9.0 Permit Requirements

F. Watershed Assessment and Planning

Baltimore County shall continue to update and revise watershed assessments that have been developed for its 10 urban watersheds (Baltimore Harbor, Bird River, Back River, Gwynns Falls, Jones Falls, Little Gunpowder, Loch Raven, Lower Gunpowder River, Middle River, and the Patapsco River). The overall goal is to ensure that each County watershed is thoroughly evaluated and has an action plan to maximize water quality improvements. Additionally, the County shall encourage the public to participate in the development and implementation of watershed restoration activities. At a minimum, the County shall:

1. Continue to perform and update detailed assessments in all of its urban watersheds. These watershed assessments shall include:
    a. Determining current water quality conditions;
    b. Identifying and ranking water quality problems;
    c. Identifying all structural and non-structural water quality improvements opportunities;
    d. Reporting the results of a visual watershed inspection;
    e. Specifying how the restoration efforts will be monitored; and
    f. Providing an estimated cost and a detailed implementation schedule for those improvement opportunities identified above.

H. Assessment of Controls

Assessment of controls is critical for determining the effectiveness of the NPDES stormwater management program and progress toward improving water quality. Therefore, Baltimore County shall use chemical, biological, and physical monitoring to document work toward meeting the watershed restoration goals identified above.

9.1 Introduction

In order to meet the permit requirements detailed in section F (1. a-e) and section H, Baltimore County has initiated chemical, biological, and geomorphological monitoring programs in addition to the specific monitoring required by the permit and detailed in Section 8. The chemical monitoring program (9.2) consists of two elements, stream baseflow monitoring and tidal water monitoring. A third element consisting of storm event monitoring at USGS gage sites has been sporadic and will not be included in this report. The stream geomorphological monitoring program (9.3) includes monitoring of stream restoration projects and conducting stream assessments in support of the Small Watershed Action Plan preparation. The biological monitoring program (9.4) has four elements including probabilistic monitoring, CIP monitoring, reference site monitoring, and submerged aquatic vegetation monitoring.

9.2 Chemical Monitoring Program

In order to determine the chemical condition of Baltimore County waters, two chemical monitoring programs have been implemented. The chemical monitoring program is intended to provide information on ambient chemical conditions and, over time, to assess trends in both chemical concentrations and chemical loads. The information will be used to better target restoration activities, to provide data for the calibration of pollutant load models, and to provide local data to assess the results of the Chesapeake Bay Program modeling efforts and TMDL modeling. The data will be used to assess water quality improvements that are the result of restoration efforts. It will also be used to determine progress in meeting the pollutant load reductions required by the Chesapeake Bay restoration efforts and as determined by the development of Total Maximum Daily Loads (TMDLs). These programs will partially fulfill the restoration effectiveness monitoring required under NPDES Permit section F.1 and H above.

The two current, chemically oriented programs, the Baseflow Monitoring Program and the Tidal Waters Monitoring Program are described in Sections 9.2.1 and 9.2.2, respectively.

9.2.1 Baseflow Monitoring

A baseflow monitoring program was initiated in 1999. The initial effort was targeted at watersheds that were undergoing or about to undergo the preparation of a Water Quality Management plan. The targeted watersheds included the Lower Gunpowder, the Little Gunpowder, the Middle River and the Baltimore Harbor watersheds. The limited data was used in the calibration of the SWMM pollutant load models that were included in the Water Quality Management plans. In the fall of 2000, the baseflow monitoring was shifted to the Back River, Jones Falls and Gwynns Falls watersheds. The shift was intended to address the lack of chemical monitoring information available for these watersheds. These watersheds were monitored until the spring of 2001. The data collected was presented in the NPDES – 2001 Annual Report. Staffing levels curtailed the continuance of the baseflow monitoring program until the spring of 2003.

The baseflow monitoring program, which resumed in 2003 was also redesigned. Baseflows are monitored in the Patapsco/Back River Basin in odd-numbered years, while the Gunpowder Basin/Deer Creek are monitored in the even-numbered years. In 2007, because of staff time constraints, we created Tier 1 and Tier 2 sites. The Tier 1 sites are our regular sampling sites. Tier 2 are sites that were removed from sampling, but will be picked back up if we have a Small Watershed Action Plan (SWAP) or other project in that area. There are 31 Tier 1 and 9 Tier 2 sites in the Patapsco Back River Basin. Four of the Tier 2 sites were sampled because of our SWAP in the Upper Back River and Lower Jones Falls. Tier 1 and Tier 2 sites have not yet incorporated into the Gunpowder Basin/Deer Creek. There are 63 sampling sites in the Gunpowder Basin/Deer Creek. The points were chosen to maximize the number of subwatersheds monitored. The monitoring points within the Patapsco/Back River Basin are displayed in Figure 9-1, while the Gunpowder Basin/Deer Creek monitoring points are displayed in Figure 9-2. Appendix 9-1, at the end of this section, displays the watersheds and subwatersheds associated with each monitoring point.

The target number of baseflow samples is eight samples per year at each site. The actual number sampled will vary depending on weather conditions, staffing and other duties. The standard set of monitored pollutants includes (TSS, TS, TKN, Nitrate/Nitrite, Total Phosphorus, Ortho-phosphorus, Cadmium, Copper, Lead, Zinc, BOD, COD, Chlorides, Sodium, Hardness,

Magnesium and Calcium) as well as temperature and pH determined in *situ*. Discharge measurements are taken during each sample collection. A minimum of three days of dry weather is required prior to monitoring any baseflow site.

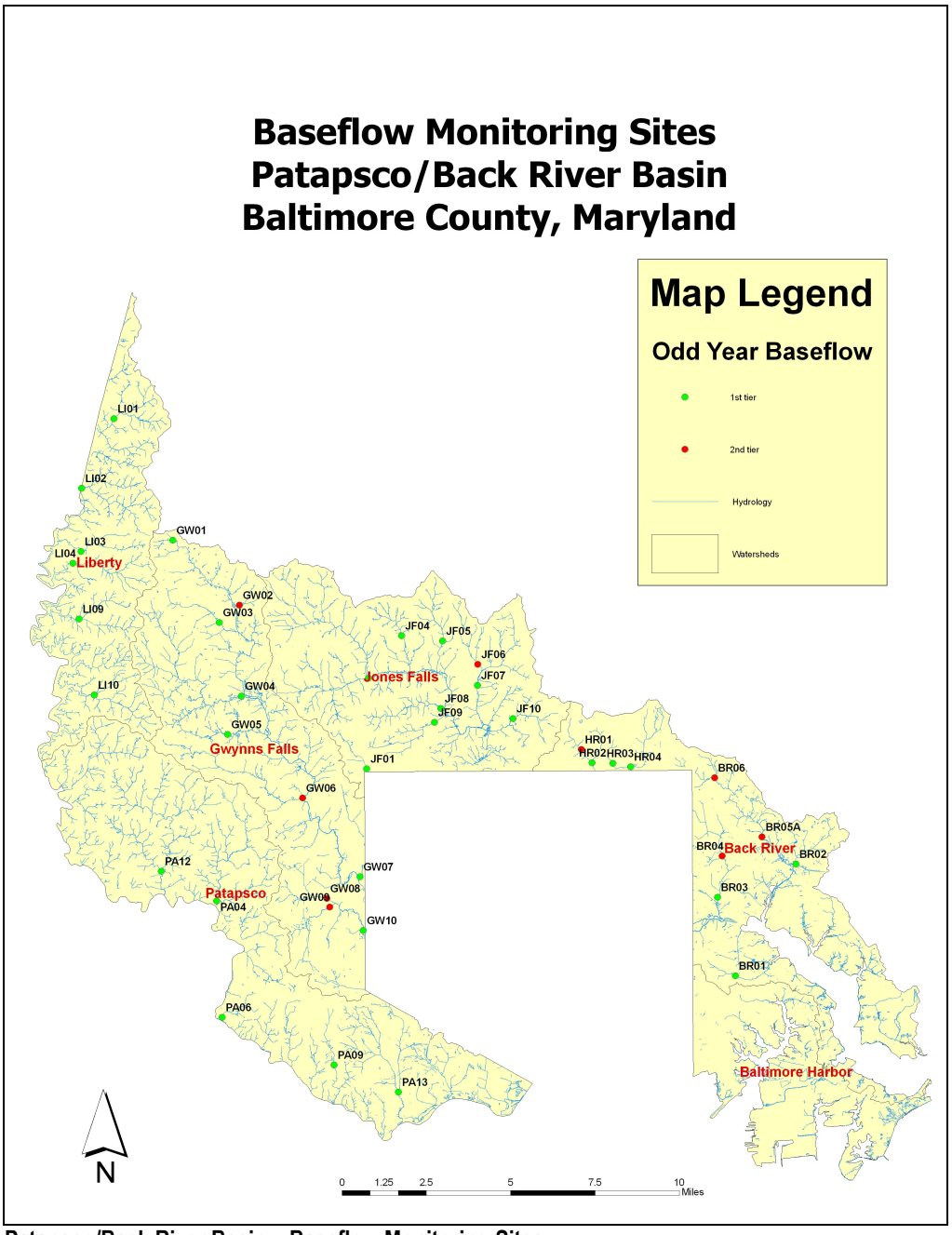


Figure 9-1: Patapsco/Back River Basin – Baseflow Monitoring Sites

The design will allow determination of ambient water quality for major portions of each watershed. The two-year sampling cycle will allow an analysis of baseflow water quality trends for the pollutant parameters analyzed.

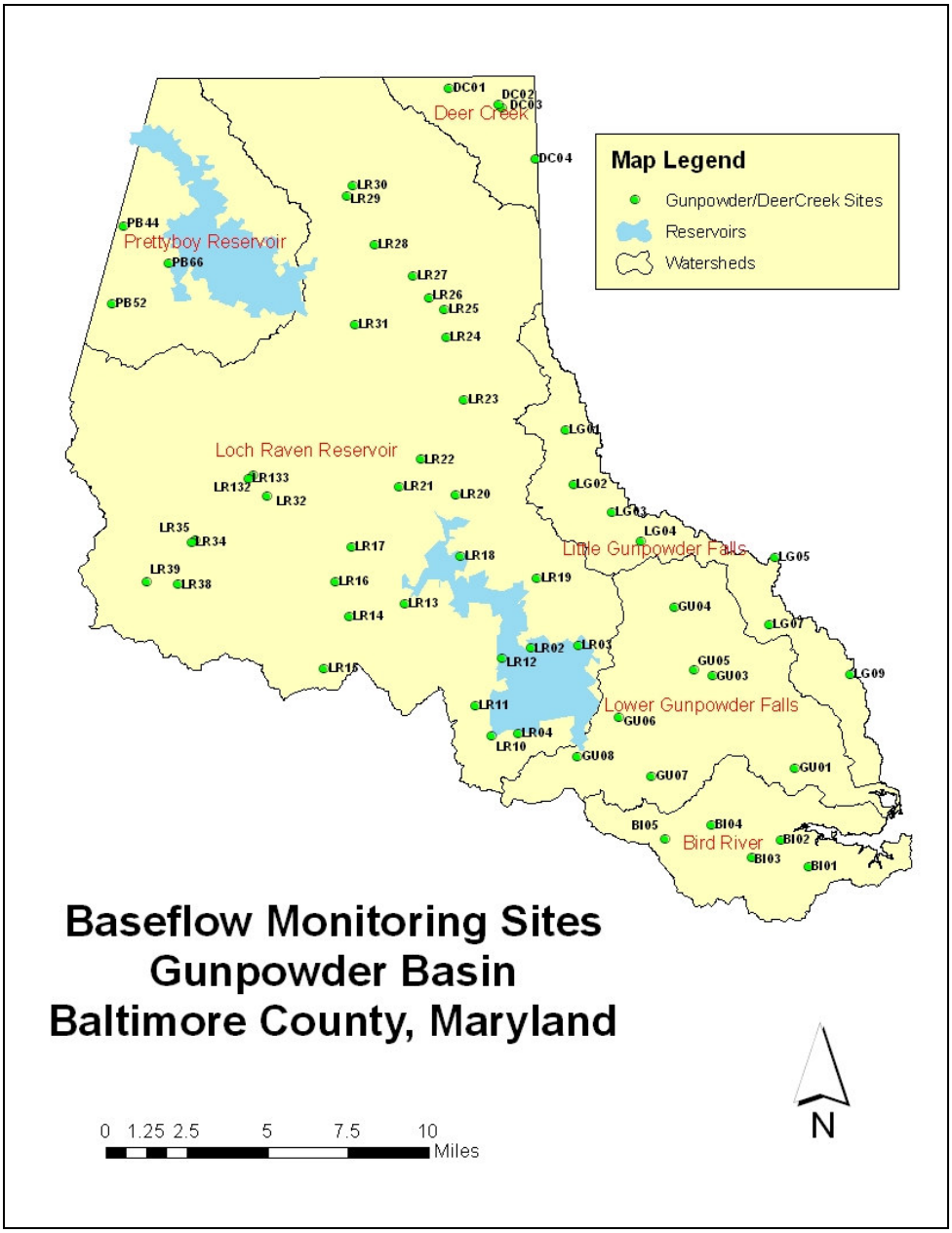


Figure 9-2: Gunpowder Basin/Deer Creek – Baseflow Monitoring Sites **PB26, PB28, PB33, PB43, and PB54 not shown on map. They were part of the Prettyboy Reservoir Watershed Restoration Strategy project and located outside the county.

A total of 148 baseflow samples were collected in the Patapsco/Back River Basin in 2007. The number of samples per site varied from one to three, with the majority of being done three times. In addition to the baseflow samples, 30 field blanks and 30 duplicate samples were collected; these are excluded from calculations and are only for quality control purposes. The mean, number of samples and the standard deviation for each site are presented at the end of this section in Appendix 9-2 for each parameter analyzed.

A frequency analysis was conducted on the metals data to determine exceedance of water quality criteria. All statistical analyses were conducted using Statistica (Ver. 6.1). Figure 9-3 displays the frequency distribution for both total copper and dissolved copper. Maryland Department of the Environment water quality criteria was used. The water quality criteria are based on dissolved metals and the toxicity is influenced by hardness. The total copper samples exceeded the chronic criteria for aquatic life for 100.0% and exceeded the acute criteria for 18.3% of the samples. For dissolved copper, 3.5% of the samples exceeded the chronic standard and .7% exceeded the acute criteria. The sample results for zinc indicated it did not exceed the water quality standards in baseflow samples. Cadmium exceeded the chronic standard (.00025 mg/L) once for total metals at a concentration of .016 mg/L and once for the dissolved metals at a concentration of .003 mg/L. Lead exceeded the chronic standard (.0025 mg/L) once for total metals at a concentration of .003 mg/L.

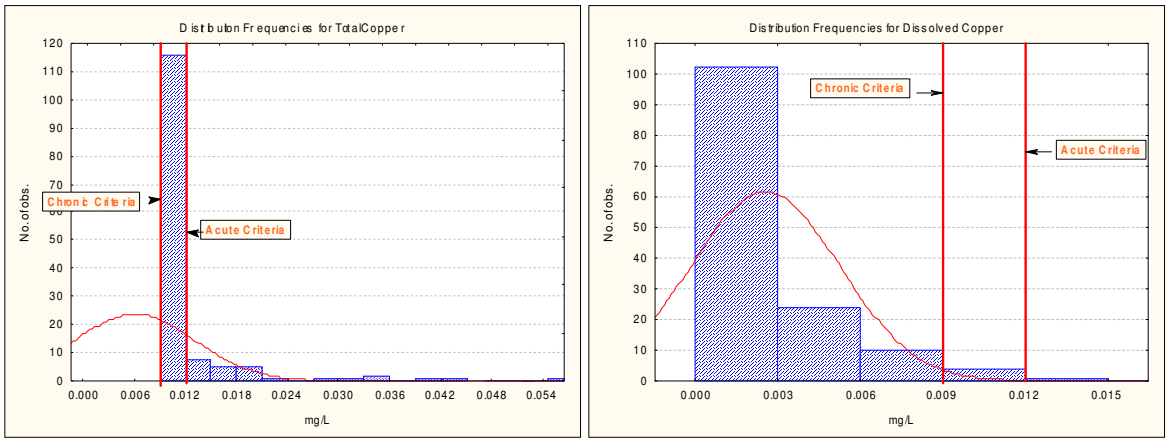


Figure 9-3: Frequency distributions by concentration for Total Copper and Dissolved Copper for the 2007 Patapsco/Back River Basin samples.

The baseflow data collected in 2007 were analyzed for differences in concentration for each pollutant between the six watersheds sampled. ANOVA and Duncan's Multiple Range tests were used to examine relationships among the watersheds. The results are displayed in Table 9-1. The results of the Duncan's Multiple Range Test are displayed with the watersheds having the highest concentrations to the left and progressing in order to the lowest concentrations on the right. The watersheds joined by the same line are not significantly different.

Table 9-1: Baseflow Pollutant ANOVA and Duncan's Multiple Range Test Results

Pollutant Parameter	df Effect	Df Error	F	P
pH	4	142	1.18	NS
TSS	4	142	0.77	NS
TS	4	143	8.12	<.001
TKN	4	133	.36	NS
Nitrate/Nitrite	4	136	5.05	<.001
TP	4	133	1.26	NS
OP	4	136	0.96	NS
Cadmium	4	137	0.43	NS
Dissolved Cadmium	4	137	0.43	NS
Total Copper	4	137	4.32	<.01
Dissolved Copper	4	137	4.33	<.01
Total Lead	4	137	1.38	NS
Dissolved Lead	4	137	0.77	NS

Pollutant Parameter	df Effect	Df Error	F	P
Zinc	4	137	1.01	NS
Dissolved Zinc	4	137	1.27	NS
BOD	4	143	1.27	NS
COD	4	143	2.54	<.05
Chloride	4	127	8.82	<.001
Hardness	4	133	15.45	<.001
Sodium	4	133	13.94	<.001
Magnesium	4	115	2.98	<.05
Calcium	4	115	16.35	<.001

Duncan's Multiple Range Test

TS	GW BR JF PA LI
Nitrate/Nitrite	LI JF GW BR PA
Total Copper	PA GW LI JF BR
Dissolved Copper	PA GW LI JF BR
Chemical Oxygen Demand (COD)	PA GW BR JF LI
Chloride	BR JF GW PA LI
Sodium	BR JF PA GW LI
Hardness	GW BR JF PA LI
Magnesium	JF GW BR PA LI
Calcium	BR GW JF PA LI

The concentrations of ten parameters were found to differ significantly between watersheds. No single watershed was dominant in highest concentrations; they were fairly spread out among the watersheds. The Patapsco River and Back River watersheds each had the highest concentrations for three parameters; the Patapsco River was the highest for Total and Dissolved Copper and COD and the Back River was highest for Chlorides, Sodium and Calcium. The Gwynns Falls was highest for TS and Hardness. Liberty Reservoir and Jones Falls were each highest for one parameter, NO_2/NO_3 and Magnesium, respectively. Unlike the highest concentrations for the ten parameters, Liberty Reservoir was lowest in concentrations most frequently. Liberty was lowest for seven parameters including TS, COD, Chlorides, Sodium, Hardness, Magnesium, and Calcium. Figure 9-4 displays the results of the Duncan's Multiple Range Test for COD, NO_2/NO_3, Dissolved Copper, and Chlorides. Figure 9-5 displays the results for Dissolved Copper, Nitrate/Nitrite, Chloride, and Total Phosphorus, as these are pollutants of major concern.

