

Stormwater infiltration to shallow groundwater – can soils help to improve water quality?



- Water quality guidelines and limits
- Stormwater ponds over the Cape Flats Aquifer
- How soil may retain/remove nutrients
- Redox processes in waterlogged soils
- Study site in Mitchell's Plain
- Some results from water quality study
- Link into discussion about integrated water quality management

City Water Quality Categories	Interpretation of City WQ Categories	PO4-P mg P/l	TIN mg N/l	DO mg/l	N:P	NH ₃ mg/l
GOOD	TARGET	≤ 0.015 (oligotrophic)	≤ 0.70 (oligotrophic - mesotrophic)	>7	>25	≤ 0.007
FAIR		> 0.015 - 0.025 (mesotrophic)	>0.70-1.00 (mesotrophic)	>6-7		> 0.007 - 0.015
POOR	POOR	> 0.025- 0.125 (eutrophic)	>1.00 -4.00 (mesotrophic - eutrophic)	>4 -6	10-25	> 0.015-0.1 (chronic toxicity)
UNACCEPTABLE	UNACCEPTABLE	> 0.125 (hypertrophic)	> 4.00 (eutrophic - concentrations > 10mg/L classified as hypertrophic)	≤ 4	< 10	> 0.1 (acute toxicity)

TABLE 2.1 : Wastewater limit values applicable to discharge of wastewater into a water resource

SUBSTANCE/PARAMETER	GENERAL LIMIT	SPECIAL LIMIT
Faecal Coliforms (per 100 ml)	1000	0
Chemical Oxygen Demand (mg/l)	75 (i)	30(i)
pH	5,5-9,5	5,5-7,5
Ammonia (ionised and un-ionised) as Nitrogen (mg/l)	6	2
Nitrate/Nitrite as Nitrogen (mg/l)	15	1,5
Chlorine as Free Chlorine (mg/l)	0,25	0
Suspended Solids (mg/l)	25	10
Electrical Conductivity (mS/m)	70 mS/m above intake to a maximum of 150 mS/m	50 mS/m above background receiving water, to a maximum of 100 mS/m
Ortho-Phosphate as phosphorous (mg/l)	10	1 (median) and 2,5 (maximum)
Fluoride (mg/l)	1	1
Soap, oil or grease (mg/l)	2,5	0

Irrigation guideline:

