Indirect Agricultural N_2O Emissions and the *InveN_2Ory* project

Chris Adams

Kevin Hiscock, Faye Outram

Julian Andrews

defra Department for Environment Food and Rural Affairs

UEA University of East Anglia

www.wensumalliance.org.uk

Chris Adams christopher.adams@uea.ac.uk

- N_2O and why it's a problem?
- N_2O: Sources, transport and atmospheric fluxes
- Emission Factors (EF)
- The InveN_2Ory project in brief
- How we can measure fluxes and EFs?
- Preliminary Results
- The next year and beyond

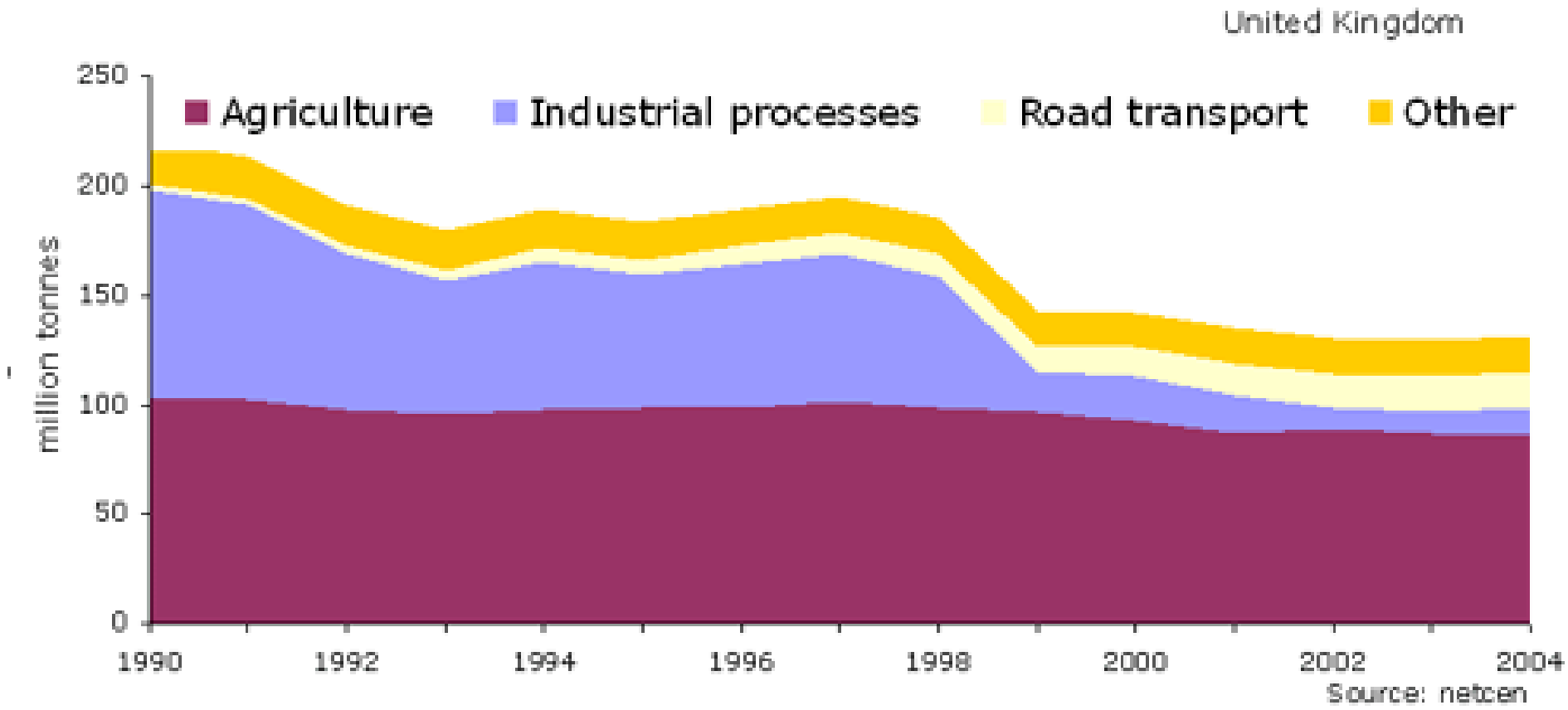
Chris Adams christopher.adams@uea.ac.uk

Current estimates of N_2O

- Greenhouse Warming Potential of 298
- Globally 12% of GHG emissions due to agriculture
- UK slightly lower at 8%
- c. 50% of those due to nitrous oxide

Chris Adams christopher.adams@uea.ac.uk

Sources of N_2O



Chris Adams christopher.adams@uea.ac.uk

Agricultural N_2O
(Current estimates)

- c. 80% N_2O direct soil emissions
  - fertiliser N applications
  - grazing returns (urine)
  - manure applications

- c. 20% N_2O indirect emissions
  - drainage & runoff (N_2O & nutrients)
  - Groundwater, drainage ditches, rivers, estuaries

Chris Adams christopher.adams@uea.ac.uk

Agricultural N_2O
(Current estimates)

- c. 80% N_2O direct soil emissions
  - fertiliser N applications
  - grazing returns (urine)
  - manure applications

- c. 20% N_2O indirect emissions
  - drainage & runoff (N_2O & nutrients)
  - Groundwater, drainage ditches, rivers, estuaries

Chris Adams christopher.adams@uea.ac.uk

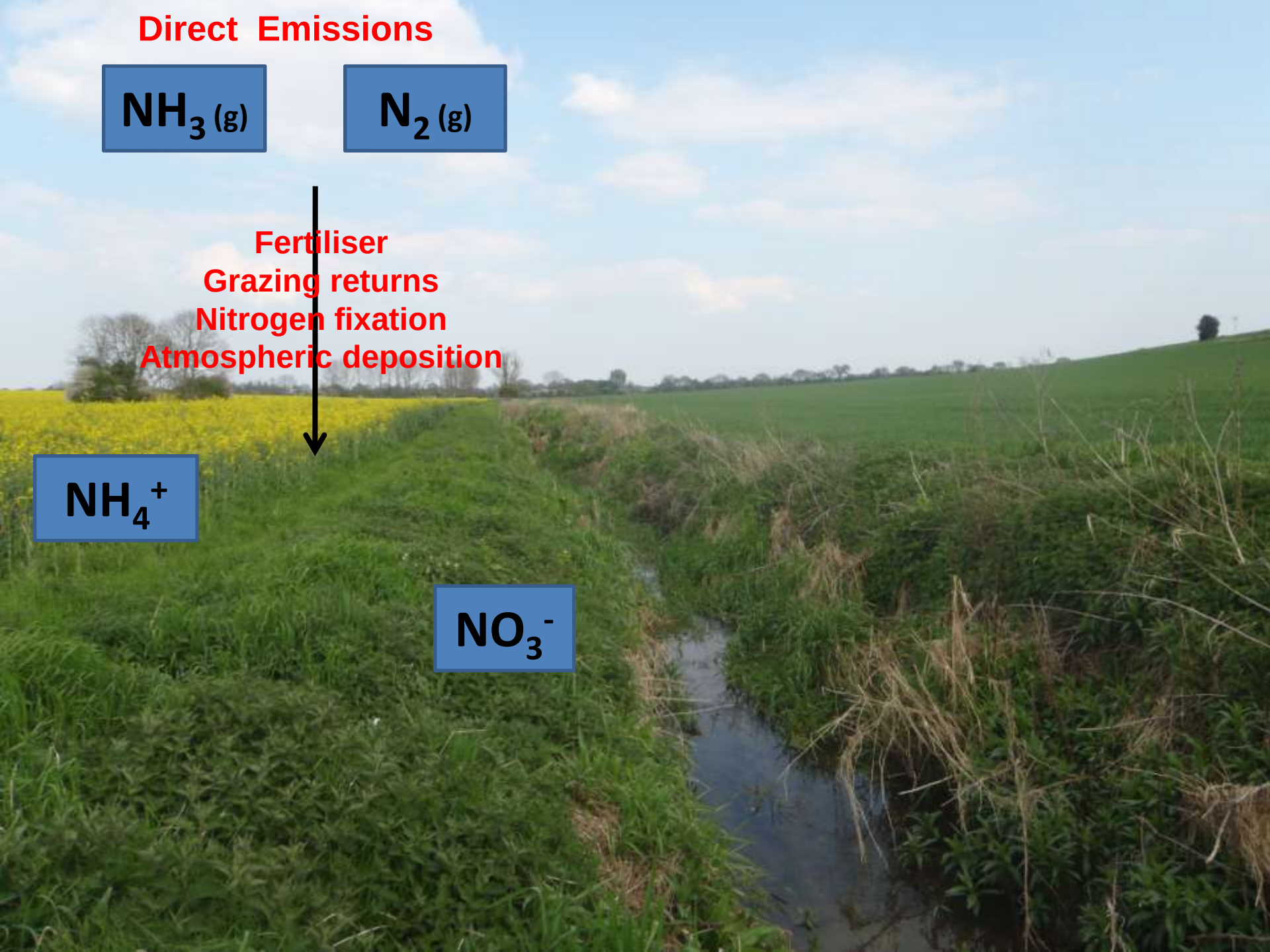
Agricultural N_2O
(Current estimates)

