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Student Edition

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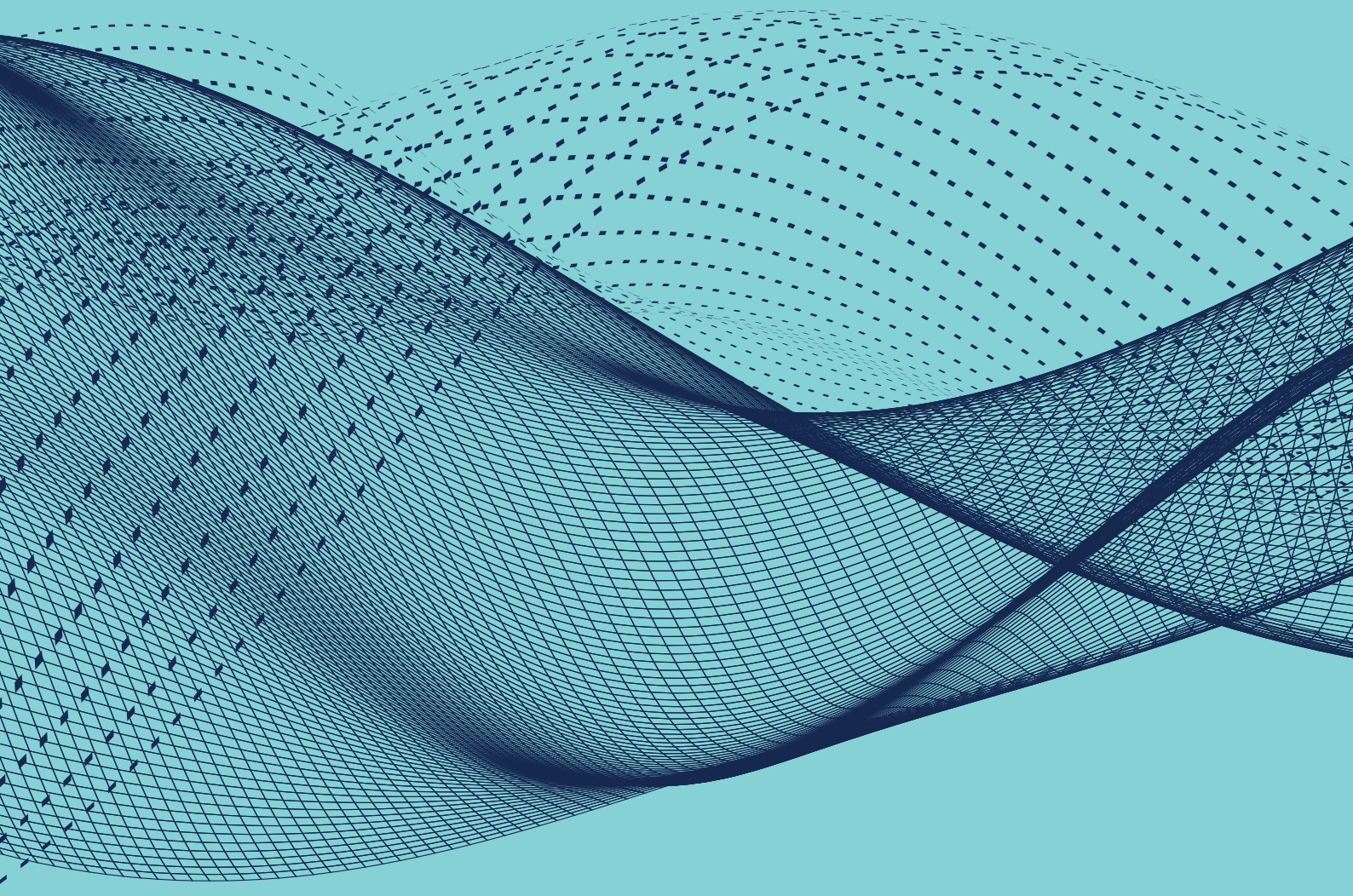

Student Research Showcase 2025

The Australian Water Association's Water e-Journal Editorial Committee is proud to spotlight the future leaders of Australia's water sector through this special edition of the Water e-Journal, dedicated entirely to ground-breaking student research. Featuring PhD students from across the country, this showcase highlights innovative studies tackling some of the most pressing challenges in water today.

Each research summary offers a glimpse into the student's objectives, the critical questions they're addressing, key discoveries so far, and the tangible benefits their work can bring to the water sector.

This year's collection features research addressing a diverse array of pressing topics, including innovative approaches to biological treatment processes, sustainable drinking water solutions, the removal of microplastics and PFAS, advanced real-time water quality monitoring, reusable water treatment technologies, collaborative water governance, and the role of land use management in catchment health. These studies reflect the ingenuity and passion of emerging water professionals and their commitment to shaping a sustainable future for the sector.

We invite you to explore this inspiring issue and learn more about the exceptional work shaping the future of water in Australia. If a particular study piques your interest, feel free to connect with the students or their universities — contact details are provided within the summaries.

On behalf of the Water e-Journal Editorial Committee,

Happy reading, and here's to supporting the next generation of water specialists!

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A comprehensive elastic water column model for water distribution system analysis

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Supervisors: Dr Aaron Zecchin, Dr Wei Zeng, Prof Martin F. Lambert

RESEARCH SUMMARY

When the research will be completed
2026

Research objectives
The aim of this research is to develop a generalised Elastic Water Column Model (EWCM) for Water Distribution Systems (WDSs) and extend its applications to industry-relevant problems.

Unlike traditional transient modelling tools, such as the Method of Characteristics, the proposed model is built entirely on ordinary differential equations (ODEs). This creates a fast, tunable, and mathematically structured framework that is compatible with powerful techniques from control theory.

Problems or questions you are trying to address
Pumps, pressure-reducing valves (PRVs), pipes, and controls are usually designed separately, despite their strong interactions during transient events. Hidden system vulnerabilities often remain undetected until failures or operational conflicts occur, for example, PRV-PRV interaction, resonance effects, or unexpected behaviour during system disturbances.

Existing transient models also lack a clean state-space structure, making it difficult to apply modern control and estimation techniques to real-world networks.

How will your research benefit the water sector?
This project provides the first fully generalised EWCM for WDSs, capable of modelling the dynamic behaviour of pipes, junctions, pumps, and PRVs within a single set of ODEs. Key benefits include:

1. A bridge between hydraulic modelling and control theory, enabling utilities to use advanced tools for optimisation, fault detection, and real-time decision support.
2. Ability to simulate dynamic interactions between network components and explore scenarios that may lead to operational problems.
3. A fast model suitable for what-if testing, controller design, and optimisation studies.
4. A foundation for improving network resilience, better design of PRV control regions, and understanding transient risks.

Findings to date

1. The generalised EWCM has been successfully formulated for complex networks and validated against both slow- and high-frequency transient scenarios.
2. Dynamic elements (pumps and PRVs) were integrated into the model, allowing investigation of controller interactions and potential conflicts across a network.
3. Modal analysis was applied to WDSs for the first time using the EWCM, enabling identification of resonance frequencies and spatially vulnerable regions.
4. Participation factor analysis offers a new approach for high-speed sensor placement, helping utilities understand where transient energy concentrates.
5. The EWCM was used to develop and test observer-based estimation tools (High-Gain Observer, Sliding-Mode Observer) for reconstructing unknown demands and boundary conditions in real time.

References

Real-time estimation of states and unknown boundary conditions in pressurized pipeline systems, accepted at Mechanical Systems and Signal Processing, 2025, https://doi.org/10.1016/j.ymssp.2025.113664

Generalization and Analysis of Elastic Water Column Model for Hydraulic Transient Analysis of Water Distribution Systems, accepted at Journal of Water Resources Planning and Management, 2025, https://doi.org/10.1061/JWRMD5.WRENG-6946

Modal Analysis of Water Distribution Systems with the Elastic Water Column Model, accepted at Journal of Water resources research, 2026, https://doi.org/10.1029/2025WR041242

Real-time Estimation of Unknown Boundary Conditions in Water distribution network, Ready for submission.

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A systematic analysis of drinking water systems in regional Australia: Integrating First Nations experiences and participation across technical, social and institutional dimensions

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Supervisors: Associate Professor Martin Andersen & Professor Greg Leslie

RESEARCH SUMMARY

When the research will be completed
Completed in August 2025

Research objectives
The objective of this research is to identify the essential components of successful drinking water systems in regional Australia and to develop a systems-based approach for assessing and improving long-term water security. It examines interactions between technical performance, governance, institutional capacity, and community experience to deliver a practical framework for more resilient, equitable, and culturally responsive water management.

Problems or questions you are trying to address
Despite substantial infrastructure investment, many regional communities continue to experience drinking water that is unsafe, unreliable, or culturally unacceptable. Existing assessments focus largely on technical compliance and often exclude small providers and First Nations perspectives, overlooking governance capacity, institutional constraints, and community trust. This research addresses how these gaps undermine system performance and how integrated assessment can reveal systemic vulnerabilities and inform better management.

How your research will benefit the water sector
The project provides the water sector with an evidence-based tool to support equitable investment, improve accountability, and strengthen long-term resilience in regional water systems. By reframing water security as both a technical and social challenge, it supports more sustainable and culturally responsive decision-making. The framework is designed to be adaptable across diverse regional and remote contexts.

Findings to date
Case studies in Walgett and Bourke identified systemic barriers including inequities in Aboriginal communities without potable supply, stranded infrastructure investments and unclear accountability, workforce shortages, ageing assets, and weak governance. These findings emerged through a systems-based assessment framework applied across technical, governance, and community dimensions, demonstrating that water insecurity cannot be solved through engineering fixes alone. It requires integrated approaches that embed First Nations leadership, strengthen governance, and build community trust alongside technical improvements.

These findings informed an Enhancement Framework that translates system weaknesses into targeted, actionable strategies, offering a practical, replicable tool to guide holistic, sustainable, and equitable water management across regional NSW and beyond.

Papers arising from the work that have been published to date

No publications to date, however, the work has received the UNSW T2 2025 Humanitarian Engineering Honours Research Thesis Award and has been recognised as useful by the collaborative partner, the Dharriwaa Elders Group.

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ACKNOWLEDGEMENTS

We would like to acknowledge our valuable collaboration with the Dharriwaa Elders Group in Walgett. Without them this study would not have been possible. We would also like to thank staff from both Walgett and Bourke Councils who were willing to be interviewed for the study.

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Analysis of Earth observations and field measurements reveals post-fire dynamics at the Gnangara Mound's recharge zone

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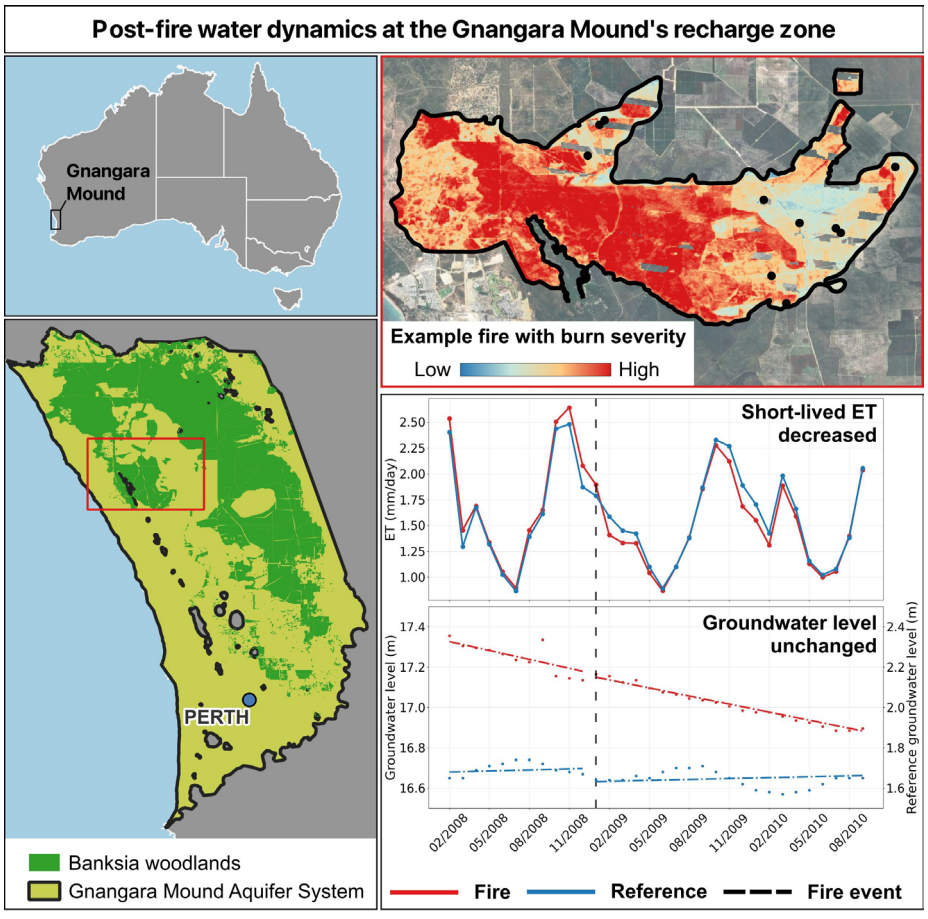
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

When the research will be completed
April 2026.

Research objectives
Groundwater is Perth's most vital water source, providing roughly 40% of the city's drinking water demand, mainly from the Gnangara Mound aquifer system. The aquifer faces pressure from Perth's rapid growth, through increased abstraction, and from climate change, through reduced recharge. Natural recharge is limited by vegetation water use at recharge zones, primarily the Banksia woodlands of the Swan Coastal Plain. These woodlands have Banksia as the dominant canopy species. The water use of this ecosystem varies with its structure, composition, and ecological disturbances, such as fire. The Banksia ecosystem is frequently affected by natural fires and prescribed burns (for hazard reduction). Understanding of fire's effects on groundwater remains limited, mainly due to a lack of empirical data on water fluxes and vegetation. This project combines Earth observations from satellites, measurements from groundwater monitoring bores, and a flux tower, as inputs to machine learning and a causal statistical framework to explore the interactions among fire, vegetation, and water.

The objectives are (i) to identify the most suitable remotely sensed product for observing fire impacts on evapotranspiration (ET), based on flux tower measurements, (ii) to map the Banksia woodlands over the past 20 years, and (iii) to conduct a regional-scale assessment, quantifying fire impacts on ET and recharge through groundwater level trends.

Among the assessed remote sensing products, namely CSIRO MODIS ReScaled ET (CMRSET), MODIS ET (MOD16), and Penman-Monteith-Leuning (PML), the PML accurately replicated ET seasonality and captured fire-induced changes in ET, with an error of only 9%. Satellite mapping of the Banksia woodlands generated a dynamic map from 2000 to 2023, showing rapid vegetation recovery within 2-3 years post-fire. PML ET estimates, combined with the dynamic ecosystem map and groundwater level data, demonstrate that fire impacts are short-lived and mainly influenced by burn severity - the level of biomass consumed by the fire - and vegetation recovery. Low-severity prescribed burns mainly affect the understorey and are hydrologically neutral. Higher-severity fires, such as wildfires and escapes from prescribed burns, impact both understorey plants and Banksia trees, significantly reducing ET after the fire and increasing subsequent annual recharge by up to 10%. These effects last from 18 months to 3 years post-fire, as vegetation recovers rapidly, reflecting their highly fire-adapted traits. These findings provide vital information for water management in the Gnangara Mound aquifer and for biodiversity conservation in the Banksia woodlands on the Swan Coastal Plain, laying the groundwork for future planning that considers fire impacts on groundwater.

Papers arising from the work that have been published to date
Nguyen, H. L., Gelsinari, S., Callow, J. N., Silberstein, R., & Thompson, S. E. (2025). Satellite and eddy covariance analysis reveals short-lived evapotranspiration changes after fire in Mediterranean woodland. Journal of Hydrology, 653, 132654.

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Artificial sweeteners in wastewater treatment plants: global distribution, patterns, and removal

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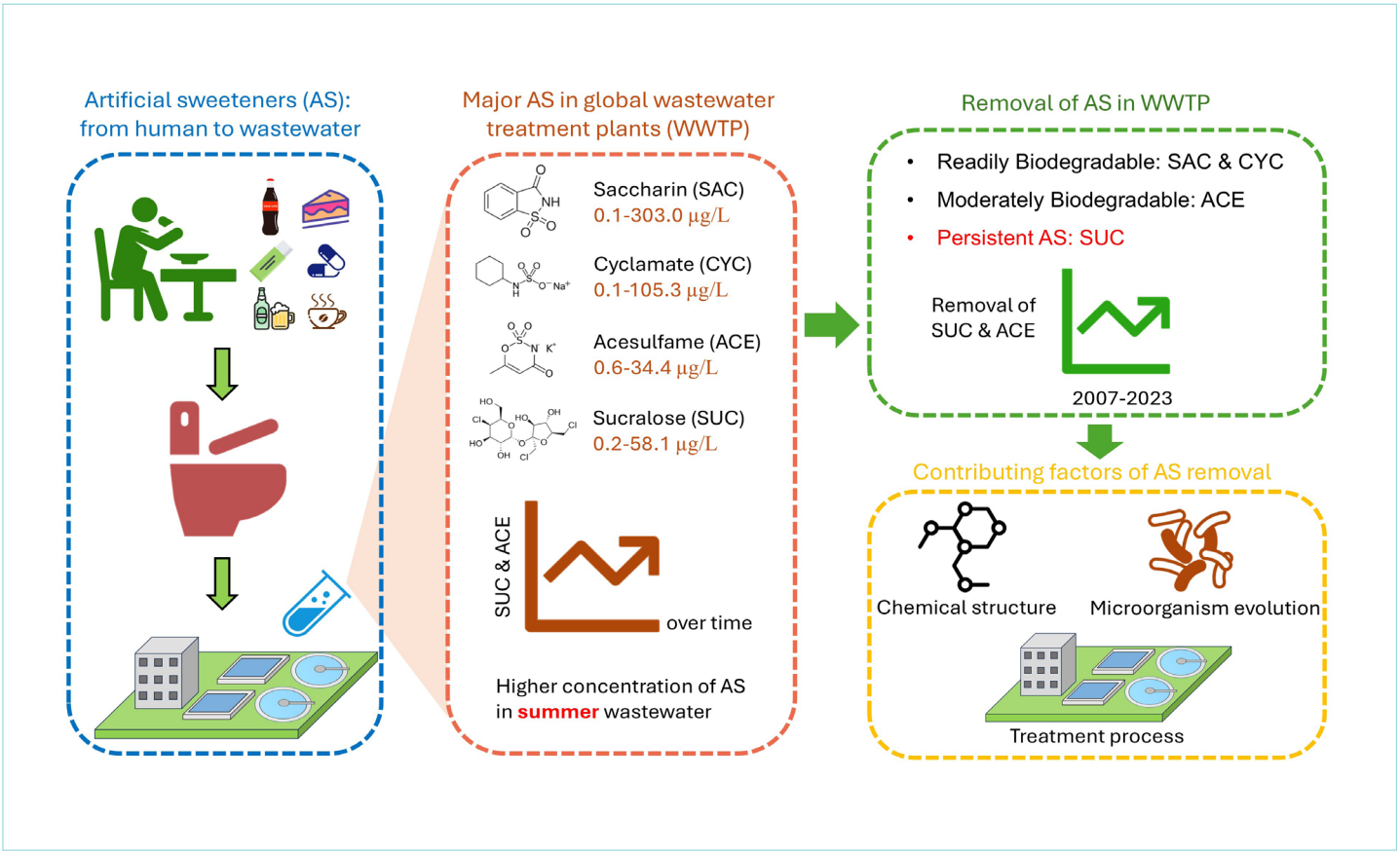
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

Problems
Sugar-free lifestyle has become a common trend in people's daily lives today due to the need for health management and weight control. Artificial sweeteners have been widely used in foods, beverages, drinks, and pharmaceuticals. Artificial sweeteners are largely excreted unchanged and have been increasingly detected in wastewater and receiving waters, becoming emerging contaminants in waters. However, water utilities lack comprehensive information on: (i) influent/effluent levels in WWTP, (ii) long-term trends and seasonal patterns, (iii) which wastewater treatment processes help or hinder removal, and (iv) future priorities.

Research objective
My research contributes to:
- Offer a comprehensive understanding of global patterns and removal status of artificial sweeteners in wastewater treatment plants (WWTPs)
- Provide insights for the water industry to choose the best process for removing artificial sweeteners in WWTP and provide recommendations for policymakers

Benefits to the water sector
- Water utilities can use artificial sweeteners as operational tracers for domestic wastewater and illicit discharge.
- Target and optimise process conditions in WWTPs that consistently improve removal.
- Provide guidance on wastewater treatment process in the design and planning of new WWTPs to comply with potential future regulation of artificial sweeteners.
- Water utilities can play a role in both environmental and public health monitoring by being aware of prevalent artificial sweeteners and their seasonal load patterns in WWTPs.

Findings to date:
- Sucralose, acesulfame, saccharin, and cyclamate are prevalent artificial sweeteners in influent in WWTPs, with a concentration ranging from 0.2 to 303.0 µg/L.
- The highest influent concentrations of sucralose, acesulfame, saccharin, and cyclamate were observed in the USA (34.4 µg/L), Spain (58.1 µg/L), India (303.0 µg/L), and Germany (105.3 µg/L).
- During 2009-2020, the average concentrations of sucralose, acesulfame, saccharin, and cyclamate in WWTP influent in Australia were 17.9 µg/L, 30.52 µg/L, 14.15 µg/L, and 19.70 µg/L, respectively. Summer wastewater generally contained 11.1–33.3% higher concentrations of artificial sweeteners than other seasons.
- Saccharin and cyclamate are the most easily degradable sweeteners (>90.0%) in WWTPs, followed by acesulfame (25.0–70.1%) and sucralose (-10.0–10.0%).
- Biological wastewater treatment processes with longer HRT and aerobic conditions generally show better removal performance than anaerobic processes. Continuous monitoring, process optimisation, and effluent concentration regulation are needed in the management of artificial sweeteners in wastewater.

Papers arising from work
Li, Jibin, Xuan Li, Yi Li, Huan Liu, and Qilin Wang. "Artificial sweeteners in wastewater treatment plants: A systematic review of global occurrence, distribution, removal, and degradation pathways." *Journal of Hazardous Materials* (2025): 138644.

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Completion date: May 2025

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Assessment of PFAS transport via runoff and the efficacy of ozone treatment

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Supervisor: Christopher Chow

RESEARCH SUMMARY

When the research will be completed
February 2025

Research objectives
The primary objective of this research is to develop and validate an integrated decision- support module that enhances the management of PFAS in surface water systems.

