Stormwater management: opportunities and challenges

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DataFEWSion Graduate Traineeship

Innovations at the Nexus of Food-Water-Energy Systems

IOWA STATE UNIVERSITY

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NSF

US EPA: stormwater runoff is the fastest growing water problem

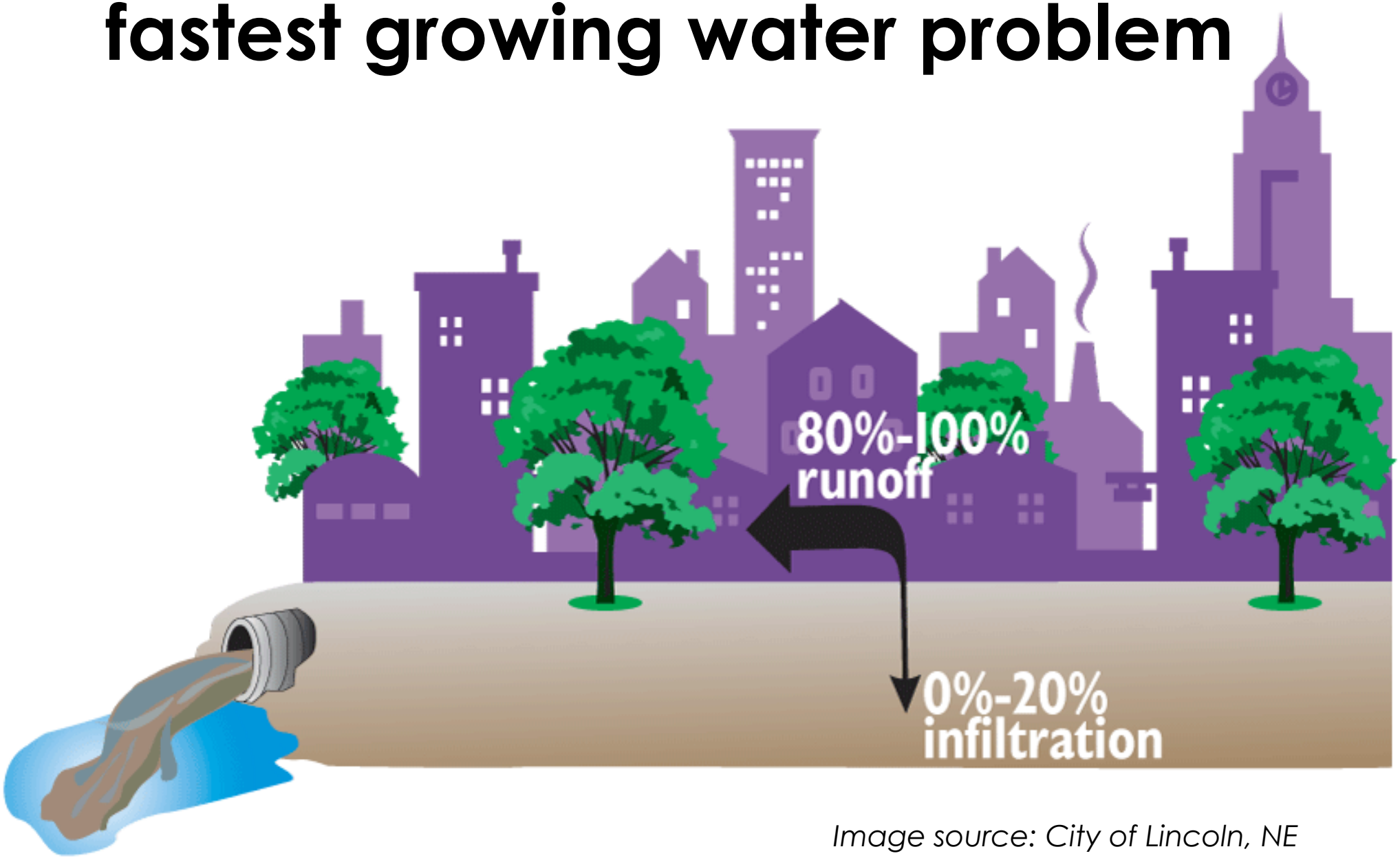
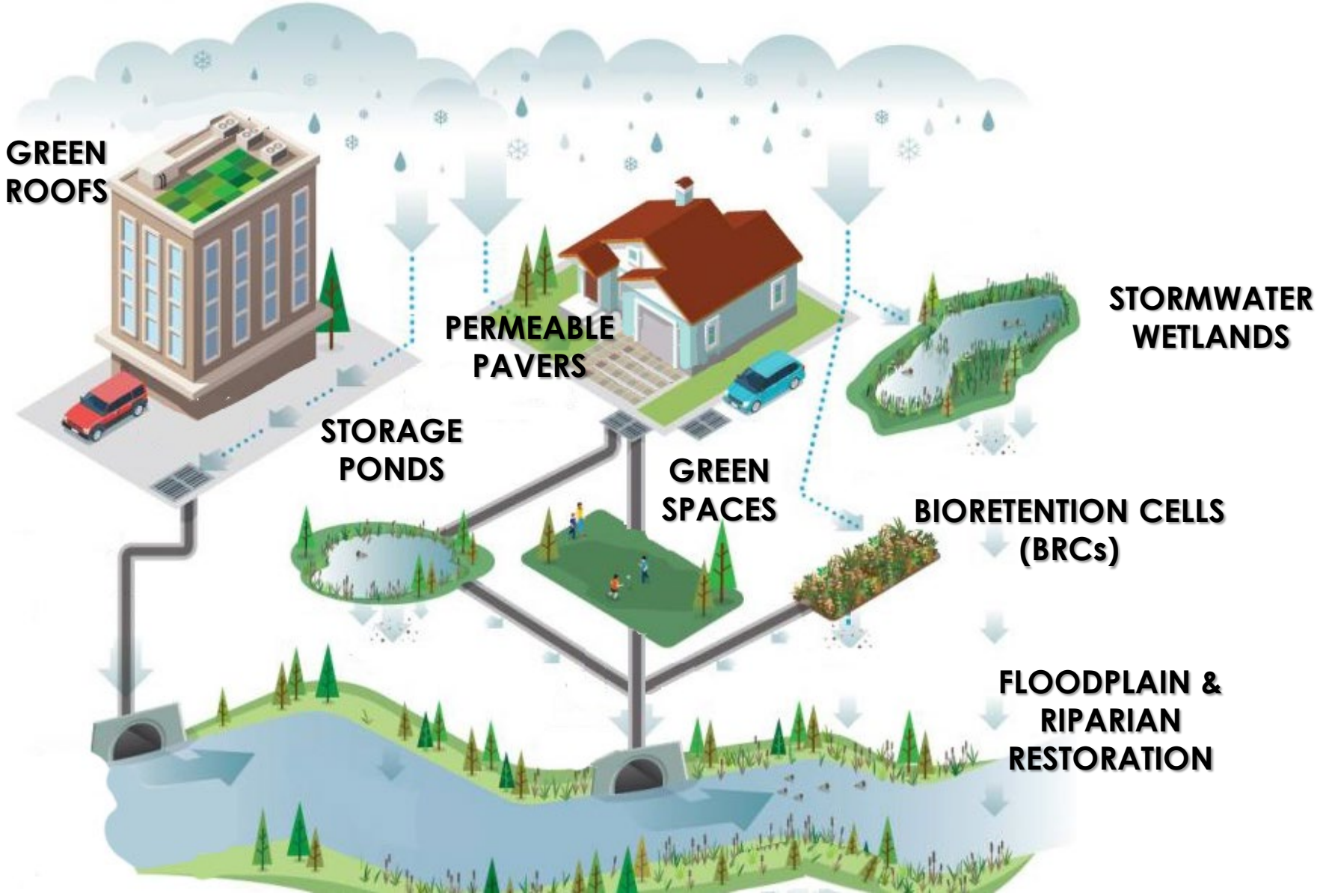


