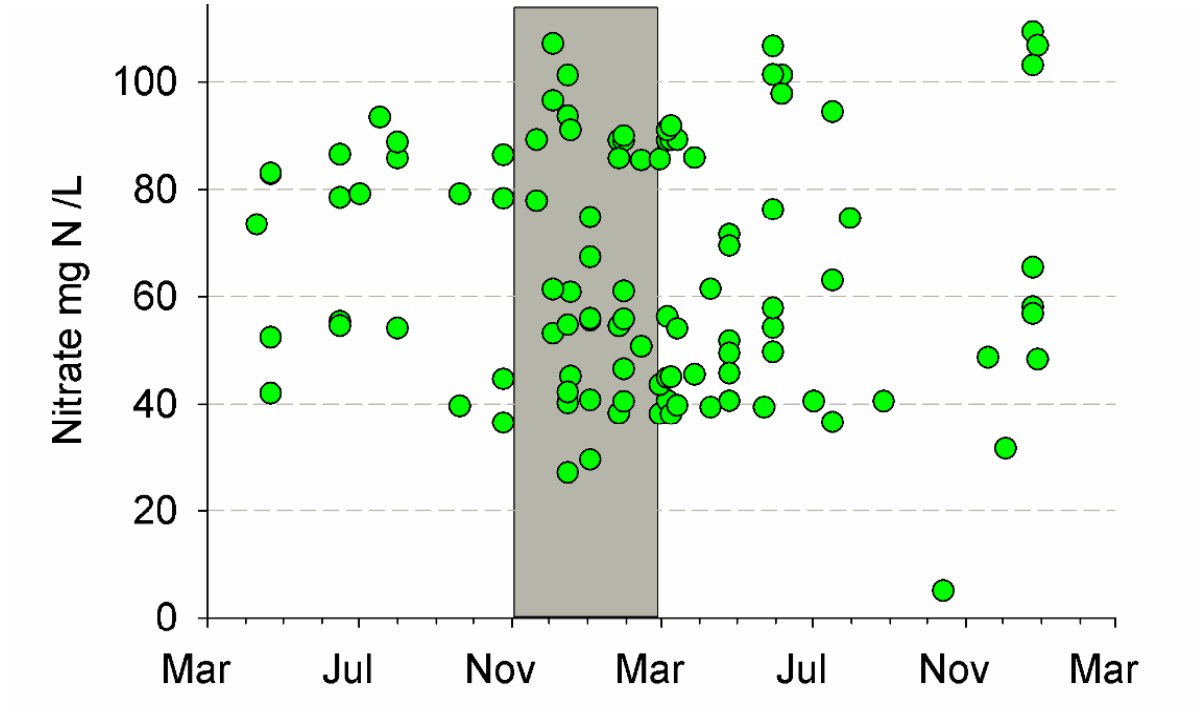
Can a Denitrification Bioreactor (DBR) reduce nitrate loading from tile drain water ?

Thanks to:
Richard Smith
Mike Cahn
Tom Bottoms
Cooperating growers

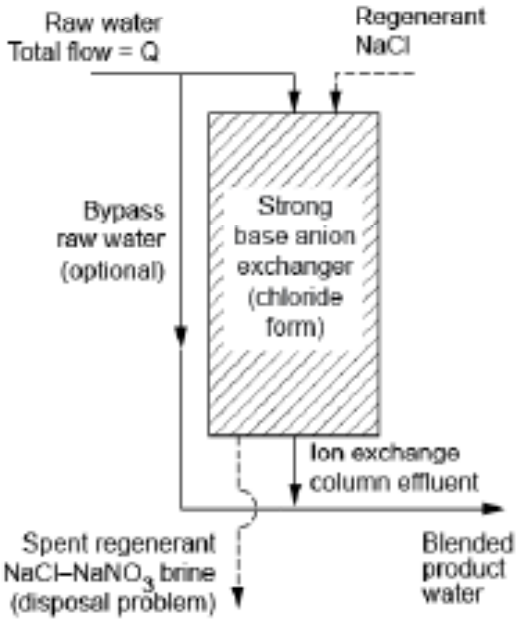
Tile drain water tends to be high NO_3-N :



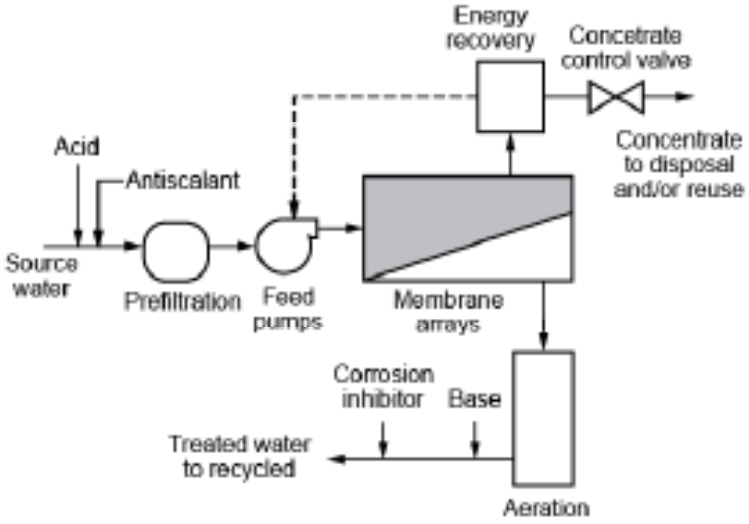
2002-04 drain tile sampling in the Salinas Valley