Model Contaminant Transport: Integrate EPA SWMM with historical monitoring contamination data to characterise runoff patterns, thereby accurately identifying PFAS "hotspots" and upstream–downstream transport pathways.

Optimise Remediation Strategy: Develop a scheduling algorithm for Ozone Micro- and Nanobubble (OMNB) technology that minimises total remediation time by optimising equipment allocation across varying flow rates (7.5, 15, and 50 m^3/h).

Demonstrate Field Applicability: Validate the module using the RAAF Base Edinburgh case study to demonstrate how this approach provides a cost-effective, targeted solution for protecting water resources and meeting environmental standards.

Problems or questions you are trying to address
The effective management of PFAS is primarily challenged by the chemical's resistance to natural degradation. Driven by strong carbon–fluorine bonds, these substances do not break down easily, leading to bioaccumulation and long-term environmental risks.

Currently, management efforts are hindered by infrequent monitoring, which makes it difficult to track contamination in real-time. Additionally, the high cost of remediation makes broad-scale cleanup impractical without a precise, targeted strategy. However, existing stormwater software lacks the specific tools needed to model how these contaminants move. This creates significant uncertainty in tracking runoff pathways from sources like the RAAF Base, making it difficult to identify where remediation is most needed.

Benefits to the water sector
This research offers the water sector a practical decision-support tool that transforms PFAS management from a costly, reactive challenge into a targeted and efficient operation. By filling the critical gap in existing stormwater software, the

developed module enables utilities to accurately pinpoint contaminant "hotspots" through runoff modeling, ensuring that expensive remediation resources are focused solely on high-risk areas. When combined with the optimised scheduling for Ozonation treatment, this approach significantly accelerates cleanup timelines and reduces operational costs, providing water authorities with a streamlined pathway to meet strict regulatory limits and safeguard water resources against persistent environmental hazards.

Findings to date

This integrated method successfully validated the efficacy of coupling hydrological modelling with targeted remediation planning. By analysing historical AECOM monitoring data (2017–2023) alongside EPA SWMM runoff simulations, the study identified a critical upstream–downstream transport pathway, mapping 35 distinct surface water bodies that require prioritised intervention. The binary analysis effectively tracked concentration fluctuations across monitoring sites, confirming the correlation between rainfall-driven runoff and contaminant migration. Furthermore, the optimised Ozonation treatment schedule demonstrated that by strategically allocating equipment across flow rates of 7.5, 15, and 50 m^3/h, the total remediation timeline could be reduced to approximately 129 days. These results confirm that the developed module not only precisely locates contamination hotspots but also provides a feasible, data-driven schedule for cost- effective site rehabilitation.

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Bridging waters: Collaborative knowledge exchange for improved flood risk management. A South Ripley, Ipswich case study

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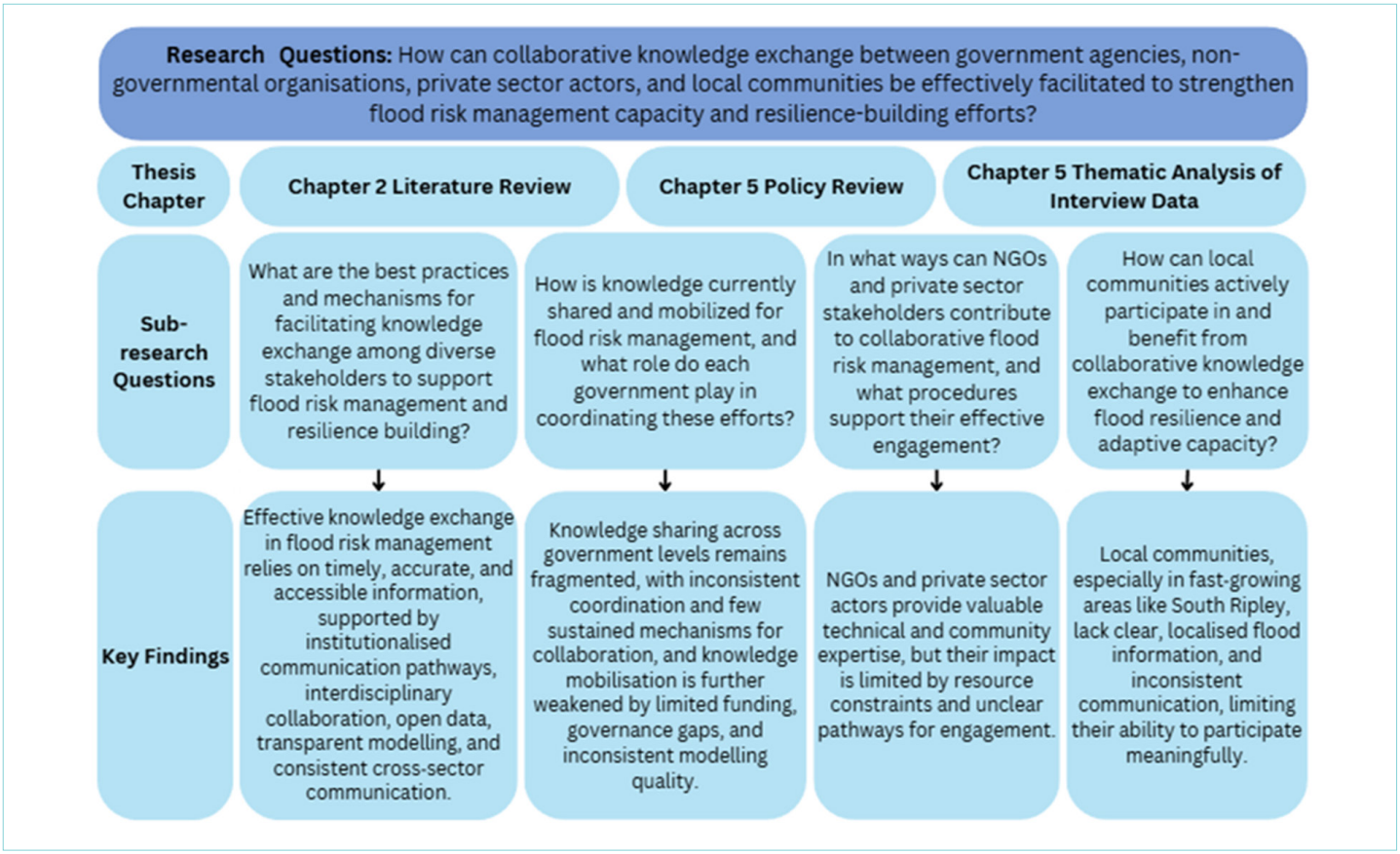
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

When the research will be completed
February 2026

Summary
This study examines how collaborative knowledge exchange improves flood risk management and resilience in South Ripley, Ipswich. Effective flood governance depends on timely, accurate, and accessible information flows across government, NGOs, industry, and communities, yet the literature highlights persistent barriers including siloed institutions, inconsistent data standards, limited resourcing, and weak community engagement.

This study also examines how information is currently shared and mobilised, the roles and contributions of key stakeholders, and the mechanisms, such as open data, cross-sector partnerships, participatory planning, and iterative learning, that support more effective knowledge exchange. By aligning local insights with global frameworks such as the UNDRR Sendai Framework, the project advances more integrated, community-centred, and adaptive approaches to flood resilience.

A policy review reveals substantial inconsistency across international, national, state, and local frameworks in their treatment of knowledge exchange, public consultation, resilience, and flood mitigation. Knowledge exchange and resilience are most consistently embedded, particularly in international frameworks that prioritise interdisciplinary learning and risk governance; however national and state policies often lack ongoing, cross-sector or community-based knowledge sharing mechanisms. Public consultation is the weakest area, with only a few instruments (e.g., the Water Act 2000, Planning Act 2016, and local planning schemes) demonstrating meaningful engagement processes.

Interviews with government, industry, NGOs, and community members reinforce these gaps, citing constraints such as limited funding, time, and resources. Participants called for open data, stronger governance, and improved flood modelling. Community members, particularly in fast-growing areas like South Ripley, expressed uncertainty and a need for clearer, more localised flood communication. Overall, this research highlights the need for more coherent, collaborative, and context-responsive communication pathways across the water sector, contributing to more resilient and community-centred flood risk management in South Ripley and beyond.

Updates to abstract in thesis
Although statutory public consultation is well established within Australian water and planning legislation, it is frequently procedural rather than collaborative.

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Can urban trees still cool our cities in a hotter, drier future?

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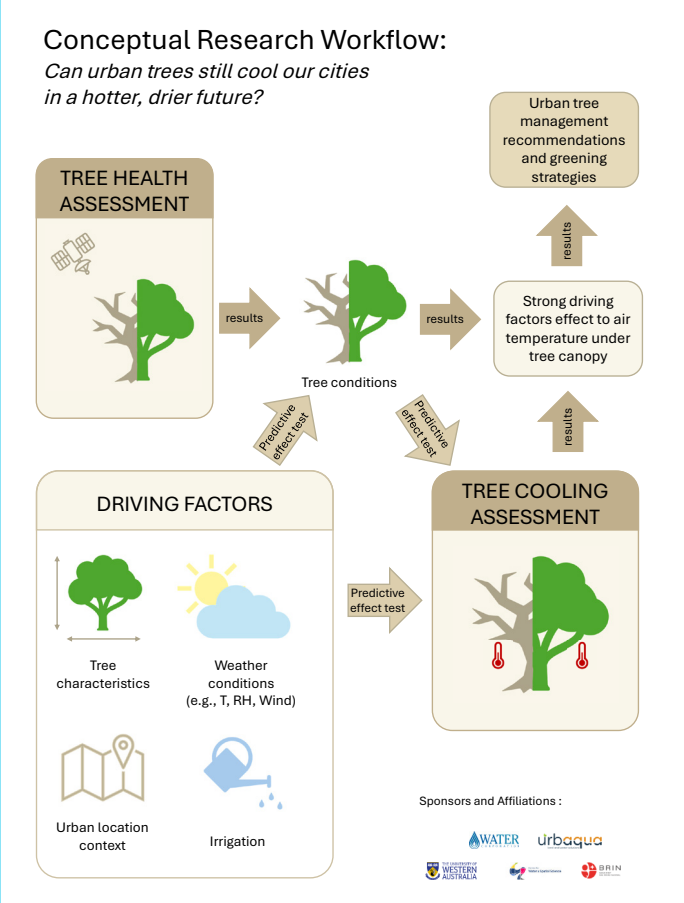
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

When the research will be completed
This research is planned to be completed by mid 2027

Research objectives
Urban trees play a critical role in reducing outdoor temperatures (cooling benefits), improving human wellbeing, and increasing property values. However, increasing temperatures and prolonged droughts raise important questions about whether these cooling benefits can be sustained in water-limited environments. Supported by Urbaqua and Water Corporation, my PhD research aims to identify practical ways to maintain the cooling benefits provided by urban trees in an increasingly hot and dry climate.

This research is guided by four key questions:

1. What impact did the record-breaking 2023-24 summer heat and drought conditions have on Perth's tree canopy?
2. Which factors predisposed trees to vulnerability or mortality during the 2023-24 summer heat and drought conditions?
3. To what extent do trees reduce air temperature compared to unshaded areas, and what factors influence their cooling performance?

4. Can below-canopy air temperatures (as a proxy for the cooling effect of a tree) be predicted from remotely sensed land surface temperature and environmental covariates?

Preliminary results indicate that approximately 80% of Greater Perth's tree canopy exhibited signs of heat and drought stress during the 2023–24 summer compared with the previous year. This assessment is based on Sentinel-2 satellite imagery, using the Normalised Difference Red Edge (NDRE) vegetation index to infer tree condition, combined with high-resolution urban tree canopy vector data that delineate tree canopy extents. These findings highlight both the vulnerability of urban trees to climate extremes and the limitations of moderate-resolution remote sensing for accurately assessing tree health in complex urban environments.

Field measurements show that the median air temperature under tree canopies is ~1.4 °C cooler than in nearby unshaded locations during daytime conditions. This relatively modest median difference obscures substantial variability in cooling performance across tree species, urban contexts, and tree health conditions. Trees located in parks generally exhibit greater cooling than those in high-rise areas, followed by residential areas. Weather conditions are the dominant driver of under-canopy air temperature, followed by tree characteristics (particularly canopy size), and urban context. In contrast, irrigation, NDRE, and species identity appear to have weaker direct effects on cooling magnitude.

Importantly, this research recognises that irrigation may influence tree health and cooling indirectly and over longer timescales. Ongoing and future field measurements, including expanded sampling across irrigation regimes, aim to better quantify these relationships. Understanding how irrigation supports long-term tree function is critical for guiding water-efficient urban greening strategies. This research therefore provides evidence to support balanced decision-making that aligns urban heat mitigation with sustainable water use, an increasingly critical challenge for semi-arid cities facing competing human and ecological demands.

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Developing a business case to support a circular economy approach in wastewater management

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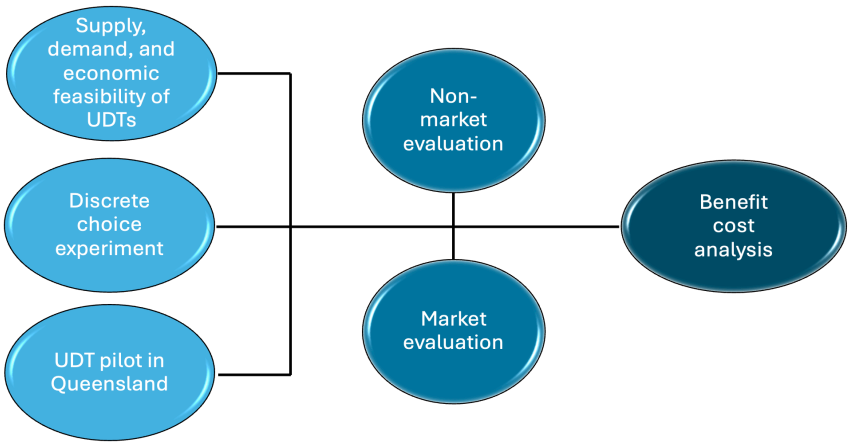
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

When the research will be completed
22 May 2026

Research objectives
Funded through the ARC ITRH Research Hub for Nutrients in a Circular Economy (NiCE) Hub, this project aims to evaluate the whole-of-system benefits of urine-diverting technologies across multiple designs and stakeholder groups.

Problems or questions you are trying to address
Implementing a circular economy approach in wastewater management requires understanding the economic trade-offs between the benefits of water savings and nutrient-recovery revenue and the rising costs of downstream treatment and environmental protection. As pressures on global nutrient supplies and energy intensify, innovative options such as urine-diverting technologies (UDTs) and urine-derived fertilisers are becoming increasingly viable and should be incorporated into utility economic forecasting. Yet their broader adoption is limited by the lack of clear evidence on both market and non-market benefits for different stakeholder groups including regulatory agencies, public end-users, and service providers. This research addresses this gap by evaluating these benefits and integrating them into a value chain analysis to inform effective promotion, communication, and ongoing technological development. The analysis considers UDT systems spanning from the treatment of source-separated urine through to the final stage of fertiliser end-use.

Research benefits for the water sector
UDTs offer a promising solution by enabling full resource recovery and reuse, reducing emissions, and lowering water and energy use. Treating urine through UDTs can also generate financial returns through the sale of recovered nutrients and urine-derived fertilisers. This research uses non-market valuation techniques (discrete choice experiments) and a benefit-cost analysis framework to assess different UDT system designs through a circular economy lens. These findings are expected to support technology development, scale-up, and the commercialisation of nutrient-recovery systems, helping urban areas address growing resources, environmental, and economic pressures in the wastewater sector. In practice, these results provide a foundation for extending economic analysis from pilot-scale systems to larger-scale applications, enabling assessment of economic feasibility prior to wider implementation.

Findings to date
The systematic review provides new insights into the supply, demand, and economic feasibility of UDTs and related products. Findings indicate good potential for wider adoption, but the market and non-market benefits remain somewhat abstract, and many end users, despite general acceptance, are not willing to pay higher prices. A discrete choice experiment with 1,610 participants across Queensland, New South Wales, and Victoria further examined public acceptance. Results show strong support for UDTs, with preferences centred on three features: the types of toilets targeted, the location targeted, and the use of recovered nutrients. Class profiling identified three distinct preferences, highlighting the importance of technological familiarity and financial considerations in shaping preferences. Respondents with greater knowledge of and trust in UDTs were notably more supportive of their adoption.

Papers arising from the work that have been published to date
Nguyen, G.T., Iftekhar, M.S., Ratnasiri, S., Roiko, A., Beal, C.D. 2024. *Supply, Demand and the Economic Effectiveness of Urine-diverting Technologies and Products: A Systematic Literature Review*. Water Research. ISI Impact Factor: 12.8. Ranking (Water Resources) 1/103 (Q1. SJR Impact: 3.10 (Q1 Water Science and Technology).

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Diagnostic data analytics for sewer inflow and infiltration

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RESEARCH SUMMARY

Expected research completion date
PhD project, July 2026

Research objective
Inflow and infiltration (I/I) into sewers drive wet-weather overflows, overload treatment plants, damage infrastructure, and increase greenhouse gas emissions. Traditional diagnostics rely on expensive flow meters, CCTV and manual interpretation, which are difficult to scale across large networks. This project aims to develop a digital, data-driven framework that uses simple, robust sensors to provide utilities with practical tools for I/I detection, quantification, prediction and localisation.

Research questions
The core questions are:
- How can utilities reliably detect when I/I occur using routine data?
- How much I/I is entering the system during wet-weather events?
- How will I/I behave under future rainfall and operating conditions?
- Can I/I sources be inferred from limited monitoring locations to guide targeted investigations and investment?

Research benefits for the water sector
The framework combines a sewer "digital twin" with field data and pilot-scale experiments. The digital twin simulates pumping station operation, groundwater behaviour, I/I dynamics, and in-pipe hydraulics, mass balance and heat transfer, allowing utilities to virtually test diagnostic methods and interpret sensor signals before investing in hardware. In parallel, existing online monitoring (flow, temperature, conductivity) from utility partners is used to develop algorithms that can run on routine SCADA data, supported by controlled trials on a pilot sewer system. The focus is on low-cost sensing, automated analytics and workflows that can be embedded into existing planning and operations systems.

Findings to date
Four key outcomes have been achieved so far.
(1) A temporal anomaly-detection approach that learns expected sewer behaviour and flags I/I-related events from routine time-series data, without fixed thresholds.
(2) A method combining statistical wastewater flow reconstruction with mass and energy balances to estimate I/I volumes from temperature and conductivity, reducing the need for flow meters.
(3) New models for rainfall- and seawater-driven I/I using physically interpretable, learnable response functions to forecast I/I under changing climate and tidal conditions.
(4) Ongoing work is exploring algorithms that use temporal patterns at a few monitoring points to infer likely I/I locations and guide optimal sensor placement.

Papers arising from the work that have been published to date
Ge, J., Li, J., Qiu, R., Shi, T., Huang, Z., Liu, Y., Yuan, Z. (2024). Identifying periods impacted by sewer inflow and infiltration using time series anomaly detection. Water Research X, 25, 100278.

Ge, J., Li, J., Qiu, R., Shi, T., Zhang, C., Huang, Z., Yuan, Z. (2024). A data-driven method for estimating sewer inflow and infiltration based on temperature and conductivity monitoring. WaterResearch, 261, 122002.

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Engineering sewer-durable, low-carbon concretes from mine tailings: Pathway from material screening to utility pilots

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RESEARCH SUMMARY

When the research will be completed
In progress (significant results in 2025; pilots planned for 2026)

Research objectives
This study aims to develop and validate a suite of low-carbon binder systems – comprising five novel mine-tailings – derived formulations (CEM-X) alongside CAC, CSA, and hybrid CSA (HB-CSA) binders – with the objective of achieving superior durability under the highly acidic and microbially aggressive conditions characteristic of sewer environments. These alternative binders aim to exceed the chemical resistance of ordinary Portland cement (OPC) while reducing embodied carbon and material costs. A key aspect is validating in-service performance through coordinated pilot installations at various Australian water utilities.

Problems or questions you are trying to address
OPC concretes used across Australia's sewer networks deteriorate rapidly when exposed to biogenic sulphuric acid, driving up reactive maintenance costs, increasing unplanned service interruptions, and elevating WHS risks for utility crews. For water authorities working to deliver reliable, affordable services under tightening budgets and ageing infrastructure, improving material durability is a clear priority. Australia has significant mine tailings stored in facilities that pose environmental risks. This study explores the use of waste-derived binder systems to enhance the durability of sewer assets while transforming these tailings into safe, valuable construction materials. This approach aligns durability innovation with resource recovery, promoting a circular economy that supports decarbonisation and the development of low-carbon, corrosion-resistant water infrastructure.

How will your research benefit the water sector?
Utilities can benefit from longer-lasting manholes, sewer pipes, and splash-zone panels in wastewater treatment plants, leading to reduced maintenance and lower whole-life asset costs. The low-carbon mixes developed in this project cut CO_2 emissions and raw material costs by 20–30% compared to OPC, supporting decarbonisation and sustainability goals. Collaboration with utilities, contractors, and material suppliers facilitates quick real-world deployment through clear specifications and QA procedures. This work aligns with AWA's priorities of enhancing asset resilience, minimising operational risk, and promoting circular, low-carbon solutions in the water industry.

Findings to date
Five novel binders derived from over 15 tailings and e-waste residues were developed, achieving over 50 MPa compressive strength at 28 days and are suitable for sewer infrastructure. Under severe acid exposure (H_2SO_4, pH ≈ 0.5), they outperformed OPC in mass loss, surface recession, and corrosion depth. Their transport properties showed significantly lower sorptivity and absorption compared to OPC, indicating reduced acid ingress. An adoption pathway with industry stakeholders is underway, with a partner using a low-carbon binder for access chambers in Australia and field pilots planned for 2026. These binders reduce embodied CO_2 and costs by 20–30% compared to OPC, showcasing their large-scale potential.

Papers arising from the work
B. Binwal, M. Valix (2026) "Characterisation of Unprocessed Mine Tailings for Use as Sustainable Concrete Aggregates" (Under review, Results in Engineering Journal)

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Environmental litter losses from ineffective maintenance of gross pollutant traps

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RESEARCH SUMMARY

When the research will be completed
2025

Research objectives
The research aimed to understand current practices and effectiveness of gross pollutant trap (GPT) maintenance in Australian municipalities.

