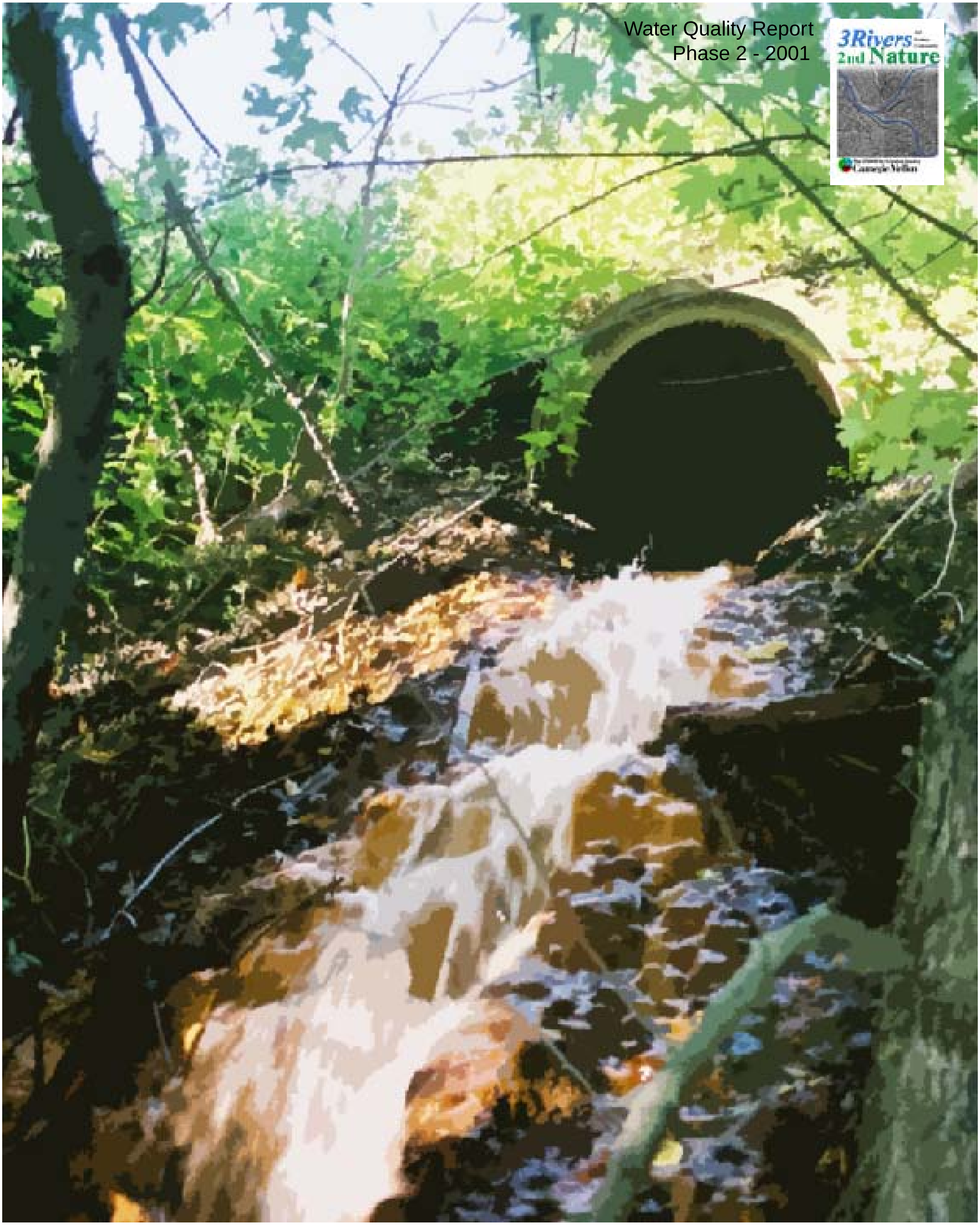
Water Quality Report
Phase 2 - 2001



WATER QUALITY REPORT

Prepared by:

Kathy Knauer, M.S.

Environmental Scientist, Allegheny County Sanitary Authority

3 Rivers - 2nd Nature

Studio for Creative Inquiry

Carnegie Mellon University

Co-Authors

Beth McCartney, GIS (Geographical Information System)
Priya Krishna, GIS

Laboratory analyses

Gary Yakub and Tracey N. Heineman of ALCOSAN
Mary Blazina David Castric, Lanie Frazier and Gim Y. Yee, of Allegheny County Health Department
Bob Houston and Katrina Lindauer of Allegheny County Laboratories

Partners in this Project

3 Rivers Wet Weather Incorporated (3RWW)
Allegheny County Health Department (ACHD)
Allegheny County Sanitary Authority (ALCOSAN)

3 Rivers - 2nd Nature Advisors

Reviewing this Report

Wilder Bancroft	Environmental Quality Manager, Allegheny County Health Dept.
Don Berman	Environmental Consultant,
David Dzombak	Professor, Civil and Environmental Engineering, Carnegie Mellon
Mary Kostalos	Professor Biology, Chatham College
Michael Lambert	Director Three Rivers Rowing
Jan Oliver	Wet Weather Program Director, ALCOSAN
John Schombert	Director 3 Rivers Wet Weather
Jeanne Vanbriessen	Assistant Professor of Civil and environmental Engineering

Reviewing the Project

John Arway	Chief Environmental Services, PA Fish and Boat Commission
Bob Bingham	Professor Art, Co-Director, STUDIO for Creative Inquiry, CMU
James Davidson	Laboratory Manager, Allegheny County Health Dept.
Mike Koryak	Limnologist, U.S. Army Corp of Engineers
Edward Muller	Professor of History, University of Pittsburgh
Beth O'Toole	Director, Pittsburgh Voyager
Tom Proch	Biologist, PA Department of Environmental Protection
Dan Sentz	Environmental Planner, Pittsburgh Department of City Planning
Joel Tarr	Caliguiri Professor of History and Public Policy, Carnegie Mellon
Steve Tonsor	Professor of Biological Science, University of Pittsburgh
Davitt Woodwell	Vice President, Pennsylvania Environmental Council

TABLE OF CONTENTS

Introduction

This water quality study is a strategic program developed by the STUDIO for Creative Inquiry, in partnership with 3 Rivers Wet Weather Inc. (3RWW), ALCOSAN, and the Allegheny County Health Department (ACHD). It is intended to reveal patterns and relationships between water quality, public use and the functioning ecosystems of our urban river systems. The project provides a relatively short-term, low-budget, strategic survey of water quality over a broad geographic area. This project began in 2000 in the Pittsburgh Pool. In 2001, Year 2, the project focused on the Monongahela River from Locks and Dam #2 at Mile Point 11.3 near Braddock, PA to the Allegheny County line at Mile Point 35.

Urban rivers have been used as a source for municipal water supply and as a sink for sewage and industrial wastes. Over the last century the rivers have been redesigned, as regional infrastructure to accommodate shipping and other commercial purposes. This view of the rivers as a raw material for industry and as an alternating source of water and sink for municipal wastes has displaced their value as a natural resource, and as an important amenity among the general public. However, the emphasis is beginning to shift from industrial-commercial uses of the rivers to public access, recreational uses and the combined aesthetic and economic values which stem from natural urban amenities. To facilitate this change, we seek to illustrate opportunities such as intact habitats, increased biodiversity, good water quality and easy public access. By also recognizing current constraints, such as sewer infrastructure problems and habitat loss, we hope to initiate a public dialogue that will help solve these problems. This work will begin to fill the information gaps that limit our ability to discuss these issues.

Our method and process is informed by a group of interdisciplinary advisors, public health officials, engineers and biologists from academia, regulatory, state and federal agencies. They provide expert guidance throughout the study.

<u>The goal of this program</u> is to reveal the dynamic nature of water quality in our region. We seek to define water quality in the context of increased public access to the rivers and tributary streams of Allegheny County. This project constitutes the initial attempt to establish a protocol that can be used by other agencies and organizations to develop a regional water quality baseline. This baseline will be used to make more informed decisions and for comparisons to future water quality changes.

<u>The objective of dry weather sampling</u> is to understand how clean the water is in terms of pathogen indicators and to assess quality of the water over a broad sampling area. This sampling program provides an initial indication of the recreation and public access potential of our surface waters.

The objective of wet weather sampling is to understand how contaminated the water becomes in terms of pathogen indicators when it is raining, how quickly the water quality return to dry weather conditions, and how consistent these changes are over a wide sampling area.

We seek to answer the following questions about surface water quality in relationship to the region's rivers and tributary streams in a variety of weather conditions.

Rivers: Multiple site sampling, analysis and comparison of water quality, in both dry and wet weather conditions.

Dry Weather

1. What is the dry weather water quality and are there spatial variations in quality?
2. Are there water quality problems indicated at points of public access?
3. Are there specific areas that warrant further study? Why?

Wet Weather

1. What is the wet weather water quality and are there spatial variations?
2. Do the water quality spatial relationships change during a rainfall?
3. Are there space and time differences in returning to dry weather conditions?
4. Are there specific areas that warrant further study? Why?

Tributary streams: Single site sampling and analysis of water quality in dry weather conditions.

1. What is the dry weather water quality and how does it vary among the streams?
2. Do the streams affect the water quality of the main stem rivers?
3. Are there water quality problems at points of public access?
4. Does each tributary have the minimum conditions to support aquatic life?
5. Do these tributary streams warrant further study? Why?

Because this study is concerned with public use issues, the rivers were monitored for bacteria that indicate the presence of fecal matter as well as basic field parameters such as temperature, pH, and dissolved oxygen. Additional chemical and physical analyses were not performed on these river samples since the project advisors have found that, through various studies and observations, there is increased biological diversity and other signs of river ecosystem health. Although it is assumed but neither tested nor confirmed that the industrial legacy, includes contaminated sediments at the bottom of the rivers.

In order to develop an initial understanding of the water quality for tributary streams and determine if they have the basic conditions to support aquatic life, the project advisors recommended additional chemical and physical analyses. They also recommended a biological study of the rivers, which began in 2001. A team of biologists with the U.S. Army Corp of Engineers have matched this study stream by stream (Koryak & Stafford, 2001).

Public Access Overview:

There are a variety of forms of public access. In 1996, Terrestrial Environmental Specialists Inc. et. al. was commissioned to assess recreation along the three rivers in Pittsburgh. Public access was defined as formal public parks, commercial marinas and fishing access. In the Riverbank Conditions component of this study, we have seen an increase in marinas on the rivers, as well as a vast number of informal public access points. These are favorite sites for fishing, sunning and other leisure activities.

While we tend to focus on access to the mainstem rivers, it is important to note that there is more potential for informal access along our region's tributary streams than rivers. In our study area in the Monongahela River, nineteen tributary streams wind through many neighborhoods, dozens of communities and a significant number of public parks.

Materials and Methods

Sampling was conducted from a 16' aluminum boat, with a jet propulsion system. This sampling platform allowed the project team to move safely into shallow creeks and tributary streams as well as approach near shore structures in shallow water.

The dry weather work was limited to pools 2 and 3 on the Monongahela. This is delimited on the downstream end by Lock and Dam #2, at Mile Point 11.2 at Braddock, PA on the Monongahela, Lock and Dam #3 at Mile Point 23.8 at Elizabeth, PA on the Monongahela out to the Allegheny County line at mile point 35.

The wet weather work included areas of the Pittsburgh Pool, as well as areas in pools 2, and 3 on the Monongahela.

SEE ATTACHED MAPS FOR OVERVIEW OF SITES

Dry Weather Sampling Program

Sampling Schedule

Sampling occurred from the period of June 21 to October 31, 2001 during dry weather when public recreation is at its greatest, and we have the best opportunity to provide baseline recreational use conditions of our river systems. Dry weather conditions were defined as a minimum of 72 hours after the last rainfall and combined sewer overflow.

One river system was sampled one day per week (weather permitting), resulting in no more than 24 samples per test run (ACHD laboratory limit). This included river sampling points as well as tributary streams. Weekly sampling occurred Monday through Thursday within the dry weather criteria.

River Monitoring

Sample sites were chosen based on the relationship between public access and inflow points into the main stem rivers (see Table 1 below). Tributary streams, culverted tributaries and combined sewer overflow structures were considered inflow points. (A detailed analysis of mixing zones and hydraulic function is beyond the scope of this investigation.)

Cross sections were established at four points within each pool of the Monongahela river in Year 2 study area. Cross-sectional samples were taken at three points across the river (50-100' from the left descending bank, midstream and 50-100' from the right descending bank) at approximately one foot below the surface. This depth was selected based on our interest in public recreation. (Swimmers and recreational users, are primarily in contact with surface waters.)

TABLE 1: Selected River Monitoring Sites in the Monongahela Pools 2 and 3.

River	Mile Point	Site Description
Monongehela	11.5	Above dam 2
Monongehela	14.3	Above Mckeesport Duquesne bridge
Monongehela	16.7	Above Mansfield bridge
Monongehela	23.2	Below dam 3
Monongehela	24.3	Above dam 3
Monongehela	27.8	Carousel Marina
Monongehela	31.7	At Monongahela City
Monongehela	35.0	At the County Line

River Monitoring Parameters

The following parameters were selected to determine the public health aspects of recreational uses of the rivers. See Appendix A for the Pennsylvania water quality criteria and descriptions of the additional field parameters selected. Sampling protocols followed Standard Methods (APHA et al. (1992) Sec. 9060). Total coliform, *E. coli*, and enterococci followed defined substrate method (Idexx Laboratories, Westbrook, ME). Thermotolerant coliform was used as a surrogate to fecal coliform in order to compare the defined substrate method to the accepted membrane filtration method found in Standard Methods (APHA et. al., 1992). This method is a modified total coliform defined substrate test where the sample is incubated in 44.5°C (Yakub et al., 2001).

