# South African experiences with wastewater based epidemiology for SARS-CoV-2

Kerrigan McCarthy, Said Rachida, Nkosenhle Ndlovu, Chinwe Iwu-Jaja, Mukhlid Yousif

For the

SOUTH AFRICAN COLLABORATIVE COVID-19 ENVIRONMENTAL SURVEILLANCE SYSTEM (SACCESS)

NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service

BILL & MELINDA GATES foundation

WATER RESEARCH COMMISSION

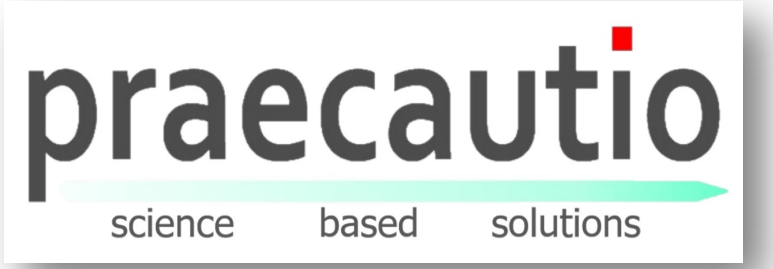
- Acknowledgements
  - NICD team
  - Funders













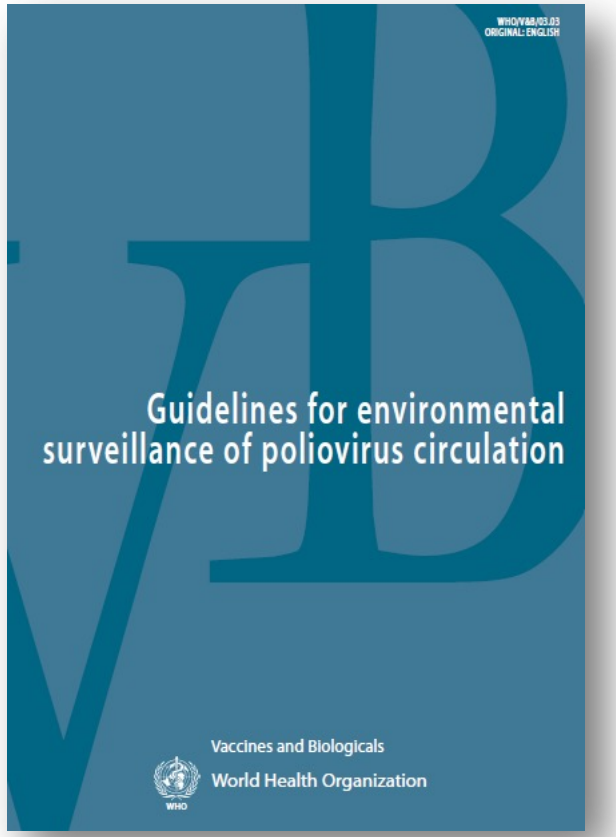
# South African experiences with wastewater-based epidemiology for SARS-CoV-2

1. The beginnings of the SACCESS network – from polio environmental surveillance to SARS-CoV-2
2. SARS-CoV-2 quantitative and sequencing results in wastewater – results
3. Sequencing SARS-CoV-2 in wastewater – successes
4. Challenges for wastewater based epidemiology
5. What is the future of wastewater based epidemiology in South Africa?

# The beginnings – from polio to SARS-CoV-2 environmental surveillance

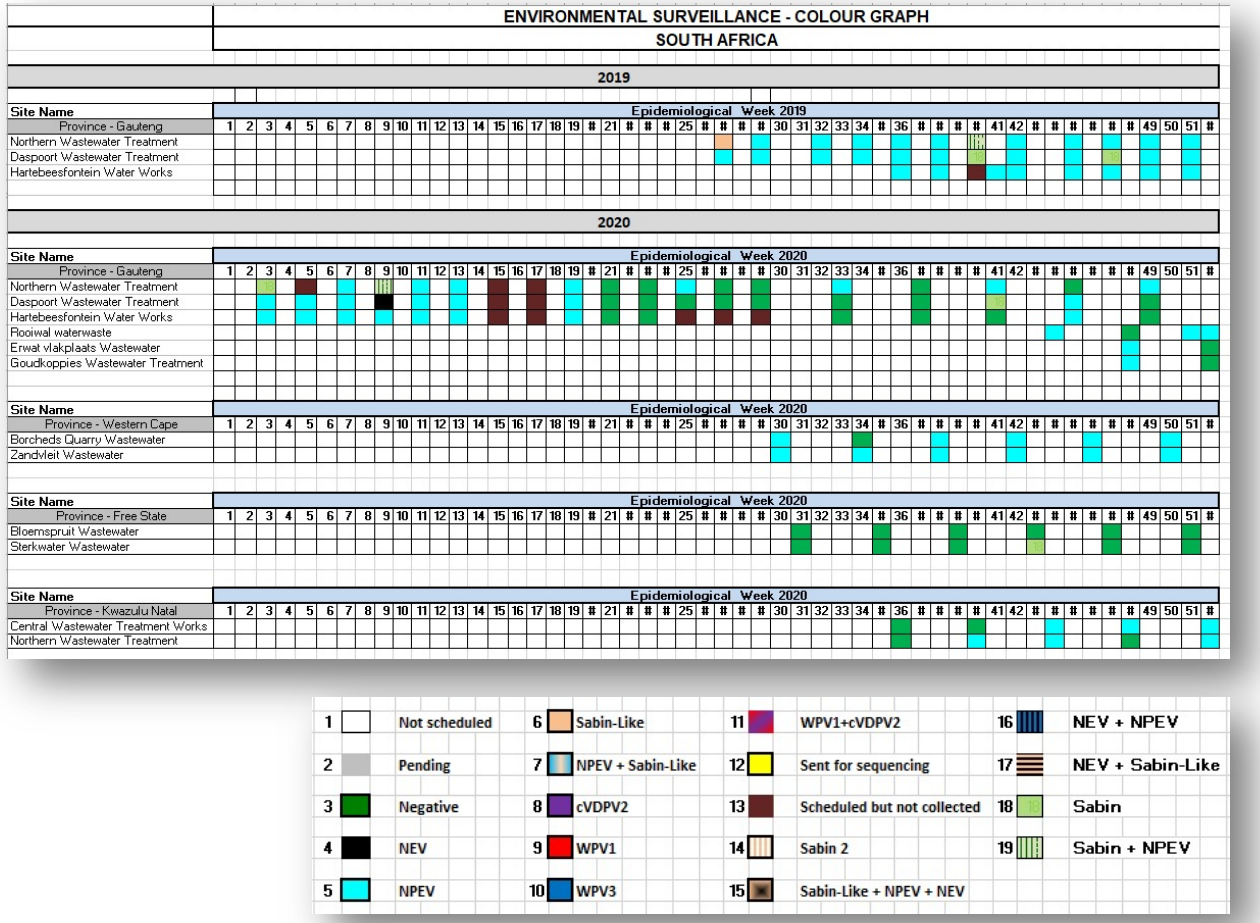
- WHO recommends environmental surveillance for polio to
  - Monitoring enteric virus circulation
  - Detecting wild-type poliovirus
  - Monitoring circulating vaccine-derived poliovirus
- The NICD is a WHO Polio Collaborating Centre and was appointed as a regional reference laboratory prior to 2010
- NICD Centre for Vaccines and Immunology commenced with polio environmental surveillance in 2018, in line with WHO suggestions.
- These data inform RSA on presence of
  - wild polio virus (last detected in clinical cases in 1989),
  - sabin-like virus (oral polio vaccine) and
  - non-polio enterovirus

  in the national sewer system and hence in patients



# The beginnings – from polio to SARS-CoV-2 environmental surveillance

- Successes of polio ES in RSA
  - Regular sampling from 18 sites in all Metros across RSA
  - Detection of Sabin strain
  - Detection of Sabin-like virus with 7 mutations
  - No cVDPV (despite 2 clinical cases of immunodeficcient VDPV detected in 2017 and 2019)



# The beginnings – from polio to SARS-CoV-2 environmental surveillance

- Emerging interest in use of SARS-CoV-2 in wastewater to monitor epidemiological patterns as early as April/May 2020
- First published results appeared in August 2020 from a number of countries including Australia, Italy, USA
- Melinda Suchard from NICD Centre for Vaccines and Immunology initiated SARS-CoV-2 testing using polio wastewater samples

# The beginnings – from polio to SARS-CoV-2 environmental surveillance

The SACCESS network comprises 8 laboratories which test **87 wastewater treatment plants every week** across South Africa:

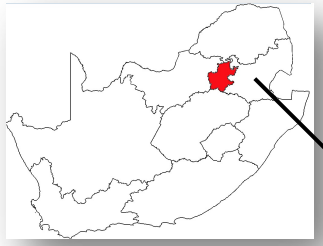
Free State: 9
Eastern Cape: 10
Gauteng: 40
Mpumalanga: 3
Northern Cape: 2
Kwazulu-Natal: 12
Western Cape: 5
Limpopo: 2
North West: 3

