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Exploring greenfield water sensitive options with the integrated planning-support model UrbanBEATS

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Introduction

The planning and implementation of water sensitive urban design (WSUD) stormwater systems is complex. Models to support this, such as MUSIC (eWater, 2011), or UWOT (Makropoulos et al., 2008), are useful in assessing how systems perform under a range of water management scenarios. They, however, do not consider key urban planning aspects that are crucial to the planning and integrated assessment of WSUD and the automation necessary to explore an array of technological combinations in an evolving urban environment. To address these needs and support stakeholders in planning for future challenges, the **Urban B**iophysical **E**nvironments **A**nd **T**echnologies **S**imulator (UrbanBEATS) was developed. Whilst the purpose of UrbanBEATS is not to predict the exact types and designs of WSUD infrastructure implemented in urban catchments, but rather to explore feasible layouts that can meet stormwater management objectives, there is still a necessity to validate the realism of the model's outputs against real-world data. The aims of this study were twofold: to test the UrbanBEATS model against a real-world greenfield project and to explore how different model setup scenarios can affect these results.

Concept & Methods

UrbanBEATS comprises 2 modules: (1) *Urban planning* and (2) *WSUD planning module*. Four input maps of land use, population, soil type and elevation are required (Figure 1). The Urban planning module is responsible for processing the spatial information and creating an abstraction of the urban form that can spatially determine where suitable WSUD stormwater systems can be placed (the module produces information e.g. impervious fractions, green space availability across the region). The WSUD planning module uses this information to firstly determine all possible locations and scales at which technologies can be placed to meet water quantity/quality and/or stormwater recycling objectives. Planning of technologies is guided by user-defined targets (e.g. pollutant load reduction, supply reliability) and a desired level of service (e.g. amount of catchment area to be treated). More information about UrbanBEATS' individual modules can be found elsewhere (Bach et al., 2013a, b).

We tested UrbanBEATS on a greenfield development in Melbourne's west for which an integrated water management plan and WSUD infrastructure layout has been designed. Toolern Precinct is a 24km^2 future suburban mixed-use development with a projected population of 55,000 (GAA, 2011). Its precinct structure plan (PSP) and a number of additional documents have provided information about the proposed on-site water management strategy. Most of the WSUD assets on-site are designed for stormwater pollution management, while stormwater harvesting storage requirements are located off-site in the adjacent Melton reservoir. For this study, we focussed solely on stormwater pollution aspects.

The case study was set up in UrbanBEATS using the proposed development master plan. The PSP and catchment modelling guidelines from the water authority were used to calibrate several key outputs (sub-catchment layout, impervious fractions, dwelling counts) from the Urban planning module. Further details on how this data was prepared are described in Bach et al. (2013c). A multi-criteria assessment (MCA) matrix of different WSUD technologies was created for the simulation, based on results from a stakeholder workshop conducted for the development during its planning and design stages. Although data is not publicly available, the outcome, in general, valued the use of constructed wetlands and ponds highly, but indicated aversion to biofiltration systems (BF), particularly because of the challenges of maintaining these systems in Melbourne's west. Notably, no biofiltration systems were used in the proposed design.

