Hydraulic design for decentralised wastewater treatment of communal ablution facilities

Results from eThekwini's Community Ablution Blocks

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Introduction

- Slums in South Africa
- Slum upgrading in South Africa
- Community Ablution Blocks in eThekwini
- End-use water monitoring
  - Methodology
  - Results

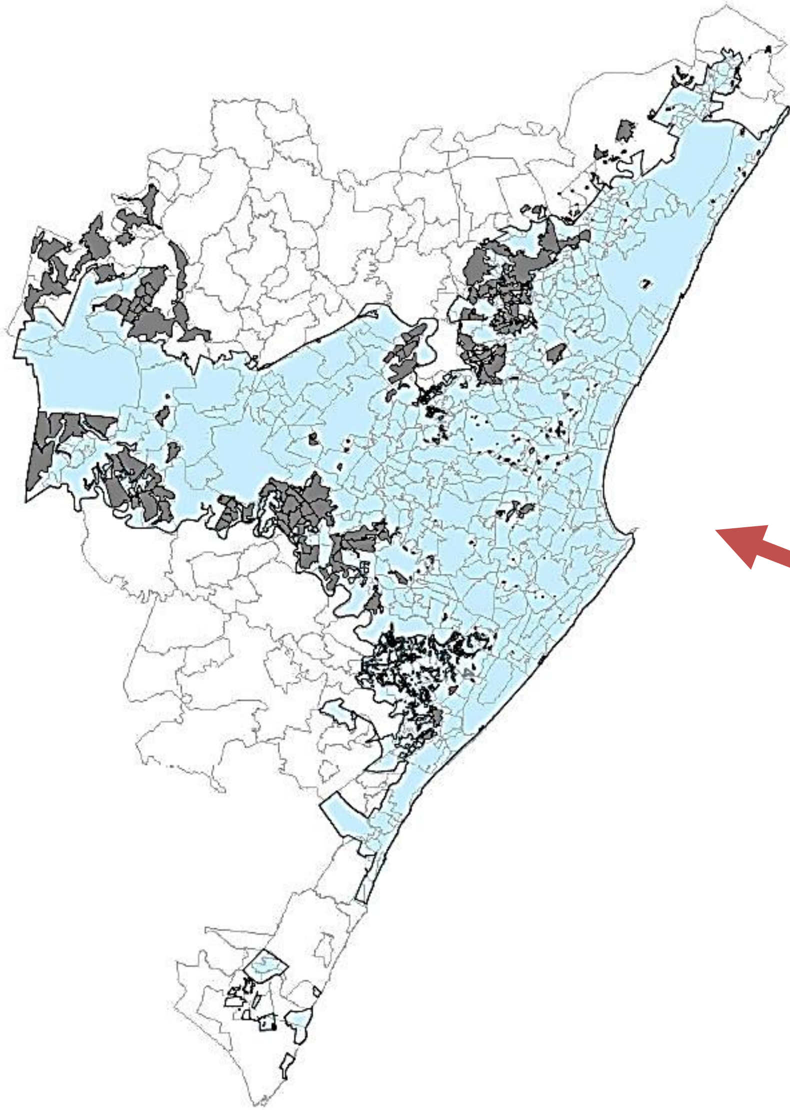
Slums in South Africa (1)

- Total population: ≈ 51.8 million (urban ≈ 60%)
- Informal population: ≈ 6 million
- South African slums vary considerably from location to location and are mainly found as either free standing settlements or backyard shacks
- Typical characteristics for free standing slums
  - High densities
  - Recycled housing materials
  - Lack of services
  - Poor environmental conditions
  - Lack of tenure rights
- Similar constraints for the provision of household sanitation in slum areas

Slum upgrading in South Africa

- South Africa has mandated the provision of interim services to meet the immediate health needs of the community
- Integrated approach to dovetail with the Housing Department's strategic upgrading plan at both a Local and Provincial government level
  - housing backlog (23 years in eThekwini)
  - Interim services to areas being upgraded > 5 years
- Interim infrastructure includes,
  - Communal water and sanitation services (first step)
  - Roads and footpaths
  - Stormwater drainage
  - Refuse removal
  - Electrification
- National priority, but for sustainability the appropriate technology is selected at local government level

eThekwini Municipality



Area: 2 297 km^2

Population: 3.4 mil.

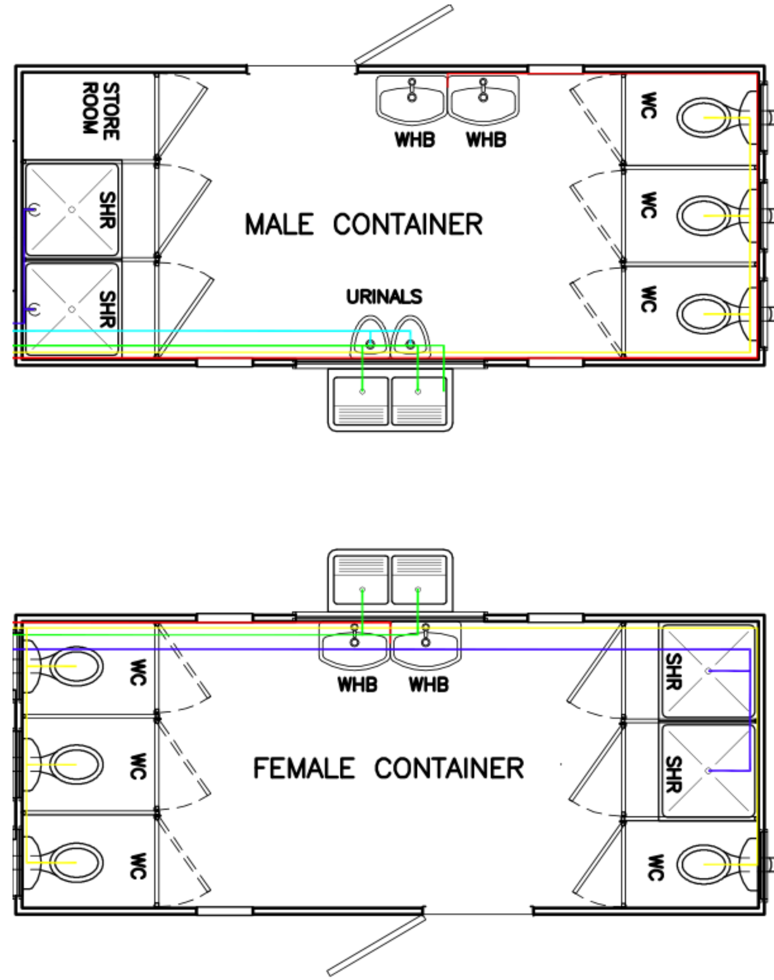
Informal population: ≈ 1 mil.

