Measuring buffer strip effectiveness in a deeply permeable sandy soil: Beltrum, NL

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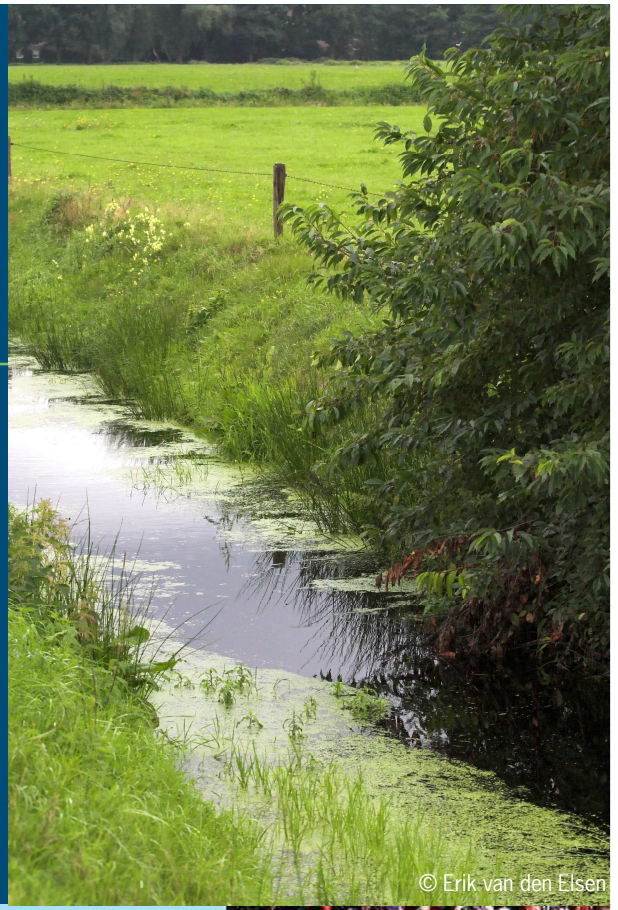

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Effectiveness Buffer strips

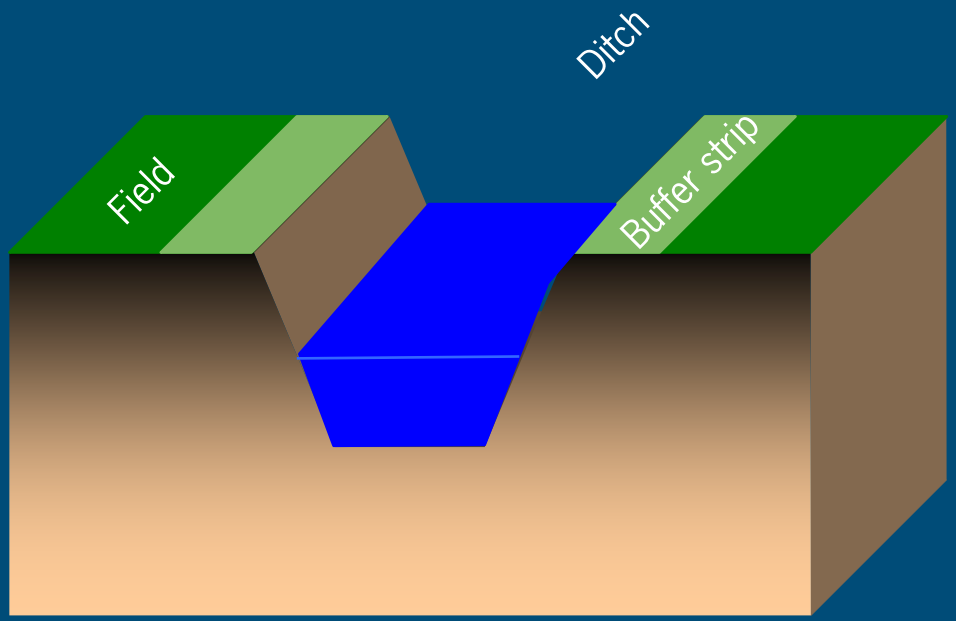
Contents

- Introduction
- Experiment at Beltrum
- Results and **B**uffer **S**trip **E**ffectiveness *BSE*
- Alternative definitions *BSE*
- Findings so far

Introduction

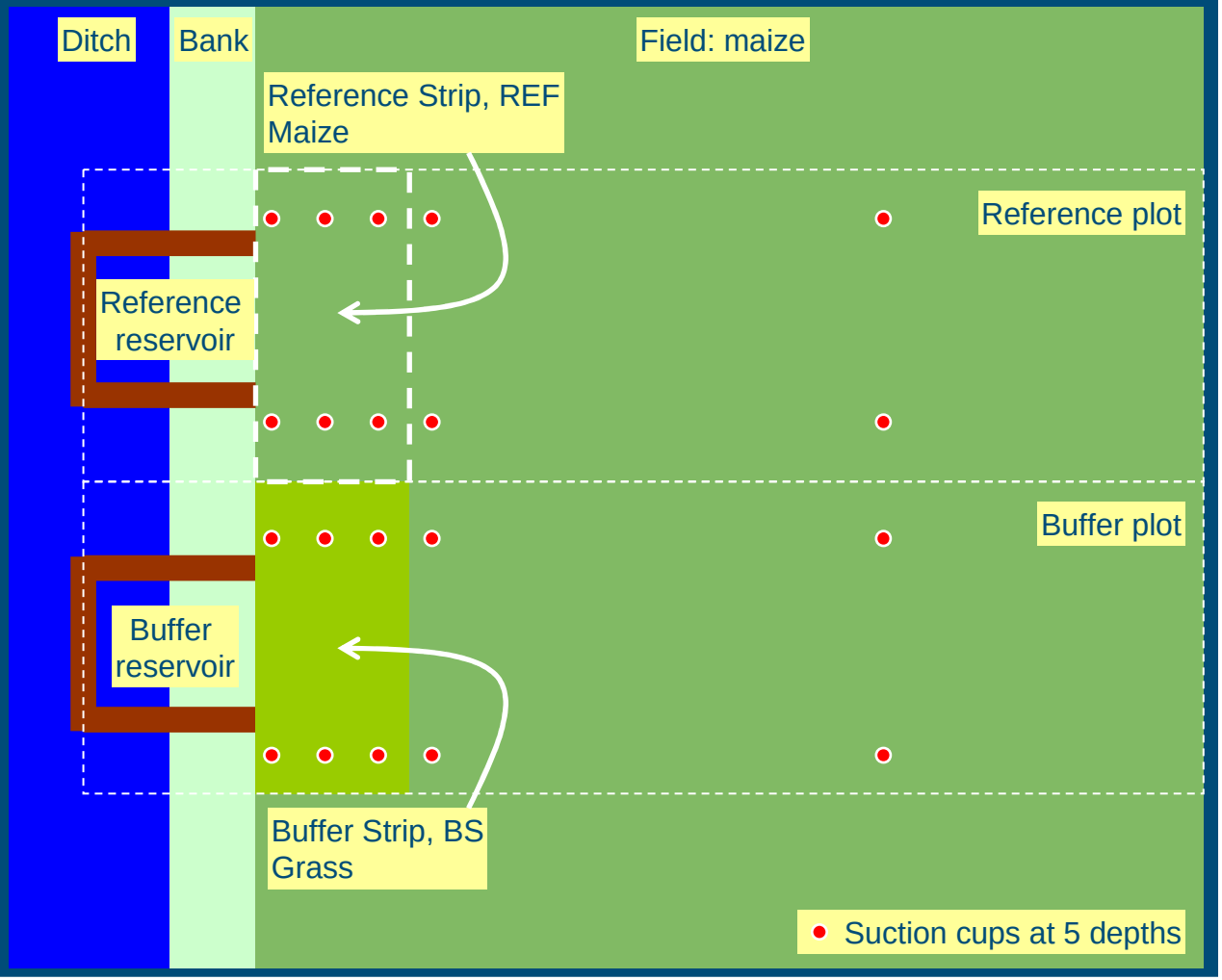
- Buffer Strips (BS) along water courses were suggested by EU
  - Doubts about effectiveness for specific geo-hydrological conditions in the NL
- 3rd Action Program Nitrates Directive
  - Along selected natural brooks: 5 m wide BS ✓
  - Do experimental research on effectiveness for other NL situations (+ model, + cost effectiveness)
- 5 Experimental sites: 2006-2010
  - Beltrum — 16 m deep permeable sand
  - Zegveld — peat
  - Winterswijk — thin sand layer
  - Loon op Zand — sand with loam layer at 2 m depth
  - Lelystad — light clay with pipe drains

