# UrbanBEATS UX Design

## Future Water ARC Linkage Workshop

10th December 2018

Summary Report

Prepared by

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# 1 INTRODUCTION

## 1.1 Workshop Background

As part of an update meeting for the Australian Research Council (ARC) Linkage Project LP160100241 and the ongoing development of the UrbanBEATS Planning-Support System, we hosted a workshop on December 10th, 2018 together with industry partners EPA Victoria, Melbourne Water and Knox City Council. The workshop's aim was to develop an understanding of past user experiences in using software and data-driven approaches in solving complex urban water management problems and to develop an understanding of user expectations and 'wishes' for UrbanBEATS as it progresses further in its design and development.

The workshop was held at Monash University and lasted 4.5 hours. It was moderated and chaired by Dr. Peter M. Bach (Eawag/Monash/ETH Zurich), lead developer of UrbanBEATS and Dr. Veljko Prodanovic (UNSW), postdoctoral researcher and co-developer. Outcomes of this workshop are summarised in this report.

## 1.2 Workshop Attendees

The workshop was attended by the following participants:

- Peter M. Bach (Eawag/Monash/ETH Zurich)
- Veljko Prodanovic (UNSW)
- Baiqian 'Luke' Shi (Monash)
- Leon Metzeling (EPA Victoria)
- Sam Leray (EPA Victoria)
- Paul Leahy (EPA Victoria)
- Alice Phung (EPA Victoria)
- Rhys Coleman (Melbourne Water)
- Trish Grant (Melbourne Water)
- Birgit Jordan (Melbourne Water)
- Monica Tewman (Melbourne Water)
- Caroline Carvalho (Knox City Council)
- Daniella Gerente (Knox City Council)

## 1.3 Workshop Agenda

A tentative agenda (Table 1) was provided to workshop participants, but the workshop took a much more flexible and fluid schedule as discussions emerged organically in the demonstration of UrbanBEATS and exercises on user experience design.

Overall, the workshop can be subdivided into three major sections: (I) Welcome, Overview and Updates, (II) Demonstration of UrbanBEATS, (III) User Experience (UX) and Visual Design (VD) Exercises. This report is subdivided into these main sections.

***Table 1*** *Tentative workshop schedule for the UrbanBEATS UX Design Workshop, the actual schedule was far more fluid and flexible than what was proposed and concluded half an hour later.*

| Time | Activity |
|---|---|
| 9:00 - 9:10 | Workshop Sign-in and Welcome |
| 9:10 - 9:30 | • Background presentation on ARC LP project<br>• Project update<br>• Q&A |
| 9:30 - 10:10 | • **UrbanBEATS demo** – presentation and run-through of current UrbanBEATS software, with case-study showcase<br>• Workshop format and aims<br>• Q&A |
| *10:10 - 10:30* | *Coffee break* |
| 10:30 - 11:15 | **Activity 1:** User Experience Design (UXD) Workshop – Designing future UrbanBEATS features. Software usability and primary functions |
| 11:15 - 11:35 | Formulating and collecting ideas from *Activity 1* |
| *11:35 - 11:45* | *Coffee break* |
| 11:45 - 12:30 | **Activity 2:** UrbanBEATS Visual Design (VD) Workshop – Creating user-friendly environment with the functions from *Activity 1* |
| 12:30 - 12:50 | Formulating and collecting ideas from *Activity 2* |
| 12:50 - 13:00 | Workshop wrap-up and Future work |
| *13:00 - 13:45* | *Lunch* |

# 2 WELCOME, OVERVIEW & UPDATES

## 2.1 Overview of the ARC Linkage Future Water Project

The Future Water ARC Linkage Project was developed to address the limited knowledge surrounding urban water pollution emissions in our catchments. In urban catchments, a rich mix of land uses and urban activities often results in a mix of diffuse and distributed point sources of pollution emissions (Fig 1). Relating discharge back to the original source is often challenging as measurements at the catchment outlet only provide an aggregate indication of overall pollution within the catchment. Knowing if a particular land use activity is detrimental to receiving waters would allow for appropriate mitigation and regulation measures to be implemented. We, however, neither have sufficient understanding in this area, specifically how different urban activities affect pollution or how discharge should be linked to sources, nor do we have appropriate planning tools to support this goal, i.e. we are unable to accurately model pollution build-up and wash-off and identify effective mitigation strategies and policy for protecting future water quality.

The ARC Linkage Project, which begun in mid-2017, but has been under development and scoping since 2014 aims to provide strong quantitative science and evidence-based knowledge on future water quality including an understanding of:

- Drivers and threats affecting future water quality
- Connectivity from source to sinks (end points), and
- How water quality will change under likely future scenarios

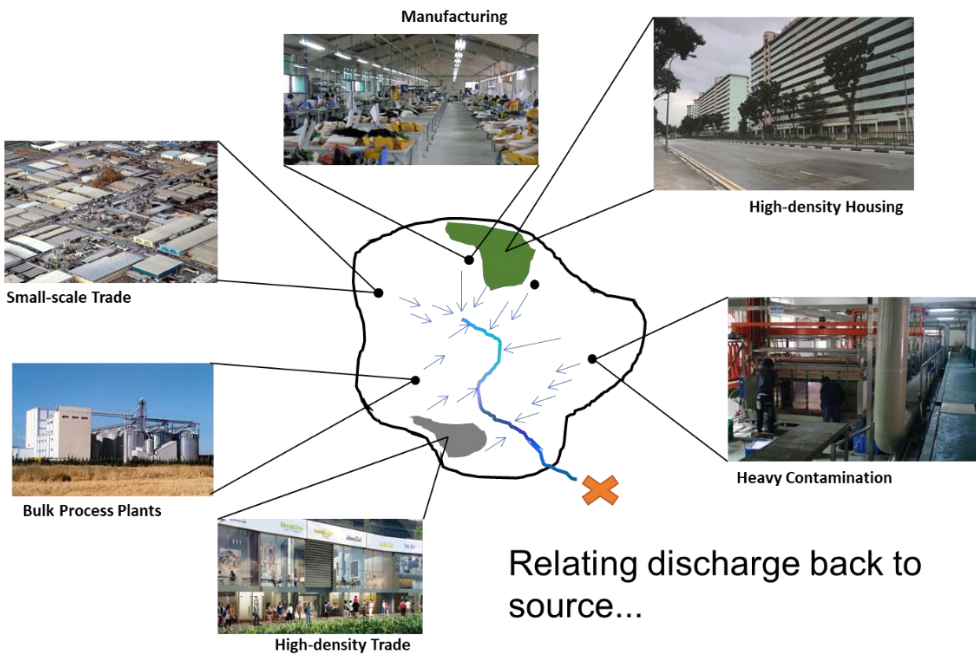


***Fig 1.*** *Overview of the problem framing for the Future Water ARC Linkage Project, relating water quality of discharges at the catchment outlet back to the diversity of land use activities and associated pollution emissions is a challenging task.*

Following a successful bid for an ARC Linkage Project, this project will undertake three major tasks: (1) link urban form and pollution emission, (2) develop techniques and tools for mapping pollution generation and fluxes and (3) validate techniques and simulate future scenarios.

## 2.2 Project Updates

Two separate updates were provided, one for the ongoing sampling campaign in the project's case study, the Upper Dandenong Creek Catchment (upper reaches to Boronia Road, including Old Joes Creek), and another update for the ongoing development of the UrbanBEATS software and added functionality.

### 2.2.1 Case Study Catchment

The project's case study is situated in the Upper Dandenong Creek Catchment. The catchment area covers the upper reaches of the Dandenong Creek Catchment up to Boronia Road (see Fig 2). The total catchment area is 81km$^2$.

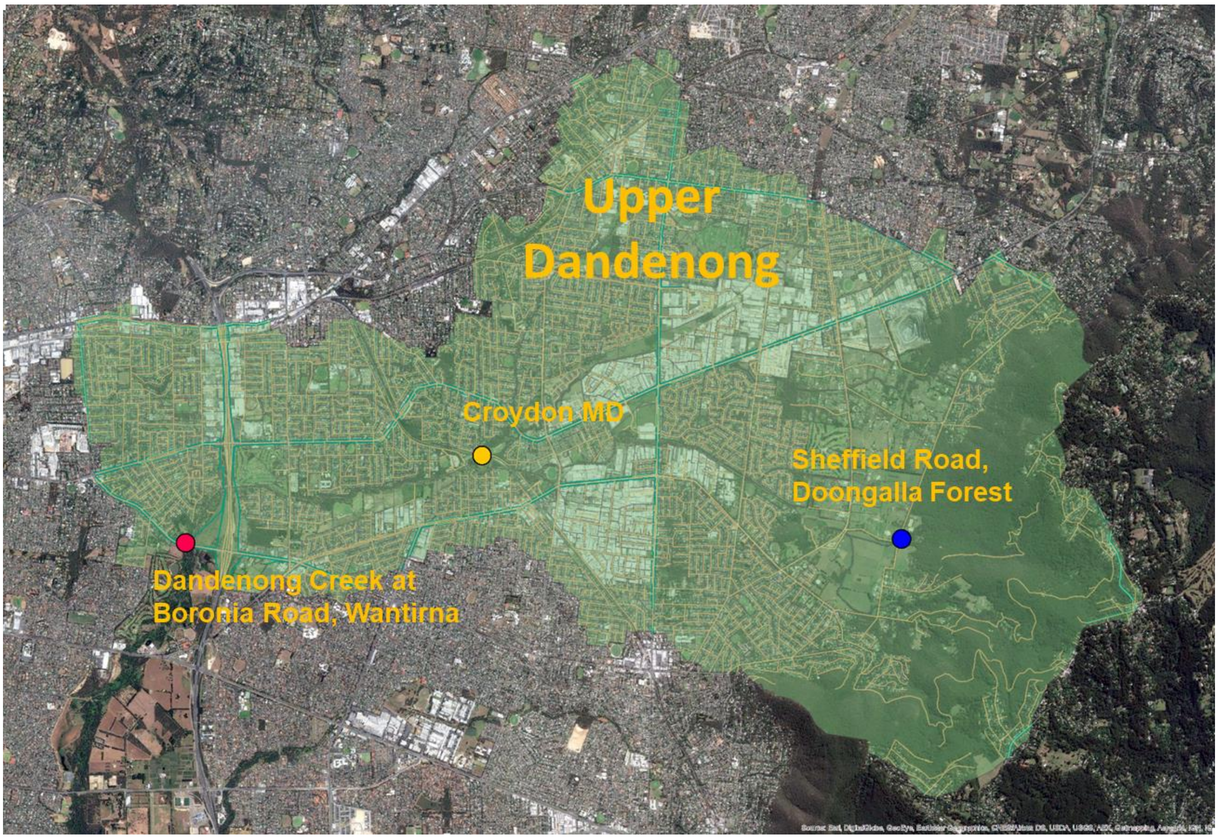


***Fig 2.** Upper Dandenong Creek Catchment, from upper reaches to Boronia Road, Wantirna*

### 2.2.2 Sampling Campaign

The project has begun sampling water quality and flows at several key sites within the Upper Dandenong Creek Catchment including: Dandenong Creek at Boronia Road, Ringwood Golf Course, Bayswater Industry at Bungalook Creek and Marie Wallace Park at Old Joes Creek. Water quality sampling of Dandenong Creek at Boronia Road reflects the overall pollutant concentrations of the entire Upper Dandenong Creek Catchment. Ringwood Golf and Baywater Industry sites reflect the water quality of residential and industrial land uses respectively. Old Joes Creek is a catchment of mixed industrial and residential land uses. As

Figure 3 shows, a flowmeter and an autosampler have been successfully installed in each of four monitoring sites. Flow and water quality data are planned to be collected over the year of 2019.

