IOWA

Chris Jones, Research Engineer, IIHR Hydroscience and Engineering

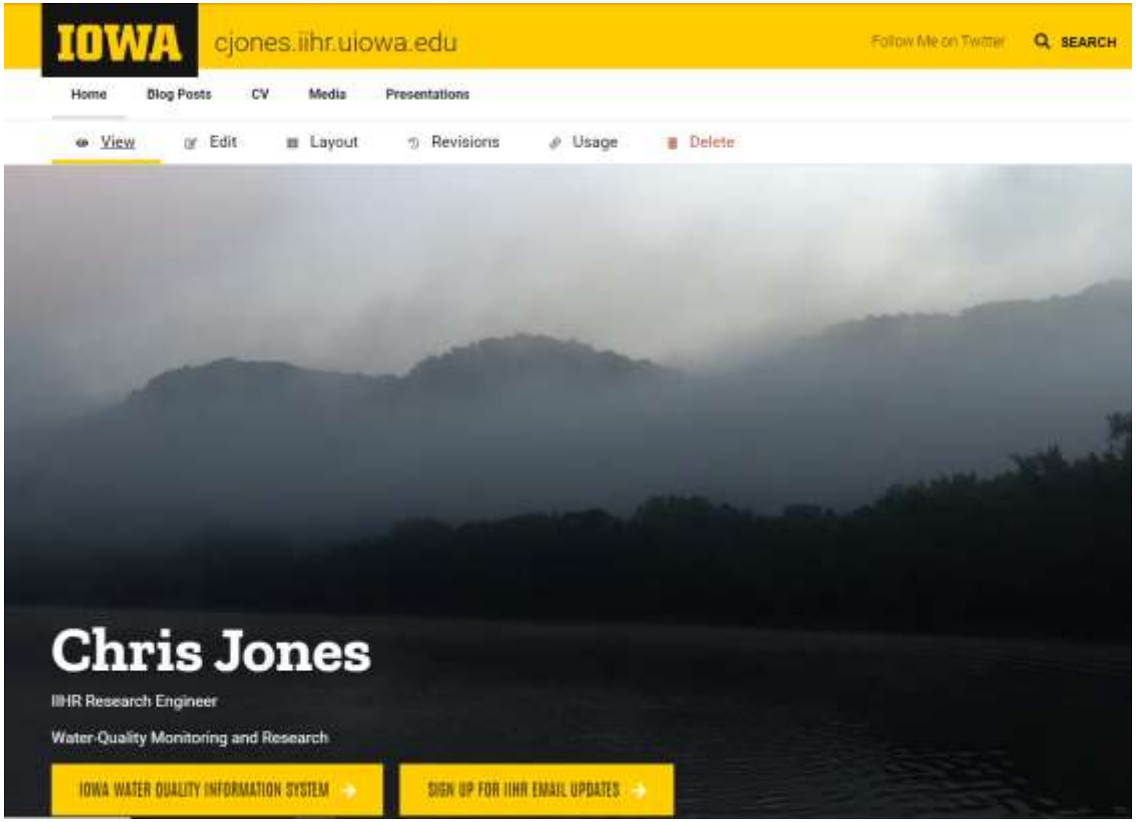
Alkalinity, Carbon, and Nitrogen

March 11, 2022

Water Quality Group

Slides Available at:

https://cjones.iihr.uiowa.edu/



What is Alkalinity?

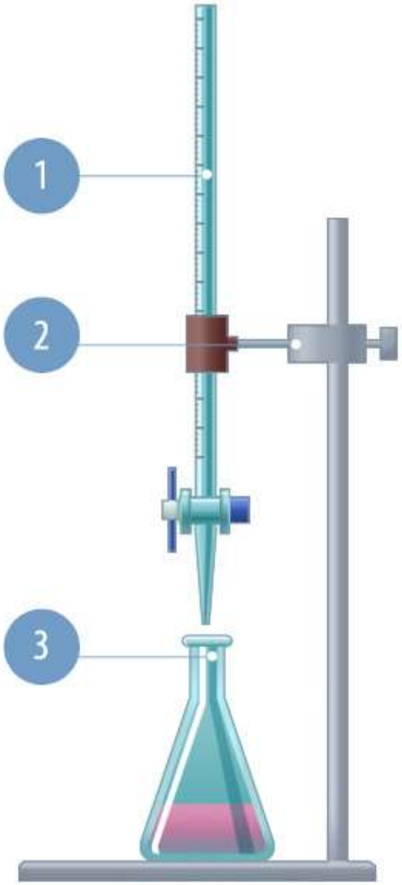
“a measure of the ability of the water body to neutralize acids and bases and thus maintain a fairly stable pH level“

Important quality for resilient soil and surface water

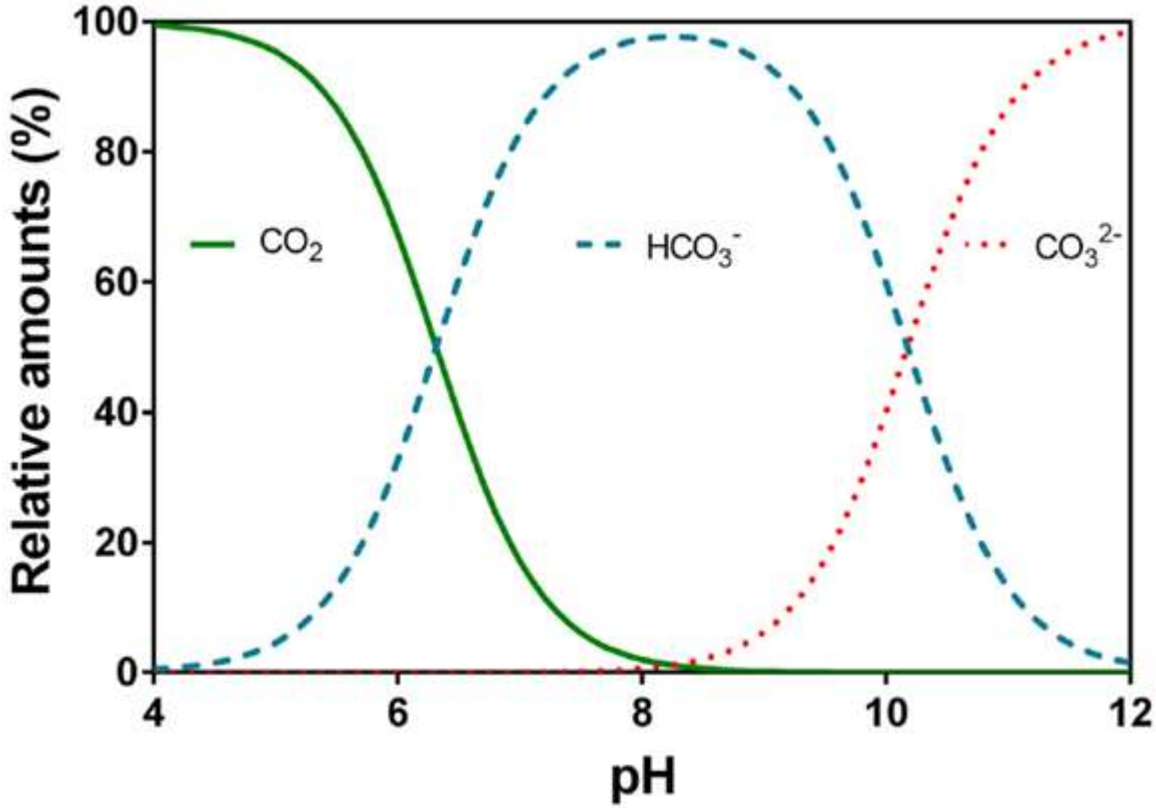
What creates alkalinity?