Engineered solutions to remove nitrate:

- **Ion exchange**



- **Reverse osmosis**

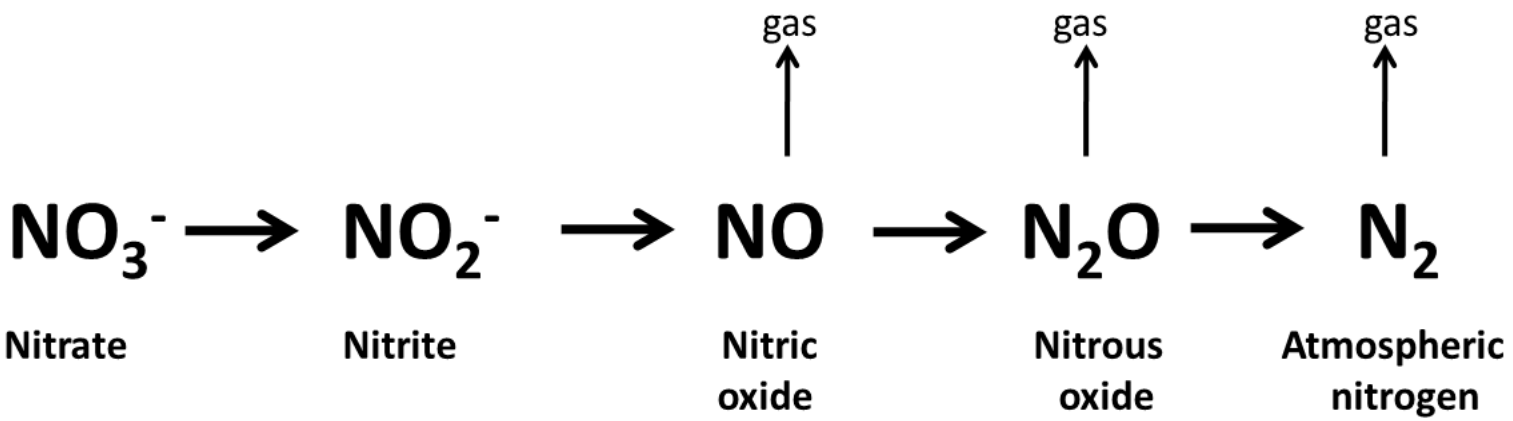


Nitrate removal by aquatic plants ?

Constructed wetland ?

