Congressional Briefing
Environmental Surveillance of the Genetic Footprint of COVID-19 in Sewersheds
Thursday, May 21 | 2:00 PM EDT
Welcome!

Peter Grevatt, PhD, CEO

The Water Research Foundation
Agenda

• Introduction
  – Peter Grevatt, PhD, CEO, The Water Research Foundation

• Case Examples
  – Dan Gerrity, PhD, Southern Nevada Water Authority
  – Jim Pletl, PhD, Hampton Roads Sanitation District
  – Ken Williamson, PhD, Clean Water Services

• Q/A
  – Peter Grevatt, PhD, CEO, The Water Research Foundation
ABOUT

MISSION

Advancing the science of water to improve the quality of life.

VISION

To create the definitive research organization to advance the science of all things water to better meet the evolving needs of subscribers and the water sector.
Use Cases of Sewershed Surveillance for Other Viruses

**Poliovirus**
- absence of virus circulation in (unvaccinated) population
- early warning outbreaks

**Adenovirus, norovirus, rotavirus, parechovirus, enterovirus, astroviruses, hepatitis A and E viruses**
- early warning outbreaks
- virus circulation in population
- virus genotypes circulating in population
Example of Genes, RNA, and Remnants of Inactive Virus

**Anatomy of a virus**
The COVID-19 virus has several features we may be able to target with drugs to break it down and stop it entering cells.

- RNA enclosed in protein
- Spike protein
- Lipid membranes

**Source:** Tim Vernon/Science Photo Library
Use Cases

Trend Occurrence

Changes in Trends

Community Prevalence
## What Can You Use Sewershed Surveillance Data For?

<table>
<thead>
<tr>
<th>General Use Cases</th>
<th>Can Inform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess Level of Community Infection</td>
<td>Tracking disease prevalence in the community. Identification of “hot spots” and areas that are not impacted by the virus</td>
</tr>
<tr>
<td>Trends/Changes in Infection</td>
<td>Early detection of disease. Tracking the impact of medical and social interventions</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td>Risk to utility workers and those exposed to raw sewage</td>
</tr>
<tr>
<td>Viral Evolution</td>
<td>Source tracking of the virus</td>
</tr>
</tbody>
</table>
Understanding the Potential of Sewershed Surveillance

- Sewershed surveillance can complement clinical data for community assessments or decision making
- Provides a leading indicator of community infection
- This work is rapidly developing, and has the potential to inform our understanding in the context of this pandemic
SNWA Water Quality R&D – Mission

1. Research that is directly applicable to water quality and ensuring a reliable water supply in Southern Nevada

2. Research that is applicable to the broader water industry, often with funding from The Water Research Foundation, Bureau of Reclamation, National Science Foundation, and other agencies

Source: GAO (2011)
SNWA Water Quality R&D – Brief History

- **Return Flow Credits** = collaborative relationship between wastewater and drinking water agencies
- Approximately 20 years of research into contaminants of emerging concern (CECs)
- R&D expanded to include *microbial* CECs in late 2019
Contaminants of Emerging Concern (CECs)

- Pharmaceuticals (2000s)
- PFAS/PFOS/PFOA (2010s)

Emerging Challenges
Create **Uncertainty**
for the Water Industry
Contaminants of Emerging Concern (CECs)

SARS-CoV-2

Water Industry Can

Reduce Uncertainty

Through Research

Knowledge from Research on Past Outbreaks (SARS, MERS, Ebola)

Knowledge from Research on Current Outbreak (COVID-19)
Quantitative Microbial Risk Assessment (QMRA)

Do our existing water systems adequately protect public health against emerging pathogens today (SARS-CoV-2) and in the future?

Source: Center for Advancing Microbial Risk Assessment
Current Understanding of Drinking Water Risk

Do our existing water systems adequately protect public health against emerging pathogens today (SARS-CoV-2) and in the future?