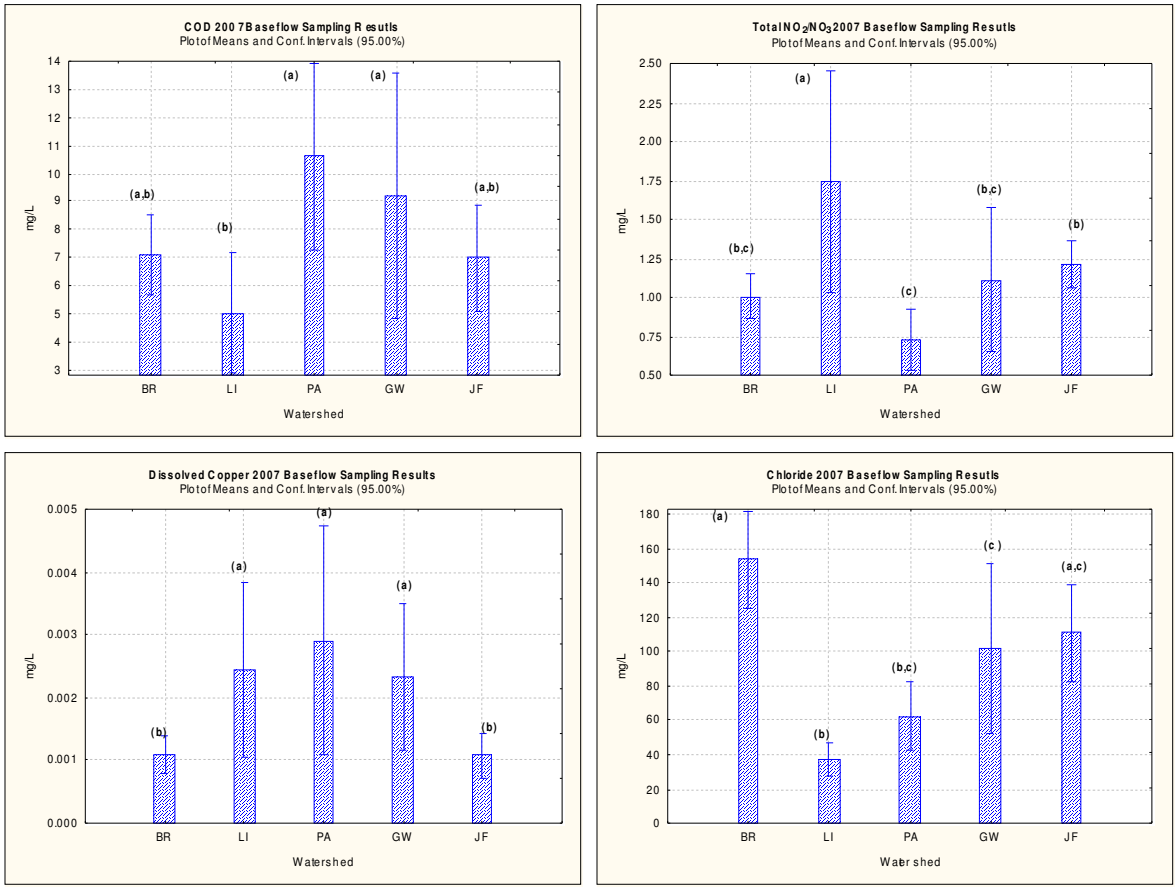
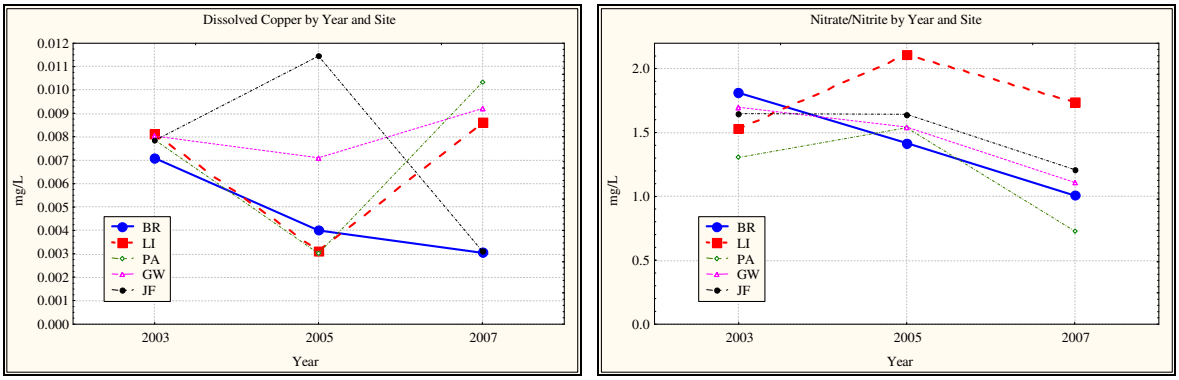


Figure 9-4: Duncan's Multiple Range Test results for COD, NO_2/NO_3, Dissolved Copper, and Chlorides.

Figure 9-5: Baseflow Dissolved Copper, Nitrate/Nitrite, Chloride, and Total Phosphorus for sampling years 2003, 2005, and 2007



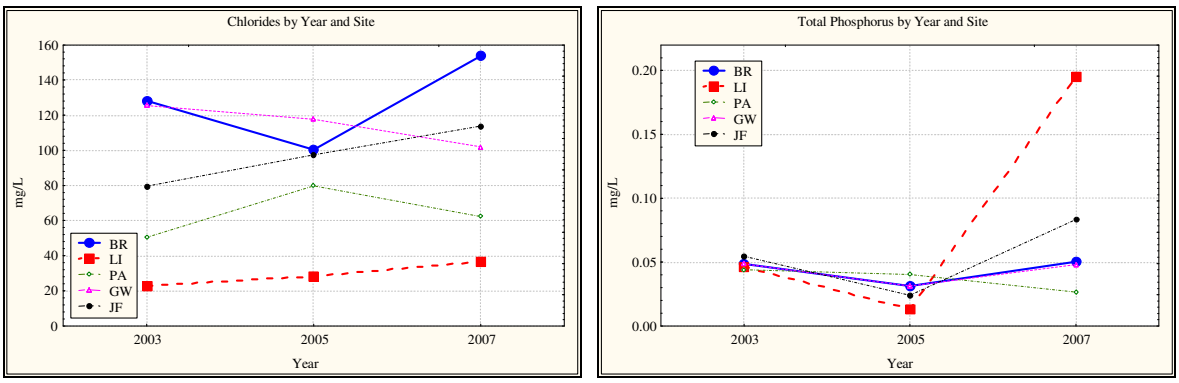


Figure 9-5: Baseflow Dissolved Copper, Nitrate/Nitrite, Chloride, and Total Phosphorus for sampling years 2003, 2005, and 2007 (continued).

Several interesting trends can be seen from the graphs in Figure 9-5.

For dissolved copper:

- Gwynns Fall, Liberty Reservoir, and Patapsco River all fell in 2005 and rose again 2007, while Back River continues its declining trend.
- Jones Falls rose in 2005, but fell dramatically in 2007 from .01 mg/L to .0003 mg/L.

For nitrate/nitrite:

- Patapsco River had the most dramatic change between 2005 and 2007, falling from 1.54 mg/L to 0.73 mg/L.
- Liberty Reservoir declined during this period as well.
- The Jones Falls, Gwynns Falls and Back River continue their declining trend.

For chlorides:

- The Jones Falls and Liberty Reservoir have been increasing since 2003.
- Back River had the most dramatic increase from 100.34 mg/L to 153.73 mg/L.
- Patapsco fell from 2005 to 2007 and Gwynns Falls continues its decline.

For total phosphorus:

- Jones Falls, Back River, and Gwynns Falls all fell from 2005 to 2007.
- Liberty Reservoir followed a similar trend, rising from .013 mg/L to .19 mg/L.

Two map displays showing the Nitrate/Nitrite and Total Phosphorus mean concentrations are shown in Figures 9-6 and 9-7 on the following two pages. As can be seen from Figure 9-6, the highest concentrations of Nitrate/Nitrite predominate in the agricultural portions of the County. These increased Nitrate/Nitrite concentrations may be the result of agricultural activities, septic system inputs, or a combination of both. Several of the urban areas, scattered in the various watersheds, show elevated Nitrate/Nitrite concentrations.

The distribution of Total Phosphorus concentrations conversely shows elevated to very high concentrations predominately in the urban areas, with several notable exceptions, including Liberty Reservoir, a rural Lower Gunpowder site, and one site in Deer Creek. The majority of

Total Phosphorus is delivered during storm events, associated with sediment. Thus the concentrations measured in baseflow sampling are much lower than during storm event sampling. The elevated concentrations in the urban areas are likely the result of increases in orthophosphate, which occurs in a dissolved form. The source is currently not known, but may be associated with sewage and various industrial processes. The elevated and very high concentrations in rural areas may be associated with animal operations where livestock have access to the stream.

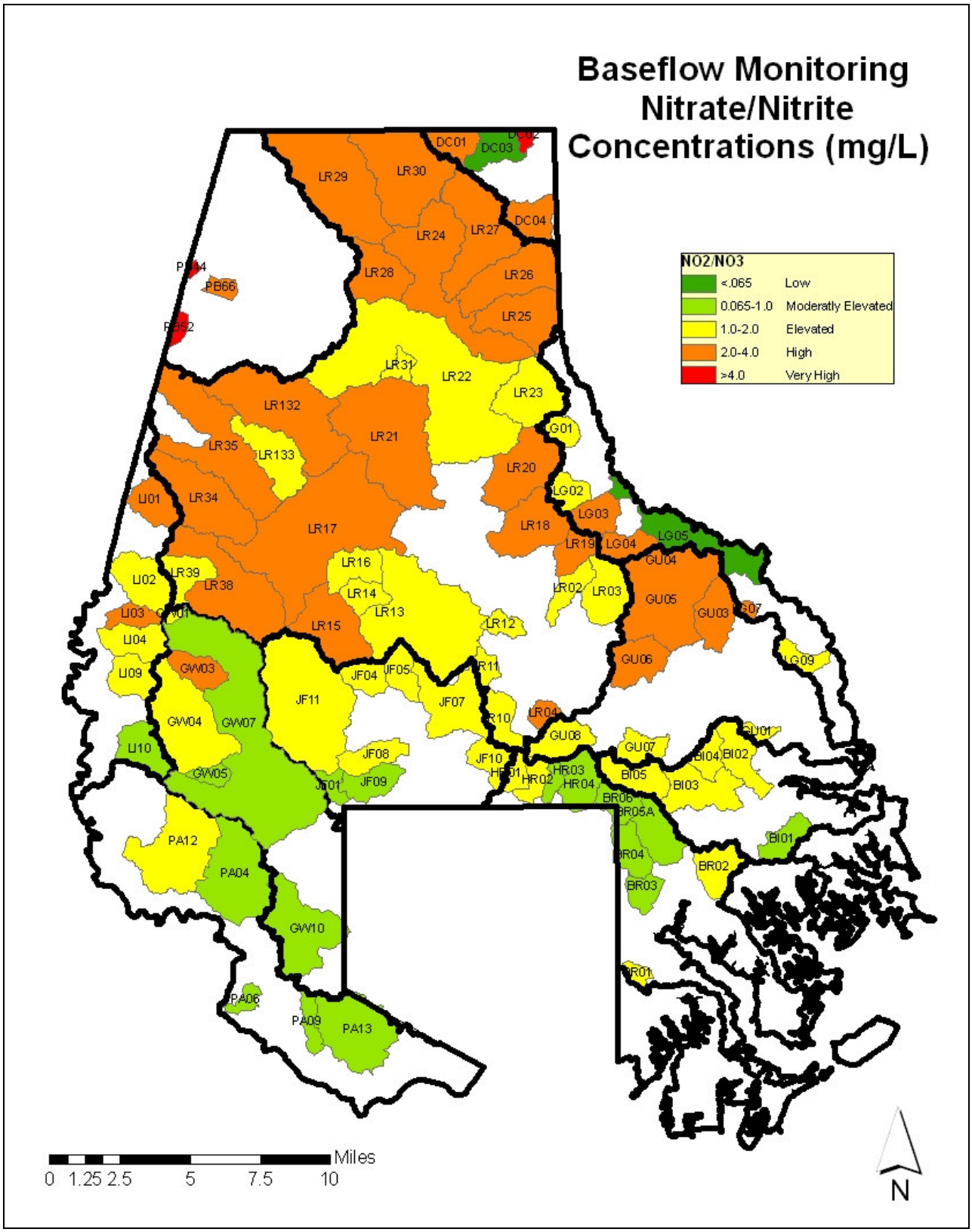


Figure 9-6: Baseflow Nitrate/Nitrite mean concentrations for monitoring years 2007 (Patapsco/Back River Basin) and 2006 (Gunpowder Basin). **PB26, PB28, PB33, PB43, and PB54 not shown on map. They were part of the Prettyboy Reservoir Watershed Restoration Strategy project and located outside the county.

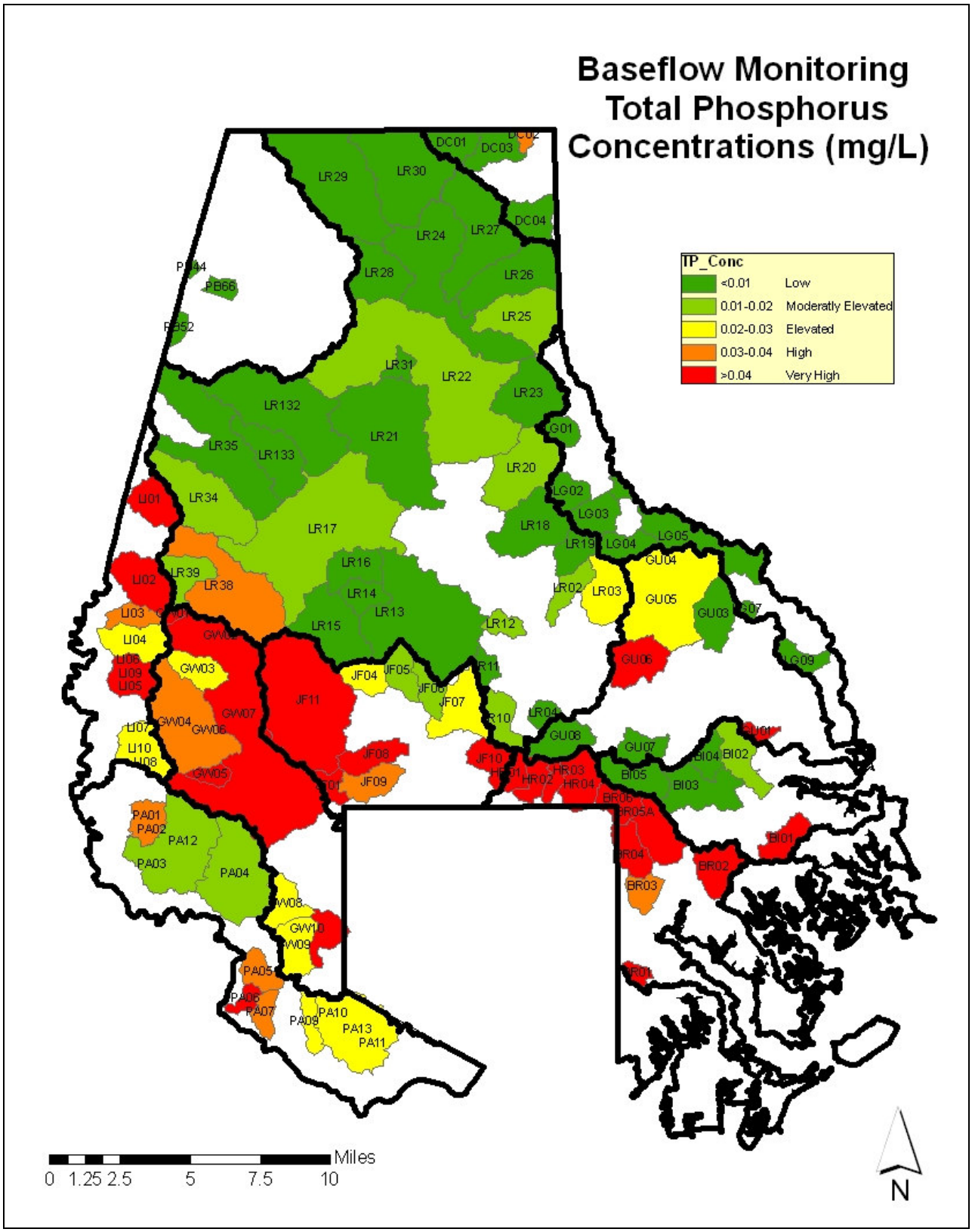


Figure 9-7: Baseflow Total Phosphorus mean concentrations for monitoring years 2007 (Patapsco/Back River Basin) and 2006 (Gunpowder Basin). **PB26, PB28, PB33, PB43, and PB54 not shown on map. They were part of the Prettyboy Reservoir Watershed Restoration Strategy project and located outside the county.

9.2.2 Tidal Waters Monitoring Program

Baltimore County has had a tidal recreational water-monitoring program since 1970. Early bacteriological sampling was conducted on a monthly basis between, Labor Day and Memorial Day, for fecal coliform. Since 2000, and the advent of the US EPA Beach Act, tidal water sampling has been conducted bi-weekly by boat for the indicator organism Enterococci. The sampling season has been extended to cover the period of April through November (weather permitting). Multiple bacteriological samples are taken in 10 zones representing areas of heavy recreational use with 4 single grab samples taken in less utilized areas. In addition, beach sampling also utilizing Enterococci is conducted at 3 permitted beach locations, on a basis alternate to recreational water sampling.

Individual sample results are recorded as well as the Geometric Mean of multiple sample zones. A value of 35 MPN (geomean) Enterococci is required to be utilized as a threshold for public safety and water contact only in association with a known or suspected sewage overflow. 35 MPN is otherwise used for comparison purposes to make general characterizations of open water.

Special sampling is also conducted to support environmental/public health evaluations after severe storm events or sanitary sewage overflows.

Starting in 2002, chemical sampling of surface waters was initiated at 7 locations designed to represent major county tidal basins. This sampling takes place during the recreational water-sampling run and has recently been expanded to ten locations. The codes for those locations as noted on the " Beach, Beach Area, And Recreational Water Sampling Locations" map and the tidal water basins they represent are found on Table 9-2.

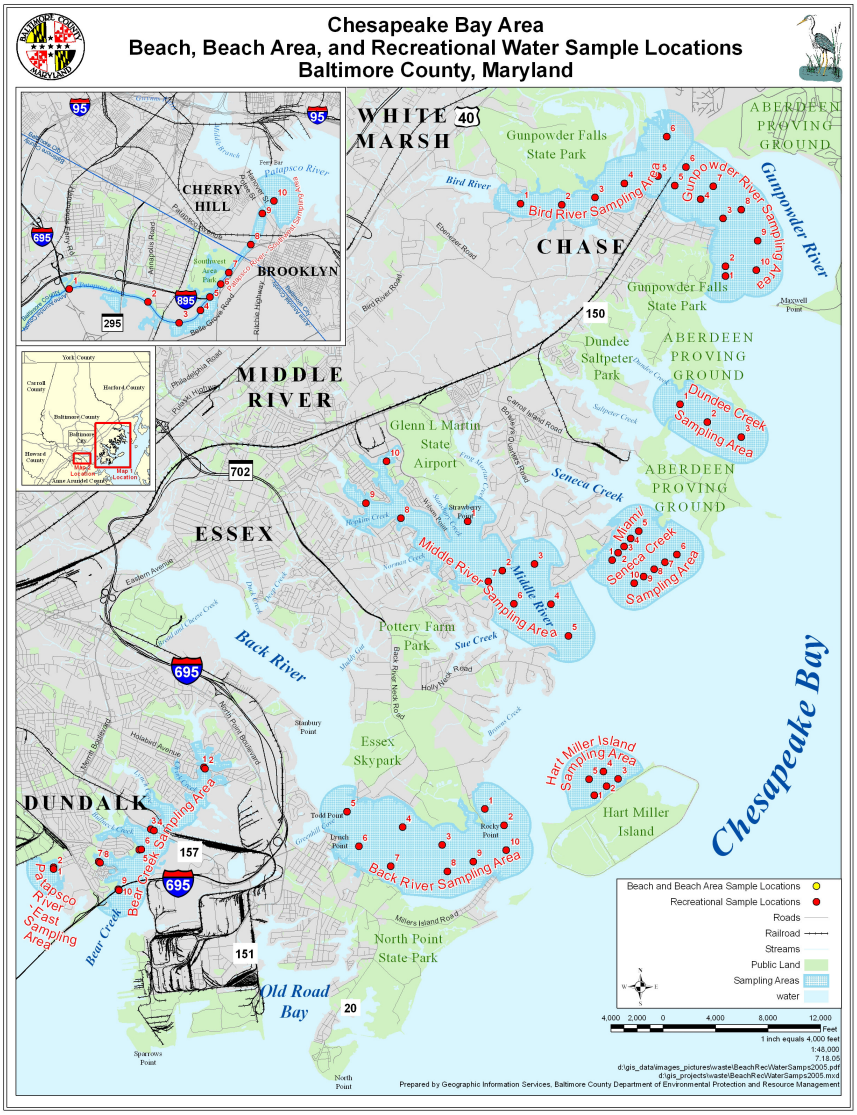


Figure 9-8: Tidal Waters Monitoring Site Locations.

Table 9-2: Site Codes and the Associated Tidal Water body

Code	Water Body
BC	Bear Creek
PR	Patapsco River - Outer
GR	Gunpowder River
MS	Miami Beach/Seneca Creek
MR	Middle River
BR	Back River
HM	Hart Miller Island
BD	Bird River
PS-F	Patapsco River – Fresh Water
PS-E	Patapsco River – Estuarine

All ten stations were monitored between fourteen and eighteen times during the time period of April 2007 through November 2007. The same standard set of pollutant parameters detailed in Section 9.1.1, were monitored in the tidal waters, excluding Magnesium, Calcium, pH and

temperature. The data are summarized by site in Appendix 9-3, which presents the means, number of samples and the standard deviation for each pollutant parameter presented.

