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Enhancing Nutrient Retention in Bioretention

Tim Van Seters

March 20, 2019

The water component of STEP is a collaborative of:

Lake Simcoe Region conservation authority

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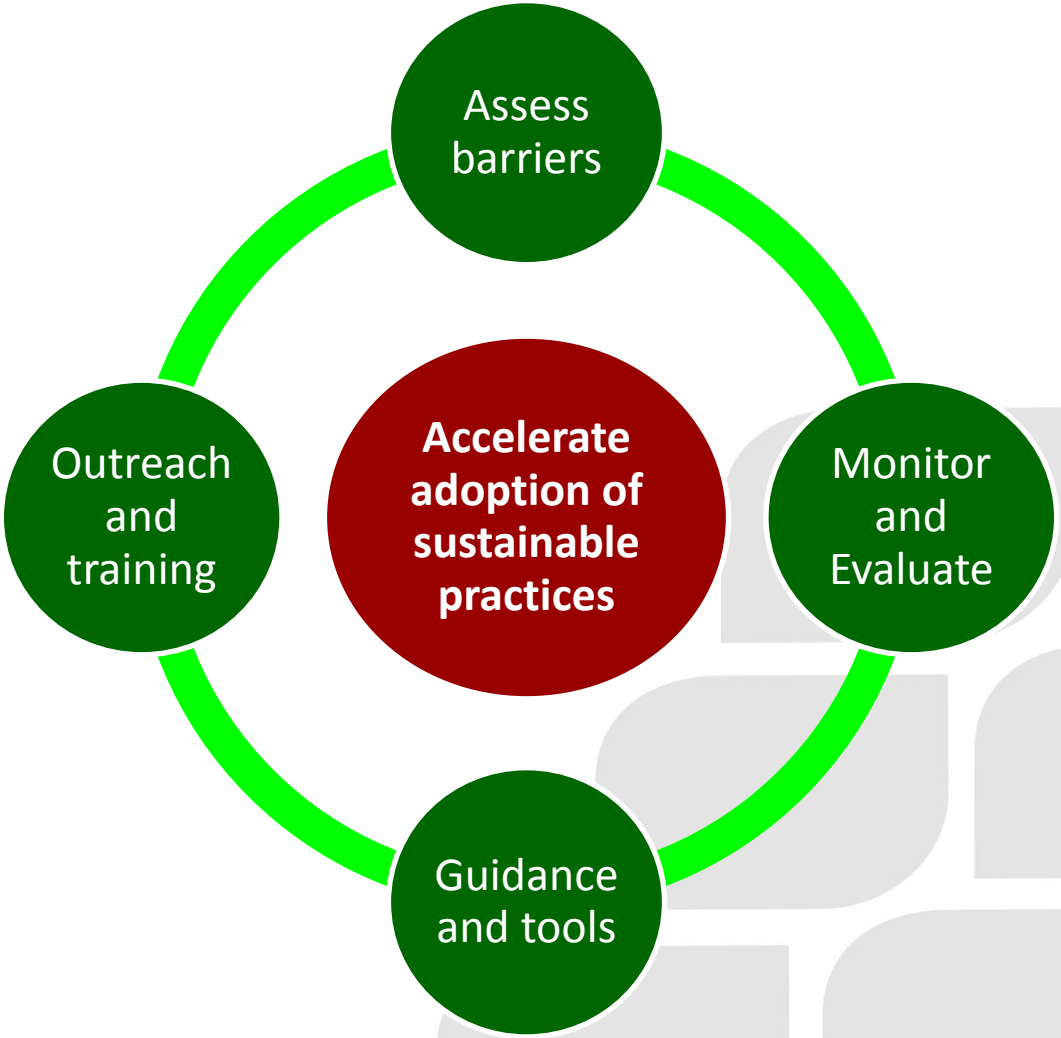
Sustainable Technologies Evaluation Program



Outline

- Background
  - Sources of phosphorus
  - Typical effluent ranges
  - Soil amendments as a method to enhance P retention
  - Material selection considerations
- Comparative field study of reactive media

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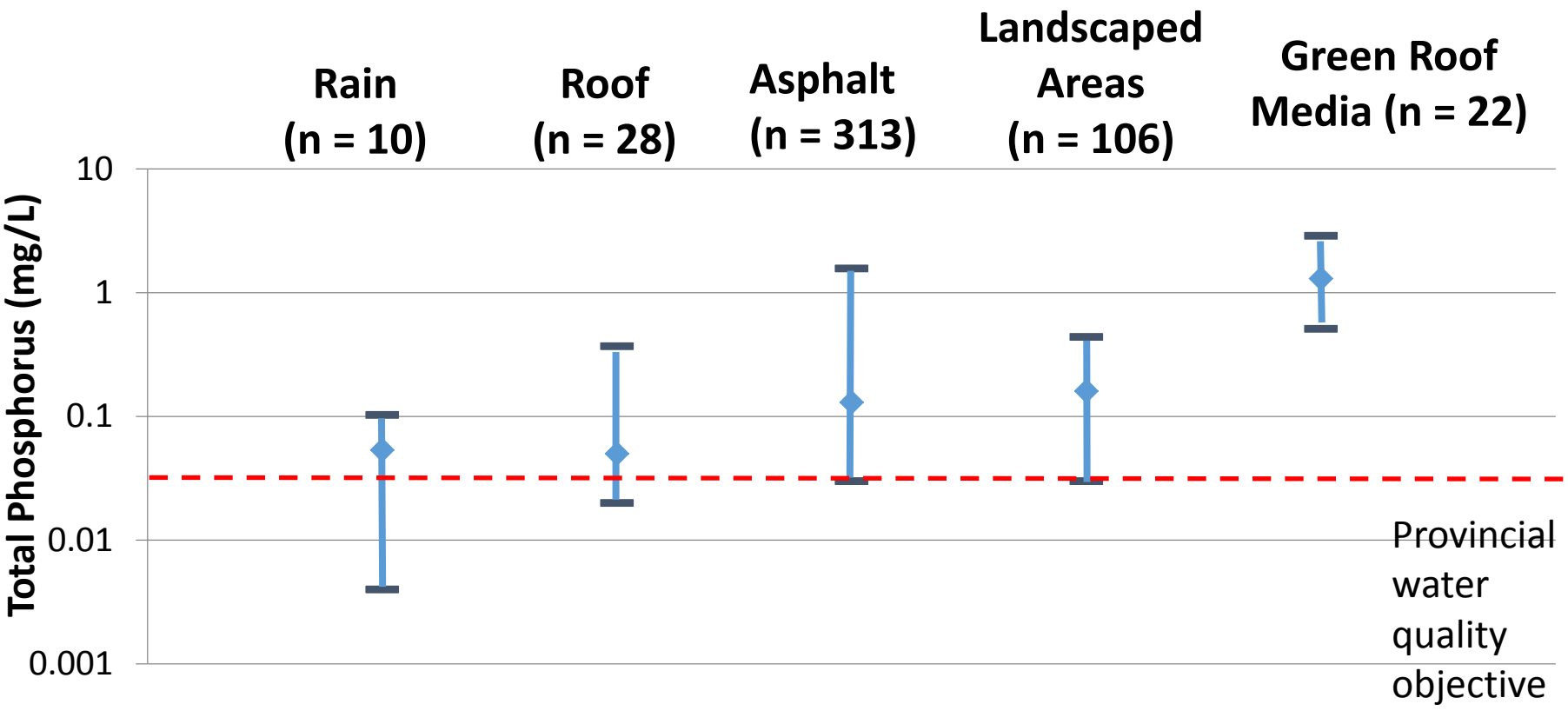
Sources of Phosphorus in Urban Runoff



