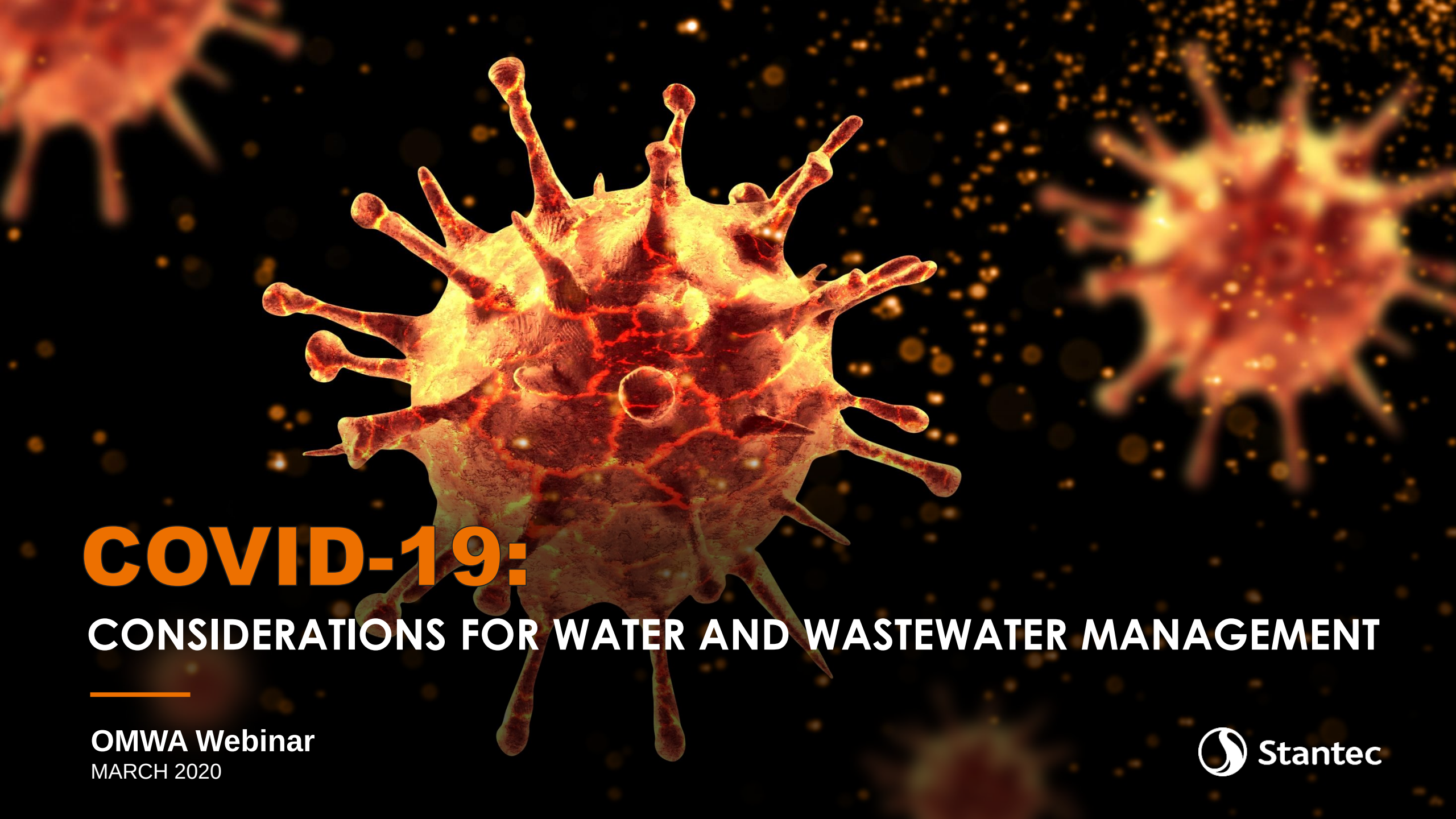


# COVID-19:

## CONSIDERATIONS FOR WATER AND WASTEWATER MANAGEMENT

**OMWA Webinar**
MARCH 2020

Stantec

# SAFETY MOMENT

## STAY ACTIVE WHILE WORKING FROM HOME

**MOVE EVERY 90 MINUTES**

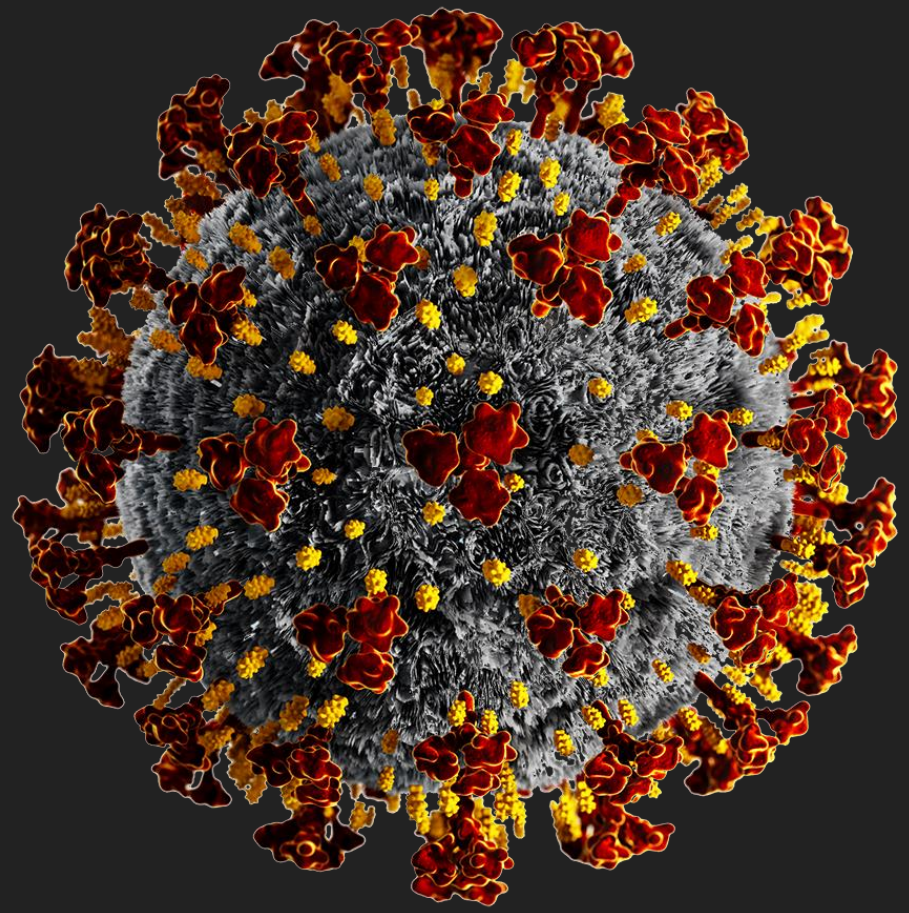
- Set a timer (don’t forget to re-set it each time)
- Set a daily step goal – use the stairs or jog on the spot
- Have an “active” meeting – take phone calls standing up
- Stretch at your desk

# AGENDA

1. INTRODUCTION TO CORONAVIRUSES
2. TREATMENT EFFICACY
3. OPERATOR CONSIDERATIONS
4. ADDRESSING THE PUBLIC
5. SUMMARY
6. Q & A (15 MIN)

# INTRODUCTION TO CORONAVIRUSES

COVID-19



# DISCLAIMER #1

INVESTIGATIONS INTO THE COVID-19 OUTBREAK ARE ONGOING.

