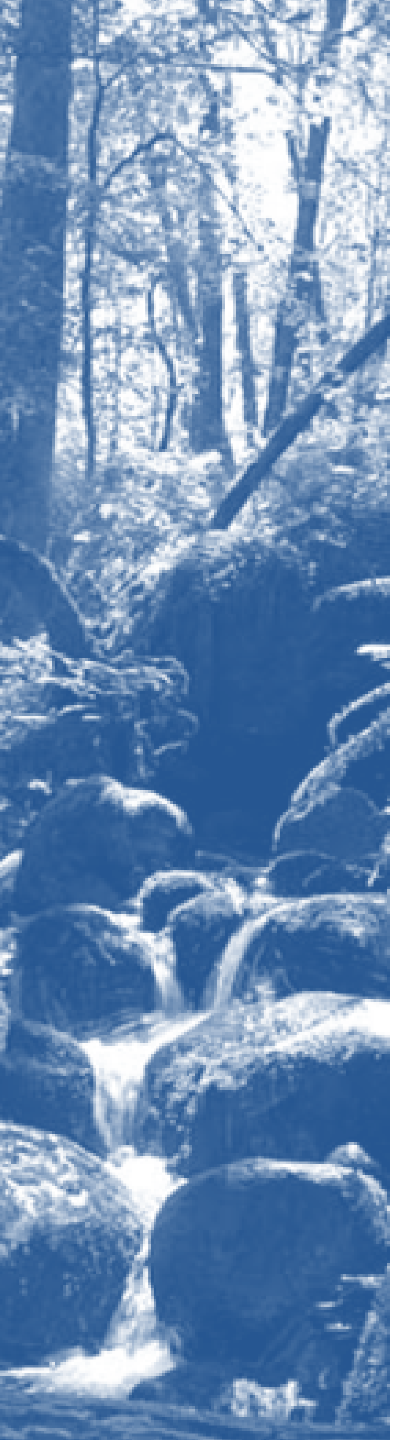

Stormwater Biofiltration Systems

FAWB and beyond...

Dr Belinda Hatt

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Hampton Park Wetland
(Melbourne Water)

Lynbrook Estate Wetland
(VicUrban)

All Nations Park Wetland
(City of Darebin)

NAB Building Forecourt
Wetland

Bracken Ridge
Bioretention Basin (BCC)

Baltusrol Estate
(Australand)

Victoria Park
(Landcom)

Cremorne Street
(City of Yarra)

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Melbourne Docklands
(Lend Lease)

Baltusrol Estate
(Australand)

Bourke Street Tree
Planters
(Lend Lease)

Building Bioretention
Planters (Portland,
Oregon, USA)

Cremorne
Street
(Melbourne)

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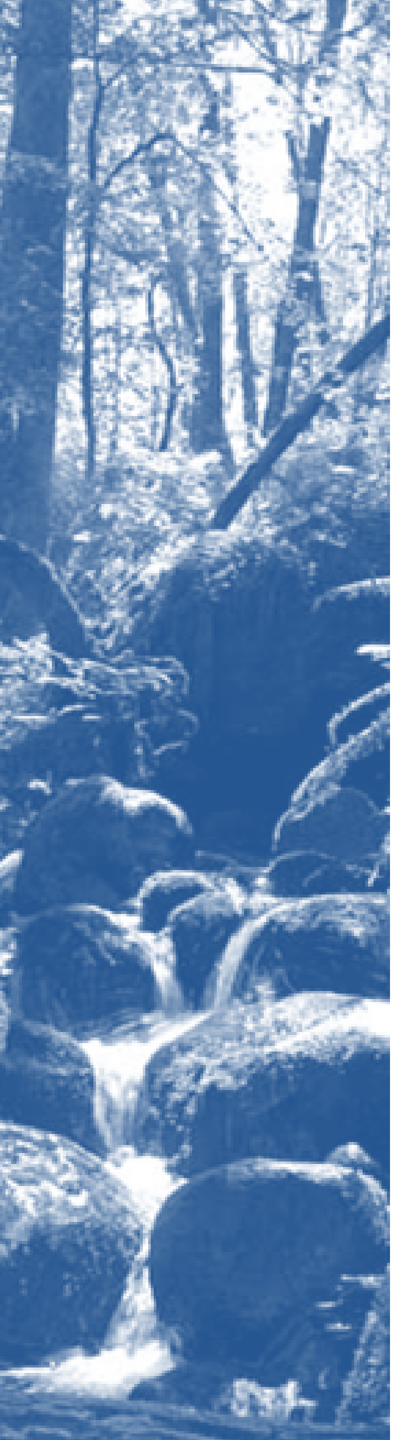
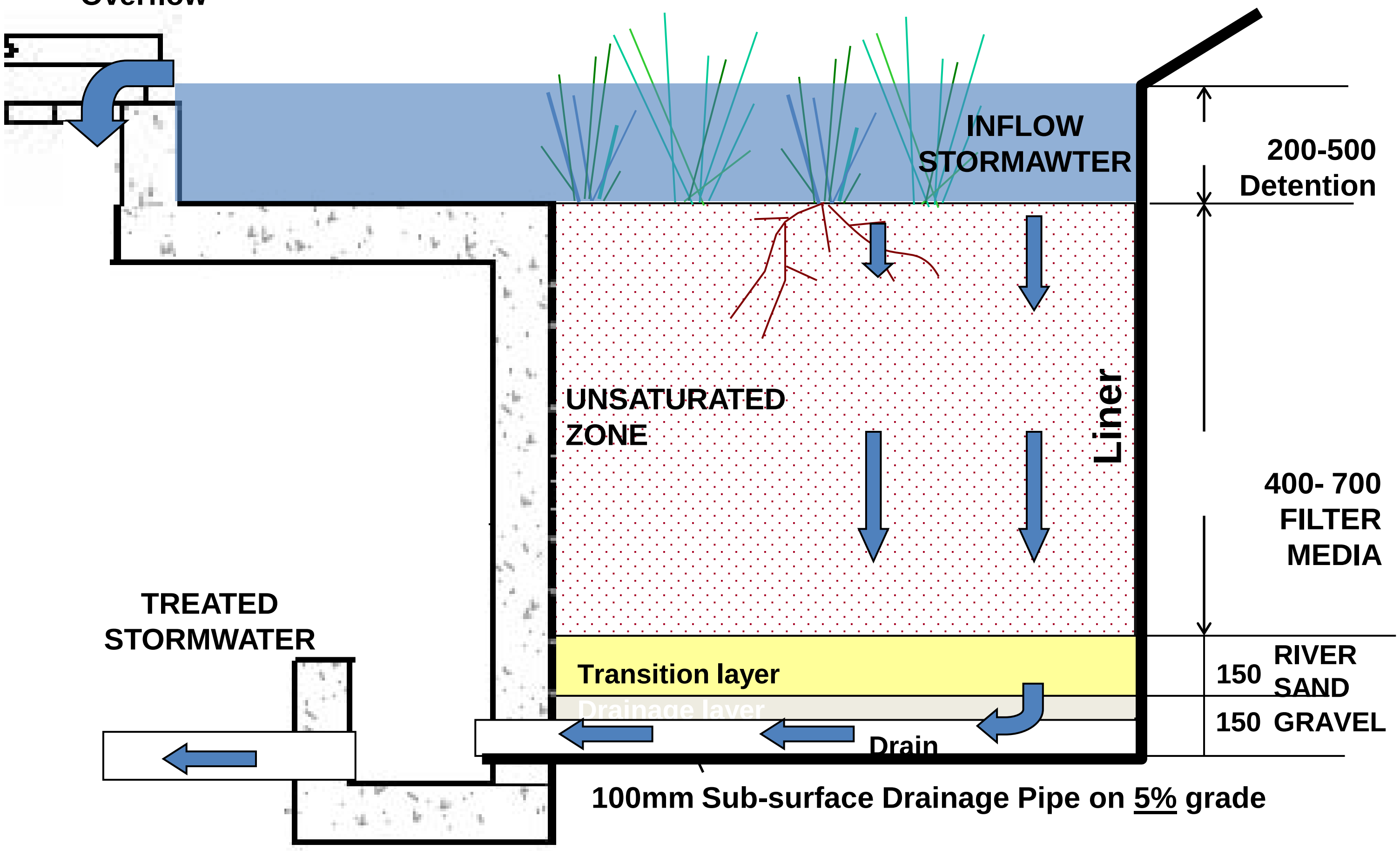


Standard Biofilter Design



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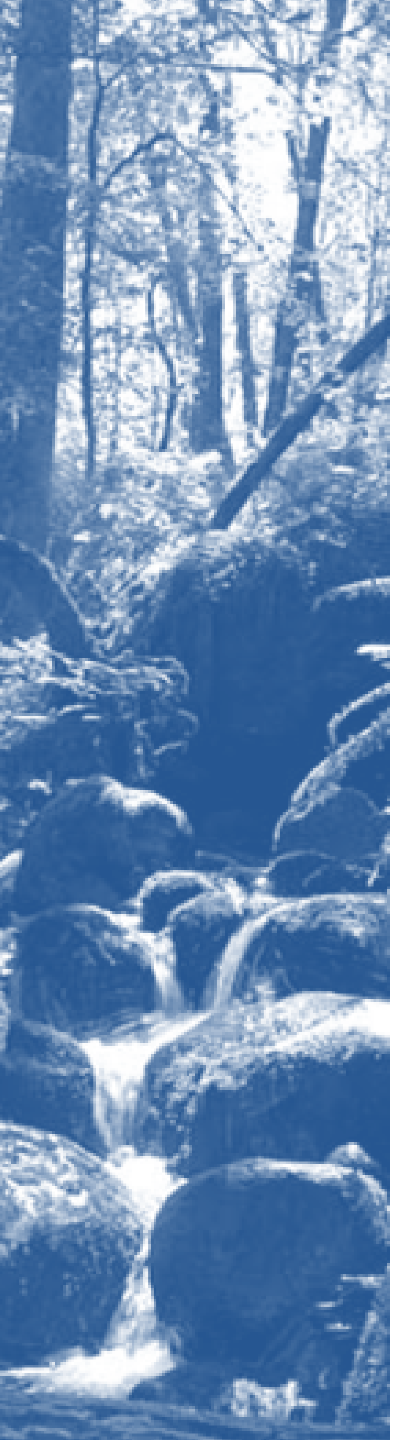

What is FAWB?

- FAWB is a joint venture between the Institute for the Sustainable Water Resources, Monash University and AECOM Design + Planning in establishing a Victorian government funded research facility
- FAWB industry partners:
  - Manningham City Council (Vic)
  - Melbourne Water (Vic)
  - Vic Roads (Vic)
  - Landcom (NSW)
  - Brisbane City Council (Qld)
  - Adelaide and Mount Lofty Ranges Natural Resources Management Board (SA)

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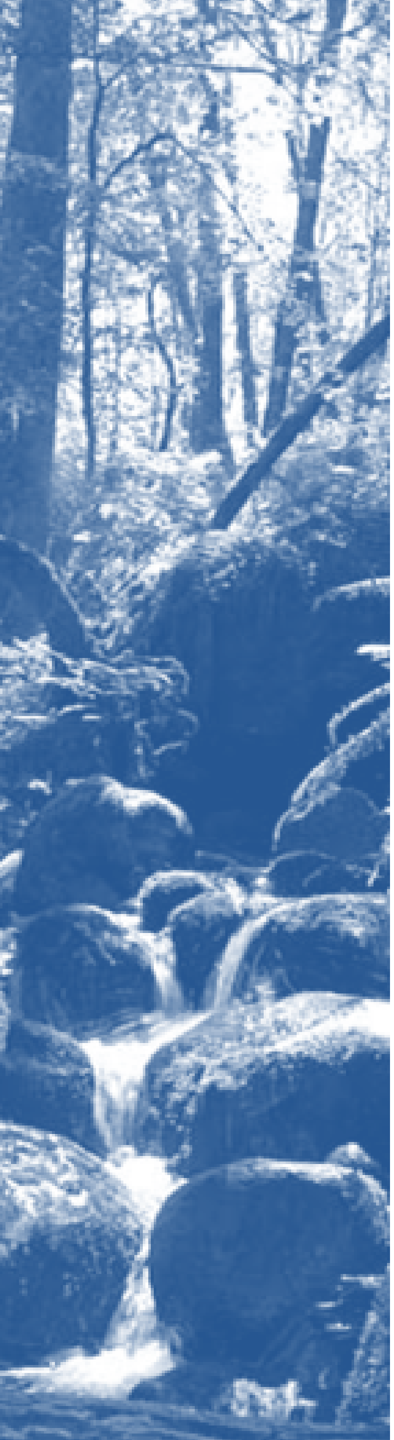
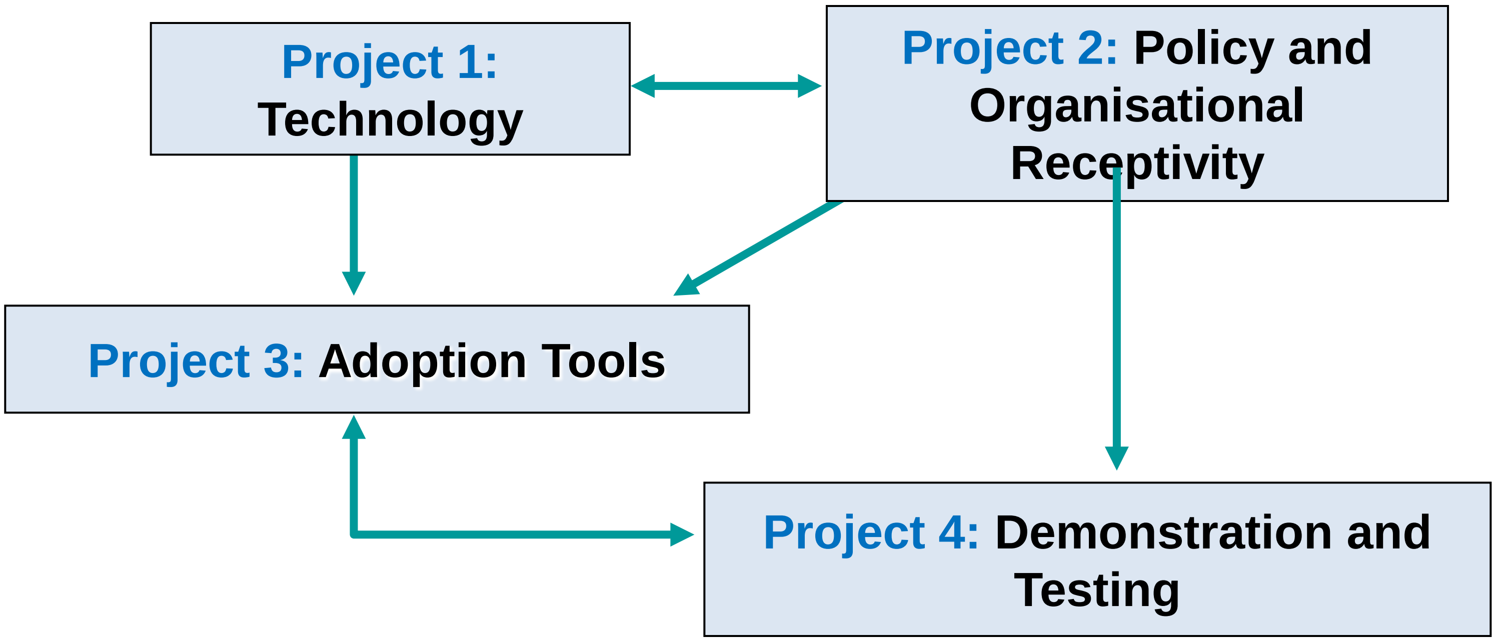
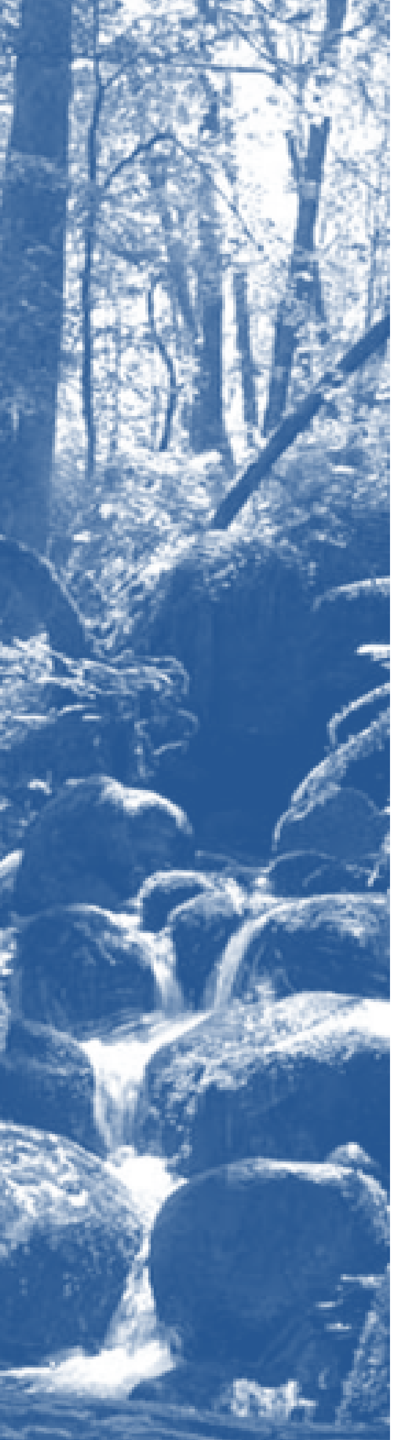


