Landscape-drainage filters mitigating agricultural N and P losses

Virtual field-trip

LEVA skype meeting 2. September 2020

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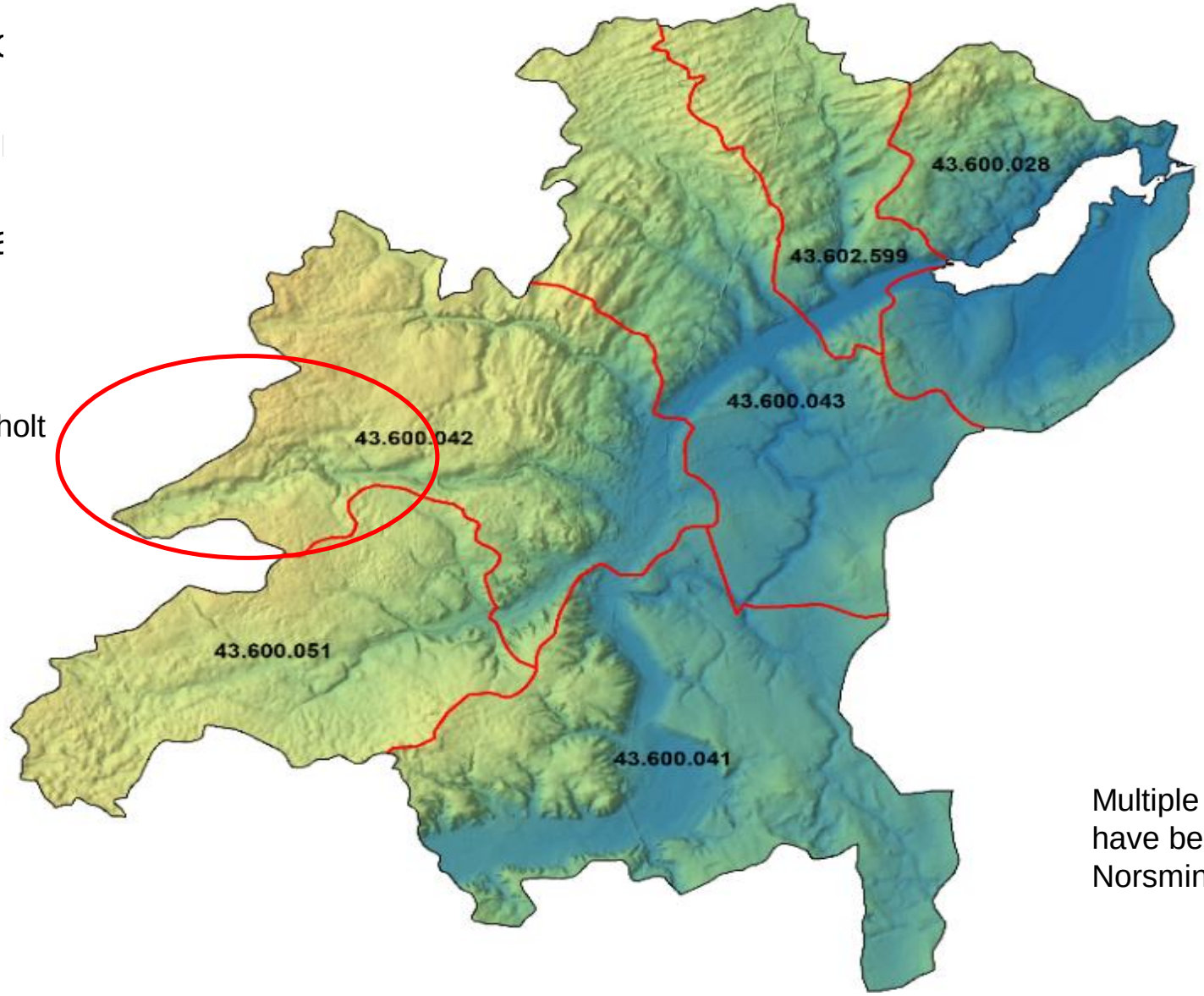
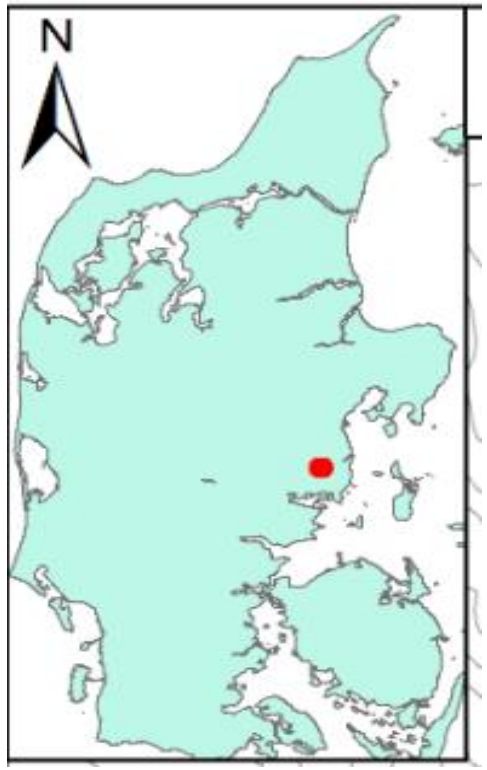
Field Trip Norsminde Fjord catchment

Norsminde Fjo

- 6 subcatch
- Significnat reduction ta

Trip into the Fensholt subcatchment





Multiple drainage measures have been implemented in Norsminde Fjord catchment

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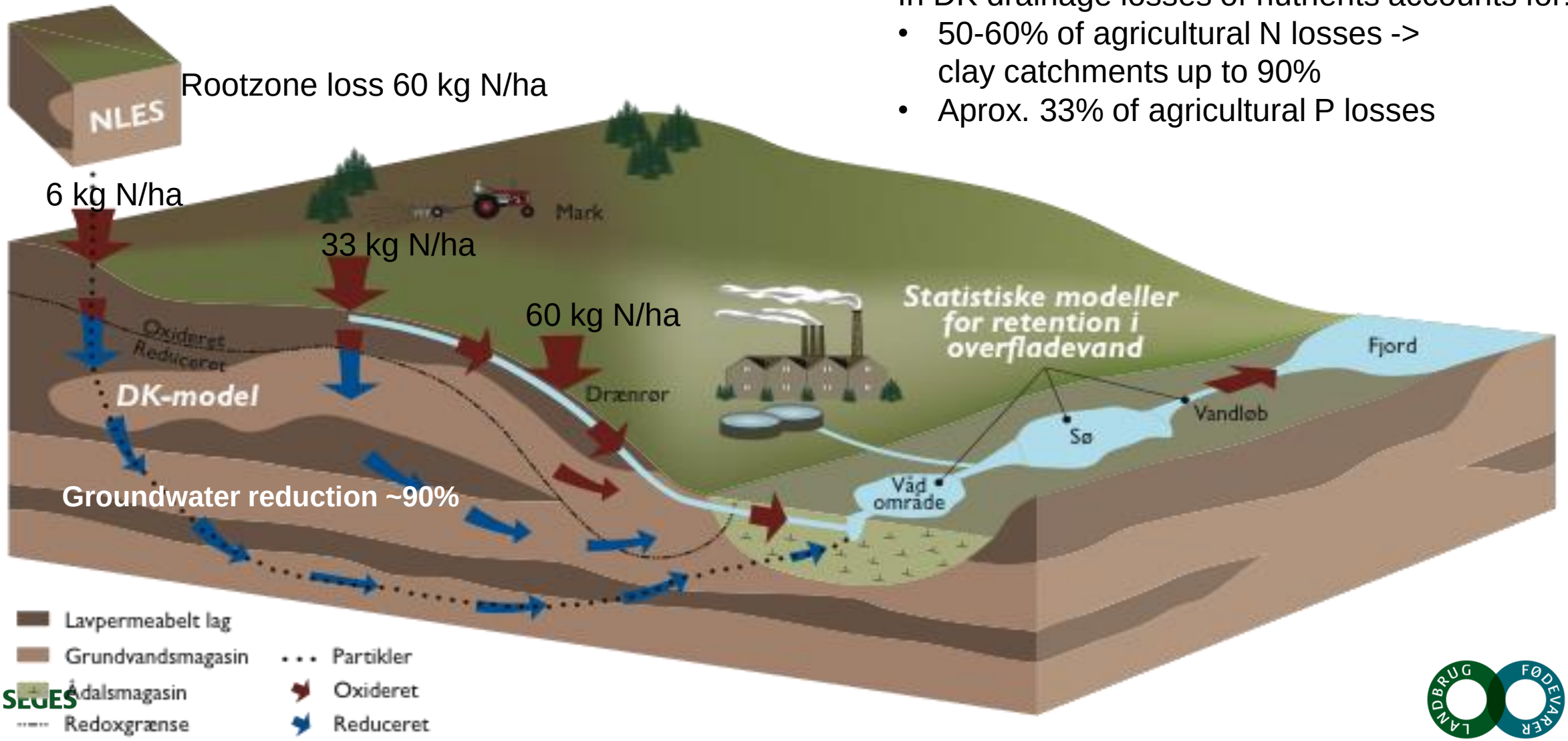
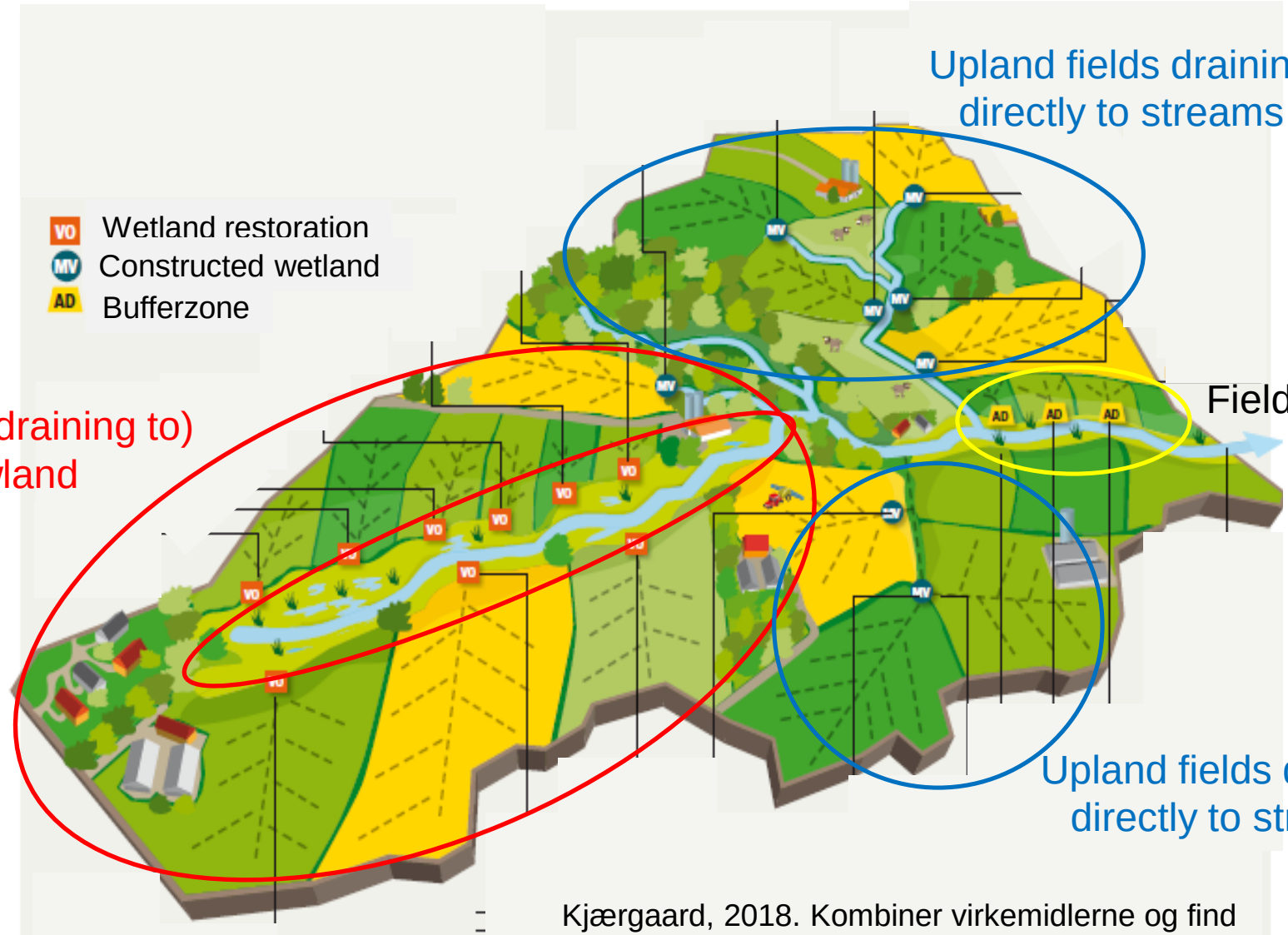
Drainage filters is a new targeted mitigation strategy