TABLE 2: Selected Parameters for Rivers and Tributary Streams in the Pittsburgh Pool

Parameter	Justification	Field/Lab	Method
pH	Important for aquatic life	Field Test	4500-H B
Temperature	Important for aquatic life	Field Test	2550 B
Conductivity	Important for aquatic life	Field Test	2510 B
DO	Important for aquatic life	Field Test	4500-O G
Thermotolerant Coliform	An estimation of fecal coliform	ALCOSAN Lab	Modified Idexx
Total Coliform	Data gathered as part of *E. coli*	ALCOSAN Lab	Idexx
E. coli	Indicator species of mammalian fecal	ALCOSAN Lab	Idexx
Enterococci	Indicator species of mammalian fecal	ALCOSAN Lab	Idexx
Fecal Coliform	Indicator for fecal contamination	ACHD Lab	9220 D

(methods taken from APHA et al., 1992 except as noted)

Tributary Stream Monitoring

Free-flowing and culverted tributary streams that flow into the Monongahela River was investigated in this survey (see Table 3). One sample site per tributary stream was selected at the lower end of the stream above the mouth to the river. These sites were selected to assure that no backflow from the rivers were affecting the samples. (This was determined by the first stream riffle, based on access by foot or by boat.) Cross-sections were not established in the tributary streams because the widths of the streams were less than 20 feet.

TABLE 3: Selected Tributary Monitoring Sites in the Pittsburgh Pool

Tributaries Pool 2	**River Mile Point**	**Reason for Sampling**
Turtle Creek	Monongehela MP 11.6	Access/use and affect on river
Thompson Run	Monongehela MP 12.2	Access/use and affect on river
Crooked Run	Monongehela MP 14.6	Access/use and affect on river
Youghiogheny River	Monongehela MP 15.5	Culverted/affect on river
Sandy Creek	Monongehela MP 17.0	Access/use and affect on river
Pine Run	Monongehela MP 18.7	Culverted / affect on river
Coursin Run	Monongehela MP 20.0	Access/use and affect on river
Peter's Creek	Monongehela MP 19.9	Access/use and affect on river
Wiley Run	Monongehela MP 22.6	Culverted /affect on river
Fallen Timber Run	Monongehela MP 23.1	Access/use and affect on river
* SEE ATTACHED MAPS		

Tributaries Pool 3	**River Mile Point**	**Reason for Sampling**
Lobbs Run	Monongehela MP 24.5	Access/use and affect on river
Perry Mill Run	Monongehela MP 25.4	Access/use and affect on river
Kelly Run	Monongehela MP 26.3	Culverted/affect on river
Bunola Run	Monongehela MP 27.2	Access/use and affect on river
Mingo Creek	Monongehela MP 30.0	Culverted / affect on river
Dry Run	Monongehela MP 31.3	Access/use and affect on river
Pigeon Creek	Monongehela MP 32.7	Access/use and affect on river
Sunfish Run	Monongehela MP 34.3	Culverted /affect on river
Beckets/Kelly Run	Monongehela MP 35.3ß	Access/use and affect on river
* SEE ATTACHED MAPS		

Tributary Monitoring Parameters

Tributary stream parameters included those in Table 2 as well as additional chemical and physical parameters listed in Table 4. (See Appendix A for parameter descriptions.)

TABLE 4: Additional Parameters for Tributary Streams in the Pittsburgh Pool

Parameter	Justification	Field/Lab	Method
TDS	Toxic to aquatic life	ACHD Lab	2540 C
Ammonia	Toxic to aquatic life	ACHD Lab	4500-NH_3 F
Hardness	Indication of metals availability	ACHD Lab	2340 C
Alkalinity	Indicator of acid mine drainage	ACHD Lab	2320 B
Iron	Indicator of acid mine drainage	ACHD Lab	3500-Fe B
Al*	Indicator of acid mine drainage	ACHD Lab	3500-Al B
Cu**	Toxic to aquatic life – synergistic effect with zinc	ACHD Lab	3500-Cu B
Zinc**	Toxic to aquatic life – synergistic effect with copper	ACHD Lab	3500-Zn B

(methods taken from APHA et al., 1992)

*Dependent of pH value. If above 8.0 or below 3.0, sample will be analyzed for Al

**Dependent on analysis of upstream NPDES discharges.

Wet Weather Sampling Program

Wet Weather sampling focused on bacteriological analyses and basic field parameters (Table 2) limited to no more than 20 samples per testing-run. In 2001, the Allegheny County Health Department asked that we concurrently sample for wet weather in the Pittsburgh pools as well as in pool 2, and 3 of the Monongahela so that we could begin to develop an overview of the upstream/downstream relationships. The Three Riverskeeper provided the boat for the concurrent work in the Pittsburgh Pool.

The sites for wet weather sampling:

Pittsburgh Pool - the first transects on each river starting from the confluence of the three rivers. Plus one additional transect above the dam on the Ohio at Emsworth, Mile Point 6.2.

Monongahela – the middle transects for pools 2 and 3.

SEE ATTACHED MAPS FOR OVERVIEW OF WET WEATHER SITES

A wet weather event (rain storm) was defined as occurring after a period of 72 hours since the previous rainfall, as recommended by USEPA (1992) for storm water sampling. A combination of the City of McKeesport, Clairton and ALCOSAN combined sewer overflow data provided the best indicator of broad-scale regional rainfall and wet weather impacts. The ALCOSAN wet well and interceptor system have been modeled to determine when overflows are occurring. This is based on the water flowing through the plant and wet well levels. We retained this system in the Mon Valley (outside of the ALCOSAN service area) because this is the same indicator used by the Allegheny County Health Department's Regional River Water Advisory Program. Sampling occurred once after a wet weather event while combined sewer overflows were occurring. The sites were then re-sampled at 12-24 hours and again at 36-48 hours after the overflows stop. Results of all three sample sets were reviewed to determine if additional days of sampling would be needed.

Rain gauge data are averaged from data-sets collected by the Municipal Authority of the City of McKeesport, Clairton Municipal Authority, and selected gauges of the Three Rivers Wet Weather Rain Gauge System.

Geographical Information System Mapping

Geographic Information Systems (GIS) have become an increasingly necessary component of analysis and decision making processes. GIS serves as a powerful tool in portraying data or a database spatially. In addition to the powerful querying capabilities, GIS displays information in the form of a map, a graph, or a report. Geographic Information Systems are continually enhanced by technological advancements, as well as peripheral device improvements, (e.g. global positioning system technology).

GIS has been instituted in almost all aspects of 3 Rivers – 2^{nd} Nature project. The water quality team established procedural protocols and designated test sites. A Global Positioning System (GPS) was used for the initial capture of these sites. The GPS was also used to navigate back to these sites for sampling. (Accuracy is within 30 feet.) These sites included river transects, consisting of 3 points, designated stream test sites, and wet weather protocol. Each site was given a specific name, which in turn will be the link between the spatial location of the site and the data collected.

After the data collection process, the data was arranged in a relational database (Microsoft Access) compatible with ESRI ArcView 3.2 software. This allows the GIS software to connect to the database enabling it to access existing tables and queries as well as create its own using SQL (a database query language). This method allows the data to be maintained in a widely known format (Microsoft Access), allows for the storing of data in a common location (a database) and allows for a streamline database design. With regard to the analysis of the river transects, the GIS served as a powerful tool for visualization. By using thematic mapping variations in parameter test values become more apparent. This can be seen in the GIS maps supplemental to the Water Quality Report.

Pathogenic Indicators

Water Quality indicators like fecal coliform and *E. coli* indicate the presence of fecal matter in the watershed. Although fecal coliform and *E. coli* themselves do not cause sickness, but they indicate the presence of other organisms caused by the fecal material of warm-blooded animals that may cause gastrointestinal illness (APHA, et. al, 1992). They do not tell us the source of the fecal matter, which could come from wild fauna such as raccoons, rabbits or deer, or domesticated animals such as dogs and cats. Furthermore, they do not tell us if the fecal matter is from humans and occurring as a result of an aged and leaking sewer system, septic system, an improper connection of a sanitary sewer to a storm sewer, or combined or separate sanitary sewer overflows. What these pathogenic indicators do tell us is the impact of fecal matter on our rivers.

This survey does not meet the sampling requirements in the regulatory standards, stated below (5 **samples per site per month). However, by sampling over a five-month period instead of one month, we were able to obtain a more complete view of water quality in the** Monongahela River Pools 2 and 3 **during the recreational season. The regulatory standards will be used as a benchmark for indicating relative water quality.**

Fecal Coliform as a Pathogenic Indicator

The Ohio River Valley Water Sanitation Commission (ORSANCO) has set fecal coliform standards for the water-contact recreational season from May to October. At a given site, fecal coliform data are not to exceed 400 Colony Forming Units (CFU) per 100ml in more than 10% of the samples during a month. The monthly geometric mean is not to exceed 200 CFU/100ml based on no less than 5 samples per month. (ORSANCO Pollution Control Standards for Discharges to the Ohio River, 1997 Revision).

During the swimming season (May 1 through September 30), the Pennsylvania Department of Environmental Protection has set a maximum fecal coliform level at a geometric mean of 200 CFU/100ml based on five consecutive samples, with each sample collected on different days in one month. For the remainder of the year, the maximum fecal coliform level is set as a geometric mean of 2,000 CFU/100ml based on five consecutive samples collected on different days. (25 PA Code § 93.7)

Keeping with our intent of using the standards as a benchmark for our data, we consider 200 CFU/100ml as our target for fecal coliform in recreational waters.

E. coli as a Pathogenic Indicator

ORSANCO has developed a recreational standard for *Escherichia coli* (*E. coli*) in the Ohio River basin of 240 CFU/100ml for any single sample and 130 CFU/100ml as a monthly geometric mean, based on no less than 5 samples per month.(ORSANCO Pollution Control Standards for discharges to the Ohio River, 1997 Revision). *E.*

coli is being recommended by the U.S. Environmental Protection Agency (USEPA, 1999b) as an indicator organism to replace fecal coliform. However, the Pennsylvania Department of Environmental Protection has not yet adopted this recommendation.

Keeping with our intent of using the standards as a benchmark for our data, we consider 130 CFU/100ml to be an acceptable target for *E. coli*.

A Brief History of Pathogenic Indicators

Enumeration of water quality indicator bacteria has always been a critical part of any water quality evaluation. The fecal coliform standard was first proposed in 1968 by the National Technical Advisory Committee of the Department of the Interior and was based on studies conducted at 4 different sites in the 1940's and 1950's (NTAC, 1968). At that time, total coliform was used as the indicator bacteria. Families at each beach site were asked to record their swimming activities and illnesses on a daily basis. From this study, it was determined that swimmers who swam in water with a median coliform density of 2,300 CFU/100ml had a higher rate of gastrointestinal illness when compared to the expected rate for the total study population. The coliform water quality index was translated into a fecal coliform index in the mid-1960's. It was determined that about 18% of the coliforms were found to be fecal coliform. Based on this ratio, 400 fecal coliforms per 100 ml would relate to statistically significant swimming-associated gastrointestinal illness. Since this was an unacceptable risk, the index was cut in half to 200 CFU/100ml, with no more than 10% of the samples above 400 CFU/100ml. The USEPA recommended this criterion again in 1976, despite criticisms of the study design and data sets. The fecal coliform indicator was also faulted because at least one member of the fecal coliform group has a non-fecal source.(USEPA, 1986)

The USEPA undertook further studies to address these concerns. In 1986 the USEPA recommended new standards for bacteriological water quality criteria based on *E. coli* for freshwater since it is the most fecal specific of the coliform indicators. The USEPA has reinforced this recommendation in its Action Plan for Beaches and Recreational Waters (1999b). Their goal is for all states to change their criteria from fecal coliform to *E. coli* or enterococci. At the time of this report, only one third of all states have adopted the new standards. This may be due to the uncertainty that states have for the applicability of the new standards and a reluctance to abandon the decades of data gathered for fecal coliform. Likewise, state governments might be concerned that a change in regulations could put into question previous public health conditions at local beaches or that large-scale, expensive wastewater infrastructure projects with goals based on existing criteria would need to be revised. (Isaac, et al, 2000)

Fecal coliform is the main water quality indicator used in Pennsylvania, and a significant body of historical data exists for the region's rivers. However, we recognize the eventual shift from fecal coliform to *E. coli* or enterococci and therefore, selected *E. coli*, enterococci and fecal coliform as indicator organisms for this study.

On the following pages you will find the results for our survey. The first two sections describe dry weather results for the two pools of the Monongahela River. For each of the pools, you will find two graphs and a table with a discussion of the results. One graph describes dry weather fecal coliform results, and one describes dry weather *E. coli* results. The table describes additional tributary stream data.

The third section describes all of the 3 Rivers – 2nd Nature data for the Monongahela River from Years 1 and 2 for fecal coliform and *E. coli*.

The fourth section describes wet weather results. The wet weather work included areas of the Pittsburgh Pool, as well as areas in pools 2, and 3 on the Monongahela. Four graphs illustrate the water quality during rain events for fecal coliform only for 4 rain events sampled during the 2001 recreational season.

Geometric mean averages are used for fecal coliform and *E. coli* in this study to compare with the USEPA and PADEP standards that are based on geometric means. According to Standard Methods, APHA et. al., 1992, the best estimate of central tendency of log-normal data is the geometric mean. The geometric means are typically used in bacteriological data because bacteria reproduce geometrically and react to a range of environmental factors. Changes in temperature for instance can result in significant variance in potential numbers of colonies from the time the sample is first taken to the time that the laboratory analyzes the water. The geometric mean is intended to balance out this factor. Some researchers have debated the use of geometric means in environmental samples because it may underestimate the true mean value by downplaying the large values. They argue for use of the arithmetic mean as a more accurate measure of central tendency (Parkhurst, 1998). Although we use geometric means in this report, in Appendix B, raw data can be found along with arithmetic means.

