Monitoring of Human Pathogens and Source Identifiers for Discharges Across the United States: QMRA from Source to Bathing Site

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Fecal Source Identification and Associated Risk Assessment Tools, SCCWRP, November 28-29, 2012

In collaboration with

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Quantification of Pathogens and Sources of Microbial Indicators for QMRA in Recreational Waters

WERF Report PATH2R08

Author(s): Stefan Wuertz, Woutrina Miller, Dustin Bambic, Graham McBride

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Type And Geographical Area Of Monitoring Sites

7-month campaign, 3+1 distinct regions, 67 samples

The WERF "Toolkit"

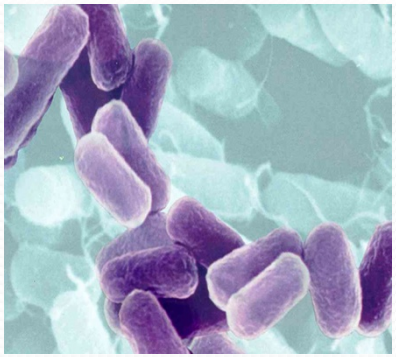
BACTERIA

V. cholerae

Campylobacter

Salmonella

V. parahaemolyticus

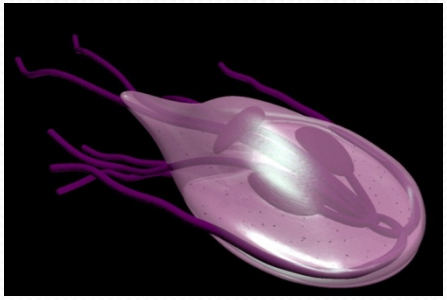


PROTOZOA

Giardia

Cryptosporidium

Toxoplasma



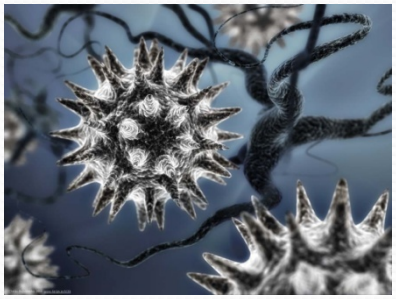
VIRUSES

Adenovirus

Enterovirus

Norovirus

Rotavirus



INDICATORS / SOURCE IDENTIFIERS

E. coli

Enterococcus

Bacteroidales (BacHum, BacCow, BacCan, BacUni)

Bird-associated assay (*Catellicoccus)*

The WERF "Toolkit"

RED = Priority Pathogens

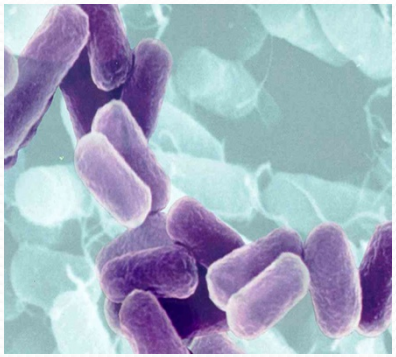
BACTERIA

V. cholerae

Campylobacter

Salmonella

V. parahaemolyticus



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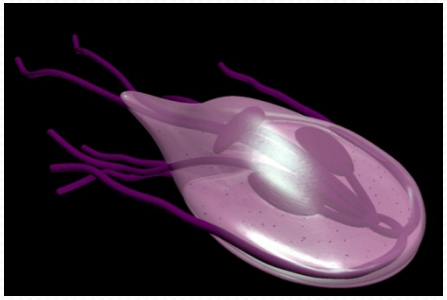

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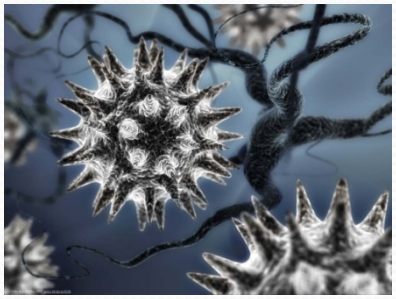
Adenovirus

