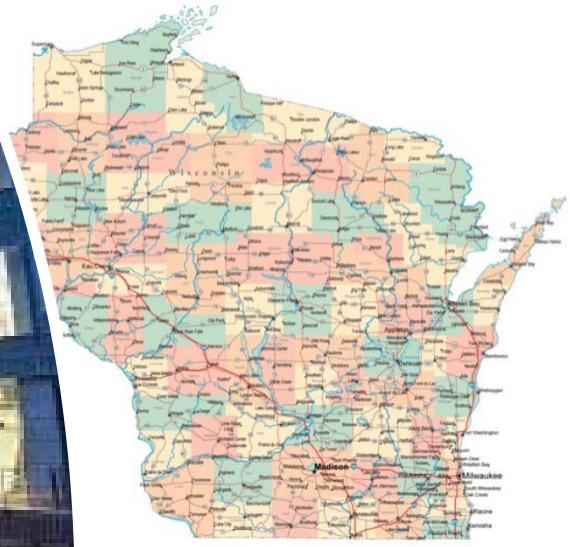
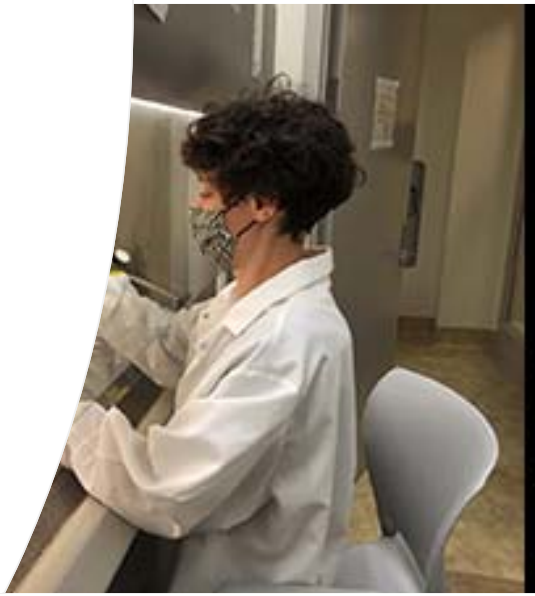
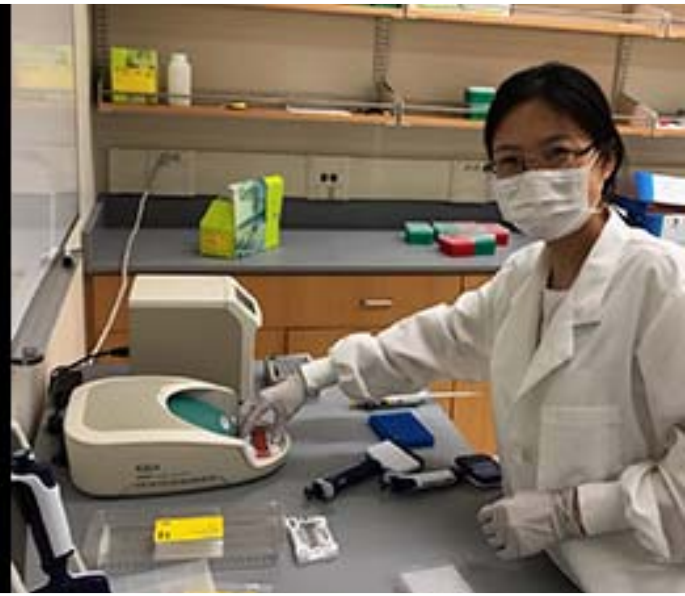
Wastewater surveillance for SARS-CoV-2 to assess citywide trends: variability, sensitivity, and correlation to case data







Sandra McLellan, Professor

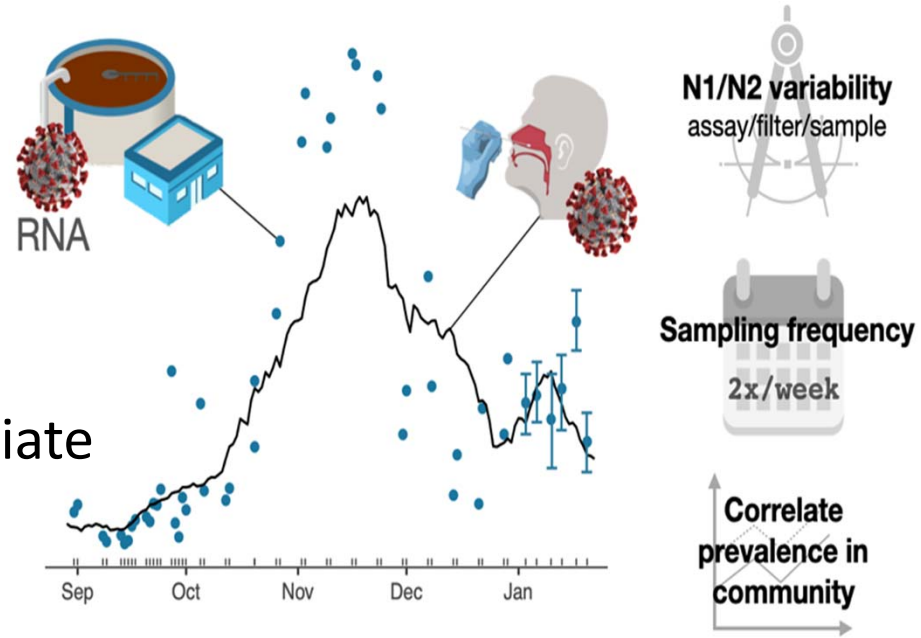
School of Freshwater Sciences,
University of Wisconsin-Milwaukee

Wisconsin SARS-CoV-2 Wastewater Surveillance

SARS-CoV-2 surveillance team

Adelaide Rouget, Post Doc
Deb Dila, Research Associate
Melinda Bootsma, Technician
Lexi Passante, Grad Student
Melissa Schussmann, Grad Student
Angela Schmoldt, GLGC Research Associate

Shuchen Feng, Post Doc
Jill McClary, Post Doc
Ryan Newton, Assistant Professor



McLellan Lab Research

New indicators of fecal pollution
Microbiome of animals and sewage

sewage population structure

What are the organisms in sewage?
What is the health risk and viral load?

water analysis

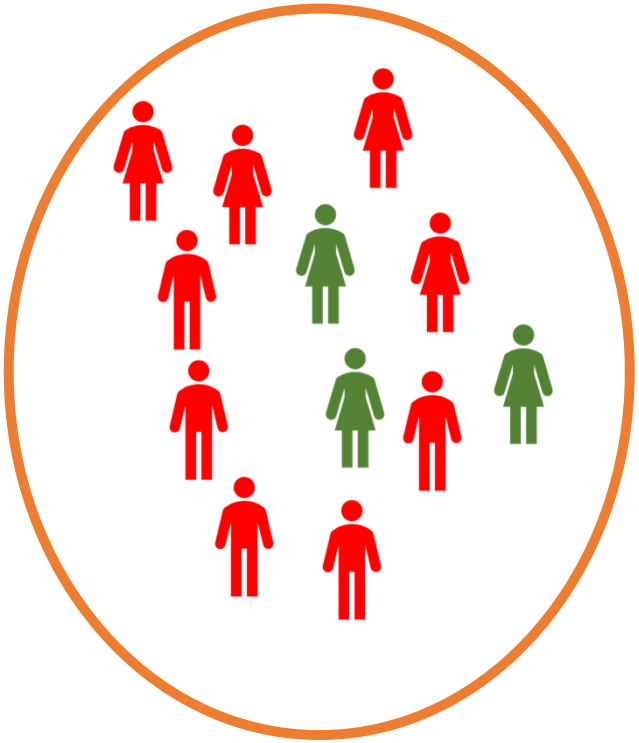
Should the beach be closed?

How can we test the whole community at once?

Sewage is a representative sample of humans

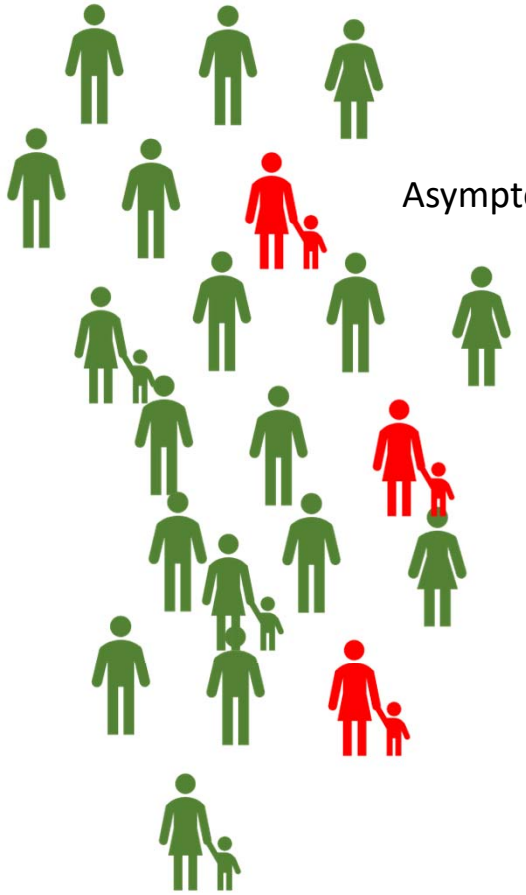
SARS-CoV-2 (viruses that causes Covid-19) is shed in feces, also enters sewer system through kleenex, salvia

How many people have Covid-19?
This was the early testing scenario



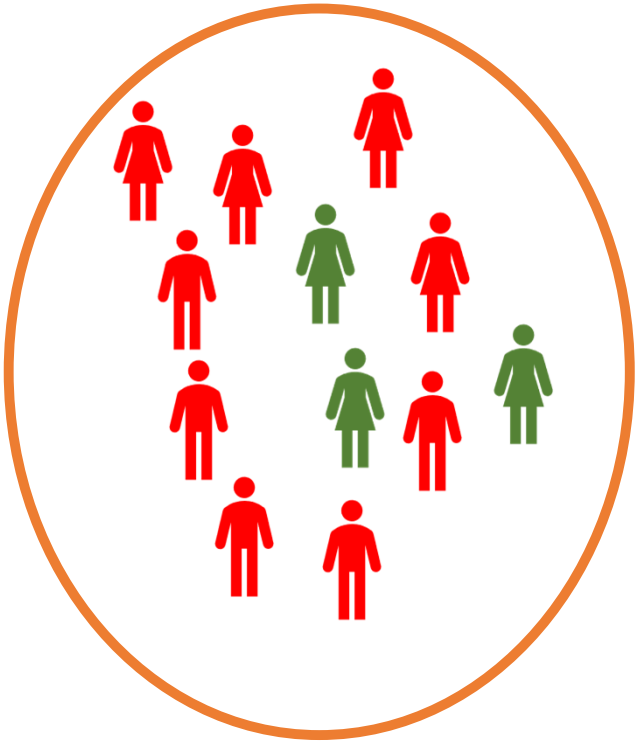
Test people who have symptoms

?

