IRP5 Workshop
Knowledge-based water sensitive city solutions for groundwater impacted developments

Summary of relevant outputs and findings from Tranche 1 research

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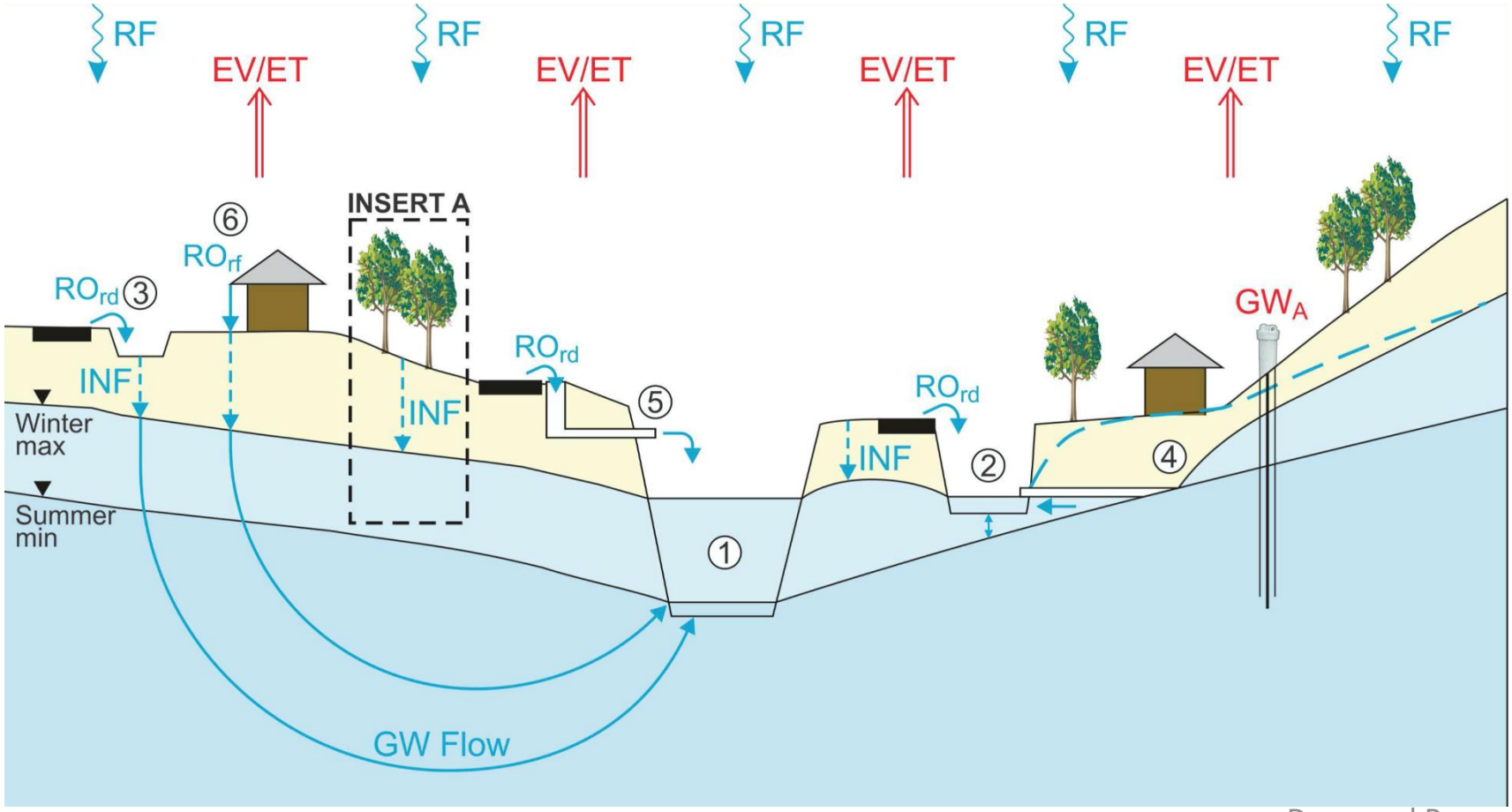
Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme
CRC for Water Sensitive Cities

Urban landscape

- Rapid population increase expected
- Stormwater management – infiltrate where possible, incorporate WSUD elements
- Where depth to groundwater > 10 m
  - Aquifer storage and recovery
  - WSUD design is understood
- Where depth to groundwater 2 - 4m ???

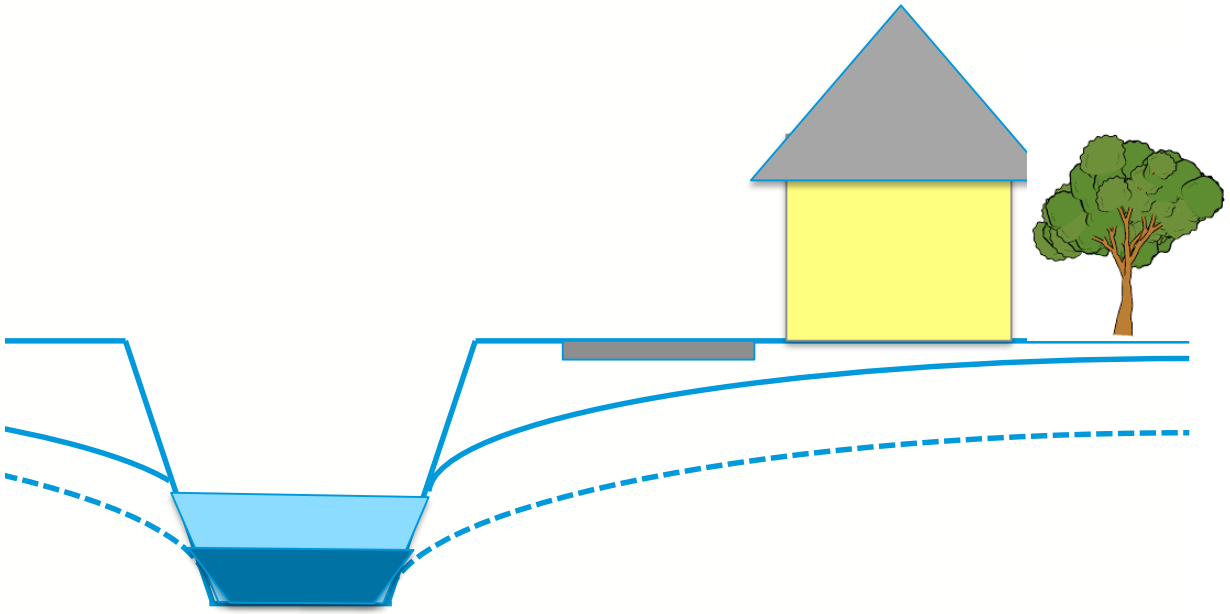
Urban water cycle



Donn and Barron 2012

Context A: Hydraulics and hydrology

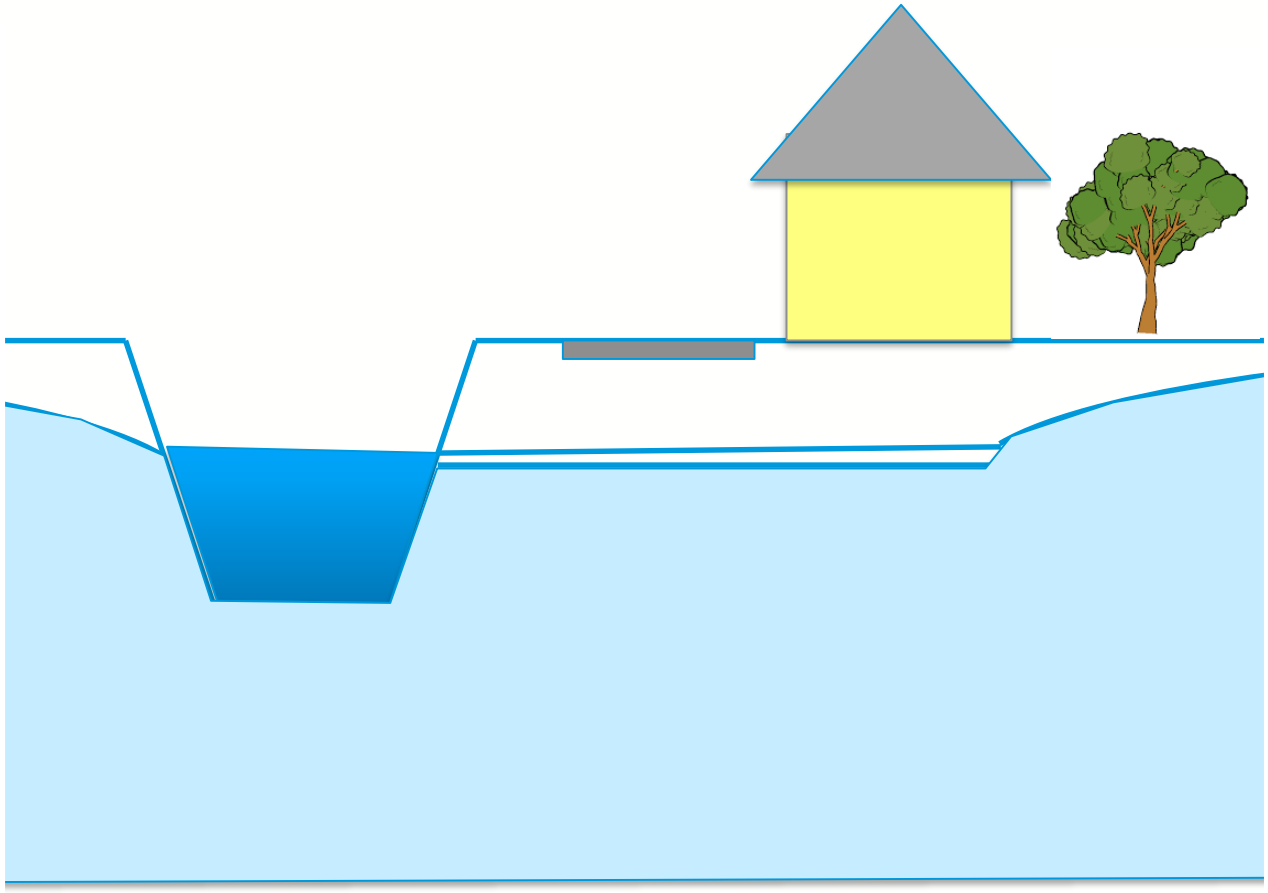
Altered groundwater levels due to urbanisation
High groundwater impacting on land development infrastructure



Context B: Ecology

High groundwater impacts on performance of stormwater management systems

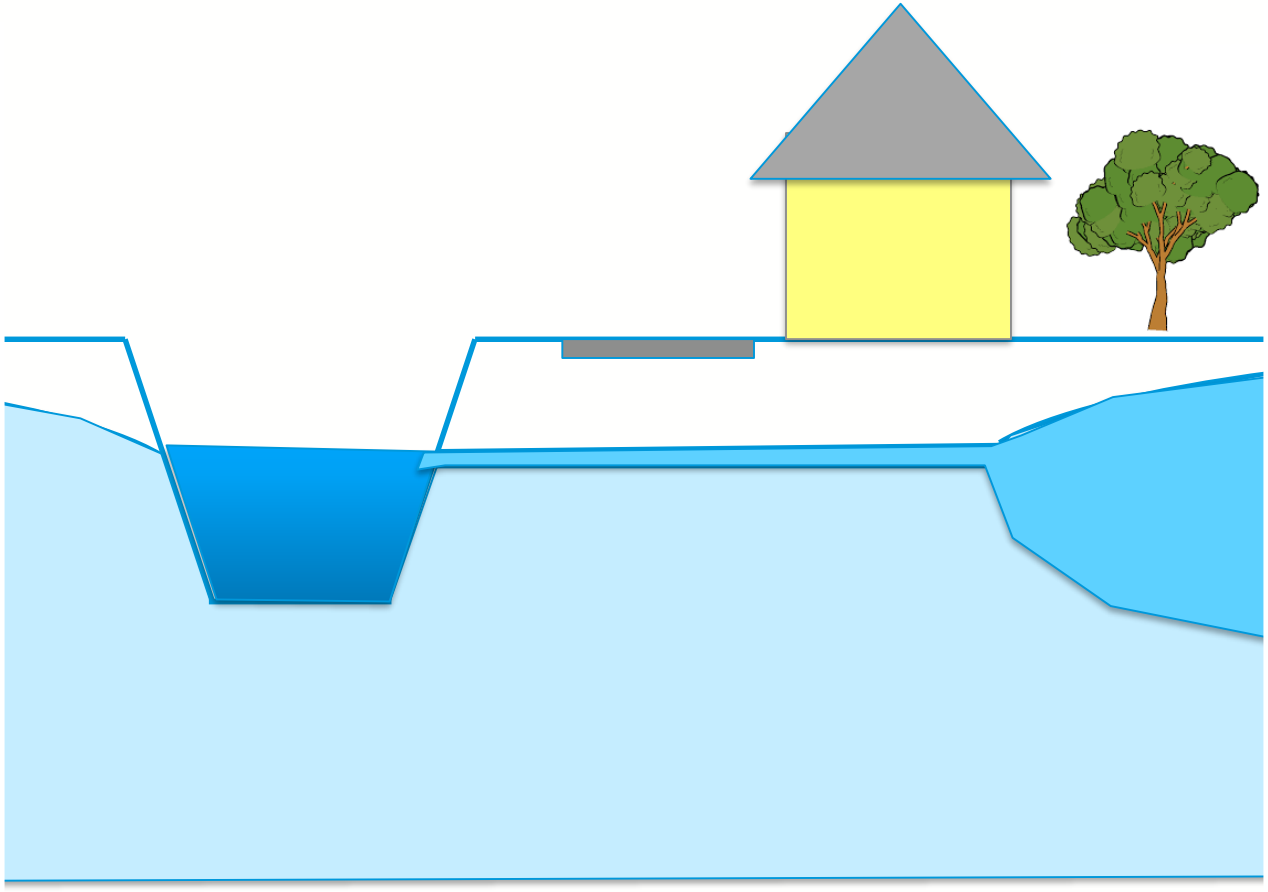
Urbanisation impacting groundwater dependent ecosystems.