Enterovirus

Norovirus

Rotavirus



INDICATORS / SOURCE IDENTIFIERS

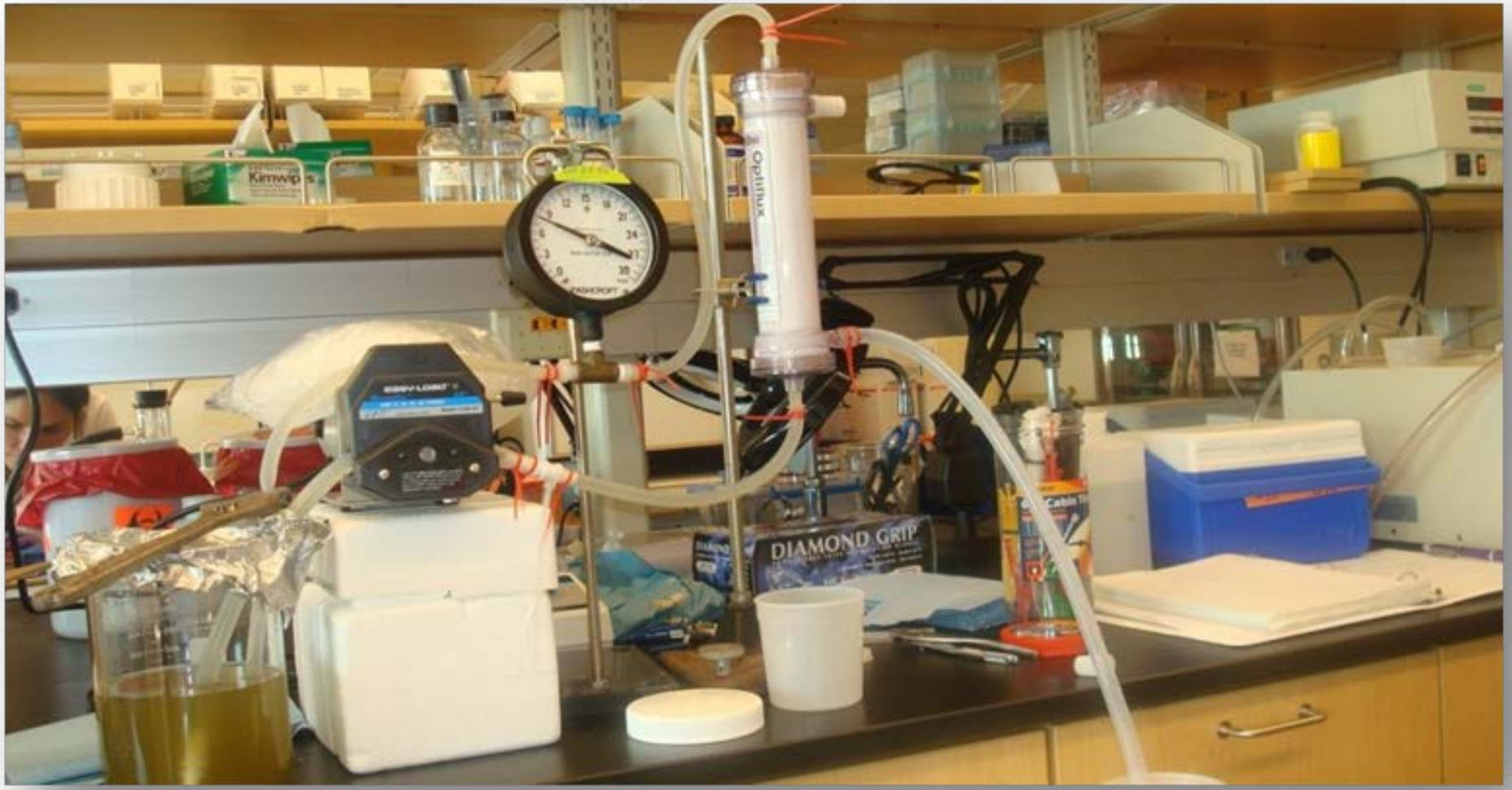
E. coli

Enterococcus

Bacteroidales (BacHum, BacCow, BacCan, BacUni)

Bird-specific assay (*Catellicoccus)*

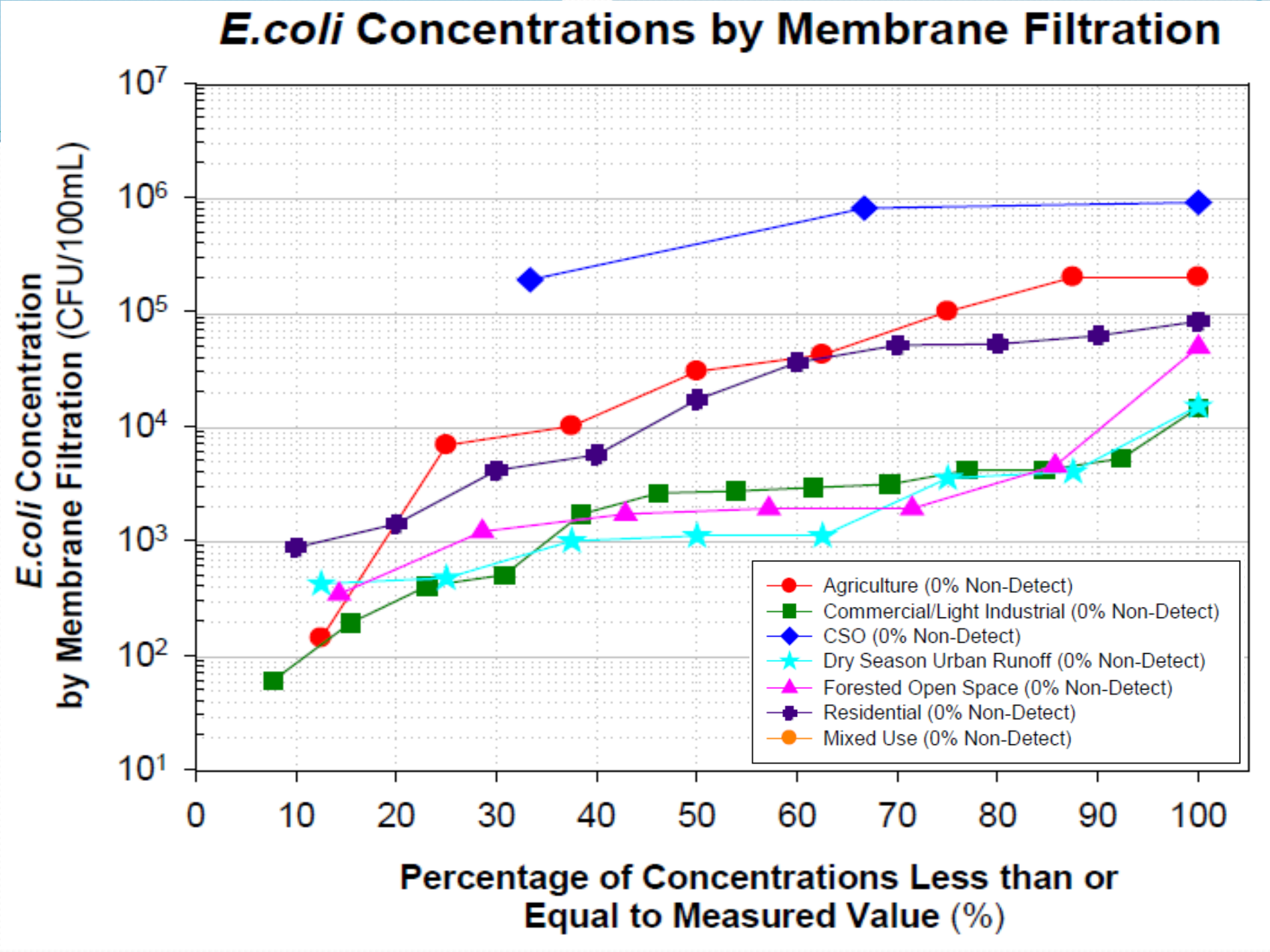
Experimental Set Up Using Fresenius Hollow-Fiber Ultrafiltration (HFF) Single-Use Cartridges



