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Canada's Premier Stormwater and Erosion and Sediment Control Conference

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HOSTS

Presented by:

Toronto and Region Conservation Authority

In association with:

Lake Simcoe Region conservation authority

Credit Valley Conservation inspired by nature

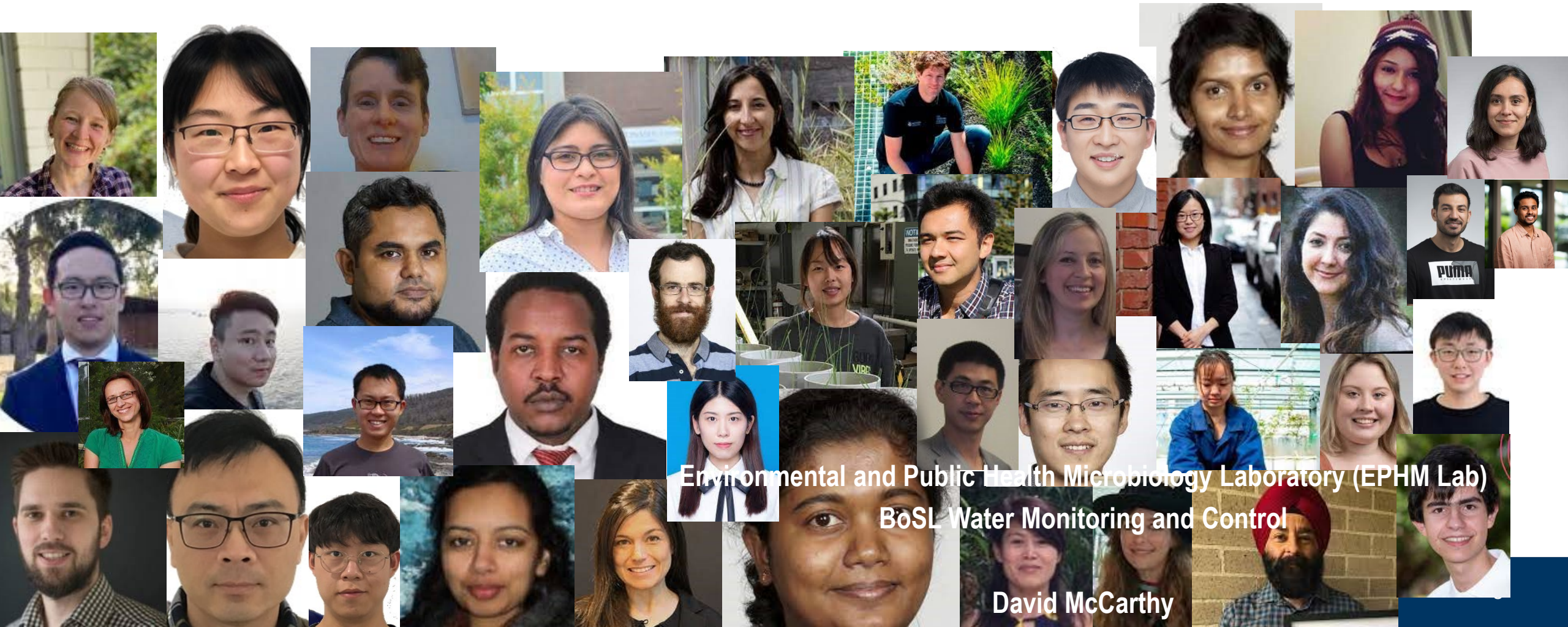
IoT enabled urban stormwater management ::

RTM and RTC

David McCarthy

University of Guelph
Queensland University of Technology
Monash University

A huge thanks to all of the team over the years…

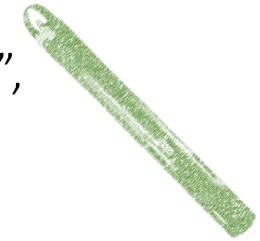


My research interests…

- My research area is water management, with specialised skills in:
  - pollutant fate and transport in environmental systems
  - surveillance of pollutants, including novel sampling and assay methods
  - health-related water microbiology and human health risk assessments
  - methods to protect ecosystems & human health, including green treatment technologies
  - sensing and modelling of biophysical-human systems to understand and reduce risks

Our sensing and sampling journey…

- Frustrations galore!
  - Loggers which could log to the cloud – costly, complicated, confusing, and rarely “all-in-one”, high power
  - High-cost sensors – prohibits collecting spatially distributed datasets
  - High maintenance frequency for sensors – further increases costs and risks
  - Risky to jump into pits
  - Often only the simple sensors worked well – more complicated parameters were on offer at high cost and high degrees of unhappiness
  - All commercial, locked-in technology – not very accessible to all walks of life



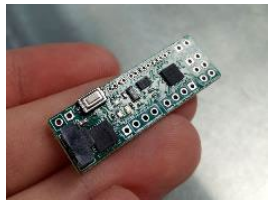
- In 2013, we developed a small research group focussing on water monitoring and control – **BoSL**
  - Many sensors exist – our aim was not to recreate the same
  - **IoT field was rapidly advancing**

Where we began…2013!