FAWB Research





Outline

- Overview of key findings from FAWB research
- Alternative filter media study
- Bio-infiltration
- Accumulation of heavy metals
- Future research

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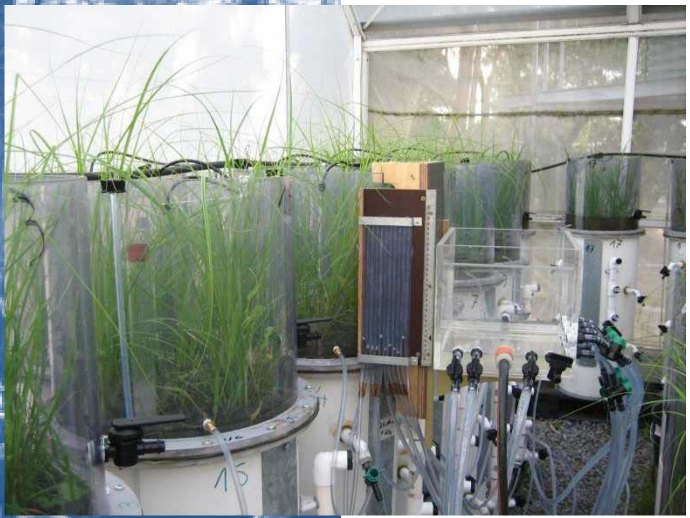
Key Findings



Design:

- Filter media
- Plant selection
- System size
  - Integrated approach
  - Clogging & breakthrough
- Submerged zone
  - Plant survival
  - Nitrogen removal

Non-vegetated filters

TABLE 2. Pollutant Removal Summary for Six Filter Media Types

	TSS	TP	TN	TOC	Cu	Mn	Pb	Zn
	Event mean hydraulic loading (g/m²)							
	29	0.08	0.45	1	0.06	0.01	0.15	0.22
	Load Reduction (%)							
S	99 ± 1	97 ± 1	38 ± 1	59 ± 8	97 ± 1	94 ± 1	99 ± 1	99 ± 1
SL	93 ± 4	−65 ± 16	−18 ± 15	−103 ± 17	97 ± 1	−32 ± 54	99 ± 1	99 ± 1
SLH	92 ± 3	−143 ± 17	−37 ± 4	−146 ± 19	96 ± 1	−71 ± 19	99 ± 1	98 ± 1
SLVP	90 ± 3	−73 ± 15	−23 ± 12	−129 ± 22	94 ± 2	−26 ± 52	95 ± 2	96 ± 4
SLCM	92 ± 4	−409 ± 40	−111 ± 41	−178 ± 13	94 ± 1	−152 ± 100	97 ± 1	96 ± 1
SLCMCH	96 ± 1	−437 ± 50	−164 ± 14	−165 ± 5	93 ± 1	−178 ± 189	97 ± 1	96 ± 1

Load reductions are reported as the mean of three replicates ± standard deviation. Note: a negative load reduction indicates leaching of previously retained pollutants and/or native material.

Hatt, B. E., T. D. Fletcher and A. Deletic (2008). Hydraulic and pollutant removal performance of fine media stormwater filtration systems. *Environmental Science & Technology* ***42(7): 2535-2541.***

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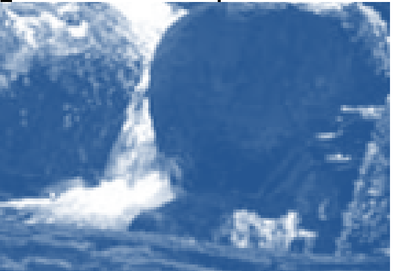
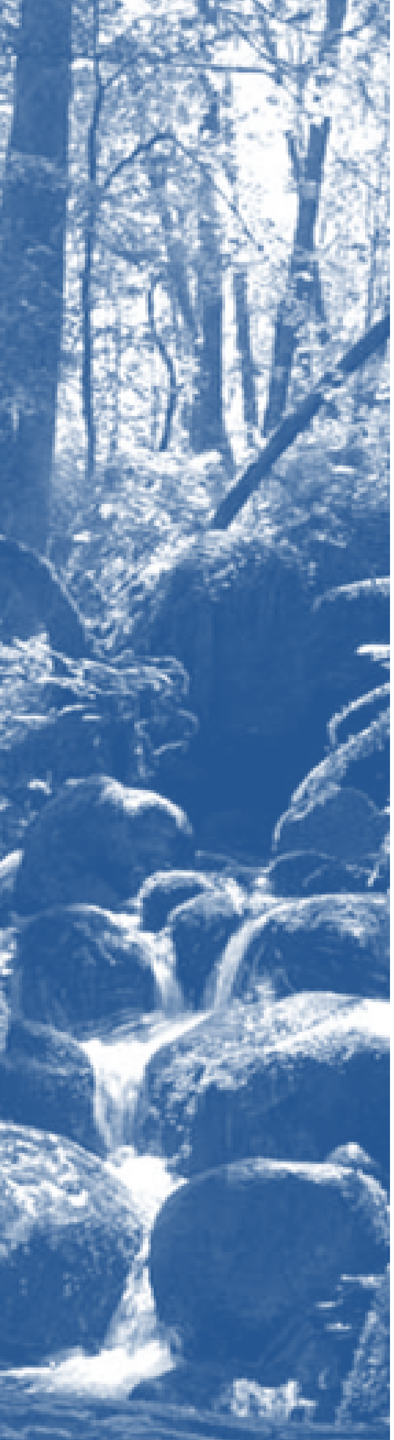
Design Optimisation Study

Factors tested	Vegetation	Inflow volume	Filter media depth	Filter media type	Inflow conc.	TP Concentration (mg/L)	TP Removal (%)	PO_4^{3-} Concentration (mg/L)	PO_4^{3-} Removal (%)
Vegetation	None	Std.	700	SL	Std.	0.083 (15)	81 (4)	0.064 (15)	50 (15)
	Carex	Std.	700	SL	Std.	0.023 (22)	95 (1)	0.013 (21)	90 (2)
	Dianella	Std.	700	SL	Std.	0.092 (19)	78 (5)	0.072 (16)	44 (20)
	Microleana	Std.	700	SL	Std.	0.074 (12)	83 (3)	0.050 (22)	61 (14)
	Leucophyta	Std.	700	SL	Std.	0.098 (9)	77 (3)	0.076 (13)	40 (19)
	Melaleuca	Std.	700	SL	Std.	0.070 (17)	84 (3)	0.034 (35)	74 (13)
Filter media depth	Carex	Std.	500	SL	Std.	0.032 (26)	93 (2)	0.016 (24)	87 (4)
	Carex	Std.	300	SL	Std.	0.038 (22)	91 (2)	0.022 (18)	83 (4)
	Microleana	Std.	500	SL	Std.	0.078 (14)	82 (3)	0.062 (17)	52 (16)
	Microleana	Std.	300	SL	Std.	0.078 (6)	82 (1)	0.053 (6)	58 (4)
	Melaleuca	Std.	500	SL	Std.	0.060 (39)	86 (6)	0.033 (60)	74 (21)
	Melaleuca	Std.	300	SL	Std.	0.050 (40)	88 (5)	0.024 (79)	81 (18)
Filter media type	Carex	Std.	700	SLVP	Std.	0.040 (31)	91 (3)	0.021 (35)	83 (7)
	Carex	Std.	700	SLCM	Std.	0.264 (48)	38 (78)	0.226 (49)	-78 (>100)



Bratieres, K., T. D. Fletcher, A. Deletic and Y. Zinger (2008). Optimisation of the treatment efficiency of biofilters; results of a large-scale laboratory study. *Water Research* 42(14): 3930-3940



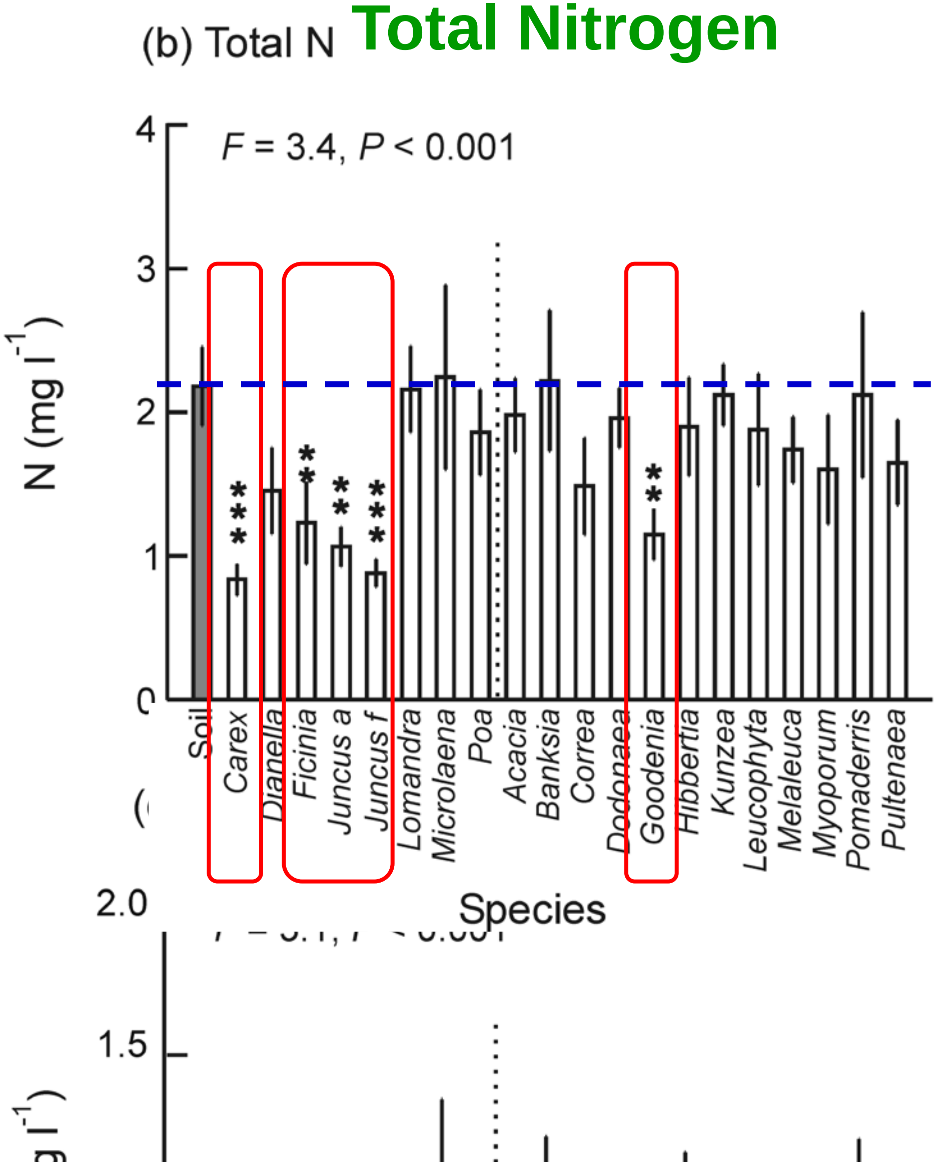
Filter media: conclusions

- Soil and sand-filters provide:
  - Excellent TSS removal
  - Excellent metals removal
- Use of an appropriate soil type also provides:
  - Excellent P removal (total *and* dissolved)

- Removal of N is more complicated and not governed by media type alone

Vegetation Trials

Total Nitrogen



For nutrients:

- Plants are important, *and*
- There are <u>significant differences</u> between species

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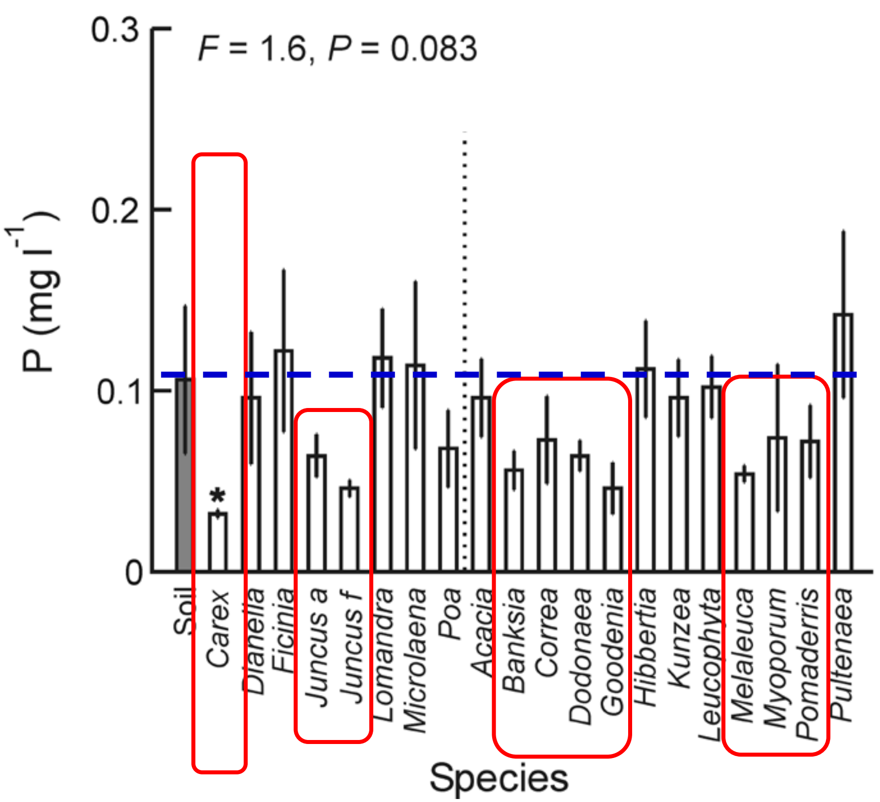
Vegetation Trials