Image source: City of Lincoln, NE



Stormwater management

Image source: Global Info Resource

Stormwater management is used to improve water quality and reduce runoff quantity

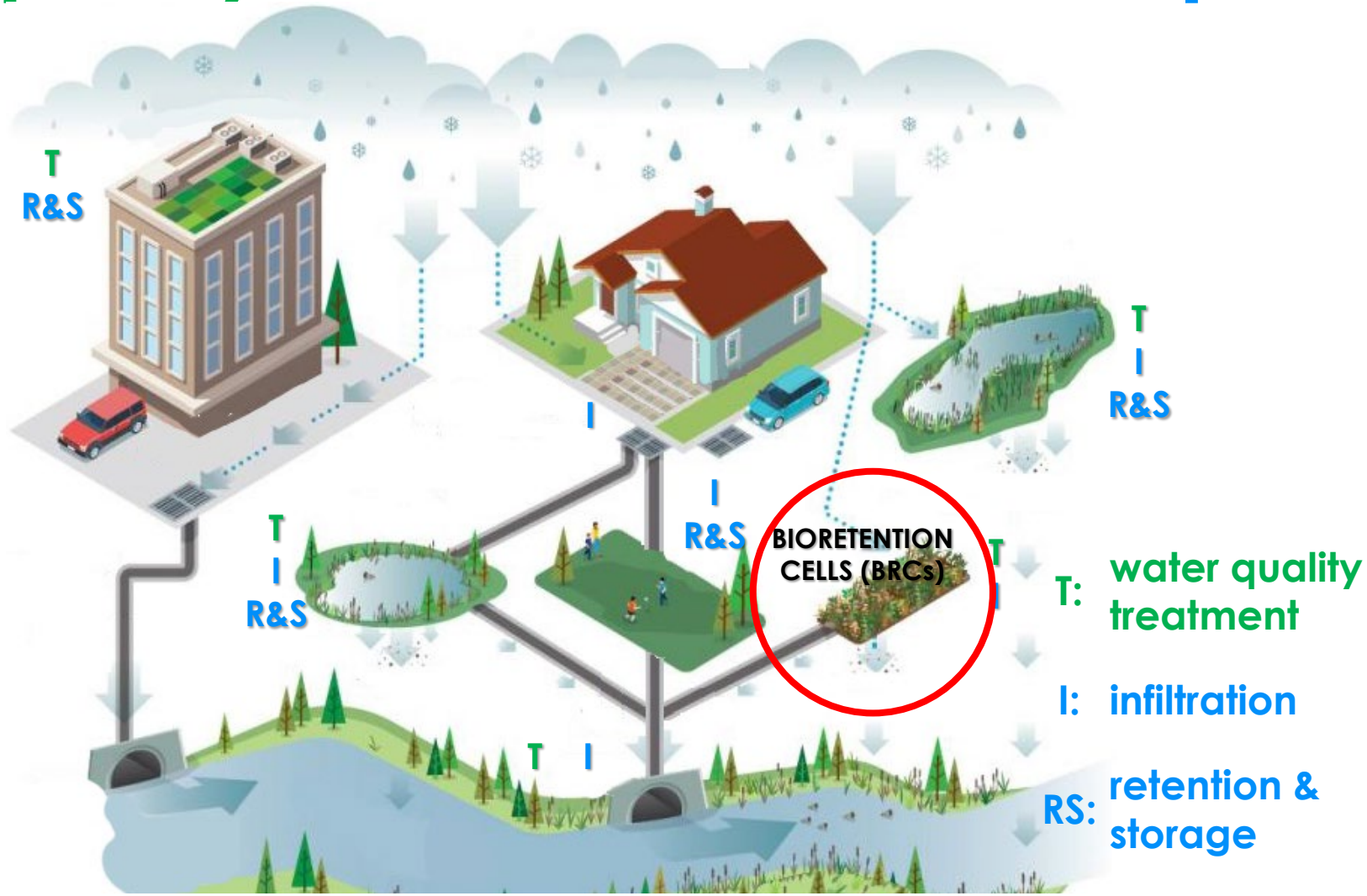