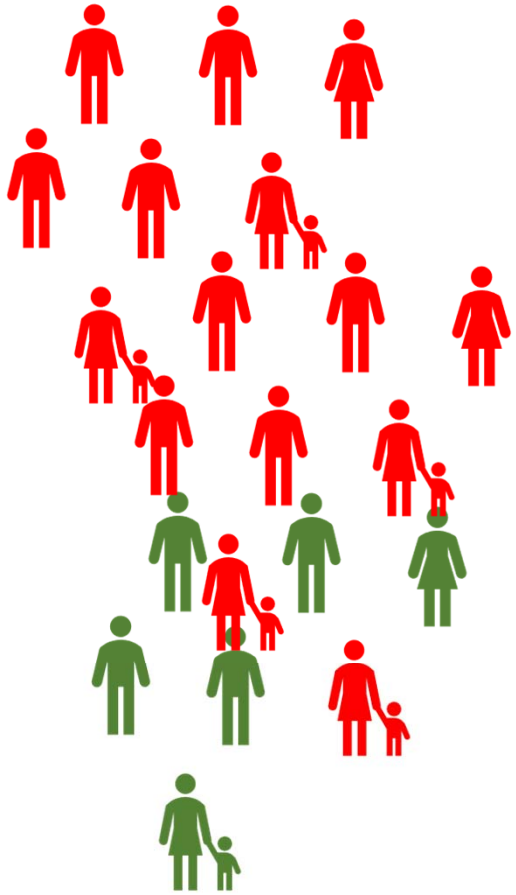


Asymptomatic carriage

How many people have Covid-19?

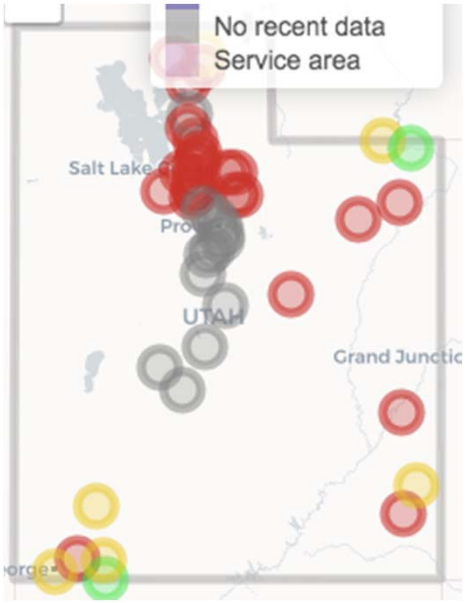


or?



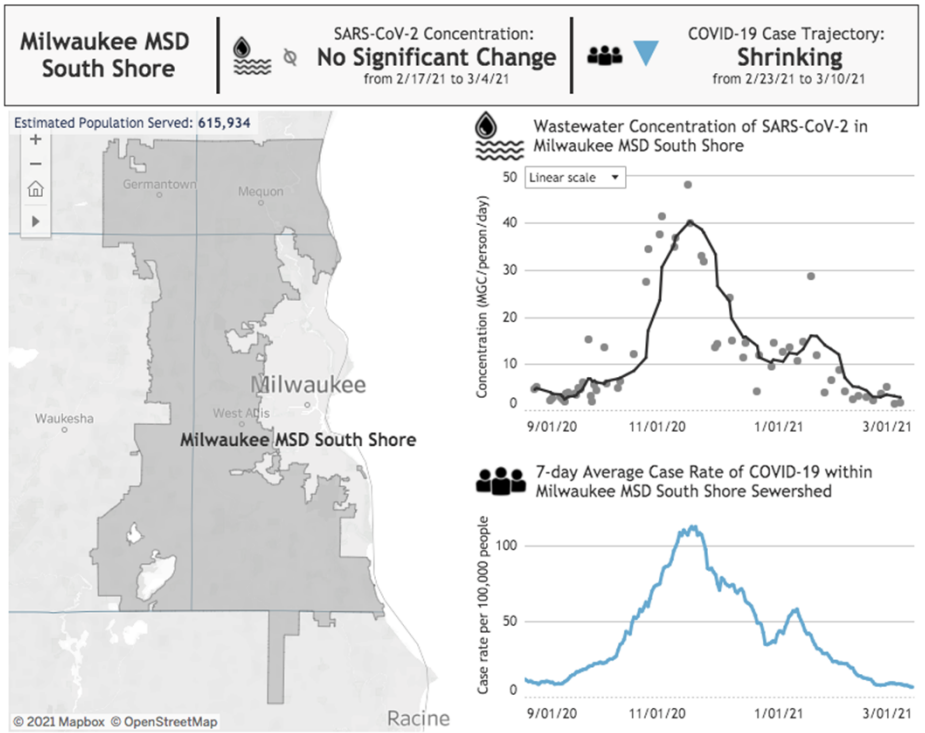
Barrier 2. Public health agencies want to see SARS-CoV-2 wastewater data in their own communities to gain confidence in its application and utility.

Growing examples in many areas



Wisconsin

Utah



Broad insights
Experts Panel

Public health insights

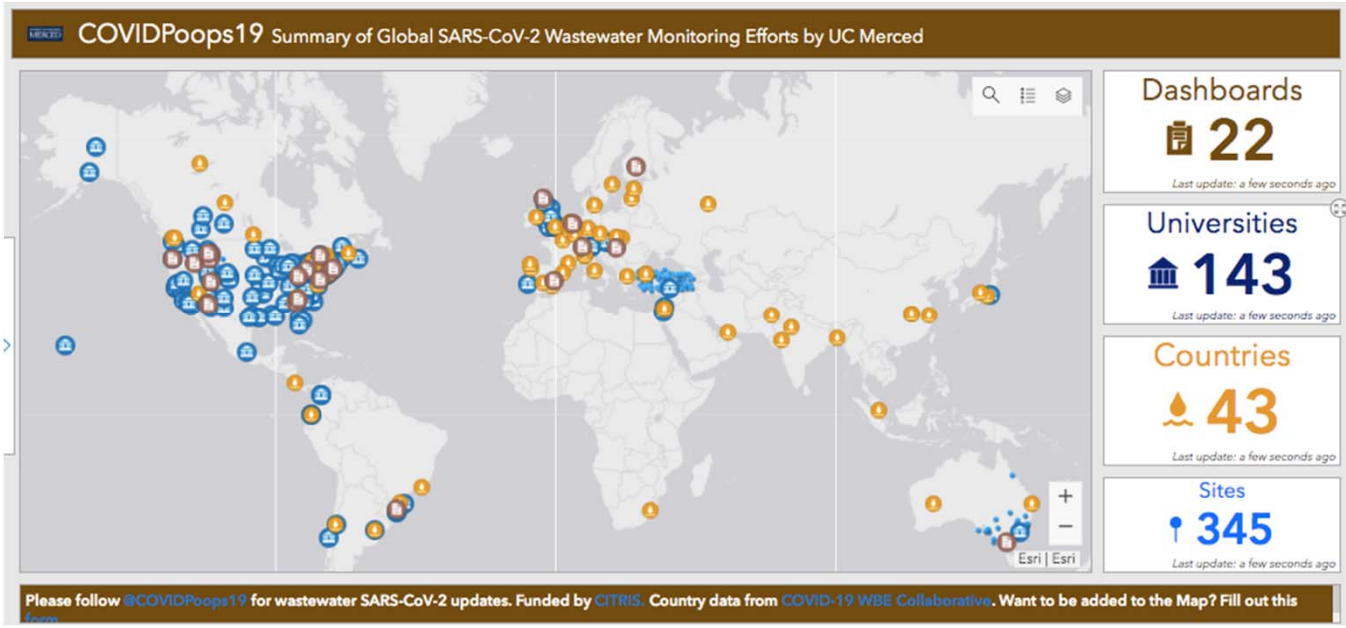
Data is not self-standing

Data needs to be simplified and easy to use

Proof of concept

Explanations on variability

Timely



https://www.covid19wbec.org/

Wisconsin SARS-CoV-2 Wastewater Surveillance

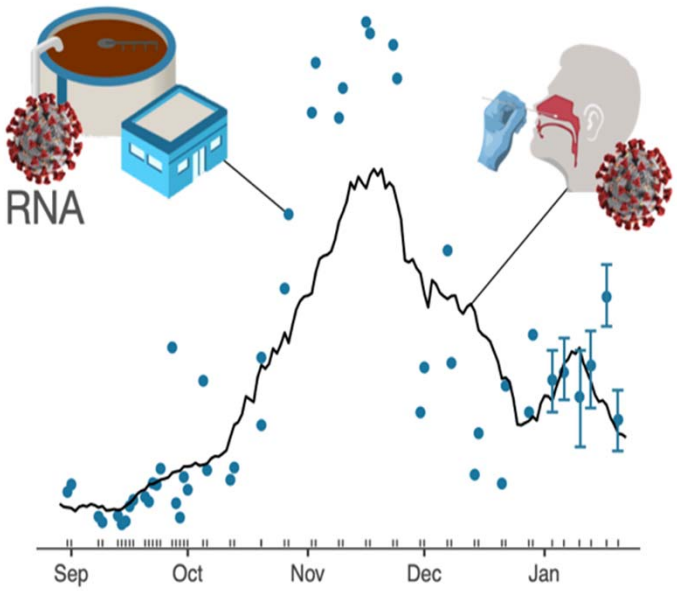
McLellan Lab Activities

- Initiated monitoring for Racine, Milwaukee, and Green Bay as part of a Statewide surveillance effort with the Wisconsin State Laboratory of Hygiene at UW-Madison, funded by Department of Health Services, now sampling **12 WWTPs**

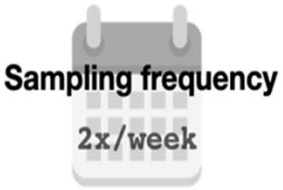
- Developing methods for tracking variants in sewage

12 service areas
~~1.8 M people

Paper submitted to Environmental Science and Technology



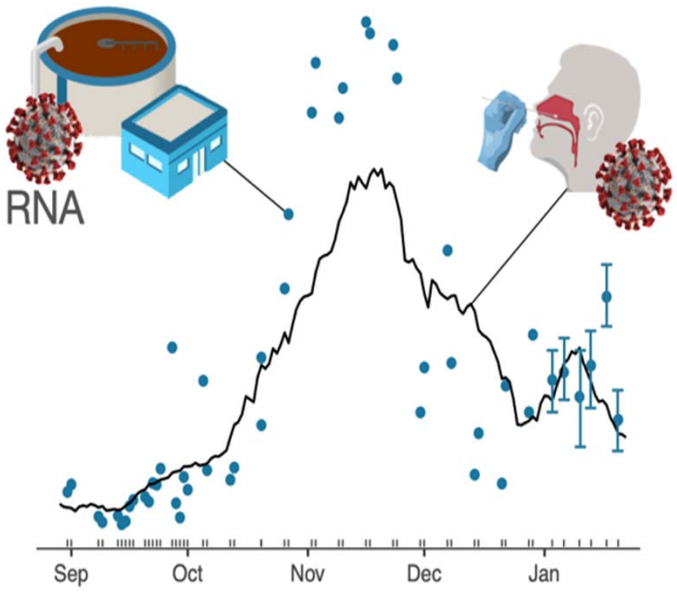
What is the precision in the measurements?



How often should we sample?

Does wastewater reflect what is happening in the community?

Paper submitted to Environmental Science and Technology



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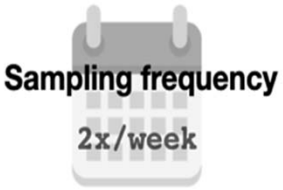


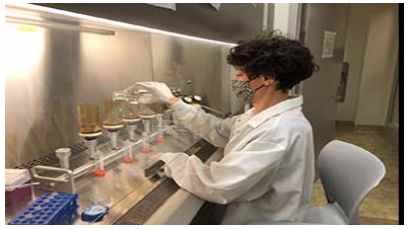
How often should we sample?