THE INFORMATION THAT WE HAVE RIGHT NOW MAY CHANGE AS WE LEARN MORE ABOUT THIS VIRUS.

# VIRUSES 101 – IN ONE SLIDE

**Biological entities with small RNA or DNA genomes and a protein capsid. Some have an additional envelope.**

## Viruses need a host cell to replicate:

- *Viruses reproduce and cause infection by binding to receptor proteins on the surface of a host cell (e.g. human lung cell) and entering the cell*
- *They take over the cell machinery to create or package numerous virus progeny*
- *Virus progeny are usually released by rupturing the host cell or by budding out of the host cell membrane*

## Zoonotic viruses:

- *Viruses tend to have a narrow range of hosts that they can bind to and infect.*
- *Zoonotic viruses originate in an animal species and evolve to infect humans. Viruses tend to have high mutation rates which allows them to typically evolve more rapidly than other microorganisms*

## Common detection methods for viruses in water (and elsewhere):

1. *Cell-culture methods would involve applying a water sample to mammalian cells grown in a lab, followed by observing for "plaques" or evidence of viral infection*
2. *Molecular methods target detection of viral genetic sequences of RNA or DNA (e.g. with PCR) which does not assess infectivity*

*Lodish H et. al. 2000. Molecular Cell Biology, 4th Ed. New York. Section 6.3, Viruses: Structure, Function, and Uses.*
*CDC. 2020. Zoonotic Diseases. <https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html>*

# CORONAVIRUSES

**CORONAVIRIDAE FAMILY** includes enveloped viruses with **RNA GENOMES** that mainly cause respiratory infections

- » *Groups 1 and 2: Infects humans and other mammals*
- » *Group 3: Infect avian species*

Novel coronaviruses are those that have not been seen before:

1. *Severe Acute Respiratory Syndrome (SARS-CoV; SARS-CoV-1)*
2. *Middle Eastern Respiratory Syndrome (MERS-CoV)*
3. ***NOVEL CORONAVIRUS DISEASE** (2019-nCoV; **COVID-19; SARS-CoV-2)***

# WHAT CAN WE LEARN FROM SARS-COV-1? (2002)

- Novel respiratory coronavirus outbreak in 32 countries in late winter 2002 to 2003
- >8400 cases, 812 deaths by July 2003 (mortality rate ~10%)

**Suspected transmission by fecal-oral route**

- » *Gastroenteritis observed in >20% of cases. RNA detected in feces ~4 months after symptom onset*
- » *Viral replication observed in small and large intestine, and SARS-COV-1 isolated by culture from stool*

**Susceptible to:**

- » *Thermal inactivation >56$^{o}$C*
- » *Range of disinfectants including bleach, alcohols, peracetic acids, and detergents*

**Quarantine measures proved successful at reducing transmission**

*Leung, W. K., et al. 2003. Enteric involvement of SARS-associated coronaviruses infection. Gastroenterology, 125(4), 1011-1017.*
*Liu, W., et al. 2004. Long-term SARS coronaviruses excretion from patient cohort, China. Emerging Infectious Diseases, 10(10), 1841.*
*McKinney, K.R. et. al. 2006. Environmental transmission of SARS at Amoy Gardens. Journal of Environmental Health 68.9.*
*Rabenau, H. F., et al. 2005. Stability and inactivation of SARS coronavirus." Medical microbiology and immunology 194.*

# WHAT WE KNOW ABOUT COVID-19 SO FAR

**An enveloped RNA virus. The seventh coronavirus known to infect humans.**

- *Spread to 175 countries, >530,000 infected, >23,900 deaths (~122,000 recovered)**
- *Mortality rate estimated to be between 1-5%*
- *Spread by person-to-person contact within 2 meters and community spread is occurring*

**Symptoms include:**

- *Fever*
- *Respiratory (coughing and shortness of breath)*
- *Gastrointestinal (vomiting and diarrhea)*
- *Loss of smell and taste*

*Johns Hopkins University, as of March 26, 2020

# PERSISTENCE OF COVID-19: AIR AND SURFACES

**COVID-19 was detected in air for 3 hours in experimental aerosols (<5µm) at 21-23$^{0}$C, which is similar to the observations for SARS-CoV-1 (2002)**

| SURFACE | PERSISTENCE OF COVID-19 IN HOURS* |
|---|---|
| Plastics | 72 |
| Stainless steel | 48 |
| Cardboard | 24 |
| Copper | 4 |

- Cleaning of surfaces with soap and water is expected to be highly effective to reduce transmission
- COVID-19 is more likely to be transmitted by air than on surfaces

*Detected by endpoint titration using tissue-culture

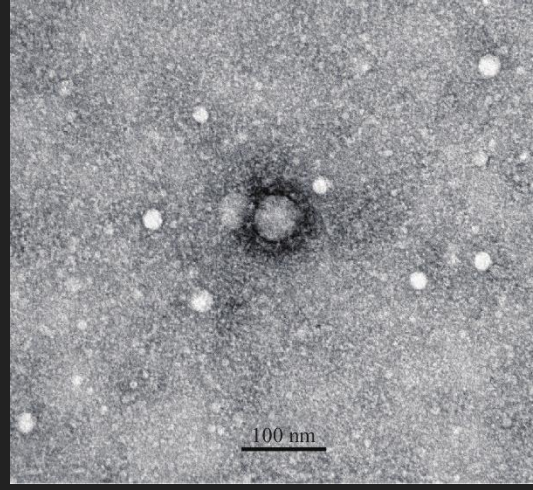
*Decay was exponential

*Similar results were seen for SARS-CoV-1, though SARS-CoV-1 was twice as stable on copper

*Doremalen et al. March 17, 2020. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1, N Engl J Med <https://www.nejm.org/doi/full/10.1056/NEJMc2004973>*

*Machamer. March 20, 2020. How long can the virus that causes COVID-19 Live on Surfaces? JHU.ed. <https://hub.jhu.edu/2020/03/20/sars-cov-2-survive-on-surfaces/>*

# COVID-19 DETECTED IN FECES




**Some coronaviruses, including SARS-CoV-1 (2002), have the capability of binding to human cells in both the lung and the intestine**

- *Binds to receptor protein ACE2 on human cells which are present in various human organs, and are abundant in the lungs and small intestine*

**COVID-19 RNA was detected in raw wastewater at the Amsterdam Airport and at a Wastewater Treatment Plant in the Netherlands**

