BELGIAN SCIENCE POLICY

Investigating the worth of flux-based approaches in development of brownfields: the FRAC-WECO project

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FRAC-WECO

Aquapôle ULg UNIVERSITÉ de Liège ArGEnCo Vrije Universiteit Brussel VITO brgm Géosciences pour une Terre durable

FRAC-WECO Consortium

- Coordinator: ULg – Geo³-Hydrogeology
  - S.Brouyère, A.Dassargues, D. Caterina
- P1: ULg – LEAE
  - J.-P. Thomé, V.Debacker, S.Crevecoeur
- P2: VITO
  - L.Diels, W.Dejonghe
- P3: VUB Hydrology and Hydraulic Engineering / Geography
  - O.Batelaan, F.Canters, J. Dujardin
- PI: BRGM – Service Eau
  - C.Hérivaux

Risk assessment before development of brownfields

- FRAC-WECO=**F**lux-based **R**isk **A**ssessment of the impact of **C**ontaminants on **W**ater resources and **ECO**systems

➔ integrated methodology for more comprehensive risk assessment of contaminated sites on water resources and ecosystems

Process studies → water & contaminant fluxes, biogeochemical properties and ecotoxicity of contaminants
Impact studies → risk assessment methodologies, socio-eco analysis

➔ Management tools & Indicators for ranking contaminated sites in terms of risks & costs

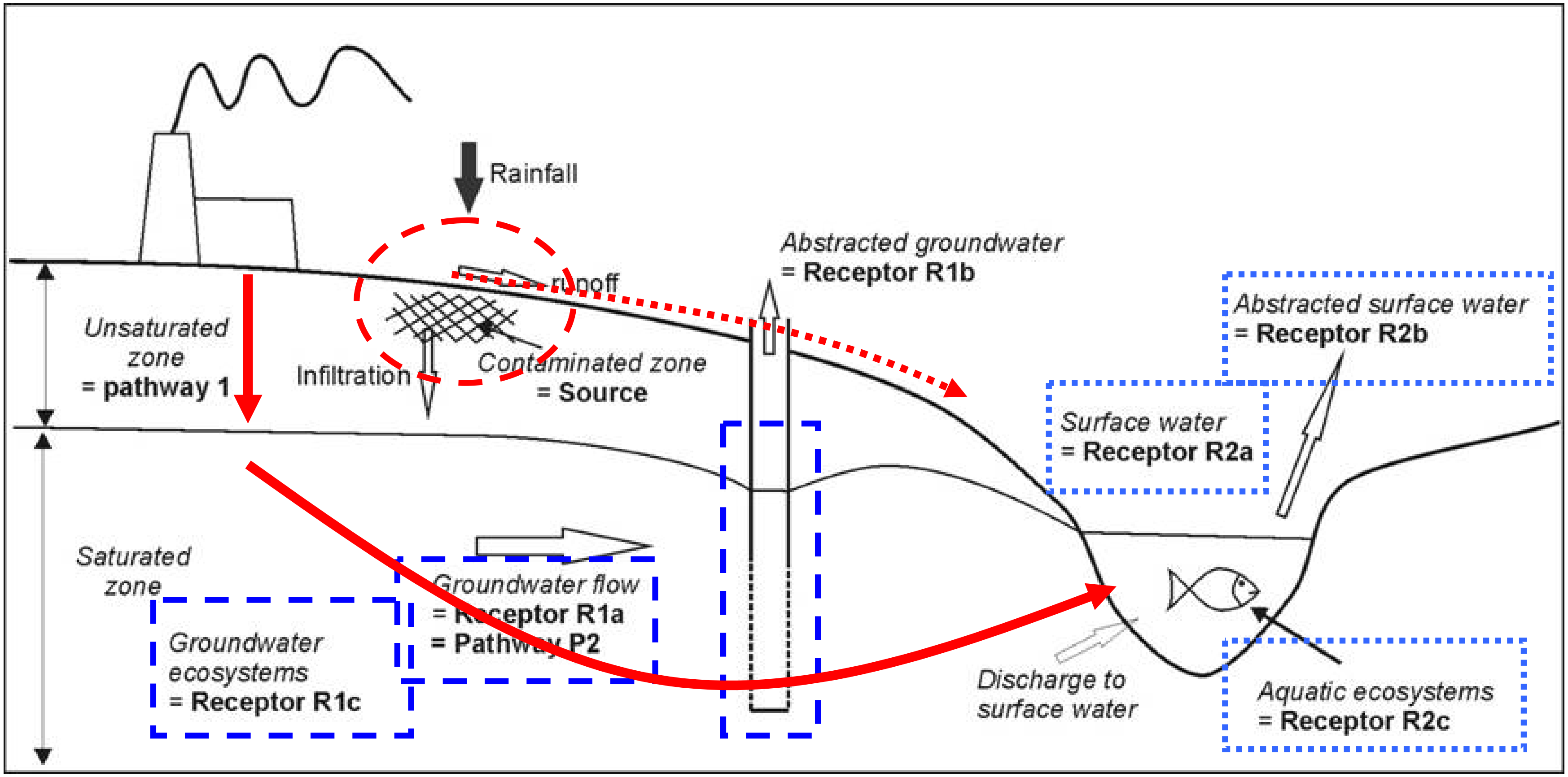
➔ Integration schema

Outline

- Conceptual description of the studied system
  - Physical components & Source-Pathway-Receptor (SPR) approach
  - Socio-eco & physical components: Drivers-Pressures-State-Impacts-Response (DPSIR)
  - Combined DPSIR – SPR approach
- Decision Support
  - Risk Assessment framework
  - DPSIR Indicators
- Process Studies
  - Study of the water flow
  - Study of the contaminant fluxes
  - Socio-Economic Analysis (State – Impacts relationships & Analysis of Responses)
- FRAC-WECO Research activities Year 1
- Example

