BUILDING A WORLD OF DIFFERENCE

CASE STUDY OF INTEGRATED WATER QUALITY APPROACH IN CINCINNATI WATERSHED

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METROPOLITAN SEWER DISTRICT of greater CINCINNATI

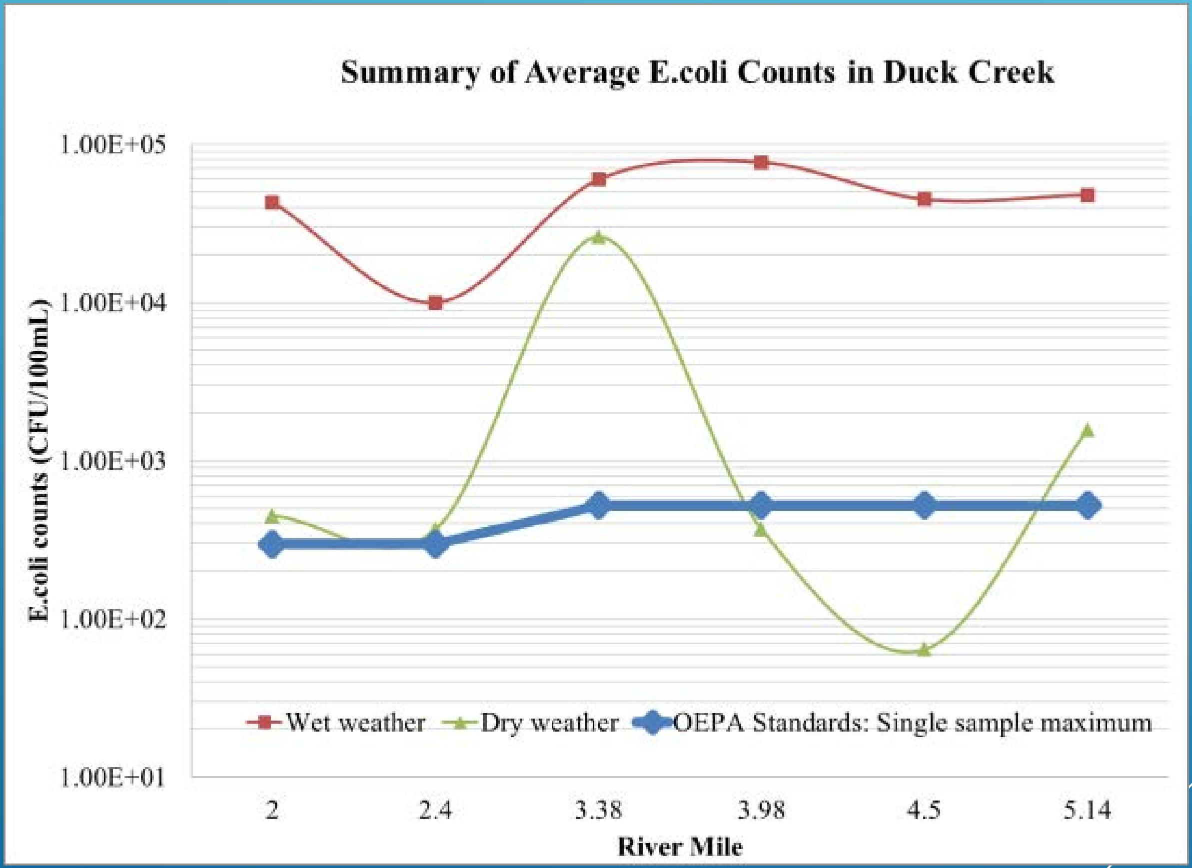
BLACK & VEATCH
Building a world of difference.

WET WEATHER IMPROVEMENT PROGRAM

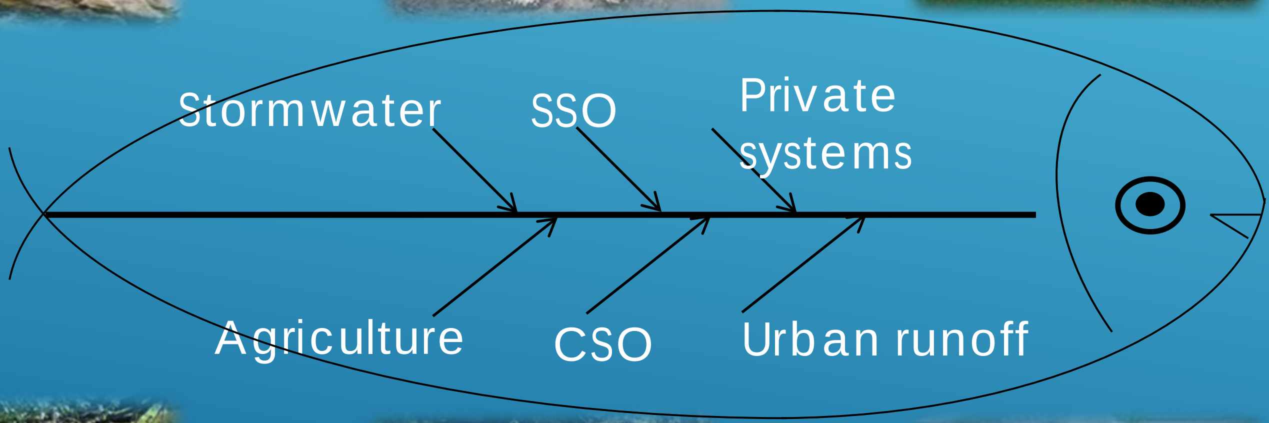
- The overarching goal of any wet weather program is to meet Water Quality targets and Clean Water Act Standard.

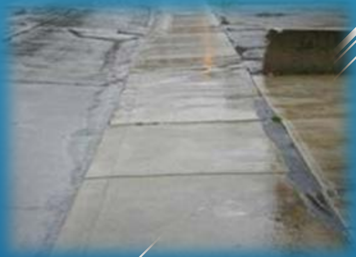
- Most multi-million $$$ consent decrees are based on Combined Sewer Overflow (CSO)/ Sanitary Sewer Overflow (SSO) frequency and volume reduction and are indirectly linked to Water Quality Improvements.