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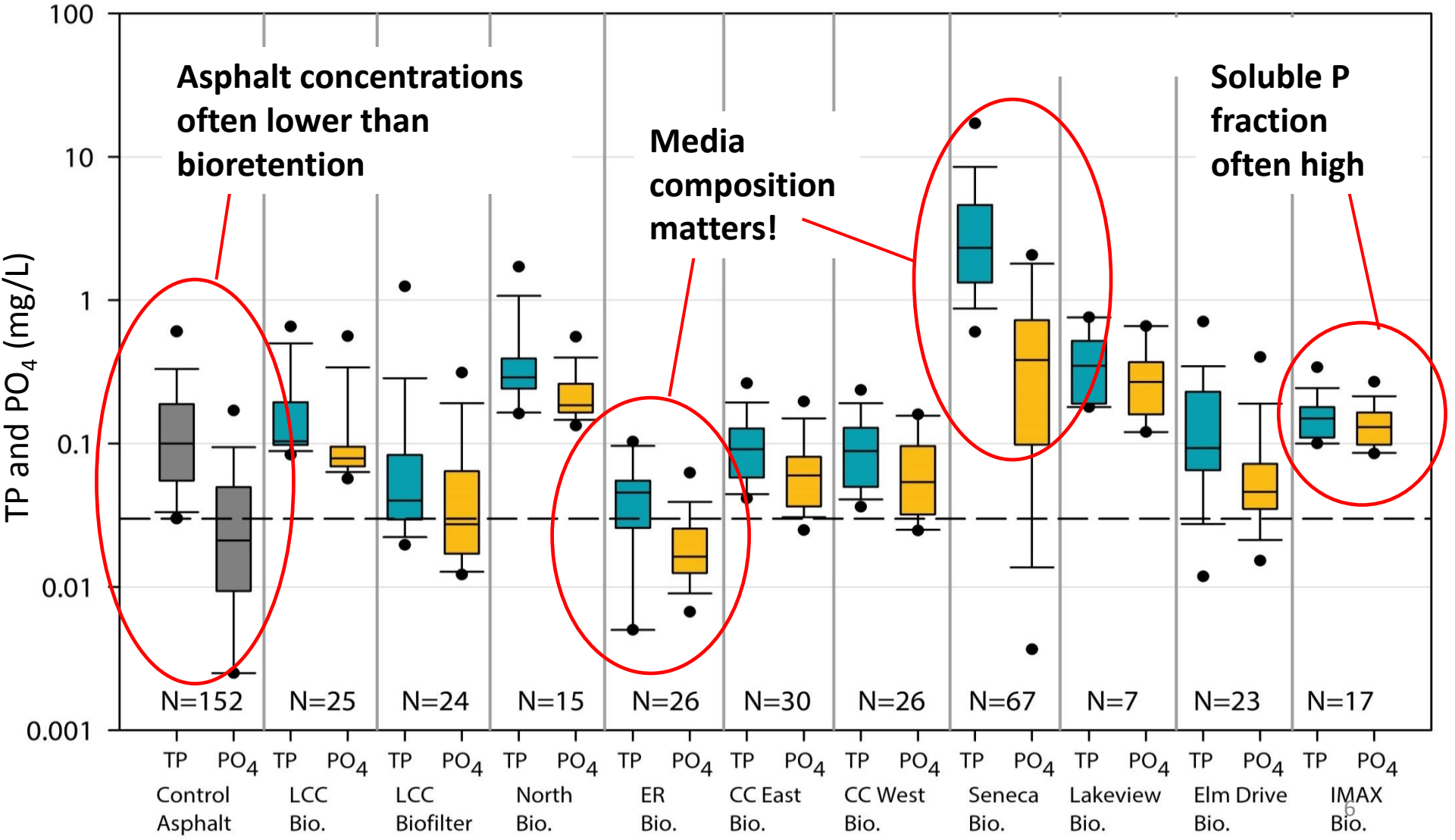
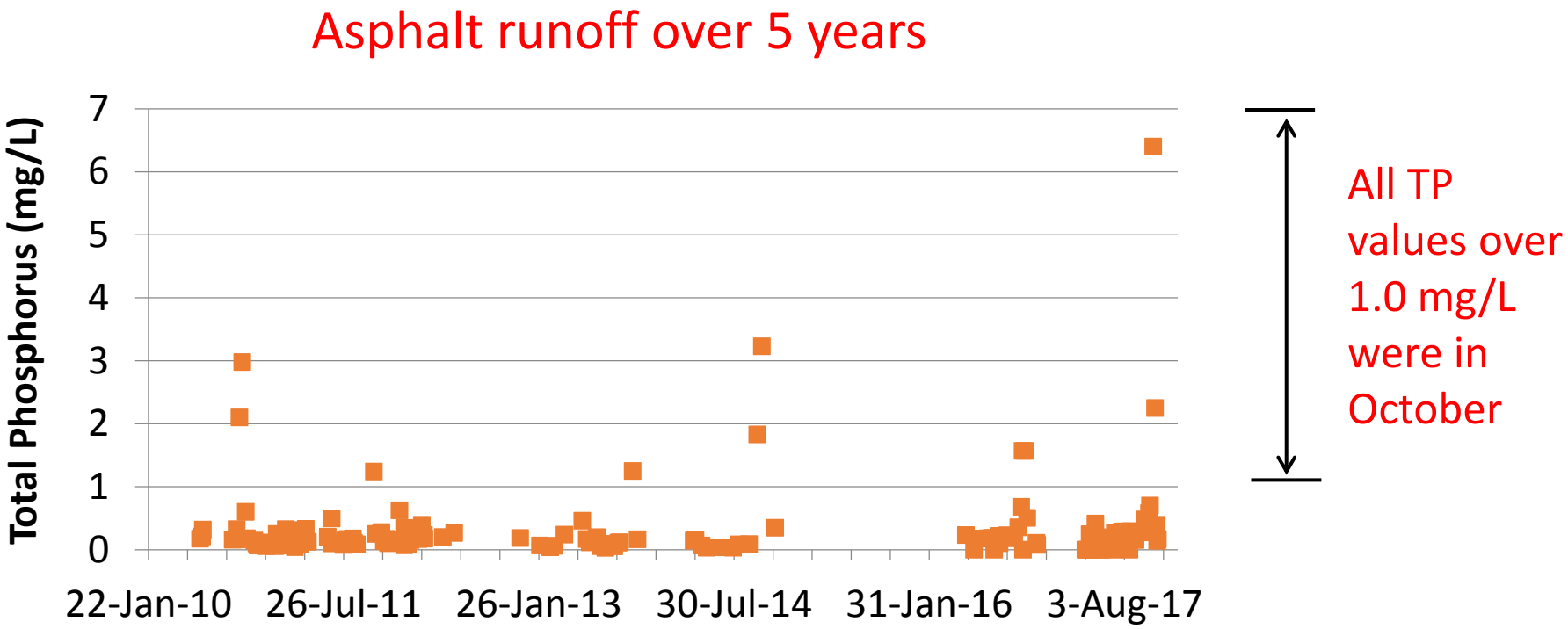
TP and PO_4 Bioretention Effluent Concentrations



Seasonal Phosphorus Release



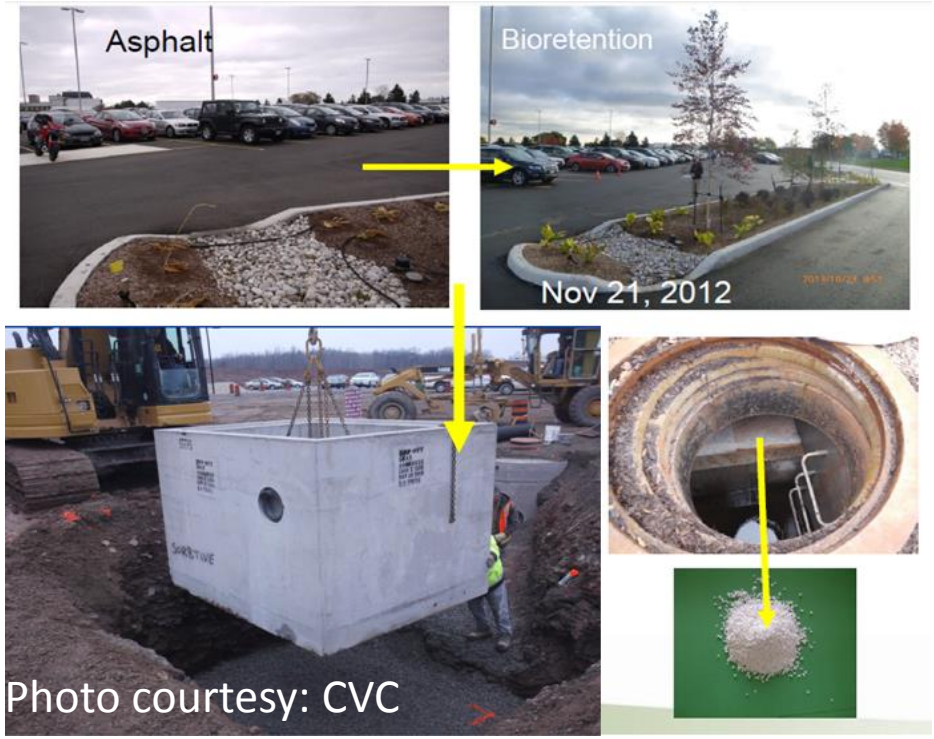
Soil amendments to enhance phosphorus retention

