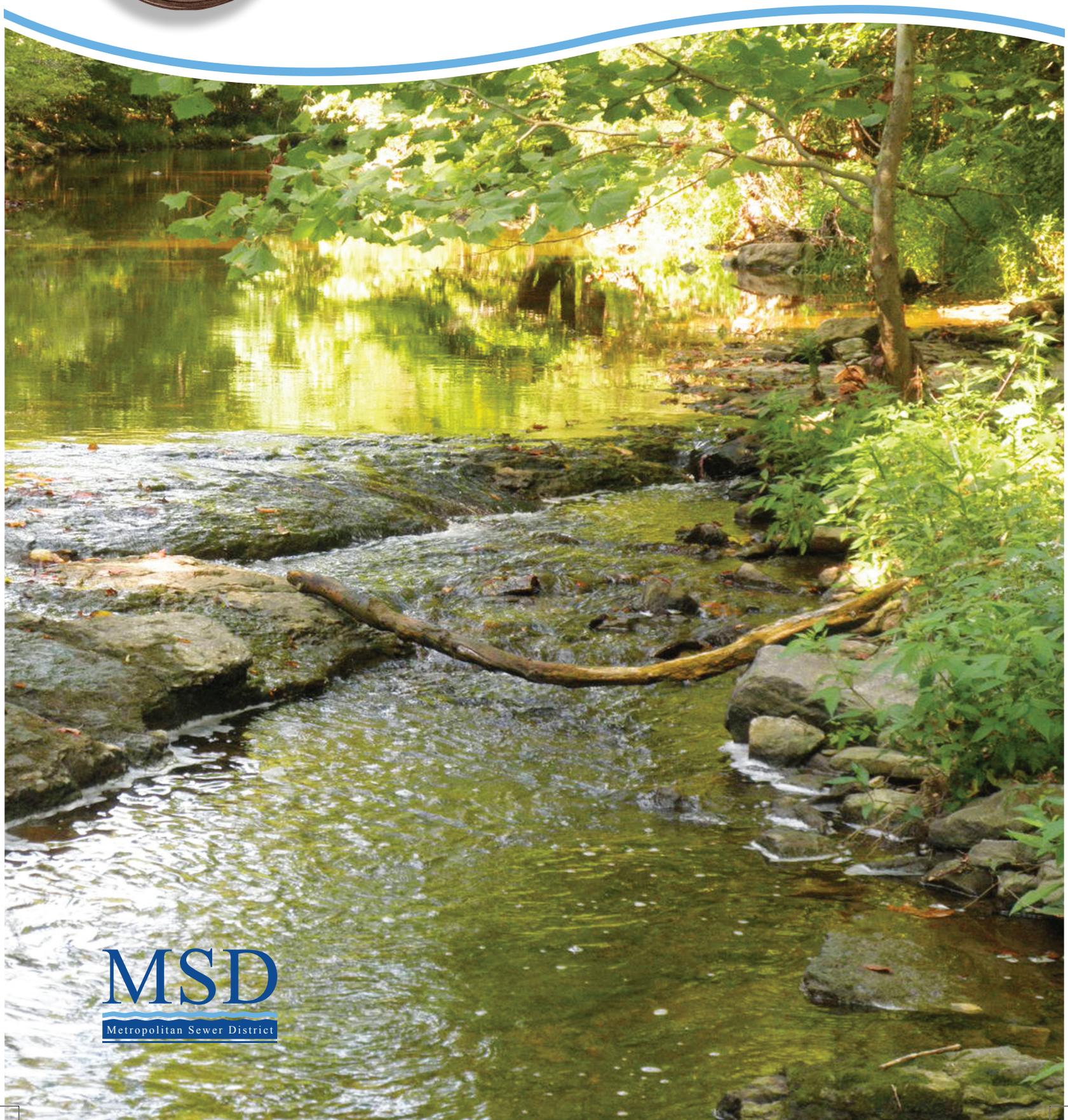
State of the Streams

2014 Water Quality Synthesis Report



MSD

Metropolitan Sewer District

To Our Community

As we share the progress of the past few years and our future plans in this report, MSD is continuing along a path of providing clean, safe waterways for our community. Our 2014 Water Quality Synthesis Report is the culmination of more than 15 years assessing the water quality of our local streams and the Ohio River.

In partnership, MSD and the U.S. Geological Survey collect physical, chemical and biological data from 27 locations along our waterways—known as the Long-Term Monitoring Network. This data is collected by permanent sampling devices which record stream flow, dissolved oxygen and water temperature. Teams of biologists collect samples of algae, fish and aquatic insects at these 27 sites every two years between May and October. Additionally, the teams collect water samples before, during and after significant rain events in the warmer months.

The most recent data reveal:

- The Middle and South Forks of Beargrass Creek continue to have a rating of "poor."
- Northern Ditch, in the Okolona area, shows significant improvement for fish and aquatic insects.
- Bacteria is an ongoing concern with most of the watersheds.
- Harrods Creek, Floyds Fork, Brier Creek and Cedar Creek in Bullitt County—which are less developed watersheds—in general support better aquatic communities.

MSD has made a great deal of progress with decreasing sewer overflows into our waterways and remains ahead of the national curve, but there is more work to be done. The Clean Water Act—passed in 1972—contains aggressive water quality standards for cities like Louisville. MSD entered into a Consent Decree in 2005 with the Kentucky Division of Water, the U.S. Environmental Protection Agency (EPA)-Region 4 and the U.S. Department of Justice to satisfy Clean Water Act requirements.

The Consent Decree requires MSD to minimize combined sewer overflows and eliminate sanitary sewer overflows, while rehabilitating our community's aging sewer system. The program is on schedule and within budget to meet these goals by 2024.

MSD is committed to setting a national standard for best practices in offering Louisville Metro exceptional wastewater, drainage and flood protection services. I invite you to join with us in making Louisville Metro a better place for all. The community and environment benefit when we all join together to do our part.

Sincerely,

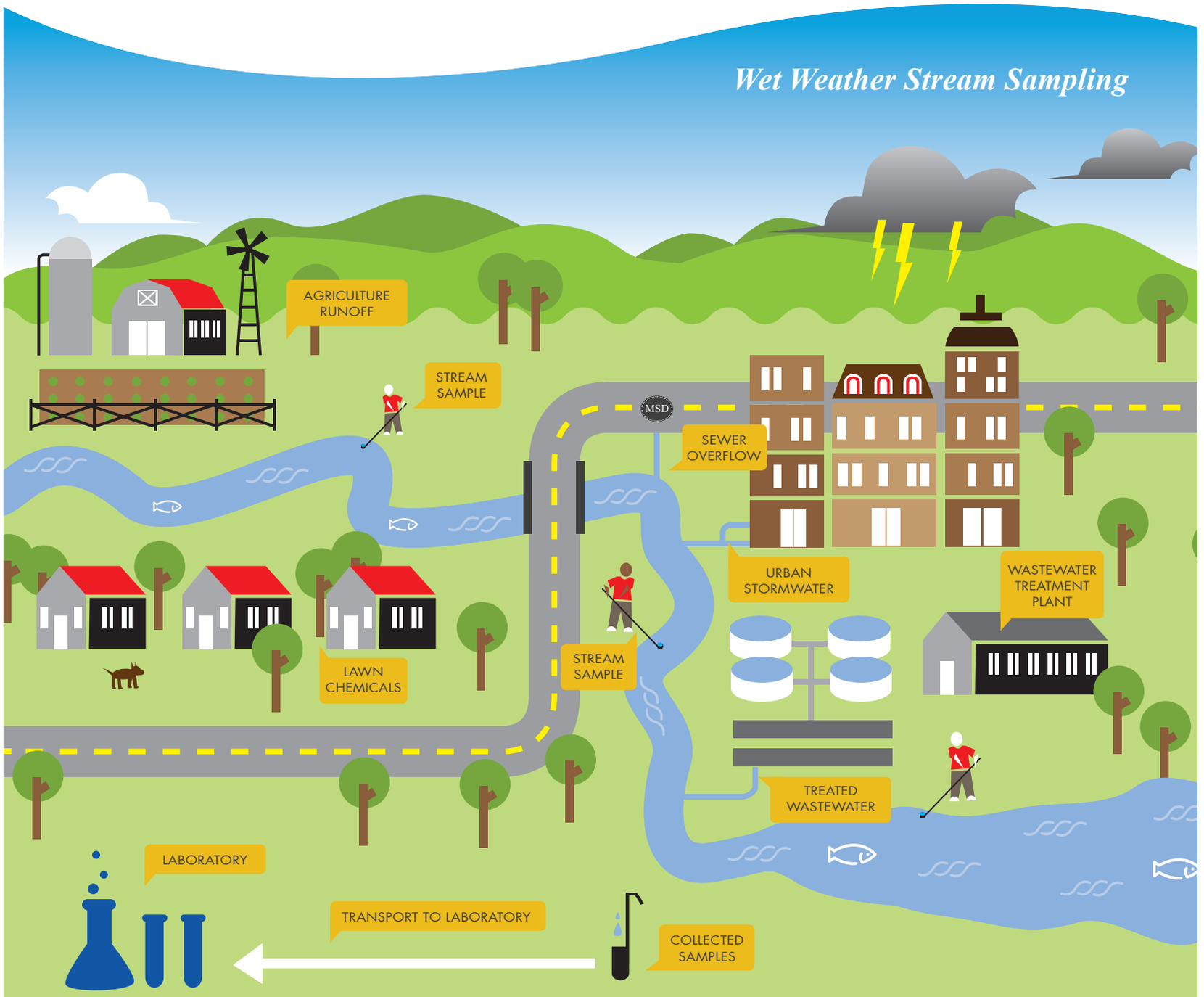
Greg C. Heitzman

Greg C. Heitzman
Executive Director

MSD
Metropolitan Sewer District

This 2014 Water Quality Synthesis Report provides a snapshot of the streams in our community – how they're doing and whether or not they're improving. The data we collect will help us make decisions about where we should focus our attention and tell us how we are doing in our mission to improve water quality in the region.

On the cover: *Big Run, just South of Glenmary Subdivision in Southeastern Jefferson County*



State of the Streams

2014 Water Quality Synthesis Report

Executive Summary

The Louisville and Jefferson County Metropolitan Sewer District (MSD), in cooperation with the United States Geological Survey (USGS), operates a Long-Term Monitoring Network (LTMN) to collect physical, chemical and biological data about streams in the Metro Area. MSD collects the water quality and biological data and USGS collects stream flow. This Synthesis Report is focused on the conditions of fish, aquatic insects, algae, stream habitat, bacteria, nutrients (nitrogen and phosphorus compounds), total suspended solids, trace metals, stream flow, dissolved oxygen, and water temperature of the streams in our community, and whether or not these things are improving. We've been collecting data at 27 Long Term Monitoring Network sites since 1999. This information will help us make decisions about where to focus our attention, and tell us how we're doing in our mission to improve water quality in the region.

The health of aquatic communities (fish, insects and algae) in streams can be compromised by one or more factors associated with urban streams:

- overflows from sewer systems
- significant and rapid runoff from impervious (hard surfaced) areas
- stream bank erosion due to increases in runoff
- sediment that covers habitat needed by fish and aquatic insects
- channel modifications such as straightening and shoring up with concrete or stones
- lack of rocks and boulders that create cascades and ponding areas
- insufficient vegetation along the banks
- periods of very low flow, high temperatures, or low dissolved oxygen

We can't control some of these factors - like low flows due to dry spells or high temperatures. Making improvements related to other factors will require numerous projects over several years, and we're committed to a program that should help. There are also things that individuals can do on private property, like minimizing the use of lawn chemicals, not mowing up to the banks of streams, or not cutting trees on the banks. We'll review these things throughout the report, and we'll look at how our major watersheds are doing with detailed sections in the report.

The charts on the next page reflect analyses of data as far back as 1999. They tell us that in 2013 for fish, algae and stream habitat, more than half the sites were in "good to excellent" condition, whereas for aquatic insects most sites were classified "poor to fair." The cooler than normal stream temperatures during 2013 sampling likely resulted in lower than normal observed aquatic insect health. Trends in fish, aquatic insects and stream habitat health indicate that more than half of the sites were improving. The algal communities at most sites either had no trend or were declining.

Biologist using a D-frame dip net to sample aquatic insects in a stream riffle.

We're also looking at other things like bacteria, nutrients and trace metals that can affect water quality. We found that:

- 20 of the 27 Long-Term Monitoring Network sites had fecal coliform readings that averaged more than the recreational contact standard of 200 colonies per 100 milliliters. From 2000 to 2013, 18 of the sites' average readings were above the recreational contact standard, so this is a concern for us.
- Oxygen is a necessary element for all forms of life, including fish and other aquatic life forms. Only one site had a "poor" status for dissolved oxygen, 4 were "fair", 19 were "good" and 3 sites do not have data. An analysis of trends in dissolved oxygen conditions (2007 to 2012) indicates that 2 sites were declining (Pennsylvania Run at Mt. Washington Road and the South Fork of Beargrass Creek at Brownsboro Road), 18 had no trend, and 4 sites were improving.
- 12 sites met water temperature standards of being no more than 31.7°C (89.1°F) 90% of the time, 12 sites met the criteria 100% of the time, and there was no data for the other 3 sites.

Partnering with the community for clean and safe waterways

- Nutrients consist of nitrates, total Kjeldahl nitrogen, and total phosphorus. We found that sites in the east and southeast parts of the region had the highest readings for nutrients while areas to the northeast and southwest had lower levels.
- For total suspended solids, only the site along Pond Creek at Manslick Road was a concern, with the other sites showing much lower readings.
- Trace metals (cadmium, copper, lead, and zinc) rarely exceed the criteria for aquatic life, and they are not a large issue of concern.

In general, we've found that streams within urban sections of our community have poorer results, especially in the lower sections of the watersheds. A variety of things contribute to the poorer water quality, but bacteria is the pollutant of major concern. As we continue to address sewer overflows, we expect this to improve. Our challenge will be to implement projects and programs, along with cooperative agreements with others, that will show tangible improvements.

For additional details on individual watersheds, please refer to the appropriate chapters in this report.

2013 Status Category	Fish	Aquatic Insects	Algae	Stream Habitat	Dissolved[1] Oxygen	Water[1] Temp	Fecal Coliform[2]	Percent of Site's Samples that are in the Upper Third of All Samples[3]			
Excellent	7 Sites		7 Sites				Average of 2013 Monthly Geometric Means	Nitrate	Total Kjeldahl Nitrogen	Total Phosphorus	Total Suspended Solids
Good	6 Sites	1 Site	10 Sites	14 Sites	19 Sites	12 Sites	7 Sites	13 Sites	13 Sites	12 sites	13 sites
Fair	8 sites	14 sites	7 sites	6 sites	4 sites	12 Sites	–	6 sites	7 sites	7 sites	8 sites
Poor	6 sites	12 sites	3 sites	7 sites	1 site	0 Sites	20 Sites	8 sites	7 sites	8 sites	6 sites

[1] Three of the sites have no data for these parameters.

[2] Green color indicates that the average is less than the bacteria criteria for recreational contact and red indicates that average is greater than the bacteria criteria for recreational contact.

[3] Green color indicates that percent is less than 29%, yellow indicates percent between 29-47% and red indicates percent greater than 47%.

Trend Category	Fish	Aquatic Insects	Algae	Stream Habitat	Dissolved[1] Oxygen	Water[1] Temp	Fecal Coliform[4]
	Oldest to 2013				2007 to 2012		Period of Record Median (middle value) of the Monthly Geometric Means
Improving	18 sites	13 sites	6 sites	14 sites	4 sites	0 sites	9 sites
No Trend	6 sites	9 sites	10 sites	10 sites	18 sites	24 sites	– –
Declining	3 sites	5 sites	11 sites	3 sites	2 sites	0 sites	18 sites

[1] Three sites have no data for these parameters.

[4] Green color indicates that the long-term median of monthly geometric means is less than the bacteria criteria for recreational contact and red indicates that the long-term median is greater than the bacteria criteria for recreational contact.

Introduction

About The Metropolitan Sewer District (MSD)

MSD was formed in 1946 to take over the operation and maintenance of Louisville's sewer systems. While wastewater treatment was added with the construction of the Morris Forman plant in the late 1950s, the basic mission remained the same through the 1970s.

Today, MSD is responsible for a much larger wastewater collection and treatment network, which continues to expand; a comprehensive public stormwater drainage system for most of Jefferson County; the operation and maintenance of the community's Ohio River flood protection system; the LOJIC computerized mapping and geographic information system; and several other programs — including stream monitoring and hazardous materials control — designed to protect and enhance the environment.

MSD is a non-profit regional utility service. Revenue comes from wastewater and stormwater service fees, plus charges for extending wastewater lines and connecting new customers. MSD does not receive supplementary income from taxes or from other local government agencies. All of the agency's revenue is used for operation, maintenance and extension, and improvement of services.

MSD is governed by an eight-member board. All members are appointed by the Louisville Metro Mayor, with the approval of the Metro Council. Members serve three-year terms and can be reappointed. The full Board meets once a month; committees meet as needed.

MSD periodically reports on the condition and quality of streams within its jurisdiction. This report fulfills requirements for MSD to produce a biennial Synthesis Report. As described below, MSD monitors the condition of streams in the Long Term Monitoring Network (LTMN) using a variety of methods.

Wet weather stream sampling.

MSD monitors streams throughout Louisville Metro, collecting samples on a regular basis and under various conditions in order to assess the quality of the water. Several steps have already been taken that are aimed at improving stream water quality. The stream monitoring program has been in place for more than 20 years. Projects that contribute to improving water quality have been underway longer than that. In the 1980s MSD began an effort to eliminate small neighborhood wastewater treatment plants and to replace aging, on-site septic systems with new sanitary sewers. In the past 30 years, more than 260 small treatment plants and approximately 190 pumping stations have been eliminated by diverting their flow to larger, regional facilities, and more than 40,000 homes that relied on septic tanks or straight pipes (that discharge waste directly to streams) have been connected to sanitary sewers.

More recently, MSD has initiated programs that improve maintenance of the collection and treatment facilities, assess the conditions of sewer systems (replacing them when practical), and offer assistance to property owners who are willing to reduce the amount of rainfall runoff into combined sewer systems that currently carry both wastewater and stormwater.

This report looks at several different criteria to assess how the streams and their watersheds are doing. What we're most interested in is whether or not water quality is improving. MSD is spending millions of dollars to reduce pollution from overflows and to provide more effective treatment of wastewater. The water quality in our streams is an indicator of how much progress is being made, and it can guide us in selecting and scheduling future projects.

In selecting the criteria for assessing stream water quality, we should also ask ourselves:

- Is the parameter a good indicator of stream water quality and ecosystem health?
- Do the indicators tell a meaningful story about the streams?
- Are the tests we run affordable, and will they continue to be available in the future?

So how do we go about assessing the water quality in our streams? Some of the criteria that we use are identified in our Municipal Separate Storm Sewer System (MS4) permit. They're mostly related to bacteria, chemicals and metals. But we also look at conditions in the streams that either support, or hamper, other living organisms like fish, algae and macroinvertebates. We'll explain these in more detail later in the report, but they're good indicators when it comes to the health of the streams.

MSD has eliminated more than 260 small treatment plants and approximately 190 pumping stations in Jefferson County

Partners with the Community

Eliminating and reducing overflows from sanitary and combined sewers is an obvious way to improve water quality, but there are also other methods that can be very effective, providing additional benefits to the community and the environment. Let's look at some of those other methods.

Eliminating Wastewater Treatment Plants

In 1980 MSD owned and operated six wastewater treatment plants. Three were regional facilities, serving large areas of the community, and three were small neighborhood plants, also known as package plants. A large portion of the community was served by privately owned package plants. These smaller facilities were expensive to operate and difficult to properly maintain. Some of the treatment plants were overstressed with more customers than they could handle, and nearing the end of their useful lives, requiring major investments in upgrades, but the private owners were reluctant to spend money on them.

In the mid-1980s we began a program to expand our wastewater system and to eliminate several of the package plants. Over the next 30+ years new regional plants were constructed and existing regional plants were expanded and upgraded. We also extended our network of sanitary sewers from the regional plants and diverted flow from the package plants to the regional systems. With every package plant elimination a "point source" of pollution was also eliminated. Today there are six regional plants, and eight package plants that are owned by MSD with only a handful of privately owned package plants still in existence. By the end of 2015 we plan to eliminate all of our remaining package plants and one of our regional plants.

Eliminating On-Site Wastewater Disposal Systems

Before sanitary sewers were available to provide service, many areas outside the city limits of Louisville were served by on-site wastewater disposal systems. This usually consisted of a septic tank where the waste would decompose and settle to the bottom. The water at the top then went to either a seepage pit or a lateral field.

A seepage pit usually consisted of a brick-lined hole in the ground. The pit was approximately three feet in diameter and sometimes more than twenty feet deep. They were usually located in the southwestern part of Jefferson County, where sandy soils were thought to allow better absorption of water from the septic tank. In reality, they do not work very well, and the State of Kentucky no longer approves the installation of seepage pits anywhere.

Lateral fields consist of a series of pipes with holes that allow the water to soak into the ground. The system can work relatively well if the tank is cleaned regularly and if the soil characteristics are such that the ground will absorb the water slowly, but in many areas of Jefferson County the soil is primarily clay and poorly drained, and the water table is high. During periods of rain, the ground becomes saturated and the ground water table rises above the level of the septic tank system, potentially allowing sewage to make its way to the streams.

In the mid-1980s, MSD's sewer expansion program was constructed with the capacity to allow property owners to abandon their on-site systems and connect to new sanitary sewers that would convey raw wastewater to regional treatment plants for treatment.

BENEFITS OF ELIMINATING WASTEWATER TREATMENT PLANTS

- Wastewater can be treated more effectively at regional facilities
- Flow from the system will be discharged to the Ohio River or to a larger stream
- Overflows from small package plants are eliminated

BENEFITS OF ELIMINATING ON-SITE WASTEWATER DISPOSAL SYSTEMS

- Regional treatment plants are much more effective at treating wastewater than septic tanks
- Failing septic systems create health hazards from raw wastewater standing in yards
- Drainage is improved since the flow from each home (approximately 200 gallons per day) doesn't have to be absorbed in the ground

Green Infrastructure

Capturing and infiltrating stormwater before it can reach streams and sewers reduces pollution in waterways. MSD's green infrastructure program uses engineered systems that act like natural landscapes to capture, cleanse and ultimately reduce the amount of stormwater entering sewers, creeks and waterways.

In combined sewer areas where pipes carry both wastewater and stormwater flows, green infrastructure projects help to reduce sewer overflows. By keeping rainwater from entering sewer systems, pipes are less full and less likely to overflow.

Solutions can take many forms and can also be installed by homeowners and businesses. A program was initiated in 2009 that allows MSD to partner with commercial, industrial and institutional property owners who are willing to install green infrastructure projects (see www.msdgreen.org).

RAIN GARDENS and Bio-swales are shallow areas with amended soil that absorb rainwater runoff into the ground.

PERVIOUS PAVEMENT consists of porous materials that allow stormwater to soak through the pavement and into the soil.

GREEN ROOFS capture stormwater with vegetation or other devices before it drains into sewers and waterways.

RAIN BARRELS and Cisterns allow property owners to collect stormwater and then use the water during dry periods.

Sewer System Evaluation Studies

MSD is under a federal Consent Decree that requires an inspection of the sewer system over a 10-year period. Besides assessing the condition of the sewers, MSD also uses the studies to develop recommendations for improvements that will reduce the amount of stormwater and groundwater that enters the sewers. Sewer System Evaluation Studies (SSESs) are extensive, and several different methods are used to gather information on the lines. Some of these methods include:

- **Closed Circuit Television Inspection**. A small camera is inserted in a manhole and run through the sewer while a technician makes notes on the condition of the pipe. Items noted include roots, hairline cracks, larger breaks, offset pipe joints, leaks, and property service connections that were not installed correctly.
- **Manhole Inspections**. A crew assesses the condition of the inside of manholes, noting any structural defects or areas where water is entering the manhole.
- **Smoke Testing**. A harmless white smoke is forced into sewers at manholes. The smoke finds its way to the surface through cracks in the sewer, from catch basins or downspouts that may be connected to the sewer, or sometimes inside homes if sump pumps and floor drains are connected directly to the sewer.

MSD has more than 3,200 miles of combined and sanitary only sewers that will be inspected over a 10-year period.

Once the studies are completed, the data is used to make recommendations for corrective actions. These can include replacing pipes, lining pipes and manholes, making repairs and disconnecting catch basins and downspouts. Removing excess rainwater and groundwater increases the available capacity in sewers and reduces the number and frequency of overflows that pollute streams.

It only takes four sump pumps running at the same time to completely fill an 8-inch diameter sewer.

Sewer Replacement Projects

In some cases, the problems are so extensive that MSD has chosen to replace the sanitary sewers in entire areas rather than doing point repairs or lining specific sections of pipes. In the Camp Taylor area, near the Louisville Zoo, sewers were installed during World War I to serve an army training facility. After the war ended, the property was subdivided and homes built with little thought to planning for utilities. This resulted in buildings being constructed over sanitary sewers and lines that are undersized for the number of properties that are connected to them. MSD has recently initiated a project to replace all of the sewers in two sections of Camp Taylor, affecting almost 500 properties.

BENEFITS OF SEWER REPLACEMENT PROJECTS

- New sewer systems that are less prone to wet weather problems
- Backups into homes and businesses caused by wet weather are eliminated
- In Beechwood Village the amount of wastewater being pumped from manholes into streams has been reduced from 20 million gallons per year to zero gallons per year

In the Beechwood Village area, groundwater levels are high, and several homes had their sump pumps connected directly to the sanitary sewer system. During rainstorms, water from the sump pumps would overwhelm the sanitary sewers, resulting in back-ups into homes. In order to prevent the back-ups, MSD would pump wastewater from a number of manholes directly into nearby creeks and ditches. As part of MSD's federal Consent Decree, these pumping arrangements had to be ended, and MSD decided to rehabilitate the sewers and disconnect all sump pumps from the system. It took six years and more than $6.5 million to complete the project, but since its completion in 2011 MSD has not had to pump any water from the Beechwood Village area manholes.

Wet Weather Storage Basins

Sometimes it's just too expensive to remove enough stormwater from the sewer system to eliminate overflows. In those cases it makes more sense to capture the excess flows, hold the water in a nearby basin until the level in the sewer drops back to normal, and then return the excess volume of water to the sewer system where it can be transported to a regional treatment plant.

MSD has constructed two large wet weather storage basins in the past year, allowing us to capture up to 120 million gallons of wastewater during any rain event where flows exceed the capacity of the sewer system.

Flood Protection Projects

Most people don't associate flood protection projects with improving water quality, but capturing the peak flows from storms reduces both the volume and the velocity in creeks and streams. Much of the erosion along stream banks is caused by rushing water, as it scours the sides of the streams. This increases the solids in the stream and chokes off the oxygen, both of which are harmful to fish and other stream life. Trees along the sides of streams can be lost during rain events, leading to less shade over the water. This raises the water temperature, which is also harmful to fish and plant life.

Flood storage basins are primarily intended to reduce flooding volumes, but reducing the velocity in creeks and streams is an added benefit.

18 million gallon wet weather storage basin at the Derek R. Guthrie Water Quality Treatment Center

Bells Lane wet weather storage basin under construction

The Long-Term Monitoring Network

In 1988, MSD and the United States Geological Survey (USGS) began monitoring water quality and stream flow throughout the Jefferson County area. This program, called the Long-Term Monitoring Network (LTMN), has changed over the years and currently includes 27 LTMN sites selected to represent streams in the Metro area (see map on page 14).

Streams are constantly changing. They are affected by rainfall runoff, temperature, land use, man-made pollutants, and a number of other factors. Assessing water quality in streams can be complicated, and MSD uses a wide variety of chemical, physical, and biological data at each LTMN site to evaluate stream quality. MSD collects and analyzes the information in accordance with standards set by the Environmental Protection Agency and the Kentucky Division of Water. A Quality Assurance Project Plan has been implemented to ensure high quality data for all these methods.

This report provides information on the important chemical and physical aspects of water quality, such as data on nutrients, total suspended solids, trace metals, dissolved oxygen, water temperature, and stream flow that are collected frequently each year. It includes wet and dry weather stream sampling through June 2014. Information also is collected on things that actually live in or near the streams, such as fish, aquatic insects (macroinvertebrates), algae, indicator bacteria, and stream habitat. Known as the biological community in streams, these organisms require clean water and suitable habitat to survive, and therefore they are an integrative tool that can be used to indicate whether streams are clean or polluted, doing better, or getting worse. The latest biological sampling was performed in 2013.

MSD has been collecting biological data since 1999, but it is not enough just knowing whether some of these organisms live in the waters. We need to know about their biological communities - what kinds (species) there are, how many of each, and if they are healthy. These communities are excellent indicators of stream health because they live in the water prior to sampling for weeks (algae) to months (insects) to years (fish) and, over that time, integrate environmental conditions such as water quality, stream flow, and the influence of other communities and habitat quality. More importantly, different species have different tolerances to the amount and types of water quality and flow conditions. Their presence, abundance, and health are indicative of conditions they experienced during their lives. By comparing past monitoring results to the most recent measures, we can determine whether sections of our streams are improving, staying the same, or declining. Also, with the right equipment they are easy to collect and identify in the field or laboratory.

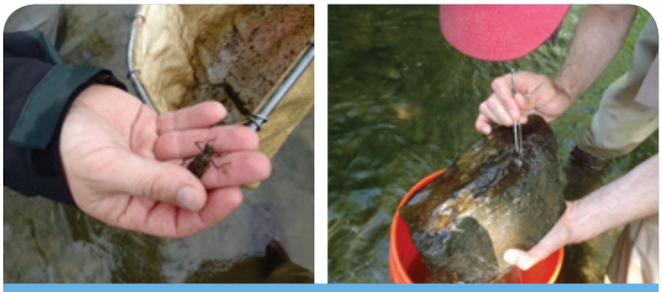
Stream habitat, along with fish, aquatic insect, and algal communities were evaluated using separate number scoring systems that consider the types and numbers of species and other factors present and the ability of each species to tolerate stressful conditions and other factors (see tables on each type). The resulting number scores are translated into a narrative rating of “excellent”, “good”, “fair”, or “poor” that considers the region of the state and the size of the stream.

Data analysis for biological and habitat assessment parameters in this report included evaluating the newest results and determining general trends based on a comparison of the oldest and newest results for each monitoring site. A trend was noted if the category changed by ten percent or more over time.

Fish: Fish are used as biological indicators in streams because of their stable populations. Fish can live for several years and are the most mobile of the three communities, moving to areas most suitable for their growth and survival as needed. Fish are particularly responsive to changes in flows, food supply, and habitat quality. They are found in many different types of streams, it’s easy to distinguish different species, and much is known about the life histories and tolerance levels of various species. Data collected between 1999 and 2013 were included in this report.

Fish are collected using a common scientific survey method known as electro-fishing. Electricity is used to stun fish before they are caught. This method is used to sample fish populations and normally the fish are returned to the stream unharmed in as little as ten minutes after being stunned. One person operates the equipment that stuns the fish while others catch the stunned fish with a net and place them in a bucket of stream water. The fish are identified and then returned to the stream.

Aquatic Insects: Aquatic insects that live on, under, and around rocks and sediment on the bottoms of streams, also called benthic macroinvertebrates, are useful as biological indicators in streams. Macroinvertebrates are organisms without backbones, which are visible to the eye without the aid of a microscope. These insects can live in water for weeks or months but are less able than fish to move to areas most suitable for their growth and survival. They include beetles, mayflies, stoneflies, dragonflies, aquatic worms, snails, leeches and a number of other organisms. They are particularly responsive to changes in flows, sediment, food supply, and habitat quality. Data collected between 2000 and 2013 was included in this report.



Collecting aquatic insects with a net, called a kick sampler, or from rocks that are in the sampling area. The "bugs" are picked, bottled in alcohol, and sent to a lab where they are identified, counted, and results are entered into a database for analysis.

Algae: The small green plant-like organisms that live on the rocks and other materials on the bottoms of streams are called benthic algae. These algae have limited mobility, staying in areas suitable for their survival for weeks to months. They are particularly responsive to stream nutrient concentrations, sunlight, and the effects of sedimentation. Data collected between 2001 and 2013 were included in this report. The photo below shows a biologist placing ceramic tiles for collecting algae in the Middle Fork of Beargrass Creek. Tiles are securely anchored in a stream and left to grow algae for a minimum of 15 days before collection for later identification and enumeration in a lab.

Placing ceramic tiles for collecting algae in the Middle Fork of Beargrass Creek.