EVEN DURING DRY WEATHER, *E. COLI* HAS EXCEEDED THE WATER QUALITY STANDARD



MANY SOURCES CONTRIBUTE TO WATER POLLUTION IN THE WATERSHED





HOLISTIC WATERSHED MANAGEMENT

Water QUANTITY based

- Presumptive approach
- Reactive
- Point source solution

Water QUALITY Based

Ecological HEALTH based

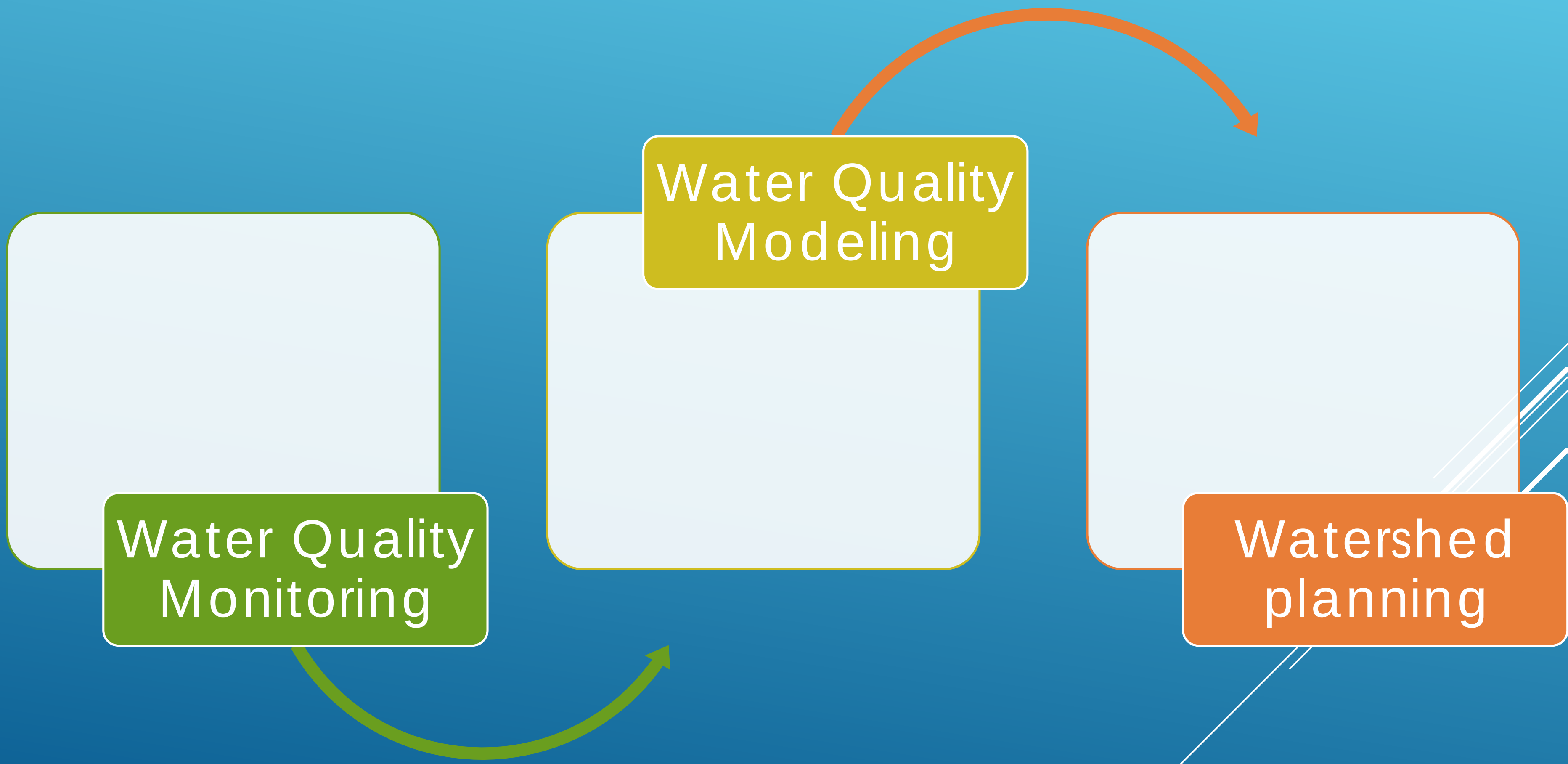
- Demonstrative approach
- Watershed scale

THE VALUE OF A WATER QUALITY PROGRAM

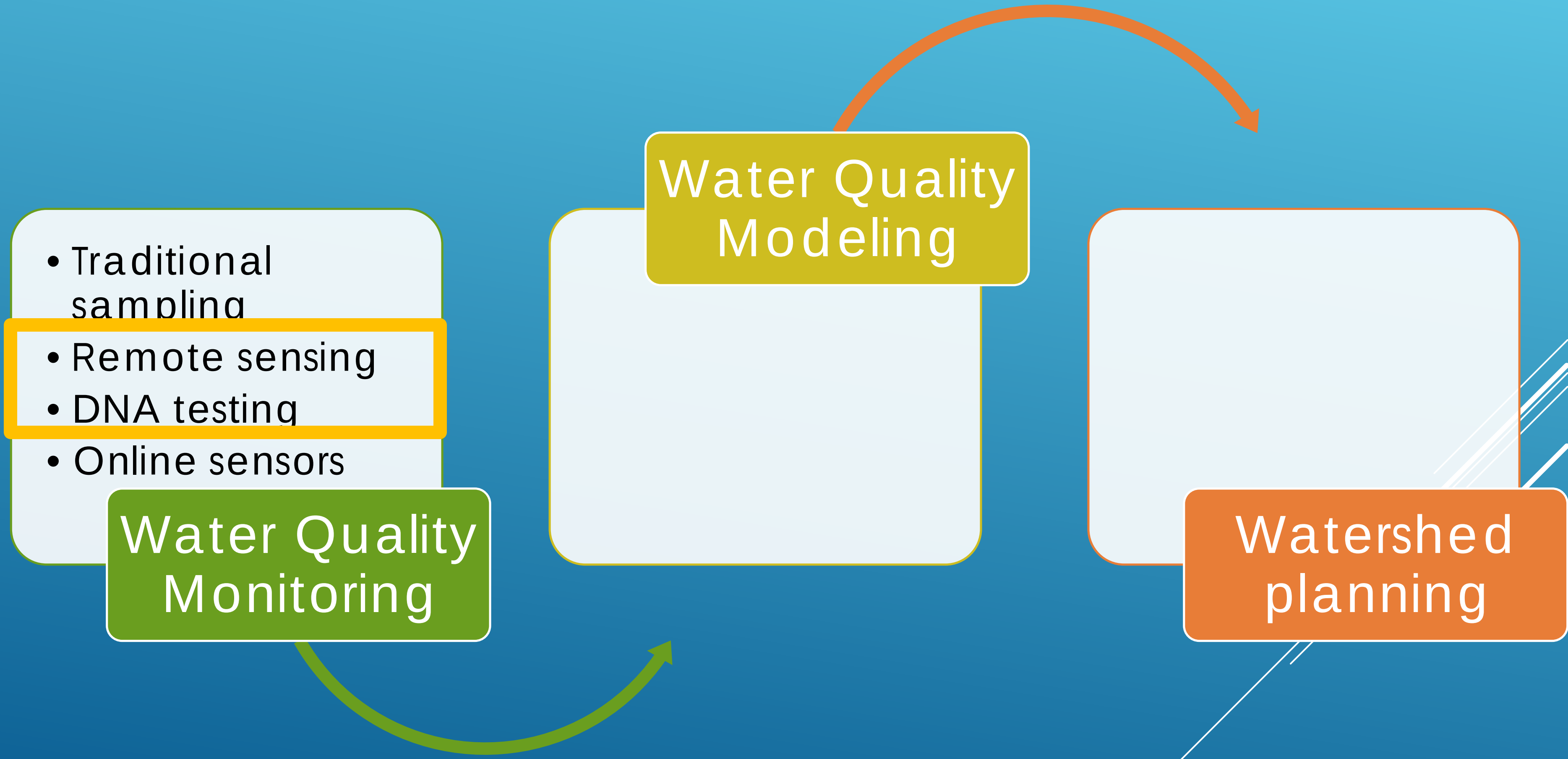
- Focus on the outcome
- Prioritizes improvement projects
- Helps demonstrate project effectiveness
- Improves communication and regulatory buy-in
- Reduce compliance cost and risk