- P sorbing materials typically contain metal cations to create insoluble compounds via sorption and/or precipitation
- Common amendments:
  - **Natural materials**: e.g. iron rich soils, limestone, volcanic soils
  - **Waste materials**: e.g. WTRs, fly ash, mining slag
  - **Processed or modified materials**: e.g. iron filings, steel wool, proprietary media

Amendment Selection Considerations

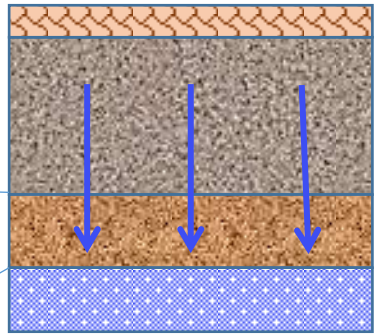
- Media properties: sorption capacity, longevity, reaction kinetics, desorption potential, physical characteristics
- Unwanted byproducts in effluent or soil
- Toxicity to soil, water, plants, humans
- Impact on soil fertility and plant uptake
- Effects on system hydraulic properties
- Effective operating conditions
- Consistent quality
- Availability and cost
- Re-use options

System Design Configurations



Drainage to bioretention to vault with reactive media

Mix reactive media with bioretention media



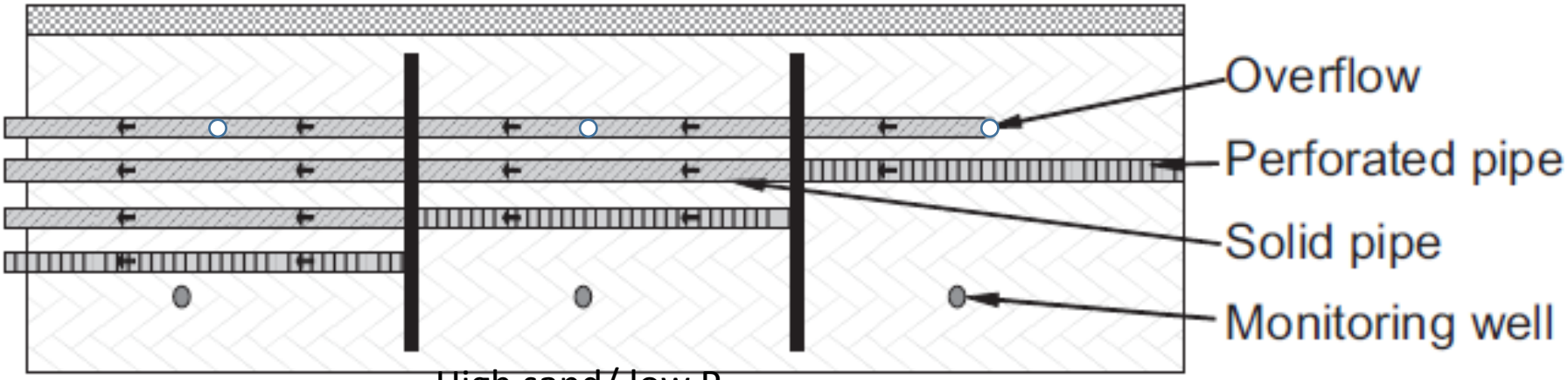