Image source: Global Info Resource

Bioretention cells (BRCs) are used to remediate urban stormwater runoff

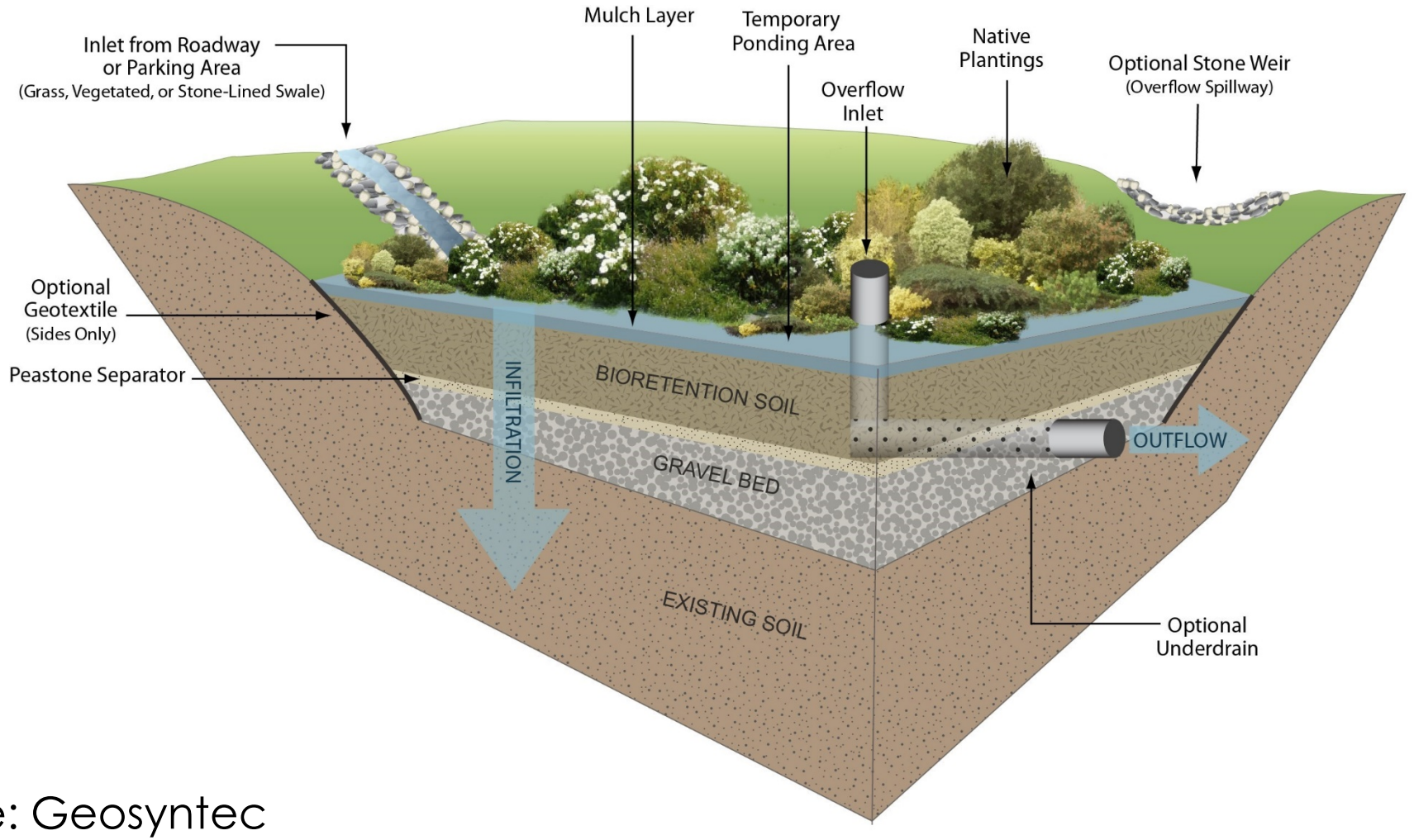
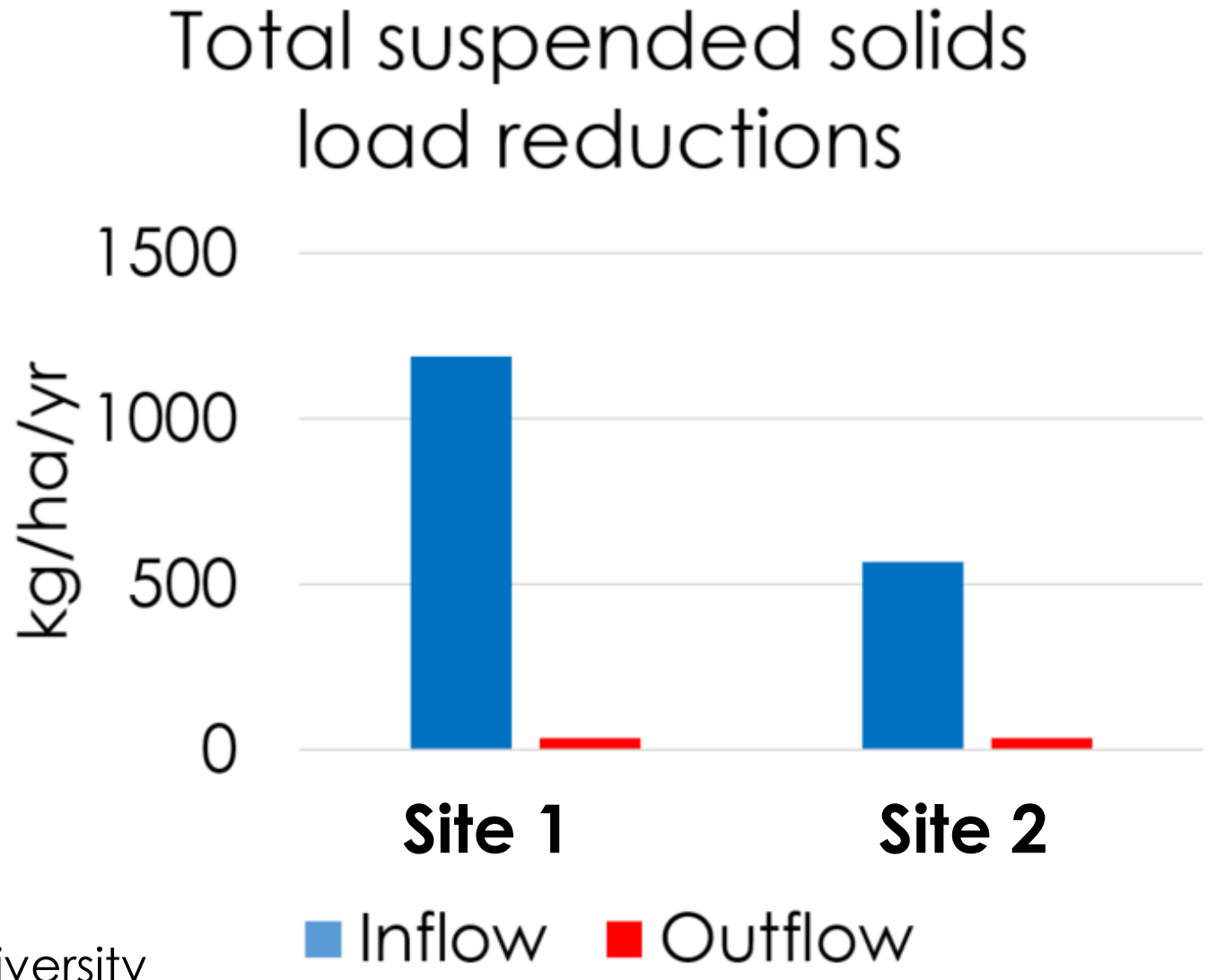


