LP130100731: Mimicking natural ecosystems to improve green roof performance

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Melbourne Water

Inner Melbourne Action Plan

'Making Melbourne More Liveable'

LP130100731 Aims:

1. Develop new green roof substrates to improve water and nutrient retention, focussing on the utilisation of waste and recycled products.
2. Assess whether ecosystem mimicry can be used to identify species which i) can survive in green roof substrates without additional fertiliser or have high nutrient uptake rates in fertilised substrates; ii) have plastic water use requirements, allowing them to survive alternate dry and wet period. This will improve green roof stormwater retention and water quality.
3. Determine how plant functional trait and species diversity affects green roof performance and resilience.
4. Validate experimental findings on a full-scale green roof
5. Model green roof thermal and hydrology performance with different substrate and plant combinations under different rainfall and climate scenarios.

Using what we know about individual species can we improve green roof performance with mixtures?

- Cooling and stormwater runoff quality/quantity

Series of inter-linked experiments

- Microcosms (0.5 m2)
- Modules (1 m2)
- Research green roof

- Experiment 1: Develop new substrates based on waste products or innovative additives (e.g. biochar) to increase PAW and nutrient retention

- Experiment 2: Plant nutrient uptake under different fertiliser regimes
  - Individual pot experiment (20 spp.)
  - Plants with high uptake
  - Plants which don't need fertiliser

Determine how plant functional trait and species diversity affects green roof performance and resilience.

Experiment 3a – Water use & stormwater runoff

9 spp. monocultures and mixtures based on water use strategies

Experiment 3b –- Plant and substrate interaction

Best sp. & mixtures from exp't 3b with best substrates developed in exp't 1

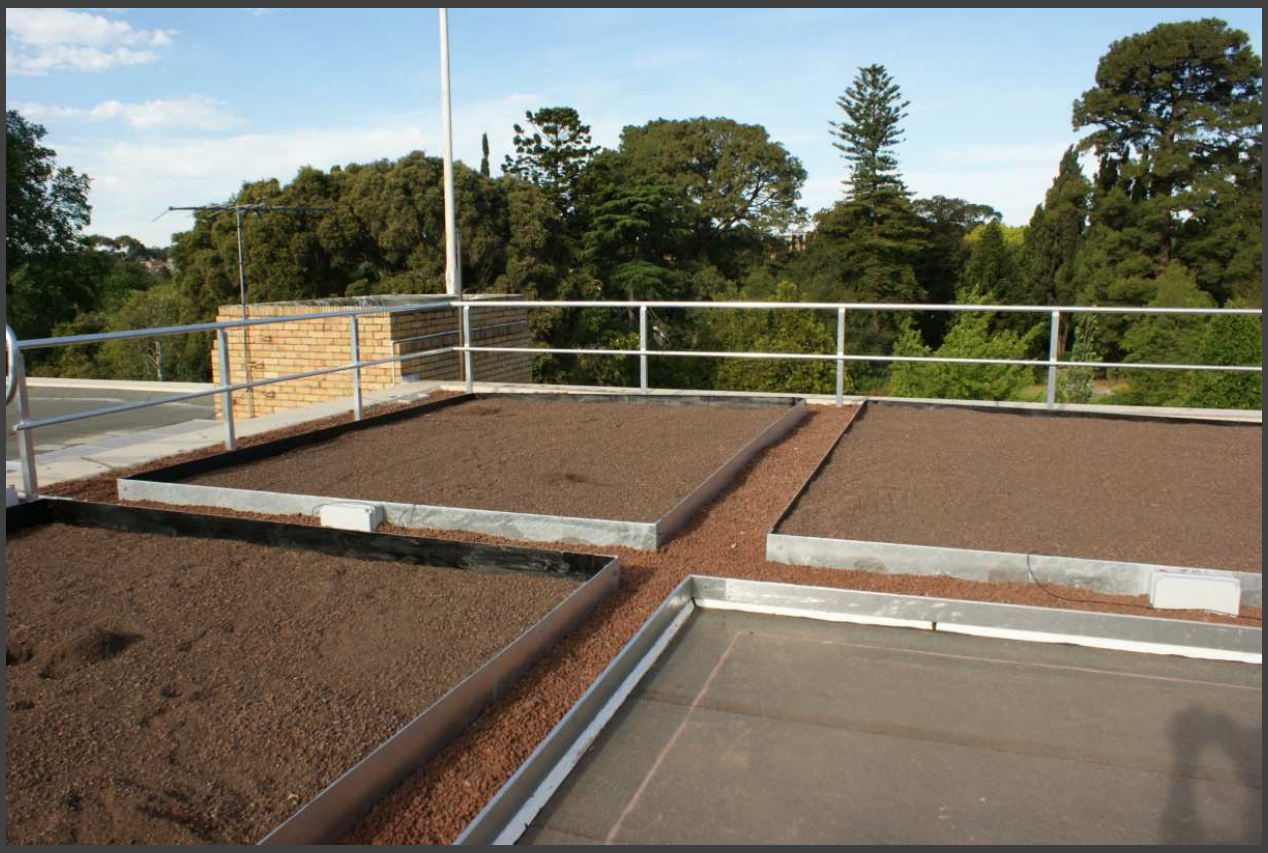
Experiment 3c – Role of nitrogen fixation

