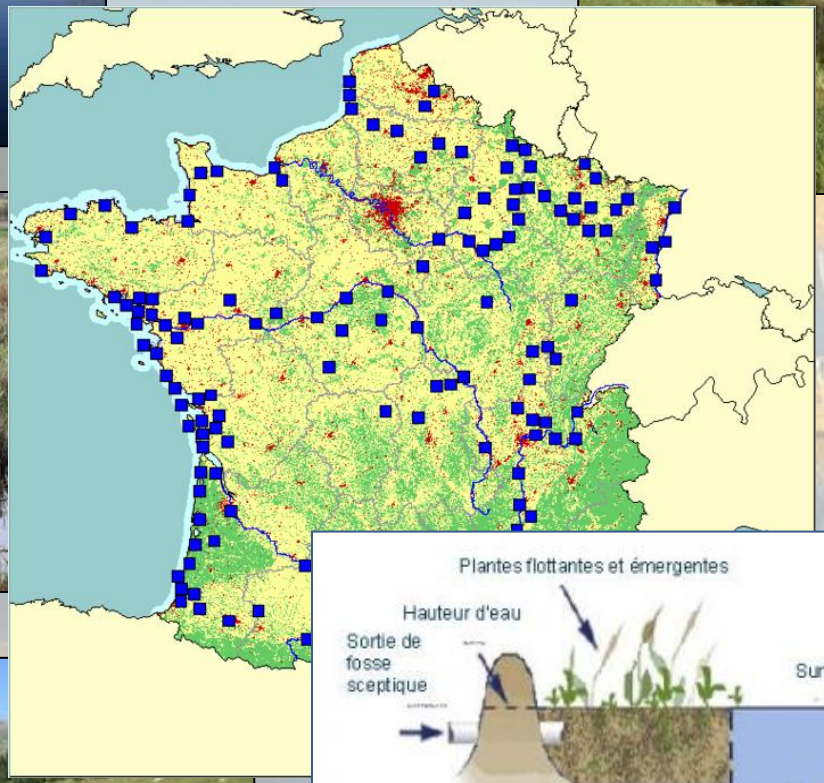
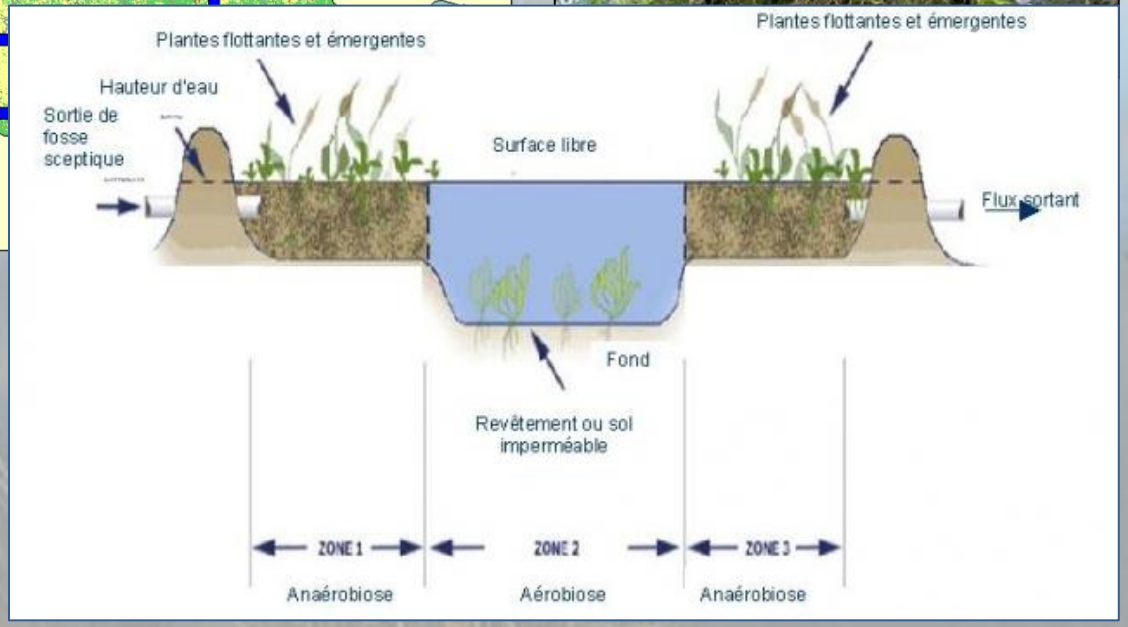
Rôles des zones humides dans les échanges eau de surface-eau souterraine

P. ACKERER
LHyGeS, Université de Strasbourg/CNRS

Richesse et diversité d'un patrimoine collectif

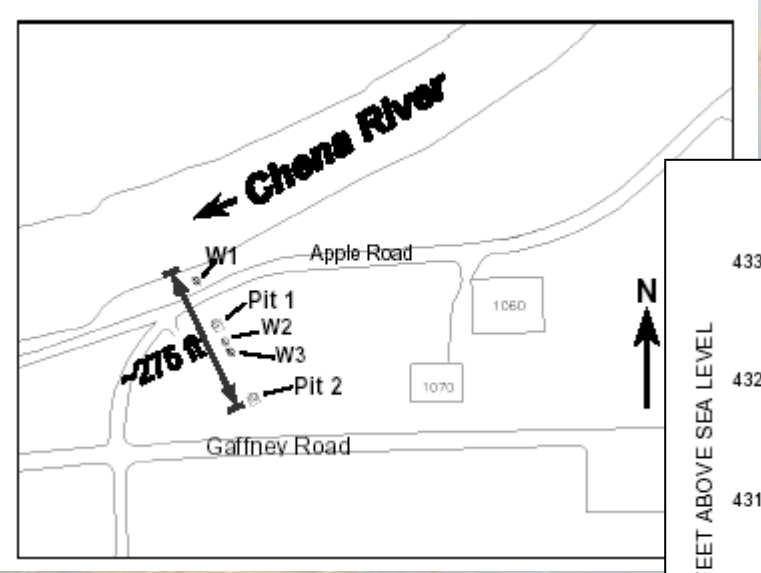
Qu'est-ce qu'une zone humide ?

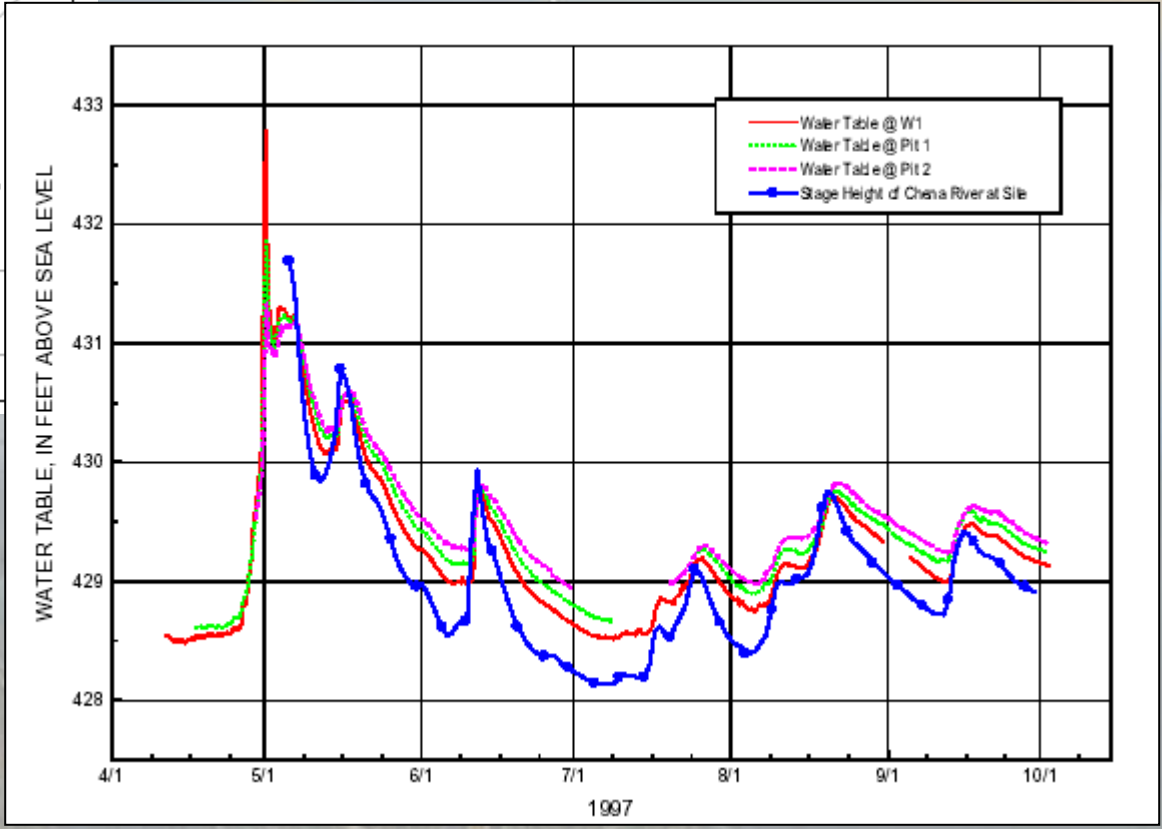



Plantes flottantes et émergentes
Plantes flottantes et émergentes
Hauteur d'eau
Sortie de fosse sceptique
Surface libre
Flux sortant
Fond
Revêtement ou sol imperméable
ZONE 1
ZONE 2
ZONE 3
Anaérobiose
Aérobiose
Anaérobiose

