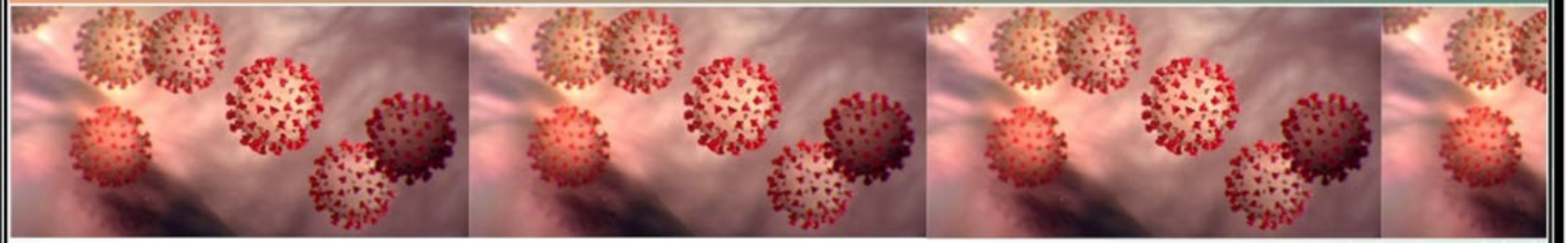
SYLVESTER COMPREHENSIVE CANCER CENTER
UNIVERSITY OF MIAMI HEALTH SYSTEM

Shared Resources
Advanced Biomedical Technology Seminar



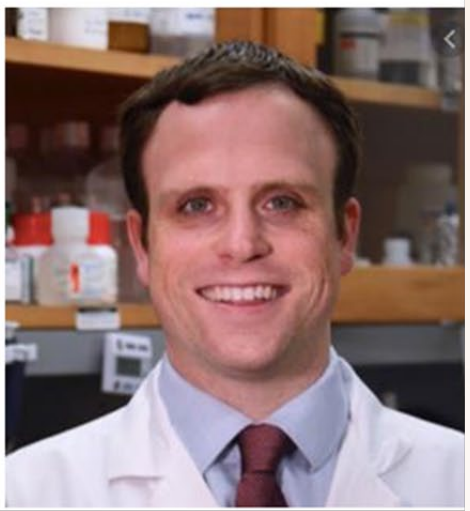
Lessons Learned from Environmental Monitoring of SARS-CoV-2

Thursday, April 14, 2022
1:00 pm EST

Speakers

Helena Solo-Gabriele, Ph.D., P.E.
Professor, Civil, Architectural &
Environmental Engineering
Associate Dean for Research
College of Engineering, University of Miami

Stephan Schürer, Ph.D.
Professor, Pharmacology
Associate Director, Data Sciences
Sylvester Comprehensive Cancer Center
Miller School of Medicine, University of Miami



Christopher E. Mason, Ph.D.
Professor, Physiology and Biophysics
Director, WorldQuant Initiative
for Quantitative Prediction
Weill Cornell Medicine, Cornell University

George S. Grills
Associate Director, Shared Resources
Sylvester Comprehensive Cancer Center
Miller School of Medicine, University of Miami

South Florida - Rapid Acceleration of Diagnostics (SF-RAD):

Development and Proof-of-Concept Implementation of the South Florida Miami RADx-rad SARS-CoV-2 Wastewater-Based Surveillance Infrastructure

Funded by
NIH RADx-rad Grant
1U01DA053941-01

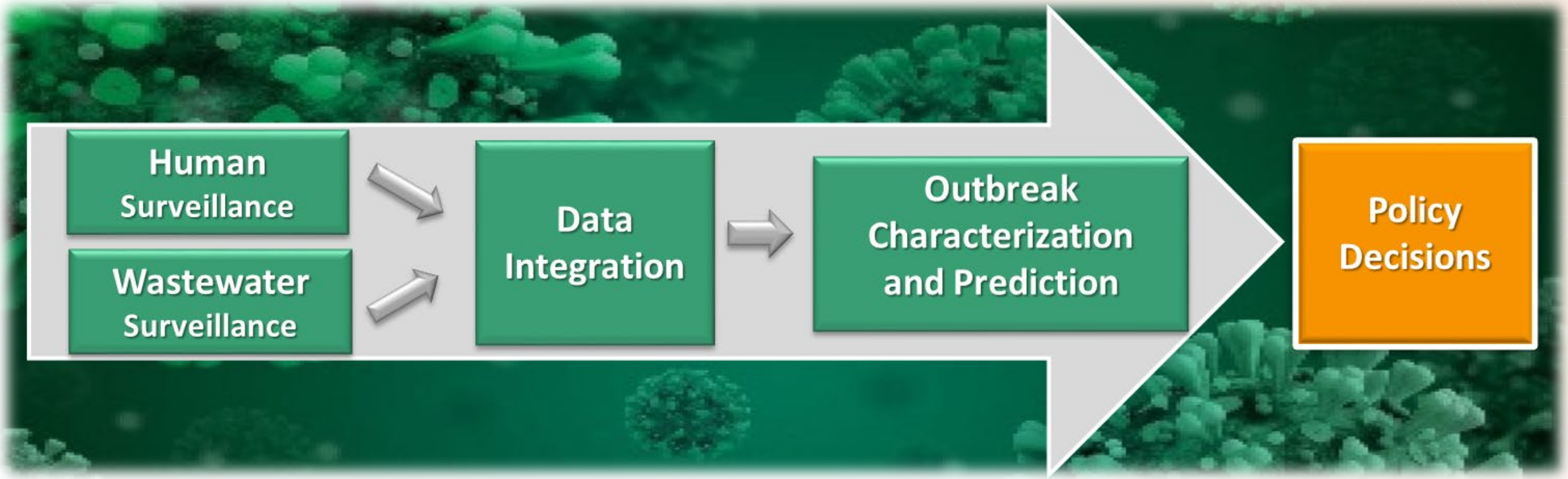
UNIVERSITY OF MIAMI

Weill Cornell Medicine

www.covidsfrad.org

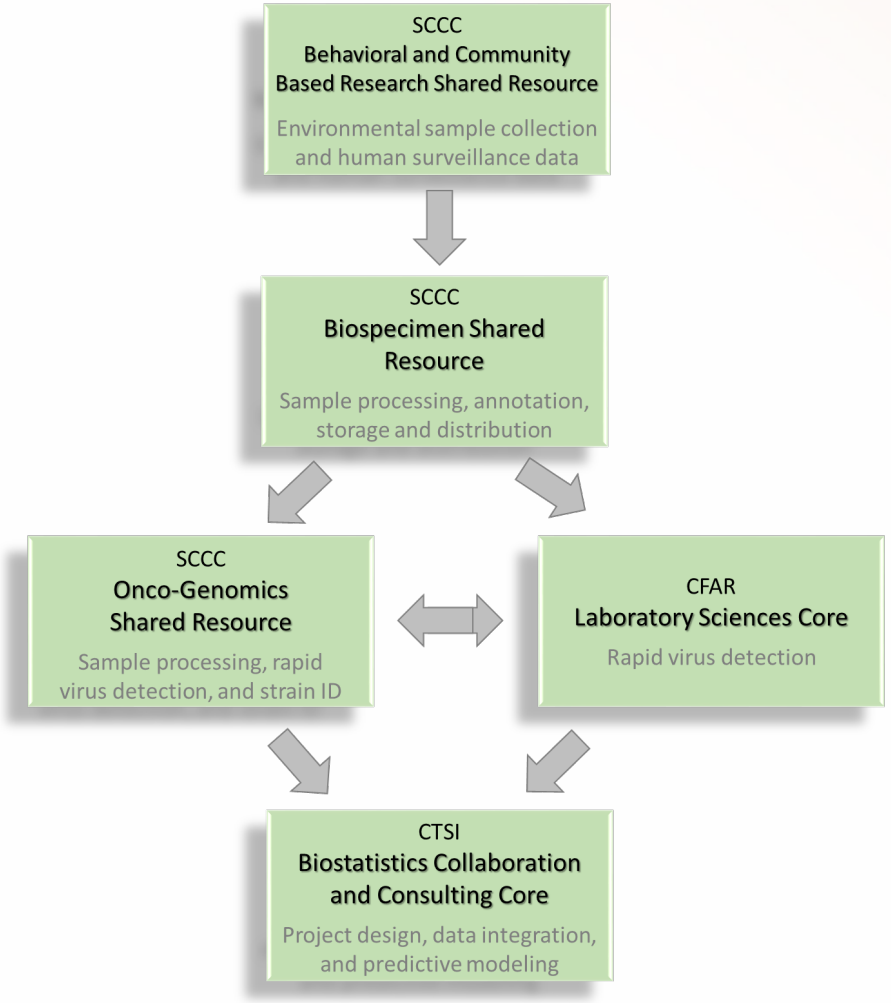
SF-RAD: SARS-CoV-2 Wastewater-Based Surveillance

Aims



SF-RAD: SARS-CoV-2 Wastewater-Based Surveillance

Integrated Multi-Shared Resources Support



Sylvester Comprehensive Cancer Center

Behavioral & Community-Based Research Shared Resource
Biospecimen Shared Resource
Onco-Genomics Shared Resource

Center for AIDS Research

Laboratory Sciences Core

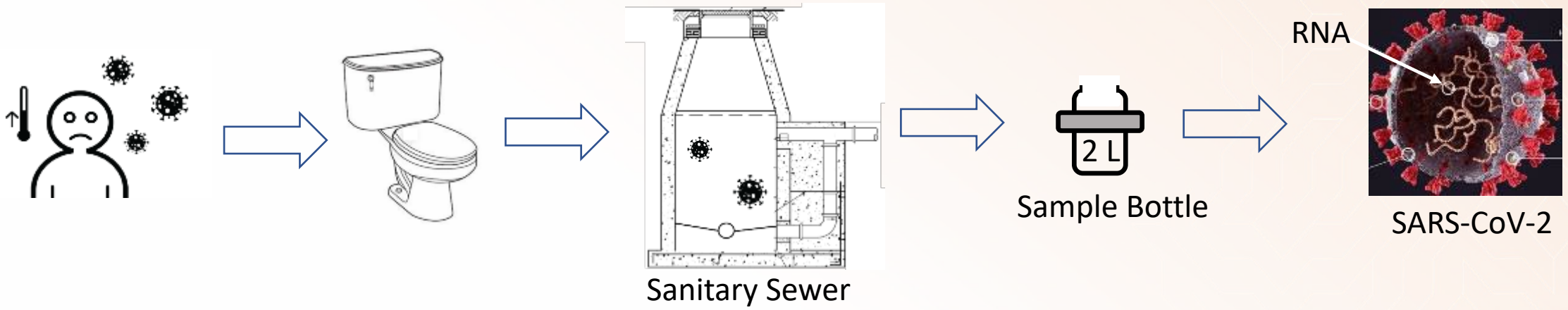
Clinical & Translational Science Institute

Biostatistics Collaboration and Consulting Core

Aim:
Wastewater Characterization

Motivation & Objectives

Infected humans excrete COVID-19 virus in feces and urine

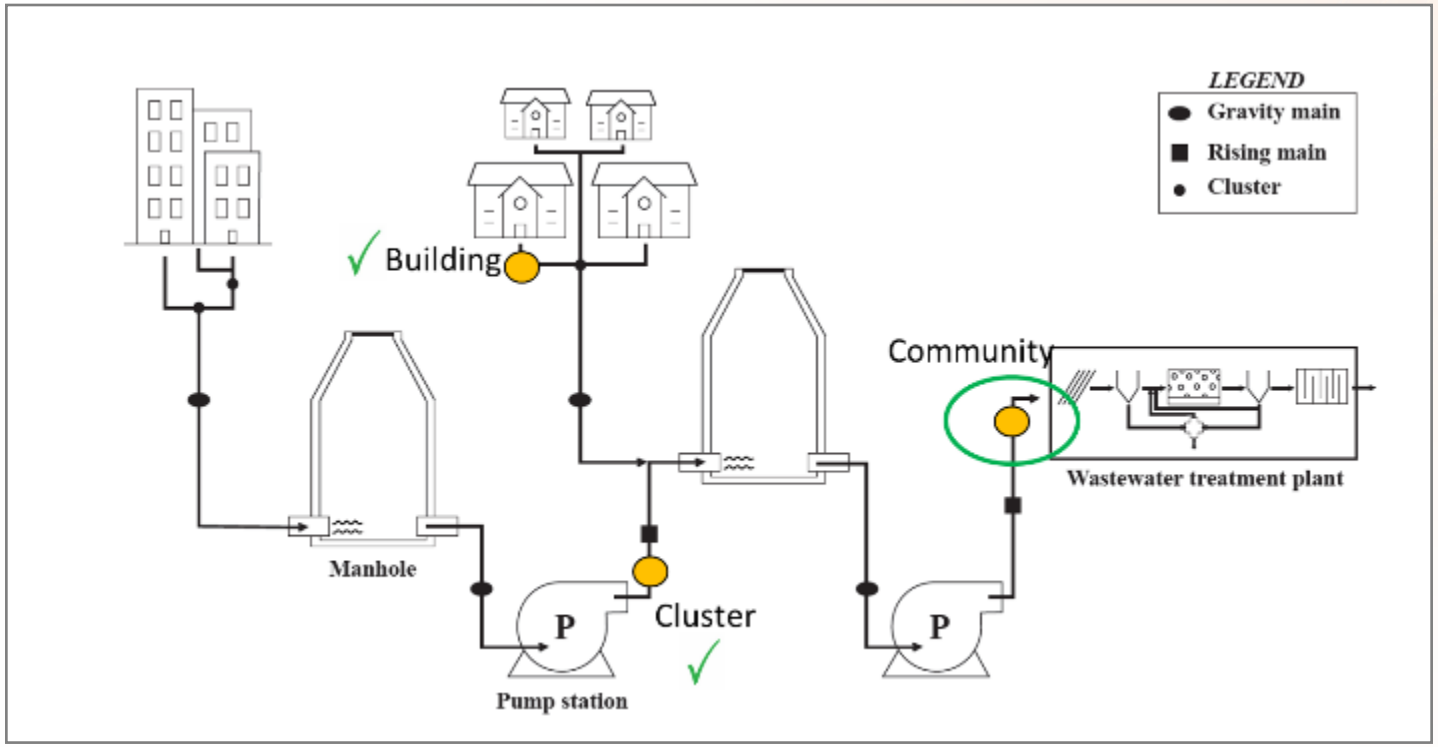


Ultimate objective: Relate wastewater measurements to predict COVID-19 cases.