In DK drainage losses of nutrients accounts for:

- 50-60% of agricultural N losses -> clay catchments up to 90%
- Aprox. 33% of agricultural P losses



Filter solutions depends on the position in the landscape



Kjærgaard, 2018. Kombiner virkemidlerne og find den optimale løsning. Landbrugsavisen, Juni 2019

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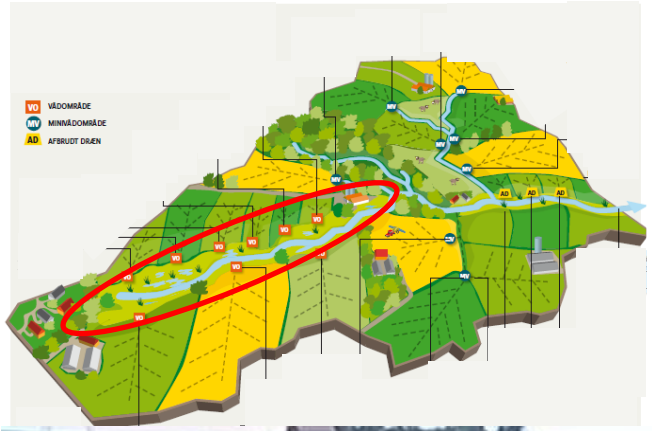
Riparian lowlands (wetlands) as natural drainage filters



Fields

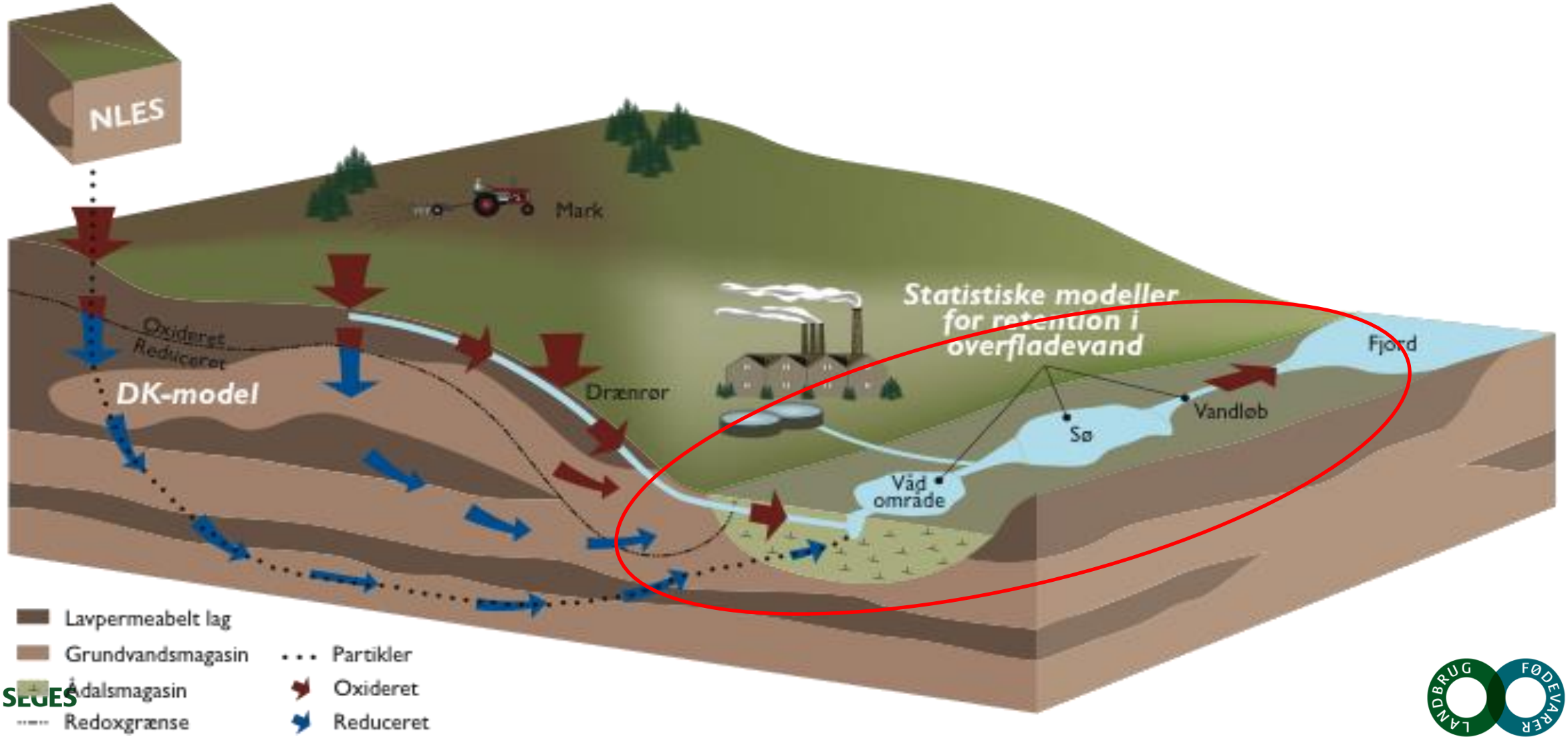
Stream

Lowland

Fields

Photo: SEGES

Riparian lowlands (wetlands) as natural drainage filters



Riparian lowlands (wetlands) as landscape filters

Wetland restoration (groundwater discharge)

Floodplains (river flooding lowlands)

- N-removal 50% (average)
- P risk assessment required for all projects (guideline)

