ASPIRE Keynote presentation – Hong Kong, 1 Nov 2019

Aspiring towards a Circular Economy using Digital Twins and Smart Water-Energy-Resource Solutions

Professor Jurg Keller FTSE, IWA Fellow

Advanced Water Management Centre, The University of Queensland

& CRC for Water Sensitive Cities

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CRC for Water Sensitive Cities

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Advanced Water Management Centre - UQ

- One of the top water research centers in the world
- Celebrated our 20th anniversary in 2016
- Over 140 staff and PhD students
- 100+ journal articles annually
  - Papers in Nature, Science, Water Research and other leading journals
- Delivered substantial industry benefits
  - The sewer research program alone delivered $400+M cost savings to the Australian water industry
- Long-term partnership with:
  - All major water utilities in Australia
  - Private-sector companies GHD, KBR, Aquatec-Maxcon, etc.
  - Several water utilities/companies overseas including PUB, DC Water, Aquafin, Veolia, etc.
- Three spin-offs

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SewerX
Sulfide modelling and control in sewers

Cloevis

LODOMAT

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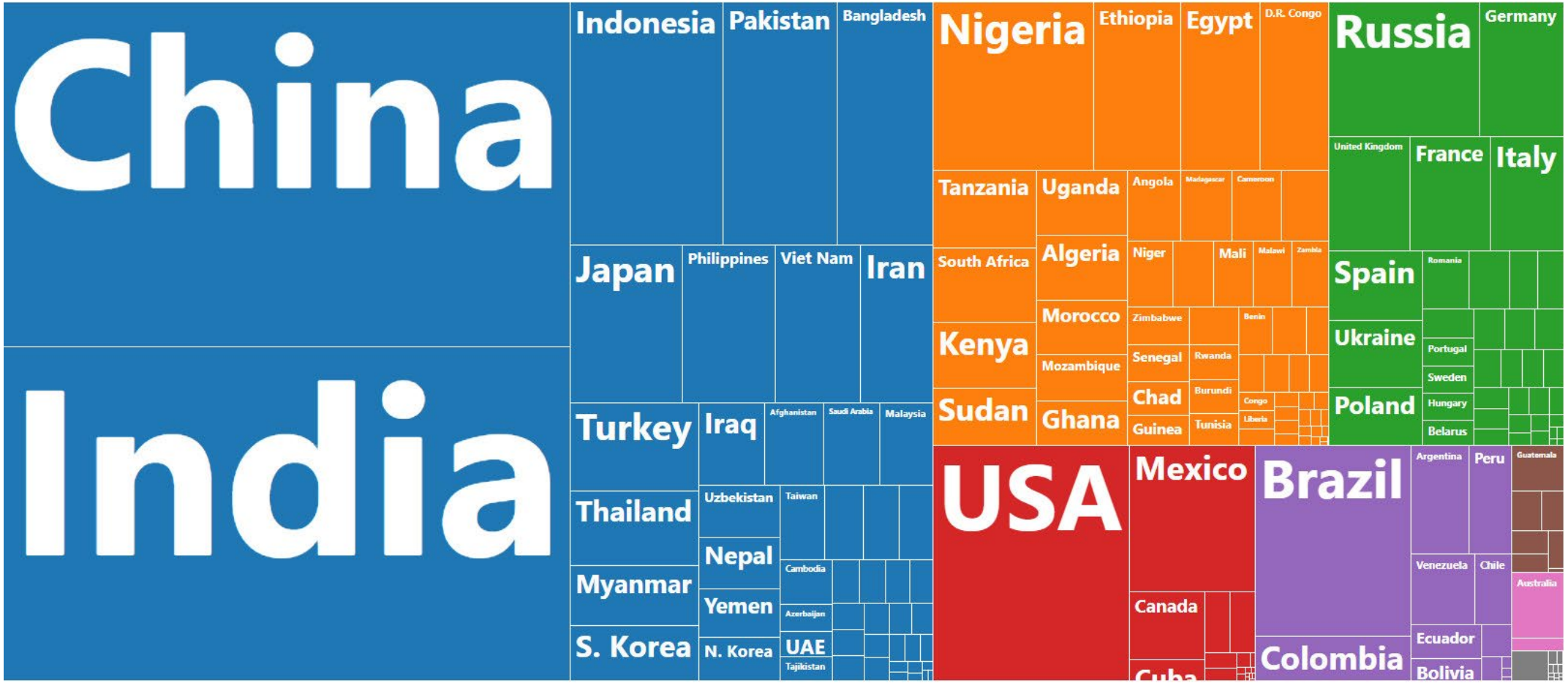
Global Population Distributions are Shifting



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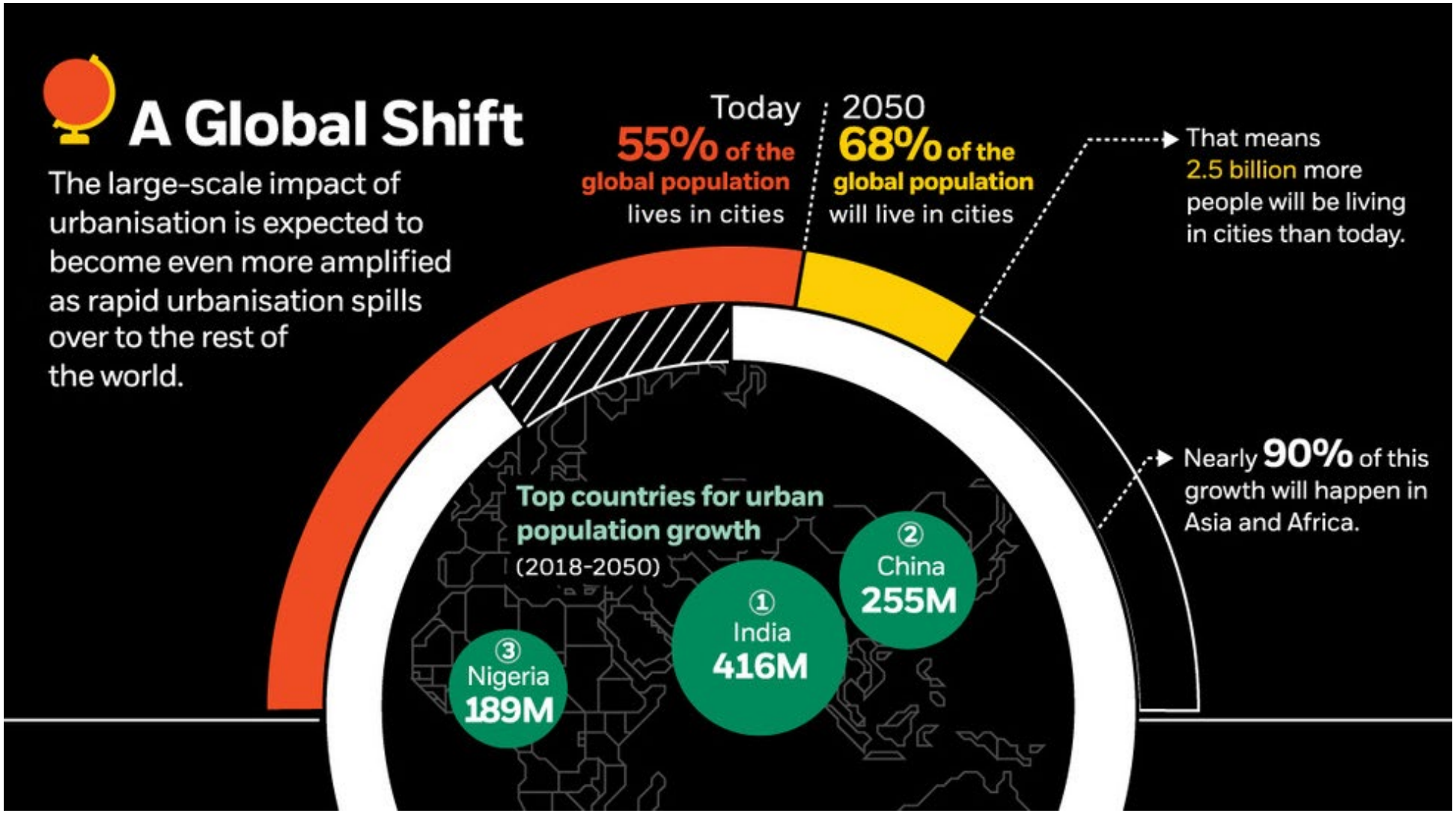
Even More People will be Living in Cities