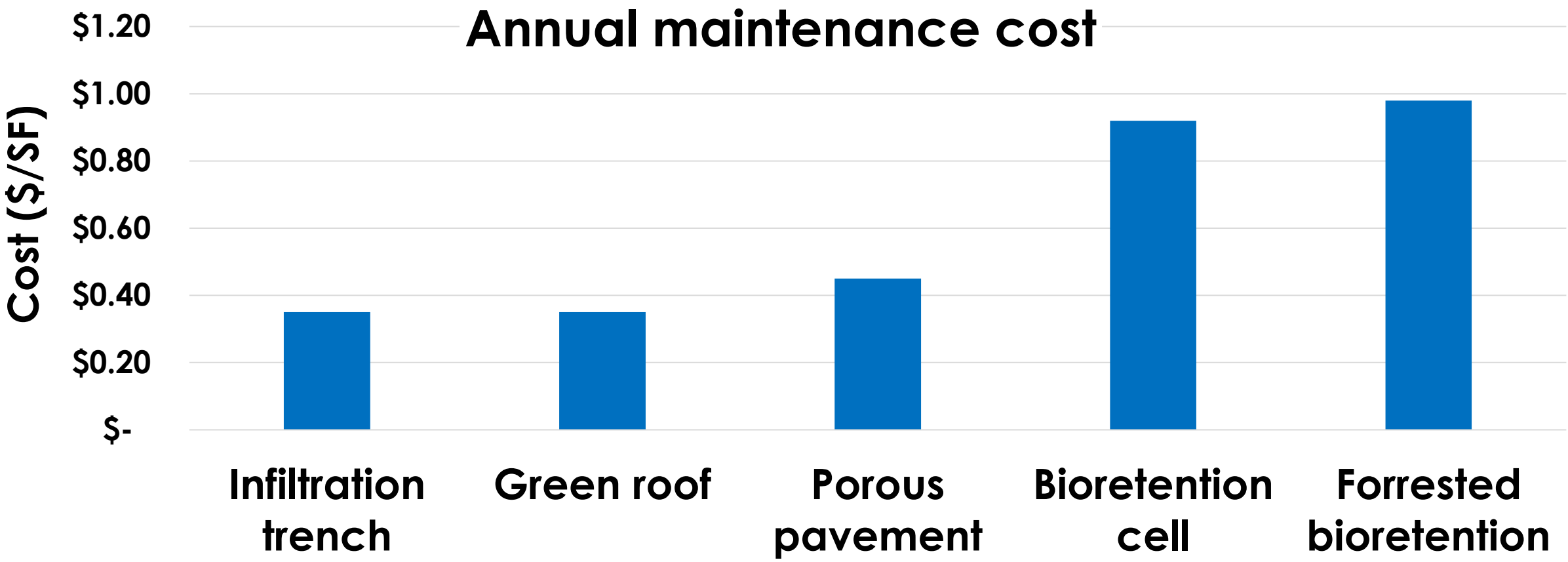
Image source: Geosyntec

Studies show BRCs improve water quality

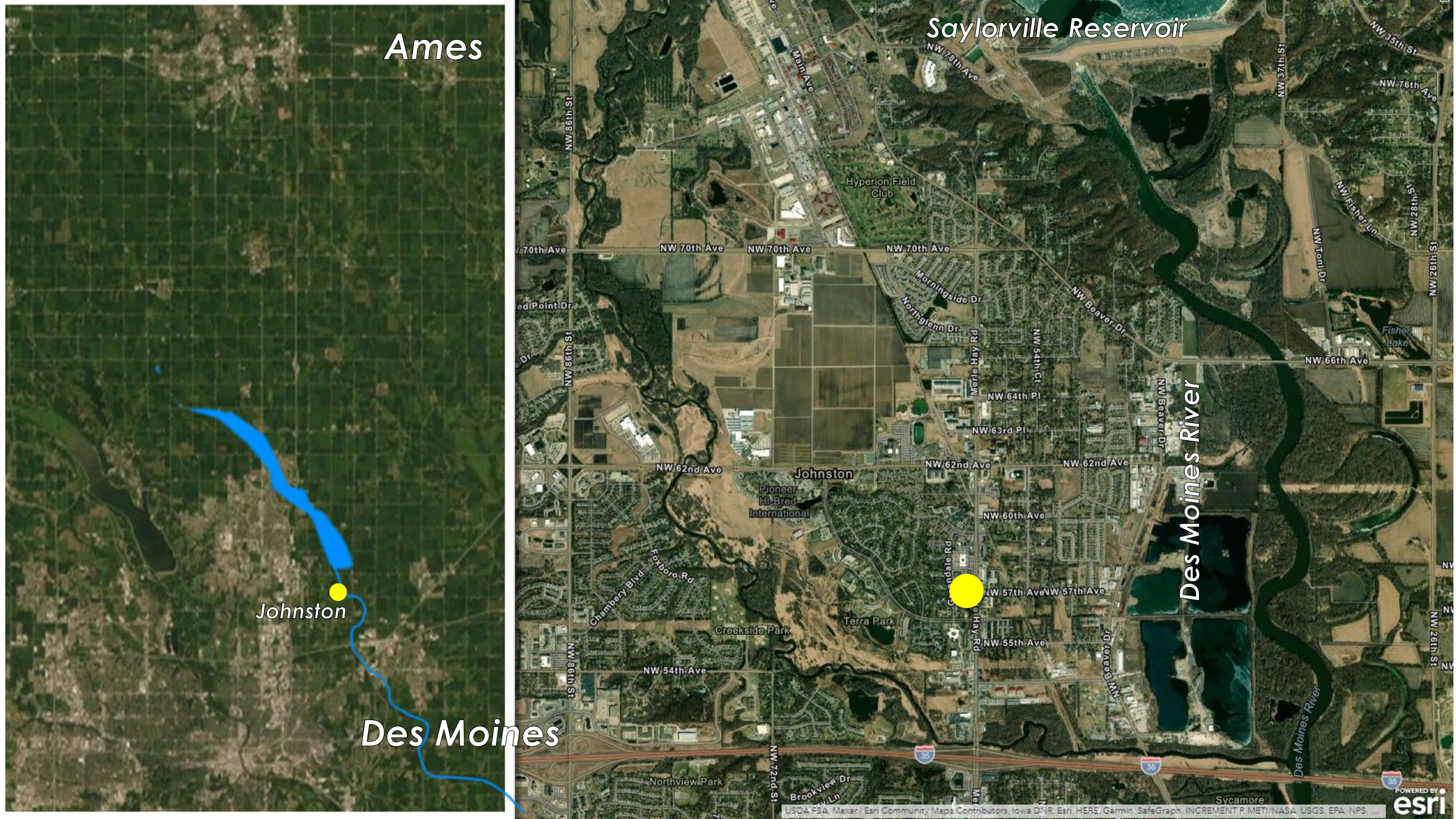


Data adapted from:
Bill Hunt, NC State University

But sediments can clog the BRC and lead to costly maintenance



Data adapted from: Water Environment Federation


Ames
Saylorville Reservoir
Johnston
Des Moines
Des Moines River
Hyperion Field Club
Pioneer Hi-Bred International
Terra Park
Creekside Park
Northview Park
Fisher Lake
Sycamore
NW 78th Ave