- *The first positive Airport sample was collected 4 days after the first confirmed case in the Netherlands*
- *Viral RNA was detected at the WWTP within the first week of the first confirmed case of COVID-19*

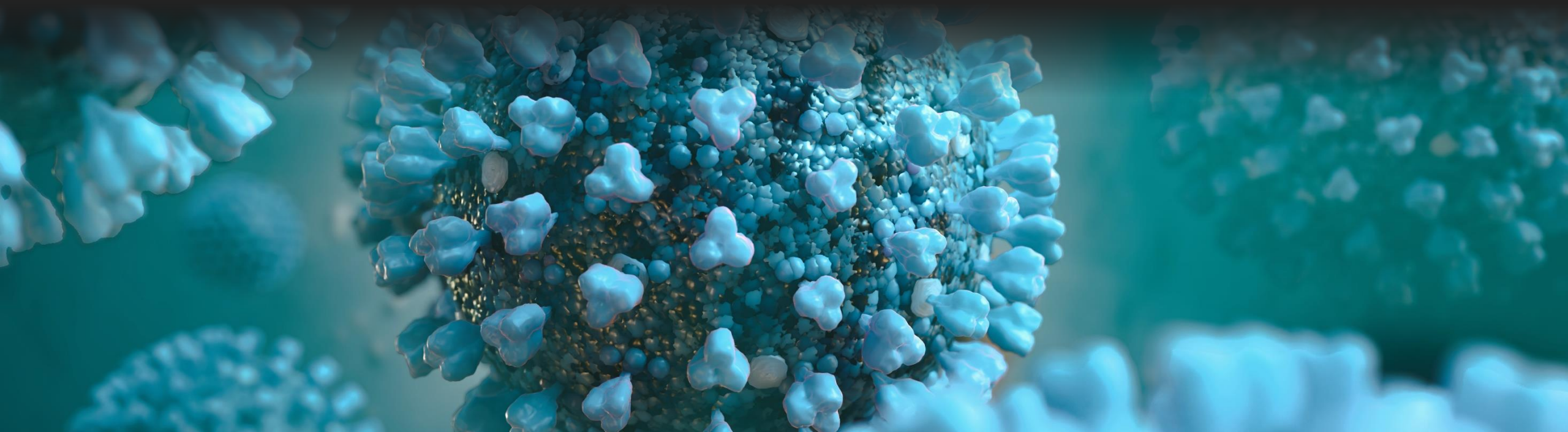
**Active COVID-19 was detected in the feces of a confirmed case in China (see figure)**

- *COVID-19 patients can have live virus in stool specimens (Zhang et al. 2020)*
- *Suggests the virus could be transmitted through the potential fecal-oral route*

*Hamming et al. 2004. Tissue distribution of ACE2 Protein, the functional receptor for SARS CoV. J. Pathol, 203 (2), 631-7.*
*RIVM. March 24,2020. Novel coronavirus found in wastewater. https://www.rivm.nl/en/news/novel-coronavirus-found-in-wastewater*
*Figure Source: Zhang et al. 2020. Isolation of 2019-nCoV from a stool specimen of a laboratory-confirmed case of the coronavirus disease 2019 (COVID-19). CCDC Weekly.*

# PERSISTENCE OF CORONAVIRUSES IN WATER

- Coronaviruses seem to remain infective longer in colder water than in warmer water
- Human viruses do not replicate in the environment



# PERSISTENCE IN WATER AND WASTEWATER: STUDIES OF OTHER CORONAVIRUSES

**Two peer-reviewed studies explored the persistence of infectious human and non-human coronaviruses at bench-scale by adding these viruses to dechlorinated waters and holding them at 4°C and 23-25°C**

» *Inactivation was observed to follow first-order kinetics at 25°C*

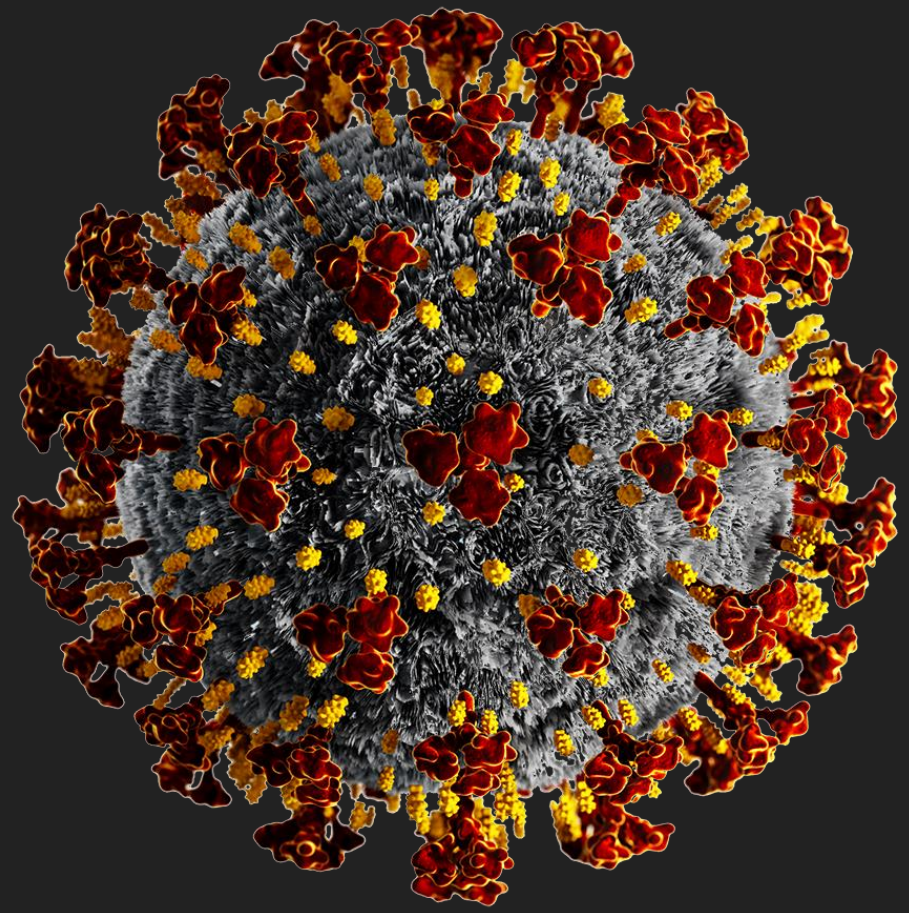
| WATER MATRIX | WASTEWATER – PRIMARY AND SECONDARY EFFLUENT[1] | | LAKE WATER | FILTERED TAP WATER (THROUGH 0.2 MICRON) | |
|---|---|---|---|---|---|
| | 4°C | 25°C | 25°C | 4°C | 25°C |
| DAYS TO ACHIEVE 99% REDUCTION IN INFECTIVITY | 49-70 | 2-7 | 14 | >110 | 7-21 |

[1]Primary Effluent was collected after settling with 110-220 mg/L suspended solids; Secondary Effluent was collected after activated sludge process and prior to disinfection with 90-95% reduction in BOD and SS

*Casanova, L, et al. 2009. Survival of surrogate coronaviruses in water. Water Research 43.7: 1893-1898.*
*Gundy, P. M., Gerba, C. P., Pepper, I. L. 2009. Survival of coronaviruses in water and wastewater. Food and Environmental Virology, 1(1), 10.*

# TREATMENT EFFICACY

CORONAVIRUSES



# DISCLAIMER #2

AN EXTENSIVE BODY OF LITERATURE ON THE EFFECTIVENESS OF WATER AND WASTEWATER TREATMENT PROCESSES FOR CORONAVIRUSES IS NOT AVAILABLE.

