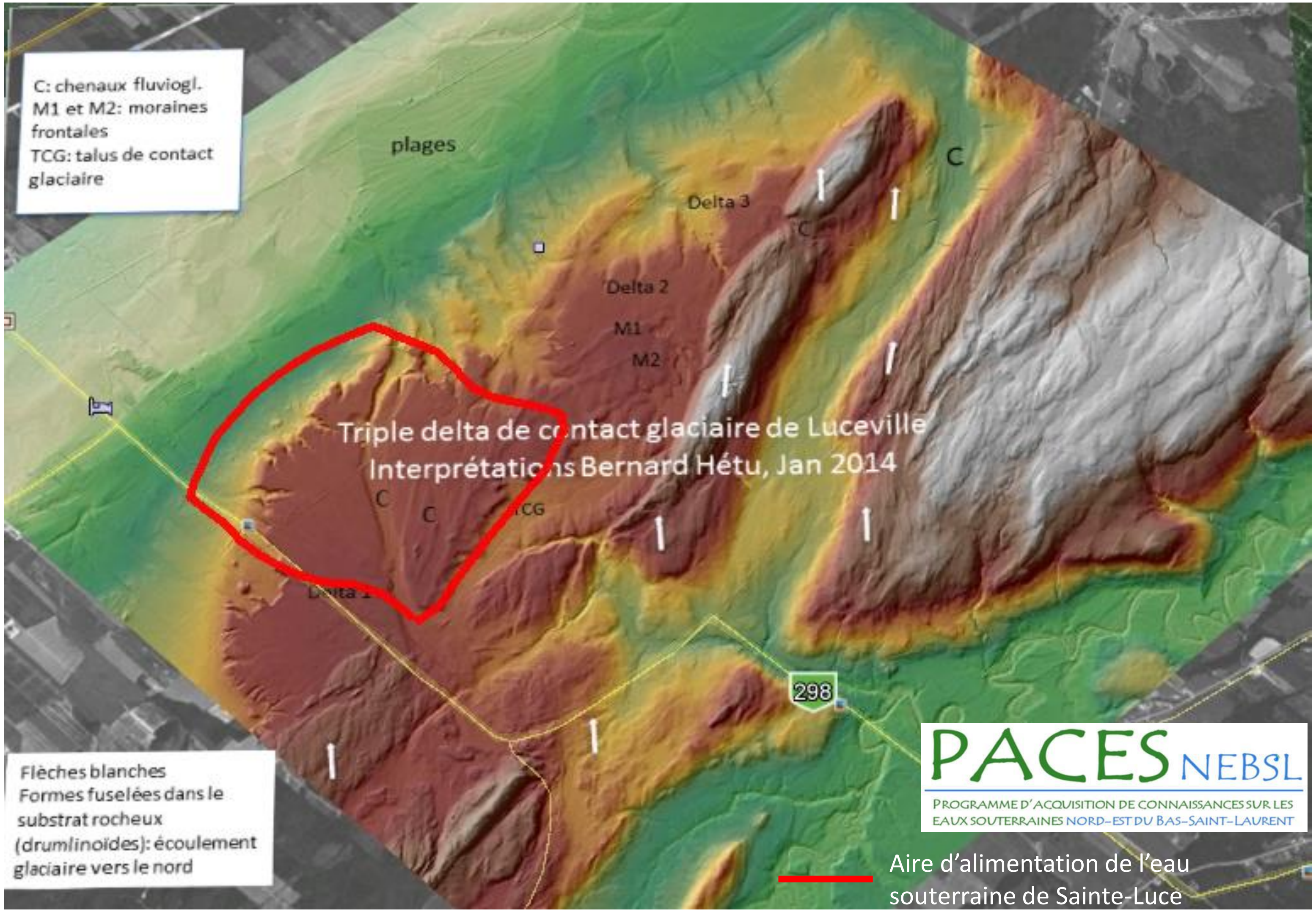
Cycle de l'azote : contribuer à une meilleure compréhension de la connectivité entre les eaux souterraines et les activités de surfaces en milieu agricole

Éric Filion, candidat à la maitrise en géographie à l'UQAR

Directrice : Gwénaelle Chaillou (UQAR)
Co-directeur : Richard Saint-Louis (UQAR)
Co-directeur : Louis Drainville (Terre-Eau inc.)

