Passive irrigation of street trees to improve tree health and support urban cooling

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The project team

- City of Monash
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- Melbourne Water
  - Keysha Milenkovic, Rachelle Adamowicz, Sarah Watkins
- With help from…
  - Ralf Pfleiderer, Chris Braddock, Tim Fletcher
- Monash University
  - Andrew Coutts, Jasmine Thom, Caitlin Moore
- University of Melbourne
  - Chris Szota, Stephen Livesley, Harry Virahsawmy

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Pressures on urban street trees

- High temperatures due to the UHI
- Drier urban atmosphere increases the vapour pressure deficit (VPD)
- High radiation loads:
  - Isolated tree exposed to high solar radiation
  - Additional radiation from urban surfaces
- Extreme heat events

High evaporative demand!

Low soil water availability:

- High stormwater runoff
- Drought
- Water restrictions
- Reduced infiltration:
  - Hydrophobic soils
  - Compacted soils

Limited water to meet demand!

City branches out to replace drought-hit trees

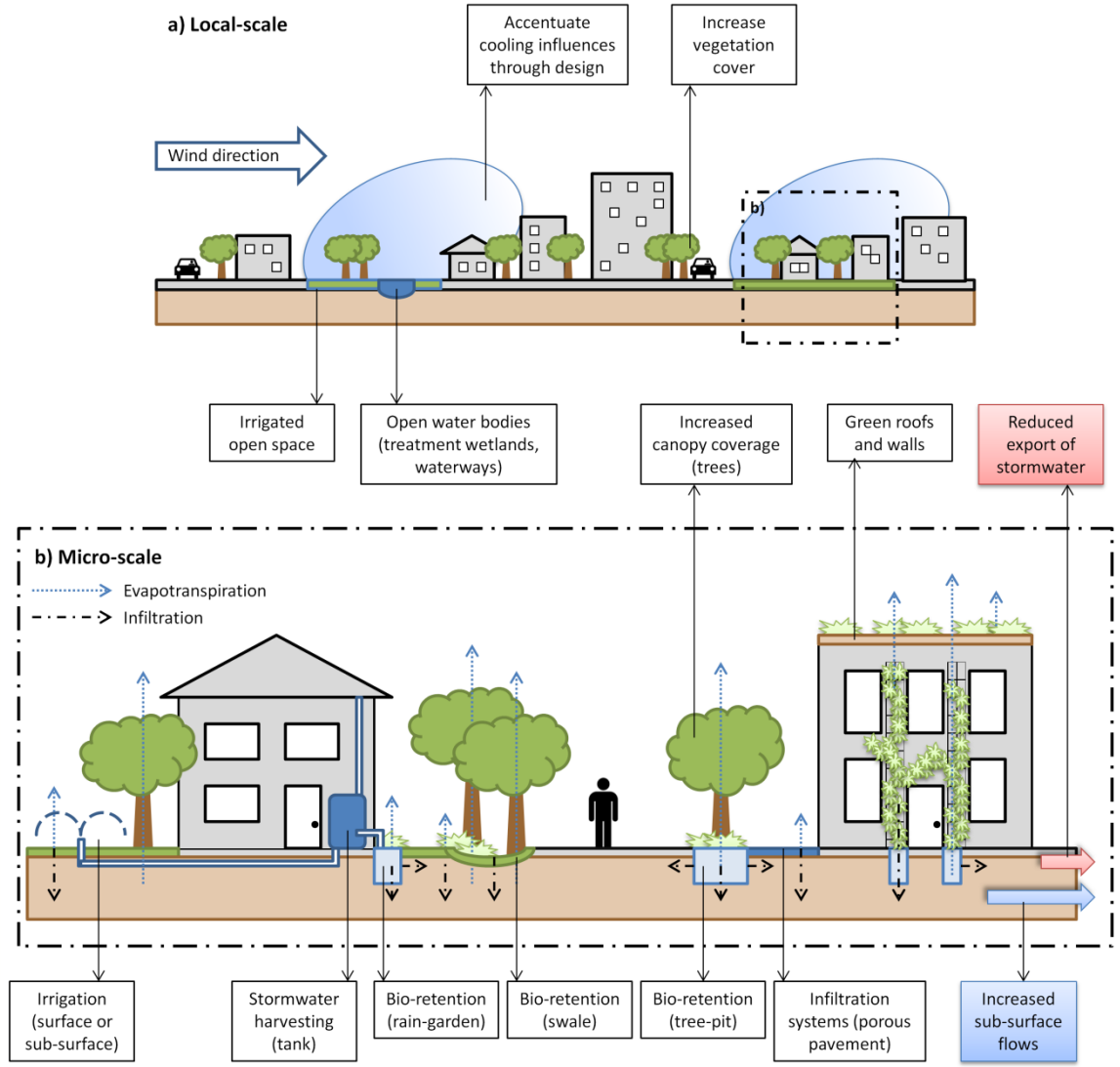
Dewi Cooke
May 11, 2010

Comments 17

Extreme weather and the ravages of time have left many of Melbourne's trees in need of replacement. *Photo: Justin McManus*

