Remediation of tile drain water using bioreactors

Collaboration:

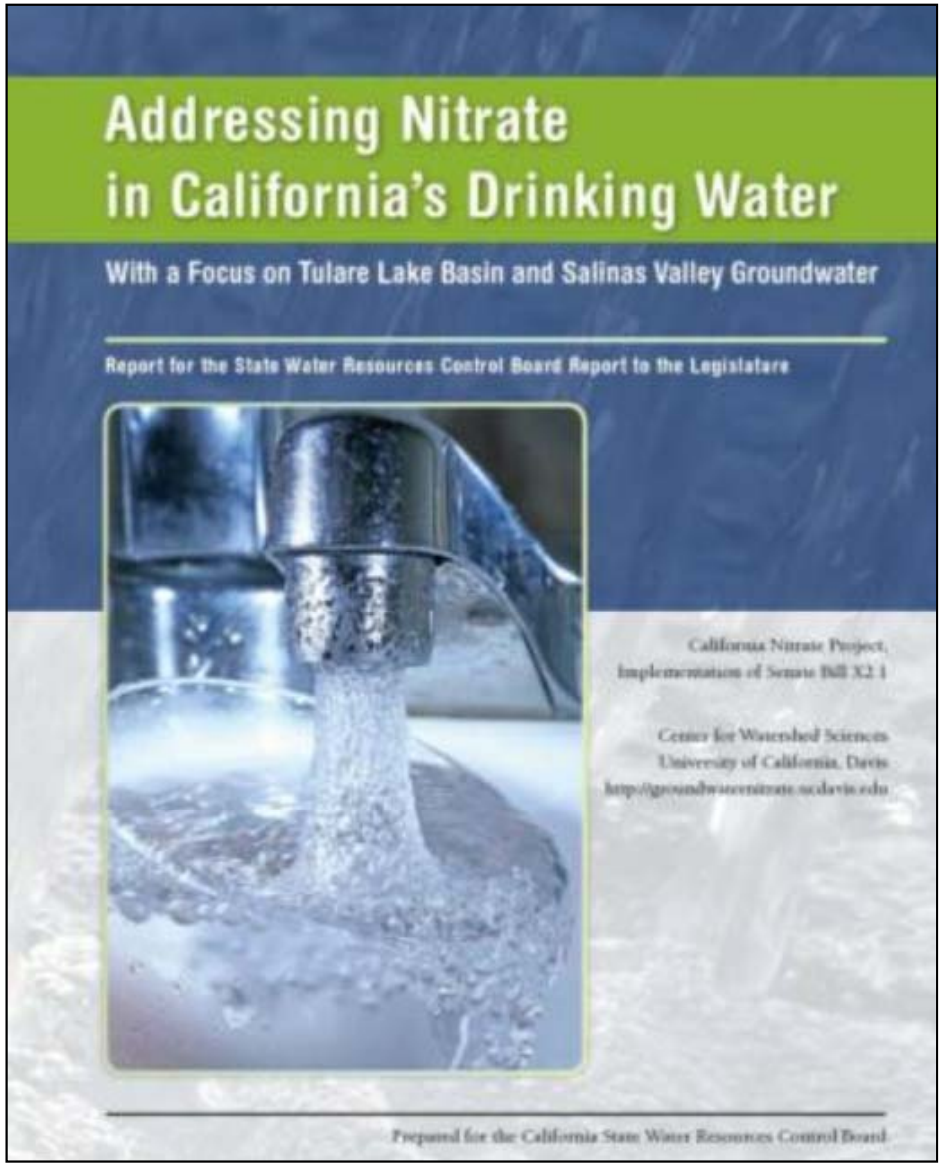
- Richard Smith and Mike Cahn
- Cooperating growers

Funding:

- CDFA - FREP
- Leafy Greens Research Board

California agriculture has an environmental water quality problem …

- **Groundwater commonly exceeds the Federal drinking water standard of 10 PPM NO_3-N**



California agriculture has an environmental water quality problem …

- **In many areas surface water exceeds regulatory goals**
  - **Drinking water : 10 PPM NO_3-N**
  - **'Non-stimulatory' level : < 2 PPM NO_3-N, < 0.1 PPM PO_4-P**

Why is this so ?

- High value crops, often twice a year
- Irrigated agriculture dominates the landscape
- Low annual rainfall provides minimal ‘dilution’ of agricultural wastewater

What can be done ?