- TWQR for TIN as N: 5 mg/L
- No value for P
- No value for COD, TOC or DOC

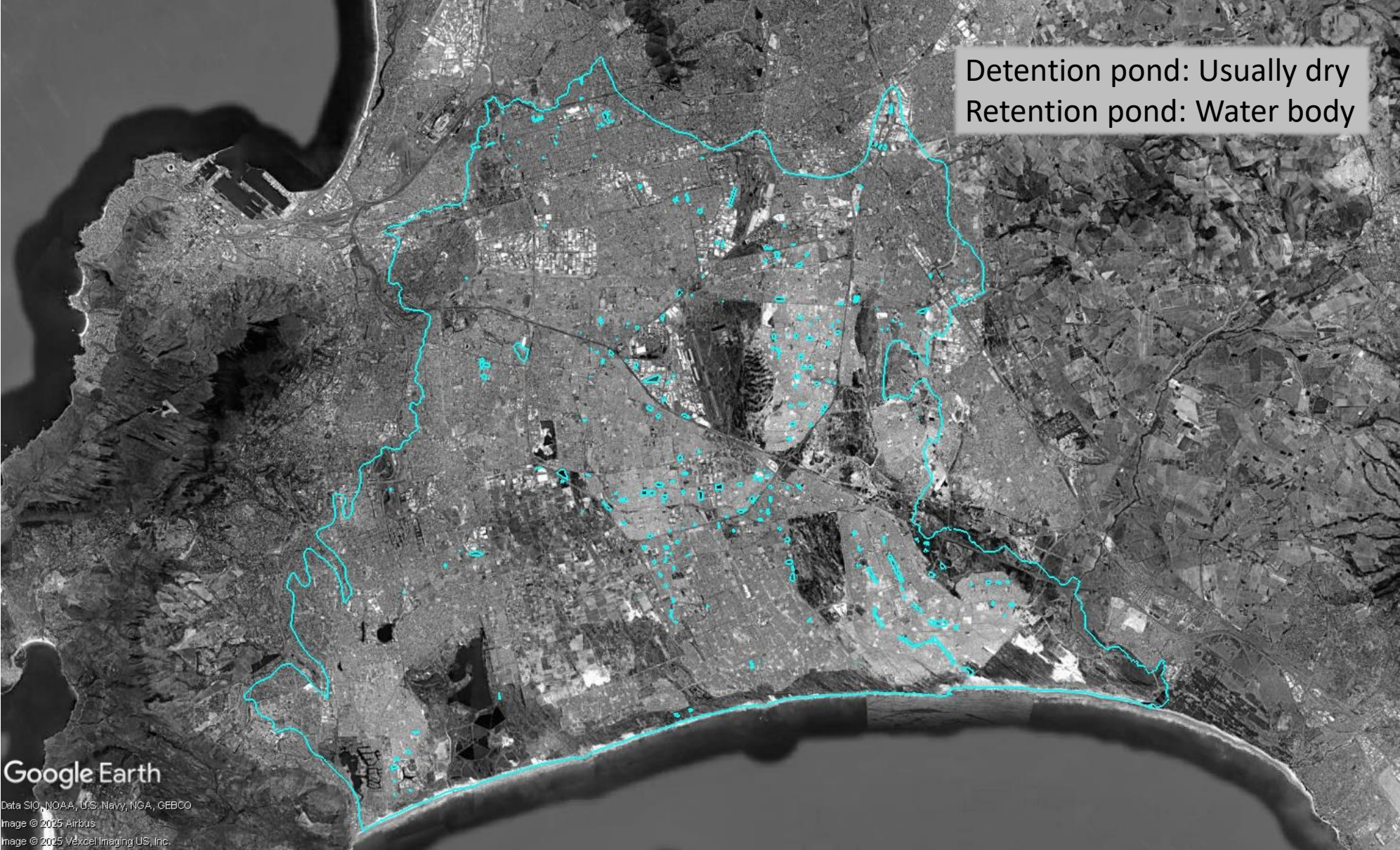
SANS 241 Drinking water

- Nitrate as N limit is 11 mg/L
- Ammonia limit is 1.5 mg/L
- TOC limit is 10 mg/L
- No value for P