IMPACTS SUR LES EAUX SOUTERRAINES

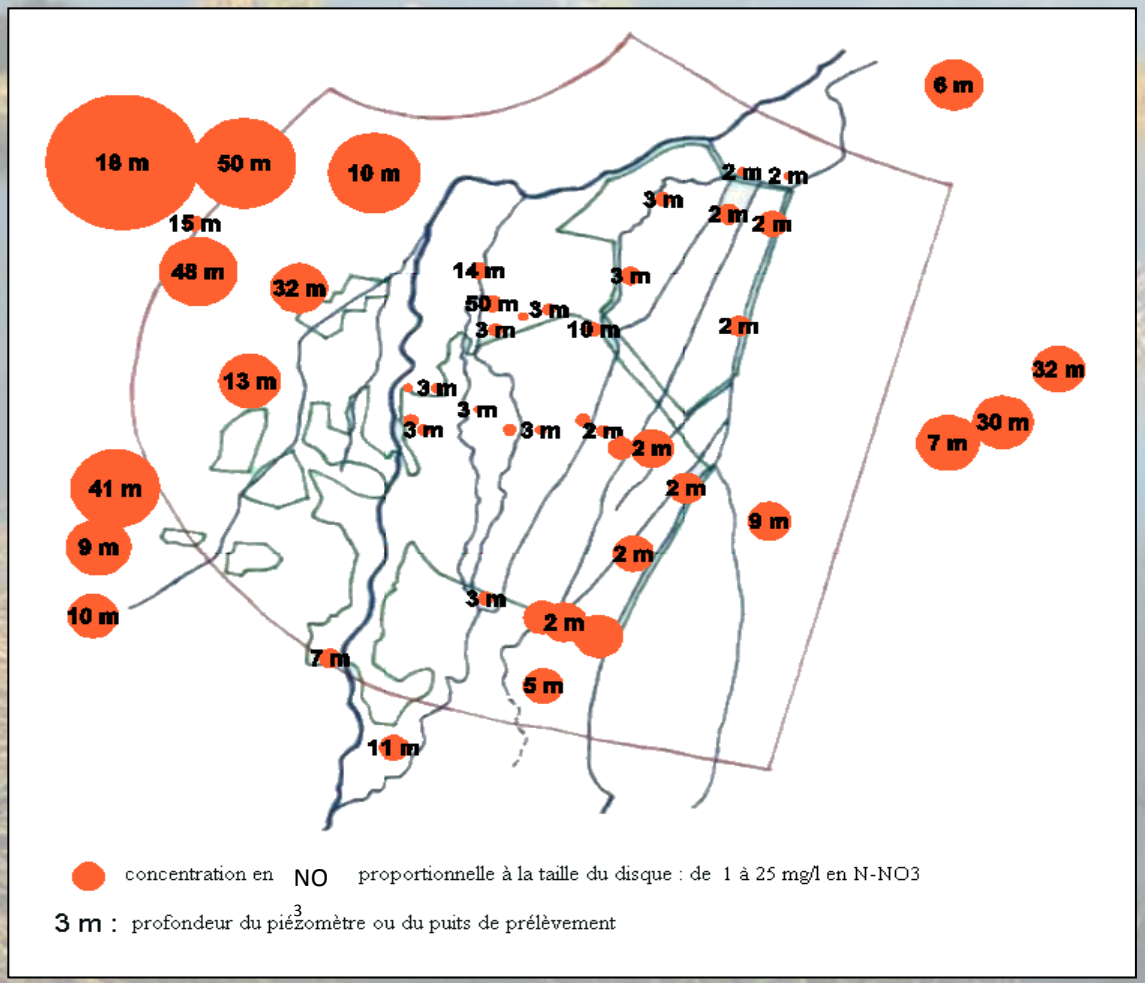
Impacts sur l'hydrodynamique





IMPACTS SUR LES EAUX SOUTERRAINES

Impacts sur la qualité de l'eau



IMPACTS SUR LES EAUX SOUTERRAINES

Bilan global en flux journaliers pour le secteur de l'Illwald.

Modèle hydrodynamique et concentrations mesurées				
	Entrée (E)	**Sortie (S)**	**(S-E)**	**(S – E) / E**
Cl^- (kg/j)				
Rivière	80730	104663	23933	30
Nappe	28938	6604	-22333	-74
Atmosphère	132	0	-132	-100
Total	109800	111267	1468	1%

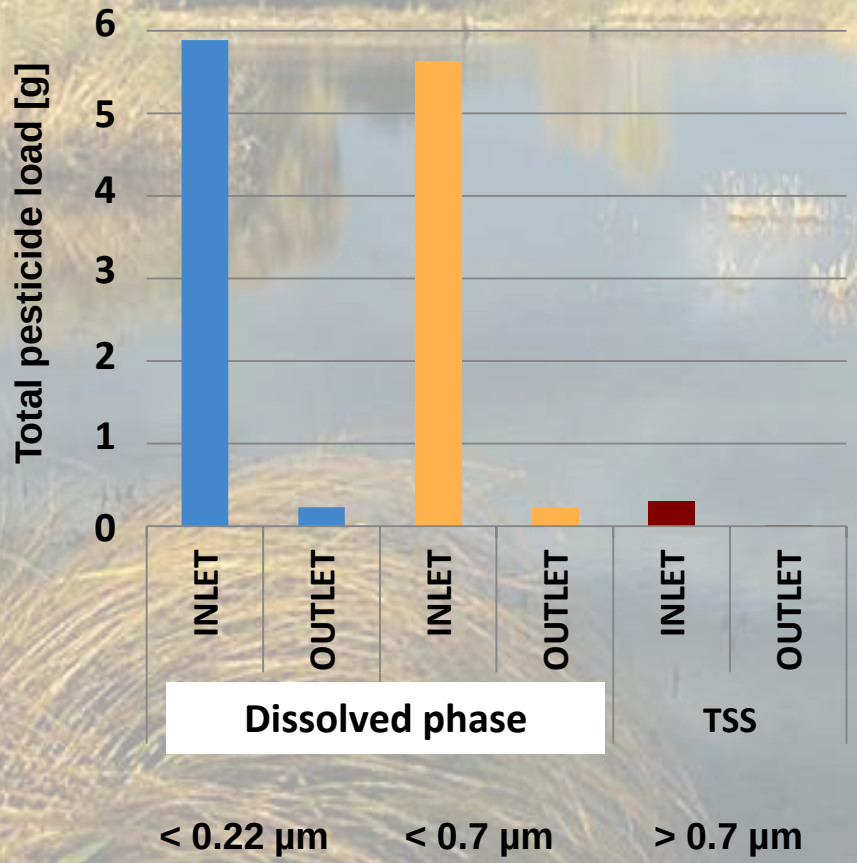
NO_3^- (kg/j)				
Rivière	3987	4210	223	6
Nappe	1677	370	-1307	-78
Atmosphère	36	?	-36	
Total	5700	4580	-1120	-20

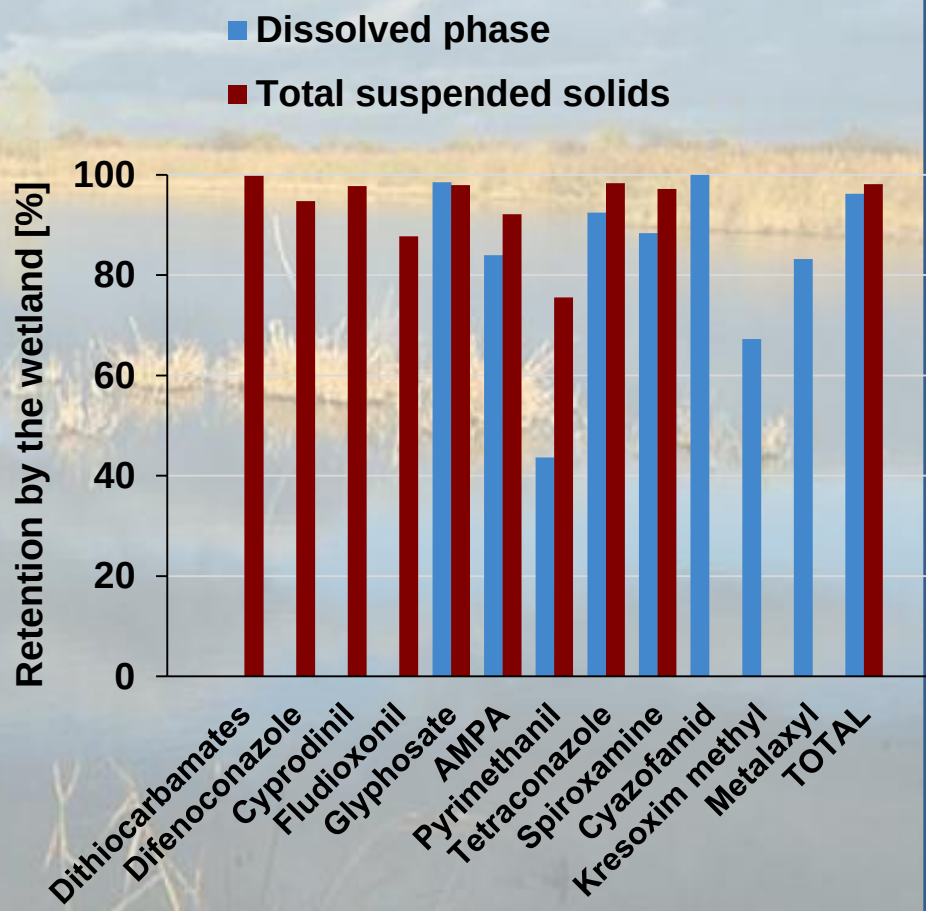
La capacité épuratoire du complexe sol-plante à l'Illwald : 195 kg N/ha/an.

L'eau drainée provient d'une profondeur pouvant atteindre 40m.

IMPACTS SUR LES EAUX SOUTERRAINES

Effets d'une zone humide artificielle sur différentes molécules pesticides.