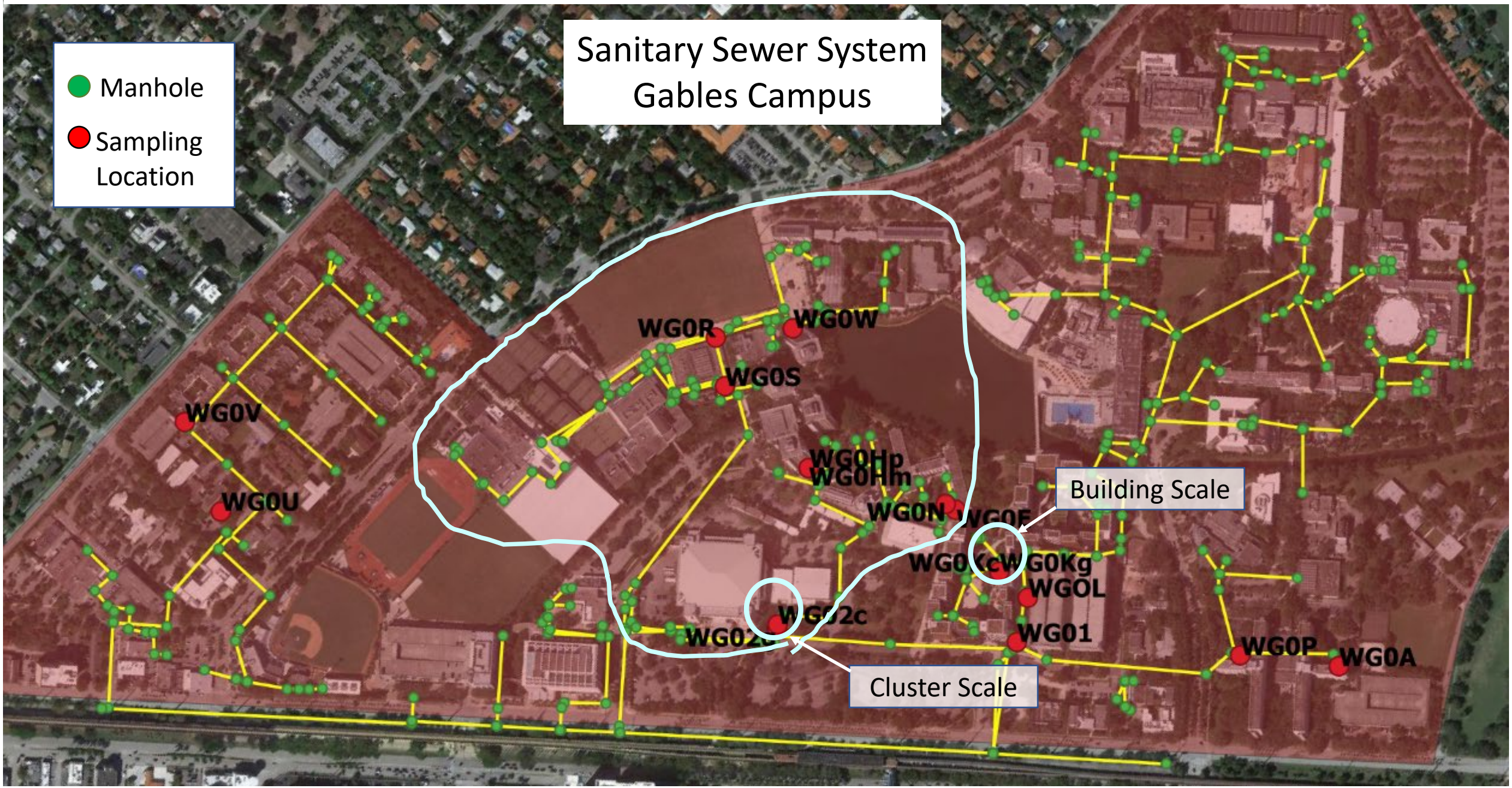
Wastewater Characterization

Aims

- Evaluate influence of watershed scale
- Evaluate sample concentration methods
- Evaluate sample collection method on SARS-CoV-2 measures
- Relate wastewater to human surveillance data

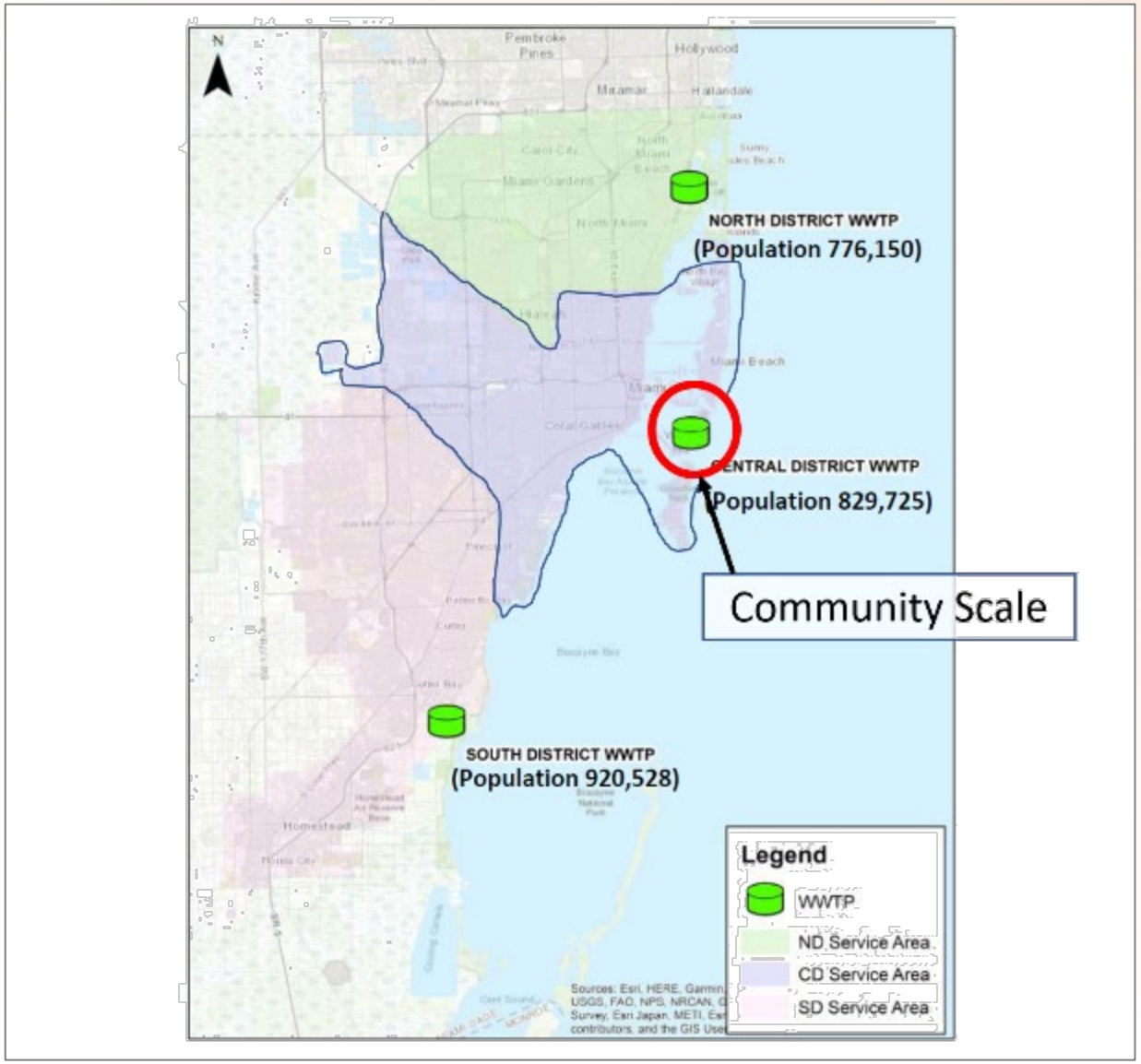


Evaluate Sewershed Scale



Sewershed Scale

Sanitary Sewer Coverage for Miami Dade County



Human & Wastewater Sample Collection

Human Surveillance

University of Miami

Student Campus Residents, UMiami Gables/Marine (Sep. 2020)

Fall'20/Spring'21
- Students tested weekly (nasal swab, qPCR) Supplemented by breath test
- COVID results and total tests by building/dorm room

Summer/Fall'21
- Unvaccinated students tested weekly
- All students tested when wastewater exceeds

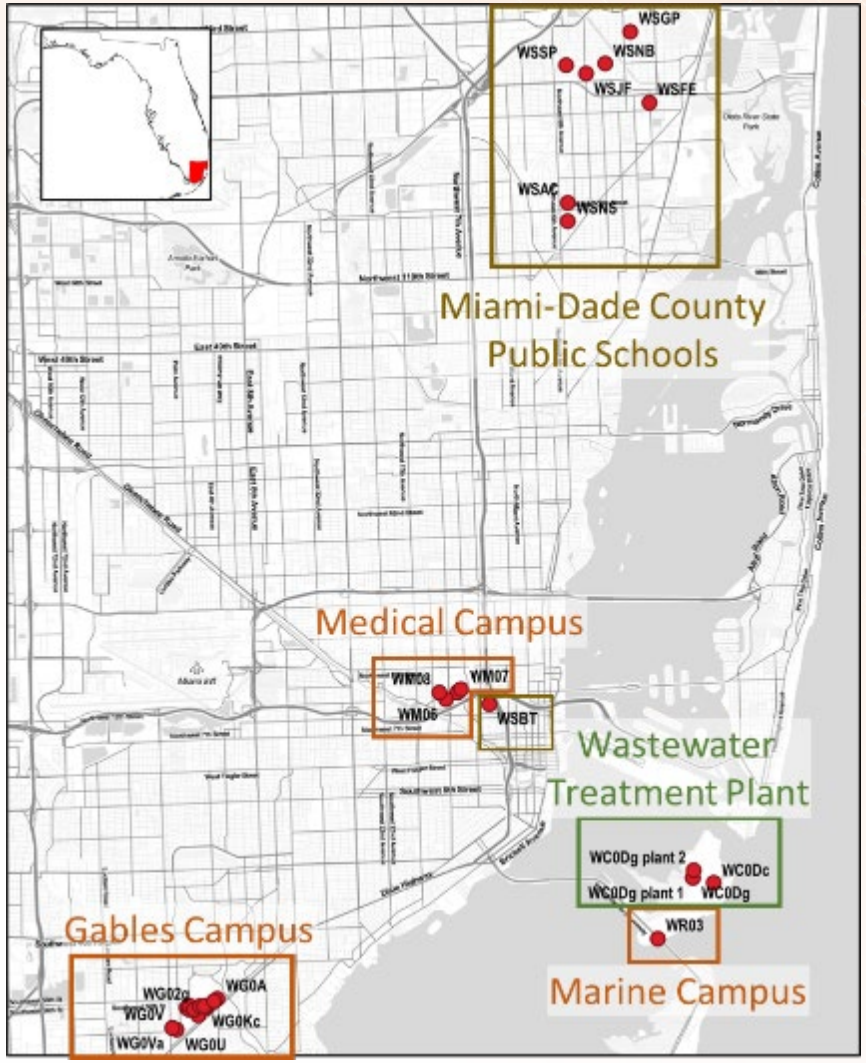
University Hospital, UMiami Medical (Sep. 2020)
- Treat known COVID patients
- Electronic medical records pulled regularly

Miami-Dade County

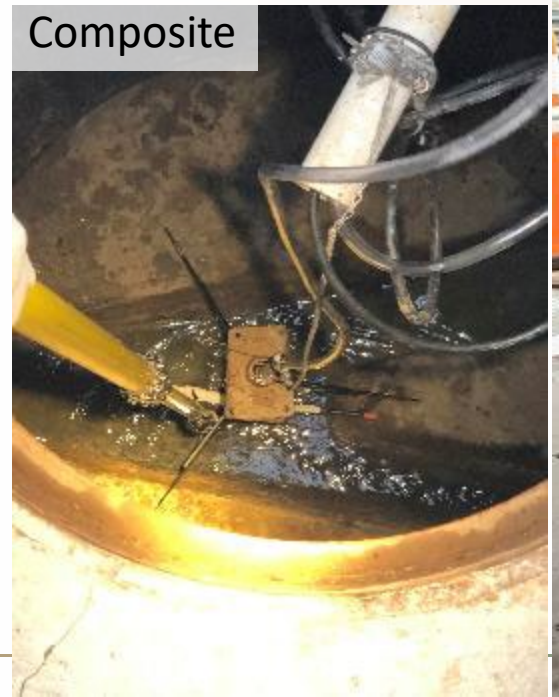
Miami-Dade County Residents, FDOH WWTP (Jan. 2021)
- Positives by zip code
- Number of tests by zip code
- Augment with Biobot wastewater data (Apr. 2020)

Pilot, **Miami-Dade County Public Schools**, MDCPS (Jan. 2022)
- In collaboration with RADx-UP project (Gwynn, PI)
- 9 Schools (4 Elementary, 2 Middle, 3 High Schools)

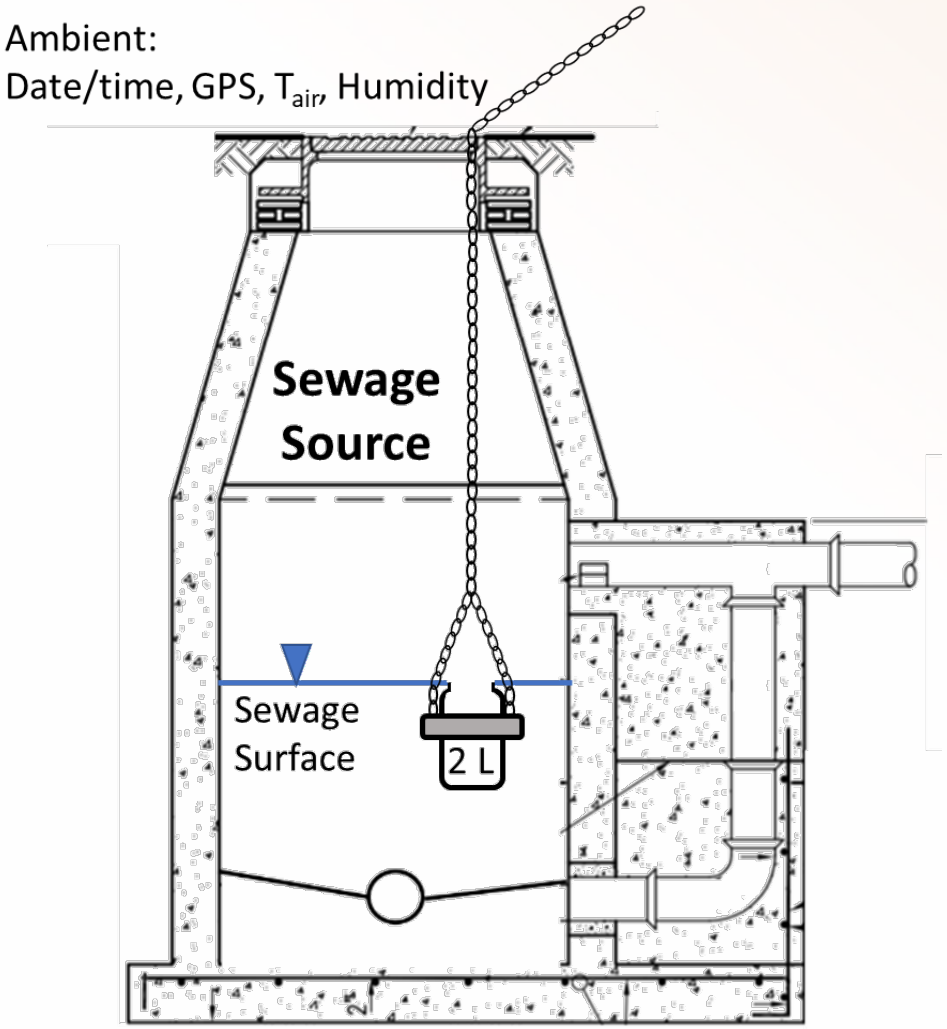
Sample Collection Plans



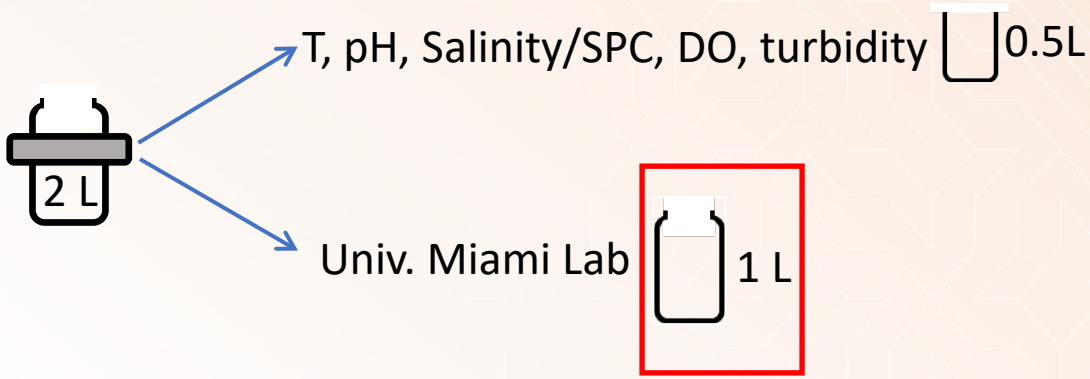
Sample Collection Strategies (Composite vs Grab)