The network is funded by the NICD and the Water Research Commission (WRC)

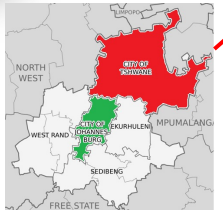
# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels and variants present across Gauteng

South Africa
Gauteng Province



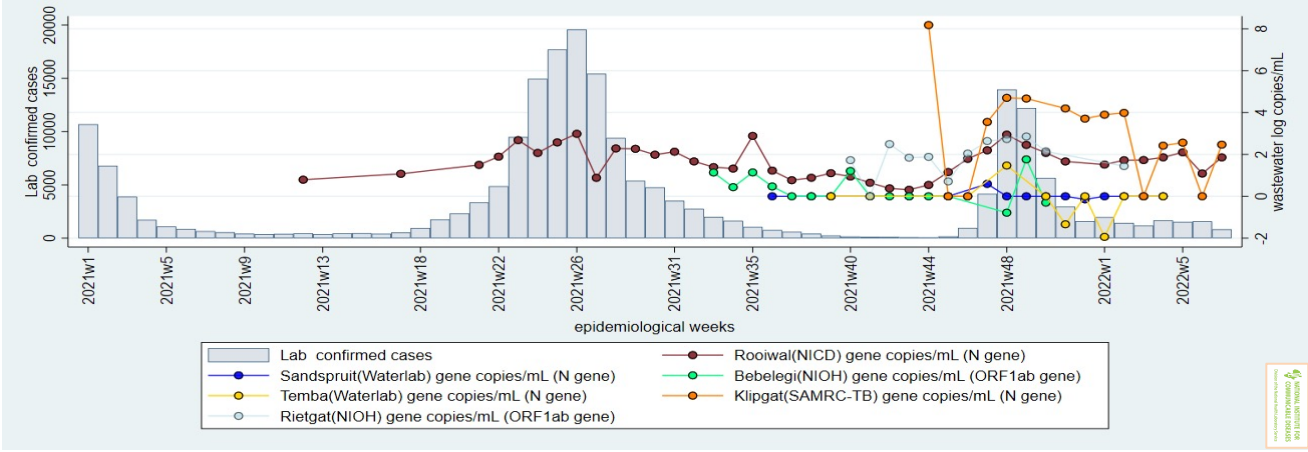
City of Tshwane



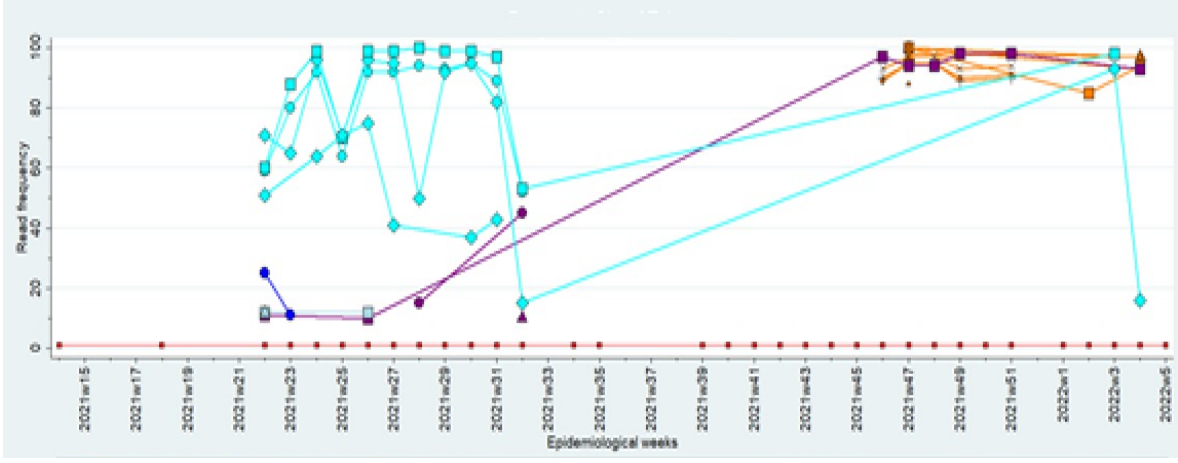

City of Johannesburg

## City of Tshwane, Gauteng Province

Levels of SARS-CoV-2 present in wastewater from wastewater plants, City of Tshwane



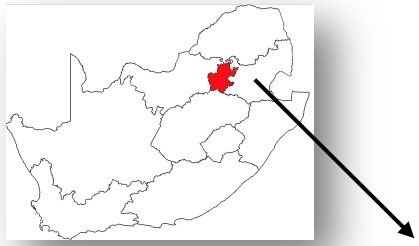

SARS-CoV-2 variants present in wastewater from Daspoort, City of Tshwane

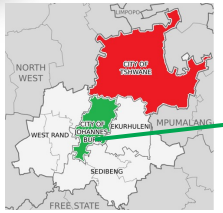


# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels across Gauteng

South Africa
Gauteng Province

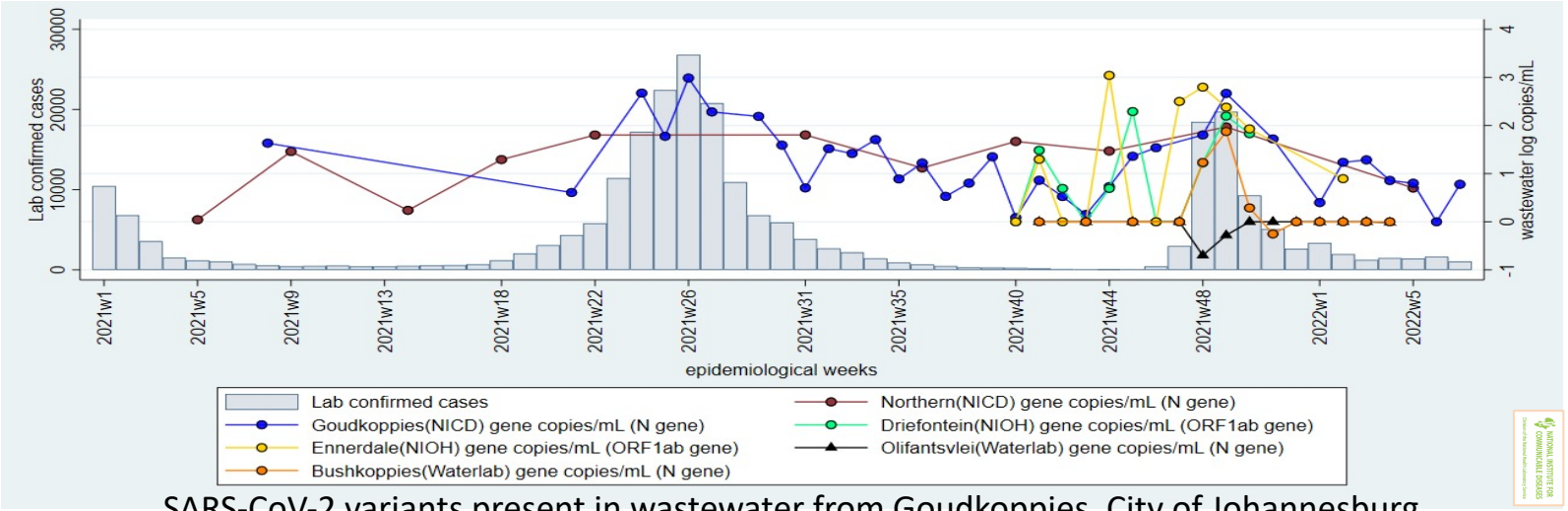




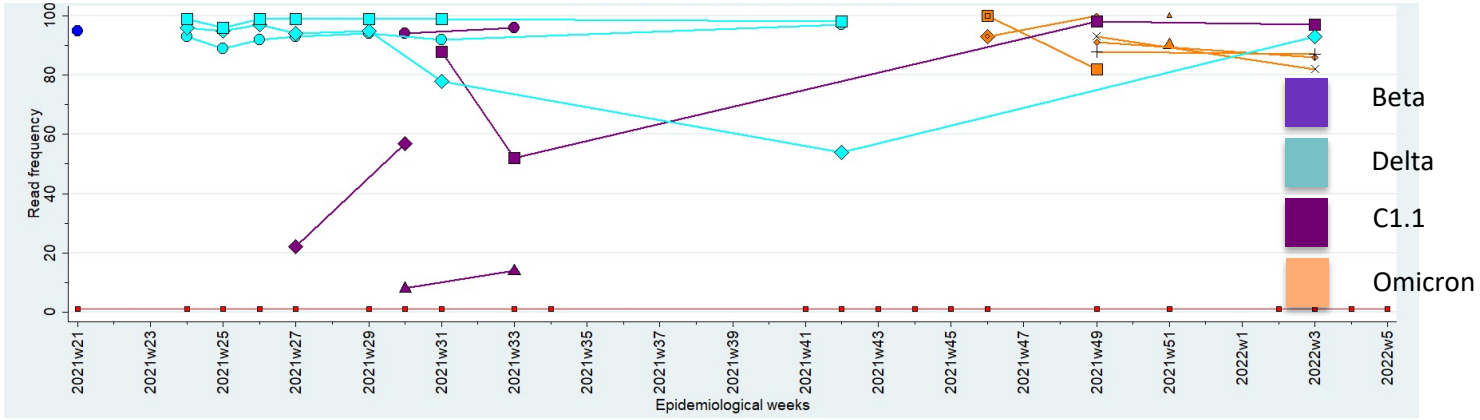

City of Johannesburg

## Gauteng wastewater treatment plants

Levels of SARS-CoV-2 present in wastewater from wastewater plants, City of Johannesburg