As a layer under bio media

Study Site

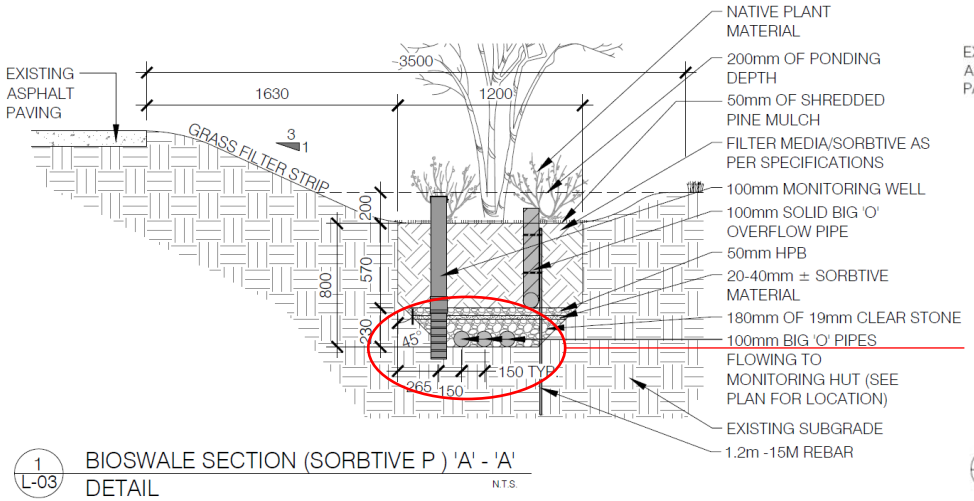

Sorbtive®
Control
Red Sand
Drainage Area = 1,150 m²
Asphalt Control
Google

Experimental Set-up

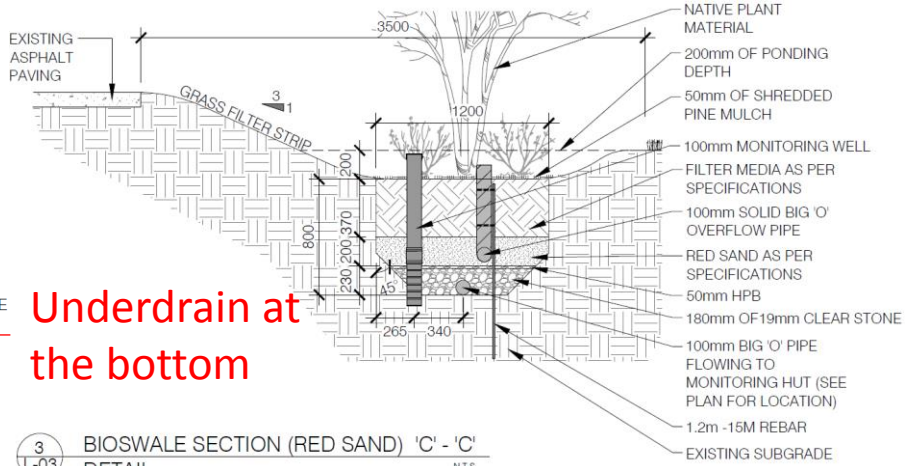
Sorbtive® **Control** **Red Sand**



High sand/ low P



1 L-03 BIOSWALE SECTION (SORBTIVE P) 'A' - 'A' DETAIL N.T.S.



Underdrain at the bottom

3 L-03 BIOSWALE SECTION (RED SAND) 'C' - 'C' DETAIL N.T.S.

Construction and Installation

Monitoring set-up

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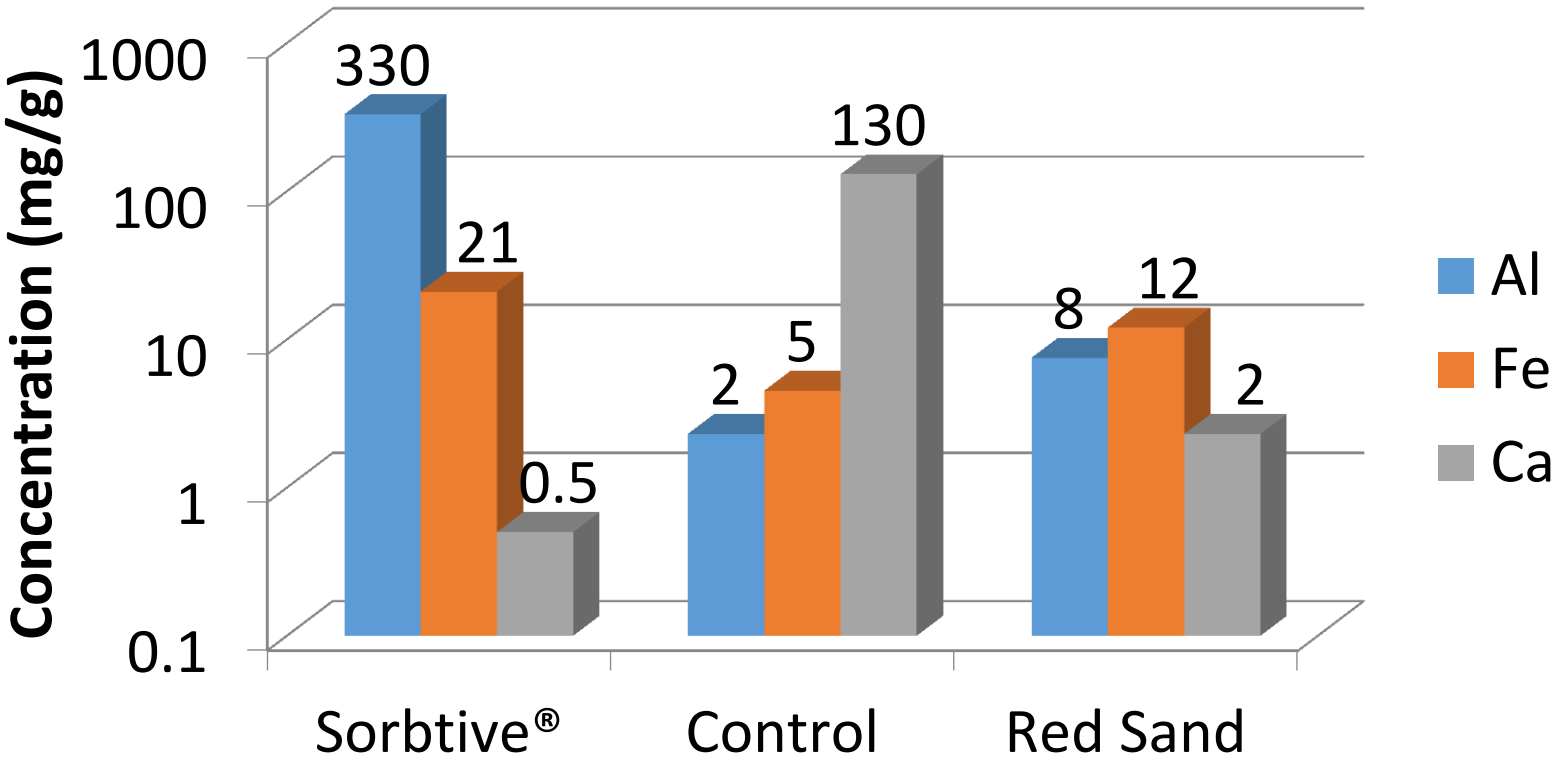
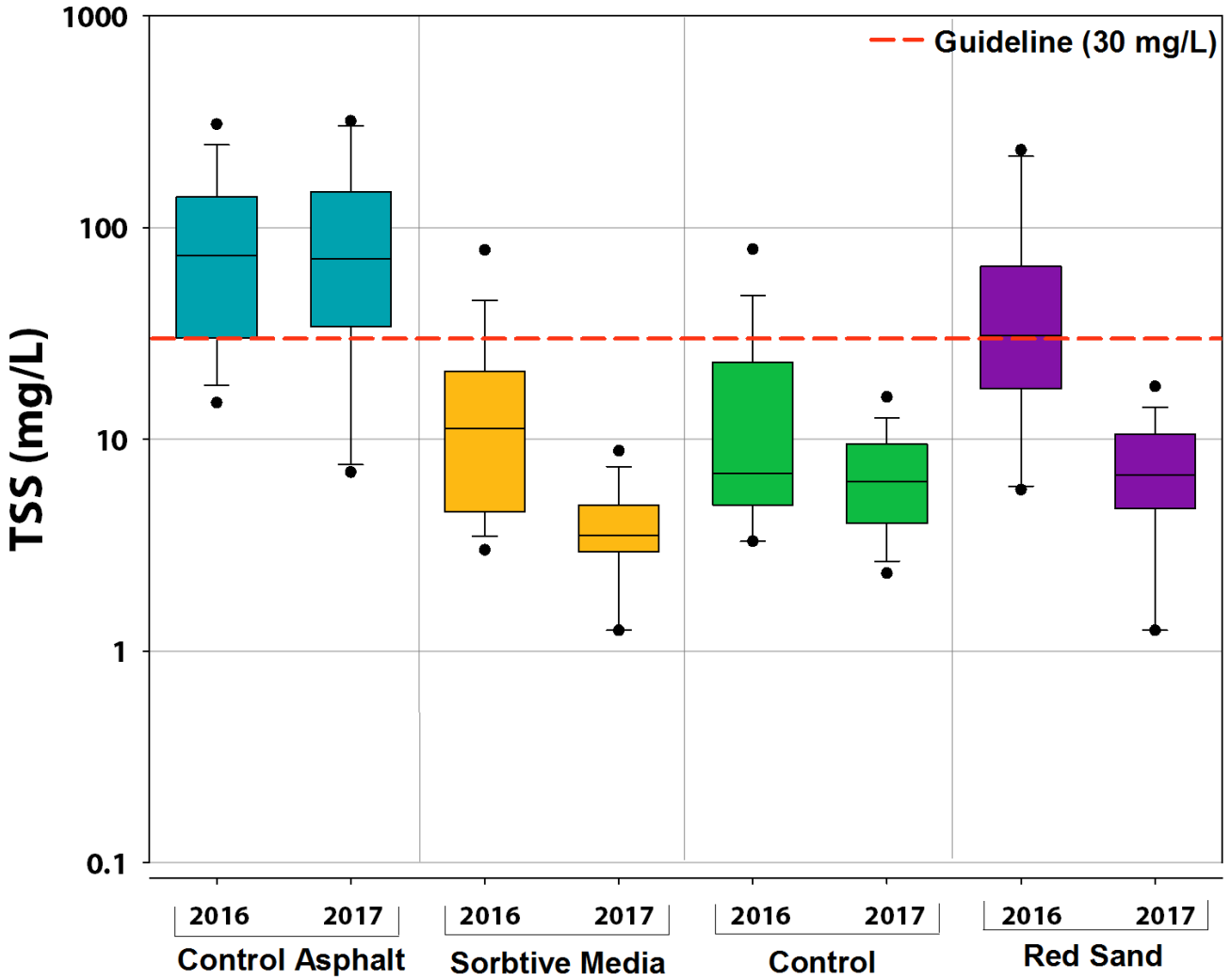
Monitoring Program

- Continuous flow and temperature monitoring – May to Nov, 2016 and 2017 (dry and wet years)
- 109 events monitored (1-44 mm, avg 6 mm)
- Flow Proportioned Samples
  - Control: 52 events;
  - Sorbtive: 47 events
  - Red Sand: 43 events
  - Asphalt: 43 events
- Volumes and flow rates measured with calibrated tipping bucket flow gauges

