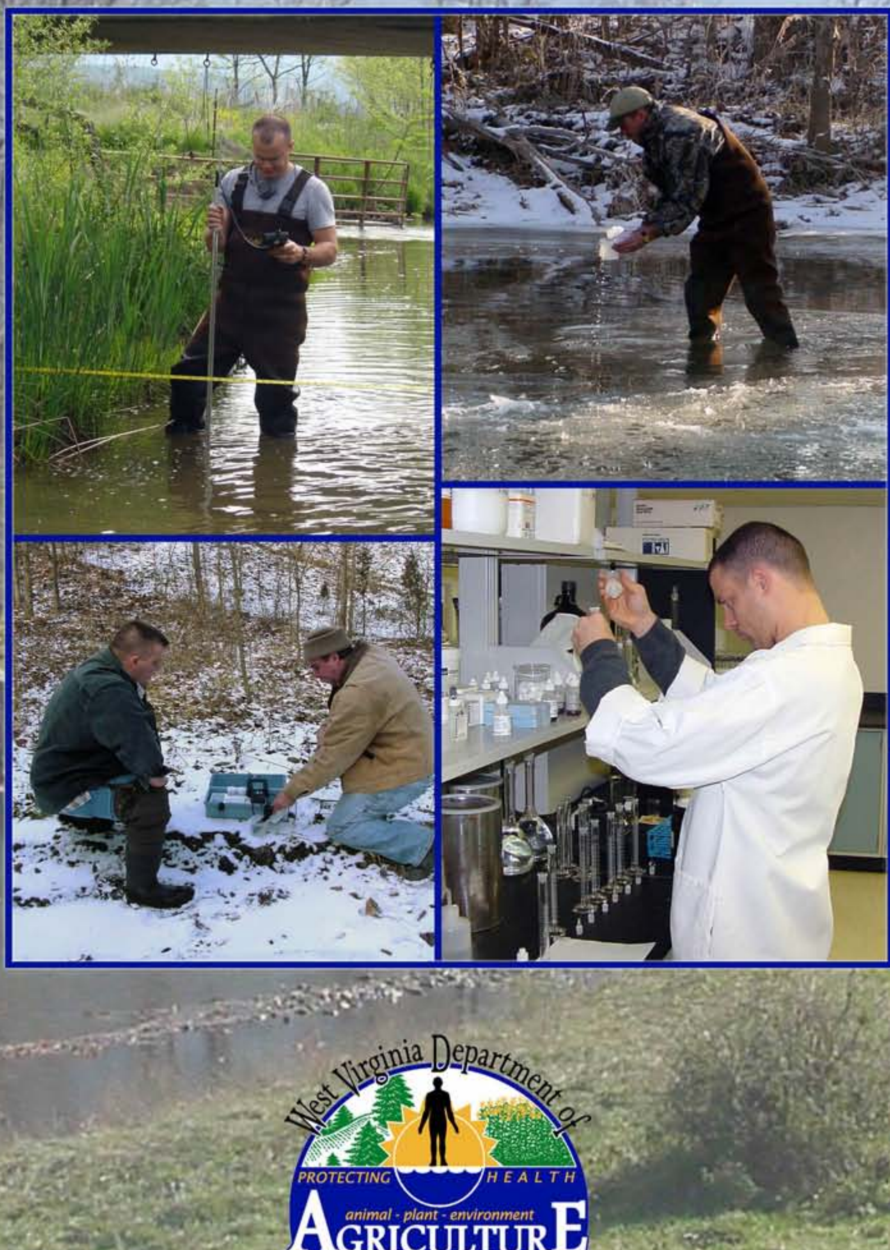
A Synopsis of the Potomac Headwaters Water Quality Report

July 1998-June 2004



West Virginia Department of Agriculture
Gus R. Douglass, Commissioner

MISSION STATEMENT

The West Virginia Department of Agriculture's (WVDA) Environmental Program serves the citizens of West Virginia by encouraging the farm community to continue to produce food and fiber for global distribution while preserving the surrounding natural resources for the generations of the future. A strong program for maintaining high water and air quality is achieved through the efforts of a professional staff. Participation in cooperative projects with other state agencies, national programs, and producer associations results in the WVDA maintaining an innovative role in agricultural conservation.