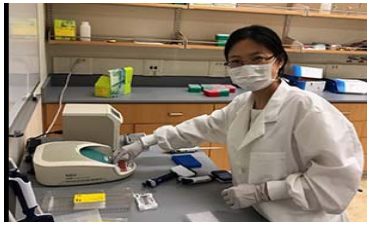
Does wastewater reflect what is happening in the community?

Sampling and method overview

24 hour flow weighted sample at the WWTP

Sample processing (RNA concentration) → RNA extraction → ddPCR quantification





Sampling and method overview

24 hour flow weighted sample at the WWTP

Standard

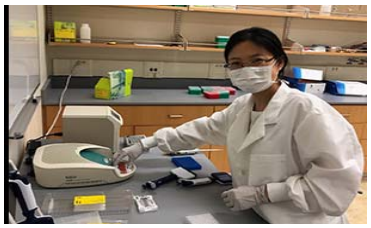
Tricky

Just like the clinical lab

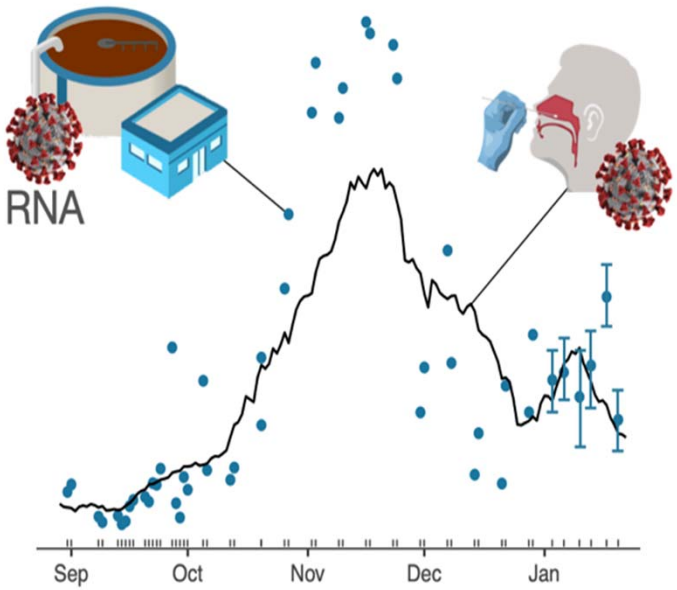
Sample processing (RNA concentration)

RNA extraction

ddPCR quantification



Paper submitted to Environmental Science and Technology



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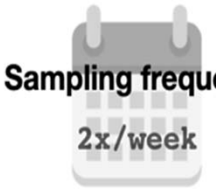
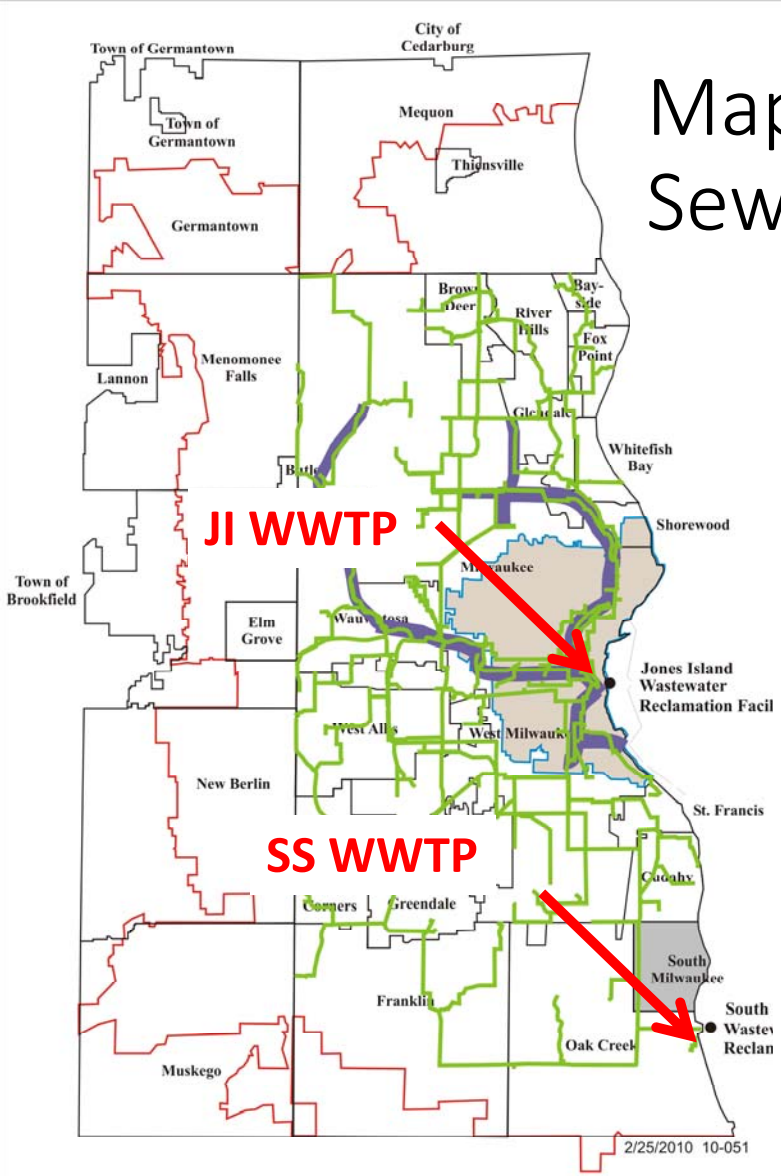


How often should we sample?

Does wastewater reflect what is happening in the community?

Map of Milwaukee, WI Sewer Service Area



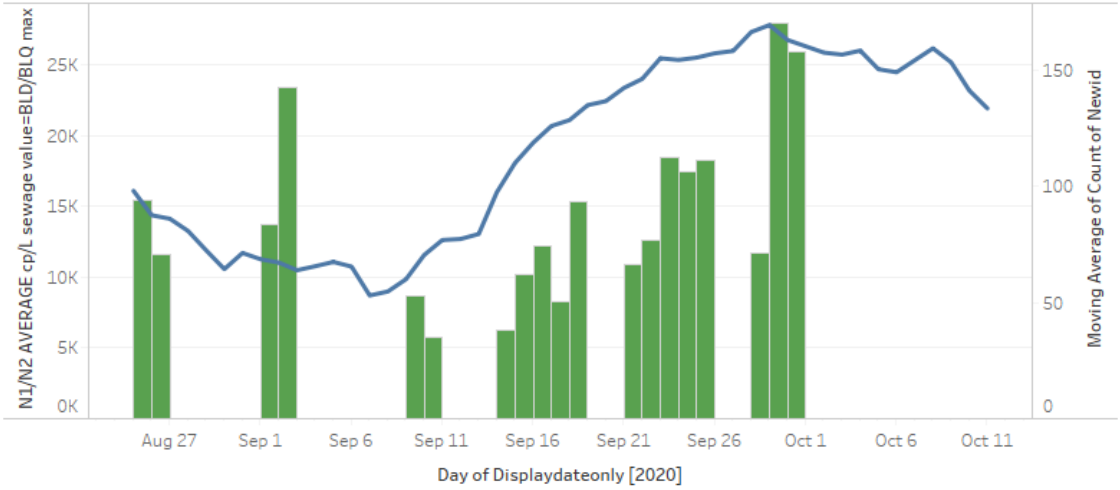
400 square miles
6,000 miles of pipes

1M people

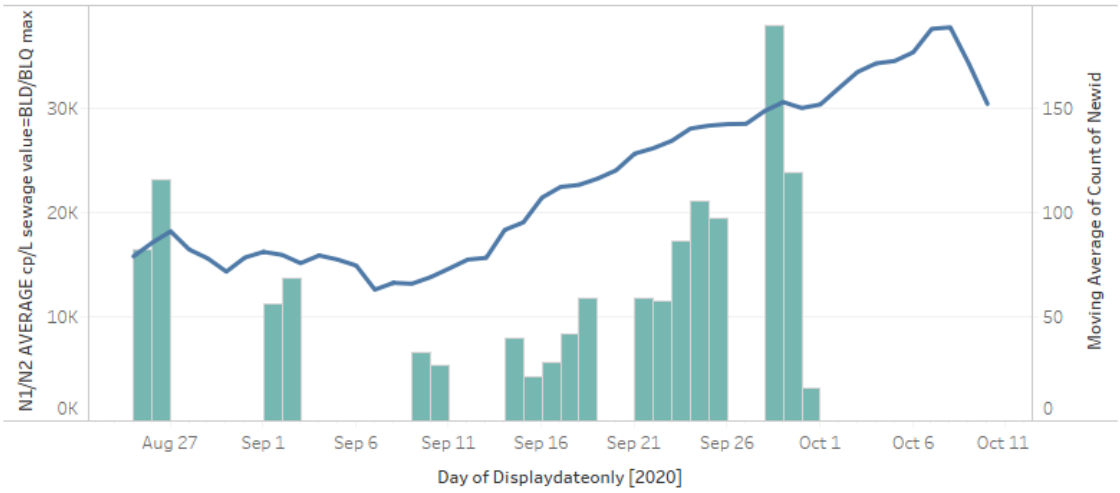
Two treatment plants

Separated sewer system (88%)
Combined sewer system (12%)