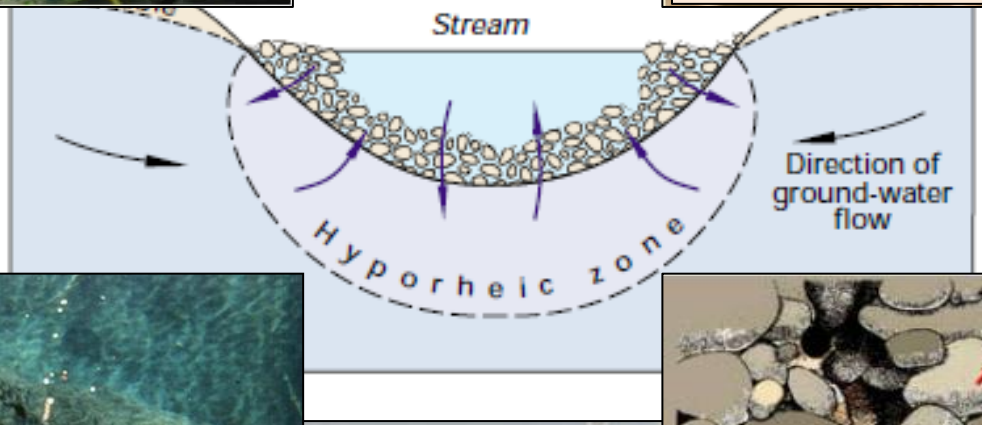


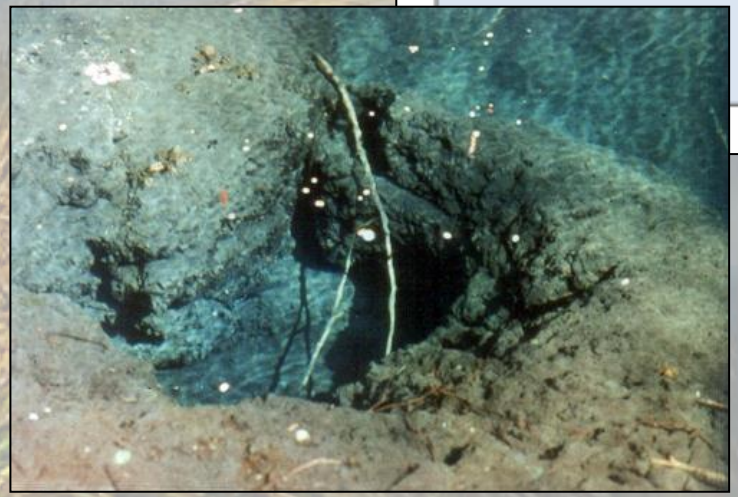


Maillard et al., 2011, STOTEN; 2012, IJEAC; Maillard et al., in prep. ES&T

DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

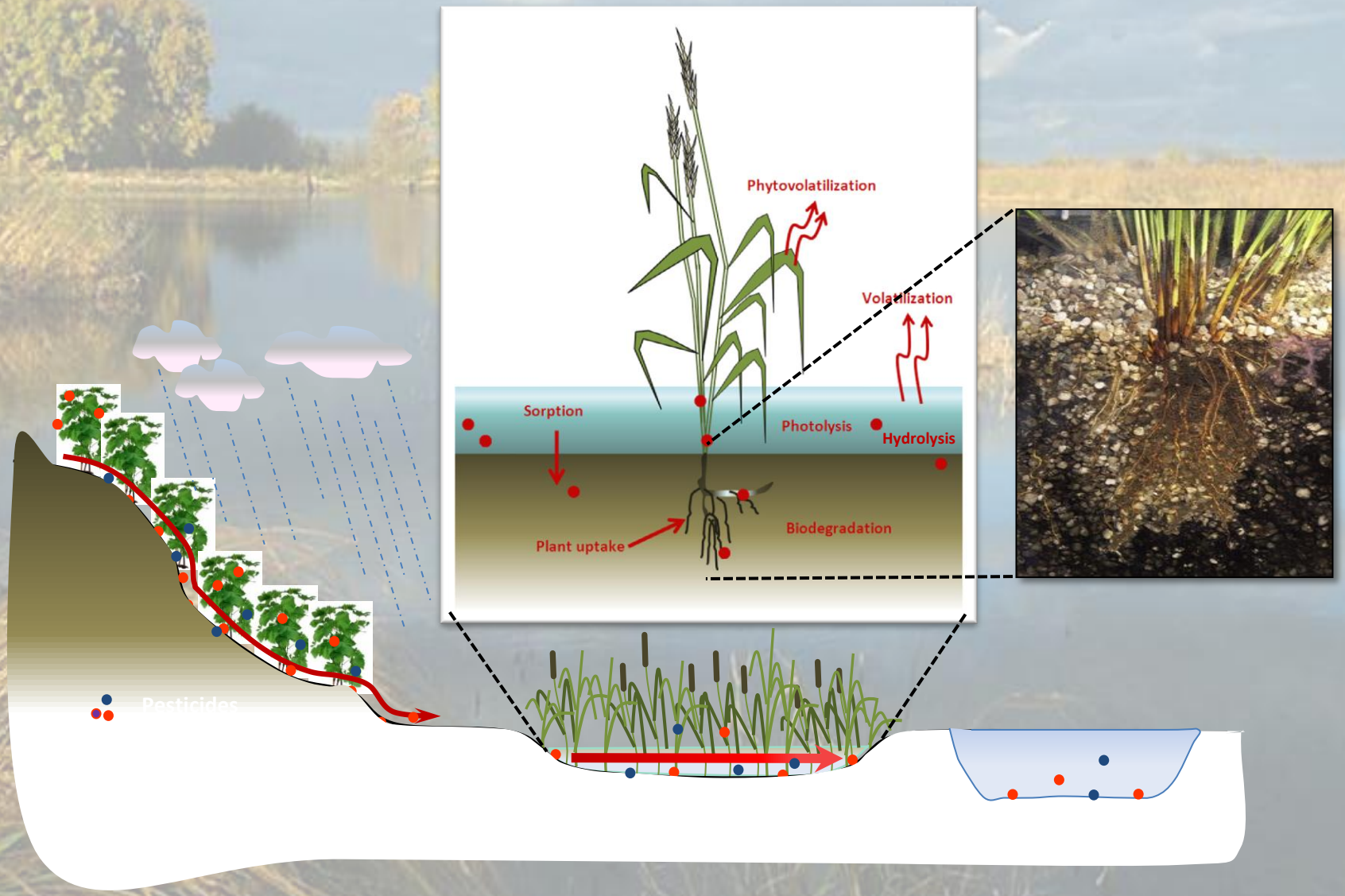
http://wikhydro.developpement-durable.gouv.fr





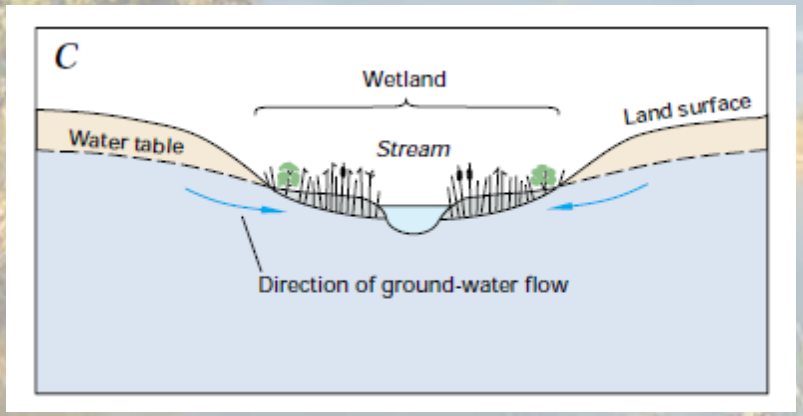
http://wikhydro.developpement-

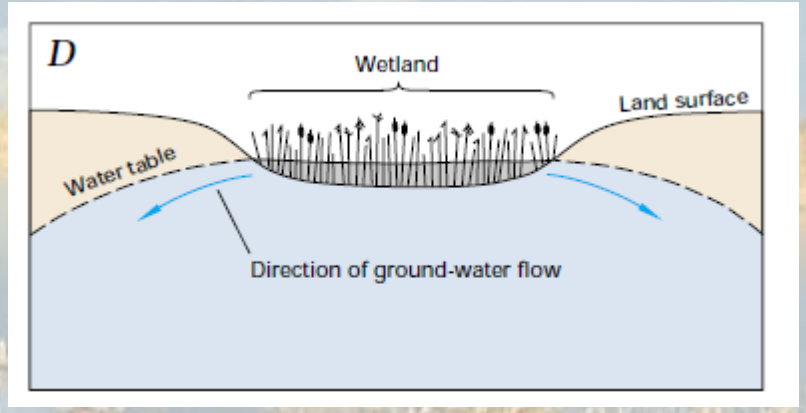
DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

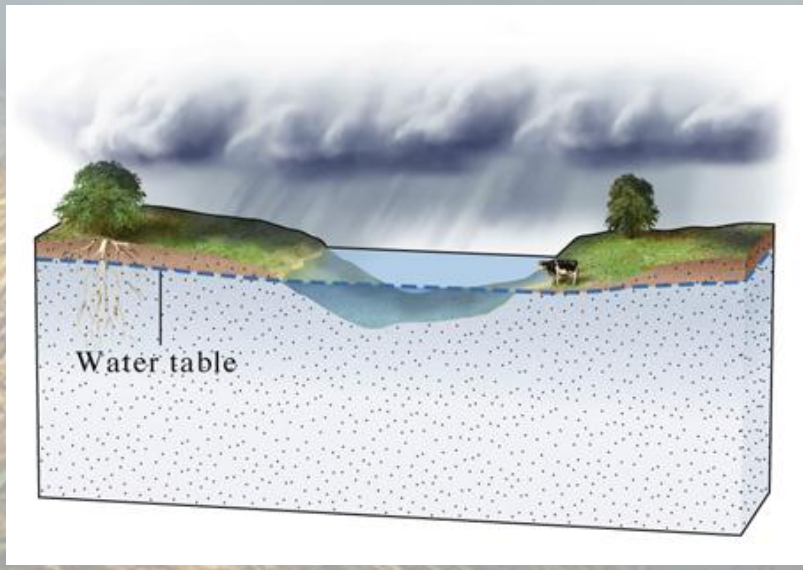


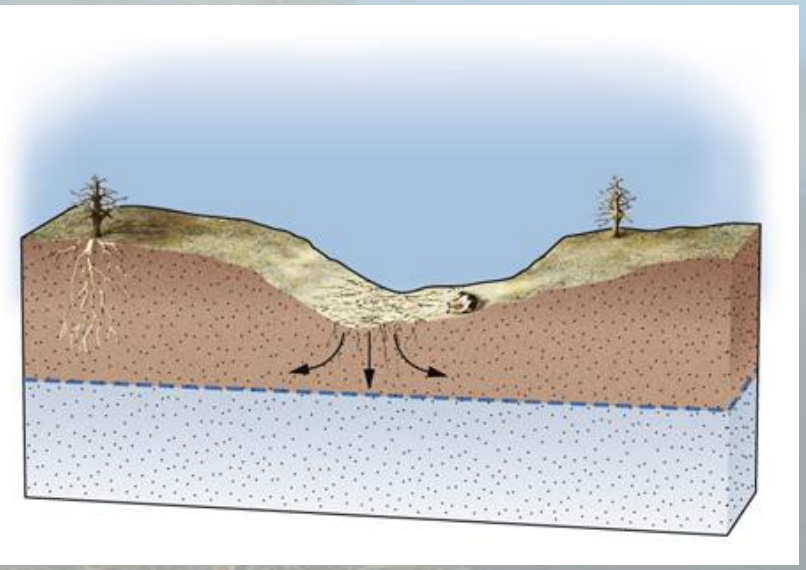
DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