TABLE OF CONTENTS

FOREWORD

Gus R. Douglass

As Commissioner of Agriculture, I believe that farming in West Virginia is not only an important contributor to our economy, but also adds to the natural beauty and heritage of the Mountain State. I have been farming for more than half a century at my home in Mason County, and can assure you that it can be difficult work. Decisions made can affect the future of farmland for generations, so adequate research and exploration must occur prior to changing any aspect of farming operations.

This report is the ongoing work of the West Virginia Department of Agriculture (WVDA) in response to concerns about water quality that arose because of the mid 1990s expansion of poultry production in the Potomac Headwaters region. A short-term study by the USGS during that period indicated that some streams were contaminated with fecal coliform bacteria and, as a result, seven Potomac Highland streams were listed by the WVDEP as being impaired. Agriculture was named the prime suspect. Out of concern that the listing of these waters was based on insufficient data, I directed the WVDA to collect additional data that would more accurately establish the condition of these streams.

This report details the findings of the WVDA's water quality sampling efforts from July 1998 to June 2004 along the Potomac headwaters of West Virginia. In an effort to continue to preserve our resources, the WVDA strives to promote farming while encouraging and supporting the implementation of Best Management Practices.

Thanks to the pioneering spirit and cooperation of landowners and state and federal agencies, we are continuing to make considerable progress in tracking and controlling potential contamination in the Potomac River Basin. With the preliminary success of the program in the Eastern Panhandle, it is being considered as a model for other states, in addition to being used to answer water quality questions in other areas of the Mountain State.

For more information about this and other WVDA programs, please contact me at (304) 558-2201, or by e-mail at douglass@ag.state.wv.us.

ACKNOWLEDGEMENTS

The West Virginia Department of Agriculture would like to express our gratitude to the following individuals for their support throughout this project:

We would like to sincerely thank Neil Gillies of Cacapon Institute for his efforts and patience in developing this comprehensive report. This report would not have been possible without his knowledge and understanding.

Frank Rodgers, Cacapon Institute; Douglas Chambers, United States Geological Survey (USGS); John Wirts, West Virginia Department of Environmental Protection (WVDEP); and Teresa Koon, WVDEP for their valuable insight and suggestions.

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The West Virginia Conservation Agency (WVCA), USDA Natural Resources Conservation Service (NRCS), West Virginia University National Research Center for Coal and Energy (NRCCE), West Virginia University Extension Service, West Virginia Conservation Districts, West Virginia Department of Environmental Protection (WVDEP), North Fork Watershed Association, and United States Geological Survey (USGS) for their assistance in many ways during the six years covered in this report. To each of them is extended sincere gratitude for their extremely valuable assistance.

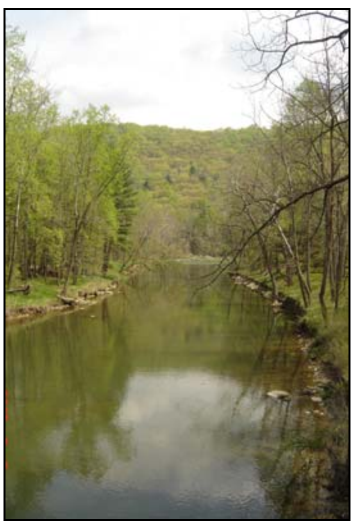
WEST VIRGINIA DEPARTMENT OF AGRICULTURE
WATER QUALITY REPORT
July 1998 – June 2004

Background

West Virginia is known for its high quality rivers and streams. These waters generate income for the State, provide recreational opportunities for residents and tourists, and water for drinking, irrigation, and industry. In order to protect this vital resource, state and federal agencies and other organizations conduct water quality studies to determine the characteristics of the water and identify waters in need of improvement. The quality of every stream's water is affected by natural factors such as geology, soils, and forest type. They can also be impacted by the activities of people, and it is human effects that are, in excess, described as pollution.