- Bicarbonates
- Carbonates
- Hydroxides

- Total alkalinity is measured by measuring the amount of acid (e.g., sulfuric acid) needed to bring the sample to a pH of 4.2. At this pH all the alkaline compounds in the sample are "used up." The result is reported as milligrams per liter of calcium carbonate (mg/L $CaCO_3$).

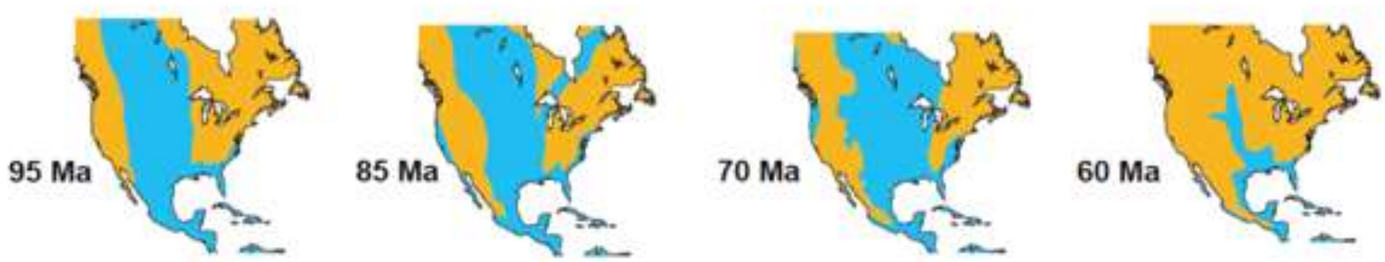


Inorganic carbon is in the form of bicarbonate alkalinity in most natural waters



There is a lot of alkalinity in Iowa water and soil

End of the Cretaceous period Iowa was at the bottom of the ocean



Four Papers

Assessing the Relative Importance of Nitrogen-Retention Processes in a Large Reservoir Using Time-Series Modeling

Elizabeth HANSEN, Kung-Sik CHAN, Christopher S. JONES, and Keith SCHILLING

Journal of Agricultural, Biological and Environmental Statistics, 2015

Related total hardness, total suspended solids, total alkalinity, pH to nitrate concentrations in Saylorville Reservoir

Saylorville Reservoir

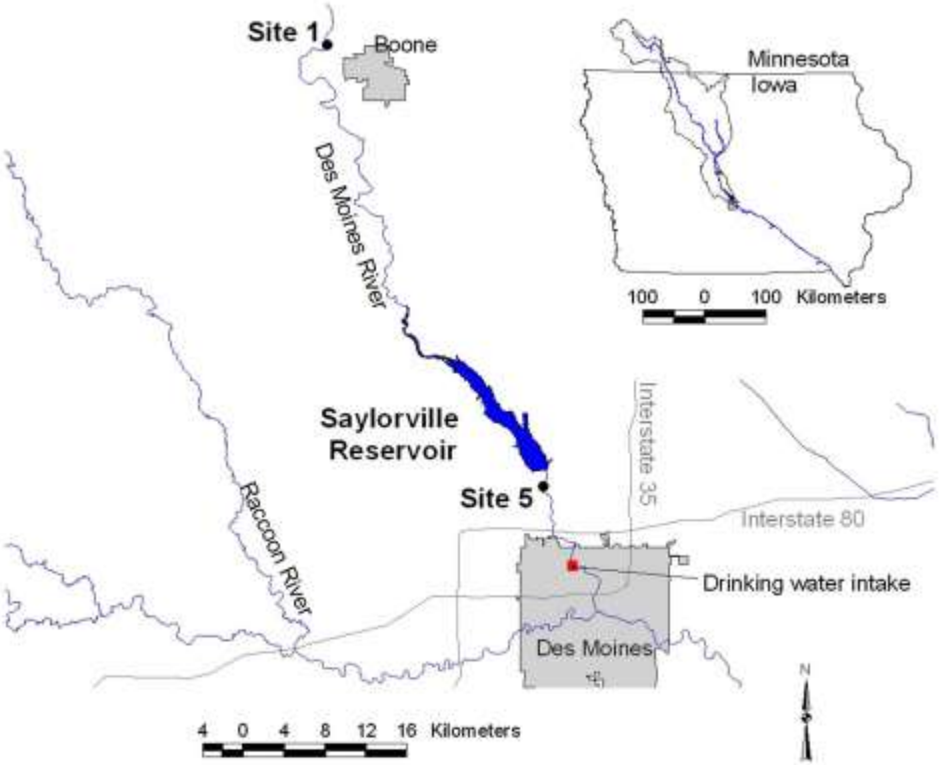


Figure 1. Location of Saylorville Reservoir and water sampling points.

Conceptual Model

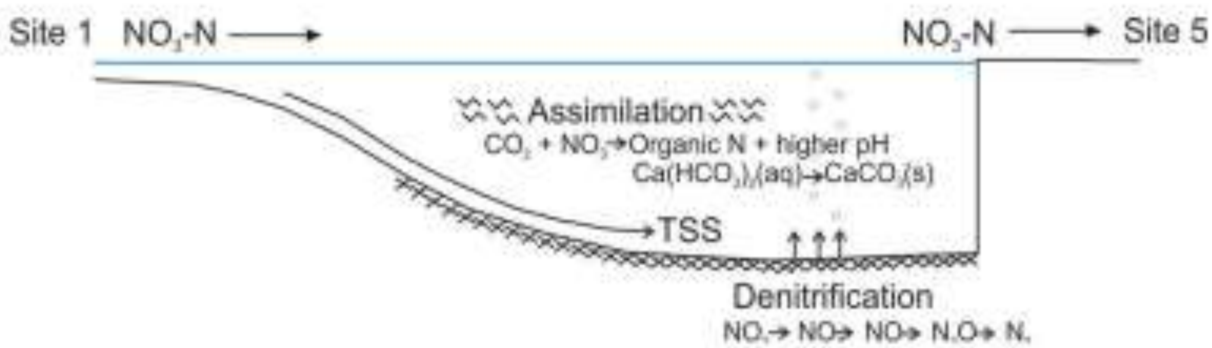


Figure 3. Conceptual model of nitrate retention processes in Saylorville Reservoir.