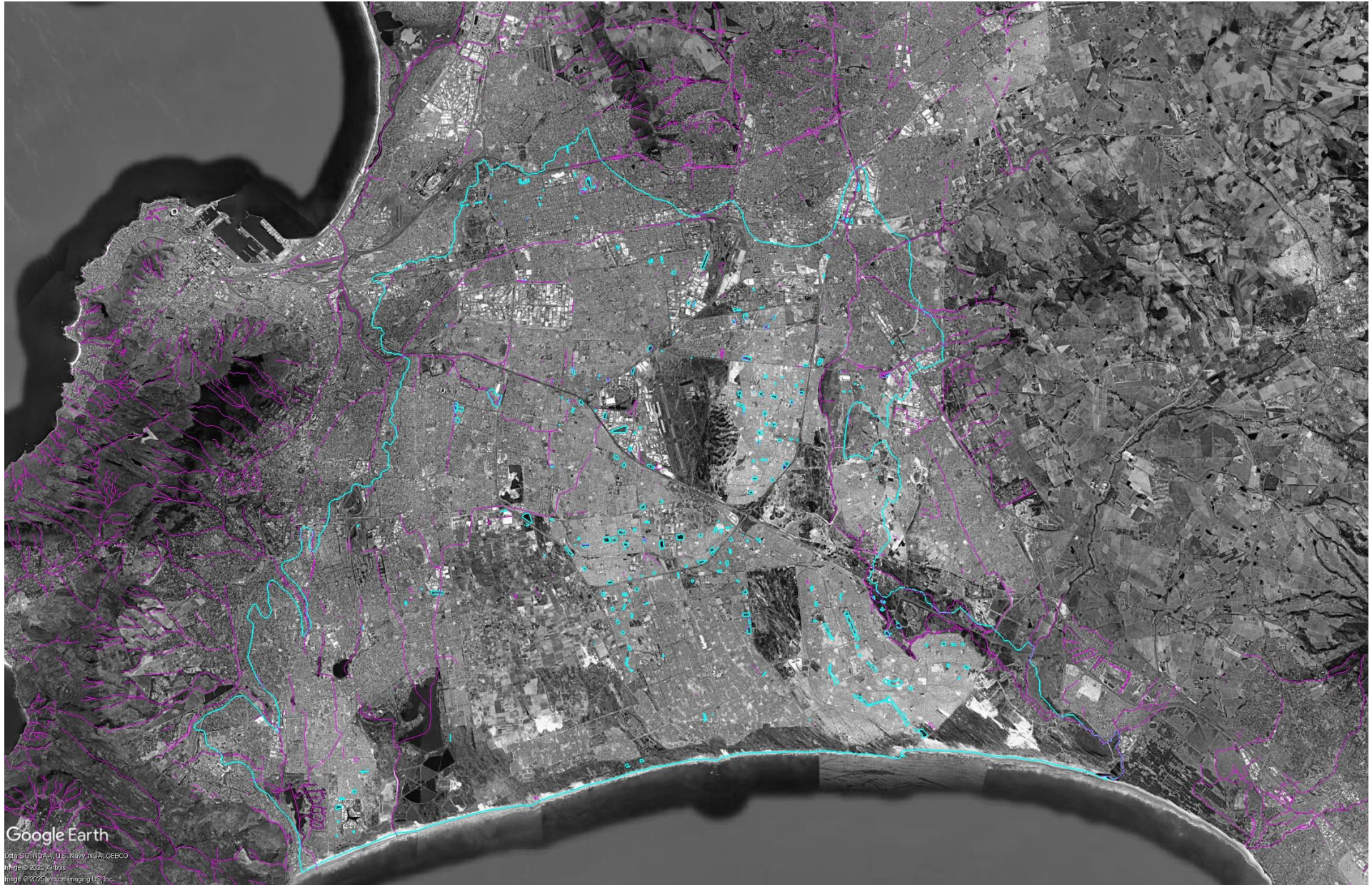
Industrial use guideline

- TWQR for COD is 10 mg/L
- No values for nutrients

Stormwater ponds over the Cape Flats Aquifer

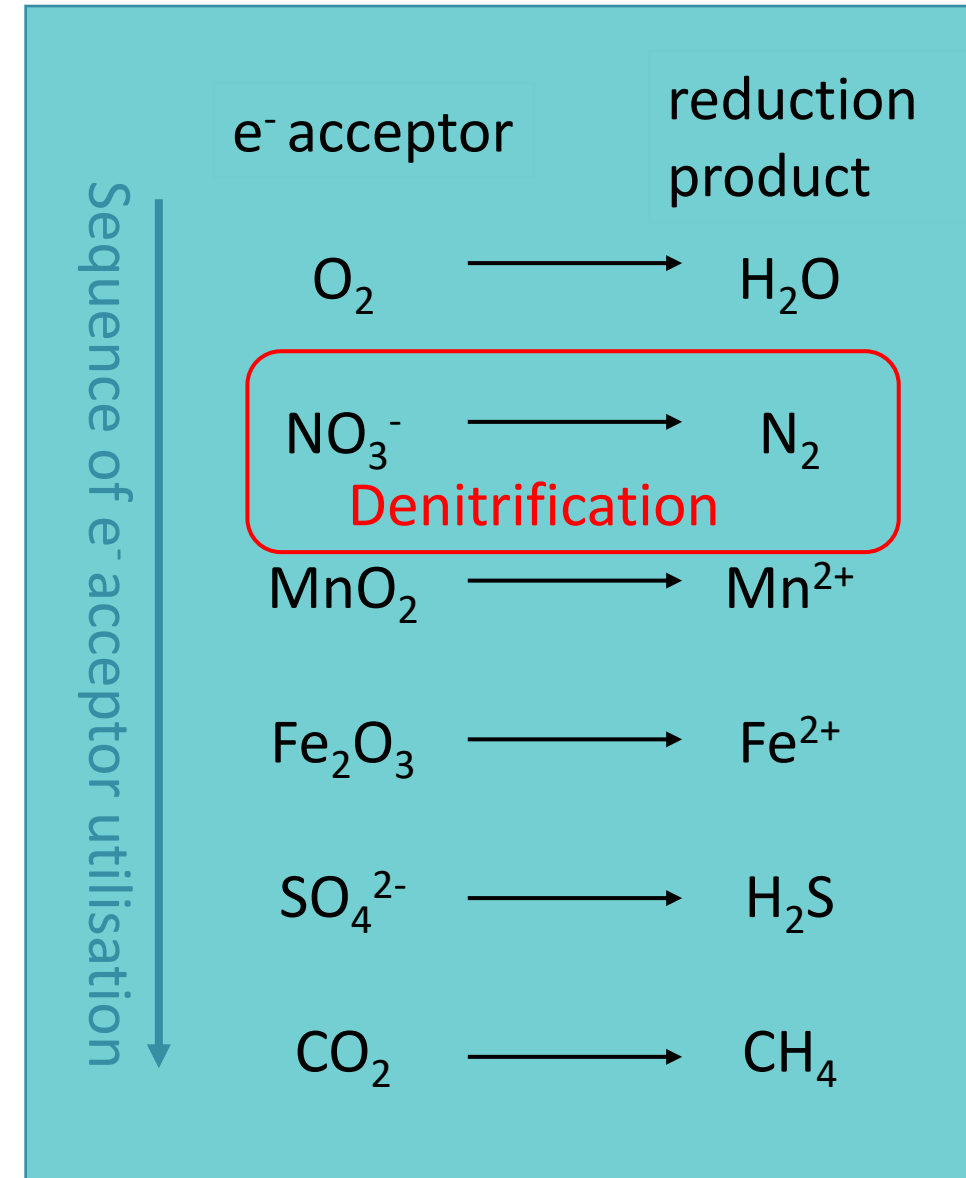


More stormwater ponds \leftrightarrow fewer rivers



- **Physical settling and filtration** – particles and anything bound to the particles
- Phosphate is typically well retained on soil particles (**sorption**) – iron and aluminum oxides play important role
- Ammonium movement is slowed down by **cation exchange** – clays are important here
- Ammonium is converted to nitrate by microbial oxidation process called **nitrification** – usually requires oxygen
- Nitrate is converted to nitrogen gas by a microbial reduction process called **denitrification** – typically low or no oxygen conditions required
- Organic carbon may be retained in soil through **sorption** processes
- Organic carbon is consumed and transformed by **microbial processes** (including denitrification)