Irrigation and fertilization practices can be improved …

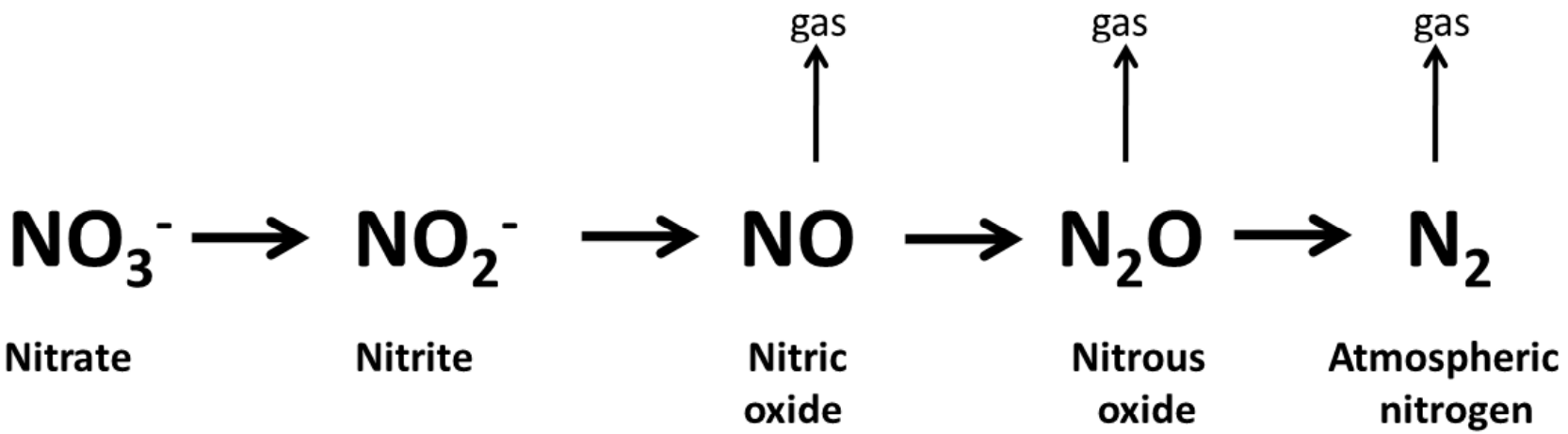
… but some wastewater remediation may be needed to consistently meet environmental targets

What remediation practices can remove soluble nutrients ?

- **Conservation practices that remove sediment are generally effective in reducing total N and P, but are ineffective in removing *soluble* nutrients (NO_3-N, PO_4-P)**

- **Biological denitrification has potential**
  - **wetlands**
  - **denitrification bioreactors**

Biological denitrification :



Requirements for denitrification:

- **Anaerobic conditions**
- **Bacteria capable of reducing NO_3-N**
- **Labile (microbially-available) carbon to support the reaction**

Wetland treatment systems have serious limitations :

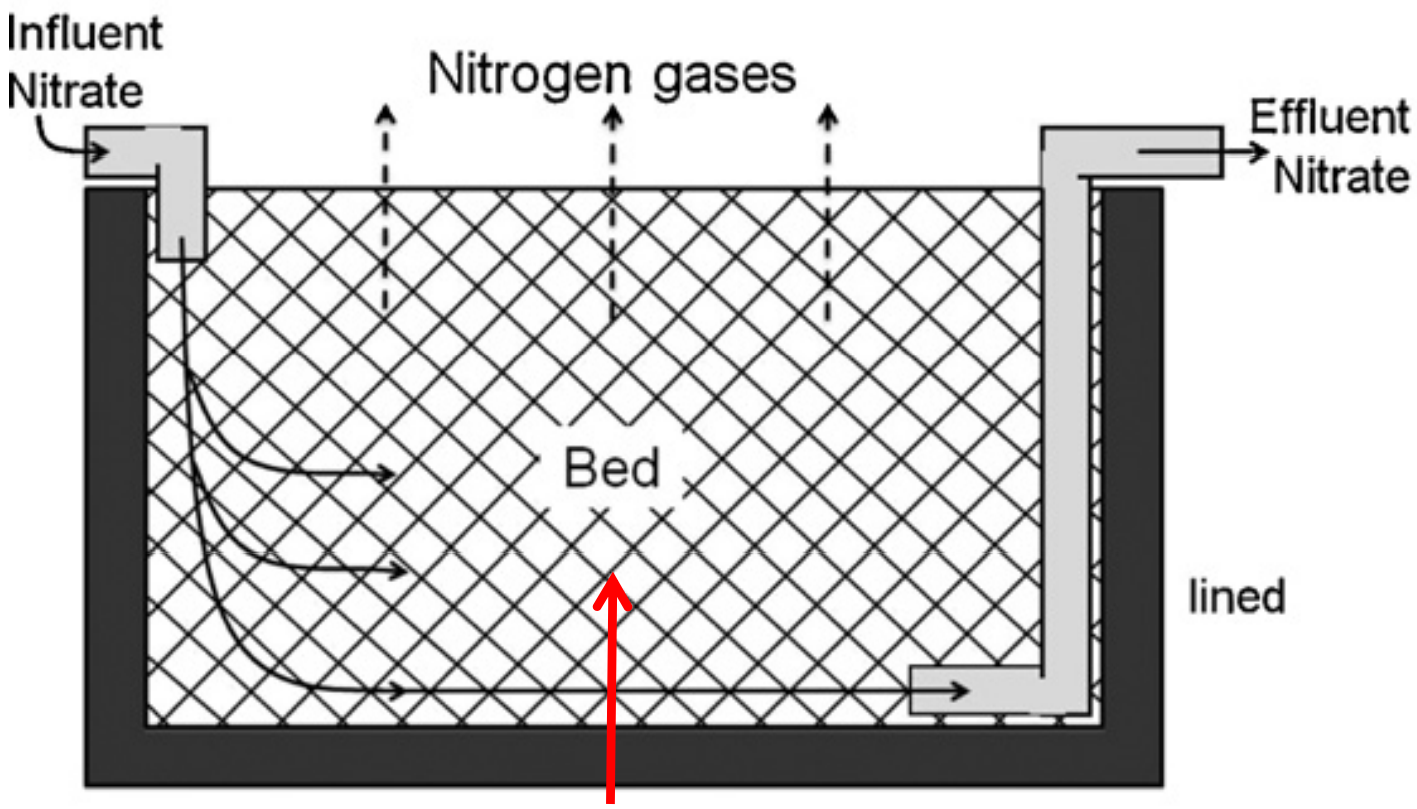
- Relatively slow nitrate removal requires a large ‘footprint’
- potential wildlife attraction raises microbial food safety concerns

