Ecohydrologie des agrosystèmes

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Université Laval

Co-demandeurs : Alain N. Rousseau et Thiago Gumiere

Objectif principal

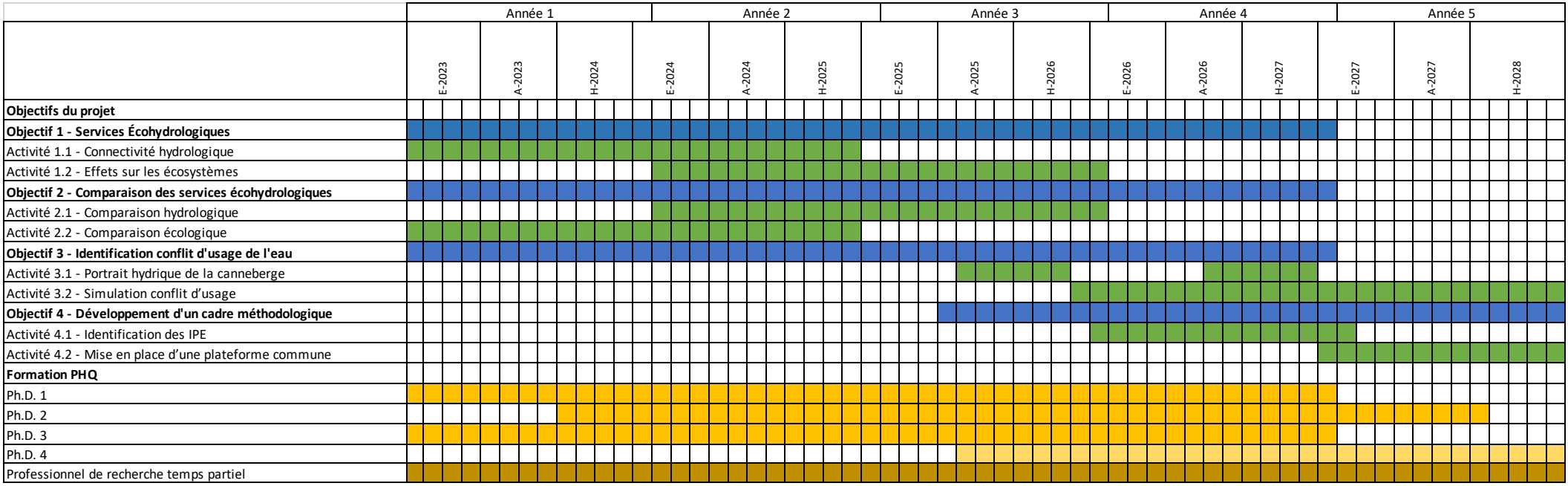
- Comprendre les impacts Ecohydrologique des fermes de canneberges au sein d'un bassin versant.

1. Optimiser les services écohydrologiques et diminuer les impacts;
2. Améliorer la santé de l'agrosystème par la gestion de l'eau;
3. Orienter une meilleure règlementation de la gestion de l'eau.

Axes

- Axe 1 – Connectivité hydrologique et interaction au sein du bassin versant;
- Axe 2 – Service écohydrologique des fermes de canneberges comparées à d'autres objets du paysage;
- Axe 3 – Conflit d'usage et aide à la décision pour les nouvelles fermes et procédures de règlementation.

Avancement du projet



Connectivité hydrologique et interaction au sein du bassin versant

Thèses de doctorat de Nafseh et Amani

Step 1

PHYSITEL and HYDROTEL

Application d'une plateforme de modélisation hydrologique distribuée pour évaluer les impacts individuels et cumulatifs des prélèvements d'eau sur les étiages du réseau de la rivière Bécancour

Step 2

Modélisation du comportement de la ferme et de son sous-bassin versant avec un modèle deterministe (MIKE-SHE);

Development d'un modèle à l'échele de la ferme;

Integration du modèle sur HYDROTEL

Step 3

Ajout d'un module socio-hydrologique à HYDROTEL pour concevoir et évaluer l'impact des futurs développements agricoles, municipaux et industriels dans le bassin versant de la Bécancour en tenant compte des changements climatiques.

Questionnaires destinés à recueillir la planification stratégique des parties prenantes engagées

Objective

Adapt the distributed hydrological model behind Quebec's Hydroclimatic Atlas, namely PHYSITEL-HYDROTEL, to analyze the effect of various current and future water allocation permits (e.g., agricultural, municipal, industrial) on stream flows…

Surface water

Irrigation

Livestock

Municipal and rural (off grid and distributed)

WWTP effluents

Industrial, commercial, institutional

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- Could additional water allocations compromise ecohydraulic and hydrological conditions during low flow periods?

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- What is the effect of each type of water allocation permits and their cumulative effects?

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- Could additional water allocations compromise ecohydraulic and hydrological conditions during low flow periods?
- What is the effect of each type of water allocation permits and their cumulative effects?
- Could effluent discharges offset some water allocations (and use) in certain parts of a watershed?

Surface water

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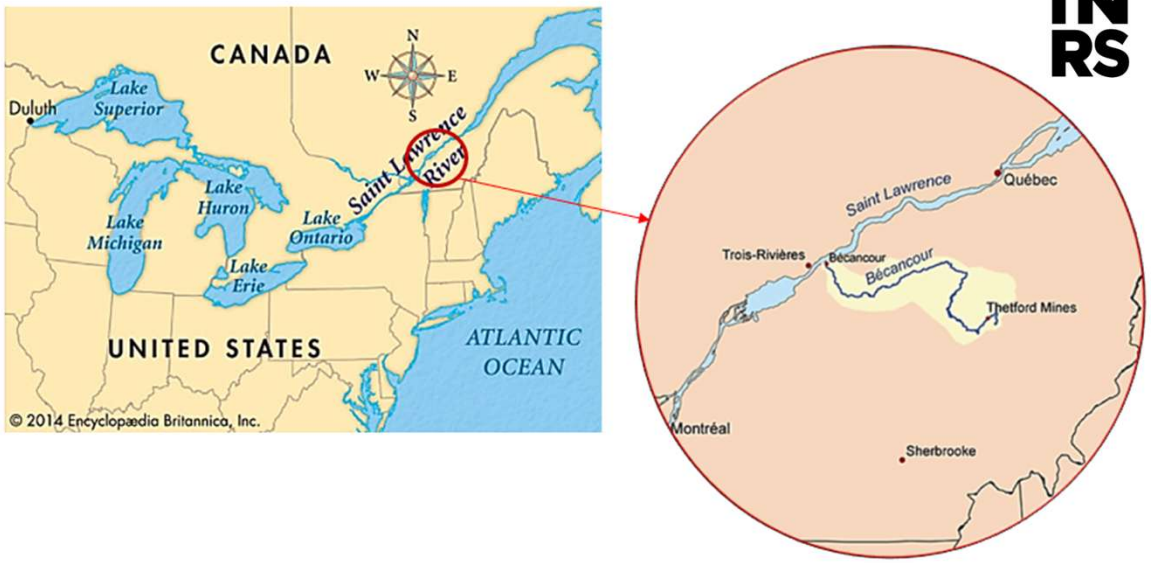
WWTP effluents

Industrial, commercial, institutional

Case study

Becancour River watershed (3847 km^2) on the south shore of the Saint Lawrence River

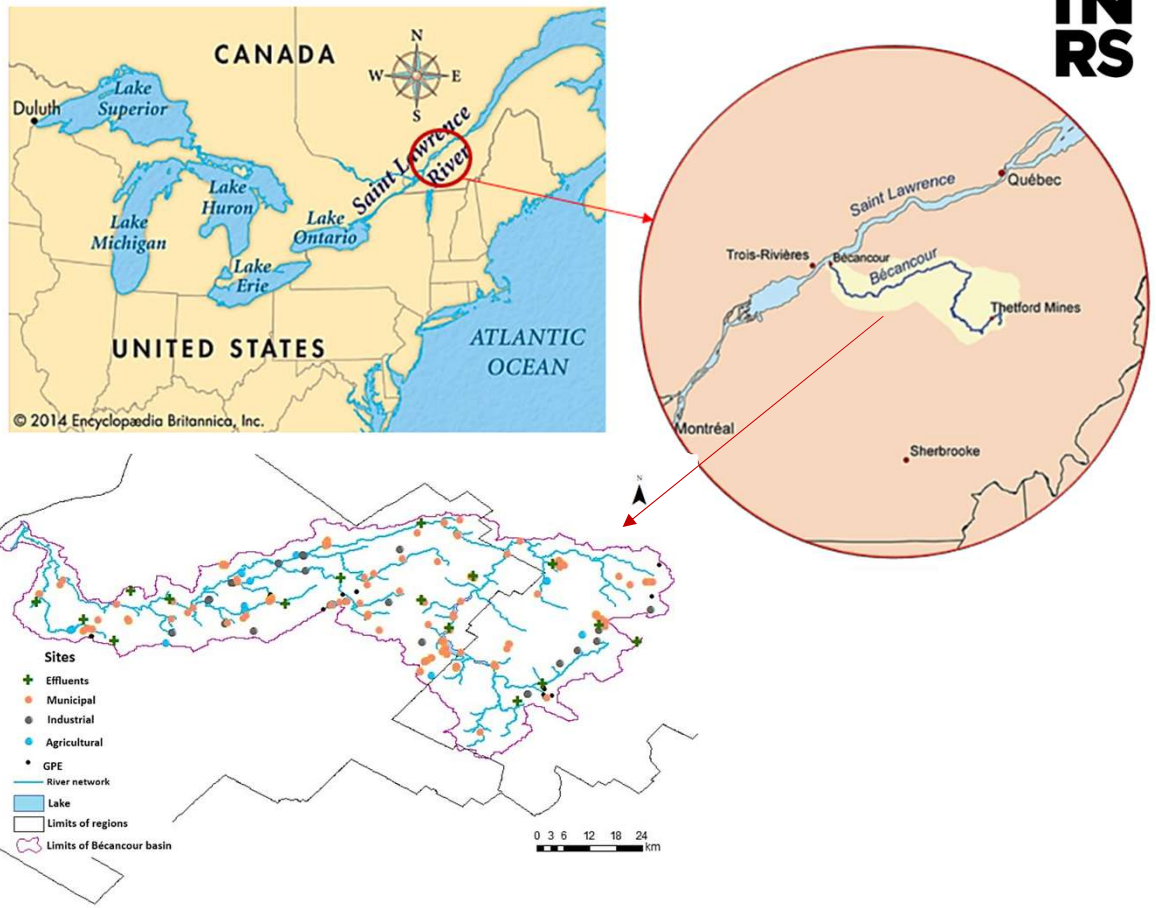


Case study

Becancour River watershed (3847 km^2) on the south shore of the Saint Lawrence River

Estimated surface water withdrawals and effluents

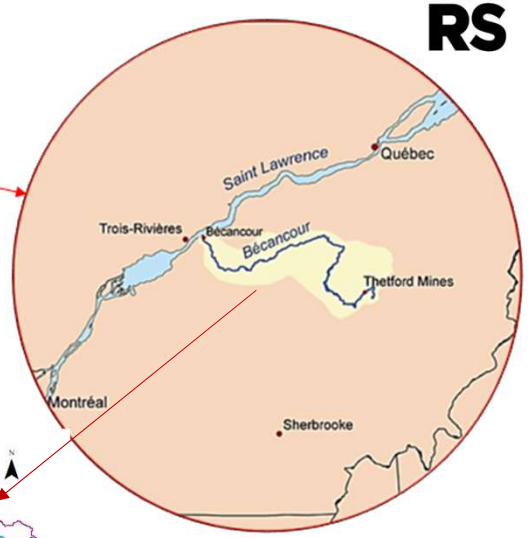
Site type	The number of sites (gpe) –Surface source	Estimated Annual volume(ML)	Proportion of Withdrawal (%)
Agricultural	13 (2)	-896.4	6.64
Municipal	2(2)	-3362.4	24.89
Industrial	8 (6)	-8767.7	64.90
Commercial	12 (8)	-408.9	3.03
Private	3	-73.12	0.54
Total uptake	**38(18)**	**-13508.52**	**100**
Effluent	16	+13059.5	

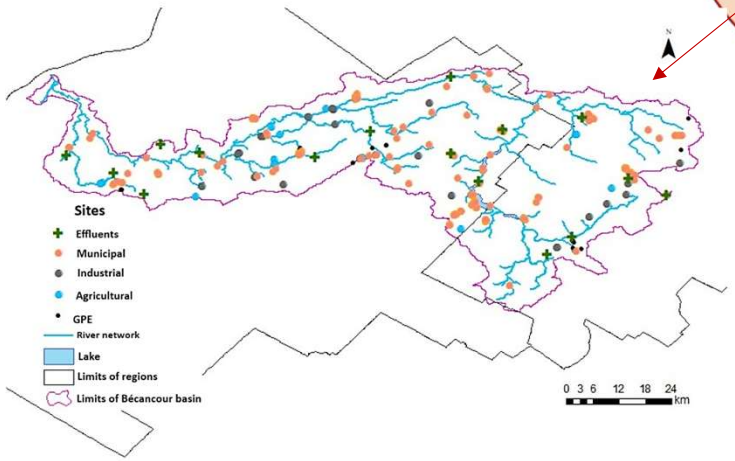


Case study

Becancour River watershed (3847 km^2) on the south shore of the Saint Lawrence River

Population and government: *Could water availability be threatened by development & addition of cranberry farm sites ?*





Agricultural
(development of cranberry farms)

