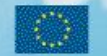


# PEGASE, A model dedicated to Surface Water Quality Assessment that helps stakeholders implementing the WFD

**European Geosciences Union  
General Assembly 2011**

Vienna, Austria, 03-08 April 2011

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**P Weingertner, C Conan, JL Salleron** : French Water Agency Rhin-Meuse  
**O Coulon, O de Guibert** : French Water Agency Loire-Bretagne



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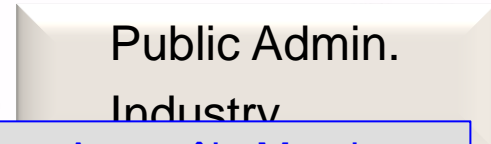
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- **The PEGASE Model**
  - Working Scheme
- **APPLICATIONS FROM STAKEHOLDERS**
  - French Water Agency : AERM
  - French Water Agency : AELB
- **CONCLUSIONS**

# Introduction



R&D centre  
Expertise in water domain

- Biology
- CART (Water analysis)
- CEBEDEAU (Measurements & purification)
- Climatology
- Ecotoxicology
- Geomatic
- Geomorphology
- Hydraulic
- Hydrology & Agronomy
- Hydrogeology
- Hydrography
- Oceanology
- Topoclimatology
- Toxicology
- Water & Environment Unit

- ❑ Integrated water analysis & management
  - Management tools improvement → ecological, economic
  - Predictive models (e.g. PEGASE model)
  - Support public and private operators
- ❑ Treatment and management of wastewater
- ❑ Analytic measurements of water quality
- ❑ Cooperation with Southern countries
- ❑ Knowledge of aquatic ecosystems & biodiversity

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L'eau nous fait progresser. Faisons progresser l'eau

# PEGASE Model

## Planification Et Gestion de l'Assainissement des Eaux Planning and Management of Water Purification

Developed for 25 years  
By 3 universities

Main Partners → Public Authorities in charge of surface water management  
EU / Applications Out of EU

### Objectives

- Better understand the mechanisms of the hydro-system
- Quantify “pressure-impact” relationships and ease decision making
- Structure knowledge (including “Input Data”)

### Usage

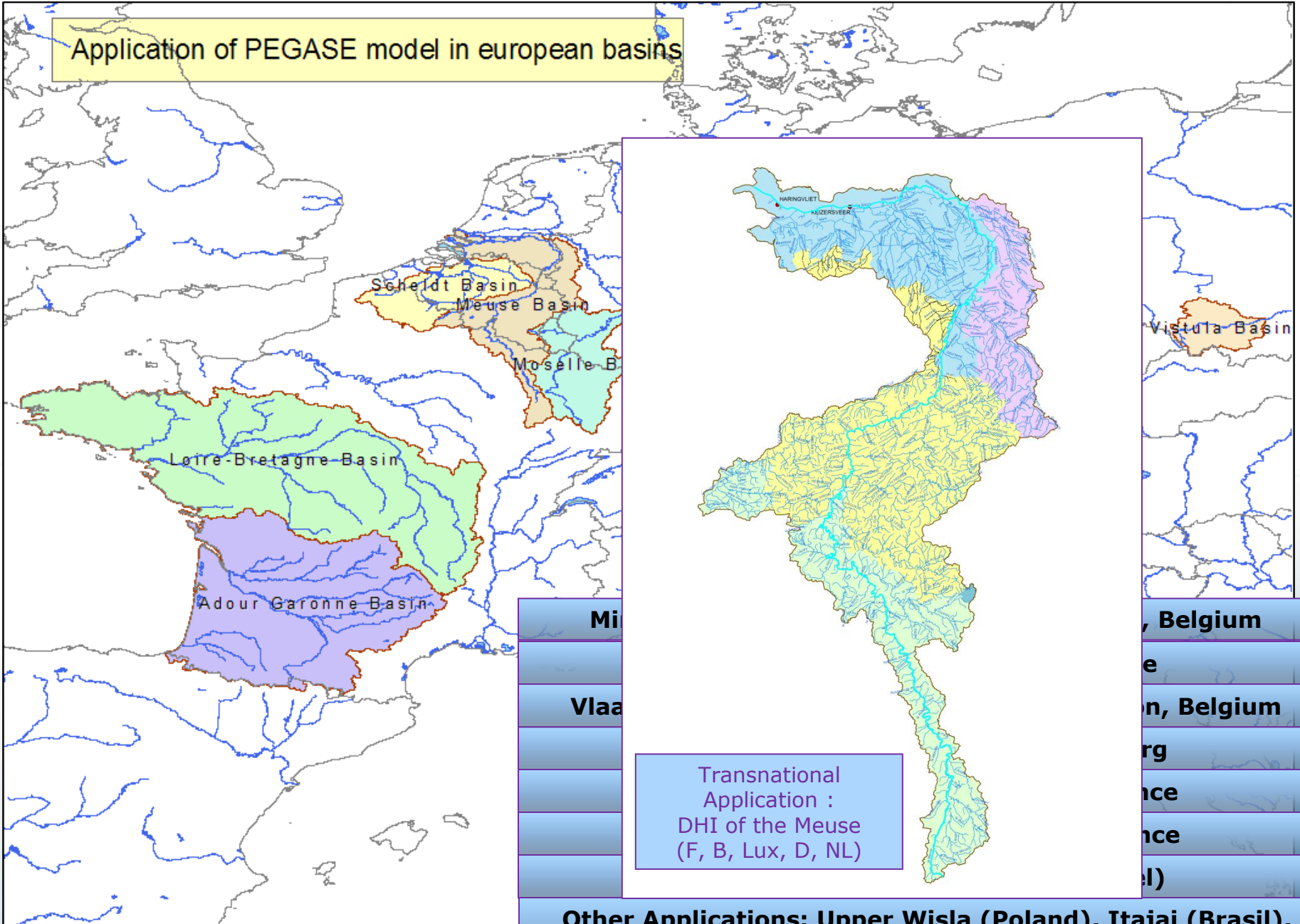
#### 1) Simulation of surface water quality

