Urban pollution footprints on the Great Lakes

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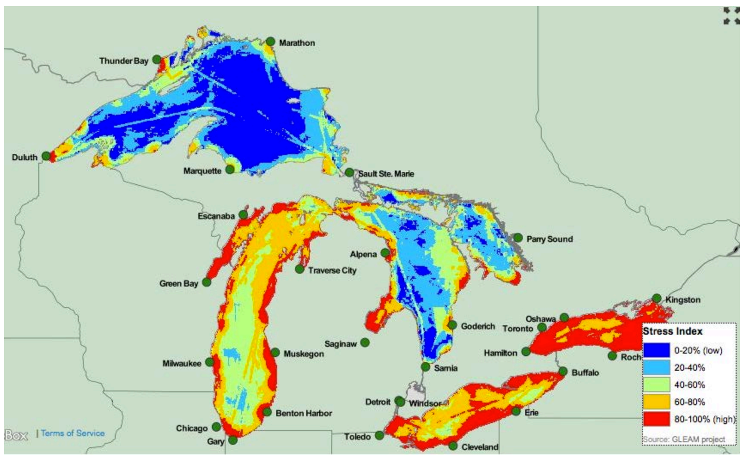
Urbanization of Great Lakes watersheds stresses our water resources



Pathogens carried by fecal pollution in surface waters

Sources: **Agricultural runoff***
Sewage discharges*
Urban stormwater

Map: University of Michigan Water Center

Agricultural runoff also a major stressor

How do watershed managers find a needle in a haystack?

- Up to 30% of wastewater is "lost" in the system (USGS)
- Major metropolitan area: 3,000 miles of city owned

Project Overview

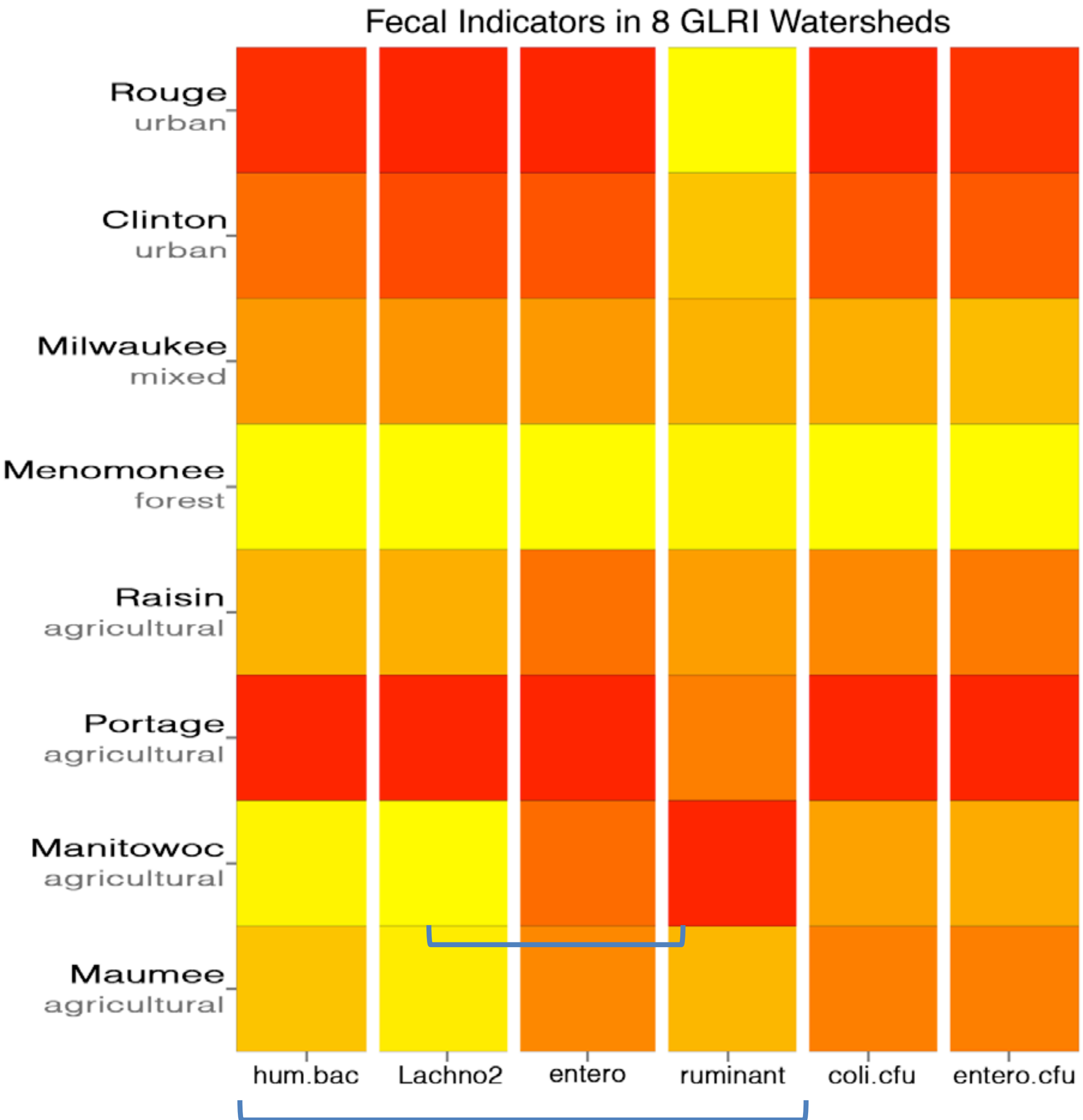
Lake wide   Nearshore by beaches   City block