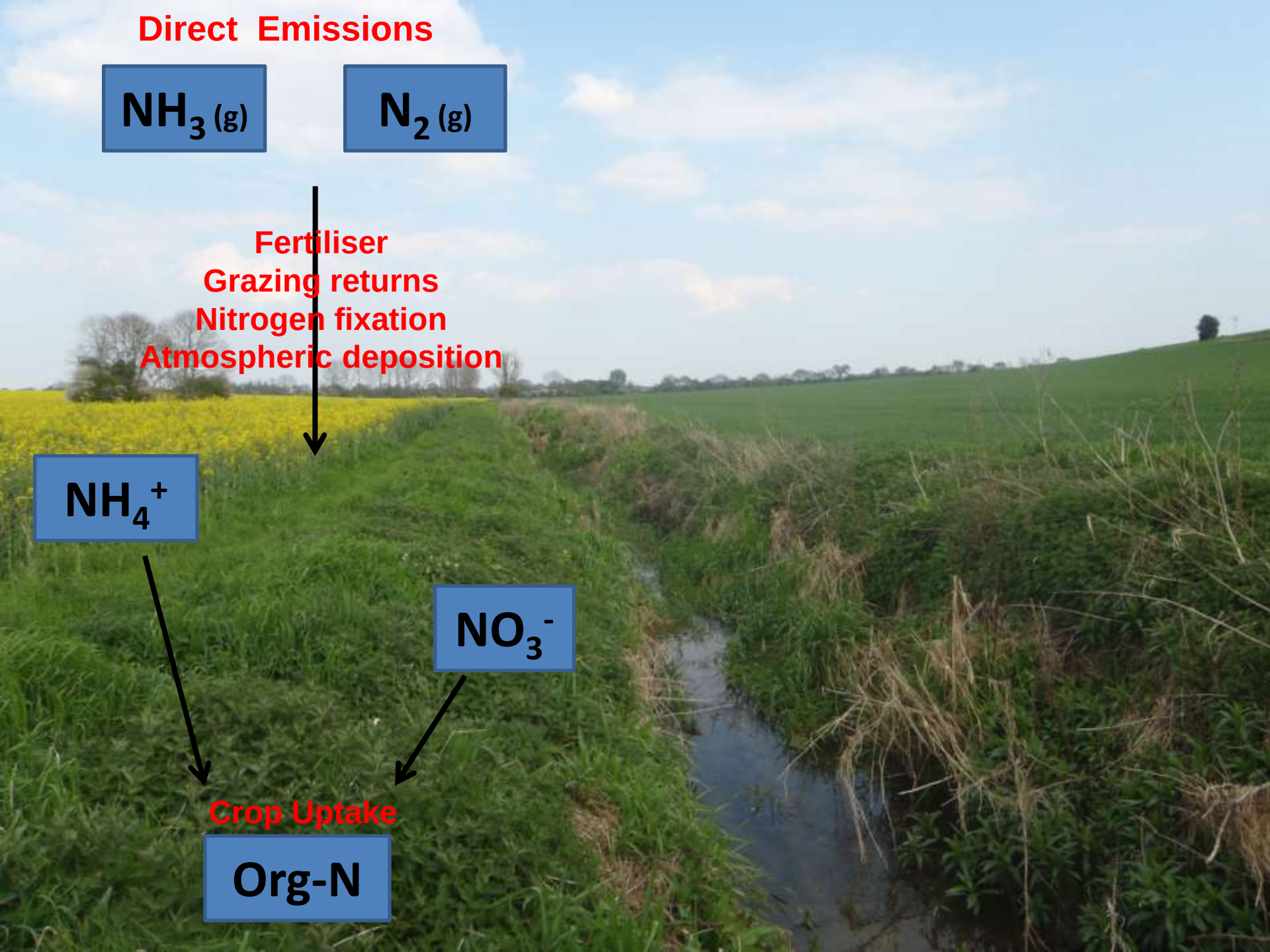
- c. 80% N_2O direct soil emissions
  - fertiliser N applications
  - grazing returns (urine)
  - manure applications

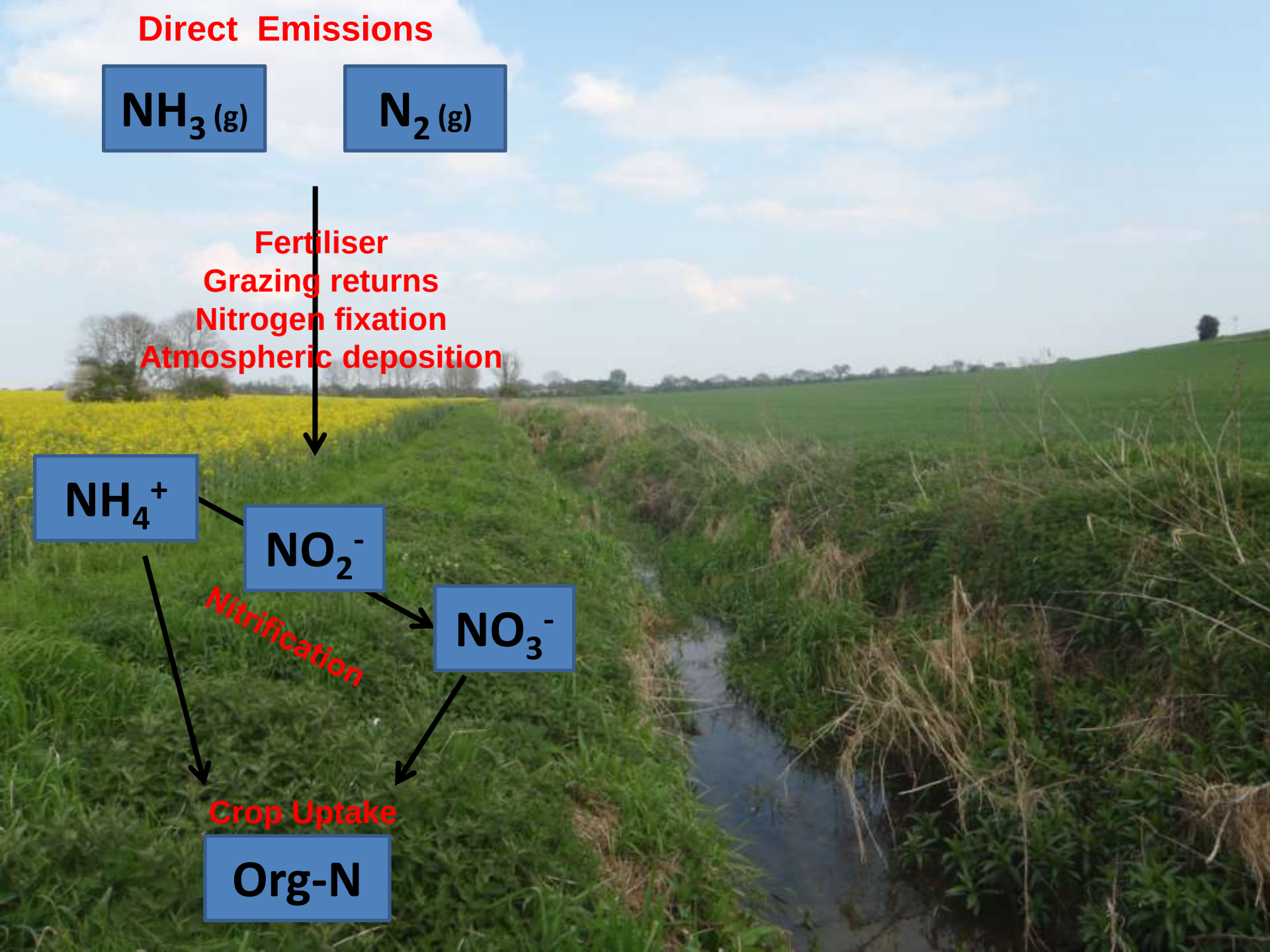
- c. 20% N_2O indirect emissions
  - drainage & runoff (N_2O & nutrients)
  - Groundwater, drainage ditches, rivers, estuaries

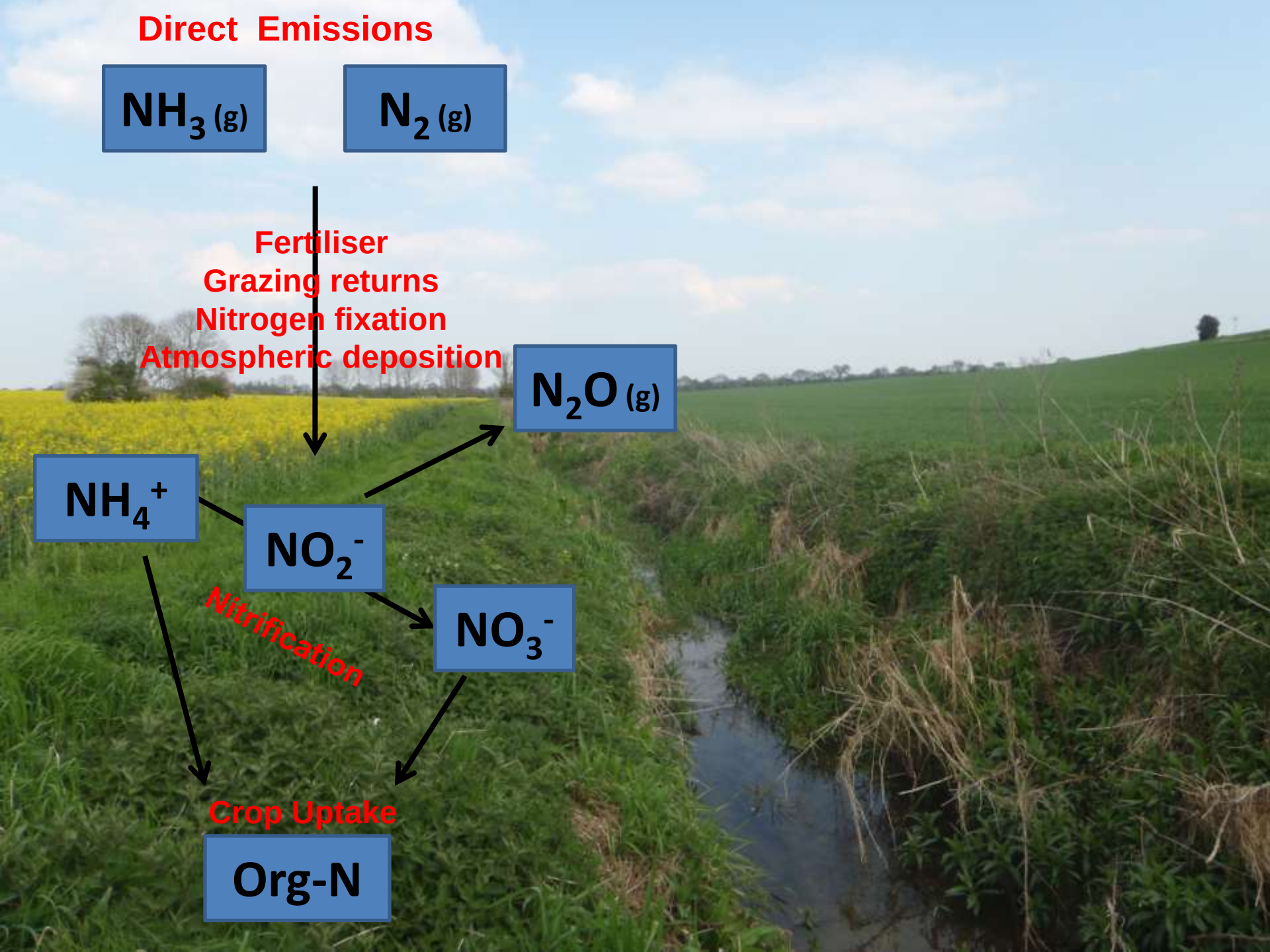
2/3 of the uncertainty due to indirect emissions