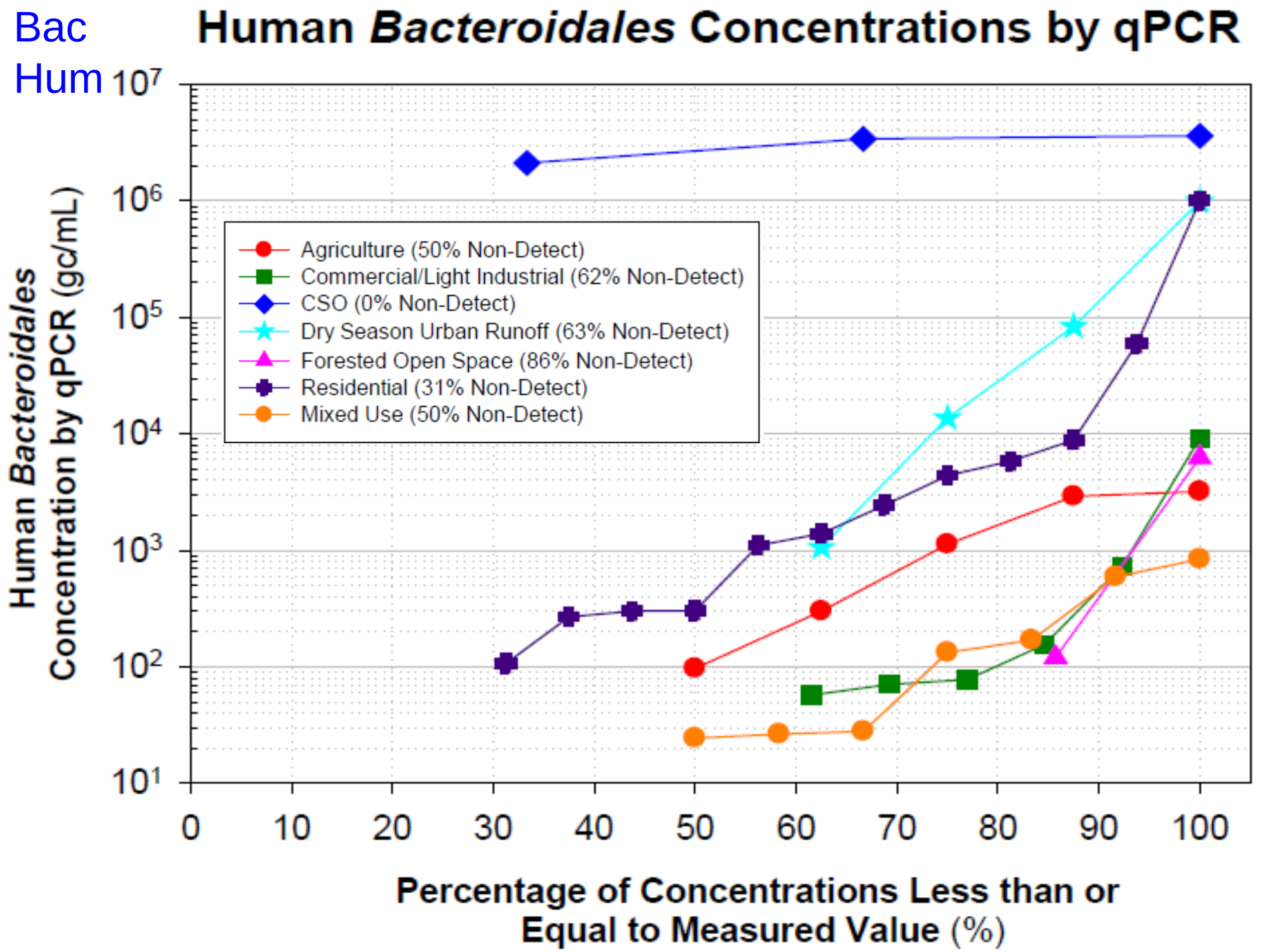
Monitoring Results: Pathogens

- Norovirus, Rotavirus, and Adenovirus 40/41 were more prevalent than *Cryptosporidium*, *Giardia* and pathogenic bacteria in stormwater or natural runoff.