Buffer Strip (BS): unfertilized field edge

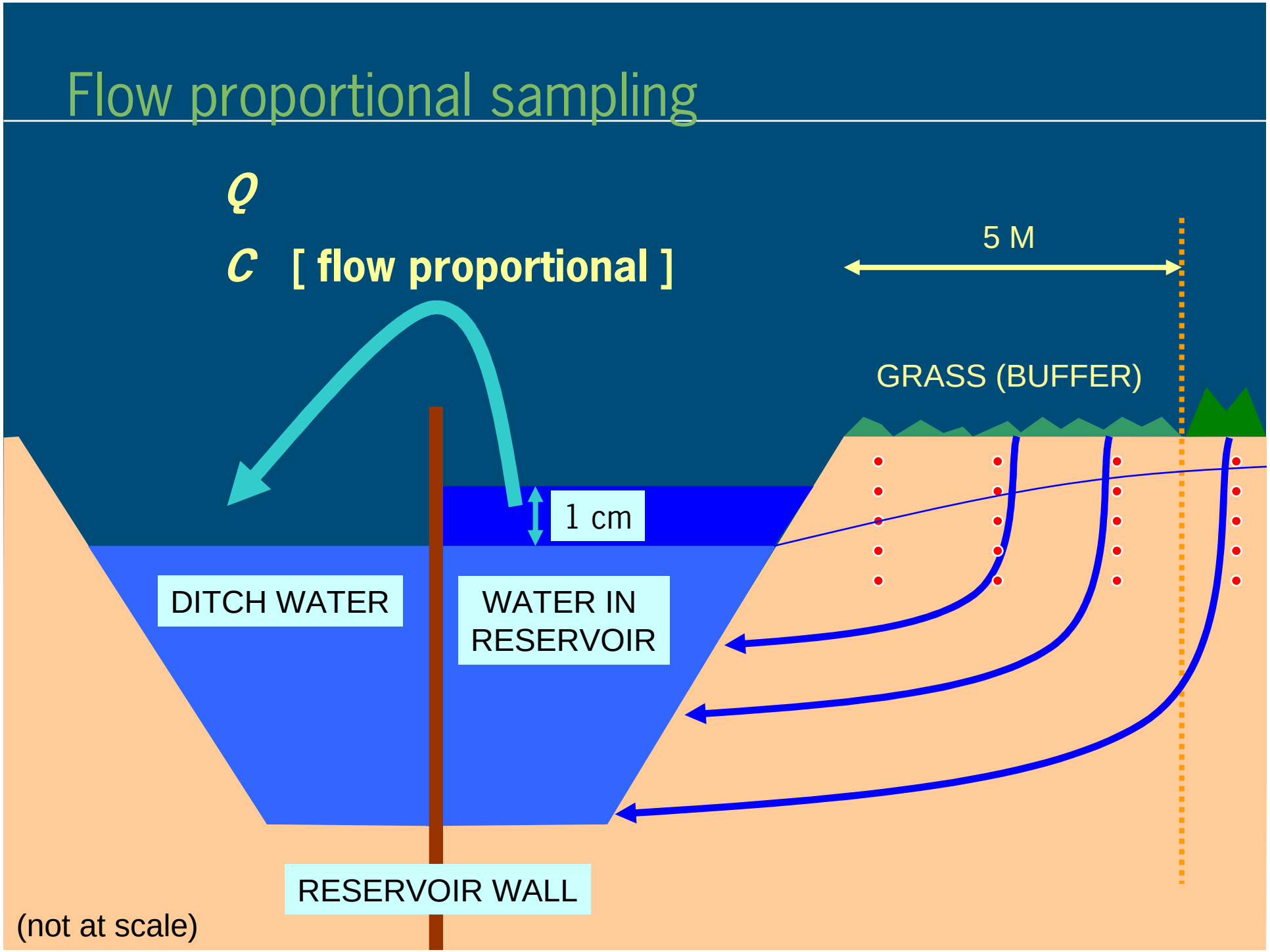


Treatments, replications

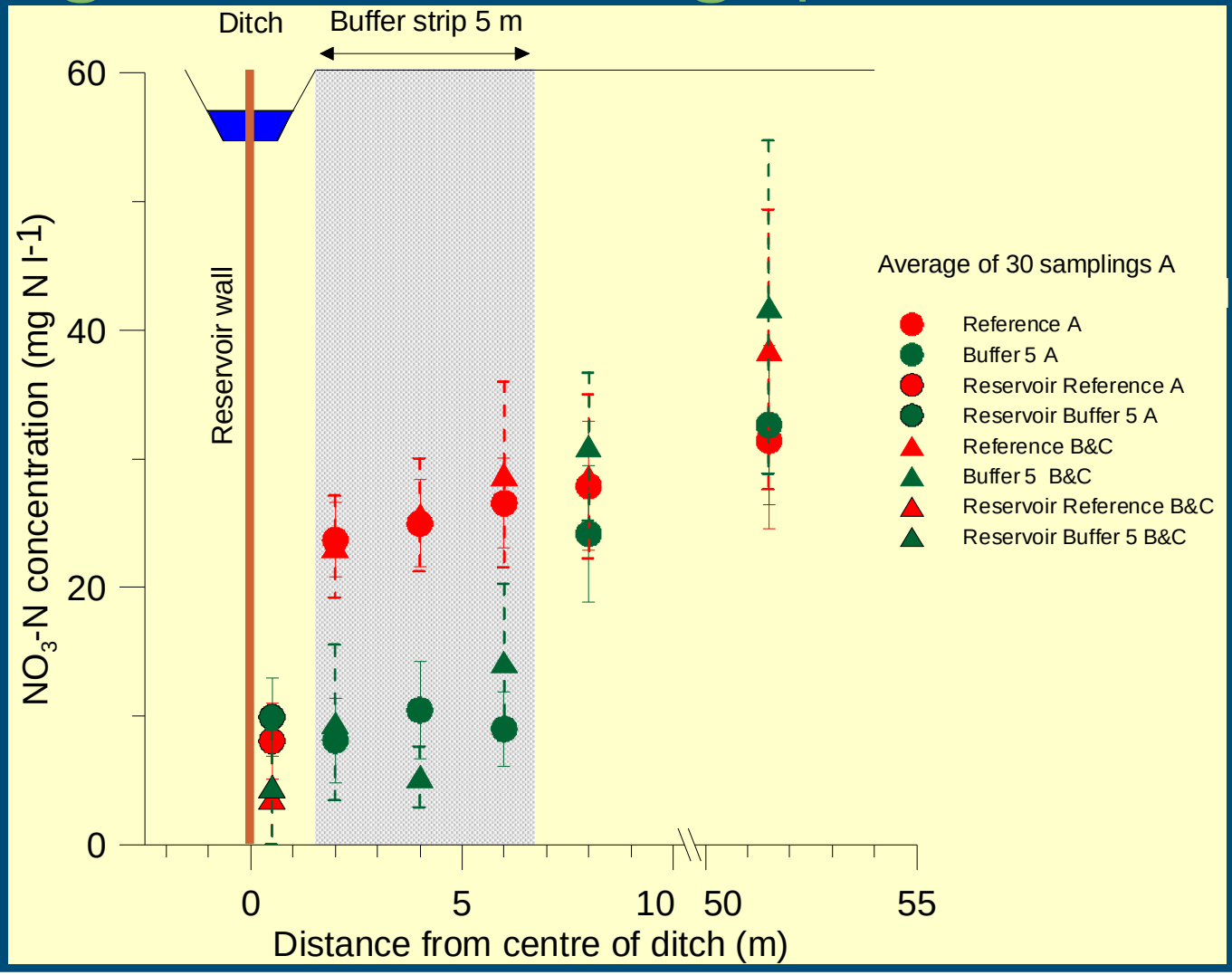
- Unfertilized buffer strip (BS) versus fertilized reference strip (REF)
- Replication A: start 2006