Soil/Sediment samples



Total Suspended Solids

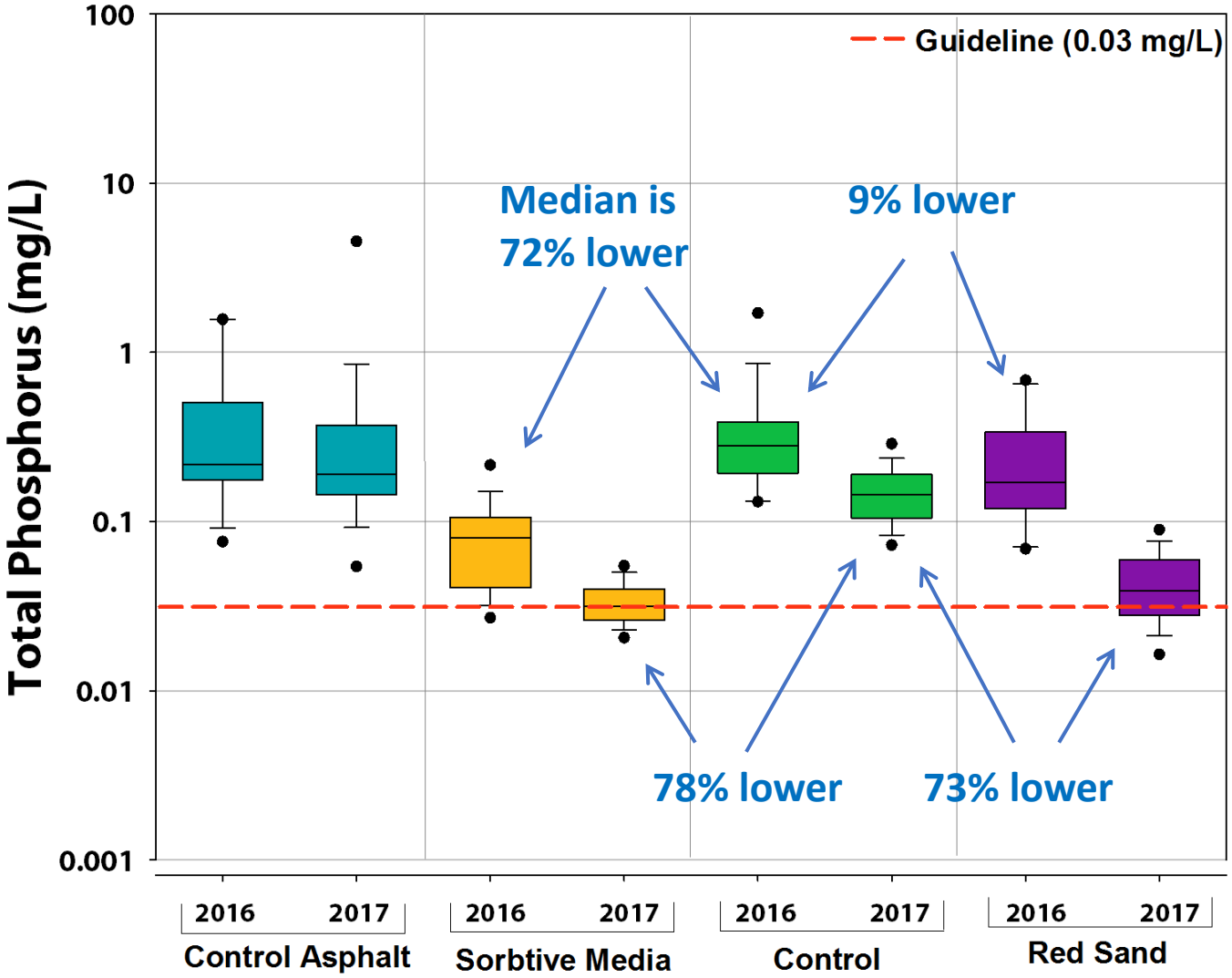


Lower bioretention values show filtering effect

Further decreases in 2017 values indicate stabilization of media

Colour Differences

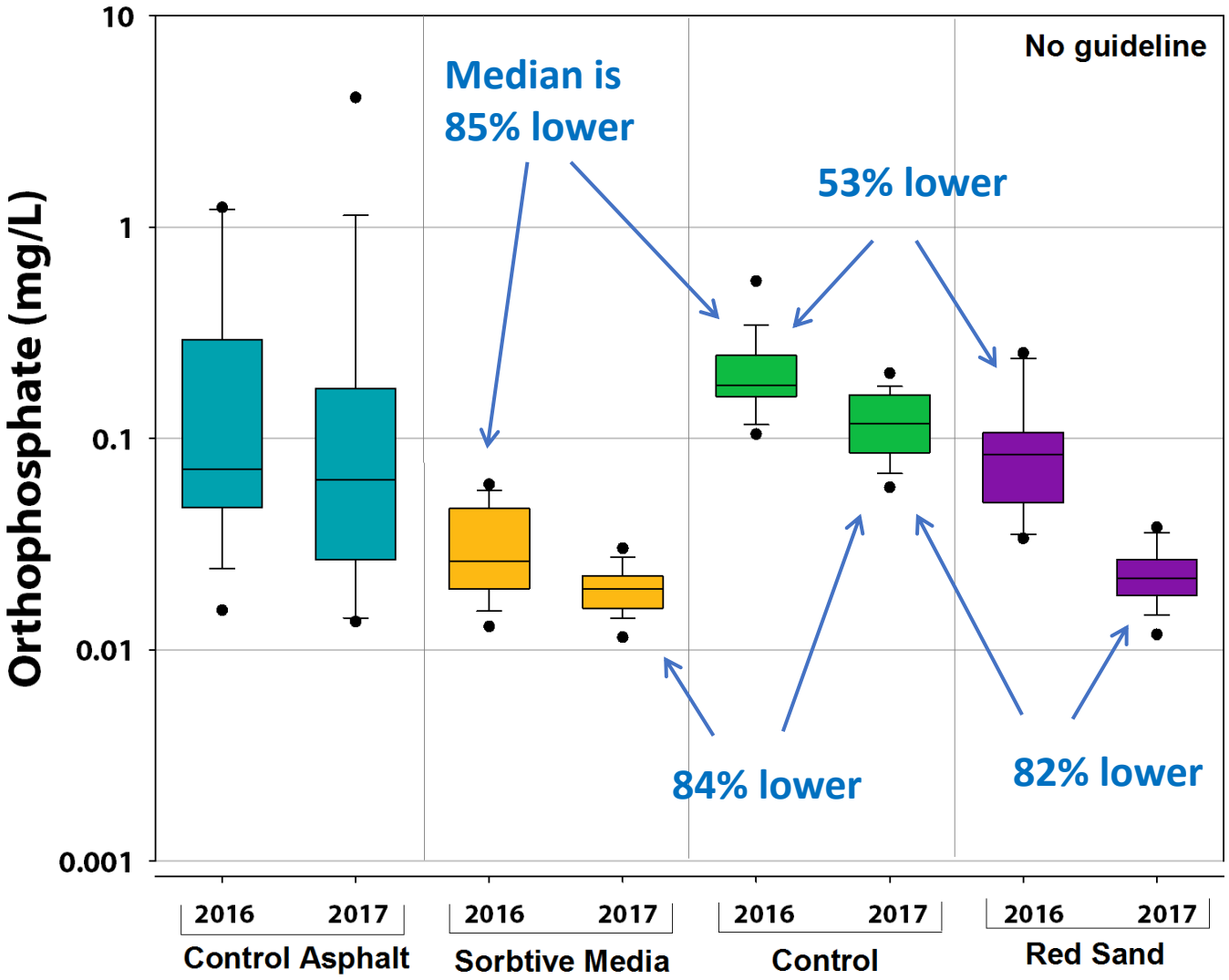
Total Phosphorus



Sorbtive® significantly lower than Red Sand in 2016

Sorbtive® significantly lower than asphalt and bioretention control in both years