MKE_Jones Island

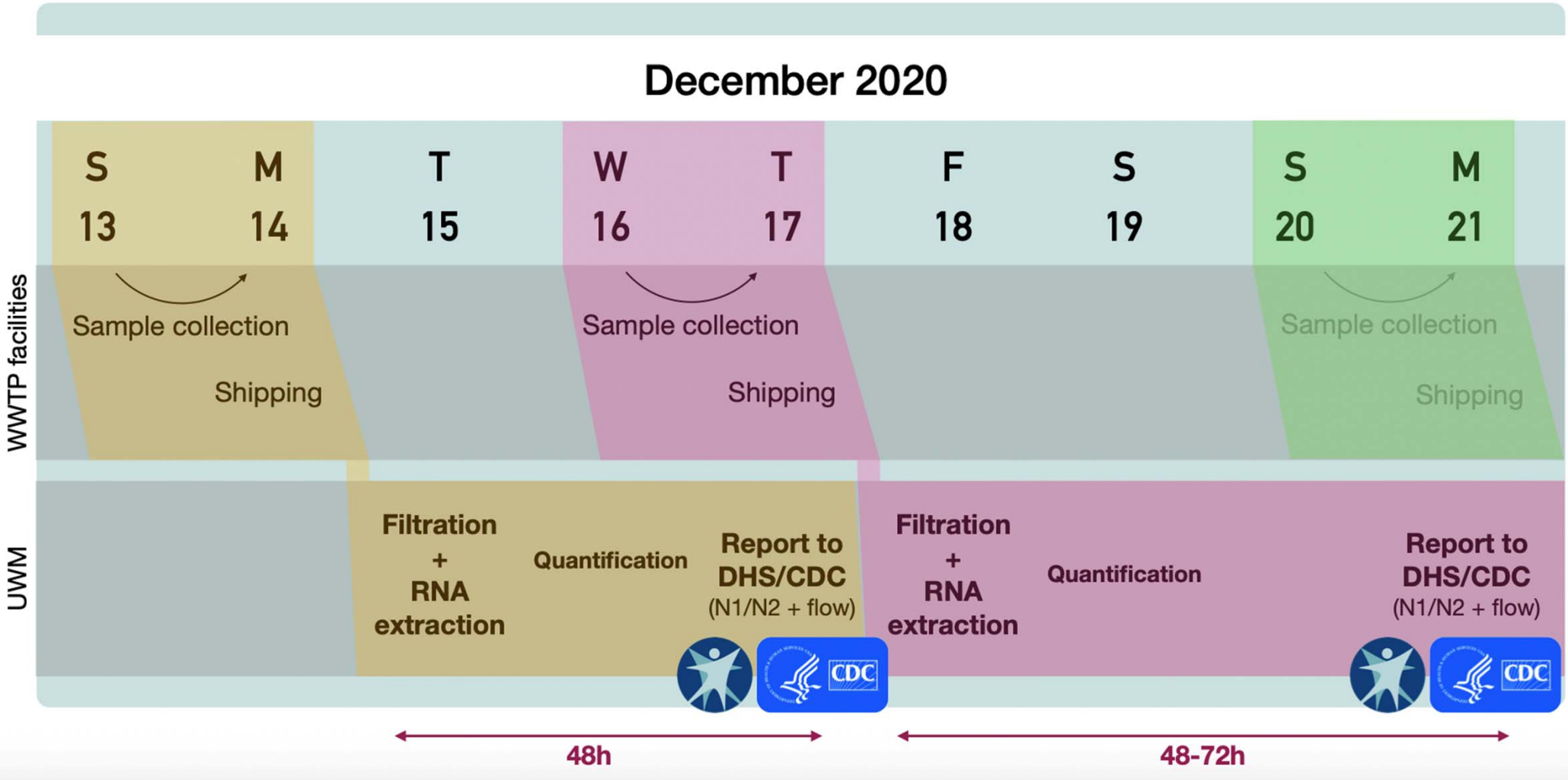


MKE_South Shore

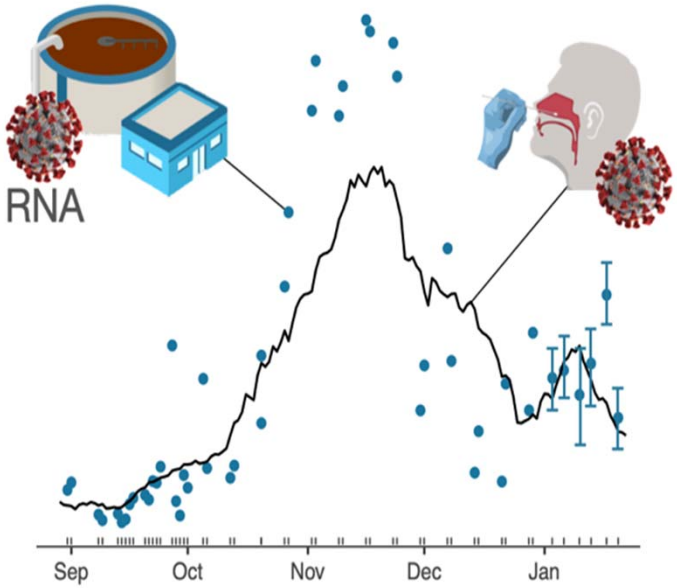


Two days a week could capture the trends

Each sample can be $350-$450
Need to be cost effective while providing good data


December 2020
S 13
M 14
T 15
W 16
T 17
F 18
S 19
S 20
M 21
WWTP facilities
Sample collection
Shipping
Sample collection
Shipping
Sample collection
Shipping
UWM
Filtration + RNA extraction
Quantification
Report to DHS/CDC (N1/N2 + flow)
Filtration + RNA extraction
Quantification
Report to DHS/CDC (N1/N2 + flow)
CDC
CDC
48h
48-72h

Paper submitted to Environmental Science and Technology



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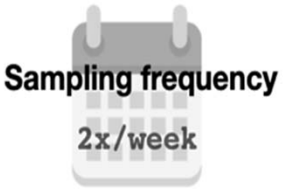
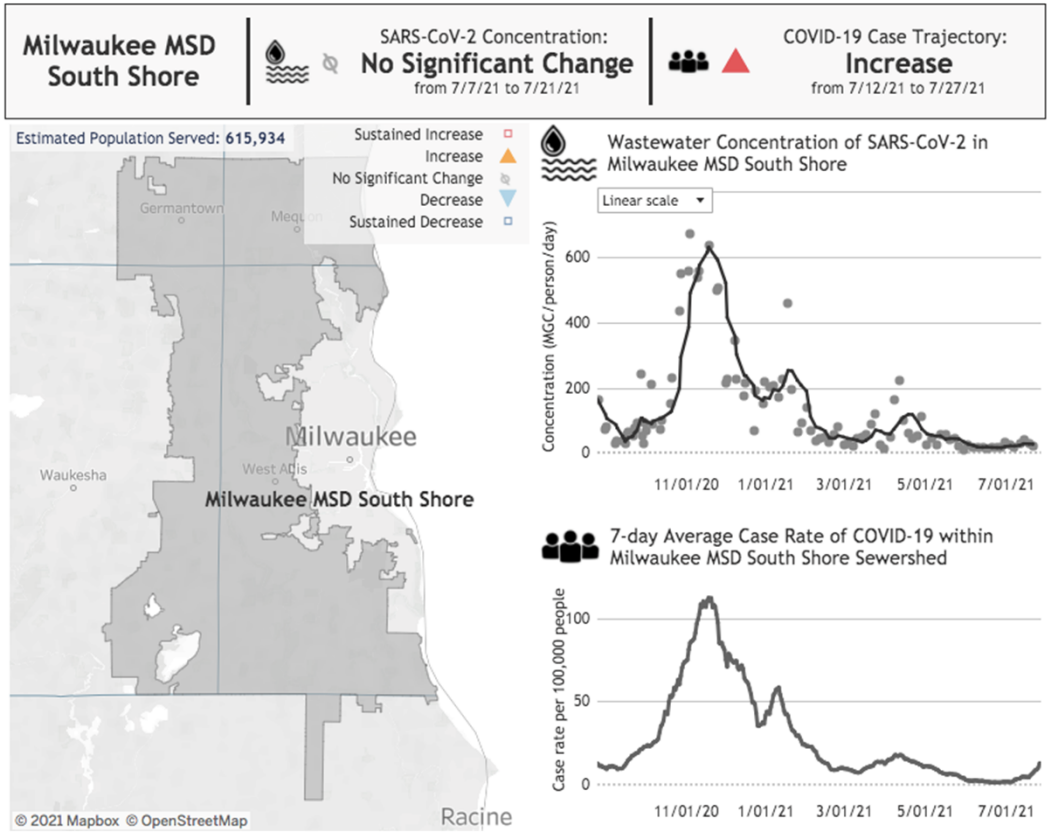


How often should we sample?

Does wastewater reflect what is happening in the community?