Physical components & SPR approach

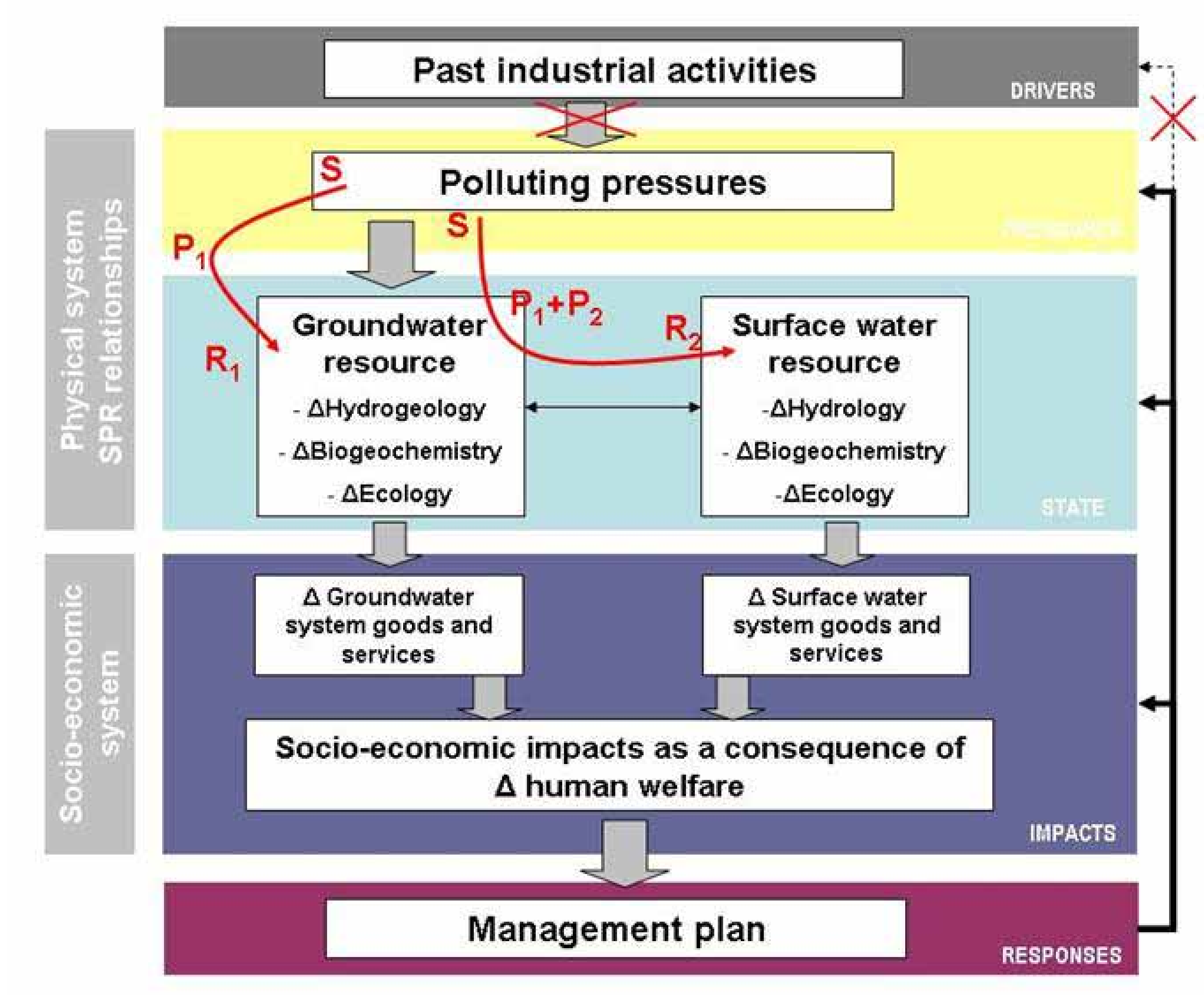
Source – Pathway – Receptor approach



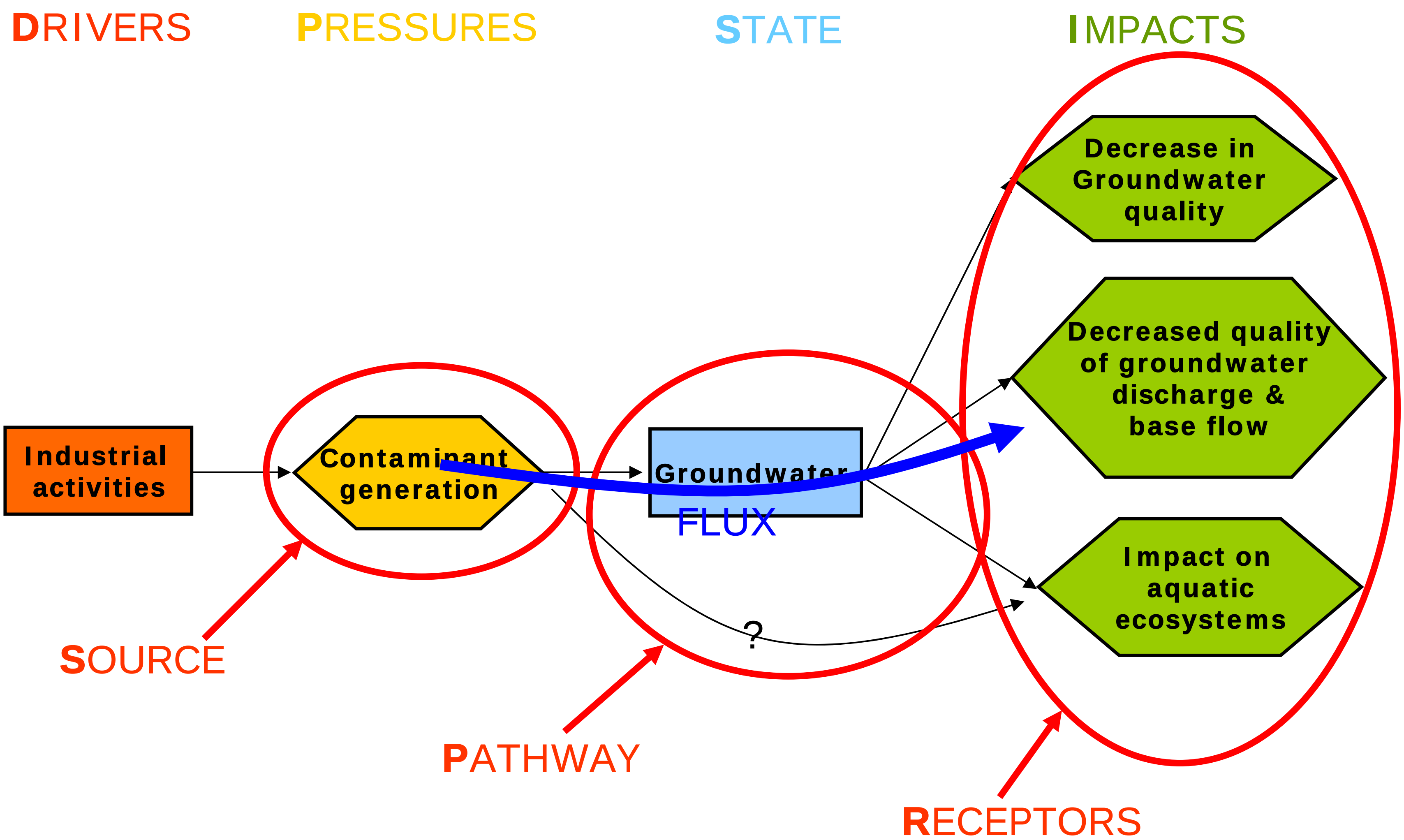
Socio-Eco & Physical Components: DPSIR

- Drivers
  - Existing contamination sources ➔ Drivers not explicitely considered as potential components of the analysis, no preventive measures possible
- Pressures = Source of contaminants, from where contaminants are emitted
- State: aquatic system related to
  - Groundwater
  - Surface water as impacted by groundwater
- Impacts
  - Related to changes in the aquatic system
  - Characterized as changes of goods and services provided by aquatic systems → change in human welfare
  - Expressed in monetary terms = change of the total economic value (TEV) of the aquatic systems due to change in their state
- Responses
  - Decision Makers have to take decisions to improve the state or mitigate the impacts