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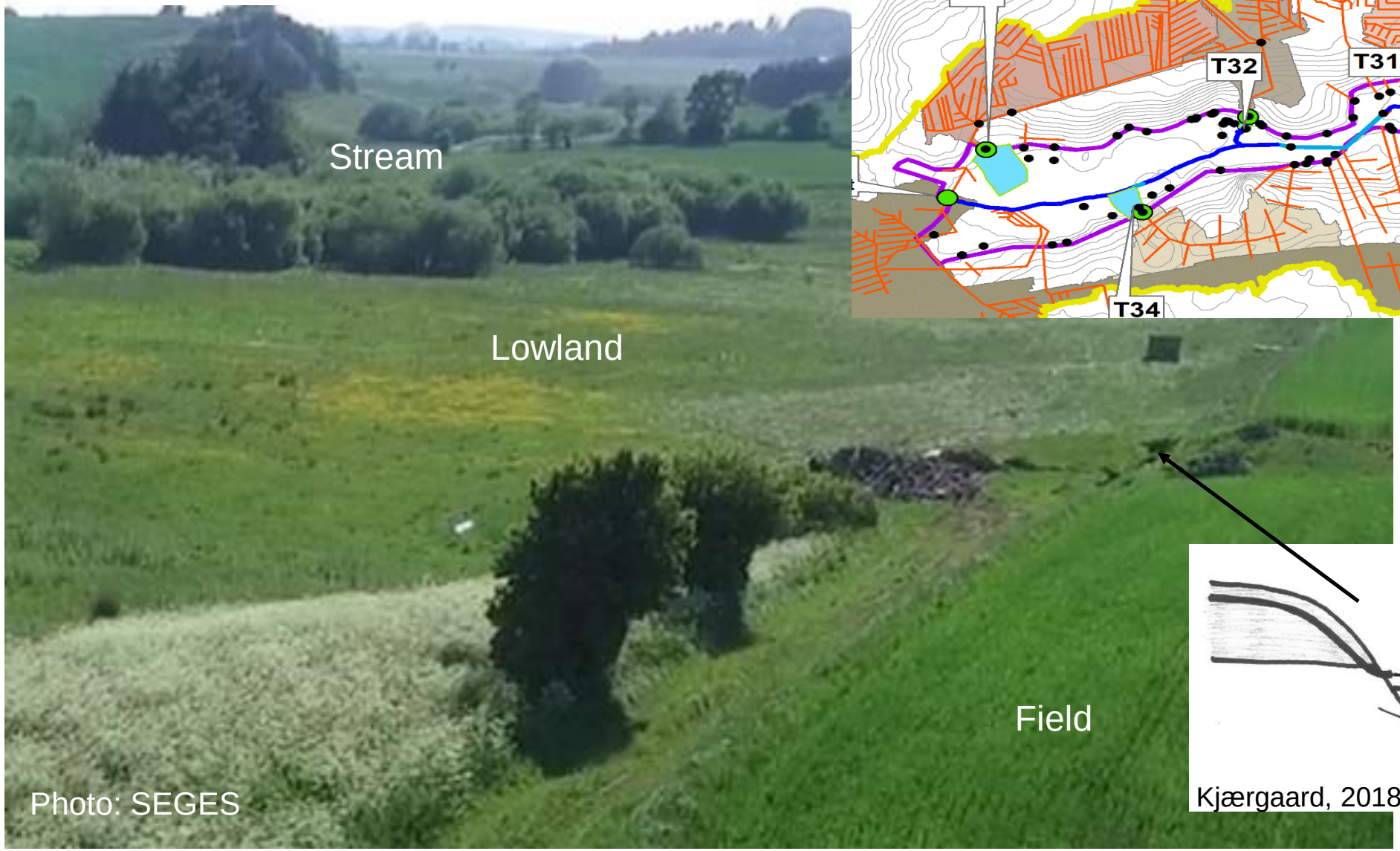
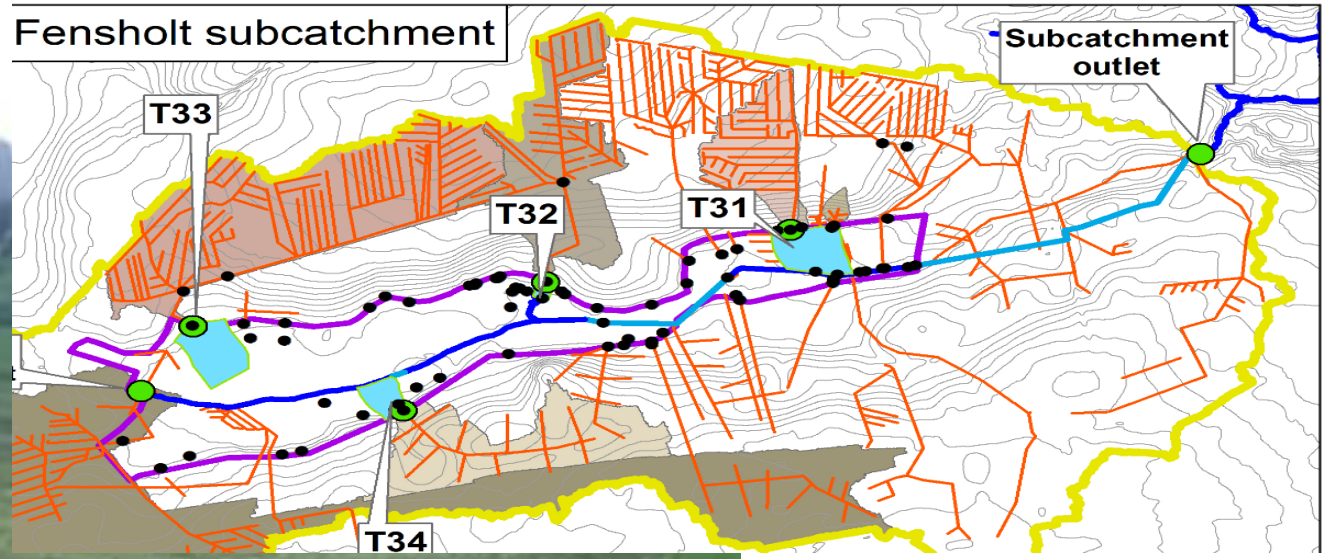
Disconnecting tile-drains

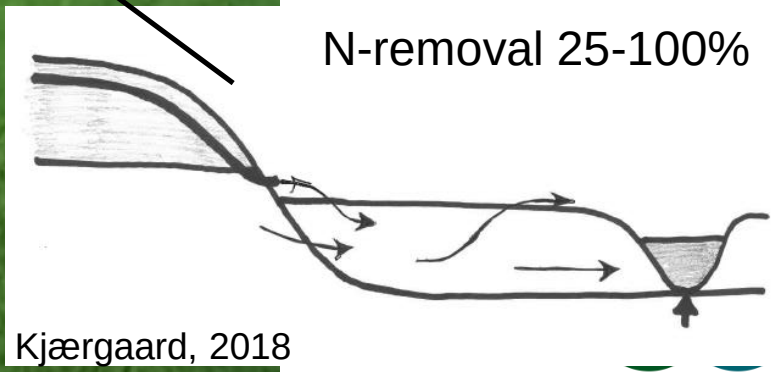
194 ha fields and 26 riparian peat lowland





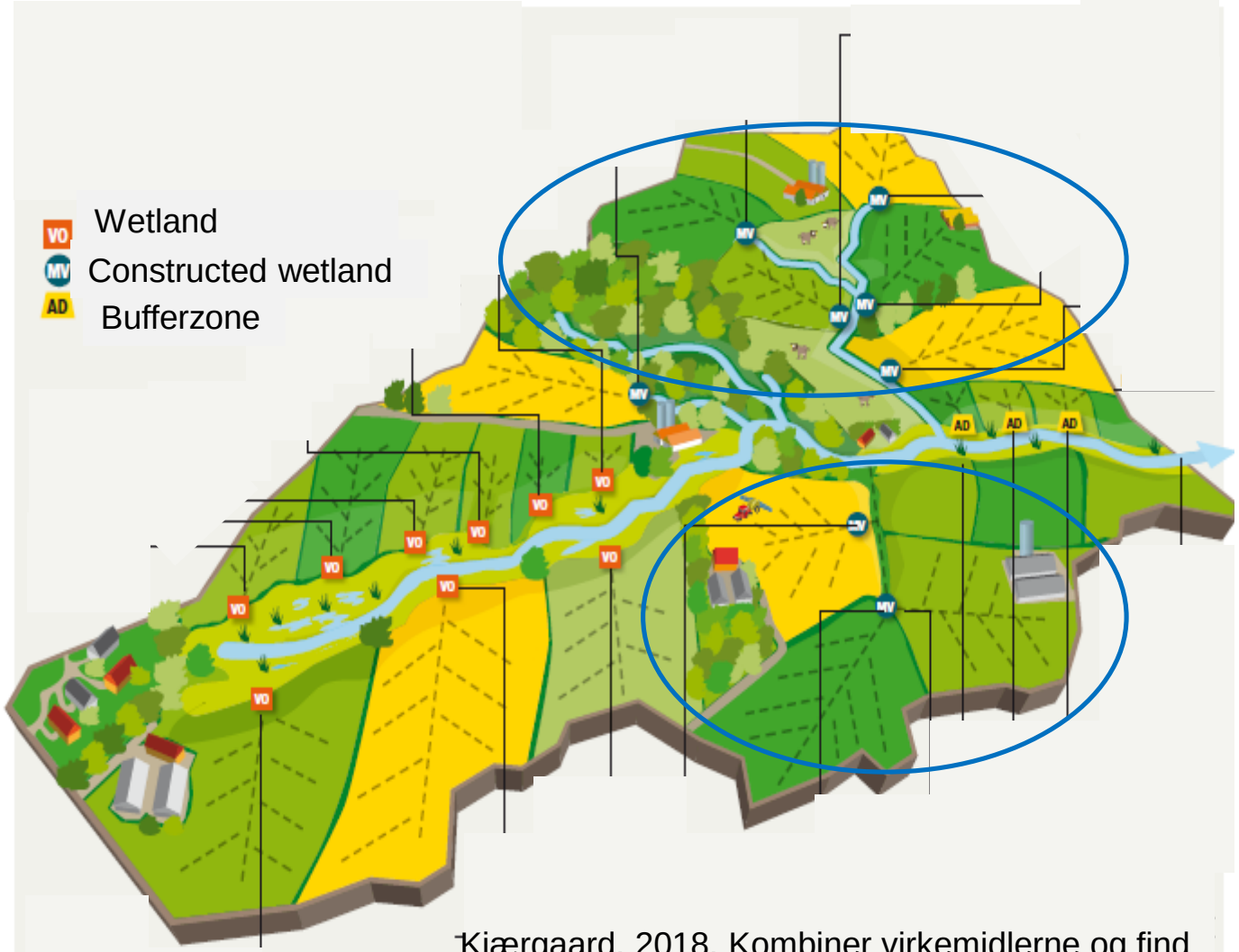
Petersen et al., 2020. Water Res.. Res.56 https://doi.org/10.1029/2019WR025808