Stream Habitat: Stream habitat is both the underwater environment that is used as a living space by fish, aquatic insects, other plants and animals, and the vegetation conditions near the stream channel. Fish, aquatic insects, and algae must rely on their local environment for food and shelter. Streams that have a variety of habitats, with shallow and deep areas, fast and slow water, and places with plenty of rocks and shade are characteristics of good habitats. Streams with eroding banks, large amounts of silt and sediment, and straightened stream channels are characteristics of poorer habitats. Data collected between 2005 and 2013 were included in this report. A Kentucky stream habitat index was used that has ten metrics (measures) to determine habitat condition and includes measures of the frequency of riffles and bends, overall bank stability, velocity/depth variability, amount of flow, percent vegetative protection along banks, width of the riparian area, suitability of streambed for insect/fish cover, sediment deposition/bed stability, embeddedness of rocks, and the degree of channel alteration.

Streams that have a variety of habitats, with shallow and deep areas, fast and slow water, and places with plenty of rocks and shade are characteristics of good habitats.

Indicator Bacteria: Bacteria and viruses that live in the water and on the bottom of streams are both natural and critical components in healthy streams. Some bacteria and viruses in wastewater inflows and runoff from urban surfaces, however, can lead to less healthy conditions, especially if they come from untreated animal or human waste. There are two types of bacteria that are commonly used to indicate whether streams are clean or polluted, getting better or worse. Fecal coliform bacteria are one type, more generally indicative of the presence of some kinds of fecal material. The other type, *E. coli* bacteria, is more indicative of the presence of fecal material from warm blooded animals, including humans. Both bacteria types have established criteria by the Kentucky Division of Water, mainly related to body contact recreation by humans. MSD has collected data on fecal coliform bacteria since 2000 and *E. coli* bacteria since 2011. These data were included in this report. Unlike fish and aquatic insects, which used computed indices of health, the status and trends of bacteria at each site were measured by computing the geometric means of samples collected in each month from April through October and comparing the average (status of 2013) and the period of record medians of these geometric means to the Kentucky criteria for contact recreation.

AQUATIC COMMUNITIES ARE ASSESSED USING MULTIPLE INDICATORS (KNOWN AS METRICS) DEVELOPED BY THE KENTUCKY DIVISION OF WATER. METRICS FOR EACH COMMUNITY ARE COMBINED FOR AN OVERALL COMMUNITY SCORE FOR A STREAM. NARRATIVE CRITERIA (EXCELLENT, GOOD, FAIR, POOR) FOR A SCORE ARE BASED ON REGIONAL STREAM DATA AND SIZE.

FISH COMMUNITY METRICS	AQUATIC INSECT COMMUNITY METRICS	ALGAE COMMUNITY METRICS (MOSTLY DIATOMS)
Total number of native species present in a sample. Non-natives are indicators of impairment (only used in wadeable streams).	A measure derived from pollution tolerance values assigned to insects present within a sample (Modified Hilsenhoff Biotic Index).	Total number of certain species present in a sample that are susceptible to impairment by sedimentation (Siltation Index).
Total number of species present that fall within the darter tribe, madtom genus, and sculpin genus.	Total number of mayfly, stonefly, and caddisfly classifications present in a sample.	How many different species and how evenly distributed they are (Shannon Diversity Index).
Total number of intolerant (most susceptible to impairment) species present in a sample.	Total number of all classifications present in a sample, also known as taxa richness.	Total number of diatom taxa, also known as taxa richness.
Total number of species that require relatively clean gravel for simple spawning.	Relative abundance (percent) of mayfly, stonefly, and caddisfly taxa excluding the relatively tolerant caddisfly genus *Cheumatopsyche*.	Relative abundance of pollution tolerant species that increase in abundance due to impairment (Pollution Tolerance Index).
Relative abundance of individuals of species that consume insects, excluding tolerant individuals.	Relative abundance of organisms that require hard, silt-free surfaces on which to "cling".	Relative abundance of individuals that are in the *Fragilaria* Group (*Fragilaria* Group Richness).
Relative abundance of pollution tolerant species that increase in abundance due to impairment.	Relative abundance of midges and freshwater worms, which are generally pollution tolerant organisms.	Relative abundance of individuals that are in the *Cymbella* Group (*Cymbella* Group Richness).
Relative abundance of species that are atypical of headwater streams.	Relative abundance of mayfly taxa (only in headwater streams).	

Dissolved Oxygen and Stream Temperature: Both fish and aquatic insects rely on oxygen that is dissolved in water to "breathe". When oxygen levels are too low, it causes stress on all aquatic organisms. A dissolved oxygen reading less than four milligrams per liter at any time, or average readings of less than five milligrams per liter over a 24-hour period, are considered stressful for aquatic organisms. Dissolved oxygen can be lowered by natural factors such as low streamflow, hot days, and lack of shade, and also by excessive algae and organic pollution. Stream temperature also is important to the health of aquatic communities. Water temperatures in excess of 31.7°C (89.1°F) also stress the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen.

MSD and the USGS have continuously monitored stream temperature and dissolved oxygen at the 27 LTMN sites since 2000. This level of effort highlights MSD's commitment to effectively monitor the quality and condition of streams in Jefferson County. The data are collected using protocols developed by the USGS. It is important to note that collection of continuous dissolved oxygen data requires diligent attention to cleaning and calibrating the monitor probes that are used to collect the readings every 15 minutes. In some streams, the probes can become dirty or covered by silt, resulting in missing or erroneous data. MSD has developed a Quality Assurance Project Plan with USGS to improve the maintenance of these probes. Dissolved oxygen and water temperature data collected by MSD and USGS between 2005 and 2013 were assessed for this report.

For this report, the average daily dissolved oxygen concentration was calculated from dissolved oxygen readings collected at 15 minute intervals. Days with more than half of the data missing were not included in the analysis. Results were grouped into rating categories based on the percent of days when average dissolved oxygen concentrations were above five parts per million. A "good" rating is when 100 percent of the days with valid data per year were above five parts per million, a "fair" rating is when more than 90 percent of days with valid data per year were above five parts per million; and a "poor" rating is when less than 90 percent of days with valid data per year were above five parts per million.

The 15 minute water temperature data were used to compute a maximum for each day with valid data to compare to the criteria. A "good" rating is when 100 percent of the days with valid data per year were below the criteria of 31.7°C (89.1°F), a "fair" rating is when more than 90 percent of days per year were within criteria, and a "poor" rating is when less than 90 percent of days per year were within the criteria.

Total Suspended Solids: The amount of sediment carried in a stream depends on the amount of erosion of unprotected land surfaces, wash off of impervious surfaces, and erosion or scouring of the stream banks and beds in the watershed during rainfall events. When carried in large amounts, sediment can deposit on and reduce the quality of stream habitat for fish and other aquatic organisms downstream. Data on the concentrations of total suspended solids in streams is a measure of those processes. MSD monitored concentrations of total suspended solids in streams periodically from 2000 to 2004 and on a quarterly basis since 2005 at all sites.

Stream Nutrients: The amount of nutrients carried in a stream depends on the amount of wash off of various land surfaces and the erosion or scouring of the stream bed and banks during rainfall events. Nutrients are necessary for the growth of algae, which is a food source for fish and aquatic insects. When carried in large amounts, however, nutrients can lead to excessive algal growth and reduce both the dissolved oxygen and quality of stream habitat needed by fish and other aquatic organisms in a stream. Data on the concentrations of total phosphorus, nitrate nitrogen, and total Kjeldahl nitrogen (a laboratory measure of the total ammonia and organic nitrogen) in streams are chemical analyses that help measure, in part, the chemical health of a stream. MSD monitored concentrations of nutrients (nitrogen and phosphorus) in streams periodically from 2000 to 2004 and on a quarterly basis since 2005 at all sites.

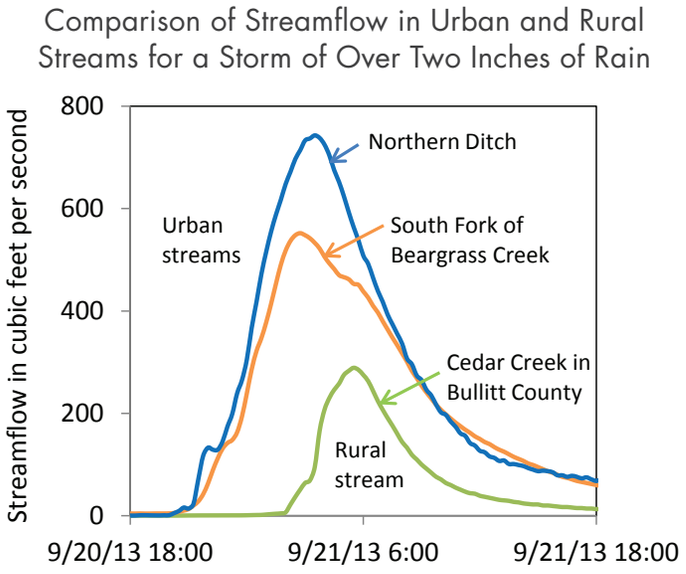
Owing to a current lack of water quality criteria for nutrients and total suspended solids in streams, a relative comparison of all LTMN data was used. The breakpoint concentration between the upper third and lower two thirds of all samples at all 27 MSD LTMN sites collected since 2005 were calculated for each of these constituents. The percent of samples above these breakpoints for each site was considered indicative of how each site qualitatively relates to other streams in the Louisville Metro area. In a sense, by using all data at all sites for comparison, this approach is a combined measure of status and trends.

Trace Metals: Trace metals generally are carried, as the name implies, in trace amounts, either dissolved or more commonly on particles (sediment) in stream flow. The amount of metals carried in a stream not only depends on the amount of wash off of various land surfaces during rainfall events but also in the discharge of wastewaters during both low and high flows. Trace amounts of metals are necessary for the healthy growth of algae, fish, and aquatic insects. When carried in excess of their needs, however, metals in water can lead to unhealthy exposure to fish and other aquatic organisms. Data on the concentrations of total metals in streams are chemical analyses that, in part, reflect the chemical health of a stream. MSD monitored concentrations of total metals in streams periodically from 2000 to 2004 and on a quarterly basis since 2005. Concentrations of total metals at each site were compared to the Kentucky acute Aquatic Life Criteria (ALC), where they exist, based either on a published value or on an equation using total hardness concentrations.

MSD Laboratory personnel perform analyses of water samples.

Streamflow: The amount of flow in a stream has a major influence on fish and aquatic insects. Streamflow varies naturally in response to rain, and seasonally tends to be higher in the winter and spring, lower in summer and fall. Streams may flow very little or not at all during times of drought. Periodic low flows can stress aquatic organisms by reducing the amount of stream habitat available to them, and if concurrent with hot air temperatures, can lead to excessive stream temperature and low dissolved oxygen conditions. Very high flow can reduce habitat quality critical to organisms by eroding stream banks and beds, by moving or covering stream bed habitat like rocks and woody debris, and by physical scouring or displacement of organisms. Higher stream flow can increase significantly both in frequency and volume in areas where impervious (hard) surfaces such as roofs and roads prevent water from filtering into the soil. MSD and the USGS have continuously monitored stream flow at 25 of the 27 LTMN sites. The analysis of stream flow for this report focused simply on a comparison of the average annual runoff at each LTMN site since 1999. Stream flow data is used by many agencies besides MSD for a variety of purposes, including planning for water supply, floods, and droughts, as well as understanding stream conditions in different land use settings.

The graph of streamflow (to the right) illustrates the differences in runoff from three watersheds of different land use. The urban watersheds, Northern Ditch and the South Fork of Beargrass Creek, tend to have higher streamflow during the same storm than the similar sized rural or undeveloped watershed, Cedar Creek in Bullitt County. These urban streams have more impervious surfaces (17 and 22 percent, respectively), including roadways, rooftops and driveways, where decreased infiltration of rain results in more water running off and therefore, higher stream flows. Less developed watersheds in the outer perimeter of the Louisville Metro area tend to have a more gradual or at least smaller rise in stream flow, like the Cedar Creek example.



This USGS streamflow gage (gray box in photo) is located on Cedar Creek at Thixton Lane. This type of gage is used to continuously monitor stream temperature, dissolved oxygen, and stream flow. The antenna to the right of the box transmits data to a satellite for real time monitoring results via the web at *http://waterwatch.usgs*.gov

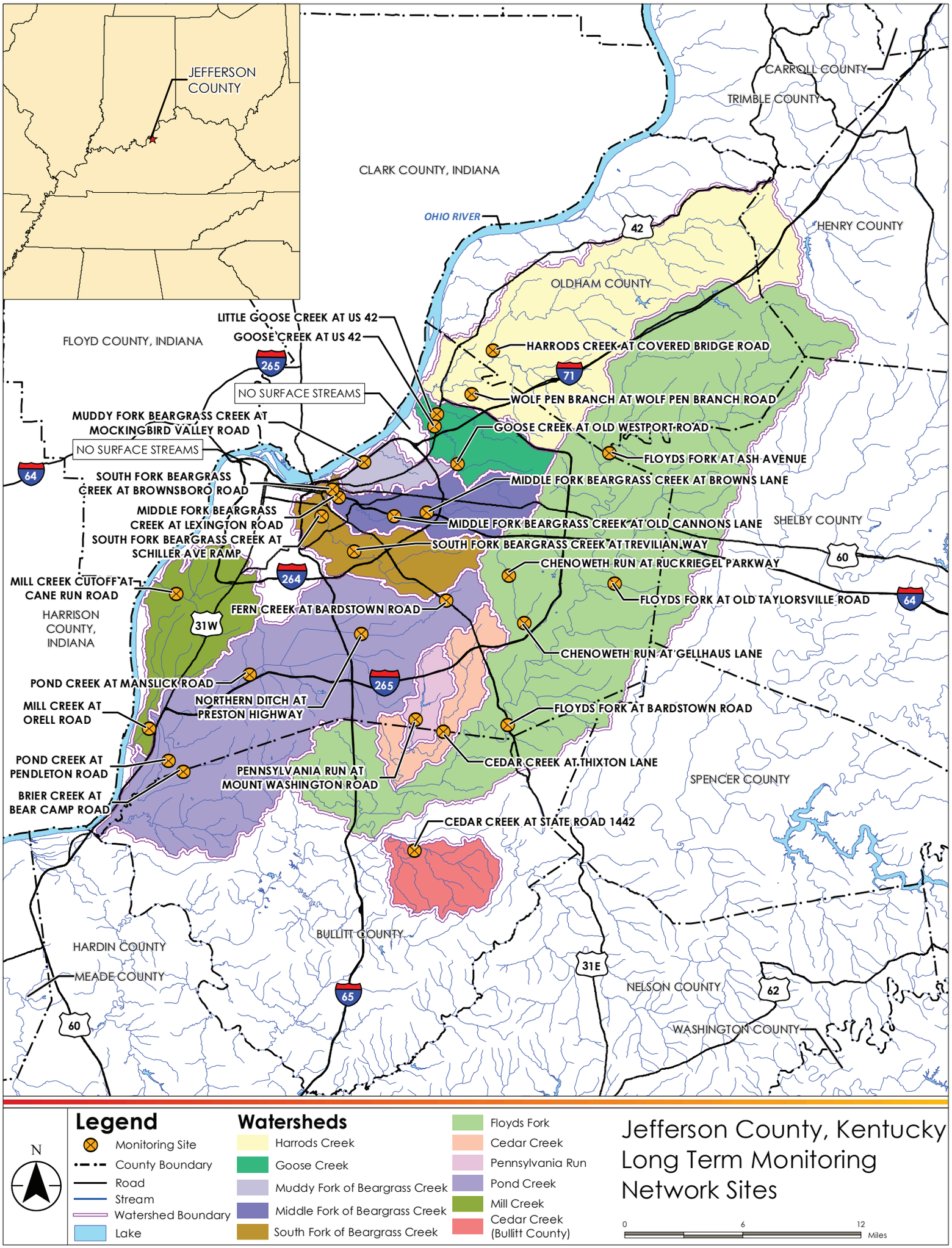
Watershed Reports

There are ten primary watersheds in Jefferson County, Kentucky (see the map on the facing page). Two of the streams (Harrods Creek and Floyds Fork) have their headwaters in other counties and flow into Jefferson County. About a quarter of the Pond Creek watershed lies in Bullitt County, and that water enters the main stem of the creek near the southwestern tip of Jefferson County.

MSD has been collecting stream samples from these watersheds for decades, along with a watershed that lies entirely in Bullitt County. Cedar Creek in Bullitt County was included in MSD's sampling program to act as a "control" because there is relatively little development in the watershed and impervious surfaces (roads, parking lots, roofs, etc.) are minimal when compared to the ten other watersheds.

In order to assess our past efforts to improve water quality, and to make decisions on future actions, samples are collected from streams and those samples are analyzed for a number of parameters, including bacteria, suspended solids, oxygen demand, nutrients, metals and more. This report utilizes stream samples that were collected through June 2014. We also evaluate habitats in the streams for a variety of organisms like fish, algae and aquatic insects. This information is compared to previous samples and compiled into reports for each watershed. The results are presented on the following pages in this section.

Big Run, along the Glenmary golf course in Southeastern Jefferson County


JEFFERSON COUNTY
CLARK COUNTY, INDIANA
OHIO RIVER
CARROLL COUNTY
TRIMBLE COUNTY
HENRY COUNTY
OLDHAM COUNTY
FLOYD COUNTY, INDIANA
LITTLE GOOSE CREEK AT US 42
GOOSE CREEK AT US 42
NO SURFACE STREAMS
NO SURFACE STREAMS
MUDDY FORK BEARGRASS CREEK AT MOCKINGBIRD VALLEY ROAD
SOUTH FORK BEARGRASS CREEK AT BROWNSBORO ROAD
MIDDLE FORK BEARGRASS CREEK AT LEXINGTON ROAD
SOUTH FORK BEARGRASS CREEK AT SCHILLER AVE RAMP
MILL CREEK CUTOFF AT CANE RUN ROAD
HARRISON COUNTY, INDIANA
POND CREEK AT MANSLICK ROAD
MILL CREEK AT ORELL ROAD
POND CREEK AT PENDLETON ROAD
BRIER CREEK AT BEAR CAMP ROAD
HARRODS CREEK AT COVERED BRIDGE ROAD
WOLF PEN BRANCH AT WOLF PEN BRANCH ROAD
GOOSE CREEK AT OLD WESTPORT ROAD
FLOYDS FORK AT ASH AVENUE
MIDDLE FORK BEARGRASS CREEK AT BROWNS LANE
MIDDLE FORK BEARGRASS CREEK AT OLD CANNONS LANE
SHELBY COUNTY
SOUTH FORK BEARGRASS CREEK AT TREVILIAN WAY
CHENOWETH RUN AT RUCKRIEGEL PARKWAY
FLOYDS FORK AT OLD TAYLORSVILLE ROAD
FERN CREEK AT BARDSTOWN ROAD
CHENOWETH RUN AT GELLHAUS LANE
NORTHERN DITCH AT PRESTON HIGHWAY
FLOYDS FORK AT BARDSTOWN ROAD
CEDAR CREEK AT THIXTON LANE
PENNSYLVANIA RUN AT MOUNT WASHINGTON ROAD
SPENCER COUNTY
CEDAR CREEK AT STATE ROAD 1442
BULLITT COUNTY
HARDIN COUNTY
MEADE COUNTY
NELSON COUNTY
WASHINGTON COUNTY
42
265
71
64
264
31W
265
60
64
31E
65
60
62
Legend
Monitoring Site
County Boundary
Road
Stream
Watershed Boundary
Lake
Watersheds
Harrods Creek
Goose Creek
Muddy Fork of Beargrass Creek
Middle Fork of Beargrass Creek
South Fork of Beargrass Creek
Floyds Fork
Cedar Creek
Pennsylvania Run
Pond Creek
Mill Creek
Cedar Creek (Bullitt County)
N
0
6
12
Miles
Jefferson County, Kentucky
Long Term Monitoring Network Sites

3.1

Harrods Creek Watershed

The small streams that eventually form Harrods Creek originate in Trimble County. Harrods Creek flows southwest through Oldham County and drains into the Ohio River in northern Jefferson County near Prospect. The Harrods Creek watershed drains approximately 92 square miles. Commercial and residential development has been expanding in the area.

Watershed Assessment

The health of the aquatic communities in the two sites of the Harrods Creek watershed was variable over time and between sites. The fish communities in Harrods Creek currently were rated "good" but were variably in "fair" to "excellent" condition over time. Fish communities in Wolf Pen Branch have been declining from "good' in 2002 to "fair" condition in 2005-2013. Since 2000, the aquatic insect community at the Harrods Creek site has declined steadily from an "excellent" to a "fair" condition in 2013 and also has declined since 2005 in Wolf Pen Branch from "fair" to "poor" conditions. The algal community at the Harrods Creek site improved from "good" in 2001 to "excellent" in 2011 and 2013 but the change in the assessment was less than 10% so no trend was indicated. The Wolf Pen Branch site was in "fair" condition in 2013, and was rated variably "fair" to "excellent" in the past but the long term change was less than 10% so no trend was indicated.

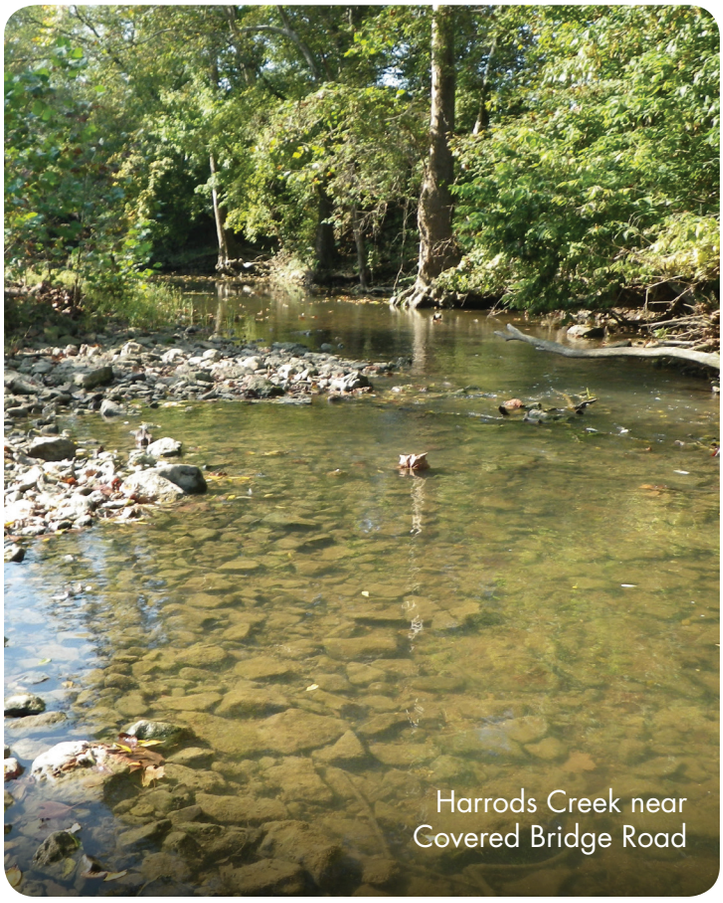
In Harrods Creek, stream habitat quality was classified as "good" in all years since 2005. Habitat quality improved from "poor" to "good" in Wolf Pen Branch between 2005 and 2013. Sediment deposition and an unstable stream bed were identified as habitat limitations in Wolf Pen Branch during previous years.

For fecal coliform bacteria, the period of record median (the middle value) of the monthly geomeans for the Harrods Creek site was below the recreational standard of 200 colonies/100ml, whereas, the median for Wolf Pen Branch was above the standard. Individual monthly geomeans were variably above and below the standard, with no apparent trend over time. For the three years of data of *E. coli* bacteria, most of the monthly geomeans at the Wolf Pen Branch site were above the recreational standard of 130 colonies/100ml, whereas, many of Harrods Creek geomeans were not.

Total phosphorus, nitrate, total Kjeldahl nitrogen, and total suspended solids values were relatively low at both sites compared to other LTMN sites, indicating that currently excessive nutrients are not a major concern in the watershed.

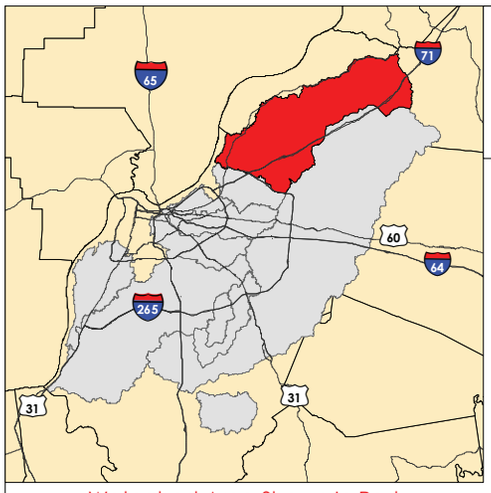
More recent wet weather event sampling data confirms the historical data here in that trace metals are not much of an issue of concern in these streams.

Dissolved oxygen conditions were in "good" condition at the Harrods Creek site for the last five years and water temperature criteria (no more than 31.7°C (89.1°F)) were met 96.7 to 100 percent of the time. The Wolf Pen Branch site had no data. Periodic hot days and low stream flows occasionally can cause exceedances of dissolved oxygen or temperature criteria.



Harrods Creek near Covered Bridge Road

HARRODS CREEK WATERSHED WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

CLARK COUNTY, INDIANA

TRIMBLE COUNTY

Ohio River

Harrods Creek

Wolf Pen Branch

HENRY COUNTY

OLDHAM COUNTY

JEFFERSON COUNTY

SHELBY COUNTY

42 53 393 71 329 22 265 264 64 60

Harrods Creek at Covered Bridge Road
(70.3 square miles and 9 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	—	↓	—	—	↑	—	B	~

Wolf Pen Branch at 8111 Wolf Pen Branch Road
(2.08 square miles and 24 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↓	↓	—	↑	ND	ND	A	~

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

RATINGS KEY

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

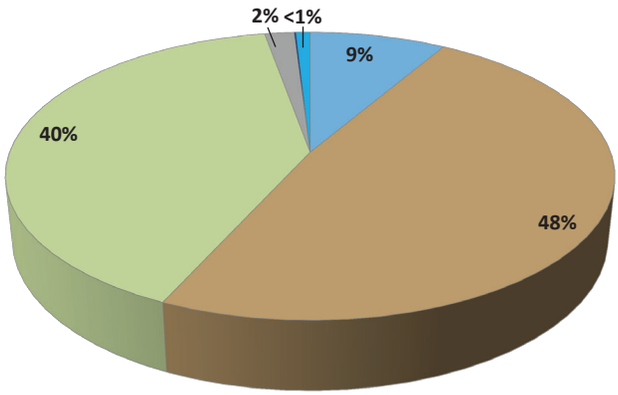
STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

Background and Land Use

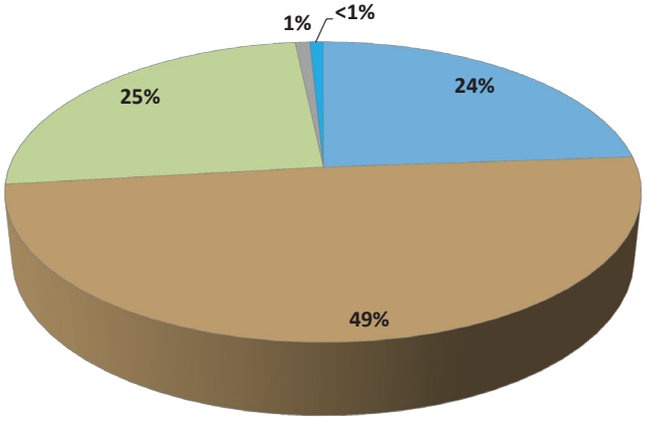
MSD has been monitoring water quality and flow in Harrods Creek at Covered Bridge Road since 1999. There are 70.3 square miles of land draining to the monitoring site on Harrods Creek at Covered Bridge Road. This land is mostly agricultural and forest. Nine percent of the land has been developed for urban and suburban uses. Approximately 1.3 percent of the land is covered by impervious surfaces such as roads, rooftops and driveways.

MSD has been monitoring water quality of the Wolf Pen Branch tributary since 2002; flow is not monitored at this location. There are 2 square miles of land draining to the monitoring site on Wolf Pen Branch. This land is a mix of agricultural, forest, and 24 percent is developed for urban and suburban uses. Approximately 7 percent of the land is covered by impervious surfaces.

Land Use Upstream of Harrods Creek at Covered Bridge Road



Land Use Upstream of Wolf Pen Branch at 8111 Wolf Pen Branch Road



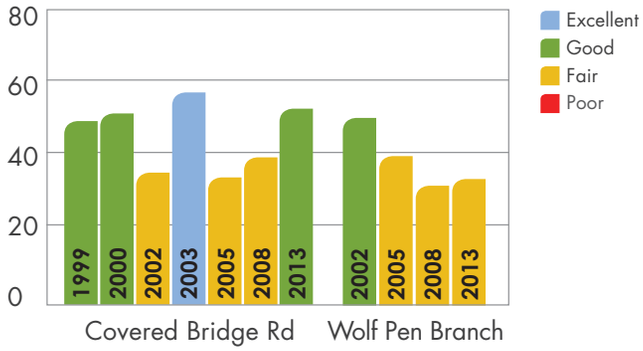
Urban & Suburban
Agriculture
Barren
Water & Wetland
Forest
Grassland

Monitoring Findings

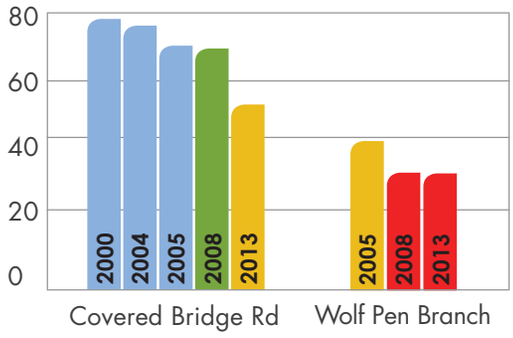
MSD has monitored the fish communities in Harrods Creek at Covered Bridge Road since 1999. During this time, the fish communities were variably in "fair" to "excellent" condition and currently "good". Fish communities in Wolf Pen Branch have been declining from "good' in 2002 to "fair" condition in 2005-2013.

Since 2000, the aquatic insect communities at the Harrods Creek site have declined steadily from an "excellent" to a "fair" condition in 2013. The aquatic insect communities in Wolf Pen Branch also have declined since 2005 from "fair" to "poor" condition.

Condition of the Fish Communities in the Harrods Creek Watershed

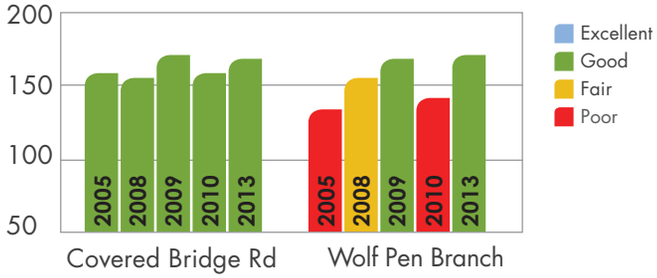


Condition of Aquatic Insect Communities in the Harrods Creek Watershed



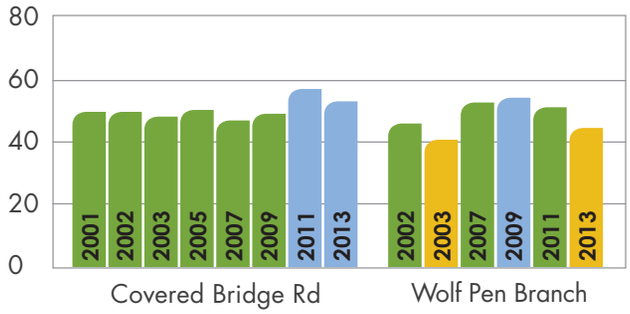
MSD has assessed stream habitat when fish and aquatic insects were sampled since 2005. In Harrods Creek, habitat was classified as "good" in all years since. Habitat quality improved from "poor" to "good" in Wolf Pen Branch between 2005 and 2013. Sediment deposition and an unstable stream bed were identified as habitat limitations in the Wolf Pen Branch site in previous years.

Condition of Stream Habitat Communities in the Harrods Creek Watershed



MSD has monitored benthic algal communities, largely diatoms, in the Harrods Creek watershed since 2001. Using a Diatom Bioassessment Index (DBI), the Covered Bridge Road site was rated "good" from 2001 through 2009 and improved to an "excellent" condition in 2011 and 2013. The Wolf Pen Branch site was rated variably "fair" to "excellent" through 2009 but has declined to a "fair" condition in 2013.

Condition of Algal Communities in the Harrods Creek Watershed



MSD plans to eliminate five neighborhood wastewater treatment plants in the Prospect area in 2015, including the Timberlake plant *(above right)* and the Hunting Creek South plant *(right)*.