An analysis of variance (ANOVA) was used for each pollutant to determine if there were significant differences between the ten sites. The results of the ANOVA are displayed in Table 9-3. Analyses were not run on Ortho-phosphorus, Cadmium, and Fluoride because there was no variance in the samples. If a significant difference was found a post hoc Duncan's Multiple Range Test was used to determine which sites were significantly different. The results of the Duncan's Multiple Range Test are presented at the end of Table 9-3. When interpreting the results of the Duncan's Multiple Range Test, the sites are arranged from highest concentration of the parameter to the lowest concentration. The same line joins the sites that are not significantly different.

Table 9-3: ANOVA and Duncan's Multiple Range Test Results

Pollutant Parameter	df Effect	Df Error	F	P
TSS	9	148	3.81	NS
TS	9	148	18.27	<.001
TKN	9	150	12.45	<.001
Nitrate/Nitrite	9	122	1.00	NS
TP	9	150	2.55	<.01
Total Copper	9	150	2.62	<.01
Dissolved Copper	9	150	2.60	<.01
Total Lead	9	150	4.20	<.001
Dissolved Lead	9	150	3.57	<.001
Total Zinc	9	150	1.69	NS
Dissolved Zinc	9	150	1.56	NS
BOD	9	151	7.07	<.001
COD	9	152	2.33	<.05
Chloride	9	141	15.18	<.001
Sulfate	9	140	15.65	<.001

Duncan's Multiple Range Test

Total Solids (TS)	PR BC PS-E HM MS MR BR GR BD PS-F
Total Kjeldahl Nitrogen (TKN)	BR PR PS-E BD BC PS-F MR GR HM MS
Total Phosphorus (TP)	BR BC PR BD PS-E HM GR MR MS PS-F
Total Copper	PR BC MR HM PS-E GR MS BD BR PS-F
Dissolved Copper	PR BC MS MR HM PS-E GR BR BD PS-F
Total Lead	PR BC P-SE MS MR BR HM PS-F BD GR
Dissolved Lead	PR BC MS HM GR MR BR PS-E PS-F BD
Biological Oxygen Demand (BOD)	PR BR BC PS-E BD HM PS-F MR MS GR
Chemical Oxygen Demand (COD)	PR BC BR MS HM PS-E BD MR GR PS-F
Chloride	PR BC PS-E HM MS BR MR GR BD PS-F
Sulfate	PR BC PS-E HM MS BR MR GR BD PS-F

Sampling results for 2007 indicated that eleven of the parameters (TS, TKN, TP, Total Copper, Dissolved Copper, Total Lead, Dissolved Lead, BOD, COD, Chloride, and Sulfate had mean concentrations that differed among sites.

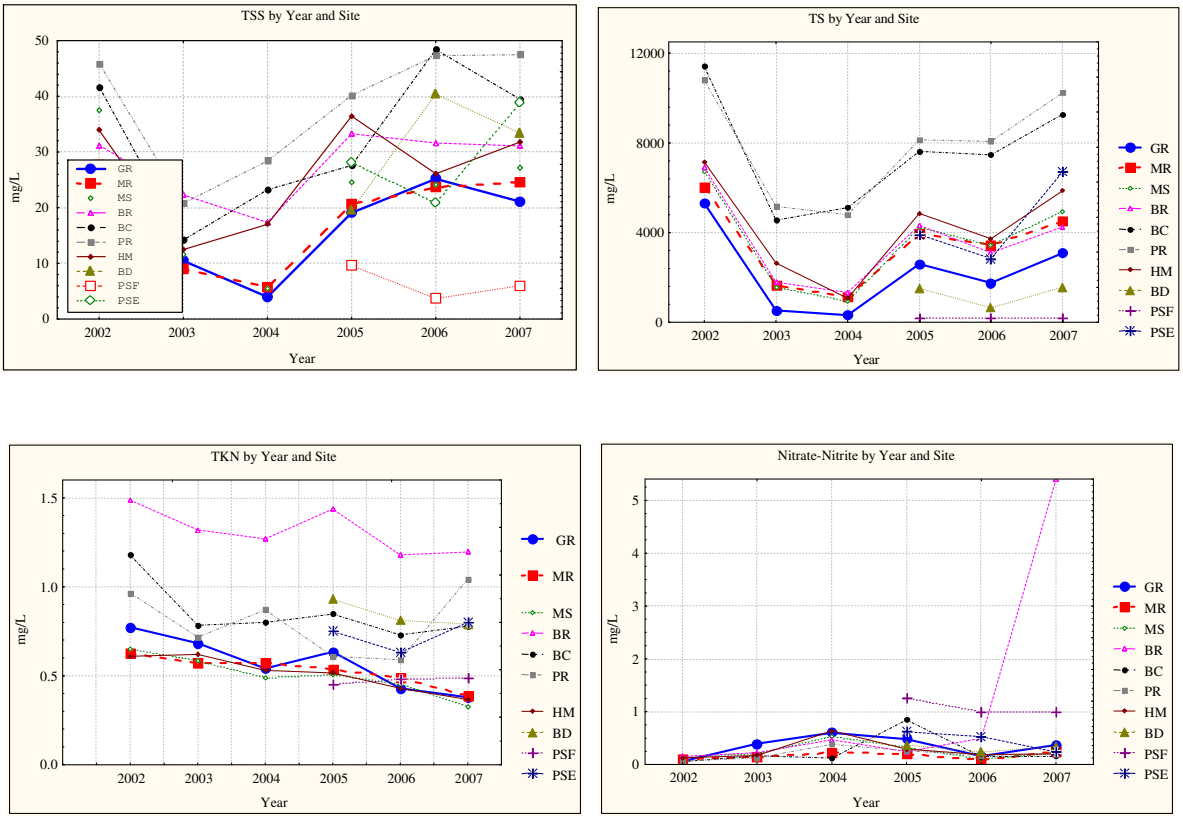
There were few changes in the relative ranking of the sites from highest to lowest between years for the eleven parameters that were found to have a significant difference among sites. Both the TS and chloride parameters for the Patapsco River (PR) and Bear Creek (BC) sites had the highest concentrations. This would indicate that these sites had the highest mean salinity. Back River (BR) along with the Patapsco River-Outer had significantly higher TKN concentrations than the other nine sites. This is probably due to the presence of the Waste Water Treatment Plant (WWTP) in both these areas. BD (Bird River) and BC (Bear Creek) also have relatively high TKN concentrations and were joined by PS-E (Patapsco River – Estuarine), the same as last year. This may also be related to the relatively poorer connection with open bay waters and the presence of algal populations, which would increase the organic nitrogen concentration. BR

(Back River) had the highest concentration and PS-F had the lowest concentration for Total Phosphorus mean concentrations, the same as last year. The presence of the Back River WWTP could account for the elevated concentrations of Total Phosphorus. The Patapsco River (PR) and Bear Creek (BC) sites had the highest and second highest mean concentrations of total and dissolved lead and total and dissolved copper. These sites have significant amounts of industrial activity in the watershed, which may account for the relatively higher metal concentrations.

Patapsco River (PR), Back River (BR), had the highest mean concentrations for biological oxygen demand. These two these sites also had the highest elevated TKN levels. This could indicate that the two sites had a greater algal population than the other sites. This would result in an increase in the biological oxygen demand. The Patapsco River (PR) and Back River (BR) also had the highest concentrations for COD and Sulfate.

A graphical comparison between years for site and select pollutants was conducted. Bird River (BD), PS-F (Patapsco River – Fresh), and PS-E (Patapsco River – Estuarine) have only three years of data. The results are presented in Figure 9-9.

Figure 9-9: Pollutant Between Year Variation by Site



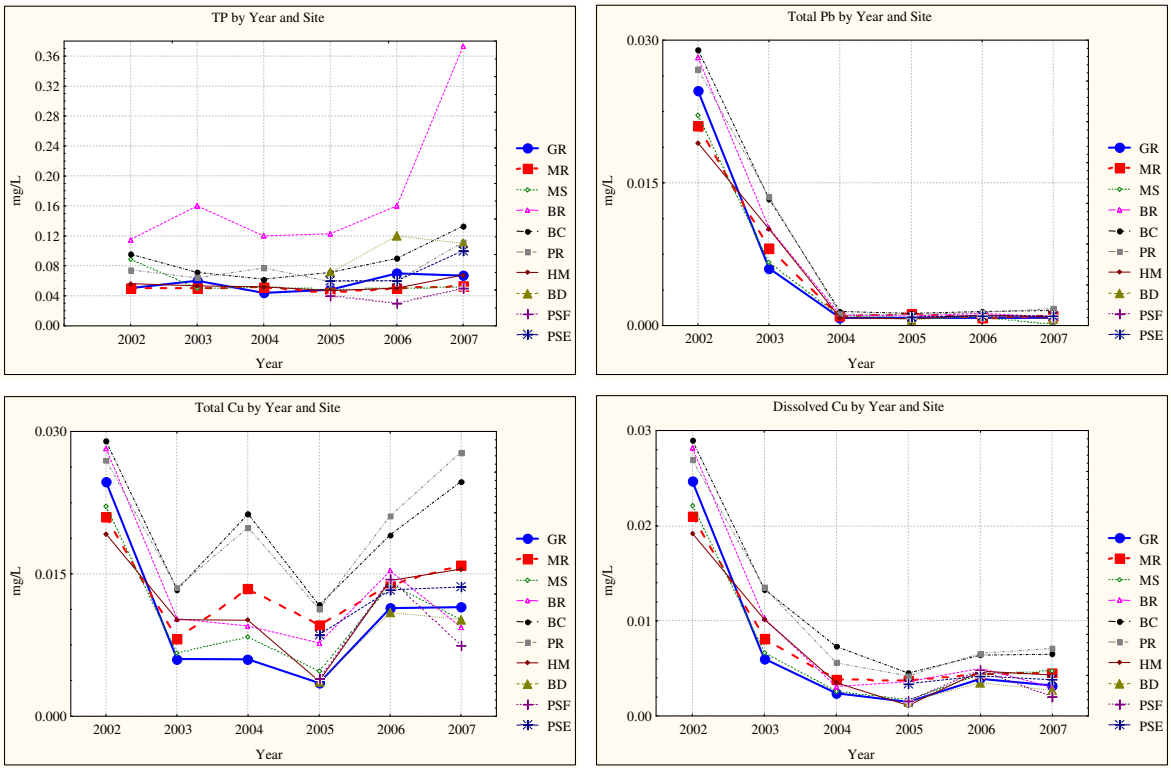


Figure 9-9: Pollutant Between Year Variation by Site (continued).

Several interesting trends can be seen from the graphs in Figure 9-9.

For Total Suspended Solids (TSS):

- All the sites are following the same trend except PSF (Patapsco River- Fresh), which has much lower levels than the other sites.
- A noted decrease in concentrations for all sites can be noted between 2002 and 2003.
- Since 2004, there has generally been an increasing trend.

For Total Solids (TS) and Total Copper:

- The TS reduction between 2002 and 2003 is undoubtedly related to the reduced salinity that resulted from the increased runoff.
- There was an increase in 2005 for all sites.
- From 2006 to 2007 there was again a moderate increase for all sites except PSF.
- Some sites had a slight increase in concentration and some with a slight decrease in 2004 relative to 2003.
- In 2005, all sites exhibited an increase in TSS concentrations while at the same time displaying a decrease in Total Copper concentrations.
- For 2007, both TSS and Total Copper increased, except for Total Copper levels in BR (Back River) and MS (Miami Beach/Seneca Creek).

For Dissolved Copper and Total Lead:

- They both continued to decrease in 2004 and 2005 for all sites.
- For 2007, Dissolved Copper decreased slightly in about half the sites including BD, GR, PSF, and BR while the remaining sites held steady.
- Total Lead held steady in 2006 and 2007.

For Nitrate/Nitrite:

- Concentrations increased in 2004 (with the exception of Bear Creek) relative to the 2003 and 2002 concentrations
- They decreased in 2005 (except for the HM site).
- Concentrations saw a large decrease in 2006, with the exception of Back River (BR), which increased by 48%.
- In 2007, there was a slight increase except in Back River (BR). In Back River (BR) there was a sample taken on May 15 that exhibited the extraordinarily high concentration of 67.24 mg/L. The mean without this outlier goes from 5.40 mg/L to 0.24 mg/L.
- PSF generally has higher concentrations than the other sites.

For Total Kjeldahl Nitrogen (TKN):

- Concentrations continue to decrease or stay about the same, except for PR (Patapsco River) and PSE (Patapsco River – Estuarine), which increased significantly in 2007.

For Total Phosphorus:

- Concentrations have varied little over the years.
- However, there was a slight increase in 2006, which continued in 2007.
- Total Phosphorus in Back River (BR) had one sample taken in August that was much higher (3.16 mg/L) than the other samples, and raised the mean concentration for that area. The mean without this outlier goes from 0.37 mg/L to 0.19 mg/L

9.3 Stream Geomorphological Monitoring

Baltimore County DEPRM performs post-project monitoring of its completed stream restoration projects in accordance with applicable federal and state waterway construction permit requirements. The field monitoring and reports are either done completely in-house or by consulting firms competent in this work. These monitoring activities also provide compliance with the NPDES permit requirement to monitor effectiveness of restoration projects.

9.3.1 Stream Restoration Project Monitoring

The U.S. Army Corps of Engineers authorization for stream restoration activity is generally required pursuant to Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act of 1899. Additionally, projects are normally eligible for authorization by the Maryland State Programmatic General Permit (MDSPGP) as published in the Special Public Notice 96-19 issued in June, 1996. For these projects, the conditions of the (MDSPGP) authorization normally require the development of a monitoring plan that will be used to identify and evaluate changes in the completed stream restoration project and to take remedial measures as necessary in coordination with the regulatory agencies. For each project, specific elements of

the monitoring plan are identified as determined by the regulatory agencies. See Exhibit 5-1 of the 2003 NPDES Report for an example of an authorization document/permit and monitoring criteria. Periodic field monitoring followed by a written report of findings and any proposed remedial measures are submitted to the Army Corps of Engineers, Maryland Section Northern and to the Maryland Department of the Environment (MDE) Non-Tidal Wetland and Waterways Division as called for in the monitoring plans. Monitoring is also utilized to determine if the capital project implementation meets the goals of the project. Further, the DEPRM believes that the post construction monitoring program provides valuable feed-back information that enables it to improve the effectiveness of its future project design and construction approaches.

The post construction monitoring plans require periodic collection of field data – usually annually for 2 to 5 years. Additional monitoring may be required after large storms. In most cases, monumented and surveyed channel cross-sections located at strategic points along the project are required. Occasionally, longitudinal profiles are required or elected to be done by DEPRM. Field data are collected using Standard Operating Procedures for pebble counts, cross sectional surveys, and longitudinal surveys. Data from the cross-sections and longitudinal surveys are entered into a computer program and plotted. For multi-year surveys these plots are overlayed (current over prior year(s)) to detect any changes in morphology that may have occurred between these periods. Bed material characterization via the Wolman pebble count procedure, inspection of the condition of any riparian plantings, visual inspection of the degree of channel erosion or deposition etc., and photographing the channel and banks at key locations are other components that may be included in the monitoring plan and report.

Table 9-4 summarizes the streams and stream restoration projects monitored and/or reported to the regulatory agencies in 2007. Copies of the completed reports submitted and listed in Table 9-4 are on file at the Maryland Department of the Environment (MDE) Non-Tidal Wetland and Waterways Division and at the DEPRM CIP Section where they are available for inspection.

Table 9-4: Summary of Capital Improvements Projects Monitoring Reports Submitted for 2007

Project	Submitted	Responsible Personnel
Hampton Branch Stream Restoration	2007	In-House WMM
Minebank Run II Stream Restoration	2007	GPI
North Fork Stream Restoration	2006	KCI
Stemmers Run at Glenwest Stream Restoration	2007	In-House WMM
White Marsh Run Wetland	2007	Sub KCI
Woodvalley Stream Restoration	2007	In-House WMM

9.3.2 Stream Stability Assessments

DEPRM is utilizing consulting assistance through a multi-year on-call contract to perform planning level stream stability assessments on various streams in Baltimore County. These assessments entail field teams who "cruise", by walking, assigned stream reaches collecting morphological, riparian, habitat quality, and other data useful in making evaluative assessments of stream condition and evidence of change. Other information will be collected related to infrastructure conflicts, pollution sources, fish blockages, etc. The stream assessments will be in support of the Small Watershed Action Plan (SWAP) process, TMDL's, and for comparison of baseline conditions and stream management/restoration needs, and for consideration of potential stream restoration projects. Four stream stability assessments have been completed to date: *Hunt Valley Stream Stability Assessment, Prettyboy Reservoir Stream Stability Assessment (Compass Run and Frog Hollow Subwatersheds), Lower Jones Falls Stream Stability Assessment, and*

Upper Back River Stream Stability Assessment. An electronic copy of these reports was submitted with the NPDES 2006 Annual Report. Electronic copies of the Lower Jones Falls and Upper Back River reports are included with this report. These assessments have identified potential restoration projects by category, including:

- Stream restoration/stabilization,
- Buffer enhancement,
- Bank plantings,
- Utility conflict resolution,
- Habitat enhancement,
- Trash cleanup,
- Yard waste cleanup, and
- Invasive species removal.

9.3.3 Geomorphological Monitoring Summary

In summarizing the results of the in-house monitoring completed through 2006 and mid year 2007, it can be stated that the stream restoration projects have been successful in achieving the goals of self-maintaining channel stability, reduction of bed and bank erosion, protection of private and public infrastructure, and habitat improvement. Improvements in aesthetics and public safety aspects have been additional benefits. Most of the problems observed have been localized and minor in scale such as shifting of rock elements in grade control structures, bank scouring at the downstream end of bank protection structures, depositional bar build-up in the vicinity of grade control structures, and channel erosion at intra project segments that were not restored or modified during the overall project. The information gained from the monitoring has enabled DEPRM to improve its stream restoration approaches such as increasing the size of the rock elements in grade control structures subject to high tractive forces, and more closely relating the height of bank protection structures to bank full elevation. The challenges of effective stream improvement in an urban setting are formidable. Through the knowledge and experience gained with its design, construction, and monitoring efforts, DEPRM continues to build upon a successful stream restoration program.

9.4 Biological Monitoring

In addition to the biological monitoring required at Scotts Level Branch under Baltimore County's NPDES permit, the County has four additional biological monitoring programs. These programs use the biological community to assess the ecological health of the streams within the County (Probabilistic Monitoring Program, Section 9.4.1), assess the effectiveness of stream restoration projects (CIP Monitoring Program, Section 9.4.2), provide data on the best streams in Baltimore County to serve as bench marks for other stream assessments (Reference Site Monitoring Program, Section 9.4.3), and assess Submerged Aquatic Vegetation (Submerged Aquatic Vegetation (SAV) Monitoring Program, Section 9.4.4). The first three programs use assessments based on the benthic macroinvertebrate community and, in some cases, the fish assemblage. It is widely accepted that the biological community of streams is sensitive to anthropogenic perturbations. By monitoring the biological community, the County can assess the amount of change due to anthropogenic activities and the benefit of stream restoration to stream organisms. The SAV Monitoring Program provides an assessment of the coverage of SAV and progress made in meeting the new water quality standards for water clarity and SAV coverage in Baltimore County tidal waters.

9.4.1 Probabilistic Monitoring

The County adopted Maryland Biological Stream Survey (MBSS) methodologies in 2003, which has allowed for direct comparisons with State generated data. This has expanded upon the available data for assessing County waters. Probabilistic monitoring (randomly selected monitoring sites) has allowed statistically valid statements regarding the state of the waters. Using the targeted site monitoring design, as was conducted previously by Save Our Streams (SOS), did not allow for statistical analysis or direct data comparability with the State.

The County has contracted a consultant to perform the probabilistic monitoring. Each year a different basin is sampled, with the Patapsco/Back River Basin monitored in odd years and the Gunpowder River Basin and Deer Creek watersheds monitored in the even years. One hundred sites are selected at random for each year's sampling effort. The contractor samples these 100 sites during the spring index period, March 1 to April 30, for macroinvertebrates using the MBSS protocols. These samples are sub-sampled to 100 organisms and identified to Genus or the lowest possible taxonomic level. A Benthic Index of Biotic Integrity (BIBI) is calculated. The BIBI describes the biological condition of the streams in the County. In 2006, a subset of previously sampled random sites was selected to serve as sentinel sites. The sites were located towards the base of major subwatersheds. Eighteen sentinel sites were selected in the Patapsco/Back River basin, and 13 sentinel sites were selected in the Gunpowder/Deer Creek basin. The sentinel sites will be used to monitor biological condition over a range of watershed and stream conditions.

The current BIBI uses six metrics. These six metrics, what they measure and the expected response to stressors are displayed in Table 9-5.