- Replications B&C: start 2007



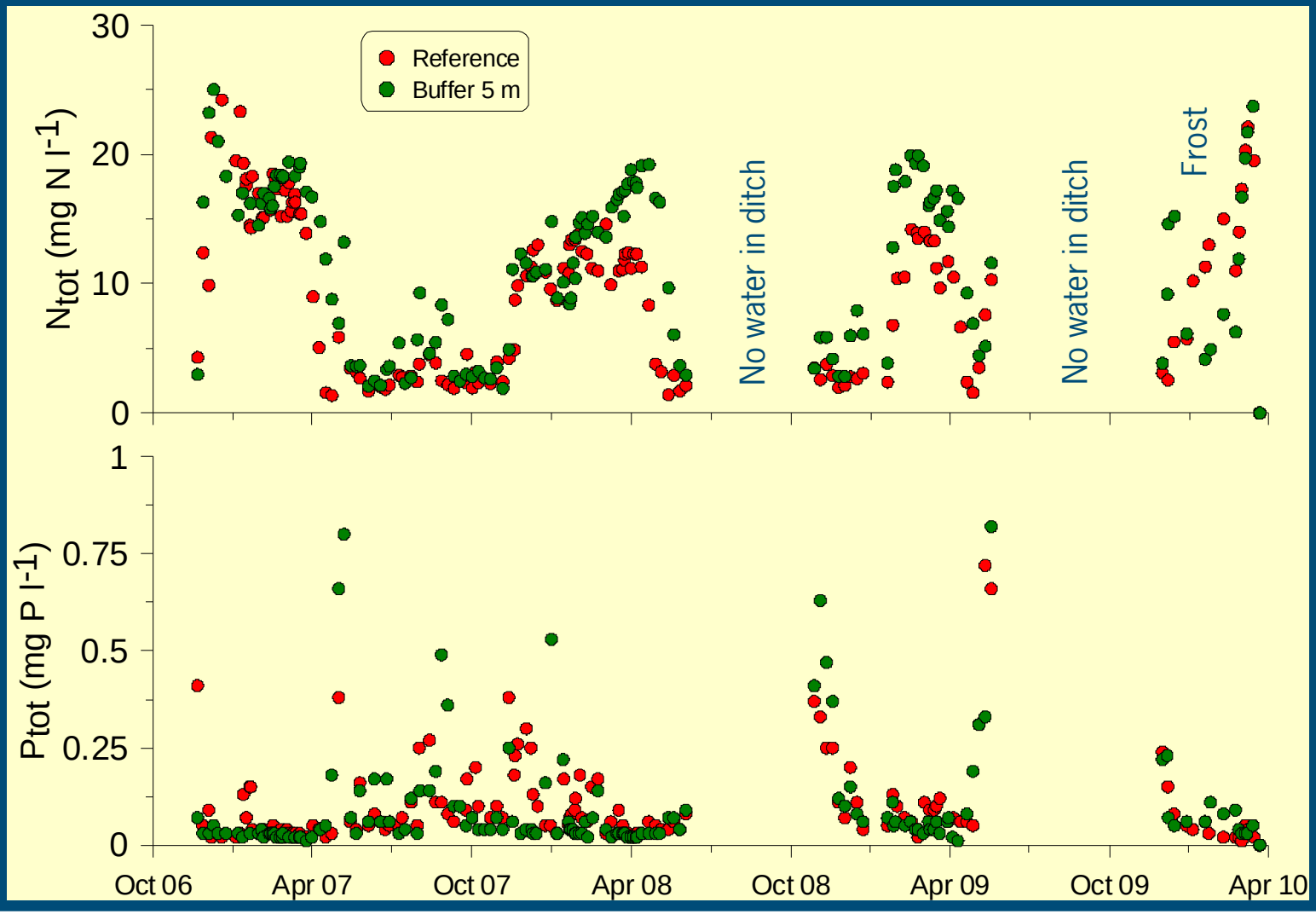
Flow proportional sampling



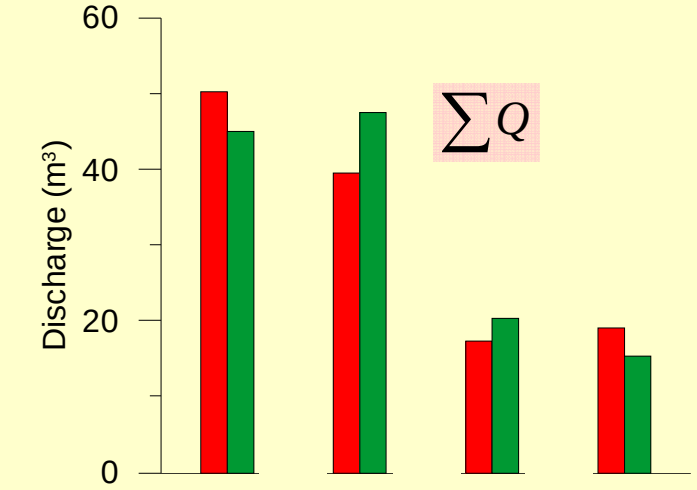
Upper groundwater: average pattern



Concentration in reservoirs (Beltrum, A)