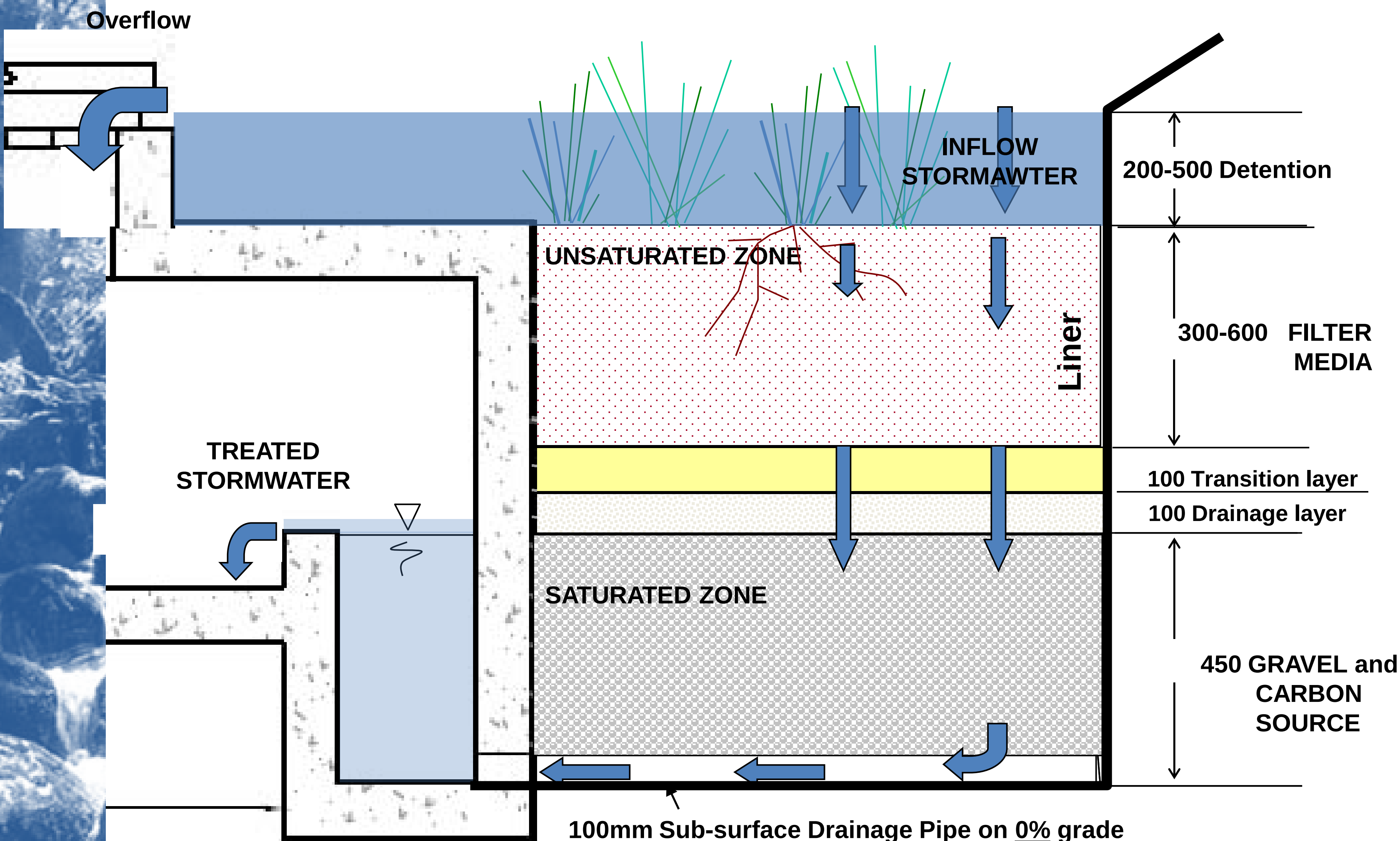
Total Phosphorus



For nutrients:

- Plants are important, *and*
- There are significant differences between species

Submerged Zone



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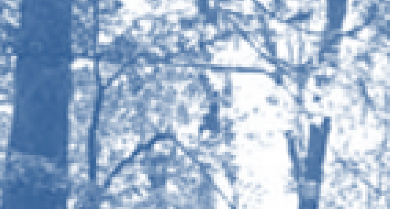
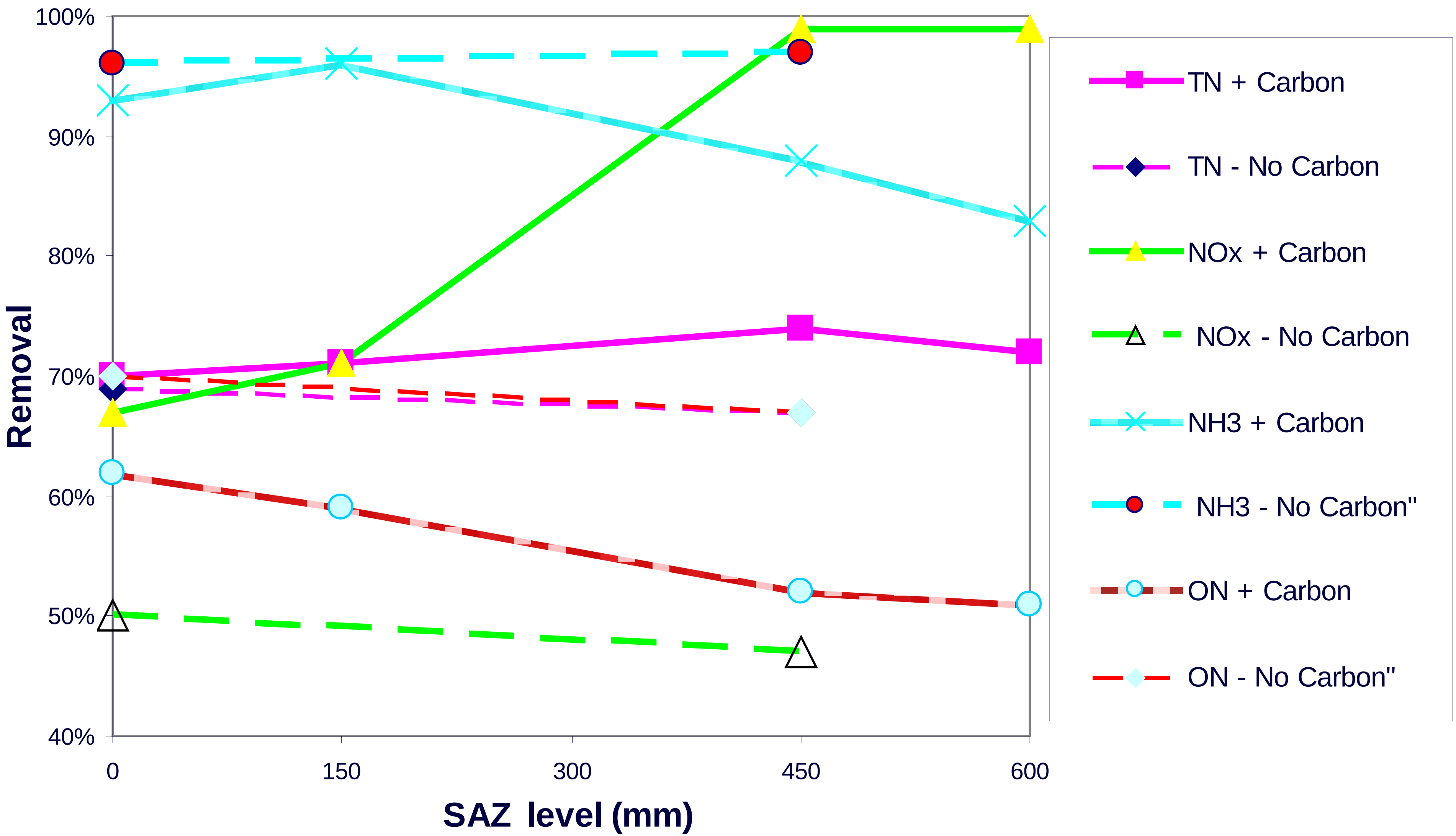
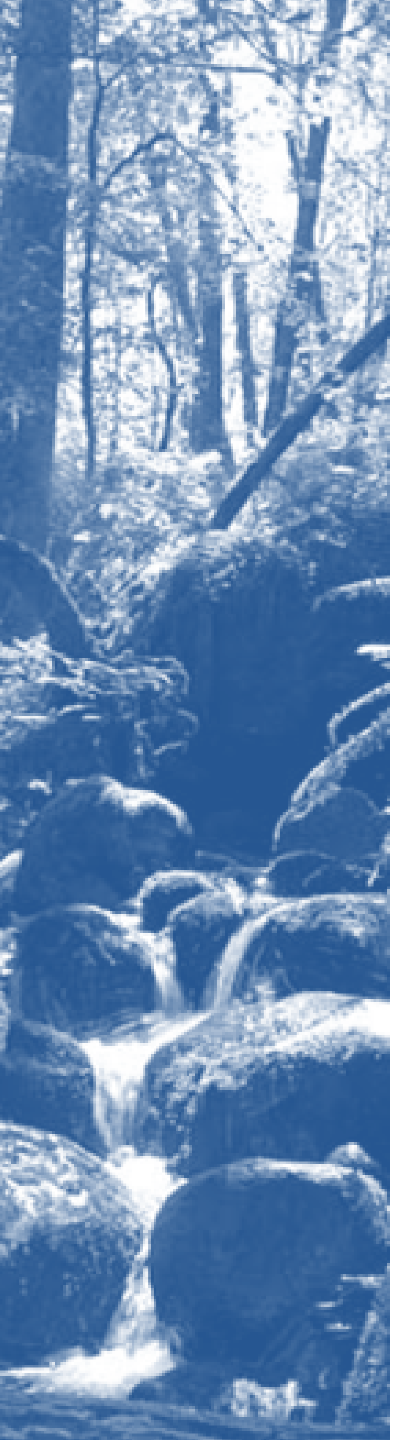


Results: N removal





Submerged Zone

The presence of a permanently submerged zone **>300 mm** made from **sand or gravel with a carbon source** (around 5% by volume) will:

- Improve nitrate/nitrite (NO_x) removal, by promoting denitrification
- Improve Cu and Zn removal (to meet ANZECC targets)
- Support plant survival during dry periods and therefore
- Ensure TN removal after dry spells

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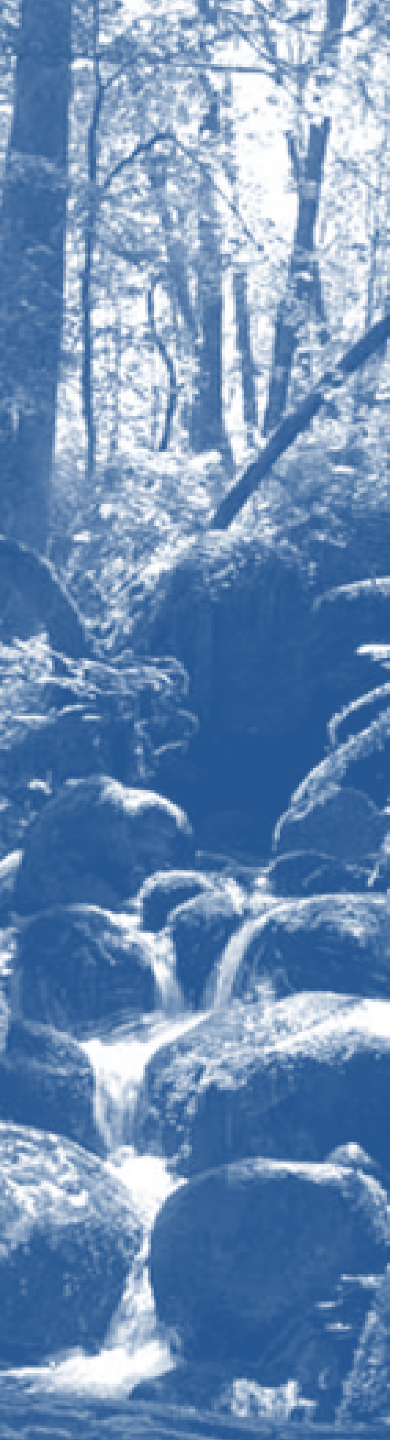

Alternative Filter Media

- Recommended biofilter specification: loamy sand base (e.g. FAWB)
- Proposals from industry/consultants: sand base + organic matter and fertiliser
- Advantages:
  - Easily and reliably reproduced from inert material
  - Greater control and precision over final media characteristics

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Alternative Filter Media

Top layer ameliorated with standard dynamic lifter (organic matter, fertiliser + trace elements)