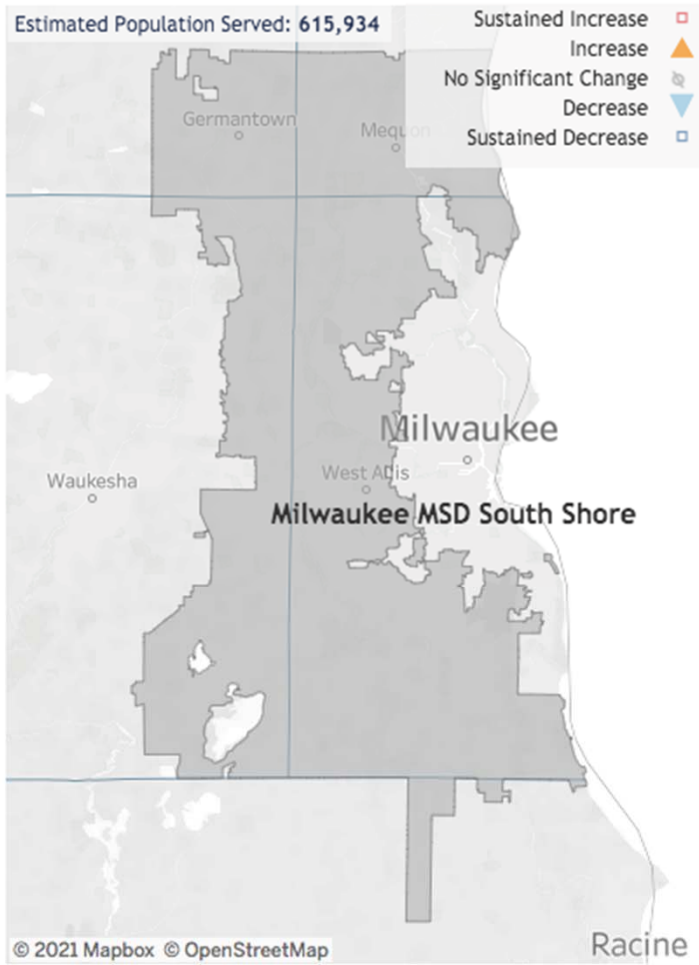
Wastewater dashboard

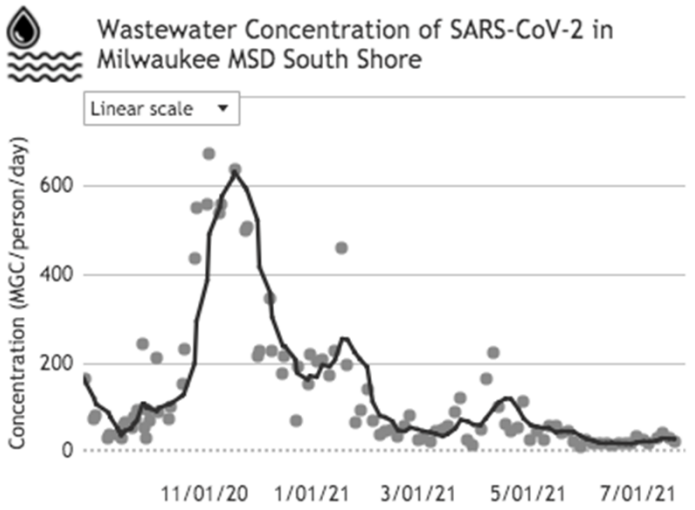


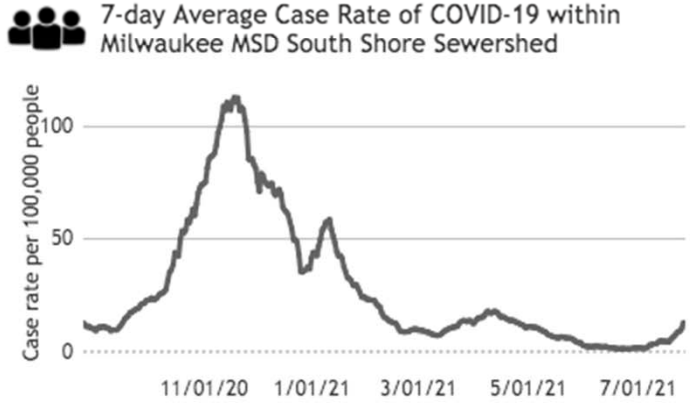
Milwaukee MSD South Shore

SARS-CoV-2 Concentration:
No Significant Change
from 7/7/21 to 7/21/21

COVID-19 Case Trajectory:
Increase
from 7/12/21 to 7/27/21







Milwaukee MSD Jones Island

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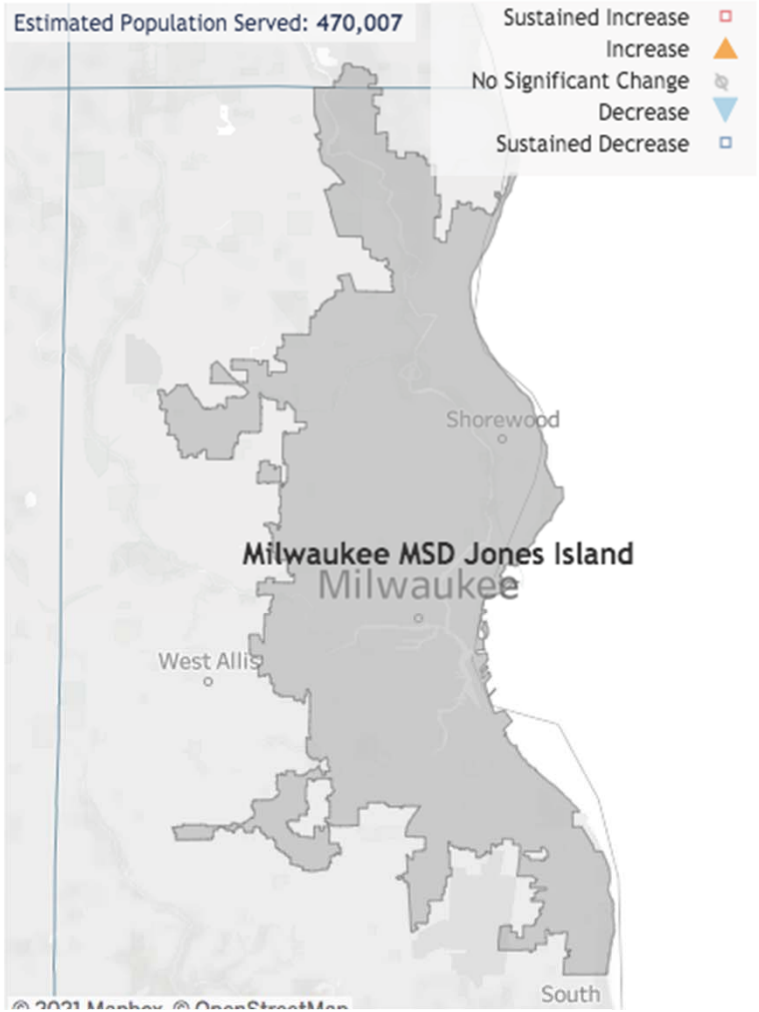
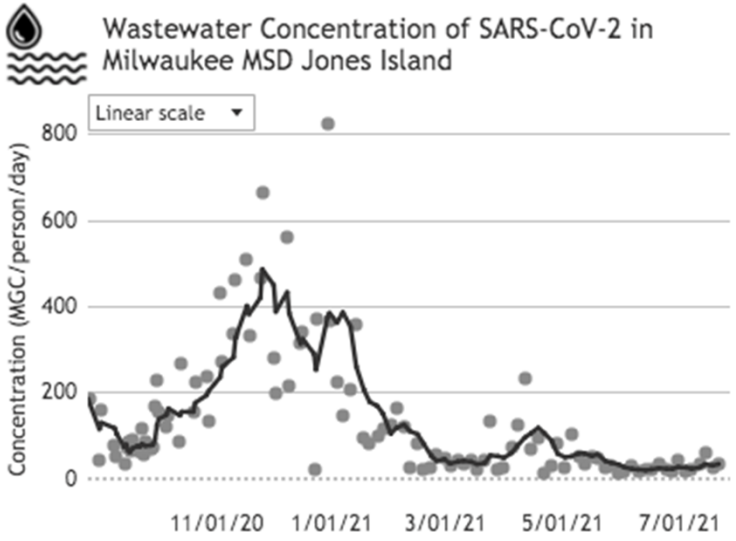
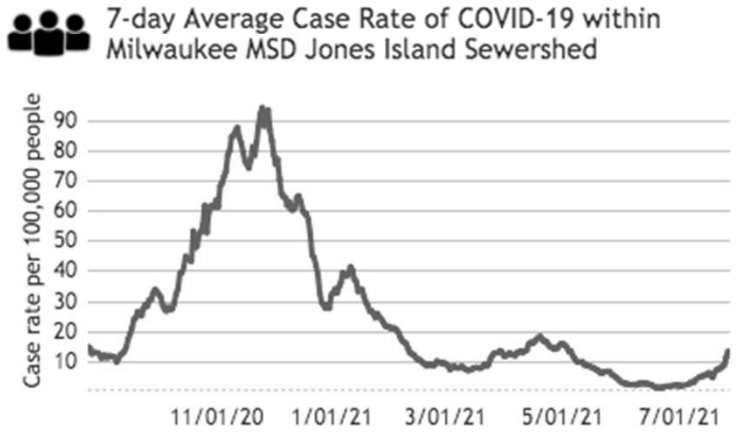