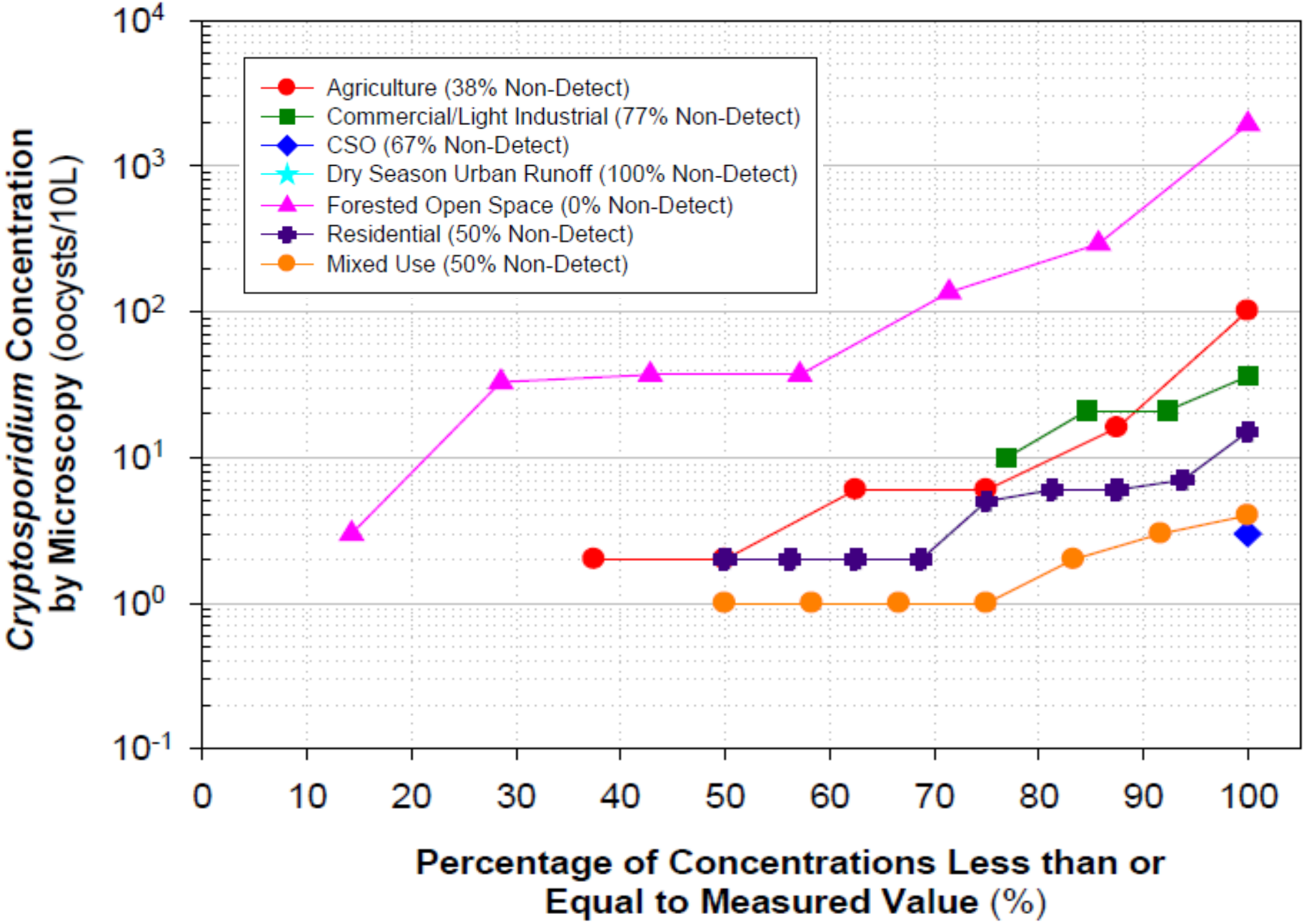
- Norovirus GI and GII were reasonable predictors of other pathogens like Adenovirus 40/41, Adenovirus C, *Giardia* and *Cryptosporidium*.