Reach 48

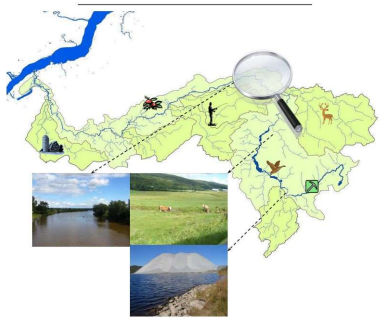
Reach 1

Reach 20

Municipal

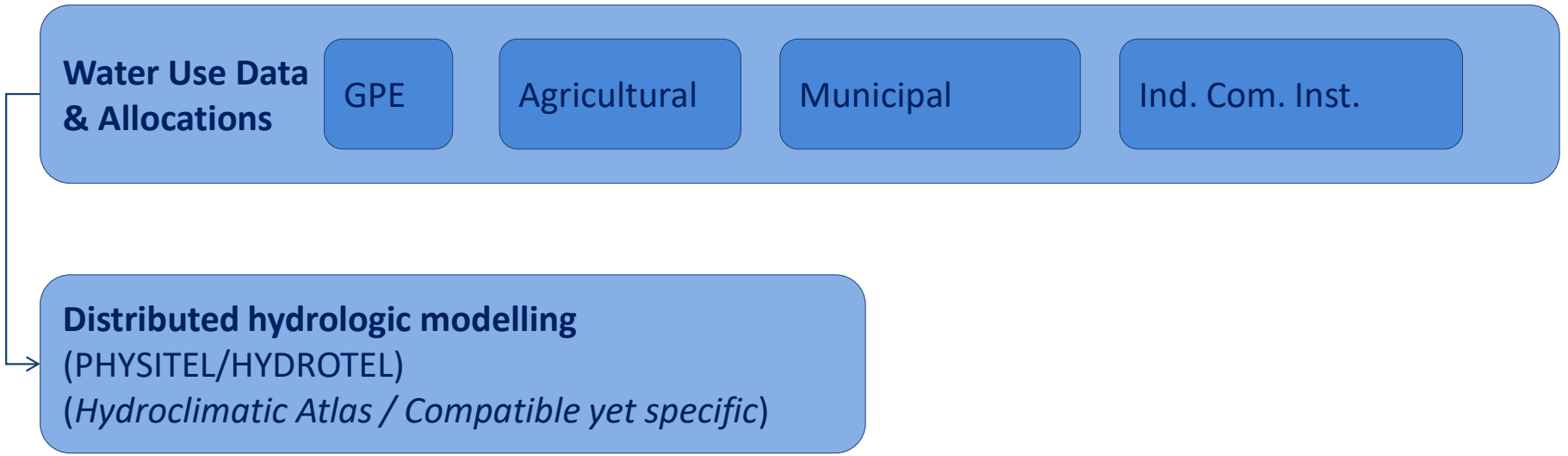
Industrial

Reach 88



Limits of Relatively Homogeneous Hydrological Units (RHHU)
River network
Rivers under analysis
Limits of subbasins
Lakes
Hydrometric stations
Thetford mines :1282.96 ML of water uptake (surface and ground resources)


Water Use Data & Allocations
GPE
Agricultural
Municipal
Ind. Com. Inst.


Water Use Data & Allocations
GPE
Agricultural
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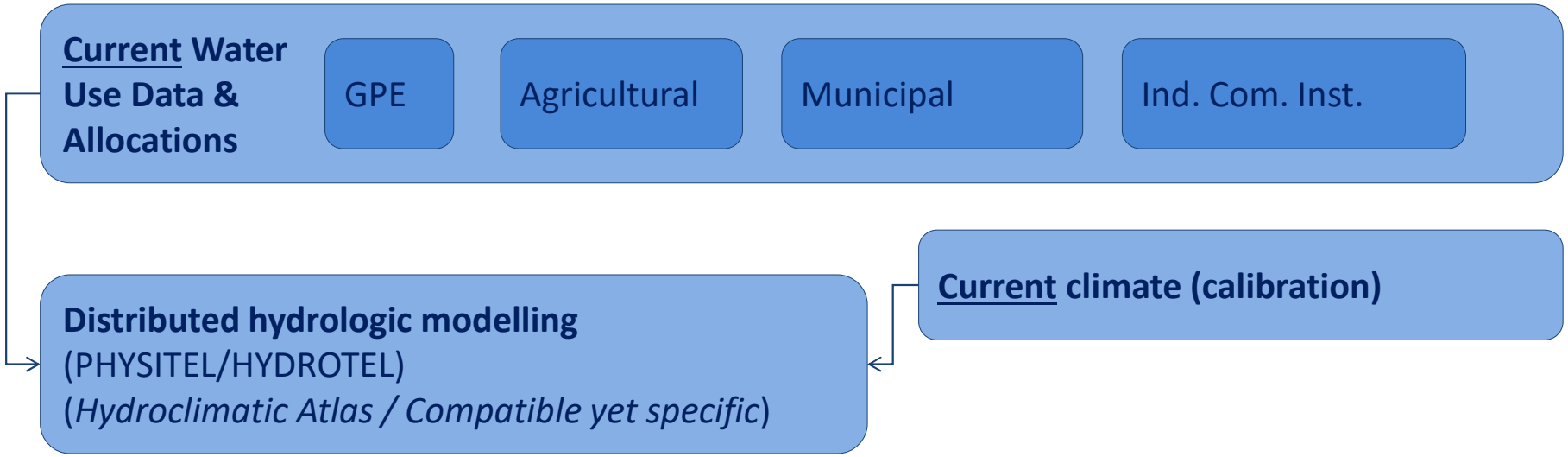
Distributed hydrologic modelling
(PHYSITEL/HYDROTEL)
(*Hydroclimatic Atlas / Compatible yet specific*)


Current Water Use Data & Allocations
GPE
Agricultural
Municipal
Ind. Com. Inst.
Current climate (calibration)
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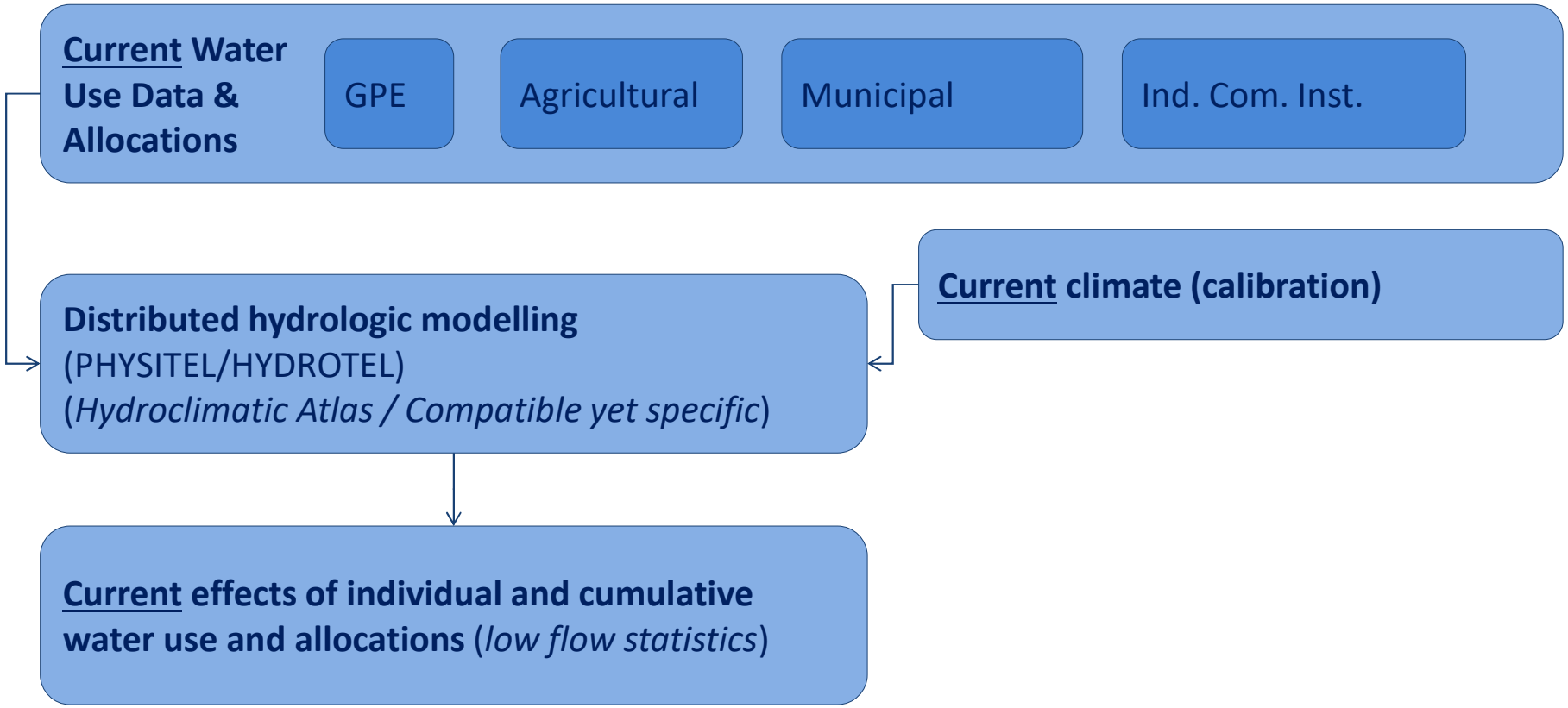
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Current climate (calibration)
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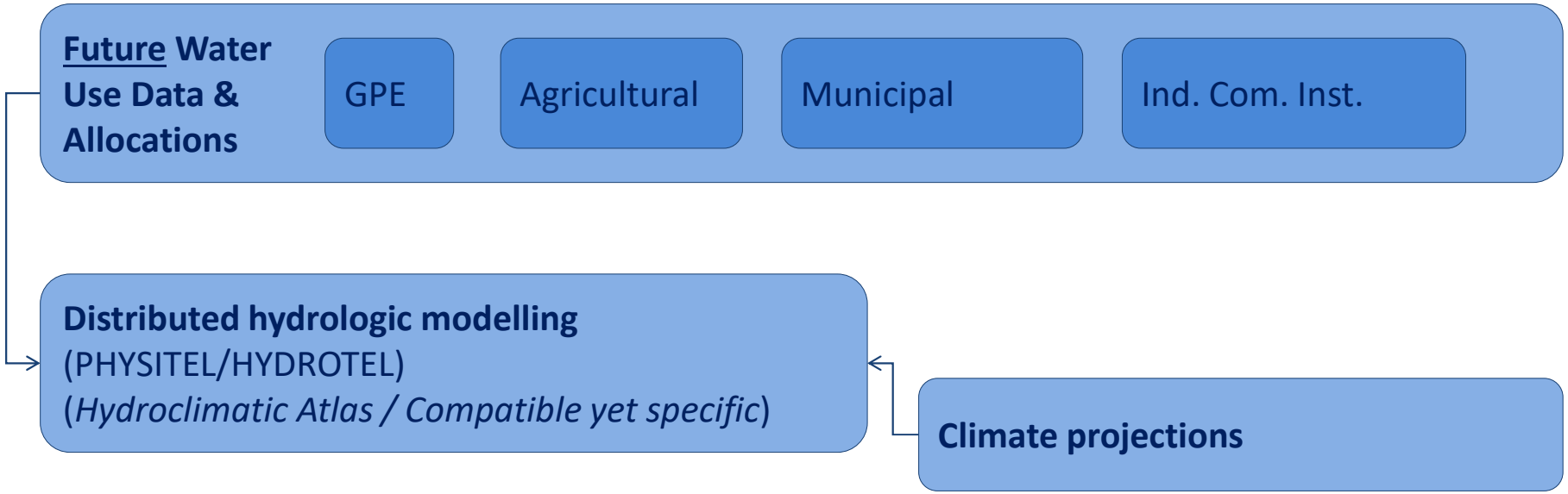
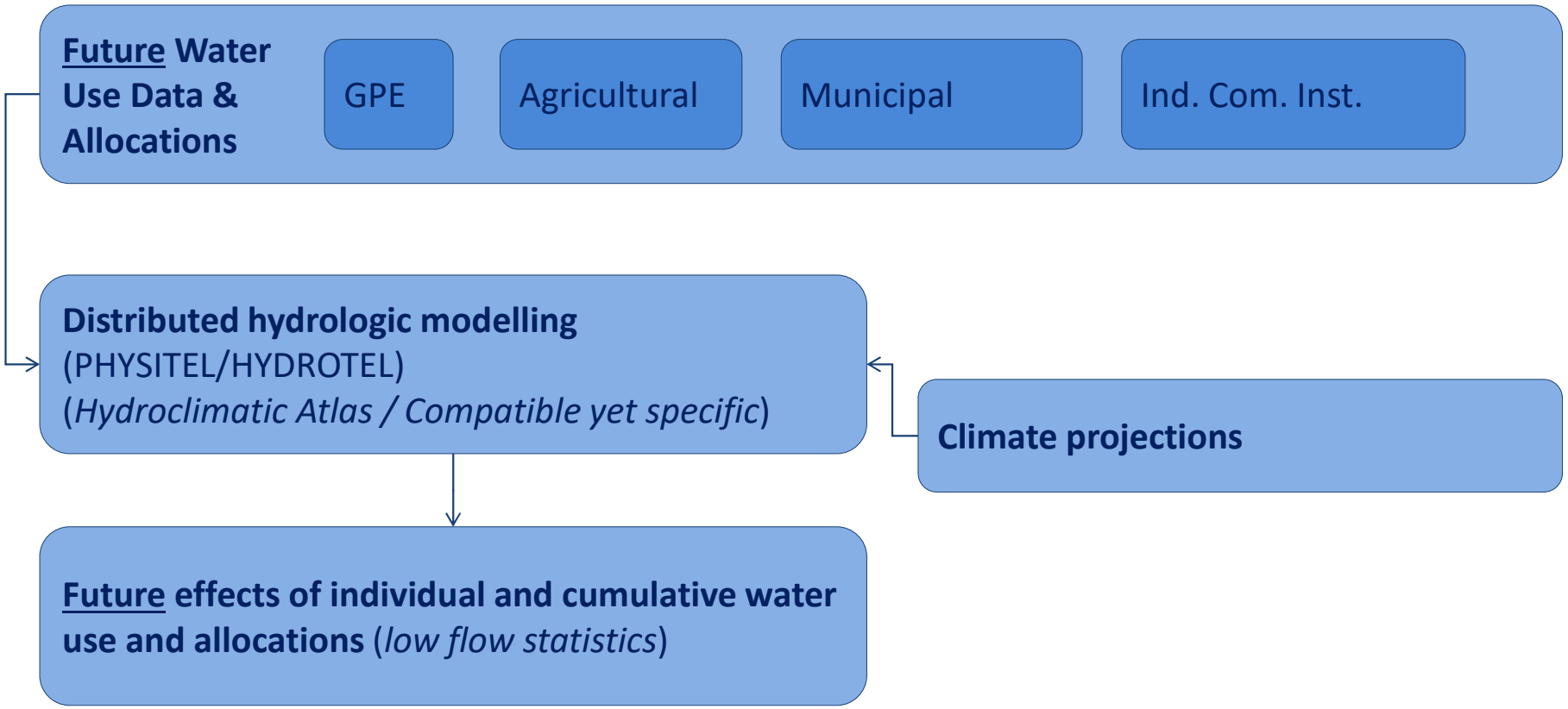
Current effects of individual and cumulative water use and allocations (low flow statistics)