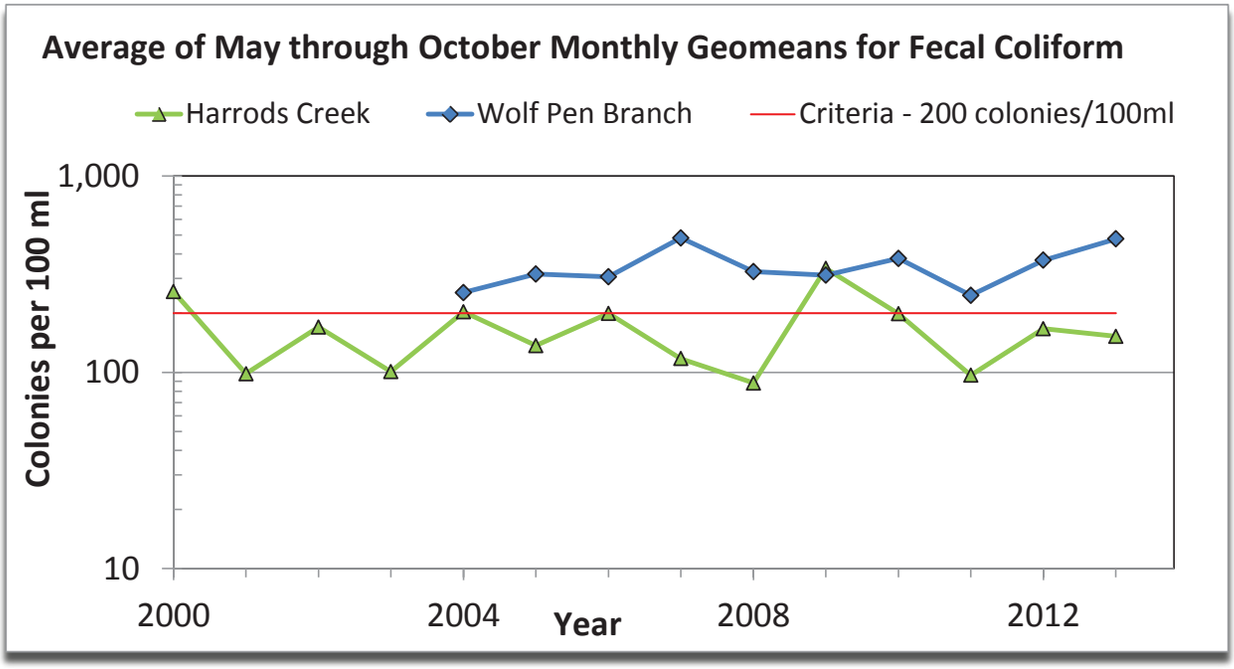
Timberlake wastewater treatment plant in Prospect

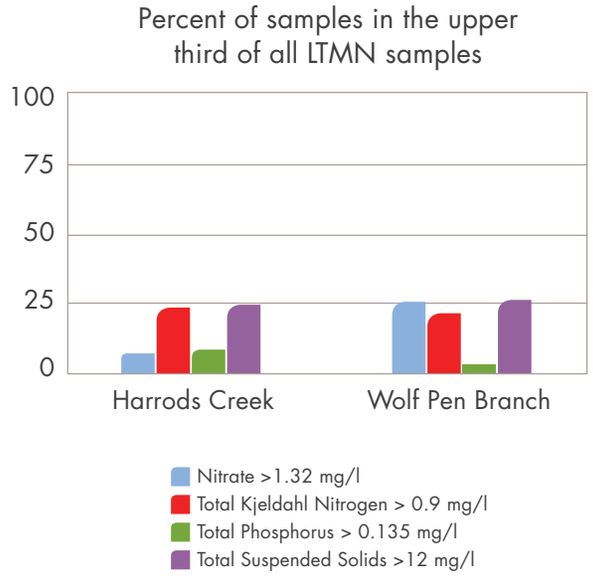
Hunting Creek South wastewater treatment plant in Prospect

Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E. coli* bacteria were collected similarly, but only since 2011. The monthly geomeans of bacteria concentrations were calculated and compared to the recreational contact standard or criteria for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record median (the middle value) of the monthly geomeans for the Harrods Creek site was below the recreational standard of 200 colonies/100ml, whereas, the 10 year median for Wolf Pen Branch was above the standard. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the period of record. There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season.

For the three years of data collection of *E. coli* bacteria (not shown), most of the monthly geomeans at the Wolf Pen Branch site were above the recreational standard of 130 colonies/100ml, whereas, many of Harrods Creek geomeans were not.





MSD monitored the concentrations of nutrients (nitrogen and phosphorus) and total suspended solids in streams periodically from 2000 to 2005 and on a quarterly basis since 2005 at two sites in the Harrods Creek watershed. The percent of samples taken at these sites which fall into the upper third of all samples at all 27 sites were calculated as a comparison to other streams in the watershed and throughout the Metro area.

Both sites in the Harrods Creek watershed had relatively low numbers of samples in the upper third for nutrient data, with most parameters under 25%. The sites also had very similar values for all parameters with the exception of nitrate, which was somewhat higher at the Wolf Pen Branch site than the Harrods Creek site.

MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The acute ALC for total concentrations of cadmium, copper, lead, and zinc were not exceeded in any samples at either of the two sites.

MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature on Harrods Creek at Covered Bridge Road (Highway 329). Streamflow has been monitored at this USGS gage (number 03292470) since 1999.

Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four parts per million (as an instantaneous standard) or five parts per million (as a mean daily standard) are what is deemed necessary. Water temperatures in excess of 31.7°C (89.1°F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

Dissolved oxygen criteria were met 95.5 to 100 percent of the time and in "good" condition at the Harrods Creek site for the last five years, but in 2007 it was 87.8 percent and in 'fair' condition. Occasional excursions of low dissolved oxygen likely were a result of very low stream flows on very warm days or some other transient factor.

Water temperature criteria were met 100 percent of the time in 2008 to 2010 at the Harrods Creek site. The percent of the time that the criteria were met in 2007, 2011, and 2012 was 99.3, 96.7, and 98.6 percent, respectively. Temperature data was not available for the Wolf Pen Branch site. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of the criteria.

Wolf Pen Branch

3.2

Goose Creek Watershed

The streams that form the Goose Creek Watershed, Little Goose Creek and Goose Creek, flow northwest from Anchorage to Glenview Acres. Goose Creek enters into the Ohio River near Lime Kiln Lane and River Road.

Watershed Assessment

The fish and algal communities and stream habitat at all three Goose Creek sites are in "good to excellent" health in 2013, whereas, the aquatic insect communities generally were in "poor" or "fair" health at all three sites. The health of the fish communities and stream habitat generally have improved over time. The algal communities upstream at Old Westport Road have improved over time, but conditions in aquatic insect and algal communities in Goose Creek at US 42 have declined. Sediment deposition and unstable banks have been identified in these streams as a limitation of the habitat quality that would affect both insects and algae health.

For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans for the two Goose Creek sites were above the recreational standard of 200 colonies/100ml, whereas, the period of record median for the Little Goose Creek site was below the standard. Individual monthly geomeans were variably above and below the standard, with no apparent trend over time. For the three years of data on *E. coli* bacteria, most of the monthly geomeans at the three sites were above the recreational standard of 130 colonies/100ml.

Compared to the other LTMN sites, Goose Creek at US 42 also had a relatively high number of nitrate samples in the upper third at 48 percent. Little Goose Creek at US 42 had some of the highest values for nitrate, total Kjeldahl nitrogen, and total suspended solids, with nearly 80 percent of its samples in the upper third of all LTMN samples for nitrate and over 60 percent of samples in the upper third for the latter two parameters. Goose Creek at Old Westport Road, had lower numbers of samples in the upper third for nitrogen, total Kjeldahl nitrogen, total phosphorus and total suspended solids compared to the other two sites in the watershed. Total suspended solids are relatively low at the two Goose Creek sites. Total phosphorus is relatively low at all the three sites.

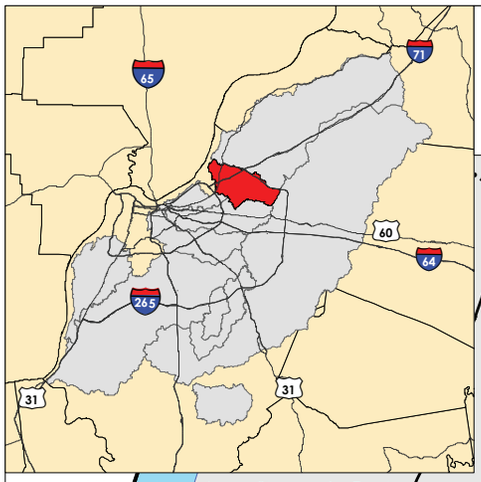

Little Goose Creek

The land use upstream of the Little Goose Creek site is 66 percent urban and in Goose Creek it is about 50 percent urban. Little Goose Creek, however, has almost twice the impervious area of Goose Creek. Differences in land use and management practices, like the use of lawn fertilizers, within these watersheds likely account for some of the observed differences.

More recent wet weather event sampling data confirms the historical data that trace metals are not a large issue of concern in these LTMN streams.

Dissolved oxygen criteria were met 100 percent of the time at the Little Goose Creek site. Conditions were in the "good" range at both Goose Creek sites as well. Water temperature criteria (no more than 31.7°C (89.1°F)) were met 100 percent of the time at all three sites. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of these criteria, but that is not the case in these sites.

GOOSE CREEK WATERSHED
WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

CLARK COUNTY, INDIANA

OLDHAM COUNTY

JEFFERSON COUNTY

Ohio River

Little Goose Creek

Goose Creek

42

71

265

264

60

Little Goose Creek at US 42
(5.82 square miles and 66 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	—	↑	—	—	B	~

Goose Creek at US 42
(10.1 square miles and 49 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↓	↓	—	—	—	A	~

Goose Creek at Old Westport Road
(6.0 square miles and 53 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	↑	↑	—	—	A	~

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

RATINGS KEY

Background and Land Use

There are 19 square miles of land in the Goose Creek Watershed. The land use associated with each monitoring site, like the entire watershed, is a mix of urban, forest and some agriculture. MSD monitors three stream sites in the watershed: Goose Creek at Old Westport Road, Goose Creek at US 42 and Little Goose Creek at US 42.

The areas draining to the two sites in Goose Creek have very similar land uses. There are 6.0 square miles draining to Goose Creek at Old Westport Road, with almost 10 percent impervious surfaces, such as roads, rooftops and driveways. There are 10.1 square miles of land draining to Goose Creek at US 42, with almost 11 percent impervious surfaces. Approximately half of the land is used for urban and suburban purposes, approximately 40 percent is forested and 10 percent is agriculture.

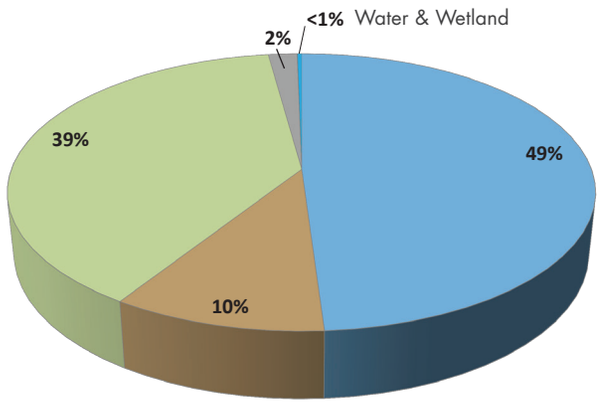
There are 5.82 square miles of land draining to Little Goose Creek at US 42, with 18 percent impervious surfaces. With 66 percent of the land area used for urban and suburban development, there is less agriculture and forest in this tributary to Goose Creek. This watershed is the most developed of the three Goose Creek sites.

Goose Creek, north of Old Westport Road

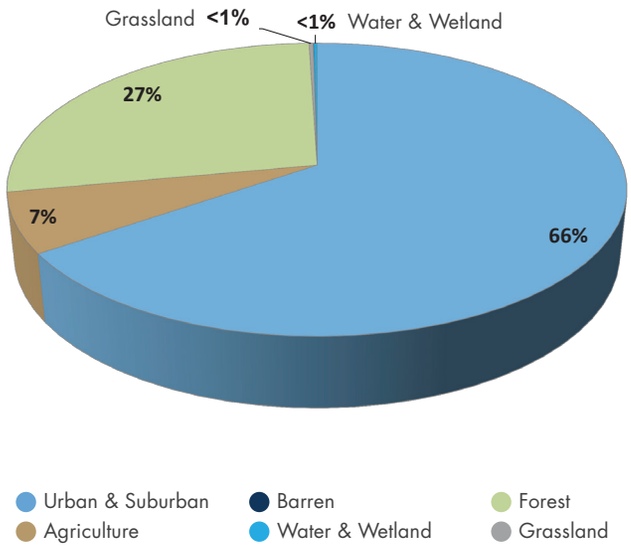
Monitoring Findings

MSD monitored fish communities in the Goose Creek watershed since 1999. The fish communities generally have improved at all three sites since then. The fish communities at the Old Westport Road site have improved from "fair" in 2000 to "good" in 2013. Conditions at the US 42 site have improved from "fair" in 1999 to "excellent" in 2013. The fish communities in Little Goose Creek have improved most dramatically from "very poor" prior to 2000 to "excellent" in 2008 and "good" in 2013.

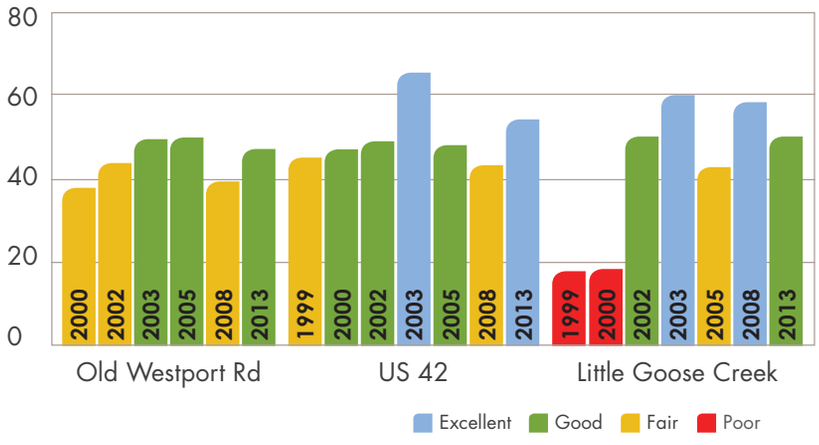
Land Use Upstream of Goose Creek at US 42



Land Use Upstream of Little Goose Creek at US 42



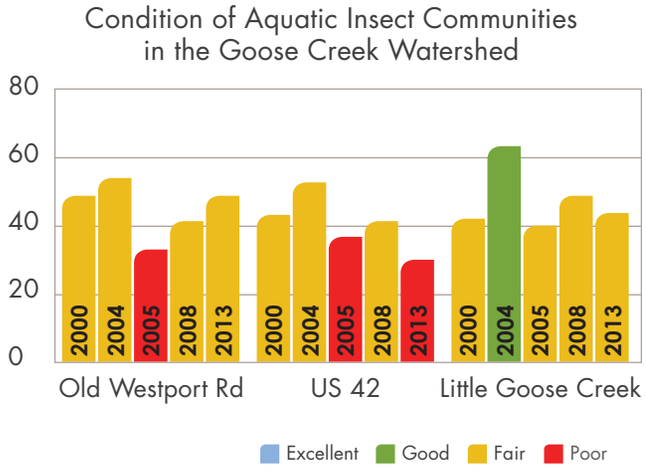
Condition of the Fish Communities in the Goose Creek Watershed

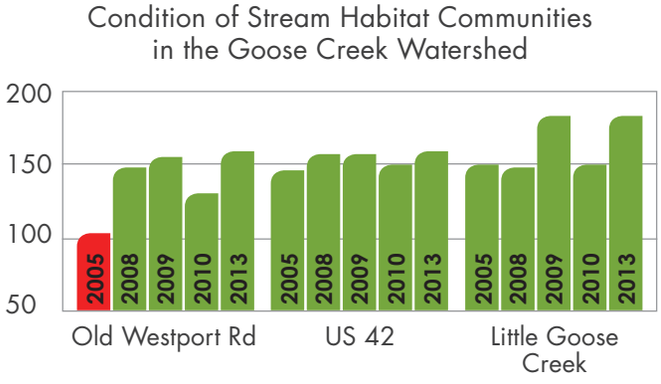


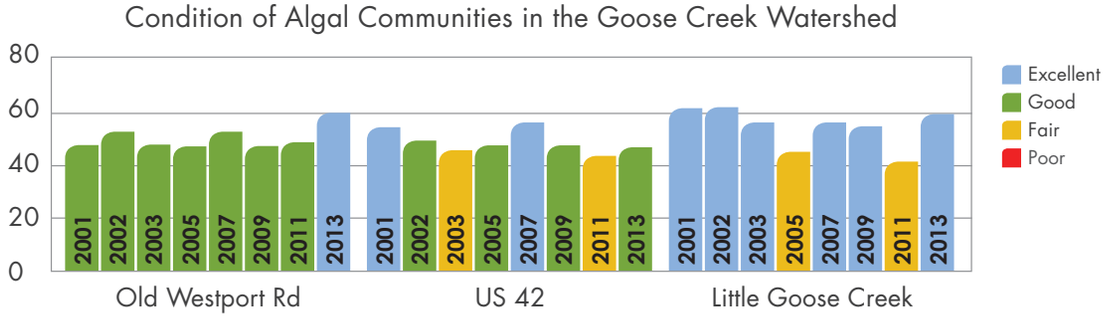
MSD monitored aquatic insect communities at the three sites since 2000. The aquatic insect communities generally were classified as "poor" or "fair" at all three sites, except in 2004, when Little Goose Creek was classified as "good". Overall, the aquatic insect communities in Goose Creek appear to have declined some between 2004 and 2013, especially in Goose Creek at US 42.

MSD has assessed stream habitat quality when fish and aquatic insects were sampled since 2005. At all three sites, stream habitat was classified as "good" since 2008 and trends indicate improvement over time at Old Westport Road and at Little Goose Creek. Sediment deposition and unstable banks were identified in these streams as a limitation of the habitat quality and Old Westport Road is lacking somewhat in rocky riffles that are used as habitat by aquatic organisms.

MSD has monitored benthic algal communities, largely diatoms, at the three sites since 2001. Using a Diatom Bioassessment Index (DBI), the upstream Old Westport Road site was rated "good" through 2011 and was "excellent" in 2013. The downstream US 42 site was rated variably "fair" to "excellent" throughout and was "good" in 2013. The Little Goose Creek site was generally "excellent" throughout and in 2013, but twice it dipped into "fair" condition in 2005 and 2011.







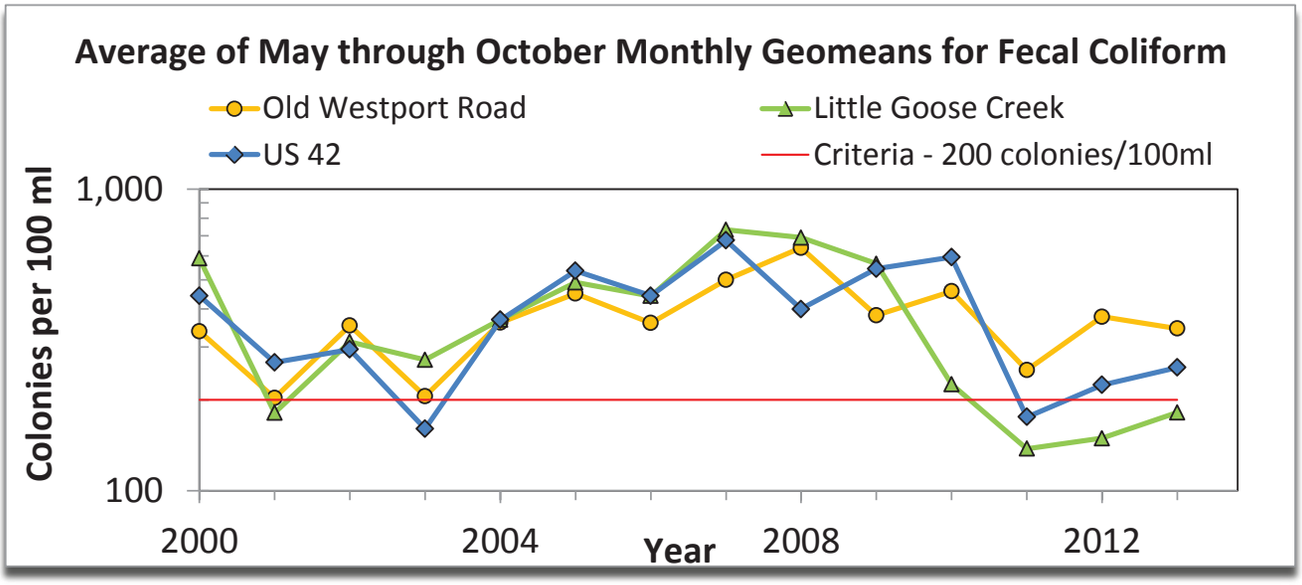
The Bancroft Subdivision treatment facility is the only plant remaining in the Goose Creek Watershed. It is scheduled for elimination in 2015.

Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E coli* bacteria were collected similarly but only since 2011. The monthly geometric means (geomeans) of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record median of the monthly geomeans for all three sites were above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the period of record.

There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season. Also, the average annual values for 2004 through 2010 are considerably higher than most other years.

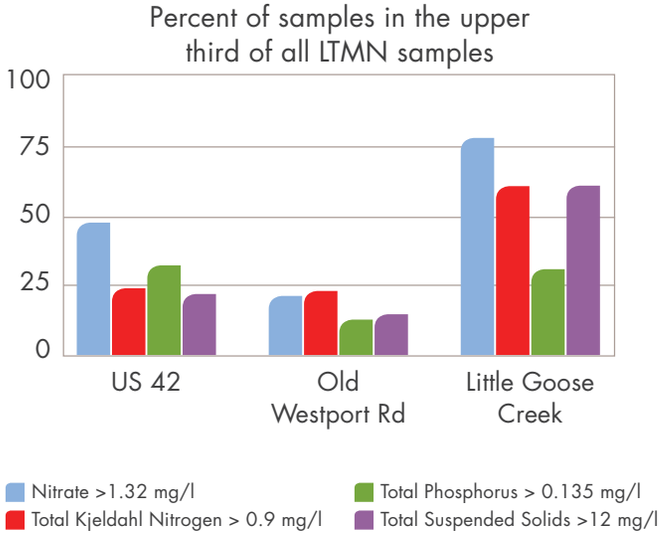
For the three years of data collection of *E coli* bacteria (not shown), most all of the monthly geomeans at the three sites were above the recreational standard of 130 colonies/100ml.



The Kentucky standard for fecal coliform for recreational contact in streams – between May 1 and October 31 – is 200 colonies per 100ml.

MSD monitored the concentrations of nutrients (nitrogen and phosphorus) and total suspended solids periodically from 2000 to 2005 and, more consistently, on a quarterly basis since 2005 at the three sites. The breakpoint concentration between the upper third and lower two thirds of all samples at all 27 MSD LTMN sites collected since 2005 were calculated for each of these constituents. The percent of samples above these breakpoints for each of the three sites is indicative of how they compare to each other and to other LTMN streams in the Metro area.

The Little Goose Creek site had significantly higher values than the other two sites for nitrate, total Kjeldahl nitrogen, and total suspended solids, and nitrate is relatively high much of the time at the site, with almost 80 percent of the nitrate samples in the upper third of all LTMN samples. Total phosphorus is relatively low at the three sites. Total suspended solids are relatively low at the two Goose Creek sites.



MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The acute ALC for total concentrations of cadmium, lead, and zinc were not exceeded in any samples at either of the two sites. The ALCs, however, were exceeded for copper in one sample at Old Westport Road.

MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature at the three sites in the Goose Creek watershed. Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four or five parts per million are what is deemed necessary. Water temperatures in excess of 31.7°C (89°F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

US GEOLOGICAL SURVEY - GAGING STATIONS

USGS GAGE NUMBER	STREAM NAME AND LOCATION OF FLOW GAGE	YEAR STARTED
03292474	Goose Creek at Old Westport Road	1996
03292475	Goose Creek at US 42	1999
03292480	Little Goose Creek at US 42	1998

Dissolved oxygen criteria were met 100 percent of the time at the Little Goose Creek site for the last six years. Dissolved oxygen conditions were above five parts per million and in the "good" range at both Goose Creek sites as well. Occasional excursions of low dissolved oxygen likely were a result of very low stream flows on very warm days or some other transient factor.

Water temperature criteria were met 100 percent of the time each year over the last six years at all three sites. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of the criteria, but that is not the case in these sites.

DISSOLVED OXYGEN

SITE	PERCENT OF THE TIME DISSOLVED OXYGEN CRITERIA WERE MET EACH YEAR					
	2007	2008	2009	2010	2011	2012
Old Westport Road	99.6%	96.7%	98.8%	93.5%	98.2%	98.3%
US 42	100.0%	100.0%	100.0%	98.6%	99.7%	99.4%
Little Goose Creek	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

3.3

Muddy Fork of Beargrass Creek Watershed

The Muddy Fork of Beargrass Creek is one of the three streams that join to form the larger Beargrass Creek watershed. The Muddy Fork flows west from Windy Hills toward the Ohio River, then southwest along Interstate 71 before joining with the South Fork to become Beargrass Creek near Mellwood and Story Avenues. Historically, major segments of Muddy Fork have been straightened along Interstate 71 and along Mockingbird Valley Road.

Watershed Assessment

The fish communities at the Muddy Fork at Mockingbird Valley Road site were highly variable from year to year, but conditions were "good" in 2013. The aquatic insect communities were consistently classified as in "poor" and "very poor" condition. Algal communities were rated "excellent" through 2007 and then declined to "fair" condition in 2011 and 2013. Stream habitat on Muddy Fork was consistently "poor" and associated with straightening of the channel, lack of trees and other protective vegetation along the stream banks, eroding banks, and a largely silt stream bottom. These issues have contributed to sediment accumulating in the stream, not ideal habitat for aquatic organisms.

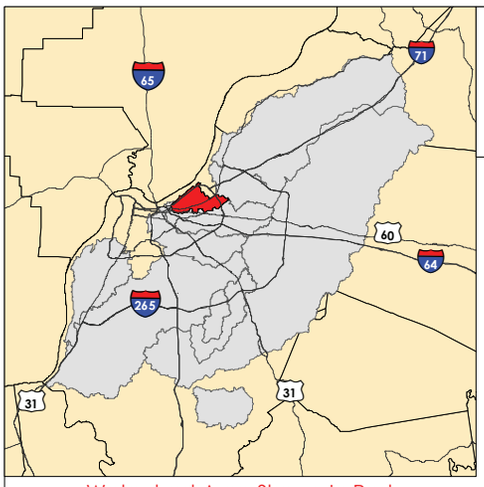
For fecal coliform bacteria, the period of record median (the middle value) of the monthly geomeans for the Muddy Fork site was above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variable but usually above the standard, with no apparent trend over the period of record. For the three years of data collection of *E. coli* bacteria, most all of the monthly geomeans at the site were above the recreational standard of 130 colonies/100ml.

Nutrient and total suspended solids levels in this largely forested urban residential watershed are in the lower concentration groupings compared to other LTMN sites. More recent wet weather event sampling data confirms the historical LTMN metals data that trace metals are not an issue of concern in this stream.

Dissolved oxygen conditions were "good" (criteria met more than 93.5 percent of the time) at the Muddy Fork sites over the last six years. Water temperature criteria (no more than 31.7°C (89.1°F)) at the Muddy Fork site were met 100 percent of the time over the last six years, except for occasional excursions in 2010 and 2012. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of these criteria.

The Mellwood Avenue Pumping Station near Muddy Fork at Mockingbird Valley Road eliminated an overflow from the existing sewer system.

MUDDY FORK OF BEARGRASS CREEK WATERSHED
WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

Muddy Fork of Beargrass Creek at Mockingbird Valley Road (6.2 square miles and 46 percent urban)								
2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	—	↑	↓	↑	—	—	A	~

CLARK COUNTY, INDIANA

Harrods Creek

Little Goose Creek

Ohio River

42

Goose Creek

71

JEFFERSON COUNTY

Muddy Fork of Beargrass Creek

Beargrass Creek

Middle Fork of Beargrass Creek

LEXINGTON RD

60

150

64

264

31

South Fork of Beargrass Creek

South Fork of Beargrass Creek

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

TREND

- Improving
- Declining
- Varies
- No Change
- ND No Data

STATUS

- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

RATINGS KEY

Background and Land Use

There are about 9 square miles of land draining the entire Muddy Fork Watershed and 6.2 square miles of land draining to the Muddy Fork at Mockingbird Valley Road site. The land use draining to the monitoring site, like the entire Muddy Fork watershed, is a mix of forest and urban and suburban uses. Fifty-two percent of the watershed is classified as forest. However, this area of Louisville is densely developed and many of the areas classified as forested are actually tree-covered developed areas. There is a small area of agricultural land in the very upper part of the watershed. Impervious surfaces such as roads, rooftops and driveways cover about 9 percent of this watershed.

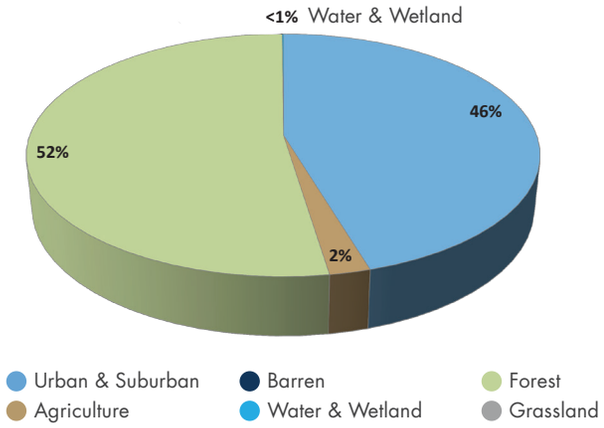
Monitoring Findings

MSD monitored the fish communities in the Muddy Fork since 2002. The fish communities at the Muddy Fork at Mockingbird Valley Road site were highly variable from year to year, but conditions were "good" in 2013.

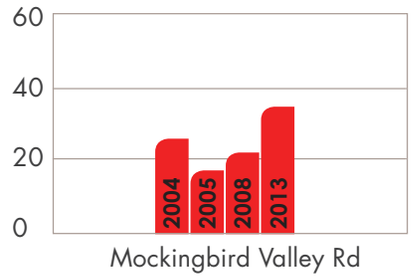
MSD monitored aquatic insect communities at the Muddy Fork site since 2004. The aquatic insect communities were consistently classified as "poor" and "very poor" at the Mockingbird Valley Road site on Muddy Fork.

MSD has assessed stream habitat when fish and aquatic insects were sampled since 2005. Habitat on Muddy Fork was consistently "poor" and associated with straightening of the channel, lack of trees and other protective vegetation along the stream banks, and eroding banks. These issues have contributed to silt and sediment accumulating in the stream, which covers habitats used by aquatic insects and fish.

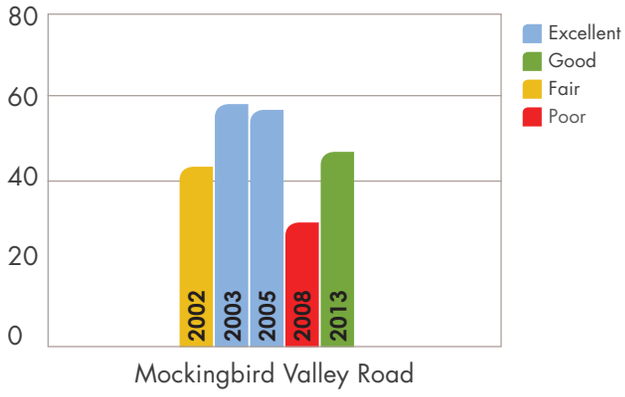
Land Use Upstream of Muddy Fork of Beargrass Creek at Mockingbird Valley Road



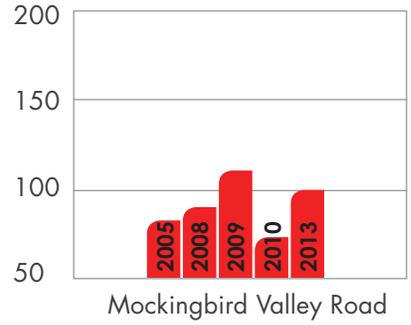
Condition of Aquatic Insect Communities in the Muddy Fork of Beargrass Creek Watershed



Condition of Fish Communities in the Muddy Fork of Beargrass Creek Watershed



Condition of Stream Habitat Communities Muddy Fork of Beargrass Creek Watershed



Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E. coli* bacteria were collected similarly but only since 2011. The monthly geometric means (geomeans) of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record median of the monthly geomeans for the Muddy Fork site was above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variable but usually above the standard (not shown), with no apparent trend over the period of record.