Problems or questions you are trying to address
- Stormwater is a major but under-recognised pathway for anthropogenic litter entering oceans
- GPTs are widely installed but not always maintained, leading to litter bypassing into waterways. What is the average condition of GPTs in Australia?
- Councils vary greatly in their GPT management practices, documentation and governance structures. What measures lead to improved GPT maintenance?

How will your research benefit the water sector?
- Identification of practices associated with higher GPT performance, such as maintenance schedules and following manufacturers' guidelines.
- Insights that can assist councils in improving asset management and reducing marine pollution.
- Support for stormwater treatment policy development, such as implementing registers, maintenance schedules, guidelines and potentially levies.
- Quantification of potential environmental gains if GPTs function optimally, helping guide strategic investment in stormwater management.
- Clear evidence of the scale of litter losses through stormwater when GPTs are poorly maintained.

Findings to date
Based on the audits of 1,269 GPTs over multiple Australian states, the majority of GPTs are non-operational. The following graph demonstrates that only 5 % of GPTs are fully operational, 15 % are in good condition and 23 % are in moderate condition.

Additional insights
- Two factors had significant positive associations with better GPT operational conditions: having a formal GPT maintenance schedule and following manufacturers' maintenance guidelines.
- Australia loses an estimated 106,000 tonnes of litter annually to the ocean via stormwater when GPTs are poorly maintained.

Conclusion
Poor GPT maintenance leads to substantial preventable litter pollution to waterways and oceans. Ensuring consistent GPT maintenance schedules and improved stormwater governance could significantly reduce marine litter in Australia and internationally.

Publication details
Barrett J, Vince J, Dalrymple B, Powell M & Hardesty BD, 202X. Environmental litter losses from ineffective maintenance of gross pollutant traps. Manuscript submitted to *Urban Water Journal* and is being reviewed.

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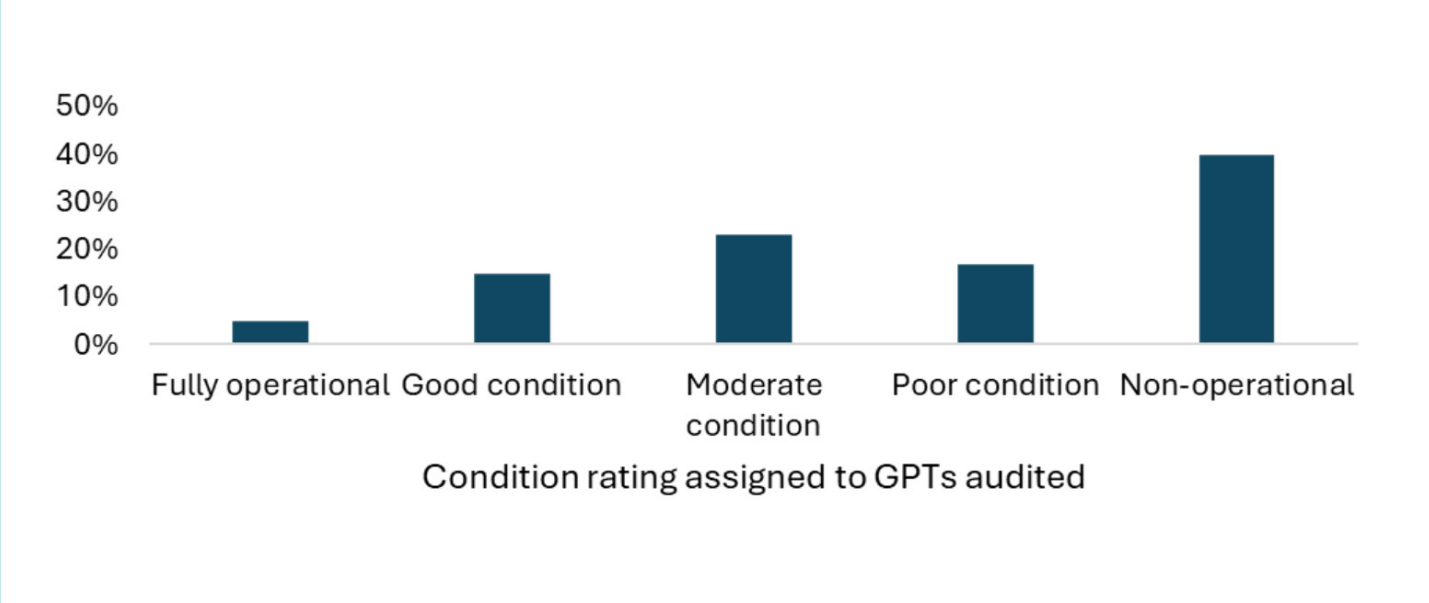

Figure 1. The condition rating assigned to GPTs audited between 2019 – 2024 (percentage per total GPTs, n=1,269)

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Erosion initiation and control in mined landscape rehabilitation

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RESEARCH SUMMARY

When the research will be completed
August 2026

Summary
Gully erosion limits rehabilitation success in post-mining landscapes. When gullies form, soil, seeds and seedlings are displaced downslope, buried too deep for growth and sediments can be carried out of the mining footprint, contaminating surrounding ecosystems, waterways or drinking water catchments. Understanding the causes of gully erosion in post-mining landscapes is crucial to prevent these outcomes and improve success.

While many factors contribute to the complexity of gully initiation and growth, the force exerted by concentrated flow across a surface, and the soil strength to resist channel incision are key (Knapen & Poesen, 2010; Poesen et al., 2003). Therefore, factors affecting surface water concentration, depth, and velocity can be key in controlling erosion formation; alongside factors that affect soil strength and cohesion in supporting resistance to gullying. While many control options exist around modifying these key factors, such as improving soil strength through reinforcement or reducing runoff generation by promoting soil water infiltration, in large scale mining rehabilitation there are limited levers available due to competing land use objectives and regulatory completion criteria.

One such available lever is landscape topography, where both micro-topography, at the ~1 m scale governing the surface finish of the rehabilitated area, and macro-topography, at the larger ~100 m scale governing the overall landform shape, are used to store and slow surface water movement and can be considered erosion prevention techniques. On both these scales, the hydrologic response of the landscape is altered by the imposed topography. However, the effect of this topography on surface water generation and movement, and therefore its effectiveness as an erosion control method, is not completely understood.

Using high resolution digital elevation models from rehabilitated mining areas, my research aims to bridge the understanding gap to show how topographic design influences hydrological response and therefore erosion potential and control. Three key areas are investigated, 1) erosion risk prediction using surface features, 2) the effect of microtopography on runoff, and 3) the effect of macro-topography on soil water saturation.

two are completed with papers in preparation and research area three is under investigation.

Research area one found surface feature information such as upslope area, slope gradient and curvature metrics, are insufficient to predict gully location risk alone, reflecting the complex nature of gully formation. However, the topographic threshold (Montgomery & Dietrich, 1988) can conservatively predict risk areas across a landscape using upslope area and slope gradient, highlighting key areas for monitoring or intervention.

Contour tillage is applied as micro-topography in mining rehabilitation through the creation of ridges and furrows along a surface contour to slow and store surface water. To better understand how contour tillage modifies surface water movement to achieve these goals, research area two used flow networks, the pathways that runoff creates across the soil surface, and accumulation, the upslope area flowing to points along those paths, and compared them to networks that may form on unmodified surfaces. While contour tillage creates both longer and less direct flow paths downslope, it increases accumulation on steeper slope areas, with confounding effects for erosion risk.

The third area of research aims to understand how macro-topographic choices in landscape rehabilitation impact soil water saturation with the goal of enabling erosion sensitive rehabilitation design.

Combining the three research areas will provide a comprehensive understanding of the effect of rehabilitation design choices on gully formation, enabling the provision of guidelines for the design and execution of erosion resilient rehabilitation.

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Future stormwater resilience under climate change and urbanisation: WSUD retrofit impacts in West Melbourne

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RESEARCH SUMMARY

When the research will be completed
Research completed in December 2025

Summary
Urban catchments in Melbourne are facing growing flood risk and declining water quality due to heavier rains and more impervious surfaces. The study investigates how the retrofitting of Water Sensitive Urban Design (WSUD) such as rainwater tanks, rain gardens, and a hybrid system can help to bolster stormwater resilience in a 170-hectare residential catchment in Hoppers Crossing. Through PCSWMM modelling, the performance of the system was assessed under existing conditions and future 2050 and 2070 climate and urban growth scenarios.

Research objectives
To identify the most climate-resilient and cost-effective WSUD retrofit strategy for existing suburbs under future climate change and urbanisation scenarios by integrating hydrologic, hydraulic, water-quality, and life-cycle cost analysis.

Problems addressed
Conventional pipe-based drainage systems are nearing capacity and are not designed for future rainfall intensity or urban density. Councils lack evidence on whether rain gardens (RG) and rainwater tanks (RWT), or Hybrid strategies deliver the best long-term resilience for retrofit-constrained areas.

Key findings to date
1. Future climate–urbanisation pressures may increase annual runoff by ≈84% by 2070. Ability to simulate dynamic interactions between network components and explore scenarios that may lead to operational problems.
2. 50% RG provided the highest water-quality improvement and runoff reduction, but at the highest cost.
3. 50% RWT delivered substantial volume reduction at lower cost but limited pollutant removal.
4. The Hybrid scenario (25% RWT + 25% RG) produced the best overall balance in hydraulic, water quality and cost effectiveness.

Benefit to the water sector
This research provides councils and consultants with a data-driven decision framework for prioritising WSUD retrofits in established areas. The findings demonstrate how mixed WSUD systems can delay major pipe upgrades, reduce flood risk, improve water quality, and support climate-adaptation policies.

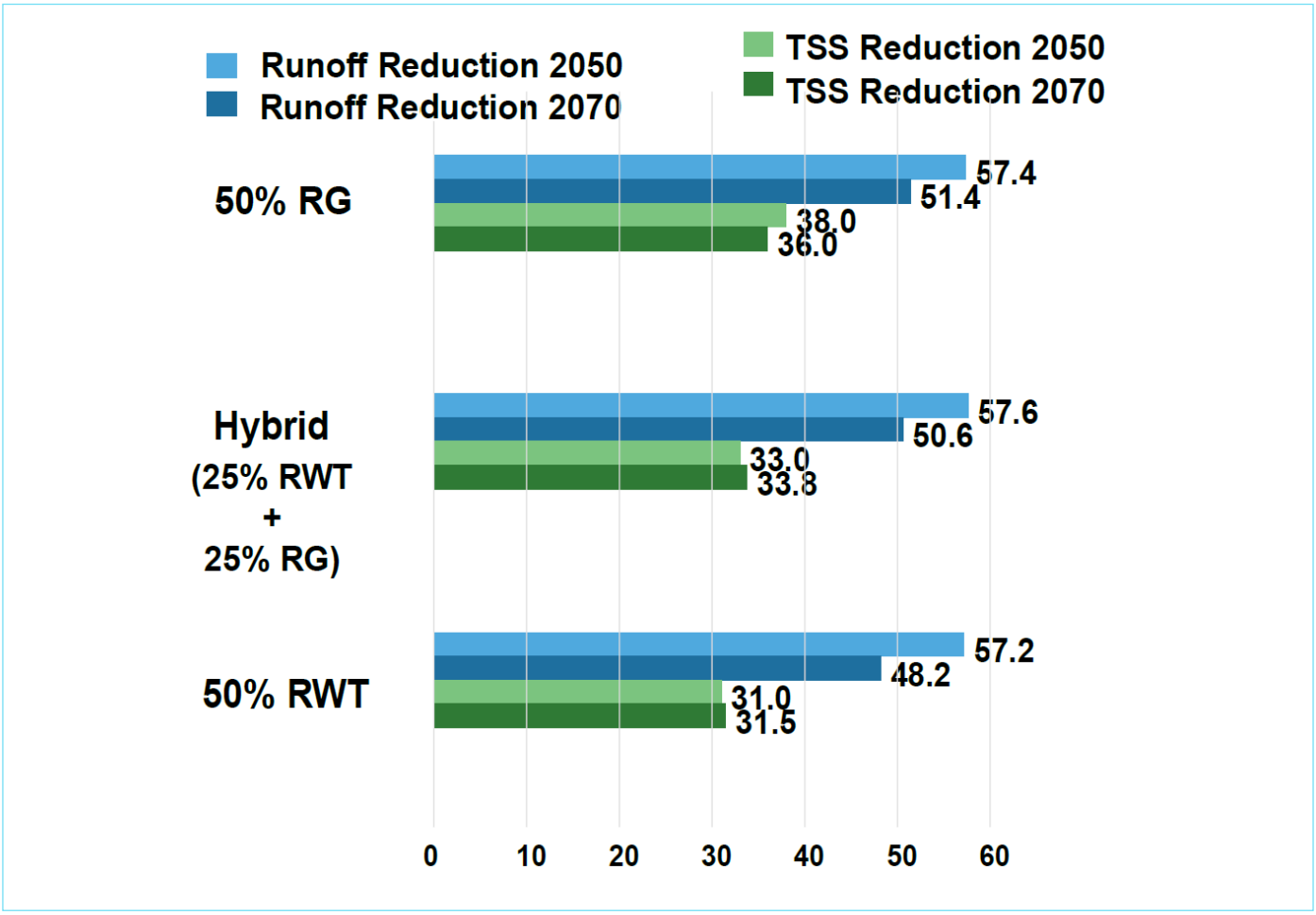

Figure 1: Key findings

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Global water and energy use for bathing and showering could double by 2050

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RESEARCH SUMMARY

When the research will be completed
30 September 2025

Summary
In the coming decades, the water sector must cater to a growing population despite high uncertainty in water supplies. Efficient showers are an important opportunity to reduce water demand, while also reducing energy use and greenhouse gas emissions. In Australia, showers are typically supplied by hot water systems (HWS), which can be responsible for up to 50% of residential energy consumption. Therefore, this study sought to estimate the global water and energy consumption for bathing and showering. On a global scale, many people use alternative systems (Figure 1). The study estimated global access to HWS using a novel proxy indicator which takes the minimum value of access to clean water and access to clean energy. These figures were used in conjunction with reported water and energy consumption in literature to project global consumption. The analysis demonstrated that a maximum of 65% of the global population feasibly had access to HWS in 2020 based on this proxy. Based on this number, the global water and energy consumption associated with bathing and showering was estimated at 100 – 470 million L/day and 3 – 15 TWh/day, and projected to double by 2050. This is equivalent to between 1% and 3% of current global energy consumption, which is on par with the energy consumption of the aviation industry. However, the 2020 water and energy consumption could be maintained through to 2050 if the energy and water consumption for showering was halved. This could potentially be achieved through much faster adoption of water efficient showers and reduced shower duration.

Publications arising from this PhD

Hall, R., Kenway, S., Memon, F. A., & O'Brien, K. R. (2025). Trade-offs between total and peak energy consumption due to plumbing layouts in Australian and UK domestic hot water systems. JCP 518, 145941. https://doi.org/10.1016/j.jclepro.2025.145941

Hall, R., Kenway, S., O'Brien, K. R., & Memon, F. A. (2025). Quantification of residential water-related energy needs cohesion, validation and global representation to unlock efficiency gains. RSER., 207, 114906. https://doi.org/10.1016/j.rser.2024.114906

Hall, R., O'Brien, K. R., Kenway, S., & Memon, F. A. (2024). Heat loss from non-circulating domestic hot water pipes increases water consumption and energy demand. RCR., 206, 107658. https://doi.org/10.1016/j.resconrec.2024.107658

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Figure 1: Global methods of bathing and showering (images retrieved from Dollar Street - photos as data to kill country stereotypes on 10/12/25)

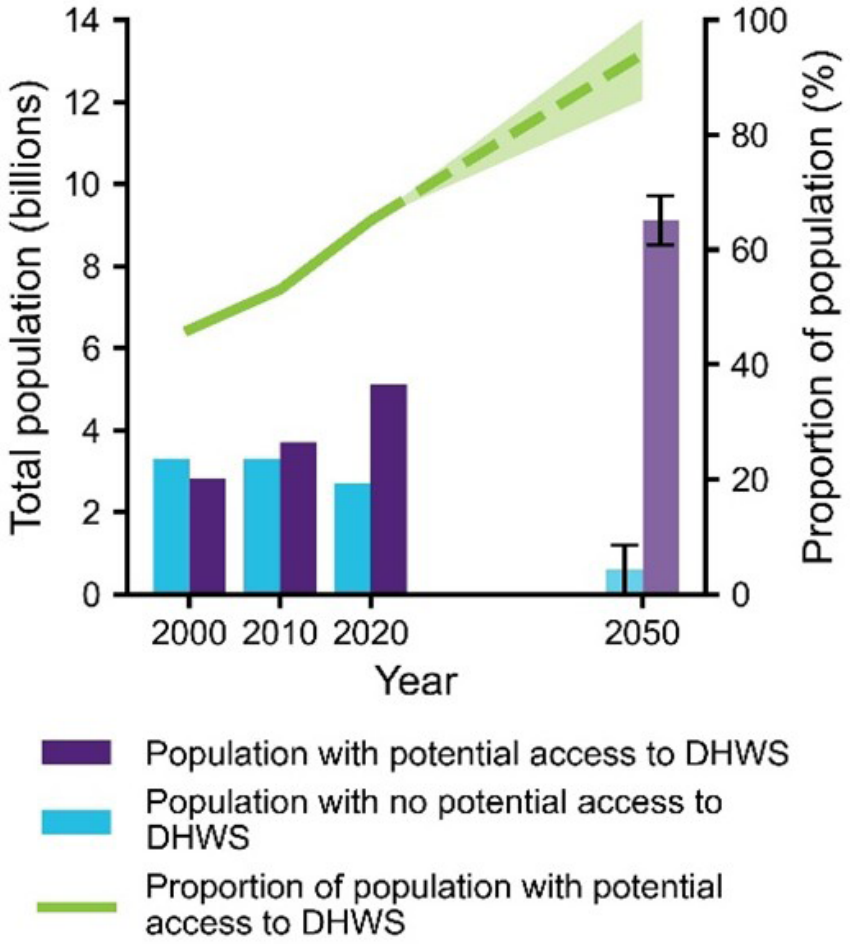

Figure 2: Proxy metric for access to DHWS derived from World Development Indicators | DataBank. Error bars for 2050 represent variability in global population of 9.7±0.7 billion people.

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Green synthesis of heteroatom-doped carbon dots from human hair as a label-free fluorescent sensor for the dual detection of Cr(VI) and Fe(III) in drinking water

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RESEARCH SUMMARY

When the research will be completed
October 2025

Research objectives
The research aims to develop a green, low-cost, highly sensitive fluorescent sensor for the selective and quantitative dual detection of Cr(VI) and Fe(III) in drinking water by synthesising heteroatom-doped carbon dots (CDs) from human hair via a one-step pyrolysis method, optimising their optical properties, and evaluating their selectivity, sensitivity, quantitative performance, and real-world applicability.

Problems or questions you are trying to address
Chronic exposure to heavy metals in drinking water affects millions worldwide, with around 2 billion people consuming contaminated water, leading to approximately 1.6 million child deaths annually. Traditional detection methods are often expensive, time-consuming, require complex sample preparation, and use hazardous chemicals.

This research aims to address the following key questions:

1. Can a waste-derived, environmentally friendly carbon source (human hair) be used to create cost-effective fluorescent sensors?
2. Is it possible to achieve highly selective and sensitive detection of Cr(VI) and Fe(III), two harmful and widely occurring contaminants, using a simple, chemical-free synthesis method?
3. Can this sensing approach be applied reliably to real drinking water samples for practical water monitoring?

How will your research benefit the water sector
This research provides a low-cost, sustainable, and practical tool for monitoring heavy metals in drinking water. By converting human hair waste into fluorescent CDs via simple, chemical-free pyrolysis, it supports circular-economy practices and reduces reliance on costly instruments. The sensor enables reliable quantification of Cr(VI) and Fe(III) at concentrations near or above regulatory limits, and successful testing with real drinking water samples demonstrates its strong potential for industry-relevant monitoring.

Findings to date
- The synthesised human hair-derived carbon dots (HH-CDs) under optimal conditions exhibited strong selectivity, showing a “turn-off”

- fluorescence response toward Cr(VI) and Fe(III) over other metal ions including Ag(I), Au(III), Cd(II), Co(II), Cu(I), Cu(II), Fe(II), Hg(II), Mn(II), Ni(II), Pb(II), and Zn(II).
- Quantitative analysis of Cr(VI) and Fe(III) was performed using calibration curves. The sensor exhibited high sensitivity, with LODs of 0.008 mg/L for Cr(VI) and 0.007 mg/L for Fe(III), both well below the WHO regulatory limits (0.05 mg/L for Cr(VI) and 0.3 mg/L for Fe(III)). The corresponding LOQs were 0.03 mg/L for Cr(VI) and 0.02 mg/L for Fe(III), indicating that the sensor can reliably quantify both ions across the concentrations relevant for drinking water monitoring.
- The fluorescence quantum yield of the synthesised HH-CDs was 8.4% (The fraction of photons released to photons absorbed through fluorescence is known as the fluorescence quantum yield).
- To evaluate the real-world applicability of the synthesised HH-CDs under optimal conditions, the standard addition method was applied to real drinking water samples. The recoveries of Cr(VI) and Fe(III) ranged from 95% to 104% and 98% to 103%, respectively, with relative standard deviations below 5% in both cases. These results highlight the excellent performance of the synthesised HH-CDs as a reliable and practical fluorescent sensor for dual detection of Cr(VI) and Fe(III) in real drinking water samples.