- **Combines plant nitrate uptake with denitrification**

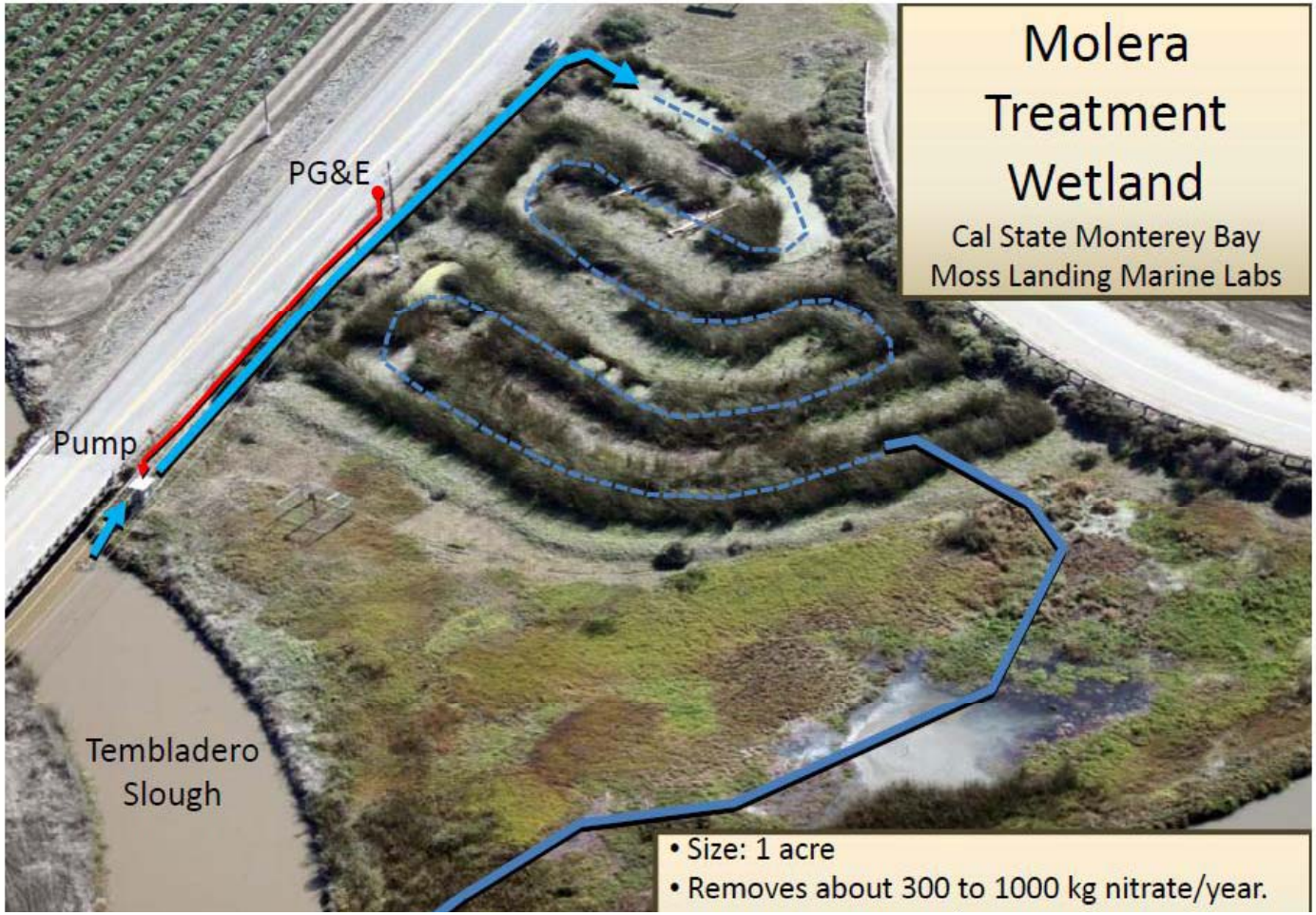
Denitrification chemistry :



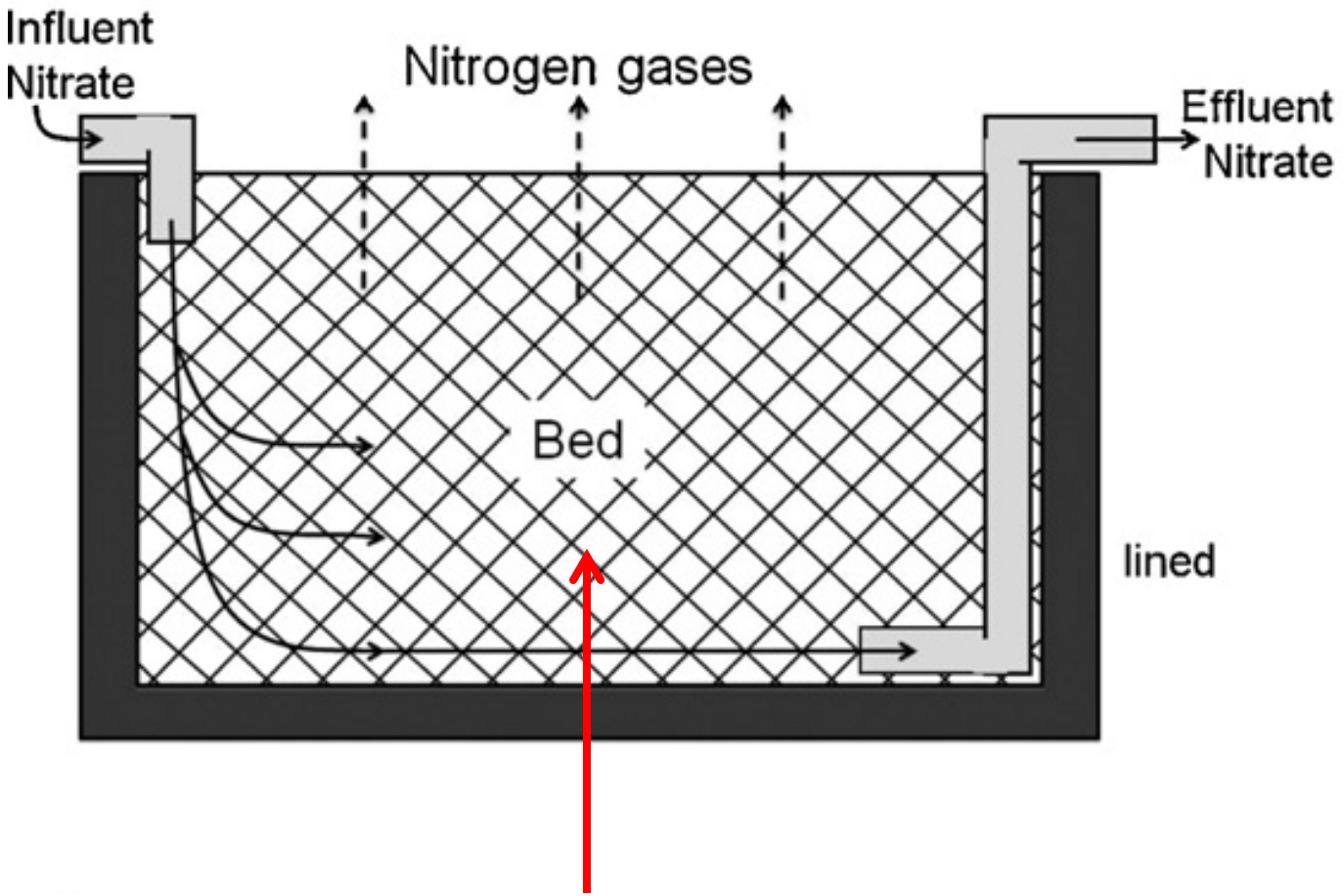
Requirements for denitrification:

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

Denitrification occurs naturally in wetland systems,
but the rate is usually slow due to carbon limitation



A denitrification bioreactor (DBR) offers a way to increase denitrification rate:



Organic waste material to provide labile carbon

Building a DBR, spring 2011 :

chipped construction wood from Monterey Regional Waste Management District

Denitrification Bioreactor 1 (DBR 1) 930 cubic feet

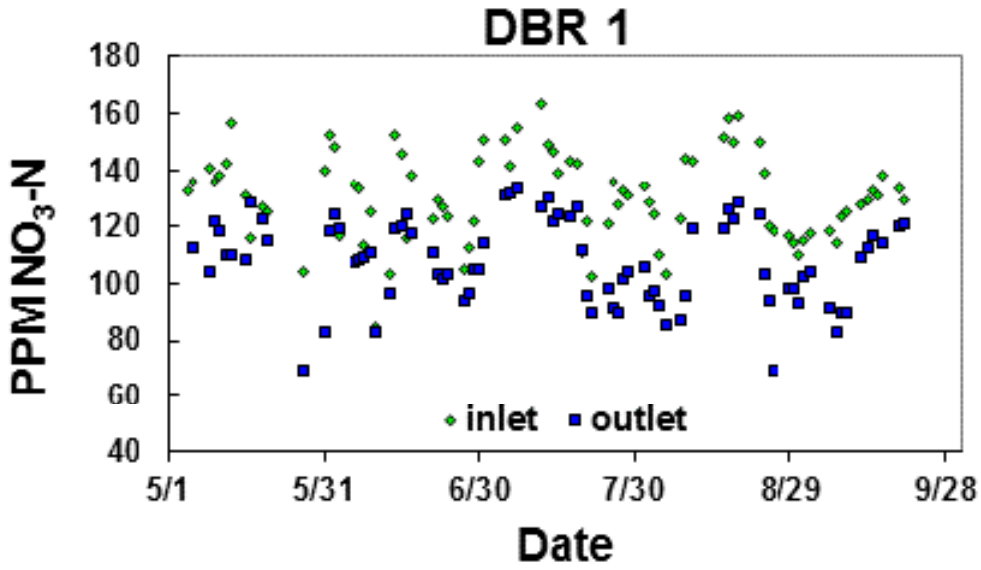
Denitrification Bioreactor 2 (DBR 2) 450 cubic feet

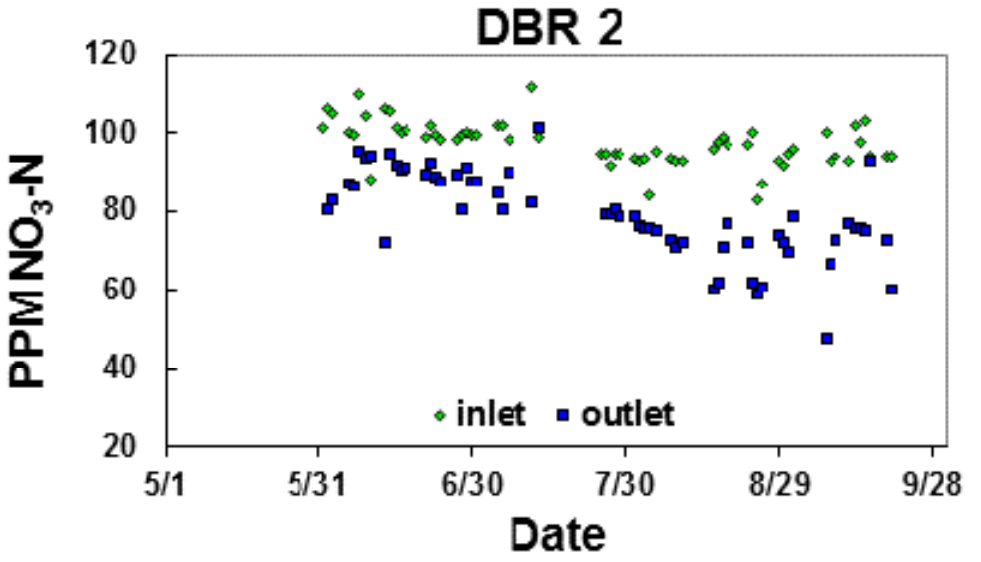
Continuous pumping into DBR from tile drain sump