There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season. For the three years of data collection of *E. coli* bacteria (not shown), most all of the monthly geomeans at the site were above the recreational standard of 130 colonies/100ml.

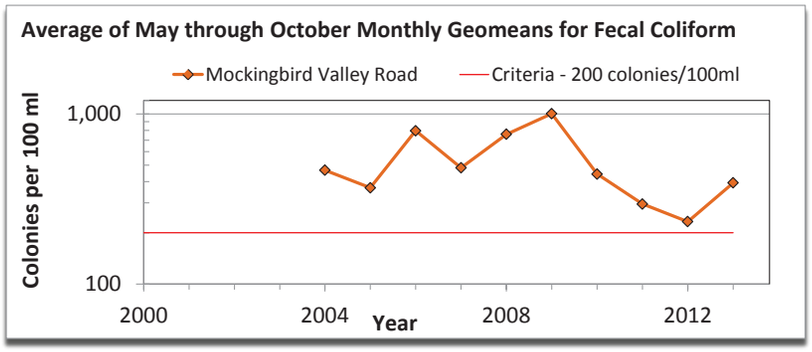
MSD has monitored benthic algal communities, largely diatoms, in the Muddy Fork watershed since 2002. Using a Diatom Bioassessment Index (DBI), the Muddy Fork site was rated "excellent" through 2007 and then declined to "fair" condition in 2011 and 2013. The site showed significant decline in the condition of the algal communities over the period of study.

MSD monitored the concentrations of nutrients (nitrogen and phosphorus) in streams and total suspended solids periodically from 2000 to 2005 and on a quarterly basis since 2005 at the Muddy Fork site. The percent of samples taken at these sites which fall into the upper third of all LTMN samples were calculated as a comparison to other streams in the area. Nutrient and total suspended solids levels in this largely forested urban residential watershed are generally in the low concentration grouping compared to the other LTMN sites.

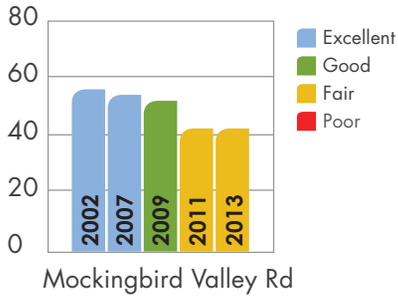
MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The ALCs were exceeded for cadmium in nine samples, copper in 11 samples, for lead in 11 samples, and zinc in two samples.

MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature on the Muddy Fork of Beargrass Creek at Mockingbird Valley Road (USGS gage 03293530) since 2002. Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four parts per million (as an instantaneous standard) or five parts per million (as a mean daily standard) are what is deemed necessary. Water temperatures in excess of 31.7°C (89°F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

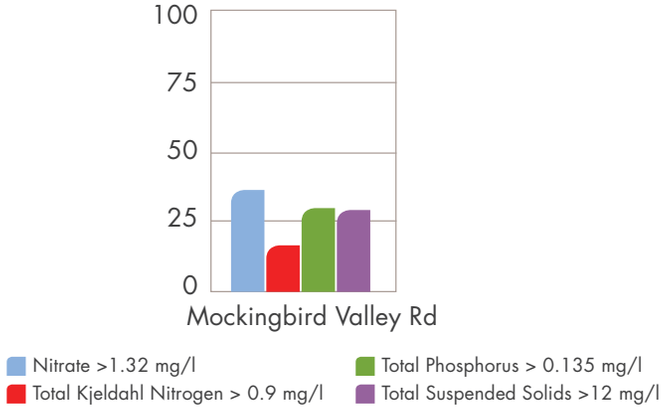
Dissolved oxygen conditions were "good" (criteria met more than 93.5 percent of the time) at the Muddy Fork sites over the last six years. Water temperature criteria at the Muddy Fork site were met 100 percent of the time over the last six years, except for occasional excursions in 2010 and 2012. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of these criteria.



Condition of Algal Communities in the Muddy Fork of Beargrass Creek Watershed



Percent of samples in the upper third of all LTMN samples




Muddy Fork of Beargrass Creek near Mockingbird Valley Road

3.4

Middle Fork of Beargrass Creek Watershed

The Middle Fork of Beargrass Creek is one of the three streams that join to form the larger Beargrass Creek watershed. The small streams that eventually form the Middle Fork of Beargrass Creek originate in Middletown and Douglass Hills, and flow west across Saint Matthews before joining the South Fork of Beargrass Creek near Irish Hill. The South Fork then joins with the Muddy Fork to become Beargrass Creek near the intersection of Interstates 71 and 64. Prominent features of this watershed include Cherokee Park, Seneca Park and Cave Hill Cemetery. A portion of this part of Louisville is currently served by combined sewers.

Watershed Assessment

The health of the aquatic communities at the three Middle Fork sites was variable over time and between sites. Since 1999, the fish communities showed significant improvement from "poor" to "good" at the furthest upstream Browns Lane site and from "poor" to "fair" at the mid-watershed Old Cannons Lane. Fish communities were consistently "poor" at the Lexington Road site. The aquatic insect communities at all three sites generally were classified as "poor" or "fair" and generally the same or declining. The stream habitat conditions were generally "good" at the three sites since 2005 and generally improving at the two upstream sites. The algal community at the upstream Browns Lane site was rated in "fair" condition in 2013, the Old Cannons Lane site was in "good" condition, and the downstream Lexington Road site was rated "excellent" in 2013. Browns Lane showed some decline in the condition of the algal community over time.

Some of the highest bacterial concentrations are found in the Beargrass Creek sites, especially in the lower parts of the watersheds. For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans for all three sites were above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variable but usually above the standard, with no apparent trend over time. For the three years of data of *E. coli* bacteria, most of the monthly geomeans at the sites were above the recreational standard of 130 colonies/100ml.

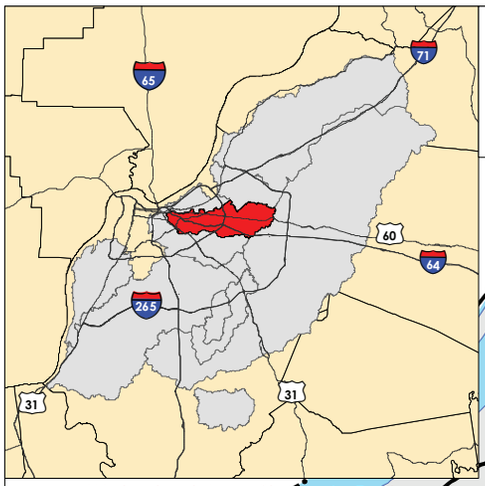
The Lexington Road site had the highest number of samples in the upper third for total Kjeldahl nitrogen, total suspended solids, and phosphorus, but lower nitrate numbers than all other Middle Fork sites. Total phosphorus, total Kjeldahl nitrogen, and total suspended solids all increased from upstream (Browns Lane) to downstream (Lexington Road), whereas, nitrate decreased from upstream to downstream. Nutrient and total suspended solids levels in these sites generally are average or in the lower grouping compared to other LTMN sites.

More recent wet weather event sampling data confirms the historical data that trace metals are not a large issue of concern in these LTMN streams.

Dissolved oxygen conditions were "good" and water temperature criteria were met 100 percent of the time at the Old Cannons Lane site, except for occasional excursions in 2010 and 2012. Dissolved oxygen conditions were "poor to fair" and water temperature criteria (no more than 31.7°C (89.1°F)) were met 97.2 percent of the time or more at the Lexington Road site, with occasional excursions most years. Periodic hot days and low stream flows can cause an exceedance of the dissolved oxygen or temperature criteria. The presence of the many parks, which provide natural areas to absorb runoff from developed areas as well as tree cover, probably help buffer this watershed to some degree from the otherwise significant urban influences (urban area above 70 percent).

Big Rock in Cherokee Park along the Middle Fork of Beargrass Creek after two inches of rain

MIDDLE FORK OF BEARGRASS CREEK WATERSHED WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

Ohio River

Beargrass Creek

Middle Fork of Beargrass Creek

South Fork of Beargrass Creek

JEFFERSON COUNTY

Middle Fork of Beargrass Cr at Lexington Rd
(24.8 square miles and 73 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	—	↓	—	—	↑	—	A	~

Middle Fork of Beargrass Creek at Browns Lane
(15.2 square miles and 73 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	↓	↑	ND	ND	A	~

Middle Fork of Beargrass Cr at Old Cannons Ln
(18.9 square miles and 76 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	—	↓	—	↑	—	—	A	~

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

RATINGS KEY

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

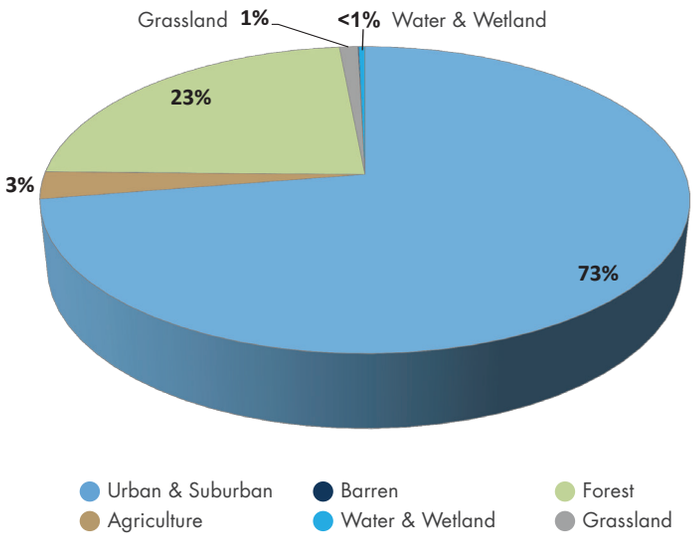
STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

Background and Land Use

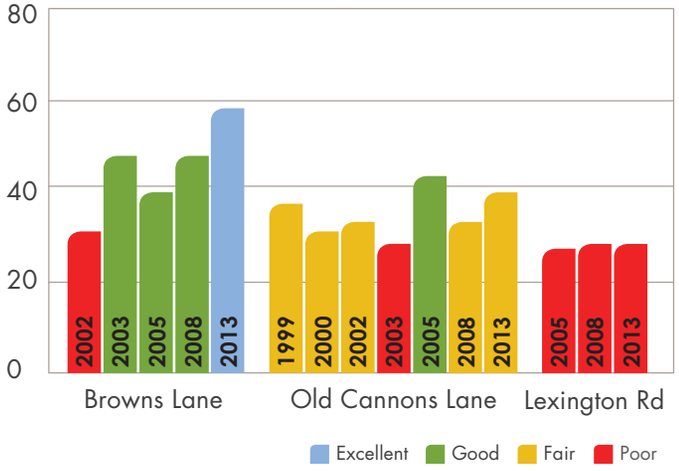
There are just over 25 square miles of land in the Middle Fork of Beargrass Creek Watershed. MSD monitors three stream sites in the watershed: at Old Cannons Lane, at Browns Lane and at Lexington Road. There are 15.2 square miles of land draining to the Browns Lane site; 18.9 square miles to the Old Cannons Lane site and 24.8 square miles to the Lexington Road site.

The land use associated with each monitoring site, like the entire watershed, is mostly developed for urban and suburban uses. Portions of the watershed classified as forest include Cherokee Park and Seneca Park. However, this area of Louisville is densely developed, and some of the areas classified as forested in the western part of the watershed are actually tree-covered developed areas. There is a small area of agricultural land in the middle part of the watershed. Impervious surfaces such as roads, rooftops and driveways cover about 23 percent of this watershed.

Land Use Upstream of Middle Fork of Beargrass Creek at Lexington Road



Condition of the Fish Communities in the Middle Fork of Beargrass Creek Watersheds



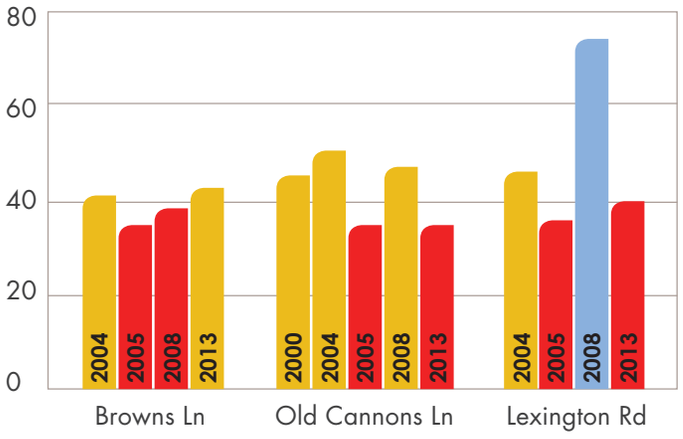
Monitoring Findings

MSD monitored the fish communities in the Middle Fork watershed since 1999. The fish communities at the Browns Lane site improved from "fair" in 2002 to "excellent" in 2013. Since 1999, fish communities at Old Cannons Lane were variable but generally "fair". The fish communities were "poor" at the most downstream Lexington Road site since 2005.

MSD monitored aquatic insect communities at the Old Cannons Lane site since 2000 and at the other three sites since 2004. The aquatic insect communities at the Browns Lane, Old Cannons Lane, and Lexington Road sites have been variably "poor" to "fair" except for an "excellent" in 2008 at Lexington Road.

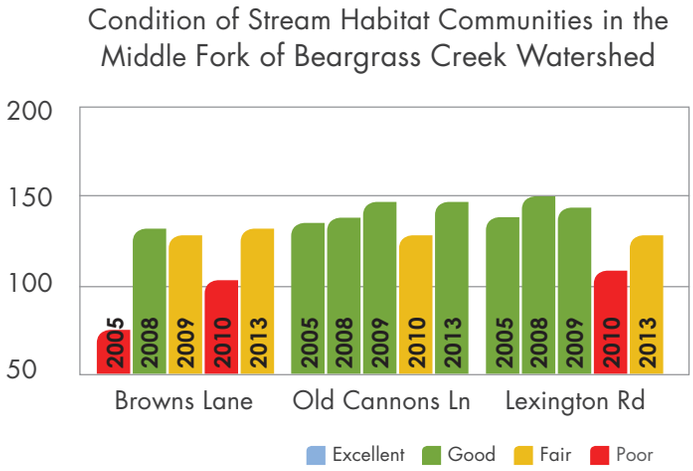
MSD has assessed stream habitat when fish and aquatic insects were sampled since 2005. The aquatic habitat at Browns Lane was "poor" in 2005 and variably improving to "fair" in 2013, generally "good" at Old Cannons Lane, and declining from "good" in 2005 to "fair" in 2013 at the Lexington Road site. Similar to many urban streams, the habitat assessment noted a lack of trees and other protective vegetation along stream banks, and unstable stream beds or stream banks.

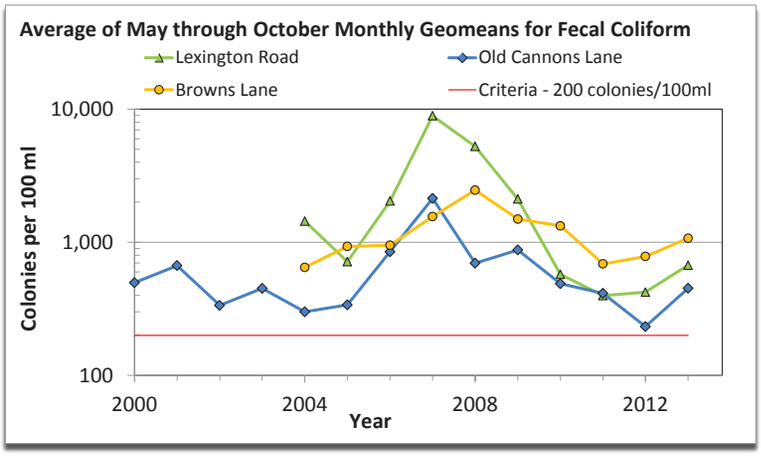
Condition of the Aquatic Insect Communities in the Middle Fork of Beargrass Creek Watersheds



Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E. coli* bacteria were collected similarly but only since 2011. The monthly geometric means (geomeans) of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record medians of the monthly geomeans for all three sites were above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variable but usually above the standard (not shown), with no apparent trend over the period of record. There was a tendency, however, for

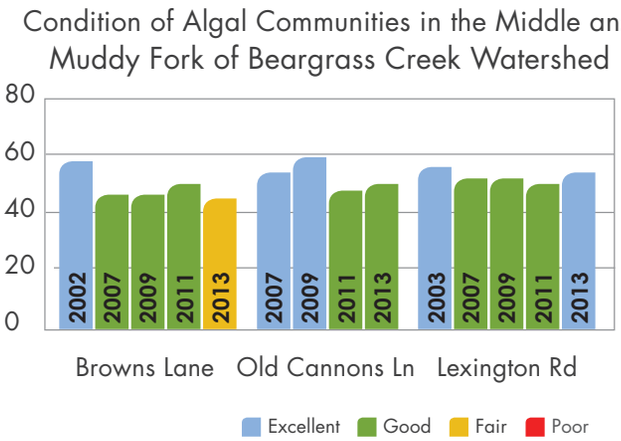




higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season. For the three years of data collection of *E. coli* bacteria (not shown), most all of the monthly geomeans at the sites were above the recreational standard of 130 colonies/100ml.

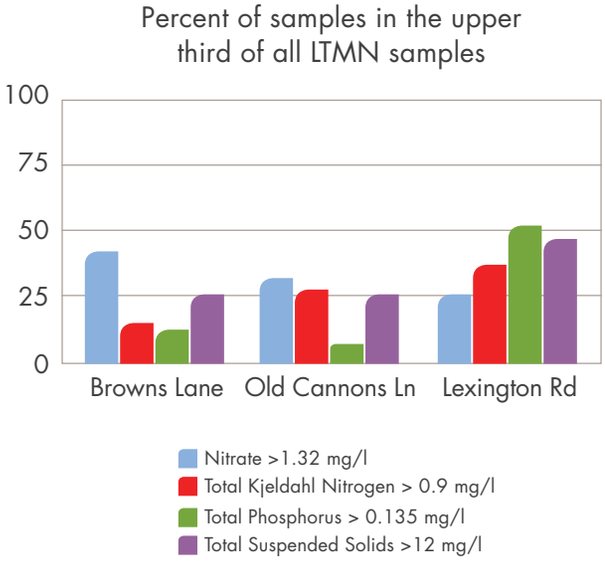
MSD has monitored benthic algal communities, largely diatoms, in the Middle Fork watershed since 2002. Using a Diatom Bioassessment Index (DBI), the upstream Browns Lane site was rated "excellent" in 2002 and then declined to "fair" condition in 2013. The Old Cannons Lane site was rated "excellent" in 2007 and 2009 but then declined to "good" condition in 2011 and 2013. The downstream Lexington Road site was rated "excellent" in 2003, declined to "good" condition in 2007 to 2011, and was "excellent" again in 2013. Two of the sites showed some decline in the condition of their algal communities over the period of study.

MSD monitored the concentrations of nutrients (nitrogen and phosphorus) in streams and total suspended solids periodically from 2000 to 2005 and on a quarterly basis since 2005 at the three sites in the Middle Fork of Beargrass Creek watershed. The percent of samples taken at these sites which fall into the upper third of all samples were calculated as a comparison to other streams in the watershed and throughout the area.



The Lexington Road site had the greatest number of total suspended solids, total Kjeldahl nitrogen, and total phosphorus samples in the upper third of all LTMN samples and the lowest number of nitrate samples compared to the other sites. The Browns Lane site had the highest number of nitrate samples in the upper third. Total phosphorus was significantly lower at both the Browns Lane and Old Cannons Lane sites than the downstream Lexington Road site. Nutrient and total suspended solids levels in these sites are average or in the lower grouping compared to other LTMN sites.

MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The ALCs were exceeded for cadmium in nine samples, copper in 11 samples, for lead in 11 samples, and zinc in two samples.



A student spends the afternoon at Big Rock in Cherokee Park along the Middle Fork of Beargrass Creek

MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature on the Middle Fork of Beargrass Creek at Old Cannons Lane (USGS gage 03293000) and at Lexington Road (USGS gage 03293500). Stream flow has been monitored at Old Cannons Lane since 1944 and at Lexington Road since 2003.

Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four parts per million (as an instantaneous standard) or five parts per million (as a mean daily standard) are what is deemed necessary. Water temperatures in excess of 31.7°C (89°F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

Dissolved oxygen conditions were "good" (criteria met more than 93.5 percent of the time) at the Old Cannons Lane site over the last six years. Occasional excursions of low dissolved oxygen likely were a result of very low stream flows on very warm days or some other transient factor. Dissolved oxygen conditions were "poor to fair" (72 to 87.7 percent) at Lexington Road, a site with significant combined sewer inflows upstream.

Water temperature criteria at the Old Cannons Lane site were met 100 percent of the time over the last six years, except for occasional excursions in 2012. Water temperature criteria at the Lexington Road site were met at least 97.2 percent of the time over the last six years, with occasional excursions most years. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of the criteria.

The Middle Fork of Beargrass Creek is one of the most diverse watersheds in Jefferson County. The upper areas are primarily suburban, with residential neighborhoods and large shopping centers. Combined sewers, carrying both stormwater and sanitary waste, serve the lower area. The watershed contains two significant public parks, Cherokee and Seneca, along with Cave Hill cemetery, the largest cemetery in the city.

Beargrass Creek

3.5

South Fork of Beargrass Creek Watershed

The South Fork of Beargrass Creek is one of the three streams that join to form the larger Beargrass Creek Watershed. The small streams that eventually form the South Fork of Beargrass Creek originate in Jeffersontown and Hurstbourne Acres. The South Fork of Beargrass Creek flows west across Buechel and Audubon Park before joining the Middle Fork of Beargrass Creek near Irish Hill. The South Fork then joins with the Muddy Fork to become Beargrass Creek near the intersection of Interstates 71 and 64. Streams in this watershed were straightened and several miles have been enclosed in concrete channels in the past to reduce flooding.


South Fork of Beargrass Creek near Eastern Parkway

Watershed Assessment

The health of the aquatic communities in the three South Fork sites was variable over time and between sites. The fish communities at the Trevilian Way and Brownsboro Road sites were rated "fair" in 2013 and were "very poor" at the Schiller Avenue Ramp. Only the Brownsboro Road site has shown improvement in the fish community over time. The aquatic insect communities at the three sites were "poor" in 2013 but improving some over time. Algal conditions at the upstream Trevilian Way site were "excellent" in 2013 and unchanged. Algal conditions at the Schiller Avenue Ramp site were "fair" in 2013 and generally declining. Algal community conditions at the Brownsboro Road site were rated "good" in 2013 but declining over time, perhaps a result of heavy tree cover.

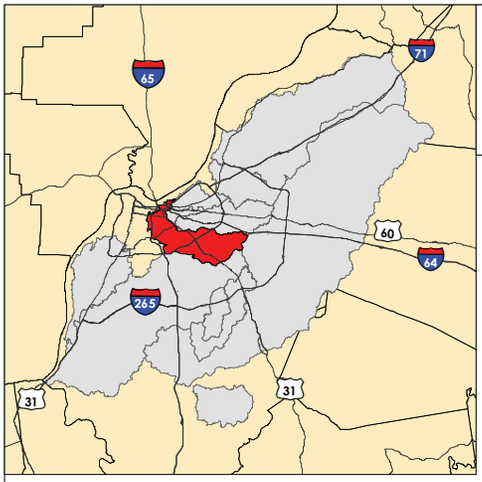
Stream habitat conditions were "poor" in 2013 for the two upstream sites and "good" at the Brownsboro Road site. Stream habitat at Trevilian Way and Schiller Avenue Ramp was affected by many of the issues that affect urban streams: altered stream channels, concrete lined or unstable banks, silt and sediment accumulation, and lack of shallow rocky riffles and slow deep pools. These habitat issues also affect the Brownsboro Road site, but less severely in that the stream bed there has a substantial rocky substrate, not concrete or sediment laden.

For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans for the three sites were above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variably above and below the standard, with no apparent trend over the period of record. For the three years of data collection of *E. coli* bacteria, most of the monthly geomeans at the three sites were above the recreational standard of 130 colonies/100ml. These and other Beargrass Creek watershed sites receive sewer overflows during rainfall events and have some of the highest bacterial concentrations in the LTMN.

Generally the number of nutrient and total suspended solids samples were average or relatively low at all sites in the South Fork watershed compared to other LTMN sites. The results indicate that both nitrate and total phosphorus increased from upstream to downstream in the South Fork. This could be due to sewer inflows, tributaries, or surface runoff from suburban and urban areas between these sites.

More recent wet weather event sampling data confirms the historical data findings that trace metals are not a large issue of concern in these LTMN streams. Despite having the largest portion of the exceedances observed in all LTMN sites (41 samples out of over 1,200 LTMN samples), exceedances were still relatively infrequent and not considered to be a large concern.

Dissolved oxygen conditions were "good" at the Trevilian Way and Schiller Avenue Ramp sites, but conditions were "poor to fair" at Brownsboro Road, a site with significant sewer inflows upstream. Water temperature criteria (no more than 31.7°C (89.1°F)) at all three sites were met 100 percent of the time most years over the last six years, except for occasional excursions in 2010 and 2012. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of both the dissolved oxygen and temperature criteria.



SOUTH FORK OF BEARGRASS CREEK WATERSHED WATER QUALITY STATUS AND TRENDS

CLARK COUNTY, INDIANA

JEFFERSON COUNTY

Ohio River

Beargrass Creek

Muddy Fork

Little Goose Creek

Goose Creek

Middle Fork Beargrass Creek

South Fork of Beargrass Creek

Fern Creek

South Fork Beargrass Creek at Brownsboro Rd
(51.5 square miles and 78 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↓	↑	↓	—	A	~

South Fork Beargrass Cr at Schiller Ave Ramp
(22.8 square miles and 81 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↓	↑	↓	—	—	—	A	~

South Fork Beargrass Creek at Trevilian Way
(17.2 square miles and 85 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	—	↑	—	↑	—	—	A	~

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

RATINGS KEY

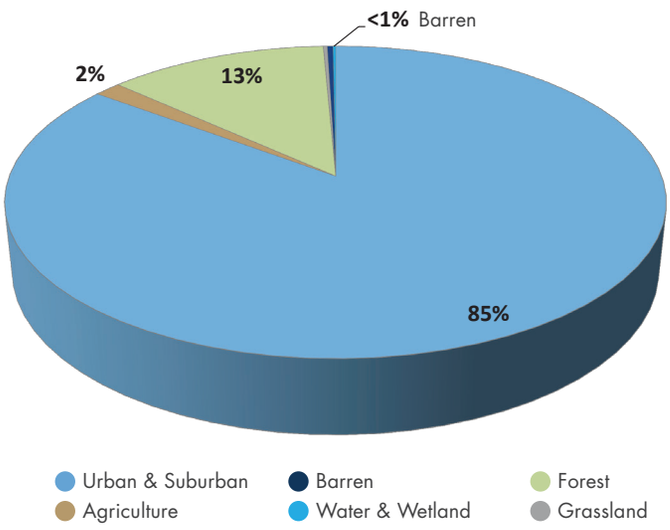
Background and Land Use

There are about 25 square miles of land in the entire South Fork of Beargrass Creek Watershed. MSD has been monitoring water quality in the South Fork of Beargrass Creek at the Trevilian Way site since 1999, at Schiller Avenue since 2000, and at Brownsboro Road since 2004.

In the upper part of the watershed, there are 17.2 square miles of land draining to the Trevilian Way site. At the lower end, 22.8 square miles of land are draining to the Schiller Avenue site and 51.5 square miles of land are draining to the Brownsboro Road site.

The land use associated with each monitoring site, like the entire watershed, is mostly developed for urban and suburban uses. Impervious areas, including roadways, rooftops and driveways cover 32 percent of the land draining to the Trevilian Way monitoring site. At the Brownsboro Road monitoring site, impervious surfaces cover 28 percent of the land area. A modest percentage of the land is forested and a very small amount of land is agricultural in the uppermost part of the watershed.

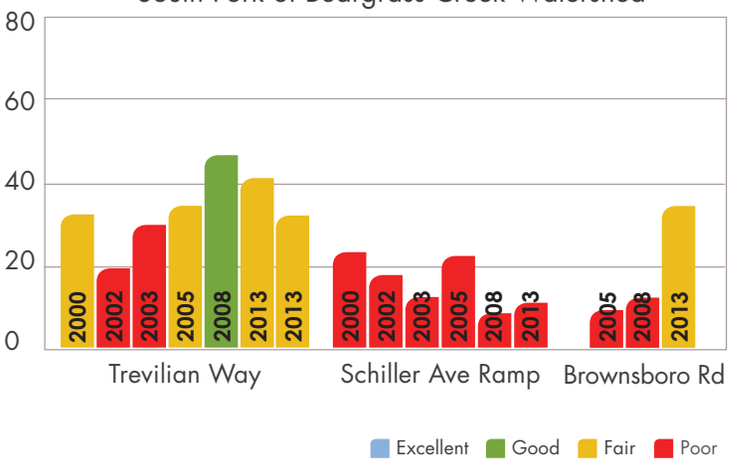
Land Use Upstream of South Fork of Beargrass Creek at Trevilian Way



Monitoring Findings

MSD has monitored fish communities in the South Fork of Beargrass Creek watershed since 1999. At Trevilian Way, the most upstream site, the fish communities variably were "poor to good" but have been "fair" since 2008. The Schiller Avenue Ramp site was "very poor" or "poor" throughout the sampling period, which is not surprising since the channel is concrete lined at that point. The Brownsboro Road site furthest downstream was sampled only since 2005 and was rated "very poor" until 2013, when the fish community improved to "fair".

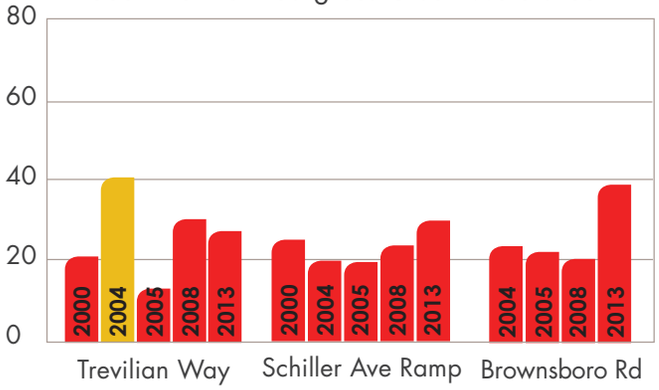
Condition of the Fish Communities in the South Fork of Beargrass Creek Watershed

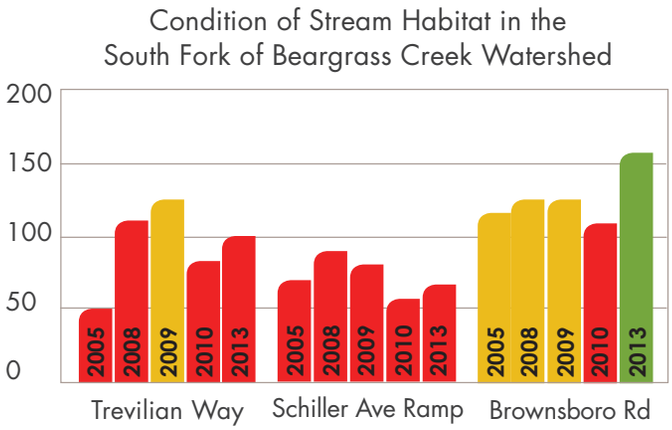


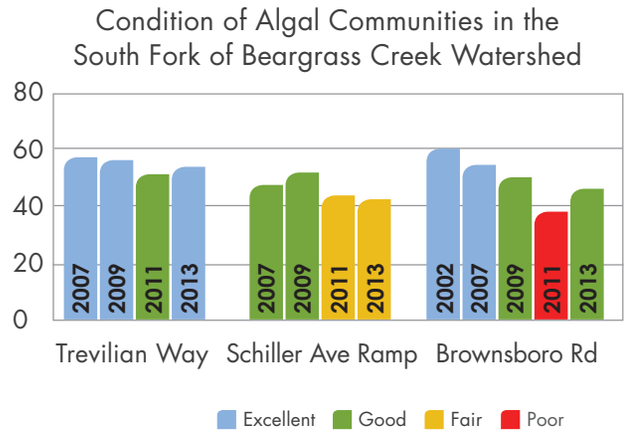
MSD monitored aquatic insect communities in the South Fork of Beargrass Creek watershed since 2000. The aquatic insect communities were found to be in "very poor" or "poor" condition throughout, except in 2004, when the Trevilian Way site was classified as "fair". The numerical indices at the three sites, however, actually show a slight improvement over time.