Context C: Contamination

Contaminated groundwater

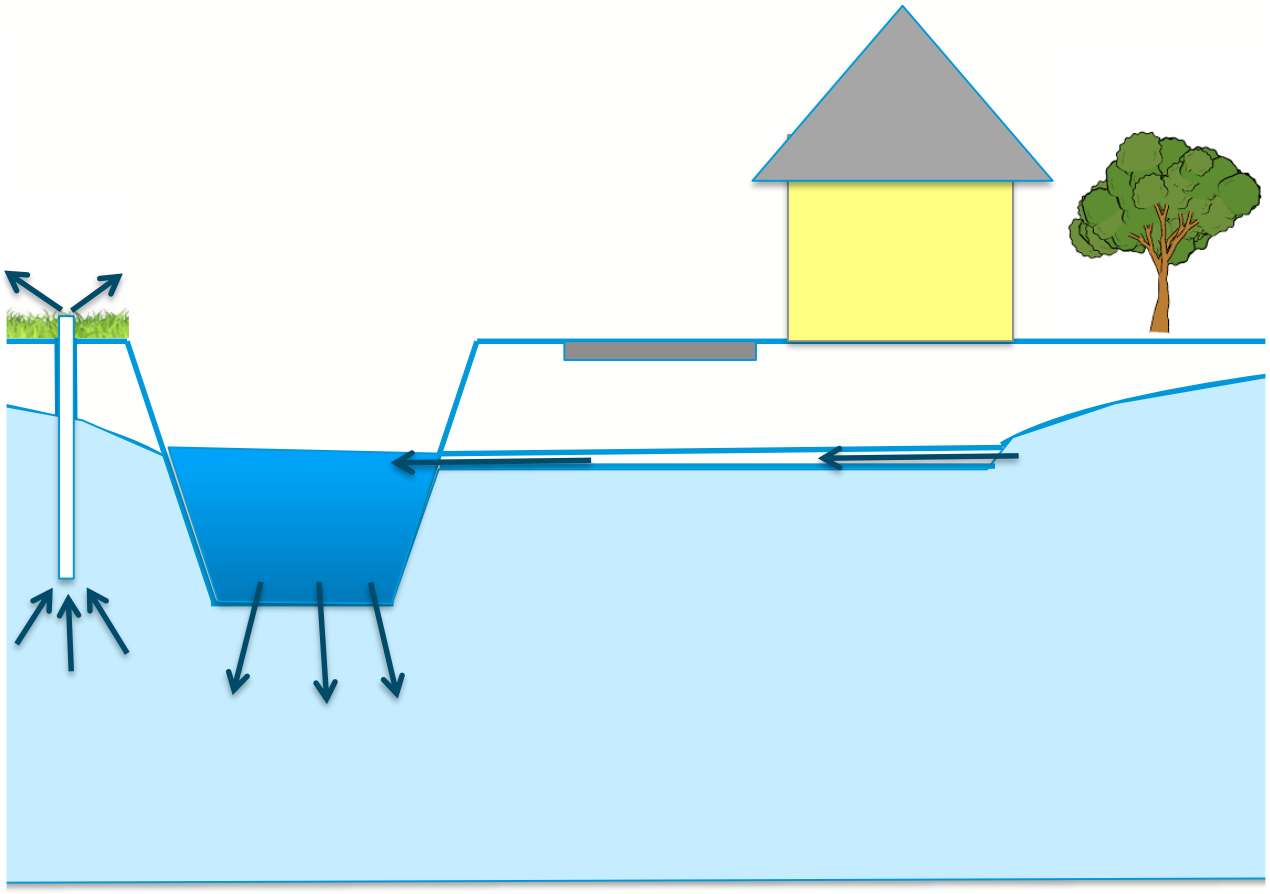
Nutrients (inorganic and organic), non-nutrients, salinity



Context D: Beneficial re-use

Managed groundwater provides opportunity for re-use

Controlling saline intrusion



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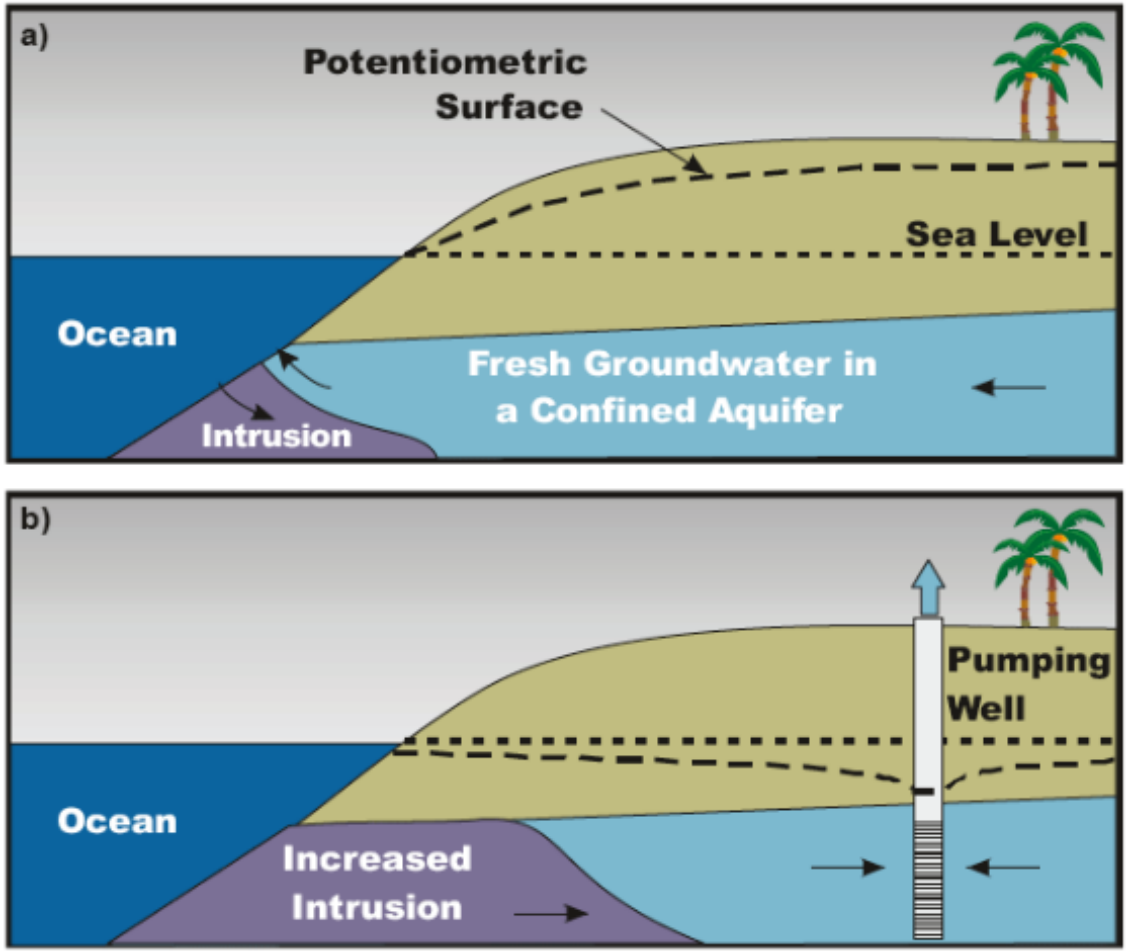
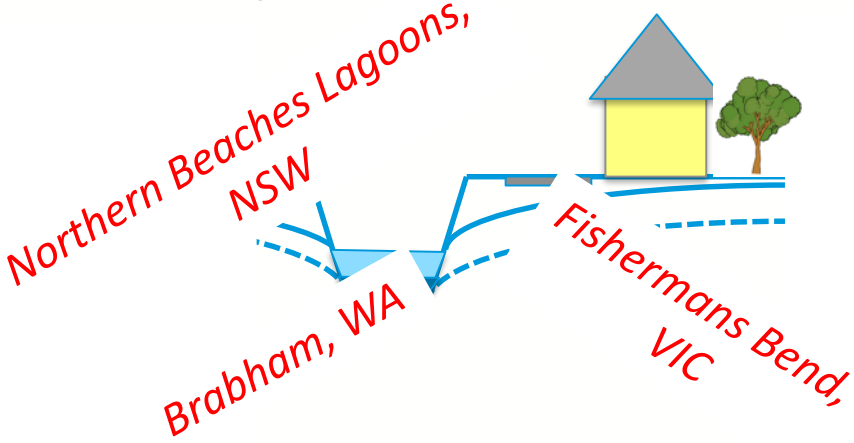


A: Hydraulics

Altered hydrology

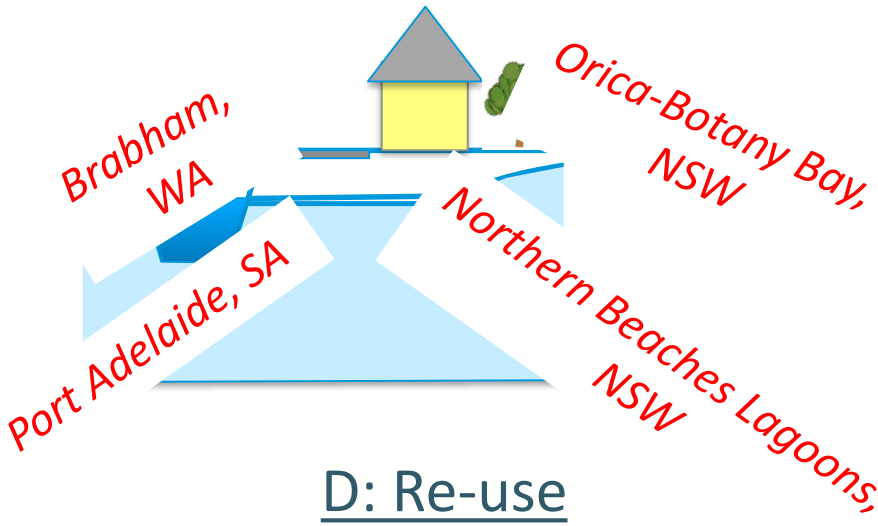
Impact on infrastructure



B: Ecology

Impact on WSUD performance

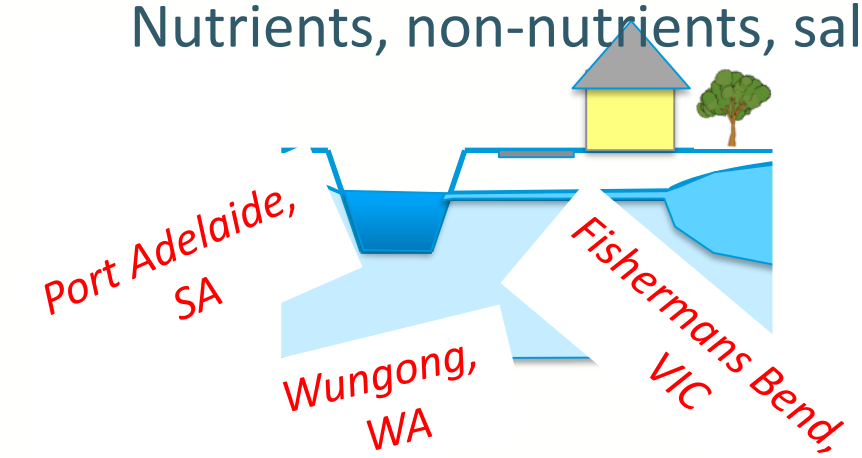
Impact on receiving ecosystems



D: Contamination

Contaminated groundwater

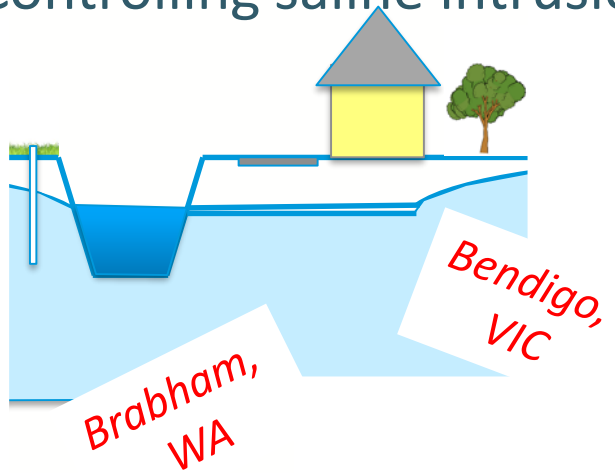
Nutrients, non-nutrients, salinity



D: Re-use

Managed groundwater re-use

Controlling saline intrusion



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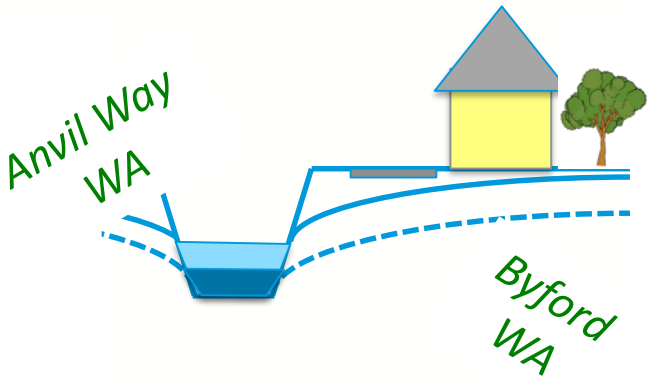

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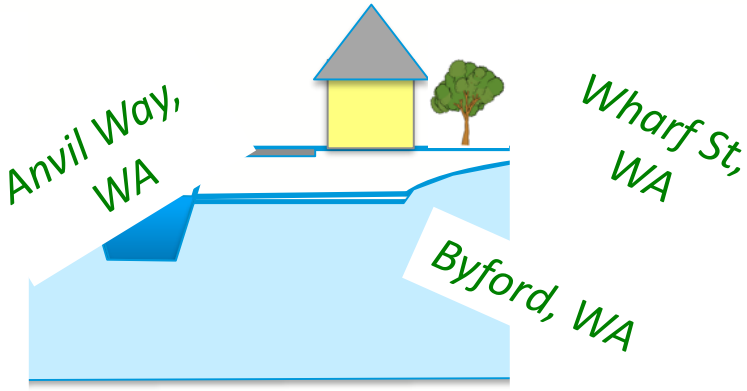
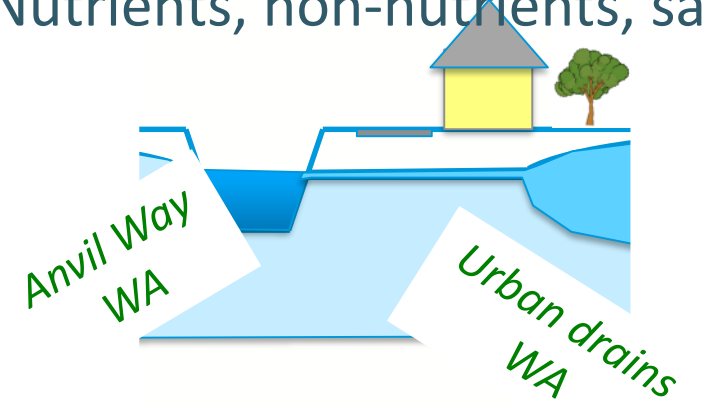