Table 9-5: BIBI Metrics

BIBI Metric	Metric Measure	Expected Response
Number of Taxa	Species Richness	Decrease
Number of EPT	Species Richness	Decrease
Number of Ephemeroptera	Species Richness	Decrease
Percent Intolerant to Urban	Tolerance/Intolerance	Decrease
Percent Chironomidae	Taxonomic Composition	Increase
Percent Clingers	Habit	Decrease

The results for each site from the 2007 probabilistic monitoring are displayed in Appendix 9-4 at the end of this section. The sites are grouped by subwatershed and 12-digit watershed, along with their respective BIBI and condition rating. The sites are assigned condition ratings based on the BIBI scores, with 1.00 – 1.99 being "Very Poor," 2.00 – 2.99 being "Poor," 3.00 – 3.99 being "Fair," and 4.00 – 5.00 being "Good." Figure 9-10 displays the site condition by color code for each of the 192 sites sampled in 2004 and 2005. Figure 9-11 displays the same information for sites sampled in 2006 and 2007, respectively.

Table 9-6 shows the results, by watershed, as the percentage of sites within each BIBI range. The Patapsco/Back River Basin data show an improvement in biological condition. Sites within the Good and Fair categories increased from 15% in 2003 to 44% in 2007. This may be the result of natural stress from the drought of 2002 and record wet year of 2003, with a subsequent recovery in 2005. Continued low, but stable flows between 2005 and 2007 may have allowed for better recruitment and subsequent expansions in density and diversity of benthic macroinvertebrate populations. Liberty Reservoir had all 20 sampled sites in the Fair and Good

categories in 2007. As in 2005, Jones Falls had the next highest percentage of sites in the Fair and Good categories (46%).

The 2004 and 2006 sampling results for the Gunpowder Basin/Deer Creek watersheds indicated a decrease in water quality. In 2004, 79% of sites were in the Fair and Good categories, while in 2006 only 66% of sites rated Fair and Good. The biological condition of streams in the Gunpowder River/Deer Creek watersheds continues to be better than in Patapsco/Back River. Gunpowder River/Deer Creek streams had higher percentages of sites rated Fair and Good, and Patapsco/Back River had higher percentages of streams rated Very Poor and Poor. This is likely a reflection of higher population density and greater development pressure in Patapsco/Back River. However, over the entire county for the 5-year sampling period, the percentages of streams rated Fair and Good (47%) is roughly equal to percentage rated Very Poor and Poor (53%).

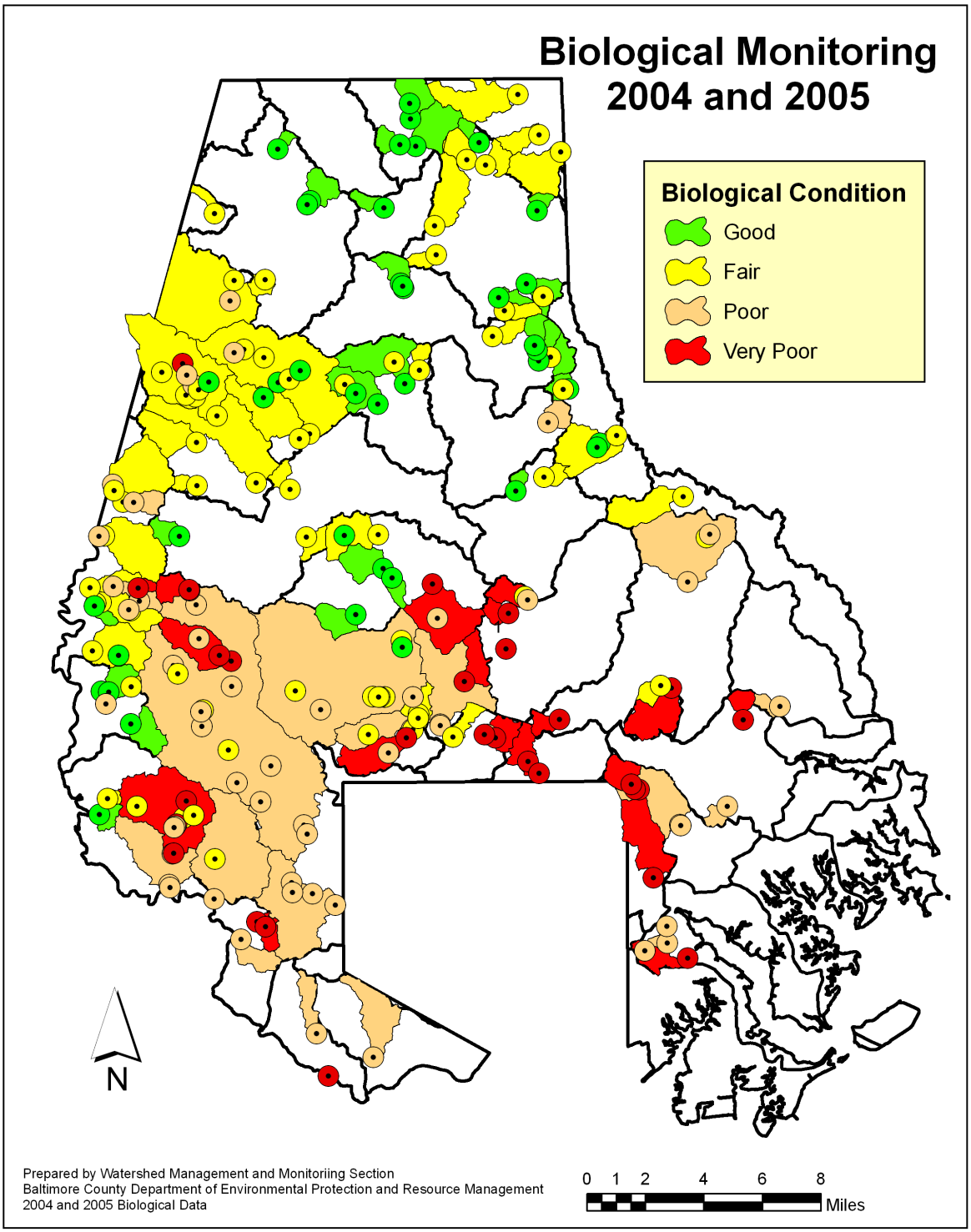


Figure 9-10: Probabilistic Biological Monitoring results for 2004 and 2005.

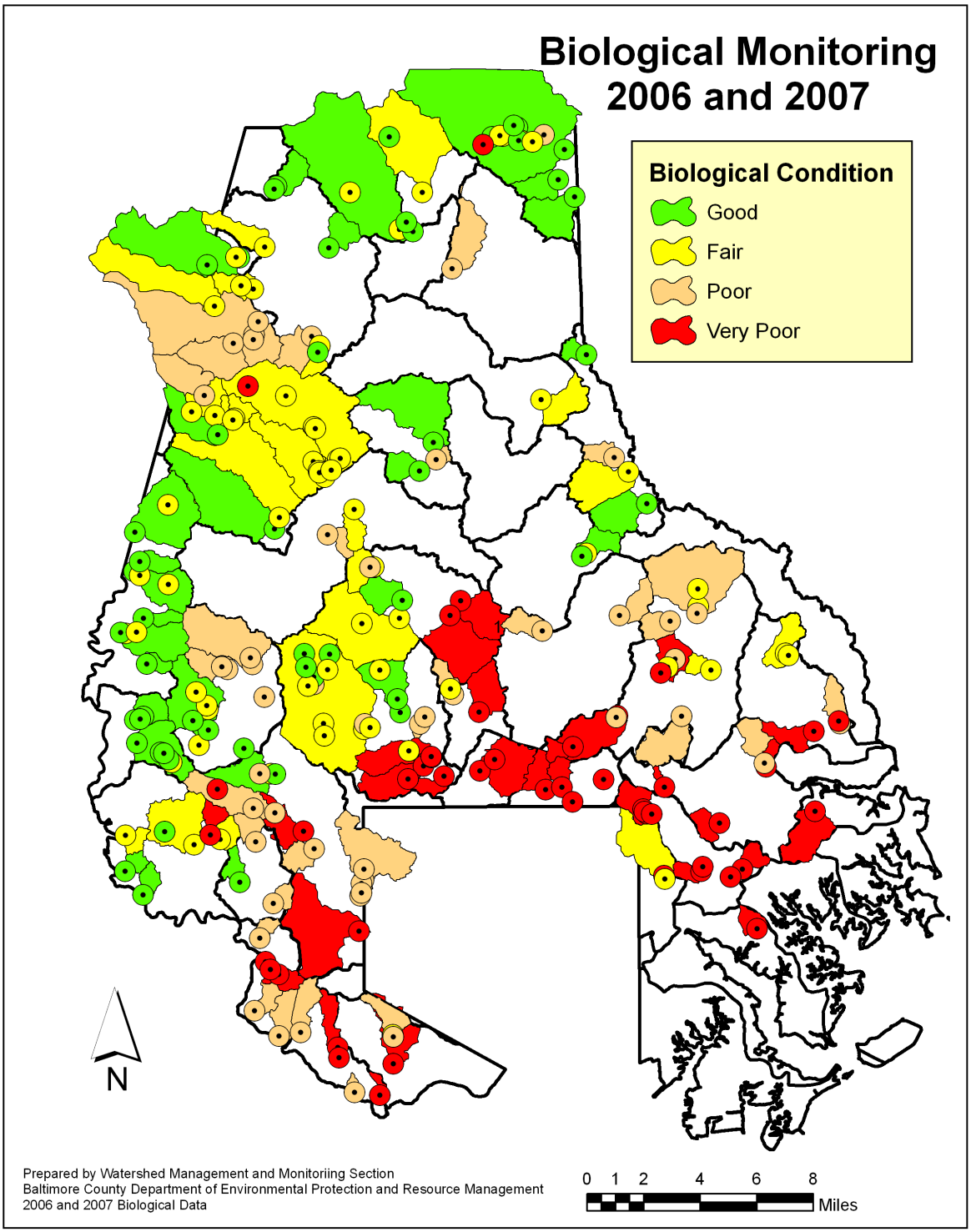
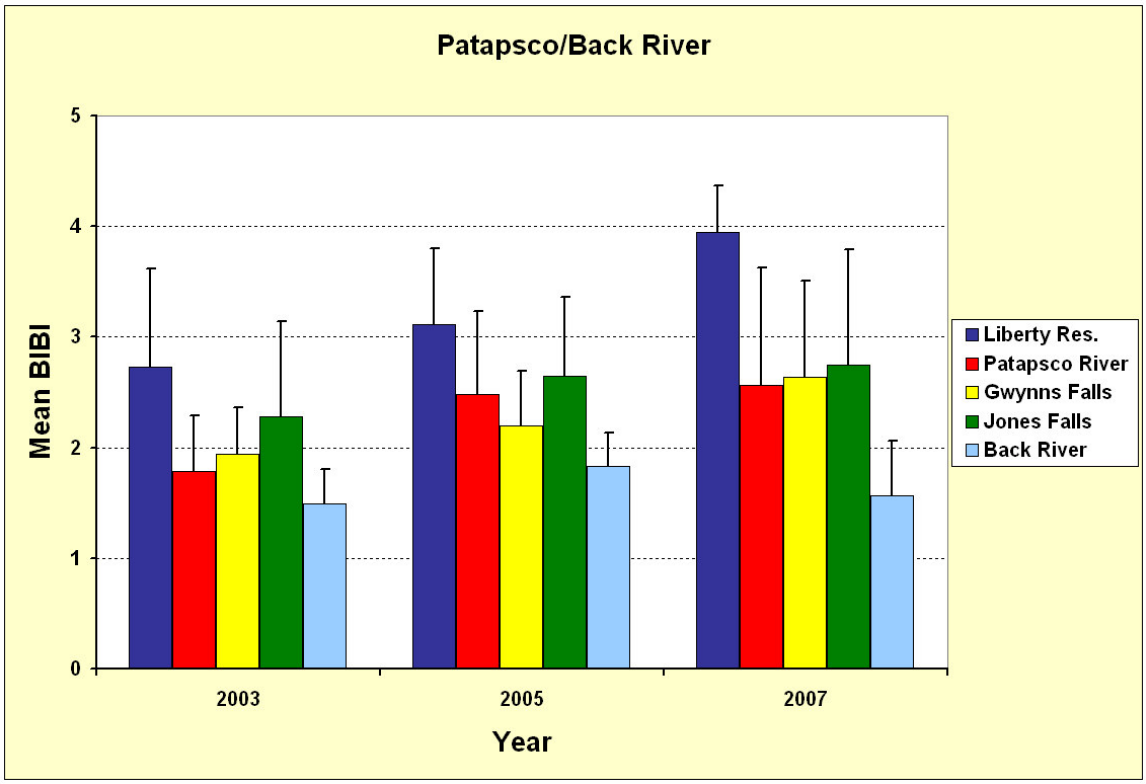


Figure 9-11: Probabilistic Biological Monitoring results for 2006 and 2007.

Table 9-6: BIBI Score Distribution by Watershed (% by Category)

Watershed	N	1.00-1.99 Very Poor	2.00-2.99 Poor	3.00-3.99 Fair	4.00-5.00 Good
Patapsco/Back River Basin – Sampled in 2003					
Liberty Reservoir	10	10	50	30	10
Patapsco River	13	54	46	0	0
Gwynns Falls	30	43	53	3	0
Jones Falls	32	38	31	25	6
Back River	15	87	13	0	0
Total	**100**	**46**	**39**	**12**	**3**
Gunpowder River Basin/Deer Creek – Sampled in 2004					
Deer Creek	3	0	33	67	0
Prettyboy Reservoir	7	0	14	43	43
Loch Raven Res.	67	6	9	43	42
Lower Gunpowder	7	29	43	29	0
Little Gunpowder	6	0	0	50	50
Bird River	2	50	50	0	0
Total	**92**	**8**	**13**	**42**	**37**
Patapsco/Back River Basin – Sampled in 2005					
Liberty Reservoir	22	5	32	41	23
Patapsco River	21	29	43	24	4
Gwynns Falls	22	18	68	14	0
Jones Falls	23	17	30	48	4
Back River	12	58	42	0	0
Total	**100**	**22**	**43**	**28**	**7**
Gunpowder River Basin/Deer Creek – Sampled in 2006					
Deer Creek	13	8	8	31	53
Prettyboy Reservoir	17	0	30	35	35
Loch Raven Res.	44	7	16	57	20
Lower Gunpowder	17	30	35	35	0
Little Gunpowder	4	0	25	25	50
Bird River	5	80	20	0	0
Total	**100**	**13**	**21**	**42**	**24**
Patapsco/Back River Basin – Sampled in 2007					
Liberty Reservoir	20	0	0	30	70
Patapsco River	24	33	33	17	17
Gwynns Falls	26	12	54	19	15
Jones Falls	28	29	25	25	21
Back River	19	84	11	5	0
Total	**117**	**30**	**26**	**20**	**24**
County Total	**509**	**24**	**29**	**28**	**19**

Figure 9-12 shows the means and standard deviations of the BIBI scores for each watershed. The mean scores for the 2003 sampling year indicate that all Patapsco/Back River watersheds were in the Poor to Very Poor categories. In 2005 and 2007, Liberty Reservoir watershed improved to a mean rating of Fair. Two watersheds (Patapsco River and Gwynns Falls) improved from Very Poor to Poor between 2003 and 2005, and maintained that rating in 2007. As explained above, this may be a result of the extended drought in 2001-2002, followed by the extremely wet year in 2003. The 2005 and later results may be a recovery from these naturally stressful conditions. Watersheds in the Gunpowder River and Deer Creek basins were stable. The Deer Creek, Prettyboy Reservoir, Loch Raven Reservoir, and Little Gunpowder watersheds had Fair mean BIBI scores in both 2004 and 2006. The Lower Gunpowder and Bird River had Poor and Very Poor mean BIBI scores, respectively.



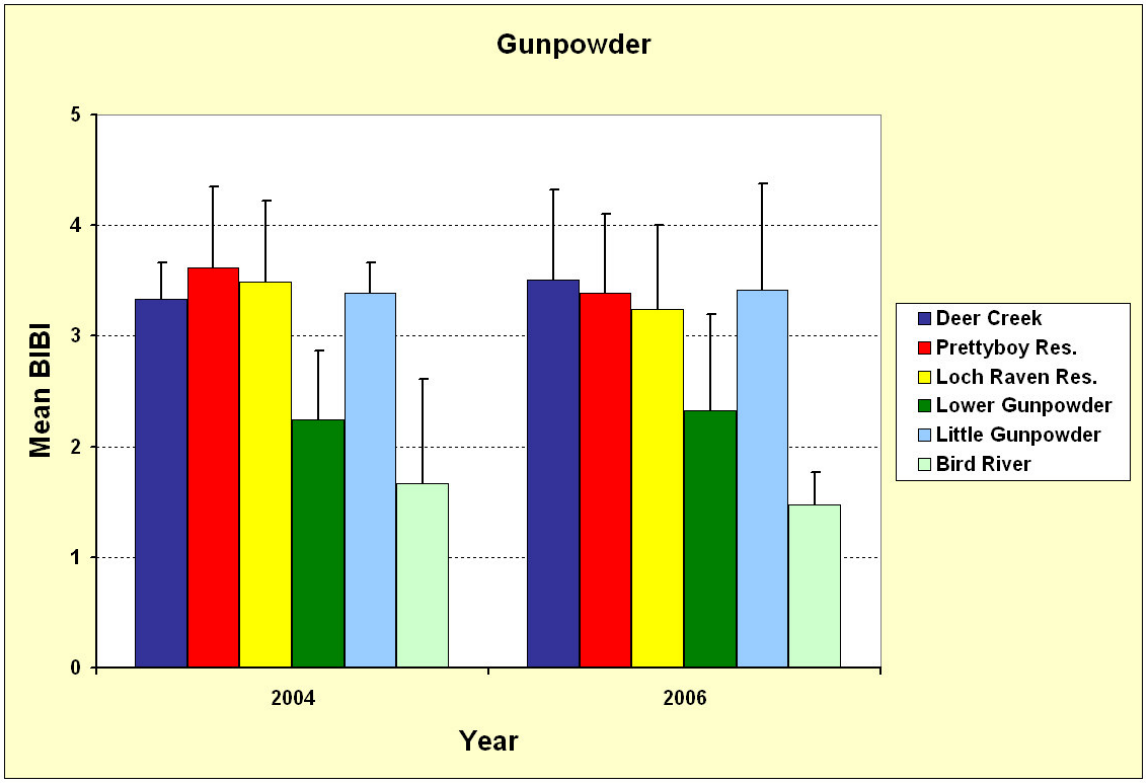


Figure 9-12: Means and Standard Deviations of BIBI Scores by Watershed

The methodology developed by Maryland Department of the Environment and Maryland Department of Natural Resources to determine biological impairment of fresh water streams was used to determine the watershed condition for all five sampling years. The methodology is detailed in Appendix G at the following web site:
http://www.mde.state.md.us/assets/document/2006DRAFTList_Appendices(1).pdf

This methodology is applied to watersheds that have a minimum of 10 sampling locations. Less than 10 sampling locations in a watershed are indicated as having insufficient data to make a determination. The determination is based on the mean BIBI and the 90% confidence intervals. The results of the analysis are presented in Table 9-7. A new listing methodology for biology is currently under review, and, if approved, will list the percentage of stream miles impaired by watershed. Baltimore County will apply the new method when it is approved.

Table 9-7: Watershed Biological Condition

Watershed	BIBI Mean	N	CL_{Lower}	CL_{Upper}	Condition
2003 Sampling Year					
Liberty	2.73	10	2.22	3.25	Inconclusive
Patapsco River	1.79	13	1.55	2.04	Impaired
Gwynns Falls	1.94	30	1.81	2.07	Impaired
Jones Falls	2.28	32	2.02	2.54	Impaired
Back River	1.49	15	1.35	1.63	Impaired
2004 Sampling Year					
Deer Creek	3.33	3	2.77	3.90	Insufficient Data
Prettyboy	3.62	7	3.08	4.16	Insufficient Data
Loch Raven	3.49	67	3.34	3.64	Meets Criteria
Lower Gunpowder	2.24	7	1.78	2.70	Insufficient Data
Little Gunpowder	3.89	6	3.66	4.11	Insufficient Data
Bird River	1.67	2	-2.54	5.88	Insufficient Data
2005 Sampling Year					
Liberty	3.11	22	2.85	3.36	Inconclusive
Patapsco River	2.48	21	2.20	2.76	Impaired
Gwynns Falls	2.20	22	2.02	2.37	Impaired
Jones Falls	2.65	23	2.40	2.91	Impaired
Back River	1.83	12	1.68	1.99	Impaired
2006 Sampling Year					
Deer Creek	3.51	13	3.11	3.91	Meets Criteria
Prettyboy	3.39	17	3.09	3.69	Meets Criteria
Loch Raven	3.24	44	3.05	3.43	Meets Criteria
Lower Gunpowder	2.33	17	1.34	3.32	Inconclusive
Little Gunpowder	3.42	4	1.84	5.00	Insufficient Data
Bird River	1.47	5	0.98	1.96	Insufficient Data
2007 Sampling Year					
Liberty	3.95	20	3.79	4.11	Meets Criteria
Patapsco River	2.56	24	2.20	2.92	Impaired
Gwynns Falls	2.64	26	2.36	2.92	Impaired
Jones Falls	2.75	28	2.43	3.07	Inconclusive
Back River	1.58	19	1.39	1.76	Impaired

Three watersheds (Patapsco River, Gwynns Falls, and Back River) are impaired, as they have consistently failed to meet biological criteria. The Liberty Reservoir watershed met criteria in 2007. Loch Raven Reservoir watershed met the criteria in both 2004 and 2006. Deer Creek and Prettyboy watersheds met the criteria in 2006. The balance of the watersheds had either insufficient data to make a determination or the data were inconclusive. Three watersheds are

not assessed using the Biological Probabilistic Monitoring Program (Baltimore Harbor, Middle River, and Gunpowder River) due to the limited miles of free flowing streams in the watersheds.

