Source Water Assessments
for

City of Frederick
Frederick County, Maryland

Fishing Creek Reservoir with intake

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SUMMARY

The 1996 Safe Drinking Water Act Amendments require states to develop and implement source water assessment programs to evaluate the safety of all public drinking water systems. A Source Water Assessment (SWA) is a process for evaluating the vulnerability to contamination of the *source* of a public drinking water supply. The assessment does not address the treatment processes, or the storage and distribution aspects of the water system, which are covered under separate provisions of the Safe Drinking Water Act. The Maryland Department of the Environment (MDE) is the lead state agency in this source water assessment effort.

There are three main steps in the assessment process: (1) *delineating* the watershed drainage area that is likely to contribute to the drinking water supply, (2) *identifying* potential contaminants within that area and (3) *assessing* the vulnerability of the system to those contaminants. This document reflects all of the information gathered and analyzed required by those three steps. MDE looked at many factors to determine the vulnerability of this water supply to contamination, including the size and type of water system, available water quality data, the characteristics of the potential contaminants, and the capacity of the natural environment to attenuate any risk.

The City of Frederick source water supplies are from three surface sources: the Monocacy River, Linganore Creek and Fishing Creek Reservoir. The Monocacy River is the largest Maryland tributary to the Potomac River, the area above the City of Frederick's intake and encompasses approximately 700 sq. miles (448,000 acres) of mixed land use with over 60% of cropland and pasture. About 75% of the source protection area is located in Frederick and Carroll counties of Maryland and 25% of the watershed is located in Adams County, Pennsylvania. Potential sources of contamination to the Monocacy River upstream of the City's intake are agricultural land, including crops and pasture, discharges from three major and several minor wastewater treatment plants, spills and runoffs from roads and railroads, existing and future housing developments in the watershed. Review of water quality data available for the Monocacy River indicates that nutrient enrichment, sedimentation and contamination by pathogenic organisms are the major concerns.

Linganore Creek, a major tributary of the Monocacy River, is another source of the City's surface water supply. At the point of intake, Linganore Creek drains approximately 85 square miles (54,000 acres) of land. Lake Linganore is the largest impoundment in Frederick County, storing over 800 million gallons of water, located approximately 1.5 miles upstream of the City's intake. The Lake Linganore Association owns and operates the lake that was constructed for recreational use and water supply. Frederick County also withdraws water directly from the lake for their water treatment plant located at the

vicinity of the reservoir. In addition to potential sources of contamination discussed above for the Monocacy River intake, 3,730 acres of land surrounding the lake with an ultimate potential of 3,200 housing units, swimming beaches and boat access ramps, is another major challenge affecting the water quality of Lake Linganore for water supply. Development of this land from forest to housing units will cause more nutrients to Lake Linganore and further degrade water quality through eutrophication.

Fishing Creek Reservoir was developed as a water supply source for the City in 1897 after the Tuscarora receiver was constructed in 1870. The intake on Tuscarora Creek is abandoned and no longer in use. Fishing Creek Reservoir watershed lies mostly within the City of Frederick's forest that encompasses 7.4 square miles (4,775 acres) with almost 99% of forested land. Because of its protected watershed, the potential of many contaminants to reach the reservoir is minimum. Fishing Creek Reservoir, like any other surface water, is subject to high turbidity during heavy storms and snow melts and susceptible to contamination by *giardia*, *cryptosporidium* and other pathogens.

All of the above City's surface water sources are vulnerable to land use activities occurring within the watershed. Continuous monitoring of contaminants is important to understand changes in raw water quality to assure delivery of safe drinking water to the City's customers. Furthermore, in order to maintain and/or improve the quality of water supply the City of Frederick is encouraged to implement the recommendations for an active source water protection plan as included in Section VII of this report.

I. INTRODUCTION

The City of Frederick is located in the central part of Frederick County and encompasses 18.1 square miles. It is a growing city within commuting distance to Baltimore and Washington D.C. regions (Fig.1) with many emerging neighborhoods and commercial and industrial areas. The City owns and operates three water treatment plants serving an estimated population of 51,000 people.

The City of Frederick water system serves one of 14 regional service areas in Frederick County. Frederick County's population has increased by 74% between 1970 and 1990. During the 1990-1999 time frame, the average annual increase has been approximately 4,900 persons, bringing the total county population to 199,369. The area of the county experiencing the largest share of population growth have been the Frederick and New Market Planning Regions. During 1999, 68% of the total county population increase occurred in these two regions. According to Maryland Department of Planning (DOP) and Frederick County Planning Department, the total population of Frederick County will increase to 267,100 persons by 2020. Subsequently, if the trend continues, the City of Frederick and New Market area will reach to approximately 180,000 persons by 2020 (Frederick County and City of Frederick Comprehensive Plan).

Currently, raw water is supplied by three surface water sources: the Monocacy River, Linganore Creek, and Fishing Creek Reservoir. An intake located on Tuscarora Creek is abandoned and no longer in use. A summary of updated water appropriation and use permits for these surface water sources are shown in Table 1 below.

Permit No. Source	Daily Average (GPD)	Daily Maximum (GPD)
FR245001 Fishing Creek Reservoir	1,910,000	3,800,000
FR305001 Tuscarora Creek (abandoned)	810,000	1,000,000
FR405001 * Linganore Creek	6,000,000	9,000,000
FR615001 Monocacy River	5,700,000	8,500,000
Total **	14,420,000	22,300,000

Table 1. City of Frederick's Water Appropriation and Use Permit

* The County, the City of Frederick and Lake Linganore Association, Inc. executed an agreement on December 14, 2000 approving the provision to authorize the release up to 10.46 million gallons per day (MGD) from Lake Linganore. This will allow the City to withdraw the full 6.0 MGD allocation

of water from Linganore Creek assuming no change in the City's current flow-by requirement.

** Maryland Department of the Environment Water Rights Division estimated daily average water demand for the City of Frederick to be 10,200,000 gallons by 2012, which is substantially less than the present total permitted amounts of 14,420,000 gallons per day average. This projection is based on records of the City's water use for the past 14 years.

A. Description of Surface Water Supply Sources

Fishing Creek Reservoir

Fishing Creek was developed as a water supply source for the City of Frederick in 1897 and became the second source of water for the City after the Tuscarora receiver was constructed in 1870. The dam on Fishing Creek was constructed in 1924 to increase the safe yield of this source. When originally constructed, the dam impounded approximately 60 MG of water, but in 1933 the dam and spillway level was increased by five feet to impound approximately 77 MG of water. As a result of modifications to the dam and spillway in 1981 (to comply with the dam safety requirements), the storage capacity of the reservoir was reduced to a capacity of 56 MG. According to the City of Frederick officials, the current capacity of the reservoir is 50 MG.

Fishing Creek Dam is an earth embankment, approximately 580 feet long and 49 feet high above the original stream bottom. The earth fill, which was placed around a concrete core wall extending entirely through the dam, has an upstream slope of 3:1 and down stream slope of 2:1 (Fishing Creek Dam Safety Improvements; Whitman, Requardt & Associates, Dec., 1980).

The intake structure is located in the lake area upstream from the dam and is accessible only by boat. A six (6) foot concrete arched conduit extends from the intake structure passing through the earth dam. The intake structure at the reservoir has screen gates at depths of 10 feet and 25 feet. Water from both screened valves flows through a common 12-inch transmission main to the Lester R. Dingle Water Treatment Plant approximately 4 miles away.

The Fishing Creek Reservoir watershed lies mostly within the City of Frederick's forest at the intersection of Mountaindale Road and Gambrill Park Road. Soils in the watershed are predominantly Edgemont Chandler Series, a very stony loam, and slopes ranging from 20 to 60 percent.

The Edgemont Series soils consist of moderately deep, well developed well drained soils derived from materials weathered from quartz schist, quartzitic sandstone and some fairly pure quartzite. Nearly all of the gravelly Edgemont soils in Frederick County occupy elevated areas or ridges in the Piedmont Plateau. The soils are generally low in fertility and not very productive. Most of the acreage, especially that on the mountains, is in forest that is dominated by oaks and contains some short leaf pine, hickory, dogwood and other trees (U.S. Department of Agriculture, Soil Survey of Frederick County, 1960).

Frederick County's location in two physiographic regions (Piedmont and Blue Ridge) provides a topography which ranges from the gently rolling to rugged and mountainous. This creates a variety of local climates. Fishing Creek Reservoir is located in the Catoctin Mountain range of the Blue Ridge Region, with an average annual temperature of 50° F and average precipitation ranges between 44 and 46 inches.

Linganore Creek

Linganore Creek, a major tributary of the Monocacy River, is another source of the City's surface water supply and has been utilized since the construction of Linganore Creek Water Treatment Plant in 1932. The plant intake draws water directly from Linganore Creek approximately one mile upstream from its confluence with the Monacacy River and approximately 1 ½ miles downstream from the Lake Linganore Dam. The Lake Linganore Dam was constructed in 1972 by Lake Linganore Association (LLA), Inc. as a recreational lake for Lake Linganore Planned Unit Development according with an agreement between the county and LLA dated November 1, 1968. The Dam consists of an earth embankment approximately 750 feet long and 62.5 feet high at its maximum section. Several relevant statistics for Lake Linganore are provided in Table 2.

Location	Frederick County, MD Latitude N 39° 25' 10" Longitude W 77° 20' 20"
Surface Area	Normal Pool Level 215 acres Maximum Pool Level 388 acres Top of Dam 407 acres
Drainage Area	82 sq. miles 52,480 acres
Storage (volume)	2,700 acre-feet at normal pool level

Table 2. Physical Characteristics of Lake Linganore*

*Department of the Army, Corps of Engineers, July 1980

At the point of intake, Linganore Creek drains approximately 85 square miles of land. The watershed lies east of the City's intake, primarily in Frederick County, but extends a short distance into Carroll County. The entire watershed is located in the Piedmont Region. Soils in the watershed at the vicinity of the intake predominantly are Chewacla Silt loam that consist of recently deposited fine materials washed from acidic crystalline rocks, mainly schist. They are moderately well drained but are likely to remain wet after thaws or after rainy spells. (U.S. Department of Agriculture, Soil Survey of Frederick County, 1960).

The area surrounding the Linganore Creek intake, like the rest of Frederick County, has a humid, temperate climate with an average temperature of 50° F and an average precipitation range between 44 and 46 inches.

Monocacy River

The City of Frederick has the largest appropriation of all withdrawals from the Monocacy River. Fort Detrick, a small army base at Frederick, also uses water from the Monocacy River but has a separate water system. The Monocacy River is the largest Maryland tributary to the Potomac River and forms by confluence of Rock Creek and Marsh Creek at the Pennsylvania-Maryland state line 25 miles north of Frederick, Maryland. The river flows for 57.1 miles generally in a southerly direction across the entire width of the State to the Potomac River near Dickerson, Maryland. The City's intake is located approximately 17 miles upstream from the mouth near Route Md-26. The intake for Fort Detrick water supply is in the same area as the City of Frederick's.

The Monocacy watershed, a sub-basin of the Middle Potomac River basin, encompasses 774 square miles (476,200 acres), 75% of which is in the state of Maryland and 25% is in the state of Pennsylvania. The area of watershed above the City of Frederick's intake encompasses approximately 700 sq. miles (448,000 acres). The major tributaries of the Monocacy River above the City's intake are: Tom's Creek, Marsh Creek, Tuscarora Creek, Fishing Creek, Big Pipe, Little Pipe Creek, Piney Alloway Creek, and Israel Creek. The Monocacy River, which meanders through the Frederick Valley in a wide, shallow riverbed, is a slow flowing river with an average drop of 2.8 feet/mile from the Maryland-Pennsylvania border to its mouth.

The Monocacy River watershed is located in Piedmont and Blue Ridge Provinces. The rock formation that influences the river basin's geological history is intensely metamorphosed, or highly compact and crystalline. Three rock types are found in the western division: the Frederick Valley Region, the Triassic Upland Region and the Piedmont Upland Region. The lower part of the basin, the Frederick Valley Region, is characterized by easily erodible sedimentary rocks that have deep soils, shallow banked streams and gently rolling topography. Piedmont Upland Region contains more metamorphic material. In the river's upper watershed, the Triassic Upland Region has harder rock materials overlaying the softer limestones. This latter geological phenomenon has created some shallow, highly erodible soils (Maryland Scenic River Report, The Monocacy River Scenic River Local Advisory Board, May 1990).

B. Water Supply Development

The City owns and operates three individual water treatment plants that use three separate surface water sources as discussed previously. These three water treatment plants are interconnected by an extensive distribution network to serve the entire service area. The City's distribution is also connected to Frederick County and Fort Detrick systems to share water resources in emergency situations. The following is a brief description of the City's water treatment plants.

Lester R. Dingle Water Treatment Plant

Lester R. Dingle Water Treatment Plant consists of five (5) pressure filters with the combined design capacity of 3.5 MGD and with an average daily flow between 1.2 to 1.4 mgd and operates 24 hours a day. Each pressure filter is 10 feet in diameter and contains two layers of filter media, 12 inches of anthracite and 24 inches of sand. The raw water source is the Fishing Creek Reservoir. The raw water intake structure at the reservoir has screened gates at the depth of 10' and 25'. Raw water flows through a 12-inch transmission main to the plant. Downstream from the dam, lime, gas chlorine and fluoride are injected into the raw water main. There are eight homes serviced by the raw water line and each home is equipped with an individual cartidge filter.

Linganore Creek Water Treatment Plant

The original conventional treatment plant was constructed in 1932 with three filters and upgraded in 1954 with three additional filters. The plant was rehabilitated in 1990, including flocculation and sedimentation, replacing media and underdrains in all six filters with complete computerized controls and instrumentation. With a design capacity of 6.0 MGD, the plant operates 24 hours a day, treating an average of 4.1 MGD. The raw water source is Linganore Creek. Raw water flows by gravity from the creek through a 24-inch pipe to a traveling screen, then to a 12' x 14' suction well. From the suction well, water is pumped by one or two (of three) pumps to a six MG pre-sedimentation pond. From the pond, water flows by gravity to the head of the plant. The treatment processes at the plant consist of corrosion control, coagulation, flocculation, sedimentation, filtration, fluoridation, and disinfection. Alum and chlorine are added to two flash mix tanks. If needed, carbon lime and polymer can be added here to aid the treatment processes.

Monocacy Filtration Plant

A water supply analysis conducted in 1958 concluded that Frederick's two existing sources (Fishing Creek and Linganore Creek) could not keep up with the peak water demand for its customers. A third new abundant source, the Monocacy River, was selected to provide adequate and reliable water supply for the Frederick area through an integrated system fed by three major sources. A conventional treatment plant was constructed in 1961 with an initial capacity of 2 MGD. The design capacity was upgraded to its current capacity of 3 MGD. The plant is usually operated for 24 hours a day with an average daily flow of 1.9 MGD. Similar to the Linganore Creek plant, the treatment processes at the Monocacy Plant consists of corrosion control, fluoridation, coagulation, flocculation, sedimentation, filtration and disinfection.