To achieve our vision of high spatial resolution monitoring

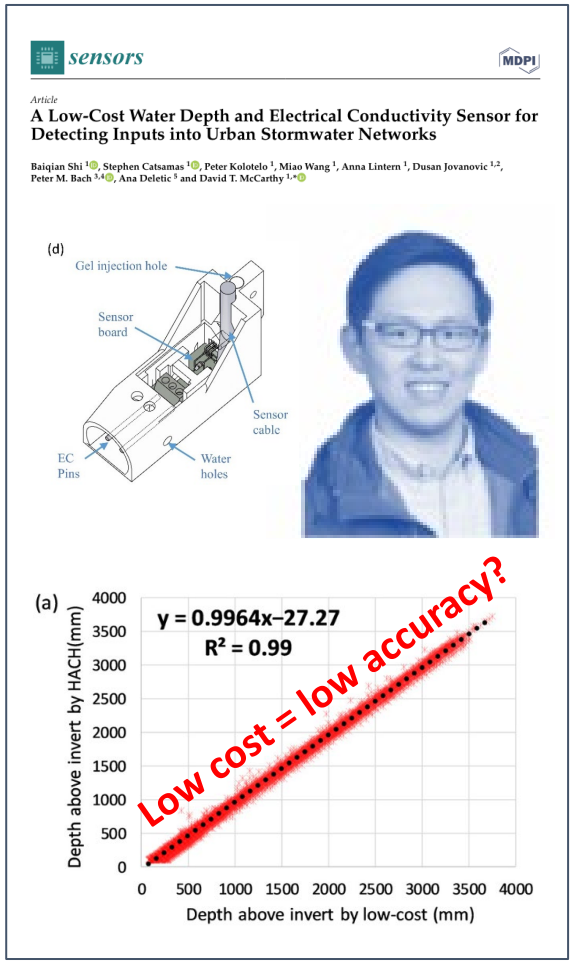
OPEN SOURCE & OPEN IP
LOW COST

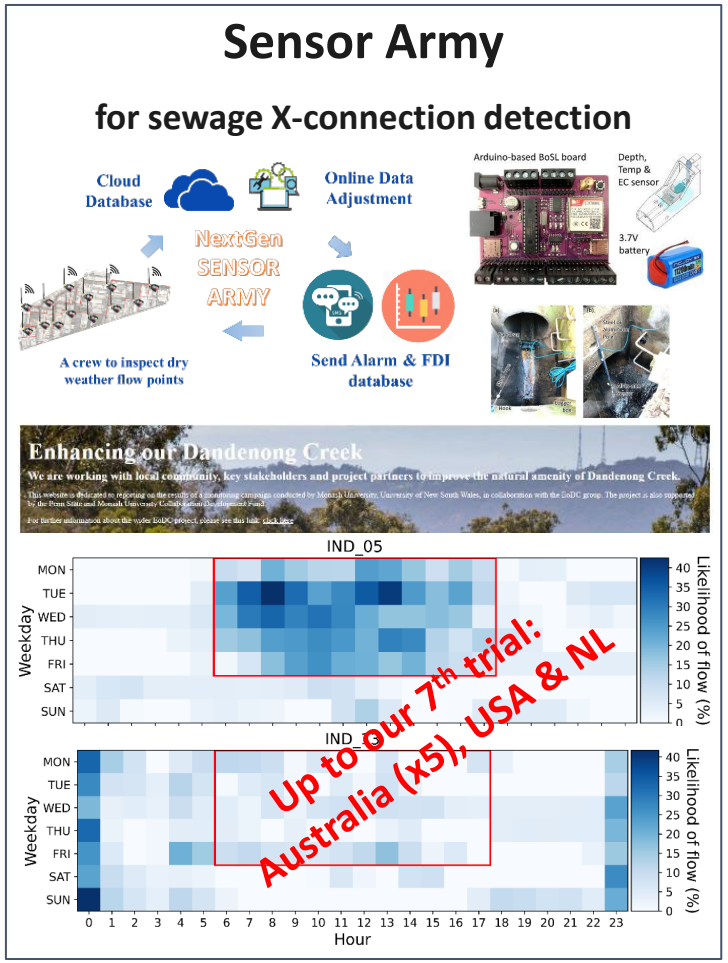
…we could probably do better…

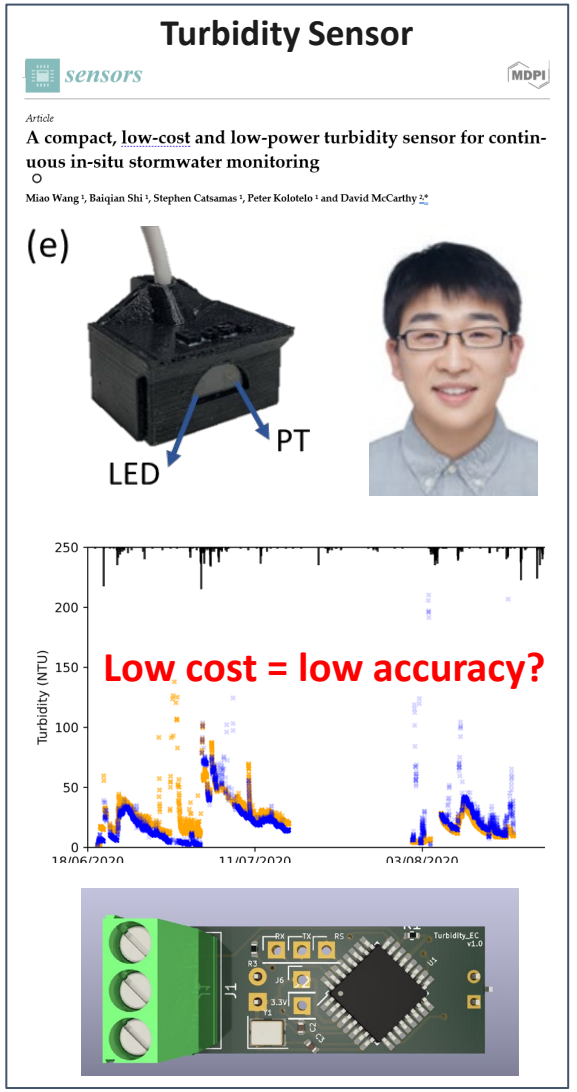