Combined DPSIR-SPR approach



FRAC-WECO & DPSIR & SPR

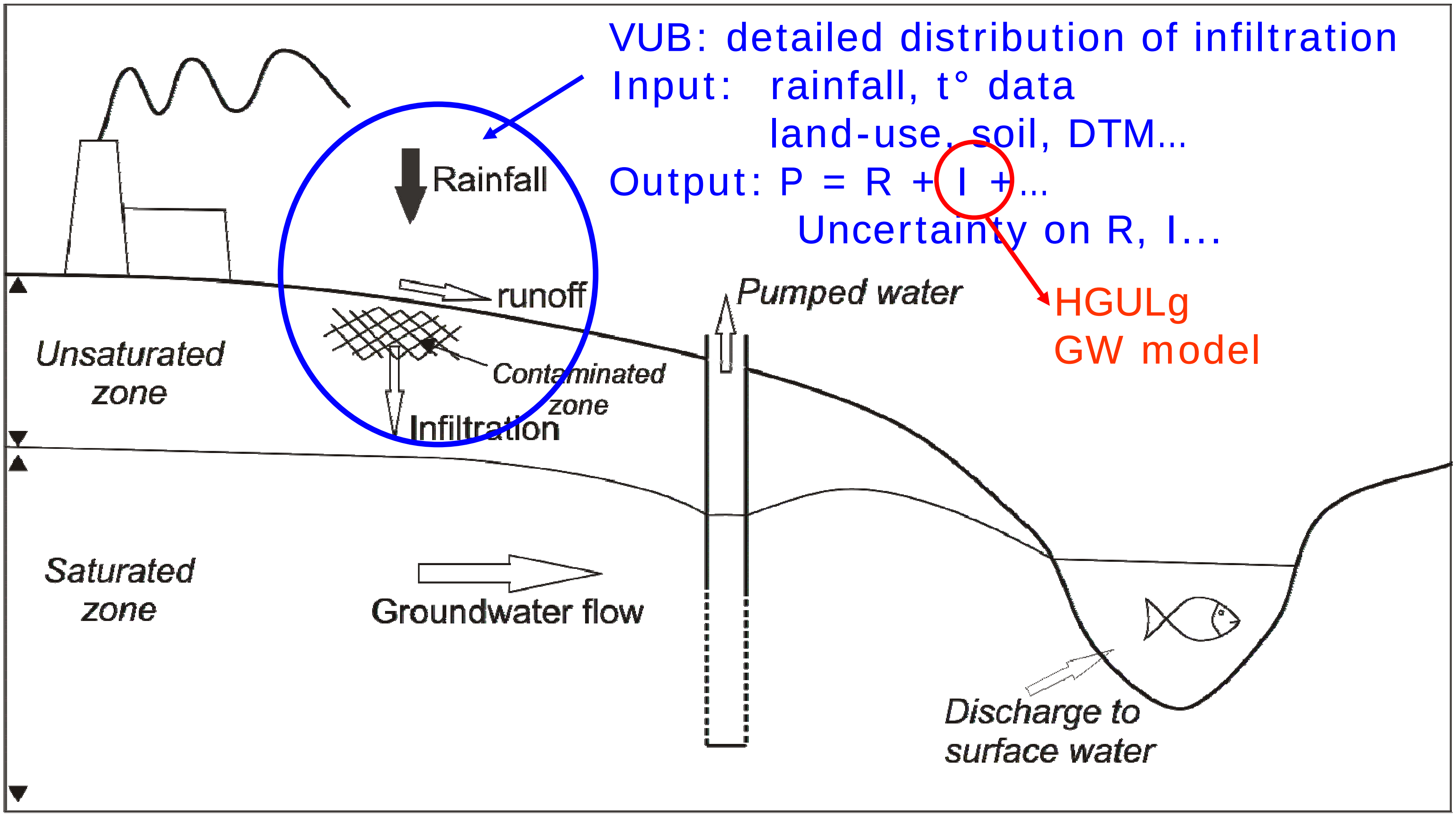


Decision Support

- Combined DPSIR – SPR ➔ Conceptual framework for understanding and structuring the problem (contamination issue)
- To take decisions:
  - ➔ **Flux-based indicators** (decisional variables) used as reference values for Risk Assessment and Socio-Economic Analysis
  - ➔ Good description of the Physical System + Modelling Tools for quantifying ongoing processes and calculating these indicators
  - ➔ Socio-economic framework for evaluating and ranking alternative responses

