Demonstration
Test
Catchments

University of East Anglia

Reducing diffuse nitrate pollution in an intensive arable catchment: an interdisciplinary approach

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Department for Environment Food & Rural Affairs

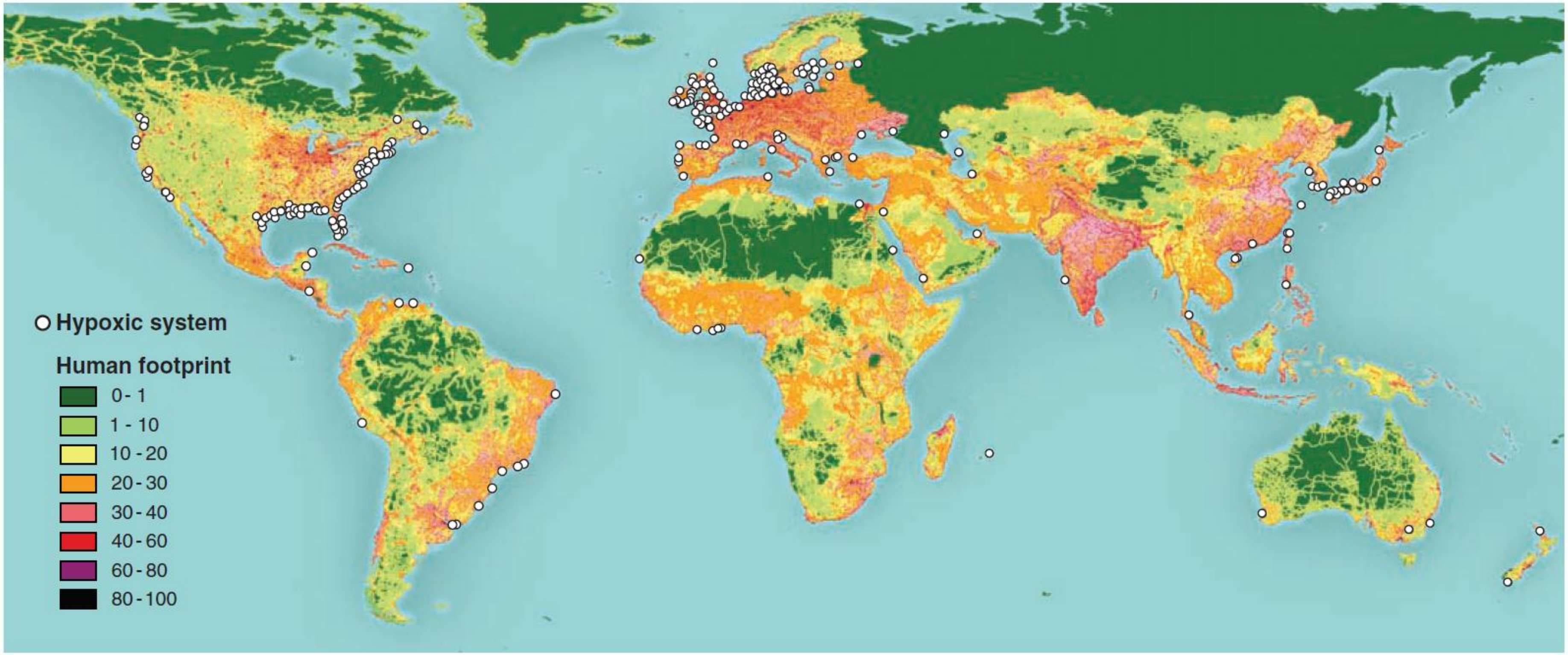
Environment Agency

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Living With Environmental Change

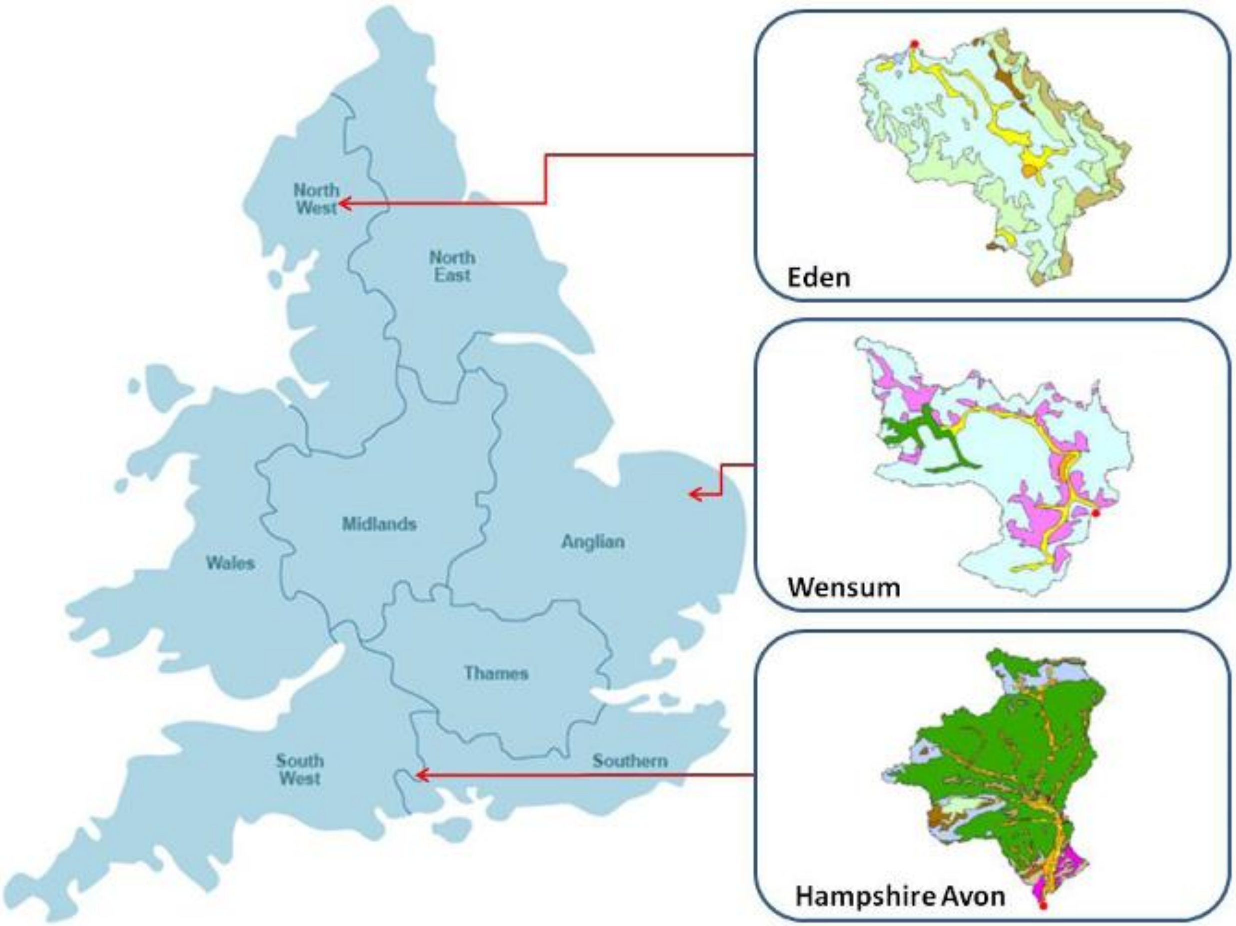
Wensum Alliance

Global distribution of >400 hypoxic 'dead zones' mapped against the global human footprint[1,2]



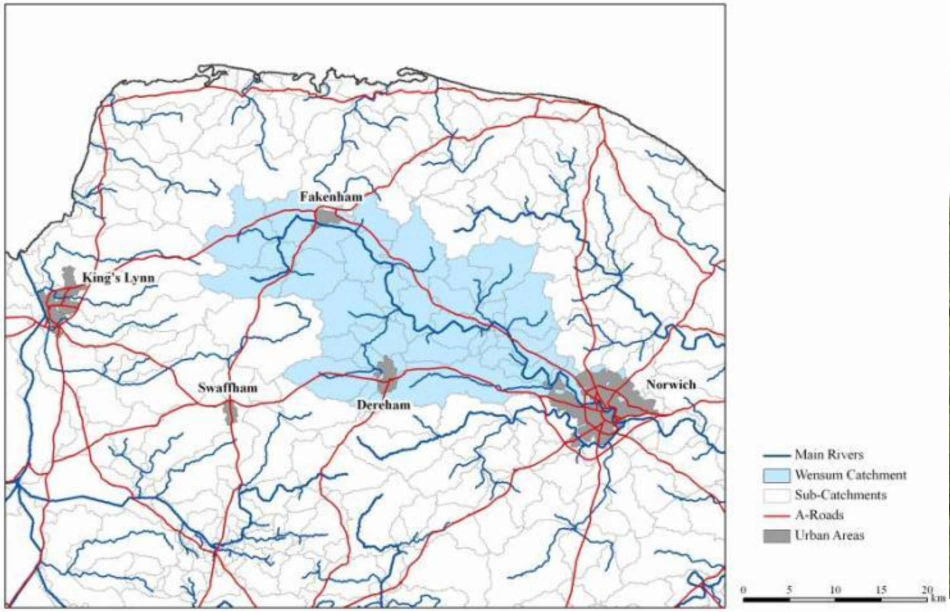
[1] Diaz & Rosenberg (2008)
[2] Sanderson et al. (2002)