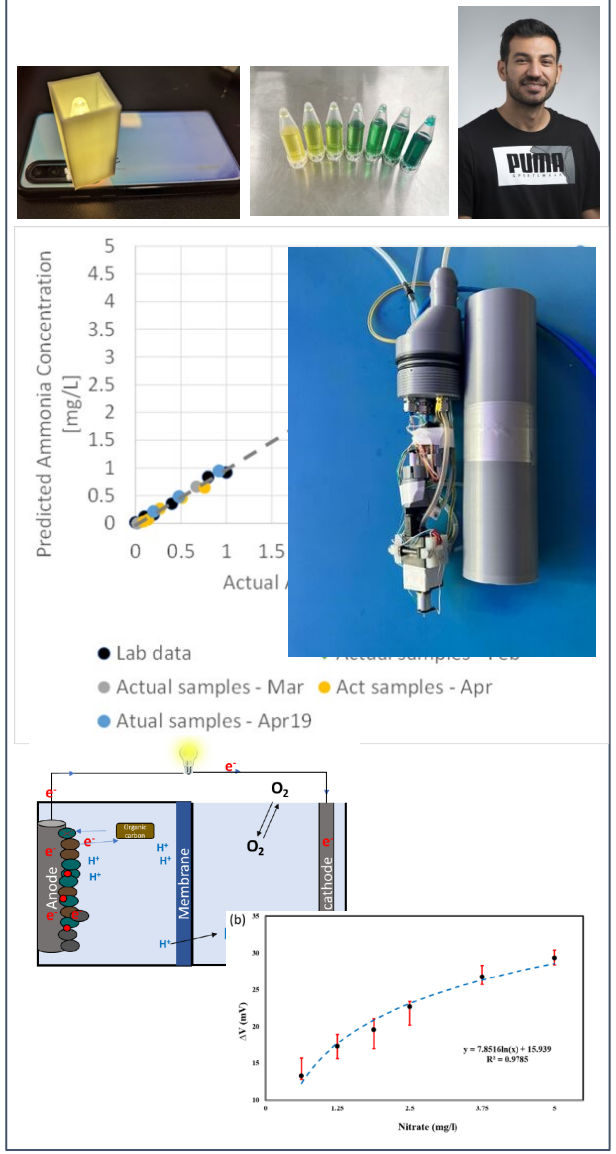
In-water sensors

Maintenance
Installation



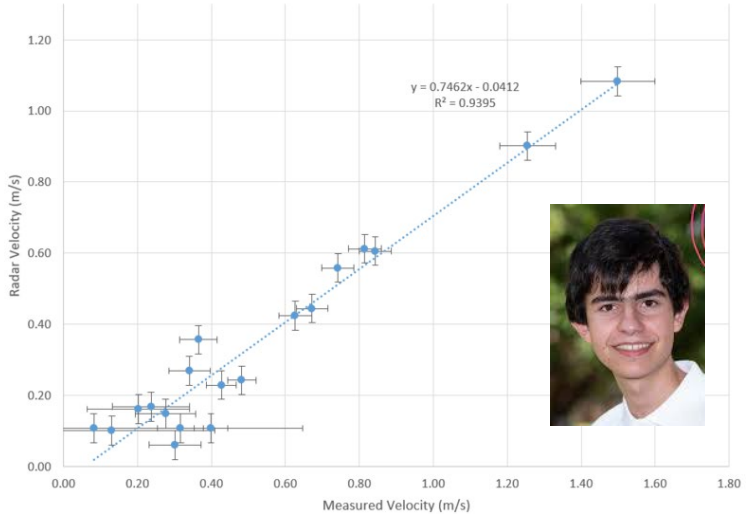


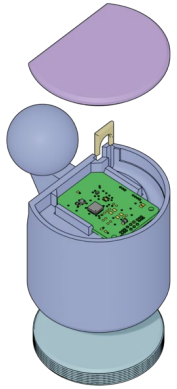




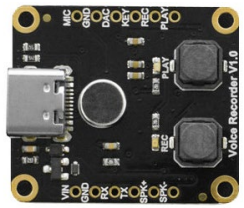
Out of water sensors – ground-based non-contact