D: Contamination

Contaminated groundwater

Nutrients, non-nutrients, salinity



D: Re-use

Managed groundwater re-use

Controlling saline intrusion

Project B2.4:Hydrology and nutrient transport processes in groundwater/ surface water systems

Project C4.1: Integrated multi-functional urban water systems

Key outcomes

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Bronwyn Rennie (DoW), Kelsey Hunt (GHD)

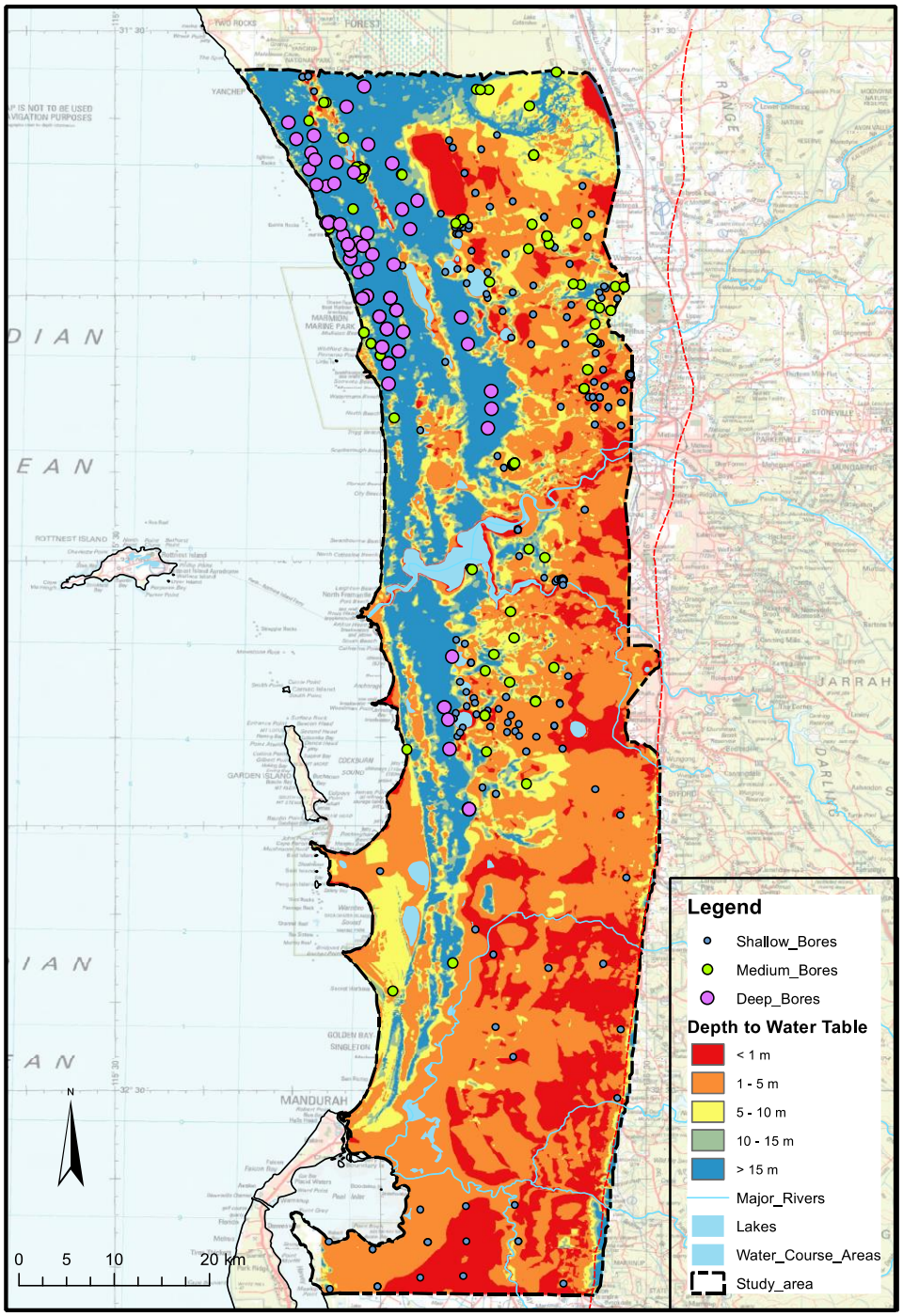
CRC for Water Sensitive Cities

B2.4 Project objectives

a) Define hydrological responses to the urbanization of areas where groundwater - surface water interactions are pronounced, including those areas with high or perched groundwater tables;

a) Define the impact of changing hydrological regimes on the fate and transport of nutrients in areas with significant groundwater - surface water interactions; and

b) Use this improved understanding to inform water sensitive urban design and how to best manage shallow groundwater in the urban environment.



Depth to groundwater

- Depth to water table across Perth Coastal Plain
- Very high degree of patchiness
- North-west: depth to water table > 10 m
- East and south: depth to water table 0-5 m

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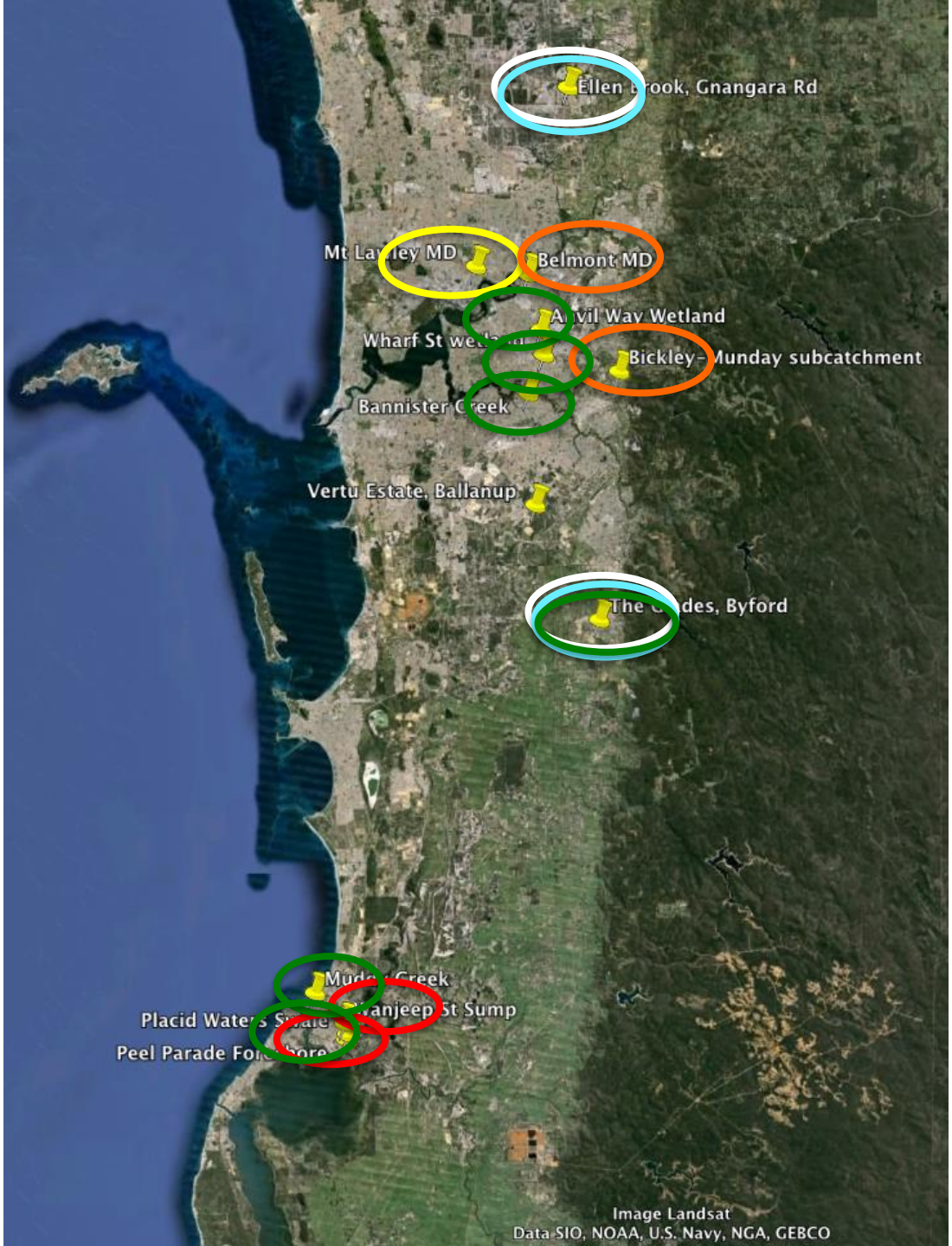

- Surface flow drains
- Subsurface flow drains
- Sub-surface drains
- Precinct drainage
- Infiltration basins
- Swales/streams/wetlands

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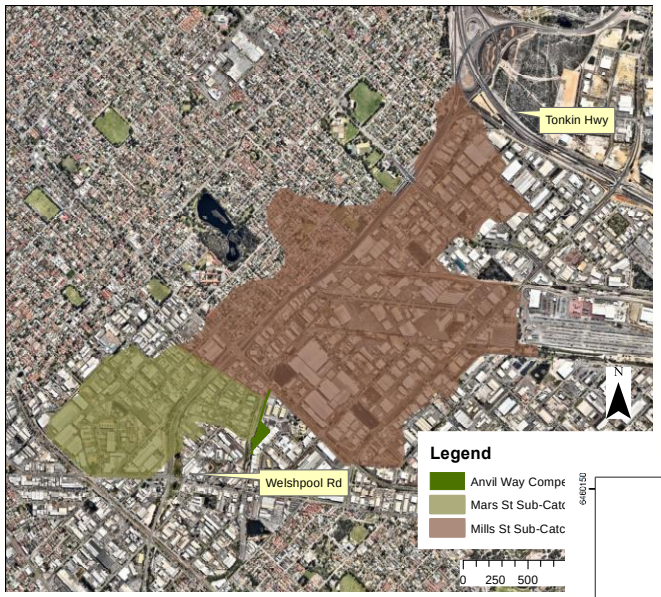
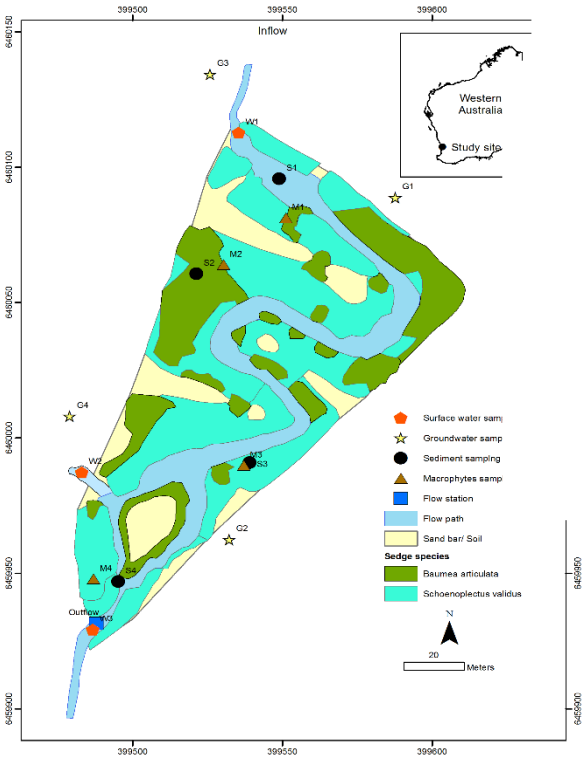
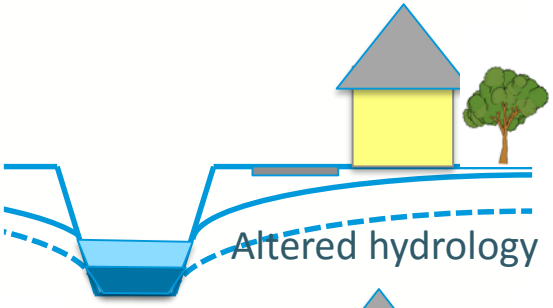
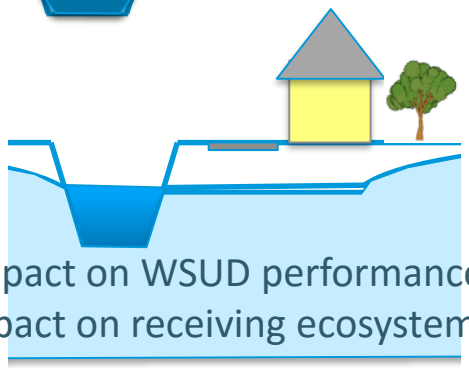
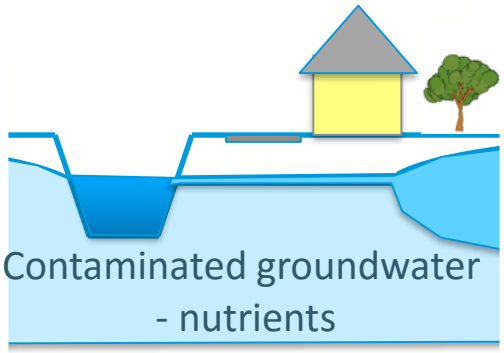
Anvil Way Constructed Wetland











