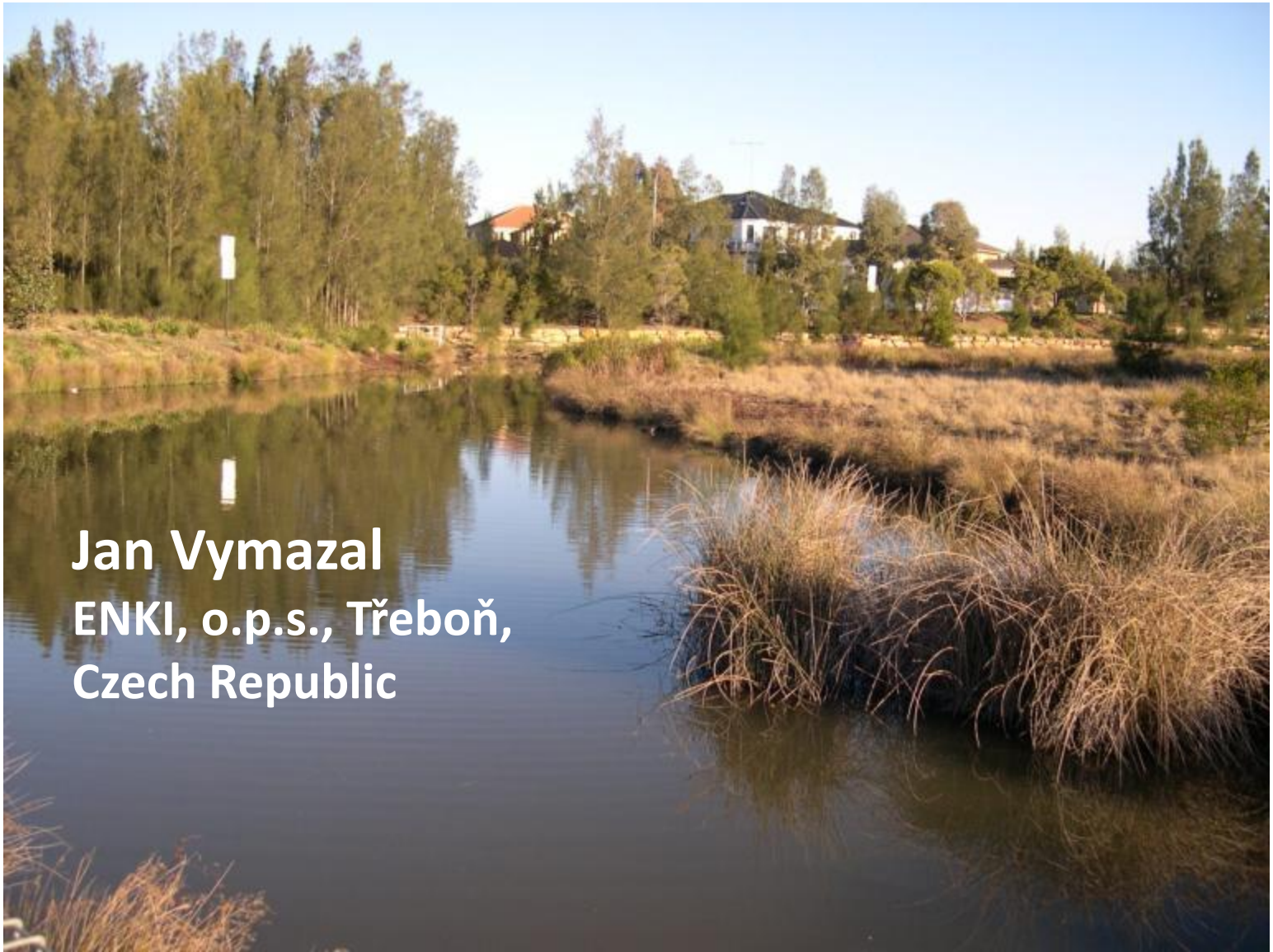
Application of Wetlands for Nutrient Polishing in Urban Environments



(Constructed) wetlands have been used to treat many types of stormwater runoff

Streets, parking lots: Suspended solids, heavy metals (organics, nutrients)

Roads, highways: Suspended solids, heavy metals (organics, nutrients)

Airports: organics

Golfcourses: organics (herbicides, paints), nutrients (fertilizers)