SAMPLING at UMiami

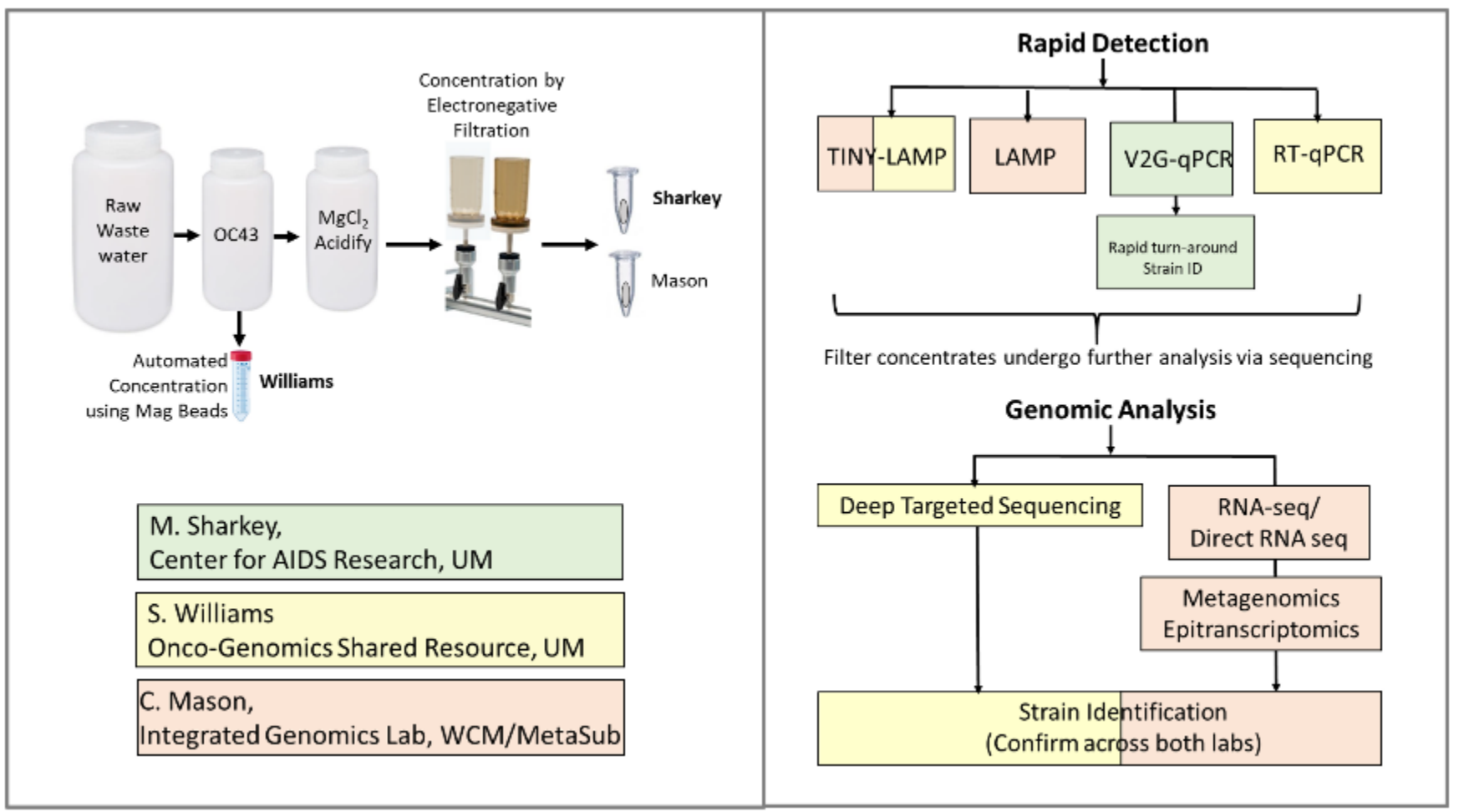


<u>Collect Samples Weekly</u>
Results available in 12 hours

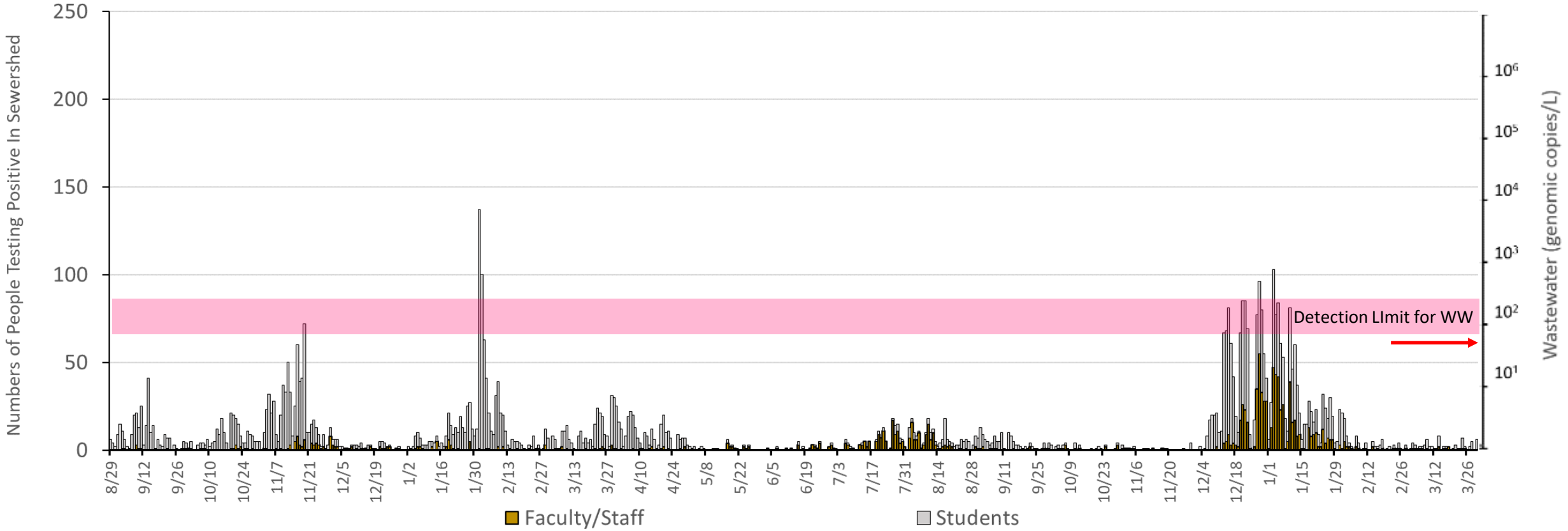


Wastewater Characterization

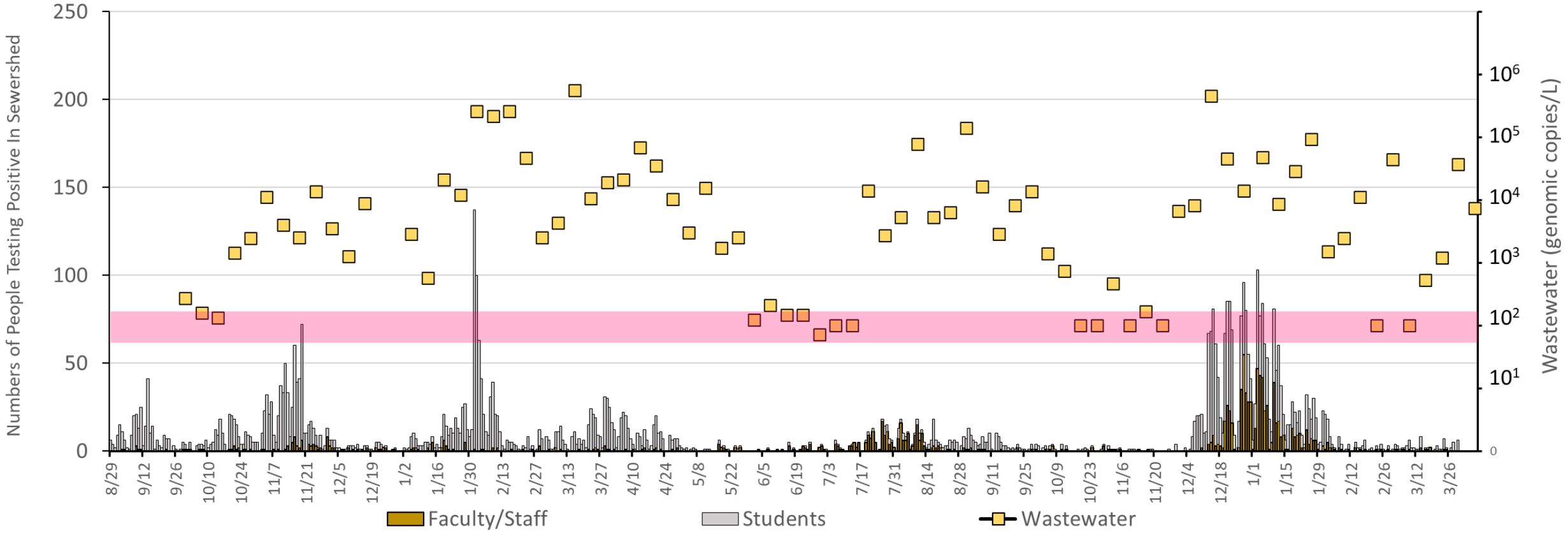
Sample Processing & Data Generation



Campus (cluster scale) time series plot



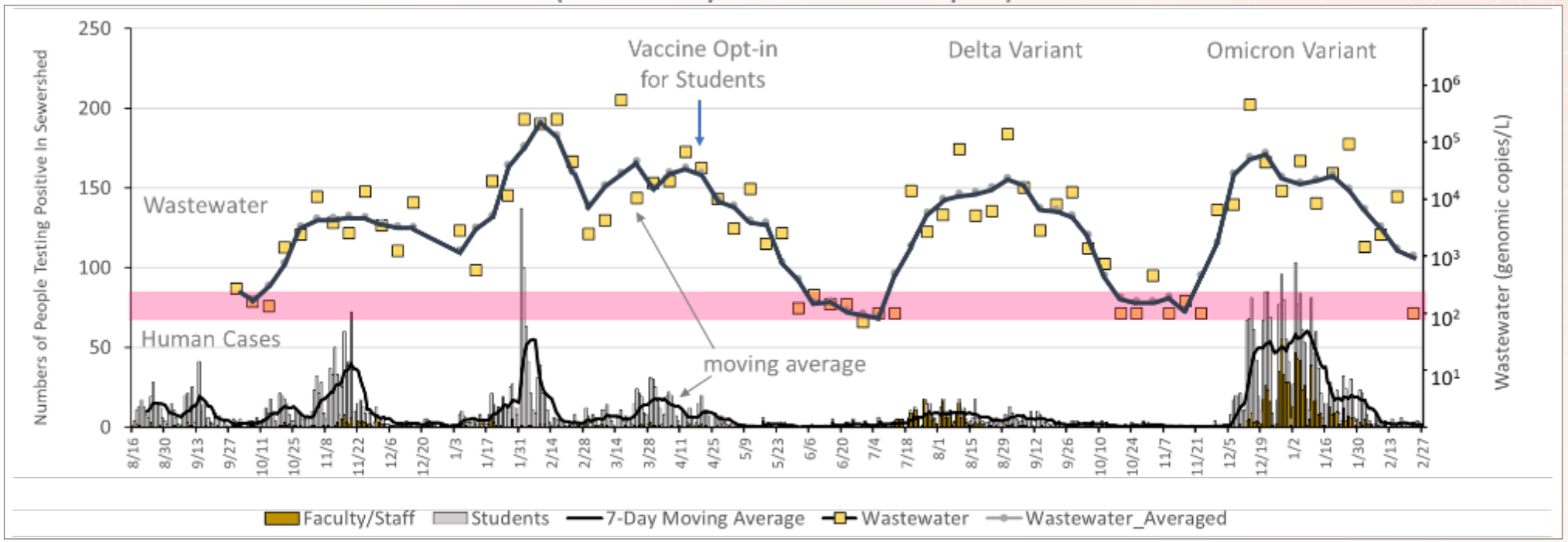
Campus (cluster scale) time series plot



Integration of Human and Environmental Surveillance

Building Cluster Scale

(University of Miami Campus)



SARS-CoV-2 in wastewater was a 4-day lead indicator

Positivity (%) = 9 ln(C) / 10

10^2 gc/L of SARS-CoV-2 in wastewater associated with 4% positivity.

10^4 gc/L→ 8%

10^6 gc/L→ 12%

Sharkey et al. 2021, https://doi.org/10.1016/j.scitotenv.2021.149177

Model by Dr. Naresh Kumar

Air and Surface Sampling Added to Wastewater Monitoring

	Prediction of COVID-19 cases (2-day lagged)
Air	100%
Surface	82%
Wastewater	73%

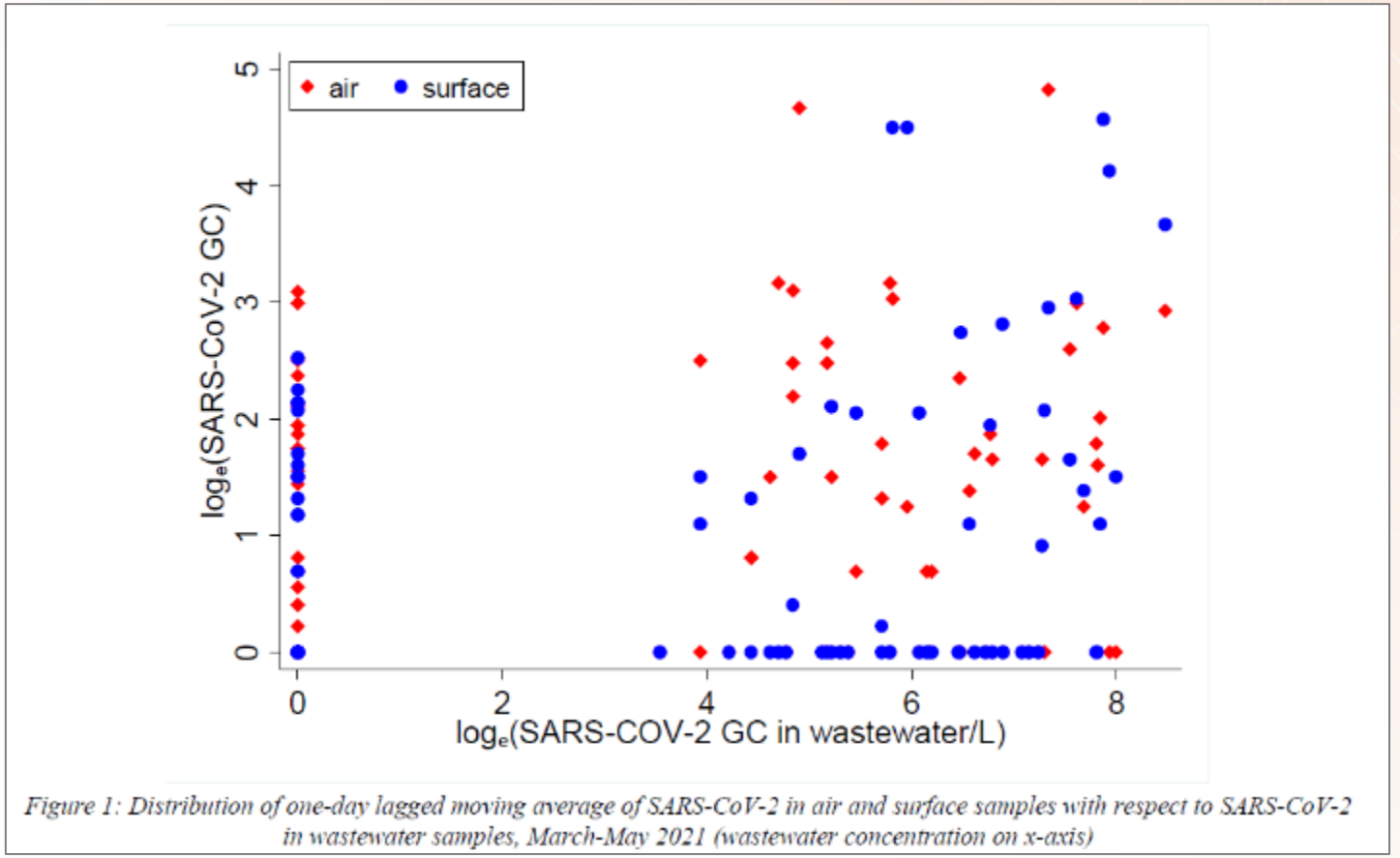


Figure 1: Distribution of one-day lagged moving average of SARS-CoV-2 in air and surface samples with respect to SARS-CoV-2 in wastewater samples, March-May 2021 (wastewater concentration on x-axis)