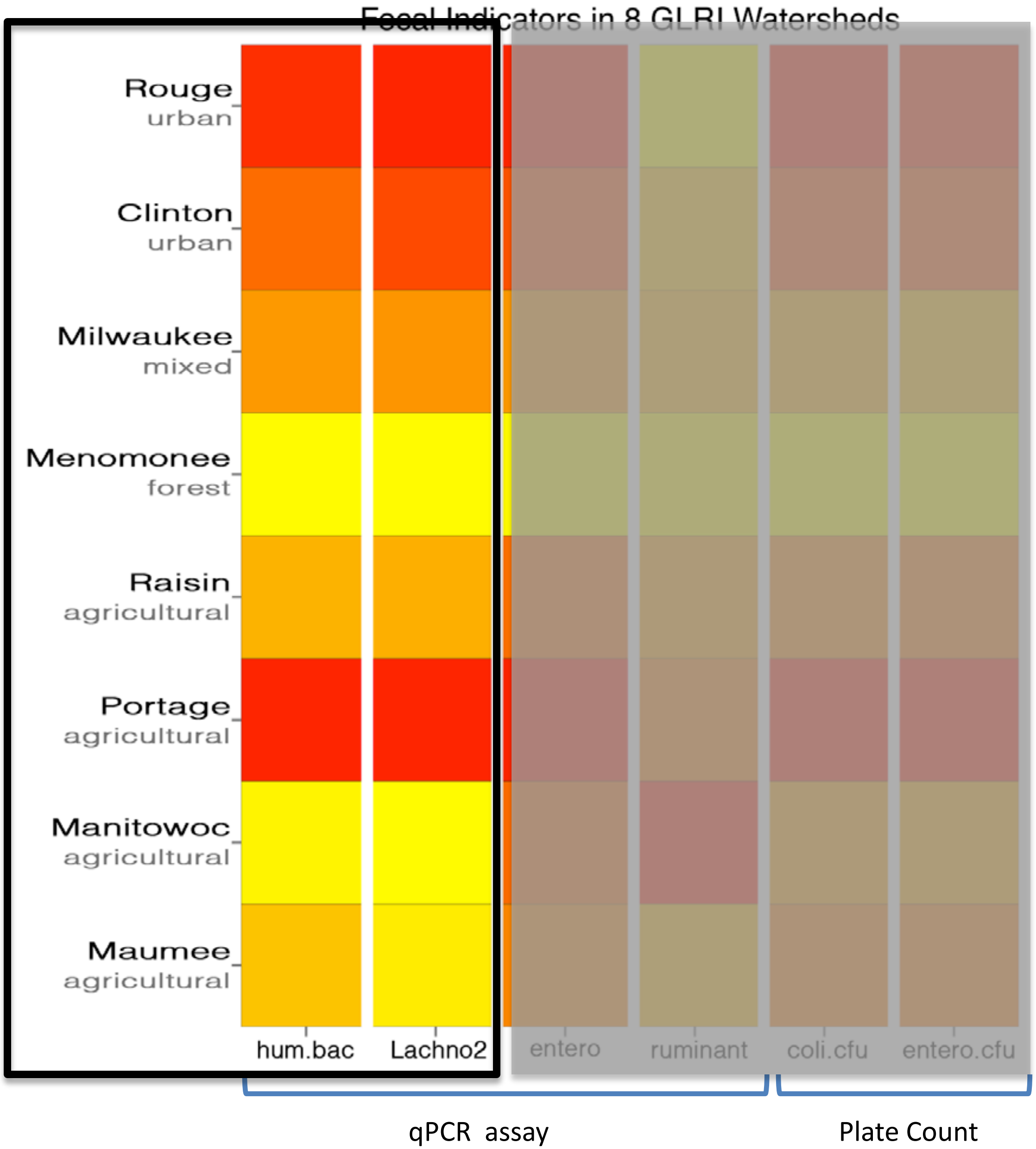
- How much sewage is released from watersheds? *(Compare this to agriculture, compare across urban areas)*