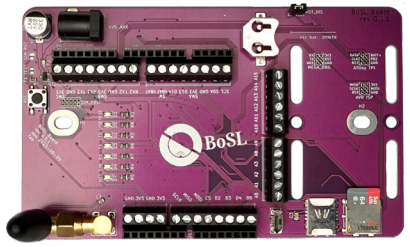
NON-CONTACT DEPTH & VELOCITY RADAR

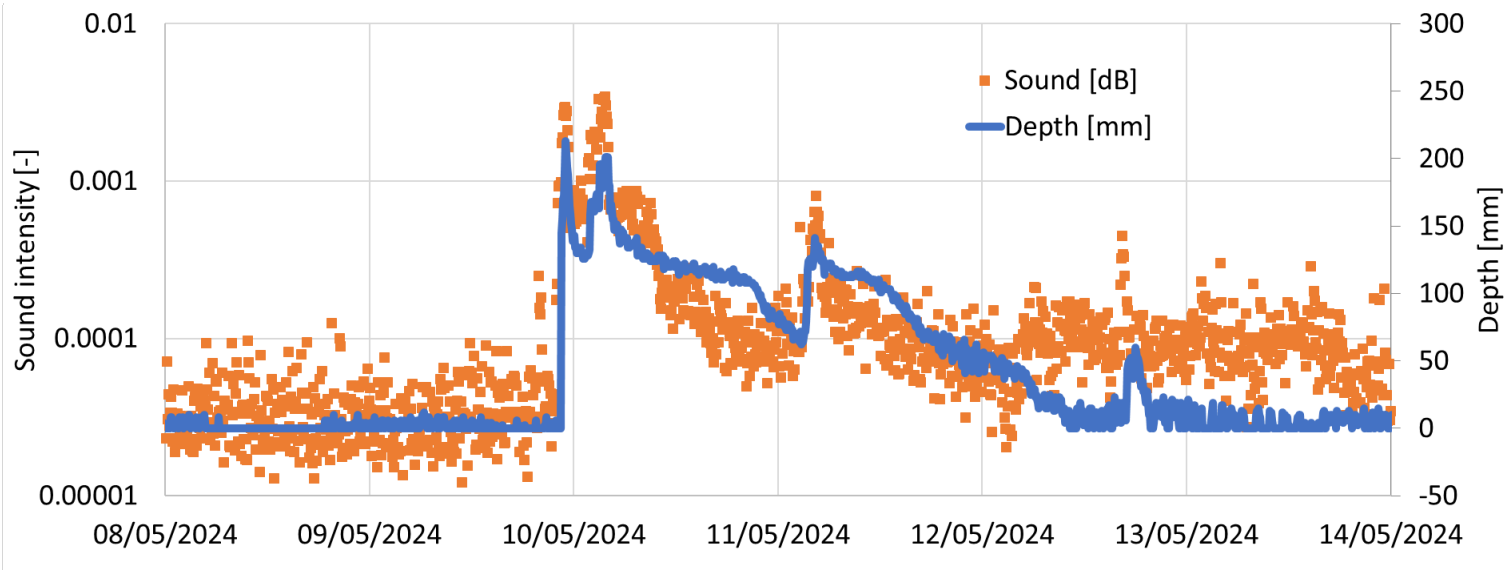




USING AUDIO FOR SYSTEM MEASUREMENTS



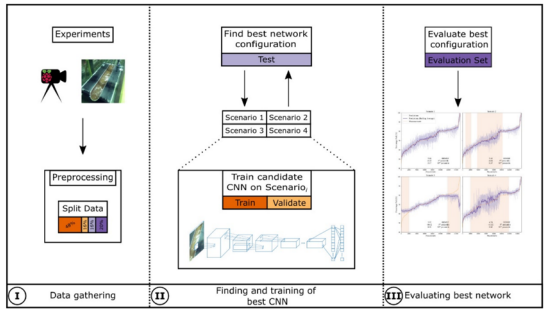




A picture is worth 1000 words…

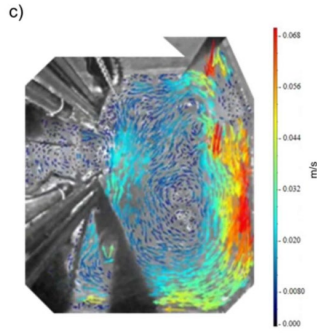
Flow sensing

Meier *et al.*



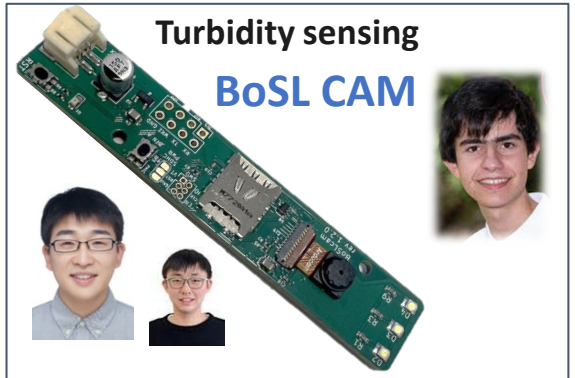
Fat berg and depth sensing

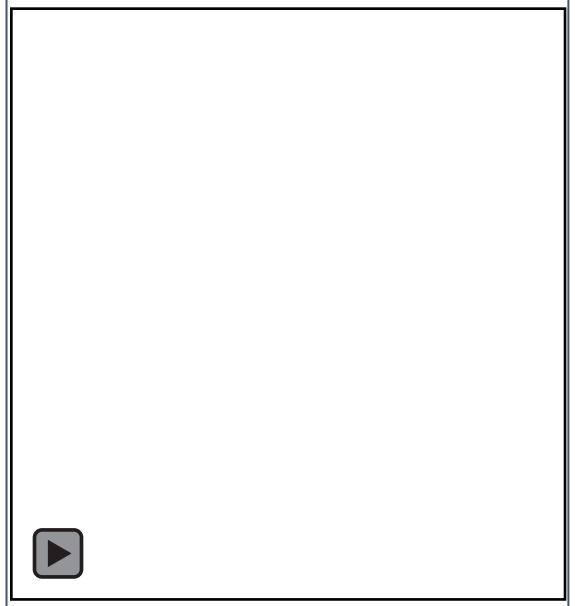
Moreno-Rodenas *et al.*



Turbidity sensing

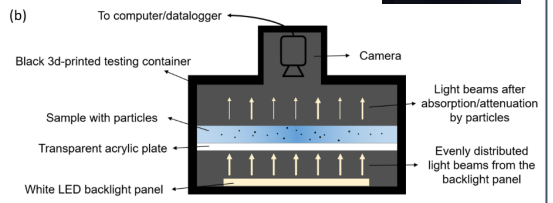
BoSL CAM

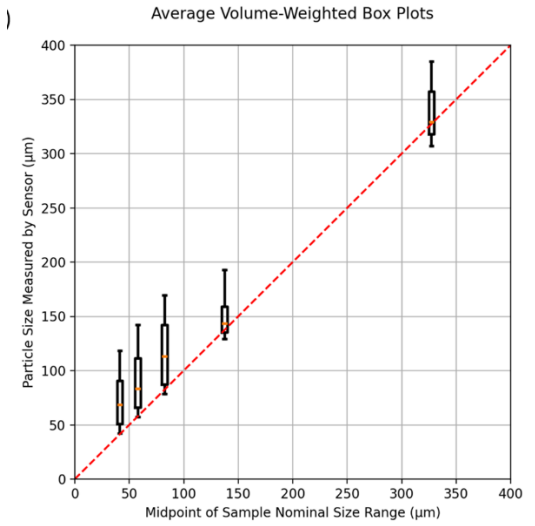




Particle Size Distribution

BoSL CAM



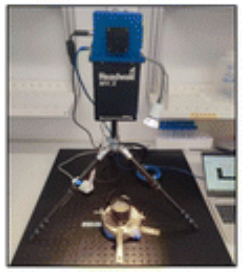


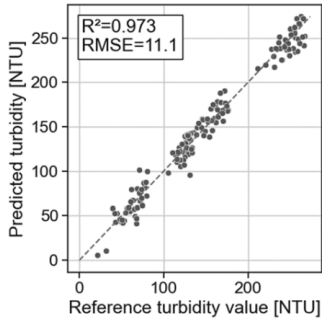
If a RGB picture is worth 1000 words, then what is a hyperspectral image worth?

Water quality sensing

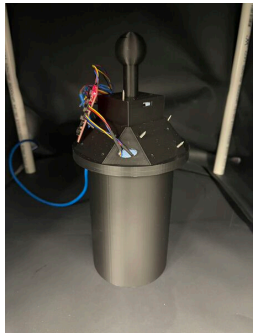
Lechevallier et al.

Hyperspectral acquisition of wastewater