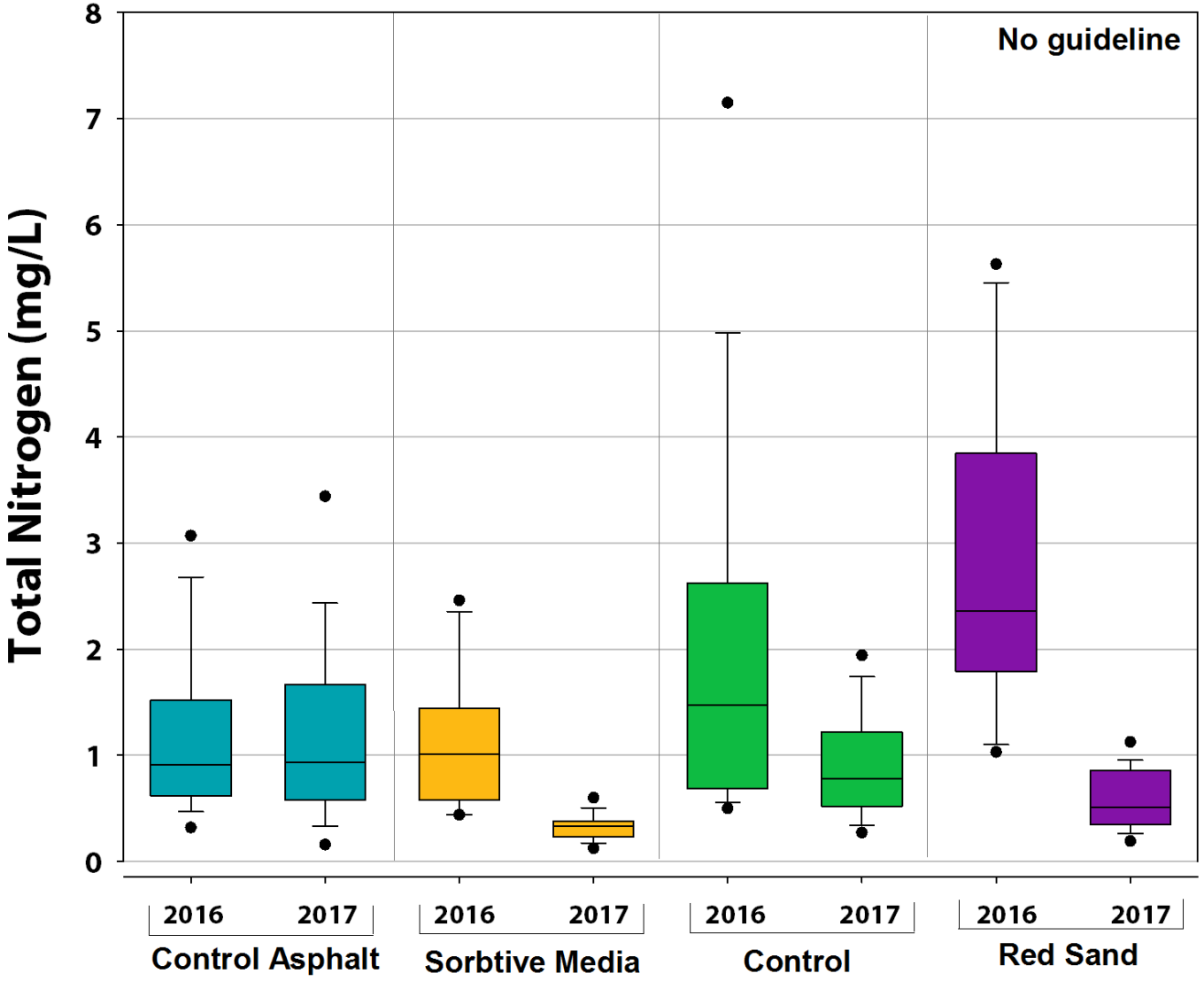
Soluble or bioavailable phosphorus (PO^4)



Reactive media effluents not statistically different in either year

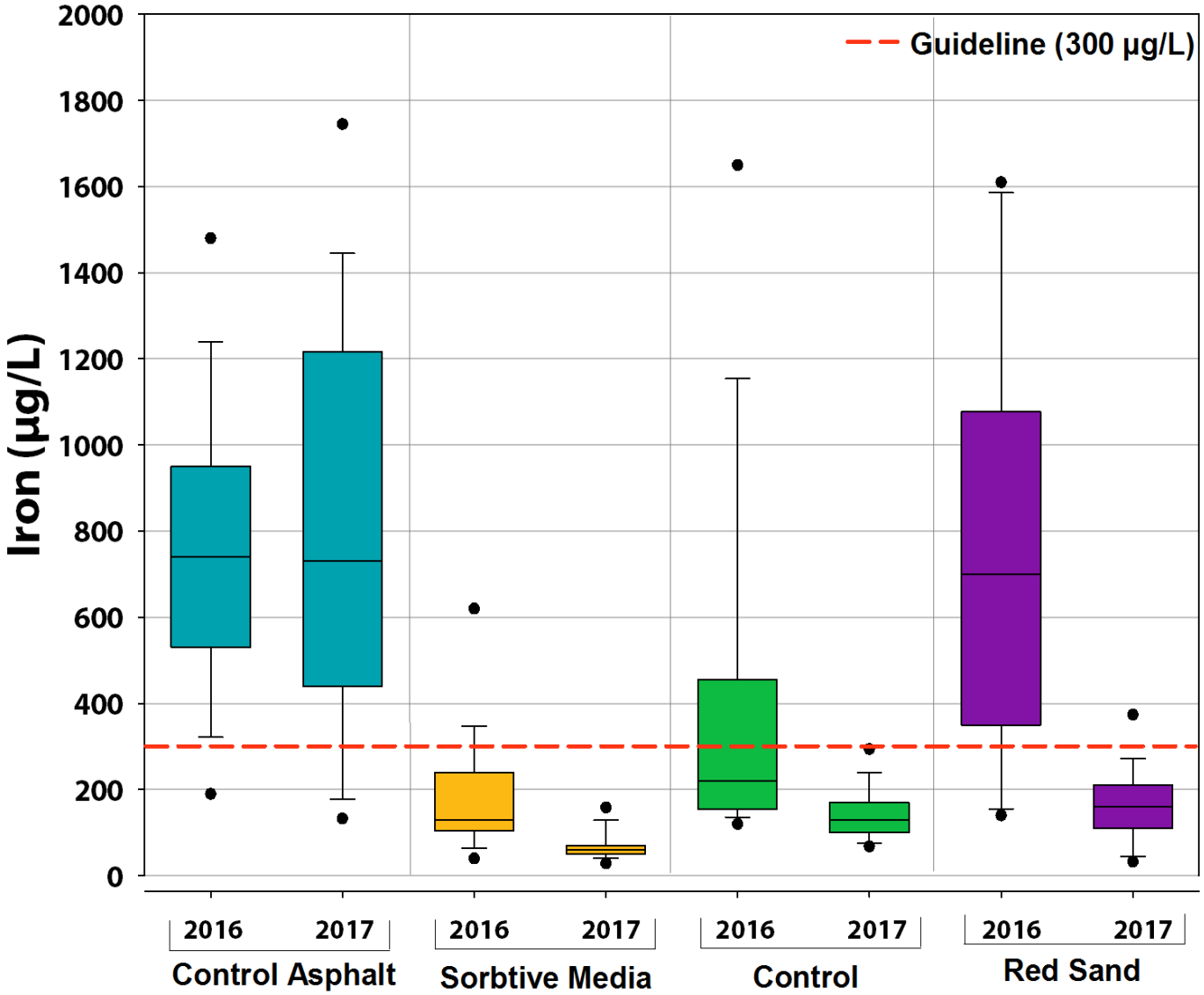
Sorbtive® lower than control in both years; red sand only in 2017