Les dépôts meubles du NEBSL

Le delta de contact glaciaire de Luceville

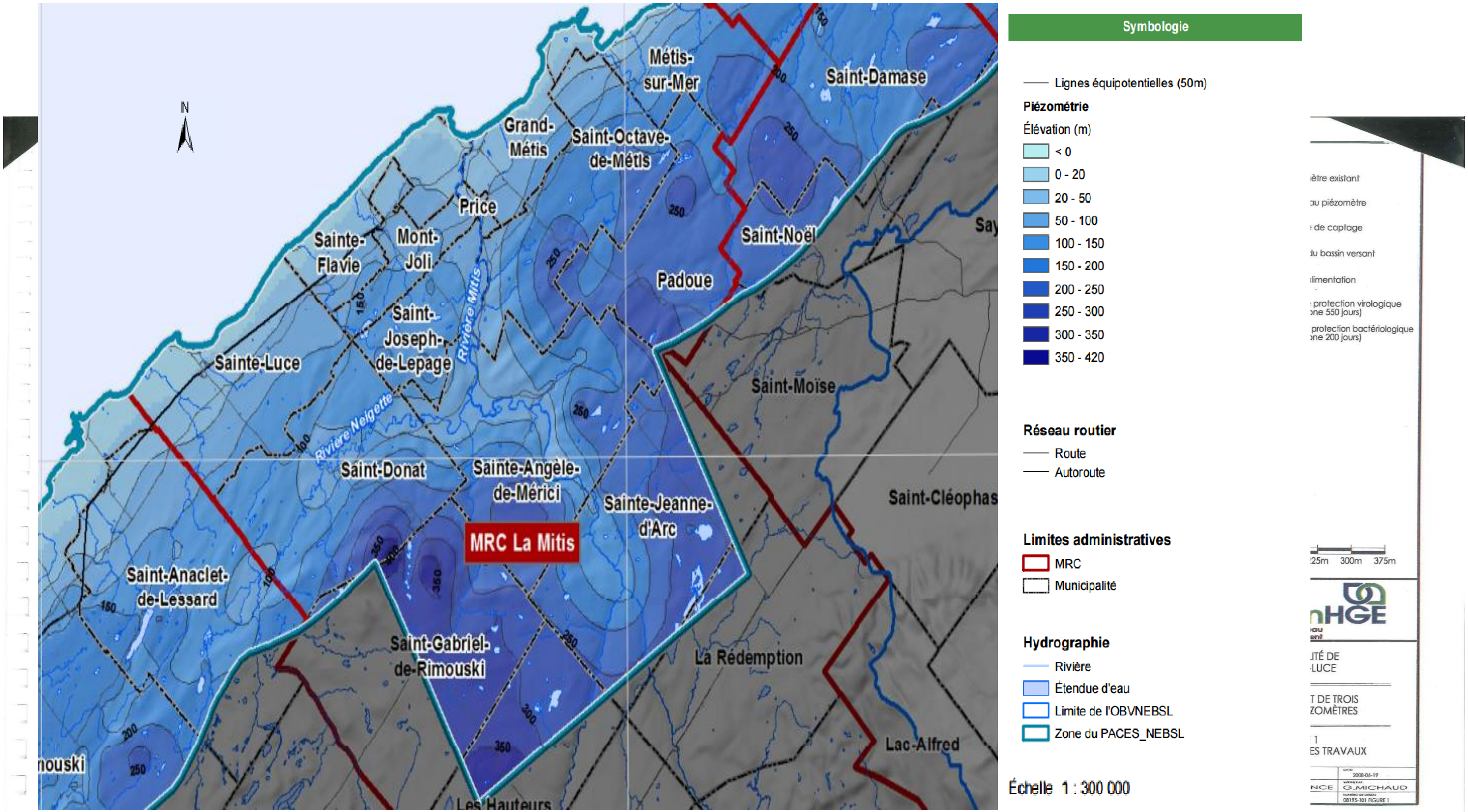


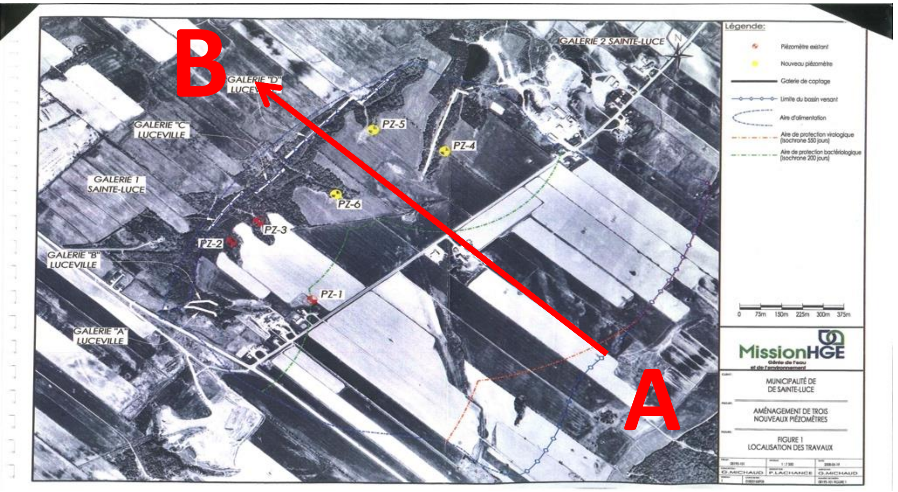
Aire d'alimentation de l'eau souterraine de Sainte-Luce