Greenhouses, nurseries: nutrients, herbicides

Crop fields: nutrients, suspended solids, organics (pesticides)

(Constructed) wetlands have been used to treat many types of stormwater runoff

Streets, parking lots: Suspended solids, heavy matals (organics, nutrients)

Roads, highways: Suspended solids, heavy matals (organics, nutrients)

Airports: organics

Golfcourses: organics (herbicides, paints), nutrients (fertilizers)

Greenhouses, nurseries: nutrients, herbicides

Crop fields: nutrients, suspended solids, organics (pesicides)

Urban applications

Airport runoff

Aircraft de-icing before take-off


ELEPHANT
CSA

London Heathrow, de-icing and runoff waters


Edmonton International Airport runoff waters CW
Photo Jim Higgins

Buffalo/Niagara International Airport runoff constructed wetlands

Golfcourse runoff


CW for golfcourse runoff,
Charleston, South Carolina, USA

Felixstowe Ferry Golf Course, United Kingdom

A typical Midwest golfcourse receives, on average per ha/year (Throssell et al. (1995)

7 kg of pesticides, 41 kg N, 4 kg P, 22 kg K

Purdue University Kampen Golf Course (Kohler et al., 2004):

Golf course area: 27.8 ha, 10.1 ha drained into created wetland with the area of 1.95 ha

Amounts of nutrients applied to 10.1 ha during 1998-2000: 7304 kg N, 922 kg P, 4582 kg K, 1271 kg S, 4.9 kg Cu, 349 kg Fe, 5.2 kg Mn, 4.8 kg Zn

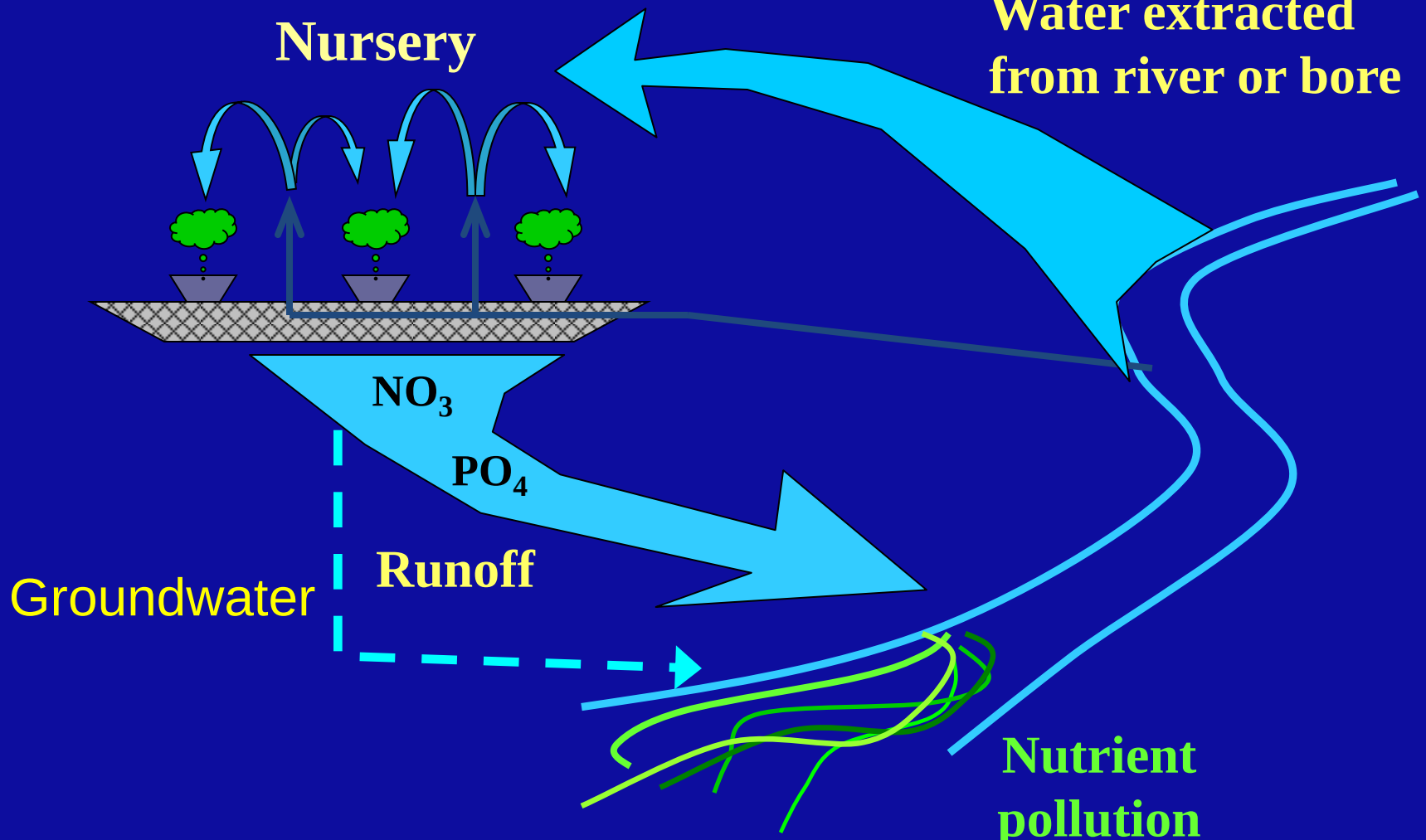
Throssell et al. (1995)