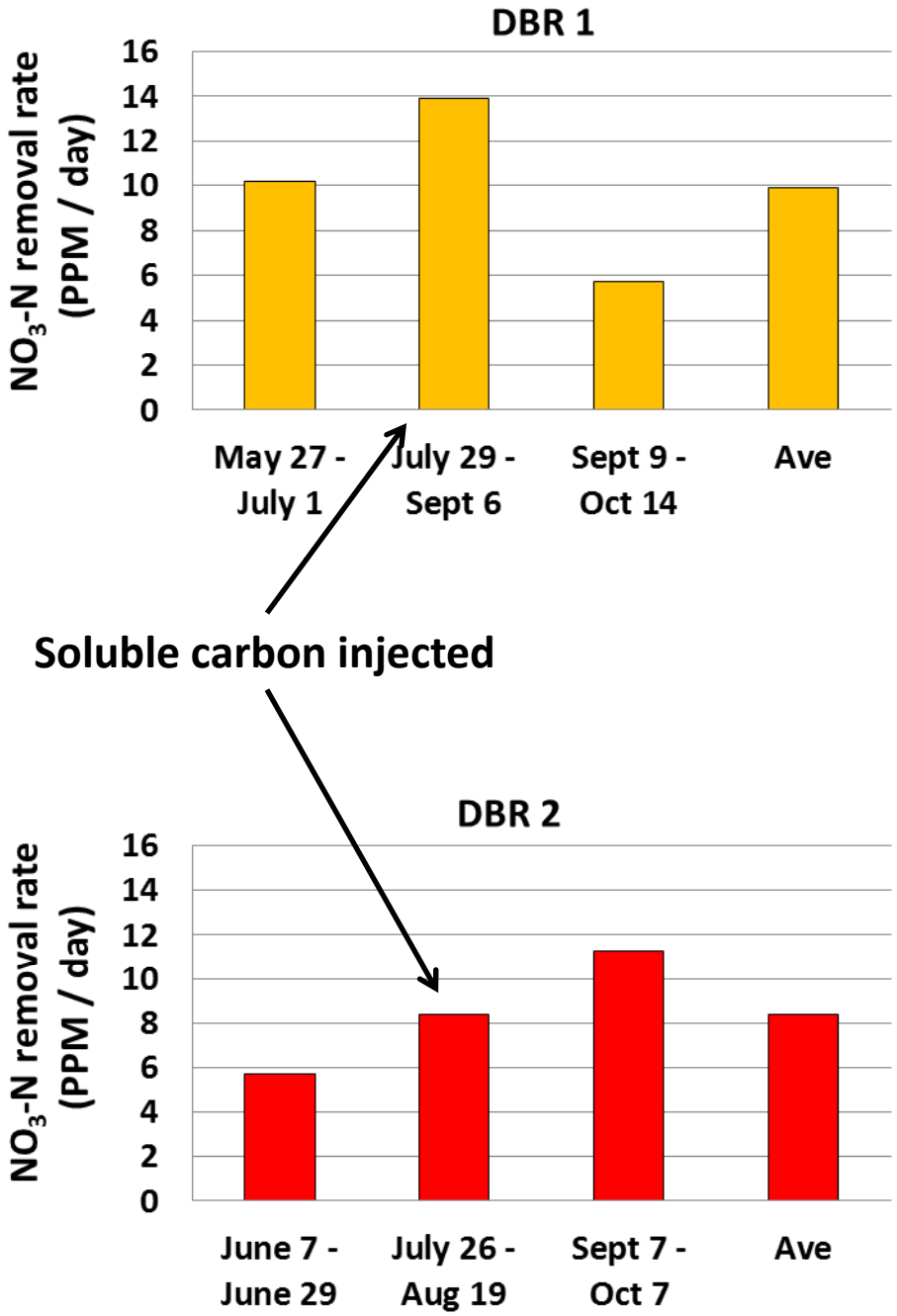
Outlet drains into surface ditch after approximately 2 days residence time