Future Water Use Data & Allocations
GPE
Agricultural
Municipal
Ind. Com. Inst.
Distributed hydrologic modelling
(PHYSITEL/HYDROTEL)
(Hydroclimatic Atlas / Compatible yet specific)
Climate projections


Future Water Use Data & Allocations
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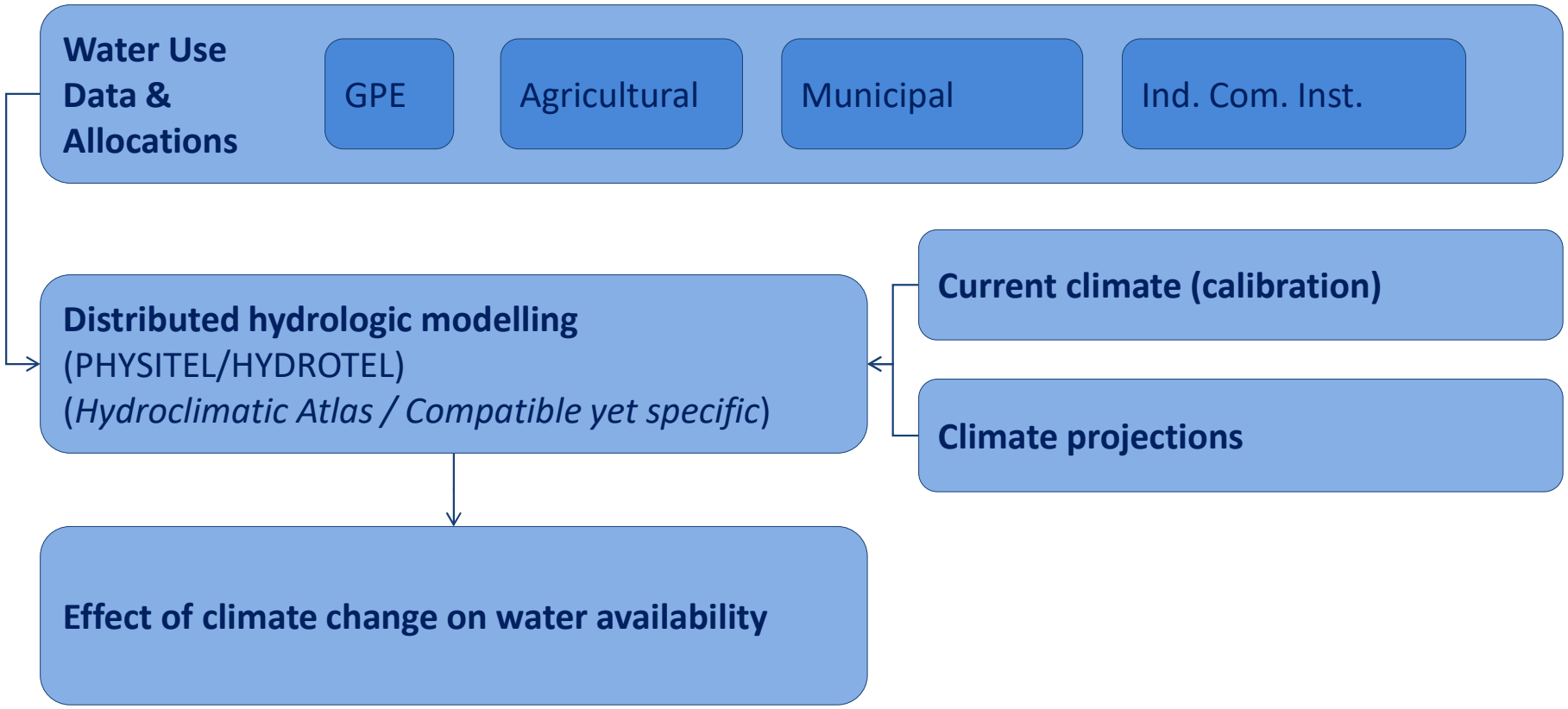
Water Use Data & Allocations
GPE
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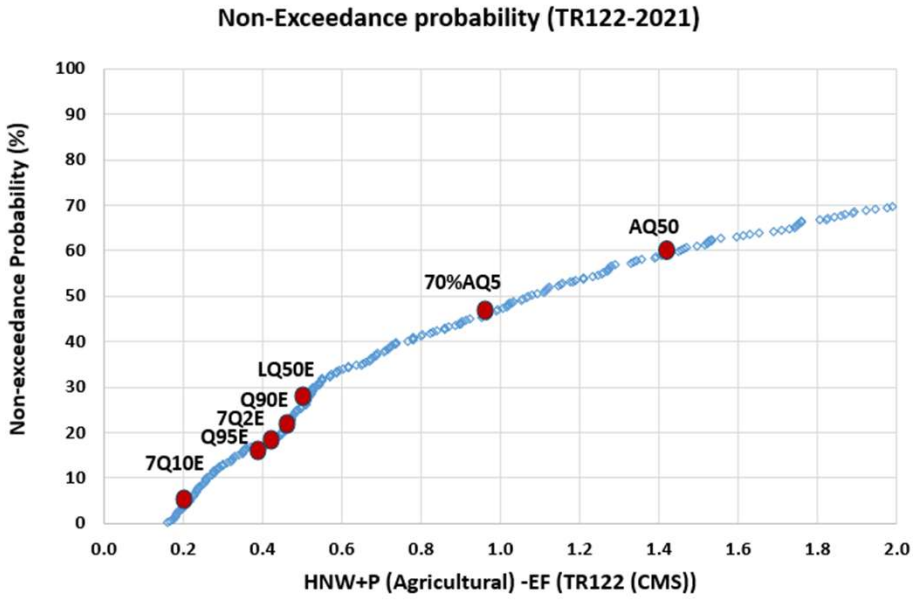
Current climate (calibration)
Climate projections
Effect of climate change on water availability

Which ecohydraulic and hydrological Indicators of low-flow conditions For example, the Bourbon River



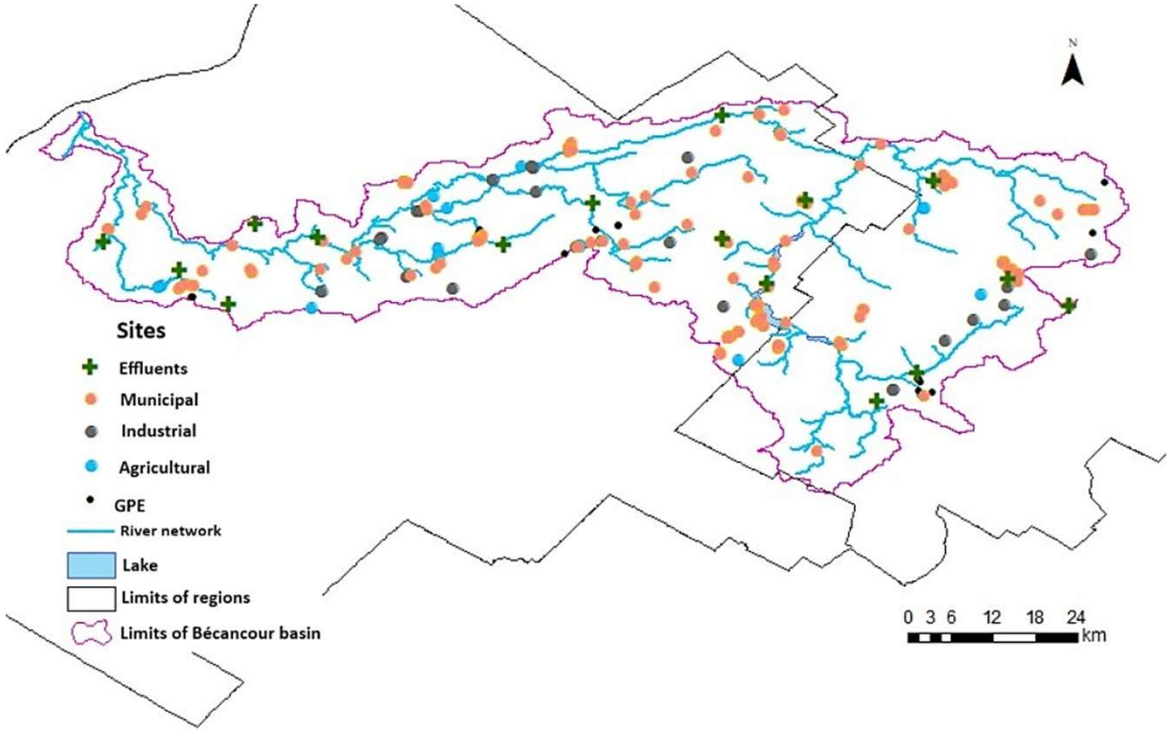
Why 7Q10E?

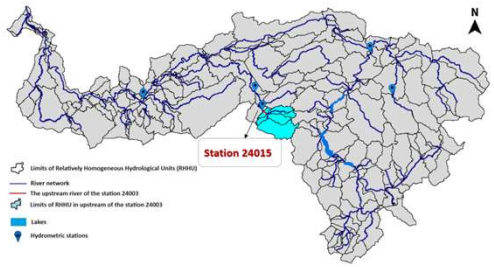
flowrate conditions, the $Q_{7,10}$ on an annual basis is expected to simulate even more extreme low flow conditions (Smakhtnin 2001). For instance, Ouyang (2012) reported that, for basins in Mississippi and Florida (USA), the $Q_{7,10}$ was equivalent to a low flow expected to be observed 96% and sometimes 100% of the time.

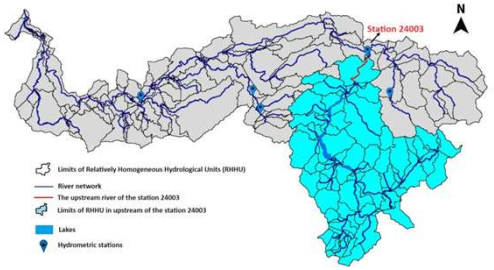
Why 0.85*7Q2E?