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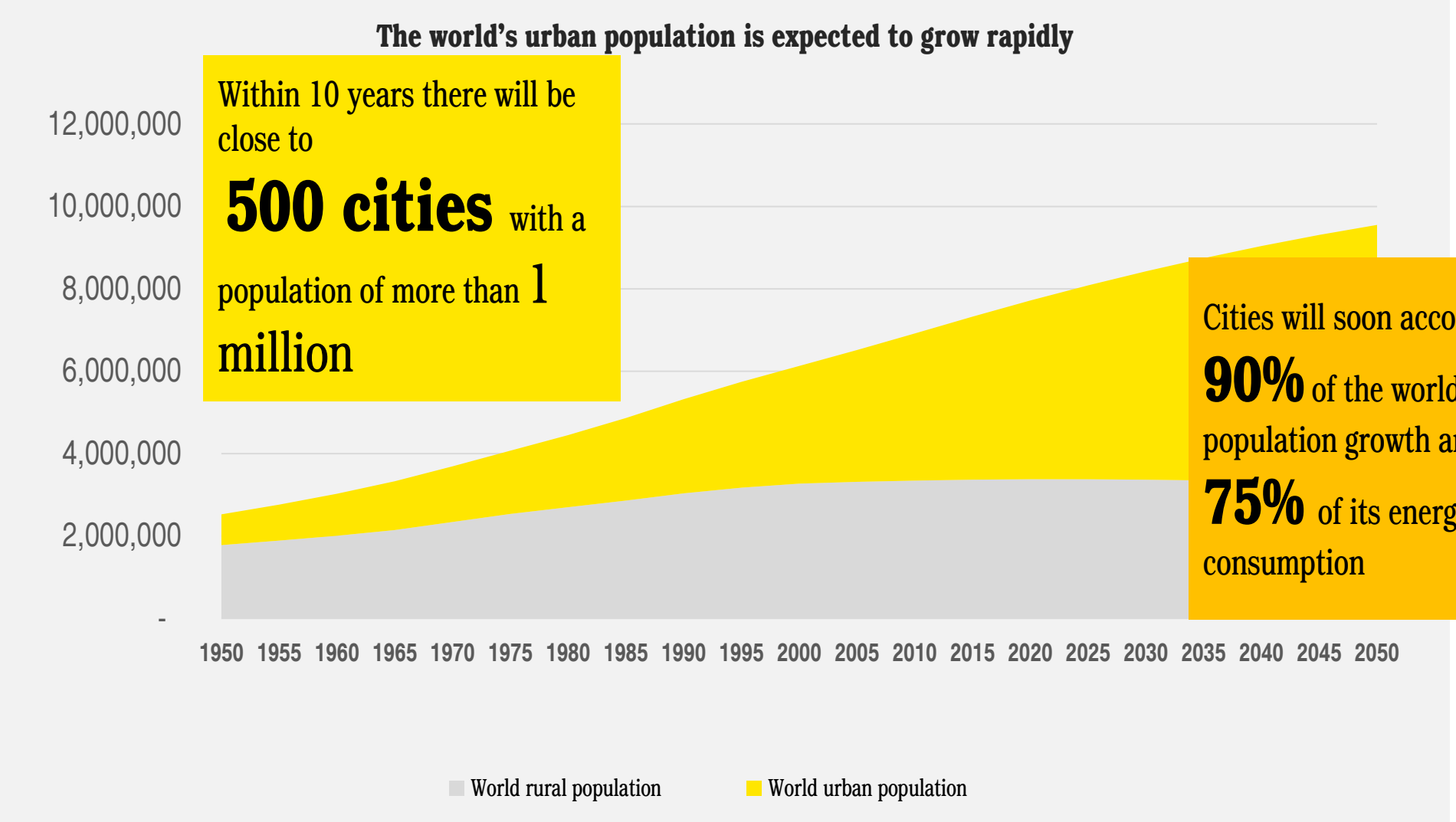
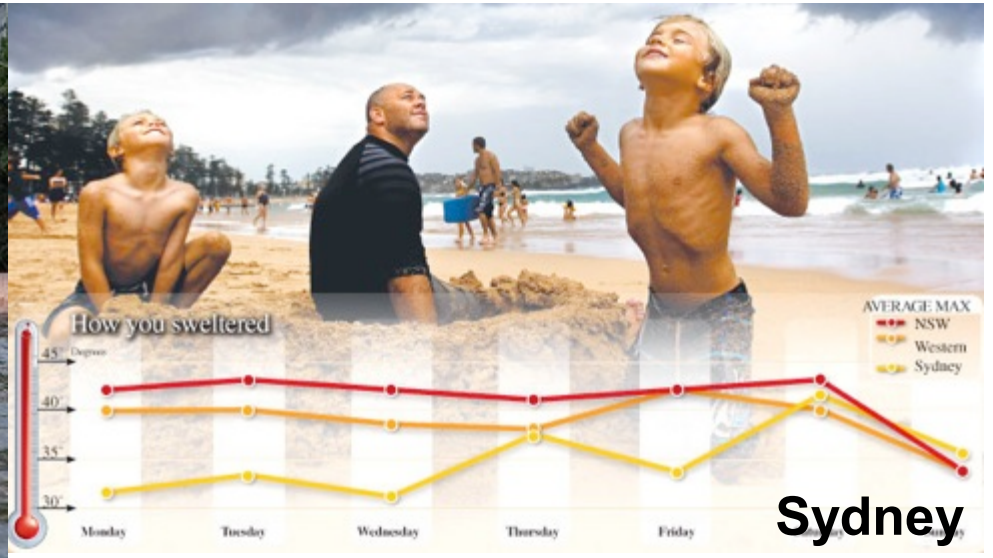
Demands on Cities are Growing



Challenges are Changing: Climate Extremes



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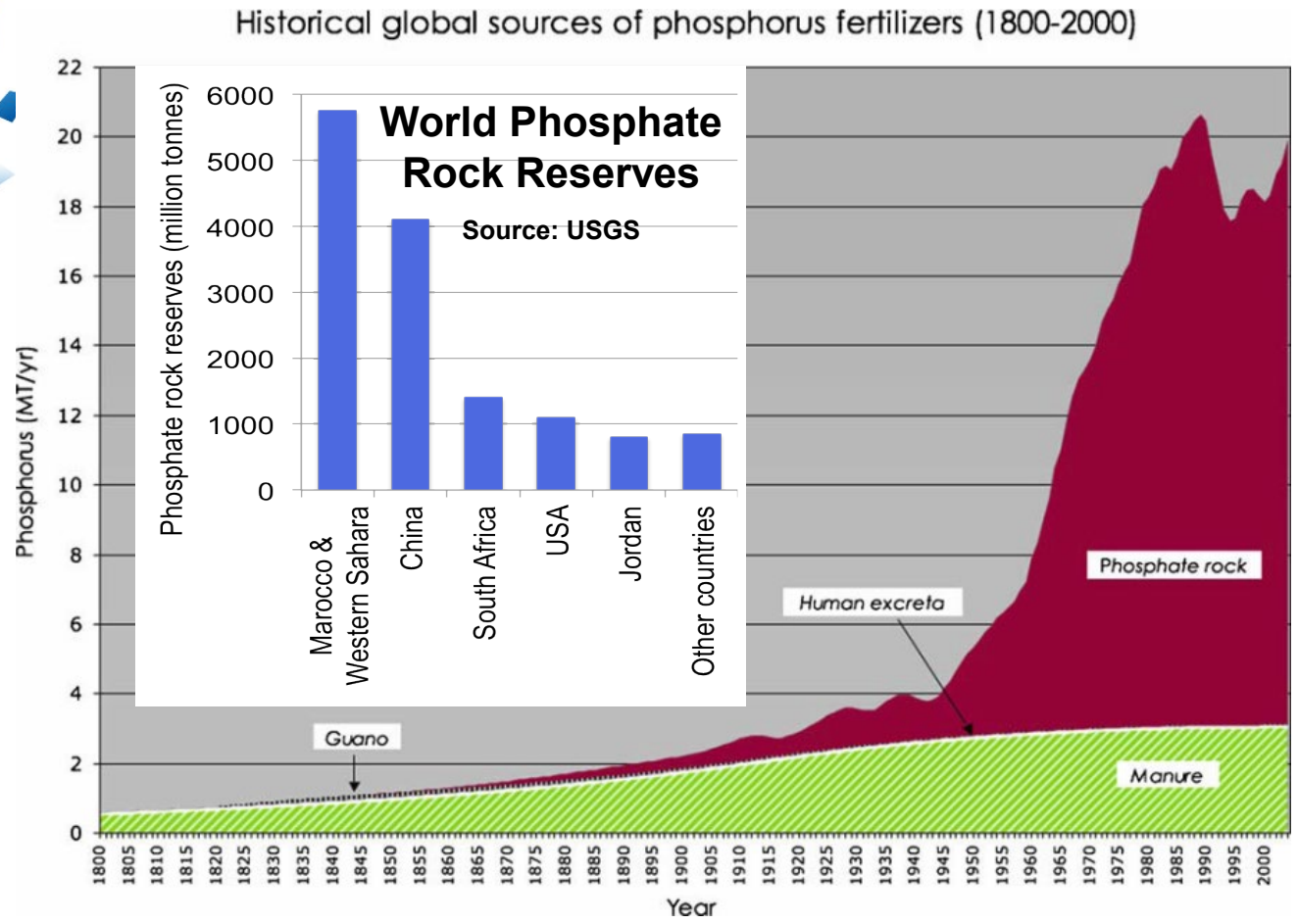
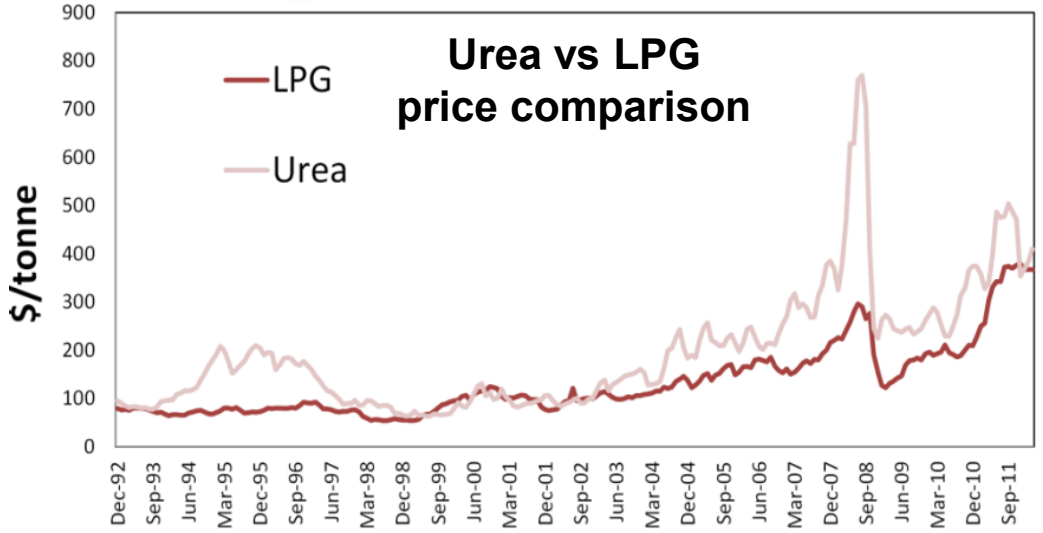
Resources are Finite and Competitive



"The story of phosphorus: Global food security and food for thought", 2009, Dana Cordell, Jan-Olof Dranger, Stuart White