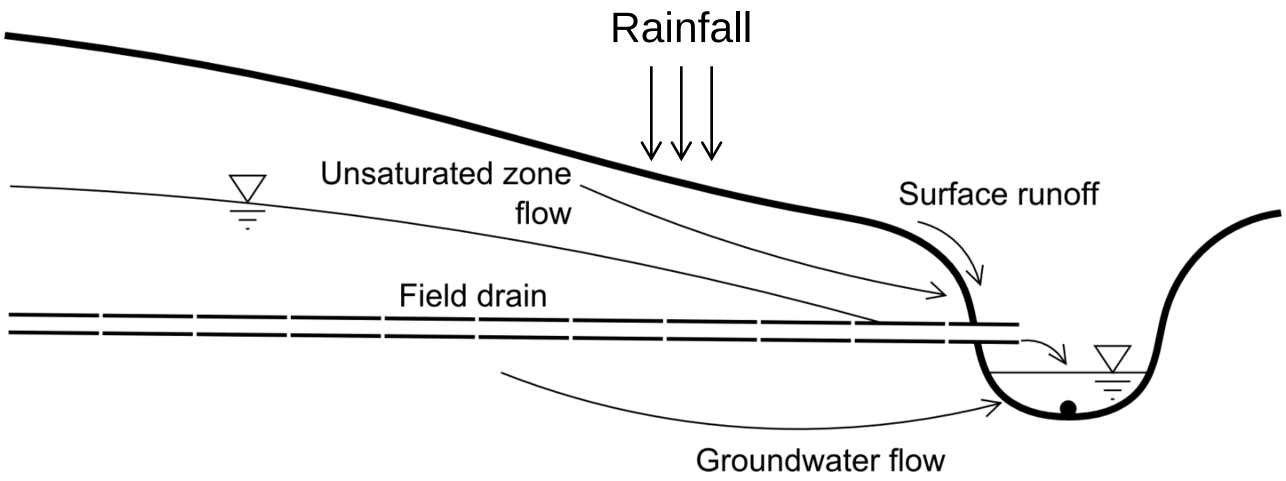
The Demonstration Test Catchments



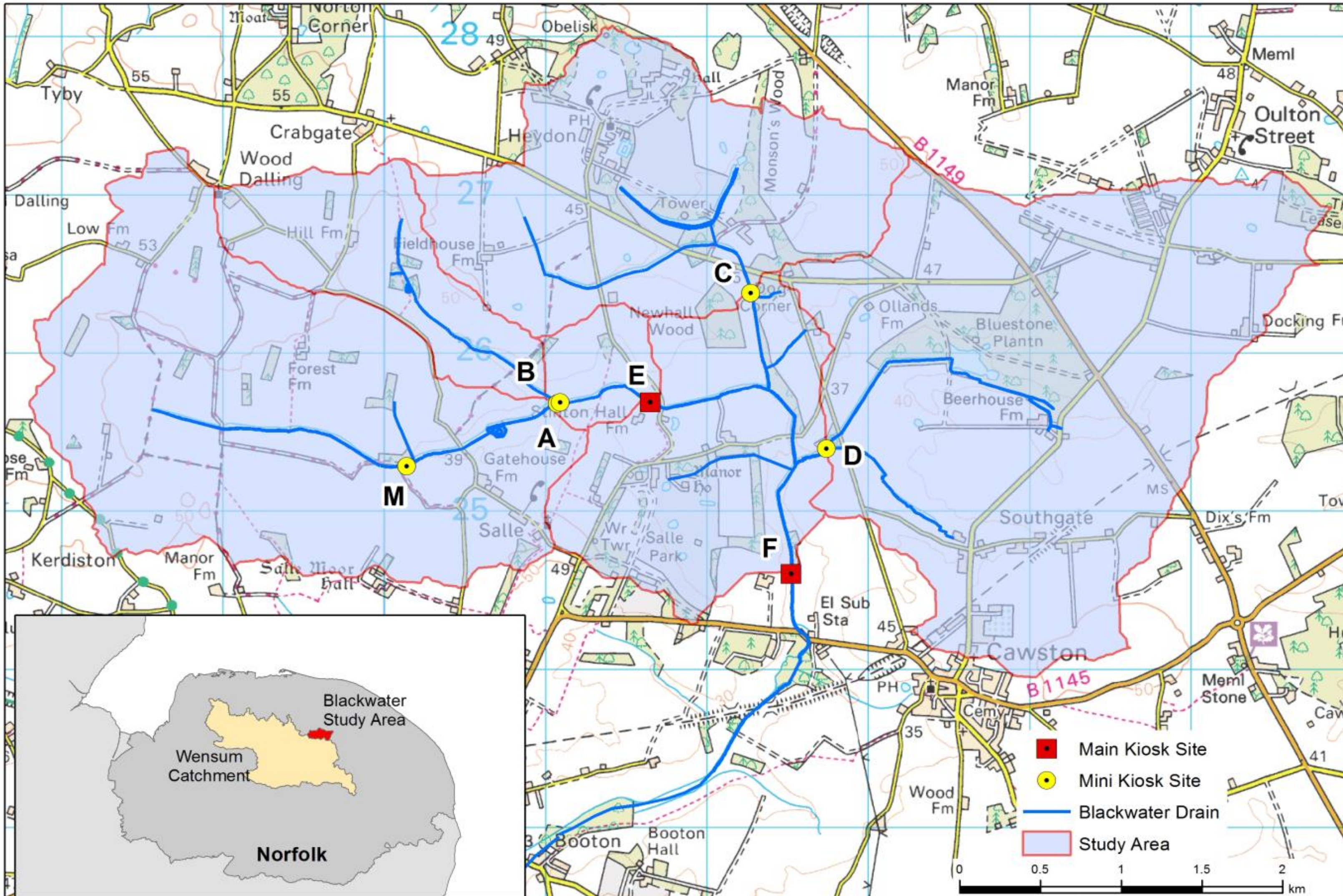
The DTC project aims to evaluate the extent to which on-farm mitigation measures can cost-effectively reduce the impacts of water pollution on river ecology while maintaining food production capacity

Wensum catchment – location and conceptual model





Blackwater sub-catchment study area



Mini kiosk installation

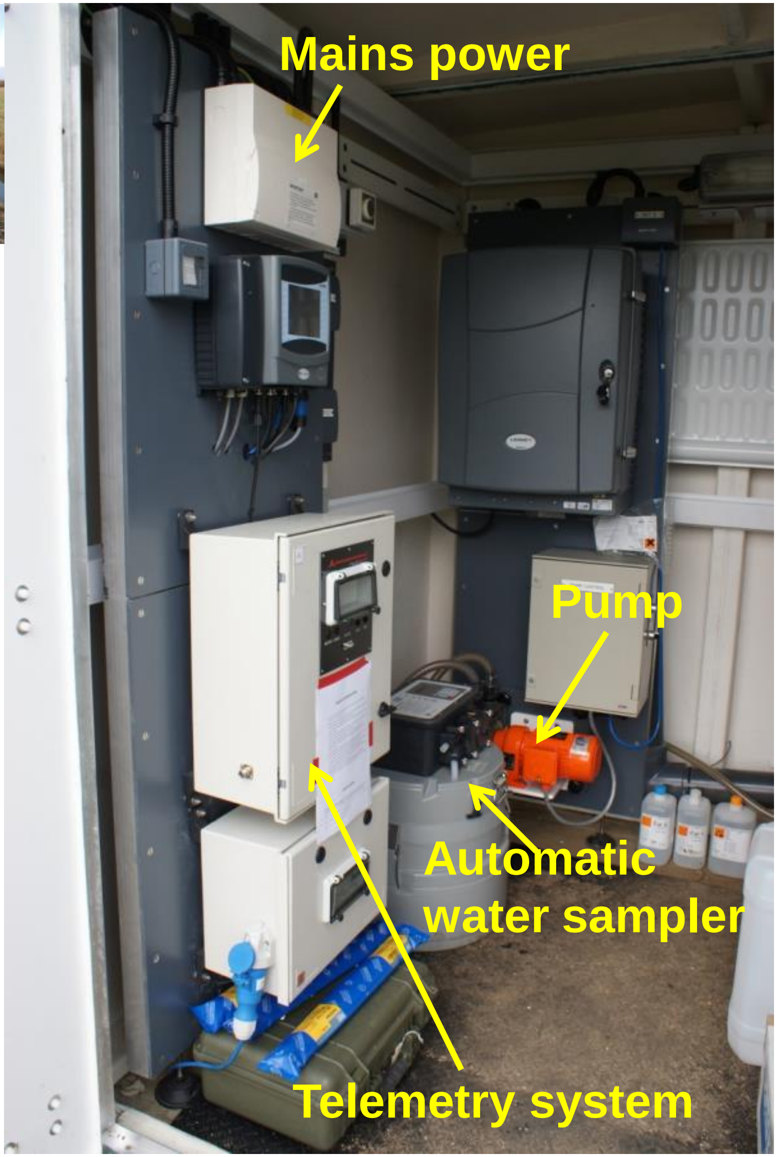
Taking half hourly measurements of:

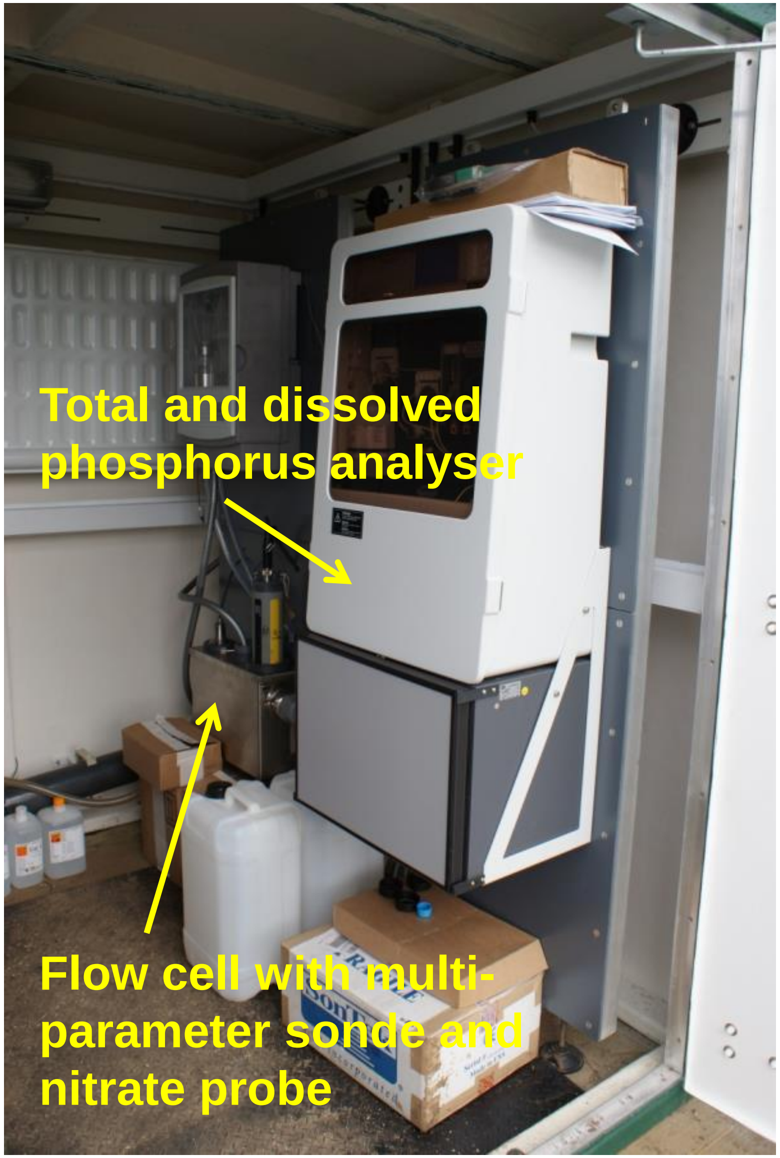
- Dissolved oxygen
- pH
- Conductivity
- *Chlorophyll a*
- Temperature
- Turbidity

- Stage

- ISCO automatic sampler to be triggered during storm events

High spec kiosk installation



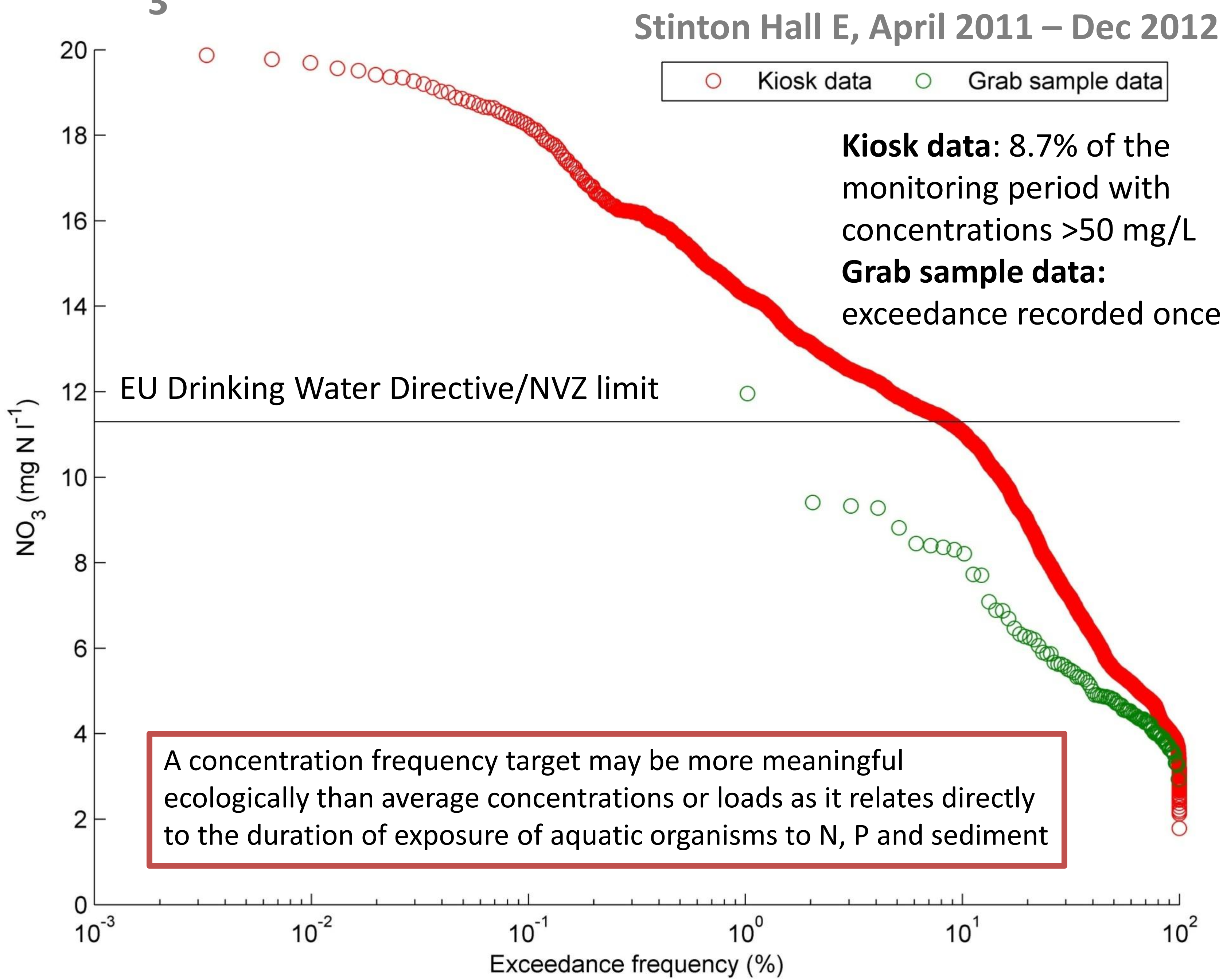


Storm event
27 November 2012

View 1 (Wood Dalling)

View 1 (Wood Dalling)
27 November 2012

NO_3 exceedance curve



Kiosk data: 8.7% of the monitoring period with concentrations >50 mg/L

Grab sample data: exceedance recorded once

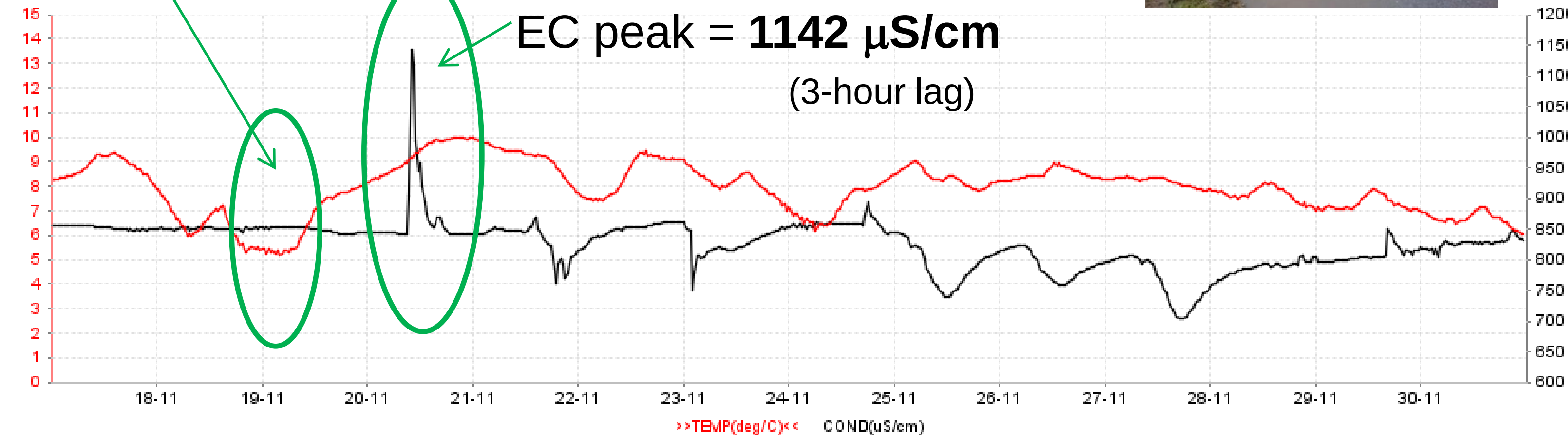
A concentration frequency target may be more meaningful ecologically than average concentrations or loads as it relates directly to the duration of exposure of aquatic organisms to N, P and sediment