Old Joes Creek | Flowmeter & Autosampler | Ringwood Golf Site | Bayswater Industry Bungalook Creek

***Fig 3.*** *Sampling sites within the Upper Dandenong Ck Catchment, where autosamplers have been installed and are monitoring flow and water quality*

In addition to the autosamplers and flowmeters, we are also trialling a novel 'cheap' sensor network, which have been under development. This includes an array of Arduino boards containing a range of sensors for detecting changes in pH, water pressure, temperature and electrical conductivity. Recent testing of depth probes within the Monash University Living Lab Flume led to some breakthroughs in operationalising this 'cheap' sensor approach. Deployment is taking place at the moment.

### 2.2.3 Model Development

UrbanBEATS is an integrated model for the planning of sustainable urban water systems . It began its development in 2010 as part of Dr. Bach's PhD thesis and has since grown in size and international research team. UrbanBEATS lays the foundation for all the modelling work within the Future Water ARC Linkage Project. In an effort to ensure ease of adaptability and operability, UrbanBEATS underwent a complete overhaul in early 2018. It has been almost one year since work started on reprogramming the entire framework. A few major changes to the original model have been proposed including:

- Changing the software from 32-bit (only capable of supporting 4GB of memory) to a 64-bit (able to leverage greater memory capacity and thus simulate larger case studies)
- Separating code bases for user interface and model core, enabling users to run the model through scripts and in batch mode without the need for a graphical user interface, this is appealing to hardcore modellers or to those who wish to integrated UrbanBEATS with other software or on cloud platforms.
- Re-organising different model widgets into their respective modules, introducing new modules into the framework, this was necessary as the aims and objectives of UrbanBEATS as an integrated modelling and planning-support tool were becoming increasingly diverse.
- Setting up the framework for the addition of future functionality including the wastewater network and fast flood modelling, this required better management of data, modelling scenarios and use of semantics and terminology throughout.

- Optimising the current code base to support larger case studies (>1000km$^2$), which was not possible in the old version.

Re-development of UrbanBEATS is about 60 to 70% complete. The main user interface has been completely re-designed, the model structure and simulation core have been refined and reimplemented, the first of three major modules has been 90% implemented and the second module has reached 50% of its implementation. It is anticipated that the model should be functional again by early 2019 and beta-testing on existing model features can begin shortly thereafter. Apart from these developments, new features have also been added to UrbanBEATS. These are demonstrated in Section 3 on a number of case studies.

The ongoing development of the UrbanBEATS framework (Fig 4) for model overview, is supported by four universities and a core research team of 16 people. New key features under development include:

- An urban development model, which simulates how land use changes in a city due to growth/decline and other attraction/repulsion factors, loosely based on the urban models developed by (White et al., 2015), (Batty, 2007) and the work of Prof. Richard Dawson at the University of Newcastle.
- A spatial mapping module for mapping a range of metrics including planning overlays, water consumption, land cover and pollution emissions
- A data manager and viewer for obtaining peripheral data that is specific to a city and/or case study. This data manager will link UrbanBEATS with a cloud storage platform, which can be updated by local authorities with up-to-date information (discussed further in Section 3)
- Addition of the wastewater system into the modelling framework (this is undertaken by the Swiss Federal Institute of Aquatic Science and Technology in Switzerland)

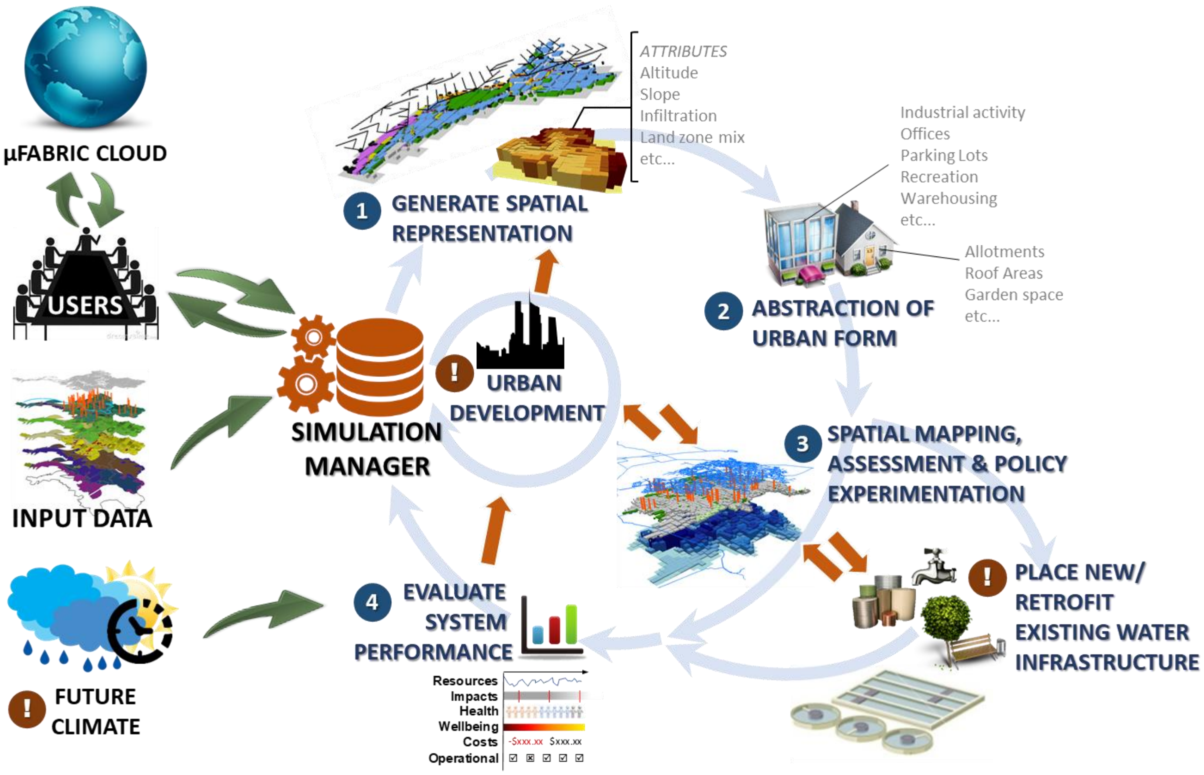


*Fig 4. The revised UrbanBEATS planning-support system framework showing modules, workflows and data interactions including links to an online cloud platform for data storage, sharing and other functionalities*

In addition to these core developments, UrbanBEATS will also benefit from recent research that has emerged from our recent PhD students. This includes a mapping tool for the spatial suitability of various Water Sensitive Urban Design (WSUD) systems, known as SSANTO (Kuller et al., 2018), rapid flood mapping and inundation assessment (Jamali et al., 2018) and an agent-based approach to modelling the uptake of WSUD infrastructure (Castonguay et al., 2018).

Finally, Fig. 4 also depicts a cloud platform known as μFABRIC. Not much will be said about this just yet, but it is a long-term plan that the development team has in mind to create a more seamless collaborative planning experience among stakeholders of the urban water system. At the time of the workshop, cloud capabilities are currently being explored for data storage, update and retrieval purposes. Further plans will be revealed in due time.

### 2.2.4 Model Testing on Upper Dandenong Ck Catchment

Although it has been presented in previous workshops of the Future Water ARC Linkage, an update of UrbanBEATS on the Upper Dandenong Ck catchment was once again shown as a demonstration of model capabilities. We set up the case study in both the old and new versions of UrbanBEATS. Details in this section reflect the modelling and calibration undertaken in the catchment to date. New insights are presented in Section 3.

The catchment was trialled at different model resolutions (Fig. 5). Ultimately, a Block size of 500m was decided as suitable for the case study as it best reflected different drainage catchments determined by Melbourne Water. Modifications to the original algorithms in UrbanBEATS were made in early 2017 to better delineate sub-catchments. The current model runs are able to reflect these more accurately.

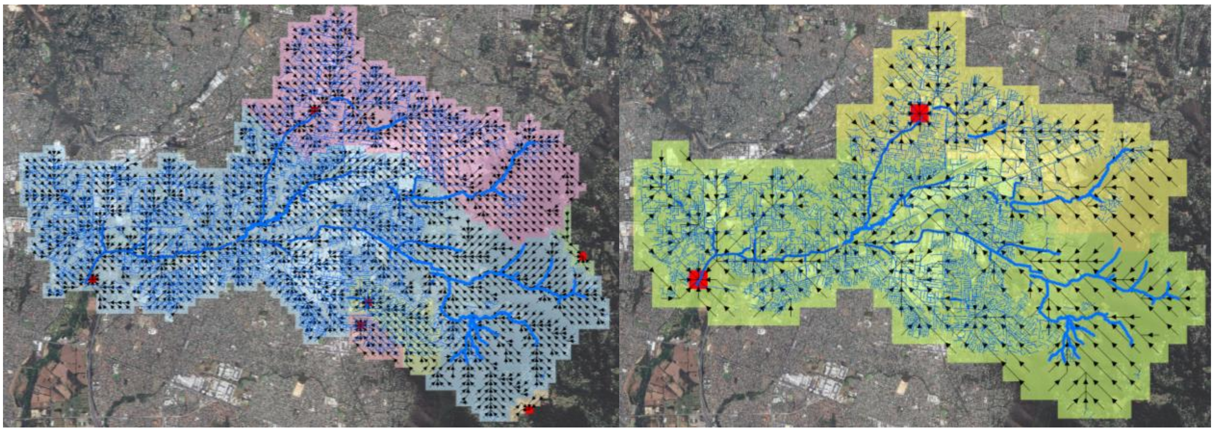

***Fig 5.*** *UrbanBEATS representation of the Upper Dandenong Ck Catchment using 200m x 200m Blocks (left) and 500m x 500m Blocks (right). Red boxes represent catchment 'outlets' where major drainage features are present. Different shaded regions represent sub-catchments delineated by the model. Water courses and drainage pipes are overlaid on top of Blocks. Satellite image courtesy of ESRI World.*

In an effort to create an accurate representation of the urban form, the catchment's modelled impervious area was calibrated to a spatial data set of impervious areas that was created for Metropolitan Melbourne (Grace Detailed-GIS Services, 2012). We compared this data set with supervised classification of impervious areas in Fig. 6 and opted for the former in model calibration. Our progress made so far on obtaining a match between modelled and estimated impervious area for the case study catchment is shown in Fig. 6. As the model development progresses, we will revisit this calibration and, through improvements in model algorithms, hopefully achieve satisfactory calibration for imperviousness and a number of other land cover parameters (e.g. roof area). This is essential for predicting how different proportions of urban elements (e.g. roofs, roads, sealed surfaces) associated with various land uses (e.g. residential, commercial, industrial) will contribute to water quality and runoff volume.

