How alternating gaining and losing conditions along a low order agricultural stream govern the behavior of nitrogen species

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CRC 1253 CATCHMENTS AS REACTORS CAMPOS

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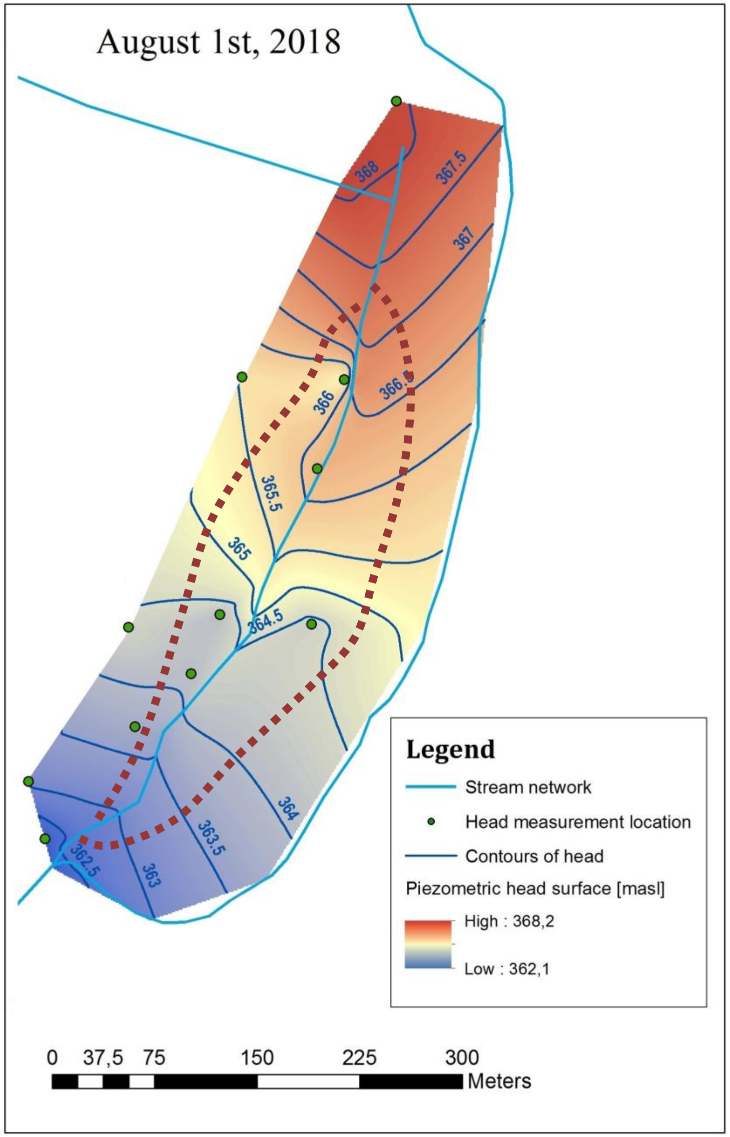
DFG

Once we have understood the complex hydro(geo)logy at the Schönbrunnen...

Understand potential BIOGEOCHEMICAL processes in the transition between GW & SW

Methods:

- Hydrogeological and hydrochemical monitoring
- Stable isotopes $^{15}N\text{-}NO_3^-$ and $^{18}O\text{-}NO_3^-$
- Comprehensive molecular approaches

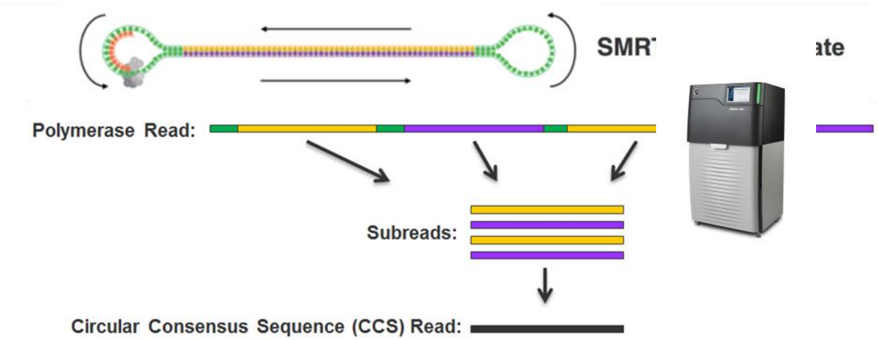


Methods

Molecular approaches

3rd generation sequencing technologies

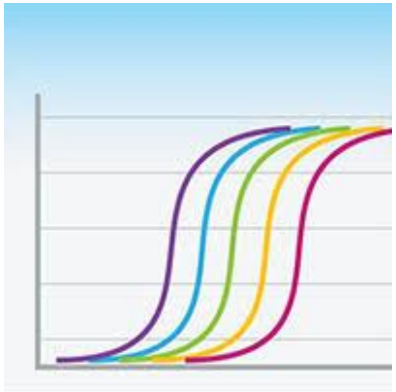
Full-length marker gene sequencing (~1.6 kb)



PacBio Sequel® platform:

- Long-read sequencing (up to 30 kb reads)
- Full-length sequencing of 16S rRNA and functional marker genes
- Metagenome-assembled genomes (MAGs)

And to quantify potential denitrifying microorganisms and their relative abundance in each sample, qPCR targeting ***nirS*** and ***nirK*** as well as the bacterial 16S rRNA gene was performed.