There are 18 sentinel sites in the Patapsco/Back River drainage and 13 sentinel sites in the Gunpowder River/Deer Creek drainage. Sentinel sites were sampled 2003, 2004, 2006, and 2007. Table 9-8 shows the sentinel site locations and biological condition by year. As with the probabilistic monitoring, the biological condition of sentinel sites in the Gunpowder River/Deer Creek drainage was generally better than the biological condition of sentinel sites in the Patapsco/Back River drainage. The Gunpowder River/Deer Creek had 31% and 23% of sites rated Good in 2004 and 2006, respectively, whereas the Patapsco/Back River had only 6% and 17% of sites rated Good in 2003 and 2007, respectively. A more dramatic difference existed between the two drainages when comparing the percentage of sites rated Poor or Very Poor. The Patapsco/Back River had 83% and 67% of sites rated Poor or Very Poor in 2003 and 2007, respectively. The Gunpowder River/Deer Creek had 31% and 46% of sites rated Poor or Very Poor in 2004 and 2006, respectively. Not surprisingly, sites rated Poor or Very Poor were located in urbanized and agricultural areas. Good sites were in less populated, more forested subwatersheds. Four of the 13 Gunpowder River/Deer Creek sites (31%) decreased in biological condition between 2004 and 2006, while three sites (23%) increased. Five of the 18 Patapsco/Back River sites (28%) increased in biological condition between 2003 and 2007, while two sites (11%) decreased. As shown in Table 9-9, no benthic macroinvertebrates were found in the sample at site 1203022 in 2007. A site was considered to have changed in biological condition if the BIBI score differed by at least one condition category. Condition changes within categories were not considered significant change.

Table 9-8: Sentinel Site Locations and Biological Condition for 2003, 2004, 2006, and 2007. "NS" indicates that a site was not sampled in a given year, while "NA" indicates that no benthic macroinvertebrates were found at site 1203022 in 2007.

Station	Subwatershed	Benthic Index of Biotic Integrity Scores			
		2003	2004	2006	2007
503010	Norris Run	3.67	NS	NS	3.33
503017	Locust Run	4.00	NS	NS	4.33
603058	East Branch Herbert Run	1.33	NS	NS	1.86
703003	Gwynns Falls	2.00	NS	NS	2.33
703017	Horsehead Branch	2.67	NS	NS	2.67
703033	Gwynns Falls	1.67	NS	NS	2.00
703040	Red Run	2.67	NS	NS	4.00
703067	Scotts Level Branch	1.33	NS	NS	1.33
703075	Dead Run	2.00	NS	NS	1.67
803008	Dipping Pond Run	3.33	NS	NS	4.33
803025	Slaughterhouse Branch	2.33	NS	NS	3.00
803031	Moores Branch	1.00	NS	NS	1.67
803060	Deep Run-Jones Falls	1.33	NS	NS	2.00
1203002	Herring Run-B	1.67	NS	NS	1.00
1203017	Stemmers Run	2.00	NS	NS	1.86
1203020	Brians Run	2.00	NS	NS	1.57
1203021	Brians Run	1.33	NS	NS	1.57
1203022	Herring Run-B	1.67	NS	NS	NA
204014	Prettyboy Direct 3	NS	4.00	4.00	NS

Station	Subwatershed	Benthic Index of Biotic Integrity Scores			
		2003	2004	2005	2006
204033	Georges Run	NS	3.00	2.33	NS
304021	Fourth Mine Branch	NS	3.67	2.67	NS
304084	Piney Run	NS	3.67	3.67	NS
304121	Blackrock Run	NS	4.00	3.67	NS
304197	Baisman Run	NS	4.33	4.00	NS
304208	Goodwin Run	NS	1.33	1.67	NS
304214	Merrymans Branch	NS	2.33	2.33	NS
404001	Little Deer Creek	NS	3.33	3.33	NS
404006	Plumtree Branch	NS	3.67	4.00	NS
904008	Parker Branch	NS	4.00	3.67	NS
1004002	Jennifer Branch	NS	1.67	2.33	NS
1004029	Long Green Creek	NS	1.67	2.00	NS

9.4.2 Capital Improvement Projects Monitoring

Baltimore County monitors benthic macroinvertebrate and fish assemblages in conjunction with several capital improvement stream restoration projects. Monitoring is performed in the stream segments where the restoration will take place or has taken place. The segments are monitored pre- and post-construction to document any change in the biological community. As with the Probabilistic Monitoring Program, MBSS methods are followed. Stream physical habitat data are also collected during macroinvertebrate and fish surveys. Habitat assessments are based on visual ratings of instream and riparian zone characteristics that are important to stream biological communities. The Minebank Run and Woodvalley projects are currently being monitored under the Capital Improvement Projects Monitoring Program. Their ADC map locations are displayed in Table 9-9.

Table 9-9: Stream Restoration Biological Monitoring Site Locations

Station	Stream and Location	ADC Map, Grid
Minebank Run II Stream Restoration		
MNBK-1	Minebank Run upstream of Gunpowder River	28 C2
MNBK-2	Minebank Run upstream of USGS gage	28 B3
MNBK-3	Minebank Run downstream of bridge @ park	28 A4
MNBK-4	Minebank Run upstream of bridge @ park	28 A4
MNBK-5	Minebank Run behind Loch Raven High School	27 K5
MNBK-6	Minebank Run upstream of Cowpens Road	27 J5
MNBK-7	Minebank Run upstream of Glen Eagles Court	27 H6
MNBK-8	Minebank Run upstream of MNBK-7	27 H6
MNBK-9	Minebank Run downstream of Cromwell ES	27 G6
JB-1	Jennifer Branch upstream of Gunpowder River	28 J2
JB-2	Jennifer Branch near archery range	28 J3
Woodvalley Stream Restoration		
WDVL-1	Unnamed Trib to Jones Falls at Michelle Way	25 F7
WDVL-2	Unnamed Trib to Jones Falls at Gardenview Way	25 G6
WDVL-3	Unnamed Trib to Jones Falls at Evan Way	25 F6

The staff of the Watershed Management and Monitoring Section of DEPRM has conducted yearly biological assessments of the Minebank Run stream restoration project since April, 2004,

at eleven sampling stations (Figure 9-13). The stream restoration was completed in 2002 (Phase I) on the reach where MNBK-6, MNBK-7, MNBK-8, and MNBK-9 are located. The stream restoration was completed in 2005 (Phase II) where MNBK-2, MNBK-3, MNBK-4, and MNBK-5 are located. Stations MNBK-1, JB-1, and JB-2 are controls. As of 2007, DEPRM has collected four years of post-restoration data at the Phase I stations, and two years of pre-restoration and two years of post-restoration data at the Phase II stations.

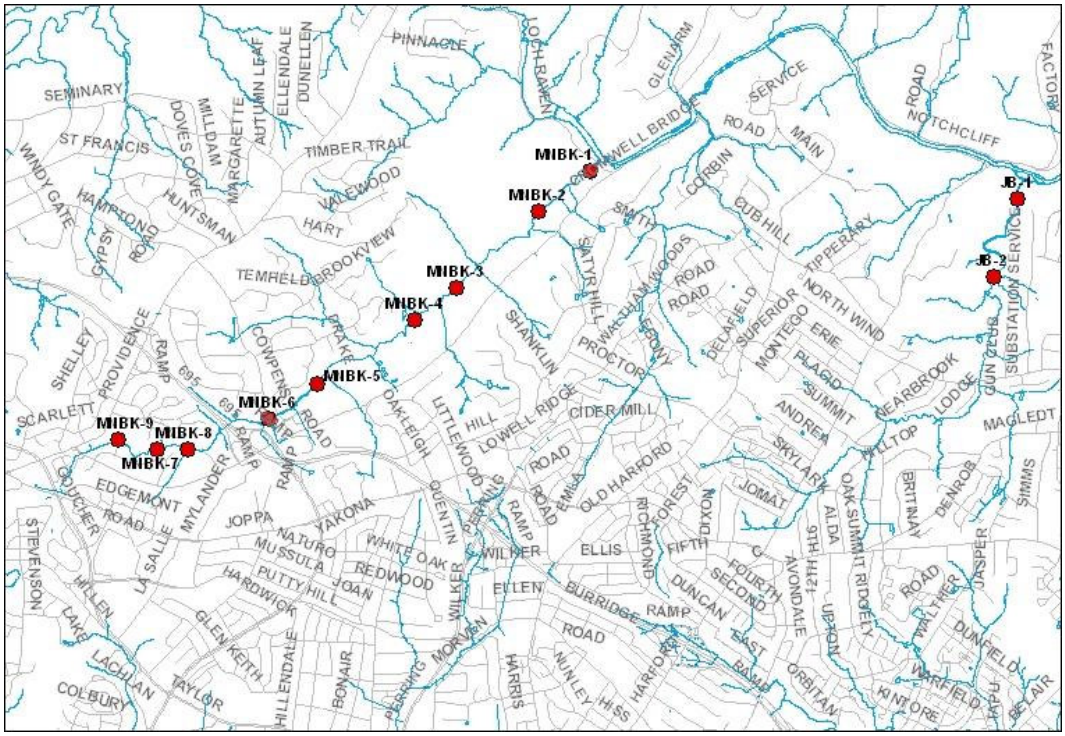


Figure 9-13: Minebank Run biological monitoring stations.

All eleven stations were sampled yearly for macroinvertebrates. Fish surveys were completed for a sub-set of the stations: MNBK-1, MNBK-2, MNBK-7, and JB-1 in 2004; MNBK-1, MNBK-7, and JB-1 in 2005; MNBK-1, MNBK-2, MNBK-4, MNBK-7, and JB-1 in 2006 and 2007. Stream physical habitat was assessed, and habitat scores derived, as detailed in Section 8.3.4.

Means and standard deviations of BIBI, FIBI, riparian buffer width, and habitat scores are presented in Table 9-10. The BIBI scores were Very Poor at control and Phase I and Phase II restored stations (Table 9-10), except for Phase II stations in 2005, which was Poor. Control stations had the highest FIBI scores, which, after 2004, were consistently in Fair Condition. Control stations always had wider riparian buffers and higher habitat scores. Phase I had wider riparian buffers than Phase II stations, which would be expected, because Phase I stations were restored three years earlier than Phase II stations. Habitat scores between Phase I, and Phase II stations were essentially similar, although Phase I stations had slightly better scores than Phase II stations. Overall means for biology and habitat reflect these conclusions (Table 9-10). Comparisons of pre- and post-restoration BIBI and FIBI scores at Phase II stations show little difference in biological condition before and after restoration. The mean BIBI was 1.58 before restoration and 1.00 after restoration. The FIBI at the one Phase II fish station was 2.00 in 2004, and averaged 2.08 between 2006 and 2007.

Table 9-10: Minebank Run Phase I vs. Phase II, Comparison of Biological and Habitat Condition *

Treatment	Year	BIBI	FIBI	Buffer Width (m)	Habitat Score
Phase I	2004	1.00 (0.00)	1.67	29 (17)	54 (8)
Phase II	2004	1.17 (0.19)	2.00	16 (14)	50 (14)
Control	2004	1.33 (0.00)	2.83	43 (12)	72 (10)
Phase I	2005	1.17 (0.24)	2.67	33 (18)	50 (6)
Phase II	2005	2.00 (0.88)	**	22 (16)	47 (7)
Control	2005	1.44 (0.51)	3.50	50 (0)	63 (10)
Phase I	2006	1.00 (0.00)	2.67	19 (11)	46 (8)
Phase II	2006	1.00 (0.00)	2.50	15 (15)	48 (7)
Control	2006	1.00 (0.00)	3.50	43 (12)	64 (16)
Phase I	2007	1.00 (0.00)	2.67	28 (13)	46 (15)
Phase II	2007	1.00 (0.00)	1.67	24 (13)	40 (4)
Control	2007	1.00 (0.00)	3.84	43 (12)	61 (10)
Phase I	Overall	1.03 (0.09)	2.42 (0.50)	27 (16)	49 (9)
Phase II	Overall	1.24 (0.53)	2.07 (0.72)	20 (13)	46 (9)
Control	Overall	1.19 (0.30)	3.42 (0.71)	45 (9)	65 (11)

* Numbers in parentheses for BIBI, FIBI, Buffer Width, and Habitat Score represent one standard deviation of the mean. Standard deviations for FIBI are presented only for overall means, as there is only one station in Phase II and two stations in Phase I.

** The one fish station in Phase II was not sampled in 2005.

It is likely that high storm flows continue to impair development of the benthic community, while fish, being more mobile, are better able to react and adapt to periodic storm flows. In contrast to previous years, no brown trout were collected at any of the stations in 2007. As shown in Table 9-10, collection of multiple years of pre- and post-restoration data has allowed DEPRM to get some idea of the amount of variability present in recovering biological communities.

The Woodvalley stream restoration project was completed in 2005. Pre-restoration data were collected in 2004 and 2005. Two stations, WDVL-1, unnamed tributary to Jones Falls at Michelle Way (within the restored reach), and WDVL-2, unnamed tributary to Jones Falls at Gardenview Way (control reach), were sampled for benthos and fish in 2004. A third station, WDVL-3, unnamed tributary to Jones Falls at Evan Way and Park Heights Avenue, was added as a control in 2005, because no fish were collected at WDVL-2 in 2004, and its upstream watershed area is less than 300 acres. Post-restoration data were collected beginning in 2006. See Figure 9-14 for station locations. Due to time and staffing constraints, WDVL-2 was not sampled in 2005.

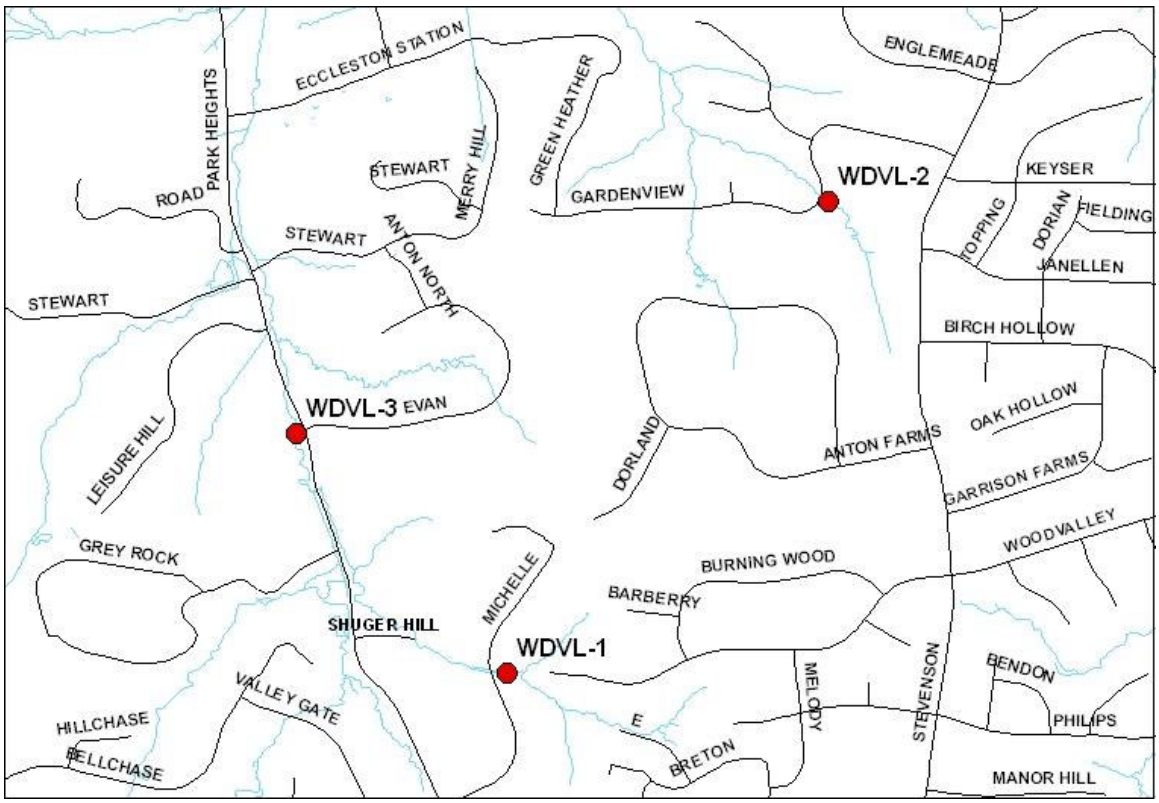


Figure 9-14: Woodvalley biological monitoring station locations.

The BIBI and FIBI (Table 9-11) scores rated Very Poor, except for the pre-restoration FIBI at WDVL-1, which rated Poor. No apparent difference exists between pre- and post-restoration biological and habitat condition. The decrease in buffer width at WDVL-1 is an artifact of assessments being done by different personnel. The pre-restoration buffer was interpreted as the amount of pre-existing lawn, while the post-restoration buffer was measured as the actual buffer planted for the stream restoration. As more data are collected, the width of the planted buffer will be analyzed as a function of time, which will be a more accurate measure of the progress of the restoration project. At present, the planted riparian buffer has not had time to mature and achieve its full function. However, observations made during the geomorphological survey conducted in October 2007, suggest that the buffer is becoming established. Although no trout were collected from within either study reach, one wild brown trout was collected, from just downstream of WDVL-3, while the electrofishing probes were being tested prior to sampling. The continued presence of brown trout within the control reach (documented in previous NPDES reports) suggests the potential of the stream restoration reach to provide habitat for wild salmonids.

Table 9-11: Woodvalley, Comparison of Pre- and Post-restoration Biological and Habitat Condition *

Station	Treatment	BIBI	FIBI	Buffer Width (m)	Habitat Score
WDVL-1	Pre-restoration	1.17	2.33	36	51
WDVL-1	Post-restoration	1.33	1.67	16	46
WDVL-2	Pre-restoration	1.17	**	22	60
WDVL-2	Post-restoration	1.33	**	28	59
WDVL-3	Pre-restoration	1.00	1.67	24	61
WDVL-3	Post-restoration	1.00	1.50	28	61

* No measure of variation around the mean is presented, as means are calculated from only two values.

** Fish sampling discontinued after 2004 due to absence of fish at site and watershed area < 300 acres.

9.4.3 Reference Site Monitoring

Baltimore County has been monitoring eight (8) reference sites since spring of 2001. GIS was used to identify watersheds within the County that contained greater than 50% forested land use and less than 20% urban land use. An initial suite of twenty-one (21) sites was reduced to eight (8) sites for future monitoring based on land use, chemical, and stream physical habitat benchmarks. The ADC map site locations, along with the stream name are displayed in Table 9-12.

Table 9-12: Reference Site Locations

Station	Stream Name and Location	ADC Map, Grid
REF-001	Baisman Run upstream of Ivy Hill Road	18 C5
REF-004	Poplar Run upstream of Gunpowder Road	1 H11
REF-009	Springhouse Run upstream of Gunpowder Rd	1 H8
REF-012	Panther Branch upstream of Gunpowder Falls	7 H8
REF-013	Mingo Branch upstream of Gunpowder Falls	7 C7
REF-015	Charles Run upstream of Gerting Road	8 F11
REF-017	Sunnyking Run near Sunnyking Drive	24 A3
REF-019	Fourth Mine Branch upstream of Stablers Church Road	3 H12

The eight sites are sampled annually for benthic macroinvertebrates in the spring index period using MBSS sampling protocols. The samples are sorted and identified in the laboratory to genus or the lowest practical taxonomic level. The metrics in Table 9-5 are used to calculate BIBIs. Benthic macroinvertebrates were collected in 2001, 2003, and 2005-2007. Fish were sampled in 2003 and 2007, during the summer index period (June 1-September 30). Fish sampling is done only periodically to reduce stress to the naturally reproducing trout populations inhabiting these streams. In 2003, only three sites were sampled for fish. In 2007, all sites except REF-004 and REF-009 were sampled for fish. REF-004 had been electrofished in 2006 by the Maryland Department of Natural Resources Fisheries Service. REF-009 is no longer sampled due to loss of landowner permission. Alternate locations on the same stream are currently being evaluated for inclusion as a reference site beginning in 2008.

Data from 2001-2007 are presented here. Water chemistry data were collected in 2000-2001. Stream physical habitat data were collected in 2001-2003 following Maryland Save Our Streams protocols, and in 2005-2007 using MBSS protocols. Benthic community condition is the primary means by which the reference sites are evaluated as benchmarks for other streams in the

county. Fish community condition is an ancillary measure. Fish data will be included in future reports in years when the fish community is sampled.