From Naresh Kumar

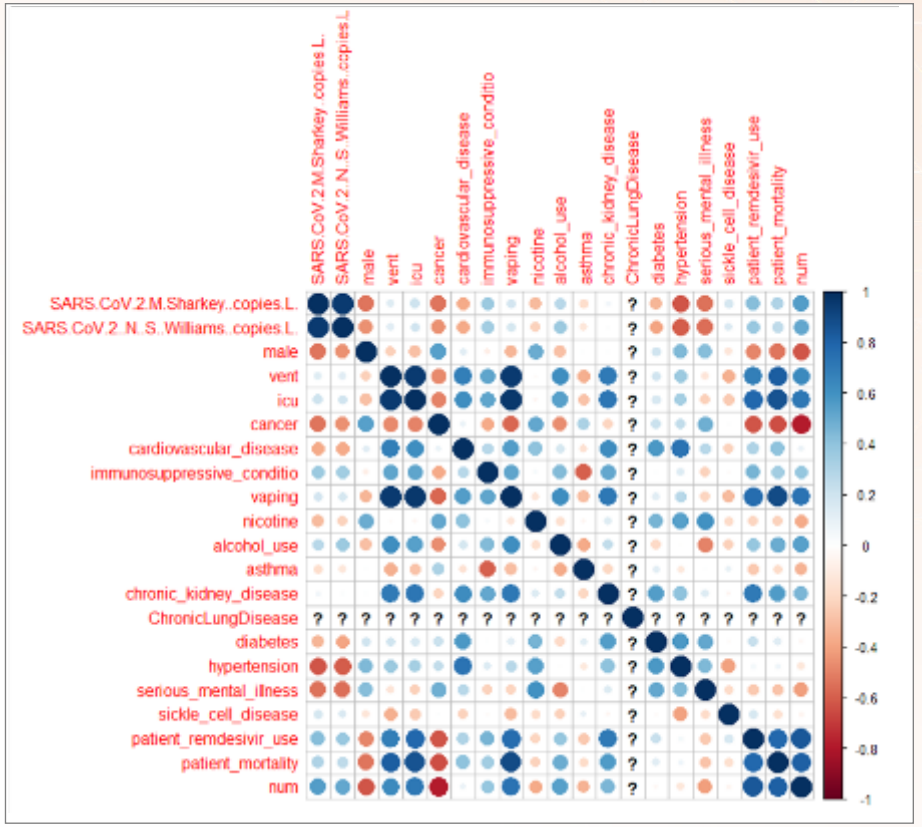
Integration of Human and Environmental Surveillance

Correlations with Hospital Data

Correlation of wastewater data
to severity of clinical COVID-19 disease

Positive correlates:

- Total number of COVID-19 positive cases
  admitted on given day of wastewater sampling
  (strong, expected)
- Mortality
  (positive, expected)
- Patients requiring treatment with remdesivir
  (positive, counterintuitive
  as remdesivir disrupts viral replication)
- Patients with immunosuppressive conditions
  (positive, expected)
- Patients requiring ventilators and critical care
  (weak, expect strong correlation, but may be due
  to nursing care and waste disposal into trash)



From Bhavarth Shukla and Alejandro Mantero

Aim:
Data Standardization

FAIR Guiding Principles for Scientific Data

Findable:

- F1. Globally unique and persistent identifiers
- F2. Rich and qualified metadata
- F3. Registered or indexed in a searchable resources

Accessible (and Attributable):

- A1. Retrievable by their identifier in an open & free protocol
- A2. Formal data citation record and provenance

Interoperable:

- I1. Formal language for knowledge representation
- I2. Vocabularies / ontologies and qualified references

Reusable:

- R1. Clear and accessible data usage license
- R2. Provenance

Replicable:

- R3. Experimental metadata (reporting guidelines)

Wilkinson et al *Nat Sci Data* **2016**

Standards to Report Biomedical Data

- **Reporting guidelines (minimum information specifications):** specify what information need to be captured about an experiment for a particular purpose
- **Controlled vocabularies:** terminological resource that provides the identification and formal definition of entities - **Ontologies**
- **Data exchange formats:** specification how data are encoded to be computer-readable / -processable
- **Policies:** required data standards and experimental data quality by research consortia, funders, publishers

FAIRsharing - Resource for Data Standards and Policies

Standards

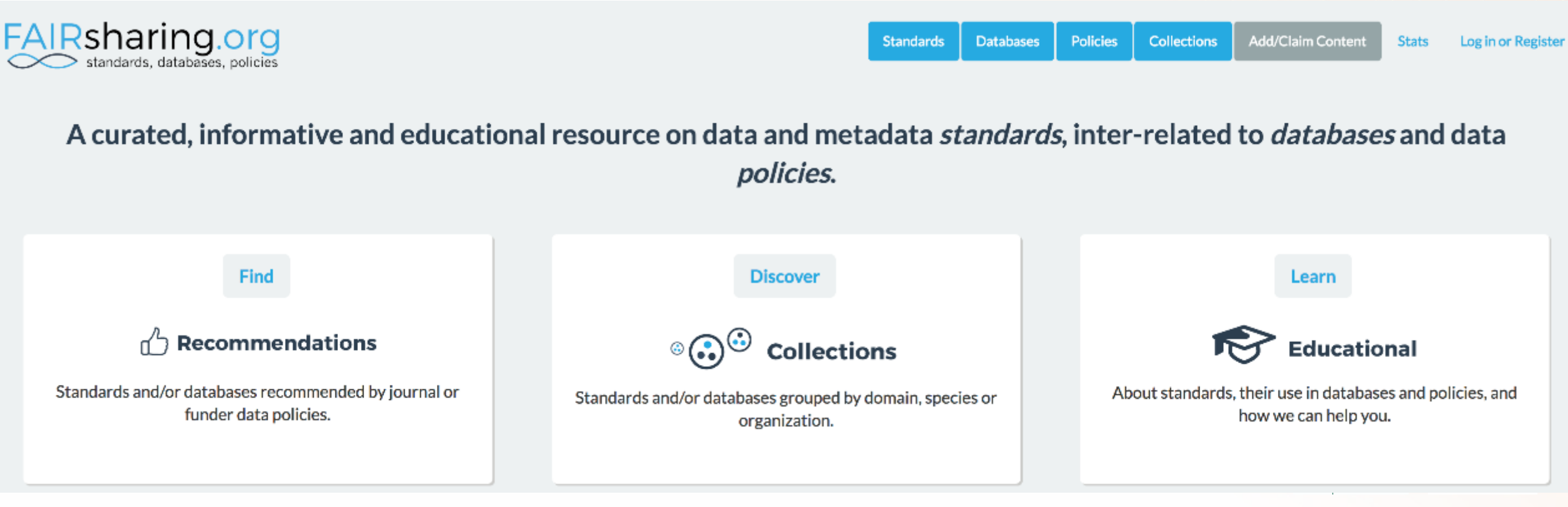
- Reporting guidelines
- Terminology artifacts
- Model / format

Policies

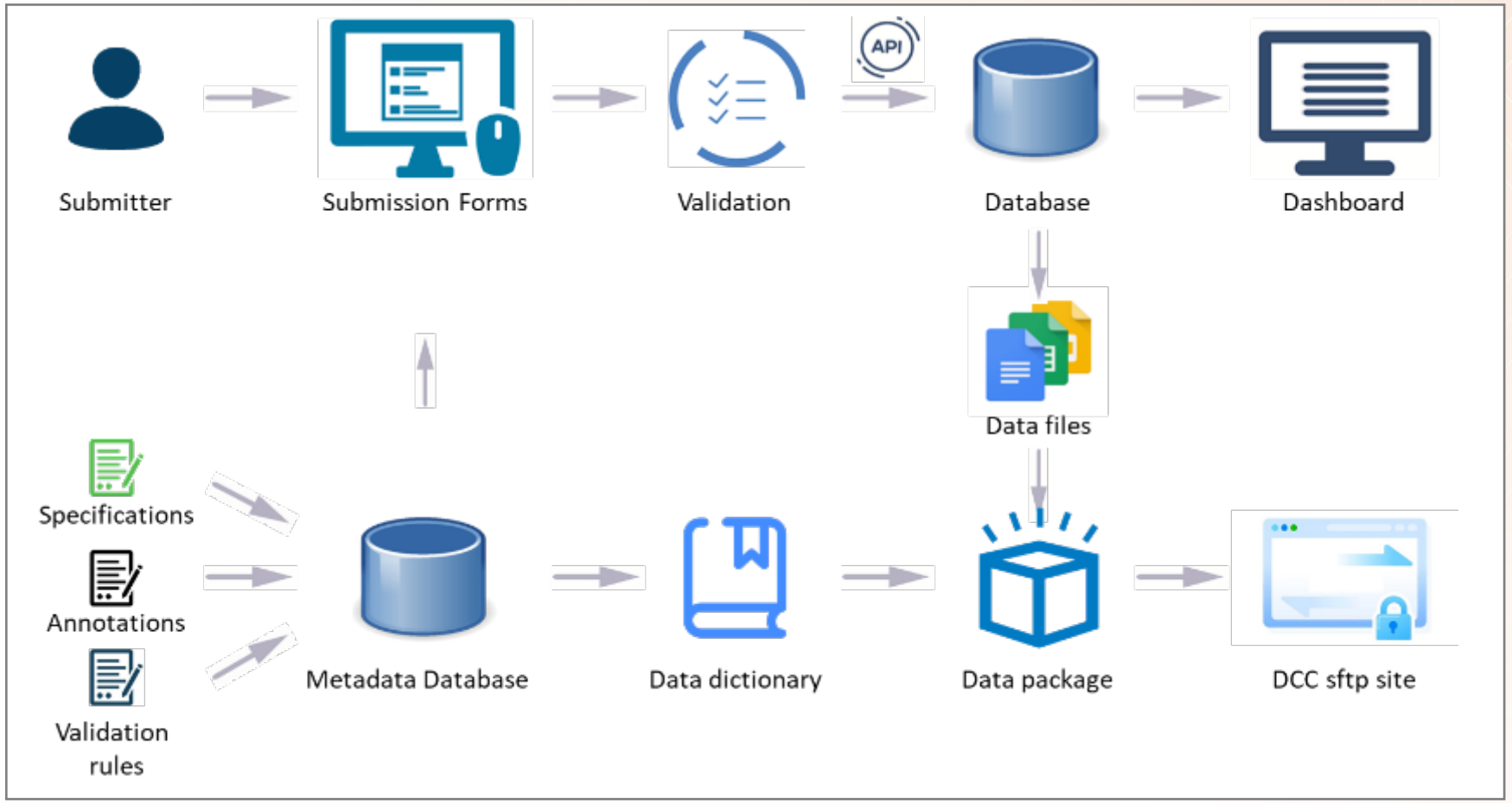
Journal
Funder
Society

Associated databases

Collections

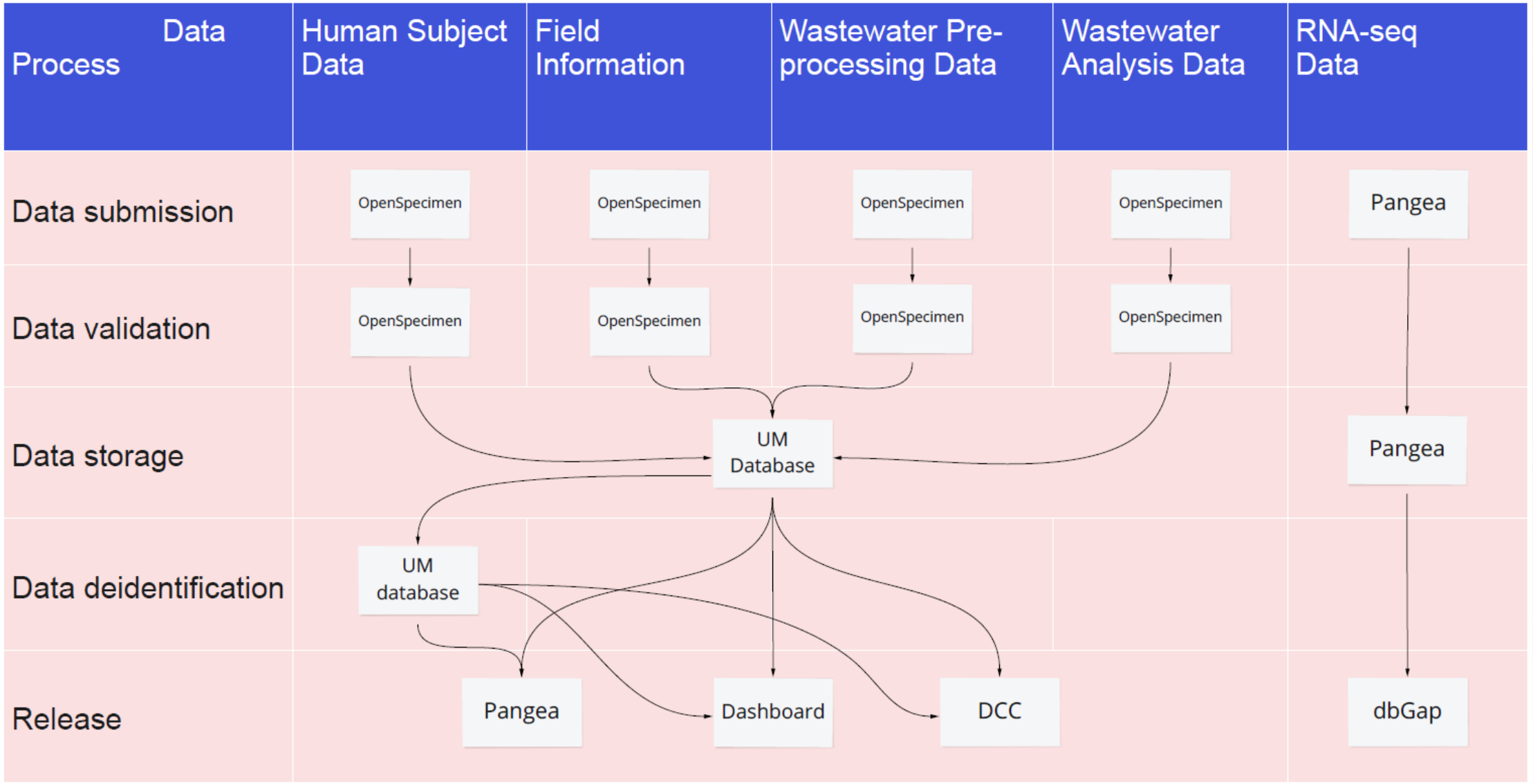


Standardized SF-RAD Data & Metadata Management



- Establish data and metadata categories and develop metadata standards
- Establish end-to-end data flow process
- Implement operational informatics infrastructure to manage data & metadata
- Implement Data Portal for data access and integration

End-to-end SF-RAD Data Flow



Status of SF-RAD Metadata Development

	Category Name	Category Description	Number of specifications	Developed
Field Info	Field Data	Sample collection information from the field	59	☑
	Continuous Measurements of Water Quality	Continuous record of water quality measured by a sonde	19	☑
Wastewater pre-processing	Pretreatment	Sample splitting and addition of recovery control	43	☑
	Concentration	Sample concentration by different methods	48	☑
	Bacterial Culture Analyses	Fecal Coliform Bacterial Results	19	☑
Analysis sample preparation	Extraction	Nucleic acid extraction	43	☑
Wastewater analysis	qPCR Results	V2G-qPCR, RT-qPCR, LAMP assay results	66	☑
	RNA-seq Results	RNA-seq assay results	42	☑
Human subject data	Clinical Patient Data	Individual deidentified patient data from hospital	56	☑
	Students Individual Data	Individual deidentified students data from campus	-	☐
	Students Aggregated Data	Aggregated students testing data from campus	7	☑
	County Level Data	County level data from the FDOH	-	☐

SF-RAD metadata are aligned across the RADx-rad research consortium (https://www.radxrad.org) and CDC (https://covid.cdc.gov/covid-data-tracker/#wastewater-surveillance)

SF-RAD Field Metadata Example

SF-RAD Metadata Specifications for:

Field Data

Importance 1: Required, 0: Optional

SF-RAD Field Name	Definition	Importance
matrix_type	What is tested: wastewater (W); air (A); surface swab (S)	1
sample_location_code	Code corresponding to the location (e.g. WG01)	1
sample_id	Format: Sample Location-Date-Time (parent ID) [XXXX-YYMMDDHH]	1
sampling_date	Date of the sampling	1
sampling_time	Time of the sampling	1
gps_latitude_degrees	GPS coordinates (latitude) of the sampling location, in degrees	0
gps_latitude_minutes	GPS coordinates (latitude) of the sampling location, in minutes	0
gps_latitude_seconds	GPS coordinates (latitude) of the sampling location, in seconds	0
gps_longitude_degrees	GPS coordinates (longitude) of the sampling location, in degrees	0
gps_longitude_minutes	GPS coordinates (longitude) of the sampling location, in minutes	0
gps_longitude_seconds	GPS coordinates (longitude) of the sampling location, in seconds	0
water_temp	Temperature of the sampled wastewater, in C	1
water_ph	pH value of the sample in the field	1
water_salinity	Salinity, quantity of dissolved salts (NaCl, Mg2SO4, KNO3, NaHCO3), in ppt (part per thousand)	0
water_conductivity	Specific Conductiviy, measure of water's ability to carry an electric charge which is related to the dissolved salts in the sample (ÂµS/cm)	1
sample_turbidity	Turbidity (light scattering property of water that results in loss of transparency) of the sample, in nephelometric turbidity units (ntu)	0
sample_dissolved_oxygen	Dissolved Oxygen, amount of oxygen dissolved in sample, in mg/L	0
location_air_temp	Temperature of the air at the location and time of sampling, in C	0
location_air_humidity	Humidity of the air at the location and time of sampling, in %	0