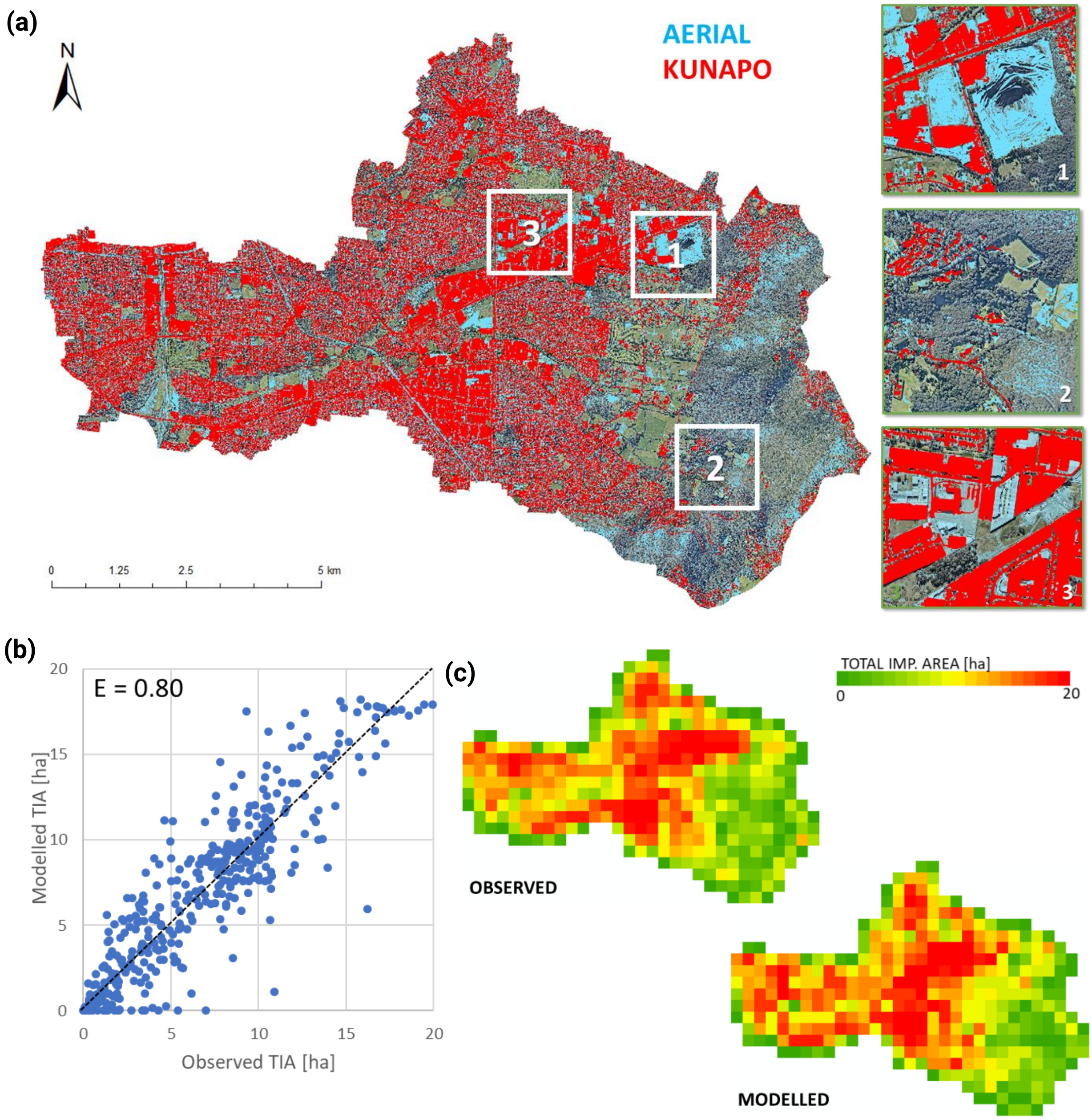


*Fig 6. Preliminary calibration of impervious areas in the Upper Dandenong Ck Catchment, (a) calibration data set comparison between supervised classification of aerial imagery and the Melbourne impervious area data set by Kunapo et al., 2011), (b) preliminary calibration results between observed total impervious area (TIA) and modelled TIA, (c) spatial comparison of observed and modelled impervious area.*

# 3 UrbanBEATS DEMONSTRATION

## 3.1 General Demonstration of the Model Software

A demonstration of the UrbanBEATS Planning-Support System in its current form was given after the update round. This demo walked through the creation and setup of an UrbanBEATS project for the Upper Dandenong Ck Catchment. It included the explanation of how the new UrbanBEATS workflow looks like and the simulation of the first module, which includes the delineation of Blocks, water flow paths and drainage basins as well as designation of council and suburban boundaries within the case study.

The new workflow in UrbanBEATS is more closely based around the concept of scenarios within a project. Users now have the ability to create multiple scenarios for a single project and quickly perform comparative analyses between them. As such, a planner may use the model to first establish a calibrated baseline prediction of a neighbourhood and then choose to alter this baseline to reflect future scenarios or technological innovations. Fig. 7 illustrates the structure of an UrbanBEATS project.

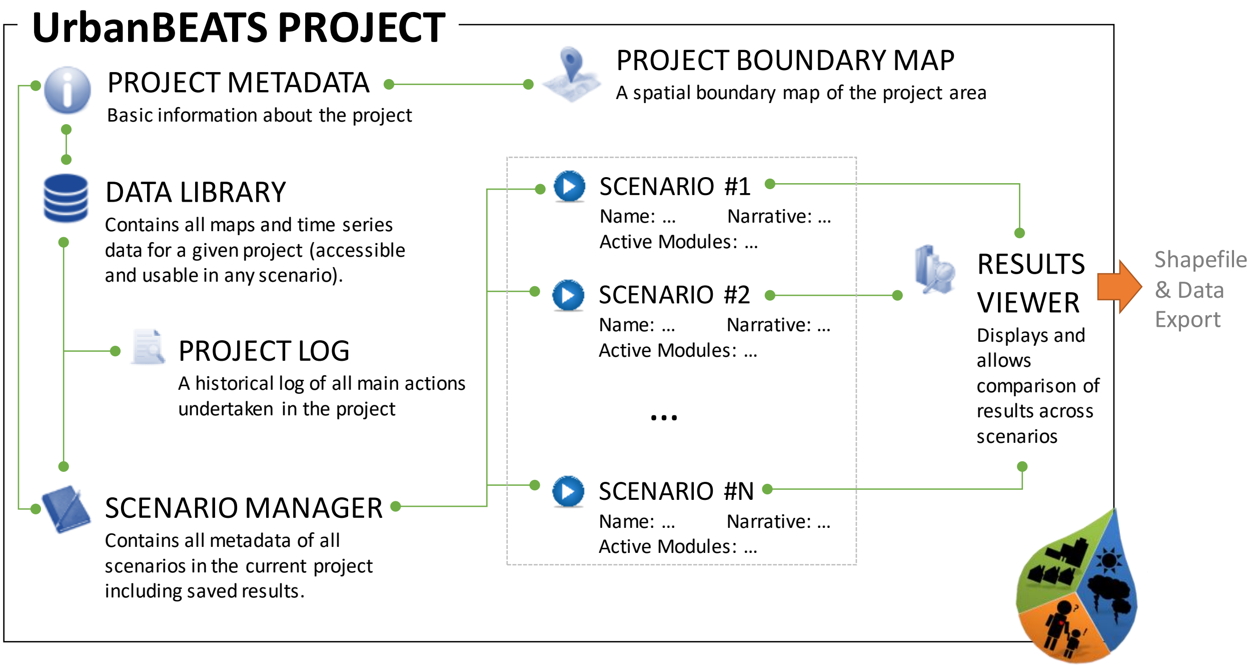


*Fig 7. Outline of the revised UrbanBEATS Project workflow, which now works on the basis of a project, comprising relevant metadata and a data library as well as a scenario manager. The project itself is defined within a specific boundary and is logged to track user actions.*

The revised model user interface is shown in Fig 8 below. It now features a spatial map on the landing screen to provide the user with local context of the project being worked on. Many of the old user interfaces from the legacy version have been transferred to the new version, but with notable visual improvements. Several simulations of case studies of different sizes were conducted prior to the workshop and presented to participants as well. Fig. 9 shows three notable Australian areas: (a) the Future Water Linkage case study, Upper Dandenong Ck Catchment, (b) the Dandenong Integrated Water Management Forum and (c) Wangaratta City Council's region, which is the case study of another ongoing project.

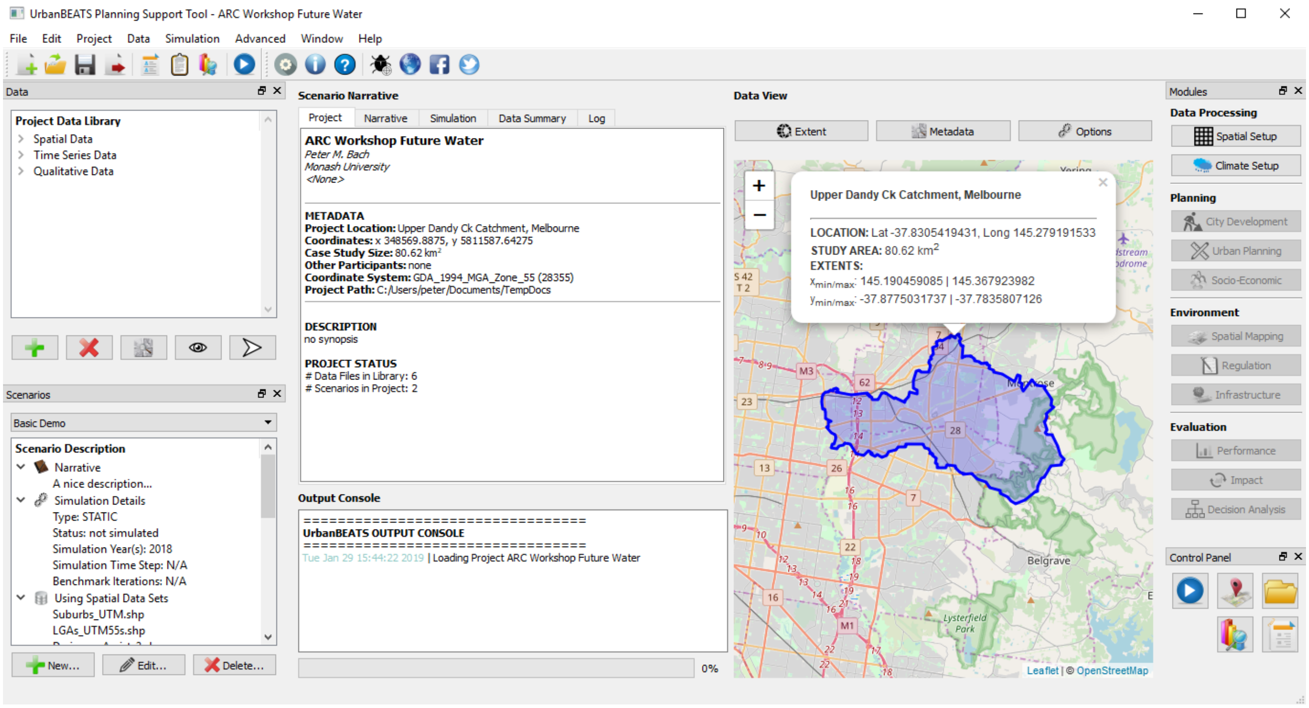


*Fig 8. Screenshot of the revised UrbanBEATS Planning-Support System User Interface showing the project file on the Upper Dandenong Ck Catchment case study.*