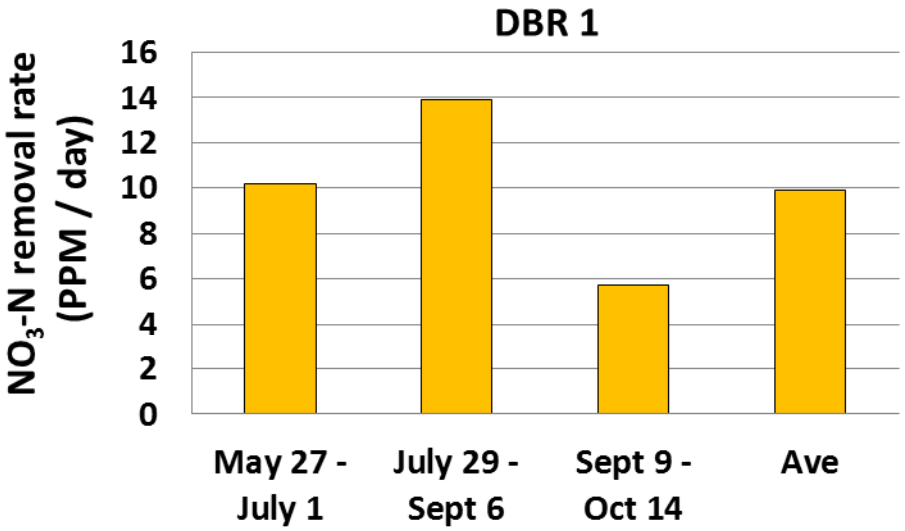
Continuous sampling from both inlet and outlet

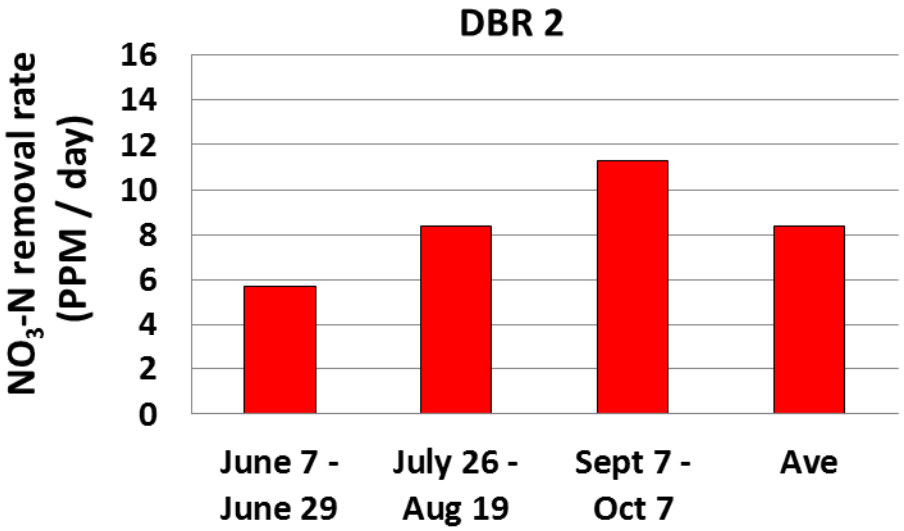
How much denitrification was achieved ?






DBR 1
NO_3-N removal rate (PPM / day)
16
14
12
10
8
6
4
2
0
May 27 - July 1
July 29 - Sept 6
Sept 9 - Oct 14
Ave
Soluble carbon injected
DBR 2
NO_3-N removal rate (PPM / day)
16
14
12
10
8
6
4
2
0
June 7 - June 29
July 26 - Aug 19
Sept 7 - Oct 7
Ave