‘Managed’ denitrification :

Municipal or industrial wastewater treatment

Agricultural denitrification bioreactors

Denitrification bioreactors (DBR) :



Organic waste material to provide labile carbon

Project objective:

- **Evaluate the performance of denitrification bioreactors treating tile drain effluent, and surface runoff, from Salinas Valley farms**

Building a DBR

Salinas Valley, 2011 :

chipped construction wood from Monterey Regional Waste Management District

DBR 1, 2011
34 cubic yards
treat tile drain water

DBR 2, 2011
17 cubic yards
treat tile drain water

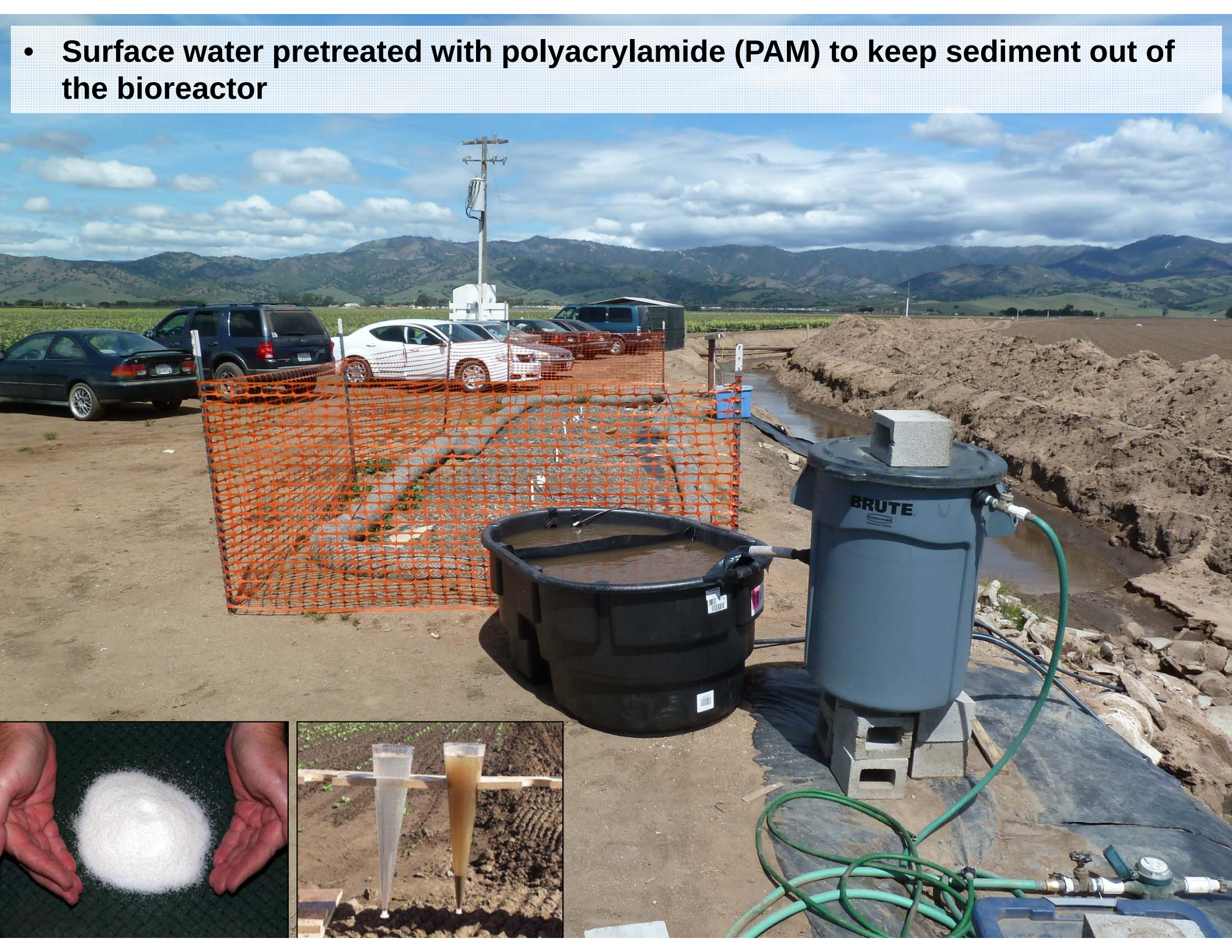
DBR 3, 2012
16 cubic yards
treat surface runoff