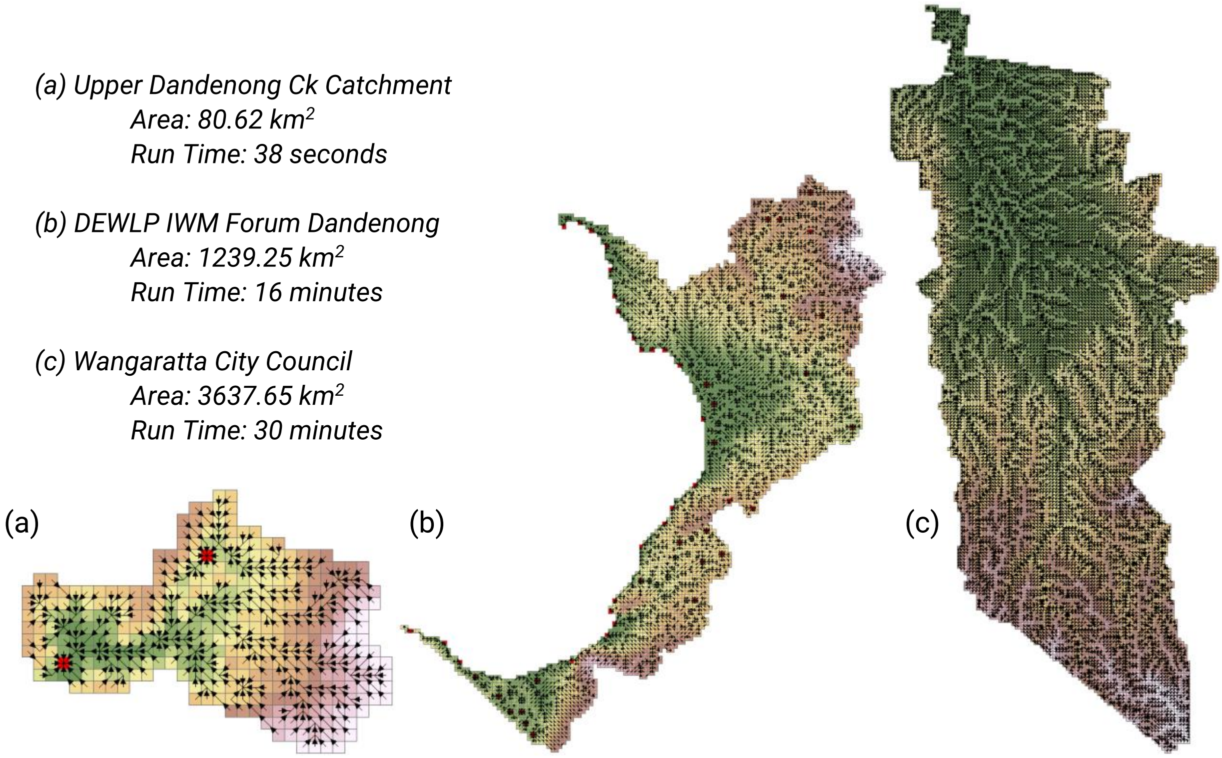


*Fig 9. UrbanBEATS Benchmarks for three different Australian case studies of varying sizes (80 to 3,000 km$^2$). Results are for simulations including loading and processing of spatial data, Block creation, neighbourhood search, flow paths and sub-catchment delineation. Simulations on a Core i7-7700HQ CPU, 2.8GHz with 32GB of available RAM, 64-bit operating system.*

Run-times of the first module (Block delineation, data transfer, flow paths and basins) are shown in Fig 9. As can be seen, notable computational improvements (30 mins for over 3,500 km$^2$ of simulation area) have been made and that the model is capable of dealing with much larger case studies, which was a reassuring sign to many participants in the workshop.

## 3.2 Demonstration of the Data Manager and Viewer

Current working copies of UrbanBEATS' Data Manager and Viewer were presented to project partners and future implementations discussed. Neither module is currently linked with main UrbanBEATS core due to ongoing re-development of UrbanBEATS' main interface. However, both Data Manager and Viewer will be integrated within main program in the future updates.

UrbanBEATS files needed for specific types of assessments, case studies and adequate localisation of the model (e.g. rainfall maps, design curves, water quality measurements, emission inventory points), will be kept in separate ***online repository*** and they will not be available within the basic installation of UrbanBEATS. This was decided upon in an effort to reduce the size of the UrbanBEATS installer and remove unnecessary accumulation of sometimes irrelevant data on local systems. The ***online repository*** will allow for the creation of a single, cross-organisation database of relevant information, which can be loaded into UrbanBEATS for visualisation and output modelling, but only upon users' request, making it user-dependent, rather than system-dependent. The access to the online repository will be through the new UrbanBEATS' module: the Data Manager, which is described below. Currently, the research team is still looking for an appropriate "location" or hosting platform for the data repository. Initially, it was suggested that we can utilise the University of Melbourne's AURIN platform for data storage (https://aurin.org.au). However, due to difficulties in integrating AURIN with UrbanBEATS, alternative online repository solutions are being sought.

### 3.2.1 Data Manager

The purpose of Data Manager is to provide a Graphical User Interface for access to the online repository and download of appropriate local data sets for modelling and visualisation. It encompasses a user interface presented in Fig. 10, with options to view, select and download requested files. *Section 1 (Repository Explorer)* gives an insight into which regional data and type of data the online repository currently stores. Navigating through the selection menu, users can search for a particular country, city or region for all available data, or simply select specific layers (physical, water quality, planning, emissions inventory, etc.) or sub-layers. After the user makes an appropriate selection (highlights selection), the "Check Available Data" button (*Section 4*) will query the online repository and list all available data sets in *Section 2 – Available Data*. If no data exists for the user selection, the user is informed through the pop-up "No results" (Fig. 10) and a new selection needs to be made.

Once the available data is shown in *Section 2*, metadata including "Name", "Type" (map, csv, txt, image, etc.), "Date Modified", file download "Size", and data "Source" (who contributed data to the repository) is shown for each individual item. This is based on the current version of the Data Manager; however, this list can be expanded/modified based on project partner inputs. Additionally, each item will have a brief description of what it contains, which will be viewable upon item selection in *Section 3 – Comments.* After the appropriate item/file has been selected for download, the "Download" button should be pressed, which saves file locally on a user's computer and sends a message prompt: "File downloaded" (Fig. 10). If the file is not available due to a database error or incorrect file selection, the message "No file downloaded" will be provided and the database administrator should be contacted to look into this error.

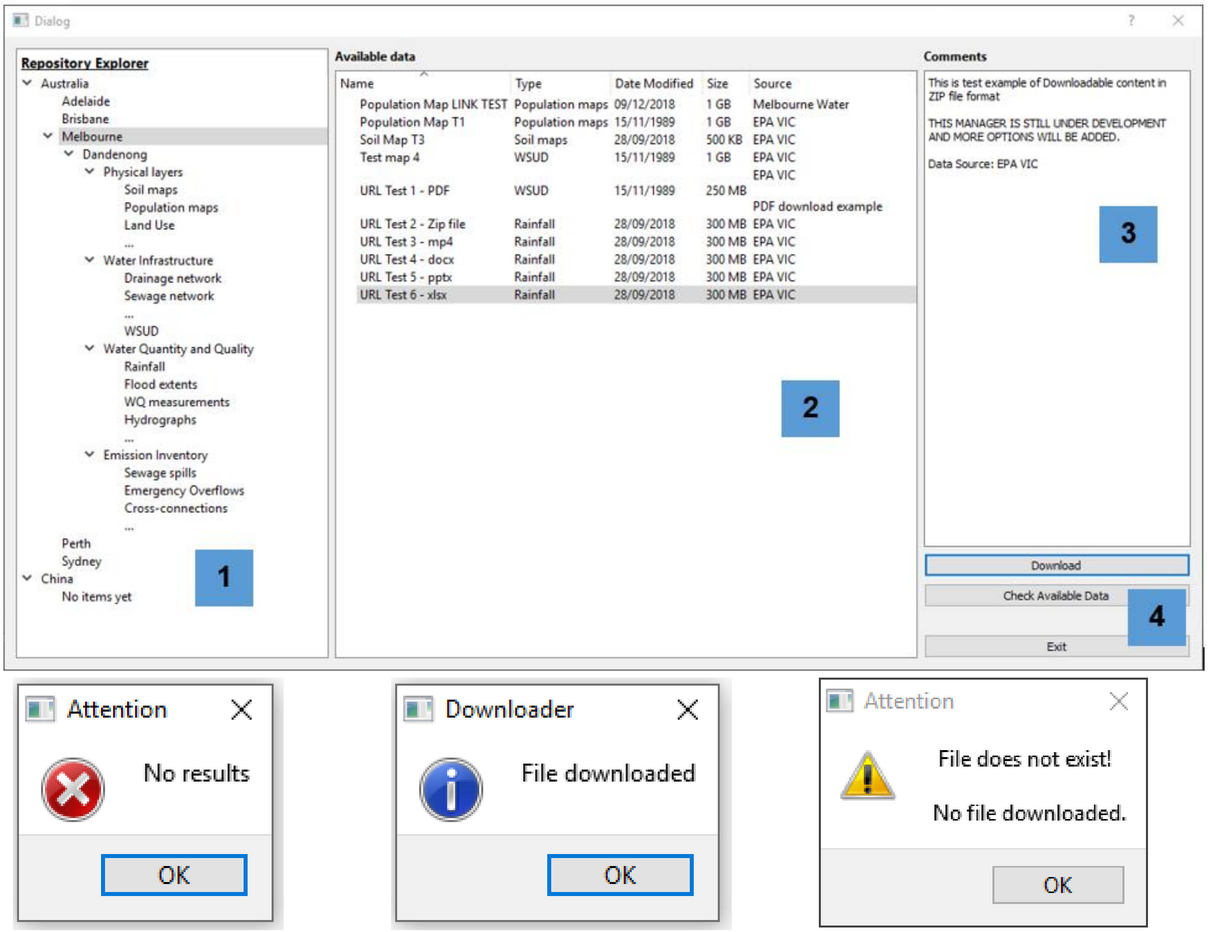


*Fig 10. Overview of Data Manager User Interface and its functionality (top) including user communication messages through pop-ups (bottom).*

The Data Manager plugin is still under development and further improvements will be made before release. A feature to change the save file directory will be introduced, for easier management of files stored locally on the computer. Some potential additions to the Data manager include: (1) implementation of a mini-map, so spatial extent of the data is highlighted and (2) quick data viewer, for available data formats. If more features are needed, contact the developer Veljko Prodanovic directly.