Can species which fix nitrogen (exp't 2) facilitate growth of species with high water use (exp't 3a) on green roofs without fertiliser?

Experiment 3d – Performance of mixes with high nutrient and water use

Can species with high nutrient (exp't 2) and high water use (exp't 3a) improve green roof runoff quality and quantity?

Experiment 4 - Validate experimental findings on



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2014 Overview

- set up and completed nutrient uptake experiment (Sept 2014; nutrient analysis still to be done and other data is being analysed)
- set up first rainfall simulation experiment (commencing March 2015) with plants which modify water use according to availability
- Presented biochar and substrate research at:
  - International Hort Congress (Brisbane, August 2014)
  - World Green Infrastructure Network Conference (Sydney, Oct 2014)

Student Progress

- Zheng Zhang commenced PhD July 2015 working on stormwater performance of green roofs as affected by plant mixtures and traits
- Joerg Werdin, research assistant has resigned to start a PhD with us on substrate development using biochar (Experiment 1)

Student Progress

- Zhanna Grebenshchykova, from the University of Bordeaux completed her internship on *The nutrient removal performance of vegetated roofs: quantification of an optimal fertilisation regime* (Experiment 2)
- Andrew Pianella. PhD student *Thermal performance of green roofs* candidature was confirmed – August 2014
  - Completed his first experiment

48th International Conference of the Architectural Science Association (ANZAScA)
ACROSS: Architectural Research through to Practice
Genoa, 10-13 December 2014

Thermal conductivity of green roofs substrates under different moisture content

Andrea Pianella
PhD Candidate
The University of Melbourne

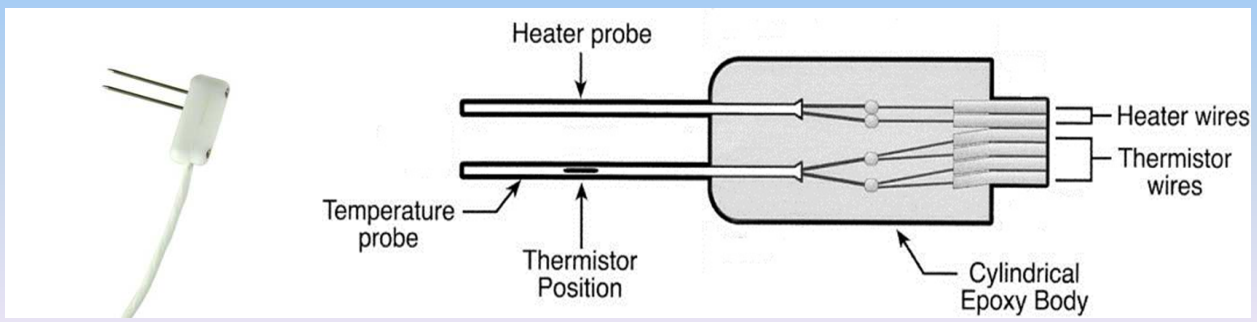
Materials & Methods

Crushed rooftile substrate	Envir-o-agg substrate	Scoria substrate
80% crushed rooftile 8 mm screening 20% composted coir	60% bottom ash* 2 mm screening 20% Eraring Filter 20% composted coir *waste product of coal fired power stations	60% scoria 8 mm screening 20% scoria 7 mm screening 20% composted coir