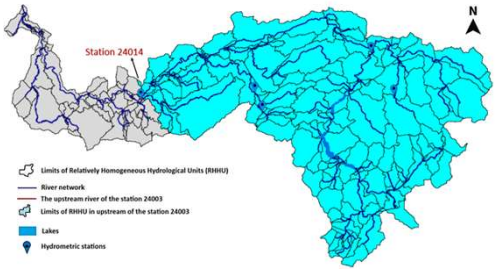
Government regulation threshold requiring maintaining a minimum flow of 0.85*7Q2E during low-flow periods

HYDROTEL - Calibration under current conditions and estimated water use and allocations (2009-2021)

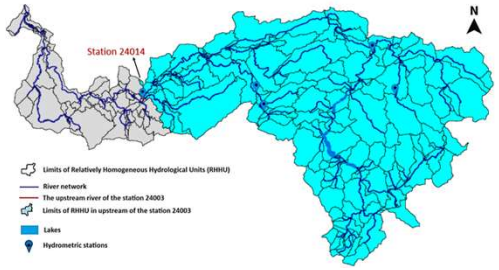


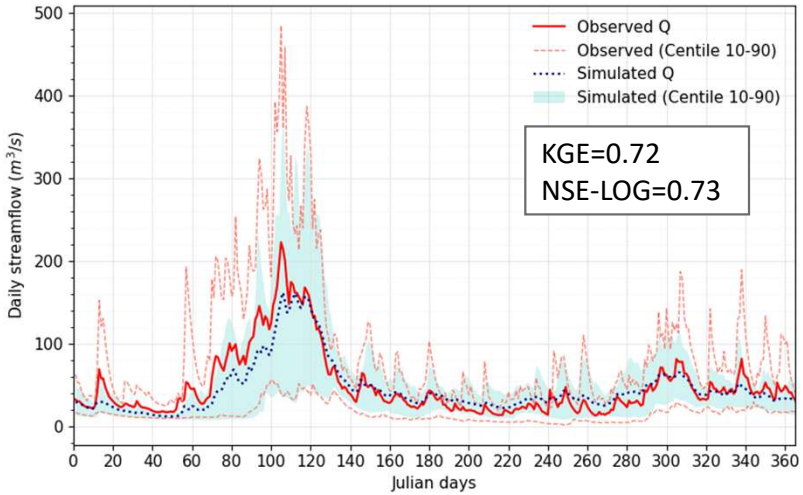




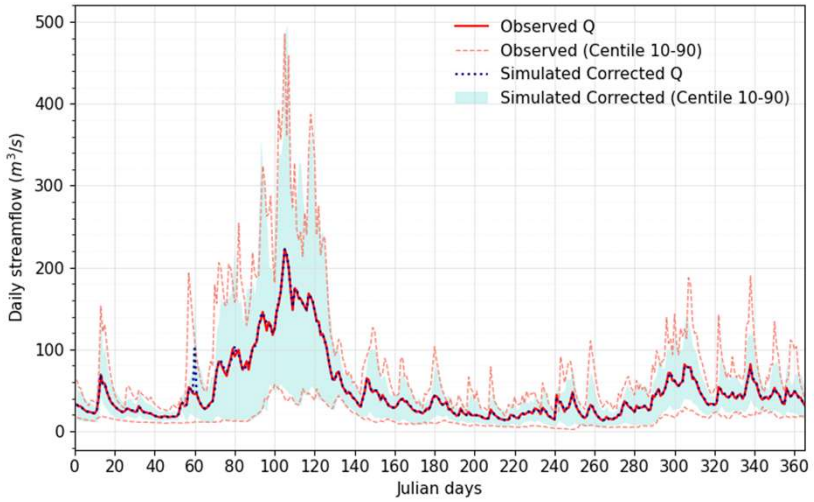


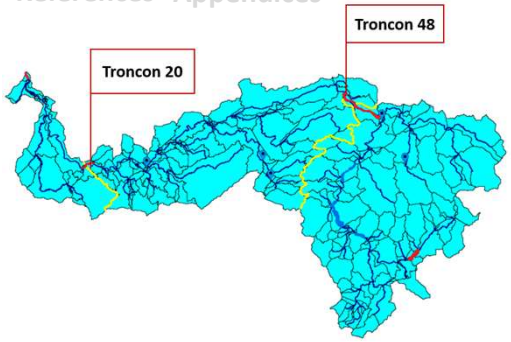
Calibration – average annual hydrograph – station 24014



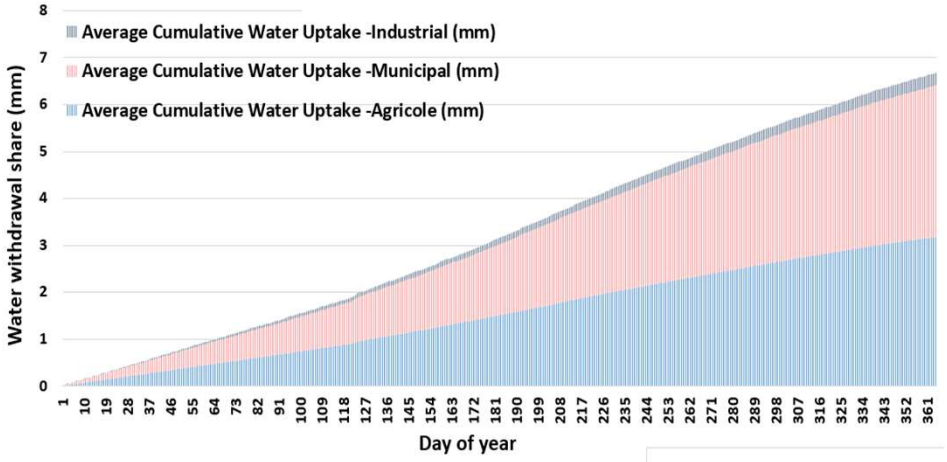


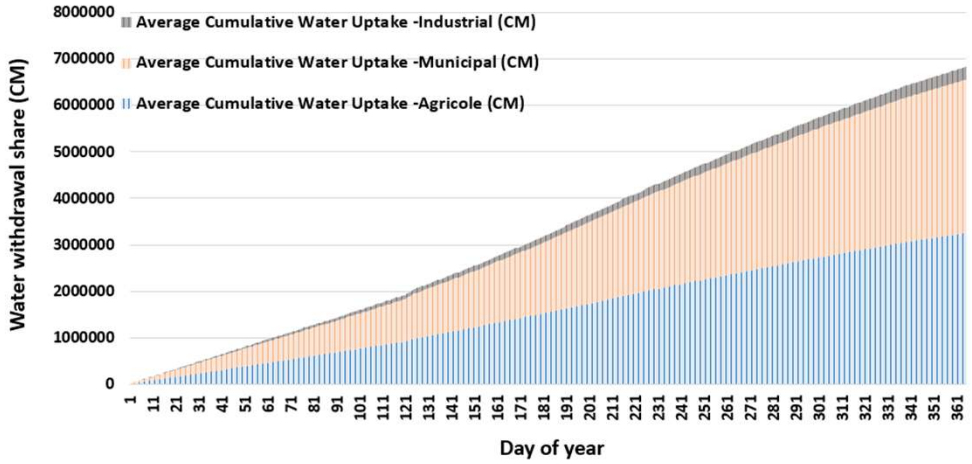
Bias-corrected simulated data

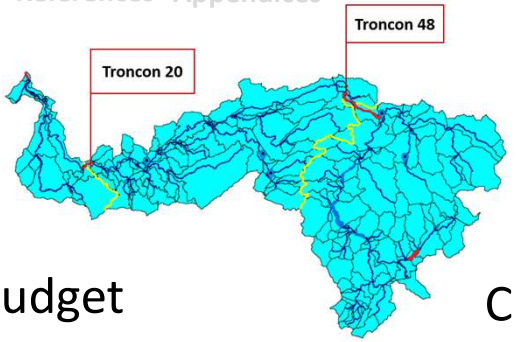




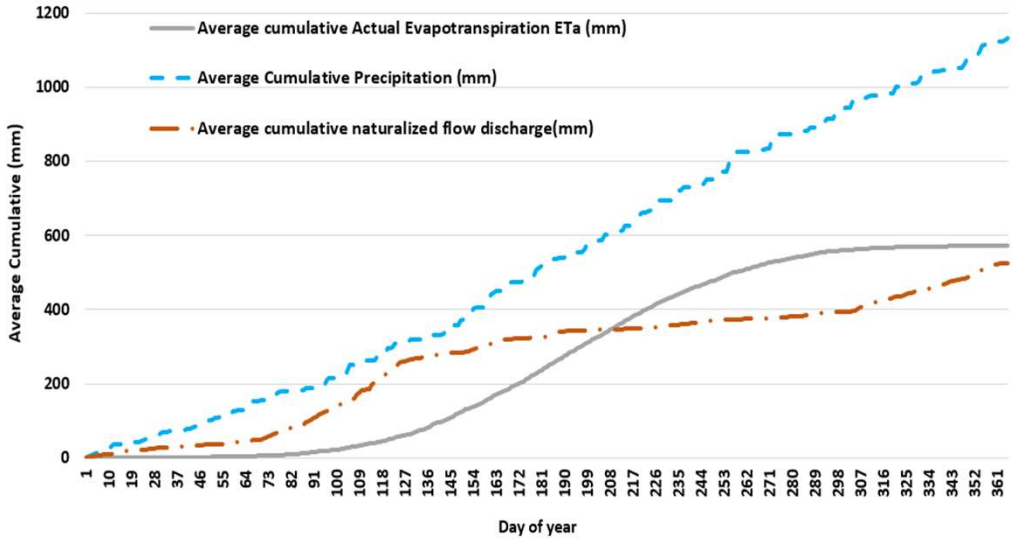
Average cumulative effect of each water uptake