20 columns

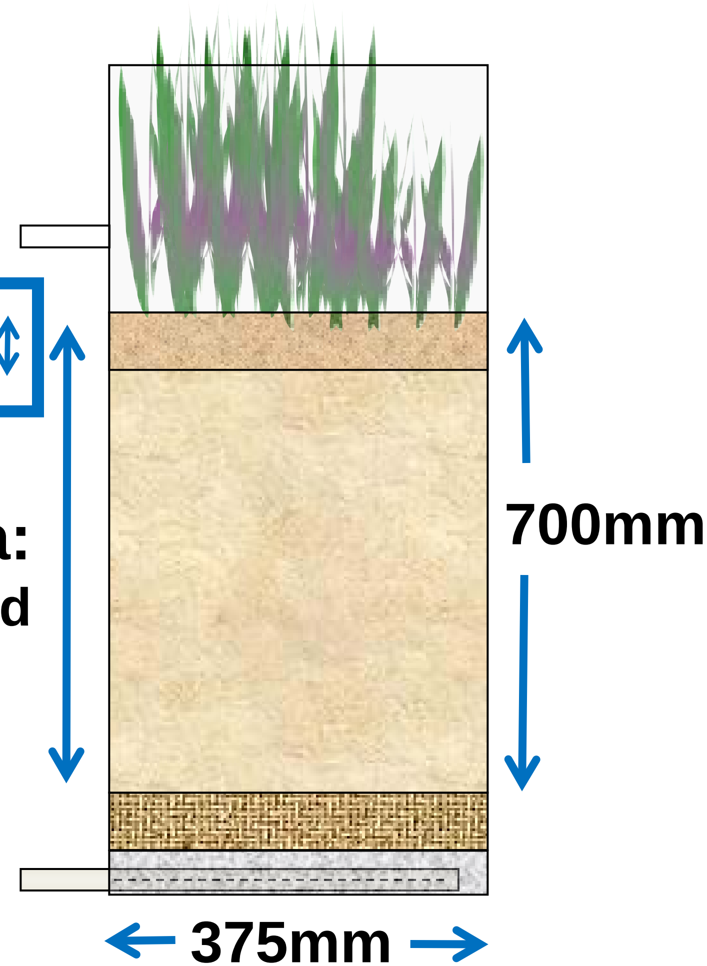
Vegetation

Ameliorated layer

filter media:
triple washed sand

drainage layer

outlet



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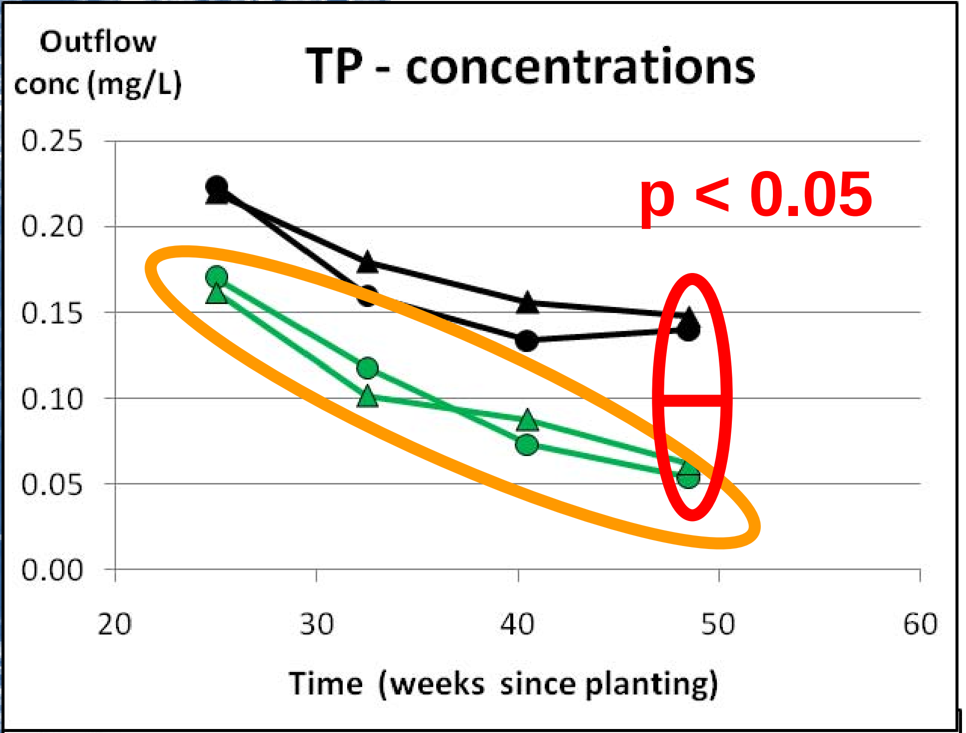
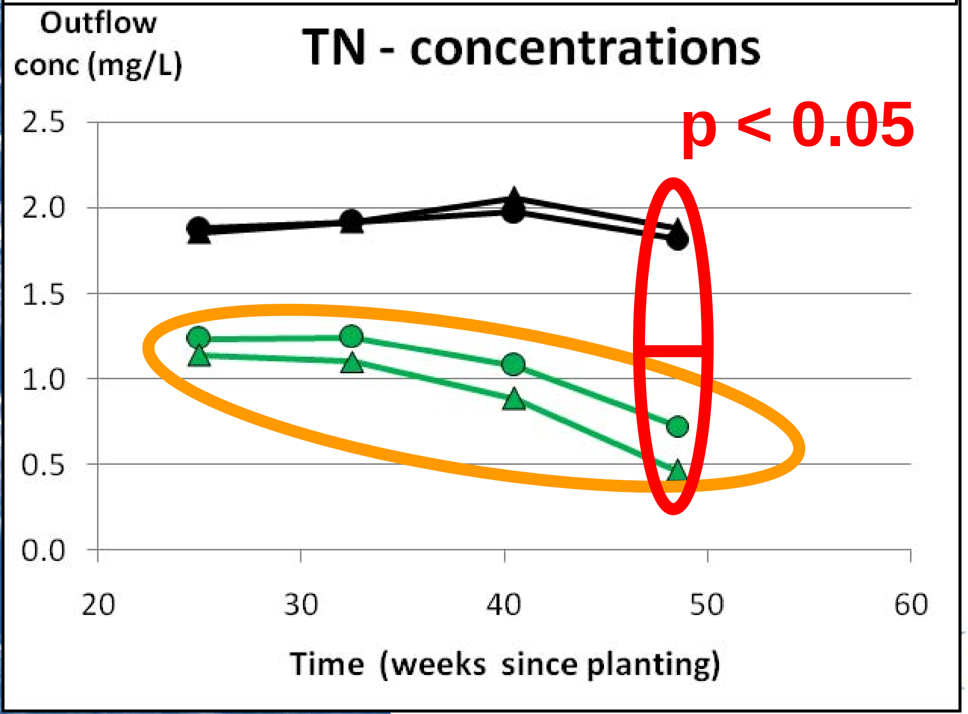
Results – *Sand-based biofilters*

Influence of vegetation

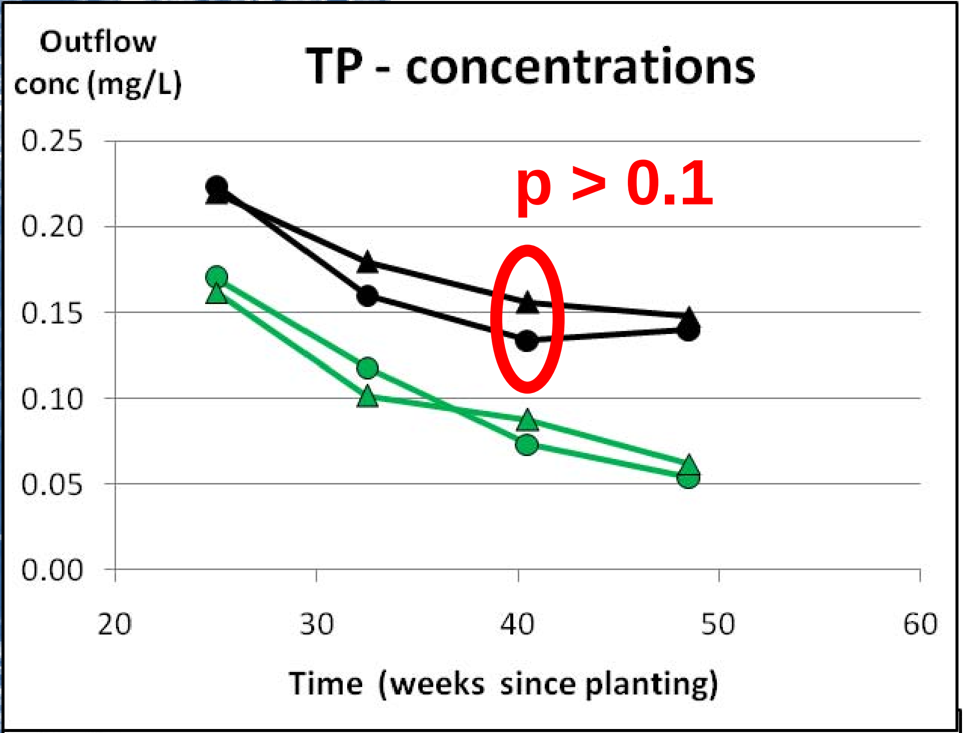


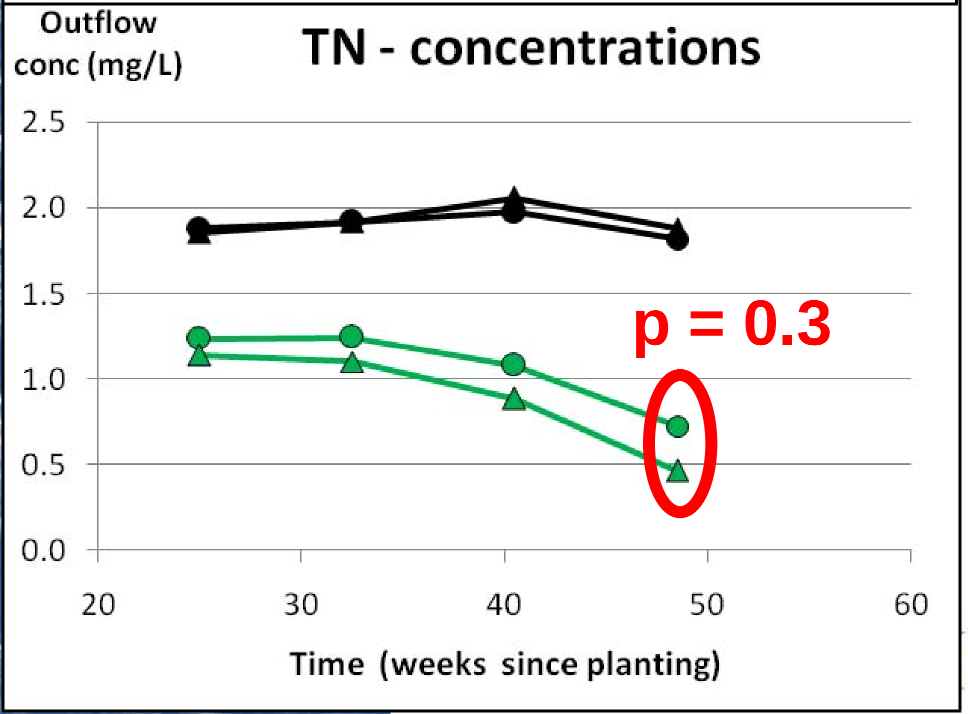


Results – *Sand-based biofilters*

Influence of vegetation

Influence of filter media





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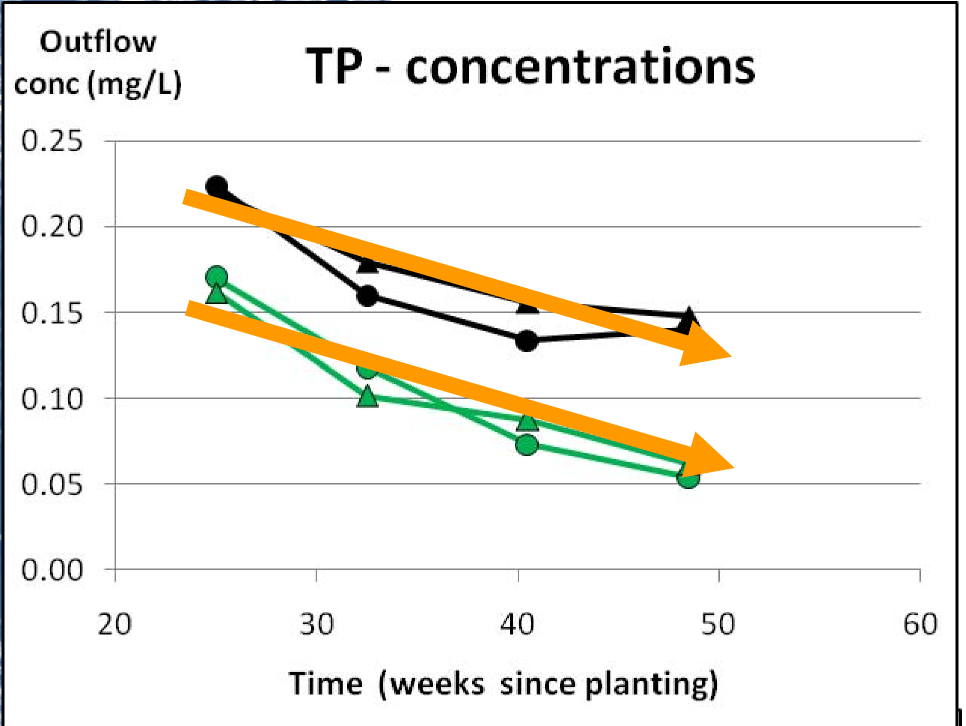
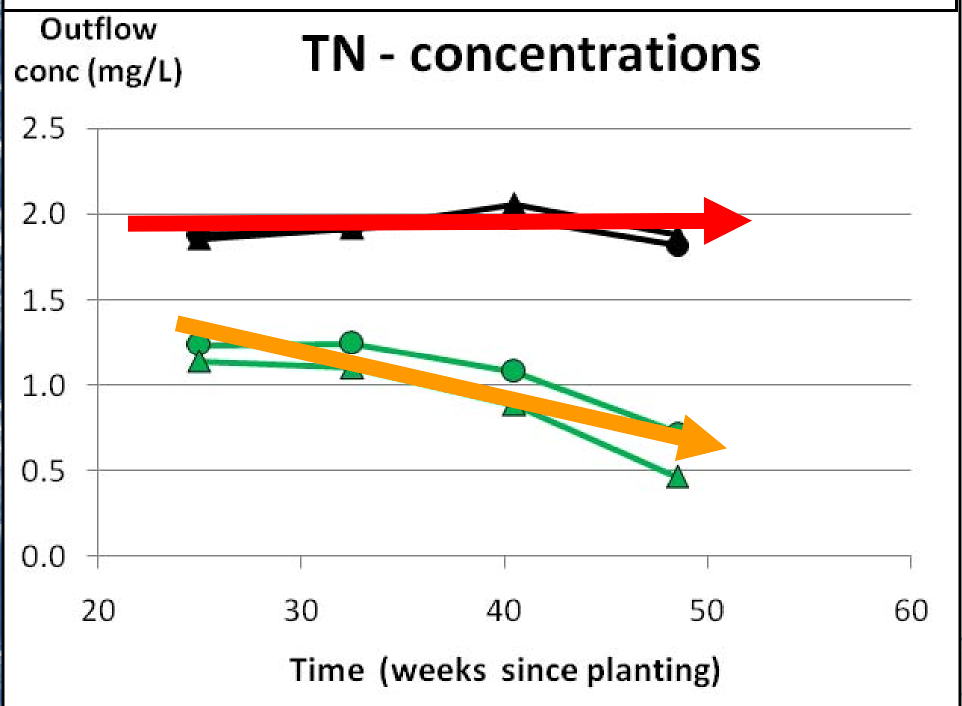
Results – *Sand-based biofilters*