Raw water from a bank river intake flows by gravity through a 30-inch pipe to a raw water pump pit. Water from the Monocacy River is pumped by three low service pumps with the capacity of 1400 gallons per minute (GPM) each. Gas chlorine as pre-disinfectant and powder aluminum sulfate and non ionic polymer as coagulants are added to the raw water pipe prior to rapid mixer.

II. RESULTS OF SITE VISIT(S)

Water Supply Program personnel conducted a site survey of the City of Frederick's water sources and other raw water facilities in order to accomplish the following tasks:

- To collect information regarding the locations of raw water sources and intakes by using Global Positioning System (GPS) equipment.
- To determine the general condition and structural integrity of intakes and other raw water facilities.
- To discuss source water issues and concerns with the City's water system operators.
- To conduct a windshield survey of the watershed and to document potential problem areas. Additional tours of the watersheds were taken on follow-up visits. (Photographs of raw water system obtained during the site survey appear in APPENDIX A.)

A summary of site visits' findings and discussions for each source is as follows:

A. Fishing Creek

Intake Integrity

The intake structure is located in the lake and is accessible only by boat. It is a two-level intake with a ¼-inch wire mesh screen. Screens are cleaned every three months and the sluice gate has been repaired recently. The operator did not express any concerns regarding the intake. Raw water is gravity fed to Lester R. Dingle Water Treatment Plant by a 12-inch cast iron pipe. The existing 12-inch water line meanders south for approximately four miles crossing Bethel and Yellow Springs Roads before reaching the treatment plant. Immediately below the dam, the existing 12-inch water line appears to encroach the private properties where eight houses have direct service connection to the raw water line. It is not known whether the City has acquired an easement along the entire length of this raw water main. At the time of our site visit, no leaks were apparent in the raw water line, but there were a few segments of pipeline exposed without proper cover and embedment.

Concerns and Site Observations

In addition to looking at the dam and intake structure, a watershed survey of the area surrounding the reservoir was conducted to verify the current land use characteristics compared to Maryland Department of Planning's 1997 land use data and to document potential problem areas. Through discussions with the City's plant operators, a list of their concerns regarding the raw water quality was also compiled. The following is a list of operators' concerns and MDE site observation:

- When turbidity reaches 2.0-2.5 nephelometric turbidity units (NTU), the operators shut down the intake at the reservoir because of the inability of the plant to treat water at these turbidity levels.
- Raw water from the reservoir cannot be utilized during low flow times.
- When the reservoir water is shut down due to turbidity levels over 2.0-2.5 units, a well located at the toe of the dam (downstream) will be activated to serve the eight houses with connections from a 12-inch line. Whenever the switch over from surface water to ground water occurs, the City is required to issue boil water advisory notices to those customers below the dam. This situation creates some problems to the operators, especially when a storm event occurs during late nights or early mornings.
- No fishing, boating or swimming is allowed around the City property.
- Raw water turbidity on the day of site visit was 0.4 NTU and finished water turbidity was 0.053 NTU.

B. Linganore Creek

Intake Integrity

The intake structure is located at the north bank of the Linganore Creek approximately 60 feet from the water treatment building. It is a one-level intake consisting of concrete structure with wing walls at the edge of the creek. The raw water travels by gravity from the creek through a 24-inch pipe and a mechanical (traveling) screen to a suction well. From the suction well, water is pumped by one or two (of three) 3.1 MGD pumps to a six MG pre-sedimentation pond with an average 2 to 3 days detention time. From the pond, raw water flows by gravity through one 20" pipe to two rapid mix chambers at the head of the water treatment plant. The concrete structure appears to be in fair condition but the sluice gate at the intake vault is not operable; a gate valve located on the 24" raw water line inside the building regulates the flow to the suction well.

Concerns and Site Observations

In addition to looking at the intake and immediate land along the Linganore Creek, multiple visits were made to survey the watershed of Linganore Creek and Lake Linganore. The observed land use characteristics were compared with the Maryland Department of Planning's 1997 land use data and document. Meetings with plant operators and Lake Linganore Association officials were held to discuss concerns regarding the potential or known sources of contamination to the source water. The list below reflects plant operators, Lake Linganore Association members' concerns and MDE site observations:

- Frederick County 30-inch sewer constructed adjacent to Lake Linganore crosses Linganore Creek and plant raw water line.
- A sewer line owned and operated by the County above Lake Linganore has experienced some leakage in the past.
- The City constructed a drainage system to collect the seepage from the pre-sedimentation pond which drains to Linganore Creek at a location upstream of the intake. The water treatment plant yard and roof storm drains also discharge the storm water to the creek above the intake.
- There is an abandoned dumpster and discarded construction material located in the city-owned property above the intake.
- Development in the watershed, specifically Spring Ridge development that is located contiguously with the Linganore Creek east of the City's intake. A sediment trap pond from this large development drains to the creek approximately three hundred yards above the intake.
- Geese migration and activities around Lake Linganore.
- Sedimentation and siltation are the major concerns; Lake Linganore Association is hiring a consultant to complete a bathymetric study for Lake Linganore. This study will determine the storage volume of the Lake at spillway elevation and loss of storage compared to the original design.
- Lake Linganore Association members expressed concerns that under existing local regulations the watershed is not protected and is subject to development and other land use changes.

C. Monocacy River

Intake Integrity

The intake for the Monocacy Filtration Plant is a bank river intake consisting of a concrete channel with steel sheet piling supports and steel screen. The raw water travels through a mechanical leaf removal traveling screen and by gravity flows through approximately 190 feet of 30-inch concrete pipe to a raw water pumping station. The water from the Monacacy River is pumped to the plant by three low service pumps each with a capacity of 1400 GM. The river is free flowing without any major obstructions; An island divides the river in the vicinity of the intake. The intake structure and raw water line are in good condition and the plant operators did not report any problems or concerns regarding the structural integrity of the intake or the raw water line. However, the operators expressed concerns about the efficiency of the leaf removing traveling screen that activates once every hour.

Concerns and Site Observations
The following is a list of MDE personnel observations and the City of Frederick water treatment operators concerns and discussions:

- Operators expressed concerns with Atrazine in the raw water, high amount of pastureland and the high turbidity of this source.
- There is an unexplained high chlorine demand that occurs occasionally in the summer, during low flow. The operator of Fort Detrick Water Treatment Plant also commented on the same occurrence. This could be related to algae blooms.
- Development along the Monocacy River and construction of new bridge at Route 26.
- A skating rink with storm water pond adjacent to the plant, approximately 200 feet upstream from intake. There is also a car wash located in the general area, upstream of the intake.

III. WATERSHED CHARACTERIZATION

Source Water Assessment Area Delineation Method (Surface Water)
An important aspect of the source water assessment process is to delineate the watershed area that contributes to the source of drinking water. A source water protection area is defined as the whole watershed area upstream from a water plant's intake (MDE, 1999). Delineation of the source water area was performed by using ESRI's Arc View Geographic Information Software (GIS), utilizing existing GIS data, and by collecting location data using a Global Positioning System (GPS). GPS point locations were taken at the water source intake and differentially corrected (for an accuracy of +/-2 meters) at MDE. Once the intake location was established, the contributing area was delineated based on existing Maryland Department of Natural Resources digital watershed data and Maryland State Highway Administration digital stream coverage. Digital USGS 7.5 topographical maps were also used to perform "heads up" digitizing, or editing, or watershed boundaries.

A. Fishing Creek Reservoir

General Characteristics

The source water protection area for Fishing Creek Reservoir watershed encompasses 7.4 square miles (4,775 acres) above the reservoir. There are two streams, Fishing Creek and Little Fishing Creek, within the City of Frederick Municipal Forest that drain into the Fishing Creek Reservoir. The watershed map, Fig. (1A) shows the land use in the watershed draining into Fishing Creek Reservoir is almost entirely forested. Because of the relatively small size of the watershed, the delineated area shows the whole watershed without a breakdown into subwatershed.

Land Use Characteristics

Based on the Maryland Department of Planning's 1997 land use data, the land use distribution in the Fishing Creek Reservoir is summarized in Table 3 and Chart 1.

Land Use	Total Area in Acres	Percent of Total Watershed
Residential	39.896	0.8%
Cropland	0.463	< 0.1%
Forest	4718.903	98.8%
Open Water	16.208	0.3%

Table 3. 1997 Land Use Data in Fishing Creek Reservoir

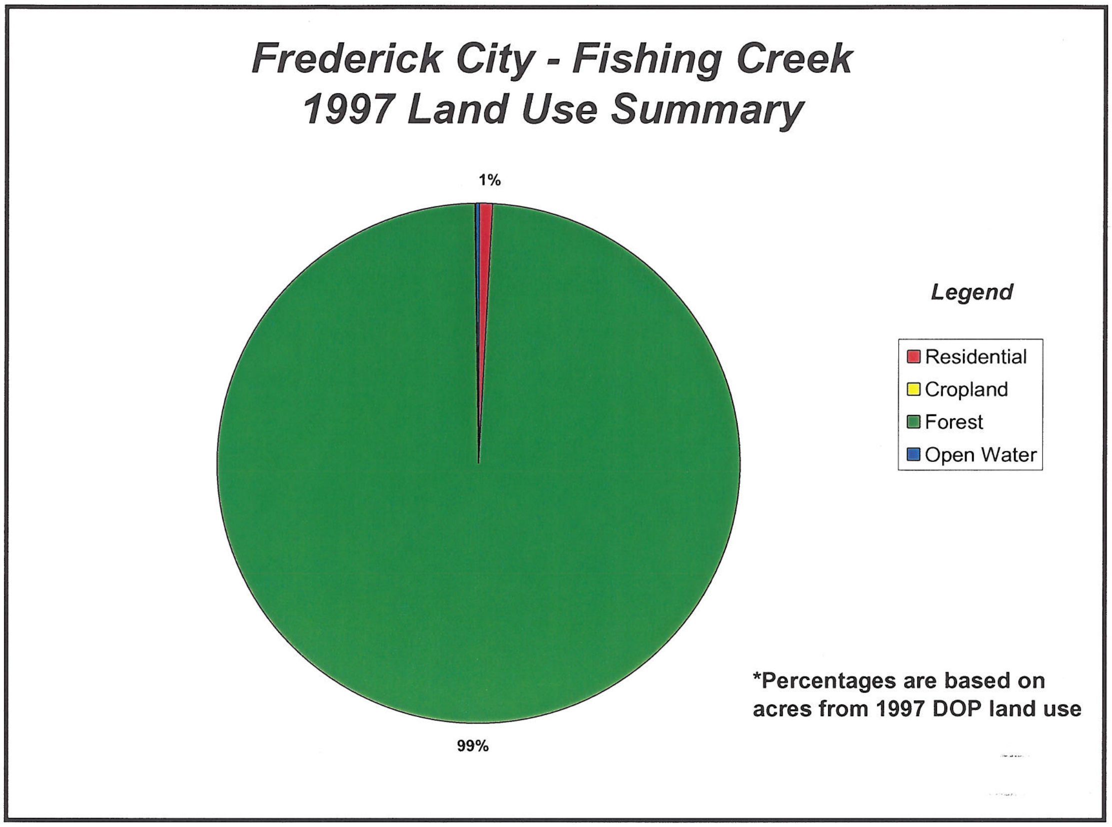


Chart 1. Frederick City – Fishing Creek 1997 Land Use Summary

<u>Localized Characteristics</u>
The City of Frederick owns 3,065 acres of land in the watershed of Fishing Creek Reservoir. This land is part of the Frederick Municipal Forest that includes most of the land around the reservoir's shoreline and is entirely wooded. The remaining land in the watershed is owned by the State Department of Natural Resources and some private individuals. Fishing, swimming and/or boating are not allowed at the reservoir site; some recreational activities occur in the upper watershed, limited to hunting and hiking. There are no residences adjacent to the reservoir; there are some residences sparsely distributed along Little Fishing Creek Road and Gambrill Park Road within the source water protection area.

B. Linganore Creek

<u>General Characteristics</u>
The source water protection area for Linganore Creek intake encompasses approximately 85 square miles (54,000 acres) of mixed land use with predominantly cropland and forested land. The entire watershed is located in Frederick County with a small portion extending into Carroll County (Fig. 2A).

Land Use Characteristics
Based on the Maryland Department of Planning's 1997 land use data, the land use distribution in Linganore Creek Watershed is summarized in Table 4 and Chart 2 as shown below:

Land Use	Total Area in Acres	Percent of Total Watershed
Residential	6753.529	12.6%
Commercial	289.9	0.5%
Industrial	14.582	< 0.1%
Urban Public Lands	197.291	0.4%
Cropland	29119.709	54.4%
Pasture	3544.377	6.6%
Forest	13228.95	24.7%
Barren Land	24.305	< 0.1%
Concentrated Agriculture	165.212	0.3%
Open Water	124.002	0.2%
Wetlands	32.485	0.1%

Table 4. 1997 Land Use Data in Linganore Creek Watershed

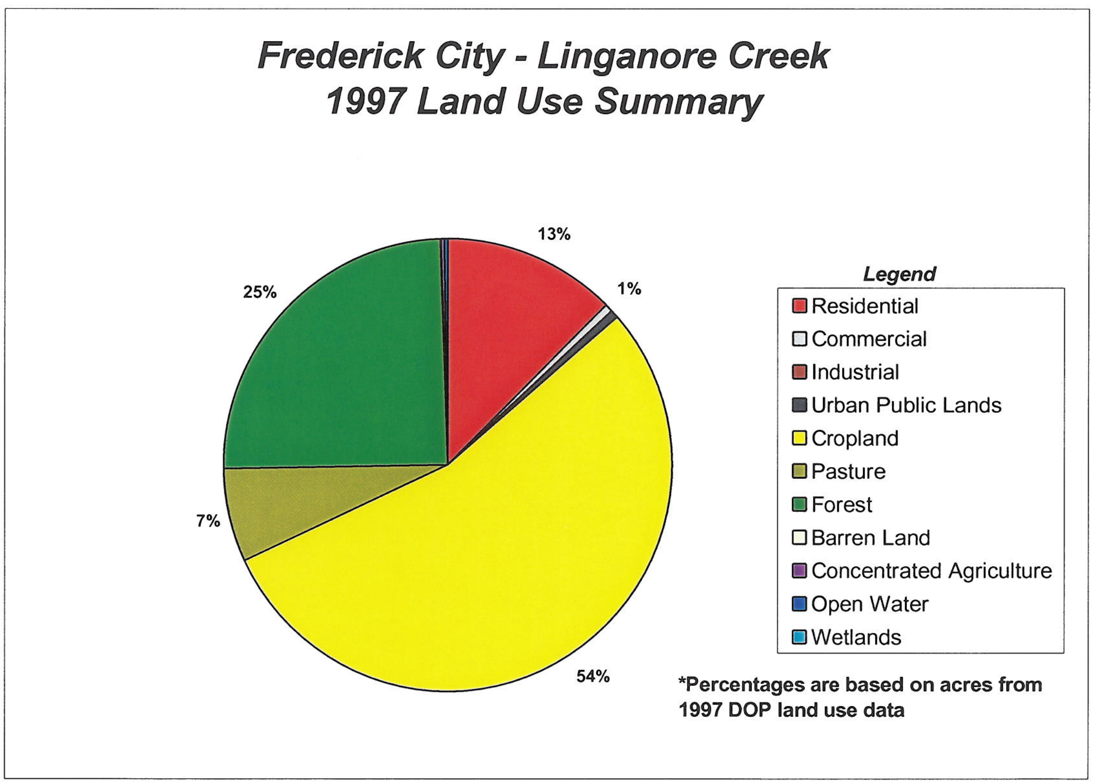


Chart 2. Frederick City – Linganore Creek 1997 Land Use Summary

Localized Characteristics

The City of Frederick owns approximately 145 acres of land that covers Linganore Creek Filtration Plant property and the area immediately above the intake along the creek. A short distance upstream from the City's intake, Spring Ridge Planned Unit Development, a large residential subdivision, is located at the southside of Linganore Creek extending easterly to Interstate Highway 70. The topography of this area consists of steep slopes and man-made terraces and stormwater management ponds. Approximately 1.5 miles upstream from the water treatment plant, Lake Linganore is the largest impoundment in Frederick County, storing over eight hundred MG of water for recreational use and water supply. The lake is approximately 3.7 miles long and as much as 40 feet deep with a surface area of 216 acres. The lake originally was formed to provide recreational and aesthetic amenities for a new residential community development. The Lake Linganore development covers approximately 3,730 acres of land with an ultimate potential of 8,200 housing units surrounding the lake with swimming beaches and boat access ramps.