Aspects hydrodynamiques







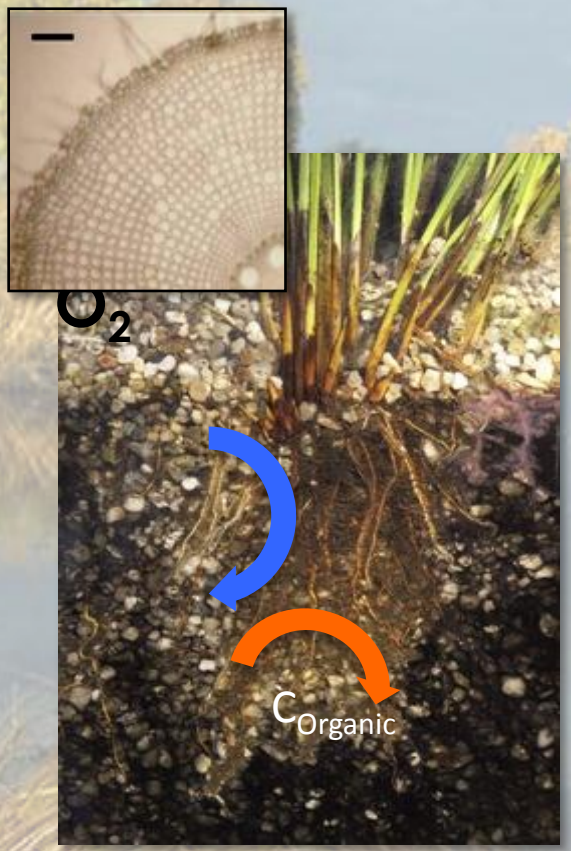


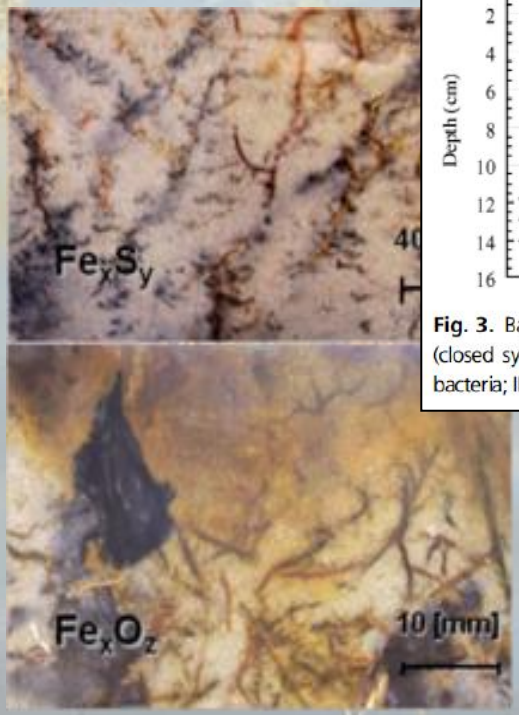
DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

$$Q = \alpha(h_r - h_n) \qquad \alpha = f(e, k, géométrie, ...)$$

DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

Aspects microbio-géochimiques





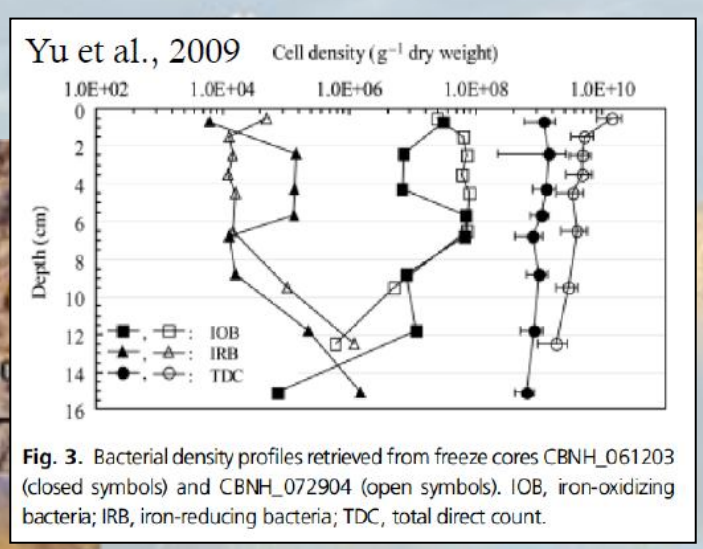


Fig. 3. Bacterial density profiles retrieved from freeze cores CBNH_061203 (closed symbols) and CBNH_072904 (open symbols). IOB, iron-oxidizing bacteria; IRB, iron-reducing bacteria; TDC, total direct count.

- Des gradients physico-chimiques et microbiologiques très forts.
- Une très forte diversité de processus (nutriments, gaz à effet de serre, métaux, polluants organiques,…)

DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

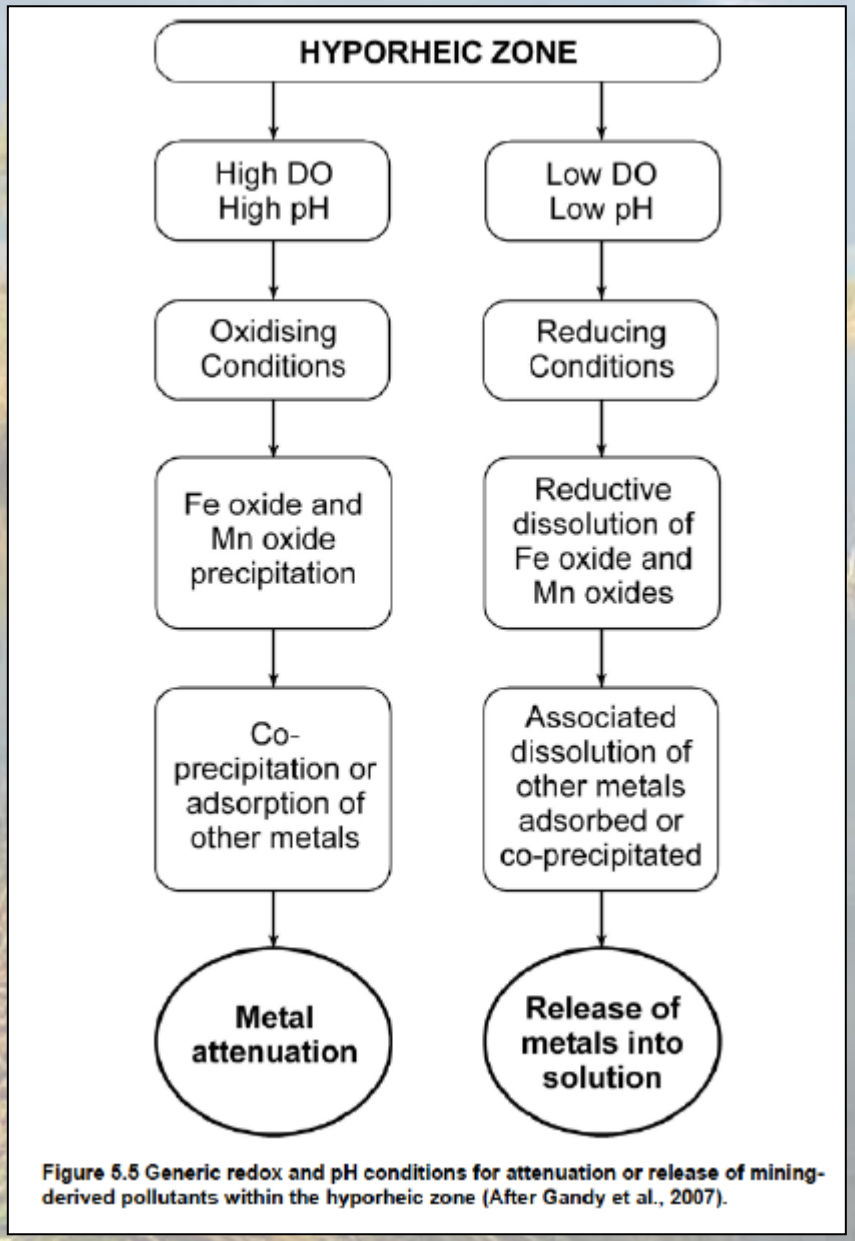
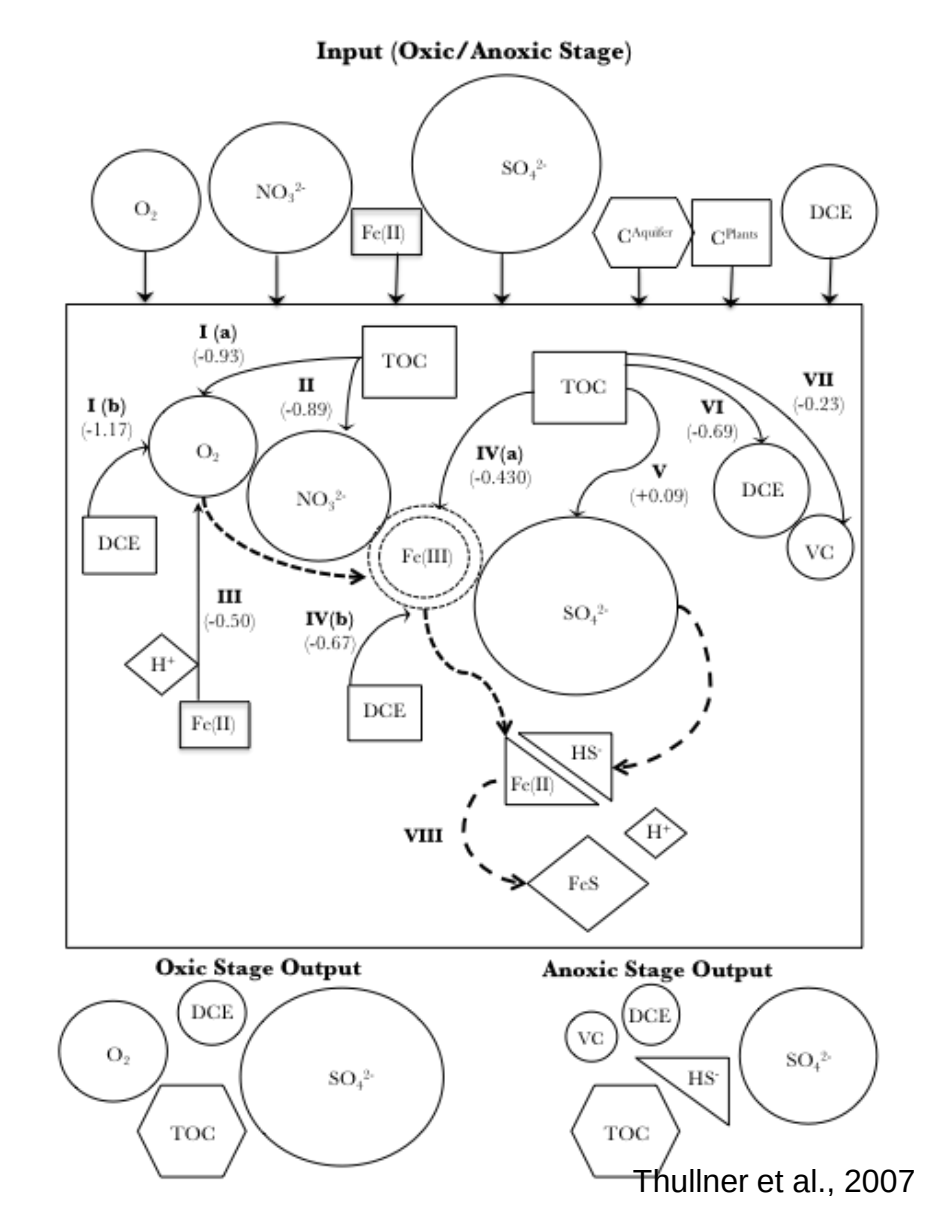


Figure 5.5 Generic redox and pH conditions for attenuation or release of mining-derived pollutants within the hyporheic zone (After Gandy et al., 2007).