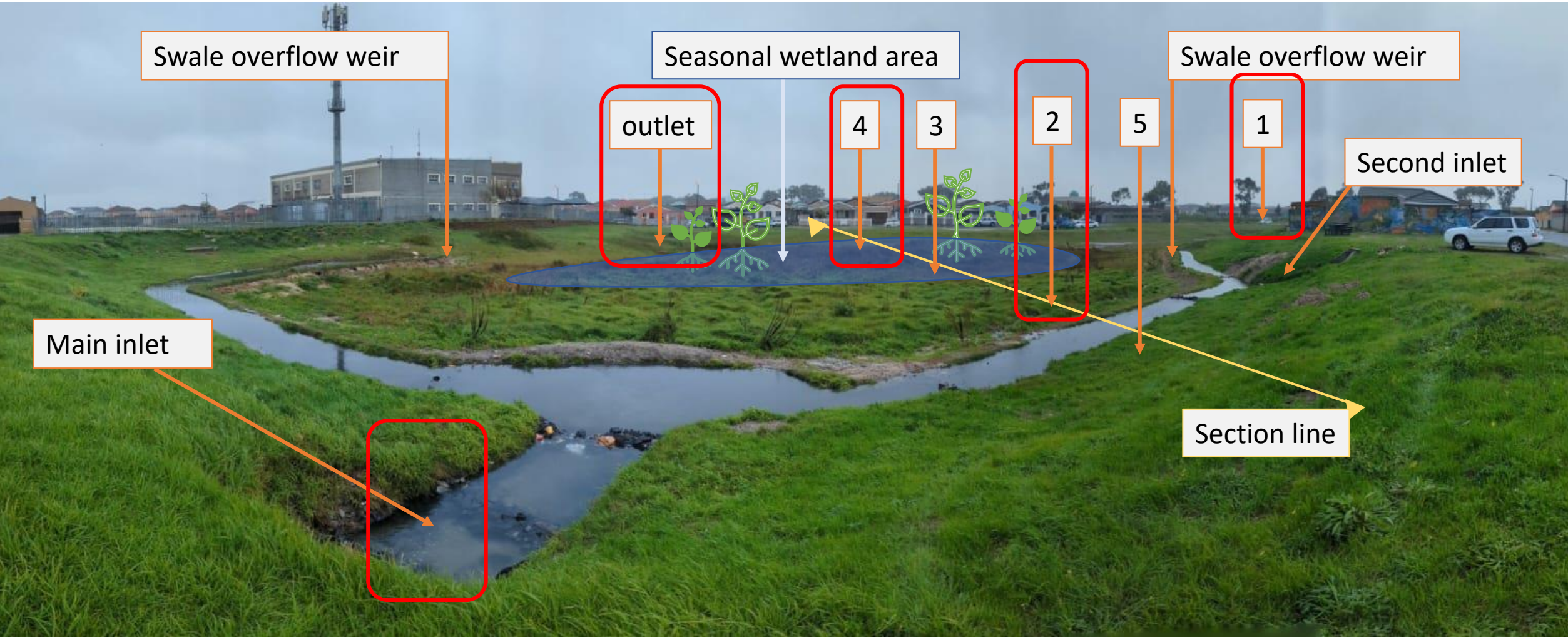
- In waterlogged soils **organic carbon** is utilised by microbial populations
- Available electron acceptors are utilized in this process
- The most energetically favourable, O_2 , is consumed first, followed by NO_3^- and then Mn and Fe oxides in the soil
- Further reduction utilises SO_4^{2-} , and finally CO_2 which results in the H_2S and CH_4 – familiar odours!