Influence of vegetation

Influence of filter media

Temporal evolution





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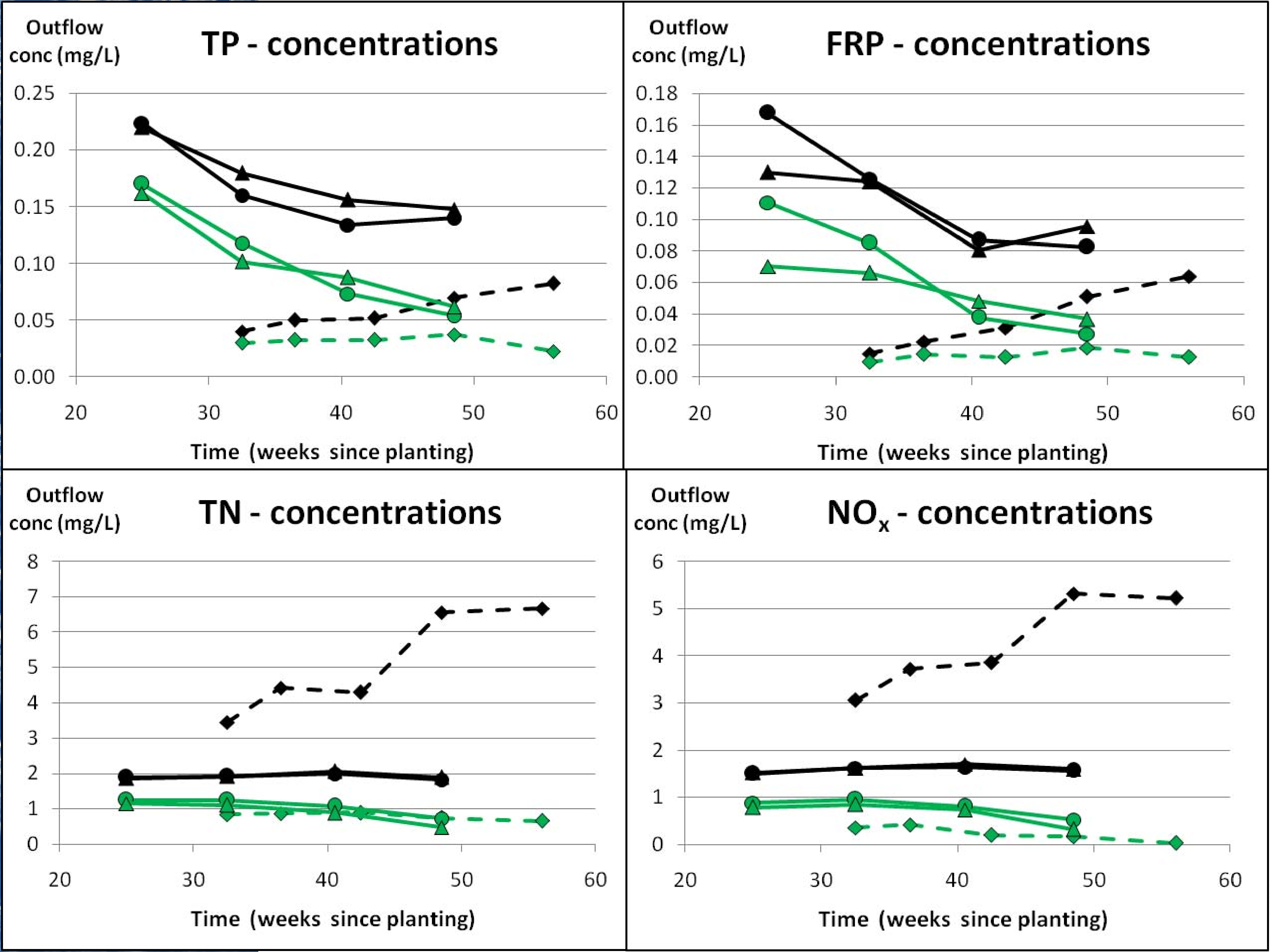
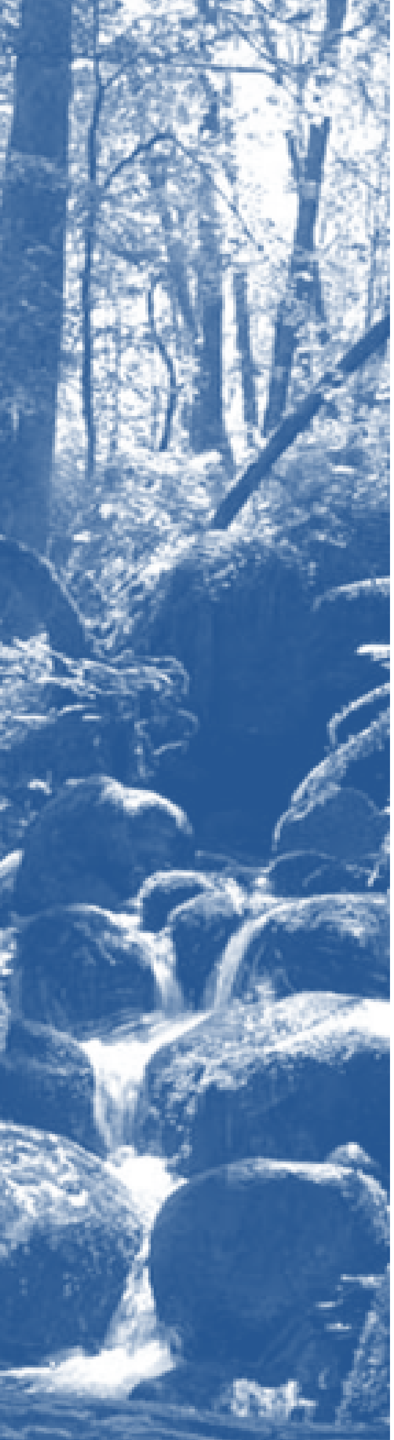

Outflow conc (mg/L)
TP - concentrations
0.25
0.20
0.15
0.10
0.05
0.00
20
30
40
50
60
Time (weeks since planting)
Outflow conc (mg/L)
FRP - concentrations
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
20
30
40
50
60
Time (weeks since planting)
Outflow conc (mg/L)
TN - concentrations
8
7
6
5
4
3
2
1
0
20
30
40
50
60
Time (weeks since planting)
Outflow conc (mg/L)
NO_x - concentrations
6
5
4
3
2
1
0
20
30
40
50
60
Time (weeks since planting)



Alternative Filter Media Study

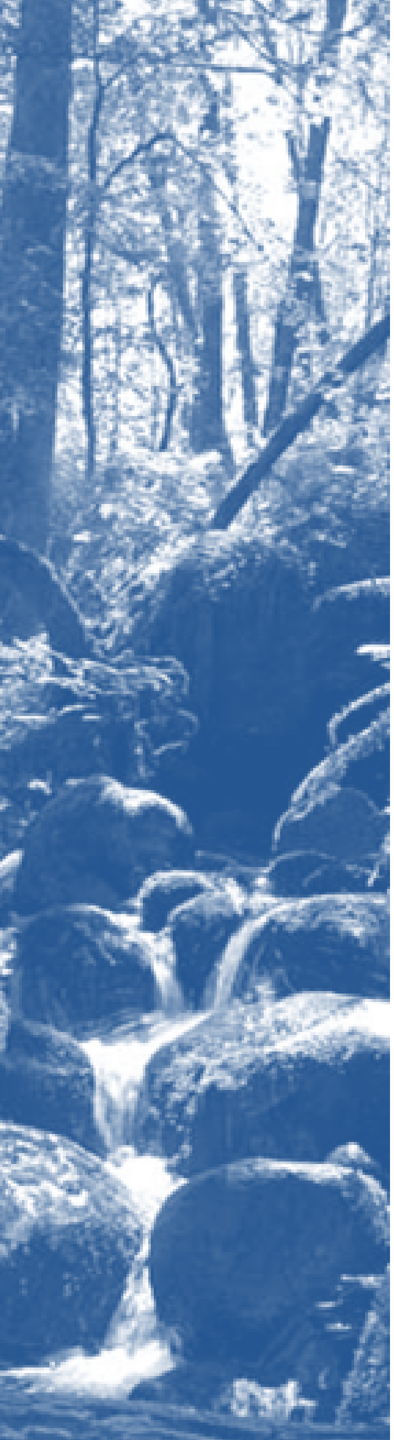
Conclusion and recommendations:

Advantages:

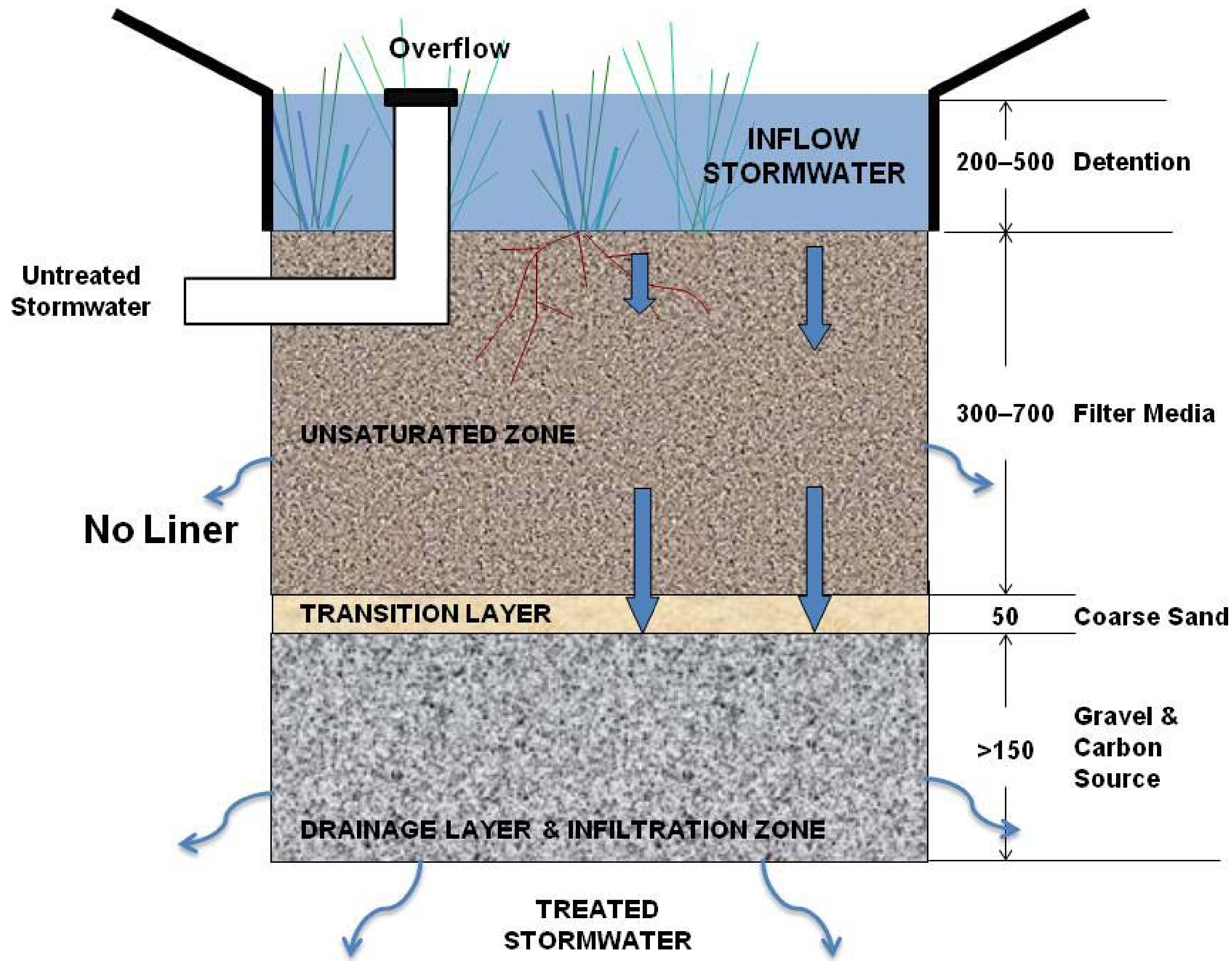
- NO nitrogen leaching
- Filter media easily obtained
- Simple formula -> reliably reproduced

Disadvantages:

- Poor performance for first 6 months
- Slightly lower performance after 1 year



Bio-infiltration



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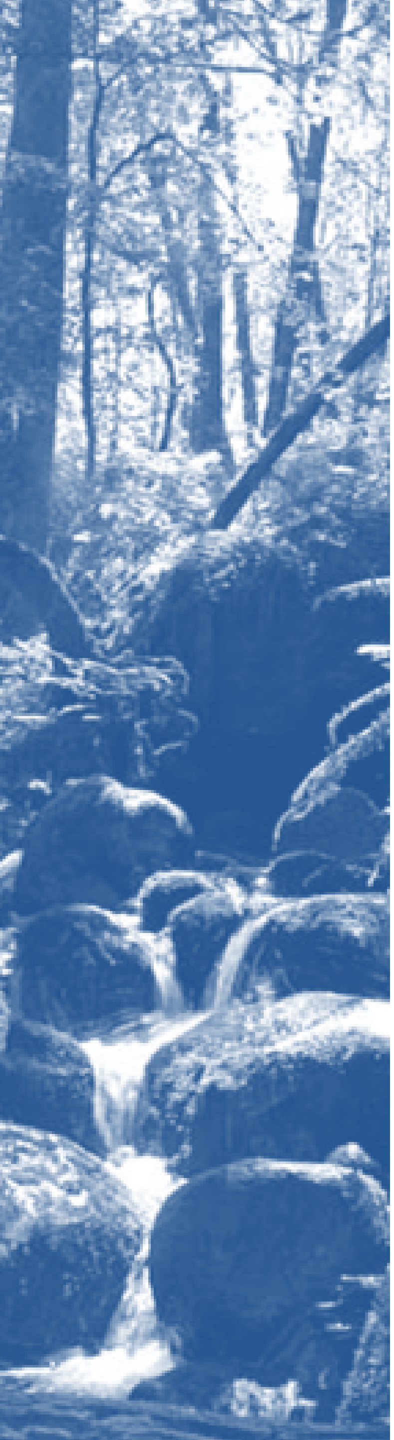

Case Study: Allotment rain-garden

Rangeview Road, Mt Evelyn

- Very low permeability (in theory 0.05 mm/hr!)

  "you can't build infiltration there!"
- Close to infrastructure (lining required)
- Use of scoria
- Performance over time
  - The reality of infiltration rate
  - The 'growing' role of ET

Rangeview Rd

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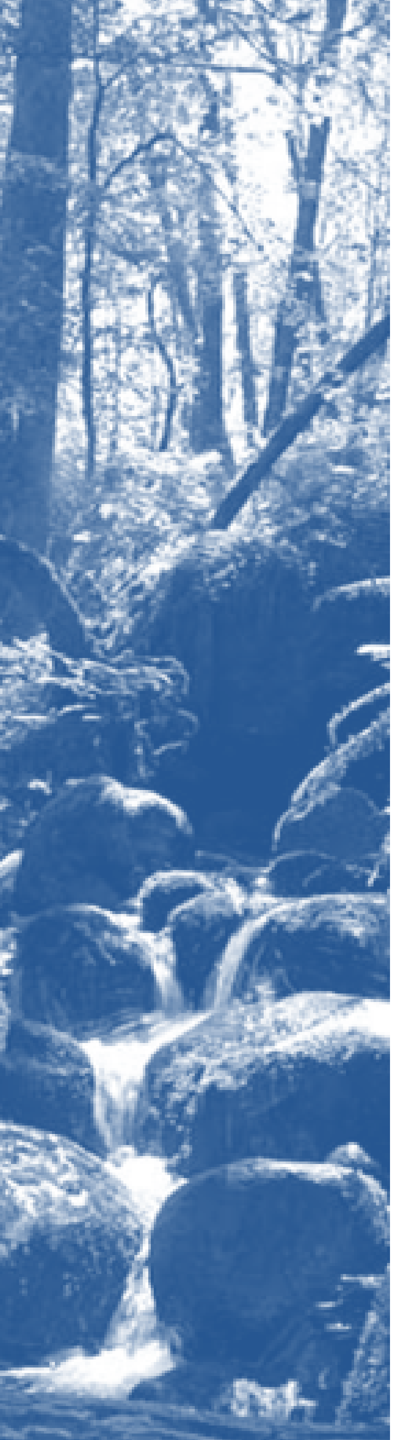