SARS-CoV-2 variants present in wastewater from Goudkoppies, City of Johannesburg

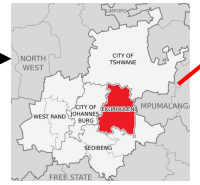


# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels across Gauteng

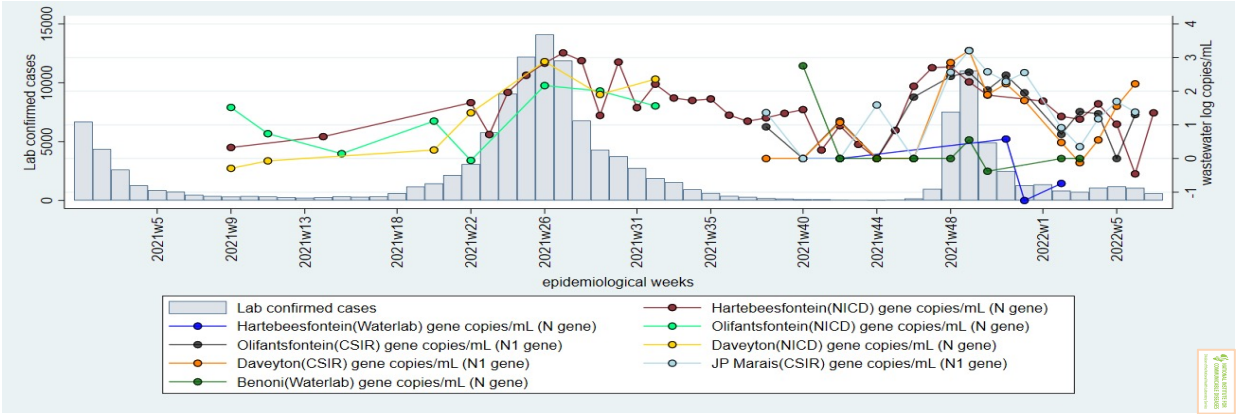
South Africa
Gauteng Province

Ekurhuleni

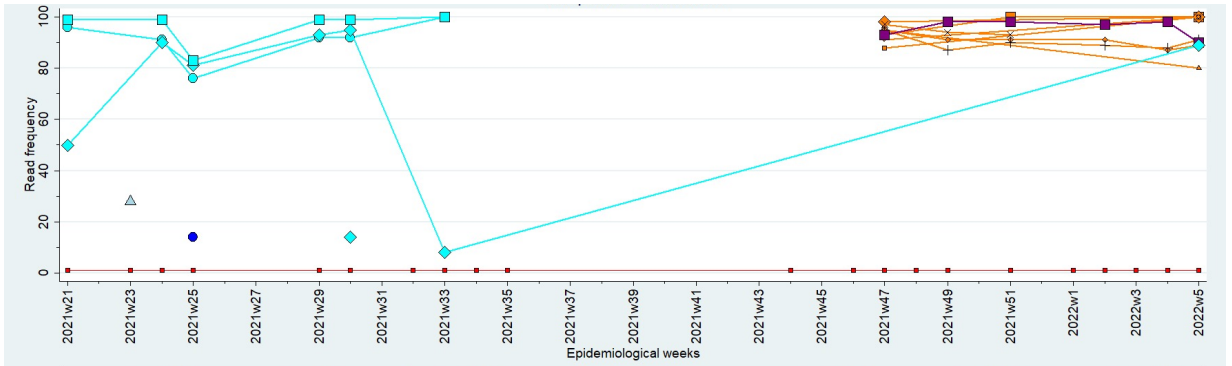



## Gauteng wastewater treatment plants

Levels of SARS-CoV-2 present in wastewater from wastewater plants, City of Ekurhuleni




SARS-CoV-2 variants present in wastewater from Hartbeesfontein, City of Ekurhuleni

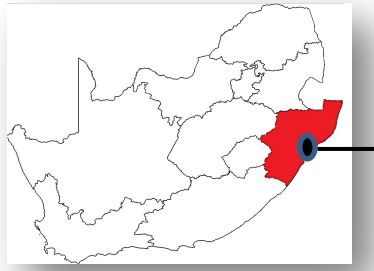


# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels across eThekwini wastewater plants