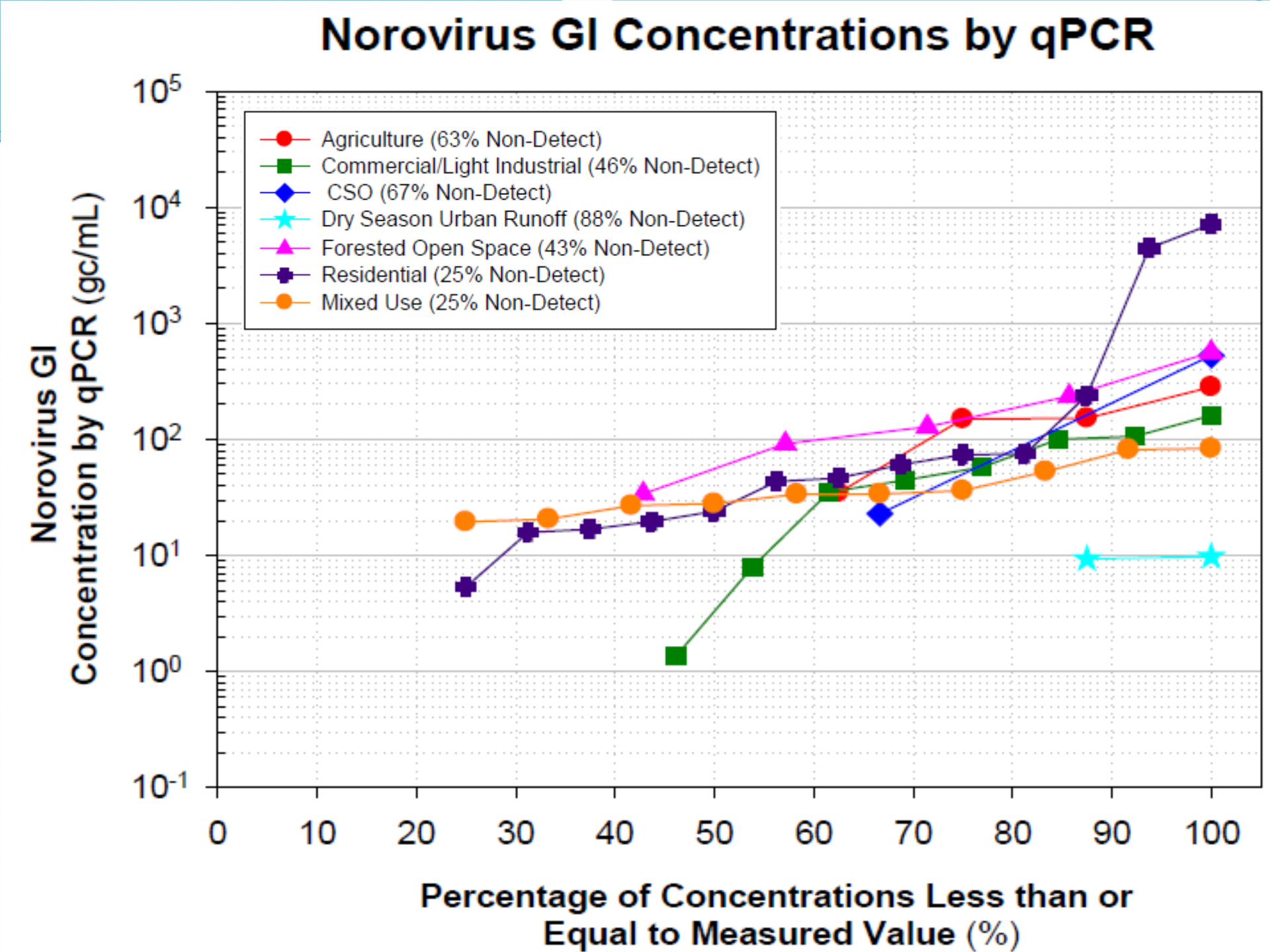

E.coli Concentrations by Membrane Filtration
E.coli Concentration by Membrane Filtration (CFU/100mL)
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
10
20
30
40
50
60
70
80
90
100
Percentage of Concentrations Less than or Equal to Measured Value (%)
Agriculture (0% Non-Detect)
Commercial/Light Industrial (0% Non-Detect)
CSO (0% Non-Detect)
Dry Season Urban Runoff (0% Non-Detect)
Forested Open Space (0% Non-Detect)
Residential (0% Non-Detect)
Mixed Use (0% Non-Detect)

Bac
Hum


Human Bacteroidales Concentrations by qPCR
Human Bacteroidales Concentration by qPCR (gc/mL)
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
10
20
30
40
50
60
70
80
90
100
Percentage of Concentrations Less than or Equal to Measured Value (%)
Agriculture (50% Non-Detect)
Commercial/Light Industrial (62% Non-Detect)
CSO (0% Non-Detect)
Dry Season Urban Runoff (63% Non-Detect)
Forested Open Space (86% Non-Detect)
Residential (31% Non-Detect)
Mixed Use (50% Non-Detect)

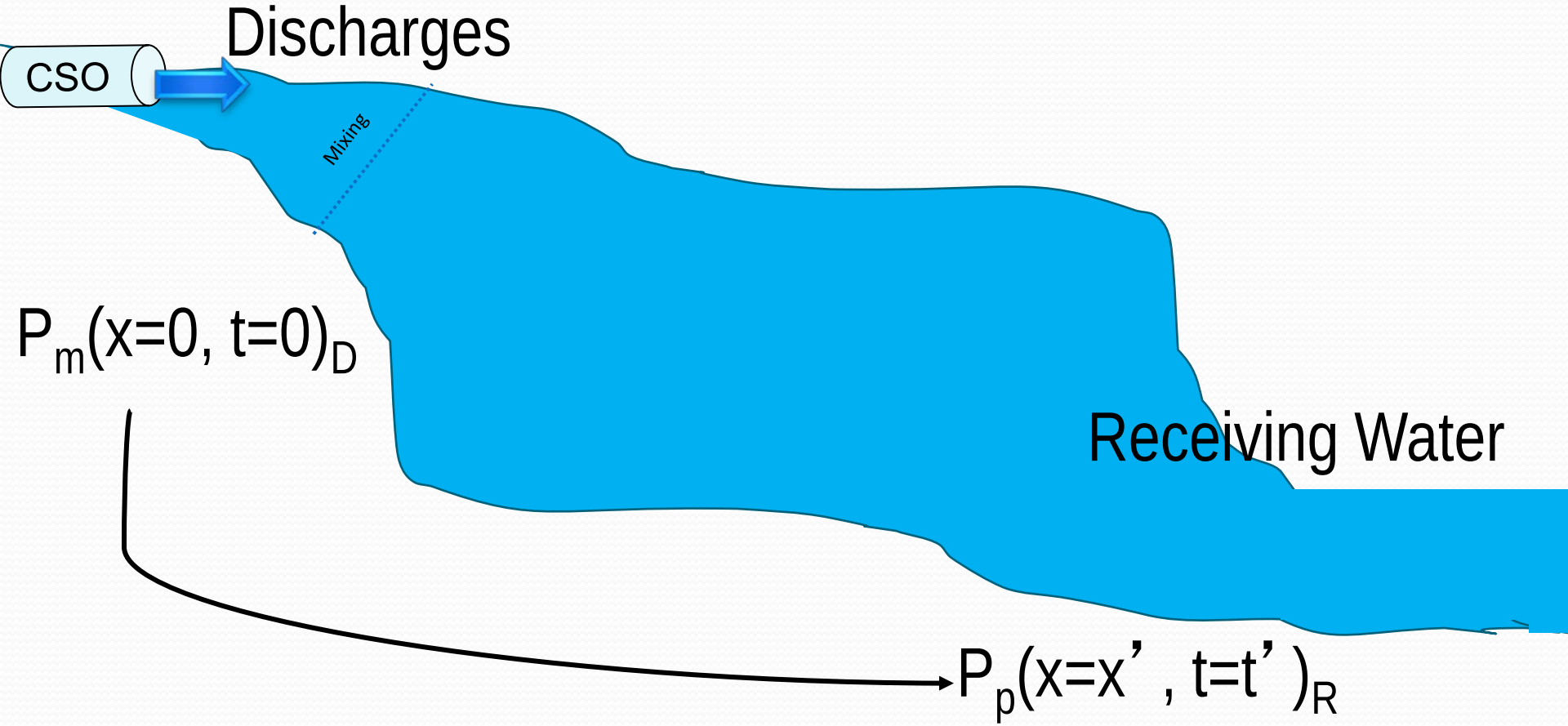
Cryptosporidium Concentrations by Microscopy