NW 70th Ave
NW 66th Ave
NW 64th Pl
NW 63rd Pl
NW 62nd Ave
NW 60th Ave
NW 57th Ave
NW 55th Ave
NW 54th Ave
NW 72nd St
NW 86th St
NW 54th Ct
NW 37th St
NW 35th St
NW 76th Ave
NW 28th St
NW 26th St
NW Fisher Ln
NW Toni Dr
NW Beaver Dr
Merle Hay Rd
Morningside Dr
Northglenn Dr
Foxboro Rd
Chambery Blvd
Brookview Dr
Main Ave
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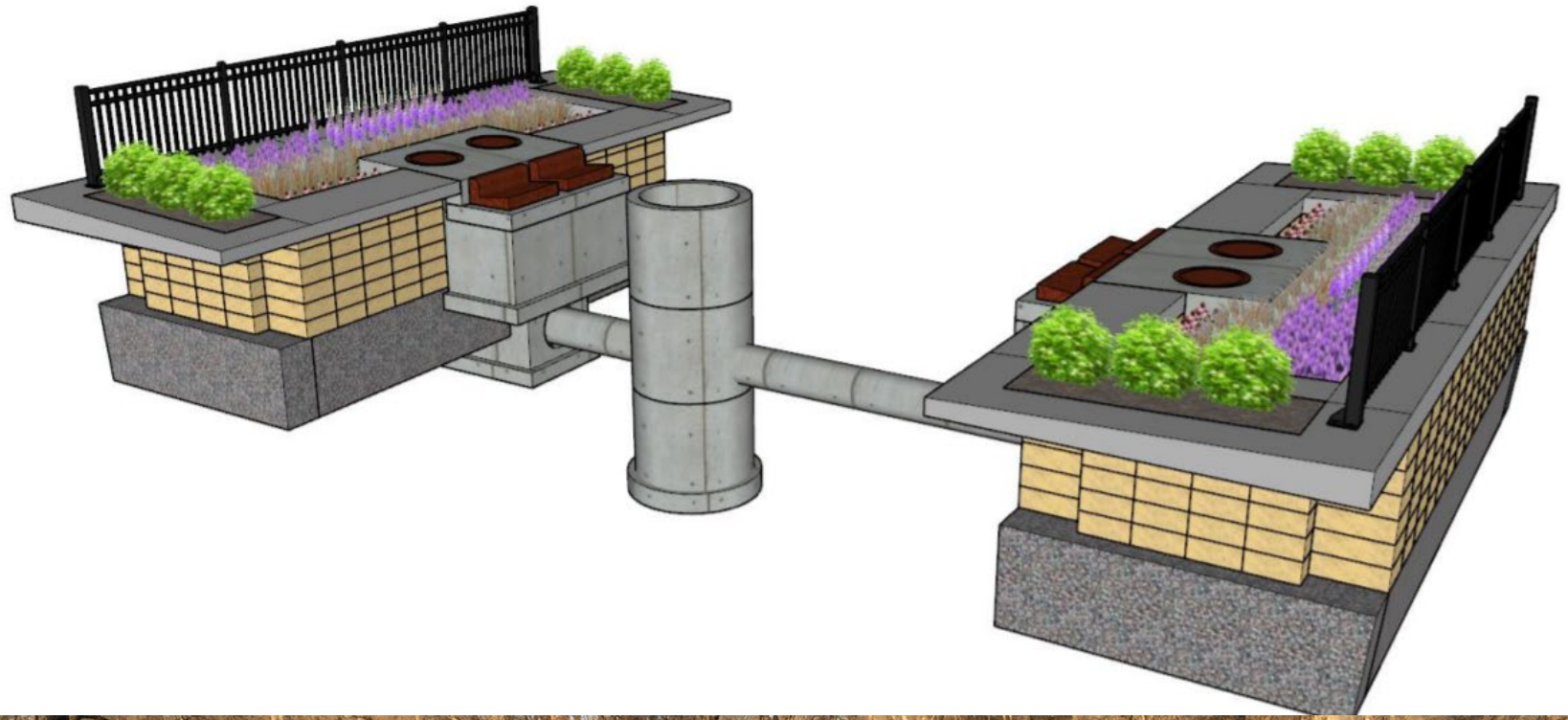
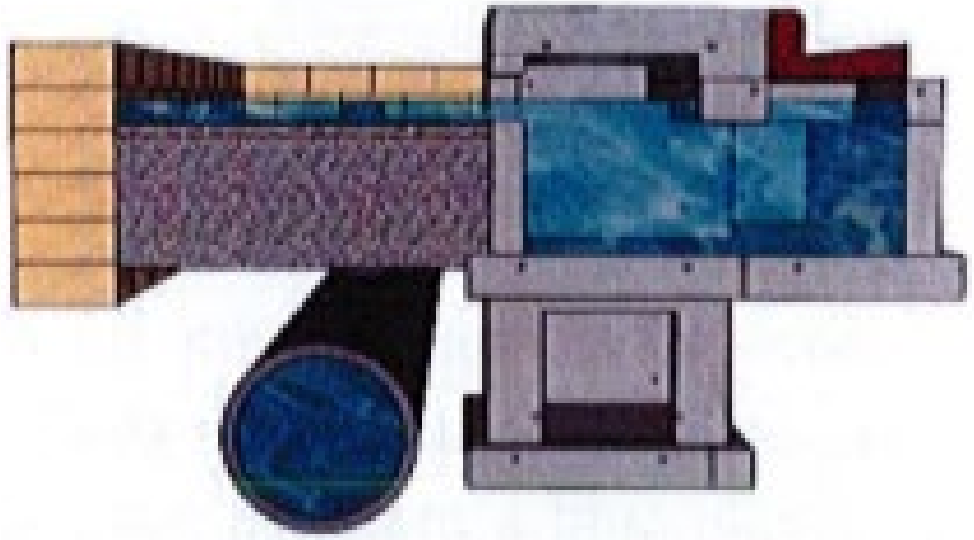
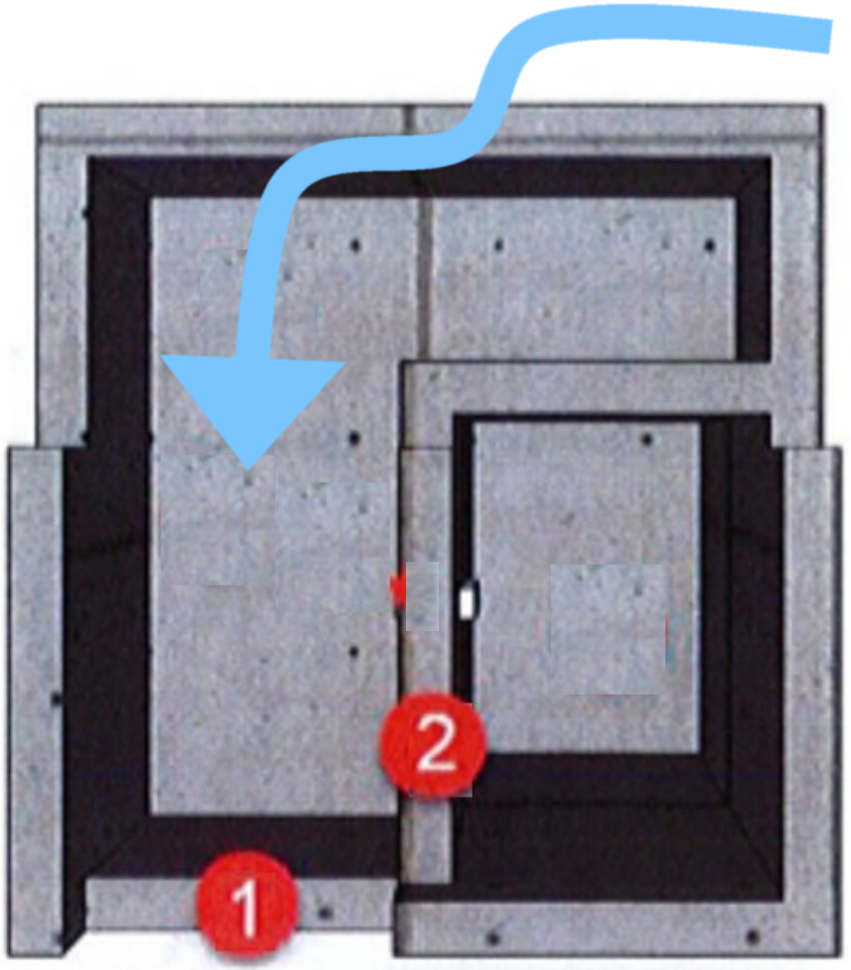