SITE-SPECIFIC WATER-QUALITY AND TREATMENT-PLANT DETAILS MAY RESULT IN VARIATION BETWEEN FULL-SCALE EFFECTIVENESS AND RESEARCH RESULTS FOUND IN THE LABORATORY.

# EFFICACY OF WASTEWATER TREATMENT FOR REMOVAL AND INACTIVATION OF VIRUSES

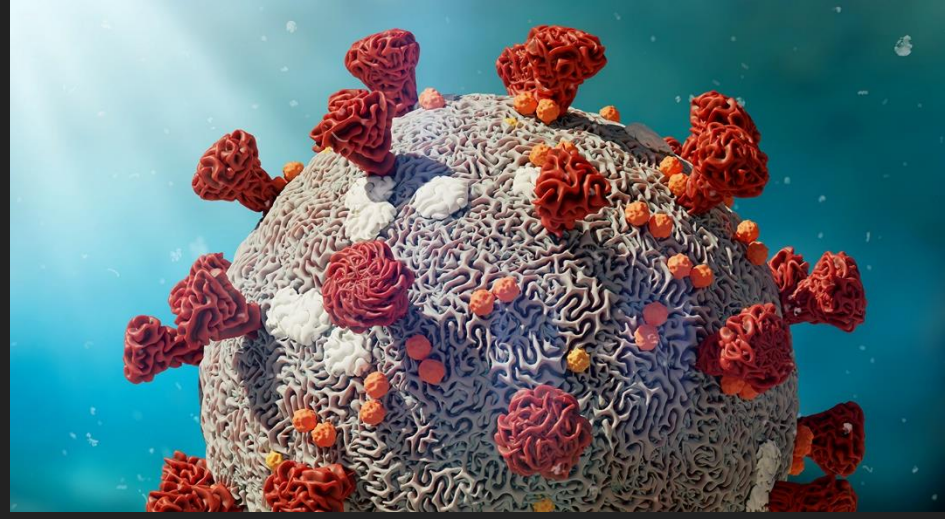
In general, the removal and inactivation of human viruses by secondary wastewater treatment (i.e. disinfection pre-treatment) is highly variable

- » *Between insignificant removal to >2 log removal (99%)*

Due to this variability, the primary process for the inactivation of viruses in wastewater treatment is chemical disinfection (i.e. chlorination) and/or ultraviolet (UV) light disinfection

*Hewitt, J., et al. 2013. Evaluation of human adenovirus and human polyomavirus as indicators of human sewage contamination in the aquatic environment. Water Research, 47(17), 6750-6761.*
*USEPA. 1986. Design Manual: Municipal Wastewater Disinfection. Office of Research and Development.*

# CORONAVIRUSES: MORE SUSCEPTIBLE TO DISINFECTION THAN OTHER HUMAN VIRUSES



Coronaviruses have been found to be more susceptible to inactivation by disinfection in wastewaters and surface waters than other microorganisms that are commonly used as surrogates for treatment performance evaluations:

- *E. coli*
- *Phage ($f_2$)*
- *Poliovirus 1*

As COVID-19 is an enveloped virus, sufficient damage to the viral envelope is expected to inactivate the virus

*Gundy, P. M., Gerba, C. P., Pepper, I. L. 2009. Survival of coronaviruses in water and wastewater. Food and Environmental Virology, 1(1), 10.*
*Wang, et al. 2005. Study on the resistance of SARS-associated coronaviruses. J Vir Methods, 126(1-2), 171-177.*

# EFFICACY OF WASTEWATER DISINFECTION: CHLORINATION

**Depends on numerous water quality factors such as the presence of disinfectant-demanding substances including ammonia, pH, temperature and other factors**

Chloramines

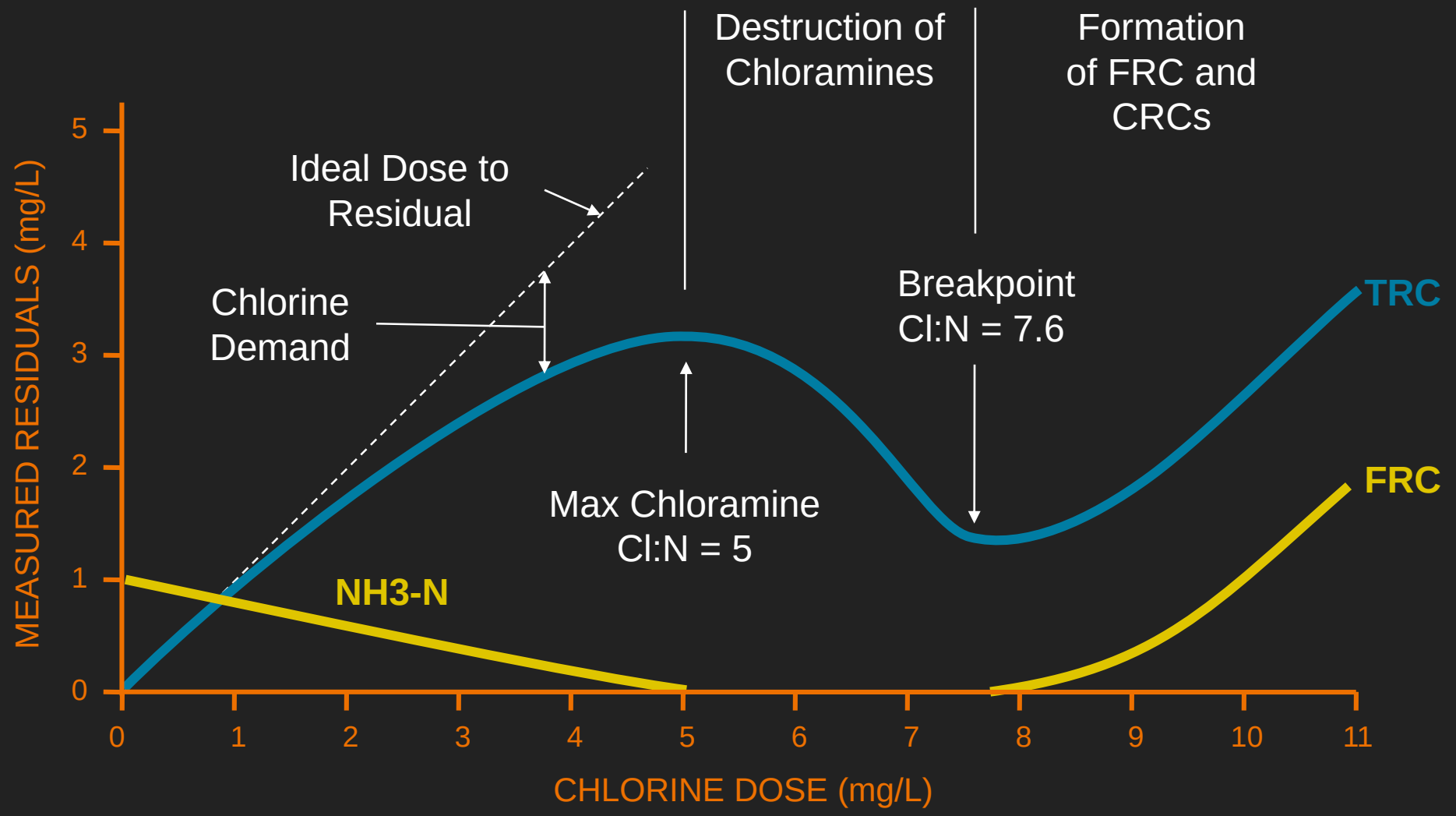
- *Ammonia reacts with chlorine to form chloramines*
- *In general, chloramines are weaker disinfectants against viruses when compared to free available chlorine*