Bioreactor operation :

Continuous pumping into DBRs from tile drain sump or tailwater pond

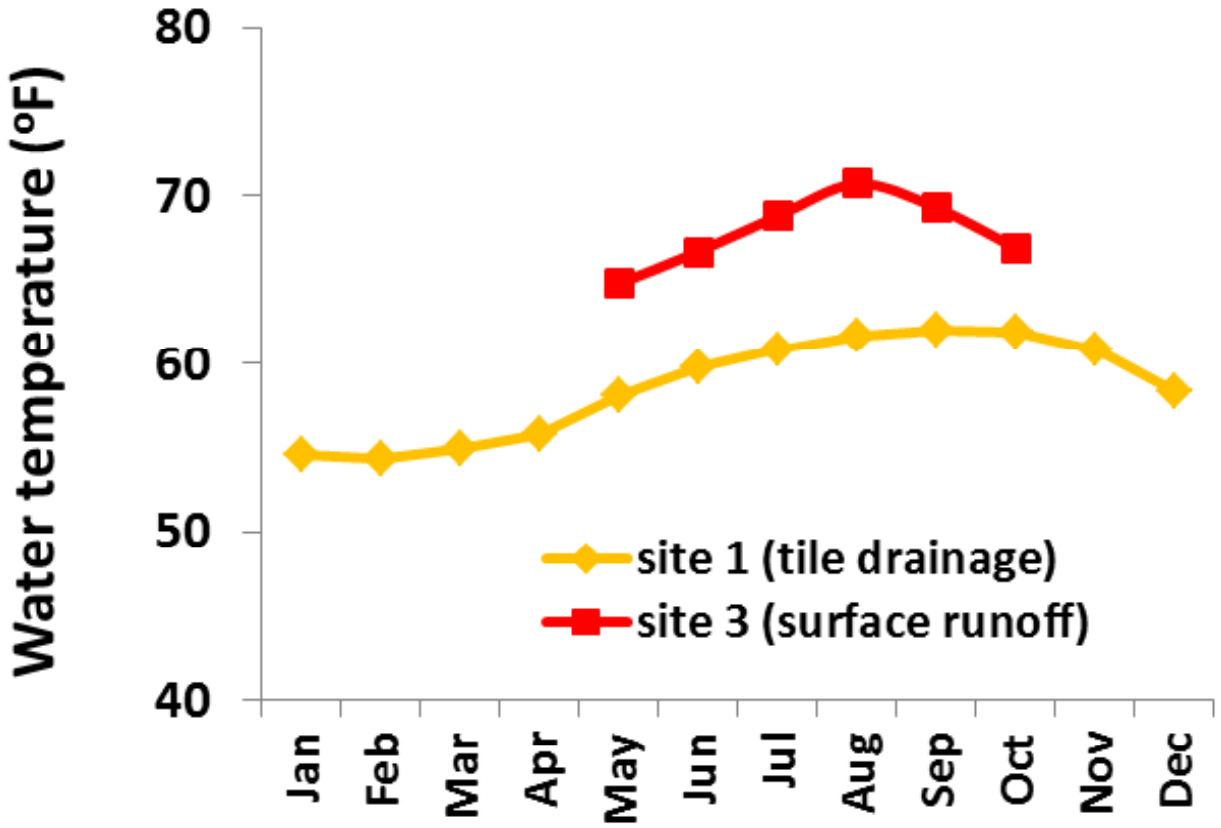
DBR outlet drains into surface ditch
after approximately 2 days residence time

- **Surface water pretreated with polyacrylamide (PAM) to keep sediment out of the bioreactor**