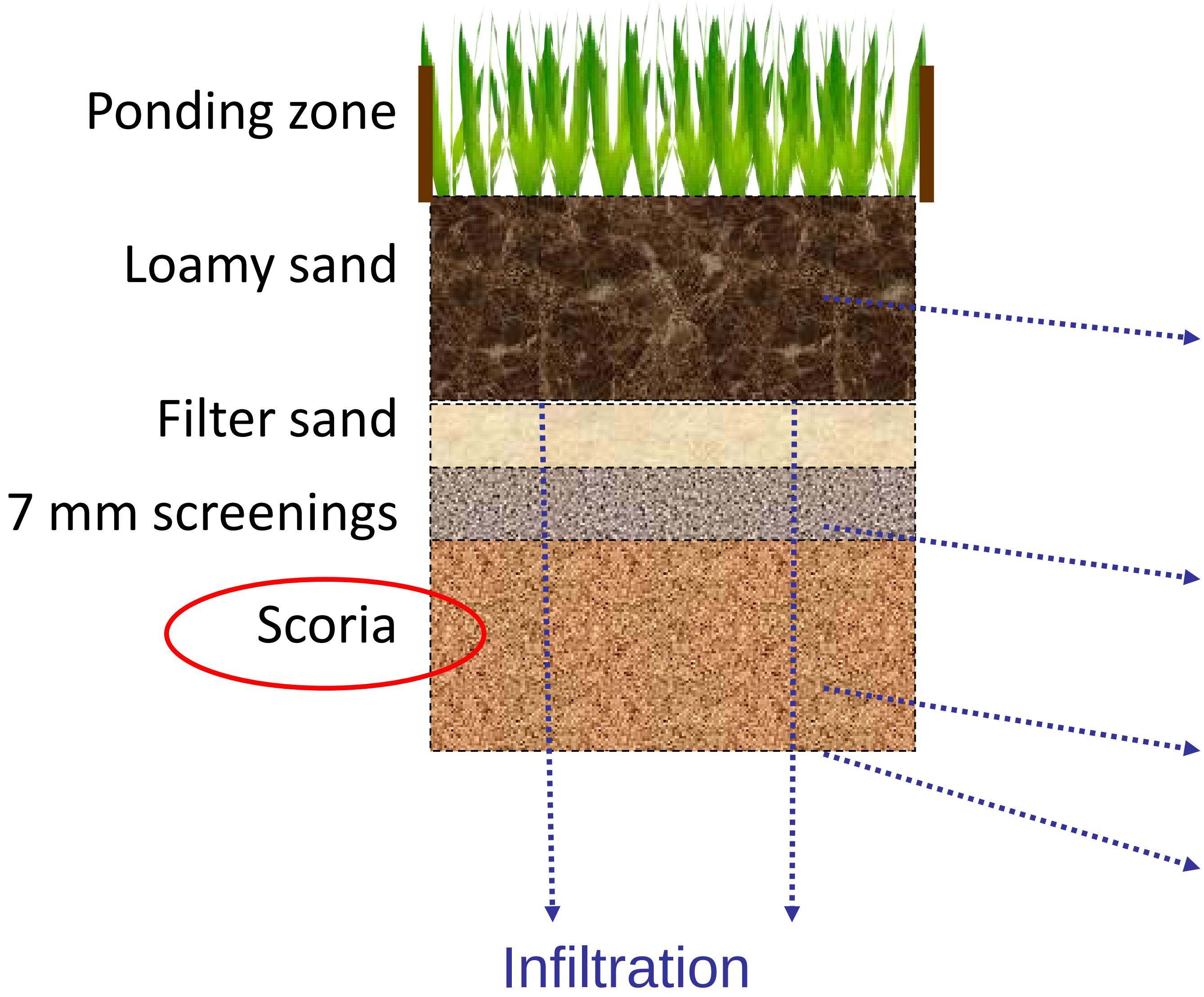
Ponding zone
Loamy sand
Filter sand
7 mm screenings
Scoria
Infiltration

Lining and offset distances

Soil type	Saturated hydraulic conductivity (mm/h)	Minimum distance from structures and property boundaries (m)
Sand	> 180	1
Sandy clay	36-180	2
Weathered or fractured rock	3.6-36	2
Medium clay	3.6-36	4
Heavy clay	0.036-3.6	5

Source: WSUD: Engineering Procedures (2005)

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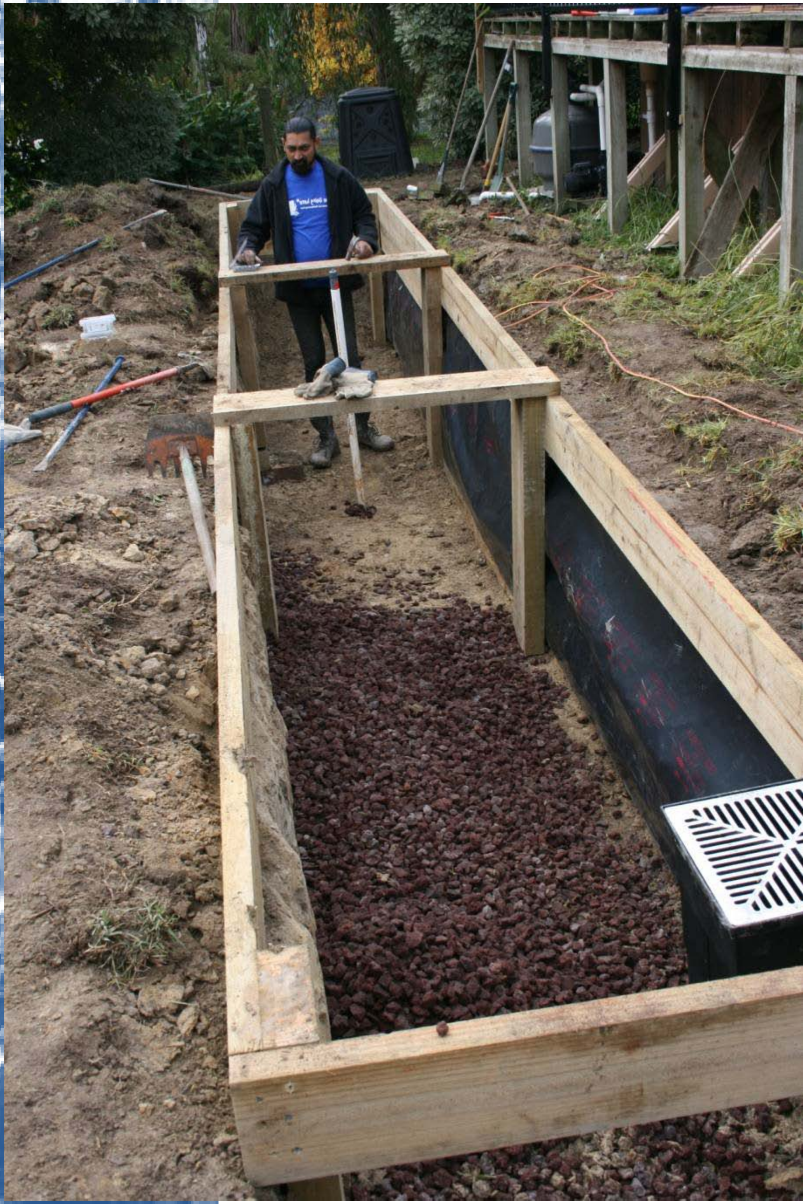
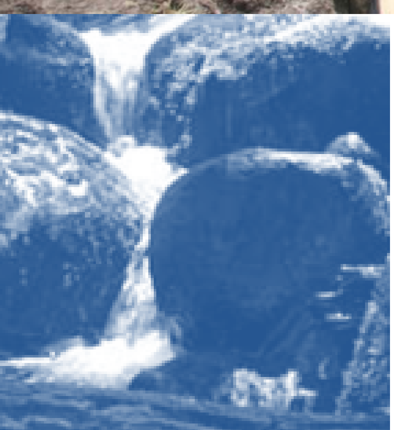


- Partial lining
- Subsequent testing

Scoria with carbon source



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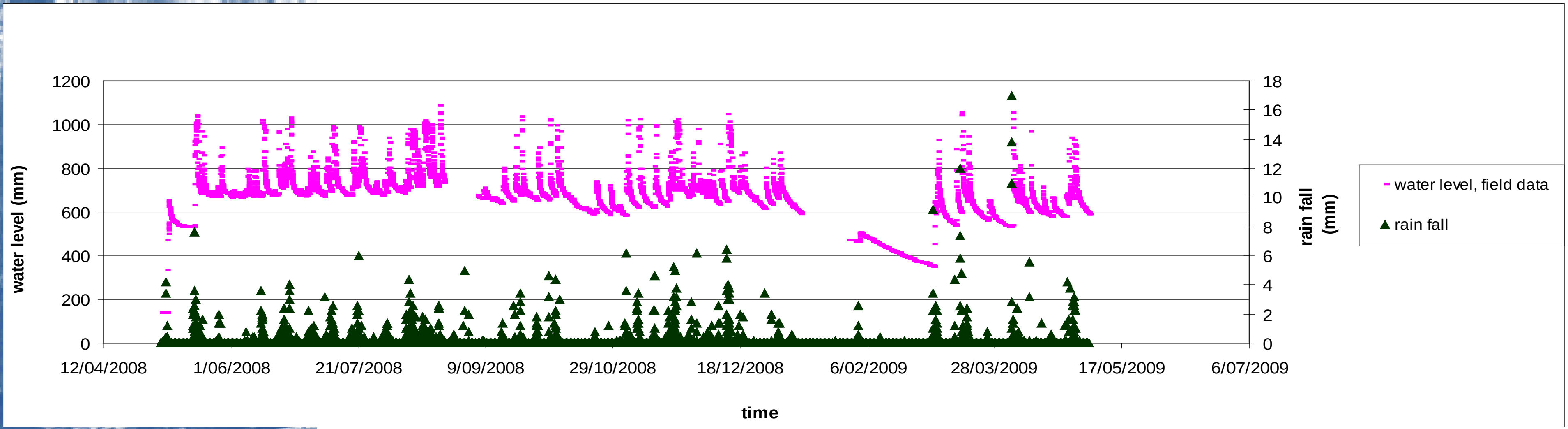

- Rare overflow
- Fast shallow exfiltration
- V slow deep exfiltration (most difficult soils in Melb)
- Substantial ET losses (increase with time)
- Near-complete restoration of block's hydrologic cycle

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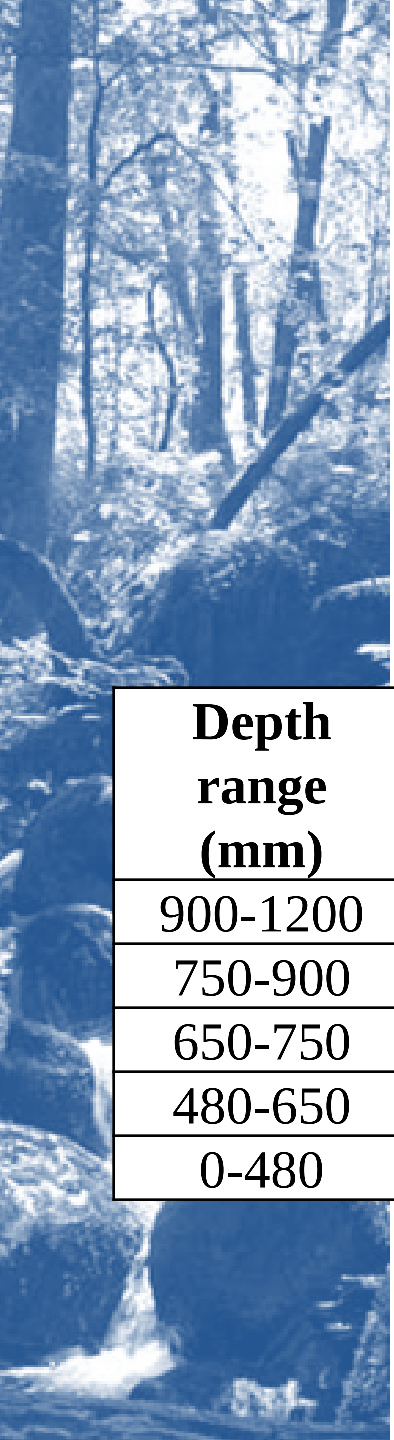

The reality of permeability

- Significant vertical profile
- Upper layer highly permeable – promotes further evapotranspiration

Depth range (mm)	Wetted Area (m^2)	Average exfiltration rate over entire depth (mm/h)	Exfiltration rate (mm/h) for given 'slice' (mm/h)
900-1200	3.24	40	266
750-900	1.62	3	33
650-750	1.08	0.3	4
480-650	1.84	0.05	0.4
0-480	15.26	0.01	0.01