Materials & Methods

TRANSIENT

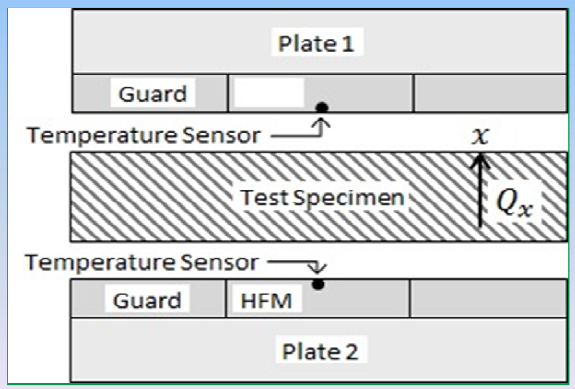
- Pine-wood holding frames with a volume of 4.5L
- Three different moisture contents:
  dry (0%), moist (18-22%) and fully saturated (30-48%)
- 3 cm dual needle probe following ASTM D5334 standard
- Each sample replicated 3 times



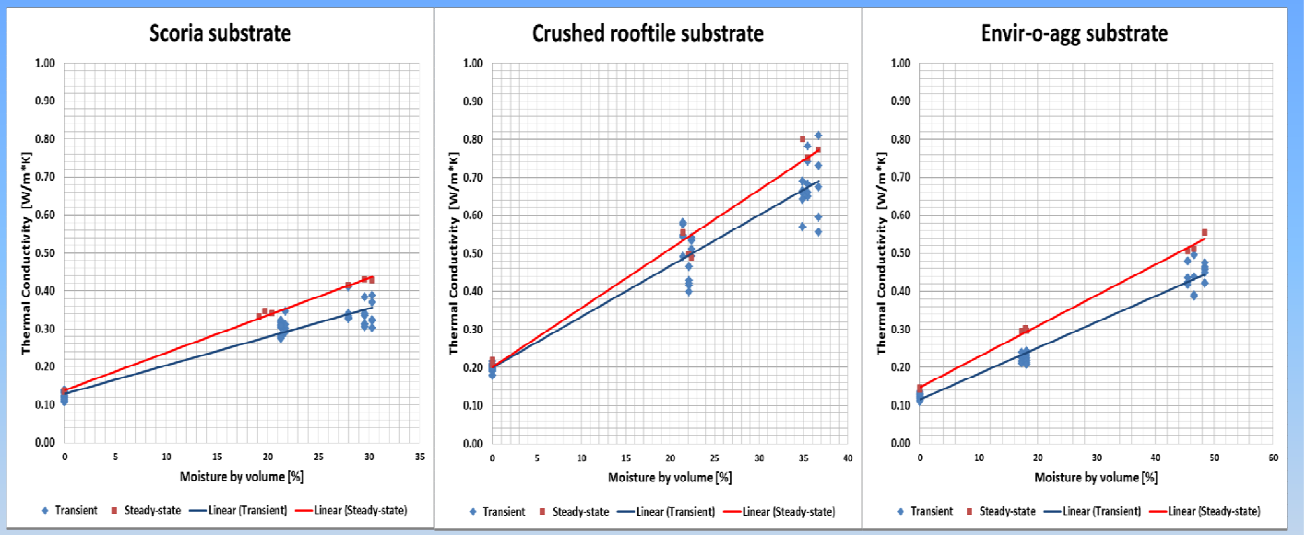
Materials & Methods

STEADY-STATE

- Pine-wood holding frames with a volume of 4.5L
- Three different moisture contents:
  dry (0%), moist (18-22%) and fully saturated (30-48%)
- k-Matic apparatus following ASTM C518 standard
- Each sample replicated 3 times



Results



The crushed rooftile substrate has the highest k-values while the Envir-o-agg and the scoria substrates have the lowest.