Free Available Chlorine

- *Expected to have similar efficacy to the inactivation of other viruses*
  *e.g. free chlorine residual of >0.5 mg/L for 30 min*

*Wang, et al. 2005. Study on the resistance of SARS-associated coronaviruses. J Vir Methods, 126(1-2), 171-177.*

# DISINFECTION KINETICS – CHLORINE RESIDUAL



# FREE CHLORINE VS CHLORAMINES FOR INACTIVATION OF VIRUSES

In general, the required CT for chloramines to inactivate 4 log viruses is approximately 2 orders of magnitude more than that of free chlorine

**Table 3-5. Estimated Range of CT Values (mg-min/L) for Inactivation of Bacteria and Viruses. (Tchobanoglous et al., 2003 with permission from McGraw Hill)**

| | Free Chlorine | Chloramines |
|---|---|---|
| Bacteria | | |
| 2-log | 0.4 – 0.8 | 12 - 20 |
| 3-log | 1.5 – 3 | 30 – 75 |
| 4-log | 10 – 12 | 200 – 250 |
| Virus | | |
| 2-log | 2.5 – 3.5 | 300 - 400 |
| 3-log | 4 – 5 | 500 – 800 |
| 4-log | 6 – 7 | 200 – 1,200 |
| Protozoan Cysts | | |
| 2-log | 35 – 45 | 70 – 80 |
| 3-log | 700 – 1,000 | 1,100 – 2,000 |

# EFFICACY OF WASTEWATER DISINFECTION: UV

UV can be an effective treatment barrier for viruses in wastewater treatment when designed accordingly, and can be more effective than chlorination in wastewater applications

**However, it is not possible to estimate virus inactivation for systems in general and many systems are not designed specifically for viral inactivation**

Efficacy of UV disinfection of viruses in wastewater is highly dependent on site-specific factors such as:

- *Viral load*
- *Water quality*
- *Performance of upstream processes*
- *System design*
- *Fluence achieved*

*Blatchley III, ER et al. 2007. Effects of wastewater disinfection on waterborne bacteria and viruses. Water environment research 79.1: 81-92.*

# EFFICACY OF DRINKING WATER TREATMENT

## Optimized Conventional Filtration

- *Optimized conventional filtration can achieve 2 (99%) log virus removal*

## Free Available Chlorine

- *Chlorination at levels typically used for controlling viruses in general (e.g. 4-log inactivation) are expected to be effective for COVID-19*

## UV Disinfection

- *Dose of 44 mJ/cm$^2$ can achieve up to 3 log (99.9%) inactivation of poliovirus1 and rotaviruses*
- *Dose of 40-199 mJ/cm$^2$ can inactivate up to 3 log (99.9%) of adenoviruses*

*Health Canada. 2019. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Enteric Viruses. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.*
*USEPA. 2006. UV Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Federal Register.*

# DRINKING WATER TREATMENT CONSIDERATIONS

Surface water treatment plants with upstream wastewater impacts may be susceptible to the presence of coronaviruses in the raw water supply during, and after, an outbreak

- *Ensure that disinfection performance is continuously monitored*
- *Turbidity*
- *Disinfectant dose*
- *Disinfectant residual*
- *pH*
- *Temperature*
- *Flow*

**Common disinfection methods used in water treatment are expected to be effective for inactivation of coronaviruses when executed properly**

# QMRA PLUG: EMERGENCY PREPAREDNESS FOR DRINKING WATER TREATMENT PLANTS

Quantitative Microbial Risk Assessment (QMRA) is a statistical tool that water utilities can use to:

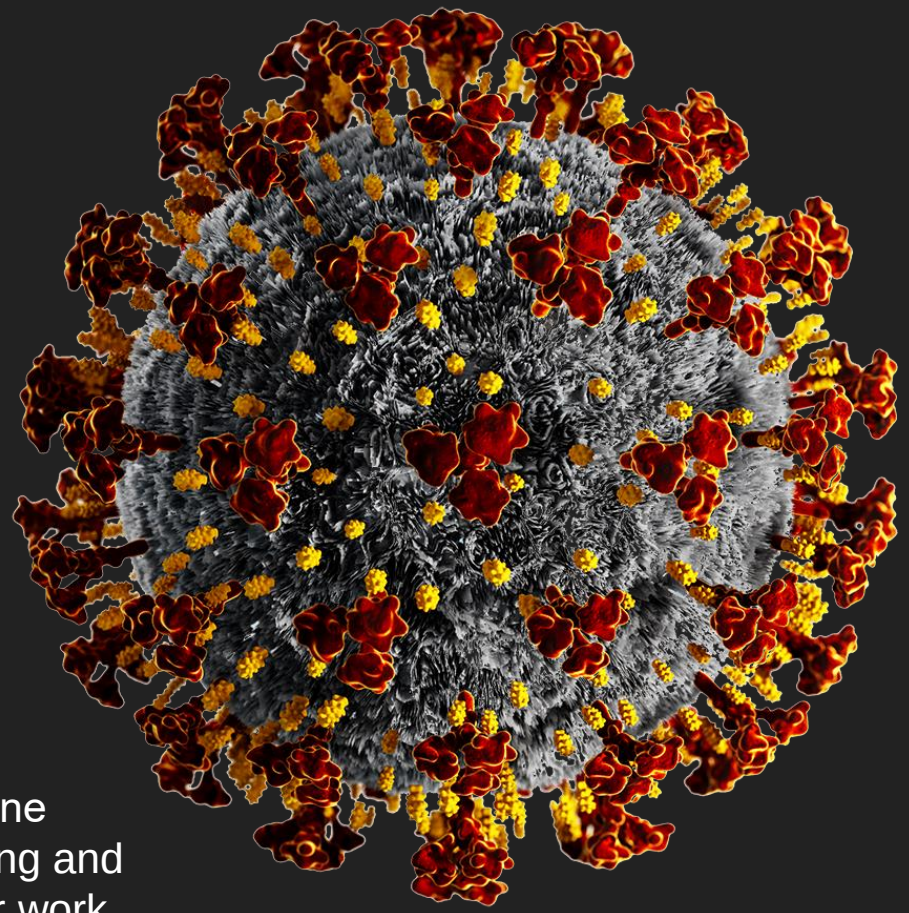
- *Understand the treatment barriers for viruses in their process train*
- *Plan for emergencies such as loss of disinfection*
- *Select and prioritize treatment upgrades*