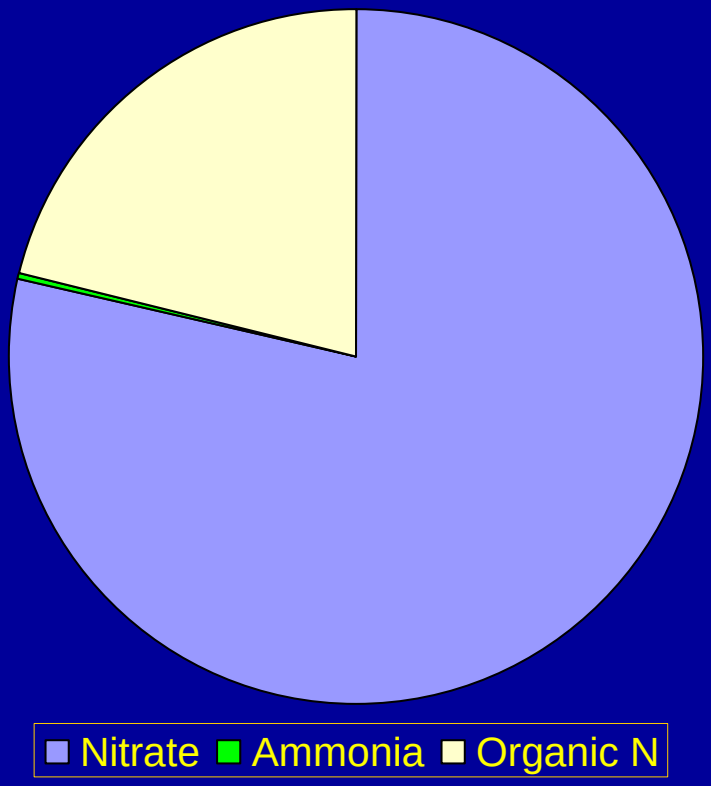
Mass flow (mg/s) and treatment efficiency during the storm events (average from 6 storm events):

	UI	AWO	GTC	GCO	% removal
N_{ox}-N	8.2	3.2	1.2	0.25	97
NH_4-N	17.9	3.4	0.3	0.0	100
P	2.1	1.24	0.69	0.71	74
COD	1465	330	54	154	90