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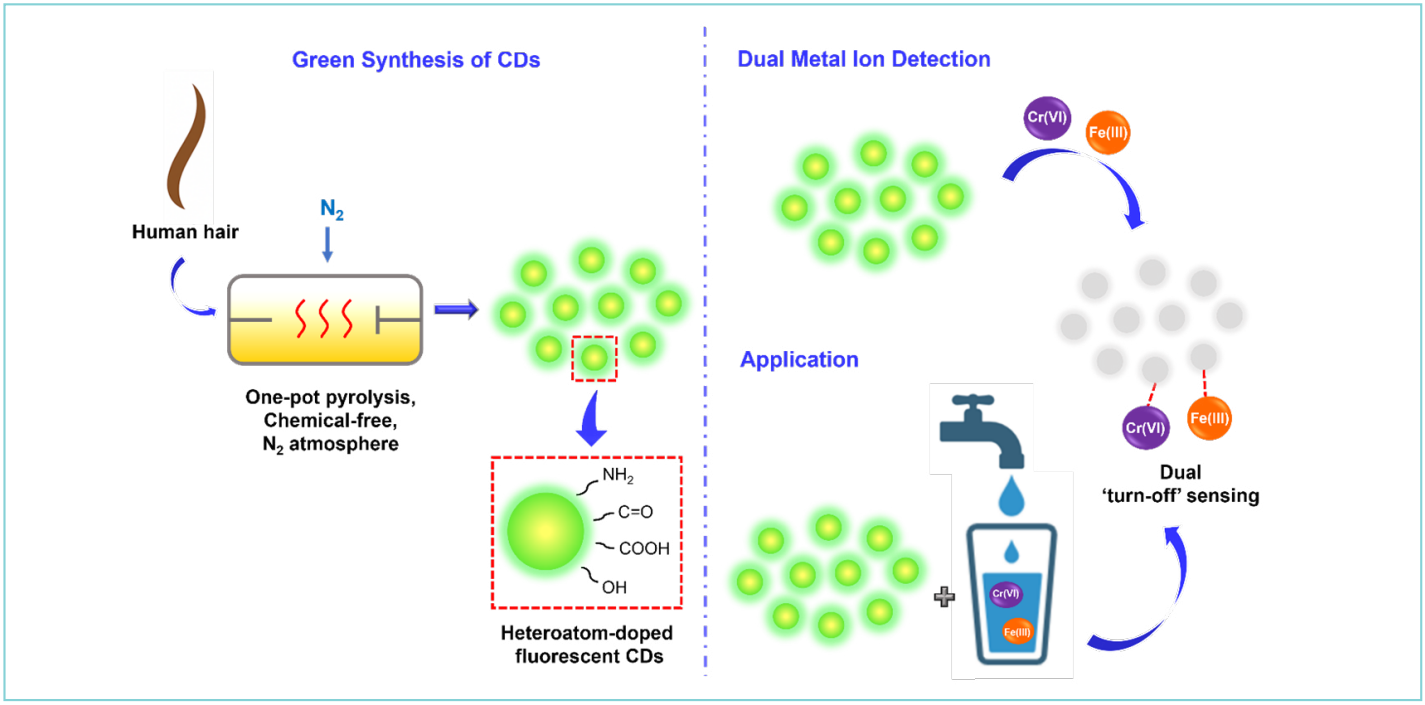

Fig.1. Graphical illustration of the topic.

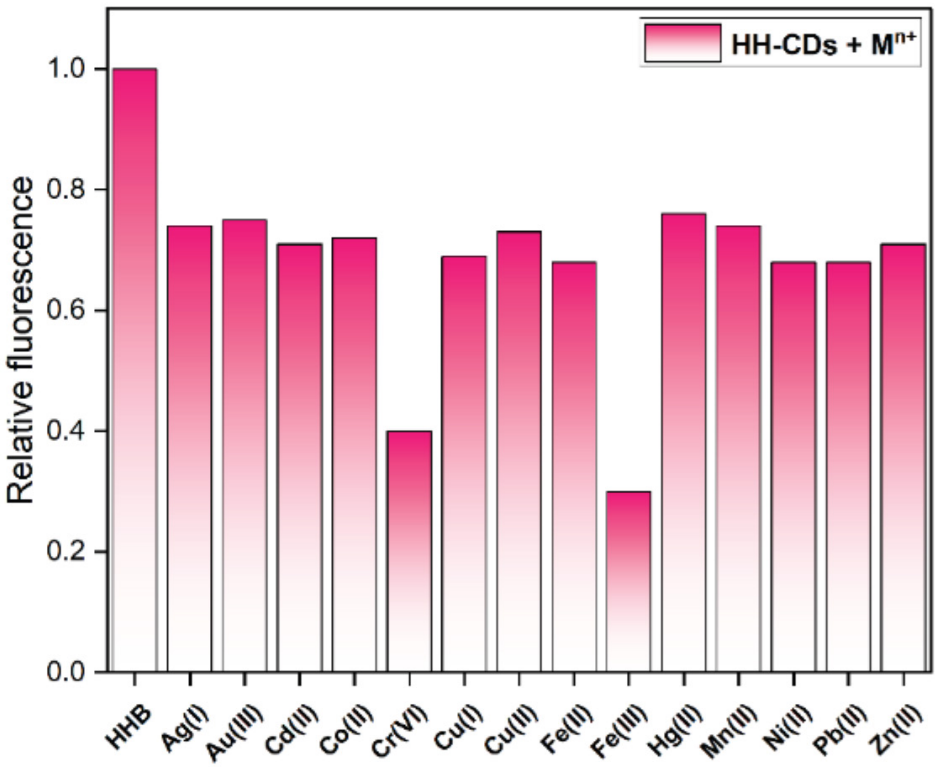

Fig.2. Fluorescence behavior of synthesised HH-CDs upon interaction with various heavy metal ions (M^{n+}) in aqueous media.

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Greenhouse gas emission dynamics and trajectories in urban water supply and wastewater systems

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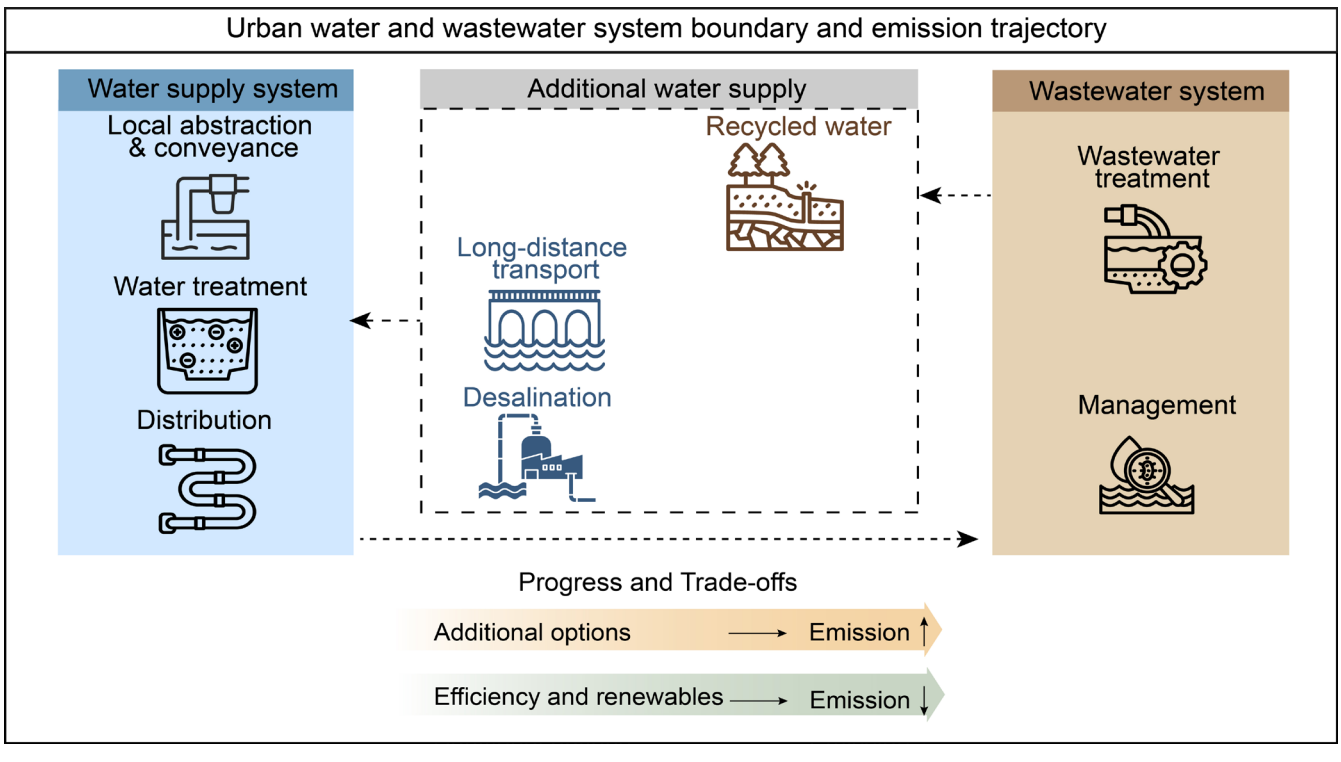
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

When the research will be completed
2025

Research objectives
Develop a social-technical assessment approach for urban water supply and wastewater system GHG emissions at the city level.

Problems or questions you are trying to address
What are emissions trajectories for water supply and wastewater systems (through time) and influencing factors in major cities (where good data is available), and the influence of reporting boundaries?

How will your research benefit the water sector?
This research could help the water sector understand long-term greenhouse gas emissions trends, clarify reporting boundaries, and evaluate the carbon trade-offs of new water supply/wastewater treatment options to support more credible net-zero planning.

Findings to date
This work develops a system-wide assessment approach to analyse the historical trends of urban water/wastewater GHG emissions. In many systems, "additional" or "new" water sources, such as desalination or long-distance water transfers, can dominate the emissions trends. Results highlighted that while the inconsistent inclusion of infrastructure for these supplies complicates city comparisons, clarity is needed for those reporting emissions and whether emissions from recycled water (potable and non-potable) are reported as water supply or wastewater emissions. The creation of water and wastewater-emission trajectories illustrates trade-offs occurring with management.

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Identifying and addressing challenges in gross pollutant trap maintenance

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RESEARCH SUMMARY

When the research will be completed
2025

Research objectives
The research aimed to investigate why most gross pollutant traps (GPTs) are not effectively maintained in Australia, leading to pollution accumulation and bypass into waterways and oceans

Problems or questions you are trying to address
- What are the major barriers hindering effective, routine maintenance of GPTs in Australia?
- What strategies could strengthen GPT maintenance across the sector?
- Which agency/organisation is best positioned to manage, regulate and enforce stormwater treatment responsibilities?

How will your research benefit the water sector?
- Helps governments and practitioners understand what prevents effective GPT performance, enabling more targeted interventions
- Identifies priority areas for investment, including resourcing, accountability and national standards.
- Highlights the need for aligned stormwater governance, reducing fragmentation across jurisdictions.
- Offers evidence to guide policy reform, such as stormwater levies and standardised maintenance requirements.
- Supports improved stormwater quality outcomes, ultimately reducing pollution entering waterways, estuaries and marine environments.

Finding to date
Key findings from the national stormwater industry survey (n = 94) - see graphic on next page:

Table: The barriers preventing efficient GPT maintenance and improvement strategies to overcome them, as ranked by the stormwater industry

GPT maintenance	
Barriers	Improvements
1. Lack of resources (funding, staff, equipment, information).	1. Increase resource allocation for maintenance.
2. Lack of consequences for not maintaining GPTs.	2. Introduce legal consequences for failing to maintain GPTs.
3. Low priority of GPT maintenance within councils/municipalities.	3. Develop nationwide GPT maintenance standards.
Additional barriers raised included poor handover from developers, lack of accountability, poor design/modelling, and difficulties disposing of collected pollutants.	Additional improvements include reviewing developer handover and increasing awareness of the importance of GPT maintenance.

Additional insights

- 68% of survey respondents believe local governments should manage and maintain stormwater assets
- 59% think state governments should lead regulation and enforcement.
- 82% support a stormwater levy as a funding mechanism for maintenance.

Conclusion

Australia's stormwater industry views GPT maintenance challenges as systemic, linked to inadequate resourcing, misaligned governance, and minimal enforcement. Improved national coordination, funding mechanisms and regulatory tools are suggested to improve GPT maintenance which will ultimately reduce pollution entering natural waterways.

Publication details

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Implementing Water Sensitive Urban Design approaches under the existing developments in urban areas

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RESEARCH SUMMARY

Summary

Urbanisation and population growth are increasing impervious surfaces, driving higher stormwater volumes and pollutant loads that threaten freshwater ecosystems. Water Sensitive Urban Design (WSUD) offers an integrated approach to mitigate these impacts, yet retrofitting WSUD in established suburbs remains challenging due to space, infrastructure, financial, and social constraints. This research, completed in June 2025, attempted to bridge critical knowledge gaps by developing an optimisation framework to identify the most effective locations, scales, and types of WSUD assets for managing stormwater quantity and quality under urbanisation and climate variability. Unlike greenfield developments, this study focuses on distributed WSUD systems – such as raingardens, infiltration trenches, and permeable pavements – strategically placed within allotments and available green spaces in existing suburbs.

Three key questions guided the research were: What constraints limit WSUD implementation in existing urban areas? Which WSUD approaches deliver optimal performance considering location, size, and type? How long can stormwater system augmentation be deferred through WSUD adoption? Using stormwater modelling (i.e., SWMM) and adopting GreenPlan-IT optimisation tool (https://www.sfei.org/projects/greenplan-it), revealed transformative outcomes as 1 - Optimal WSUD placement reduces stormwater volume and pollutant loads by up to 40%; 2 - Cost savings of $20 million compared to non-optimised solutions; 3 - Increasing WSUD assets does not compromise performance under rapid urbanisation and future climate change. The findings demonstrate that WSUD performs best when implemented at small sub-catchment scales, significantly improving stormwater management at the catchment outlet.

This study not only enhances environmental outcomes, but also provides councils and water authorities with a decision-support framework for smarter investment and long-term resilience. As climate change intensifies rainfall and flood risks, combining WSUD with rainwater harvesting and green infrastructure will be vital for creating sustainable, liveable cities. This research lays the foundation for future planning guidelines and capacity-building initiatives, enabling local governments to embed WSUD into everyday practice and defer costly stormwater system upgrades.

Papers arising from the work that have been published to date

Rashetnia, S.; Sharma, A.K.; Ladson, A.R.; Browne, D.; Yaghoubi, E. Effectiveness of Water-Sensitive Urban Design Techniques on Stormwater Quantity Management at a Residential Allotment Scale. Water 2025, 17, 899. https://doi.org/10.3390/w17060899

Samira Rashetnia, Ashok K Sharma, Anthony R Ladson, Dale Browne & Ehsan Yaghoubi (2022): A scoping review on Water Sensitive Urban Design aims and achievements, Urban Water Journal. https://doi.org/10.1080/1573062X.2022.2044494

Rashetnia, S., A. K. Sharma, A. Ladson, and D. Browne. 2018. "Understanding Limitations to Implementing Water Sensitive Urban Design (WSUD) Systems in Existing Urbanised Catchments [Online]. "In Hydrology and Water Resources Symposium (HWRS 2018): Water and Communities, edited by HWRS 2018, 696–710. Melbourne: Engineers Australia. Accessed 12 December 2019.

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Informing water management strategies in the Upper Canning River through hydrologic modelling of future climate and river release scenarios

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RESEARCH SUMMARY

When the research will be completed
13 October 2025

Research problems
Streamflow in South-West Western Australia (SWWA) has declined due to a warming and drying climate and is already supplemented by river releases in ecologically and socially significant catchments. Ongoing climate change means that these releases must be continued in the future, but the magnitude of future releases that will maintain environmental integrity is unknown.

Research objectives
Using the Upper Canning River catchment (part of the Swan-Canning system in SWWA) as a case-study, investigate concerns of changes to the frequency of days above minimum acceptable streamflow (1.8 ML/day at the catchment outlet) and how river releases can be used to support flows in the future, using the Mesoscale Hydrologic Model.

Findings to date
Based on the rainfall decline of 12% between 1998 and 2024 and a decline in streamflow of 30%, we modelled daily streamflow at the catchment outlet. A 14-member parameter ensemble was used for all model experiments to address model parameter uncertainty. Two drier climate scenarios from the National Hydrological Projections downscaled Coupled Model Intercomparison Project 5 (CMIP5) climate projections were selected and used to force future streamflow models

Results demonstrated that streamflow in the future period 2027 to 2052 will decline between 38% to 61% compared to historical streamflow. The days above minimum acceptable streamflow will decrease in the future period to between 55% and 79% compared to 91% in the historical period.

Future potential river releases were represented in the model as increases in current annual release volumes. Results suggest releases will need to be increased by up to 30% in the future to maintain historical minimum streamflow frequency, considering parameter, future climate and baseflow uncertainty. Further research should include re-calibrating the model with observed river release and surface water abstraction data, using predicted changes to land cover and leaf area index, and considering all possible future climate scenarios.

Benefits to the water sector
This project aligns with state department ecological water requirement guidelines, helping to ensure that river releases protect critical ecosystem functions under a drying climate. The results provide valuable insight for regulators and water managers aiming to balance security of water supply with the health of our river systems.

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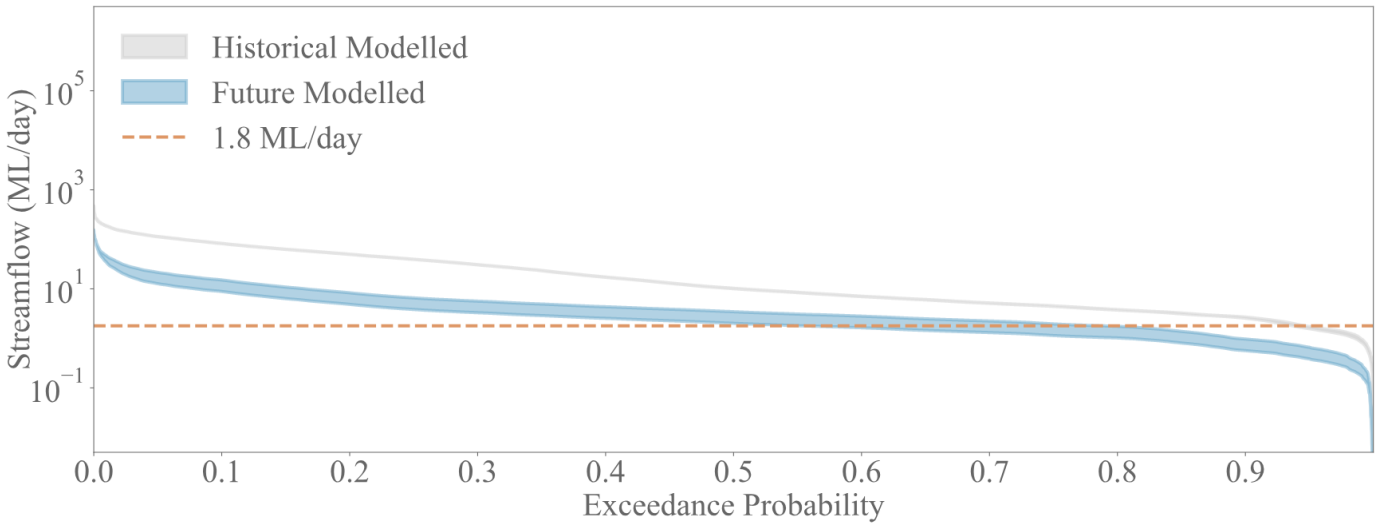

Figure 1. Flow duration curve for daily streamflow between October and May for the historical and future periods, showing the frequency of days that exceeded the minimum acceptable streamflow

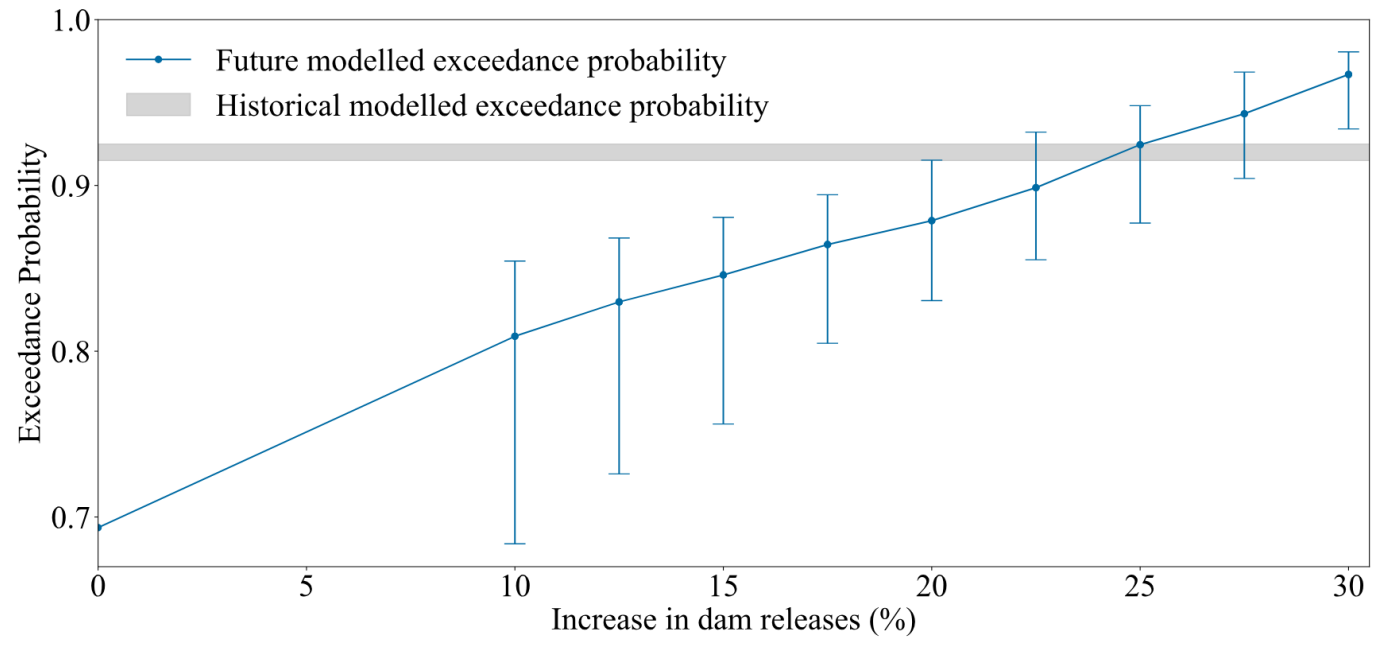

Figure 2. Increase in river releases against probability of falling below the minimum threshold. Future releases should increase by 30% to maintain historical minimum streamflow frequency (shown in grey). Error bars represent the 95% confidence interval.

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‘Just’ water for whom? Understanding (in)justice in accessing safe drinking water in Davao City, Philippines

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Supervisors: Dr Brooke Wilmsen (Principal supervisor) and Dr Lisa Denney (Co-supervisor)

RESEARCH SUMMARY

When the research will be completed
February 2028

Research objectives
1. Examine how water actors and users' understandings of water (in)justice manifest in and reshape hydrosocial relations.
2. Develop a transformative water governance framework based on the understandings of water (in)justice by water actors and users.

Problems or questions you are trying to address
How is access to water defined, negotiated, and contested in practice in Davao City, Philippines?