Informal settlements: ≈ 500

Community Ablution Blocks (1)

- Project started in 2009
- Cooperative project involving:
  - eThekwini Water and Sanitation Unit
  - eThekwini Housing Department
  - eThekwini Health Department
- A Total of 302 CAB projects have been completed in 117 informal settlements (Sep '12)
- CABs serve a maximum of 75 households at a maximum distance of 200 m from the household to the CABs

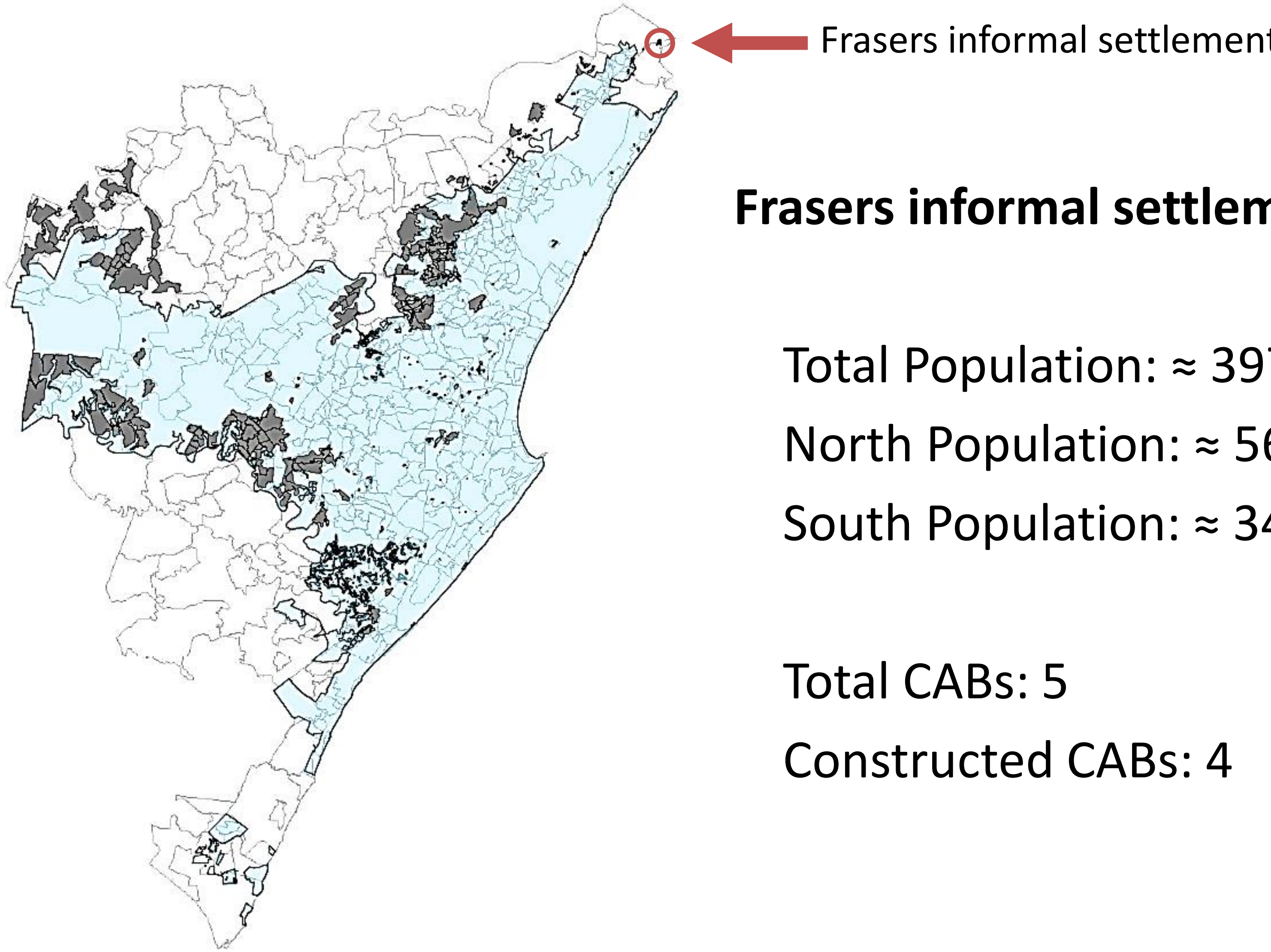
Community Ablution Blocks (2)



Motivation for research

- Provision of CABs were traditionally connected to existing water and sewer infrastructure and the Municipal minimum standards were sufficient
- However, due to increasing political pressure, there is a need to extend the provision of CABs beyond the urban edge
- Yet, there are currently no national water demand guidelines for on site treatment of ablution facilities (with showers, basins and laundry facilities) – (SANS 10400)