Methods:
GW transects

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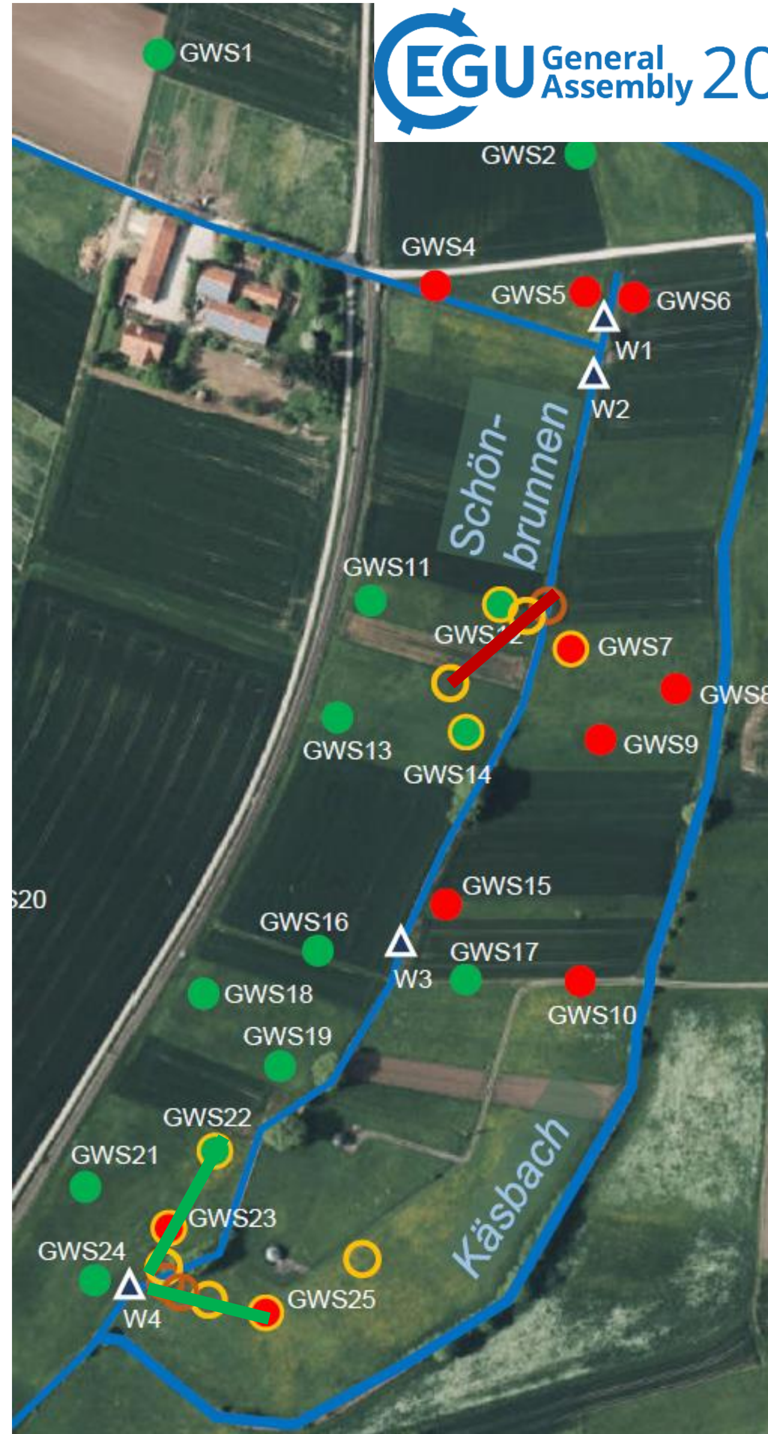
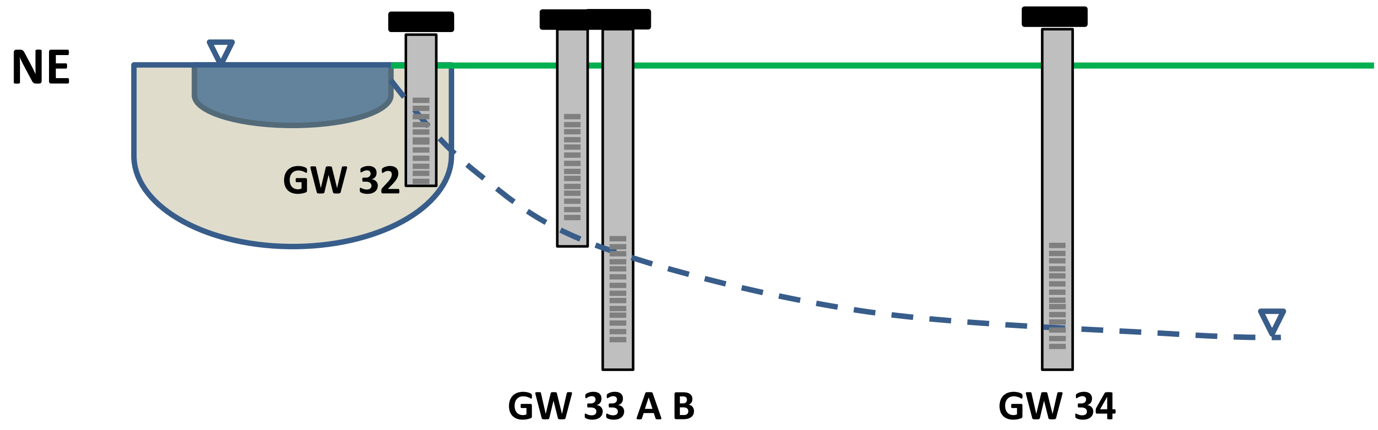