How will your research benefit the water sector?
It will provide empirical evidence on how technical, legal, and political processes of water delivery co-construct water (in) access, leading to the development of a transformational water governance framework that prioritises justice.

Findings to date
N/A – Data collection starts from December 2025 to July 2026

Summary

Global water scarcity affects 2.2 billion people, leaving them without access to safe drinking water (United Nations, 2025). For these individuals, gaining access to water remains an ongoing fight for water justice. Mainstream literature portrays unequal water access as a technical problem caused by physical and economic water scarcity (Biswas et al., 2025; Seckler et al., 1999), often overlooking the influence of power and politics. This research responds to water justice scholars' call to understand "how people on the ground experience and define water justice" and how they create “alternative hydrosocial orders" (Boelens et al., 2018, pp. 22-23). It will examine how the technical, legal, social, and political processes involved in water delivery co-construct water (in)access, advocating for “transformational water governance” that centres justice. The study will investigate how water service providers deliver domestic water and how residents access water, highlighting power relations and politics that sustain water (in)justice.

To examine the power dynamics and politics surrounding water access, this research adopts a hydrosociality framework through the hydrosocial cycle, which views water, technology, and society as mutually constitutive (Linton & Budds, 2014). It

aims to explore understandings of water (in)justice as experienced and perceived by multiple water actors and users. A qualitative case study approach is suitable for this research, allowing an in-depth exploration of place-based and contextual experiences of water (in)justice. Various qualitative data collection methods will be used, including one-on-one narrative and key informant interviews, focus groups, document analysis, non-participant observation, photo stories, and a hydrosocial exploration group activity (such as a hydrosocial walk, hydrosocial map, and hydrosocial photo) to answer the question: How is water access defined, negotiated, and contested in practice in Davao City, Philippines? Participants in this study include residential water users, water service providers, water authorities, and other stakeholders.

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Machine learning–based dam level forecasting to support water supply resilience under climate variability

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RESEARCH SUMMARY

When the research will be completed
November 2025

Research objectives
This research investigates how data driven machine learning (ML) models can improve reservoir water-level forecasting and support water-supply resilience in Australia. The study aims to (1) compare traditional statistical, hydrological, and machine-learning methods, (2) develop an automated ML forecasting framework applicable under Australian context, and (3) evaluate how improved predictability can enhance water-planning decisions under climate variability.

Problems or questions you are trying to address
Australian reservoirs face highly variable hydrological regimes driven by El Niño–Southern Oscillation and increasing climatic extremes. Traditional forecasting tools such as multi-linear regression, and hydrological models like eWater Source struggle with non-linear dynamics, heavy calibration requirements, and limited scalability. There is a gap in applying modern ML approaches to Australian dams, particularly regarding automation, hydrologically meaningful metrics, and operational usefulness.

How will your research benefit the water sector?
More accurate and adaptive reservoir forecasts can support: 1) early drought-risk detection and demand-management decisions; 2) improved operational planning of releases and storage; 3) faster model updates with new observations; 4) evidence-based infrastructure planning. The automated ML framework reduces time and expertise required for model setup, making advanced forecasting accessible to authorities.

Findings to date
Rocky Creek Dam in NSW was modelled. Machine-learning methods, especially XGBoost, significantly outperformed traditional approaches, achieving: 1) <1% MSE and 0.71 KGE at Rocky Creek; 2) clearer capture of seasonal behaviour (Figure 1); Table 1), strong performance even with noisy and incomplete datasets.

Hydrological model (GR4J) in eWater Source underperformed when data were sparse (KGE of -1.59), reinforcing the need for flexible, data-adaptive tools. The study also developed a reproducible automated ML pipeline integrating feature engineering, hyperparameter tuning, retraining, and forecasting without manual intervention. The framework integrates real-time data streams to retrain the model and deliver continuously updated forecasts.

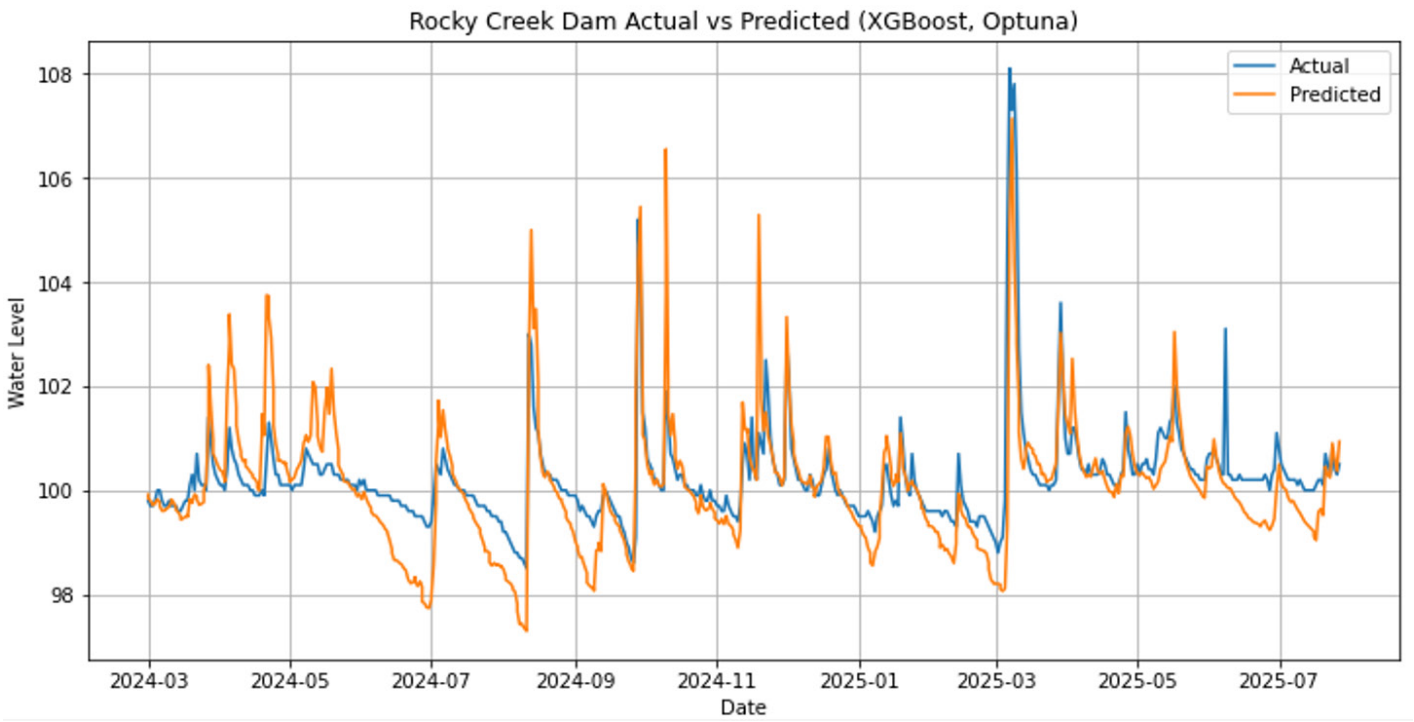

Figure 1: Actual Water Level vs Predicted ML Forecasts for Rocky Creek Dam

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Microbial degradation of microplastics for wastewater treatment

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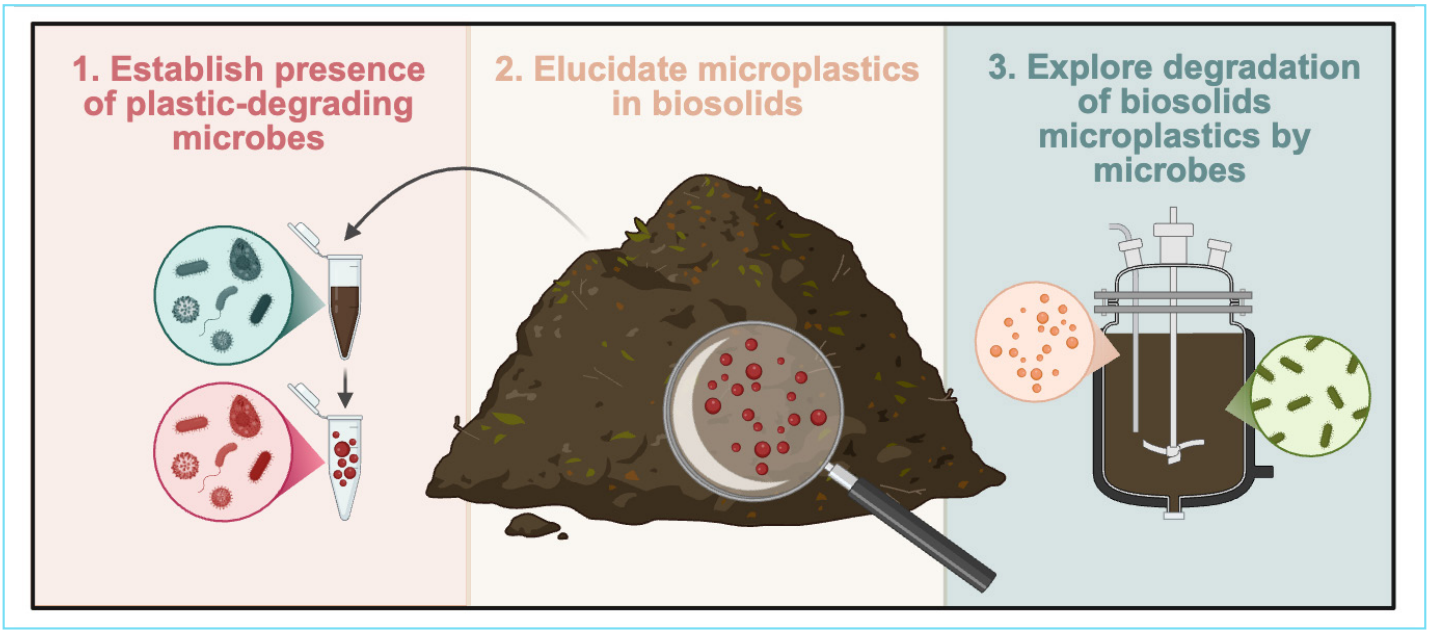
GRAPHICAL ABSTRACT



Created in BioRender. Heric, K. (2026)

RESEARCH SUMMARY

When the research will be completed
Early 2027

Research objectives
The project aims to explore the potential of microbial biodegradation for the removal of microplastics in a wastewater treatment setting.

Problems or questions you are trying to address
Microplastics enter terrestrial environments through land applications of fertilisers made from wastewater biosolids. These microplastics can negatively impact plant development and yield through altering soil structure and microbial communities and can move into aquatic systems through rainwater runoff. The potential for microbial biodegradation of microplastics in biosolids is guided by the following research questions: 1. Are plastic-degrading microbes present in wastewater biosolids? 2. What is the extent of microplastics contamination in biosolids? 3. Do plastic-degrading microbes found in biosolids effectively degrade common wastewater microplastics?

How will your research benefit the water sector
Microbial degradation has been proposed as a solution to the growing plastic pollution problem, however, specific applications are lacking. This work will establish the presence of plastic- degrading microbes that could be harnessed for their biodegradation abilities in wastewater treatment systems. It will contribute to the growing body of knowledge evaluating the transfer of microplastics from wastewater to terrestrial systems. Finally, the project will inform whether harnessing microbial degradation for wastewater treatment is a worthwhile venture for the removal of microplastics from wastewater by-products.

Findings to date
Plastic-degrading microbes exist in biosolids, including species of Pseudomonas and Bacillus which have previously been shown to degrade multiple polymer substrates. Most plastic-degrading genera appeared in low relative abundance. Preliminary findings indicate the ubiquity of microplastics, which were present in all wastewater biosolids samples. Common microplastics detected were polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET) and polyurethane (PU). PP appeared in highest relative abundance and the dominant morphology type observed was microplastic fragments in the 20 - 100 µm size range.

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National-scale environmental assessment of biosolids processing pathways in Australia under emerging PFAS regulation

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RESEARCH SUMMARY

When the research will be completed
This research is expected to be completed in 2026

Abstract
Australia's biosolids sector is entering a major transition due to forthcoming regulatory updates on PFAS requirements for biosolids end-use. These changes are expected to alter both end-use pathways and processing practices across the country, with broad implications on the environmental performance of biosolids processing systems on a national scale. However, the extent and direction of these system-wide impacts are not yet well understood. This project delivers the first national-scale life cycle assessment (LCA) of Australia's biosolids processing systems, integrating jurisdiction-specific biosolids production, technology mixes, and projected electricity-grid changes. The assessment quantifies current environmental burdens and evaluates how different regulatory, technological, and utility-response scenarios may shape future national outcomes.

Research objectives
- Quantify Australia's current environmental burdens from biosolids processing across global warming, eutrophication, human toxicity, and ecotoxicity indicators.
- Evaluate how PFAS-driven regulatory changes may reshape national environmental outcomes.
- Assess how technology choices, utility responses, and biochar end-uses influence future impacts.
- Examine implications for national nutrient-recovery potential (N and P).

Problems or questions you are trying to address
- How do national environmental implications from biosolids processing vary across jurisdictions and over time?Evaluate how PFAS-driven regulatory changes may reshape national environmental outcomes.
- What are the environmental implications of diverting biosolids from land application under PFAS regulations, assuming the adoption of thermal technologies for PFAS destruction?
- How do electricity-grid decarbonisation, technology uptake, and PFAS content influence long-term sustainability trajectories?
- What is the effect of regulatory transitions on Australia's nutrient recovery capacity from biosolids?

How will your research benefit the water sector?
This work provides the first evidence base quantifying how PFAS regulation, electricity-grid transitions, and technology adoption interact to shape Australia's biosolids sustainability profile. The findings directly support:

- Utilities to understand the comparative environmental performance of different biosolids processing options from a life cycle perspective
- Utilities planning long-term infrastructure investments considering changing regulatory landscape and decarbonising grid electricity.
- Regulators evaluating the environmental implications of PFAS thresholds and compliance timelines.
- Industry stakeholders seeking to avoid unintended burden-shifting during regulatory transitions.

Findings to date
In 2023, biosolids processing systems in Australia generated approximately 461,000 tonnes CO_2-eq, representing about 0.1% of national emissions, with Victoria, Queensland, and New South Wales together responsible for nearly 80% of the total impact. For future projections, the analysis indicates that projected electricity-grid decarbonisation will not mitigate impacts from biosolids processing. Instead, it increases global warming potential (GWP), eutrophication potential (EP), and ecotoxicity potential (ETP) because cleaner grids reduce the electricity-offset credits traditionally provided by energy recovery from biogas utilisation.

Under potential PFAS regulatory updates, between 4% and 36% of biosolids may require diversion from land application by 2035, depending on regulatory stringency. Stricter regulations generally lower national GWP, EP, and human-toxicity burdens, but increase ETP due to the higher electricity demand of thermal technologies. National nutrient recovery potential is also projected to decline by 20–45% under high-stringency regulation, with implications for nutrient circularity at the national scale. University Press. While differences in thermal technology type and biochar end-use have comparatively minor influence on outcomes, utility responses and variations in biosolids PFAS content exhibit stronger effects and play a key role in shaping the future environmental performance of biosolids processing systems.

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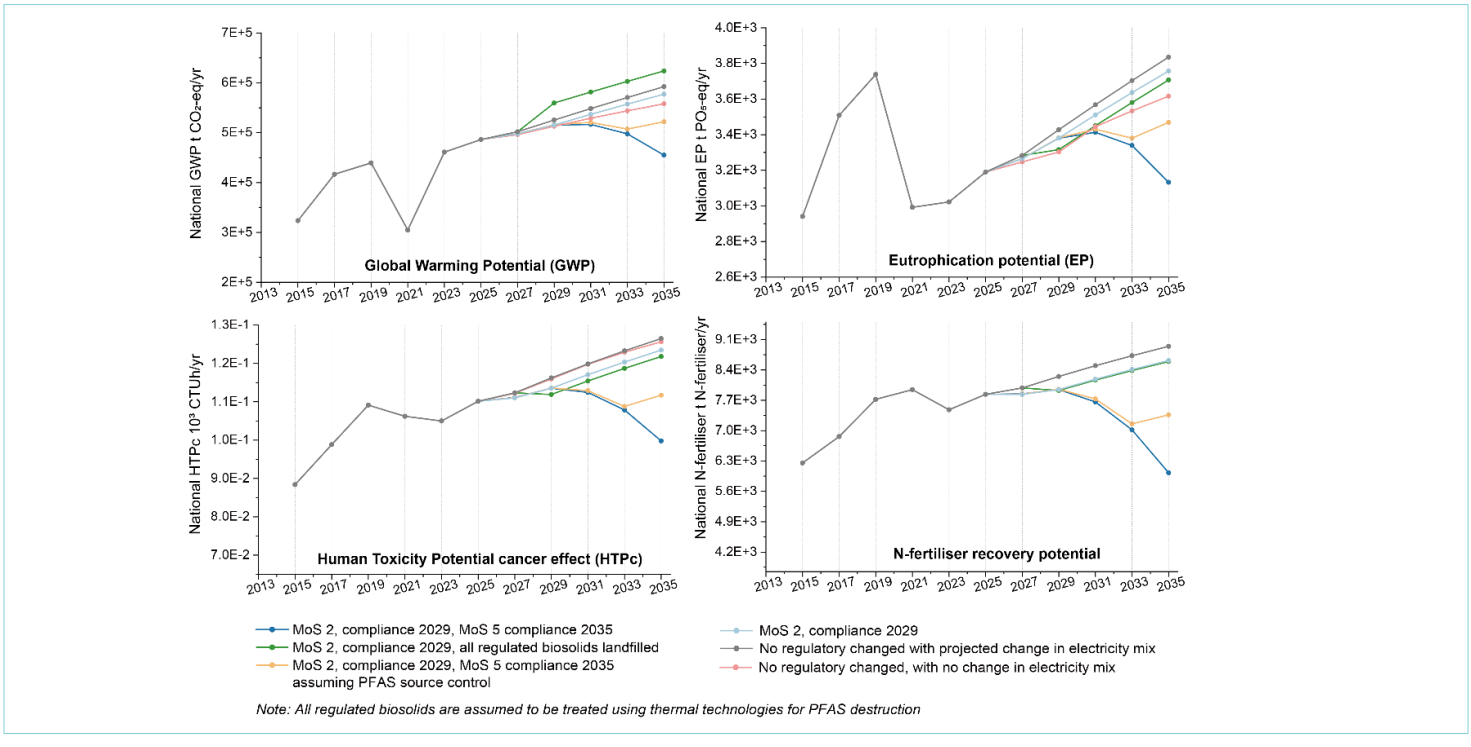

Figure. 1 National environmental implications of biosolids processing in Australia under scenarios that vary in regulatory stringency (Margin of Safety), projected changes in electricity mix, and potential reductions in PFAS content

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Nature-water design: The benefits of integrating biodiversity and Water Sensitive Urban Design

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Supervisors: Professor Sarah Bekessy, Dr. Casey Visintin

RESEARCH SUMMARY

When the research will be completed
February 2026

Research objectives
We apply the first example of Nature-Water Design (NWD) - a novel framework integrating Biodiversity and Water Sensitive Urban Design (BSUD & WSUD) - to a street in Beveridge North, Victoria (Fig.1.), just south of where Yarra Valley Water is planning to develop Hazelwynde Estate into a cost effective, biodiversity positive, carbon negative residential precinct. Our objective was to evaluate the performance of biodiversity and water outcomes across three street design scenarios: Business-As-Usual (BAU), Water Sensitive Urban Design (WSUD), and the integration of Biodiversity- and Water Sensitive Urban Design (Nature-Water Design, NWD; Fig.2.).

Problems or questions you are trying to address
Does designing an urban streetscape for nature and water by considering Biodiversity and Water Sensitive Urban design (BSUD & WSUD) together improve biodiversity (e.g., species and habitat diversity & habitat suitability for target species) and water outcomes (e.g., water quality, evapotranspirative cooling, runoff reduction) compared to designing for WSUD alone or not at all (Business-As-Usual, BAU)?

How your research will benefit the water sector
Our research provides numerous potential benefits for the water sector, including improvements to the efficiency and delivery of biodiversity positive WSUD outcomes (e.g., water quality, evapotranspirative cooling, harvesting and runoff reduction). It is the first application of a framework that integrates BSUD & WSUD and provides a valuable model for further case studies to build on. Encouraging application of the Nature-Water Design framework enables the water sector to avoid overlooking important biodiversity-water relationships and encourages interdisciplinary collaboration between ecologists and hydrologists – as is necessary to achieve better outcomes for nature, water and people into a future with an increasing need for resilience to climate extremes.

Findings to date
Our results demonstrate that integrating Biodiversity and Water Sensitive Urban Design (BSUD & WSUD) together can lead to improved outcomes for both biodiversity and water, above considering them separately (WSUD) or not at all (BAU). We

evaluated benefits to biodiversity using a Vegetation Assessment Tool (Fig.3) analysing different types of vegetative diversity for species habitat and using a habitat suitability checklist for four relevant native target species: the Australian Emperor Dragonfly, Pobblebonk Frog, Superb Fairy Wren and Blue-banded bee (Fig.4). We demonstrated benefits to WSUD outcomes (e.g., water quality, evaporation, runoff reduction) by digitising and modelling each street design scenario in MUSICX (eWater) software (Fig.5).

Papers arising from this work

Nature-Water Design: Integrating biodiversity and water sensitive urban design (2026), F. Hoegh-Guldberg, T. Fletcher, Y.E. Chee, C. Visintin, H. Kirk, G. Garrard, M. Selinske, S.A. Bekessy. Nature-based Solutions. https://doi.org/10.1016/j.nbsj.2026.100312

The synergistic benefits of integrating biodiversity and water in urban design (In prep.), F. Hoegh-Guldberg, C. Visintin, Y. En Chee, H. Kirk, T. Fletcher, S. A. Bekessy. Nature Cities.