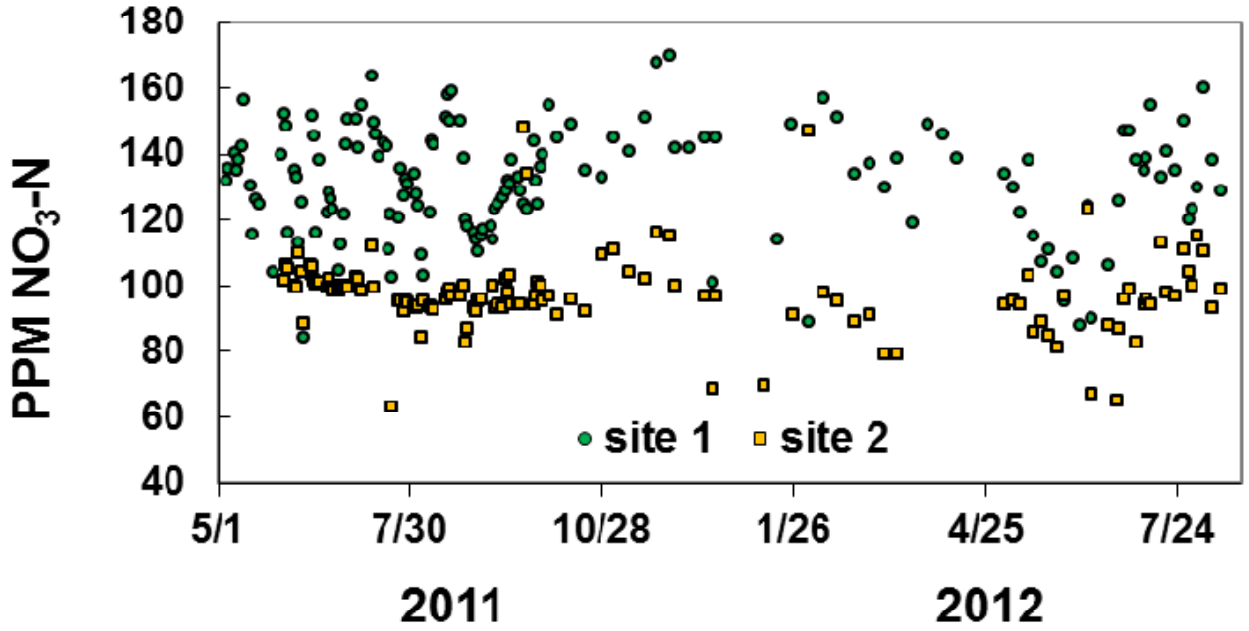
Results :

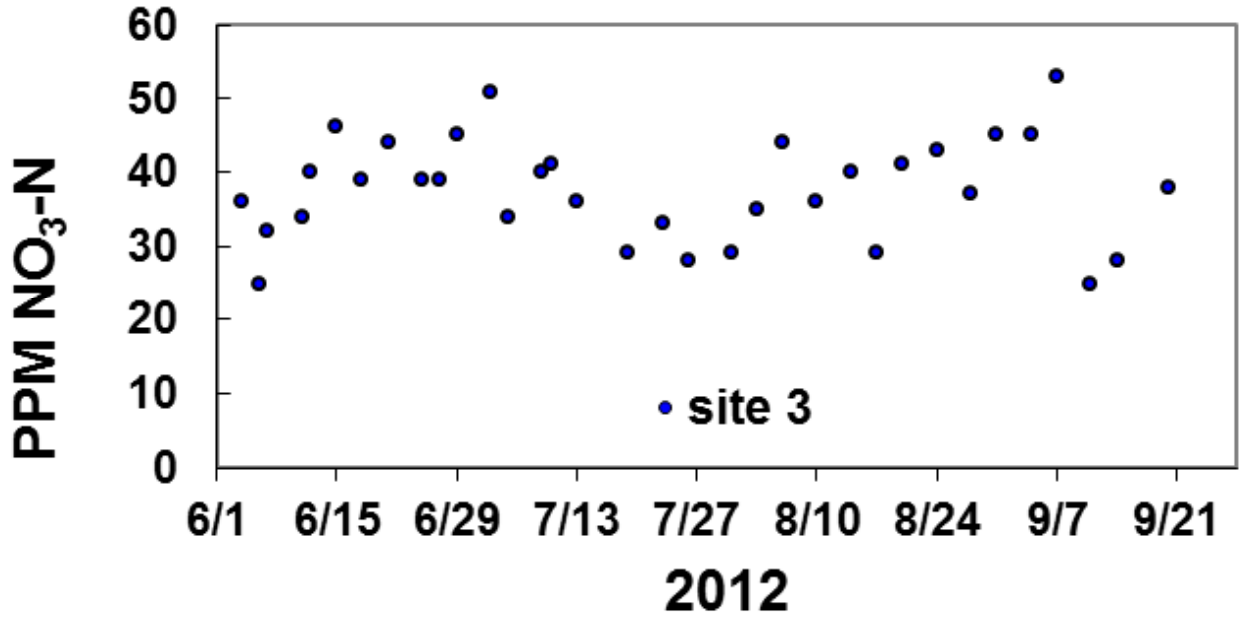
- **Moderate temperature allows denitrification all year**