For more information see Health Canada's Guidance document on the use of QMRA

*Health Canada. 2019. Guidelines for Canadian Drinking Water Quality: Guidance on the use of quantitative microbial risk assessment in drinking water. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.*

# OPERATOR CONSIDERATIONS

## COVID-19



“Wastewater treatment plant operations should ensure workers follow routine practices to prevent exposure to wastewater, including using the engineering and administrative controls, safe work practices, and PPE normally required for work tasks when handling untreated wastewater”.

**– OSHA, March 20, 2020**

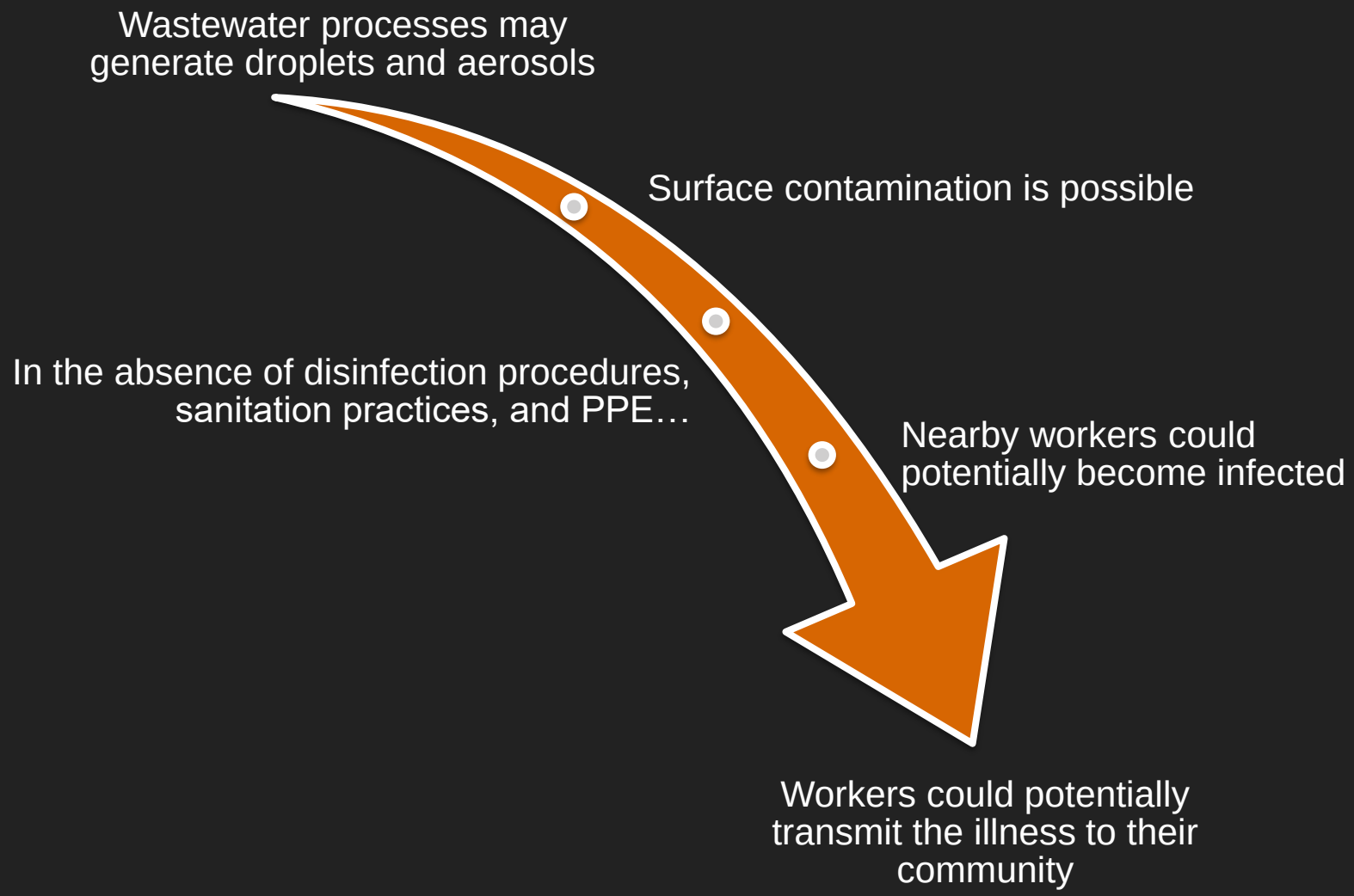
# SAFETY MOMENT

Wash your hands and between fingers with soap and warm water for at least 20 seconds

Avoid touching your nose, mouth or eyes

Stay home if you are ill.
Avoid others who are ill or meet the risk criteria.

# POTENTIAL RISKS TO OPERATORS




**WHO states that COVID-19** "seems to behave like other coronaviruses and … may persist on surfaces for a few hours or up to several days"

# SHOULD YOU WEAR A MASK?

**In response to the detection of COVID-19 RNA in raw wastewater, the Netherlands issued the following statement:**

> *"Standard procedure for WWTP personnel is as follows: During all activities that lead to possible contact with wastewater, they must wear personal protective equipment, including protective clothing, gloves, boots, safety glasses, a face mask and/or a FFP3 respirator mask."*

Check with local OSHA recommendations for PPE for various activities


*RIVM. March 24,2020. Novel coronavirus found in wastewater. <https://www.rivm.nl/en/news/novel-coronavirus-found-in-wastewater>*

# LIMITING OPERATOR EXPOSURES

| | | | |
|---|---|---|---|
| Routinely wash down surfaces that may come in contact with aerosols from WWT process. | Ensure proper PPE is available to prevent staff exposure to wastewater droplets. | Entering manholes is not recommended during the pandemic unless deemed critical. | Ensure PPE is worn, and social distancing is practiced, during deliveries or work that requires more than one person. |
| Provide hand sanitizer and ensure dispensers are regularly filled. | Routinely and thoroughly clean and disinfect all common surfaces e.g. lunch-room, keyboards. | Ensure masks are available for people who may develop a cough or fever on site. | Ensure staff who are ill stay home. |
| Communicate to your staff if a member becomes ill or is a confirmed case. | Split staff into shifts to encourage social distancing during shift changes. | Take separate breaks to meet social distancing of 6 ft+. | Implement measures to prevent transmission from the workplace to home. |

