World Water Congress & Exhibition 2022

11 – 15 September 2022 | Copenhagen, Denmark

the international water association

Evaluating the water treatment functionality of a retrofitted stormwater detention pond

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inspiring change

FUTURE WATER

Ministry of Foreign Affairs of Denmark
DANIDA | International Development Cooperation

INTRODUCTION – THE CITY OF CAPE TOWN

Agricultural, industrial, commercial, formal residential, and informal residential

INTRODUCTION – WATER IN THE CITY

CITY OF CAPE TOWN WATER STRATEGY – 5 COMMITMENTS

1

SAFE ACCESS TO WATER AND SANITATION

The City of Cape Town

2

WISE USE

The City will promote the wise use of water by all water users. This will include promoting water conservation behaviour through

3

SUFFICIENT, RELIABLE WATER FROM DIVERSE SOURCES

4

SHARED BENEFITS FROM REGIONAL WATER RESOURCES

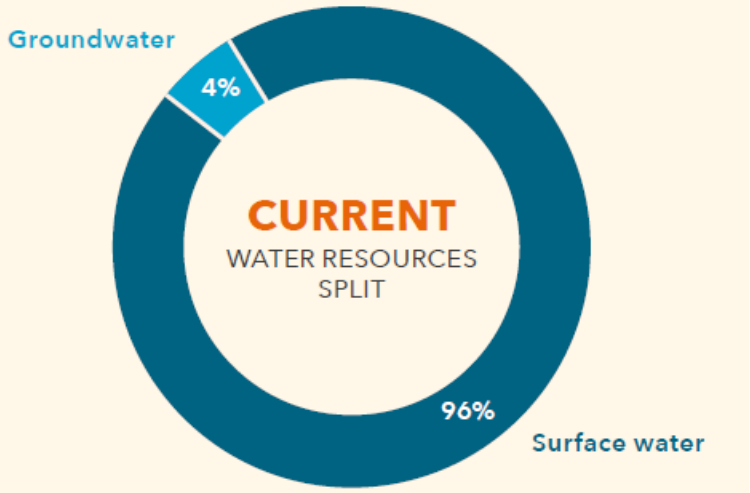
The City will work with key

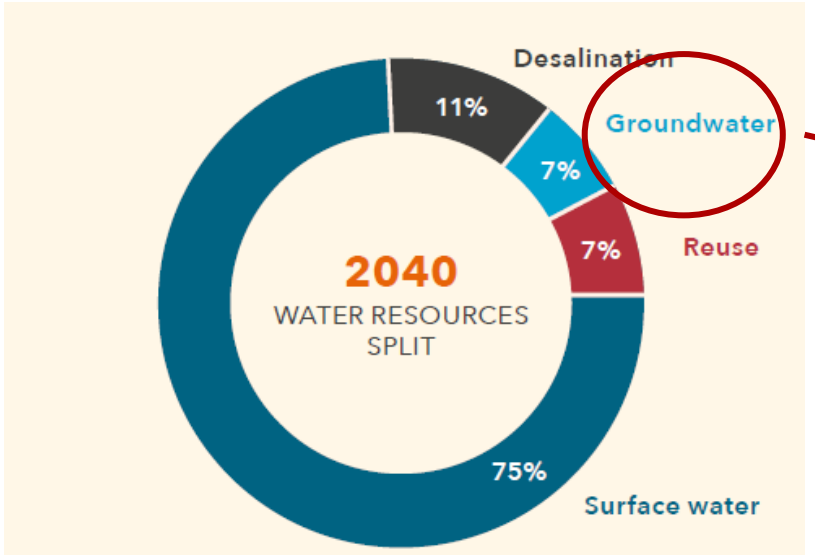
5

A WATER-SENSITIVE CITY[5]

The City will actively facilitate the transition of

FIGURE 6: HOW CAPE TOWN'S WATER SUPPLY SYSTEM WILL CHANGE





Including groundwater from the Cape Flats Aquifer

INTRODUCTION – WATER IN THE CITY

5

A WATER-SENSITIVE CITY[5]

… optimal use of **stormwater** and urban waterways for the purposes of flood control, **aquifer recharge**, …