Cumulative discharge and load, and concentration: N_{tot}



$$\sum Q$$

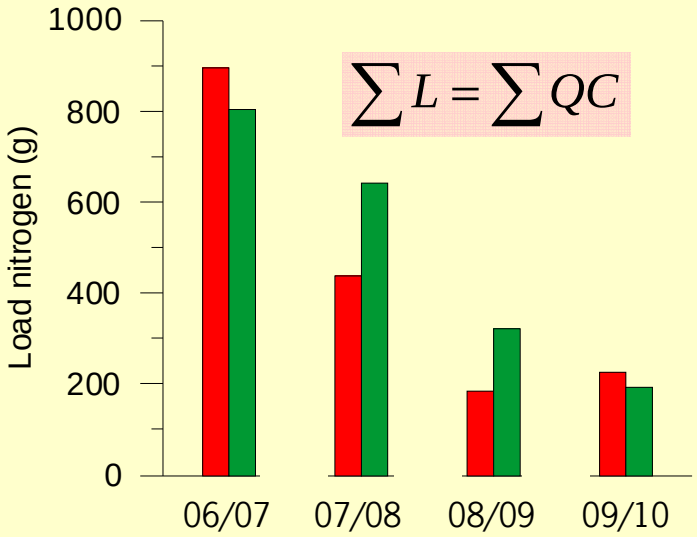
Beltrum, A

Reference plot

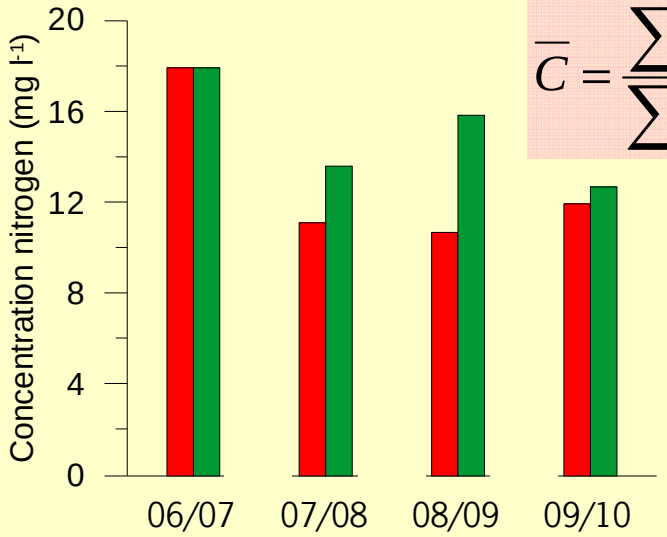
Buffer strip plot

Patterns in discharge dominate patterns in load.

We prefer to use flow-averaged concentrations.