"Clean Water Act- restore and maintain the chemical, physical, and biological integrity"

WATER QUALITY PROGRAM COMPONENT

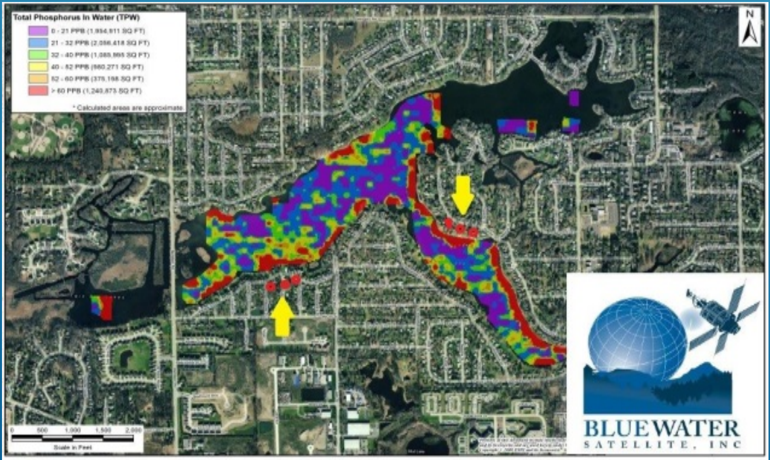


WATER QUALITY PROGRAM COMPONENT



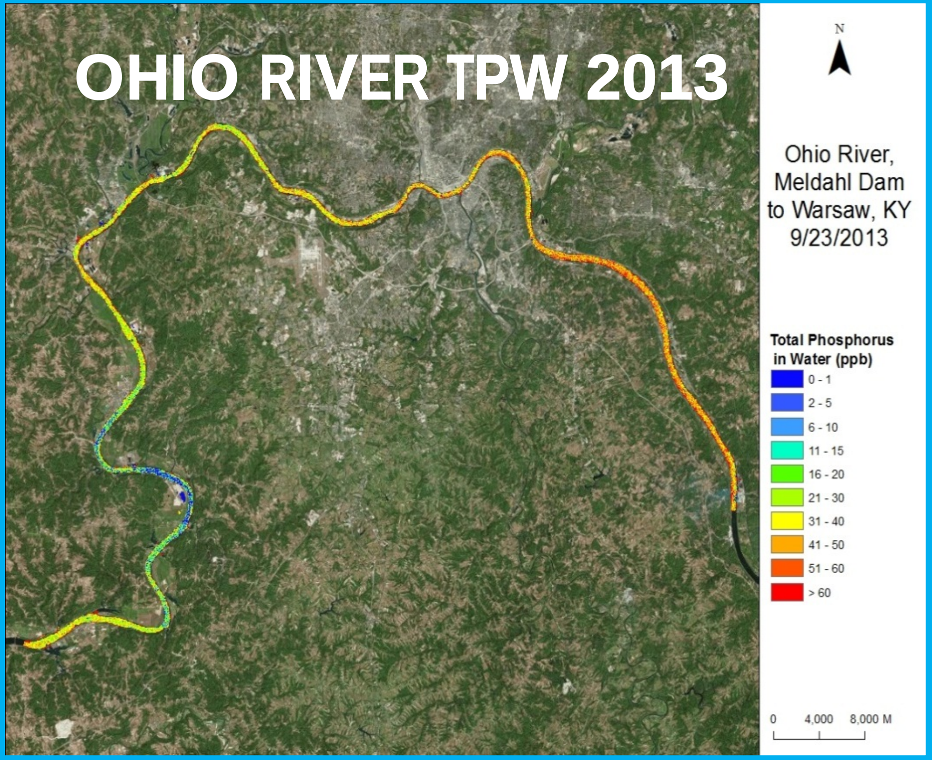
REMOTE SENSING: COST-EFFECTIVELY IDENTIFYING WATERSHED POLLUTION

- Remote detection of non-microbial contaminants
- Identifies sources and hotspots on watershed scale
- Documents water quality trends



REMOTE SENSING CASE STUDY: NUTRIENT AND WQ POLLUTANTS MAPPED TO GUIDE WATERSHED-BASED DECISION MAKING

7/2/2012 NATURAL COLOR

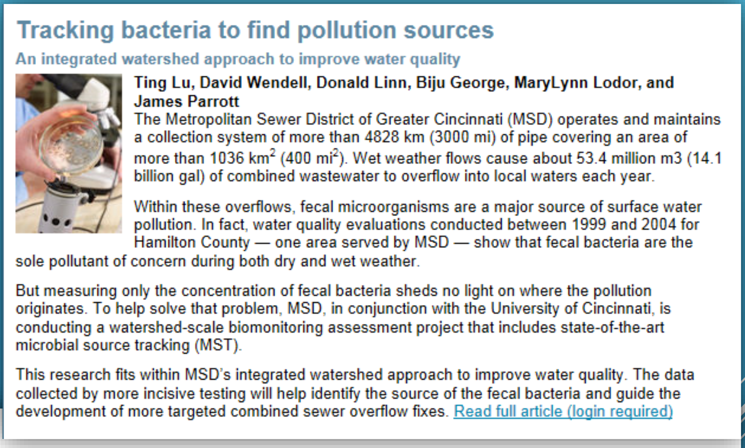


REMOTE SENSING OUTCOME

- **Gain understanding of what's really happening across the entire watershed**
  - Low flow (normal conditions) shows low total phosphorus
  - High level clusters of total phosphorus are visible
  - High total phosphorus after a major rain event
- **Reduced sampling and monitoring costs**
- **Targeting mitigation investment**

DNA TESTING: A UNIQUE AND INNOVATIVE APPROACH RECOGNIZED BY THE INDUSTRY

- 1st integrated fecal source tracking strategy
- 1st optimized study applied to large urban watershed



Tracking bacteria to find pollution sources

An integrated watershed approach to improve water quality

Ting Lu, David Wendell, Donald Linn, Biju George, MaryLynn Lodor, and James Parrott

The Metropolitan Sewer District of Greater Cincinnati (MSD) operates and maintains a collection system of more than 4828 km (3000 mi) of pipe covering an area of more than 1036 km^2 (400 mi^2). Wet weather flows cause about 53.4 million m3 (14.1 billion gal) of combined wastewater to overflow into local waters each year.

Within these overflows, fecal microorganisms are a major source of surface water pollution. In fact, water quality evaluations conducted between 1999 and 2004 for Hamilton County — one area served by MSD — show that fecal bacteria are the sole pollutant of concern during both dry and wet weather.