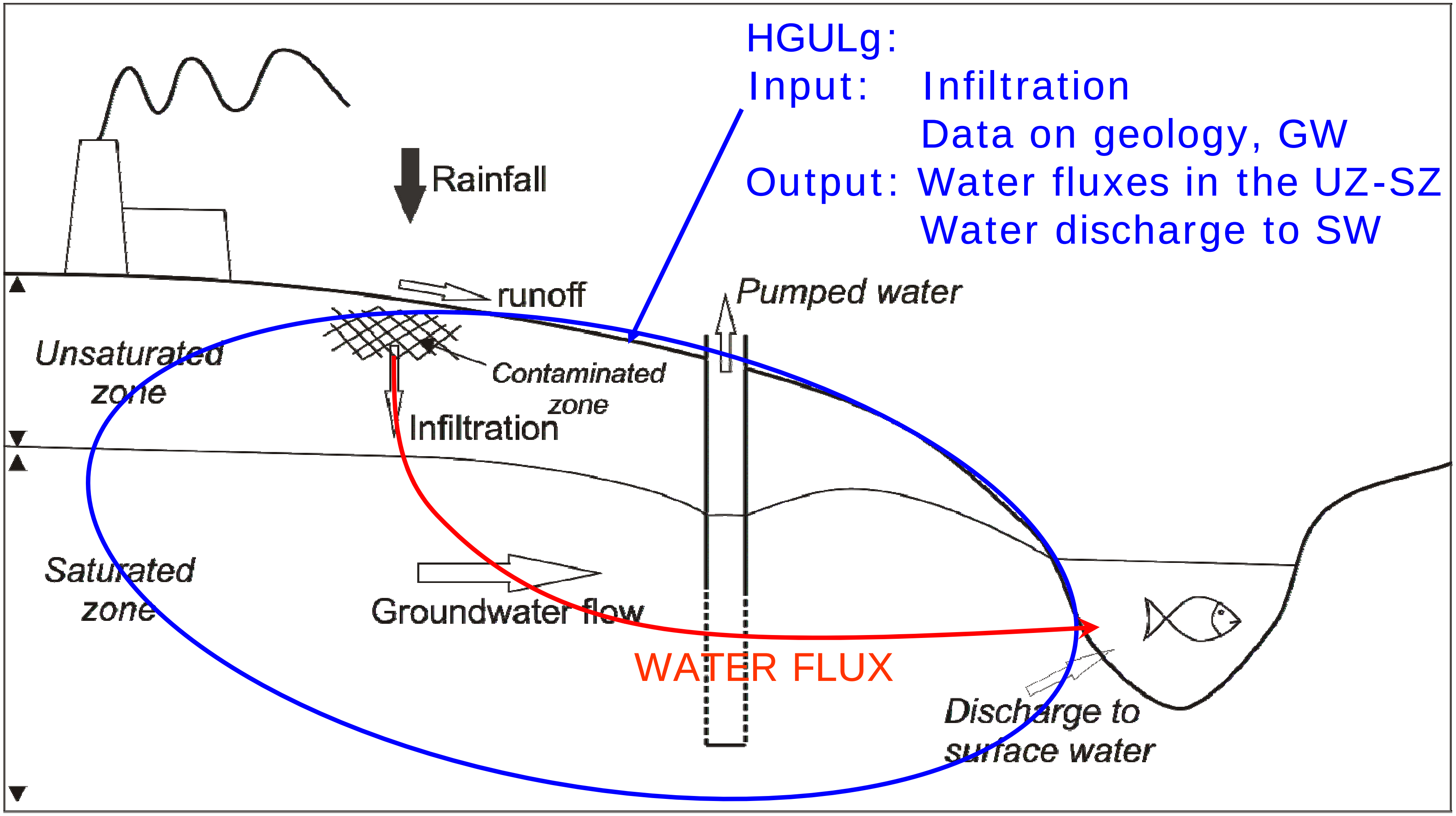
Progress in Process Studies

- Processes governing water flows



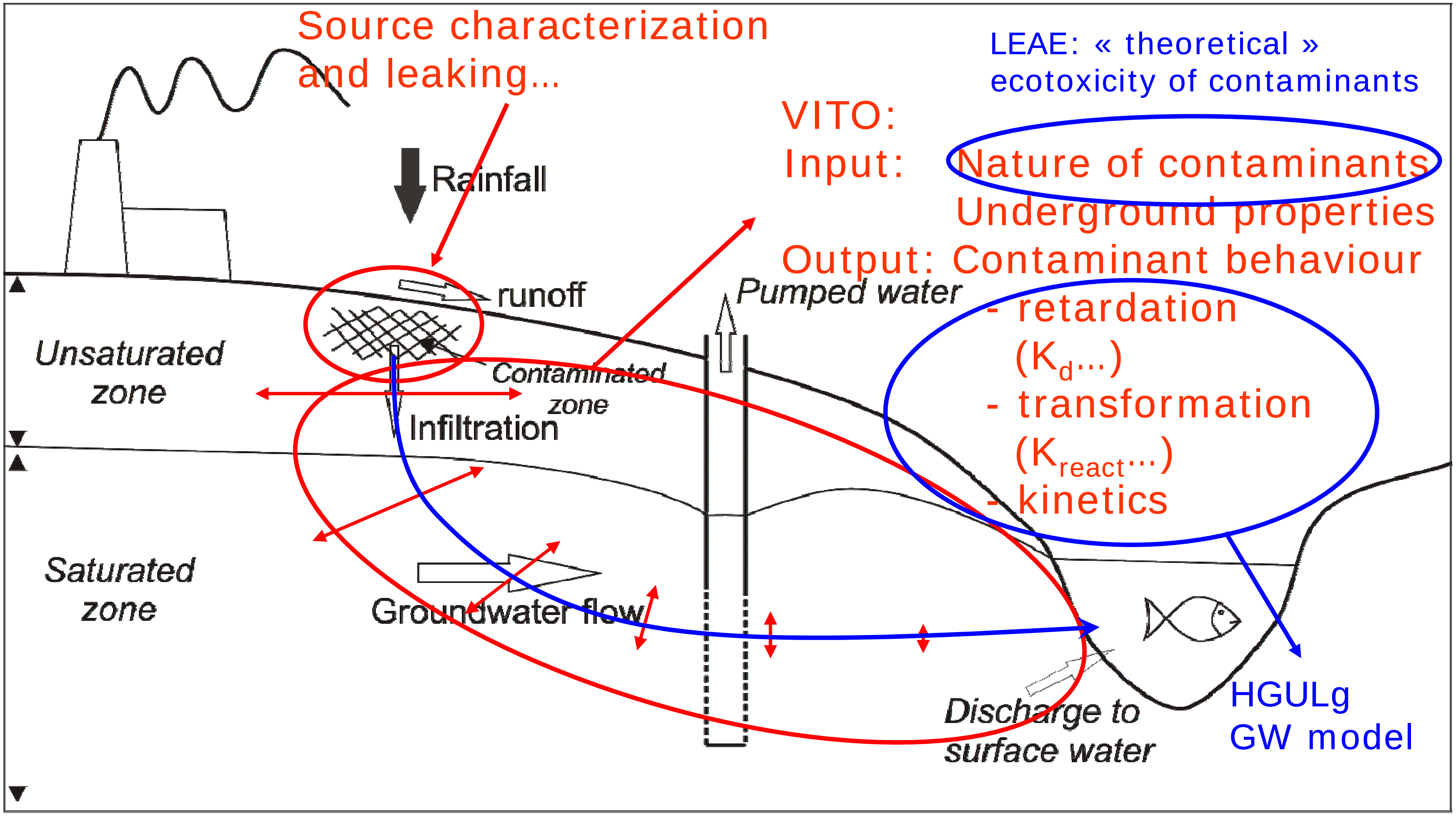
Process Studies

- Processes governing water flows



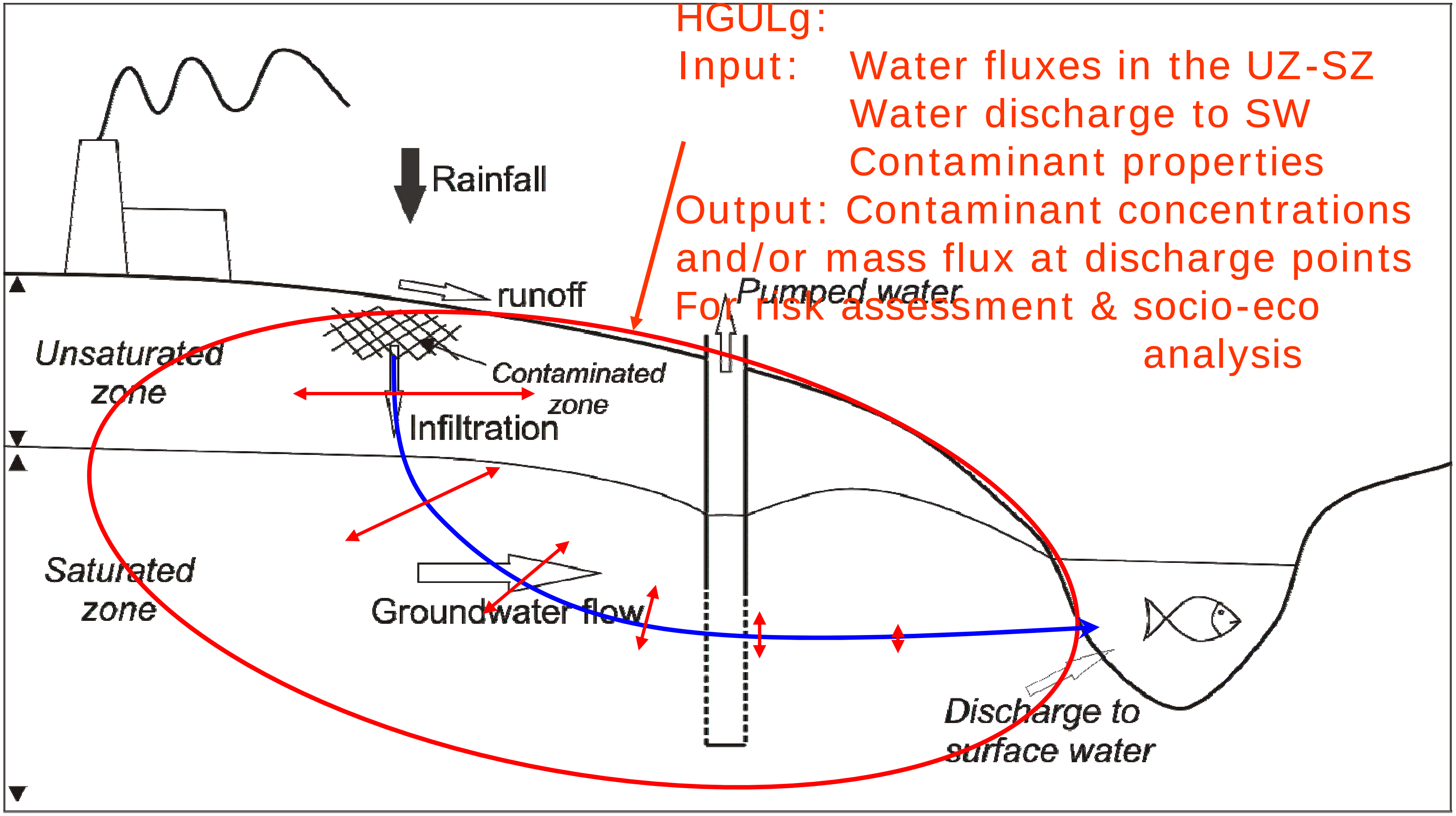
Process Studies

- Processes governing contaminant fluxes



Process Studies

- Processes governing contaminant fluxes



HGULg:

Input: Water fluxes in the UZ-SZ
Water discharge to SW
Contaminant properties

Output: Contaminant concentrations and/or mass flux at discharge points

For risk assessment & socio-eco analysis

Socio-Economic Analysis (S-I relationships)

BRGM

- Policy context
  - DPSIR & Economic Analysis → Decision support
  - Economic Analysis of environmental damages & management plans in line with WFD and GWDD
  - However:
    - Quality threshold values to be established for GW bodies at risk for the end of 2008

→ Economic analysis to be carried out in close cooperation with end-users of the project (OVAM, SPAQuE, DGRNE...)

FRAC-WECO Research activities Year 1

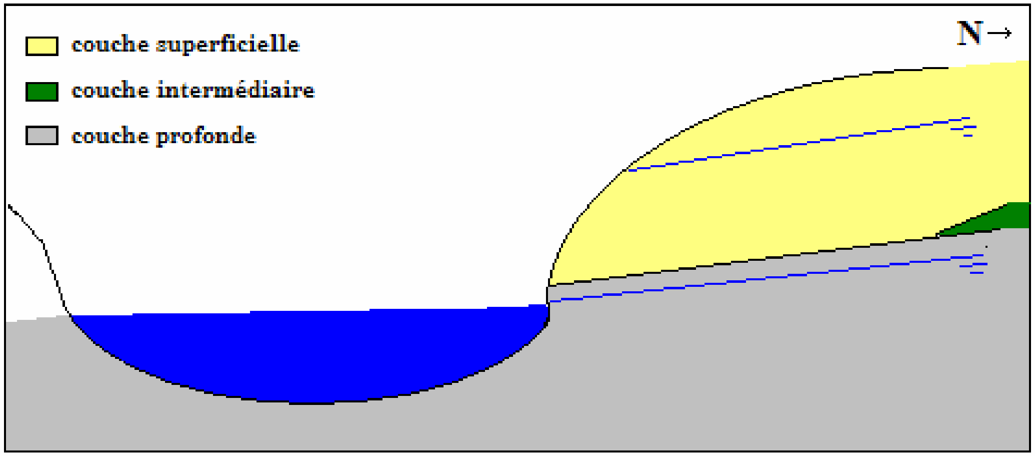
- ULg-HG
  - Data collection for the test sites
  - First field investigations
  - Integration methodology
  - Review of risk assessment tools
  - Groundwater model development for the Morlanwelz test site
- VUB
  - Image selection and preprocessing
  - Object –oriented land cover mapping
  - Image segmentation and classification
  - Validation of the classification results

FRAC-WECO Research activities Year 1

- VITO
  - Batch tests to study CAH degradation potential at three locations at the Zenne study site
- ULg – LEAE
  - Sampling water and invertebrates
  - Analysis of contaminants
  - Ecotoxicological tests and risk assessment
- Brgm
  - Integration methodology and literature review
  - Consultation of end-users
  - Typology of environmental damage
  - Data collection for the 2 case studies

FRAC-WECO Research activities Year 1

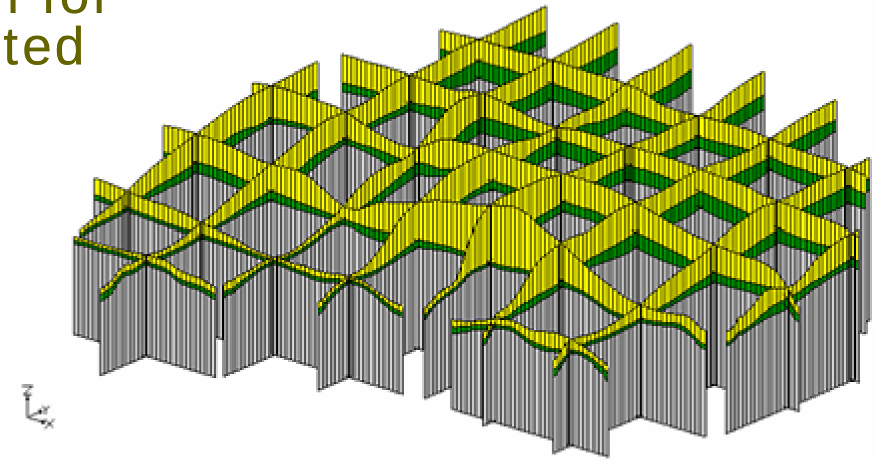
SPAQuE sa, 2006 (modified)



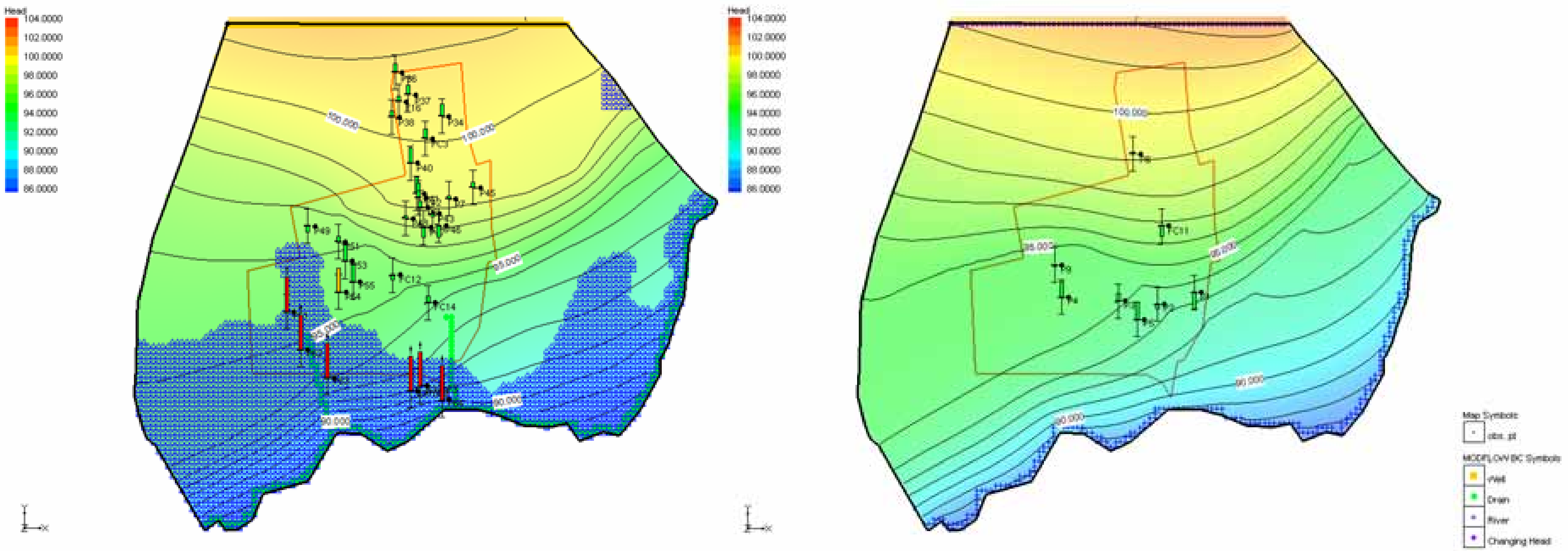
Two study sites are selected with heavy CAH contamination for application of the integrated methodology:

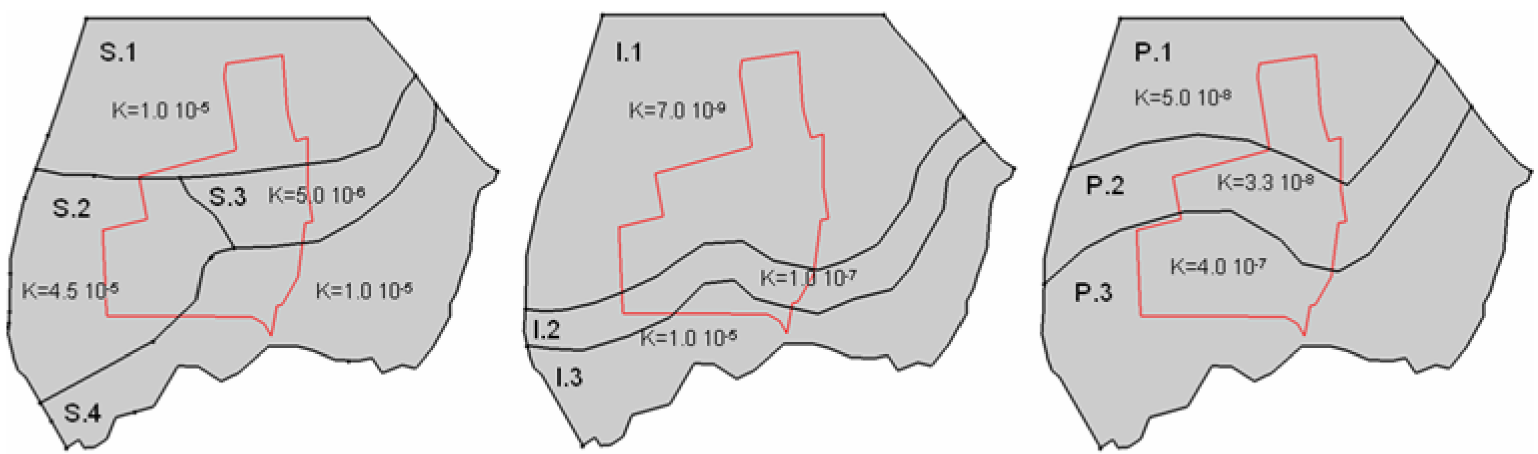
- Zenne
- Morlanwelz

Here: exemple of the Morlanwelz site



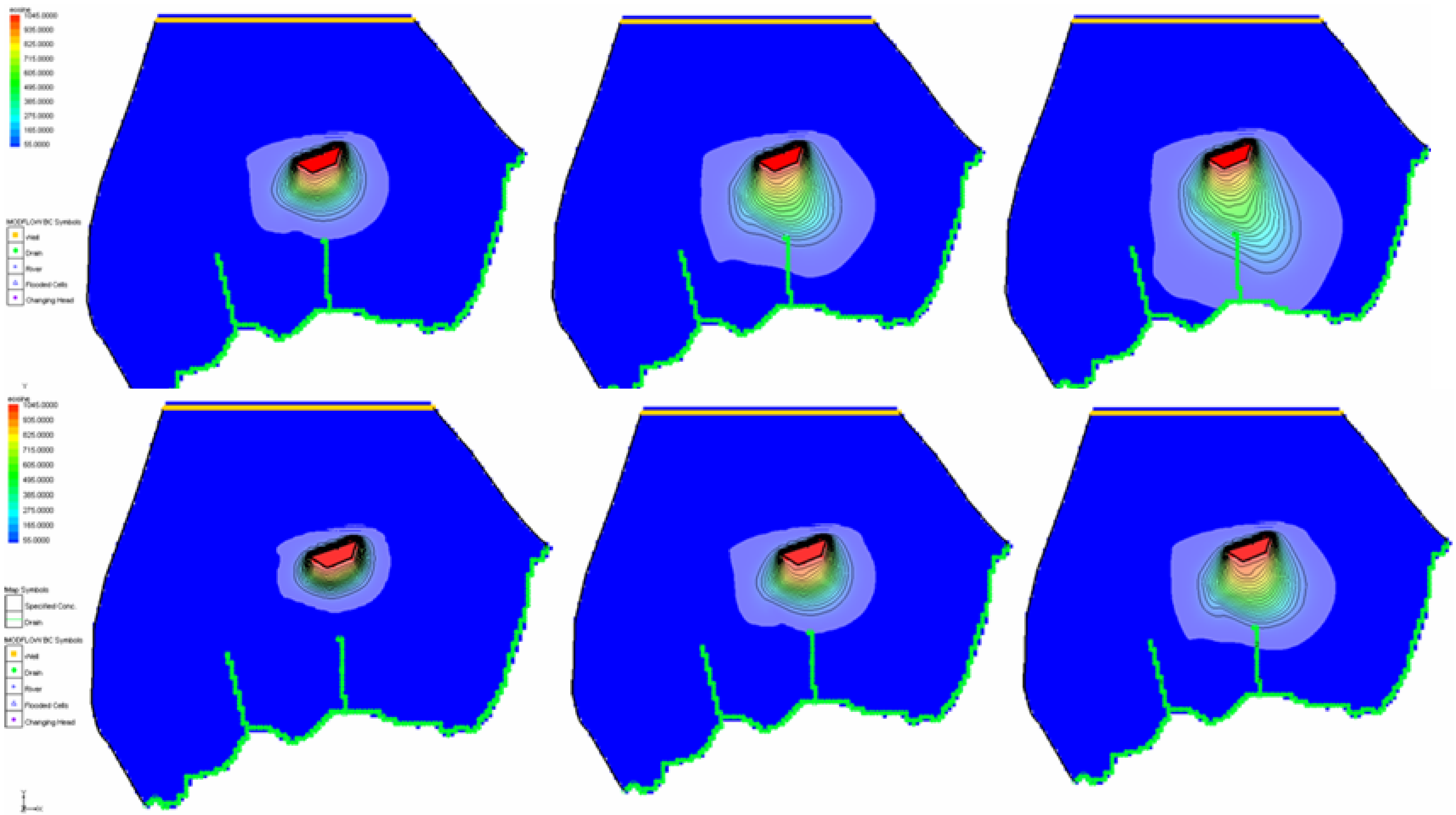
FRAC-WECO Research activities Year 1





FRAC-WECO Research activities Year 1

Preliminary results of solute transport with adsorption and degradation …



Conclusions (1)

- development of brownfields while preserving and restoring natural resources and ecosystems
- efficient remediation from a risk and economical point of view requiring prioritization :

  (a) methodologies and norms;

  (b) evaluation of the possible impact, by direct exposure but also, by dispersion in the environment, particularly through water resources;

  (c) risk assessment for humans, natural resources and ecosystems;

  (d) tools and methodologies for optimizing remediation measures.