C. Monocacy River

General Characteristics

The drainage area above the City's intake on the Monocacy River encompasses approximately 700 square miles 448,000 acres of mixed land use with over 60% of cropland and pasture. About 75% of the source protection area is located in Frederick and Carroll Counties of Maryland and 25% of the watershed is located in Adams County, Pennsylvania. Most of the forested land is located at higher elevation in the western part of the watershed and some wooded areas extend along the river corridor (Fig. 3A and Fig. 4A).

Land Use Characteristics

According to the Maryland Department of Planning's 1997 land use data, the following Table 5 shows the land use distribution in the Monocacy River watershed.

Land Use	Total Area in Acres	Percent of Total Watershed
Residential	22967.49	7.6%
Commercial	2621.319	0.9%
Industrial	374.96	0.1%
Mining	914.398	0.3%
Urban Public Lands	764.165	0.3%
Cropland	164715.2	54.2%
Pasture	25464.178	8.4%
Orchards	1350.806	0.4%
Forest	82961.33	27.3%
Open Water	125.824	< 0.1%

Barren Land	53.374	< 0.1%
Concentrated Agriculture	1639.013	0.5%

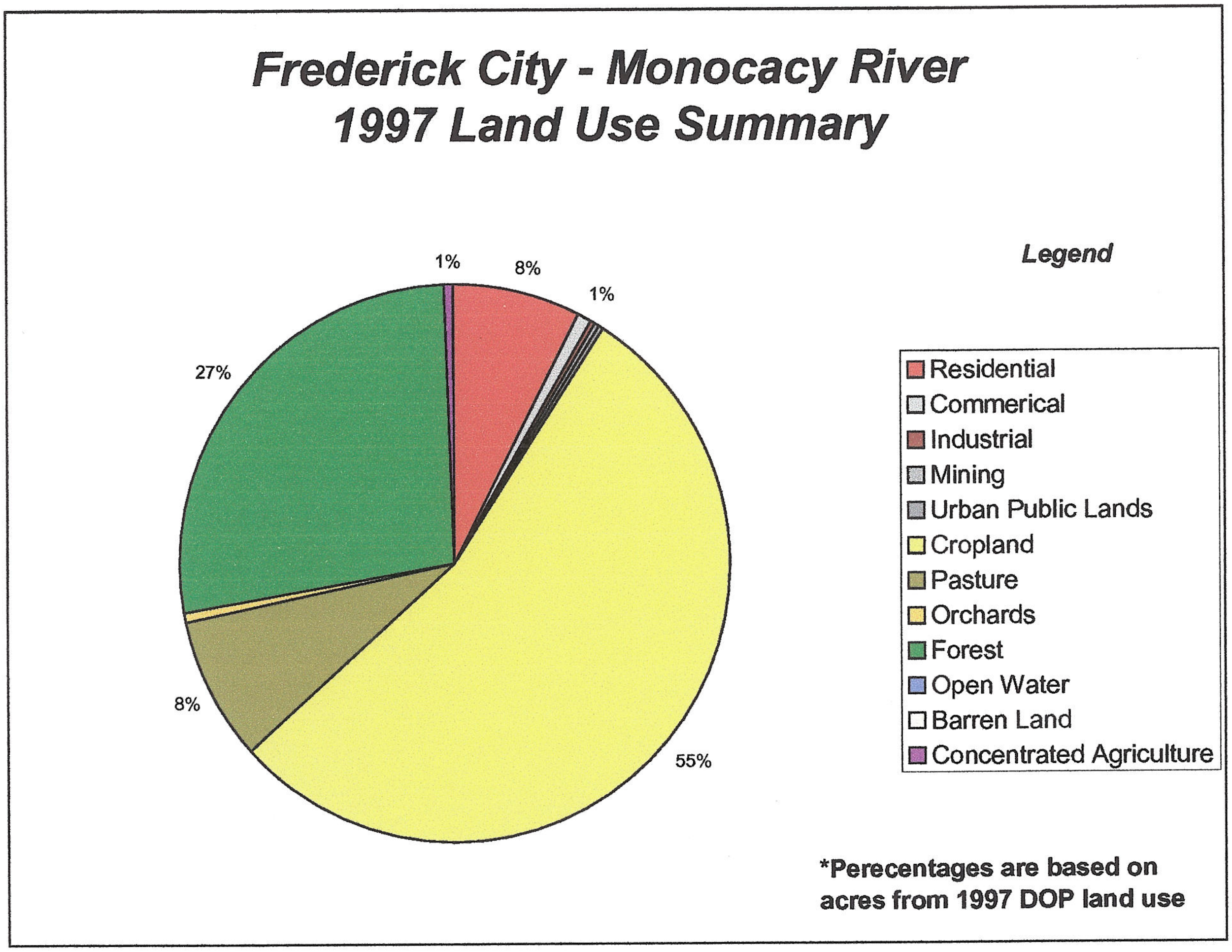


Table 5. 1997 Land Use Data in Monocacy River Watershed

Chart 3. Frederick City – Monocacy River 1997 Land Use Summary

Localized Characteristics

The City of Frederick does not own and maintain land in the watershed except a small portion of land around the intake structure and water treatment plant. The source protection area covers ten municipalities in Frederick and Carroll Counties of Maryland and two municipalities in Pennsylvania as listed below:

Maryland		Pennsylvania
Emittsburg	Union Bridge	Gettysburg
Frederick	Uniontown	Littlestown
New Windsor	Walkersville	
Taneytown	Westminster	
Thurmont	Woodsboro	

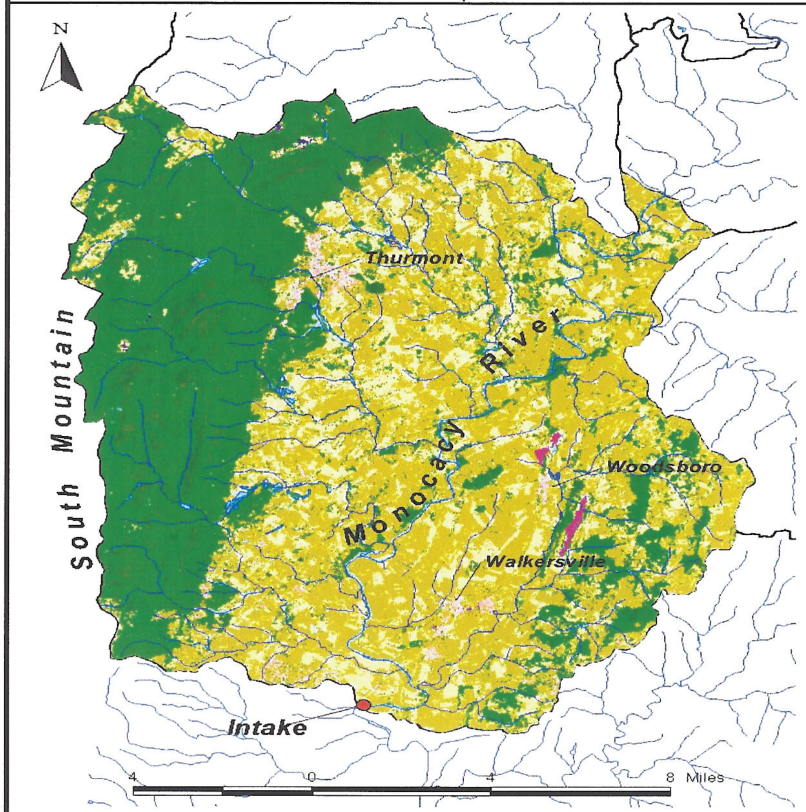
U.S. Highway 15 and State Highways 194, 26 and 140 are the major transportation corridors in the watershed.

Subwatersheds

Maryland Source Water Assessment Plan states that larger source water protection areas will be segmented into smaller subwatersheds to provide better assessment and identify watersheds of concern. The Monocacy watershed was segmented into five subwatersheds for this assessment. These subwatersheds are similar to the Maryland Department of Natural Resources (MD-DNR) 12 digit hydrologic unit codes. They were based on MD-DNR data and were edited by digital topographic maps. The following pages depict the five subwatersheds in the Monocacy River source water protection area.

MONOCACY - INTAKE

Total Area = **205** square miles

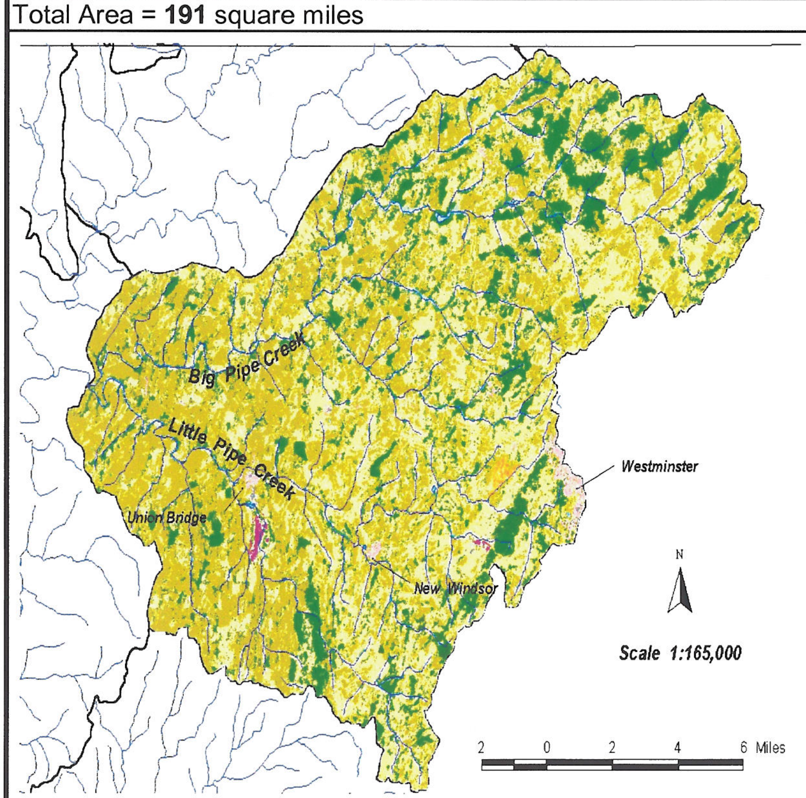


Land Use	Total Acres	% Watershed
Open Water	977	0.8
Residential	1556	1.2
Commercial/Industrial	219	0.2
Pasture/Hay	44906	34.5
Cropland	28608	22
Forested	52132	40.1
Wetlands	1416	1.1
Mined or Abandoned	226	0.2
Transitional	86	0.1
Total:	130126	100

This is the largest subwatershed in the basin and contains the greatest amount of land used for agriculture. Approximately 40% of the watershed is forested and lies in the higher elevation extending from northwest to southwest of the subwatershed. U.S.Highway 15 crosses through the western part of this sub-basin.

DOUBLE PIPE CREEK

Total Area = **191** square miles

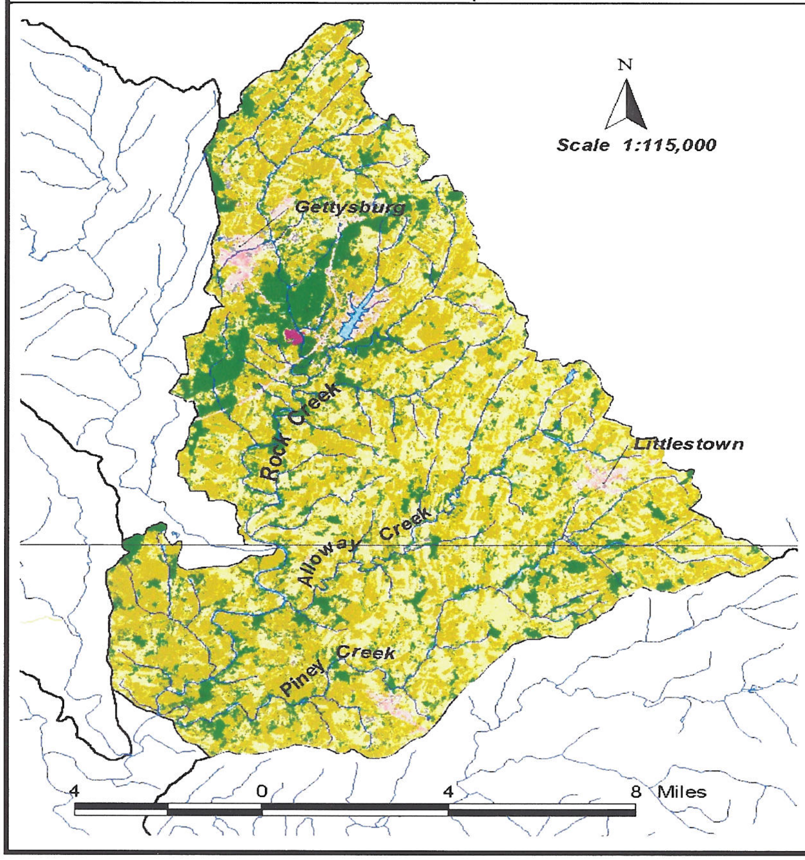


Land Use	Total Acres	% Watershed
Open Water	478	0.4
Residential	1223	1
Commercial/Industrial	139	0.1
Pasture/Hay	42995	35.5
Cropland	52865	43.7
Urban Parkland	187	0.2
Forested	21721	17.9
Wetlands	1306	1.1
Mined or Abandoned	163	0.1
Totals:	121076	100

This subwatershed has two main tributaries, Big Pipe Creek and Little Pipe Creek. Almost 80% of the land is used for pasture and cropland. A portion of the City of Westminster and Towns of New Windsor and Union Bridge are located in this sub-basin.