MSD has assessed stream habitat quality when fish and aquatic insects were sampled since 2005. Stream habitat conditions at the Trevilian Way and Schiller Avenue Ramp sites generally were "poor". At Trevilian Way, the stream has been channelized and has accumulations of silt and sediment, which cover habitat used by fish and aquatic insects. At the Schiller Avenue Ramp, the South Fork is a concrete lined channel lacking any likeness to a natural stream. In both of these sites, the stream lacks the variety of habitats typically found in good quality streams, including shallow rocky riffles and slow deep pools. These issues also affect the Brownsboro Road site, but stream habitat conditions at that site actually have improved from "poor" to "good" over time due to an abundance of tree cover and a cobble stream bed.

Condition of Aquatic Insect Communities in the South Fork of Beargrass Creek Watershed







MSD has monitored benthic algal communities, largely diatoms, at the downstream Brownsboro Road site since 2002. Using a Diatom Bioassessment Index (DBI), the site was rated "excellent" in 2002 and 2007 but declined to a "poor" condition in 2011 and back up to a "good" condition in 2013. Conditions at the Schiller Avenue Ramp site declined from a "good" condition in 2007 and 2009 to a "fair" condition in 2011 and 2013. Conditions of the algal communities at the upstream Trevilian Way site generally were "excellent".

Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E. coli* bacteria were monitored similarly but only since 2011. The monthly geometric means (geomeans) of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

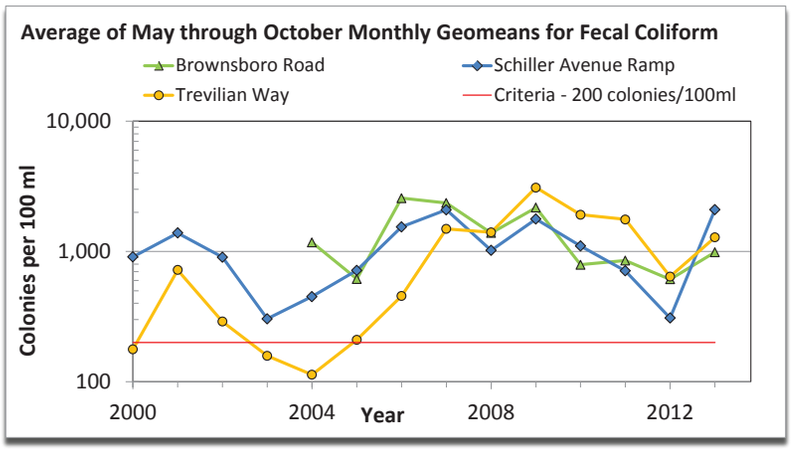
For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record medians (the middle values) of the monthly geomeans for all three sites were above the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the period of record.

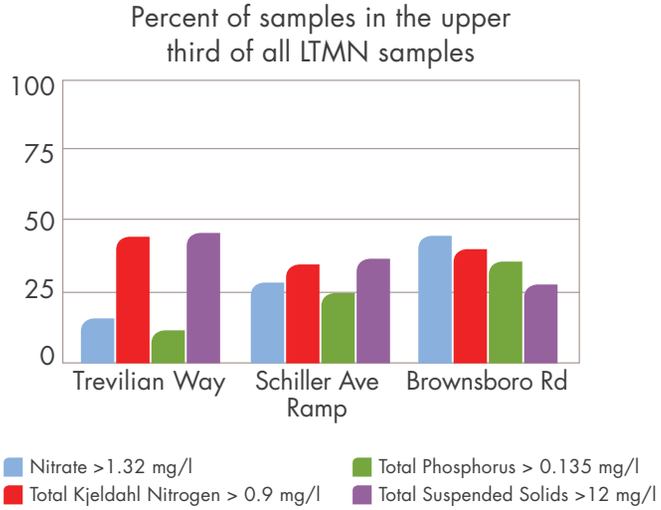
There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season.

For the three years of data collection of *E. coli* bacteria (not shown), most of the monthly geomeans at the three sites were above the recreational standard of 130 colonies/100ml.

MSD monitored the concentrations of nutrients (nitrogen and phosphorus) in streams and total suspended solids periodically from 2000 to 2005 and on a quarterly basis since 2005 at three sites in the South Fork of Beargrass Creek watershed. The percent of samples taken at these sites which fall into the upper third of all samples were calculated as a comparison to other streams in the watershed and throughout the area.

Generally all nutrient parameters were average or relatively low at all sites in the South Fork watershed compared to other Long Term Monitoring Network (LTMN) sites. The site on South Fork at Trevilian had the greatest number of total suspended solids and total Kjeldahl nitrogen samples in the upper third of all samples, but had relatively low nitrate and total phosphorus values. The site at Brownsboro Road had higher nitrate and total phosphorus than the other two sites in the watershed.





MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The acute ALC for total concentrations were exceeded for cadmium in 11 samples, for copper in 20 samples, for lead in nine samples, and for zinc in one sample.

MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature at two sites in the South Fork of Beargrass Creek watershed. Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four parts per million (as an instantaneous standard) or five parts per million (as a mean daily standard) are what is deemed necessary. Water temperatures in excess of 31.7 °C (89.1 °F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

Dissolved oxygen conditions were "good" (criteria met more than 90 percent of the time) at the Trevilian and Schiller Avenue Ramp sites for the last six years. Occasional excursions of low dissolved oxygen likely were a result of very low stream flows on very warm days or some other transient factor. Dissolved oxygen conditions were "poor to fair" (72 to 87.7 percent) at the Brownsboro Road site.

Water temperature criteria at all three sites were met 100 percent of the time most years over the last six years, except for occasional excursions in 2010 and 2012. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of the criteria.

MSD plans to construct a wet weather storage basin near Logan and Breckinridge Streets in 2015.

US GEOLOGICAL SURVEY - GAGING STATIONS

USGS GAGE NUMBER	STREAM NAME AND LOCATION OF FLOW GAGE	YEAR STARTED
03292500	South Fork of Beargrass Creek at Trevilian Way	1939
03292550	South Fork of Beargrass Creek at Winter Avenue	1998

A group of students paddles by MSD's Beargrass Creek Flood Pumping Station on a tour of the stream.

Beargrass Creek

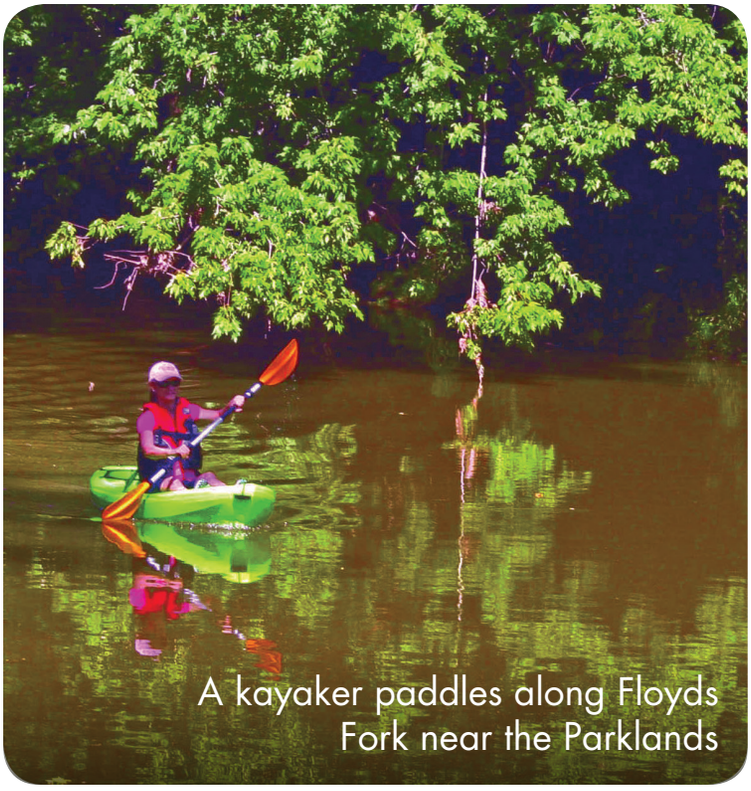
3.6

Floyds Fork Watershed

The small streams that form Floyds Fork originate in Oldham, Shelby, and Henry Counties. Floyds Fork flows south through Oldham, eastern Jefferson, and northern Bullitt Counties where it drains into the Salt River near Shepherdsville.

Watershed Assessment

Conditions of the fish communities in 2013 at the five sites in the Floyds Fork watershed ranged from "fair" at the two Chenoweth Run sites to "good" at the Ash Avenue site to "excellent" at the two downstream Floyds Fork sites. All sites showed significant improvement over time. The aquatic insect communities at all five sites were "fair" in 2013. Only Chenoweth Run at Ruckriegel Parkway and Floyds Fork at Ash Avenue have shown improvement in the insect communities over time. Conditions of the algal communities were "fair" at the Bardstown Road and Gellhaus Lane sites and "good" at the other three sites in 2013. Conditions of the algal communities have been improving since 2011 at all but Bardstown Road. Stream habitat conditions generally were "good" at all three Floyds Fork sites and at the Gellhaus Lane site. Chenoweth Run at Ruckriegel Parkway had a "fair" rating in 2013, but habitat appears to be improving at both Chenoweth Run sites.



A kayaker paddles along Floyds Fork near the Parklands

For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans at all three Floyds Fork sites and the Chenoweth Run at Gellhaus Lane site were below the recreational standard of 200 colonies/100ml, while the value was above the standard for the Ruckriegel Parkway site. Individual monthly geomeans were variably above and below the standard, with no apparent trend. For three years of data on *E. coli* bacteria, most of the monthly geomeans at the 5 sites were above the recreational standard of 130 colonies/100ml.

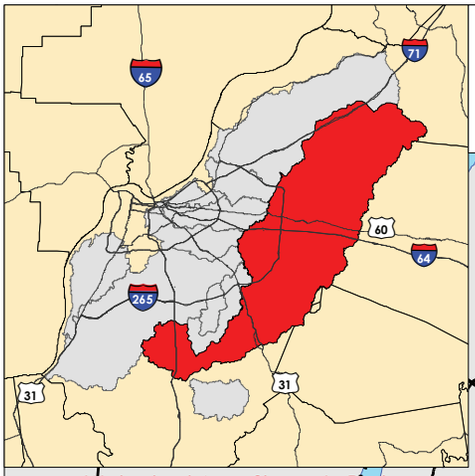
The five sites had some of the highest percentages of nutrient measurements in the top third of all 27 LTMN samples. Total suspended solids were not much of an issue in Chenoweth Run but were higher at all three sites on Floyds Fork. Nitrate and total Kjeldahl nitrogen were highest in the Chenoweth Run at Gellhaus Lane site.

Removal of the Jeffersontown Water Quality Treatment Center effluent to Chenoweth Run in late 2015 should lead to much improved nutrient conditions, but as flows also will be reduced, only time will tell how the aquatic communities will respond. Continued water quality monitoring to document the changes is all that more important in this watershed.

The acute Aquatic Life Criteria was exceeded for cadmium in one sample at Gellhaus Lane and for copper in two samples (at Ruckriegel Parkway and at Old Taylorsville Road). The criteria for lead and zinc were not exceeded in any samples. More recent wet weather event sampling data confirms the historical data suggesting that trace metals are not an issue of concern in these LTMN streams.

Dissolved oxygen conditions were in the "good" range in both Chenoweth Run sites and the two downstream Floyds Fork sites, but conditions in the Ash Avenue site were in the "fair" range for two of the three years of record. It is not clear if the low dissolved oxygen readings were a result of very low stream flows or some other factor like fouling of the probe. Water temperature criteria (no more than 31.7°C (89.1°F)) were met 100 percent of the time at the Ruckriegel site and at least 97 percent of the time at the other four sites. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of the water temperature or dissolved oxygen criteria.

FLOYDS FORK WATERSHED
WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

CLARK COUNTY, INDIANA

Ohio River

OLDHAM COUNTY

HENRY COUNTY

SHELBY COUNTY

JEFFERSON COUNTY

SPENCER COUNTY

BULLITT COUNTY

NELSON COUNTY

Chenoweth Run

Floyds Fork

Salt River

42 71 265 60 264 31 64 65 44

Floyds Fork at Ash Avenue
(80 square miles and 9 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	—	—	—	—	A	~

Chenoweth Run at Ruckriegel Parkway
(5.47 square miles and 75 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↓	↑	↑	—	A	~

Floyds Fork at Old Taylorsville Road
(138 square miles and 13 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	—	—	—	—	B	~

Chenoweth Run at Gellhaus Lane
(11.6 square miles and 52 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	↓	↑	—	—	A	~

Floyds Fork at Bardstown Road
(213 square miles and 14 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↓	—	—	—	A	~

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

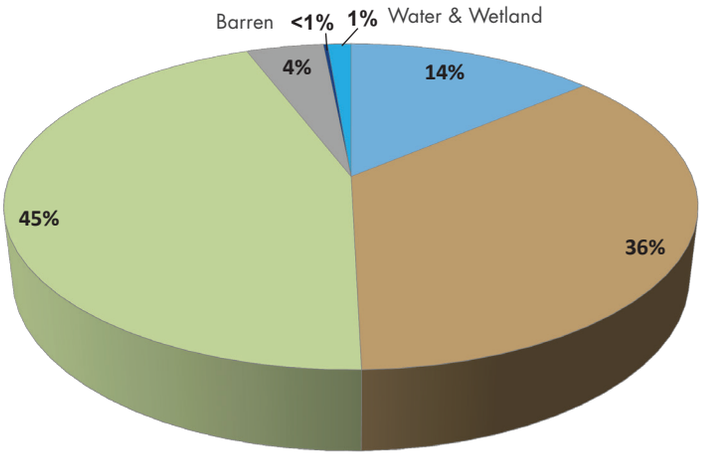
RATINGS KEY

Background and Land Use

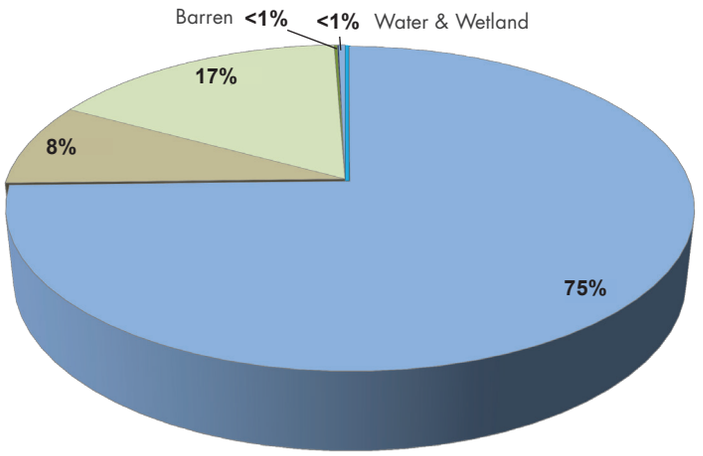
The Floyds Fork Water Quality Treatment Center was constructed by MSD to eliminate less efficient small package plants and septic systems from the most populated areas of the watershed. The Jeffersontown Wastewater Treatment Plant currently discharges treated effluent into Chenoweth Run, but the piping system to redirect these discharges to the Cedar Creek Wastewater Treatment Plant currently is under construction. A premier park system, The Parklands of Floyds Fork, is being developed along Floyds Fork (website at: *http://www.theparklands.org/*). Extensive tracts of land have been preserved and the system of five parks is providing a variety of opportunities for recreation and enjoyment of the stream and natural areas.

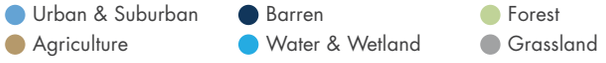
Currently, MSD monitors water quality and streamflow at five stream sites in the Floyds Fork watershed -- three sites on Floyds Fork and two on Chenoweth Run, a tributary that enters Floyds Fork from the west and upstream of the Bardstown Road site. There are 80, 138, and 213 square miles of land draining to Floyds Fork at the Ash Avenue, Old Taylorsville Road, and Bardstown Road sites, respectively. The land use for the three sites on Floyds Fork is mostly forest and agricultural. There also is a modest amount of land developed and developing for urban and suburban uses, mostly in the portions of the watersheds nearer to Louisville. Impervious area, including roadways, rooftops and driveways, is less than 4 percent in Floyds Fork. There are 5.5 and 11.6 square miles of land draining to Chenoweth Run at the Ruckriegel Parkway and Gellhaus Lane sites, respectively. Chenoweth Run drains land in Jeffersontown that is mostly urban and suburban. In contrast to Floyds Fork, the area draining to Chenoweth Run at Ruckriegel Parkway is over 33 percent impervious (75 percent urban and suburban), and the area draining to Gellhaus Lane is 21 percent impervious.

Land Use Upstream of Floyds Fork at Bardstown Road

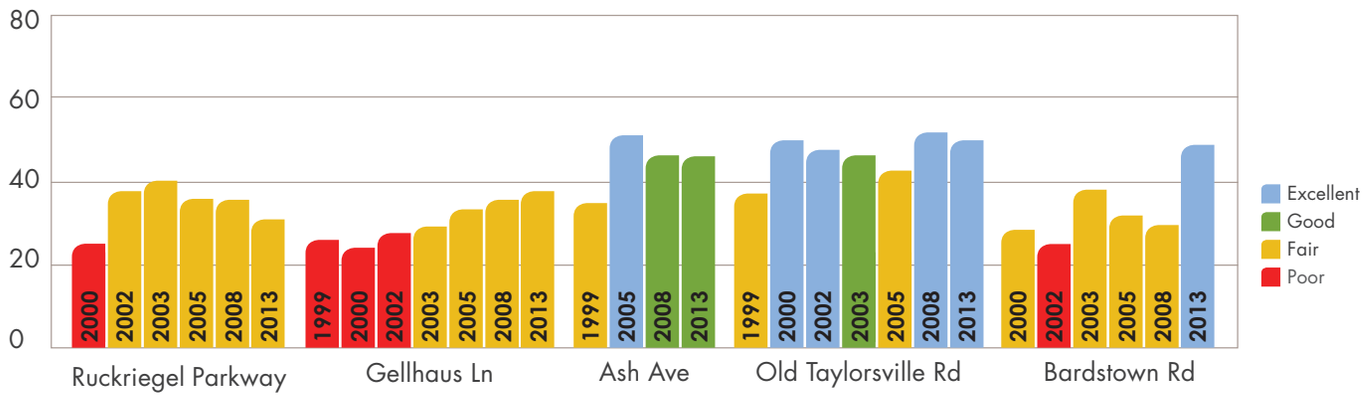


Land Use Upstream of Chenoweth Run at Ruckriegel Parkway





Condition of the Fish Communities in the Floyds Fork Watershed



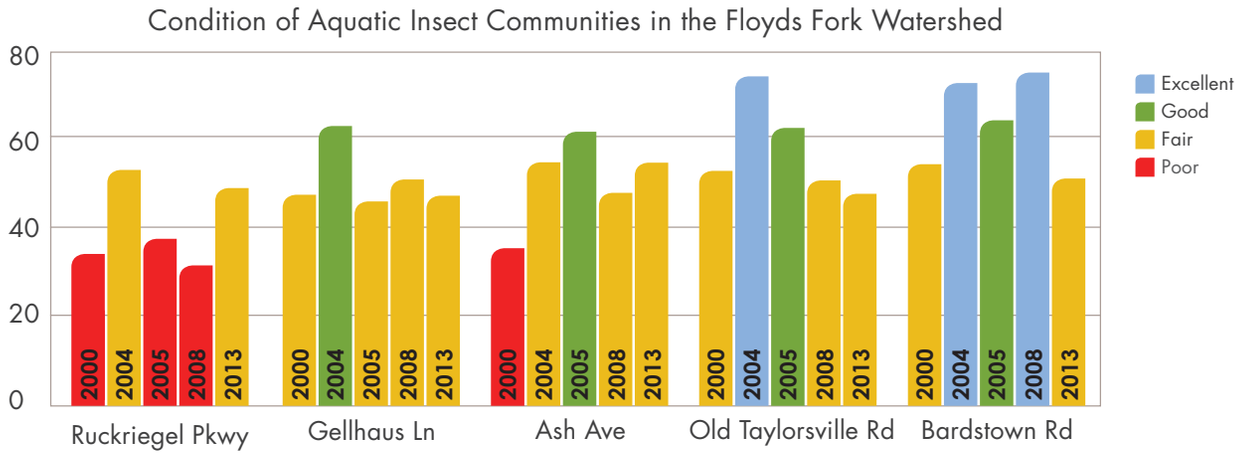
Monitoring Findings

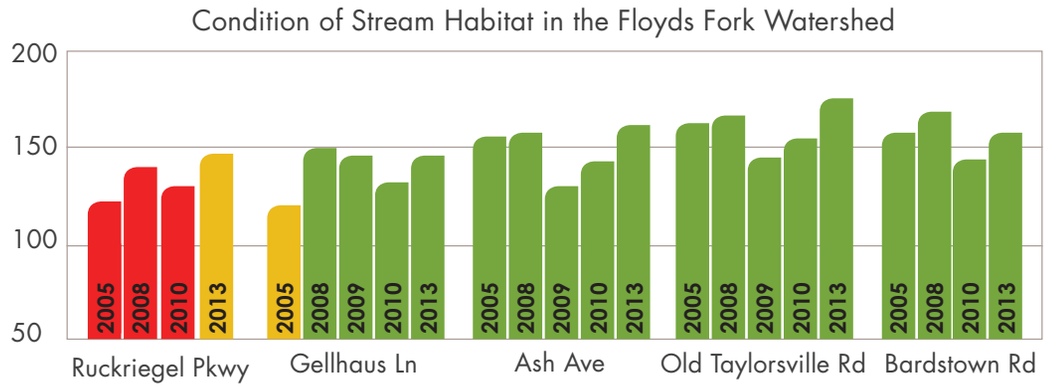
MSD has monitored the fish communities in the Floyds Fork watershed since 1999.The fish communities in Chenoweth Run at the Ruckriegel Parkway site are generally in "fair" condition, but the numerical indices have declined some since 2003. The Gellhaus Lane site has steadily improved from "poor" in 1999 to "fair" in 2013.

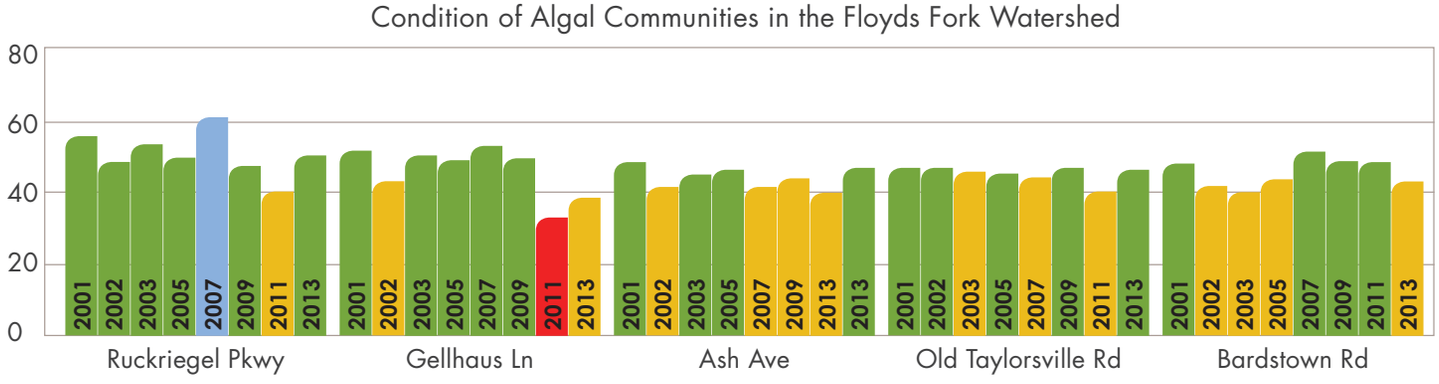
The Ash Avenue site has improved from "fair" in 1999 to "excellent" and "good" since 2005. The Old Taylorsville Road site has improved from "fair" in 1999 to "excellent" in 2008 and 2013. The Bardstown Road site has improved from "fair" in 2000 to "excellent" in 2013.

MSD has monitored aquatic insect communities at five sites in the Floyds Fork watershed since 2000. All sites were classified as "poor" or "fair" in 2000 and all are "fair" in 2013. At Ash Avenue, the aquatic insect communities had improved to "good" in 2005. At Old Taylorsville Road, the aquatic insect communities had improved to "excellent" in 2004. At Bardstown Road, the aquatic insect communities improved to "excellent" in 2004 and 2008. The aquatic insect communities at all 3 Floyds Fork sites have declined to "fair" in 2013.

The aquatic insect communities at Gellhaus Lane were "fair" and improved to "good" in 2008 but declined to "fair" since. Aquatic insect communities in Chenoweth Run at Ruckriegel Parkway had a "poor" rating and improved to "fair" in 2004 and 2013.







MSD assessed stream habitat in Floyds Fork since 2000. At the three Floyds Fork sites, stream habitat was "good" over that period. In Chenoweth Run at Gellhaus Lane, habitat also was generally "good". In Chenoweth Run at Ruckriegel Parkway, habitat was classified as "poor" in 2005 to 2010 but improved to "fair" in 2013. Sediment deposition, unstable banks and a general lack of trees and other protective bank vegetation were identified at Ruckriegel Parkway as limitations of habitat quality.

MSD has monitored benthic algal communities, largely diatoms, at five sites in the Floyds Fork watershed since 2001. All sites, classified using a Diatom Bioassessment Index (DBI), were rated "good" that year and all are "fair" or "good" in 2013.

The Chenoweth Run at Ruckriegel Parkway site had an "excellent" rating in 2007 and a "fair" rating in 2011, otherwise it has had "good" ratings. Early on conditions at Gellhaus Lane were generally "good" except in 2002 and then declined to "poor" and "fair" in 2011 and 2013, respectively. All three Floyds Fork sites have been variably "good" to "fair" since 2001.

MSD and USGS continuously monitor dissolved oxygen, water temperature, and streamflow at all 5 stream sites in the watershed. Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than five parts per million are what is deemed necessary. Water temperatures in excess of 31.7°C (89.1°F) also stress the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen.

More than half of the daily data was available for 2004 through 2006 at Ash Avenue, for all years between 2002 and 2008 at Old Taylorsville Road, and for 2003, 2007 and 2008 at Bardstown Road, indicating good and improving data quality. The percent of days when the average amount of dissolved oxygen in the water was above five parts per million increased from "poor" in 2004 to "fair" in 2005 and 2006 at Ash Avenue. Downstream at Old Taylorsville Road, the percent of days when dissolved oxygen conditions were above five parts per million improved steadily from "fair" to "good" between 2002 and 2008, but did not meet the 10% criteria to merit an improving trend. The percent of days when the average amount of dissolved oxygen in water was above five parts per million was consistently "good" for 2003, 2007 and 2008 in Floyds Fork at Bardstown Road.

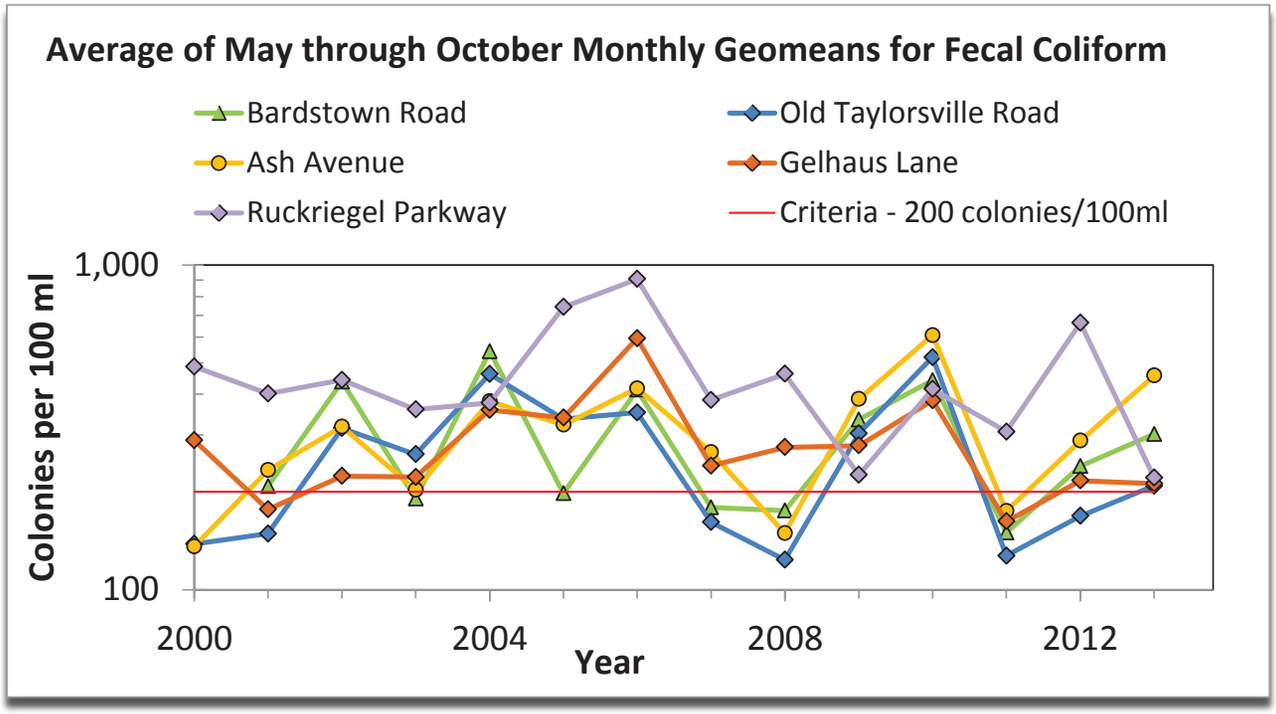
The Parklands at Floyds Fork has several spots for recreational activities like canoeing, kayaking and bike trails near the stream

In Chenoweth Run at Ruckriegel Parkway, more than half of the daily data was available for all years between 2002 and 2008, except 2003 and 2004. At Gellhaus Lane, more than half of the daily data was available between 2003 and 2008, except 2004 and 2006, indicating good data quality. At Ruckriegel Parkway, the percent of days when the average amount of dissolved oxygen in the water was above five parts per million declined from "good" in 2002 to "poor" in 2005, but improved to "good" by 2008. At Gellhaus Lane, the percent of days when dissolved oxygen conditions were above five parts per million was consistently "good" between 2003 and 2008.

MSD and the USGS monitor flow at all five sites in the Floyds Fork watershed. In September 2005, stream flows were below normal at the three sites on Floyds Fork when fish and aquatic insect samples were collected. In August 2005, stream flows in Floyds Fork were average. In Chenoweth Run, stream flows were average in September 2005, when fish and aquatic insect samples were collected. In August, stream flows in Chenoweth Run also were above average. In 2008, conditions throughout the watershed were drier, with below normal stream flows for two to three months prior to the sampling event in October throughout the watershed. In general, low stream flows can cause stress on fish and aquatic insects.

From 2000 to 2013, MSD monitored fecal coliform bacteria three to five times a month during the recreational season (April-October) at all five sites in the Floyds Fork watershed. E *coli* bacteria, a method more specific to bacteria that live in the guts of warm-blooded animals, were collected similarly only since 2011. The monthly geomeans of bacteria concentrations in stream waters were calculated for both bacterial types and compared to the recreational contact standard for each.

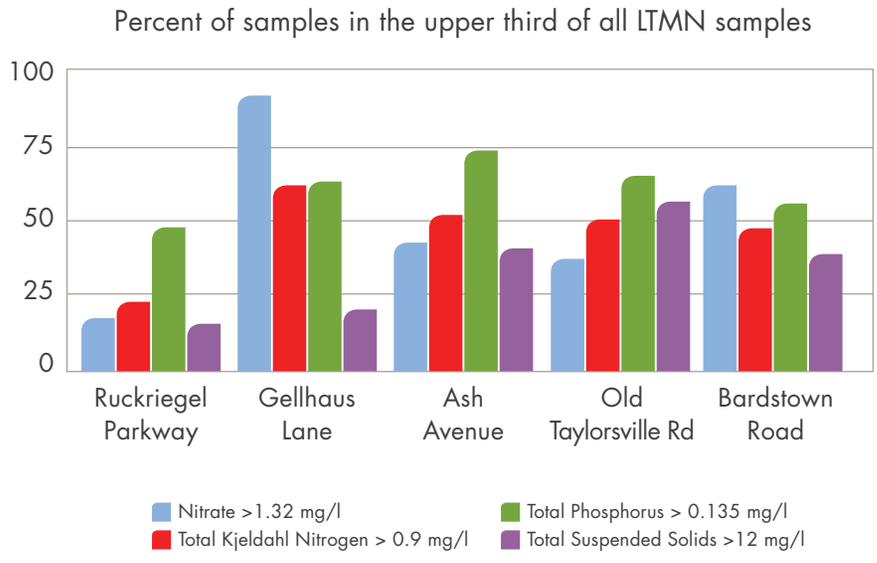
For the 14 years of data collection on fecal coliform bacteria (2000-2013), the medians of the monthly geomeans at all three of the Floyds Fork sites and the Chenoweth Run at Gellhaus Lane site were below the recreational standard of 200 colonies/100ml, whereas, the 14 year median for Chenoweth Run at Ruckreigel Parkway was above the standard. For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the 14 year period. There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season. For the three years of data collection of E *coli* bacteria (not shown), most all of the monthly geomeans for E *coli* at the 5 sites were above the recreational standard of 130 colonies/100ml.