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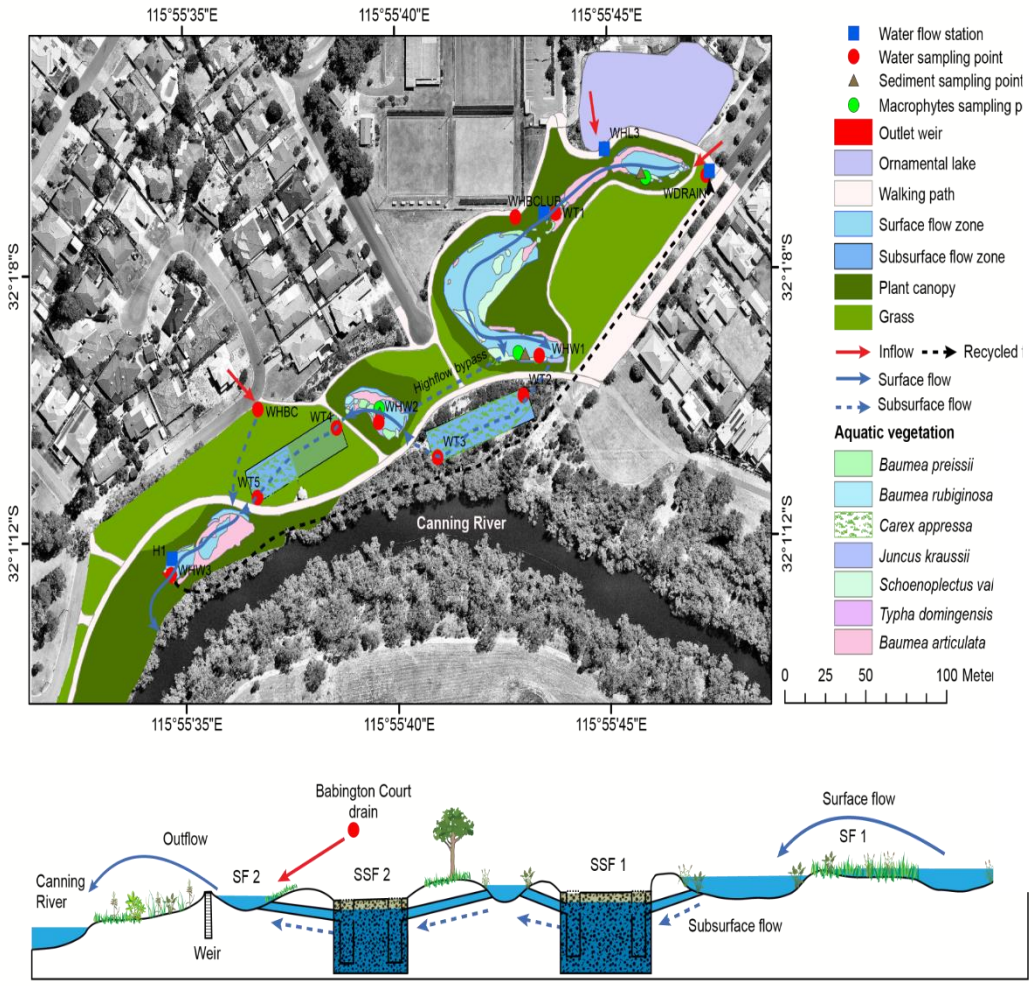
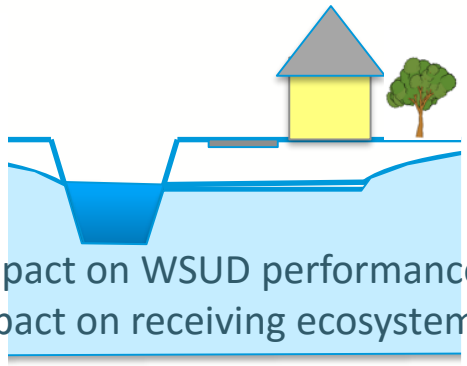
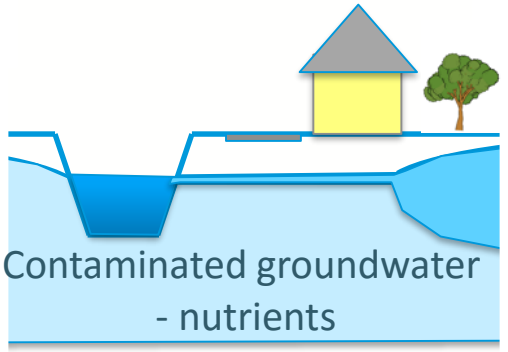
Wharf St Constructed Wetland



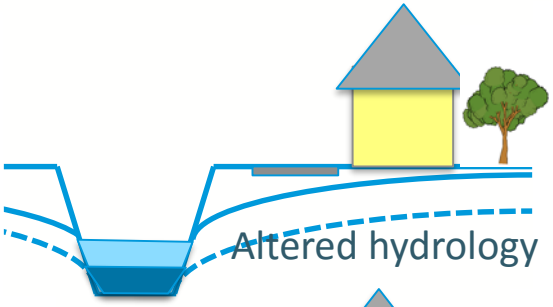


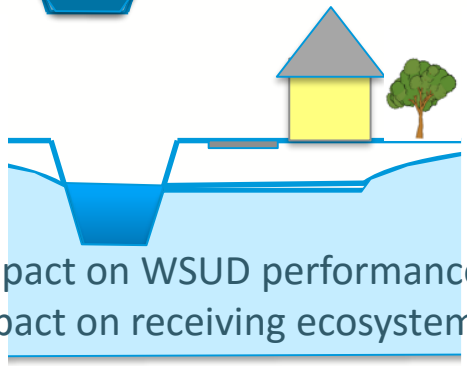
Impact on WSUD performance
Impact on receiving ecosystems



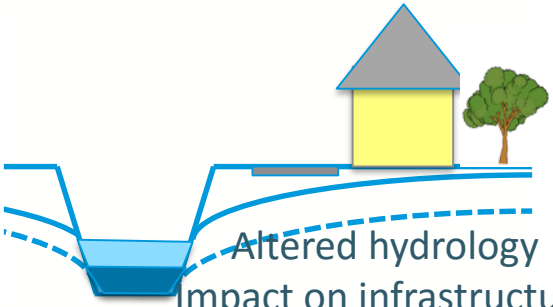
Contaminated groundwater
- nutrients

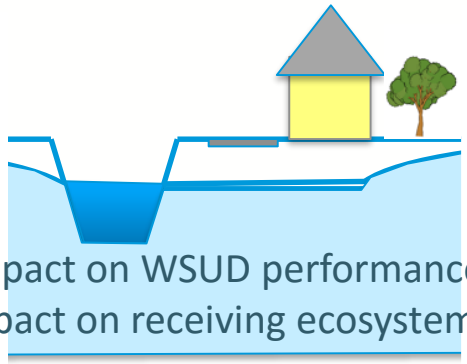
Mandurah infiltration basins

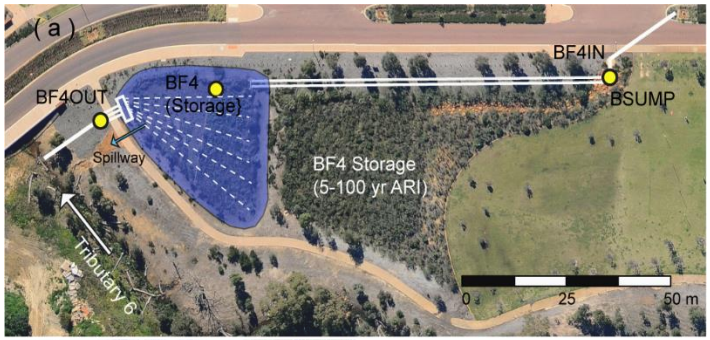


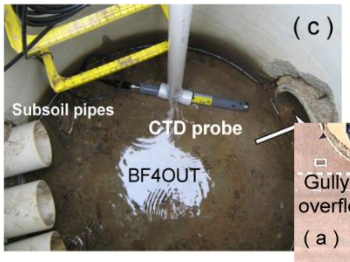


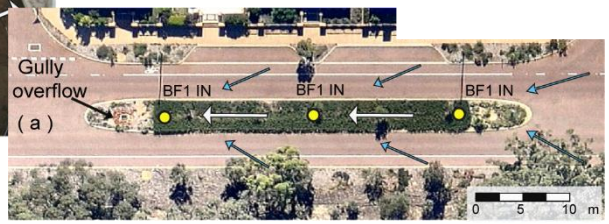
Infiltration basins at the Glades, Byford

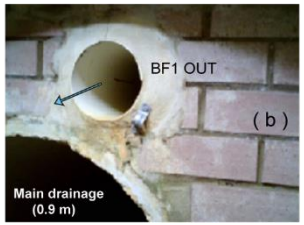


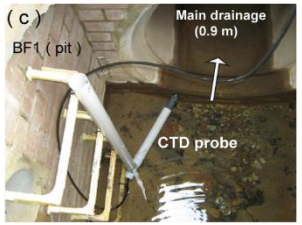












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Infiltration and sub-surface drainage: impacts of high groundwater

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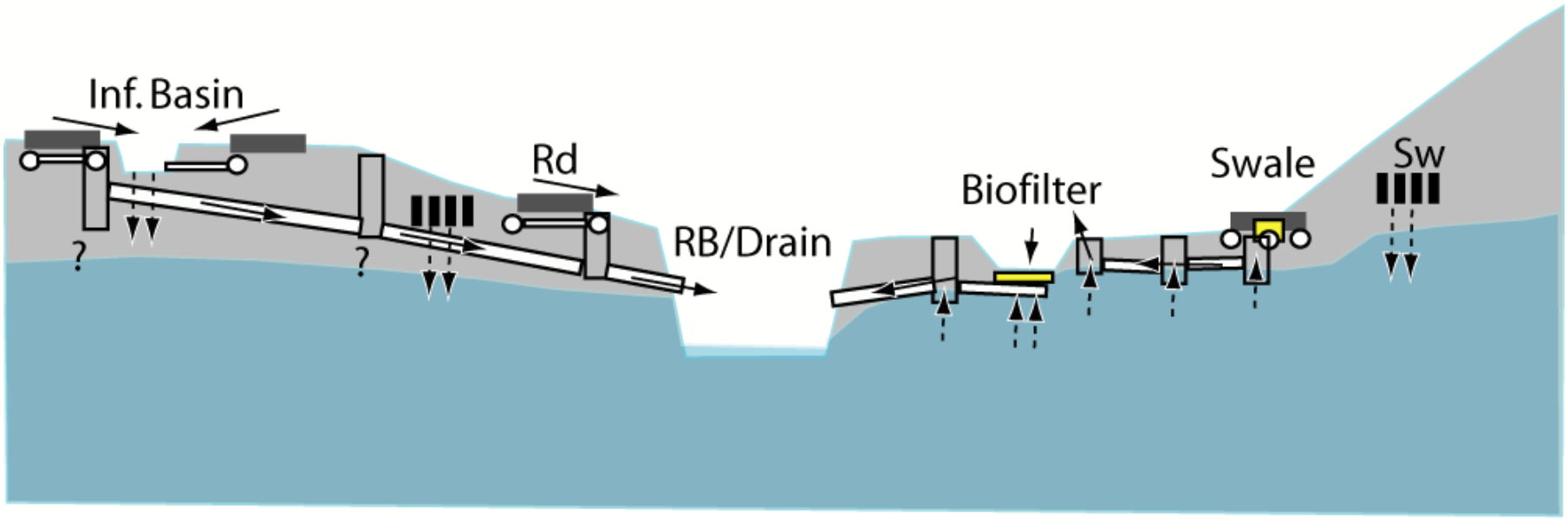
Urban karst

Intricate conveyance system (trenches, tunnels, pipes) - alters the pre-development porosity and permeability of the soil

- Variety of artificial recharge sources: linear and point sources,
- Direct recharge sources (infiltration from undisturbed land) and
- Local source from paths traditionally believed to be impervious (carparks, driveways, low permeability areas).



Recharge to groundwater

Raingardens

- 37-42 % (Schlea et al. 2014)
- Actual recharge higher than design conditions 1 y ARI (Lewellyn et al. 2015)
- Percolation 3 times faster than from soil
- Due to connectivity of the subsurface media to drainage pipes.

Infiltration trenches

- Recharge rate order of magnitude greater than lawn (Newcomer et al. 2014):
- 40% greater than thought

Retention basins

- Recharge affected by presence of shallow water table (Laws et al. 2011)
- 80% infiltration found at 2 m below

Urban pavements

- 21%, via cracks and joints (Wiles and Sharp 2008)

Pervious pavement with infiltration trenches

- Recharge increased by several orders of magnitude when water reaches sand fill and pipes (Brown and Borst 2015).