N-removal 25-100%



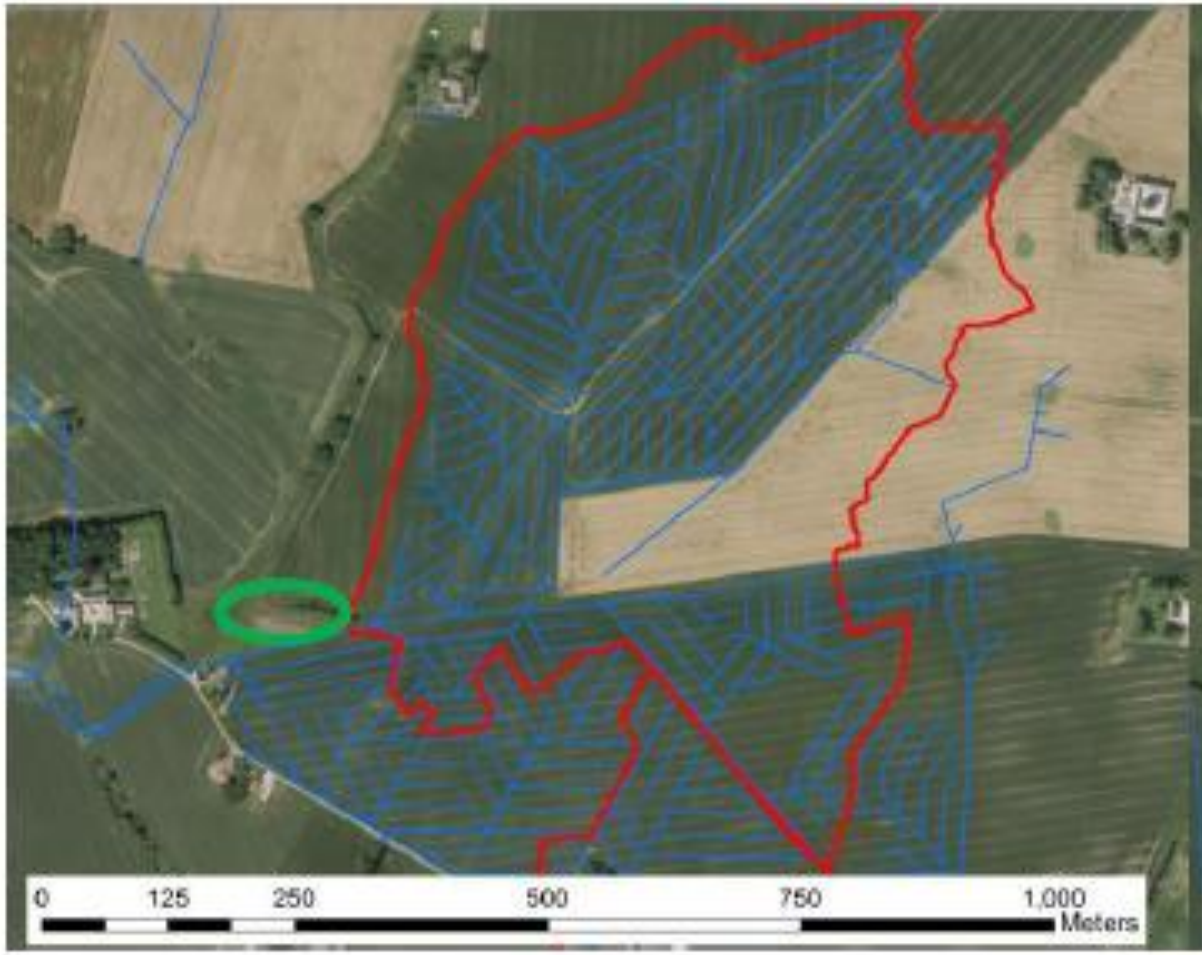
Kjærgaard, 2018

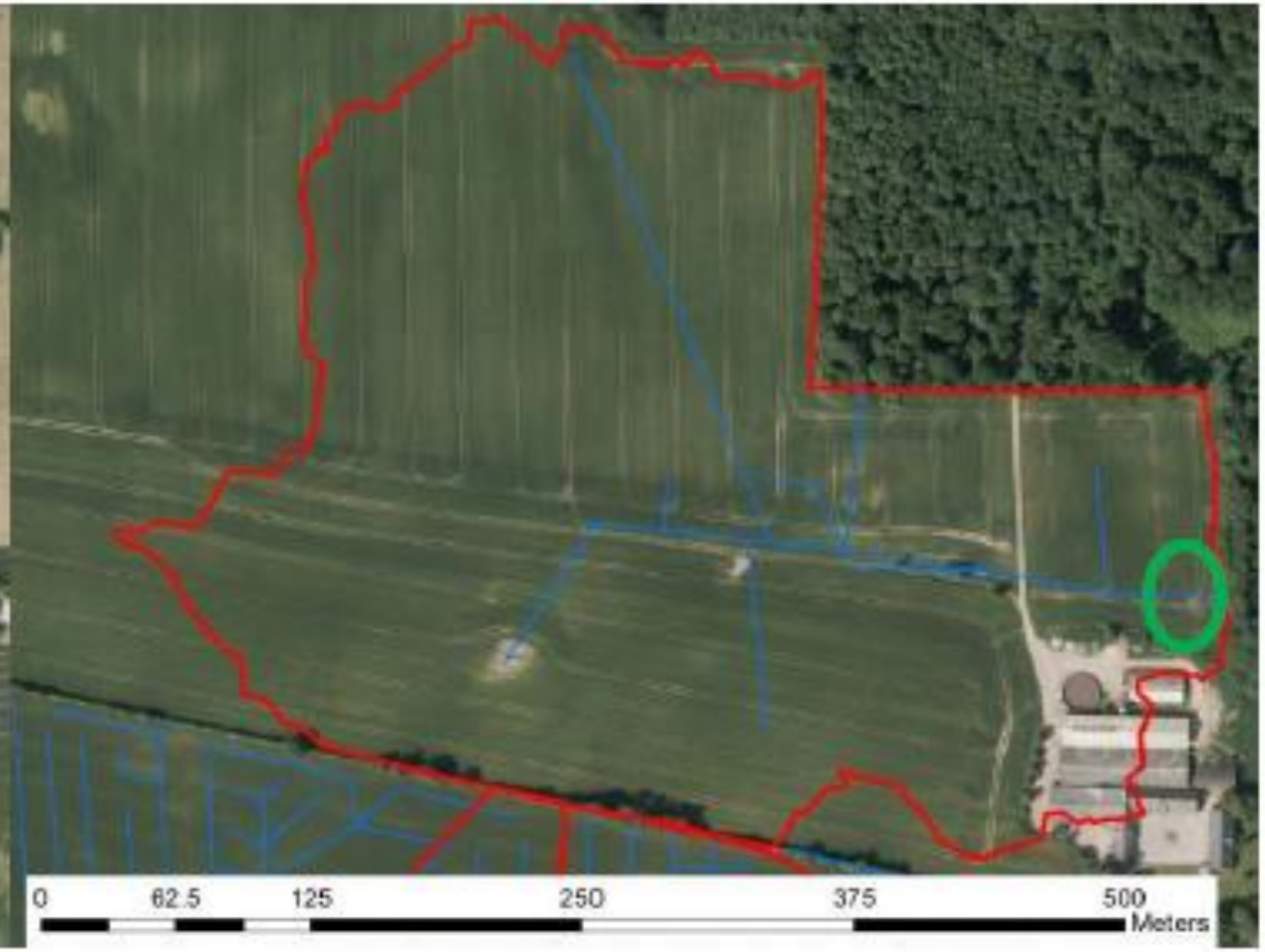
Drainage filters – constructed wetlands



Kjærgaard, 2018. Kombiner virkemidlerne og find den optimale løsning. Landbrugsavisen, Juni 2019

Drainage filters are considered end-of-pipe solutions





Kjærgaard, C. & Hoffmann, C.C. 2017. Retningslinjer for etablering af konstruerede minivådområder med overfladestrømning. Design manual. DCA – Nationalt Center for Jordbrug & Fødevarer, 3. marts 2017.

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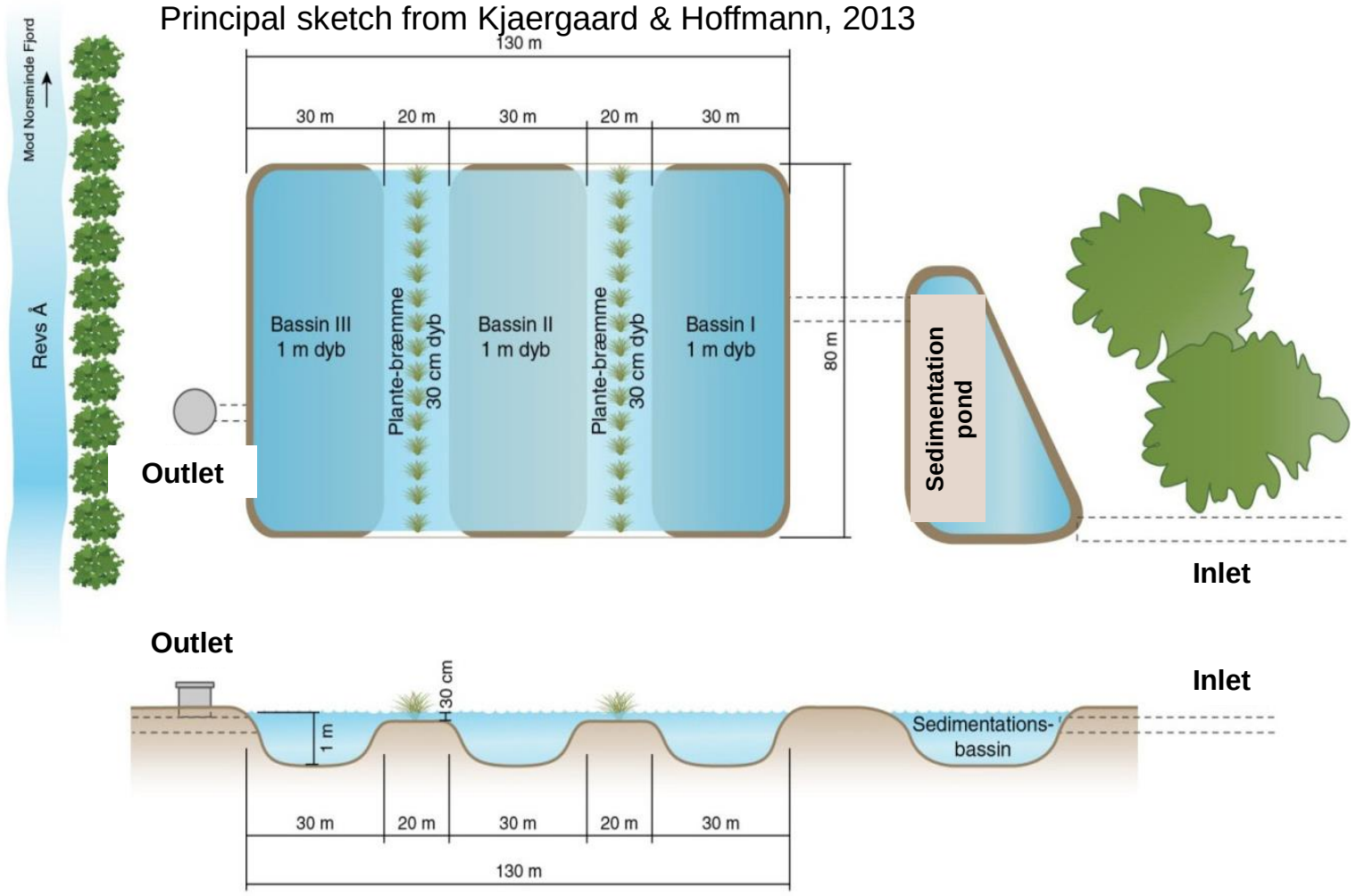
Surface-flow constructed wetlands (SF-CW)

Principal sketch from Kjaergaard & Hoffmann, 2013



Construction

- Size: 1% of the drainage catchment (Min. HRT ~1 day)
- Guidelines for construction