SF-RAD qPCR Metadata Example

SF-RAD Metadata Specifications for:

Field Data

Importance 1: Required, 0: Optional

SF-RAD Field Name	Definition	Importance
matrix_type	What is tested: wastewater (W); air (A); surface swab (S)	1
sample_location_code	Code corresponding to the location (e.g. WG01)	1
sample_id	Format: Sample Location-Date-Time (parent ID) [XXXX-YYMMDDHH]	1
sampling_date	Date of the sampling	1
sampling_time		
gps_latitude_degrees		
gps_latitude_minutes		
gps_latitude_seconds		
gps_longitude_degrees		
gps_longitude_minutes		
gps_longitude_seconds		
water_temp		
water_ph		
water_salinity		
water_conductivity		
sample_turbidity		
sample_dissolved_oxygen		
location_air_temp		
location_air_humidity		

SF-RAD Metadata Specifications for:

qPCR Results

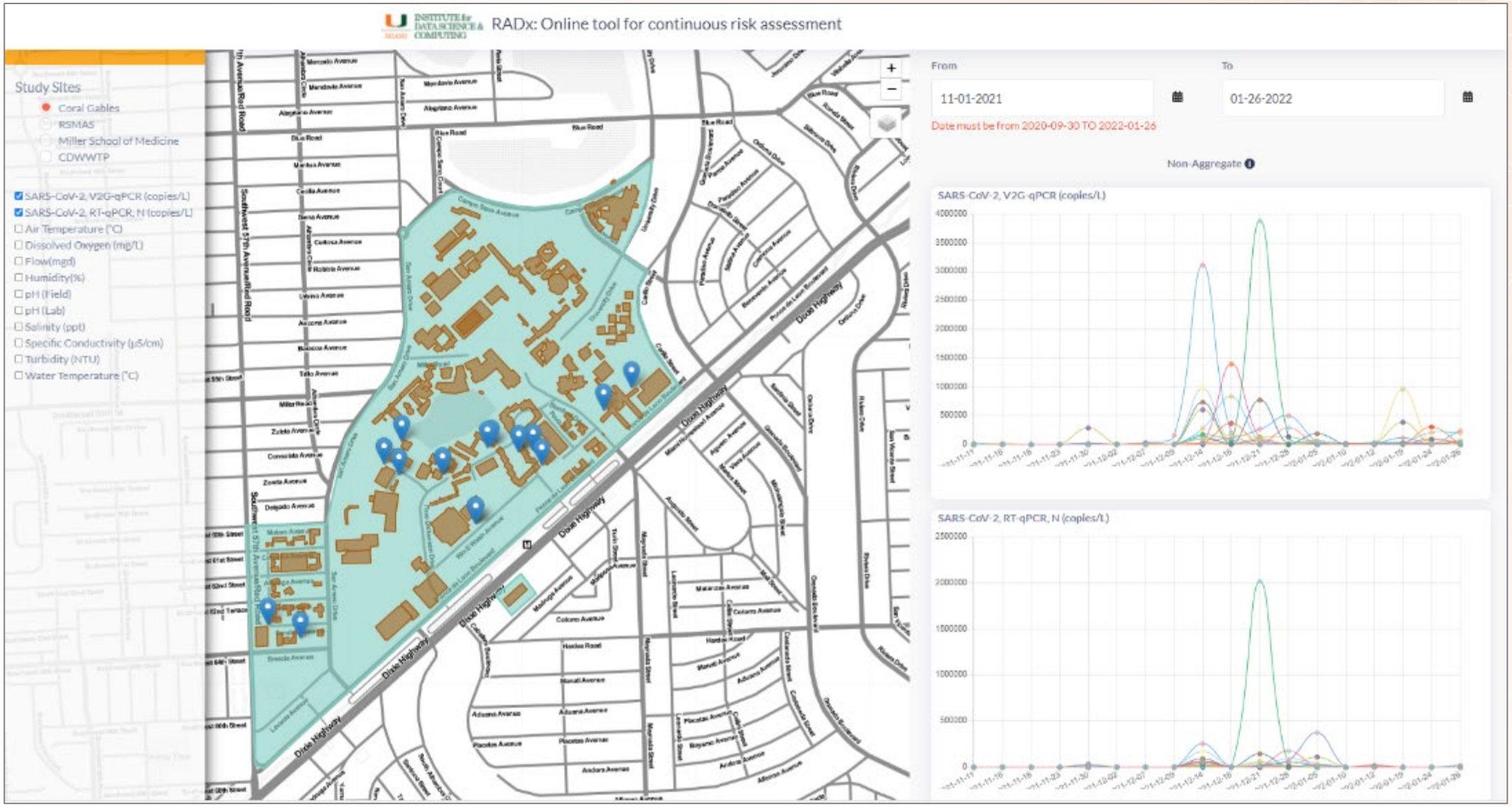
Importance 1: Required, 0: Optional

SF-RAD Field Name	Definition	Importance
qpcr_run_id	Unique identifier for the qPCR run	1
instrument_model	Maker and model of qPCR instrument used for the assay	1
instrument_serial_number	Serial number of instrument used for the assay	1
instrument_software_name	Name of software/firmware responsible for action of the instrument	1
instrument_software_version	Version of software/firmware for instrument activity	1
analysis_software_name	Software name used for performing analyses	1
analysis_software_version	Version of software used for analyses	1
plate_format	Type of plate used for assay (number of wells)	1
assay_date	Date of assay performed	1
user	User name running assay (lab name or person)	1
file_name	File (.csv or .tsv) name containing final data and calculated values	1
pcr_type	Type/molecular principle of PCR assay	1
pcr_protocol_name	Protocol name used for the experiment	1

Status of SF-RAD Data Processing and Submission

	Category Name	Submission forms	Preprocessing/QC	Preparing for DCC	Submitted to DCC
Field Info	Field Data	☑	☑	☑	☑
	Continuous Measurements of Water Quality	☐	☐	NA	NA
Wastewater pre-processing	Pretreatment	☐	☐	☐	☐
	Concentration	☑	☑	☐	☐
	Bacterial Culture Analyses	☐	☐	NA	NA
Analysis sample preparation	Extraction	☑	☑	☐	☐
Wastewater analysis	qPCR Results	☑	☑	☑	☑
	RNA-seq Results	☐	☐	☐	☐
Human subject data	Clinical Patient Data	☑	☑	☐	☐
	Students Individual Data	☐	☐	☐	☐
	Students Aggregated Data	☑	☑	☐	☐
	County Level Data	☐	☐	☐	☐

SF-RAD COVID Dashboard (alpha release)



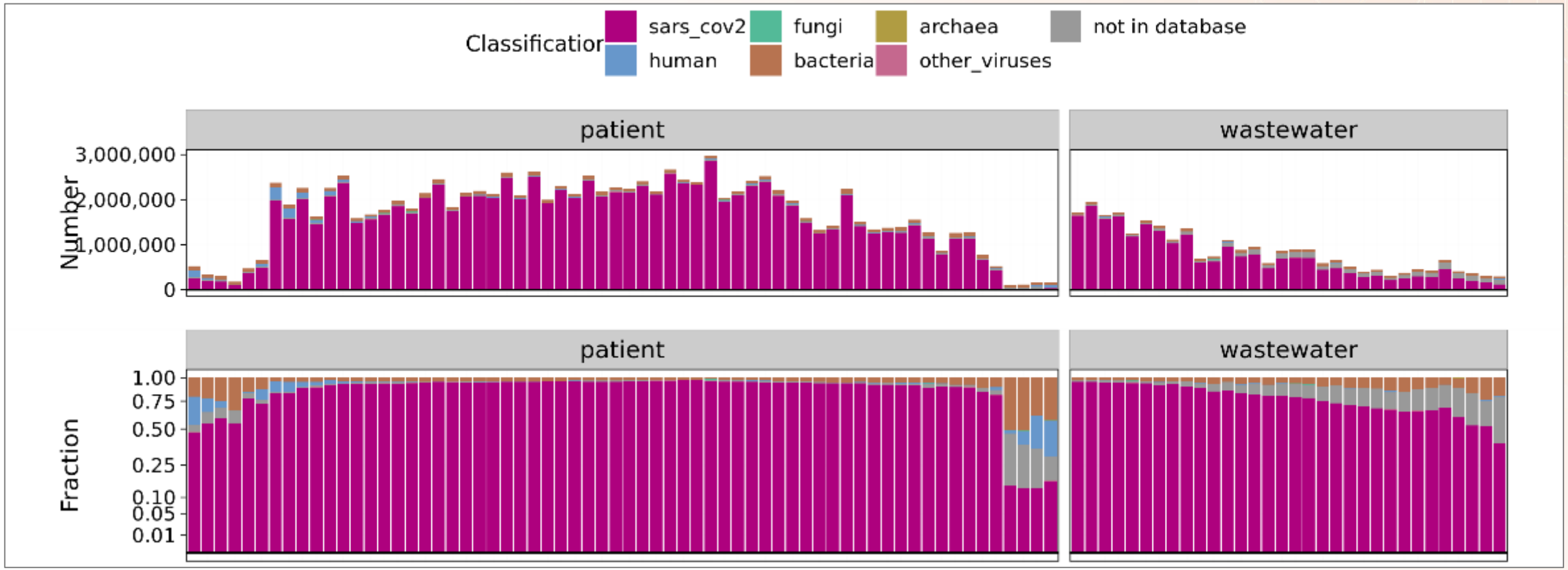
Aim:
Integration with
Human Health Surveillance

Wastewater VOC Detection Methodology

1. Assign taxonomy to all reads and filter SARS-CoV-2 matches with **kraken2**
   - Run using custom pan-kingdom DB
   - Generate SARS-CoV-2 FASTQs leveraging **seqtk**
2. Align to Wuhan reference with **bwa mem**
   - Sort and index alignment with **sambamba**
3. Trim primers with **ivar trim** using version-specific ARTIC BED file
   - Get coverage statistics on trimmed BAMs
     - **bedtools genomecov** for per-base coverage
     - **mosdepth** for per-amplicon coverage
4. Call variants using hybrid approach with **lofreq** and **ivar**
   - Take union of calls to avoid FNs and use mean DP/VAF per mutation call
5. Annotate mutations (assign gene, impact, amino acid substitutions) with **VEP**
6. Estimate relative VOC lineage abundances with **Freyja**

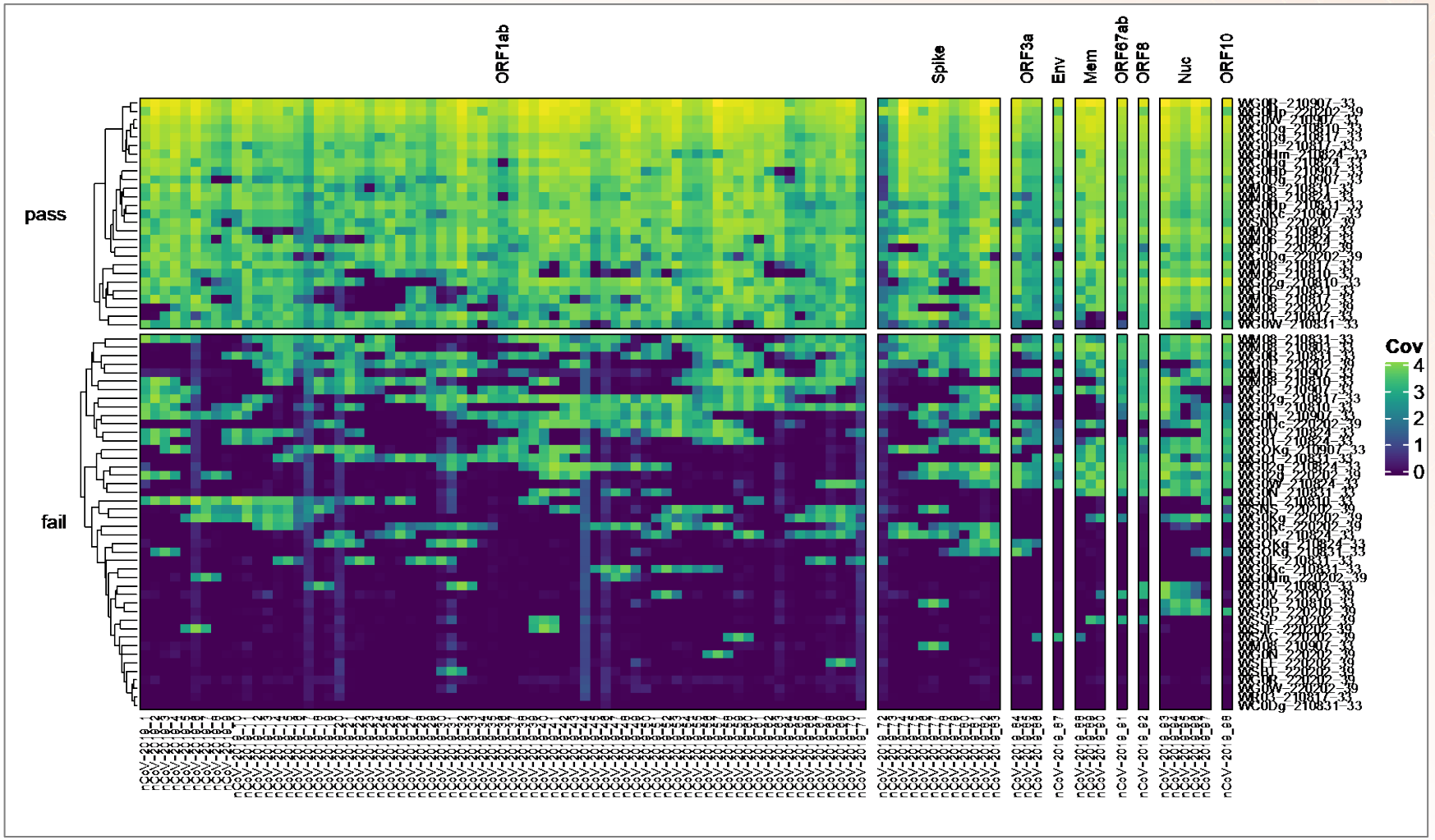
Performance of ARTIC protocol on clinical and wastewater samples

Good library efficiency to amplify SARS-CoV-2



Samples are filtered by total genome coverage

Minimum of 75% of SARS-CoV-2 genome must be covered with at least 50x
Example shown from 2022-02-07 run



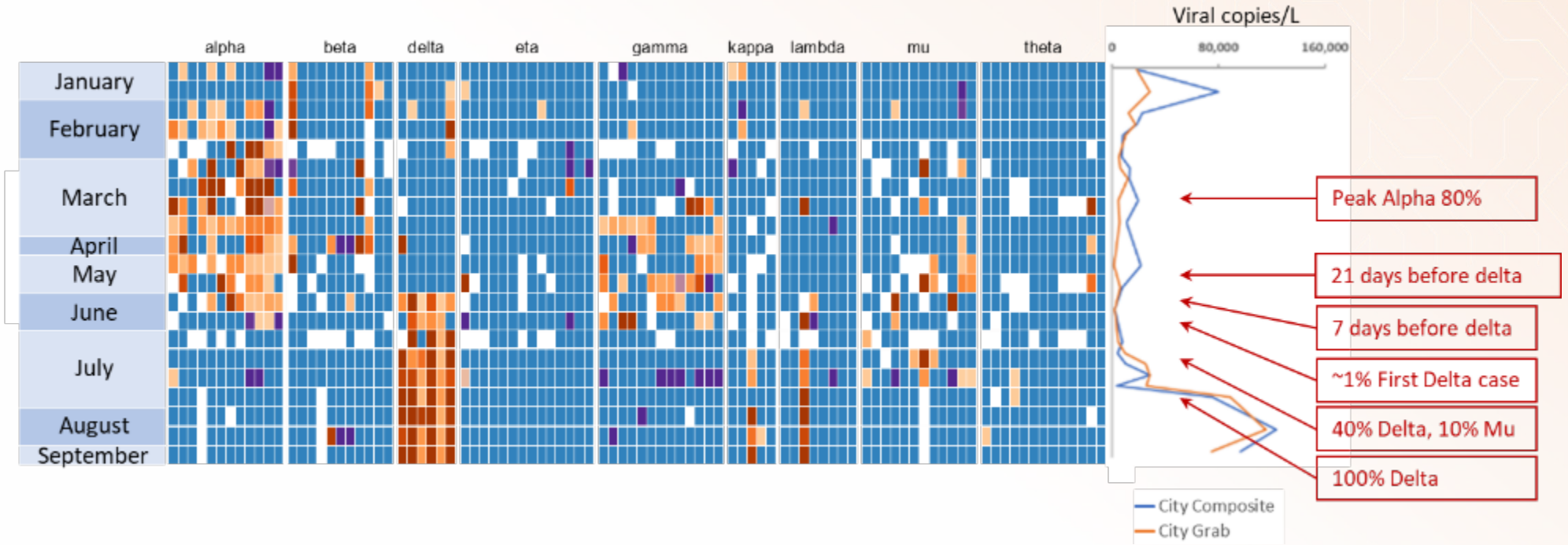
Tracking signature mutations across all 2021 WW samples