MSD monitored the concentrations of nutrients (nitrogen and phosphorus) and total suspended solids in streams periodically from 2000 to 2005 and, more consistently on a quarterly basis since 2005 at all five sites in the Floyds Fork watershed. The breakpoint concentration between the upper third and lower two thirds of all samples at all 27 MSD sites collected since 2005 were calculated for each of these constituents. The percent of samples above these breakpoints (shown next to the constituent on the graph) for each of the five sites is indicative of how they relate to other streams in the Metro area.

Components of total nitrogen (nitrate and total Kjeldahl nitrogen) were highest at the Chenoweth Run at Gellhaus Lane site. Total phosphorus was highest at the Floyds Fork at the Ash Avenue site. Total suspended solids were not much of an issue in Chenoweth Run and were highest in the Old Taylorsville Road site on Floyds Fork.

MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005 at all five sites in the Floyds Fork watershed. About 200 samples were collected for trace elements at the five sites. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The acute ALC for total concentrations of lead and zinc were not exceeded in any samples at any of the five sites. Criteria were exceeded for cadmium in one sample and for copper in two samples.



USGS MONITORS FLOW AT FIVE SITES IN THE FLOYDS FORK WATERSHED		
USGS GAGE NUMBER	**STREAM NAME AND LOCATION OF FLOW GAGE**	**YEAR STARTED**
03297900	Floyds Fork at Ash Avenue	1991
03298000	Floyds Fork at Old Taylorsville Road	1944
03298200	Floyds Fork at Bardstown Road	2001
03298135	Chenoweth Run at Ruckriegel Parkway	1999
03298150	Chenoweth Run at Gellhaus Lane	1996

Floyds Fork

MSD will eliminate the Jeffersontown Water Quality Treatment Center in 2015.

Chenoweth Run near Ruckriegel Parkway

3.7

Cedar Creeks/Pennsylvania Run Watersheds

The small streams that eventually form Cedar Creek in Jefferson County originate in the Fern Creek area and flow south. Cedar Creek empties into Floyds Fork in Bullitt County east of Shepherdsville. The Cedar Creek Wastewater Treatment Center discharges treated wastewater into Cedar Creek. This facility was constructed in 1995 and was expanded to have the capacity to treat 7.5 million gallons per day of wastewater in 2003. The small streams that eventually form the other Cedar Creek in Bullitt County originate in the Cedar Grove area. It flows north and empties into the Salt River east of Shepherdsville. Pennsylvania Run originates in the Highview area and flows south through the 46 acre McNeely Lake and empties into Cedar Creek east of Zoneton.

Watershed Assessment

The health of the aquatic communities in the three watersheds was variable over time and between sites. The fish, insect, and algal communities and stream habitat at Cedar Creek in Bullitt County, one of the least urban watersheds in the LTMN, were all in "good to excellent" health in 2013 and generally improving over time. The Thixton Lane and Pennsylvania Run sites are 37 and 39 percent urban, respectively, mid-range for LTMN sites. The fish and insect communities and stream habitat in Pennsylvania Run were in "fair" condition in 2013 and the algal community was in "good" status in 2013, but all three communities and aquatic insects generally were improving over time. The fish communities and stream habitat in Thixton Lane site were in "good" condition in 2013 and the insect and algal communities were in "poor" and "fair" status, respectively, but generally staying the same over time.

Stream reaches at the two Cedar Creek sites have stable banks, and the stream beds were only slightly degraded by some silt and sediment deposition. At the Pennsylvania Run site, the stream banks have some stability problems and the stream lacks shallow, rocky riffles. None of the three stream channels appear to have been straightened or otherwise altered.

For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans for both Cedar Creek sites were below the recreational standard of 200 colonies/100ml, whereas, the period of record median for Pennsylvania Run was above the standard. Individual monthly geomeans were variably above and below the standard, with no apparent trend over the period of record. For the 3 years of data of *E coli* bacteria, most of the monthly geomeans at the three sites were above the recreational standard of 130 colonies/100ml.

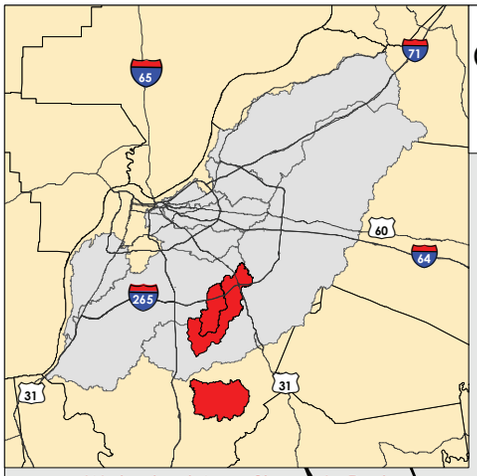
It is unclear why the Pennsylvania Run site had so many more samples in the upper third for total phosphorus (89 percent, one of the highest of LTMN sites) compared to the neighboring Thixton Lane site (8 percent) with similar land use. Both total phosphorus and total suspended solids were of little concern at the Thixton Lane site even though this site receives treated wastewater. Both sites had high percentages of samples in the upper third for nitrate and total Kjeldahl nitrogen; in fact, the Thixton Lane is the highest of LTMN sites for nitrate.

The Cedar Creek site in Bullitt County had relatively low numbers of samples in the upper third for all nutrients and total suspended solids. Compared to other LTMN sites, the Bullitt County watershed has a higher percentage of forested land and very little urban and suburban land use. For these particular parameters, the forest character provides a buffer for surface runoff and fewer sources for excess nutrients to enter the stream.

More recent wet weather event sampling data confirms the historical data that trace metals are not a large issue of concern in the LTMN streams.

Dissolved oxygen conditions at the Thixton Lane and Bullitt County sites reflect 'good' conditions for the last six years, whereas, conditions at the Pennsylvania Run site reflect "poor to good" conditions and "fair" more recently. Water temperature criteria (no more than 31.7°C (89.1°F)) were met 100 percent of the time at the two Cedar Creek sites, with excursions above the criteria at the Bullitt County site only in 2007 and 2012. Periodic hot days and low stream flows occasionally cause exceedances of both criteria; more frequent exceedances of dissolved oxygen at the Pennsylvania Run site likely also reflect some other transient factor(s).

CEDAR CREEKS AND PENNSYLVANIA RUN WATERSHEDS WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

JEFFERSON COUNTY

BULLITT COUNTY

SPENCER COUNTY

NELSON COUNTY

Mc Neely Lake

Pennsylvania Run

Cedar Creek

Floyds Fork

Salt River

RIDGE RD

CEDAR GROVE RD

Cedar Creek at Thixton Lane
(6.4 square miles and 37 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	—	—	↑	—	—	B	~

Pennsylvania Run at Mount Washington Road
(11.1 square miles and 39 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↑	↑	↓	—	A	~

Cedar Creek at State Road 1442
(12.1 square miles and 6 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↑	—	—	—	B	~

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

RATINGS KEY

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

Background and Land Use

There are 11.1 and 6.4 square miles of land draining to the Cedar Creek at Thixton Road and Pennsylvania Run sites, respectively. The land includes urban, agriculture and forested areas. Small areas are classified as grassland. About 10 and 9 percent, respectively, of these watersheds is covered by impervious surfaces such as roads, rooftops and driveways.

The small streams that eventually form the other Cedar Creek originate in the Cedar Grove area of Bullitt County. Cedar Creek flows north and empties into the Salt River east of Shepherdsville. This site is located outside of the urban influences of Louisville and provides a basis for comparison of water quality conditions in a less urbanized watershed to the more urbanized sites in the Louisville Metro area.

There are 12.1 square miles of land draining to the Cedar Creek in Bullitt County site. This land is mostly forested, with significant amounts of agriculture and grasslands. A relatively small percentage of the land has been developed for urban and suburban uses. Impervious area covers only 0.2 percent of this watershed.

MSD has been monitoring water quality and stream flow in Cedar Creek at Thixton Road and Pennsylvania Run sites since 1999 and at Cedar Creek at State Highway 1442 (Bullitt County) since 2002.

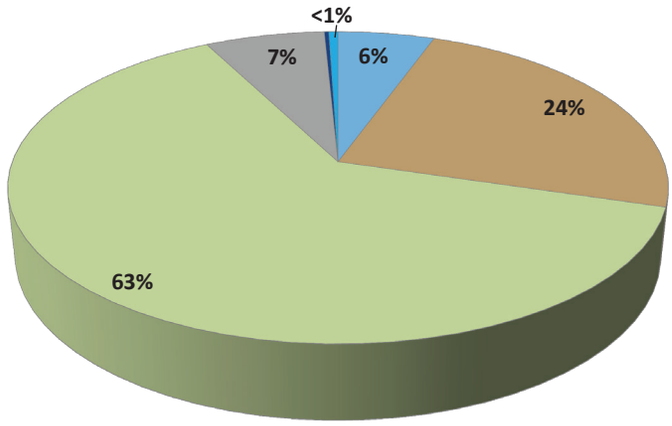
Monitoring Findings

MSD monitored fish communities at the Thixton Lane and Pennsylvania Run at Mount Washington Road sites since 1999 and at the State Road 1442 site in Bullitt County since 2002. Fish community results were variably "fair/poor" to "excellent" at the Thixton Lane and Pennsylvania Run sites and were "good" and "fair" in 2013, respectively. The fish communities in State Road 1442 were classified as "good" to "excellent" and appear to have steadily improved since 2002.

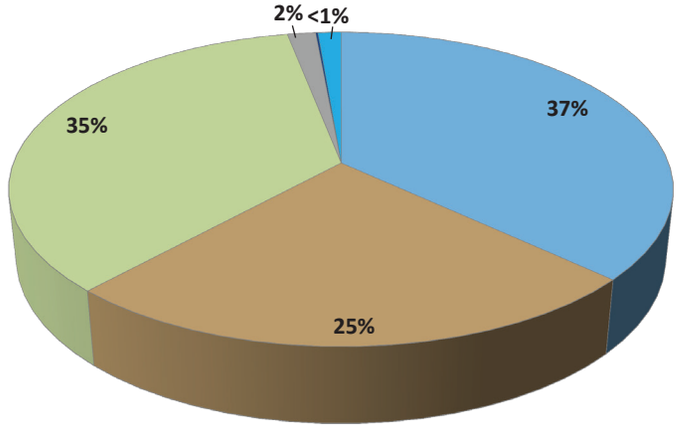
MSD has monitored aquatic insect communities at the Thixton Lane and Pennsylvania Run at Mount Washington Road sites since 2000. The aquatic insect communities have been variably "fair" to "poor", and currently are in "poor" and "fair" condition, respectively. The aquatic insect communities in Cedar Creek at State Road 1442 were classified as "fair" in 2004 and improved to "good" currently.

MSD has assessed stream habitat since 2005 at all three sites when fish and aquatic insects were sampled. Except for 2008, habitat quality at the two Cedar Creek sites generally were "good", meaning that both streams provide good habitat for fish and aquatic insect communities. These streams have stable banks and the stream beds were only slightly degraded by some silt and sediment deposition. The stream channels do not appear to have been straightened or otherwise altered.

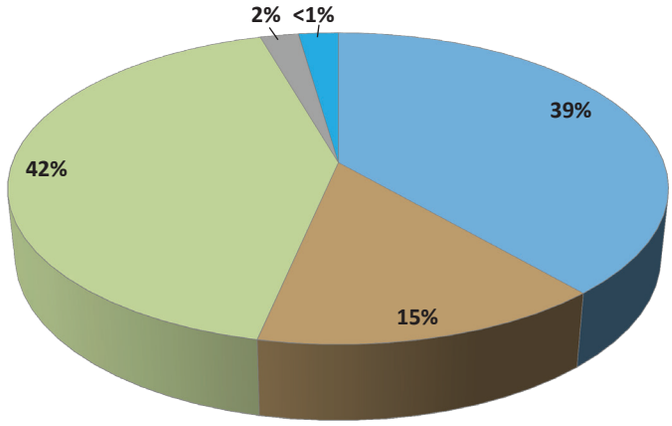
Land Use Upstream of Cedar Creek at State Highway 1442 (Bullitt County)

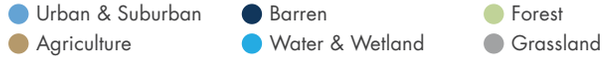


Land Use Upstream of Cedar Creek at Thixton Lane

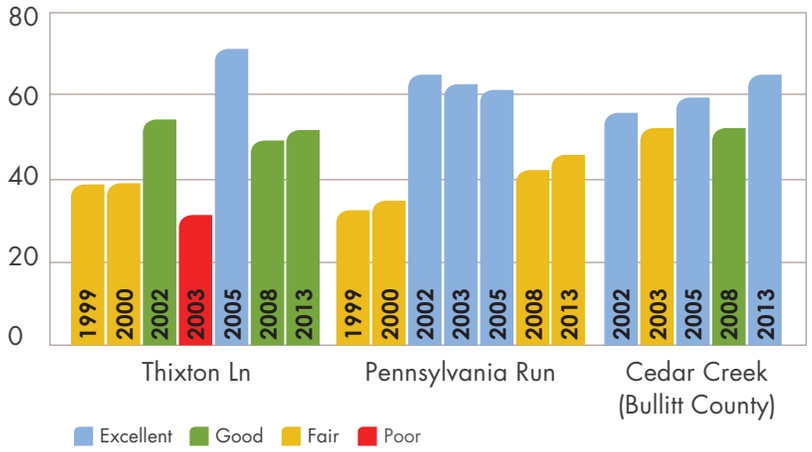


Land Use Upstream of Pennsylvania Run at Mount Washington Road

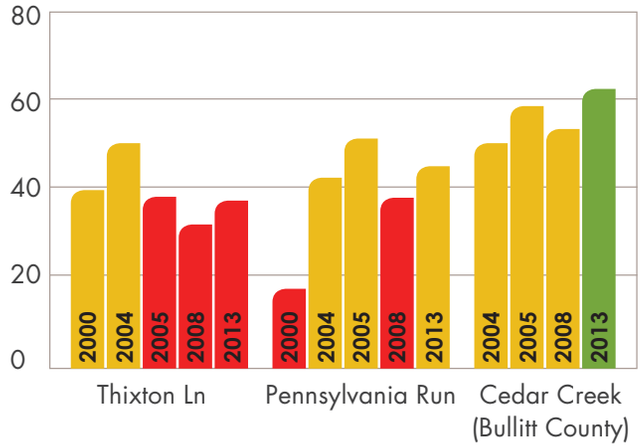




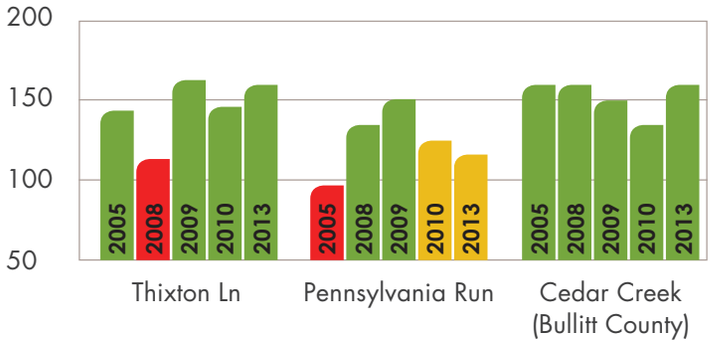
Condition of the Fish Communities in the Cedar Creek and Pennsylvania Run Watersheds



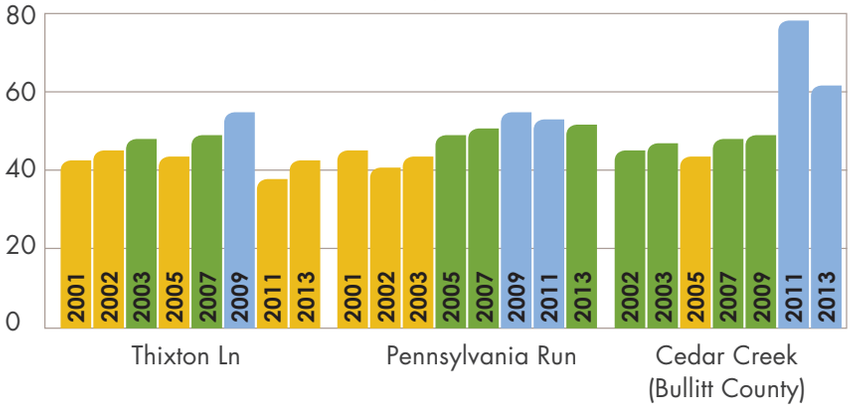
Condition of the Aquatic Insect Communities in the Cedar Creek and Pennsylvania Run Watersheds



Condition of the Stream Habitat in the Cedar Creek and Pennsylvania Run Watersheds



Condition of Algal Communities in the Cedar Creek and Pennsylvania Run Watersheds

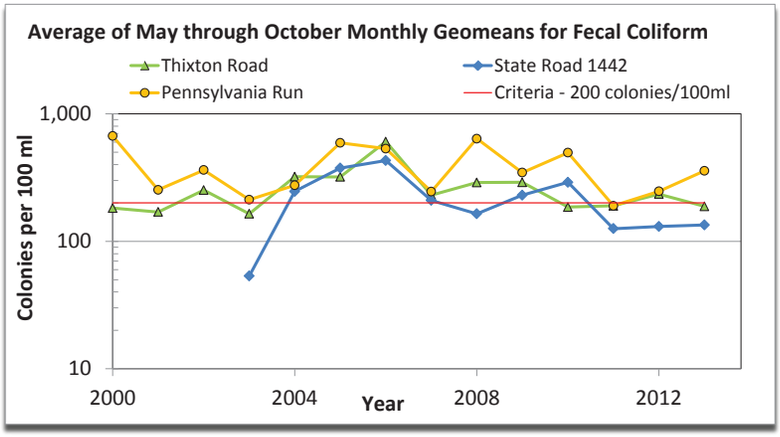


At the Pennsylvania Run site, habitat quality was variably "poor" to "good" and has declined since 2009 to "fair" currently, but has improved over the long term. The stream banks have some stability problems and the stream lacks shallow, rocky riffles that provide good habitat for aquatic insects and fish. The stream channel does not appear to have been straightened or otherwise altered.

MSD has monitored benthic algal communities, largely diatoms, in the Thixton Lane and Pennsylvania Run sites since 2001, and at Cedar Creek (Bullitt County) since 2002. Using a Diatom Bioassessment Index (DBI), the sites were rated "fair" to "excellent" with "fair" conditions at Thixton Lane in 2011-13. Algal community conditions have steadily improved in the Bullitt County and Pennsylvania Run sites over time and are "excellent" and "good" in 2013, respectively.

Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E coli* bacteria were collected similarly but only since 2011. The monthly geomeans of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record medians of the monthly geomeans for both Cedar Creek sites were below the recreational standard of 200 colonies/100ml, whereas, the period of record median for Pennsylvania Run was above the standard. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the period of record. There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season.

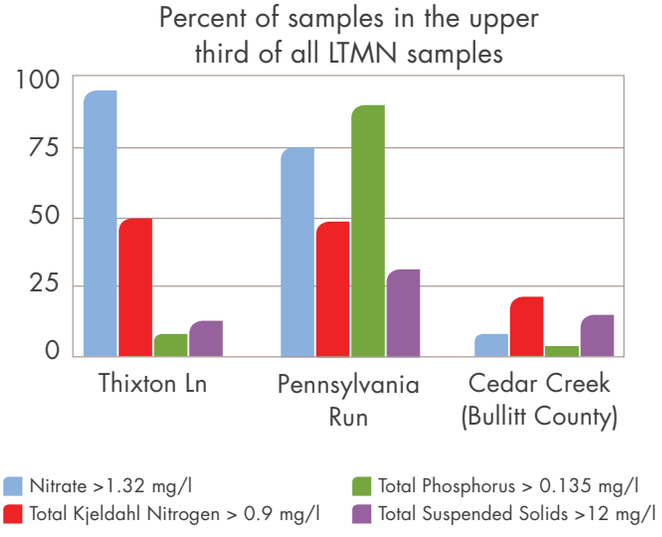


For the three years of data collection of *E. coli* bacteria (not shown), most all of the monthly geomeans at the three sites were above the recreational standard of 130 colonies/100ml.

MSD monitored the concentrations of nutrients (nitrogen and phosphorus) in streams and total suspended solids periodically from 2000 to 2005 and on a quarterly basis since 2005 at the three sites. The percent of samples taken at these sites which fall into the upper third of all samples were calculated as a comparison to other streams in the watershed and throughout the area.

The Thixton Lane site had the highest percentage of samples for nitrate in the upper third of all sites in the county while the Pennsylvania Run site had the fourth highest. The Pennsylvania Run site also had the second highest phosphorus percentage compared to all other sites in the county. About half of the TKN samples were in the upper third and TSS numbers were relatively low for the two sites, but neither are a major concern compared to nitrate and phosphorus. Due to its relatively undeveloped condition, the Cedar Creek site in Bullitt County had some of the lowest numbers of samples in the upper third of all samples for all nutrients and total suspended solids.

MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The acute ALC for total concentrations of cadmium, copper, lead, and zinc were not exceeded in any samples at any of the three sites.



MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature at all three sites. Streamflow has been monitored on Cedar Creek at Thixton Road (USGS gage number 03298250) since 1999, on Cedar Creek in Bullitt County (USGS gage number 03297800) since 2002, and on Pennsylvania Run (USGS gage number 03298300) since 1998.

Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four or five parts per million are what is deemed necessary. Water temperatures in excess of 31.7°C (89.1°F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

Dissolved oxygen criteria at the Thixton Road site were met 99.1 to 100 percent of the time and the Bullitt County site were met 91.7 to 100 percent; both reflecting 'good' conditions for the last six years. Occasional excursions of low dissolved oxygen likely were a result of very low stream flows on very warm days or some other transient factor. Dissolved oxygen criteria at the Pennsylvania Run site were met 66.7 to 94.3 percent of the time for the last six years, reflecting 'poor to good' conditions and "fair" more recently. These more frequent excursions of low dissolved oxygen likely were both a result of very low stream flows on very warm days and likely some other transient factor(s).

Water temperature criteria were met 100 percent of the time at the Cedar Creek at Thixton Road and Pennsylvania Run sites. Water temperature criteria were met 98.9 to 100 percent of the time at the Bullitt County site, with excursions above the criteria only in 2007 and 2012. Periodic hot days and low stream flows are common in the summer and occasionally cause an exceedance of the criteria.

MSD constructed the Cedar Creek Water Quality Treatment Center in 1995, in order to eliminate several small neighborhood package plants. The facility was expanded in 2003, and can now treat 7.5 million gallons of wastewater per day.

Cedar Creek near Thixton Lane

3.8

Pond Creek Watershed

The Pond Creek watershed drains about 126 square miles in southern and southwestern Louisville Metro area. Approximately 89 square miles are located in Jefferson County and 37 square miles are in Bullitt County. The Louisville International Airport and its associated large industrial complex, and Jefferson Memorial Forest are prominent features in this watershed.

Watershed Assessment

The health of the aquatic communities in the five sites was variable over time and between sites. The fish communities were most improved at the Northern Ditch and Brier Creek sites, both in "excellent" condition in 2013. The fish communities were "poor" or "very poor" at the Fern Creek, Manslick Road, Pendleton Road sites, but conditions have improved over time at the two upstream sites but declined at the Pendleton Road site. The aquatic insect communities at the five sites were rated "poor" to "fair" in 2013. Conditions have not improved any at the Fern Creek site, but have improved at the other four sites over the period of record. The algal community in the Fern Creek site was in "excellent" condition in 2013, having improved over time. The Northern Ditch, Manslick Road, and Pendleton Road sites were rated "poor" in 2013 and generally were the same or declining over time. Conditions of the algal communities in Brier Creek were "good" in 2013 but have generally declined over time.

Habitat quality has improved from "poor" to "fair" at the Fern Creek site and from "poor" to "good" at the Northern Ditch site. Good stream bed habitat is limited at the Fern Creek site by bedrock, but both growth of stream bank vegetation and development of a rocky substrate at the Northern Ditch site have improved habitat considerably. Habitat quality was "poor" in 2013 and has declined over time at both Pond Creek sites. Both of these sites have been channelized and have unstable, sediment laden stream beds and a general lack of rocky riffles, which provide important habitat for fish and aquatic insects. In Brier Creek, habitat quality improved from "poor" in 2005 to "good" in 2009, but has declined to "fair" since then. The stream in this location generally has unstable banks as well as shifting sediment deposits in the stream bed. This site has a very small drainage area and is affected by longer periods of low to zero stream flow.

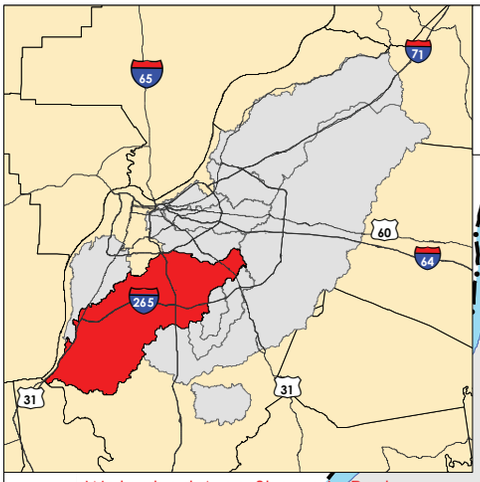
For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans for the Brier Creek, Northern Ditch, and Pendleton Road sites were below the recreational standard of 200 colonies/100ml, whereas, the period of record medians for the Fern Creek and Manslick Road sites were above the standard. Individual monthly geomeans were variably above and below the standard, with no apparent trend over time. There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season. For the three years of data of *E. coli* bacteria, most of the monthly geomeans at four of the sites were above the recreational standard of 130 colonies/100ml. Many of the Brier Creek monthly medians for *E. coli* were below the standard.

All sites except Fern Creek had very low numbers of nitrate samples in the upper third of all LTMN samples. Northern Ditch and Brier Creek sites had very low numbers for all nutrients and total suspended solids. Compared to all LTMN sites, Brier Creek had the lowest number of samples in the upper third of all samples for total Kjeldahl nitrogen and total phosphorus. The Northern Ditch site had the lowest number of samples in the upper third for total suspended solids (9 percent) compared to other LTMN sites, whereas, Pond Creek at Manslick Road had by far the highest number of samples in the upper third for total suspended solids (94 percent). Both Pond Creek sites had extremely low numbers of samples in the upper third for nitrate, with the lowest and second lowest numbers among all sites.

More recent wet weather event sampling data confirms the low occurrence of trace metals in the historical data. This strongly suggests that trace metals are not an issue of concern in these LTMN streams.

Dissolved oxygen conditions were in the "good" range in all but the Brier Creek site, which was in "fair" condition more recently. Water temperature criteria (no more than 31.7°C (89.1°F)) were met 100 percent of the time at the Brier Creek and Fern Creek sites; were in a "fair" range (between 91.7 and 99.7 percent) at the other three sites. Brier Creek and Fern Creek have very small drainage areas and are affected by longer periods of low to zero stream flow. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of these criteria. Riparian tree cover can help minimize these excursions.

POND CREEK WATERSHED
WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

Fern Creek at Old Bardstown Road
(3.5 square miles and 60 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	–	↑	↑	–	–	A	~

Pond Creek at Manslick Road
(64 square miles and 58 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	–	↓	–	–	A	~

Northern Ditch at Preston Highway
(11.1 square miles and 62 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↓	↑	–	–	B	~

Brier Creek at Bear Camp Road
(4.13 square miles and 1 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↓	–	–	–	B	~

Pond Creek at Pendleton Road
(80.3 square miles and 60 percent urban)

2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↓	↑	↓	↓	–	–	B	~

Middle Fork Beargrass Creek
South Fork Beargrass Creek
JEFFERSON COUNTY
Fern Creek
Northern Ditch
Southern Ditch
HARRISON COUNTY, INDIANA
Ohio River
Floyds Fork
Brier Creek
Pond Creek
Salt River
Salt River
BULLITT COUNTY
NELSON COUNTY
HARDIN COUNTY
60
264
31
65
265
31

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

TREND
- ↑ Improving
- ↓ Declining
- ~ Varies
- No Change
- ND No Data

STATUS
- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria

RATINGS KEY

Background and Land Use

Small streams, which flow west out of the Jeffersontown and Fern Creek areas, join to form Fern Creek; and then becomes Northern Ditch downstream near Shepherdsville Road. Just to the south, small streams flow west out of Okolona and form Southern Ditch near Interstate-65. Southern joins Northern Ditch and forms Pond Creek near New Cut Road, where it flows west into the Salt River near West Point, Kentucky. Brier Creek is a small tributary draining into Pond Creek just south of Pendleton Road.

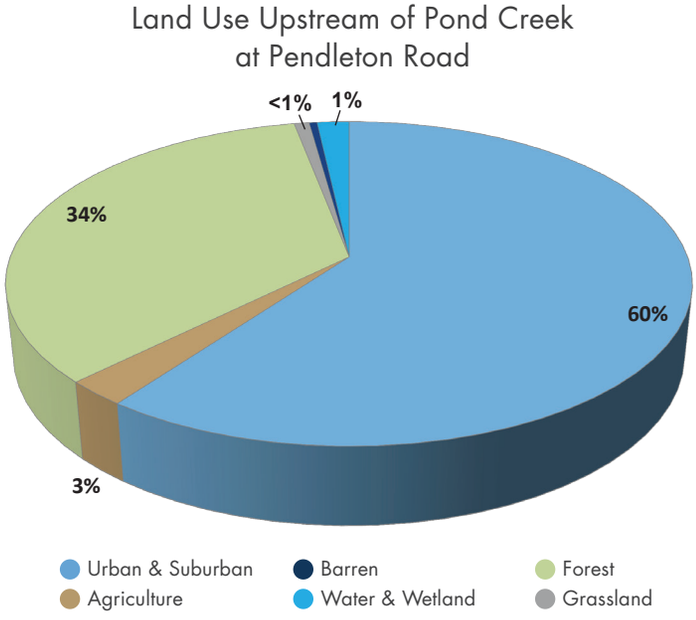
The relatively flat portion of the Pond Creek watershed was once a shallow lake, which gradually filled with silt and debris to form a flat plain with standing water and dense swamp vegetation. Parts of this area were known as the "wet woods" in the past.

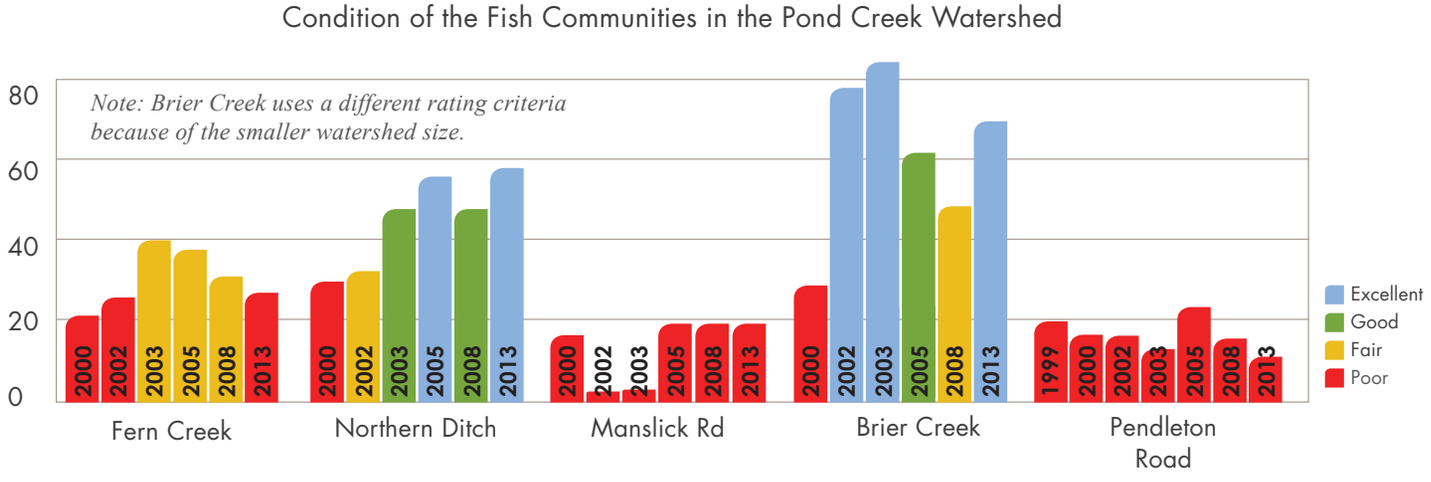
Starting in the 1850's, a system of man-made ditches was developed to reduce flooding and to increase the amount of land suitable for development, which continued to expand before and after World War II. Many of the streams in the Pond Creek watershed have been extensively channelized, and large flat areas are now drained by Northern Ditch and Southern Ditch.