- ✓ Relation Watershed / Rivers (→ extending “river” models)
- ✓ Taking into account all Pollutants loads and Discharges  
→ data structuration
- ✓ Representation of the Aquatic Ecosystem and the Water Quality (O<sub>2</sub>, C, N, P, ...)  
→ Deterministic model and physically based

#### 2) Operational Decision Making Tool for

- ✓ Purification and Depollution
- ✓ Management of aquatic environment quality / WFD / Management plans ...  
→ Continuous interaction with users

Application of PEGASE model in european basins



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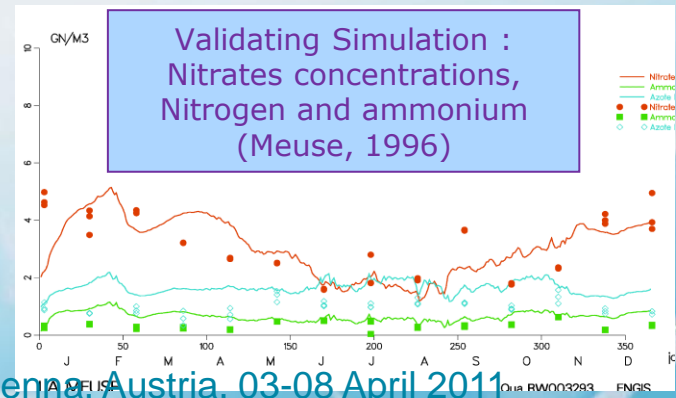
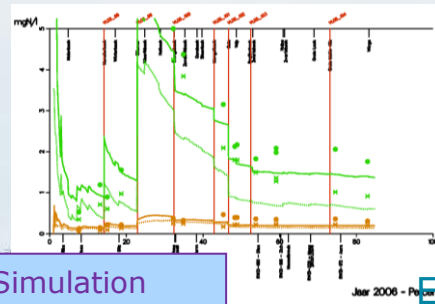
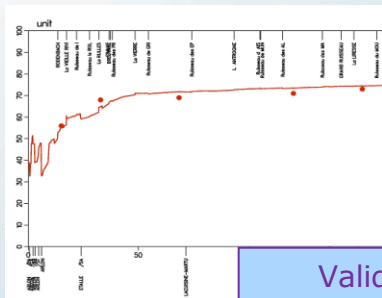
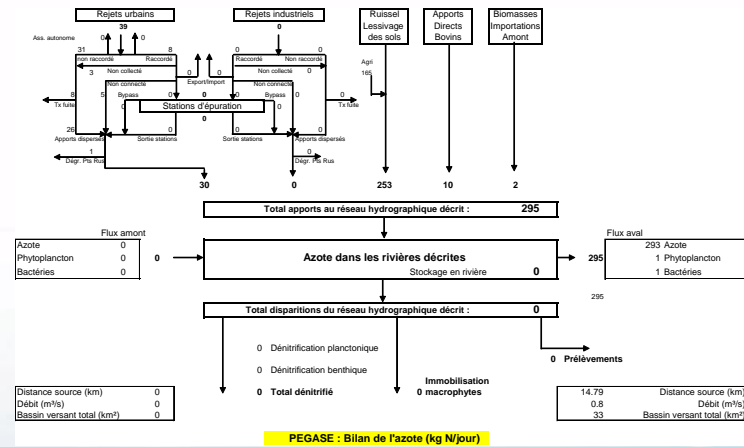
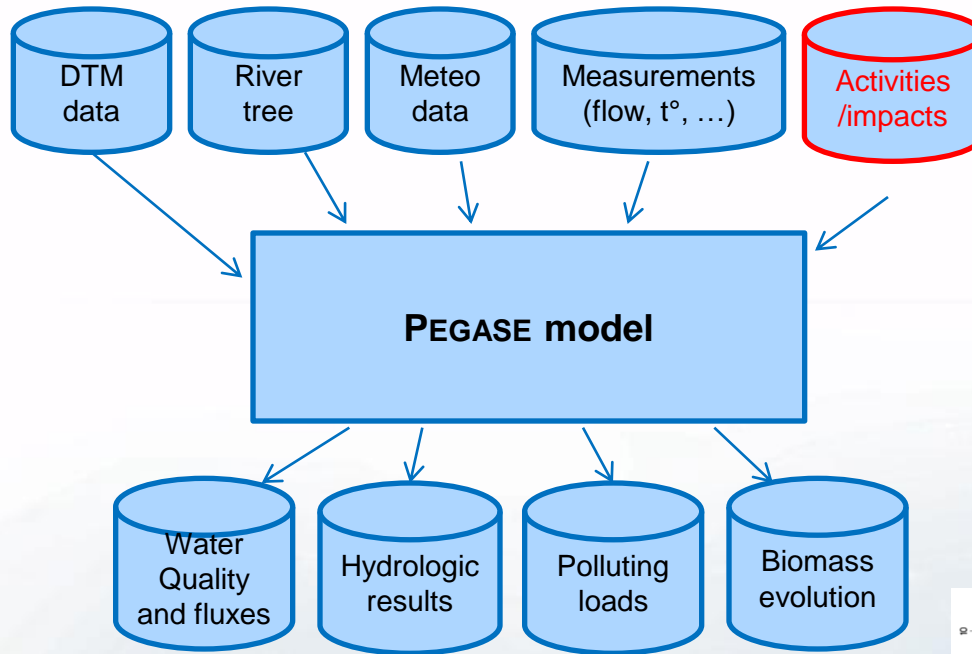
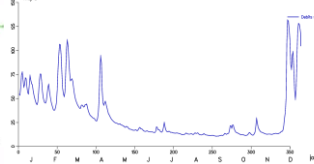
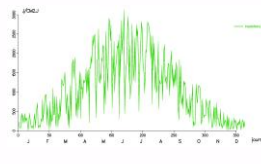
Transnational Application :  
DHI of the Meuse  
(F, B, Lux, D, NL)

