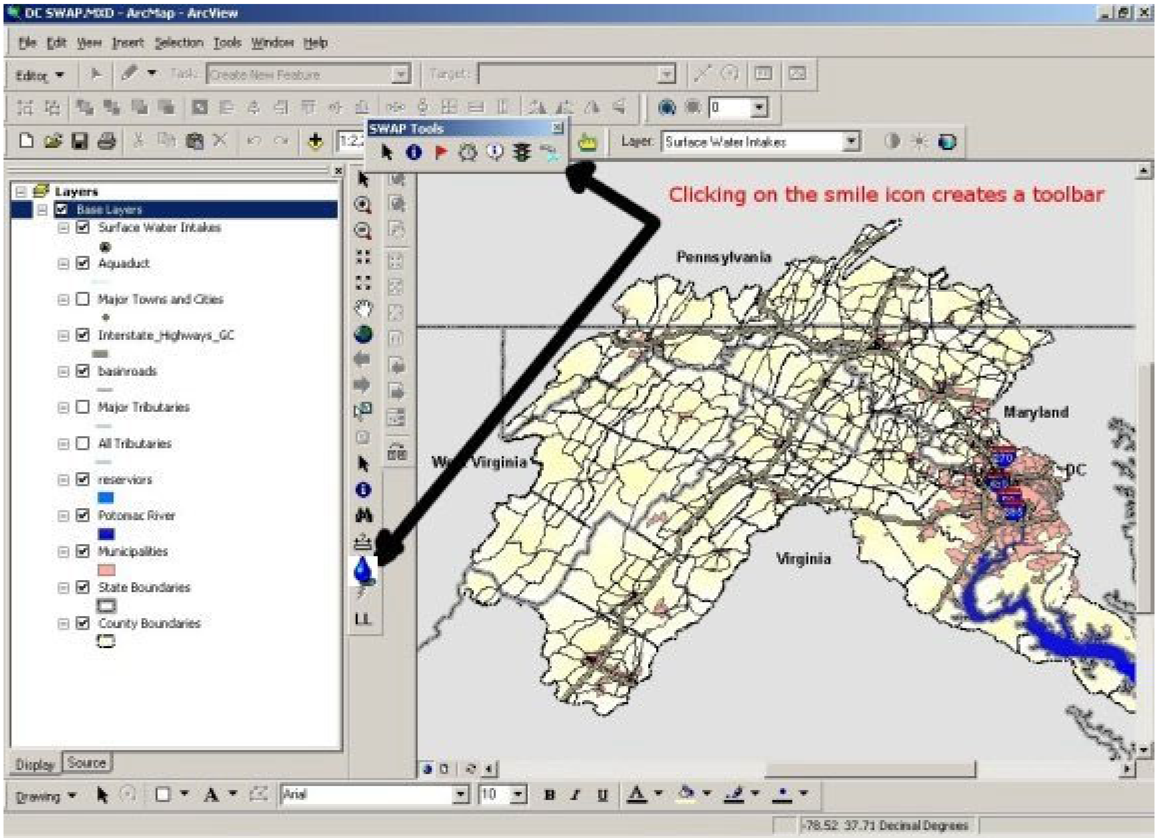
Open the SWAP GIS Application

Step 1. To start the SWAP GIS application, double click on the DC Swap.mxd file in the root directory of your SWAP GIS Application CD, or if you've copied it to your local hard drive, then the same file on your local hard drive. Clicking on this file should cause ArcMap to open with the project in view.

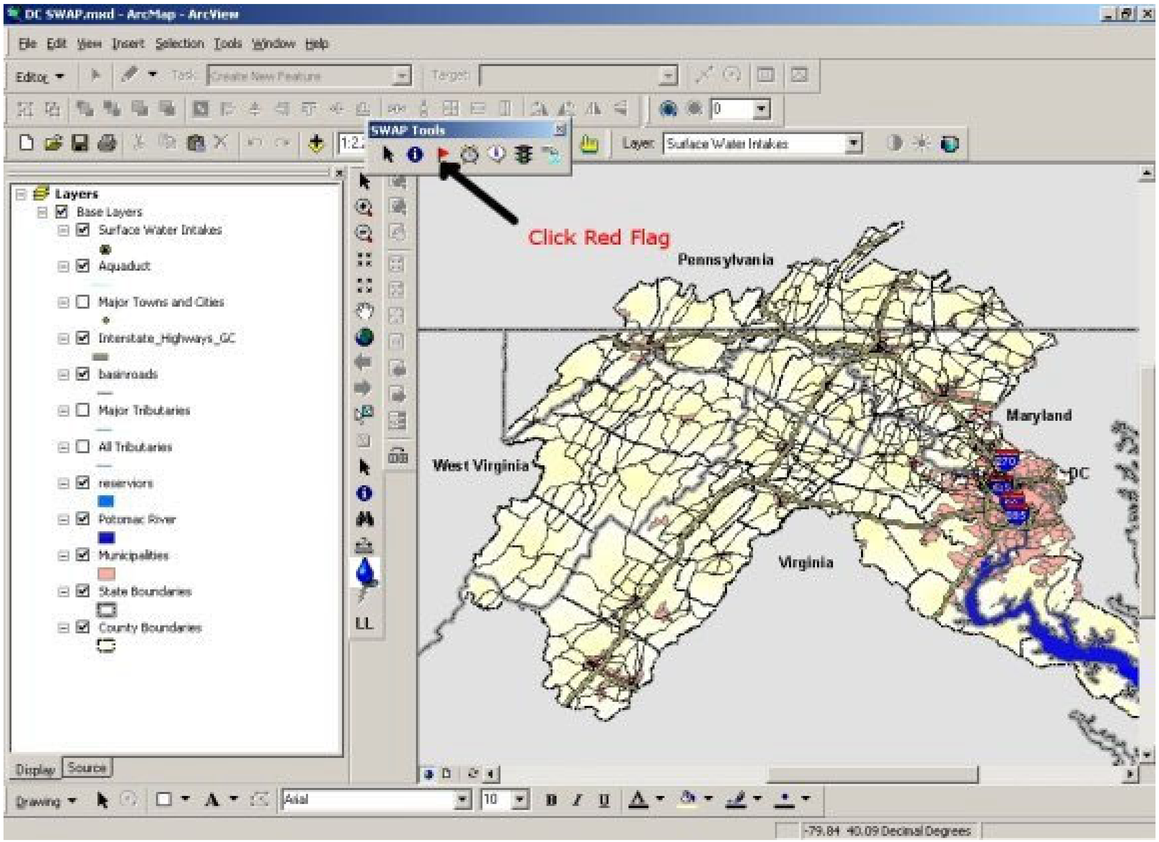


Adding Locational Data

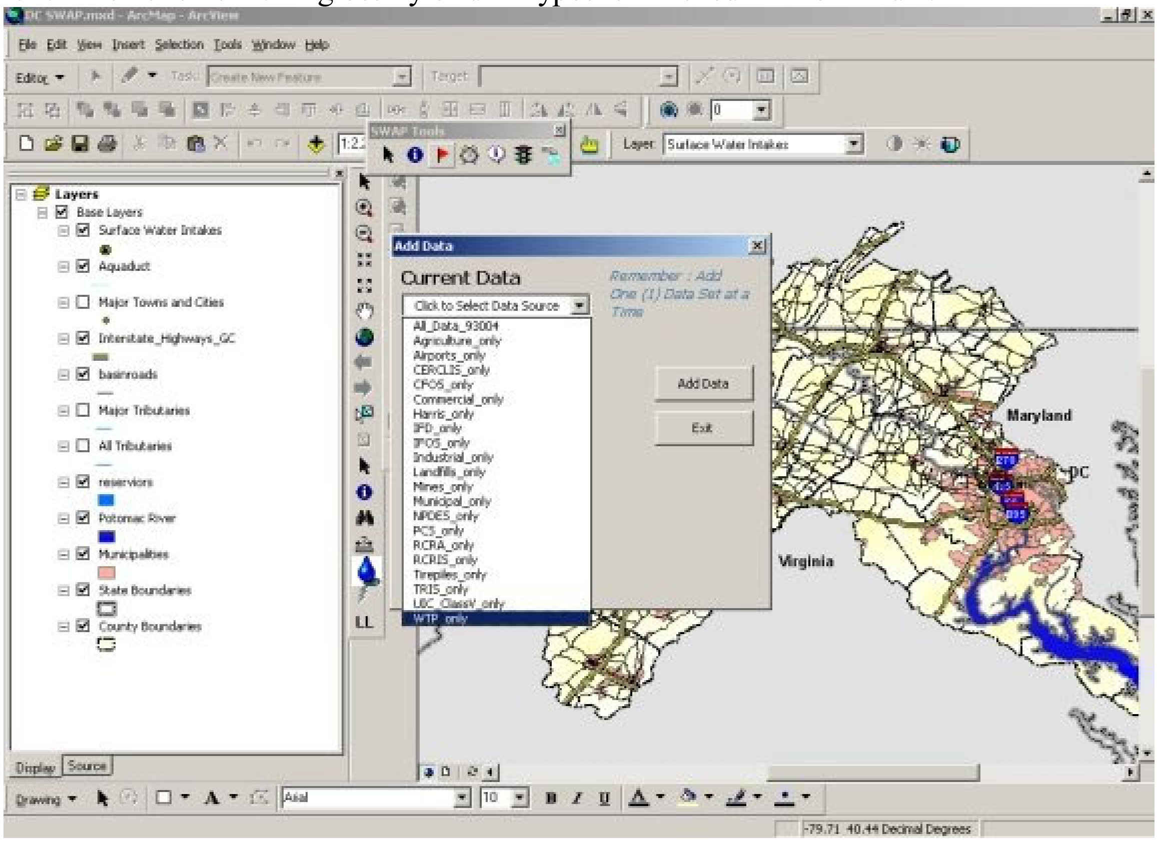
Step 2. To begin adding locational data, click the blue waterdrop icon in the toolbar. This will cause SWAP Tools Toolbar to pop up.