MELBOURNE will look to such countries as Spain, Chile and the US for replacements of thousands of drought-ravaged trees

Water sensitive urban design (WSUD)



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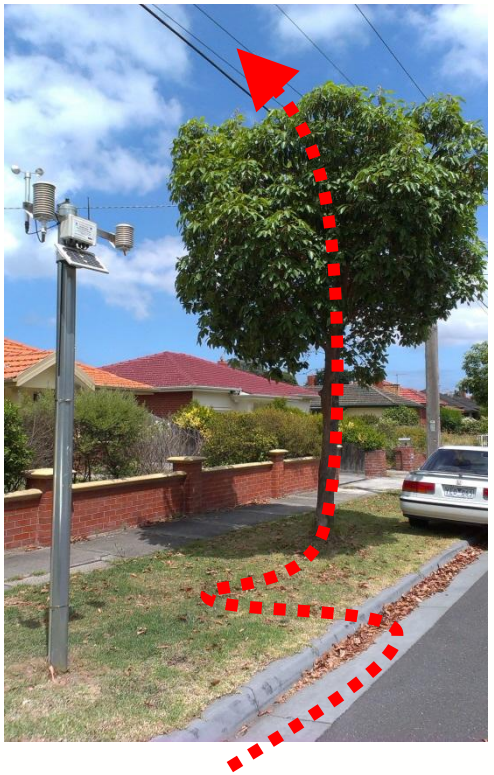
Coutts et al. 2013

Passive Irrigation Project

This project involves the trialling, testing and promotion of simple, cost effective WSUD street tree systems to maximise benefits for stormwater reduction and street tree amenity

CONCEPT:

- Redirecting runoff into nature strips
- Infiltration trenches alongside established trees



AIMS:

- Reduce the ***volume*** and **frequency** of runoff
  - Improve urban waterways
  - Reduce pressure on drainage network
- Improve the ***health*** of existing street trees
  - Reduce water stress / risk of drought death

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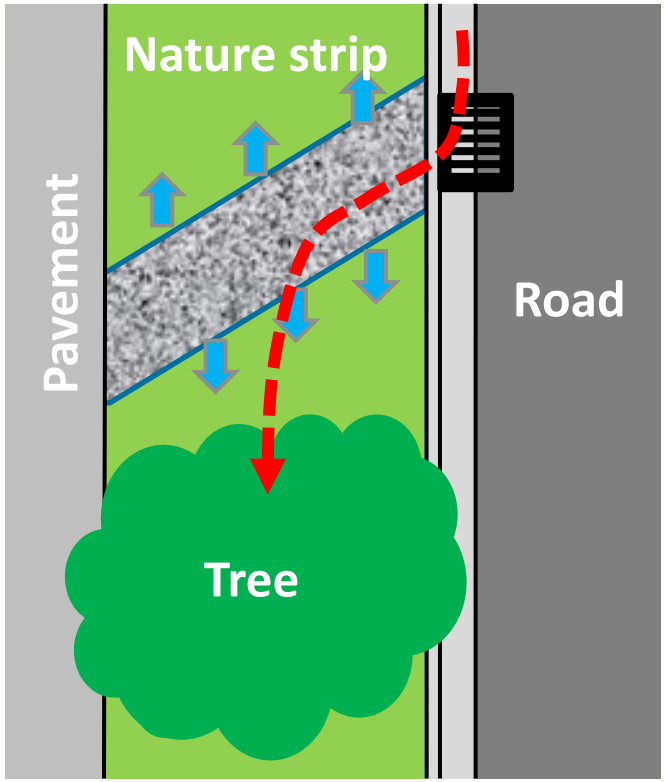
Experimental design

- 4 streets
- 9 trees per street (3 control)
- 2 passive irrigation designs (3 each)

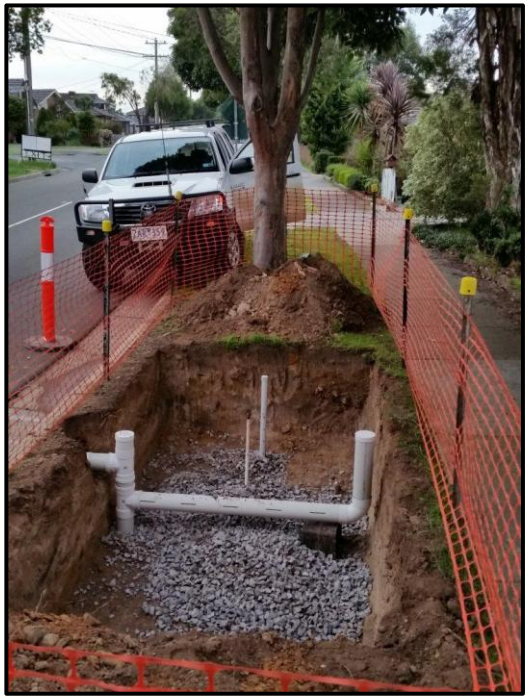


- Pre-modification = 2013-14 summer
- Post-modification = 2014-15 summer

Passive irrigation design

Infiltration trench:

- 0.6 x 2.0 x ~4.0 m
- 20-40 mm gravel aggregate: 40% porosity
- Storage ~ 1440 L



Type 1: Pit Inlet

- 'High Capture, High Maintenance'
- 600 x 600 x 600 mm
- Permeable paver filter

Type 2: Lintel Inlet

'Low Capture, Low Maintenance'

Monash Council design

Vortex, grate (weir)

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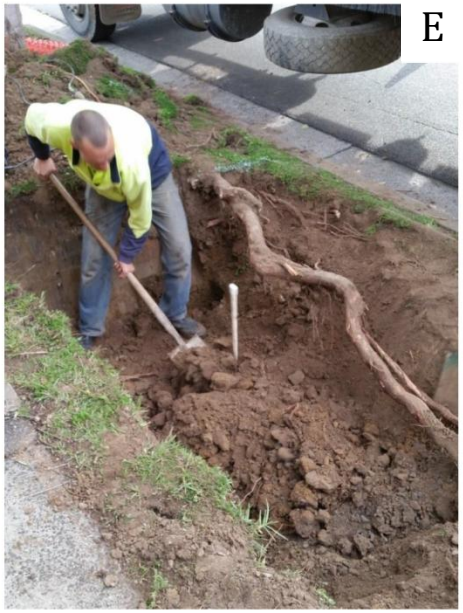
Construction of treatments


A


B


C


D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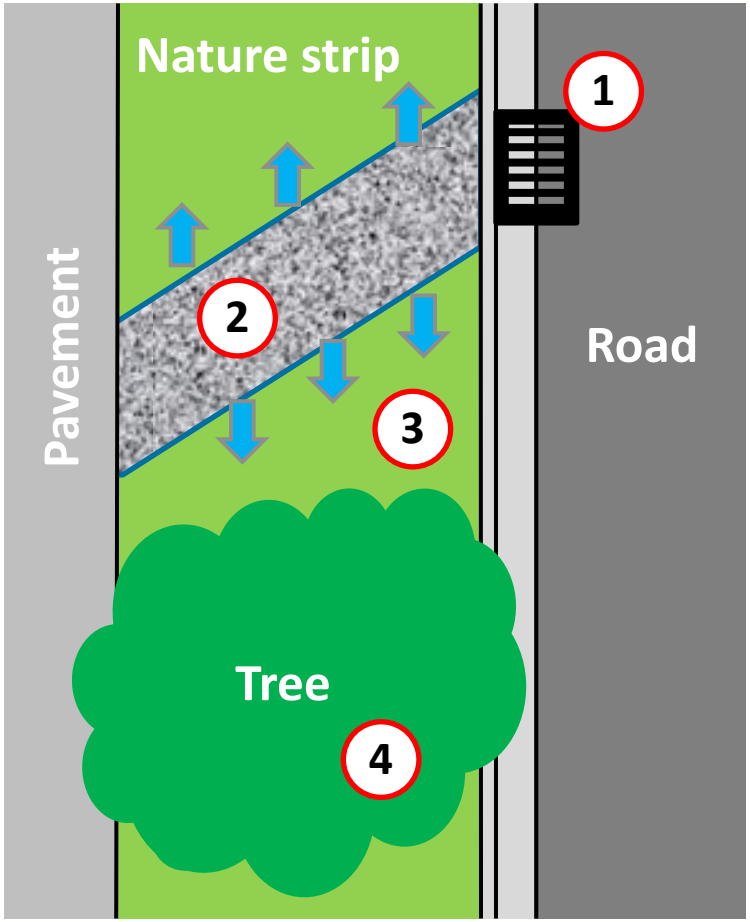
K

Key research questions



1. How effective are the inlets at diverting stormwater runoff into the nature strip?
2. What is the performance of the gravel trenches in storing water for exfiltration?
3. Does additional water infiltrate into adjacent soils and become available for tree roots?
4. Do the trees use additional water to meet the evaporative demand and limit water stress?