- Processus éventuels: sorption, complexation, précipitation, dissolution.
- Variables géochimiques: pH, rédox
- Variables microbiologiques: respiration, oxydation/réduction
- Régulation: flux hydriques (O_2, MO)

DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

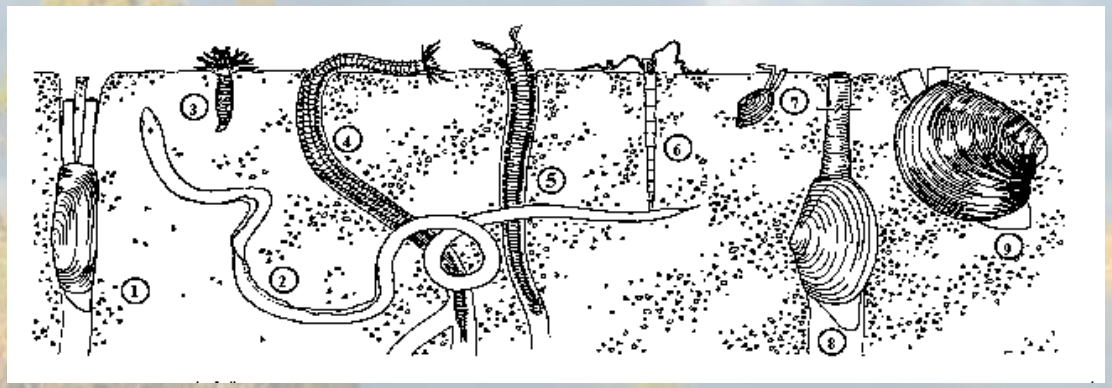


Thullner et al., 2007

Modèle biogéochimique du transfert de DCE

DES TRANSFERTS À TRAVERS UNE ZONE CLÉ: LA ZONE HYPORHÉIQUE

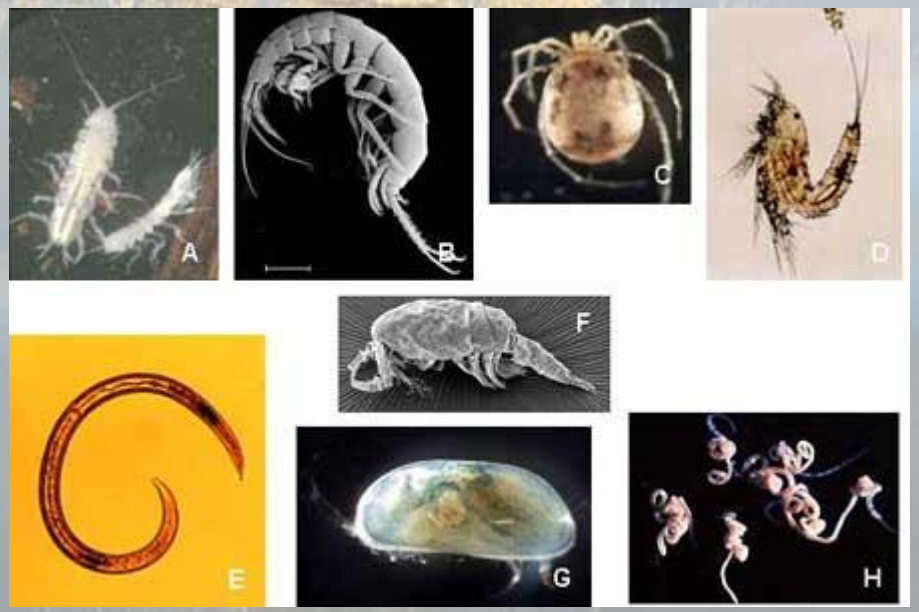
Aspects éco-biologiques



Impacts sur la perméabilité des sédiments

Impacts sur les transferts de carbone, de nutriments et d'énergie.

Impacts sur les transferts de polluants.



http://www.pascalis-project.com/

Pour résumer de manière synthétique ….

Boulton et al., 2010, J. NABS, 29: 26.

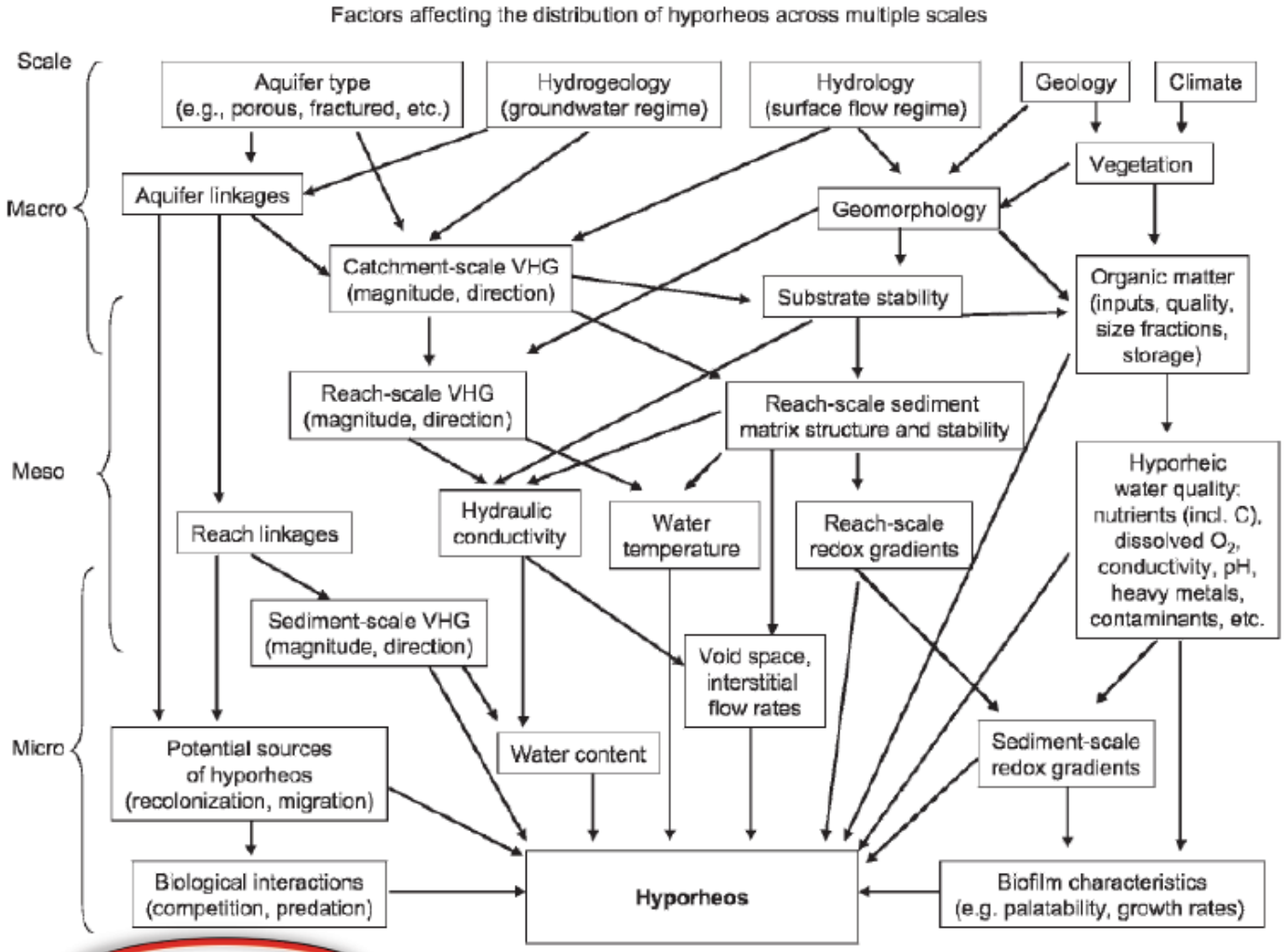


FIG. 2. Simplified diagram of the interactions among variables across 3 overlapping spatial scales (macro = landscape–catchment, meso = catchment–reach, micro = reach–sediment particle) that potentially influence the distribution and composition of the hyporheos.

QUELQUES PISTES DE RECHERCHE …..

La mise en œuvre de traçage

Traceurs thermiques

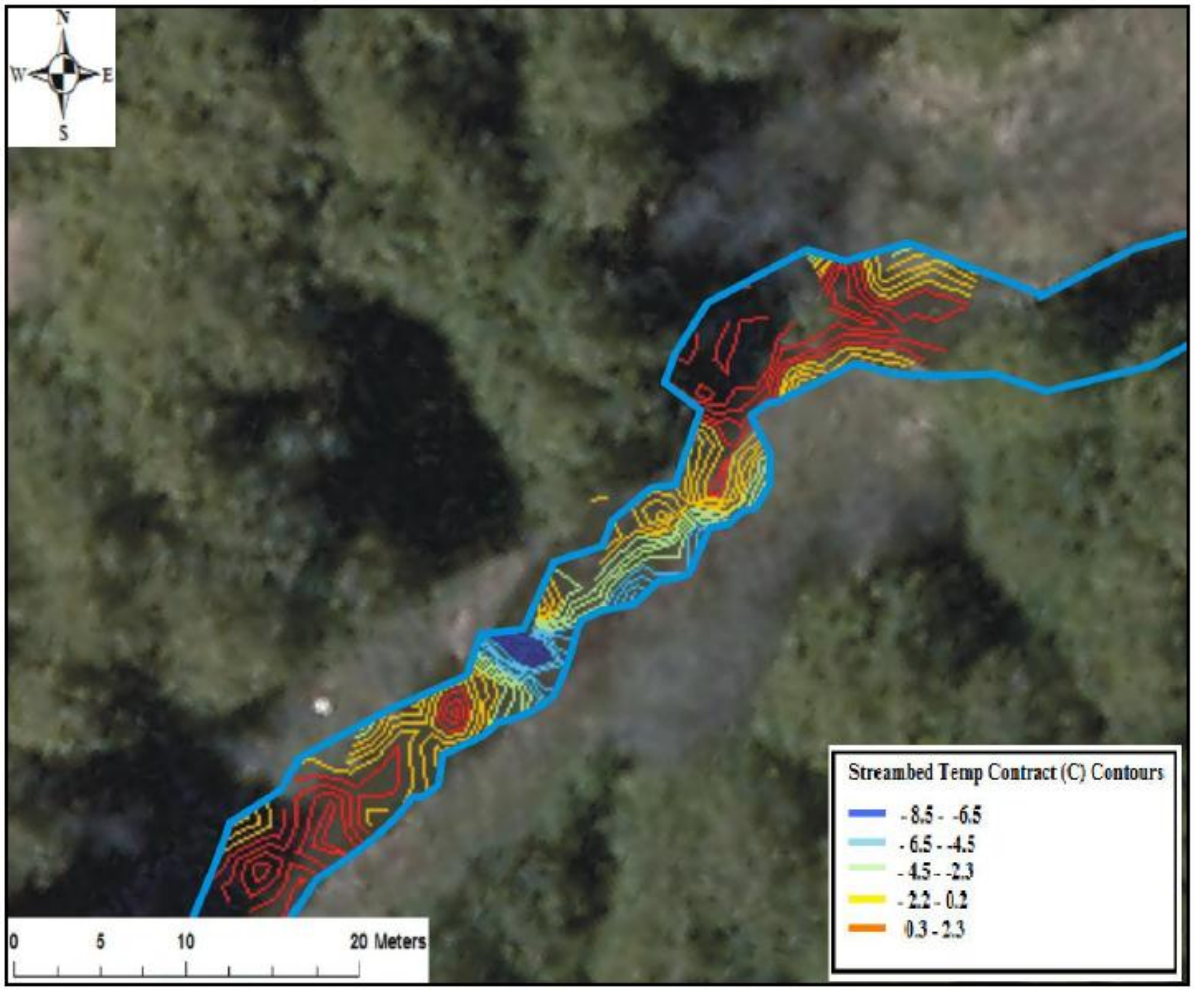
Traceurs géochimiques

Traceurs isotopiques (Carbone,Oxygène, $^{234}U/^{238}U$, ….)