Other Applications: Upper Wisla (Poland), Itajai (Brasil), Nicolet (Canada), Iskar (Bulgaria), Medjerda (Tunisia)

# PEGASE Working Scheme



Pôle de recherche et d'expertise en sciences de l'eau



Validating Simulation

# Loads and Discharges



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et d'expertise en sciences de l'eau

## Estimates of loads and discharges (C, N, P)

### Urban Releases

Equivalent-inhabitant

Consideration of abatements in treatment plants (measures or estimates)



### Industrial releases

Inventory of discharges (fees, ...)



### Cattle

“Accidental” direct discharge of Livestock (tanks, ...)

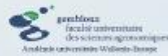


### Diffuse Loads

Semi-statistical functions, region specific

= run-off x leaching concentrations

possibility of coupling with soils models



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EGU, Vienna, Austria, 03-08 April 2011

# PEGASE Model

## Additional Features



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- Integrated model for rivers & watershed
- Accurate Simulations for a few km<sup>2</sup> → several 100 000 km<sup>2</sup>
- “Refined” Description of river tree (>> Thousands rivers)
- Complete Description of ecosystems (phytoplankton, bacteria...)
- “Coherent and complete” modelling of loads and discharges

- Stationary and/or unstationary Simulations (coupled with...)
- Globalisation of results per river,
- Calculation of statistics for comp (p90, mean, median, ...)



- ✓ Complementary Modules → WFD (cost/efficiency, balance, ...)
- ✓ User-friendly interface
- ✓ Linked to GIS
- ✓ Numerous IO Format
- ✓ Coupled to hydrogeological/hydrological/meteorological/... Modules if necessary
- ✓ Open MI Compliant

# The Water Quality Model

## Processes

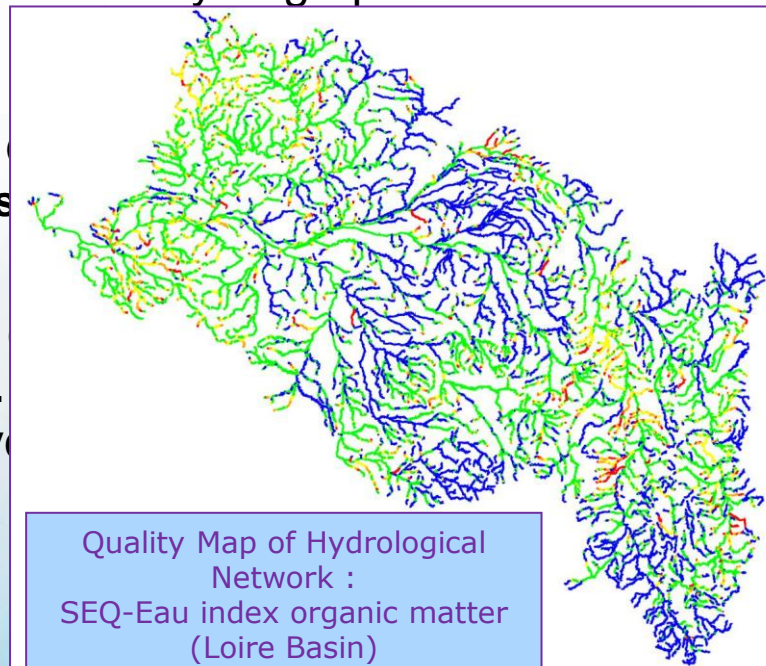
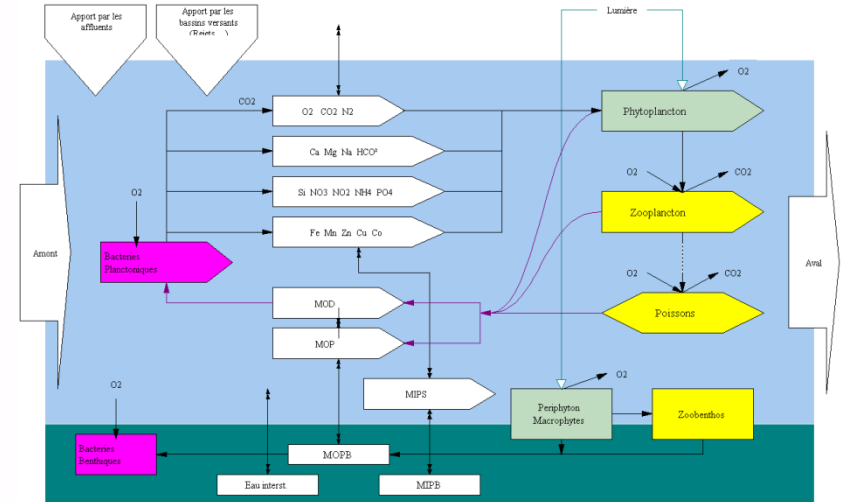
- primary production
- mortality, biomasses respiration
- degradation organic matter
- nitrification, de-nitrification
- re-aeration