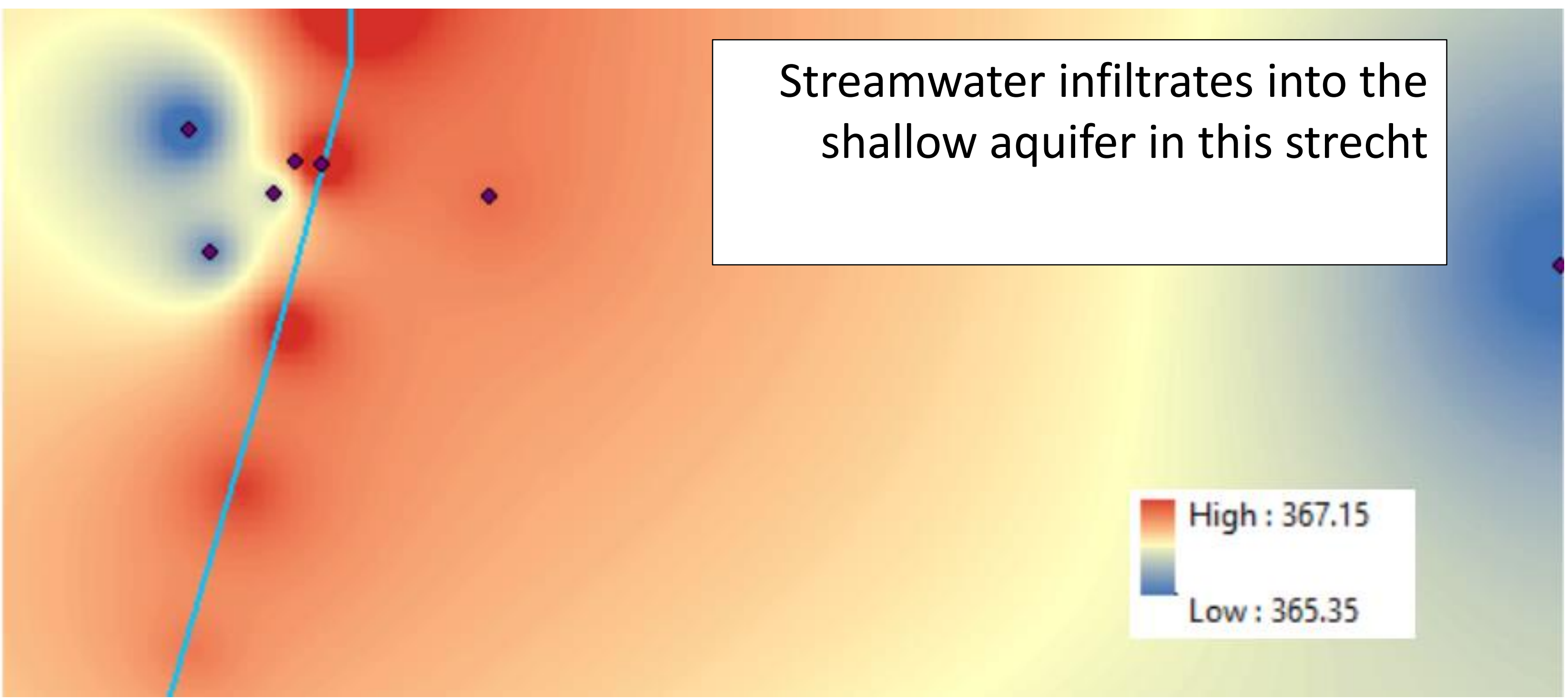
- 1 transect along the loosing stretch
- 2 transects along the gaining stretches from:
  - West
  - East