Methodology: Site (1)



Frasers informal settlement

Total Population: ≈ 397 hh

North Population: ≈ 56 hh

South Population: ≈ 341 hh

Total CABs: 5

Constructed CABs: 4

Methodology: Site (2)

Methodology: Monitoring (1)

- Each CAB fitted with domestic (Class C) water meters for each male and female fitting (9 per CAB)
- Water meters connect to telemetric data loggers (4 per CAB)
- Data loggers record water demand (volume) every 15 minutes and transmit the data to a webserver every 24 hours
- Water monitoring equipment was stored in a concrete enclosure to protect the equipment from vandalism, theft and water damage

Methodology: Monitoring (2)

Telemetric data loggers elevated to protect against water damage

Domestic water meters

Male facility monitoring set up

Methodology: Results

- For hydraulic design purposes

$$V_{design} = PF \times V_{avg}$$

where,

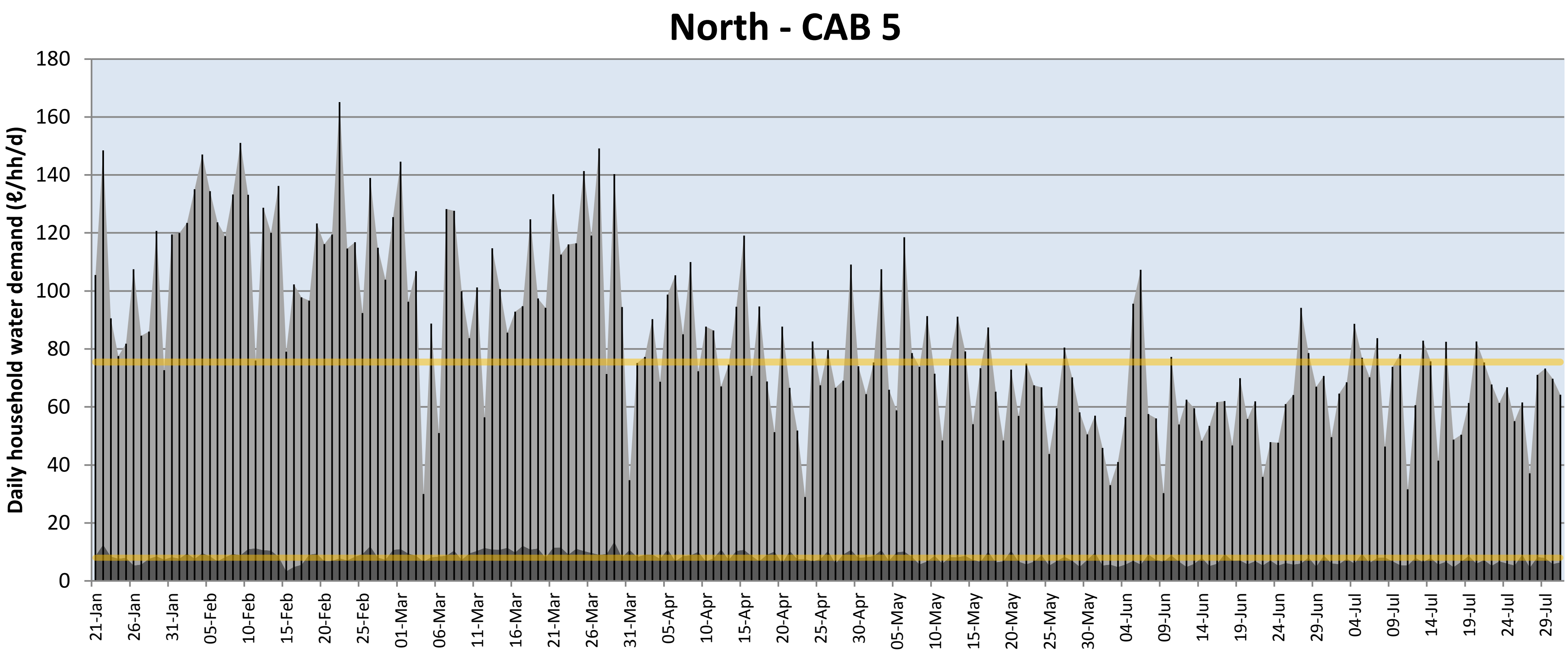
$$PF = \frac{V_{peak}}{V_{avg}}$$

And V_{peak} is the statistically relevant peak water volume. This was selected as the 7 day return period, i.e. the peak volume occurs on average once per week