Integration of Human and Environmental Surveillance

Detection of SARS-CoV-2 lineages in wastewater

- SARS-CoV-2 lineages in City wastewater mirror patient data
- Even at low viral load lineages can be discerned
- High diversity followed by Alpha, Gamma, Mu, then Delta
- Delta detectable at -7 days before first sequenced case

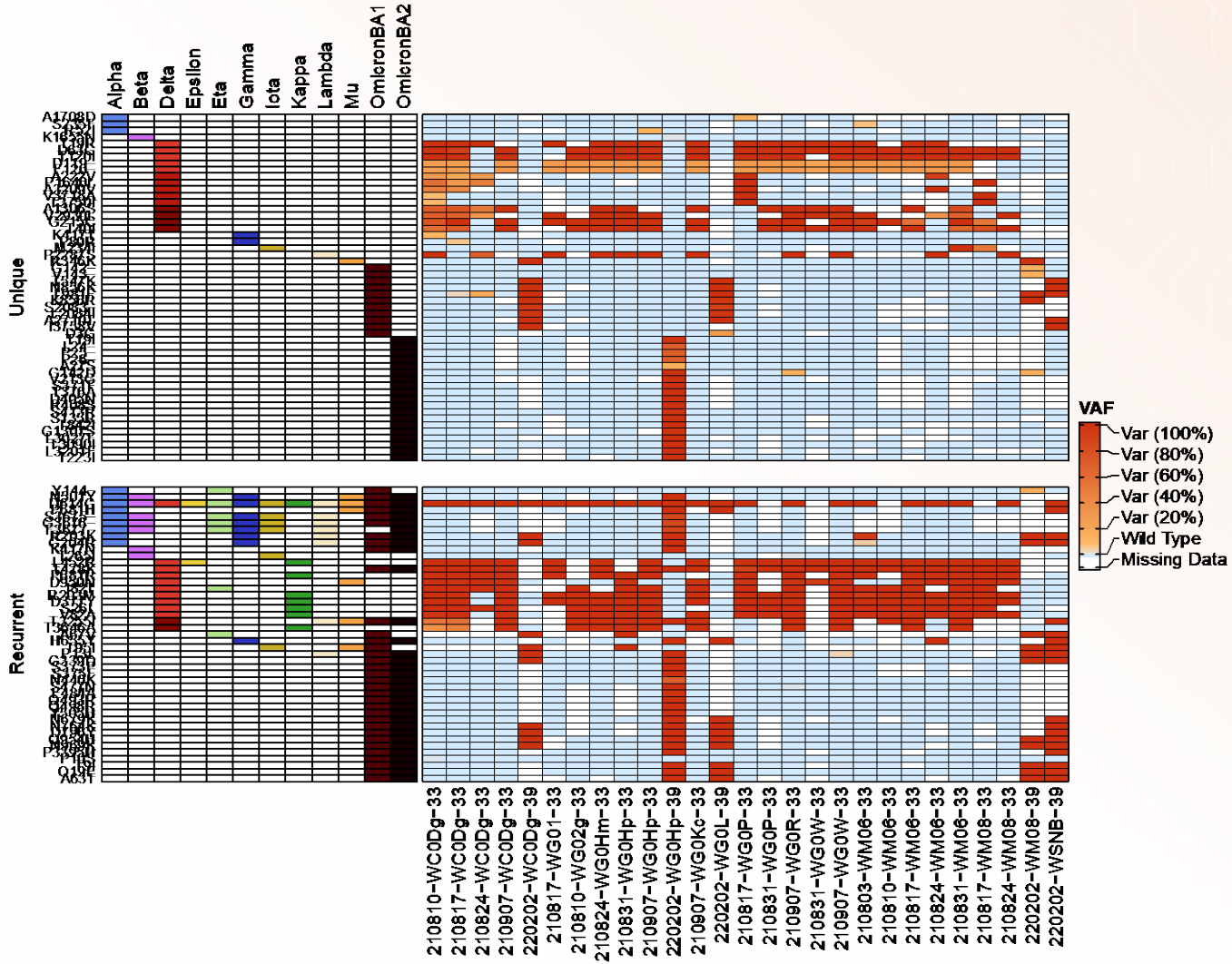
City of Miami
(Jan.-Sept. 2021)



Integration of Human and Environmental Surveillance

Monitoring of new variants-of-concern in wastewater

Dynamically updating VOCs to monitor: Samples shown here include Jan/Feb 2022 along with some summer 2021 samples. Omicron BA.2 signature mutations added in January 2022.



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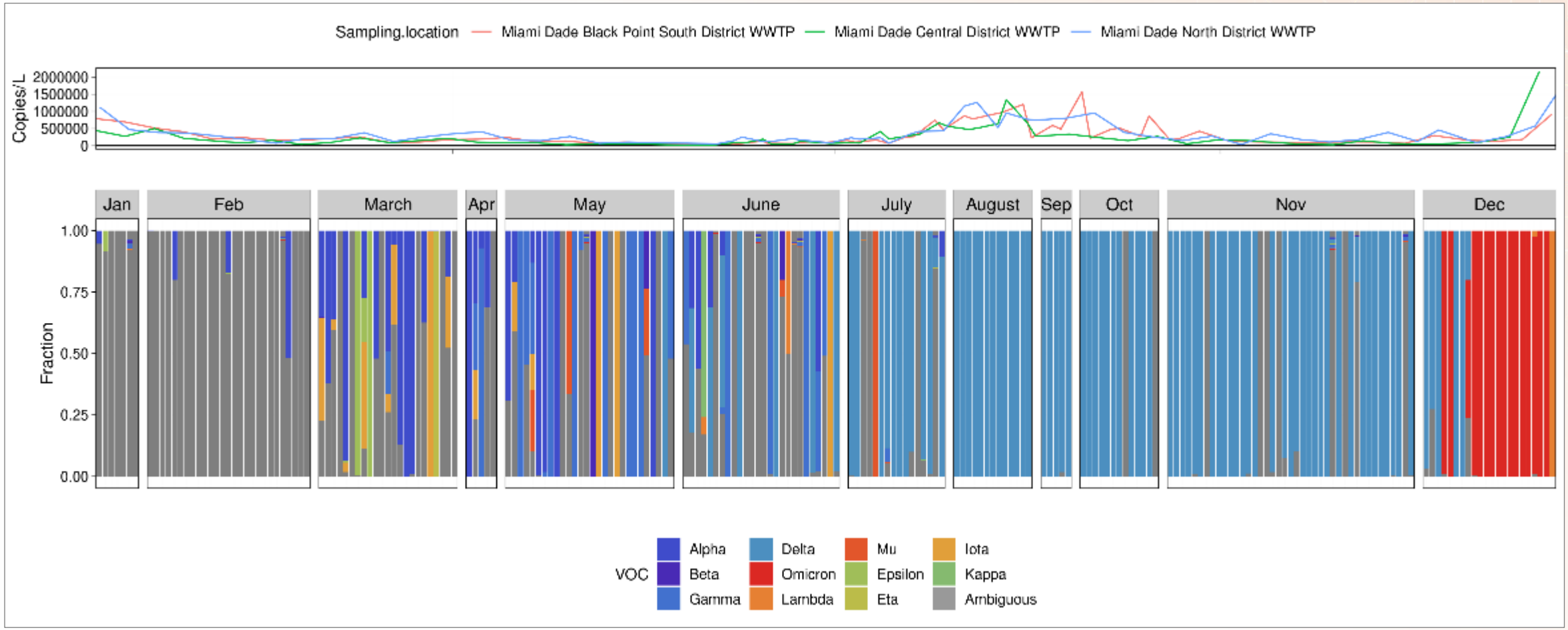
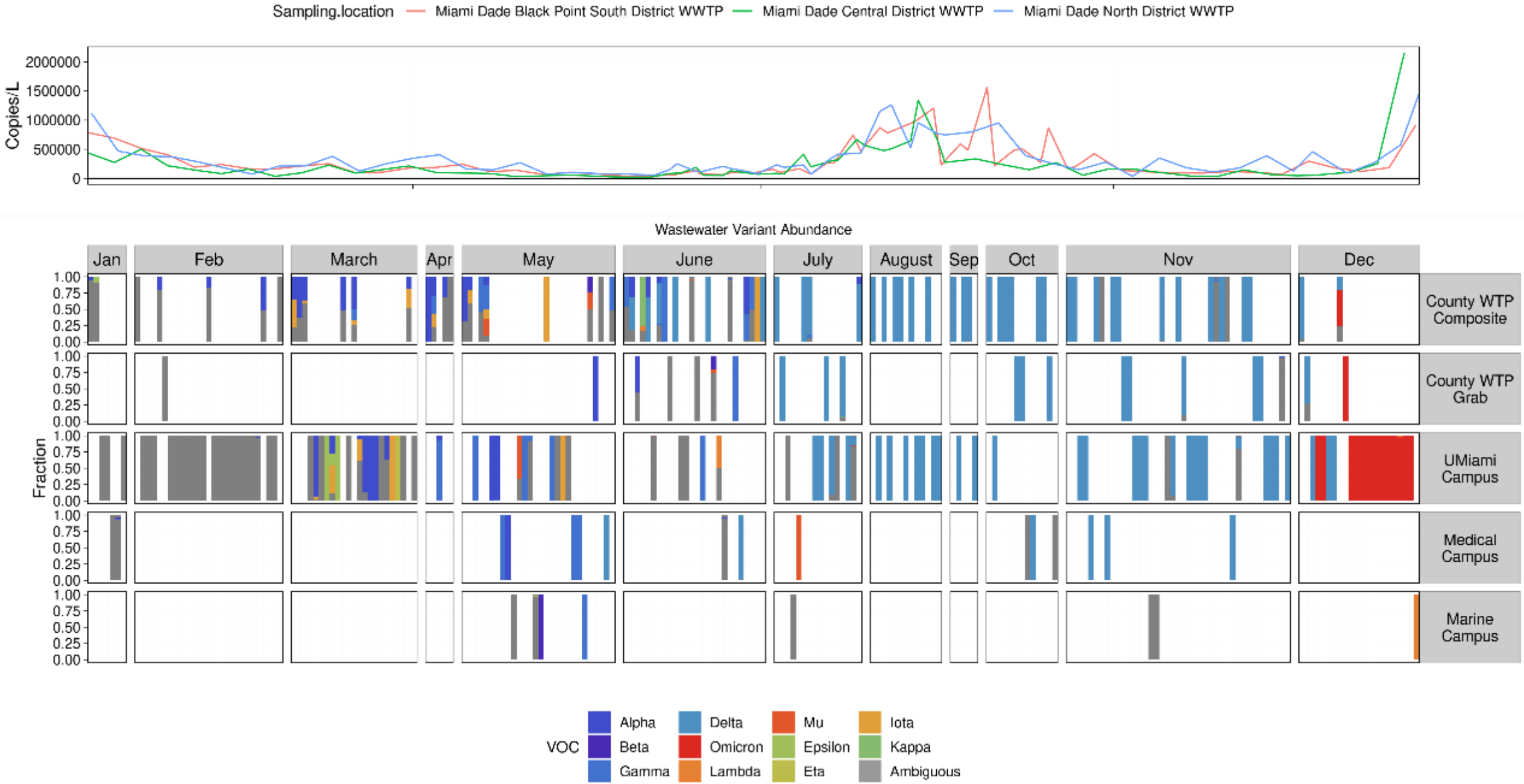
Weill Cornell Medicine

Integration of Human and Environmental Surveillance

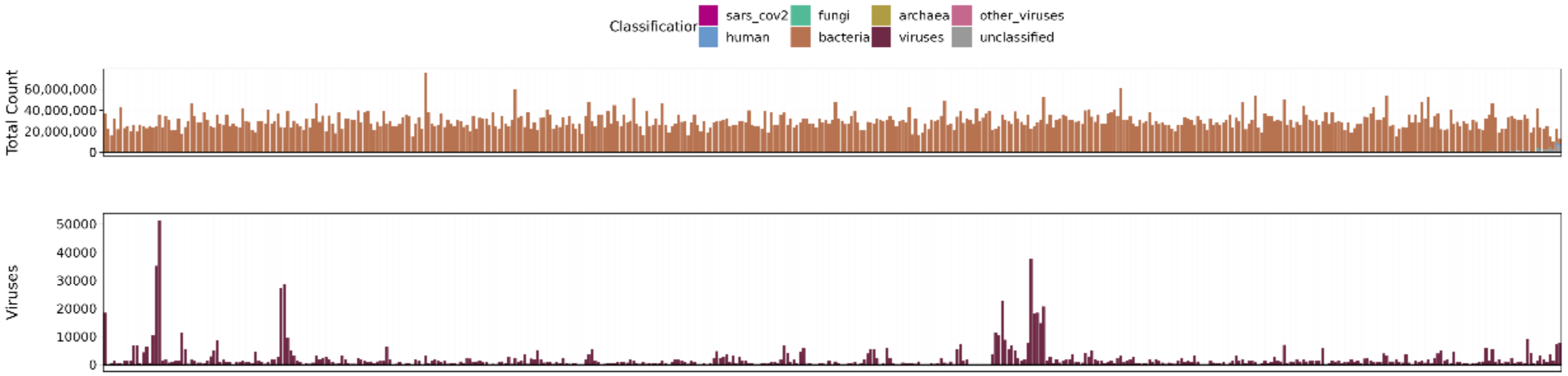
Tracking changes in SARS-CoV-2 lineages in wastewater