## Variables

- flows, velocities, transfer time in the hydrographical network
- temperature
- concentrations : **OM, DOC, dissolved**  
**biomasses**

## Results

- longitudinal results, temporal calculation of statistics (p90, .
- globalisation of results per river flux, balances



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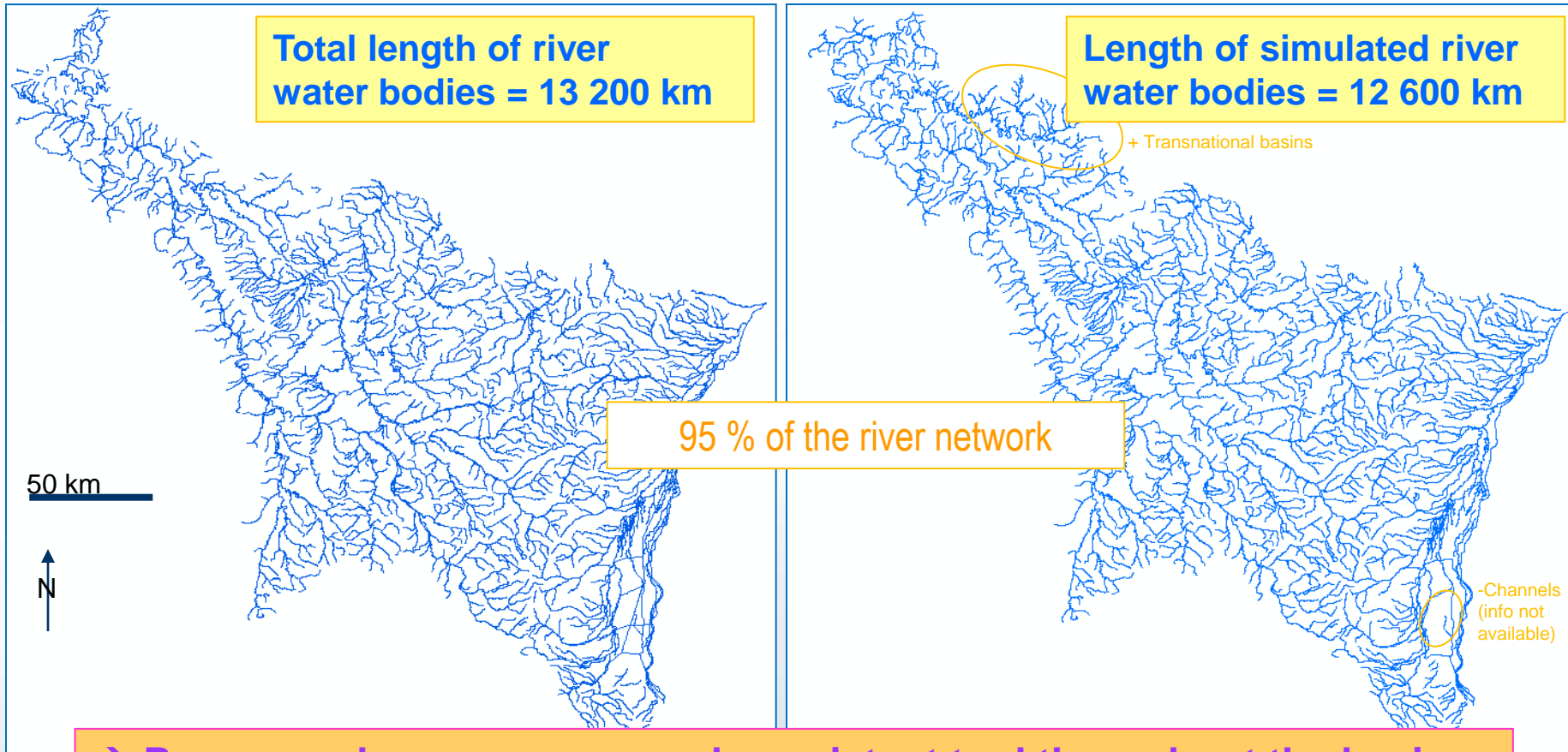
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is progresser l'eau

# Application from Stakeholder AERM (French Water Agency : Agence de l'Eau Rhin-Meuse)

PEGASE Modeling

PATRICK WEINGERTNER, CÉLINE CONAN



→ PEGASE : a homogeneous and consistent tool throughout the basin

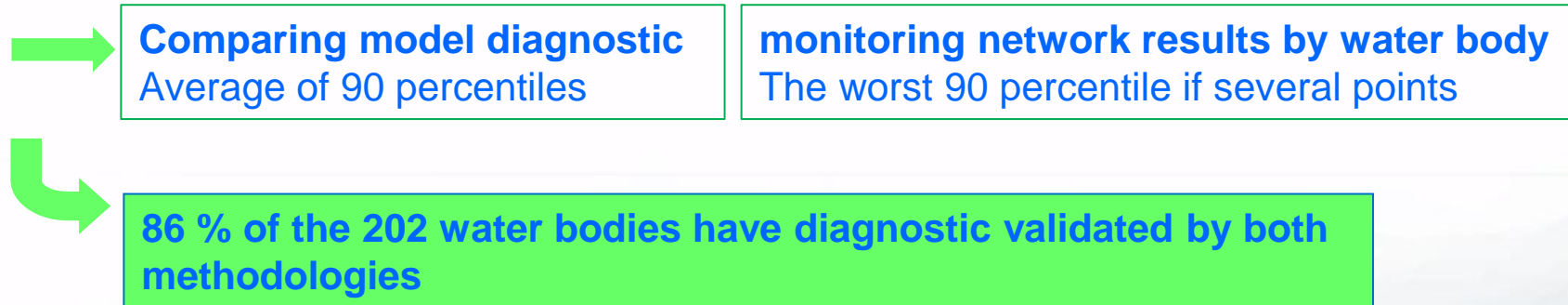
# Application from Stakeholder AERM (French Water Agency : Agence de l'Eau Rhin-Meuse)