Detection of road salt runoff at Swanhills A 20 November 2012

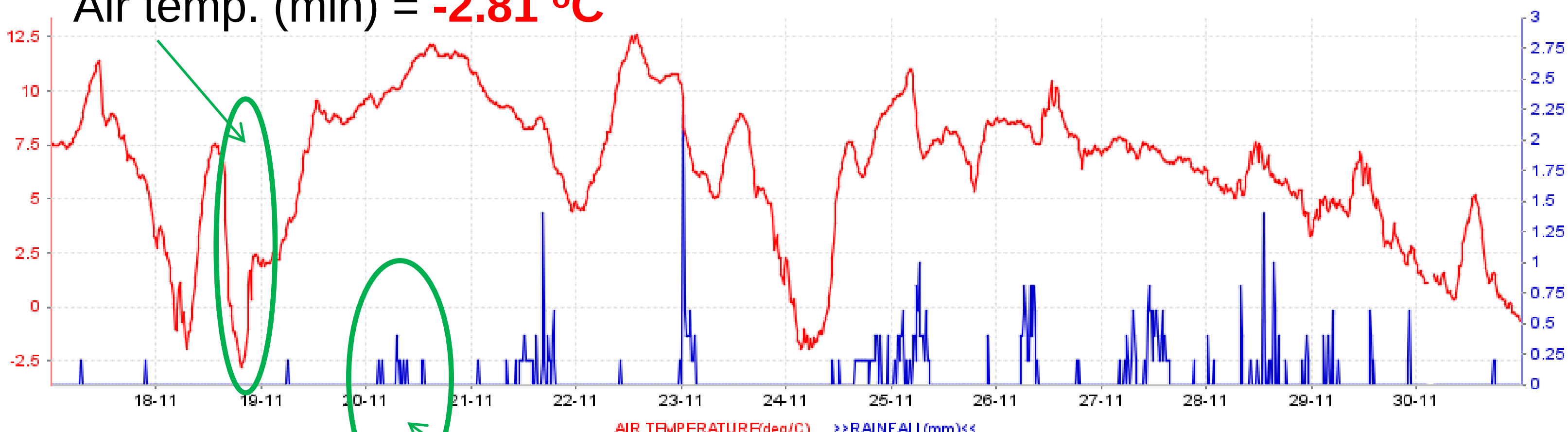
Water temp. (min) = **5.20 °C**

EC peak = **1142 µS/cm**

(3-hour lag)