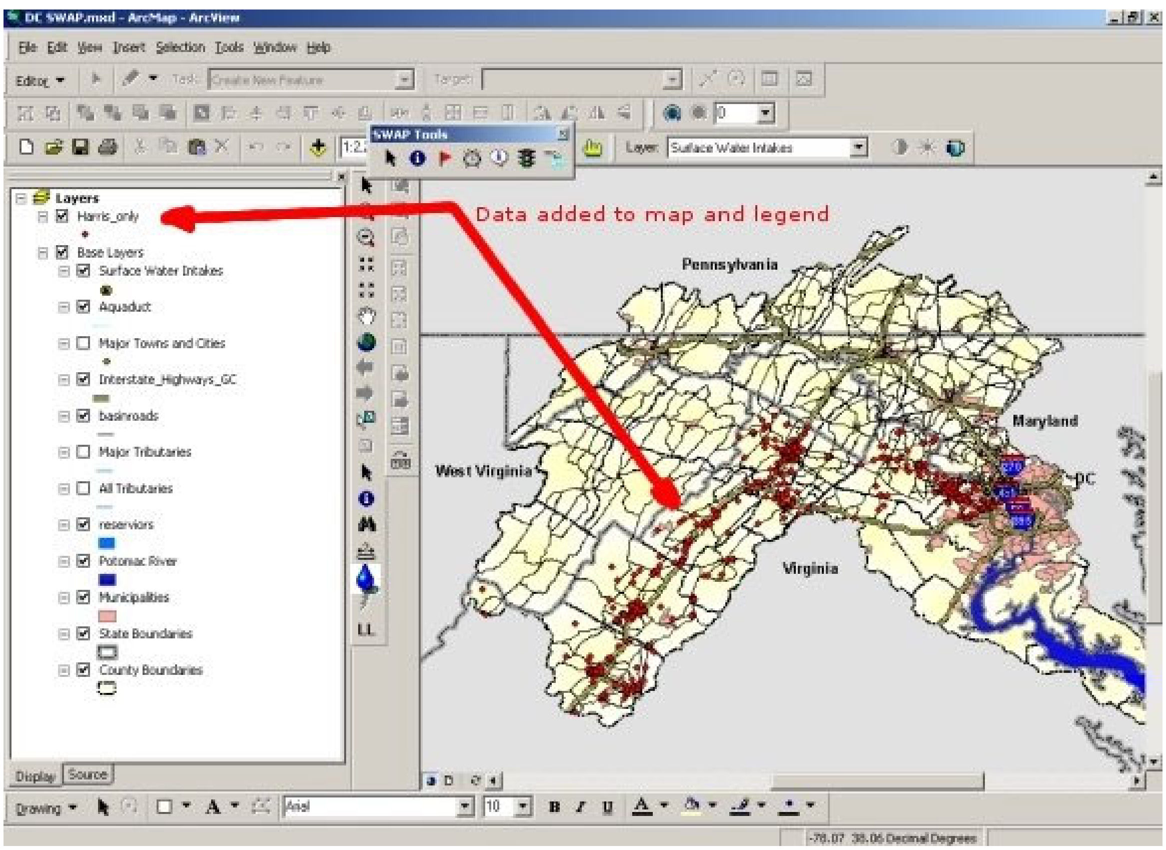


Step 3. Click on the red flag icon in the SWAP Tools toolbar.



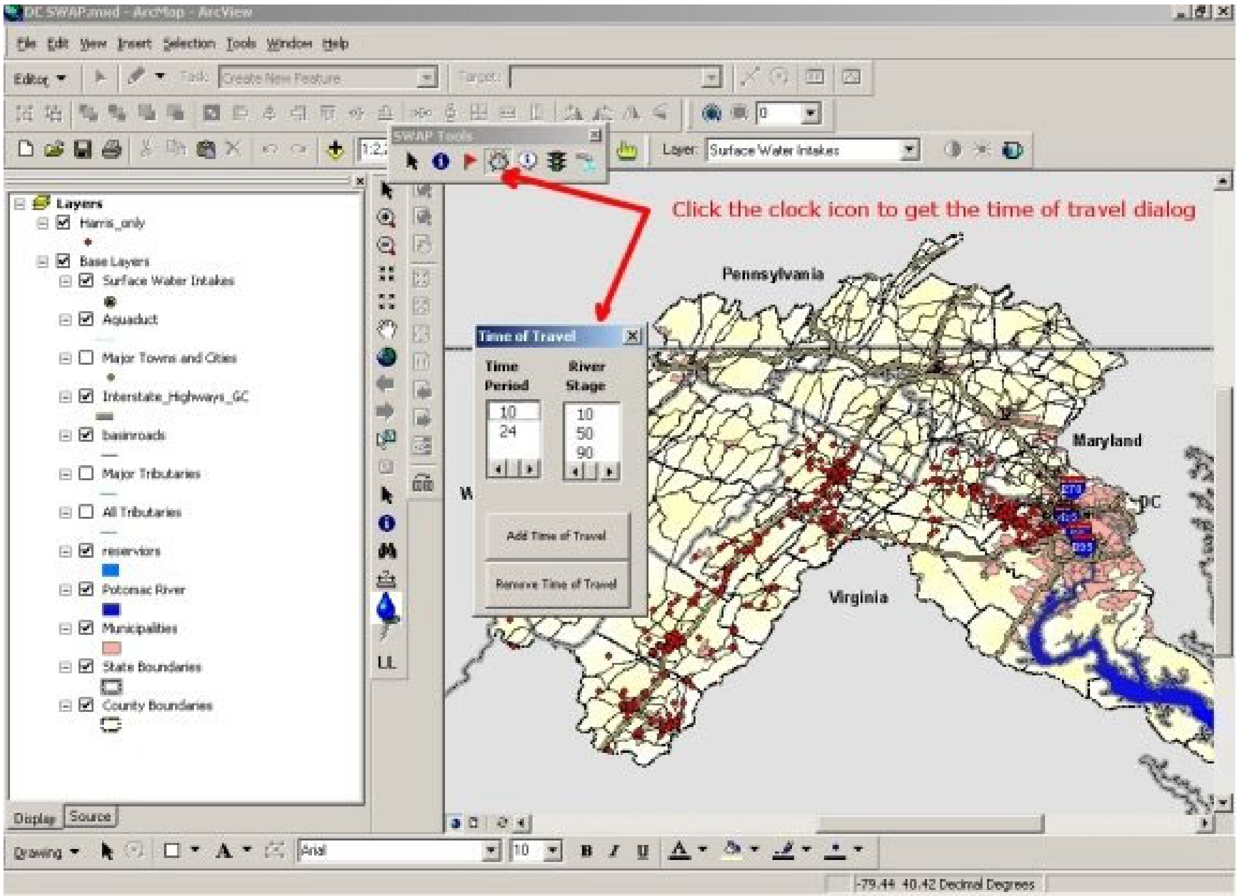
Step 4. The Add Data dialog appears. Click on the drop down menu and select the data you wish to add to the map. Then click on the "add data" button. The map will now display the data you selected as points on the map, and the data layer name will appear in the legend on the left. Then click exit. A glossary of data types is attached in this manual.





Adding Time of Travel

Step 5. To add time of travel, click the clock icon in the SWAP Tools Toolbar. The Time of Travel dialog should appear.



Step 6. In the Time of Travel dialog, select both a time period as well as a river stage, then click the button "Add Time of Travel". This will cause a layer to appear which represents the time of travel in the system for a particular river stage. Do not attempt to add more than one Time of Travel option to each map. In the left hand legend, uncheck the checkbox next to the item "base layers".

(To remove a time of travel, select (highlight) the time of travel layer on the left, click the time of travel button on the SWAP Tools toolbar, then click the button "Remove Time of Travel".)

[REDACTED]

Select data inside desired time of travel

Step 7. While holding down the shift key, click on the time of travel and locational data layers to highlight them. The time of travel layer must be on top.

[REDACTED]

Step 8. Click on the blue "i" icon in the SWAP Tools toolbar, then click anywhere inside of the time of travel in the map. This will then select all data points inside the time of travel.

[REDACTED]

Run Susceptibility Evaluation

Step 9. Click on the location data item in the legend at the left and drag it up so that it becomes the first item in the legend. Then click once on the locational data item, hold down the shift key, the click on the time of travel item (in diagram example "50_@_24") to highlight both.

[REDACTED]

Step 10. Click on the Stoplight icon in the SWAP Tools toolbar to bring up the susceptibility evaluation dialog box. Click on any of the three desired ranking levels and click exit to show which of the locational data points have the desired susceptibility ranking.

[REDACTED]

Step 11. In the Select by Attribute dialog, click the dropdown next to "Method" and choose "Select from current selection". Click the apply button, then click the close button.

[REDACTED]

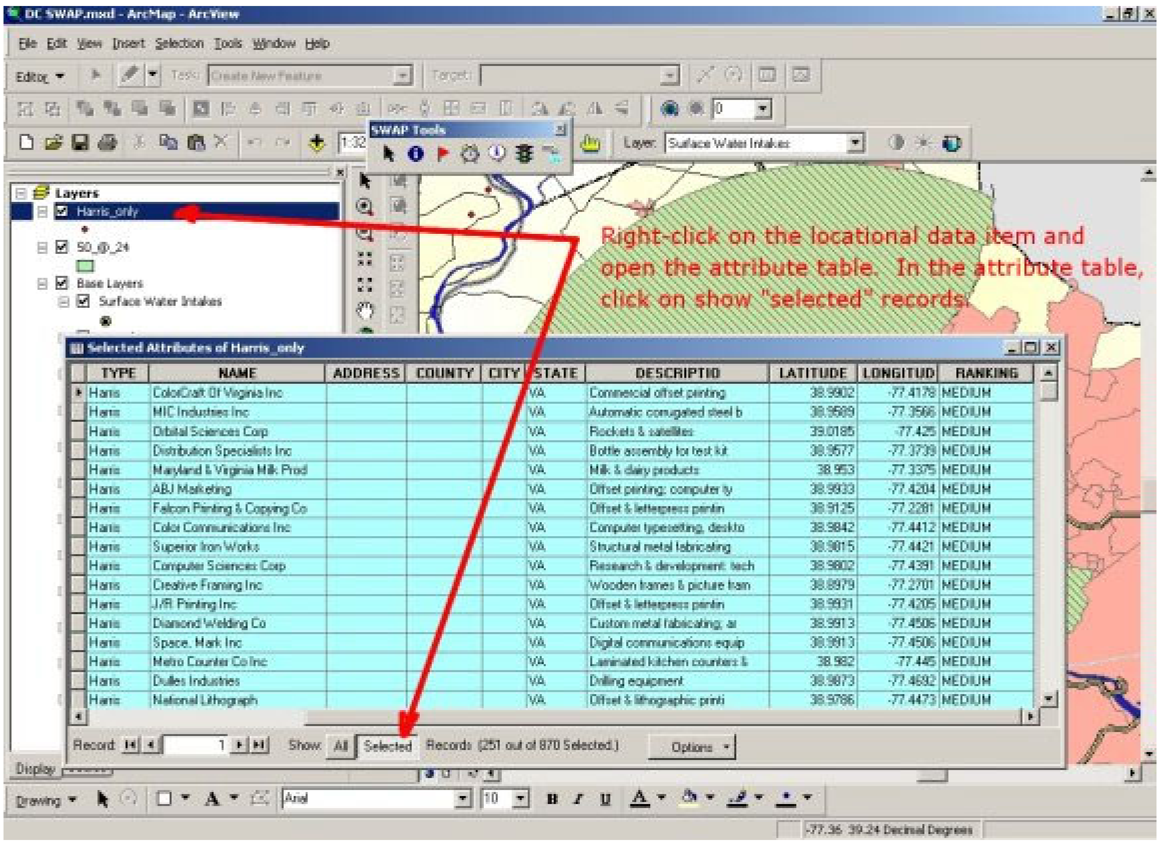
Step 12. What is now shown on screen are the locational data sites highlighted in yellow which have a ranking as selected in step 10, either High, Medium or Low.