Lunice Creek

In 1996, segments of seven rivers within West Virginia's Potomac watershed (Lost River, South Branch of the Potomac, North Fork of the South Branch, South Fork of the South Branch, Mill Creek, Lunice Creek and Anderson Run) were placed on West Virginia's 303(d) list of impaired water bodies due to fecal coliform bacteria. Out of concern that the listing of these waters was based on insufficient data, in 1998 the West Virginia Department of Agriculture (WVDA) began a water quality sampling program in these watersheds to collect additional data that would more accurately establish the condition of these streams.



Lost River

Mill Creek

Anderson Run

North Fork

South Fork

South Branch

This six year report presents WVDA Water Quality Program findings for nutrient and bacteria data collected between July 1998 and June 2004. During this period, over 13,000 samples were collected at 100 sites throughout this region. Eighty three of those sites, with 12,778 total samples, are discussed in this report. The original sampling sites were located in the watersheds noted above. Additional sites known as the Outer Run were added later (some in 1999, some in 2002) to develop water quality information needed by the Chesapeake Bay Program to improve the accuracy of its water quality modeling and forecasting.

All of the sampling sites were in basins that were affected by anthropogenic (human) influences and, therefore, water quality in all sites show the signature of human uses of the land. In order to reduce sampling bias, all samples were collected based on a preset schedule, and were collected regardless of weather conditions, including both high and low flows, and during periods of low, normal, and high precipitation.

A Region in Flux

This section highlights conditions during the study period that might have influenced the results, including hydrological conditions, a changing agricultural scene, and rapid population growth. These conditions included:

- The study began during a period of unusual drought, and ended during period that was unusually wet. During wet years the potential for movement of non point source pollutants into streams is increased, but concentrations may not increase dramatically due to dilution effects. Also during wet years, the impact of point sources on parameter concentrations decreases due to increased dilution. The impact of point sources on stream quality is greatest during dry years. These patterns make the study of water quality in rivers and streams very challenging

- The agricultural sector experienced dynamic change during the study years. In particular, the poultry industry completed an expansion that tripled production in WV’s Potomac Headwaters region, leading to specific concerns that increased amounts of poultry litter (a mixture of poultry manure and bedding materials) in the watershed might impact water quality. To address those concerns, the Potomac Headwaters Land Treatment Program was initiated in the mid-1990’s. This government cost share project focused on accelerated development of nutrient management plans and installation of agriculture waste storage structures, mortality composters and livestock confinement areas. Eighty-five percent of poultry growers in the five county area of the Potomac Valley Conservation District are currently participating in this program.

Nutrient Results

Nutrients occur naturally in soil, water and the atmosphere. Nutrients are essential to all life, but an excess can cause problems, such as the excessive growth of algae in rivers. Wastewater treatment plants, untreated sewage, industrial discharges, vehicle exhaust, atmospheric deposition, and runoff of fertilizer and manure from agricultural, residential and urban areas all contribute nutrients to our rivers. The three important nutrients discussed in this report are total phosphorus, ammonia-nitrogen, and nitrate-nitrogen.

Total Phosphorus

Total phosphorus is the sum of all forms of phosphorus: organic and inorganic, suspended and dissolved. Phosphorus does not move easily though ground water but erosion can transport large amounts of sediment-bound phosphorus to surface waters during severe precipitation events. Other studies estimate that over 90% of the annual phosphorus load can be delivered by a few big storms each year.