South Africa

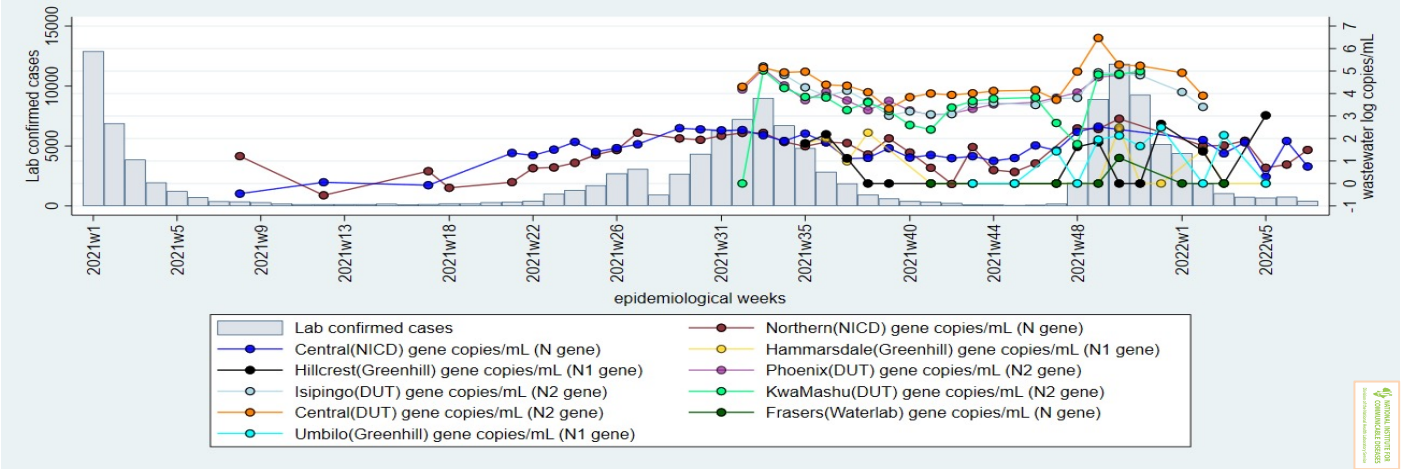
KwaZulu-Natal Province



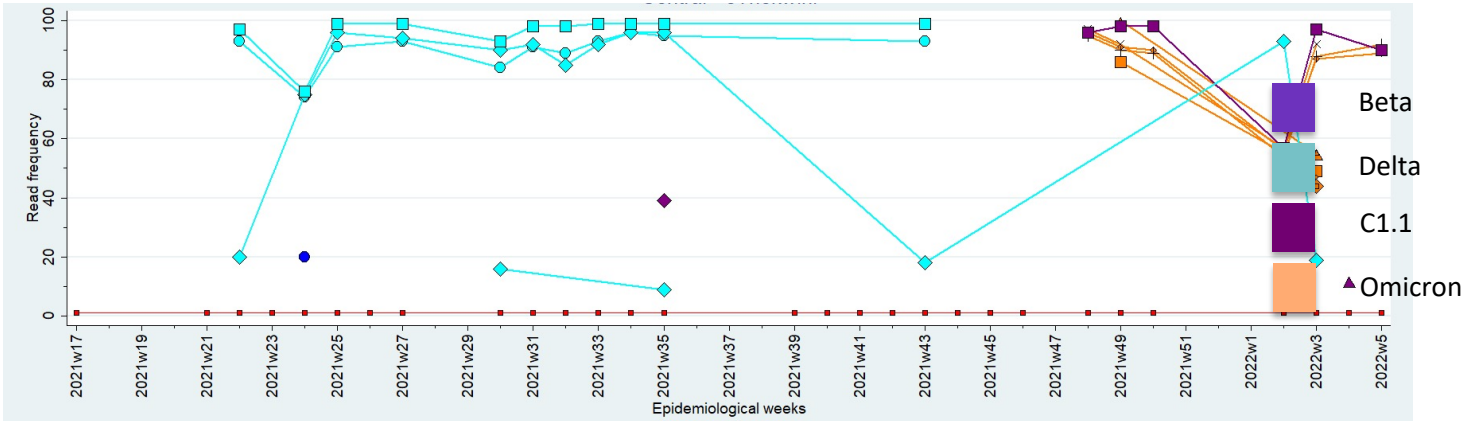
eThekwini

## Ethekwini wastewater treatment plants

Levels of SARS-CoV-2 present in wastewater from wastewater plants, eThekwini

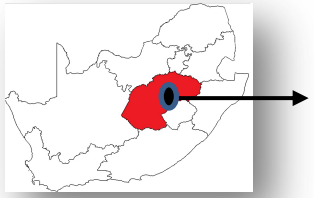



SARS-CoV-2 variants present in wastewater from Central WWTP, eThekwini



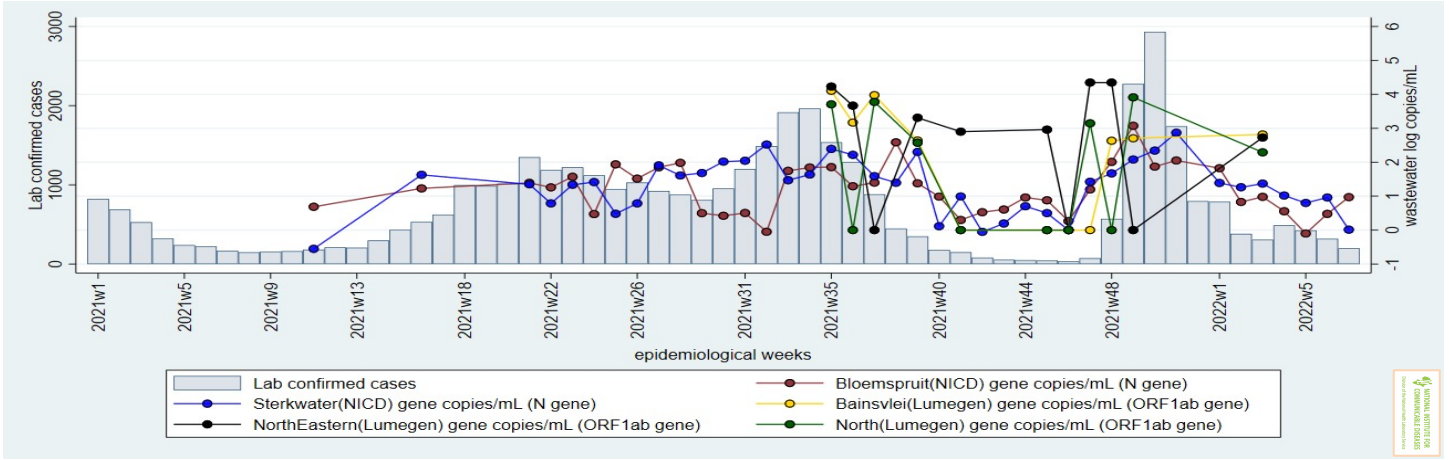
# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels across Mangaung wastewater plants

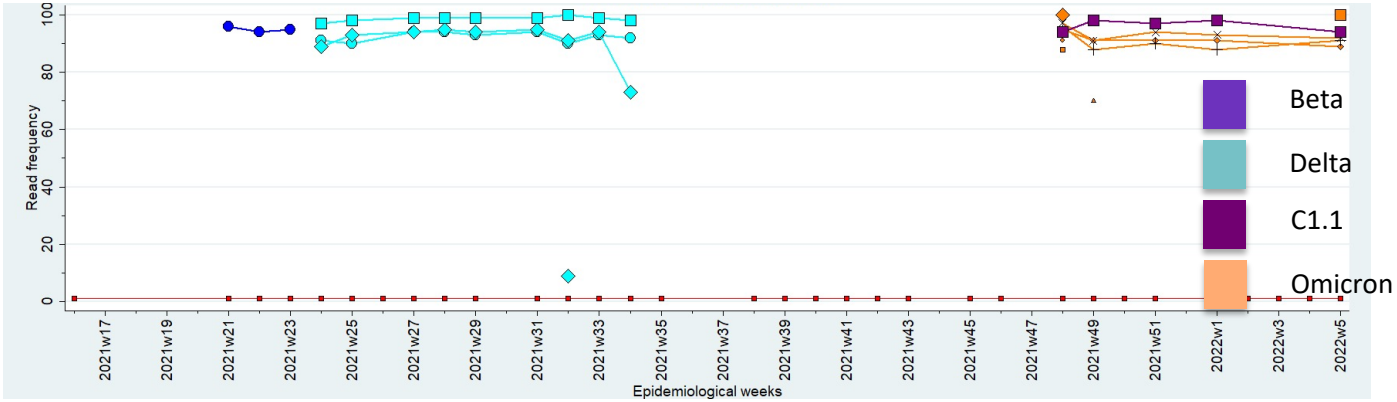



## Mangaung waste water treatment plants

Levels of SARS-CoV-2 present in wastewater from wastewater plants, Mangaung

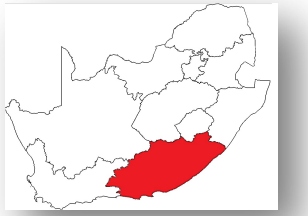



SARS-CoV-2 variants present in wastewater from Bloemspruit WWTP, Mangaung



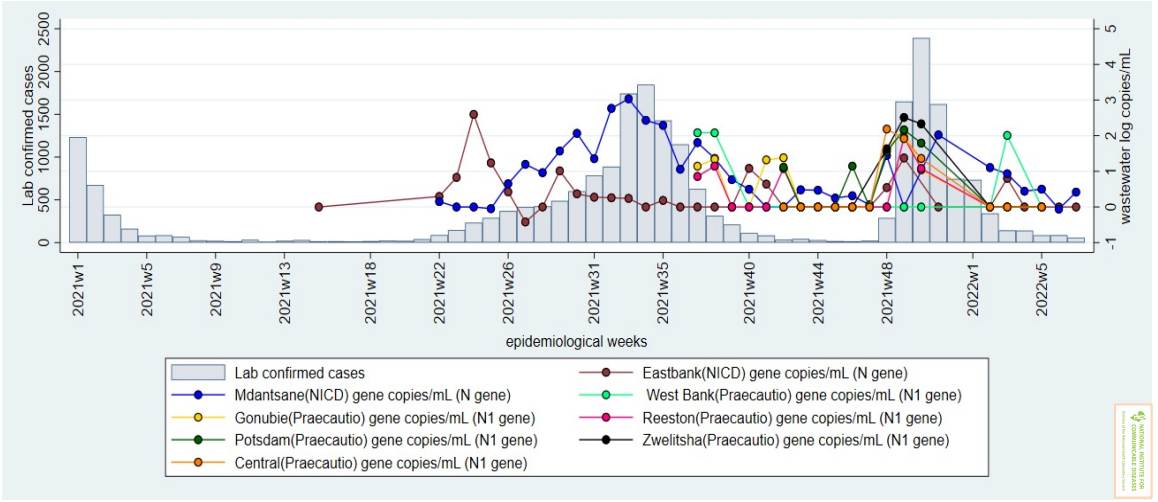
# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels across NMMB wastewater plants