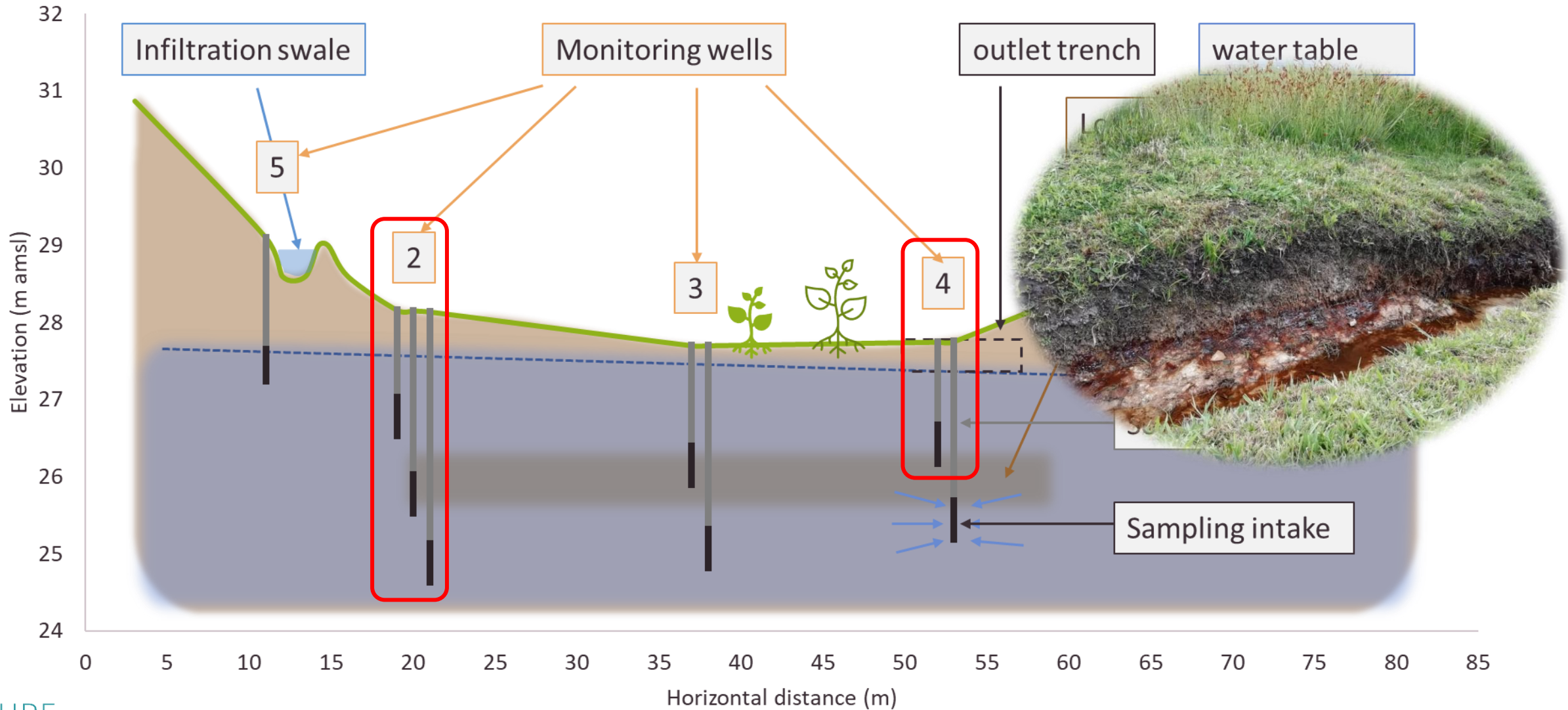
Study site location



Study site layout



Cross section showing monitoring wells



Mean concentrations over study period

Parameter	units	Background GW	SW (inlet)	OUT (outlet)
Temp	°C	18.5	17.5	16.4
pH		6.7	7.66	7.39
EC	mS/m	73.4	15.7	61.9
ORP	mV	113	163	43
DO	mg/L	1.4	7.4	4.9
Fe(II)	µg/L	80	18	506
NH4	mg/L as N	0.01	0.34	0.01
NO2	mg/L as N	0.123	0.039	0.001
NO3	mg/L as N	15.2	0.7	0.1
TIN	mg/L as N	15.4	1.1	0.1
TOC	mg/L	2.7	25.1	7.0
Cl	mg/L	51.9	7.9	22.8
TDP	µg/L	19	160	18
Al	µg/L	10	81	5
Zn	µg/L	6.3	36	11.8