Delta de contact glaciaire de Luceville

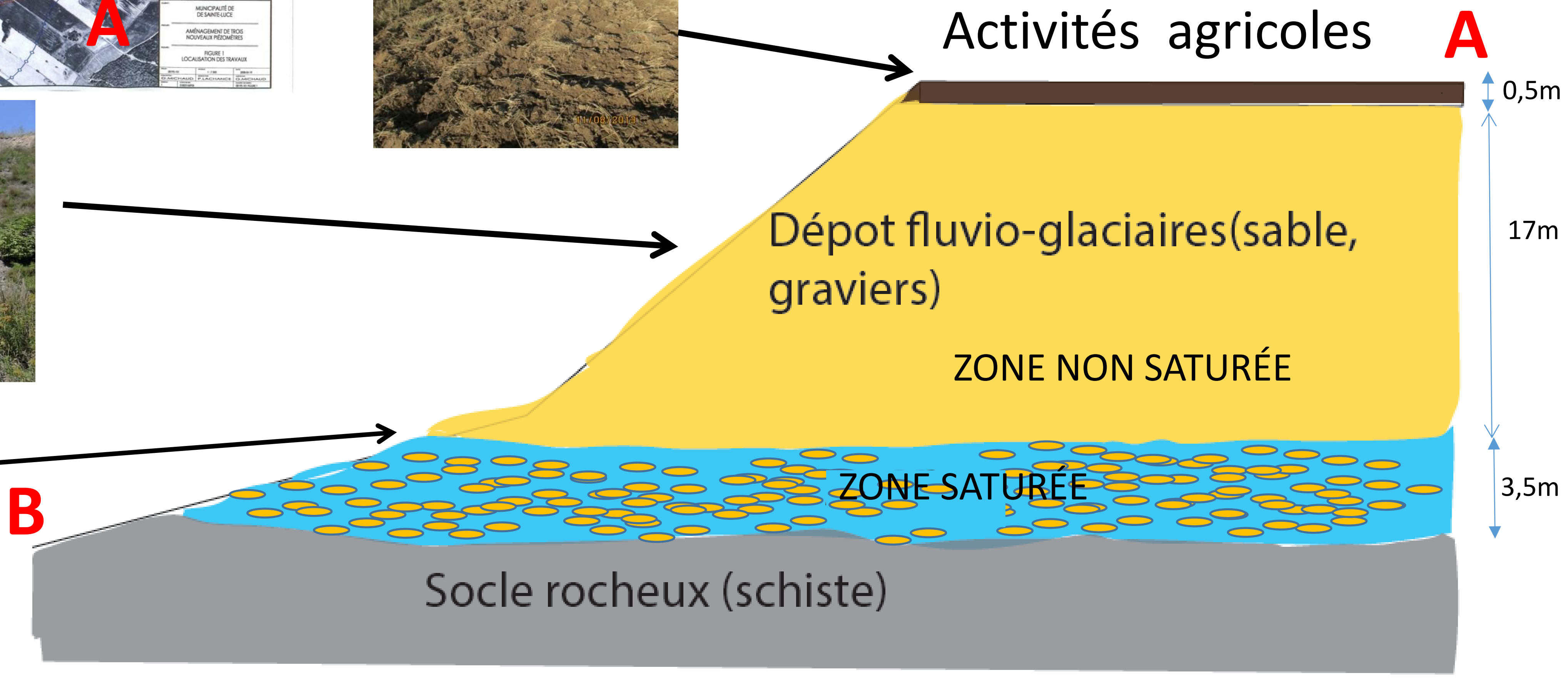
Dépôt fluvio-glaciaire

Dépôt fluvio-glaciaire

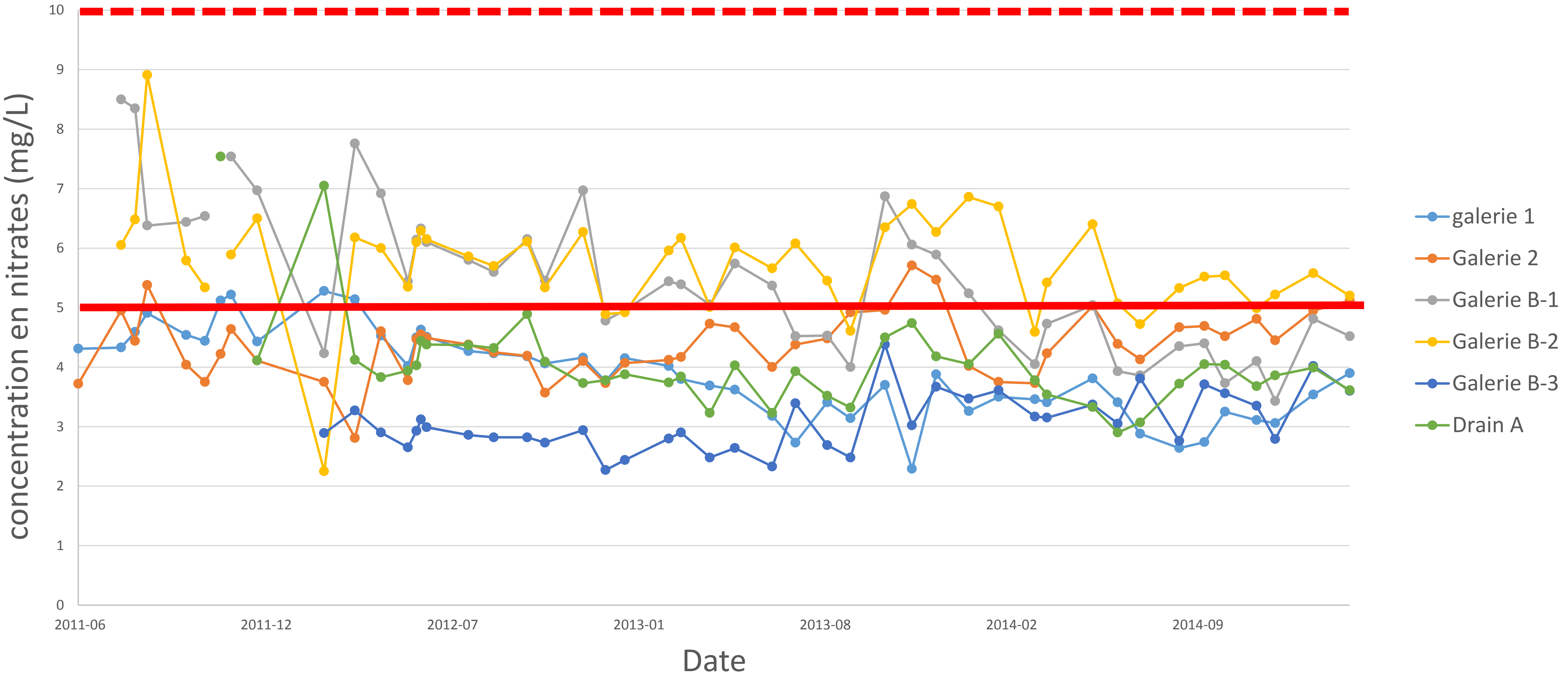

N
Métis-sur-Mer
Saint-Damase
Grand-Métis
Saint-Octave-de-Métis
Price
Sainte-Flavie
Mont-Joli
Saint-Noël
Padoue
Saint-Joseph-de-Lepage
Rivière Mitis
Sainte-Luce
Rivière Neigette
Saint-Moïse
Saint-Donat
Sainte-Angèle-de-Mérici
Sainte-Jeanne-d'Arc
Saint-Cléophas
MRC La Mitis
Saint-Anaclet-de-Lessard
Saint-Gabriel-de-Rimouski
La Rédemption
Lac-Alfred
Les Hauteurs
Say
150
250
200
100
350
300
400
Symbologie
Lignes équipotentielles (50m)
Piézométrie
Élévation (m)
< 0
0 - 20
20 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
350 - 420
Réseau routier
Route
Autoroute
Limites administratives
MRC
Municipalité
Hydrographie
Rivière
Étendue d'eau
Limite de l'OBVNEBSL
Zone du PACES_NEBSL
Échelle 1 : 300 000
de captage
du bassin versant
protection virologique
protection bactériologique
300m
375m
HGE
T DE TROIS
ES TRAVAUX
G.MICHAUD


B
A
Légende:
GALERIE 2 SAINTE-LUCE
GALERIE "C" LUCEVILLE
GALERIE 1 SAINTE-LUCE
GALERIE "B" LUCEVILLE
GALERIE "A" LUCEVILLE
PZ-1
PZ-2
PZ-3
PZ-4
PZ-5
PZ-6
MissionHGE

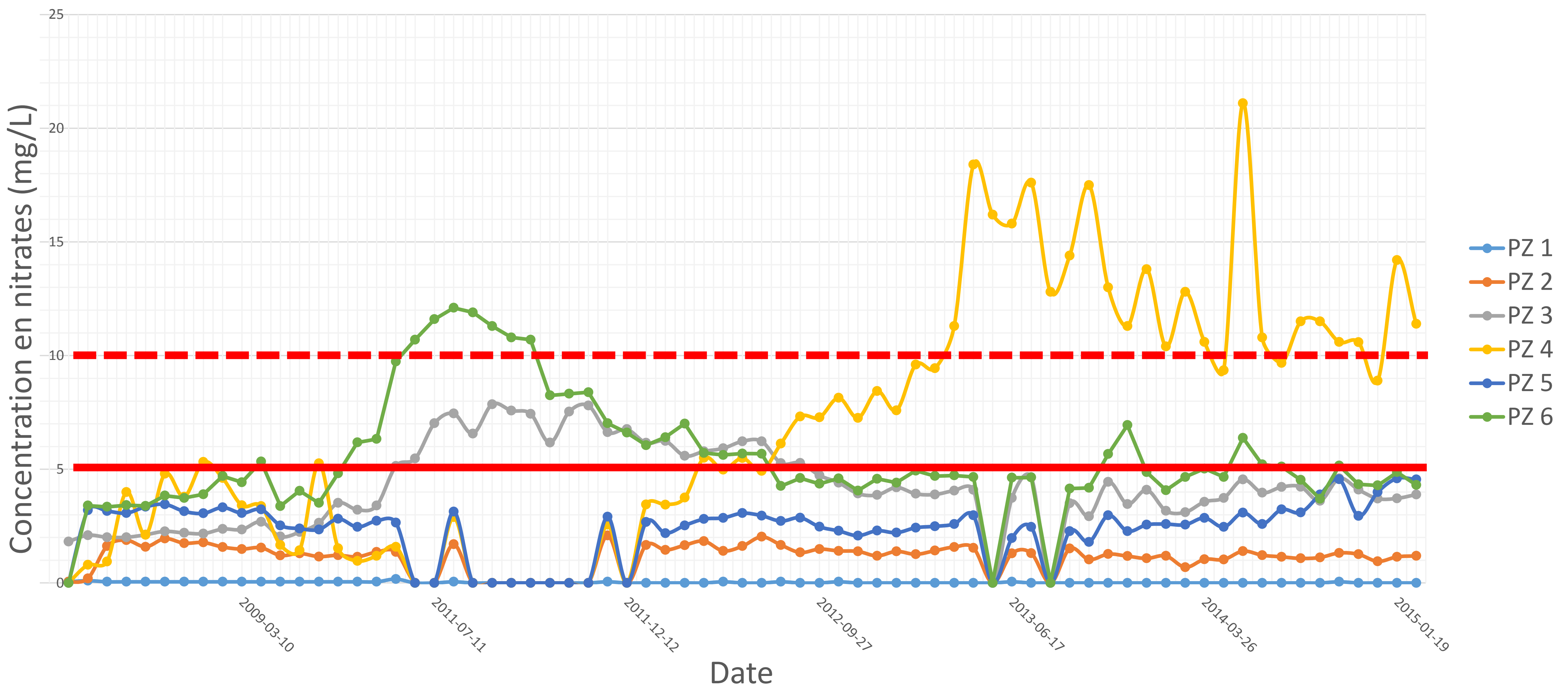

Localisation du début de la galerie


Activités agricoles
A
0,5m
Dépot fluvio-glaciaires(sable, graviers)
ZONE NON SATURÉE
17m
ZONE SATURÉE
3,5m
B
Socle rocheux (schiste)