Annual N & P effects

- Average 25% (17-45%) N-reduction
- Average 43% (30-80%) P retention

Approved as drainage measure 2017

- 1.000-1.500 SF-CW in 2018-2021 targeting 900 ton N/yr

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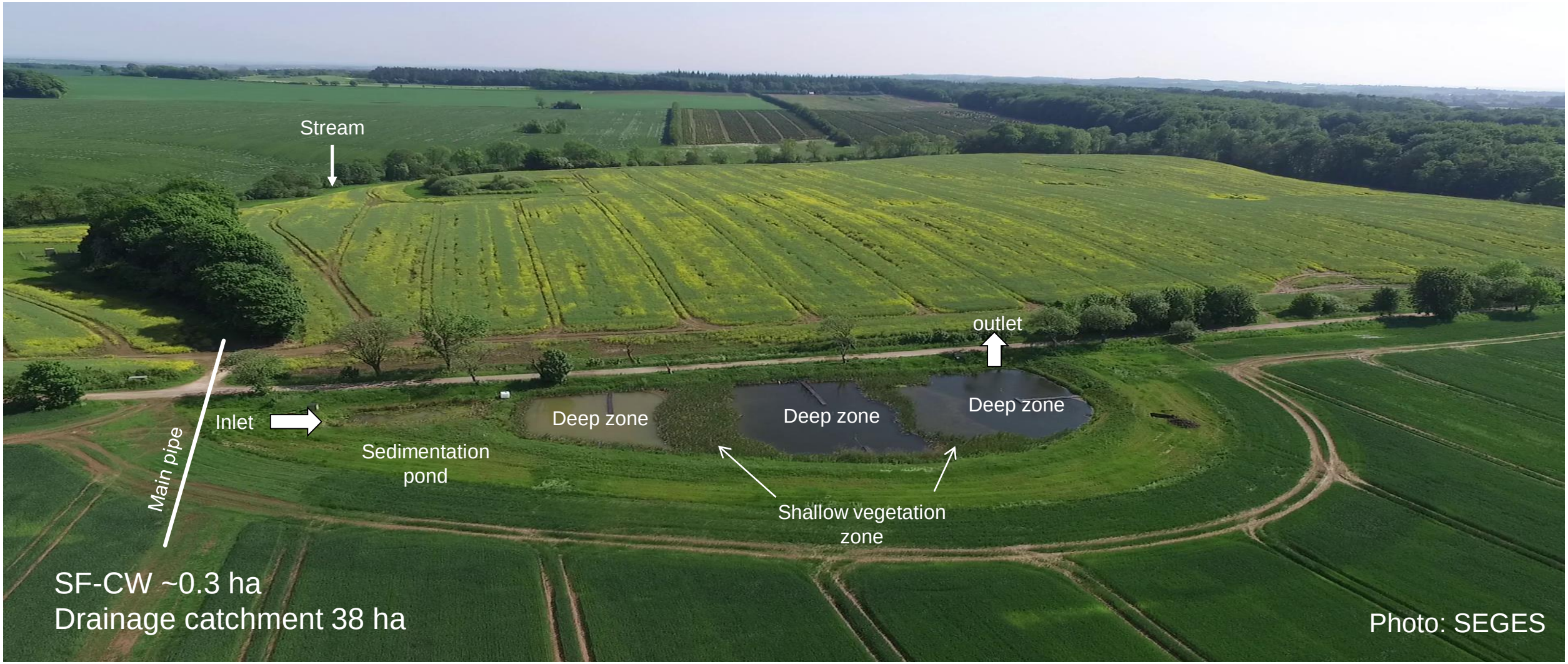
Surface-flow constructed wetland Fillerup, Odder (2010)

SF-CW constructed in a natural landscape depression within the field



Surface-flow constructed wetland Odder (2010)

Photo: Charlotte Kjærgaard

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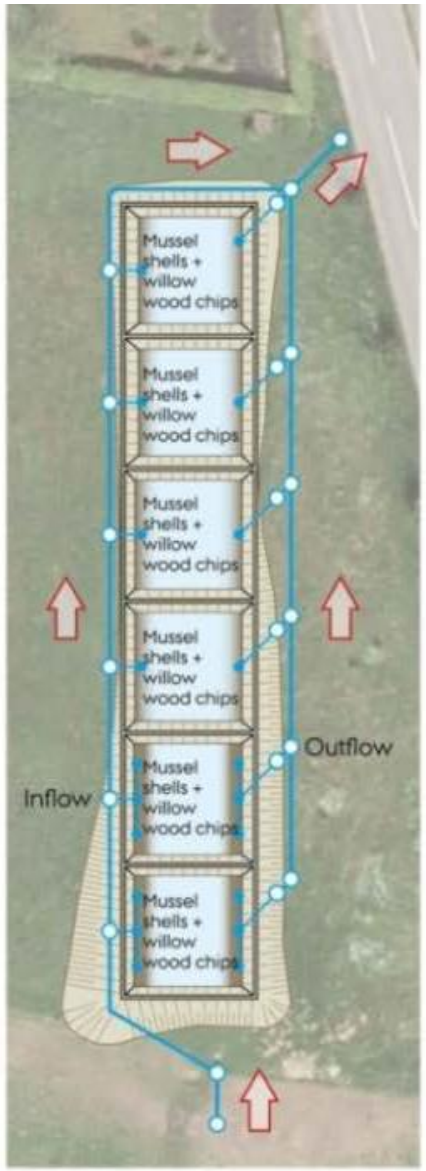
Surface-flow constructed wetland (2016)

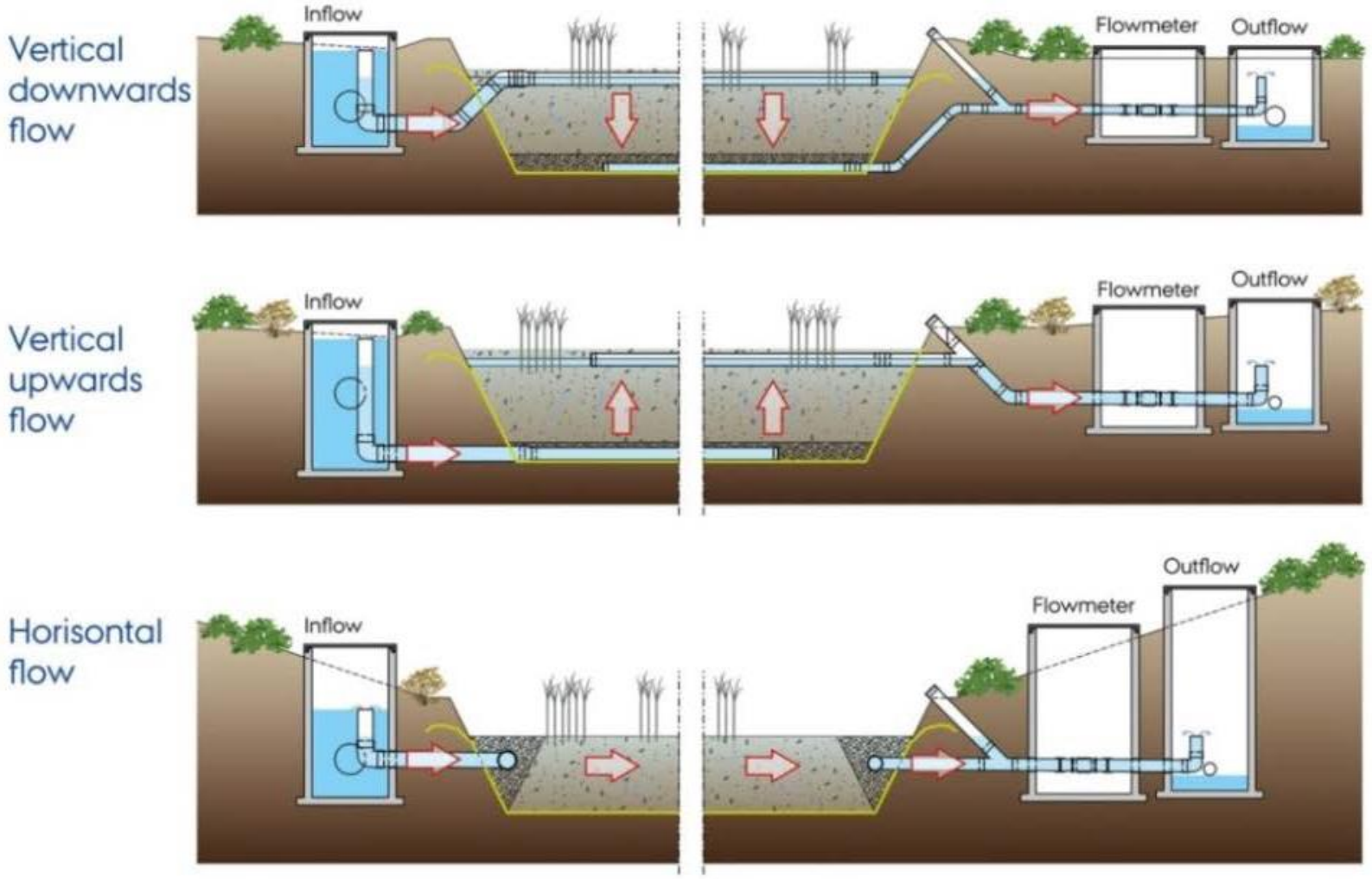
Photo: SEGES

Sub-surface flow willow woodships based biofilters

www.supremetech.dk



Hoffmann, Larsen & Kjaergaard, 2019. J. Env. Quality 29



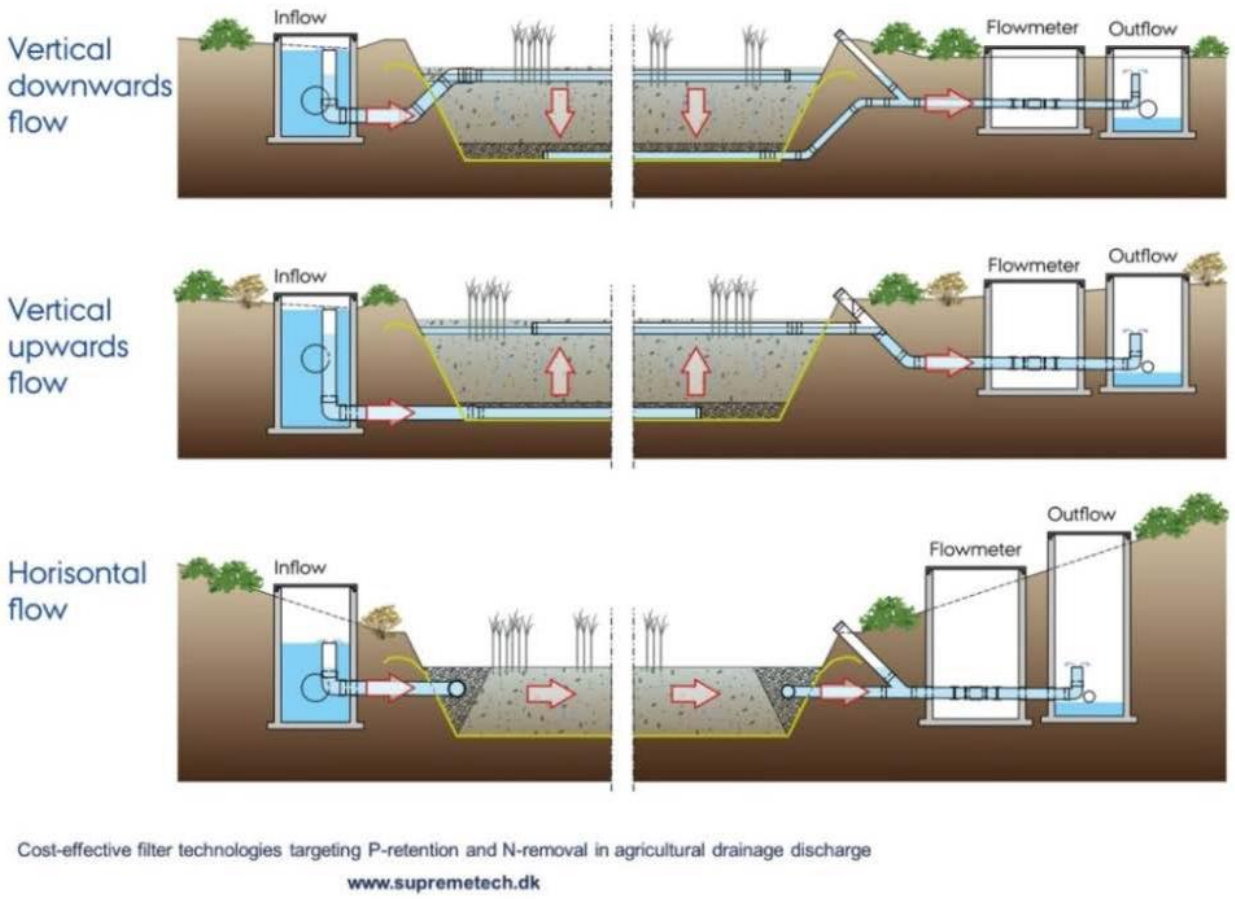
Cost-effective filter technologies targeting P-retention and N-removal in agricultural drainage discharge