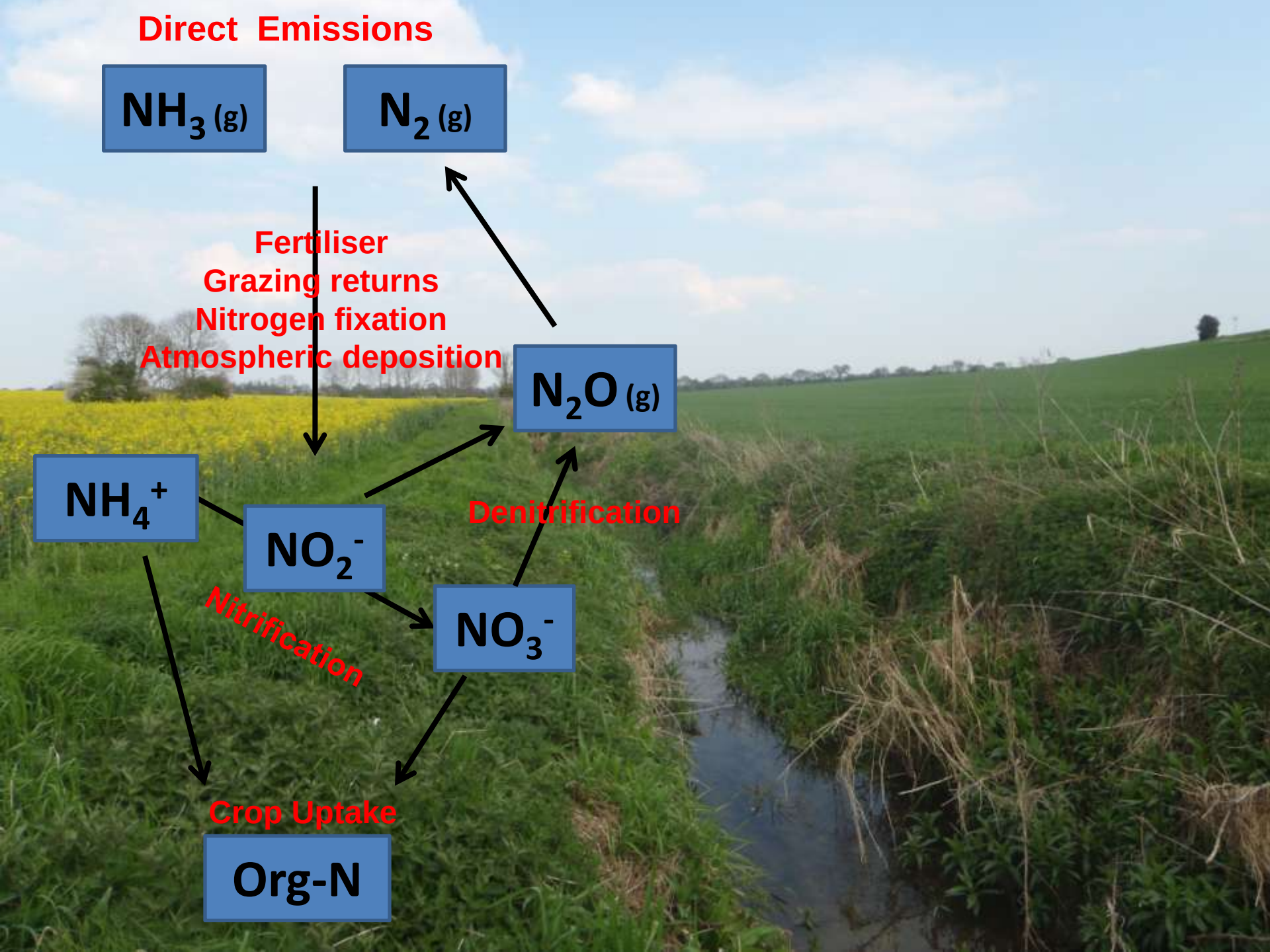
Chris Adams christopher.adams@uea.ac.uk

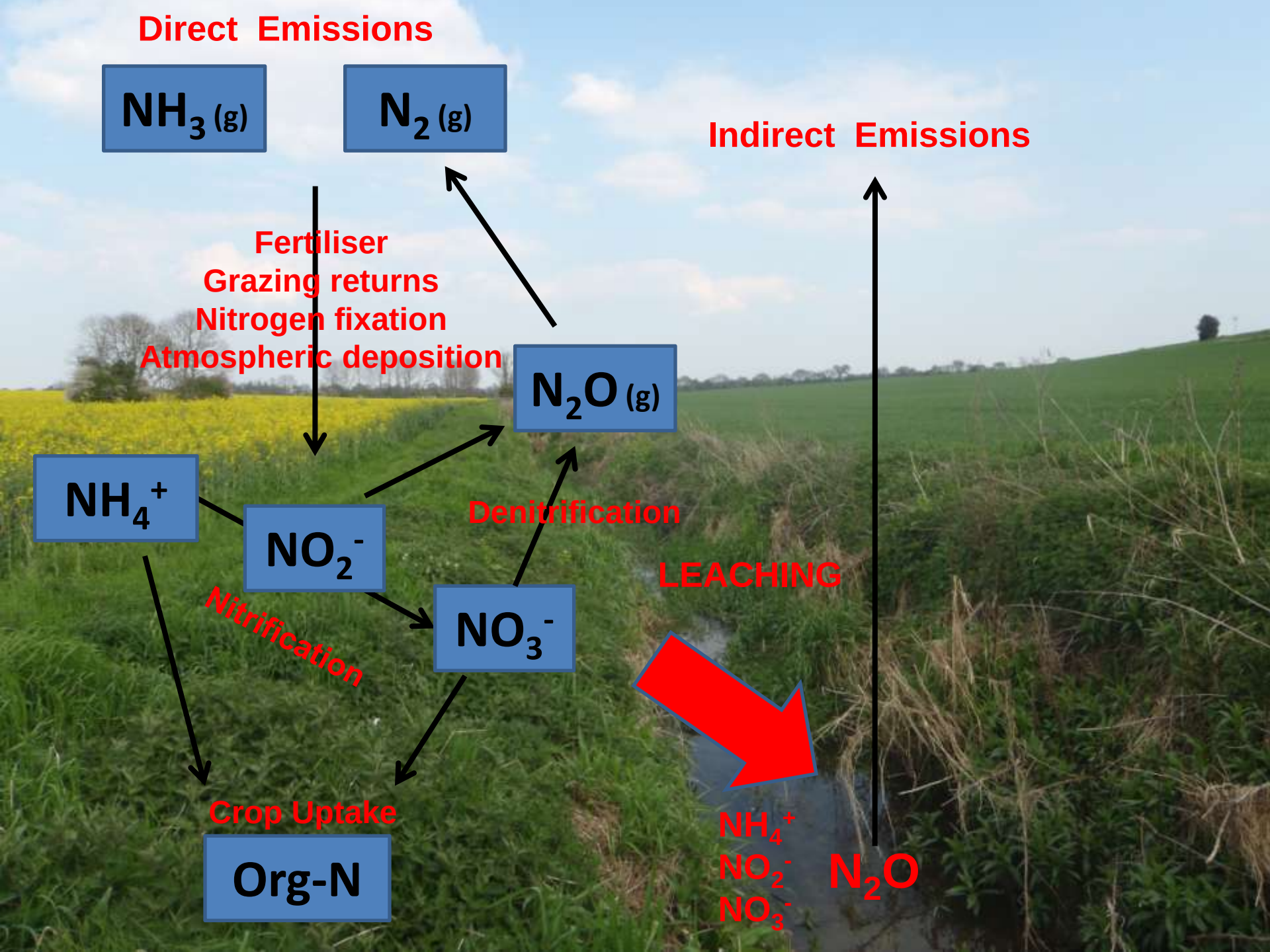

Direct Emissions
NH_3 (g)
N_2 (g)
Fertiliser
Grazing returns
Nitrogen fixation
Atmospheric deposition
NH_4^+
NO_3^-


Direct Emissions
NH_3 (g)
N_2 (g)
Fertiliser
Grazing returns
Nitrogen fixation
Atmospheric deposition
NH_4^+
NO_3^-
Crop Uptake
Org-N


Direct Emissions
NH_3 (g)
N_2 (g)
Fertiliser
Grazing returns
Nitrogen fixation
Atmospheric deposition
NH_4^+
NO_2^-
Nitrification
NO_3^-
Crop Uptake
Org-N


Direct Emissions
NH_3 (g)
N_2 (g)
Fertiliser
Grazing returns
Nitrogen fixation
Atmospheric deposition
N_2O (g)
NH_4^+
NO_2^-
Nitrification
NO_3^-
Crop Uptake
Org-N


Direct Emissions
NH_3 (g)
N_2 (g)
Fertiliser
Grazing returns
Nitrogen fixation
Atmospheric deposition
N_2O (g)
NH_4^+
NO_2^-
Denitrification
Nitrification
NO_3^-
Crop Uptake
Org-N


Direct Emissions
NH_3 (g)
N_2 (g)
Indirect Emissions
Fertiliser
Grazing returns
Nitrogen fixation
Atmospheric deposition
N_2O (g)
NH_4^+
NO_2^-
Denitrification
LEACHING
Nitrification
NO_3^-
Crop Uptake
Org-N
NH_4^+
NO_2^-
NO_3^-
N_2O

Emission factors
(current estimates)

- **Used by the IPCC to *estimate* N_2O fluxes**
- **Relate N_2O fluxes to the nitrogen in the system of interest**
- **EF-5 groundwater, drainage, rivers, estuaries**
- **% of nutrients leached**

  IPCC 2006 default value of 0.3 (0.1–0.8)
- **% of leached nutrients converted to N_2O**

  N_2O-N as % of NO_3-N

Chris Adams christopher.adams@uea.ac.uk

Emission factors
(current estimates)

- **Previously IPCC 0.025%**

Chris Adams christopher.adams@uea.ac.uk

Emission factors
(current estimates)

- **Previously IPCC 0.025%**

- **Downward revision in 2006 to 0.0075%**
  - **0.0025% from groundwater and drainage ditches**
  - **0.0025% rivers**
  - **0.0025% estuaries**

Chris Adams christopher.adams@uea.ac.uk

Emission factors
(current estimates)

- **Previously IPCC 0.025%**

- **Downward revision in 2006 to 0.0075%**
  - **0.0025% from groundwater and drainage ditches**
  - **0.0025% rivers**
  - **0.0025% estuaries**

General, not regional or catchment specific

Chris Adams christopher.adams@uea.ac.uk

InvenN_2Ory Project

- DEFRA funded, £12.6 million
- 5 year programme
- IPCC methods
- Provides Direct N_2O fluxes and emission factors
- Linked with the DTC to provide Indirect N_2O fluxes and emission factors
- UK specific and where possible specific to agricultural systems and geoclimatic regions

Chris Adams christopher.adams@uea.ac.uk

Measuring N_2O

- Water samples for dissolved N_2O
  - Combine with nutrient data to give Emission factors
  - Combine with atmospheric N_2O to *estimate* fluxes

Chris Adams christopher.adams@uea.ac.uk

Measuring N_2O

- Water samples for dissolved N_2O
  - Combine with nutrient data to give Emission factors
  - Combine with atmospheric N_2O to estimate fluxes
- Chambers
  - Concentration increase over time to *measure* fluxes
  - Investigate the effect of plants and flow conditions