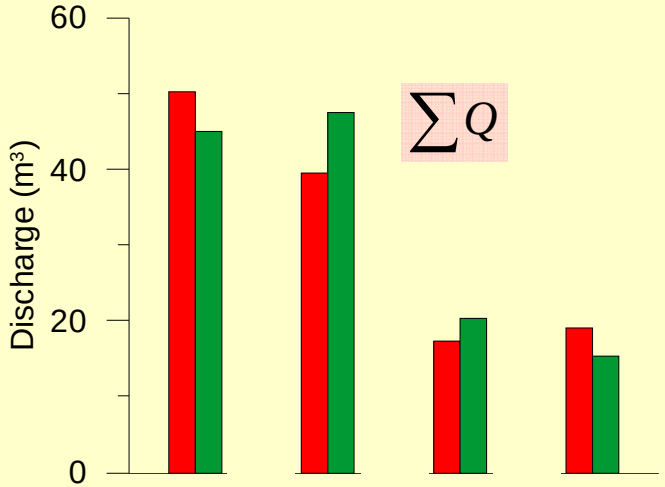


$$\sum L = \sum QC$$



$$\overline{C} = \frac{\sum L}{\sum Q}$$

Cumulative discharge and load, and concentration: P_{tot}

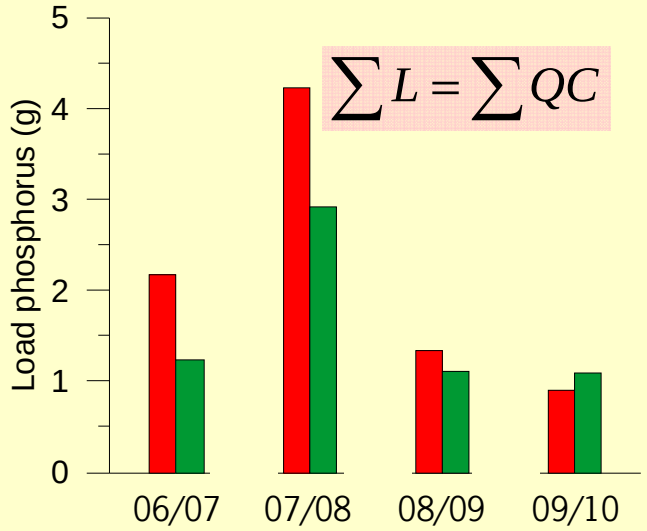


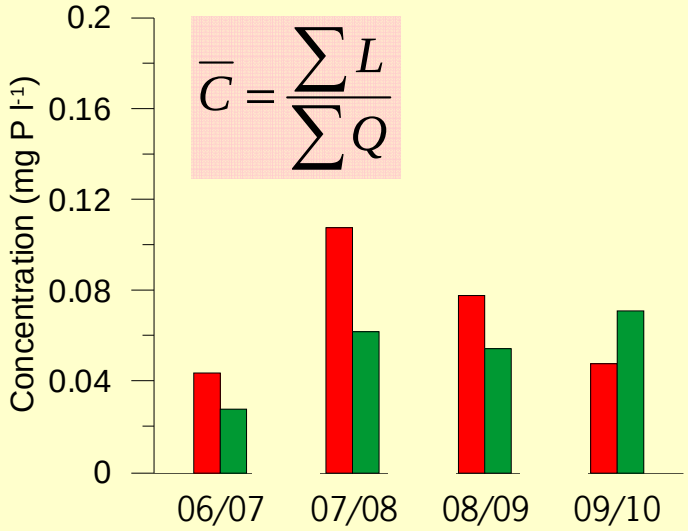
Beltrum, A

Reference plot

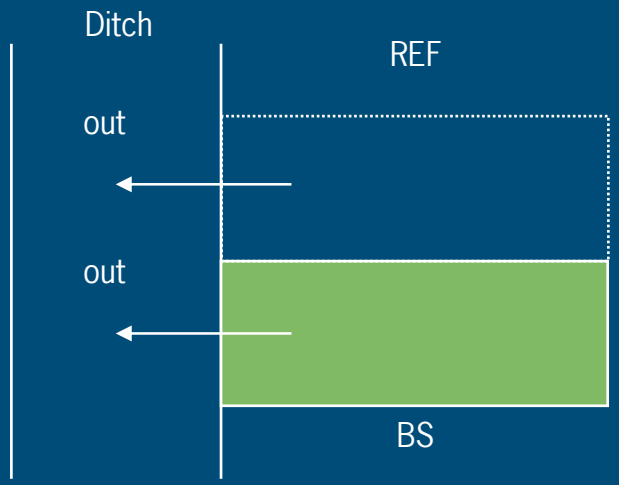
Buffer strip plot

P loads do not follow discharge pattern, opposite to N.





Buffer **S**trip **E**ffectiveness: *BSE*

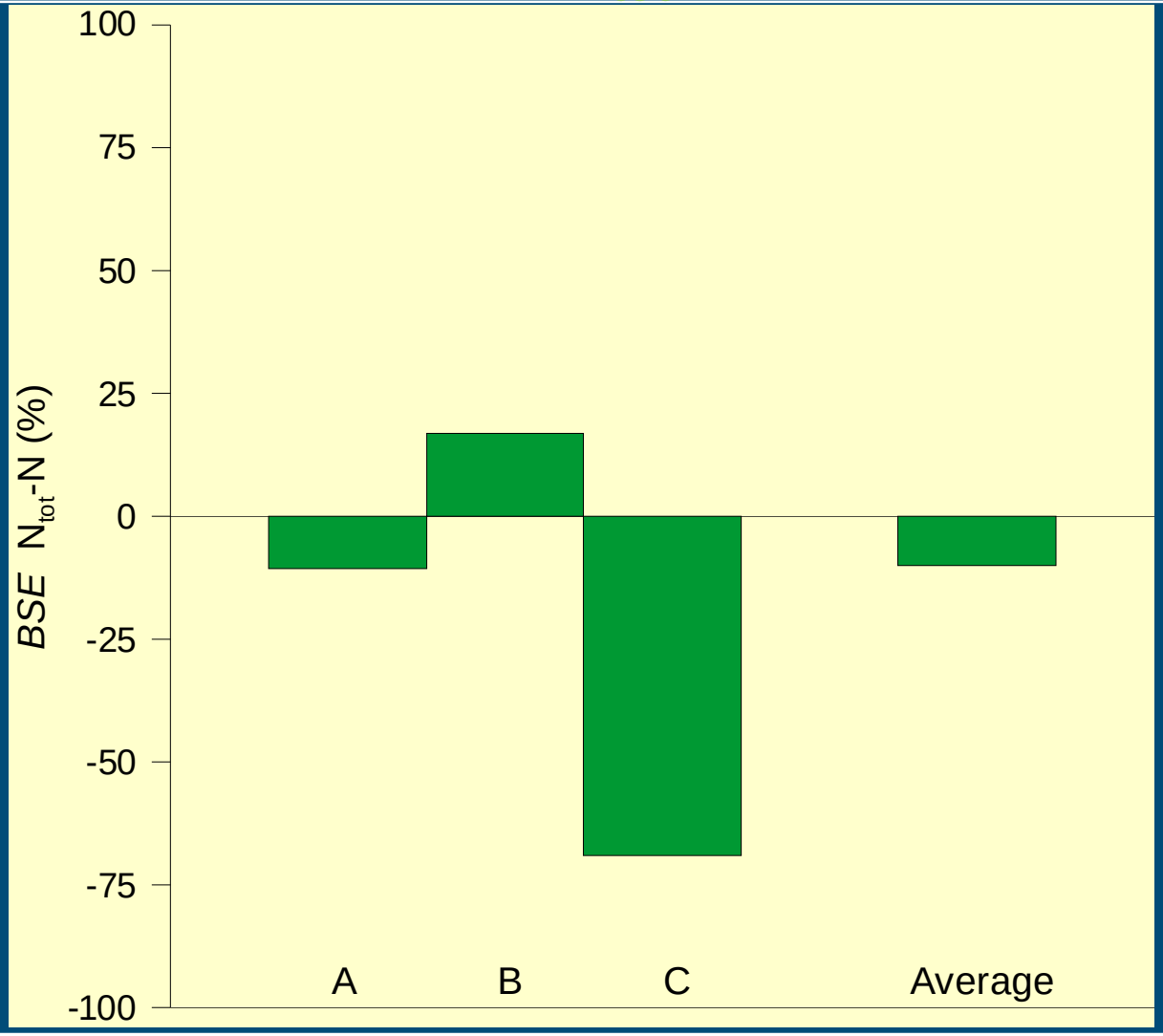


$$BSE = \frac{\overline{C}_{REF} - \overline{C}_{BS}}{\overline{C}_{REF}} = 1 - \frac{\overline{C}_{BS}}{\overline{C}_{REF}}$$