- How is sewage distributed to nearby beaches? *(Milwaukee as a case study)*

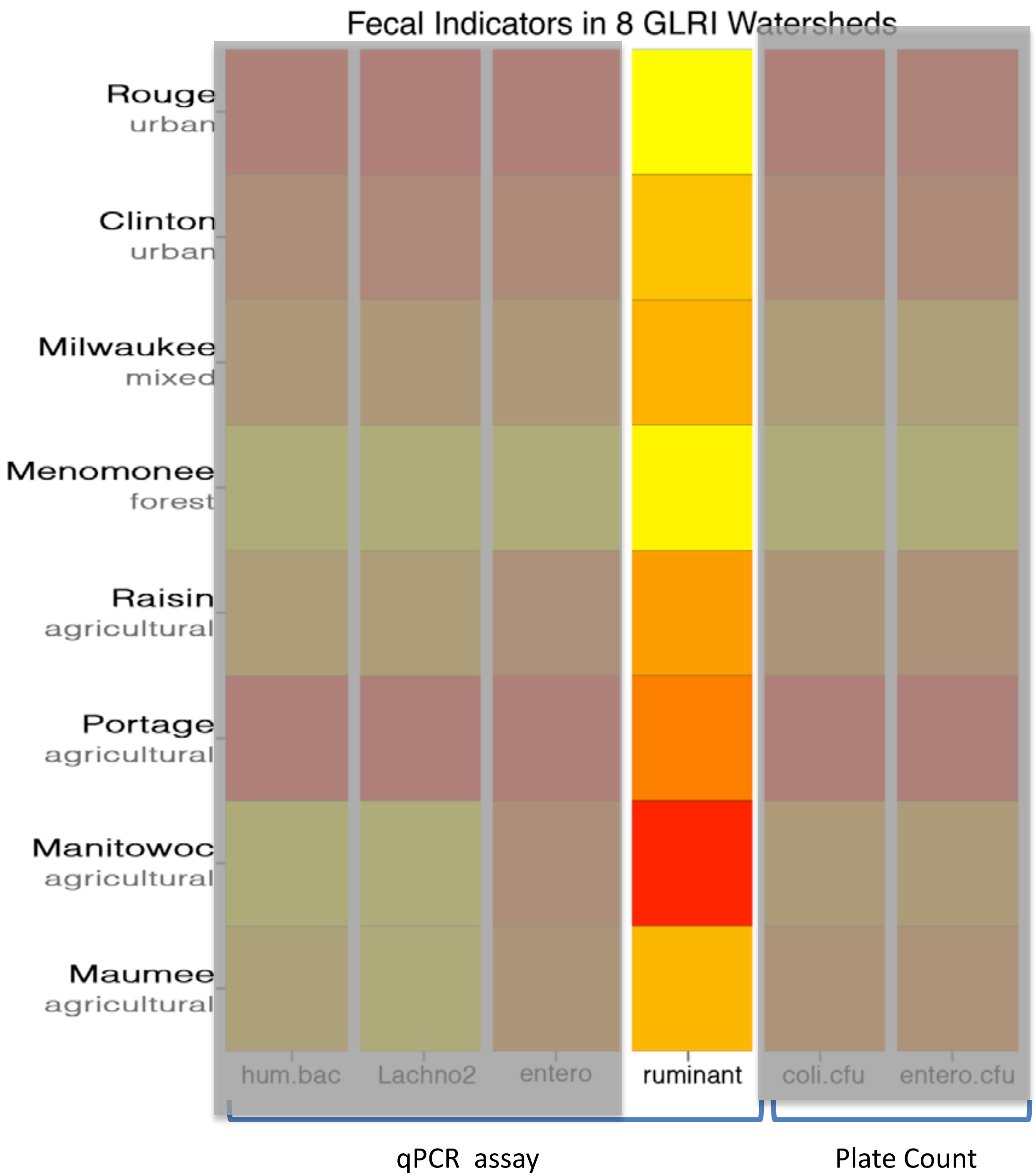
- How can we locate the physical breeches in the system? *(create a optical sensor, deploy in two test areas, Milwaukee and Clinton)*