Total Nitrogen



Similar pattern to TSS: Concentrations drop in 2017

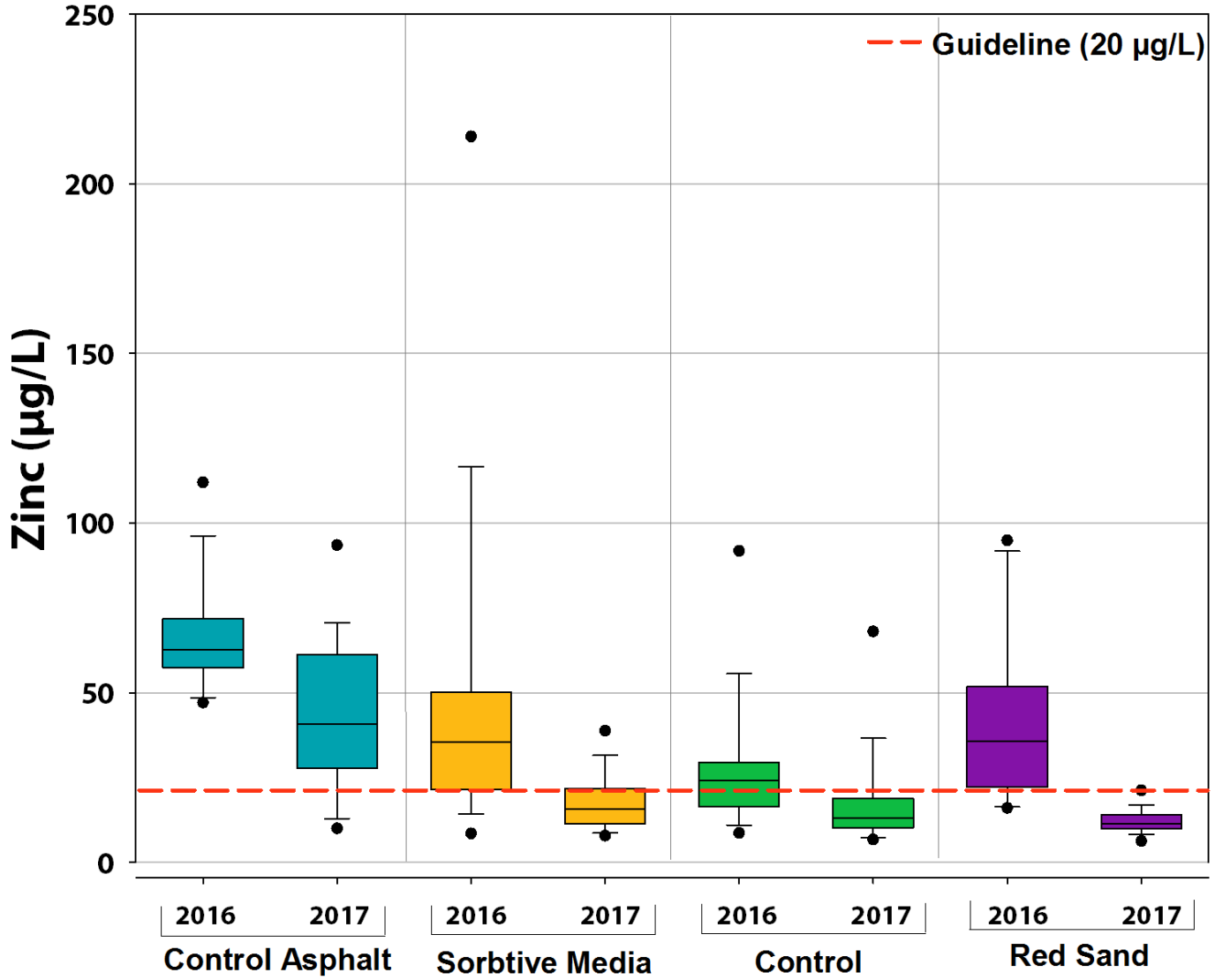
Iron



Sorbtive® lower than red sand in both years

Considerably lower Al levels as well from Sorbtive®

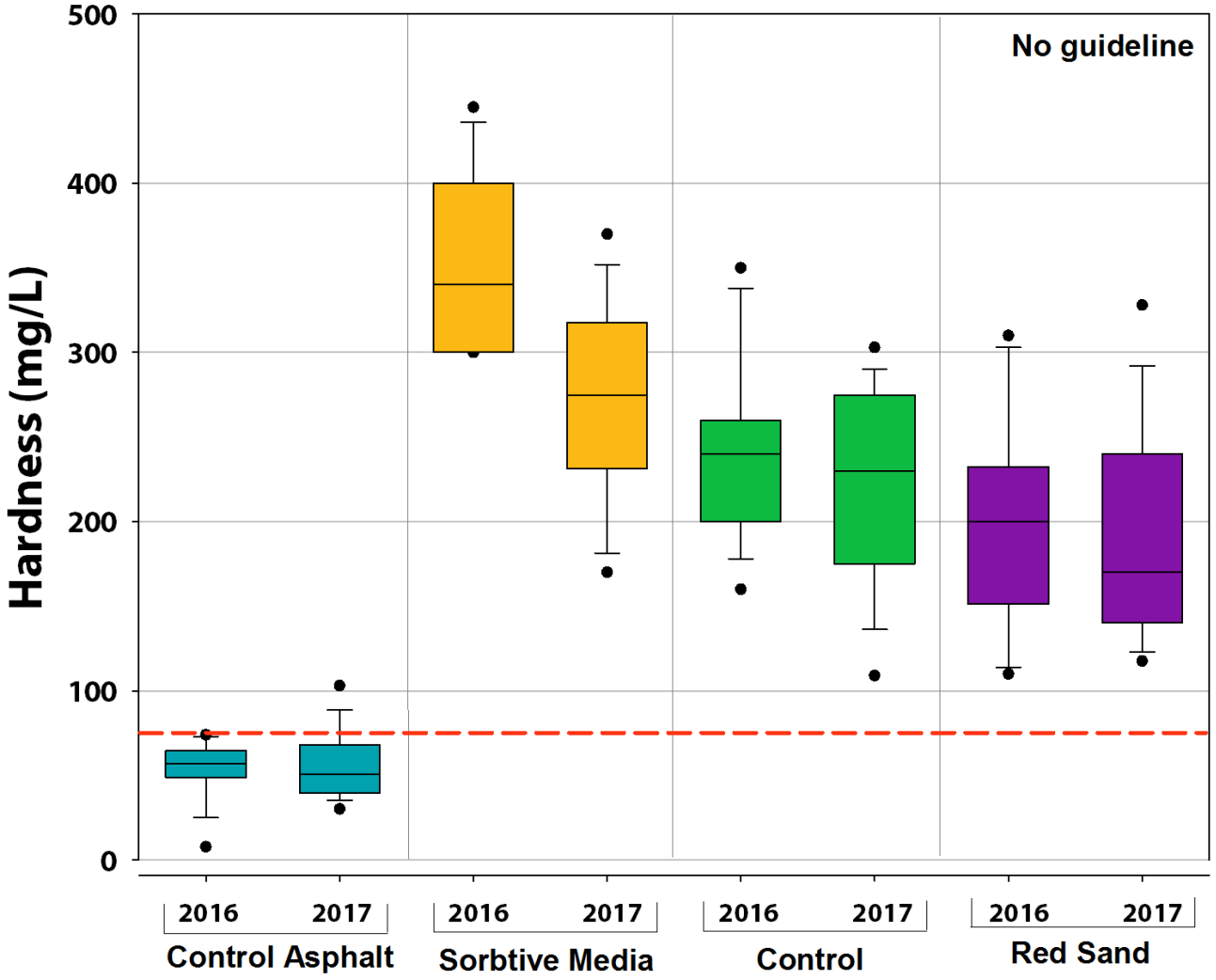
Zinc



No clear winner among media types

Asphalt higher in both years

Hardness



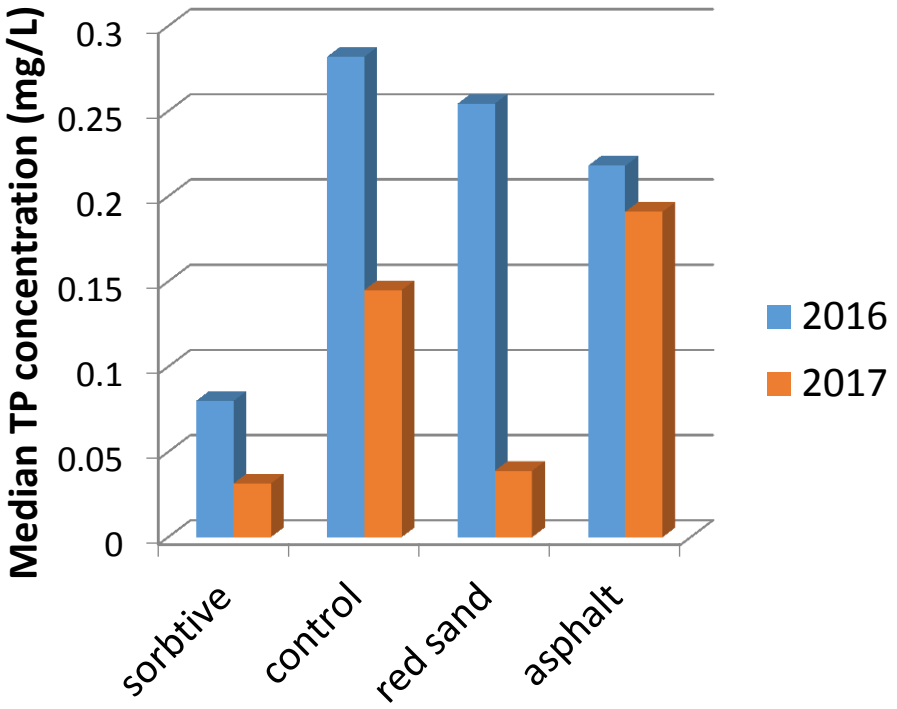
Sorbtive® exhibits higher overall hardness levels