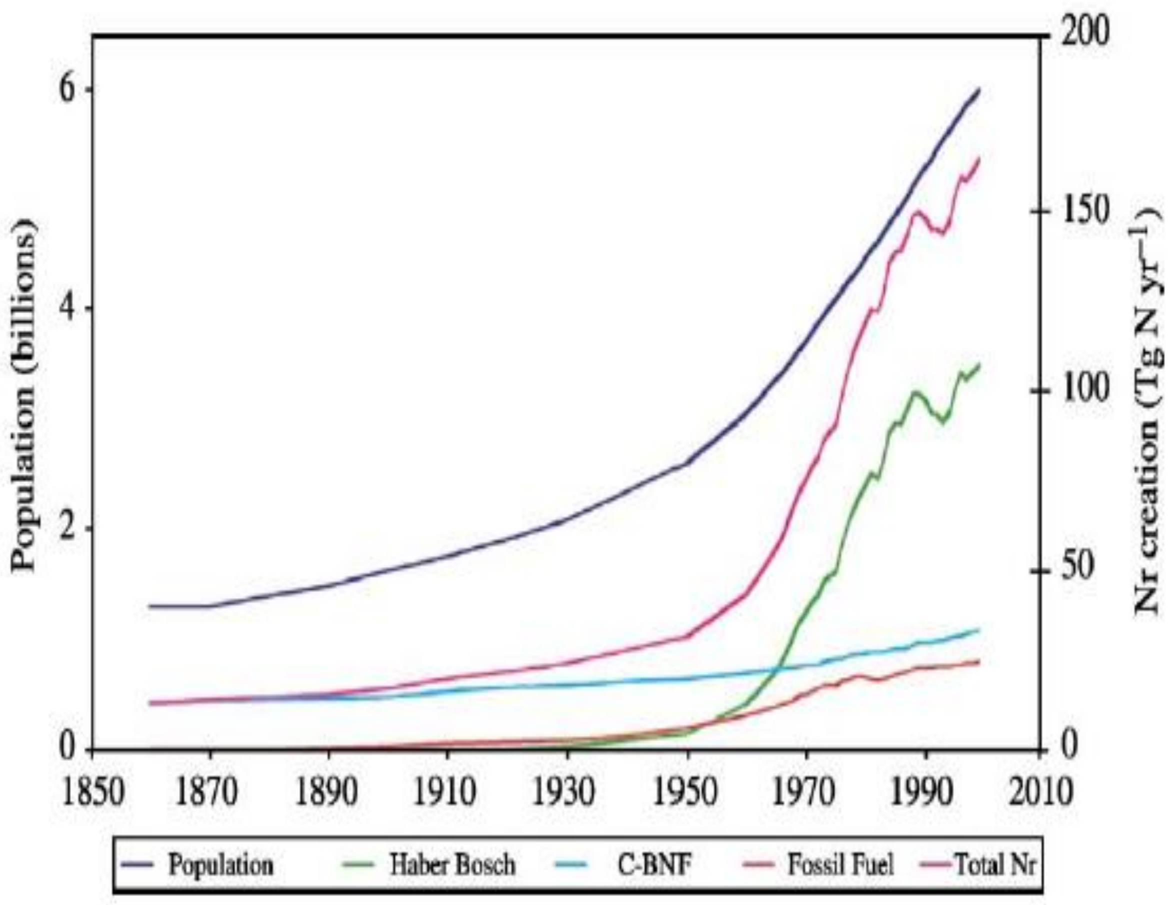
Concentration en nitrates dans les ouvrages de captation de l'eau souterraine de Sainte-Luce



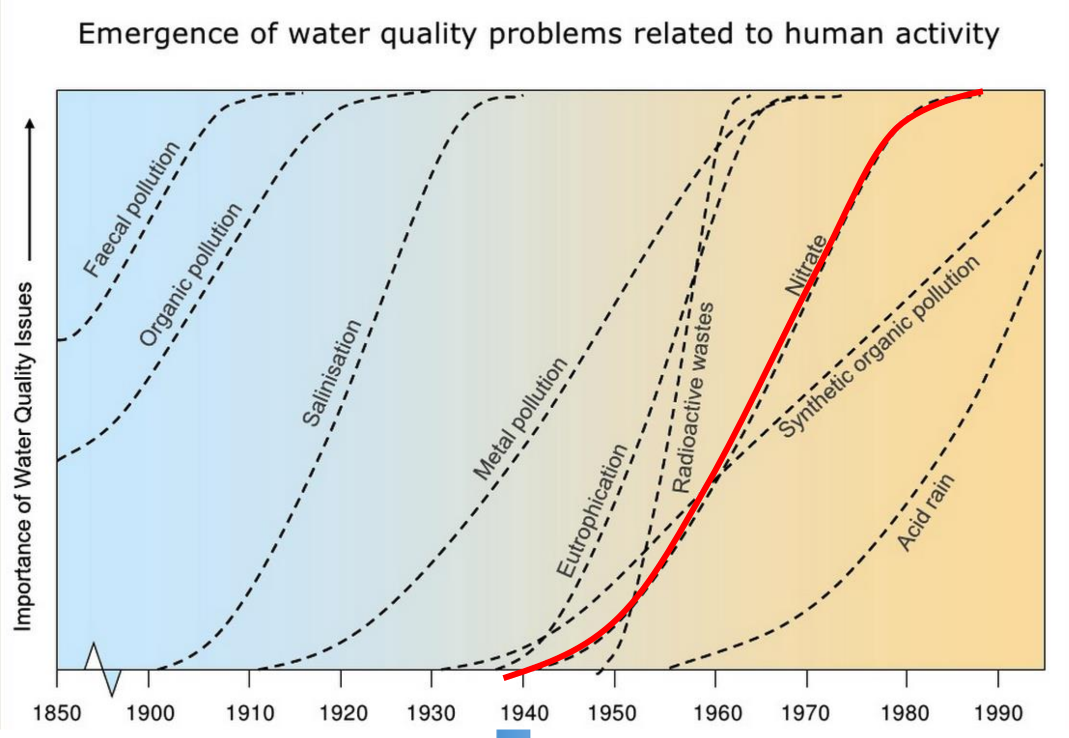
Concentration en nitrates dans les piézomètres d'observation de l'eau souterraine de Sainte-Luce



Enjeu local, problématique mondiale…



Galloway, 2003



UNESCO,2006

Lien étroit entre l'agriculture intensive et la contamination de l'eau souterraine par les nitrates (Primeau et Grimard 1989, Bergstrom et Jarvis, 1991.)