Results

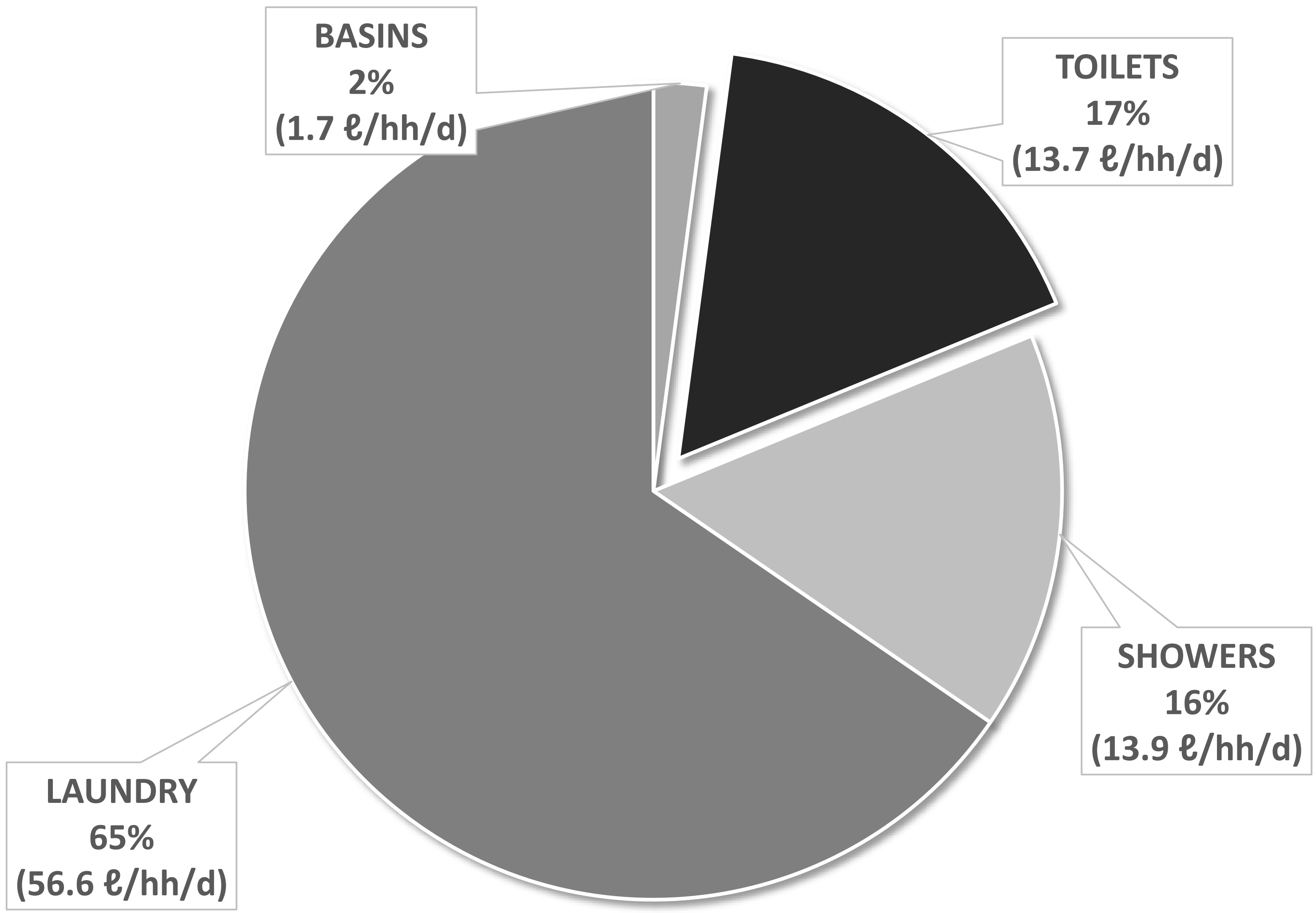
Water and wastewater volumes

Results: Daily water demand



	CAB 5	CAB 2	CAB 1 and CAB 3	AVERAGE
Monitoring period (days)	193	26	106	
Estimate population served (hh)	56	114	227	
Average water demand (ℓ/hh/d)	83.5	93.0	84.2	**86.9**
Average blackwater demand (ℓ/hh/d)	8.2 (10%)	18.1 (19%)	14.8 (18%)	**14.8**
Average greywater demand (ℓ/hh/d)	75.5 (90%)	74.9 (81%)	69.2 (82%)	**72.1**

Results: End-use water demand



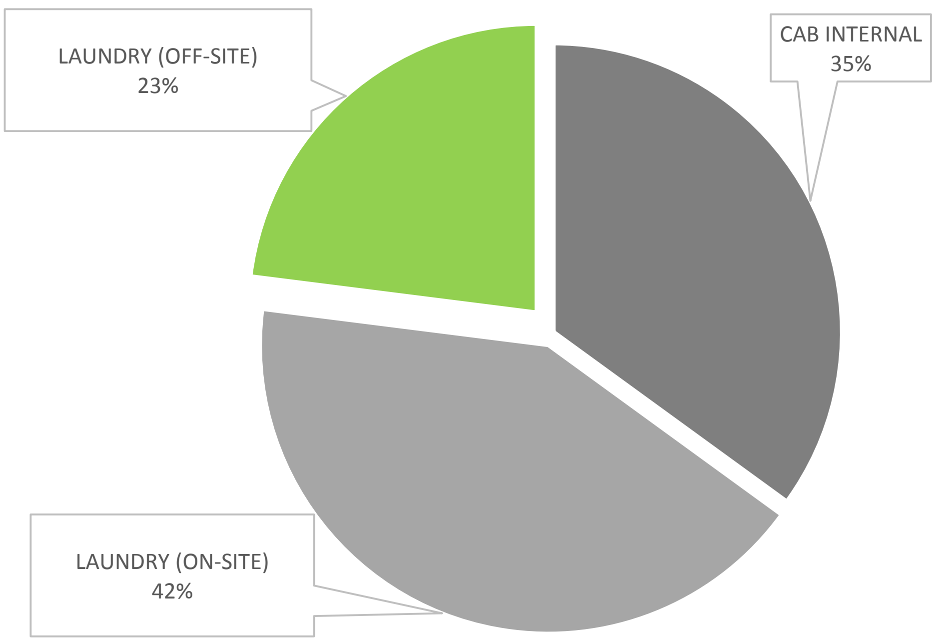
What becomes wastewater?

- Internally, the CAB is a closed system, i.e. the water used within the CAB facility is discharged into the wastewater treatment system.
- However, evidence suggests that this does not hold for the laundry facilities as water is carried away from site for domestic purposes.
- It was hypothesised that each household carries one container of water (typically 20ℓ) away from the CAB site, which accounts for 19% of the total CAB water demand.