Toxicity of some metals increases as hardness falls below 100 mg/L

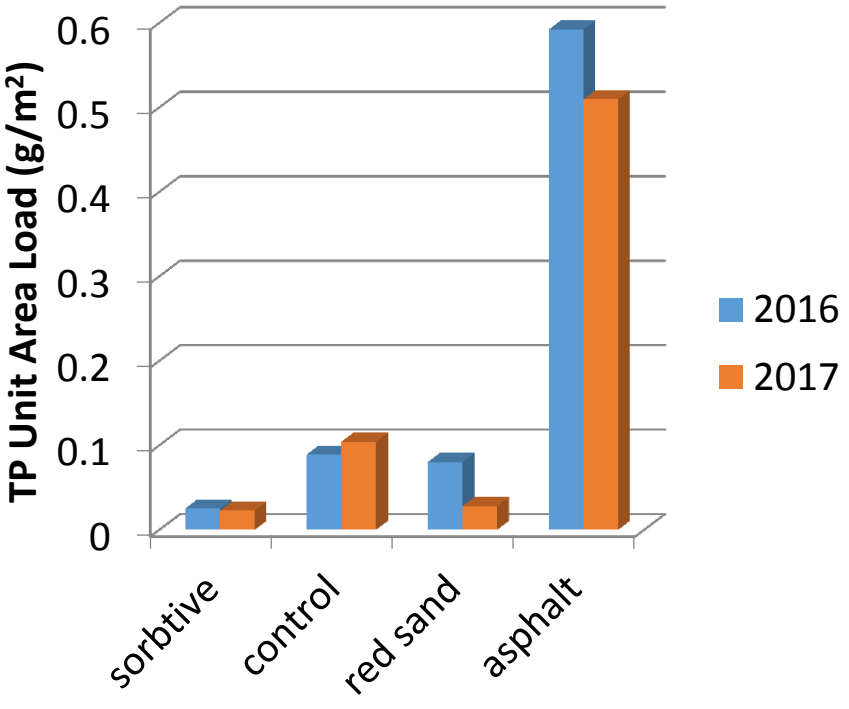
Lest we forget…

Infiltration drives P ‘removal’ rates

Concentrations



Loads



Reported issues with Red Sand (other studies)

Clumping and reduced permeability under anoxic conditions

Leptothrix ochracea: iron loving bacteria that prefer low oxygen conditions

Desorption of P attributed to anoxic conditions

Key Findings

- Red Sand and Sorbtive® media showed better phosphorus retention than unamended media
- Sorbtive® media showed better overall water quality performance
- Particularly useful for lined or low infiltration practices where water quality treatment is the primary goal
- Limited field data yet on longevity, alternate configurations.

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Thank you!

For more information:

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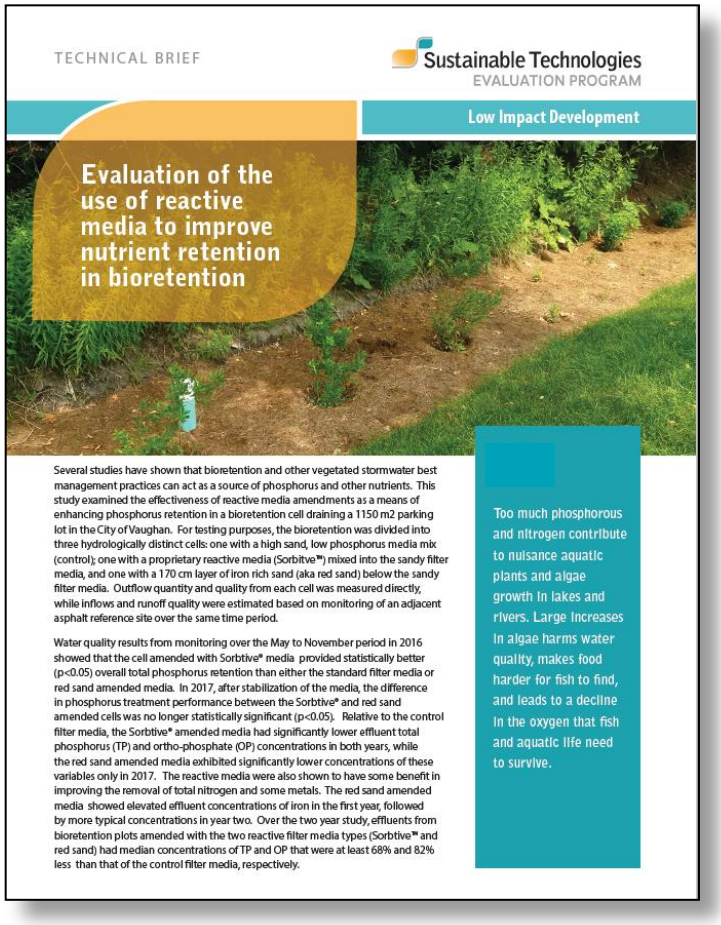
Visit www.sustainabletechnologies.ca for more information.


TECHNICAL BRIEF

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Low Impact Development

Evaluation of the use of reactive media to improve nutrient retention in bioretention

Several studies have shown that bioretention and other vegetated stormwater best management practices can act as a source of phosphorus and other nutrients. This study examined the effectiveness of reactive media amendments as a means of enhancing phosphorus retention in a bioretention cell draining a 1150 m2 parking lot in the City of Vaughan. For testing purposes, the bioretention was divided into three hydrologically distinct cells: one with a high sand, low phosphorus media mix (control); one with a proprietary reactive media (Sorbitve™) mixed into the sandy filter media, and one with a 170 cm layer of iron rich sand (aka red sand) below the sandy filter media. Outflow quantity and quality from each cell was measured directly, while inflows and runoff quality were estimated based on monitoring of an adjacent asphalt reference site over the same time period.

Water quality results from monitoring over the May to November period in 2016 showed that the cell amended with Sorbtive® media provided statistically better ($p<0.05$) overall total phosphorus retention than either the standard filter media or red sand amended media. In 2017, after stabilization of the media, the difference in phosphorus treatment performance between the Sorbtive® and red sand amended cells was no longer statistically significant ($p<0.05$). Relative to the control filter media, the Sorbtive® amended media had significantly lower effluent total phosphorus (TP) and ortho-phosphate (OP) concentrations in both years, while the red sand amended media exhibited significantly lower concentrations of these variables only in 2017. The reactive media were also shown to have some benefit in improving the removal of total nitrogen and some metals. The red sand amended media showed elevated effluent concentrations of iron in the first year, followed by more typical concentrations in year two. Over the two year study, effluents from bioretention plots amended with the two reactive filter media types (Sorbtive™ and red sand) had median concentrations of TP and OP that were at least 68% and 82% less than that of the control filter media, respectively.

Too much phosphorous and nitrogen contribute to nuisance aquatic plants and algae growth in lakes and rivers. Large increases in algae harms water quality, makes food harder for fish to find, and leads to a decline in the oxygen that fish and aquatic life need to survive.

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