	2D	2S	4M
	18.5	18.1	18.1
	7.1	7.1	6.9
	64.4	66.7	81.8
	90	66	-61
	1.2	1.3	1.5
	42	121	978
	0.03	0.03	0.01
	0.058	0.169	0.000
	6.3	6.6	0.2
	6.4	6.8	0.2
	1.3	1.0	2.0
	34.2	36.5	58.4
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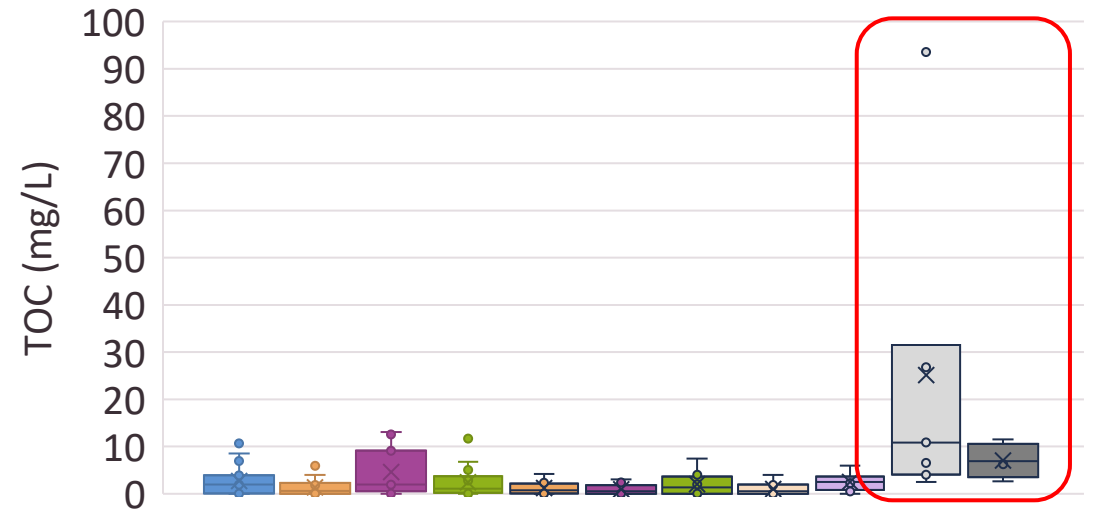
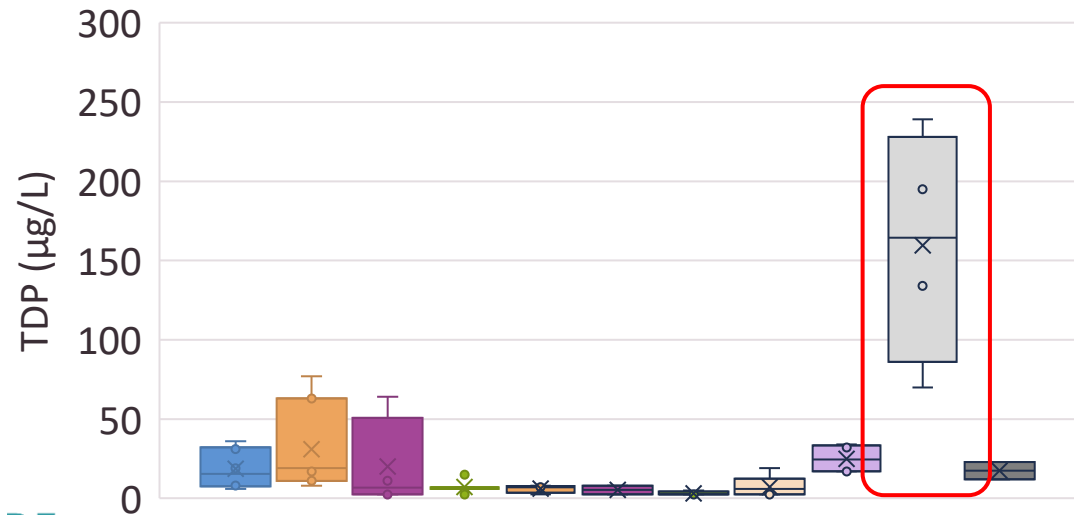