Retention basins and high groundwater

STORAGE

SOIL MEDIA

OUTFLOW

CREEK

RECHARGE

WATERTABLE

Retention basins and high groundwater

STORAGE

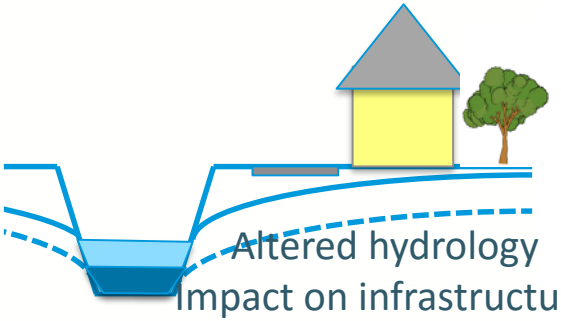
SOIL MEDIA

OUTFLOW

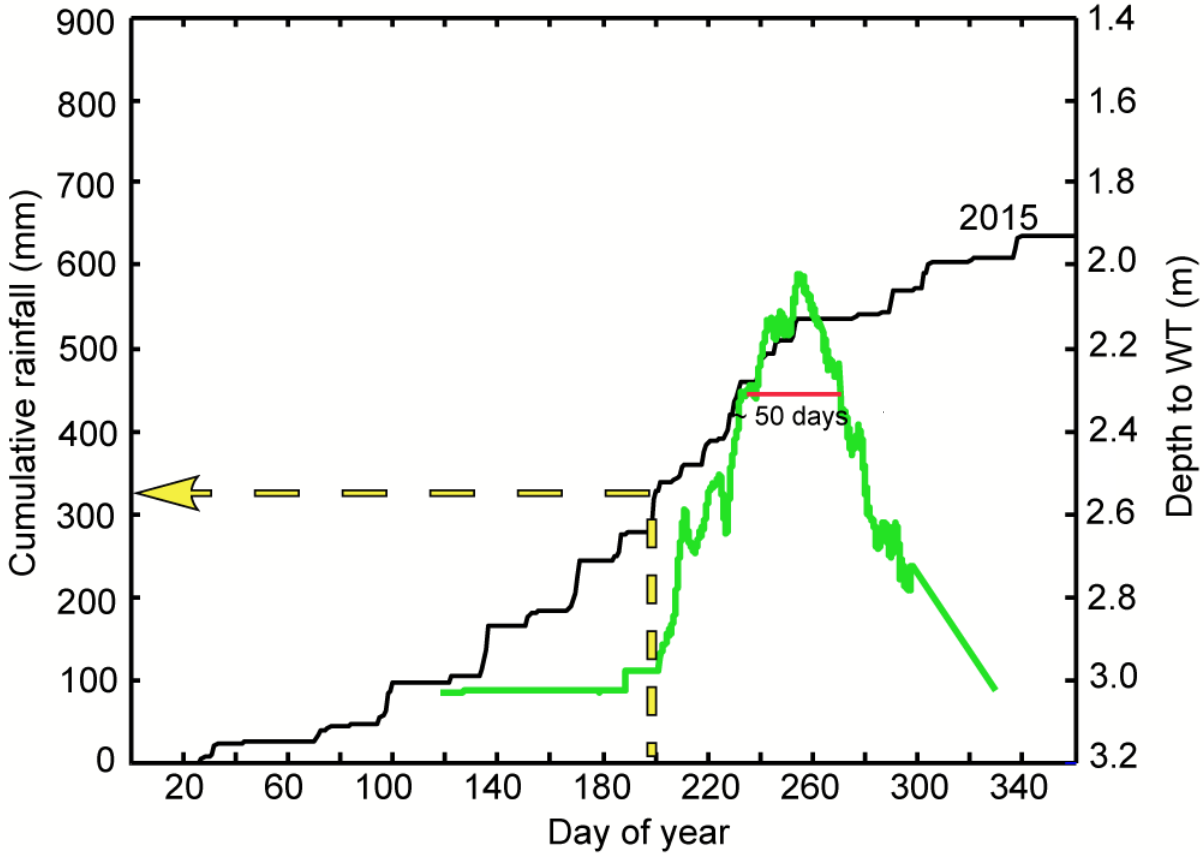
WATERTABLE

CREEK

DISCHARGE



High groundwater dynamics



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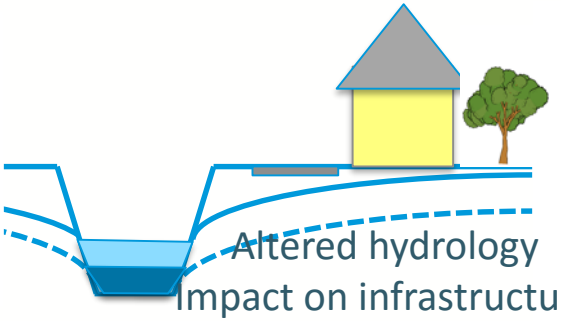

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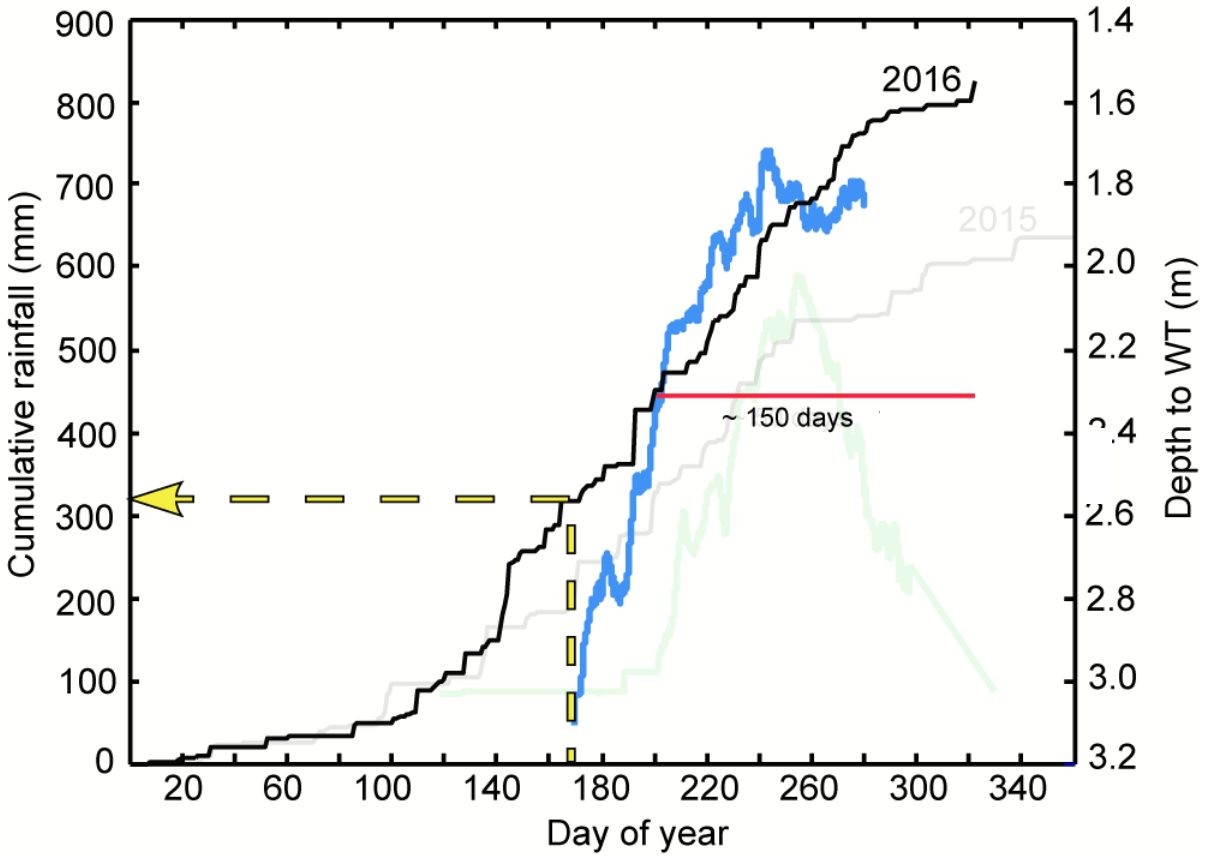
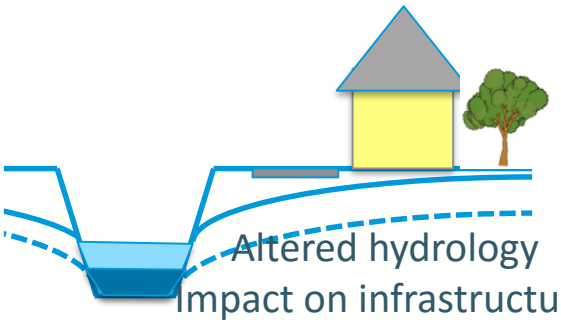
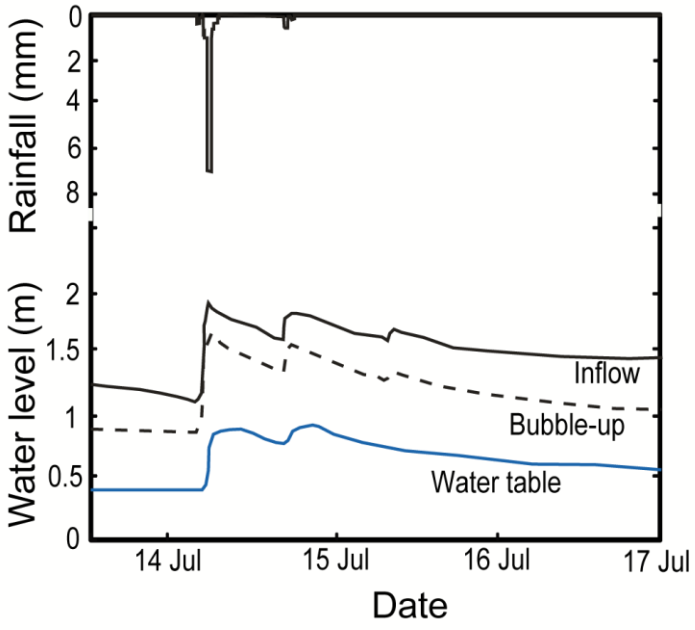


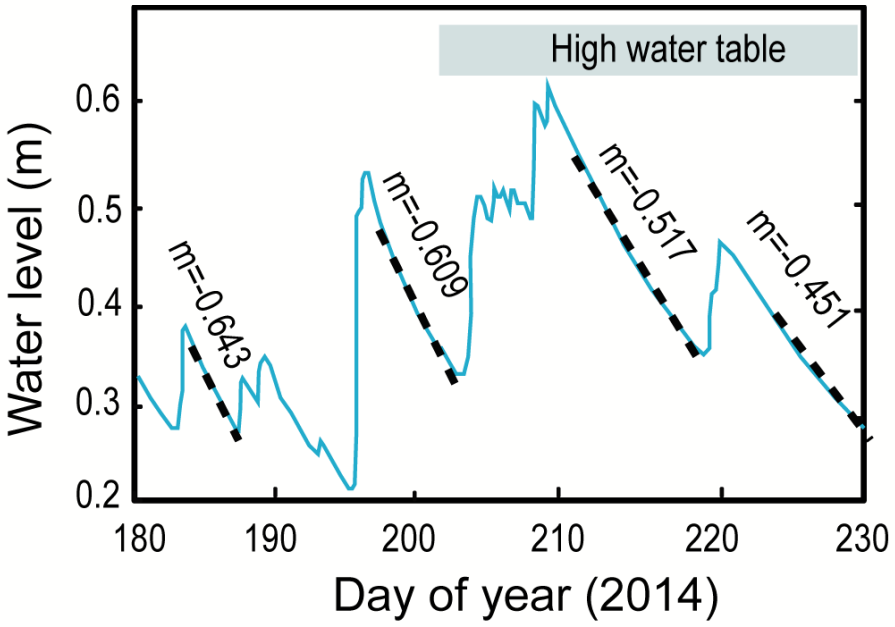


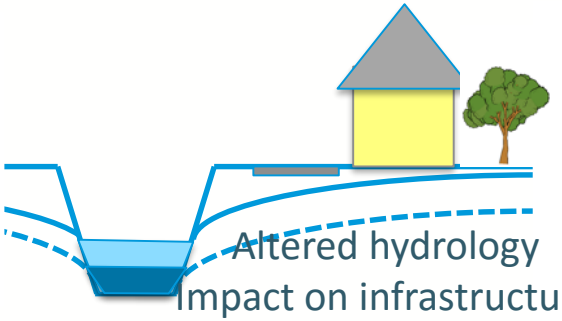
Retention basins - rapid infiltration and high groundwater

Vegetated swale

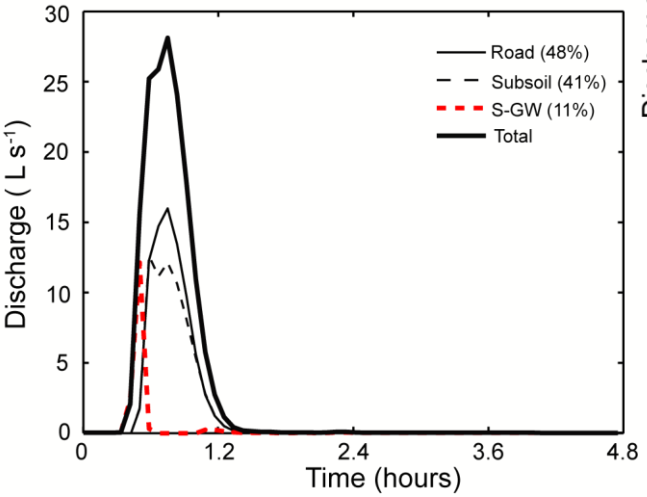


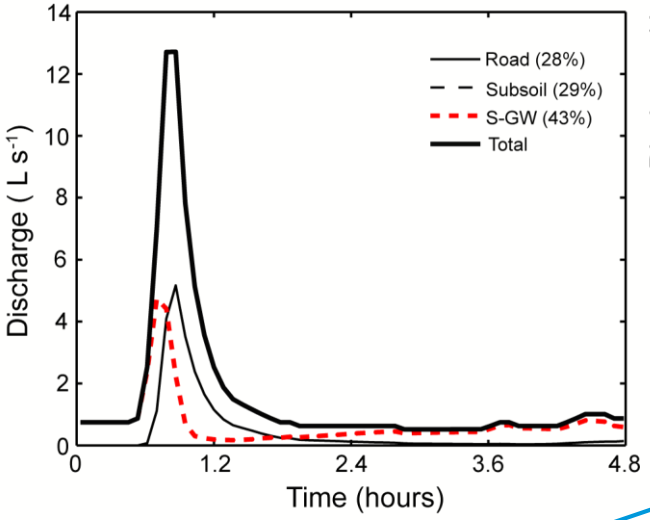
Detention basin (surface storage)

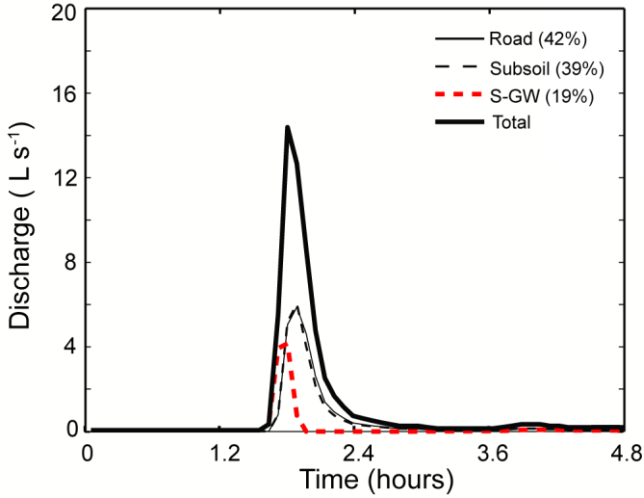




Raingarden - Discharge from high groundwater







Nutrient removal in WSUD elements: impact of high groundwater

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Nutrient attenuation

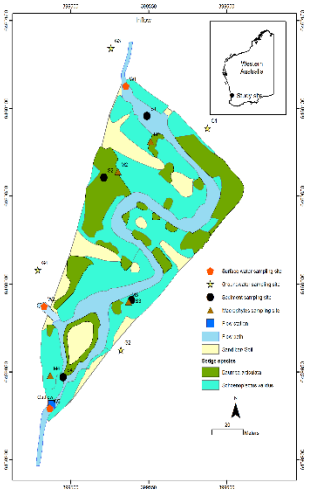
DEFINE PERFORMANCE

a) Do WSUD elements reduce nutrient concentrations to below ANZECC Guideline values?