Results and Discussion

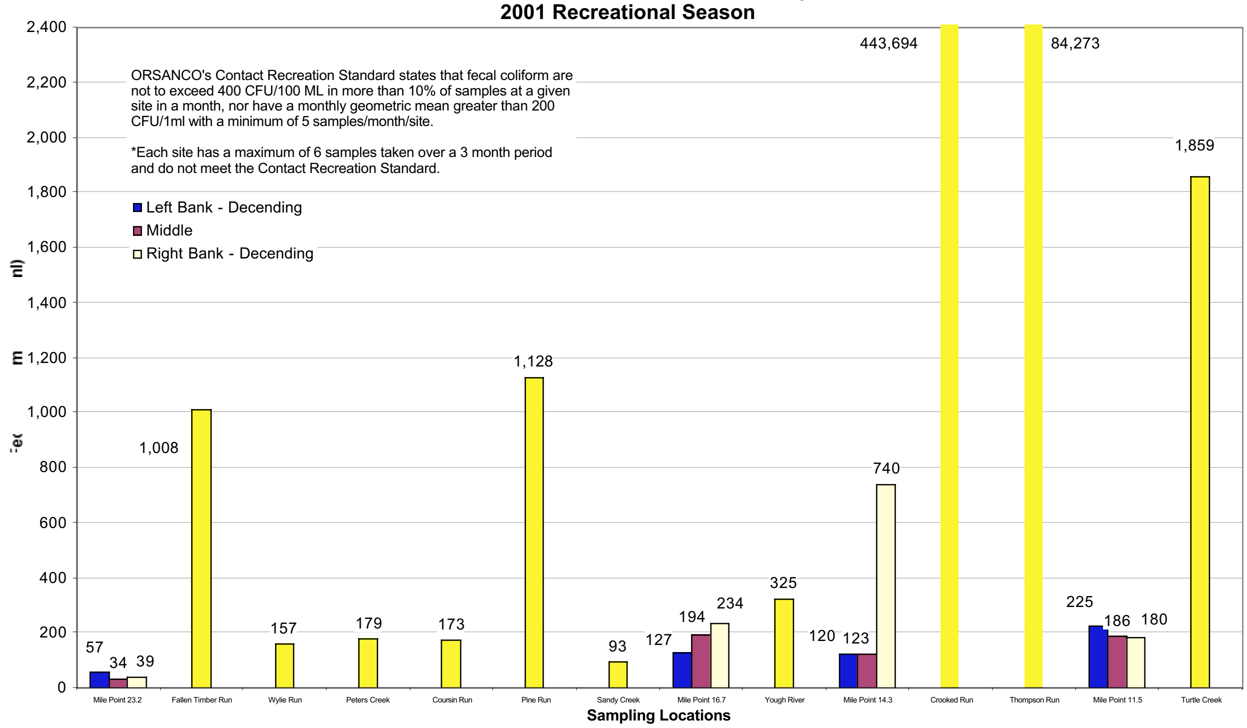
Monongahela River – Pool 2 Dry Weather

The Monongahela River was divided into two sections in Year 2 of the study in 2001. In each section, sampling locations include four river transects and the major tributary streams. The first section, called Pool 2, is bounded by the Locks and Dam #2 at Braddock, PA and Locks and Dam #3 at Elizabeth, PA. Sampling of this river system occurred on six different dry weather days from May 16, 2001 to August 15, 2001. The results are discussed below.

***Each site has a maximum of 6 samples taken over a 3 month period and do not meet the Contact Recreation Standard.**

Fecal Coliform Data

Figure 1: Geometric Mean* of Fecal Coliform Data in the Monongehela River and its Tributaries from the Elizabeth Dam to the Braddock Dam in Dry Weather 2001 Recreational Season



Since our sampling scheme did not permit sampling to take place more than twice per month with no more than six samples collected per site over the 2001 recreations season, the above standards shown in Figure 1 cannot be directly applied to this data but are used in this instance as an benchmark to indicate relative water quality.

With this in mind, the Monongahela River sites (indicated by Mile Points) are within the geometric mean standard of 200 CFU/100ml except for Mile Points 16.7 Right Bank, 14.3 Right Bank, and 11.5 Left Bank.

The river transect with the maximum fecal concentration is Mile Point 14.3 Right Bank with 2 samples at 2,300 and 2,400 CFU/100ml (see Appendix B). This site is downstream of the Youghiogheny River. The maximum fecal coliform concentration for the Yough River is 510 CFU/100ml taken near the town of Boston (see Appendix B). This could indicate that there is fecal contamination downstream of Boston in the Yough River or fecal contamination downstream of Mile Point 16.7 in the Monongahela River. From Mile Points 16.7 to 14.3, the area consists of 3 communities, all of which have municipal sewage treatment.

While several of the tributary streams are within the 200 CFU/100ml benchmark, many exceed it. Most notably, fecal coliform concentrations in Crooked Run in McKeesport are extremely high. The geometric mean is 443,694 CFU/100ml as shown in Figure 1. The maximum concentration at this site is 1.5×10^6 cfu/100ml. (see Appendix B). The sampling team noted odors indicating raw sewage and a white milky appearance of the stream as it flowed out of a culvert to the river. The Municipal Authority of the City of McKeesport has also found high fecal coliform concentrations in Crooked Run and believes that there are malfunctioning septic systems discharging into the culverted stream (personal correspondence). This problem spans the municipalities of White Oak, North Versailles, and McKeesport. Although fewer samples exist for Thompson Run, high fecal coliform concentrations were also found. The stream receives discharges from several sewage treatment plants upstream.

E. coli Data

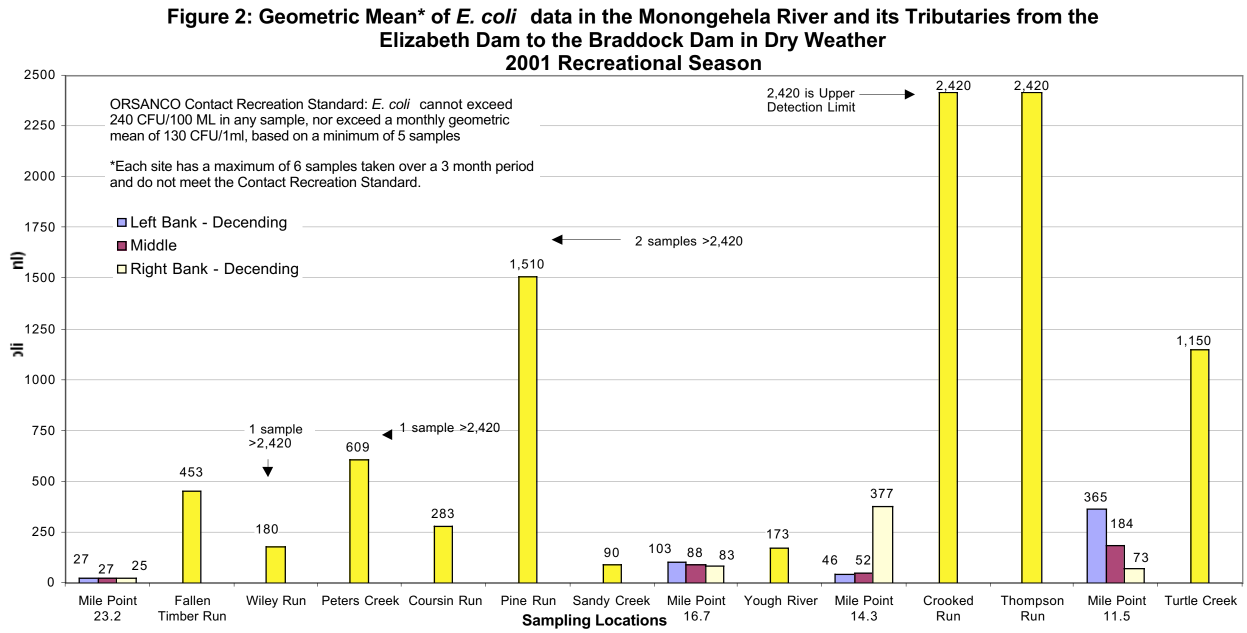


Figure 2 shows the geometric means of the river and tributary stream data for *E. coli* for Monongahela River Pool 3. As stated above, our sampling scheme did not permit sampling to take place more than twice per month with no more than six samples collected per site during the 2001 recreational season. Thus, the above standards shown in Figure 2 cannot be directly applied to this data but are used in this instance as a benchmark. With this in mind, the geometric means of the river transects are below the ORSANCO standard of 130 CFU/100 ml except for 14.3 Right Bank, and 11.5 Left Bank and Middle. This is similar to fecal coliform results except that Mile Point 16.7 is within the ORSANCO benchmark standard for *E. coli*. With the exception of Sandy Creek, the tributaries are above this geometric mean standard.

Additional Parameters for Tributary Streams

Average concentrations of each of the chemical and field parameters are shown in. All of the streams are designated as warm water fisheries except Peters Creek, which is designated for trout stocking (25 PA Code § 93.9v). Crooked Run, Thompson Run and Turtle Creek are also designated as warm water fisheries but have a Total Dissolved Solids criteria of 1,500 mg/l as a daily maximum. (Typical warm water fisheries have a TDS maximum of 750 mg/L).

Most parameters are within the Pennsylvania water quality criteria for the designated uses of the tributary streams. One exceptions is Crooked Run, which exceeded the Dissolved Oxygen criteria of a minimum of 4.0 mg/L. Only one of the six DO measurements taken over the recreational season were above 4.0. Three of the six measurements were less than 0.1 mg/L. The two Thompson Run measurements taken were above 9.0, exceeding the requirement that pH lie between 6-9. These are the streams with the highest fecal coliform concentrations in Pool 2, indicating that there may be sewage contamination.

Several of the streams exceeded the Total Dissolved Solids (TDS) criteria of a daily maximum of 750 mg/L. Peters Creek exceeded the temperature requirement for trout stocked streams on June 27 of 22.2 °C with a temperature of 23.2 °C. The temperature requirement increases to 23.3 °C on July 1-31. See Appendix A for the PADEP water quality criteria.

Table 5: Average Concentrations of Additional Parameters for Tributary Streams in Pool 2 of the Monongehela River from the Locks and Dam #2 in Braddock, PA to the Locks and Dam #3 in Elizabeth, PA in the 2001 Recreational Season. (Six samples per site except Thompson Run which has two samples)

Pool 2	Ammonia mg/L	TDS mg/L	Alkalinity mg/L	Hard-ness mg/L	Total Iron mg/L	Nitrate mg/L	Ortho Phosphate mg/L	Temp °C	PH SU	DO mg/L	Conductivity mg/L
Fallen Timber Run	0.066	918	153	316	0.225	0.3	0.19	15.59	7.76	8.56	1208
Wiley Run	0.069	1095	78	380	0.279	0.3	0.17	16.32	7.42	7.23	1338
Peters Creek	0.199	797	97	262	0.938	2.4	1.06	19.73	7.63	8.62	
Coursin Run	0.054	546	157	238	0.116	0.6	0.13	14.59	7.97	9.15	743
Pine Run	0.071	852	54	262	0.192	1.7	1.06	16.10	7.57	9.00	1162
Sandy Creek	0.058	1175	81	402	0.092	0.3	0.37	16.19	7.76	8.65	1483
Yough River	0.055	195	33	63	0.440	0.6	0.14	20.52	7.61	7.40	289
Crooked Run	9.572	477	126	143	0.533	0.7	1.43	17.93	7.26	2.09	758
Thompson Run	1.675	909	78	288	0.460	2.3	1.32	18.71	9.43	7.24	1214
Turtle Creek	0.117	697	73	227	0.877	1.5	0.22	18.58	7.42	7.60	1021

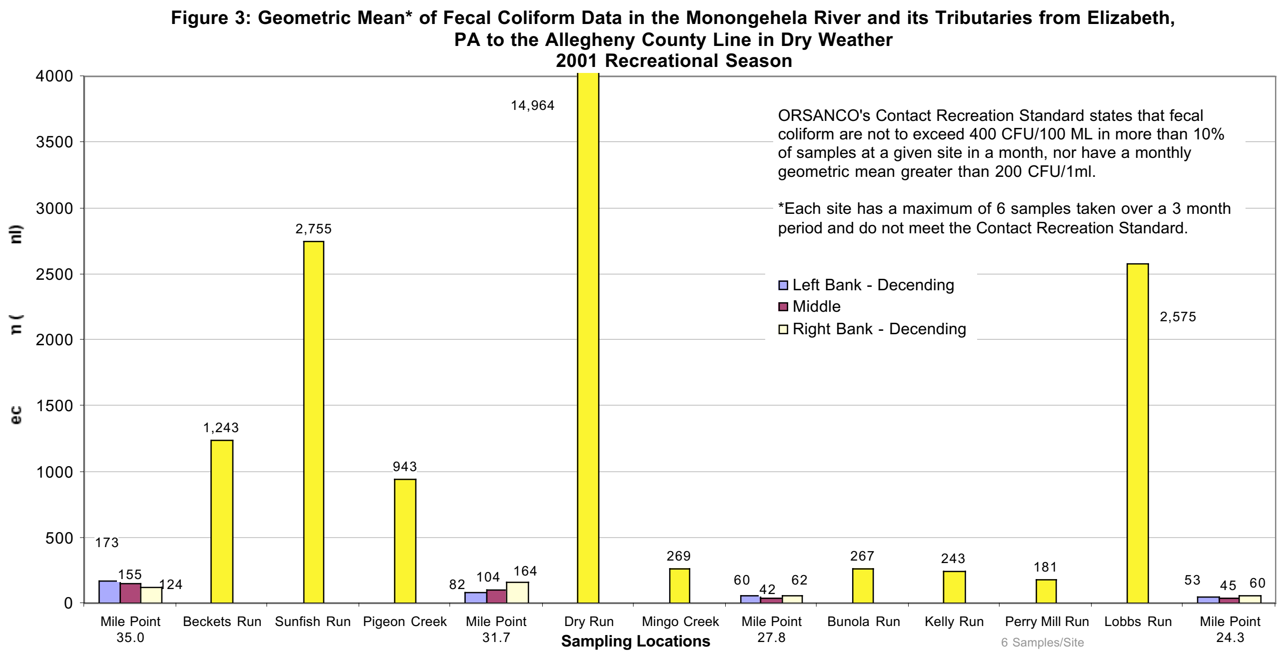
Conductivity unavailable for Peters Creek.