Upper bound: *BSE* = 1

Lower bound: *BSE* → - ∞

BSE for surface water N_{tot}: total period



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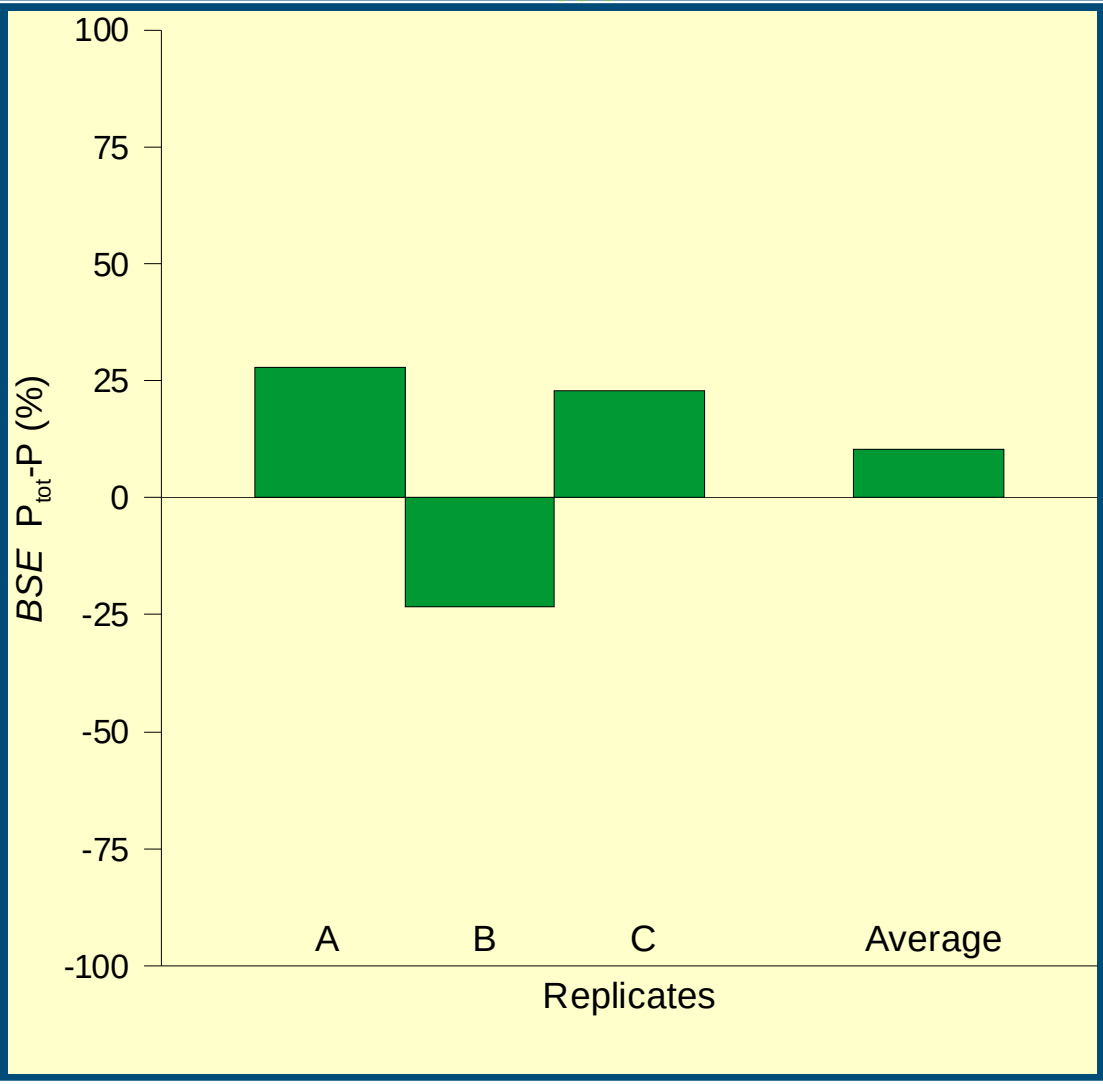
BSE for surface water P_{tot}: total period



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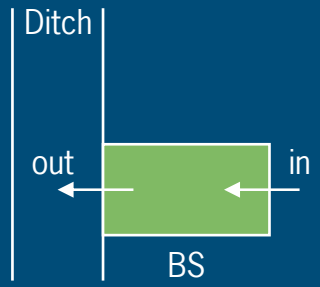
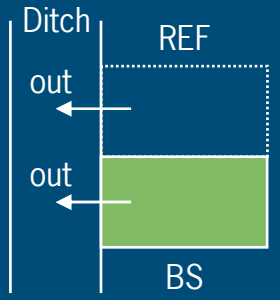
Different *BSE* formulations



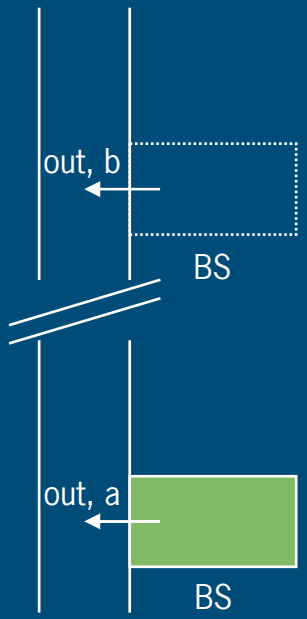
$$BSE = 1 - \frac{Y_{BS,out}}{Y_{BS,in}}$$

I



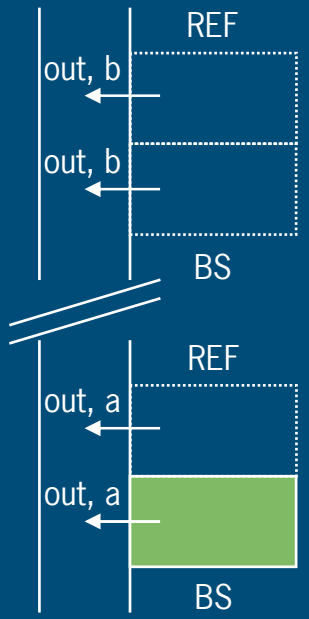
$$BSE = 1 - \frac{Y_{BS,out}}{Y_{REF,out}}$$

II



$$BSE = 1 - \frac{Y_{BS,a,out}}{Y_{BS,b,out}}$$

III



First leaching season serves as the before-treatment period

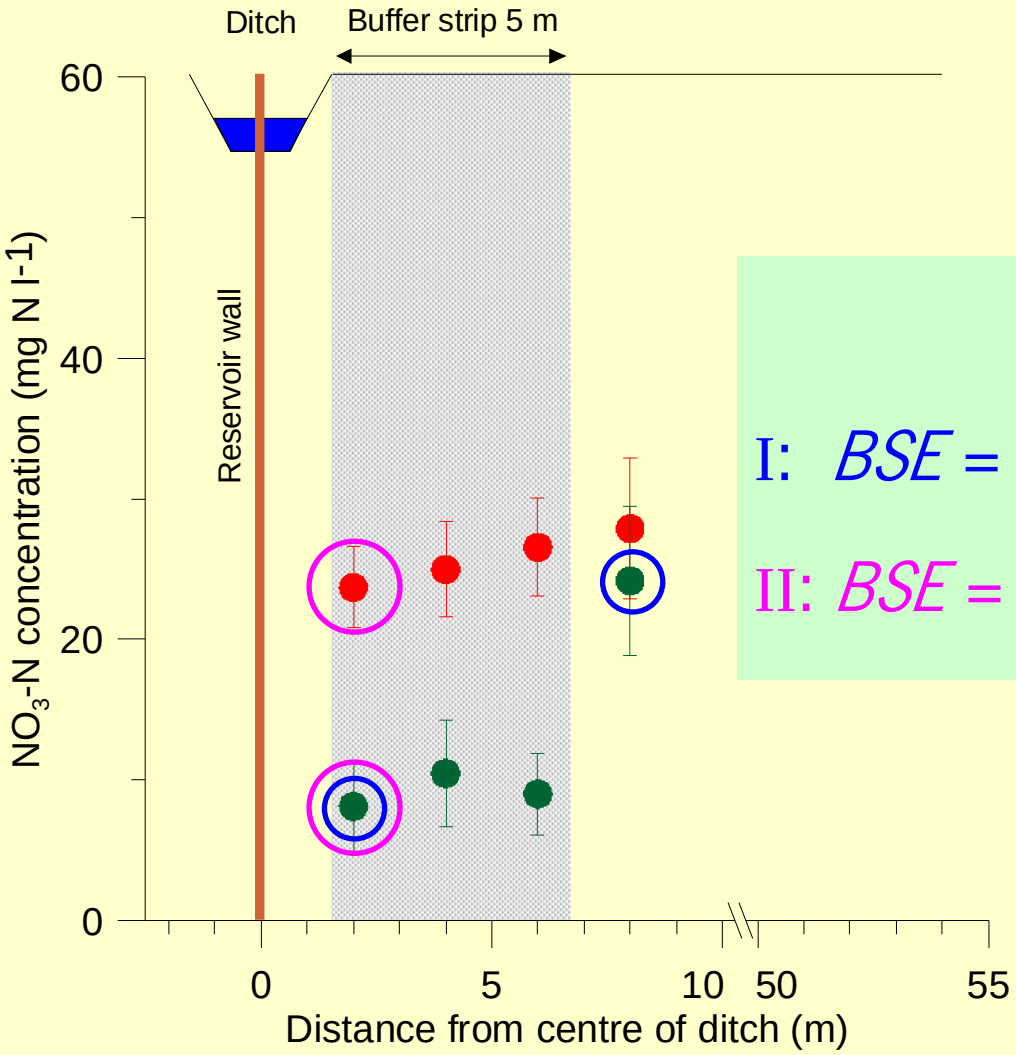
$$BSE = 1 - \frac{Y_{BS,a,out}}{Y_{REF,a,out}} \frac{Y_{REF,b,out}}{Y_{BS,b,out}}$$