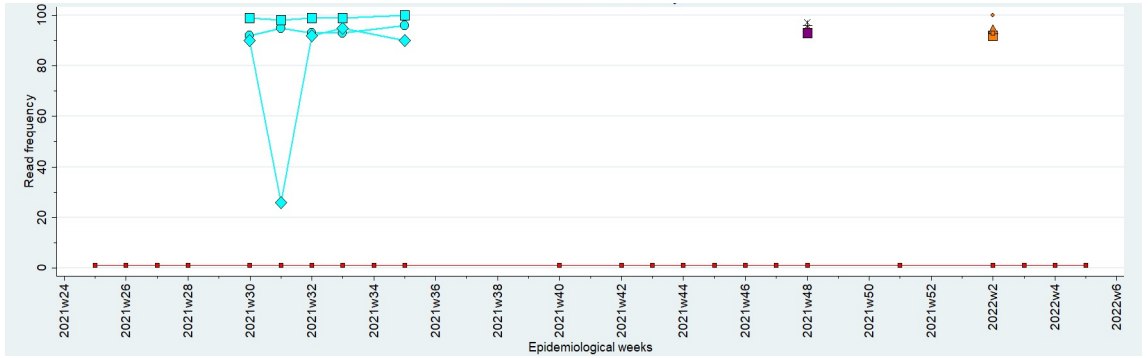


## Eastern Cape wastewater treatment plants

Levels of SARS-CoV-2 present in wastewater from wastewater plants, Mangaung

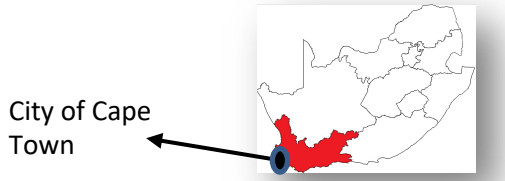



SARS-CoV-2 variants present in wastewater from Bloemspruit WWTP, Mangaung



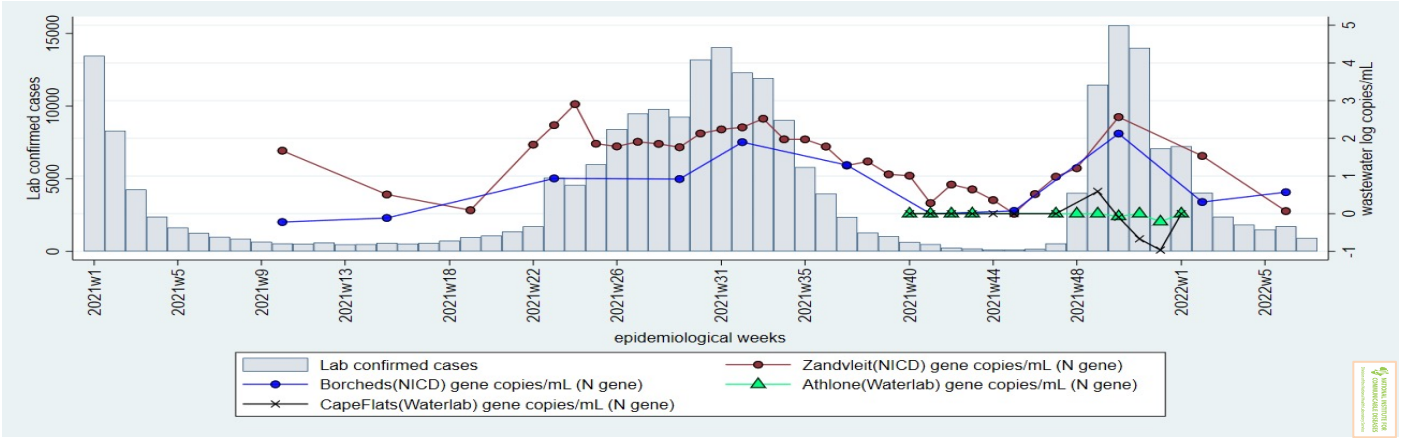
# Quantitative SARS-CoV-2 in wastewater – results

- Current trends in SARS-CoV-2 levels across City of Cape Town wastewater plants

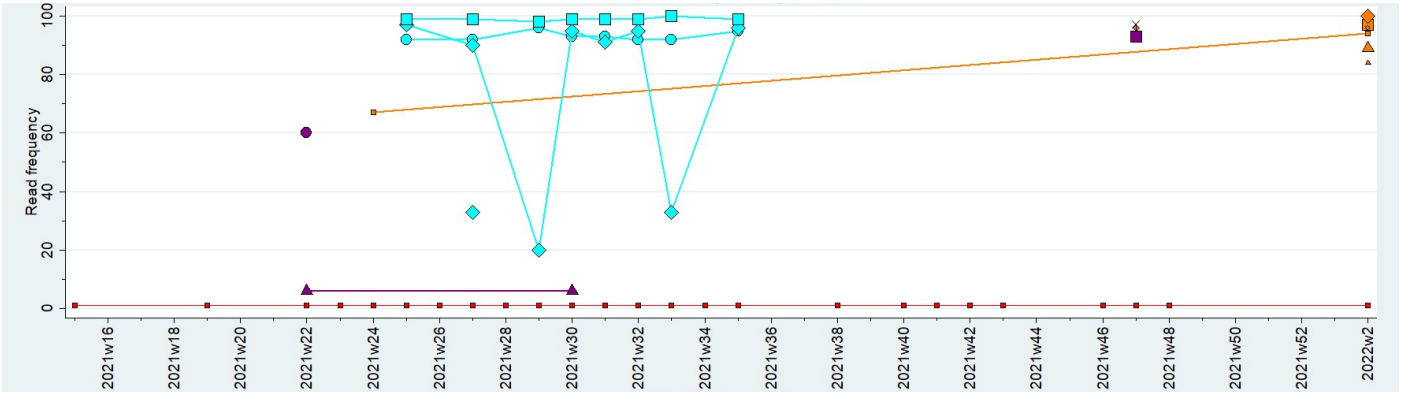



## City of Cape Town wastewater treatment plants

Levels of SARS-CoV-2 present in wastewater from wastewater plants, Mangaung




SARS-CoV-2 variants present in wastewater from Bloemspruit WWTP, Mangaung



# Quantitative SARS-CoV-2 in wastewater –successes

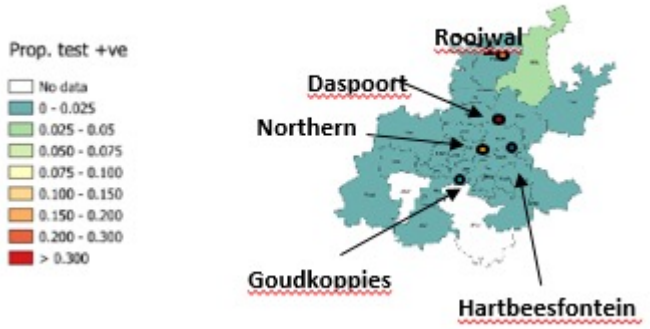
- Convincing public health managers that wastewater is a useful surveillance tool
  - Good correlations between cases and admissions with SARS-CoV-2 levels in wastewater

| | Cases vs wastewater levels | | | | | Admissions vs wastewater levels | | | | | In hospital deaths vs wastewater levels | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wastewater plants | Correlation co-efficient (Spearman's) | p-value | Regression coefficient | p-value | R squared (Coeeficient of determination) | Correlation co-efficient (Spearman's) | p-value | Regression co-efficient | p-value | R squared (Coeeficient of determination) | Correlation co-efficient (Spearman's) | p-value | Regression co-efficient | p-value | R squared (co-efficient of determination) |
| Goudkoppies | 0.7489 | 0.0001 | 8488.301 | 0.0001 | 0.5815 | 0.7519 | 0.0001 | 849.1814 | 0.0000 | 0.6134 | 0.7684 | 0.0001 | 195.6434 | 0.0001 | 0.5979 |
| Northern | 0.3095 | 0.4556 | 1381.574 | 0.2383 | 0.2222 | 0.3333 | 0.4198 | 100.8705 | 0.5783 | 0.0544 | 0.2515 | 0.5479 | 24.52558 | 0.6213 | 0.0432 |
| Goudkoppies + Northern | | | | | | | | | | | | | | | |
| Rooiwal | 0.7513 | 0.0000 | 4815.663 | 0.0020 | 0.3595 | 0.7200 | 0.0001 | 463.8325 | 0.0011 | 0.3900 | 0.6690 | 0.0004 | 98.40376 | 0.0042 | 0.3169 |
| Daspoort | 0.8948 | 0.0000 | 5492.838 | 0.0000 | 0.6424 | 0.8948 | 0.0000 | 554.2203 | 0.0000 | 0.7585 | 0.8434 | 0.8434 | 114.3431 | 0.0000 | 0.5962 |
| Olifantsfontein | 0.4762 | 0.2329 | 3114.056 | 0.1546 | 0.3064 | 0.6190 | 0.1017 | 371.1455 | 0.0827 | 0.4190 | 0.7306 | 0.0396 | 128.4205 | 0.0372 | 0.5424 |
| Vlakplaats | 0.7061 | 0.0033 | 3078.111 | 0.0658 | 0.4059 | 0.7312 | 0.0020 | 433.1515 | 0.0106 | 0.4059 | 0.7563 | 0.0011 | 135.0431 | 0.0050 | 0.4666 |
| Daveyton | 0.8929 | 0.0068 | 2882.361 | 0.0532 | 0.5594 | 0.8571 | 0.0137 | 315.0192 | 0.0233 | 0.6756 | 0.9286 | 0.0025 | 94.7016 | 0.0295 | 0.6455 |
| Hartebeesfontein | 0.7075 | 0.0002 | 3723.197 | 0.0002 | 0.4800 | 0.7131 | 0.0001 | 432.6562 | 0.0001 | 0.5474 | 0.7734 | 0.0000 | 133.0977 | 0.0000 | 0.6022 |