MSD has been monitoring water quality and stream flow in this watershed since 1999 at five locations. The sites are listed here from upstream to downstream: Fern Creek at Old Bardstown Road, Northern Ditch at Preston Highway, Pond Creek at Manslick Road, Pond Creek at Pendleton Road, and Brier Creek at Bear Camp Road. The amount of land draining to each site in square miles is 3.50, 11.1, 64.0, 80.3, and 4.13, respectively.

The first four sites are similar in land use to Pond Creek at Pendleton Road, with 60 percent or more of the land in urban and suburban uses. The amount of impervious surfaces such as roads, rooftops and driveways, ranges from 16 percent to 24 percent. Forest ranges from 28 to 34 percent and agriculture ranges from 2 to 7 percent.

The land draining to Brier Creek is quite different from the other four sites. This small stream drains steep wooded areas southwest of Jefferson Memorial Forest. The watershed is largely undeveloped with 83 percent forest and 14 percent agriculture.





Monitoring Findings

MSD has monitored fish communities in the Pond Creek watershed since 1999. During this time, fish communities improved at the Northern Ditch site from "fair" to "excellent" in 2013. The fish communities vary widely in Brier Creek from "poor" to "excellent" but were "good' to "excellent" most years. The fish communities are consistently "poor" or "very poor" at the Manslick Road and Pendleton Road sites and "poor" to "fair" at the Fern Creek site.

MSD has monitored the aquatic insect communities in the Pond Creek watershed since 2000. The aquatic insect communities at the Northern Ditch site improved from "poor" to "fair" in 2013. At the Fern Creek site, conditions improved from "poor" in 2000 to "good" in 2004 and back to "poor" in 2008 and 2013. Conditions in Pond Creek at Pendleton Road and Manslick Road were variably "poor" to "fair". In Brier Creek, conditions improved from "poor" in 2000 to "good" in 2004 but have been "fair" since 2005.

MSD has assessed stream habitat quality when fish and aquatic insects were sampled since 2005. Habitat quality has improved from "poor" to "fair" at the Fern Creek site and from "poor" to "good" at the Northern Ditch site. Good stream bed habitat is limited at the Fern Creek site by bedrock, but both growth of stream bank vegetation and development of a rocky substrate at the Northern Ditch site have improved habitat considerably.

Habitat quality was "good" at the Manslick Road site in 2008 but has declined to "poor" since then. Habitat quality was consistently "poor" at the Pendleton Road site and declining. Both of these sites have been channelized and have unstable, sediment laden stream beds and a general lack of rocky riffles. These features provide important habitat for fish and aquatic insects.

In Brier Creek, habitat quality improved from "poor" in 2005 to "good" in 2009, but has declined to "fair" since then. Habitat in this location generally lacks trees and other large vegetation along the banks, resulting in unstable banks as well as shifting sediment deposits in the stream bed. This site has a very small drainage area, and is affected by longer periods of low to zero stream flow.

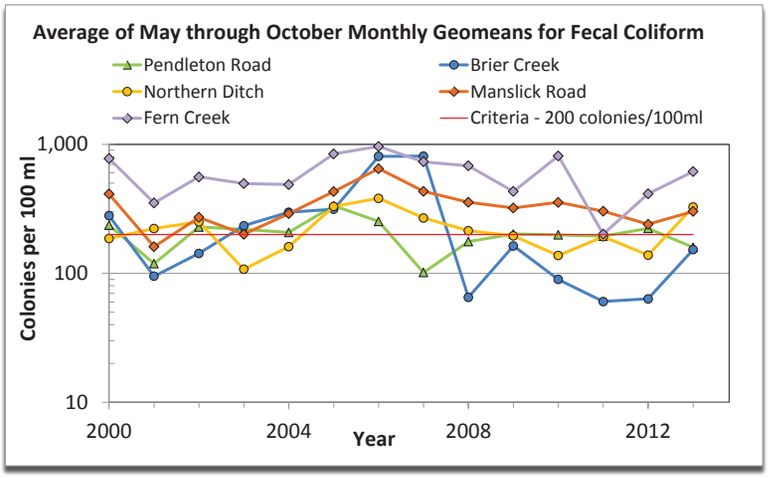
MSD has monitored benthic algal communities, largely diatoms, in the Pond Creek watershed since 2001. Using a Diatom Bioassessment Index (DBI), the rating in the Fern Creek site improved from "good" to "fair" prior to 2005 to "excellent" or "good" condition since then. The Northern Ditch site improved from "fair" prior to 2005, to "excellent" in 2007, but then declined to a "poor" condition by 2013. Conditions of the algal communities were variably "fair" or "good" at the Manslick Road and Pendleton Road sites before 2007, both improved to "excellent" and then declined to "poor" by 2013. Using a different rating for the smaller headwater site on Brier Creek, conditions of the algal communities were "excellent" in 2001 and 2002, and were variably "poor" to "good" since then.

Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E. coli* bacteria were collected similarly but only since 2011. The monthly geometric means (geomeans) of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record medians (the middle value) of the monthly geomeans for the Brier Creek, Northern Ditch, and Pendleton Road sites were below the recreational standard of 200 colonies/100ml, whereas, the period of record medians for the Fern Creek and Manslick Road were above the standard. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the period of record. There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season.

For the three years of data collection of *E. coli* bacteria (not shown), most of the monthly geomeans at four of the sites were above the recreational standard of 130 colonies/100ml. Many of the Brier Creek monthly medians for *E. coli* were below the standard.

MSD monitored the concentrations of nutrients (nitrogen and phosphorus) in streams and total suspended solids periodically from 2000 to 2005 and on a quarterly basis since 2005 at five sites in the Pond Creek watershed. The percent of samples taken at these sites which fall into the upper third of all samples collected in the Long Term Monitoring Network (LTMN) sites were calculated as a comparison to other streams in the watershed and the Metro area.

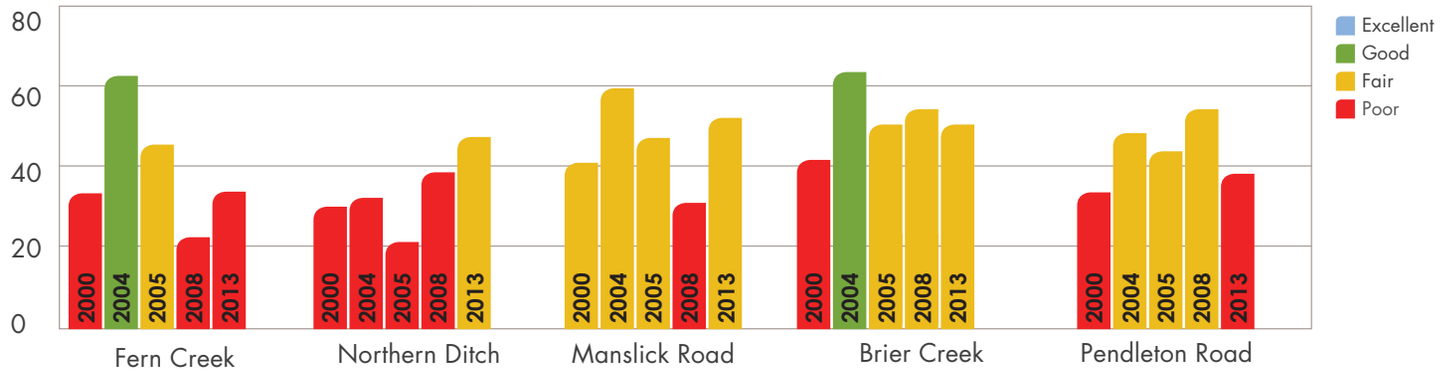


All sites except Fern Creek had very low numbers of nitrate samples in the upper third of all samples. Northern Ditch and Brier Creek sites had very low numbers for all nutrients and total suspended solids. Compared to all sites across the county, Brier Creek had the lowest number of samples in the upper third of all samples for total Kjeldahl nitrogen and total phosphorus. The Northern Ditch site had the lowest number of samples in the upper third for total suspended solids compared to all other sites in the county. Both Pond Creek sites had extremely low numbers of samples in the upper third for nitrate, with the lowest and second lowest numbers among all sites.

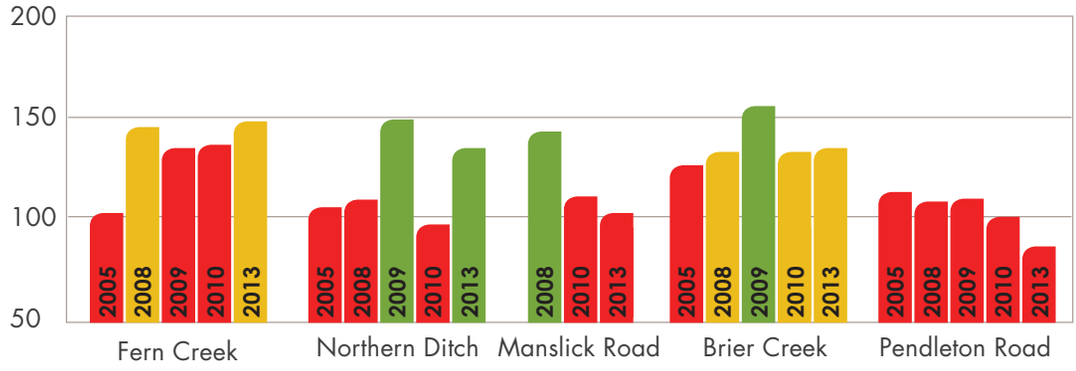
MSD monitored concentrations of trace metals in streams periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The acute ALC for total concentrations of cadmium and lead were not exceeded in any samples at any of the five sites. The ALCs, however, were exceeded for copper in one sample, and for zinc in one sample.

MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature at the five sites in the Pond Creek watershed. Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four parts per million (as an instantaneous standard) or five parts per million (as a mean daily standard) are what is deemed necessary. Water temperatures in excess of 31.7°C (89.1°F) are very stressful on aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

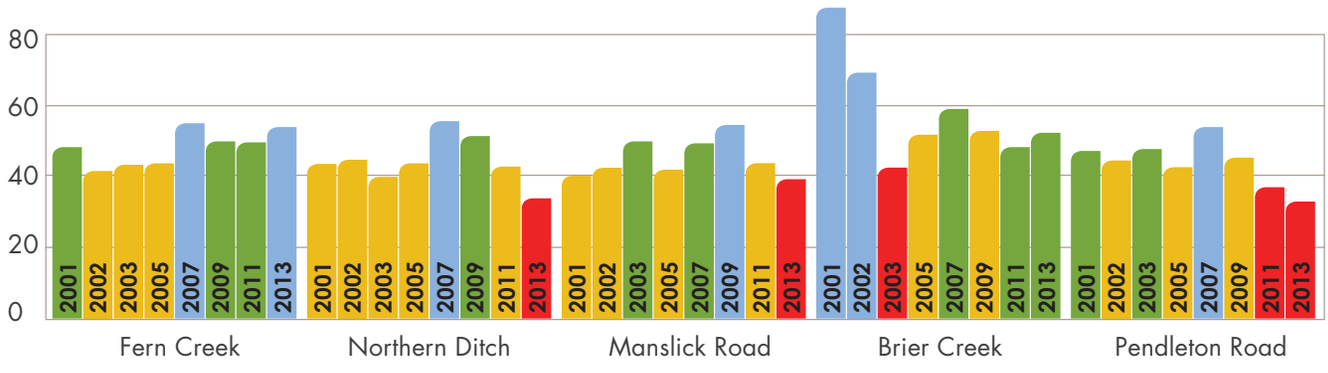
Condition of the Aquatic Insect Communities in the Pond Creek Watershed



Condition of the Stream Habitat in the Pond Creek Watershed

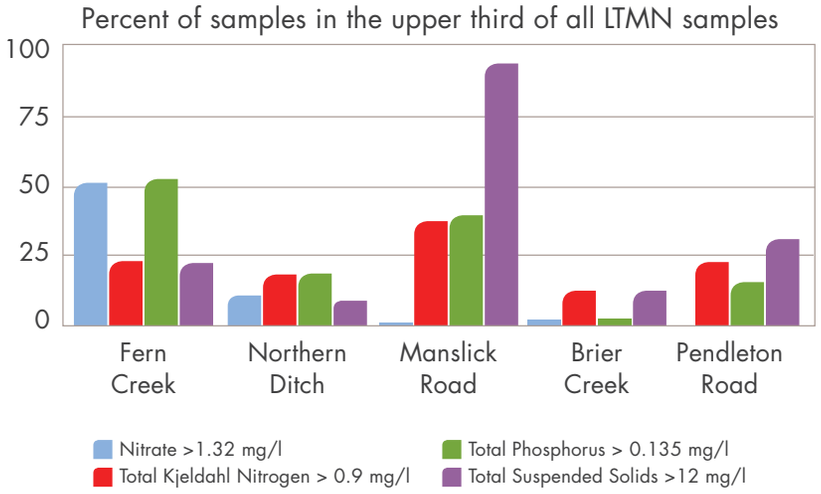


Condition of the Algal Communities in the Pond Creek Watershed



The percent of days when the average amount of dissolved oxygen in the water was above five parts per million was in the "good" range in the Fern Creek, Northern Ditch, and Pond Creek at Manslick Road sites. In both Brier Creek and Pond Creek at Pendleton Road, the dissolved oxygen conditions were in the "fair" range most years. It is not clear if the low dissolved oxygen readings were a result of very low stream flows or some other factor.

Water temperature criteria were met 100 percent of the time over the last six years at the Brier Creek and Fern Creek sites and at least 92 percent of the time each year with ratings of "fair" to "good" at both Pond Creek sites. Criteria at the Northern Ditch site were rated "fair" to "good" except for a "poor" rating in 2010. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of the criteria. Riparian tree cover can help minimize these excursions.



Northern Ditch

Northern Ditch is an example of a stream that has been severely altered as a result of urban development. As the city was developed, the stream was re-routed and straightened in order to convey stormwater out of the area more quickly and to reduce flooding. Trees and vegetation along the stream were removed as part of the construction effort, and while the project did improve drainage in the area, the health of the stream suffered. However, since the MSD Long Term Monitoring Network program was initiated, the biological monitoring results have indicated a general increase in stream health.

Stream quality based on the conditions of the fish communities are assessed using the Kentucky Index of Biotic Integrity (KIBI). It uses multiple indicators of the types and numbers of fish (known as metrics) and combines them to come up with an overall score for the section of stream where fish are collected. The KIBI results are presented in a narrative rating (excellent, good, fair, poor, or very poor), which corresponds to a range of KIBI scores. For more information on the factors used to determine the KIBI, please refer to the Biological Assessment section on page 10.

As the chart on page 59 shows, the fish KIBI score for Northern Ditch has trended upward since the first assessment in 2000, when conditions were "Poor", to where it currently is in "Excellent" condition.

Similar to fish assessments, aquatic insect communities also are assessed using the Kentucky Macroinvertebrate Bioassessment Index (MBI), also based on multiple factors (metrics) of the types and numbers of insects. The MBI results are presented in a narrative rating (excellent, good, fair, poor, or very poor), which corresponds to a range of MBI scores. For more information on the factors used to determine the MBI, please refer to the Biological Assessment section on page 10. The second chart also shows a general upward trend for the MBI at Northern Ditch. While not as dramatic as the KIBI score, the current MBI score now falls in the "Fair" range.

Over the years, the stream has evolved within its existing straightened channel to form small meanders and riffle/run/pool complexes. Woody vegetation is developing along the once treeless, steep sides of the channel. The trees are providing shade, which decreases water temperatures in the stream, and the habitat is more varied both allowing colonization of less tolerant fish and insects. These factors, along with improved storm water and pollution management, have most likely played an integral role in improving the overall integrity of Northern Ditch.

Creek chub is a species of minnow that can grow to 10 inches and is tolerant to a wide variety of water conditions.

The diet of the colorful longear sunfish generally includes aquatic insects and small fish.

3.9

Mill Creek Watershed

The Mill Creek watershed drains about 34 square miles in western Louisville, near the Ohio River. The northern part of the watershed includes streams that drain to the Mill Creek Cutoff, which flows directly into the Ohio River near Shively. The southern part of the watershed flows south through Pleasure Ridge Park and then into the Ohio River near Watson Lane. Many of the streams in this watershed have been straightened or channelized in the past to reduce flooding.

Watershed Assessment

Fish community conditions at the Mill Creek Cutoff site have improved from "poor" to "fair" since 2000. At Orell Road, fish communities were variably "poor" or "fair" early on, but have steadily declined to "poor" since 2000. The aquatic insect communities varied from "very poor" to "poor" at the Mill Creek Cutoff site. At Orell Road, aquatic insect communities were classified in "fair" condition throughout the sampling period.

Stream habitat at both sites was in "poor" condition in 2013 and appears to be declining over time at the Orell Road site. These sites are located in straight man-made channels that lack rocky riffles and tree lined banks. These features provide important habitat for fish and aquatic insects. The less than optimal stream habitat and the natural effects of low stream flow may have stressed aquatic communities at the two sites. The man-made channels that lack rocky riffles and tree lined banks actually could favor algal growth. Both sites were rated variably "fair" to "excellent" over time and in a "good" condition in 2013.

For fecal coliform bacteria, the period of record medians (the middle values) of the monthly geomeans for both sites were below the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variably above and below the standard, with no apparent trend over the period of record. For the three years of data of *E. coli* bacteria, most of the monthly geomeans at the two sites were above the recreational standard of 130 colonies/100ml.

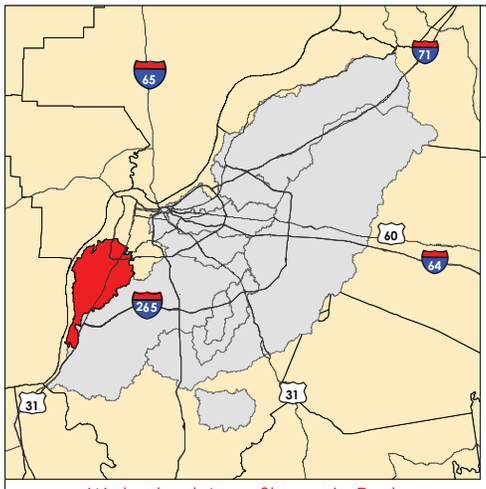
Both sites had very low numbers of nitrate in the upper third of all samples compared to other LTMN sites. The values for total Kjeldahl nitrogen, total phosphorus, and total suspended solids were similar between the two sites and about average for LTMN sites.

More recent wet weather event sampling data confirms the historical data at these sites that trace metals are not a large issue of concern in these LTMN streams.

Dissolved oxygen criteria improved from 'fair' condition in 2007 and 2008 to "good" condition at the Orell Road site and water temperature criteria (no more than 31.7°C (89.1°F)) were met 100 percent of the time. The Mill Creek Cutoff site had no data. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of these criteria, but that is not usually the case at this site.

Derek R. Guthrie Water Quality Treatment Center

MILL CREEK WATERSHED
WATER QUALITY STATUS AND TRENDS



Watershed Area Shown In Red

FLOYD COUNTY, INDIANA

HARRISON COUNTY, INDIANA

JEFFERSON COUNTY

BULLITT COUNTY

Ohio River

Mill Creek Cutoff

Mill Creek

Mill Creek

264

60

31

265

Mill Creek Cutoff at Old Cane Run Road (24.4 square miles and 86 percent urban)								
2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	↑	↑	↑	—	ND	ND	B	~

Mill Creek at Orell Road (13.5 square miles and 69 percent urban)								
2013 Status	Fish	Insects	Algae	Habitat	D.Oxygen	W.Temp.	F.Coliform	Nutrients
Trend	—	—	↑	↓	↑	—	B	~

N

Legend

- Monitoring Site
- Sewage Treatment Plant (Operated by MSD)
- Sewage Treatment Plant (Operated by Other Agency)
- Stream
- Road
- County Boundary
- Watershed Boundary
- Lake

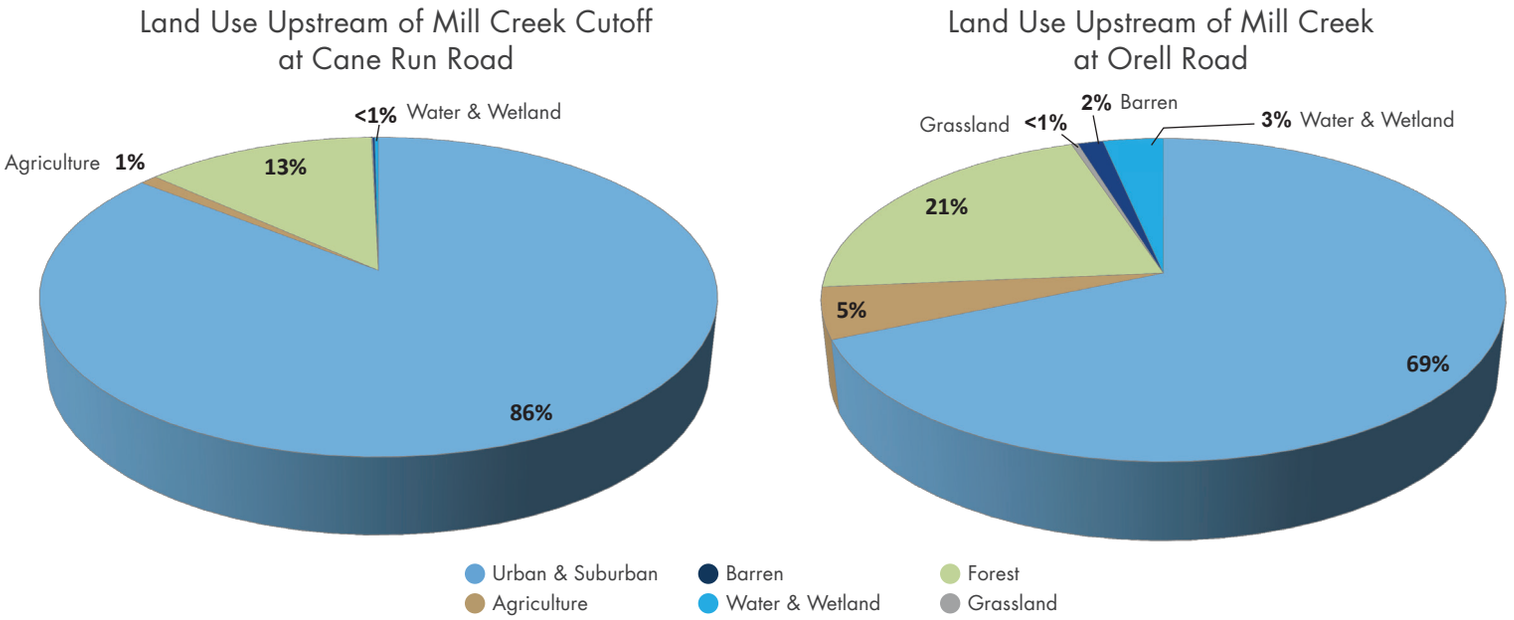
RATINGS KEY

TREND

- ↑ Improving
- ↓ Declining
- ~ Varies
- — No Change
- ND No Data

STATUS

- Excellent
- Good
- Fair
- Poor / Very Poor
- A Long Term Median Above the Criteria
- B Long Term Median Below the Criteria



Background and Land Use

MSD has been monitoring water quality at two sites in this watershed since 1999; on Mill Creek Cutoff at Old Cane Run Road and on Mill Creek at Orell Road. There are 24.4 square miles of land draining to the Mill Creek Cutoff site and 13.5 square miles of land draining to the Orell Road site. Both of these watersheds are highly urbanized, with some forest and very little agriculture. Approximately 38 and 21 percent of the land draining to the Mill Creek Cutoff and Orell Road sites, respectively, is covered by impervious surfaces such as roads, rooftops and driveways.

Monitoring Findings

MSD has monitored fish communities at the two sites since 1999. During this time, ratings have improved from "poor" to "fair" at the Mill Creek Cutoff site. At Orell Road, fish communities were variably "poor" or "fair" early on, but have steadily declined to "poor" since 2000.

MSD has monitored aquatic insect communities at the two sites since 2000. The aquatic insect communities improved slightly from "very poor" to "poor" at the Mill Creek Cutoff site. At Orell Road, aquatic insect communities were classified in "fair" condition throughout the sampling period.

MSD has assessed stream habitat quality when fish and aquatic insects were sampled since 2005. Except for 2008, habitat quality at the Mill Creek Cutoff site was "poor". This site is located in a straight man-made channel that lacks rocky riffles and tree lined banks that provide habitat for fish and aquatic insects.

Habitat quality at the Orell Road site was "fair" prior to 2008 and declined to a "poor" condition since 2009. Mill Creek at this site also consists of a man-made channel, so it lacks a mix of rocky riffles and deep, slow pools. These features provide important habitat for fish and aquatic insects. The site also has sediment deposition that is affecting stream habitat quality.

MSD has monitored benthic algal communities, largely diatoms, at the two sites in the Mill Creek watershed since 2001. Using a Diatom Bioassessment Index (DBI), both sites were rated variably "fair" to "excellent" and both are in a "good" condition in 2013.

Since 2000, MSD has monitored fecal coliform bacteria three to five times a month during the recreational season (April-October). *E. coli* bacteria were collected similarly but only since 2011. The monthly geometric means (geomeans) of bacteria concentrations were calculated and compared to the recreational contact standard for each type.

For fecal coliform bacteria, the recreational contact season runs from May 1 through October 31 each year. The period of record medians (the middle values) of the monthly geomeans for both sites were below the recreational standard of 200 colonies/100ml. Individual monthly geomeans were variably above and below the standard (not shown), with no apparent trend over the period of record. There was a tendency, however, for higher monthly geomeans earlier in the recreational season than later in the season for some years, which could be related to lower stream flows later in the season.

For the three years of data collection of *E. coli* bacteria (not shown), most of the monthly geomeans at the two sites were above the recreational standard of 130 colonies/100ml. MSD monitored the concentrations of nutrients (nitrogen and phosphorus) in streams and total suspended solids periodically from 2000 to 2005 and on a quarterly basis since 2005 at two sites in the Mill Creek watershed. The percent of samples taken at these sites which fall into the upper third of all samples were calculated as a comparison to other streams in the watershed and throughout the area.

Both sites had very low numbers of nitrate in the upper third of all samples compared to other sites in the county. The values for total Kjeldahl nitrogen, total phosphorus, and total suspended solids were similar between the two sites, with all parameters slightly higher at the Mill Creek Cutoff site compared to the Orell Road site.

MSD monitored concentrations of trace metals in streams

periodically from 2000 to 2005 and on a quarterly basis since 2005. For those metals with criteria, total metal concentrations in stream samples were compared to the acute Aquatic Life Criteria (ALC) for each metal. The ALCs were exceeded for cadmium in 10 samples, copper in 10 samples, for lead in one sample, and zinc in one sample.

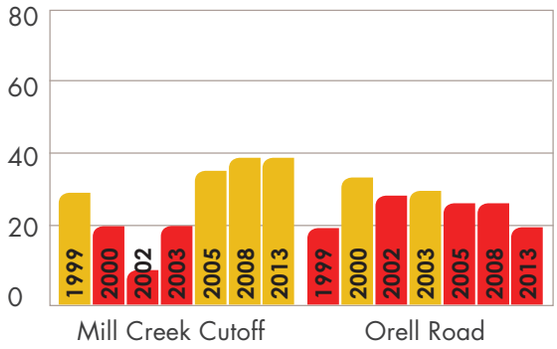
MSD and the US Geological Survey continuously monitor streamflow, dissolved oxygen, and water temperature on Mill Creek at Orell Road. Streamflow has been monitored at the Orell Road site (USGS gage number 03294570) since 1999 and at the Mill Creek Cutoff site (USGS gage number 03294550) since 1988.

Fish and aquatic insects need dissolved oxygen to breathe, and amounts greater than four parts per million (as an instantaneous standard) or five parts per million (as a mean daily standard) are what is deemed necessary. Water temperatures in excess of 31.7°C (89.1°F) are very stressful on the aquatic communities both by increasing metabolism and respiration, and by lowering the capacity of water to actually hold dissolved oxygen. In general, extended periods of low stream flows also can cause stress on aquatic communities.

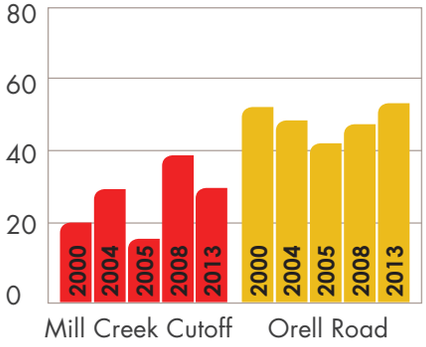
Dissolved oxygen criteria improved from 'fair' condition in 2007 and 2008 to "good" condition at the Orell Road site since then. Occasional excursions of low dissolved oxygen likely were a result of very low stream flows on very warm days or some other transient factor.

Water temperature criteria were met 100 percent of the time since 2006 at the Orell Road site. Periodic hot days and low stream flows are common in the summer and occasionally can cause an exceedance of the criteria, but that was not the case at this site.

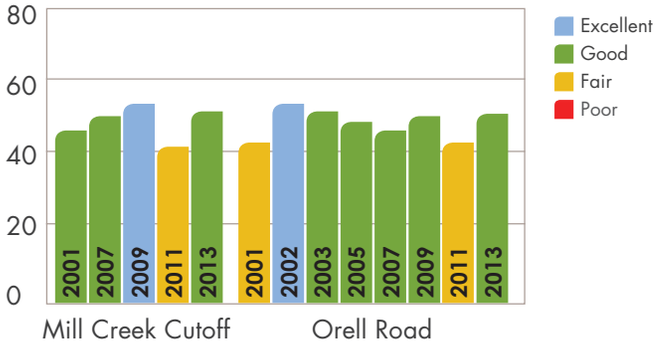
Condition of the Fish Communities in the Mill Creek Watershed



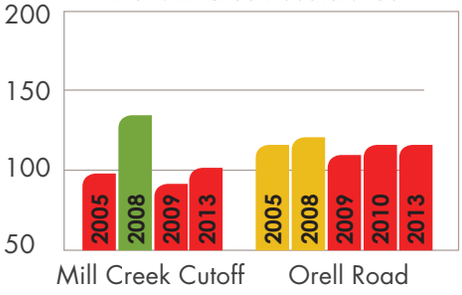
Condition of the Aquatic Insect Communities in the Mill Creek Watershed

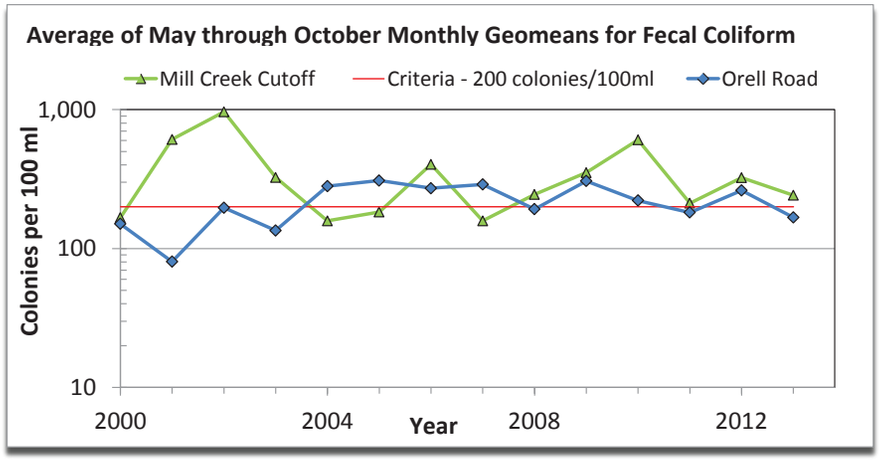


Condition of the Algal Communities in the Mill Creek Watershed

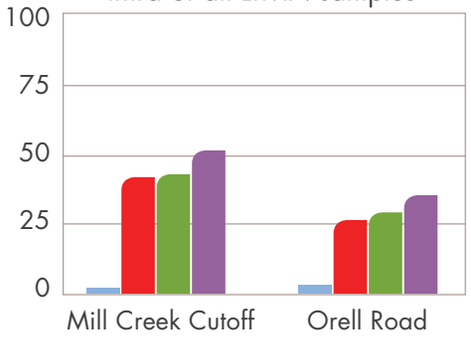


Condition of the Stream Habitat in the Mill Creek Watershed





Percent of samples in the upper third of all LTMN samples

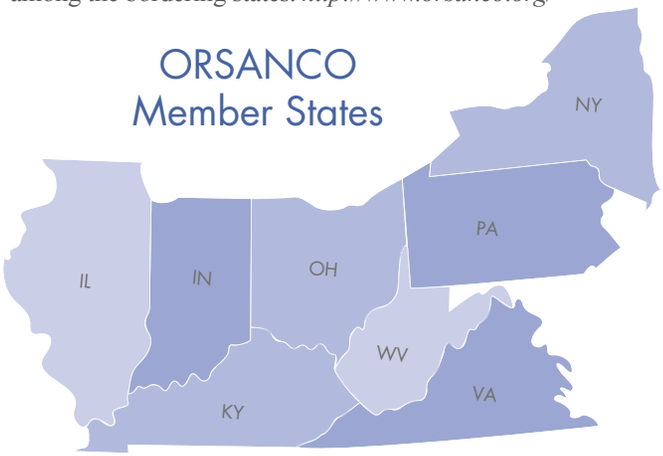


Nitrate >1.32 mg/l
Total Phosphorus > 0.135 mg/l
Total Kjeldahl Nitrogen > 0.9 mg/l
Total Suspended Solids >12 mg/l

Ohio River Watershed

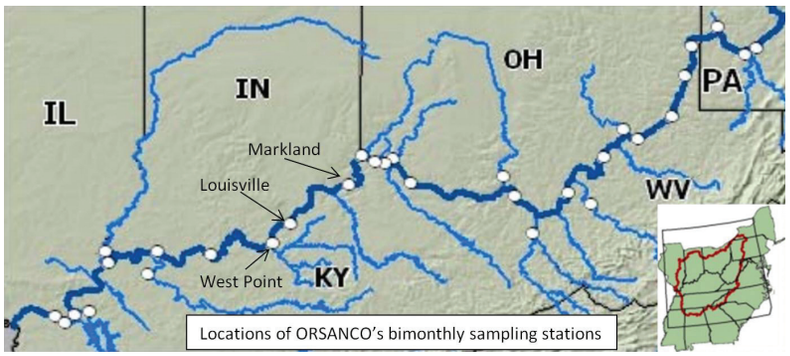
The Ohio River is one of the nation's great natural resources. The river not only provides drinking water for over five million people, but serves as a warm water habitat for aquatic life, provides numerous recreational opportunities, is used as a major transportation route, and is a source of water for the manufacturing and power industries. The Ohio River begins in Pittsburgh, Pennsylvania at the confluence of the Allegheny and Monongahela Rivers and flows southwesterly for 981 miles, joining the Mississippi River near Cairo, Illinois. For the stretch of river near Louisville, it forms the state boundaries between Indiana to the north and Kentucky to the south.