Monongahela River – Pool 3

The Monongahela River was divided into two sections in Year 2 of the study in 2001. In each section, sampling locations include four river transects and the major tributary streams. The second section, called Pool 3, is bounded by the Locks and Dam #3 at Elizabeth, PA to Mile Point 35.0 at the Allegheny County Line. Sampling of this river system occurred on six different dry weather days from June 12, 2001 to September 5, 2001. The results are discussed below.

Fecal Coliform Data

***Each site has a maximum of 6 samples taken over a 3 -month period and do not meet the Contact Recreation Standard.**



Since our sampling scheme did not permit sampling to take place more than once or twice per month with no more than six samples collected per site over the recreations season, the above standards shown in Figure 3 cannot be directly applied to this data, but are used in this instance as an benchmark to indicate relative water quality. With this in mind, the Monongahela River transects (indicated by Mile Points) are within the geometric mean standard of 200 CFU/100ml. The river site with the highest fecal coliform concentration is MP 24.3 Left Bank. Out of six samples, the maximum concentration for this site is 2,300 CFU/100ml. The five other samples range from 105 to 5 CFU/100ml (see Appendix B).

Only one tributary stream, Perry Mill Run, is within this 200 CFU/100ml benchmark. Several tributary streams are just over 200 CFU/100ml. Dry Run has the highest fecal coliform concentration, with a maximum of 136,000 CFU/100ml (see Appendix B). This watershed is mostly rural, with the lower watershed flowing though New Eagle and Monongahela, PA, both of which have municipal sewage systems. This watershed, as well as Mingo and Pigeon Creeks are within Washington County where limited watershed data exists.

The Allegheny County Health Department has identified several areas with no means of sewage treatment. The areas Gallatin and Sunnyside have sewage running off into yards. This is near the mouth of Sunfish Run. (Allegheny County Comprehensive Sanitary Sewage Management Plan, 1999).

E. coli Data

**Figure 4: Geometric Mean* of *E. coli* data in the Monongehela River and its Tributaries from the Alleghency County line to Elizabeth, PA
2001 Recreational Season**

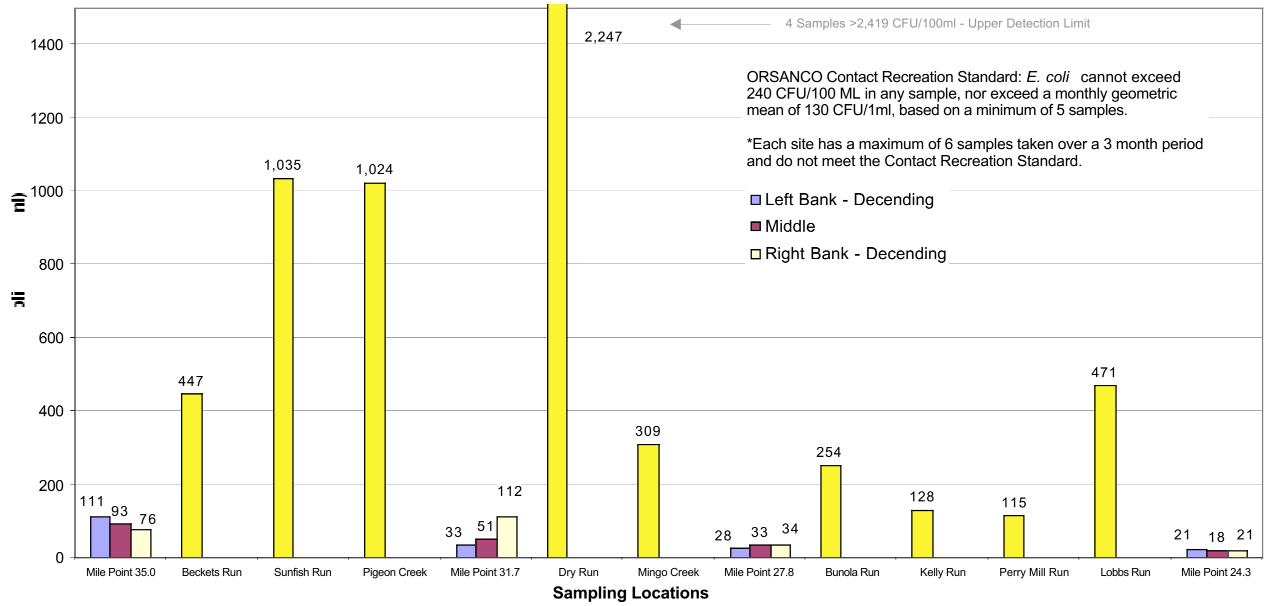


Figure 4 shows the geometric means of the Monongahela River Pool data for *E. coli*. As stated above, our sampling scheme did not permit sampling to take place more than once or twice per month with no more than six samples collected per site over the 2001 recreational season. Thus, the above standards shown in Figure 4 cannot be directly applied to this data but are used in this instance as a benchmark. With this in mind, the geometric means for *E. coli* of the river transects are below the ORSANCO standard of 130 CFU/100 ml. These results are similar to fecal coliform results shown in Figure 3. With the exception of Kelly Run and Perry Mill Run, the tributary streams are above this geometric mean standard.

Additional Parameters for Tributary Streams

Average concentrations of each of the chemical and field parameters are shown in Table 6. All of the tributary streams are designated as warm water fisheries except Mingo Creek, which is designated for trout stocking (25 PA Code § 93.9v).

Most parameters are within the Pennsylvania water quality criteria for the designated uses of the tributary streams. One exceptions is Sunfish Run, which exceeded the Total Iron daily average of 1.5 mg/L on all 6 samples. Five of the six samples ranged from 10.5 to 17.4 mg/L. One sample contained 207 mg/L of total iron. During the sampling events, this tributary stream was observed to have heavy sediment. Beckets Run also exceeded the total iron daily average 3 of the 6 sampling events.

All of the streams exceeded the Total Dissolved Solids (TDS) criteria of a daily maximum of 750 mg/L on at least one occasion. Sunfish Run exceeded the criteria for all 6 samples. See Appendix A for the PADEP water quality criteria.

Table 6: Average Concentrations of Additional Parameters for Tributary Streams in Pool 3 of the Monongehala River from the Allegheny County Line to Locks and Dam #3 in Elizabeth, PA in the 2001 Recreational Season. (Six samples/site)

	Ammonia	TDS	Alkalinity	Hardness	Iron	Nitrate	Ortho Phosphate	Temp	PH	DO	Conductivity
Beckets Run	0.053	635	186	188	2.920	0.6	0.07	18.28	7.40	9.08	605
Sunfish Run	0.513	1346	276	259	46.25	1.0	0.20	15.84	7.83	8.97	1772
Pigeon Creek	0.103	1828	175	292	0.634	0.3	0.16	19.31	7.73	7.03	2470
Dry Run	0.117	617	198	214	0.460	0.5	0.20	20.02	7.67	7.26	763
Mingo Creek	0.066	914	196	227	0.294	0.3	0.07	18.69	7.85	7.66	1205
Bunola Run	0.070	711	100	286	0.465	0.9	0.08	18.21	7.40	7.91	845
Kelly Run	0.061	686	156	261	0.377	0.4	0.07	18.98	7.49	7.90	826
Perry Mill Run	0.042	806	232	214	0.290	0.3	0.10	19.83	7.72	8.20	843
Lobbs Run	1.14	2141	130	275	0.579	0.7	0.22	19.47	7.65	6.29	3021

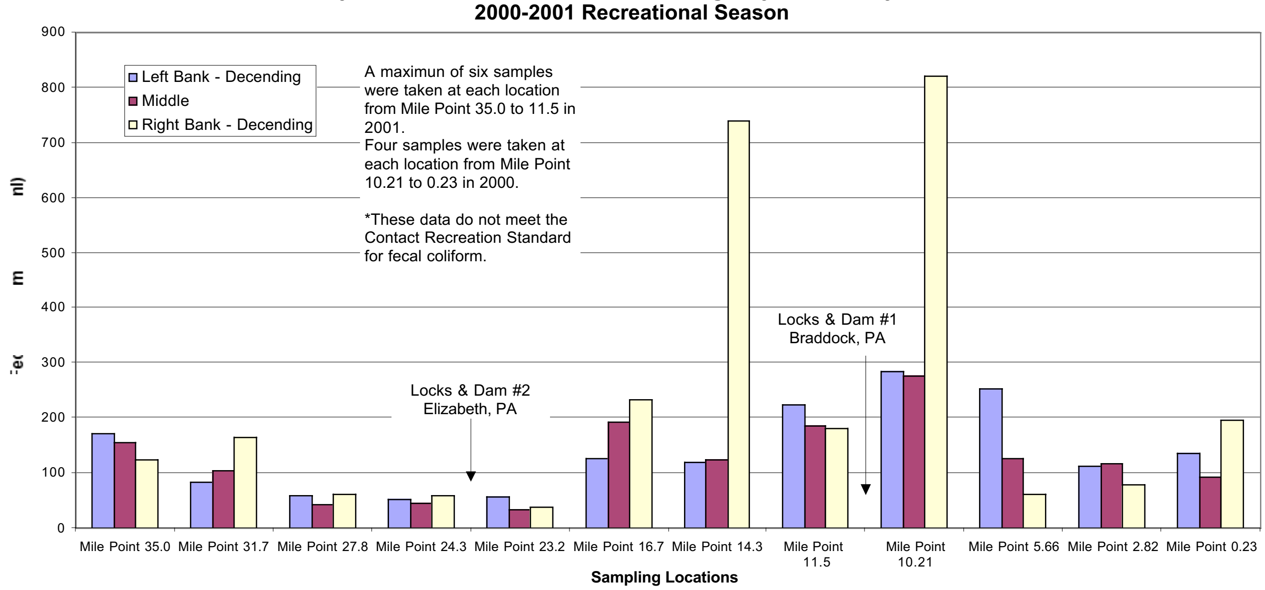
Monongahela River Transects – MP 35.0 – 0.23.

The length of the Monongahela River in Allegheny County is approximately 35 miles from Downtown Pittsburgh to the border with Washington County just north of Donora, PA. In Years 1 and 2 of the Three Rivers-Second Nature project, the 12 transects along the 35 mile length have been sampled. Two Locks and Dams split the river into 3 pools for our sampling purposes (see Figure 5). The following graphs compare the data from the river from Mile Points 0.23 to 35.0.

***Each site has a maximum of 6 samples taken over a 3-month period and do not meet the Contact Recreation Standard.**

Figure 5 compares the fecal coliform concentrations along the 35-mile length of the Monongahela River in

Figure 5: Geometric Mean* of Fecal Coliform Data in the Monongehela River from the Allegheny County Line to the Confluence with the Allegheny River in Dry Weather 2000-2001 Recreational Season



Allegheny County. This figure illustrates that in dry weather, fecal coliform concentrations are relatively low (less than 200 CFU/100ml) with the notable exception of Mile Points 14.3, right bank and Mile Point 10.21, right bank. The causes for these two transects to have geometric means between 740 and 822 CFU/100ml cannot be determined by our sampling scheme. Both sections of the river are downstream of major tributaries. The mouth of the Youghiogheny River is approximately one mile upstream and on the same side of the river as Mile Point 14.3, right bank. The mouth of Turtle Creek is approximately one mile upstream and on the same side of the river as Mile Point 10.21, right bank. These two tributary flows may be impacting the river before they are completely mixed with the river flows.

Figure 6:Geometric Mean* of *E. coli* Data in the Monongehela River from the Allegheny County Line to the Confluence with the Allegheny River in Dry Weather 2000-2001 Recreational Season