But measuring only the concentration of fecal bacteria sheds no light on where the pollution originates. To help solve that problem, MSD, in conjunction with the University of Cincinnati, is conducting a watershed-scale biomonitoring assessment project that includes state-of-the-art microbial source tracking (MST).

This research fits within MSD's integrated watershed approach to improve water quality. The data collected by more incisive testing will help identify the source of the fecal bacteria and guide the development of more targeted combined sewer overflow fixes. Read full article (login required)

What is the right biomarker for water quality monitoring?

Pros and cons of fecal coliforms, *E. coli*, and alternative microorganisms and how they are used in watershed monitoring and water quality improvements

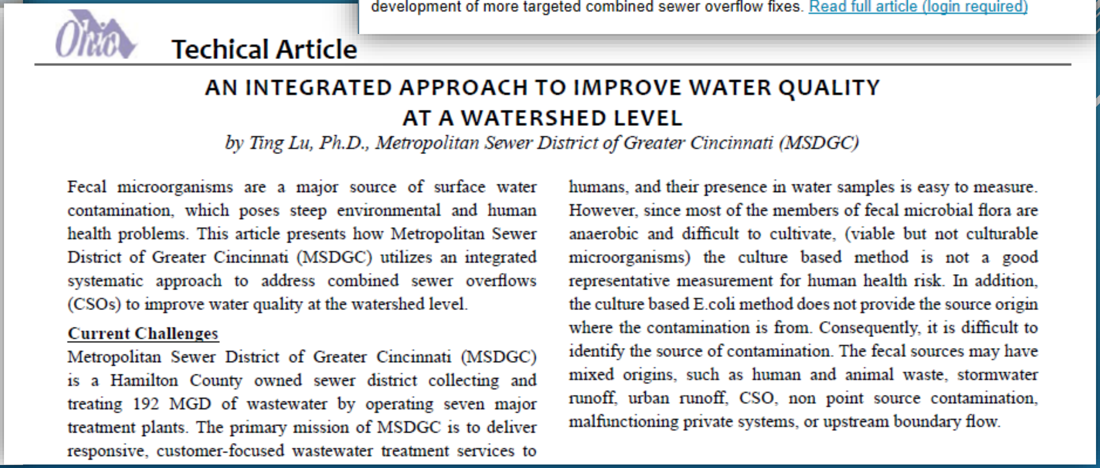
Ting Lu, Biju George, MaryLynn Lodor, Deborah Metz, James Parrott, James Fitzpatrick, Gary Hunter, Vikram Kapoor, and David Wendell

In the late 19th century, researchers developed the total plate count method for coliform colony counting as an indicator for pathogen and human health risk. By the mid-20th century, technologies were developed to distinguish total coliform, fecal coliform, and *Escherichia coli*. In 1986, the U.S. Environmental Protection Agency (EPA) recommended that *E. coli* be used as the indicator organism for recreational waters. In 2012, EPA recommended that both *E. coli* and enterococci be used for fresh waters.

In the last few decades, advances in molecular tools have made it possible to identify and quantify a large number of bacterial species without having to culture them. These molecular tools have several advantages:

- Since the reaction targets bacterial DNA and RNA, it eliminates false positive and false negative results from culture-based methods (i.e., viable but not culturable [VBNC] microorganisms will be detected by molecular methods but not by culture-based methods).
- These tools have a much faster turnaround time, require a small sample volume, and represent a majority of bacterial structure instead of single bacterial species.

A recent study undertaken by the Metropolitan Sewer District of Greater Cincinnati and the University of Cincinnati used biological water quality data – including fecal coliforms and *E. coli* along with some emerging pathogen indicators (*Bacteroides*, *E. coli* O157: H7, *Norovirus*, and *Streptococcus*) – to understand and identify pollution in the Duck Creek watershed with molecular tools (Kapoor et al., 2013).



Techical Article

AN INTEGRATED APPROACH TO IMPROVE WATER QUALITY AT A WATERSHED LEVEL

by Ting Lu, Ph.D., Metropolitan Sewer District of Greater Cincinnati (MSDGC)

Fecal microorganisms are a major source of surface water contamination, which poses steep environmental and human health problems. This article presents how Metropolitan Sewer District of Greater Cincinnati (MSDGC) utilizes an integrated systematic approach to address combined sewer overflows (CSOs) to improve water quality at the watershed level.

Current Challenges

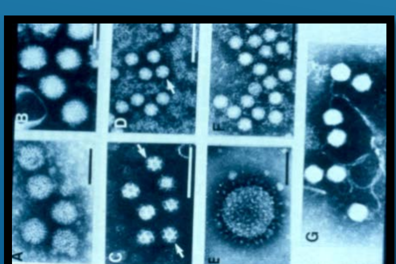
Metropolitan Sewer District of Greater Cincinnati (MSDGC) is a Hamilton County owned sewer district collecting and treating 192 MGD of wastewater by operating seven major treatment plants. The primary mission of MSDGC is to deliver responsive, customer-focused wastewater treatment services to humans, and their presence in water samples is easy to measure. However, since most of the members of fecal microbial flora are anaerobic and difficult to cultivate, (viable but not culturable microorganisms) the culture based method is not a good representative measurement for human health risk. In addition, the culture based E.coli method does not provide the source origin where the contamination is from. Consequently, it is difficult to identify the source of contamination. The fecal sources may have mixed origins, such as human and animal waste, stormwater runoff, urban runoff, CSO, non point source contamination, malfunctioning private systems, or upstream boundary flow.

MICROBIAL SOURCE TRACKING

Culture-based methods

- Total coliform
- Fecal coliform
- *E. coli*
- *Bacteroides*
  - Human
  - Bovine
  - Canine
  - Avian
- Pathogens
  - *E. coli* O157: H7
  - *Norovirus*
  - *Streptococcus*