The Ohio River Valley Water Sanitation Commission (ORSANCO) is an interstate agency charged with abating existing pollution in the Ohio River basin and preventing future degradation of its waters. ORSANCO was created in 1948 with the signing of the Ohio River Valley Water Sanitation Compact among the bordering states. *http://www.orsanco.org/*



ORSANCO's Bimonthly Monitoring Program, in existence since 1975, is comprised of 31 monitoring sites; 17 locations on the main stem of the Ohio River and 14 points near the mouth of major tributaries. The Bimonthly Sampling Program currently collects six samples per year, every other month, down from a monthly frequency that ended in 1992. ORSANCO also operates a recreational contact monitoring program for bacteria where samples are taken five times per month for the entire recreational season.


A young volunteer collects trash during the annual Ohio River Sweep



Locations of ORSANCO's bimonthly sampling stations

Every two years, ORSANCO completes an assessment of conditions of Ohio River water quality and the ability to which the river supports each of its four designated uses; warm water aquatic life, public water supply, contact recreation, and fish consumption. ORSANCO's 2012 assessment (their 305b Report) indicates that, for the reach of the Ohio River in the vicinity of Louisville, both the aquatic life and public water supply uses are being met. As indicated by concentrations of bacteria in their river surveys, the use of the Ohio River for contact recreation is impaired and a plan for remediation is in progress. The entire 981 miles of the Ohio River is designated as impaired for the fish consumption use, caused by PCBs and dioxin.

http://www.orsanco.org/images/stories/files/publications/305b/docs/2012/2012ohioriver305breport.pdf

ORSANCO has analyzed the trends in various water quality measures at Ohio River sampling sites from 1990 to 2007. At the three Ohio River sites near Louisville (see figure), concentrations of nitrogen compounds, total suspended solids, iron, and zinc in the river are declining or staying the same. Concentrations of total phosphorus and chloride, however, are increasing over time.

TRENDS IN CONCENTRATIONS AT THREE OHIO RIVER SITES NEAR LOUISVILLE FROM 1990 TO 2007

OHIO RIVER SITE	AMMONIA-NITROGEN	NITRATE NITROGEN	TOTAL PHOSPHORUS	TOTAL SUSPENDED SOLIDS	IRON	ZINC	CHLORIDE
Markland	–	DEC	INC	DEC	DEC	DEC	INC
Louisville	dec	–	INC	–	–	DEC	–
West Point	–	–	INC	–	DEC	DEC	INC

Key: INC = significantly strong increasing trend, DEC = significantly strong decreasing trend, dec = less significant decreasing trend, and – = no trend found

http://www.orsanco.org/images/stories/files/publications/trendsreport/2008trendsanalysis.pdf

The overall fish community health in the Ohio River has been improving, but the entire 981 miles of the river is designated as "impaired" for the consumption of fish, caused by PCBs and dioxin.

ORSANCO also has conducted fish surveys to evaluate the Ohio River since 1957. Various measures of the condition of the fish communities have increased over time indicating an improvement in the overall fish community health. For example, the percentage of pollution tolerant fish species in the Ohio River has declined since 1957 and the fish surveys indicate increasing numbers of pollution intolerant and native species. The McAlpine Lock and Dam pool survey, the portion of the river above and in the Louisville Metro area, indicates that the fish community is in good health.

http://www.orsanco.org/images/stories/files/publications/biological/usingfishtoevaluate.pdf

Summary and Conclusions

The Louisville and Jefferson County Metropolitan Sewer District (MSD) in cooperation with the United States Geological Survey (USGS) operates a Long-Term Monitoring Network (LTMN) to collect physical, chemical and biological data about streams in the Metro Area. MSD collects the water quality and biological data and USGS collects stream flow. This Synthesis Report is focused on the conditions of fish, aquatic insects, benthic algae, stream habitat, bacteria, nutrients (nitrogen and phosphorus compounds), total suspended solids, trace metals, stream flow, dissolved oxygen, and water temperature of the streams in our community, and whether or not measures of these components are improving. The data collected at the 27 LTMN sites since 1999 helps us make decisions about where to focus our attention and tells us how we're doing in our mission to improve water quality in the region. This report augments a previous MSD report: "State of the Streams, 2011 Water Quality Synthesis Report" (available in the library section at *http://msdprojectwin.org*).

The health of aquatic communities in streams of the Metro Area can be compromised by one or more factors that commonly affect urban and suburban streams. Significant and rapid runoff from impervious areas often leads to stream bank erosion due to increases in the percentage of rainfall that becomes runoff (more frequent flushing). More rapid runoff can also cause scouring of stream beds and deposition of sediment that covers habitat needed by fish and other aquatic organisms. Channel modifications such as straightening and shoring up the bank with concrete or large stones leads to limited amounts of rock riffle habitat and insufficient protective tree cover along the banks, both of which are needed for healthy aquatic communities. Occasional periods of very low flow, high temperatures, or low dissolved oxygen infrequently contribute to lower than desired observed health of aquatic communities.

In addition to the typical urban effects, a major impact on stream quality in the older urban areas of Louisville is related to the presence of combined sewer systems that release sewage and stormwater during larger rainfall events. The lower parts of the South and Middle Forks of Beargrass Creek are affected by combined and sanitary sewer overflows, and their aquatic communities are usually rated as in "poor to very poor" condition. Very high concentrations of bacteria also were observed in these watersheds. These are being mitigated by extensive projects to eliminate or reduce the frequency and volume of overflows.

The aquatic communities in watersheds with impervious area greater than 20 percent have shown variable responses to the effects of development depending, in part, on the presence of healthy stream habitat. Parts of the Beargrass Creek (Muddy, Middle, and South Forks) watershed have poor habitat and generally poor to very poor conditions of their aquatic communities. Some watersheds, like Pond Creek and Mill Creek, have considerable amounts of man-made channels without the healthy mix of rocky riffles and tree covered banks. As a result, the aquatic communities generally are in "poor to fair" condition and they are declining at some sites. Northern Ditch is an exception in that the conditions of the aquatic communities are showing significant improvement, perhaps in part, due to channel stabilization projects.

Streams that run on bedrock, like Cedar Creek, Fern Creek, and Pennsylvania Run, to some extent lack the variety of in-stream habitat types such as deep pools and rocky riffles that provide good habitat for fish and aquatic insect communities. As a result, their aquatic communities are in "poor to good" condition but for other reasons they are still showing improvement.

The predominance of forested and agricultural land in less developed watersheds, like Harrods Creek, Floyds Fork, Brier Creek, and Cedar Creek (Bullitt County), helps slow down and absorb runoff during rain events. As such, healthier stream habitat conditions in these systems were found to be supporting healthier aquatic communities, even in Floyds Fork despite it having some of the highest nutrient levels in the county.

Measures of aquatic community health in 2013 indicate that for fish, algae, and stream habitat, over half of the sites were in "good to excellent" condition, whereas, for aquatic insects most sites were in "poor to fair" status. The cooler than normal stream temperatures during 2013 sampling likely resulted in lower than normal observed aquatic insect health. Trends in fish, aquatic insect, and stream habitat health indicate that over half of the sites were improving. The algal communities at most sites had no trend or were declining.

The "fair to poor" habitat conditions of about half of the streams can be attributed to historic stream channelization and straightening along with the loss of rock riffles, bends, vegetative bank protection, and the now less stable banks and narrow to nonexistent riparian corridors. Some consideration for using well-planned stream restoration techniques and riparian tree plantings might greatly improve conditions for fish and insects in streams with poorer habitat conditions.

Data in 2013 for fecal coliform bacteria indicate that 17 of the LTMN sites had an average monthly geometric mean (geomean) higher than the recreational contact criteria of 200 colonies per 100ml. For the period of record from 2000 to 2013, the median of all monthly fecal coliform geomeans indicates that 14 sites were above the criteria and 13 sites were below the criteria. The lower parts of the South and Middle Forks of Beargrass Creek had the highest concentrations of bacteria. These impacts are being mitigated by extensive projects to eliminate or reduce the frequency and volume of sewer system overflows during larger rainfall events.

Dissolved oxygen data in 2013 indicate that 19 sites were in "good" status, four were "fair", and only one site was in "poor" status (South Fork of Beargrass Creek at Brownsboro Road). Trends in the historical data (2007-2012) indicate that dissolved oxygen conditions at two sites were declining (Pennsylvania Run and the Brownsboro Road site), 18 sites had no trend, and at four sites conditions were improving. Water temperature conditions in 2013 indicate that half of the sites met the criteria (not greater than 31.7°C (89.1°F)) 100 percent of the time and half met the criteria at least 90 percent of the time. There were no measurable trends in water temperature data. Periodic hot days and low stream flows occasionally can cause an exceedance of dissolved oxygen or temperature criteria. The presence of significant tree cover at many sites and potential for groundwater influence at some sites probably helps buffer these measurements to some degree from otherwise significant urban influences.

The levels of nutrients (nitrate, total Kjeldahl nitrogen, and total phosphorus) and total suspended solids in each site were compared to all samples at 27 LTMN sites collected since 2005. Using a natural break in the data, seven to eight sites had the highest number of samples in the upper third of all LTMN samples for these nutrients. Those sites are mainly east or south of the city (Floyds Fork, Chenoweth Run, Cedar Creek, Pennsylvania Run, Fern Creek, and Little Goose Creek) and have more agricultural or suburban land use types, generally with higher use of fertilizers on crops and lawns. The 12 or 13 sites that had the lowest number of samples in the upper third of all LTMN samples for nutrients are mainly north (Harrods Creek and Goose Creek) or southwest of the city (Pond Creek, Mill Creek, and Cedar Creek-Bullitt). Six to seven sites were mid-range and largely urban.

In its un-ionized form, ammonia can be toxic to fish and other aquatic organisms. MSD collected samples for total ammonia since 2000 at 25 LTMN sites. For a comparison to the Kentucky water quality criterion, the un-ionized form of ammonia was calculated using water temperature and pH data with equations from the State's water quality standards 401 KAR 10:031. One sample each at Chenoweth Run at Gellhaus Lane in 2007 and 2008 were above the calculated un-ionized ammonia criterion. The source of these two higher ammonia concentrations is not known. Concentrations of un-ionized ammonia were below the criterion of 0.05 mg/l in all other samples at the 25 sites with available data since 2006, suggesting that un-ionized ammonia currently is not an issue at LTMN sites. Data on pH were not always available prior to 2006, but total ammonia nitrogen concentrations were judged high enough to likely have exceeded the un-ionized ammonia criteria in fifteen samples at four sites in 2001 and two sites in 2004, all in the Beargrass Creek watershed.

The picture of total suspended solids is a little different. Pond Creek at Manslick Road is very dominant with 94 percent of its samples in the upper third of all LTMN total suspended solids samples. It is suspected that the banks and sediment-laden stream bed in this channelized system are highly erodible and that even small rises in flow can lead to higher suspended solids. Sites on Little Goose Creek, Mill Creek, and Floyds Fork follow next, but were well behind in percent of samples in the upper third of all LTMN samples. Otherwise, the rest of the sites do not seem to have much of a problem with suspended solids.

Of more than 1,230 total samples collected for each trace metal at LTMN sites since 1999, copper had the most exceedances with 45 at 12 sites, cadmium had 31 exceedances at 9 sites, lead had 21 exceedances at 7 sites, and zinc had 5 exceedances at 4 sites. In summary, 73 percent of the metal exceedances were in the Beargrass Creek watershed and 22 percent were in the Mill Creek watershed. Otherwise, other exceedances were singular occurrences at six other sites. The relatively few exceedances of Aquatic Life Criteria in the historical data would indicate that trace metals are not a large issue of concern in LTMN streams.

Of the 1,427 LTMN samples for biochemical oxygen demand (BOD) and 911 samples for chemical oxygen demand (COD) detections were below 10 mg/l in 95 and 50 percent of the samples, respectively. The highest concentrations of BOD, about 5 to 10 mg/l on average, were found in the three sites on the South Fork of Beargrass Creek, and these were two to four times on average more than any other sites. The South Fork BODs likely were derived from sewer overflows. BOD and COD at each site were not correlated. The higher concentrations of COD were found at sites that likely had higher concentrations of dissolved and particulate organic carbon, which is derived from the natural decay of organic materials like leaves and other organic detritus or from dissolved iron (ferrous) compounds in poorly oxygenated ground water inflows or both. In fact, the highest COD (maximum of 238 mg/l and an average of 21 mg/l) was found in Cedar Creek, Bullitt County, which is a largely forested and undeveloped watershed.

The analysis of the historical LTMN data suggests that, in about half of the streams, bacteria continues to be an issue, and that "fair" to "poor" habitat quality significantly affected the observed health of fish and aquatic insect communities. The natural effects of drought conditions likely contributed to lower aquatic health status in some streams in some years as well. The effects of lower dissolved oxygen and higher temperature conditions are much more subtle and probably limited to a few sites for short periods. For example, below normal stream flows prior to and during the 2005 and 2008 sampling events likely affected observed health in aquatic insect and fish communities, affecting the aquatic insects more than fish. The cooler than normal stream temperatures during sampling likely affected the observed health of the aquatic insect communities in 2013. One of the values of a long-term network like the LTMN is the ability to identify these naturally induced fluctuations in water quality as well.

State of the Streams

Summary of the Status and Trends in Stream Water Quality from 1999 to 2013 for the MSD Long Term Monitoring Network

MSD Site Name	Percent of Watershed that is Urban	Percent of Watershed that is Impervious	Drainage Area (square miles)	Average Streamflow 1999-2013 (cubic feet per second per square mile)	Fish Status (2013)	Fish KIBI Trend (oldest to 2013)	Aquatic Insect Status (2013)	Aquatic Insect MBI Trend (oldest to 2013)	Algal Status (2013)	Algal DBI Trend (oldest to 2013)	Stream Habitat Status (2013)	Stream Habitat Trend (2005 to 2013)
Harrods Creek at Covered Bridge Road	9	1	70.3	1.88	Good	-2%	Fair	-37%	Excellent	8%	Good	6%
Wolf Pen Branch at 8111 Wolf Pen Branch Road	24	7	2.08	No gage	Fair	-41%	Poor	-25%	Fair	-2%	Good	24%
Goose Creek at Old Westport Road	53	11	6.00	1.66	Good	23%	Fair	-1%	Excellent	24%	Good	39%
Goose Creek at US 42	49	10	10.1	1.45	Excellent	18%	Poor	-33%	Good	-15%	Good	8%
Little Goose Creek at US 42	66	18	5.82	2.19	Good	77%	Fair	3%	Excellent	-3%	Good	21%
Muddy Fork of Beargrass Creek at Mockingbird Valley Road	46	9	6.20	1.59	Good	9%	Poor	36%	Fair	-27%	Poor	22%
Middle Fork of Beargrass Creek at Browns Lane	73	24	15.2	No gage	Excellent	61%	Fair	5%	Fair	-24%	Fair	49%
Middle Fork of Beargrass Creek at Old Cannons Lane	76	24	18.9	1.61	Fair	8%	Poor	-26%	Good	-9%	Good	9%
Middle Fork of Beargrass Creek at Lexington Road	73	22	24.8	1.53	Poor	4%	Poor	-13%	Excellent	-3%	Fair	-7%
South Fork Beargrass Creek at Trevilian Way	85	32	17.2	1.62	Fair	0%	Poor	25%	Excellent	-5%	Poor	53%
South Fork Beargrass Creek at Schiller Avenue Ramp	81	30	22.8	1.59	Very Poor	-77%	Poor	22%	Fair	-11%	Poor	-4%
South Fork Beargrass Creek at Brownsboro Road	78	28	51.5	1.56	Fair	137%	Poor	59%	Good	-25%	Good	31%
Floyds Fork at Ash Avenue	9	1	80.0	1.70	Good	24%	Fair	38%	Good	-4%	Good	3%
Floyds Fork at Old Taylorsville Road	13	3	138	1.66	Excellent	28%	Fair	-8%	Good	-1%	Good	7%
Floyds Fork at Bardstown Road	14	4	213	1.65	Excellent	58%	Fair	-5%	Fair	-10%	Good	-1%
Chenoweth Run at Ruckriegel Parkway	75	33	5.47	1.99	Fair	18%	Fair	32%	Good	-10%	Fair	16%
Chenoweth Run at Gellhaus Lane	52	21	11.6	2.34	Fair	39%	Fair	-4%	Fair	-25%	Good	18%
Cedar Creek at Thixton Lane	37	10	6.40	3.40	Good	28%	Poor	-6%	Fair	2%	Good	12%
Pennsylvania Run at Mount Washington Road	39	9	11.1	0.95	Fair	27%	Fair	74%	Good	13%	Fair	16%
Cedar Creek at State Road 1442 Bullitt County	6	0.2	12.1	1.66	Excellent	17%	Good	22%	Excellent	29%	Good	0%
Fern Creek at Old Bardstown Road	60	17	3.50	2.00	Poor	19%	Poor	1%	Excellent	12%	Fair	34%
Northern Ditch at Preston Highway	62	17	11.1	1.80	Excellent	62%	Fair	49%	Poor	-23%	Good	23%
Pond Creek at Manslick Road	58	25	64.0	1.57	Poor	53%	Fair	25%	Poor	-3%	Poor	-34%
Pond Creek at Pendleton Road	60	21	80.3	1.74	Very Poor	-55%	Poor	11%	Poor	-34%	Poor	-28%
Brier Creek at Bear Camp Road	1	0.05	4.13	1.39	Excellent	68%	Fair	18%	Good	-60%	Fair	7%
Mill Creek Cutoff at Old Cane Run Road	86	38	24.4	0.65	Fair	32%	Poor	36%	Good	10%	Poor	5%
Mill Creek at Orell Road	69	21	13.5	1.70	Poor	0%	Fair	1%	Good	15%	Poor	-13%

Fecal Coliform in colonies/100ml		Percent of Time Dissolved Oxygen Criteria Met (2012)		Percent of Time Water Temperature Criteria Met (2012)	Water Temperature Trend (2007 to 2012)	Ranking Based on the Percent of Samples in the Upper Third of All Sites (red shading is in the higest percent, green is in the lowest percent, and yellow is in between)				Short Name	MSD Site Number
Average Monthly Geomean (2013)	Median of All Monthly Geomeans (oldest to 2013)	5 mg/l Daily Criteria	Trend (2007 to 2012)			Nitrate > 1.32 mg/l	Total Kjeldahl Nitrogen > 0.9 mg/l	Total Phosphorus > 0.135 mg/l	Total Suspended Solids > 12 mg/l		
152	131	100%	12%	98.6%	-1%	8%	23%	9%	24%	Harrods Creek	EHCHC001
478	281	No Data	No Data	No Data	No Data	26%	21%	3%	27%	Wolf Pen Branch	EHCWP001
345	280	98%	-1%	100.0%	0%	22%	24%	13%	15%	Old Westport Road	EGCGC001
256	278	99%	-1%	100.0%	0%	48%	24%	33%	22%	US 42	EGCGC002
182	240	100%	0%	100.0%	0%	79%	62%	31%	62%	Little Goose Creek	EGCLG001
393	376	98%	-2%	100.0%	0%	37%	17%	30%	29%	Mockingbird Valley Road	EMUMU001
1073	921	No Data	No Data	No Data	No Data	43%	15%	13%	27%	Browns Lane	EMIMI009
451	374	99%	-1%	99.7%	0%	33%	29%	7%	26%	Old Cannons Lane	EMIMI002
672	912	83%	14%	98.6%	-1%	24%	38%	53%	48%	Lexington Road	EMIMI010
1284	434	93%	3%	100.0%	0%	16%	44%	12%	46%	Trevilian Way	ESFSF001
2094	633	95%	-5%	99.7%	0%	28%	35%	25%	37%	Schiller Avenue Ramp	ESFSF002
986	846	62%	-29%	99.7%	0%	45%	40%	36%	28%	Brownsboro Road	ESFSF006
456	203	90%	-6%	100.0%	2%	43%	52%	74%	41%	Ash Avenue	EFFFF001
209	169	100%	5%	97.8%	-2%	60%	50%	65%	57%	Old Taylorsville Rd	EFFFF003
301	200	98%	-1%	99.7%	1%	62%	48%	56%	39%	Bardstown Road	EFFFF002
221	334	99%	23%	100.0%	0%	17%	23%	48%	16%	Ruckriegel Parkway	EFFCR002
212	219	100%	1%	97.2%	-2%	92%	62%	91%	20%	Gellhaus Lane	EFFCR001
188	219	100%	1%	100.0%	0%	94%	49%	8%	13%	Thixton Lane	ECCCC001
357	305	80%	-17%	100.0%	0%	74%	48%	89%	31%	Mt. Washington Road	EPRPR001
134	146	92%	-4%	98.9%	-1%	9%	21%	4%	15%	State Road 1442	ECBCB001
615	462	100%	7%	100.0%	0%	52%	23%	53%	23%	Fern Creek	EPCFC001
326	173	97%	-4%	91.7%	-9%	11%	18%	19%	9%	Northern Ditch	EPCND001
302	271	93%	-2%	92.9%	-4%	1%	37%	40%	94%	Manslick Road	EPCPC001
159	154	91%	-6%	99.7%	0%	0%	23%	16%	31%	Pendleton Road	EPCPC002
153	131	82%	8%	100.0%	0%	2%	13%	3%	13%	Brier Creek	EPCBC001
242	186	No Data	No Data	No Data	No Data	2%	41%	42%	51%	Mill Creek Cutoff	EMCMX001
167	151	99%	13%	100.0%	0%	3%	25%	29%	35%	Orell Road	EMCMC001

Important Terms

Aquatic Insects: Aquatic insects, also known as benthic macroinvertebrates, are small animals (bugs) that can be seen with the naked eye, live on the bottom of streams and lakes, and don't have a backbone. They are often the immature aquatic forms of insects that live on land as adults, and they are an important food source for fish and other aquatic organisms.

Benthic Algae: The small green plant-like organisms that live on the rocks and other materials on the bottoms of streams are called benthic algae. Benthic algae have limited mobility, growing in areas suitable for their survival for weeks to months. They are particularly responsive to stream nutrient concentrations, sunlight, and the effects of sedimentation. Many algae types (especially diatoms, green algae, and blue-green algae) are an important food source for many fish and aquatic insects.

Biological Indices: Various methods used in this report to assess water quality by applying measures (metrics) of biological communities to derive a narrative rating of "good', "fair", or "poor" condition of the aquatic communities in a stream. A number of metrics are used, including the total number and diversity of species, tolerance to pollution, and other assessments. This report used data on the fish, aquatic insect, algae, and stream habitat communities to rate each stream.

Dissolved oxygen: Dissolved oxygen is the oxygen that is freely available in water, and that is vital to fish and other aquatic life and for the prevention of odors. Dissolved oxygen levels are considered an important indicator of a water body's ability to support desirable aquatic life. Dissolved oxygen levels fluctuate seasonally and over a 24- hour period. They also vary with water temperature and altitude (elevation). Water at the same temperature holds less oxygen at higher altitudes and cold water holds more oxygen than warm water.

Erosion: Erosion is when soil, silt, sand, rock and other particles are removed from unprotected land surfaces or stream banks usually by flowing water (runoff and stream flow) and are deposited downstream as sediment (mud, silt, sand, and gravel). Sediment becomes problematic when it covers rocks and other stream habitat needed by fish and other aquatic life.

Floodplain: A floodplain, or flood plain, is the flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current.

Geomeans: the geometric mean (geomean) is a way of averaging a set of numbers by using the product of their values, as opposed to the arithmetic mean, which uses their sum. The geometric mean is defined as the nth root of the product of n numbers. It is used in this report to compute a value of multiple samples of bacteria for comparison with a standard value or criteria.

Impervious Surface: An impervious surface is any surface that is covered by materials that block the infiltration of water into the ground or soil. Impervious surfaces include roads, sidewalks, driveways, parking lots, and rooftops. Compacted soils (including some lawns) can also behave like impervious surfaces.

Indicator Bacteria: Bacteria and viruses that live in the water and on the bottom of streams are both natural and beneficial conditions in healthy streams. Bacteria and viruses in wastewater inflows and runoff from urban surfaces can lead to less healthy conditions, especially if they contain untreated animal or human waste. There are two types of bacteria that are used to indicate whether streams are clean or polluted, getting better or worse. Fecal coliform bacteria are one type more generally indicative of the presence of some kind of fecal material. The other type, *E. coli* bacteria, is more indicative of the presence of fecal material from the gut of warm blooded animals, including humans. Both types have established criteria mainly related to body contact recreation by humans.

Nutrients: The primary nutrients in streams are nitrogen and phosphorus compounds carried in runoff and other inflows. They are important for the growth and health of aquatic organisms. In excess, however, they can lead to nuisance growths of algae and low dissolved oxygen. Nitrate nitrogen is largely in a dissolved form, derived from fertilizers and wastewaters. The other compounds are both in dissolved and particulate forms. Total Kjeldahl is a measure of both ammonia and organic nitrogen carried with sediment runoff and wastewater inflows. Total phosphorus is particularly important for algal growth and also is delivered to the stream with sediment runoff and wastewater inflows.

Riffle: A riffle is a short, steeper, relatively shallow and coarse-bedded length of stream over which the stream flows at a faster velocity and higher turbulence than in a pooled reach of a stream. Riffles are usually caused by an increase in a stream bed's slope or an obstruction (rocks, logs, etc.) in the flow. Riffles typically increase dissolved oxygen and provide high quality aquatic habitat.

Riparian zone or area: A riparian zone is the area of land at and near the stream interface. Riparian zones, when well vegetated, have a significant role in stream bank stabilization, soil conservation, filtration of chemicals and sediment in runoff, and in providing shade and food (organic material).

Runoff: Runoff is the portion of rain, snow melt, or irrigation water that arrives in streams, rivers, lakes, ponds, drains or sewers.

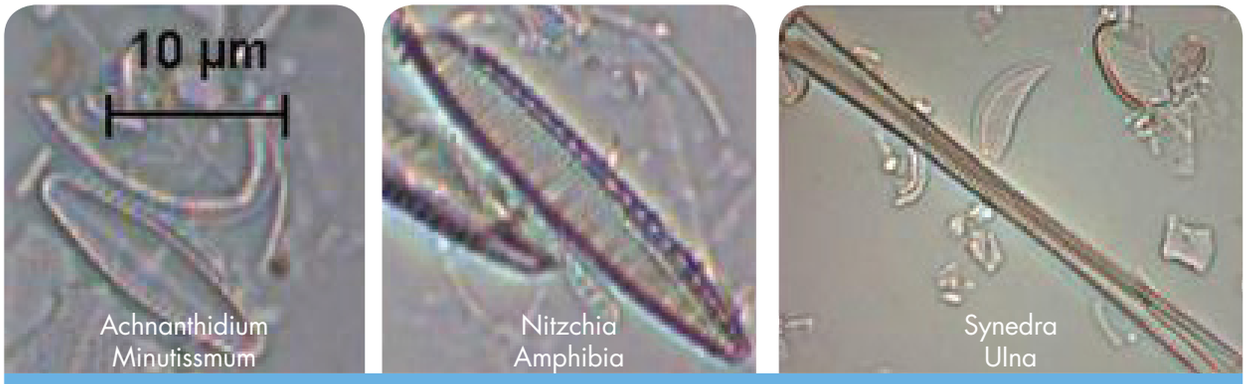
Stream Flow: Stream flow is the volume of water flowing past a point in a fixed unit of time. Stream flow is often expressed in cubic feet per second (ft^3/ sec).

Stream habitat: Stream habitat is the underwater environment that is used as a living space by fish, aquatic insects, other plants and animals. Vegetation near the channel also is important for quality habitat. Streams that have a variety of habitats, with shallow and deep areas, fast and slow water, and places with rocks, gravel, woody debris, tree covered banks, and shade are characteristics of good habitats.

Total Suspended Solids: Total suspended solids in streams are indicative of the amount of sediment washing off watershed surfaces and from erosion of stream banks. Sediment carried in higher flows, when deposited downstream, can reduce the quality of aquatic habitat and negatively affect aquatic communities.

Trace Metals: Various metals carried in trace amounts in runoff and other inflows. They are both in dissolved and particulate forms and in higher concentrations can affect the health of aquatic organisms. Criteria exist for the more important metals.

Watershed: The area of land where all the water drains to a particular stream or location along a stream. The boundary of a watershed is formed by the highest elevations surrounding the stream. A rain drop of water falling outside the watershed boundary will drain to another watershed. Small watersheds join together to form larger watersheds. A major river, such as the Ohio River, will encompass many smaller watersheds.



Three of the more common diatom species that were collected from algae tiles in 2013 at sites with "excellent" ratings.

67,668 catch basins...

...billions of leaves!

On rainy days, rainwater—and anything else that is on the streets—flows into the storm drains, also known as catch basins. If they are clogged with leaves and debris, water can quickly flood the street. This localized flooding can result in hazardous conditions.

We salute the 98 powerful people in MSD Drainage and Flood Protection, who collectively work around the clock seven days a week—every day of the year. They do their best to keep our community safe from flooding.

You can see that, with 67,668 basins, we could use your help. Just a few minutes of your time can help prevent street flooding in your neighborhood. Rake leaves and debris away from the basins, and dispose of such debris properly. If basins are still clogged, **contact MSD Customer Relations—at 502-587-0603**—to receive assistance.

Together, we can achieve clean, safe waterways
for a healthy and vibrant community.

MSD
Metropolitan Sewer District

Providing Exceptional Wastewater, Drainage and Flood Protection Services for Our Community

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Everyday our customers flush **2,948 miles** of **toilet paper...**

...more than the distance from New York to Los Angeles

Our wastewater treatment equipment is designed for toilet paper and human waste. Other items cause trouble—creating clumps that become entangled in our pumps. This can lead to sewage backups, overflows and increased maintenance costs. Please help the environment and your wallet by putting these items in a trash can.

Do not flush:

- Condoms
- Dental floss
- Diapers
- Fats, oils and grease
- Feminine-hygiene products
- Hair
- Medications
- Paper towels
- Wipes

We salute the 125 powerful people in MSD Wastewater Treatment, who collectively work 24/7/365.

They do their best to help us achieve clean, safe waterways for a healthy and vibrant community.

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This 2014 Water Quality Synthesis Report was prepared by MSD and Stantec Consulting Services, Inc.

Stantec