[REDACTED]

Step 13. There are two ways to view information about sites highlighted in yellow (the sites determined to be of the ranking selected in step 10):

A. View information about individual sites within the time of travel:
Click on the white "i" icon in the SWAP Tools toolbar to the left of the red flag, then click on any of the yellow highlight points. This will bring up a window with attributes for that point only.

B. View information about all highlighted sites within the time of travel:
To view the sites that have been selected based on the selected ranking, right-click on the location data item in the legend, then click "Open Attribute table". After the attribute table opens, at the bottom, click on the button labeled show "selected" records. What appears in the table is a list of all location data sites which have the requested ranking.



Step 14. To restart a Susceptibility Evaluation or choose a different Time of Travel, the user may either:

A. Exit the the application by closing ArcGIS without saving the previous instance. Begin again from step 1.

B. Highlight all layers in the left-hand pane except base layers, then right-click to remove. Begin again from step 1.

Glossary of Data Sources

Federal databases
CERCLIS – Comprehensive Environmental Response, Compensation, and Liability Information System
IFD – Industrial facility discharge
MINES – USGS Mineral database
NPDES – National Pollutant Discharge Elimination System
PCS – Permit Compliance System (for NPDES)
RCRA – Resource Conservation and Recovery Act sites
RCRIS – Resource Conservation and Recovery Information System (for RCRA)
TRIs - Toxic Release Inventory
WTP – water treatment plants

Virginia state databases
Airports
CFOs – Commercial facility operations
Harris - Harris Industrial database
IFOs – Industrial facility operations
Landfills
Tilepiles
UIC_ClassV – Underground Injection Wells

West Virginia state databases
Agriculture
Commercial
Industrial
Municipal

APPENDIX D: PUBLIC PARTICIPATION

This Plan was reviewed and commented upon by Citizens' and Technical Advisory committee members. A Citizens' Advisory Committee organizational meeting was held at the Metropolitan Washington Council of Governments on November 17, 1998. A second meeting, of the combined committees, to review an early draft of this Plan and receive comments was held on December 17, 1998. A third meeting, of the combined committees with invitations extended to the public, was held on January 20, 1999. Committee rosters, summaries of meeting discussions, and written comments received are provided as follows:

Roster: Citizens' Advisory Committee

Wesley A. Brown	
James Booze	
Neal Fitzpatrick	Audubon Naturalist Society
Rodney Livingston	CEC
Erik Olson	Natural Resources Defense Council
Steve Donkin	
Phillip A. Flemming	
Grace Fleming	
John W. Finney	Coalition for Responsible Urban Disposal at Dalecarlia
Mary D. Jackson	ANC 7E Chairperson
Luci Murphy	League of Women Voters
Maria Holleran-Rivera	District of Columbia Corporation Council
James H. Jones	
Carla Pappalardo	Clean Water Action
Tricia McPherson	Clean Water Action
Regina Owens	District of Columbia City Administrator's Office
Davelene Renshaw	

Roster: Technical Advisory Committee

Jerusalem Bekele	District of Columbia Department of Health
Miranda Brown	Washington Aqueduct Division
Michael Marcott	District of Columbia Water and Sewer Authority
Gary Fisher	US Geological Survey
Frederick Mac Millan	US Environmental Protection Agency, Region III
Gerald Peaks	Virginia Department of Health
John Grace	Maryland Department of the Environment
Traci Kammer-Goldberg	Fairfax County Water Authority
Robert Buglass	Washington Suburban Sanitary Commission

Three meetings were held to discuss the Plan and its development, and a number of written comments were received and incorporated. Summaries of these activities are provided on the following pages.

Meeting Summary
Source Water Assessment Program (SWAP)
Citizens' Advisory Committee Meeting

November 17, 1998
6:00 pm
Metropolitan Washington Council of Governments

The meeting was opened by Karl Berger of the Council of Governments (MWCOG). Introductions were made around the table. Attention was called to the handouts that included the program guidance for the EPA Source Water Assessment Programs; as well as a draft outline for a source water assessment plan for the District.

Fred Mac Millan, EPA Region III, (Philadelphia), described the SWAP Program. The SWAP is the most proactive part of the Safe Drinking Water Act of 1996. He described five primary parts of the Multi - Barrier Approach

1. To prevent contamination of and protect drinking water sources
2. Propose design and treatment options
3. Provide well trained personnel
4. ?
5. Develop proper standards

SWAP for the District has five steps:

1. Getting Started and the public involvement
2. Where are the well heads, water intakes, etc.?
3. What are we going to protect our source water from?
4. Are our source water managers doing the best job they can to protect source water?
5. Contingency planning for contamination events.

This meeting represents the start of the SWAP plan process. The draft final plan is due to EPA on February 6, 1999. This plan will be reviewed, amend (if necessary) and approved within nine months. The entire project will take two years to implement with an 18 month extension at most.

Jim Collier - DC Department of Health (DoH), The DC DoH is overseeing the development of this SWAP for the District of Columbia with help from ICPRB and MWCOG. The District and its water intakes are situated at the bottom end of the nontidal portion of the Potomac River Watershed which includes four states, Virginia, Maryland, West Virginia and Pennsylvania. While there are intakes throughout these subwatersheds, there are also, effluent or outfall pipes into the same body(s) of water. This is an area of many concerns and common interests.

To be prepared for proper treatment of this water, the wastewater treatment operators have to determine the primary land use where the water originates; Urban (developed) Land or Rural Land.

The long term assumption is that the land use pattern of the past 50 years will continue until all rural land is converted to urban land use. In order for treatment facilities to prepare for proper treatment operations, these land uses must be understood. That is because the water coming off of these types of land use are very different. One is not necessarily better than the other, just different.

The drinking water intakes for the District are located in the nontidal section of the Potomac River.

Ross Mandel - Interstate Commission on the Potomac River Basin (ICPRB), explained ICPRB's role in the oversight of the Potomac River. He described how the Source Water assessment plan is to be carried out.

The Plan Assessment has four major tools:
1. Public participation
2. Delineate watershed
3. Identify potential contributors
4. Conduct susceptibility analysis

Mr. Mandel passed out a map showing the watershed for the Potomac River and locating the District of Columbia's drinking water intakes.

1. Public participation

   Form a citizens' advisory committee.

2. Delineate Source Water Area (The Watershed)

   Identify the location of Intakes and other sources. The District has two intakes near Great Falls on the Potomac and a few ground water wells. The groundwater wells total five, and are not used for drinking water, only for groundwater monitoring purposes and some other non-drinking water purposes.

3. Identify the Potential Contaminants

   Make a list of potential contaminants
   Use existing water quality data
   Use existing NPDES (National Pollution Discharge Elimination System) permitting information and urban and regional forest cover data
   Have information on feed lots, farms, etc. for fecal coliform contributions
   Have information on air deposition of contaminants
   Use data for nonpoint source pollution, runoff from fields etc.

Mr. Mandel said that each state will perform their own assessment. A question was raised regarding Virginia agencies cooperation for data exchange. How will their data overlap with ours. It was pointed out that this is an important point because Virginia's data is a subset of DC's data set as are all the surrounding states. The states will be performing their own separate assessments and DC use this data to form their own conclusions.

4. Susceptibility Analysis
   Decisions to be made on the potential threat from each contaminant.

The Susceptibility Analysis will look at transport, integrity of the system, intakes themselves. It will also examine the source water taken in and the finished water.

Comment made to establish a feedback loop between the technical group and the citizens advisory group

Mr. Berger opened the discussion to the group. He stated that the next meeting would occur during the week of January 18 - 22, when the plan would be in draft form for comment by the group. Mr. Berger stated that all attendees at the meeting are considered to be on the citizens group unless they indicate otherwise.

Discussion of the workplan time line. A great concern arose over the short time line and the citizens groups expressed a strong desire to meet in late December or early January in addition to the late January meeting.

A general concern was whether ICPRB could meet this deadline for having a working draft available to the committee for comment.

There was also a great concern over the citizens access to the document over the internet. DC, ICPRB and COG will explore the possibility of doing this.

A comment was made about putting information in water billing statements, however, it was pointed out that the billing cycle had already occurred.

The group indicated that if a draft plan was not available, that they want to meet in late December or early January and can look at plans from other states to become familiar with them and be prepared when reviewing the Districts plan.

A question arose over who was on the Technical Advisory Committee for the DC plan. The technical committee will be comprised of staff from the District, ICPRB, The Washington Aqueduct, and COG. It will not be a formal technical committee per se. A suggestion was made to have someone from the U.S. Geological Survey to participate on the technical committee.

Suggestions were made on how to notify citizens about the next meetings; press releases, newspaper notification, DC Cable Television,

The next meeting is tentatively scheduled for the week of December 14th whether the draft was ready or not. Potentially, December 16th or 18th.

The meeting adjourned at 8:20 P.M.

Meeting Summary

Meeting of Citizens' Advisory Committee for the District of Columbia Source Water Assessment Plan

December 17, 1998
Metropolitan Washington Council of Governments

The meeting was called to order at approximately 6 p.m. by Karl Berger of the Metropolitan Washington Council of Governments (COG).

Presentation by Roland Steiner:

Mr. Steiner of the Interstate Commission on the Potomac River Basin (ICPRB) provided background information on the development of EPA's Source Water Assessment initiative, noting that the three main issues to be addressed by source water assessment plans (SWAPs) are:

1) Delineation of the drinking water source (the Potomac River upstream of the Washington Aqueduct intakes)

2) Contaminant identification (This can include everything from household chemicals to potentially hazardous materials stored in large quantities by commercial enterprises.)