Pôle de recherche  
et d'expertise en sciences de l'eau

## PEGASE Implementation

The diagnostic is consistent with results of the monitoring networks



→ PEGASE : a powerful tool supplemented by expertise in case of discrepancy

# Application from Stakeholder AERM (French Water Agency : Agence de l'Eau Rhin-Meuse)



Pôle de recherche  
et d'expertise en sciences de l'eau

## PEGASE Model application

PEGASE = tool for assessing the physico-chemical quality of surface water bodies  
Thanks to the validation processes

### ■ Setting up the programs of WFD measures

- Estimating the impact of local measures on the aquatic environment  
combination of PEGASE results and the expertise of the stakeholder

➔ impact of the measures taken to reduce emissions of classical pollutants (organic matter, nitrogen or phosphorus) from domestic and industrial waste water

Simulations of prospective quality considering different hypothesis :

- population trend of the 3300 municipalities
- improvement of the individual purification for 600 municipalities
- 650 new sewage connections
- 300 new wastewater treatment plants (in addition to the 650 existing)
- 100 measures on industrial releases (on 360 releases)

# Application from Stakeholder AERM (French Water Agency : Agence de l'Eau Rhin-Meuse)



Pôle de recherche  
et d'expertise en sciences de l'eau

## PEGASE Model application

PEGASE = tool for assessing the physico-chemical quality of surface water bodies  
Thanks to the validation processes

### ■ Setting up the programs of WFD measures

- Selection of the most effective local measures  
analysis « **cost-efficiency** »

➔ *combination of the most economical measures among the combinations of possible measures to achieve environmental objectives (particular care for measures related to the communities purification [which are the more expensive])*

Achieving annual saving of  $60 \cdot 10^6$  €  
(8% of the cost of good status)

# Type of Results



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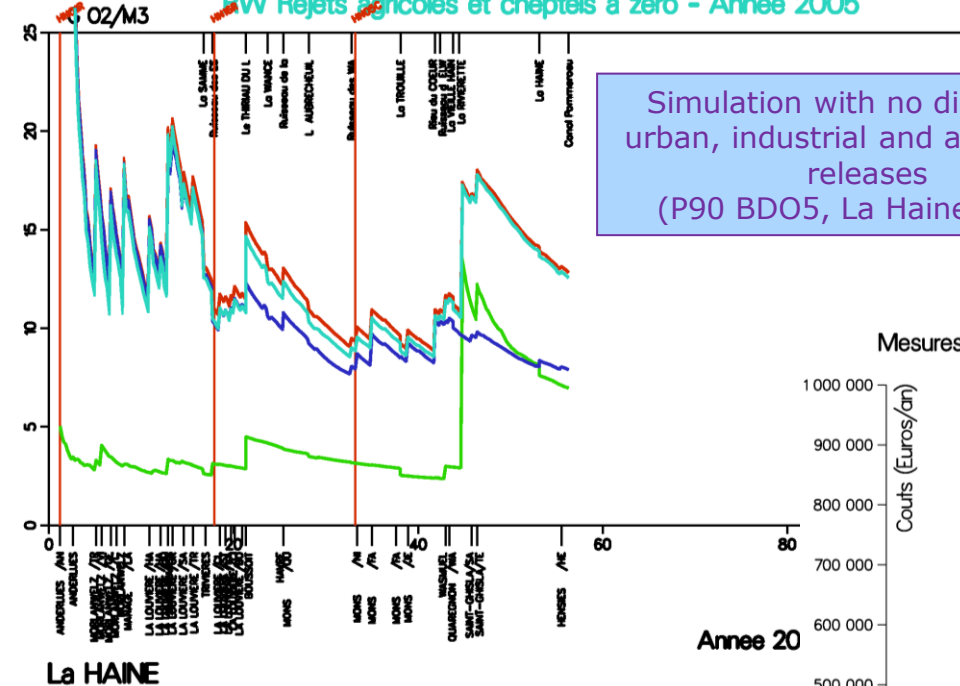
## CONCENTRATIONS DANS LE RESEAU HYDROGRAPHIQUE "DBO5" CARBONE (GO2/M3)

RW Simulation de reference - Region Wallone

RW Rejets urbains a zero - Annee 2005

RW Rejets industriels a zero - Annee 2005

RW Rejets agricoles et cheptels a zero - Annee 2005



Simulation with no discharge: urban, industrial and agricultural releases (P90 BDO5, La Haine, 2005)

Mesures de base : Indice qualite minimum : 54.2 - parametre declassant : IMP\_PO4  
 Nombre de combinaisons de mesure permettant d'atteindre le bon etat 10 / 31