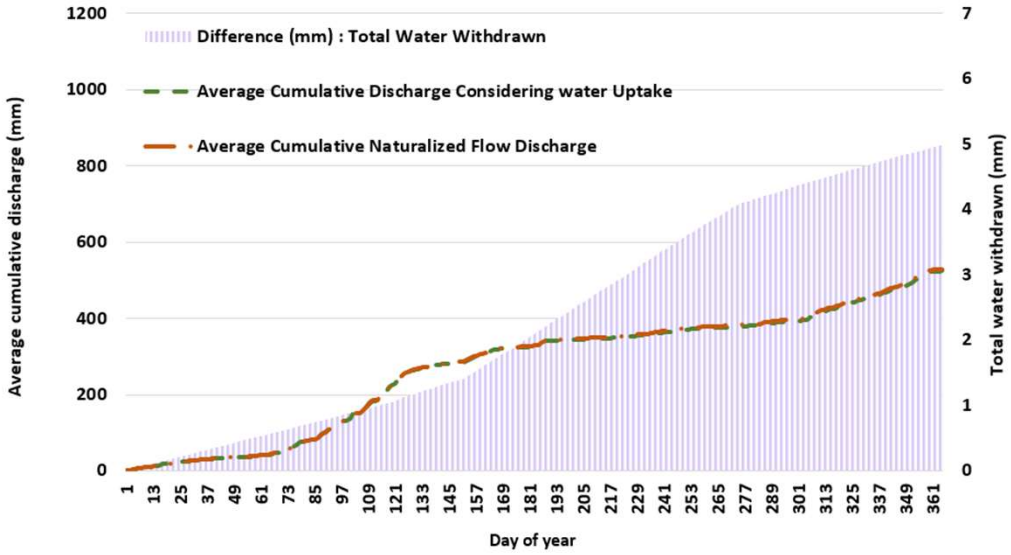




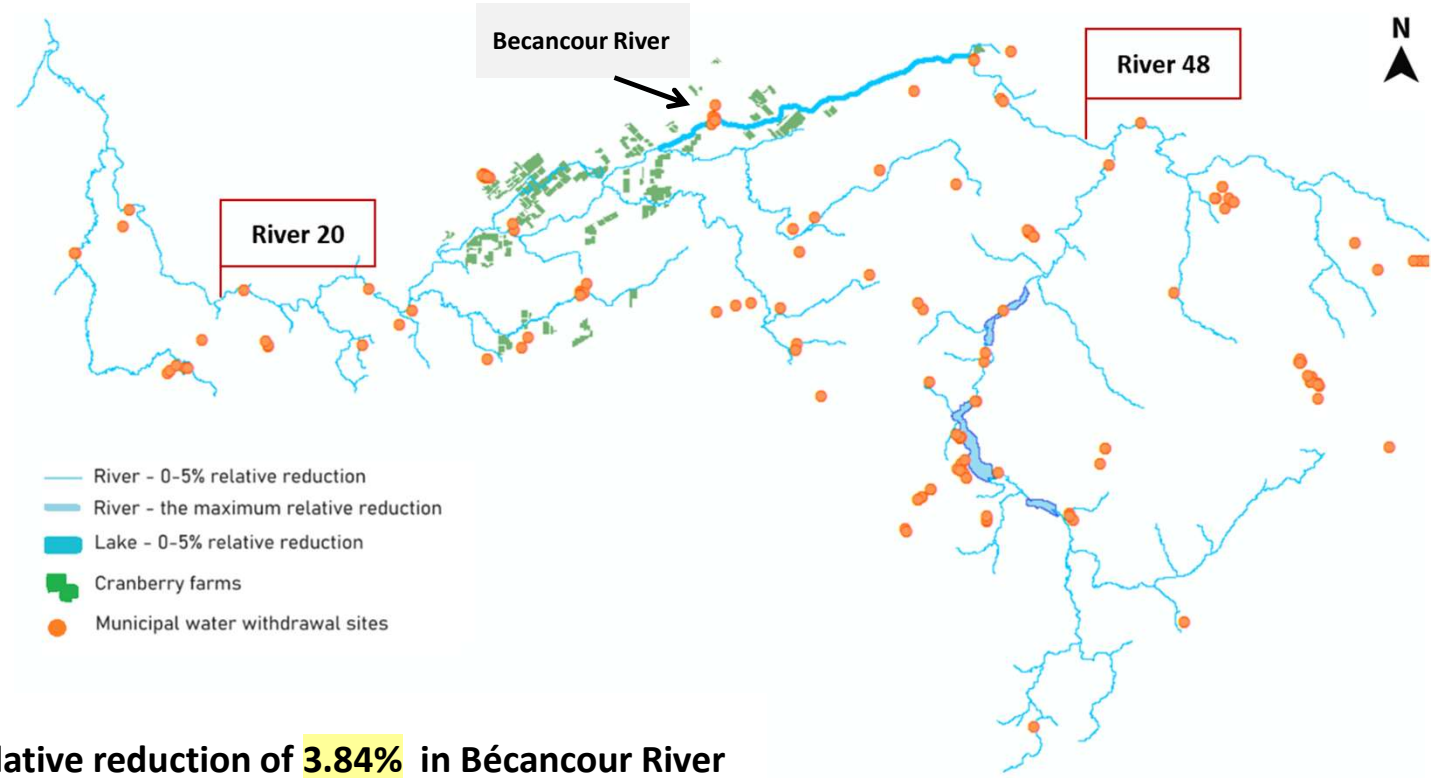
Average hydrological budget



Cumulative effect of total water uptakes

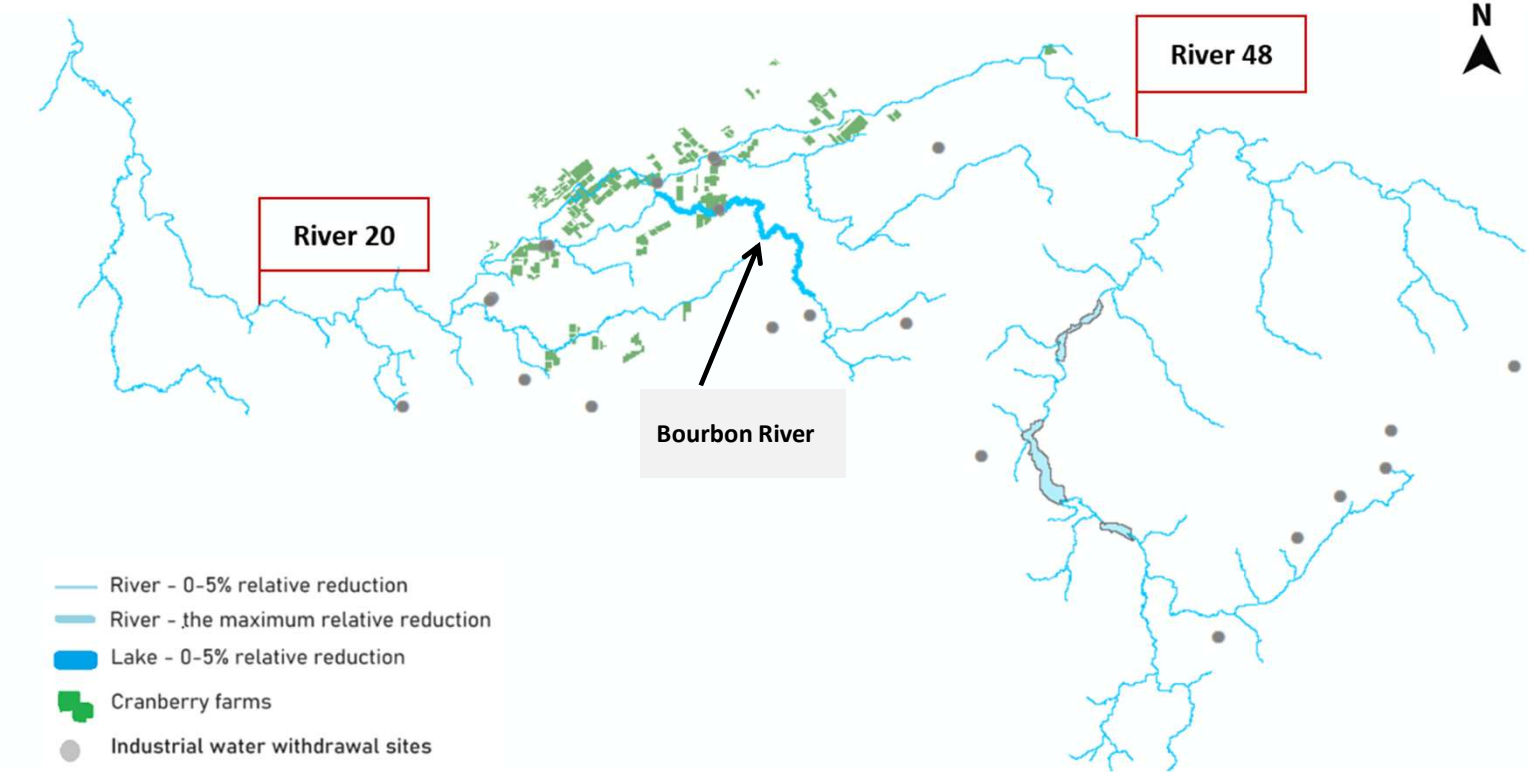


Relative % difference in 7Q10E of scenario (flow considering **municipal** uptake only) and that of reference (naturalized flow) for 2009-2021



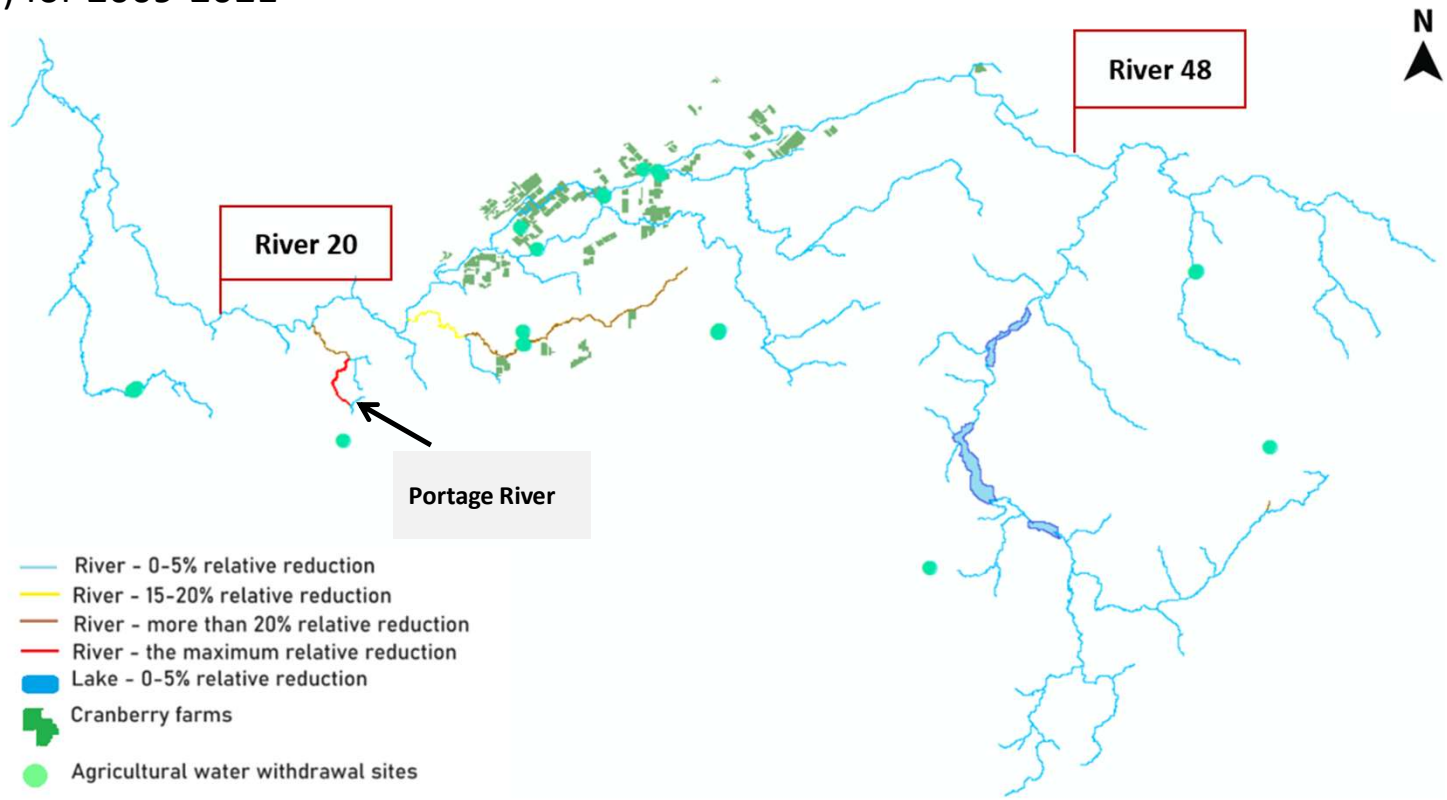
The maximum relative reduction of 3.84% in Bécancour River

Relative % difference in 7Q10E of scenario (flow considering **industrial** uptake only) and that of reference (naturalized flow) for 2009-2021



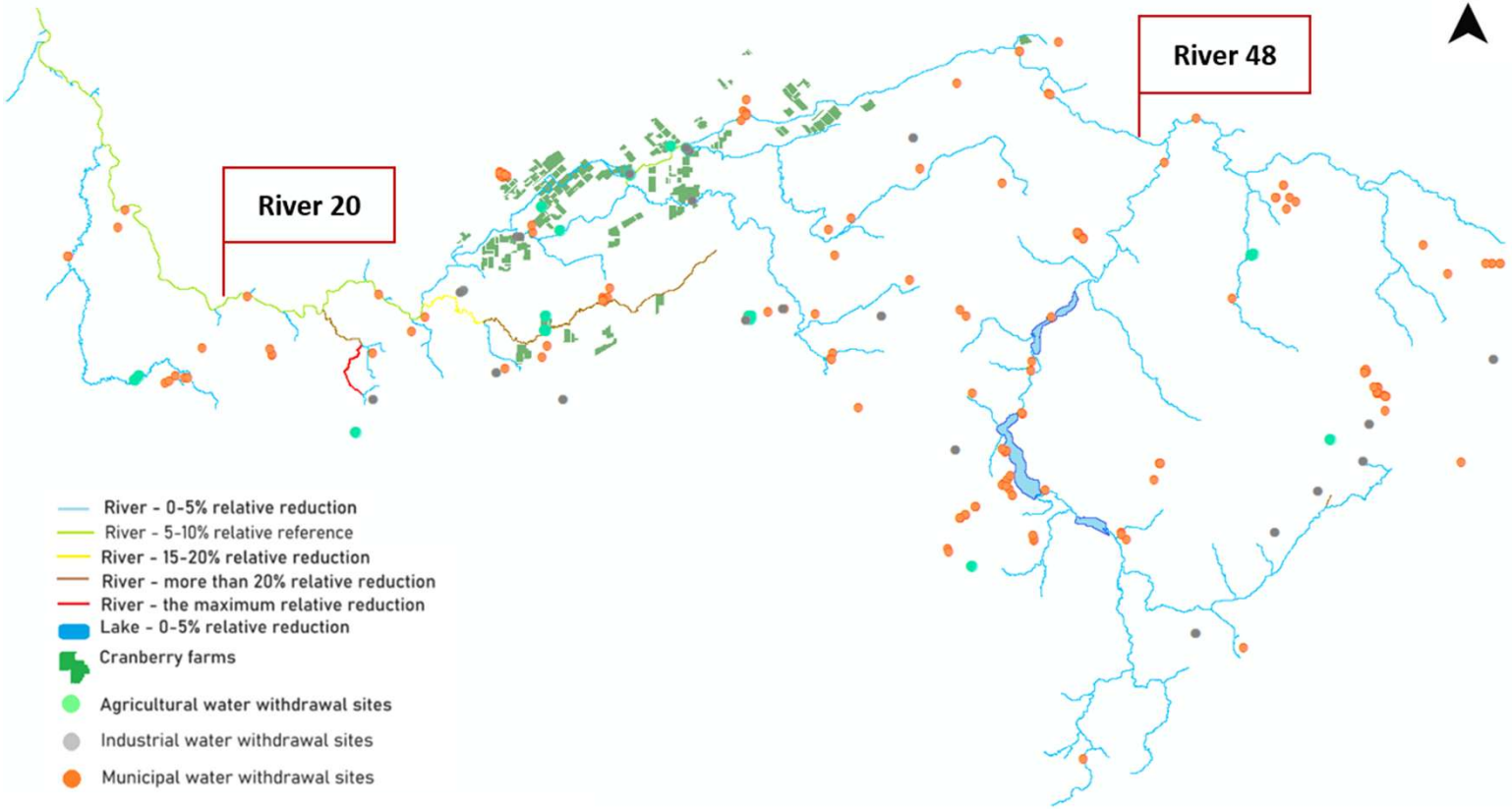
The maximum relative reduction of 3.64% in Bourbon River

Relative % difference in 7Q10E of scenario (flow considering **agricultural** uptake only) and that of reference (naturalized flow) for 2009-2021



Maximum relative reduction of 73.99% in Portage River

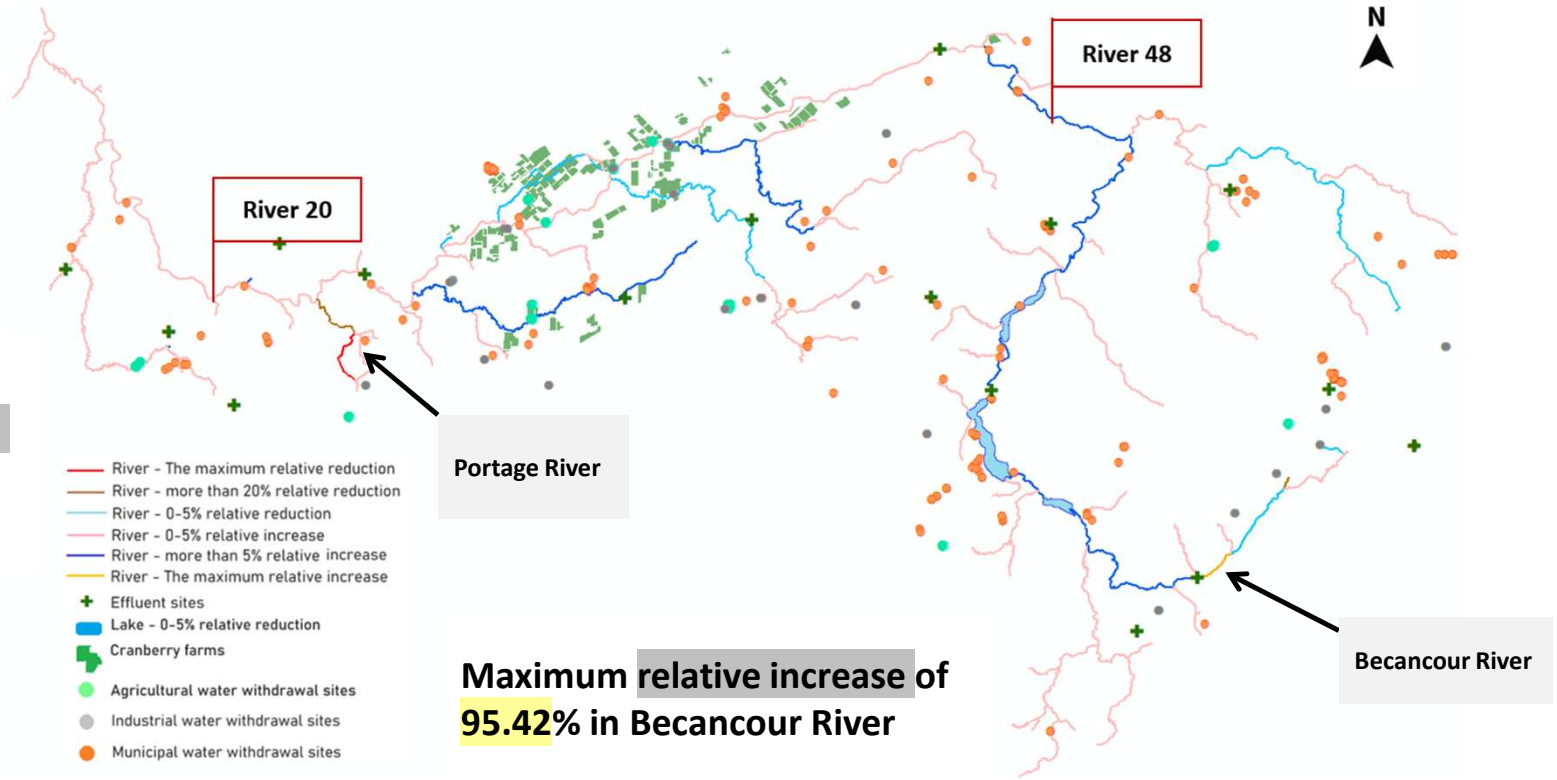
Relative % difference in 7Q10E of scenario (flow considering **all** uptakes) and that of reference (naturalized flow) for 2009-2021