Water quality: a huge challenge

SITE SETTING

Study site: formal residential, low-income, Mitchell's Plain

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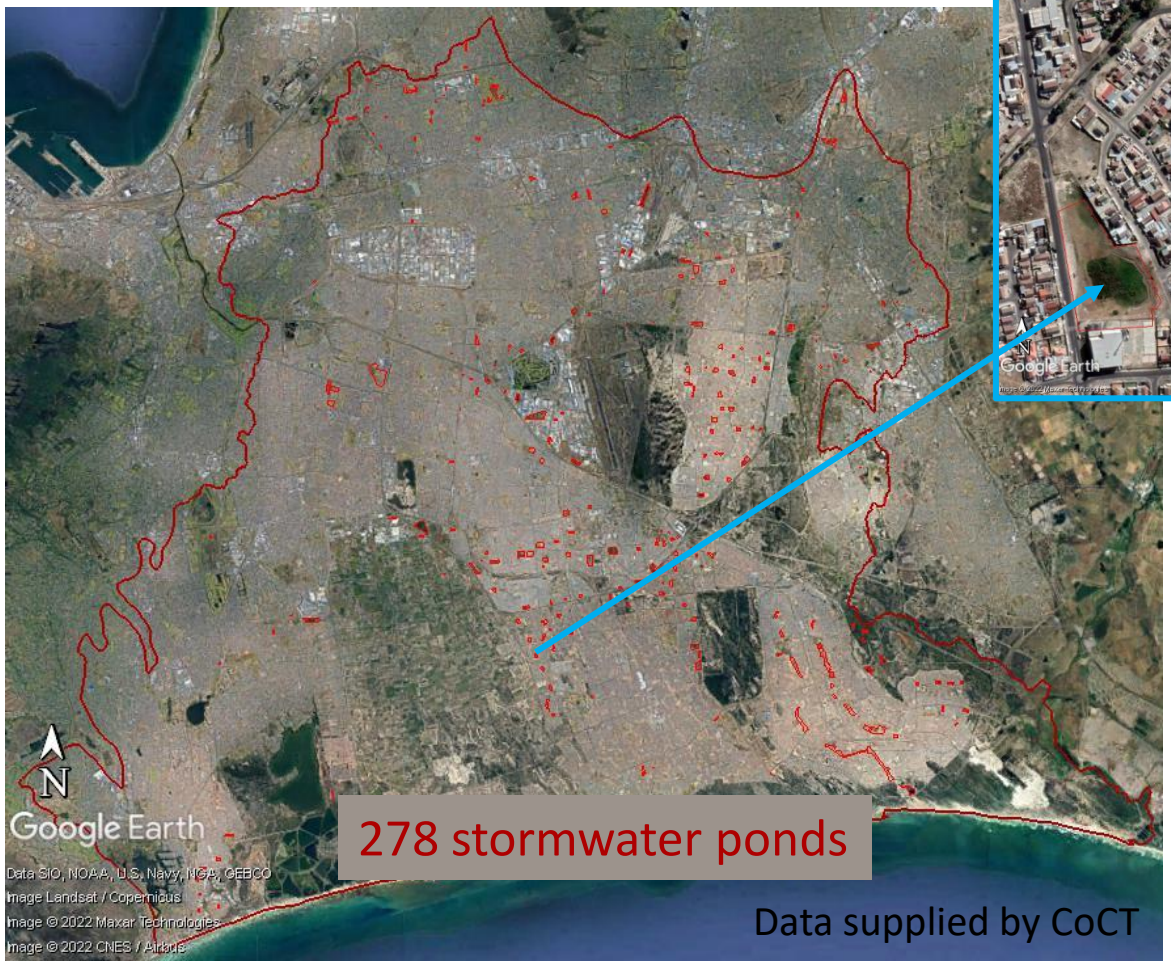
The Cape Flats Aquifer



How can we increase infiltration?

Engagement and buy in from local communities

Activate the space

Co-design

Biodiversity

Mural painting

What water treatment functionality does this system provide?

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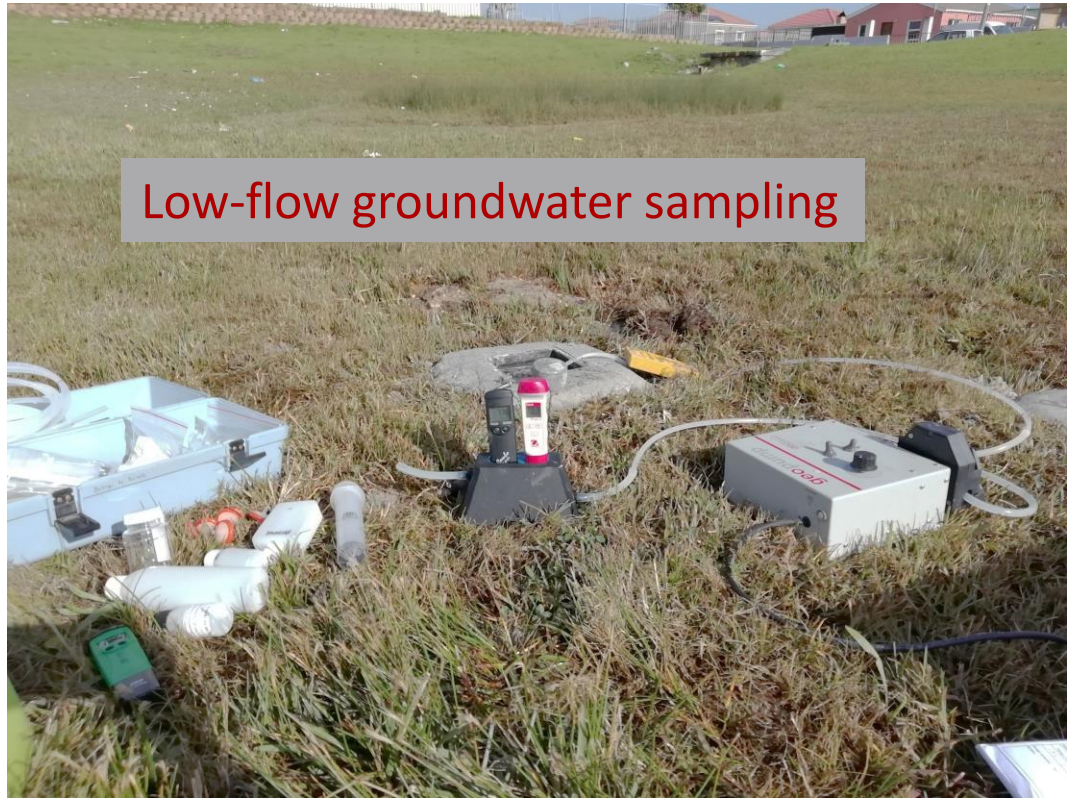
Monitoring well Installations