The Johnston BRC has an intake structure that can function as settling chamber

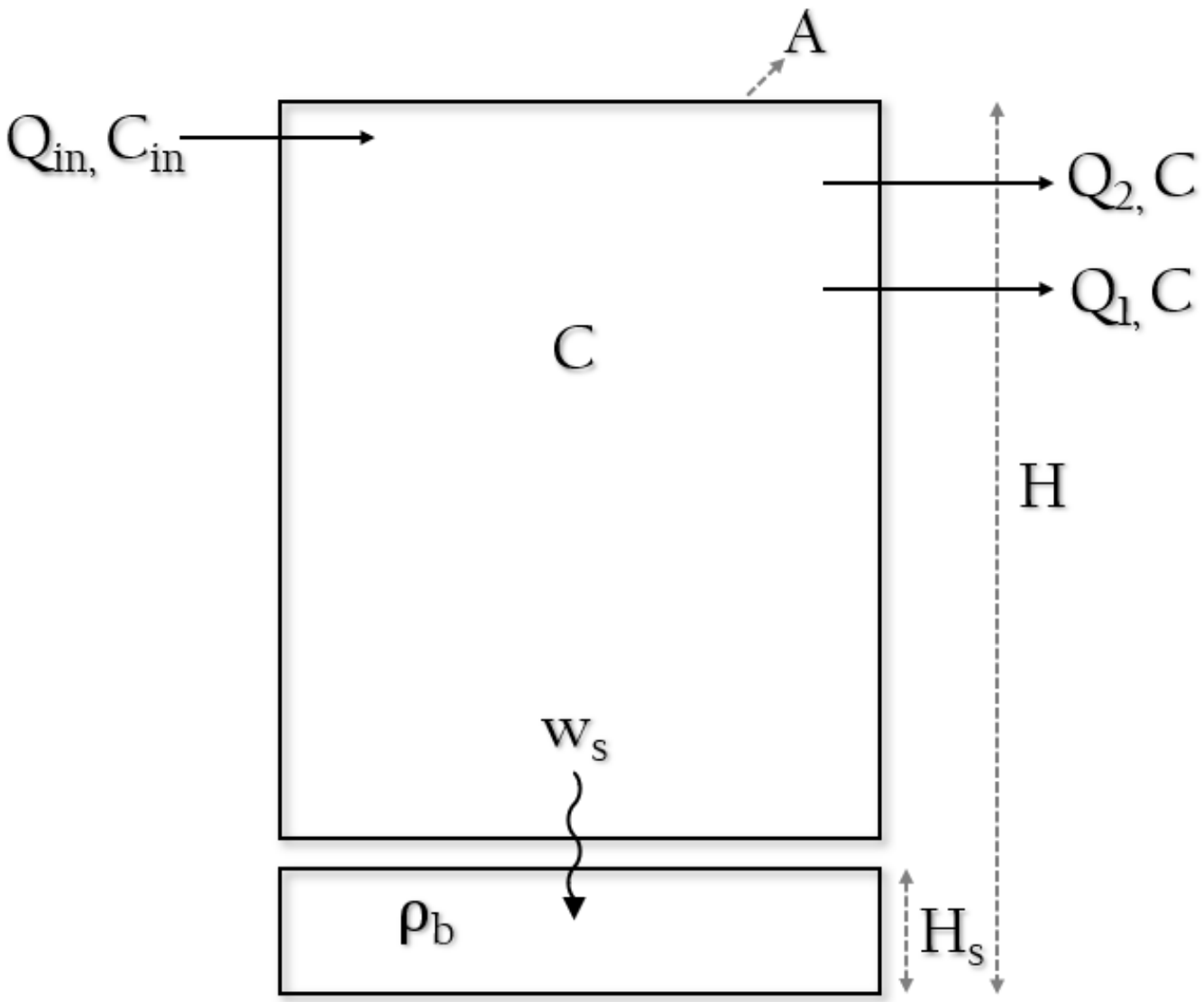




Inflow

1 Weir to BRC

2 Weir to storm sewer



$$A\frac{d}{dt}(H - H_s) = Q_{in} - Q_{out}$$

$$A\frac{d}{dt}[C(H - H_s)] = QC_{in} - Q_{out}C - w_sAC$$