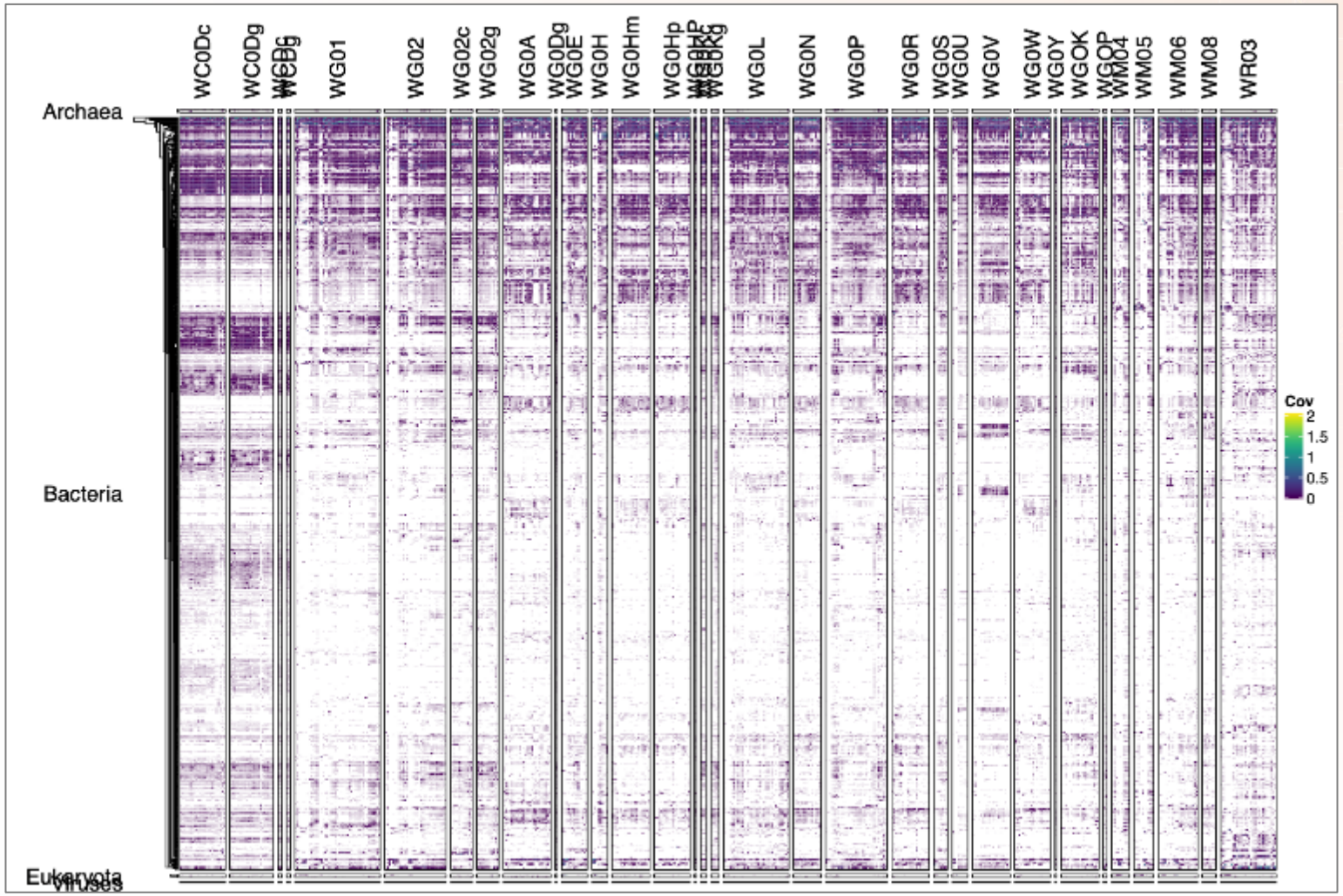
Signature mutation profiles fed into demixing model to estimate relative lineage abundances


Sampling.location
Miami Dade Black Point South District WWTP
Miami Dade Central District WWTP
Miami Dade North District WWTP
Copies/L
2000000
1500000
1000000
500000
0
Wastewater Variant Abundance
Jan
Feb
March
Apr
May
June
July
August
Sep
Oct
Nov
Dec
Fraction
1.00
0.75
0.50
0.25
0.00
County WTP Composite
County WTP Grab
UMiami Campus
Medical Campus
Marine Campus
VOC
Alpha
Beta
Gamma
Delta
Omicron
Lambda
Mu
Epsilon
Eta
Iota
Kappa
Ambiguous

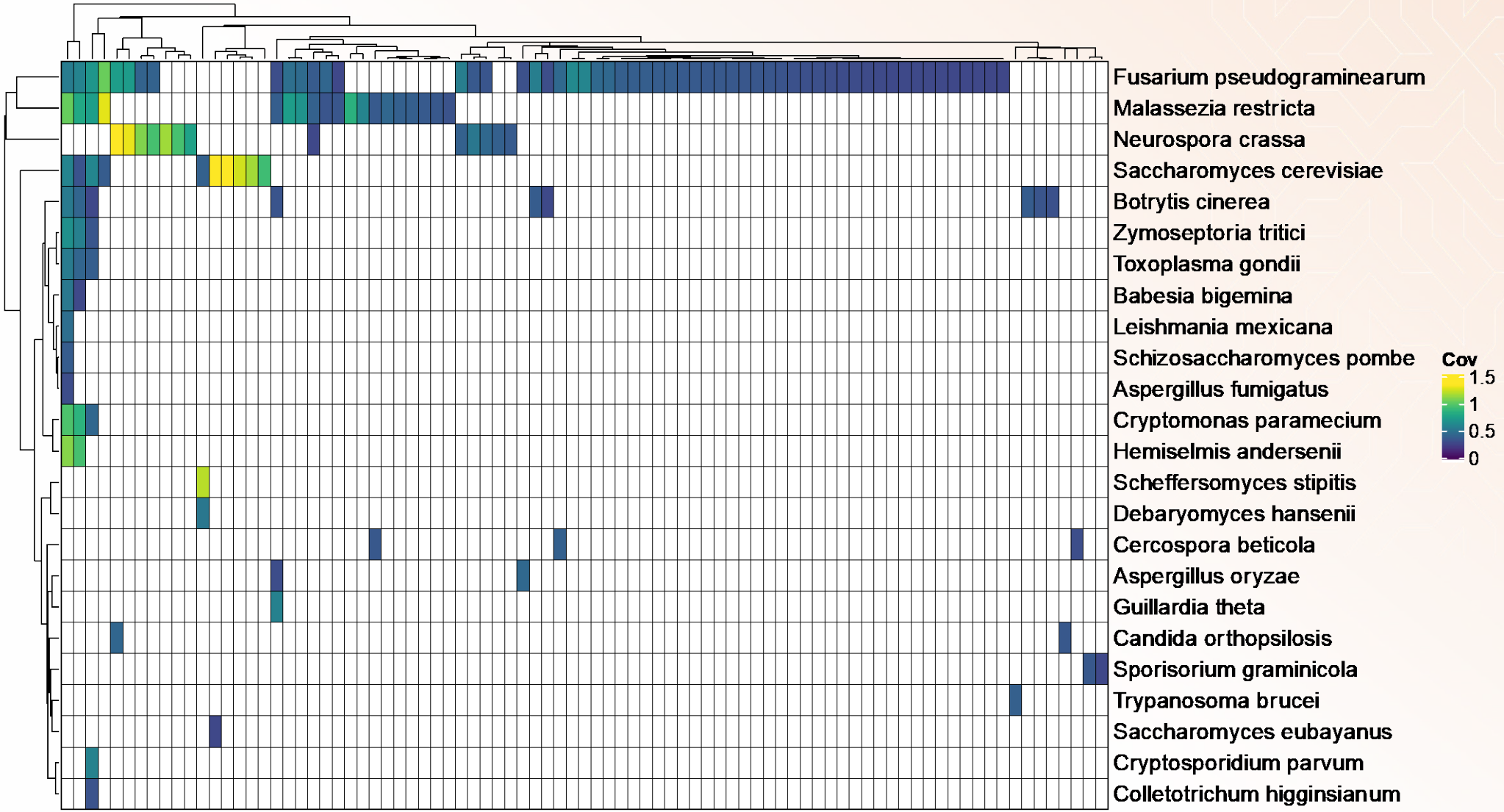
Wastewater shotgun RNAseq: untargeted monitoring of viruses/pathogens



Shotgun RNAseq enables pan-domain surveillance of microbes

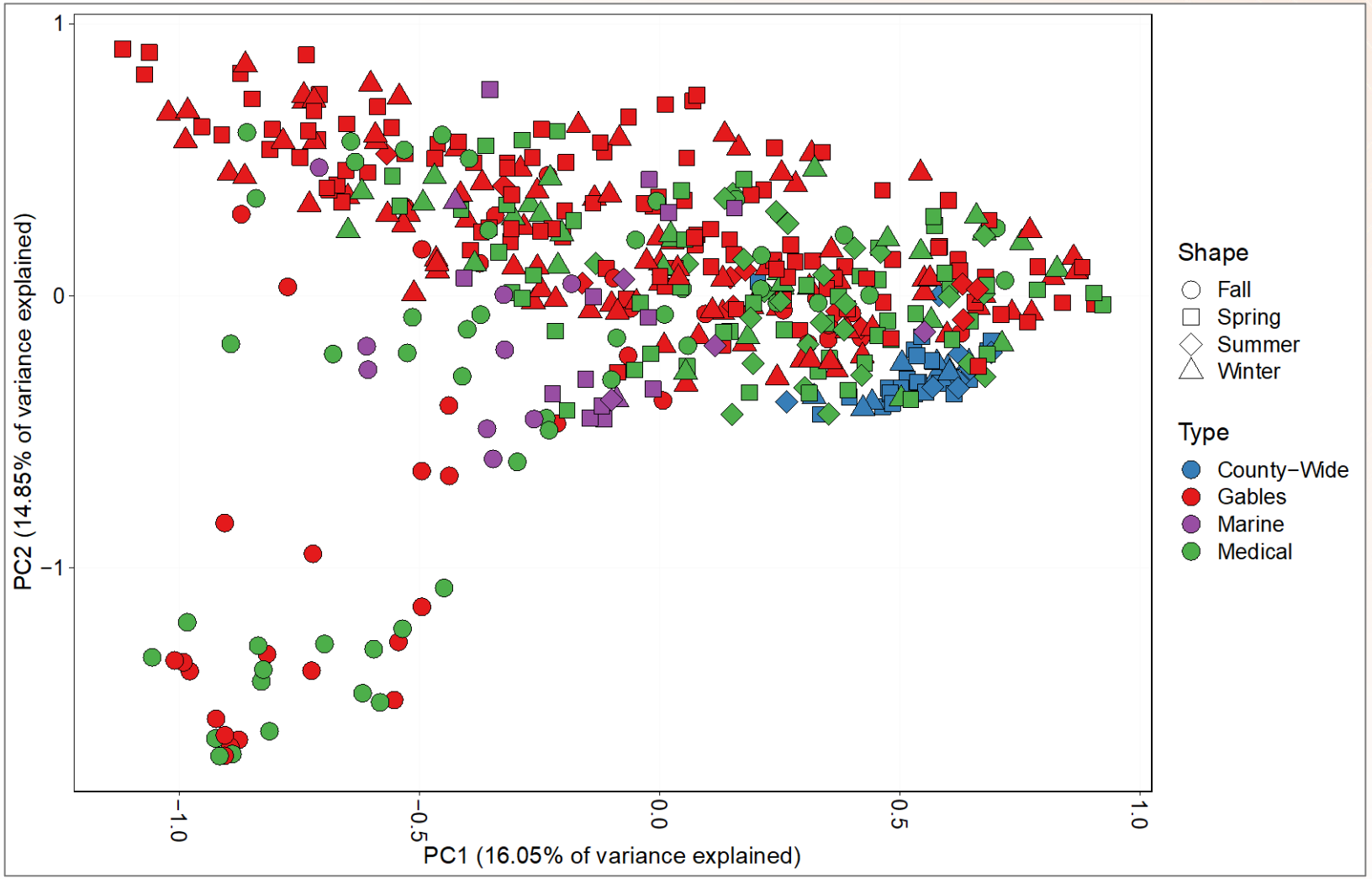


Top Fungi observed in shotgun RNA-seq

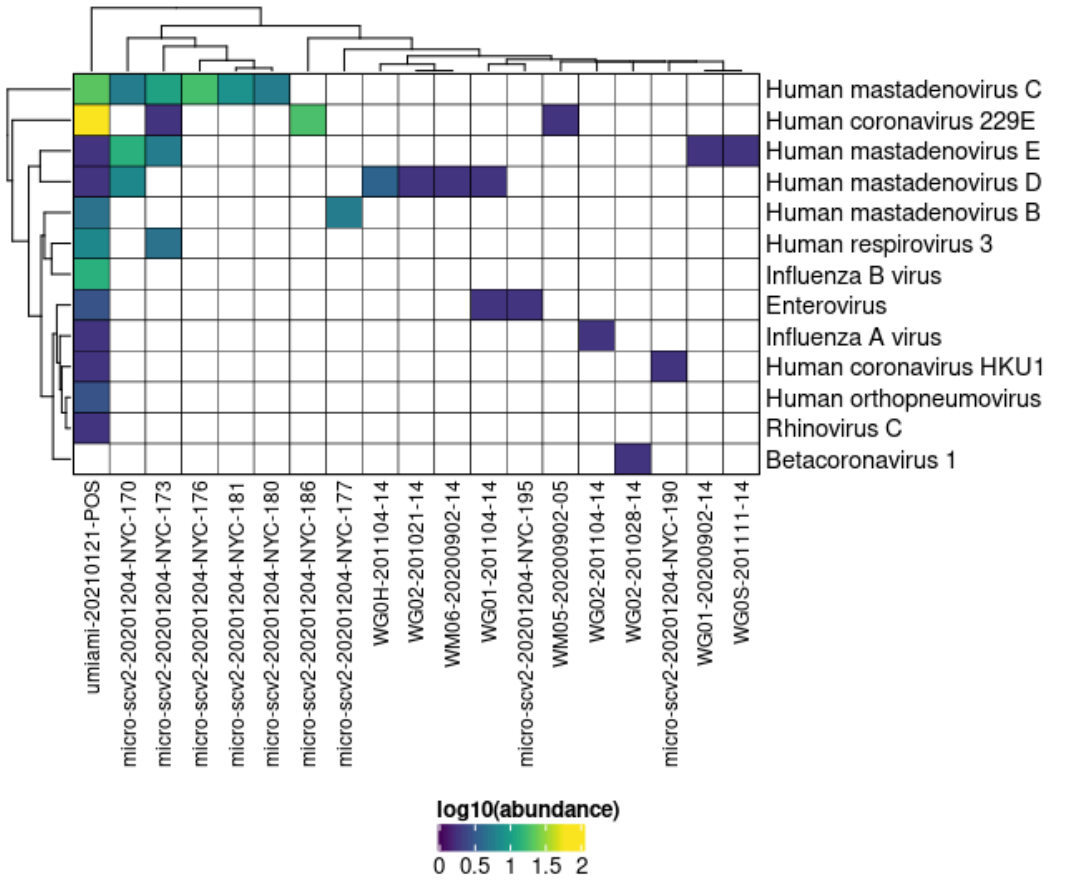


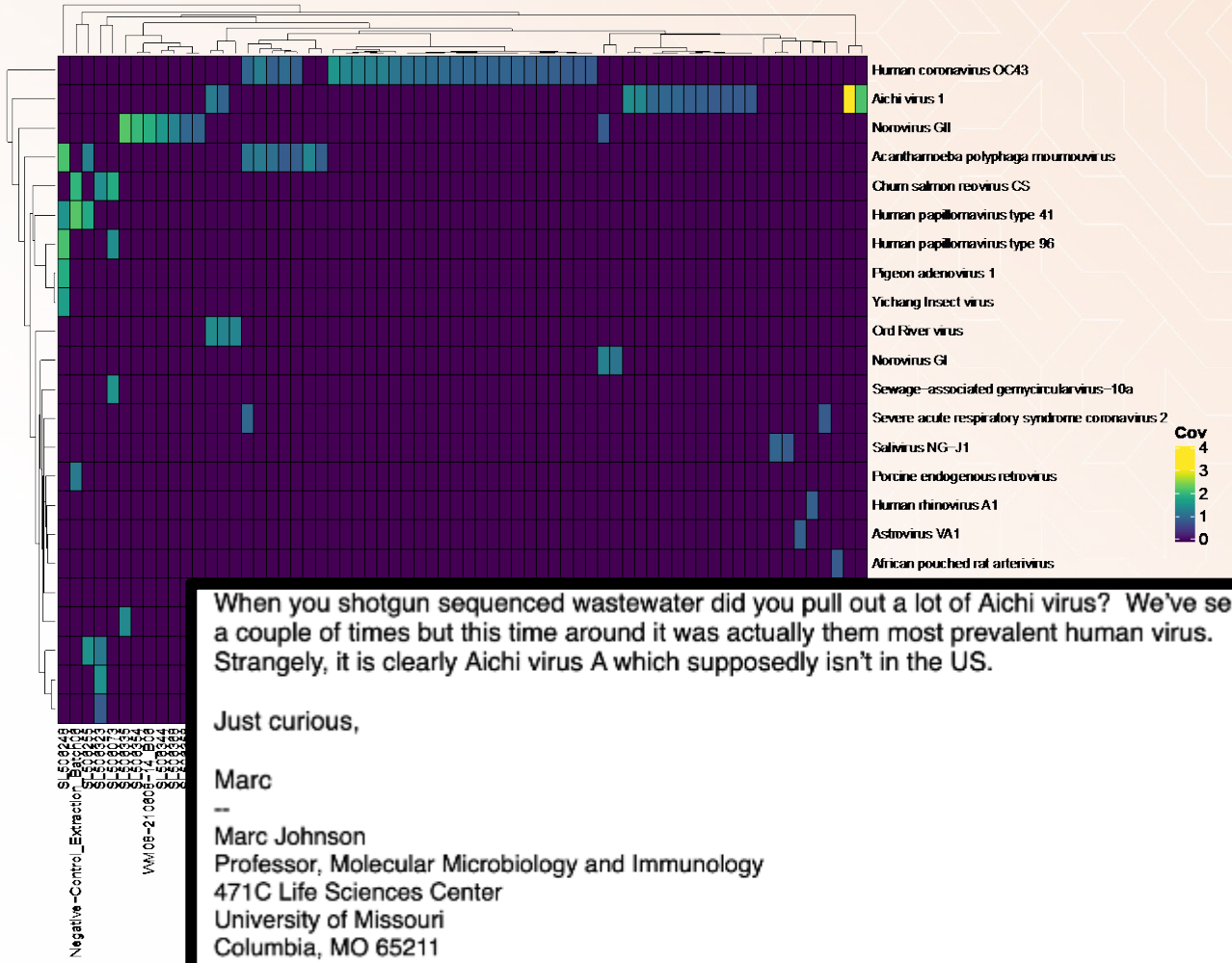

Bacteria
Xanthomonas euvesicatoria pv. alfalfae
Tolumonas auensis DSM 9187
Sphaerotilus natans subsp. sulfidivorans
Dechloromonas aromatica RCB
Roseburia intestinalis L1−82
Paludibacter propionicigenes WB4
Streptomyces lividans 1326
Prevotella ruminicola 23
Ramlibacter tataouinensis TTB310
Comamonas terrigena NBRC 13299
Bacteroides vulgatus ATCC 8482
Arcobacter nitrofigilis DSM 7299
Prevotella dentalis DSM 3688
[Eubacterium] eligens ATCC 27750
Fibrobacter succinogenes subsp. succinogenes
Prevotella sp. oral taxon 299 str. F0039
Sulfuritalea hydrogenivorans sk43H
Selenomonas ruminantium subsp. lactilytica
Paraprevotella xylaniphila YIT 11841
Candidatus Accumulibacter phosphatis clade IIA str. UW−1
Arcobacter suis CECT 7833
Paraburkholderia rhizoxinica HKI 454
Salmonella enterica subsp. enterica
Desulfomicrobium baculatum DSM 4028
Arcobacter cryaerophilus D2610
Cov
1.5
1
0.5
0

Modeling pathogen abundances over space and time



Targeted search for respiratory pathogens





When you shotgun sequenced wastewater did you pull out a lot of Aichi virus? We've seen it a couple of times but this time around it was actually them most prevalent human virus. Strangely, it is clearly Aichi virus A which supposedly isn't in the US.