Objective 1: Quantify fecal pollution amounts and sources from eight watersheds across a gradient of agricultural to urbanized land use





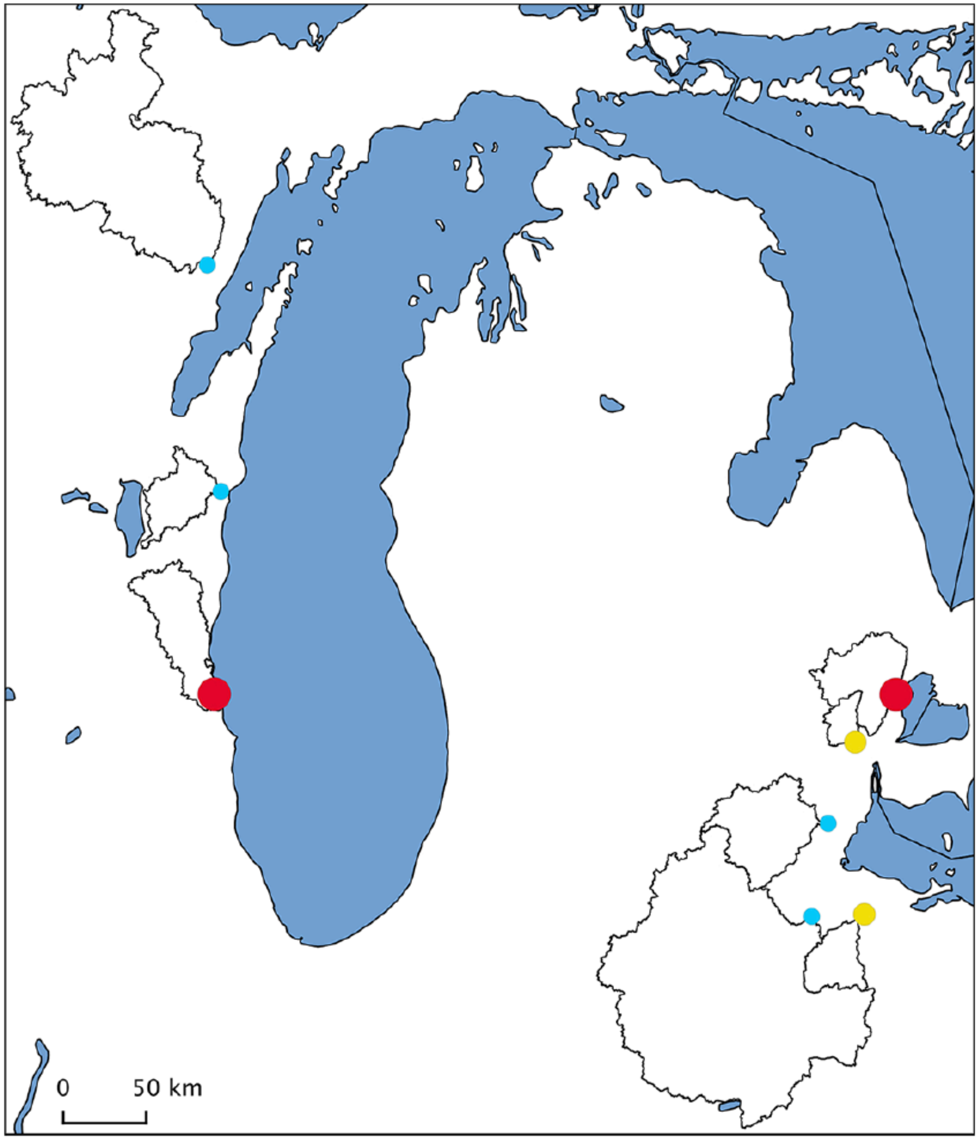
Heat map comparing concentrations of fecal indicators in river sites. (Compare columns, not rows)