### 3.2.2 Data Viewer

The Viewer performs data visualisation for interpretation and mapping of either existing data or model results. It is designed as a semi-interactive, data-driven interface where the user can plot specified static local data types on an online dynamic map (*Leaflet service*), allowing for scrolling and zooming (similar to Google Maps). Depending on the static data format and type, some interaction with the data will be allowed, showing pop-up dialogs with additional information (names, pollution types and concentrations, graphical charts, etc.), as seen in the demonstration in Fig. 11, presented during the UX workshop. For the workshop demonstration we plotted LGA boundaries, water bodies and Melbourne Water quality sampling sites on Greater Melbourne dynamic map and highlighted some of the Viewer capability with pop-up menus and map navigation. Future implementation of other visual elements that will be possible for addition are flood extents, pollution heat maps, green spaces, heat islands, etc.

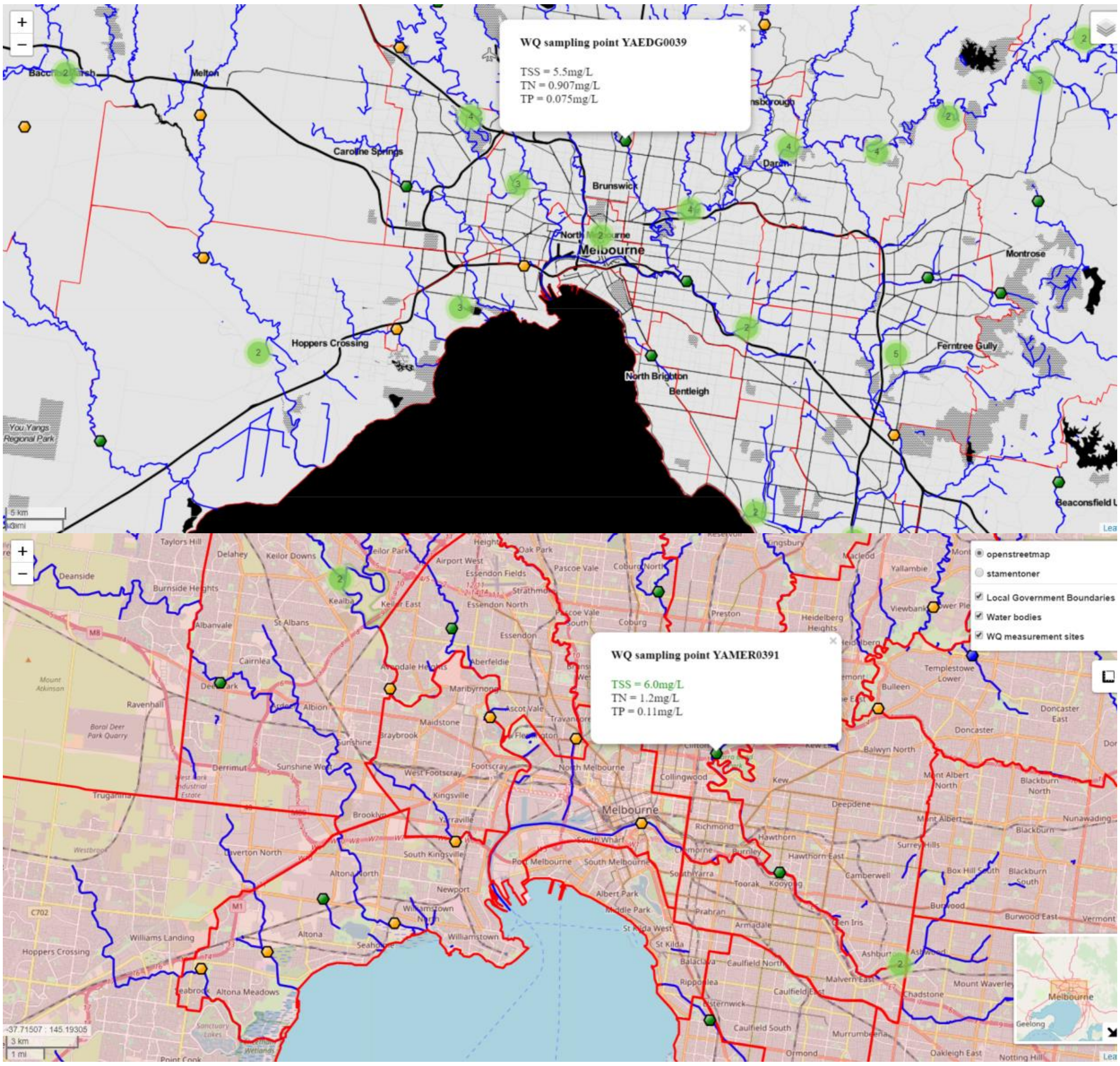


*Fig 11. Development of Data Viewer with visualisation of sample data; version 1 (top), version 2 (bottom)*

During the workshop, it was proposed to add punchier visualisation to these maps, with different colour and shape icons used for different purposes. For example, it was proposed to stick with a "traffic-light" visual system for pollution intensity, with "red" showing severe pollution (in comparison to current standards), "yellow" showing medium pollution, "green" showing light pollution and, additionally, "blue" for very low pollution. Some preliminary colour-coding has been added to current version of the map (see Fig 11 bottom), but new options will be added in future to define the colouring based on which pollution standard is to be followed. Icon shapes will also be redesigned for better user experience.

The Data Viewer is currently a stand-alone module (during the redevelopment of UrbanBEATS' main core). However, it will be integrated into the main program soon.

## 3.3 Mapping Open Space Networks and Connectivity

The most recent model developments on UrbanBEATS focussed on the idea of open space networks. There is a lot of literature on the importance and health benefits of open spaces in cities around the world (e.g. de Vries et al., 2003). As part of the redevelopment of

UrbanBEATS, a new additional feature was implemented into the model and this was demonstrated at the workshop.

The model explores two fundamental metrics: accessibility to open space and connectivity of open spaces. Despite its abstract representation using Blocks, we nevertheless are able to calculate an approximate distance to the closest available open space from any patch of land in the urban environment. This enables us to make judgments about an area's recreational value and 'walkability'. Furthermore, the linkage of open spaces is often crucial for health, recreation and urban ecology. As such, we also perform a pseudo network analysis within UrbanBEATS by determining how *connected open spaces* are within the simulation boundary. An open space is considered to be connected to another open space if they are less than a certain distance apart (see Fig. 12 for concepts and illustration). This distance is 1.41 x Block Size (1.41 approximately the square root of 2). The distances are calculated from the centroid of open space land patches, hence the need to set a minimum threshold distance.

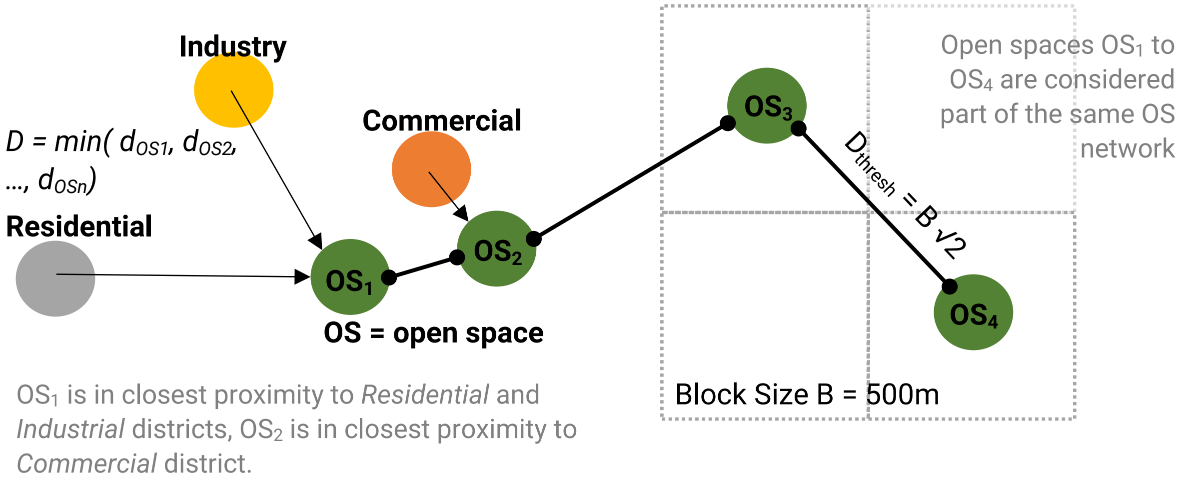


***Fig 12.*** *Concept for open space proximity and connectivity in UrbanBEATS. On the left side, open space proximity is shown as the minimum distance to the nearest open space. The connectivity of open spaces is determined based on a minimum threshold distance. This leads to the creation of different open space sub-networks, which can be further analysed.*

The analysis was presented for two case studies, the Upper Dandenong Ck Catchment and the DELWP (Department of Environment Land Water and Planning) IWM (Integrated Water Management Forum) region of Dandenong (DELWP, 2017) and results are illustrated in Fig. 13 below. To better understand these results, we point to several crucial observations in the open space distribution of both case studies.

Firstly, for Upper Dandenong Ck Catchment (Fig 13a), open spaces, in general, are fairly connected. The eastern part of the catchment is protected forest and is predominantly natural cover. Along the creek lines, we can observe a dense network of much smaller interconnected open spaces. This denser network is not as strongly connected to the forested areas with only two smaller links in the south of the catchment. Planners may choose to enhance these connections by creating future green corridors. In general, many urban built-up areas have access to green spaces. The regions where access is more remote (i.e. red lines) contain industrial activity and business parks. It is therefore up to the planners to judge whether the access to open space is crucial for industries and businesses in these areas.

For the Dandenong IWM Forum case study, the picture is much more complex given the size of the catchment. Most built-up areas occur in the north, whereas in the south, many predominant regions with low access (i.e. the many concentrations of red lines) are actually agriculture or undeveloped. Connectivity of open spaces is generally good, but many sub-networks can be seen within this case study. A continuous network along the coast line is visible. Future versions of UrbanBEATS will provide many more quantitative summary metrics that will provide users a better insight into the characteristics of open spaces across a case study. The discussion at the workshop on this feature, however, has raised potential in such a functionality for generating improved dialogue between urban planners and urban water managers.