PINEY - ALLOWAY

Total Area = **137.5** square miles

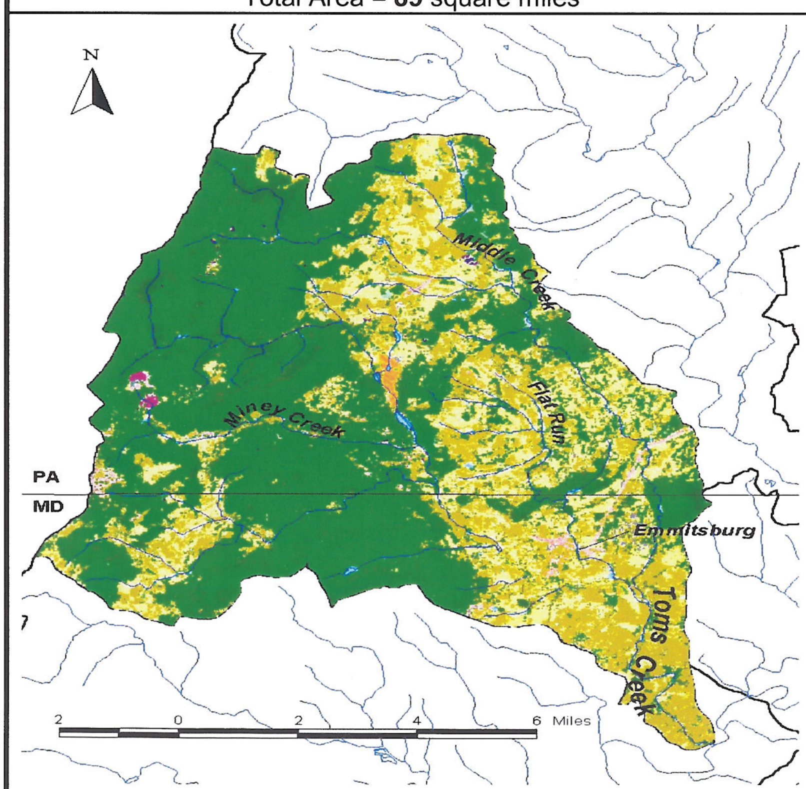


Land Use	Total Acres	% Watershed
Open Water	599	0.7
Residential	2373	2.7
Commercial/Industrial	404	0.5
Pasture/Hay	30990	35.6
Cropland	35564	40.8
Forested	15973	18.3
Wetlands	1192	1.4
Mined or Abandoned	69	0.1
Total:	87164	100

Two municipalities in Pennsylvania, the City of Gettysburg and City of Littlestown, are located in this subwatershed. With approximately 2,777 acres of residential and commercial land, this sub-basin contains the highest percentage of urban area compared to the other basins. Agriculture is predominant land use in this subwatershed covering approximately 76% of Piney Alloway watersheds.

TOMS CREEK

Total Area = **89** square miles

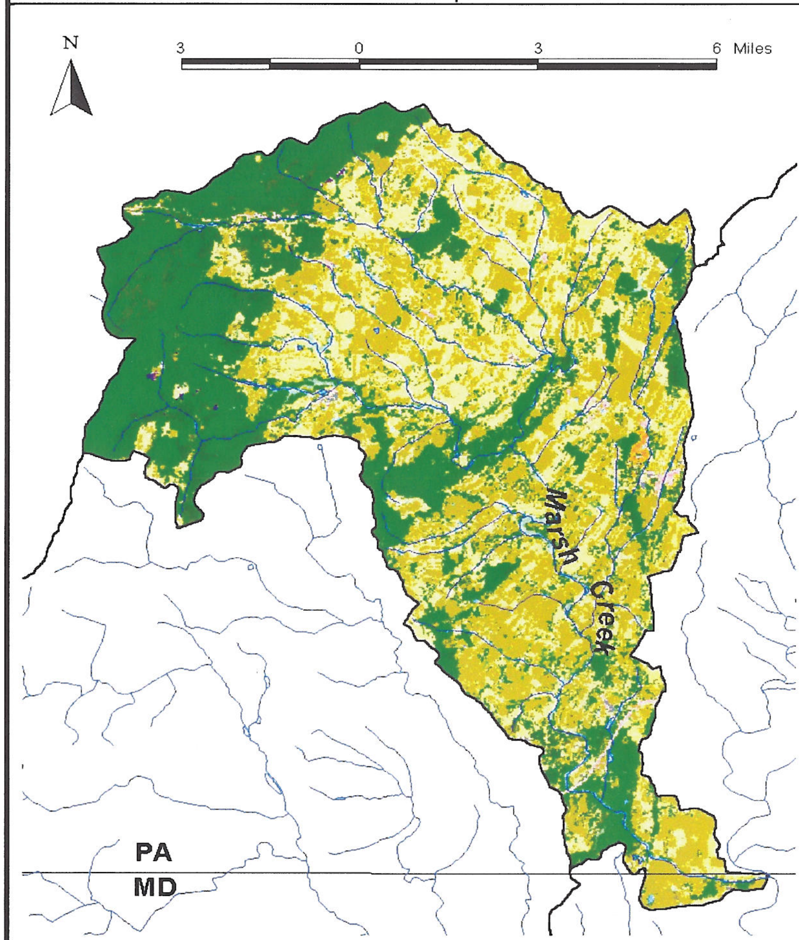


Land Use	Total Acres	% Watershed
Open Water	255	0.5
Residential	735	1.3
Commercial/Industrial	133	0.2
Pasture/Hay	9569	17
Cropland	11452	20.4
Urban Parkland	170	0.3
Forested	33214	59.1
Wetlands	532	0.9
Mined or Abandoned	54	0.1
Transitional	72	0.1
Total:	56185	100

With over 59% of forested land, this watershed is the most forested of the subwatersheds. The Town of Emmitsburg, Maryland is the only major municipality in this sub-basin. Over 50% of the watershed is within the southern part of Adams County, Pennsylvania.

MARSH CREEK

Total Area = **80** square miles



Land Use	Total Acres	% Watershed
Open Water	288	0.6
Residential	448	0.9
Commercial/Industrial	97	0.2
Pasture/Hay	13577	26.7
Cropland	16054	31.5
Urban Parkland	59	0.1
Forested	19271	37.9
Wetlands	1054	2.1
Transitional	48	0.1
Total:	50896	100

The Marsh Creek subwatershed is the smallest in the basin. Marsh Creek and Rock Creek form the headwater of the Monocacy River and are located in Pennsylvania. The City of Gettysburg obtains its water from Marsh Creek. Water quality sampling station taken from the Monocacy River downstream of the confluence of Marsh Creek and Rock Creek indicate good water quality from these streams.

IV. SIGNIFICANT SOURCES OF CONTAMINATION

A. Fishing Creek

Non-Point Concerns

Almost 99% of the Fishing Creek Reservoir watershed is forested and protected from urban non-point pollution runoff. Analysis of land use maps and satellite photography shows that both Fishing Creek and Little Fishing Creek draining into the reservoir are buffered by forest. Less than 1% of the watershed area is residential land use with individual on-site septic system. The entire source water assessment area is located outside of Frederick County's water and sewer planned area.

It appears that some logging activities were performed in the City of Frederick Municipal Forest in the past. Improper forestry practices can increase the amount of sediment in streams and lead to potential turbidity problems in the reservoir intake.

Point Source Concerns

No point sources of contamination were identified in the Fishing Creek Reservoir Source Water Assessment Area (SWAA).

Transportation Related Concerns

Almost all of the roads in the watershed are unimproved with the exception of the paved section of Gambrill Park Road that is located in the western boundary of the SWAA. The roads which are adjacent to the streams leading to the reservoir and may be of concern for spills are: Mountaindale Road, Gambrill Park Road, and Fishing Creek Road. All roads in the watershed are small access roads with light traffic used by the local residents. See Fig. 1-A.

B. Linganore Creek

Non-Point Concerns

According to 1997 Department of Planning land use data, 61% of the watershed is used for agricultural purposes (54.4% cropland, 6.6% pasture). Land used to grow crops can be a source of nutrients (from fertilizer), synthetic organic compounds (herbicides) and sediment load. Pastures used to graze livestock can be sources of nutrients and pathogenic protozoa, viruses and bacteria from animal waste. The predominate soils within the source protection area are from Manor-Glenelg and Manor-Linganore-Urbana series. The Manor soils, which dominate in these soil series, are fairly shallow and skeletal. Erosion throughout the region can create problems and careful farm management is important (New Market Region Plan, October 1993).

While less than 13% of the watershed is listed as residential, there are two areas of concern based on their size and location:

Lake Linganore at Eaglehead, a Planned Unit Development (PUD) community, is located between I-70 and Gas House Pike and is approximately 3,730 acres. The PUD and surrounding area consist of a mixture of housing types including single family, villa and apartment units planned around Lake Linganore and five smaller lakes. In 1993, the population of Lake Linganore at Eaglehead was approximately 3,700 persons with an ultimate potential of 8,200 units and a population of 20,000-25,000 persons.

Another large Planned Unit Development is the Spring Ridge PUD located southwest of Lake Linganore, on both sides of I-70 and west of Quinn Road. In the area north of I-70, approximately half of this housing development is located within the City of Frederick's watershed of Linganore Creek and includes a mixture of single family, townhouse and multi-family units. In 1993, the population of Spring Ridge was approximately 940 persons with an ultimate population expected to be approximately 4,600 persons in over 1,500 housing units (Frederick County New Market Region Plan, October 1993).

Because of the close proximity of the above residential areas to the Lake Linganore and Linganore Creek that are located above the City's intake, and high population density, pollution due to non-point runoff from these large housing developments can be a major concern.

In addition to the above residential areas, there are two incorporated municipalities, the Towns of New Market, Mount Airy, two unincorporated communities, New London and Libertytown and there are several rural subdivisions and housing developments in the watershed with on-site septic systems.

Point Source Concerns

The only point source of pollution located in Linganore Creek watershed is the Libertytown Wastewater Treatment Plant. This facility, NPDES Permit MD0060577 is operated by Frederick County Division of Utilities and Solid Waste Management. Treated effluent is discharged into Town Branch, upper stream reaches of Linganore Creek. The Libertytown service area is approximately 0.5 square miles, encompassing the unincorporated community of Libertytown located at the intersection of M26 and 75. The community has a current population of 526. The Libertytown Wastewater Treatment Plant was built by the County in 1986 with a capacity of 50,000 GPD. It treats an average flow of 30,000 GPD. The projected population of Libertytown is expected to be 1,050 by the year 2010. The wastewater plant will need to be expanded to 100,000 GPD to meet the projected population growth by 2010. MDE records indicate that due to mechanical problems of the plant equipment, the levels of BOD and total suspended solid exceeded the NPDES Permit on December of 2001 and April of 2002. The sewerage system is also experiencing I/I problem. Currently, the maximum permitted discharge is 50,000 gallons per day, with effluent limits of BOD_5 average monthly of 30 mg/l total suspended solid monthly average of 30 mg/l, and the concentration of fecal coliforms of 200 MPN per 100 ML (monthly log mean value). A request for renewal NPDES permit for Libertytown Wastewater Plant was submitted by Frederick County with no increase in flow and/or changes in effluent limits.

Transportation Related Concerns
Major roads in the Linganore Creek source water protection area include: Route 75 extending from the southern to northern boundaries of the watershed; Route 26 runs along the northern boundary for most of the watershed; and sections of Route 31 and Route 27 also located within the watershed boundary. There are also numerous secondary roads and residential access roads throughout the watershed. Concentration of residential access roads with heavy traffic within Lake Linganore at Eaglehead and lack of proper stormwater management practices in some areas of the development can expedite further siltation of Lake Linganore.

The following is a list of local roads in the watershed which are adjacent to and/or cross the tributaries and may be of concerns for spills: Boyers Mill Road (bridge over Lake Linganore), Gas House Pike (bridge over Linganore Creek), Old Annapolis Road, Woodville Road and Buffalo Road (See Fig. 2-A).

Land Use Planning Concerns
A comparison between 1990 and 1997 Maryland DOP land use data shows changes in watershed land development. Land use percentages are shown below:

Type of Land Use	Percent of Watershed in 1990	Percent of Watershed in 1997
Residential	6.2%	12.6%
Commercial	1.1%	0.5%
Industrial	< 0.1%	< 0.1%
Mining	< 0.1%	N/A
Urban Public Lands	0.5%	0.4%
Cropland	56.7%	54.4%
Pasture	7.7%	6.6%
Forest	26.4%	24.7%
Barren Land	0.6%	< 0.1%
Concentrated Agriculture	0.6%	0.3%
Open Water	0.3%	0.2%
Wetlands	N/A	0.1%

Table 6. Land use Planning Concerns in Watershed Land Development in Linganore Creek

The most significant change is the increase in residential land use over the past seven years. This land use trend is seen in the rest of Frederick County. The changes in agricultural (cropland and pasture) land use appear to be modest (approximately 740 acres). A significant percentage of the land slated for new development on the south side of Lake Linganore, however, is currently forested and the potential residential or commercial developments of large tracts of forested land in the watershed threatens the water quality in streams and Lake Linganore.

C. Monocacy River

Non-Point Pollution Sources

According to 1997 DOP land use data, 62.6% of the watershed is used for agricultural purposes (54.2% cropland, 8.4% pasture). As described above, land used to grow crops can be a source of nutrients (from fertilizer), synthetic organic compounds (from herbicides), and sediment load. Pastures used to graze livestock can be sources of nutrients and pathogenic protozoa, and viruses and bacteria from animal waste. Compared to most of the upper Potomac River, the Monocacy is more enriched in nutrients due to extensive agriculture and higher human and animal populations. High nutrient levels in the Monocacy River increase the growth of blue-green algae, a plant that thrives in a nutrient enriched environment. The decaying matter, as algae dies, decreases the availability of oxygen in the river, and algae growth increases the total organic carbon in the water. The reaction of organic carbon with disinfectants used in the water treatment process results in the production of disinfection-by-products in the treated water.