Conclusions (2)

- a methodology based on the 'Source-Pathway-Receptor' approach for conceptualizing the physical system and on the European Environmental Agency DPSIR concept for integrating the physical and socio-economical components
- ongoing activities combining measurements and modeling for calculating **water and contaminant fluxes** from the contaminated sites at the catchment scale, including biogeochemical processes, retardation and reactivity of various contaminants
- in relation with groundwater vulnerability and eco-toxicological risk that must be taken into account for adequate management and cleaning

THANKS to the Belgian Science Policy !

FRAC-WECO Follow-up Committee

- End-users
  - OVAM (K.Van de Wiele)
  - SPAQuE (H.Halen)
  - RW DGRNE Dir. Eaux Souterraines (IC.Popescu)
  - IBGE (F.Onclincx)
- Scientific & Research Units
  - KUL (D. Springael)
  - FUSAGx (E.Haubruge)
  - CRP G.Lippmann EVA – Luxemburg (L.Hofmann)
  - ULaval – Québec (R.Therrien)
  - INRA Rennes – France (L.Lagadic)
  - UParis VI – France (M.Chevreuil)
  - UTübingen – Germany (J.Barth)

I. Role in the project

VUB Partner

•Prof. O. Batelaan, Department of Hydrology and Hydraulic Engineering (HYDR)
•Prof. F. Canters, Cartography and GIS research group, Department of Geography (CGIS)

•Research on catchment scale water and contaminant budgeting and routing: involving remote sensing of land cover and groundwater recharge modeling, run-off routing, and uncertainty assessment

II. Activities of the partner

VUB Partner

Two VUB-partners combine → hydrological modelling / → remote sensing

HYDR: numerical modelling in hydrology
Development, calibration and validation:
rainfall-runoff, groundwater flow, water quality, integrated water management and ecohydrology

CGIS: mapping of land cover in urbanised areas with HR sensors: object-based classification, sub-pixel proportion mapping, uncertainty modelling

Added value of combining expertise shown in: modelling the impact of RS mapped impervious surfaces on runoff in the Woluwe catchment

III. WP relevant activities for the project (1)

VUB Partner

WP2: Catchment scale water and contaminant budgeting and routing

Task 2.1: High-resolution groundwater recharge simulation and surface run-off routing

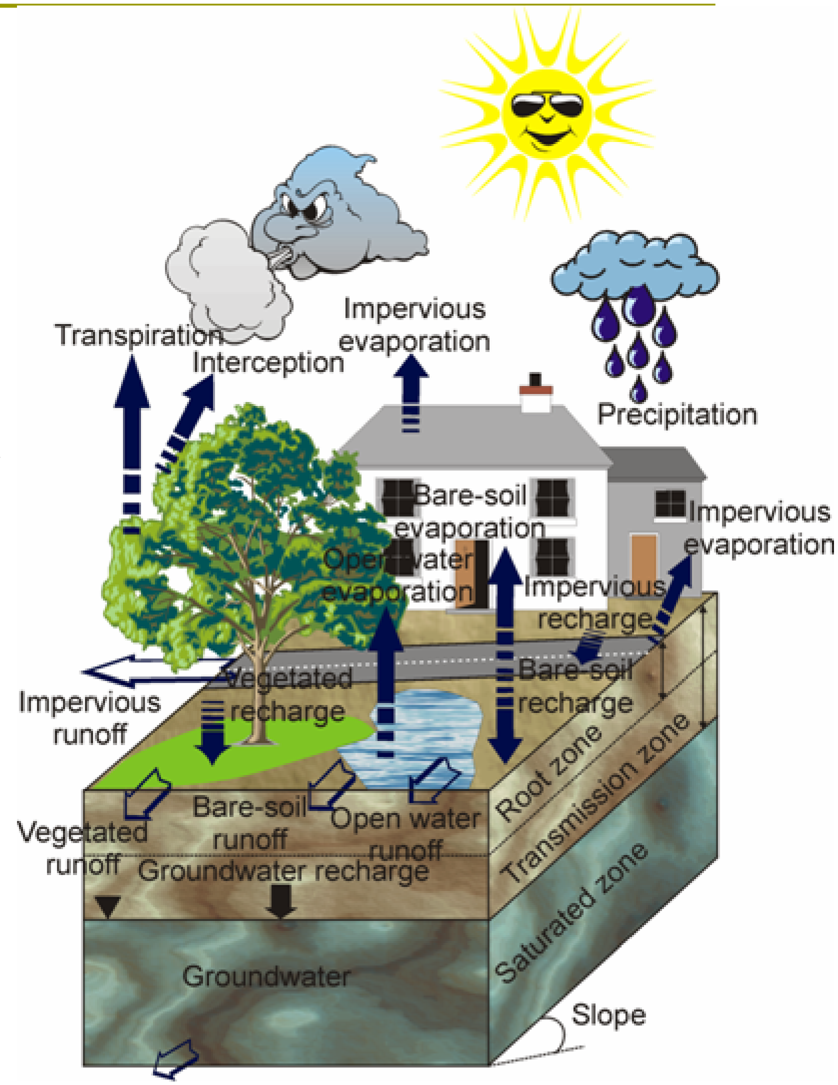
1. Object-oriented land-cover mapping
2. Spatially distributed surface water budgeting
3. Multi-temporal analysis of water fluxes
4. Impacts of land-cover classification uncertainty

IV. WP relevant activities for the project (2)

VUB Partner

WP6: Test sites

Task 6.3 Application of the integrated methodology to the test sites:
Zenne
Morlanwelz



V. Interaction with the other WPs and/or partners

VUB Partner

VUB task in WP2: Catchment scale water and contaminant budgeting and routing is input to

Task 2.2 Variably saturated groundwater modeling of ULg-HG partner

VUB task in WP6: Contribution to interaction in testing methodology with all partners on test sites

ULg-HG Partner

I) Role in the project

II) Activities of the partner

III) WP relevant activities for the project (1)

IV) WP relevant activities for the project (2)

V) Interaction with the other WPs and/or partners

I. Role in the project

ULg-HG Partner

- Coordinating and managing the whole project
- Variably saturated subsurface flow modeling and transport modeling
- Development of a physically-based groundwater specific vulnerability and risk assessment method
- Data mining, acquisition and processing in relation with the test sites

II. Activities of the partner

ULg - HG Partner

1- Characterisation, optimisation of field and labo measurements, modelling groundwater quantity and quality

2- Solute transport (tracers and reactive compounds) in saturated and partially saturated porous and fissured media

3- Interactions and coupling groundwater models with surface water and river models within integrated approaches

4- Hydrogeological vulnerability and risk mapping

5- Hydrogeological characterisation in semi-arid and arid regions

III. WP relevant activities for the project (1)

ULg-HG Partner

- WP1: Project management and integration

  Task 1.1: Project coordination and management
  Task 1.2: Integration of process studies and tools with the socio-economical analysis
  Task 1.3: Links with stakeholders and decision-makers

- WP2: Catchment scale water and contaminant budgeting and routing

  Task 2.2: Variably saturated groundwater modeling

IV. WP relevant activities for the project (2)

ULg - HG Partner

- WP4: Development of risk assessment tools and indicators

  Task 4.1: Groundwater vulnerability mapping and flux-based risk assessment

- WP6: Test sites

  Task 6.3 Application of the integrated methodology to the test sites

V. Interaction with the other WPs and/or partners

ULg-HG Partner

- ULg-HG task in WP1: Contribution to the management for interactions *with all partners in developing methodology*

- ULg-HG Task 2.2 - Variably saturated groundwater modeling (in WP2) is output to *tasks of VITO, ULG-LEAE and BRGM partners*