3) Susceptibility analysis (What are the risk factors and which materials potentially pose the greatest and least risks?)

Mr. Steiner said that ICPRB staff currently is developing a plan to conduct the assessment. EPA regulations require and ICPRB is seeking citizen input into the plan. In particular, ICPRB is expecting input from the Citizens Advisory Committee (CAC), which is designed to be representative of the views of District citizens in general.

Mr. Steiner also noted that people with knowledge of drinking water issues from both the District and neighboring states are represented on a Technical Advisory Committee (TAC) that ICPRB has formed. The members include:

Jerry Peaks, source water coordinator for the Virginia Department of Health;
John Grace, source water coordinator for the Maryland Department of the Environment;
Jerusalem Bekele, project manager for D.C. Dept. of Health, Environmental Health Admin.;
Miranda Brown, Washington Aqueduct Division of the U.S. Army Corps of Engineers;

Mike Marcotte, Deputy Director, D. C. Water and Sewer Administration;
Gary Fisher, U.S. Geological Survey;
Fred Mac Millan, EPA Region III;
Robert Buglass, Washington Suburban Sanitary Commission;
Tracy Goldberg, Fairfax County Water Authority.

Although there are no separate meetings of the TAC planned, ICPRB staff will coordinate with its members to obtain review and comment on the plan. In addition, TAC members have and will be invited to all CAC meetings.

Mr. Steiner noted the following highlights in the schedule for developing the plan:

Jan. 20, 1999 - next meeting of the CAC (public comment meeting)

Jan. 27, 1999 - final date for any comments on the plan

Feb. 5, 1999 - final plan transmitted to EPA Region III.

Approximately 7 - 10 days prior to the Jan. 20 meeting, a draft of the plan will be sent to members of the Citizens Advisory Committee. This draft will include comments received to date and any responses to those comments.

Comment: Tricia McPherson asked if there will be other opportunities to comment on the plan aside from the Jan. 20 meeting.
Response: Mr. Steiner said that ICPRB will accept comments directly via phone, FAX or email at any time up to the Jan. 27 comment deadline.

Mr. Steiner noted that after the plan is submitted, EPA has up to nine months to review it, request any changes and approve it.

Comment: Erik Olson asked what happens if EPA does not approve a plan by the Nov. 6 deadline.
Response: Fred Mac Millan said that EPA intends to work with the submitting agencies to ensure that all SWAPs are approved by the Nov. 6 deadline.

<u>Discussion of outline/draft framework of the plan (Roland Steiner):</u>

Advisory group members asked a number of questions and raised several concerns regarding the current incomplete draft of the plan. However, because of time constraints, not all of their comments and questions were registered at the meeting. The members agreed, where possible, to post questions via email for all members of the group.

Among the questions raised at the meeting were:

What assumptions will be used to determine time or travel estimates for potential contaminants, particularly as regards river flow?

Who will determine the environmental decay rate for pesticides and other contaminants?

How well can the Chesapeake Bay Program watershed model, which was desinged to estimate nutrient and sediment loads to the bay, estimate concentrations of contaminants in the Potomac River?

Comment: Neal Fitzpatrick expressed concern that any results from modelling be verified by actual monitoring data.

Overall concerns:

Comment: Rodney Livingston recommended that questions, responses and all other information regarding the plan be published on the Internet through a dedicated site that would have a "chat room" feature.
Response: Mr. Steiner said this is not possible with the time and money allocated to this phase of the project. However, ICPRB staff will list any questions it receives through other means as an appendix to the draft plan.

Comment: John Finney, noting that the quality of the drinking water for the District is dependent on what happens in a watershed outside of its boundaries, recommended that the District SWAP be conducted as part of a regional Potomac River effort in which all of the upstream states participate. Conducting a regional SWAP also would avoid duplication and minimize the costs of the project, he said.
Response: Ross Mandel and **Mr. Steiner** noted that they are working with staff from these states and that some aspects of the plan will be coordinated. However, there are some aspects that will be unique to the District plan.

Comment: Mr. Olson enquired about the cost of actually doing the assessment.
Response: Mr. Steiner said it will depend in part on what's called for in the final version of the plan. He also noted that the District's Department of Health is responsible for conducting the assessment either directly or through contractors.

Comment: Mr. Olson asked how much money the District has budgeted for conducting the assessment and what is the source of any such funds.
Response: Jerusalem Bekele said the Department of Health currently has budgeted about $250,000 for this task. She was not certain of the source of those funds.

Discussion of public outreach activities (Karl Berger):

Mr. Berger noted that COG staff plans to produce a news release for submission to a series of community papers in the District. It also will produce and distribute a flyer that will publicize the Jan. 20 meeting and encourage additional public comment. The flyer could be distributed through District government agencies, the city's Advisory Neighborhood commissions and civic groups.

Mr. Berger further noted that the members had recommended that a means be found to post the draft plan on an Internet site prior to the public meeting, but that none of the agencies involved could promise that such a posting could occur within the required time frame. COG staff will attempt to provide copies of the draft, when available, to the various branches of the D. C. Public Library and in the COG Information Center for public access.

Comment: Mr. Livingston complained that no means of either Internet or cable television access to the draft plan would be provided as he had requested at the previous CAG meeting.
Response: Mr. Steiner said that the currently involved agencies lack the resources to implement these suggestions.

Comment: Ms. McPherson suggested that community groups could put information concerning the plan and plan drafts on their own Internet access sites.

Comment: Davelene Renshaw recommended that copies of the flyer be made available to CAG members who may be able to further distribute them.

Comment: Mr. Olson asked whether the CAG would continue to be able to provide input into the District SWAP process once the plan is submitted on Feb. 5. The members strongly supported continued involvement.
Response: Mr. Berger noted that, at present, ICPRB and COG's involvement is scheduled to end with the submission of the plan to EPA, hence this request will have to be addressed by EPA and the District Department of Health. However, the members' strong support for continued involvement can be noted as a recommendation in the plan.

Ms. Bekele further noted that Jim Collier and Ted Gordon of the Department of Health's Environmental Health Administration will be the main District government contacts on the SWAP process.

<u>Summary actions:</u>

Mr. Steiner provided a comment sheet that provided instructions for providing comments to ICPRB via phone, fax or email. He recommended that CAG members provide comments directly to ICPRB staff.

The meeting was adjourned at 8 p.m.

List of Handouts

Draft Outline of Framework, D.C. Source Water Assessment and Protection Program Plan
Draft Framework, D.C. Source Water Assessment and Protection Program Plan
Comments on Draft Plan submitted by John Finney

List of Attendees

Neal Fitzpatrick	Audubon Naturalist Society
Davelene Renshaw	
Macara Lousberg	
Rodney Livingston	CEC/DICEE
Erik Olson	NRDC
Roland Steiner	ICPRB
Ross Mandel	ICPRB
Jan Ducnuigeen	ICPRB
Erik Hagen	ICPRB
John Finney	CRUDD
Tracy Goldberg	FCWA
Maria Holleran-Rivera	DC Corporation Counsel
Carla Pappalardo	Clean Water Action
Tricia McPherson	Clean Water Action
Jerusalem Bekele	Environmental Health Administration, D. C. Dept. of Health
Sharon Gonder	Environmental Health Administration, D. C. Dept. of Health
Fred Mac Millan	EPA Region III

Meeting Summary

Third Meeting of the Citizens Advisory Committee for the District of Columbia Source Water Assessment Plan

January 20, 1999
Metropolitan Washington Council of Governments

The meeting was called to order at approximately 6:15 p.m. by Karl Berger of the Metropolitan Washington Council of Governments. The group agreed on an informal discussion of their comments on the draft source water assessment plan (SWAP).

Presentations:

Fred Mac Millan, EPA Region III noted that source water protection is one aspect of EPA's multi-barrier approach to drinking water safety. Summarizing the activities of the District's project to date, he noted that the last day for public comment on the plan is Jan. 27 and the deadline for the SWAP to be submitted to EPA is Feb. 6.

Roland Steiner, Interstate Commission on the Potomac River Basin (ICPRB) noted that all the states in the Potomac basin have agreed to share source water data with each other, a process that ICPRB will facilitate. He also addressed concerns about the accuracy of data from other states by noting that there are major treatment plants on the Potomac River whose intakes are just upstream from those of the Aqueduct which serve Maryland and northern Virginia. Hence, these states should be just as interested in good assessments as the District is. Mr. Steiner also noted that work is proceeding to update the draft SWAP, including the address of public comments.

Comments from Citizen Advisory Committee members:

Mr. Steiner read the text of FAX comments received from **Charles Verharen**, who is concerned about the potential impact on the District's drinking water of discharges from water treatment plants located upstream. **Mr. Steiner** responded by noting that although this could be investigated, there are no known toxic materials in these discharges. Based on her interpretation of these comments, **Carla Pappalardo** asked if combined sewer overflow discharges pose a threat to drinking water supplies. **Mr. Steiner** response was that these would be investigated where applicable upstream of the intakes.

There were several comments and questions about the source and amount of funds for the actual assessment phase of the project. **Mr. Finney**, for example, stated his interpretation, derived from a conversation with an EPA Region III official, that the District would receive a $400,000 grant from EPA to conduct the assessment, partly as a means of building environmental expertise in the District's Department of Health.

However, **Mr. Mac Millan** said that the $400,000 has been set aside from the District's share of the state revolving loan funds disbursed by EPA.

Erik Olson noted continuing concern with the future of public participation once the plan is submitted and the assessment phase begins. He said it is critical for citizen input to continue in this phase and suggested that the current advisory committee should continue. In response, **Mr. Steiner** noted that there has been support for this idea among state and EPA officials. **Jerusalem Bekele** of the District Department of Health said the department is giving serious consideration to this recommendation.

The Citizens Advisory Committee members approved a motion in support of continuing to function during the assessment phase.

Mr. Olson asked whether COG and ICPRB would have a role during the assessment phase. In response, **Mr. Steiner** said that the District Health Department will be conducting the assessment and have indicated plans to seek bids from entities interested in doing the assessment work, Thus, he said, there are no guarantees that COG and ICPRB will continue to be involved in the project, even assuming that they choose to submit bids. **Ms. Bekele** confirmed that the Department of Health intends to seek bids to do the assessment work, which, she said, is a required by the department's procurement rules.