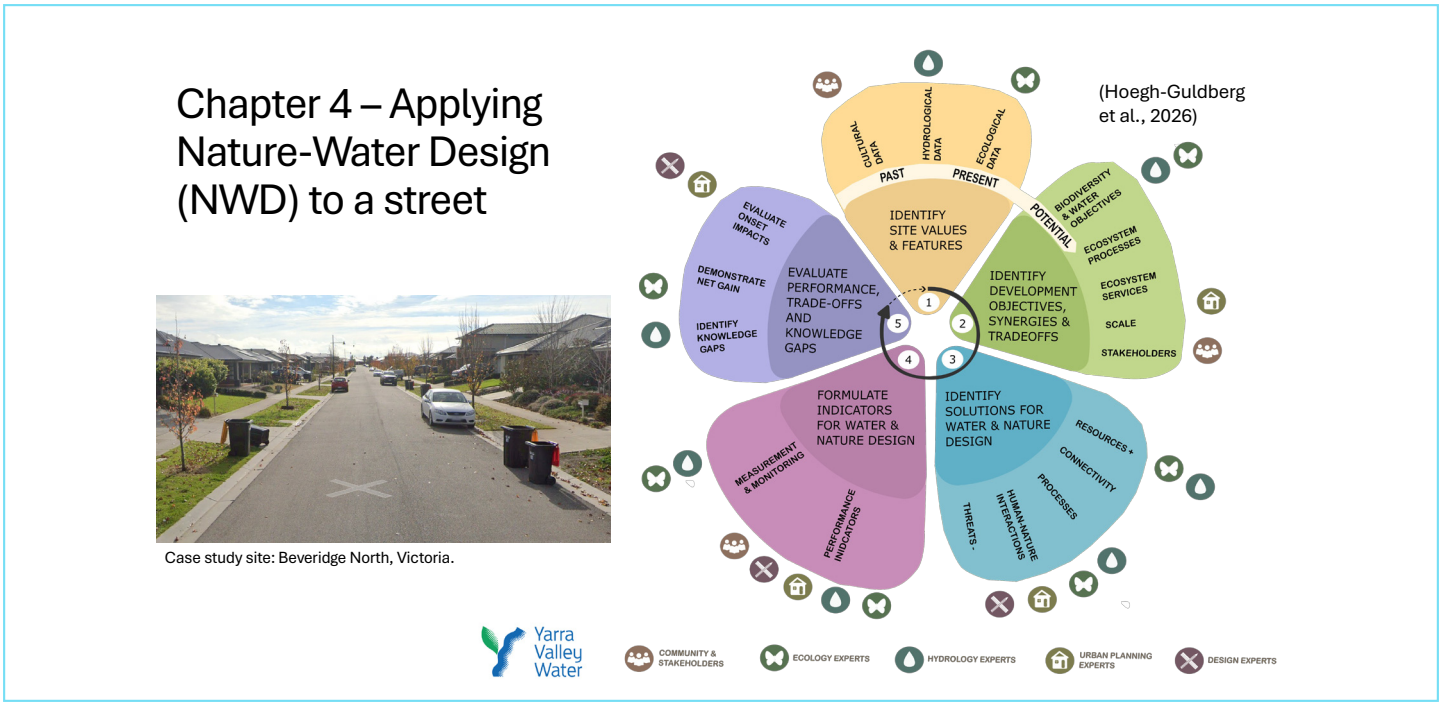

Fig.1. The Nature-Water Design framework, integrating Biodiversity and Water Sensitive Urban Design.

Business-As-Usual | Water Sensitive Urban Design (WSUD) | Nature-Water Design

Fig.2. The three streetscape scenarios compared for their performance across biodiversity and water outcomes (Hoegh-Guldberg et al., In prep).

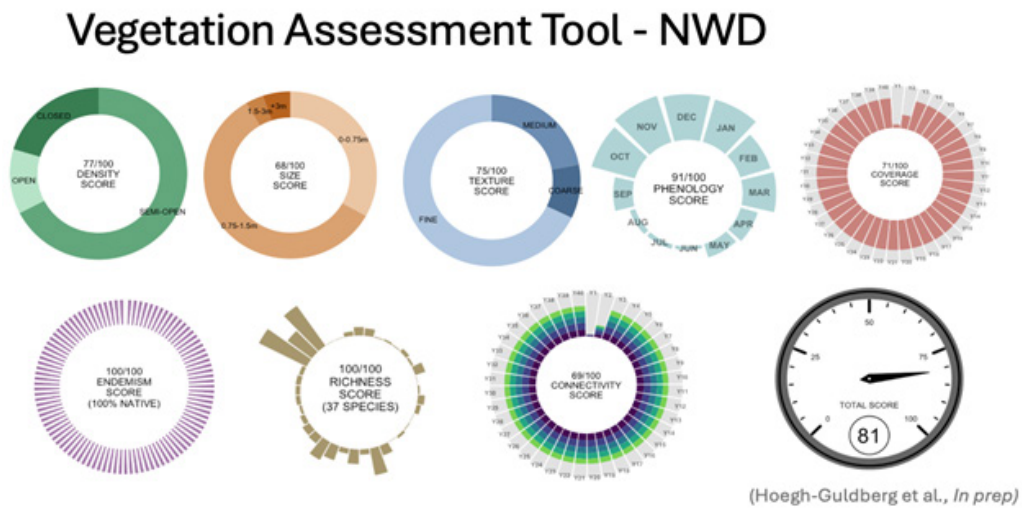

Fig 3. An example of the biodiversity outcomes measured for the Nature-Water Design scenario using the Vegetation Assessment Tool.

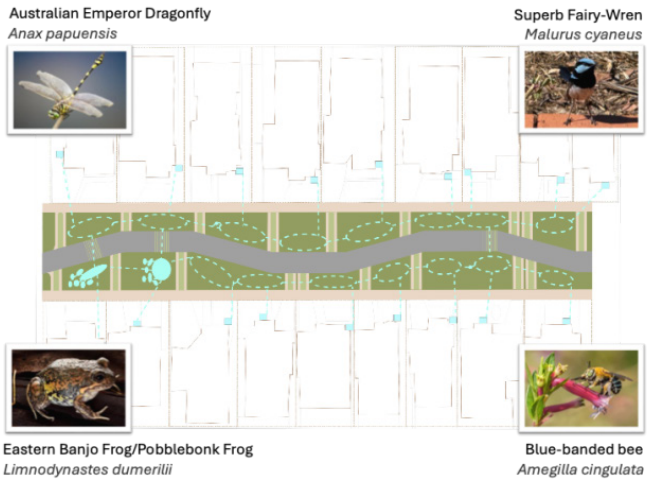

Fig 4. Each scenario was evaluated for its ability to support the four target species across the species' full life cycle.

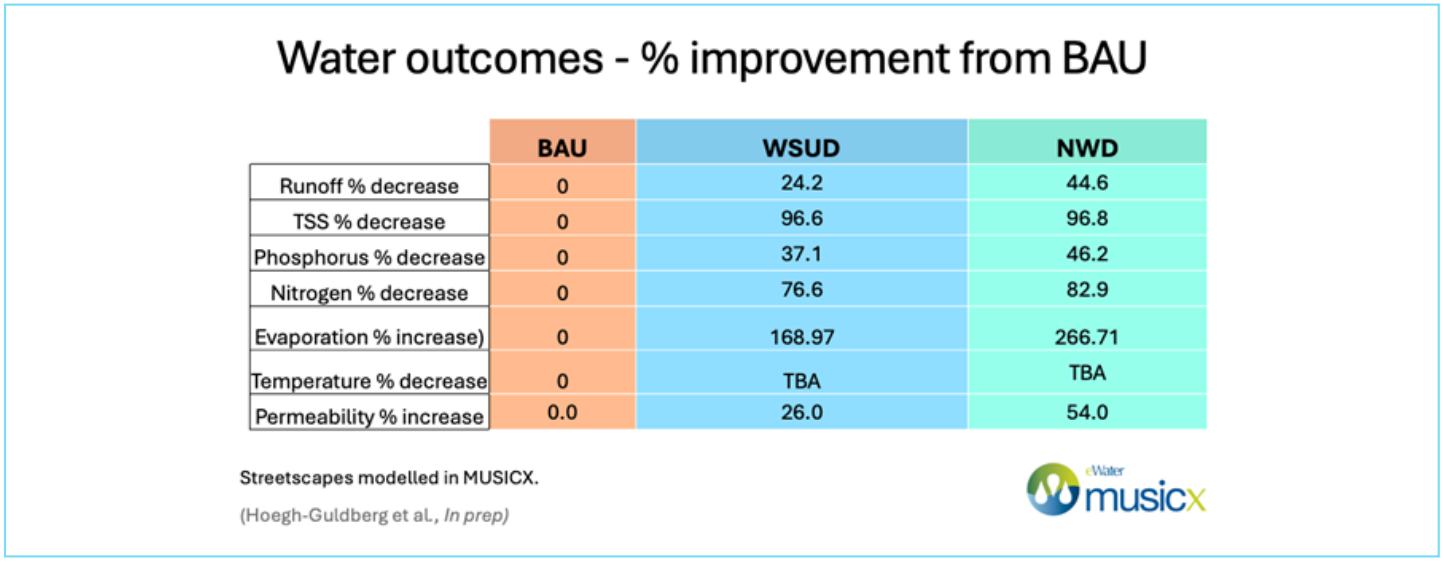

Fig 5. An example of the percentage improvements for water outcomes that we modelled and evaluated in MUSICX for each scenario, as compared to the digitised Business-As-Usual (BAU) scenario software.

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Optimised placement of vibration sensors in urban water networks

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RESEARCH SUMMARY

When the research will be completed
May 2026

Summary
It is common to have water leakages in an underground pipe network from deterioration over time. Many of these underground pipe leaks remain undetected for a long time causing damage and water loss. To address this, South East Water (SEW) in Melbourne has introduced a vibration sensor device called SOTTO®, which can be installed inside digital meters to identify leaks. Since deploying and monitoring many sensors is costly, the focus of this research is on creating an optimisation algorithm that determines the minimum number and best placement of sensors to detect the majority of leaks at the lowest cost.

This research has three research objectives as below:

- **Sensor sensitivity statistical model** capable of predicting the probability with which a sensor can detect a leak, depending on the leak's distance from the sensor, the leak size, and the material composition of the intervening pipes.
- **Formulating an Optimisation** model that integrates the sensor sensitivity model to an optimisation problem.
- **Investigation of scale-up methodologies** in applying optimisation problems for larger water networks.

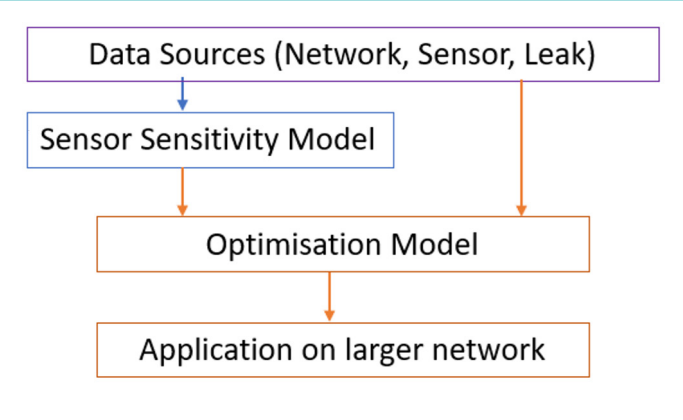

Figure 1: high-level project structure

Figure 1 illustrates the high-level project structure. Data sources obtained from SEW are transformed into appropriate formats that satisfy the sensor sensitivity and optimisation models.

Sensor sensitivity
Sensor sensitivity model predicts the behaviour of sensors using leak size (Lx) and pipe characteristics along the path of leak location x to sensor z. The logistic regression model was taken as the binary prediction model, where a sensor detecting a leak is a positive response (Az=1), and a sensor not detecting a leak is a negative response (Az=0). Model evaluation demonstrated accuracies of 0.73 and 0.70 for training and test datasets respectively.

Optimisation model
A mixed-integer convex formulation was created to determine the optimum number of sensors and undetected leaks in the overall network. The optimisation model incorporates the statistical sensor sensitivity framework and expected leak size distributions as constraint functions. Based on initial results of the study, the optimisation model shows potential to minimise the loss of income through undetected water leaks, offset by the cost of the deployed sensors.

Application of optimisation model in larger networks
Scaling the sensor placement optimisation model to larger water networks presents significant challenges. To address this, the network was partitioned into smaller, computationally tractable subnetworks. Optimal solutions were first obtained for each subnetwork and subsequently integrated to form the solution for the overall network. We implemented an algorithm to segment the network based on spatial properties and then apply the sensor placement model on individual subnetworks in such a way that information from previously solved subnetworks was preserved and incorporated into subsequent optimisation steps, ensuring consistency and efficiency in scaling to larger systems.

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Proactive detection of wastewater overflows in smart wastewater systems

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RESEARCH SUMMARY

When the research will be completed
31st October 2026

Summary

Wastewater overflows caused by blockages have become a major concern for water utilities, as these events lead to environmental harm, service disruptions, costly emergency responses, and potential regulatory penalties. Most importantly, repeated overflows erode community trust in utilities. Proactive detection offers a pathway to break this cycle. By identifying emerging blockages early, utilities can intervene before failures occur, reducing operational costs, protecting the environment, and strengthening customer confidence.

This research aims to develop reliable, proactive methods for preventing wastewater overflows using Internet of Things (IoT) sensing systems. Firstly, advanced data analytics incorporating statistical techniques are applied to historical event data to characterise blockage behaviour. These insights enhance prediction accuracy in level-based detection methods and reduce false alarms in current smart sewer systems. Secondly, an acoustic-based method is investigated, where low-cost IoT acoustic sensors capture reflection signals generated by blockages. This approach not only detects the presence of a blockage, but also estimates its size and location, - information essential for targeted maintenance. Finally, to support system-wide scalability, a novel method integrating a genetic algorithm with blockage detection conditions developed based on network topology and elevation data is introduced to optimise sensor placement, enabling utilities to achieve maximum coverage with minimal investment.

Findings show that the advanced data analytics approach is both feasible and effective for detecting gradual and rapid sewer blockages. It can identify early-stage anomalies, particularly for gradual blockages, giving utilities the opportunity to intervene well before an overflow occurs. This work has been submitted to the Journal of Water Science and Engineering and is currently under review.

The acoustic-based method has also been validated under a range of operating conditions and can distinguish between blockage types based on both size (partial or complete) and material (e.g., tree roots versus solids used to simulate wet wipes or grease). These findings have been published in the Journal of Applied Acoustics. This technique is now being advanced into a potential commercial product designed to support both water utilities and household customers in proactive blockage detection.

Finally, the optimisation framework has demonstrated strong capability in identifying locations where sensors are most effective at detecting blockages before they trigger downstream overflows. This provides a scalable, cost-effective strategy for utilities to expand sensor networks across initial and future investment phases. The findings have been published in the Journal of Water Resources Planning and Management.

Together, these outcomes provide an integrated approach for early detection, accurate localisation, and efficient monitoring of sewer blockages. The research delivers both practical tools for immediate use and strategic guidance for utilities moving from reactive to proactive management. Overall, it offers a promising combination of science and practical application to enhance system resilience and protect the environment.

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Quantifying flow regulation and climate change impacts to guide environmental flow management on the Murrumbidgee River

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RESEARCH SUMMARY

When the research will be completed
Research completed in May 2025.

Summary
Australia's water industry is being asked to deliver water security, meet Basin Plan requirements, and restore freshwater ecosystems in a changing climate. To support this, we quantified both the individual and combined effects of river regulation and projected climate change on flows in the Murrumbidgee River and its largest wetland ecosystem, the Lowbidgee Floodplain (3,250 km^2). Using long-term hydrological data (1890-2022) and satellite-derived inundation maps (1988-2023), we reconstructed 'natural' (pre-development) flow, assessed regulation impacts through time, and propagated mid-century climate signals to reveal what is driving the drying of the nationally important Lowbidgee wetlands.

Three insights matter most for practice. First, regulation impacts dominated change: median annual flows to Hay (upstream of the Lowbidgee) fell 43% under high regulation (1958-2018) and 55% in the last three decades. Major-flood return intervals more than doubled (from 2.0 to 4.4 years) and event duration shortened from 11.3 to 4.5 days, reducing the river-floodplain connectivity that sustains ecosystem productivity. Second, climate change compounds these effects: projections indicated an additional 7-10% decline in median annual flow by 2047-2075, with the annual duration of major floods contracting to 1.6-1.8 days if operations remain unchanged. Third, seasonal flow regimes have been homogenised: historically wet winter-spring seasons show 47-66% median reductions relative to natural flow, eroding the boom-and-bust dynamics that cue fish spawning, waterbird breeding, and riparian recruitment.

Methodologically, we provide a transferable, data-lean framework useful to agencies without bespoke river system models. We (i) developed a runoff-streamflow model that reconstructed natural flow from gridded runoff and gauge records (1890-2022); (ii) coupled CMIP5/CMIP6 climate change signals to simulate future natural and regulated flows; and (iii) linked river discharge to satellite-mapped inundation (1989-2023) to quantify how many hectares, and how often, the floodplain wets

under alternative scenarios. This discharge-inundation relationship ($R^2 \approx 0.78$; $p<0.001$) translates flow targets into explicit spatial outcomes for wetlands.

These findings offer practical guidance for water managers: prioritise measures that recover the magnitude, frequency, and duration of large events (through environmental water deliveries, operational rules that protect high flows, and barrier removals), then layer climate adaptation on top. The seasonal analyses point to when water yields the greatest ecological return (winter-spring), while the inundation model provides spatial watering curves to specify habitat reconnection per megalitre. This framework is readily portable to other regulated catchments across the Murray-Darling Basin and globally, where streamflow data are available.

Publications to date:

Kreibich J (2025): Flow regulation and climate change impacts on a major Australian river ecosystem. PhD thesis. UNSW Sydney, Australia.
DOI: https://doi.org/10.26190/unsworks/31084.

Kreibich J, Glamore W, Zheng H, Chiew F, Bino G, Kingsford RT (2025): From natural variability to flow homogenisation: how dams, water diversions, and climate change reduced seasonal flows in Australia's Murrumbidgee River. Preprint. EarthArXiv. DOI: https://doi.org/10.31223/X5D441.

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Kreibich J, Bino G, Kingsford RT (2023): River flow changes with river regulation and climate change – effects on a nationally important wetland ecosystem in semi-arid Australia. In: Nones M et al. (eds.), Proceedings of the 4th IAHR Young Professionals Congress, p11-12.

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Removal of per- and polyfluoroalkyl substances (PFAS) from wastewater through foam separation in aerated bioreactors

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Supervisors: Stefano Freguia, Bradley O. Clarke, Anthony D. Stickland

RESEARCH SUMMARY

When the research will be completed
September 2025

Research objectives
To assess the potential of integrating foam-based PFAS removal within aerated bioreactors under current operating conditions at wastewater treatment facilities.

Problems or questions you are trying to address
Removal of PFAS from wastewater at treatment facilities can be costly due to the large volumes of water. This study explores a simple approach that leverages the existing aeration and foaming conditions in aerated bioreactors to remove PFAS through a foam separation process. In this process, PFAS are captured using foam as the separation medium, generating a smaller and concentrated waste stream for efficient destructive treatment, while the majority of the treated water retains low PFAS concentrations, likely within safe limits for discharge into water bodies.

How will your research benefit the water sector?
The method examined in this research demonstrates the potential to reduce PFAS treatment costs, minimise environmental emissions, and protect public health. The outcomes of this study offer a scalable and practical PFAS remediation solution for existing wastewater treatment facilities.

Findings to date
Long-chain PFAS, such as PFOA, were found to be concentrated in foam at levels up to approximately 90 times higher than in the underlying water of aerated bioreactors, indicating that foam can serve as an effective PFAS separation and concentration medium. In addition, lab-scale experiments demonstrated that foam separation achieved long-chain PFAS removal efficiencies ranging from 70 % to 100 %, while the foam accounted for only about 2 % of the total influent volume.

Papers arising from the work that have been published to date
(1) **We, A. C. E.**, Chen, C. X., Stickland, A. D., Clarke, B. O., Freguia S. (2026). Influence of microbial communities on foam fractionation of wastewater for PFAS removal, Water Research, 291, 125144.
(2) **We, A. C. E.,** Stickland, A. D., Clarke, B. O., Freguia S. (2025). PFAS removal through foam harvesting during wastewater aeration, Journal of Hazardous Materials, 491, 137936.
(3) **We, A. C. E.**, Stickland, A. D., Clarke, B. O., Freguia S. (2024). Analysis of wastewater treatment plant

data identifies the drivers of PFAS enrichment in foams, Water Research, 266, 122397.
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(5) **We, A. C. E.,** Zamyadi, A., Stickland, A. D., Clarke, B. O., Freguia, S. (2024). A review of foam fractionation for the removal of per- and polyfluoroalkyl substances (PFAS) from aqueous matrices, Journal of Hazardous Materials, 465, 133182.

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Safeguarding public health and the environment: Unpacking the safety of urine-derived fertilisers

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RESEARCH SUMMARY

When the research will be completed
April 2027

Research objective
To assess the chemical and biological safety of urine-derived fertilisers.

Research questions
1. What is the current understanding of hazards present in human urine that may pose health risks?
2. Do urine-derived fertilisers treated using membrane technologies (UrVal and Ugold), or extended storage, reach compliance with Australian wastewater reuse guidelines (1 µDALY) for use in home gardens and urban green areas?
3. How long must urine be stored, considering the local operational environment and dilution from flush water in urine-separating toilets, to comply with reuse guidelines?
4. Do urine-derived fertilisers cause biological effects in the environment due to micropollutant residues present in urine, either before or after membrane treatment?

Research benefits for the water sector
To establish a circular economy, large-scale nutrient recovery from urine-separated wastewater has emerged as an innovative approach to transform the wastewater industry. Wastewater is a major source of nitrogen and phosphorus released into surface waters, leading to eutrophication that disrupts ecosystems and adversely affects drinking water supplies, fisheries, aquaculture, and water-based commerce and recreation. As nitrogen and phosphorus in sewage are primarily found in urine, urine-separation technologies (source separation) potentially enable the recovery of these nutrients, thereby alleviating pressures from urban intensification, waterway pollution, and climate change, and enhancing resilience in both wastewater management and urban farming sectors. This project uses Quantitative Microbial Risk Assessment (QMRA) and in vitro bioassays to characterise potential risks and inform appropriate risk management strategies to ensure the safe use of recovered fertiliser products for human health and the environment.