Low-flow groundwater sampling

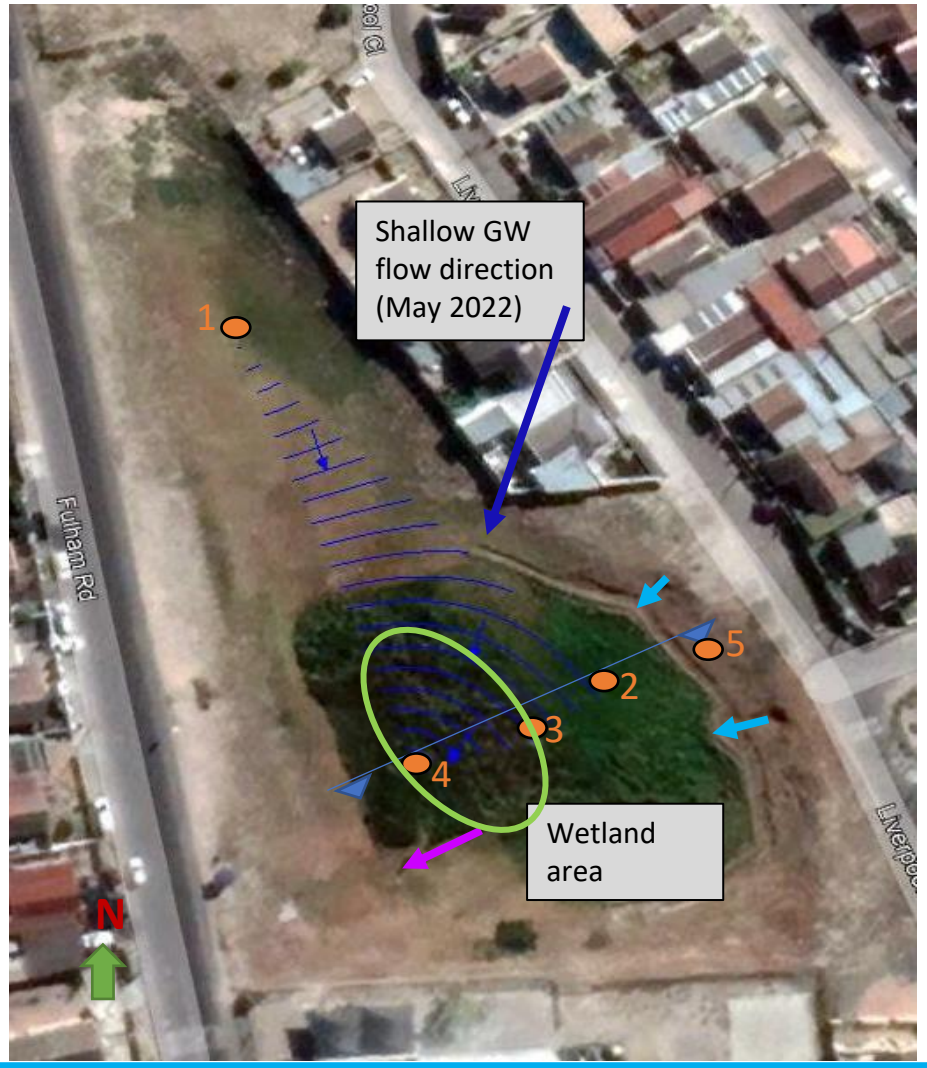
- Grab samples from stormwater inlet and pond outlet
- Measurement of pH, EC, DO and ORP on site
- Determination of TOC, TN, NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, Cl^- and Fe(II) in the laboratory