Phosphorus concentrations downstream of point sources such as sewage treatment plants are often very high. However, phosphorus that is washed into streams from non point sources, even where sources are extremely abundant, can be elusive. Phosphorus that enters the stream attached to sediment quickly drops from the water column to the stream bottom. Phosphorus that enters the stream in dissolved forms is rapidly taken up by microbes and plants, or chemically adsorbed to sediment – and mostly disappears from the water column as well. Phosphorus is a limiting resource. It is removed from the water column rapidly because it is in short supply. Even at low concentrations phosphorus can have a profound biological effect.

For parameters that are present in the water column at very low concentrations, such as phosphorus, much of the data collected provides little in the way of comparative information. At all but a very few sites, at least 25% of the samples had phosphorus concentrations below the detection limit for the analytical method being used, and most sites had medians at or only slightly higher than the method detection limit. For many sites it was only in the upper few percentiles of the data that differences in phosphorus became apparent.

Median phosphorus concentrations ranged from a low of 0.0065 mg/l (below the detection limit) at 18 out of 83 sites, to a high of 0.161 at a South Branch site located below the town of Moorefield. Of the remaining sites, median concentrations at all but four sites ranged very narrowly between 0.01 and 0.019 mg/l. With very few exceptions at least 25% of the data at every site was below the detection limit. No watershed wide patterns were observed, and at least three of the few sites with slightly elevated median phosphorus concentrations were associated with known significant point sources in Moorefield and in the South Mill Creek watershed.

"Below the detection limit" results do not mean phosphorus was not present. It simply means that the analytical methods used were not sensitive enough to detect the phosphorus that was in the water column. Also, phosphorus stored in reservoirs of plant material and minerals does not show up in water samples.

Ammonia-nitrogen

Ammonia, an important form of nitrogen, is a colorless gas with a sharp odor that many people recognize as a household cleaning agent. Natural sources of ammonia include decomposing animal and plant tissue, and human and animal waste. Humans also synthesize ammonia, about 80% of which is used as fertilizer. Small amounts of ammonia are a useful source of nitrogen for plants, but in excess it can be toxic, particularly in its un-ionized form. Ammonia is generally more toxic to fish than to freshwater invertebrates, and toxic effects are greater at early life stages. West Virginia has a water quality standard for ammonia due to its toxic effects on aquatic life.

Median ammonia-N concentrations ranged more than one order of magnitude, from a low of 0.011 mg/l at a site in the North Fork of the South Branch to a high of 0.495 in Abram Creek. Ammonia at the

Abram Creek site was distinctly high, with the next highest median concentration in Stony River (0.183 mg/l), followed by a Mill Creek site (0.166 mg/l). Seventy four of 83 sites had median ammonia concentrations below 0.100 mg/l. Most sites had detectable ammonia in more than 75% of the samples collected. Maximum ammonia-N concentrations ranged more than two orders of magnitude from a low of 0.154 mg/l at a North Fork site to a high of 17.37 mg/l at Abram Creek. In comparison to other study watersheds, ammonia was significantly elevated in the Mill Creek watershed, followed by slightly lower levels in Lunice Creek and the Lost River.

Twelve of nineteen one-time exceedences of the chronic water quality criterion concentration for ammonia were observed at sites in the Mill Creek watershed, with six of these occurring during a single storm event. However, no sites exceeded the chronic criterion in 10% or more of the samples collected and no sites would, therefore, be considered impaired for ammonia by the WV DEP. Ammonia concentrations were distinctly low in the North Fork watershed.

Nitrate-nitrogen

Nitrate is a form of nitrogen that is essential for plant growth. Much of the earth's natural supply of nitrate is produced by bacteria and algae that convert nitrogen gas to nitrate through various chemical reactions. In addition, nitrogen applied to crops as ammonium and organic N can be converted to nitrate by various chemical and biological pathways. Nitrate readily dissolves in water, is chemically stable over a broad range of environmental conditions and moves easily through ground and surface waters. Once in the stream, nitrate concentrations are much more persistent in the water column than either phosphorus or ammonia. However, microbial processes that occur at the stream bed interface transform nitrate in a number of ways, including removal from the stream via conversion to elemental (gaseous) nitrogen. These processes have the greatest effect on in-stream nitrate concentrations during low flow conditions. Various studies, including this one, indicate that nitrate is often the best quantitative indicator of nitrogen in WV's rivers.