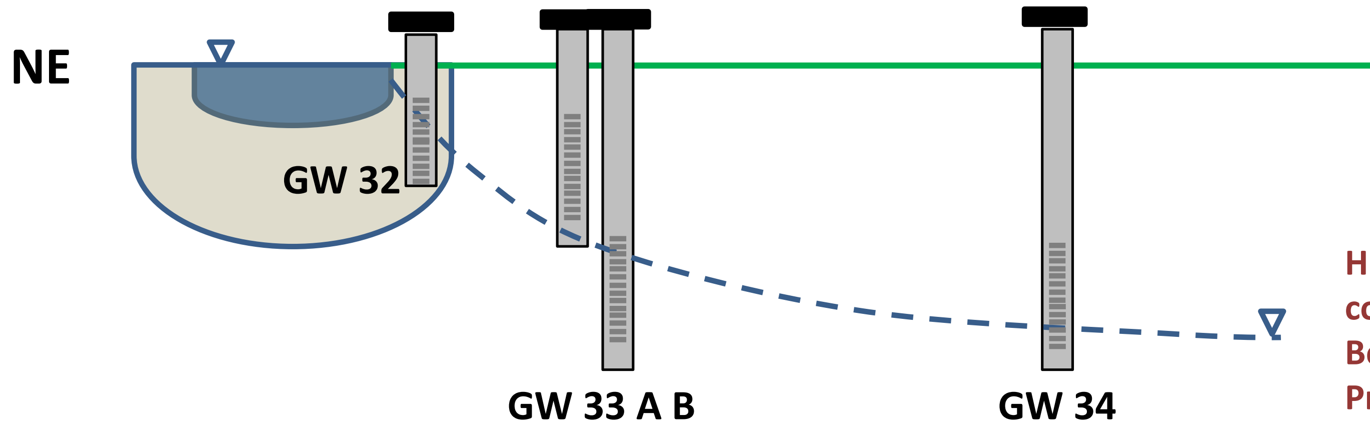


GW transect – LOSING stretch

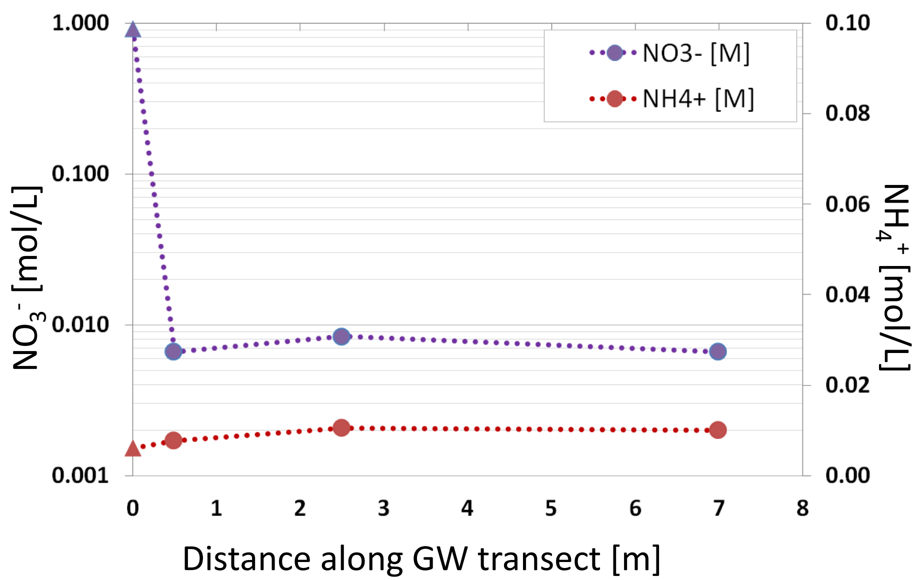


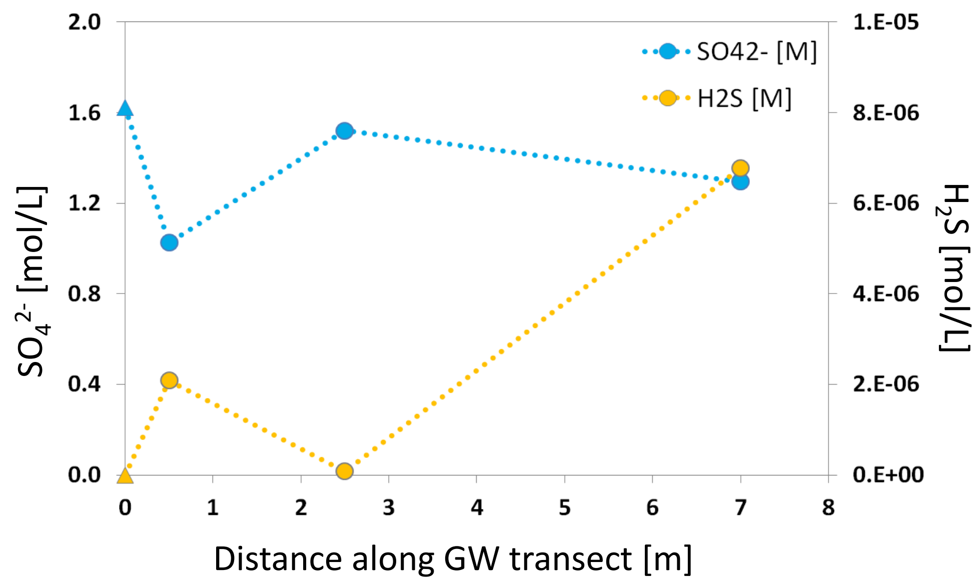


GW transect – LOSING stretch



High uncertainty in Sulfide concentrations.
Better to report it as Presence/Absence of Sulfide