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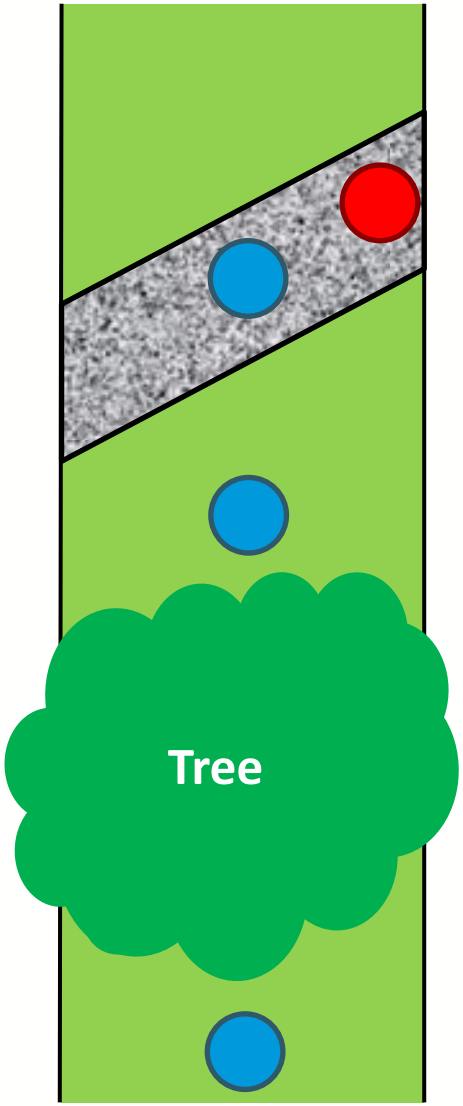
Monitoring – water availability



Stormwater runoff capture:

- Odyssey water level sensors (Dataflow Systems Pty. Ltd., Christchurch, NZ) with changes converted to litres of stormwater captured
- 'Runoff reduction' based on runoff generated by the impervious catchment feeding each infiltration trench.

Soil moisture:

- Three locations per tree (trench, upstream and downstream)

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Monitoring – microclimate and tree stress

Micro-climate monitoring:

- Two stations per street:
  - Air temperature
  - Vapour Pressure Deficit
  - Solar radiation
  - Wind speed
  - CO_2 Concentrations
  - Mean radiant temperature
  - Soil moisture
  - Soil temperature

Pre-dawn leaf water potential

- Scholander-type pressure bomb (Soil Moisture Equipment Corp., Santa Barbara, CA, USA)
- Fortnightly measures during summer

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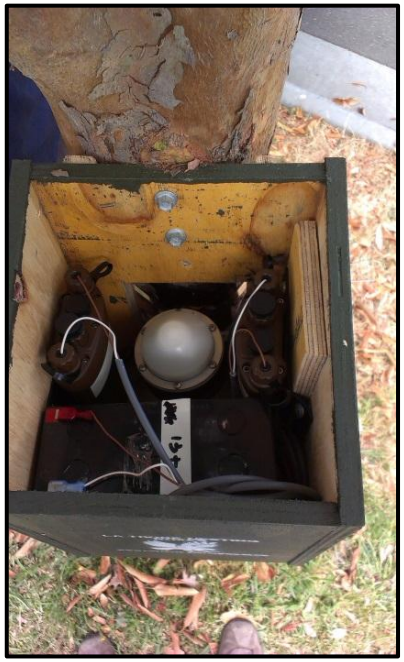
Monitoring – Tree water use

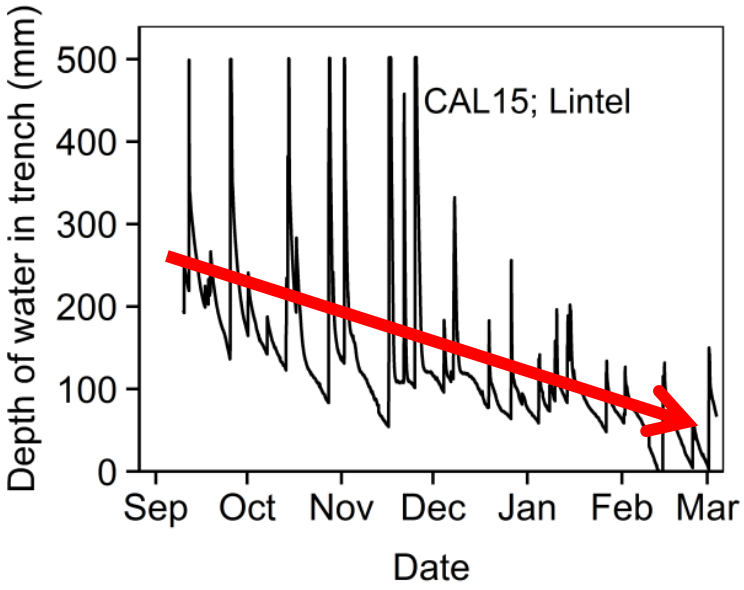
- Calembeena Ave. only
  - Evergreen
  - *Lophostemon Confertus*
  - Sandy Soil