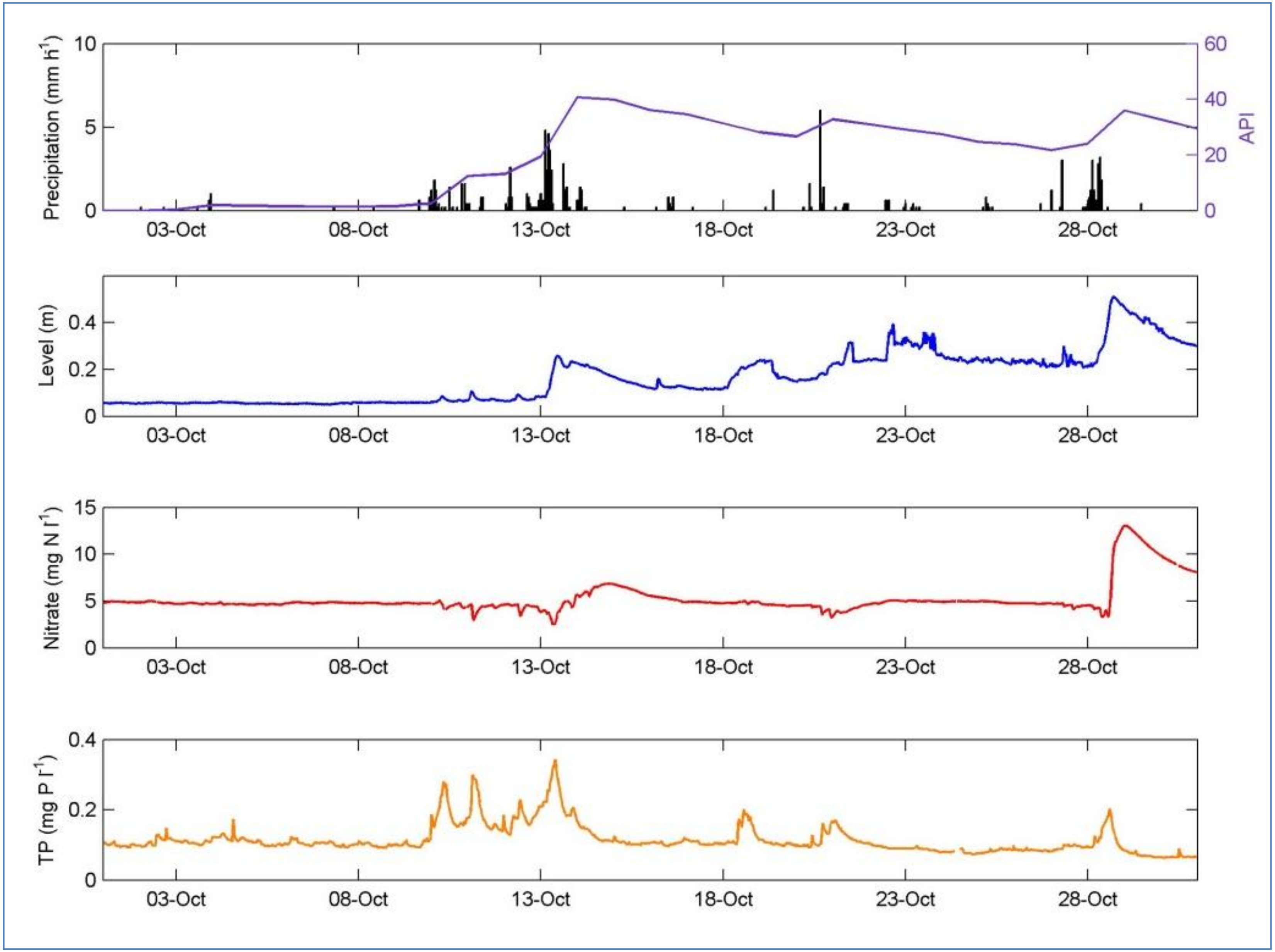


Air temp. (min) = **-2.81 °C**

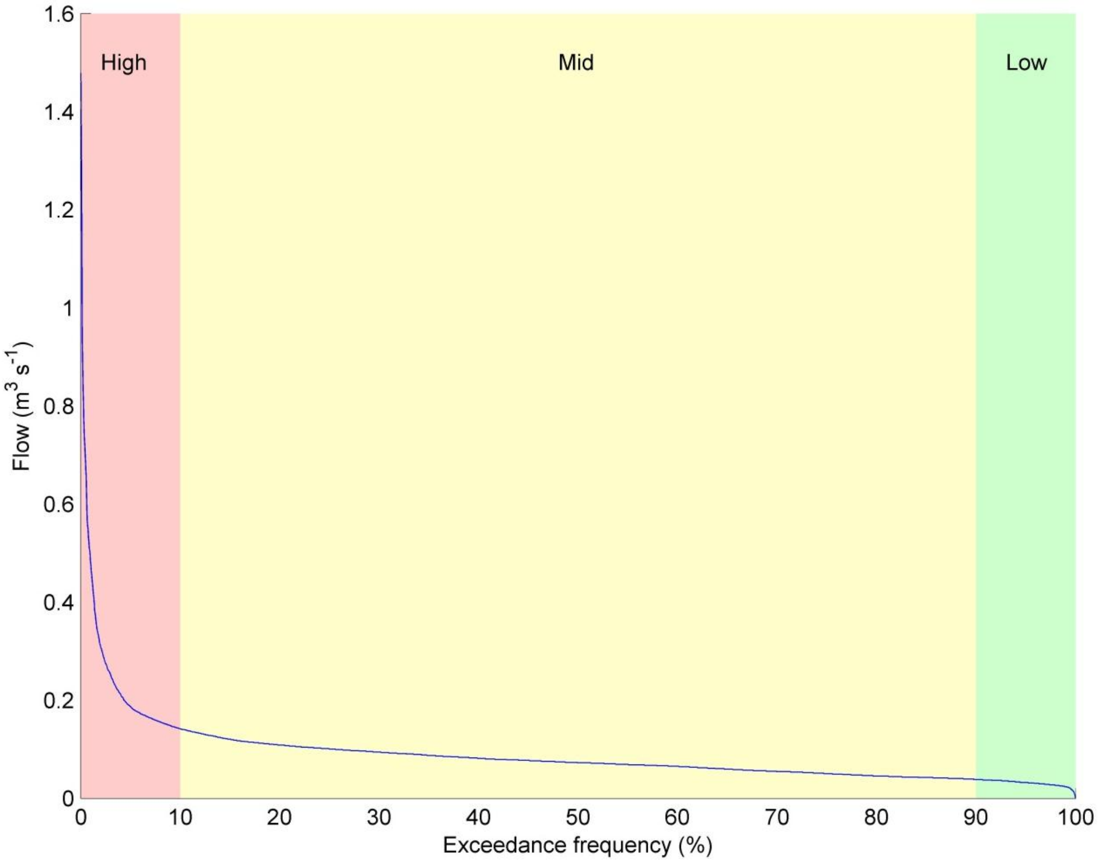


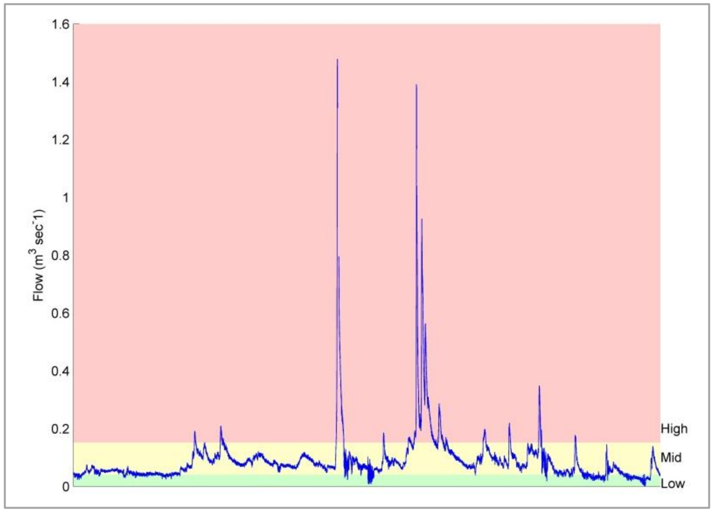
Rainfall = **2.2 mm**

Example monitoring data - Stinton Hall Farm - October 2013

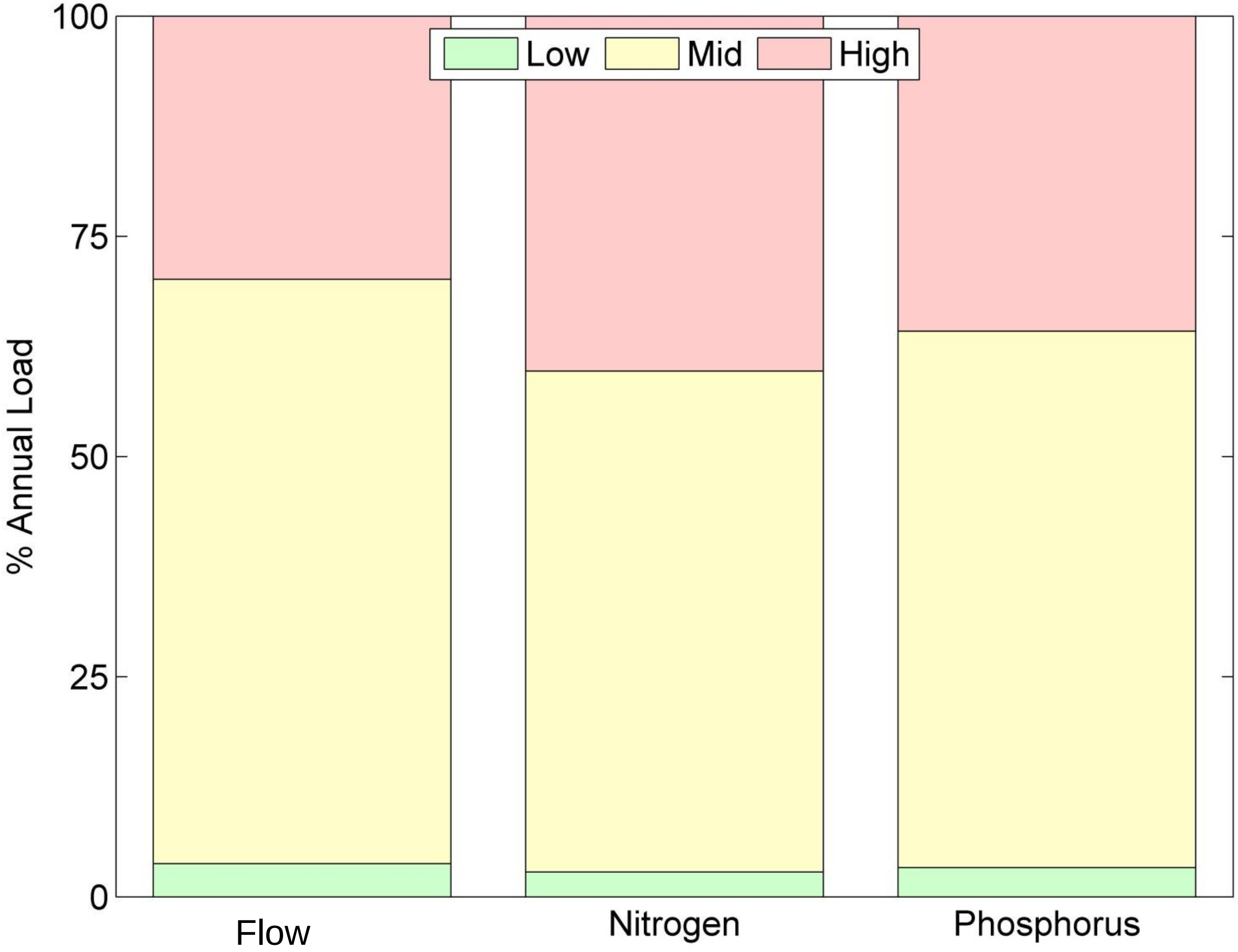


Low, mid and high flow conditions
Oct 2011 – Sept 2012



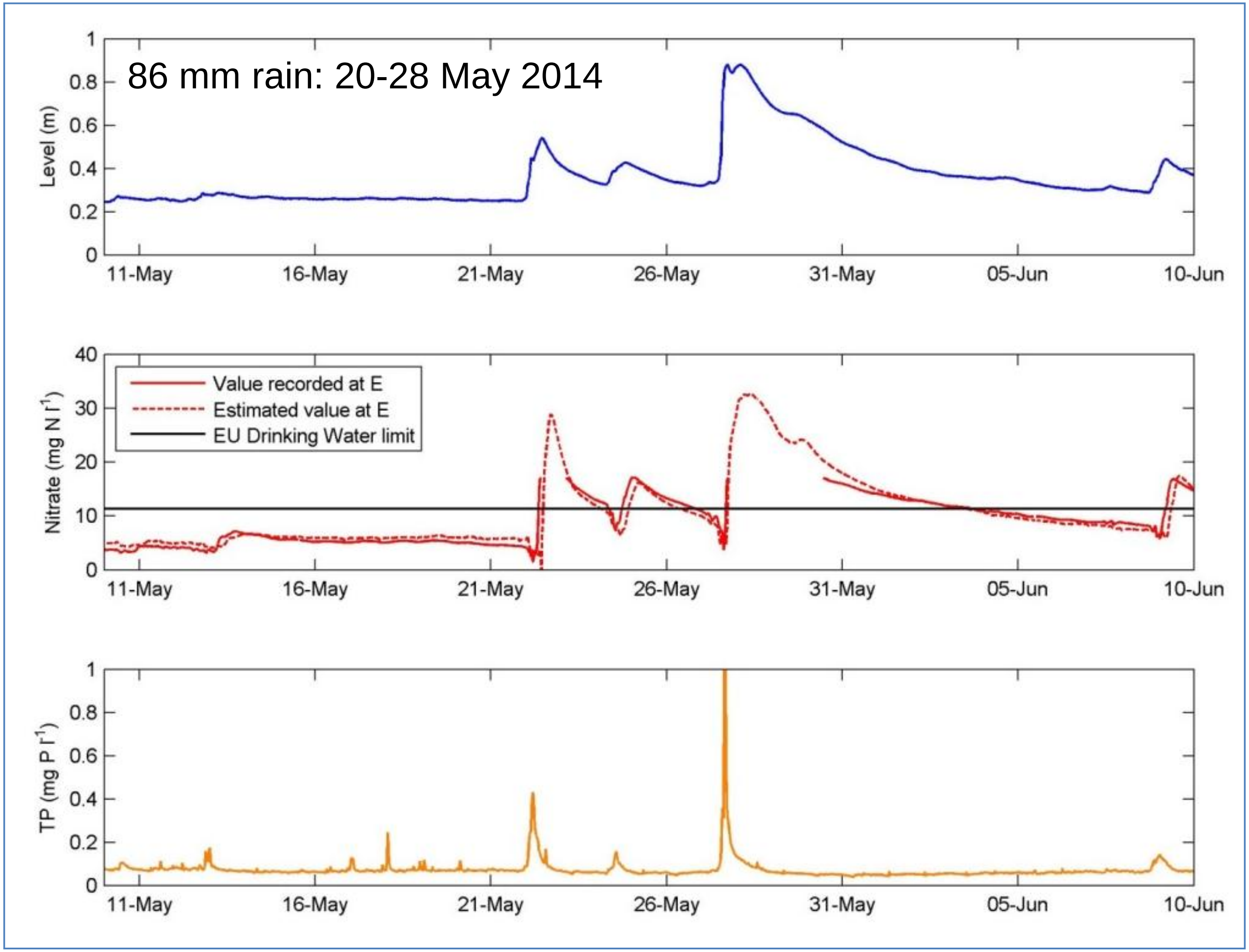


Annual contribution to flow and pollutant loads under low, mid and high flow conditions
Oct 2011 – Sept 2012



N.B. Gaps in phosphorus record are likely to mean that there is an under-estimation of the high-flow contribution