Mr. Olson asked how nonpoint sources would be inventoried and identified under the District's assessment. In response, **Mr. Steiner** noted that the plan calls for use of federal Agricultural Census data, which can quantify cropland acres or animal numbers in individual counties. However, it was noted that there may be issues regarding the confidentiality of such data.

Mr. Olson strongly expressed the view that potential nonpoint sources of pollutants should be identified just as point sources are. Identifying sources by name will be one of the main means by which the public can exert pressure to clean up any problem sources, he said.

Steve Donkin asked if the budgeted $400,000 will be sufficient to conduct the plan. **Mr. Steiner** said that, in cooperation with the other states, the District should be able to locate and name all major sources for that amount. However, **Ross Mandel of ICPRB** noted that other states may not agree to disclosure of the names of all potential polluters.

Mr. Olson asked who would make decisions about the disclosure of data and **Ms. Pappalardo** asked how will the District be able to reconcile differing approaches to susceptibility analysis (e.g., fixed radius delineation in Virginia versus Maryland's strategy of using sub-watershed delineations). She also is concerned with the quality of data the District may get from Virginia.

In response, **Mr. Mac Millan** said that EPA will be evaluating each of the plans submitted by the various states and compatibility will be an issue. **Mr. Mandel** noted that data collection should not be a problem for the District even if there were minimal cooperation from the other states in the basin given the existence of other, easily accessible data sets. **Ms. Bekele** noted that the District will be able to independently analyze the data and draw conclusions that may be different than the conclusions drawn in other states.

Mr. Olson asked if the plan considers the possibility of getting new monitoring data to assess such things as temporal variations in the level of Cryptosporidium found in the river. He expressed concern with an over-reliance on modeling results to assess the impact of nonpoint pollution sources. In response, **Mr. Steiner** said the assessment could be that detailed, depending on funding and other priorities.

Mr. Olson also expressed an interest in having U. S. Geological Survey involvement in the assessment phase. **Mr. Steiner** said this is possible provided funding is available. **Mr. Berger** noted that the other basin states and the District could jointly contract for USGS services.

Several comments were made concerning word choice and clarity in the draft plan, which **Mr. Steiner** promised to address.

The meeting was adjourned at approximately 7:50 p.m.

<u>List of Handouts</u>

Meeting Summary from December 17, 1998
Draft Outline of Framework, D.C. Source Water Assessment and Protection Program Plan
Appendix III from the Draft Plan - National Primary Drinking Water Regulations

Comments on Draft Plan submitted by Charles Verharen
Comments on Draft submitted by WSSC
Comments on Draft Plan submitted by John Finney

<u>List of Attendees</u>

Davelene Renshaw
Erik Olson NRDC
Roland Steiner ICPRB
Ross Mandel ICPRB
Jan Ducnuigeen ICPRB
Steve Donkin DC Green Party
John Finney CRUDD
Tracy Goldberg FCWA

Carla Pappalardo Clean Water Action
Tricia McPherson Clean Water Action
Jerusalem Bekele Environmental Health Administration, D. C. Dept. of Health
James Booze
Fred Mac Millan EPA Region III
Geri Albers LWVDC

Written Comments Were Received From:

John W. Finney	December 13, 1998
Davelene Renshaw	December 18, 1998
Neal Fitzpatrick	December 21, 1998
Gary Fisher	December 28, 1998
John W. Finney	January 12, 1999
Robert Buglass	January 19, 1999
Charles C. Verharen	January 20, 1999
Neal Fitzpatrick	January 21, 1999
Carla Pappalardo & Tricia McPherson	January 27, 1999

Date: Sun, 13 Dec 1998 17:20:17 -0500
To: kberger@mwcog.org
From: John Finney <finneyj@worldnet.att.net>
Subject: Comments on Draft Plan
Cc: thomas.p.jacobus@wad01.usace.army.mil, ppagano@ids2.idsonline, nvj@epaibm.rtpnc.epa.gov

To: Karl Berger COG Department of Environmental Programs
RE: Draft dated 12/11/98 of D.C. Source Water Assessment and Protection.

Dear Mr. Berger:

Thank you for sending along the Draft of the Program Plan for protecting the sources of drinking water for the District of Columbia. I must say that as written, it is an ambitious plan whose worthwhile points sometimes get lost in bureaucratic use of the English language. But then I am not sure the Plan was written for members of the civilian advisory council that you have so kindly assembled but rather for the officials who will pass upon and enact the plan eventually adopted. With some termerity, therefore, I offer the following comments on the Draft:

1. It seems here is a case whether the District of Columbia should stake out a claim for recognition and uniqueness in more forceful terms than contained in the report. When it comes to sources of drinking water in the Potomac River Basin, the District of Columbia is unique. It has no drinking water resources of its own. Its discharges do not pollute the drinking water resources of any other state. Rather, it is dependent upon all the other states in the Potomac Basin for its water supplies. Correspondingly it is the recipient of the cummulative contaminants that other states let flow into the Potomac and its tributaries. Therefore, it follows that the burden of protecting the drinking water resources of the District (and Falls Chruch and Arlington) in the future depends not upon actions taken by the District of Columbia but rather upon the individual and collections actions of the states in the Potomac River Basin. The District of Columbia presents a prime example of the need for regional action in protecting its drinking water supplies, for only by regional action can they be protected.

In a way the Draft states that in the third pargraph on p. 2 when it says: "Delineation of DC's source watershed will instead cover the whole topgraphic watershed extending well beyond the limitations of jurisdictional borders and into neighboring states." Try swallowing that sentence for its verbal pollution! Why not give a little zing to the report by pointing out, as described above, how the District is at the mercy of other states when it comes to its water supply. Here is a case where the District can stand on its soapbox and show a little independence as well as point the finger at all those states that are so indifferent to the tribulations of the District. I need not tell you that water involves not just numbers but also politics.

[Section on interjurisdictional cooperation and coordination added to Introduction. The compound sentence was divided into two simpler ones.]

2. I was particularly glad to see in the first pgh of page 3 reference to the need for river-side buffer strips to curb runoff of potential contaminants. That, of course, is one of the major solutions to protecting the water sources of the District of Columbia, the Potomac River and the Cheseapeake Bay. May I suggest that we go beyond buffer strips to study the concept of set aside or trade-offs of land so as to reduce sedimentary runoffs. Thus, a waterworks could offset the post-treatment sediments it returns to the river by buying land upstream and reducing the sedimentary runoff by an equivalent amount.

[It was not intended that buffer strips be set up in the assessment process; therefore, the wording now refers to stream-side assessment zones.]

3. At the bottom of page 3, the draft states that "the relevant potential contaminants have been ideintified in the DC-SWAP Plan. Where are they identified? What are they? It is not enough, if this is to be a Plan understandable to the general public, to say that the inventory "include contaminants listed in the National Primary and Secondaryt Drinking Water." I know you are all acting in the public behalf; but you have to describe your actions in words and terms that are understandable to the public. That means avoiding insider terms, such as "contaminant transport" on page 6.

*[**Appendix II.** National Primary and Secondary Drinking Water Regulations: Chemicals, has been added. "Contaminant transport" has been re-worded.]*

4. I was glad to see sediments listed among the potential contaminants. From my limited knowledge, I think sediments (in other words sand and soil that have run off into the river) are the principal pollutant in the drinking water sources of the District of Columbia. The Washington Aqueduct Authority goes to considerable expense --costs that are passed on to the water users-- in getting rid of the sediment before distributing the water to the District of Columbia, Arlington and Falls Church. In the process, certain coagulants are used, such as forms of alum. There is an unresolved debate over whether the treated sediments represent a pollutant, either to human of to fish and plant life. In the case of the Washington Aqueduct Authority, the treated sediments presumably do not present a hazard to human life since, so far as I know, no city or state draws drinking water from the Potomac below the fall line where the river becomes tidal. A new scientific study is about to be launched on whether the discharged sediments are harmful to fish and plant life in the Potomac.

What to do with the sediments raises all kinds of enviornmental questions. The Washington Aqueduct currently discharges the sediments into the river at time of high river flow to assure dispersal. The EPA has raised the prospect of stopping discharge of the sediments into the river. If that is done, the sediments would have to be trucked out of the Washington Aqueduct complex, which sits next to a residential neighborhood. If that were done, it would raise enviornmental hazards for residents of the District of Columbia, in diesel exhausts, cited as dangerous by the EPA, in noise pollution in residental neighborhoods, in safety to the elderly and young on neighborhood streets since dump trucks are notoriously uninspected for safety or exhausts, and to the quality of life (and the price of housing) in residential neighborhoods.

The obvious answer is to reduce the sediments, and that brings us back to the initial observation that the District of Columbia should stand up and fight for old D.C. by insisting that states upstrream in the Potomac watershed drastically reduce the runoff of sediments into the river. It can be done, as demonstrated by the initial, encouraging results of the Chesapeake Bay plan.

At the bottom of page 7, you talk about assigning numeric values to each of the pollutants. What numeric value do you place on sediments. I think it should be a high one as far as the District of Columbia is concerned.

[Sediment is universally acknowledged as a serious water treatment problem. The relative numerical values will be assigned by those tasked with conducting the Assessment.]

I had trouble understanding the paragraph at the bottom of page l0 and at the tp of page 11 talking about The Watershed Model. The Draft states that the Watershed Model can not simulate (or measure) sediment-bound constituents and "the cost of these addisional efforts is beyond the resources of the DC-SWAP. If these sediment-bound consituents pose a public health hazard, then surely ways can be found to obtain the money to make the necessary studies.

[Clarifying language has been added to the section describing the use of the Watershed Model. Sampling and modeling programs for sediment-bound constituents are usually conducted on a smaller scale than the Potomac River Basin. The cost of the collection and analysis of sediment samples is greater than $1000 per sample. Implementation of a monitoring/modeling program for toxics and sediment would cost many times the budget of the entire DC-SWAP. This cost cannot be justified unless it is shown that a potential for a significant threat from sediment-bound constituents exists. The activities outlined in the SWAP will attempt to assess how significant that threat is.]

5. On page 12, The Draft has trouble deciding whether data is singular or plural . The common usage according to Fowler is that the word is plural in Latin, singular in English, just as in the case of agenda.

[Fowler is followed.]

Please feel free to distribute these comments, for what they are worth, before or during the meeting on Dec. 17. I hope to see you there.