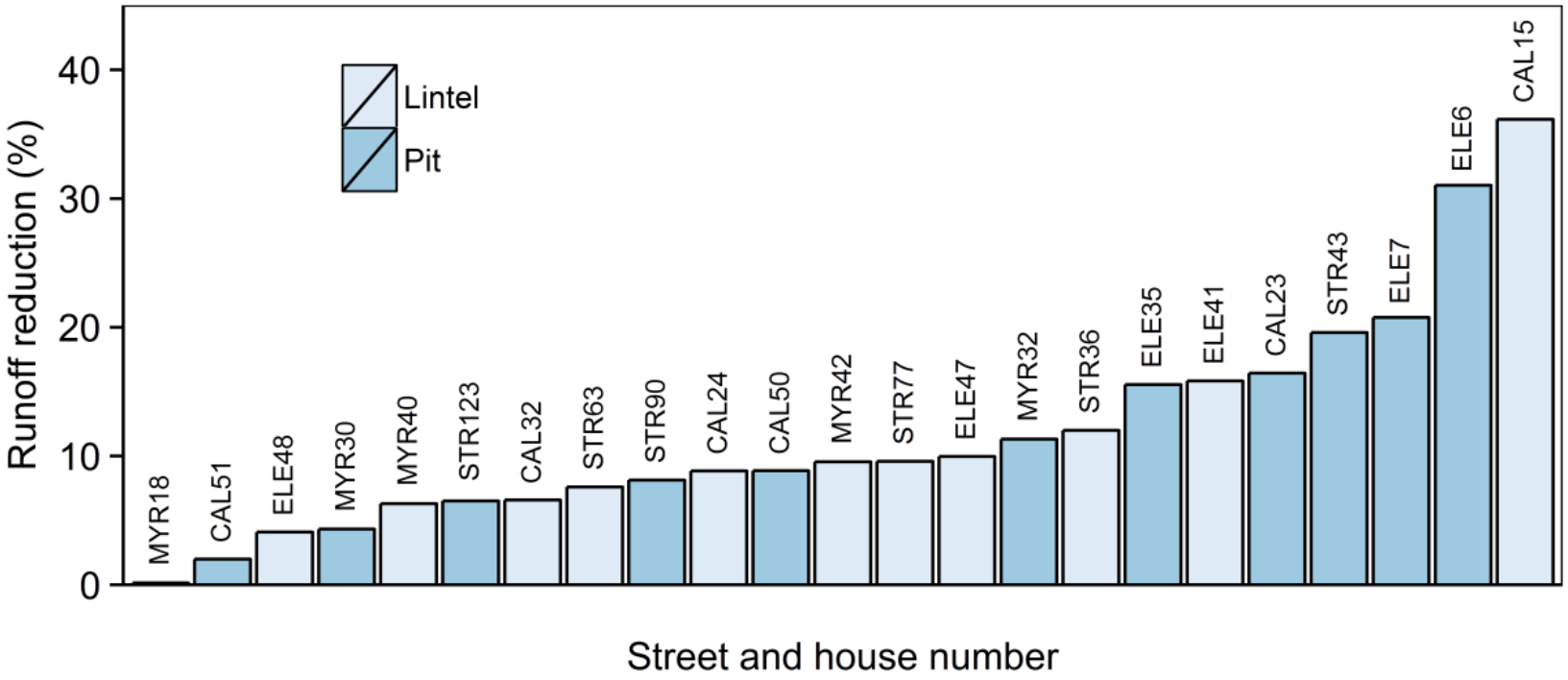


- Sap flow for measuring tree water use
  - Heat Ratio Method
  - Two sensors per tree
  - SFM1 sap flow meters (ICT International)
  - Gives L/tree
- Tree LAI estimated
  - Fish-eye photos
  - Gives L/m^2

Stormwater capture

- 12% average runoff reduction
- Variance of 0 – 36%
- No system performed better than the other





Issues with stormwater capture

Leaks:

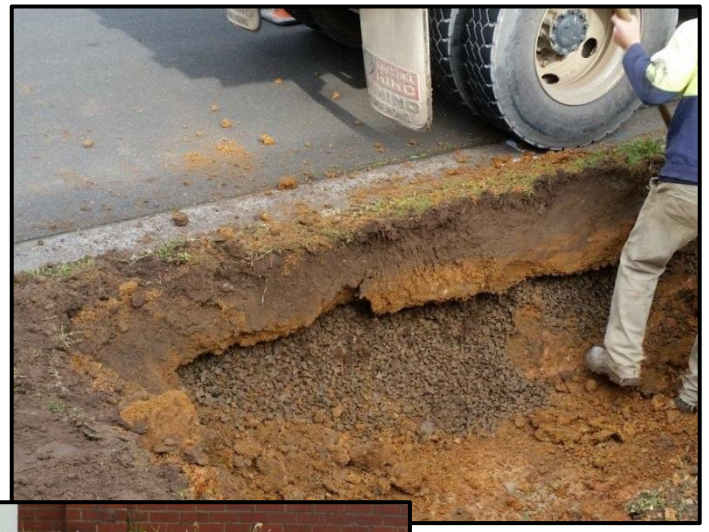
- Leaks from the infiltration trench into the under-kerb drainage system
- Leaks into stormwater drainage network