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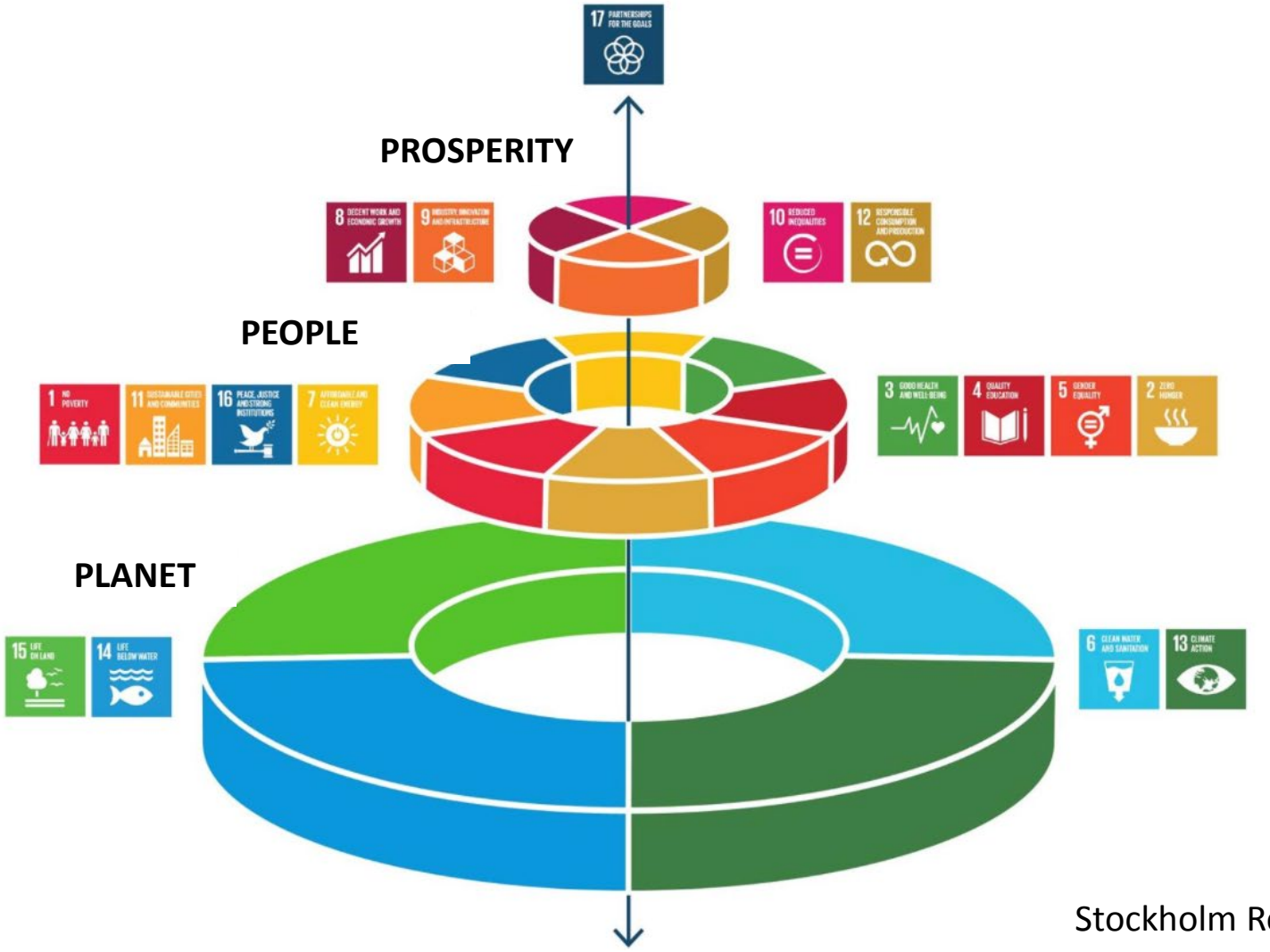
Planetary Goals underpin all Sustainable Development Goals (SDGs)



Stockholm Resilience Centre

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Challenges ➔ Drivers for Change

- Innovation in urban structures and functions
- System-wide integration, collaboration and resource sharing
- Socio-economic considerations: diversity, inclusion, equality

First Story

Innovative re/use of iron salts in an integrated urban water system

Zhiguo Yuan and the whole MulFe Team

Coagulant use in an urban water system

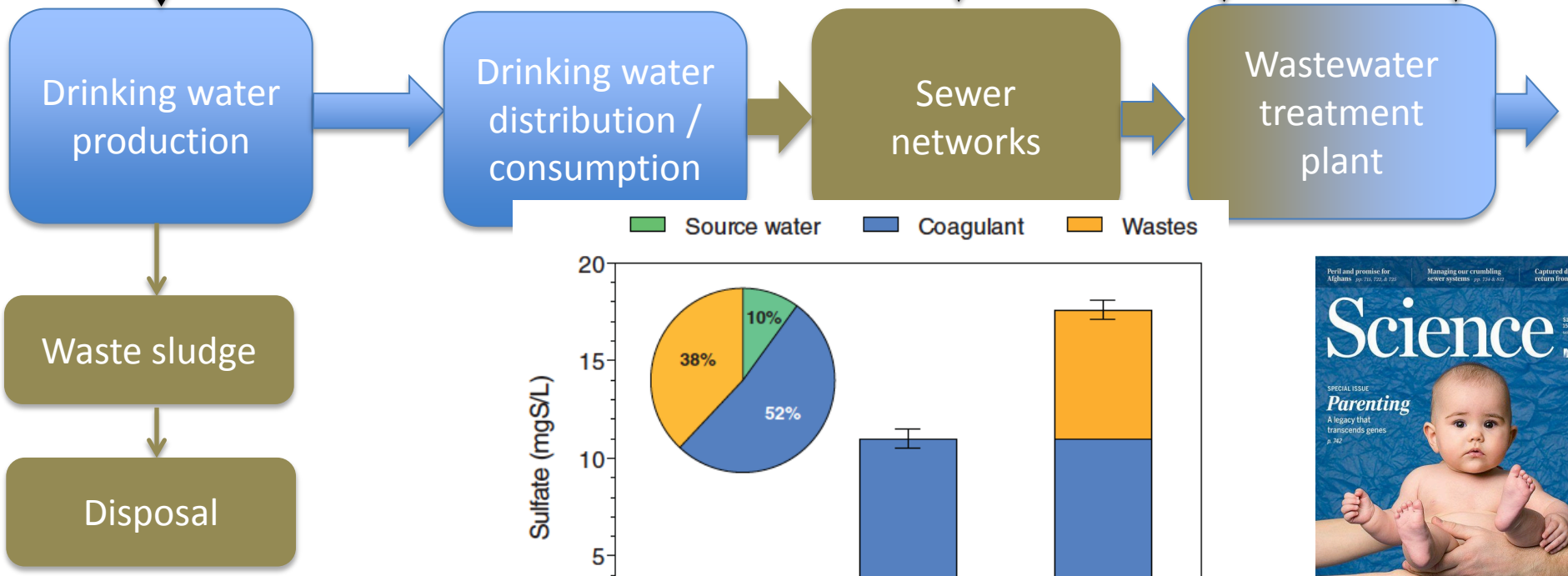
$Al_2(SO_4)_3$ for solids & organics removal