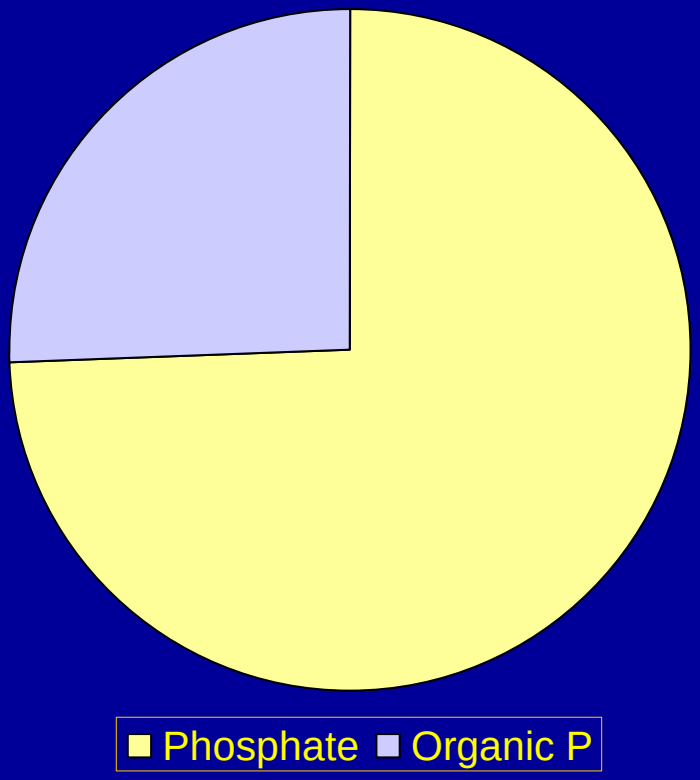
Greenhouse and nursery runoff

Traditional Open System





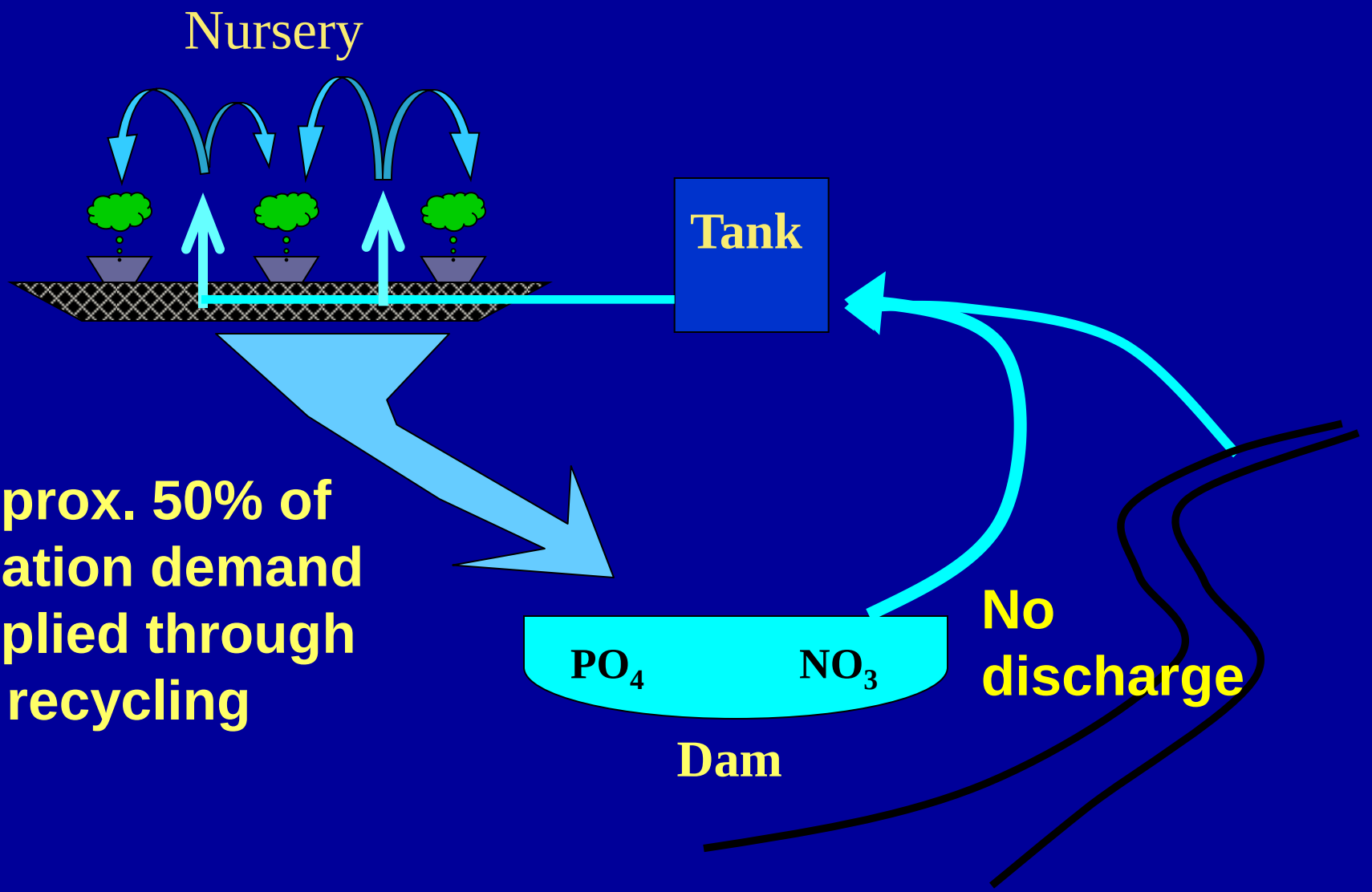
Total Nitrogen = 10 mg/L
(2.5 - 20)