www.supremetech.dk

Sub-surface flow willow woodships based biofilters

www.supremetech.dk

Hoffmann, Larsen & Kjaergaard, 2019. J. Env. Quality 29



Construction

- Size: 0.2% of the drainage catchment (Min. HRT ~10 h)
- Guidelines for construction

Annual N & P effects

- Average 50% (45-64%) N-reduction
- Average ?% P-retention (increasing from <0 to 48%)

”Approved” as drainage measure 2018

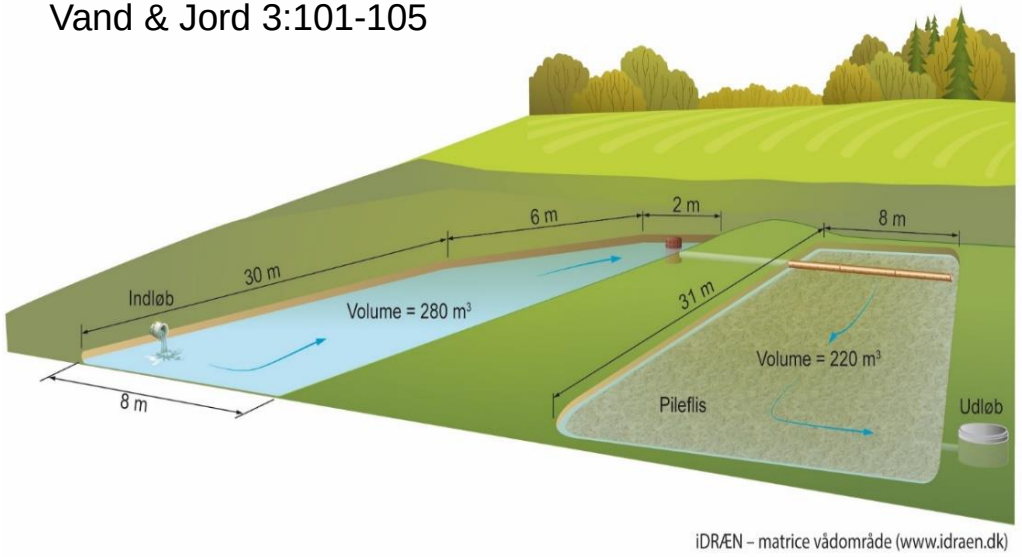
- Controlled implementation with budget limited to 10-20 yearly biofilters

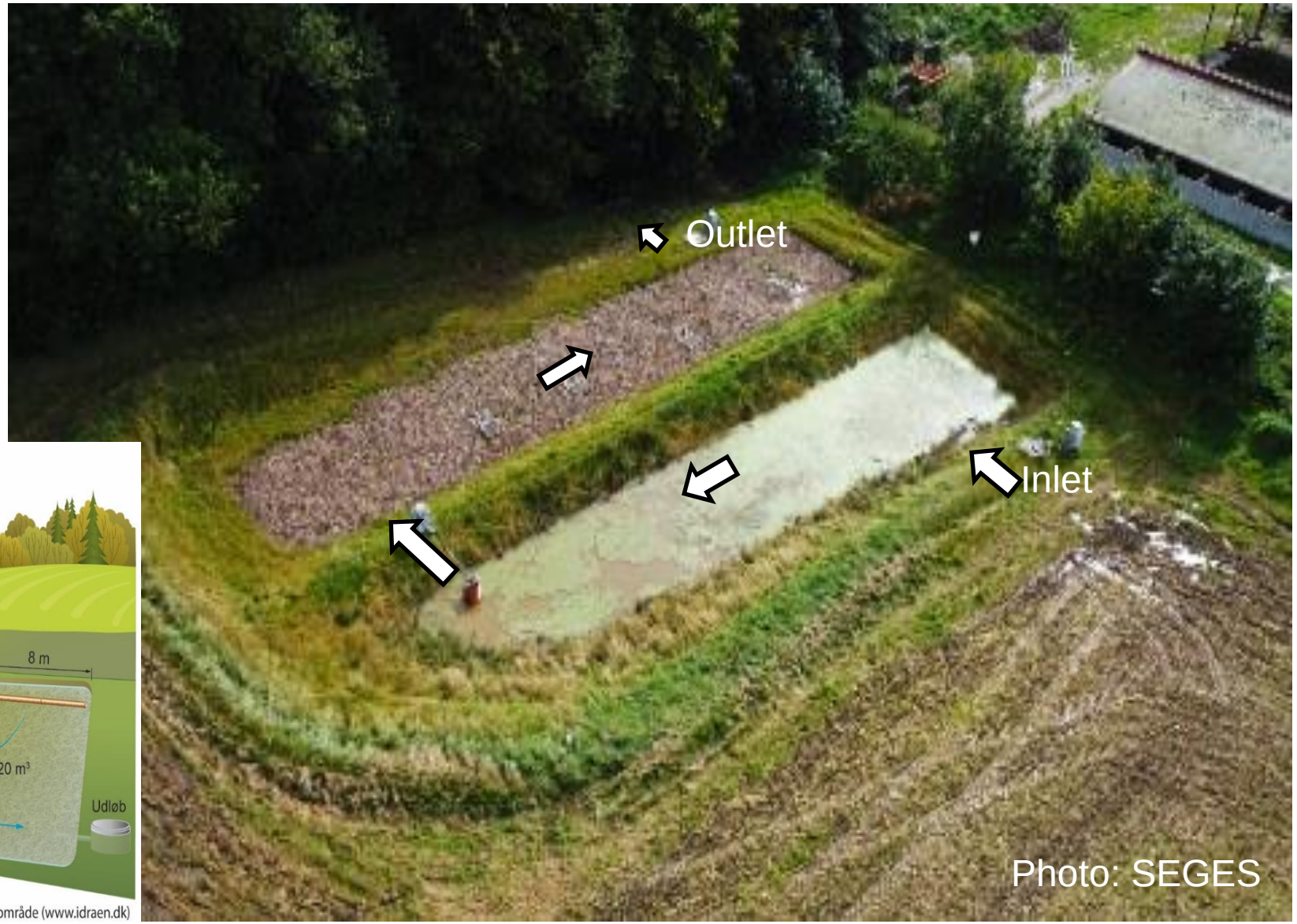
Woodships based biofilter with storage pond

Biofilter constructed 2015

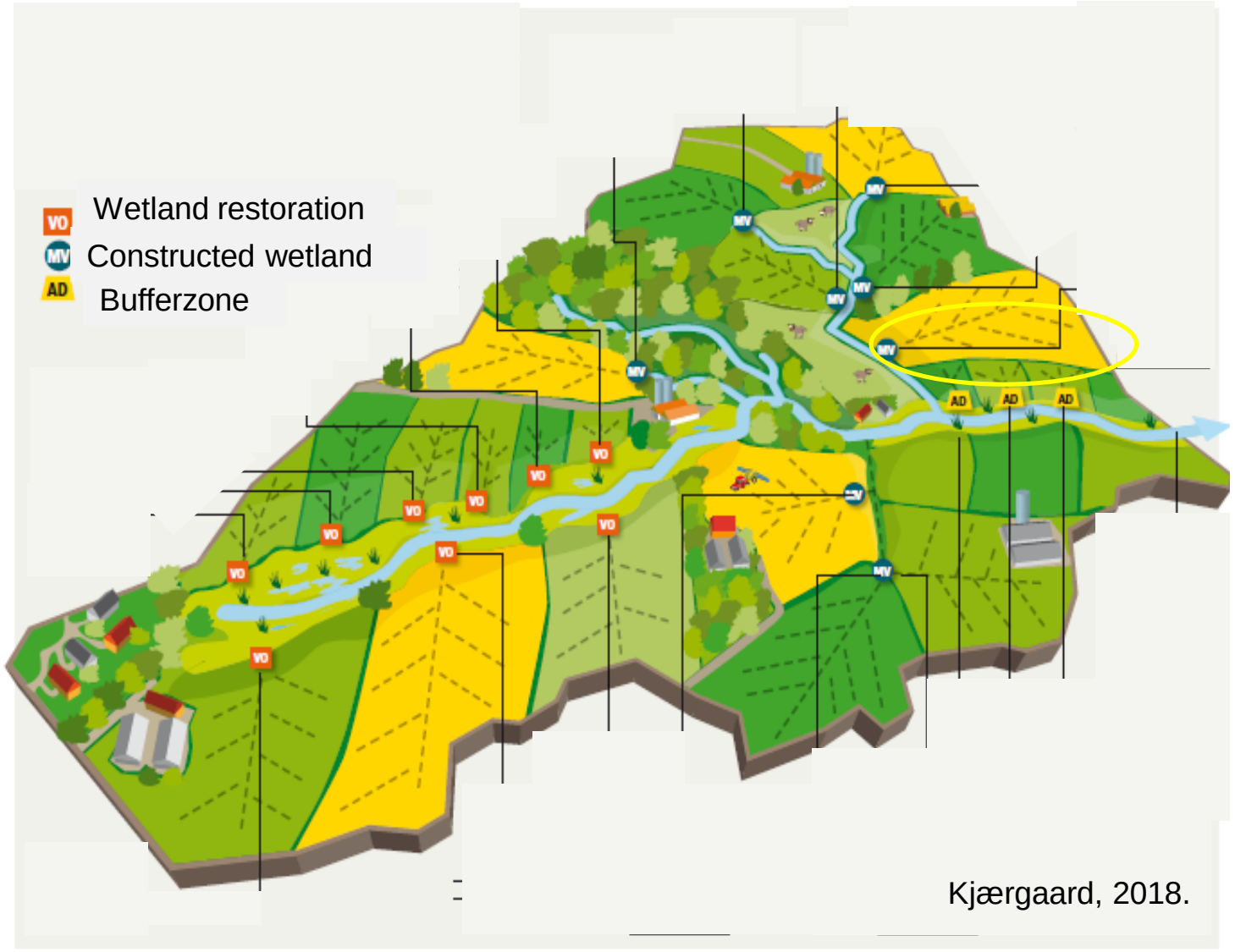
- Drainage catchment ~25 ha
- Storage pond 280 m^3
- Biofilter 220 m^3 (1 m deep)
- 50-70% N-reduction