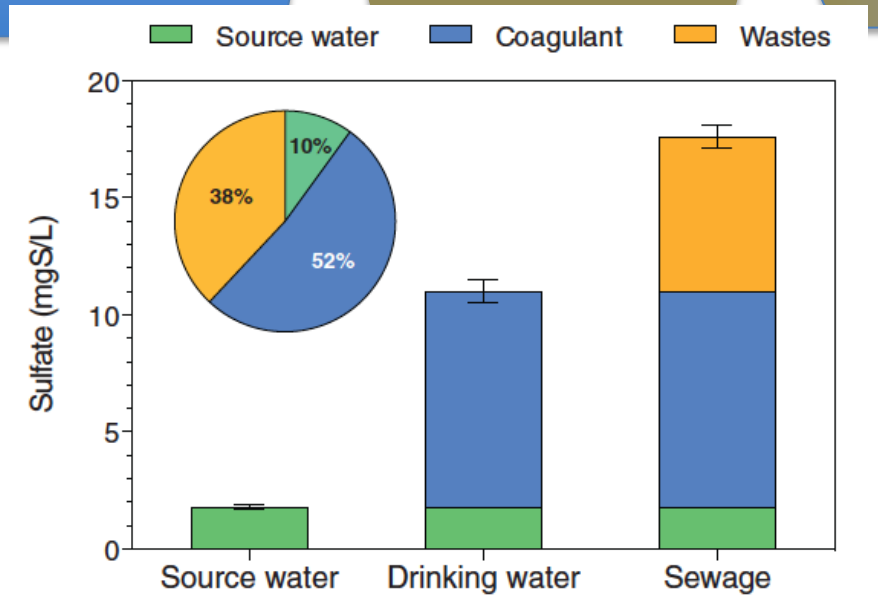
$FeCl_3$ dosing

H_2S control

P removal

H_2S control in AD





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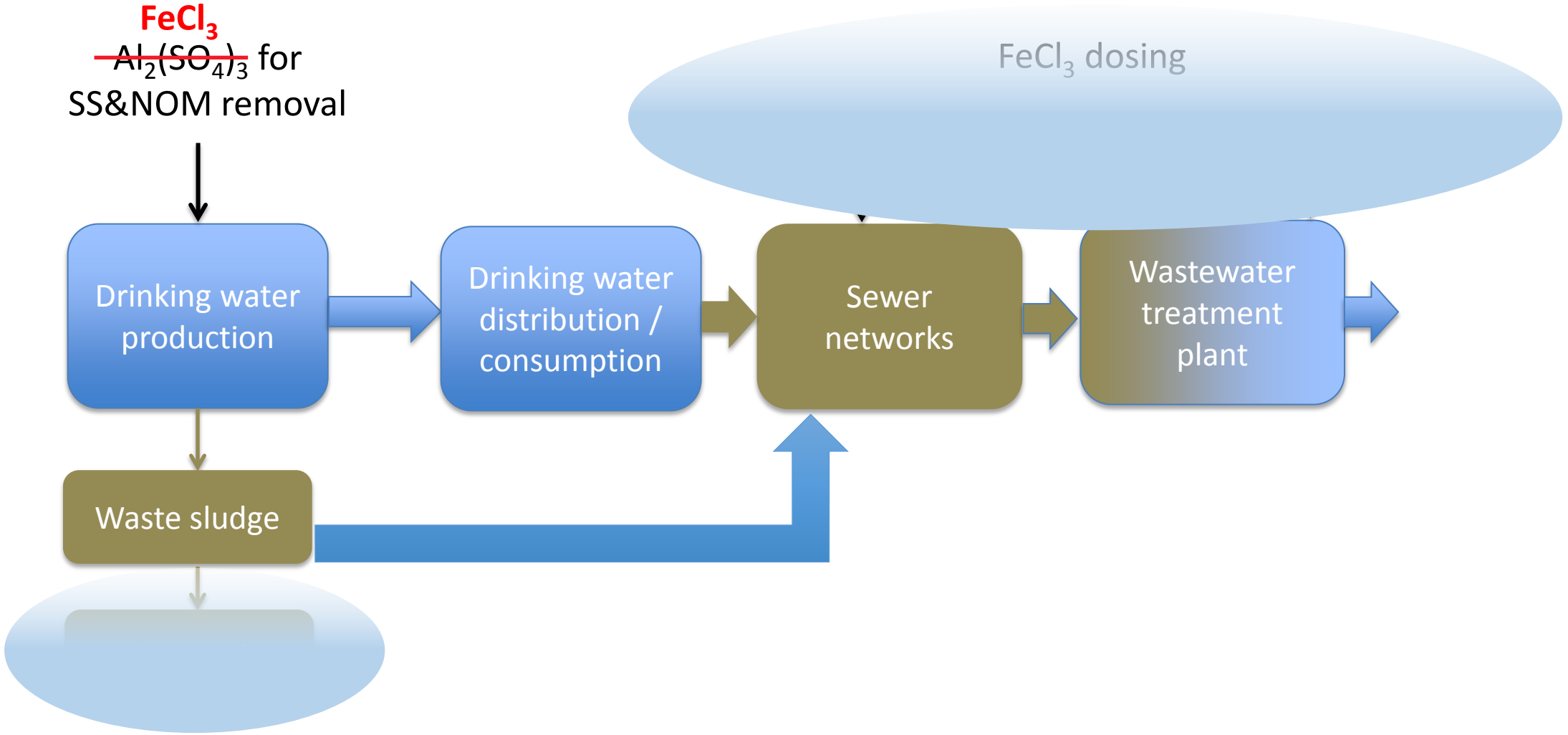
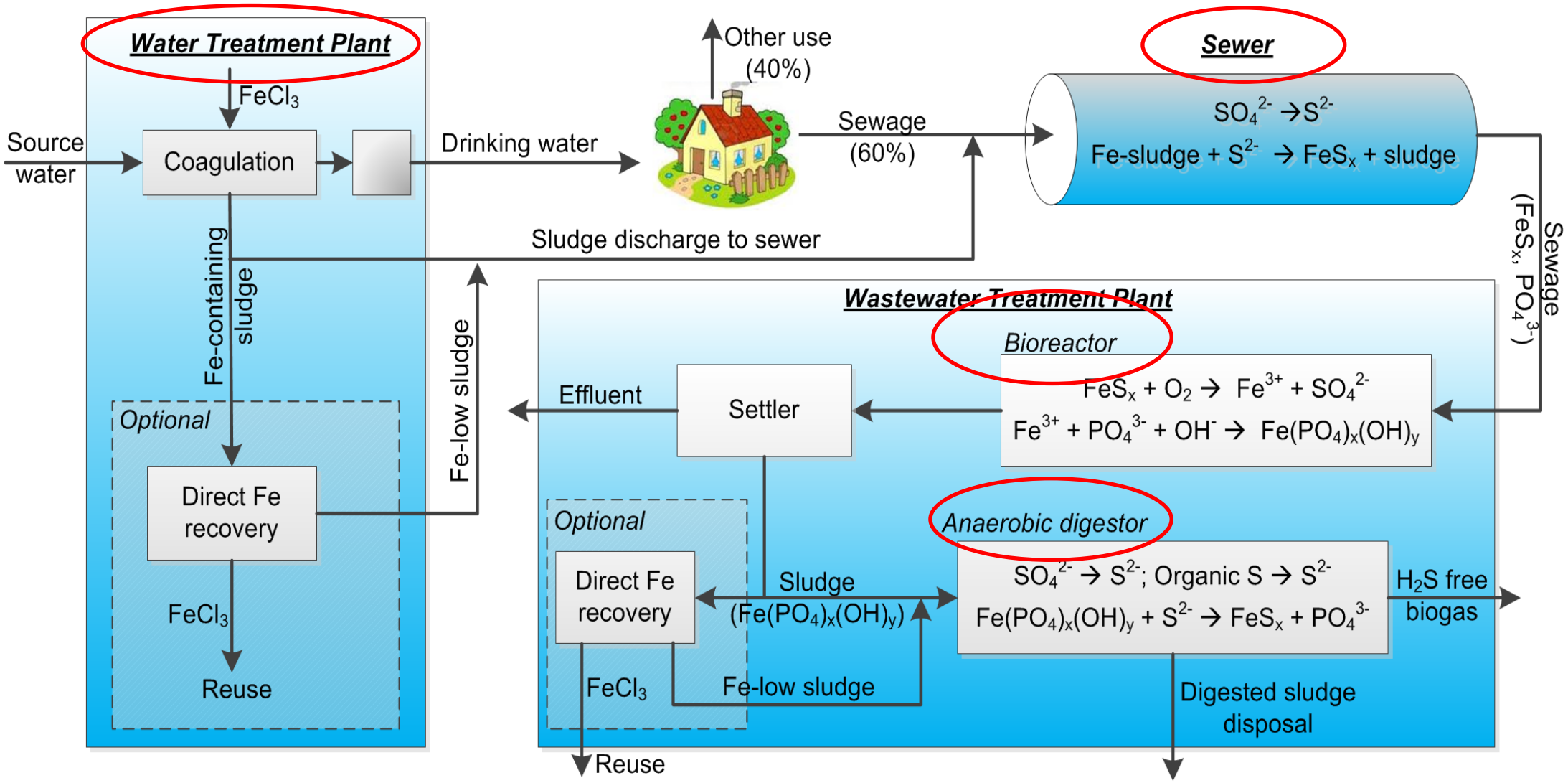
Coagulant use in an urban water system

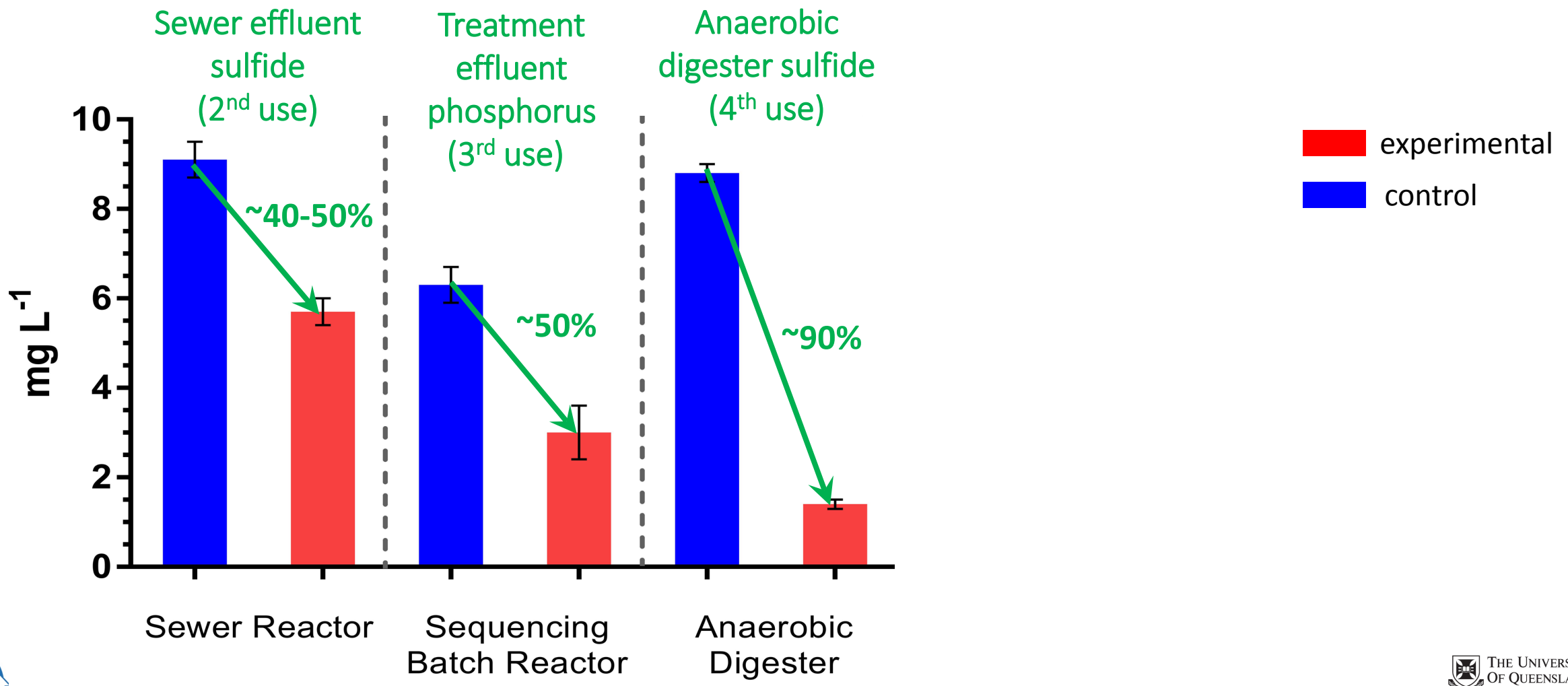


Chemistry should work out!



Results from Direct Comparison Lab Set-up

10mgFe^{3+}/L dosing of Drinking Water Sludge to sewer



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Multiple benefits across urban water system

Fe^{3+} addition to sewers…

Observed/demonstrated at	lab-scale	full-scale
reduces hydrogen sulfide levels in sewer air	?	?
improves P removal in WWTP	?	?
improves sulfide removal in anaerobic sludge digester	?	?
does not affect biogas production	?	?
enhances dewaterability of anaerobically digested sludge	?	