Median nitrate-N concentrations ranged more than one order of magnitude from a low of 0.10 mg/l at two South Fork sites to a high of 1.90 at the Opequon Creek outlet at the Potomac River. Nitrate at the Opequon site was distinctly high, with the next highest median concentrations at the Potomac River at Harpers Ferry, a site in the Lost River, and two sites in the Shenandoah River. Most sites had detectable nitrate in more than 90% of the samples collected. Maximum nitrate-N concentrations ranged more than one order of magnitude from a low of 0.60 mg/l at a South Fork site and a North Fork site to a high of 11.2 mg/l at a Lost River site. The latter was the only instance during this study of a nitrate-N concentration exceeding the drinking water standard of 10.0 mg/l. In comparison to other main study watersheds, nitrate was significantly elevated in the Lost River watershed, followed by somewhat lower levels in Anderson Run and Mill Creek. Nitrate concentrations were relatively low in the North and South Fork watersheds.

Fecal Coliform Bacteria Results

Fecal coliform bacteria thrive in the intestines of warm blooded animals and enter the environment when animals defecate. While fecal coliforms themselves are usually not harmful, they are often associated with other human pathogens carried in feces. Researchers use the presence of fecal coliforms as an indication that water is contaminated with fecal matter. Fecal coliforms can enter waters through direct deposition by animals, via straight pipes, failing septic tanks, runoff from fields, forests, parking lots and yards, and via sewage treatment plants and other point sources. This parameter is the one most commonly used to determine if a river is suitable for water contact recreation. The Lost River, South Branch of the Potomac, North Fork of the South Branch, South Fork of the South Branch, Mill Creek, Lunice Creek, and Anderson Run were listed on the USEPA's 303(d) list for water bodies not meeting their designated use due to fecal contamination as this study began.

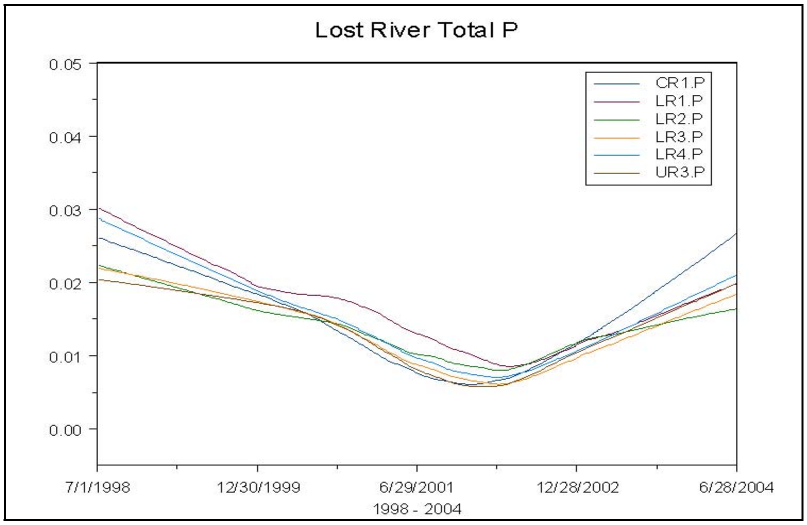
The WV State water quality standard for fecal coliform bacteria is in two parts; if water quality fails either part the stream is considered in violation. The first part of the standard says that a violation occurs if the geometric mean of five or more samples collected within thirty days exceeds 200 colony forming units (cfu) in 100 milliliters of water (100ml). The second part of the standard says that a violation occurs if 10% or more of samples collected at a site exceed 400 cfu/100ml. There were often large differences in the number of samples collected for fecal coliform bacteria analysis at different sites; this complicates comparisons. Median fecal coliform bacteria concentrations ranged broadly from a low of 7 cfu/100 ml at a North Fork site to a high of 420 cfu/100 ml at a South Mill Creek site (SMC1) where fecal coliform concentrations were distinctly high. The next highest median concentration of 190 cfu/100ml was found at another Mill Creek site. Maximum fecal coliform concentrations ranged from a low of 167 cfu/100 ml at a South Branch to a high of 692,000 cfu/100ml at Mill Creek site SMC1.