Chris Adams christopher.adams@uea.ac.uk

Measuring N_2O

- Water samples for dissolved N_2O
  - Combine with nutrient data to give Emission factors
  - Combine with atmospheric N_2O to estimate fluxes
- Chambers
  - Concentration increase over time to *measure* fluxes
  - Investigate the effect of plants and flow conditions
- Basic modelling of flux rates
- SF_6 tracer experiments to *measure* flux rates

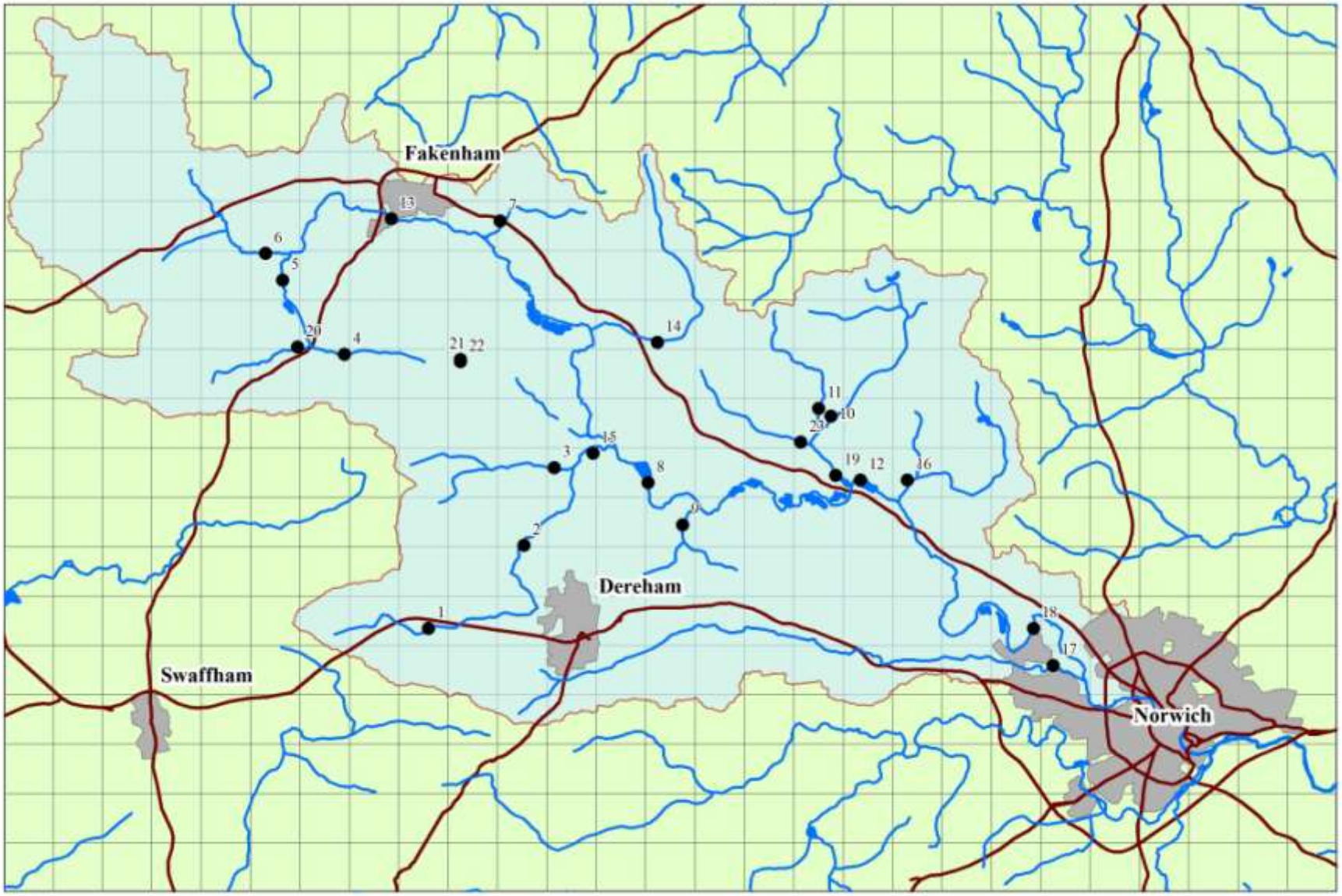
Chris Adams christopher.adams@uea.ac.uk

Tiered sampling structure

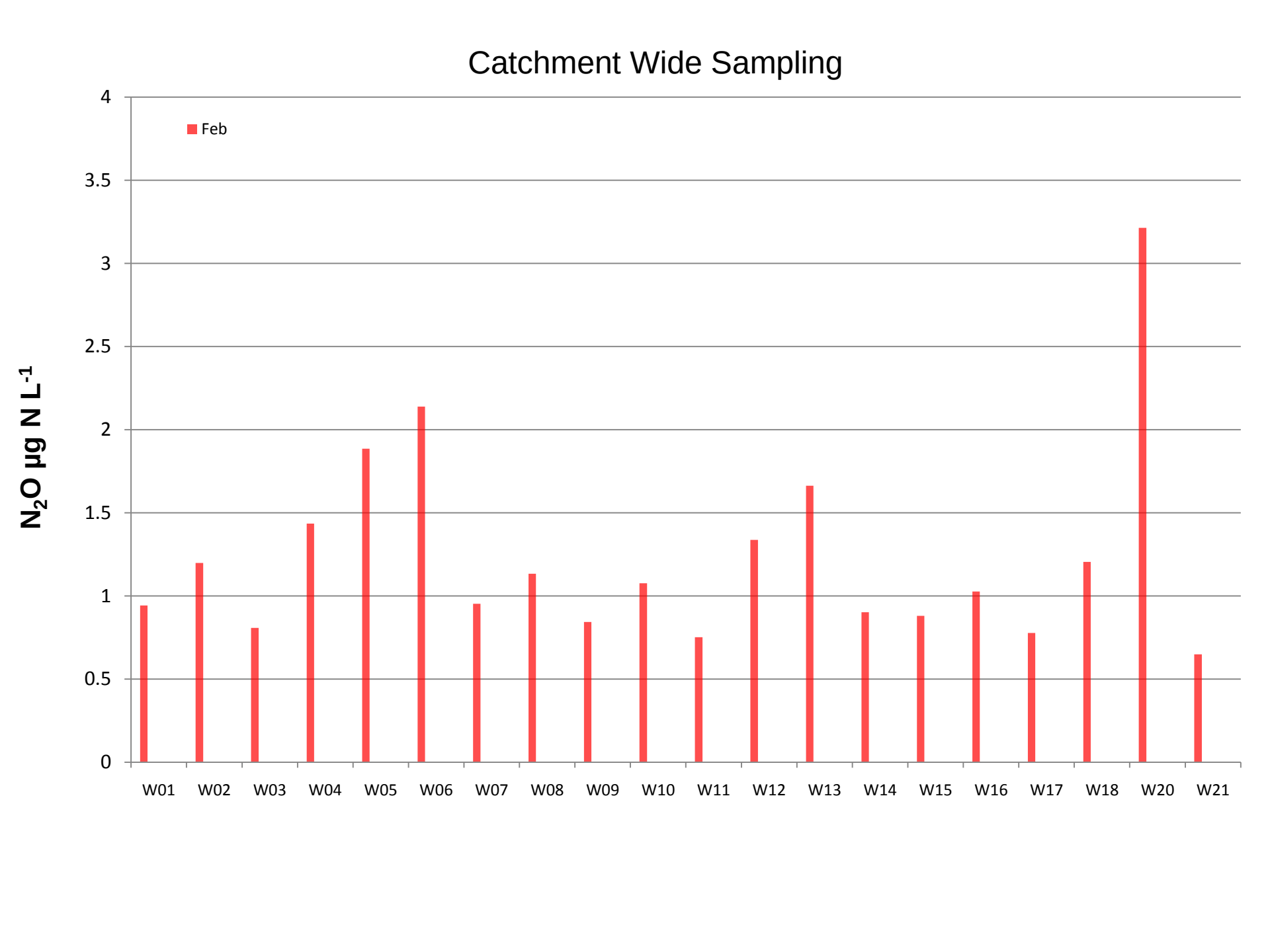
- **Tier 1** (baseline and traditional EF-5s)
  - Monthly: catchment wide sampling
  - Weekly: 6 DTC sampling locations
  - Groundwater sampling (DTC boreholes)