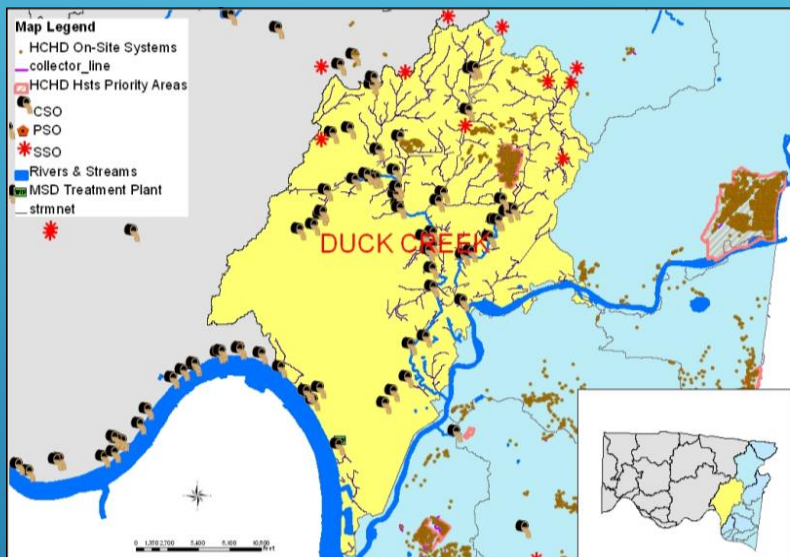
Molecular-based methods

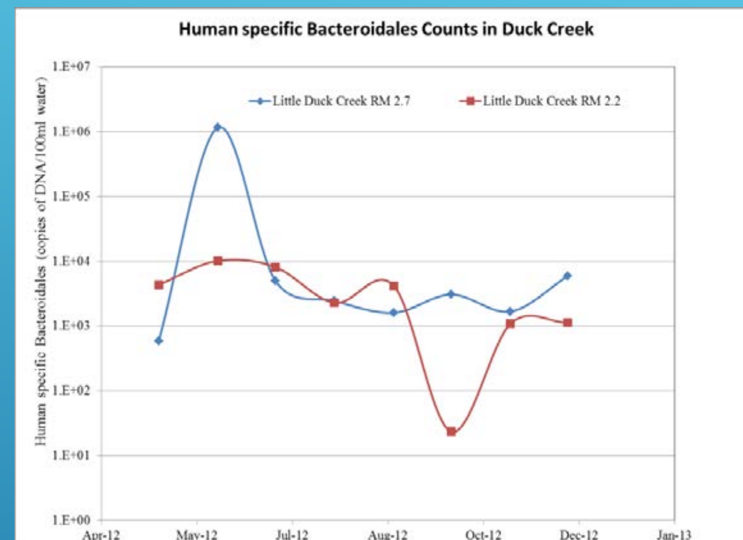


LINKING THE SOURCES WITH THE CAUSES

GIS Mapping

Source Quantification





Source Identification

Pollution origin	Pollution detection and causes/reasons
Human	Yes, CSO, SSO, and septic tanks
Bovine	No, no cattle in the watershed
Canine	Yes, pet facility nearby or parks
Avian	Yes, wild waterfowl

WATER QUALITY PROGRAM COMPONENT

Water Quality Monitoring

- Traditional sampling
- Remote sensing
- DNA testing
- Online sensors

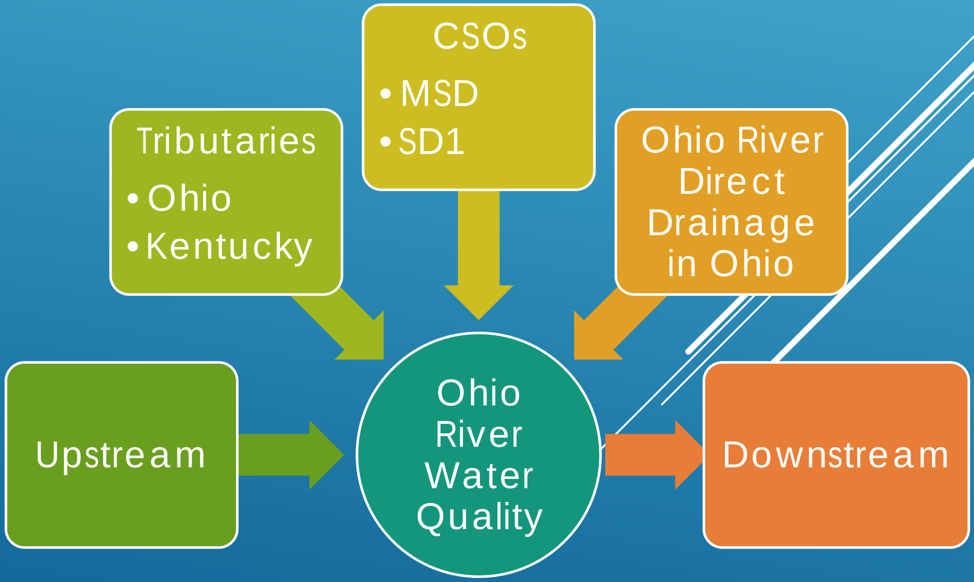
Water Quality Modeling

- Collection model
- Watershed model
- Receiving stream model

Watershed planning

WATER QUALITY MODEL GOALS

- Characterize Contaminant Sources and Load Allocations
- Refine Water Quality Model With Better Resolution and Nutrient Fate and Transport
- Provide Guidance for Phase II Wet Weather Improvement Program and Watershed Operations Division



INTEGRATED MODEL FOR EACH STREAM

Sewered area → Hydraulic model (SWMM)

Non-sewered area → Watershed model (EFDC)