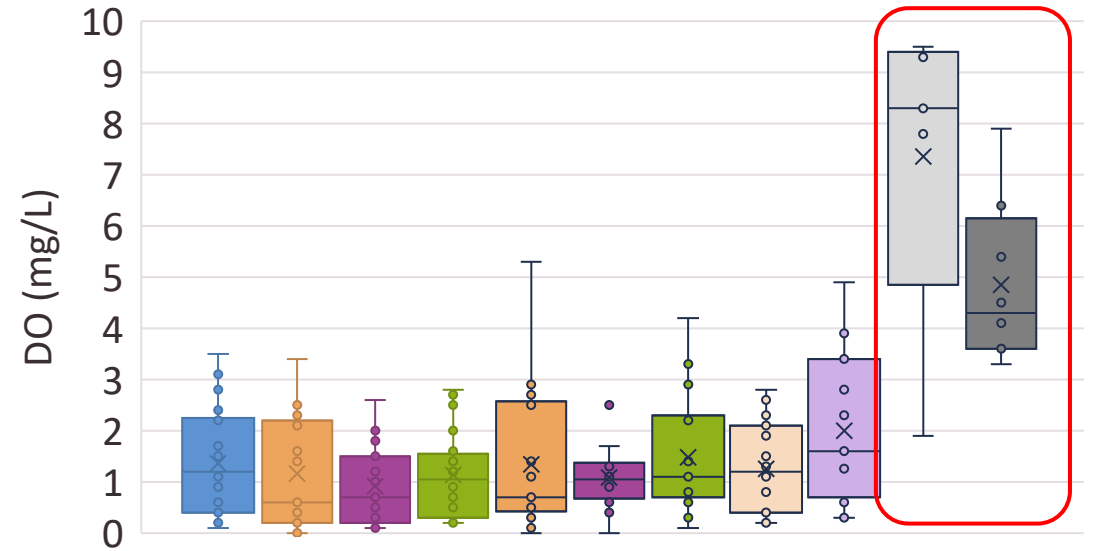
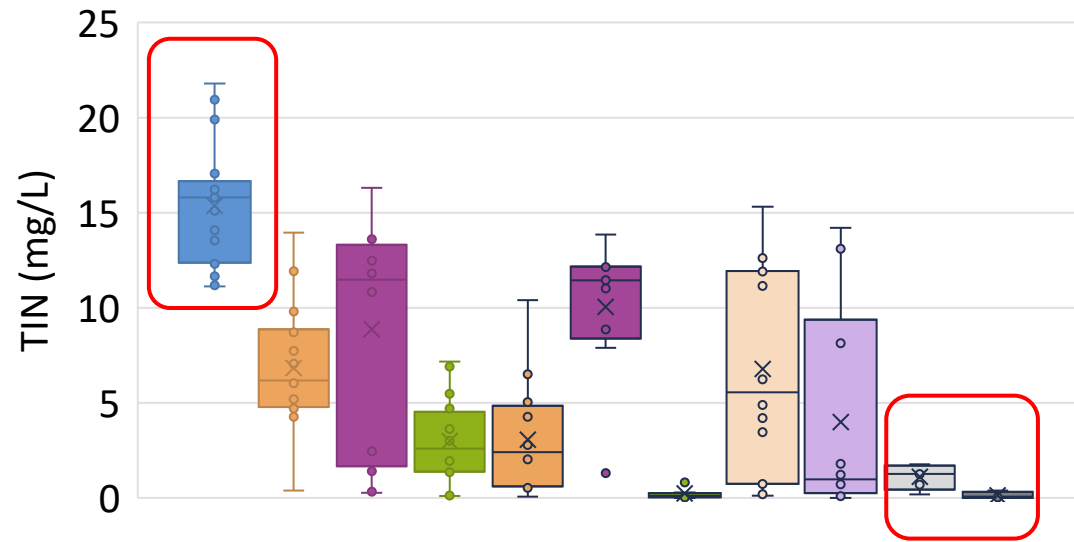
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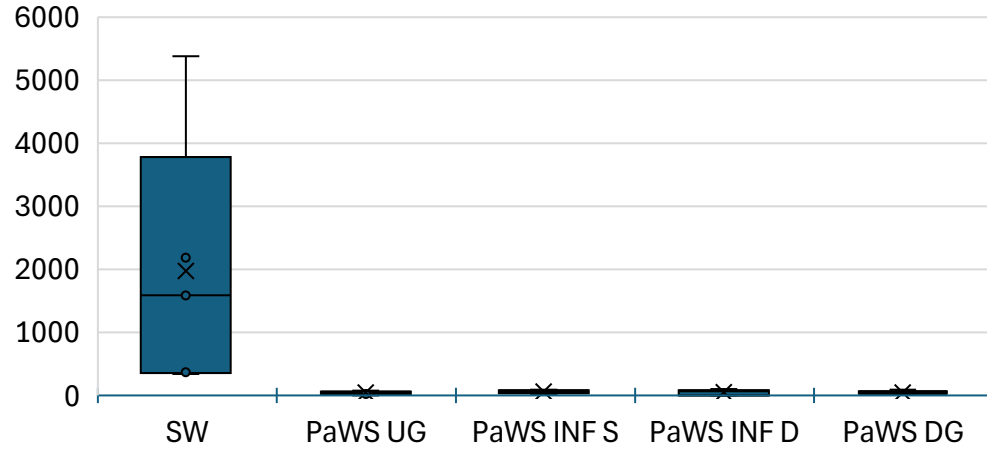
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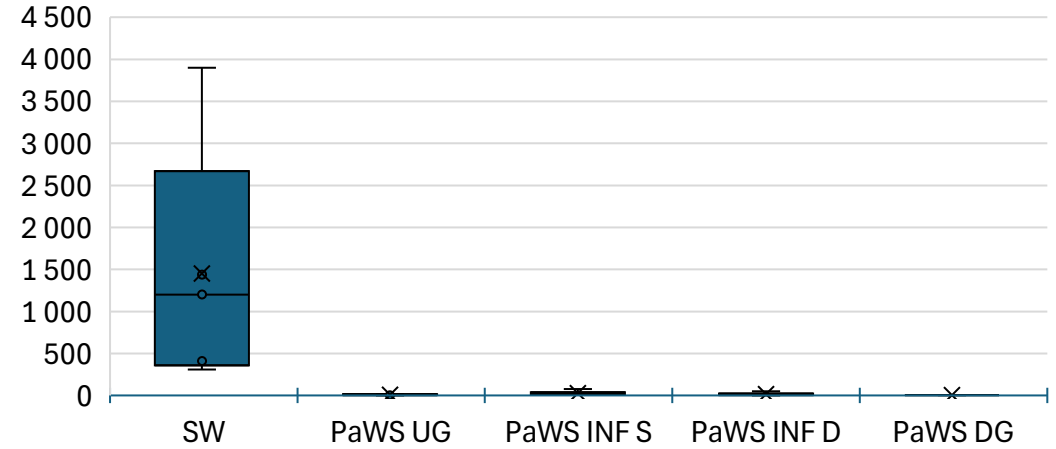
Nitrogen, phosphate, oxygen, and carbon