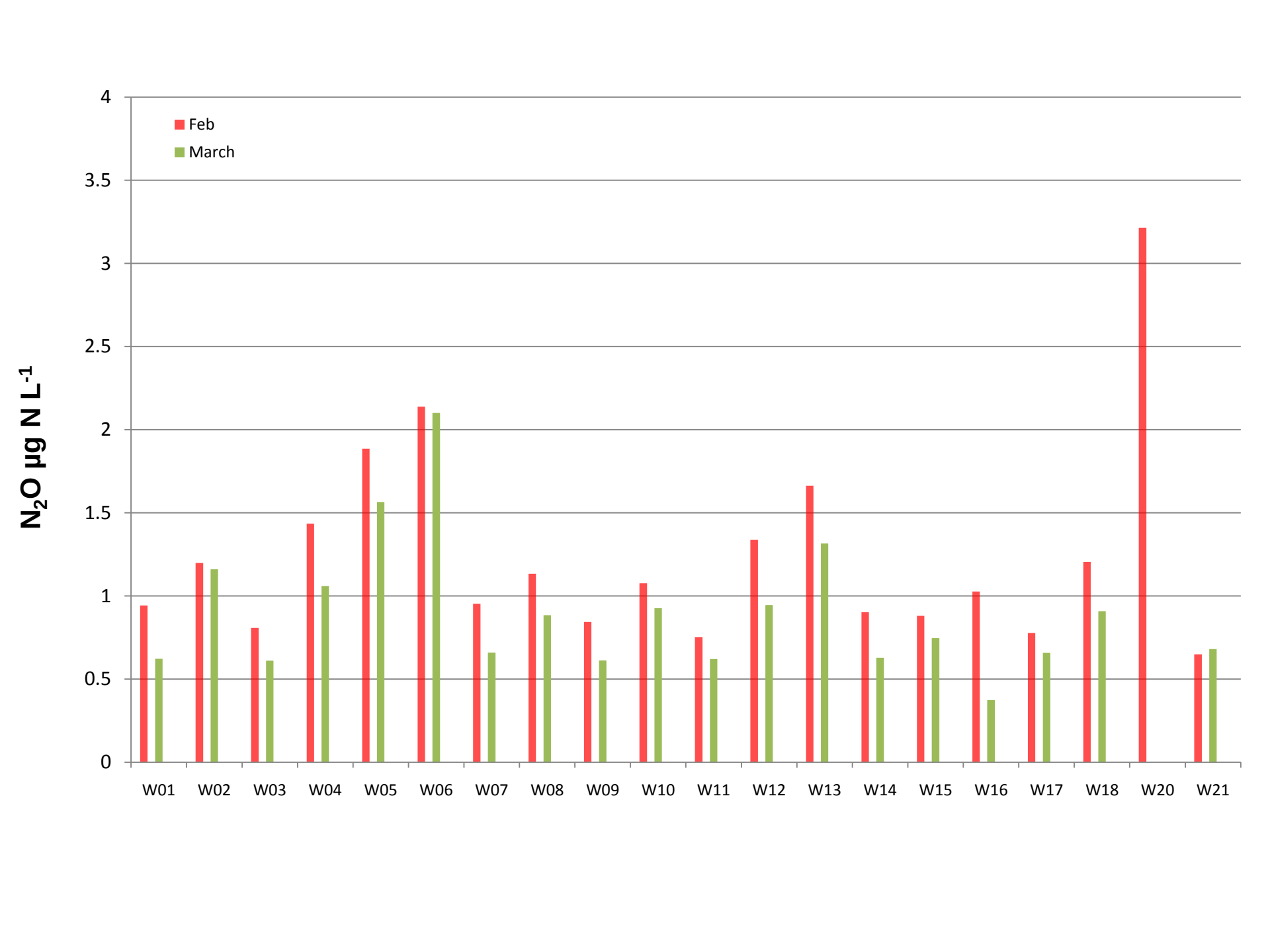
Chris Adams christopher.adams@uea.ac.uk

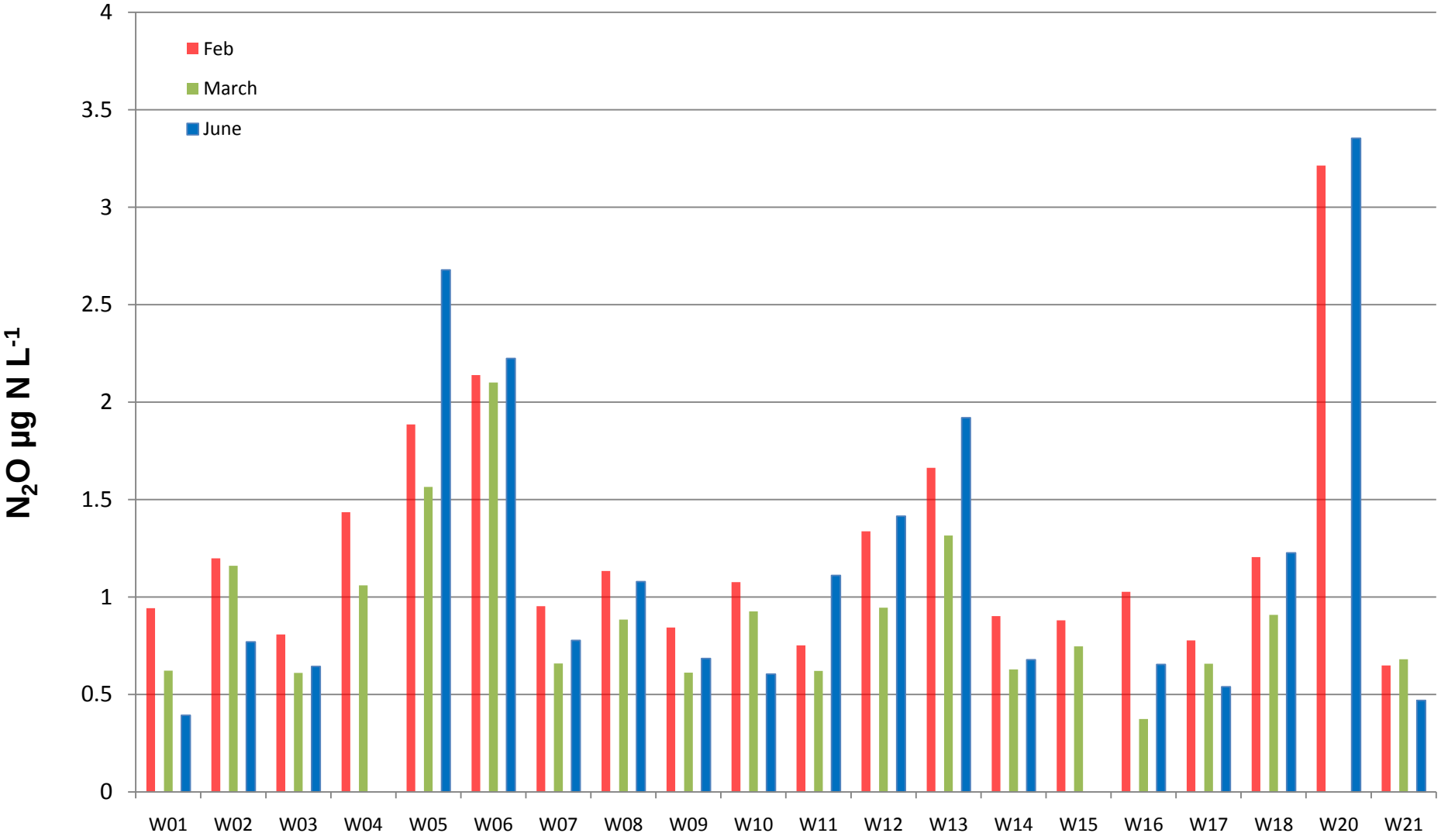
Wensum Chemical Sampling Points

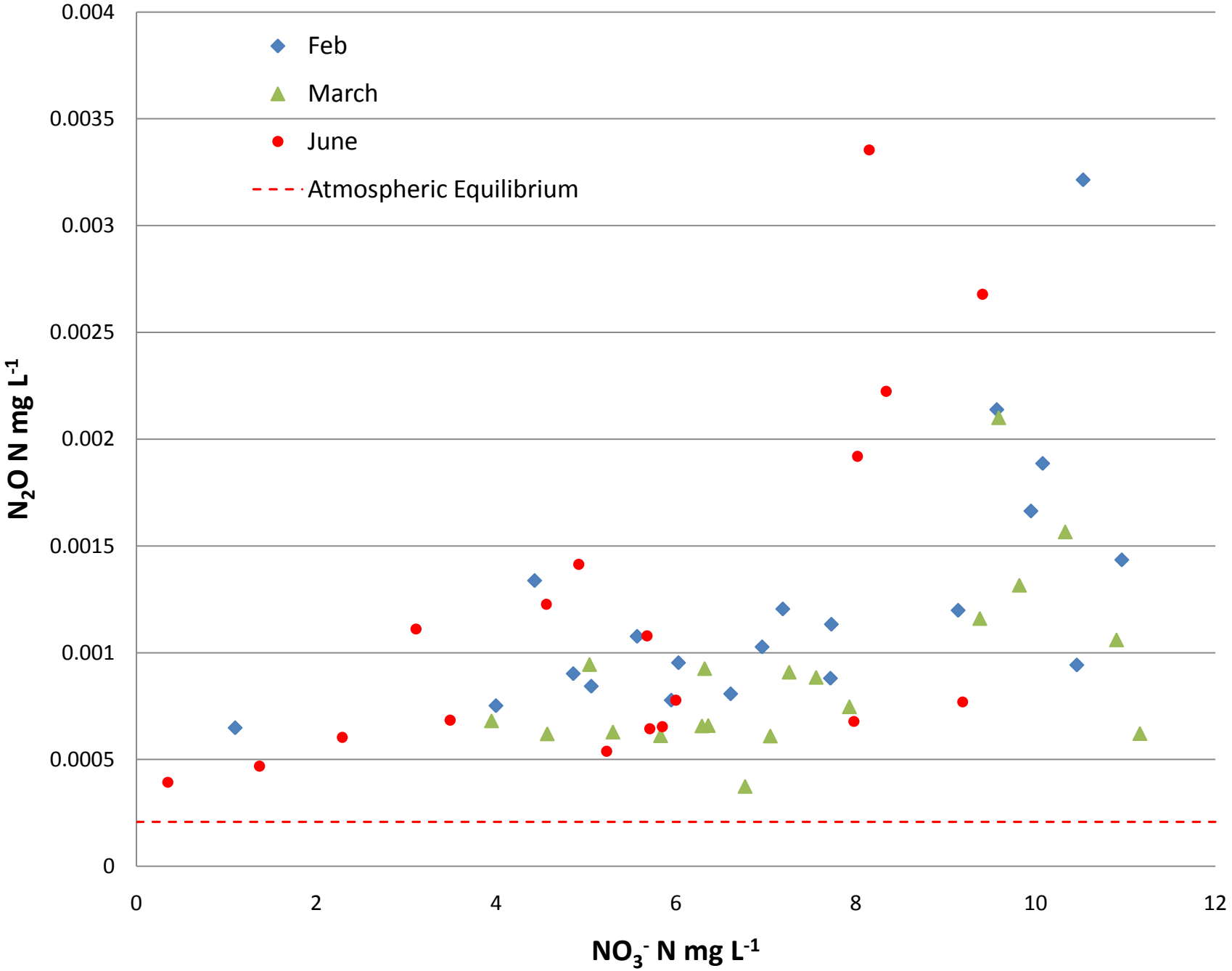


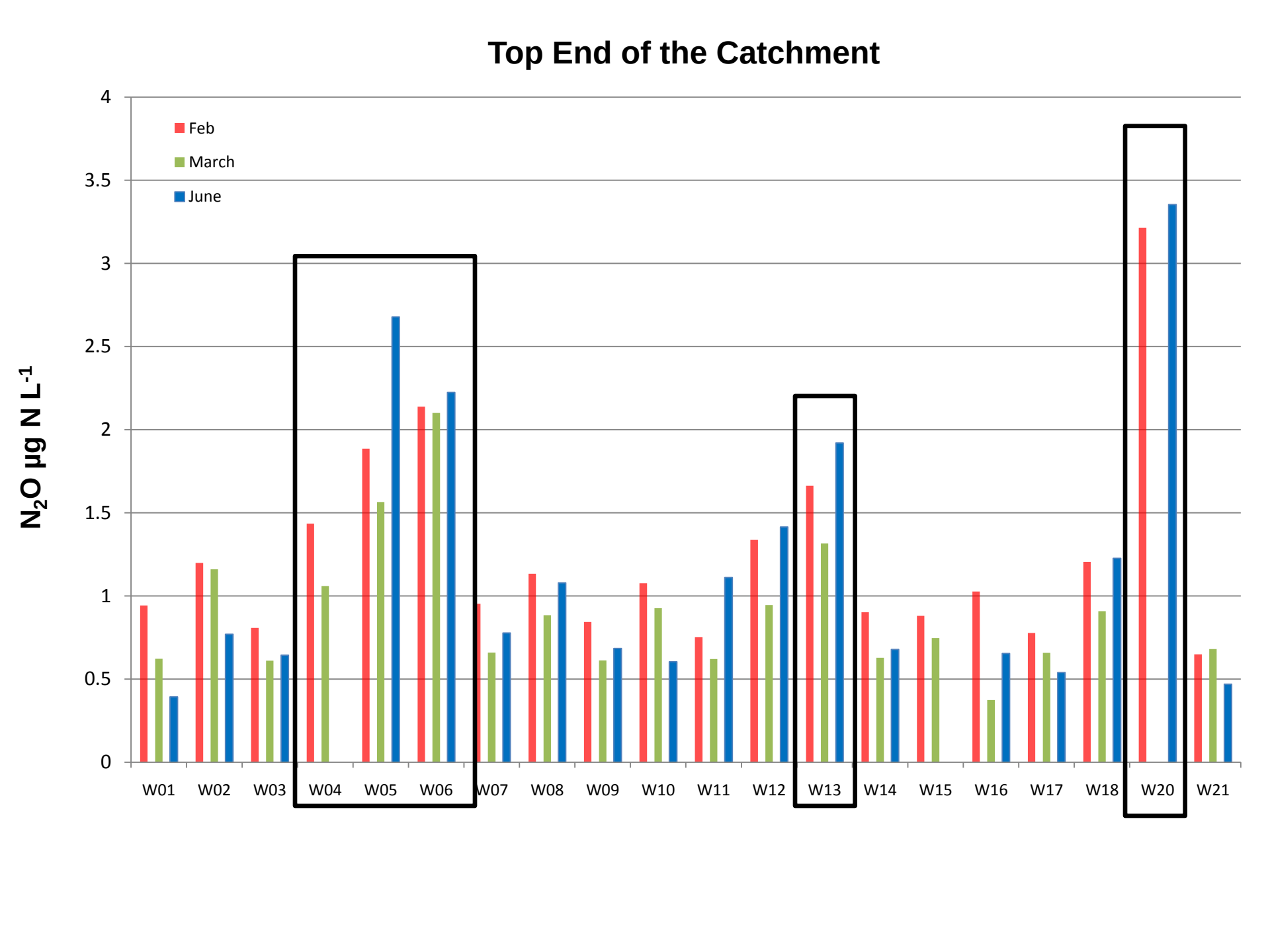
Wensum_DTC_new/Wen4/Wensum/WensumChemicalSamplingPoints07012011.mxd


Catchment Wide Sampling
Feb
N_2O µg N L^{-1}
4
3.5
3
2.5
2
1.5
1
0.5
0
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
W12
W13
W14
W15
W16
W17
W18
W20
W21

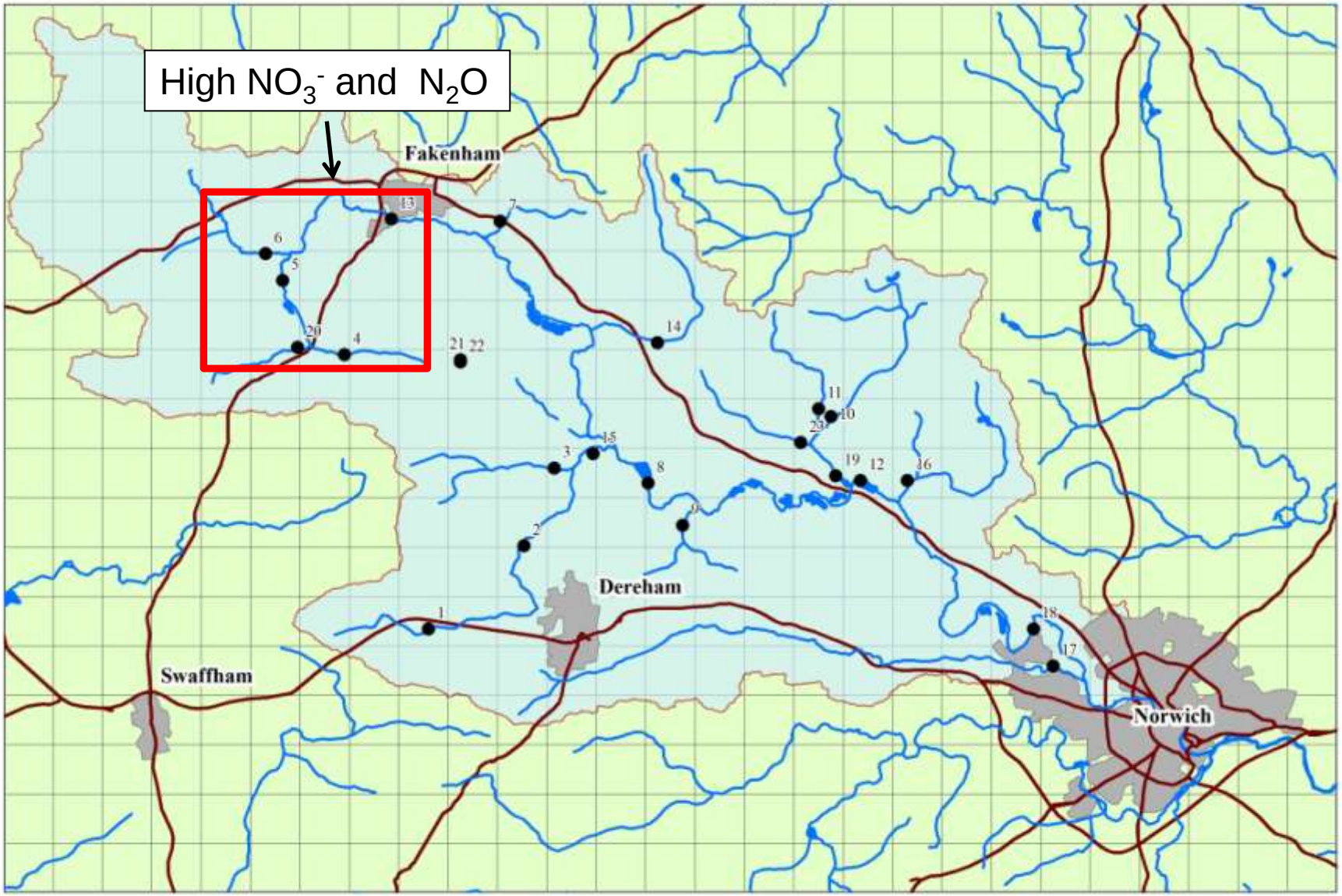

Feb
March
4
3.5
3
2.5
2
1.5
1
0.5
0
N2O µg N L-1