Enjeu local, problématique mondiale…

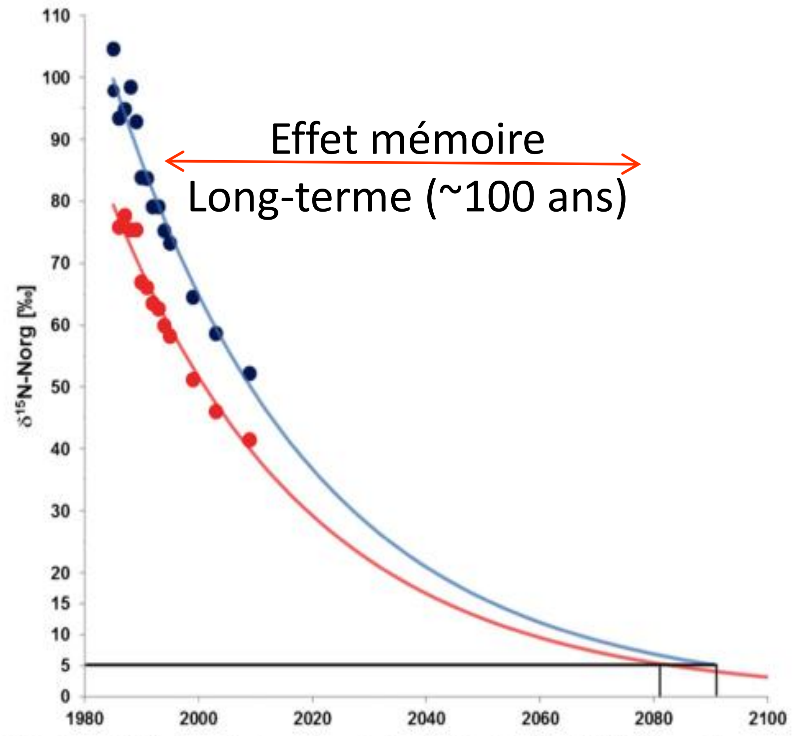
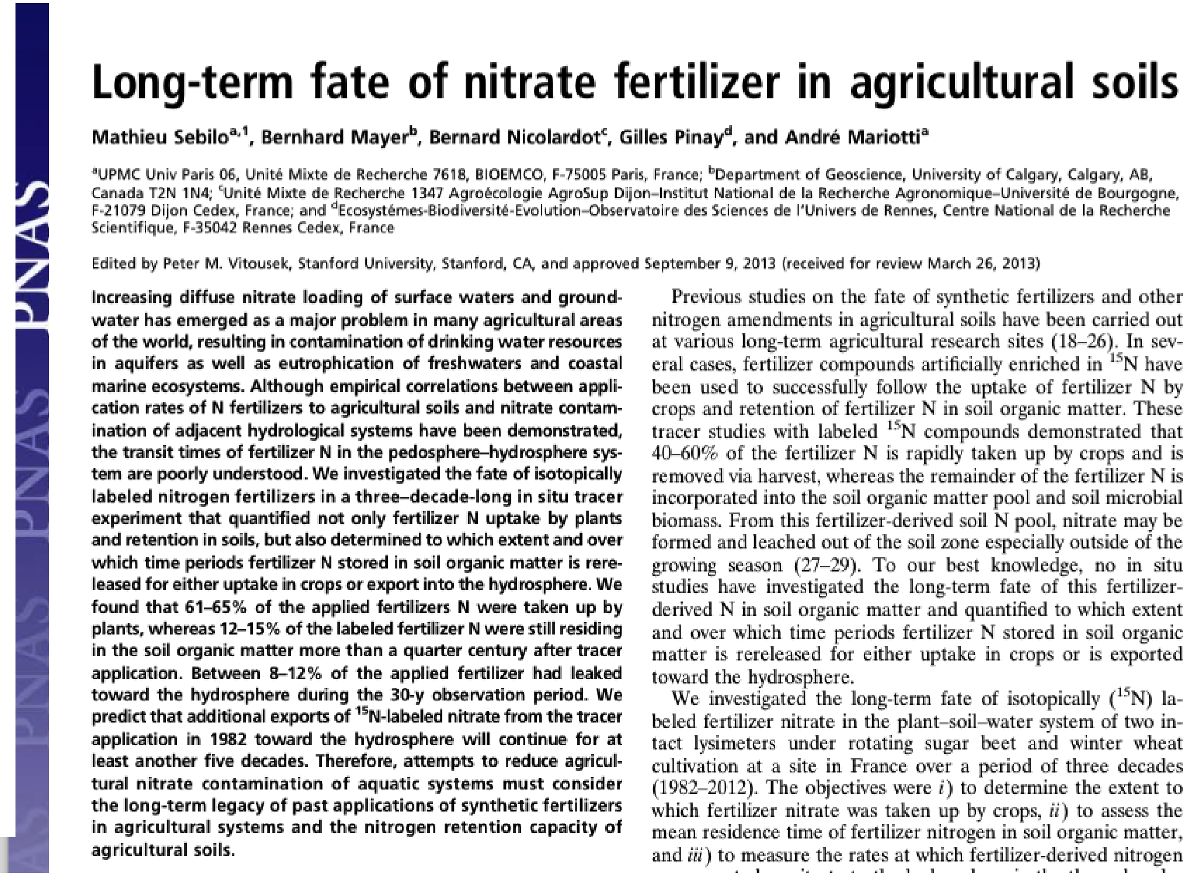


Fig. 3. Decay functions fitted to observed $\delta^{15}N$ values of soil organic matter from Lys S (red) and Lys W (blue). The model suggests that it will take circa 100 y to reach the background $\delta^{15}N$ values of circa +5‰ observed before tracer application.



PNAS

Long-term fate of nitrate fertilizer in agricultural soils

Mathieu Sebilo[a,1], Bernhard Mayer[b], Bernard Nicolardot[c], Gilles Pinay[d], and André Mariotti[a]

[a]UPMC Univ Paris 06, Unité Mixte de Recherche 7618, BIOEMCO, F-75005 Paris, France; [b]Department of Geoscience, University of Calgary, Calgary, AB, Canada T2N 1N4; [c]Unité Mixte de Recherche 1347 Agroécologie AgroSup Dijon–Institut National de la Recherche Agronomique–Université de Bourgogne, F-21079 Dijon Cedex, France; and [d]Ecosystémes-Biodiversité-Evolution–Observatoire des Sciences de l'Univers de Rennes, Centre National de la Recherche Scientifique, F-35042 Rennes Cedex, France

Edited by Peter M. Vitousek, Stanford University, Stanford, CA, and approved September 9, 2013 (received for review March 26, 2013)

Increasing diffuse nitrate loading of surface waters and groundwater has emerged as a major problem in many agricultural areas of the world, resulting in contamination of drinking water resources in aquifers as well as eutrophication of freshwaters and coastal marine ecosystems. Although empirical correlations between application rates of N fertilizers to agricultural soils and nitrate contamination of adjacent hydrological systems have been demonstrated, the transit times of fertilizer N in the pedosphere–hydrosphere system are poorly understood. We investigated the fate of isotopically labeled nitrogen fertilizers in a three–decade-long in situ tracer experiment that quantified not only fertilizer N uptake by plants and retention in soils, but also determined to which extent and over which time periods fertilizer N stored in soil organic matter is rereleased for either uptake in crops or export into the hydrosphere. We found that 61–65% of the applied fertilizers N were taken up by plants, whereas 12–15% of the labeled fertilizer N were still residing in the soil organic matter more than a quarter century after tracer application. Between 8–12% of the applied fertilizer had leaked toward the hydrosphere during the 30-y observation period. We predict that additional exports of ^{15}N-labeled nitrate from the tracer application in 1982 toward the hydrosphere will continue for at least another five decades. Therefore, attempts to reduce agricultural nitrate contamination of aquatic systems must consider the long-term legacy of past applications of synthetic fertilizers in agricultural systems and the nitrogen retention capacity of agricultural soils.