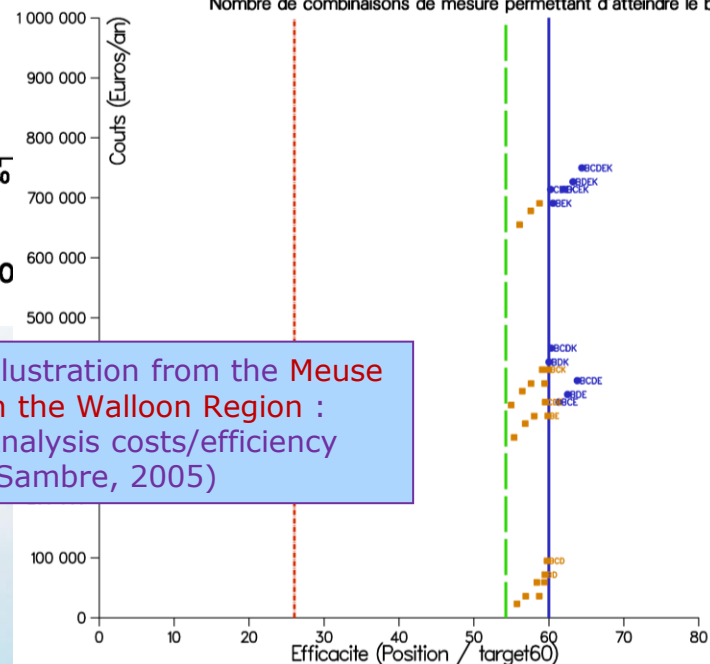


Illustration from the Meuse in the Walloon Region : Analysis costs/efficiency (Sambre, 2005)

--- IQ atteint avec situation de reference (IQ=26.0)  
 --- IQ atteint avec mesures de base (IQ=54.2)  
 — Limite bonne qualite (IQ=60.0)

LISTE DES MESURES SIMULEES	COUTS EUROS/AN	IQmes	C marginal Compl.	Keuros/pt
A : tert step exist 2000-10000	0	54.2	-	-
B : tert nouvel step 2000-10000	35 964	58.7	8.064	-
C : tert step exist 500-2000	23 135	55.7	15.632	-
D : tert nouvel step 500-2000	35 746	56.9	13.438	-
E : assainissement autonome	300 475	55.4	268.282	-
F : reduct 20% rejind IPPC non racc	0	54.2	-	-
G : reduct 20% suppl rejind IPPC non racc	0	54.2	-	-
H : reduct 20% rejind non IPPC non racc	0	54.2	-	-
I : reduct 20% suppl rejind non IPPC non racc	0	54.2	-	-
J : reduct 50% apports inconnus	0	54.2	-	-
K : reduct 20% apports diffus	354 600	55.0	492.499	-

## Application from Stakeholder AERM (French Water Agency : Agence de l'Eau Rhin-Meuse)



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et d'expertise en sciences de l'eau

### PEGASE Model application : Preliminary conclusions

PEGASE = tool for assessing the physico-chemical quality of surface water bodies  
Thanks to the validation processes

- **Helps to establish the priorities of intervention programs of the Agency (selectivity of operations)**
  - **Impact of the releases on the status of the surface water bodies**  
estimation of the expected status of the water bodies  
(physico-chemical quality added by the biological quality)
  - **Indication of the water flows at the point of the releases**  
in order to assign a priority level
  
- **Supports the development of the state of the art in the International basin Mosel-Saar (France, Luxemburg, Germany)**

# Application from Stakeholder AELB (French Water Agency : Agence de l'Eau Loire-Bretagne)

O. COULON, O. DE GUIBERT



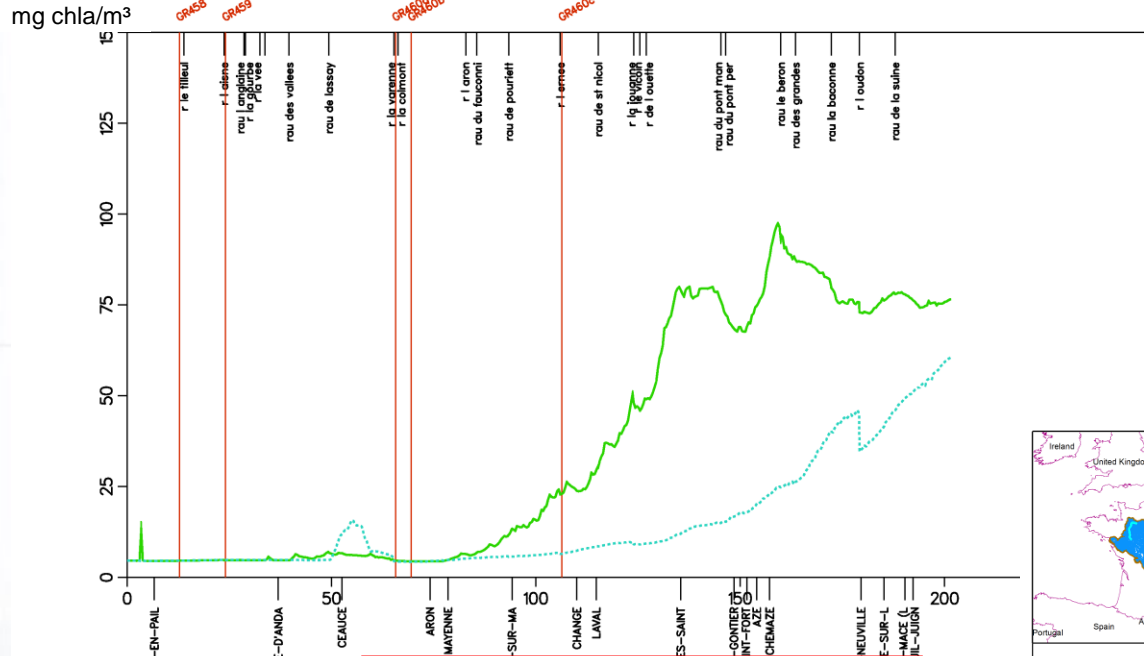
Pôle de recherche et d'expertise en sciences de l'eau