…plus avoids chemical sludge processing at water treatment plant

Pilot plant testing on-going

Queensland Urban Utilities/UQ Innovation Centre at Luggage Point WWTP

Second Story

Next-Generation urban development with focus on integrated water, energy and liveability outcomes

CRC for Water Sensitive Cities
South-East Water (Melbourne)
Villawood Properties


AQUAREVO
LYNDHURST
A leading edge water and energy efficient residential development
villawood properties
Communities Designed for Living
South East Water

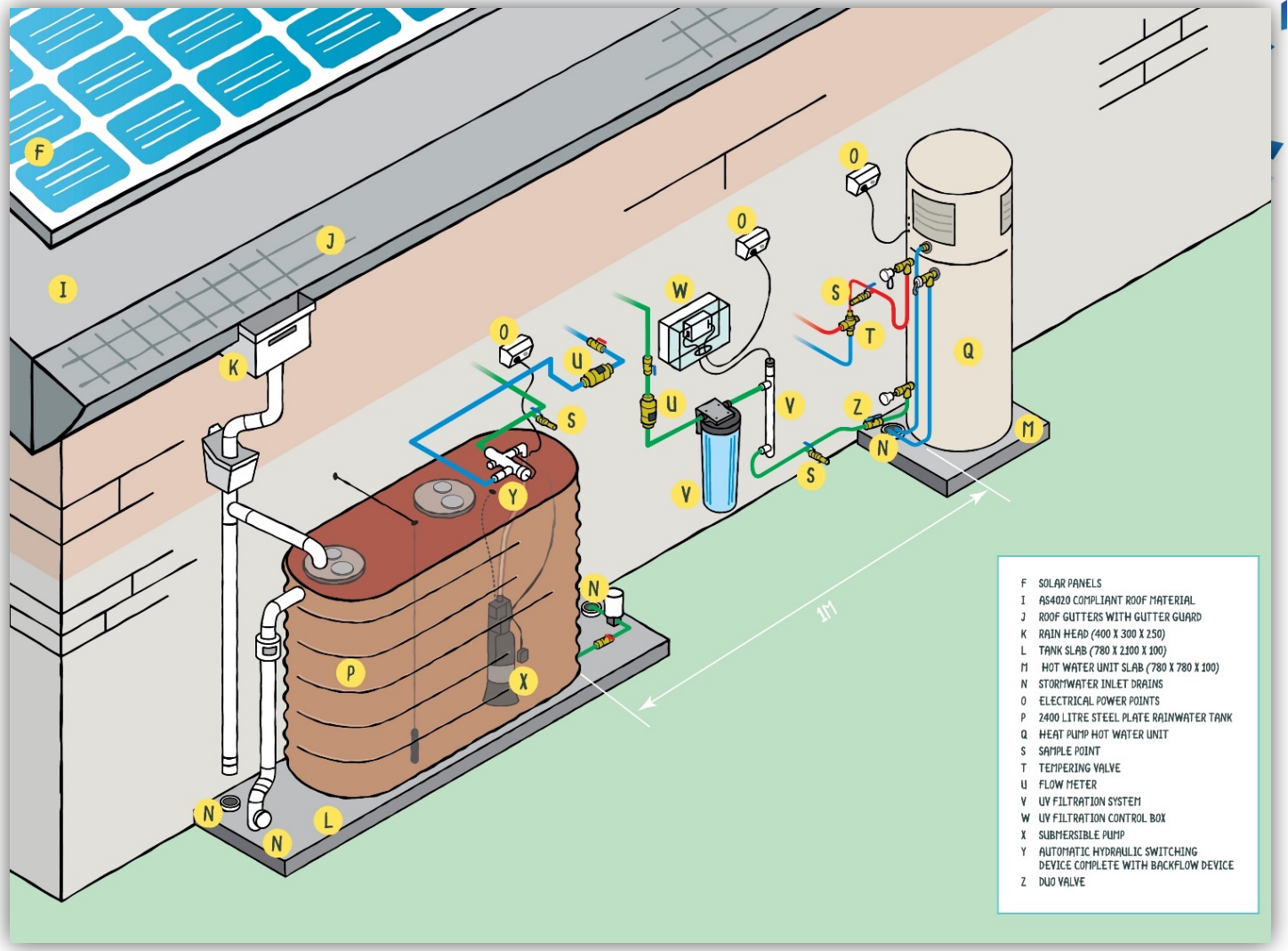
Technology Innovations

Rain to hot water

- Rainwater tank
- Microfiltration
- UV disinfection
- Heat-pump hot water system, **reducing energy input by 60-70%**

Tanks for Stormwater management

All rainwater tanks are centrally controlled for **stormwater management**



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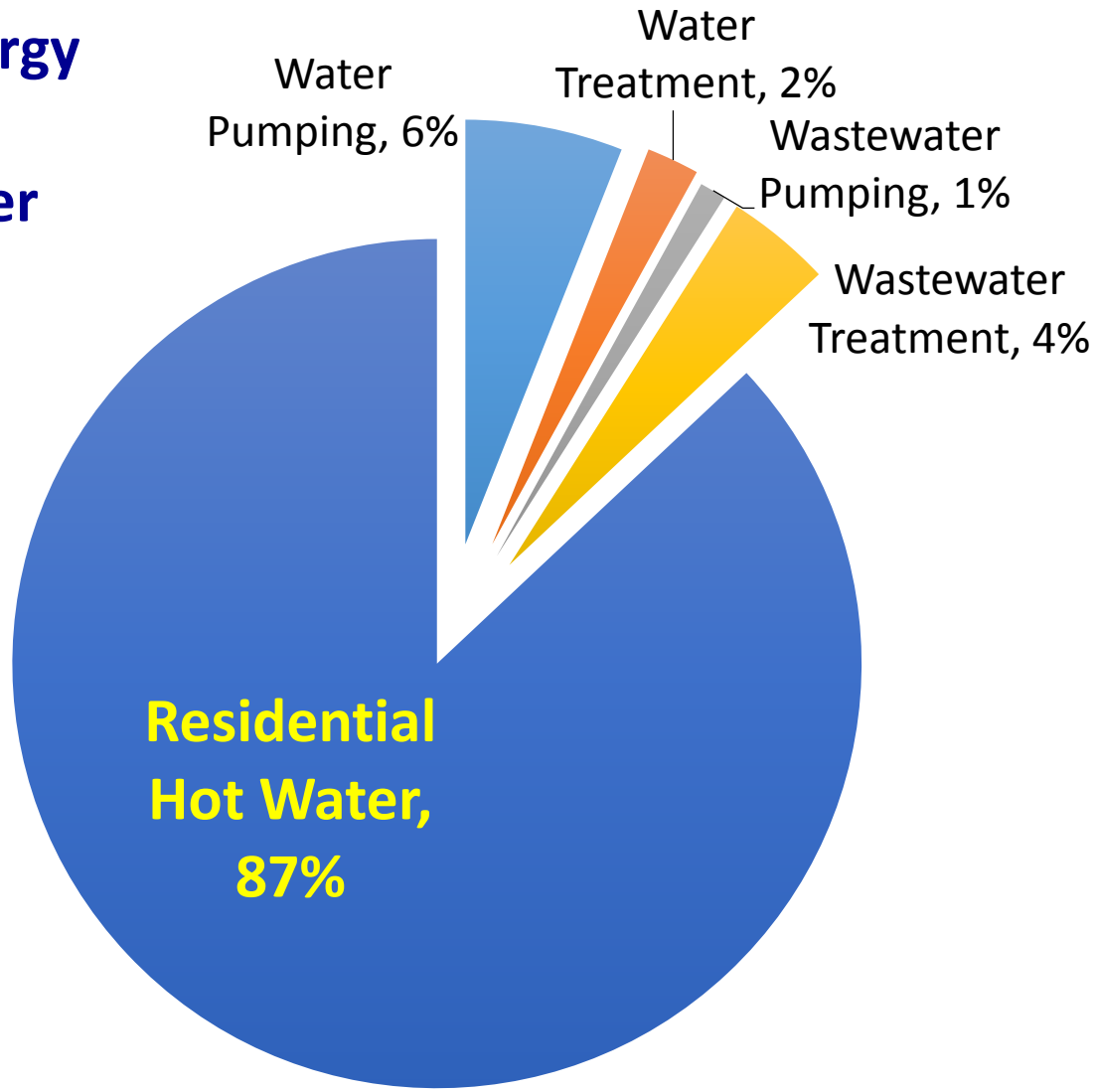
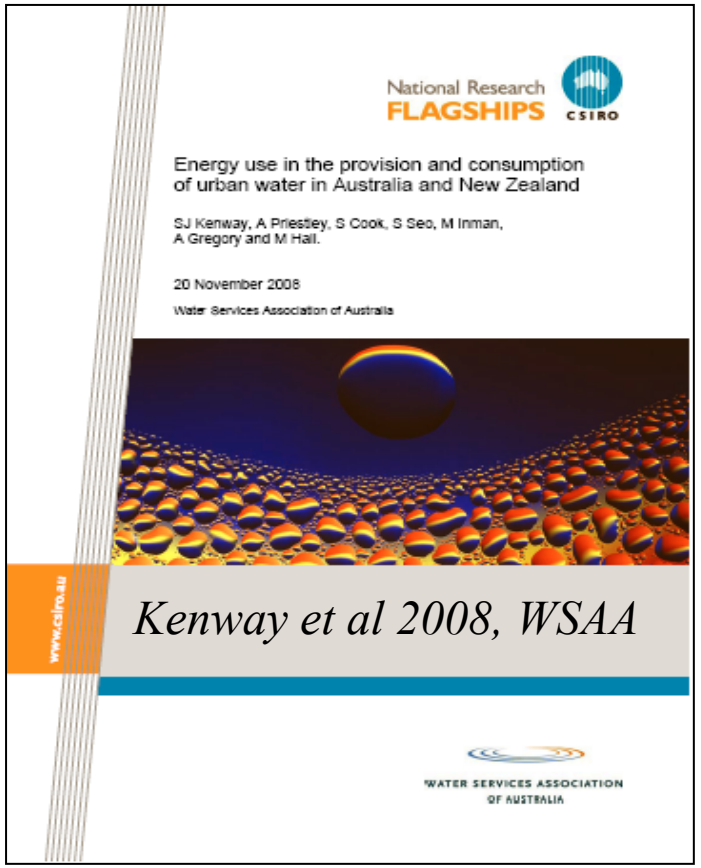
Urban Water System Energy Demand: Seeing the bigger picture

Overall Energy Demand of Urban Water System





Based on major Australian/NZ Cities

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More Aquarevo Technology Innovations