Heat map comparing concentrations of fecal indicators in river sites. (Compare columns, not rows)

Yields: What watersheds add the most human fecal pollution per acreage?

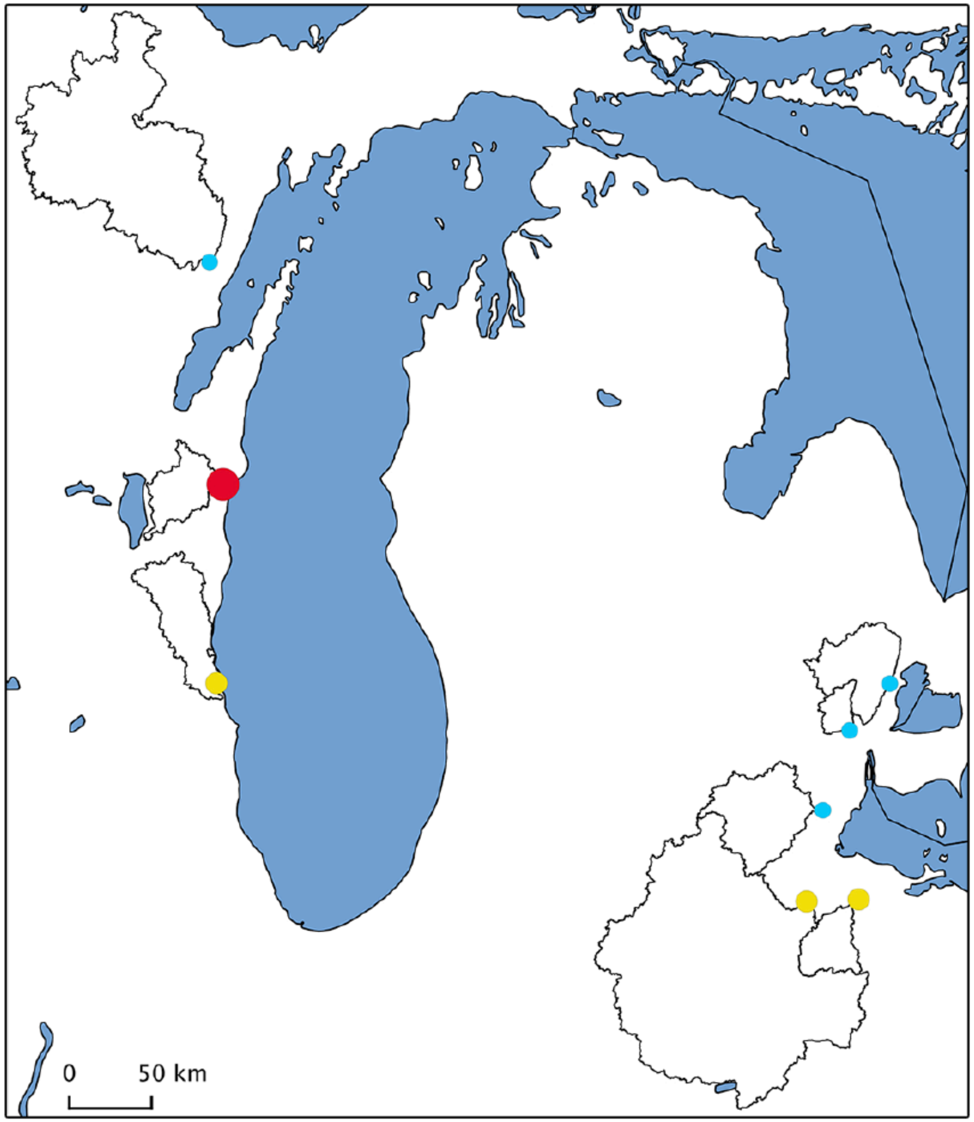
Optical sensor work focused on the two worst



Human Lachnospiraceae: Average Event **Yield** (CN/km²)

- 3.57E+10 - 1.80E+12
- 5.70E+12 - 8.06E+12
- 9.60E+12 - 1.12E+13

Yields: What watersheds add the most ruminant fecal pollution per acreage?