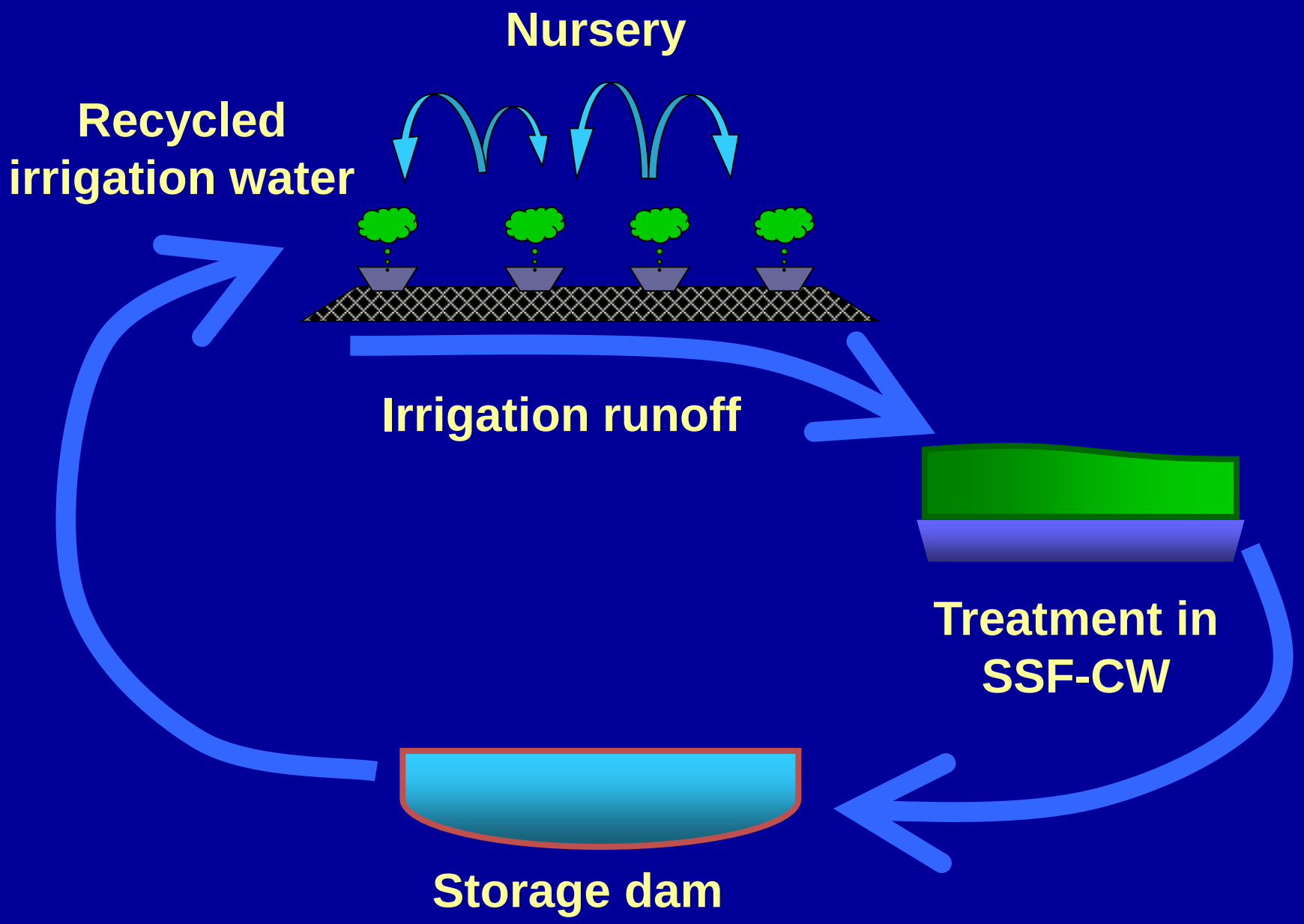


Total Phosphorus = 0.5 mg/L
(0.2 - 1.2)