1. Expected concentrations of SARS-CoV-2 genetic material?
   - **Non-detect** in treated wastewater, source water, and drinking water

2. Expected concentrations of infectious SARS-CoV-2?
   - Appear to be **low (if any)** in feces and ultimately raw wastewater

3. Reductions during natural and engineered treatment?
   - Likely **highly susceptible to treatment** based on surrogates (literature)
SNWA Response to COVID-19 and SARS-CoV-2

- Enacted elements of *Pandemic Readiness and Response Plan* on March 17 to ensure continued reliable water supply for Southern Nevada
- Quickly initiated monitoring of SARS-CoV-2 ‘fingerprint’ in wastewater, source water, and drinking water in early March
- Developed guidance documents and presentations leveraging past research findings and new monitoring data
- Communicated findings to the public through social media
Molecular Targets for Environmental Surveillance

4 targets in SNWA study

- Chinese CDC Target = Non-structural Proteins (orf1a)
- WHO Target = Envelope Protein (E)
- CDC Target = Nucleocapsid Proteins (N1, N2, N3)

Sources: CDC, 2020
Corman et al., 2020
Lu et al., 2020

The genome provides the genetic template for virus structures and proteins. We look for portions of the genome as an indication that the virus is present.
New Cases

- **SARS-CoV-2 Data for Southern Nevada**

  - Multiple samples with ‘hits’ for all 4 molecular targets
  - Consistent signal in untreated wastewater at Facility 1

  - **Service Area 1:** 200-600 cases per 100,000
    - Consistent ‘hits’ in untreated wastewater
  - **Service Area 2:** <200 cases per 100,000
    - Fewer ‘hits’ in untreated wastewater

  - Data source: SNHD Office of Epidemiology and Disease Surveillance

  **Source:** Southern Nevada Health District
Potential for Prevalence Calculations

\[
\text{Infections (persons)} = \frac{\text{Concentration (gene copies/L)}}{\text{Feces Production Rate (grams/person-day)}} \times \frac{\text{Wastewater Flow Rate (L/day)}}{\text{Fecal Shedding Rate (gene copies/gram)}}
\]

- Environmental surveillance has the potential to inform prevalence calculations
- This tool requires further refinement to reduce uncertainty and capture variability of key parameters
- Ratios of SARS-CoV-2 RNA to common wastewater constituents may be valuable

Future Outcomes of Environmental Surveillance

- We have an **opportunity** and **responsibility** to leverage our resources to:
  - Learn from the current pandemic to establish best practices
  - Develop effective tools to better inform policymakers/stakeholders
  - Prepare for future challenges so that we can quickly respond

- **Environmental surveillance** is a critical ‘piece of the puzzle’ in understanding the link between water and public health
Jim Pletl, PhD
Director of Water Quality
Hampton Roads Sanitation District
Hampton Roads Sanitation District (HRSD)

- Independent political subdivision
- 18 cities and counties
- 1.8 million residents served
- 17 facilities total, 9 majors
- 3100 square mile service area
- >500 miles of pipe
- >100 pump stations
- 150 mgd avg daily flow treated
HRSD Wastewater Surveillance

• Began qPCR and microbial source tracking 5 years ago
• Successful in identifying failed infrastructure causing violations of water quality standards in local surface waters
• Use biomarkers unique to human wastewater to trace sources
• Dedicating 1-2 managers and 3-4 field sampling/laboratory staff at any point in time
• Staff have also been involved in other PCR-viral projects:
  – national inter-laboratory studies of viral analytical methods
  – wastewater load and treatment studies of viruses
  – viral investigations relative to potable uses of highly treated wastewater
Why Pursue a COVID-19 WS Study?

• ...basic tools and knowledge in place
• ...desire to support local health officials
• ...genetic primers available for qPCR
• ...understood the value based on previous WS studies investigating community stress relative to opioids
• ...test to see how long it takes for our staff to come up to speed given a new target
HRSD COVID-19 Study

- Sampled influent of 9 major facilities, pump stations and treatment facility effluent, starting March 11
- 180 samples analyzed using PCR to measure genetic signal
- Not an infectivity study
- Trends in prevalence evident at different plants serving different portions of the Hampton Roads population
- Sensitivity of plant influent monitoring can detect 1 in 10,000 occurrence or better
Percent Carriers By Plant

Calculated Percent SARS-CoV-2 Carriers by WWTP Catchment

Percent Carriers in Catchment
Community Prevalence Time Series

SARS-CoV-2 Percent Carriers by WWTP Catchment

Calculated Percent Carriers

© 2020 The Water Research Foundation. ALL RIGHTS RESERVED.
HRSD COVID-19 Monitoring Investment