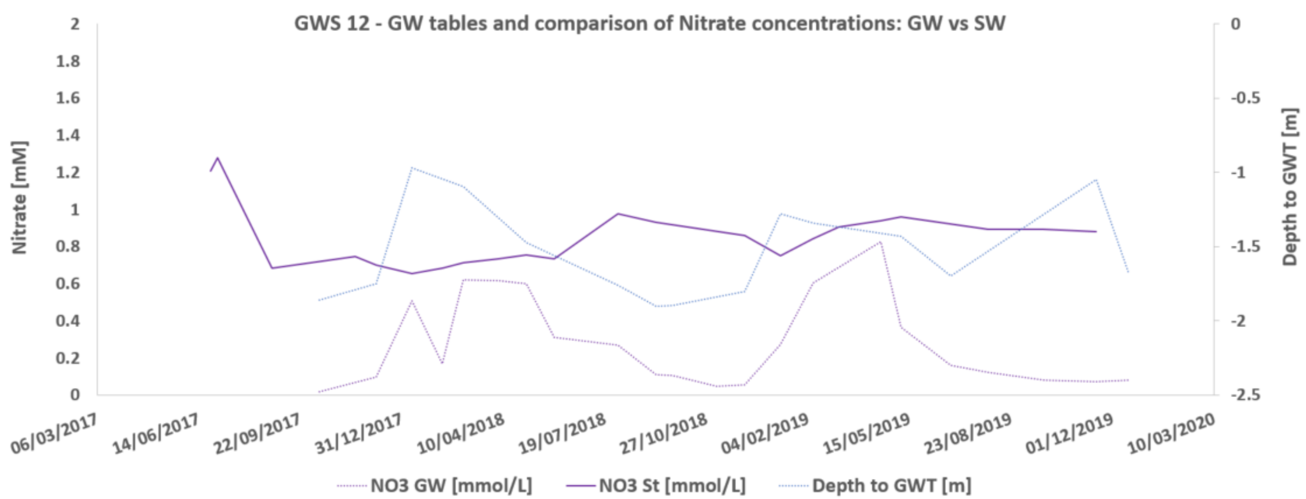


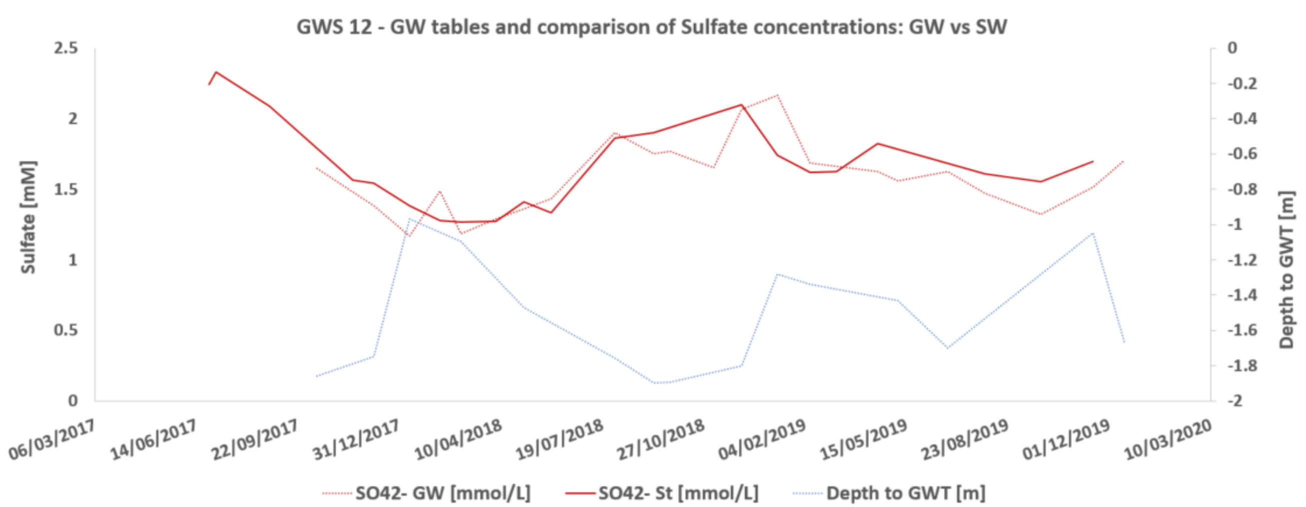


▲ Streamwater
● Groundwater

- **HIGH Reduction potential in streambed**
  - Nitrate is gone within few dm along the streambed
  - Sulfate reduction also occurs within few dm along the streambed

Temporal GW-SW Interaction LOSING stretch





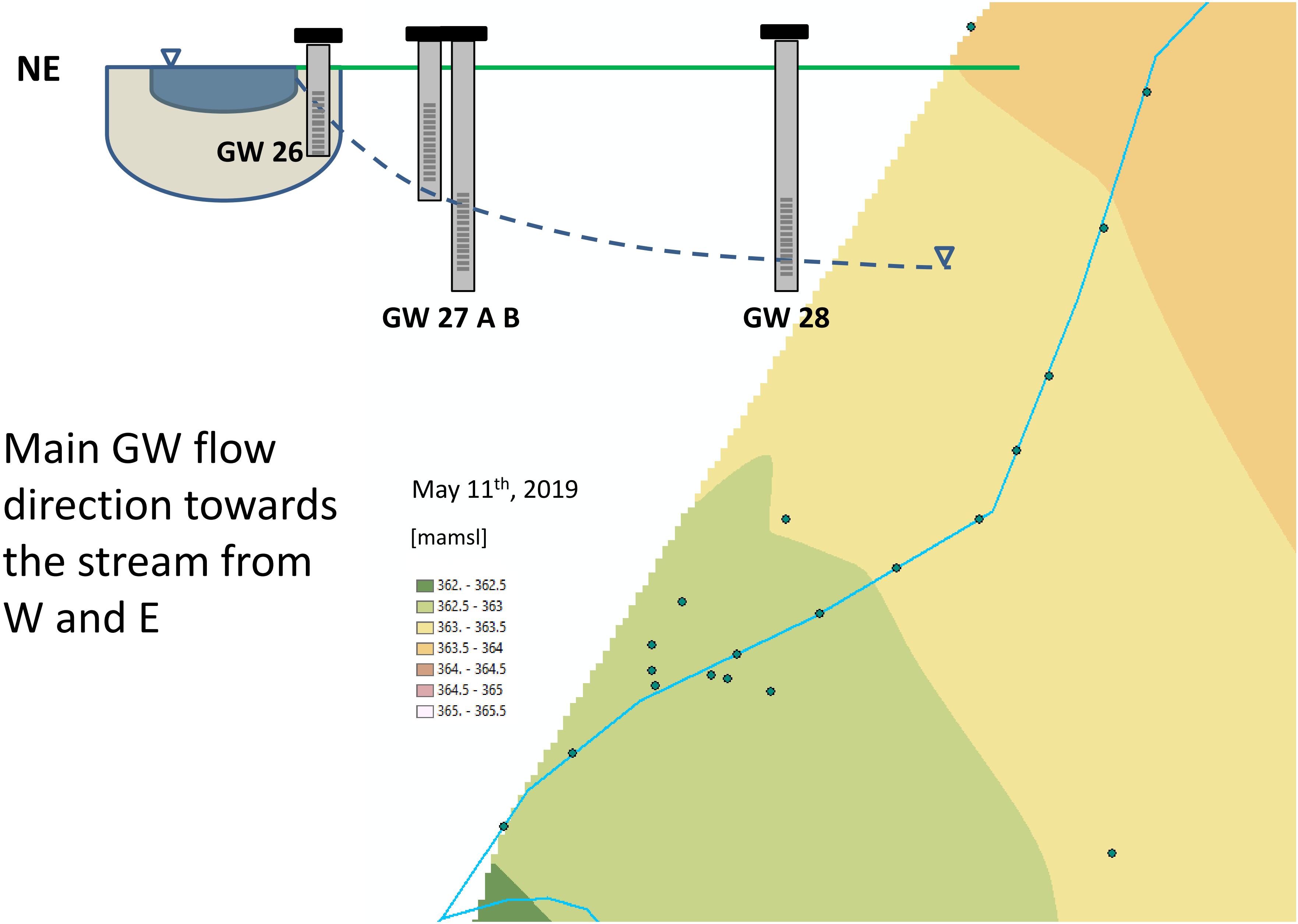
- Nitrate in streamwater (St) and GW are affected by seasonal changes in GW levels (R^2 = 0.4 and p = 0.044). Sulfate is not significantly influenced.