IV

BS = buffer strip b = **b**efore installing treatment

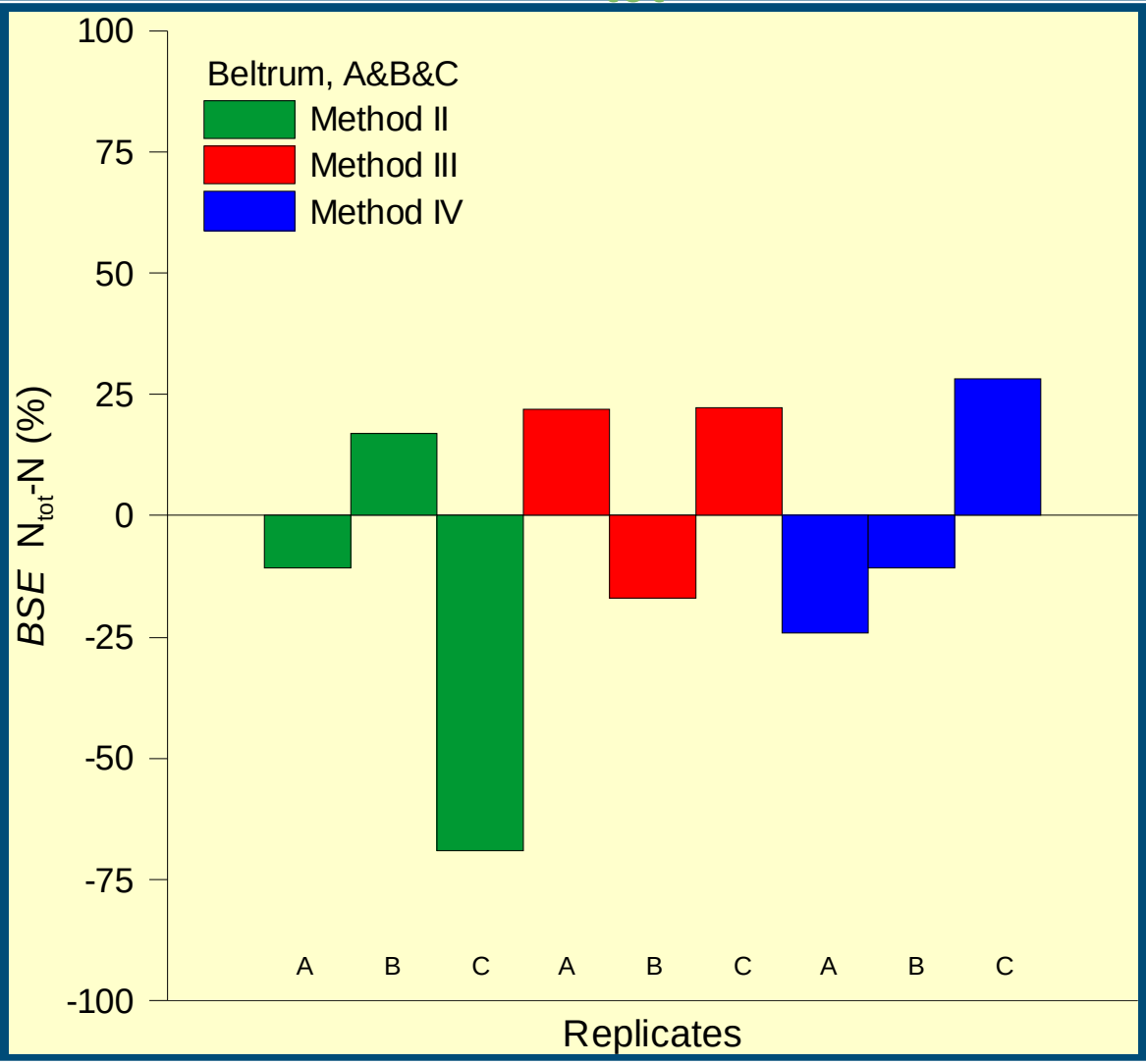
REF = reference strip a = **a**fter installing treatment