Clogged inlets (*No maintenance):

- Blocking of runoff entry (e.g. sediment)
- Permeable pavements in pits clogged

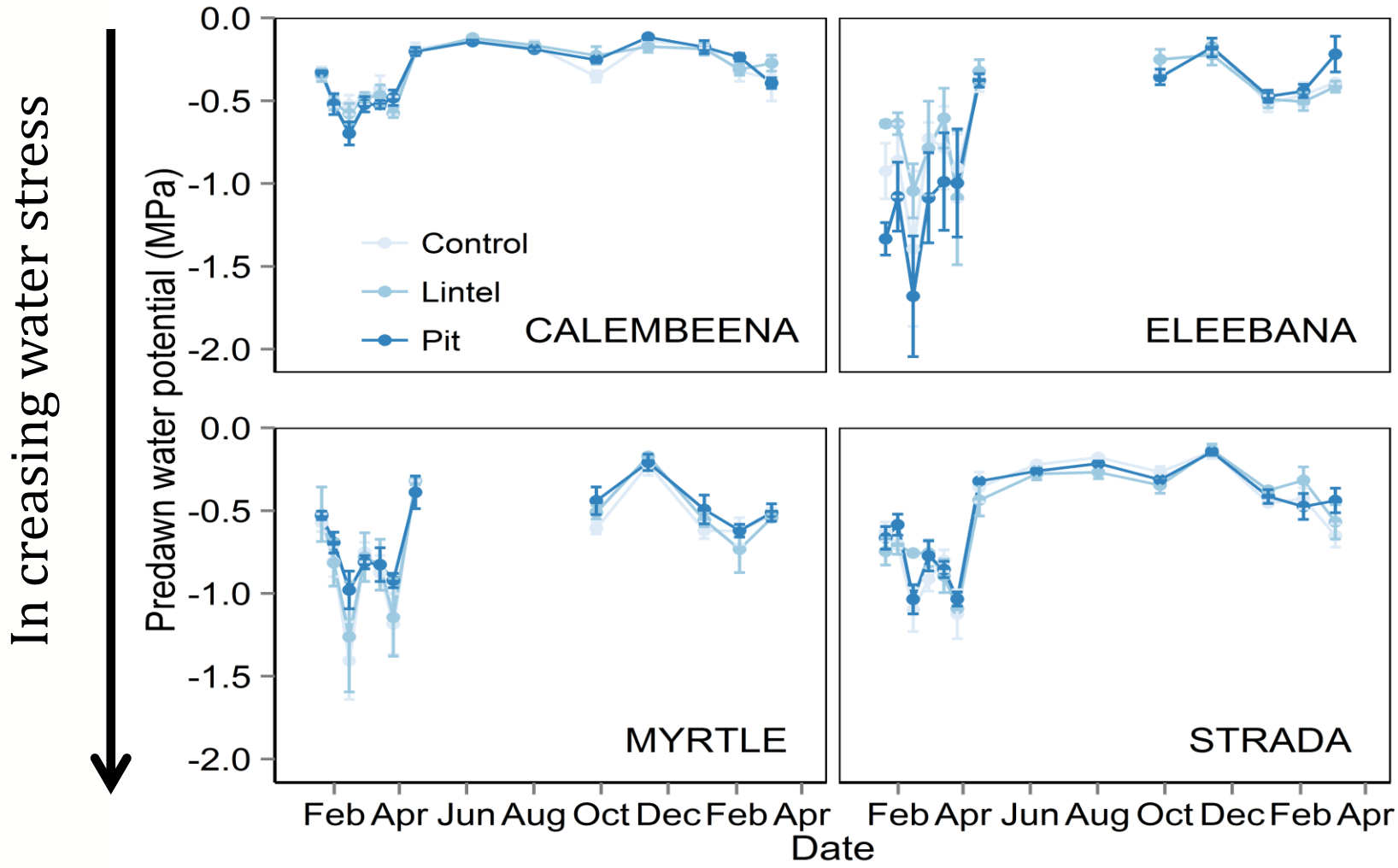
Design issues:

- Some Lintel inlets captured little runoff (street slope, kerb angle, water velocity)
- Some permeable pavers were not sealed – more water got in