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
W12
W13
W14
W15
W16
W17
W18
W20
W21


Feb
March
June
N_2O µg N L^{-1}
4
3.5
3
2.5
2
1.5
1
0.5
0
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
W12
W13
W14
W15
W16
W17
W18
W20
W21

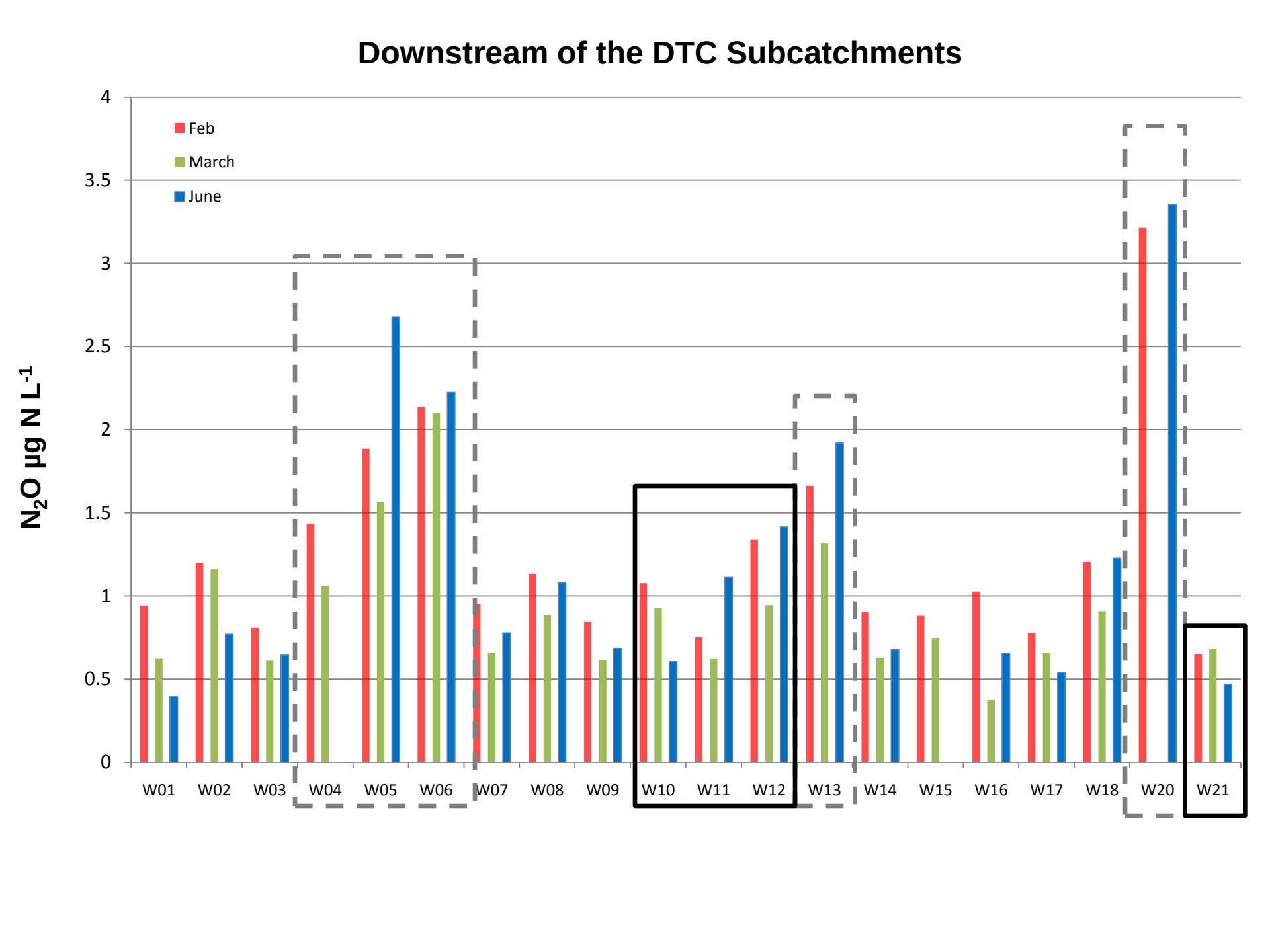

0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Feb
March
June
Atmospheric Equilibrium
N2O N mg L-1
0
2
4
6
8
10
12
NO3- N mg L-1


Top End of the Catchment
Feb
March
June
N_2O µg N L^{-1}
4
3.5
3
2.5
2
1.5
1
0.5
0
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
W12
W13
W14
W15
W16
W17
W18
W20
W21