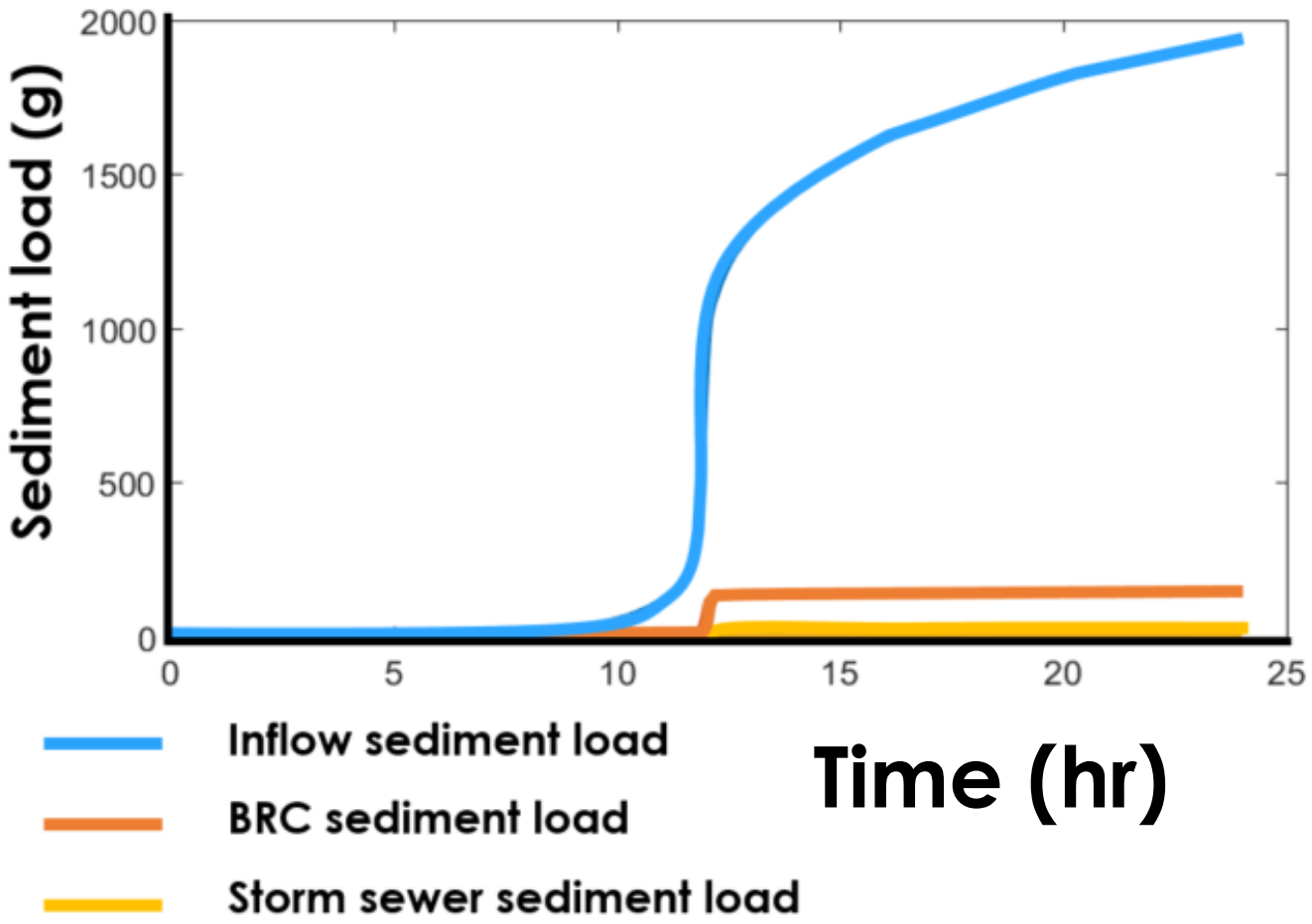
$$A\frac{d}{dt}(\rho_b H_s) = w_sAC$$

$$\frac{dH}{dt} = \frac{Q_{in} - Q_{out}}{A} + \frac{w_s\,C}{\rho_b}$$

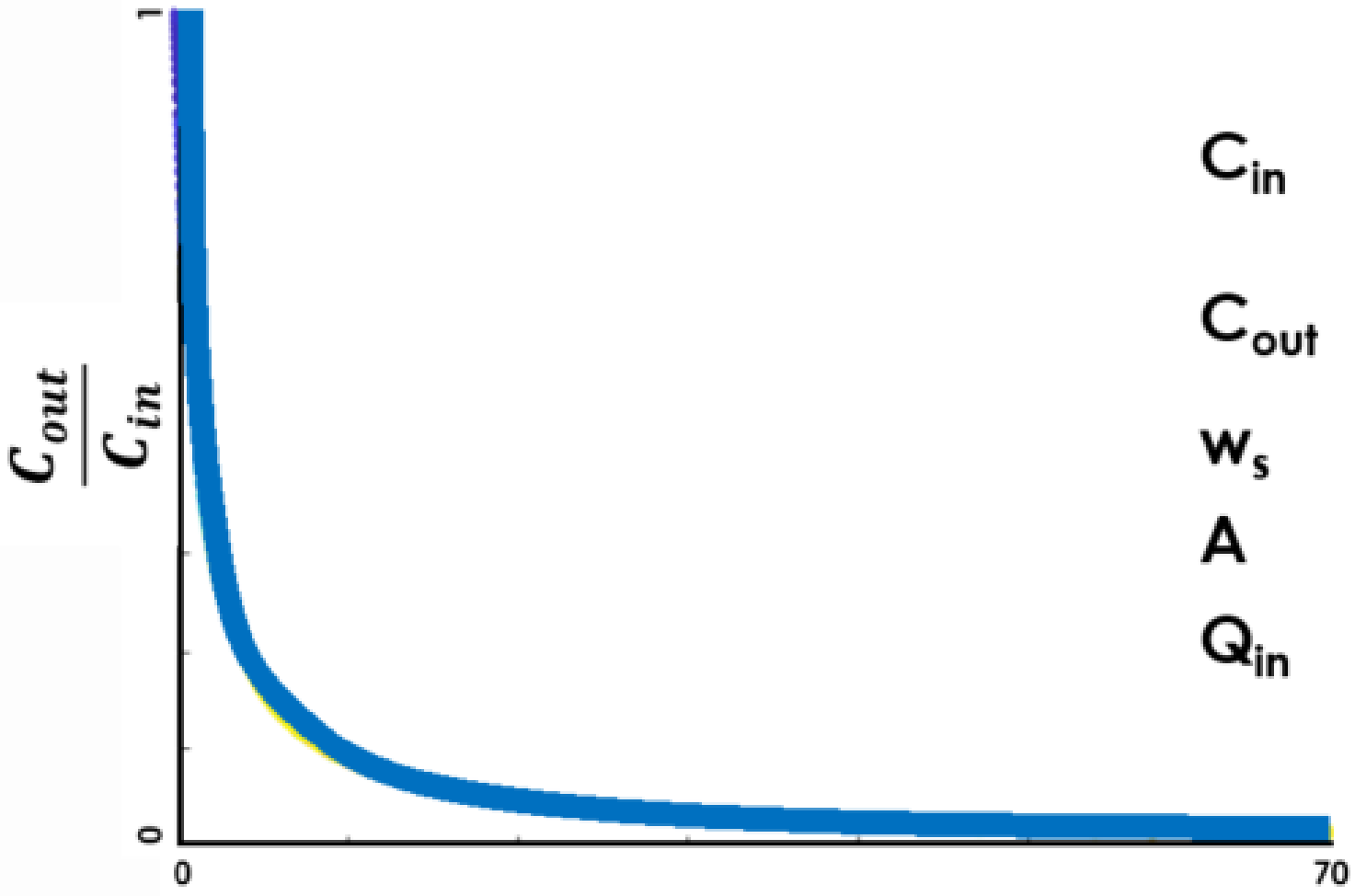
$$\frac{dH_s}{dt} = \frac{w_s\,C}{\rho_b}$$