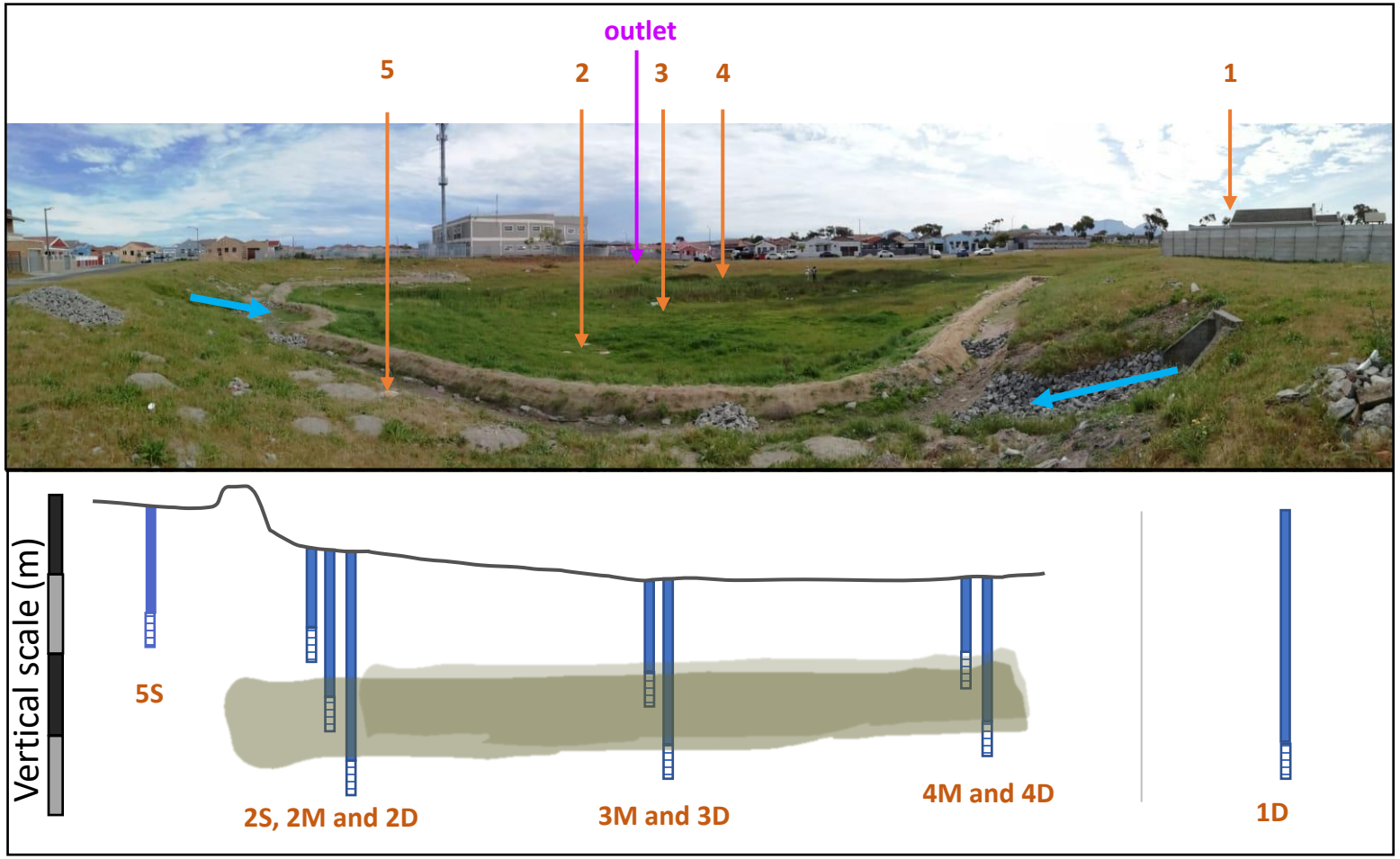
FIELDWORK


Before infiltration trench

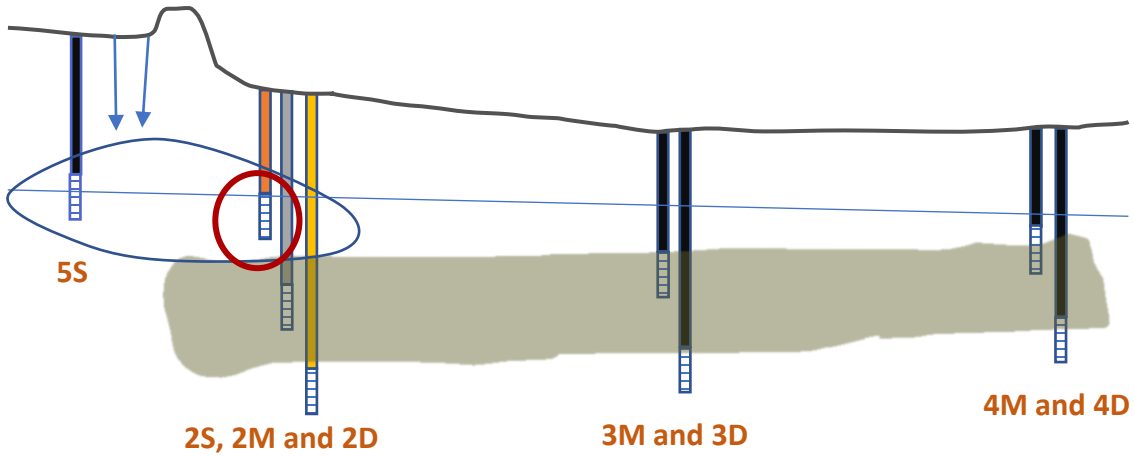

After infiltration trench
Berm Design: Craig Tanyanyiwa, PhD candidate, Future Water Institute, UCT