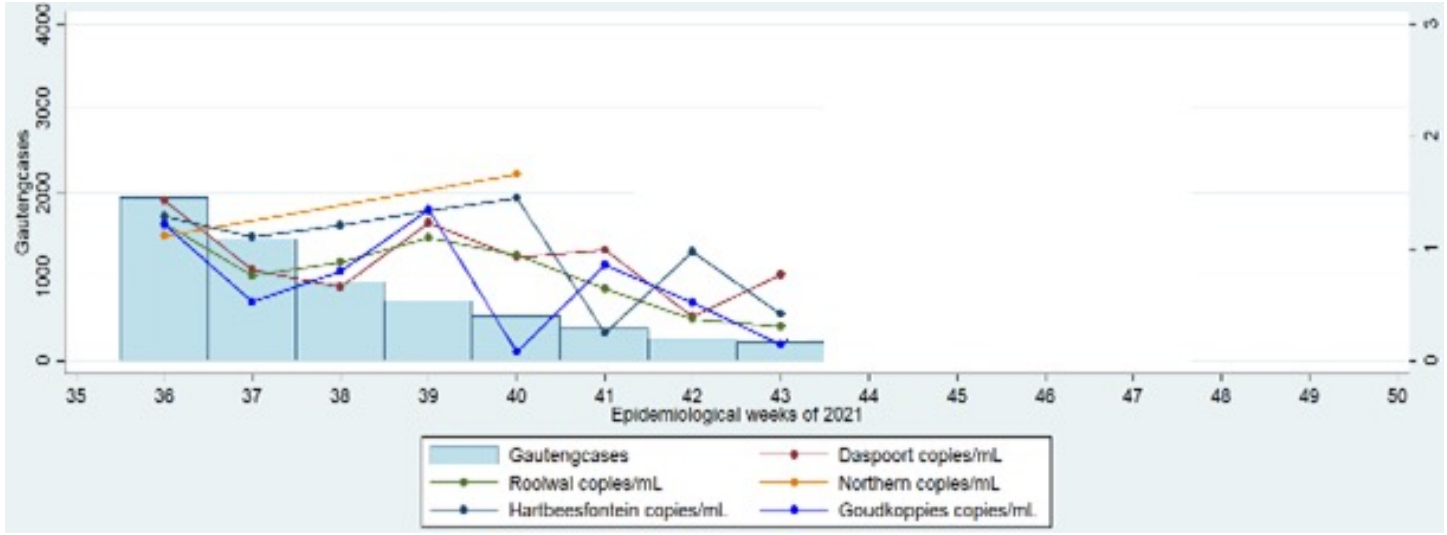
# Quantitative SARS-CoV-2 in wastewater – successes

- Convincing public health managers that wastewater is a useful surveillance tool
  - Many epidemiologists were sceptical about the value of wastewater
  - Early in the 4th wave, we started picking up increases in levels in Tshwane plants

% of PCR test which were positive, clinical samples patients, **week 43, 2021**




Cases of SARS-CoV-2 (bars) and levels of SARS-CoV-2 in wastewater, **week 43, 2021**

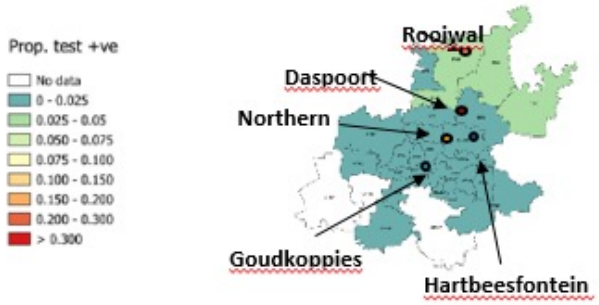



Wastewater levels (lines) at selected treatment plants, by total Gauteng cases, epi weeks 36-47, 2021

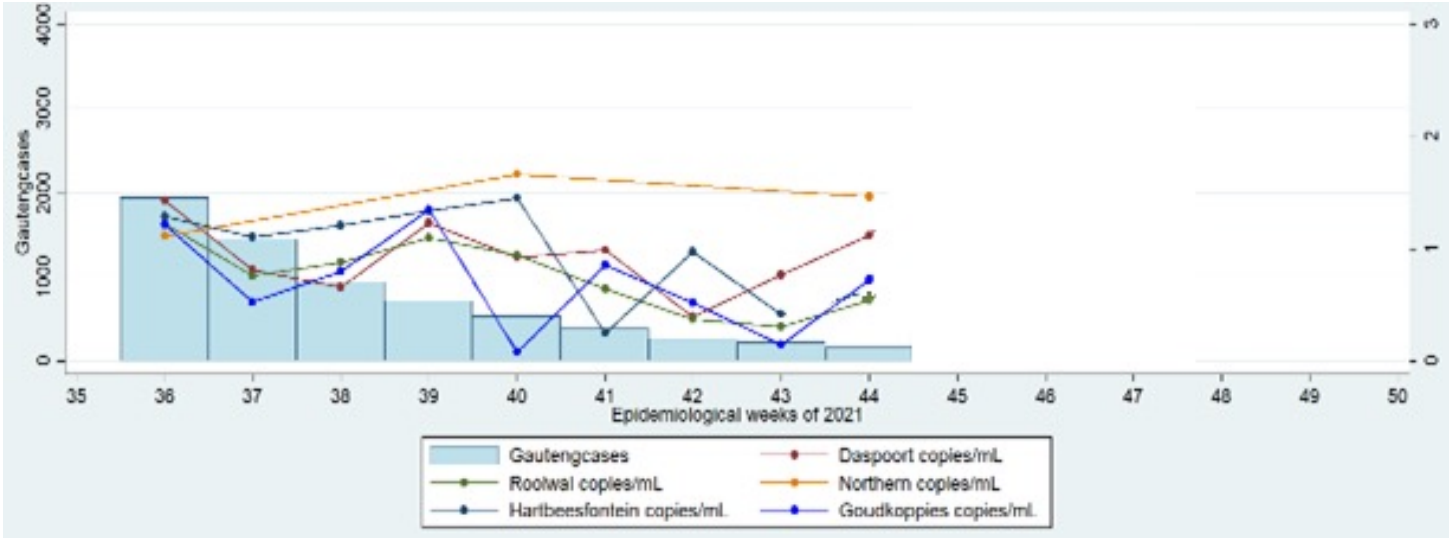
# Quantitative SARS-CoV-2 in wastewater – successes

- Convincing public health managers that wastewater is a useful surveillance tool
  - Many epidemiologists were sceptical about the value of wastewater
  - Early in the 4th wave, we started picking up increases in levels in Tshwane plants

% of PCR test which were positive, clinical samples patients, **week 44, 2021**




Cases of SARS-CoV-2 (bars) and levels of SARS-CoV-2 in wastewater, **week 44, 2021**

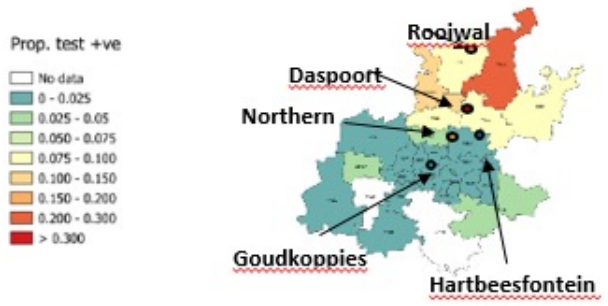



Wastewater levels (lines) at selected treatment plants, by total Gauteng cases, epi weeks 36-47, 2021

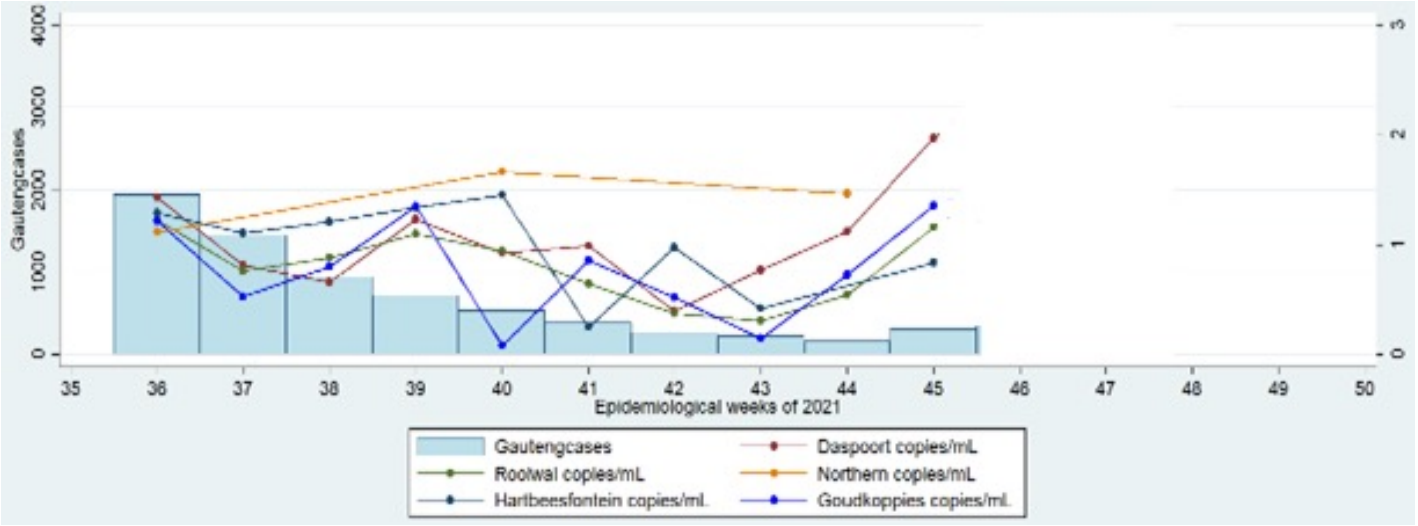
# Quantitative SARS-CoV-2 in wastewater – successes