Results: Laundry water (1)

Results: Laundry water (2)

- These values were not monitored but are based on educated guess work
- Proposed Laundry tap usage
- Off-site (20 ℓ/hh/d)
    - Cleaning
    - Cooking
    - Drinking
  - On-site (36.6 ℓ/hh/d)
    - Clothes washing
    - Dish washing



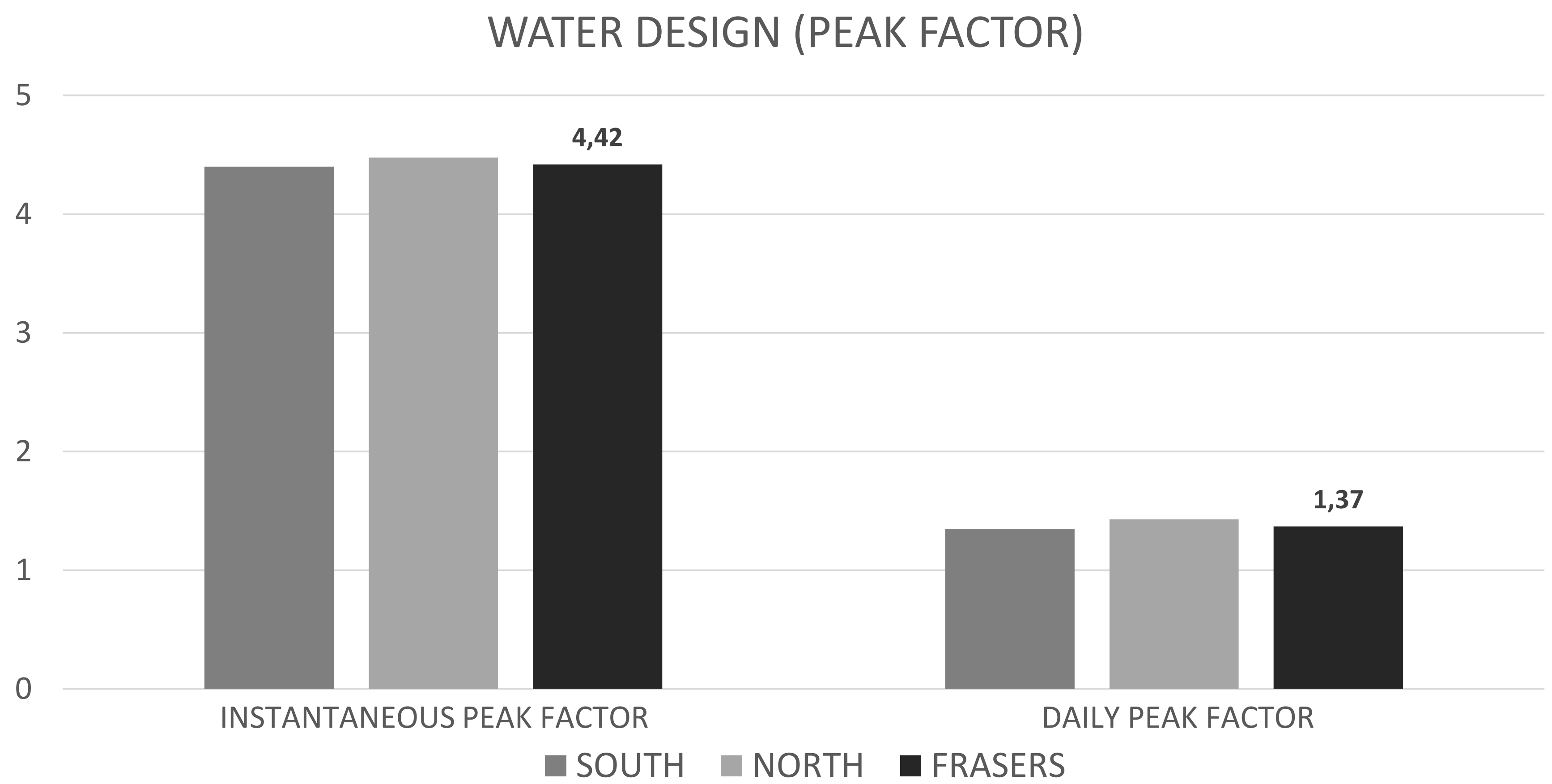
Results: Additional water sources

- In addition to the four CAB facilities, Frasers is serviced by five standpipes – however, these were not monitored
- In order to quantify the unaccounted water, the experience of a study in 2011 was used, where 1 021 households were interviewed throughout eThekwini. The study found that a fraction of the households (≈ 20%) preferred standpipes for bathing and laundry washing due to either closer distance or availability
- These factors theoretically increase the household water demand of the CABs by 18% to increase the total household water demand to 103 ℓ/hh/day