Ruminant Bacteroidaceae: Average Event **Yield** (CN/km²)

- 2.29E+10 - 1.25E+12
- 3.14E+12 - 7.31E+12
- 1.24E+13

Objective 1: Quantify fecal pollution amounts and sources from six watersheds across agricultural to urbanized land use

Stakeholders: Watershed managers

Initial: TMDL team (occurring now)

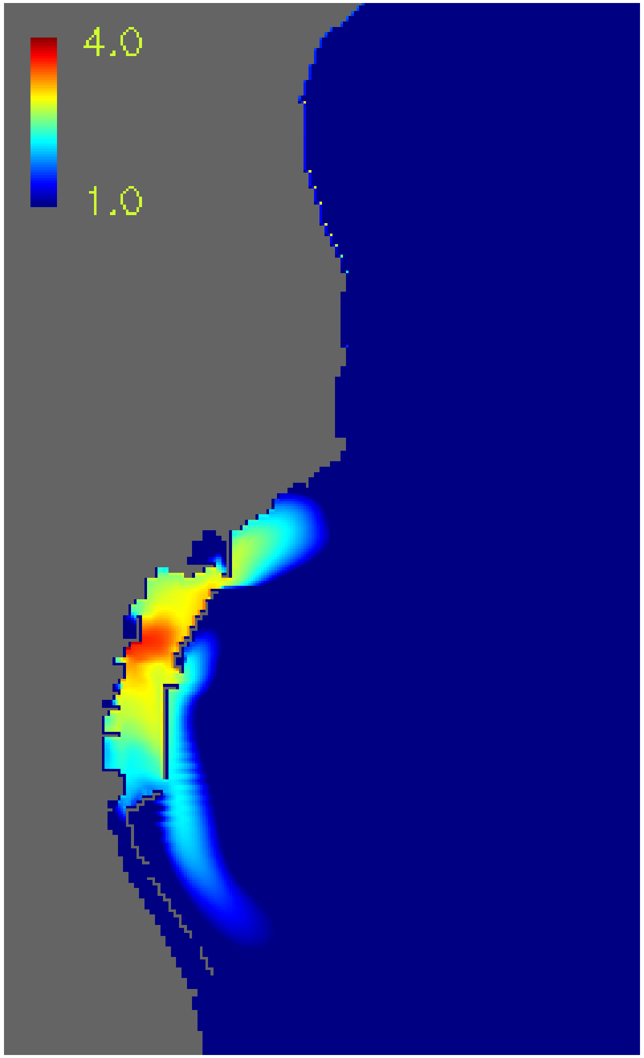
Future: Clinton River Watershed (with USGS)

How information will be used:

Prioritize management to reduce sources. i.e. **TMDLs, permitting -** *work directly with TMDL team*

Policy Brief Key Message: **High fecal coliforms are from human and non-human sources. Human sources are the greats health risk**

Objective 2) Integrate source specific loading into nearshore hydrodynamic modeling