- Convincing public health managers that wastewater is a useful surveillance tool
  - Many epidemiologists were sceptical about the value of wastewater
  - Early in the 4th wave, we started picking up increases in levels in Tshwane plants

% of PCR test which were positive, clinical samples patients, **week 45, 2021**




Cases of SARS-CoV-2 (bars) and levels of SARS-CoV-2 in wastewater, **week 45, 2021**

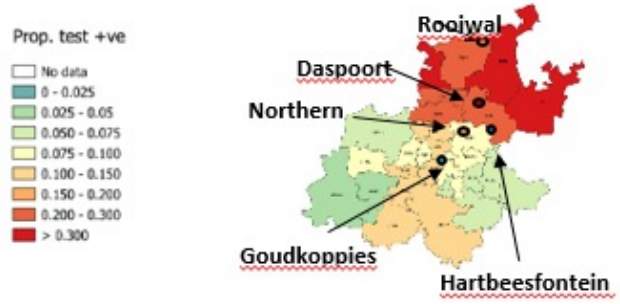



Wastewater levels (lines) at selected treatment plants, by total Gauteng cases, epi weeks 36-47, 2021

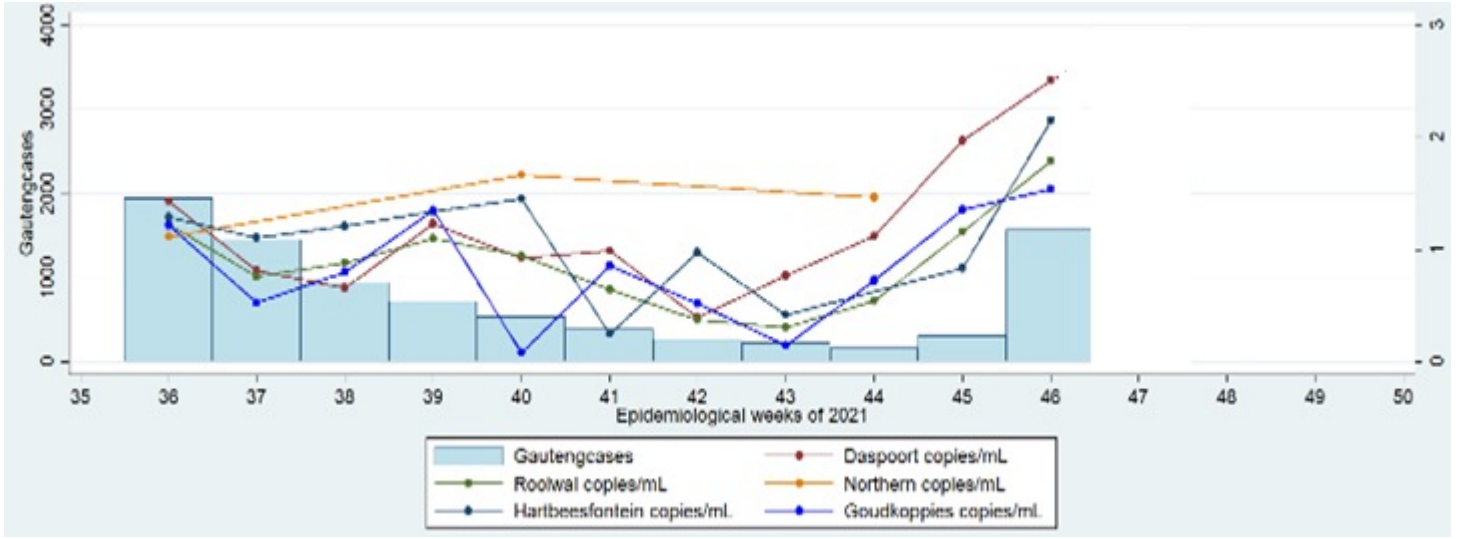
# Quantitative SARS-CoV-2 in wastewater – successes

- Convincing public health managers that wastewater is a useful surveillance tool
  - Many epidemiologists were sceptical about the value of wastewater
  - Early in the 4th wave, we started picking up increases in levels in Tshwane plants

% of PCR test which were positive, clinical samples patients, **week 46, 2021**




Cases of SARS-CoV-2 (bars) and levels of SARS-CoV-2 in wastewater, **week 46, 2021**

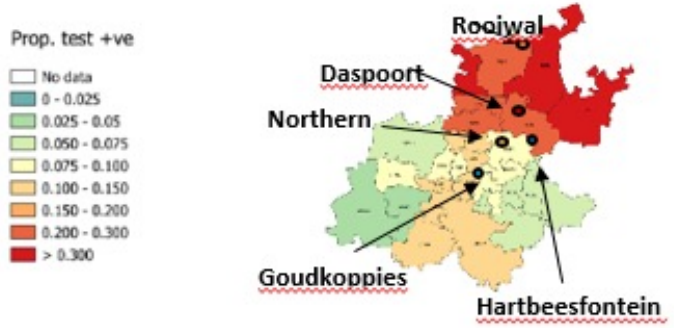



Wastewater levels (lines) at selected treatment plants, by total Gauteng cases, epi weeks 36-47, 2021

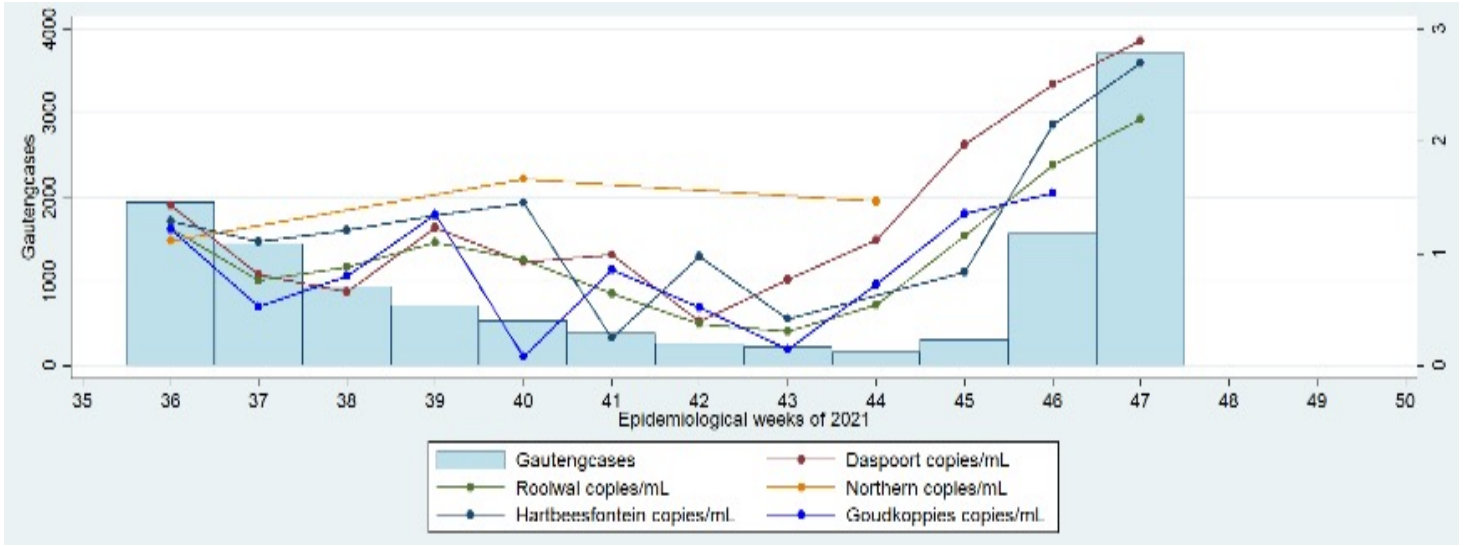
# Quantitative SARS-CoV-2 in wastewater – successes

- Convincing public health managers that wastewater is a useful surveillance tool
  - Many epidemiologists were sceptical about the value of wastewater
  - Early in the 4th wave, we started picking up increases in levels in Tshwane plants

% of PCR test which were positive, clinical samples patients, **week 47, 2021**




Cases of SARS-CoV-2 (bars) and levels of SARS-CoV-2 in wastewater, **week 47, 2021**