Maximum relative reduction of 73.99% in Portage River

Relative % difference in 7Q10E of scenario (flow considering **all** uptakes + **effluents**) and that of reference (naturalized flow) for 2009-2021

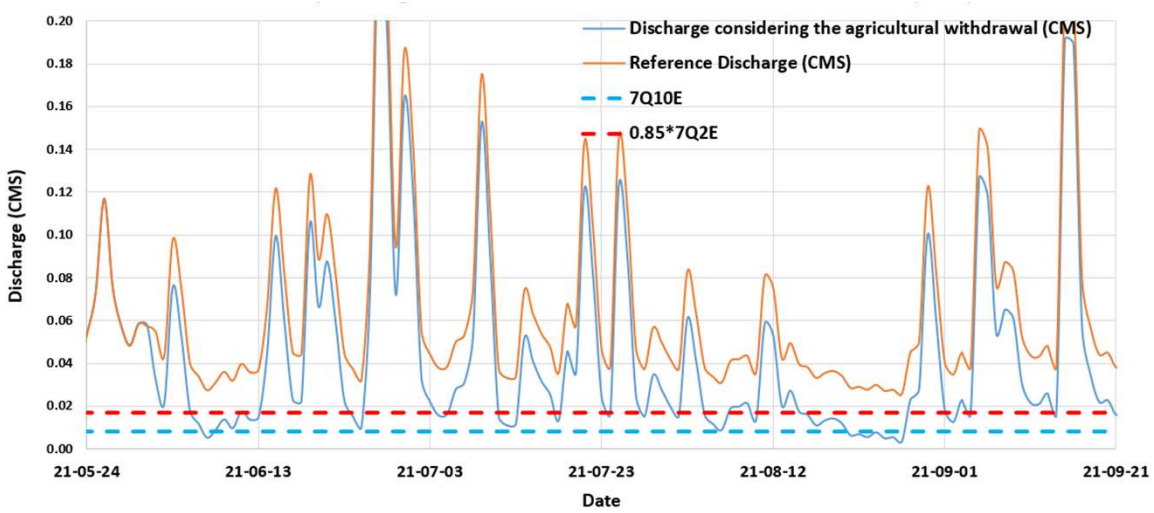
Maximum relative reduction of 73.99% in Portage River



Maximum relative increase of 95.42% in Becancour River

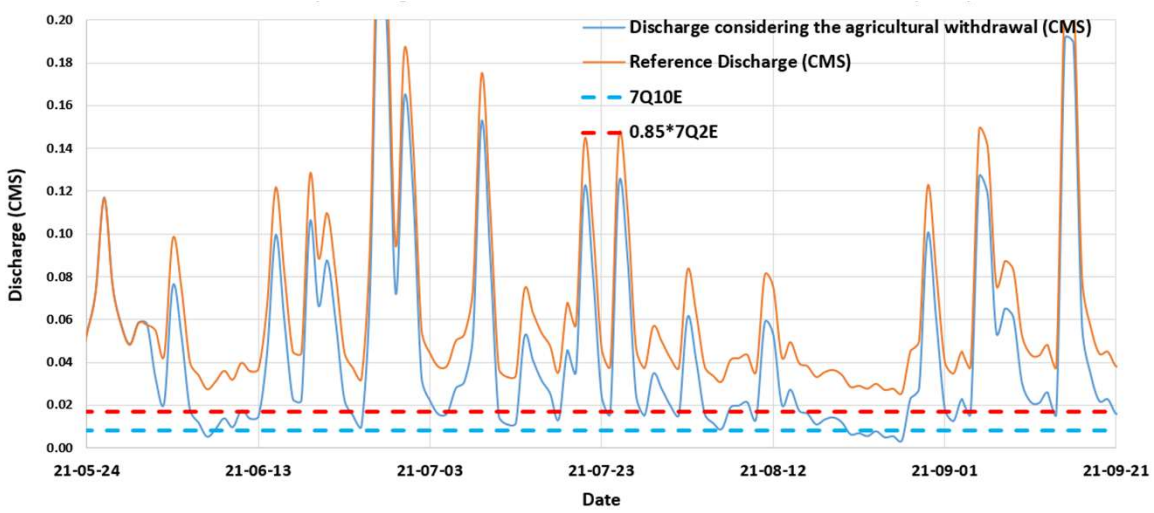
Portage River – 2021 conditions

Daily discharge and key hydrological indicators

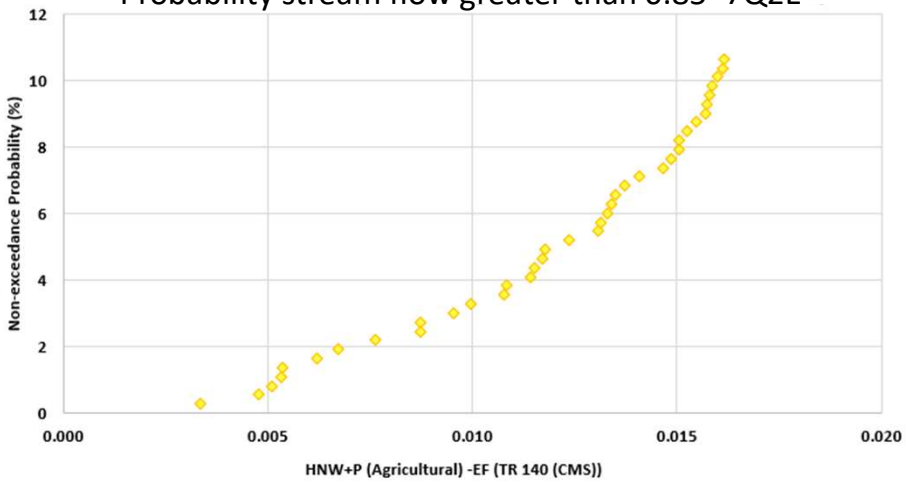


Portage River – 2021 conditions

Daily discharge and key hydrological indicators

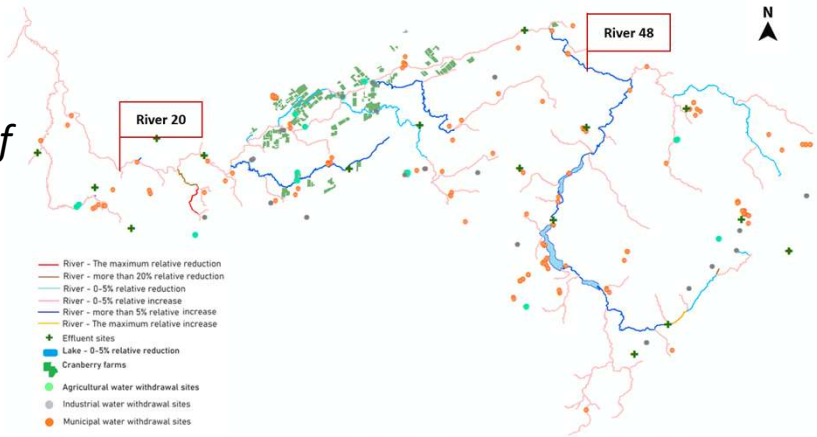


Probability stream flow greater than 0.85*7Q2E



In the Becancour River watershed…

- Effect of water use and allocation…
  - A few river reaches experiencing significant footprint due to individual and cumulative water withdrawals
  - **The Portage River** facing notable challenges given agricultural withdrawals (*individually or in combination with other types of withdrawals and accounting for effluent discharges*)



In the Becancour River watershed…

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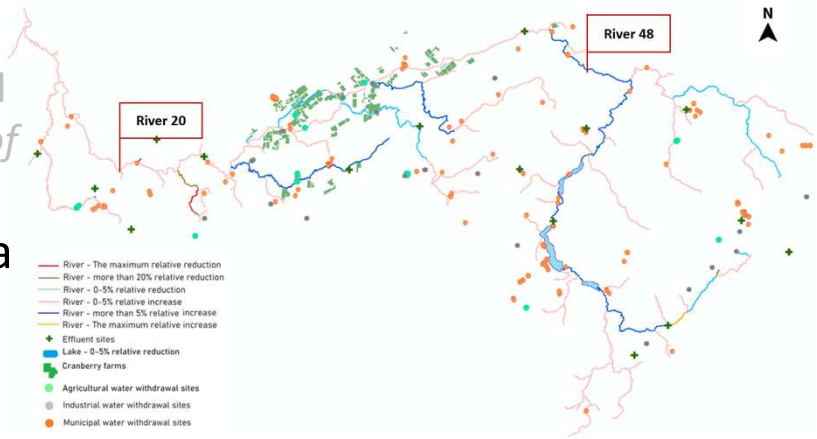
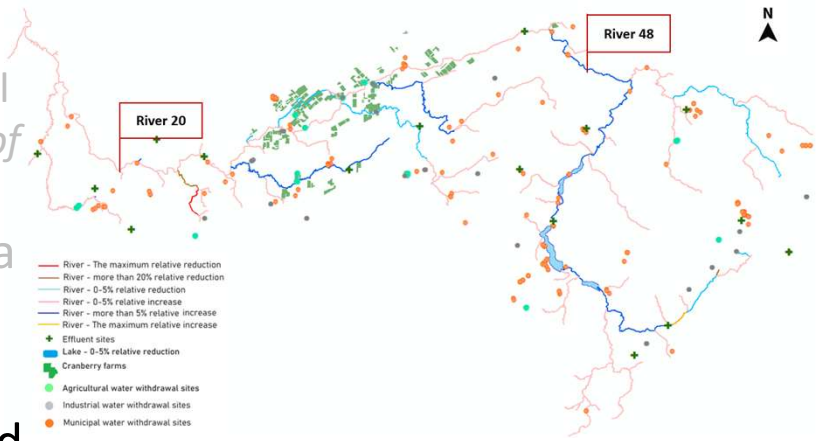
  - A few river reaches experiencing significant footprint due to individual and cumulative water withdrawals
  - **The Portage River** facing notable challenges given agricultural withdrawals (*individually or in combination with other types of withdrawals and accounting for effluent discharges*)
- Municipal and industrial withdrawals generally having a limited impact, contributing less than 5% of 7Q10E reduction



In the Becancour River watershed…

- Effect of water use and allocation…
  - A few river reaches experiencing significant footprint due to individual and cumulative water withdrawals
  - **The Portage River** facing notable challenges given agricultural withdrawals (*individually or in combination with other types of withdrawals and accounting for effluent discharges*)
- Municipal and industrial withdrawals generally having a limited impact, contributing less than 5% of 7Q10E reduction
- Need to assess any future agricultural development and during low flow conditions consider specific mitigation strategies under current and future climate conditions