Concentrations 10x higher where fertigation is practiced

Closed-loop System




Nursery
Recycled irrigation water
Irrigation runoff
Treatment in SSF-CW
Storage dam

Rule of thumb:

reed bed surface area = 4% of the nursery surface area

Residential stormwater runoff

Composition of residential areas stormwater runoff (Kaldec and Knight, 1996)

BOD_5	3.6 - 20 mg/L
TSS	18 - 140 mg/L
TN	1.1 - 2.8 mg/L
TP	0.14 - 0.51 mg/L

Average nitrogen concentrations (mg/L) in the stormwater in the United States (Collins et al., 2010)

	NH_3-N	$NO_{2,3}$-N	TKN	TN
Residential (n=1042)	0.31	0.60	1.5	2.1
Mixed residential (n=611)	0.39	0.57	1.4	2.0
Commercial (n=527)	0.50	0.60	1.5	2.1

Summary for TN inflow/outflow concentrations (mg/L) in various treatment facilities (Collins et al., 2010)

Wet ponds (n = 46)	1.7 / 1.4	Dry ponds (n= 25)	1.2 / 2.1
Green roots (n = 14)	1.3 / 1.8	Bioretention (n = 57)	1.3 / 0.8
Filters (n = 38)	1.3 / 0.8	Wetlands (n = 19)	2.1 / 1.2

Distribution of nitrogen fractions in the urban stormwater in Melbourne, Australia (Taylor et al., 2005)

NO_X	36%
NH_3	12%
DON	28%
PON	24%

Mean concentrations (mg/L) of various nitrogen fractions in stormwater

TN	2.13
TKN	1.39
Org-N	1.10
NO_X	0.74
NH_3	0.29


Treatment of parking lot runoff,
Charleston, South Carolina, USA

Treatment of stormwater runoff in a „Water Garden“, Madison, Wisconsin

Stormwater runoff control buffer zones, Charleston, SC, USA

Shezihlinpi Wetland, Kaohsiung city, Taiwan

Photo Brian Shutes

Zhouzhai wetland Park, Kaohsiung, Taiwan, stormwater

Urban runoff,

Bonnyrigg Park, NWS, Australia

Constructed wetland with floating emergent macrophytes for stormwater runoff, Bornem, Belgium

Sydney Olympic Park, Australia, stormwater runoff

Beijing Olympic Park stormwater runoff constructed wetland

Urban runoff, Plumpton Park, NSW, Australia


Built in 1994, wetland area: 0.45 ha, residential catchment: 75 ha, wetland/catchment: 0.006