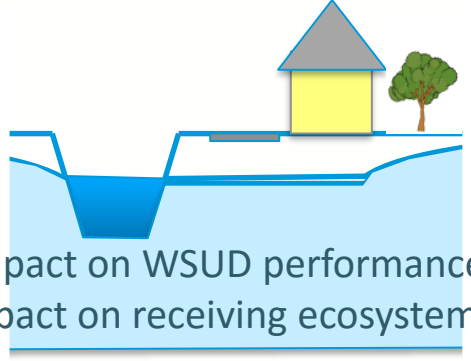
"**nutrient concentration reduction**"

a) Do WSUD elements attenuate nutrient load (mass of nutrients)? By how much?

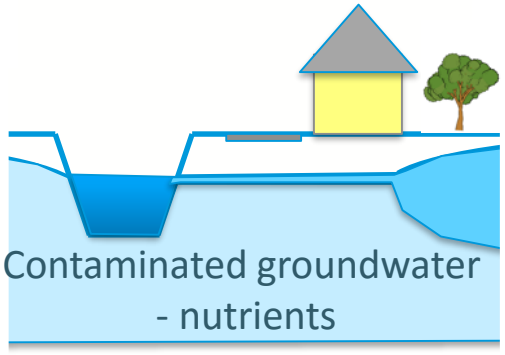
"**nutrient load attenuation**"



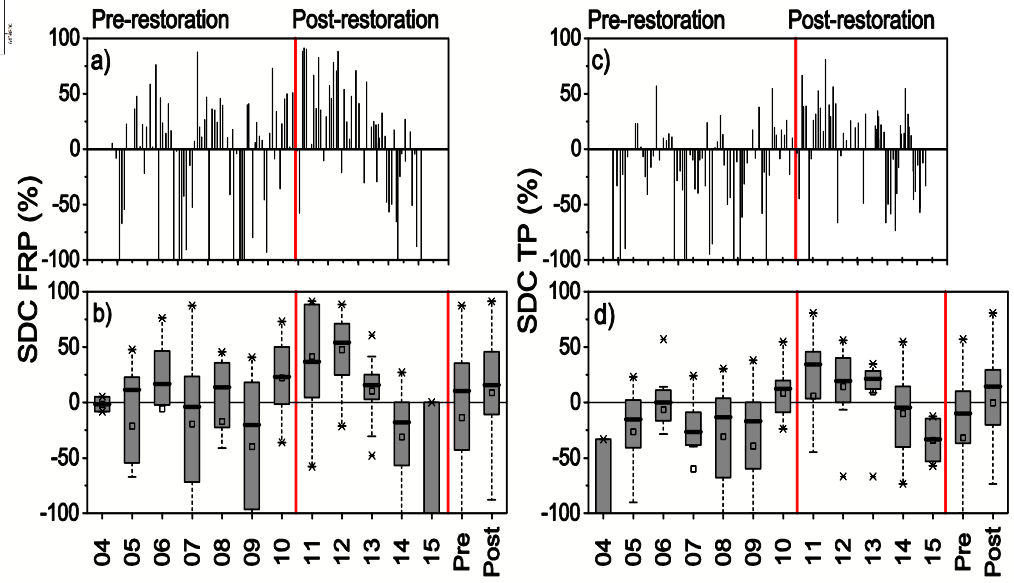
Nutrient concentration reduction
Long term changes: phosphorus

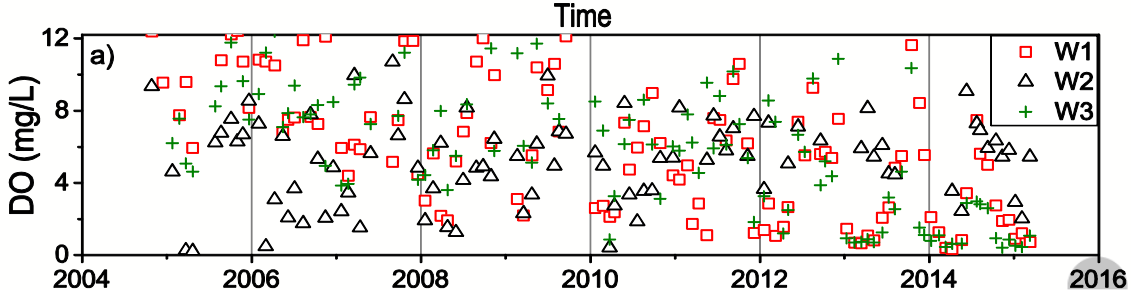


Impact on WSUD performance
Impact on receiving ecosystems



Contaminated groundwater - nutrients





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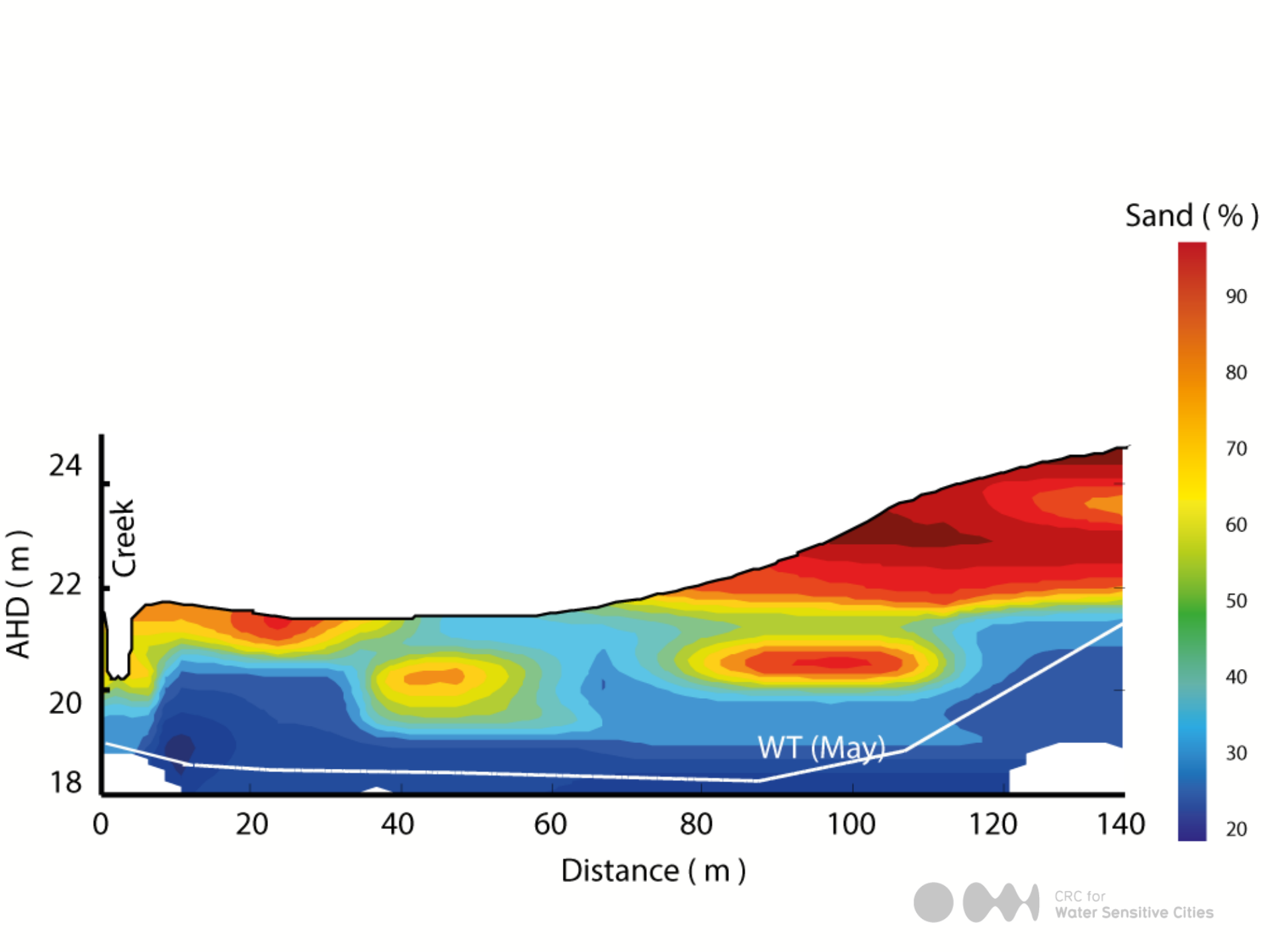
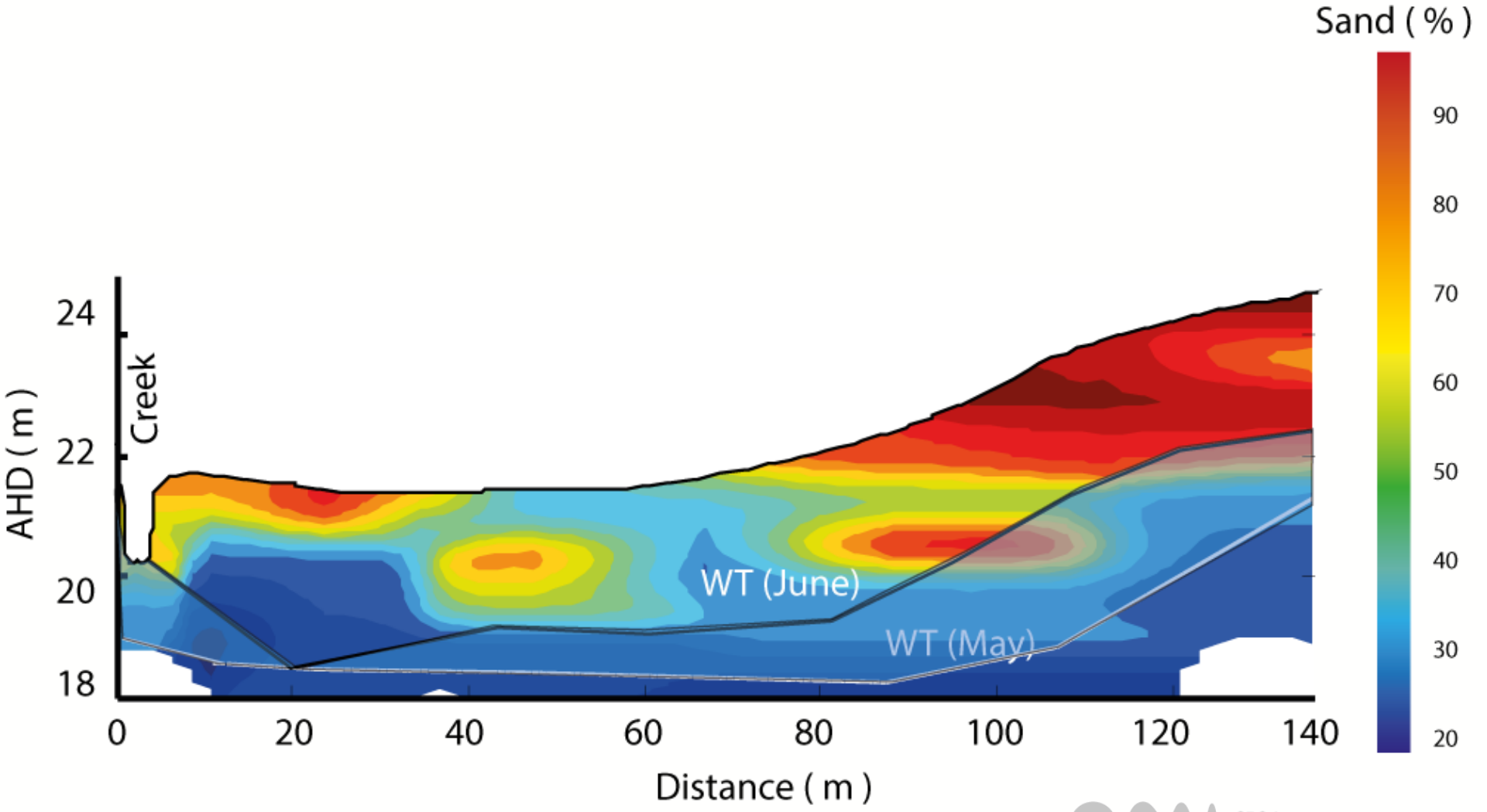
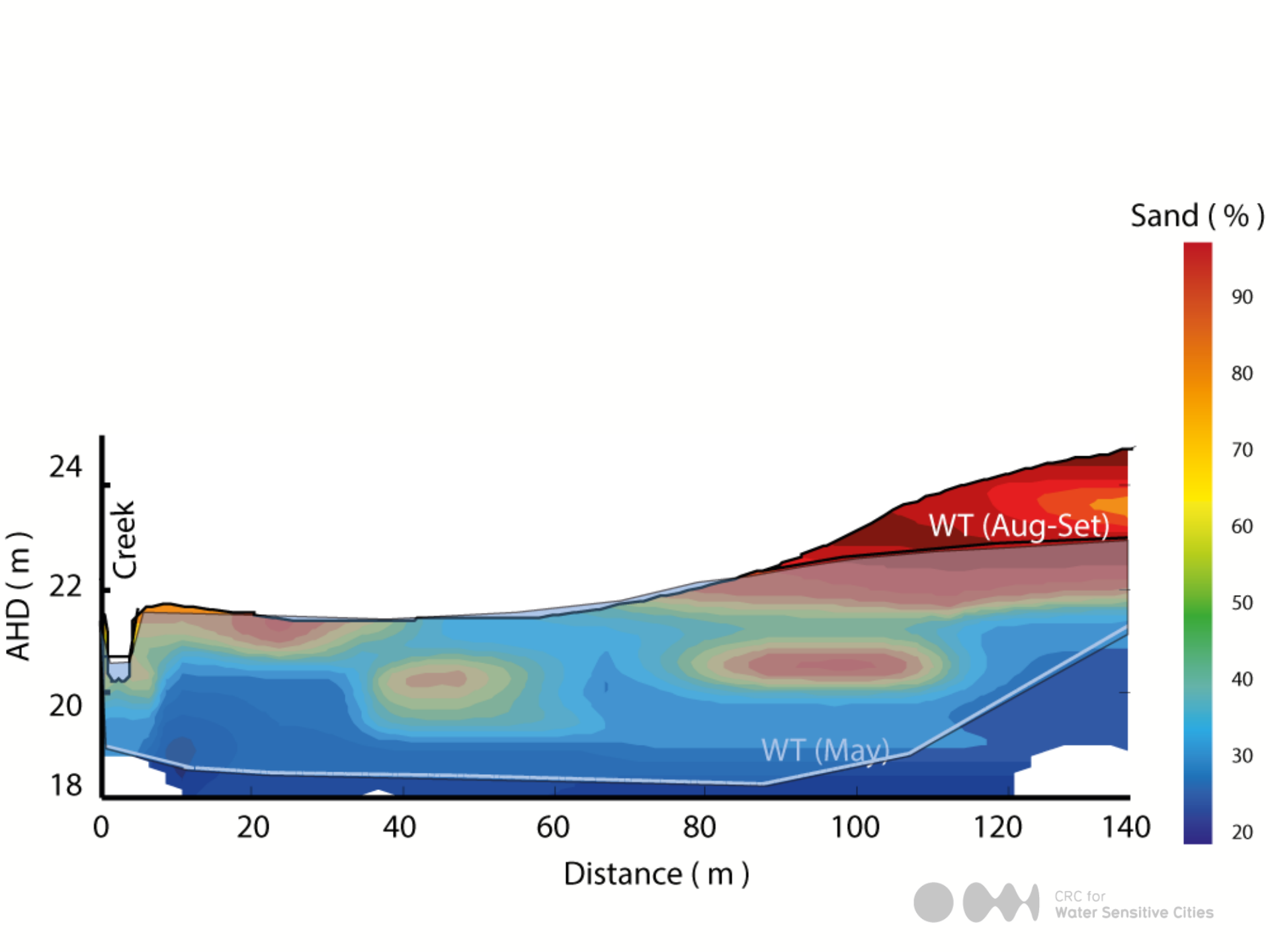
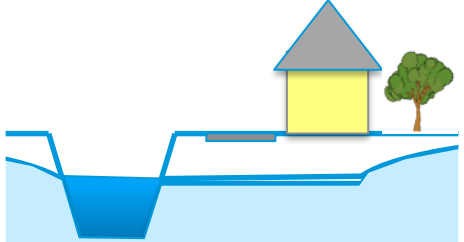