Renewable energy generation on each house

Water recycling for non-potable reuse

Mobile app to monitor all water & energy services

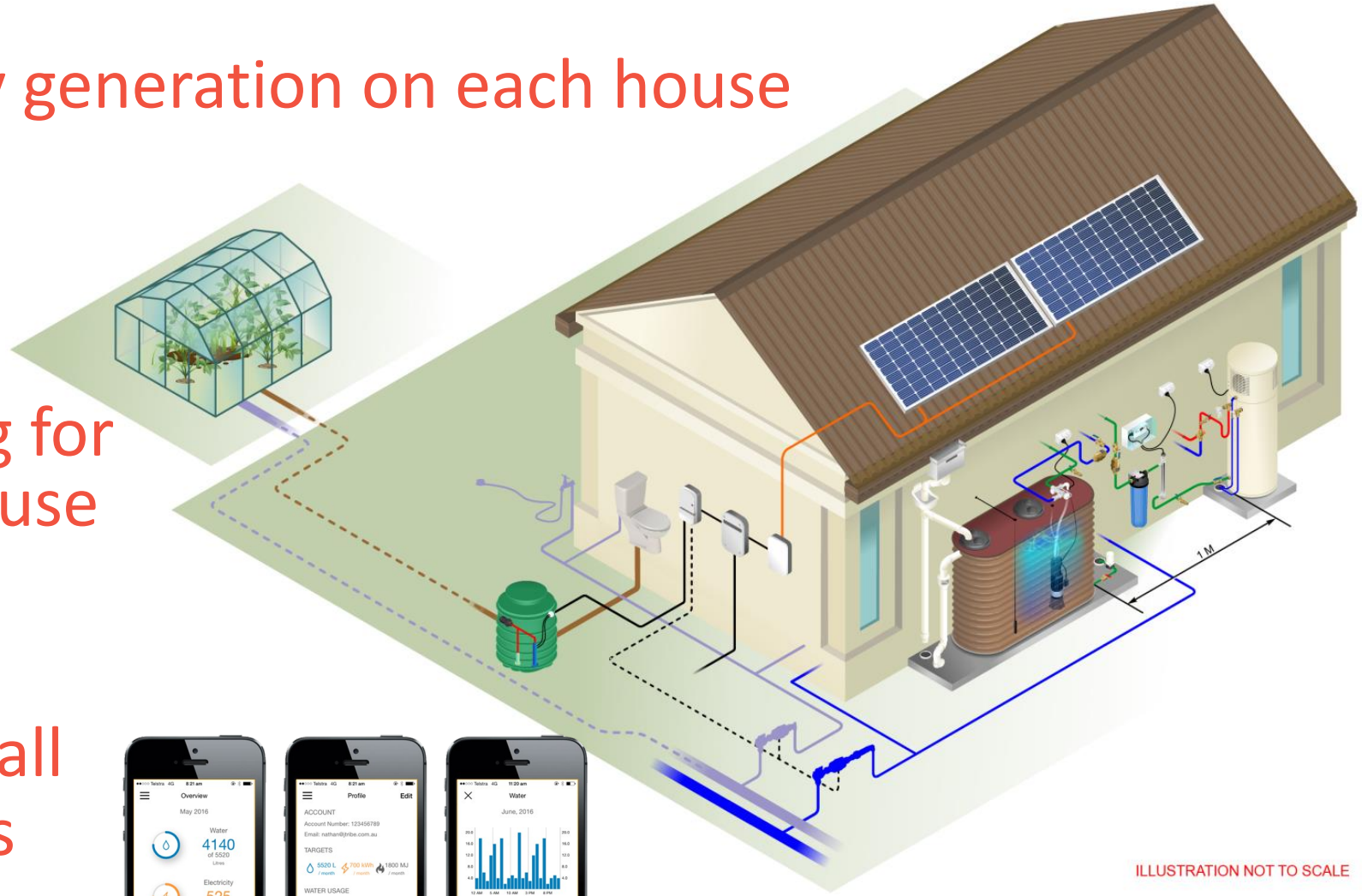
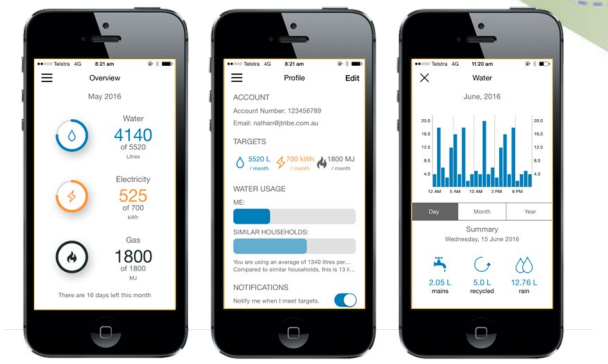


ILLUSTRATION NOT TO SCALE



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AQUAREVO

Expected Outcomes

1 million litres of rainwater storage capacity in household rainwater tanks

55% reduction in annual stormwater discharge

70% reduction in potable water use compared with average households

Highly attractive housing estate with high sustainability & liveability value

26% reduction in peak stormwater runoff flows

35% reduction in stormwater nutrient loads beyond best practice

55ML/year of water infiltrated to enhance soil moisture and support **urban forest**

Third Story

Using Digital Twins to Help Achieve Multiple and Integrated Urban Development Outcomes

Christian Urich, Monash University, and
CRCWSC Tools & Products team

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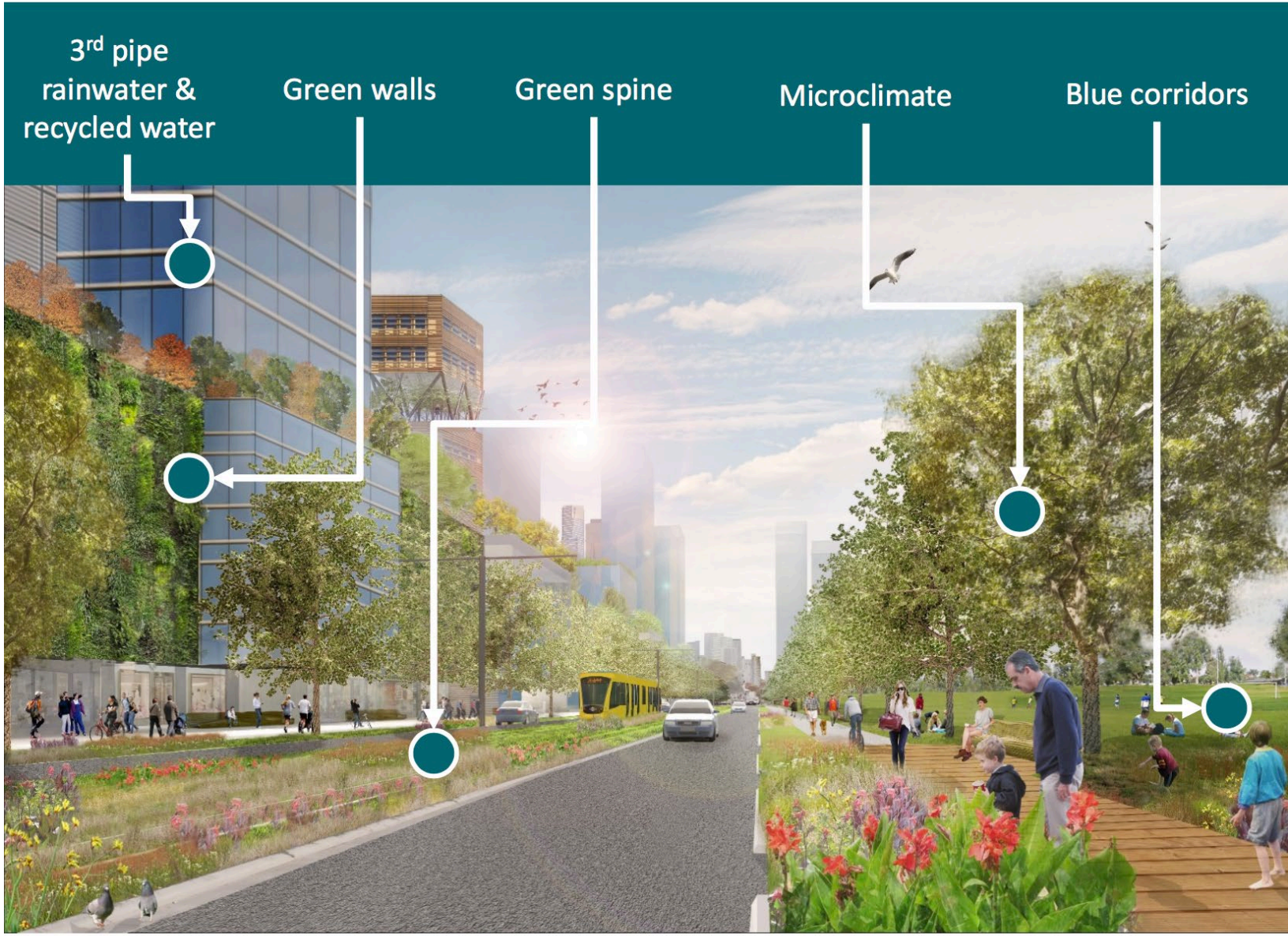
Water Sensitive Cities Scenario Tool

Testing and evaluating:

- **Concept ideas**
- **Urban design scenarios**
- **Technology solutions**
- **Policy & regulation impacts**



CRC for Water Sensitive Cities

Digital Twin – Inputs

Base Data

- **Urban form**

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Digital Twin – Inputs

Base Data

- Urban form
- **Elevation and soil data**

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Digital Twin – Inputs

Base Data

- Urban form
- Elevation and soil data
- **Socio – demographic data**

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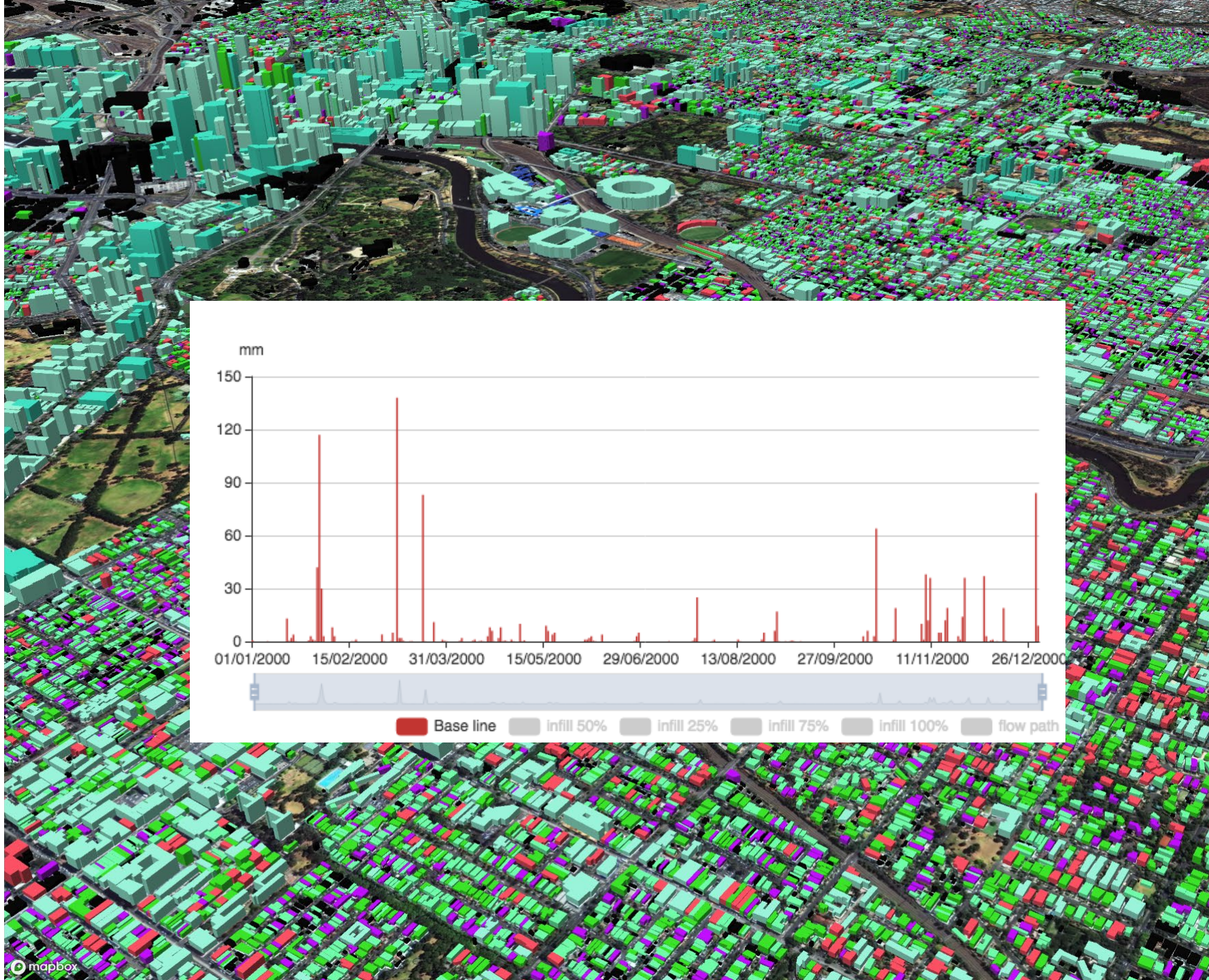
Digital Twin – Inputs