PEGASE : Application bassin de la LOIRE Agence de l'eau Loire-Bretagne

## PHYTOPLANKTON

### TEST NSTO2 SIMULATION DE REFERENCE

### TEST NSTO21 SCENARIO AVEC SUPPRESSION SEUILS <= 4 Metres

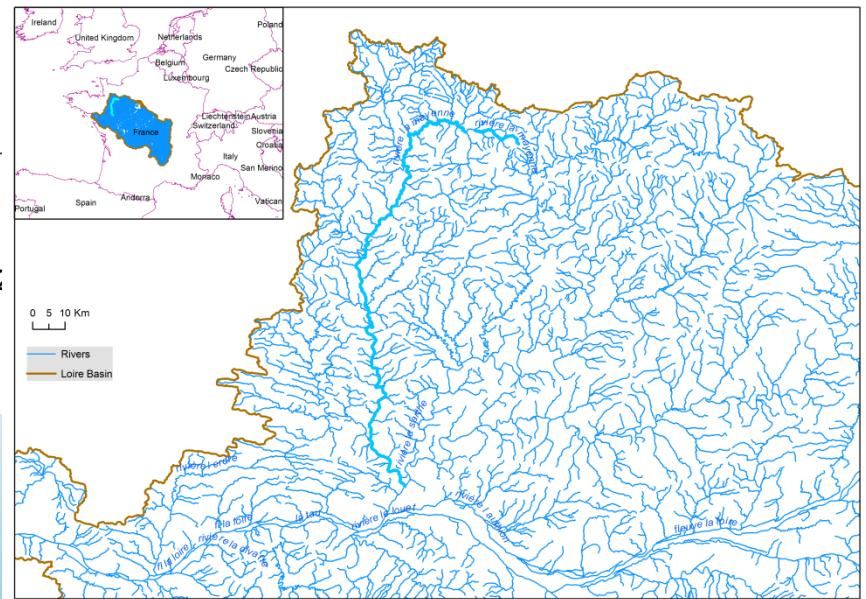


In the framework of the SDAGE (schéma directeur d'aménagement et de gestion des eaux), reducing the phytoplankton concentration in the river

WFD implementation (SDAGE elaboration) Reduce the phytoplankton

Two solutions to achieve this objective:

- Dephosphatation in WWTP (< 2 000 EH)
- **Remove the barriers** (which contribute to eutrophication)



Année 2

# Application from Stakeholder AELB (French Water Agency : Agence de l'Eau Loire-Bretagne)

PEGASE : Application bassin de la LOIRE Agence de l'eau Loire-Bretagne

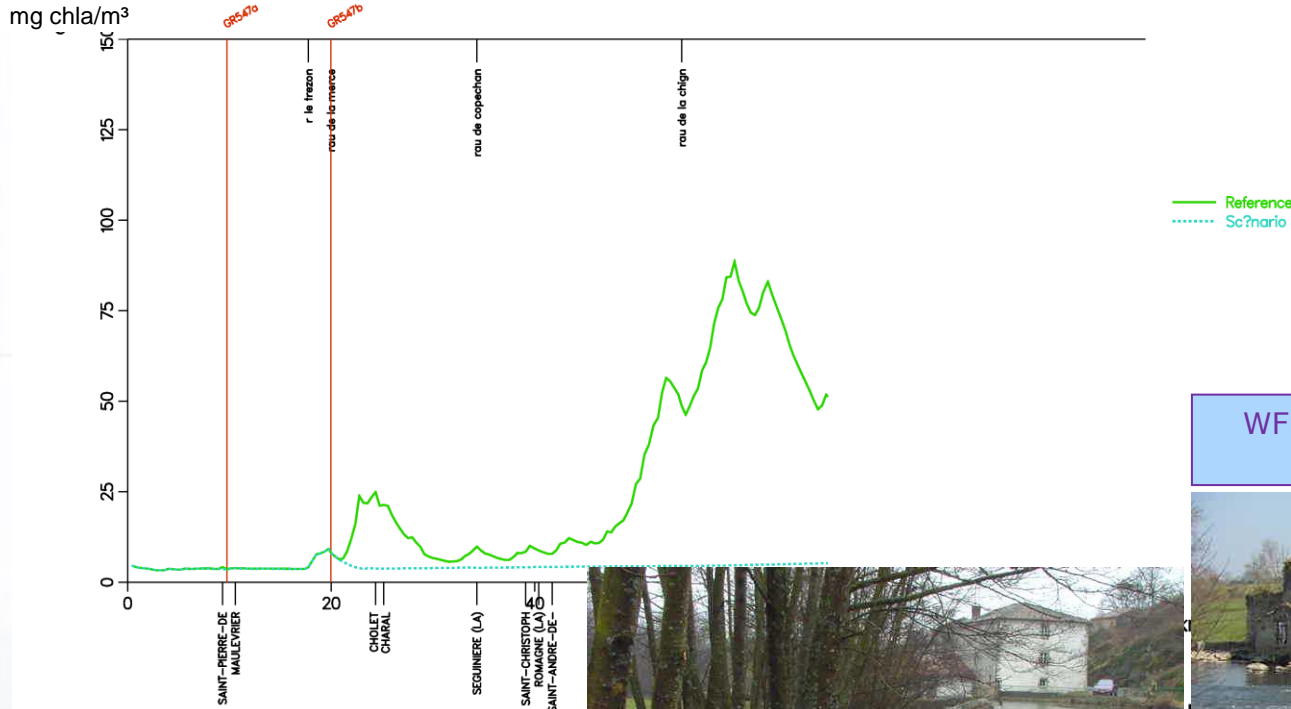
## PHYTOPLANKTON

TEST NST02 SIMULATION DE REFERENCE

TEST NST021 SCENARIO AVEC SUPPRESSION SEUILS  $\leq 4$  Metres



Pôle de recherche  
et d'expertise en sciences de l'eau



WFD implementation (SDAGE elaboration)  
Reduce the phytoplankton



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# Application from Stakeholder AELB (French Water Agency : Agence de l'Eau Loire-Bretagne)