Tree water stress

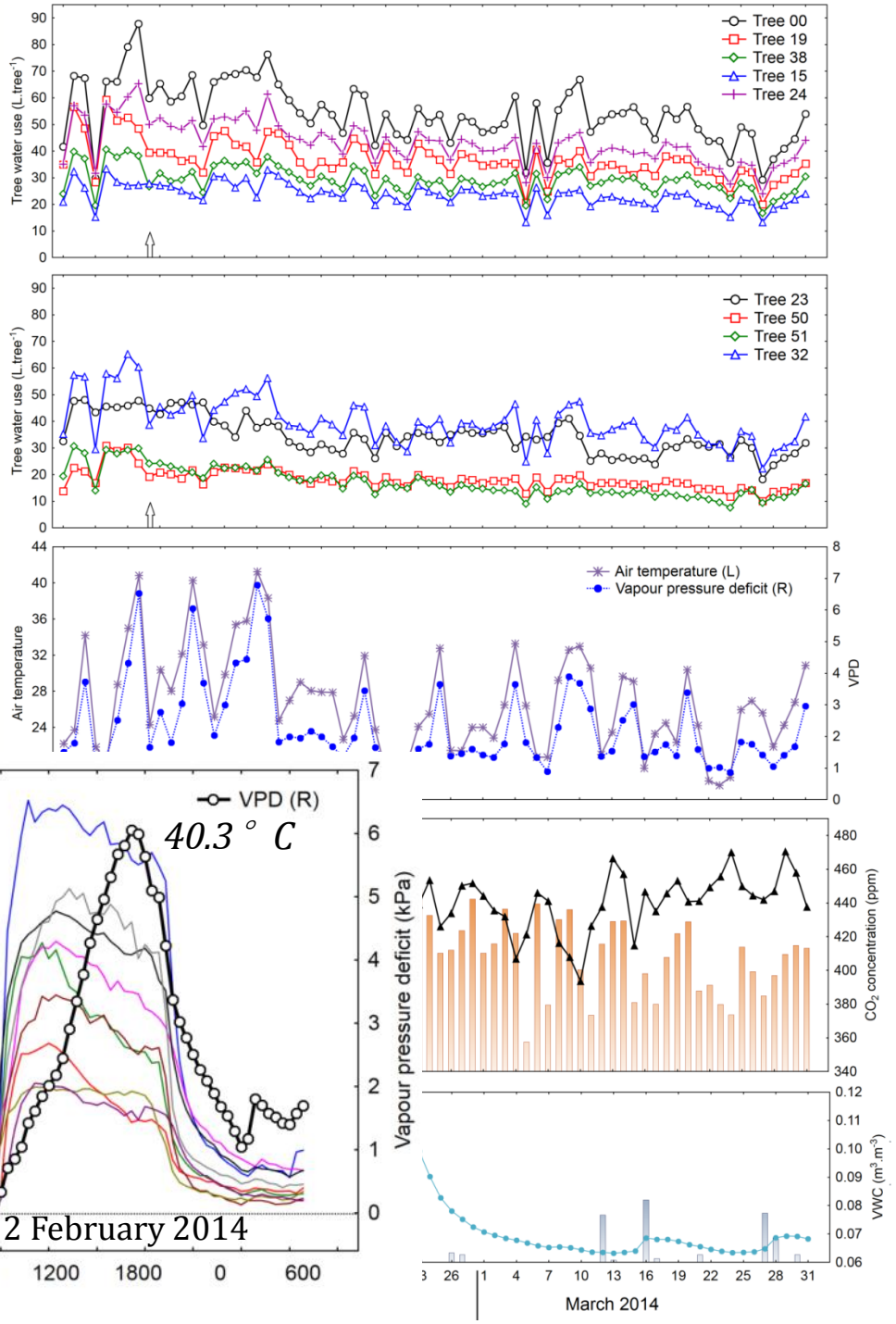
- 2013-14 Summer was hot and dry – several heat events
- 2014-15 Summer was mild and wet – trees not stressed