2012 monthly mean water temperature

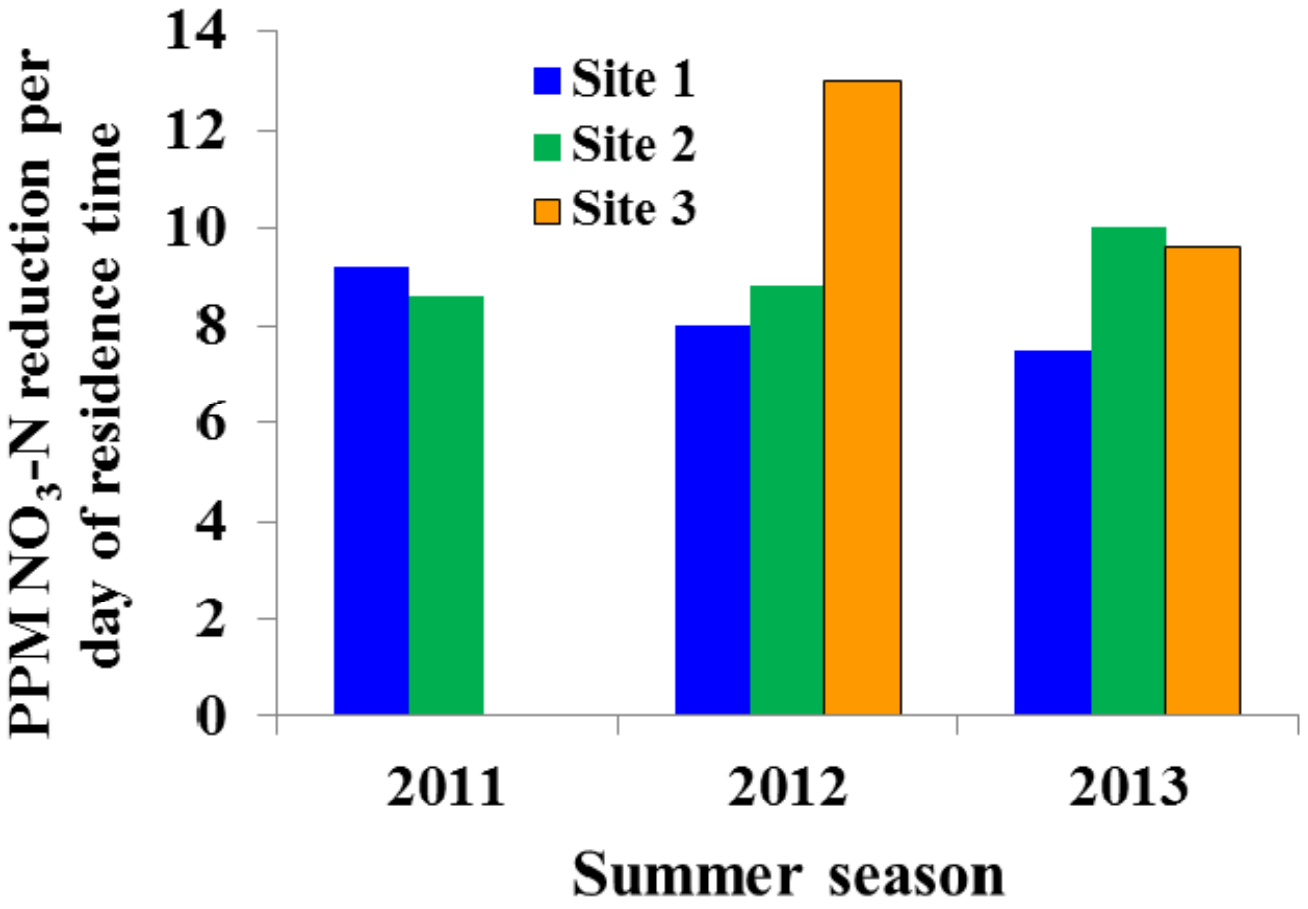
Inlet NO_3-N concentration was variable, but consistently high :





Mean denitrification rates achieved :

(PPM NO_3-N reduction per day of residence time)



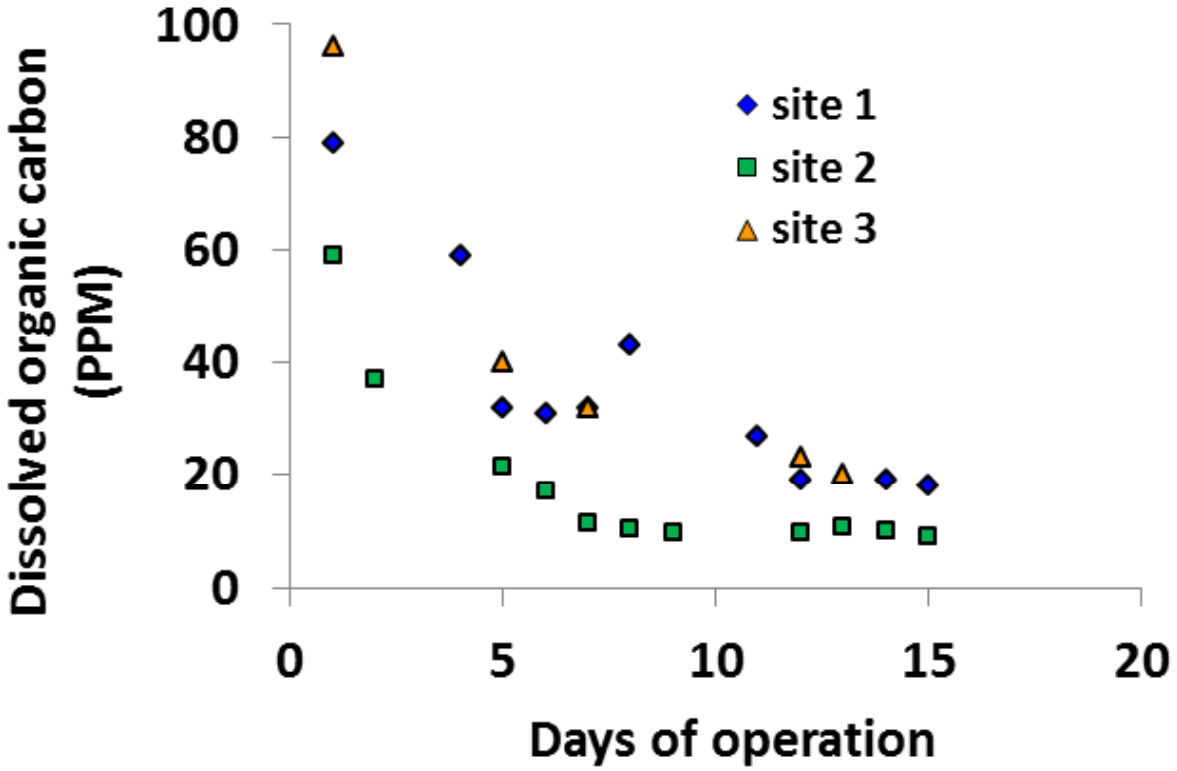
Winter rates of approximately 5 PPM NO_3-N reduction per day of residence time at sites 1 and 2