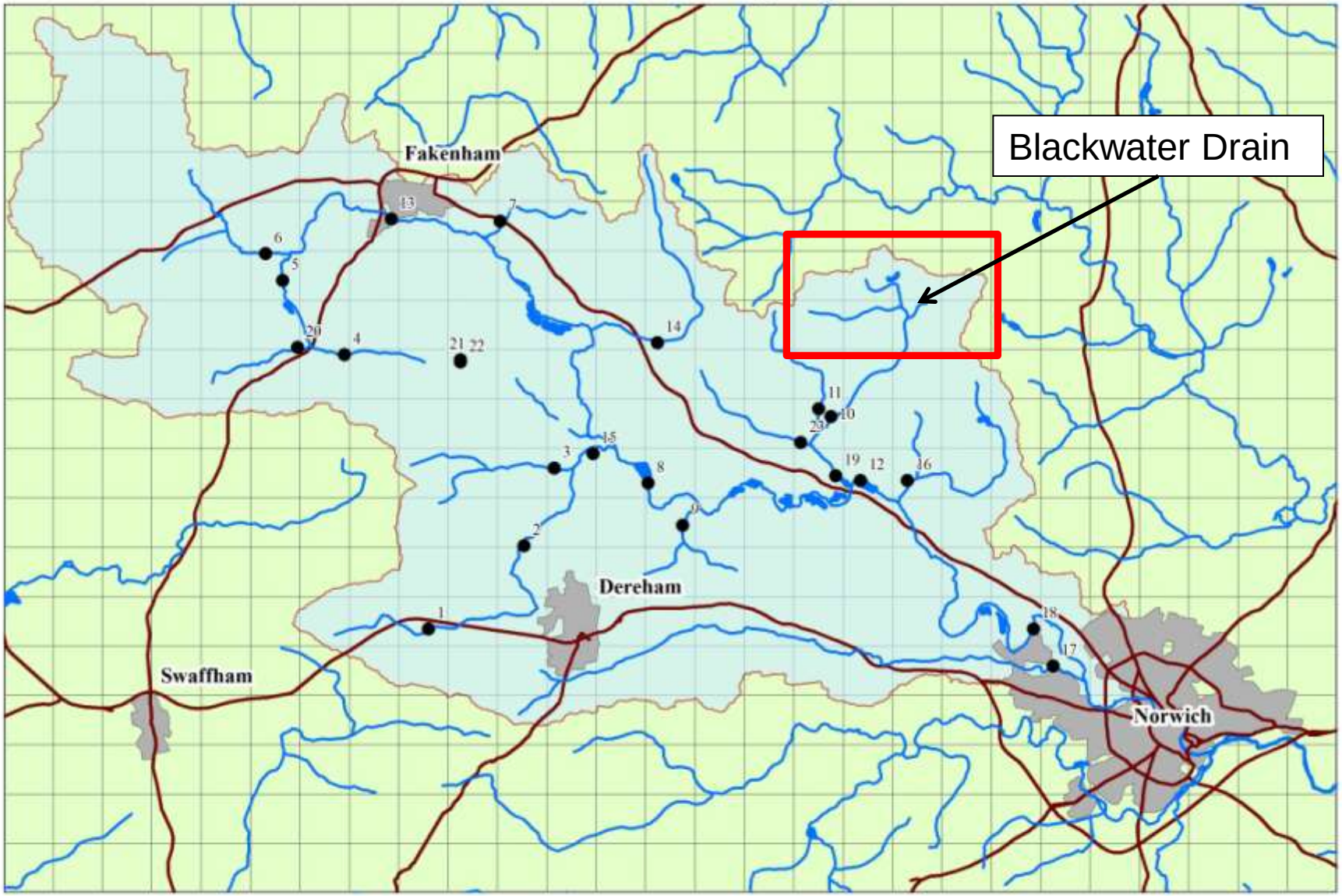
Wensum DTC area



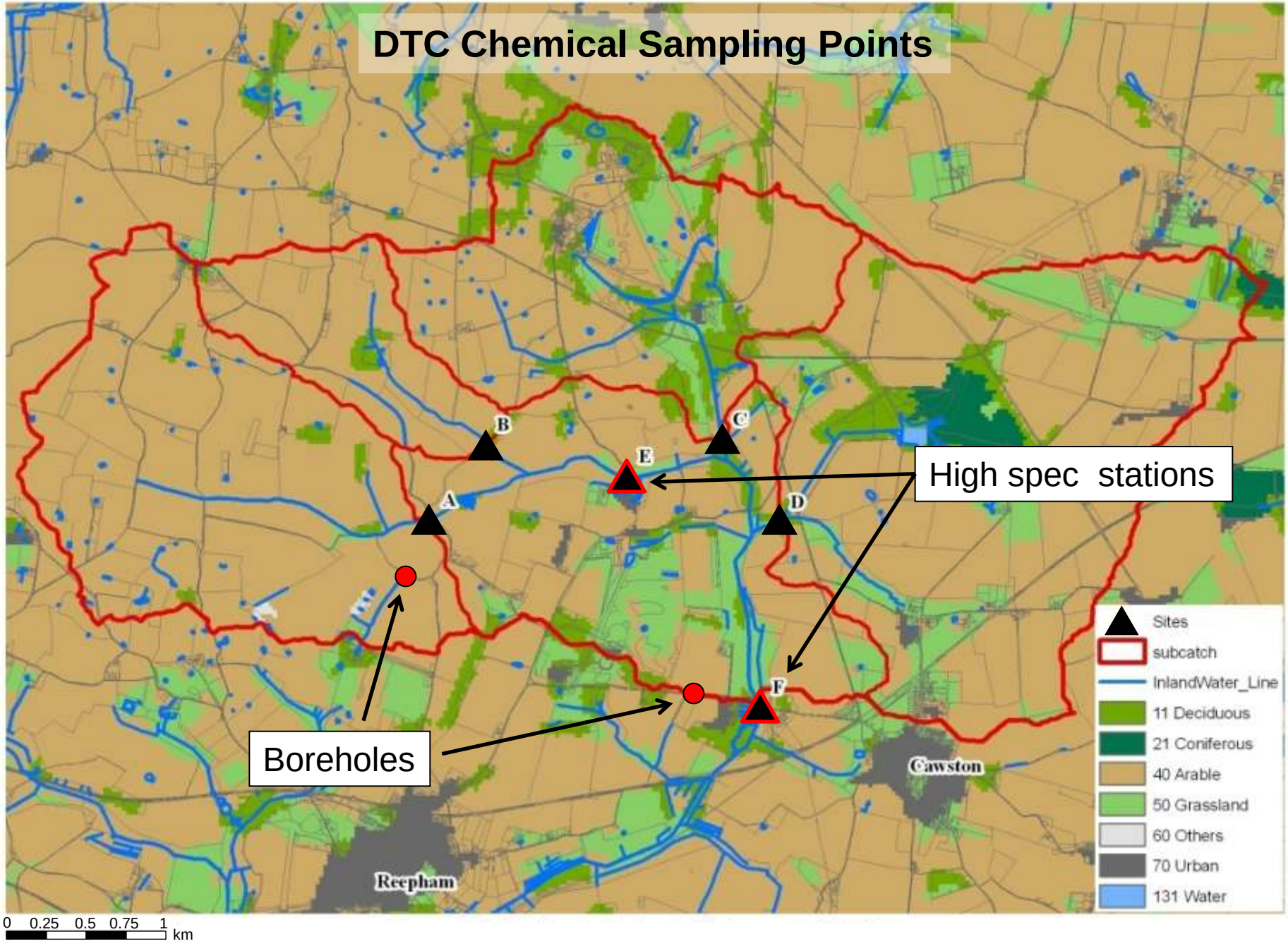
Wensum_DTC_new/Wen4/Wensum/WensumChemicalSamplingPoints07012011.mxd

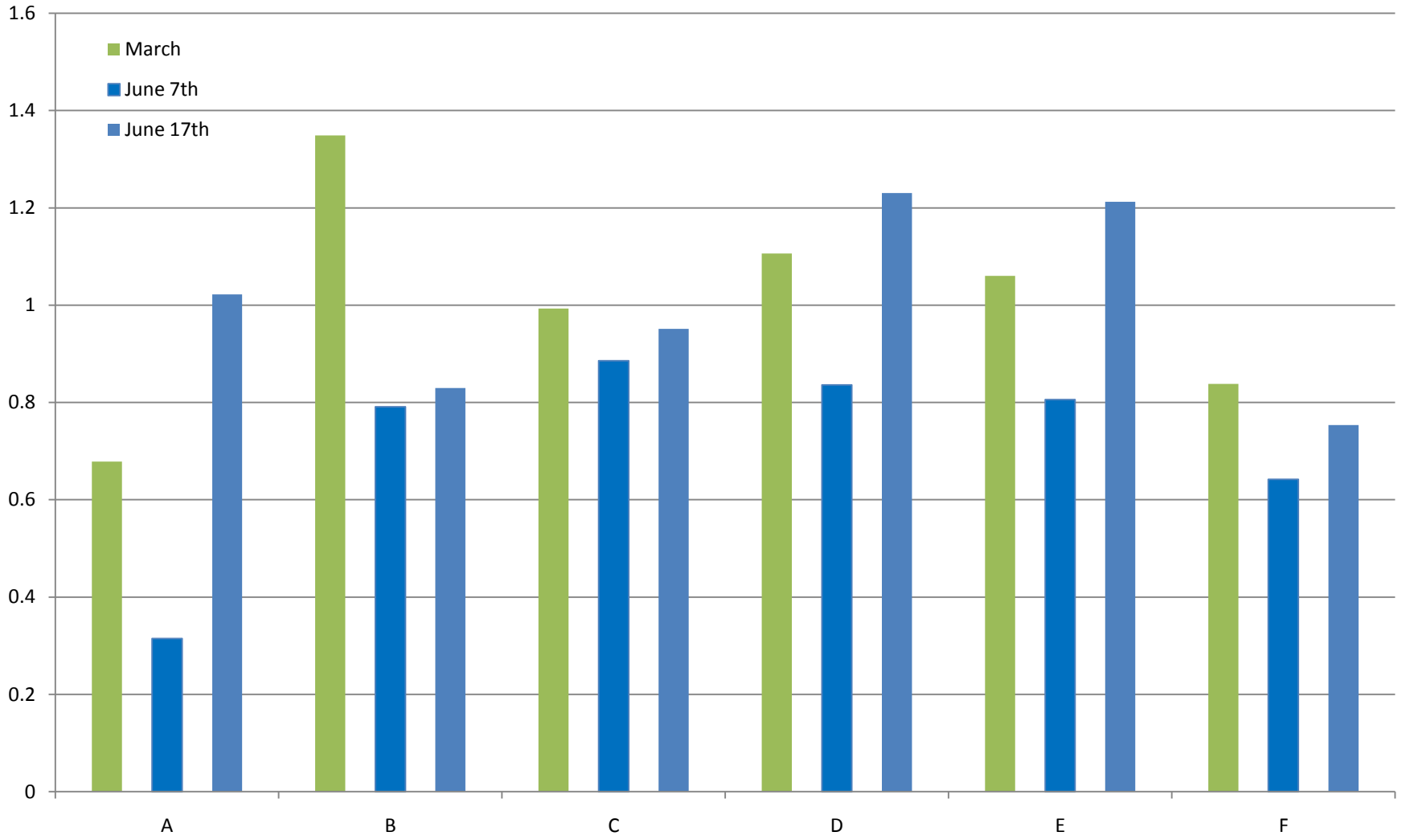

Downstream of the DTC Subcatchments
Feb
March
June
N_2O µg N L^{-1}
4
3.5
3
2.5
2
1.5
1
0.5
0
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
W12
W13
W14
W15
W16
W17
W18
W20
W21