- 1 Manager with expertise in PCR, microbiology and wastewater; 10-20 hours per week
- 2 fully trained analytical specialists; 12 hours per week
- 2 fully trained sample collection specialists; 36 hours per week
- Equipment: $70k (digital PCR), $70k (automated RNA extractor)
- Supplies: wastewater concentrator, portable refrigerated samplers
- Cost/sample: $100/sample
Wastewater Surveillance Considerations

• Only a tool to support event management
• Community social and clinical information critical
• Requires partnership with local/state health professionals
• Site-specific circumstances define approach
  – Central or decentralized system
  – Gravity vs. force mains
  – Timing with event
  – Industrial contributions
  – Population stability – military, commuting, tourism, etc.
Wastewater Surveillance Considerations

• PCR sample prep and analytical methods are not standardized
  – Can affect use of data
  – Comparability in data sets within and between studies uncertain

• Data Interpretation
  – Asymptomatic infection, “true” prevalence
  – Connecting PCR data to infection prevalence
  – Presence/absence, detection
  – Quantitation
Wastewater Surveillance Considerations

• Many moving parts and uncertainty require collaboration
  – Community of Practice
    ▪ Help standardize method
    ▪ Develop monitoring framework
    ▪ Answer questions
    ▪ Drive consensus
    ▪ Municipal network of labs
    ▪ Possibly perform event “drills”, Norovirus
Research Priorities

• Characterize viral shedding magnitude and variability
• Inter-lab study of sample prep and analytical methods
  – Define performance standards, quality objectives
  – Avoid prescriptive methods to facilitate adoption
• Convert PCR info to a metric for infectivity
• Small epidemiological studies with random sampling of population
  – Understand contribution of asymptomatic individuals to load
  – Needed to reliably translate wastewater data to community prevalence
• Wastewater exposure risk
  – Liquid
  – Aerosols
  – Solids
Federal Role in Wastewater Surveillance

- Facilitate health professional – wastewater partnerships
- Support analytical method guidance development
- Sampling/analytical safety standards
- Fund research
- Fund pilots to demonstrate utility
  - Link data, community action and results
Kenneth Williamson, PhD, PE
Research and Innovation Director
Clean Water Services
Clean Water Services

• Public utility serving 613,000 residents west of Portland
• 4 Water Resource Recovery Facilities
• 1,982 miles of collection system
• 90% of flow residential; 10% industrial
• State’s fastest growing county
• Oregon’s first confirmed case of COVID-19: Feb 28, 2020
Biobot Analytics survey

- National sampling data from more than 100 facilities
- Starting March 30, CWS has been providing weekly from each of our 4 facilities
- Broad community data
- Shows prevalence, trends
OSU/CWS collaboration

• Oregon State University/CWS collaborative research, Drs. Tyler Radniecki and Christine Kelly
• Two objectives:
  – Compare influent sample results to Biobot study, improve sampling and analysis techniques
  – Sample within selected areas of concern (micro-sewersheds) such as nursing homes, hospitals, food processing plants, prisons, schools, etc.
• Funded by NSF’s Rapid Response Research (RAPID), Award No. 1519467, on April 27, 2020
Sewershed sampling

- Targeted research at 21 sites
- Mix of land uses, business types & communities
  - Hospitals
  - Food industries
  - Jails
  - Nursing Homes
  - Schools
  - Retirement communities
  - Low-income communities
- Weekly data for 1 year
Added value of sewer surveillance

- Virus concentrations in wastewater must be correlated with a health response
- Collaboration is needed between water utilities and local, state and national health professionals

Wurtzer, et al., 2020
Expanding research partnerships

• OSU Colleges of Public Health and Human Sciences, Science, Veterinary Medicine, and Agricultural Sciences-TRACE program
  – Conduct testing for COVID-19 in Corvallis and Bend, Or, and compare with spatial and temporal virus signals in the sewershed

• Oregon Health Sciences University (OHSU)
  – Working to correlate public health tracing (symptomatic and asymptomatic infections, antibodies) results with sewage tracking results in Hillsboro, Portland and Lake Oswego, Or

• Oregon Health Authority
  – Proposal to expand OSU/CWS research to 30 treatment plants in Oregon over a two year period to track the spread, recession and any potential new waves of COVID-19 infections
Q&A and Next Steps

Peter Grevatt, PhD
Chief Executive Officer
The Water Research Foundation
Thank You!