- Stream (St) & GW nitrate correlate negatively,

whereas St & GW sulfate correlate positively

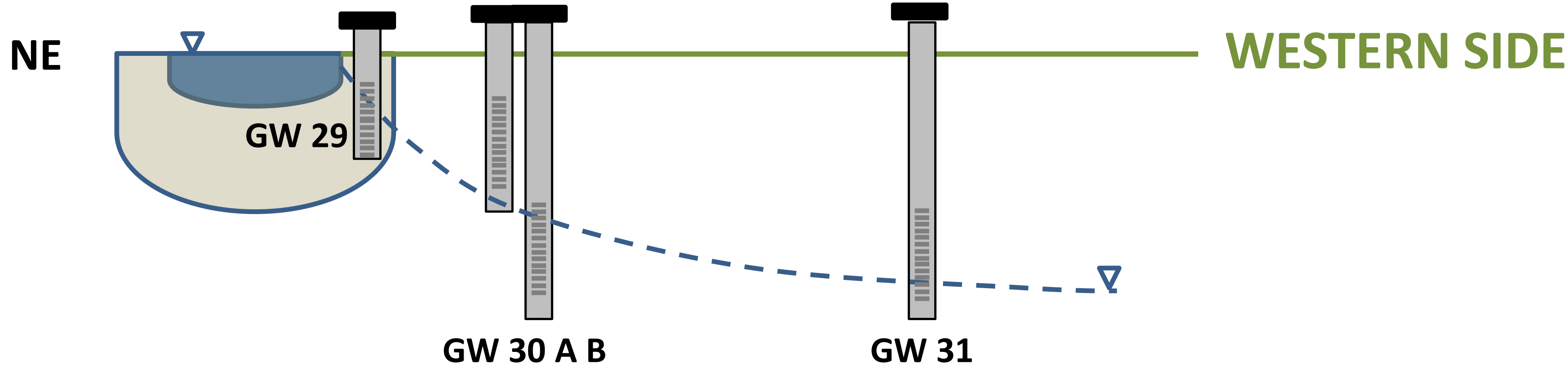
- From St to GW: DENITRIFICATION

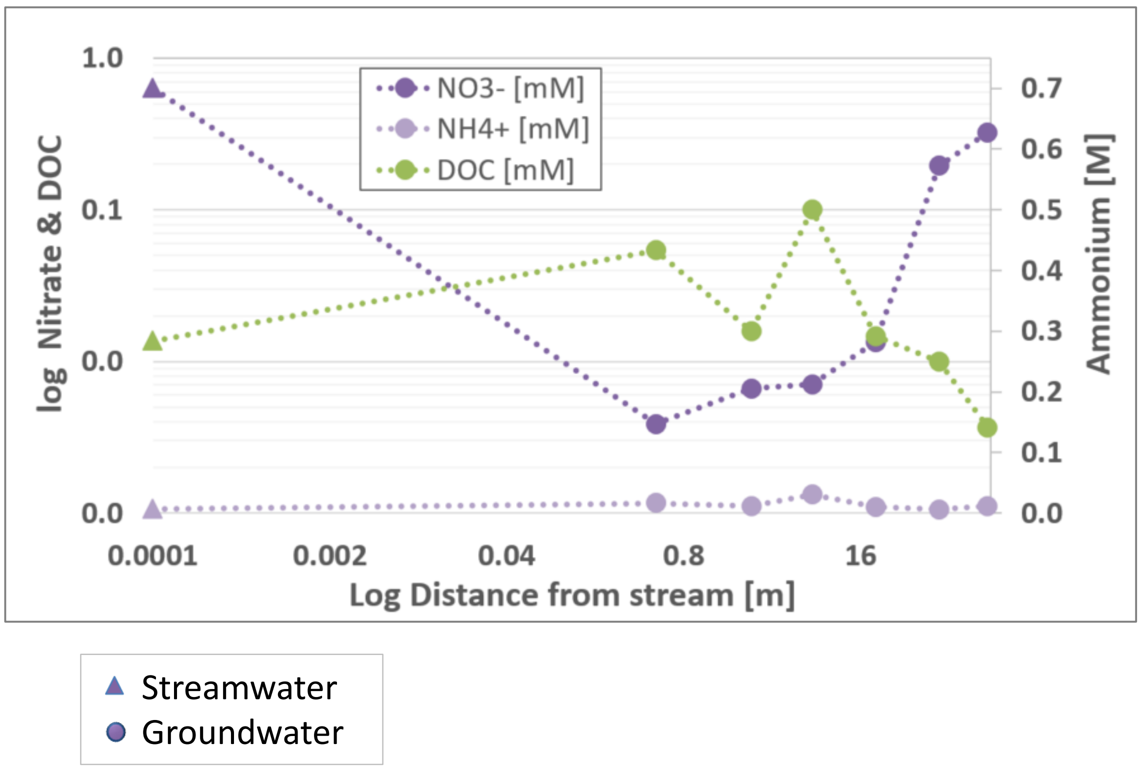
GW transect – GAINING stretcht



Main GW flow direction towards the stream from W and E

GW transect – GAINING stretch





- Nitrate depletion along GW flowpath towards the stream.
- Ammonium stays relatively absent over distance.
- Negative correlation between Nitrate and DOC

GW transect – GAINING stretch

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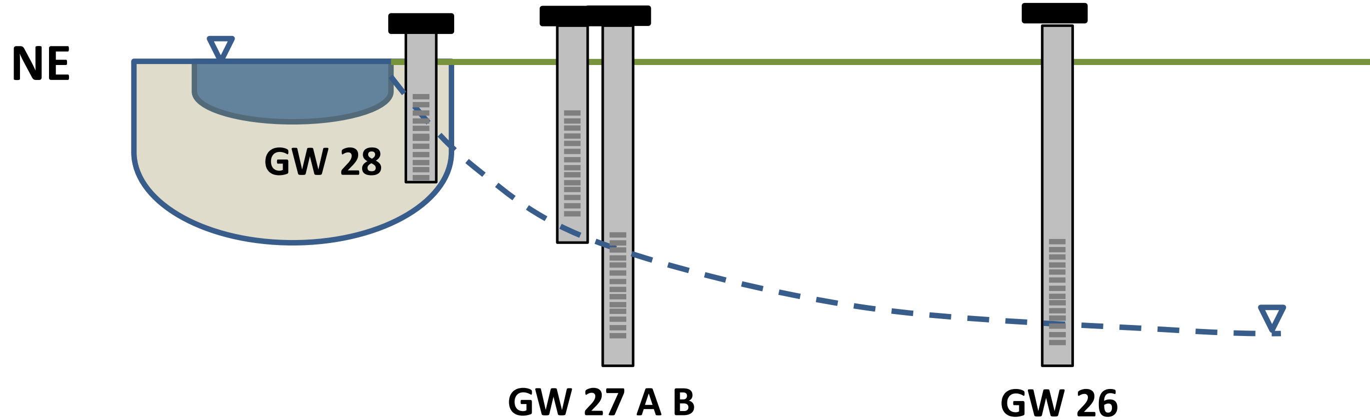