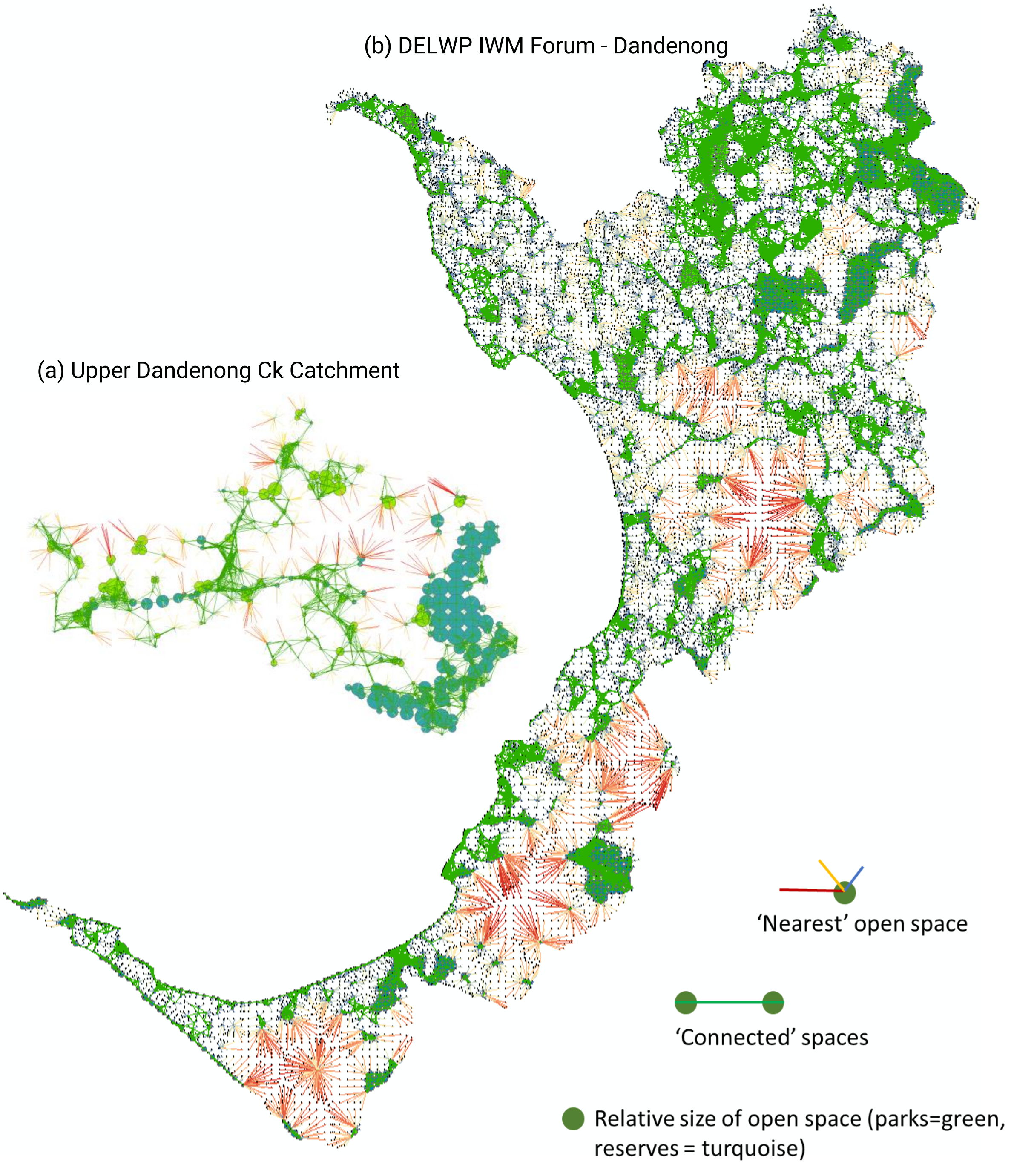


***Fig 13.** UrbanBEATS Simulation results for open space proximity and connectivity for the (a) Upper Dandenong Ck Catchment and (b) DEWLP IWM Forum – Dandenong regions.*

## 3.4 Mapping Suitability for Water Sensitive Urban Design (SSANTO Implementation)

As mentioned earlier, there is ongoing effort in implementing a suitability mapping tool known as SSANTO, developed by Dr. Martijn Kuller, who recently completed his PhD, into the UrbanBEATS framework. SSANTO maps the suitability of spatial locations for different WSUD systems based on a spatial multi-criteria decision analysis algorithm and numerous input maps. A preliminary mapping was undertaken for the Upper Dandenong Ck catchment case study (shown in Fig 14) to illustrate the opportunities and needs for WSUD. In SSANT, *opportunities* represent locations that could accommodate a piece of WSUD infrastructure due to suitable ground conditions, socio-economic conditions and planning arrangements. On the flipside, *needs* represent locations that would significantly benefit from the presence of WSUD infrastructure as they would improve local ecological, recreation and amenity or provide much needed water, climate and/or other regulation of the local environment.

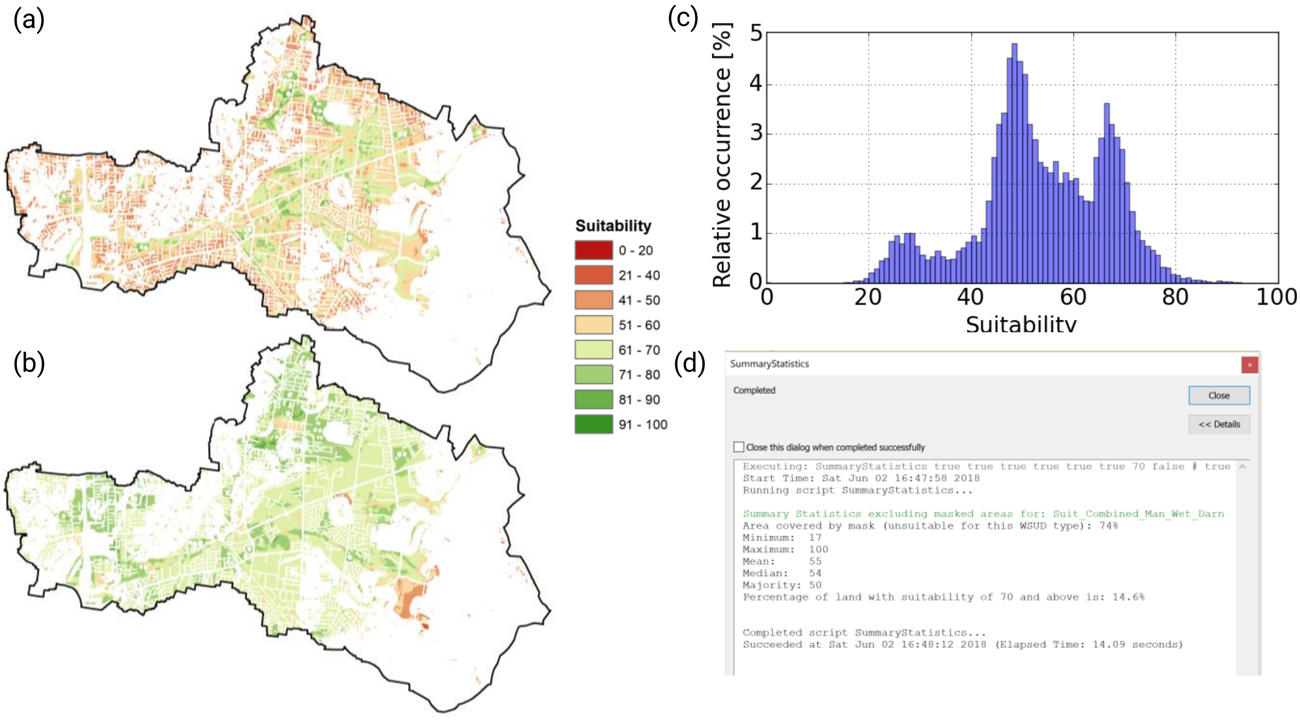


***Fig 14.*** *Suitability map for Water Sensitive Urban Design Systems in the Upper Dandenong Ck catchment showing (a) map of opportunities for constructed wetlands, (b) map of needs for constructed wetlands in the catchment, (c) a frequency plot on the relative occurrence of different suitability values and (d) a screenshot of SSANTO's current implementation in ArcMap.*

Examples of SSANTO's outputs are presented in Fig 14 for the Upper Dandenong Ck Catchment. The tool is currently implemented as an ESRI ArcMap Plugin and users are required to source their own data sets for their respective case study. However, as part of the ongoing development of UrbanBEATS, in particular its plugin feature, online data functionality and push towards a more rigorous planning platform, SSANTO's implementation hopes to reduce much of the preparatory work for users. As a plugin, SSANTO can either be used as a standalone tool as part of a planning exercise. Alternatively, we also intend to couple the suitability outputs of SSANTO with UrbanBEATS' WSUD Planning Module for more refined planning and options generation within the model.

# 4 USER EXPERIENCE AND VISUAL DESIGN EXERCISES

Following a demonstration of the current version of UrbanBEATS, the workshop then progressed to two key activities: (1) user experience design and (2) visual communication styles that the platform should consider. Here are brief overviews and outcomes thereof.

## 4.1 User Experience (UX) Design Exercise

Adapting from an effective exercise that Dr. Bach engaged in while at Eawag in the last four months, a modified and shorter version of the Rich Picture method was used to engage participants (Lewis, 1992). The Rich Picture method is a technique from the Soft Systems Methodology (Checkland, 2000) and is an unbiased and expressive form of engaging all participants within the workshop setting. The aim of this user experience design exercise was not only to obtain an insight into how our industry practitioners perceive and use models in their day-to-day projects, but also how the scientific work, communicated through UrbanBEATS can better bridge with practice. Drawing upon the work and philosophy of the Transdisciplinary Research Lab at ETH Zurich, we began by illustrating the relationships between science and practice (see Fig 15). Problem framing, analysis and implementation are three overarching activities that bridge the two areas. However, without adequate problem framing, developers on UrbanBEATS will be unable to tailor the tool to solving practical challenges. Rich picture building is an effective tool for beginning the problem framing exercise .

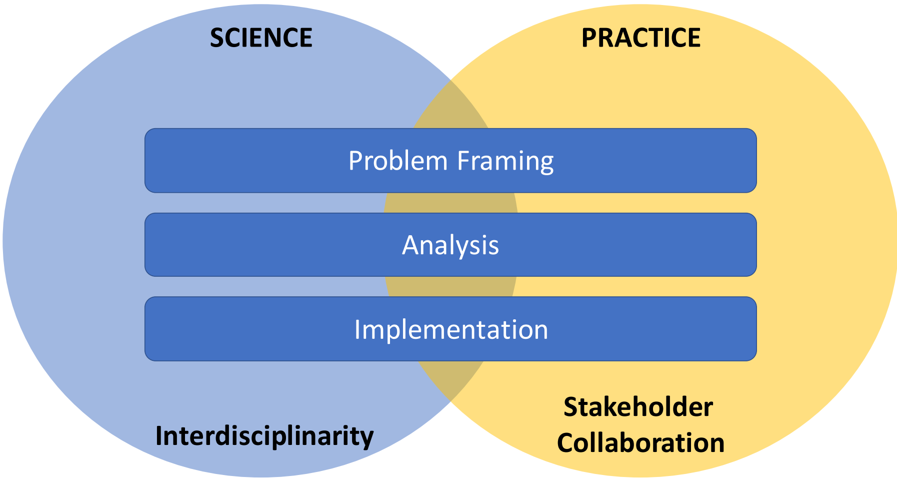


***Fig 15.*** Framing of transdisciplinary research within the science-policy practice (figure courtesy of B. Pearce, Transdisciplinary Research Lab, ETH Zurich)

Participants were asked in describing a past experience (an activity or project) in the form of a 'Rich Picture', where software or systematic data analysis was used to address a complex water management problem. As part of their picture, they were required to identify relevant people, processes, objects, structures, environments, issues and conflicts. In the spirit of rich picture thinking, they were encouraged to use any form of illustration or language, i.e. text, symbols, cartoons, words, flowcharts. Two groups of four discussed their pictures with each other and noted down commonalities and contrasts. Observations were captured on butchers' paper (see Fig 16, all rich pictures are shown in Fig 17).