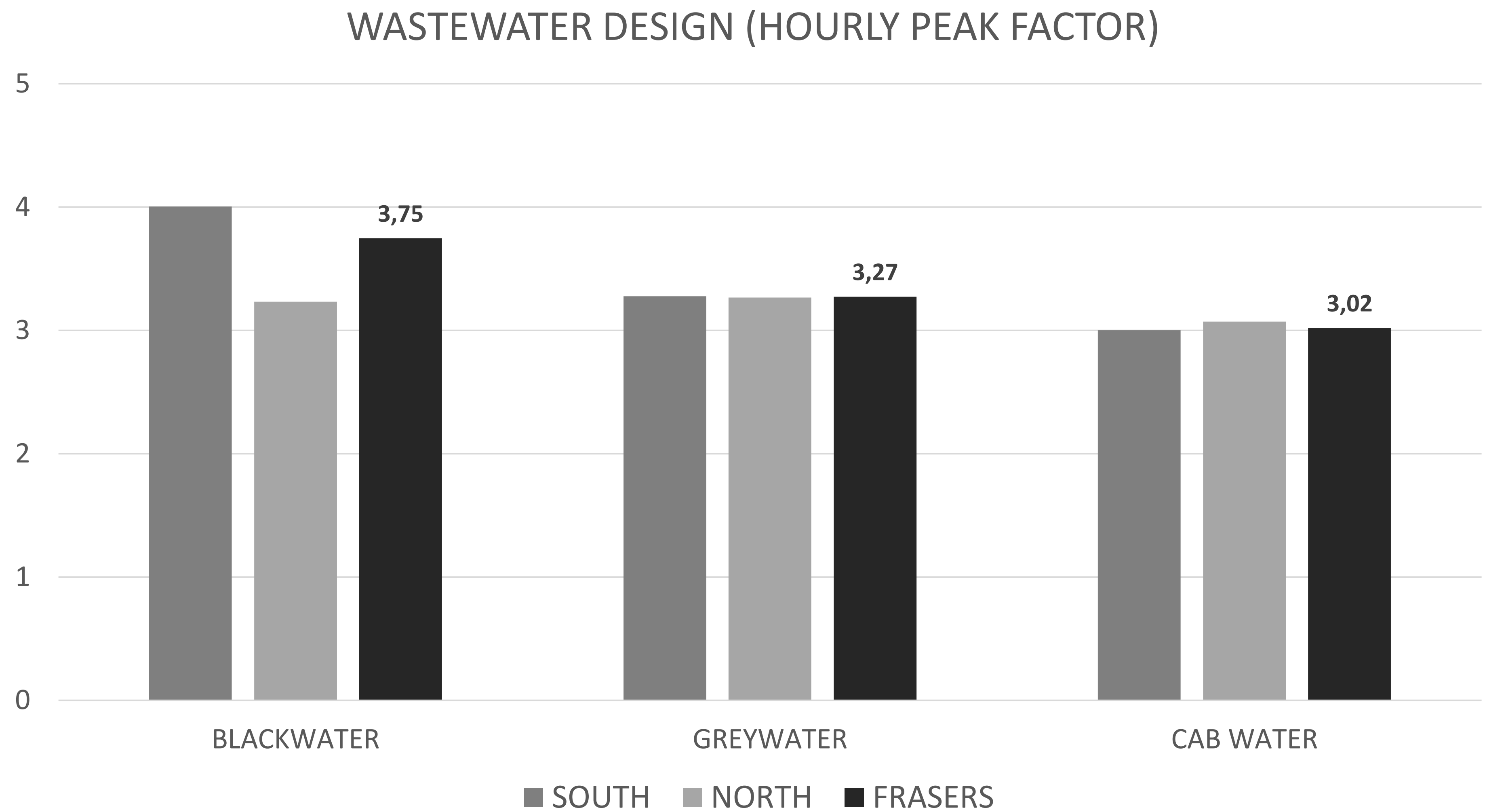
Results

Peak Factors

Results: Peak Factors (1)



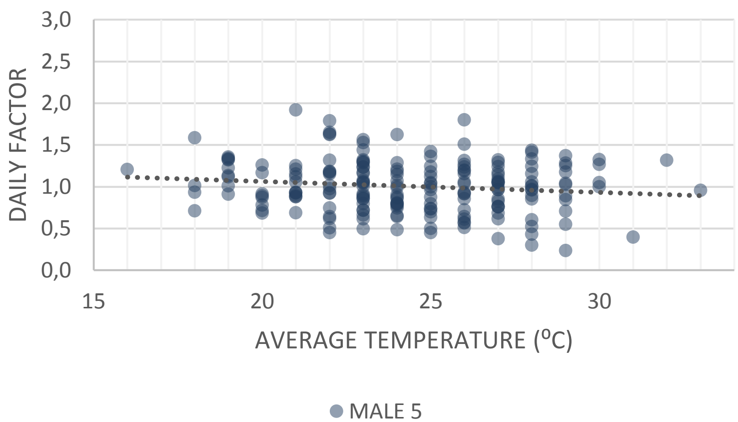
Results: Peak Factors (2)