The probe measurements sufficiently match with the k-Matic data at low moisture content ($\sigma = 0.009$), while they become less accurate with the increase in moisture content ($\sigma = 0.046$).

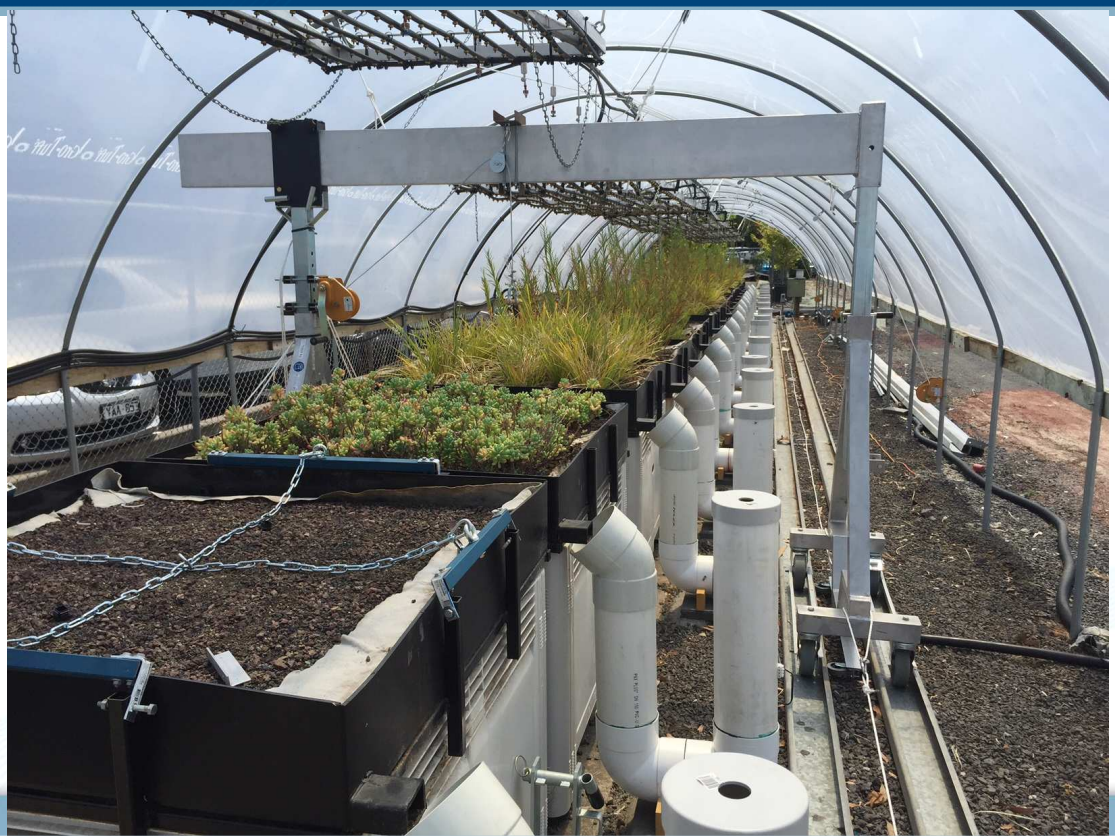
Conclusions

- K-values of scoria and Envir-o-agg lower than most green roof substrates studied overseas.
- Alternative substrates to employ in green roof industry.
- Novel technique to estimate the thermal conductivity of green roof substrates.
- New accurate data for existing green roof thermal model.

Research Infrastructure

- Developed new infrastructure for rainfall simulation experiments - irrigation system, weighing equipment and instrumented stormwater runoff collection apparatus
- Started development of new substrate testing apparatus (sand-table etc.) to improve measurements of substrate water-holding capacity -instrumentation of the research roof (planting to be done in March 2015)

Modules



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Thank You

Any Questions ?