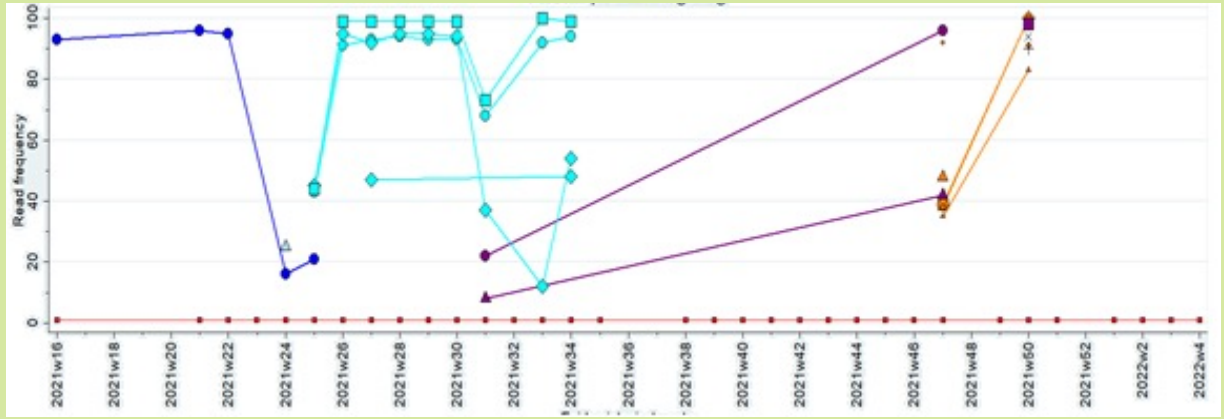

Wastewater levels (lines) at selected treatment plants, by total Gauteng cases, epi weeks 36-47, 2021

# Sequencing SARS-CoV-2 in wastewater – successes

- Convincing public health managers that wastewater is a useful surveillance tool

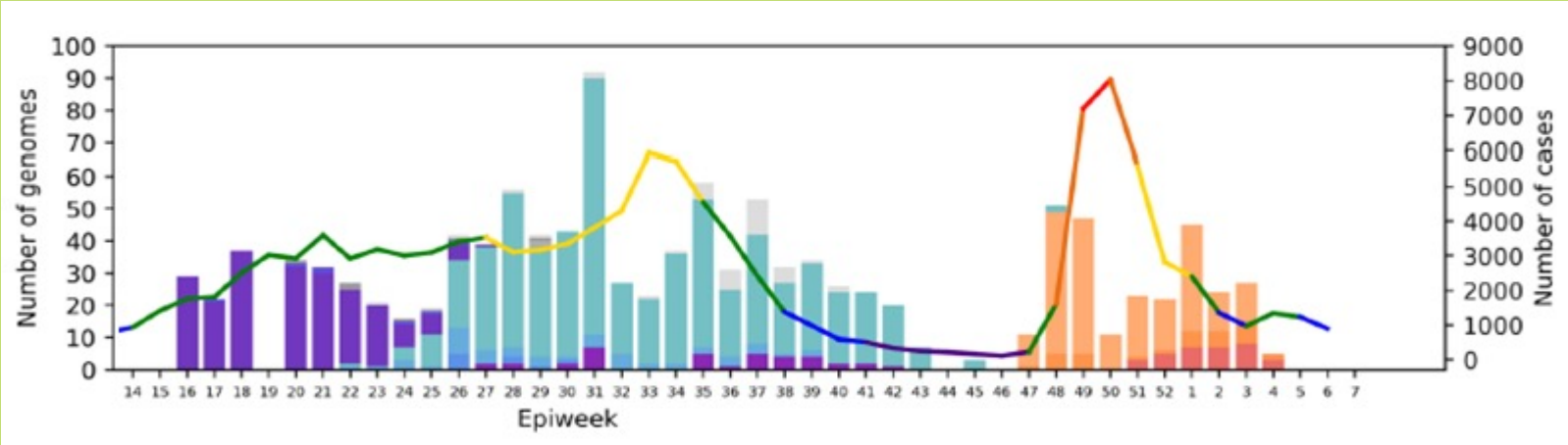
- Wastewater sequence findings correspond with clinical SARS-CoV-2 sequences both by time and location
- Read frequency of SNPs corresponds with proportion of isolates in population

SNP mutations corresponding with specific variants identified in **wastewater samples**




Beta
Delta
C1.1
Omicron

SARS-CoV-2 variants from **clinical isolates** obtained from Free State province (n=c.1300)



# Challenges for wastewater based epidemiology

- Quantification
  - Methodology
    - Standardising methods
    - Eliminating variation where possible (e.g. due to rainfall)
    - Turn-around-time
  - Interpretation of results
    - When is an increase something to worry about?
  - Utilisation and confidence in results
    - Getting policy makers to use results
  - Uptake of results by public
    - Getting the public to trust and use results

# Challenges for wastewater based epidemiology

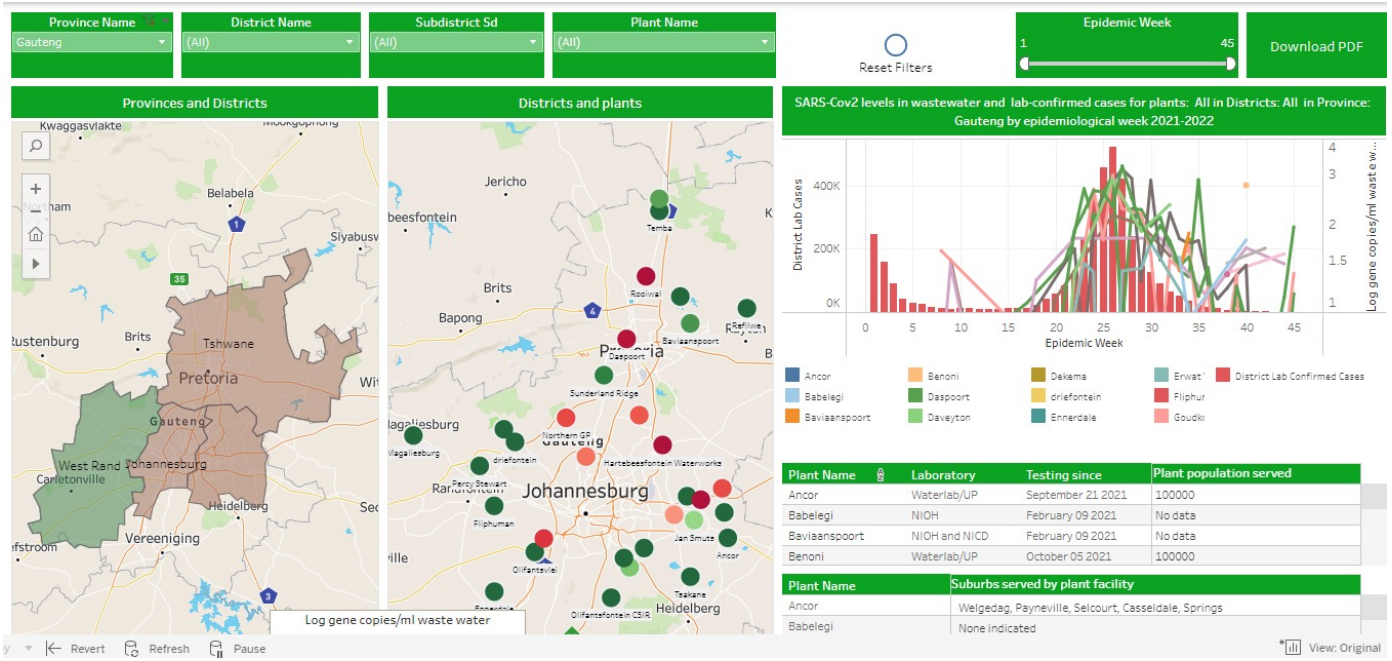
- Quantification
  - Methodology
    - Standardising methods
    - Eliminating variation where possible (e.g. due to rainfall)
    - Turn-around-time
  - Interpretation of results
    - When is an increase something to worry about?
  - Utilisation and confidence in results
    - Getting policy makers to use results
  - Uptake of results by public
    - Getting the public to trust and use results

- Genomics
  - Methodology
    - Reliable amplification of RNA, especially when SARS-Cov-2 is present at low levels
    - Methods only work for known VOC/variants identified by clinical samples
      - Need to develop methods to detect signals when new variants are present
    - Turn around time

# What is the future of wastewater based epidemiology in South Africa?

## FOCUS AREAS for 2022

- Strengthening communication tools
- Advocating public and policy-maker use of data
- Formulating interpretive thresholds and models
- Strengthening interpretation of results in relation to population health of persons contributing to sewer network
- Widening scope of network to include other communicable diseases
  - Hepatitis A, measles, influenza, tuberculosis, antimicrobial resistance




Soon to come – wastewater dashboard

# THANK YOU

**Weekly wastewater surveillance reports are published on the NICD website.**

https://www.nicd.ac.za/diseases-a-z-index/disease-index-covid-19/surveillance-reports/