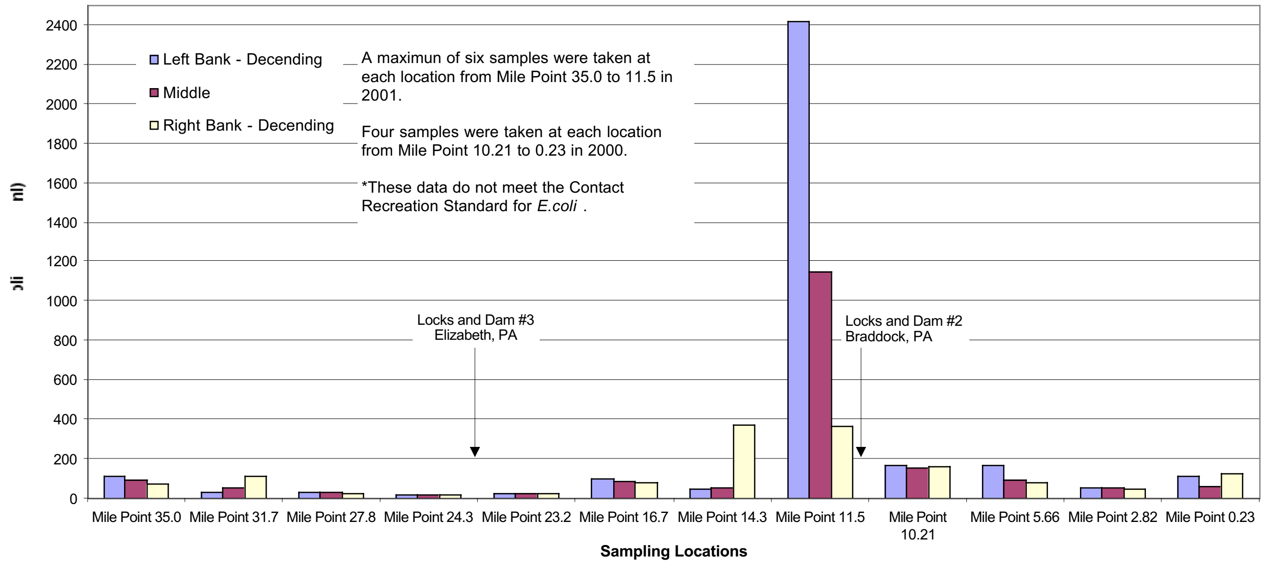


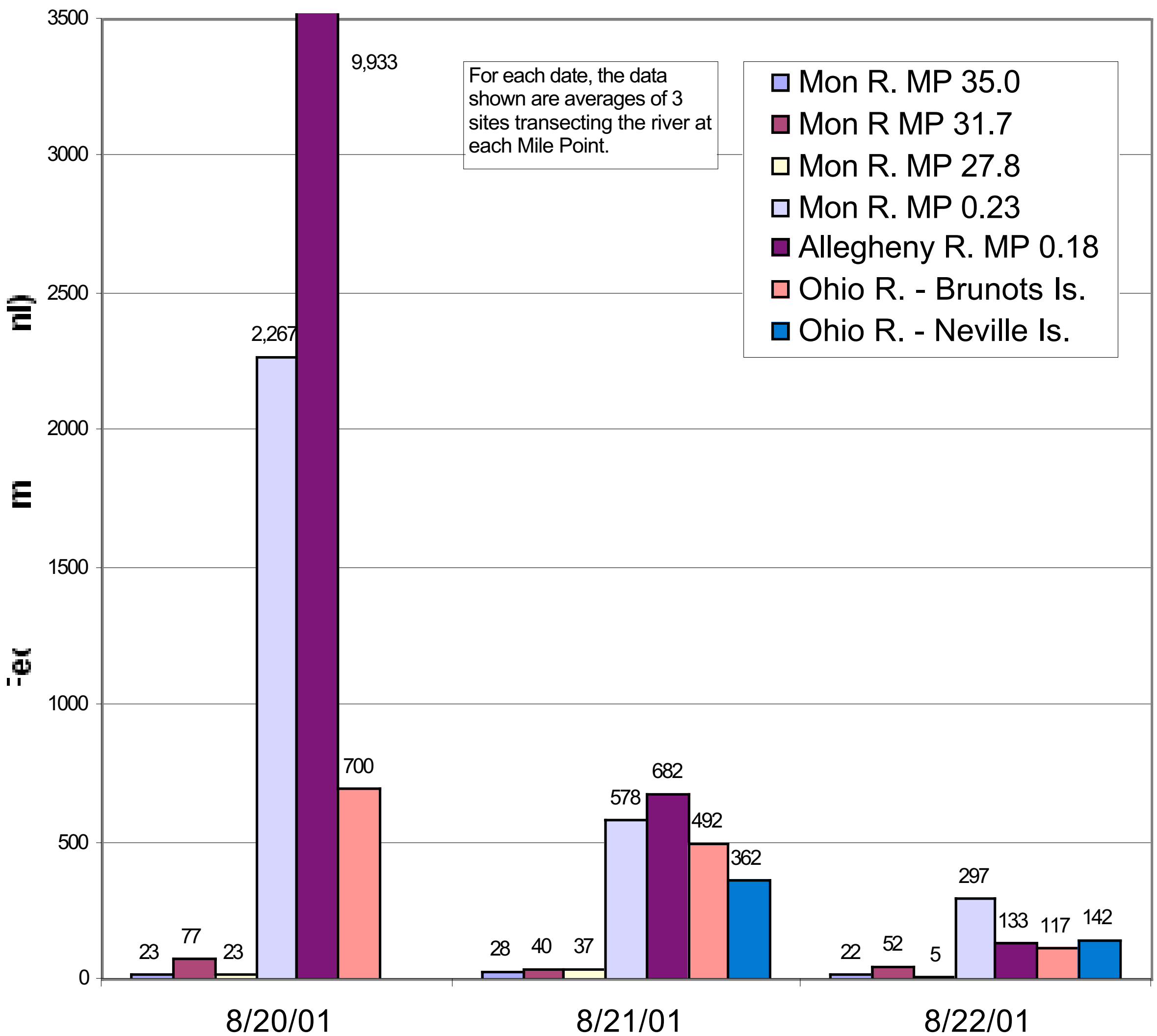
Figure 6 compares the *E. coli* concentrations along the 35-mile length of the Monongahela River in Allegheny County. This figure illustrates that in dry weather, fecal coliform concentrations are relatively low (less than 200 CFU/100ml) with the notable exception of Mile Points 14.3, right bank and Mile Point 10.21, left bank. This differs from the fecal coliform concentrations in that the Mile Point 10.21 right bank has higher fecal coliform concentrations than the left bank. All three points along the MP 10.21 transect are higher than any other transect sampled.

Although sampling occurred in 2000 for the Mile Point 10.21 to 0.23 and the remainder of the river was sampled in 2001, dry weather conditions were the same. The results may indicate that fecal coliform pollution from outside Allegheny County is not impacting the Monongahela River water quality within the county in dry weather. The impacts of wet weather flows were studied and are presented in the following section.

Monongahela River Wet Weather

For the 2001 season, there were 4 wet weather events sampled. Select sites in the Monongahela River in Pools 2 and 3 as well as select sites in the Pittsburgh Pool along the Monongahela, Allegheny, and Ohio Rivers were sampled. Sampling occurred for 2-4 days after a rain event (as close as possible to rain events) from Monday though Thursday (See Appendix B for raw Fecal Coliform data). Rain gauge data are averaged from data collected by the Municipal Authority of the City of McKeesport, Clairton Municipal Authority, and selected gauges of the Three Rivers Wet Weather Rain Gauge System. Combined Sewer Overflow data was gathered from McKeesport, Clairton and the Allegheny County Sanitary Authority.

Figure 7: Average Fecal Coliform Data from Select Sites along the Monongahela, Allegheny and Ohio Rivers during Wet Weather from August 20-22, 2001

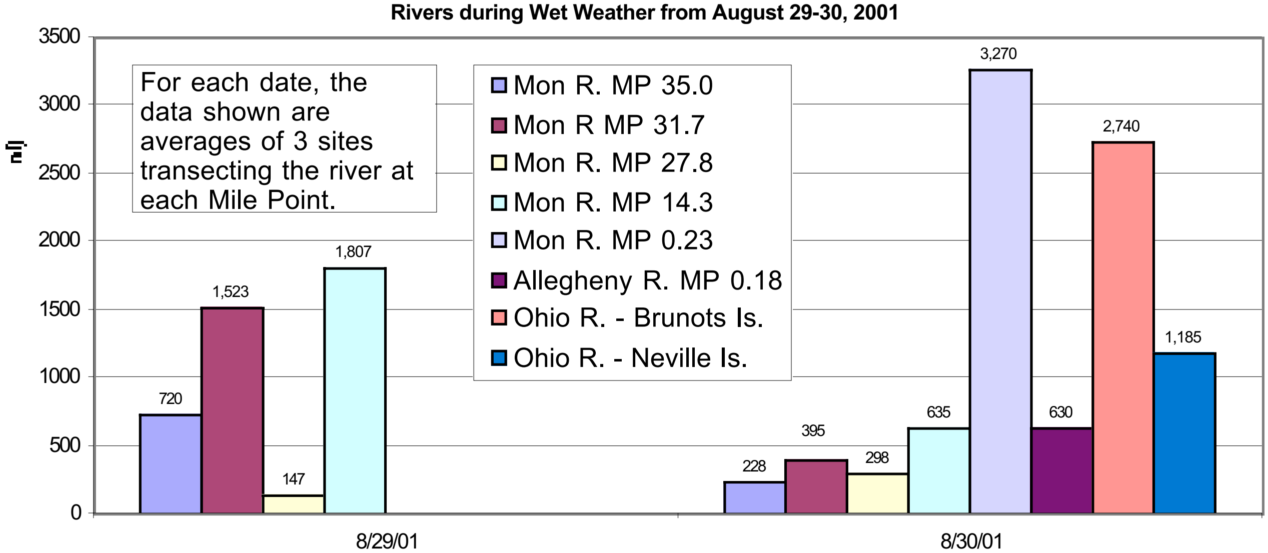


On 8/19/01:
Ave Rainfall for southern Alleheny County from 13:00 to 16:00 = 0.30 "
CSO Hours = 2 for Mckeesport, 3.2 ending 18:30 for ALCOSAN

An average of less than a half inch of rain fell across the Monongahela Valley on August 19, 2001 approximately 15 hours from the first day of sampling on August 20. Combined sewer overflows were reported by several sewage treatment plants in the Monongahela Valley for August 19th. As shown in Figure 7, the Monongahela River sites in Pool 3, Mile Points 35.0 and 31.7, do not show an increase of fecal coliform above dry weather conditions during this sampling event (see Figure 3). This area is rural with small watersheds draining to the river. Therefore, no impacts in fecal coliform concentrations were observed for this quick rain event at these sampling sites.

The points in the Pittsburgh Pool - Monongahela River MP 0.23 and the sites along the Allegheny and Ohio Rivers - show elevated levels of fecal coliform during the first and second days of sampling, August 20-21. The Monongahela Pool 2 and the Pittsburgh Pool are urban areas with influences of combined sewer overflows. This may account for the elevated levels. On August 22, fecal coliform concentrations return to normal dry weather levels (see Water Quality Phase 1 Report – Year 2000, 3 Rivers 2nd Nature). The Allegheny County Health Department started a CSO River Water Advisory on August 16 and called it off on August 21st.

Figure 8: Average Fecal Coliform Data from Select Sites along the Monongahela, Allegheny and Ohio Rivers during Wet Weather from August 29-30, 2001



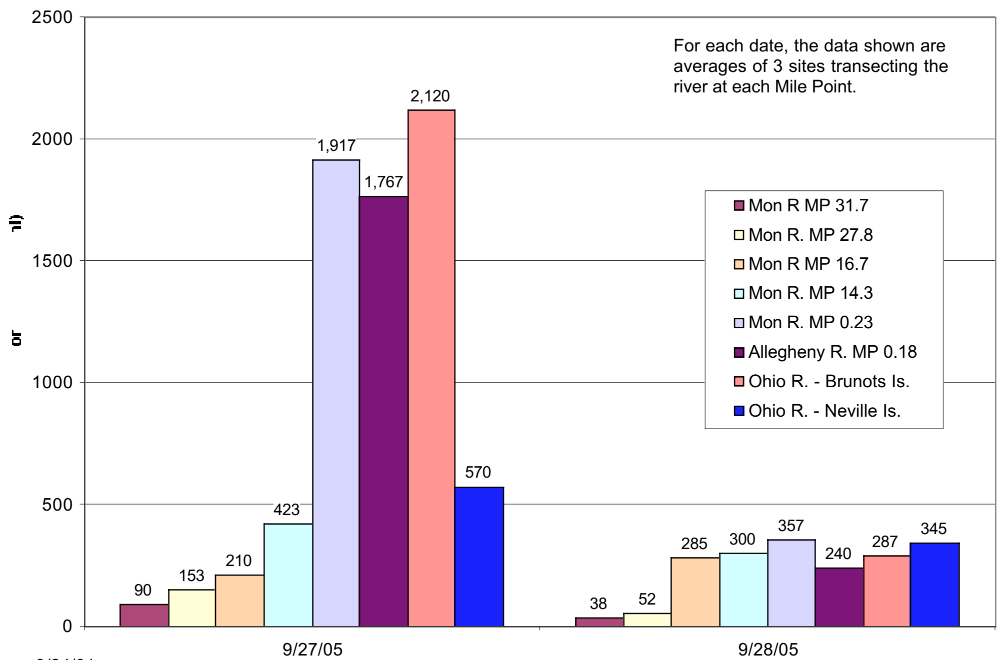
On 8/28/01: Ave Rainfall for southern Alleheny County from 14:30 to 16:30 = 1.2 ";
CSO Hours = 2 for Mckeesport, 9.4 ending at 2:00 on 8/29/01 for ACSA
On 8/29/01: #CSO Hours - 9.4 from 9:10 to 16:50 for ALCOSAN

In the sampling event of August 29, 2001 in Figure 8, an average of 1.2 inches of rain fell over a 2 hour period approximately 15 hours before the first sample was taken. In this storm event, Mile Points 35 and 31.7 have elevated levels of fecal coliform above the dry weather results shown in Figure 3. This rain event was more significant in terms of rainfall than the August 20- 22nd event that resulted in little observable impact in these two locations.

On August 29, Mile Point 14.3 also has elevated concentrations of fecal coliform during this sampling event. This is the site with the highest concentration of fecal coliform in dry weather. The fecal coliform result for the right bank of Mile Point 14.3 sampling location is 3,300 CFU/100ml (Figure 8 shows the average of all three points along the transects for each mile point). This section of the river flows through urbanized areas and is down stream of combined sewer overflows of several municipalities.

Results for the Pittsburgh Pool are only available for August 30. These results also show elevated levels of fecal coliform. These sections of the rivers also flow through urbanized combined sewer overflow areas. The Allegheny County Health Department called a River Water Advisory from August 27 to September 5 due to combined sewer overflows in the county.