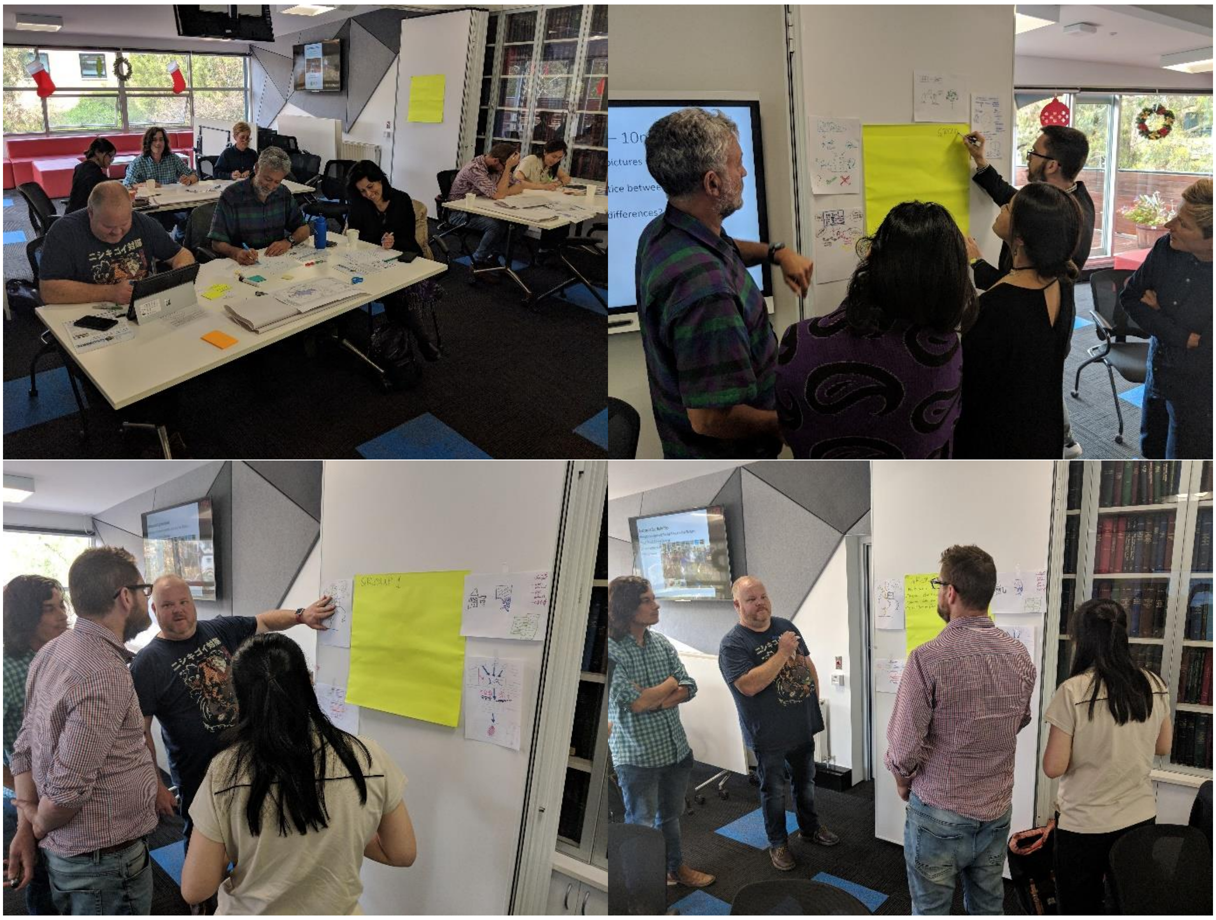

***Fig 16.*** *Workshop participants undertaking the Rich Picture Exercise*

Following this 20-minute exercise, we then undertook some brief design-thinking in which participants discussed their insights, in particular, those that they found most interesting and/or surprising. The goal was to determine the perceived need, or what was 'lacking' among the commonalities of experiences discovered through the rich pictures. These needs would go on to become some of the key user experiences that the development team can then centre the model design around. The exercise lasted for about another 15 minutes and was followed by a general discussion.

Group discussion covered a number of different topic areas including: multi-scale reporting, the use of diverse data sources (i.e. data, expert opinion and local knowledge), prioritisation and scenarios testing, the importance of economic modelling, community and stakeholder engagement. The importance of centralisation and organisation of data (such as nested categories) was mentioned on the one hand. Experiences questioned usefulness and applicability of different data. In parallel, visualisation and communication in the 'right' manner were also deemed to have equally important attention. In summarising the discussions, for the model to support good collaboration, users' ***tacit knowledge*** should be combined with three dominant elements that can be addressed:

- **Consistency:** a formal, consistent and comprehensive manner of organising, updating, storing and communicating data and information throughout the modelling process;
- **Visualisation:** a visual, transparent and effective means of presenting essential information to users, and;
- **Good Data:** ensuring data quality and addressing potential uncertainties associated with the data in analyses, as with consistency, this also include good metadata.

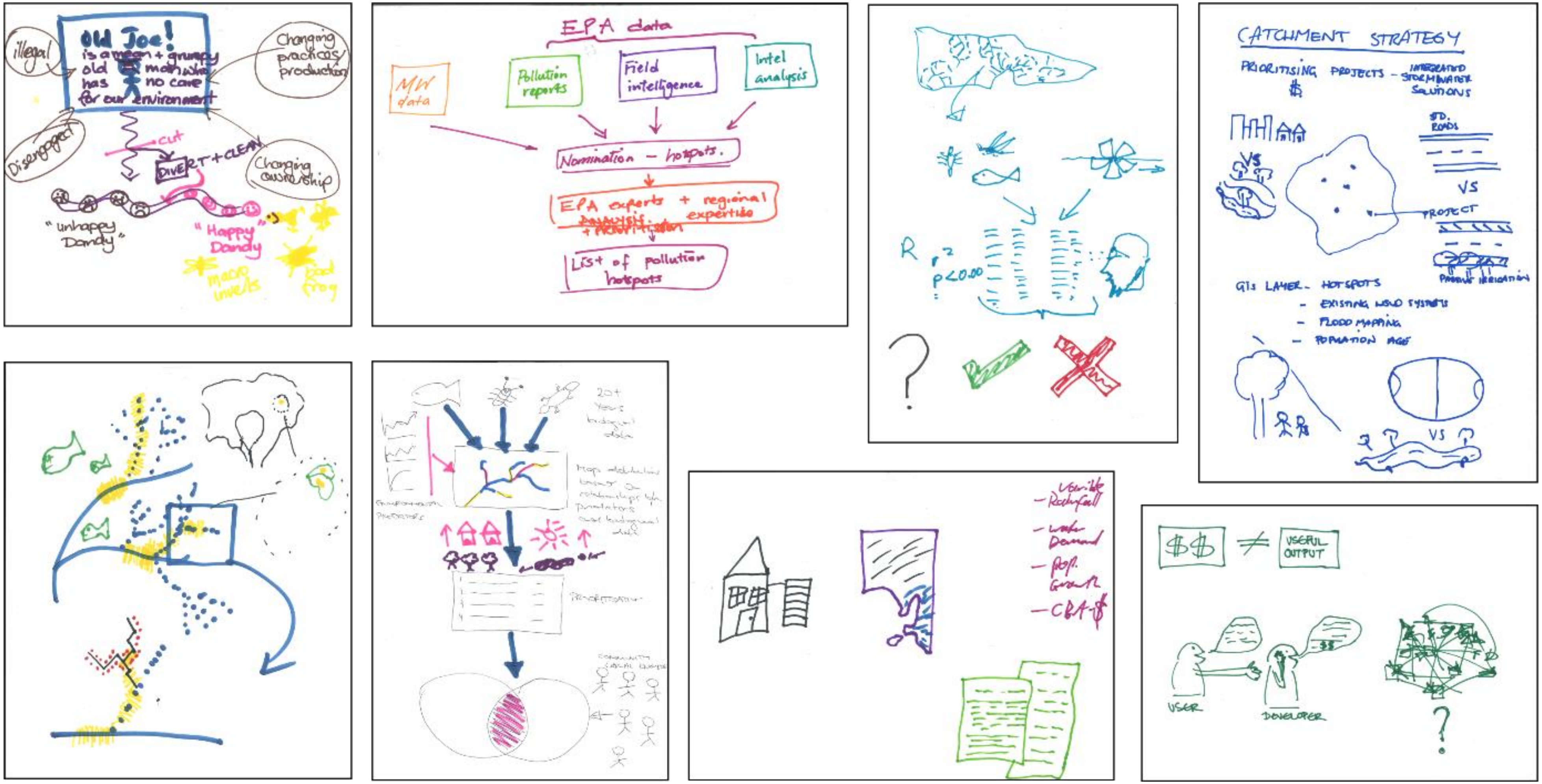


*Fig 17. Overview of "Rich Pictures" drawn and presented by participants, these rich pictures were drawn to reflect a current or past activity or project where software or systematic data analysis was used to address a complex water management problem*

## 4.2 Visual Design Exercise

After exploring key design expectations, this part of the workshop was designed so that researchers/developers can understand how UrbanBEATS is going to be used by project partners and customise functionality of the program and its modules to partners' needs (examples of which are shown in Fig 18 below). In the same two groups as before, participants discussed and proposed improvements to UrbanBEATS' visual data representation including new desired program features. Each group had 20 minutes of group discussion before reporting the results. Some overlaps in discussion points have been noted between both groups, but we separate key workshop deliverables into following sections: Data Visualisation, Feature Implementation and Reporting.

### 4.2.1 Data and Map Visualisation

One group had the task of creating a Wishlist of preferred visual features and how they could be implemented within UrbanBEATS for easier and user-friendly querying of important data. *Usability* and *functionality* were the keywords for this group for thinking about improvements.