From Hoffmann & Kjærgaard, 2017.
Vand & Jord 3:101-105





Visions for the targeted drainage mitigation strategy



Bufferzone filters

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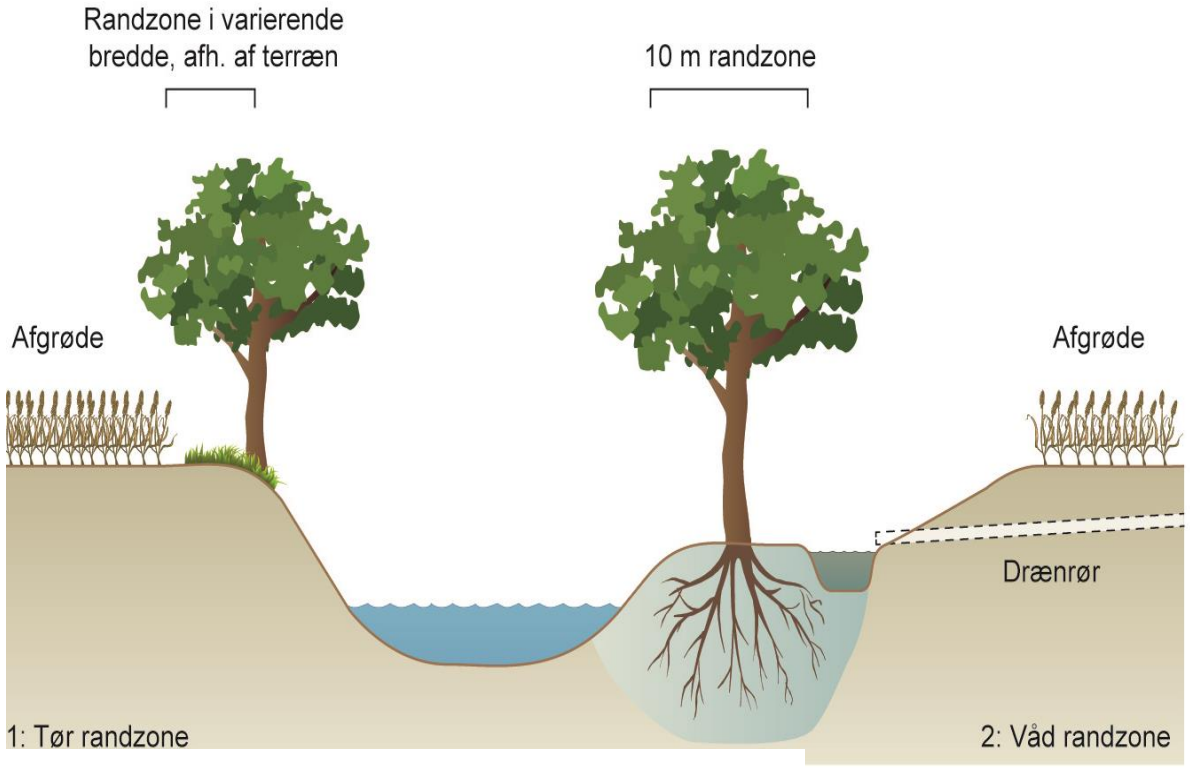
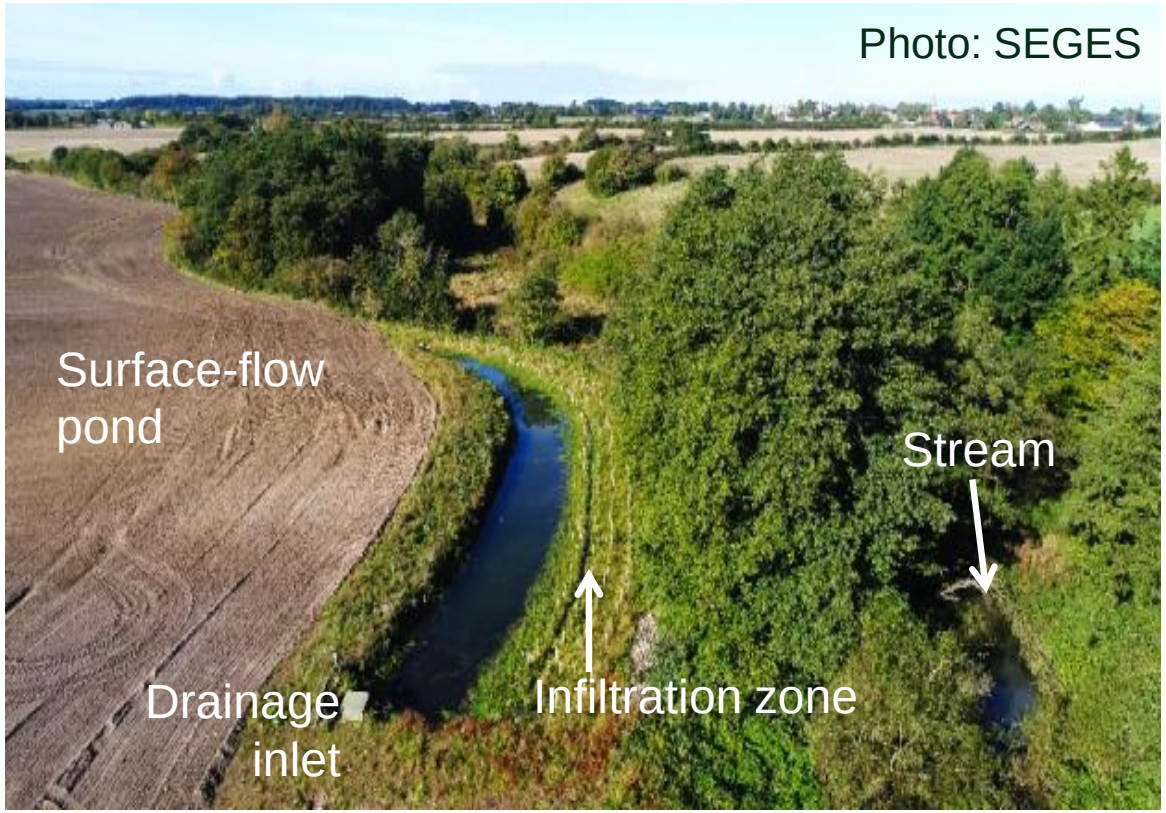
Integrated bufferzones (IBZ)

www.buffertech.dk

Tile-drain intercepted by surface-flow pond followed by infiltration in planted bufferzone



From Kronvang et al., 2017



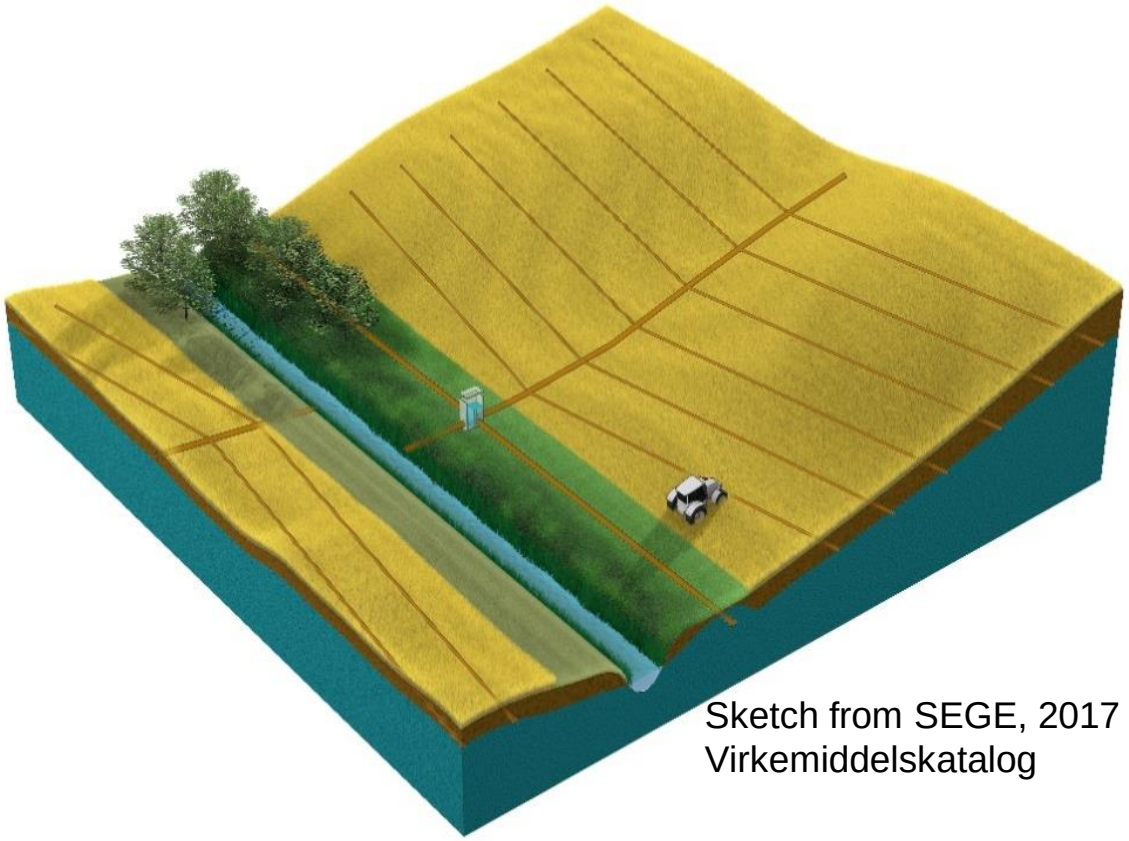
Size: 1% of drainage catchment
Not yet approved