PEGASE : Application bassin de la LOIRE Agence de l'eau Loire-Bretagne

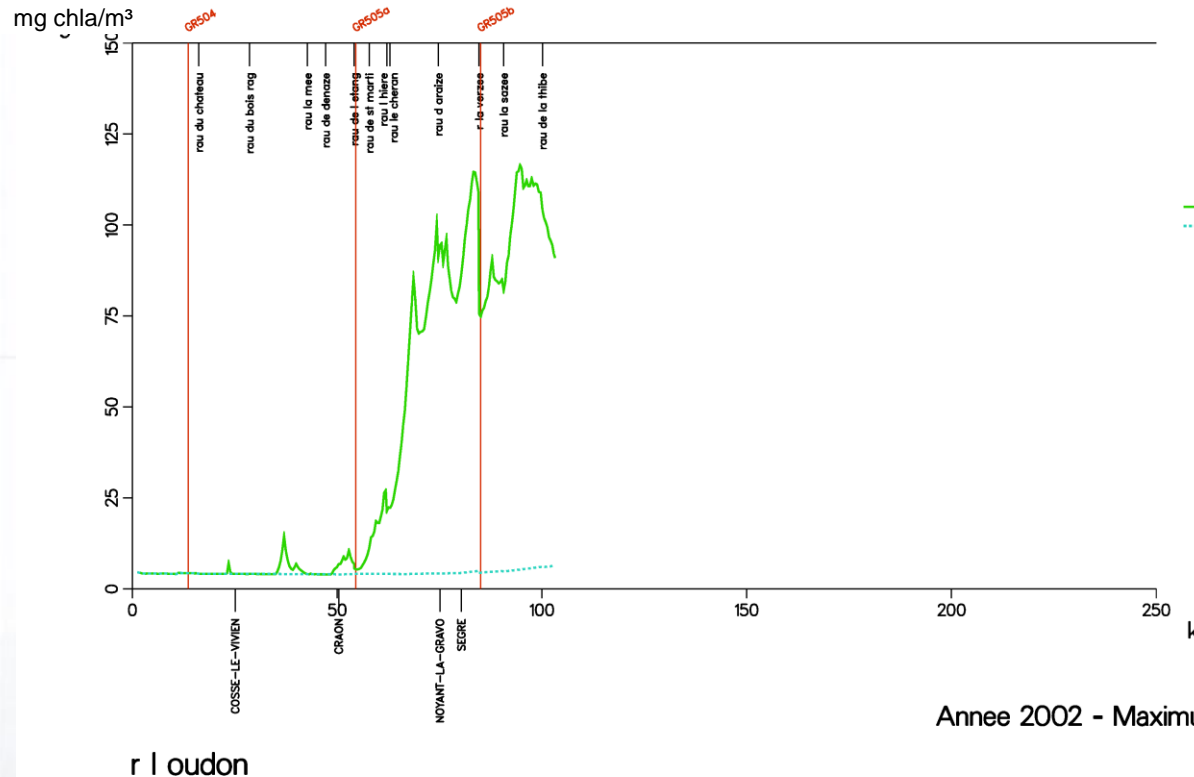
PHYTOPLANKTON

TEST NST02 SIMULATION DE REFERENCE

TEST NST021 SCENARIO AVEC SUPPRESSION SEUILS  $\leq 4$  Metres



Pôle de recherche  
et d'expertise en sciences de l'eau



### Conclusions:

- Simulations indicate that barriers removal may be effective
- No change imposed to the WWTP
- Open debate to choose the best solution regarding the local complete characteristics of the river system

WFD implementation (SDAGE elaboration)  
Reduce the phytoplankton



# Conclusions



- ✓ **Contribution to the implementation of the Water Frame Directive (2000/60/CE)**
  - **Diagnostic of river and channel water bodies before and after considering various scenarios of measures**
  - **Extrapolation of locally sampled data to the whole set of water bodies**
  - **Analysis cost/efficiency of various combinations of possible measures**
  - **Support to programmes of measures elaboration**
  
- ✓ **Contribution of balances and diagnostics to interventions and specific valuations**
  - **Establishment of intervention priorities (e.g. In the field of purification)**
  - **Technical support to administrations for local actions**
  - **Impact studies of treatment plant, industrial or urban releases**
  - **Geographical modulation of subventions and fees**
  - **Support to definition of actions at international level (cross-border basins)**

# Application from Stakeholder AERM (French Water Agency : Agence de l'Eau Rhin-Meuse)



Pôle de recherche  
et d'expertise en sciences de l'eau

## Own Conclusions

**PEGASE = tool for assessing the physicochemical quality of surface water bodies through the validation processes**

### The model implementation allows

- **Technical support for agencies**  
credibility, optimization of choices and funding provided
- **Setting up of intervention priorities**
- **Choice of required measures to**  
achieve the objectives of good status over water bodies
- **Better use of public funds**  
Economy for communities or industries to carry out work



**Thanks for your attention**