Land Use

Land use within the reference site watersheds is predominantly forest (Figure 9-15). Agriculture is also a significant activity within the reference site watersheds.

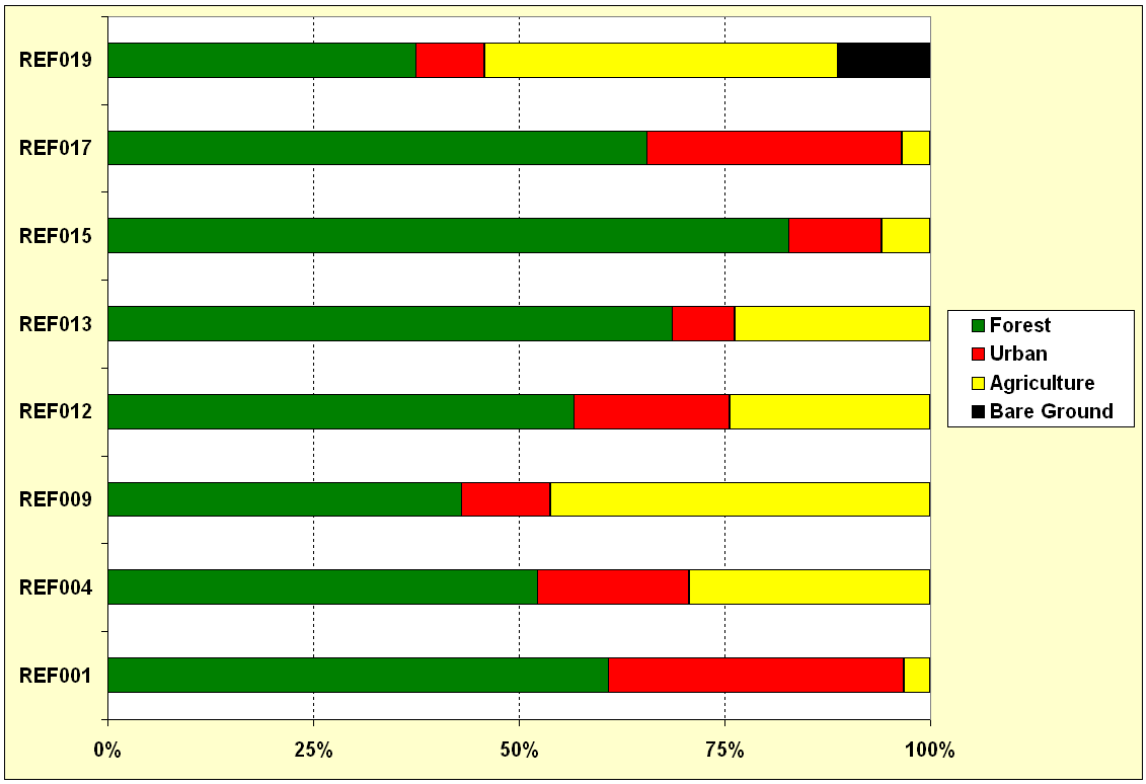


Figure 9-15: Reference site land use.

Water Chemistry

Water chemistry parameters are presented in Table 9-13. Data are shown for key parameters, which were used to evaluate whether potential sites represented reference conditions.

Table 9-13: Reference Site Water Chemistry

Station	Date	DO	pH	TS	NO_2/NO_3	SO_4	CL
REF-001	10/26/00	9.76	7.21	80	1.32	2.58	19.97
REF-004	10/05/00	9.38	7.36	58	1.90	NA	10.48
REF-009	10/12/00	10.19	6.99	62	3.40	2.02	6.16
REF-012	10/19/00	10.57	7.52	188	2.69	4.42	64.16
REF-013	10/19/00	10.11	7.44	265	1.39	5.91	110.86
REF-015	10/19/00	9.59	7.41	26	<0.06	3.91	3.37

Station	Date	DO	pH	TS	NO_2/NO_3	SO_4	CL
REF-017	10/26/00	9.01	7.55	121	1.56	4.73	14.48
REF-019	11/16/00	12.53	7.17	120	2.88	5.06	41.10
REF-001	10/18/01	10.11	6.93	<1	0.78	1.54	19.65
REF-004	10/18/01	11.72	7.07	25	0.98	2.75	10.87
REF-009	10/18/01	10.50	6.74	27	1.92	2.13	6.17
REF-012	10/18/01	10.19	7.06	155	1.76	3.34	58.17
REF-013	10/18/01	9.79	7.07	119	0.97	4.51	109.24
REF-015	10/18/01	9.70	7.13	1	<0.06	3.28	3.72
REF-017	10/18/01	10.69	6.81	86	1.61	1.24	19.59
REF-019	10/18/01	10.36	6.88	58	1.56	2.41	43.21

The most notable exceptions to "reference" water chemistry occurred at REF-012, REF-013, and REF-019 for chloride. The elimination threshold for chloride was 26.5 mg/l. Although all three sites were higher than the threshold on both sampling dates, they were retained in the reference site suite because previous sampling had shown good benthic biology. The high chloride is likely from impervious drainage in the headwaters from York Road (REF-012) and Interstate-83 (REF-013 and REF-019).

Stream Physical Habitat

Stream physical habitat was assessed following Maryland Save Our Streams protocols in 2001-2003 and MBSS Summer Index Period protocols in 2005-2007. The protocols are visual estimates of key instream, stream bank, and riparian zone parameters. Staff members that were trained to make accurate estimates of the parameters made the assessments. To account for the change in protocol, "habitat scores" were derived by converting the sum of key parameters to a percentage of the total possible sum. Table 9-14 shows the habitat parameters from each protocol that were included in the habitat scores. Note that summer index period habitat assessments were made during the spring index period because

Table 9-14: Habitat parameters for derived habitat scores at reference sites

Protocol	Parameter	Definition
Save Our Streams	Attachment Sites for Macroinvertebrates	Quality of benthic macroinvertebrate habitat
	Embeddedness	Extent to which substrates surrounded by fine sediment
	Shelter for Fish	Quality of fish habitat
	Channel Alteration	Degree to which channel has been artificially altered
	Sediment Deposition	Amount of deposition of fine sediment
	Stream Velocity and Depth Combinations	Representation of fast, slow, deep, and shallow areas
	Channel Flow Status	Amount of water within channel
	Bank Vegetative Protection	Degree to which stream banks vegetated
	Condition of Banks	Degree of stream bank stability

Protocol	Parameter	Definition
	Riparian Vegetative Zone	Width of riparian zone
MBSS	Instream Habitat	Quality of fish habitat
	Epifaunal Substrate	Quality of benthic macroinvertebrate habitat
	Velocity Depth Diversity	Representation of fast, slow, deep, and shallow areas
	Pool/Glide/Eddy Quality	Extent of pool habitat
	Riffle/Run Quality	Extent of riffle habitat
	Embeddedness	Percent of riffle substrates surrounded by fine sediment
	Shading	Percent of wetted area shaded by vegetation
	Trash Rating	Amount of trash present in reach

electrofishing is not conducted every year at the reference sites. These data were deemed useful, however, because they would still indicate the general quality of stream habitat available for biota.

Benthic Macroinvertebrates

Benthic IBI values have been fair to good over the entire monitoring period (Figure 9-16), with several exceptions. Sites REF-013, REF-017, and REF-019 have been

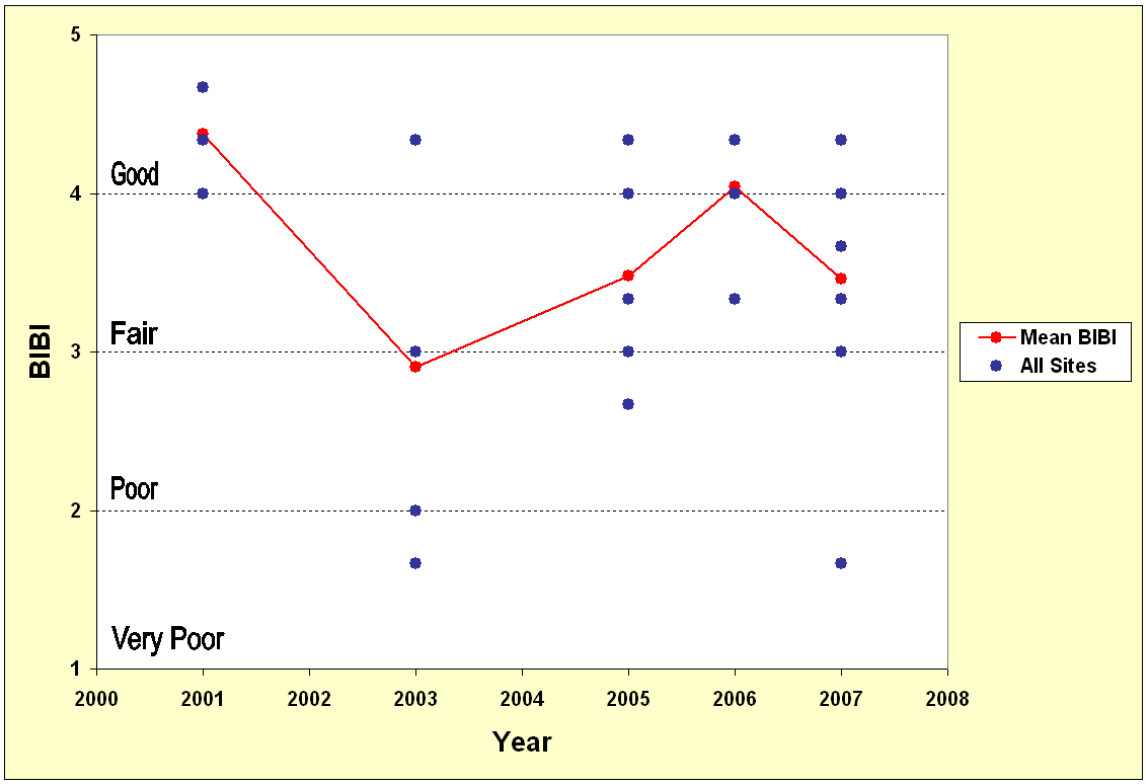


Figure 9-16: Reference site BIBIs by year. The mean BIBI for all sites is represented by the red line.

variable, as REF-013 and REF-019 have each rated poor for one year. Habitat quality has increased since 2003 (Figure 9-17). Sites with the lowest habitat scores also had the

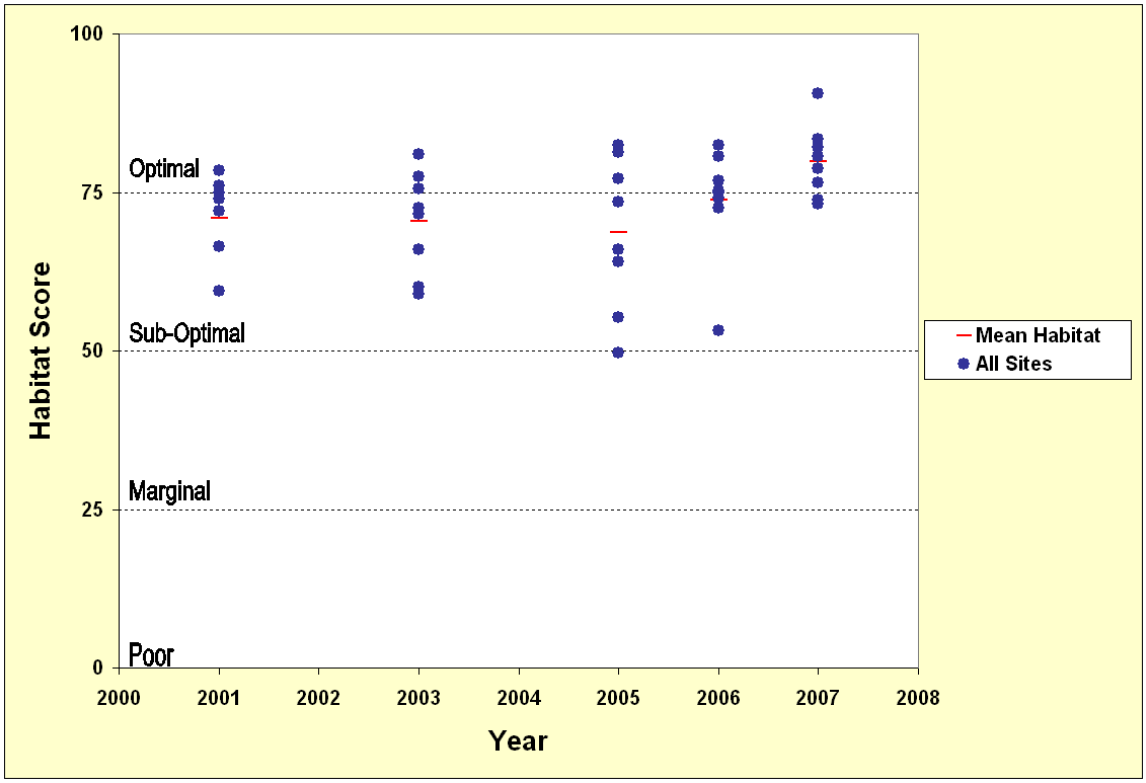


Figure 9-17: Reference site stream habitat by year. Mean habitat score is represented by the red line.

lowest BIBIs (REF-013, REF-017, and REF-019). The patterns in the benthic data were likely due in part to patterns in precipitation and hydrology. Precipitation was below normal from 2000-2002, and there were several large storms during winter 2003; lower BIBI scores in 2003 reflect the accumulated stress of these extremes in hydrologic regime. Drought may cause mortality of benthic macroinvertebrates, but many benthic macroinvertebrates migrate to the saturated habitat beneath the stream bed (the hyporheic zone) until hydrologic conditions return to normal. This, in addition to aerial dispersal during mating flights, is responsible for the persistence and stability of benthic macroinvertebrate populations during periods of fluctuating climactic conditions. Precipitation increased in 2003, and although no data were collected for 2004, BIBI values increased and remained relatively stable between 2005-2007, suggesting a response to changing precipitation amounts. The increase in habitat quality during 2005-2007 suggests that higher precipitation provided more of the living space needed by macroinvertebrates. The influence of land use on benthic communities has been well documented. At present, the current land use data that are needed to examine whether any land use change has occurred, and what effects, if any, such change has had on the benthic communities of the reference sites, is unavailable.

Fish

Fish IBI values were generally poor (Table 9-15). This is typical of small, forested headwater streams. Headwater streams typically support a few species of fish, which have narrow environmental requirements. Both brook and brown trout have been collected at most of the

sites during the monitoring period (Table 9-15). Trout are only found in cold-water streams with minimal anthropogenic influences.

Table 9-15: Fish IBIs and Trout Presence for Reference Sites in 2003 and 2007

Station	Year	FIBI	Condition	Trout Present
REF-013	2003	3.67	Fair	Yes
REF-015	2003	2.00	Poor	Yes
REF-019	2003	1.33	Very Poor	No
REF-001	2007	1.67	Very Poor	Yes
REF-012	2007	4.00	Good	Yes
REF-013	2007	4.33	Good	Yes
REF-015	2007	2.67	Poor	Yes
REF-017	2007	2.67	Poor	No
REF-019	2007	2.33	Poor	Yes

The reference sites appear to be performing their intended function, that is, providing a benchmark with which to compare stream biological condition in other, anthropogenically-affected streams. Benthic macroinvertebrate communities of the reference sites seem to be responding to physical and climactic influences in predictable ways, and should prove useful in assessing human-induced changes to other Baltimore County streams.

9.4.4 Submerged Aquatic Vegetation Monitoring Program

Baltimore County has conducted Submerged Aquatic Vegetation monitoring since 1989 on certain waterways. With the advent of water quality standards for submerged aquatic vegetation, reporting on the monitoring results will commence this year. During the last Water Quality Standards Triennial Review Maryland Department of the Environment adopted standards for tidal water submerged aquatic vegetation and water clarity, among other standards also adopted. The standards are based on water quality segments that are derived from the Chesapeake Bay Program model. There are a total of seven segments in Baltimore County tidal waters. Three of the segments (MIDOH, GUNOH1, and BACOH) are entirely within Baltimore County tidal waters. Four other segments have tidal waters that extend to other jurisdictions. Two of these segments (CB2OH and CB#MH) are Chesapeake Bay mainstem segments and extend to the eastern shore of Maryland. The Chesapeake Bay Program draft document *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2006 Addendum* provides guidance on assessing the attainment of the SAV acreage criteria. The document states "the shallow-water bay grass designated use is considered in attainment if there are sufficient acres of SAV observed within the segment or there are enough acres of shallow-water habitat meeting the applicable water clarity criteria to support restoration of the desired acres of SAV for that segment." The recommended procedure is to use the **single best year SAV acreage** based on the most recent three-year period of available data. The criteria may also be met by attaining water clarity acres for the most recent three-year period of available data. Water clarity data is currently not collected in Baltimore County, so only the SAV acreage will be used.

Baltimore County monitors SAV distributions in the spring and summer of each year in accordance with the US Fish and Wildlife methodologies. There are currently 29 waterways in the County that are monitored. In order to assess the total acres of yearly coverage for the creeks surveyed, the data for the spring and summer were analyzed for overlap in SAV distribution between the two seasons. The total SAV coverage for each year is calculated by the following formula:

Total SAV_{acres} = (Spring SAV_{acres} – $Overlap_{acres}$) + ($Summer_{acres}$ SAV – $Overlap_{acres}$) + $Overlap_{acres}$

To estimate the progress in meeting the SAV goal for each tidal segment the Total SAV_{acres} are divided by the SAV goal for that segment. Since only three of the seven segments are totally within Baltimore County jurisdiction and therefore can be assessed for SAV criteria attainment. The other four segments provide a conservative estimate of the SAV criteria attainment.

Table 9-16 presents the SAV water quality standard for each segment and the results of the last three years of SAV monitoring. The yellow highlighted water quality segments lie entirely within Baltimore County. The red highlighted cells are the highest percent attainment for each water quality segment based on the last three years of data.

Table 9-16: SAV Standards and Baltimore County SAV Monitoring Results (2005-2007)

Water Quality Segment	SAV Goal (Acres)	2005		2006		2007	
		Acres	% of Goal	Acres	% of Goal		
MIDOH	879	432	49.1	234	26.7	240.7	27.3
GUNOH1	1,860	**	**	**	**	**	**
GUNOH2	572	13	9.2	84	14.7	194.36	33.9
BACOH	0	13	100	5	100	6.31	100
PATMH	389	53	13.5	5	1.3	8.95	2.30
CB2OH	705	202	28.6	152	21.6	133.8	19
CB3MH	1,370	10	0.7	55	4.0	44.31	3.23
Total SAV Acres				**301**		**381.42**	

* Acres of SAV area surveyed
** No monitoring conducted by Baltimore County in this segment.

The Middle River segment (MIDOH) has consistently the highest acreage of SAV coverage each year. In 2004 Middle River attained 54.9% of the SAV criteria. Since that time period there has been a decrease in the SAV coverage, with 2005 having the highest coverage at 49.1%. Only the last three years are considered in assessing the attainment of the SAV coverage. Back River has no SAV criteria, and generally has the least amount of SAV coverage. The Gunpowder segment (GUNOH1) is not monitored by Baltimore County. Of all the County's waterways surveyed, Middle River has the largest area of monitoring and Back River has the least amount of area monitored.