Just curious,

Marc

--

Marc Johnson
Professor, Molecular Microbiology and Immunology
471C Life Sciences Center
University of Missouri
Columbia, MO 65211

Impact and Future Directions

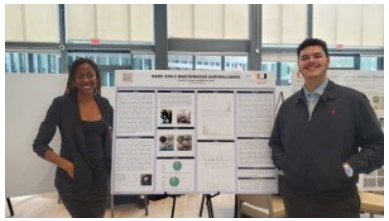
Ethics Related Activities

- **Ethics consultation service:** including consultation on public-facing communications, data management, and surveillance
- **Wastewater surveillance ethics project:** collaboration with colleagues at UCSD and with other stakeholders
- **Outreach:**
  - American Medical Informatics Association (AMIA) presentation
  - RADx/rad ELSI “office hours”
  - University of Miami Institute for Bioethics and Health Policy: Responsible Conduct of Research (RCR) program

From Ken Goodman, Ph.D.

Outreach

MAR 01 2022



- **Student participation:** (1) Students win first place for a poster titled “SARS-CoV-2 Wastewater Surveillance” in the University of Miami College of Engineering Research Day 2022 undergraduate poster competition. (2) Global City Sampling Day.

FEB 18 2022

NEWS@TheU

- **Print and online news:** article in University of Miami newsletter: “Poop sleuths: Why researchers are tracking coronavirus in wastewater.”

JAN 19 2022

- **TV news (local):** University of Miami's student television station, UMTV, covered the SF-RAD project on their half-hour live campus news show, NewsVision.

JAN 09 2022

NASA

- **Public webinar** on “Sewers, Subways, and Space Stations: 3 Fountains for Metagenomic and Metatransciptome Discovery” (Dr. Chris Mason)

DEC 09 2021

- **TV new (national):** Spanish language interview about the SF-RAD project on Telemundo (Dr. Helena Solo-Gabriele)

Publications

Lessons learned from SARS-CoV-2 measurements in wastewater

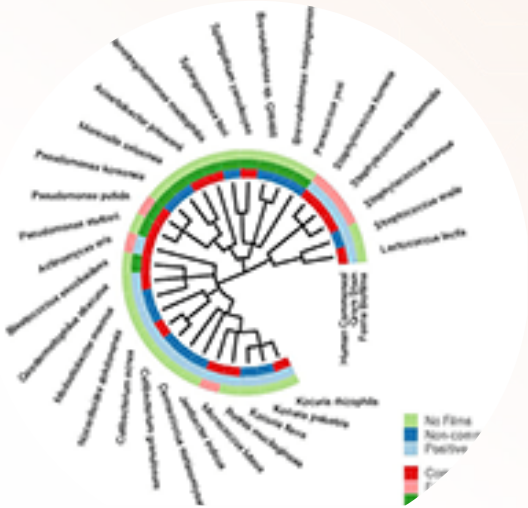
Sharkey ME, Kumar N, Mantero AMA, Babler KM, Boone MM, Cardentey Y, Cortizas EM, Grills GS, Herrin J, Kemper JM, Kenney R, Kobetz E, Laine J, Lamar WE, Mader CC, Mason CE, Quintero AZ, Reding BD, Roca MA, Ryon K, Solle NS, Schürer SC, Shukla B, Stevenson M, Stone T, Tallon JJ Jr, Venkatapuram SS, Vidovic D, Williams SL, Young B, Solo-Gabriele HM. **Lessons learned from SARS-CoV-2 measurements in wastewater**. ***Sci Total Environ.*** 2021 Dec 1;798:149177.doi.org/10.1016/j.scitotenv.2021.149177 PMID: 34375259; PMC8294117.

A rapid, isothermal, and point-of-care system for COVID-19 diagnostics

Christopher Mozsary, Duncan McCloskey, Kristina M. Babler, Juan Boza, Daniel Butler, Benjamin Currall, Sion Williams, Anne Wiley, George S. Grills, Mark E. Sharkey, Prem Premsrirut, Helena Solo-Gabriele, Yoslayma Cardentey, David Erickson, Christopher E. Mason. **A Rapid, Isothermal, and Point-of-Care System for COVID-19 Diagnostics**. ***J Biomol Tech.*** 2021 Sep;32(3):221-227. doi: 10.7171/jbt.21-3203-019. PMID: 35136383, PMCID: PMC8802758.

A global metagenomic map of urban microbiomes and antimicrobial resistance

David Danko, Daniela Bezdan, Evan E. Afshin, Sibo Zhu, Christopher E. Mason, et al. **A global metagenomic map of urban microbiomes and antimicrobial resistance,** ***Cell.*** 2021 Jun 24;184(13):3376-3393. https://doi.org/10.1016/j.cell.2021.05.002. PMID: 34043940.



Publications

Publication Received
Journal of Biomolecular Techniques

2021 Manuscript of the Year Award

JBT JOURNAL OF BIOMOLECULAR TECHNIQUES | AIB RIF

Loop-Mediated Isothermal Amplification Detection of SARS-CoV-2 and Myriad Other Applications.

J Biomol Tech. 2021 Sep;32(3):228-275. doi: 10.7171/jbt.21-3203-017.
PMID: 35136384; PMCID: PMC8802757.

Keith J. M. Moore, Jeremy Cahill, Guy Aidelberg, Rachel Aronoff, Ali Bektaş, Daniela Bezdan, Daniel J. Butler, Sridar V. Chittur, Martin Codyre, Fernan Federici, Nathan A. Tanner, Scott W. Tighe, Randy True, Sarah B. Ware, Anne L. Wyllie, Evan E. Afshin, Andres Bendesky, Connie B. Chang, Richard Dela Rosa, II, Eran Elhaik, David Erickson, Andrew S. Goldsborough, George Grills, Kathrin Hadasch, Andrew Hayden, Seong-Young Her, Julie A. Karl, Chang Hee Kim, Alison J. Kriegel, Thomas Kunstman, Zeph Landau, Kevin Land, Bradley W. Langhorst, Ariel B. Lindner, Benjamin E. Mayer, Lee A. McLaughlin, Matthew T. McLaughlin, Jenny Molloy, Christopher Mozsary, Jerry L. Nadler, Melinee D'Silva, David Ng, David H. O'Connor, Jerry E. Ongerth, Olayinka Osuolale, Ana Pinharanda, Dennis Plenker, Ravi Ranjan, Michael Rosbash, Assaf Rotem, Jacob Segarra, Stephan Schürer, Scott Sherrill-Mix, Helena Solo-Gabriele, Shaina To, Merly C. Vogt, Albert D. Yu, Christopher E. Mason, The gLAMP Consortium

Spin-off research: Ongoing and potential pilot projects

- Wastewater surveillance of COVID-19 in public schools
  - Pilot project in collaboration with a RADx/UP funded investigator at the University of Miami (1OT2HD108111, Dr. Lisa Gwynn, principal investigator)
- Airplane and airport wastewater surveillance
  - In collaboration with the CDC-NWSS, NIST, and the Rockefeller Foundation
- Wastewater surveillance for influenza, for antibiotic resistant pathogens, and for other biomarkers of disease

National Consortium

NIH
Rapid Acceleration of Diagnostics (RADx)

RADx Radical (RADx-rad)

Support new, non-traditional approaches to address current testing gaps, and non-traditional applications of existing approaches

7 awards related to wastewater detection of SARS-CoV-2, including the SF-RAD project

RADx Underserved Populations (RADx-UP)

Understand and reduce the disparities in COVID-19 morbidity and mortality for those disproportionately affected by COVID-19

Including a grant award that is funding the pilot project for wastewater monitoring in public schools

RADx Tech

Speed innovative point-of-care, home-based, and clinical laboratory tests for COVID-19

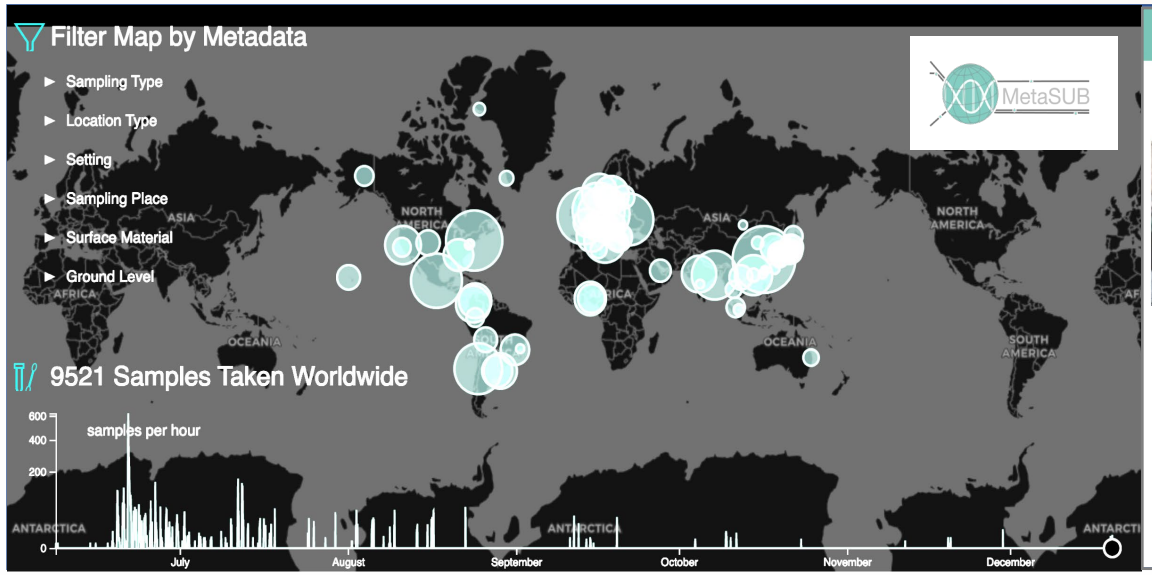
Grant application for development of a new portable technology for wastewater monitoring

RADx Advanced Technology Platforms (RADx-ATP)

Identify testing platforms that are far enough advanced for rapid scale-up or expanded geographical placement

International Consortium

Metagenomics and Metadesign of the Subways and Urban Biomes (MetaSUB)



Ongoing MetaSUB Projects

Monumentome

- **189** surface samples

12 different cities

21 monuments/landmarks

- **47** surface samples from the ancient city of Tel Megiddo

MetaSEW

- **500+** wastewater samples collected

14 different cities

Current focus on COVID-19 surveillance and variant testing

MetaCoV

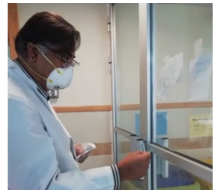
- **Sampling since March of 2020, beginning of the pandemic**

27 different cities

3971 surface samples received

2256 samples on Pangea

MetaMED



1000+ surface samples

Aim to collect and analyze samples from hospital/medical

MetaSUB

Metagenomics of Urban Biomes (MetaSUB) Annual Meeting

Miami, FL, Nov. 18-21, 2022

metasub.org

Acknowledgments





UM Leadership
- President Frenk
- Erin Kobetz
- Stephen Nimer
- Helena Solo-Gabriele
- George Grills

Sampling
- Sylvester Behavioral and Community-Based Research Shared Resource
  - Tom Stone
- Brian Reding
- Sam Comerford
- Marleina Drane

Sample Prep
- Sylvester Biospecimen Shared Resource
  - Melinda Boone
  - Elena Cortizas
- Kristina Babler
- Shashana Fiedler

Detection & Analysis
- CFAR Laboratory Sciences Core
  - Mario Stevenson
  - Mark Sharkey
  - Jessica Salinas
- Sylvester Onco-Genomics Shared Resource
  - Sion Williams
  - Benjamin Currall
  - Marissa Brooks
  - Aaron Ruby
- Weill Cornell
  - Chris Mason
  - David Danko
  - Krista Ryon
  - Jon Foox
  - Dan Butler
  - Braden Tierney

Data Standards
- Stephan Schürer
- Dusica Vidovic
- Daniel Cooper
- Chris Mader
- Caty Chung
- Nakul Datar
- Julio Perez
- Shreeharsha Ven

Human Health
- Naresh Kumar
- CTSI Biostatistics Core
  - Alejandro Mantero
- Sylvester Behavioral and Community-Based Research Shared Resource
  - Natasha Solle
  - Cynthia Beaver
- Bhavarth Shukla
- Darryl Pronty
- Sebastian Arenas

Ethics
- Ken Goodman

Environmental Health & Safety
- Jennifer Laine
- Brian Reding
- Shane Gillooly
- Melanie Peapell
- Vaughn Munro

Security
- Ray Valdes
- City of Miami Police

Facilities, UM Medical Campus
- Walter Lamar
- Ed Hengtgen
- Rob Curtis
- Joseph Vota
- Leo Petrache
- S. Perritano
- M. Kuindua
- Yanelis Reyes

Facilities, UM Gables & RSMAS
- John Tallon
- Georgia Norton
- Norman Pasquier
- Cecil Bowen
- Orlando Escorcia
- Trent Williams
- Henry Blanco
- Jesus Gonzalez
- Jose Iglesias
- Lazaro Chavez
- Selvon Villafana

Students
- Johann Amirali
- Gabriella Cosculluela
- Collette Thomas
- Samantha Abelson
- Julio Contreras
- Johnathan Penso
- Erik Lamm
- Danni Mackler
- Matthew Roca
- Tori Thomas
- Shelja Kumar
- Julio Contreras
- Wei Zhang
- Jiangnan Lyu
- Luis Sosa
- David Cohen
- Felix Ngyuen
- Qingyu Zhan

Administration
- Maria Robertson
- Xue (Sherry) Yin

Acknowledgements

Funding:

- NIH RADx-rad 1U01DA053941-01
- NIH/NCI (CCSG) 1P30CA240139-01
- NIH (CFAR) P30AI073961
- NIH (CTSI) 1UL1TR000460
- University of Miami internal funding
- MetaSUB is supported by crowdfunding and by industry partners, including Copan, CosmosID, GISCloud, IBM, Illumina, OneCodex, Promega, QIAGEN, Isohelix and Zymo Research

https://covidsfrad.org

MIAMI

Weill Cornell Medicine

ABOUT APPROACH RESOURCES MEDIA NEWS + EVENTS COMMUNITY

SF-RAD: COVID-19 PREDICTIONS FROM WASTEWATER

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