Diurnal pH swings
caused by algae blooms

Nitrate concentrations decline about 20%

Of that decline:

- **61% was denitrification**
- **38% was algal assimilation**
- **1% sedimentation**

2nd Paper

Journal of Environmental Quality
TECHNICAL REPORTS
LANDSCAPE AND WATERSHED PROCESSES

Carbon Export from the Raccoon River, Iowa: Patterns, Processes, and Opportunities

Christopher S. Jones* and Keith E. Schilling

2nd Paper

nature

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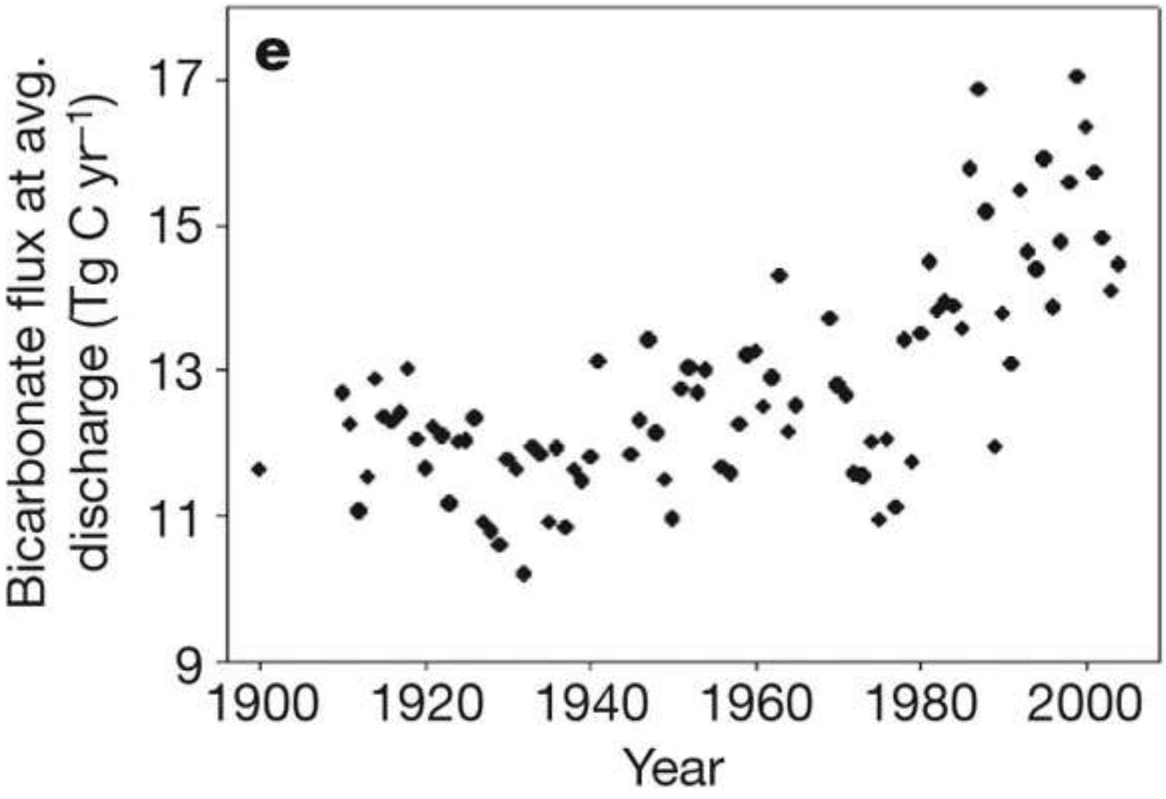
nature > letters > article

Published: 24 January 2008

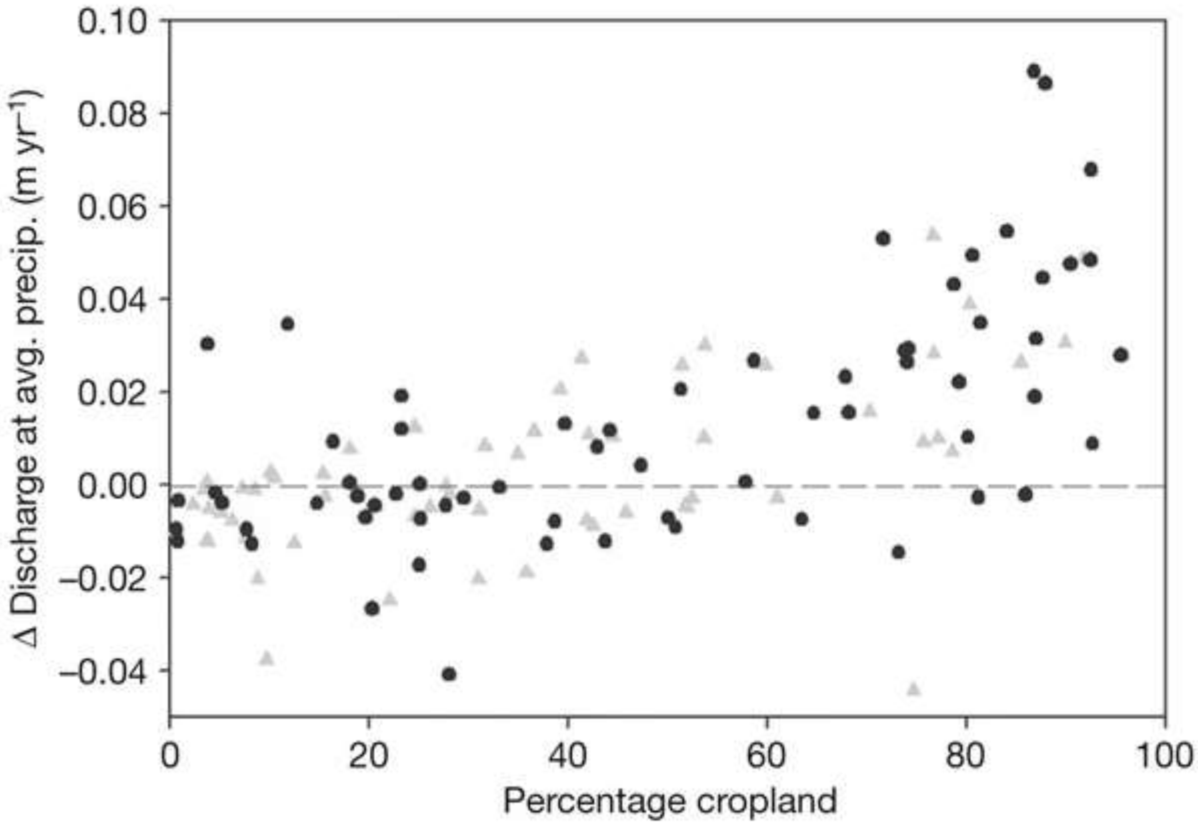
Anthropogenically enhanced fluxes of water and carbon from the Mississippi River

Peter A. Raymond, Neung-Hwan Oh, R. Eugene Turner & Whitney Broussard

Raymond et al.