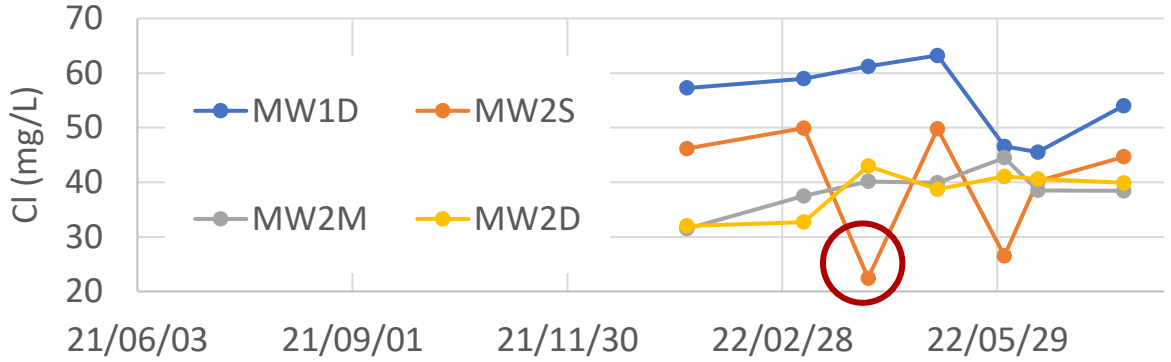
THE STUDY SITE

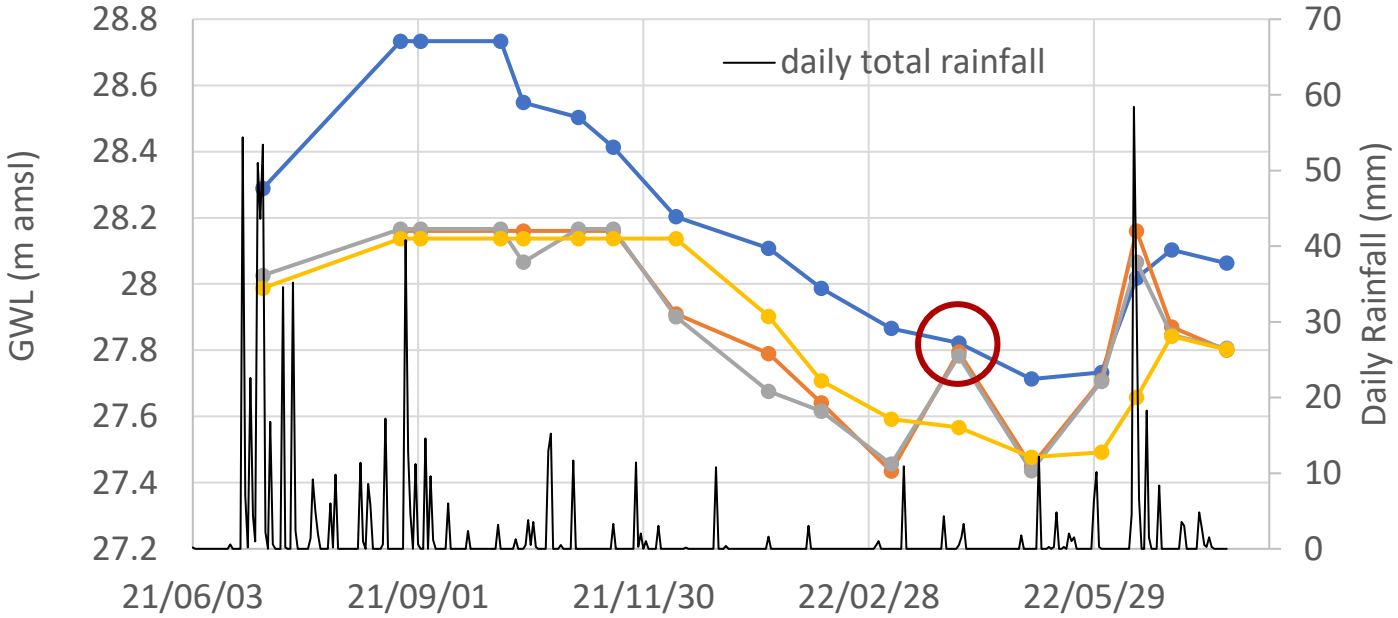




RESULTS – INFILTRATION AND WATER LEVELS





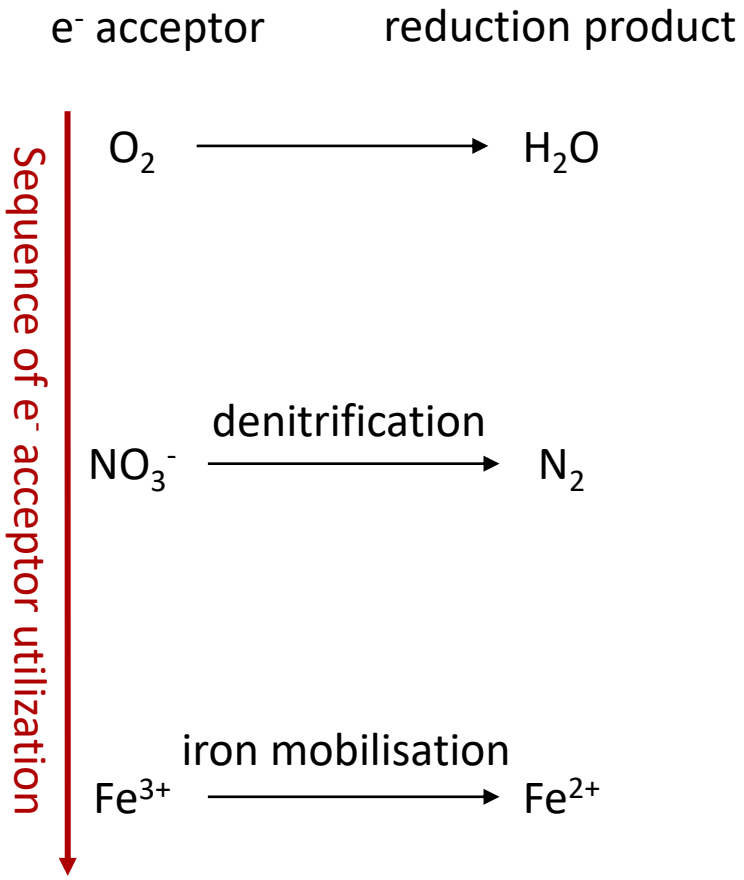


Cl^- concentration lower in SW than in GW used to calculate % infiltrated SW being sampled