Previous studies on the fate of synthetic fertilizers and other nitrogen amendments in agricultural soils have been carried out at various long-term agricultural research sites (18–26). In several cases, fertilizer compounds artificially enriched in ^{15}N have been used to successfully follow the uptake of fertilizer N by crops and retention of fertilizer N in soil organic matter. These tracer studies with labeled ^{15}N compounds demonstrated that 40–60% of the fertilizer N is rapidly taken up by crops and is removed via harvest, whereas the remainder of the fertilizer N is incorporated into the soil organic matter pool and soil microbial biomass. From this fertilizer-derived soil N pool, nitrate may be formed and leached out of the soil zone especially outside of the growing season (27–29). To our best knowledge, no in situ studies have investigated the long-term fate of this fertilizer-derived N in soil organic matter and quantified to which extent and over which time periods fertilizer N stored in soil organic matter is rereleased for either uptake in crops or is exported toward the hydrosphere.

We investigated the long-term fate of isotopically (^{15}N) labeled fertilizer nitrate in the plant–soil–water system of two intact lysimeters under rotating sugar beet and winter wheat cultivation at a site in France over a period of three decades (1982–2012). The objectives were *i*) to determine the extent to which fertilizer nitrate was taken up by crops, *ii*) to assess the mean residence time of fertilizer nitrogen in soil organic matter, and *iii*) to measure the rates at which fertilizer-derived nitrogen

Sebilo et al 2013

Importance du cycle de l’azote dans le sol

erine nitrate loading (41–45).

Our findings reinforce the importance of soil organic matter management in agricultural soils as a buffer to mitigate diffuse nitrogen pollution of surface waters and groundwaters. They stress the need to take into account this long-term N-recycling component in soil N and catchment models to better understand and simulate nitrate-leaching lag times often observed between fertilizer N applications to soils and nitrate transfers in drainage basins. Our data also imply that the current trends of nitrate concentration increases observed in hydrological systems associated with many agricultural areas of the world are the result of both current and past activities throughout the last decades. Therefore, mitigation or restoration measures must take into account the delay resulting from legacies of past applications of synthetic fertilizers in agricultural systems.