Tree water use 2013-14

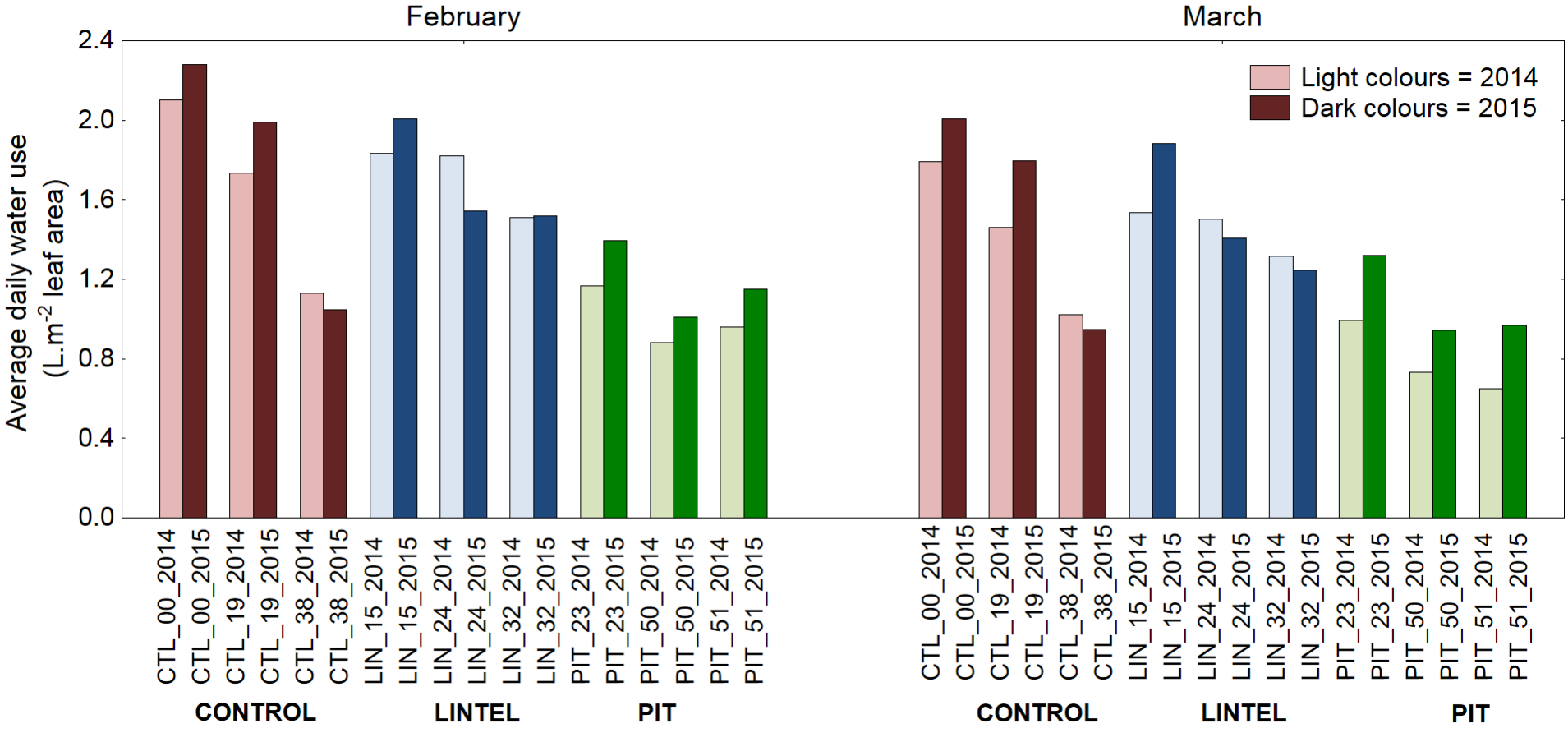
Calembeena Ave.

- Tree water use between 20 and 65 L per day
- Maximum observed of **90 L per day**
- Follow patterns in
  - Light (PAR)
  - VPD
- Evidence of stomatal control on water loss



Tree water use pre- and post-modification

- No clear pattern in tree water use between treatments
- No clear increase in water use due to treatments
  - Milder, wetter summer – control trees increased water use too
  - Control trees not really 'control' trees

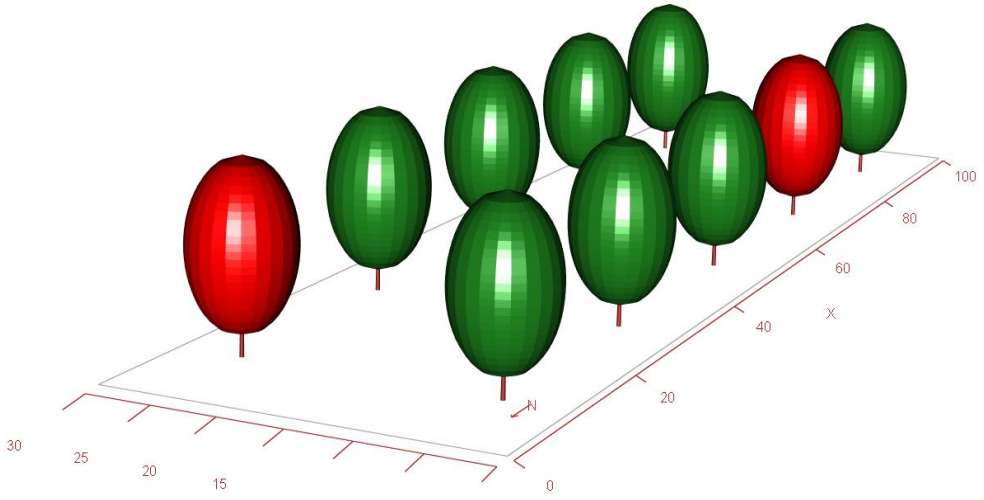


Further research

- Continue monitoring for 2015-16 Summer
- Conduct frequent maintenance of systems
- Line the systems to prevent leakage into underdrain
- Investigate possible water sources – soil moisture

- Apply the Single Plant Ecosystem (SPE) model (MAESPA) to explore changes in soil moisture and meteorological conditions
- Validation of the model using this dataset

Thanks for listening!



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