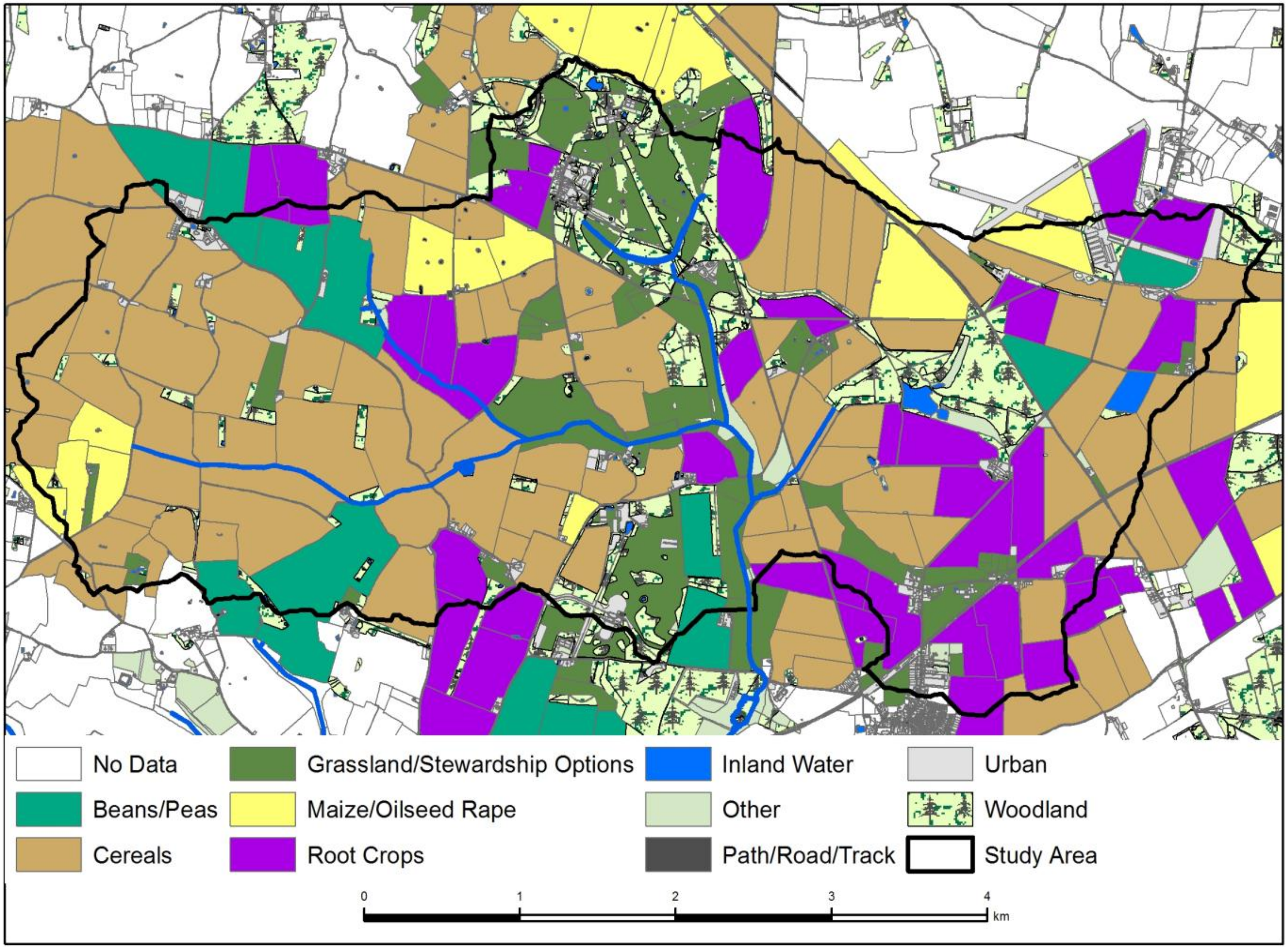
Example monitoring data - Stinton Hall Farm, E - May 2014



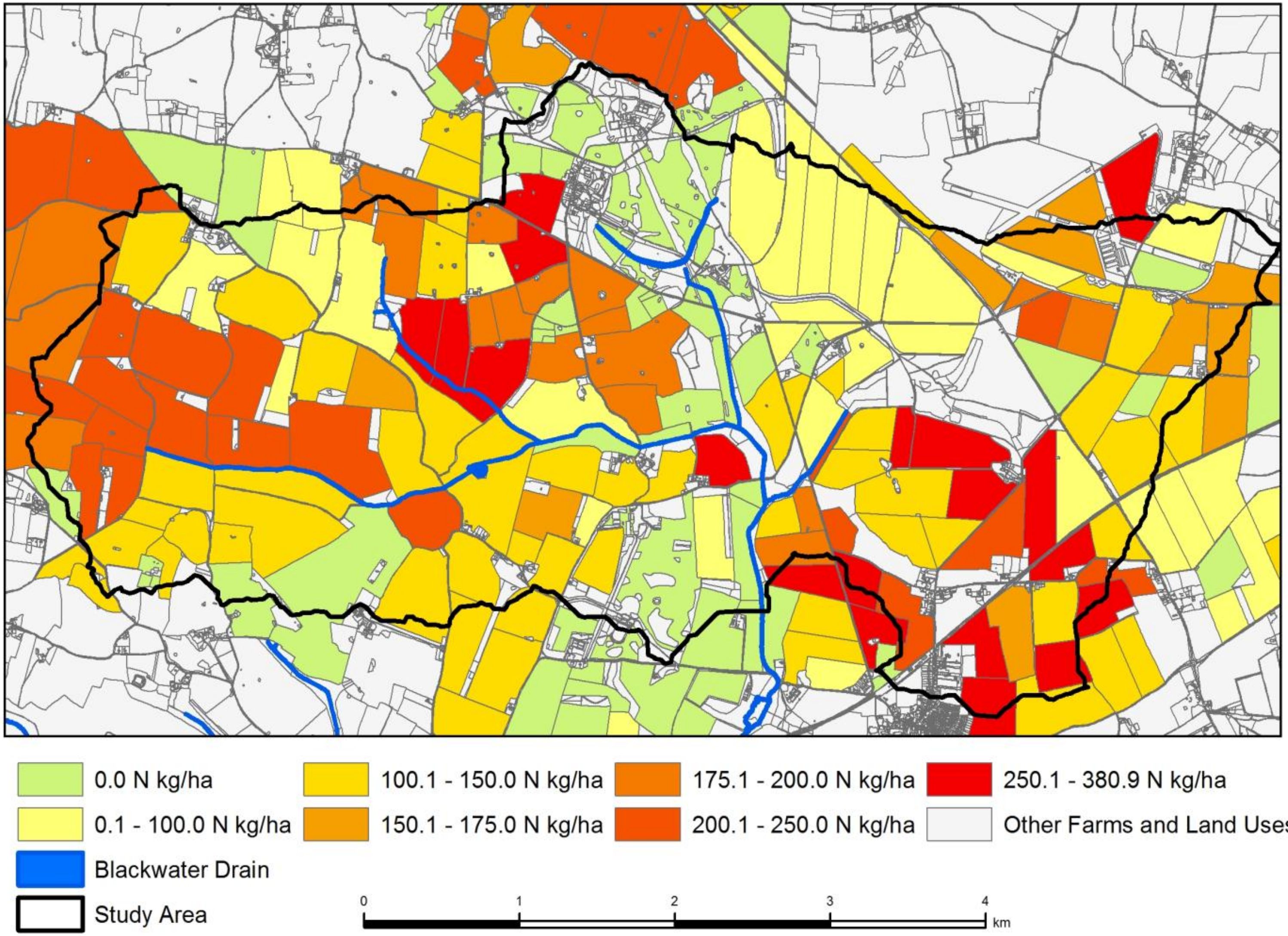
Nutrient fluxes for this period are around 6500 kg of N and 35 kg P

Losses equivalent to ~9 kg N / ha and 0.05 kg P / ha in a period of a few weeks

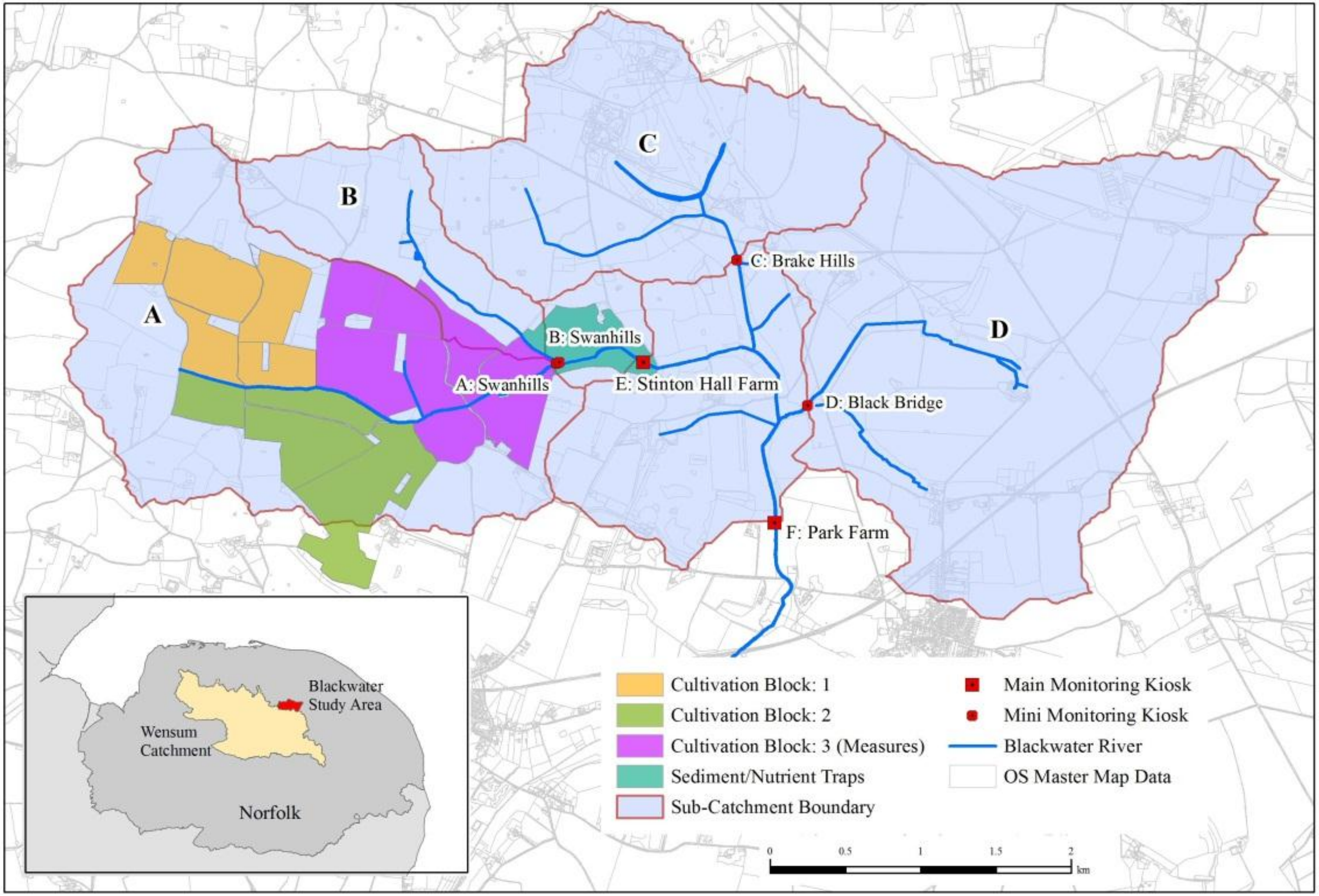
Land use in the Blackwater headwaters (2012-13)