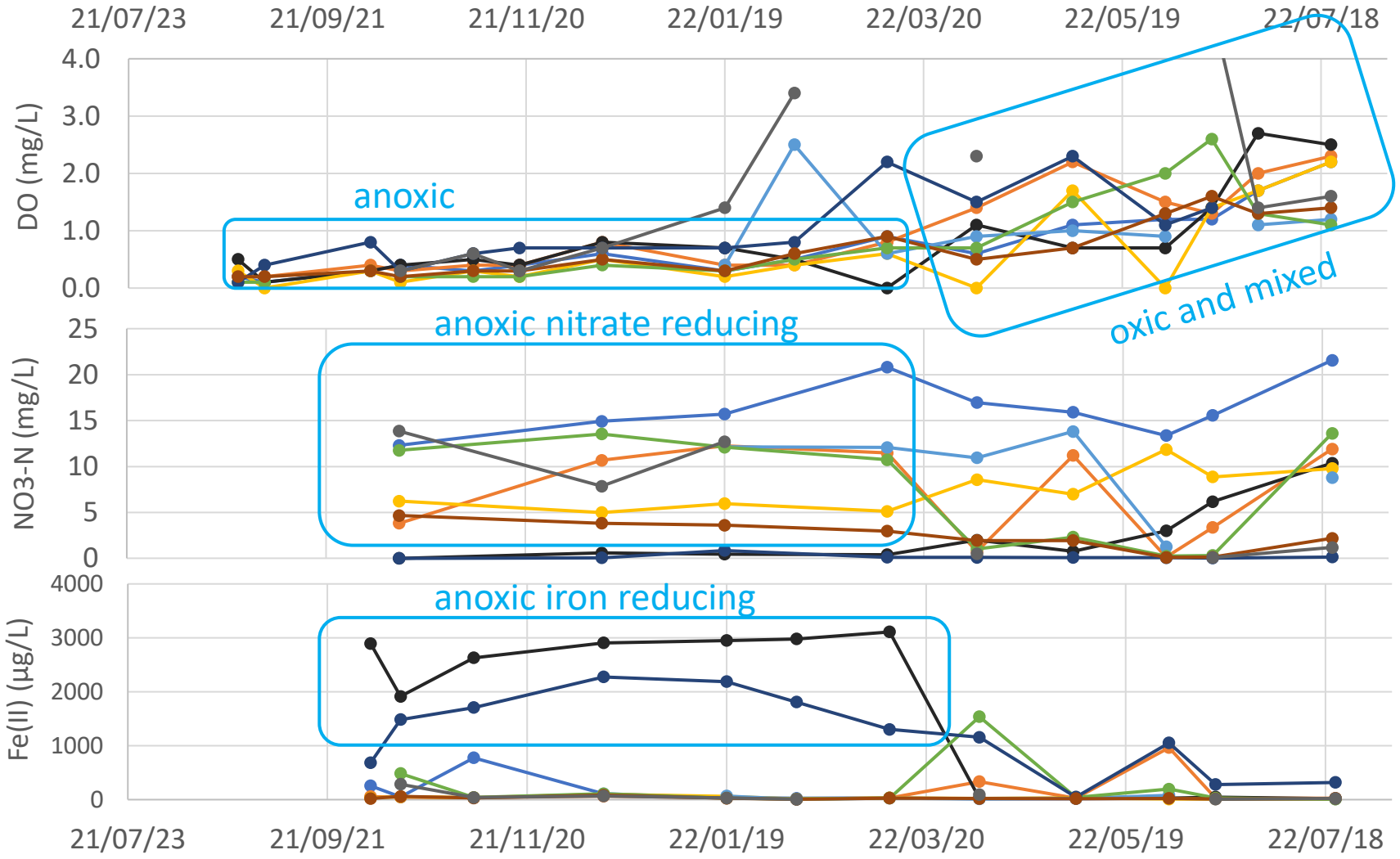
Shallow and medium wells responded quicker to rainfall events while deep wells were slower

GROUNDWATER REDOX CONDITIONS

- Organic carbon in the subsurface is degraded by microbial populations
- Available electron acceptors are utilized in this process
- The most energetically favourable, O_2, is consumed first, followed by NO_3^- and then Mn and Fe oxides in the aquifer matrix