Respectfully submitted,

John W. Finney

Co-Chairperson of the Coalition for Responsible Urban Disposal at Dalecarlia (CRUDD)

Date Sent: Friday, December 18, 1998 11:25 AM
From: MAIL <"MAIL@SMTP {Bendavie@aol.com}"@c2smtp.potomac-commission.org
To: COMMENTS <COMMENTS@c2smtp.potomac-commission.org
Subject: DC Source Watter Assessment & Protection Program Plan

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This is to reiterate my offer to distribute flyers of notice of the Draft Plan to my neighborhood (Southwest) and also that I understand that you will provide me with a copy of that Draft Plan. I also concur that it would be a very good idea to place copies in the Public Libraries and, if you have electronic data, to send in an attached file to those of us who have E-Mail.
Thanks, Davelene Renshaw
1245 4th St., S. W., E-501
WDC 20024
(202) 488-1926

[Attempts will be made to get flyers to you and distribute copies of the Plan to libraries.]

AUDUBON NATURALIST SOCIETY, 8940 Jones Mill Road, Chevy Chase, MD 20815
Phone: 301-652-9188, Fax: 301-951-7179, http:/www.audubonnaturalist.org

12/21/98

Roland Steiner
ICPRB

Thanks for providing the opportunity to comment on Draft Framework for the DC Source Water Assessment and Protection.

On page 4, I suggest that a sentence be added that explains EPA's role in setting rules for monitoring raw water for contaminants.

[Done]

Add highways, pipelines, incinerators, power plants to table 1, page 5.

[Table 1 is a list of activities for which potential contaminants have been identified. Highways, pipelines, incinerators, power plants have been identified as needing similar information.]

What data is already available about the structural integrity of DC's surface water intakes? While I agree this is a factor, I question why it is listed first. Should all of these factors be given equal weight? How will priorities be set for determining susceptibility given limited resources?

[Structural integrity of system components is the first assessment item mentioned in the US EPA guidance. It is included in the Plan mostly for completeness.]

More explanation is needed to justify using time of travel of water as a surrogate to assess the sensitivity of the watershed.

[Travel time analysis has been restated to refer only to instream issues.]

On page 9, will DC attempt to delineate buffer zones in MD, VA, PA, WV?

[It was not intended that buffer strips be set up in the assessment process; therefore, the wording now refers to stream-side assessment zones.]

More explanation is needed to justify using the HSPF model as an assessment tool. What experience can be used to justify the significant reliance placed on HSPF? For example, what does the HSPF say about sediment loads in the Cabin John Creek, Difficult Run, Watts Branch, Muddy Branch watersheds upstream of DC water intakes? How will protection of DC source water from upstream sediment loads be achieved?

[Clarifying language has been added to the section describing the use of the Watershed Model. The Watershed Model has been calibrated to predict fall line nutrient and sediment concentrations on the basis of upstream land use and point source discharges. The model has been successfully verified, and is being used by Maryland, Virginia, Pennsylvania, the District of Columbia, and federal agencies involved in the Chesapeake Bay Program to plan regulatory and voluntary programs to reduce nutrients and sediment loads to the Chesapeake Bay. One of the purposes of the model is to predict the effects of implementing these programs, and most of the uses of the model envisioned in the DC-SWAP are extensions of the use of the model's predictive capability in the Bay Program. The model does not simulate the transport of sediment and nutrients in smaller tributaries directly. It does, however, simulate, on a broad scale, how land use activities and point sources in the watersheds of upstream tributaries contribute to the sediment and nutrient loads at the fall line. It can therefore, on a broad scale, be used to measure the relative contribution of geographic regions to fall line loads, to determine under what hydrologic conditions the greatest fall line impacts are likely to occur, and, in many respects, how future changes in upstream land use activities will affect water quality at the fall line.]

What efforts will be made to assess chemical contaminants from airborne sources? For example, mercury emissions have contaminated the food chain in farm ponds near Dickerson.

What efforts will be made to evaluate the susceptibility of source water contamination from degradation products that are created when chemical contaminants interact with the environment?

[Air-borne and degradation products have been added to the list of activities to be considered as potentially contaminating source water.]

Evidence from numerous places indicate that protecting natural systems - especially forests, wetlands, and open spaces - plays a significant role in protecting source waters around the country. No mention of this option is included in the Draft Framework. This option would require all states within the Potomac River watershed to coordinate a basinwide approach. John Finney raised the question at the December 17 meeting about cooperation among states that share the Potomac River. Why wasn't a basinwide approach used?

[The present project is to develop a Plan to guide the Assessment of potential contamination to source waters. Forests, wetlands, and open spaces might

follow as remediation and protection measures. The 1996 Amendments to the SDWA were developed with significant "stakeholder input" resulting in state-by-state responsibility for implementation.]

Neal Fitzpatrick
Conservation Director

WATER RESOURCES DIVISION
8987 Yellow Brick Road
Baltimore, Maryland 21237
(410)238-4200 FAX (410)238-4210
December 28, 1998

Dr. Roland Steiner
Interstate Commission on the Potomac River Basin
6110 Executive Boulevard, Suite 300
Rockville, MD 20852-3903

Dear Roland:

Thank you for the opportunity to review the draft framework for the Washington, D.C. Source Water Assessment and Protection Program Plan. The framework seems to be well thought out and is consistent with other documents that we have seen from EPA and MDE. Although we are not able to participate fully on your Technical Advisory Group, we have several comments and suggestions for your consideration.

A general observation is that the framework does not take advantage of the large body of data and interpretive reports that have been produced by the USGS National Water-Quality Assessment (NAWQA) project in the Potomac River Basin. These products may provide a good foundation for much of your data gathering and analysis activities. Information can be found on the World-Wide Web at http://md.usgs.gov/pnawqa/ or you can contact Joel Blomquist at (410)238-4260.

You mention (page 2) that delineation of the watershed above the two D.C. surface-water intakes will be based on USGS 1:250,000 and 1:24,000 scale mapping. The Potomac NAWQA project has produced watershed delineations for the Potomac River at Chain Bridge and for selected upstream subwatersheds where fixed-site sampling was conducted. These were based on 1:100,000 mapping and any discontinuities at map sheet boundaries have already been addressed. You may contact the NAWQA project through Joel Blomquist at (410)238-4260 to discuss availability of this data layer. It is important that watershed boundaries do not vary between agencies and that major agencies agree on watershed delineations. You will likely want to add delineations of watersheds above selected water withdrawal points.

The section on Chesapeake Bay Fall Line Monitoring Program (page 4) needs revisions. It is important to directly acknowledge the federal and state participants in that effort, which is done not by the Chesapeake Bay Program but in support of it. The following (underlined) is suggested to replace the current text. Also, note that the title of the monitoring program has been changed to be more precise.

Chesapeake Bay River Input Monitoring Program

The U.S. Geological Survey, in cooperation with the Maryland Department of Natural Resources and the Virginia Department of Environmental Quality, monitors nutrient and sediment concentrations at the downstream freshwater limit of nine major tributaries to Chesapeake Bay, including the Potomac River at Chain Bridge.
[REDACTED] The monitoring
program is a contribution to the Chesapeake Bay Program, and is described on the World-Wide Web at http://va.water.usgs/chesbay/RIMP/. The Chesapeake Bay Program and cooperating agencies, including USGS, also monitor toxics and metals at the downstream freshwater limit of the Susquehanna, James, and Potomac Rivers. These stations are at or near where the physiographic Fall Line crosses the rivers, and the locations are sometimes called Fall-Line stations. While monitoring programs for metals and toxics are not as extensive as those for nutrients and sediment, they still provide significant data on which contaminants may impact the District's raw water supply.

In the section on Sensitivity of the Watershed (page 6), we are uncomfortable with stating that time-of-travel "implicitly incorporates consideration of these sensitivity factors". We agree that it would be a good surrogate to assess watershed sensitivty closer to headwaters. However, at points farther downstream, the complexity of a watershed such as the Potomac would negate the usefulness of time-of-travel as single representative parameter. Nonetheless, time-of-travel is a critical parameter for assessing susceptibility to effects from upstream inputs of any pollutant.

Your general direction of using existing HSPF watershed modeling as a starting point is good.

For Assessment Round I (page 8), you should incorporate obtaining any GIS data from sources such as USGS, and in particular the delineation of the watersheds. You should also incorporate any data and interpretive products available from sources such as USGS NAWQA, in particular its nutrient and pesticide retrospective studies, its synoptic water-quality studies, and its bottom sediment and tissue study.

In the References, note that Jack (1984) should state "Petersburg to Green Spring", and that Taylor (1970) and Taylor (1971) are both Maryland Geological Survey Information Circulars.

[All comments have been incorporated.]

If you have any questions about our comments, please contact me at (410)238-4259 or gtfisher@usgs.gov.

For the District Chief, MD-DE-DC
Gary T. Fisher, P.E.
Hydrologist, Surface-Water Specialist

cc: Jerusalem Bekele, DC DoH
Miranda Brown, WAD
Michael Marcott, WASA
Frederick MacMillan, EPA Region III
Gerald Peaks, VA DoH
John Grace, MDE
James Gerhart, USGS MD-DE-DC District
Ward Staubitz, USGS VA District
Joel Blomquist, USGS Potomac NAWQA

>>Return-Path: <finneyj@worldnet.att.net>
>>X-Sender: finneyj@postoffice.worldnet.att.net
>>Date: Tue, 12 Jan 1999 23:05:21 -0500
>>To: kberger@mwcog.org
>>From: John Finney <finneyj@worldnet.att.net>
>>Subject: Jan. 8 Draft of Source Water Assessment Plan
>>Cc: thomas.p.jacobus@wad01.usace.army.mil, nvj@epaibm.rtpnc.epa.gov,
>> hamner.rebecca@epamail.epa.gov, ppagano@ids2.idsonline.com
>>
>>Dear Mr. Berger:
>>
>> Thank you for sending me a revised copy of draft plan for the District of
>>Columbia's Source Water Assessment Program.
>> I find the revised draft, while still awfully wordy, a great improvement
>>over the earlier draft. For me, the statement of purpose of the project, as
>>explained on pages 6 and 7, is much clearer and more understandable.
>>Indeed, it finally is made clear that the future protection of D.C. water
>>supplies depends on what takes place upstream from the District. The plan,
>>therefore, proposes that the District survey the entire watershed for
>>future contaminants of its water supply, drawing upon information supplied
>>by the upstream states and federal agencies, but acting on its own.
>> I still find this a very ambitious project for a District government
>>which has trouble fixing water pipes in its own domain. And I still believe
>>a regional approach would be preferable. But after talking with Vicky
>>Bennetti of EPA, I have a better understanding of why it is proposed the
>>the District do the study on its own.
>>
>> I gather there is a touch of paternalism (or in this case maternalism) in
>>EPA urging the District to conduct the study on its own. The hope within
>>the EPA is that the District will develop knowledge, skills and competence
>>in environmental matters in doing the study on its own but with federal
>>financing. I am not sure that such paternalism, however well-intended,
>>falls within the mandate of the EPA. But if the effect is to prepare the
>>District government to defend its citizens against neighborhood pollution
>>ordered by the EPA, then I can only applaud the effort.
>>
>> As I understand the funding, EPA has made a grant of $400,000 to the
>>District to conduct the basin-wide study, with the expectation the study
>>will be carried out by the Interstate Commission on the Potomac River
>>Basin under the direction of a staff person from the District's Office
>>Environmntal Health. The $400,000 is not an insignificant sum given the
>>needs of the District of Columbia, but it still is small enough to keep
>>the study from becoming a big boondoggle.
>> In connection with the funding, I wonder whether the statement at the top

>>of page 6 that the source of funding will be a set aside from the 1997
>>allotment to the District (I believe for $12.5 million) is correct. My
>>understanding is that the funding is a direct grant from EPA since the
>>District does not have a Drinking Water Revolving Fund, as do the states.