Raymond et al.



Raymond et al.

- Strong correlation between ag land cover and increase in Q and Q at average precipitation
- Acceleration of the water budget in the Mississippi basin because of Ag practices
- "*Remembering that these agricultural landscapes are highly modified, have soils that are well buffered and moderately transport limited, and therefore have high concentrations of bicarbonate and other important biogeochemical constituents, this amounts to significant increases in fluxes from the US cropland centres.*"

Raymond et al.

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Jones and Schilling

$CaCO_3 + CO_{2\ (Atmos)} + H_2O \rightarrow Ca^{2+} + 2HCO_3^-$

insoluble soluble

Weathering

$CO_{2\ (Atmos)} + 2H_2O + light \rightarrow CH_2O + O_2 + H_2O$

Photosynthesis

$CH_2O + O_2 \rightarrow CO_2 + H_2O$

Oxidation

?

$$CaCO_3 + CO_{2\,(Atmos)} + H_2O \rightarrow Ca^{2+} + 2HCO_3^-$$

Loess Kindchen

Lime Application

25% of applied C lost to atmosphere as CO2
33,000 metric tons in the Raccoon Watershed

Deposits

Raccoon Alkalinity

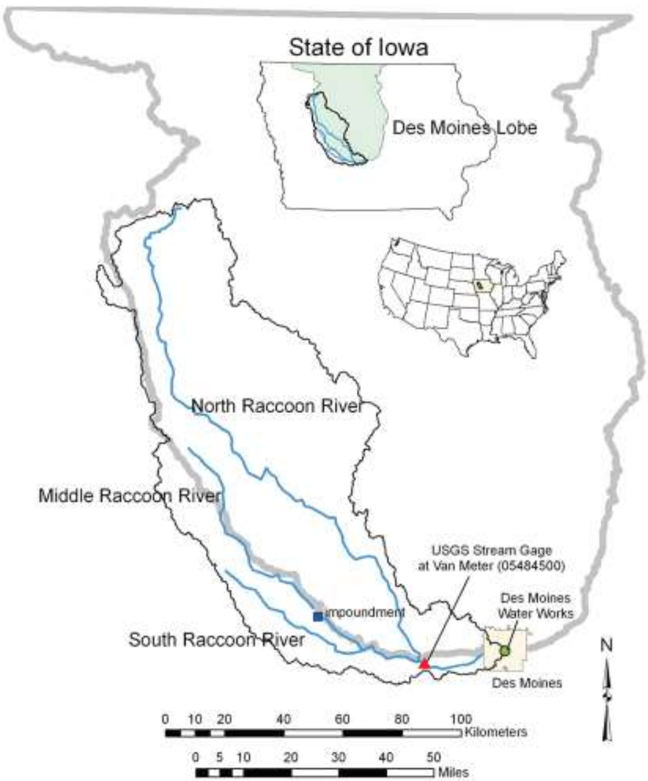


Fig. 1. Location of the Raccoon River watershed.

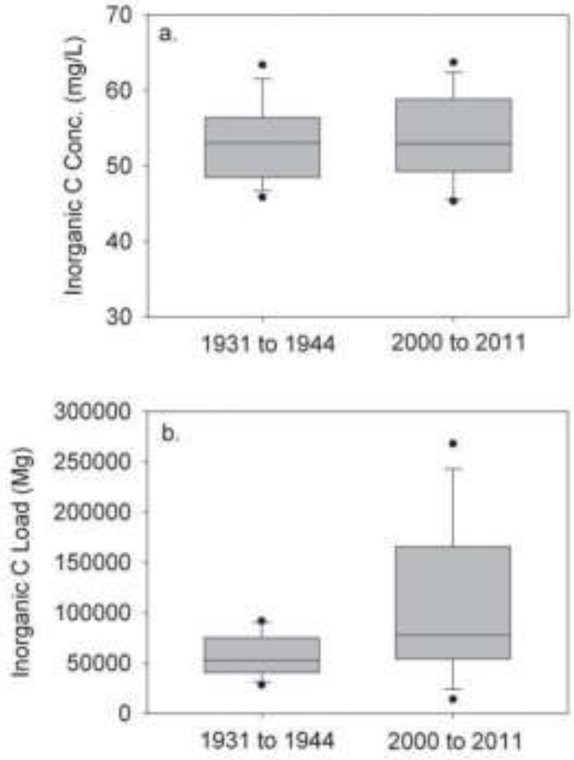


Fig. 6. Comparison of Raccoon River inorganic C concentrations and loads, 1931 to 1944 versus 2000 to 2011.

Implications

Hernandez-Ramirez et al. (2011)

Soil C loss from DM Lobe soil was 104 g m^{-2} yr^{-1} ('04-'07)

Because only ½ of tile alkalinity can be sourced to SOC, we calculate 6.1 g m^{-2} yr^{-1}

Hernandez-Ramirez measured SOC at 24 kg m^{-2} to depth of 1.2m (tile depth)

Conclusions

- C export from Raccoon basin averaged 106,000 Mg/yr
- Inorganic C contributes 90% of the C flux
- C export is transport limited

- *“If farmers can reduce water throughput through engineered and drained systems, most of which are likely transport limited for C export, they may be able to achieve C sequestration rates relatively similar to practices such as reduced tillage and crop rotation complexity”*