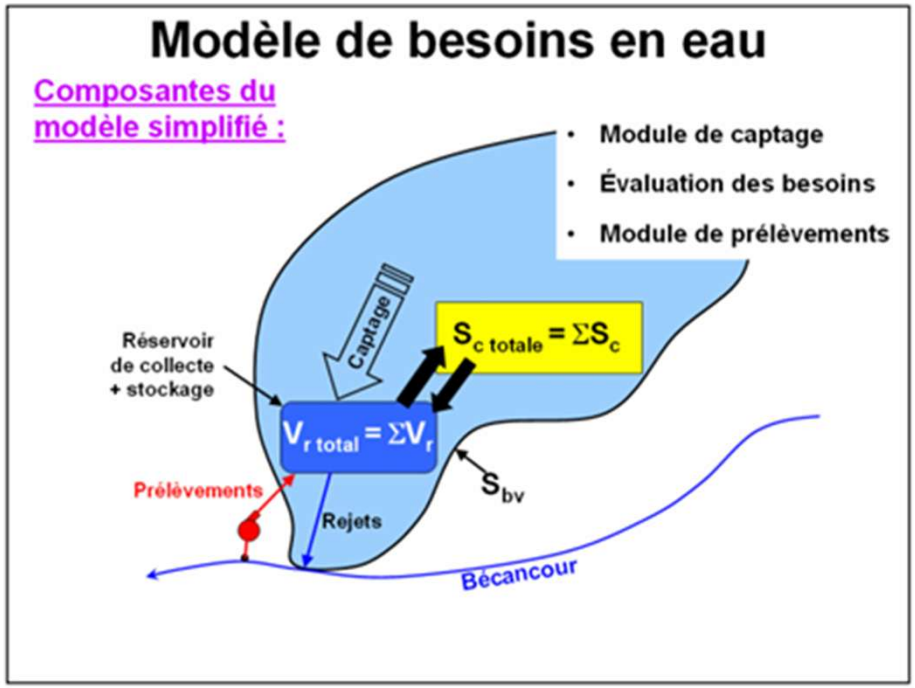


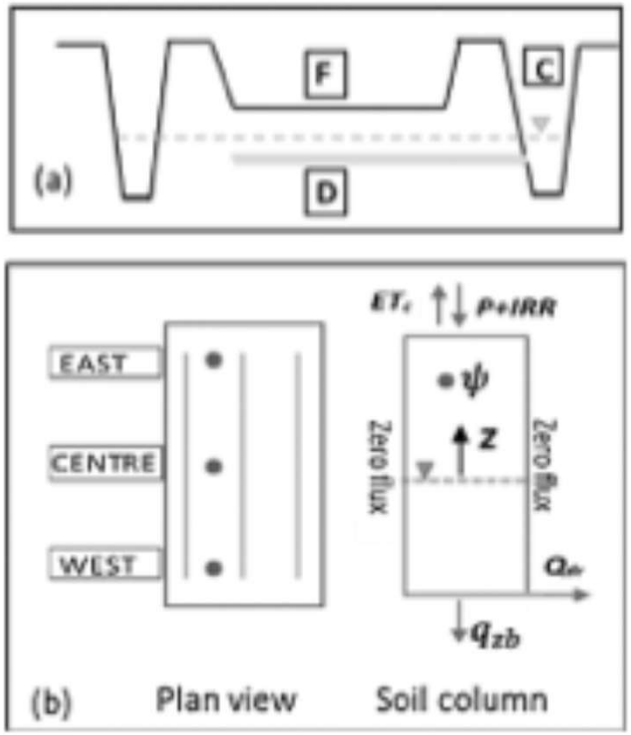
- Usefulness of HYDROTEL to assess individual and cumulative effects of all types of current and future water use and allocations as well as mitigation strategies during low flow periods under current and future climate conditions in terms of…

- Usefulness of HYDROTEL to assess individual and cumulative effects of all types of current and future water use and allocations as well as mitigation strategies during low flow periods under current and future climate conditions in terms of…
  - Ecohydraulic and hydrological indicators
  - Ecohydraulic indicators estimated using the HAND (*Height above the Nearest Drainage*) framework and synthetic rating curves

- Usefulness of HYDROTEL to assess individual and cumulative effects of all types of current and future water use and allocations as well as mitigation strategies during low flow periods under current and future climate conditions in terms of…
  - Ecohydraulic and hydrological indicators
  - Ecohydraulic indicators estimated using the HAND (*Height above the Nearest Drainage*) framework and synthetic rating curves
- Next step – development and integration of a cranberry farm water management model

Schematic representation of the **daily water demand model** on a cranberry farm





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journal homepage: www.elsevier.com/locate/agwat

Development of a steady-state model to predict daily water table depth and root zone soil matric potential of a cranberry field with a subirrigation system

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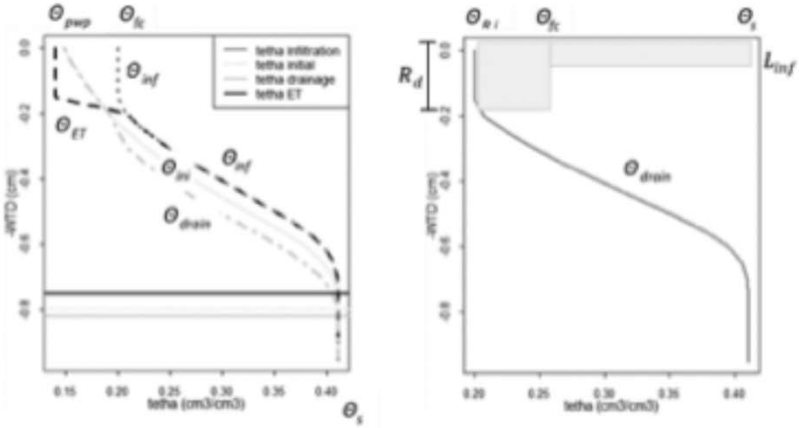
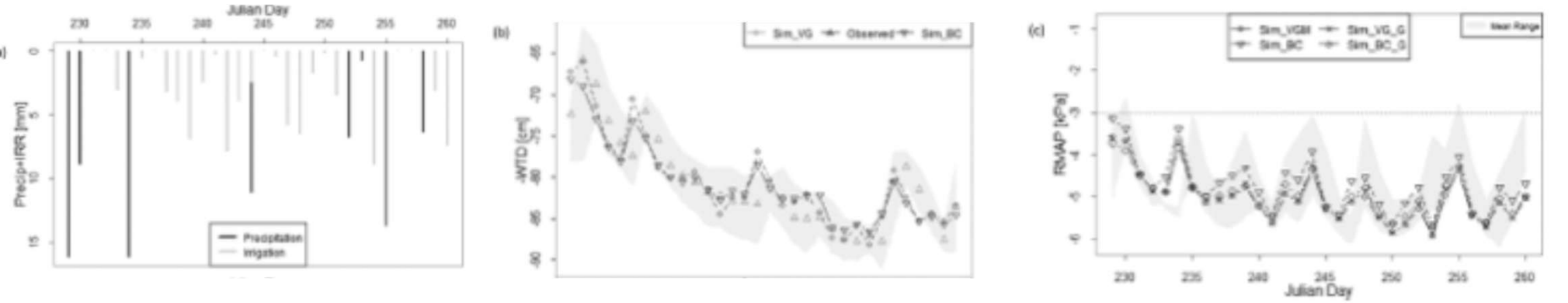
[b] Faculté des Sciences de l'agriculture et de l'alimentation, Université Laval, 2425 rue de l'Agriculture, Québec, G1V 0A6, Canada



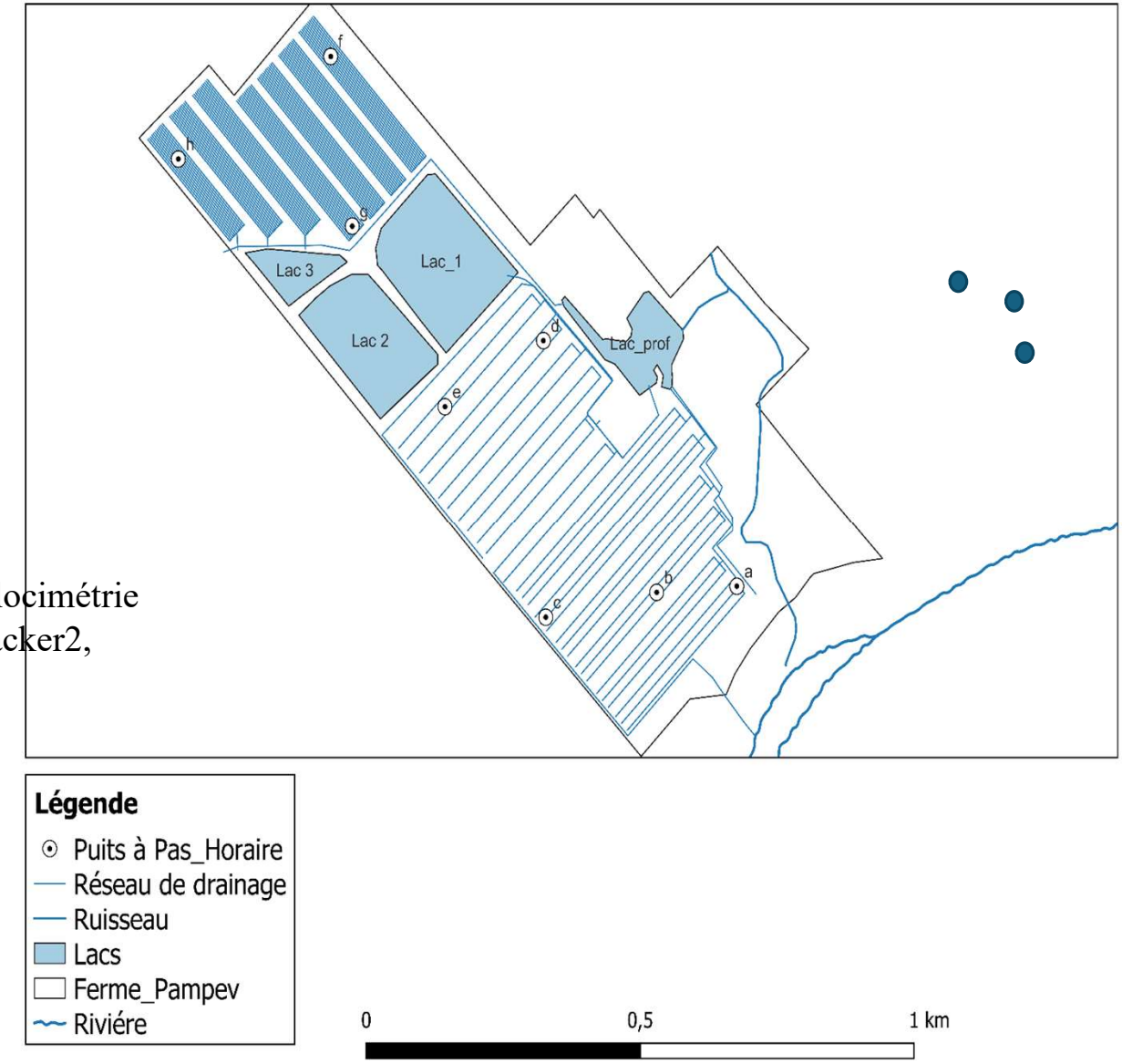


Campagnes de mesures

Suivi de la hauteur de la nappe
8 Puits à pas de temps horaire :
a, b, c, d, e, f, g, et h

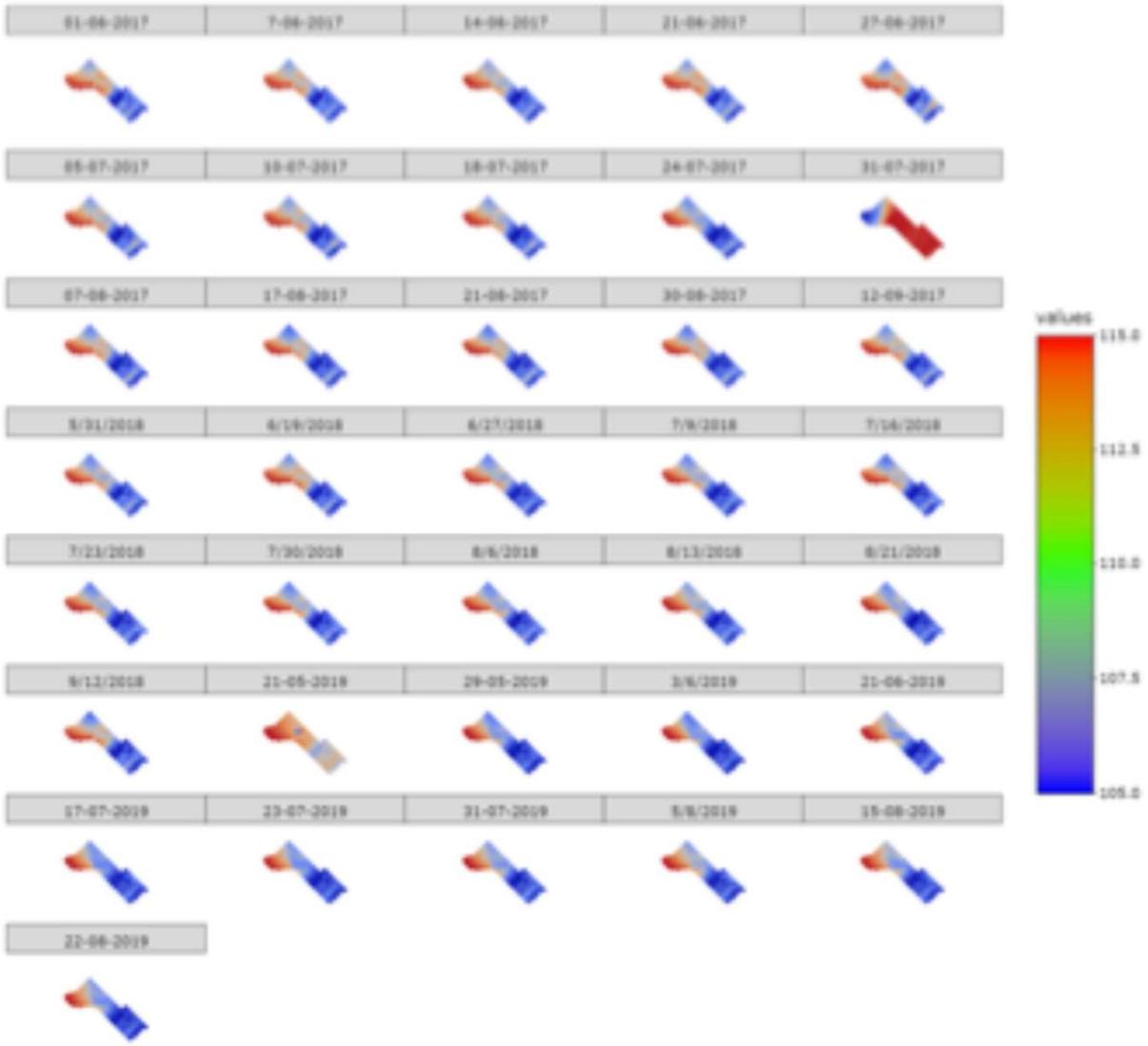
Du 14/07/2017 au 30/09/2017
Du 8/06/2018 au 05/10/2018
Du 10/05/2019 au 26/09/2019

- **Mesure du débit du cours d'eau** avec la vélocimétrie acoustique à effet Doppler (ADV®) FlowTracker2, Novembre 2023

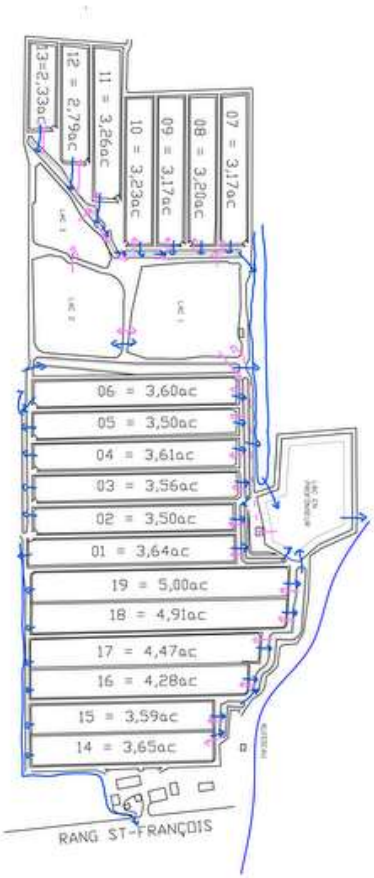


Variation de la nappe sur 3 ans.