Norovirus GI Concentrations by qPCR
Agriculture (63% Non-Detect)
Commercial/Light Industrial (46% Non-Detect)
CSO (67% Non-Detect)
Dry Season Urban Runoff (88% Non-Detect)
Forested Open Space (43% Non-Detect)
Residential (25% Non-Detect)
Mixed Use (25% Non-Detect)
Norovirus GI Concentration by qPCR (gc/mL)
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
0
10
20
30
40
50
60
70
80
90
100
Percentage of Concentrations Less than or Equal to Measured Value (%)

Step 1: Discharges ⟶ Receiving Water

$P_m(x=0, t=0)_D \longrightarrow P_p(x=x', t=t')_R$



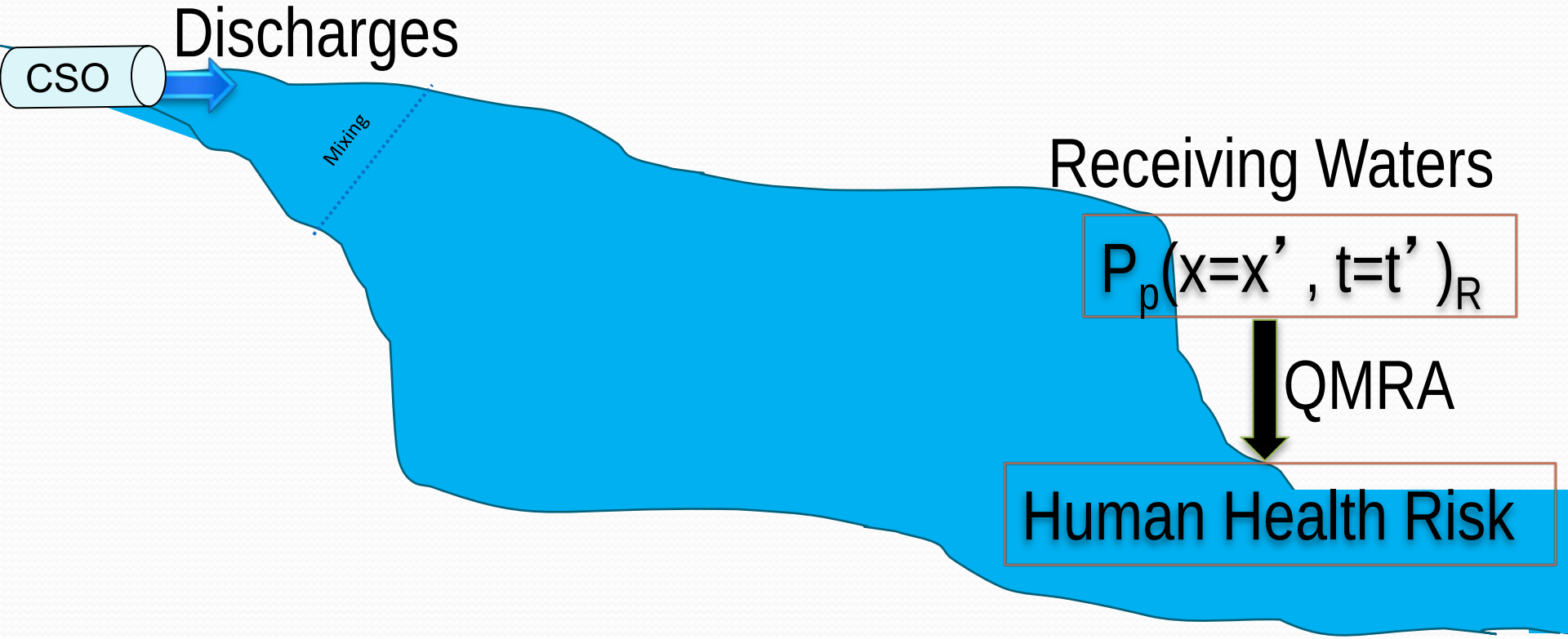
P_p= Predicted Pathogen Conc.

P_m = Measured Pathogen Conc.