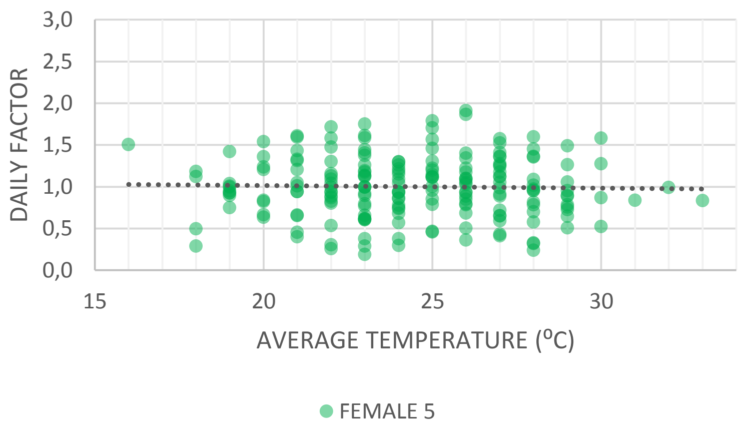


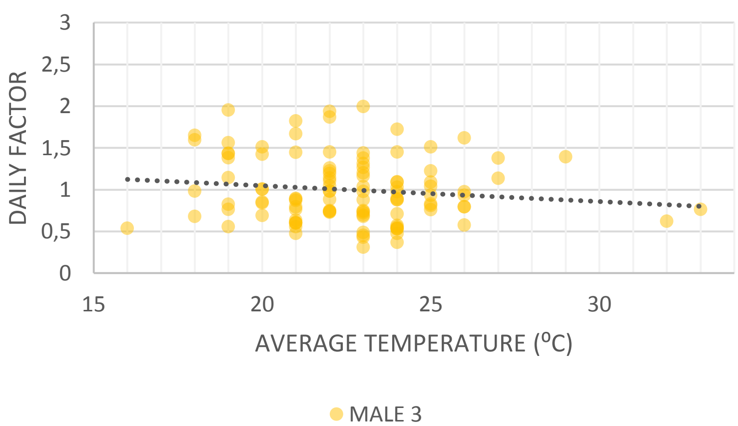
Results

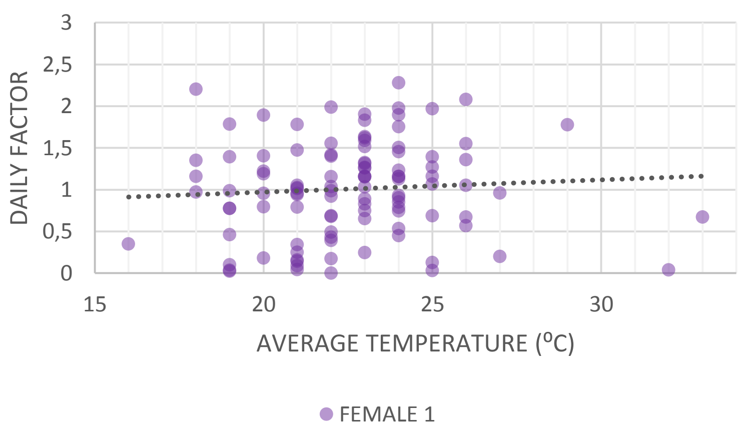
The effect of weather

Results: Temperature vs Laundry

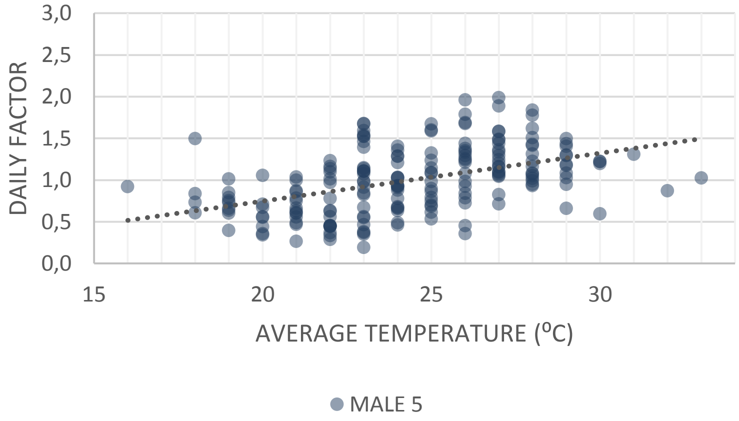


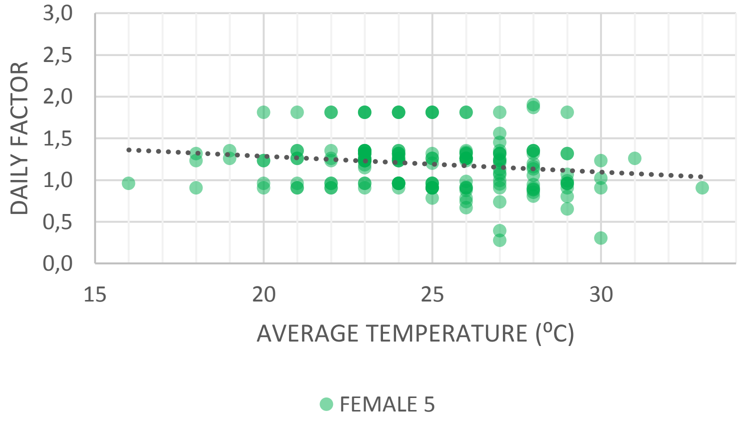


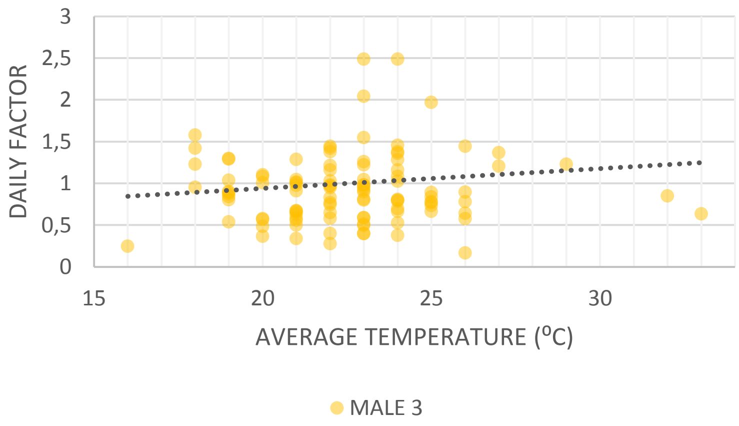


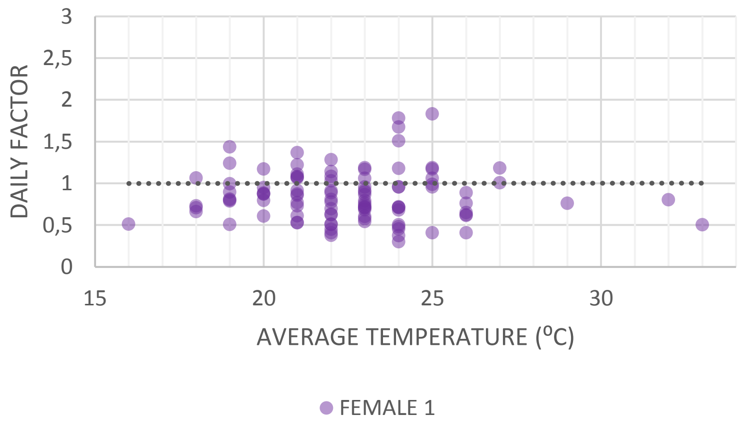


Results: Temperature vs Toilets

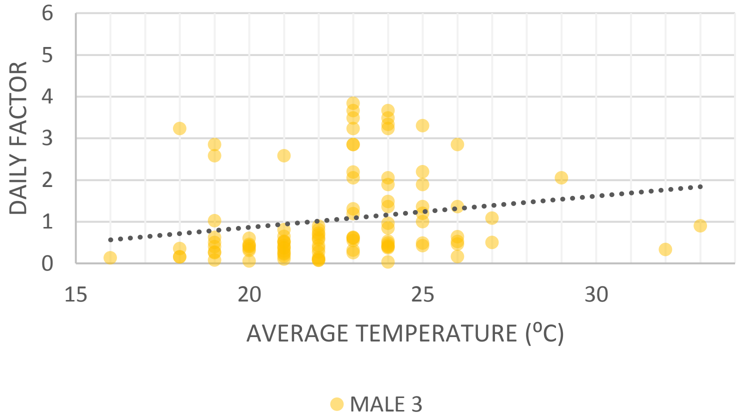


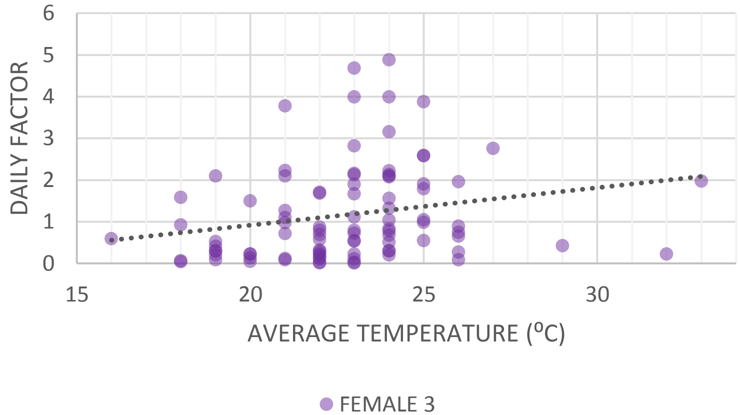


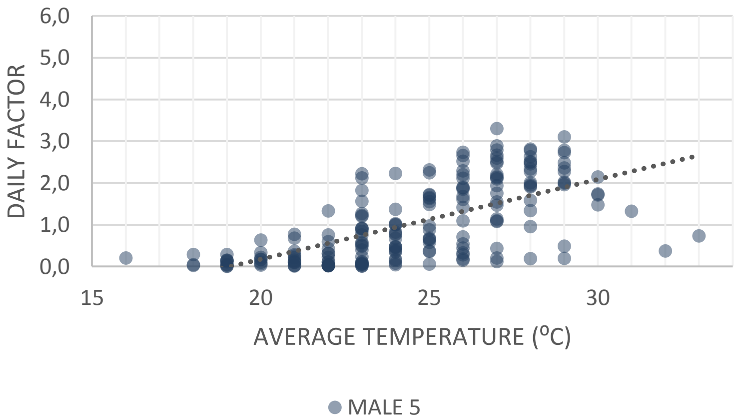


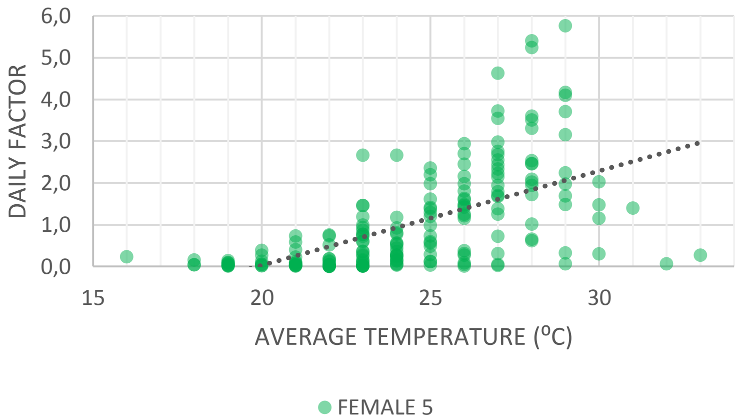


Results: Temperature vs showers









Design guidelines

		WATER SUPPLY		WASTEWATER DESIGN	
		WATER DEMAND (ℓ/hh/d)	PEAK FACTOR (15-min)	WW VOLUME (ℓ/hh/d)	PEAK FACTOR (1-hour)
TOILETS	**BW**	**14.8**	**-**	**14.8**	**3.8**
BASINS	**GW**	**1.7**	**-**	**1.7**	**3.3**
SHOWERS		**13.9**		**13.9**	
LAUNDRY*		**52.6**		**52.6**	
DOMESTIC USE		**20**		**-**	
	TOTAL	**103**	**4.2**	**83**	**3.0**

*includes additional water added from the other water sources

Conclusions

- Communal sanitation is being rolled out as an interim solution in the incremental upgrading of slum areas in South Africa
- Communal or shared sanitation facilities are often the only practical method of sanitation provision in urban and peri-urban slum areas
- This study provided a method for monitoring water demands in a communal facility and provides quantitative end-use data on water demands and wastewater volumes

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