$$\frac{dC}{dt} = \left[\frac{1}{H - H_s}\right]\left(\frac{Q_{in}(C_{in} - C)}{A} - w_sC\right)$$

Our model shows up to 80% of the total sediment is captured in the intake structure



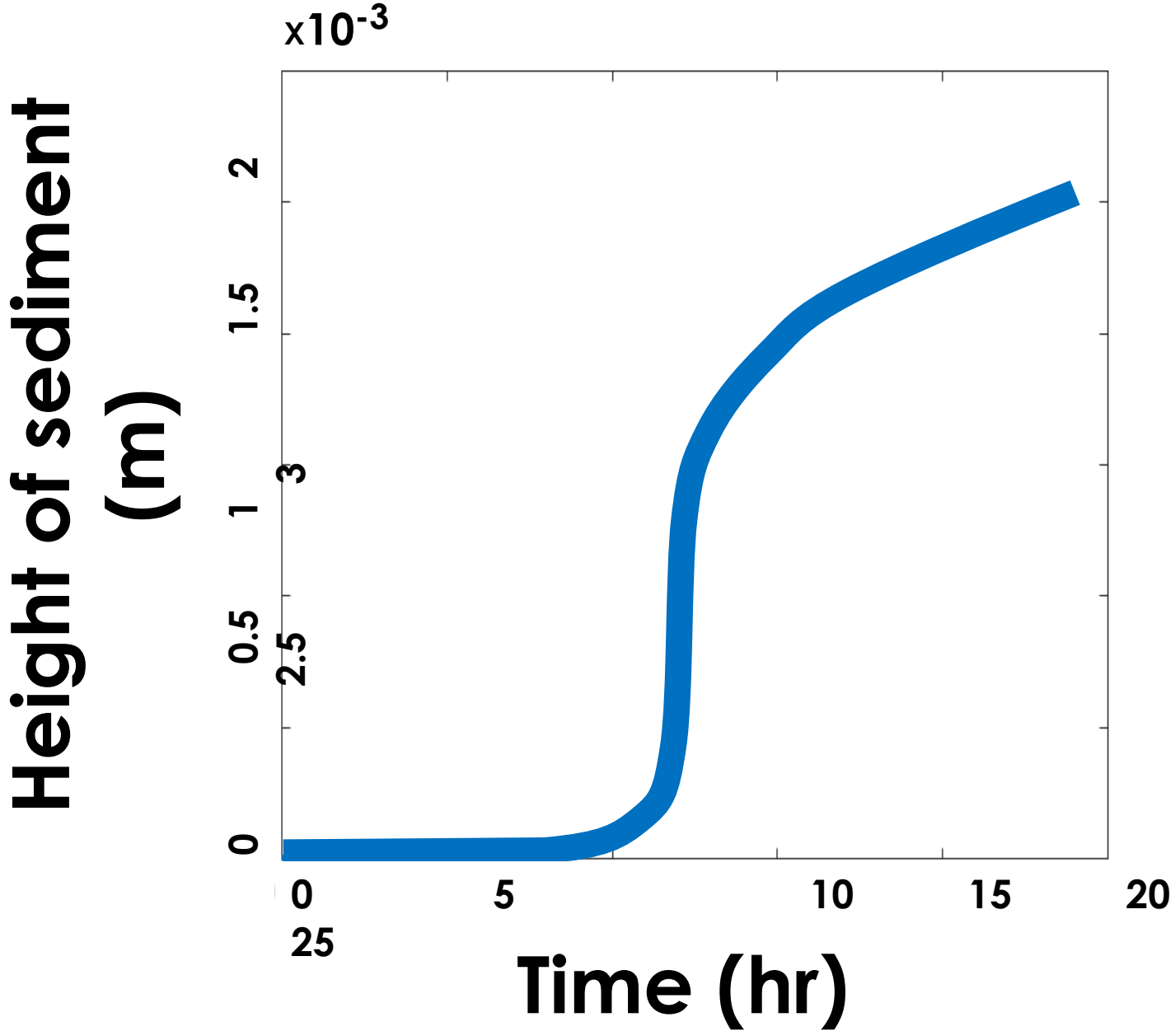
Sediment capture depends on BRC design and site conditions



C_{in}	Inflow concentration	g/m³
C_{out}	Outflow concentration	g/m³
w_s	Settling velocity	m/s
A	Area of structure	m³
Q_{in}	Flowrate in	m³/s

$$\frac{w_s A}{Q_{in}}$$

Optimizing BRC design can prolong performance and improve water quality


x10-3
Height of sediment (m)
0
0.5
1
1.5
2
2.5
3
0
5
10
15
20
25
Time (hr)