Appendix 9-1: Baseflow Monitoring Sites by Watershed

Liberty Reservoir – 6 Sites			
Site ID	**Subwatershed**	**Site ID**	**Subwatershed**
LI-01	Cliffs Branch	LI-09	Timber Run
LI-02	Glen Falls Run	LI-10	Locust Run
LI-03	Keysers Run		
LI-04	Norris Run		
Patapsco River – 5 Sites			
PA-04	Ben's Run	PA-12	Brice Run
PA-06	Cooper Branch	PA-13	West Branch
PA-09	Soapstone Branch		
Gwynns Falls – 6 Sites			
GW-01	Gwynns Falls – Glyndon	GW-05	Horsehead Branch
GW-03	Holly Branch	GW-07	Gwynn's Falls Trib.
GW-04	Red Run	GW-10	Dead Run – Mainstem
Jones Falls – 8 Sites			
JF-01	Western Run	JF-08	Shaughterhouse Run
JF-04	Dipping Pond Run	JF-09	Moores Run
JF-05	Deep Run	JF-10	Towson Run
JF-07	Roland Run	JF-11	Jones Falls
Back River – 10 Sites			
HR-01	West Branch – Herring Run	BR-02	Brians Run
HR-02	West Branch – Herring Run	BR-03	Redhouse Run
HR-03	East Branch – Herring Run	BR-04	Redhouse Run
HR-04	East Branch – Herring Run	BR-05A	Stemmers Run
BR-01	Bread and Cheese Creek	BR-06	Stemmers Run
Deer Creek – 4 Sites			
DC-01	Harris Mill	DC-03	Deer Creek – mainstem
DC-02	Ebaughs Creek	DC-04	Plumtree Branch
Prettyboy Reservoir – 8 Sites			
PB-26	Gunpowder Falls South Branch	PB-44	Graves Run
PB-28	Gunpowder Falls South Branch	PB-52	Murphy's Run
PB-33	Gunpowder Falls- Unnamed Trib.	PB-54	Georges Run
PB-43	Indian Run	PB-66	Compass Run
Loch Raven Reservoir – 32 Sites			
LR-02	Fitzhugh Run	LR-23	Charles Run
LR-03	Dulaney Valley Branch	LR-24	Little Falls
LR-04	Loch Raven Res. Unnamed Trib.	LR-25	First Mine Branch
LR-10 (LQ3)	Long Quarter Branch	LR-26	Second Mine Branch
LR-11 (SB-3)	Spring Branch	LR-27	Third Mine Branch
LR-12	Merryman Branch	LR-28	Owl Branch
LR-13 (BR1)	Beaver Dam Run – York Road	LR-29	Little Falls
LR-14	Baisman Run	LR-30	Beetree Run
LR-15	Beaver Dam Run – Rises Court	LR-31	Mingo Branch
LR-16	Oregon Branch	LR-32	Black Rock Run – Western Run
LR-17 (WR1)	Western Run	LR-34	McGill Run
LR-18	Green Branch	LR-35	Piney Run
LR-19 (OR1)	Overshot Run	LR-38	Delaware Run
LR-20	Carroll Branch	LR-39	Slade Run

LR-21	Piney Creek	LR-132	Black Rock Rn. (LR-32 Relocated)
LR-22 (GF1)	Gunpowder Falls - Glencoe	LR-133	Indian Run (LR-33 Relocated)
Lower Gunpowder Falls – 7 Sites			
GU-01	Bean Run	GU-06	Cowen Run
GU-03	Haystack Branch	GU-07	Jennifer Branch
GU-04	Long Green Creek – Hydes Rd.	GU-08	Minebank Run
GU-05	Long Green Creek – Hartley Mill		
Little Gunpowder Falls – 7 Sites			
LG-01	Nelson Branch	LG-05	Little Gunpowder Falls
LG-02	Parker Branch	LG-07	Little Gunpowder Falls
LG-03	Sawmill Branch	LG-09	Frannklinville Channel.
LG-04	Little Gunpowder Falls		
Bird River – 5 Sites			
BI-01	Windlass Run	BI-04	North Fork
BI-02	Honeygo Run	BI-05	Whitemarsh Run – Mainstem
BI-03	Whitemarsh Run - Headwaters		

Appendix 9-2: Baseflow Water Quality Data by Site

Site	Pollutant Parameter					
	pH			TSS		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Liberty Reservoir						
LI-01	7.36	3	0.49	1.67	3	2.02
LI-02	7.25	3	0.43	0.50	3	0.00
LI-03	7.07	3	0.36	0.50	3	0.00
LI-04	6.94	3	0.48	0.50	2	0.00
LI-09	6.98	3	0.42	3.00	3	4.33
LI-10	7.74	3	0.21	1.00	3	0.87
Patapsco River						
PA-04	8.43	4	0.37	4.13	4	2.59
PA-06	8.14	4	0.38	2.38	4	3.75
PA-09	8.07	3	0.06	0.88	4	0.75
PA-12	8.04	4	0.30	1.88	4	2.75
PA-13	8.28	4	0.65	3.38	4	5.75
Gwynns Falls						
GW-01	7.14	4	0.65	5.75	4	9.53
GW-03	7.15	3	0.34	1.00	3	0.87
GW-04	7.46	3	0.49	18.17	3	22.87
GW-05	7.38	3	0.51	0.50	3	0.00
GW-07	7.80	3	0.23	2.33	3	3.18
GW-10	7.79	3	0.07	0.50	3	0.00
Site	**Pollutant Parameter**					
	pH			**TSS**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	7.38	7	0.73	1.50	7	1.71
JF-04	7.30	3	0.32	21.67	3	36.66
JF-05	7.48	3	0.31	1.67	3	2.02
JF-07	8.17	3	0.18	3.67	3	5.48
JF-08	7.49	7	0.80	4.00	7	7.18
JF-09	7.76	7	0.88	0.50	7	0.00
JF-10	7.78	3	0.12	2.33	3	3.18
JF-11	8.13	3	0.31	3.67	3	5.48
Back River						
HR-01	8.01	6	0.63	0.50	6	0.00
HR-02	7.50	6	0.58	2.58	6	3.71
HR-03	7.27	6	0.54	4.33	6	6.07
HR-04	7.59	6	0.36	6.58	6	9.64
BR-01	7.98	1	0.00	10.00	1	0.00
BR-02	7.45	6	0.34	0.50	6	0.00
BR-03	7.79	6	0.33	1.08	6	1.43
BR-04	8.00	6	0.6	1.08	6	1.43
BR-05A	7.70	6	0.39	3.17	6	2.84
BR-06	7.64	6	0.37	0.75	6	0.61
Site	**Pollutant Parameter**					
	TS			**TKN**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**

Liberty Reservoir						
LI-01	165.33	3	53.15	0.15	3	0.09
LI-02	159.33	3	15.53	0.15	3	0.08
LI-03	119.33	3	36.46	0.10	3	0.00
LI-04	162.67	3	77.00	0.10	3	0.00
LI-09	82.67	3	50.77	0.18	3	0.14
LI-10	138.67	3	35.23	0.10	3	0.00
Patapsco River						
PA-04	212.50	4	49.70	0.22	4	0.17
PA-06	228.50	4	36.38	0.21	4	0.15
PA-09	268.50	4	48.07	0.20	4	0.12
PA-12	140.00	4	30.94	0.30	4	0.24
PA-13	510.00	4	52.59	0.33	4	0.32
Gwynns Falls						
GW-01	728.50	4	446.97	0.16	3	0.10
GW-03	314.67	3	19.73	0.10	2	0.00
GW-04	224.67	3	82.08	0.10	2	0.00
GW-05	181.33	3	19.01	0.18	2	0.11
GW-07	324.67	3	69.58	0.27	3	0.04
GW-10	565.33	3	209.06	0.47	3	0.19
Site	**Pollutant Parameter**					
	TS			**TKN**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	323.43	7	94.10	0.80	6	1.40
JF-04	173.33	3	66.40	0.10	3	0.00
JF-05	155.33	3	37.75	0.10	3	0.00
JF-07	454.00	3	275.16	0.18	3	0.07
JF-08	405.43	7	94.50	0.10	6	0.00
JF-09	320.86	7	42.12	0.10	6	0.00
JF-10	564.00	3	253.62	0.21	3	0.11
JF-11	176.67	3	25.79	0.11	3	0.01
Back River						
HR-01	263.67	6	67.82	0.14	6	0.07
HR-02	375.67	6	83.94	0.14	6	0.06
HR-03	384.42	6	206.07	0.15	6	0.13
HR-04	429.33	6	262.63	0.31	6	0.22
BR-01	430.00	1	0.00	0.25	1	0.00
BR-02	374.67	6	96.69	0.30	5	0.22
BR-03	298.33	6	101.38	0.24	5	0.13
BR-04	291.33	6	83.59	0.98	5	1.66
BR-05A	487.33	6	101.68	0.18	6	0.09
BR-06	314.33	6	57.83	0.20	6	0.09
Site	**Pollutant Parameter**					
	NO_2-NO_3			**TP**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	3.93	3	1.93	0.05	3	0.03
LI-02	1.47	3	0.90	0.98	3	1.62
LI-03	2.02	3	0.92	0.03	3	0.04
LI-04	1.52	3	0.72	0.03	3	0.02
LI-09	1.07	3	0.64	0.05	3	0.03
LI-10	0.43	3	0.40	0.03	3	0.03

Patapsco River						
PA-04	0.41	4	0.13	0.02	4	0.01
PA-06	0.50	4	0.24	0.05	4	0.03
PA-09	0.54	4	0.08	0.02	4	0.02
PA-12	1.48	4	0.18	0.02	4	0.01
PA-13	0.71	4	0.16	0.03	4	0.02
Gwynns Falls						
GW-01	1.74	4	0.70	0.06	3	0.03
GW-03	2.36	3	1.32	0.03	2	0.01
GW-04	1.04	3	0.71	0.04	2	0.00
GW-05	0.42	3	0.03	0.05	2	0.01
GW-07	0.54	3	0.05	0.04	3	0.02
GW-10	0.36	3	0.10	0.06	3	0.02
Site	**Pollutant Parameter**					
	NO_2-NO_3			**TP**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.76	6	0.35	0.28	6	0.53
JF-04	1.72	3	0.11	0.03	3	0.02
JF-05	1.39	3	0.33	0.02	3	0.01
JF-07	1.2	3	0.16	0.03	3	0.02
JF-08	1.52	6	0.12	0.05	6	0.02
JF-09	0.76	6	0.16	0.04	6	0.02
JF-10	1.70	3	0.21	0.07	3	0.06
JF-11	1.26	3	0.11	0.05	3	0.03
Back River						
HR-01	1.57	5	0.24	0.05	6	0.02
HR-02	1.31	5	0.10	0.04	6	0.02
HR-03	0.98	5	0.28	0.05	6	0.02
HR-04	0.71	5	0.28	0.06	6	0.02
BR-01	1.75	1	0.00	0.09	1	0.00
BR-02	1.79	6	0.39	0.04	5	0.03
BR-03	0.86	6	0.22	0.04	5	0.02
BR-04	0.92	6	0.34	0.06	5	0.06
BR-05A	0.36	6	0.19	0.07	6	0.08
BR-06	0.54	6	0.31	0.04	6	0.02
Site	**Pollutant Parameter**					
	Cd			**Cd-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0005	3	0.0000	0.0005	3	0.0000
LI-02	0.0005	3	0.0000	0.0005	3	0.0000
LI-03	0.0005	3	0.0000	0.0005	3	0.0000
LI-04	0.0005	3	0.0000	0.0005	3	0.0000
LI-09	0.0005	3	0.0000	0.0005	3	0.0000
LI-10	0.0005	3	0.0000	0.0005	3	0.0000
Patapsco River						
PA-04	0.0005	4	0.0000	0.0005	4	0.0000
PA-06	0.0005	4	0.0000	0.0005	4	0.0000
PA-09	0.0005	4	0.0000	0.0005	4	0.0000
PA-12	0.0005	4	0.0000	0.0005	4	0.0000
PA-13	0.0005	4	0.0000	0.0005	4	0.0000

Gwynns Falls						
GW-01	0.0005	4	0.0000	0.0005	4	0.0000
GW-03	0.0005	3	0.0000	0.0005	3	0.0000
GW-04	0.0005	3	0.0000	0.0005	3	0.0000
GW-05	0.0005	3	0.0000	0.0005	3	0.0000
GW-07	0.0005	3	0.0000	0.0005	3	0.0000
GW-10	0.0005	3	0.0000	0.0005	3	0.0000
Site	**Pollutant Parameter**					
	Cd			**Cd-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.0005	6	0.0000	0.0005	6	0.0000
JF-04	0.0005	3	0.0000	0.0005	3	0.0000
JF-05	0.0005	3	0.0000	0.0005	3	0.0000
JF-07	0.0005	3	0.0000	0.0005	3	0.0000
JF-08	0.0005	6	0.0000	0.0005	6	0.0000
JF-09	0.0005	6	0.0000	0.0005	6	0.0000
JF-10	0.0005	3	0.0000	0.0005	3	0.0000
JF-11	0.0005	3	0.0000	0.0005	3	0.0000
Back River						
HR-01	0.0005	6	0.0000	0.0005	6	0.0000
HR-02	0.0005	6	0.0000	0.0005	6	0.0000
HR-03	0.0031	6	0.0063	0.00092	6	0.001
HR-04	0.0005	6	0.0000	0.0005	6	0.0000
BR-01	0.0005	1	0.0000	0.0005	1	0.0000
BR-02	0.0005	5	0.0000	0.0005	5	0.0000
BR-03	0.0005	5	0.0000	0.0005	5	0.0000
BR-04	0.0005	5	0.0000	0.0005	5	0.0000
BR-05A	0.0005	6	0.0000	0.0005	6	0.0000
BR-06	0.0005	6	0.0000	0.0005	6	0.0000
Site	**Pollutant Parameter**					
	Cu			**Cu-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0167	3	0.0176	0.0030	3	0.0043
LI-02	0.0095	3	0.0143	0.0023	3	0.0032
LI-03	0.0113	3	0.0188	0.0023	3	0.0032
LI-04	0.0057	3	0.0089	0.0023	3	0.0032
LI-09	0.0060	3	0.0095	0.0023	3	0.0032
LI-10	0.0087	3	0.0081	0.0023	3	0.0023
Patapsco River						
PA-04	0.0049	4	0.0055	0.0014	4	0.0011
PA-06	0.0104	4	0.0158	0.0029	4	0.0041
PA-09	0.0114	4	0.0191	0.0028	4	0.0042
PA-12	0.0081	4	0.0078	0.0044	4	0.0058
PA-13	0.0169	4	0.0281	0.0031	4	0.0046
Gwynns Falls						
GW-01	0.0046	4	0.0046	0.0011	4	0.0006
GW-03	0.0032	3	0.0024	0.0008	3	0.0003
GW-04	0.0040	3	0.0061	0.0010	3	0.0009
GW-05	0.0077	3	0.0051	0.0025	3	0.0023
GW-07	0.0120	3	0.0082	0.0033	3	0.0025
GW-10	0.0253	3	0.0200	0.0057	3	0.0035

Site	Pollutant Parameter					
	Cu			Cu-dissolved		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Jones Falls						
JF-01	0.0027	6	0.0051	0.0010	6	0.0010
JF-04	0.0037	3	0.0055	0.0010	3	0.0009
JF-05	0.0037	3	0.0038	0.0013	3	0.0006
JF-07	0.0020	3	0.0026	0.0007	3	0.0003
JF-08	0.0047	6	0.0067	0.0015	6	0.0018
JF-09	0.0023	6	0.0043	0.0010	6	0.0010
JF-10	0.0042	3	0.0038	0.0012	3	0.0008
JF-11	0.0010	3	0.0009	0.0007	3	0.0003
Back River						
HR-01	0.0030	6	0.0059	0.0010	6	0.0010
HR-02	0.0030	6	0.0054	0.0010	6	0.0010
HR-03	0.0027	6	0.0046	0.0010	6	0.0010
HR-04	0.0045	6	0.0062	0.0009	6	0.0010
BR-01	0.0005	1	0.0000	0.0005	1	0.0000
BR-02	0.0023	5	0.0038	0.0008	5	0.0007
BR-03	0.0023	5	0.0038	0.0011	5	0.0011
BR-04	0.0048	5	0.0085	0.0018	5	0.0024
BR-05A	0.0027	6	0.0039	0.0008	6	0.0006
BR-06	0.0027	6	0.0039	0.0012	6	0.0011
Site	**Pollutant Parameter**					
	Pb			**Pb-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0010	3	0.0009	0.0007	3	0.0007
LI-02	0.0010	3	0.0009	0.0007	3	0.0007
LI-03	0.0010	3	0.0009	0.0005	3	0.0005
LI-04	0.0010	3	0.0009	0.0007	3	0.0007
LI-09	0.0007	3	0.0003	0.0007	3	0.0007
LI-10	0.0008	3	0.0003	0.0005	3	0.0005
Patapsco River						
PA-04	0.0006	4	0.0003	0.0005	4	0.0005
PA-06	0.0009	4	0.0008	0.0006	4	0.0006
PA-09	0.0009	4	0.0008	0.0006	4	0.0006
PA-12	0.0006	4	0.0003	0.0005	4	0.0005
PA-13	0.0011	4	0.0013	0.0006	4	0.0006
Gwynns Falls						
GW-01	0.0006	4	0.0003	0.0005	4	0.0005
GW-03	0.0008	3	0.0003	0.0005	3	0.0005
GW-04	0.0012	3	0.0008	0.0007	3	0.0007
GW-05	0.0008	3	0.0003	0.0005	3	0.0005
GW-07	0.0007	3	0.0003	0.0005	3	0.0005
GW-10	0.0010	3	0.0009	0.0007	4	0.0007
Site	**Pollutant Parameter**					
	Pb			**Pb-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.0006	6	0.0002	0.0005	6	0.0005
JF-04	0.0007	3	0.0003	0.0005	3	0.0005
JF-05	0.0007	3	0.0003	0.0005	3	0.0005

JF-07	0.0005	3	0.0000	0.0005	3	0.0005
JF-08	0.0008	6	0.0006	0.0006	6	0.0006
JF-09	0.0006	6	0.0002	0.0006	6	0.0006
JF-10	0.0005	3	0.0000	0.0005	3	0.0005
JF-11	0.0005	3	0.0000	0.0005	3	0.0005
Back River						
HR-01	0.0007	6	0.0003	0.0006	6	0.0006
HR-02	0.0008	6	0.0006	0.0006	6	0.0006
HR-03	0.0007	6	0.0003	0.0006	6	0.0006
HR-04	0.0008	6	0.0006	0.0006	6	0.0006
BR-01	0.0010	1	0.0000	0.0005	1	0.0000
BR-02	0.0006	5	0.0002	0.0005	5	0.0005
BR-03	0.0009	5	0.0007	0.0006	5	0.0006
BR-04	0.0008	5	0.0003	0.0005	5	0.0005
BR-05A	0.0008	6	0.0006	0.0006	6	0.0006
BR-06	0.0006	6	0.0002	0.0005	6	0.0005
Site	**Pollutant Parameter**					
	Zn			**Zn-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0090	3	0.0147	0.0027	3	0.0038
LI-02	0.0137	3	0.0228	0.0030	3	0.0043
LI-03	0.0070	3	0.0113	0.0023	3	0.0032
LI-04	0.0097	3	0.0159	0.0033	3	0.0049
LI-09	0.0050	3	0.0078	0.0013	3	0.0014
LI-10	0.0120	3	0.0079	0.0023	3	0.0015
Patapsco River						
PA-04	0.0091	4	0.0094	0.0026	4	0.0017
PA-06	0.0203	4	0.0180	0.0054	4	0.0044
PA-09	0.0061	4	0.0062	0.0016	4	0.0011
PA-12	0.0066	4	0.0081	0.0024	4	0.0031
PA-13	0.0105	4	0.0064	0.0028	4	0.0022
Gwynns Falls						
GW-01	0.0131	4	0.0146	0.0044	4	0.0043
GW-03	0.0142	3	0.0119	0.0052	3	0.0043
GW-04	0.0135	3	0.0113	0.0038	3	0.0038
GW-05	0.0125	3	0.0110	0.0038	3	0.0038
GW-07	0.0040	3	0.0061	0.0010	3	0.0009
GW-10	0.0063	3	0.0101	0.0030	3	0.0043
Site	**Pollutant Parameter**					
	Zn			**Zn-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.0066	6	0.0082	0.0019	6	0.0018
JF-04	0.0040	3	0.0061	0.0013	3	0.0014
JF-05	0.0150	3	0.0140	0.0032	3	0.0024
JF-07	0.0045	3	0.0065	0.0012	3	0.0008
JF-08	0.0083	6	0.0087	0.0023	6	0.0024
JF-09	0.0061	6	0.0063	0.0019	6	0.0016
JF-10	0.0045	3	0.0057	0.0015	3	0.0013
JF-11	0.0007	3	0.0003	0.0005	3	0.0000
Back River						
HR-01	0.0056	6	0.0077	0.0014	6	0.0012