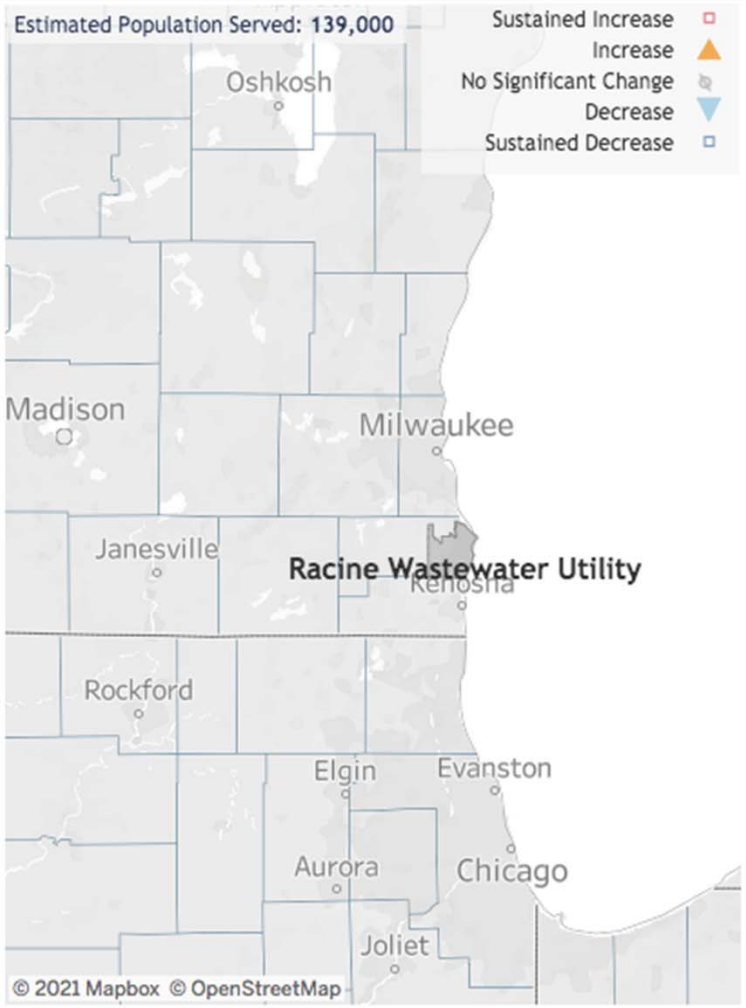


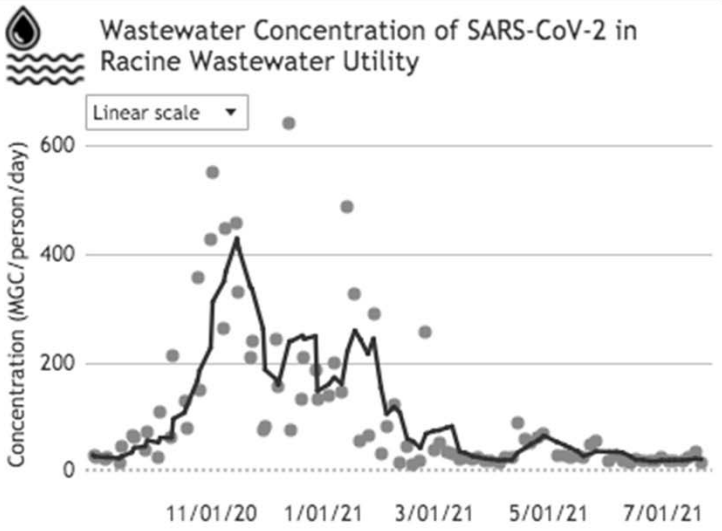


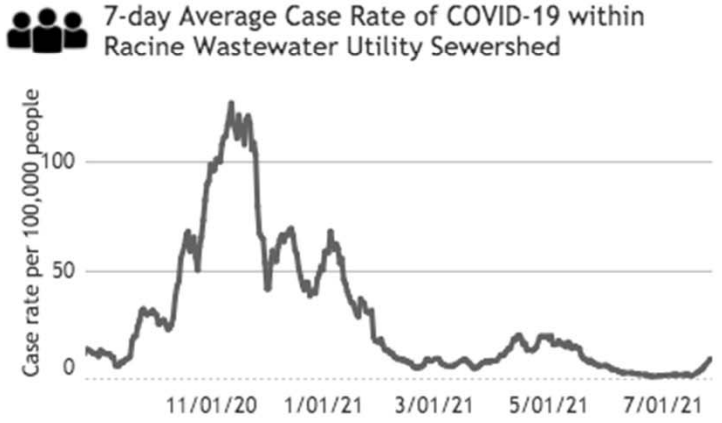
Racine Wastewater Utility

SARS-CoV-2 Concentration:
No Significant Change
from 7/7/21 to 7/21/21

COVID-19 Case Trajectory:
Increase
from 7/12/21 to 7/27/21



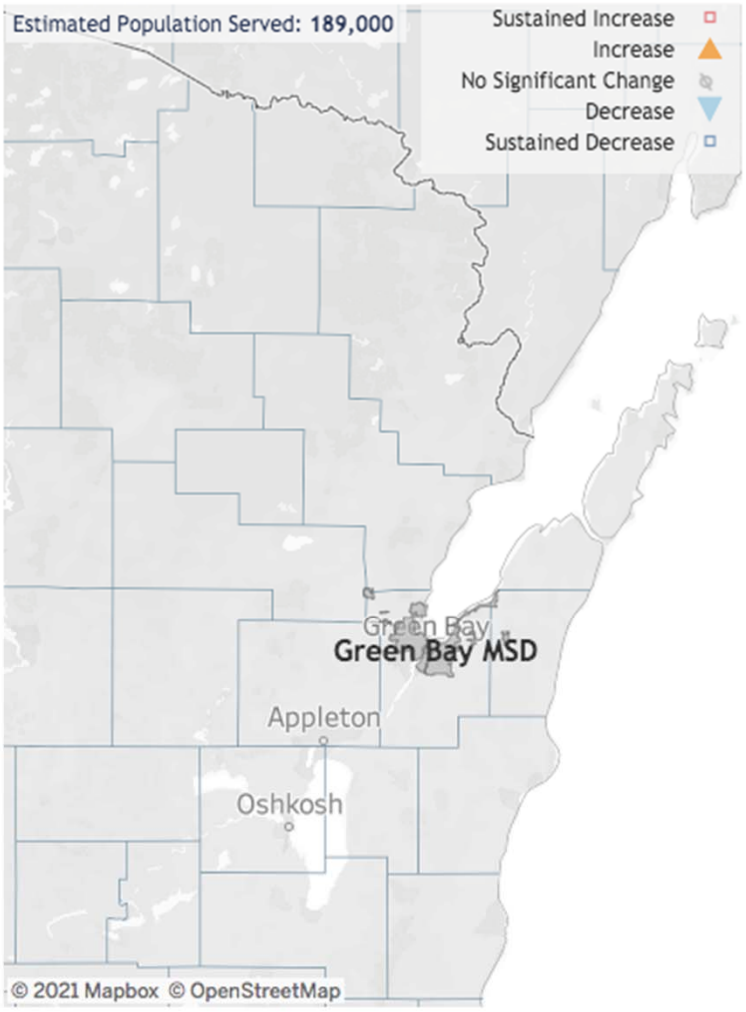


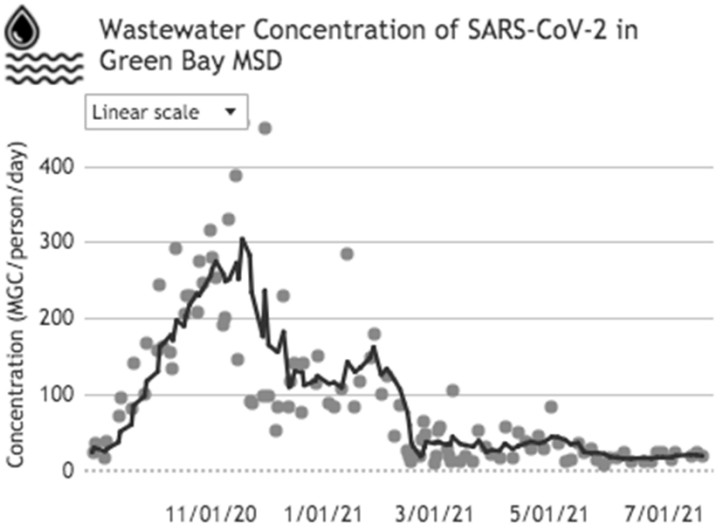


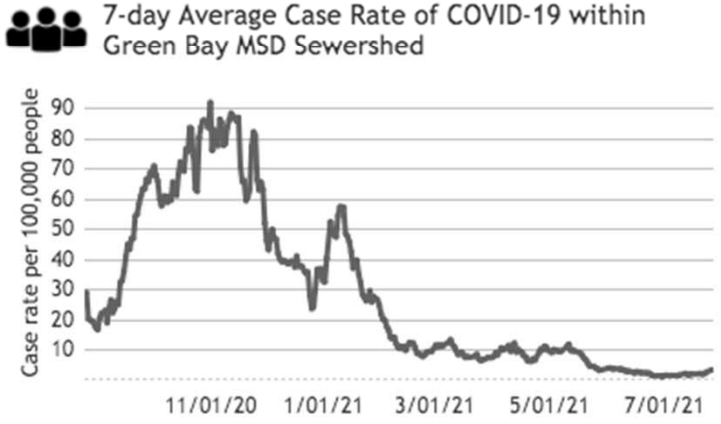
Green Bay MSD

SARS-CoV-2 Concentration:
No Significant Change
from 7/5/21 to 7/21/21

COVID-19 Case Trajectory:
Increase
from 7/12/21 to 7/27/21







https://www.dhs.wisconsin.gov/covid-19/wastewater.htm

ACS ES&T Water

pubs.acs.org/estwater

Article

Evaluation of Sampling, Analysis, and Normalization Methods for SARS-CoV-2 Concentrations in Wastewater to Assess COVID-19 Burdens in Wisconsin Communities

Shuchen Feng, Adelaide Roguet, Jill S. McClary-Gutierrez, Ryan J. Newton, Nathan Kloczko, Jonathan G. Meiman, and Sandra L. McLellan*

Cite This: https://doi.org/10.1021/acsestwater.1c00160

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Volume 27, Number 9—September 2021

Online Report

SARS-CoV-2 Wastewater Surveillance for Public Health Action

Jill S. McClary-Gutierrez[1], Mia C. Mattioli, Perrine Marcenac, Andrea I. Silverman, Alexandria B. Boehm, Kyle Bibby, Michael Balliet, Francis L. de los Reyes, Daniel Gerrity, John F. Griffith, Patricia A. Holden, Dimitrios Katehis, Greg Kester, Nathan LaCross, Erin K. Lipp, Jonathan Meiman, Rachel T. Noble, Dominique Brossard✉, and Sandra L. McLellan✉

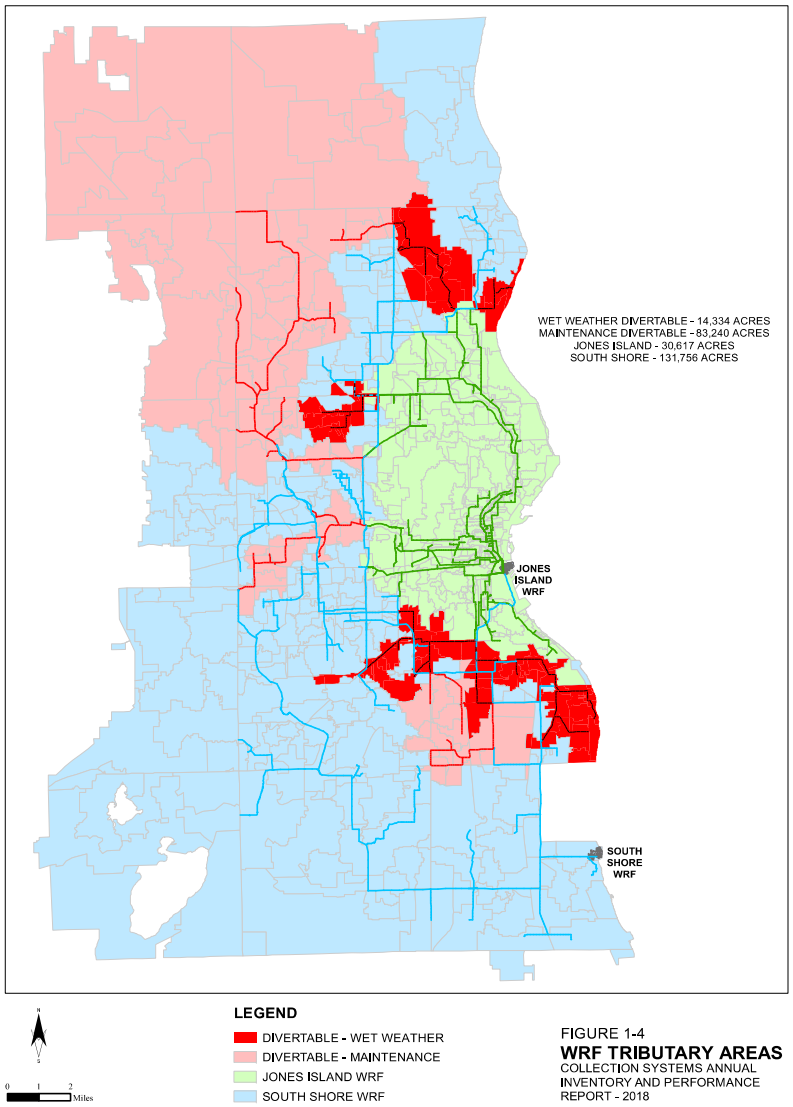
On This Page

Interdisciplinary Focus Group Discussions

Many basic science questions remain

What is the effect of travel time?

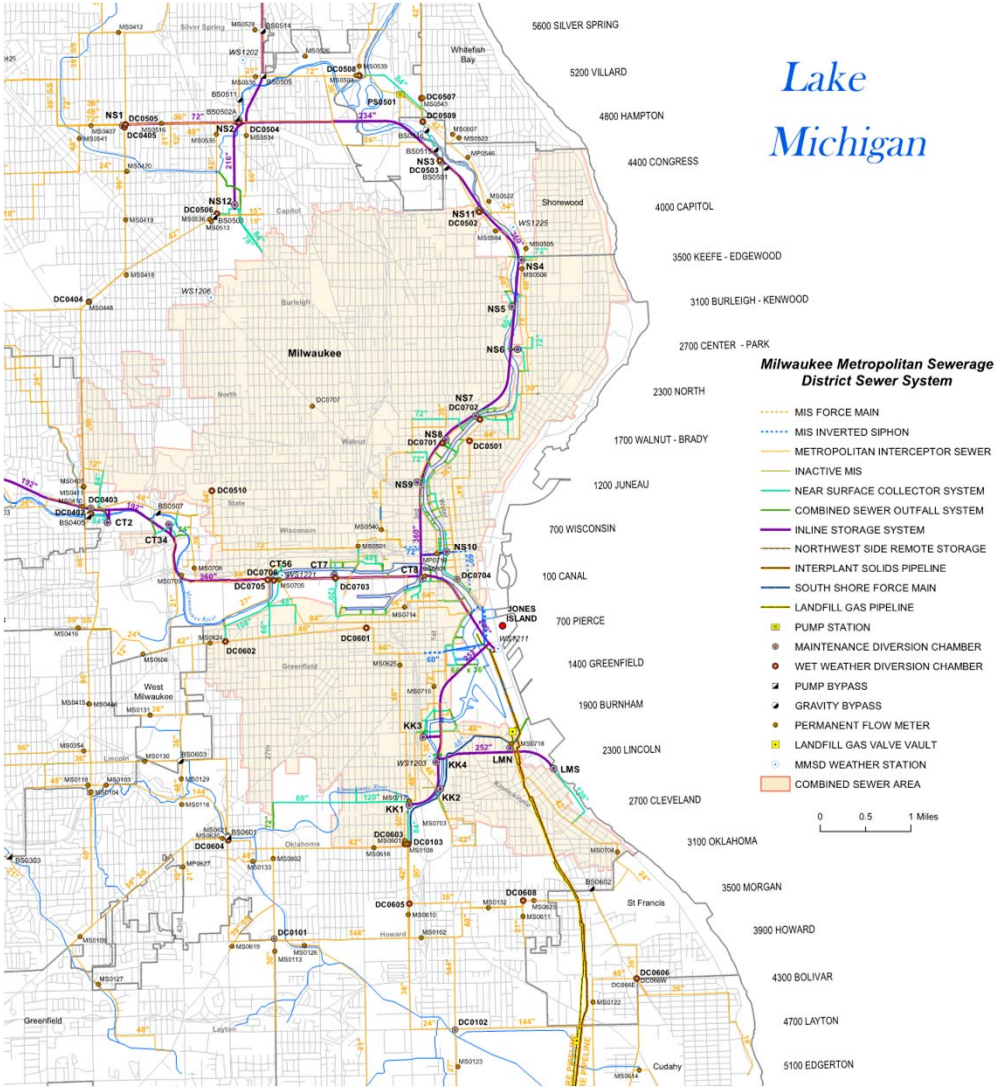
What is the effect of temperature?



Many basic science questions remain

What is the effect of travel time?

What is the effect of temperature?