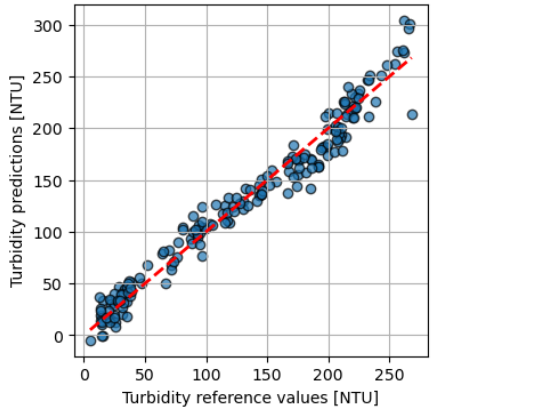




Low-cost water quality sensing



Global using Average Reading (R^2 = 0.97, RMSE = 14.4 NTU)



Real time control of SW treatment systems

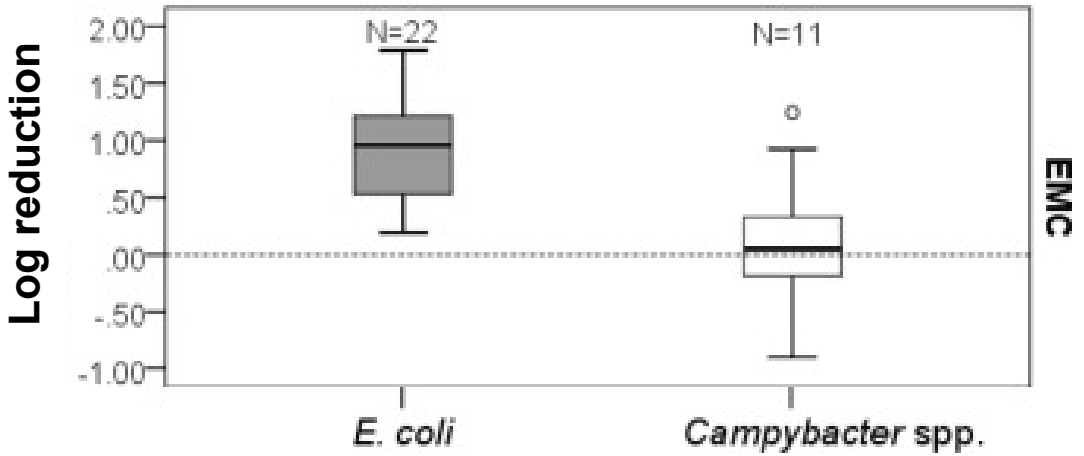
:: biofilters and wetlands

Existing SW systems weren't consistently removing pollutants

Faecal Indicator Removal Performance

E. coli (-611) - 92%

Enterococci (-132) - 86%

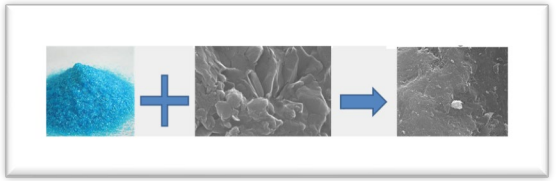


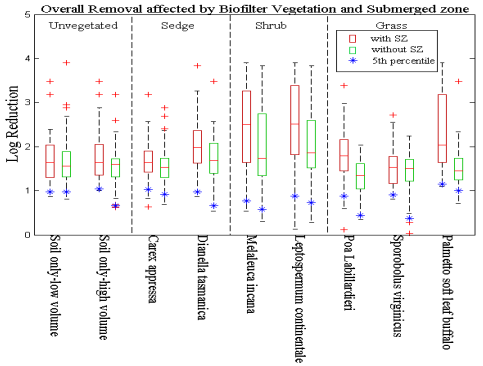
Optimisation of SW treatment systems

- Spent a decade trying to optimise the design of biofilters and wetlands for pollutant reduction:
  - Plant selection, including antimicrobial producing plants
  - Media type and antimicrobial coatings
  - Retention time and storage zones

- Able to increase the overall performance – not a wasted decade
  - But still a high degree of variability in performance