[The funding statement has been clarified in the document.]

>> I initially was skeptical about the capability of the District government
>>to manage such a project. But I gather from D.C. Council Member Kathy
>>Patterson that the Environmental Health Administration of the D.C.
>>Department of Health has gathered together a competent group of officials,
>>including my Palisades neighbor Nick Kaufman, for whom I have the highest
>>regard.
>> So after my initial reservations, I say let's get to it. Let the District
>>demonstrate it can stand on its own two feet in defending its drinking
>>water sources against contamination by the uperiver states. I am not sure
>>the states, which tend to treat our distirct as an orphan, will cooperate
>>fully or will pay much attention to the conclusions reached by the
>>District study. But at least the Disgtrict will have a study to shove in
>>the faces of the states if they continue to disregard the interests of the
>>District in protecting the purity of the Potomac River above the fall line.
>>[REDACTED]

[REDACTED]

>> Before you go to the printer, however, you may want to find another word
>>for anthropormorphic at the bottom of page 12. Anthropomorphic refers to
>>the attribution of human characteristics to non-human objects. Thus, for
>>example, the EPA has anthropomorphic feelings about the bullhead minnows
>>that swim in the shadow of Chain Bridge. I think the word you are looking
>>for is "mamade."

[The suggested replacement was made in the document.]

>> Congratulations on your efforts to get this project underway. I know that
>>you and Mr. Steiner have worked hard on this in the face of carping from
>>civilians on an advisory panel. But I think the study will be all the
>>better for being blessed with the observations of those who eventually
>>will drink the water you are trying to protect.
>> If you would, please send along a copy of this to Mr. Steiner, and
>>circulate it in any way you wish.

\>>
\>> Sincerely yours,
\>>
\>> John W. Finney
\>> Co-Chair of CRUDD>>

Date Sent: Tuesday, January 19, 1999 6:01 PM
From: "Buglass, Bob" <"MAIL@SMTP
{bBuglas@wssc.dst.md.us}"@c2smtp.potomac-commission.org>
To: RSTEINER <RSTEINER@c2smtp.potomac-commission.org>
Subject: DC SWAP Draft Comments

Roland -

This draft looks very well done to me. I have a few minor comments/suggestions for your consideration. Some may not be appropriate to the current stage; feel free to ignore or defer.

* Page 6 and page 15, may want to note whether both intakes are shore intakes, which are more susceptible to effects of local tributary runoff water quality.
* Page 9, may be worthwhile to mention and get data from the Rockville water plant, with its intake [REDACTED].
* Page 11, besides sand and gravel, other types of mining (active and abandoned) may be significant. "Biosolids" is the current preferred term for municipal wastewater plant sludge.

[The list of activities in the Plan is for those activities which contaminants have been associated.]

* Page 12, last paragraph, may want to emphasize that urbanization increases surface runoff peak flows far more than would be predicted by the increase in impervious area, because of hydrologic/hydraulic modification. The result is often extensive stream channel erosion from fairly minor storms.
* Page 13, under Potential Sources of Contamination, even undeveloped areas have potential sources of contamination, e.g. pathogens from large deer populations.
* Page 13, under Susceptibility, may want to consider biodegradability along with the listed removal mechanisms.
* Page 18, under Taste and Odor, runoff from snow melt, and when the ground is frozen, often contains ammonia which results in taste and odor problems. Also, some roadway deicing chemicals contain urea, another nitrogen source, and another taste and odor precursor.
* Page 19, minor typos, second paragraph, Westvaco is spelled differently; third paragraph "their transport".

[All comments incorporated except as noted above.]

I'm not sure if I can come to the meeting tomorrow night. If any questions, please call at 301-206-8082, or return e-mail.

January 20, 1999

Mr. Roland Steiner
Interstate Commission on the Potomac River Basin
6110 Executive Boulevard
Suite 300
Rockville, MD 20852

Dear Mr. Steiner:

Thank you for inviting me to have these remarks read into the record at the Source Water Assessment Plan public meeting tonight.

With Mr. John Finney, I am concerned that sediment deposition in the Potomac above the Washington Aqueduct Water Treatment Plant adds to the water quality and waste disposal problems of the Aqueduct Plant.

I am particularly concerned that the drinking water treatment plants above Washington add to this problem by discharging their waste directly into the Potomac.

You indicated in our phone conversation that around twenty drinking water treatment plants may be sited above Washington. You also indicated that the WSSC treatment plant now discharges all its solid waste directly back into the Potomac some few miles above the Aqueduct intakes.

Mr. Karl Berger at the Metropolitan Washington Council of Governments said to me by phone today that WSSC was contracting for a plant that would eliminate some but by no means all solid discharge.

I would like to see the current SWAP plan (January 8, 1999) revised to include assessment of the threats posed by all water treatment plants in the Potomac River Basin to the quality of Washington's drinking water.

> *[Water treatment plant discharges are subject to NPDES permits, and as such will be considered in the Assessment.]*

I would also like to see the current SWAP plan include arguments for and against the discharge of the Washington Aqueduct Water Treatment plant's own waste products back into the Potomac.

> *[The DC treatment plant solids are discharged to the river down stream of the intakes; therefore, they are outside the scope of the DC Source Water Assessment. The fact that there are no other drinking water withdrawals*

down stream of those discharges makes it unlikely that they will be considered in any Source Water Assessment.]

Thank you for your attention.

Sincerely,

Charles C. Verharen
1207 35th Street, Northwest Phone: 202-338-6033
Washington, DC 20007 Fax : 202-965-4735

1/21/99

Roland Steiner
ICPRB

Thanks for the opportunity to submit these additional comments and questions about the Draft Source Water Assessment and Protection Program Plan for the District of Columbia.

Page numbers refer to the December 11, 1998 Draft. So far, I have not taken the time to compare the 12/11/98 Draft with the 1/8/99 Draft. It would help to have new language delineated.

Sincerely,

Neal Fitzpatrick

General Comments

The Watershed Model and the Hydrologic Simulation Program-Fortran (HSPF) are both existing tools, which were developed for specific purposes other than those described in this document. While models and simulations can be extended, evolved, improved and otherwise modified, it is extremely risky for modifications of the type described in this document to be done by those who developed the original model or simulation. Typically many assumptions, both explicit and implicit, are necessary in the process of developing models and simulations. No matter how well documented, important assumptions will not be apparent to other users, which can lead to significant problems.

The biggest problem with modeling and simulation is believability of the results. It is very important, particularly when adding capabilities to an existing model, to first establish a baseline of the characteristics of the model before modification. As important capabilities are added, incremental checks of specific functions or characteristics should be examined very carefully. The objective of these checks should be to determine if the tool produces results that make sense; for a set of inputs that correspond to an intuitive case, does the tool produce results that are consistent with expectations? This type of systematic approach is not discussed in the document.

Modeling and simulation can easily become open-ended activities. The trial and error approach rarely yields the desired results.

Specific Comments

The Potomac River, upstream of the fall line, is divided into eleven segments with each segment representing a river reach and the area of land that contributes to it. Are the characteristics of each segment the same for the entire segment, or can there be multiple land uses within a segment?

> *[There are multiple land uses within each segment.]*

What does "fully-calibrated hydrology" mean? Does it mean that the HSPF models the flow of water in the hydrological cycle, representing precipitation, evaporation, runoff, ground water flow, and transport to some level of agreement with measured data for all of the types of land use to be considered? What about transpiration? Infiltration?

> *[In this case, "fully-calibrated" means that the average daily flows calculated by the model are in agreement with the daily flows measured at the USGS monitoring station at Chain Bridge. The flows predicted by the model are also calibrated to observed data at other locations, such as Millville, WV, for the Shenandoah River and Shepherdstown, WV, for the upper Potomac. All aspects of the hydrologic cycle, including transpiration and infiltration, are represented in the model.]*

It is stated on page 12 that the HSPF is capable of modeling the transport of fecal coliform bacteria, and that the Watershed Model will be adapted to simulate the fate and transport of fecal coliforms. To what extent has the HSPF be validated for this use? Have the predicted results from HSPF been compared to measured results at the upper end of the contamination level? Interpolation is vastly preferable to extrapolation.

> *[HSPF is a flexible model that can be used to study the fate and transport of a wide range of contaminants. The user determines the contaminant of interest and specifies the parameters that describe its behavior in an input file. The model itself does not need to be validated; it will be calibrated against observed monitoring data. Neither interpolation or extrapolation should be necessary. The Watershed Model, in a sense, is just a set of input files for HSPF, though, of course, it takes an enormous effort to develop and maintain the input files, calibrate the model, and analyze the results.]*

At the bottom of page 12 there are several tasks identified as "necessary to adapt the Watershed Model to the representation of the fate and transport of fecal coliform bacteria." If HSPF is the underlying simulation and it already covers these effects, then shouldn't the modifications to the Watershed Model be minimal?

> *[As stated above, the user must specify which constituents are modeled and the parameters to describe their fate and transport. Currently, the Watershed Model does not simulate fecal coliforms, so the parameters necessary to represent them will have to be added to the input files that currently run the model. The underlying model hydrology and hydraulics, however, will not*

change, therefore much of the work in developing a model has already been done.]