Findings to date
Based on the results of a systematic literature review accepted for publication in the Journal of Water Reuse, thirty-five studies rigorously addressed hazards present in urine before and after treatment. The findings reveal that the range of contaminants in urine has expanded since source separation was introduced in the 1990s. Key knowledge gaps include uncertainties in pathogen concentrations at the source, the efficacy and stability of urea hydrolysis (storage) as a single treatment method, and the use of surrogate pathogens to represent inactivation dynamics – especially for viruses – in hydrolysed urine. Antimicrobial resistance genes (AMR) have also emerged as a hazard of concern that could affect the safety of urine reuse, as antibiotics

and AMR genes are primarily excreted in urine. The main exposure pathways identified include accidental ingestion of unwashed or uncooked home-grown crops, occupational exposure during the handling and mixing of urine fertiliser, and recreational exposure of toddlers playing in green areas where fertiliser has been recently applied. The modelling results indicate that membrane treatment can greatly reduce health risks associated with the use of urine-derived fertilisers, bringing the risk to a level sufficiently low to meet Australian targets. The results also show that inactivation of both bacteria and viruses through urine storage alone is unlikely to meet safety targets without extended storage durations. Whilst the outcomes of this research will support informed decision-making on the introduction of urine-derived fertiliser, biological effect assessment of micropollutant residues that may be present in urine-derived fertiliser still need to be conducted in subsequent steps.

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Sustainable PFAS remediation in biosolids for land applications

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RESEARCH SUMMARY

When the research will be completed
This project commenced in April 2024 and is expected to be completed by September 2027.

Research objectives
The widespread use of Per- and Polyfluoroalkyl Substances (PFAS) has led to their accumulation in biosolids, which are commonly applied to agricultural land as nutrient-rich soil amendments. This practice creates a significant pathway for PFAS transfer into the food chain, posing environmental and human health risks due to their persistence and bioaccumulation. This project aims to develop and evaluate innovative and sustainable remediation strategies for PFAS-contaminated biosolids, addressing the current lack of integrated assessments that simultaneously consider PFAS immobilisation performance, nutrient retention, and scalability under conditions relevant to wastewater treatment and agricultural reuse. To achieve this aim, the study first investigates thermal treatment as a means of degrading and removing PFAS from biosolids, with process conditions optimised to maximise removal efficiency. It then evaluates sorbent-based immobilisation strategies to stabilise residual PFAS in treated biosolids and minimise subsequent environmental release. Additionally, biochar produced through thermal treatment is assessed as an internal sorbent applied back into biosolids prior to land application, demonstrating a circular, waste-minimising approach in which the treatment by-product is repurposed to enhance PFAS immobilisation.

Research problems or questions
This study is designed to address several critical questions related to the management of PFAS-impacted biosolids. These include:

- What treatment approaches offer practical, scalable, and sustainable solutions for managing PFAS-impacted biosolids in real-world settings?
- Can thermally produced biochar be repurposed as an efficient sorbent to enhance PFAS immobilisation and support circular treatment strategies?
- How can PFAS be effectively removed or stabilised in biosolids to minimise their long-term environmental and health risks?

How your research will benefit the water sector
This research will provide the water sector with a proof-of-concept and lab-based results on the outcomes of the experiments. Our data shows

that immobilisation effectively prevents the migration of residual PFAS into soil, crops, and water bodies. The outcomes will support utilities in producing safer biosolids for land application, lowering the risk of PFAS entering groundwater or surface water, reducing long-term liability and disposal costs, and enabling more sustainable resource recovery practices aligned with emerging regulatory thresholds.

Findings to date

PFAS concentrations in biosolids before and after treatment were quantified by solvent extraction followed by LC–MS/MS analysis, showing ≥99% reduction in total PFAS concentrations in the solid phase following pyrolysis, indicating effective removal and suggesting substantial thermal degradation. Biochar produced at 900 °C for 1 h exhibited the highest BET surface area (24.42 m^2 g^{-1}), supporting enhanced sorption of PFAS during subsequent immobilisation experiments. Incubation of biosolids with 1% (w/w) sorbents resulted in >80% retention of long-chain PFAS, demonstrating strong stabilisation performance. Elemental concentrations determined by ICP analysis showed that while aluminium and iron were substantially reduced, essential nutrients such as potassium and phosphorus were largely retained, with ~60% remaining bioavailable. Other elements (e.g. Zicn, Arsenic and Copper) showed low leachability, with concentrations decreasing following pyrolysis. Overall, these findings highlight the dual benefit of effective PFAS removal and stabilisation while preserving key nutrient value in treated biosolids. Moreover, long-term stability of PFAS immobilisation will be evaluated in future work using controlled incubation followed by the leaching tests to assess the persistence of PFAS retention over time.

Papers arising from the work that have been published to date

Two manuscripts arising from this work, titled "Assessment of Sorbent-Amended Immobilisation Strategies for Reducing PFAS Mobility in Biosolids" and "Optimisation of Pyrolysis Conditions for PFAS Removal from Biosolids", are currently in preparation and under review; however, no papers have been published to date.

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The fate of the cyanotoxin microcystin in Australian agricultural soils

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Dr Crystal Sweetman, Associate Professor Martin Breed, Dr Timothy Cavagnaro, Dr Peter Hobson

RESEARCH SUMMARY

When the research will be completed
2028

Research objectives
The scope of this research is focused primarily on the identification of critical concentration limits of the cyanotoxin microcystin (MC), in reclaimed water used for food crop irrigation. These toxins have multiple deleterious effects including suppression of vegetative growth, interfering with animal and human metabolism causing potential hepatotoxicosis of the liver, leading eventually to death by hemorrhagic shock or liver failure. Recent studies have indicated that these toxins can bioaccumulate in the edible parts of food crops and potentially pose a risk to public health. It has been estimated that, as of 2022, 3% of Australia's food crops, including produce eaten raw, sugar cane and wine grapes, are irrigated with water sourced from recycled municipal wastewater, with this percentage set to increase in the coming decades.

The aim of this study is to investigate the fate of the MCs introduced to the soil matrix, and consequently the availability of the toxin in the soil solute available for plant uptake. Toxin and soil interactions including degradation pathways and soil sorption processes determines toxin availability in the soil solution. The high variability of these processes, influenced by soil composition, crop type, soil microbiota and historic exposure to MCs require comprehensive investigation to quantify these processes in varying environments and soil types.

To date, the project has focused on identifying knowledge gaps and reviewing quantified values relating to degradation and sorption in varying soil types. Additionally, computer modelling has been undertaken to identify processes and environmental factors which have highest impact toxin availability.

At present we have identified inconsistencies in reported degradation and sorption values due to variation in methodologies and differences in soil classification systems used. Therefore, research employing a robust and consistent approach is required. Additionally, initial modelling has indicated that soil clay content and microbial population composition and activity have the greatest influence on MC concentrations available in the soil solution.

The outcome of this study will endeavour to generate quantifiable knowledge to inform management

decisions and risk mitigation relating to the use of reclaimed wastewater, and additionally other water sources, for food crop irrigation. The study also has the potential to impact public health initiatives as diverse as food security, public health expenditure, population mortality rates, and local/regional development goals. As these issues are not confined by national borders, this study has potential to have global implications in ameliorating worldwide issues arising from current climate change trends.

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The impact of urban heat mitigation strategies on water security

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RESEARCH SUMMARY

When the research will be completed
Sept 2025

Research objectives
1. To investigate the tension between water saving and cooling objectives during drought.
2. To investigate how alternative water sources could provide water for cooling without exacerbating water security issues.

Summary
Climate change is anticipated to increase the likelihood that cities will be facing heat stress and water supply stress simultaneously. Hence, it is important to consider how cities and their infrastructure can be designed to achieve both cooling and water security aims. This work considers these two challenges in tandem to understand how they impact each other, with a particular focus on using irrigation of urban greenery as a heat mitigation strategy. This project addresses three questions:
1. What are the heat implications of restricting water for plants?
2. How does varying the amount of irrigation for urban greenery affect heat mitigation and water consumption?
3. How can alternative water supplies increase capacity to provide passive cooling via urban greenery during hot periods?

Findings from simulations from 2010-2020 of a Melbourne case-study site, using an hourly microclimate model (UT&C) and a daily water mass balance model (SUWMBA), suggest:
- Restricting or ceasing irrigation will increase days exceeding 28 °C (Melbourne's mortality threshold) increasing by 15% and 20%, respectively, implying an increase in heat-related deaths.
- Conversely, each 1.5 mm wk–1 increase in irrigation reduced heat stress days (Universal Thermal Climate Index (UTCI) > 32 °C) by one per year.
- In a low-density case study site (approx. 11 dwellings/ha), rainwater harvesting (RWH) generally had higher predicted yields than greywater harvesting (GWH) and was able to meet a higher proportion of irrigation demand. However, we expect GWH to provide a more reliable source in higher density areas, or where there is higher greywater use per square meter of irrigated greenery.
- RWH was predicted to lower the irrigation demand on the centralised system, even in dry years, with tank sizes of 1, 2, and 5m^3 predicted

- to reduce mains water consumption by 27%, 35%, and 51%, respectively, for 'Typical' irrigation.
- Pairing alternative water sources with greenery helps enable irrigation of urban greenery in periods of water stress, by lowering the irrigation demand on the centralised water system, ensuring cooling is maintained during combined heatwave-drought events.

This project additionally provides discussion on how both cooling and responsible water consumption can be achieved in city design and management, by considering (a) how combined heat and water stress can be better managed, and (b) how to design future cities that can deliver cooling without exacerbating water security concerns. These results contribute towards a Water-Sensitive Cities vision, strengthening water security and liveability for future communities in the face of droughts and heatwaves.

Papers arising from the work that have been published to date

Swinbourne, C., Kenway, S., and O'Brien, K. R. (2024). Urban greenery and alternative water sources critically interconnect water supply, cooling, and drainage in urban precincts. Urban Climate, 53:101812.

Swinbourne, C., Kenway, S., O'Brien, K. R., Cheung, P. K. (2025). Trade-off between water-saving and cooling objectives: restricting irrigation increases the number of hot days. Environmental Research Letters, 20: 12.

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Turning tides: Transforming Western Australia's seaweed into renewable bio-ethanol

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RESEARCH SUMMARY

When the research will be completed
Early 2025

Summary

Western Australia's beach-cast seaweed is usually treated as a waste problem that councils have to remove from beaches. This project investigates how seaweed can be used as a local fuel source. The work evaluates a two-step biological process: first, seaweed is treated with the Bacillus subtilis to break down the material and release fermentable sugars. Then these sugars are fermented with yeast to produce bioethanol under mild and practical operating conditions. The study focuses on three main questions. First, can wrack management be turned from an ongoing cost into a useful product stream for local councils and the water sector? Second, which process conditions give the highest concentration of fermentable sugars without using aggressive chemicals or high energy input? Third, which fermentation conditions give reliable ethanol production in a short time and in a way that can be repeated and scaled up?

Tests on the saccharification (sugar-release) step showed that the best conditions were 48 hours of reaction time with an inoculum ratio of 1 g of dry seaweed per 5 mL of Bacillus subtilis culture, at about 38 °C and mildly acidic pH. Under these conditions, the process reached a maximum sugar concentration of about 9.54 g/L. The liquid produced under these conditions was then fermented with Saccharomyces cerevisiae (brewer's yeast). Fermentation trials with different times and inoculum levels showed the best fermentation conditions were 24 hours at 30 °C and pH 5.5, with 7.5% v/v yeast inoculum under anaerobic conditions. At this point, the remaining sugar was about 1.52 g/L, and the maximum ethanol concentration was 3.69 g/L, confirmed by GC-MS. This corresponds to an ethanol yield of around 75.6% of the theoretical maximum.

For the water sector, this work links beach cleaning with energy recovery. It shows two practical pathways: direct production of bioethanol from collected wrack and potential biogas production by biorefinery integration with other types of waste. Using seaweed "waste" as the feedstock helps councils maintain clean beaches and reduce the amount of material sent to landfill, which can lower methane emissions and handling costs.

Critically, using seaweed avoids the irrigation water and farmland needed for many first-generation bioethanol crops. Those crop-based systems often have water footprints of about 500–1000 L of water per litre of bioethanol. In comparison, bioethanol production from seaweeds can use around 8–15 L of water per litre of fuel, and seawater can replace freshwater in mid-steps, which further reduces freshwater demand.

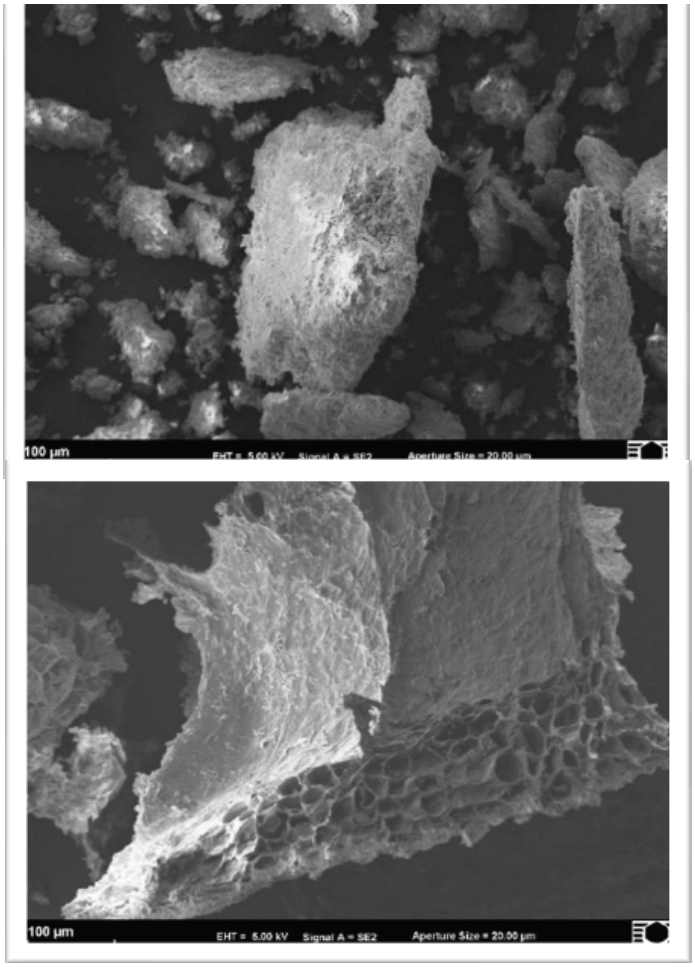

Figure 1. Scanning Electron Microscopy (SEM) for feedstock (top) and treated biomass (bottom) at a magnification of 100µm.

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Ultrasonication shows promise for the treatment of PFAS-contaminated water

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RESEARCH SUMMARY

When the research will be completed
September 2025

Summary
This research investigates the degradation of per- and polyfluoroalkyl substances (PFAS), using ultrasonication, a technique that employs high-frequency sound waves to generate acoustic cavitation, producing extreme local temperatures and pressures capable of breaking strong chemical bonds, while examining how operational parameters, water chemistry, and surfactants influence degradation efficiency. The persistence of PFAS poses significant challenges for remediation due to the high bond energy of the C–F bond (≈485 kJ/mol), and their widespread use in various industries has led to global water contamination, prompting the need for effective remediation strategies. The project explores ultrasonication as a promising technique for PFAS degradation, addressing key challenges, such as degradation mechanisms, operational parameters, and matrix effects.

One of the key findings demonstrates that ultrasonication achieved up to 97% PFAS degradation in foamate/foam fractionate (FF) and approximately 65% in aqueous film-forming foam (AFFF) samples prepared in milli-Q (MQ) (>18 MΩ•cm) (Figure 1). These results suggest the feasibility of coupling foam fractionation with ultrasonication as a hybrid process to simultaneously concentrate and destroy PFAS, thereby removing the requirement for additional treatment steps. While background water chemistry and ionic composition influenced degradation rates, ultrasonication remained an effective and adaptable remediation strategy in PFAS-spiked seawater (SW) and creek water (CW), indicating the robustness of the approach across environmentally relevant matrices. Surfactant studies revealed that high concentrations at the critical micelle concentration (CMC) hinder degradation due to bubble shielding, whereas lower surfactant levels enhanced PFAS breakdown. Furthermore, enhanced analytical approaches, including a modified Total Oxidizable Precursor (TOP) assay, were proposed to address the limited ability of conventional TOP assays to capture ultrashort-chain PFAS and highly persistent fluorinated transformation products, thereby improving detection and enabling a more comprehensive assessment of PFAS transformation and mineralisation. Overall, this work advances understanding of PFAS remediation processes and demonstrates the potential of ultrasonication as a non-chemical treatment technology, with scale-up applications still at an early stage of development.

Outputs from the research include four peer-reviewed journal articles published in Chemosphere, Journal of Water Process Engineering, Journal of Cleaner Production, and Environments, as well as two book chapters (including Zero PFAS Future), and two media releases, reflecting its broader impact on environmental science and water management.

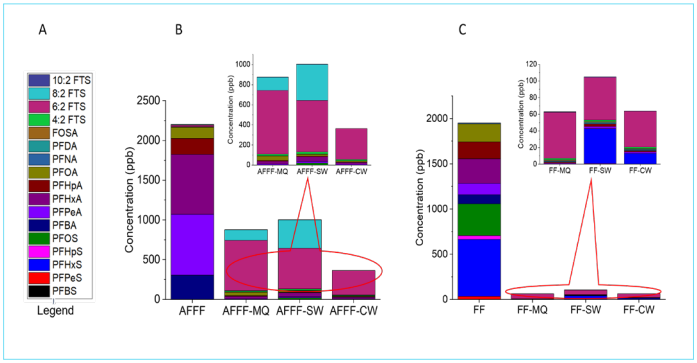

Fig. 1. Degradation of AFFF (1000x) and FF (1000x) in natural waters. (A) is the legend of PFAS detected. (B) compares the TOP assay results with the ultrasonication treatment of AFFF in MQ (AFFF-MQ), SW (AFFF-SW), and CW (AFFF-CW). (C) compares the TOP assay results with the ultrasonication treatment of FF in MQ (FF-MQ), SW (FF-SW), and CW (FF-CW).

Research outputs from the project

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Awoyemi, O. S., Naidu, R., & Fang, C. (2025). Surfactant-assisted ultrasonic degradation of per- and polyfluoroalkyl substances (PFAS): Effect of surfactant concentration. *Journal of cleaner production,* 519, 146042. https://doi.org/10.1016/j.jclepro.2025.146042

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Understanding greywater characteristics from houseboats to design a treatment process

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Supervisors: Dr Brandon Winfrey (Main Supervisor), Dr Arash Zamyadi, Dr Joanne Tanner

RESEARCH SUMMARY

When the research will be completed
The research is expected to be completed in early 2026.

Problems or questions you are trying to address
Considerable variation in quantity and quality characteristics of greywater makes it difficult to select a suitable technique for its treatment. Thus, a better understanding of greywater composition from different sources will help in deciding the economic and environmentally friendly treatment technology. In this research, a comprehensive review of greywater characteristics was conducted, with the main focus on the significant variability in quality and quantity across different sources, including the kitchen, bathroom, and laundry. Characterisation of greywater can indicate the level of pollution load that will reach the treatment system and how it will be utilised. This research aims to determine a clear range of physical, chemical and biological contaminants that influence treatability.

Greywater characteristics must be identified before selecting a treatment method, as the type and scale of treatment depend on these characteristics. Despite extensive research on greywater from households, buildings, and small communities, little is known about greywater produced from houseboats, even though the number of houseboats is increasing worldwide. Greywater from the houseboats is often discharged directly into surface waters, raising environmental concerns. However, due to space constraints on houseboats, treatment systems need to be compact, efficient, and easy to integrate. Understanding greywater characteristics is thus the essential first step in designing a system that can effectively remove contaminants in real-world conditions. An efficient treatment system will help reduce contaminant discharge into the environment, support regulatory compliance, and promote sustainable water management in residential settings with limited space.

Limited understanding of greywater characteristics generated from houseboats, particularly particle size distribution and lack of compact and integrated treatment systems for space- limited environments, has led to these key research questions:

What are the key physical and chemical characteristics of greywater generated from houseboats, particularly regarding particle size distribution and pollutant composition?

How can understanding these greywater characteristics help the development of compact and integrated treatment systems for space-limited houseboat environments?

What are the key physical and chemical characteristics of greywater generated from houseboats, particularly regarding particle size distribution and pollutant composition?

Key findings to date:
Based on a comprehensive literature review, it became evident that no dedicated research specified the characteristics of greywater from houseboats. Furthermore, several studies have been conducted on the characterisation of synthetic greywater, but these studies often focus more on controlled laboratory conditions rather than real-life conditions. Also, the characterisation of surface water from which the greywater is generated has been thoroughly investigated.

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Understanding the mechanisms of fats, oils and grease deposits formation in sewer lines and developing a novel biopolymer dispersant for proactive management of FOG accumulation

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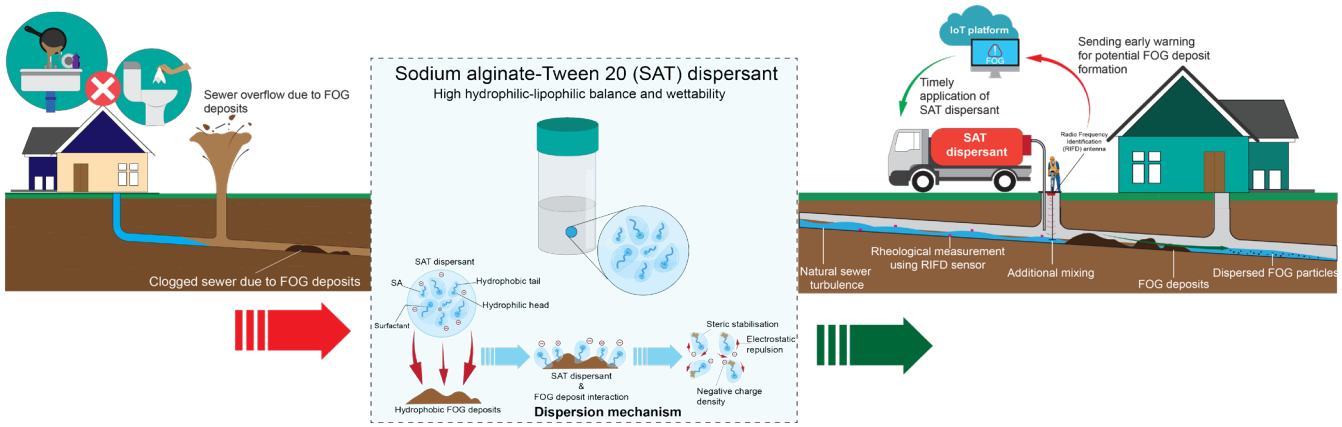
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

When the research will be completed
April 2026

Research objectives
My project addresses the critical gap between source control and in-sewer management by understanding the key drivers and mechanisms behind FOG deposit formation in various wastewater conditions and developing a novel dispersant for proactive management of FOG accumulation.

Problems or questions you are trying to address
By understanding the wastewater conditions and changes in physicochemical properties that promote FOG formation, and by characterising the rheology of deposits – can an early detection model be developed to predict where and when blockages are likely to occur?