- ULg-HG task in WP4: Development of risk assessment tools and indicators *will be defined in close collaboration with ULg-LEAE*

- ULg-HG task in WP6: Contribution to interaction in testing methodology *with all partners on test sites*

VITO Partner

I) Role in the project

II) Activities of the partner

III) WP relevant activities for the project (1)

IV) WP relevant activities for the project (2)

V) Interaction with the other WPs and/or partners

I. Role in the project

VITO Partner

Identification/ quantification biogeochemical processes:

- contaminant degradation/ transformation during transfer (vadose zone, groundwater, sediment, surface water)
- fate of contaminants ~ changing environmental conditions
    - **CAH**, organochlorinated compounds, heavy metals, PAH, BTEX
    - Eh, pH, organic matter, redox conditions, micro-organisms
- degradation of pollutants along the flow path
    - monitoring of natural attenuation
    - (bio)stimulation of degradation

II. Activities of VITO

VITO Partner

480 researchers, 7 centers of expertise:

- energy consumption in processes
- new materials
- environmental protection and innovation

- Environmental and Process Technology Center (MPT)
  - research in new soil remediation methods
    phytoremediation, ex-in-situ bioremediation, (enhanced) natural attenuation, physicochemical transformation of (in)organic pollutants (CAH, BTEX, heavy metals, PAH, MTBE, oil,…)
  - advice, evaluation and demonstrations for companies or governmental organizations
    purification of waste water and ground water
    cleaning of soil and dredging materials

III. WP relevant activities for the project

VITO Partner

- Soil/water/sediment sampling (partly)
- Evaluation of pollutant degradation
  - Natural attenuation
  - Biostimulation
    - addition of carbon-sources (lactate, molasses, HRC,…)
    - addition of electron-acceptors (NO_3^-, SO_4^{2-})
    - addition of nutrients (N, P, K)
  - Bioaugmentation
    - characterisation of present bacteria (PCR, DGGE)
    - addition of degrading microorganisms

→ Batchtests, microcosms (oxic, anoxic)

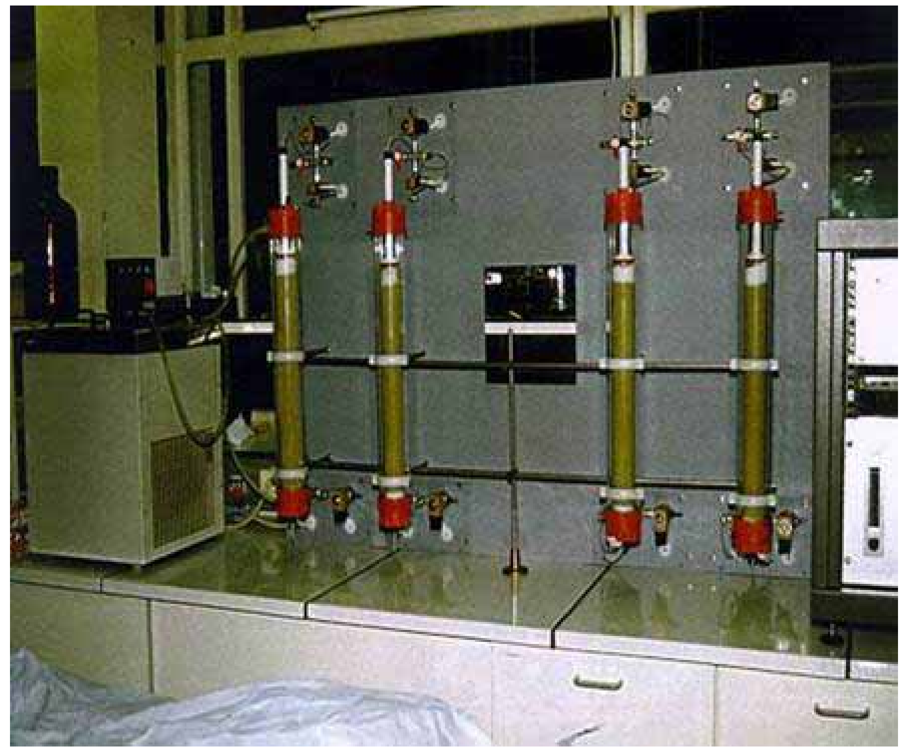
IV. WP relevant activities for the project

VITO Partner

- Determination of relevant degradation parameters for modeling purposes
  - K_d, half life, break-through, …
  - input parameters for models VUB, ULg

→ Column tests

Realistic in situ conditions !



V. Interaction with the other WPs and/or partners

VITO Partner

- Advice on soil/water/sediment sampling for modeling purposes
- Adivice on analysis techniques of organic, inorganic parameters
- Testsite Zenne, Vilvoorde:
  - Datasets on hydrology, geology, pollution concentrations
- ULg-LEAE: ecotoxicity of contaminants
  - microbial analysis ((Q)-PCR, DGGE, …)
  - toxicity tests (Microtox, Cytotox, Vitotox)
- ULg-HG: flow modeling and transport modeling
  - existing groundwater and transport models of Zenne site
  - determining necessary parameters for use in transport/ degradation models via batchtests and column tests

ULg-LEAE Partner

I) Activities of the partner

II) Role in the project

III) WP relevant activities for the project (1)

IV) WP relevant activities for the project (2)

V) Interaction with the other WPs and/or partners

ULg-LEAE Partner

I. Activities of the partner

- **Laboratory of Animal Ecology and Ecotoxicology (LEAE) – Prof. J-P. Thomé**

→ Expertise in fundamental and applied Ecology and Ecotoxicology

- Study of energy and matter fluxes and transfer within aquatic freshwater ecosystems (particularly planktonic org.)

- Ecotoxicological effects, fate and transfer of POPs (organochlorines: pesticides, PCBs,...)

- Assessment of freshwater quality using

→ bioindicator organisms

→ biochemical exposure and effects biomarkers

→ The Laboratory entered the CART (« Centre for Analysis of Residues in Traces ») as an active member

II. Role in the project

ULg-LEAE Partner

- Ecotoxicological approach
  - → Study of contaminants
  - → Impact on species survival

III. WP relevant activities for the project

ULg - LEAE Partner

WP3:

→ Sampling ground- and surface waters

→ Sampling of subsurface representative organisms (collaboration with Dr. P. Martin, IRSNB)

→ Sampling sites

- River Zenne, Morlanwelz, Chimeuse
- Néblon (reference)

Niphargus virei

IV. WP relevant activities for the project

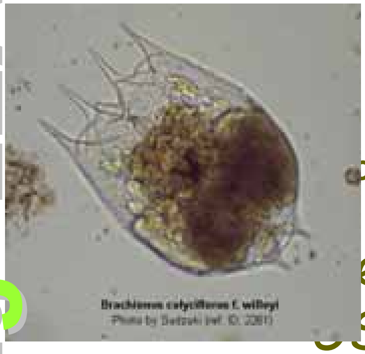
ULg-LEAE Partner

→ Analysis of contaminants

- Polychlorobiphenyls (7 standard and dioxin-like PCBs)
- Organochlorinated pesticides (lindane, DDT and its metabolites)
- Selected herbicides (Prof. E. De Pauw, ULg)

→ Ecotoxicological testing

- Acute sensitivity of invertebrate organisms using LC_{50} determination approach
- Chronic sensitivity of invertebrate organisms using EC_{50} determination approach (e.g. ...oduction aspects).



...etermine induction of biomarkers (EROD, ...ST, AChE) activity in water organisms