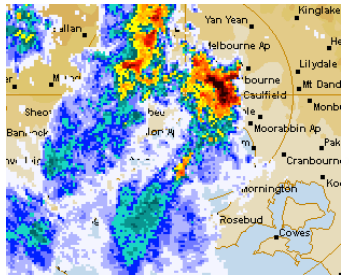
- Further work needed us to move beyond design optimisation
  - Instead we needed to control these highly variable systems

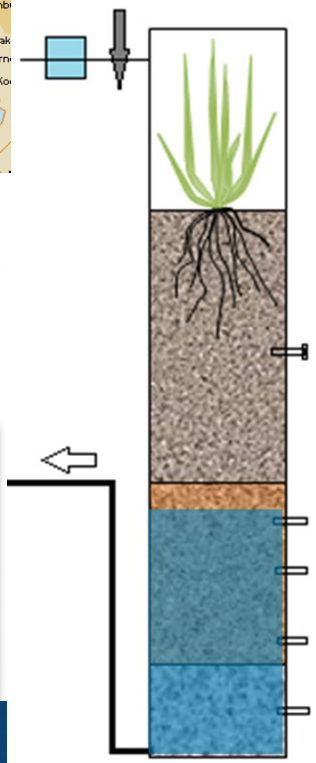




Real-time control of biofilters for pollutant removal

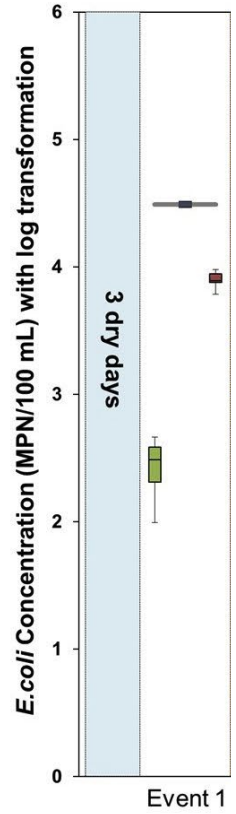
- Operational conditions are also really important!
  - If we could control these, then perhaps we could achieve a better pathogen reduction
- Real time monitoring & control with cheap actuators and sensors
  - Low cost, simple, easy to maintain and easy to retrofit





Real-time control of biofilters for pollutant removal

- **Strategy 1:** ensure water only enter maximum every 12 hours

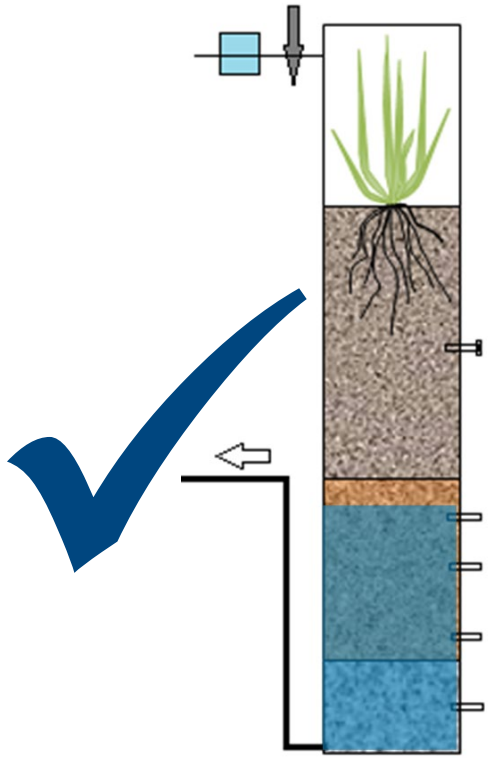


Inflow concentration

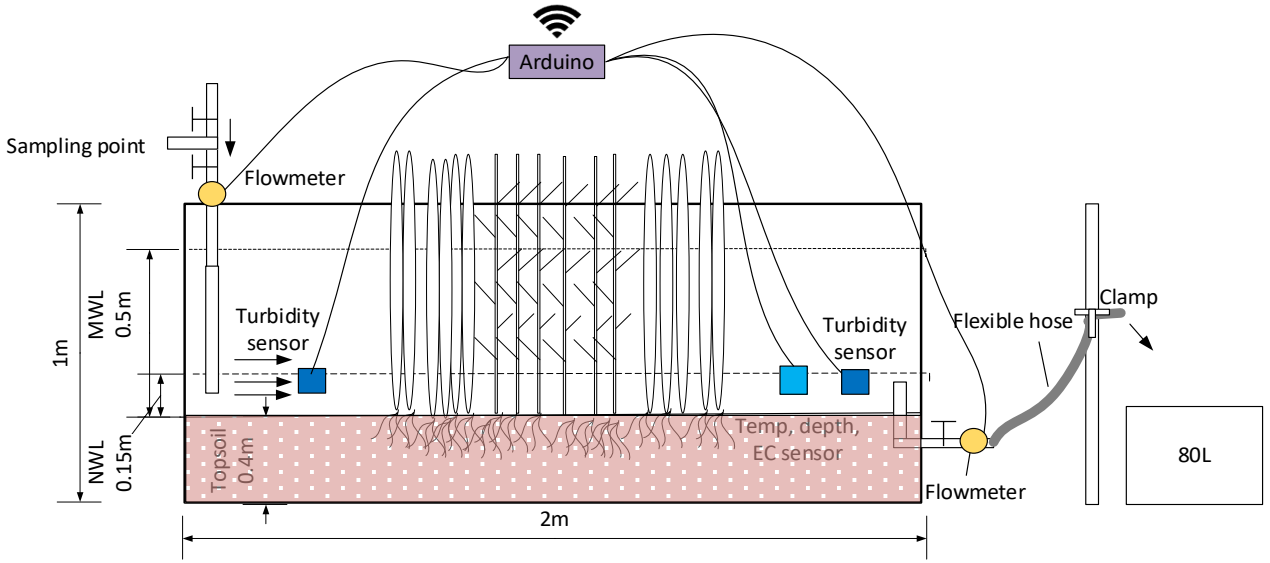
Outlet concentration for normal system

Outlet concentration for Real Time Controlled system

RTC on biofilters works…what about wetlands?