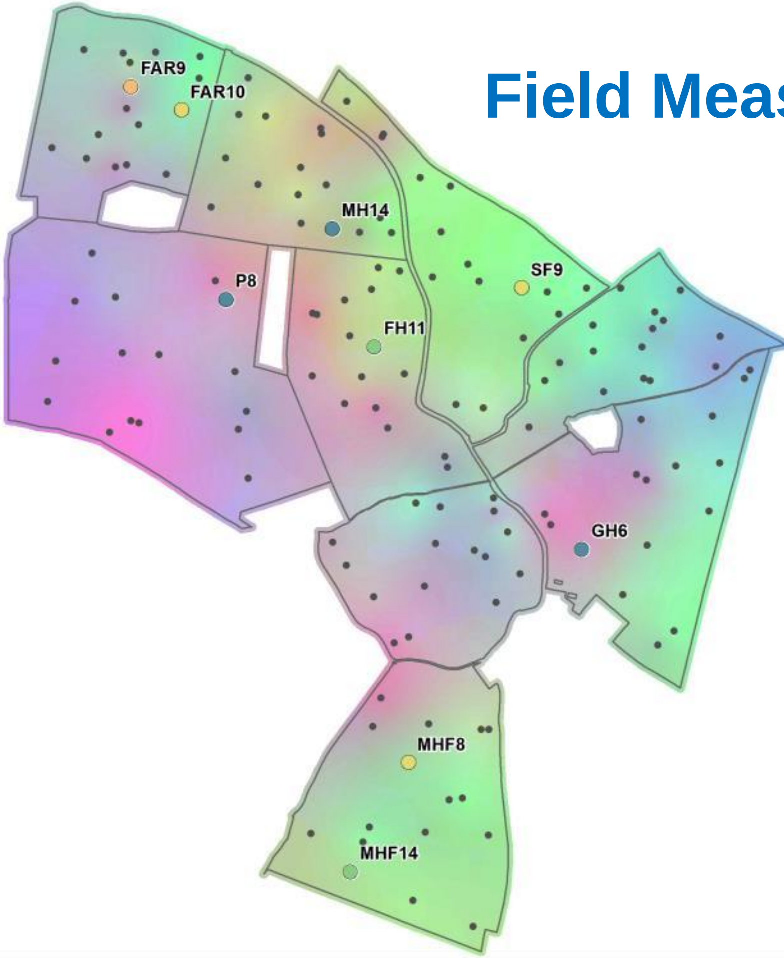
Nitrogen fertiliser application rates (kg/ha) (2012-13)



Target Area for Mitigation Measures (Cultivation Block 3)



Field Measurements

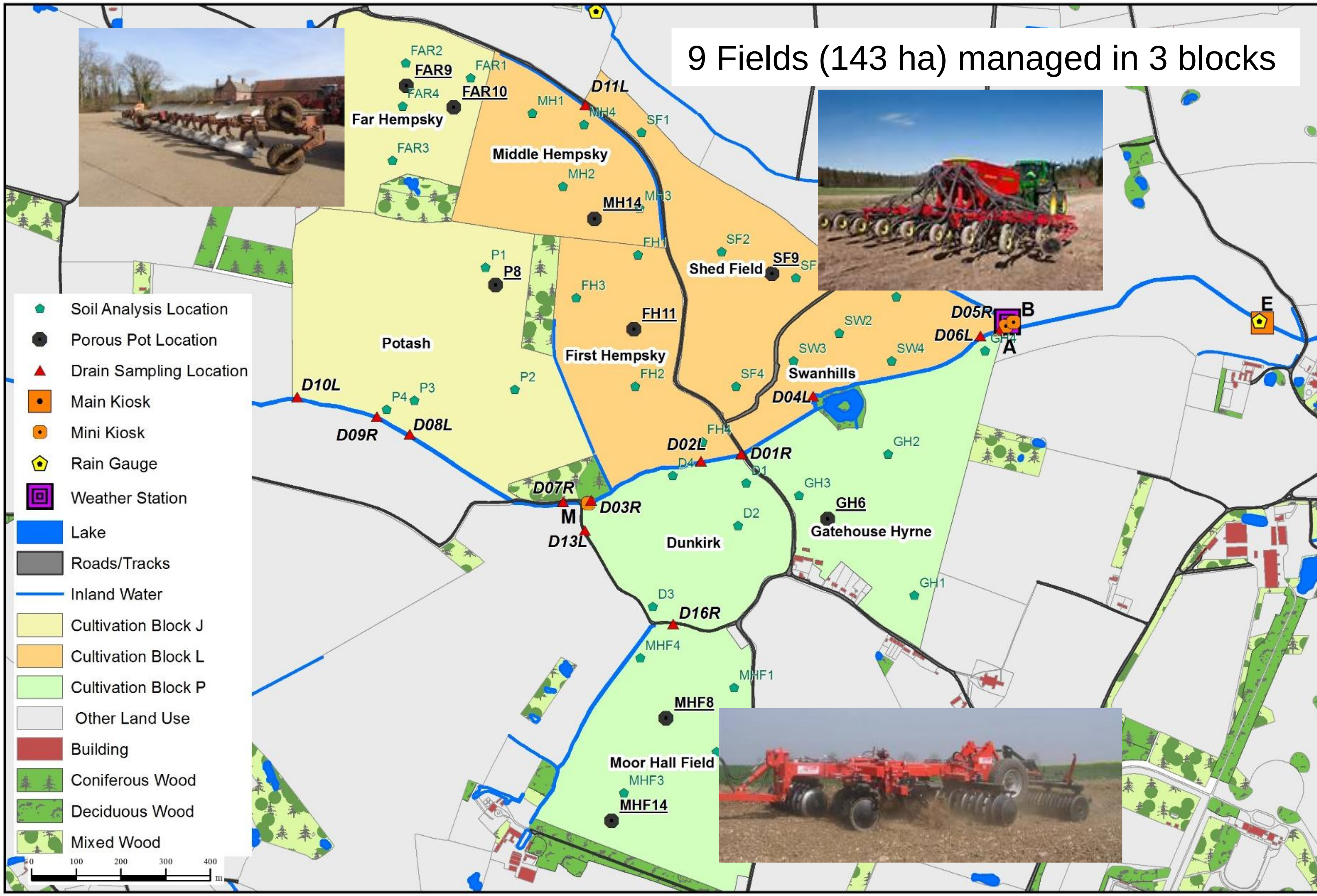


- Soil texture
- Soil structure
- Infiltration rate
- Bulk density

- Dry matter %w/w
- Soil mineral N mg/kg
- pH
- P, K, Mg indices

- Soil biology
- Crop cover (nutrient levels)
- Soil water quality (porous pots)
- Weekly monitoring of field drains

Implementation of Mitigation Measures



Wensum_DTC_new/Blackwater/DrainageWeekley/Drainage_and_Porous_Pots_03032014.mxd

6 October 2013

Oilseed radish:
Seed rate: 18 kg/ha (total 1836 kg)
Cost £4,957

Starter fertiliser N:
Application rate: 30 kg/ha
Cost £2,093

2 February 2014

Measures fields following completion of drilling spring bean crop 21/3/14

Sampling period: May & June 2014

Block	Bulk density (gm/cm^3)				Infiltration rate (mm/h)				Penetrometer (N)			
	Mean	n	St. dev	t-test	Mean	n	St. dev	t-test	Mean	n	St. dev	t-test
J (Control)	1.49	24	0.07		56	8	22		245	24	58	
L	1.67	48	0.11	p=<0.001	34	16	19	p=0.017	310	48	49	p=0.008
P	1.59	36	0.13	p=0.067	38	12	16	p=0.046	233	36	36	p=0.597

Note: p value calculated between a given block and the control block (J)

Oilseed radish leaf and root matter analysis
(22 January 2014)

	Mean N content LEAF (kg N/ha)	Mean dry matter yield LEAF (t/ha)	Mean N content ROOT (kg N/ha)	Mean dry matter yield ROOT (t/ha)	Mean N content TOTAL (root & leaf) (kg N/ha)	Mean dry matter yield TOTAL (root & leaf) (t/ha)
Without starter N	57.31	1.91	13.15	0.64	70.46	2.55
With starter N	63.57	2.17	11.97	0.61	75.54	2.78

Porous pot results (90 cm depth)

(5–6 February 2014)