Use existing nearshore Milwaukee Model with 16 events

Determine the degree in which beaches are impacted by sewage discharges

Stakeholders: beach managers

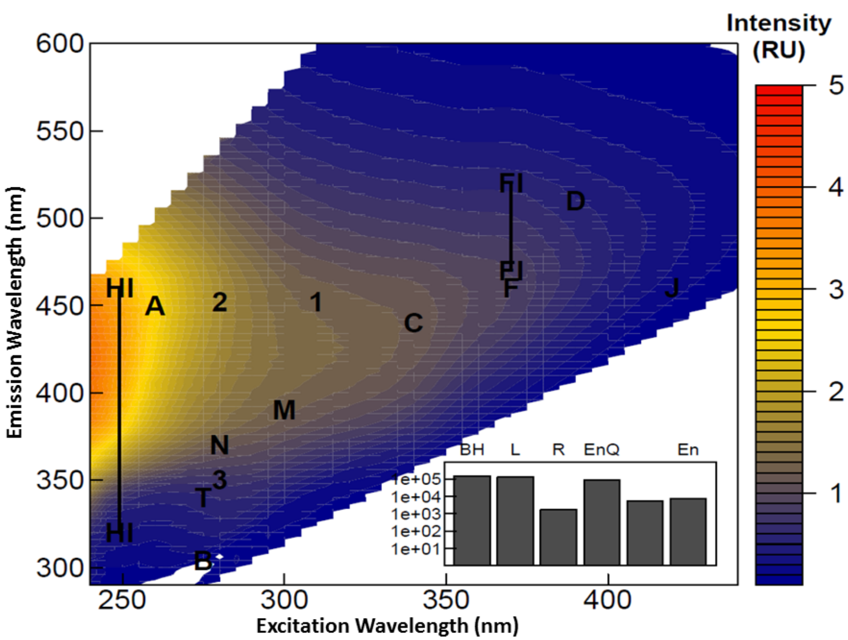
Policy Brief Key Message:
Beaches may need to be preemptively closed following major rain events under specific conditions

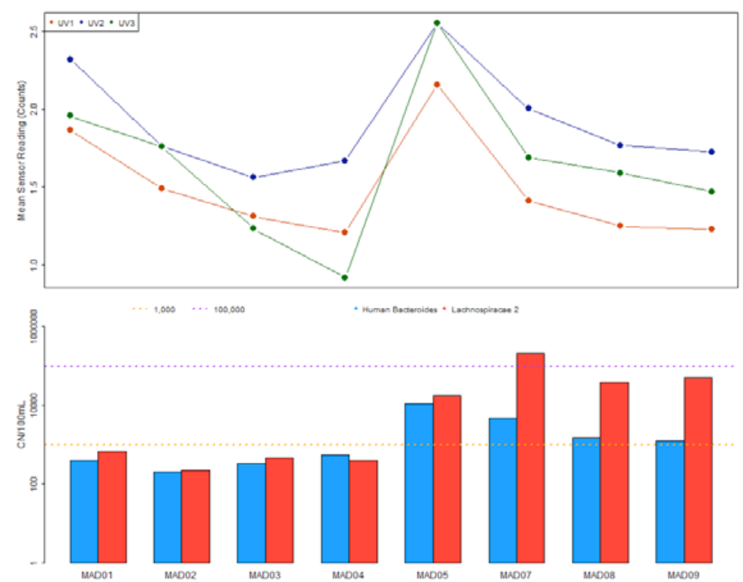
Objective 3) correlate optical properties with alternative indicators

Alternative bacterial indicators indicators detected by qPCR are three orders of magnitude more sensitive than optical signals

Stakeholders: municipalities

Policy Brief Key Message: **Rapid sensor technology is needed to effectively direct fiscal resource to address widespread problem**





Stakeholders engagement

- Workshop with stakeholders (conceptual model)- near completion
- Beach manager surveys (has shaped dissemination)
- Policy briefs and technical reports (translational aspect of publications)
- Directly working with the TMDL team (iterative input during TMDL implementation, longstanding collaboration leads to opportunities)

Policy briefs

Key message

Graphic

Science gap

Policy Recommendation

Source Specific Fecal Indicators Emphasize Human Health Risk for Water Quality Monitoring

Key Message High concentrations of fecal coliforms from human and non-human sources are a frequent and costly impairment of water quality. Human sources carry the greatest health risk and should be minimized.

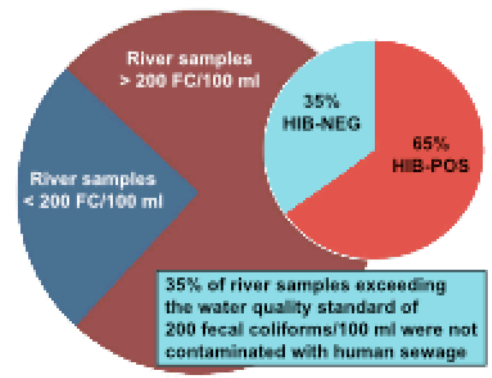
What is the Issue?