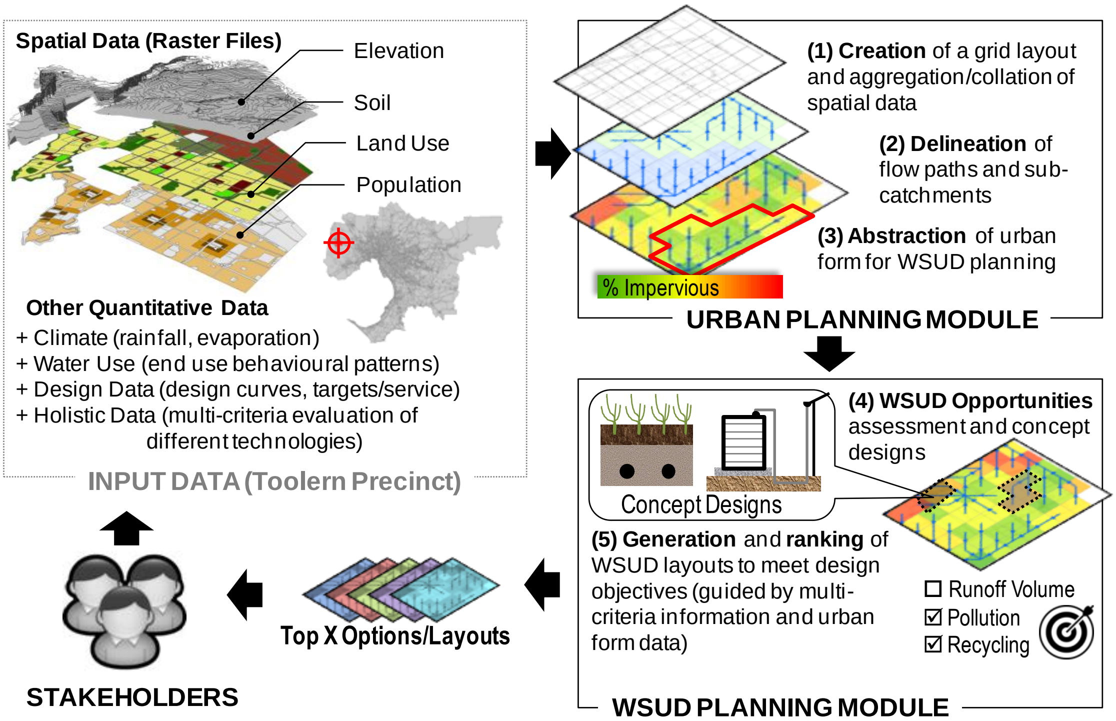

Figure 1. Overview of the UrbanBEATS Model and Illustration of Toolern Case Study

It was not the intention to optimize UrbanBEATS' simulations, but rather provide the model sufficient information and constraints such that outputs it produced were similar to proposed systems in terms of design and location. Thereby, three different simulation scenarios were tested:

- **Toolern MCA + no BF:** used the created MCA and disallowed the model to use bioretention systems on-site (seeing as these were absent in the real design)
- **Toolern MCA + BF:** used the created MCA and allowed the use of biofiltration systems (to see whether relying on the MCA would be sufficient to produce similar results).
- **No MCA + BF:** did not use any MCA matrix to influence the design and allowed the use of biofiltration systems.

The model was run 10 times for each scenario. Each run generated 1000 layouts from which the top 5 were selected as outputs. This totalled 50 layouts per scenario, which were analysed as a group and compared individually with the proposed designs. The closest matching designs were determined based on total design surface areas of the different technologies. Location matching of different proposed assets was undertaken qualitatively.

Results & Discussion

Figure 2 shows the design results from the three scenarios in terms of total system surface area required for each layout. The box plots represent the distribution of total WSUD technology surface across the 50 options (whiskers denote the 5th and 95th percentiles) while the three best modelled layouts are plotted alongside the proposed design. In general, modelled results envelope or resemble the proposed layout, indicating that realistic options can be generated by the model. Differences between modelled and proposed designs were greater when biofilters were allowed. This is because biofilters can occupy less area for the same treatment benefit compared with wetlands and ponds, meaning that even a small implementation of this technology can produce a considerable saving of space and significantly reduce the total surface areas required for wetlands and ponds on-site. There are, however, economic implications for using biofilters in this region (which are partly reflected in the MCA), but not currently quantifiable in the model. The third scenario, which did not use the MCA, resulted in less pond area and greater wetland and biofilter usage. This makes technical sense as ponds are less efficient in treatment than the other two technologies.