N and P effects

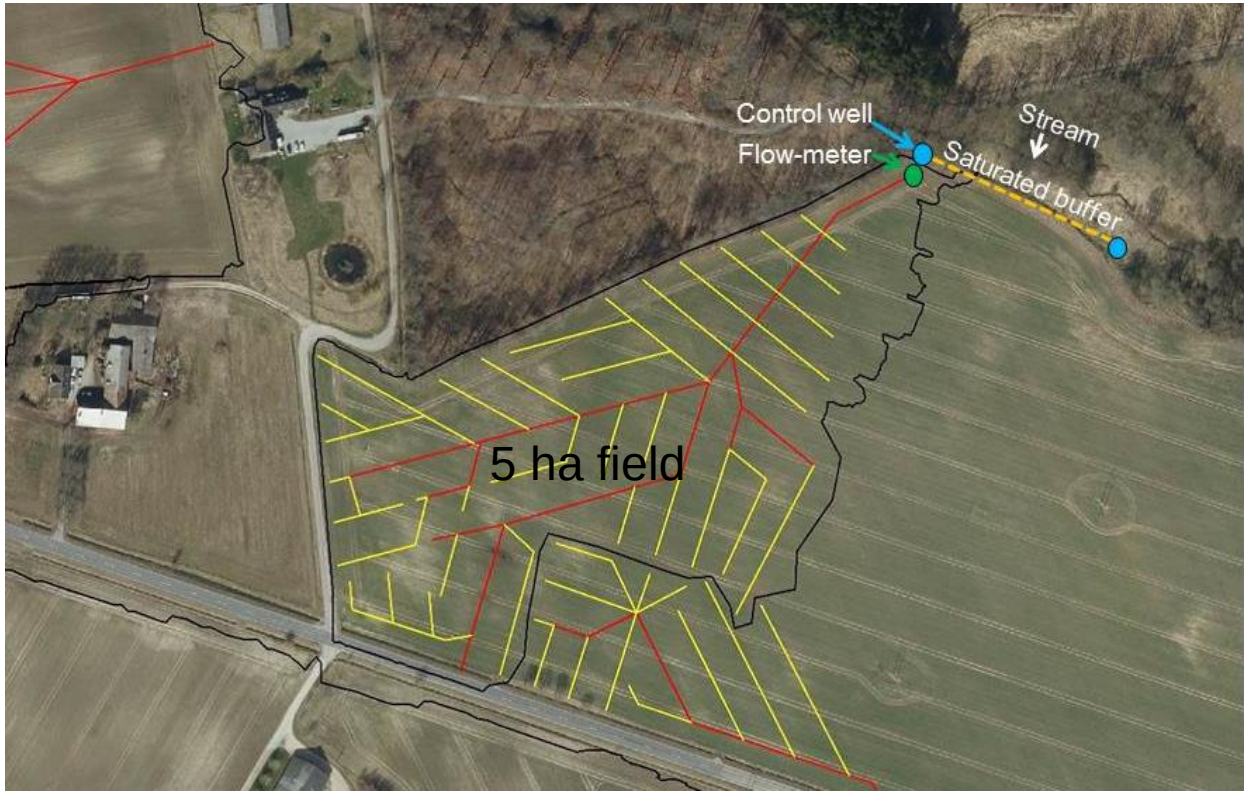
- Annual N-reduction: 20-36%
- Annual P-retention: 40-50%

Saturated bufferzones

Tile drains are intercepted and drainage water allowed to infiltrate in the buffer zone



Sketch from SEGE, 2017
Virkemiddelskatalog



First Danish projects 2018-2020 (SEGES, AU-BIOS)

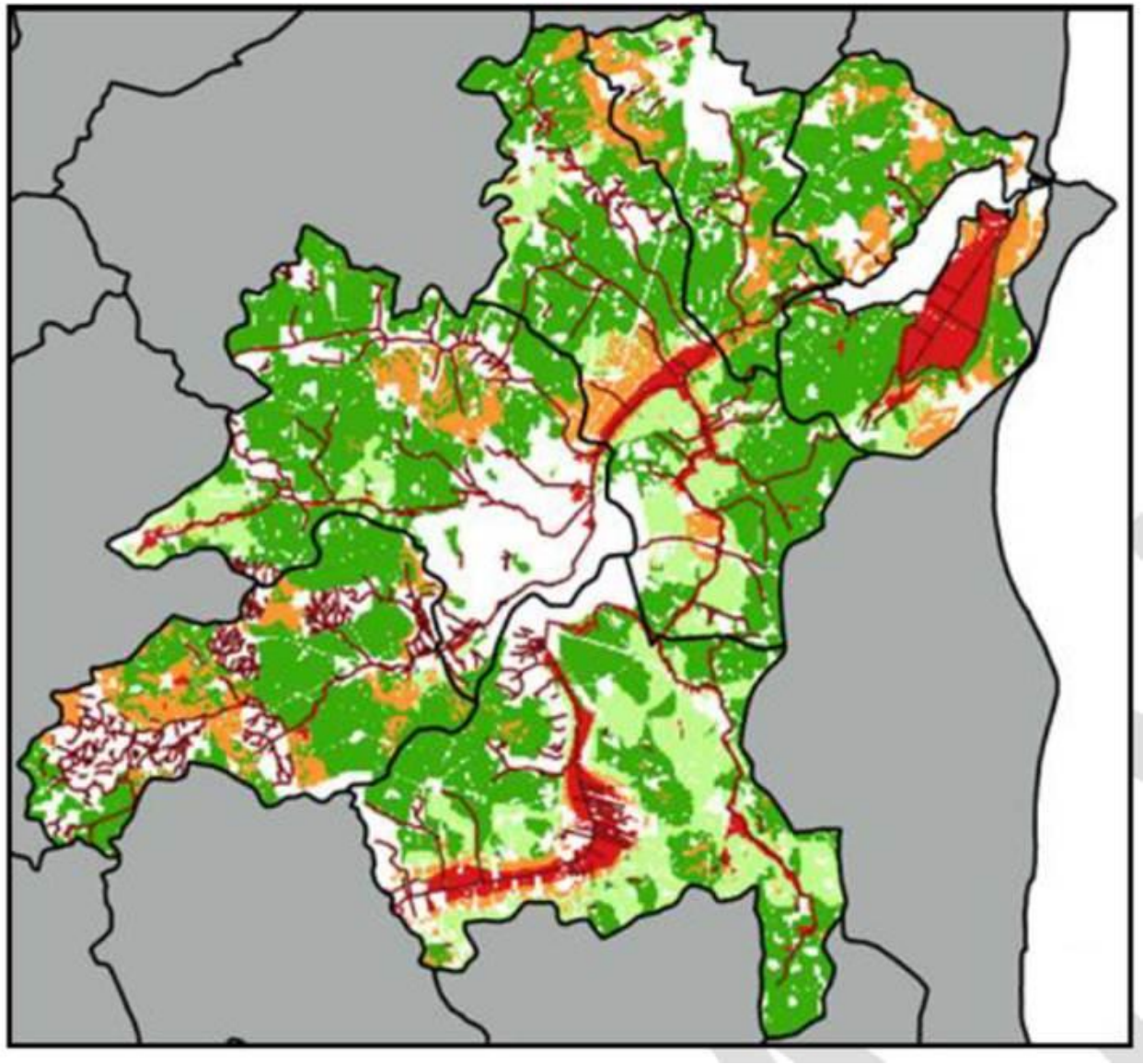
Four drainage filters – summarizing

Mitigation measure	Position in landscape	Area required (% of drainage catchment)	N-reduction efficiency %	P-retention efficiency %
Riparian lowland / restored wetland	Lowland	10*	50 (20-100)	Risk evaluation
Surface-flow wetland	Upland tile-drained field	1	25 (17-45)	43 (30-80)
Subsurface-flow bioreactor	Upland tile-drained field	0.2	50 (45-70)	<0 to 48 (woodchips effects)
Integrated buffer zone	Bufferzone tile-drained field	1	20 (20-36)	40-50

National suitability map

Kjærgaard, C, Bach, E.O., Greve, M.H., Iversen, B.V., Børgesen, C.D. 2017. Kortlægning af potentielle områder til etablering af konstruerede minivådområder. DCA – Nationalt Center for Fødevarer & Jordbrug, 19. Maj 2017. https://pure.au.dk/ws/files/116512758/Besvarelse_Miniv_domr_de effekt_kg_N_pr._ha_miniv_omr_de_002_.pdf

Suitability map Norsminde Fjord catchment



Areas suitabel for constructed wetlands and/or riparian wetlands/disconnected tile drains

ID15 oplande	Egnet minivådområde (%)	Opland til riparisk lavbund (%)	Riparisk lavbund (%)
43600028	61	4.4	16
43600041	50	33	11
43600042	75	11	2,5
43600043	61	22	6,2
43600051	73	1,1	0,9
43602599	72	5,4	1,1
Total	4.815 (63)	1.224 (16)	541 (7)

Constructed wetlands

Riparian lowland

Kjærgaard, C., Hoffmann, C.C., Iversen, B.V. 2017. Filtre i landskabet øger retentionen. I: Filtre i landskabet, Vand & Jord, nr. 3, s. 106-110

Mitigation stategy and cost-efficiency

What is required to reach the N-reduction target in 2021 for a ID15 subcatchment with four measures?

- Calculations conducted for a ID15 subcatchment (1.500 ha) with 70% agricultural area (1.050 ha)
- Average N-leaching from rootzone ~60 kg N/ha and average N-retention is 62%

From Kjærgaard et al., 2019. Terrænnær redox og retentionskortlægning til differentieret målrettet virkemiddelsindsats indenfor ID15 oplande (T-REX)

Mitigation measure	N-reduction target (kg N/yr)	N-effect rootzone (kg N/ha/yr)	N-effect on coastal load (kg N/ha/yr)	Required area of measure (ha)	Cost of measure (€/ha/yr)	Cost of mitigation strategy (ID15) €/yr
Catch crops	2.594	30	11.4	**228**	94	21.319
Set-aside	2.594	50	19.0	**137**	535	73.092
SF-CW	2.594	14	6.75	**3.84**	87*	33.433*
Bioreactor	2.594	27	13.5	**0.38**	51**	9.773**

*Construction cost depreciation in 10 years (very low maintenace cost)
** Constuction cost depreciation in 5 years (not including new supply of woodchips every 5 years)

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Photo: Charlotte Kjærgaard