Tracer les échanges, les temps de transfert ET les processus

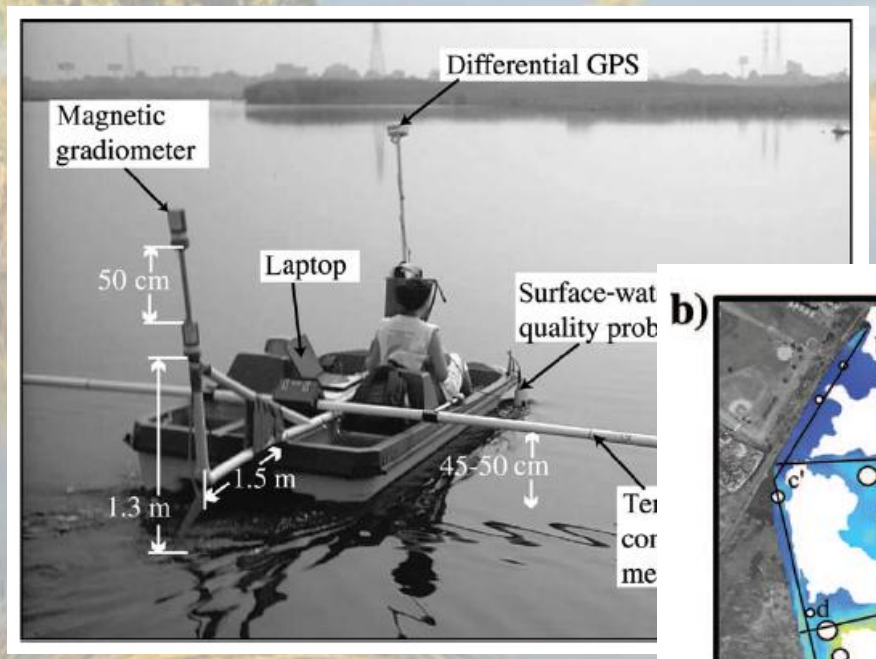
QUELQUES PISTES DE RECHERCHE …

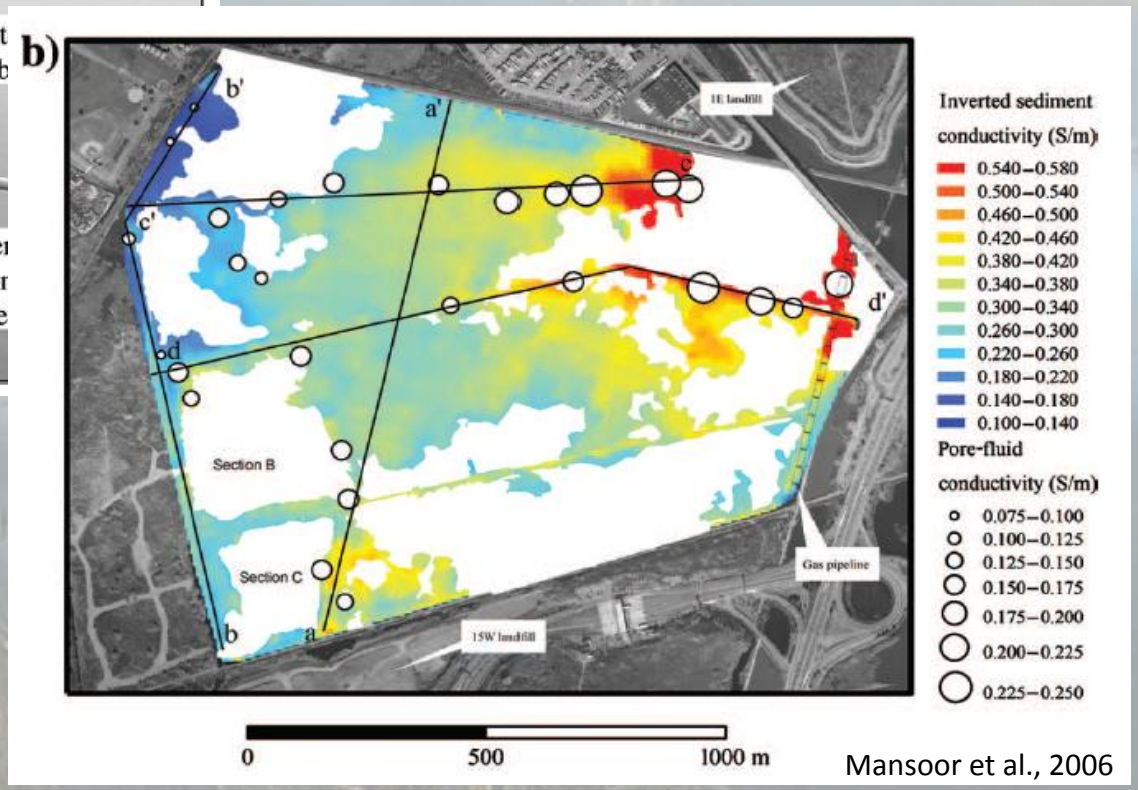
Les données aéroportées



QUELQUES PISTES DE RECHERCHE …

Les apports de la géophysique

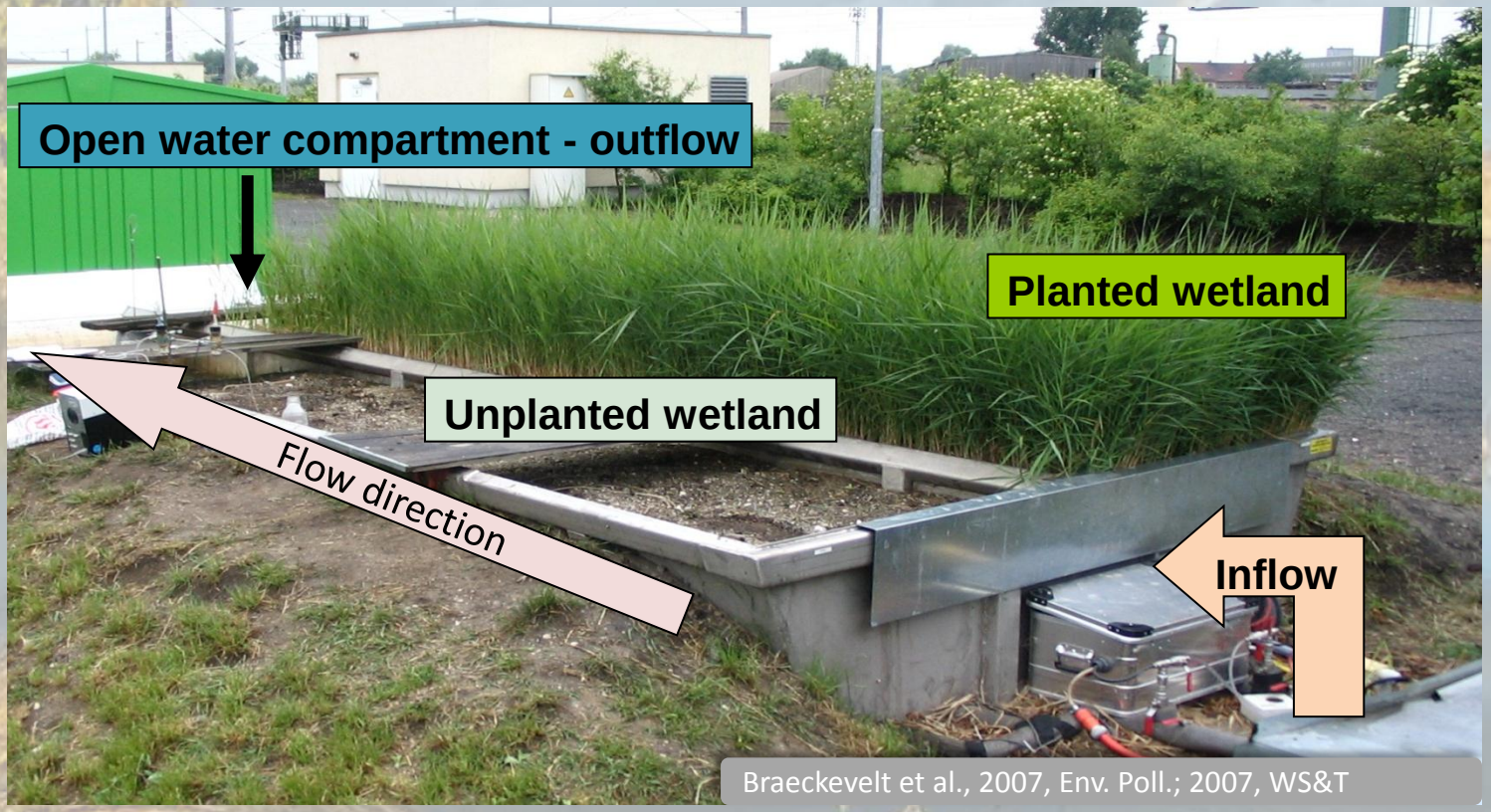




Mansoor et al., 2006

QUELQUES PISTES DE RECHERCHE …

L'expérimentation multi-échelle et contrôlée

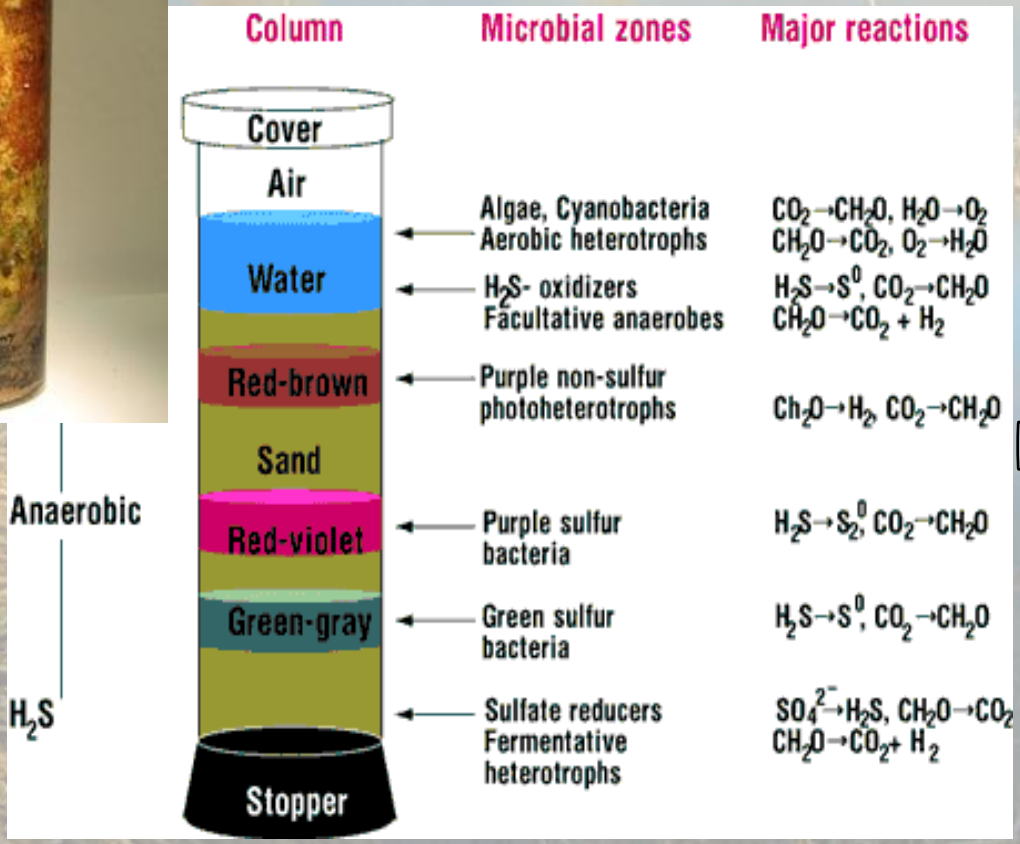


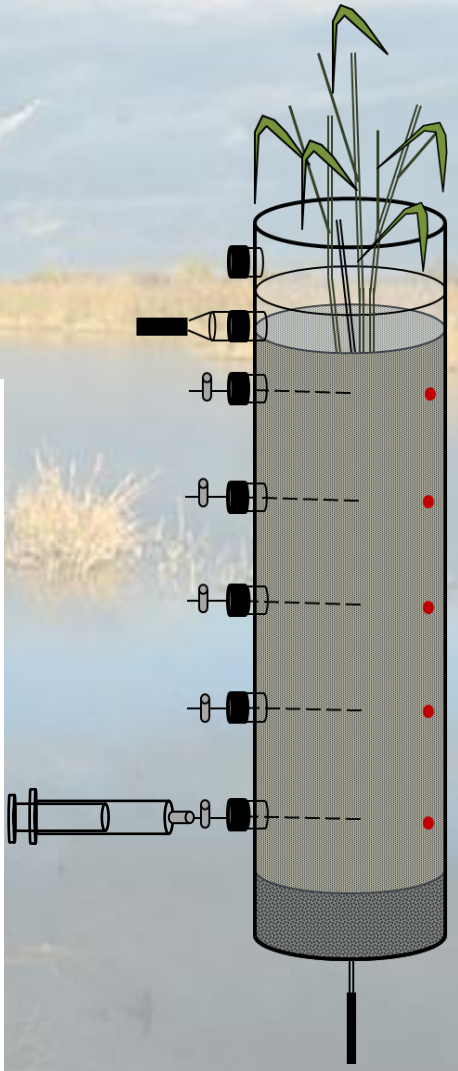
Braeckevelt et al., 2007, Env. Poll.; 2007, WS&T

QUELQUES PISTES DE RECHERCHE …

L'expérimentation multi-échelle et contrôlée

Winogradski column (1880's)





CONCLUSION …

Les Zones Humides ont un impact très fort sur les eaux souterraines: eau, matière, énergie.

Les transferts se font à travers une zone limitée où cohabitent:

Des forçages à temps caractéristiques très différents: battements de nappe, colmatage, biofilm, cycle de vie des animaux et végétaux, ….

Des processus couplés et fortement non linéaires, ….

Une originalité forte par rapport à d'autres compartiments des hydrosystèmes: les effets de la macrofaune et de la macroflore.

Quelques pistes:

Une observation multi-supports sur des sites pilotes.

Des expérimentations pluri-échelles en liens avec les sites pilotes.

Une amélioration de notre compréhension quantitative au travers des modélisations multi-processus.

P.S. : Merci à la MI au soutien de EC2CO, 'pourvu que ça dure'.

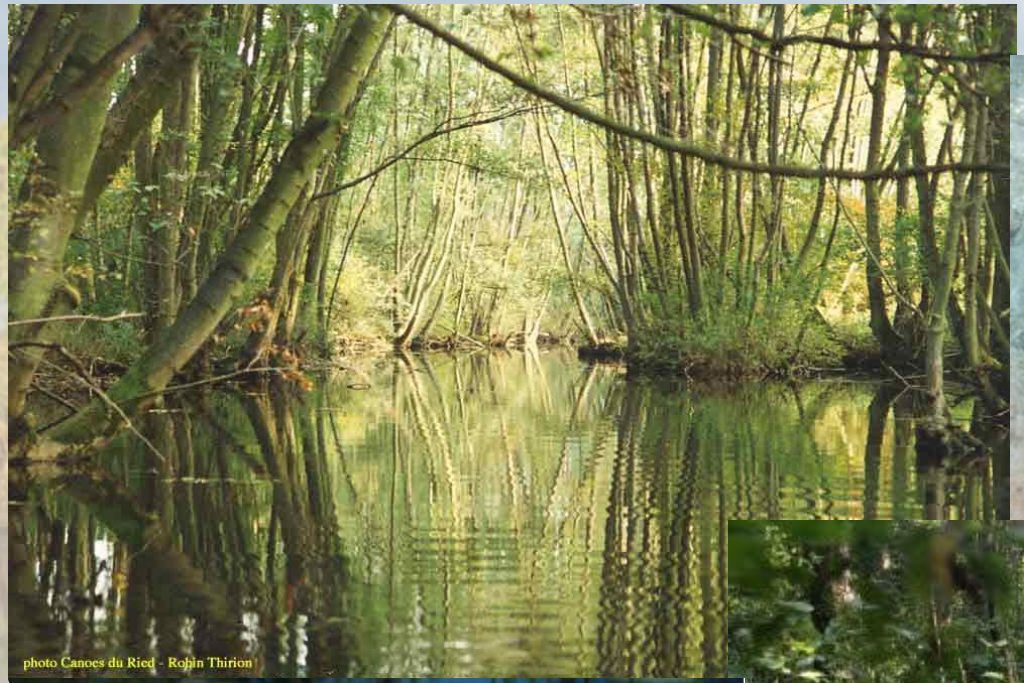
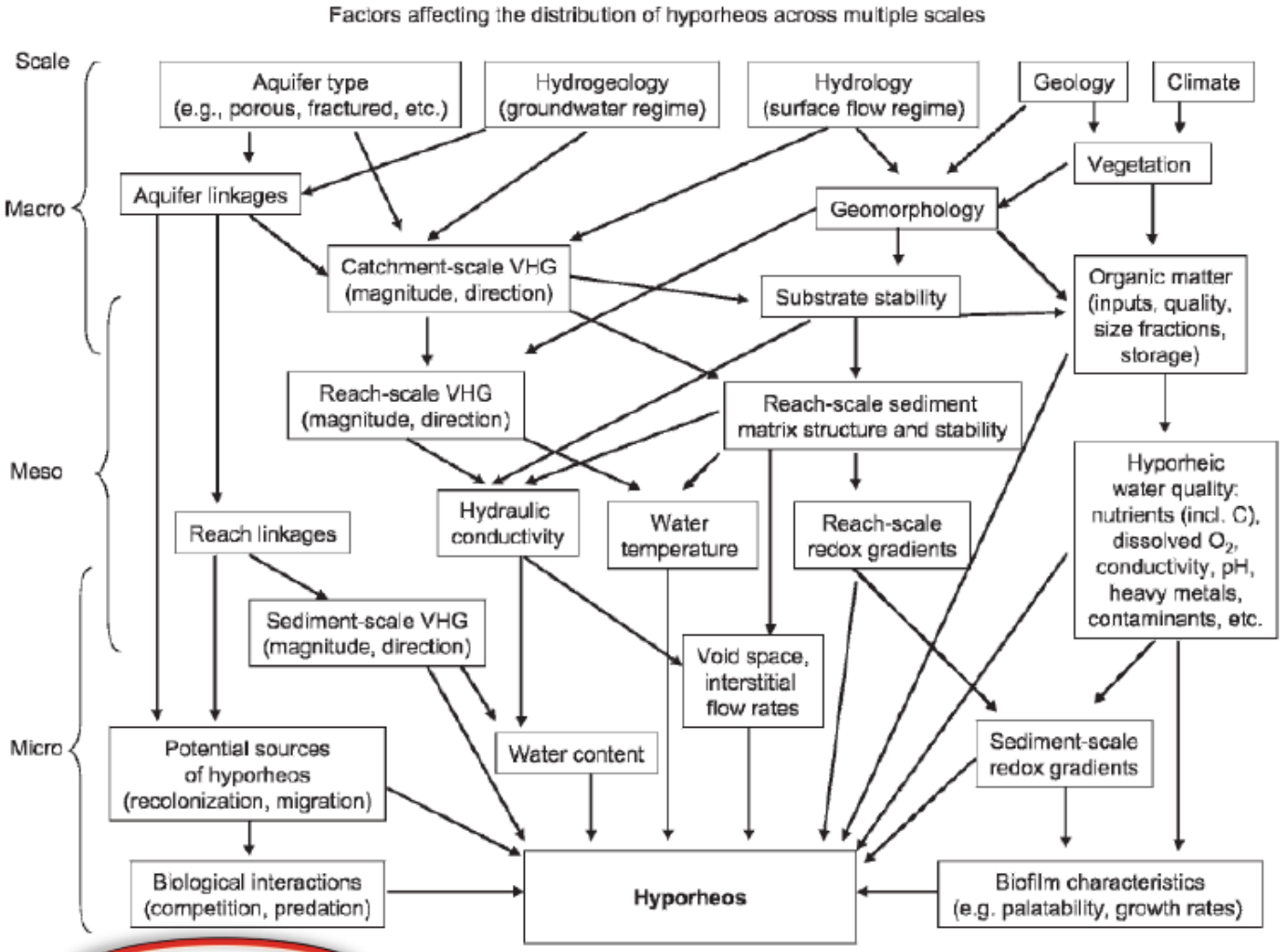


photo Canoes du Ried - Robin Thirion

MERCI POUR VOTRE ATTENTION

Boulton et al., 2010, J. NABS, 29: 26.