With 8.6% urban land use (7.6% residential, 0.9% commercial, 0.1% industrial) combined with 62.6% of the agricultural area in the watershed, sedimentation is another serious problem of the Monocacy River. On a per acre basis, the Monocacy watershed contributes sediment at more than twice the rate of all other watersheds draining into the Potomac upriver of Point of Rocks. The Monocacy also has numerous bends that may trap sediment over a period of time. This physiographic phenomenon possibly allows for a great deal of sediment to be stored in the river system (Monocacy. Scenic River Study & Management Plan, 1990).

The most common herbicides found in water samples used on row crops are atrazine, simazine and metalachlor. Levels are higher in late spring due to runoff events. Non-point sources of pathogenic organisms include urban and residential lands as well as pasture land. Runoff events carry the organisms to the river and higher levels would be expected following such storms.

Point Source Concerns

There are three major plants (WWTP), and several minor wastewater treatment plants (WWTP) that are located in the Monocacy River Source Water Assessment Area (SWAA). The three major plants include Westminster, Thurmont, and Gettysburg Municipal Authority. The total daily average flow from these three plants is 5.1 MGD. The total average daily discharge from all major and minor municipal wastewater treatment plants is approximately 7.4 MGD.

The flow of the Monocacy River near the City's intake under low flow conditions (7 day once in 10 year occurrence) is 40.5 cubic feet per second (CFS).

All of these major and minor facilities require Maryland or Pennsylvania discharge permits or NPDES permits to satisfy the regulatory requirements of the National Pollutant Discharge Elimination System (NPDES) established under the Federal Clean Water Act. Each discharge permit specifies limits for water quality criteria specific to the designated uses of the receiving surface water stream. The Monocacy River and tributaries in the SWAA are designated as USE IV-P-recreational trout waters and water supply. These facilities are regulated for total suspended solids, biochemical oxygen demand, phosphorous, total nitrogen, pH, dissolved oxygen and fecal coliform bacteria but are not directly regulated for the control of disinfectant resistant *giardia* and *cryptosporidium*, or pharmaceutical chemicals. Review of State compliance data indicates that currently the facilities are in compliance with the NPDES permits requirements. If a facility does not comply with the permit requirements, an enforcement action to correct the problem will be issued by the State.

Transportation Related Concerns

Major roads in the Monocacy River source water protection area include U.S. Route 15 extending from the south to the northern boundaries of the watershed, and a section of U.S. 30 in the northern most portion of the watershed. State Routes 194, 140 and 26 are also located in the watershed. The highest volumes of traffic occur on U.S. Highway 15 which crosses the Monocacy River's major tributaries at several locations. In addition to roads, there is also an extensive network of railways that cross and are adjacent to tributaries for considerable distances and may be of concern for spills. (See Fig. 3-A for location of transportation corridors).

Land Use Planning Concerns

A comparison between 1990 and 1997 Maryland DOP land use data shows changes in watershed land development. Land use percentages are shown below:

Land Use	Percent of Watershed in 1990	Percent of Watershed in 1997
Residential	5.4%	7.6%
Commercial	0.7%	0.9%
Industrial	< 0.1%	0.1%
Mining	0.3%	0.3%
Urban Public Lands	0.2%	0.3%
Cropland	55.2%	54.2%
Pasture	9.2%	8.4%
Orchards	0.4%	0.4%
Forest	27.8%	27.3%
Open Water	0.1%	< 0.1%
Barren Land	0.1%	< 0.1%
Concentrated Agriculture	0.6%	0.5%

Table 7. Land Use Planning Concerns in Watershed Land Development in the Monocacy River Watershed

Trends in the Monocacy River's watershed land use are similar to trends in the rest of Frederick County. The increase in residential development is the most significant land use change over the period of seven years in the watershed and remains a main land use concern. Over 75% of the watershed is located in Maryland's Frederick and Carroll Counties. The Comprehensive Plan for Frederick County and Carroll County's Master Plan are planning tools that provide direction for accommodating desirable growth while maintaining the quality of life. An understanding of existing local land use and water resources management plan and related State and federal programs is an important component of the source water protection program.

V. REVIEW OF WATER QUALITY DATA

Several sources of water quality data were reviewed for all of the three source water assessment areas. These include MDE Water Supply Program's database for safe drinking water contaminants and monthly operating reports for the City of Frederick Water Treatment Plants (Fishing Creek, Linganore Creek and Monocacy), Frederick County Health Department, United States Geological Survey, MD Department of Natural Resources, and Lake Linganore Association bacteriological data.

Water quality data for all three water sources will be compared with Maximum Contaminant Levels (MCLs) set by the U.S. Environmental Protection Agency to ensure safe drinking water. If the monitoring data is greater than 50% of a MCL for at least 10% of the time, a detailed susceptibility analysis will be performed for that contaminant and its potential sources.

Existing Plant Data
The City of Frederick is required to perform water quality tests on the drinking water produced from three water treatment plants owned and operated by the City in order to ensure compliance with the EPA's Safe Drinking Water Act (SDWA) requirements. The City is also required to submit monthly operating reports to MDE's Water Supply Program, which includes daily testing of some raw water quality parameters such as turbidity (cloudiness of water), alkalinity,and pH. Other plant data included in the Monthly Operating Report (MOR) reflects the quality of treated (finished) water. All contaminants detects from plant data (finished) and the year 2000 raw water turbidity and pH for each plant are listed below.

A. Lester Dingle Plant/Fishing Creek Source Water

Raw Water Turbidity and pH
Review of raw water turbidity and pH of Fishing Creek Reservoir during the year 2000 indicates that the reservoir turbidity is consistently below 2.0 nephelometric turbidity units (NTU) while the plant is in operation. When turbidity reaches 2.0-2.5 NTU, the operators shut down the plant because of its inability to treat water with slightly elevated turbidity. The pH of the reservoir is relatively stable. The average value for the year 2000 is 6.85 which is within the 6.5-8.5 secondary standard for drinking water.

Below is a summary of Average, Maximum and Minimum Values for turbidity and pH during the year 2000:

Date	Average / Month		Maximum / Month		Minimum / Month	
	Turb. NTU	PH	Turb. NTU	pH	Turb. NTU	PH
January	0.4	6.6	0.7	7.0	0.3	6.3
February (Plant ran 11 days)	0.4	6.9	0.5	7.0	0.3	6.8
March (Plant Shut Down)						
April (Shut Down)						
May (Shut Down)						
June (Ran 3 days, 28, 29, and 30)	1.7	6.9	1.8	6.9	1.5	6.6
July (Ran 1-14 and 27-28)	1.7	6.9	2.1	7.1	1.1	6.5
August (Ran 4-31)	1.5	6.8	2.0	7.1	0.9	6.6
September (Shut Down 13-18, 20-26)	1.7	6.8	1.9	7.01.3	6.0	
October	1.0	6.8	1.6	8.0	0.7	6.7
November	0.7	7.0	0.8	7.3	0.6	6.7
December (Shut Down 17-20)	0.5	7.0	1.1	7.6	0.3	6.6
End of Year Summary	Avg.Turb. /Year **1.2**	Avg. pH Year **6.85**	Highest Turb in 2000 **2.1**	Highest pH **8.0**	Lowest Turb in 2000 **0.3**	Lowest pH in 2000 **6.3**

Table 8. Lester Dingle Plant/Fishing Creek (Raw Water Turbidity and pH for 2000)

<u>*Inorganic Compounds (IOCs)*</u>

Lester R. Dingle Water Treatment Plant regularly tests for the presence of nitrate and other inorganic compounds in finished drinking water. Below is a summary of testing results for IOCs detected in finished water. No IOCs exceeded the 50% MCL level in the water. Fluoride is added during the treatment process; therefore, levels are not reflective of raw water conditions.

Contaminant	Date	Result (ppm)	MCL (ppm)
BARIUM	10/18/96	0.0271	2
BARIUM	02/03/99	0.037	2
BARIUM	06/18/99	0.036	2
BARIUM	10/25/00	0.022	2
CHROMIUM	10/25/00	0.0003	0.1
FLUORIDE	11/09/93	0.85	4
FLUORIDE	11/10/94	0.94	4
FLUORIDE	05/02/95	0.76	4
FLUORIDE	09/04/96	0.9	4
FLUORIDE	10/18/96	0.98	4
FLUORIDE	06/24/97	1.15	4
FLUORIDE	02/03/99	1	4
FLUORIDE	06/18/99	1	4
FLUORIDE	10/25/00	1	4
NICKEL	11/10/94	0.05	0.1*
NICKEL	10/18/96	0.0013	0.1*
NICKEL	10/25/00	0.0007	0.1*
NITRITE	11/09/93	0.01	1
NITRITE	11/10/94	0.02	1
NITRITE	09/04/96	0.002	1
NITRITE	06/24/97	0.006	1
NITRATE	03/23/93	2	10
NITRATE	05/14/93	0.1	10
NITRATE	11/09/93	2.2	10
NITRATE	11/10/94	0.2	10
NITRATE	05/02/95	0.2	10
NITRATE	07/19/95	0.086	10
NITRATE	09/04/96	0.3	10
NITRATE	03/10/97	0.1	10
NITRATE	06/24/97	0.2	10
SELENIUM	11/09/93	0.003	0.05
SELENIUM	02/03/99	0.005	0.05
SODIUM	09/04/96	1.9	***
SODIUM	10/18/96	1.07	***
SODIUM	02/03/99	0.78	***
SODIUM	06/18/99	0.76	***
SODIUM	10/25/00	1.4	***
SULFATE	11/09/93	44	250**
SULFATE	11/10/94	2	250**
SULFATE	05/02/95	5.2	250**
SULFATE	09/04/96	9.4	250**
SULFATE	10/18/96	1.92	250**
SULFATE	06/24/97	5.3	250**
SULFATE	02/03/99	5	250**

* Health Advisory
** Secondary Standard
***Secondary Standard for Chloride is 250 ppm

Table 9. Inorganic Compounds (IOCs) Fishing Creek Source

Synthetic Organic Compounds (SOCs)

SOC samples are collected by MDE. Below is a summary of SOC's for the years 1995-2000, detected in finished water. No SOCs exceeded the 50% MCL level.

Contaminant	Sample Date	Result (ppb)	MCL (ppb)
DI(2-ETHYLHEXYL) PHTHALATE	05/02/95	0.72	6
DI(2-ETHYLHEXYL) PHTHALATE	07/05/00	0.7	6
DI(2-ETHYLHEXYL) PHTHALATE	07/05/00	0.9	6
ATRAZINE	06/28/00	0.1	3
DALAPON	09/04/96	0.385	200

Table 10. Synthetic Organic Compounds (SOC's) Fishing Creek Source

Volatile Organic Compounds (VOCs)

No volatile organic compounds other than disinfection by-products were detected in the water leaving the Lester Dingle treatment plant. Compliance with the disinfection by-product standards is determined by levels in the distribution system. Data from distribution samples collected in 1999 and 2000 are shown below. These results indicate that changes will be needed for the facility to consistently meet the current total trihalomethane (THM) standard of 0.080 mg/l and 0.060 mg/l for total haloecetic acids (HAA).

THM (1999)

Sample Site #	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Average
3010						
3011						
3012		0.1940	0.1100	0.0280	0.3320	0.1107
3013		0.0793	0.1080	0.0210	0.2083	0.0694
Avg.		0.1367	0.1090	0.0245	0.2702	0.0901

THM (2000)

3009	0.035	0.067	0.069	0.041	0.212	0.0530
3010	0.039	0.048	0.069	0.031	0.187	0.0468
3011	0.029	0.041	0.064	0.053	0.187	0.0468
3012	0.036	0.069	0.094	0.038	0.235	0.0588
Avg.	0.0348	0.0558	0.0740	0.0408	0.2054	0.0514

HAA (1999)

3010	0.0565				0.0565	0.0565
3011	0.0611				0.0611	0.0611
3012	0.0685	0.0455	0.0708	0.0400	0.2248	0.0562
3013	0.0521	0.0448	0.1000	0.0240	0.2209	0.0552
Avg.	0.0596	0.0452	0.0854	0.0320	0.2222	0.0573

HAA (2000)

3009	0.050	0.045	0.082	0.026	0.203	0.0508
3010	0.033	0.035	0.013	0.024	0.105	0.0262
3011	0.023	0.034	0.014	0.052	0.123	0.0308
3012	0.040	0.051	0.016	0.038	0.145	0.03625
Avg.	0.0365	0.04125	0.03125	0.0350	0.144	0.0369

Table 11. THM and HAA detects in finished water leaving the Lester Dingle plant from four sites in the distribution system (1999-2000) - all data in milligrams per liter (mg/l).

Microbiological Contaminants

MDE with cooperation of the City of Frederick water plant operators is currently conducting a raw water bactibiological monitoring study for a period of two years. The raw water samples are collected weekly and tested by Frederick City laboratory personnel for fecal coliform. Upon completion of the study, the data will be reviewed to further understand the microbiological quality of the raw water. The comparison of fecal coliform data collected to date from all three sources are shown in Figure 4. Of the three watersheds, Fishing Creek water typically has the lowest concentration of fecal coliform. These levels are well below Maryland's water quality standard of 200 colonies per 100 millileters for source waters. MDE is also collecting samples from Fishing Creek for *cryptosporidium* analysis during dry weather and storm events. This data will be included in a supplemental report to make a more complete susceptibility analysis for microbiological contaminants. Initial findings have shown non detectable levels during base flow conditions and peak *cryptosporidium* concentrations of the main stream entering the reservoirs to be between <1 oocysts per liter to 38 oocysts per liter.