# SLUDGE MANAGEMENT

It is possible that COVID-19 could be present in raw sewage and settled sludge

The persistence of infectious COVID-19 in sludge is unknown but is expected to vary significantly depending on site-specific sludge handling and treatment procedures

- *If COVID-19 is similar to other coronaviruses, then its persistence in sludge could be on the order of days in warm environments and weeks in cold environments*

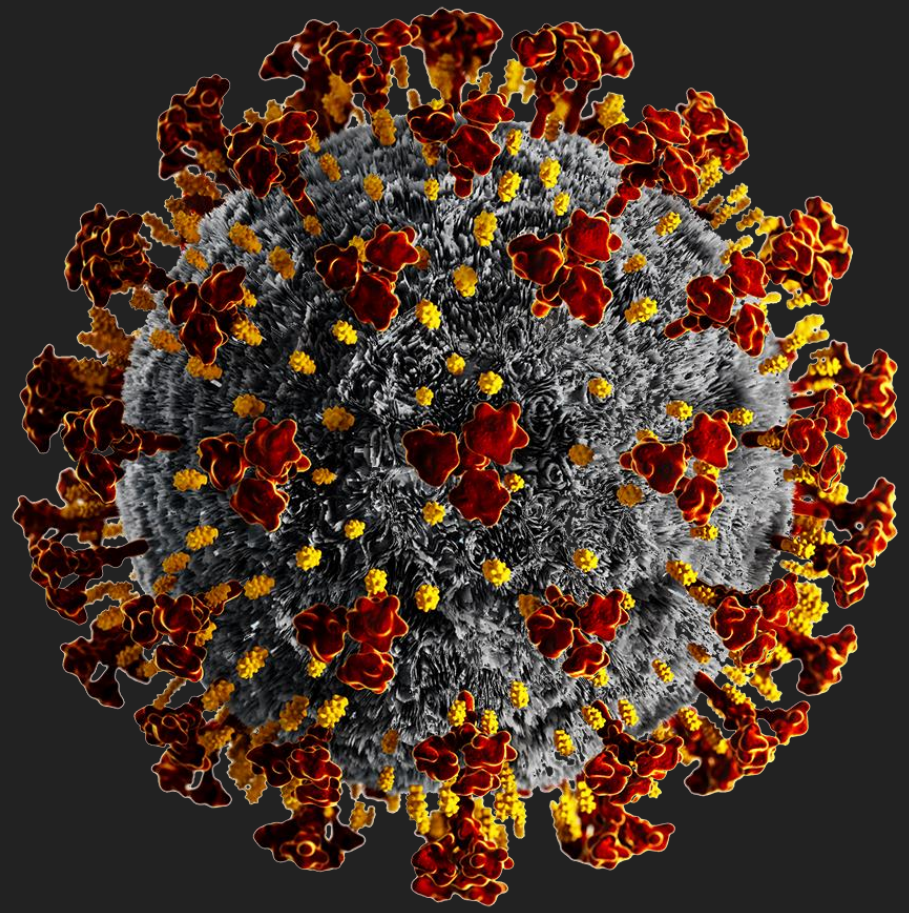
The USEPA Part 503 rule provides comprehensive requirements for the management of biosolids generated during the process of treating municipal wastewater

*USEPA. 2004. A Guide to the Biosolids Risk Assessment Methodology for the EPA 503 Rule. Office of Wastewater Management. EPA/832-8- 93-005.*

*Biosolids Applied to Land, Advancing Standards and Practices. National Research Council of the National Academies. The National Academies Press. Washington, D.C. 2002.*

# ADDRESSING THE PUBLIC

COVID-19



# Can spraying alcohol or chlorine all over your body kill the new coronavirus?

No. Spraying alcohol or chlorine all over your body will not kill viruses that have already entered your body. Spraying such substances can be harmful to clothes or mucous membranes (i.e., eyes, mouth).
Be aware that both alcohol and chlorine can be useful to disinfect surfaces, but they need to be used under appropriate recommendations.

World Health Organization

#2019nCoV

# Can an ultraviolet disinfection lamp kill the new coronavirus?

UV lamps should not be used to sterilize hands or other areas of skin as UV radiation can cause skin irritation.

World Health Organization

#2019nCoV

# PUBLIC SAFETY: OVERFLOWS

Operational combined sewer overflows and bypasses of treatment barriers could contribute to the release of human viruses into the environment

Persistence of infectious COVID-19 in natural waters is unknown

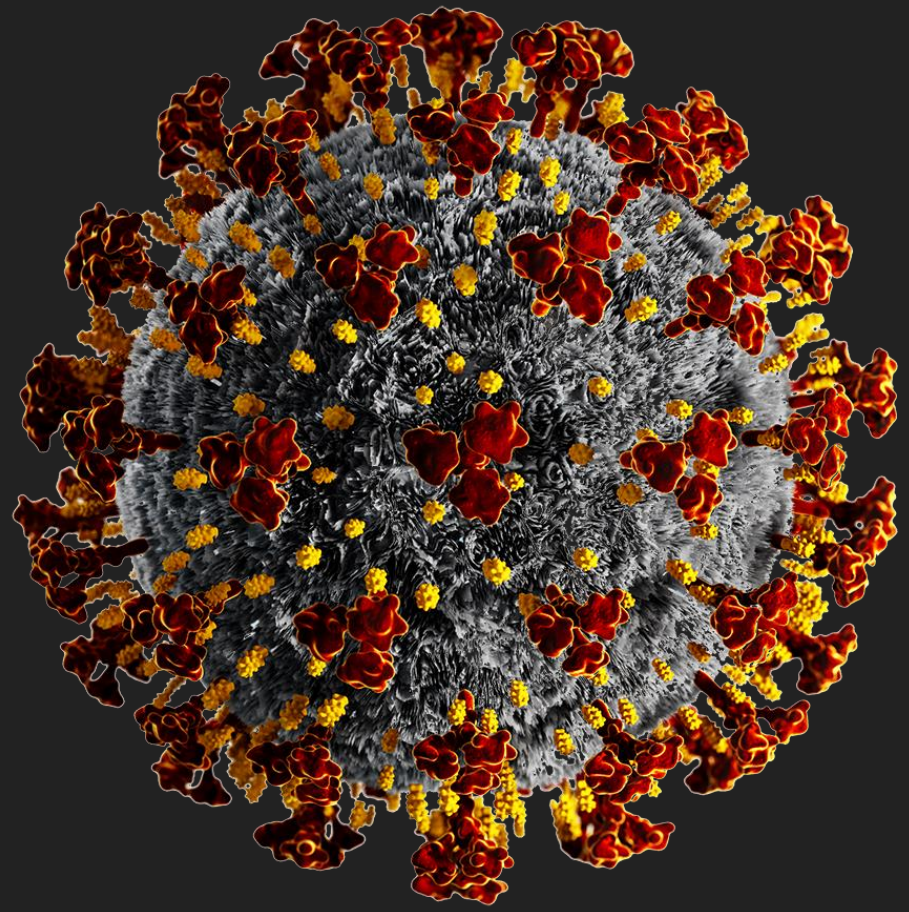
- *If COVID-19 is similar to that of other coronaviruses, then it could be on the order of weeks in warm conditions to months in cold conditions*

**Consider public notices and restricted access at these locations during and after a storm or snow-melt event**

*Casanova, L, et al. 2009. Survival of surrogate coronaviruses in water. Water Research 43.7: 1893-1898.*
*https://www.theglobeandmail.com/opinion/article-to-understand-covid-19-transmission-we-have-to-understand-our/*

# SUMMARY

COVID-19



# SUMMARY

Infectious coronaviruses may be present in raw wastewater collected from an infected population.