x = Distance, t = Time , D = Discharge, R = Receiving Water

Step 2: Prediction of Health Risk

$P_p\,(x=x',\ t=t')_R \xrightarrow{\text{QMRA}}$ Human Health Risk

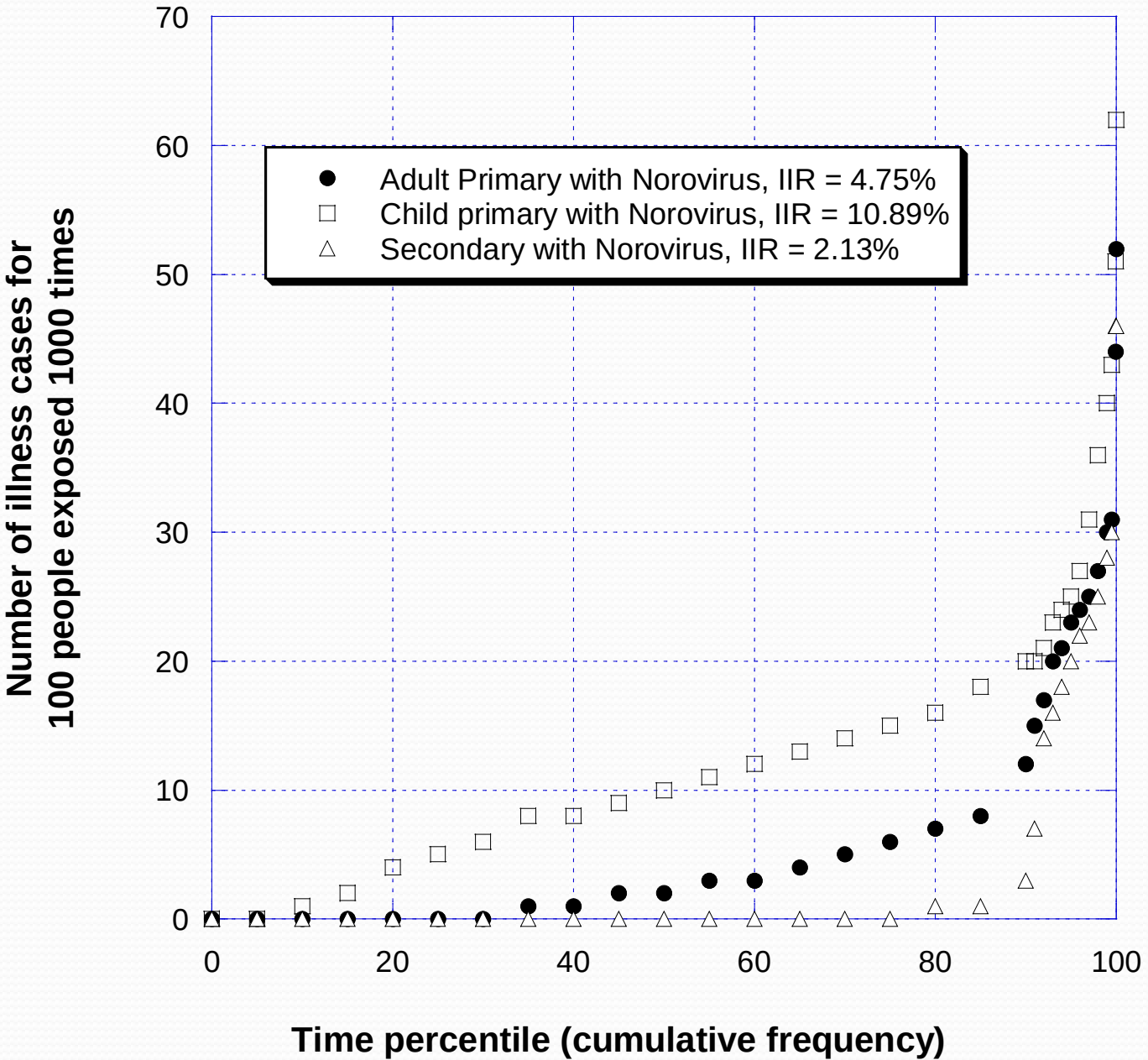


P_p= Predicted Pathogen Conc.; P_m = Measured Pathogen Conc.
x = Distance; t = Time; D = Discharge; R = Receiving Water

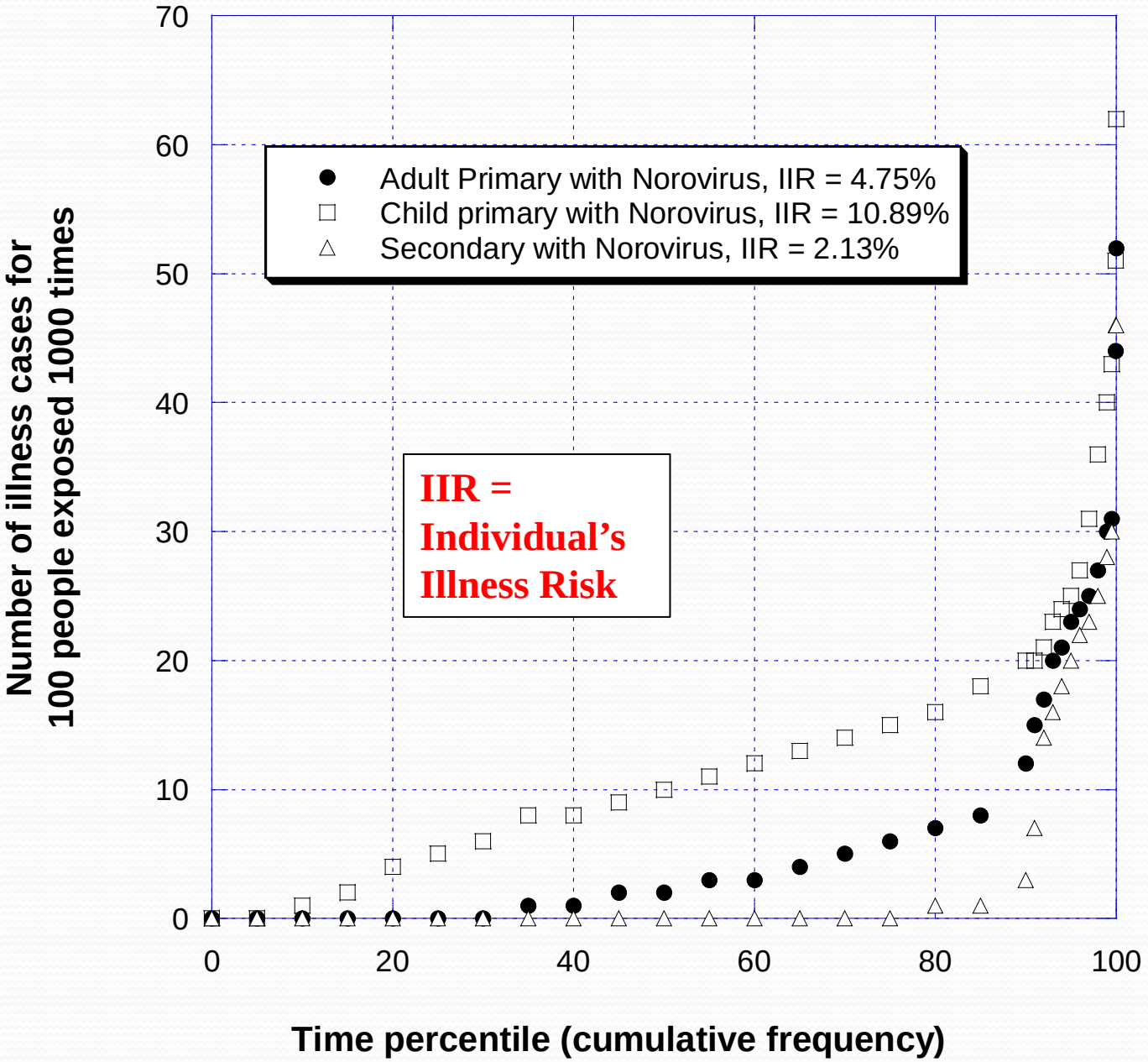
Example: Application of Discharge-based QMRA (Simplified)