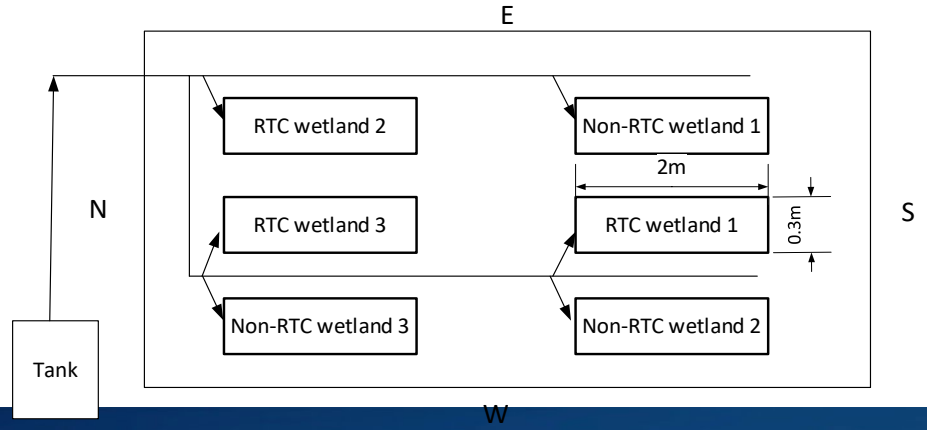


Real-time control of wetlands for pollutant removal



(a)

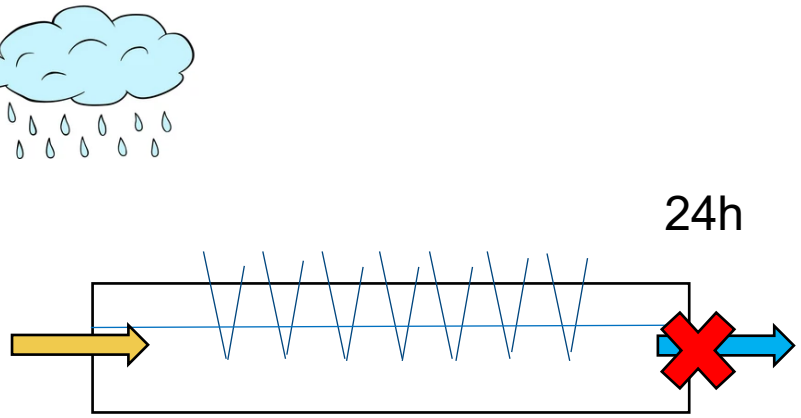
Pipe system



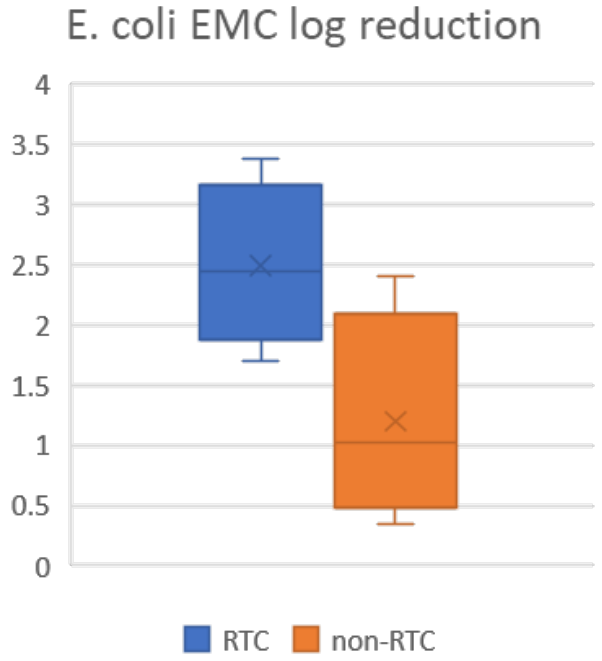
(b)

Real-time control of wetlands for pathogen removal

- RTC Strategy 1: Outlet closure

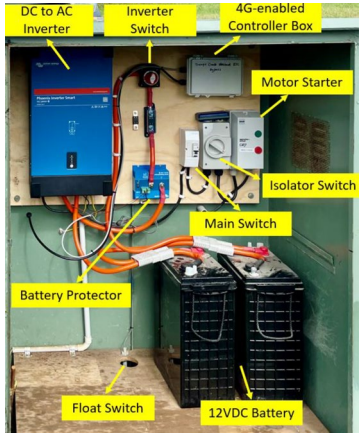


(increase retention time)