HR-02	0.0113	6	0.0140	0.0021	6	0.0023
HR-03	0.0093	6	0.0081	0.0018	6	0.0015
HR-04	0.0080	6	0.0117	0.0060	6	0.0024
BR-01	0.0200	1	0.0000	0.0041	1	0.0000
BR-02	0.0135	5	0.0099	0.0038	5	0.0034
BR-03	0.0170	5	0.0244	0.0029	5	0.0046
BR-04	0.0117	5	0.0202	0.0057	5	0.0041
BR-05A	0.0183	6	0.0226	0.0029	6	0.0061
BR-06	0.0108	6	0.01818	0.0060	6	0.0041
Site	**Pollutant Parameter**					
	BOD			**COD**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	1.00	3	0.00	6.00	3	6.06
LI-02	1.00	3	0.00	5.00	3	4.33
LI-03	1.00	3	0.00	4.67	3	3.75
LI-04	1.00	3	0.00	2.50	3	0.00
LI-09	1.00	3	0.00	6.33	3	6.64
LI-10	1.00	3	0.00	5.67	3	5.48
Patapsco River						
PA-04	1.00	4	0.00	9.88	4	5.92
PA-06	1.00	4	0.00	10.38	4	6.02
PA-09	1.00	4	0.00	9.00	4	7.78
PA-12	2.00	4	2.00	10.38	4	5.68
PA-13	1.00	4	0.00	13.38	4	11.88
Gwynns Falls						
GW-01	1.75	4	1.50	8.13	4	11.25
GW-03	0.67	3	0.58	4.33	3	3.18
GW-04	1.00	3	0.00	6.67	3	7.22
GW-05	1.00	3	0.00	4.33	3	3.18
GW-07	1.00	3	0.00	8.50	3	6.26
GW-10	1.00	3	0.00	23.67	3	5.69
Site	**Pollutant Parameter**					
	BOD			**COD**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	1.86	7	1.86	12.64	7	7.06
JF-04	1.00	3	0.00	6.83	3	4.25
JF-05	1.00	3	0.00	5.67	3	5.48
JF-07	1.00	3	0.00	8.17	3	5.01
JF-08	2.14	7	1.86	5.29	7	4.94
JF-09	1.57	7	0.98	4.36	7	3.92
JF-10	1.00	3	0.00	7.83	3	4.86
JF-11	1.00	3	0.00	3.33	3	1.44
Back River						
HR-01	1.67	6	1.03	6.92	6	6.03
HR-02	2.17	6	2.86	9.08	6	7.47
HR-03	1.83	6	1.33	5.33	6	3.13
HR-04	3.83	6	3.31	10.83	6	6.85
BR-01	1.00	1	0.00	9.00	1	0.00
BR-02	1.17	6	0.41	8.67	6	6.43
BR-03	1.00	6	0.00	5.00	6	3.92
BR-04	1.00	6	0.00	7.00	6	3.99

BR-05A	1.00	6	0.00	5.92	6	3.87
BR-06	1.00	6	0.00	4.83	6	3.74
Site	**Pollutant Parameter**					
	Cl			**Na**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	39.11	3	10.22	22.83	3	13.28
LI-02	45.58	3	19.99	24.82	3	14.15
LI-03	38.80	3	11.64	20.52	3	11.28
LI-04	60.63	3	15.41	23.30	3	13.18
LI-09	17.25	3	9.25	21.18	2	10.01
LI-10	19.62	3	11.68	13.87	3	4.78
Patapsco River						
PA-04	42.92	4	6.86	58.54	4	34.50
PA-06	53.12	4	14.13	58.35	4	26.56
PA-09	75.55	4	10.83	56.04	4	25.45
PA-12	27.89	4	2.43	39.21	4	35.16
PA-13	161.56	2	2.59	93.93	4	36.83
Gwynns Falls						
GW-01	193.08	3	201.35	74.02	3	37.81
GW-03	87.60	3	8.24	49.75	2	12.80
GW-04	73.66	3	0.71	46.38	2	16.51
GW-05	15.46	3	1.90	22.78	3	6.57
GW-07	91.66	3	24.57	45.75	3	9.61
GW-10	174.04	2	90.91	83.77	3	10.47
Site	**Pollutant Parameter**					
	Cl			**Na**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	142.42	6	46.05	84.94	6	19.14
JF-04	37.98	2	2.57	56.32	3	16.61
JF-05	59.85	2	24.30	45.65	3	8.88
JF-07	94.95	2	15.34	52.71	3	24.06
JF-08	156.30	6	34.55	87.55	6	15.97
JF-09	76.14	6	8.78	43.93	6	7.66
JF-10	201.44	2	242.91	109.86	3	104.92
JF-11	36.48	2	2.16	39.51	3	26.98
Back River						
HR-01	92.08	5	25.33	58.23	6	24.04
HR-02	119.09	5	29.78	70.64	6	23.04
HR-03	176.47	5	60.38	87.75	6	42.38
HR-04	216.28	5	202.23	117.14	6	81.72
BR-01	108.78	1	0.00	119.80	1	0.00
BR-02	187.26	6	100.43	120.56	5	40.64
BR-03	110.99	6	51.86	89.06	5	41.08
BR-04	102.11	6	44.43	77.85	5	34.52
BR-05A	265.72	6	128.25	160.28	6	31.16
BR-06	119.21	6	48.38	91.00	6	35.79
Site	**Pollutant Parameter**					
	Hardness			**Mg**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	66.44	3	33.51	5.92	3	3.85

LI-02	61.87	3	31.39	5.53	3	3.71
LI-03	56.18	3	13.63	5.07	3	2.39
LI-04	69.98	3	20.18	5.85	3	3.26
LI-09	31.47	2	8.89	4.77	2	2.45
LI-10	79.18	3	56.99	11.50	3	12.80
Patapsco River						
PA-04	163.98	4	60.31	17.74	4	10.07
PA-06	145.63	4	51.72	12.48	4	6.42
PA-09	184.40	4	57.03	14.76	4	7.88
PA-12	97.06	4	23.96	7.55	4	3.56
PA-13	260.53	4	111.32	21.13	4	12.03
Gwynns Falls						
GW-01	427.80	3	281.33	36.22	3	21.34
GW-03	139.91	2	49.30	14.80	2	3.89
GW-04	144.60	2	53.83	16.23	2	5.06
GW-05	154.10	3	35.27	11.90	3	1.88
GW-07	262.66	3	91.32	24.30	3	10.13
GW-10	399.87	3	125.20	40.55	3	15.14
Site	**Pollutant Parameter**					
	Hardness			**Mg**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	160.46	6	83.91	12.19	5	2.79
JF-04	101.80	3	76.46	21.39	3	16.97
JF-05	129.17	3	114.84	31.45	3	28.92
JF-07	201.31	3	149.04	137.79	3	198.69
JF-08	219.78	6	54.65	15.61	5	1.65
JF-09	305.14	6	66.49	22.55	5	2.43
JF-10	185.60	3	102.07	120.91	3	178.64
JF-11	151.68	3	109.36	63.69	3	81.40
Back River						
HR-01	204.73	6	41.69	15.38	4	0.86
HR-02	243.62	6	12.48	17.64	4	1.24
HR-03	274.81	6	60.39	23.51	4	1.90
HR-04	217.93	6	57.09	15.48	4	2.48
BR-01	266.45	1	0.00	20.50	1	0.00
BR-02	232.19	5	41.89	15.13	4	1.20
BR-03	200.86	5	31.38	13.14	4	3.08
BR-04	206.84	5	25.21	13.24	4	2.09
BR-05A	265.12	6	29.08	17.99	4	2.43
BR-06	239.13	6	43.08	19.61	4	3.48
Site	**Pollutant Parameter**					
	Ca					
	Mean	**N**	**Std.Dev**			
Liberty Reservoir						
LI-01	16.85	3	7.50			
LI-02	15.64	3	6.67			
LI-03	14.13	3	1.77			
LI-04	18.38	3	2.75			
LI-09	4.74	2	0.47			
LI-10	12.74	3	5.67			
Patapsco River						
PA-04	36.42	4	9.35			

PA-06	37.75	4	11.67			
PA-09	49.51	4	11.60			
PA-12	26.41	4	4.93			
PA-13	69.50	4	28.31			
Gwynns Falls						
GW-01	111.60	3	77.80			
GW-03	31.63	2	13.33			
GW-04	31.18	2	13.19			
GW-05	42.08	3	11.07			
GW-07	65.17	3	21.34			
GW-10	93.27	3	25.18			
Site	**Pollutant Parameter**					
	Ca					
	Mean	**N**	**Std.Dev**			
Jones Falls						
JF-01	49.81	5	25.46			
JF-04	26.57	3	21.88			
JF-05	36.05	3	31.16			
JF-07	60.18	3	26.78			
JF-08	63.35	5	21.73			
JF-09	86.25	5	25.86			
JF-10	53.80	3	25.24			
JF-11	43.30	3	25.80			
Back River						
HR-01	63.80	4	6.77			
HR-02	71.20	4	2.51			
HR-04	65.16	4	12.16			
HR-03	82.34	4	1.13			
BR-01	72.90	1	0.00			
BR-02	62.15	4	10.52			
BR-03	58.00	4	9.66			
BR-04	58.60	4	8.23			
BR-05A	73.51	4	9.64			
BR-06	68.16	4	14.02			

Appendix 9-3: Tidal Waters Chemical Monitoring Results

Site	TSS			TS		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	39.5	15.0	23.8	9273.3	15	3390.3
PR	47.5	15.0	28.6	10238.9	15	3964.0
BD	34.3	16.0	22.4	1725.3	16	1856.0
BR	31.1	16.0	17.6	4246.6	16	2644.7
GR	21.1	16.0	14.9	3084.1	16	2598.4
MR	24.5	16.0	19.8	4513.9	16	3383.4
MS	27.3	16.0	21.5	4950.8	16	3592.1
PSE	39.9	17.0	41.4	6881.1	17	2494.3
PSF	6.3	17.0	13.4	187.4	17	63.9
HM	31.8	14.0	20.9	5861.7	14	3402.1
Site	**TKN**			**NO_2-NO_3**		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.7788	16	0.3168	0.1546	13	0.2485
PR	1.0438	16	0.6876	0.2046	13	0.2834
BD	0.7838	16	0.2260	0.3831	13	0.5302
BR	1.1963	16	0.3768	5.3969	13	18.5830
GR	0.3794	16	0.1976	0.3700	13	0.4615
MR	0.3863	16	0.1812	0.2369	13	0.3049
MS	0.3269	16	0.1375	0.2146	13	0.2986
PSE	0.8112	17	0.4277	0.1947	15	0.2276
PSF	0.5047	17	0.3764	0.9680	15	0.5319
HM	0.3657	14	0.1420	0.2018	11	0.3333
Site	**TP**			**OP**		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.1331	16	0.0767	0.05	13	0.00
PR	0.1119	16	0.0856	0.05	13	0.00
BD	0.1094	16	0.0448	0.05	13	0.00
BR	0.3731	16	0.7491	0.05	13	0.00
GR	0.0669	16	0.0316	0.05	13	0.00
MR	0.0531	16	0.0145	0.05	13	0.00
MS	0.0513	16	0.0200	0.05	13	0.00
PSE	0.1035	17	0.0637	0.05	15	0.00
PSF	0.0500	17	0.0392	0.05	15	0.00
HM	0.0679	14	0.0181	0.05	11	0.00
Site	**Cd**			**Cd-dissolved**		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0005	16	0.0000	0.0005	16	0.0000
PR	0.0005	16	0.0000	0.0005	16	0.0000
BD	0.0005	16	0.0000	0.0005	16	0.0000
BR	0.0005	16	0.0000	0.0005	16	0.0000
GR	0.0005	16	0.0000	0.0005	16	0.0000
MR	0.0005	16	0.0000	0.0005	16	0.0000
MS	0.0005	16	0.0000	0.0005	16	0.0000
PSE	0.0005	17	0.0000	0.0005	17	0.0000
PSF	0.0005	17	0.0000	0.0005	17	0.0000
HM	0.0005	14	0.0000	0.0005	14	0.0000

Site	Cu			Cu-dissolved		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0247	16	0.0128	0.0065	16	0.0032
PR	0.0278	16	0.0157	0.0071	16	0.0037
BD	0.0095	16	0.0164	0.0025	16	0.0028
BR	0.0094	16	0.0104	0.0030	16	0.0030
GR	0.0115	16	0.0187	0.0032	16	0.0033
MR	0.0159	16	0.0282	0.0045	16	0.0057
MS	0.0102	16	0.0105	0.0047	16	0.0067
PSE	0.0143	17	0.0144	0.0040	17	0.0037
PSF	0.0078	17	0.0139	0.0021	17	0.0029
HM	0.0155	14	0.0194	0.0043	14	0.0041

Site	Pb			Pb-dissolved		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0016	16	0.0008	0.0008	16	0.0004
PR	0.0018	16	0.0010	0.0009	16	0.0004
BD	0.0008	16	0.0005	0.0005	16	0.0001
BR	0.0009	16	0.0007	0.0006	16	0.0002
GR	0.0008	16	0.0005	0.0006	16	0.0002
MR	0.0010	16	0.0006	0.0006	16	0.0002
MS	0.0010	16	0.0008	0.0007	16	0.0002
PSE	0.0010	17	0.0008	0.0006	17	0.0002
PSF	0.0008	17	0.0006	0.0006	17	0.0002
HM	0.0009	14	0.0006	0.0006	14	0.0002

Site	Zn			Zn-dissolved		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0187	16	0.0185	0.0048	16	0.0040
PR	0.0161	16	0.0171	0.0041	16	0.0039
BD	0.0077	16	0.0090	0.0023	16	0.0024
BR	0.0127	16	0.0153	0.0033	16	0.0036
GR	0.0064	16	0.0059	0.0020	16	0.0017
MR	0.0095	16	0.0103	0.0030	16	0.0027
MS	0.0087	16	0.0084	0.0026	16	0.0024
PSE	0.0133	17	0.0133	0.0036	17	0.0032
PSF	0.0089	17	0.0130	0.0026	17	0.0033
HM	0.0067	14	0.0100	0.0017	14	0.0021

Site	BOD			COD		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	3.9	16	1.5	27.2	16	12.1
PR	5.3	16	6.0	43.2	16	63.3
BD	3.0	16	1.0	16.8	16	18.3
BR	4.6	16	2.2	23.1	16	18.9
GR	1.1	16	0.3	13.8	16	14.4
MR	1.2	16	0.4	13.8	16	7.5
MS	1.1	16	0.3	21.6	16	19.5
PSE	3.4	17	3.0	17.8	18	13.8
PSF	1.4	18	1.0	11.2	18	8.6
HM	1.7	14	1.4	20.3	14	16.0

Site	CL			Fl		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	4820.9	15	2063.7	0.25	15	0.00
PR	5585.3	15	2588.0	0.25	15	0.00

BD	852.3	15	1000.3	0.25	15	0.00
BR	2356.1	15	1502.6	0.25	15	0.00
GR	1665.3	15	1560.9	0.25	15	0.00
MR	2079.9	15	1888.5	0.25	15	0.00
MS	2655.2	15	2161.7	0.25	15	0.00
PSE	4217.0	16	1697.4	0.25	17	0.00
PSF	46.1	17	11.3	0.25	17	0.00
HM	3242.7	13	2029.8	0.25	13	0.00

Site	**SO_4**					
	Mean	**N**	**Std.Dev**			
BC	702.35	14	294.86			
PR	790.24	15	332.30			
BD	128.93	15	146.63			
BR	353.13	15	208.26			
GR	248.02	15	222.00			
MR	353.10	15	269.14			
MS	397.48	15	299.25			
PSE	596.93	16	225.39			
PSF	17.93	17	4.53			
HM	485.65	13	276.84			

Appendix 9-4: Results of 2007 Probabilistic Monitoring

Station ID	Subwatershed	DNR 12 Digit Subsheds	Benthic Index of Biotic Integrity Score	Rating
Liberty Reservoir				
503010	Norris Run	048	3.33	Fair
503017	Locust Run	046	4.33	Good
507009	Norris Run	048	3.67	Fair
507016	Locust Run	046	4.33	Good
507018	Glen Falls Run	048	4.00	Good
507019	Norris Run	048	4.33	Good
507020	Liberty Reservoir-F	046	4.33	Good
507025	Cliffs Branch	048	3.00	Fair
507027	Locust Run	046	3.33	Fair
507028	Locust Run	046	4.00	Good
507032	Glen Falls Run	048	3.33	Fair
507033	Cliffs Branch	048	4.00	Good
507038	Timber Run	048	4.00	Good
507041	Keyser Run	048	4.00	Good
507047	Glen Falls Run	048	3.67	Fair
507050	Glen Falls Run	048	4.33	Good
507052	Locust Run	046	4.33	Good
507054	Liberty Reservoir-F	046	4.00	Good
507055	Liberty Reservoir-F	046	4.33	Good
507058	Locust Run	046	4.33	Good
Patapsco River				
603058	Herbert Run (E. Br)	012	1.86	Very Poor
607003	Patapsco River-A	017	2.67	Poor
607006	Herbert Run (E. Br)	012	3.29	Fair
607011	Bull Branch	016	1.67	Very Poor
607017	Mardella Run	019	4.00	Good
607021	Brice Run	019	3.67	Fair
607022	Mardella Run	019	3.00	Fair
607027	Miller Branch	017	1.33	Very Poor
607029	Brice Run	019	1.67	Very Poor
607031	Ben's Run	018	2.33	Poor
607032	Cedar Branch	017	2.33	Poor
607036	Patapsco River-E	019	4.33	Good
607041	Herbert Run (E. Br)	012	2.43	Poor
607043	Cooper Branch	017	2.00	Poor
607047	Dogwood Run	018	2.33	Poor
607062	Ben's Run	018	4.67	Good
607064	Patapsco River (N.Br)	019	3.67	Fair

607069	Patapsco River-A	016	1.86	Very Poor
607074	Bull Branch	016	1.33	Very Poor
607076	Patapsco River-E	019	4.33	Good
607091	Patapsco River-A	016	2.33	Poor
607110	Patapsco River-A	016	2.00	Poor
607111	Miller Branch	017	1.33	Very Poor
607112	Miller Branch	017	1.00	Very Poor
Gwynns Falls				
703003	Gwynns Falls-B	045	2.33	Poor
703017	Horsehead Branch	044	2.67	Poor
703033	Gwynns Falls-B	045	2.00	Poor
703040	Red Run	045	4.00	Good
703067	Scotts Level	044	1.33	Very Poor
703075	Dead Run	044	1.67	Very Poor
707002	Powder Mill Run	044	2.00	Poor
707005	Scotts Level	044	2.00	Poor
707011	Powder Mill Run	044	2.33	Poor
707012	Red Run	045	3.33	Fair
707014	Scotts Level	044	1.67	Very Poor
707019	Powder Mill Run	044	2.00	Poor
707030	Gwynns Falls-B	045	2.33	Poor
707034	Horsehead Branch	044	3.00	Fair
707036	Gwynns Falls-B	045	2.00	Poor
707038	Red Run	045	4.00	Good
707039	Red Run	045	3.67	Fair
707044	Red Run	045	3.33	Fair
707048	Powder Mill Run	044	2.00	Poor
707057	Gwynns Falls-B	045	2.67	Poor
707061	Red Run	045	4.33	Good
707069	Gwynns Falls-B	044	2.00	Poor
707070	Powder Mill Run	044	2.00	Poor
707071	Horsehead Branch	044	4.00	Good
707072	Red Run	045	3.67	Fair
707077	Scotts Level	044	2.33	Poor
Jones Falls				
803008	Dipping Pond Run	036	4.33	Good
803025	Slaughterhouse Branch	036	3.00	Fair
803031	Moores Branch	036	1.67	Very Poor
803060	Deep Run-Jones Falls	036	2.00	Poor
807001	Jones Falls	036	3.00	Fair
807002	Roland Run	037	2.00	Poor
807009	Jones Falls (North Branch)	036	2.67	Poor
807012	Jones Falls	036	2.67	Poor
807014	Moores Branch	036	1.33	Very Poor

807017	Jones Falls	036	1.67	Very Poor
807019	Dipping Pond Run	036	3.33	Fair
807021	Jones Falls (North Branch)	036	4.00	Good
807027	Jones Falls (North Branch)	036	4.00	Good
807029	Towson Run	034	1.33	Very Poor
807030	Towson Run	034	1.33	Very Poor
807031	Jones Falls (North Branch)	036	2.33	Poor
807042	Roland Run	037	2.00	Poor
807043	Dipping Pond Run	036	4.00	Good
807045	Roland Run	037	1.67	Very Poor
807051	Jones Falls	036	3.67	Fair
807054	Jones Falls	036	3.33	Fair
807057	Jones Falls (North Branch)	036	4.67	Good
807060	Jones Falls (North Branch)	036	4.00	Good
807064	Jones Falls (North Branch)	036	3.33	Fair
807065	Jones Falls	036	1.67	Very Poor
807066	Slaughterhouse Branch	036	1.67	Very Poor
807068	Jones Falls (North Branch)	036	2.67	Poor
807071	Jones Falls	036	3.67	Fair
Back River				
1203002	Herring Run-B	042	1.00	Very Poor
1203017	Brians Run	039	1.86	Very Poor
1203020	Stemmers Run	039	1.57	Very Poor
1203021	Brians Run	039	1.57	Very Poor
1203022	Herring Run-B	042	NA	NA
1207003	Stemmers Run	039	1.67	Very Poor
1207007	Herring Run-B	042	1.33	Very Poor
1207011	Herring Run-B	042	1.00	Very Poor
1207013	Stemmers Run	039	1.33	Very Poor
1207014	Stemmers Run	039	1.33	Very Poor
1207018	Stemmers Run	039	1.00	Very Poor
1207023	Herring Run-B	042	1.33	Very Poor
1207025	Brians Run	039	1.29	Very Poor
1207026	Redhouse Run	040	1.67	Very Poor
1207028	Deep Creek	038	1.57	Very Poor
1207035	Redhouse Run	040	3.00	Fair
1207036	Stemmers Run	039	1.33	Very Poor
1207038	Herring Run-B	042	2.00	Poor
1207042	Back River-E	038	2.33	Poor
1207043	Redhouse Run	040	1.67	Very Poor