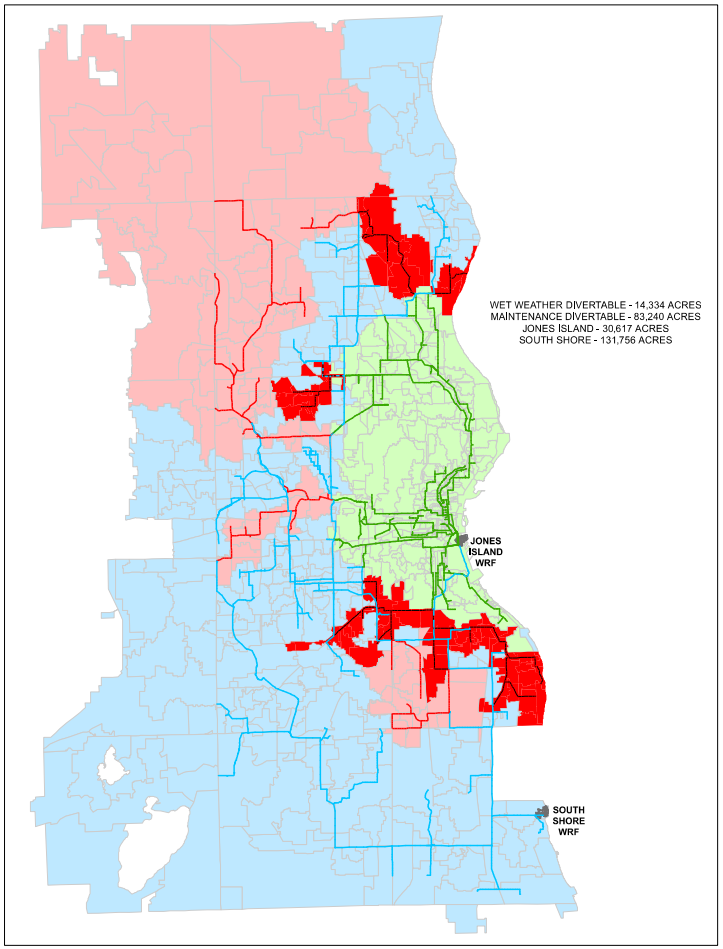
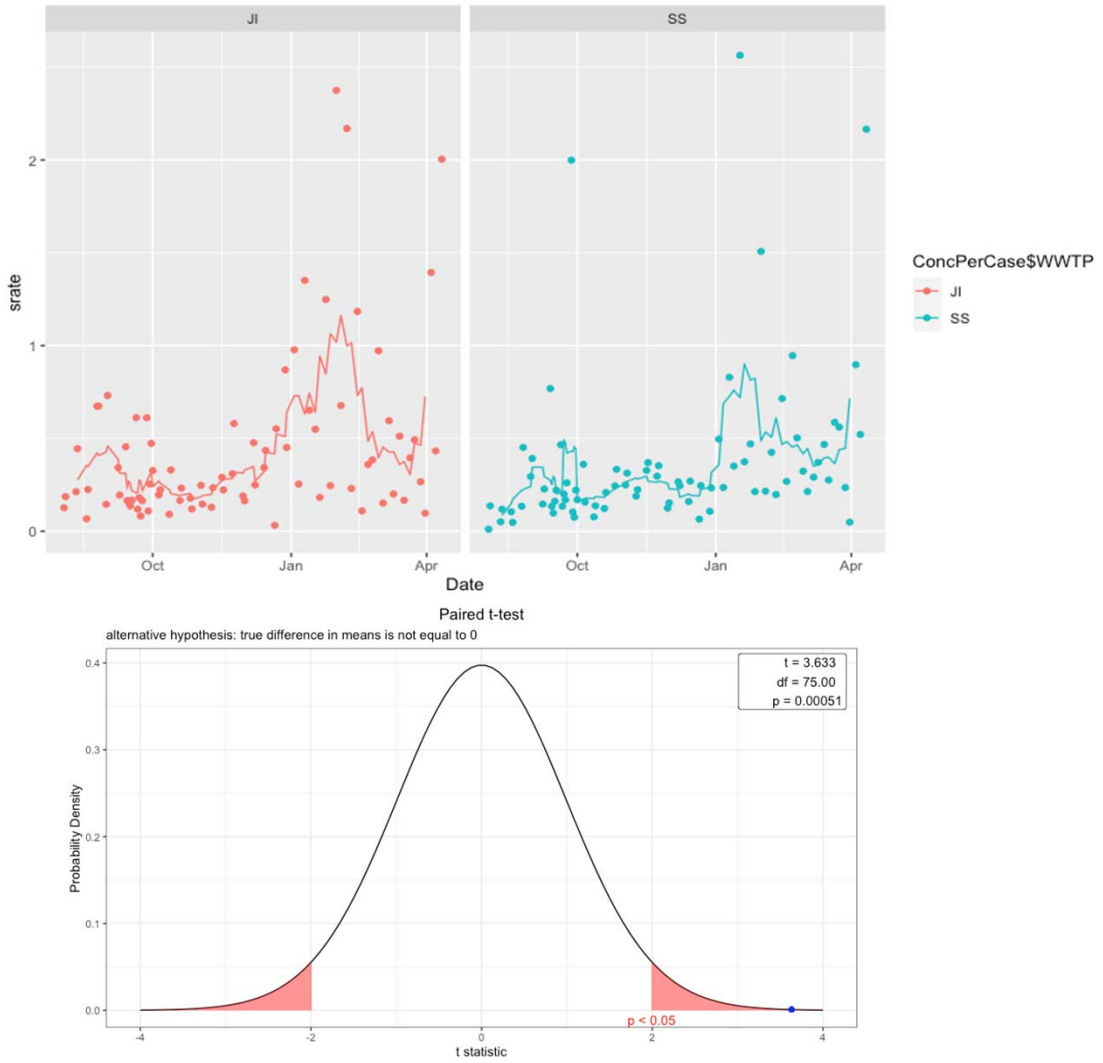
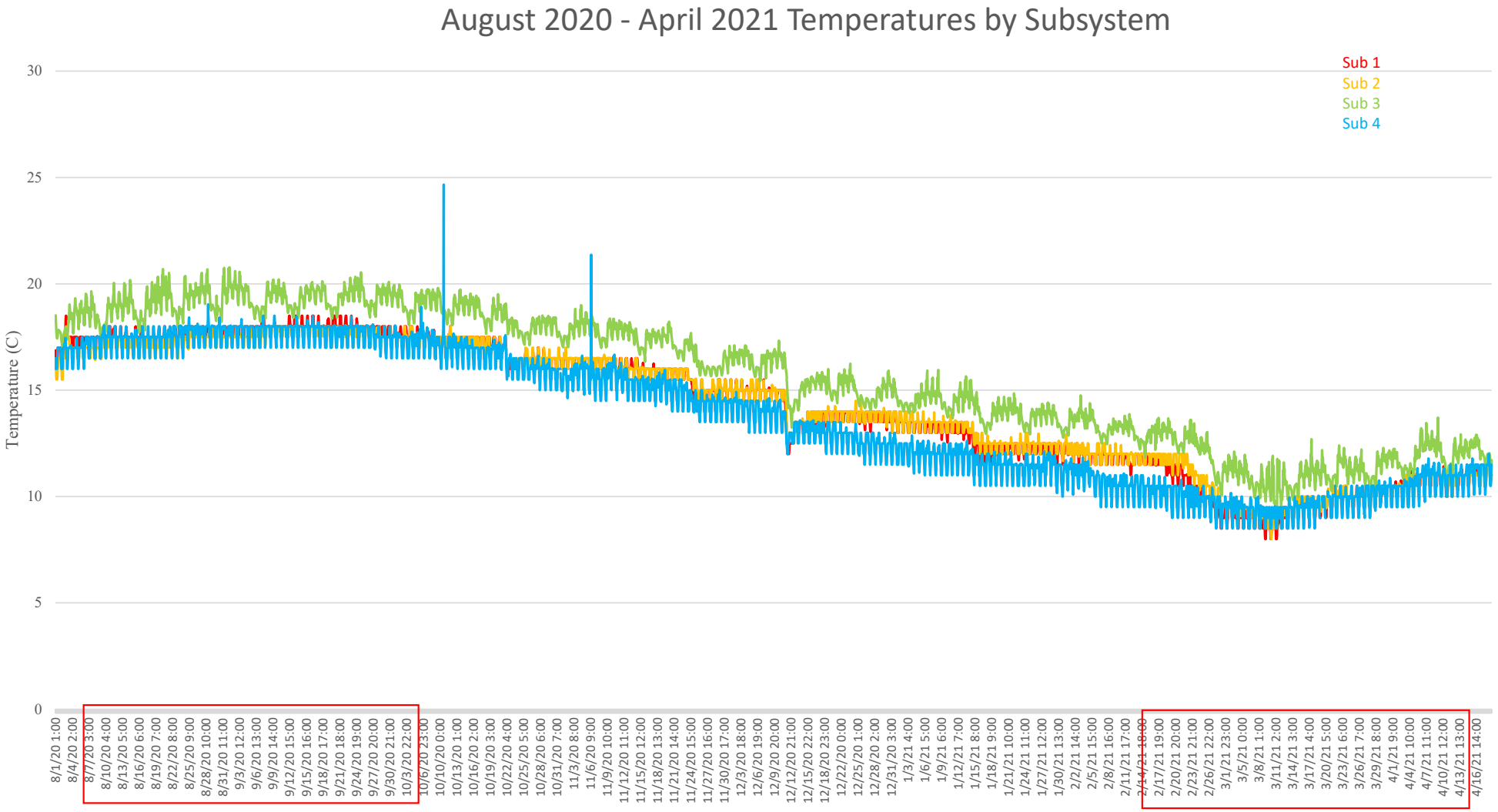


FIGURE 1-4
WRF TRIBUTARY AREAS
COLLECTION SYSTEMS ANNUAL INVENTORY AND PERFORMANCE REPORT - 2018




August 2020 - April 2021 Temperatures by Subsystem
Sub 1
Sub 2
Sub 3
Sub 4
Temperature (C)
30
25
20
15
10
5
0
8/1/20 1:00
8/4/20 2:00
8/7/20 3:00
8/10/20 4:00
8/13/20 5:00
8/16/20 6:00
8/19/20 7:00
8/22/20 8:00
8/25/20 9:00
8/28/20 10:00
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9/3/20 12:00
9/6/20 13:00
9/9/20 14:00
9/12/20 15:00
9/15/20 16:00
9/18/20 17:00
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10/22/20 4:00
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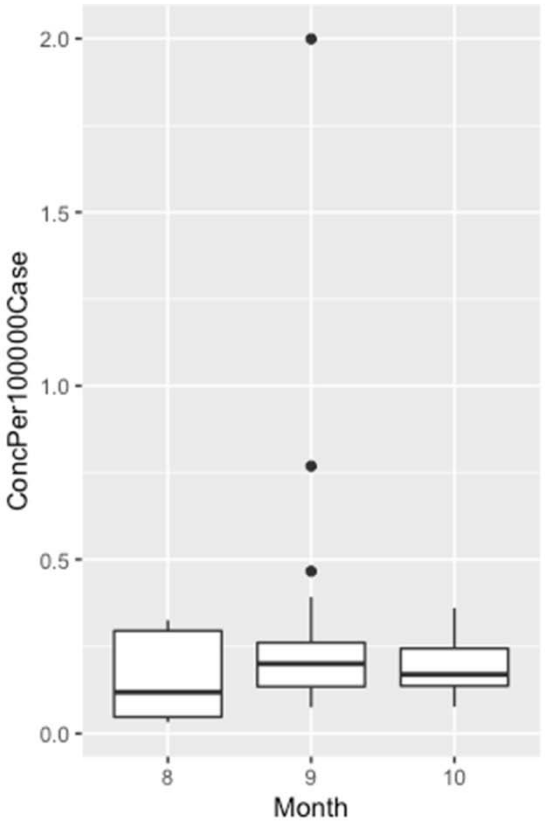
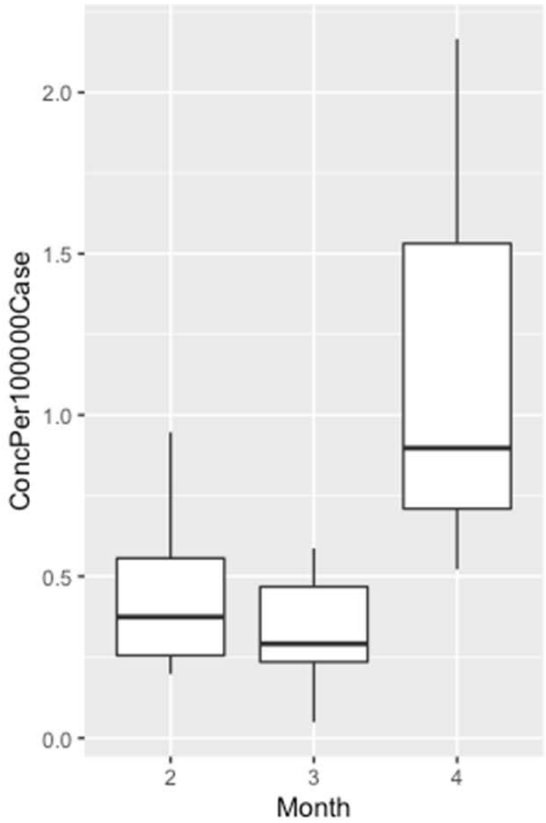
4/16/21 14:00