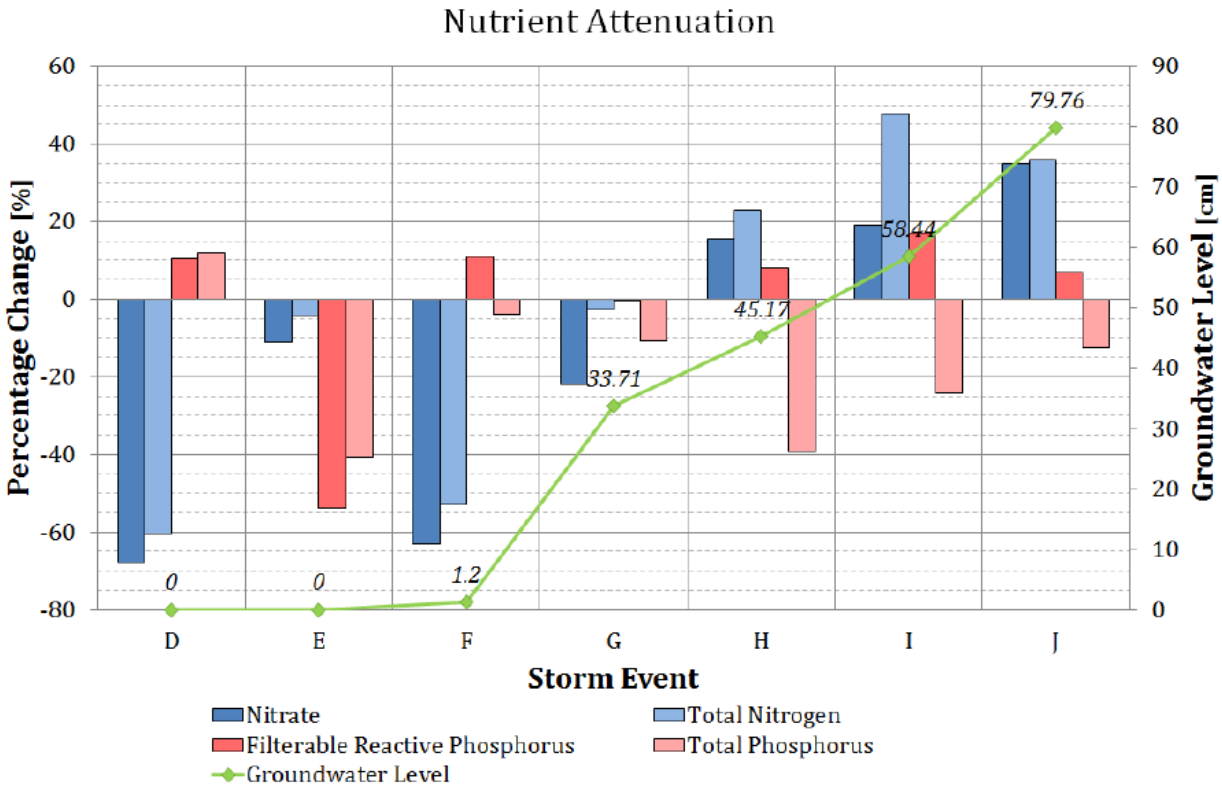


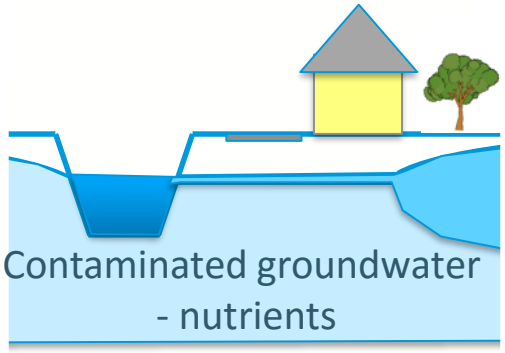

Sand (%)
90
80
70
60
50
40
30
20
AHD (m)
24
22
20
18
Creek
WT (Aug-Set)
WT (May)
0
20
40
60
80
100
120
140
Distance (m)
CRC for
Water Sensitive Cities



Impact on WSUD performance
Impact on receiving ecosystems

Nutrient load attenuation – Seasonal variability

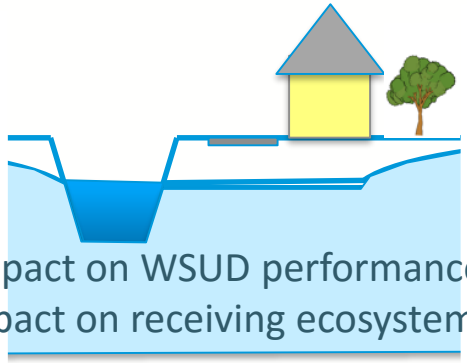


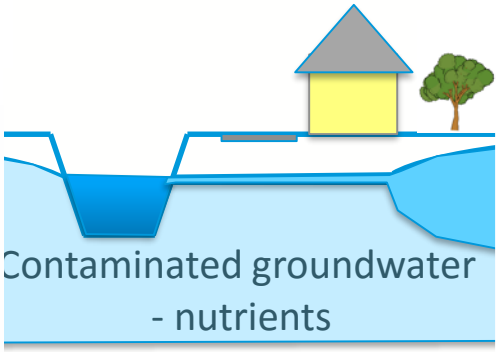


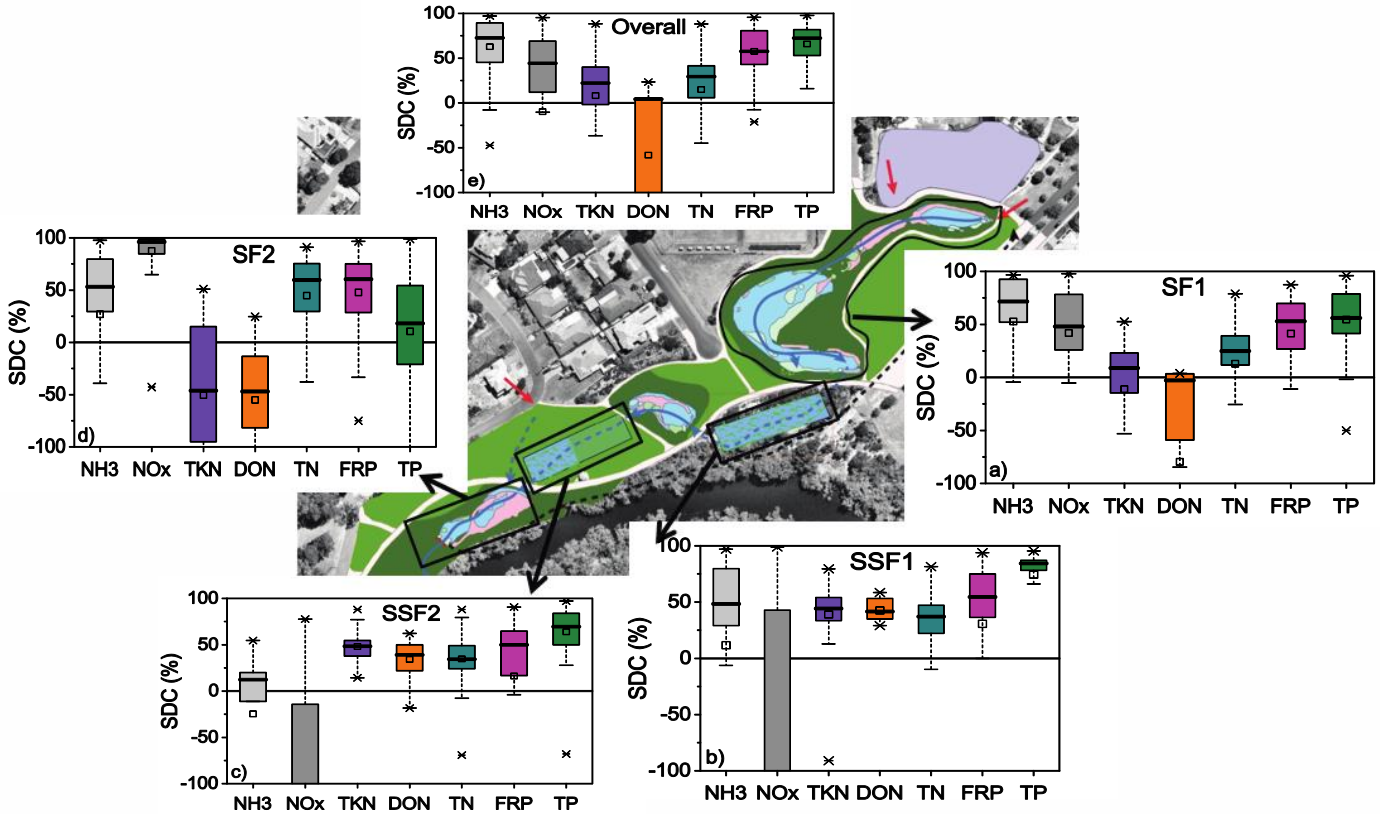
Contaminated groundwater - nutrients

CRC for Water Sensitive Cities

Nutrient concentration reduction – Spatial variability

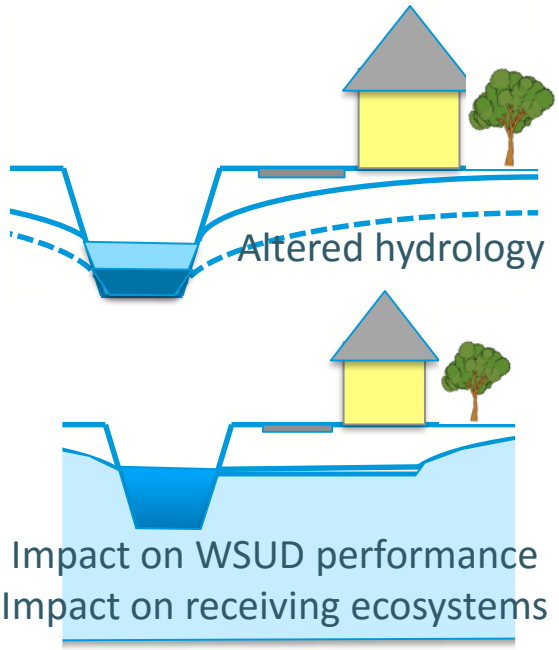




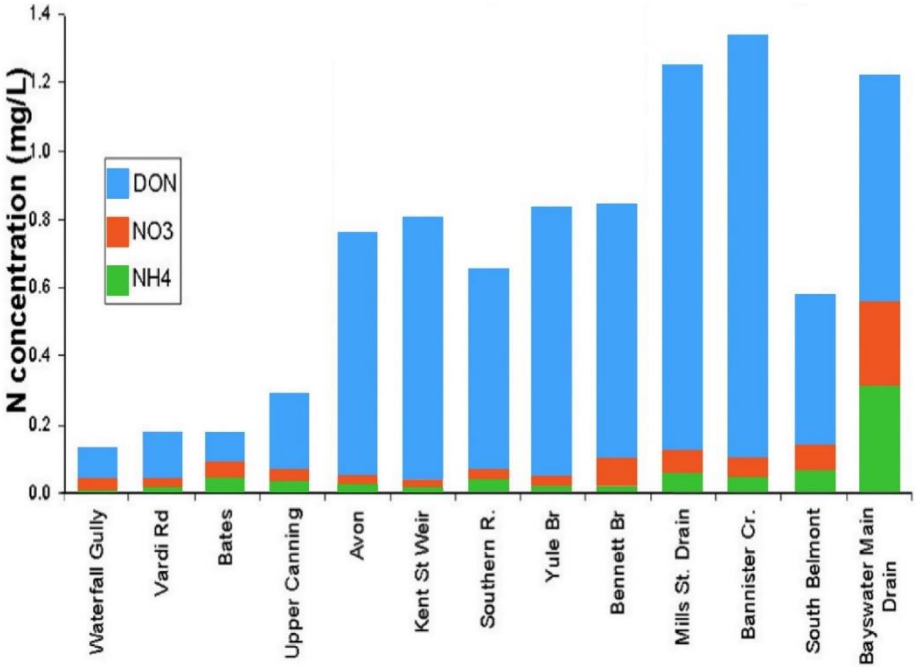


CRC for Water Sensitive Cities

Nutrient concentrations – inorganic-N vs organic-N



- Urban streams, drains and groundwater frequently dominated by organic nutrients;
- WSUD elements often release Inorg-N and Org-N – need to understand this more.