BSE based on upper groundwater



	A	B&C	Average
I:	*BSE* = 67.3%	67.7%	67.5%
II:	*BSE* = 67.1%	63.1%	65.0%

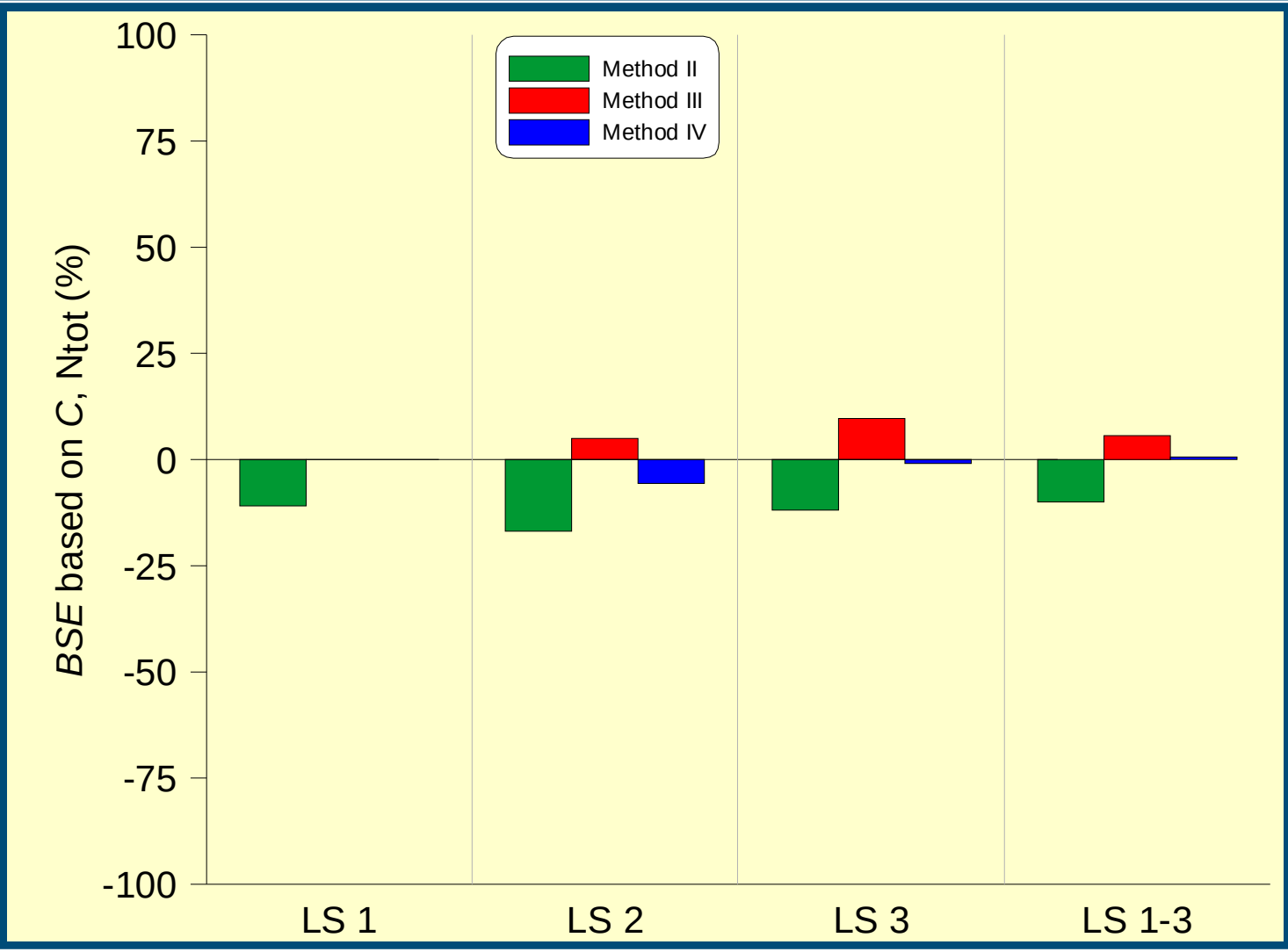
BSE for surface water N_{tot}: total period



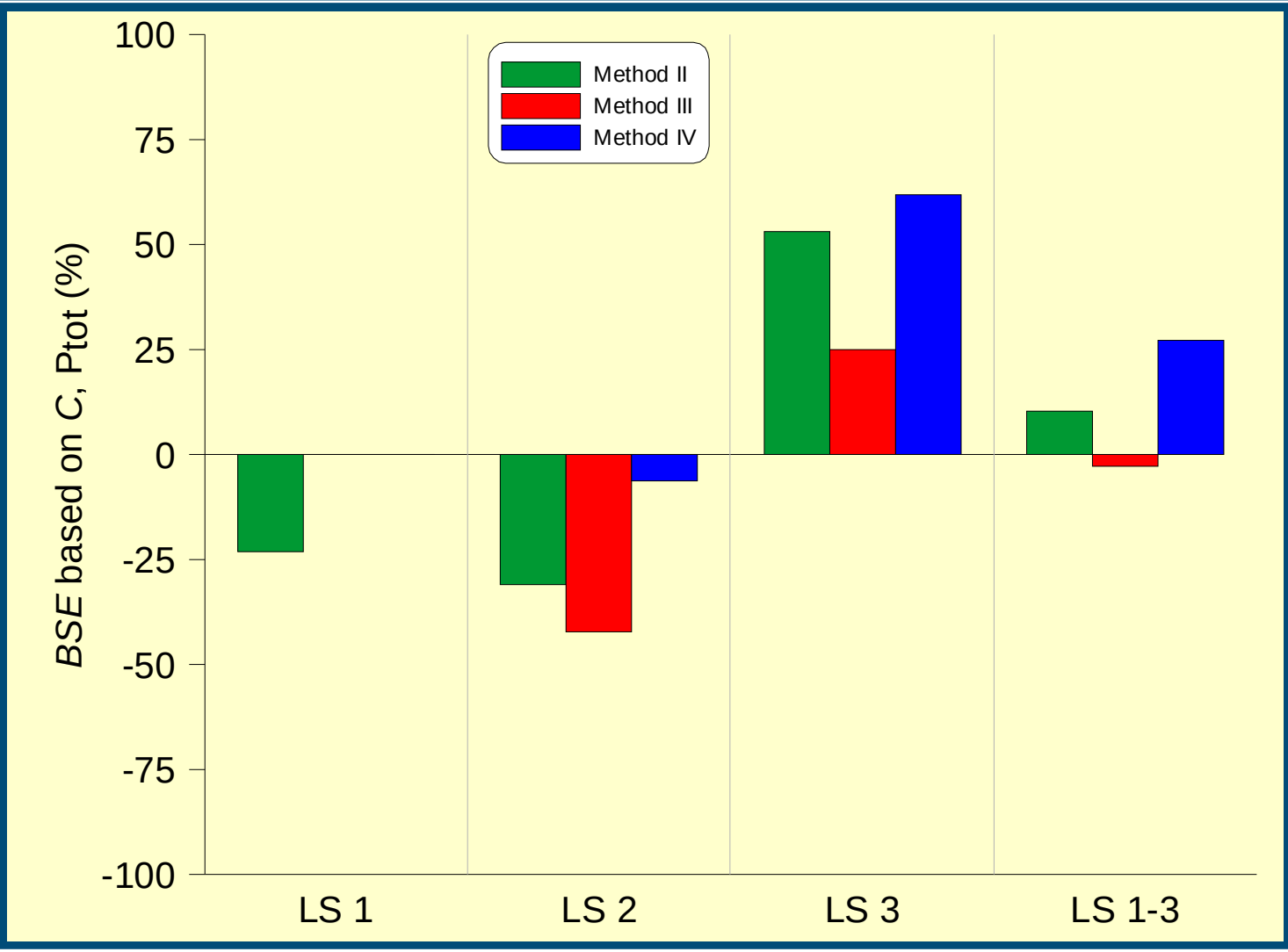
Method I not possible.

For nitrate similar patterns were obtained.

Average (A,B,C) *BSE* for surface water N_{tot}



Average *BSE* for surface water P_{tot}



Findings so far

- Beltrum: deep sandy soil: great effect in upper ground water, but not in ditch water
  - Ditch obtains water from greater depths not influenced by the BS
  - Denitrification in ditch bank and ditch bottom
- *BSE* for surface water for the deep sandy soil at Beltrum
  - Variation between replicates
  - N_{tot}: low, around zero
  - P_{tot}: positive, about 10%
- General: there are several ways to compute *BSE*
  - The different methods yield different estimates of *BSE*
  - The method that takes into account before-treatment measurements AND reference treatments should be preferred (method IV)

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Thank you