Activating lazy wetlands
:: using RTC to get them to their full potential

What about in practice? In field conditions…



Melbourne Water

South East Water

Australian Government
Australian Research Council

water level regimes

vegetation cover

water quality treatment processes

pollutant removal and hydrologic regime

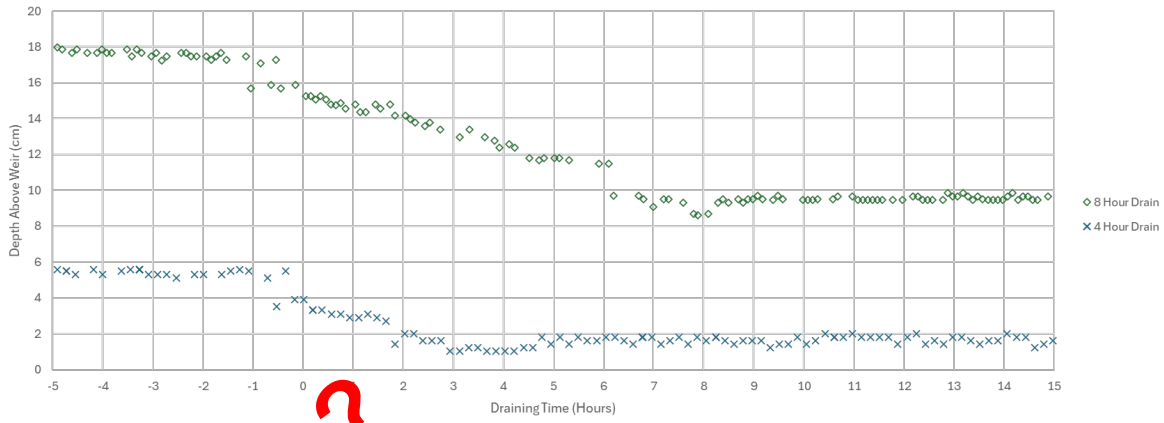
extraction of water for non potable uses

flood mitigation

Activating lazy wetlands
:: using RTC to get them to their full potential

- Pre-drain – drain wetland before predicted rainfall event

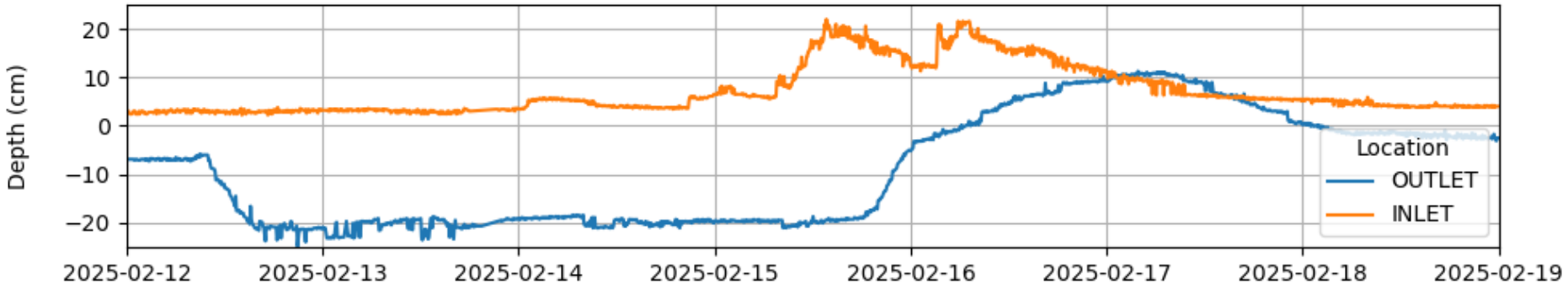
Draining Rate ≈ 1 cm / hr



Quality?

Activating lazy wetlands :: using RTC to get them to their full potential

- Pre-drain before 30mm event & hold without release for >24hrs

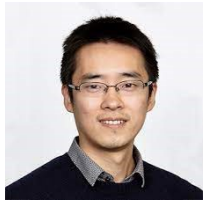


Conclusions & future work for our team….

- Conclusions:
  - Low-cost sensors are being developed
    - Not just by us – huge movement!
    - Low maintenance, non-contact
    - Challenge – low cost does not mean low-accuracy – cost-appropriate
  - Real time monitoring of urban water systems is a useful and cost-effective method of determining illicit connections
    - But has so much more potential – monitoring of assets
  - RTC can help improve pollutant removal in stormwater biofilters and wetland systems
- Future:
  - Sensor development and testing – non-contact, optical sensors, etc.
  - Development and testing of RTC strategies
    - Field testing of RTM and RTC for both biofilters and wetlands
    - Development of guidelines

If you are interested in RTM and RTC:

- If interested in RTM or RTC, a few groups to check out:
  - Ours – QUT, University of Guelph, and BoSL www.bosl.com.au



  - Kefeng Zhang at University of New South Wales (Sydney, Australia)

  - Tim Fletcher, Uni. of Melb. (Australia) and Fred Cherqui, INSA (Lyon, France)

  - South East Water's Tank Talk (Melbourne, Australia)

  - Branko Kerkez, University of Michigan (USA), Jon Hathaway at University of Tennessee (USA) & Ryan Winston at Ohio State

IoT WATER HUB

$11.5M ARC ITRH in IoT for Water Hub

WE WON!!!!!

Our many workshops held from 2019 to 2023 identified seven research themes required to deliver the IoT Water Hub vision:

Theme 1: Sensors, placement & operation

Theme 2: Networks, data, security, governance & standards

Theme 3: Advanced analysis & visualization of integrated data

Theme 4: Asset control, optimisation & decision making

Theme 5: Business models & engaged communities

Theme 6: Best-practice application & upscaling

Theme 7: Training and knowledge transfer

10 Research providers

36 partners

Developers & suppliers

Service providers

Regulators

End-users

17 co-led projects, 7 themes, 7+ post-docs, 3+research assistants, 24+PhD students

Australian Government

Australian Research Council

Research Hubs engage Australia's best researchers to develop collaborative solutions to the strategic priorities. The focus is on the creation of **industry** and academic partnerships working together on research and development projects to create **innovative and transformative solutions for industry.**

Acknowledgements

EPHM Lab

BoSL
Water Monitoring and Control

QUT Queensland University of Technology

MONASH University

EPA VICTORIA | Environment Protection Authority Victoria

Melbourne Water

South East Water

VICTORIA State Government | Department of Health

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