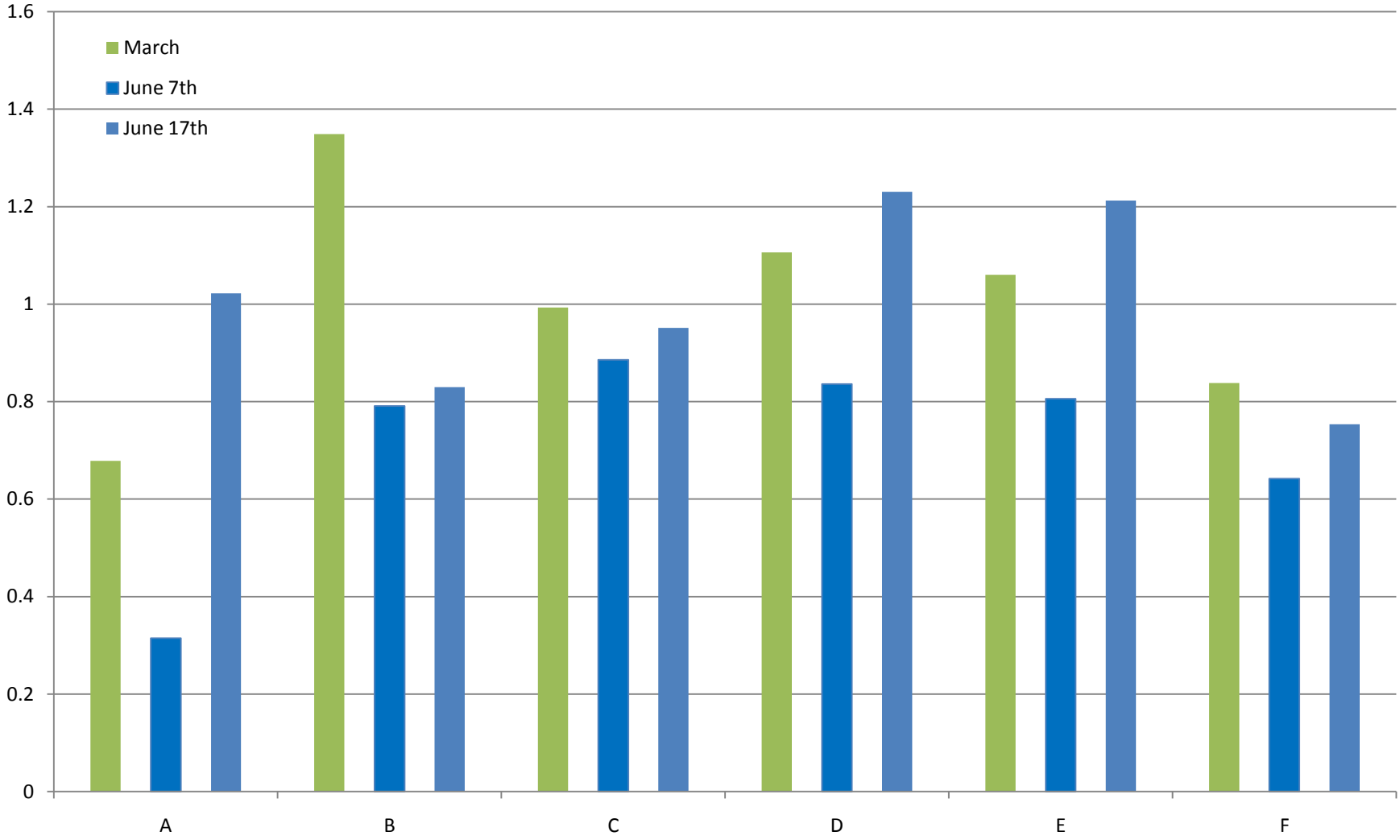
Wensum DTC area



Wensum_DTC_new/Wen4/Wensum/WensumChemicalSamplingPoints07012011.mxd


DTC Chemical Sampling Points
High spec stations
Boreholes
A
B
C
D
E
F
Reepham
Cawston
Sites
subcatch
InlandWater_Line
11 Deciduous
21 Coniferous
40 Arable
50 Grassland
60 Others
70 Urban
131 Water
0 0.25 0.5 0.75 1
km


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
March
June 7th
June 17th
A
B
C
D
E
F



Early in the year Site E is a mixing of A and B

Later in the year there is higher N_2O levels at E, perhaps produced in steam

Nitrogen leaching rate calculation

Period: 21/3/11 00:00 to 27/3/11 15:00 (= 6.625 days)

Mean flow rate = 0.045 m^3/s

Mean nitrate concentration = 6.25 mg N/L

Nitrate-N flux = 24.3 kg N/day

Leaching rate for mini-catchments A and B (579.8 ha) = **15.3** kg N/ha/a

(~7 – 8 % of applied N amount)

Leaching Factor of 0.07-0.08
much lower than the IPCC value of 0.3 (0.1-0.9)

Chris Adams christopher.adams@uea.ac.uk

Example nitrous oxide flux and EF calculation

Mean flow rate = 0.045 m^3/s

Dissolved N_2O concentration = 1.06 µg N/L

Dissolved N_2O N flux = 0.004 kg N/day

Emission factor for mini-catchments A and B : 0.004/24.3 = 0.00017

Lower than the IPCC value of 0.0025%

Chris Adams christopher.adams@uea.ac.uk

Tiered sampling structure

- **Tier 2**
  - **High spatial resolution** sampling along drainage networks
  - Includes potential **flux hotspots**

field drains,

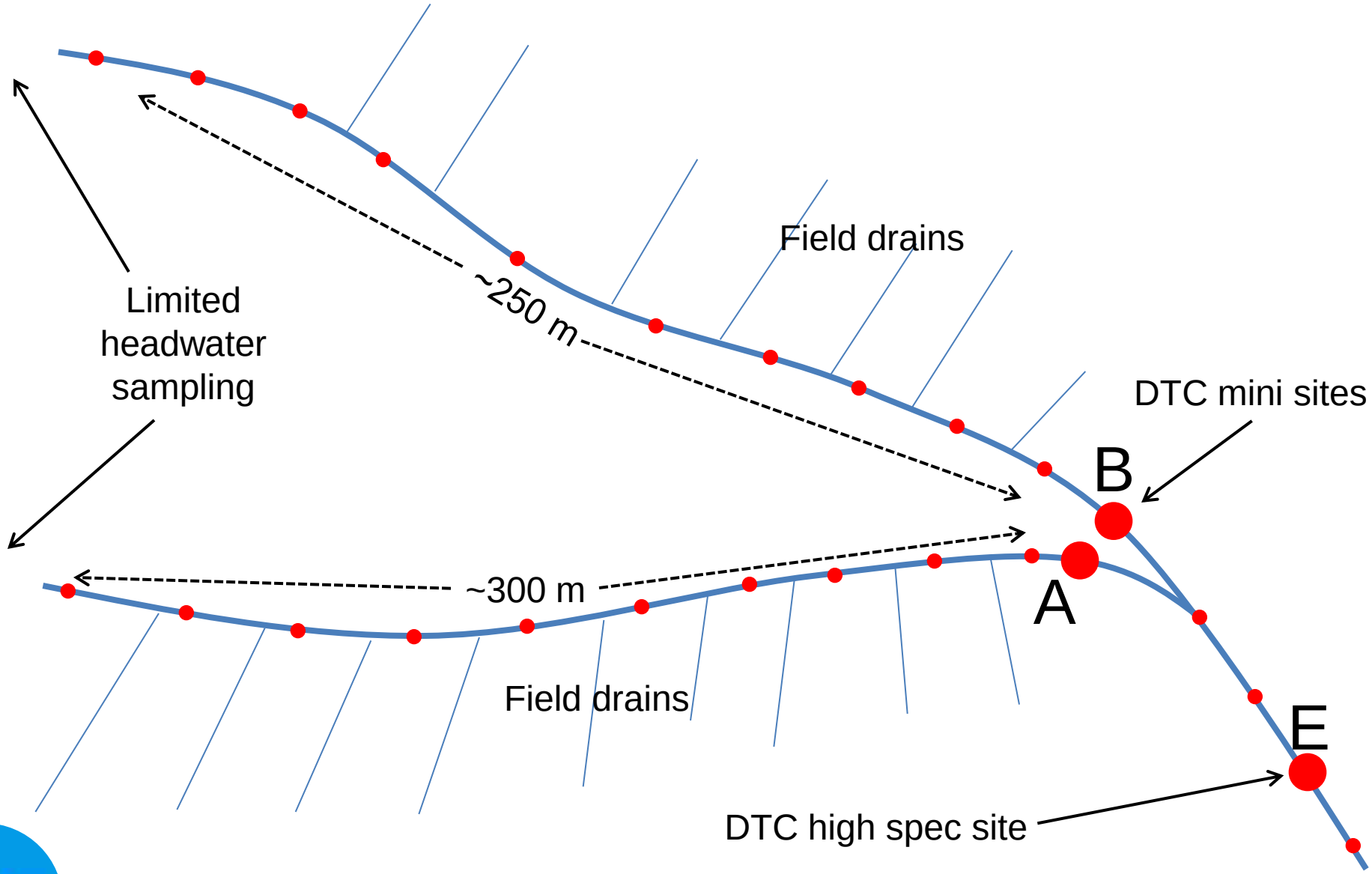
riffle features,

weirs, etc.

Chris Adams christopher.adams@uea.ac.uk


26
Watery Lane
B
A
E
42
Dunkirk
Swanhills Plantation
Gatehouse Farm
0 0.050.1 0.2 kilometre

Tier 2 sampling in the Wensum DTC



Chris Adams christopher.adams@uea.ac.uk

- Monthly N_2O data for 6 months
- Everything in place for 1 years intensive field study
- High spatial resolution sampling in all DTC's but especially the Wensum
- Diurnal cycles
- Storm events
- Seasonal variations, plant cover etc.

Chris Adams christopher.adams@uea.ac.uk