Field	Mean NO_3-N (mg/L)	Mean NO_2-N (µg/L)	Mean NH_4-N (µg/L)	Mean TDN (mg/L)
Middle Hempsky	**0.50 (n = 10)**	**2.81 (n = 8)**	**8.19 (n = 8)**	**1.85 (n =6)**
First Hempsky	**0.42 (n = 8)**	**6.59 (n = 5)**	**45.98 (n = 5)**	**1.75 (n = 4)**
Sheds Field	**0.45 (n = 8)**	**9.04 (n = 4)**	**32.34 (n = 4)**	**0.80 (n = 1)**
Moor Hall Field	**0.25 (n = 19)**	**5.41 (n = 6)**	**7.24 (n =6)**	Not analysed
Gatehouse Hyrne	**1.37 (n = 10)**	**14.44 (n = 6)**	**32.69 (n = 6)**	**4.57 (n = 1)**
Far Hempsky (No cover crop)	17.52 (n = 20)	245.16 (n = 14)	27.95 (n = 14)	22.40 (n = 12)
Potash (No cover crop)	10.95 (n = 10)	293.92 (n = 8)	10.43 (n = 8)	18.37 (n = 5)

n = number of samples

Weekly Monitoring of Field Drains

Crop and Control Fields

Drain Order Downstream

Cover Crop Fields

Drain Code	Fields Drained	Cropping 12/13	Autumn 13 Status	Mean NO_3 mg N/L 19/02 - 30/04 2013	Mean NO_3 mg N/L 22/10 - 17/12 2013
D10L	Howards Barn/Potash	Winter Wheat	Sugar Beet/Control (ploughed, left over-winter)	12.19	12.30
D09R	Kerdy Green	Winter Barley	Winter OSR	11.76	4.92
D08L	Potash/Far Hempsky	Winter Wheat/ Spring Barley	Control (ploughed, left over-winter)	5.61	18.27
D07R	Merrisons	Spring Beans	Winter Wheat	6.48	11.61
D13L	Merrisons	Spring Beans	Winter Wheat		18.42
D03R	Dunkirk	Winter Wheat	Radish Cover Crop	5.71	1.31
D02L	First Hempsky	Spring Barley	Radish Cover Crop	2.52	1.08
D16R	Moor Hall	Spring Barley	Radish Cover Crop		3.72
D01R	Dunkirk/Moor Hall	Winter Wheat/ Spring Barley	Radish Cover Crop	8.61	5.56
D04L	Swanhills	Spring Barley	Radish Cover Crop	3.34	1.43

Porous pot results
(90 cm depth)
(28 - 29 April 2014)

Field	Mean NO_3-N (mg/L)	Mean NO_2-N (µg/L)	Mean NH_4-N (µg/L)	Mean TDN (mg/L)
Middle Hempsky	**3.01** (n = 4)	Not analysed	Not analysed	Not analysed
First Hempsky	**2.75** (n = 7)	**1.12** (n = 1)	**10.07** (n = 1)	Not analysed
Sheds Field	**2.76** (n = 9)	**1.84** (n = 3)	**13.93** (n = 2)	**9.04** (n = 2)
Moor Hall Field	**2.60** (n =18)	**12.44** (n = 15)	**145.25** (n = 5)	**10.66** (n = 12)
Gatehouse Hyrne	**2.39** (n =4)	**5.86** (n = 3)	**11.93** (n = 1)	**13.33** (n = 1)
Far Hempsky (No cover crop)	15.52 (n = 8)	17.51 (n = 2)	221.71 (n = 1)	Not analysed
Potash (No cover crop)	9.81 (n = 8)	14.91 (n = 6)	19.53 (n = 2)	25.86 (n = 1)

n = number of samples

Drain flow nitrate concentration and flux data: 27 May & 10 June 2014

Field block	Drain ID	Area (ha)	Flow (L/sec)	Nitrate (mg N/L)	Load (mg N/sec)	Flow (L/sec)	Nitrate (mg N/L)	Load (mg N/sec)	Nitrate flux (kg N/ha sec)*10^{-6}	Nitrate flux (kg N/ha sec)*10^{-6}	Nitrate flux[1] (kg N/ha)	Nitrate flux[1] (kg N/ha)
			27-May	27-May	27-May	10-Jun	10-Jun	10-Jun	27-May	10-Jun	27-May	10-Jun
Control fields	D10L	1.86	0.69	37.42	25.94	0.24	24.00	5.83	13.95	3.137	8.44	1.90
	D08L	0.99	0.18	11.24	1.98	0.04	8.46	0.31	2.00	0.311	1.21	0.19
Measures fields	D07R	1.60	No flow			0.01	1.14	0.01		0.007		0.004
	D03R	0.05	0.03	3.33	0.09	0.01	3.41	0.04	1.76	0.793	1.07	0.48
	D02L	0.29	0.08	1.50	0.12	0.08	1.89	0.16	0.43	0.552	0.26	0.33
	D01R	21.23	0.39	3.88	1.53	0.28	5.22	1.44	0.07	0.068	0.04	0.04
	D04L	0.17	0.07	2.39	0.18	0.07	3.25	0.24	1.03	1.399	0.62	0.85
	D06L	1.87	0.02	3.55	0.08	0.01	5.88	0.08	0.04	0.041	0.02	0.02
	D05R	0.91	0.03	9.68	0.28	0.02	11.45	0.26	0.31	0.282	0.19	0.17
	D16R	6.00	0.05	5.37	0.27	0.02	6.99	0.17	0.04	0.029	0.03	0.02

	27-May	10-Jun
Mean (control fields)	**4.82**	**1.04**
Mean (measures fields)	**0.32**	**0.24**
Mean (all fields)	**1.32**	**0.40**

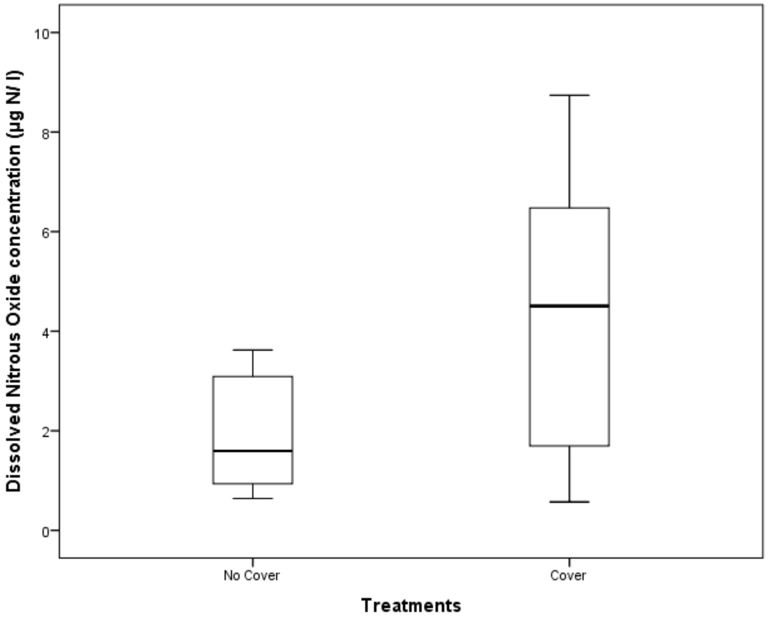
Kiosk data:

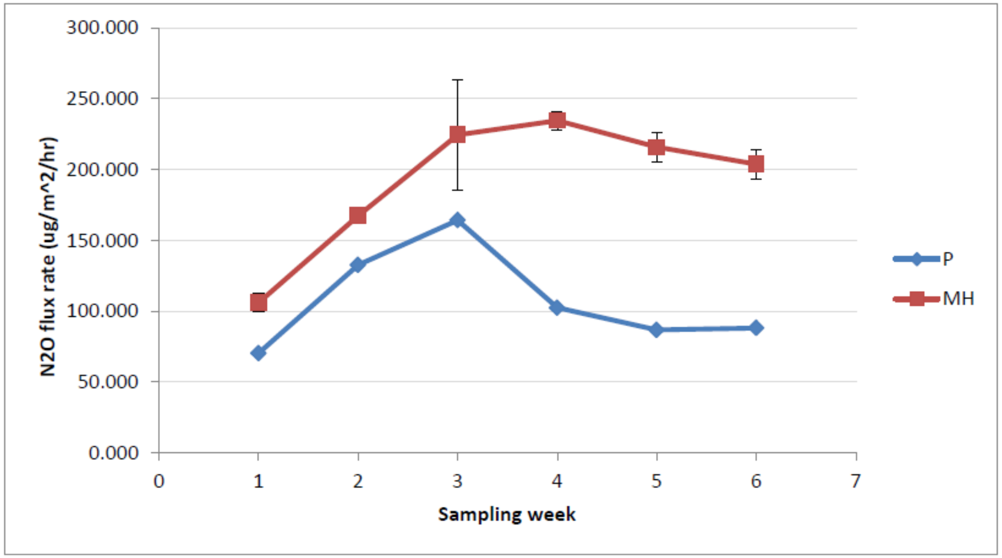
	Area (ha)	Flow (L/sec)	Nitrate (mg N/L)	Load (mg N/sec)	Nitrate flux (kg N/ha sec)*10^{-6}	Nitrate flux[1] (kg N/ha)
Swanhills A	540	29	11.20	324.88	0.60	0.36

Note:

[1]Nitrate flux in kg N/ha calculated assuming a seven-day flow period

Issue of 'pollution swapping' – direct and indirect nitrous oxide emissions





Indirect (drain) N_2O concentrations in last month of cover crop (Feb 2014)

Temporal variation in direct N_2O emissions, 19 June – 21 July 2014

Summary

- Need to improve understanding of the impacts of agriculture on water quality to meet commitments under the EU Drinking Water and Water Framework Directives.
- High-frequency monitoring provides detailed knowledge of catchment processes and nutrient flux estimates.
- Cover crops effectively mitigate autumn leaching losses of residual nitrate.
- Change in soil physical and chemical properties under cover cropping and direct drilling may initially cause increased GHG (nitrous oxide) emissions.