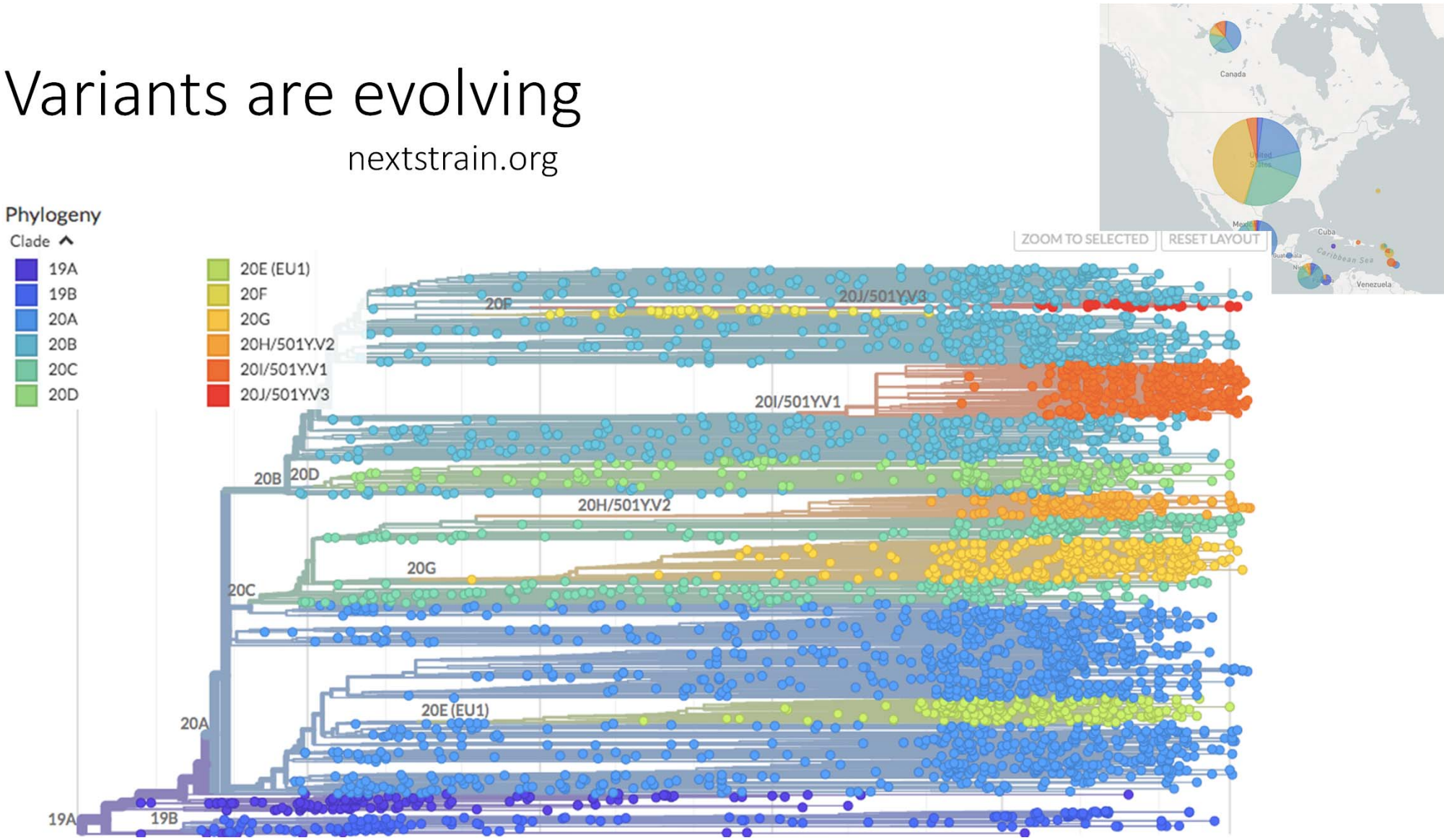




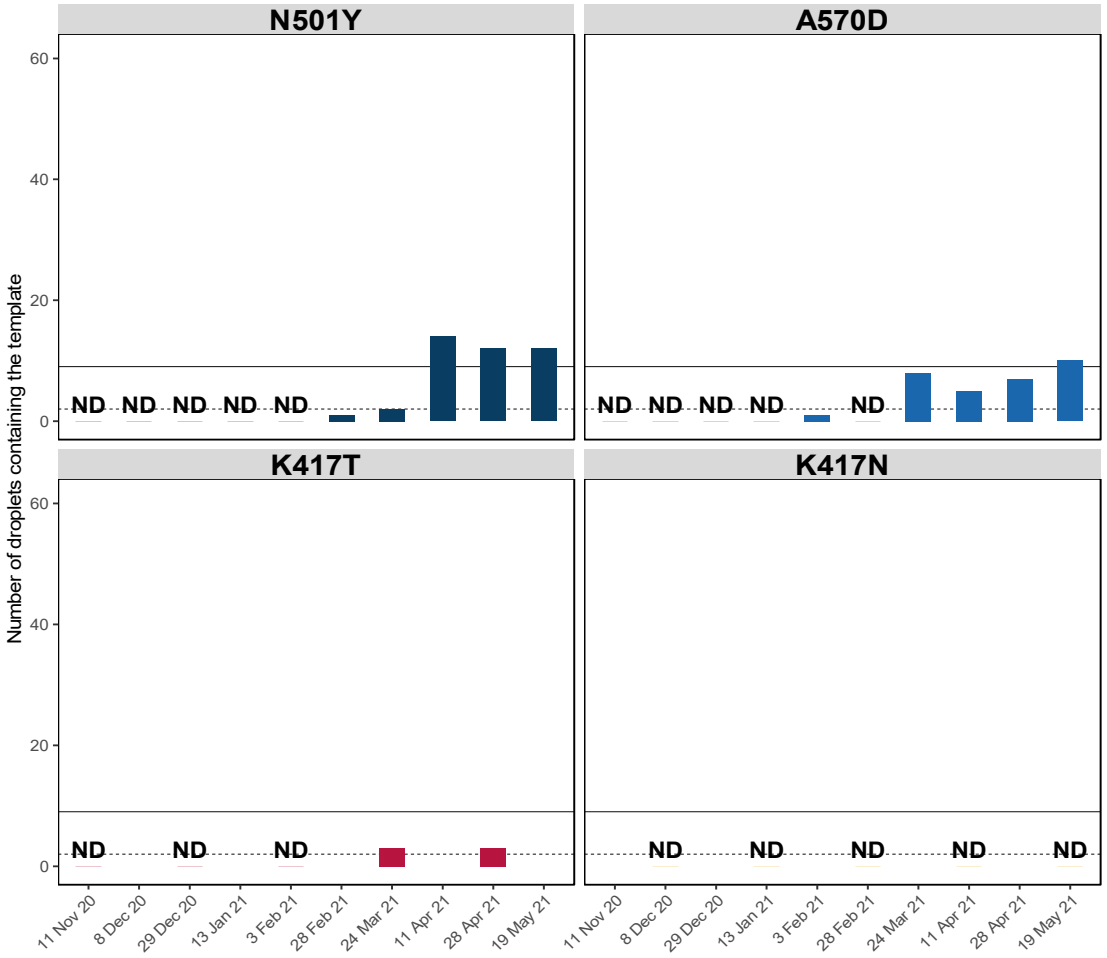

```
 Response AveTemp :
                  Df Sum Sq Mean Sq F value  Pr(>F)
ConcPer100000Case  1  58.53  58.532  6.7993 0.01075 *
Residuals         86 740.33   8.608
 Response Month :
                   Df Sum Sq Mean Sq F value  Pr(>F)
ConcPer100000Case  1  44.15  44.154  6.8276 0.01059 *
Residuals         86 556.16   6.467
```

Variants are evolving

nextstrain.org



Detection level of SARS-CoV-2 mutations (dark colors) and wild-type (light colors)

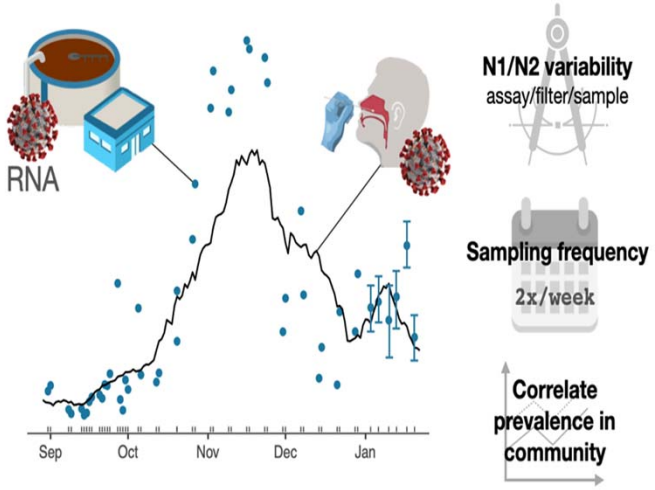


N501Y targets Alpha, Gamma, and Beta variants

A570D targets Alpha
K417T targets Gamma
K417N targets Beta

High levels of the wild-type SARS-CoV-2 were detected in November to February, followed by a drop in overall levels, and increasing detection of the Alpha and Gamma variants.

Conclusions



Wastewater monitoring for SARS-CoV-2 captures the community burden of COVID-19

Low sampling and technical variability makes this method sensitive to changes in COVID-19 burdens: 9 cases /100,000

Ongoing research is needed to understand fate and transport of the virus to aid in result interpretation

Detection and sequencing of variants in sewage samples is useful to benchmark spread and success of different variants

Acknowledgments

Ryan Newton, Assistant Professor
Adelaide Roguet, Post Doc
Melissa Schussman
Elexius Passante
Deb Dila, Research Specialist
Angela Schmoldt, GLGC

Shuchen Feng, Post Doc*
Jill McClary, Post Doc*

Angela Schmoldt, GLGC

Dagmara Antkiewicz, Scientist
Jocelyn Hemming, Senior Microbiologist
Martin Shafer, Senior Scientist
Martin Collins, Senior Microbiologist
Dawn Perkins, Environmental Toxicologist

Jon Meiman, Chief Medical Officer
Nathan Kloczko, Applied Epidemiology Fellow

Funding

UWM Office of the Chancellor
School of Freshwater Sciences
Department of Health Services, State of Wisconsin
Alfred P. Sloan Foundation
Milwaukee Metropolitan Sewerage District student fellowships ***and in kind sampling***

Questions?