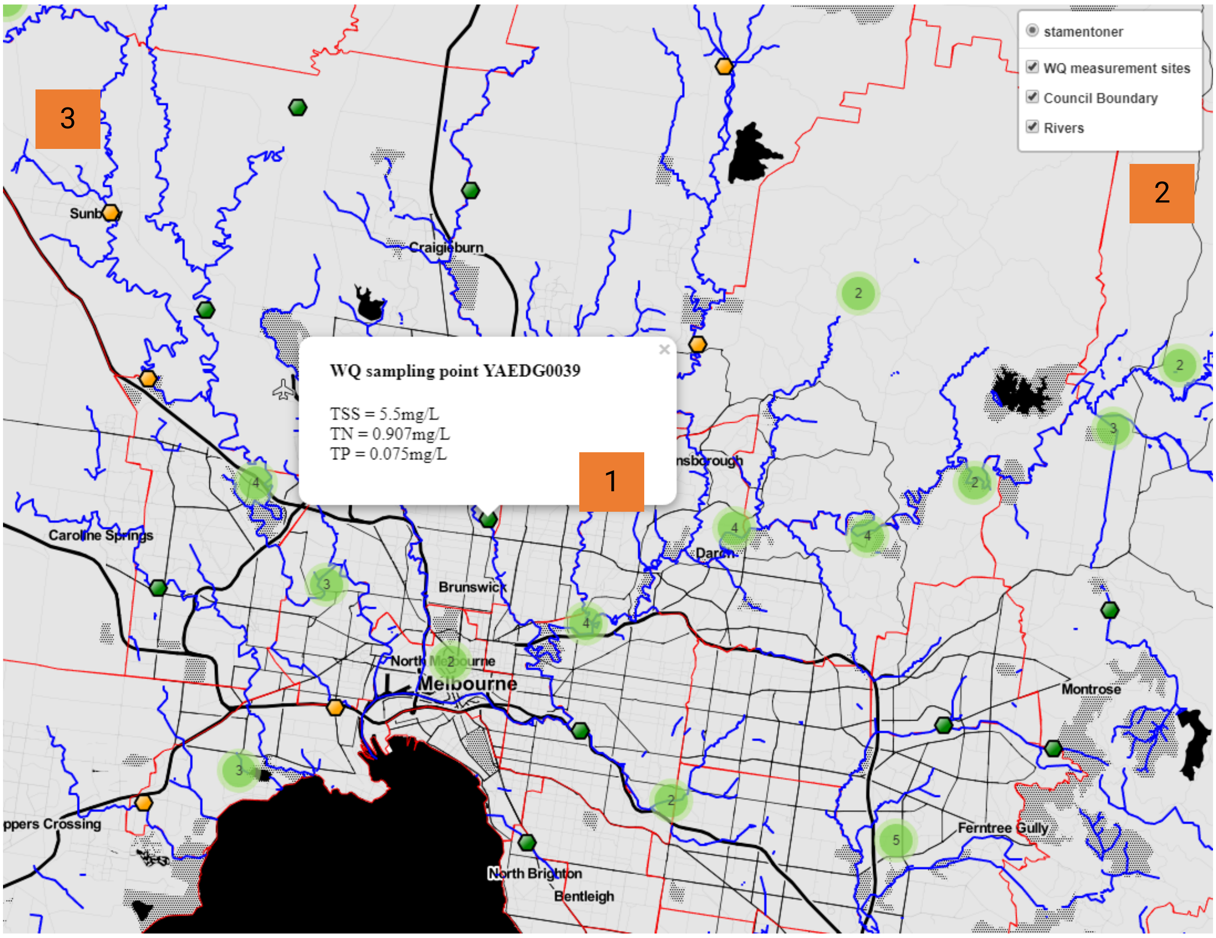


***Fig 18.*** *Elements of current Data Viewer: 1) information pop-up, 2) map overlays, 3) overall map area and background information*

The main needs and desired improvements can be divided into three topics:

1. Enhancing the map's "pop-up" menus
    a. Use "traffic-light" representation (red-yellow-green-blue) for pollutant concentration values, showing how actual values relate to selected standard
    b. Include standards (e.g. SEPP, BPEM, etc.) and compare to measurements
    c. Include data source (MW, EPA…)

    d. Include stream name, not just sampling site code
    e. Add more sampling information, such as number of sampling, date of sampling (or time span)
    f. Wetland pop-ups should include details of construction
    g. Add time series of pollution and other relevant pop-up info
    h. Show pie-charts with likely pollution sources (land uses) – or just land uses for specific site catchment (catchment structure)
    i. Wet versus dry weather concentrations, visual representation within a pop-up
    j. Link to additional data (developer comment: maybe add a name of the file which is used for data visualisation)

2. Adding more overlay options
    a. Sub-catchment scale focussed overlays
    b. Heat Vulnerability overlays (like Nigel Tappers Heat Wave maps) to show colour coding of high (red) to low impact (green and blue) areas
    c. Locations of importance: - blue spaces/assets; green spaces/assets; linkages between green and blue spaces = opportunities at bird's-eye view
    d. Litter hotspots (intersection between different land use types)
    e. WSUD asset overlay including GPTs
    f. Additional overlay types:
        i. Flood hotspots
        ii. Waterways
        iii. Heat islands
        iv. Vulnerable communities
        v. Green spaces
        vi. Active open space (spots)
        vii. Ideal locations for BG systems
        viii. Planning zones overlay
        ix. Historical pollution incidents overlay

3. General map visual improvements
    a. Colour coding all the map info to show "traffic light" colours (red – bad, yellow – appropriate/low risk, green – good, blue – great)
    b. Overlaying multiple map types to assist with decision-making – e.g. age demographic map with heat map to find spots with highest vulnerability;
    c. Wetland pollution data – show where and what is the level of pollution (waste categorise)
    d. Visualise outputs from SSANTO
    e. Visualise flooding outputs
    f. Integration of IWM Forum Plan info
    g. Adding more background map options – Addition of background layer as seen in Melway maps (www.melway.com.au, "Open Street Maps") and other maps

### 4.2.2 New Features Implementation and Reporting

The other group had a task of discussing and planning new functional features that could be useful if implemented within UrbanBEATS and the desired output/reporting formats that UrbanBEATS should produce after the analysis has completed. They further discussed expected user-program interaction needs and the level of simulation customisation desirable for different types of users (engineers, planners, stakeholders, etc.). Key discussion points are summarised in four topics:

1. Adapting UrbanBEATS to varied expertise levels

One of the key discussion topics was adaptation of UrbanBEATS' outputs for use by different user types. Due to the varied complexity level of simulation results needed, default results should be reported with easy-to-understand graphs such as bar or pie charts, and less detailed technical descriptions, focusing on key results. However, per user's request, UrbanBEATS should be able to generate more detailed results viewer, giving correlations between data types and outputs, with spatial/point/scatter graphs, which are more useful to experts.

2. Building a feedback functionality into the map

Being able to click on a map and place a new point which can be used to interrogate flows upstream/downstream from the point, or place new stormwater tanks, or WSUDs and see how that influences flooding/pollution control. This can be useful to test the range and the effect of pollution spills, but also for new data input. In addition to this, "click-and-add" point option for the map would allow user to add new, custom data points to selected overlay, making it easier to capture experts' knowledge during project development.

While the addition of this option would be very useful, developers need to test if this will be possible during Projects time-frame, or this is more a long-term goal. (Note for developers: Check out https://urbanstreams.net for ideas).

3. Dynamic pollution progression

Visualisation of timestamped data with pollution source and spread based on measurements and/or calculation. This can be used to determine pollution reach and time needed for pollution spread based on base river/creek flows and pollution diffusion and decomposition. This would be semi-dynamic representation, where data would be initially generated and then time progression of the pollution (or hot spots) showed on a map. This could be also used for interrogation and exploring differences between dry and wet weather events (suggested by partners).

4. Results customisation through criteria selection or custom overlays

It was discussed that UrbanBEATS would benefit from the option to select appropriate regulations for comparison with the results (especially for urban planning and water quality). This would enhance usability for users who are interested in complying with specific regulation, or users who wish to test how model outputs comply with different regulations (historic, current, or future). Based on the regulation selection, visual aspect should use "traffic-light" colour scheme to highlight how results comply with selected standard.

While customising UrbanBEATS' output results, workshop attendees have also expressed an interest to include option for import and visualisation of custom layers/overlays in program's map. This would allow user to add custom info to the program map and provide better understanding of the results. However, due to the complexity of rules for formatting these custom maps, this is likely a long-term goal for developers.

# 5 WRAP-UP, CONCLUDING REMARKS & NEXT STEPS

This workshop was one of the first intensive activities, which engaged our industry partners in the co-development and design of the UrbanBEATS Planning-Support Tool. It not only allowed the ARC Linkage Project team to provide a comprehensive update and demonstration of project deliverables for the near future, but also for the broader model development team to gain insight into the usability, thought processes and desirable features that are relevant to the Australian water planning and management practice.

The workshop demonstrated for the first time, the newly developed and overhauled version of the UrbanBEATS Planning-Support System in its current version including upcoming features such as the revised project workflow, data manager and viewer as well as new model features including the mapping of open space proximity and connectivity and the mapping of suitability for WSUD.

Two exercises were conducted as a means for developing a roadmap for development: a User Experience Design exercise (using the rich picture and design thinking methodologies) and a Visual Design Exercise. Overall, the key message of the rich picture exercise emphasised the need to combine modelling tools, which are **consistent** (both structurally and in how they process information), **visualisation** (transparent and effective) and **good data** (where quality is assured and errors and uncertainties are understood) with **tacit knowledge** and **good communication** if effective collaboration in planning future water management is to be created. The key messages of the Visual Design Exercise included (1) the need for a **user-friendly interface** with the option for the user to select which data will be highlighted on the map and inside the pop-up views, along with more user-friendly colour scheme (traffic-light scheme), (2) **more visual and functional overlay options**, so that relevant spatial maps can be compared both visually and through numerical correlations (within a different "graph viewer"), and (3) **semi-dynamic approach to results viewing and examination**, where time-stamped data could be examined to understand pollution levels and reach. It is also noted that the last point can be further enhanced with fully dynamic results examination, allowing for user to pass new information (adding new pollution spills, or rainwater tanks, or WSUDs, etc.) from the Viewer into the program for multi-scenario testing on a single interactive map.

Over the next few months, more features will be added to UrbanBEATS as most of the old functionality is restored in the new interface. We will be testing the model on a number of different case studies including several across Victoria and New South Wales, Australia, Nanjing in China and Zurich in Switzerland. An urban development module is under development and it will soon be able to simulate changes in land uses in catchments, allowing for future urban development scenarios to be tested. Implementation of the wastewater system into the model will allow for more intricate water management options to be developed, which could potentially combine stormwater and wastewater management. Viewer development will focus on adding user-customizable map options and understanding how to make viewer and model more dynamic, with user defined custom map add-ons.

As UrbanBEATS grows in size and usability, the development team will seek to organise more future workshops, hopefully with a much larger group of stakeholders. With the support of our current industry partners, we also hope to demonstrate the value-add of UrbanBEATS in supporting an integrated water management planning exercise such as the integrated water forums currently underway in Victoria Australia.

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