Jones and Kult

Journal of Environmental Quality

SPECIAL SECTION

MOVING DENITRIFYING BIOREACTORS BEYOND PROOF OF CONCEPT

Use Alkalinity Monitoring to Optimize Bioreactor Performance

Christopher S. Jones* and Keegan J. Kult

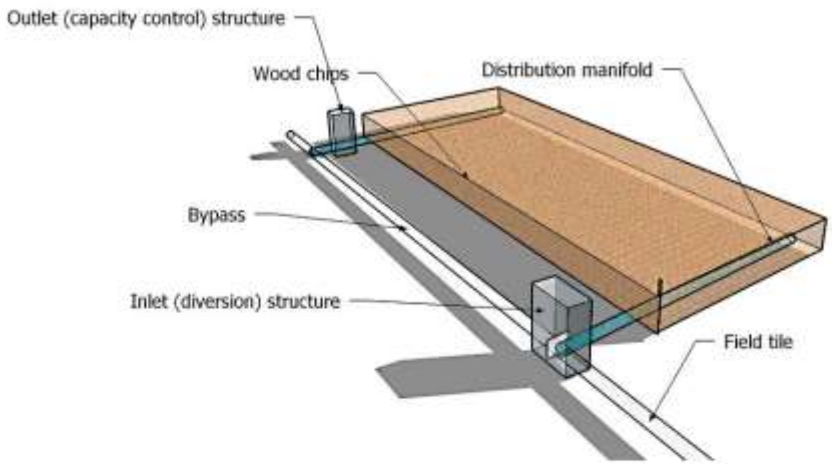
Denitrification

$$4NO_3^- + 5CH_2O \rightarrow 2N_2\ (gas) + 5HCO_3^- + H^+ + 2H_2O$$

$$2NO_3^- + 2CH_2O \rightarrow N_2O\ (gas) + 2HCO_3^- + H_2O$$

$$SO_4^{-2} + 5CH_2O \rightarrow HS^- + 2HCO_3^- + H^+$$

Inorganic Hg to Bioavailable Hg



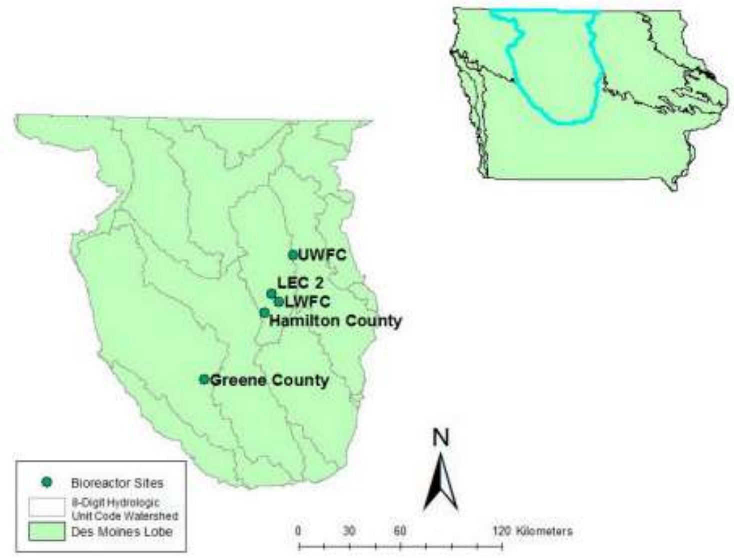


Table 1. Bioreactor design specifications for the five Iowa bioreactors.

Data analyzed:
NO3, SO4, TOC, IC (alkalinity), N2O

If ratio > 0.79, then influent N_2O was > effluent N_2O (good)
If ratio < 0.79, then effluent N_2O was > influent N_2O (bad)

Table 4. Influent and effluent N_2O concentrations, percent nitrate reduction, and inorganic carbon ratios in the studied bioreactors.

Bioreactor† (date)	N_2O–N influent	N_2O–N effluent	Nitrate-N reduction	Effluent IC measured/predicted‡
	mg L^{-1}		%	
Greene (6 July 2015)	0.17	0.98	31	0.48
Greene (22 July 2015)	0.03	1.38	62	0.60
Hamilton (16 July 2015)	0.05	0.00	97	1.08
Hamilton (22 July 2015)	0.02	0.00	99	0.98
LWFC (7 July 2015)	0.03	0.45	60	0.75
LWFC (16 July 2015)	0.01	0.00	96	1.80
LWFC (22 July 2015)	0.01	0.00	96	1.94
UWFC (7 July 2015)	0.23	0.91	33	0.79
UWFC (16 July 2015)	0.11	0.95	31	1.08
LEC2 (7 July 2015)	0.03	0.91	51	0.76
LEC2 (16 July 2015)	0.01	0.84	83	0.56

† LEC2, Lower Eagle Creek; LWFC Lower White Fox Creek; UWFC, Upper White Fox Creek.

‡ Ratio of measured effluent inorganic carbon concentration compared with the concentration predicted by the stoichiometry of Eq. [5] if N_2 was the only product of denitrification.

Journal of Environmental Quality

Jones, Schilling, Seeman 2019

Agricultural Water Management 213 (2019) 12–23

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journal homepage: www.elsevier.com/locate/agwat

Relating carbon and nitrogen transport from constructed farm drainage

Christopher S. Jones[a,*], Keith E. Schilling[b], Anthony Seeman[c]

[a] IIHR-Hydroscience and Engineering, University of Iowa, 100 C. Stanley Maxwell Hydraulics Laboratory, Iowa City, Iowa, 52242, USA
[b] Iowa Geological Survey, 334 Trowbridge Hall, Iowa City, Iowa, 52242, USA
[c] Iowa Soybean Association, 1255 Prairie Trail Parkway, Ankeny, Iowa, 50023, USA