Elevated counts of fecal indicator bacteria, including fecal coliforms, are used to warn of possible pathogens in recreational waters, and pathogens are the most frequent water quality impairments in the United States (EPA, 2014). Advisories and beach closures are regularly implemented to minimize recreational exposure to impacted waters and reduce disease outcomes. There are many sources of fecal coliforms, both human and non-human, but human fecal pollution has well documented association with illness following recreational exposure to sewage-contaminated water (EPA, 2010). Traditional water quality monitoring does not discern the source of fecal pollution, and reliance solely on fecal coliform monitoring may misdirect cleanup efforts by focusing on sources that are not associated with the pathogen impairment.

The Context

Fecal indicator bacteria used for water quality monitoring are common to human, non-human and environmental sources (ref). Generally fecal indicator bacteria do not cause disease but they are easy to measure in water samples and elevated counts may indicate a human sewage pollution source. When the source of pollution in recreational waters is human sewage there is an increased risk for exposure to human pathogens and the association between sewage pollution and gastrointestinal illness is well documented (ref). However, frequently the source of fecal coliforms and other fecal indicator bacteria is not human sewage and health risks associated with exposure can be much lower (Soller et al., 2010).

The ultimate rational behind testing for fecal pollution is to protect public health. But, recreational water advisories, beach closings, and regulating bacteria through total maximum daily loads (TMDLs) are very costly outcomes for municipalities (ref). Even when the source is not human, elevated fecal indicators force managers to make financially resonant decisions based on little pathogen risk. For these reasons it is critical to identify areas with human sewage contributions to water quality issues as they pose the highest health risk and knowledge of sewage-impacted water quality issues will allow managers to confidently impose control strategies. When human specific indicators of fecal pollution are targeted in monitoring efforts, we will do a much better job of protecting public health, well-being and assets.



~~Figure 1.~~ River samples that did not meet water quality standards were not always impacted by sewage pollution. Risk from human pathogens would be comparatively lower in those samples. Samples were collected at sites in Milwaukee, WI from 2009-2013.

What is the Science Gap?

Hot spots for fecal pollution are not always hot spots for human sewage (Figure 1).

Policy Recommendation

Prioritize reducing human sources for the maximum human health benefit.

Policy briefs

Key message

Graphic

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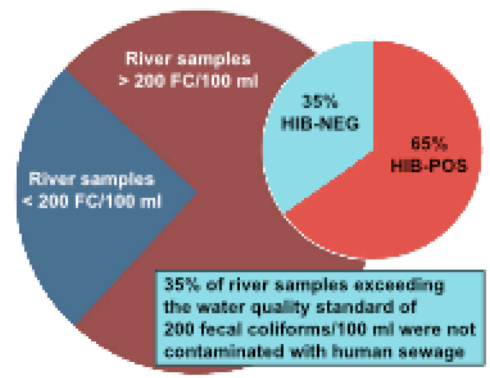

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Policy Recommendation

Prioritize reducing human sources for the maximum human health benefit.

Project Expertise

Principal Investigator
Sandra McLellan, Professor
School of Freshwater Sciences
University of Wisconsin-Milwaukee
Environmental Microbiology and Bacterial Genetics: tracking fecal pollution sources in the environment using alternative indicators

Co-Principal investigators
Hector Bravo, Professor
Department of Civil Eng. and Mechanics
University of Wisconsin-Milwaukee
Modeling: hydrodynamic model of nearshore to determine sewage distribution of beaches

Steve Corsi, Hydrologist
United States Geological Survey
Madison, Wisconsin
Hydrology: calculating pollutant loads from eight watersheds (GLRI), innovative sampling and detection of pollutants

Additional Team Members
Jenny Kehl
Director, Center for Water Policy
School of Freshwater Sciences
University of Wisconsin-Milwaukee
Water Policy: communicating science for policy makers and stakeholders, creating policy briefs

Georgia Mavrommati
Post Doctoral Researcher
Water Sciences Center
Michigan State University
Environmental Economics: stakeholder engagement, socioeconomic and natural systems linked in a model (water quality/sewage case study)