Figure 9: Average Fecal Coliform Data from Select Sites along the Monongahela, Allegheny and Ohio Rivers during Wet Weather from September 26-27, 2001



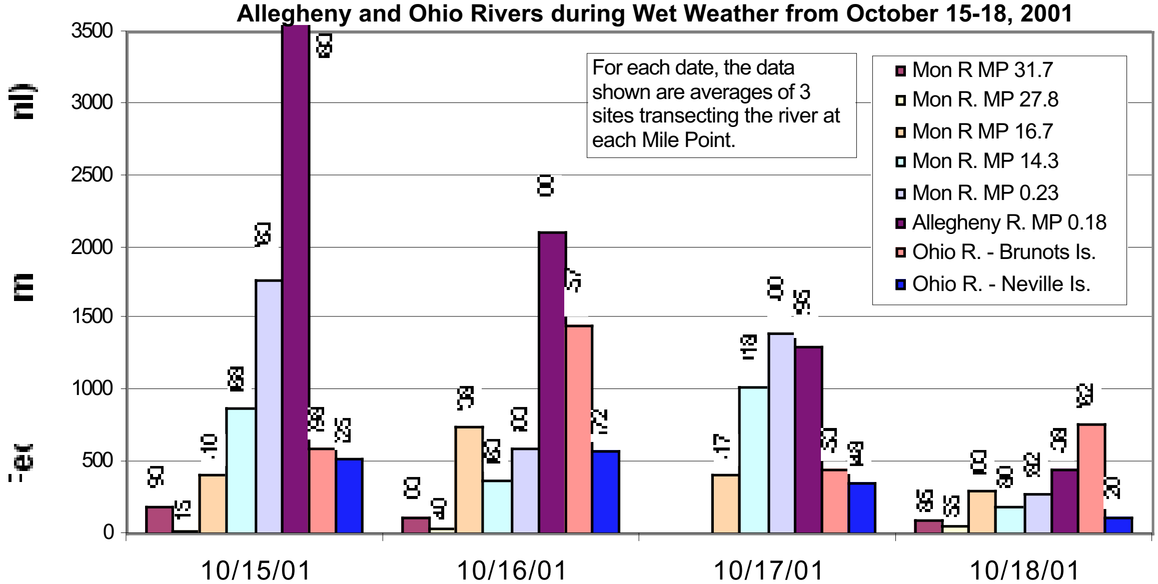
9/24/01:
Ave. rainfall for southern Allegheny County from 7:00 to 23:00 = 0.68"
CSO Hours = 6 for McKeesport; 17 ending 24:00 for ALCOSAN

In the sampling event of September 26, 2001, an average of 0.68 inches of rain fell over a 16-hour period approximately 30 hours before the first sample was taken, with McKeesport, Clairton, and ALCOSAN reporting combined sewer overflows for this period ending around midnight on September 25. In this storm event, Mile Point 31.7 is not elevated significantly above dry weather sampling results. Mile Points 27.8, 16.7 and 14.3 are slightly elevated above the dry weather results shown in Figure 1 and 3, but this may be normal sample variation in the fecal coliform test

Results for the Pittsburgh Pool sites show higher fecal coliform concentrations than dry weather results from 2000 levels (see Water Quality Phase 1 Report – Year 2000, 3 Rivers 2nd Nature). Samples were taken 30 hours since any rainfall or combined sewer overflows. On September 27, results for the Pittsburgh Pool decreased to concentrations similar to dry weather results (refer to 2000 report).

The Allegheny County Health Department called a River Water Advisory for this time period from September 20 to October 1 due to rainfall on September 20 and 24 that resulted in combined sewer overflows in the county. The Advisory program ceased on October 1st.

Figure 10: Average Fecal Coliform Data from Select Sites along the Monongahela, Allegheny and Ohio Rivers during Wet Weather from October 15-18, 2001



10/14/01: Ave. rainfall for southern Allegheny County from 11:00 to 18:00 = 0.18"
#CSO Hours = 1 for McKeesport, 8.1 ending 21:00 for ALCOSAN

10/16/01: Ave rainfall for southern Allegheny County from 11:00 to 13:00 = 0.09"
#CSO Hours = 1 for McKeesport, 3.4 ending 16:00 for ALCOSAN

In the sampling event of October 15, 2001 shown in Figure 10, an average of 0.20 inches fell over a 7-hour period approximately 24 hours before the first sample was taken. Results for Mile Points 16.7 and 14.3 are above the dry weather concentrations for fecal coliform shown in Figure 1. Pittsburgh Pool sites are elevated as well from October 15 to 17.

On October 17, Mile Points 14.3 and 0.23 results showed an observable increase from October 16, (possibly from the 0.09" of rain on the 16th and the reported combined sewer overflows from McKeesport and ALCOSAN). On October 18, results for all sites are decreased.

Water Quality Conclusions

This survey was developed to begin to understand the patterns and relationships between water quality, public use, and functioning ecosystems in our urban river system. Our data indicate that fecal pollution impacts tributary streams in dry weather. This is a primary area for further study because the number of stream miles is four times the number of river miles. Streams frequently run through parks and neighborhoods. On the rivers, we found some good news. For the most part, the dry weather conditions of the rivers are within the 200 CFU/100ml fecal coliform benchmark used in this study. In wet weather, sites in the Monongahela conditions, the benchmark was exceed at all river-sampling sites. Higher concentrations of fecal coliform as would be expected, were in this region.

More sampling in both the rivers and tributary streams is needed to further define the relationship between water quality issues and public recreation opportunities. From a public health perspective, determining the sources of fecal contamination in the tributary streams should be a priority. Once sources have been identified, it is important to stop the contamination or reduce its impact. It is also important to determine the ecological health of the upper reaches of the tributary streams in full studies of the major watersheds. This will help us understand the full potential of these tributary streams as assets to the community.

In the following pages, you will find a discussion of the water quality issues on the rivers in dry weather, wet weather, and the tributary streams.

Rivers

In Dry Weather

1. What is the water quality baseline and are there spatial variations in quality?

As Table 7 indicates, each river test point on the Monongahela River (calculating a geometric mean for all data for each river) is within our specific target number for fecal coliform of 200 CFU/100ml. Despite this, specific points along the Monongahela River have high levels of fecal coliform. This is evident on the Monongahela River at Mile Point 14.3 Right Bank, downstream of the mouth of the Youghiogheny River and urbanized areas. There was at least one sample at most sites over the 200 CFU/100ml benchmark, except Mile Point 27.8 left bank, Mile Point 24.3 mid and right bank and Mile Point 23.2 down river of the Locks and Dam #2, for which no samples were over 100 CFU/100 ml. See attached map "Dry Weather Water Quality Fecal Geomean Indicator, 2001."

Table 7: Fecal Coliform Results for River Samples in the Monongahela River for the 2001 Recreational Season in Dry Weather*

Source	Geometric Mean ** CFU/100ml
Pool 3 – MP 35.0 – 24.3	83
Pool 2 – MP 23.2 – 11.5	150
Pittsburgh Pool – MP 10.21 – 0.23***	119

*At least 3 days without rain or known combined sewer overflows.
**Geometric means are calculated from fecal coliform results from all sampling locations in each Pool (approx. 72 samples/river).
***2000 Recreational Season

2. Are there water quality problems indicated at points of public access?
During dry weather, our results indicate high fecal coliform concentrations at Mile Point 14.3, downstream of a public boat launch at the mouth of the Youghiogheny River and several marinas.

3. Are there specific areas that warrant further study? Why?
Since our data is limited to six sampling events per river, further study is necessary to more fully understand the dry weather baseline conditions in the Monongahela River in Pools 2 and 3.

The Monongahela River Conservation Plan, Final Report, November 1998, states that there is a lack of an overall understanding of the impact of water pollution because reliable regional data does not exist. The conservation plan identifies several main sources impacting the Monongahela River: nonpoint source pollution, acid mine drainage, combined sewer overflows, industrial discharges, navigational demands and discharges from "wildcat" sewers. A comprehensive study with appropriate indicators is necessary to fully understand the impact of these sources on the Monongahela River.

Rivers:

In Wet Weather

1. What is the wet weather water quality and are there spatial variations?
In the four wet weather events, the August 29-30, 2001 event showed the most impact in Pool 2 and 3. This event had the most rainfall out of the four events at 1.2 inches. Our data suggest that sites in Pool 3 may be impacted less or for a shorter time by minor rain events than Pool 2 or the Pittsburgh Pool. This is most likely because

that section of the Monongahela River watershed is less urbanized than down river. Sites sampled in Pool 2 show elevated levels of fecal coliform concentrations following rain events, especially at Mile Point 14.3 Right. This site is downstream of the Youghiogheny River and the City of McKeesport. Unlike Year 1, 2000 data in the Pittsburgh Pool, Pools 2 and 3 data did not indicate any pattern of spatial variations within river transects.

Pittsburgh Pool fecal coliform data taken in Year 2, 2001, have higher concentrations during the same events than Pools 2 or 3. Fecal coliform concentrations decreased with each subsequent sampling day within an event. This is similar to the results from Year 1, 2000 (see Water Quality Phase I Report – Year 2000, 3R-2N).

The sites in the Pittsburgh Pool are within the Allegheny County Sanitary Authority's service area and near combined sewer overflows. Due to its large drainage area, ALCOSAN's system overflows for a longer period than the municipal sewage treatment plants in the Mon Valley in Pool 2. See attached maps "Wet Weather Day 1 Fecal Geomean Indicator" and Wet Weather Day 2 Fecal Geomean Indicator."

Table 8: Geometric Means of 2001 Fecal Coliform Wet Weather Data for the Monongehela River on Day 1 and Day 2 following 3 Rain Events

Fecal Coliform	Pittsburgh Pool (24 data points/day)	Pool 2 Braddock-Elizabeth (15 data points/day)	Pool 3 Elizabeth-County Line (21 data points/day)
Day 1 Geometric Means (CFU/100ml)	1199	472	174
Day 2 Geometric Means (CFU/100ml)	514	394	106

Dates for Rain Events Day 1: Aug 29, Sept 26, Oct 15, 2001
Dates for Rain Events Day 2: Aug 30, Sept 27, Oct 16, 2001

The above table describes the fecal coliform results for each pool for one and two days following a rain event. It illustrates that fecal coliform results are lower in the upper pools following a rain storm. These upper pools are less urban than the Pittsburgh Pool and therefore have less urban runoff and combined sewer overflows. The table does not describe the differing rain amounts or intensities.

2. Are there wet weather water quality problems at points of public access?

The two most notable sites that have high fecal coliform concentrations as well as public access points are as follows:

Mile Point 31.7 (Mid and Right Descending Bank): City of Monongahela

Mile Point 14.3 (Right Descending Bank): Just below public boat launch at the mouth of the Monongahela River and several marinas.
Mile Point 0.23: Above confluence with the Allegheny River and Point State Park
Mile Point 0.18 on the Allegheny River: Near PNC Park and upstream of Point State Park.
Mile Point 1.5 on the Ohio River: Near several marinas

3. Are there space and time differences regarding a return to dry weather conditions?

The Monongahela River Pool 2 and the Pittsburgh Pool are more impacted than the sites sampled in the Monongahela River Pool 3 and slower to return to baseline conditions after a rain event.

4. Are there specific areas that warrant further study? Why?

Our results indicate that there is a relationship between urban density and wet weather water quality problems. If this relationship is confirmed, then land use and development density will provide better indications of wet weather water quality problems than was previously considered. This would occur due to the relative impervious nature of urban systems and the more pervious nature of rural systems. Further testing could be indicated by mapping development density in relative relationship to specific surface stream, or river drainage areas. The next round of wet weather testing could then target areas just downstream from highly urbanized areas.

Tributary streams:

1. What is the water quality and how does it vary among the tributary streams?

Of the 19 tributary streams sampled in the Monongahela River Pools 2 and 3, few have been thoroughly studied. The exceptions are the Youghiogheny River and Turtle Creek. According to the Youghiogheny River Conservation Plan, Preliminary Findings Report, September 1997, several water quality studies have been conducted on the river, but none of the data is either current or comprehensive. However, the report identifies numerous areas of abandoned mine drainage in the lower Youghiogheny River as well as agricultural runoff and sewage treatment discharges.

Many of the tributary streams sampled have high concentrations of fecal coliform. The three most noteworthy are Dry Run in Pool 3 and Crooked and Thompson Runs in Pool 2. These streams had samples as high as 10^5 and 10^6 CFU/100ml.

Monongahela River Tributary Streams Pool 2

Most Impacted with Fecal Coliform: Crooked Run, Turtle Creek

Least Impacted with Fecal Coliform: Sandy Creek

Little Flow: Coursin Run

Monongahela River Tributary Streams Pool 3

Most Impacted: Dry Run

Least Impacted: Perry Mill

2. Do tributary streams add or subtract from the water quality of the main stem rivers?

The relative effect of tributary streams on the amount of water flowing in the rivers is minimal. The mouths of these tributary streams however are of some concern due to shallow waters, good fishing and minimal opportunity for dilution. Generally, our data does not indicate that the tributary streams are impacting the main stem river in dry weather condition. (We have not studied the streams in wet weather conditions.) However, Mile Point 14.3 Right bank has the highest fecal coliform concentration of all the river sites. This site is downstream of the mouth of Youghiogheny River.

3. Are there water quality problems indicated at points of public access?

At the mouths of most of the larger tributary streams a shallow water sand bar is created that attracts people. Many people were observed fishing in these areas. Several of the tributary streams flow through a number of towns and neighborhoods where children can easily access them.

4. Does each tributary stream have the minimum conditions to support aquatic life?

Despite high fecal coliform concentrations found in our study, many of these tributary streams support a range of wildlife, as observed during sampling.

Crooked Run in Pool 2, with the highest fecal coliform concentrations, also had very low Dissolved Oxygen concentrations. Three out of six samples measured less than 0.1 mg/L DO. This stream flows though a culvert before discharging to the river. It is doubtful that this stretch of stream can support life.

Several of the streams exceeded the Total Dissolved Solids (TDS) criteria of a daily maximum of 750 mg/L. Sunfish Run and Beckets Run in Pool 3 exceed the Total Iron daily average of 1.5 mg/L.

5. Do these tributary streams warrant further study? Why?

A more detailed look at the biology is important to understand how much "life" these tributary streams are sustaining presently. The US Army Corp of Engineers has conducted a benthic macroinvertebrate study for each of the main tributary streams in this study area (see Koryak & Stafford, *Aquatic Invertebrate Biological Assessments*, October 2001).

Benthic macroinvertebrates are the insects and other invertebrates that live on the bottom of rivers and tributary streams. They are the food sources for fish and birds. Monitoring these benthic communities tells us significant information about the health of the stream from a biological point of view.

In our 2002 Study Area, four streams were identified by the USACE, as "slightly impaired" (the highest rating in Allegheny County).

Pine Creek, Mingo Creek, Dry Run and Sandy Creek.