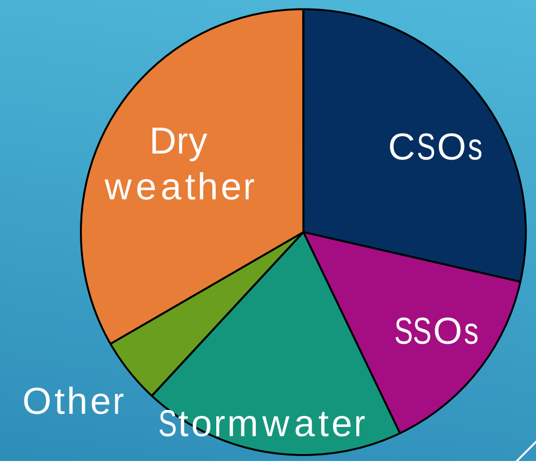
Surface Water Model

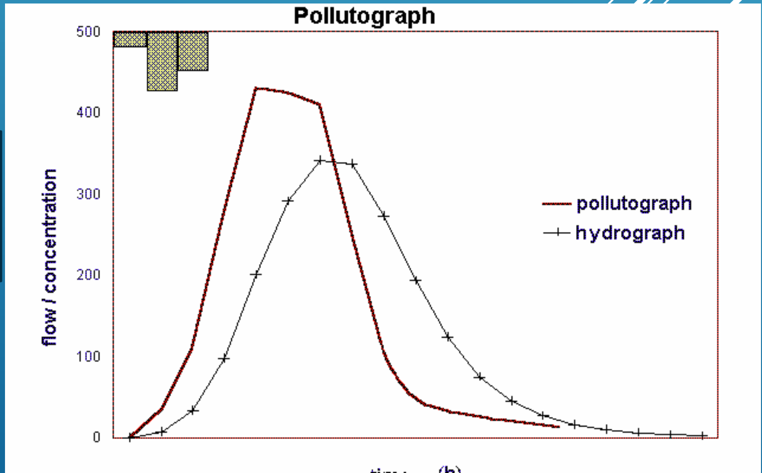
EFDC or WASP

→ River Hydrographs

→ River Pollutographs

Component Analysis





WATER QUALITY PROGRAM COMPONENT

Water Quality Monitoring

- Traditional sampling
- Remote sensing
- DNA testing
- Online sensors

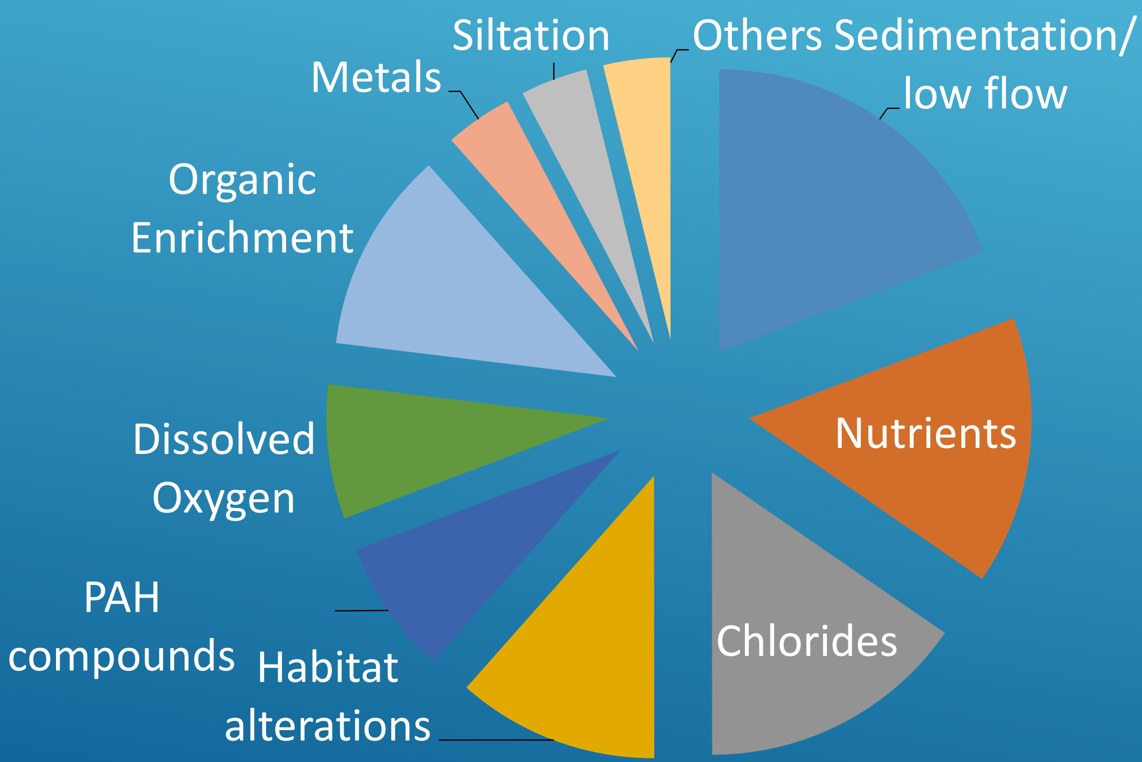
Water Quality Modeling

- Collection model
- Watershed model
- Receiving stream model

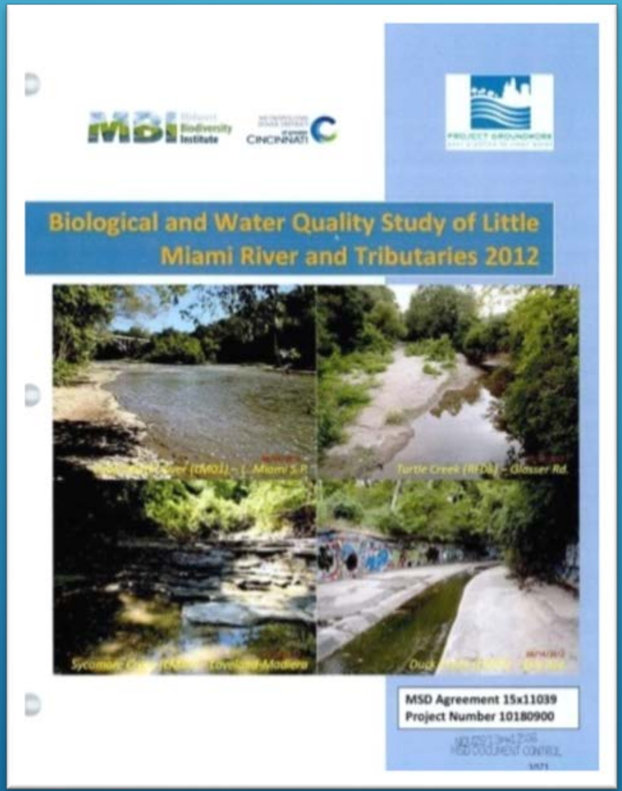
Watershed planning

- Pollutant sources/Causes Determination
- Integrated Watershed planning

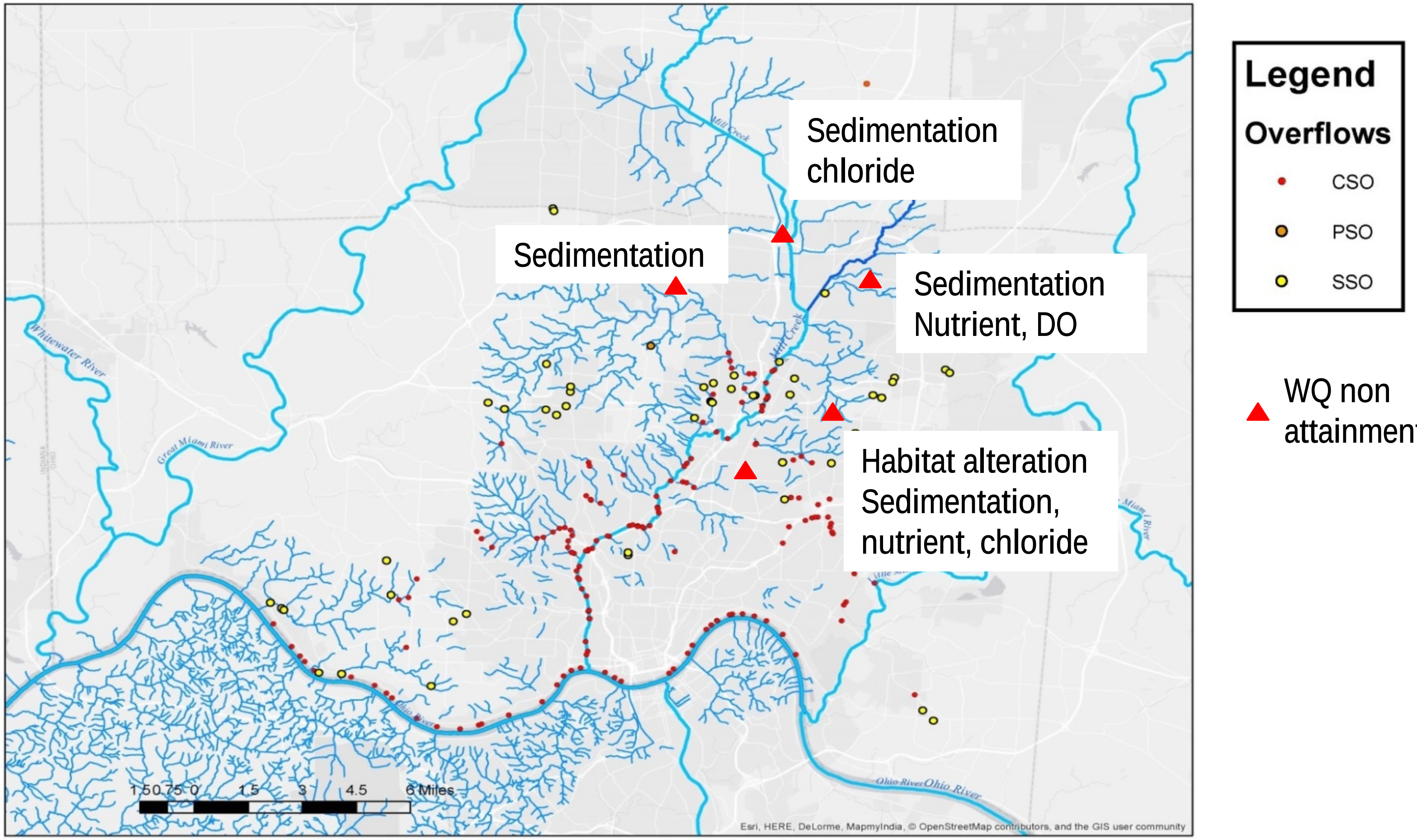
WATER QUALITY STRESSORS AND POTENTIAL SOURCES