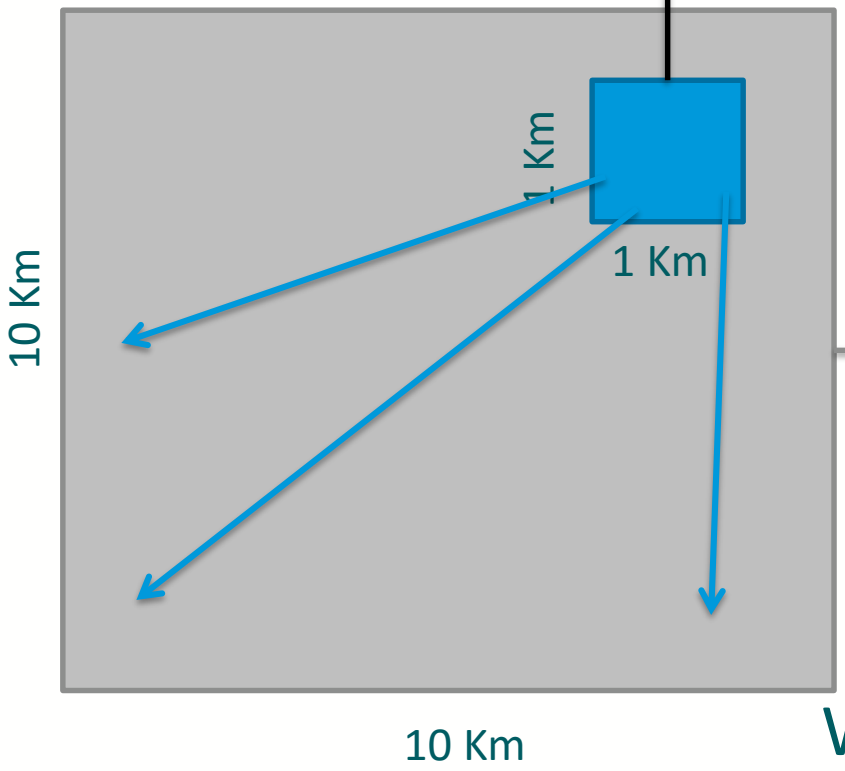
Implications for urban water management

- **Recharge** is higher than often assumed, even from impervious surfaces.
- Use of sub-surface drainage and sand fill **fundamentally alters hydraulics of landscape** => impact on flows, oxygen conditions and nutrients
- Careful when, where and how you monitor!
- Assess importance of **organic nutrients.**
- Design to specifically manage **dissolved oxygen**, like we do in lakes and estuaries - change of mind set.
- Consider designing for **multi-compartment** and **multi-functional** wetlands – alternating redox conditions.
- Manipulate using aeration, windmills, **sub-surface flow pathway**s.

Questions arising…

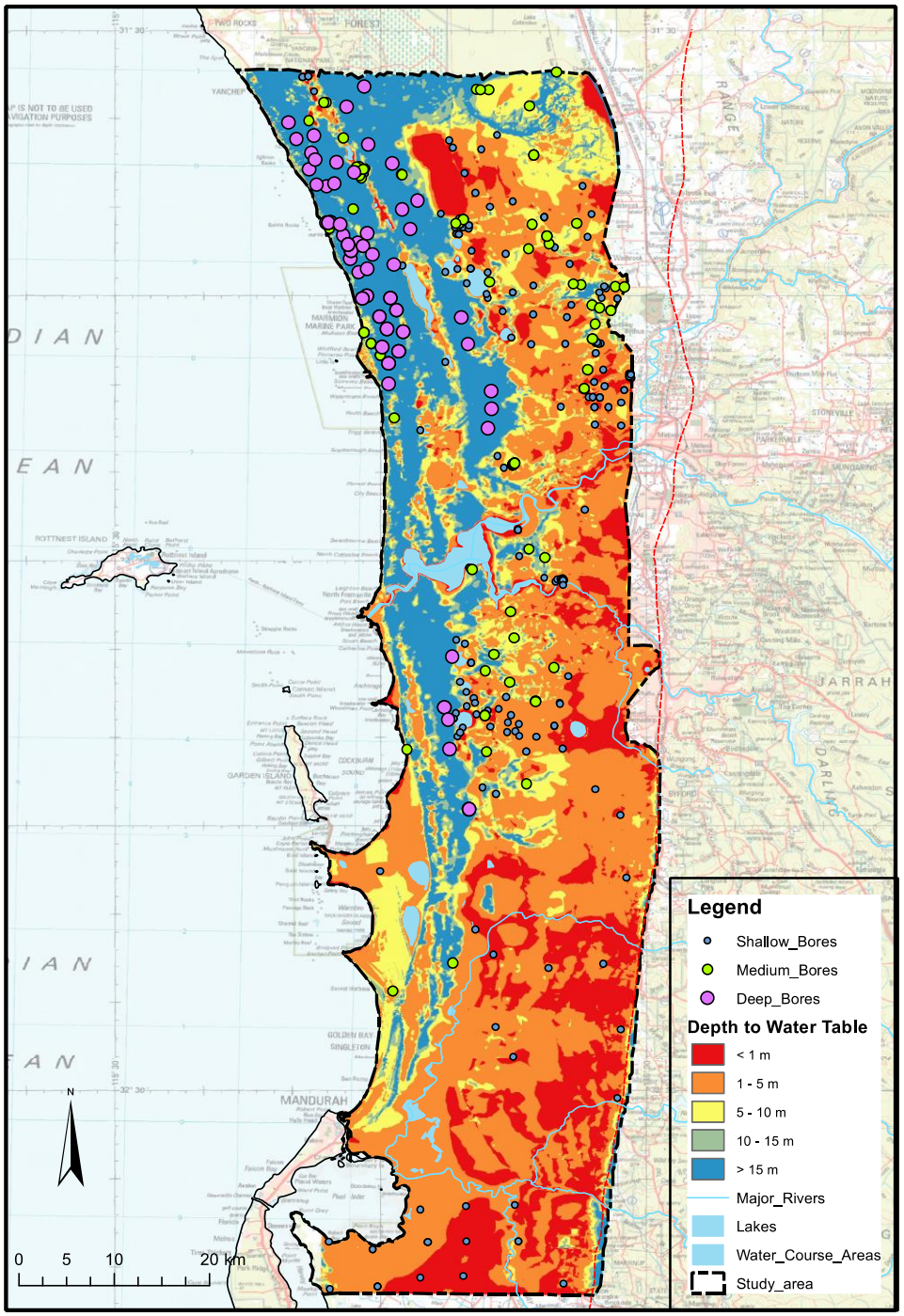
- How should we manage organic nutrients?
- What are recharge and runoff rates for all urban typologies and housing densities?
- How do we design for optimal treatment effectiveness under a range of hydrogeological conditions and development scales?
- How to optimise water quality monitoring?
- How to challenge “business as usual” development – considering different development construction and catchment-scale solutions

Scales of management and innovation



Urban Form Innovation

Water Management Innovation



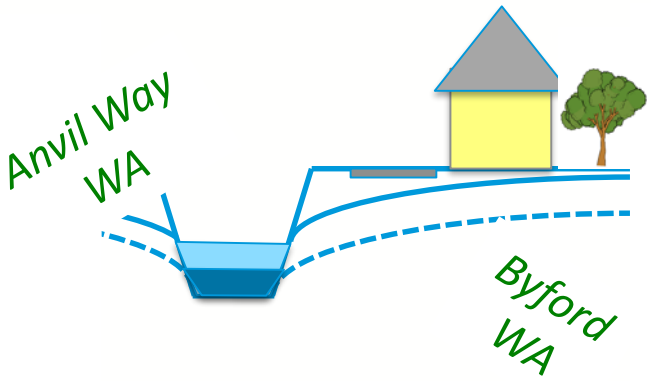
Depth to groundwater

CRC for Water Sensitive Cities

A: Hydraulics

Altered hydrology

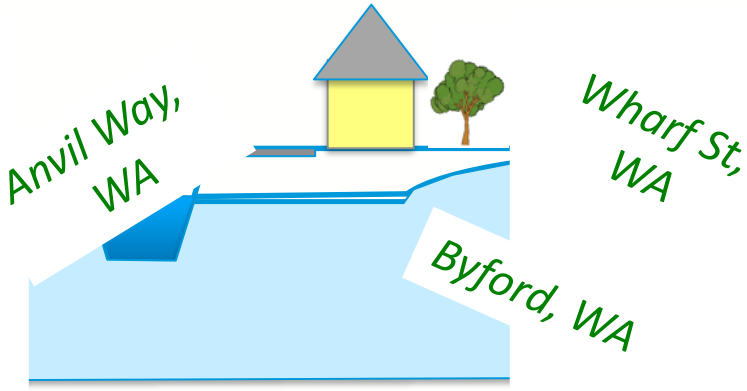
Impact on infrastructure



B: Ecology

Impact on WSUD performance

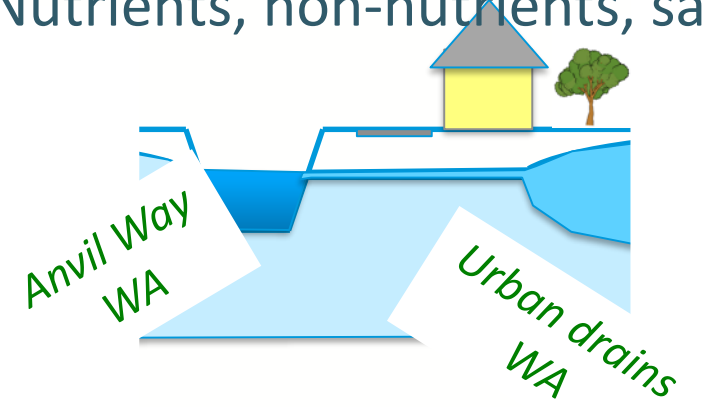
Impact on receiving ecosystems



D: Contamination

Contaminated groundwater

Nutrients, non-nutrients, salinity



D: Re-use

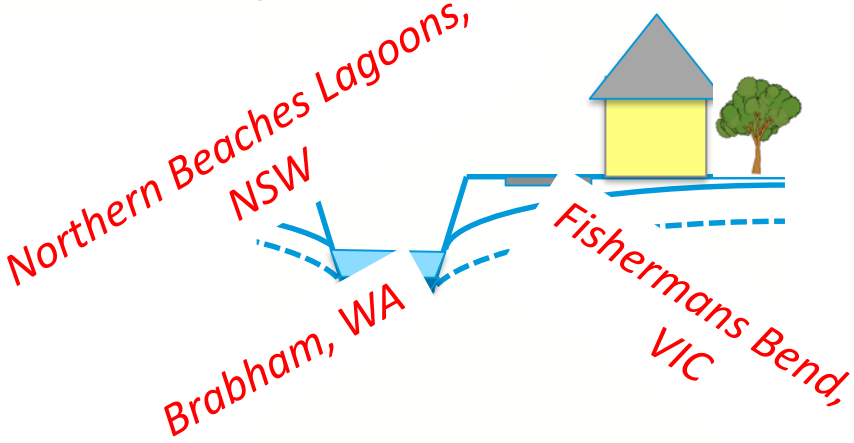
Managed groundwater re-use

Controlling saline intrusion

A: Hydraulics

Altered hydrology

Impact on infrastructure



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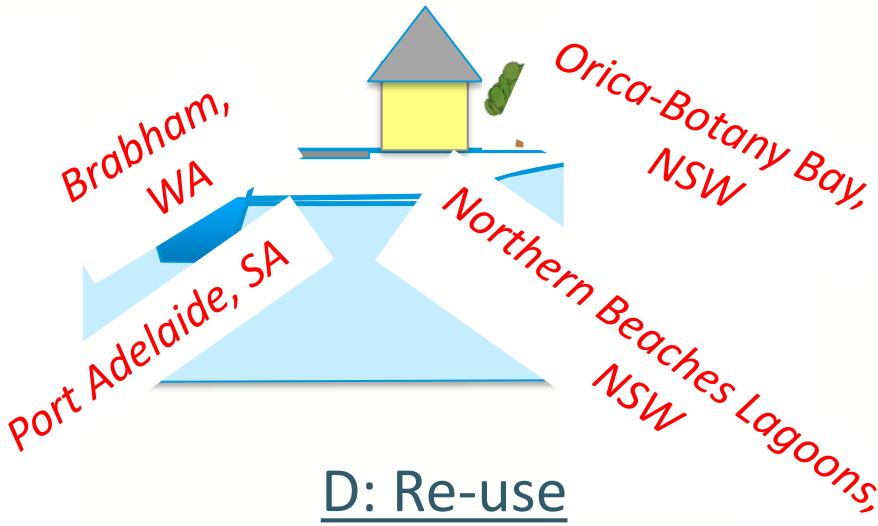

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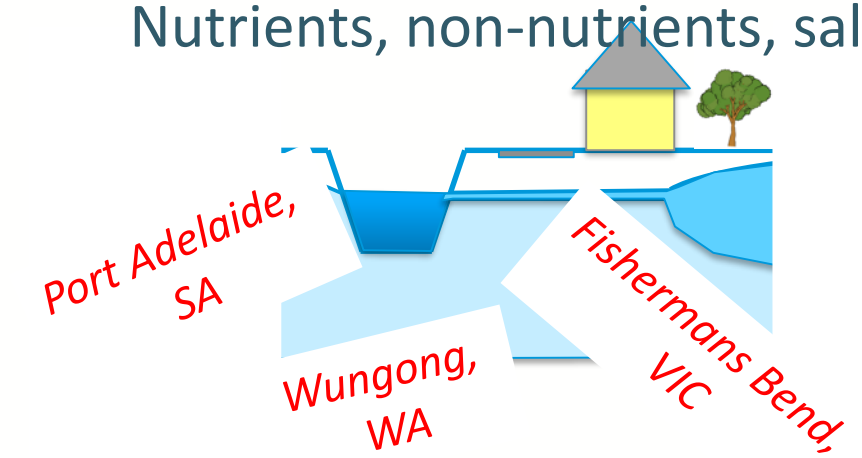

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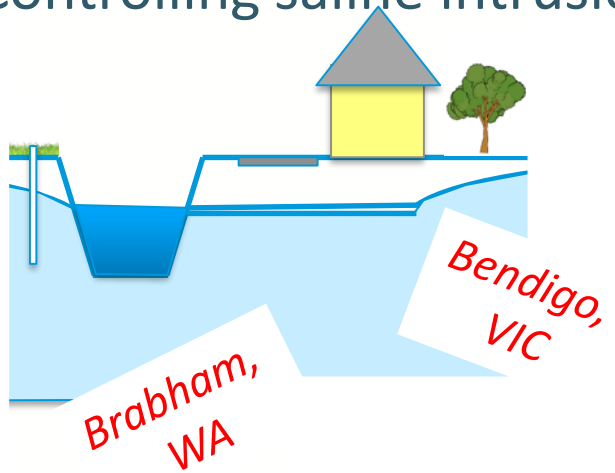

Questions?