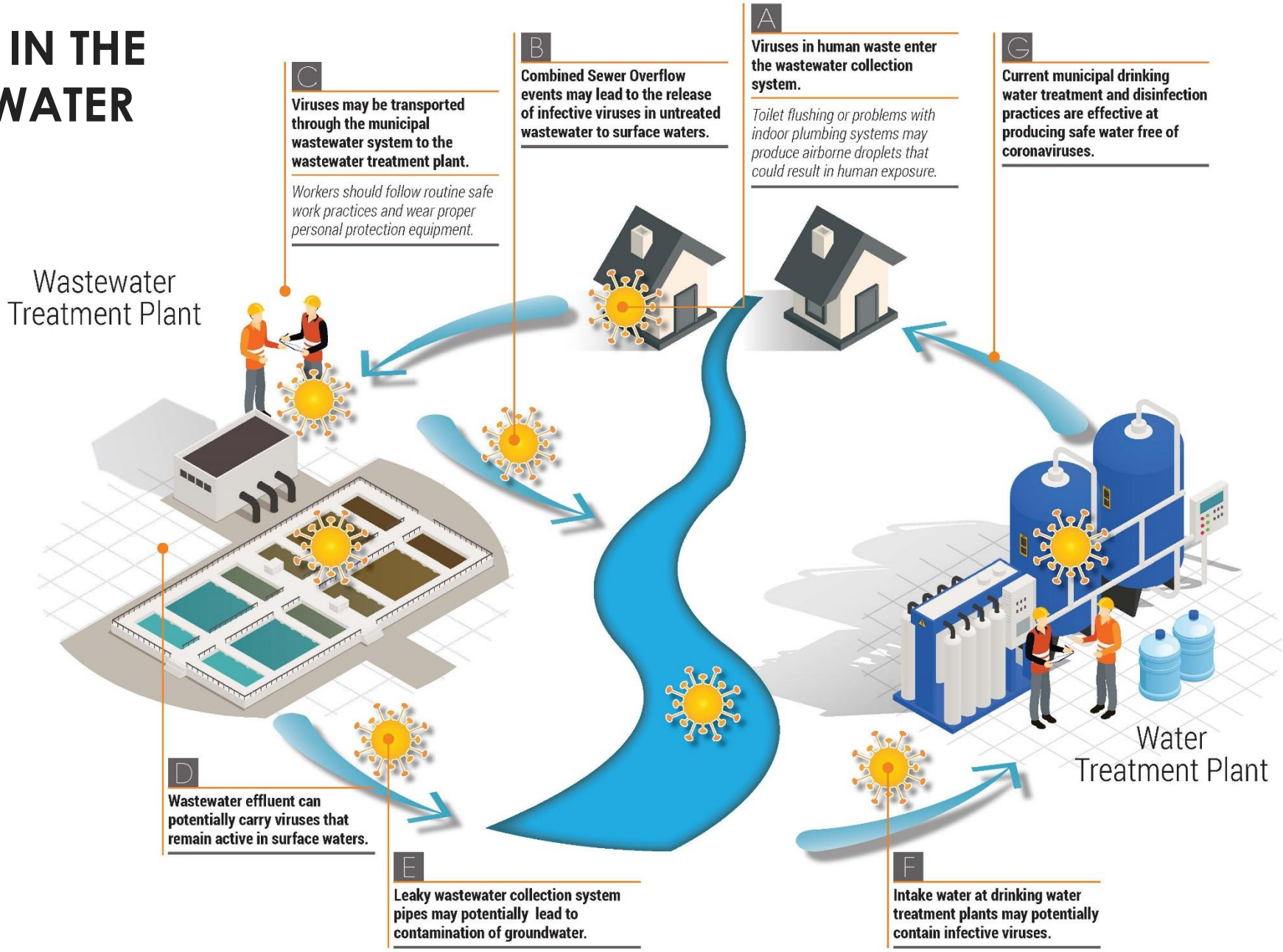
Coronaviruses may remain infective for a few days if present in raw wastewater.

The quantity, persistence, and risk to human health from COVID-19 in raw wastewater is currently unknown.

# CRITICAL CONTROL POINTS

| CRITICAL CONTROL POINT | POTENTIAL RISK | RISK RESPONSE |
|---|---|---|
| Wastewater Treatment – Open Basins | Aerosols or droplets created during treatment process | • Communicate risks by providing signage<br>• Provide PPE barriers and hand-washing stations<br>• Routinely disinfect surfaces |
| Combined sewer overflows | Community exposure | • Communicate risks by providing signage<br>• Prevent or limit access to these areas during and following storm events |
| Meetings | Person-to-person transmission | • Limit meetings<br>• Practice social distancing and maintain distance of >2m<br>• Post signage and hand sanitizer<br>• Do not meet if you are ill |

# VIRUSES IN THE URBAN WATER CYCLE



# CLOSING

Stay up to date

- *WHO, Johns Hopkins University, Health Canada, Local news stations*
- *Visit wef.org*

Develop an electronic strategy to connect with staff during social distancing

- *Weekly conference calls*
- *Frequent e-mail updates*
- *Clearly communicate tasks and deadlines*
- *Ensure all staff contact information is up-to-date*

Encourage staff to stay home if:

- *They have travelled outside the country*
- *They have come in contact with, or cared for, a confirmed case of COVID-19*
- *They are ill*

*WEF.org "Coronavirus: Field Guide" https://www.wef.org/news-hub/wef-news/the-water-professionals-guide-to-the-2019-novel-coronavirus/*

# AUTHOR INFORMATION


**NICOLE MCLELLAN** M.A.Sc., Ph.D. Candidate

Process Specialist | Water | Stantec

Direct: 519 575-4229
Mobile: 519 722-2004
Fax: 519 579-6733
Nicole.McLellan@stantec.com

**JOE JACANGELO, PHD**

REHS Vice President Director of Research

**DAVID PERNITSKY, PHD, P.Eng.**

Global Practice Leader - Water Treatment

**ART K. UMBLE PHD, PE, BCEE, F.WEF**

Senior Vice President Global Wastewater Practice Leader