Base Data

- Urban form
- Elevation and soil data
- Socio – demographic data
- **Climate data**



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Digital Twin – Inputs

Base Data

- Urban form
- Elevation and soil data
- Socio – demographic data
- Climate data

Predictive Information

- Heat vulnerability mapping
- Future climate predictions
- Urban population trends

Own Data

- Land use zoning
- Infrastructure data
- …

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Digital Twin – Models & Scenarios

Urban Development

- Greenfield and infill

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Digital Twin – Models & Scenarios

Urban Development

- Greenfield and infill
- Urban design typologies

Existing

Business-as-usual (BAU)

Water Sensitive Urban Development (WSUD)

Digital Twin – Models & Scenarios

Urban development

- Greenfield and infill
- Urban design typologies

Infrastructure Placement

- Combined sewer-stormwater solutions
- Blue-green technologies
- Trees, parks, public/private open spaces
- Activity corridors (walkways, bike paths etc.)

Digital Twin – Integrated Performance Assessment

- Urban heat impacts
  - Land surface temperature
  - Air temperature
  - Human thermal comfort

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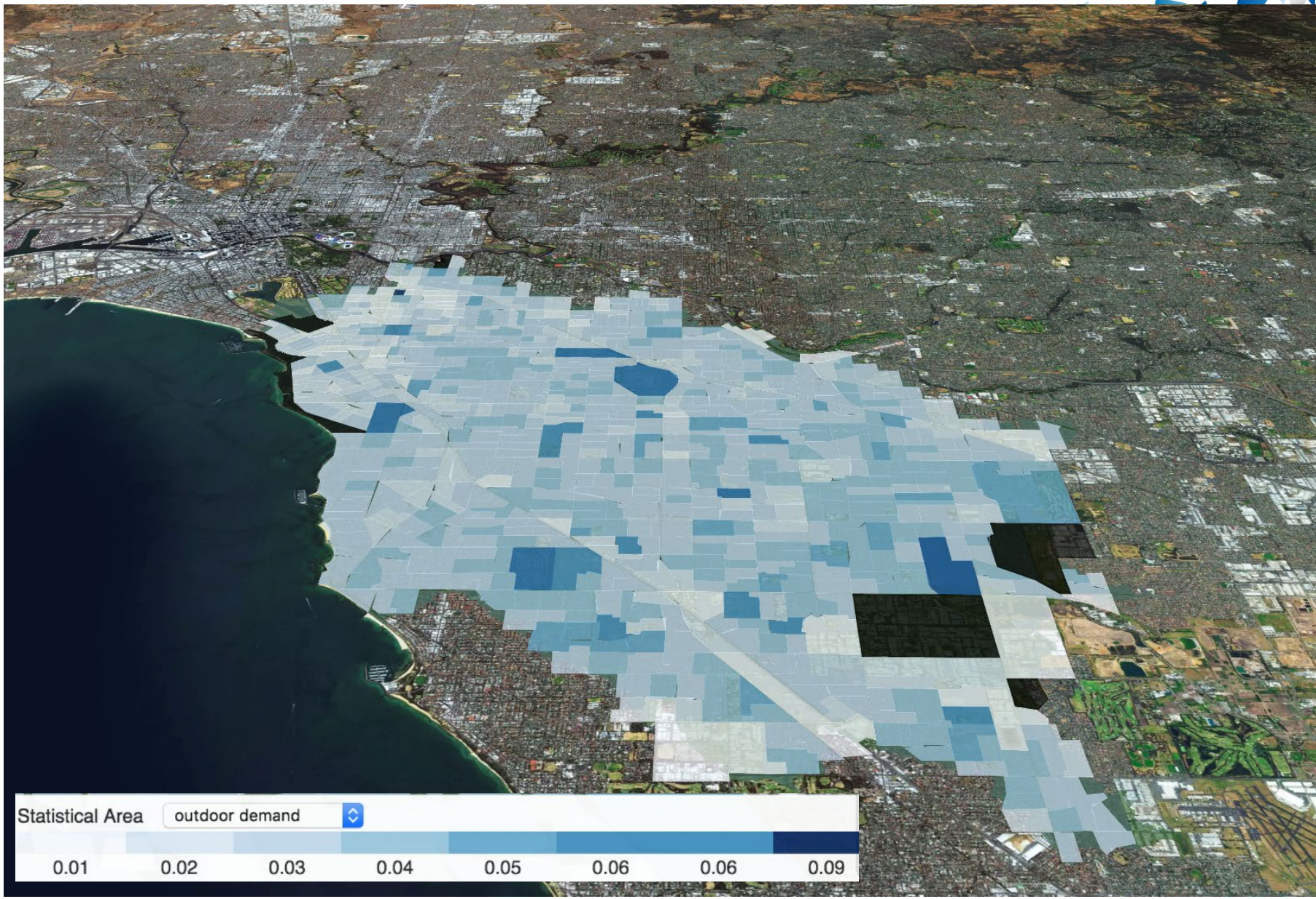
Digital Twin – Integrated Performance Assessment

- **Urban water cycle / balances**
- **Nutrient run-off**

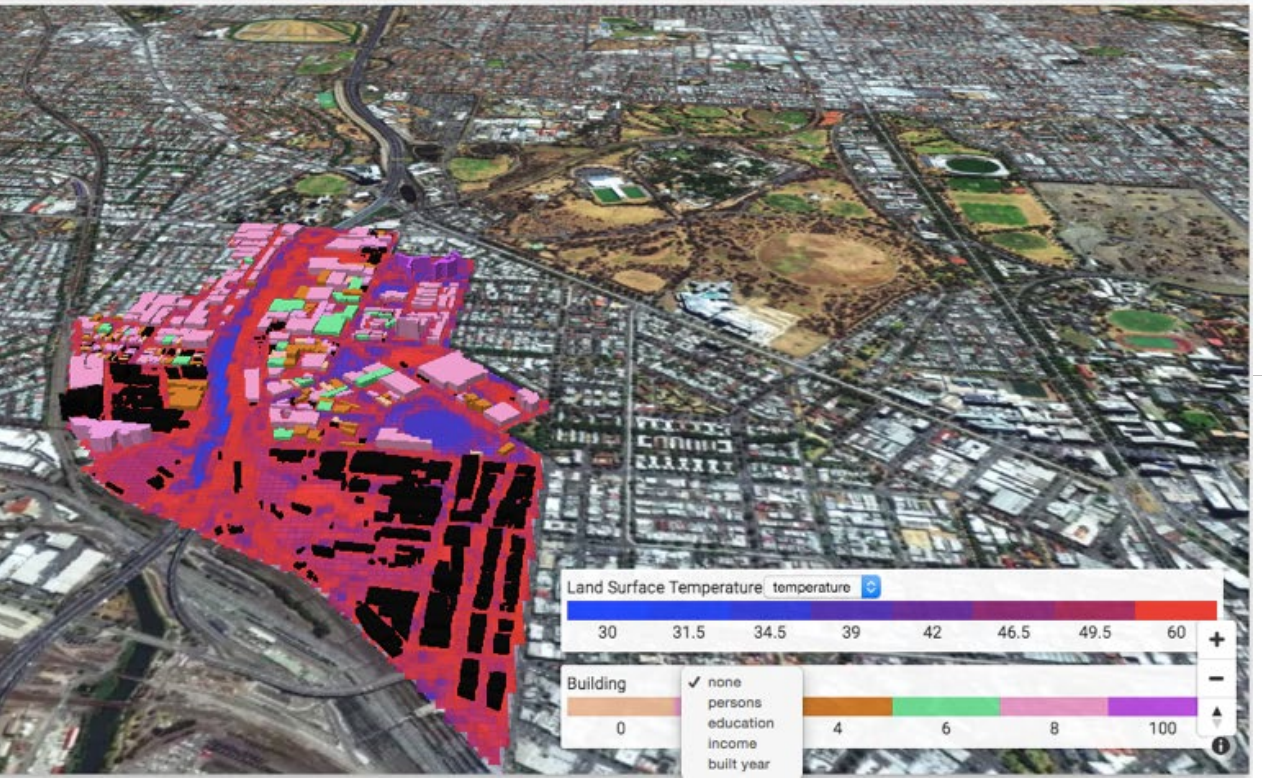


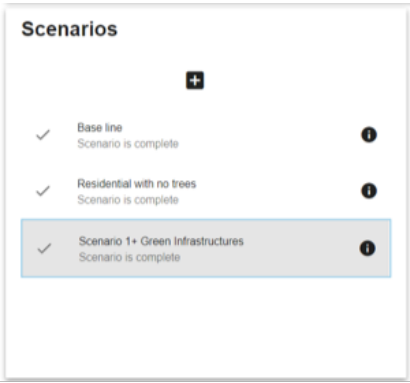
Digital Twin – Integrated Performance Assessment