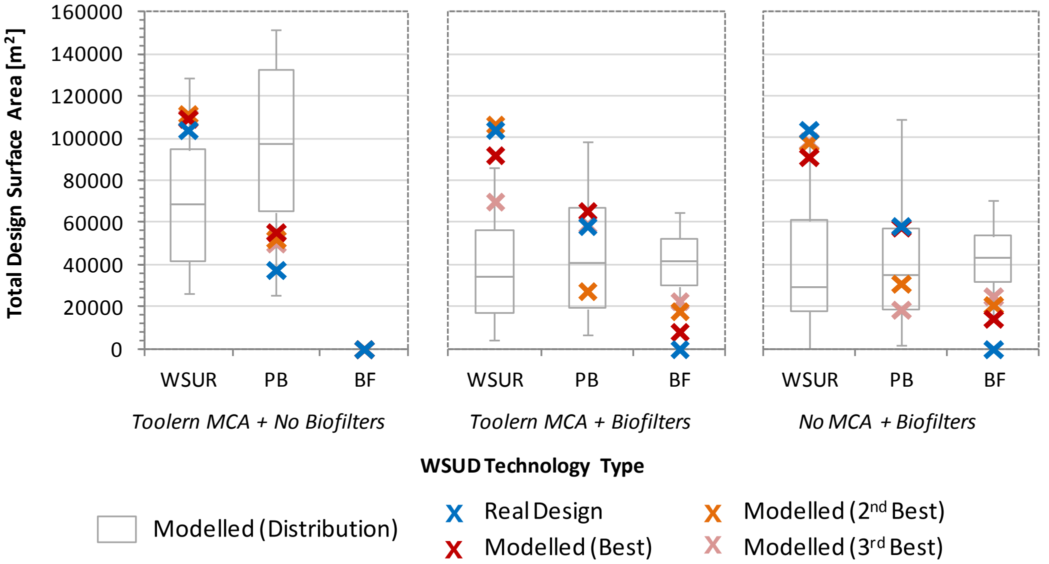

Figure 2. Modelled (distributions and three most similar) vs. proposed system (real design) surface areas of the three main WSUD technologies (WSUR=wetlands, PB=ponds, BF=biofilters) in Toolern for three different model setups

Two layouts from the best matching model outputs for scenarios are shown in Figure 3, both of which used the Toolern MCA. Only the eastern part of Toolern precinct is shown, as no data on the location of systems within the western region could be obtained. Positions of systems indicated by the model are also relative to that particular block. Evidently, the model selects similar locations for the majority of systems regardless of scenario. Interestingly, the model also did not use the space in Parks & Gardens for WSUD infrastructure, which is consistent with proposed designs despite the availability of this space. This may be due to required system sizes and the position of the local parks within the sub-catchments. Some systems were also placed in the western and southern areas. Although different, this result is useful as it highlights potential areas of opportunities, which designers can harness if future water management for the region is required.