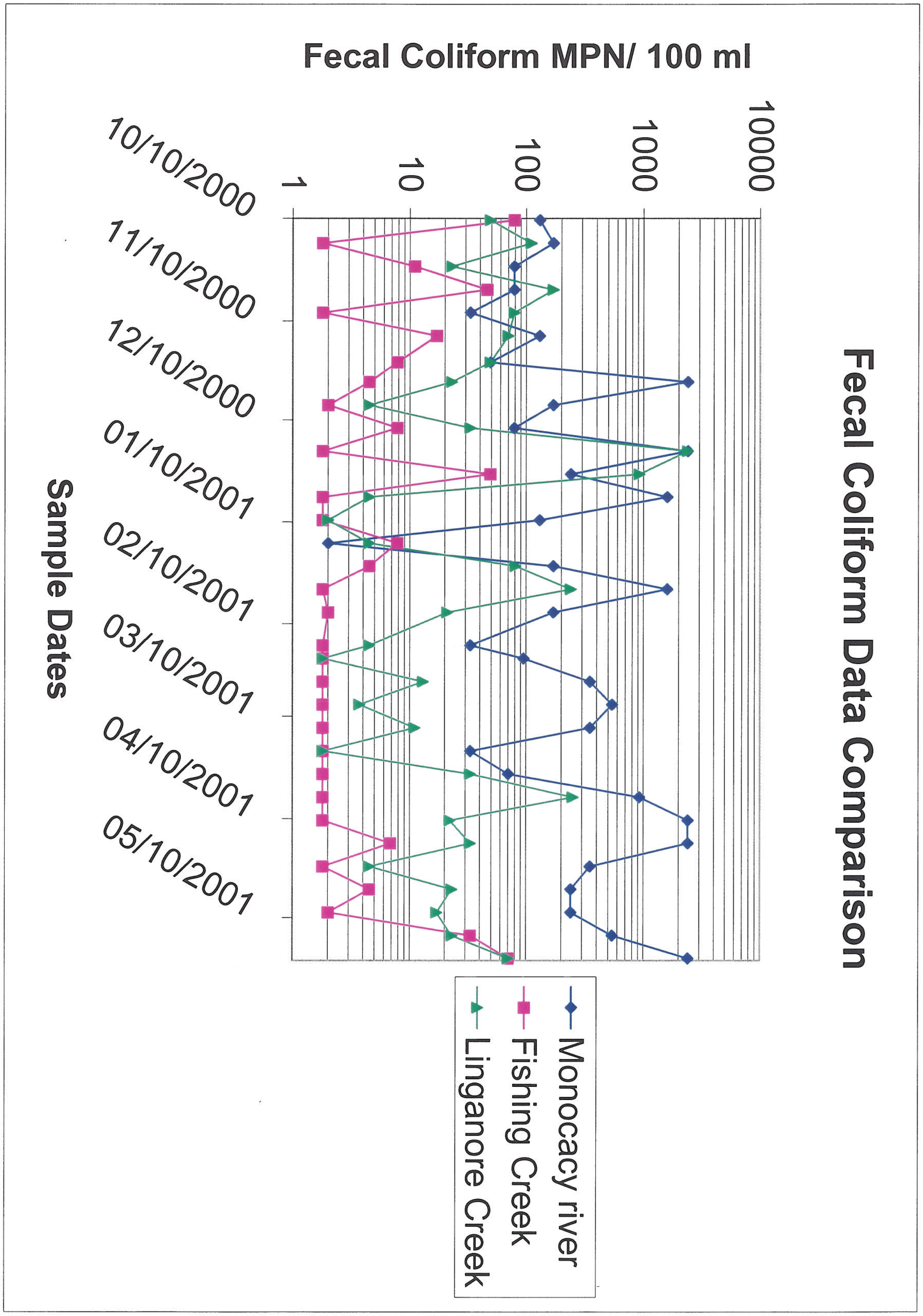

Fecal Coliform Data Comparison
Fecal Coliform MPN/ 100 ml
10000
1000
100
10
1
10/10/2000
11/10/2000
12/10/2000
01/10/2001
02/10/2001
03/10/2001
04/10/2001
05/10/2001
Sample Dates
Monocacy river
Fishing Creek
Linganore Creek

Figure 4

B. Linganore Creek

Raw Water Turbidity and pH

Our review of the City's monthly operating reports from January 2000 to December 2000 indicates that the average monthly turbidity of the raw water following pre-sedimentation fluctuates from 4.0 NTU to 24.7 NTU. The average pH of the raw water is from 6.6 to 8.4 and within the 6.5 – 8.5 range as recommended by secondary standard for drinking water. Below is a list of turbidity and pH values (monthly average, maximum and minimum) for Linganore Creek raw water leaving the pre-sedimentation pond during the year 2000.

Date	Average Monthly Value		Maximum / Month		Minimum / Month	
	Turb. NTU	PH	Turb. NTU	pH	Turb. NTU	pH
January	5.7	7.6	8.0	7.9	3.1	6.6
February	11.8	7.5	41.2	7.8	1.8	7.0
March	20.7	7.3	60.6	7.5	10.1	6.8
April	14.0	7.0	22.8	7.6	10.4	7.1
May	5.1	7.4	9.9	8.0	3.5	7.2
June	5.9	7.8	16.8	8.4	3.5	7.5
July	4.0	7.5	7.3	8.0	2.6	7.1
August	10.1	7.8	46.6	8.1	3.8	7.3
September	5.8	7.4	12.2 (1.47")	7.8	4.2	7.1
October	4.7	7.5	6.6	7.7	3.2	7.3
November	4.2	7.5	4.9	7.8	3.1	7.0
December	24.7	7.4	80.6	7.8	2.7	7.0
	Avg. Turb/Year NTU **9.72**	Avg. pH year **7.48**	Highest Turb. In Year 2000 **80.6**	Highest pH Year 2000 **8.4**	Lowest Turb. **1.8**	Lowest pH **6.6**

Table 12. Linganore Plant/Linganore Creek (Raw Water Turbidity and pH for 2000)

Inorganic Compounds (IOCs)

Linganore plant regularly tests for the presence of nitrate and other inorganic compounds in finished drinking water. Below is a summary of testing results for IOCs detected in finished water. Fluorides added during the treatment process; therefore, levels are not reflective of raw water conditions. Nitrate exceeded 50% of the MCL in one of thirteen samples collected since 1993. No inorganic compounds exceeded MDE's criteria for a detailed susceptibility analysis.

Contaminant	Date	Result (ppm)	MCL (ppm)
BARIUM	07/19/95	0.036	2
BARIUM	10/18/96	0.0312	2
BARIUM	06/18/99	0.025	2
BARIUM	10/25/00	0.033	2
CHROMIUM	10/25/00	0.0003	0.1
FLUORIDE	11/09/93	1.54	4
FLUORIDE	11/10/94	0.91	4
FLUORIDE	05/02/95	0.86	4
FLUORIDE	09/18/96	0.94	4
FLUORIDE	10/18/96	0.84	4
FLUORIDE	06/30/97	0.87	4
FLUORIDE	04/27/98	1.04	4
FLUORIDE	06/18/99	1	4
FLUORIDE	10/25/00	1.1	4
NICKEL	11/09/93	0.01	0.1*
NICKEL	11/10/94	0.06	0.1*
NICKEL	10/25/00	0.0036	0.1*
NITRITE	11/09/93	0.01	1
NITRITE	11/10/94	0.02	1
NITRITE	09/18/96	0.002	1
NITRATE	03/23/93	2.9	10
NITRATE	05/14/93	2.6	10
NITRATE	11/09/93	1.7	10
NITRATE	11/10/94	1.6	10
NITRATE	05/02/95	2.5	10
NITRATE	07/19/95	1.13	10
NITRATE	09/18/96	2.2	10
NITRATE	10/18/96	5.54	10
NITRATE	03/10/97	2.3	10
NITRATE	06/30/97	2	10
NITRATE	04/27/98	2.5	10
NITRATE	12/22/98	1.9	10
NITRATE	06/18/99	1.1	10
NITRATE	10/25/00	1.4	10
SELENIUM	11/09/93	0.003	0.05
SODIUM	10/18/96	5.47	***
SODIUM	06/30/97	6.8	***
SODIUM	04/27/98	6	***
SODIUM	06/18/99	4.3	***
SODIUM	10/25/00	7	***
SULFATE	11/09/93	37	**
SULFATE	11/10/94	31	250

SULFATE	05/02/95	22.9	250
SULFATE	07/19/95	30.6	250
SULFATE	09/18/96	29.6	250
SULFATE	10/18/96	21.1	250
SULFATE	06/30/97	24.6	250
SULFATE	04/27/98	27.1	250
SULFATE	06/18/99	30	250
SULFATE	10/25/00	36	250

*health advisory
**secondary standard
***secondary standard for chloride is 250 ppm

Table 13. Inorganic Compounds (IOCs) from Linganore Creek Treatment Plant

Radionuclides
No significant detection of radionuclides were found in the finished water.

Synthetic Organic Compounds (SOCs)
SOC samples are collected by Frederick City and MDE. Below is a summary of SOCs detected for years 1993-2000. Atrazine, a commonly used agricultural herbicide, was detected ten times during these years, once above 50% of the maximum contaminant level. A detailed discussion of the atrazine findings will be covered in the susceptibility analysis.

Contaminant	Date	Result (ppb)	MCL (ppb)
2,4-D	09/26/00	0.27	70
ATRAZINE	06/25/96	2.59	3
ATRAZINE	07/18/96	1.01	3
ATRAZINE	06/26/97	0.27	3
ATRAZINE	06/30/97	0.44	3
ATRAZINE	07/23/97	0.12	3
ATRAZINE	06/24/98	0.45	3
ATRAZINE	07/22/98	0.51	3
ATRAZINE	06/21/99	0.17	3
ATRAZINE	06/28/00	0.51	3
ATRAZINE	07/20/00	0.1	3
BENZO(a)PYRENE	06/26/97	0.05	0.2
DALAPON	04/27/98	0.05	200
DALAPON	08/03/98	0.55	200
DALAPON	09/26/00	3.41	200
DI(2-ETHYLHEXYL) ADIPATE	06/05/00	0.5	400
DI(2-ETHYLHEXYL) PHTHALATE	05/02/95	0.81	6
DI(2-ETHYLHEXYL)	04/27/98	11.5*	6

PHTHALATE			
DI(2-ETHYLHEXYL) PHTHALATE	06/05/00	0.9	6
DI(2-ETHYLHEXYL) PHTHALATE	06/05/00	0.9	6
HEXACHLOROCYCLO P ENTADIENE	07/18/96	0.15	50
METHOXYCHLOR	06/28/00	0.48	40
METOLACHLOR	06/25/96	1.24	40
METOLACHLOR	06/28/00	1.3	40
SIMAZINE	06/25/96	0.61	4
SIMAZINE	06/26/97	0.13	4
SIMAZINE	06/24/98	0.22	4
SIMAZINE	07/22/98	0.31	4
SIMAZINE	06/28/00	0.3	4

Table 14. Synthetic Organic Compounds (SOCs)
Linganore Creek Source

*Lab sheet comment indicates this quantity to be unreliable. A sample collected on August 3, 1998 showed no detectable amount.

Volatile Organic Compounds (VOCs)

No volatile organic compounds other than disinfection by-products were detected in the finished water leaving Linganore Water Treatment Plant. Compliance with the disinfection by-product standards is determined by levels in the distribution system. Levels of disinfection by products in the distribution exceed 50% of the recently established MCLs for total THM (0.080 mg/l) and HAA (0.060 mg/l).

THM (1999)

Sample Site #	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Average
2005	0.0480				0.0480	0.0480
2006	0.0484	0.0355	0.0458		0.1297	0.0432
2007	0.0457			0.0220	0.0677	0.0339
2008	0.0737				0.0737	0.0737
Avg.	0.0540	0.0355	0.0458	0.0220		0.0497

THM (2000)

2005	0.029	0.084	0.077	0.029	0.219	0.0548
2006	0.031	0.068	0.053	0.029	0.181	0.0452
2007	0.023	0.051	0.040	0.029	0.143	0.0358
2008	0.037	0.063	0.062	0.058	0.220	0.055
Avg.	0.0300	0.0665	0.0590	0.0362		0.0479

HAA (1999)

2005					0.0000	
2006	0.0485	0.0592	0.0842		0.1919	0.0640
2007				0.0160	0.0160	0.0160
2008					0.0000	
Avg.	0.0485	0.0592	0.0842	0.0160		0.0400

HAA (2000)

2005	0.050	0.074	0.023	0.040	0.187	0.0468
2006	0.037	0.043	0.033	0.039	0.152	0.0380
2007	0.030	0.040	0.080	0.028	0.178	0.0445
2008	0.039	0.042	0.005	0.048	0.134	0.0335
Avg.	0.039	0.0498	0.0352	0.0388		0.0407

Table 15. Trihalomethane (THM) and Haloecetic acids (HAA) detects in finished water leaving Linganore Creek Water Treatment Plant from four sites in the distribution system during 1999-2000. All data in milligrams per liter (mg/l).

Microbiological Contaminants

Lake Linganore Association operates several bathing beaches around the lake in accordance with the County Health Department permit. Review and analysis of the data from the County Health Department, Lake Linganore Association, and data from Frederick County Department of Public Works since 1991 reveals that fecal coliform counts exceeded the 200 MPN per 100 ml on several occasions. A total of 267 sample results from various sites at Lake Linganore were analyzed to determine the values of the minimum, maximum, and geometric mean of the existing data. The range of the values are: minimum from 1.5 to 20, maximum from 1,100 to 240,000 and geometric mean from 46.8 to 988.6.

MDE's raw water bacteriological monitoring study testing for fecal coliform from Linganore Creek Water Treatment Plan is in progress. The comparison of fecal coliform data collected to May, 2001 from all three sources are shown in Figure 4. Higher levels occurred following precipitation, indicating non point sources being the most significant. Of the thirty-three samples shown on Figure 4, six were greater than 100 colonies per 100 milliliters and four greater than Maryland's water quality standard of 200 colonies per 100 milliliters. MDE is conducting a multiphase study to assess the occurrence and behavior of selected pathogens in the Potomac River basin. As part of this study, samples are collected for baseflow and stormflow from various locations. Baseflow sample results show negative for *cryptosporidium* at Linganore Creek sampling sites upstream of the reservoir. But during the stormflow, two samples dated 9/25/01 and 9/26/01 tested positive with 29 and 3 oocysts/liter respectively.

C. Monocacy Plant/Monocacy River

Raw Water Turbidity and pH

A review of raw water turbidity and pH for the Monocacy River plant show that the river is subject to occasional periods of high turbidity, generally caused by high intensity rains. As shown below, the maximum turbidity during the month of December, 2000 after 1.75 inches of rain was over 280 NTU. The pH of the river ranged from a maximum of 8.6, to a minimum of 6.3. The average value is 7.6 generally within the range of 6.5-8.5 secondary standards for drinking water. An average pH greater than seven is a result of alkalinity provided by carbonate minerals from limestone bedrock of Frederick Valley and other sedimentary deposits in the Monocacy watershed. Below is a summary of average, maximum and minimum values for turbidity and pH during the year 2000.