Sebilo et al., 2013

pH

Climat

Teneur en oxygène

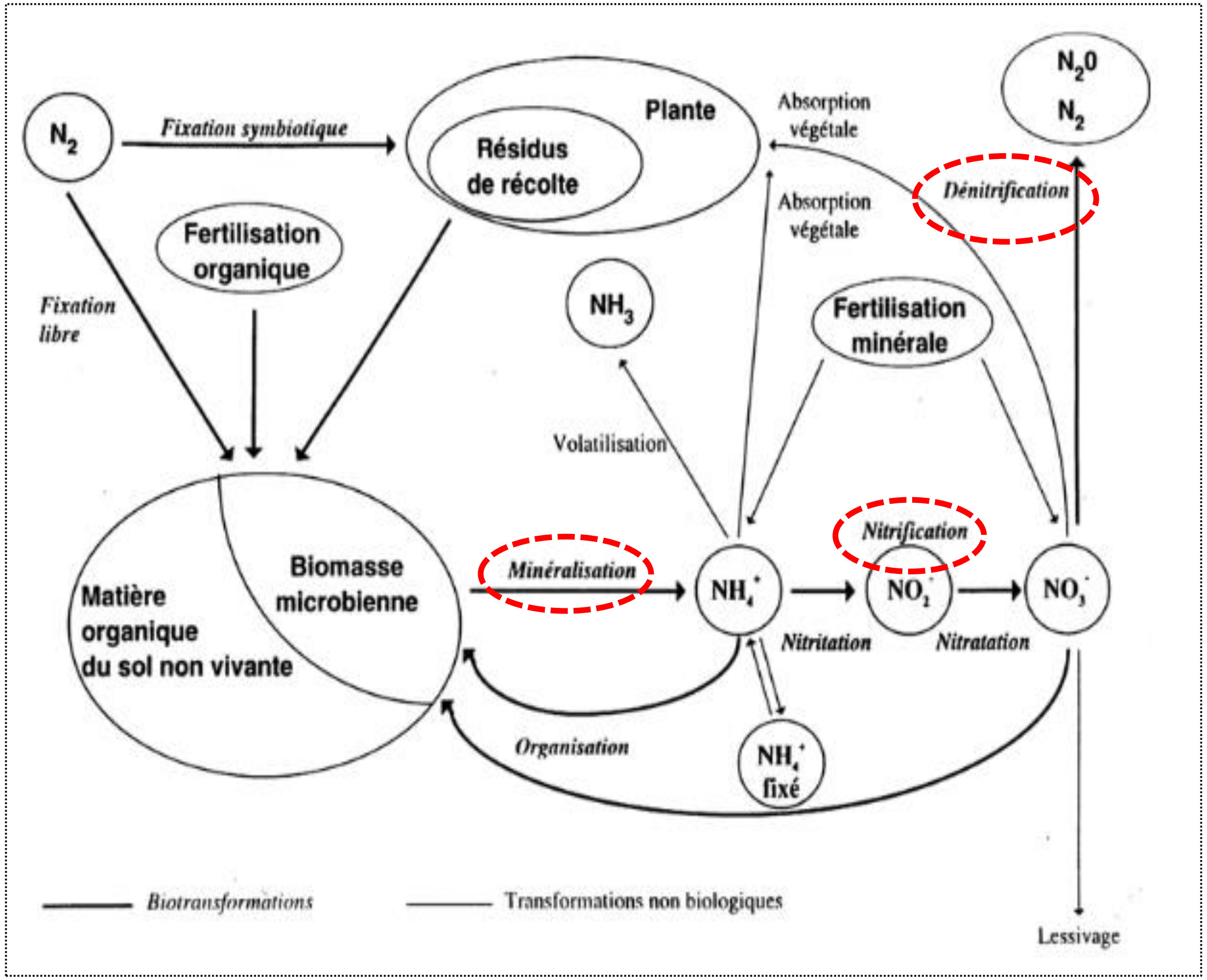
Type de culture

Population microbienne

Rapport C/N

Texture du sol

% de matière organique



Cycle de l’azote dans le sol, Nicolardot et al. 1997

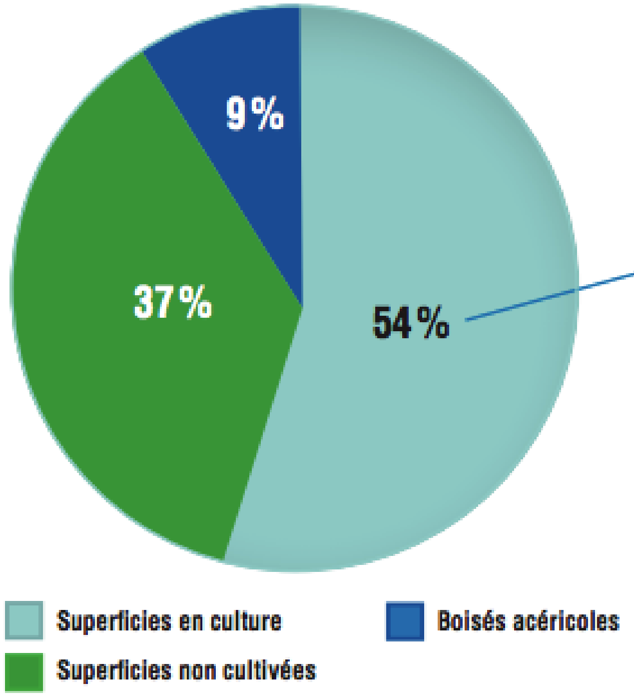
Un équilibre spécifique

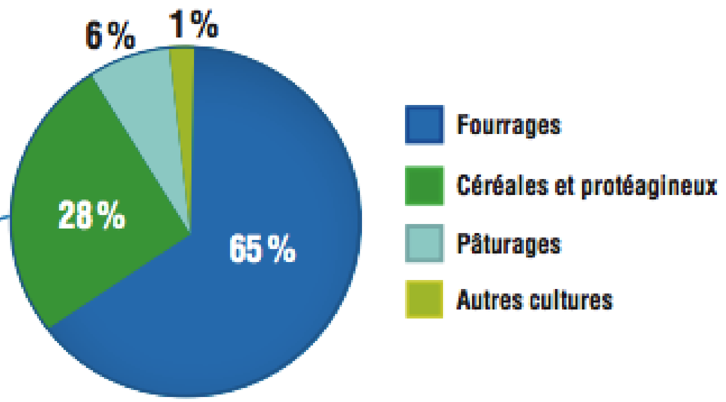
$\downarrow\downarrow NO_3^-$

$\uparrow\uparrow NO_3^-$

Importance de l'agriculture dans le portrait socio-économique de la région BSL

Figure 4 : Répartition des superficies agricoles au Bas-Saint-Laurent en 2010





Source : MAPAQ. *Fiche d'enregistrement des exploitations agricoles 2010.*

La figure ci-dessus démontre l'importance des superficies en cultures fourragères, celles-ci étant principalement destinées à l'alimentation animale, en concordance avec la prédominance des productions animales. Par ailleurs, le secteur privé s'intéresse de plus en plus à la production et à la commercialisation des fourrages.

MAPAQ, 2012

Quelle est la dynamique de l’azote dans les sols agricoles du BSL?

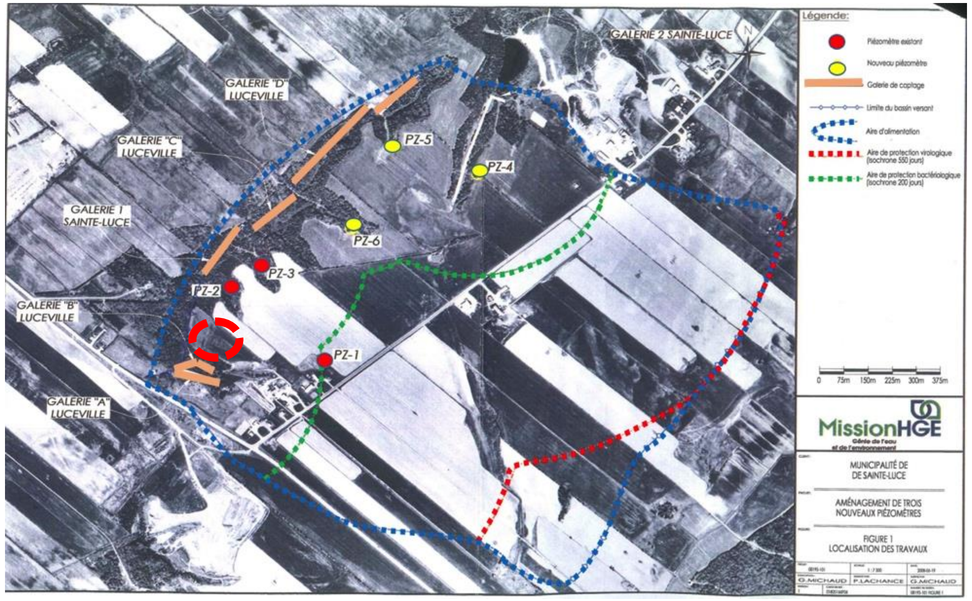
Cas de Luceville: un laboratoire naturel pour l’étude du lessivage de l’azote dans les sols de la série Neigette (loam à loam limoneux très graveleux) de la région

Objectifs:

- 1) Documenter le bilan de l’azote dans les sols d’une parcelle expérimentale

- 2) Déterminer les effets du chaulage et d’un amendement organique sur la dynamique du cycle de l’azote et sur les concentrations en nitrates dans l’eau souterraine.