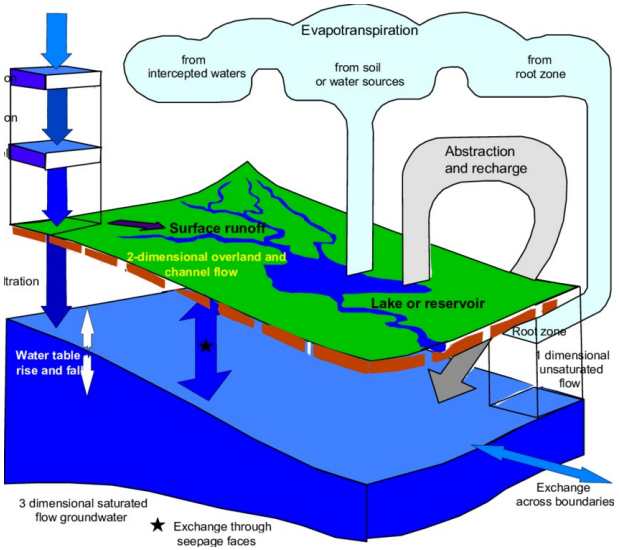
Avec un système de drainage
Performant, la nappe attend
sa profondeur optimale
entre 2 à 3 jours.

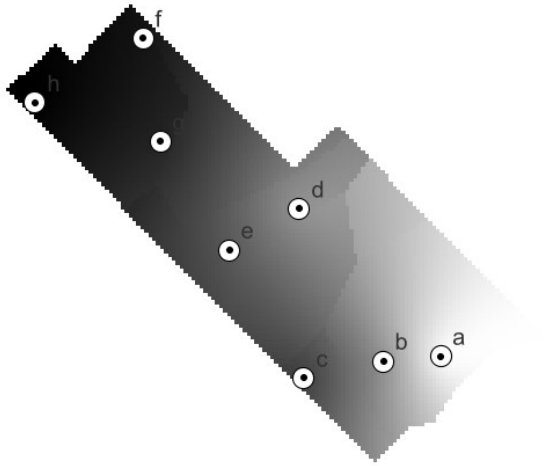


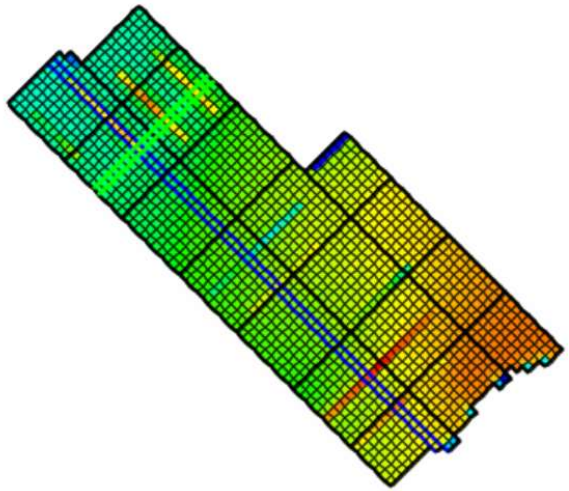
Avec des simulations HYDRUS 2D, sans drains, la nappe au prends au mois 20 jours à s’équilibrer.



Mise en place de MIKE-SHE

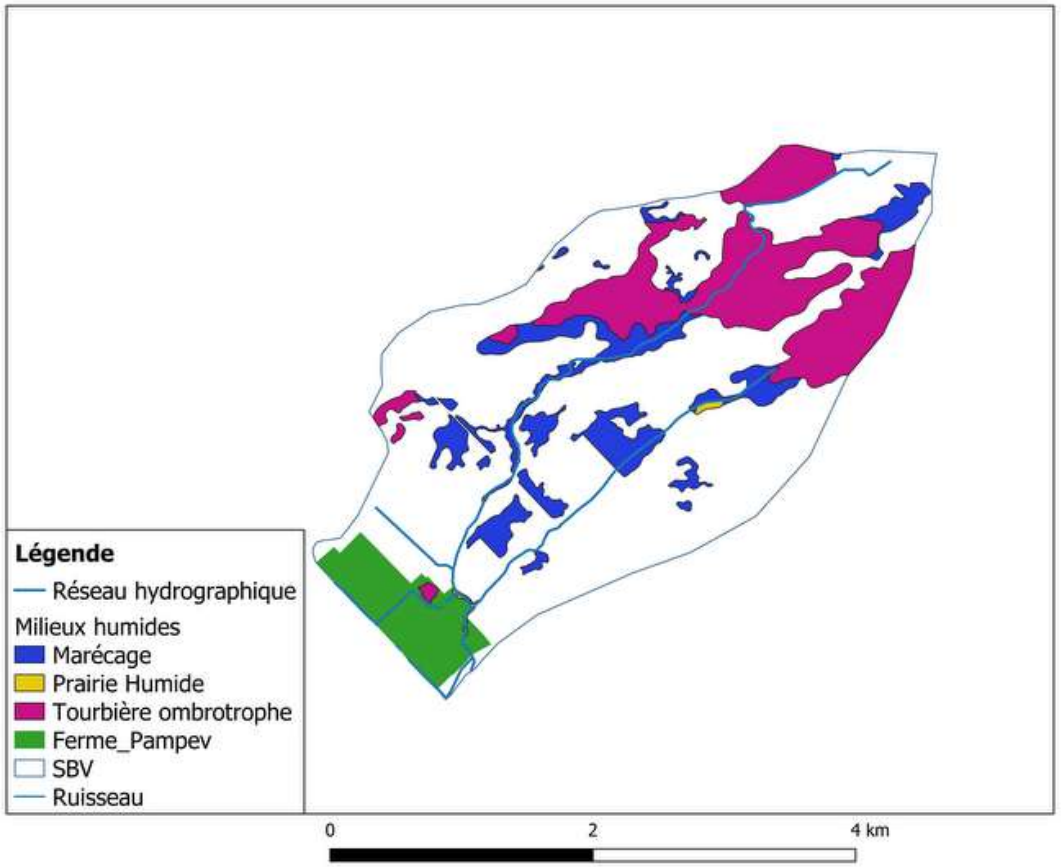


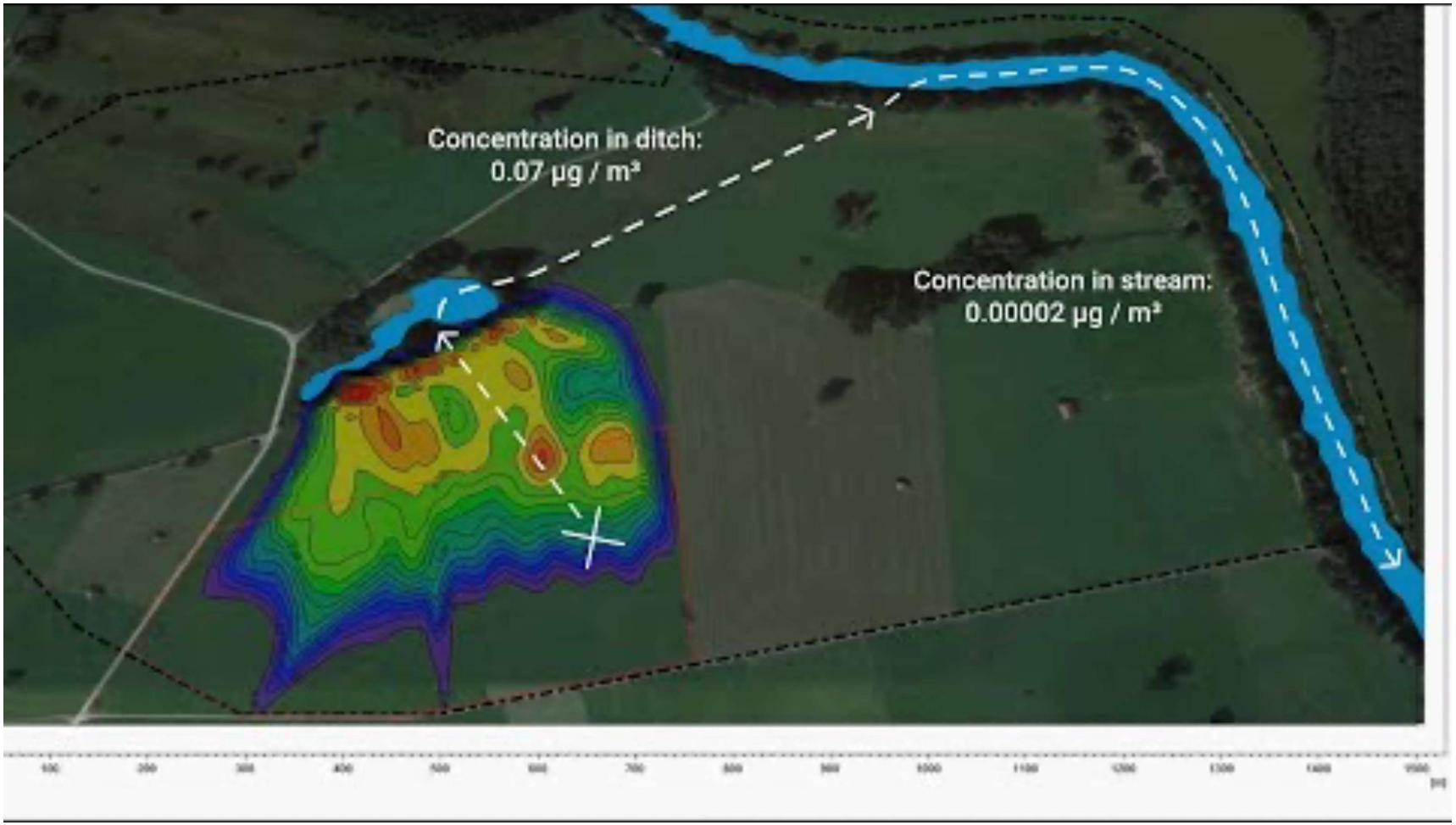




Modélisation à l'échelle du sous-bassin versant :

Observer les interactions et les échanges d'eau (souterraine et de surface) avec les milieux humides et le cours d'eau




Concentration in ditch:
0.07 µg / m³
Concentration in stream:
0.00002 µg / m³

Merci !!!

Enquête sociohydrologique pour élucider la contribution de la production de canneberges à la gestion intégrée des usages de l'eau à l'échelle du bassin

Nafiseh Khoramshokooh, Alain N. Rousseau, Silvio J. Gumière, Paul Célicourt

Jeudi, 30 janvier 2025

Complexe Hôtelier Du Pré

555, rue Saint-Jacques Est, Princeville (Québec) G6L 4X6

Journée INPACQ CANNEBERGES

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notre canneberge .com

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Motivations

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- **Comprendre les besoins et les défis des agriculteurs**
  - Nous voulons comprendre vos pratiques agricoles, votre utilisation de l'eau et les défis que vous rencontrez afin d'améliorer sa gestion

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- **Soutenir l'augmentation des rendements et la rentabilité**
  - Notre objectif est d'intégrer avec justesse les usages journaliers de l'eau à la ferme dans la modélisation hydrologique afin d'élucider son effet sur la disponibilité de l'eau

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  - Nous cherchons à différencier l'usage de l'eau des secteurs agricole, industriel et municipal afin de déterminer leur effet individuel et cumulatif sur les débits des rivières

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- **Collaborer pour une meilleure gestion de l'eau**
  - Vos opinions contribueront à l'élaboration de politiques de gestion de l'eau justes et efficaces visant à soutenir l'agriculture et assurer sa durabilité à long terme

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Sections principales du sondage (*# de questions*)

A. Renseignements généraux (2)

B. Démographie (2)

C. Impact économique (6)

D. Perception sociale et implication communautaire (5)

E. Sensibilisation et pratiques environnementales (4)

F. Politiques et réglementations (4)

G. Conflit et coopération (4)

H. Population et consommation (1)

I. Planification future (7)

Motivations

merci !