‘Managed’ systems can achieve a denitrification rate of 20 PPM NO_3-N reduction per hour; why the difference?

Bioreactors have:

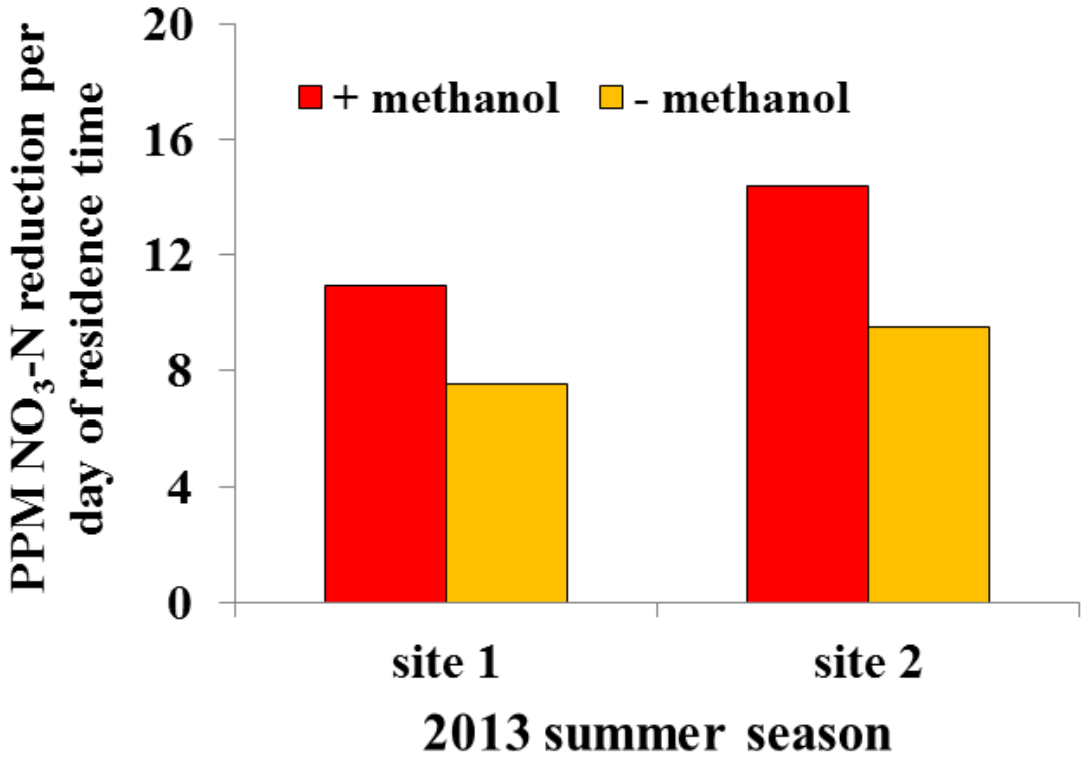
- **Limited labile carbon**
- **Diffusion limitation**

Wood chip bioreactors are carbon-limited :