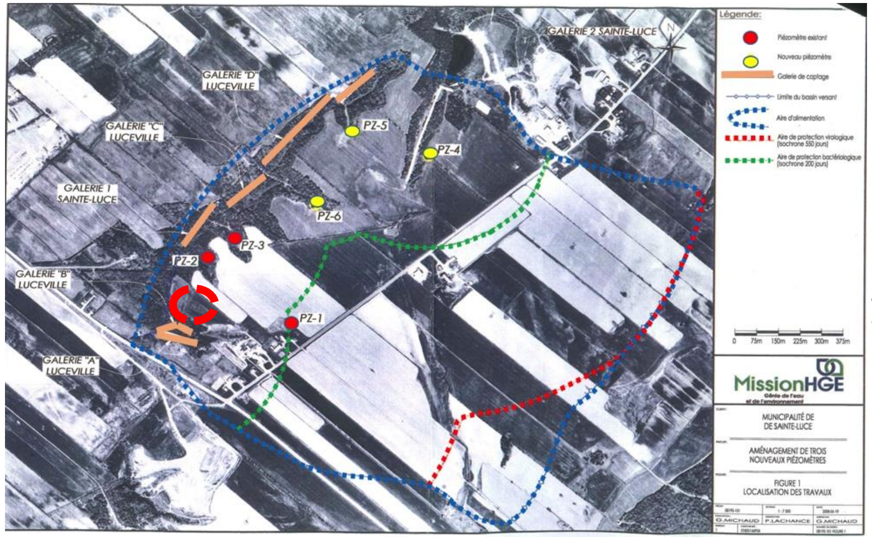
Parcelle expérimentale

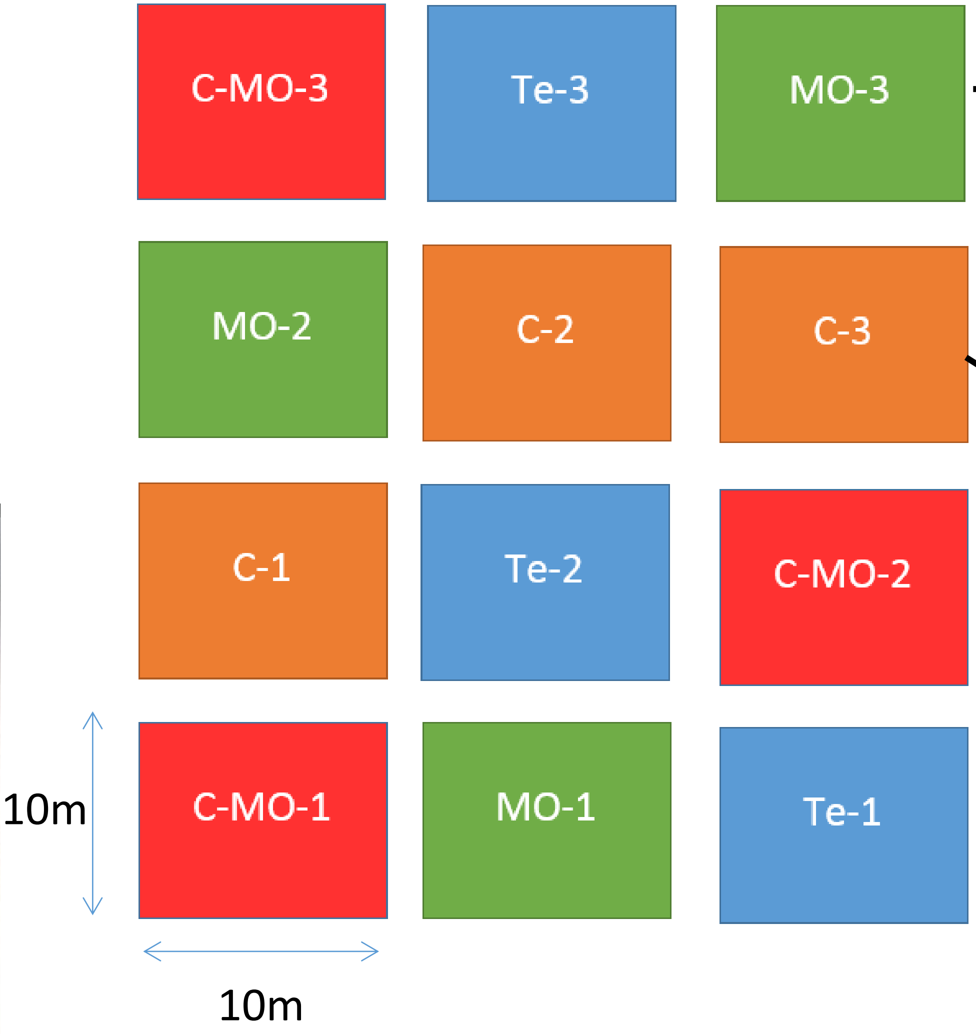


N total (%)	0.29	C / N	13.3
N-NO3 (ppm)	4.4	N-NH4 (ppm)	
Conductivité électrique (mmhos/cm)		Fer (ppm)	334
Texture	Sable %	Limon %	Argile %
	44.0	30.1	25.9
Classe texturale		L	
Type de sol		Léger	
Densité estimée g/cm3		Moyenne	0.99
Porosité estimée %		Moyenne	61.0
Perméabilité estimée		perméable	
Coefficient de perméabilité estimée cm / h		2	Bon
Coefficient réserve eau utile (CRU) g eau / 100 g sol sec		19.0	Bon

Caractéristique de la parcelle expérimentale (rapport de Terre-Eau inc. 2013)

Parcelle expérimentale

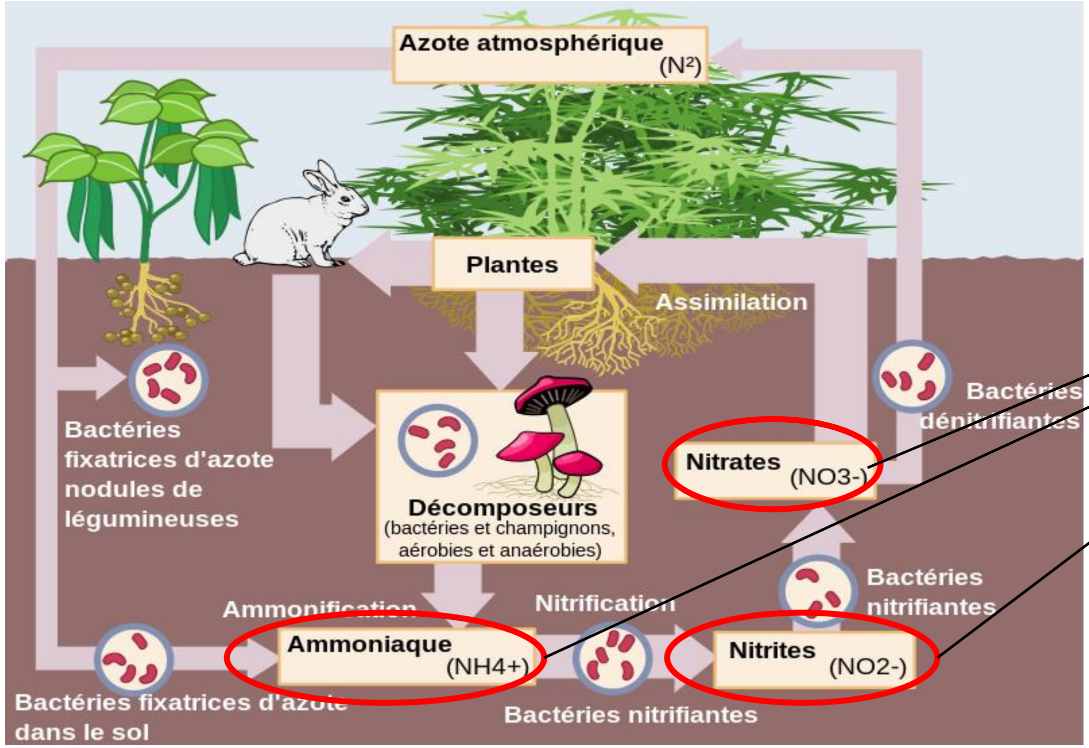




Bran de scie de feuillu (8 tonnes/ha)

Chaux : (3 tonnes/ha)

Échantillonnage et analyse



Charge en azote

AQUIFÈRE

BILAN AZOTÉ DU SOL (objectif 1)

BILAN AZOTÉ DE L'EAU GRAVITAIRE (objectif 2)

Meilleure compréhension de la connectivité entre les eaux souterraines et les activités de surfaces

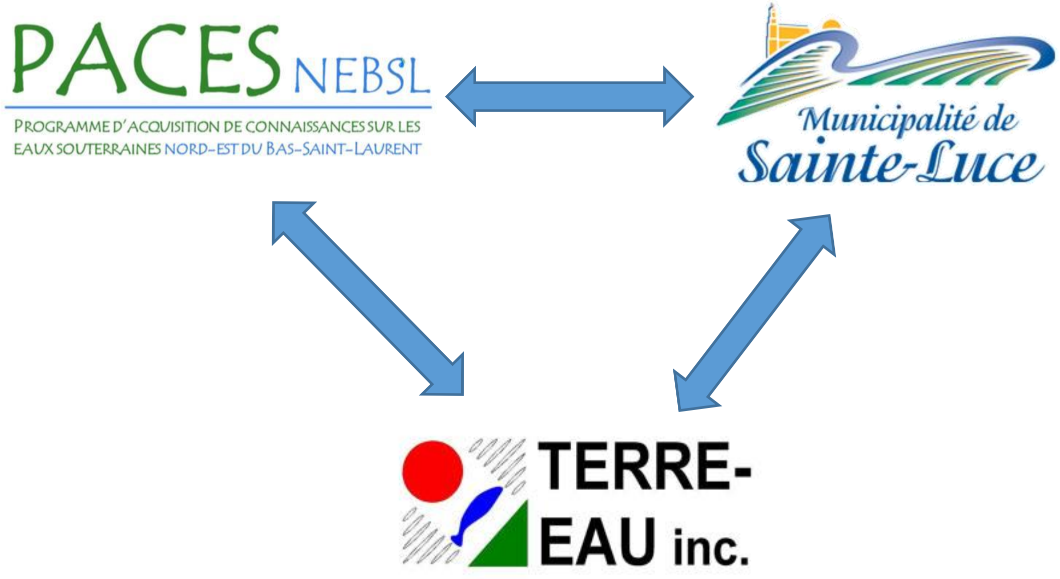
Conclusion

Échelle globale

- ❑Modèle pour les aquifères de types granulaires
- ❑Adapter les pratiques agricoles
- ❑Meilleure gestion des fertilisants azotés

Échelle locale

- ❑Préservation de l'eau souterraine dans le Bas-Saint-Laurent



QUESTIONS???