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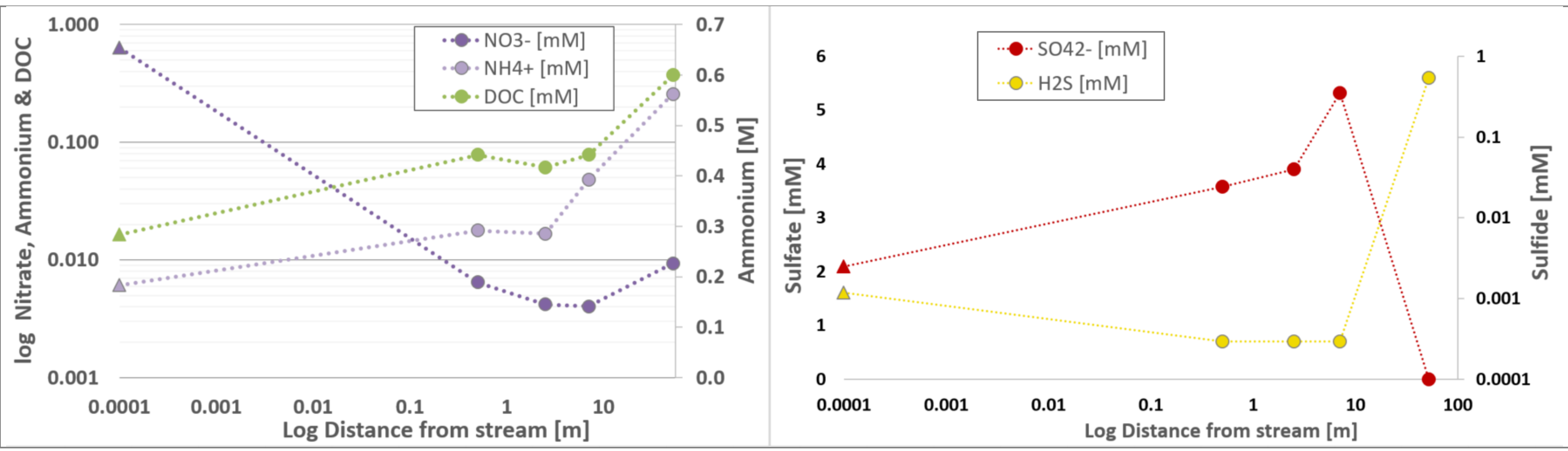

▲ Streamwater
● Groundwater

- Increase of Nitrate from GW towards the stream, coupled with ammonium and DOC decrease
- Sulfate depletion and presence of sulfide

Temporal GW-SW Interaction
GAINING stretch

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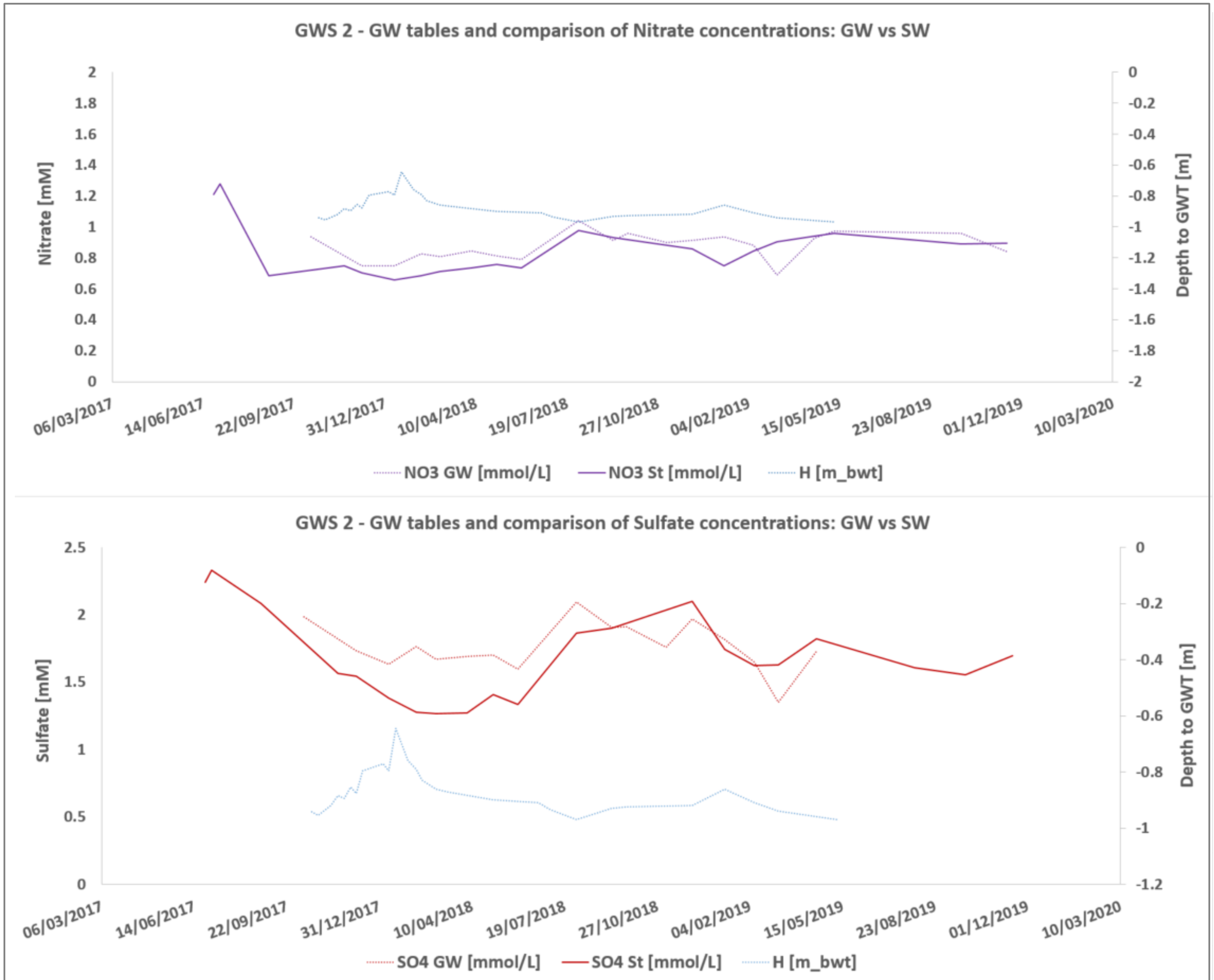
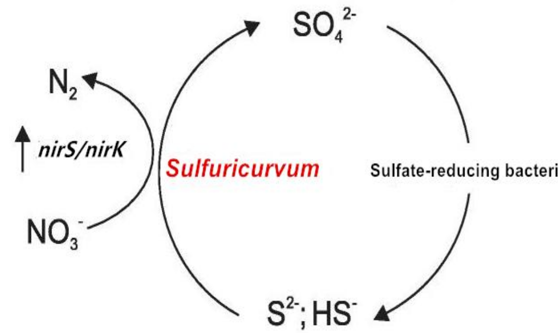