In our 2002 Study Area, nine streams were identified by the USACE, as "moderately impaired".

Pigeon Creek, Lobbs Run, Fallen Timber Run, Perry Mill Run, Kelley Run, Peters Creek, Thompson Run (draining into Turtle Creek) and Wylie Run.

In our 2002 Study Area, four streams were identified by the USACE, as "severely impaired".

Bunola Run, Glass Run, Coal Bluff Run and Turtle Creek.

A targeted pathogen study of the upper watersheds of each stream will begin to tell us where sources of pollution are located and whether they are point or non-point sources. This, in turn will give us a much better sense of the public health issues on each specific watershed.

A targeted biological study, will give us a sense of the duration of the problems, and help inform the understanding of the intensity (through pathogen analysis) and duration (through benthic analysis) of the problem.

<u>In summation</u>

Dry Weather

Our sampling indicates that dry weather water quality conditions meet our target water quality standard for recreational use most of the time. In the 2001 recreational season (May 15 – September 30), there were 70 of 138 days when it was considered safe for direct contact with river water by ACHD River Water Advisories. According to the advisories, it was considered safe to use our rivers for direct body contact only 51% of the time from May to September 30, 2001.

Wet Weather

Our data suggest that in Pool 3, Mile Point 35 to 27.8, little lasting impact on fecal coliform concentrations is seen with storms less than 0.70 inches. Higher fecal coliform concentrations were seen for a wet weather event with 1.2” of rain. Pool 2 data from Mile Point 16.7 and 14.3 indicated a larger impact on fecal coliform concentrations for the 3 wet weather events. These areas were sampled compared to Pool 3. Pittsburgh Pool data had higher concentrations of fecal coliform during the same sampling events as the upper pools.

From May to October, the Allegheny County Health Department notifies the general public of health concerns during and after a rainfall through their River Water Advisories. For the 2000 recreational season, there was a total of 68 of 138 days when it was unsafe (or 49% of the time) for direct contact with river water according to the Allegheny County Health Department.

Tributary Streams

Our study shows that during dry weather, fecal coliform vary among the tributary streams studied. While several streams had fecal coliform concentrations under 200 CFU/100ml, three streams had samples greater than 10^5 CFU/100ml. Chemical and field tests indicate most parameters within an expected range for this region and within state water quality standards. However, many of these tributary streams flow through municipal parks or neighborhoods.

Conclusion

Our study indicates that during dry weather most of our sampling sites along the Monongahela River are below our target number for fecal coliform, indicating little fecal contamination. However, during dry weather the tributary streams have much higher concentrations of fecal coliform than river sites. Wet weather river water quality does not exceed our target number for fecal coliform after a rain event in Pool 3, except for one sampling event with 1.2” rain. Sites in Pool 2, however, indicated a larger impact than these upper sites for two of the wet weather events studied. The Pittsburgh Pool sites had the greatest impact out of all study locations. Extensive monitoring and modeling of the river systems will be necessary to fully understand this system.

The 3 Rivers - 2nd Nature project will continue its work over the next four years. In 2002, our effort will take up the Allegheny River to the edges of Allegheny County. This study and more information will be available at **http://3r2n.cfa.cmu.edu/**.

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Appendix A – PA Water Quality Criteria, Physical and Chemical Parameters

Warm Water Fisheries	(mg/L) unless noted	25 PA Code § 93.7, 93.9u-v
Alkalinity	20	Minimum allowable
Ammonia Nitrogen	site specific	Based on pH and Temp
Dissolved Iron	0.3	Max allowable
Dissolved Oxygen	0.4	Minimum allowable
Fecal coliform	200	CFU/100ML – Geometric mean for recreational season
Total Iron	1.5	Daily ave
pH	6-9	S.U. – Range of allowable concentration
Temp	28.9-18.9	Celcius – Seasonal max from June 15-Oct 31
TDS	500	Monthly Average
	750	Max allowable
TDS	1500	Max allowable for Turtle Creek, Thompson Run, Crooked Run
		Mon River, Yough River, Becketts Run, Sunfish Run, Pigeon Run, Dry Run, Bunola Run, Kelly Run, Perry Mill Run, Lobbs Run, Fallen Timber Run, Wylie Run, Turtle Creek, Thompson Run, Crooked Run

Trout Stocked	(mg/L) unless noted	25 PA Code § 93.7, 93.9u
Alkalinity	20	Minimum allowable
Ammonia Nitrogen	site specific	Based on pH and Temp
Dissolved Iron	0.3	Max allowable
DO	5	Min from Feb 15-July 31
DO	4	Min for remainder of year
Fecal	200	CFU/100ml – Geometric mean for recreational season
Total Iron	1.5	Daily ave
pH	6-9	S.U. – Range of allowable concentration
Temp	22.2-18.9	Celcius – Seasonal max from June 15-Oct 31
TDS	500	Monthly Average
	750	Max allowable
		Mingo Creek, Peters Creek

pH

The measurement of pH is one of the most important and frequently used tests in water chemistry. pH represents the effective concentration (activity) of hydrogen (H+) ions in water. The activity of hydrogen ions can be expressed most conveniently in logarithmic units. pH is defined as the negative logarithm of the activity of H+ ions:

$pH = -log[H^+]$

As H+ increases, pH decreases. Since pH is on a log scale based on 10, the pH changes by 1 for every power of 10 change in $[H^+]$ (APHA et al, 1992). Several factors affect pH. Carbon dioxide (CO_2) enters water from a variety of sources, including the atmosphere, runoff from land, release from bacteria in the water and respiration by aquatic organisms. This dissolved CO_2 form a weak acid. Because plants take in CO_2 during the day and release it during the night, pH levels in water can change from day to night. Acidic and alkaline compounds can be released into water from different types of rock and soil. When calcite ($CaCO_3$) is present, carbonates (HCO_3, CO_3^{2-}) can be released, increasing the alkalinity of the water. Drainage from forests and marshes is often slightly acidic, due to the presence of organic acids produced from decaying vegetation. Mine drainage also be acidic. Air pollution can increase the concentrations of nitrogen oxides and sulfur dioxide in the air. These pollutants react in the atmosphere to form nitric and sulfuric acids. These acids can affect the pH of streams by combining with moisture in the air and falling to the earth as acid rain or snow.

Very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic life. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels (9-14) can harm fish by denaturing cellular membranes. Changes in pH can also affect aquatic life indirectly by altering other aspects of water chemistry. Low pH levels accelerate the release of metals from rocks or sediments in the stream. These metals can affect fish metabolism and the ability to take water in through the gills (Murphy, 2000).

DO

Dissolved Oxygen is a very important indicator of a water body's ability to support aquatic life. Fish breathe by absorbing dissolved oxygen through their gills. Oxygen enters the water from the atmosphere or by aquatic plant and algae photosynthesis. Oxygen is removed from the water by respiration and decomposition of organic matter.

Temperature affects DO concentrations. The colder the water, the more oxygen that will be dissolved in the water. Therefore, DO concentrations at one location are usually higher in the winter than the summer. During dry seasons, water levels decrease and the flow rate of a river slows. As the water moves slower, it mixes with less air and the DO concentrations decreases. (Murphy, 2000).

Photosynthesis affects DO concentrations. During photosynthesis, plants release oxygen into the water. In the absence of sunlight, plants respire and remove oxygen from the water. Bacteria and fungi also use oxygen as they decompose dead organic matter in the water. If many plants are present, the water can be supersaturated with DO during the day, as photosynthesis occurs. Concentrations of DO can decrease significantly during the night because of respiration. Anthropogenic inputs of organic waste can result in algal and microbial blooms, which may cause marked oxygen depletion, especially at night. Waters that contain toxic chemicals are often low in oxygen, which can influence contaminant toxicity. (Hoffman et. al., 1995)

Temperature

Temperature of water is very important factor for aquatic life. It controls the rate of metabolic and reproductive activities. Most fish are ectothermic, meaning the body temperature closely tracks the environmental temperature. The temperature tolerance zone varies greatly among species and, to a lesser degree, with age, physiological condition and temperature to which the fish has been acclimated. Sublethal exposure to toxic chemicals may reduce the upper lethal temperatures of fish, thereby constricting the tolerance zone. Futhermore, fish show reduced growth and impaired swimming ability when subjected to the extremes of their temperature tolerance zone. (Hoffman et al., 1995)

Temperature also affects the concentration of dissolved oxygen, as discussed above, and can influence the activity of bacteria and toxic chemicals in water. Toxicity of ammonia to fish is influenced greatly by pH and temperature as discussed below.

Riparian vegetation provides shade to the stream, preventing the sun from heating up the water. During dry season when there is less water in a stream, it flows more slowly, allowing the water to warm up more quickly. Industrial discharges and sewage effluents can also cause elevated temperatures in a stream or river.

Conductivity

Specific Conductance, SC, is a measure of the ability of water to conduct an electrical current. This ability depends on the presence of ions; on their total concentration, mobility, and valence, and on the temperature measurement. Ions come from the breakdown of compounds and conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, specific conductance is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron and can be used as an indicator of water pollution. Solutions of most inorganic compounds are relatively good conductors. Molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly. (APHA et al, 1992)

Some ions occur naturally when water flows over rock or soil containing calcite ($CaCO_3$), such as calcareous shales, calcium, and carbonate ions will dissolve into the water and increase SC. Acid mine drainage may contribute iron, sulfate, copper, cadmium, arsenic and other ions if minerals containing these constituents are present and are exposed to air and water. Runnoff from farms can contain fertilizers, in which phosphate and nitrate are present. Runoff from roads can also carry salts and leaked automobile fluids that contribute ions to water. Although conductivity is not regulated, it is a good indicator of the amount of dissolved solids in water.

Total Dissolved Solids

Total Solids is a term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature. Total solids includes Total Suspended Solids, the portion of the sample retained by a filter and Total Dissolved Solids, the portion of the sample that passes through the filter. (APHA et al., 1992) TDS is a measure of material dissolved in water such as carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions and other ions. A certain level of these ions in water is necessary for aquatic life. Changes in TDS concentrations can be harmful because the density of the water determines the flow of water into and out of an organism's cells. However, if TDS concentrations are too high or too low, the growth of aquatic life can be limited, and death may occur. High concentrations of TDS may also reduce water clarity, contribute of a decrease of photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature (Murphy, 2000).

Dissolved solids can occur when water flows over rock or soil that release ions easily, as described above for specific conductance. Runnoff from streets containing salts, fertilizers, and other material can be washed into streams or rivers. Treated sewage effluents may also add dissolved solids to a body of water. As plants and animals decay, dissolved organic particles are released and can contribute to the TDS concentration.

Alkalinity

Alkalinity is the measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution. Alkalinity does not refer to pH, but instead refers to the ability to resist change in pH. These buffering materials are primarily bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^-), borates, silicates, phosphates, ammonium, sulfides and organic ligands. As increasing amounts of acids are added to a water body, the pH of the water decreases, and the buffering capacity of the water is consumed. If natural buffering materials are present, pH will drop slowly to around 6; then a rapid pH drop occurs as the biocarbonate buffering capacity (HCO_3^- and CO_3^{2-}) is used up. At pH 5.5, only very weak buffering capacity remains, and the pH drops further with additional acid. A solution having a pH below 4.5 contains no alkalinity, because there are no HCO_3^- and CO_3^{2-} ions left (Murphy, 2000).

Alkalinity not only helps regulate the pH of a water body, but also the metal content. Biocarbonate and carbonate ions in water can remove toxic metals (such as lead, arsenic, and cadmium) by precipitating the metals out of solution.

Carbonates are added to a water system if the water passes through soil and rock that contain carbonate materials. Where limestone and sedimentary rocks and carbonate-rich soils are predominant, waters will often have high alkalinity. Treated sewage effluents can also add alkalinity to a stream. Levels of 20-200 mg/L are typical of fresh water. A total alkalinity of 100-200 mg/L will stabilize the pH level in a stream.

Ammonia

Nitrogen is required by all organisms for the basic processes of life to make proteins, to grow, and to reproduce. Nitrogen is very common and found in many forms in the environment. Inorganic forms include nitrate (NO_3), nitrite (NO_2), ammonia (NH_3) and nitrogen gas (N_2). Nitrogen is most abundant in the environment as N_2 gas. Nitrogen is continually recycled by plants and animals. This recycling is known as the nitrogen cycle. Most organisms can't use nitrogen in the gaseous form, and depend on other organisms to convert nitrogen gas to ammonia, nitrate, nitrite or amino acids.

When plants and animals die, proteins are broken down by bacteria to form ammonia. This process is called ammonification. Certain bacteria break ammonia down to nitrite then to nitrate. This conversion is called nitrification. Nitrates are then reduced to gaseous nitrogen.

Ammonia is the least stable form of nitrogen in water. Ammonia is easily transformed to nitrate in waters that contain oxygen and can be transformed to nitrogen gas in waters that are low in oxygen. Ammonia is found in water in two forms: as ammonium ions (NH_4^+) or as dissolved, un-ionized (no electrical charge) ammonia (NH_3). Total ammonia is the sum of both types. Ionized ammonia has little toxicity, whereas the un-ionized form is highly toxic. This may be because the un-ionized ammonia ion is a neutral ion and can diffuse more readily through epithelial membranes of aquatic organisms than the ionized ion (USEPA, 1999c).

The dominant form depends on the pH and temperature of water:

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^- .$$

As the pH increases, H^+ concentration decreases and OH^- concentration increases, increasing the amount of NH_3, un-ionized ammonia. (USEPA, 1999c) At a constant temperature, a rise of one pH unit causes an approximate tenfold increase in the un-ionized form of ammonia. A 10°C rise in temperature at any given pH results in a threefold increase in formation of un-ionized ammonia (Hoffman et al., 1995).

Ammonia can affect the early life stages of fish, by affecting hatching and growth rates of fish. It also can cause changes in tissues of gills, liver, and kidneys during structural development (Murphy, 2000). The effect of temperature and pH on the toxicity of ammonia is not well understood (Hoffman et al., 1995).