- In 2013 methanol was injected during alternate summer months at sites 1 and 2

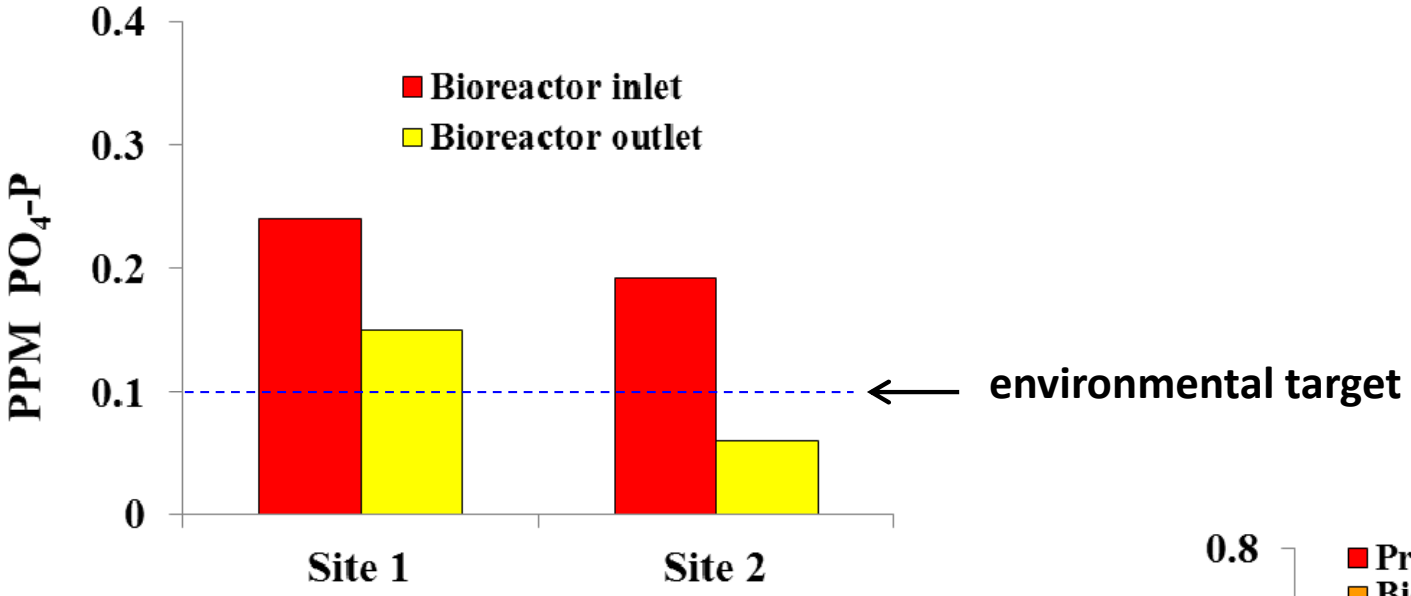
- **Injection of 20 PPM carbon increased denitrification rate by > 30%**



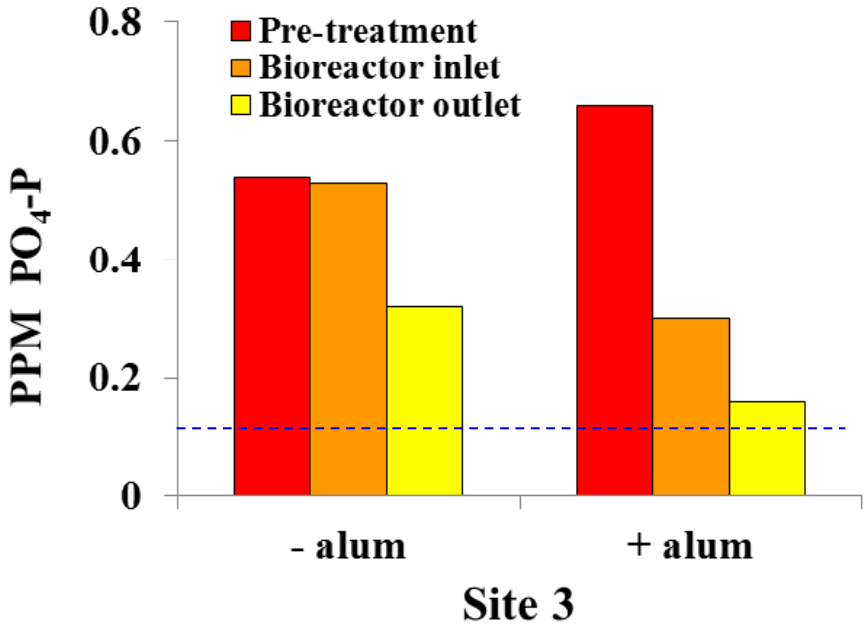
What about PO_4-P ?

- Bioreactor treatment reduces PO_4-P
- Alum (aluminum sulfate) injection also effective

2013 means:



← environmental target



Is this technology commercially viable ?

- **Performance to date suggest that *annual* N removal would be > 2-3 lb NO_3-N/yd^3 of bioreactor volume, perhaps 4+ lb NO_3-N/yd^3 with carbon enrichment**
- ***Preliminary* cost estimates for construction and operation over a 10 year period suggest that each pound of NO_3-N denitrified will cost approximately $1.50-2.00 for tile drainage remediation; surface water remediation more expensive**
- **Management practices that increase denitrification rate *may* decrease cost**
- **Agronomic management that reduces environmental NO_3-N loading is likely to be more cost-effective than remediation**