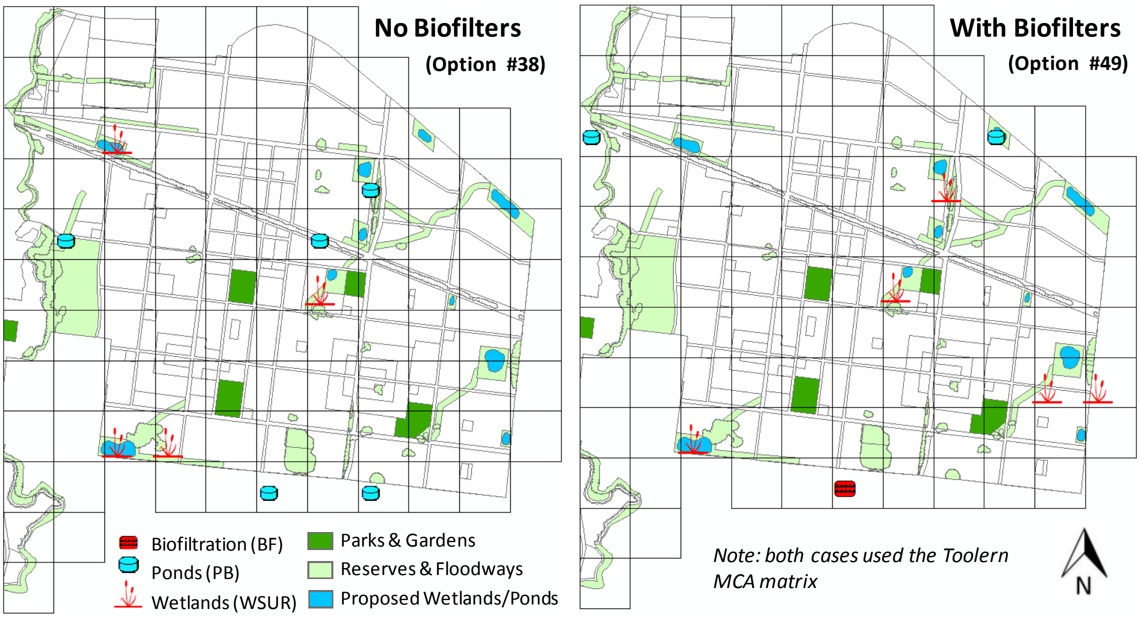

Figure 3. Location of WSUD technologies for best matching modelled layouts in Toolern MCA + No BF (left) and Toolern MCA + BF (right) scenarios compared with proposed system designs (location data only available for eastern region of precinct)

Conclusions & Further Work

We tested UrbanBEATS on a greenfield development project for which an integrated water management plan has been established. Three different model scenarios were tested for the design of stormwater pollution management and compared with proposed systems. Results showed that UrbanBEATS can produce similar realistic layouts of WSUD stormwater systems and that the technical as well as the multi-criteria aspects are influential factors. Future research for improving realism and usability of the model to planners and stakeholders can include: (1) consideration of planning overlays, which restrict or alter constraints surrounding WSUD implementation and (2) quantification of economic costs for the different layouts.

References

BACH, P. M., DELETIC, A., URICH, C., SITZENFREI, R., KLEIDORFER, M., RAUCH, W. & MCCARTHY, D. T. 2013a. Modelling Interactions Between Lot-Scale Decentralised Water Infrastructure and Urban Form - a Case Study on Infiltration Systems. *Water Resources Management,* 27**,** 4845-4863.

BACH, P. M., MCCARTHY, D. T. & DELETIC, A. 2013b. UrbanBEATS: A strategic planning tool for exploring water sensitive futures. *8th International Water Sensitive Urban Design Conference (WSUD2013).* Gold Coast, Australia.

BACH, P. M., MCCARTHY, D. T., URICH, C., SITZENFREI, R., KLEIDORFER, M., RAUCH, W. & DELETIC, A. 2013c. A planning algorithm for quantifying decentralised water management opportunities in urban environments. *Water Science & Technology,* 68**,** 1857-1865.

EWATER 2011. *MUSIC by eWater, User Manual,* Melbourne, Australia, eWater.

GAA 2011. Toolern - Precinct Structure Plan (Including Toolern Native Vegetation Precinct Plan). Victoria, Australia: prepared by Melton Shire Council and Growth Area Authorities.

MAKROPOULOS, C. K., NATSIS, K., LIU, S., MITTAS, K. & BUTLER, D. 2008. Decision support for sustainable option selection in integrated urban water management. *Environmental Modelling & Software,* 23**,** 1448-1460.

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Is the presenting author an IWA Young Water Professional?

Yes
(i.e. an IWA member under 35 years of age)

Bio: Peter Bach is a research fellow at Monash University's Water for Liveability Centre. He completed his PhD in integrated urban water modelling in 2014, which produced the UrbanBEATS planning-support tool. His current research interests focus on advancing the science of integrated urban water modelling, understanding interactions between urban planning and urban water management and harnessing big data for urban water systems. He hopes to improve current water infrastructure planning approaches through more effective techniques of integrated model development, application and stakeholder engagement.