Anthropogenic sources of ammonia are treated sewage effluents, industrial discharges, fertilizer runnoff, and animal wastes. Pennsylvania's water quality criteria are based on the pH and temperature of a water body (25 PA Code § 93.7).

Hardness

Hardness is a measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentrations of calcium (Ca^{2+}) and Magnesium (Mg^{2+}) ions, because these are the most common polyvalent cations. Other ions, such as iron (Fe^{2+}) and manganese (Mn^{2+}) may also contribute to the hardness of water, but are generally present in much lower concentrations (APHA et al., 1992).

Hardness mitigates metals toxicity, because Ca^{2+} and Mg^{2+} help keep fish from absorbing metals such as lead, arsenic, and cadmium into their bloodstream through their gills. The greater the hardness, the harder it is for toxic metals to be absorbed through the gills (Murphy, 2000).

Soft waters are mainly derived from the drainage of igneous rocks, because these rocks don't weather very easily and so don't release many cations. Hard water is often derived from the drainage of calcareous (calcite-rich) sediments because calcite dissolves and releases the calcium. Mine drainage also contributes calcium, magnesium, iron, manganese and other ions if minerals containing these constituents are present and are exposed to air and water. Treated sewage effluents and industrial discharges may also contribute to the hardness of water (Murphy, 2000).

Because hardness varies greatly due to differences in geology, there aren't general standards for hardness. Hardness of water can naturally range from zero to hundreds of milligrams per liter.

Iron

Acid mine drainage comes from pyrite or iron sulfide, a mineral associated with coal mining. When pyrite is disturbed, as it is during coal mining or highway construction, it weathers and reacts with oxygen and water to cause high levels of iron, aluminum, and sulfate in runoff water. AMD is formed by a series of complex geo-chemical and microbial reactions that occur when water comes in contact with pyrite (iron disulfide minerals) in coal, refuse or the overburden of a mine operation. The resulting water is usually high in acidity and dissolved metals. The metals stay dissolved in solution until the pH raises to a level where precipitation occurs. The iron essentially clogs the gills of fish.

Appendix B

Fecal Coliform Data for the Monongahela River and its Tributaries in Pool 2

	Mile Point 23.2			Fallen	Wylie	Peters	Coursin	Pine	Sandy	Mile Point 16.7			Yough	Mile Point 14.3			Crooked	Thompson	Mile Point 11.5			Turtle
	Left	Mid	Right	Timber Run	Run	Creek	Run	Run	Creek	Left	Mid	Right	River	Left	Mid	Right	Run	Run	Left	Mid	Right	Creek
5/16/01					20	10	160	50	250	30	105	400	510	55	60	2,400	578,000		320	150	85	2,000
5/30/01	48		20	1,200	4,500	2,800	425	1,600	30	120	195	180		170	215	2,300	36,000		245	75	205	760
6/27/01			75	700	280	260	190	2,000	65	120	115	180			70	480	390,000	67,000	95	70	250	1,400
7/17/01	45	15	50	720	140	133	70	3,100	70	165	180	185	155	95	75	310	814,000	106,000	60	150	135	1,400
8/7/01	70	65	40	740	50	100		2,700	220	380	480	300	360	160	255	500	1,500,000		220	705	180	1,500
8/15/01	70	40	30	2,330	85	345		1,540	85	155	260	230	390	175	200	400	770,000		350	1,540	385	9,240
Min	**45**	**15**	**20**	**700**	**20**	**10**	**70**	**50**	**30**	**30**	**105**	**180**	**155**	**55**	**60**	**310**	**36,000**	**67,000**	**60**	**70**	**85**	**760**
Max	**70**	**65**	**75**	**2,330**	**4,500**	**2,800**	**425**	**3,100**	**250**	**380**	**480**	**400**	**510**	**175**	**255**	**2,400**	**1,500,000**	**106,000**	**350**	**1,540**	**385**	**9,240**
Median	**59**	**40**	**40**	**740**	**113**	**197**	**175**	**1,800**	**78**	**138**	**188**	**208**	**375**	**160**	**138**	**490**	**674,000**	**86,500**	**233**	**150**	**193**	**1,450**
Average	**58**	**40**	**43**	**1,138**	**846**	**608**	**211**	**1,832**	**120**	**162**	**223**	**246**	**354**	**131**	**146**	**1,065**	**681,333**	**86,500**	**215**	**448**	**207**	**2,717**

E. coli Data for the Monongahela River and its Tributaries in Pool 2

	Mile Point 23.2			Fallen	Wylie	Peters	Coursin	Pine	Sandy	Mile Point 16.7			Yough	Mile Point 14.3			Crooked	Thompson	Mile Point 11.5			Turtle
	Left	Mid	Right	Timber Run	Run	Creek	Run	Run	Creek	Left	Mid	Right	River	Left	Mid	Right	Run	Run	Left	Mid	Right	Creek
5/16/01	5	3	5	178	46	517	727	548	1,046	45	54	46	1,414	17	8	225	2,420		36	365	325	579
5/30/01	613	488	222	76	2,420	2,420	387	2,420	43	140	137	72	201	115	114	2,419	2,420		173	659	199	378
6/27/01	20	26	19	1,733	179	727	345	2,419	46	61	23	91	125	35	44	770	2,420	2,420	40	126	249	1,986
7/17/01	12	15	23	548	326	152	66	2,420	51	134	105	74	96	50	68	260	2,420	2,420	52	179	135	1,553
8/7/01	29	26	25	435	34	1,553		1,986	194	192	190	185	115	66	142	204	2,420		113	387	116	1,414
8/15/01	19	29	22	1,553	154	238		770	26	118	133	82	68	40	52	130	2,420		101	1,120	152	2,420
Min	**5**	**3**	**5**	**76**	**34**	**152**	**66**	**548**	**26**	**45**	**23**	**46**	**68**	**17**	**8**	**130**	**2,420**	**2,420**	**36**	**126**	**116**	**378**
Max	**613**	**488**	**222**	**1,733**	**2,420**	**2,420**	**727**	**2,420**	**1,046**	**192**	**190**	**185**	**1,414**	**115**	**142**	**2,419**	**2,420**	**2,420**	**173**	**1,120**	**325**	**2,420**
Median	**20**	**26**	**23**	**492**	**167**	**622**	**366**	**2,203**	**49**	**126**	**119**	**78**	**120**	**45**	**60**	**243**	**2,420**	**2,420**	**77**	**376**	**176**	**1,484**
Average	**116**	**98**	**53**	**754**	**527**	**935**	**381**	**1,761**	**234**	**115**	**107**	**92**	**337**	**54**	**71**	**668**	**2,420**	**2,420**	**86**	**473**	**196**	**1,388**

*2420 is the maximum detection limit

** Blank entries indicate missing or damaged samples

Appendix B

Fecal Coliform Data for the Monongahela River and its Tributaries in Pool 3

	Mile Point 35.0			Beckets	Sunfish	Pigeon	Mile Point 31.7			Dry	Mingo	Mile Point 27.8			Bunola	Kelly	Perry Mill	Lobbs	Mile Point 24.3		
	Left	Mid	Right	Run	Run	Run	Left	Mid	Right	Run	Creek	Left	Mid	Right	Run	Run	Run	Run	Left	Mid	Right
6/12/01	400	250	190	34,000	1,500	1,500	310	280	250	2,300	390	190	270	400	120	100	390	924,000	2,300	180	160
6/19/01	280	220	120	2,300	2,900	760	200	210	170	14,000	620	95	45	110	890	310	250	4,300	50	120	80
7/24/01	300	320	260	850	5,400	600	65	95	310	77,000	460	35	45	45	560	620	140	500	35	15	50
7/31/01	120	60	100	120	17,000	700	130	70	500	1,800	360	170	85	60	200	130	120	215	105	85	50
8/22/01	40	15	10	450	550	525	20	60	75	136,000	105	5	5	5	85	120	155	440	10	20	60
9/5/01	165	860	620	1,030	1,990	2,800	30	55	40	18,500	90	85	25	100	360	685	140	1,550	5	15	25
Min	**40**	**15**	**10**	**120**	**550**	**525**	**20**	**55**	**40**	**1,800**	**90**	**5**	**5**	**5**	**85**	**100**	**120**	**215**	**5**	**15**	**25**
Max	**400**	**860**	**620**	**34,000**	**17,000**	**2,800**	**310**	**280**	**500**	**136,000**	**620**	**190**	**270**	**400**	**890**	**685**	**390**	**924,000**	**2,300**	**180**	**160**
Median	**223**	**235**	**155**	**940**	**2,445**	**730**	**98**	**83**	**210**	**16,250**	**375**	**90**	**45**	**80**	**280**	**220**	**148**	**1,025**	**43**	**53**	**55**
Average	**218**	**288**	**217**	**6,458**	**4,890**	**1,148**	**126**	**128**	**224**	**41,600**	**338**	**97**	**79**	**120**	**369**	**328**	**199**	**155,168**	**418**	**73**	**71**

E. coli Data for the Monongahela River and its Tributaries in Pool 3

	Mile Point 35.0			Beckets	Sunfish	Pigeon	Mile Point 31.7			Dry	Mingo	Mile Point 27.8			Bunola	Kelly	Perry Mill	Lobbs	Mile Point 24.3		
	Left	Mid	Right	Run	Run	Run	Left	Mid	Right	Run	Creek	Left	Mid	Right	Run	Run	Run	Run	Left	Mid	Right
6/12/01	326	206	135	2,420	387	1,553	194	162	148	1,553	921	173	167	184	152	292	249	2,420	250	167	162
6/19/01	114	107	70	613	1,203	727	68	50	49	2,420	185	26	21	27	281	111	238	2,419	21	25	22
7/24/01	122	121	41	1,553		687	16	21	162	2,420	345	3	13	17	1,203	63	89	195	8	5	7
7/31/01	117	69	91	96	2,420	1,414	75	93	1,733	2,419	172	63	75	78	131	137	37	178	103	55	40
8/22/01	5	7	10	228	435	435	13	42	40	2,420	248	7	6	3	96	27	167	104	4	3	16
9/5/01	687	517	548	159	2,419	2,420	6	27	24	2,420	345	82	63	77	411	579	71	517	5	9	5
Min	**5**	**7**	**10**	**96**	**387**	**435**	**6**	**21**	**24**	**1,553**	**172**	**3**	**6**	**3**	**96**	**27**	**37**	**104**	**4**	**3**	**5**
Max	**687**	**517**	**548**	**2,420**	**2,420**	**2,420**	**194**	**162**	**1,733**	**2,420**	**921**	**173**	**167**	**184**	**1,203**	**579**	**249**	**2,420**	**250**	**167**	**162**
Median	**120**	**114**	**81**	**421**	**1,203**	**1,071**	**42**	**46**	**99**	**2,420**	**297**	**45**	**42**	**52**	**217**	**124**	**128**	**356**	**15**	**17**	**19**
Average	**229**	**171**	**149**	**845**	**1,373**	**1,206**	**62**	**66**	**359**	**2,275**	**369**	**59**	**58**	**64**	**379**	**202**	**142**	**972**	**65**	**44**	**42**

*2420 is the maximum detection limit

** Blank entries indicate missing or damaged samples

Appendix B

Fecal Coliform Data for Wet Weather Events in the Monongahela River from Mile Points 35.0 to 0.23, Allegheny River Mile Point 0.18 and the Ohio River Mile Points 1.5 and 5.0 for the 2001 Recreational Season

	Mile Point 35.0			Mile Point 31.7			Mile Point 27.8			Mile Point 0.23			Allegheny MP 0.18			Ohio River MP 1.5			Ohio River MP 5.0		
	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right
8/20/01	30	25	15	40	80	110	15	15	40	3,100	1,900	1,800	2,600	26,000	1,200	500	1,000	600			
8/21/01	40	35	10	55	35	30	5	15	90	590	585	560	635	675	735	565	450	460	280	535	270
8/22/01	40	15	10	20	60	75	5	5	5	440	290	160	145	120	135	110	160	80	120	110	195

	Mile Point 35.0			Mile Point 31.7			Mile Point 27.8			Mile Point 14.3			Mile Point 0.23			Allegheny MP 0.18			Ohio River MP 1.5			Ohio River MP 5.0		
	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right
8/29/01	1,040	560	560	870	1,400	2,300	120	180	140	820	1,300	3,300												
8/30/01	330	160	195	470	445	270	390	260	245	420	475	1,010	3,600	1,010	5,200	650	560	680	3,900	3,100	1,220	2,300	615	640

	Mile Point 31.7			Mile Point 27.8			Mile Point 16.7			Mile Point 14.3			Mile Point 0.23			Allegheny MP 0.18			Ohio River MP 1.5			Ohio River MP 5.0		
	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right
9/26/01	85	55	130	120	110	230	315	210	105	275	160	835	2,170	1,390	2,190	1,550	1,270	2,480	2,430	2,790	1,140	170	130	1,410
9/27/01	45	35	35	45	60	50	395	210	250	210	150	540	385	285	400	260	160	300	325	310	225	255	440	340

	Mile Point 31.7			Mile Point 27.8			Mile Point 16.7			Mile Point 14.3			Mile Point 0.23			Allegheny MP 0.18			Ohio River MP 1.5			Ohio River MP 5.0		
	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right	Left	Mid	Right
10/15/01	190	200	190	15	20	10	660	70	500	750	735	1,120	2,300	1,570	1,420	12,700	4,300	1,250	530	610	655	455	680	440
10/16/01	170	85	55	25	55	40	595	945	675	285	175	630	815	175	820	2,700	880	2,720	1,160	2,000	1,210	885	615	215
10/17/01							340	455	455	230	225	2,600	2,000	1,600	600	825	2,400	660	460	480	420	370	520	155
10/18/01	60	100	95	60	45	60	270	335	305	70	215	255	310	335	200	350	340	625	800	695	790	130	160	70

geomean Pool 3