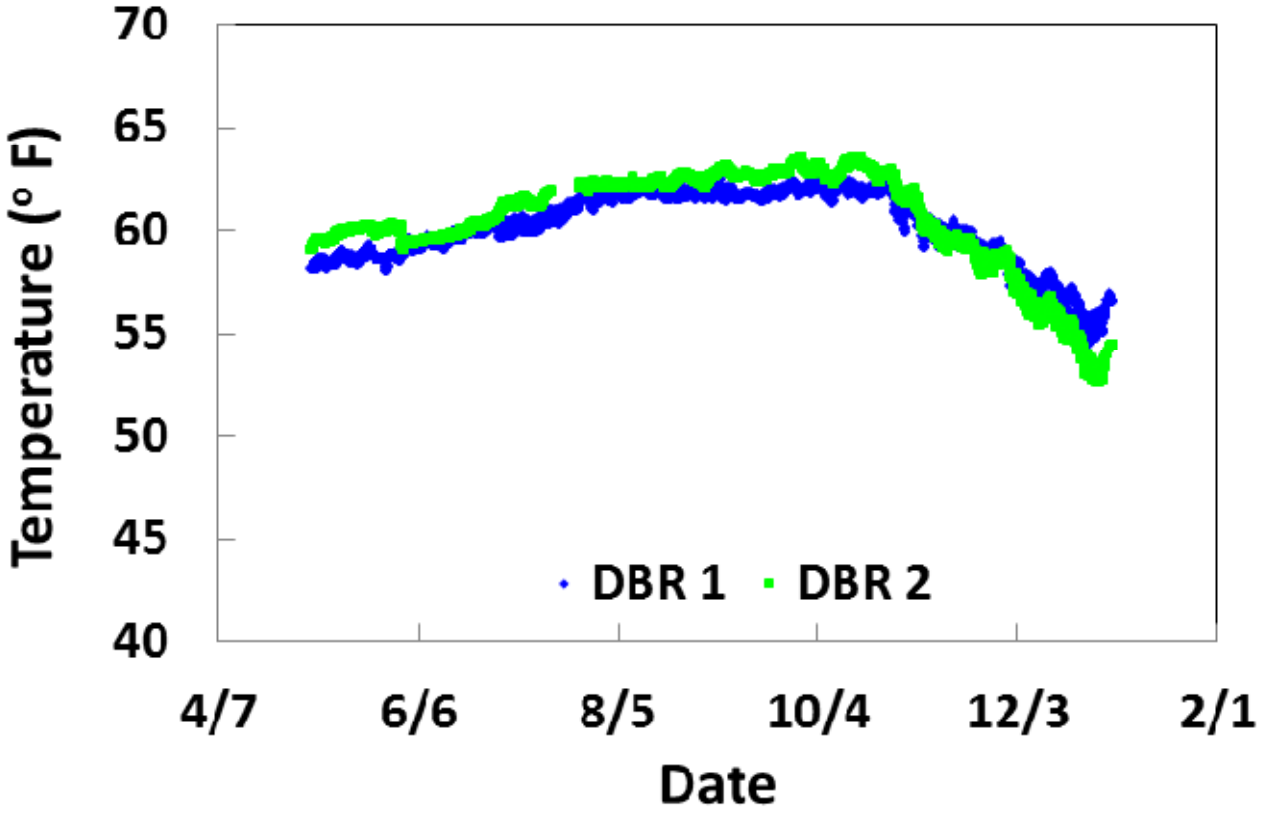




How does this performance compare to other research reports ?

- The overall average of 8 - 9 PPM NO_3-N/day is approximately 7 g N/m^3/day
- Other research reports give rates between 3 - 10 g N/m^3/day

Mild coastal temperature limits denitrification rate :



Denitrification rate reported to increase as much as 5% per ^{o}F

Can we do better ?

- find better media
- develop ways of increasing C availability

Chipped wood Pine bark

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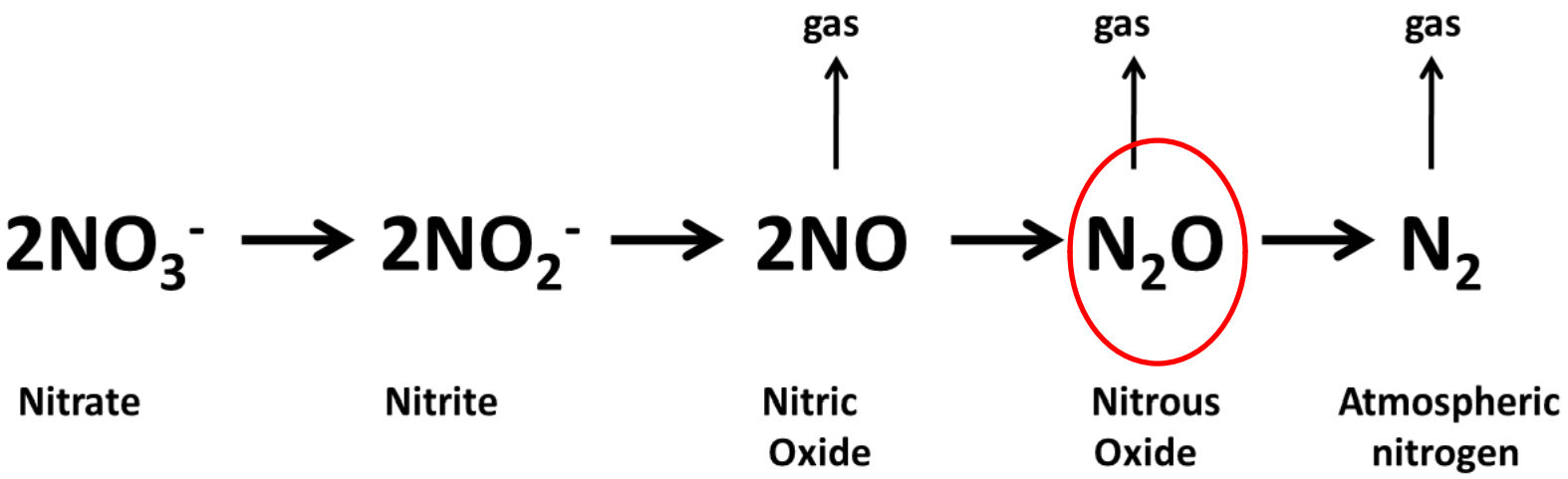
- develop ways of increasing C availability

Chipped wood Pine bark

@ 59 ^{o}F bark is averaging > 12 PPM NO_3-N removal per day

Are there environmental issues with DBRs ?

- Incomplete denitrification can release nitrous oxide (N_2O)
  - initial measurements suggest that < 1% of N is lost as N_2O



Are there environmental issues with DBRs ?