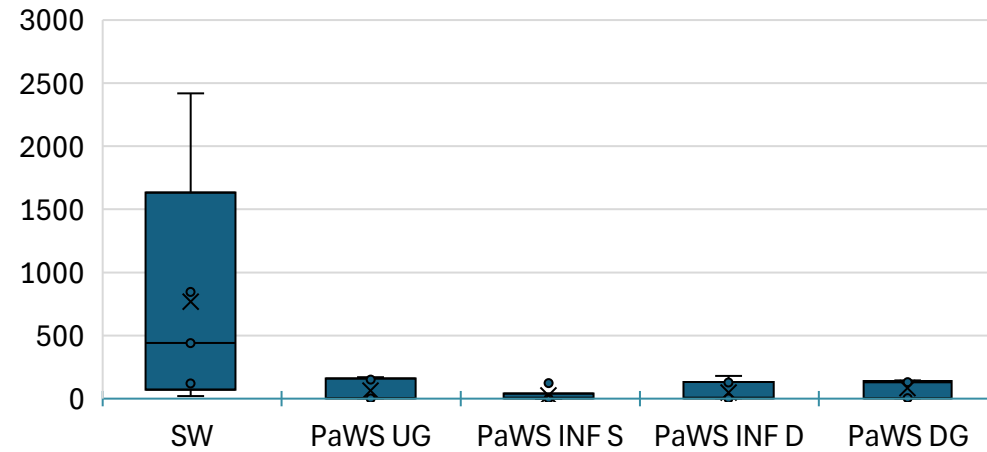
Caffeine



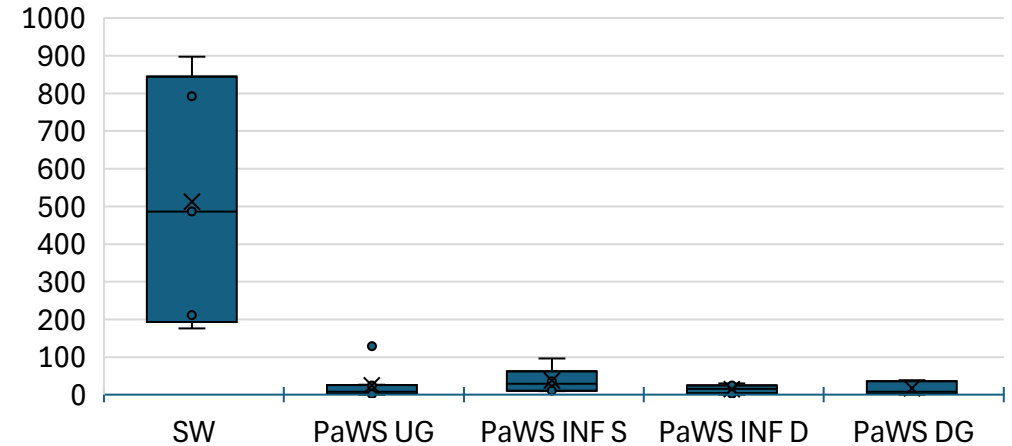
Methaqualone



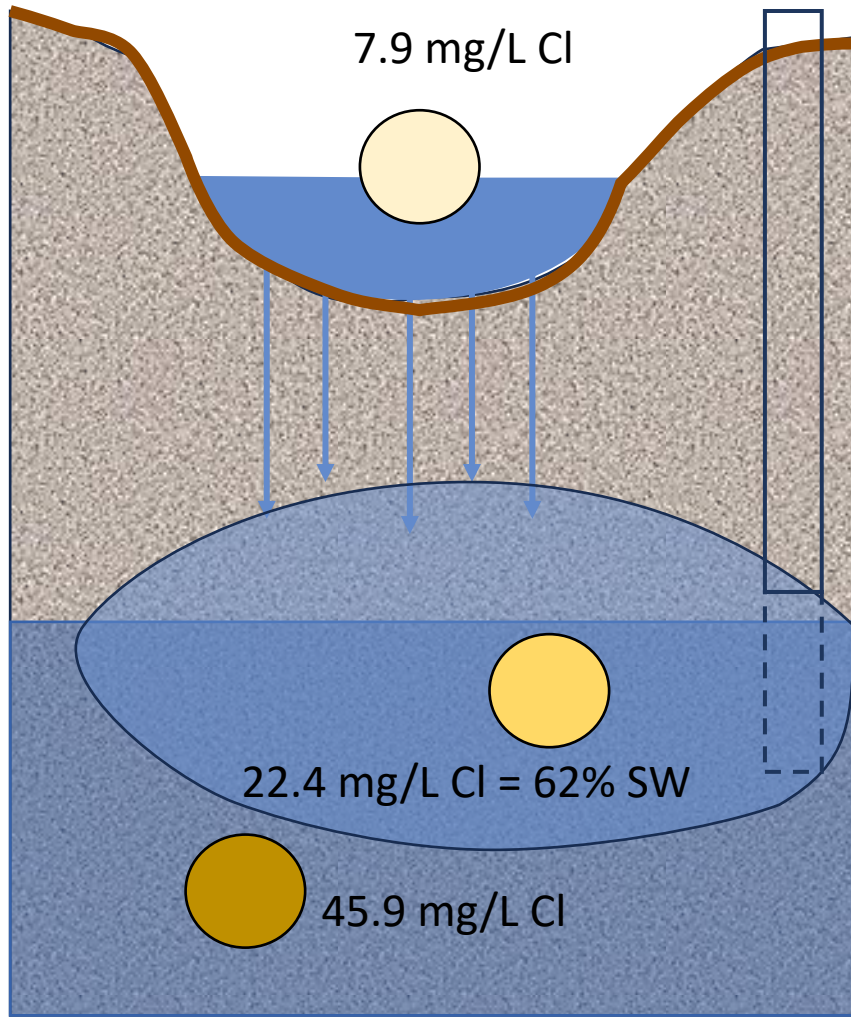
Acetaminophen



Benzotriazole



n = 5 to 10 samples



- Sample groundwater
- Sample stormwater
- Sample infiltrated stormwater/groundwater mix
- Use chloride concentration as a tracer to calculate mix ratio
- Calculate contaminant concentration due to mixing
- Determine amount of contaminant removed

Removed from stormwater:

- Ammonium: 88%
- Phosphate: 92%
- Zinc: 91%
- Organic carbon: 90%

Removed from groundwater:

- Nitrate: 74%

Integrated water quality management for a water sensitive and resilient city

Fit for purpose water quality

OUR SHARED WATER FUTURE

CAPE TOWN'S WATER STRATEGY

Healthy aquatic ecosystems

Water reuse

Sustainable groundwater

Safe drinking water from diverse sources

Safe recreational water bodies

Thank you for your attendance!

Questions & discussion . . .