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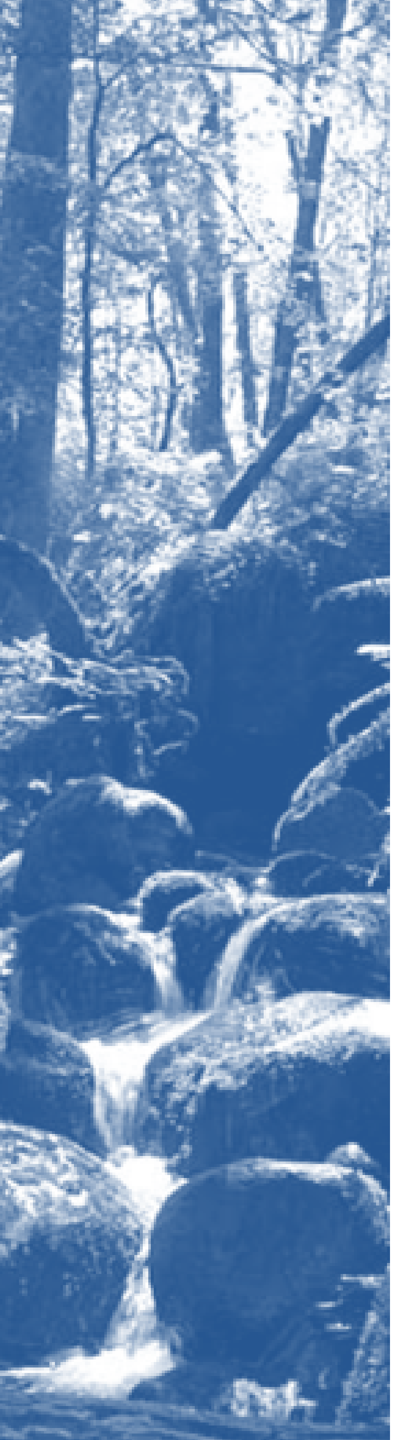
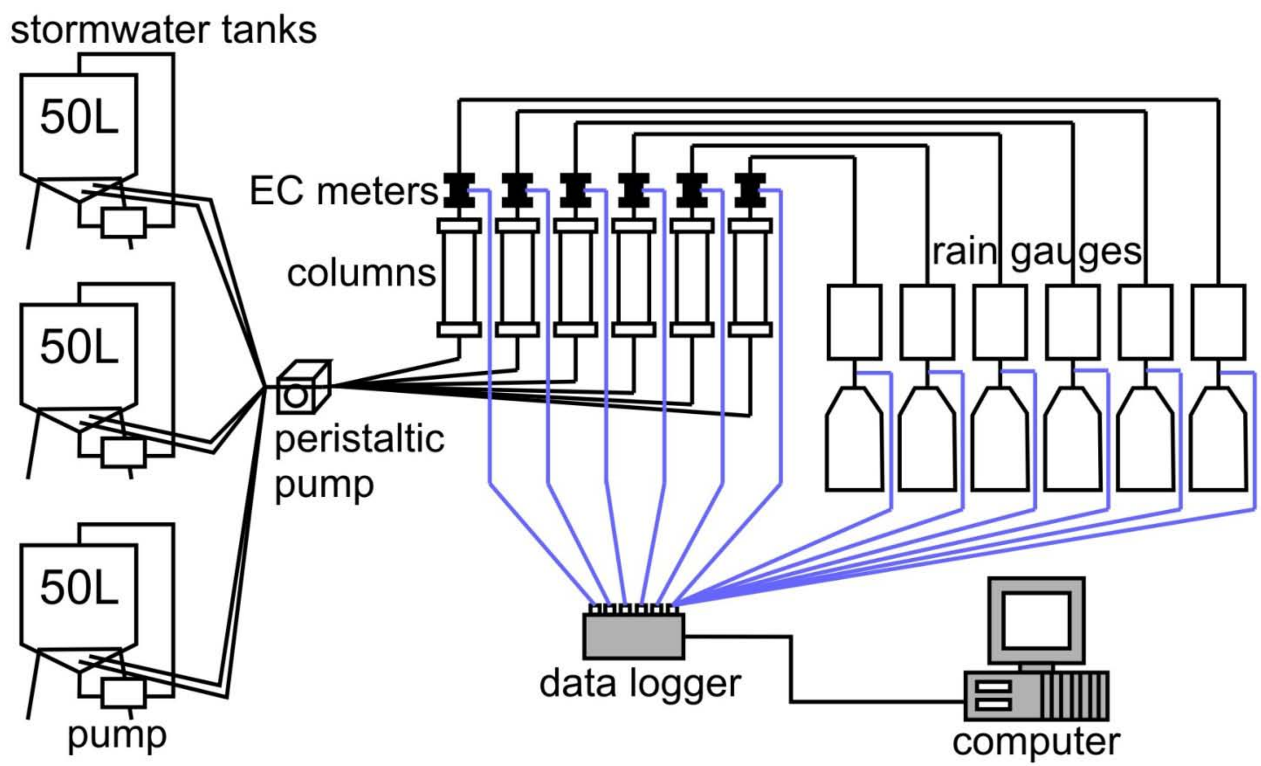
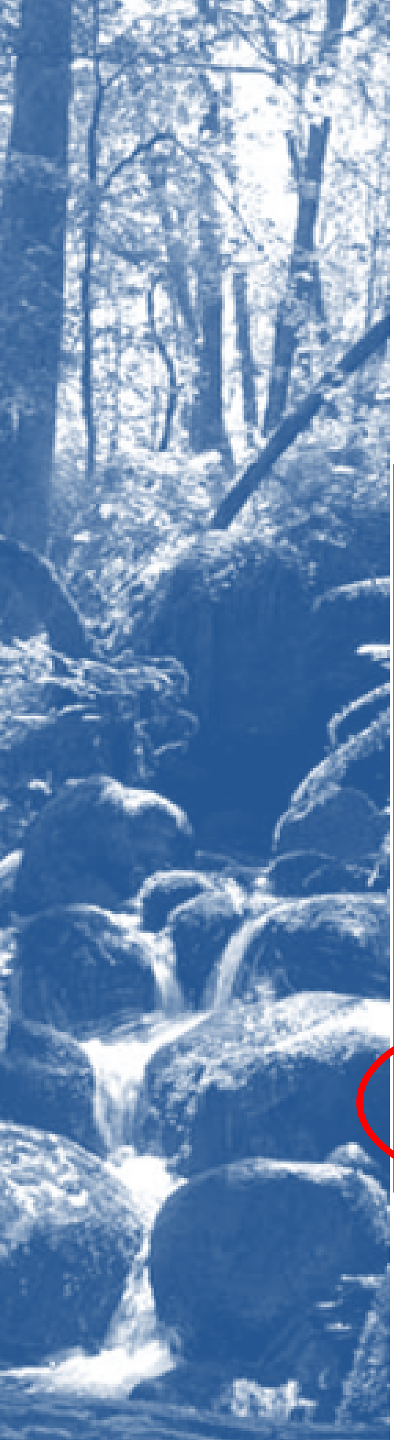


How long will a biofilter last?

Breakthrough of heavy metals

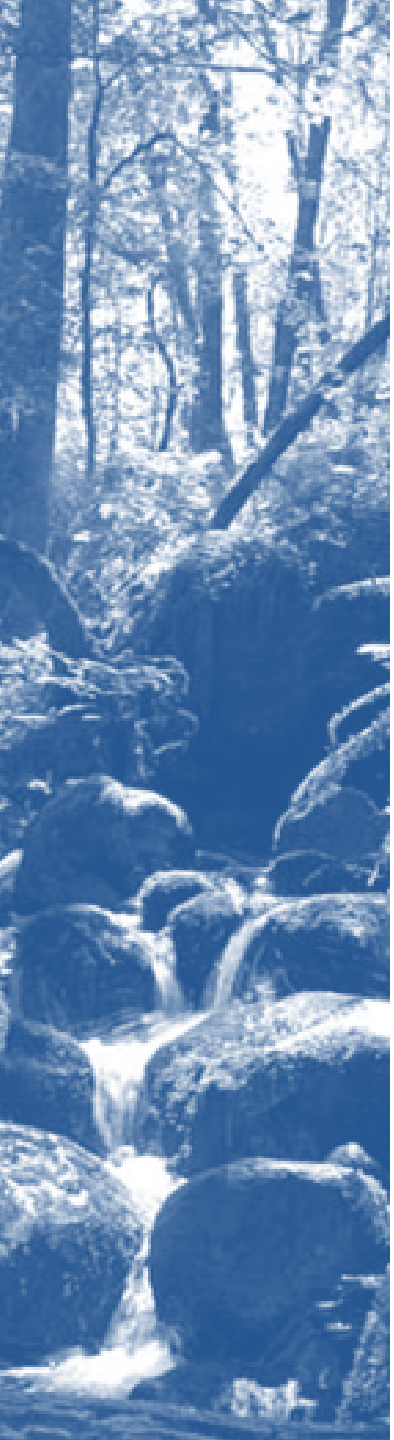




How long will a biofilter last?

Years to breakthrough of zinc

Filter Media	Depth (m)	Perth – % of impervious catchment				
		1	2	3	4	5
Loamy sand	0.3	3	7	11	15	18
	0.5	6	12	18	25	31
	0.7	8	17	26	35	44
Loamy sand + vermiculite+ perlite	0.3	2	5	8	11	14
	0.5	4	9	14	18	23
	0.7	6	13	19	26	33
Loamy sand + compost	0.3	4	9	14	18	23
	0.5	7	15	23	31	39
	0.7	11	22	33	44	55



How long will a biofilter last?

- Study of 29 biofilters in Brisbane, Sydney & Melbourne
  - Varying design characteristics, system age, catchment characteristics
  - Land-use, development type and climate were all found to influence accumulation of heavy metals
  - Results compared to national soil quality targets
    - Lead was the first metal to reach the human Soil Investigation Level
    - Zinc was the first metal to reach the ecological Soil Investigation Level

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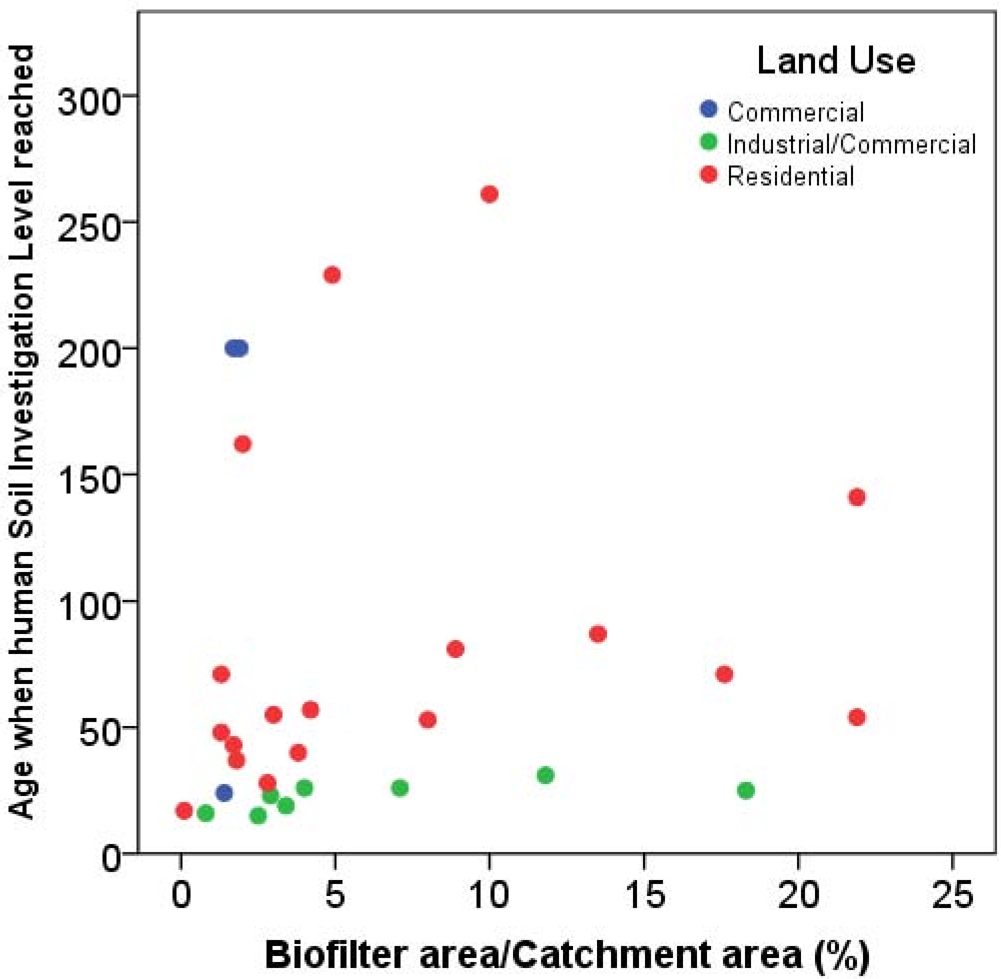
Influence of size and land use



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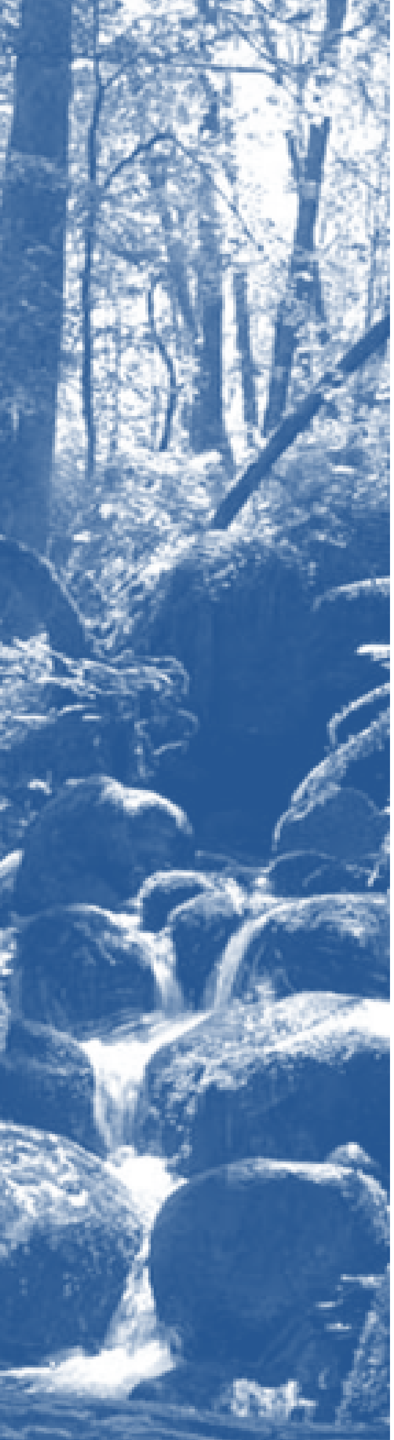
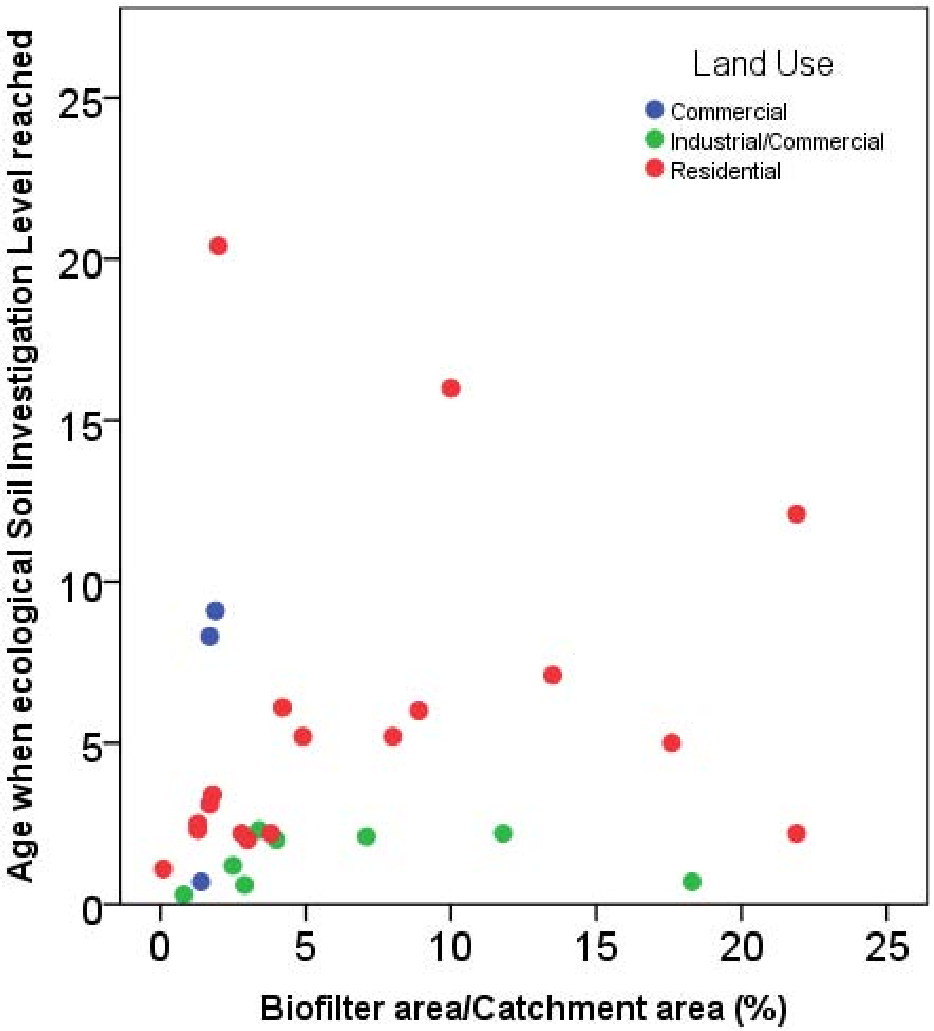
Influence of size and land use