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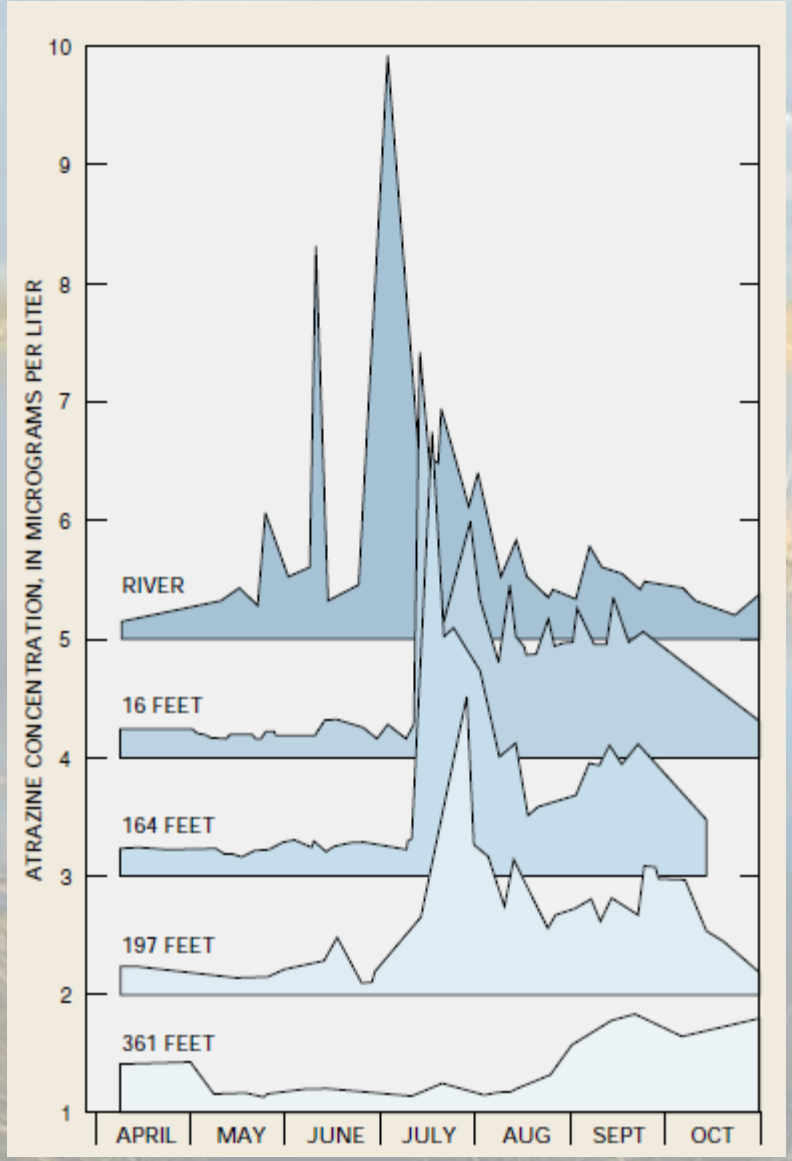
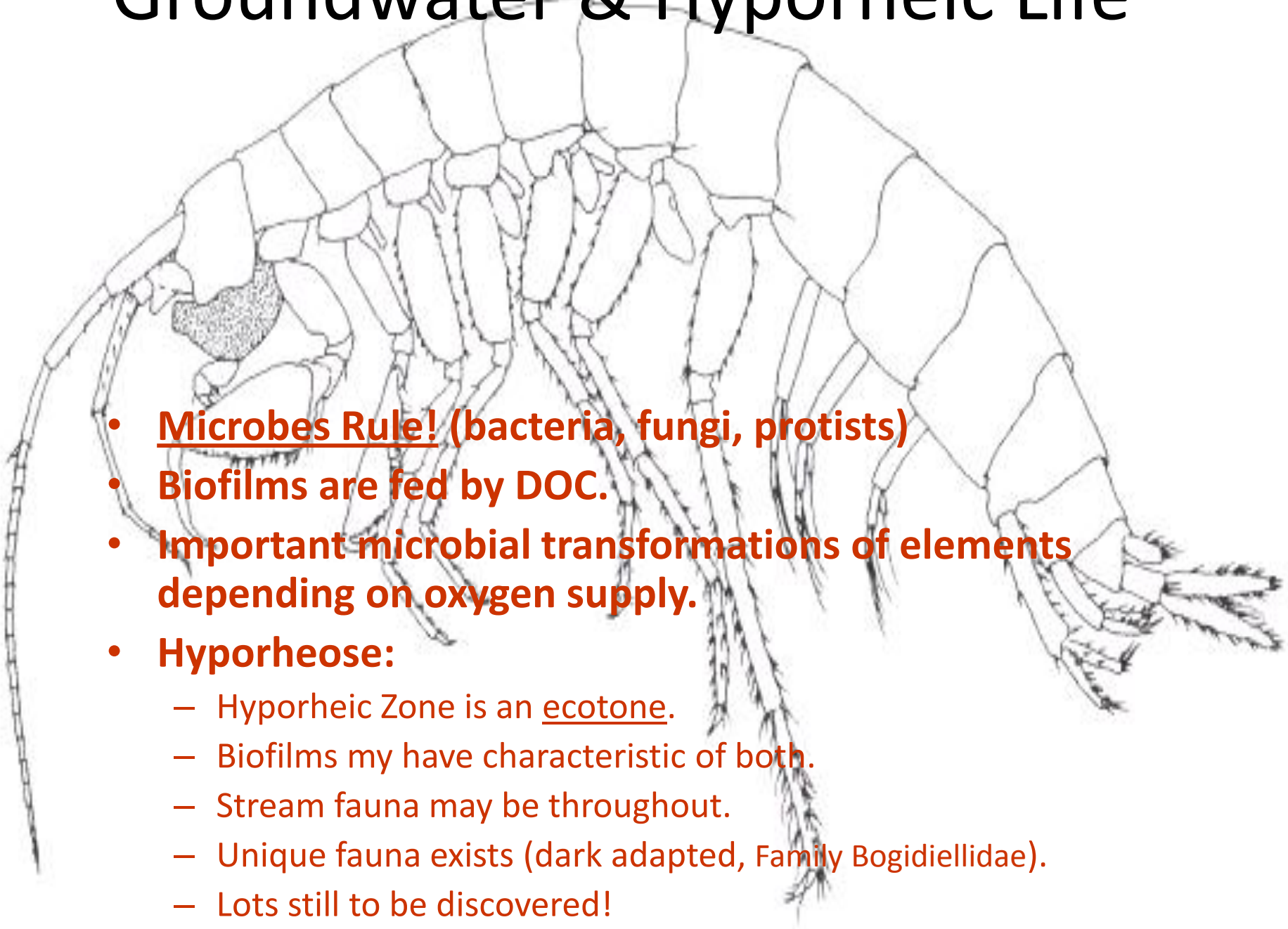

ATRAZINE CONCENTRATION, IN MICROGRAMS PER LITER
10
9
8
7
6
5
4
3
2
1
RIVER
16 FEET
164 FEET
197 FEET
361 FEET
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT

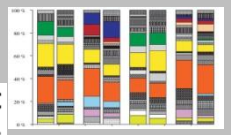
Groundwater & Hyporheic Life



- **Microbes Rule! (bacteria, fungi, protists)**
- **Biofilms are fed by DOC.**
- **Important microbial transformations of elements depending on oxygen supply.**
- **Hyporheose:**
  - Hyporheic Zone is an ecotone.
  - Biofilms my have characteristic of both.
  - Stream fauna may be throughout.
  - Unique fauna exists (dark adapted, Family Bogidiellidae).
  - Lots still to be discovered!

Analysis of chloroacetanilide herbicides

Microbiology

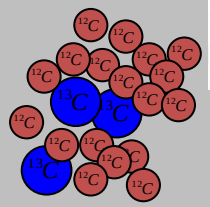
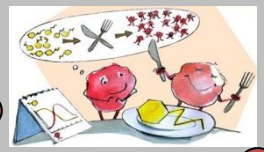
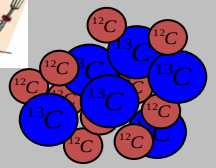


T-RFLP

Carbon stable isotope analysis

CSIA : Assessment of changes in the carbon isotopic signatures of the chloroacetamide molecules indicating biodegradation

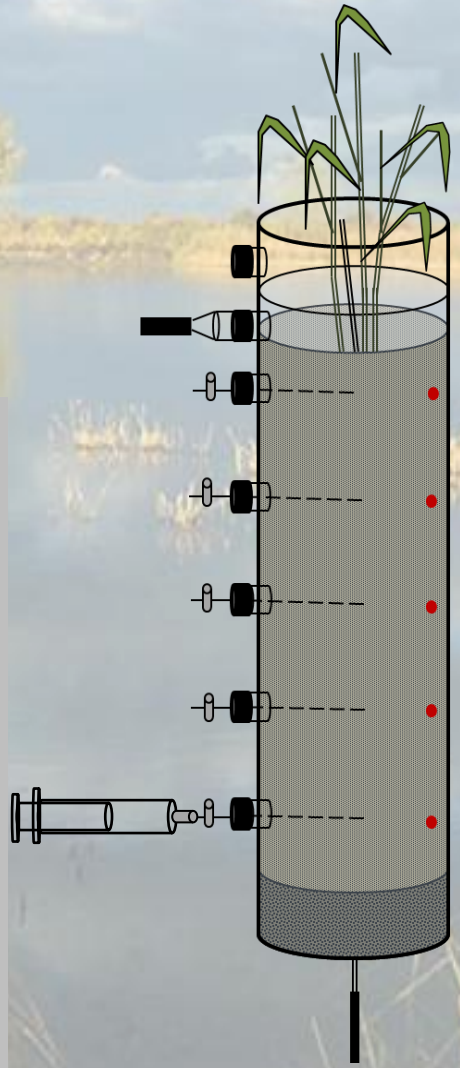
GC-C- IRMS

"Natural abundance" chloroacetamides:
^{12}C:^{13}C ~ 99:1

"Heavy" residual fraction:
^{13}C > 1%

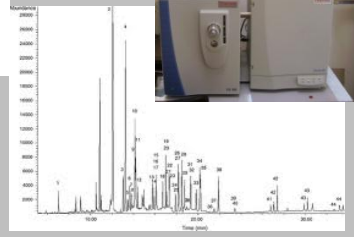
BIODEGRADATION (Preferential for ^{12}C chloroacetamides)



Investigation period : 112 d
Biweekly sampling

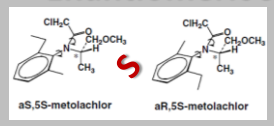
Chloroacetamides

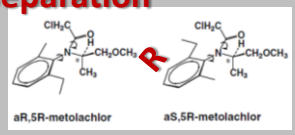
SPE



GC-MSMS

Enantiomeric separation





Degradation products analysis
LC-MS

Hydrochemistry

Anions
Cations
Carbon
Nutrients
Oxygen
...