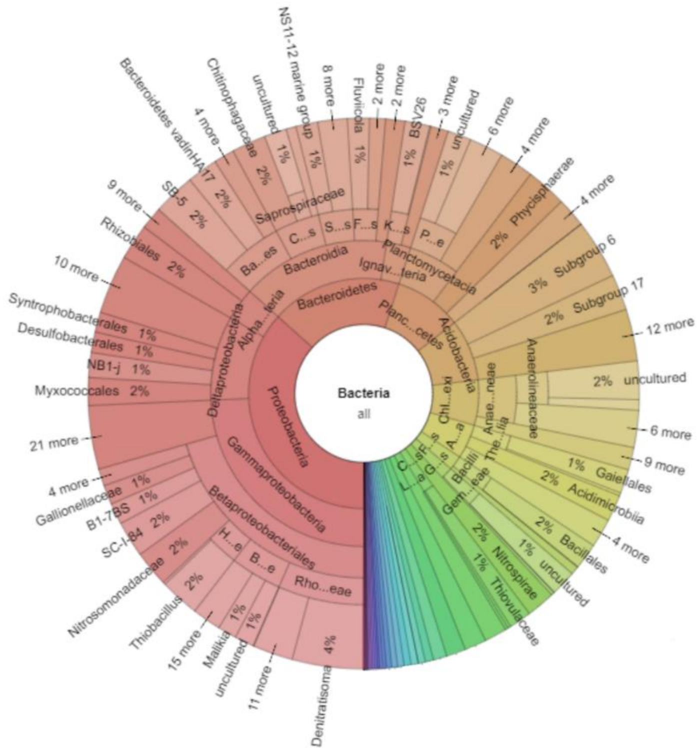
- Nitrate in streamwater (St) and GW are affected by seasonal changes in GW levels (R^2 = 0.81 and p = 0.00055). Sulfate is not significantly influenced.

- Stream (St) & GW nitrate positively negatively, whereas St & GW sulfate have slight positive correlation

- From GW to St: NITRATE reduction

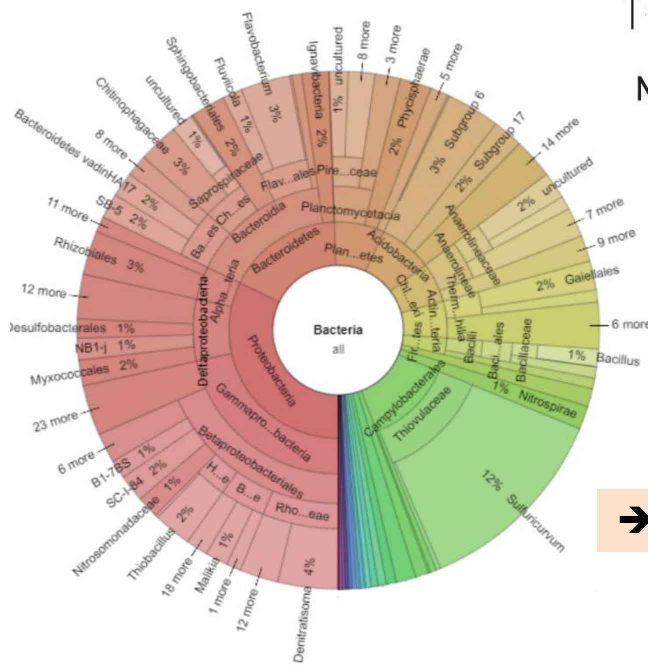
Linking S- and N-cyling in microcosm microbiomes?





Day 0

Down-stream deeper depth microcosm sample



Day 18

➔ 12% *Sulfuricurvum* !

➔ Sulfide-driven denitrification as important mechanism in denitrification deeper mid stream sediments?

Summary and Conclusions

- Redox sensitive species in GW show large interaction with stream:
  - Nitrate reduction in **losing stretch (A)** and **western** transect of the **gaining stretch (B)**
    - **(A)** Denitrification: confirmed by isotope's data
    - **(B)** Nitrate reduction coupled with pyrite (sulfide) oxidation as suggested by molecular analyses.
  - Nitrate increase in anoxic **eastern** transect of the **gaining stretch** coupled with sulfate reduction and presence of sulfide.

- Temporal behavior:
  - High GW levels in winter time lead to low nitrate concentrations → Denitrification is higher in winter? Or only nitrate concentrations are higher in summer?
  - Nitrate peaks are obviously found after fertilizer application

- The scope of the transition zone between GW and SW is variable over space and over time, especially within the losing stretches

Thank you! ☺

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