In comparison to other study watersheds, fecal coliform bacteria concentrations were significantly elevated in the Mill Creek watershed, followed by somewhat lower levels in Lost River, Anderson Run and Lunice Creek; all but a few sites in these watersheds had at least 10% of fecal coliform samples in excess of 400 cfu/100 ml. Fecal coliform concentrations were distinctly lower in the South Branch 1&2, North Fork, and South Fork watersheds; no sites in these watersheds had as many as 10% of samples exceed 400 cfu/100 ml. While sampling for bacteria was discontinued at sites in the South and North Fork watersheds during 1999 and 2000, and was discontinuous in the South Branch 1&2 watersheds, the WVDA data generally indicates that the South Fork, North Fork and South Branch 1&2 watersheds were meeting fecal coliform water quality standards.

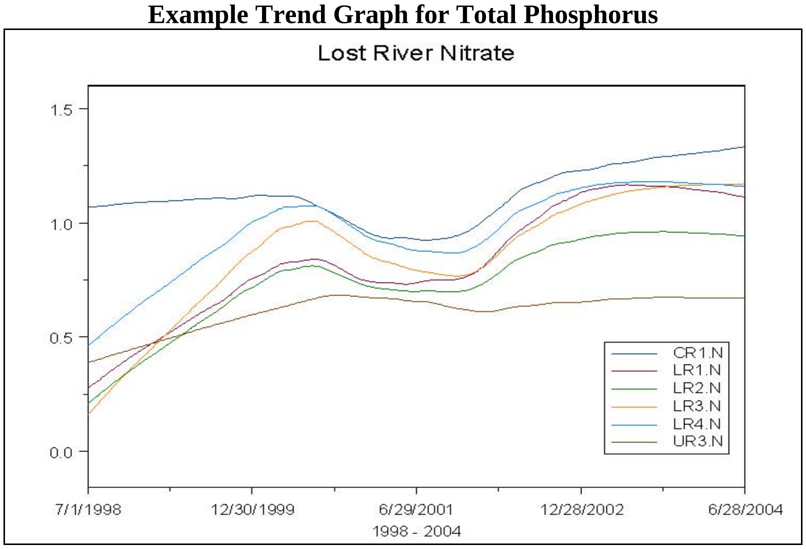
Trends

The primary challenge in analyzing water quality data for trends is to separate the components of variability related to human impacts from natural variability, in particular streamflow and season. During the six year study period discussed in this report, agriculture in the Potomac Highlands region was expanding rapidly, agricultural best management practices were being installed on many farms, the human population was growing (explosively in some areas), and the region experienced extreme drought at the beginning of the study followed by an exceptionally wet period near the end. Any of these factors alone would make interpretation of trends difficult, but the lack of flow data for study sites made interpretation of trend analyses particularly problematic.