Plumpton Park

TP
Inflow: 0.19 – 8.01 mg/L
Outflow: 0.04-1.06 mg/L
60% removal

TKN
Inflow: 0.5 – 40.1 mg/L
45% removal

Woodcroft Estate near Sydney, Australia

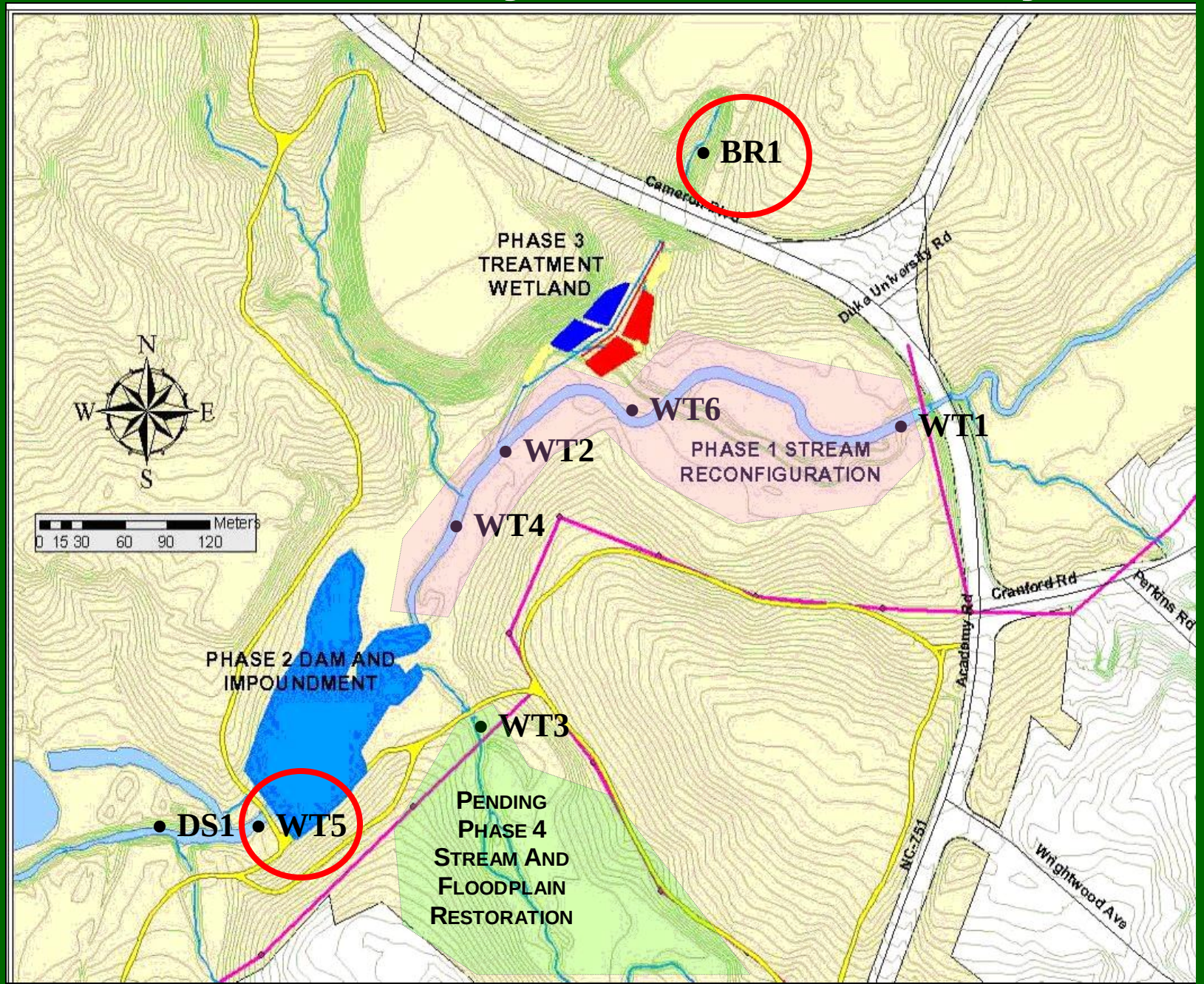
Built in 1995, Area: 1.5 ha, 53 ha catchment area
Wetland/catchment ratio: 0.028

Woodcroft Estate

TP
Inflow: 0.16 - 1.91 mg/l
Outflow: 0.1 - 0.96 mg/L

TKN
Inflow: 0.94 - 46.8 mg/L
Outflow: 0.1 – 16.7 mg/L

Duke University Stormwater Project




Former stream bed


Restored stream

http://www.google.com/maps
05-31-2007

http://www.google.com/maps
07-05-2010


Microsoft
Virtual Earth™
25 yds
© 2008 Microsoft Corporation © 2008 NAVTEQ © AND
© 2008 Pictometry International Corp.

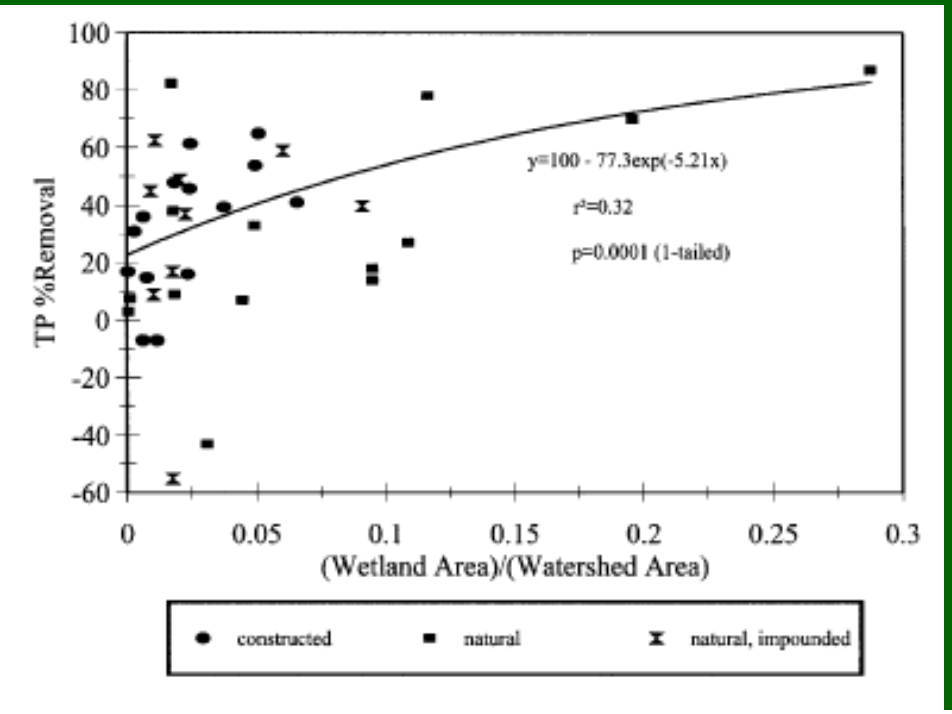
Removal of nutrients in the Duke University Stormwater Project