Biological and Water Quality Studies 2011-2014

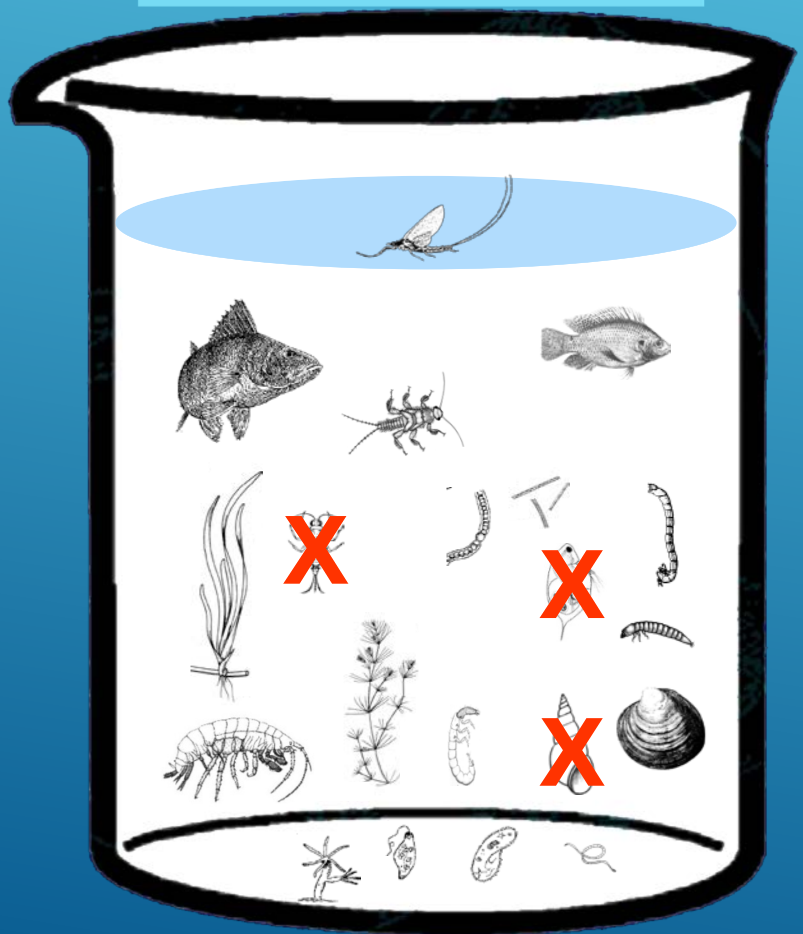


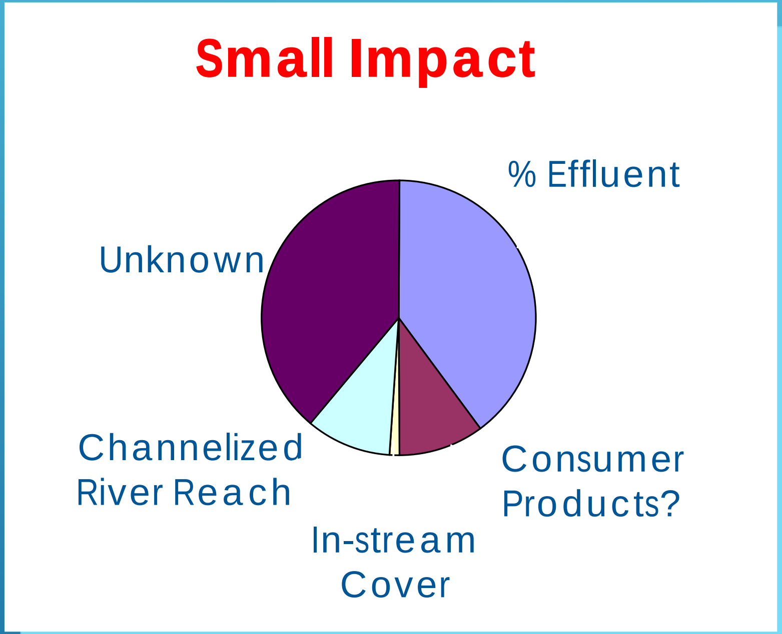
BIOASSESSMENTS HAVE VERIFIED CSOs ARE NOT THE ONLY SOURCE OF IMPAIRMENT



STRESSOR PRIORITIZATION: MULTIVARIATE ANALYSIS

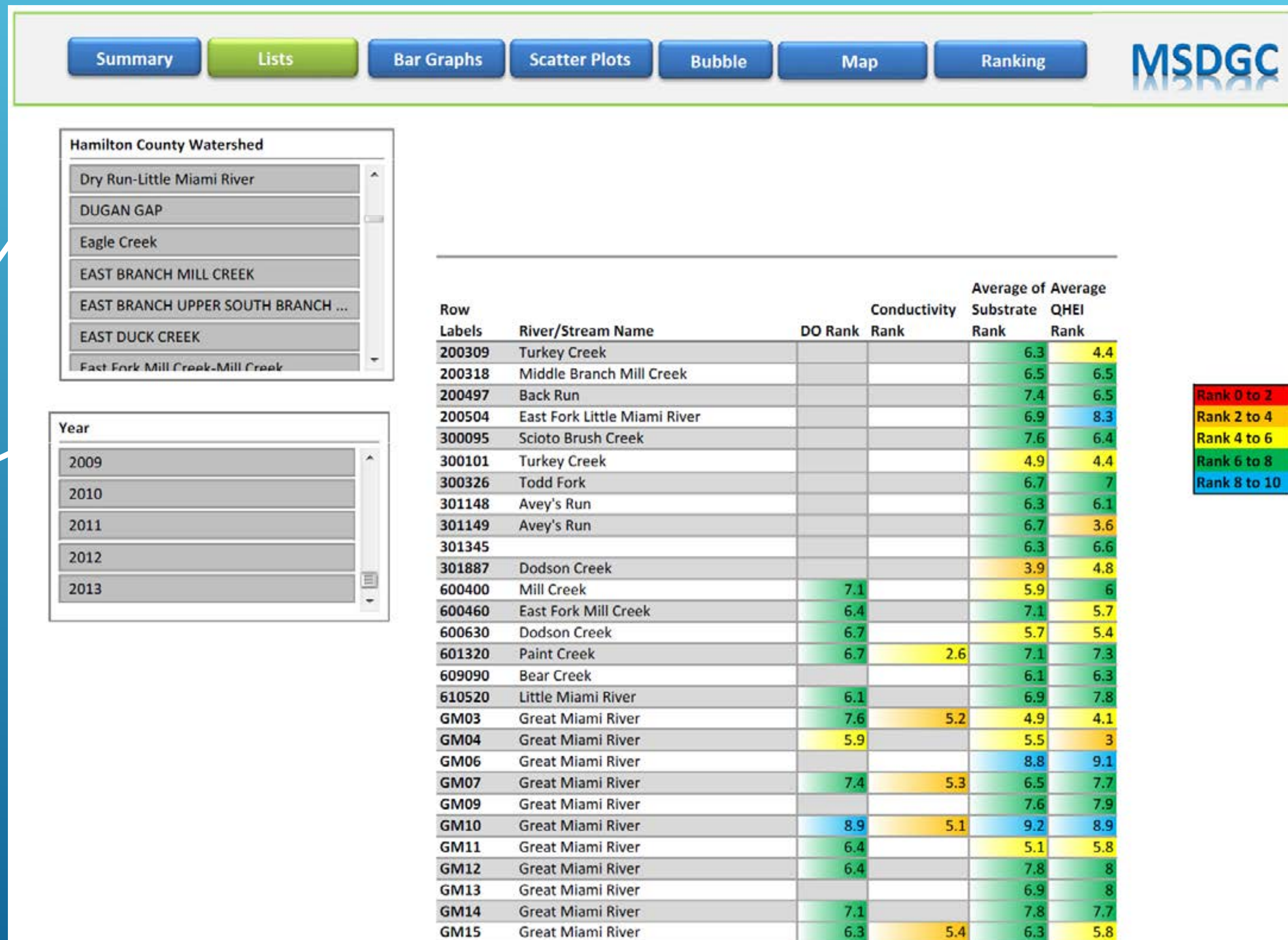
Missing Species





Figures courtesy of Scott_Dyer_PG

IPS DASHBOARD – SHOWS RANKINGS FOR STREAMS AND SITES



Row Labels	River/Stream Name	DO Rank	Conductivity Rank	Average of Substrate Rank	Average QHEI Rank
200309	Turkey Creek			6.3	4.4
200318	Middle Branch Mill Creek			6.5	6.5
200497	Back Run			7.4	6.5
200504	East Fork Little Miami River			6.9	8.3
300095	Scioto Brush Creek			7.6	6.4
300101	Turkey Creek			4.9	4.4
300326	Todd Fork			6.7	7
301148	Avey's Run			6.3	6.1
301149	Avey's Run			6.7	3.6
301345				6.3	6.6
301887	Dodson Creek			3.9	4.8
600400	Mill Creek	7.1		5.9	6
600460	East Fork Mill Creek	6.4		7.1	5.7
600630	Dodson Creek	6.7		5.7	5.4
601320	Paint Creek	6.7	2.6	7.1	7.3
609090	Bear Creek			6.1	6.3
610520	Little Miami River	6.1		6.9	7.8
GM03	Great Miami River	7.6	5.2	4.9	4.1
GM04	Great Miami River	5.9		5.5	3
GM06	Great Miami River			8.8	9.1
GM07	Great Miami River	7.4	5.3	6.5	7.7
GM09	Great Miami River			7.6	7.9