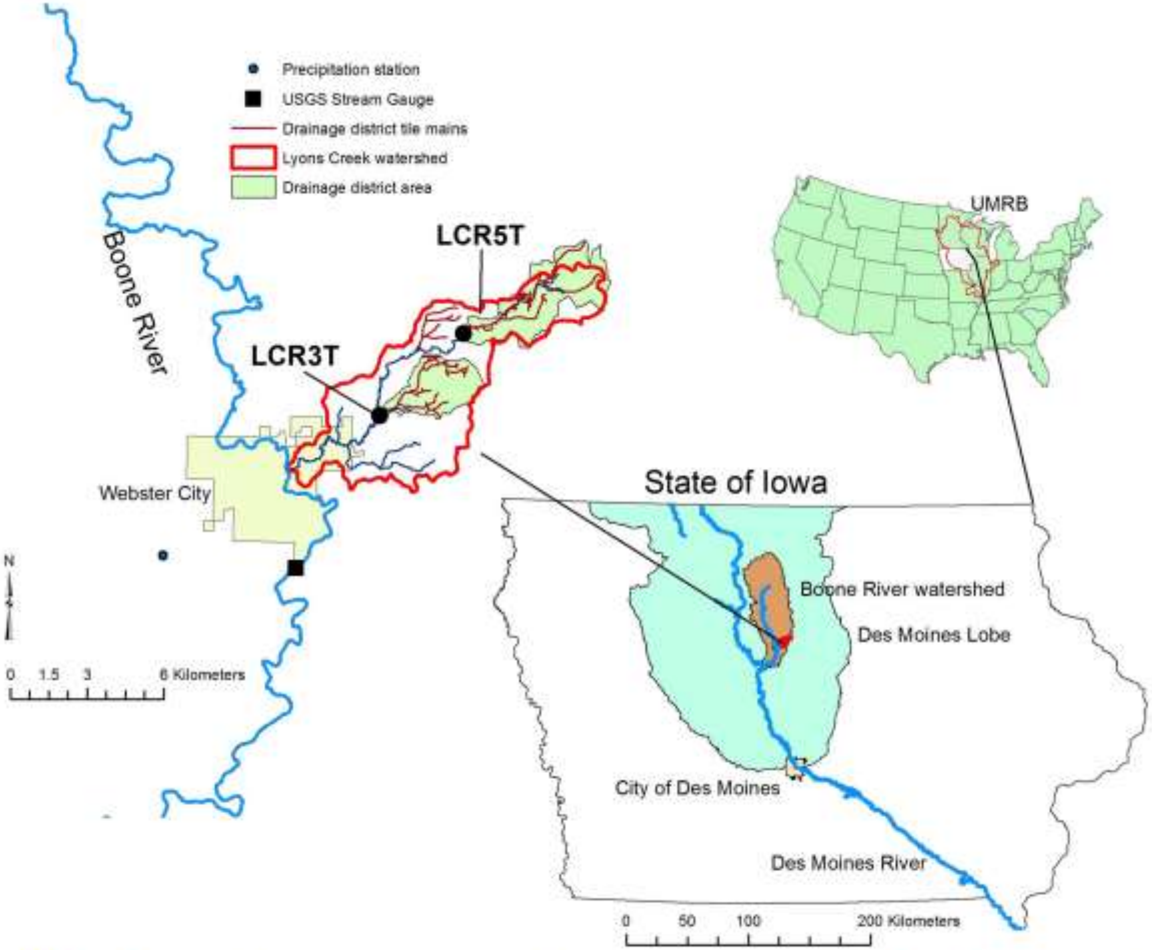
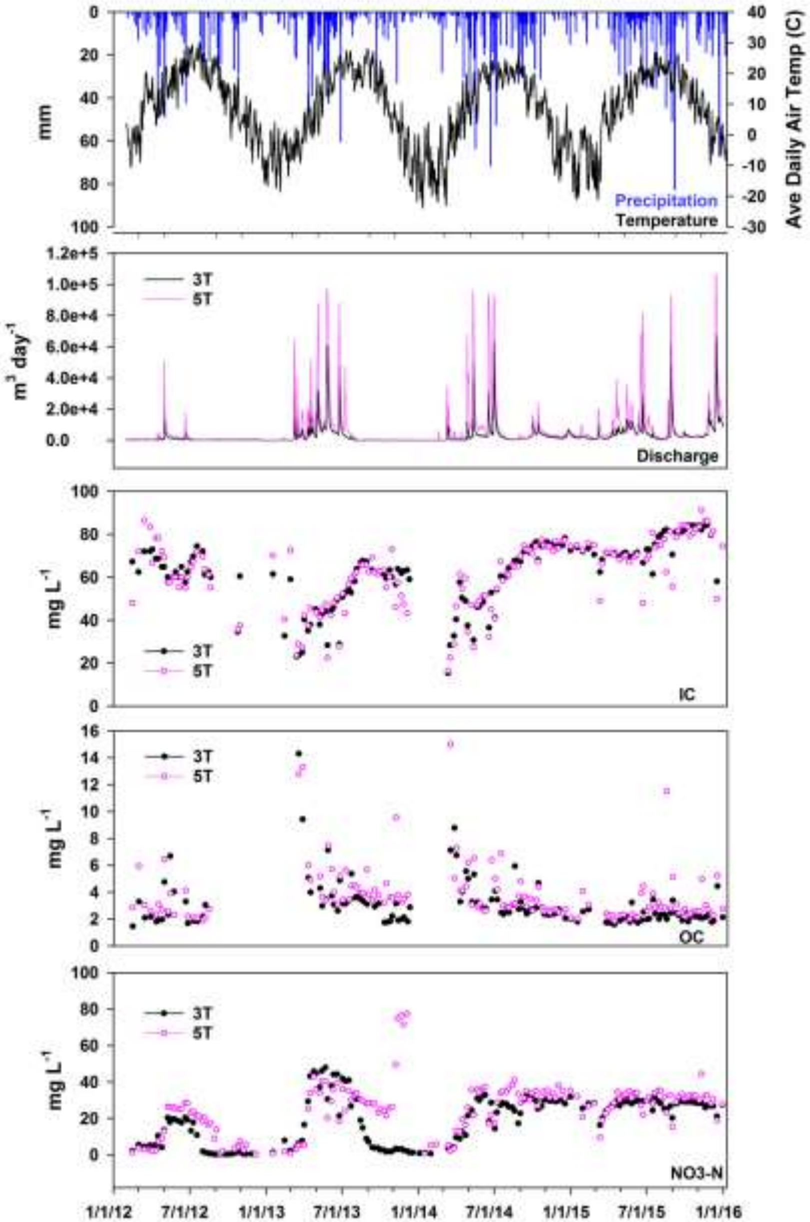
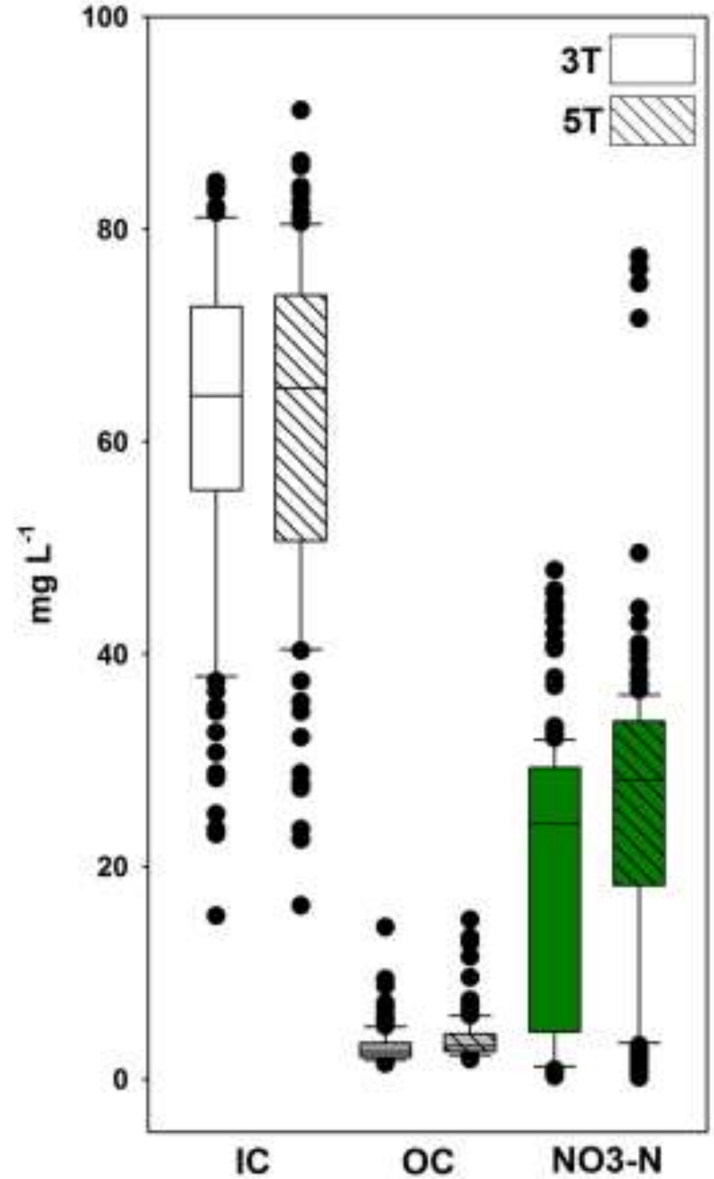