GROUNDWATER REDOX CONDITIONS



e⁻ acceptor — reduction product

Sequence of e⁻ acceptor utilization

O_2 → H_2O

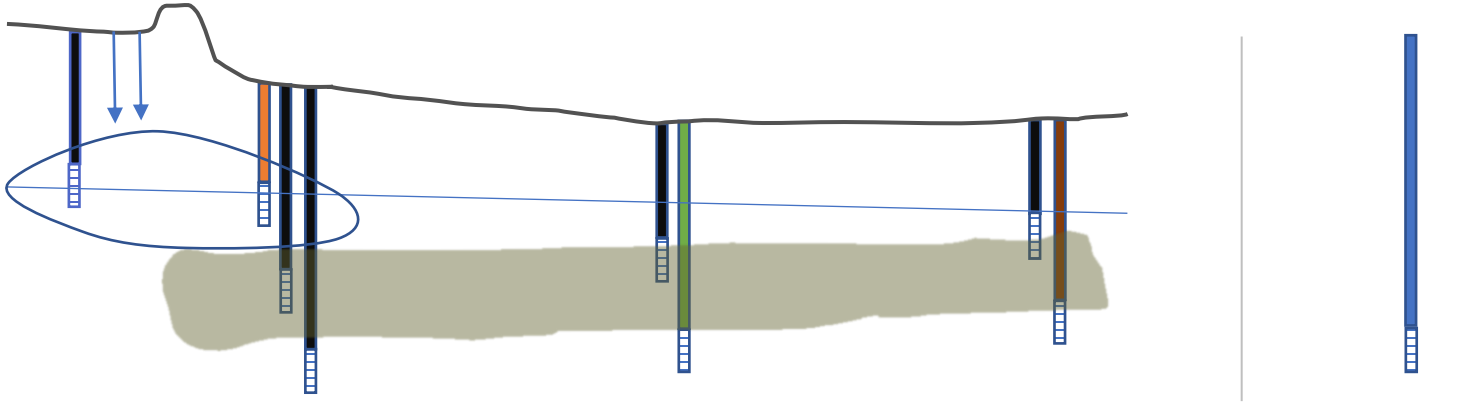
denitrification

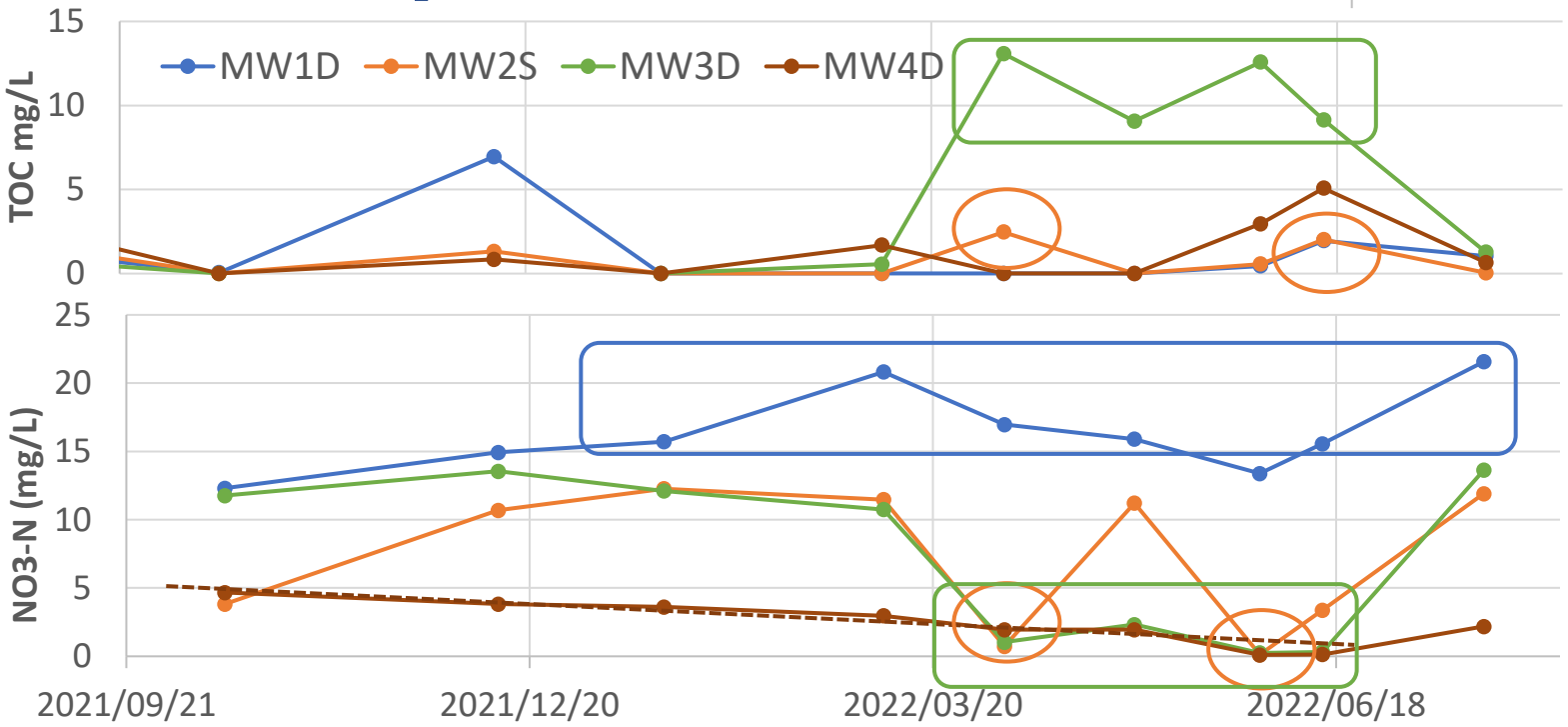
NO_3^- → N_2

iron mobilisation

Fe^{3+} → Fe^{2+}

RESULTS – ORGANIC CARBON & NITRATE





MW1D:

- High background nitrate concentration

MW2S:

- Direct organic carbon input from stormwater
- Actual nitrate lower than that predicted by dilution

MW3D:

- Spike in TOC and corresponding denitrification

MW4D:

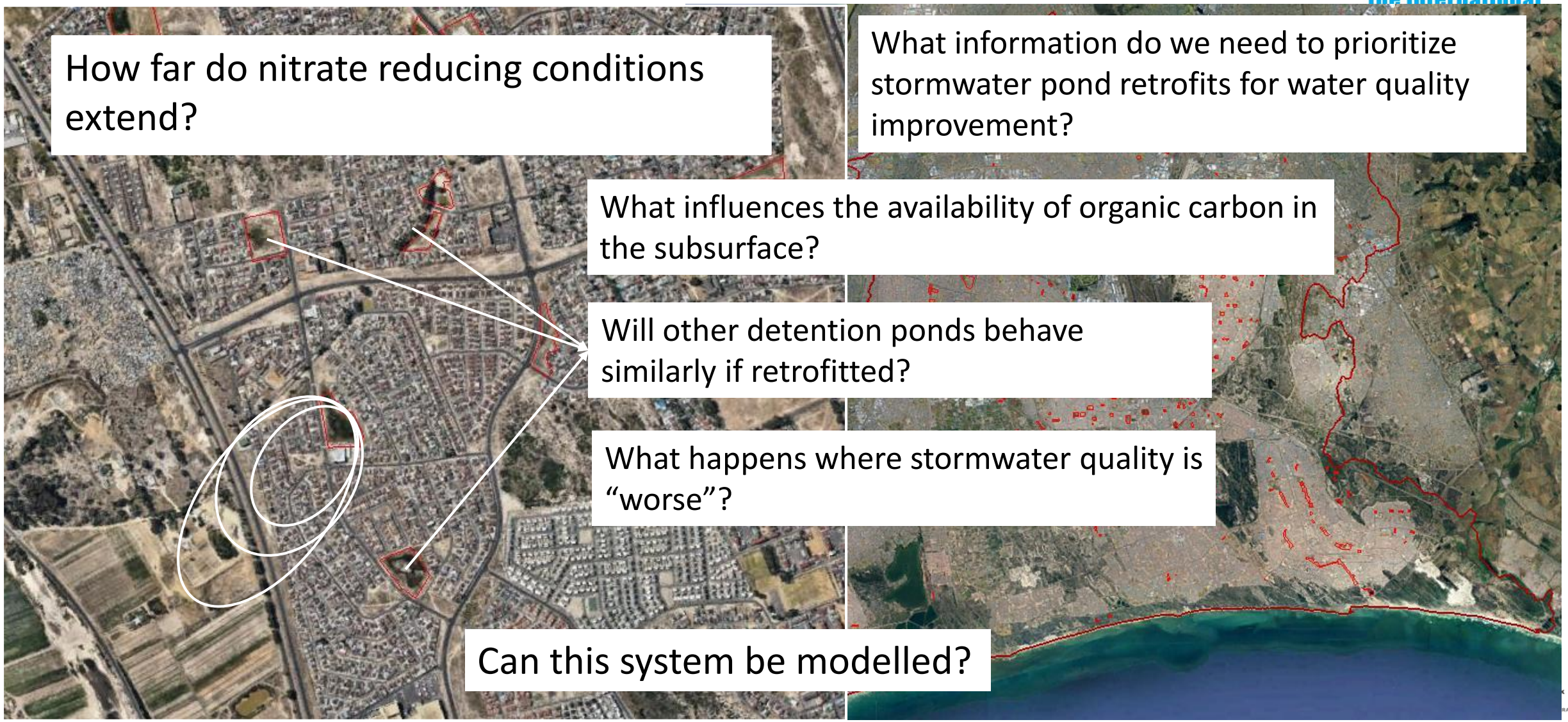
- Apparent zero-order denitrification rate: 5.1 mg L^{-1} $year^{-1}$

STORMWATER INLET AND OUTLET WATER QUALITY

	Stormwater inflow		Outlet	
TOC (mg/L)	33.5	± 42	**7.0**	± 3.7
TN (mg/L)	2.19	± 2.43	2.44	± 3.00
NH_4^+-N (mg/L)	0.21	± 0.26	**0.01**	± 0.01
NO_3^--N (mg/L)	0.48	± 0.46	**<0.3**	
NO_2^--N (mg/L)	0.04	± 0.03	**<0.001**	
Fe(II) (µg/L)	26		506	± 767

- Outlet seeps in spring and early summer
- Reduction in TOC and inorganic nitrogen
- Iron precipitates out in the outlet channel

~~CONCLUSIONS~~ QUESTIONS FOR FURTHER RESEARCH



How far do nitrate reducing conditions extend?

What information do we need to prioritize stormwater pond retrofits for water quality improvement?

What influences the availability of organic carbon in the subsurface?

Will other detention ponds behave similarly if retrofitted?

What happens where stormwater quality is “worse”?

Can this system be modelled?

ACKNOWLEDGEMENTS

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