Date	Average / Month		Maximum / Month		Minimum / Month	
	Turb. NTU	PH	Turb. NTU	pH	Turb. NTU	pH
January	6.7	7.6	40.9	7.8	2.4	7.4
February	24.9	7.6	103.4	7.8	2.1	7.2
March	22.9	7.4	218.0	7.8	6.1	7.0
April	19.0	8.0	119.7	8.6	3.0	7.2
May	11.6	7.6	33.8	7.9	4.4	7.0
June	24.1	7.5	115.3 (1.65" rain)	7.8	6.85	7.0
July	28.4	7.6	187.4 (0.35" rain)	7.9	5.5	7.2
August	6.8	7.5	17.9	7.8	5.2	7.1
September	44.1	7.5	181.7 (7/20) 7/19 (1.47" rain)	7.9	19.0	7.2
October	7.9	7.8	19.4	8.0	4.0	7.6
November Shutdown 7-13 & 28-30	4.8	7.8	7.3 (1.25" rain)	7.1	3.4	7.5
December Shutdown 1-11	30.9	7.4	280.8 (1.75" rain)	7.9	4.3	6.3
	Avg. Turb/Year NTU **17.8**	Avg. pH year **7.6**	Highest Turb. In Year 2000 **280.8**	Highest pH **8.6**	Lowest Turb. In Year 2000 **2.1**	Lowes t pH in Year 2000 **6.3**

Table 16. Monocacy Plant/Monocacy River (Raw water turbidity and pH for year 2000)

Inorganic Compounds (IOCs)

Monocacy River plant regularly tests for the presence of nitrate and other inorganic compounds. Below is the summary of testing results for IOCs detected in finished water. Fluoride is added during the treatment process; therefore, levels are not reflective of raw water conditions. No inorganic compounds exceeded MDE's criteria for a detailed susceptibility analysis.

Contaminant	Date	Result (ppm)	MCL (ppm)
BARIUM	07/19/95	0.03	2
BARIUM	10/18/96	0.0263	2
BARIUM	06/18/99	0.019	2
BARIUM	10/25/00	0.03	2
CHROMIUM	10/25/00	0.0003	0.1
FLUORIDE	04/17/92	1.18	4
FLUORIDE	11/09/93	0.66	4
FLUORIDE	11/10/94	0.88	4
FLUORIDE	05/02/95	1.03	4
FLUORIDE	07/19/95	1.09	4
FLUORIDE	09/04/96	0.9	4
FLUORIDE	10/18/96	0.98	4
FLUORIDE	06/24/97	1.04	4
FLUORIDE	04/27/98	1.18	4
FLUORIDE	06/18/99	0.7	4
FLUORIDE	10/25/00	0.8	4
NICKEL	11/09/93	0.01	0.1*
NICKEL	11/10/94	0.05	0.1*
NICKEL	10/18/96	0.0012	0.1*
NICKEL	10/25/00	0.0044	0.1*
NITRATE	04/17/92	1.8	10
NITRATE	03/23/93	0.2	10
NITRATE	05/14/93	2.1	10
NITRATE	11/09/93	0.1	10
NITRATE	11/10/94	2	10
NITRATE	05/02/95	2.5	10
NITRATE	07/19/95	2.3	10
NITRATE	09/04/96	2.7	10
NITRATE	10/18/96	5.43	10
NITRATE	03/10/97	2	10
NITRATE	06/24/97	2	10
NITRATE	04/27/98	1.8	10
NITRATE	12/22/98	3.1	10
NITRATE	06/18/99	1.6	10
NITRATE	10/25/00	2.1	10
NITRITE	11/09/93	0.01	1
NITRITE	11/10/94	0.02	1

NITRITE	05/02/95	.004	1
NITRITE	09/04/96	0.002	1
NITRITE	03/10/97	0.01	1
NITRITE	06/24/97	0.006	1
SELENIUM	11/09/93	0.002	0.05
SODIUM	04/17/92	9.9	***
SODIUM	09/04/96	9.8	***
SODIUM	10/18/96	8.76	***
SODIUM	04/27/98	9.9	***
SODIUM	06/18/99	8.5	***
SODIUM	10/25/00	12	***
SULFATE	04/17/92	39.4	250
SULFATE	11/10/94	47	250
SULFATE	05/02/95	34.2	250
SULFATE	07/19/95	3.23	250
SULFATE	09/04/96	35.7	250
SULFATE	10/18/96	26.8	250
SULFATE	06/24/97	31.6	250
SULFATE	04/27/98	39.4	250
SULFATE	06/18/99	38	250
SULFATE	10/25/00	37	250

*Health Advisory
**Secondary Standard
***Secondary Standard for Chloride is 250 ppm

Table 17. Inorganic Compounds (IOCs) Monocacy Plant

Synthetic Organic Compounds (SOCs)

Samples are collected by MDE. Below is a summary of SOCs for the years 1995-2000, detected in finished water. Atrazine was detected nine times during this period, three times exceeding 50% of the maximum contaminant level. A more detailed discussion of these findings will be covered in the susceptibility analysis.

Contaminant	Date	Result (ppb)	MCL (ppb)
2,4-D	04/19/99	0.14	70
ATRAZINE	06/25/96	2.93	3
ATRAZINE	07/18/96	0.54	3
ATRAZINE	06/26/97	0.14	3
ATRAZINE	06/24/98	2.1	3
ATRAZINE	07/22/98	0.32	3
ATRAZINE	06/21/99	0.19	3
ATRAZINE	06/05/00	0.5	3
ATRAZINE	06/28/00	3.3	3
ATRAZINE	07/20/00	0.1	3
BENZO(a)PYRENE	06/26/97	0.05	0.2

DALAPON	09/04/96	0.385	200
DALAPON	06/24/97	0.87	200
DALAPON	04/27/98	0.05	200
DALAPON	04/19/99	1.37	200
DALAPON	08/17/99	0.59	200
DI(2-ETHYLHEXYL) ADIPATE	06/05/00	0.5	400
DI(2-ETHYLHEXYL) PHTHALATE	05/02/95	0.94	6
DI(2-ETHYLHEXYL) PHTHALATE	06/26/97	0.62	6
DI(2-ETHYLHEXYL) PHTHALATE	04/19/99	0.8	6
DI(2-ETHYLHEXYL) PHTHALATE	08/17/99	0.5	6
DI(2-ETHYLHEXYL) PHTHALATE	06/05/00	1.2	6
DI(2-ETHYLHEXYL) PHTHALATE	06/05/00	1.2	6
METOLACHLOR	06/25/96	1.8	
METOLACHLOR	06/28/00	1.3	
SIMAZINE	06/25/96	0.72	4
SIMAZINE	06/24/98	0.74	4
SIMAZINE	06/28/00	0.79	4

Table 18. Synthetic Organic Compounds (SOCs) Monocacy Plant

Volatile Organic Compounds (VOCs)

No volatile organic compounds other than disinfection by-products were detected in the water leaving the Monocacy River Water Treatment Plant. Compliance with disinfection by-product is determined by levels in the distribution system. Data shown from distribution samples collected in 1999-2000 are shown below. These data indicate that changes will be needed at the Monocacy Plant for the facility to consistently meet the current standards of 0.080 mg/l for total THM and 0.060 mg/l for HAA at all locations.

THM (1999)

Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Average
1001					00	
1002	0.0503	0.2110	0.0597	0.0250	0.3460	0.0865
1003						
1004						
Avg.	0.0503	0.2110	0.0597	0.0250		0.0865

THM (2000)

Site	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Average
1001	0.048	0.095	0.066	0.066	0.275	0.0688
1002	0.049	0.102	0.088	0.047	0.286	0.0715
1003	0.052	0.102	0.098	0.050	0.302	0.0755
1004	0.046	0.060	0.077	0.046	0.229	0.0572
Avg.	0.0488	0.0898	0.0822	0.0522		0.0682

HAA (1999)

1001	0.0510				0.0510	0.0510
1002	0.0605	0.0525	0.0760	0.0330	0.2220	0.0555
1003	0.0578				0.0578	0.0578
1004	0.0570				0.0570	0.0570
Avg.	0.0566	0.0525	0.0760	0.0330		0.0553

HAA (2000)

1001	0.033	0.065	0.118	0.062	0.278	0.0695
1002	0.076	0.080	0.123	0.060	0.339	0.0848
1003	0.094	0.090	0.173	0.062	0.419	0.1048
1004	0.056	0.050	0.130	0.053	0.172	0.0043
Avg.	0.0882	0.0712	0.1360	0.0592		0.0658

Table 19. THM and HAA detects in finished water samples from four sites in the distribution system served by the Monocacy water plant during 1999-2000. All results in milligrams per liter (mg/l).

Microbiological Contaminants

MDE with cooperation of the City of Frederick water plant operators is currently conducting a raw water bactibiological monitoring study for a period of two years. The raw water samples are collected weekly and tested by Frederick City laboratory personnel for fecal coliform and E.coli. Upon completion of the study, the data will be reviewed to further understand the microbiological quality of the raw water. The comparison of fecal coliform data collected to date from the three sources are shown in Figure 4. The data shows that the raw water supplying the Monocacy Plant is half the time over the Maryland water quality standard of 200 colonies per 100 mililiters for fecal coliform. Fecal coliform levels in this supply are constantly higher than the levels found in either of the City's two other water sources.

DNR Watershed Data

The Maryland Department of Natural Resources has collected monthly data for several parameters from three water quality sampling stations in the Monocacy River watershed from 1991 through 1996. The two stations are located on the main stem of the Monocacy River, Bridgeport Bridge on MD 97 and the Monocacy River bridge on Miggs Ford Road. The third station is located at Big Pipe Bridge on Biggs Ford Road. The following table is a statistical summary of data collected from each station from 1991-1996.

Station	Parameter	Minimum Concentration (mg/l)	Maximum Concentration (mg/l)	Avg. Concentration (mg/l)
MON0269 Monocacy River on Biggs Ford Road	Ammonia (NH4)	0.008	0.341	0.047
	Chlorophylla	0.199	20.783	2.090
	Dissolved Oxygen	5.500	14.780	9.739
	Phosphorous	0.007	0.412	0.081
	Nitrate	1.000	4.300	2.495
	Total Nitrogen	1.750	6.900	3.146
	Total Organic Carbon	1.890	9.280	4.418
MON0528 Monocacy River on MD Rt. 97	Ammonia (NH4)	0.008	0.302	0.052
	Chlorophylla	0.112	13.457	2.388
	Dissolved Oxygen	4.600	15.580	9.378
	Phosphorous	0.014	0.310	0.075
	Nitrate	0.020	4.700	1.503
	Total Nitrogen	0.070	6.000	2.179
	Total Organic Carbon	2.500	10.160	5.461
BPC0035 Big Pipe Bridge on Biggs Ford Rd.	Ammonia (NH4)	0.008	0.346	0.040
	Chlorophylla	0.199	99.281	6.286
	Dissolved Oxygen	6.390	14.790	10.203
	Phosphorous	0.004	0.646	0.052
	Nitrate	2.00	5.296	3.460
	Total Nitrogen	2.400	7.510	4.024
	Total Organic Carbon	1.390	14.640	3.467

Table 20. Statistical Summary Data from Monocacy River Basin.

City of Frederick TOC Data

In order to comply with the EPA's Disinfection By-Product (DBP) Rule, the City of Frederick is required to implement a treatment technique to reduce DBP precursors to minimize the formation of unknown DBPs. It requires that a specific percentage of raw water total organic carbon (TOC) be removed during treatment. The treatment technique uses TOC as a surrogate for natural organic carbon (NOM), the precursor material for DBPs. The City is collecting TOC data from raw and finished water for all three water treatment plants. The table below shows the monthly average, monthly minimum and monthly maximum of TOC concentration in raw and finished water from January 2000 to November of 2001 at each water plant.

Plant	Raw Water			Finished Water		
	Monthly Avg.(mg/l)	Minimum (mg/l)	Maximum (mg/l)	Monthly Avg. (mg/l)	Minimum (mg/l)	Maximum (mg/l)
Monocacy	4.33	1.8	9.4	2.37	0.9	4.5
Linganore	3.59	1.25	5.6	1.98	1.0	2.4
Fishing Creek	1.25	<0.7	2.7	0.97	<0.7	1.9

Table 21. Total Organic Carbon Table

VI. SUSCEPTIBILITY ANALYSIS

Each class of contaminants that were detected in the water quality data have been analyzed to determine the potential they have to contaminate the City of Frederick's raw water sources. The analysis has identified suspected sources of contaminants, evaluated the natural condition of the watershed, increase or decrease the likelihood of a contaminant entering the raw water, and the impact that future changes may have on the susceptibility of the City's sources.

A. Fishing Creek Reservoir

The Fishing Creek Reservoir watershed is approximately 99% forested and the streams above the reservoir are protected by forest. This reduces the potential for many contaminants to ever reach the reservoir. The average turbidity in the reservoir during the year 2000 while the plant was being operated was 1.2 NTU and the highest raw turbidity recorded for that year was 2.1 NTU. When turbidity levels exceed 2.0 NTU, the operators shut down the plant due to treatment plant limitations. Fishing Creek reservoir, like any other surface source, is subject to higher turbidity during heavy storms and snowmelt. Higher turbidity levels can be associated with harmful microorganisms entering drinking water supplies. When compared to other sources of water, the high turbidity levels experienced in Fishing Creek are quite low. A sampling program being carried out by Frederick City for fecal and E.coli bacteria shows that the median value was only 12 colonies per 100 milliliters and that the highest levels reached 79 colonies per 100 ml. These results indicate that this source meets the State standard of 200 colonies per 100 milliliters for fecal coliform bacteria and is generally not susceptible to microbial contamination.

This Fishing Creek source, because of its protected watershed, is not susceptible to inorganic, volatile organic or synthetic organic chemicals. Like most all surface water sources, the supply is susceptibile to contamination by *giardia*, *cryptosporidium* and other pathogens. The source does, however, have sufficient natural organic matter (from decaying leaves, etc.) that when combined with chlorine can result in disinfection by-product levels that can exceed the new MCL of 80 ppb for total trihalomethanes. This supply is susceptible to disinfection by products. The existing practice of chlorinating the raw water prior to treatment may be a significant factor contributing to the elevated total trihalomethane levels.

B. Linganore Creek

Turbidity and Sediment

The average turbidity in Linganore Creek during the year 2000 was approximately 9.72 NTU; the highest average turbidity of 80.6 NTU was recorded during the month of December, 2000. High levels of turbidity in the creek can result from storm events (rainfall) and snowmelt. Lake Linganore is located approximately 1 ½ miles upstream of the City's intake with approximately 82 square miles of drainage area. The sediment loads into Lake Linganore are severe because of the high density residential development surrounding the lake and the high percentage of agricultural land in the watershed. Based on visual inspection and discussion with the Lake Linganore Association, noticeable siltation has occurred since the dam was constructed. A bathymetric survey has not been performed since the construction of the dam; therefore, the storage loss of the lake cannot be determined at this time.

Future land use changes in the Linganore Creek watershed could increase the turbidity contamination. Most of the watershed is privately owned and development of forested land will increase the amount of exposed surfaces that can lead to erosion. Changes of cropland and pasture to low density residential land use in the watershed is another factor which could lead to increased turbidity in the Linganore Creek.