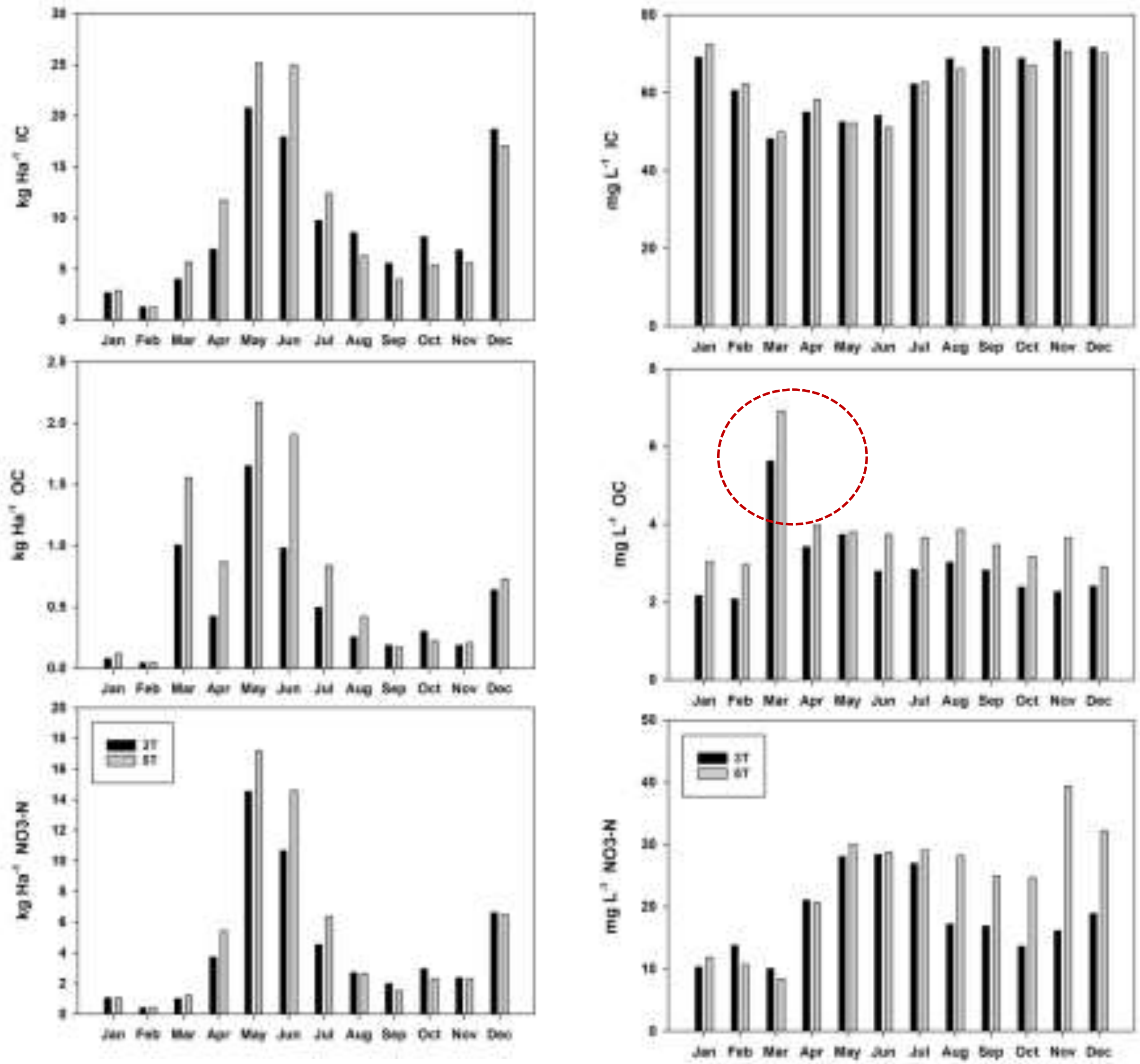
Fig. 1. Location of 3 T and 5 T drainage districts in Iowa that were evaluated in this study, along with the receiving Boone and Des Moines Rivers, and the watersheds' location with the state of Iowa, the continental U.S., and the Upper Mississippi River Basin (UMRB).


mm
Ave Daily Air Temp (C)
Precipitation
Temperature
m3 day-1
3T
5T
Discharge
mg L-1
IC
OC
NO3-N
1/1/12
7/1/12
1/1/13
7/1/13
1/1/14
7/1/14
1/1/15
7/1/15
1/1/16


3T
5T
mg L-1
IC
OC
NO3-N

Monthly Averages

Yields (kg/ha) Conc (mg/L)