At the top of page 13 it states, "Additional analysis will be necessary to make inferences from the results of the fecal coliform simulation which apply to pathogens such as giardia and cryptosporidium." What types of analysis? Fecal coliforms are probably not good indicator for other pathogens in all conditions. How will this be included?

[The statement was intended to express the recognition that fecal coliforms are not necessarily a good indicator of other pathogens, and has been changed to reflect that. Many states, including Pennsylvania and Maryland, have studies to examine the sources, fate, and transport of cryptosporidium., and the DC SWAP will make use of the results of those studies to determine the susceptibility of DC's drinking water supply to contamination from it.]

On page 13 it states "The Watershed Model calculates nutrient concentrations, as well as chlorpophyll concentrations, at the fall line." Where are the intakes relative to the fall line? Is it not necessary to calculate these concentrations at the intakes to correlate cause and effect?

[Chain Bridge is [REDACTED]. Since the purpose of using the Watershed Model is to evaluate the relative contribution of different regions in the watershed to fecal coliform concentrations at the intakes, it should not be necessary to correct the model for the exact location of the intakes. In determining, for example, whether the South Branch of the Potomac or the Conococheague Creek contributes more to the concentration of fecal coliform concentrations at the intakes, there is no need to correct for the 1.5 or 10 mile difference in location, because those distances are small compared to the size of the basin.]

Date Sent: Wednesday, January 27, 1999 11:46 PM
From: CWA Program Staff <"MAIL@SMTP dccwa@cleanwater.org}"@c2smtp.potomac-commission.org>
To: RSTEINER <RSTEINER@c2smtp.potomac-commission.org>,
kberger <"MAIL@SMTP {kberger@mwcog.org}"@c2smtp.potomac-commission.org>
Subject: Final SWAP Comments

District of Columbia
SOURCE WATER ASSESSMENT PROGRAM

Comments Submitted by:

Carla Pappalardo, Tricia McPherson, and Clean Water Action

Prepared by: Carla Pappalardo and Tricia McPherson

January 27, 1999These written comments regarding the District of Columbia's Draft Source Water Assessment Plan are submitted by Carla Pappalardo and Tricia McPherson (a District resident) as members of the required Citizens' Advisory Committee (as stated in the EPA guidelines for the Source Water Assessment Plans each state, including the District of Columbia, must submit to the EPA for approval). This documentation is submitted by Carla Pappalardo as the Chesapeake Regional Coordinator and Tricia McPherson as the Field Canvass Director for Clean Water Action's National Headquarters in the District of Columbia. Where comments directly relate to specific parts of the Draft SWAP, those sections will be identified.

Funding Constraints:

We want to thank the Council of Governments for its role in this process as well as the EPA and ICPRB for their work in providing answers to our questions. Regarding funding for the Plan and the actual Assessment, it was quite clear through meetings of the CAC, that the Department of Health is unclear as to the actual amount of money set aside for this and where it comes from. We therefore urge ICPRB to continue its role through the actual assessment by submitting a bid. Our hope is for the Department of Health to open up the bidding process and not take on the role themselves.

Furthermore there are concerns as to the sufficiency of the allotted EPA grant of $400,000 that was given to the District, to not only complete the assessment, but carry out the plan. Some concerns arise as to if this allocated sum of money is in fact sufficient. Will there be enough to fully implement an assessment of the potential and relevant contaminants? Will there be enough to carry out the "massaging" of other states' data as needed for DC's Plan? And finally, will there be enough to incorporate all data into an effective plan that would essentially protect and prevent source water contamination? If this grant is in fact the only available source of funding, and required findings for a comprehensive assessment exceed that amount, then does this mean that some contaminant sources will not be included? Or will additional monies be made available, such as what was suggested at the last "public" meeting in regards to states in the watershed area pooling money to do a regional study?

> *[Until a budget and scope of work are developed for the Assessment, it is difficult to address the issue of supplemental funds for the Assessment phase.]*

Public Participation/Inter-jurisdictional Coordination:

In some ways DC is ahead of other states in public participation even though the process was started much later in other places. One question that still needs to be addressed is, what range of residents was contacted in the District and did this represent a well-rounded group of residents? We are requesting that a list of these outreach efforts be sent to us.

> *[MWCOG sent letters soliciting interest in helping to develop the District of Columbia's SWAP Plan to more than 100 individuals. These people included all of those who attended a public meeting on drinking water issues in Washington, D.C., held by EPA Region III in March 1996. They included other representatives of civic and environmental organizations in the city, the chairs of the 29 Advisory Neighborhood Commission subdistricts in the city, and representatives of various city government agencies or other organizations involved in drinking water and public health issues.]*

Thank you for the "extra" meeting that the CAC requested for further comment on these draft plans. In light of the importance of these Assessments (for protection of our drinking water), and the fact that in part, we must rely on the neighboring states of Maryland, Virginia, West Virginia, and Pennsylvania (for their state plans' data), we foresee a potential need for additional comments beyond the submission date requirements. Any future comments will be submitted to EPA, Region III or the District of Columbia Department of Health.

There are still major concerns regarding "Inter-jurisdictional Cooperation and Coordination." As mentioned above, DC will need to rely on the data provided to us by our neighbors. In the last SWAP meeting it was clarified that we will use only their data and not their plans or assessments, and that once we have that data, it will be massaged for the District's plan. Perhaps it is the suggestion of massaging the data that brings concern. Or perhaps it is the question of overall sufficiency of that data. Yes, the EPA still has to approve those state plans. However, with no citizen oversight there can be no guarantee our concerns will be addressed, particularly since we are unaware as to who will actually carry out the plan.

[It is noted in the Plan that the Citizens' Advisory Committee recommended a continuing role for public involvement.]

Potential Contaminants:

The topographic watershed approach to source delineation is important in the necessity to meet the EPA indications for Source Water Assessment Plans. In regards to Section II.D and Section III. there are concerns which have been mentioned in CAC meetings, but not fully addressed. There is discussion in Section II.D of Zone Segmentation and subsequent delineation to be "based on potential pollution pathways and the varying degree of susceptibility posed by the different classes of potential contaminants and sources." Who will determine these issues?

[These issues will be determined by the staff conducting the Assessment.]

It is recognized that there are funding "limitations." However, all potential contaminants, not just "relevant" ones (Section III.A.) must be searched for, their pathways and travel times to water sources projected. We must be certain that the data received from the other states in the Potomac River Basin Watershed covers all potential contaminants and potential travel times, even if they are not considered "relevant," which usually means "expected." Through accidents such as human error or even through natural causes the unexpected can become the expected.

In Section II.E dealing with Mapping Delineation, it is sited that the hydrologic layer will include "major" rivers, streams, lakes, and reservoirs. All reservoirs are "major" to those who draw their drinking water from them. There are concerns regarding what constitutes "major." Sources of contamination to our source waters do not choose to locate themselves only on "major" waterways. When taking the inventory of business types and activities, for which related potential contaminants are identified (Section III, Table 1.) the hydrologic layer of mapping should include all "pertinant" rivers, streams, lakes, and reservoirs. In determining which are pertinent, it will be necessary to evaluate what businesses or activites may in fact be located on "minor" rivers, streams, lakes, and reservoirs. Since the delineation element of the Assessment will be founded on this base map, to have an Assessment done on source water which is accurate, complete, and cost effective this would need to be addressed in the SWAP Plan. The same would hold true for "minor" roads as a potential source for contamination, unless this solely deals with a base map for viewing purposes only and not as an actual basis for where to do assessments.

[Your latter statement is nearer to our thinking. It is intended that rivers and roads be shown down to some level of detail which is not too crowded. If a potential contaminant source exists, it will be assessed regardless of whether it is located on a mapped river or road.]

It is our understanding that monitoring is not as extensive in some states as in other states. In addition, enforcement on that monitoring has been seen as problematic. We are once again dependent upon our neighbors for their monitoring data, which may or may not be adequate. Section III.B states that an "attempt" will be made to determine the source of identified contaminants of "concern" as they are discovered in the monitoring data. The District's Plan should be clear on what contaminants are of concern to DC and if those contaminants are not a part of the monitoring data from a neighboring state, should be identified and data obtained.

[Contaminants found in the water demonstrate susceptibility; therefore, the Assessment is a priori done. We are trying to push a little farther here if we can — into what would be the watershed protection phase.]

Referencing Table 1 again, some minor adjustments in wording of certain activites and additions to that list are recommended. The list mentions Municipal Wastewater/Sewer lines and Septage lagoons and sludge. We would suggest language include Combined Sewer Overflows. Retention ponds at wastewater treatment facilities may reach capacity, and overflow is not treated before discharge. Another potential contaminant would be superfund sights. Although the Front Royal site in Virginia is listed there is no mention of other sites. Highways and different types of land uses are mentioned, however, areas of extensive residential development are not. These areas can be a contributing factor to source water contamination due to various practices including pesticide applications, runoff, oil changes, accidental dumping of toxic household chemicals, etc.

[We propose two methods of determining if a potential contaminant is present in the watershed: (1) direct assessment = presence in water monitoring data, and (2) potential contaminant assumed to be associated with a known activity in the watershed. Table 1 and other similar information sources allow us to translate from activity to presumed presence of potential contaminant when that contaminant has not been found in water quality monitoring. Therefore, Table 1 is one source of information we found to translate from "activity" to possible presence of potential contaminant. We know that other such tables exist and are more complete — covering activities you mention above.]

Enforcement:

There is currently no enforcement mechanism to "assure that as they [the states] implement source water protection programs the water sources for the District of

Columbia are also protected" (from section I.D of the Introduction). One issue discussed frequently at our DC SWAP meetings has been the suggestion to continue the involvement of the Citizens' Advisory Committee in the actual assessment. This could be an effective way of including more public participation in the Assessment, as well as ensuring the information available to DC is extensive enough to meet the needs of protecting the water supply of our nation's Capitol. We strongly urge the continued presence of the Citizen's Advisory Board in the furthering of this project. This could also be a way for citizen's to take ownership over ensuring clean water for the District and to assist with fostering the necessary working relationships with "upstream" states. Clean Water Action would be more than willing to help forge relationships with our neighbors, and with the capability of reaching almost 100,000 member households, can have an effective impact in this campaign for clean and safe water.

> *[Again, it is noted in the Plan that the Citizens' Advisory Committee recommended a continuing role for public involvement.]*

Please respond in writing regarding our public comments. We look forward to the continuance of the Citizens' Advisory Committee in an official capacity.