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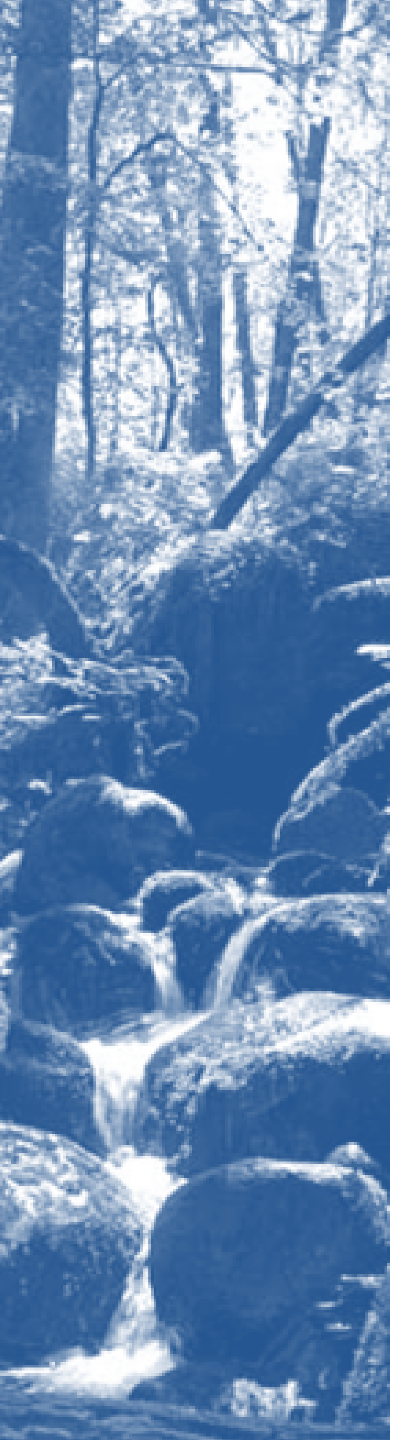
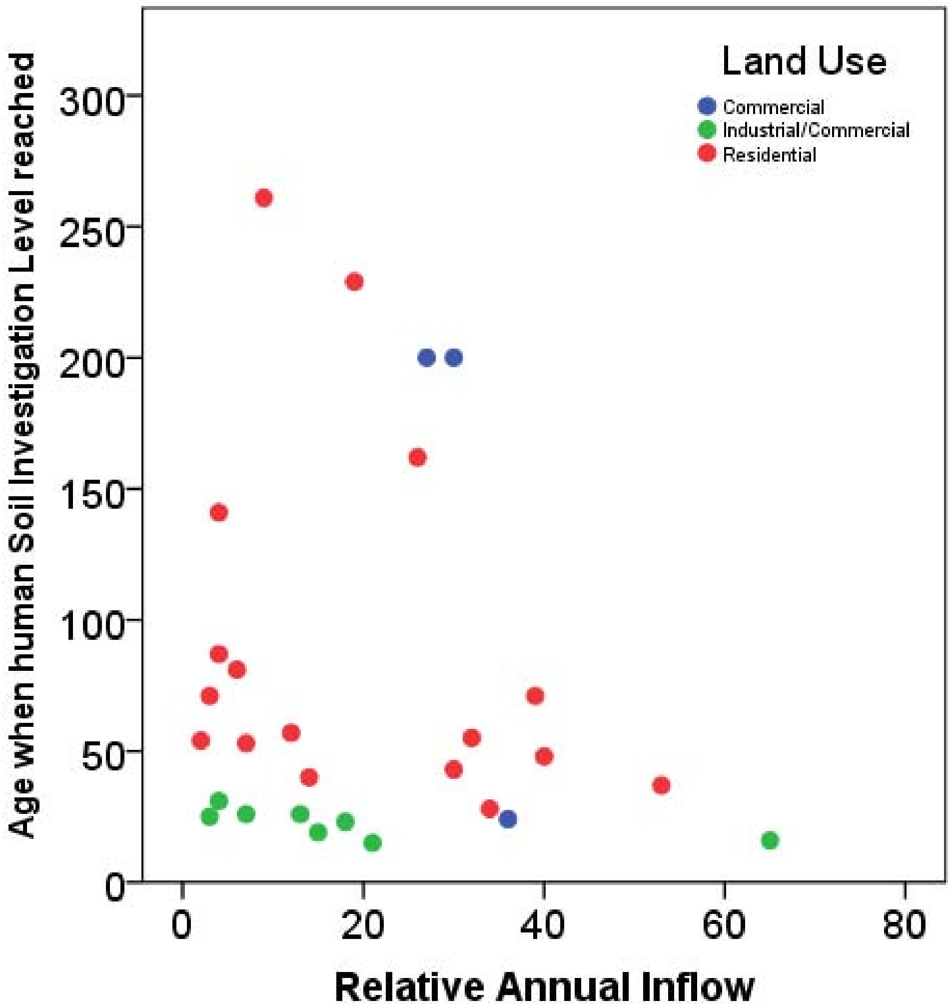
Influence of climate





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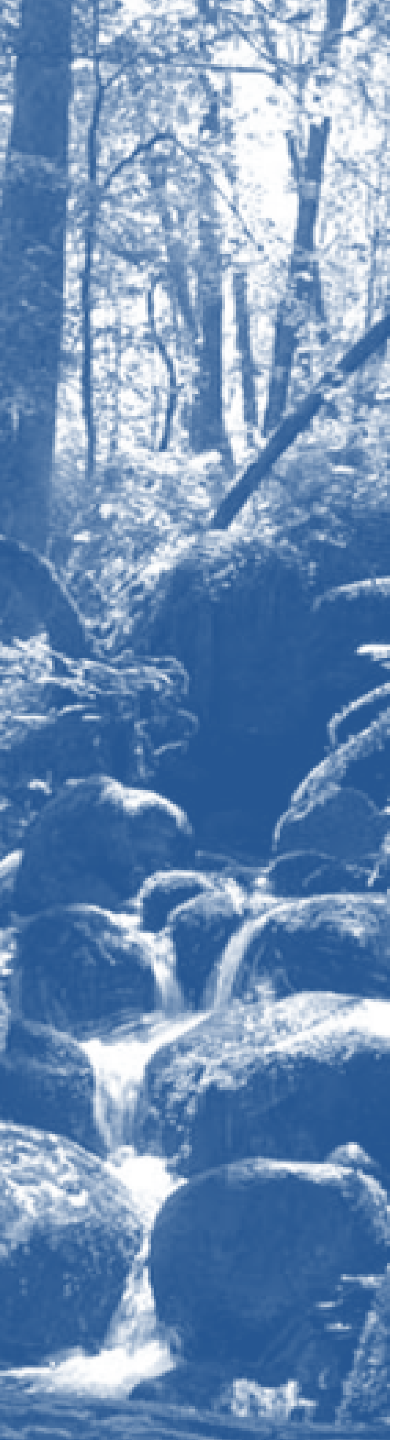

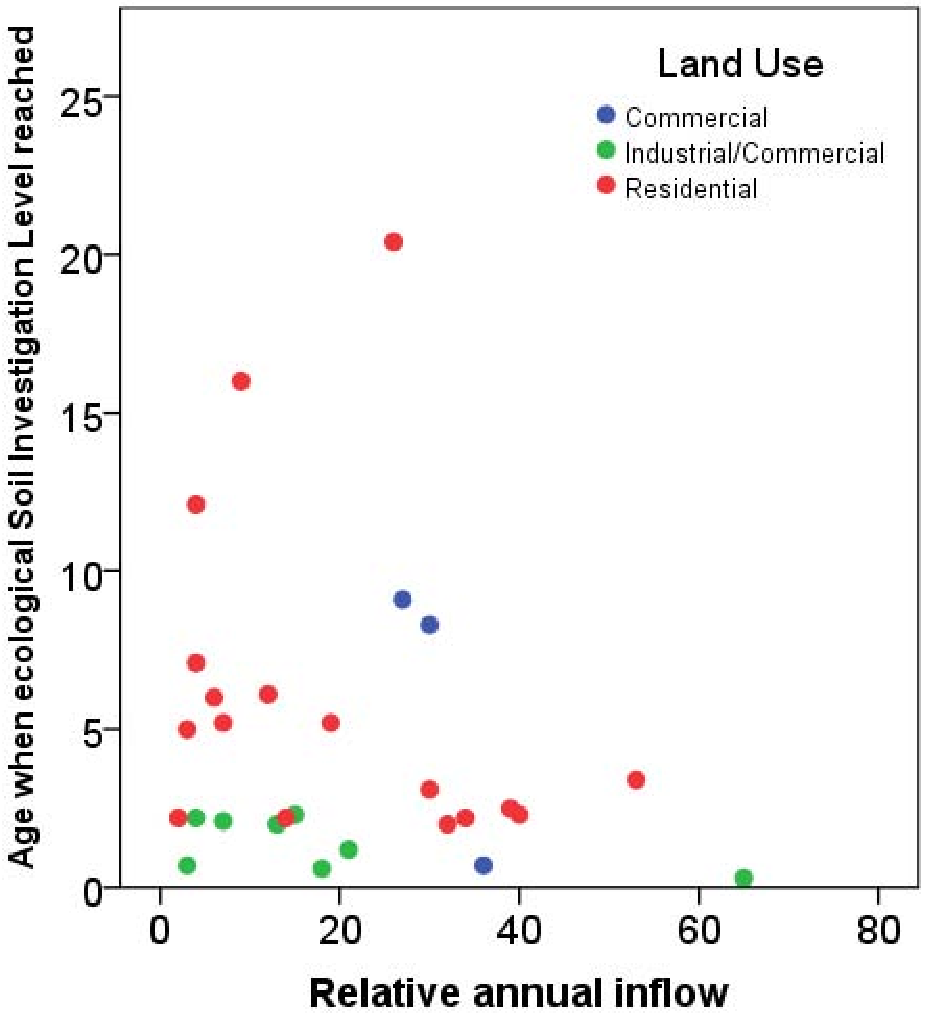

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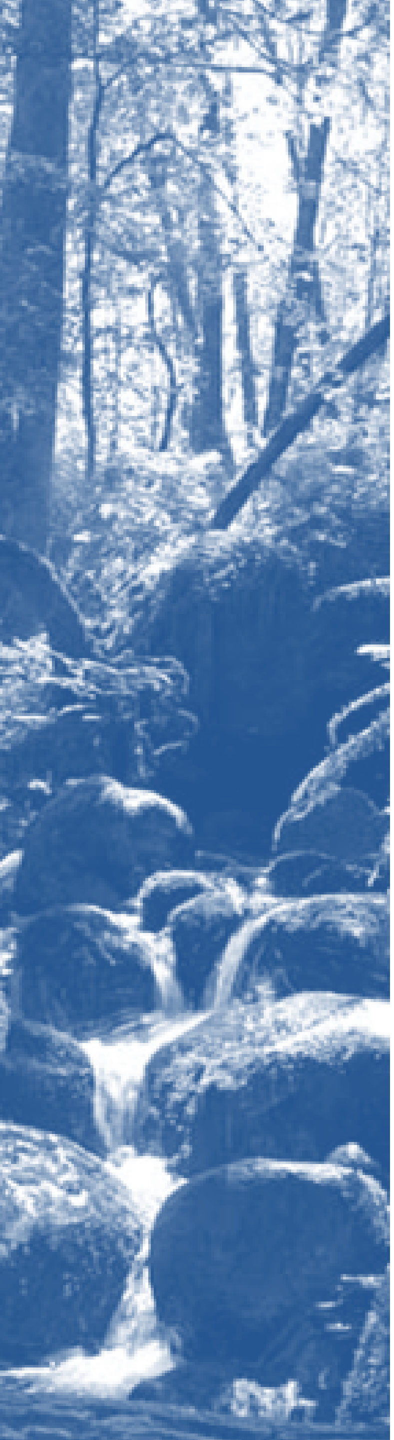
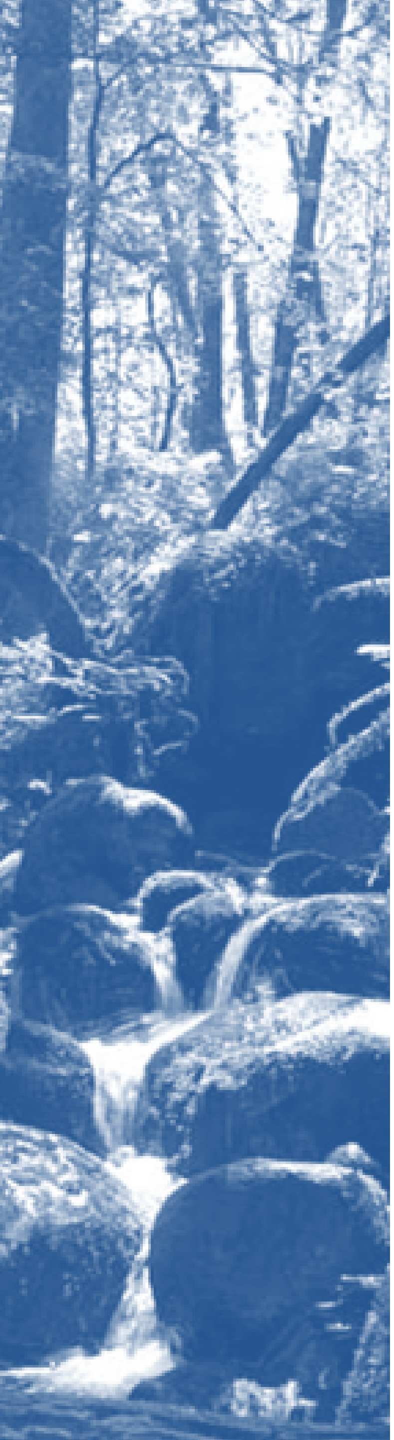


Implications

- If...
  - Rainfall is high
  - Past or present industrial land-use
  - Biofilter is a retrofit

...heavy metals will accumulate to levels of concern at a faster rate

- Will filter media be contaminated and require special disposal?
  - Possibly, but semi-frequent maintenance can avoid this



Looking to the future

- Influence of plants on nitrogen removal by biofiltration

  (*In collaboration with the Department of Water and Melbourne Water)*
- Reconnecting urban streams to their riparian zones
- Cities as Water Supply Catchments

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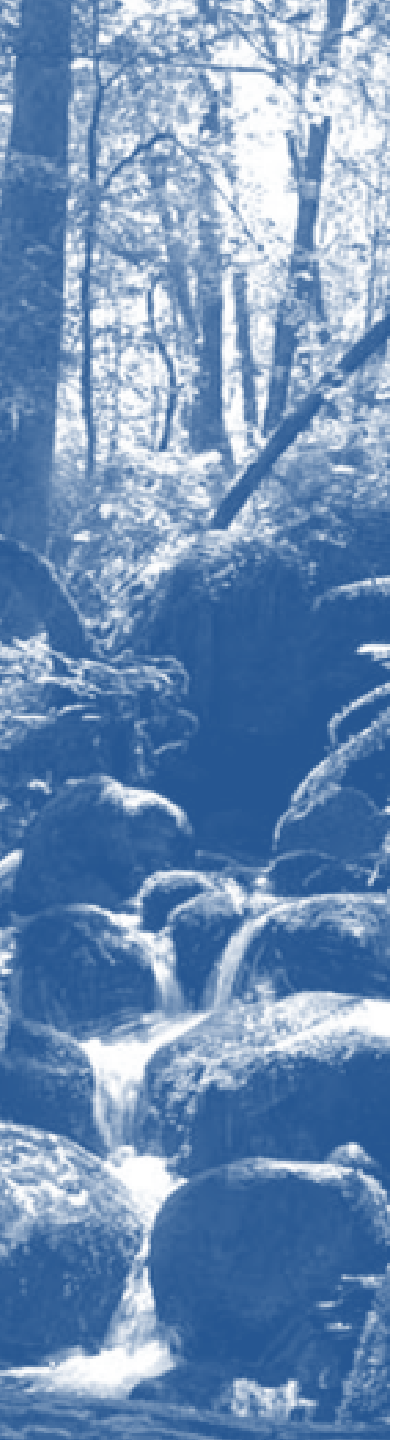

Thank you!

Adoption Guidelines can be downloaded from:
www.monash.edu.au/fawb/products

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