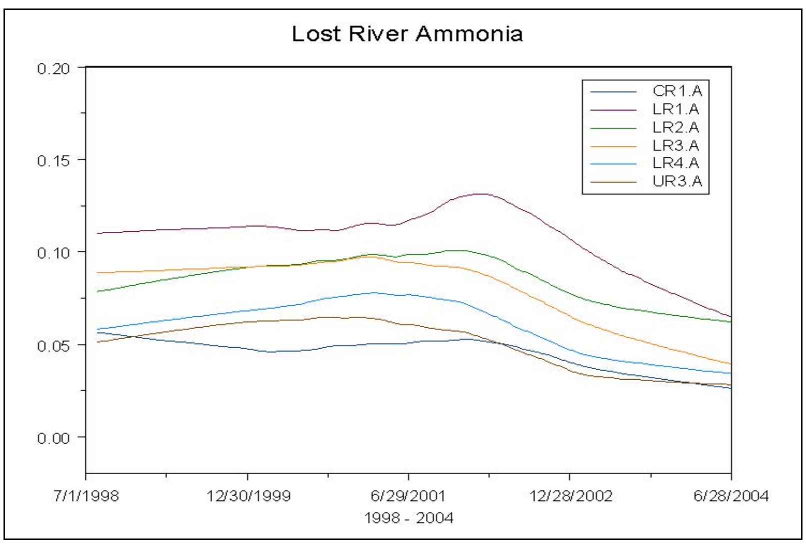
Trend analyses at the sites with the most complete multi-year records indicated that phosphorus and ammonia were decreasing at roughly 65% of the 39 trend sites and nitrate was increasing at 92% of the 39 trend sites. Each of these parameters displayed conspicuous and nearly uniform temporal patterns at most sampling sites during the study period. Phosphorus was highest at the beginning, lowest in the middle, and increasing at the end. Nitrate was lowest in the beginning and increased throughout the study period. Ammonia median concentrations increased slightly from 1998 through 2002, and then dropped distinctly in 2003 and 2004. A visual assessment of trends, as well as the uniformity of trend patterns across sites, suggested that hydrology probably played a large role in shaping trend analysis results for nutrients. The graphs on the following page provide examples of the nutrient trends along the Lost River.



Example Trend Graph for Total Phosphorus



Example Trend Graph for Nitrate



Example Trend Graph for Ammonia

Of the 26 sites with sufficient data for fecal coliform bacteria trend analysis, 14 had significant decreasing fecal coliform trends, and 12 had no detectable trend. The sites with decreasing trends tended to have the highest concentrations in 1998, followed by similar levels between 1999 and 2003, and lowest levels in 2004. However, the temporal patterns for sites with significant trends for fecal coliforms were quite variable.

In all cases, the report concluded that more data over time at trend sites, ideally in concert with site-specific flow data, will be necessary to determine if parameter concentrations at individual sites or regionally were actually changing, or if apparent changes were artifacts of hydrological conditions during the study period.

Summary

In research programs carefully designed to measure changes in water quality due to improvements in land management, the typical study design calls for two or more years of baseline data collection followed by three to six years of sampling after implementation of new land use practices. There is a need for patience in measuring changes in water quality in watersheds primarily impacted by non point sources, and the West Virginia Department of Agriculture understands this need. Although program parameters have changed over time, and may need to change further to accommodate shifting needs of information, WVDA water quality programs will continue to collect data to accurately ascertain the condition of rivers and streams throughout West Virginia.

This six year report is an executive summary of the "West Virginia Department of Agriculture's Comprehensive Water Quality Report" published in May 2006. The comprehensive report includes detailed descriptions, graphs, charts and maps pertaining to the overall project. An introductory section provides a description of monitoring program and an overview of the results from the entire WVDA data set. The introduction is followed by site-by-site data from each study watershed, followed by a comparison of the main study watersheds with each other. The discussion provides an overview of the results, discussing trends and sources.

In addition, a description of the WV Department of Agriculture's field and laboratory methods is provided in Appendix 1. Summary statistics are provided in Appendix 2. Complete results of the time series and seasonal Kendall tests are provided in tabular form in Appendix 3, along with more technical descriptions of the statistical methods used.

The "Comprehensive Report" can be accessed on line at www.wvagriculture.org. Click on the Regulatory and Environmental section, and then click on "Go to Environmental Programs." Printed copies and CD copies can be requested by calling 304-538-2397 or writing to WVDA, 60B Industrial Park Road, Moorefield, WV 26836.

WVDA Moorefield Field Office