- **Release of water with high dissolved organic carbon (DOC) could be problematic**

	PPM DOC
Reclamation ditch	5 - 10
Tile drain water	5 - 10
Initial DBR effluent	> 100
‘mature’ DBR effluent	8 - 15

Are there microbial food safety implications?

- No exposed water = no wildlife attraction
- Fate of microbial pathogens in this anaerobic environment is unclear

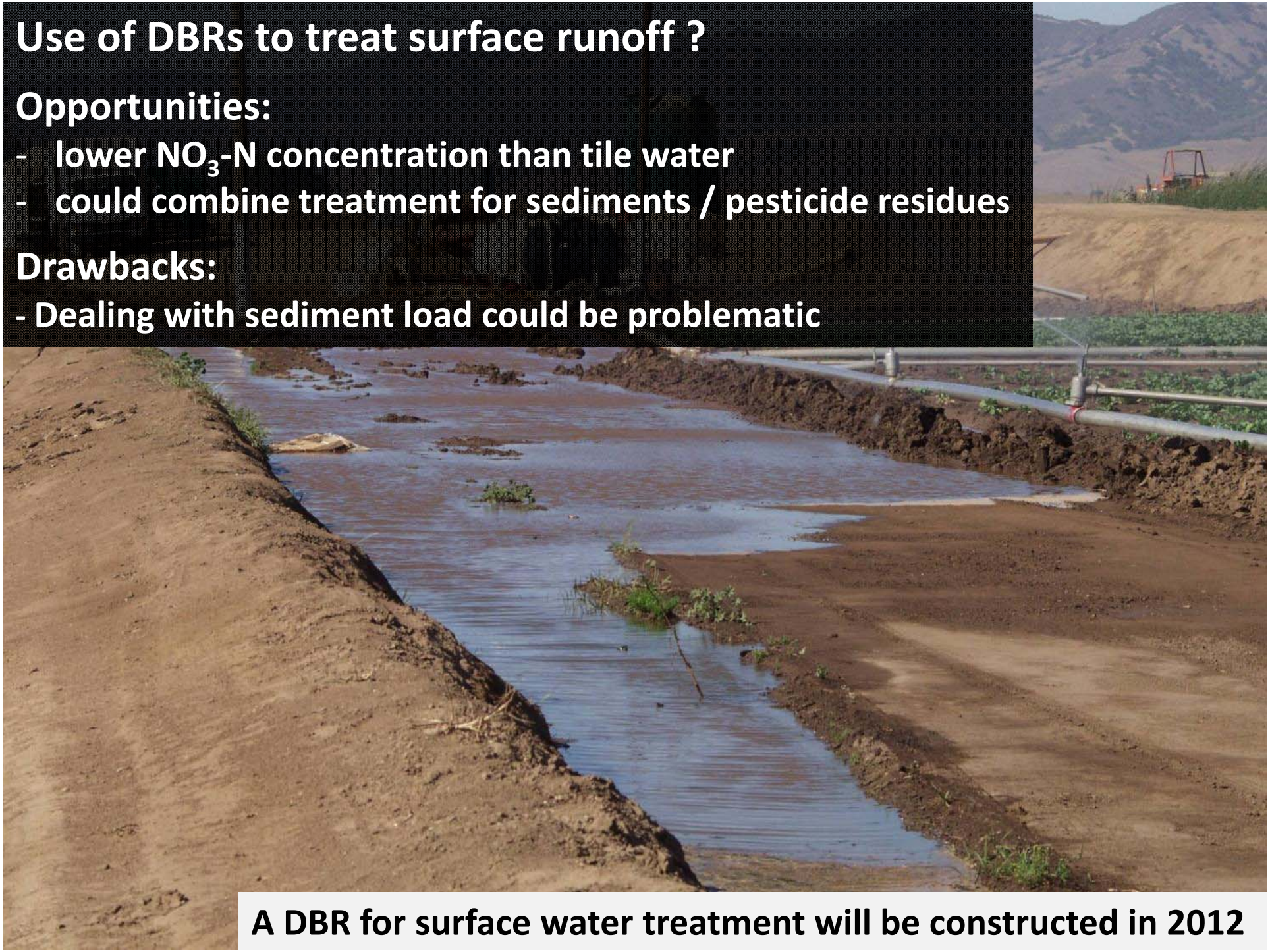
Use of DBRs to treat surface runoff ?

Opportunities:

- lower NO_3-N concentration than tile water
- could combine treatment for sediments / pesticide residues

Drawbacks:

- Dealing with sediment load could be problematic



A DBR for surface water treatment will be constructed in 2012

Is a DBR feasible on a commercial scale ?

- Based on a year-around average of 5 g N removal/m^3/day of residence time, a 0.5 acre DBR 4 feet deep could theoretically remove ≈ 10,000 lb NO_3-N / year

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- ***DBR size requirement can be reduced by reducing the N loading rate***