GM10	Great Miami River	8.9	5.1	9.2	8.9
GM11	Great Miami River	6.4		5.1	5.8
GM12	Great Miami River	6.4		7.8	8
GM13	Great Miami River			6.9	8
GM14	Great Miami River	7.1		7.8	7.7
GM15	Great Miami River	6.3	5.4	6.3	5.8

Excel spreadsheet allows user to select specific streams, sites, & year of data

HOLISTIC WATER QUALITY MANAGEMENT

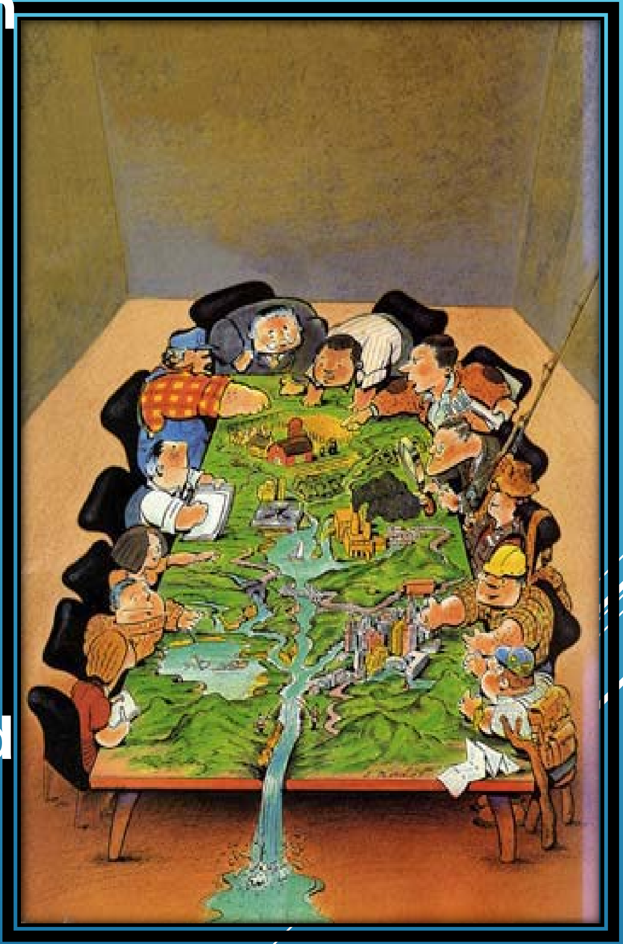
Water Quality

Habitat Restoration

Meeting Compliance

WATER QUALITY PROGRAM ANSWERS

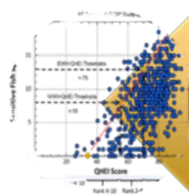
- What are impacts of CSOs and SSOs on the water quality?
- What are the other pollution contributions?
- What is impact of water quantity vs. water quality?
- How to prioritize engineering projects?
- How to measure engineering project effectiveness?
- How should we optimize the watershed operation?
- How do we assess human health risk when exposed to the impairment of water body?



COLLABORATED PROGRAM

- Conduct wet weather sampling

- Update water quality models



- Scenario evaluations with Integrated Priority System Tool

- Perform additional innovative technologies

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Together

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