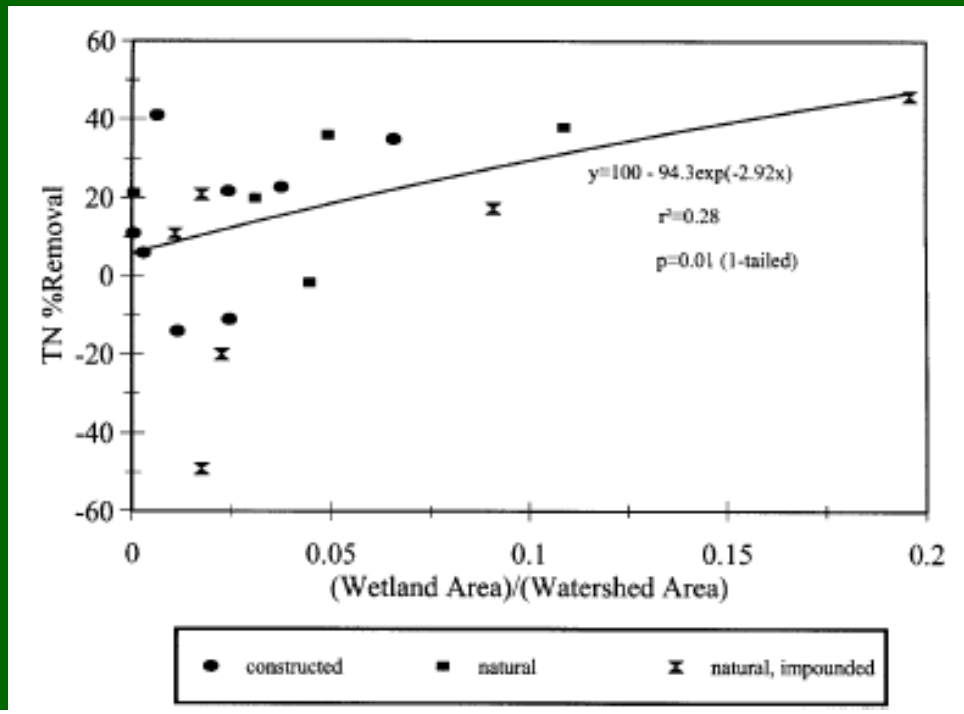
	TN	$NO_{2,3}^-$	NH_4^+	TP	SRP
		ug/L			
Inflow	3121	2697	159	401	295
Outflow	933	266	108	144	49
Removal (%)	70	58	32	64	83

Richardson et al. (2011)

Wetland: Watershed area ratio:
usually between 0.01 and 0.04

Stormwater wetland survey throughout the United States





TP and TN removal versus wetland-to watershed area ratio (Carleton et al., 2001)

Conclusions

In the urban environment, constructed wetlands could be used for treatment of several types of stormwater runoff, namely from the streets, parking lots, nurseries and greenhouses, golfcourses and airports.

For stormwater runoff treatment all types of constructed wetlands have been used

Wetlands are effective in nutrient removal from stormwater runoff but removal of nitrogen could be limited by the lack of organic compounds in the runoff.

Wetlands provide ecologically friendly solution for nutrient removal from stormwater runoff in urban areas.


Thank you for your attention