Duration curves

High flows have lower conc, low and mid-range flows have higher conc

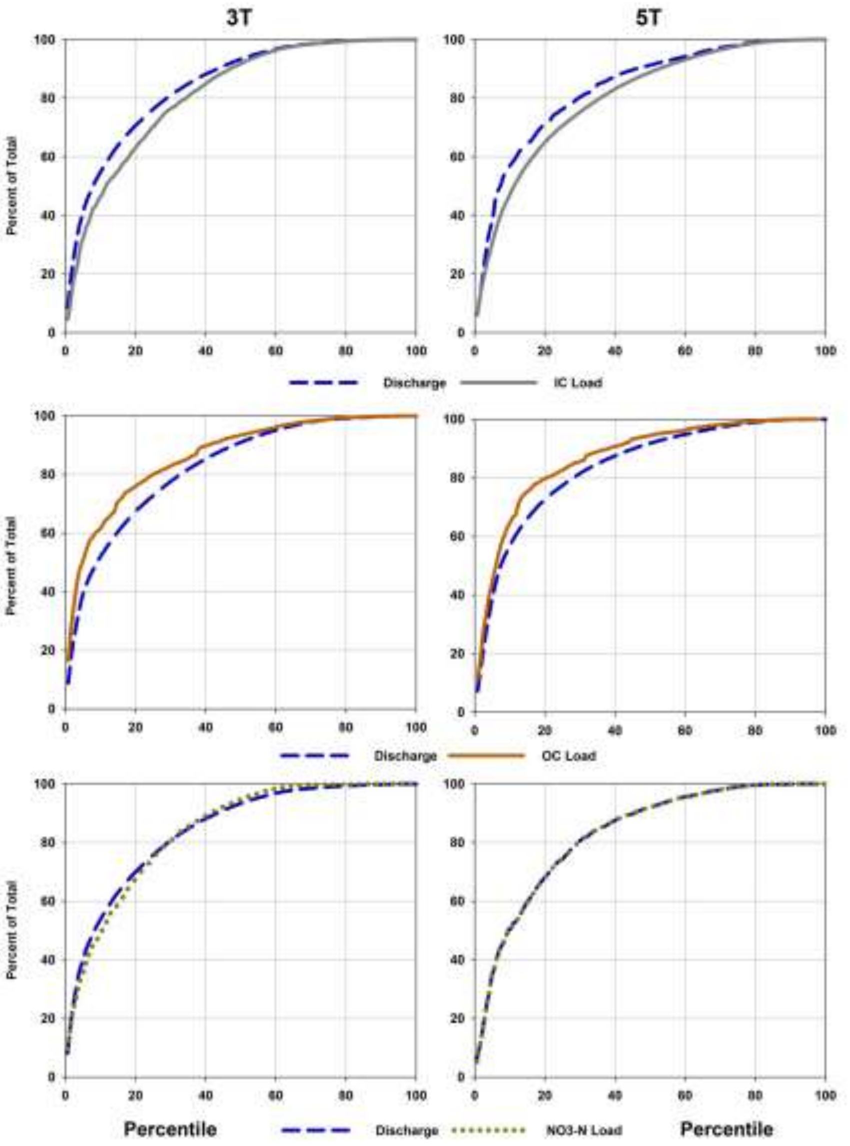
IC

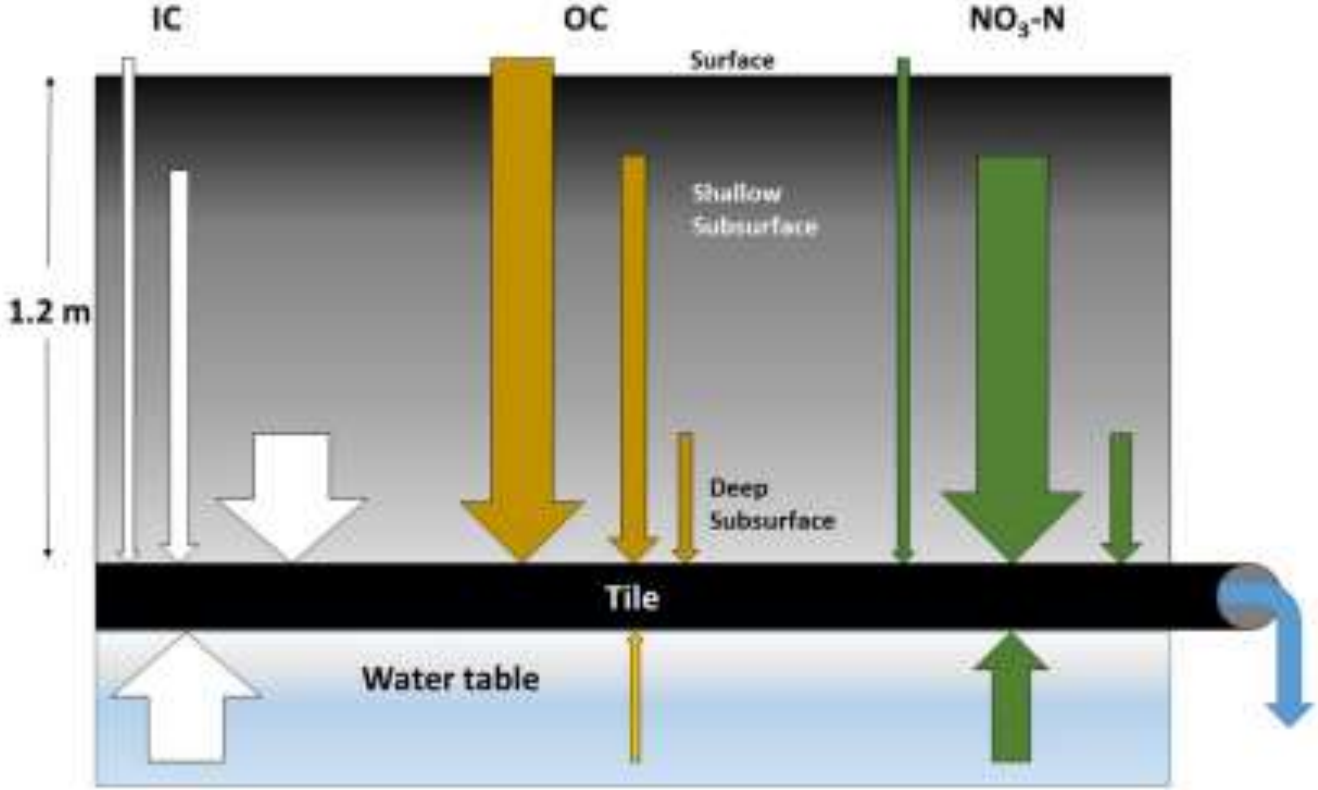
Higher flows have higher conc, low and mid-range flows have lower conc

OC

Flow weighted average concentrations are similar throughout all flow regimes

NO3




IC
OC
NO_3-N
Surface
1.2 m
Shallow
Subsurface
Deep
Subsurface
Tile
Water table

Conclusions

Carbon yields through the drainage network

124 kg ha^{-1} yr^{-1} with 116 kg as Inorganic carbon and 8 kg as organic carbon

Amount small relative to soil organic matter stores (0.03%) and carbon exported in the grain harvest

"A return to a system where carbon and nitrogen cycle together in the soil profile would provide an opportunity to reduce stream impairment from nitrogen pollution"

https://cjones.iihr.uiowa.edu/

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