Inorganic Compounds
Several inorganic compounds (IOCs) have been detected below the maximum contaminant level in the finished water from Linganore Creek Water Treatment Plant. Nitrate was the most common IOC detected with only one result exceeding the 50% of MCL, with a concentration of 5.54 ppm. Nitrates can enter the water supply via ground water and surface runoff. Fertilizer losses, leachate from septic tanks, animal wastes, wastewater effluent, atmospheric deposition, and erosion of natural deposits are all sources of nitrates. Unless livestock numbers, fertilizer usage and number of homes using on-site disposal drastically increases, it is unlikely that nitrate concentration will increase in the future. Nitrate is not a threat to contaminate the Linganore Creek at the present time.

Very low levels of other inorganic compounds have been detected in the finished water leaving the Linganore Creek Water Treatment Plant (Table 13). None has been greater than 50% of the MCL.

Synthetic Organic Compounds (SOCs)
There are several SOC detects at the Linganore Creek plant, but all results are less than 50% of MCL, with the exception of two compounds: Atrazine and (di(2-ethylhexyl)) Phthalate. Atrazine has been documented to enter streams and rivers in Maryland following springtime herbicide application. Atrazine is water soluble, and residues on soil, vegetation or other surfaces can be easily carried by runoff into streams. Review of Maryland Pesticide Statistics for the years 1985, 1988, 1991, 1994, and 1997 prepared by Maryland Department of Agriculture indicates that the usage of Atrazine in Frederick County decreased from 105,000 pounds in 1988 to 55,000 pounds in 1997. If the trend continues, it is unlikely that Atrazine concentration will increase in the future. The one detection of di(2 ethylhexyl) Phthalate over the MCL was reported as unreliable on the lab sheet and was not detected in a subsequent sample. Its prevalence in plastics makes it a hard compound to sample and test. This compound was reported in corresponding laboratory blanks; therefore, reported quantities are not likely reflective of levels in the environment but rather laboratory artifacts.

Disinfection Byproducts
Trihalomethanes (THMs) and haloacetic acids (HAAs) both exceeded 50% of the MCL. The Disinfection Byproducts Rule (DBPR) requires that water system serving 10,000 or more persons must comply with the rule's provisions beginning December 2001. The rule establishes MCLs for the most common and well-studied halogenated DBPs: total trihalomethane (TTHMs) and five of the nine haloacetic acids (HAAs) as well as bromate and chlorite. TTHM is defined as the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane; HAA is defined as the

sum of mono-, di-, and trichloroaceticaeids, and mono- and dibromacetic acids. The MCLs for the disinfection byproducts are shown below:

Total Trihalomethanes (TTHMs)	0.080 mg/l
Haloacetic Acids (HAAs)	0.060 mg/l
Bromate	0.060 mg/l
Chlorite	1.0 mg/l

Table 22. MCLs for the Stage 1 DBPR

In addition to MCLs, the DBPR requires the use of treatment techniques to reduce DBP precursors and to minimize the formation of unknown DBPs. It requires that a specific percentage of influent total organic carbon (TOC) be removed during treatment. The treatment technique uses TOC as a surrogate for natural organic matter (NOM), the precursor material for DBPs. A TOC concentration of greater than 2.0 mg/l in a system's raw water is the trigger for implementation of the treatment technique. Required removal of TOC by enhanced coagulation for plants using conventional treatment is shown in the table below:

Source Water TOC (mg/l)	**Source Water Alkalinity (mg/l as CaCo3)**		
	0-60	>60 to 120	>120
>2.0 – 4.0	35%	25%	15%
>4.0 – 8.0	45%	35%	25%
>8.0	50%	40%	30%

Table 23. Total Organic Carbon Removal Requirements

Review of the TOC data collected by the City of Frederick from January 2000 to November 2001 indicates that the treatment process removes the required percentage of TOC from the Linganore Creek raw water. However, the City should continue monitoring for TOC in the raw and finished water to ensure compliance with the DBP Rule.

The amount of organic matter in Linganore Creek is probably high due to the nature of the watershed and the existing condition of Lake Linganore. According to the Lake Linganore Water Quality Study of September 1979, prepared by Whitman, Requardt and Associates Engineers, Lake Linganore is in the early stages of eutrophication. Eutrophication is defined as the increase in the amount of algae associated with the enrichment of lakes and reservoirs with algal nutrients such as nitrogen (N) and phosphorus (P). The absence of dissolved oxygen in the bottom waters, the occurrence of an algae bloom coinciding with fall turnover, and the high nutrient, iron and manganese concentrations in the bottom water were observed during the 1979 study period (Lake Linganore Water Quality Study, September 1979. Whitman & Requart Assoc.).

The watershed is a major source of THM precursors. Lake Linganore's watershed includes approximately 86% agricultural and forested areas, and runoff from these areas contribute to the delivery of particulate and dissolved organic matter to the lake. Since phosphorus appears to be the limiting nutrient for algae growth in Lake Linganore during the fall algae bloom, watershed management efforts should concentrate on control of this nutrient to reduce aquatic growth. A comparison between phosphorus loading (in terms of pounds per acre per year) from the discharge of the Libertytown Wastewater Plant and agricultural land in the watershed revealed that the contribution from the wastewater plant is rather insignificant compared to agricultural activities in the watershed (Chesapeake Model DNR). Farming practices would have to be adopted to either reduce fertilizer applications or to reduce runoff from fertilized land to reduce phosphorus loading.

Microbiological Contaminants

The consistent presence of fecal coliform bacteria in Lake Linganore and Linganore Creek indicates susceptibility to pathogenic microorganisms. The fecal coliform data from different sources, summarized in Section V Review of Water Quality Data, shows that counts periodically exceeded the level of 200 MPN/100 ml, as set by the State water quality standard and bathing beaches' closings ordered by the Frederick County Health Department to assure compliance with the permit. Three sampling locations: Ben's Branch, Linganore Creek and Nightingale Beach test results from June 1992-September 2001show the highest geometric mean value of 602, 988 and 355 MPN/100 ml respectively.

In order to better assess the susceptibility of Linganore Creek, fecal coliform sampling at the creek and Lake Linganore began in October 2000 and will continue for at least two years as part of a special source water assessment project. This data and *cryptosporidium* data collected from Linganore Creek will be included in a supplemental report to make a more complete analysis for microbiological contaminants. Upon completion of the study, the data will be reviewed to further understand the microbiological quality of the raw water.

Giardia and *cryptosporidium* are fairly common in surface water and associated with human and animal waste, including birds and various wildlife species such as deer, raccoons, opossums, rabbits, rats and squirrels. Like most all surface water supplies, the water intake is susceptible to contamination by *giardia*, *cryptosporidium* and other pathogens. Sampling data indicates that highest fecal and *cryptosporidium* levels are associated with stormwater runoff. Sampling locations indicate that high levels are present prior to entering the reservoir, thus indicating that agricultural sources are likely to be significant.

C. Monocacy River

Turbidity and Sediment
Average turbidity in the Monacacy at the intake during the year 2000 was approximately 17.8 NTU; the highest average turbidity of 80.8 NTU was recorded for the month of December, 2000. High levels of turbidity occur during rainfalls and snowmelts. Excessive turbidity can interfere with water treatment and can carry harmful microorganisms into drinking water supplies.

Sedimentation, the movement of solids such as soil, minerals and sand in water, is the most serious problem of the Monocacy River. The Monocacy River watershed contributes sediment at more than twice the rate of other land draining into the Potomac upriver of Point of Rock (Monocacy Scenic River Study and Management Plan, May 1990).

Inorganic Compounds
Several inorganic compounds (IOC) have been detected below the maximum contaminant level in finished water from the Monocacy River Water Treatment Plant. Nitrate was the most common IOC detected with only one result exceeding 50% of the MCL at a concentration of 5.43 PPM.

Synthetic Organic Compounds (SOCs)
There are several SOC detects at the Monocacy Plant, but all results are less than 50% of MCL, with the exception of atrazine which exceeded 50% of MCL on three occasions from 1995 through 2000. As discussed in Linganore Creek's susceptibility analysis to SOCs, atrazine can enter the Monocacy River following springtime herbicide application. A review of the documents from the Maryland Department of Agriculture suggests that the usage of atrazine has declined in Frederick County in the past ten years and if the trend continues, it is unlikely that atrazine concentration will increase in the future. However, it is important to continue monitoring for atrazine concentration in finished water in order to track the trend of this compound in water supply.

Disinfection Byproducts
Similar to the Linganore Creek Plant, Trihalomethane (THMs) and Haloacetic acids (HAAs) both exceeded 50% of MCL from water treated at the Monocacy Plant. The Disinfection Byproducts Rule (DBPR) is applicable to the Monocacy Plant as described for the Linganore Plant on pages 44 through 46 of this report.

A review of TOC data collected by the City of Frederick from January 2000 to November 2001 indicates that the treatment process removes the required percentage of TOC from the Monocacy River raw water. However, the City should continue monitoring for TOC in the raw and finished water to ensure compliance with the DBPR.

Over 90% of the source water assessment area for the Monocacy River intake consists of agricultural and forested lands which are the major sources of THM precursors. The runoff from these areas contribute to the delivery of particulate and dissolved organic matter to the Monocacy River. A review of data collected by DNR from three quality sampling stations in the Monocacy River watershed indicates that the level of chlorophylla concentration is higher during the summer months. This is often related to algae growth due to nutrients enriched runoff from the watershed. Higher algae levels contribute to increased disinfection by product precursors and algae cells are significant contributions to THMs should they be reacted with chlorine prior to removal by filtration.

Microbial Contaminants
The consistent presence of fecal coliform bacteria in the Monocacy River indicates susceptibility to pathogenic microorganisms. A sampling program being carried out by Frederick City for fecal bacteria shows that the values for the Monocacy River are constantly higher than the levels found in either of City's two other sources. The data also shows that the Monocacy River raw water is half the time over the Maryland water quality standard of 200 colonies per 100 milliliter for fecal coliform. As substantial numbers were found under various flow conditions, many reflect input from both point sources (sewage treatment plants) and non point sources (urban and agricultural runoff). Recent data is not available within the various subwatersheds of the Monocacy to identify differences in levels. Historical data in the Double Pipe Creek watershed indicates similar and higher levels than those measured at the Monocacy water plant.

VII. RECOMMENDATIONS FOR SOURCE WATER PROTECTION PLAN

This report is compiled based on the existing and available data from several sources. It provides general information as a first step towards establishing and implementing source water protection plans for the City of Frederick's three sources. Additional data may be needed to further understand the areas delineated for specific source protection goals. The following is a list of recommendations regarding watershed management for each source.

A. Fishing Creek

- Since 99% of the watershed is forested and mostly owned by the City, a comprehensive forest management plan should be developed for source water assessment areas. DNR Forest Management Division has developed a forest management plan for the City of Baltimore's property surrounding their reservoirs and is initiating a project with the Washington Suburban Sanitary Commission for the Tridelphia and Rock Gorge reservoirs. We suggest that the City of Frederick work with the DNR to survey the forest health and develop management approach that keeps water quality as the primary objective.

- As an excellent and protective water source, the City should make improvements to the Lester R. Dingle Water Treatment Plant to maximize its use of the Fishing Creek reservoir.
- Conduct a field survey of raw water line from the reservoir to the treatment plant to assess the physical condition of the old cast iron pipe and also dedicate an easement along the entire length of the raw waterline.
- Road signs explaining to the public that they are entering a protected drinking water supply watershed are an effective way of keeping the relationship of land use and water quality in the public eye, and help in the event of spill notification and response.
- Continue to monitor for all Safe Drinking Water Act as required by MDE including raw water sources when feasible.
- Continue monitoring for fecal coliform and E. Coli for raw water after the two-year MDE sponsored monitoring program is over.

B. Linganore Creek

- The City of Frederick should continue to be an active member of Lake Linganore source water protection task force, a newly formed committee interested in development and implementation of strategies to protect Lake Linganore as a drinking water source.
- Develop a formal or informal agreement to engage officials from different jurisdictions on a continuing basis.
- Encourage broad stakeholder participation, including home owners, farmers, developers and existing environmental groups.
- Establish clear and achievable goals, objectives and milestones to ensure the highest quality raw water. Some examples are listed below.
  - ✓ Complete the bathymetric survey for Lake Linganore to determine the rate of sedimentation, significant sediment sources, and the impact of sedimentation on lake storage and the treatability of the raw water.
  - ✓ Develop a predictive model to relate the tributary nutrient loadings to the lake eutrophication, water quality parameters and algae dynamics.
  - ✓ Develop baseline information on pathogen contamination in main feeder streams and at different lake locations. Continue monitoring for fecal coliform in the intake beyond the two-year MDE program (October 2002).
  - ✓ Keep track of water quality compliance violations and refer them to MDE.
  - ✓ Monitor the major tributaries for TOC and disinfection byproduct formation potential seasonally. Tributary monitoring may help pinpoint watersheds that are major precursor contributors.
  - ✓ The City and county should explore the possibility of acquiring land and conservation easements in sensitive watershed areas and along the feeder streams. Loan grants for the purchase of land or easements for

the purpose of protecting water are available from MDE and through the Maryland Agricultural Preservation Funds.

- ✓ The City of Frederick should periodically conduct its own detailed field survey of the watershed to ensure there are no new potential sources of contaminants.
- ✓ In cooperation with Frederick County, conduct ongoing monitoring for algae and/or indicators of algae blooms, such as chlorophyla levels in Lake Linganore.

C. Monocacy River

- The City of Frederick should participate in the Upper Potomac Tributary Team's regular meetings to introduce drinking water issues and concerns.
- Establish communication procedures with the wastewater treatment plants located above the City's intake to notify sewage overflow or other treatment problems concerning all of the major and minor plants in the watershed.
- Erect road signs in strategic locations to alert the public that they are entering a drinking water supply watershed.
- Continue monitoring for fecal foliform for raw water after the two-year MDE sponsored monitoring program is over.
- In cooperation with DNR and Frederick County, conduct ongoing monitoring for algae and/or indicators of algae bloom in the Monocacy River.

REFERENCES

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County, City and Lake Linganore and Regional Water System Agreement, December 2000.

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Piney Alloway Creek's Targeted Watershed Project Summary Report, 1990-1997, August 1999, MDNR.

U.S. Army Corps of Engineers, Baltimore District, 1980, Linganore Dam, Phase 1 Inspection Report.

Water Quality Trends in Big Pipe Creek During the Double Pipe Creek Rural Clean Water Program, John L. McCoy and Robert M. Summers, Proceedings of National RCWP Symposium 1992.

Whitman, Requardt Associates Engineers, 1979, Lake Linganore Water Quality Study.

OTHER SOURCES OF DATA

City of Frederick Monthly Operating Reports (MORs) and Self-Monitoring Reports.

MDE Water Supply Inspection Reports.

MDE Water Supply Oracle Database.
MDE Water Supply reader file for City of Frederick water system.
Maryland Office of Planning 1997 and 1990 Frederick County Land-Use Map.
Maryland Office of Planning 1999 Property View Tax Map, Frederick County.

FIGURES

Figure 1. General Vicinity Map of Frederick City's Drinking Water Sources