- **Assumption #1 - Relative contribution of discharges-of-concern:** Four discharges were evenly "composited", meaning a 25% by-volume contribution for each of the following: Residential stormwater, Commercial stormwater, Agricultural stormwater, and Forested Open Space stormwater.
- **Assumption #2 - Rates of dilution of discharges by other inputs:** A dilution rate of 30:1 was applied to discharges-of-concern.
- **Assumption #3 - Effects of dry versus wet conditions:** The assessed condition was wet weather and dry weather is not considered.
- **Assumption #4 - Travel times and pathogen decay rates:** While pathogen decay/inactivation is likely an important consideration for most recreational sites, this example assumes zero decay.

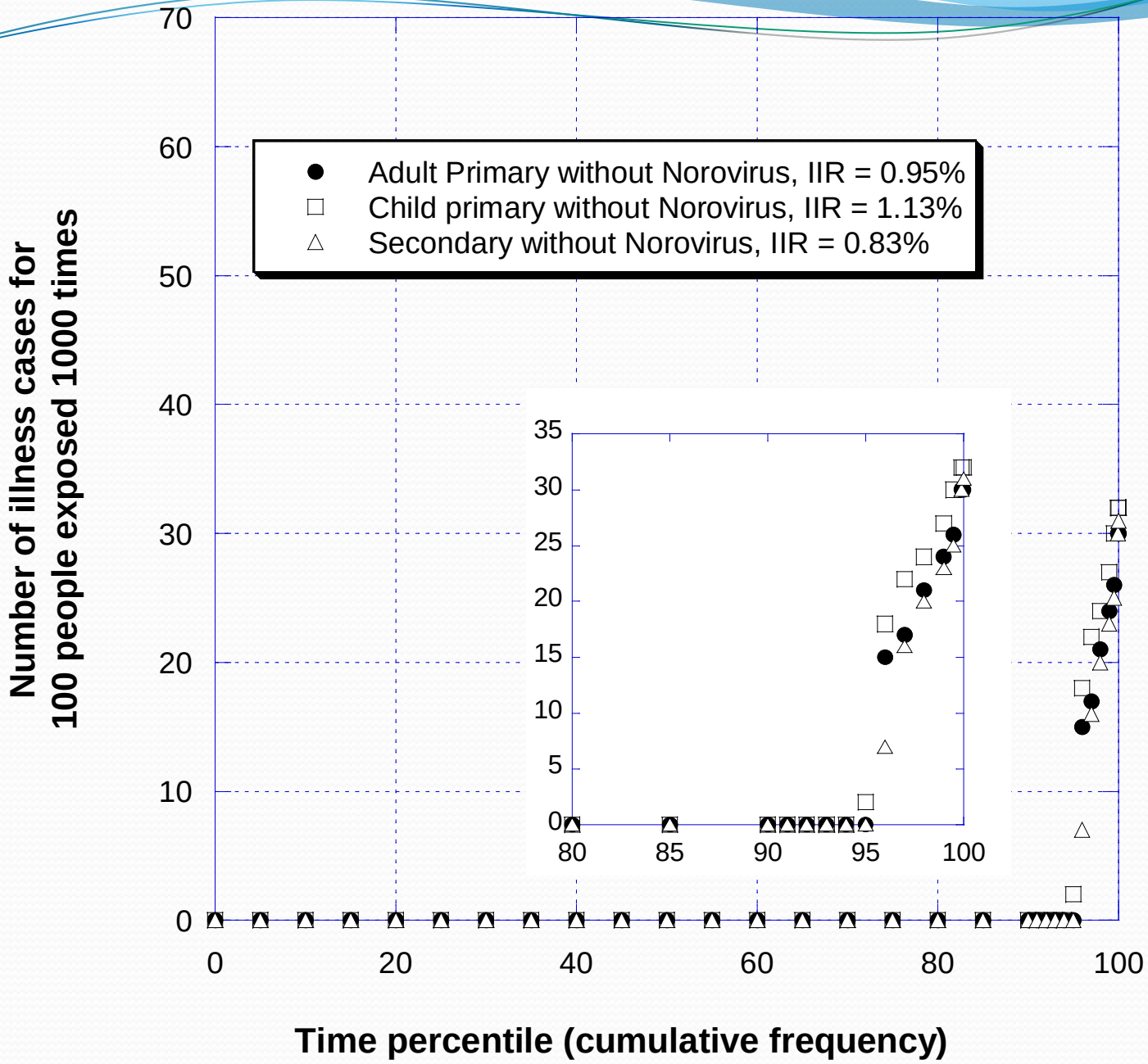
Hypothetical: Recreational Risks at an Impacted Site



Hypothetical: Recreational Risks at an Impacted Site



Risk with Norovirus Excluded from the Calculations



Conclusions

- Norovirus is the most dominant health risk.
- Rotavirus generally induced the second-highest incidence of risk among the tested pathogens.
- Can investigate relative risks from different discharges and for different densities and loadings
- Can use this QMRA approach for beaches if good knowledge of main discharges

Students and Collaborators

Wuertz lab Dr. Alexander Schriewer Dan Wang Arti Kundu Asma Rizva	UC Vet Med (Miller lab) Aiko Adell Nadira Chouicha Ann Melli Prof. Barbara Byrne Prof. Pat Conrad
AMEC Earth & Environmental Candice Owen	NIWA, New Zealand Dr. Rebecca Stott

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