Can an environmentally friendly biopolymer-based dispersant, inspired by oil-spill remediation techniques, enable the breakdown of FOG deposits in sewer lines and prevent them from coalescing?

How your work benefits the water sector
1. Potential to cut FOG-related operational and maintenance expenses by 30–50%, freeing resources for other infrastructure needs.
2. Limits the need for road closures, emergency callouts, and major excavation works, enabling smoother maintenance.
3. Minimises sewer overflows and pollution incidents, reducing regulatory risks and safeguarding waterways and public health.
4. The dispersant can be tailored for varying network conditions and integrated into existing maintenance and asset management.

Key findings to date
Practical findings for the water sector
1. Magnesium ions and palmitic acid (common in used cooking oil and GI effluent) are key drivers of hard, viscous FOG deposits.
2. Wet wipes and facial tissues bind with FOG, increasing deposit size and resistance to removal.
3. FOG deposits act as thick, shear-thinning materials requiring high pumping power, explaining why blockage is more prevalent in gravity sewer pipes.
4. A pumping power estimation model was developed to detect early signs of blockages.

Environmentally friendly biopolymer-based dispersant
1. A dispersant comprising sodium alginate and proprietary surfactant "Tween 20" (referred to as SAT). This is biodegradable and safe for wastewater treatment plants.
2. Breaks down large, sticky FOG clumps into fine particles (~0.24 µm) that remain suspended and flushable.
3. Reduces deposit viscosity by over 99%, making blockages far less likely to form.

Published papers arising so far
Yusuf, H. H., Roddick, F., & Pramanik, B. K. (2026). Sodium alginate – Tween 20 dispersant for sustainable in-sewer control of fats, oils, and grease (FOG) accumulation. Water Research, 290, 125124 (Impact Factor: 12.4)

Yusuf, H. H., Roddick, F., Jegatheesan, V., & Pramanik, B. K. (2025). Influence of improper disposal on FOG deposition: Rheological behaviour and pumping power requirements in sewer systems. Water Research, 278, 123404. (Impact Factor: 12.4)

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Urban groundwater flooding case study at Dayton, Western Australia

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Supervisor: Prof. Sally Thompson

RESEARCH SUMMARY

When the research will be completed
13 June 2026

Research objectives
To determine the hydrological impacts of urban development in groundwater-constrained areas in the north-east of Perth, Western Australia. To achieve this objective, these are the methods that would be employed: (1) Relate changes in land cover and urban area to changes in projected water balance, (2) Investigate changes in regional groundwater aligned with development timeframes, and (3) Conduct high-resolution groundwater monitoring on land adjacent to recently urbanised areas, revealing responses to rainfall events and water management (e.g., dewatering, pumping, and disposal) in the urban area.

Problems or questions you are trying to address
The rapid urbanisation of the north-eastern fringe of Perth, Western Australia, particularly in the newly developed suburbs of Dayton and Brabham, has coincided with a persistent rise in groundwater levels on adjoining Priority Agricultural land in the Swan Valley, Western Australia, despite declining rainfall. This rising groundwater trend poses significant risks to regional industries such as horticulture, viticulture, and agritourism, which depend on stable groundwater conditions [1]. Landowners have reported inundation, and their monitoring data indicate increasing groundwater levels over the past decade, suggesting that urban stormwater generation, altered drainage patterns, and changes in recharge and flow following development may be key drivers. Thus, this research examines the impact of historical and recent urban development in that area, particularly in Dayton, on landforms, land cover, and groundwater systems, and explores the implications of these changes for groundwater sustainability. A critical review of groundwater and drainage planning decisions and how these relate to the realised outcomes will showcase the interplay between hydrology, planning, and implementation.

How your research will benefit the water sector
This research will illustrate the potential for high groundwater to impact drainage and environmental outcomes in peri-urban environments. By combining historical change analysis with high-resolution monitoring, it provides actionable insights revealing where planning decisions have protected, or failed to protect, amenity and environmental values.

Findings to date

The site visit, which is a private tree farm located near the Dayton suburb (Figure 1), has experienced persistent rising groundwater coinciding with nearby urban development. The landowner has independently recorded groundwater depth measurements, which confirm an increase in water levels (Figure 2). To strengthen the existing monthly monitoring program, several level loggers have been installed across the site. Data collected from these loggers corroborate the observed upward trend (Figure 3). These are the current findings to date.

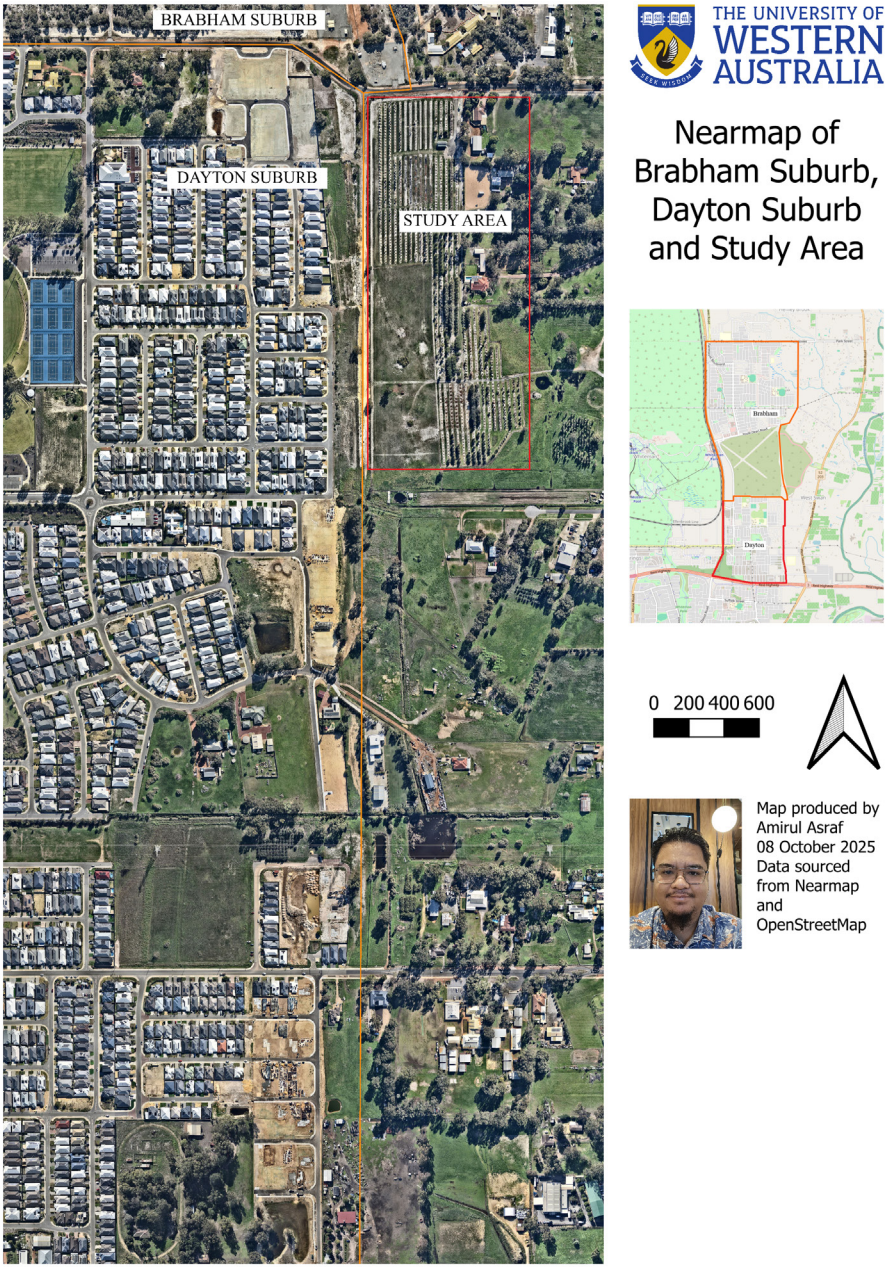

Figure 1: Study Area

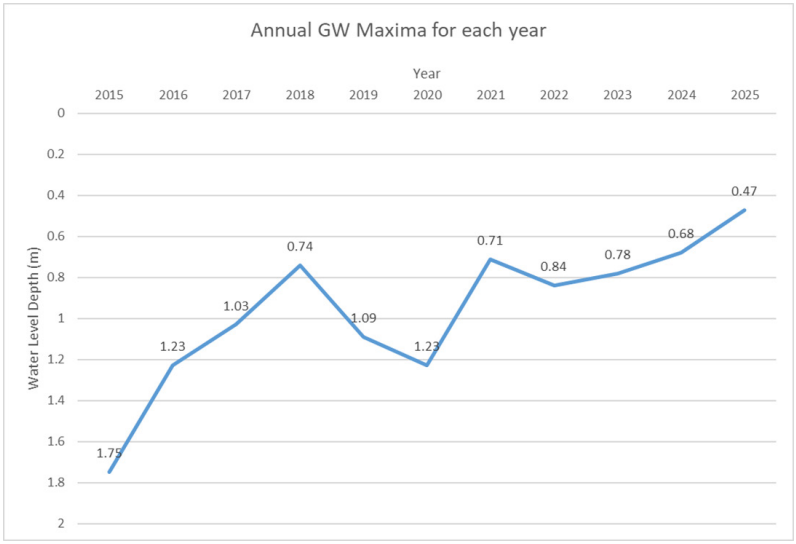

Figure 2: Groundwater Level Measurement Recorded by Landowner in the Study Area

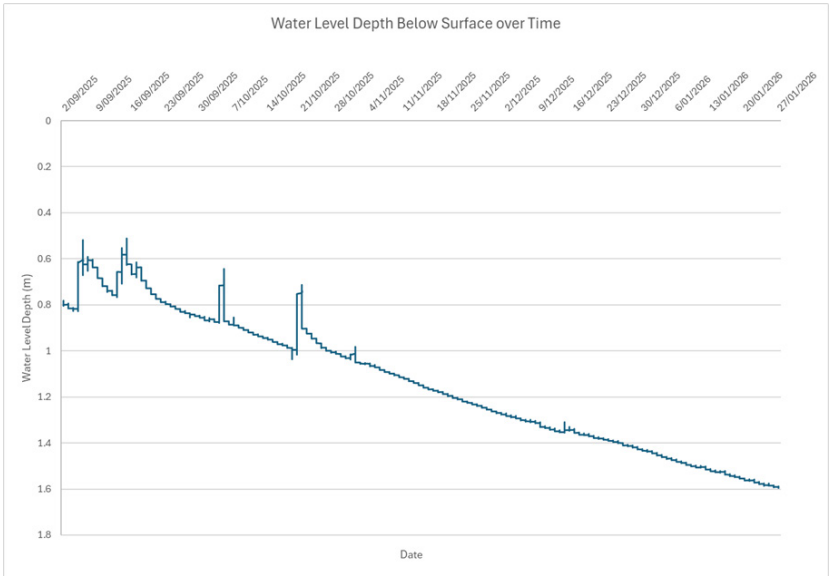

Figure 3: Groundwater Level Trends from Installed Level Loggers in the Study Area

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Valuing water conservation to better support water resilience in regional NSW

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RESEARCH SUMMARY

When the research will be completed
July 2025

Summary

This work involved undertaking a Cost Benefit Analysis (CBA) to value water conservation separately in Bathurst, Parkes and Orange (NSW) to enhance water security in the towns. The aim of this analysis was to adapt previous CBA methodologies, such as the initial Frontier Economics work [1] which calculated the value of conservation for an indicative regional NSW town, to adequately address the concerns and priorities of the Central NSW Joint Organisation (CNSWJO). Costs and volumes of two water conservation options suited to what each council could reasonably implement were calculated, with the former option containing the most cost-effective measures. Options included a mixture of leakage reduction programs, residential and non-residential audits and appliance rebates, which were compared against the monetary economic, social, and environmental benefits to complete the CBA. Examples of benefits include the value of avoiding drought, delaying infrastructure developments, reducing carbon emissions, among many others.

This work recommends that the conservation options calculated be considered for implementation by the local water utilities when deciding how to manage their water supplies into the future. This work has also created a business case for these measures, which can help the councils and the CNSWJO secure funding. The CBA model used for this work is designed to be changed to account for different variables and situations, and could therefore be utilised by other water professionals nationally or internationally to determine the value of water conservation in their respective utilities.

The analysis revealed the benefit of water conservation in Bathurst was relatively high at $13.00/ kL saved for the first option and $14.19/ kL for the second. This can be largely attributed to the size of the Bathurst community, high risk of water restrictions due to a low secure yield, and a large, anticipated cost associated with augmenting the water supply in the near future. The benefit to cost ratio (BCR) for the two identified options for this utility was 33.9 and 8.47, respectively (Figure 1). This project also revealed that the benefits of conservation in Orange were $7.14/ kL for option one and $6.88/ kL for option two, and the BCR for the measures were 8.75 and 5.55 respectively (Figure 1). This is indicative of how, despite significant water conservation measures in the past in Orange,

there is still a significant benefit of further investment. The value of water in Parkes was the lowest at $4.77/ kL for the former conservation measure and $4.69/ kL for the latter. This was a consequence of Parkes' reliable borefield resulting in a significantly lower likelihood of drought than other councils in the region. The BCR for the options in Parkes are 3.61 and 1.80 respectively, which indicates how the measures available are less economical (Figure 1).

This article is a summary of a more extensive thesis paper with the same name submitted on 28th July 2025.

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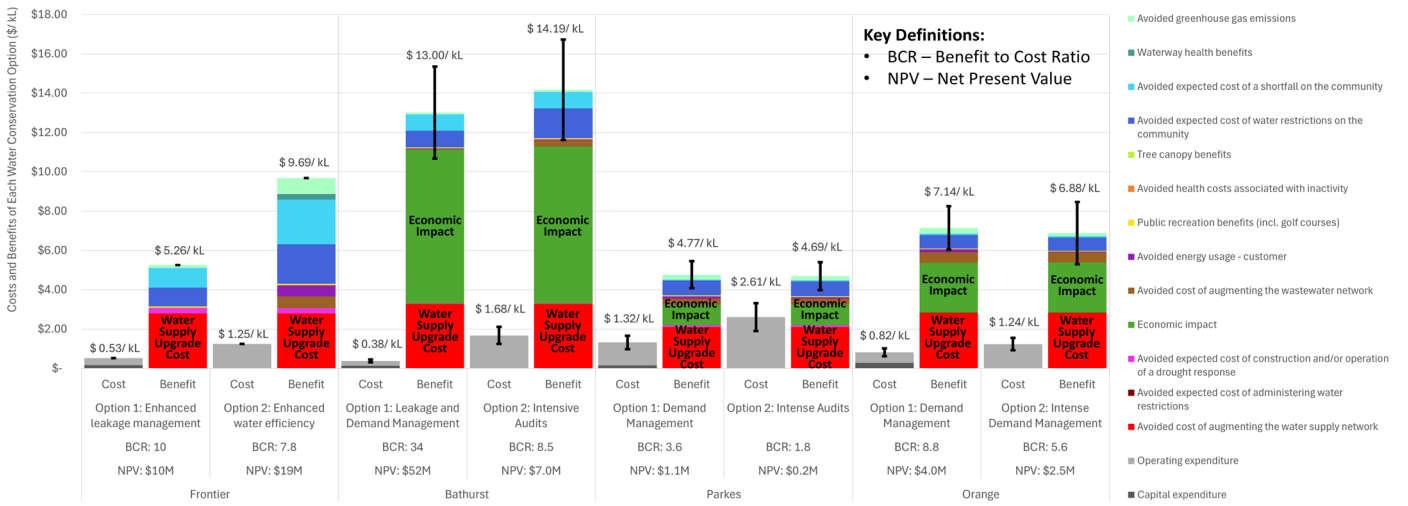

Figure 1: Costs and Benefits of Water Conservation Across the Councils in Comparison to the Initial Frontier Work

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Wastewater treatment using a consortia of filamentous algae

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Flinders University
Supervisors: Howard Fallowfield, Ryan Baring, Alexandra Keegan, Ryan Cheng, Enzo Palombo

GRAPHICAL ABSTRACT

RESEARCH SUMMARY

When the research will be completed
December 2025

Research objectives
Design and test simple, native filamentous algal ponds that can treat municipal wastewater, generating water with lower suspended solids than conventional algal ponds while maintaining high organic load removal and pathogen disinfection.

How will your research benefit the water sector
1. Produce treated water minimising the suspended solids at the outlet
2. Consume a fraction of the energy used by mechanically aerated systems
3. Control the sludge build up, saving on maintenance costs
4. Treat the wastewater without any chemical consumables
5. Readily automate the process for remote applications
6. Drastically shorten hydraulic retention times compared to other extensive systems reducing the needed infrastructure and capital expenditures

Key findings to date
I designed new, simple and reliable secondary treatment process for municipal wastewater treatment: the filamentous algal ponds. Conventional algal ponds have been known for decades to be an effective treatment alternative, although producing an effluent high in suspended solids limiting the potential uses of the treated water. By redesigning the process cycle, I was able to manage the liquid and the solids phases within the same pond, this change in the operation allowed the production of supernatants maintaining high organic load removal and pathogen disinfection rates, while maintaining suspended solids concentrations 50 to 70% lower than conventional algal ponds.

Publications from this research
Novel operating strategies for sustainable treatment of wastewater from regional community using high-rate algal ponds. (Fallowfield et al., 2025) Conference publication, Next Water 2025

High-rate algal ponds operated as sequencing batch reactors: Towards wastewater treatment with filamentous algae (Sabatte et. al, 2025)
https://doi.org/10.1007/s10811-025-03545-6

Suspended filamentous algal cultures for wastewater treatment: A review (Sabatte et. al, 2024)
https://doi.org/10.1007/s10811-024-03220-2

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Weekly field data–driven machine learning models for predicting BOD and ammonium nitrogen in wastewater treatment processes

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Project Leader: Dr Ratish Permala[3]

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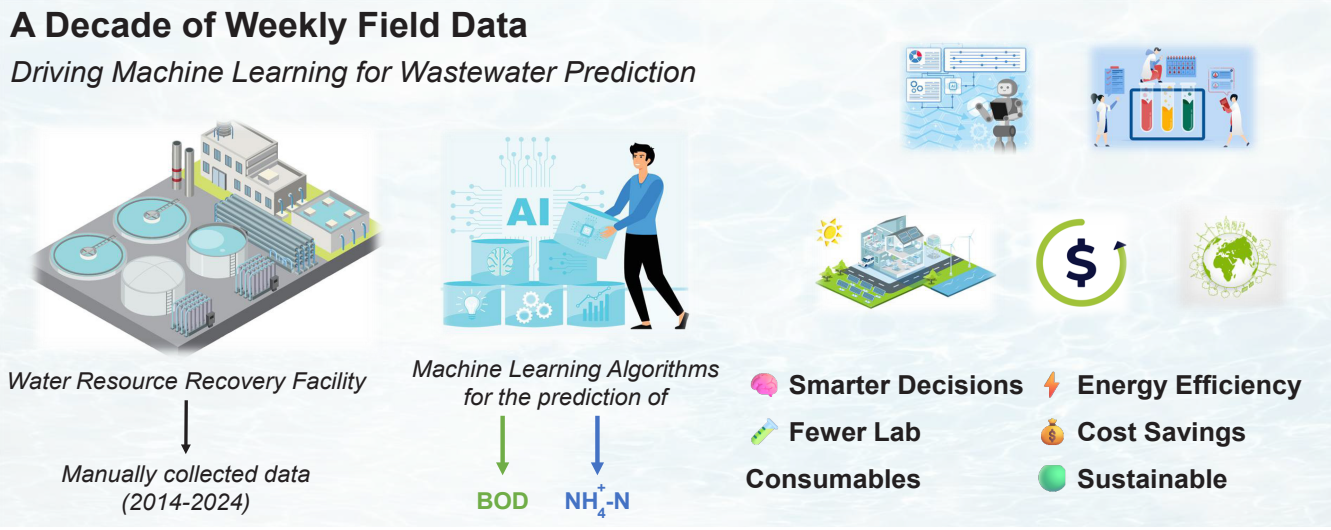
GRAPHICAL ABSTRACT



RESEARCH SUMMARY

Completed in 2025, this research investigates the machine learning (ML) capability to predict Biological Oxygen Demand (BOD) and ammonium nitrogen (NH4+-N) using weekly laboratory data from a full-scale wastewater treatment plant (WWTP). Traditional laboratory analyses, especially the five-day BOD test, are slow, labour-intensive, and limit operators' ability to respond rapidly to influent variability. The project addresses this challenge by developing predictive models that offer faster, cost-effective, and more responsive monitoring tools for WWTPs.

The study aims to determine whether ML models can accurately predict BOD and NH4+-N at three key stages, raw influent, primary, and secondary effluents, using parameters routinely measured at a full-scale Water Resource Recovery Facility (WRRF).

The research also examines which ML algorithms perform best under real-world, low-frequency sampling conditions and identifies the variables that most strongly influence model accuracy. This work directly benefits the water sector by providing a digital, data-driven approach that supplements or partially replaces conventional laboratory testing. Accurate same-day predictions enable operators to anticipate influent fluctuations, optimise aeration and chemical dosing, plan resources more effectively, and enhance compliance with discharge standards.

The project was carried out in collaboration with the Water Corporation of Western Australia, utilising long-term operational data from the Subiaco WRRF to ensure high practical relevance and scalability to other plants.

Key findings show that reliable predictions can be achieved using weekly monitoring data, making ML a feasible tool even in plants without high-frequency sensors. For raw wastewater, MLP performed best for BOD prediction (RMSE = 29.8 mg/L; MAPE = 7.0%), while SVR achieved the strongest performance for NH4+-N (RMSE = 2.3 mg/L; MAPE = 3.3%). In primary effluent, SVR (Linear) and MLP delivered the most accurate BOD estimates (RMSE ≈ 23.5 mg/L; R2 ≈ 0.51), and MLR/PLS provided comparable accuracy for NH4+-N (RMSE ≈ 2.7 mg/L). In secondary effluent, SVR (RBF) predicted BOD reliably (RMSE = 3.26 mg/L), and Random Forest achieved the lowest error for NH4+-N (RMSE = 1.5 mg/L). Sensitivity analysis identified COD, SS, and TKN as the most influential predictors.

To date, this research has resulted in two published papers and one manuscript under review. These include a study on factors influencing ML performance in raw wastewater prediction and a critical review of metric selection in wastewater ML applications, with a third manuscript focused on full-scale ML prediction of BOD and NH4+-N currently submitted.

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