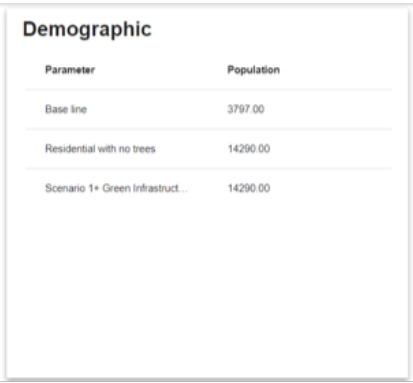
- **Stormwater management options**
- **Overland flows & flooding**

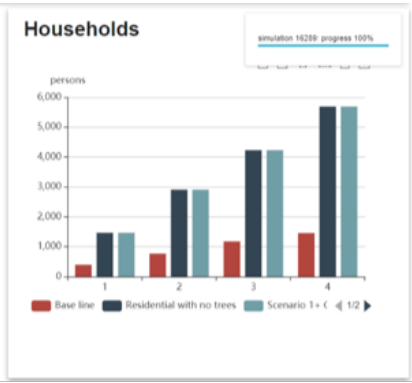
Analytics & Combined Impact Assessments

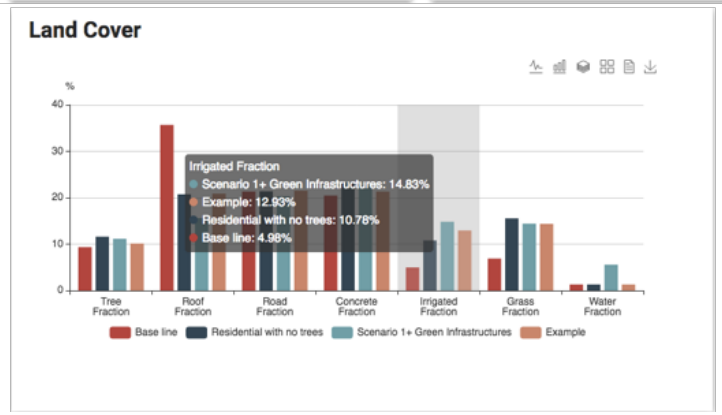
- **Scenario planning and testing**
- **Diagnostic tools**

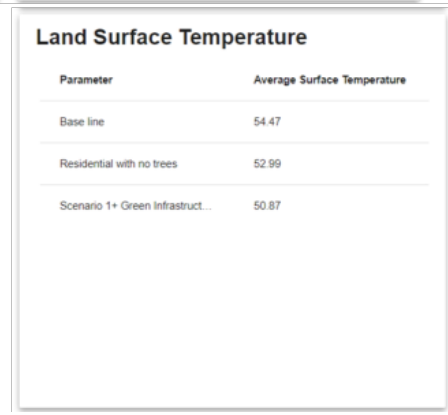












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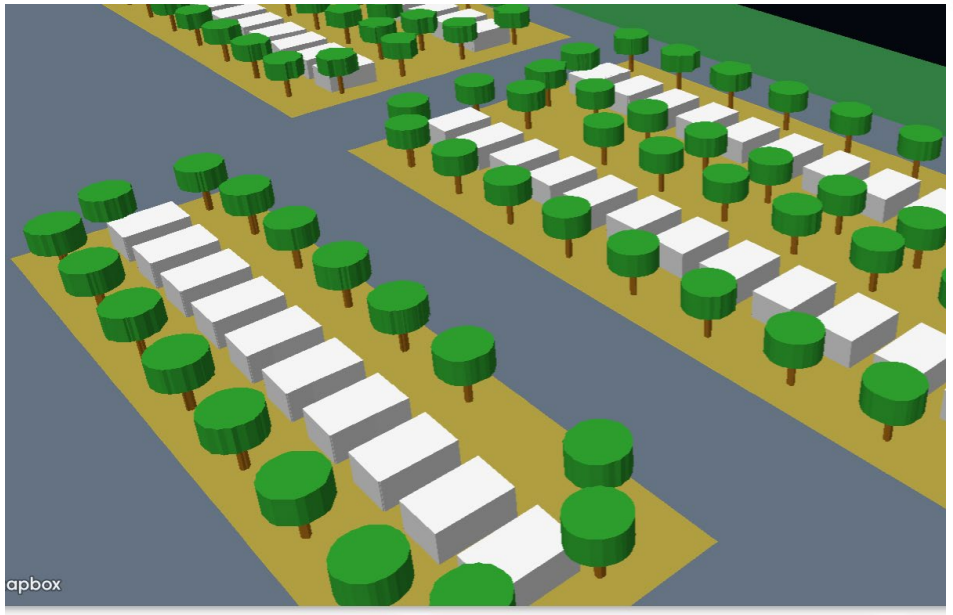
Digital Twin – Case Study Results



Models used:

- Land Surface Temperature
- Urban Heat assessment
- Water Cycle Model
- Catchment Runoff

BAU → WSC

- 5ºC land surface temperature reduction
- 285 ML/yr runoff reduction
- 1,630 kg/Total N/yr abatement

Sally Boer, E2Design Lab

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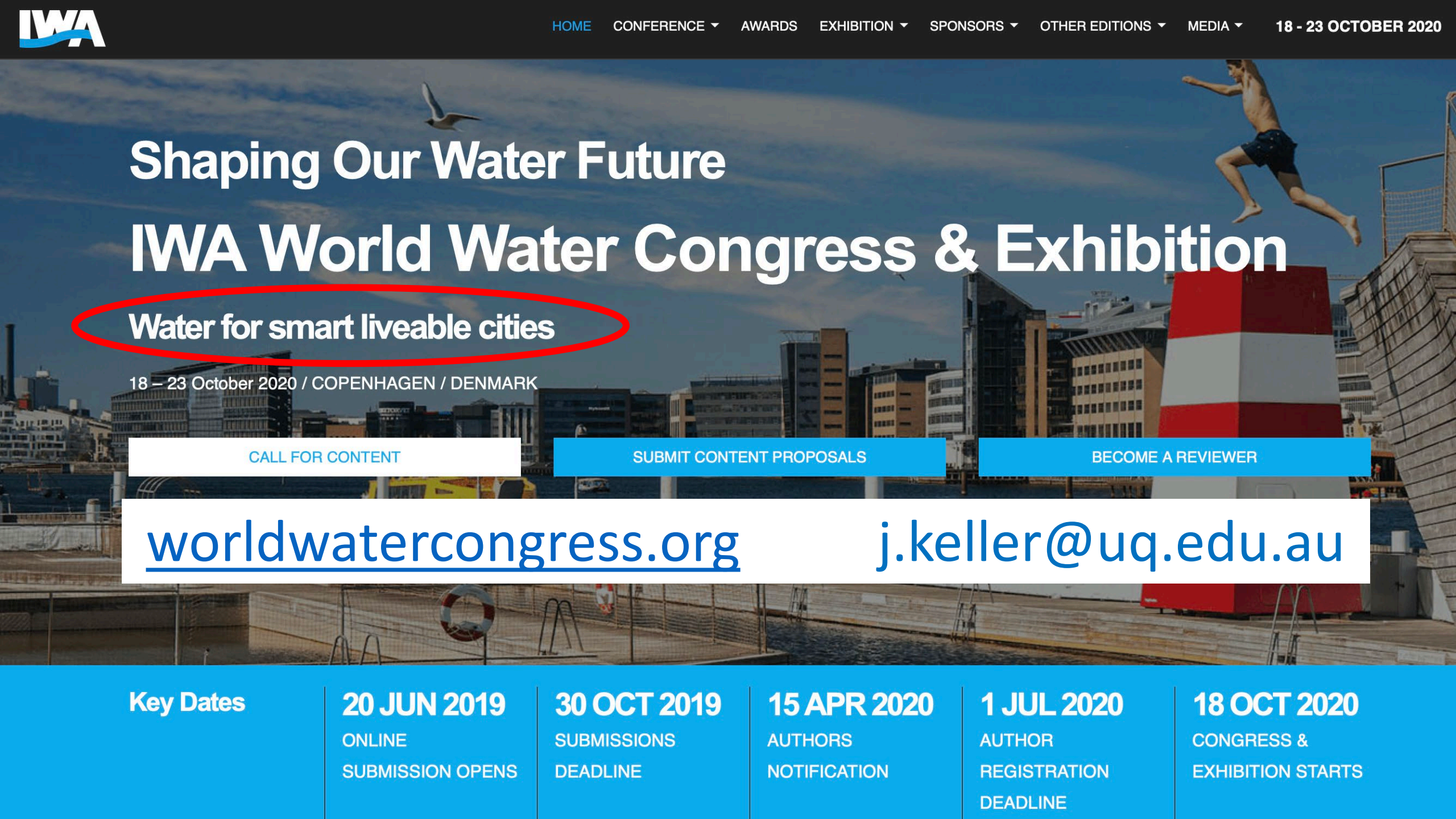
Concluding Thoughts

- **Purpose-driven innovation** is needed and highly valuable
- Whole-of-system **integration and collaboration** are essential to achieve the best overall outcomes and impacts
- **Socio-economic considerations** are critical to be included, because people make decisions for their reasons, not yours!

These solutions won't fix all challenges to urban development, but they can make some real and positive contributions!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j.keller@uq.edu.au
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ONLINE SUBMISSION OPENS
30 OCT 2019
SUBMISSIONS DEADLINE
15 APR 2020
AUTHORS NOTIFICATION
1 JUL 2020
AUTHOR REGISTRATION DEADLINE
18 OCT 2020
CONGRESS & EXHIBITION STARTS

Further Information Available Here

- **Story 1:**
  - Further info and details of academic papers is available on http://www.awmc.uq.edu.au/integrated-approach-iron-salt-use-urban-water-systems
  - As the project is nearing completion, a range of new papers will be coming out in coming months, please get in touch with Prof Zhiguo Yuan (zhiguo@awmc.uq.edu.au) for updates
- **Story 2:**
  - Further info on this is available on https://watersensitivecities.org.au/content/aquarevo-case-studysmart-model-for-residential-water-management/
  - Urban cooling information, including economic evaluations is also available from https://watersensitivecities.org.au/?s=urban+cooling
  - Much more information and links to academic papers on various related topics can be accessed through the CRCWSC website https://watersensitivecities.org.au
- **Story 3:**
  - Further info and details of WSC Scenario tool https://watersensitivecities.org.au/solutions/water-sensitive-cities-scenario-tool/
  - Other outputs from CRC for Water Sensitive Cities is available on website https://watersensitivecities.org.au